Files are in Adobe format.
Download the newest version from Adobe.

13th ANNUAL SYSTEMS ENGINEERING CONFERENCE

"Achieving Acquisition Excellence Via Effective Systems Engineering"

San Diego, CA

25 - 28 October 2010

Agenda

Tuesday, October 26, 2010

INTRODUCTION & OPENING REMARKS
- Mr. Bob Rassa, Director, Engineering Programs, Space & Airborne Systems, Raytheon Company; Chair, Systems Engineering Division, NDIA

KEYNOTE ADDRESS
- Lt Gen Richard Scofield, USAF (Ret), former Commander, Aeronautical Systems Center and Wright Patterson Air Force Base

PLENARY SESSION 1 - CHIEF SYSTEMS ENGINEERS PANEL – "*Engineering Complex Systems of the Future"*
Moderator: Mr. James Thompson, Director, Major Program Support, Systems Engineering Directorate, Office of the Director, Defense Research and Engineering
- Mr. Terry Edwards, Office of the Secretary of the Army for Acquisition, Logistics and Technology
- Mr. Ricardo Cabrera, Office of the Assistant Secretary of the Navy for Research, Development and Acquisition
- Col Shawn Shanley, USAF, Office of the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering

LUNCH SPEAKER
- Mr. Stephen Welby, Director, Systems Engineering, Office of the Director, Defense Research and Engineering

WEDNESDAY, OCTOBER 27, CONCURRENT SESSIONS

TRACK 1
Systems Engineering Effectiveness - Bayview I
- 10912 - *Systems Engineering Policy and Guidance Implementation of the Weapon Systems Acquisition Reform Act (WSARA) of 2009–One Year Later,* Ms. Sharon Vannucci, ODDR&E/SE
- 11003 - *GAO Observations on DoD Implementation of the 2009 WSARA*, Mrs. Cheryl Andrew, U.S. Government Accountability Office
- 10951 - *DoD Synergy with International Standards*, Dr. Karen J. Richter, Institute for Defense Analyses
- 10853 - *Value of Systems Engineering,* Ms. Kerri Polidore, ARDEC
- 11087 - *Improvement Initiatives at C-17*, Mr. Sivam Paramanathan, The Boeing Company
- 11106 - *Practical Agile Requirements Engineering,* Mr. Philip Matuzic, The Boeing Company
- 10773 - *NDIA Top 5 Software and Systems Engineering Issues – 2010,* Mr. Harold Wilson, Northrop Grumman Information Systems, DSD
- 10819 – *Systems Engineering Program Metrics*, Mr. Jim Thompson, ODDR&E/SE
- 11089 - *Naval Systems Engineering Technical Review Process*, Mr. Paul Dube, ASN(RDA) CHSENG
- 10850 – *System Engineering Effectiveness*, Mrs. Kalyani Tripathi, U.S. Army - ARDEC
- 10755 - *A Framework for Evaluating U.S. DoD Systems Engineering Principles Against Defense System Quality*, Dr. Nazanin Azizian, Marine Corps Systems Command
- 10787 - *The MITRE Systems Engineering Guide: Practical Guidance for FFRDC Systems Engineers*, Mr. George Rebovich, The MITRE Corporation

TRACK 2 - Net-Centric Operations/Interoperability - Bayview II
- 10849 - *Principles of Net-Centricity,* Mr. Hans Polzer, Lockheed Martin
- 10768 - *Mission Engineering for Warfighting Integration of Net-Centric Systems,* Ms. Eileen Bjorkman, U.S. Air Force
- 10852 - *Interoperability by Design,* Mr. Ken Hafner, SPAWARSYSCOM
- 10829 - *Battle Command and Simulation Interoperability Using Common Geospatial Representations*, Mr. Thomas Stanzione, VT MAK
- 10799 - *Procure-2-Pay Portal Pilot: Integrated Feasibility Assessment (IFA),* Ms. Lien Dinh, Defense Business Transformation Agency
- 11114 - *Panel: Systems Engineering Management and the Relationship of Systems Engineering to Project Management and Software Engineering*, Dr.

Raymond Madachy, Naval Postgraduate School

TRACK 2 - Property Management – Bayview II

- 10934 - *The Evolving Operational Environment as a Unifying Foundation for Systems Engineering and Acquisition Decision Making*, Mr. Vincent Roske, Institute for Defense Analyses
- 11073 – *Advancing Systems Engineering Through Use of Collaborative Space*, Mr. George Richard Freeman, U.S. Air Force
- 10796 - *Valuing System Flexibility via Total Ownership Cost Analysis*, Dr. Barry Boehm, University of Southern California

TRACK 3 – System of Systems - Bayview III

- 10913 - *Update on SoS SE: SoS SE Artifacts and A Practitioner View*, Dr. Judith Dahmann, The MITRE Corporation
- 10806 - *Key System of Systems Engineering Artifacts to Guide Engineering Activities*, Dr. Jo Ann Lane, University of Southern California
- 10598 - *Systems Engineering Processes Improvement Using the CMMI in Large System of Systems Space Programs*, Mrs. Revital Goldberg, Israel Aerospace Industries
- 10838 - *The Joint Land Component Constructive Training Capability: An SoS Success Story*, Ms. Laura Feinerman, The MITRE Corporation
- 10887 - *Army System of-Systems Engineering Processes*, Mr. Terry Edwards, ASA (ALT) SoSE
- 10888 - *Army System of-Systems Architecture Developments*, Mr. David Poole, ASA (ALT) SoSE

TRACK 3 – Joint Net-Centric/SOS- Bayview III

- 10955 - *Network Centric Patterns for System Interoperability*, Mr. Mark Bowler, The Boeing Company
- 10754 – *Understanding the Limits of Systems of Systems*, Dr. Elwin Ong, Booz Allen Hamilton
- 11065 - *Mission Level Engineering*, Ms. Helene Anderson, ASN(RDA) CHSENG

TRACK 4 – Early System Engineering - Mission I

- 10944 - *Development Planning Update: Policy Evolution from a Technical Perspective*, Mr. Michael Duffey, ODDR&E/SE
- 10766 - *Findings and Recommendations from the NDIA/OSD Development Planning Working Group*, Mr. John Lohse, Raytheon Company
- 10790 - *A Better-Informed Materiel Development Decision for USAF Programs*, Mr. Jeff Loren, Alion Science & Technology
- 10786 - *Early Systems Engineering to Achieve MS B*, Mr. Michael Gaydar, NAVAIR
- 11011 - *Systems Engineering in Development Planning and Science & Technology*, Dr. Kenneth Barker, U.S. Air Force
- 11015 - *Developing a Mission Solution: From Mission Gap Analysis to Preferred System Concept*, Ms. Elizabeth M. O'Keefe, Raytheon Company
- 10507 - *Developing a Net-Centric Mission Architecture: From Mission Analysis to Executable Model*, Mr. James Sierchio, Raytheon Missile Systems
- 11466 - Applying *NATO's Distributed Networked Battle Labs (DNBL) Initiative to Early Systems Engineering*, Mr. Hans Polzer, Lockheed Martin
- 10784 – *Suitability Impacts on Rapid Development*, Mr. Michael Gaydar, NAVAIR
- 11131 - *The Case for Considering Acquisition Program Executability Prior to Materiel Development Decision (MDD)*, Mr. Gregory Laushine, SAIC
- 10810 - *Improving Success with Technology Using an Organizational Epistemology — A Conceptual Decision Framework for Early Systems Engineering*, Dr. Chris Powell, HPTI
- 11083 - *Early Systems Engineering for Tech Base Projects*, Mr. Richard Swanson, HPTI

TRACK 5 – Modeling and Simulation - Mission II

- 11436 - *Panel: Overview of CREATE — Physics Based Modeling and Simulation*,
  - Mr. Oscar Goldfarb
  - Mr. Doug Post
  - Dr. Bob Meakin
- 10828 - *Understanding the Increasingly Important Role M&S Plays in Department of Defense Acquisition*, Ms. Philomena Zimmerman, ODDR&E/SE
- 10958 - *Results of a Study on the Management of Broadly-Needed Modeling and Simulation Tools*, Dr. James Coolahan, JHU/APL
- 10735 - *Best Practices for the Development of Models and Simulations*, Dr. Katherine Morse, JHU/APL
- 10591 - *Military Modeling & Simulation Systems Oriented Architecture (SOA) Concepts Pilot*, Dr. Gary Allen, Joint Training Evaluation and Integration Center
- 10891 - *Leveraging LVC Simulation Capabilities for Systems Analysis*, Dr. Douglas Hodson, WPAFB
- 10922 - *The Modeling and Simulation Catalog for Discovery, Knowledge and Reuse*, Mr. Steve Hunt, Alion Science and Technology
- 10813 – *Systems Engineering Initiatives for Verification, Validation, and Accreditation of DoD Models and Simulations*, Ms. Philomena Zimmerman, ODDR&E/SE
- 10959 - *NDIA Model Based Engineering (MBE) Subcommittee Report*, Mr. Frank Salvatore, HPTI
- 11063 - *Best Practices in Contracting for Models, Simulations, and Associated Data Subcommittee Report*, Mr. Dennis Shea, Center For Naval Analyses
- 10827 – *Supporting Weapon Systems Assessments with Realistic Synthetic Environment Representations —Where to Go for Authoritative Data*, Ms. Philomena Zimmerman, ODDR&E/SE
- 11091 - *Deployment of MBSE Processes Using SysML*, Mr. Timothy Tritsch, HPTI

TRACK 6 – Workforce Development - Mission III

- 10932 - *BKCASE: Body of Knowledge and Curriculum to Advance Systems Engineering*, Dr. Arthur Pyster, Stevens Institute of Technology
- 11068 - *GRCSE and GswE2009: Educational Advancements to Support Government and Industry*, Ms. Nicole Hutchison, Analytic Services, Inc.
- 11078 - *Curriculum for the Life Cycle of the Systems Engineer*, Dr. Carlee Bishop, Georgia Tech Research Institute
- 10933 - *Panel: In Search of the Principles of Systems Engineering (BKCASE*), Mr. Richard Adcock, Cranfield University
- 10939 - *Improving the Department of Defense and Industry Systems Engineering Workforce*, Dr. Don Gelosh, ODDR&E/SE, Mr. Doug Westphal and Dr. John Snoderly, DAU
- 10651 - *Realizing the Vision: Innovative Practices to Enhance the Capability of the Systems Engineering Workforce*, Dr. Janice Ziarko, The MITRE Corporation
- 10883 - *Undergraduate Systems Engineering Programs in the United States*, Dr. Arthur Pyster, Stevens Institute of Technology Dr. Don Gelosh, ODDR&E/SE
- 11006 - *Leveraging Remote Online Education for SE Competency Development*, Ms. Alice Squires, Stevens Institute of Technology
- 11445 - *The Use of Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development*, Mr. Rich Volkert, SSC Pacific

TRACK 7 – Enterprise Health Management- Palm I

Opening Presentation: Mr. Howard Savage, SCI

- 11056 - *Unmanned Ground Vehicle Integrated Diagnostics,* Mr. Larry Osentoski, DRIVE Developments, Inc.
- 11059 - *Diagnostic Improvement of Complex Systems Through Enhanced Information Usage,* Mr. Darrell Bartz, The Boeing Company
- 10967 - *Enterprise Health Management Technology Transition Issues and Path Forward,* Mr. Chris Reisig, The Boeing Company

TRACK 7 – Technology Maturity

- 11060 - *GAO's Annual Assessment of Selected Weapons Programs,* Mr. Travis Masters, U.S. Government Accountability Office
- 10715 - *Australia's Experience in Technical Risk Assessment for Defence Acquisitions,* Dr. David Wood, Department of Defence
- 10736 - *Adapting Systems Engineering Best Practices to Technology Development in Applied Research,* Mr. Jeff Craver, Defense Acquisition University
- 11099 - *Performing Software Feasibility Analysis on Major Defense Acquisition Programs,* Mr. Jim Thompson, ODDR&E/SE

TRACK 8 – Test and Evaluation in Systems Engineering - Palm II

- 10604 - *Test and Evaluation Issues for Systems of Systems: Sleepless Nights to Sominex,* Dr. Beth Wilson, Raytheon Company
- 10911 - *(JMETC) Effective T&E by Improving Distributive Test Capabilities,* Mr. Ryan Norman, Joint Mission Environment Test Capability, Lead Systems Engineer
- 10733 - *2010 Strategic Plan for DoD T&E Resources,* Dr. Suzanne Strohl, OSD AT&L Test Resource Management Center
- 10903 - *Guarding the Intent of Requirements Throughout the Test Execution Cycle,* Mr. Stephen Scukanec, Northrop Grumman, Aerospace Sector
- 10783 - *Evolution of the Tomahawk Land-Attack Missile Operational Test Launch Methodology,* Mrs. Angelica Lilly, JHU/APL
- 10831 - *T&E Methodology for Business Systems,* Dr. Aaron Drew, Defense Business Transformation Agency
- 10935 - *Strategic Enterprise Test and Evaluation Process Approach,* Ms. Harriette Tullos-Banks, Naval Surface Warfare Center, Dahlgren Division

TRACK 8 - Joint Cyber/SW Intensive – Palm II

- 10918 - *Rationalizing Governance, Engineering Practice, and Engineering Economics in the System and Software Assurance Trade Space,* Mr. Paul Croll, CSC

TRACK 9 – Human Systems Integration – Mariner Point

- 11077 - *Driving HSI into Common Industry Practice,* Dr. Noreen McQuinn, The Boeing Company
- 10724 - *Systems Engineering and User Needs — Strategies and Tactics for the Evolving System Acquisition Environment,* Dr. William Reese, Northrop Grumman Electronic Systems
- 10851 - *Assessment of Human Systems Integration in Air Force Acquisition,* Mr. John Maziarz, Booz Allen Hamilton
- 11082 - *HSI Translation of Capability Requirements to Acquisition,* Ms. Lisa Kaminski, Booz Allen Hamilton
- 11010 - *Human Systems Integration Approaches for Developmental Testing,* Dr. Matthew Risser, Pacific Science & Engineering Group
- 10971 - *A-10, Thunderbolt II — a Study of Human Systems Integration,* Dr. David Jacques, Planned Systems International

TRACK 9 - System Safety –ESOH – Mariner Point

- 11130 - *Acquisition ESOH— Follow Through After the Policy is Printed,* Mr. David Asiello, Office Deputy Under Secretary of Defense (I&E)
- 10907 - *A Case Study of an Evolving ESOH Program — One Company's Perspective,* Mr. Michael Parulis, Electric Boat Corporation
- 11120 - *Addressing Environmental Safety and Occupational Health (ESOH) in Systems Engineering Across the Entire Acquisition Life Cycle,* Mr. Ted Grady, USAF - Aeronautical Systems Center

TRACK 10 - Logistics Supportability and Sustainment - Crown Point

- 10592 - *Engineering Design Analysis (Physics of Failure),* Mr. Gary Drake, U.S. Army Materiel Systems Analysis Activity
- 10926 - *Design For Reliability (DFR) Methodology Applied to Stryker NBCRV Program,* Dr. Dmitry Tananko, GDLS
- 10780 - *NDIA Life Cycle Affordability Project,* Mr. Joel Moorvitch, Raytheon Company
- 10836 - *Logistics Demonstrations: A Strategy to Reduce Cost, Maintain Schedule, and Mitigate Risks to Achieve Performance Goals,* Mr. Jeffrey Gilbert, U.S. Army Evaluation Center
- 11071 - *Sustaining and Upgrading the Air Force's Legacy Mobility Fleet: Addressing Issues Using SE Enterprise Approach,* Mr. Ray Flores, USAF Air Mobility Directorate, Aeronautical System
- 10774 - *PLM for Systems Engineering Support within ECSS,* Mrs. Segrid Harris-Wright, Air Force Logistics Transformation Organization

TRACK 10 - Architecture - Crown Point

- 10771 - *First Steps in the Development of an Architecture Framework for a Product Development Process,* Mr. Jeffrey Williams, Southern Methodist University
- 10584 - *Enterprise Architecture Model-Driven Simulation,* Mr. Robert Byrd, Serco, Inc.
- 10841 - The *Role of Enterprise Architecture Updates in Guiding Decentralized Organizations,* Mr. John Schatz, SPEC Innovations

THURSDAY, OCTOBER 29, CONCURRENT SESSIONS

LUNCHEON SPEAKER:

- *Systems 2020,* Ms. Kristen Baldwin, Director, Systems Analysis, Systems Engineering Directorate, Office of the Director, Defense Research and Engineering

TRACK 1 - Systems Engineering Effectiveness - Bayview I

- 10812 - *Introduction to the DoD Systems Requirements Analysis Guide,* Ms. Sharon Vannucci, ODDR&E/SE
- 10867 - *Defining and Quantifying System Complexity,* Mr. John Seel, GWU and Naval Surface Warfare Center, Dahlgren Division
- 11053 - *Are Rapid Fielding and Good Systems Engineering Mutually Exclusive?,* Mr. William Decker, Defense Acquisition University
- 11107 - Panel: SE Standards: Status & Needs
  - **Moderator:** Ms. Sharon Vannucci, ODDR&E/SE
  - Ms. Cheryl Jones, Quality Engineering & System Assurance Sciences Group, RDECOM-ARDEC
  - Mr. Joel M. Manary, Engineering Process Office, SSC Pacific Air Force
  - Mr. Chris Ptachik, SAF/AQRE
  - Mr. Garry Roedler, Lockheed Martin Engineering Process Improvement Center

TRACK 2 – Program Management - Bayview II

- 10927 - *Lifecycle Management Cost Optimizer*, Mr. Jerry Cothran, Lockheed Martin
- 10910 - *Rapid Affordability and CAIV Exploration (RACE) Tool*, Mr. James Fieber, Lockheed Martin
- 10802 - *Systems Engineering Influence on Life Cycle Cost*, Dr. Elizabeth Rodriguez-Johnson, ODDR&E/SE
- 10820 - *Enhancing Performance Management via Metrics*, Mr. Peter Nolte, ODDR&E/SE
- 11135 - *A Decision-Focused Model for DoD Development Planning—A Step Toward Uncovering and Targeting the Real Program Shapers*, Mr. Gregory Laushine, SAIC
- 10785 - *Risk Management in the TACOM LCMC*, Ms. Lisa Graf, U.S. Army - TARDEC
- 10940 - *EVM Method for LOE Projects*, Mr. Lynwood Townsend, GWU and Naval Surface Warfare Center, Dahlgren Division

TRACK 3 – Joint Net-Centric/System of Systems - Bayview III

- 10889 - *System-of-Systems Engineering for Army Battle Command Convergence*, Ms. Hillary Richardson, The MITRE Corporation
- 10730 - *AT&L and DOT&E IA Cross Walk Improving Information Assurance in Systems Acquistion and Testing*, Mr. Peter Christensen, The MITRE Corporation

TRACK 3 – Joint Net-Centric/Interoperability - Bayview III

- 11033 - *The View from Here — Human Views in Architecture Models*, Mr. Tim Bowden, Jenius LLC
- 10996 - *DoD Delivering the Architecture of the Future*, Mr. Alan Golombek, Architecture & Infrastructure Directorate
- 10901 - *Enhancing the Usability of the Human Machine Interface on the Handheld Interagency Identity Detection Equipment (HIIDE)*, Mr. John J. Howard (paper, slides), Southern Methodist University

TRACK 3 – Specialty Engineering - Bayview III

- 10586 - *New Army and DoD Reliability Scorecard*, Mrs. Marguerite Shepler (paper, slides), U.S. Army Materiel Systems Analysis Activity

TRACK 4 – Early Systems Engineering - Mission I

- 10792 - *The Conversation," Applying Systems Thinking to the Science and Technology Phase of Acquisition*, Mr. Robert Rapson, Materials and Manufacturing Directorate
- 10795 - *Recapturing System Decomposition Techniques for Improved S&T Development of Future Warfighter Capabilities*, Dr. James Malas, Plans and Programs Directorate
- 10732 - *R&D Transition Interface with Early Systems Engineering: SEALION and Open Systems Case Studies*, Mr. Michael Bosworth, Naval Sea Systems Command SEA 05T
- 11446 - *Lessons Learned in the Application of System Readiness Level to the Development of Systems of Systems for the Mission Modules Program Office*, Mr. Rich Volkert, SSC Pacific
- 11012 - *Tester's Early Involvement in the Systems Engineering Process*, Dr. William Bell, The MITRE Corporation
- 10877 - *Creating a Graphical CONOPS*, Dr. Robert Cloutier, Stevens Institute of Technology

TRACK 4 – Early Systems Engineering/Test - Mission I

- 10798 - *Early Integration of Test and Evaluation Subject Matter Experts in the Acquisition Life Cycle*, Mr. Robert Kennedy, Johns Hopkins University Applied Physics Laboratory
- 11002 - *Enhancing T&E and SE Alignment Using Database Driven Documentation*, Ms. Sue O'Brien, The University of Alabama in Huntsville

TRACK 5 – Modeling & Simulation - Mission II

- 10861 - *Use of a Model-Based Approach to Minimize System Development Risk and Time-to-Field for New Systems*, Mr. Kerry Wagner, U.S. Army ARDEC Software Engineering Directorate
- 10722 - *A Game Loop Architecture for the Modeling and Simulation of Mission Threads*, Mr. Thomas Tanner, SAIC

TRACK 5 – Requirements Development - Mission II

- 10434 - *A Simple Prescription for Requirements Success*, Mr. Jeffrey Grady, JOGF System Engineering, Inc.
- 11036 - *360° Architecture/Requirements Traceability*, Mr. Peter Forsch, Northrop Grumman Aerospace Systems
- 10988 - *Air Force Requirements Traceabilty Tool*, Mr. Gil Wagner, U.S. Air Force
- 11079 - *MRAP Requirements Management Process*, Ms. Jennifer Johnson, PEO CS&CSS, PM MRAP

TRACK 6 – Workforce Development - Mission III

- 10985 - *Panel: Organizing Technical Knowledge in the SEBOK - BKCASE Track*
  - Dr. John Snoderly, Defense Acquisition University
  - Mr. Gary Roedler, Defense Acquisition University
- 11052 - *Graduate Systems Engineering Programs: Report on Outcomes and Objectives*, Ms. Alice Squires, Stevens Institute of Technology
- 11022 - *Lead Systems Integrator Role for Government*, Mr. Donald Young, Naval Air Systems Command
- 10822 - *DAU's New Continuous Learning Module on Human Systems Integration*, Dr. Fran Greene, Planned Systems International
- 11034 - *Applying Systems Engineering to Workforce Development*, Mr. Ken Mosteller, The Center for Systems Management
- 10866 - *Design Considerations in Building a Corporate Systems Engineering Training and Development Program*, Dr. Philip Trudeau, The MITRE Corporation

TRACK 7 - Technology Maturity - Palm I

- 11074 - *Keeping Legacy Systems Viable — Introducing RDT&E Processes to the O&S Phase*, Ms. Karen Metz, Johns Hopkins University - Applied Physics Laboratory
- 10840 - *Assessment of Integration Risk Within the Department of Defense for Major Acquisition Programs*, Mr. Jim Thompson, ODDR&E/SE
- 10745 - *The Trouble with the System Readiness Level (SRL) Index for Managing the Acquisition of Defense Systems* Dr. Edouard Kujawski, Naval Postgraduate School
- 10823 - *System of Systems Technology Analysis and Selection Methodology*, Mr. Lance Harper, Northrop Grumman
- 11070 - *Status of the Development of an International Standards Organization (ISO) Definition of the Technology Readiness Levels (TRL) and Their Criteria of Assessment*, Mr. William Nolte, Air Force Research Laboratory, Plans and Programs Branch
- 11041 - *DoD Manufacturing Policy and Technical Maturity Issues Challenging Affordability*, Dr. Michelle Atchison, Lockheed Martin
- 11072 - *An Integrated Approach to Managing Technology Maturation Costs*, Dr. Deganit Armon, Advatech Pacific, Inc.

- 10974 - *Evaluating the Readiness of Federations-of-Models for Use in Simulation-Based Concept Development of Advanced Warfighting Capabilities,* Mr. Bryan Herdlick, GWU and JHU/APL

TRACK 8 - Software Intensive Systems - Palm II

- 11138 - *The Critical Role for Software Engineering in Development Planning and Sustainment,* Mr. Michael McLendon, ODDR&E/SE
- 10698 - *Systems Assurance in the Age of Open Source Technology,* Mr. Edward Beck, MSE, LLC
- 10742 - *The Future of Open Source Software (OSS) in DoD,* Dr. Charles Byler, Whitfill CTSF
- 11115 - *Application of Lean Process to Software Engineering via Value-Stream Mapping,* Dr. Shawn Rahmani, The Boeing Company
- 10997 - *Software Reliability Growth Approach,* Mr. Louis Gullo, Raytheon Company
- 11117 - *Software Engineering Strengths and Weaknesses in System Engineers,* Dr. Paul Shebalin, Naval Postgraduate School

TRACK 9 – System Safety -ESOH – Mariner Point

- 11132 - *Including ESOH Requirements in JCIDS Documents,* Mr. Jefferson Walker, Booz Allen Hamilton
- 10721 - *Developmental Environment, Safety and Occupational Health Evaluation: A Risk Assessment Tool for Early Evaluation of Environment, Safety, and Occupational Health Impacts,* Mr. Thomas Bush, Hughes Associates, Inc.
- 10950 - *Can Environmental Sustainability be Factored into DoD Acquisition Programs?,* Mr. Paul Yaroschak, Office of the Secretary of Defense
- 11129 - *Environmental Hazard Analysis — Task 210 in the Change to Military Standard 882D, DoD Standard Practice for System Safety — ESOH Risk Management,* Mr. Sherman Forbes, SAF/AQRE
- 10725 - *Safety in Systems Engineering Technical Reviews,* Ms. Karen Gill, Booz Allen Hamilton
- 10837 - *Joint Service Safety Testing Standards,* Dr. Elizabeth Rodriguez-Johnson, ODDR&E/SE
- 11133 - *ESOH — Lessons Learned from DoD Acquisition Systems Engineering Program Support Reviews,* Mr. William Thacker, Booz Allen Hamilton
- 10848 - *System Safety Engineering in a System of Systems Environment,* Ms. Janet McKinney, Naval Surface Warfare Center, Dahlgren Division

TRACK 10 – Architecture – Crown Point

- 10869 - *Proposed Functional Architecture and Associated Benefits Analysis of a Common Ground Control Station for Unmanned Aircraft Systems,* Mr. Douglas Mousseau, NAVAIR
- 11004 - *Defining Factors Needed to Develop a Qualitative Approach to Assessing a Program Architecture,* Ms. Eileen McConkie, GWU and Naval Surface Warfare Center, Dahlgren Division
- 10916 - *Radar Open Architectures,* Mr. Scott Lucero, ODDR&E/SE
- 10720 - *High Availability and Fault Management in Objective Architecture Systems,* Mr. Stephen Mills, GoAhead Software
- 10760 - *Organizing For Success: Improving Our Engineering Team Architectures,* Mr. James Smith, Lockheed Martin Missiles & Fire Control

NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

13TH ANNUAL SYSTEMS ENGINEERING CONFERENCE

"ACHIEVING ACQUISITION EXCELLENCE VIA EFFECTIVE SYSTEMS ENGINEERING"

OCTOBER 25-28, 2010

WWW.NDIA.ORG/MEETINGS/1870

HYATT REGENCY MISSION BAY ▸ SAN DIEGO, CA

EVENT #1870

CONFERENCE OVERVIEW

This conference is sponsored by the National Defense Industrial Association, Systems Engineering Division, with technical co-sponsorship by IEEE AES, IEEE Systems Council and the International Council on Systems Engineering, and is supported by the Office of Under Secretary of Defense for Acquisition, Technology and Logistics, Director, Defense Research and Engineering, and the Office of the DoD Chief Information Officer.

This conference seeks to create an interactive forum for Program Managers, Systems Engineers, Chief Scientists and Engineers and Managers from the Requirements, Design, Verification, Support, Logistics and Test communities from Government, Academia, and Industry. The conference will provide the opportunity to shape policy and procedures by exchanging innovative tactics and lessons learned.

BACKGROUND

The Department of Defense continues to work to improve the acquisition of military equipment and capability to assist the warfighter in protecting the U.S. and its allies, and help oppressed nations around the world, amidst continuously changing conditions and threats. The DoD seeks to improve the acquisition process and overall program execution of military systems, to provide greater, more effective and reliable warfighting capability, at affordable cost and within reasonable schedules. One of the primary and critically important areas of program acquisition and execution lies in the umbrella discipline of Systems Engineering, which is the overall integrating function in defense programs, from proper requirements definition and flowdown, effective and affordable design that integrates reliability, availability and maintainability considerations into the overall balance of design that emphasizes supportability and usage aspects along with overall performance, cost and schedule. Systems Engineering principles embody strong technical and risk management aspects, for both the acquiring program office as well as the executing defense prime and subcontractors. Strong emphasis on systems engineering throughout the life cycle of the program, from concept development through sustainment, is a key enabler of successful programs. The annual Systems Engineering Conference explores the role of systems engineering in defense programs from all aspects and perspectives, including the pragmatic, practical and academic viewpoints, and brings key practitioners together to work on effective solutions to achieving a successful warfighting force.

2011 CALL FOR PAPERS INFORMATION

The primary objective of the 14th Annual Systems Engineering Conference is to provide insight, information and lessons learned into how we can improve the overall performance of defense programs via a better, more focused application of systems engineering that will lead to more capable, interoperable and supportable weapon systems for the warfighter, with reduced total ownership costs, to help our military meet its current and new mission area and capabilities requirements. Technical and management presentations are a key tactic in achieving this objective. You are invited to submit a short (under 300 word) abstract of a presentation for a session (see topics on the website). Abstracts must fully describe the planned content and how the presentations will advance the objectives of the conference and session. All accepted presentations will be delivered at the conference in electronic format; full papers are optional and are not required.

Abstracts must include the following administrative information: presentation title, author's name, title, e-mail address, phone number, mailing address and organization and the conference session targeted. Abstracts must be submitted no later than Sunday, May 30, 2010 via the following web link:

http://application.ndia.org/abstracts/2870

Abstracts will only be accepted through this web link, and all required information must be completed. Upon completion of the required information, you will receive an e-mail confirmation.

**Conference presenters are not exempt from registration and conference fees.

CONFERENCE PROCEEDINGS

Proceedings will be available on the web through the Defense Technical Information Center (DTIC), and will be available one to two weeks after the conference. You will receive notification via e-mail once proceedings are posted and available on the web.

2010 LT GEN THOMAS R. FERGUSON, JR. SYSTEMS ENGINEERING EXCELLENCE AWARD

The National Defense Industrial Association's Systems Engineering Excellence Awards were established in 2003 to honor the memory of Lt Gen Thomas R. Ferguson, Jr., USAF, whose leadership embodied the highest ideals in Defense Systems development and deployment.

The awards are given to an individual and to a group demonstrating outstanding achievement in the practical application of Systems Engineering principles, promotion of robust systems engineering principles throughout the organization, or effective systems engineering process development during the previous year. Their systems engineering contributions should have demonstrably helped achieve significant cost savings due to new or enhanced processes procedures and/or concepts, increased mission capabilities, or substantially increased performance. The 2010 awardees are:

- Systems Engineering Individual Leadership Award: *Mr. Harold (Hal) Wilson*
- Systems Engineering Group Award: *MDA Airborne Laser TestBed Systems Engineering Division*
- Systems Engineering Group Award: *CECOM Second Generation Forward Looking Infrared Program*

PAST AWARD WINNERS:

2003:
- Systems Engineering Individual Leadership Award: *Mr. Robert Rassa*

2004:
- Systems Engineering Individual Leadership Award: *Honorable Mike Wynne*

2005:
- Systems Engineering Individual Leadership Award: *Mr. Mark Schaeffer*

2006:
- Systems Engineering Individual Leadership Award: *Mr. Kelly Milleru*
- Systems Engineering Individual Practitioner Award: *Mr. David Stribling*
- Systems Engineering Group Award: *NUWC Division Newport Critical Transducer Program Staff*

2007:
- Systems Engineering Individual Leadership Award: *Mr. Robert Skalamera*
- Systems Engineering Group Award: *Submarine Warfare Federated Tactical System Team*

2008:
- Systems Engineering Individual Leadership Award: *Honorable James Finley*
- Systems Engineering Group Award: *Tactical Direction Agent Team for LCS Mission Package Project*

2009:
- Systems Engineering Individual Leadership Award: *Mr. Brian Wells*
- Systems Engineering Group Award: *Center for Advanced Life Cycle Engineering*

CONTACTS

Technical Program Co-Chairs:
Mr. Steve Henry:
Manager, Systems Engineering and Program Support, Northrop Grumman Information Systems, stephen.henry@ngc.com, (703) 561-5724

Dr. Tom Christian,
ASC/EN,
thomas.christian@wpafb.af.mil,
(478) 926-2457

Conference Chair:
Mr. Bob Rassa,
Director, Engineering Programs, Space & Airborne Systems, Raytheon Company; Chair, Systems Engineering Division, NDIA, rcrassa@raytheon.com, (310) 985-4962

Meeting Planner:
Ms. Taryn Crowder,
NDIA, tcrowder@ndia.org,
(703) 247-2566

Conference Director:
Mr. Sam Campagna, Assistant Vice President, Operations,
NDIA, scampagna@ndia.org,
(703) 247-2544

ATTIRE

Appropriate dress for this conference is business casual for civilians and class B uniform for military. Badges must be worn at all conference functions.

CONTINUING EDUCATION UNIT CREDIT

NDIA is offering CEU credit options for the Systems Engineering Conference. Earn 1 unit per 10 hours for $45. For more information, please contact Ms. Taryn Crowder at (703) 247-2566 or tcrowder@ndia.org.

DEPARTMENT OF DEFENSE AND THE NATIONAL DEFENSE INDUSTRIAL ASSOCIATION 2009 DoD SYSTEMS ENGINEERING TOP 5 PROGRAM AWARDS

The Department of Defense Executive Agent for Systems Engineering and the Systems Engineering Division of the National Defense Industrial Association are pleased to announce the selections of the 2009 Top 5 Department of Defense Program Awards. The 2009 Program awardees are:

- Base Expeditionary Target & Surveillance System - Combined: *Department of the Army*
- Advanced Field Artillery Tactical Data System: *Department of the Army; Raytheon Company*
- C-17 Globemaster III Modernization: *Department of the Air Force; The Boeing Company*
- Defense Readiness Reporting System - Army: *Department of the Army; Lockheed Martin IS&GS Defense; Accenture National Security Services*
- Battlefield Airborne Communications Node Joint Urgent Operational Need: *Department of the Air Force; Northrop Grumman Information Systems*

The Awards are presented to both the DoD project office and the industry prime contractor in recognition of total program performance in a DoD/industry team effort.

PAST AWARD WINNERS:

2005 Top 5 Department of Defense Programs:

- Centaur
- Integrated Exploitation Capability
- P-8A Multi Mission Maritime Aircraft
- Mission INtegration & Development
- Tomahawk Weapons System Program PMA-280

2006 Top 5 Department of Defense Programs:

- Advanced Extremely High Frequency Mission Control System
- Advanced Field Artillery Tactical Data System
- DDG 1000 MK57 Vertical Landing System
- Portable Excalibur FCS

2007 Top 5 Department of Defense Programs:

- Effects Management Tool
- MH-60 R/S Link 16
- Mortar Fire Control System - Dismounted

2008 Top 5 Department of Defense Programs:

- Wideband Global SATCOM
- Joint Light Tactical Vehicle
- STRYKER Modernization
- Broad Area Maritime Surveillance Unmanned Aircraft
- Aviation Maintenance Training Continuum System

CONFERENCE AGENDA

SUNDAY, OCTOBER 24, 2010

5:00 pm - 7:00 pm	**REGISTRATION FOR TUTORIALS AND GENERAL CONFERENCE IN THE BAYVIEW FOYER**

MONDAY, OCTOBER 25, 2010

7:00 am - 6:00 pm	**REGISTRATION IN THE BAYVIEW FOYER**
7:00 am - 8:00 am	**CONTINENTAL BREAKFAST ON THE BAYVIEW TERRACE (TUTORIAL ATTENDEES ONLY)**
8:00 am - 12:00 pm	**TUTORIAL TRACKS -** *Please refer to the following pages for session schedule*
9:45 am - 10:15 am	**MORNING BREAK ON THE BAYVIEW TERRACE (TUTORIAL ATTENDEES ONLY)**
12:00 pm - 1:00 pm	**LUNCH IN THE REGATTA PAVILION (TUTORIAL ATTENDEES ONLY)**
1:00 pm - 5:00 pm	**TUTORIAL TRACKS CONTINUED -** *Please refer to the following pages for session schedule*
2:45 pm - 3:15 pm	**AFTERNOON BREAK ON THE BAYVIEW TERRACE (TUTORIAL ATTENDEES ONLY)**
5:00 pm - 6:00 pm	**RECEPTION IN THE REGATTA PAVILION - OPEN TO ALL CONFERENCE ATTENDEES**

TUESDAY, OCTOBER 26, 2010

7:00 am - 5:15 pm	**REGISTRATION IN THE BAYVIEW FOYER**
7:15 am - 8:15 am	**CONTINENTAL BREAKFAST IN THE REGATTA PAVILION**
8:15 am - 8:30 am	**INTRODUCTION & OPENING REMARKS** ▸ Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA* ▸ Mr. Bob Rassa, *Director, Engineering Programs, Space & Airborne Systems, Raytheon Company*; *Chair, Systems Engineering Division, NDIA*
8:30 am - 9:30 am	**KEYNOTE ADDRESS** ▸ Lt Gen Richard Scofield, USAF (Ret), *former Commander, Aeronautical Systems Center and Wright Patterson Air Force Base*
9:30 am - 10:00 am	**MORNING BREAK IN THE REGATTA PAVILION**
10:00 am - 12:00 pm	**PLENARY SESSION 1 - CHIEF SYSTEMS ENGINEERS PANEL** ***Engineering Complex Systems of the Future*** **Moderator:** Mr. James Thompson, *Director, Major Program Support, Systems Engineering Directorate, Office of the Director, Defense Research and Engineering* ▸ Mr. Terry Edwards, *Office of the Secretary of the Army for Acquisition, Logistics and Technology* ▸ Mr. Ricardo Cabrera, *Office of the Assistant Secretary of the Navy for Research, Development and Acquisition* ▸ Col Shawn Shanley, USAF, *Office of the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering*
12:00 pm - 1:30 pm	**LUNCH WITH SPEAKER IN THE REGATTA PAVILION** ▸ Mr. Stephen Welby, *Director, Systems Engineering, Office of the Director, Defense Research and Engineering*

TUESDAY, OCTOBER 26, 2010 - CONTINUED

1:30 pm - 3:00 pm — **PLENARY SESSION 2 - PROGRAM MANAGER PANEL**

Systems Engineering Discipline: Foundation for Program Success?

Moderator: Col Leslie Blackham, USAF, *Military Assistant, Systems Engineering Directorate, Office of the Director, Defense Research and Engineering*

- Dr. Gary Notte, *Product Director, Fire Support Command and Control, U.S. Army*
- LTC Todd Lamb, USA, *Product Manager, Stryker Development*
- CAPT Michael E. Jabaley, Jr., USN, *Program Manager, VIRGINIA Class Submarines (PMS 450)*
- CAPT Rick Muldoon, USN, *Program Manager, H-53 Heavy Lift Helicopters (PMA-261)*
- Col Janet L. Kasmer, USAF, *Deputy Director, Global Reach Programs (SAF/AQQ)*
- Col Donald W. Robbins, USAF, *Commander, Wideband SATCOM Group*

3:00 pm - 3:15 pm — **AFTERNOON BREAK IN THE REGATTA PAVILION**

3:15 pm - 5:15 pm — **PLENARY SESSION 3 - INDUSTRY EXECUTIVES PANEL**

Challenges of Complex Systems: Need for Systems Engineering

Moderator: Mr. Bob Rassa, *Director, Engineering Programs, Space & Airborne Systems, Raytheon Company*

- Mr. Brian Wells, *Vice President, Engineering, Raytheon Company*
- Mr. Paul Zavidniak, *Technical Fellow, Director, Technology and Strategy, Airborne and Maritime Systems, Northrop Grumman*
- Mr. Patrick Goggin, *Vice President, Development Program Excellence, Chief Engineer SoCal Regional Engineering Boeing Defense, Space & Security*

5:15 pm - 6:30 pm — **RECEPTION IN THE REGATTA PAVILION**

WEDNESDAY, OCTOBER 27, 2010

7:00 am - 5:15 pm — **REGISTRATION IN THE BAYVIEW FOYER**

7:00 am - 8:00 am — **CONTINENTAL BREAKFAST IN THE REGATTA PAVILION**

8:00 am - 12:00 pm — **CONCURRENT SESSIONS -** ***Please refer to the following pages for session schedule***

9:45 am - 10:15 am — **MORNING BREAK IN THE REGATTA PAVILION**

12:00 pm - 1:30 pm — **NDIA/DoD AWARDS LUNCH IN THE REGATTA PAVILION**

- DoD Systems Engineering Top 5 Program Awards
- NDIA Lt Gen Thomas Ferguson Awards for Group and Individual Excellence in Systems Engineering

1:30 pm - 5:15 pm — **CONCURRENT SESSIONS -** ***Please refer to the following pages for session schedule***

3:15 pm - 3:30 pm — **AFTERNOON BREAK IN THE REGATTA PAVILION**

5:15 pm — **WEDNESDAY SESSION ADJOURNS**

THURSDAY, OCTOBER 28, 2010

7:00 am - 3:30 pm — **REGISTRATION IN THE BAYVIEW FOYER**

7:00 am - 8:00 am — **CONTINENTAL BREAKFAST IN THE REGATTA PAVILION**

8:00 am - 12:00 pm — **CONCURRENT SESSIONS -** ***Please refer to the following pages for session schedule***

9:45 am - 10:15 am — **MORNING BREAK IN THE REGATTA PAVILION**

12:00 pm - 1:30 pm — **LUNCH WITH SPEAKER IN THE REGATTA PAVILION**

Systems 2020

- Ms. Kristen Baldwin, *Director, Systems Analysis, Systems Engineering Directorate, Office of the Director, Defense Research and Engineering*

1:30 pm - 3:30 pm — **CONCURRENT SESSIONS -** ***Please refer to the following pages for session schedule***

3:30 pm — **CONFERENCE ADJOURNS**

MONDAY, OCTOBER 25, TUTORIAL SESSIONS

Tutorial Sessions A-B and C-D are continuous

TRACK	8:00 AM SESSION A	10:15 AM SESSION B	1:00 PM SESSION C	3:15 PM SESSION D
TRACK 8 Palm II	10803 - 1A8 - Tutorial: NCOIC Systems, Capabilities, Operations, Programs, and Enterprises (SCOPE) Model Mr. Hans Polzer, Lockheed Martin	10803 - 1B8 - Tutorial: NCOIC Systems, Capabilities, Operations, Programs, and Enterprises (SCOPE) Model Mr. Hans Polzer, Lockheed Martin	10770 - 1C8 - Tutorial: NCOIC's Network Centric Analysis Tool (NCAT TM) Dr. Todd Schneider, Raytheon Company	10770 - 1D8 - Tutorial: NCOIC's Network Centric Analysis Tool (NCAT TM) Dr. Todd Schneider, Raytheon Company
TRACK 7 Palm I	10895 - 1A7 - Tutorial: How to Design Lean Systems Engineering Processes and Procedures Mr. Tim Olson, Lean Solutions Institute, Inc.	10895 - 1A7 - Tutorial: How to Design Lean Systems Engineering Processes and Procedures Mr. Tim Olson, Lean Solutions Institute, Inc.	10894 - 1C7 - Tutorial: How to Achieve Measurable ROI Using Best-In-Class Early Defect Detection and Defect Prevention Mr. Tim Olson, Lean Solutions Institute, Inc.	10894 - 1D7 - Tutorial: How to Achieve Measurable ROI Using Best-In-Class Early Defect Detection and Defect Prevention Mr. Tim Olson, Lean Solutions Institute, Inc.
TRACK 6 Mission III	10748 - 1A6 - Tutorial: Risk Management and Beyond Mr. Al Florence, The MITRE Corporation	10748 - 1B6 - Tutorial: Risk Management and Beyond Mr. Al Florence, The MITRE Corporation	10749 - 1C6 - Tutorial: Life Cycle Configuration Management Mr. Al Florence, The MITRE Corporation	10749 - 1D6 - Tutorial: Life Cycle Configuration Management Mr. Al Florence, The MITRE Corporation
TRACK 5 Mission II	10984 - 1A5 - Tutorial: Systems Engineering Integration Effectiveness: Reducing the Uncertainties of Integration Mr. Gary Langford, Naval Postgraduate School	10984 - 1B5 - Tutorial: Systems Engineering Integration Effectiveness: Reducing the Uncertainties of Integration Mr. Gary Langford, Naval Postgraduate School	10941 - 1C5 - Tutorial: Development of Requirements for Reliable Software Systems — Guidance and Pitfalls Mr. William Bail, The MITRE Corporation	10941 - 1D5 - Tutorial: Development of Requirements for Reliable Software Systems — Guidance and Pitfalls Mr. William Bail, The MITRE Corporation
TRACK 4 Mission I	10805 - 1A4 - Tutorial: Seven Mentoring Fundamentals to Support Systems Engineering Workforce Development Mr. Nicholas Torelli, ODDR&E/SE	10805 - 1B4 - Tutorial: Seven Mentoring Fundamentals to Support Systems Engineering Workforce Development Mr. Nicholas Torelli, ODDR&E/SE	11055 - 1C4 - Tutorial: Transitioning Technology to the Warfighter Mr. William Decker, Defense Acquisition University	11055 - 1D4 - Tutorial: Transitioning Technology to the Warfighter Mr. William Decker, Defense Acquisition University
TRACK 3 Bayview I	11094 - 1A3 - Tutorial: An Introduction to the Use of Modeling and Simulation Throughout the Systems Engineering Process Dr. James Coolahan, Johns Hopkins University Applied Physics Laboratory	11094 - 1B3 - Tutorial: An Introduction to the Use of Modeling and Simulation Throughout the Systems Engineering Process Dr. James Coolahan, Johns Hopkins University Applied Physics Laboratory	10709 - 1C3 - Tutorial: Systems of Systems: Answering the Organizational Implications Dr. Stan Rifkin, U.S. Air Force Office of Scientific Research	10709 - 1D3 - Tutorial: Systems of Systems: Answering the Organizational Implications Dr. Stan Rifkin, U.S. Air Force Office of Scientific Research
TRACK 2 Bayview II	10834 - 1A2 - Tutorial: Improved Acquisition Processes Through Incremental Commitments Dr. Barry Boehm, University of Southern California	10834 - 1B2 - Tutorial: Improved Acquisition Processes Through Incremental Commitments Dr. Barry Boehm, University of Southern California	11090 - 1C2 - Tutorial: Software Technology Readiness Assessment — Defense Acquisition Guidance Dr. Peter Hantos, The Aerospace Corporation	11090 - 1C2 - Tutorial: Software Technology Readiness Assessment — Defense Acquisition Guidance Dr. Peter Hantos, The Aerospace Corporation
TRACK 1 Bayview III	10480 - 1A1 - Tutorial: Universal Architecture Description Framework Mr. Jeffrey Grady, JOG System Engineering, Inc.	10480 - 1B1 - Tutorial: Universal Architecture Description Framework Mr. Jeffrey Grady, JOG System Engineering, Inc.	10844 -1C1 - Tutorial: CONOPS Development and Architectures Dr. Steven Dam, SPEC Innovations	10844 -1D1 - Tutorial: CONOPS Development and Architectures Dr. Steven Dam, SPEC Innovations

WEDNESDAY, OCTOBER 27, CONCURRENT SESSIONS

TRACK	SESSION CHAIR	8:00 AM	8:35 AM	9:10 AM	TRACK	SESSION CHAIR	10:15 AM	10:50 AM	11:25 AM
TRACK 10 Logistics Supportability and Sustainment Crown Point	Mr. Joel Moorvitch, *Raytheon Company*	10592 - Engineering Design Analysis (Physics of Failure) Mr. Gary Drake, U.S. Army Materiel Systems Analysis Activity	10926 - Design For Reliability (DFR) Methodology Applied to Stryker NBCRV Program Dr. Dmitry Tananko, GDLS	10780 - NDIA Life Cycle Affordability Project Mr. Joel Moorvitch, Raytheon Company	TRACK 10 Logistics Supportability and Sustainment Crown Point	Mr. Joel Moorvitch, *Raytheon Company*		10836 - Logistics Demonstrations: A Strategy to Reduce Cost, Maintain Schedule, and Mitigate Risks to Achieve Performance Goals Mr. Jeffrey Gilbert, U.S. Army Evaluation Center	11071 - Sustaining and Upgrading the Air Force's Legacy Mobility Fleet: Addressing Issues Using SE Enterprise Approach Mr. Ray Flores, USAF Air Mobility Directorate, Aeronautical System
TRACK 9 Human Systems Integration Mariner Point	Ms. Elaine Thorpe, *The Boeing Company*	11077 - Driving HSI into Common Industry Practice Dr. Noreen McQuinn, The Boeing Company	10724 - Systems Engineering and User Needs — Strategies and Tactics for the Evolving System Acquisition Environment Dr. William Reese, Northrop Grumman Electronic Systems	10851 - Assessment of Human Systems Integration in Air Force Acquisition Mr. John Maziarz, Booz Allen Hamilton	TRACK 9 Human Systems Integration Mariner Point	Ms. Elaine Thorpe, *The Boeing Company*	11082 - HSI Translation of Capability Requirements to Acquisition Ms. Lisa Kaminski, Booz Allen Hamilton	10957 - Human Systems Integration Support for Rapidly Fielded Systems Mrs. Elaine Thorpe, The Boeing Company	11010 - Human Systems Integration Approaches for Developmental Testing Dr. Matthew Risser, Pacific Science & Engineering Group
TRACK 8 Test & Evaluation in Systems Engineering Palm II	Dr. Beth Wilson, *Raytheon Company* Darlene Mosser-Kerner, *ODDR&E/DT&E*	10604 - Test and Evaluation Issues for Systems of Systems: Sleepless Nights to Sominex Dr. Beth Wilson, Raytheon Company	10911 - (JMETC) Effective T&E by Improving Distributive Test Capabilities Mr. Ryan Norman, Joint Mission Environment Test Capability, Lead Systems Engineer	10733 - 2010 Strategic Plan for DoD T&E Resources Dr. Suzanne Strohl, OSD AT&L Test Resource Management Center	TRACK 8 Test & Evaluation in Systems Engineering Palm II	Dr. Beth Wilson, *Raytheon Company* Darlene Mosser-Kerner, *ODDR&E/DT&E*	10903 - Guarding the Intent of Requirements Throughout the Test Execution Cycle Mr. Stephen Scukanec, Northrop Grumman, Aerospace Sector	10741 - Defining, Implementing and Testing Non-Functional Requirements on Agile Programs: Lessons Learned Mrs. Dorothy Acton, Lockheed Martin	10783 - Evolution of the Tomahawk Land-Attack Missile Operational Test Launch Methodology Mrs. Angelica Lilly, JHU/APL
TRACK 7 Enterprise Health Management Palm I	Mr. Howard Savage, *SCI* Mr. Chris Reisig, *The Boeing Company*		11056 - Unmanned Ground Vehicle Integrated Diagnostics Mr. Larry Osentoski, DRIVE Developments, Inc.	11059 - Diagnostic Improvement of Complex Systems Through Enhanced Information Usage Mr. Darrell Bartz, The Boeing Company	TRACK 7 Enterprise Health Management Palm I	Mr. Howard Savage, *SCI* Mr. Chris Reisig, *The Boeing Company*	11032 - Using Commercial-Off-The-Shelf (COTS) Business Intelligence Software Tools to Support Aircraft and Automated Test System (ATS) Maintenance Environments Mr. Steven Head, The Boeing Company	10967 - Enterprise Health Management Technology Transition Issues and Path Forward Mr. Chris Reisig, The Boeing Company	
TRACK 6 Workforce Development Mission III	Dr. Don Gelosh, *ODDR&E/SE* Dr. Arthur Pyster, *Stevens Institute of Technology*	10932 - BKCASE: Body of Knowledge and Curriculum to Advance Systems Engineering Dr. Arthur Pyster, Stevens Institute of Technology	11068 - GRCSE and GswE2009: Educational Advancements to Support Government and Industry Ms. Nicole Hutchison, Analytic Services, Inc.	11078 - Curriculum for the Life Cycle of the Systems Engineer Dr. Carlee Bishop, Georgia Tech Research Institute	TRACK 6 Workforce Development Mission III	Dr. Don Gelosh, *ODDR&E/SE* Dr. Arthur Pyster, *Stevens Institute of Technology*	10933 - Panel: In Search of the Principles of Systems Engineering (BKCASE) Mr. Richard Adcock, Cranfield University		

TRACK 1 Systems Engineering Effectiveness Bayview I	TRACK 2 Net-Centric Operations/ Interoperability Bayview II	TRACK 3 Systems of Systems Bayview III	TRACK 4 Early Systems Engineering Mission I	TRACK 5 Modeling & Simulation Mission II
Mr. Al Brown, *The Boeing Company* **Ms. Dona Lee,** *SAIC*	**Mr. Jack Zavin,** *ASD (NII)* **Mr. Hans Polzer,** *Lockheed Martin*	**Dr. Judith Dahmann,** *The MITRE Corporation* **Mr. John R. Palmer,** *The Boeing Company*	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	**Dr. James Coolahan,** *Johns Hopkins University Applied Physics Laboratory*
10853 - Value of Systems Engineering Ms. Kerri Polidore, ARDEC	11122 - Interoperability Specifications: Characteristics and Processes for Better Achieving Interoperability Among Independently Developed Systems Dr. Carol Sledge, Software Engineering Institute	10838 - The Joint Land Component Constructive Training Capability: An SoS Success Story Ms. Laura Feinerman, The MITRE Corporation	10786 - Early Systems Engineering to Achieve MS B Mr. Michael Gaydar, NAVAIR	10828 - Understanding the Increasingly Important Role M&S Plays in Department of Defense Acquisition Ms. Philomena Zimmerman, ODDR&E/SE
11087 - Improvement Initiatives at C-17 Mr. Sivam Paramanathan, The Boeing Company	10852 - Interoperability by Design Mr. Ken Hafner, SPAWARSYSCOM	10908 - Mission Thread Workshop — Lessons Learned in End-to-End Capability and Quality Attribute Specification for SoS Architecture Development Mr. Mr. William Wood, Software Engineering Institute	11011 - Systems Engineering in Development Planning and Science & Technology Dr. Kenneth Barker, U.S. Air Force	10958 - Results of a Study on the Management of Broadly-Needed Modeling and Simulation Tools Dr. James Coolahan, JHU/APL
11106 - Practical Agile Requirements Engineering Mr. Philip Matuzic, The Boeing Company	10839 - Modernization of the JADOCS Program Mr. Steve Kovalak, Raytheon Company NCS/ CSS	11047 - A Compliance Case for Interoperability in Systems of Systems Mr. James Smith, Carnegie Mellon Software Engineering Institute	11015 - Developing a Mission Solution: From Mission Gap Analysis to Preferred System Concept Ms. Elizabeth M. O'Keefe, Raytheon Company	10735 - Best Practices for the Development of Models and Simulations Dr. Katherine Morse, JHU/ APL
10912 - Systems Engineering Policy and Guidance Implementation of the Weapon Systems Acquisition Reform Act (WSARA) of 2009–One Year Later Ms. Sharon Vannucci, ODDR&E/SE	11003 - GAO Observations on DoD Implementation of the 2009 WSARA Mrs. Cheryl Andrew, U.S. Government Accountability Office	10951 - DoD Synergy with International Standards Dr. Karen J. Richter, Institute for Defense Analyses	10790 - A Better-Informed Materiel Development Decision for USAF Programs Mr. Jeff Loren, Alion Science & Technology	11436 - Panel: Overview of CREATE — Physics Based Modeling and Simulation Mr. Oscar Goldfarb Mr. Doug Post Dr. Bob Meakin
10944 - Development Planning Update: Policy Evolution from a Technical Perspective Mr. Michael Duffey, ODDR&E/SE	10766 - Findings and Recommendations from the NDIA/OSD Development Planning Working Group Mr. John Lohse, Raytheon Company	10913 - Update on SoS SE: SoS SE Artifacts and A Practitioner View Dr. Judith Dahmann, The MITRE Corporation	10806 - Key System of Systems Engineering Artifacts to Guide Engineering Activities Dr. Jo Ann Lane, University of Southern California	10598 - Systems Engineering Processes Improvement Using the CMMI in Large System of Systems Space Programs Mrs. Revital Goldberg, Israel Aerospace Industries
10849 - Principles of Net-Centricity Mr. Hans Polzer, Lockheed Martin	10768 - Mission Engineering for Warfighting Integration of Net-Centric Systems Ms. Eileen Bjorkman, U.S. Air Force	11064 - Consolidated Findings and Approaches to SoS Interoperability Challenges: Insights from the Field Dr. Carol Sledge, Software Engineering Institute		

WEDNESDAY, OCTOBER 27, CONCURRENT SESSIONS CONTINUED

Any track listed below that contains 4 presentations will be allotted equal presentation lengths of about 25 minutes each

TRACK	SESSION CHAIR	1:30 PM	2:05 PM	2:40 PM	TRACK	SESSION CHAIR	3:30 PM	4:05PM	4:40 PM
TRACK 10 Logistics Supportability and Sustainment Crown Point	**Mr. Joel Moorvitch,** *Raytheon Company*	10753 - Systems Engineering and the WSARA Product Support Assessment CAPT Basil Gray, USN (Ret), PRTM	10774 - PLM for Systems Engineering Support within ECSS Mrs. Segrid Harris-Wright, Air Force Logistics Transformation Organization	11458 - The Art of Affordability — Getting the Best Value for Total Ownership Cost Ms. Lee-Ann Sharpe Seeling, Raytheon Company	TRACK 10 Architecture Crown Point	**Ms. Barbara Sheeley,** *The Boeing Company*	10771 - First Steps in the Development of an Architecture Framework for a Product Development Process Mr. Jeffrey Williams, Southern Methodist University	10842 - The Interaction of CONOPS and Architecture Dr. Steven Dam, SPEC Innovations	10584 - Enterprise Architecture Model-Driven Simulation Mr. Robert Byrd, Serco, Inc. 10841 - The Role of Enterprise Architecture Updates in Guiding Decentralized Organizations Mr. John Schatz, SPEC Innovations
TRACK 9 Human Systems Integration Mariner Point	**Ms. Elaine Thorpe,** *The Boeing Company*	10971 - A-10, Thunderbolt II — a Study of Human Systems Integration Dr. David Jacques, Planned Systems International	10937 - Advanced Use of Prototyping in Human Computer Interface Development Mr. Andy Orzechowski, Department of the Navy		TRACK 9 System Safety-ESOH Mariner Point	**Mr. Sherman Forbes,** *SAF/AQRE*	11130 - Acquisition ESOH— Follow Through After the Policy is Printed Mr. David Asiello, Office Deputy Under Secretary of Defense (I&E)	10907 - A Case Study of an Evolving ESOH Program — One Company's Perspective Mr. Michael Parulis, Electric Boat Corporation	11120 - Addressing Environmental Safety and Occupational Health (ESOH) in Systems Engineering Across the Entire Acquisition Life Cycle Mr. Ted Grady, USAF - Aeronautical Systems Center
TRACK 8 Test & Evaluation in Systems Engineering Palm II	**Dr. Beth Wilson,** *Raytheon Company* **Darlene Mosser-Kerner,** *ODDR&E/DT&E*	10831 - T&E Methodology for Business Systems Dr. Aaron Drew, Defense Business Transformation Agency	10935 - Strategic Enterprise Test and Evaluation Process Approach Ms. Harriette Tullos-Banks, Naval Surface Warfare Center, Dahlgren Division	10865 - Engineering for Integration Mr. Richard Shelton, Northrop Grumman Corporation	TRACK 8 Joint Cyber/SW Intensive Palm II	**Mr. Paul Croll,** *CSC*	10918 - Rationalizing Governance, Engineering Practice, and Engineering Economics in the System and Software Assurance Trade Space Mr. Paul Croll, CSC	11042 - Cyber Security and Systems Engineering Dr. Raju Patel, U.S. Air Force	
TRACK 7 Technology Maturity Palm I	**Mr. Bill Nolte** and **Dr. James Malas,** *Plans and Programs Directorate*	11060 - GAO's Annual Assessment of Selected Weapons Programs Mr. Travis Masters, U.S. Government Accountability Office	10875 - Integrating the Technology and Systems Development Lifecycles to Mature Technology for Transition Mr. Troy Peterson, Booz Allen Hamilton	10715 - Australia's Experience in Technical Risk Assessment for Defence Acquisitions Dr. David Wood, Department of Defence	TRACK 7 Technology Maturity Palm I	**Mr. Bill Nolte** and **Dr. James Malas,** *Plans and Programs Directorate*	10736 - Adapting Systems Engineering Best Practices to Technology Development in Applied Research Mr. Jeff Craver, Defense Acquisition University	11095 - The Role of Architecture Standards and Tools in Identifying Software-Critical Technology Elements Dr. Peter Hantos, The Aerospace Corporation	11099 - Performing Software Feasibility Analysis on Major Defense Acquisition Programs Mr. Jim Thompson, ODDR&E/SE
TRACK 6 Workforce Development Mission III	**Dr. Don Gelosh,** *ODDR&E/SE* **Dr. Arthur Pyster,** *Stevens Institute of Technology*	10939 - Improving the Department of Defense and Industry Systems Engineering Workforce Dr. Don Gelosh, ODDR&E/SE Mr. Doug Westphal and Dr. John Snoderly, DAU	10651 - Realizing the Vision: Innovative Practices to Enhance the Capability of the Systems Engineering Workforce Dr. Janice Ziarko, The MITRE Corporation	11123 - 7 Secrets to Develop a Great SE Training Program Mr. Jimmy Thai, SAIC	TRACK 6 Workforce Development Mission III	**Dr. Don Gelosh,** *ODDR&E/SE* **Dr. Arthur Pyster,** *Stevens Institute of Technology*	10883 - Undergraduate Systems Engineering Programs in the United States Dr. Arthur Pyster, Stevens Institute of Technology Dr. Don Gelosh, ODDR&E/SE	11006 - Leveraging Remote Online Education for SE Competency Development Ms. Alice Squires, Stevens Institute of Technology	11445 - The Use of Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development Mr. Rich Volkert, SSC Pacific

TRACK 5 Modeling & Simulation Mission II	**Dr. James Coolahan,** *Johns Hopkins University Applied Physics Laboratory*	10591 - Military Modeling & Simulation Systems Oriented Architecture (SOA) Concepts Pilot Dr. Gary Allen, Joint Training Evaluation and Integration Center	10891 - Leveraging LVC Simulation Capabilities for Systems Analysis Dr. Douglas Hodson, WPAFB	10922 - The Modeling and Simulation Catalog for Discovery, Knowledge and Reuse Mr. Steve Hunt, Alion Science and Technology 10827 - Supporting Weapon Systems Assessments with Realistic Synthetic Environment Representations —Where to Go for Authoritative Data Ms. Philomena Zimmerman, ODDR&E/SE	TRACK 5 Modeling & Simulation Mission II	**Dr. James Coolahan,** *Johns Hopkins University Applied Physics Laboratory*	10813 - Systems Engineering Initiatives for Verification, Validation, and Accreditation of DoD Models and Simulations Ms. Philomena Zimmerman, ODDR&E/SE	10959 - NDIA Model Based Engineering (MBE) Subcommittee Report Mr. Frank Salvatore, HPTI	11063 - Best Practices in Contracting for Models, Simulations, and Associated Data Subcommittee Report Mr. Dennis Shea, Center For Naval Analyses 11091 - Deployment of MBSE Processes Using SysML Mr. Timothy Tritsch, HPTI
TRACK 4 Early Systems Engineering Mission I	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	10507 - Developing a Net-Centric Mission Architecture: From Mission Analysis to Executable Model Mr. James Sierchio, Raytheon Missile Systems	11466 - Applying NATO's Distributed Networked Battle Labs (DNBL) Initiative to Early Systems Engineering Mr. Hans Polzer, Lockheed Martin	10784 - Suitability Impacts on Rapid Development Mr. Michael Gaydar, NAVAIR	TRACK 4 Early Systems Engineering Mission I	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	11131 - The Case for Considering Acquisition Program Executability Prior to Materiel Development Decision (MDD) Mr. Gregory Laushine, SAIC	10810 - Improving Success with Technology Using an Organizational Epistemology — A Conceptual Decision Framework for Early Systems Engineering Dr. Chris Powell, HPTI	11083 - Early Systems Engineering for Tech Base Projects Mr. Richard Swanson, HPTI
TRACK 3 Systems of Systems Bayview III	**Dr. Judith Dahmann,** *The MITRE Corporation* **Mr. John R. Palmer,** *The Boeing Company*	10887 - Army System-of-Systems Engineering Processes Mr. Terry Edwards, ASA (ALT) SoSE	10888 - Army System-of-Systems Architecture Developments Mr. David Poole, ASA (ALT) SoSE	10890 - Systems-of-Systems Engineering for Army Transport Mr. Terry Edwards, ASA (ALT) SoSE	TRACK 3 Joint Net-Centric/SOS Bayview III	**Mr. Jack Zavin,** *ASD (NII)* **Dr. Judith Dahmann,** *The MITRE Corporation*	10955 - Network Centric Patterns for System Interoperability Mr. Mark Bowler, The Boeing Company	10754 - Understanding the Limits of Systems of Systems Dr. Elwin Ong, Booz Allen Hamilton	11065 - Mission Level Engineering Ms. Helene Anderson, ASN(RDA) CHSENG
TRACK 2 Net-Centric Operations/ Interoperability Bayview II	**Mr. Jack Zavin,** *ASD (NII)* **Mr. Hans Polzer,** *Lockheed Martin*	10829 - Battle Command and Simulation Interoperability Using Common Geospatial Representations Mr. Thomas Stanzione, VT MAK	10799 - Procure-2-Pay Portal Pilot: Integrated Feasibility Assessment (IFA) Ms. Lien Dinh, Defense Business Transformation Agency	11114 - Panel: Systems Engineering Management and the Relationship of Systems Engineering to Project Management and Software Engineering Dr. Raymond Madachy, Naval Postgraduate School	TRACK 2 Program Management Bayview II	**Mr. Hal Wilson,** *Northrop Grumman Information Systems* **Ms. Dona Lee,** *SAIC*	10934 - The Evolving Operational Environment as a Unifying Foundation for Systems Engineering and Acquisition Decision Making Mr. Vincent Roske, Institute for Defense Analyses	11073 - Advancing Systems Engineering Through Use of Collaborative Space Mr. George Richard Freeman, U.S. Air Force	10796 - Valuing System Flexibility via Total Ownership Cost Analysis Dr. Barry Boehm, University of Southern California
TRACK 1 Systems Engineering Effectiveness Bayview I	**Mr. Al Brown,** *The Boeing Company* **Ms. Dona Lee,** *SAIC*	10773 - NDIA Top 5 Software and Systems Engineering Issues - 2010 Mr. Harold Wilson, Northrop Grumman Information Systems, DSD	10819 - Systems Engineering Program Metrics Mr. Jim Thompson, ODDR&E/SE	11089 - Naval Systems Engineering Technical Review Process Mr. Paul Dube, ASN(RDA) CHSENG	TRACK 1 Systems Engineering Effectiveness Bayview I	**Mr. Al Brown,** *The Boeing Company* **Ms. Dona Lee,** *SAIC*	10850 - System Engineering Effectiveness Mrs. Kalyani Tripathi, U.S. Army - ARDEC	10755 - A Framework for Evaluating U.S. DoD Systems Engineering Principles Against Defense System Quality Dr. Nazanin Azizian, Marine Corps Systems Command	10787 - The MITRE Systems Engineering Guide: Practical Guidance for FFRDC Systems Engineers Mr. George Rebovich, The MITRE Corporation

THURSDAY, OCTOBER 28, CONCURRENT SESSIONS

TRACK	SESSION CHAIR	8:00 AM	8:35 AM	9:10 AM	TRACK	SESSION CHAIR	10:15 AM	10:50 AM	11:25 AM
TRACK 10 Architecture Crown Point	**Ms. Barbara Sheeley,** *The Boeing Company*		10869 - Proposed Functional Architecture and Associated Benefits Analysis of a Common Ground Control Station for Unmanned Aircraft Systems Mr. Douglas Mousseau, NAVAIR	11004 - Defining Factors Needed to Develop a Qualitative Approach to Assessing a Program Architecture Ms. Eileen McConkie, GWU and Naval Surface Warfare Center, Dahlgren Division	TRACK 10 Architecture Crown Point	**Ms. Barbara Sheeley,** *The Boeing Company*	10720 - High Availability and Fault Management in Objective Architecture Systems Mr. Stephen Mills, GoAhead Software	10760 - Organizing For Success: Improving Our Engineering Team Architectures Mr. James Smith, Lockheed Martin Missiles & Fire Control	10713 - Scenario Based Evaluation of Evolution Roadmaps for Agility and Architectural Consistency Mr. William Wood, Software Engineering Institute
TRACK 9 System Safety-ESOH Mariner Point	**Mr. Sherman Forbes,** *SAF/AQRE*	11132 - Including ESOH Requirements in JCIDS Documents Mr. Jefferson Walker, Booz Allen Hamilton	10721 - Developmental Environment, Safety and Occupational Health Evaluation: A Risk Assessment Tool for Early Evaluation of Environment, Safety, and Occupational Health Impacts Mr. Thomas Bush, Hughes Associates, Inc.	10950 - Can Environmental Sustainability be Factored into DoD Acquisition Programs? Mr. Paul Yaroschak, Office of the Secretary of Defense	TRACK 9 System Safety-ESOH Mariner Point	**Mr. Sherman Forbes,** *SAF/AQRE*	11129 - Environmental Hazard Analysis — Task 210 in the Change to Military Standard 882D, DoD Standard Practice for System Safety — ESOH Risk Management Mr. Sherman Forbes, SAF/AQRE	10725 - Safety in Systems Engineering Technical Reviews Ms. Karen Gill, Booz Allen Hamilton	
TRACK 8 Software-Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* **Mr. Mike McLendon,** *ODDR&E/SE*	11138 - The Critical Role for Software Engineering in Development Planning and Sustainment Mr. Michael McLendon, ODDR&E/SE	10698 - Systems Assurance in the Age of Open Source Technology Mr. Edward Beck, MSE, LLC	10742 - The Future of Open Source Software (OSS) in DoD Dr. Charles Byler, Whitfill CTSF	TRACK 8 Software-Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* **Mr. Mike McLendon,** *ODDR&E/SE*	11115 - Application of Lean Process to Software Engineering via Value-Stream Mapping Dr. Shawn Rahmani, The Boeing Company	10763 - Considerations for Using Agile in DoD Acquisition Ms. Mary Ann Lapham, CMU/Software Engineering Institute	10997 - Software Reliability Growth Approach Mr. Louis Gullo, Raytheon Company
TRACK 7 Technology Maturity Palm I	**Mr. Bill Nolte** and **Dr. James Malas,** *Plans and Programs Directorate*	11074 - Keeping Legacy Systems Viable — Introducing RDT&E Processes to the O&S Phase Ms. Karen Metz, Johns Hopkins University - Applied Physics Laboratory	10840 - Assessment of Integration Risk Within the Department of Defense for Major Acquisition Programs Mr. Jim Thompson, ODDR&E/SE		TRACK 7 Technology Maturity Palm I	**Mr. Bill Nolte** and **Dr. James Malas,** *Plans and Programs Directorate*	10745 - The Trouble with the System Readiness Level (SRL) Index for Managing the Acquisition of Defense Systems Dr. Edouard Kujawski, Naval Postgraduate School	10823 - System of Systems Technology Analysis and Selection Methodology Mr. Lance Harper, Northrop Grumman	11070 - Status of the Development of an International Standards Organization (ISO) Definition of the Technology Readiness Levels (TRL) and Their Criteria of Assessment Mr. William Nolte, Air Force Research Laboratory, Plans and Programs Branch
TRACK 6 Workforce Development Mission III	**Dr. Don Gelosh,** *ODDR&E/SE* **Dr. Art Pyster,** *Stevens Institute of Technology*	10985 - Panel: Organizing Technical Knowledge in the SEBOK - BKCASE Track Dr. John Snoderly, Defense Acquisition University Dr. Don Gelosh, ODDR&E/SE Mr. Gary Roedler, Defense Acquisition University Mr. Michael Krueger, Defense Acquisition University			TRACK 6 Workforce Development Mission III	**Dr. Don Gelosh,** *ODDR&E/SE* **Dr. Art Pyster,** *Stevens Institute of Technology*	11052 - Graduate Systems Engineering Programs: Report on Outcomes and Objectives Ms. Alice Squires, Stevens Institute of Technology		11022 - Lead Systems Integrator Role for Government Mr. Donald Young, Naval Air Systems Command

Any track listed below that contains 4 presentations will be allotted equal presentation lengths of about 25 minutes each

TRACK 5 Modeling & Simulation Mission II	**Dr. James Coolahan,** *Johns Hopkins University Applied Physics Laboratory*	10861 - Use of a Model-Based Approach to Minimize System Development Risk and Time-to-Field for New Systems Mr. Kerry Wagner, U.S. Army ARDEC Software Engineering Directorate	10722 - A Game Loop Architecture for the Modeling and Simulation of Mission Threads Mr. Thomas Tanner, SAIC	10874 - Model-Based Systems Architecting Dr. Robert Cloutier, Stevens Institute of Technology 10739 - Integrating the Architectural Model with the Engineering Analysis Models Mr. John Watson, Lockheed Martin	TRACK 5 Requirements Development Mission II	**Mr. Gene Rosenbluth,** *Northrop Grumman Mission Systems*	10434 - A Simple Prescription for Requirements Success Mr. Jeffrey Grady, JOGF System Engineering, Inc.	11036 - 360° Architecture/ Requirements Traceability Mr. Peter Forsch, Northrop Grumman Aerospace Systems	10988 - Air Force Requirements Traceabilty Tool Mr. Gil Wagner, U.S. Air Force
TRACK 4 Early Systems Engineering Mission I	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	10792 - "The Conversation," Applying Systems Thinking to the Science and Technology Phase of Acquisition Mr. Robert Rapson, Materials and Manufacturing Directorate	10795 - Recapturing System Decomposition Techniques for Improved S&T Development of Future Warfighter Capabilities Dr. James Malas, Plans and Programs Directorate	10732 - R&D Transition Interface with Early Systems Engineering: SEALION and Open Systems Case Studies Mr. Michael Bosworth, Naval Sea Systems Command SEA 05T	TRACK 4 Early Systems Engineering Mission I	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	11446 - Lessons Learned in the Application of System Readiness Level to the Development of Systems of Systems for the Mission Modules Program Office Mr. Rich Volkert, SSC Pacific	11012 - Tester's Early Involvement in the Systems Engineering Process Dr. William Bell, The MITRE Corporation	10877 - Creating a Graphical CONOPS Dr. Robert Cloutier, Stevens Institute of Technology
TRACK 3 Joint Net-Centric/SOS Bayview III	**Mr. Jack Zavin,** *ASD (NII)* **Mr. Hans Polzer,** *Lockheed Martin* **Dr. Judith Dahmann,** *The MITRE Corporation*	11048 - Data Interoperability for Systems of Systems: An Integrated Software Engineering Perspective Mr. James Smith, Carnegie Mellon Software Engineering Institute	10889 - System-of-Systems Engineering for Army Battle Command Convergence Ms. Hillary Richardson, The MITRE Corporation	10730 - AT&L and DOT&E IA Cross Walk Improving Information Assurance in Systems Acquistion and Testing Mr. Peter Christensen, The MITRE Corporation	TRACK 3 Net-Centric Operations/ Interoperability Bayview III	**Mr. Jack Zavin,** *ASD (NII)* **Mr. Hans Polzer,** *Lockheed Martin*	11033 - The View from Here — Human Views in Architecture Models Mr. Tim Bowden, Jenius LLC	10996 - DoD Delivering the Architecture of the Future Mr. Alan Golombek, Architecture & Infrastructure Directorate	10901 - Enhancing the Usability of the Human Machine Interface on the Handheld Interagency Identity Detection Equipment (HIIDE) Mr. John J. Howard, Southern Methodist University
TRACK 2 Program Management Bayview II	**Mr. Hal Wilson,** *Northrop Grumman Information Systems* **Ms. Dona Lee,** *SAIC*	10927 - Lifecycle Management Cost Optimizer Mr. Jerry Cothran, Lockheed Martin	10910 - Rapid Affordability and CAIV Exploration (RACE) Tool Mr. James Fieber, Lockheed Martin	10802 - Systems Engineering Influence on Life Cycle Cost Dr. Elizabeth Rodriguez-Johnson, ODDR&E/SE	TRACK 2 Program Management Bayview II	**Mr. Hal Wilson,** *Northrop Grumman Information Systems* **Ms. Dona Lee,** *SAIC*	10820 - Enhancing Performance Management via Metrics Mr. Peter Nolte, ODDR&E/SE	11135 - A Decision-Focused Model for DoD Development Planning—A Step Toward Uncovering and Targeting the Real Program Shapers Mr. Gregory Laushine, SAIC	
TRACK 1 Systems Engineering Effectiveness Bayview I	**Mr. Al Brown,** *The Boeing Company* **Ms. Dona Lee,** *SAIC*	11440 - SE Effectiveness Study Redux Mr. Joseph Elm, Software Engineering Institute	10812 - Introduction to the DoD Systems Requirements Analysis Guide Ms. Sharon Vannucci, ODDR&E/SE	10867 - Defining and Quantifying System Complexity Mr. John Seel, GWU and Naval Surface Warfare Center, Dahlgren Division	TRACK 1 Systems Engineering Effectiveness Bayview I	**Mr. Al Brown,** *The Boeing Company* **Ms. Dona Lee,** *SAIC*	10881 - A Systems Engineering & Integration Methodology for Complex Systems Mr. Frederick Samson, Booz Allen Hamilton	11053 - Are Rapid Fielding and Good Systems Engineering Mutually Exclusive? Mr. William Decker, Defense Acquisition University	

THURSDAY, OCTOBER 28, CONCURRENT SESSIONS CONTINUED

TRACK	SESSION CHAIR	1:30 PM	2:10 PM	2:50 PM
TRACK 10 Architecture Crown Point	**Ms. Barbara Sheeley,** *The Boeing Company*		10916 - Radar Open Architectures Mr. Scott Lucero, ODDR&E/SE	
TRACK 9 System Safety-ESOH Mariner Point	**Mr. Sherman Forbes,** *SAF/AQRE*	10837 - Joint Service Safety Testing Standards Dr. Elizabeth Rodriguez-Johnson, ODDR&E/SE	11133 - ESOH — Lessons Learned from DoD Acquisition Systems Engineering Program Support Reviews Mr. William Thacker, Booz Allen Hamilton	10848 - System Safety Engineering in a System of Systems Environment Ms. Janet McKinney, Naval Surface Warfare Center, Dahlgren Division
TRACK 8 Software-Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* **Mr. Mike McLendon,** *ODDR&E/SE*	11080 - Top Ten Reasons for Software-Reliant Acquisition Program Failure Mr. William Novak, Software Engineering Institute	11117 - Software Engineering Strengths and Weaknesses in System Engineers Dr. Paul Shebalin, Naval Postgraduate School	
TRACK 7 Technology Maturity Palm I	**Mr. Bill Nolte** and **Dr. James Malas,** *Plans and Programs Directorate*	11041 - DoD Manufacturing Policy and Technical Maturity Issues Challenging Affordability Dr. Michelle Atchison, Lockheed Martin	11072 - An Integrated Approach to Managing Technology Maturation Costs Dr. Deganit Armon, Advatech Pacific, Inc.	10974 - Evaluating the Readiness of Federations-of-Models for Use in Simulation-Based Concept Development of Advanced Warfighting Capabilities Mr. Bryan Herdlick, GWU and JHU/APL
TRACK 6 Workforce Development Mission III	**Dr. Don Gelosh,** *ODDR&E/SE* **Dr. Art Pyster,** *Stevens Institute of Technology*	10822 - DAU's New Continuous Learning Module on Human Systems Integration Dr. Fran Greene, Planned Systems International	11034 - Applying Systems Engineering to Workforce Development Mr. Ken Mosteller, The Center for Systems Management	10866 - Design Considerations in Building a Corporate Systems Engineering Training and Development Program Dr. Philip Trudeau, The MITRE Corporation
TRACK 5 Requirements Development Mission II	**Mr. Gene Rosenbluth,** *Northrop Grumman Mission Systems*	11098 - Services Based Requirements: Acquiring "Right Sized" Systems Ms. Ronda Henning, Harris Corporation	11079 - MRAP Requirements Management Process Ms. Jennifer Johnson, PEO CS&CSS, PM MRAP	
TRACK 4 Early SE/Test Mission I	**Mr. John Lohse,** *Raytheon Company* **Mr. Jeff Loren,** *Alion Science & Technology*	10798 - Early Integration of Test and Evaluation Subject Matter Experts in the Acquisition Life Cycle Mr. Robert Kennedy, Johns Hopkins University Applied Physics Laboratory	11002 - Enhancing T&E and SE Alignment Using Database Driven Documentation Ms. Sue O'Brien, The University of Alabama in Huntsville	10611 - Cost Estimation of System of Systems at Early Development Planning Mr. Kishore Gagrani, PRICE Systems, LLC
TRACK 3 Specialty Engineering Bayview III	**Mr. Joel Moorvitch,** *Raytheon Company*	10586 - New Army and DoD Reliability Scorecard Mrs. Marguerite Shepler, U.S. Army Materiel Systems Analysis Activity		
TRACK 2 Program Management Bayview II	**Mr. Hal Wilson,** *Northrop Grumman Information Systems*		10785 - Risk Management in the TACOM LCMC Ms. Lisa Graf, U.S. Army - TARDEC	10940 - EVM Method for LOE Projects Mr. Lynwood Townsend, GWU and Naval Surface Warfare Center, Dahlgren Division
TRACK 1 Systems Engineering Effectiveness Bayview I	**Mr. Al Brown,** *The Boeing Company* **Ms. Dona Lee,** *SAIC*	11107 - Panel: SE Standards: Status & Needs Moderator: Ms. Sharon Vannucci, ODDR&E/SE Ms. Cheryl Jones, Quality Engineering & System Assurance Sciences Group, RDECOM-ARDEC Mr. Joel M. Manary, Engineering Process Office, SSC Pacific Air Force Mr. Chris Ptachik, SAF/AQRE Mr. Garry Roedler, Lockheed Martin Engineering Process Improvement Center		

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
10507	Developing a Net-Centric Mission Architecture: From Mission Analysis to Executable Model	Ms. Elizabeth O'Keefe
10586	New Army and DoD Reliability Scorecard	Ms. Nancy Welliver
10591	Military Modeling & Simulation Systems Oriented Architecture (SOA) Concepts Pilot	Ms. Anita Zabek Mr. Richard Crutchfield Mr. William Beebe
10598	Systems Engineering Processes Improvement Using the CMMI in Large System of Systems Space Programs	Mrs. Sarit Assaraf
10604	Test and Evaluation Issues for Systems of Systems: Sleepless Nights to Sominex	Dr. Judith Dahmann
10713	Scenario Based Evaluation of Evolution Roadmaps for Agility and Architectural Consistency	Dr. Ipek Ozkaya
10715	Australia's Experience in Technical Risk Assessment for Defence Acquisitions	Mr. Jim Smith Dr. Nigel McGinty
10721	Developmental Environment, Safety and Occupational Health Evaluation: A Risk Assessment Tool for Early Evaluation of Environment, Safety, and Occupational Health Impacts	Mr. Noah Lieb
10724	Systems Engineering and User Needs — Strategies and Tactics for the Evolving System Acquisition Environment	Dr. Conrad Monson
10725	Safety in Systems Engineering Technical Reviews	Ms. Kristin Thompson
10730	AT&L and DOT&E IA Cross Walk Improving Information Assurance in Systems Acquistion and Testing	Mr. Robert Smith Mr. Ralph Harris Ms. Darlene Mosser-Kerner Ms. Susan May
10733	2010 Strategic Plan for DoD T&E Resources	Mr. Rick Thomas Mr. Ashton Burke
10736	Adapting Systems Engineering Best Practices to Technology Development in Applied Research	Mr. Hossam Ahmed Mr. Mike Ellis
10745	The Trouble with the System Readiness Level (SRL) Index for Managing the Acquisition of Defense Systems	Dr. Edouard Kujawski
10755	A Framework for Evaluating U.S. DoD Systems Engineering Principles Against Defense System Quality	Mr. Nazanin Azizian
10763	Considerations for Using Agile in DoD Acquisition	Mr. Ray Williams Dr. Charles Hammons Mr. Daniel Burton Mr. Alfred Schenker
10768	Mission Engineering for Warfighting Integration of Net-Centric Systems	Mr. Timothy Menke
10770	NCOIC's Network Centric Analysis Tool (NCAT TM)	Mr. Hans Polzer
10771	First Steps in the Development of an Architecture Framework for a Product Development Process	Dr. Jerrell Stracener
10773	NDIA Top 5 Software and Systems Engineering Issues - 2010	Mr. Geoff Draper
10774	PLM for Systems Engineering Support within ECSS	Mr. Ed Kincaid Mr. Ron Krugman Mr. Steven Pavick
10780	NDIA Life Cycle Affordability Project	Mr. Bruce Pieper Mr. Jerry Cothran
10785	Risk Management in the TACOM LCMC	Mr. Michael Olsem Ms. Cheryl Rassette Ms. Barb Dmoch
10792	"The Conversation," Applying Systems Thinking to the Science and Technology Phase of Acquisition	Mr. Bryan DeHoff Ms. Carol Ventresca

10795	Recapturing System Decomposition Techniques for Improved S&T Development of Future Warfighter Capabilities	Mr. Robert Rapson Ms. Carol Ventresca Mr. Thomas Archer Mr. Bryan DeHoff
10796	Valuing System Flexibility via Total Ownership Cost Analysis	Dr. Jo Ann Lane Dr. Raymond Madachy
10798	Early Integration of Test and Evaluation Subject Matter Experts in the Acquisition Life Cycle	Mr. Roy Emanuel, II
10799	The Realization of Service Oriented Architecture (SOA) Through Design Patterns via the Defense Business Mission Area (BMA) Strategy and Roadmap	Dr. Aaron Drew
10800	SEP Preparation Guide 3.0 — It's here!	Ms. Sharon Vannucci
10803	NCOIC Systems, Capabilities, Operations, Programs, and Enterprises (SCOPE) Model	Dr. Todd Schneider
10806	Key System of Systems Engineering Artifacts to Guide Engineering Activities	Dr. Judith Dahmann Mr. George Rebovich Mr. Ralph Lowry
10812	Introduction to the DoD Systems Requirements Analysis Guide	Mr. Stuart Booth
10819	Systems Engineering Program Metrics	Mr. Peter Nolte Ms. Laura Dwinnell
10820	Enhancing Performance Management via Metrics	Ms. Laura Dwinnell Mr. Ryan Sinclair
10822	DAU's New Continuous Learning Module on Human Systems Integration	Mr. James Campbell
10823	System of Systems Technology Analysis and Selection Methodology	Mr. Art Van Nostrand Mr. William Algoso
10831	T&E Methodology for Business Systems	Mr. Keith Seaman
10834	Improved Acquisition Processes Through Incremental Commitments	Dr. Jo Ann Lane
10838	The Joint Land Component Constructive Training Capability: An SoS Success Story	Mr. Met Metivier Dr. Richard Weatherly Mr. Mike Wright Ms. Anita Zabek
10840	Assessment of Integration Risk Within the Department of Defense for Major Acquisition Programs	Mr. Lawrence Gresko Mr. Ray Lowe
10849	Principles of Net-Centricity	Dr. Todd Schneider
10851	Assessment of Human Systems Integration in Air Force Acquisition	Mr. Steven Deal Ms. Sarah Orr Lt Col Valerie Martindale Mr. Adrian Salinas Col Larry Kimm
10852	Interoperability by Design	Mr. Dave Leedom Mr. Kevin Pugh
10861	Use of a Model-Based Approach to Minimize System Development Risk and Time-to-Field for New Systems	Mr. Barry Gosnell Mr. Robert Loesh Mr. Tim Brockwell Mr. Luke Daniels
10864	Semantic Web Tools and Technologies in Systems Development	Mr. Jeffrey Wallace Mr. Alex Hoover Mr. Terrell McCloud
10869	Proposed Functional Architecture and Associated Benefits Analysis of a Common Ground Control Station for Unmanned Aircraft Systems	CDR Michael Supko Mr. Gregory Miller
10875	Integrating the Technology and Systems Development Lifecycles to Mature Technology for Transition	Mr. Troy Peterson
10877	Creating a Graphical CONOPS	Mr. Peter Korfiatis
10881	A Systems Engineering & Integration Methodology for Complex Systems	Mr. Troy Peterson
10883	Undergraduate Systems Engineering Programs in the United States	Dr. Donald Gelosh
10887	Army System-of-Systems Engineering Processes	Mr. Terry Edwards

10888	Army System-of-Systems Architecture Developments	Ms. Hillary Richardson Mr. Scott Lee
10889	System-of-Systems Engineering for Army Battle Command Convergence	Dr. Mark Matthews Dr. Michael Kwinn
10890	Systems-of-Systems Engineering for Army Transport	Mr. David Poole
10901	Enhancing the Usability of the Human Machine Interface on the Handheld Interagency Identity Detection Equipment (HIIDE)	Ms. Kelly Faddis
10903	Guarding the Intent of Requirements Throughout the Test Execution Cycle	Mr. Eric Kaplan
10907	A Case Study of an Evolving ESOH Program — One Company's Perspective	Mr. Ricky Milnarik
10908	Mission Thread Workshop — Lessons Learned in End-to-End Capability and Quality Attribute Specification for SoS Architecture Development	Mr. Michael Gagliardi
10910	Rapid Affordability and CAIV Exploration (RACE) Tool	Mr. David Anderson
10926	Design For Reliability (DFR) Methodology Applied to Stryker NBCRV Program	Dr. Dmitry Tananko Mr. Sharad Kumar Mr. Carl Elliott Mr. Michael Staniszewski
10927	Lifecycle Management Cost Optimizer	Mr. Philip Fahringer
10932	BKCASE: Body of Knowledge and Curriculum to Advance Systems Engineering	Dr. David Olwell
10935	Strategic Enterprise Test and Evaluation Process Approach	Ms. Eileen McConkie
10937	Advanced Use of Prototyping in Human Computer Interface Development	Mrs. Colleen Johnson Mrs. Robin Ross
10940	EVM Method for LOE Projects	Dr. Thomas Mazzuchi Dr. Shahram Sarkani
10951	DoD Synergy with International Standards	Mr. Edward Bauer
10957	Human Systems Integration Support for Rapidly Fielded Systems	Dr. Matthew Risser
10958	Results of a Study on the Management of Broadly-Needed Modeling and Simulation Tools	Dr. Katherine Morse Mr. Randy Saunders Mr. Stephen Kay Mr. Christopher Erdman
10959	NDIA Model Based Engineering (MBE) Subcommittee Report	Mr. Jeff Bergenthal Ms. Sandy Friedenthal Mr. Mark Rupersburg Mr. Greg Pollari
10971	A-10, Thunderbolt II — a Study of Human Systems Integration	Mr. Larry Carr
10974	Evaluating the Readiness of Federations-of-Models for Use in Simulation-Based Concept Development of Advanced Warfighting Capabilities	Dr. Shahram Sarkani Dr. Thomas Mazzuchi
10988	Air Force Requirements Traceabilty Tool	Mr. Hugh Griffis
11002	Enhancing T&E and SE Alignment Using Database Driven Documentation	Dr. Dawn Sabados Mr. Lance Warden
11003	GAO Observations on DoD Implementation of the 2009 WSARA	Mr. Mike Sullivan
11004	Defining Factors Needed to Develop a Qualitative Approach to Assessing a Program Architecture	Dr. Thomas Mazzuchi Dr. Shahram Sarkani
11010	Human Systems Integration Approaches for Developmental Testing	Ms. Alisha Belk
11011	Systems Engineering in Development Planning and Science & Technology	Mr. Jeff Loren
11033	The View from Here — Human Views in Architecture Models	Dr. Jennifer Narkevicius Ms. Sue Archer
11034	Applying Systems Engineering to Workforce Development	Mr. Ken Mosteller
11047	A Compliance Case for Interoperability in Systems of Systems	Mr. Patrick Place Mr. Marc Novakouski Mr. Phillip Boxer
11048	Data Interoperability for Systems of Systems: An Integrated Software Engineering Perspective	Mr. Patrick Place Mr. Marc Novakouski Mr. Phillip Boxer

11052	Graduate Systems Engineering Programs: Report on Outcomes and Objectives	Dr. Timothy Ferris
11060	GAO's Annual Assessment of Selected Weapons Programs	Mr. Mike Sullivan
11063	Best Practices in Contracting for Models, Simulations, and Associated Data Subcommittee Report	Ms. Julianne Nelson
11068	GRCSE and GswE2009: Educational Advancements to Support Government and Industry	Dr. Massood Towhidnejad Dr. Guilherme Travassos
11070	Status of the Development of an International Standards Organization (ISO) Definition of the Technology Readiness Levels (TRL) and Their Criteria of Assessment	Mr. Cornelius Dennehy Mr. Prasun Desai Dr. Corinne Kramer Mr. James Bilbro Mr. Richard Widman Mr. Richard Weinstein
11072	An Integrated Approach to Managing Technology Maturation Costs	Dr. Roy Smoker Mr. David Peterson
11073	Advancing Systems Engineering Through Use of Collaborative Space	Dr. Alan Heminger
11078	Curriculum for the Life Cycle of the Systems Engineer	Dr. Tommer Ender
11079	MRAP Requirements Management Process	Mr. Sebastian Iovannitti
11082	HSI Translation of Capability Requirements to Acquisition	Ms. Andrea Cooks Mr. Roderick Thornton
11083	Early Systems Engineering for Tech Base Projects	Mr. Frank Salvatore
11089	Naval Systems Engineering Technical Review Process	Mr. Paul Dube
11091	Deployment of MBSE Processes Using SysML	Mr. Tom Alameda
11106	Practical Agile Requirements Engineering	Mr. Richard Carlson
11114	Panel: Systems Engineering Management and the Relationship of Systems Engineering to Project Management and Software Engineering	Dr. Barry Boehm Dr. Ed Conrow Dr. Ken Nidiffer Dr. Garry Roedler
11115	Application of Lean Process to Software Engineering via Value-Stream Mapping	Mr. Clarence Nelson Mr. Thomas Treffner
11131	The Case for Considering Acquisition Program Executability Prior to Materiel Development Decision (MDD)	Mr. Howard Hayden
11135	A Decision-Focused Model for DoD Development Planning—A Step Toward Uncovering and Targeting the Real Program Shapers	Mr. Howard Hayden
11445	The Use of Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development	Ms. Carly Jackson Mr. Cecil Whitfield
11446	Lessons Learned in the Application of System Readiness Level to the Development of Systems of Systems for the Mission Modules Program Office	Ms. Carly Jackson Mr. Brian Sauser

THANK YOU TO OUR PROMOTIONAL PARTNER

Raytheon

Raytheon Company, with 2009 sales of $25 billion, is a technology and innovation leader specializing in defense, homeland security and other government markets throughout the world. With a history of innovation spanning 88 years, Raytheon provides state-of-the-art electronics, mission systems integration and other capabilities in the areas of sensing; effects; and command, control, communications and intelligence systems, as well as a broad range of mission support services. With headquarters in Waltham, Mass., Raytheon employs 75,000 people worldwide.

NOTES

NDIA
National Defense Industrial Association

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
2111 WILSON BOULEVARD, SUITE 400
ARLINGTON, VA 22201-3061
(703) 247-2566
(703) 522-1885 FAX
WWW.NDIA.ORG

SYSTEMS ENGINEERING CONFERENCE

OCTOBER 25-28, 2010
HYATT REGENCY MISSION BAY
SAN DIEGO, CA

FOR INFORMATION, VISIT:
WWW.WWW.NDIA.ORG/MEETINGS/1870

THANK YOU TO OUR PROMOTIONAL PARTNER

Raytheon

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Welcome

to the

13th Annual

Systems Engineering Conference

Sponsored by

NDIA Systems Engineering Division

In Conjunction With

Director, Systems Engineering, Office of the Deputy Under Secretary of Defense (AT&L), Defense Research & Engineering

With Technical CoSponsorship By

Institute of Electrical & Electronics Engineers (IEEE)
Aerospace & Electronic Systems Society and
Systems Council

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Systems Engineering

Why do we need systems engineering?

- SE is the all-important facilitative umbrella engineering and "glue" that enables and fosters successful programs
- The highly complex systems, and systems-of-systems of today demand a far greater expertise in systems engineering than ever
  - Within defense industry
  - Within the OSD & Services side
- We don't seem to have the SE talent needed to satisfy the existing and future need
- Systems are so complex and the engineering challenges so great that it takes us 15 to 20 years to do what we used to in 4 to 5 years – and we can only afford a few of these

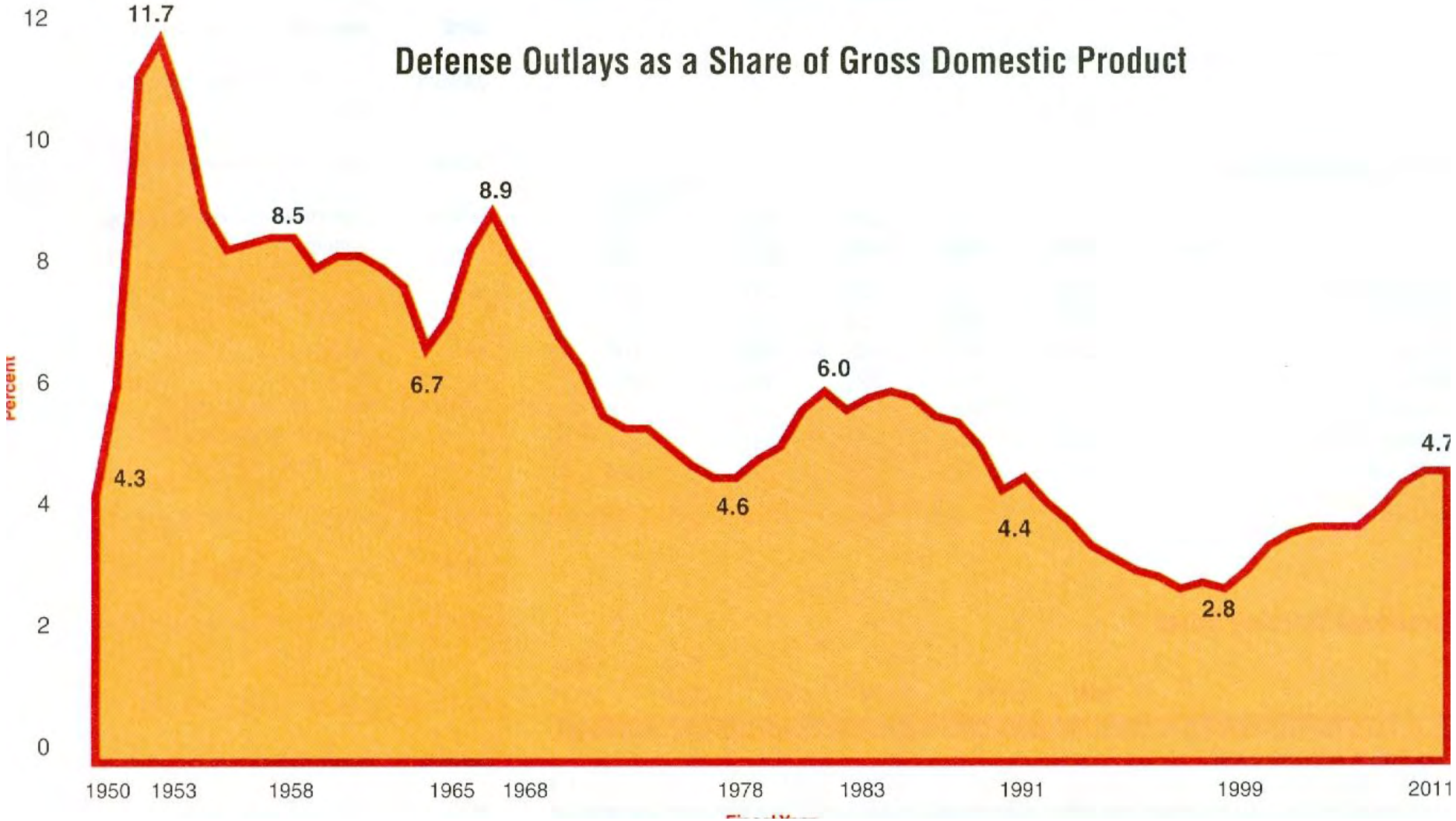
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

DoD Planning Budget 2011

Dollars Bn by Category	2009	2010	2011	2012	2013	2014	2015
Military Personnel	129.6	136.7	138.5	141.1	143.2	145.3	148.0
O&M	185.8	186.9	200.3	204.0	207.0	210.2	214
Procurement	105.5	106.2	112.9	115.0	116.7	118.5	120.6
RDT&E	82.5	81.1	76.1	77.5	78.7	79.9	81.3
Military Construction	22.7	21.3	16.9	17.2	17.5	17.7	18.1
Family Housing	3.3	2.3	1.8	1.8	1.9	1.9	1.9
Other	3.3	3.1	2.4	2.4	2.5	2.5	2.6
Total	532.5	537.6	548.9	559.0	567.3	576.0	586.4
Procurement/ Total	19.8%	19.7%	20.5%	20.5%	20.5%	20.5%	20.5%

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Defense Outlays % GDP



NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Food for thought---

- **Some USAF analyses claim that the USAF could be as many as 971 aircraft short of its minimum required inventory of 2,250 fighters by 2030.**
- **Who built our military airplanes? By WWII:**
  - **7,890 by Chance-Vought**
  - **8,810 by Martin**
  - **13,575 by Bell**
  - **15,603 by Republic**
  - **17,428 by Grumman**
  - **18,381 by Boeing**
  - **26,154 by Curtiss**
  - **30,696 by Douglas**
  - **30,903 by Consolidated Vultee**
  - **41,188 by North American**

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Why Systems Engineering---

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Program - Tuesday Oct 26 AM

0815 - 1200 PLENARY SESSION **Bayview Ballroom**

0840 – 0930: Keynote Address

Lt Gen Richard Scofield, USAF (Ret.), former Commander, USAF Aeronautical Systems Center

0930 - 1000 COFFEE BREAK **Regatta Pavilion ("Tent")**

1000 - 1200: Chief Systems Engineers Panel:

Mr Jim Thompson, OUSD(AT&L)DDR&E/SE, Director, Major Program Support ***Moderator***

Mr. Terry Edwards, SA/ALT, Director, System of Systems Engineering

Mr. Ricardo Cabrerra, ASN/RDA Chief Systems Engineer

Col Shawn Shanley, USAF; SAF/AQR- Chief, Engineering & Technology Management Div.

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Program - Tuesday Oct 26 PM

1330-1500 PLENARY SESSION **Bayview Ballroom**

Program Management Panel: Systems Engineering Discipline: Foundation for Program Success?

Col Leslie Blackham, USAF, Military Assistant, SE Directorate, DDR&E; ***Moderator***

Dr Gary Notte, USA, Product Dir, Fire Support Command & Control

LTC Todd Lamb, USA; Product Mgr, Stryker Development

CAPT Michael Jabaley Jr, USN; Prog Mgr, Virginia Class Submarines

CAPT Rick Muldoon, USN, Prog Mgr, H-53 Heavy Lift Helicopter

Col Janet L. Kasmer, USAF, Dep Dir, Gloal Reach Programs

Col Donald W Robbins, USAF, Cdr, Wideband SATCOM Group

1500 - 1515 COFFEE BREAK **Regatta Pavilion("Tent")**

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Program - Tuesday Oct 26 PM

1530-1715 PLENARY SESSION **Bayview Ballroom**

Industry Executive Panel: Challenges of Complex Systems: Need for Systems Engineering

Bob Rassa, Raytheon SAS, Director Engrg Programs *Moderator*

Mr Brian H. Wells, Raytheon, Vice President, Engineering

Mr. Paul Zavidniak, Northrop Grumman Airborne & Maritime Systems, Technical Fellow

Mr. Patrick Goggin, Boeing Defense Space & Security, Vice President, Development Program Excellence & Chief Engineer, Southern California Engineering

1715-1830 Reception in Displays Area Regatta Pavillion

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Luncheon Activities

Lunches in Regatta Pavilion

Tuesday

Mr. Stephen Welby, Director, Systems Engineering, OUSD(AT&L)DDR&E

Wednesday

- Presentation of NDIA Lt Gen Thomas Ferguson Awards for Excellence in Systems Engineering

Individual & Group

- Presentation of DoD Top 5 Programs Awards

Thursday: Systems 2020

Ms. Kristen Baldwin, Director, Systems Analysis, Systems Engineering Directorate, OUSD(AT&L)DDR&E

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Program - Wednesday Oct 27

0800-0945

1 Systems Engineering Effectiveness	Bayview I
2 Net-Centric Operations/Interoperability	Bayview II
3 System of Systems	Bayview III
4 Early Systems Engineering	Mission I
5 Modeling & Simulation	Mission II
6 Workforce Development	Mission III
7 Enterprise Health Management	Palm I
8 Test & Evaluation in Systems Engineering	Palm II
9 Human Systems Integration	Mariner Point
10 Logistics Supportability & Sustainment	Crown Point
0945 - 1015 COFFEE BREAK	**Regatta Pav.**

1015- 1200 All above continue

1200 – 1330 **Awards Luncheon in Displays Area** **Regatta Pav**

1330: Track 7, Palm I, now Technology Maturity

Other program changes occur at afternoon break

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Some Logistics Info---

Displays & Coffee Breaks are in Displays area in Regatta Pavilion.

11 Exhibitors are there to discuss their capability in Systems Engineering

Lunches are in Regatta Pavilion

Proceedings will be on DTIC Site within 3 weeks:
http://www.dtic.mil/ndia/2010systemengr/2010systemengr.html

This URL is on inside cover of your salmon Roster booklet

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

And Special Thanks To---

Technical Program Chairs:

Steve Henry, Northrop Grumman
Dr. Tom Christian, USAF AFMC/ASC

DoD Partners:

Stephen Welby, Jim Thompson, Kristen Baldwin, Nic Torelli, Darlene Mosser-Kerner, and Dona Lee

Session & Track Chairs:

WAY too many to list, visit with them in the sessions-

NDIA Meeting Executive:

Taryn Crowder, with Alison Doherty

NDIA Assistant VP Operations & Division Director

Sam Campagna

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Thanks To our Promotional Partner

Raytheon

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

14th Annual Systems Engineering Conference

October 24-27, 2011

Hyatt Regency Mission Bay

San Diego California

Call for Papers & Call for Displays is in your registration information

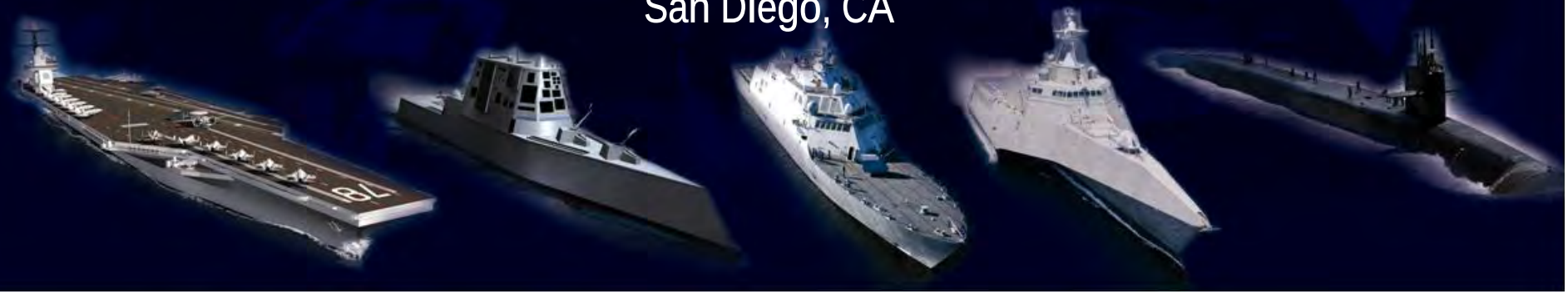
Papers Due Date: May 29, 2011

IEEE International Systems Conference
April 4-7, 2011, Montreal Canada
Abstracts due Nov 5, 2010
http://www.ieeesystemscouncil.org/

National Defense Industrial Association
Systems Engineering Division Conference
"Engineering Complex Systems of the Future"

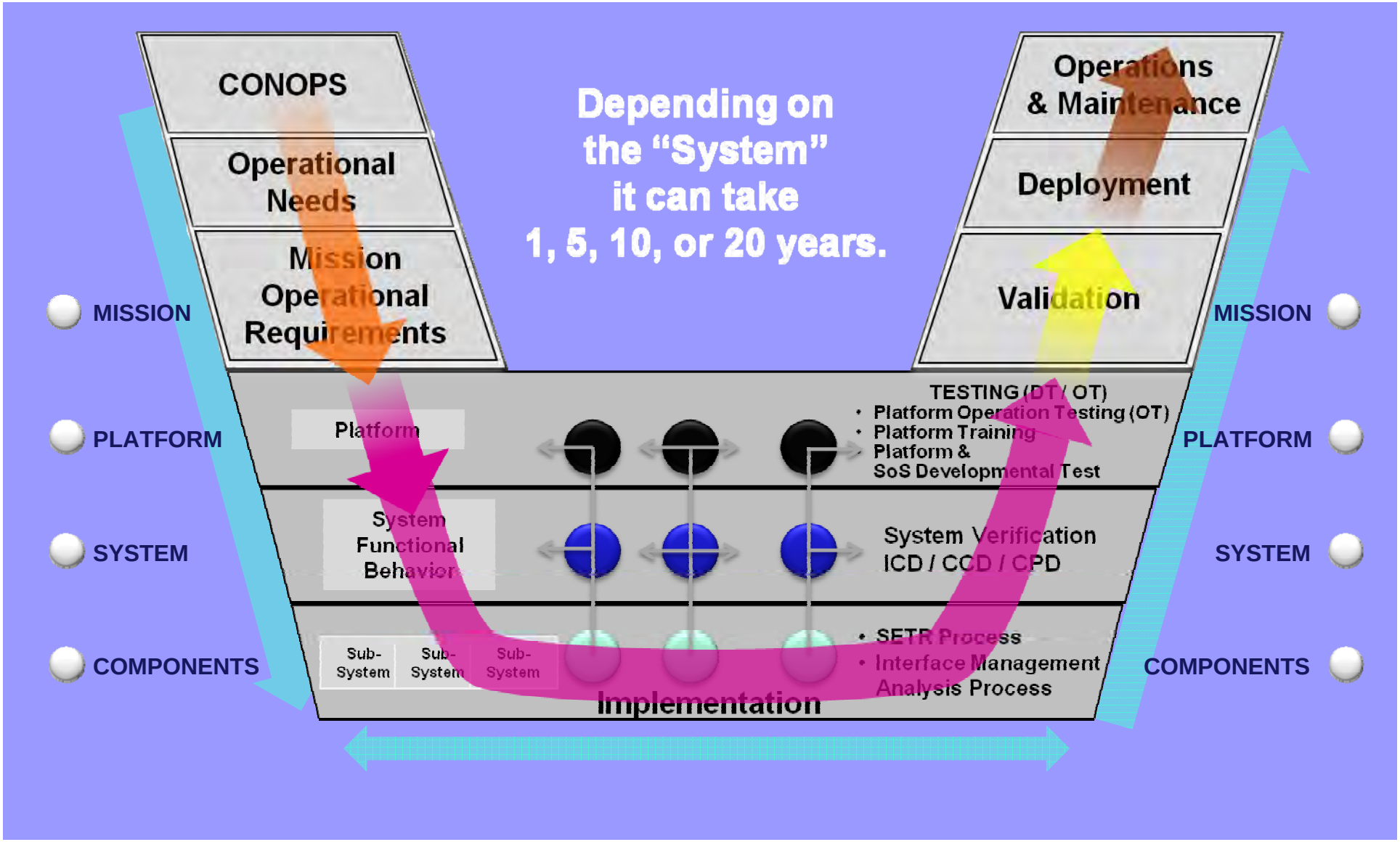
Assistant Secretary of the Navy for Research, Development, & Acquisition
SECRETARY OF THE NAVY
UNITED STATES OF AMERICA
CHIEF SYSTEMS ENGINEER

Mr. Ricardo Cabrera
ASN RDA CHSENG (Acting)
26 October 2010
San Diego, CA



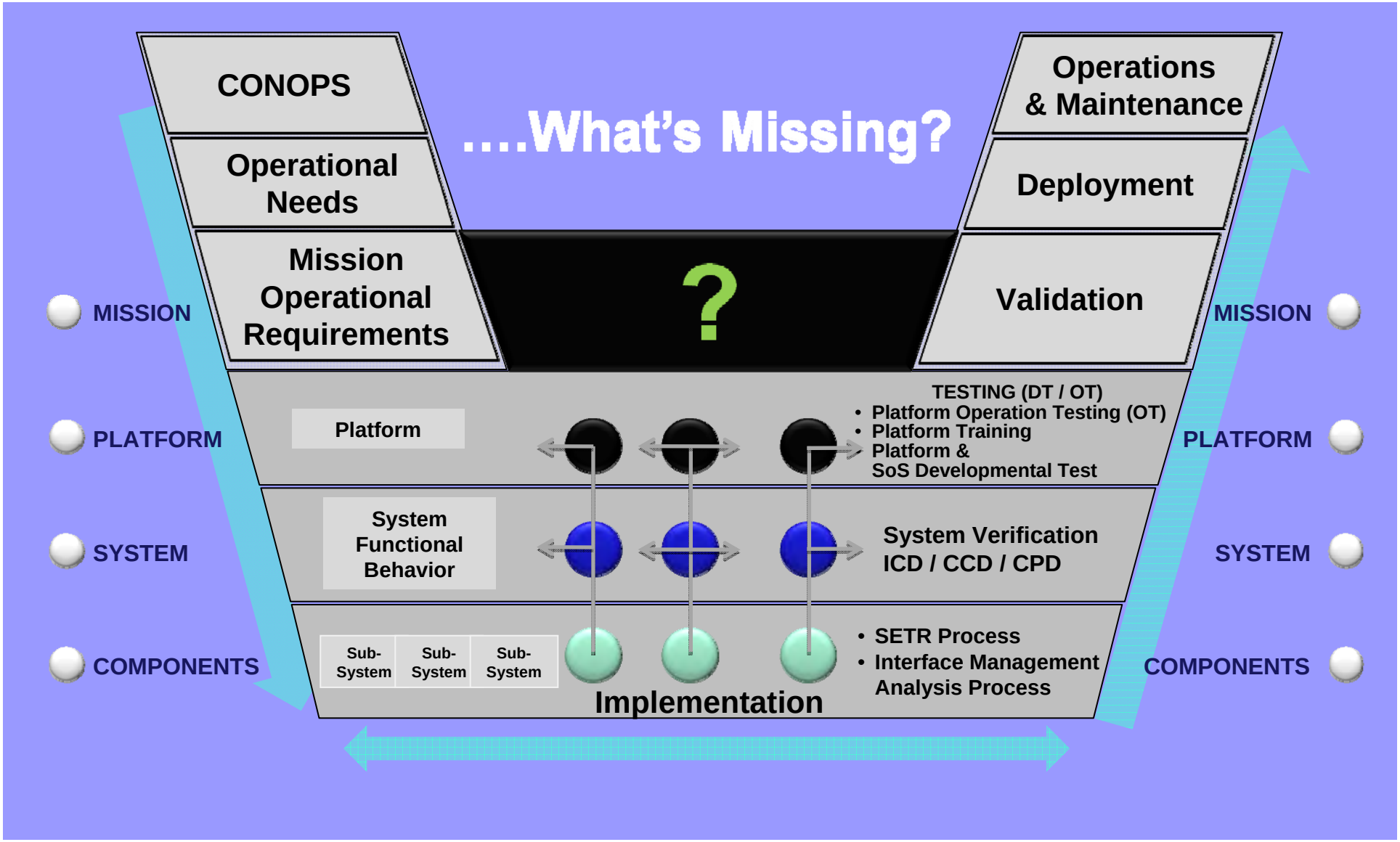
DoD 5000 Process

RDA CHIEF SYSTEMS ENGINEER



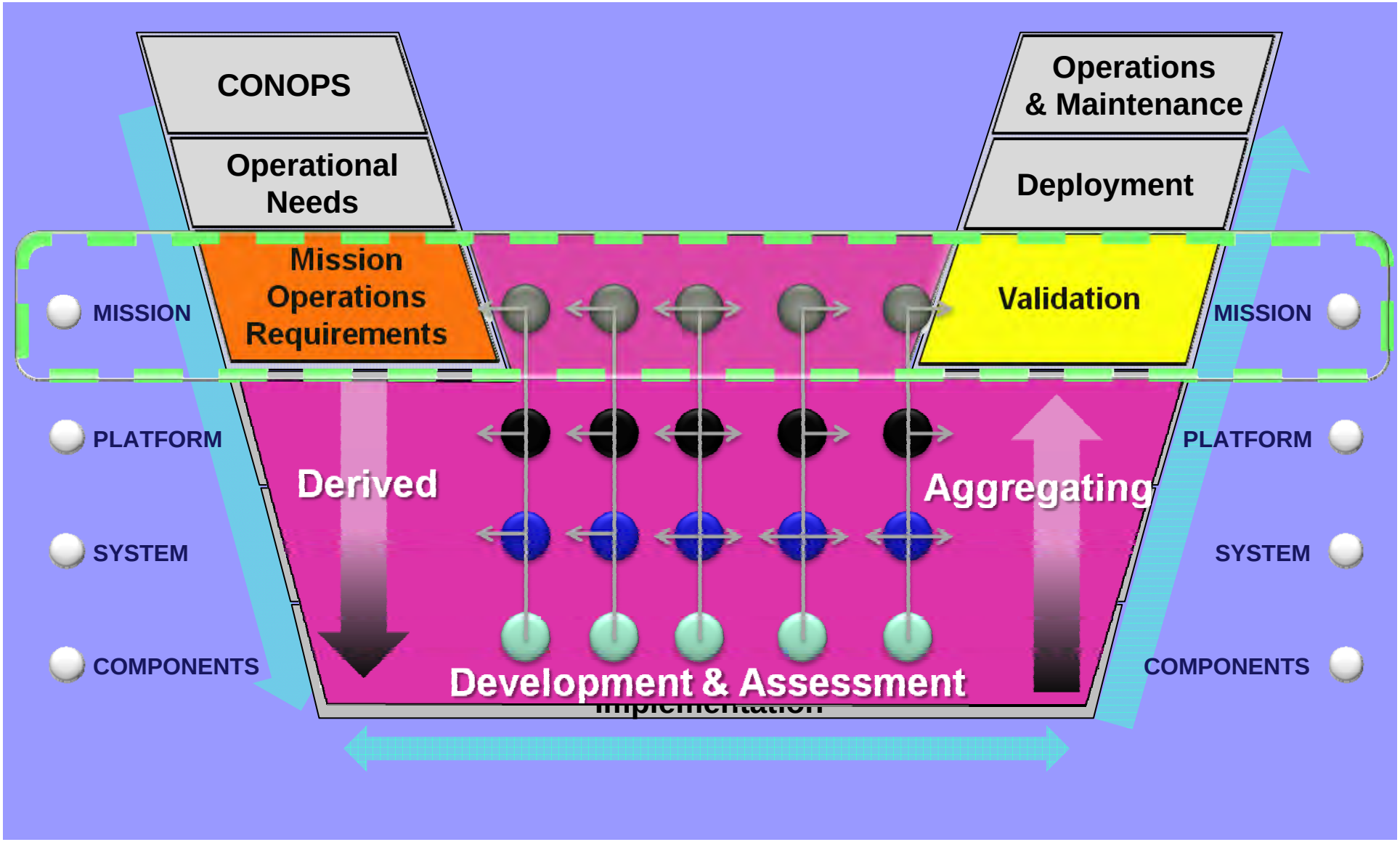
To Architect and Engineer the Naval Force…

RDA CHIEF SYSTEMS ENGINEER



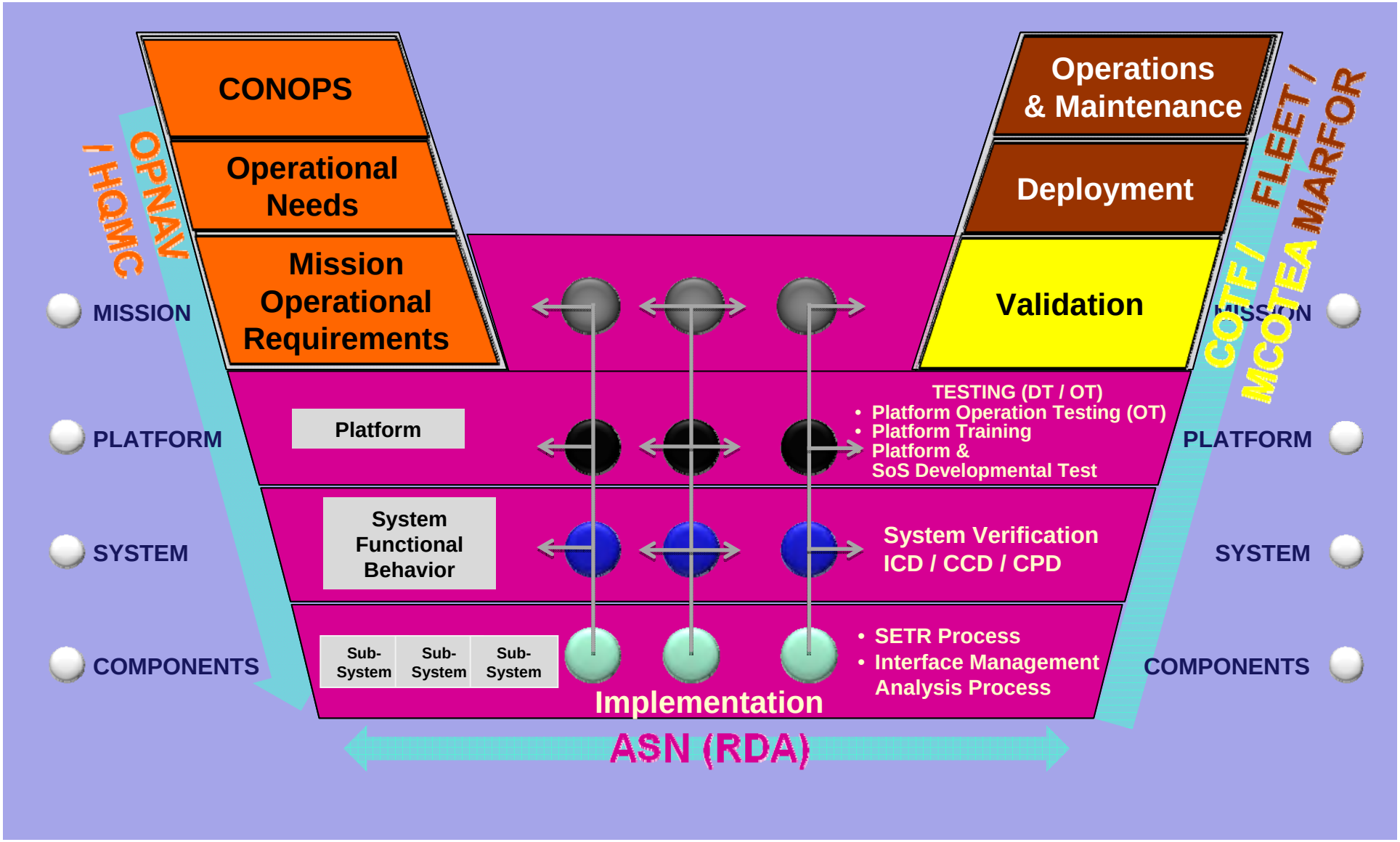
Engineering at the Mission Level

RDA CHIEF SYSTEMS ENGINEER



Mission Gap Closed

RDA CHIEF SYSTEMS ENGINEER



Mission Level Requirements & Acquisition

RDA CHIEF SYSTEMS ENGINEER

- Despite our torturous acquisition governance process, there is not a country in the world that produces high-performance, high-quality and high-volume defense systems like the United States.
- Our acquisition governance process has worked particularly well when developing individual platforms, systems, and some systems of systems.
- Developing complex systems of the future will require a governance process that affords mission-level capabilities considerations throughout the entire acquisition life cycle.

SE Conference: Plenary Session 1 – Chief Systems Engineers Panel
"Engineering Complex Systems of the Future"
Tuesday, October 26, 2010; 10:00am – 12:000pm

Panel Members

Mr. Jim Thompson (Moderator)	**Director, Major Program Support/SE Directorate, ODDR&E**
Mr. Terry Edwards	Office of the Secretary of the Army for Acquisition, Logistics and Technology
Mr. Ricardo Cabrera	Office of the Assistant Secretary of the Navy for Research, Development and Acquisition
Col Shawn Shanley	Office of the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering

Agenda:

Time	Topic	Presenter/Leader
10:00-10:10	**Introductions**	Mr. Thompson
10:10-11:05	**Engineering Complex Systems of the Future: What are your biggest challenges within the SE space and what are you doing about them?**	
10:10-10:20	• OSD Perspective (10 min)	Mr. Thompson
10:20-10:35	• Army Perspective (15 min)	Mr. Edwards
10:35-10:50	• Navy Perspective (15 min)	Mr. Cabrera
10:50-11:05	• Air Force Perspective (15 min)	Col. Shanley
11:05-11:45	**Service SE initiatives/efforts related to acquisition topics**	
	Efficiency Reviews	Cabrera, Shanley, Edwards
	Joint Reviews	Shanley, Edwards
	Measuring Performance to Plan	Cabrera, Edwards
	Competitive Prototyping	Cabrera
	Getting SE best practices instilled early in lifecycle of program	Shanley, Edwards
	Ideas on cross Service SE opportunities	Edwards, Shanley
	Low hanging SE opportunities	Edwards, Cabrera
	Specs, Standards within RFPs	Shanley
11:45-11:50	**Service: Challenge or thought for Industry (2 min/panel member)**	
11:50-12:00	**Audience Q&A**	

Army - ASA(ALT) System of Systems Engineering (SoSE)

NDIA Systems Engineering Conf 26 Oct 2010

Mr. Terry Edwards
Director, ASA(ALT) SoSE
(703) 614-4540
terry.edwards@us.army.mil

ASA(ALT) - SoSE Capstone Concept

ASA (AL&T)

Environment

- Complex Acquisition processes, stove-piped architectures driven by stovepipe requirements independent cost/schedule performance driven priorities
- Inadequate and fragmented architectures, engineering and analytical structures
- Immature work force in the discipline of SoS engineering

The System of System Engineering (SoSE) Mission

The Mission of ASA(ALT) SOSE: Provide the Army's leadership and materiel developers with the necessary engineering/architectural products to manage and shape the Army's materiel portfolio, to ensure a System Engineering discipline across the Materiel developer community throughout the acquisition life cycle and grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,...."Build the Bench".

The Army/ASA(ALT) Problem

How does ASA(ALT) apply available resources to engineer and deliver a complex architecture for the largest enterprise in the world and accomplish this mission in complex acquisition environment while supporting the Warfighter needs in multiple theaters of operation

Central Idea and Solution

The Army/ASA(ALT) must employ an empowered SoS Engineering Organization that will deliver the products to integrated and optimized materiel solution This will require:

- Team effort across the Army & Joint Staff and MSCs to deliver the blueprint to direct the Army capability development
- Enterprise vs. Stovepipe mindset
- Open Architectures focused on rapid technology evolution – leverage the countries industrial base
- Cost conscious culture
- An ability to make rapid adjustments based on a continuous assessment of Warfighter changing requirements

Supporting Ideas

- Establish the SOS Engineering Environment
- Build the core team with in concert with the PEO/PM Engineering teams
- Establish the Processes for analysis
- Promote transparency & knowledge sharing

Core Operational Actions

- Deliver the Materiel Solutions Architecture in support of ARFORGEN
- Support management of the Army portfolio
- Support the resourcing process providing the relevant trades
- Support the synchronization, and alignment of S&T, systems integration, test, and certification activities

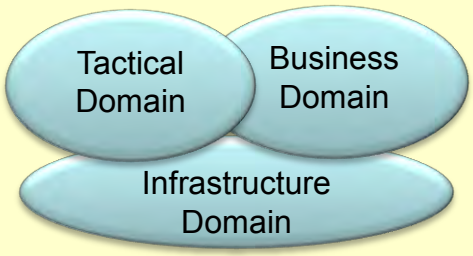
Desired End State

An establish SoS engineering environment for the Army's Materiel Enterprise that will deliver the authoritative blueprint to build superior, integrated cost effective Materiel Solutions to enable world's most capable, powerful and respected Army

System of Systems Engineering (SoSE) – Environment

ASA (AL&T)

Scope

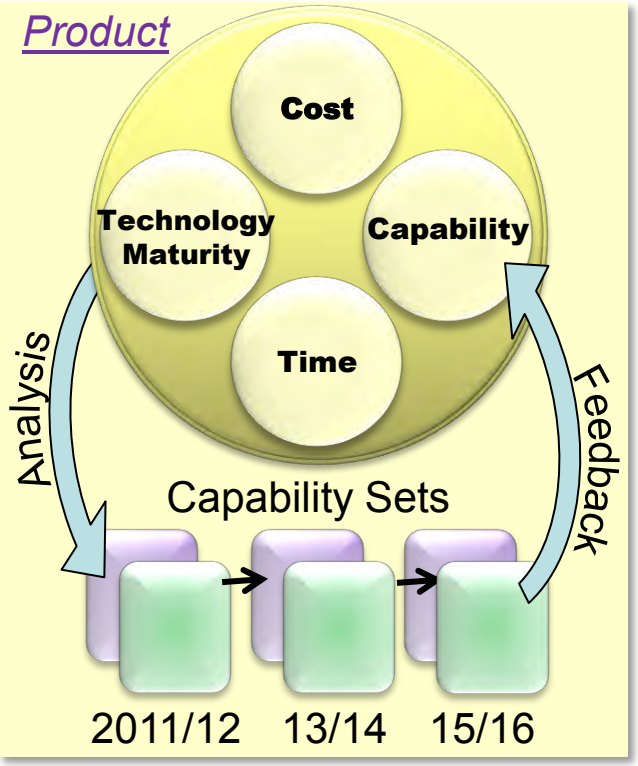


Mission

The Mission of ASA(ALT) SOSE:

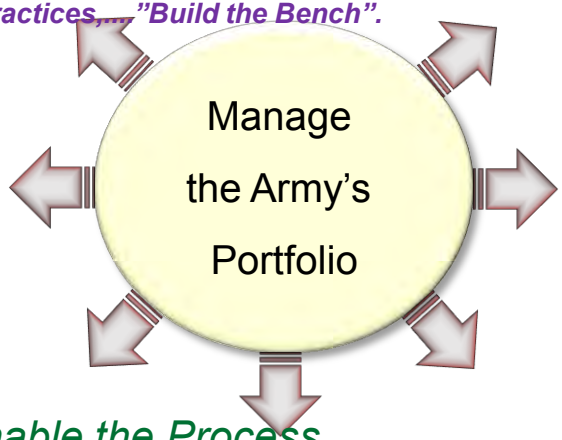
Provide the Army's leadership and materiel developers with the necessary engineering/architectural products to manage and shape the Army's materiel portfolio, to ensure a System Engineering discipline across the Materiel developer community throughout the acquisition life cycle and grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,…"Build the Bench".

Product



Build the Bench

- Organize the Army Engineering Community
- Establish Technical Authority and engineering expertise/capability
- Pursue accreditation and certifications of organic workforce & organizations



Create Data Transparency

- Establish CM and an authoritative repository for products
- Establish a collaboration environment
- Establish a common operating environment for engineering Products

Enable the Process

- Establish the engineering process to deliver synchronized capability
- Establish the analytical structure with models & simulations
- Establish the engineering compliance structure/process for acquisition execution excellence
- Deliver engineering support to HQ staff and acquisition community

Manage the Portfolio

- Support the prioritization of capabilities within the portfolio
- Set the baseline architecture roadmap over time
- Support the resourcing process
- Synchronize and align the S&T, systems integration, test, and certification activities

Ver. 2.7

Organizing the SoS Space

ASA (AL&T)

ARMY ANALYTICAL FACTORY
G3/5/7
G8
G6
ASA(ALT)
TRADOC & OTHER STAFF

LWN GOSC

AAE MilDEP

EXECUTIVE COUNCIL
DAS-M Chair *PEOs*

ENGINEERING OVERSIGHT COUNCIL (EOC)
SoSE Chair *DPEOs*

Acquisition Decision Authority

Configuration Steering Board

- *PEO*
- *SoSE*
- *S&T*
- *INTEGRATION*
- *RDECOM*
- *FFRDC*

AVIATION

BATTLE COMMAND

FIRES

TRANSPORT & NETOPS

SoSE Cross-IPT Integration WGs

Tactical Vehicle/ Sustainment

Ground Combat Systems

NETWORK INTEGRATION

MISSION COMMAND INTEGRATION

INTEG BASE DEFENSE

PLATFORM INTEGRATION

JOINT COMBAT ID

INTEL & SENSORS

SOLDIER

PEO TIER 2 SE GOVERNANCE

DOMAIN SE IPTs

Business

Chem / BIO

SIM & TRAINING

Authoritative Data Sources

Authoritative System Architectures

Acquisition Analysis

DESIGN * DEVELOP * DELIVER * DOMINATE

SoSE

Army SoSE Organization

ASA (AL&T)

Director

XO
EA

MILDEP

Deputy Director

Operations/KM

Domain Leads

- Network
- Mission Command
- Sensors
- Business Systems
- Chem /Bio
- CCCS/GCSS
- Ammo
- M&S
- AVN
- Medical
- Sim & Training

Systems Analysis

- Analysis of Complex Systems
- Systematic Root Course Analysis
- Arch Analysis/Trades
- Modeling & Sim

Systems Architecture

- Enterprise Architecture
- Systems Architecture
- Systems Arch Integration
- Architecture Analysis
- Performance Management

Program Support

- Engineering Assessments/Monitoring of Major Defense Programs
- Sys Engineering Plans
- Program Support Reviews - DAB, PDR, CDR, IPS, EIP, ITAB, OTRR
- Program Support Rev

Mission Assurance

- Sys Eng Policy Guide /
- Standards
- Specialty Eng (System Safety / Rel / Avail / Maint
- Qlty Manf, Producability, Human System Integration
- Program Protection
- ACQ Cyber Security
- Technical Engineering Workforce Development

•- Domain Leads
•- GOV
•- RDECOM
•- FFRDC/Contractor

Providing Technical and SE Leadership & Oversight to ASA (ALT) in support of planned ongoing Acquisition Programs

Way Ahead / Challenges

- As a newly formed organization, SoSE is still identifying the best initiatives and strategy for providing value-added engineering to the Army's SoS.
  - Must leverage the "Best of Breed" practices from across the community

- Must overcome existing cultural patterns and create collaborative, enterprise thinking environment that is focused on delivering integrated solution to the Warfighter in efficient and effective manner.

- Continue to find efficiencies while increasing capability

"Achieving Acquisition Excellence Via Effective Systems Engineering"

An Independent Perspective…

From a former PM & PEO

NDIA 13th Annual Systems Engineering Conference

26 Oct 10

Purpose

To offer some thoughts on how System Engineering can (should) contribute as …

"The DoD seeks to improve the acquisition process and overall program execution of military systems, to provide greater, more effective and reliable warfighting capability, at affordable cost and within reasonable schedules."

Summary- Upfront bottomline

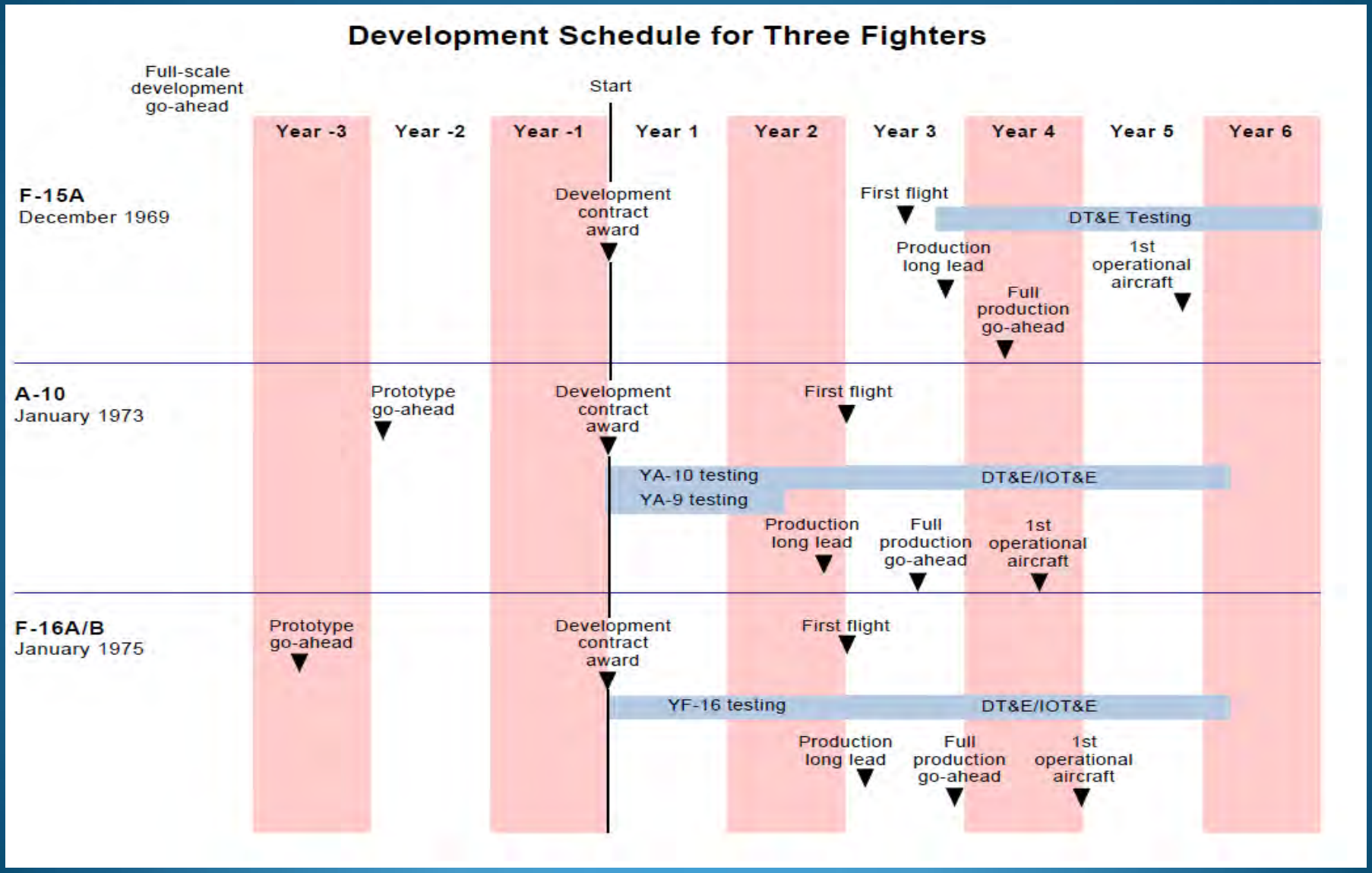
- Acquisition excellence can (only) be achieved with
  - An executable acquisition strategy
  - An enforceable (incentivized) contract strategy
  - Sufficient system engineering to support the above

- Sound System Engineering is necessary to establish
  - Adequate understanding of capability needs
  - Understanding of best available materiel solutions
  - Foundation for technical implementation of designs
  - Clarity of detail for producing and sustaining systems

What's past is prologue.

William Shakespeare

Acquisition Excellence



It's ain't what people don't know that makes them dangerous…

it's what they do know that ain't so!

Unknown…but claimed by many!

Acquisition Process Improvements

- Key 5000.02 changes which impact program starts
  - Set capability needs based on achievable solutions
  - Plan evolutionary Acquisition Strategies
  - Complete system level Preliminary Design Review (PDR) prior to MS-B with two (or more) contractors
- Weapon System Acquisition Reform Act of 2009
  - Increased emphasis on Independent Cost Estimates
  - Established joint guidance for Director of Development Test & Evaluation and Director of Systems Engineering
    - Jointly report on adequacy of early involvement in developing program plans and acquisition strategies
    - Added **Development Planning** to Systems Engineering

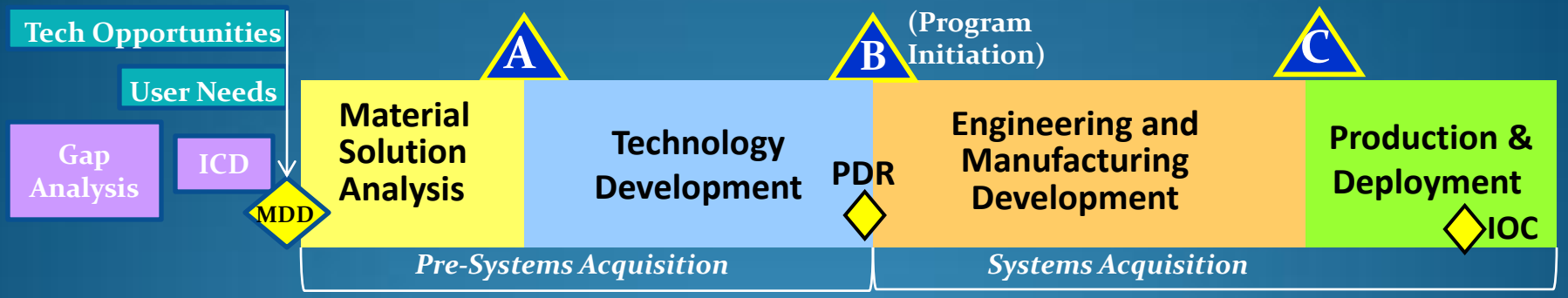
Start the right thing….right!

Acquisition Process Improvement

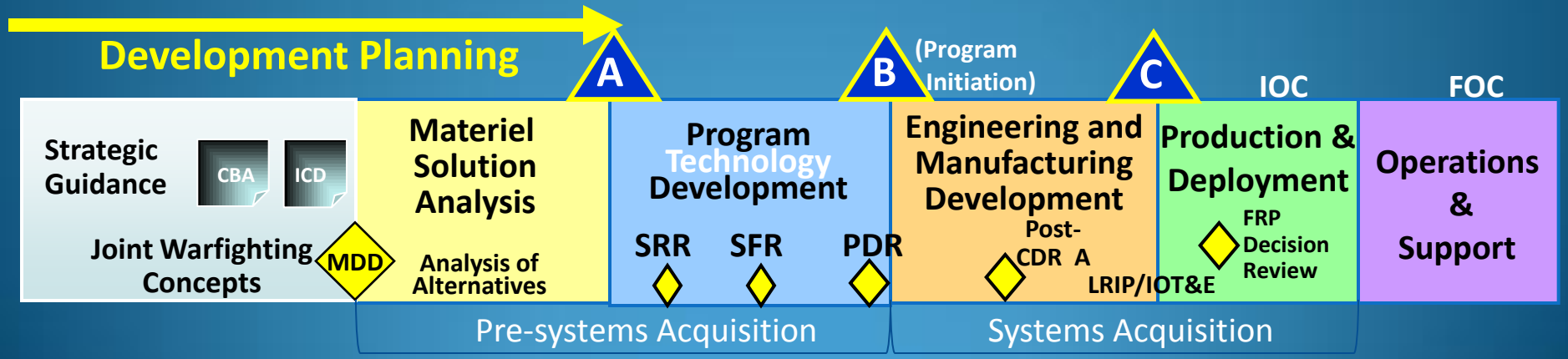
- AT&L Memo for Acquisition Professionals – 14 Sep 10
- Addresses several areas that re-enforce need for increased Systems Engineering …Development Planning
  - Mandate affordability as a requirement (KPP)
  - Drive productivity growth through Will Cost & Should Cost management…by each element of program cost
  - Eliminate redundancy within warfighter portfolios
  - Make production rates economical and hold them stable
  - Set shorter program timelines and manage to them
  - Increase the use of Fixed Price Incentive Firm Target (FPIF) contract type where appropriate using a 50/50 share line and 120 percent ceiling as a point of departure
  - Reinvigorate industry's independent research and development and protect the defense technology base

Guidance to Reality

DoDI 5000.02 2 Dec 2008

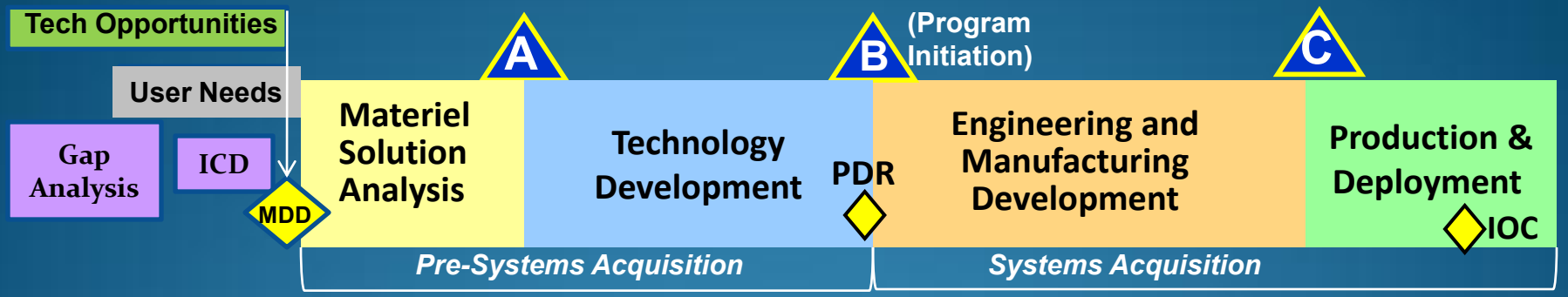


Current Operating Model (In the Practical Sense)

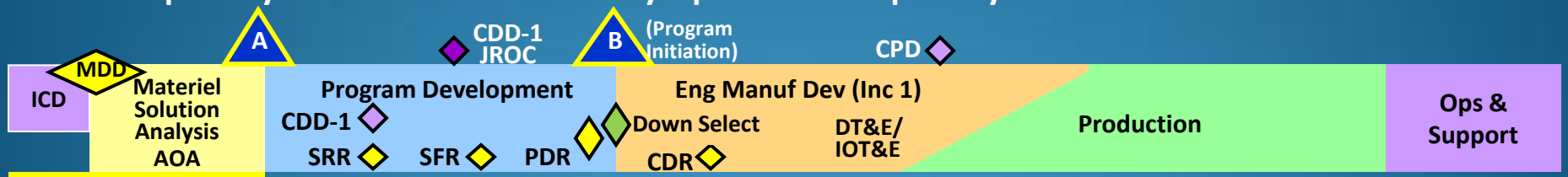


Guidance to Evolutionary Acquisition

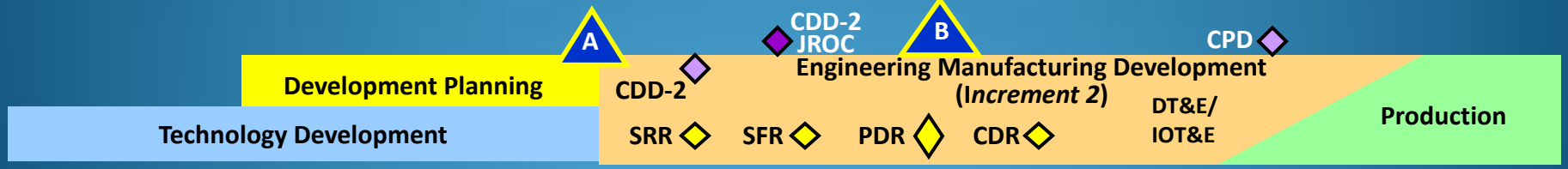
DoDI 5000.02 2 Dec 2008



New Capability Need – Increment 1 Early Operational Capability

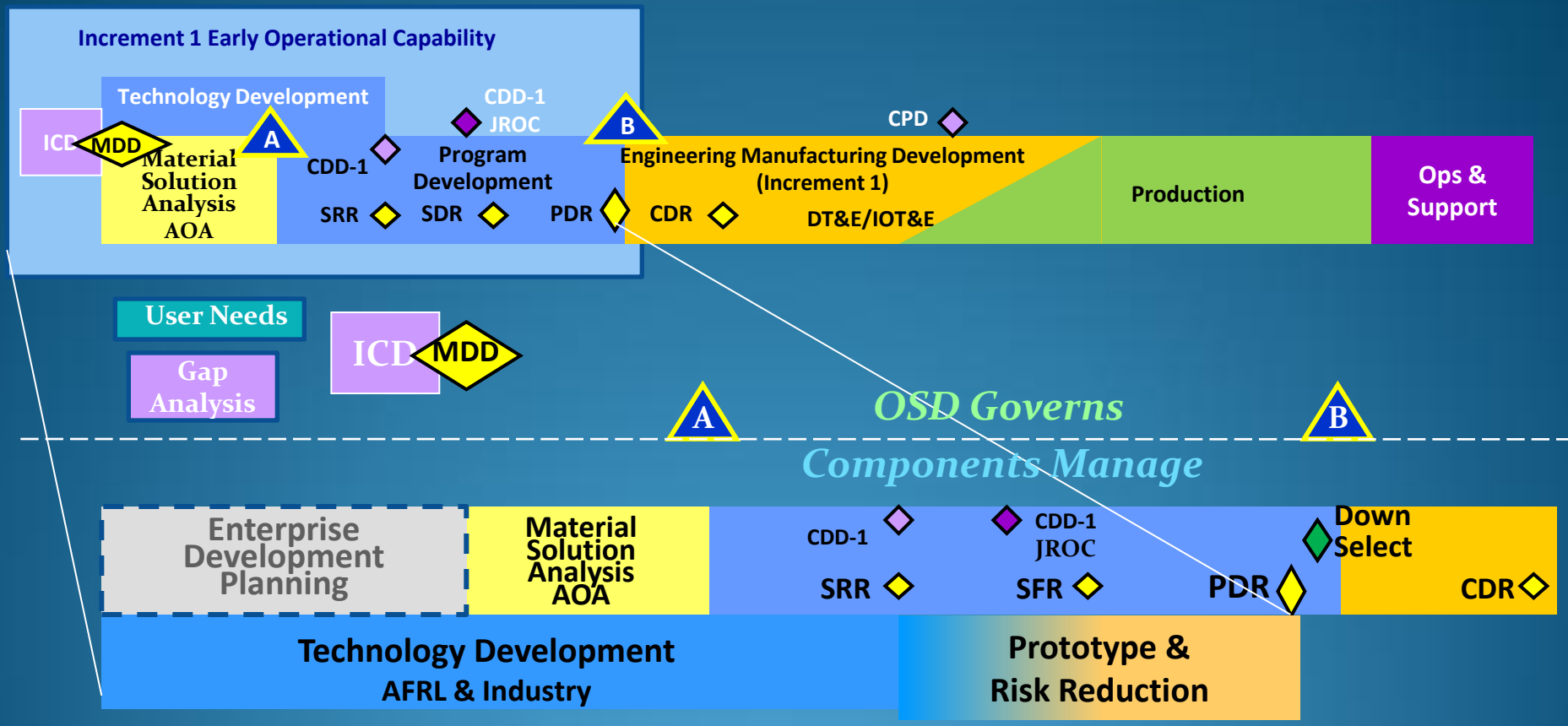


Increment 2 - Improved Operational Capability



Increment 3 – Advanced Operational Capability

Increment 1 Pre-Systems Acquisition



Enterprise Development Planning is the missing key element at Component Level

- Capability Based Analysis …Support JCS Capability Based Assessments
- Technology Integration and Standardization
- Program Planning (Systems of Systems)
- Analysis of Alternatives support to services in conjunction with OSD

Development Planning Opportunities

Concept Development and Engineering

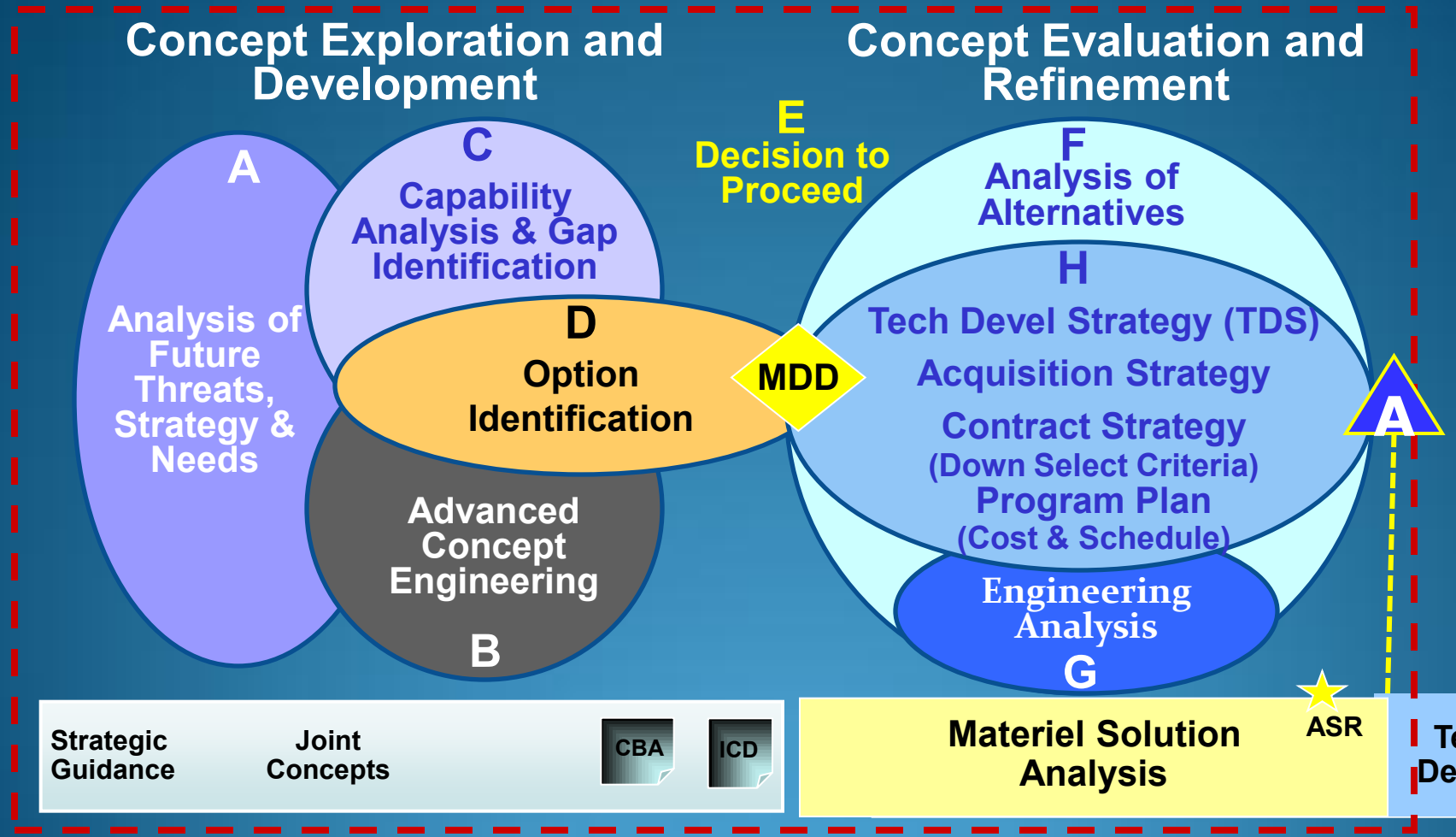
Focused SoS analysis and development of advanced systems concepts to support needs when they arise

Concept Evaluation and Refinement

Ensure optimal material solutions are identified with sound understanding of risks and opportunities

Systems Engineering Support for Increased Interaction between Users and Developers

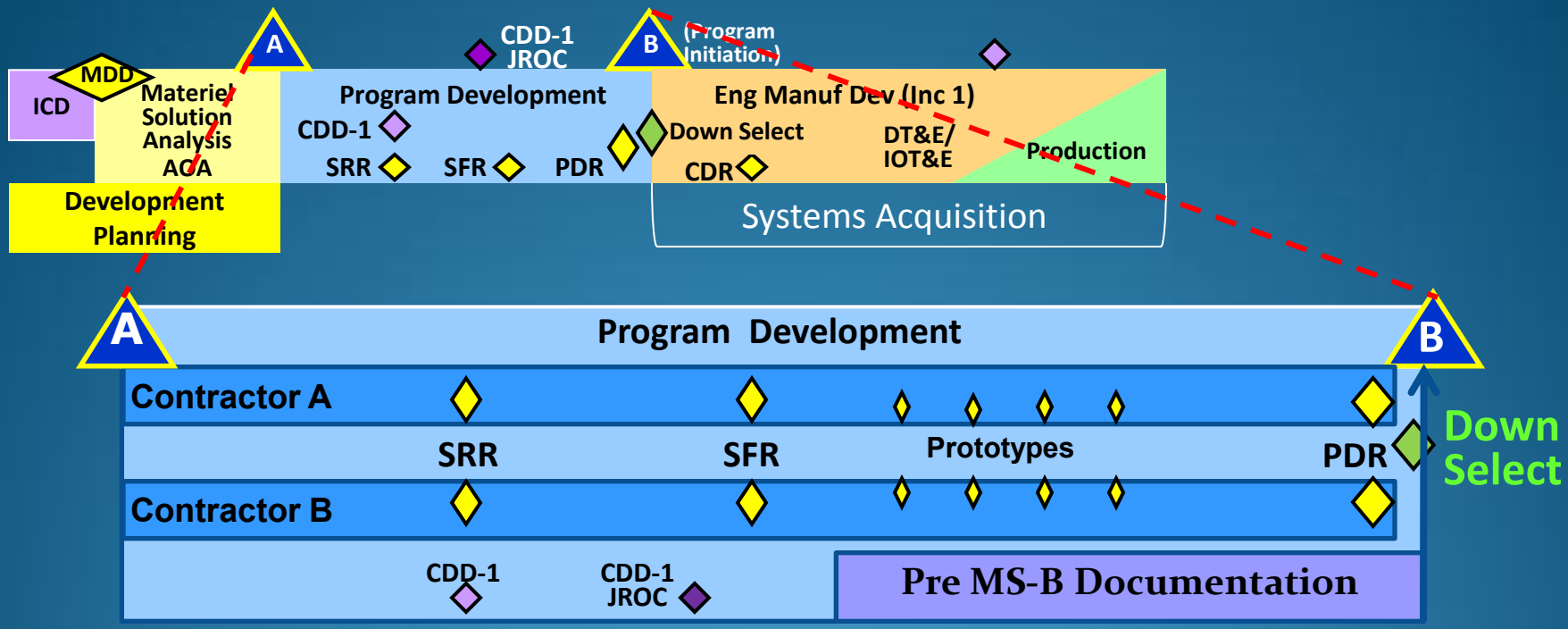
Systems Engineering/Development Planning



A: OSD/JCS/Intell/Components/Industry
B: Components/Materiel Centers/Industry
C: JCS/Components/Materiel Centers
D: OSD/JCS/Intell/Components/Mat Center

F: Materiel Center/ Selected Industry
G: Materiel Center/Selected Industry
H: Materiel Center/Selected Industry

System Engineering - Getting to MS-B



SRR

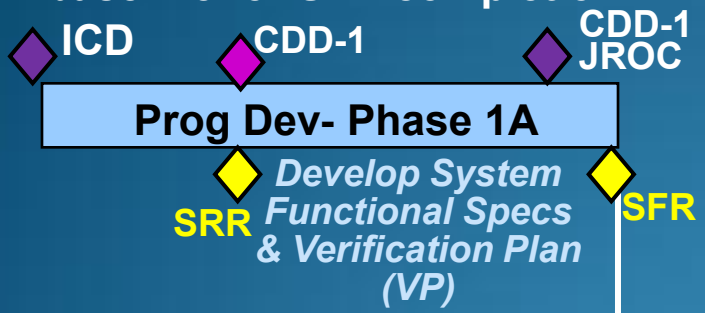
- *CDD-1 / Draft SRD*
- *Design concepts*
- *Risks identification*
- *Contractor SEP*
- *Contractor TES*
- *Draft Program Plan*
- *Define Mgt systems (IMP/IMS/EVMS)*
- *Subcontractor Mgt Plan*
- *Design Cost Estimate*

SFR

- *Systems Requirements Document*
- *Functional design (CI Spec)*
- *Capability Verification Plan (CVP)*
- *Prototype Plan*
- *Approved SEP*
- *Draft TEMP*
- *Demo'd Mgt systems (IMP/IMS/EVMS)*
- *EMD program proposal*
- *Production Program Plan*
- *Updated Cost Estimate*

Contract Down Select Strategy

CDD-1 becomes requirements baseline for SFR completion



SFR Gate (Knowledge Point) for Phase 1B

- *CDD establishes basis for*
  - *System Requirements Document (SRD)*
  - *System functional performance allocation*
  - *Capability Verification Plan (CVP)*
- *Contractors demonstrate ability to meet the SRD requirements with functional design and acceptable CVP to proceed to Phase 1B*

Four Gates to Contract Award

CDD- Establish Govt. capability needs

SFR- Complete Functional Design (CI) to meet CDD

PDR- Complete Detail Design (CI), reduce risk

Down Select- Acceptable Phase 2 proposal based on Phase 1 performance

PDR Gate (Knowledge Point) for Down-Select and MS-B

- *Contractor provides Configuration Item Design & CVP which satisfies the SRD (CDD) and meets the Down Select Criteria*
- *Contractor reduces risks as planned within budgeted resources*
- *Contractor demonstrates acceptable management performance in executing their Program Plan*
- *Contractor submits an acceptable Program Plan and proposal*

Summary

- Acquisition excellence can (only) be achieved with
  - An executable acquisition strategy
  - An enforceable contract strategy
  - Sufficient system engineering to support the above

- System Engineering necessary to establish
  - Adequate understanding of capability needs
  - Understanding of best available materiel solutions
  - Foundation for technical implementation of designs
  - Clarity of detail for producing and sustaining systems

"A pessimist sees the difficulty in every opportunity;

an optimist sees the opportunity in every difficulty"

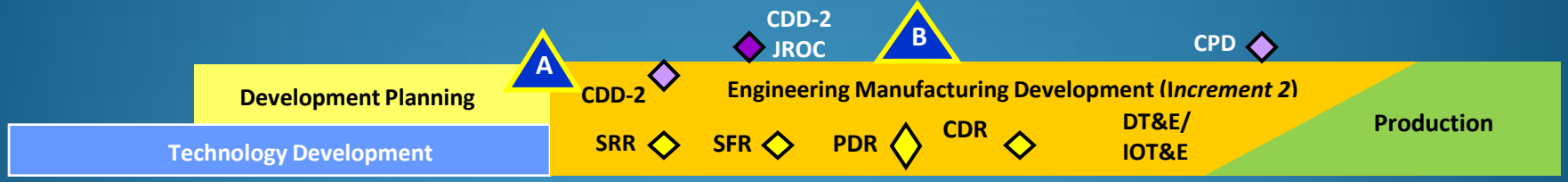
- Winston Churchill

Backups

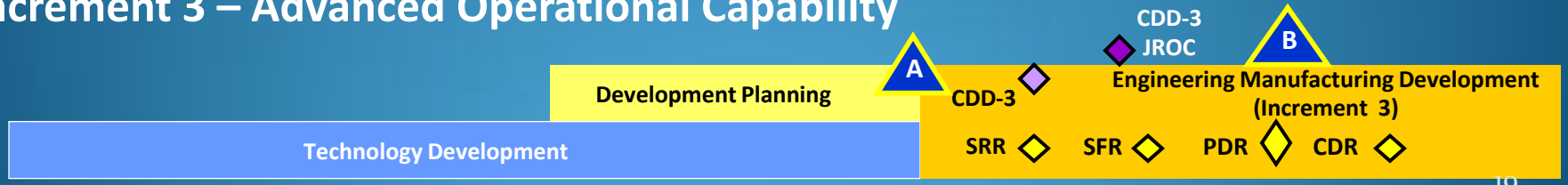
Evolutionary Acquisition

New Capability Need – Increment 1 Early Operational Capability

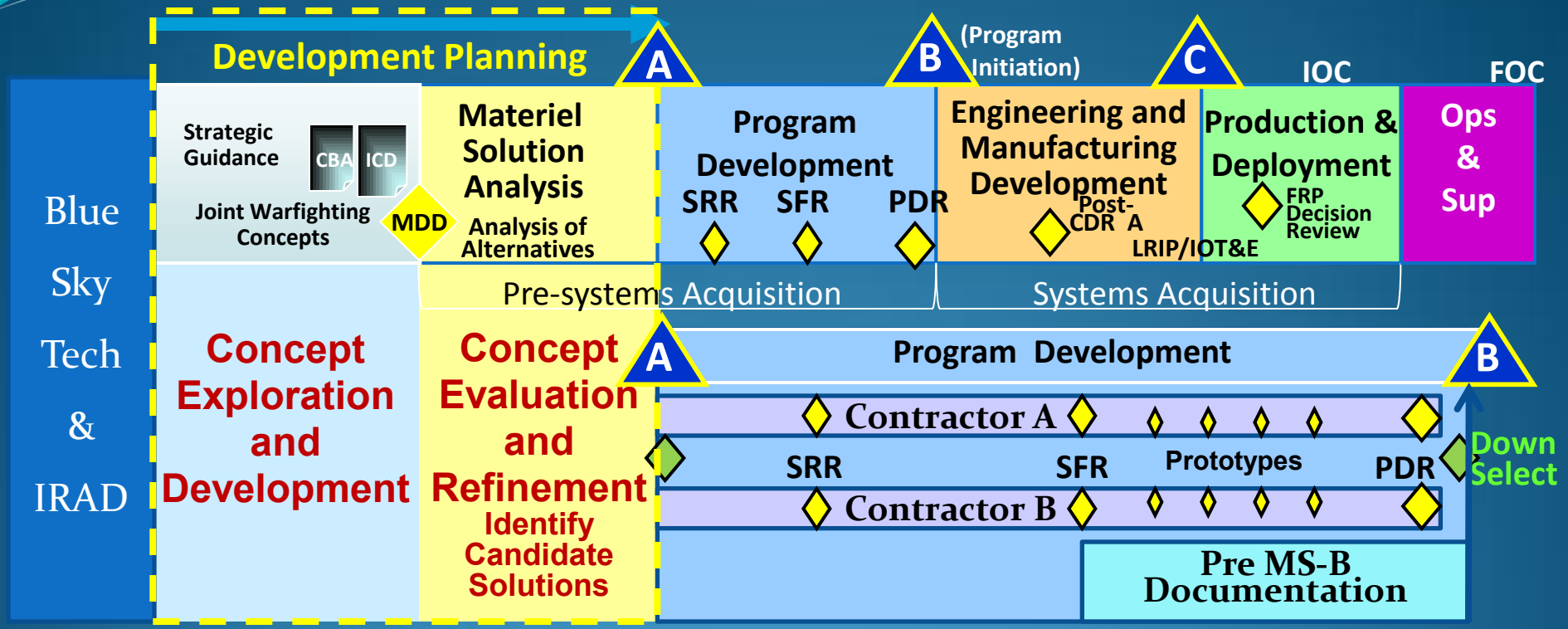
Increment 2 - Improved Operational Capability



Increment 3 – Advanced Operational Capability



Getting to MS-B



MDD

- *Validate ICD approach*
- *Approve*
  - *AoA Plan*
  - *Technology Dev Plan*
  - *Program Dev Plan*
  - *Acq Strategy Framework*
- *Establish MS-A Criteria*

MS-A

- *Acq Strategy*
- *Contract Strategy*
- *Identify solutions & contractors*
- *Establish Down Select Criteria*
- *Confirm Cost & Schedule*

SRR

- *CDD-1 / Draft SRD*
- *Design concepts*
- *Risks identification*
- *Contractor SEP*
- *Contractor TES*
- *Draft Program Plan*
- *Define Mgt systems (IMP/IMS/EVMS)*
- *Subcontractor Mgt Plan*
- *Initial Cost Estimate*

SFR

- *Systems Requirements Document*
- *Functional design*
- *Capability verification Plan*
- *Prototype Plan*
- *Approved SEP*
- *Draft TEMP*
- *Demo'd Mgt systems (IMP/IMS/EVMS)*
- *EMD program proposal*
- *Production Program Plan*
- *Updated Cost Estimate*

Headquarters U.S. Air Force

Integrity - Service - Excellence

The Way Ahead for Air Force Systems Engineering 2010 NDIA Conference

U.S. AIR FORCE

26 October 2010

Colonel Shawn Shanley
SAF/AQR

Chief, Engineering & Technical Management Division

shawn.shanley@pentagon.af.mil

U.S. AIR FORCE

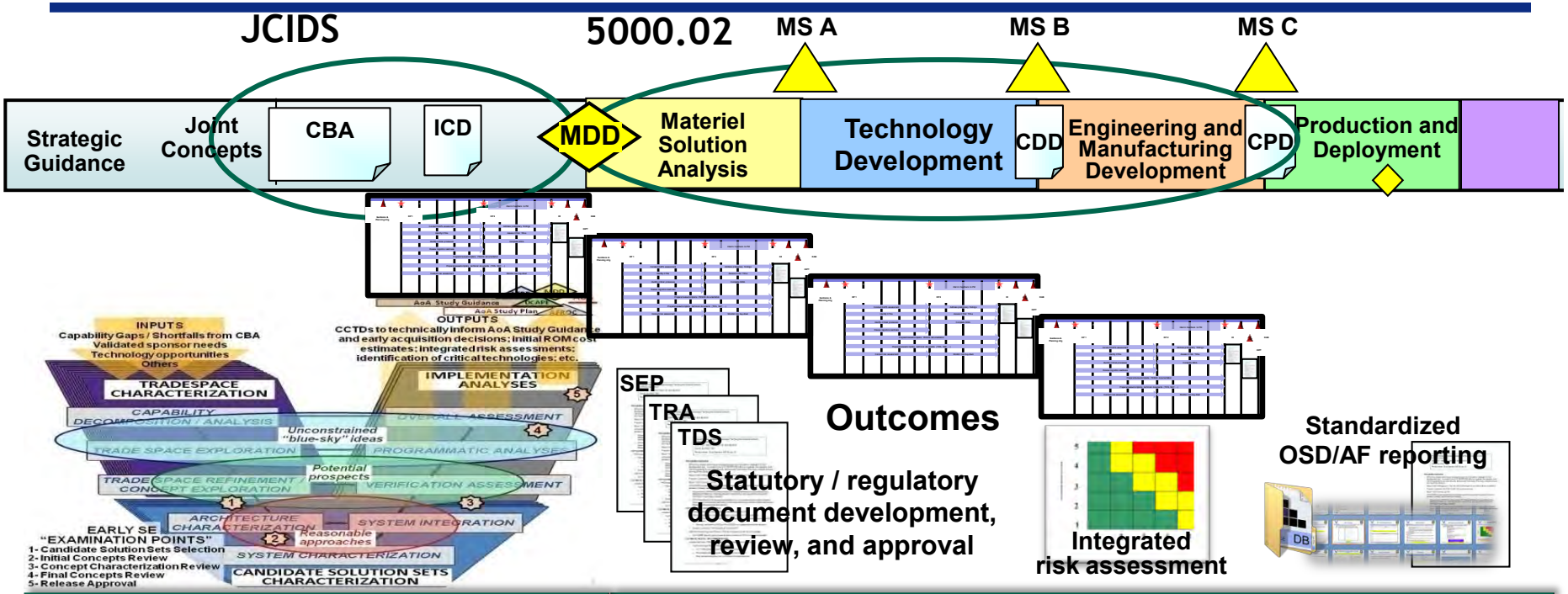
AF Top 5 SE Challenges

1. **Technical Planning & Execution**
   - *Stabilize programs before we commit resources (Pre-MS A)*
   - *Monitor/track/ assess programs to ensure they stay stable (MS A,B & C)*
   - *Integrate sustainment considerations throughout life cycle*
2. **SE Workforce**
   - Shape the way the Air Force manages our mission critical STEM capabilities
3. **Collaboration and Communication**
   - *Improve technical decision making via right info and insight at the right time to support informed & pro-active decision making*
   - *Act on available technical information to ensure effective and efficient program planning, management and execution*
4. **Technical Authority/Accountability**
   - *Codify technical accountability/authority in decision making process--Standardized SE*
   - *Drive efficiency through tailored/flexible standardization of policy, processes, practices, tools & metrics*
5. **Expediency**
   - *Characterize an expedited, tailored SE process for urgent needs, rapid fielding, and technology insertion*

U.S. AIR FORCE

Tech Planning & Execution

DP & PSR: Two Critical AF SE Initiatives



Development Planning Process (DP)

- S, T & E Engagement
- Concept/Solution selection influence
- SEP influence
- TDS influence
- T&E risk assessment
- TRL data evaluation

AF Program Support Review Process (AF PSR)

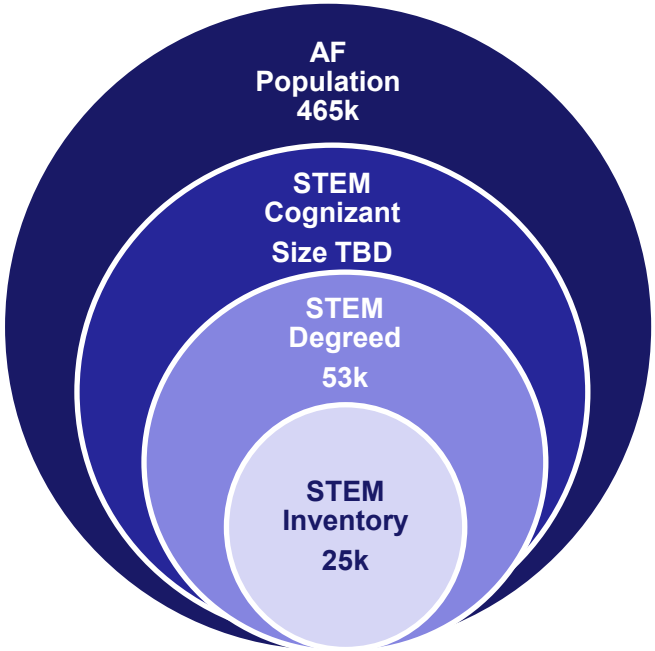
- SE Engagement up front and early with PMs to mentor/assist
- AF Standard for Tech Review Process
- Synchronized data requests to reduce program office & contractor impacts
- Identification of technology maturation/integration risks
- Collaborative with OSD to prevent surprises

U.S. AIR FORCE

SE Workforce: STEM – Revitalizing the AF Workforce

AF STEM Definition

The Air Force professionals having degrees in Science, Technology, Engineering, or Mathematics (STEM).



Goal Areas:

- Requirements/Inventory
- Funding/Resources
- Force Management
- Continuum of Learning
- Outreach
- Evaluation/Analytics

AIR FORCE STEM

U.S. AIR FORCE

Scientists & Engineering Advisory Council (SEAC)

STRATEGIC AREAS:

- S&E Qualifications, Certifications, & Credentialing
- S&E Career Development Programs & Placement
- S&E Continuing Education & Training Requirements
- S&E Workforce Capability Requirements/Advocacy/ Pipeline

U.S. AIR FORCE

Collaboration & Communication Specific Challenges

- **Planning: Ensure sufficient technical input to make informed decisions**
  - Little up-front and early technical mentoring, advice, and assessment
  - Not enough info to make a program start decision — lack of concept solution work prior to Materiel Development Decisions (MDD)
  - Programs pass milestones without adequate look at technical risk
- **Execution: Ensure technical issues/risks are discovered and addressed at the right time and at the right level**
  - Beware of the *"Sea of Green"* — "I'm OK because I've got a plan"
  - Immature technologies and integration issues continue to drive cost and schedule impacts — we need to step up our game
  - ECPs are still rampant — impacts to AF enterprise unknown; must use Configuration Steering Boards more effectively
  - Maintain discipline of SE processes — don't trade away rigor

Collaboration & Communication
AF PSR Process

U.S. AIR FORCE

DP #1—Organize, train, equip	DP #2—Provide early status	DP #3—Finalize products	Post Review
-Mentor/advise program office -TRA: ID independent review team -Early risk identification -Gain program understanding	-Provide preliminary report to PM -TRA: approve CTEs -Address risks -Cross flow information	-Out brief findings to PM -TRA: approve TRLs -Capture open risks -Complete MS deliverables	-Support AFRB/DAB -Conduct lessons learned hot-wash

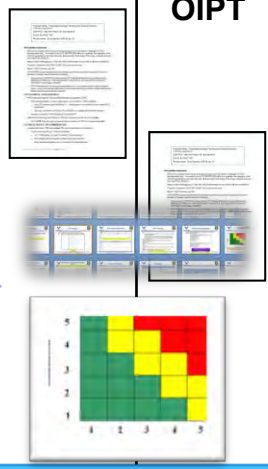
Notional Timeline

MS (-18 to -12) | MS (-17 to-11) | MS (-9 to -6) | MS (-2) | MS (-1) | MS

Guidance & Planning mtg | DP 1 | DP 2 | Interim Feedback to PM | DP 3 | AFRB | DAB | OIPT

Leverage tech reviews

DAPS (OSD-led)	Conduct DAPS assessment	Address preliminary findings
Technology	Identify CTEs	Assess CTEs' TRLs
Manufacturing	Identify critical processes	Complete MRA
Logistics	Review logistics readiness	
ESOH	Review ESOH	
Technical docs	Prepare/review/complete technical documents (TDS, SEP, PESHE, …)	
Integration Risk	Conduct risk assessment	Monitor risk buy-down



Early technical engagement to seamlessly mentor/advise, independently assess & capture risks…so PMs can act

* Statutory/regulatory process

U.S. AIR FORCE

Tech Authority/Accountability Roles & Responsibilities

Guidance Memo

PEO / DAO CSE

- Assigned by PEO / DAO
- Apply, implement, and adhere to all directive publications
- Review SEPs & oversee their implementation
- Assess performance of subordinate lead or chief systems engineers
- Verify technical review entrance/exit criteria are met & verify all technical reviews include independent subject matter
- Ensure full and complete technical information, issues, and risk are communicated

Center-lvl Tech Authority

- Assigned by Center/CC
- Assist PEOs / DAOs in the appointment of CSEs & assess performance of CSEs
- Assesses adequacy of and adherence to policies, practices, guidance, tools, education, and training
- Organize, manage, and coordinate execution of PSRs w/sub-teams, program office and contractors; provide guidance/training to programs & sub-teams

U.S. AIR FORCE

Tech Authority/Accountability Recent Policy Changes

- **Development Planning (changes to AFI 63-101 and AFI 63-1201)**
  - Establishes Concept Characterization & Tech Description (CCTD) as early SE artifact to support Materiel Development Decision/Analysis of Alternatives
  - Starting coordination Aug 10, publishing goal is Oct 10
- **Program Technical Assessments**
  - Establishes AF Program Support Review
  - Establishes responsibilities for Center-Level Technical Authority & PEO Chief Systems Engineers
  - Released over SAF/AQ signature, 10 Aug 10
- **DP Guide**
  - Released over AFMC/A5 & AFSPC/A5 signatures, Jul 10
- **CCTD Guide**
  - In final review; expect release over AQR signature Oct 10
- **Reliability, Availability, & Maintainability (RAM)**
  - Emphasizes continuous improvement & reliability growth plans, GM Jul10

U.S. AIR FORCE

Tech Authority/Accountability Specs and Standards

- **Acquisition Program Execution Problems (technical, cost, and schedule) Have a Common Root Cause:**
  - Blanket government removal of specs/standards (early 90s)
- **This Led To**
  - Absence of well-defined product characteristics
  - Inconsistent application of necessary SE processes
  - Specs and standards compliance becoming trade space in a highly cost-competitive environment
- **Plan for AF Acquisition Improvement Requires …**
  - Tailorable standard practices for SE processes (balanced)
  - Policy to mandate use in solicitations and contracts (TBD)

U.S. AIR FORCE

AF SE Strategic Plan

- **Communicate vision and goals; provide leaderships' guidance**
- **Provide framework for past, ongoing and future initiatives**
  - Roadmap of where we've been, where we are, where we are going
- **Describe relationship to other related plans/roadmaps**
  - E.g., AIP, D&SWS, S&T Roadmap, Bright Horizons
- **Synchronize initiatives to achieve vision and goals**
- **Support prioritization of resources**
- **Properly scope degree of standardization**
- **Use to communicate AF strategic direction -- near, mid, far term**

Vision: World class systems engineering enterprise efficiently and effectively supporting the development, acquisition, sustainment and disposal of compelling air, space and cyberspace capabilities.

U.S. AIR FORCE

AF SE Conference 3-5 Aug 2010

- **Key takeaways**
  - Robust SE contributes to successful programs
  - Implementing standard SE practices, processes, and policies fosters effective and efficient integrated life cycle management
  - Must take a balanced approach to reducing risk
  - Improved development and management of the technical workforce are critical to the future success of SE throughout the acquisition and sustainment life cycle
  - Ensure SEP as a “blueprint” for the technical aspects of programs instead of just a “check (√) the box” item
  - Accurate product and design data improve reliability and availability, OSS&E and sustainment
- **Feedback was overwhelmingly positive**
- **AQR, CSE, and AFMC/EN have agreed to co-sponsor next year’s conference; 2-4 Aug 2011 at WPAFB, Dayton, OH**
- **Industry panel at next conference as well as increased PM attendance**

Air Force Systems Engineering Conference

Tuesday, 3 August 2010

Day 1 Theme: Need for Disciplined SE (Policy)		
0730-0815	Check-in	
0815-0830	***Room 118/121/123;Overflow Rooms 111,112,116*** Welcome/Conference Administration	
Leadership Expectations of Systems Engineering (SE) ***Room 118/121/123; Overflow Rooms 111, 112, 116***		
0830-0900	Lt Gen Mark Shackelford, SAF/AQ	
0900-0930	Dr. Steven Butler, AFMC/CA	
0930-1000	Mr. Blaise Durante, SAF/AQX	
Keynote Address ***Room 118/121/123; Overflow Rooms 111, 112, 116***		
1000-1030	Mr. David Van Buren, Air Force Service Acquisition Executive	
1030-1050	*Break*	
SE in Acquisition (WSARA) Panel MODERATOR: Dr Steven Walker, SAF/AQR ***Room 118/121/123; Overflow Rooms 111, 112, 116***		
1050-1110	Mr. Stephen Welby, DDR&E, Systems Engineering	
1110-1130	Mr. Robert Boulware, SAF/AQXA	
1130-1150	Col Shawn Shanley, SAF/AQRE	
1150-1210	Panel Q&A	
1210-1330	*Lunch*	
Technical Sessions		
1330-1500	**1A:** SE Policy (incl. JCIDS, DoDI 5000.02 & Early SE)	Room 118/121/123
	1B: Revitalization of Specs and Standards	Room 111/112
	1C: Systems Engineering Research	Room 116
1500-1530	*Break*	
1530-1700	**1D:** Modeling & Simulation	Room 118
	1E: Architectural Frameworks	Room 121/123
	1F: Human Systems	

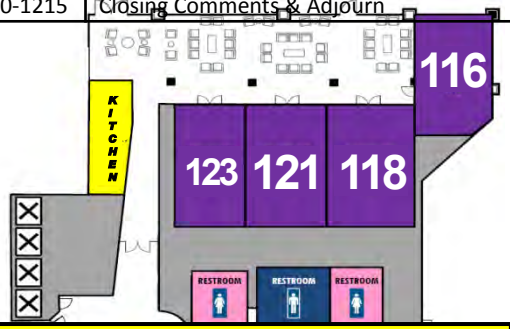
No-Host Social, 1700-1900
Hamlet Restaurant

Wednesday, 4 August 2010

Day 2 Theme: Importance of Standardized SE Across the Life Cycle (Where SE is applied and by whom)		
0730-0815	Check-in	
0815-0830	***Room 118/121/123;Overflow Rooms 111,112,116*** Conference Administration	
SE Importance Across the Acquisition Life Cycle MODERATOR: Mr G Richard Freeman, AFIT/SY ***Room 118/121/123; Overflow Rooms 111, 112, 116***		
0830-0850	Dr. Kenneth Barker, AFRL/XP	
0850-0910	Mr. Gerald Freisthler, ASC/CA	
0910-0930	Maj Gen David Eichhorn, AFFTC/CC	
0930-0950	Mr. Grover Dunn, AF/A4I	
0950-1010	Panel Q&A	
1010-1030	*Break*	
S&E Workforce Development Panel MODERATOR: Mr G Richard Freeman, AFIT/SY ***Room 118/121/123; Overflow Rooms 111, 112, 116***		
1030-1050	Dr. Donald Gelosh, DDR&E	
1050-1110	Lt Col Michelle Trigg, SAF/AQH	
1110-1130	Mr. Albert Boulter, AFPC/DPIBE	
1130-1150	Panel Q&A	
1150-1330	*Lunch*	
Technical Sessions		
1330-1500	**2A:** Integrated Master Plan & Integrated Master Schedule	Room 118/121/123
	2B: Reliability	Room 111/112
	2C: ESOH	Room 116
1500-1530	*Break*	
1530-1700	**2D:** Test and Evaluation	Room 121/123
	2E: Life Cycle Supportability	Room 118
	2F: Cool Tools (ARM, SEAM, RI3, RTT, etc)	Room 111/112

Thursday, 5 August 2010

Day 3 Theme: SE Applied (How SE is applied and measured)	
0730-0815	Check-in
0815-0830	***Room 118/121/123;Overflow Rooms 111,112,116*** Conference Administration
SE Application and Assessment Panel MODERATOR: Col Shawn Shanley, SAF/AQRE ***Room 118/121/123; Overflow Rooms 111, 112, 116***	
0830-0850	Mr. Robert Martin, AF PM&AE
0850-0910	Dr. Marvin Sambur, Univ. of Maryland
0910-0930	Mr. Russell Howard, AFMC/EN
0930-0950	Col David Swanson, SMC/EA
0950-1020	Panel Q&A
1020-1040	*Break*
Technical Assessments Panel MODERATOR: Col Shawn Shanley, SAF/AQRE ***Room 118/121/123; Overflow Rooms 111, 112, 116***	
1040-1100	Mr. James Thompson, DDR&E
1100-1120	Mr. Joseph Shearer, SDB II Program
1120-1140	Lt Col Scott Brown, SAF/AQRE
1140-1200	Panel Q&A
1200-1215	Closing Comments & Adjourn



All briefings will be posted to the AF SE Conference CoP by 12 August

https://rso.my.af.mil/afknprod/ASPs/Reg/GroupAdmin.asp?Filter=23843&EventID=14647&GroupID=19841

U.S. AIR FORCE

Summary: Way Ahead for AF SE

- Robust, disciplined SE -- sound engineering/technical management
  - People, Policy, and Processes
- Objective broker on affordability/performance/technical risks
- Thorough understanding of SE trades and programmatic technical issues
- Competent insight into contractor technical planning and execution

To meet these expectations, we must:

(1) Institutionalize Technical Rigor and Discipline Across the Life Cycle of Acquisition Programs

(2) Revitalize the AF SE Workforce

BACK UP CHARTS

U.S. AIR FORCE

MDD Information Needs – Forthcoming DDR&E Policy

To support those decisions, the DoD Components shall provide evidence at the MDD Review that will facilitate the determination that:

a. **The candidate materiel solution approaches have the potential to successfully address the capability gap(s), associated dependencies, and operational attributes.**

b. **There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data.**

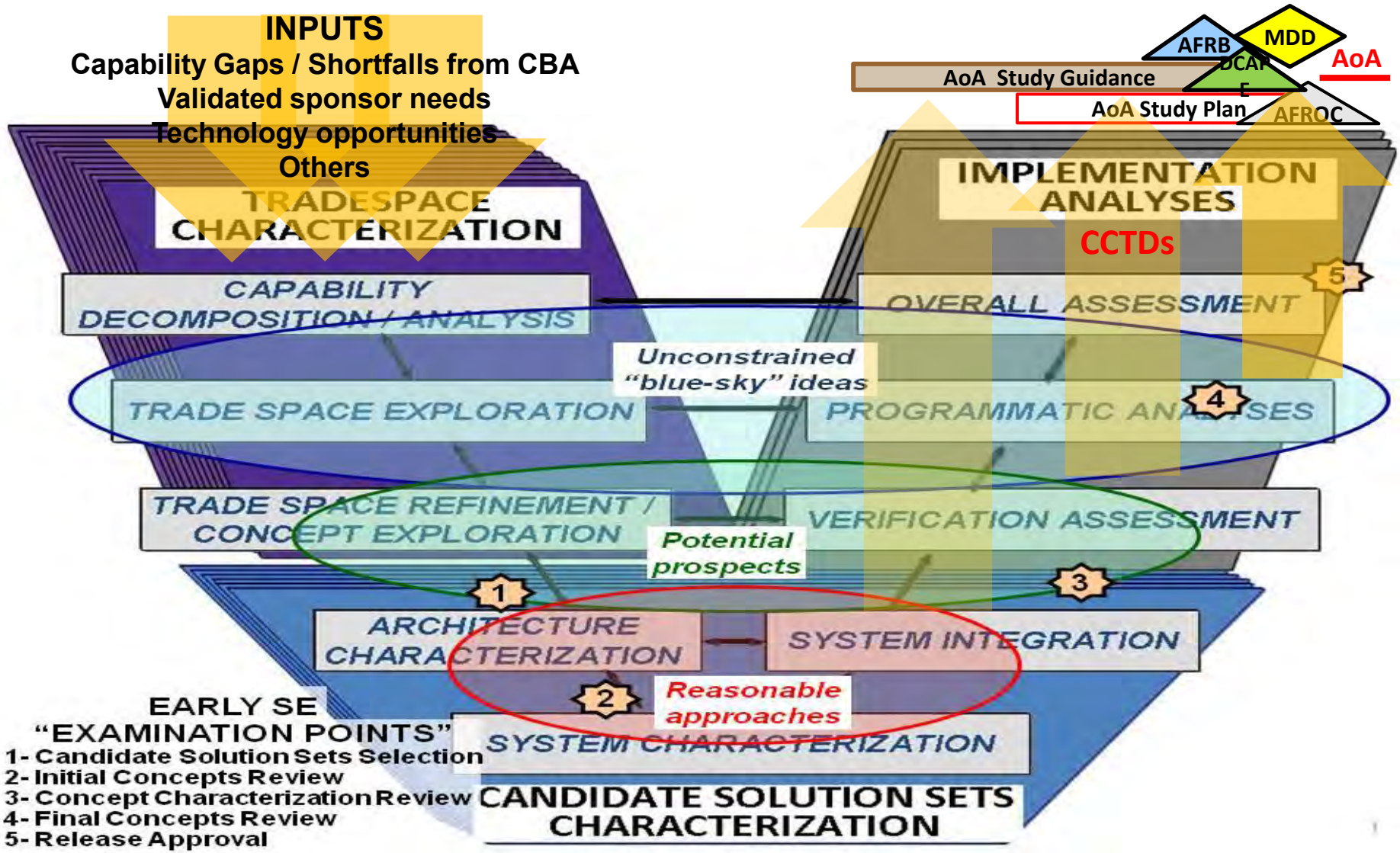
c. **Consideration has been given to near-term opportunities to provide a more rapid interim response to the capability need.**

d. **The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirements.**

- **AF is assessing issues associated with industry engagement during DP / Early SE**
- **Conflicts of interest, protection of proprietary information, solutions masquerading as concepts, contracting terms and conditions, numerous others ...**

Capability Planning, Development Planning, Early SE, and Acquisition

U.S. AIR FORCE



Chief Systems Engineers Panel

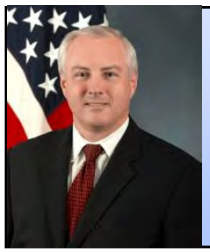
Jim Thompson

ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 26, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Mission Context



Director, Systems Engineering
Steve Welby

Systems Analysis

"Weapon Systems Acquisition Reform Act of 2009"

S.454-10; d.(1): The development and tracking of detailed measurable performance criteria as part of the systems engineering master plans…

S.454-10; d.(3): A system for storing and tracking information relating to the achievement of the performance criteria and objectives specified…

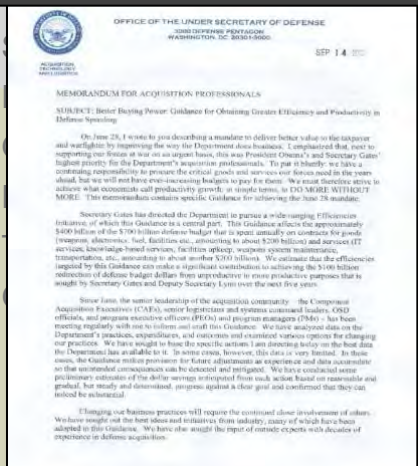
S.454-12; SEC. 103.b.(4): Evaluating the utility of performance metrics used to measure the cost, schedule, and performance of [MDAPS], and making such recommendations …to improve such metrics.

Major Program Support
James Thompson

- Program Support Reviews
- Systems Engineering Plans
- Program Technical Auditing
- OIPT/DAB Support
- DAES Database Analysis and Support
- Performance Measurement
- Systemic Root Cause Analysis

Mission Assurance

AT&L Memo, 14SEP2010
Subject: Better Buying Power: Guidance for Greater Efficiency and Productivity in Defense Spending



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

SEP 14

MEMORANDUM FOR ACQUISITION PROFESSIONALS

SUBJECT: Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending

On June 23, I wrote to you describing a mandate to deliver better value to the taxpayer and warfighter by improving the way the Department does business. I emphasized that, next to supporting our forces at war on an urgent basis, this was President Obama's and Secretary Gates' highest priority for the Department's acquisition professionals. To put it bluntly: we have a continuing responsibility to procure the critical goods and services our forces need in the years ahead, but we will not have ever-increasing budgets to pay for them. We must therefore strive to achieve what economists call productivity growth; in simple terms, to DO MORE WITHOUT MORE. This memorandum contains specific Guidance for achieving the June 28 mandate.

Secretary Gates has directed the Department to pursue a wide-ranging Efficiencies Initiative, of which this Guidance is a central part. This Guidance affects the approximately $400 billion of the $700 billion defense budget that is spent annually on contracts for goods (weapons, electronics, fuel, facilities etc., amounting to about $200 billion) and services (IT services, knowledge-based services, facilities upkeep, weapons system maintenance, transportation, etc., amounting to about $200 billion). We estimate that the efficiencies targeted by this Guidance can strike a significant contribution to achieving the $100 billion redirection of defense budget dollars from unproductive to more productive purposes that is sought by Secretary Gates and Deputy Secretary Lynn over the next five years.

Since June, the senior leadership of the acquisition community – the Component Acquisition Executives (CAEs), senior logisticians and systems command leaders, OSD officials, and program executive officers (PEOs) and program managers (PMs) – has been meeting regularly with me to inform and staff this Guidance. We have analyzed data on the Department's practices, expenditures, and outcomes and examined various options for changing our practices. We have sought to base the specific actions I am directing today on the best data the Department has available to it. In some areas, however, this data is very limited. In those cases, the Guidance makes provision for future adjustments as experience and data accumulate so that unintended consequences can be detected and mitigated. We have conducted some preliminary estimates of the dollar savings anticipated from each action based on reasonable and gradual, but steady and determined, progress against a clear goal and confirmed that they can indeed be substantial.

Changing our business practices will require the continued close involvement of others. We have sought out the best ideas and initiatives from industry, many of which have been adopted in this Guidance. We have also sought the input of outside experts with decades of experience in defense acquisition.

nability
cibility
HSI)
ment
essment

"…Set shorter program timelines and manage to them…"

"…remain cognizant of our programs' progress…and identify problems quickly…"

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Themes

- **Metrics**
  - Elegant systems engineering designs require us to augment intuition and judgment with quantitative means and effective analytical methods
  - Harness the right measures to help inform decisions
  - Industry, Academia, Agencies, Services have role in shaping quantitative methods and driving efficiencies into acquisition

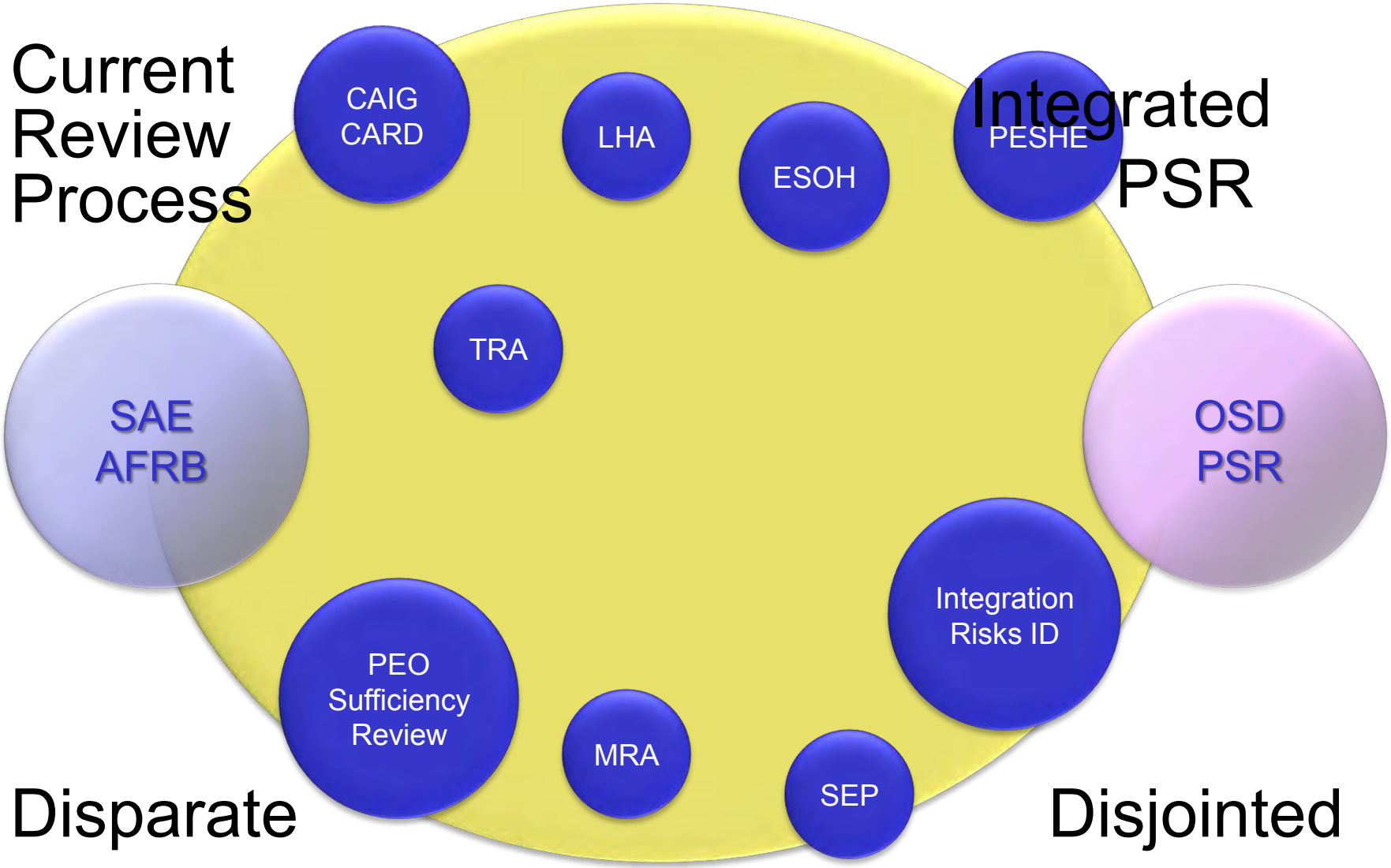
Initial focus:
- Software
- Integration
- Reliability
- Manufacturing

- **Integration**
  - Integrate the information for better domain management /problem solving
- **Communication**
  - Effectively shape, share and disseminate results:
    - Updates to policy and guidance (e.g. SEP Prep Guide)
    - Conference, symposia, white papers, etc
- **Building Bridges**
  - Services, Industry, Acquisition Leadership, Academia
  - Joint Program Reviews

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Program Review Process

U.S. AIR FORCE



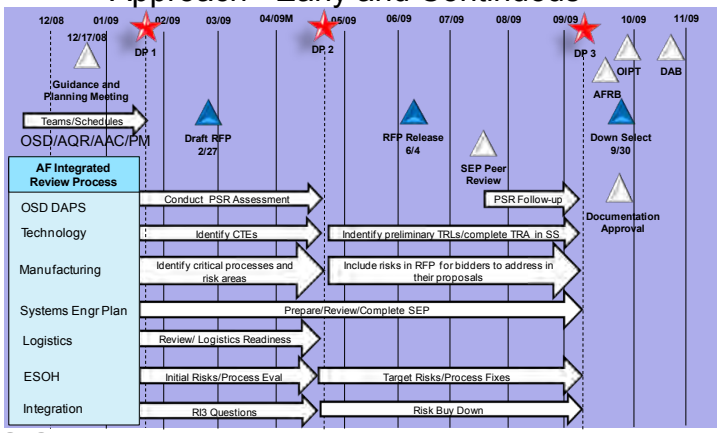
DISTRIBUTION STATEMENT A – Cleared for public release by OSR on 30 July 2010 --SR Case 10-S-2872
DISTRIBUTION STATEMENT A – Cleared for public release by OSR on 07 October 2010 --

Source: JiPRA Brief to SAF_AQ Jun 09.pptx

Integrated OSD/AF PSR SDB II Example

- **Integrated collaborative review**
  - OSD, Army, Navy, AF, Product Center
  - DDR&E/SE PSR methodology
  - Technology Readiness Assessment (TRA)
  - Risk Identification: Integration and -ilities (RI3)
  - Manufacturing Readiness Assessment (MRA)
  - Logistics Health Assessment (LHA)
  - Environment, Safety, and Occupational Health (ESOH)

Approach - Early and Continuous



- **Accomplishments**
  - Continuous Engagement
  - Constructive dialogue – site visits
  - Inputs to Draft and Final Request for Proposal
  - Preliminary Report to PM well in advance of DAB (planned ~6 months)
- **Significant Benefits**
  - Integrated and synchronized – (e.g. program impact 5 days vs. est. 38 days)
  - Significant intellectual capital from across DoD
  - **Early, actionable feedback to program office**

Early and robust technical engagement to mentor/advise collaboratively, independently assess and capture risk…so PMs can act

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Acquisition Efficiency Guidance Roadmap

5 Areas…

- **Target Affordability and Control Cost Growth**
- **Incentivize Productivity & Innovation in Industry**
- **Promote Real Competition**
- **Improve Tradecraft in Acquisition of Services**
- **Reduce Non-Productive Processes and Bureaucracy**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

For Additional Information

Jim Thompson

ODDR&E/Systems Engineering

(703) 602.0851 | James.Thompson@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Systems Engineering and Acquisition Excellence

Stephen Welby
Director, Systems Engineering
Office of the Under Secretary of Defense (AT&L)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 22 October2010 – SR 11-S-0183

Department of Defense

- *We are a nation at war*
- *Over 1.4 million active duty men and women*
- *Over 737,000 civilians*
- *Over 1.1 million Guard & Reserves*

Our Mission:

- *Protect our National Security*
- *Provide the military forces needed to deter war and prevail in conflict*

Systems Engineering in OSD

Weapon Systems Acquisition Reform Act May 2009

- Establishes the Director, Systems Engineering as principal systems engineering advisor to the SECDEF and the USD(AT&L)

OSD Systems Engineering

- Support and advocate for DoD Component Engineering initiatives
- Help program managers identify and mitigate risks
- Shape DoD technical planning and management
- Provide technical insight to OSD stakeholders
- Identify systemic issues for resolution above the program level

Program Engagement

- Engineering Assessment / Mentoring of Major Defense Programs
- Technical Reviews
- AT&L Decision Forums
- Systems Engineering Plans
- Systemic Root Cause Analysis
- Support Acquisition Leadership with Independent Engineering Analysis and Advice

Our Focus: Supporting Knowledge-Based Decision Making

Policy and Practice

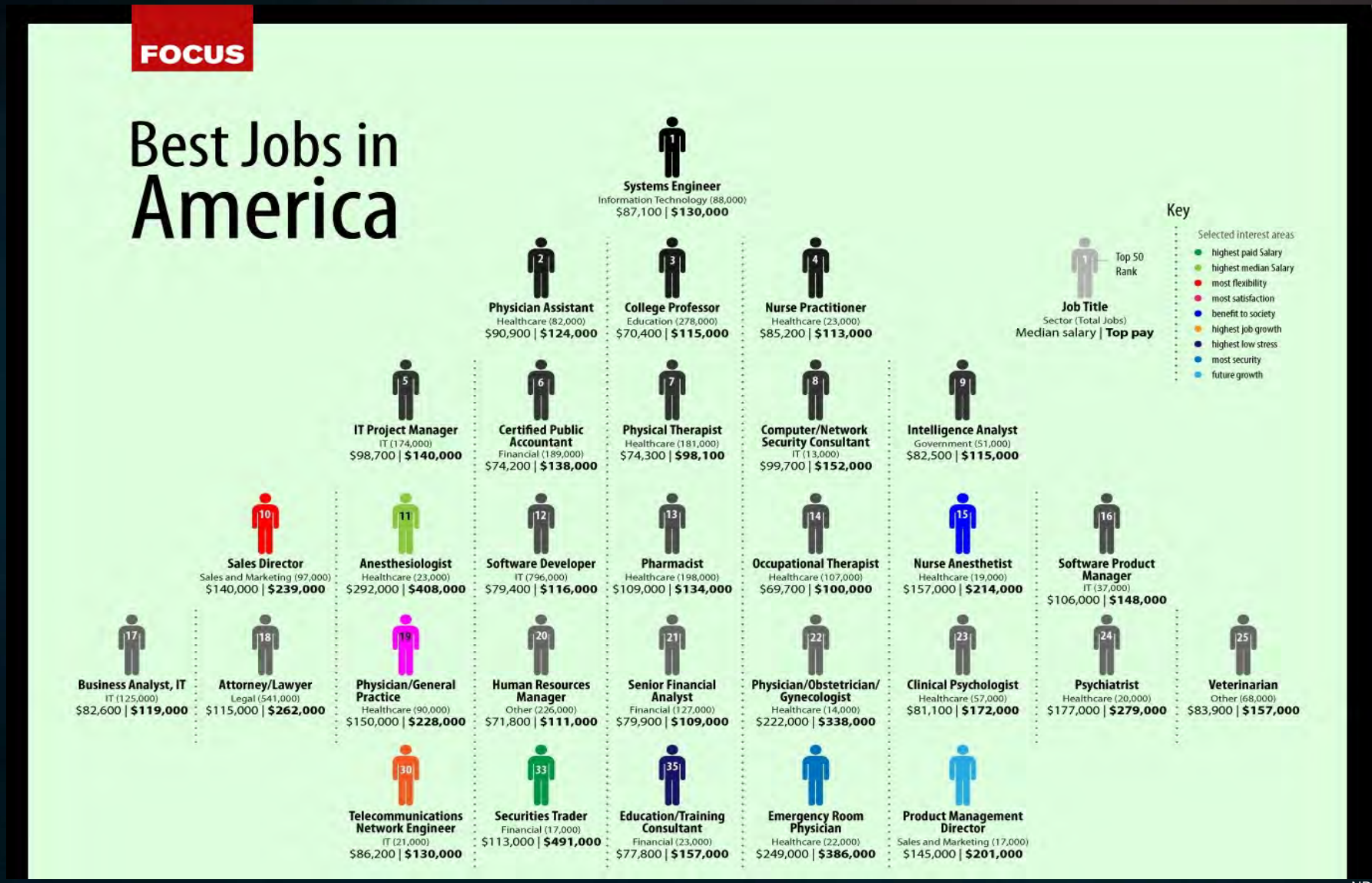
- Supporting the Current Practice
  - Department-wide Systems Engineering Policy and Guidance
  - Specialty Engineering
    - System Safety, Reliability/Availability/ Maintainability, Quality, Manufacturing, Producibility, Human Systems Integration
- Addressing Emerging Challenges
  - Complex Systems/Systems of Systems
  - Program Protection/Acquisition Cyber-Security
  - University and Industry Engineering Research
  - Modeling and Simulation Support to Acquisition

Our Focus: Policy, People and Practice

Acquisition Excellence through Systems Engineering

Our Focus: Growing Engineering Capacity Across the Department

Best Job in America – Systems Engineer



Source: http://www.focus.com/fyi/human-resources/best-jobs/ c 2010 Focus - Used with permission.

Systems Engineering Workforce

- Breadth
  - Awareness of and appreciation for other functional areas
  - Understanding of system lifecycle and processes
  - Knowledge of other engineering disciplines and how they integrate into a system solution
  - Knowledge of product domains
- Depth
  - Extensive expertise and experience in one or more engineering disciplines and in one or more product domains
- Leadership
  - Ability to motivate and inspire individuals and teams
  - Comfort in dealing with complexity
  - Focus on underpinning decisions with data
  - Capability to make tough technical decisions

Acquisition Efficiency Initiatives

Acquisition Efficiency Guidance Roadmap

Target Affordability and Control Cost Growth

- Mandate affordability as a requirement
- Implement "should cost" based management
- Eliminate redundancy within warfighter portfolios
- Achieve Stable and economical production rates
- Manage program timelines

Promote Real Competition

- Emphasize competitive strategy at each program milestone
- Remove obstacles to competition
  - Allow reasonable time to bid
  - Require non-certified cost and pricing data on single offers
  - Enforce open system architectures and set rules for acquisition of technical data rights
- Increase small business role and opportunities

Incentivize Productivity & Innovation in Industry

- Reward contractors for successful supply chain and indirect expense management
- Increase Use of FPIF contract type
- Capitalize on progress payment structures
- Institute a preferred supplier program
- Reinvigorate industry's independent research and development

Improve Tradecraft in Acquisition of Services

- Assign senior managers for acquisition of services
- Adopt uniform services market segmentation (taxonomy)
- Address causes of poor tradecraft
  - Define requirements and prevent creep
  - Conduct market research
- Increase small business participation

Reduce Non-Productive Processes and Bureaucracy

- Reduce frequency of OSD level reviews
- Work with Congress to eliminate low value added statutory requirements
- Reduce the volume and cost of Congressional Reports
- Reduce non-value added requirements imposed on industry
- Align DCMA and DCAA processes to ensure work is complementary
- Increase use of Forward Pricing Rate Recommendations (FPRRs) to reduce administrative costs

Acquisition Efficiency Guidance

Target Affordability and Cost Growth

- Mandate affordability as a requirement
- Implement “should cost” based management
- Eliminate redundancy within warfighter portfolios
- Achieve stable and economical production rates
- Manage program timelines

Acquisition Efficiency Guidance
Incentivize Productivity & Innovation in Industry

- Reward contractors for successful supply chain and indirect expense management
- Increase use of FPIF contract type
- Capitalize on progress payment structures
- Institute a preferred supplier program
- Reinvigorate industry's independent research and development

Acquisition Efficiency Guidance
Promote Real Competition

- Emphasize competitive strategy at each program milestone
- Remove obstacles to competition
  - Allow reasonable time to bid
  - Require non-certified cost and pricing data on single offers
  - Enforce open system architectures and set rules for acquisition of technical data rights
- Increase small business role and opportunities

Acquisition Efficiency Guidance
Improve Tradecraft in Acquisition of Services

- Assign senior managers for acquisition of services
- Adopt uniform services market segmentation (taxonomy)
- Address causes of poor tradecraft
- Define requirements and prevent creep
- Conduct market research
- Increase small business participation

Acquisition Efficiency Guidance

Reduce Non-Productive Processes and Bureaucracy

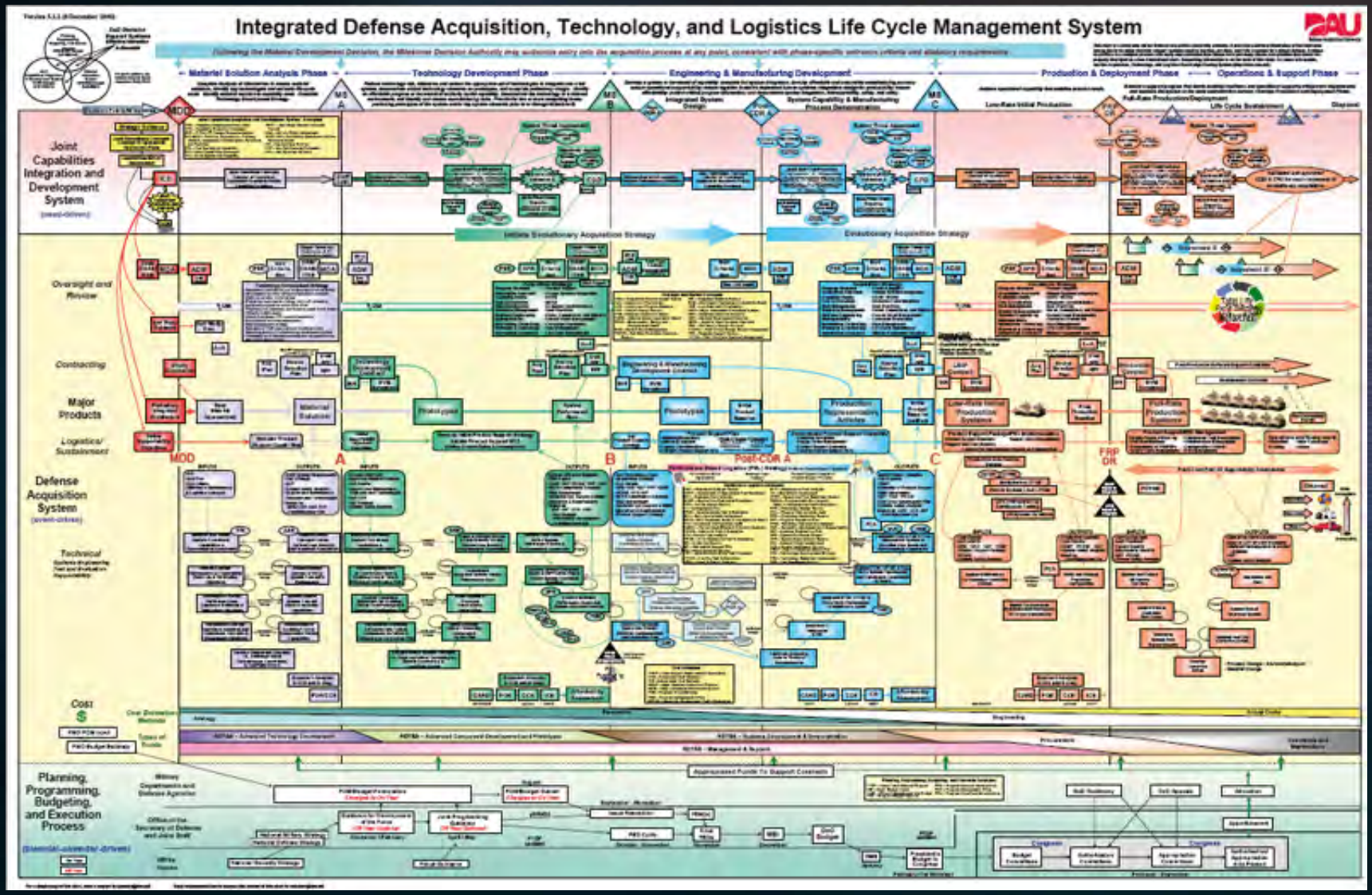
- Reduce frequency of OSD level reviews
- Work with Congress to eliminate low value added statutory requirements
- Reduce the volume and cost of Congressional Reports
- Reduce non-value added requirements imposed on industry
- Align DCMA and DCAA processes to ensure work is complementary
- Increase use of Forward Pricing Rate Recommendations (FPRRs) to reduce administrative costs

Systems Engineering and Acquisition Excellence

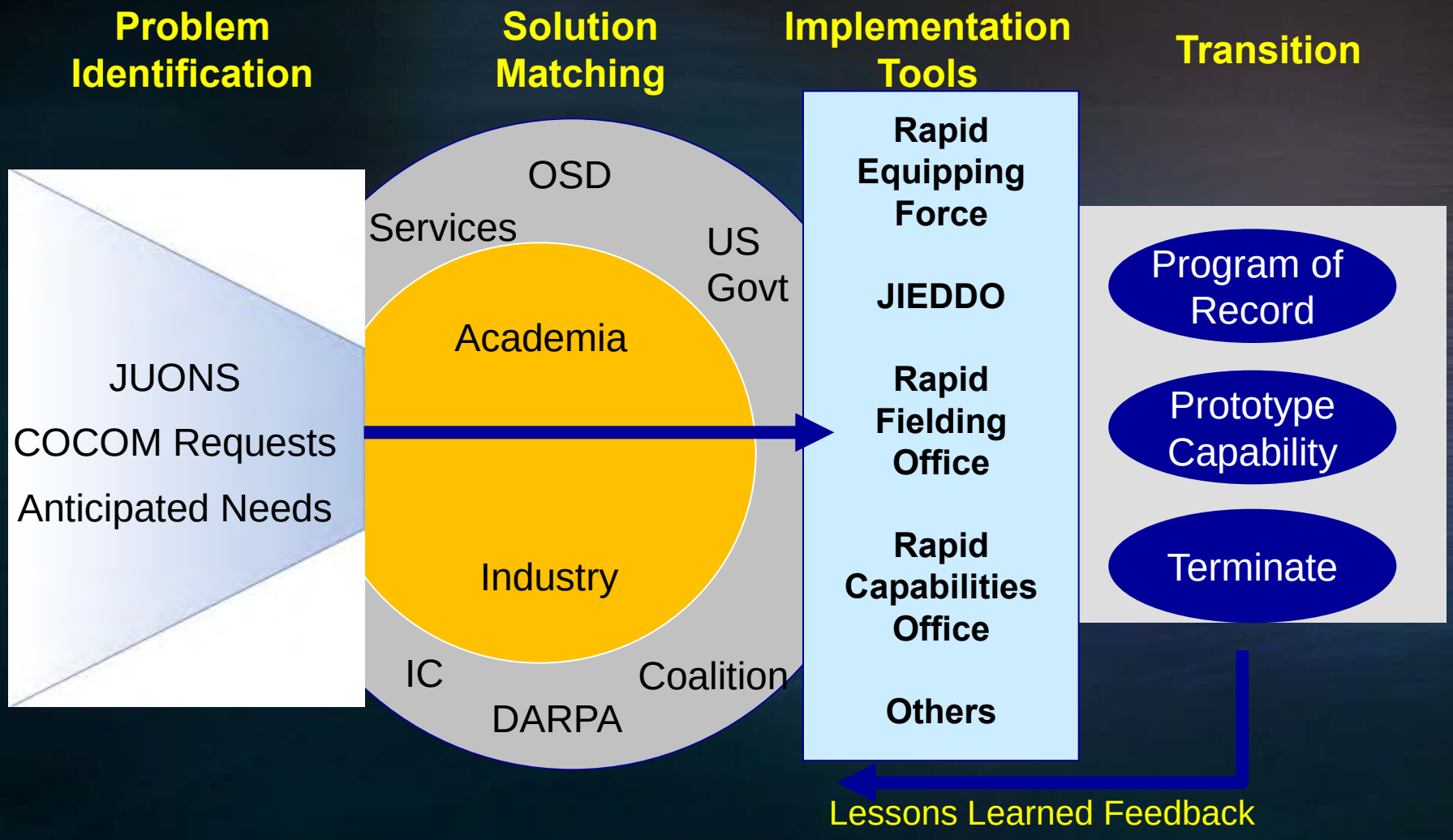
Systems Engineering Challenges

- Create the tools to enable Rapid Capability Delivery
  - Shorten the time to deliver life-saving and war-winning technologies – without compromising product integrity
- Expand the aperture of DoD Engineering practice to address 21st century technical challenges
  - Security, software-intensive, etc…
- Embrace complexity
  - Systems of Systems / Complex Adaptive Systems / Emergent behaviors
- Expand the human capital resource base
  - Reflect new insights in curricula to grow the next “crop” of technical leaders

The DoDI 5000.02 Process

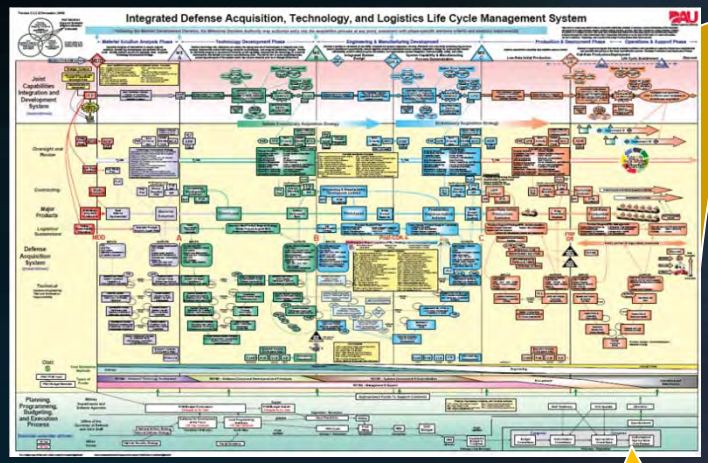


The Challenge of Rapid Fielding



Role of Systems Engineering in Rapid Fielding?

Rethinking How We Buy?

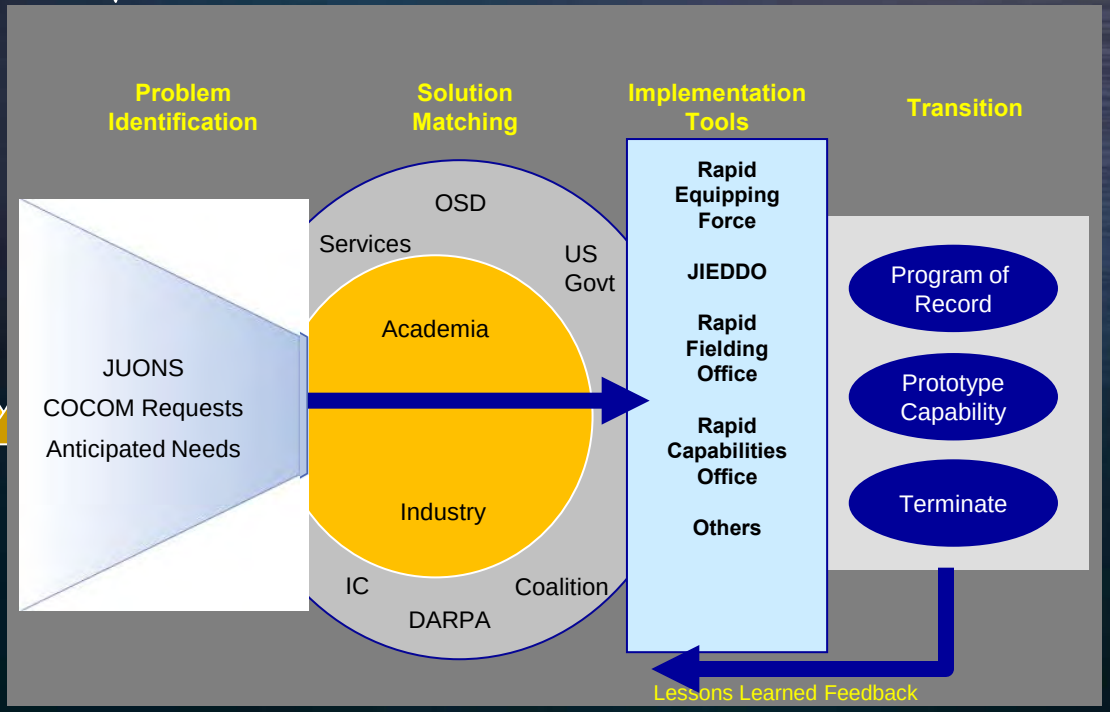


Balance Rigor & Repeatability w/ Speed & Effectiveness?

Can we increase the rigor of our rapid process?

Can we increase the speed of our rigorous process?

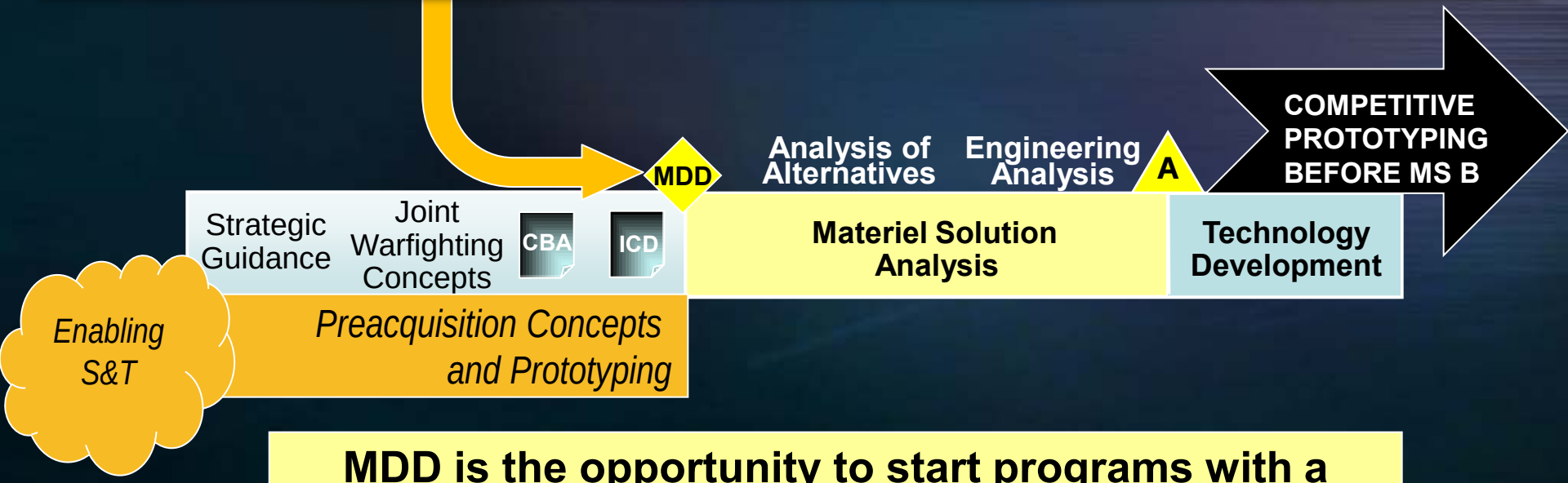
Adopt Commercial Deployment Models?



Major Initiatives:
Development Planning

Materiel Development Decision (MDD) – Formal entry into Acquisition

- Understanding of Need
- Understanding of Solution Space Feasibility
- Alternative Acquisition Models
- Resourced Plan for detailed Engineering Analysis



MDD is the opportunity to start programs with a strong early Systems Engineering foundation

Major Initiatives:

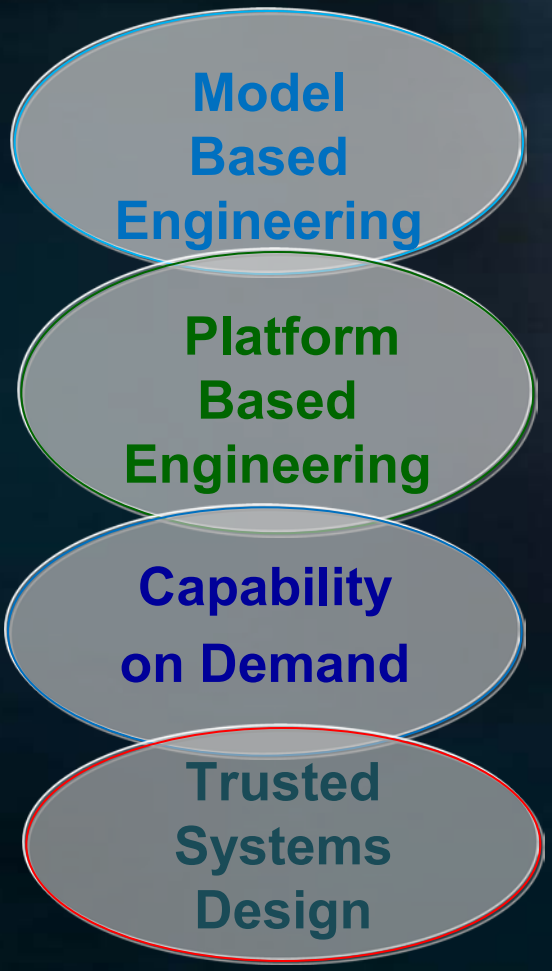
Reinvigorating Defense Standardization

- Service product centers are currently pursuing independent efforts to reinvigorate standards processes
- Opportunity for SE to advocate for and coordinate service efforts
- USD(AT&L) appointed the Director, Systems Engineering as the Defense Standardization Executive
  - Standards, DMSMS, GIDEP, Interagency Coordination

Opportunity to leverage our Standardization Processes and Products As a Key Engineering Tool in Promoting Acquisition Excellence

Major Initiatives:

Systems 2020 Research Areas



Modeling and simulation tools for concurrent design, development and manufacture

Architectural and automated design tools to rapidly insert new capabilities

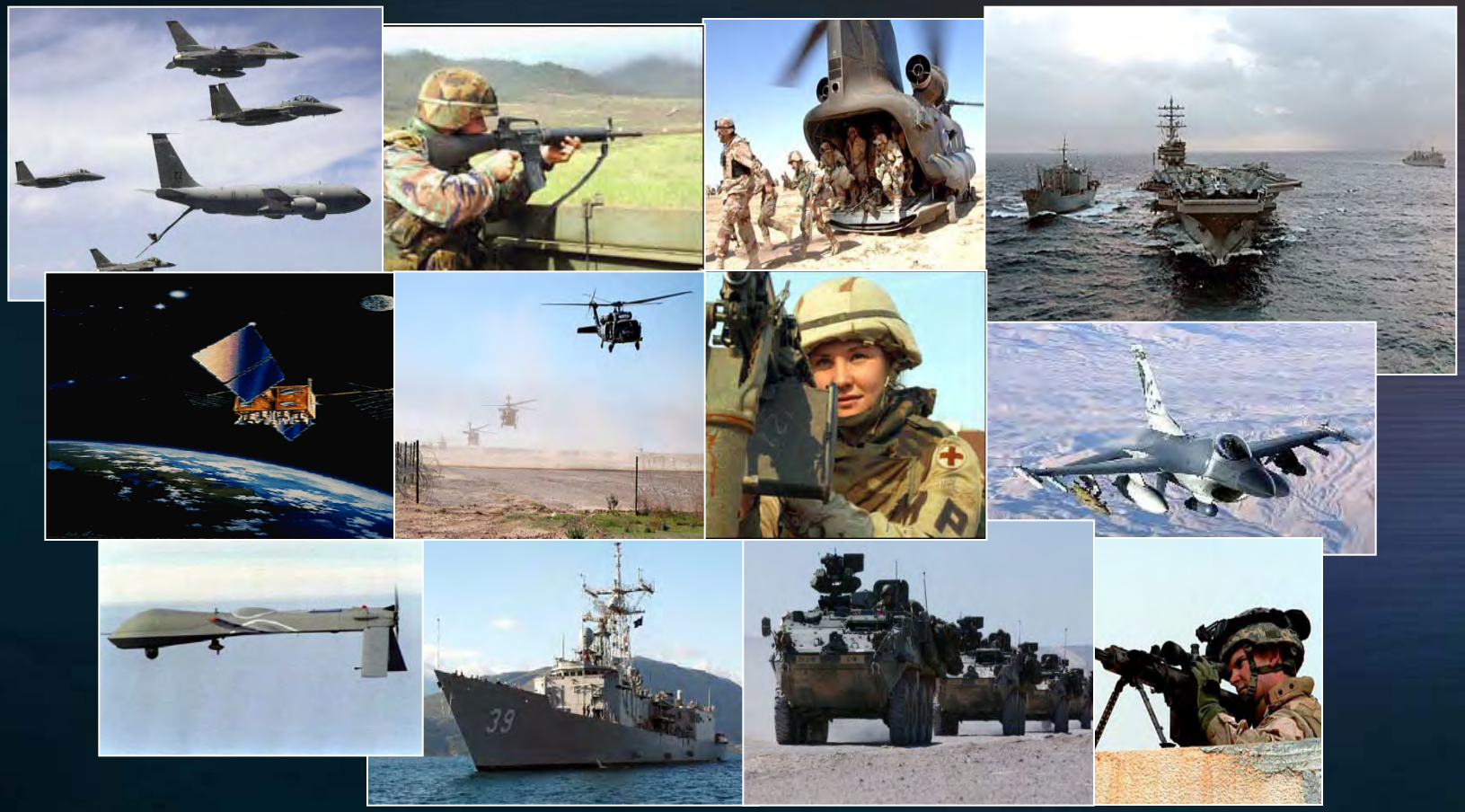
Systems embedded with organic adaptation capabilities

Design methods and tools for system assurance that detect malice or enable self-awareness

Opportunities

- Acquisition reform efforts have recognized criticality of strong Systems Engineering focus for program success
  - ***Systems Engineering toolkit focused on identifying and managing risk – in development, production and life-cycle supportability***
- Growing focus on addressing "early-acquisition" phases
  - ***Leading to more informed decisions at MS B***
- Our development processes need to evolve to provide faster product cycles, more adaptable products and address emerging technical challenges
- Future US Defense capabilities depend on a capable US engineering workforce in and out of government
  - ***Need to create opportunities to grow future "Engineering Heroes"***

Systems Engineering:
Critical to Acquisition Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

NDIA 10853 Panel: In search of the Principles of SE (BKCASE)

Rick Adcock, Cranfield University

Head of SE Defence Academy of the UK

Panel

- **Rick Adcock**, Cranfield Defence and Security at the UK Defence Academy
- **Don Gelosh**, ODDR&E/SE
- **Dr Rich Freeman**, Air Force Centre for Systems Engineering
- **Dr Barry Boehm**, Centre for Software Engineering

What is BKCASE?

- Project led by Stevens Institute of Technology and Naval Postgraduate School who are creating two primary products:
  - Body of Knowledge in systems engineering (SEBoK)
  - Graduate Reference Curriculum in Systems Engineering (GRCSE)
- Started in September 2009 and will run through 2012
- Intended for world-wide use
- Not intended to be used directly for accreditation

BKCASE

Call for Authors, Subject Matter Experts, Reviewers and Early Adopters

What is **BKCASE**?

BKCASE (pronounced "Bookcase") is the acronym for the **Body of Knowledge and Curriculum to Advance Systems Engineering**. The project scope is to define a Systems Engineering Body of Knowledge (SEBoK) and use the SEBoK to develop a Graduate Reference Curriculum for Systems Engineering (GRCSE, pronounced "Gracie").

The ideal outcome is that the SEBoK will be supported worldwide by the Systems Engineering community as the authoritative BoK for the SE discipline and that the GRCSE will receive the same global recognition and serve as the authoritative guidance for graduate degree programs in SE. A leading group of over 30 systems engineers from across the world have volunteered as authors with many more joining as subject matter experts and reviewers to collaborate over a three year period and deliver the SEBoK and GRCSE in 2012. We are seeking additional authors, subject matter experts, and reviewers. Intermediate products (Versions 0.25 and 0.50) will be released for comment in 2010 and 2011.

The BKCASE team invites you to learn more about our project.

Please access our frequently updated website (www.bkcase.org) to gain a more detailed overview of the project. We are seeking broad support across many domains from systems engineering practitioners, researchers, managers, supporters, customers, certifiers, workforce development professionals, educators, and current and potential students. We encourage and welcome feedback from the community on our project efforts; please contact the team leaders through **bkcase@stevens.edu** .

Project Lead Universities

STEVENS Institute of Technology

NPS NAVAL POSTGRADUATE SCHOOL

Organizational Partnerships

- *Department of Defense*
- *International Council on Systems Engineering (INCOSE)*
- *Institute of Electrical and Electronics Engineers (IEEE) Systems Council*
- *Institute of Electrical and Electronics Engineers (IEEE) Computer Society Educational Activities Board*
- *National Defense Industrial Association (NDIA) Systems Engineering Division*

Principal Investigators:

Art Pyster (art.pyster@stevens.edu)
and Dave Olwell (dholwell@nps.edu)

General project inquiries:
bkcase@stevens.edu

For more information please visit our website at **www.bkcase.org**

BKCASE Vision and Objectives

Vision

"Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE."

Objectives

1. Create a SEBoK that is globally recognized by the SE community as the authoritative BoK for the SE discipline.
2. Create a graduate reference curriculum for SE (GRCSE – pronounced "Gracie") that is globally recognized by the SE community as the authoritative guidance for graduate programs in SE.
3. Facilitate the global alignment of related workforce development initiatives with SEBoK and GRCSE.
4. Transfer stewardship of SE BoK and GRCSE to INCOSE and the IEEE after BKCASE publishes version 1.0 of those products, including possible integration into their certification, accreditation, and other workforce development and education initiatives.

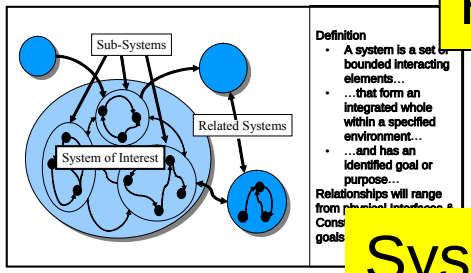
Agenda

- Questions:
  - Why should DoD (and other nations) be interested in a Systems Engineering BoK?
  - What is the value of Systems Engineering (in Defence)?
  - How does Systems Engineering relate to other disciplines?
  - What Systems Engineering skills do we need to make this happen?

Principles of Systems Engineering

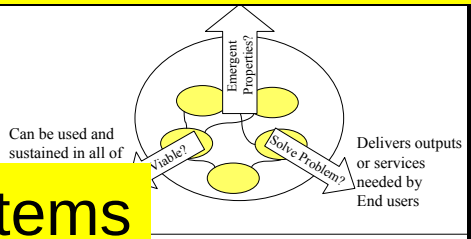
Systems

System



Definition
- A system is a set of bounded interacting elements…
- …that form an integrated whole within a specified environment…
- …and has an identified goal or purpose…

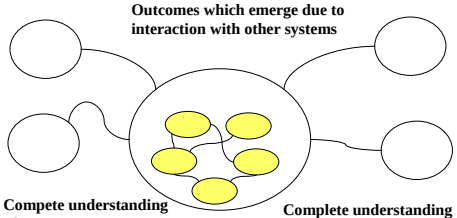
Relationships will range from physical interfaces & Cons… goals



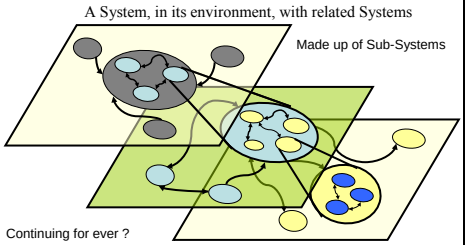
Can be used and sustained in all of

Delivers outputs or services needed by End users

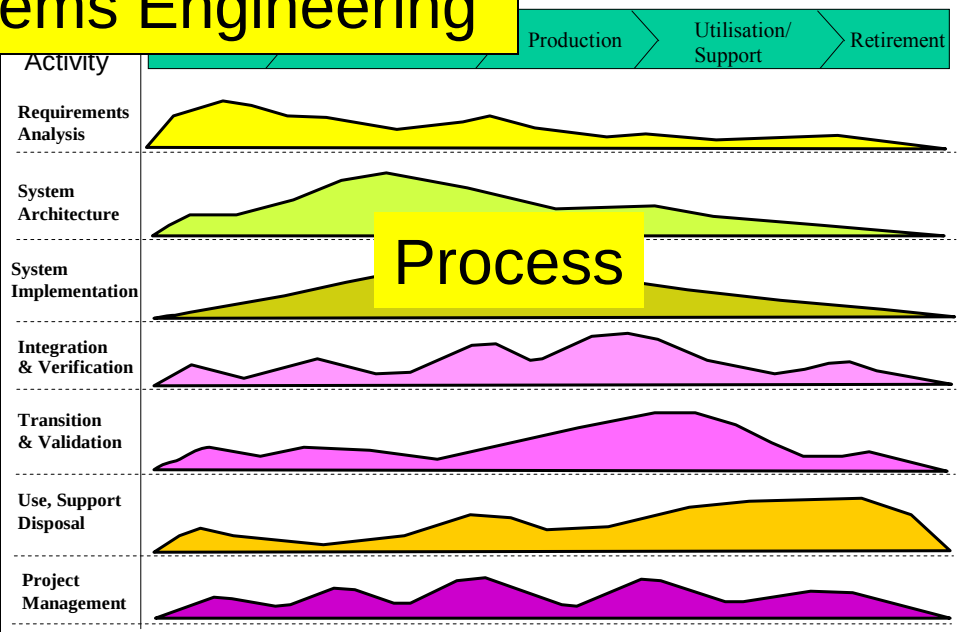
External System Issues



Levels of Resolution



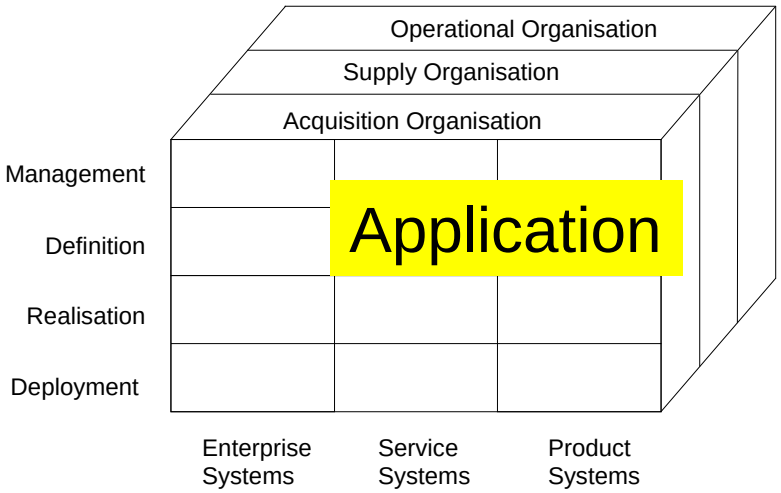
Process



Application

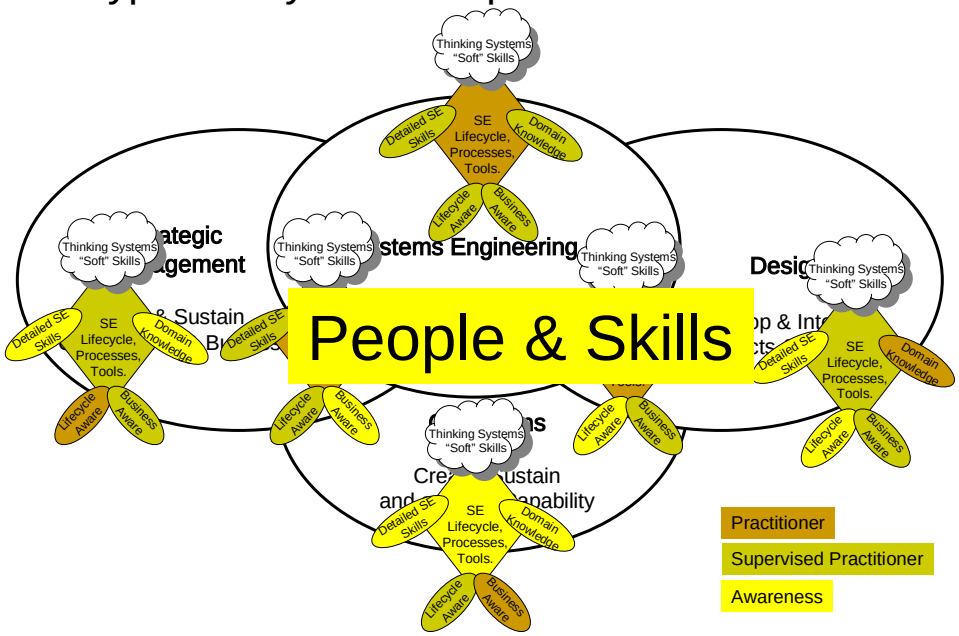
Systems Engineering Knowledge Areas (SEBoK 0.25)

BKCASE

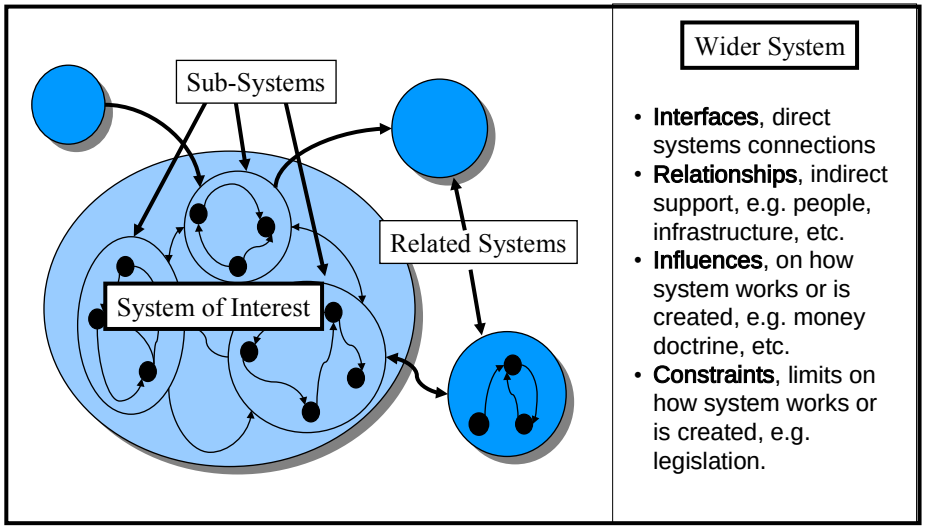


People & Skills

Types of System People



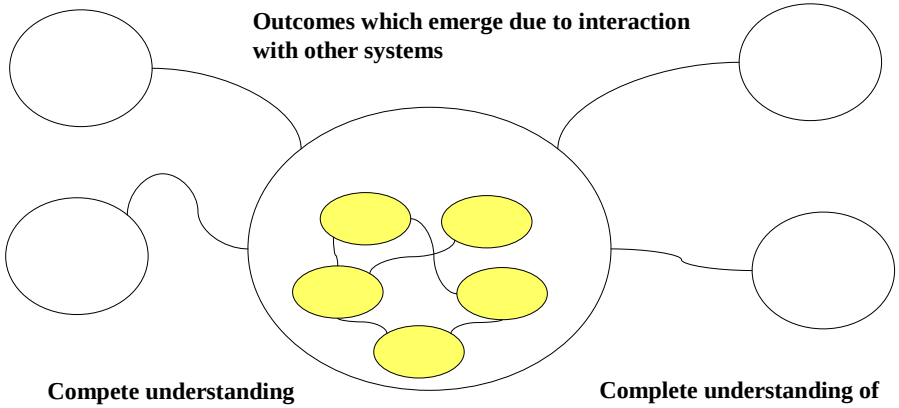
System



Wider System

- **Interfaces**, direct systems connections
- **Relationships**, indirect support, e.g. people, infrastructure, etc.
- **Influences**, on how system works or is created, e.g. money doctrine, etc.
- **Constraints**, limits on how system works or is created, e.g. legislation.

External System Issues



Outcomes which emerge due to interaction with other systems

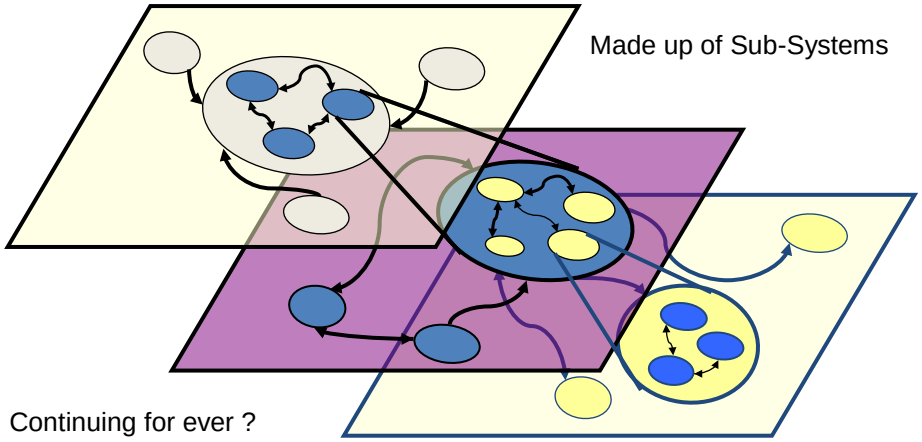
Compete understanding of Relationships and Influences on Life

Complete understanding of Needs and Constraints on Mission

Levels of Resolution

A System, in its environment, with related Systems

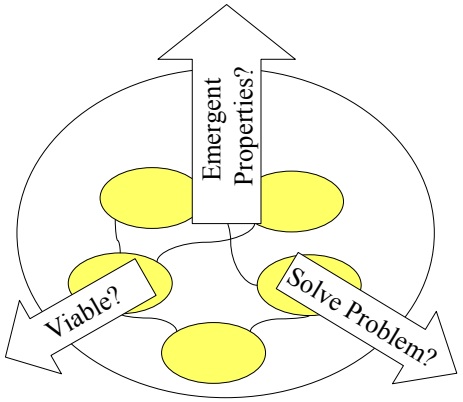
Made up of Sub-Systems



Continuing for ever ?

Internal System Issues

Properties of the whole which emerge due to interaction between elements



Can be used and sustained in all of its potential environments, through its life

Delivers outputs or services needed by End users

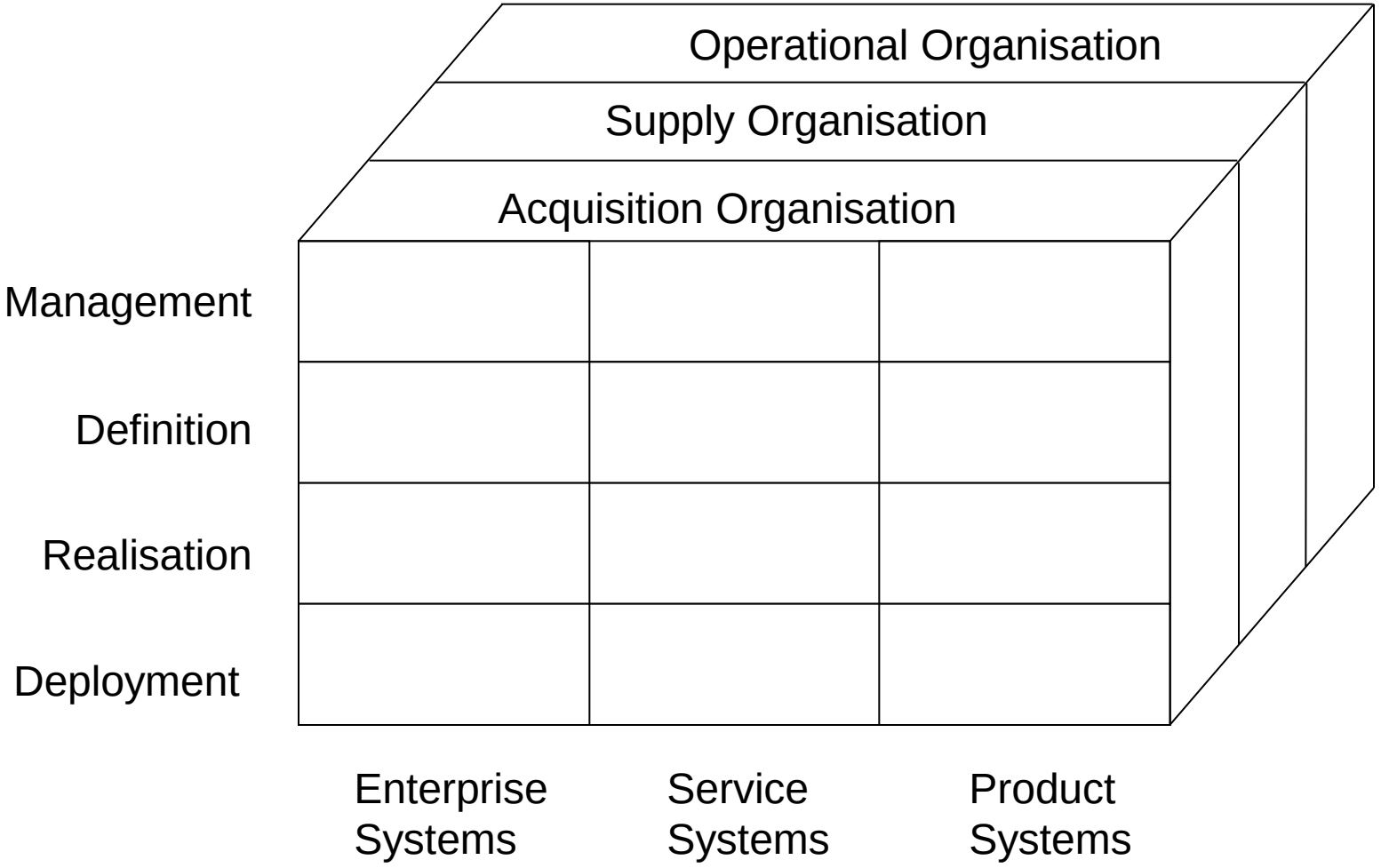
Systems Thinking

- Taking a systems approach to engineering expands the scope of scientific knowledge to include systems science or systems thinking.
- This approach will seek to
  - define problems, constraints and measures of success outside the boundary of a system of interest and
  - select and combine system elements and relationships inside the boundary in the context of wider system view.
  - It is fundamental to this view of engineering that it is both iterative and recursive in nature.
    - It includes iterative cycling between problem understanding in a wider system context, solution creation within a bounded context and solution insertion and use back in the wider context.
    - We can recursively use this system of interest, wider context approach to tackle problems at several levels of abstraction to deliver solutions to real world problems.
  - To do this we will need ways of assess and dealing with the different properties which arise from combinations of system elements at a number of levels of abstraction.

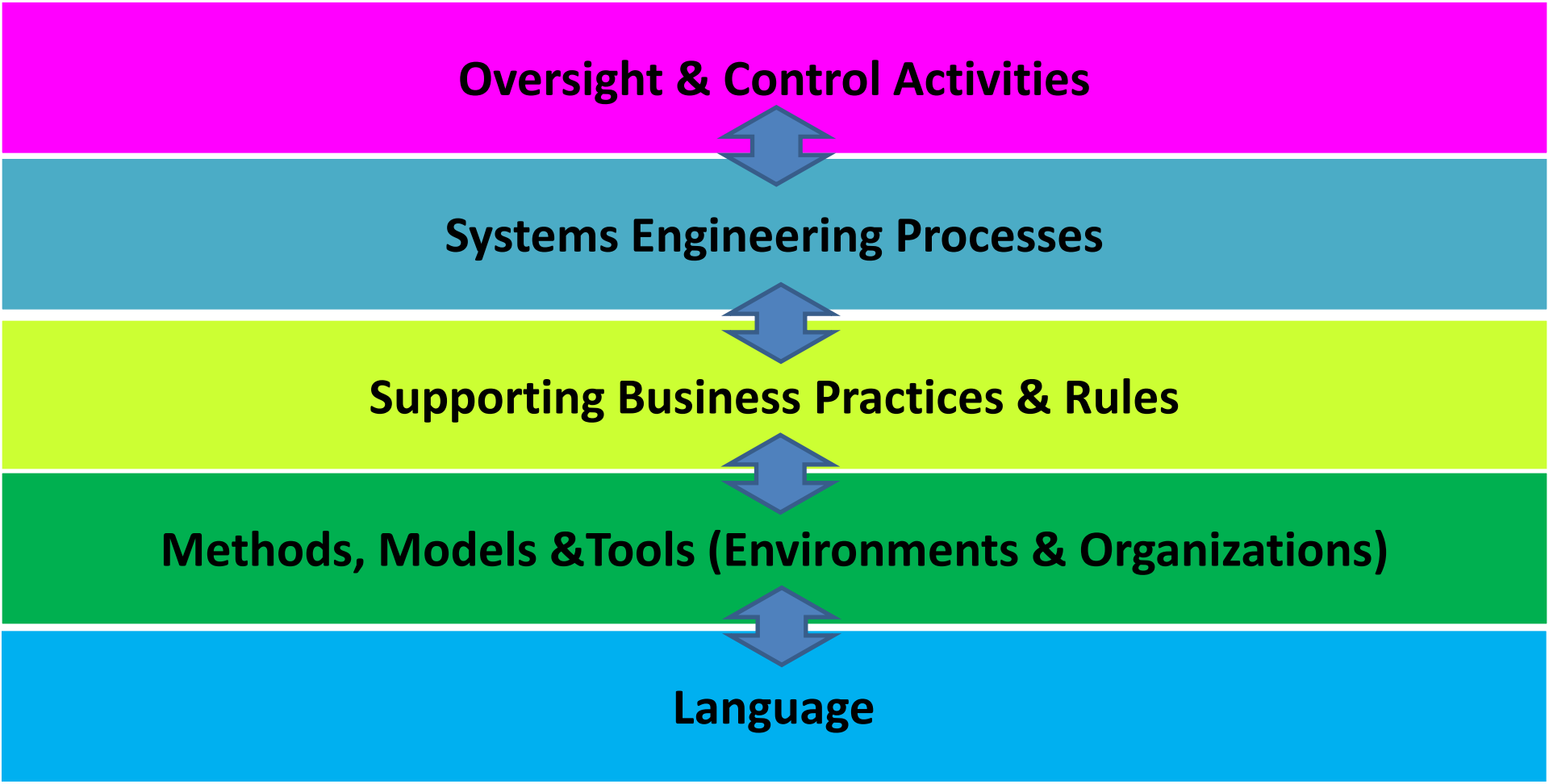
Systems Engineering

- Two definitions of Engineering:
  - The application of scientific knowledge to practical problems, or the creation of useful things.
  - To (cleverly) arrange for something to happen.
- Systems Engineering is traditionally associated with the first of these, as applied to Product Development
- We may also need to consider the second when we look at the wider application of Systems Engineering to Enterprise Success.

Systems Engineering Knowledge Areas (SEBoK 0.25)

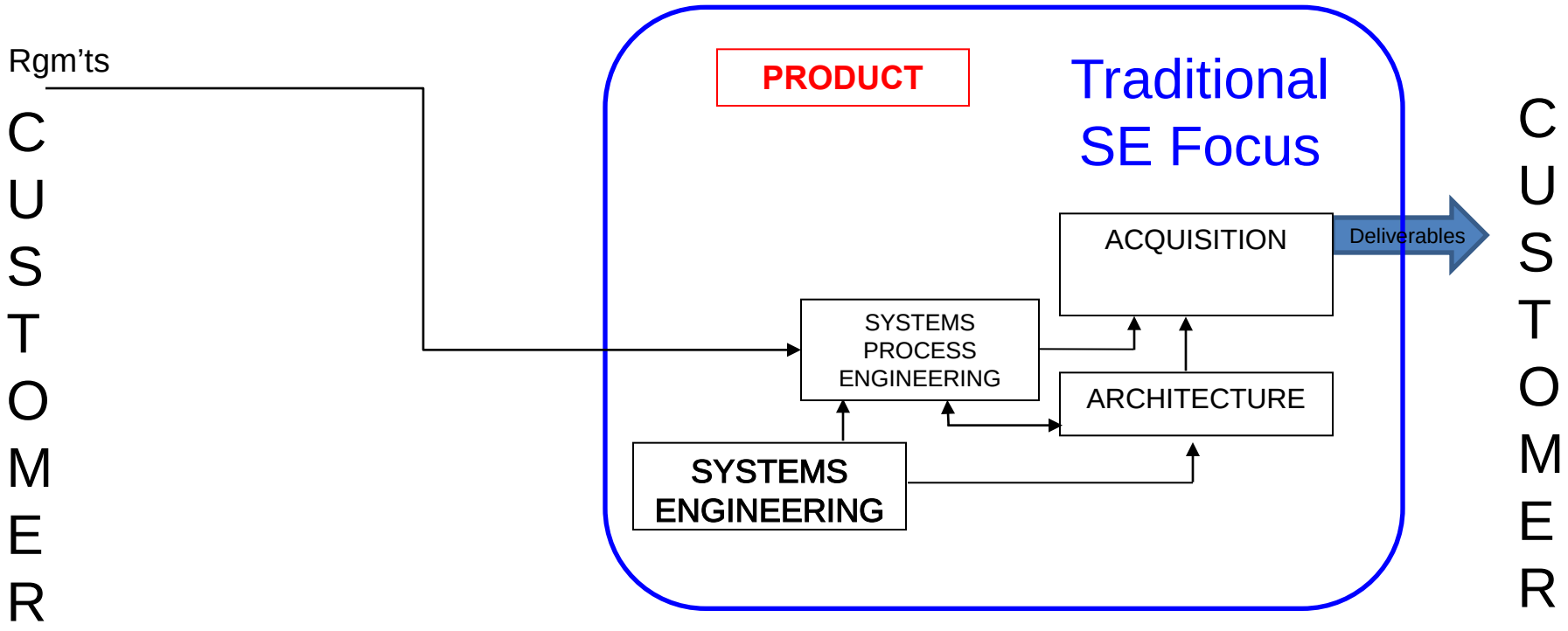


Layered Framework



Systems Engineering

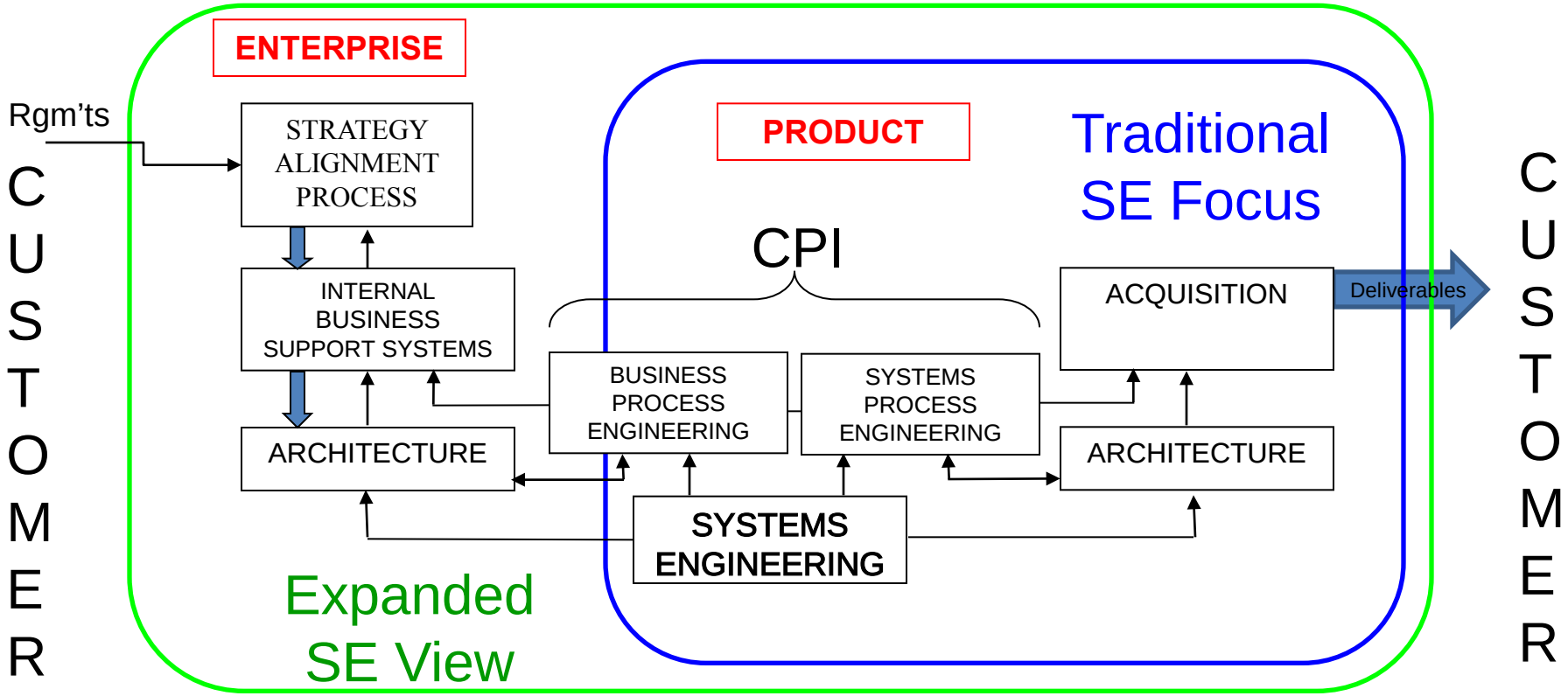
Product, Enterprise & Customer Service View Model



Integrated Systems Engineering: Looking Beyond Traditional Realms

Systems Engineering

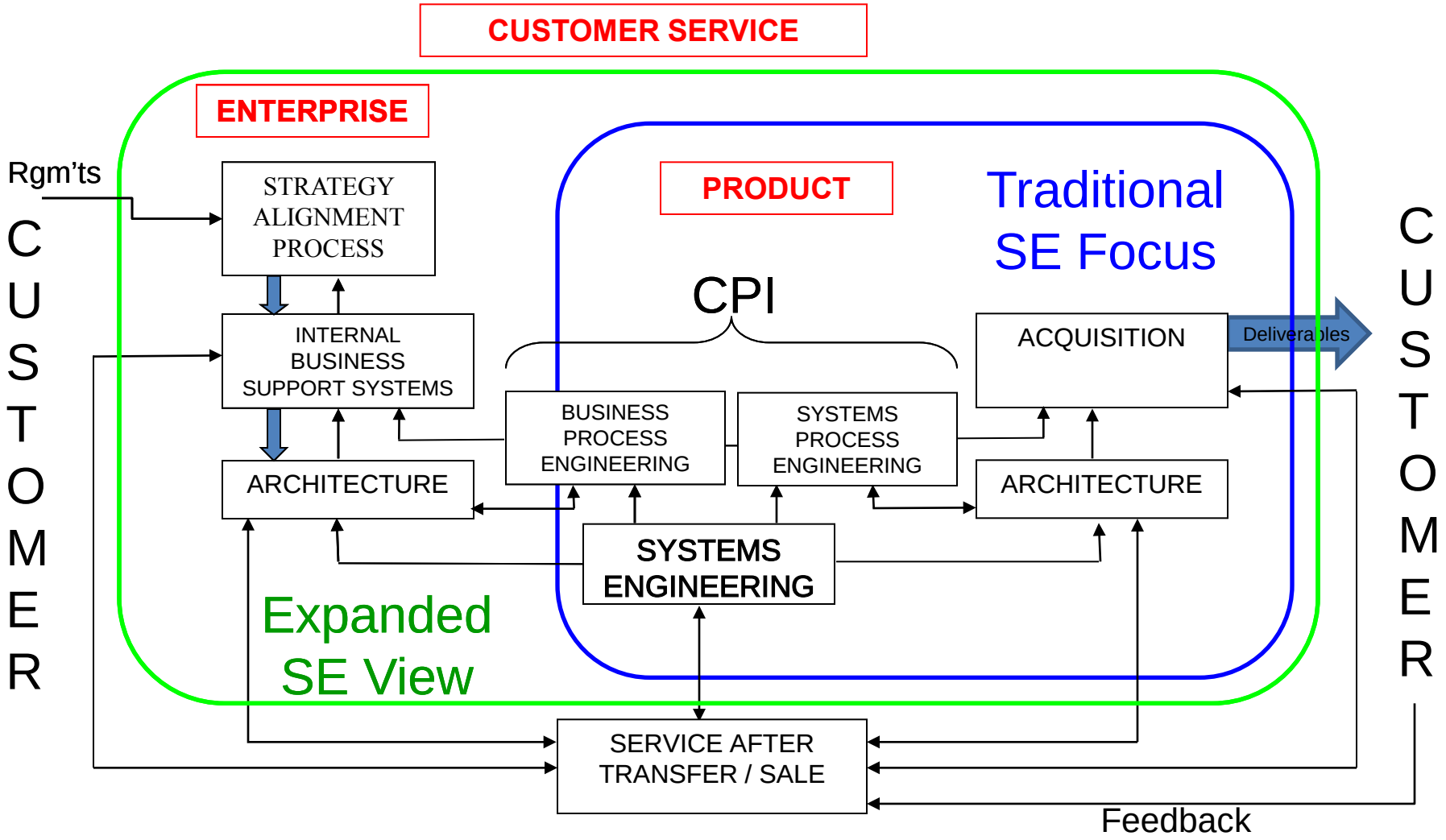
Product, Enterprise & Customer Service View Model



Integrated Systems Engineering: Looking Beyond Traditional Realms

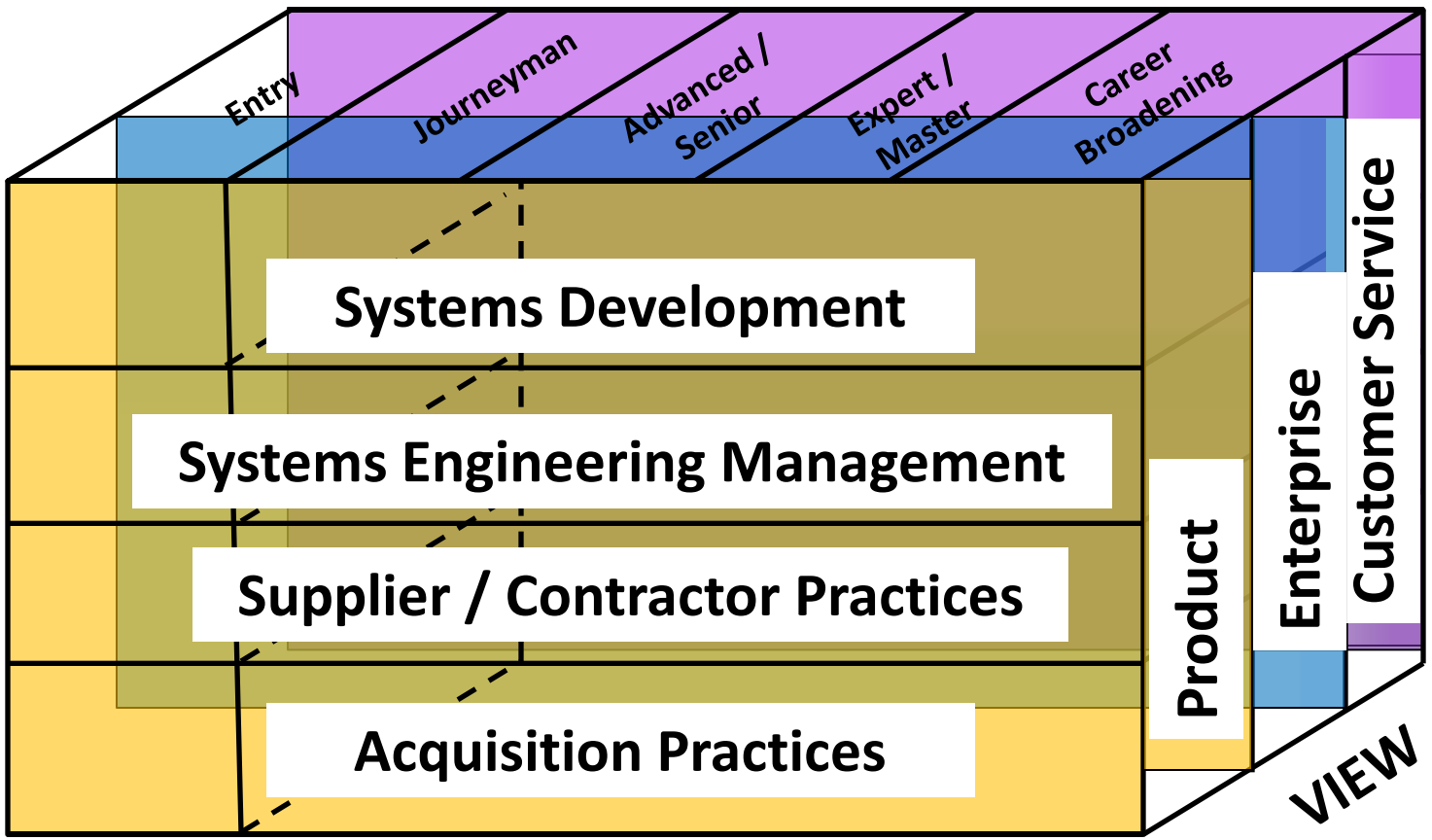
Systems Engineering

Product, Enterprise & Customer Service View Model

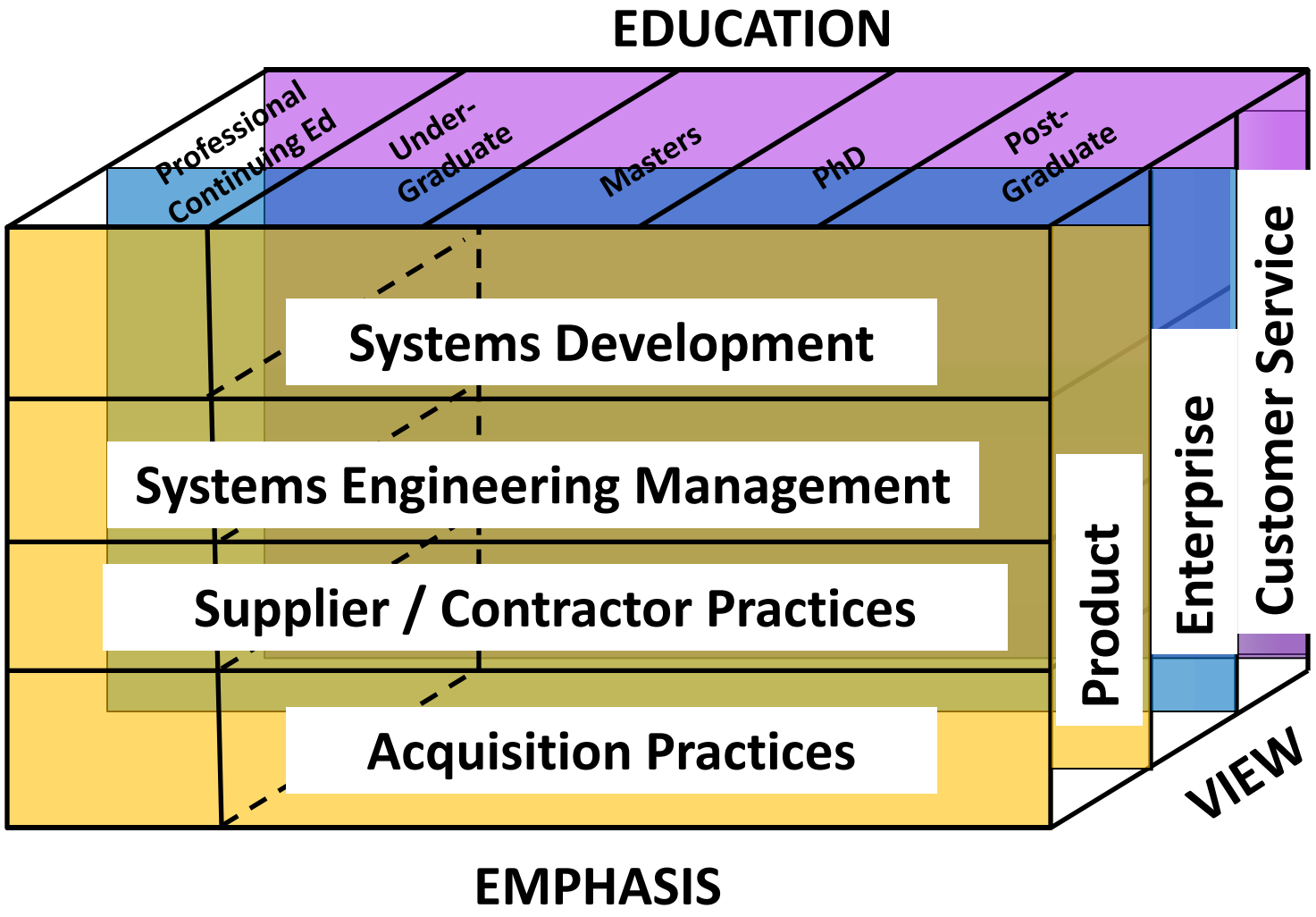


Integrated Systems Engineering: Looking Beyond Traditional Realms

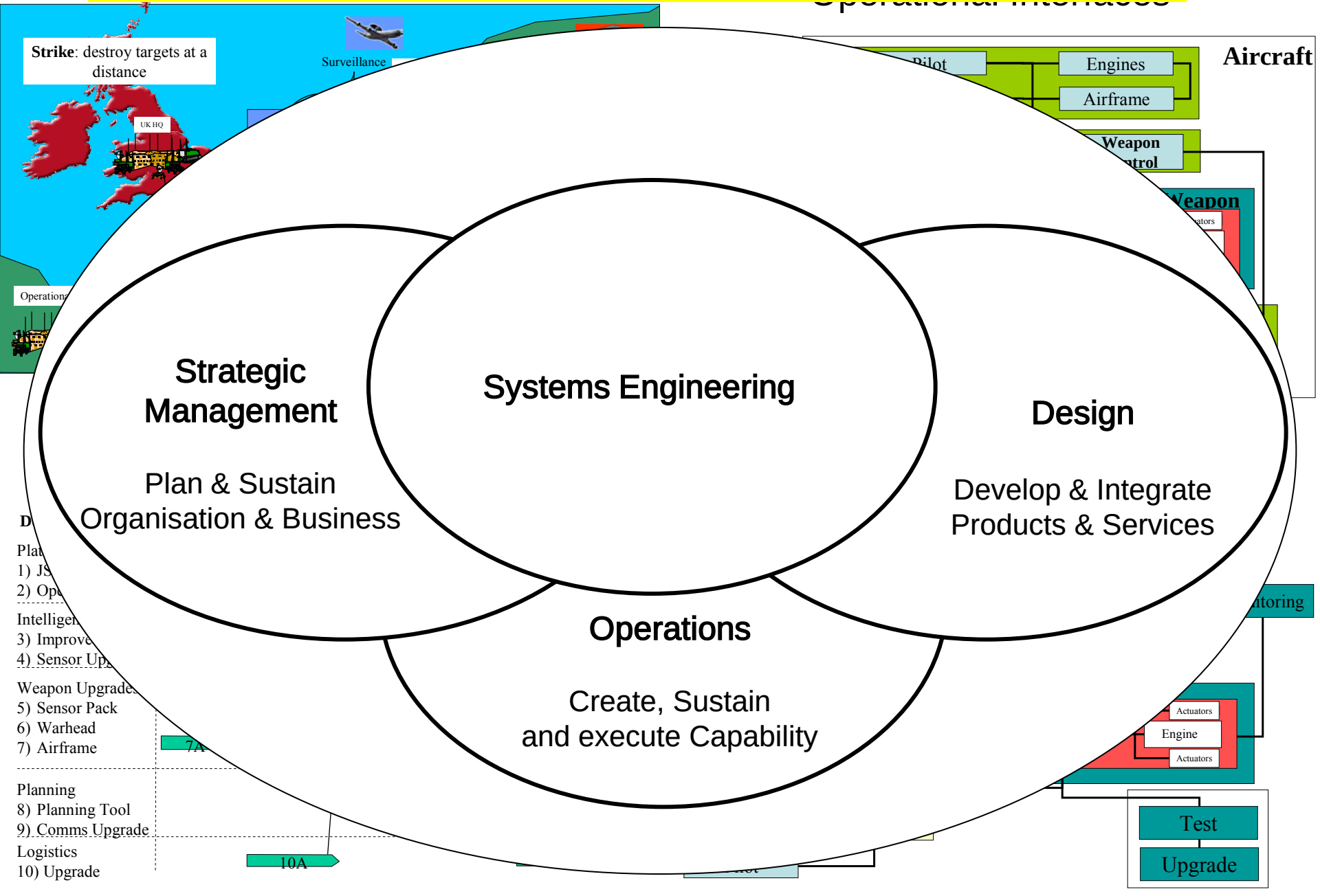
Competency Requirements Reference Cube



Competency Requirements Reference Cube

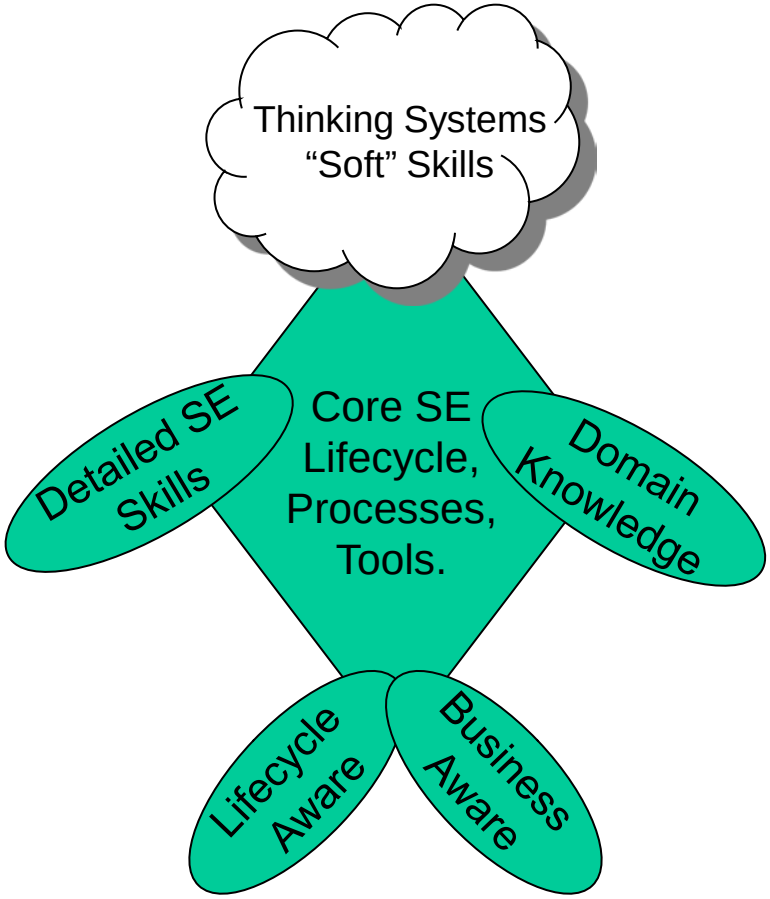


Relationship Between SE and other Disciplines



Systems People

- Behaviours (The Head)
  - Understanding system concepts and viewpoints
  - Working with people, information broker, etc.
- Core technical skills (The Heart)
  - Overview of SE processes and techniques
  - Understanding of the changing role of SE across lifecycle
- Specific technical skills (The Arms)
  - Areas of specific SE expertise, e.g Requirements, Architecture, V&V
  - Areas of specific domain or application expertise, e.g. Safety, Reliability, Simulation
- Supporting Knowledge (The Legs)
  - Awareness of wider lifecycle issues
  - Awareness of wider business or operational issues

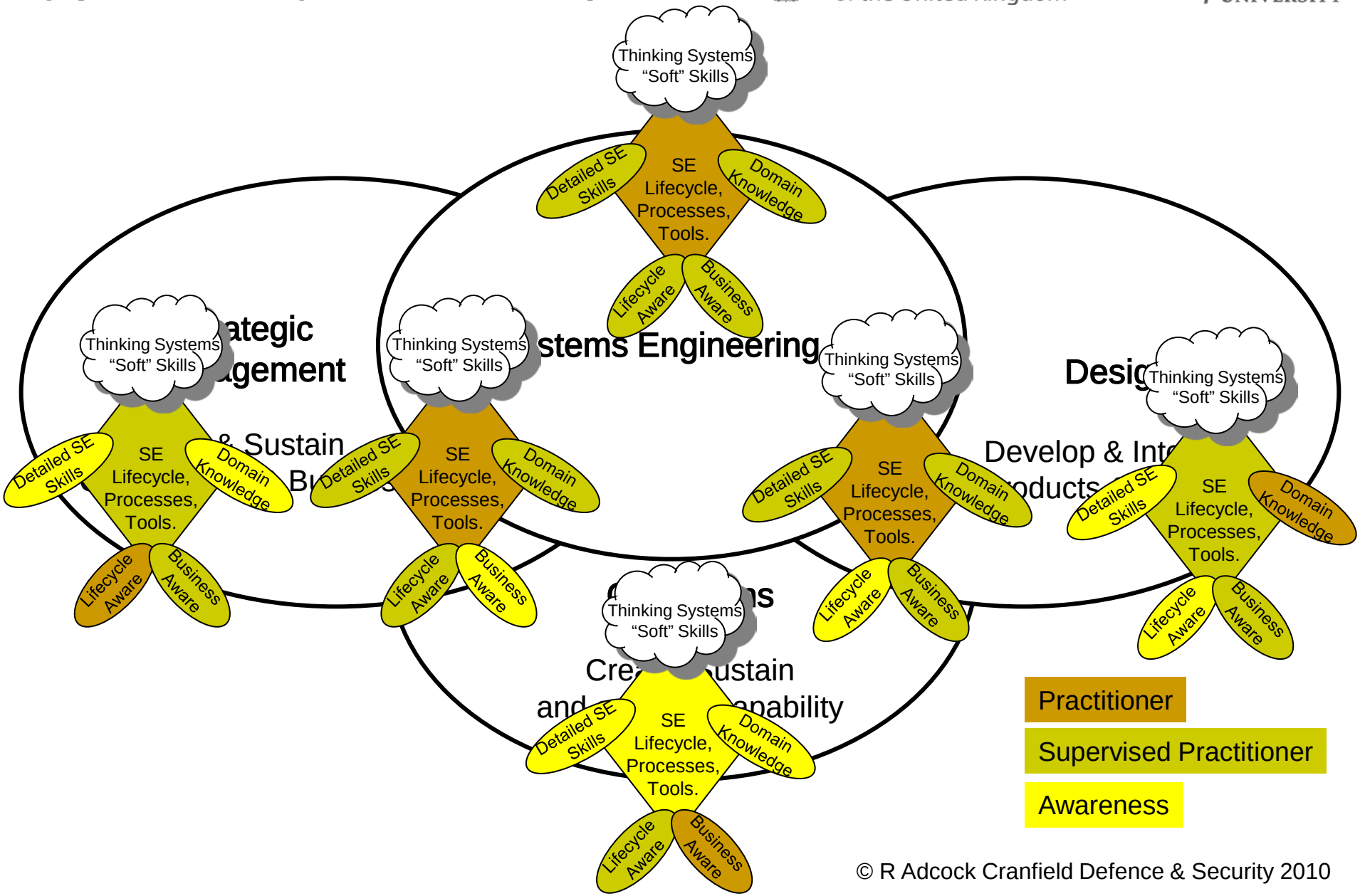


© R Adcock Cranfield Defence & Security 2010

Types of System People

Defence Academy of the United Kingdom

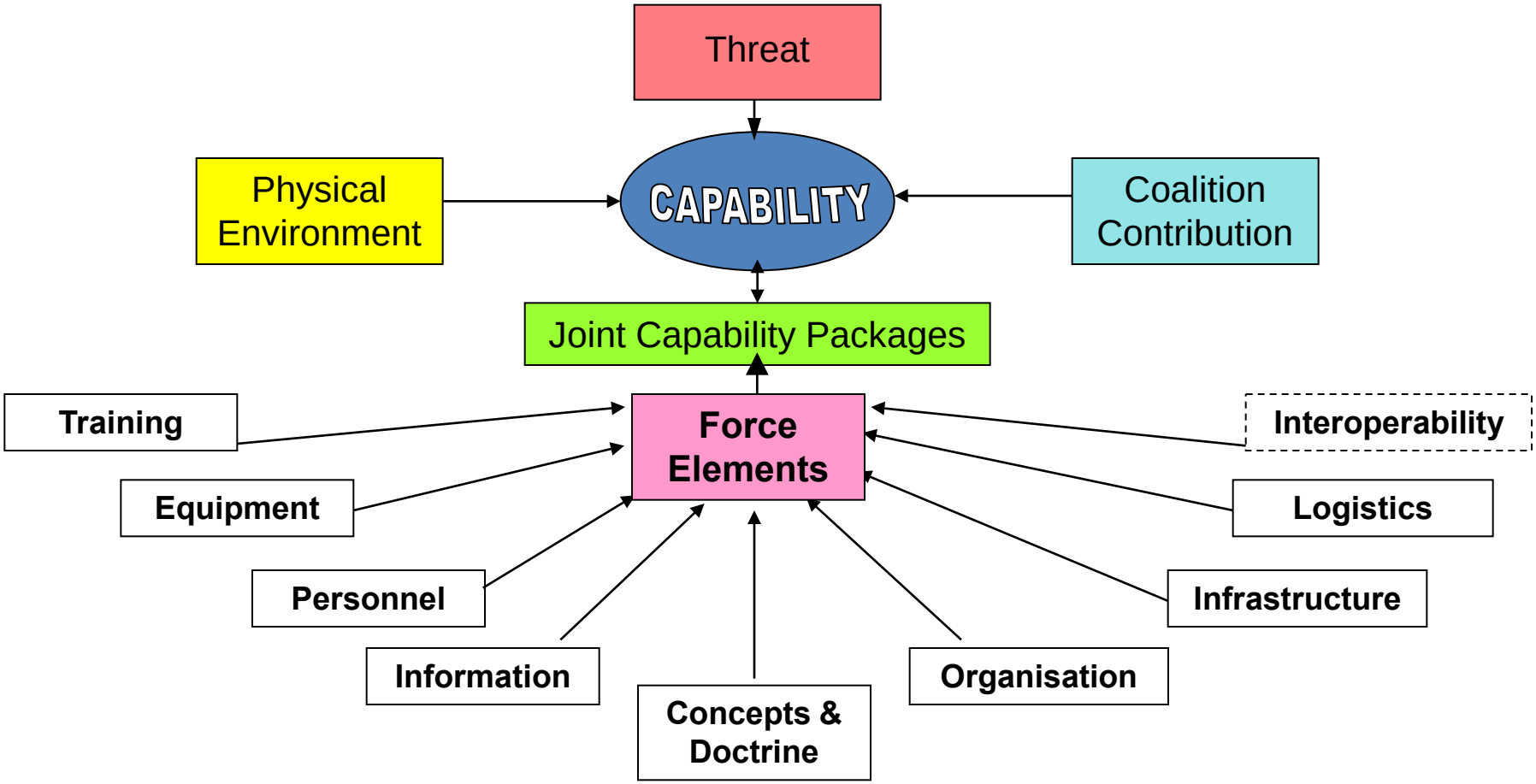
Cranfield UNIVERSITY



© R Adcock Cranfield Defence & Security 2010

Systems across UK Defence Capability

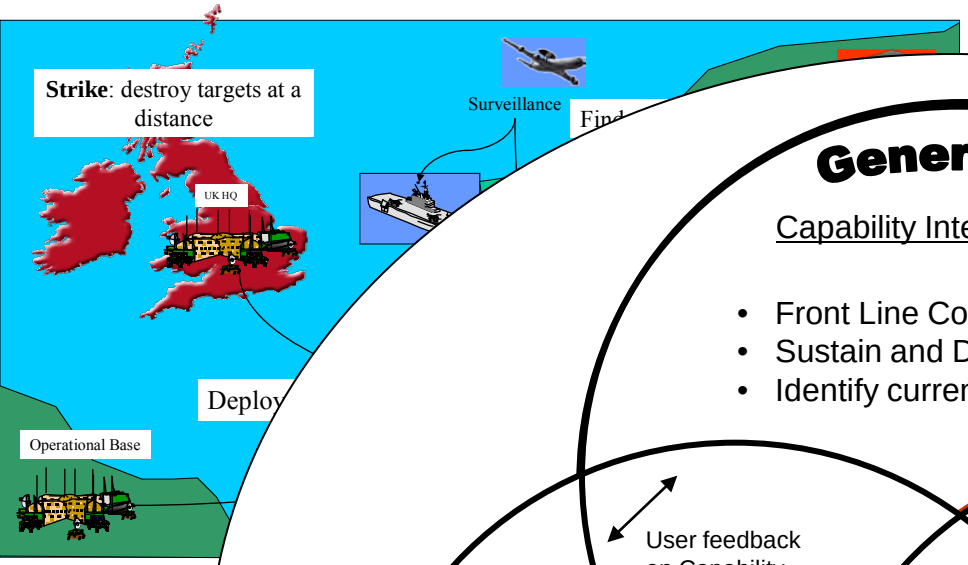
"The enduring ability to generate a desired operational outcome or effect, relative to the threat, environment and the contributions of coalition partners"



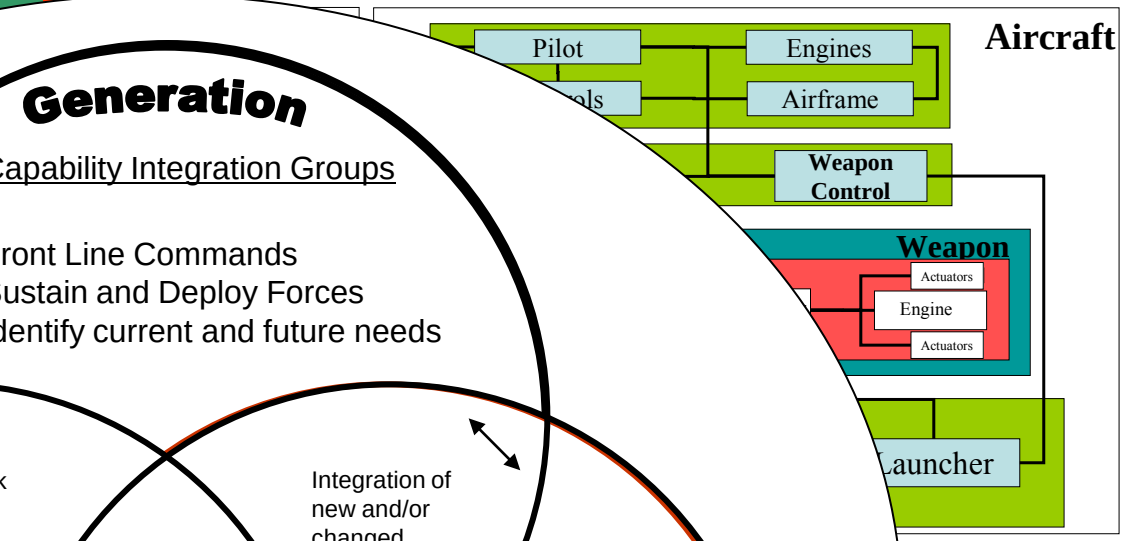
MOD Acquisition Operating Framework, www.aof.mod.uk

© Crown Copyright 2009

Operational Scenarios



Operational Interfaces



Generation

Capability Integration Groups

- Front Line Commands
- Sustain and Deploy Forces
- Identify current and future needs

User feedback on Capability shortfalls and opportunities

Integration of new and/or changed capability

Capability Management

Sponsors Programmes
Owns Capability Requirements
Programme Initiation
Acceptance

Planning

Capability Planning Groups

- Joint Customer
- DLoD Focus
- Planned Programmes of change

Delivery

Programme Boards

- Coordinates projects to deliver efficient engineered change
- All DLoD deliverers

Deep Strike

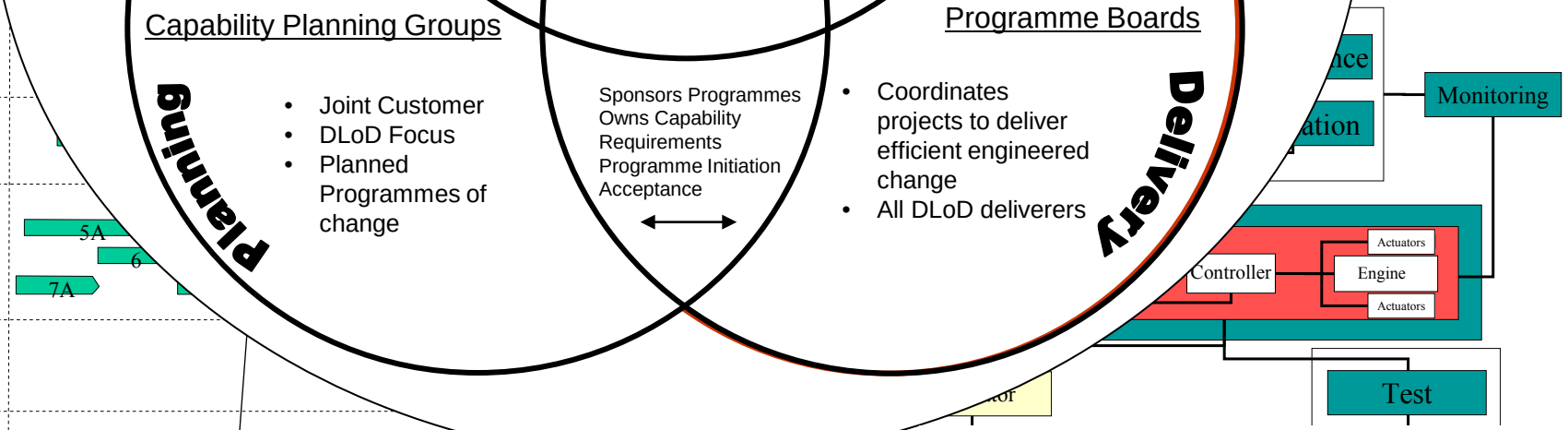
Platform
1) JSF
2) Open Interface

Intelligence
3) Improve links
4) Sensor Upgrade

Weapon Upgrades
5) Sensor Pack
6) Warhead
7) Airframe

Planning
8) Planning Tool
9) Comms Upgrade

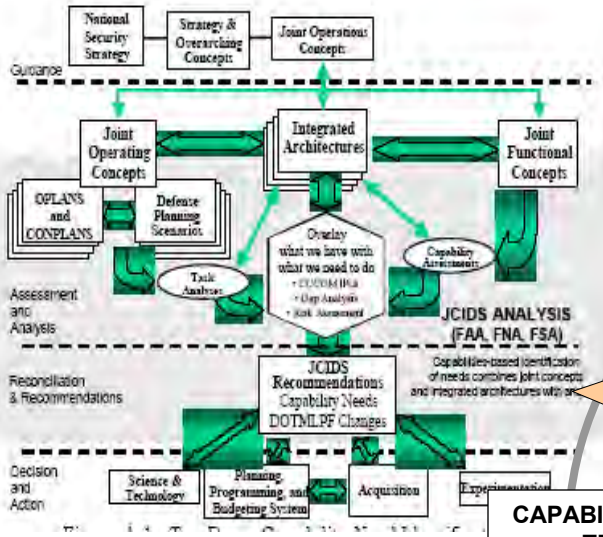
Logistics
10) Upgrade



UK MOD © Crown Copyright 2009

Systematic Approach for Warfighting Capability

JCIDS



On-Going Operations

- Combatant Commands IPLs
- Operational Lessons
- Operational Need Statements

MROC PROCESS

FORCE CAPABILITY DEVELOPMENT

CAPABILITY FIELDING & TRANSITION

Expeditionary Force Development System (JCAID PNT FWD)

DOTMLPF REQUIREMENTS

PRIORITIZATION & RESOURCING

User Needs & Technology Opportunities

PPBES

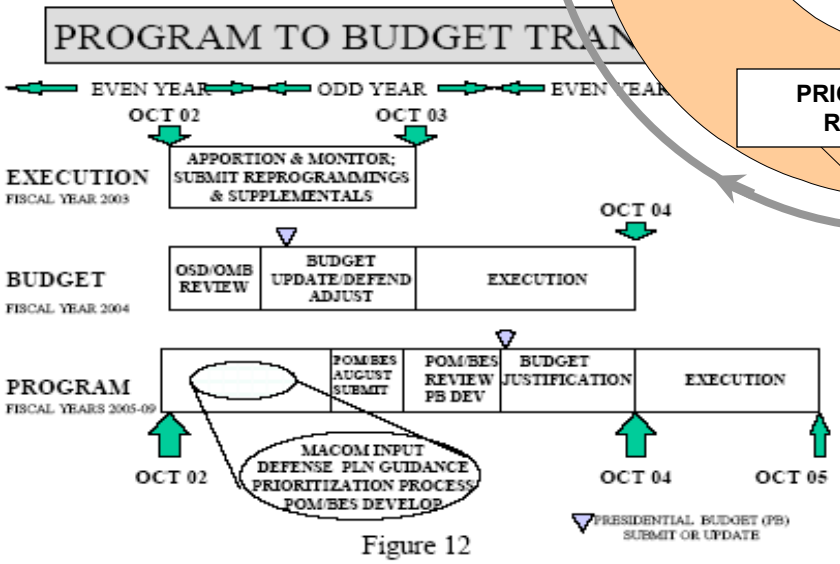
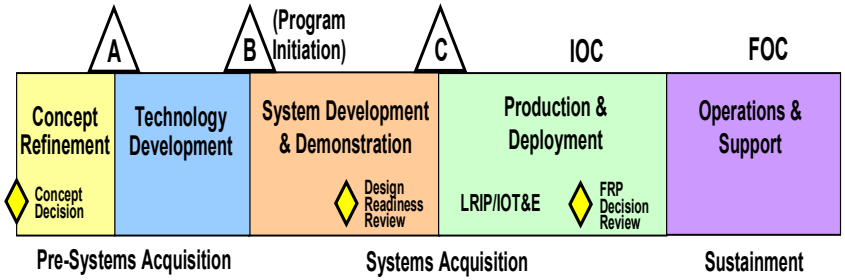


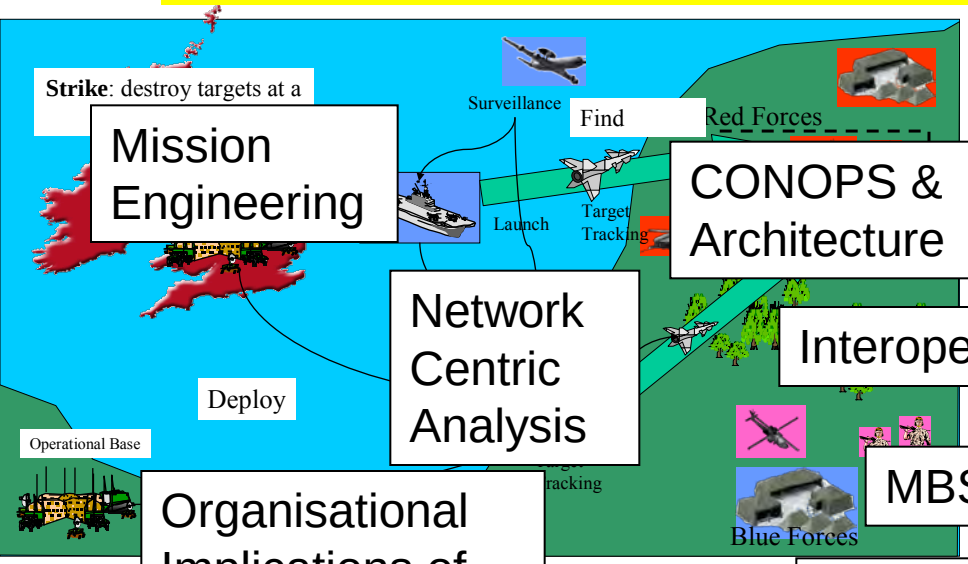
Figure 12

Acquisition

- *Process entry at Milestones A, B, or C*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*



Some of the topics covered this week



Mission Engineering

CONOPS & Architecture

Network Centric Analysis

Interoperability

MBSE

Organisational Implications of Systems Engineering

Work Force Development

Architecture Descriptions

Requirements

Technology Readiness

Test & Evaluation

Integration Effectiveness

System Safety

Health Monitoring

Lean SE

Modelling & Simulation

Risk Management

Default Detection

CMMI

Project Management
Program Management

Human Systems
Integrated Logistics

Reliable Software Requirements

Are we building on (the right) Common Principles

Questions

- Questions through Chair please
- I will share questions around the panel
- If you stick to asking questions, we will try to giving concise answer

A Model for Measuring the Correlation Between TRA and Enabling Engineering Activities, Cost, schedule, and System Quality for U.S. DoD Acquisition Programs

Nazanin Azizian[1], Dr. Mazzuchi[2],
Dr. Sarkani[2], Dr. Rico[2]

13th NDIA Systems Engineering Conference
San Diego, CA
25 Oct. – 28 Oct 2011

U.S. DoD Acquisition Challenges

Among other challenges, DoD has been facing problems in the area of acquisition

"First, this department must consistently demonstrate the commitment and leadership to stop programs that significantly exceed their budget or which spend limited tax dollars to buy more capability than the nation needs…

Second, we must ensure that requirements are reasonable and technology is adequately mature to allow the department to successfully execute the programs…

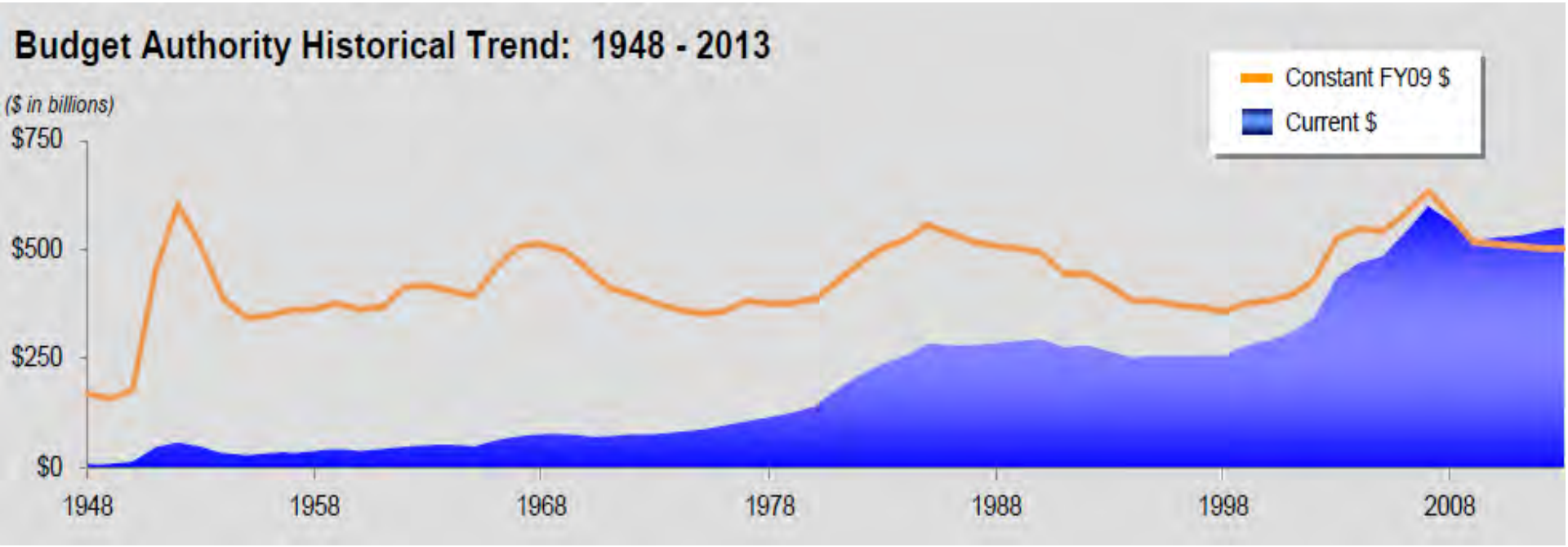
Third, realistically estimate program costs, provide budget stability for the programs we initiate, adequately staff the government acquisition team, and provide disciplined and constant oversight.

We must constantly guard against so-called "requirements creep," validate the maturity of technology at milestones, fund programs to independent cost estimates, and demand stricter contract terms and conditions."

Secretary of Defense Robert M. Gates

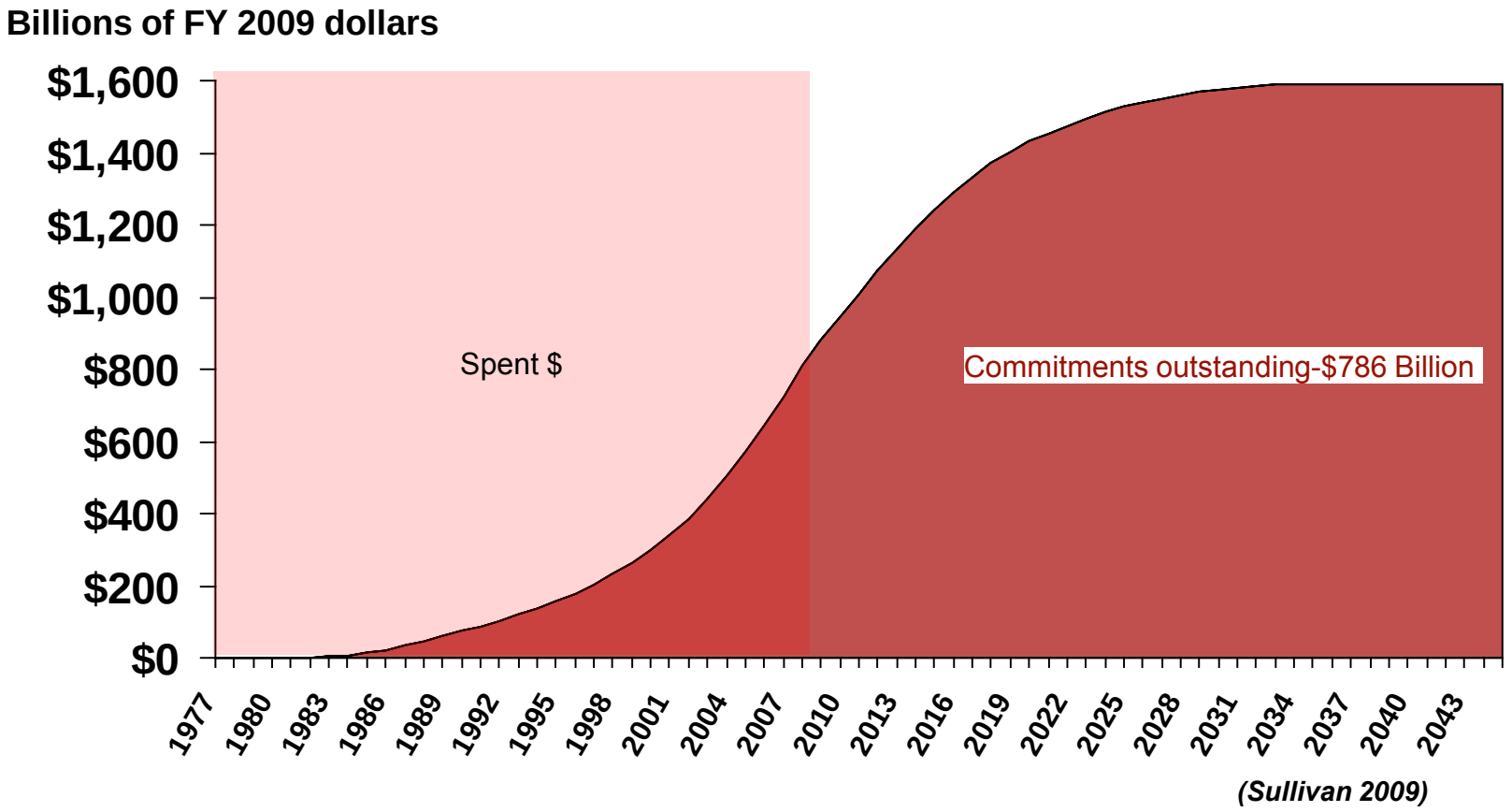
Background

Investment dollars increase, yet U.S. DoD acquisition programs continue to be susceptible to risk in the form of schedule slips, cost overrun, cancellations, and failure to meet performance objectives



U.S. Defense Historical Budget Trends From 1948 – 2013 (OM&B 2009)

Committed and Planned Spending on 2008 Portfolio of 96 Programs

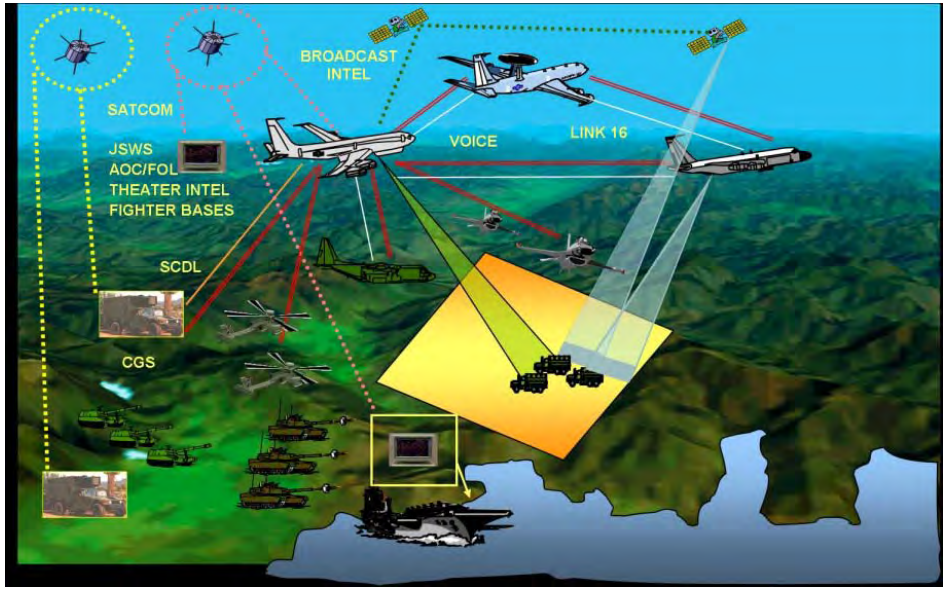


(Sullivan 2009)

Root Causes of Risk

- ✓ Unrealistic performance expectations
- ✓ Unrealistic baseline estimates for cost or schedule
- ✓ **Immature technologies or excessive manufacturing or integration risk**
- ✓ Unanticipated design, engineering, manufacturing, or technology integration issues arising during program performance
- ✓ Changes in procurement quantities
- ✓ Inadequate program funding or funding instability
- ✓ Poor performance by government or contractor personnel responsible for program management
- ✓ lack of mature manufacturing processes

- ✓ Increasingly complex Systems
- ✓ Increased data demand requirements
- ✓ Operating in a net-centric environment
- ✓ System-of-System centric
- ✓ Rapid development cycle
- ✓ Rapid technology obsolescence
- ✓ Evolving requirements

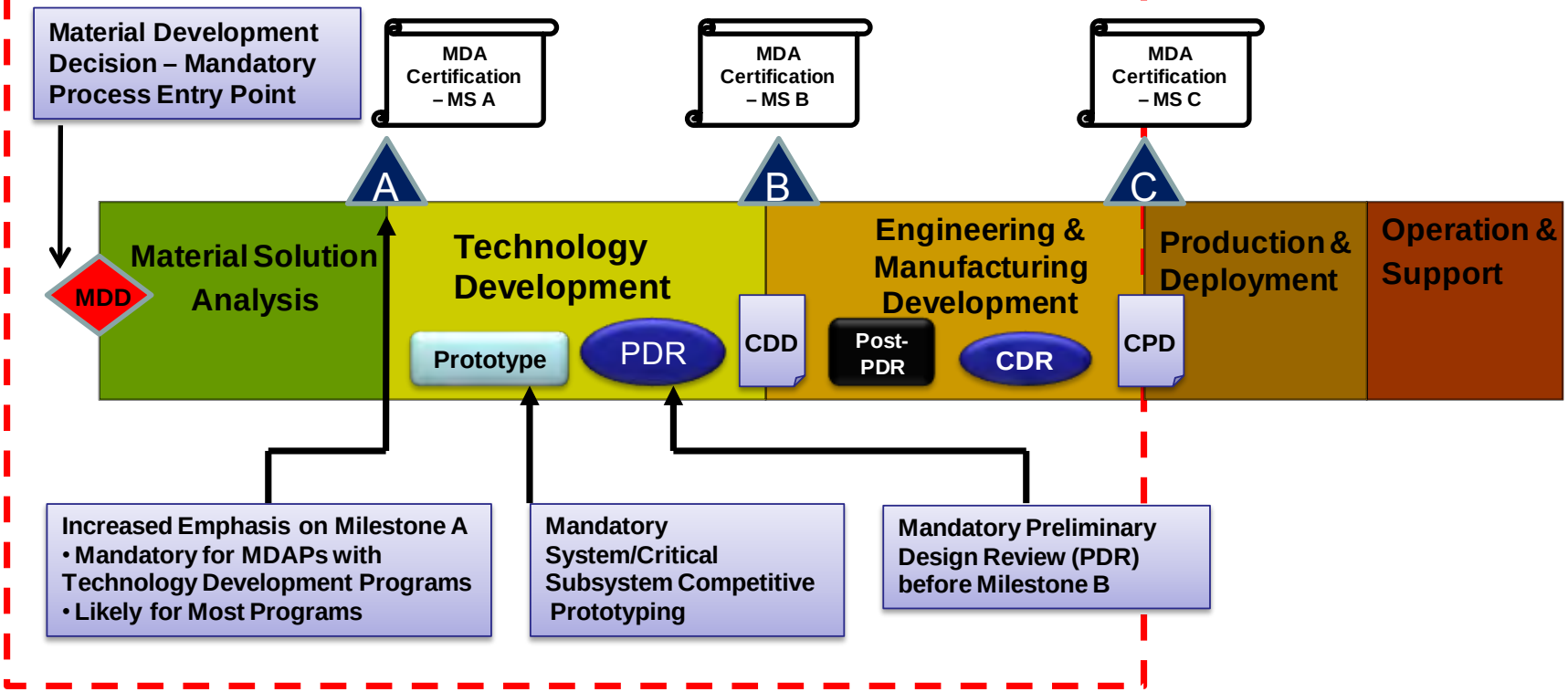


DoD Initiatives

- **Nunn-McCurdy Act 1982** -cancellation of weapons programs that experience a cost overrun of more than 25% above the original estimation
- **Packard Commission Act 1986** -streamlining of the acquisition process, increasing test and prototyping, changing the organizational culture, improve planning, and model the DOD after a competitive firm
- **Defense Acquisition Workforce Improvement Act (DAWIA) 1990** - encouraged training and education for DOD and civilian workforce
- **Federal Acquisition Streamline Act (FASA) 1994**--encouraged the adoption of commercial best practices, which was a significant movement away from Federal acquisition laws and regulations
- **Clinger-Cohen Act 1996** – built upon FASA , simplified acquisition of commercial items; placed high emphasis on accountability, performance, and result-based IT management
- **Weapon System Acquisition Reform Act (WSARA) 2009**

WSARA 2009

FOCUS OF MAJOR CHANGES



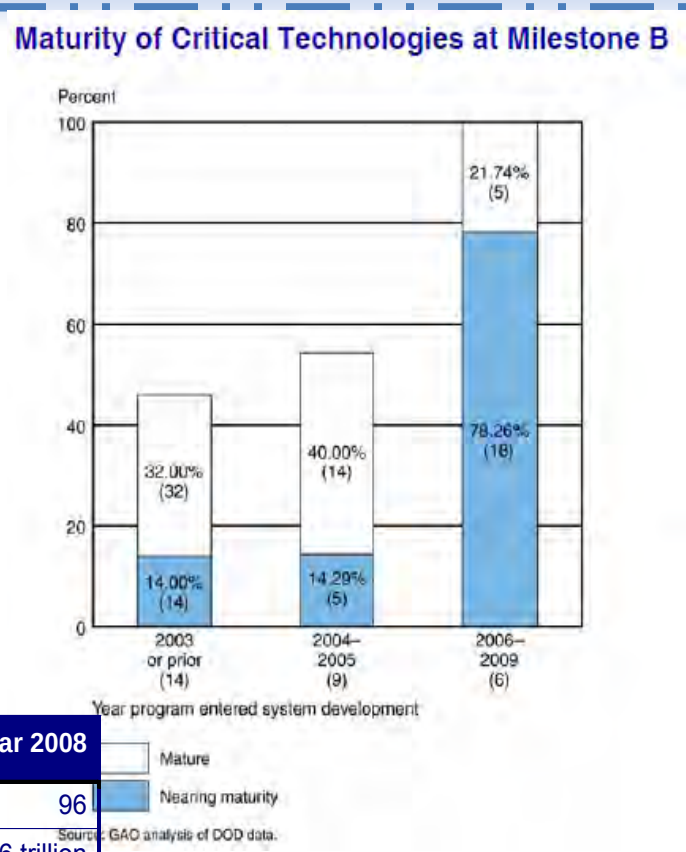
Enhanced Emphasis on:

- Technology Maturity
- Systems Engineering
- Integrated Testing and Test Planning
- Manufacturing and Producibility
- Logistics and Sustainment Planning

Acquisition Outcomes Per GAO

weapon system programs are initiated without:

1. Sufficiently mature technologies
2. Stable designs
3. Sufficiently mature manufacturing processes



Portfolio status	Fiscal year 2003	Fiscal year 2007	Fiscal year 2008
Number of programs	77	95	96
Total planned commitments	$1.2 trillion	$1.6 trillion	$1.6 trillion
Commitments outstanding	$724 billion	$875 billion	$786 billion
Change to total RDT&E costs from first estimate	37 percent	40 percent	42 percent
Change in total acquisition cost from first estimate	19 percent	26 percent	25 percent
Estimated total acquisition cost growth	$183 billion	$301 billion	$296 billion
Share of programs with 25 percent or more increase in program acquisition unit cost	41 percent	44 percent	42 percent
Average delay in delivering initial capabilities	18 months	21 months	22 months

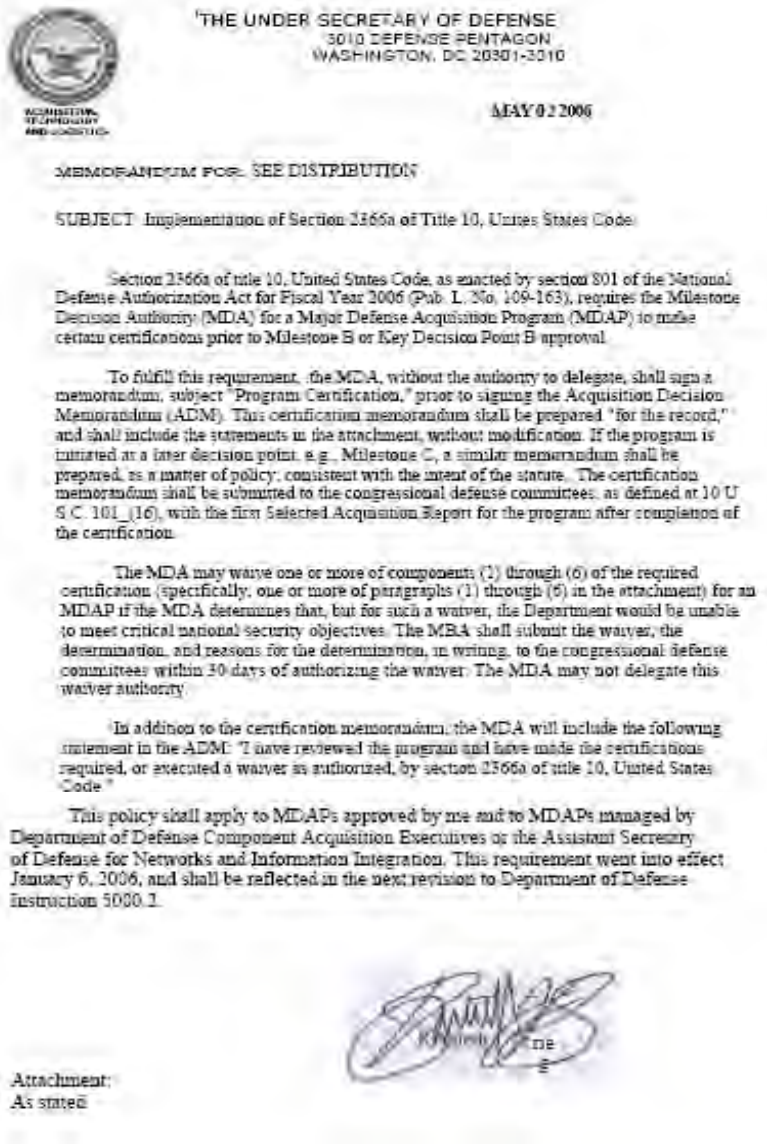
Strategy to Improve Acquisition Outcome

- **1999** - GAO stated in report that

  "Maturing new technology before it is included in a product is perhaps the most determinant of the success of the eventual product or weapon system" GAO/NSIAD-99-162
- **2001**- In a memorandum DUSD(S&T) endorsed assessing technology maturity using the TRL metrics
- **2003** - DoDI 5000.02 (2003), para 3.7.2.2 required the inspection of technology maturity by stating

  "Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition."
- **2006** – Congressional legislation (Title 10, section)

  Technology maturity must be assessed and certified to be adequate prior to MS B&C



THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

MAY 0 2 2006

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Implementation of Section 2366a of Title 10, United States Code

Section 2366a of title 10, United States Code, as enacted by section 801 of the National Defense Authorization Act for Fiscal Year 2006 (Pub. L. No. 109-163), requires the Milestone Decision Authority (MDA) for a Major Defense Acquisition Program (MDAP) to make certain certifications prior to Milestone B or Key Decision Point B approval.

To fulfill this requirement, the MDA, without the authority to delegate, shall sign a memorandum, subject "Program Certification," prior to signing the Acquisition Decision Memorandum (ADM). This certification memorandum shall be prepared "for the record," and shall include the statements in the attachment, without modification. If the program is initiated at a later decision point, e.g., Milestone C, a similar memorandum shall be prepared, as a matter of policy, consistent with the intent of the statute. The certification memorandum shall be submitted to the congressional defense committees, as defined at 10 U.S.C. 101_(16), with the first Selected Acquisition Report for the program after completion of the certification.

The MDA may waive one or more of components (1) through (6) of the required certification (specifically, one or more of paragraphs (1) through (6) in the attachment) for an MDAP if the MDA determines that, but for such a waiver, the Department would be unable to meet critical national security objectives. The MDA shall submit the waiver, the determination, and reasons for the determination, in writing, to the congressional defense committees within 30 days of authorizing the waiver. The MDA may not delegate this waiver authority.

In addition to the certification memorandum, the MDA will include the following statement in the ADM: "I have reviewed the program and have made the certifications required, or executed a waiver as authorized, by section 2366a of title 10, United States Code."

This policy shall apply to MDAPs approved by me and to MDAPs managed by Department of Defense Component Acquisition Executives or the Assistant Secretary of Defense for Networks and Information Integration. This requirement went into effect January 6, 2006, and shall be reflected in the next revision to Department of Defense Instruction 5000.2.

Attachment:
As stated

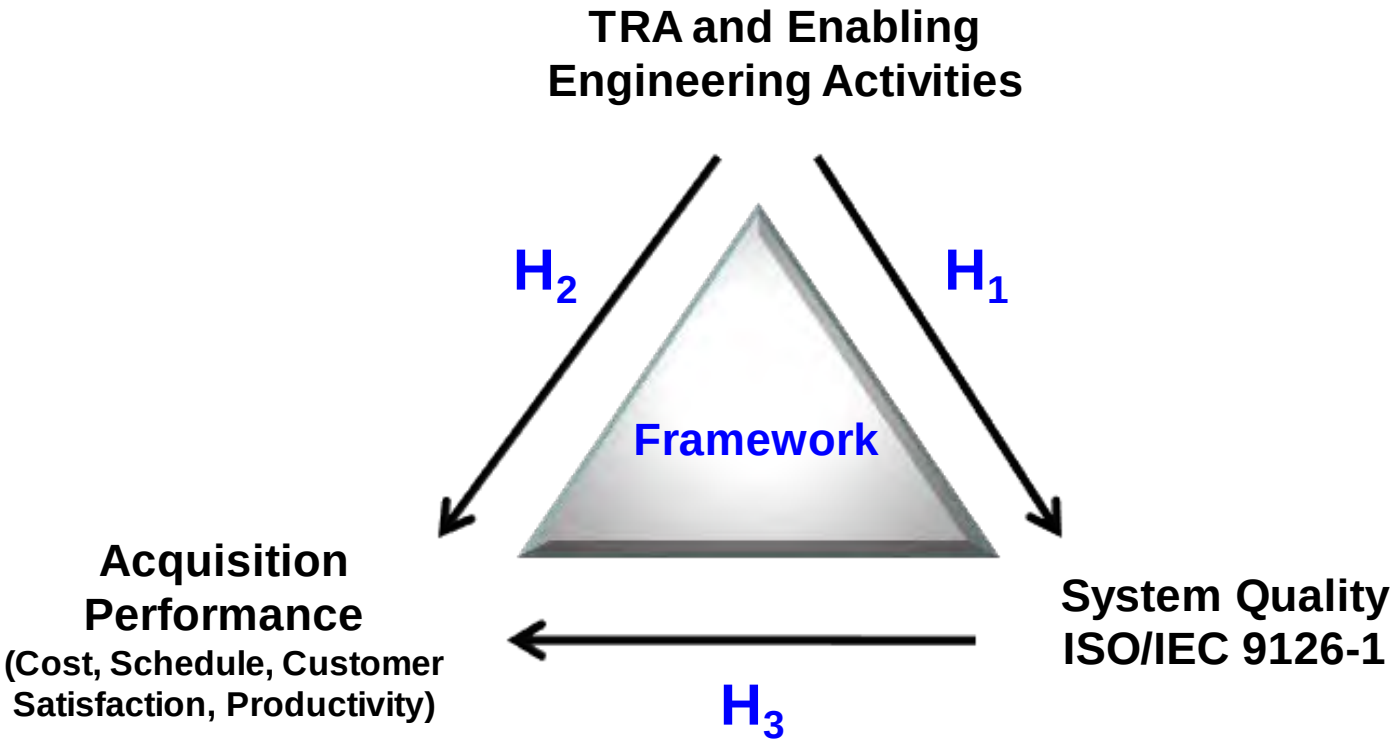
Defining Technology Readiness Assessment (TRA) and Technology Readiness Level (TRL)

- A TRA is a systematic, metrics-based process and accompanying report
- The TRA assesses the Maturity of Critical Technology Elements (CTEs)
- Critical Technology Elements (CTEs) are…
  - The system depends on this element to meet operational requirements
  - The element or its application is either new or novel.
  - Element poses major technological risk during detailed design or demonstration

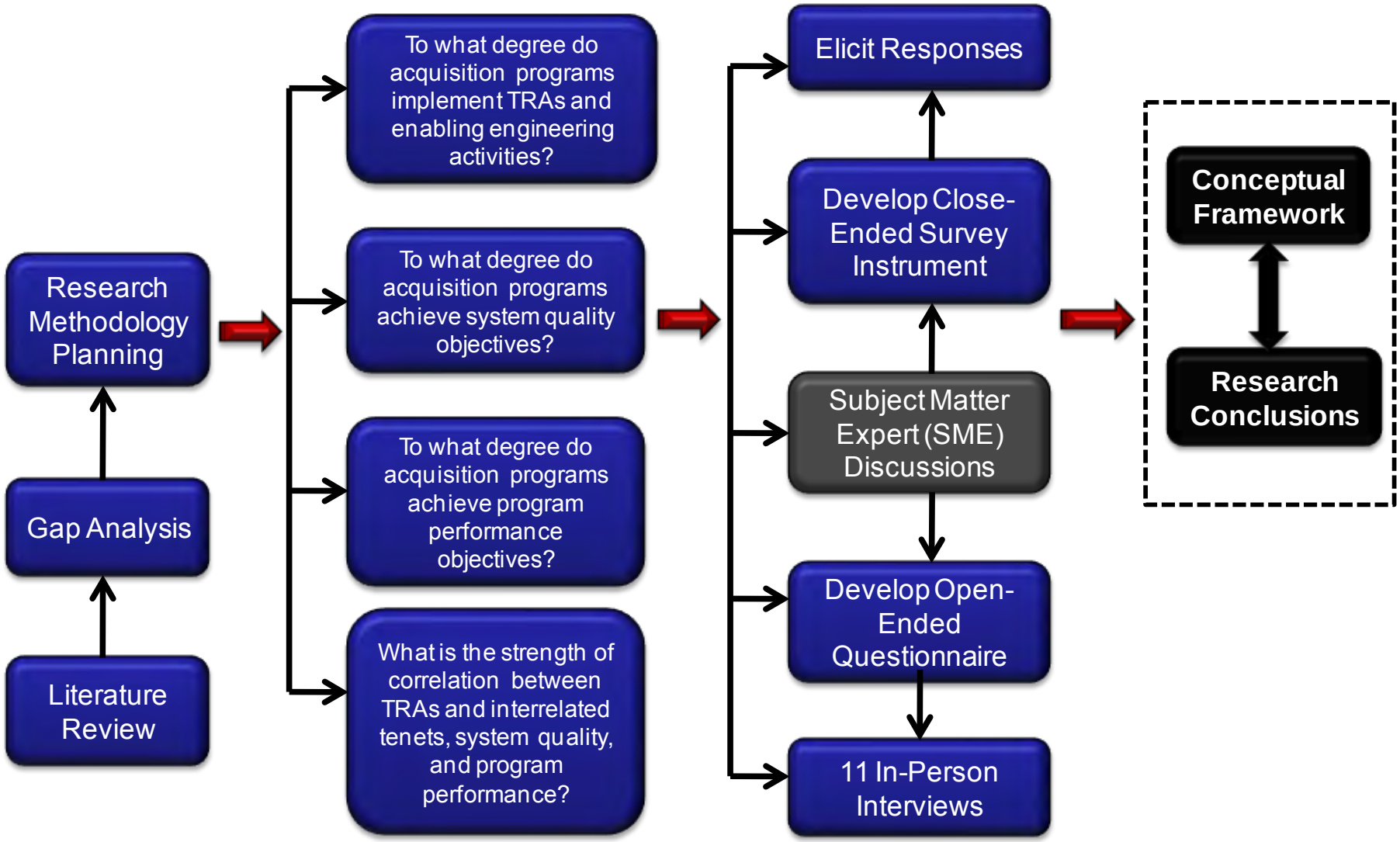
- DoD standard tool for performing TRAs is Technology Readiness Level (TRL) metric
  - Technology Readiness Level (TRL) is a 9 tier metric that systematically assess the maturity of a technology with respect to a particular use

Research Framework

Technology maturity has been linked to cost and schedule, however little emperical studies have been conducted to evaluate the degree of its correlation to the quality of DoD products and weapon systems.



Research Roadmap



Key Engineering Activities

Key Activities Leading to MS A

- White Papers
- Research Papers
- Analytical Studies
- Analysis of Alternatives
- Identification of KPPs
- CTE Identification
- Early CTE Maturity Assessment
- Systems Engineering Plan

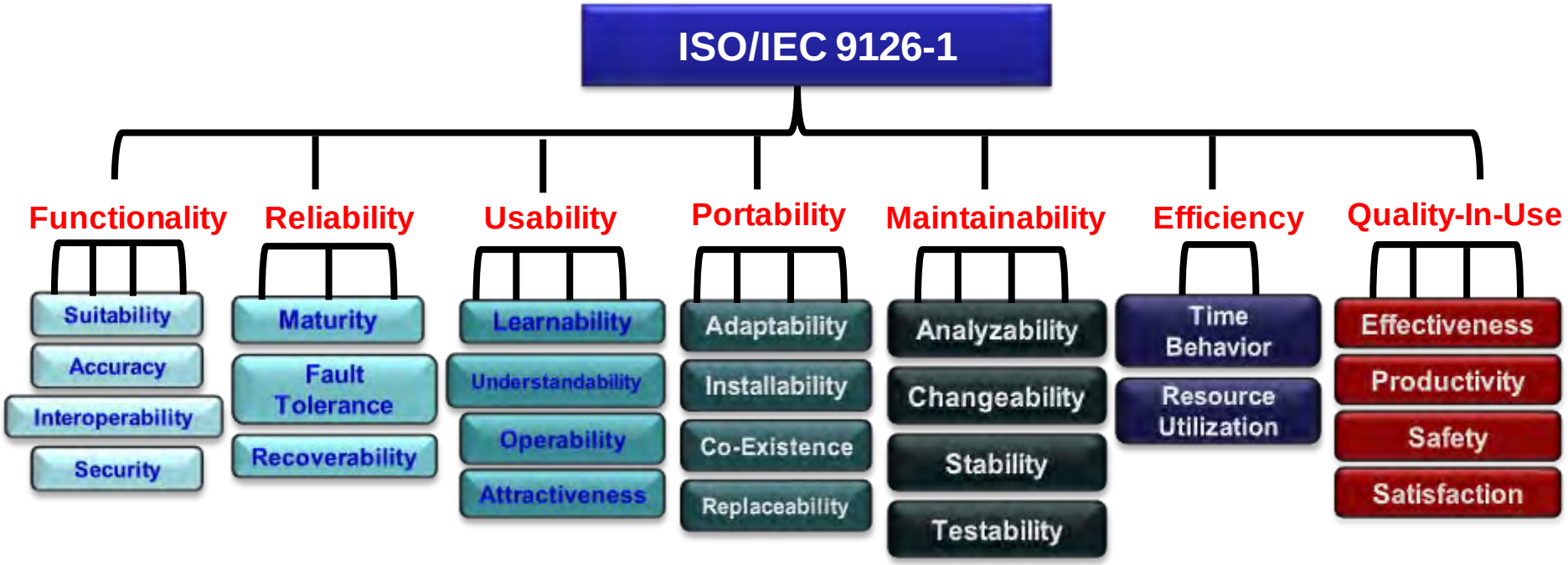
Key Activities Leading to MS B

- Laboratory Environment Evaluation of Components
- Relevant Environment Evaluation of Components
- System/Subsystem Prototyping
- Relevant Environment Evaluation of Prototype
- Milestone B TRA
- Capability Development Document (CDD)
- Test and Evaluation Master Plan (TEMP)

Key Activities Leading to MS C

- Actual System Prototyping
- System Demonstration in Relevant Environment
- System Development Testing
- Operational Testing
- Milestone C TRA
- Certification and Accreditation
- Capability Production Document (CPD)
- Information Support Plan

System Quality- ISO/IEC 9126-1



Hypotheses

H_1 -There is no correlation between TRAs and enabling engineering activities and the quality of military systems as measured by ISO/IEC 9126-1.

H_2 -There is no correlation between TRAs and enabling engineering activities and acquisition performance

- **H_{2a}** -There is no correlation between TRAs and engineering activities and acquisition cost
- **H_{2b}** -There is no correlation between TRAs and enabling engineering activities and acquisition schedule
- **H_{2c}** -There is no correlation between TRAs and enabling engineering activities and customer satisfaction
- **H_{2d}** -There is no correlation between TRAs and enabling systems engineering activities and acquisition productivity

H_3 -There is no correlation between the quality of military systems as measured by ISO/IEC 9126-1 and acquisition performance measured by cost, schedule, customer satisfaction, and productivity

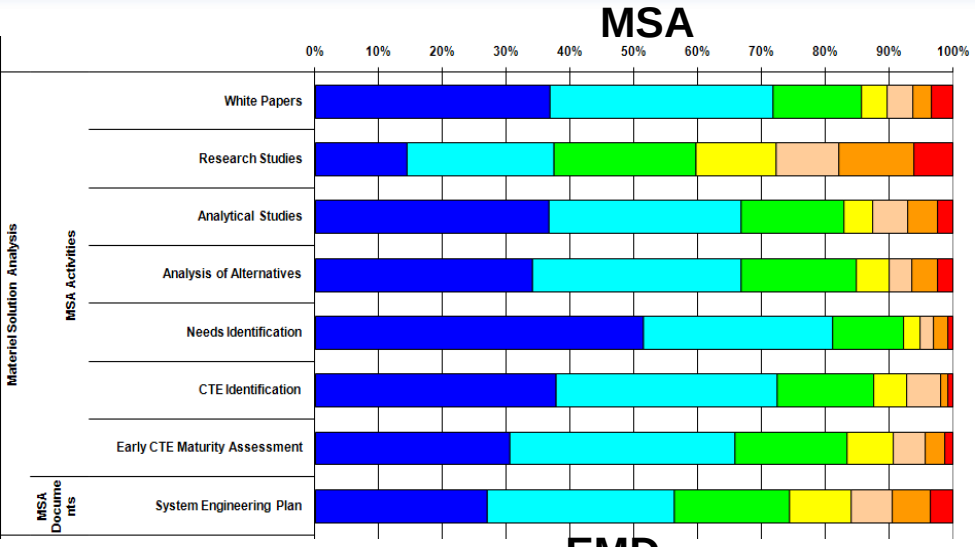
Demographic

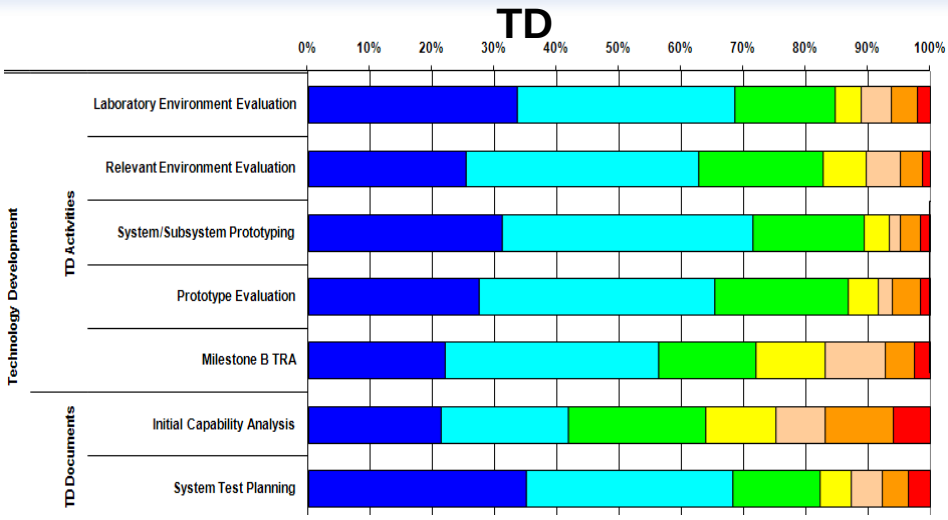
- Sample size n = 223

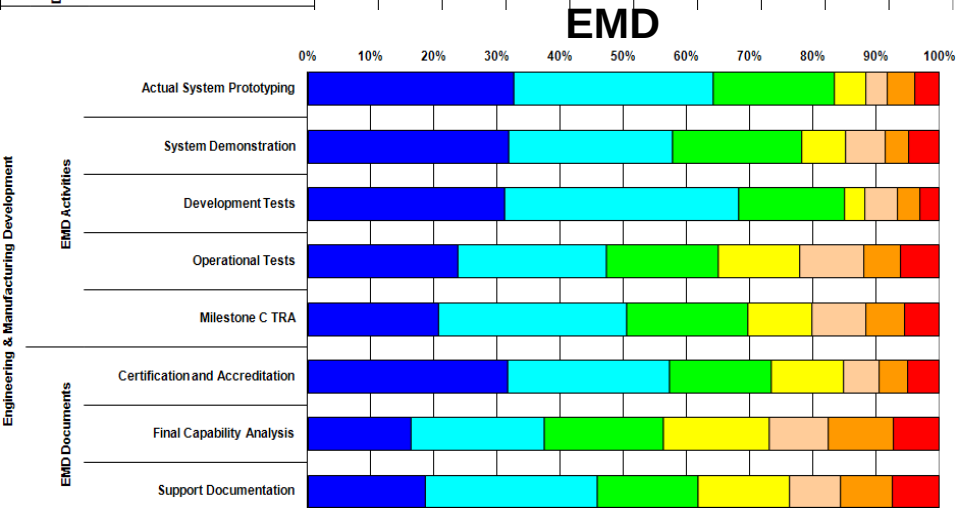
JOB FUNCTION	Freq	%
Executive	20	9%
Chief Engineer	19	9%
Director	12	5%
Program Manager	50	23%
Systems Engineer	100	45%
Hardware Engineer	8	4%
Software Engineer	13	6%
YEARS OF EXPERIENCE	**Freq**	**%**
0-5	21	11%
6-10	17	9%
11-15	18	9%
16-20	36	18%
21-25	28	14%
26-30	56	29%
31-35	20	10%

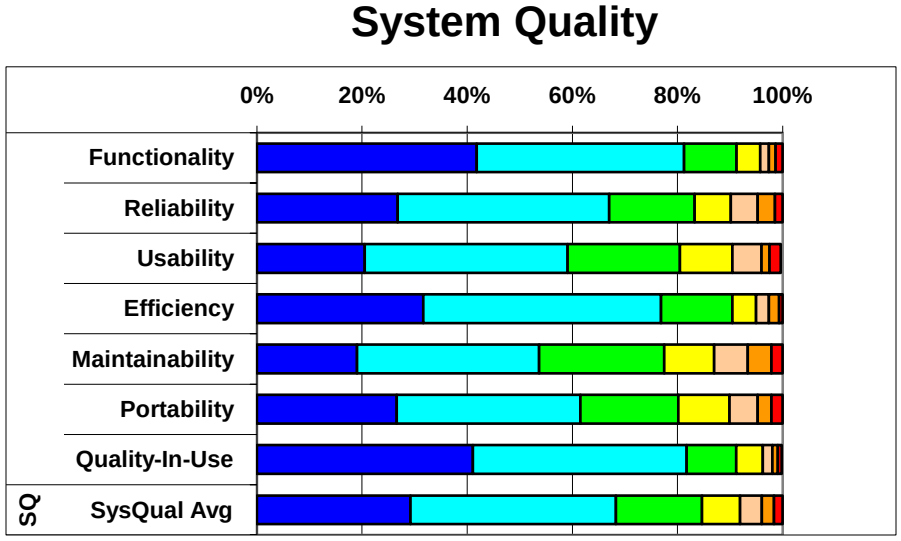
ACQUISITION PHASE	Freq	%
Material Solution Analysis	11	6%
Technology Development	48	24%
Engineering & Manufacturing Developm	61	31%
Production & Deployment	52	26%
Operation and Support	26	13%
Cancellation	2	1%
MARKET DOMAIN	**Freq**	**%**
Aircraft	47	21%
Science and Technology	42	19%
C4I Systems	52	24%
Mission Support	8	4%
Ground Vehicles	6	3%
Missile Defense	9	4%
Munitions and Missiles	4	2%
Shipbuilding and Maritime Systems	38	17%
Space Based Systems	14	6%

Degree of Compliance









Strongly Agree | Agree | Somewhat Agree | Neutral | Somewhat Disagree | Disagree | Strongly Disagree

Pearson Correlation & Cronbach's Alpha

Cronbach's Alpha Analysis

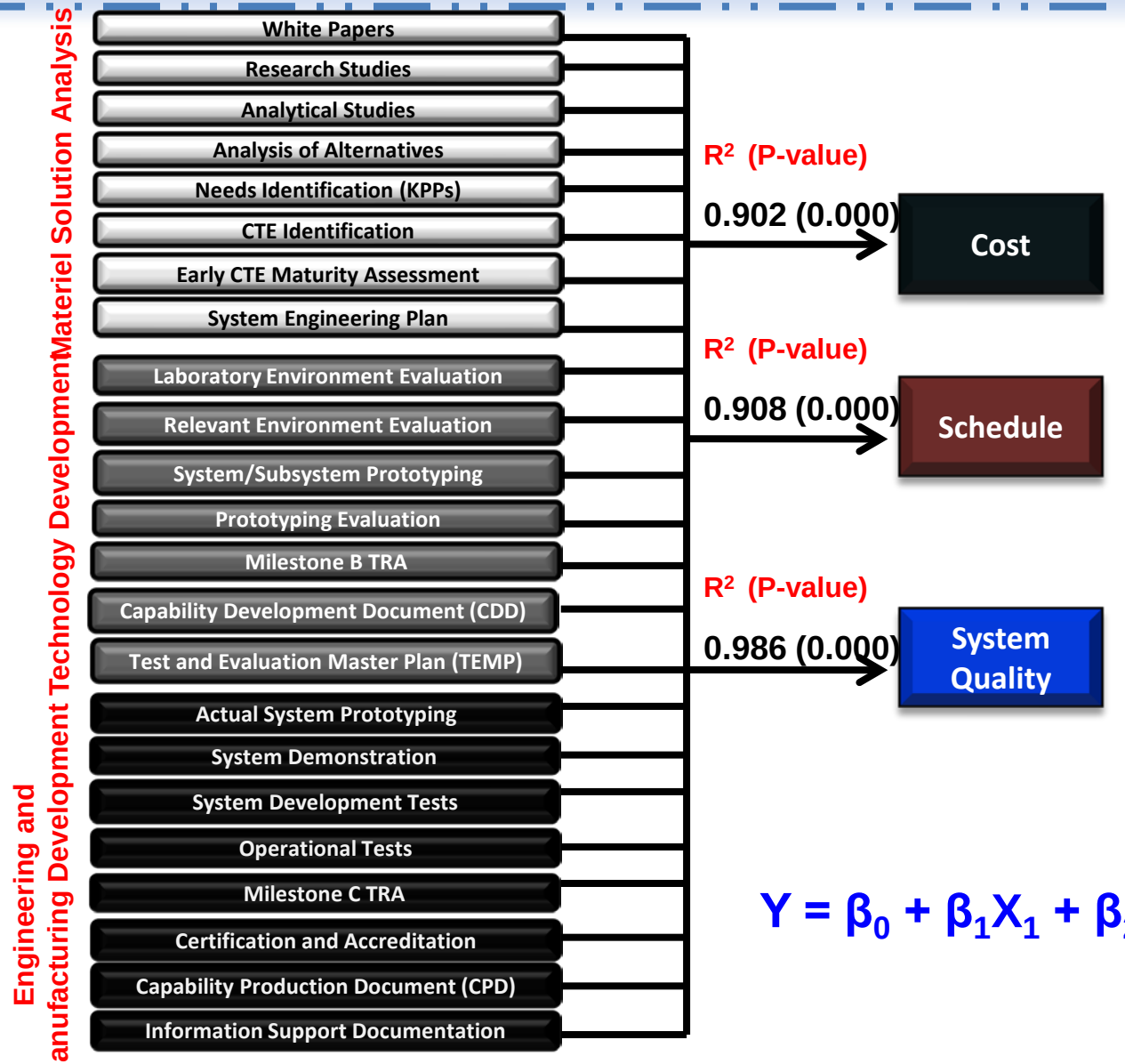
	Cronbach's Alpha	N of Items
Materiel Solution Analysis (MS)	0.862	8
Technology Development (TD)	0.862	7
Engineering and Manufacturing Development (EMD)	0.891	8
Overall System Quality	0.957	27
Cost	0.782	3
Schedule	0.766	3
Customer Satisfaction	0.749	3

Pearson Correlation Analysis

	MSA	TD	EMD	System Quality	Cost	Schedule	Customer Satisfaction	Productivity
MSA	1							
TD	.741	1						
EMD	.573	.703	1					
System Quality	.625	.610	.570	1				
Cost	.318	.311	.291	.364	1			
Schedule	.343	.307	.251	.389	.749	1		
Customer Satisfaction	.426	.397	.345	.500	.515	.550	1	
Productivity	.412	.410	.332	.532	.388	.437	.485	1

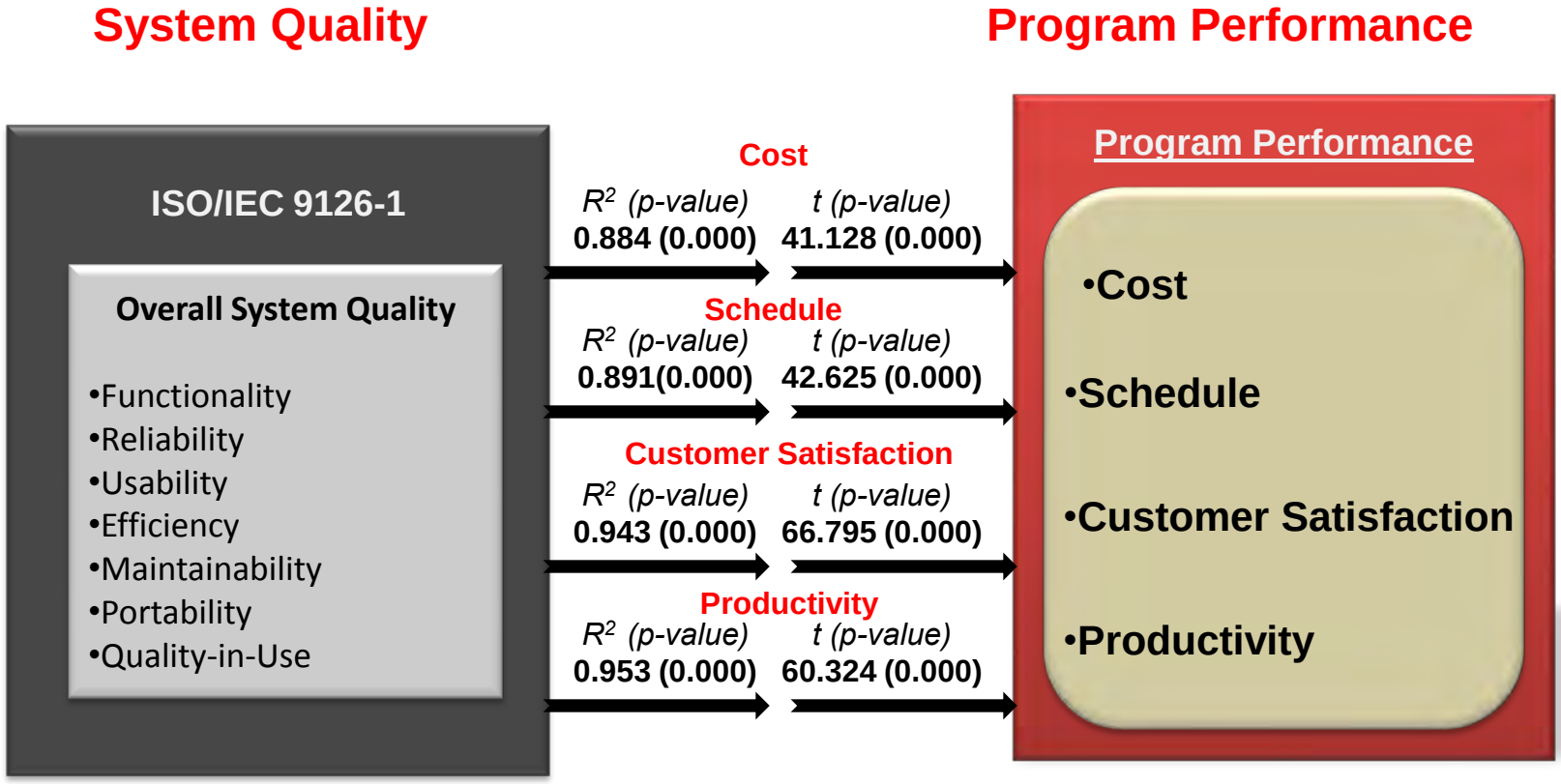
All correlations are significant p < 0.01

Regression Test



$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots + \beta_n X_n + \varepsilon$$

Acquisition Performance as a Function of System Quality



Interview Findings

- ***Finding One***: assessing technology maturity is ineffective if other recommended systems engineering activities are not implemented in parallel (i.e documentation and planning)
- ***Finding Two:*** Most did not use the TRL metric to assess technology maturity - technology readiness and maturity were assessed by test and integration of components to determine the number of requirements and specifications that are met
- ***Finding Three:*** Many acquisition programs did not develop prototypes or perform operational environment testing because they claim that it is impossible to replicate the environments and it costs too much to prototype the actual system
- ***Finding Four:*** It was determined that many acquisition programs do not implement TRA enabling systems engineering activities in the order suggested by DoD 5000. Therefore, they may be advancing through the stages of the acquisition lifecycle with knowledge gaps

Conclusions

- Rejected all null hypotheses at the 0.01 significance level and showed that TRA enabling engineering activities are strongly correlated to system quality and program performance.
  - Although Milestones B and C TRAs did not show significance on system quality, cost, schedule, and productivity, the results showed that numerous enabling systems engineering activities that support the TRA process were significant at ≤ 0.01 $\alpha \leq 0.05$
- Quality of U.S. military systems exhibited strong correlations to cost, schedule, customer satisfaction, and productivity of acquisition
- There is evidence to show that adhering to many of the U.S. DoD engineering activities related to acquisitoin that are called for in a TRA process may have a positive effect on the quality of U.S. DoD systems, as well as the cost and schedule of acquisition programs

Contact:
nazanin@gwmail.gwu.edu
571-214-4055

"Executable programs should be the natural outgrowth of a disciplined, knowledge-based process." (GAO 2008)

NDIA Top SE and SW Issues – 2010

Report on NDIA SE and SW Workshops
Held March 16-18, 2010

Presentation for NDIA SE Conference
October 2010

SW Issues - Geoff Draper, Harris
SE Issues - Hal Wilson, Northrop Grumman

Task Description

Identify Top Systems Engineering and Software Engineering problems or issues prevalent within the defense industry

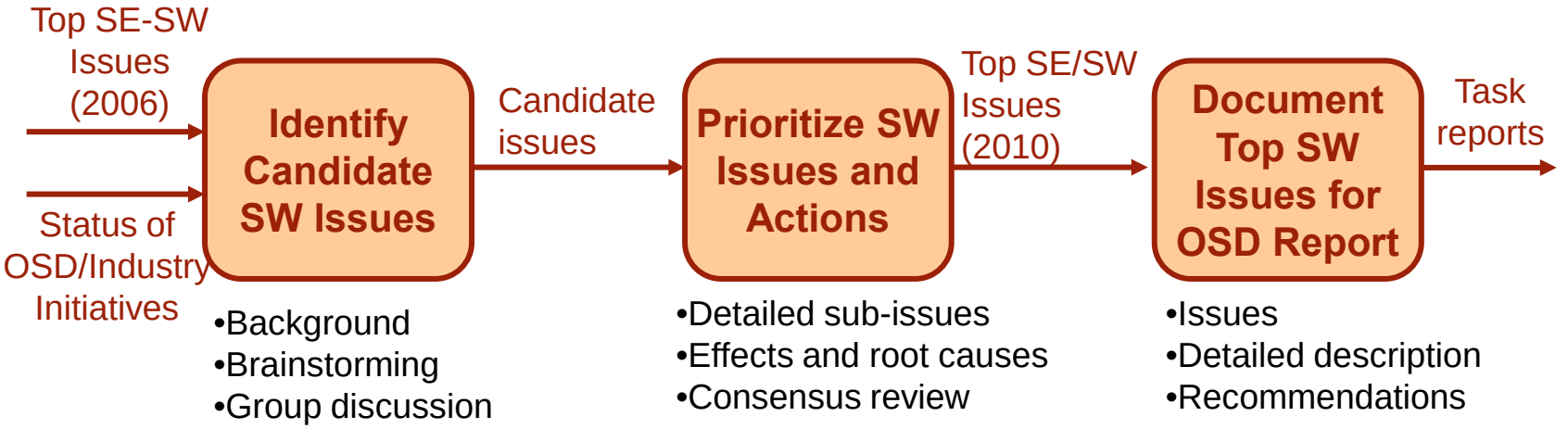
- Assess progress and update issues from 2006 workshops

Document issues

- Description and current state
- Rationale and SW impacts
- Develop recommendations (short term and long term)

Generate task report

Task Group Activities



Reports are posted on NDIA SE Division web page > Studies & Publications
http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Studies.aspx

Refer to these reports for full descriptions and consensus wording of issues/recommendations.

NDIA Top Software Issues – 2010

Results - NDIA Top SW Issues Workshop

March 16-17, 2010

2010 - Common Themes Noted

The need for rapid development has increased – rapid response to mission needs (faster, better, cheaper). Need to find ways to be more responsive, quicker.

The need for better SW architectures and modular components has been reinforced. Architectures are more difficult when accounting for legacy upgrades, SoS, and interoperability.

SW community must be engaged in advanced development planning.

Areas where action is needed:

- **Rapid acquisition** – response to urgent mission needs
- **Starting programs right** – effective program planning/startup
- **Executing programs right** – best practices, future practices
- **Sustainment** – consider total life cycle activities

2010 NDIA Top SW Issues

1. **Rapid acquisition:** **Development of software and systems must occur more rapidly than current acquisition models and development processes allow in order to meet the increasing demands of the warfighter.**

   Issues:

   - Current acquisition processes not well-suited to address rapid response needs
   - Prioritization of capabilities requires cooperative engagement between acquirer, developer and war fighter
   - Rapid development can be accelerated through reuse and use of open source and COTS but depends heavily on well-designed, flexible SW architectures
   - Multi-disciplinary approaches and processes are critical but not often in place
   - Inherent tradeoffs must balance engineering rigor with development and sustainment issues encountered post-deployment
   - Prototypes are helpful but are often declared operational as soon as introduced creating complications in support and stabilization

   Recommendations:

   1. NDIA facilitate a study or working group to characterize best practices and determine the measured effectiveness of rapid deployment techniques.
   2. NDIA establish a joint industry/government working group to investigate new acquisition approaches that accommodate rapid development.

2010 NDIA Top SW Issues

2. Start programs right: Inadequate/insufficient program planning and start-up has a negative impact on the program's SW success.

Issues:

- SW architecture and trades to achieve performance must occur earlier
- Clear and stable requirements are needed but are not often available
- Retrofits can cause significant cost and schedule impacts
- SW engineering plans are often omitted from RFPs and program plans
- Early planning often does not include software expertise, resulting in unrealistic plans and rework from late consideration of SW impacts
- Inconsistent SW estimation/measurement practices, disconnected from work planning and monitoring
- Ineffective program structures for accommodating SW changes
- Contractual constraints for flow-down, dialog with bidders, changing needs

Recommendations:

1. NDIA to provide best practices, in government and industry, that encourage the use of program assist start-up teams working directly with programs to develop comprehensive program plans, processes, and organizational structures.
2. NDIA to develop guidance and assets for improving planning and organization on software-intensive programs, with emphasis on improving the integration of software engineering with systems engineering and other program functions.

2010 NDIA Top SW Issues

3. Execute programs right: Current software development and management practices have not kept pace with emerging needs in areas such as complex systems, SoS, system assurance, software verification, and COTS/NDI integration.

Issues:

- SW management practices for traditional development are well understood, yet these practices are not always consistently followed
- Persistent issues are being addressed by new government policies and legislation
- Problems that face SW in the future:
  - Current SW engineering practices do not scale well when faced with expanding complexity of DoD systems and do not provide adequate insight into new development methodologies
  - Traditional SW integration and verification are costly and ineffective for more complex systems and integration strategies are not well integrated with system level approaches
  - System assurance practice is not adequate to anticipate and mitigate emerging vulnerabilities and threats
  - Plans and estimates for non-developmental items are often optimistic (COTS, GOTS)

2010 NDIA Top SW Issues

3. Execute programs right: (cont.)

Recommendations:

1. Government fund ongoing research into scaling software engineering practices and measures for complex systems and systems-of-systems.
2. NDIA and government collaborate on enhanced guidance for software integration and verification, and strengthened approaches for ensuring adequate software quality practices on defense programs.
3. NDIA and government define and communicate best practices for system assurance, and implement mechanisms to ensure their use on defense programs.
4. NDIA to develop guidance on strategies and practices for COTS/NDI usage and verification.

2010 NDIA Top SW Issues

4. Sustainment: There is insufficient attention given to the overall software life cycle activities including sustainment and changing threats.

Issues:

- Modern weapon systems are extensively dependent on SW-driven functionality, but sustainment resources are unable to keep up with changing mission scenarios.
- Sustainment costs are a major cost driver but not always considered adequately in system life cycle planning, engineering, and budgets.
- Mechanisms for sustainability not always built into the software architecture/design.
- Emphasis on competitive prototyping may negatively impact the consideration of sustainability and life cycle cost issues in system level trades.
- Mandated boundaries in funding, roles, and organizations can make it difficult to get focused attention on sustainment issues.
- Government life cycle cost estimates developed early in materiel concept trades constrain the quality of system baseline sustainment.

Recommendations:

1. Government to promote a product line focus within program offices to bring emphasis to sustainment issues (e.g., training, guidance).
2. Establish a government/industry task group to consider “color of money” issues and the flexibility that does exist to help mitigate the impact on sustainability.
3. Convene a joint government/industry workshop (including user community) to consider software sustainment issues across the program life cycle.

NDIA Top SE Issues – 2010

Results - NDIA Top SE Issues Workshop

March 17-18, 2010

2010 NDIA Top SE Issues

1. **Rapid Fielding: Increasingly urgent demands of the warfighter require effective capabilities be fielded more rapidly than the conventional acquisition processes and development methodologies allow.**

   Issues:

   - Quick response capability may be encumbered by tradition full –up acquisition processes
   - Strong SE capability along with appropriate SMEs is crucial to effective trades, assessment of the impacts of and the acceptance of reasonable risks
   - Rapid response to prioritized needs depends heavily on a tightly integrated and capable team which includes engagement from needed functional stakeholders.
   - Critical success factors for responding rapidly to urgent needs are not well documented or used in decision-making

   Recommendation:

   NDIA SED to convene a joint government/industry study, with cross-functional representation including T&E, to develop risk-driven guidance on tailoring SE processes and activities and DoD acquisition requirements from the Defense Acquisition System to achieve rapid acquisition and deployment.

2010 NDIA Top SE Issues

2. Human Capital: The quantity and quality of SE expertise is insufficient to meet the demands of the government and defense industry.

Issues:

- Experienced, trained SE personnel are in short supply, in industry and government
- Frequent PM/SE turnover and limited OJT/mentoring are impediments to success
- Inconsistent definition of SE roles and responsibilities results in inefficient use
- Interfaces between SE and other disciplines not adequately addressed by inexperienced work force

Recommendations:

1. Develop systems engineering expertise through role definition, selection, training, career incentives, and broadening "systems thinking" into other disciplines.
2. Establish systems engineering job codes or other indicators within government service to emphasize systems engineering in the recruiting of new hires.
3. Establish OSD policy/guidance for services to include SE expertise in RFP/proposal efforts and program start-up teams with reach-back capability.
4. NDIA SED E&T Committee investigate and recommend specific methods for developing SEs and accelerating training, including OJT rotation programs.
5. Provide contract incentives to increase development of SEs on programs.

2010 NDIA Top SE Issues

3. Effective SE: Systems engineering practices known to be effective are not consistently applied or properly resourced to enable early system definition

Issues:

- Lack of comprehensive SE impedes information available to decision-makers
- SE best practices not consistently followed; competitive pricing can lead to tradeoffs in SE process fundamentals
- SE value not consistently understood; dependencies on SE resources, experience
- Affordability and associated trades are not always performed
- Milestone reviews are often schedule-driven, not event-driven by defined criteria

Recommendations:

1. Establish a working group to develop consistent methods for presenting key SE information to decision makers, such as program managers (PMs) and Milestone Decision Authorities (MDAs).
2. Develop a recommended template for presenting key SE information, including activities, value/expected results, risk of not performing the activities, and future consequences.
3. Make the SE discipline a required process in the transition from S&T to early concept development.

2010 NDIA Top SE Issues

4. Informed decision-making: **Decision makers do not have the right information at the right time to support informed and proactive decision making that ensures effective and efficient program planning, management and execution.**

Issues:

- Many programs lack key leading indicators and measures for predictive insight
- Decisions are often not based on scientific characterizations of effective SE methods, practices, and solutions with a roadmap to address systemic issues
- We need to identify the program-specific information needs and cause and effect factors, measure them, and make sense of the patterns in order to inform in-process decisions.

Recommendations:

1. NDIA create a roadmap that programs can use to facilitate the definition and implementation of a technical measurement process to support engineering management decisions. Coordinate with INCOSE and PSM.
2. NDIA continue a research agenda to investigate causes and effects for program success and characterization of SE methods, practices, and solution approaches. Investigate context factors and how they dynamically interact.
3. NDIA continue to work with other parties to explore & potentially create a data collection and analysis capability in order to develop technical management benchmarks.

2010 NDIA Top SE Issues

5. SE technical integrity and rework: Lack of technical authority can impact the integrity of developed systems and result in cost/schedule/system performance impacts as the technical solution is iterated and reworked in later stages of the development.

Issues:

- Engineering is often not empowered to do the proper System Engineering the first time.
- System engineering fundamentals and program tradeoffs are not properly implemented in programs.
- In many cases, the technical baseline definition of a system and management of that baseline is not established before field testing.
- Technical reviews are not rigorous, comprehensive disciplined, and do not employ a sound methodology.
- Often there is no senior technical authority (or a specified chain of technical authority) to respond to the issues addressed above when they do get identified.
- Where technical authority is present, technical decision-making capability can be enhanced with the use of independent experts to broaden the technical and domain expertise in the program office.
- In most cases after examining current methods and approaches to implementing technical authority on program, it does not appear that there are sufficient technical authority mechanisms in place on AF, ARMY, NAVY and NASA program current methods. Where these mechanisms may exist, they are not empowered to drive the technical aspects of the program.

2010 NDIA Top SE Issues

5. SE technical integrity and rework (cont.)

Recommendations:

1. Add a requirement to the SEP guidance that the SEP must explicitly identify the technical authority (TA) for the program:
   - the TA role, authority, responsibility, and the performance reporting chain
   - TA conduct and chairing of technical reviews
   - the mechanism for elevating technical issues beyond the program office for resolution.

   Examine whether OSD can establish a policy directing all services to enact a technical authority process to resolve issues at a higher level than the PM.
2. NDIA review and update guidance, as needed, for entry/exit criteria and application for consistent rigor in technical reviews. Consistency will need to be flowed through development contracts.
3. Create a career path for senior technical people with broad experience that leads to seniority and authority equivalent to the PM and PEO. NDIA SE Division discuss with NDIA PM Systems Committee and OSD to determine if there are actions that can be taken through NDIA to support this.

Task Group Participant Organizations

NDIA Top SW Issues:

The Boeing Company
Booz Allen Hamilton
CSC
Harris Corporation
Lockheed Martin
NASA
Northrop Grumman
OUSD (AT&L), DDR&E
Raytheon Company
Rockwell Collins
Software Engineering Institute
Stevens Institute
U.S. Army
U.S. Air Force Office of Scientific Research
U.S. Air Force

NDIA Top SE Issues:

Alion Science & Technology
American Rheinmetall Munitions
The Boeing Company
Booz Allen Hamilton
Harris Corporation
Lockheed Martin
Northrop Grumman
OUSD (AT&L), DDR&E
Raytheon Company
Rockwell Collins
Software Engineering Institute
SynGenics Corporation
U.S. Army – HQ DA – CIA
U.S. Army – RDECOM-ARDEC
U.S. Air Force Office of Scientific Research
U.S. Navy – SPAWAR Systems Center
Vitech Corporation

Reports are posted on NDIA SE Division web page > Studies & Publications
http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Studies.aspx

The MITRE Systems Engineering Guide

Practical Guidance for Systems Engineering

October 2010

George Rebovich
Director, MITRE Systems Engineering Practice Office

13th Annual NDIA Systems Engineering Conference
October 2010

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072.

© 2010 The MITRE Corporation. All rights Reserved.

An Initiative of the Office of the Corporate Chief Engineer (OCCE)

OCCE …

- **Formed to enhance corporate-wide practice of systems engineering**
- **Enhance technical quality of MITRE work**
- **Promote cross-cutting integration**
- **Champion enterprise engineering**

Today's focus

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

The MITRE SE Guide

- Practical guidance on MITRE systems engineering
  - Like having a discussion with a MITRE expert available 24/7
- Primary Audience
  - MITRE staff leading or performing an FFRDC SE activity
  - Individuals who want to learn SE from this perspective
- Purpose
  - Convey accumulated wisdom on systems engineering practice
  - Accelerate individuals up the learning curve
  - Hit the ground running with that knowledge in customer environment
- Sources of wisdom
  - MITRE experience (> 130 senior contributors across the Corporation)
  - Other sources – when they provide practical advice for MITRE SEs
- Complements, does not duplicate, other resources
- Guide organization & focus based on MITRE SE Competency Model
- 101 articles posted, more in the works

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

SE Guide – A Resource for the Customer, Too

- Best practices & lessons learned relevant to program manager & other government member roles & responsibilities
  - Systems Engineering & Acquisition a team sport
  - Tips on specific subjects, ideas for program planning
- Brings to bear wisdom accumulated from across all MITRE customers & sponsors for the benefit of a government program

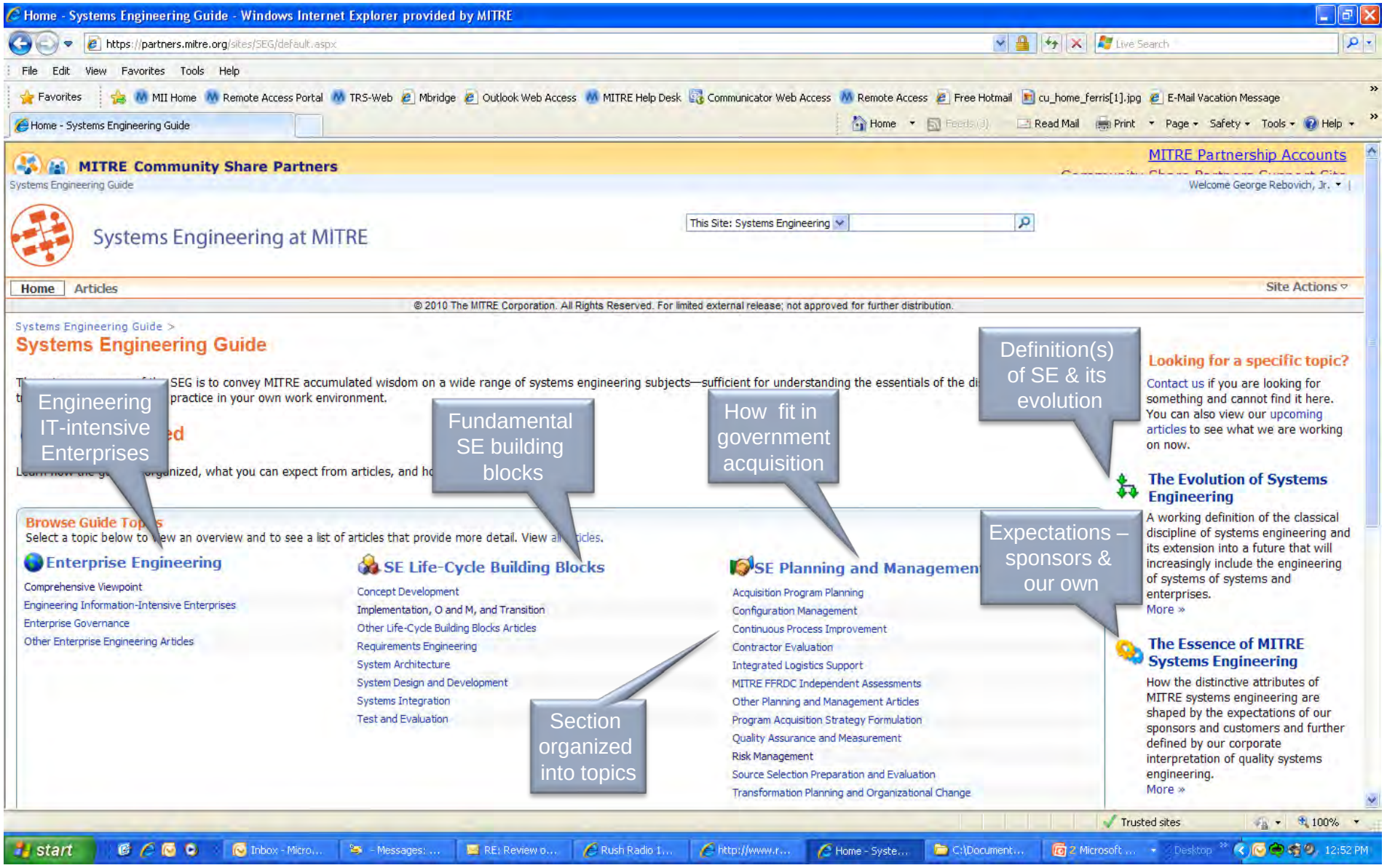
Dedicated to capturing & sharing our SE knowledge & expertise across the Corporation for the benefit of all our customers

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

5 Major SEG Sections



Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

SEG Section Page (1/2)

Home - Systems Engineering Guide - Windows Internet Explorer provided by MITRE

https://partners.mitre.org/sites/SEG/Sections%20and%20Topics/SE%20Life-Cycle%20Building%20Blocks.aspx

Systems Engineering at MITRE

This Site: Systems Engineering

Home | Articles | Site Actions

Intro & Background

List of topics

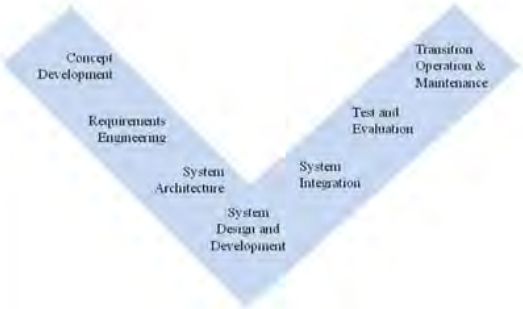
. All Rights Reserved. For limited external release; not approved for further distribution.

Systems Engineering Guide > Life-Cycle Building Blocks

SE Life-Cycle Building Blocks

Introduction

MITRE systems engineers (SEs) orchestrate the complete development of a system, from a need through operations to retirement, by applying a set of life-cycle building blocks. SEs are expected to understand and work with fundamental building blocks for engineering systems, regardless of the specific life-cycle methodology used. They are expected to define systems conceptually, transform user needs into system requirements, and develop and assess architectures. They are expected to compose and assess alternative design and development approaches; develop test and certification strategies; monitor and assess contractor efforts in design, development, integration, and test; and assist with field deployment, operations, and maintenance.



Background

All systems engineering models and processes are organized around the concept of a life cycle. Although the detailed views, implementations, and terminology used to

Topics in this Section

Name

- Concept Development
- Implementation, O and M, and Transition
- Other Life-Cycle Building Blocks Articles
- Requirements Engineering
- System Architecture
- System Design and Development
- Systems Integration
- Test and Evaluation

Sections and Topics

Enterprise Engineering Section

- Comprehensive Viewpoint
- Engineering Information-Intensive Enterprises
- Enterprise Governance
- Other Enterprise Engineering Articles

SE Life-Cycle and Building Blocks Section

- Concept Development
- Requirements Engineering
- System Architecture
- System Design and Development
- Systems Integration
- Test and Evaluation

Trusted sites | 100%

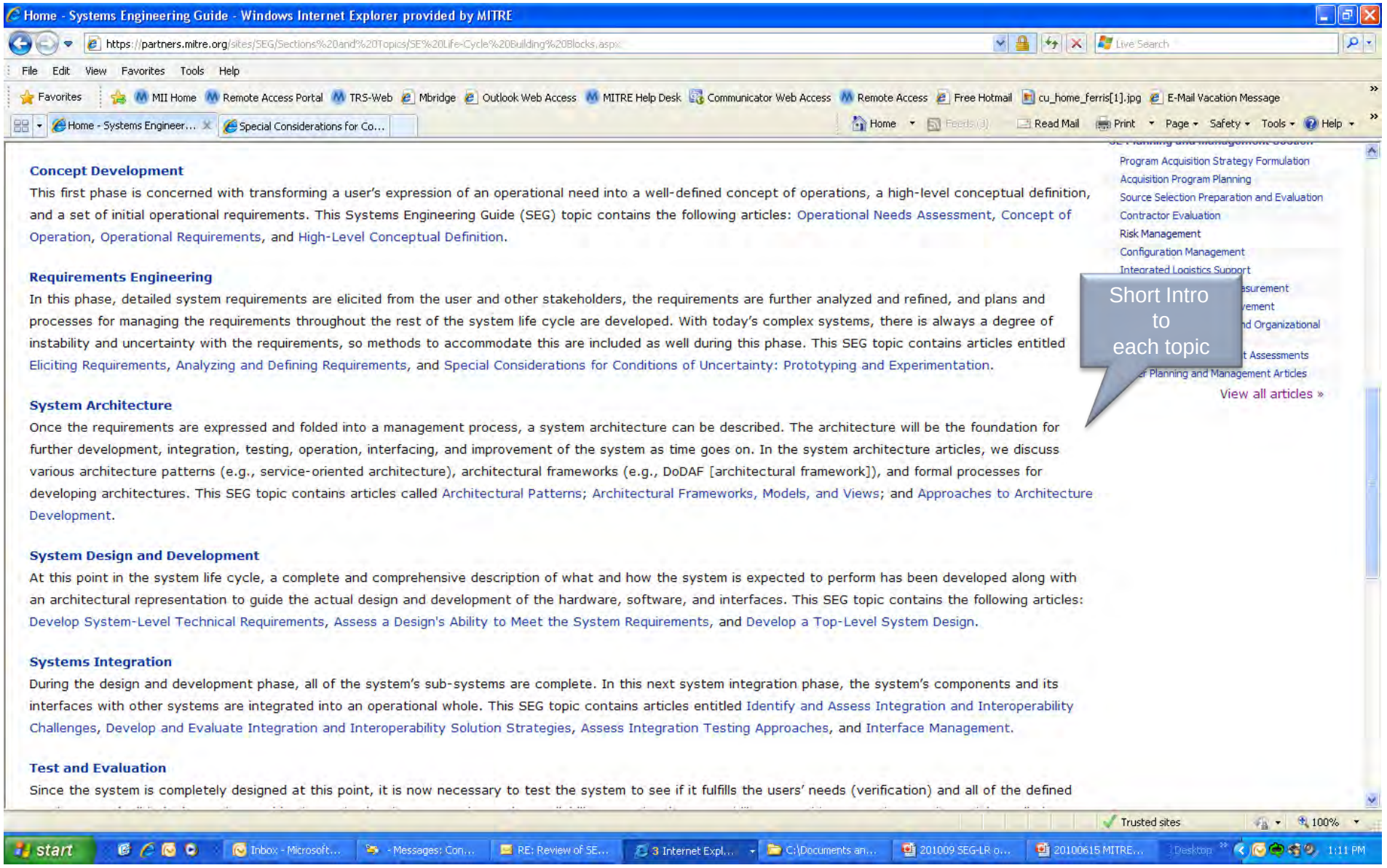
start | Inbox - Microsoft Out... | Untitled - Message (H... | Welcome to the Partn... | Home - Systems Engi... | Presentation1 | 201009 SEG-LR over... | Desktop | 9:47 AM

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

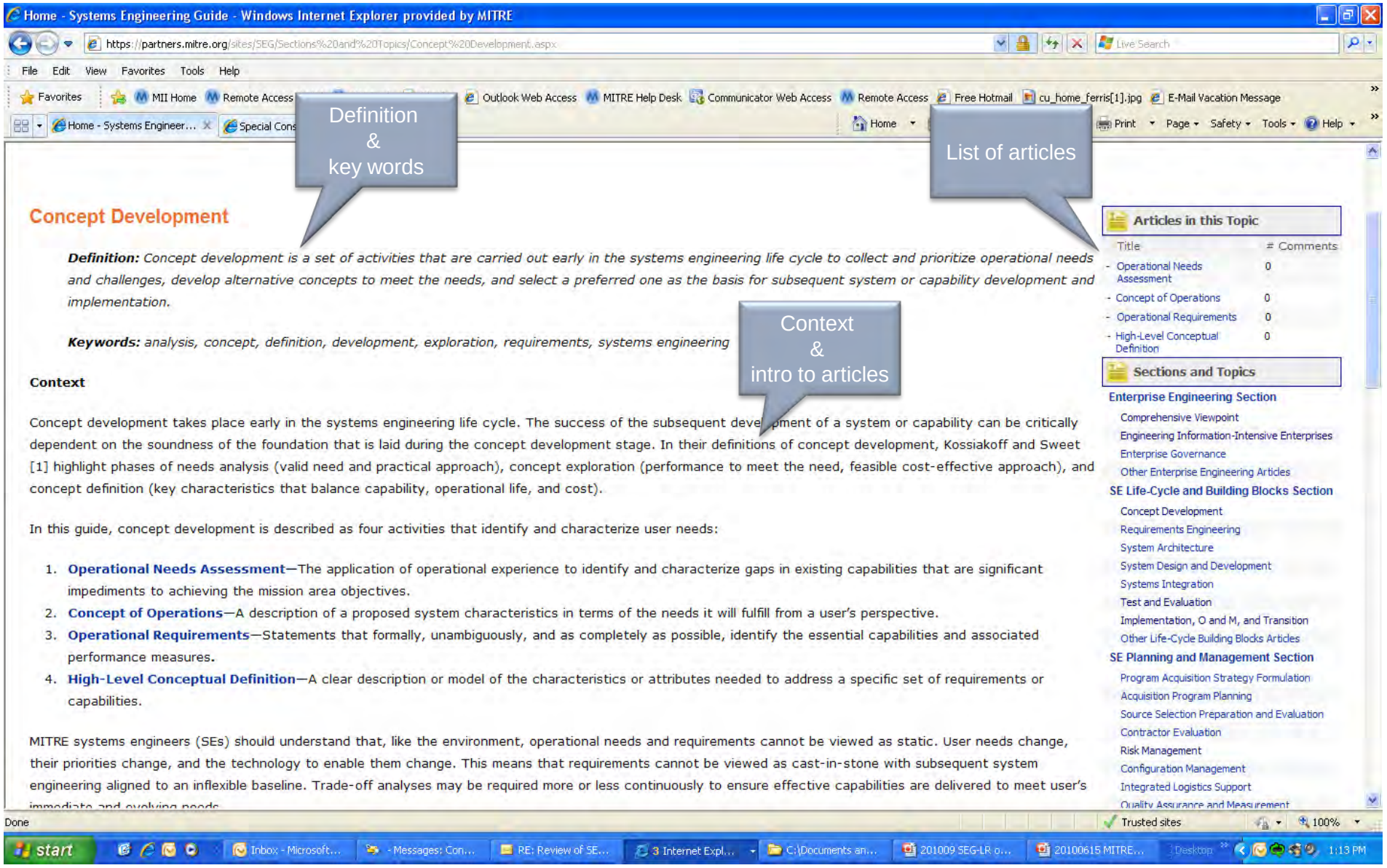
© 2010 The MITRE Corporation. All rights Reserved.

SEG Section Page (2/2)



MITRE
Approved for public release. Distribution unlimited. Case no. 10-4072
© 2010 The MITRE Corporation. All rights Reserved.

SEG Topic Page



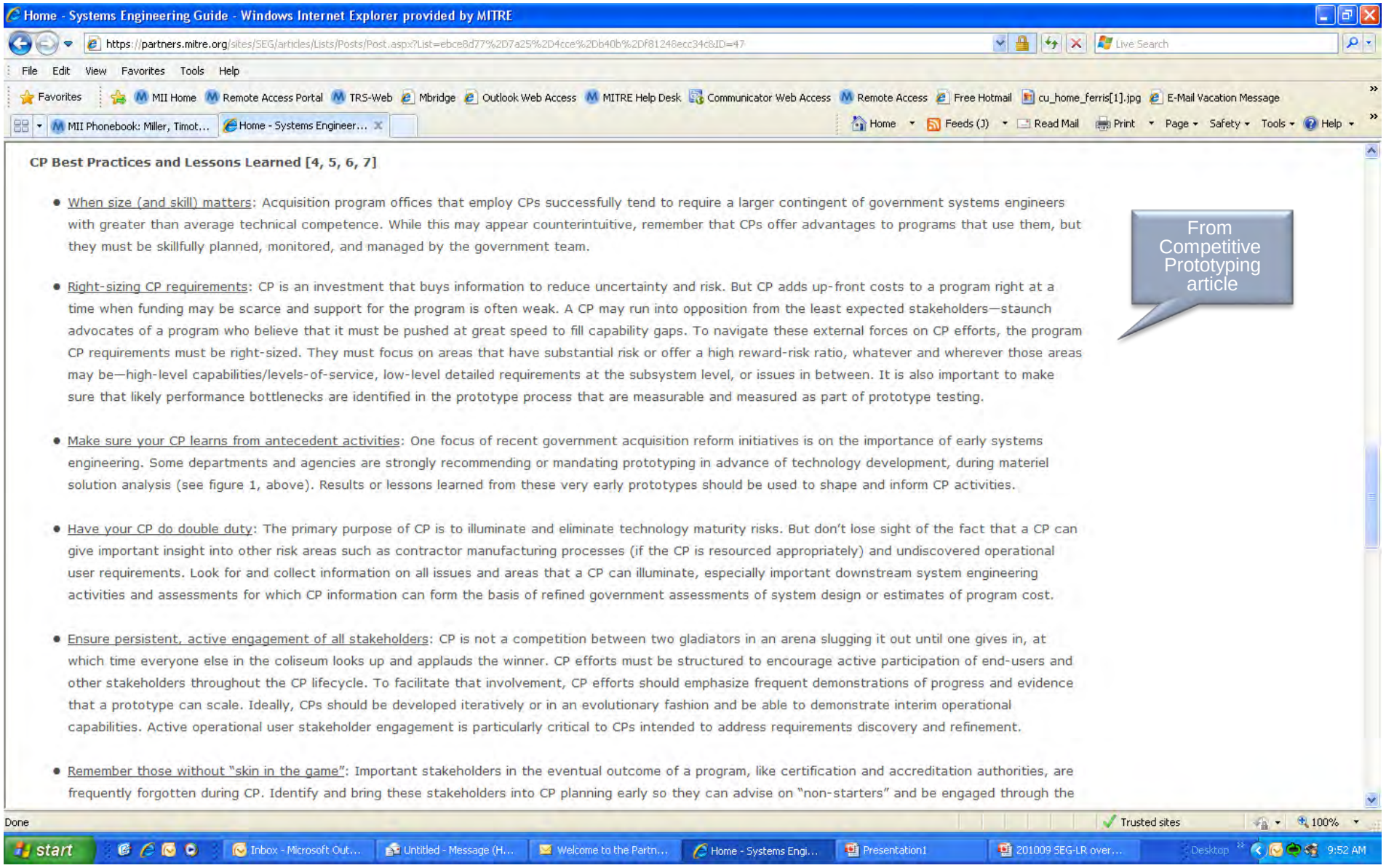
MITRE
Approved for public release. Distribution unlimited. Case no. 10-4072
© 2010 The MITRE Corporation. All rights Reserved.

SEG Article Page

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights reserved.

Competitive Prototyping Article - Best Practices & Lessons Learned



MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

To Obtain your Account … (active duty military, civilian government and FFRDC employees)

First ….

- **Send an email from your government or FFRDC email account to segteam@mitre.org that:**
  - **Requests access to the "SEG-LR extranet site"**
  - **References "George Rebovich – 13th Annual NDIA SE Conference"**

Next …

- **You'll receive an email asking you to set up a password**

Then …

- **You'll receive an email with a link to the site that you can access with your email address and password**

A final note …

- **Once in the site, you can suggest ideas for additional topics to cover or recommend your own best practices & lessons learned**

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

Contact Information

George Rebovich

Director, Systems Engineering Practice Office

The MITRE Corporation

M/S M370

202 Burlington Road

Bedford, MA 01730-1420

tel: 781-271-8503 (office)

email: grebovic@mitre.org

MITRE

Approved for public release. Distribution unlimited. Case no. 10-4072

© 2010 The MITRE Corporation. All rights Reserved.

Systems Engineering Program Metrics

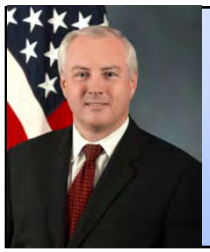
Jim Thompson

ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Mission Context



Director, Systems Engineering
Steve Welby

Systems Analysis

"Weapon Systems Acquisition Reform Act of 2009"

S.454-10; d.(1): The development and tracking of detailed measurable performance criteria as part of the systems engineering master plans…

S.454-10; d.(3): A system for storing and tracking information relating to the achievement of the performance criteria and objectives specified…

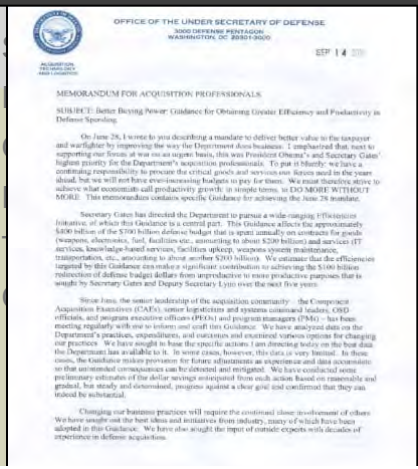
S.454-12; SEC. 103.b.(4): Evaluating the utility of performance metrics used to measure the cost, schedule, and performance of [MDAPS], and making such recommendations …to improve such metrics.

Major Program Support
James Thompson

- Program Support Reviews
- Systems Engineering Plans
- Program Technical Auditing
- OIPT/DAB Support
- DAES Database Analysis and Support
- Performance Measurement
- Systemic Root Cause Analysis

Mission Assurance

AT&L Memo, 14SEP2010
Subject: Better Buying Power: Guidance for Greater Efficiency and Productivity in Defense Spending



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

MEMORANDUM FOR ACQUISITION PROFESSIONALS

SUBJECT: Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending

nability
cibility
HSI)
ment
essment

"…Set shorter program timelines and manage to them…"

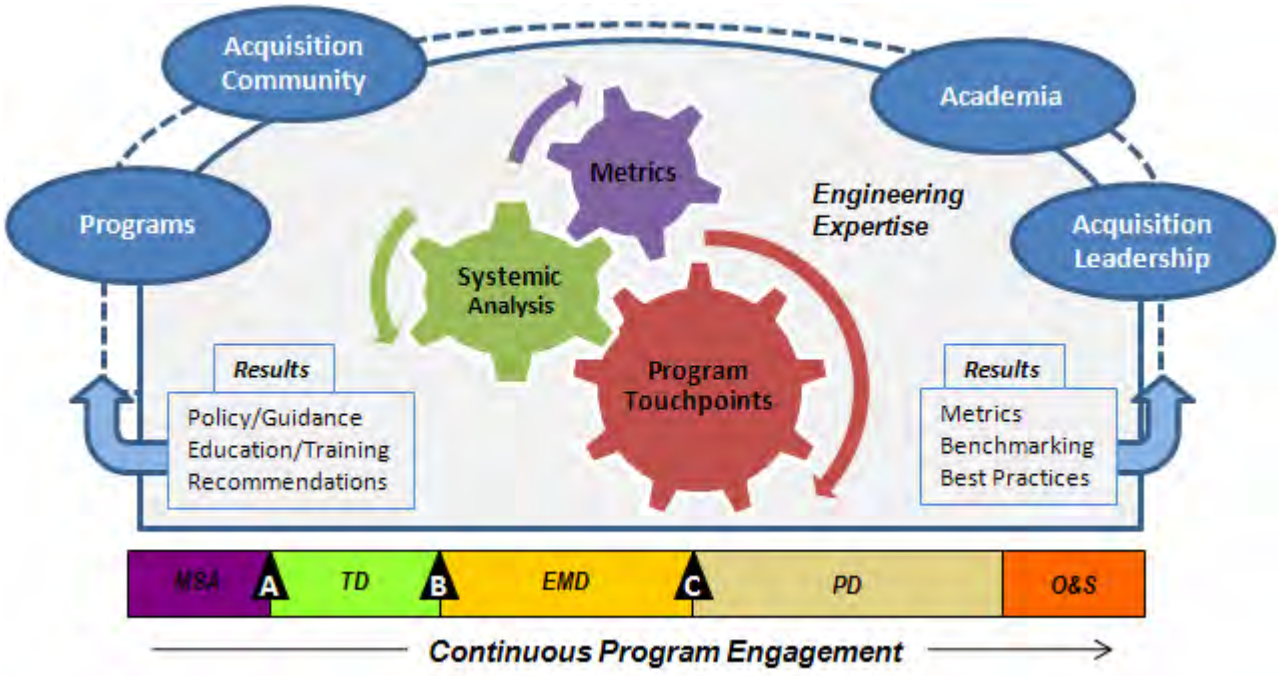
"…remain cognizant of our programs' progress…and identify problems quickly…"

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

OUSD(AT&L)/SE
Major Program Support Directorate

Mission Statement:

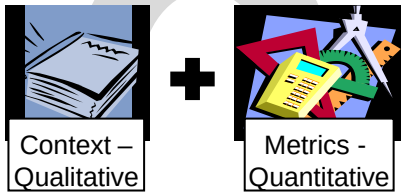
- Foster an acquisition environment of collaboration, teamwork, and joint ownership of program success through a proactive program oversight process ensuring appropriate levels of Systems Engineering discipline are applied through all phases of the acquisition life cycle



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Themes

- **Building Bridges/Collaboration**
  - Services for Service-led PSR
  - Industry for metrics/measurement
- **Communication**
  - Results fed-back thru multiple channels (e.g. SEP Prep Guide update, Annual Report, program engagement, conference/symposia
- **Integration**
- **Metrics**
  - Help programs establish effective SEP that includes metrics
  - Track execution to plan
  - Augment qualitative information with engineering quantitative data
    - Software
    - Reliability
    - Manufacturing
    - Integration

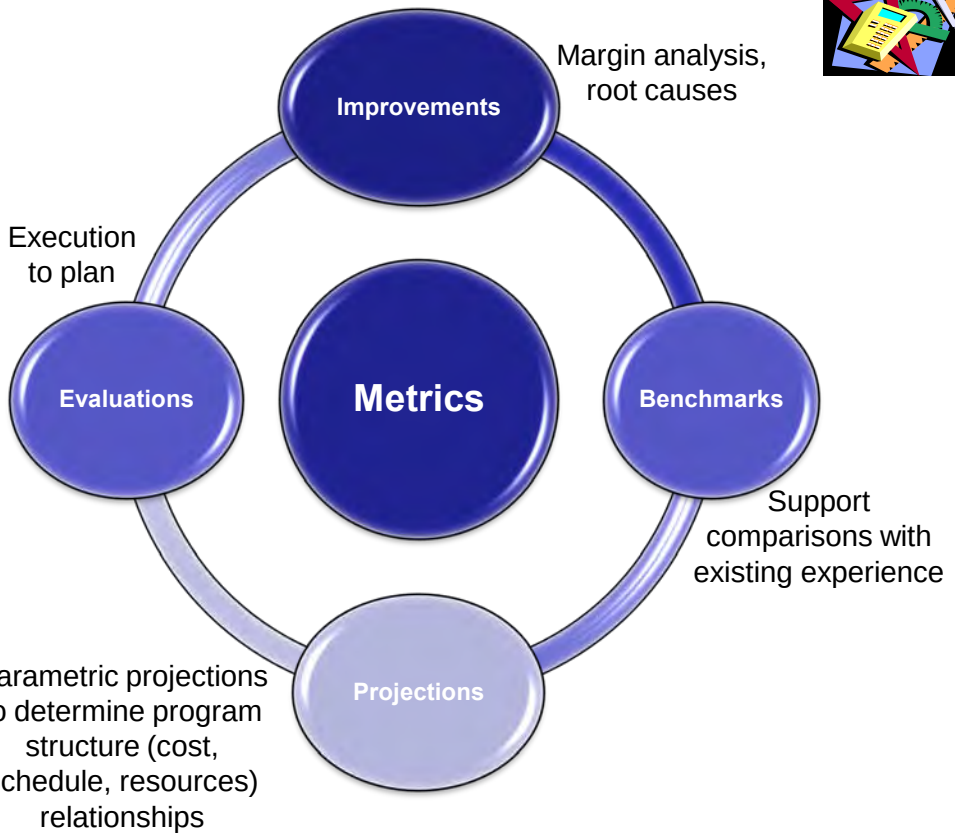


Use existing information for better decisions

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

SE Metrics Goals
"What we are trying to achieve"

- Emphasize quantitative understanding consistent with Industry practice of system engineering
- Make visible relationships between system/equipment design objectives and performance
- Harness and use existing information for timely and better decisions at the appropriate levels



"To measure is to know."
"If you can not measure it, you can not improve it."
Lord William Kelvin (1824-1907)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

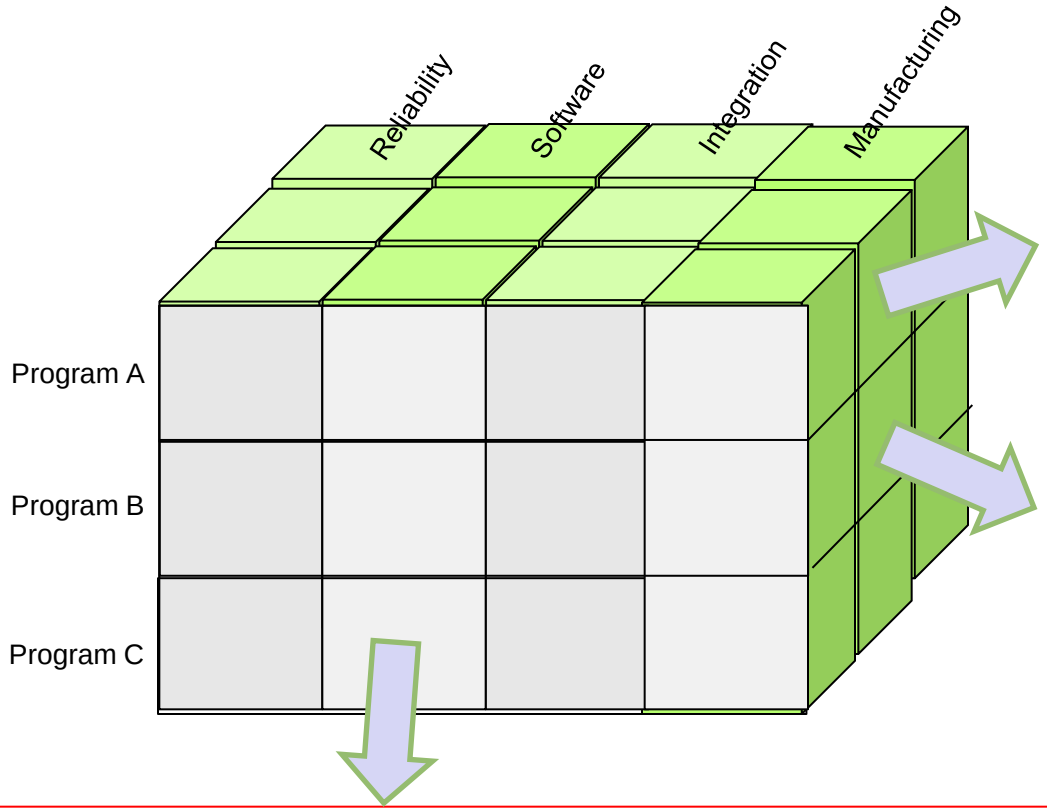
The Few vs. The Many

- There are a lot of metrics out there already
- More is not better
- Selectively harness the appropriate measure based on information needs and decision points

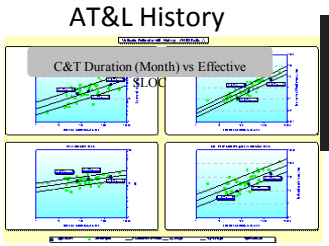
vs.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

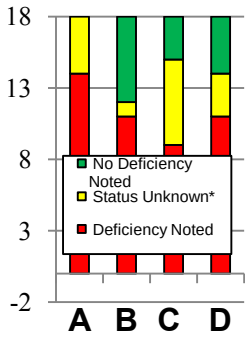
SE Products (in Progress)



Individual program comparison versus benchmarks



Performance Across Programs



Systemic Analysis

Systemic Findings 2010; Example - Software

- Software Development Plans do not exist, or lack needed information, outdated - 14% MDAP reviews conducted
- Significant variation in software development estimates – 13%
- Actual software reuse achieved significantly less than planned – 11%
- Lack of metrics prevent accurate awareness of software activities in each development phase – 10%
- Software requirements are ambiguous; not fully specified, developed and managed – 10%

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Manufacturing Metrics
Selecting Metrics to Collect

- DoD weapon system manufacturing problems: systems cost far more and take much longer to build than estimated*
- Most programs use manufacturing metrics, but there has not been a disciplined effort to collect and establish benchmarks

EMD Metrics**: Develop affordable and executable manufacturing process

- Build to Packages
  - Scheduled and change history
- Qualification Tests of LRU /critical component
  - Number scheduled and completed
- Engineering Change Numbers
  - Class 1/2 to product definition made after CDR
- Touch labor hours by end item

LRIP Metrics**: Establish initial production base; orderly increase in the production

- Delivery Performance
  - Contractual delivery date and actual date
- Touch labor hours
  - Total planned and actual hours
- Scrap, rework and repair (SRR) Hours
  - Target and actual by end item
- Travel work
  - Total travel hours by end item
- Engineering Changes
  - Number predicted and actual

Context

- Type of equipment being manufactured
- New materials processes are being used
- New factory line or existing line modified
- Last time contractor manufactured a similar system; percent similarity
- CAD/CAM system used

Notes:

*GAO Report April2010 "BEST PRACTICES: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed "

** Metrics will evolve over time

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Software Metrics

Benchmarking & Parametric Analysis Available

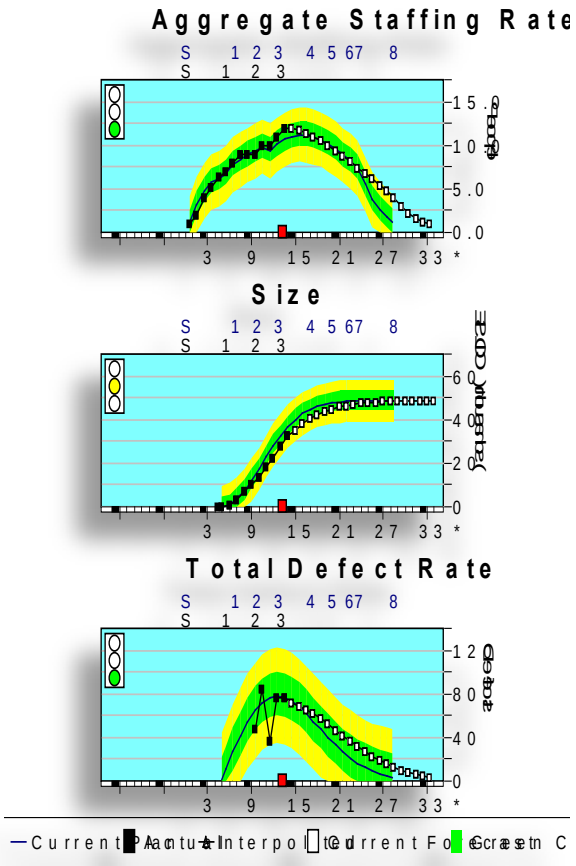
- DoD is collecting software metrics
  - Major Programs submit Software Requirements Data Report (SRDR) to Defense Cost and Resource Center

Metric

- Sizing (SLOC)
  - For each build (new/modified/reused)
  - Begins at Milestone A with progressive detail throughout acquisition cycle

Numerical Context

- Peak staffing for each build
- Effort hours for each build
- Duration (start and end dates, both planned and actual) for each
- Any reliability standard (Mean Time to Defect, MTTD) or actual defects discovered
- System type (business, scientific, real time(e.g., avionic))
- Any metrics from previously completed builds/releases is useful for direct comparison



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Reliability Metrics

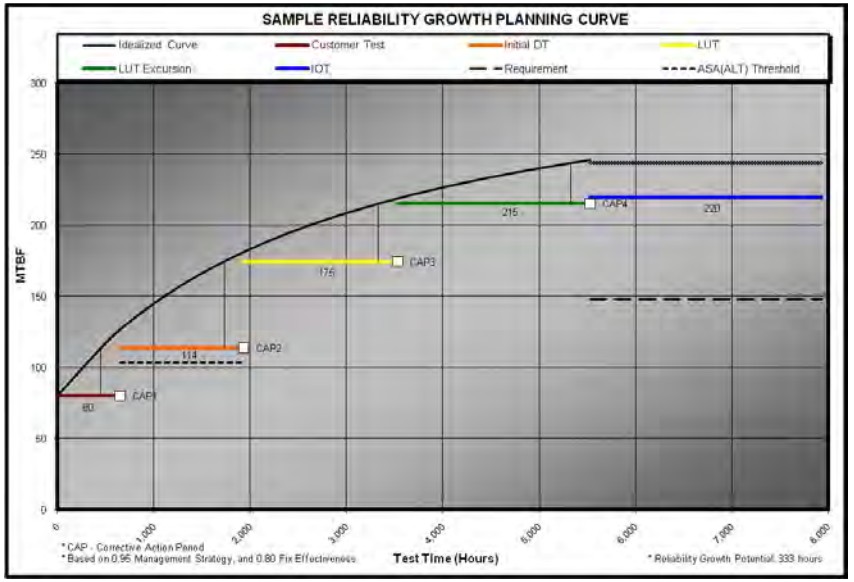
Reinvigorating DoD Metrics Field Collection Activities

- Achieving reliability objectives -- key enabler to meeting future stringent budget targets

Metrics

- General Reliability ("as planned" to "as achieved")
  - Operational Reliability
  - Logistics Reliability
- Reliability Growth Metrics
  - Mean Time Between Failures Initial ($MTBF_I$)
  - Failure Modes Identified/Addressed

Start at program initiation vs. MS B

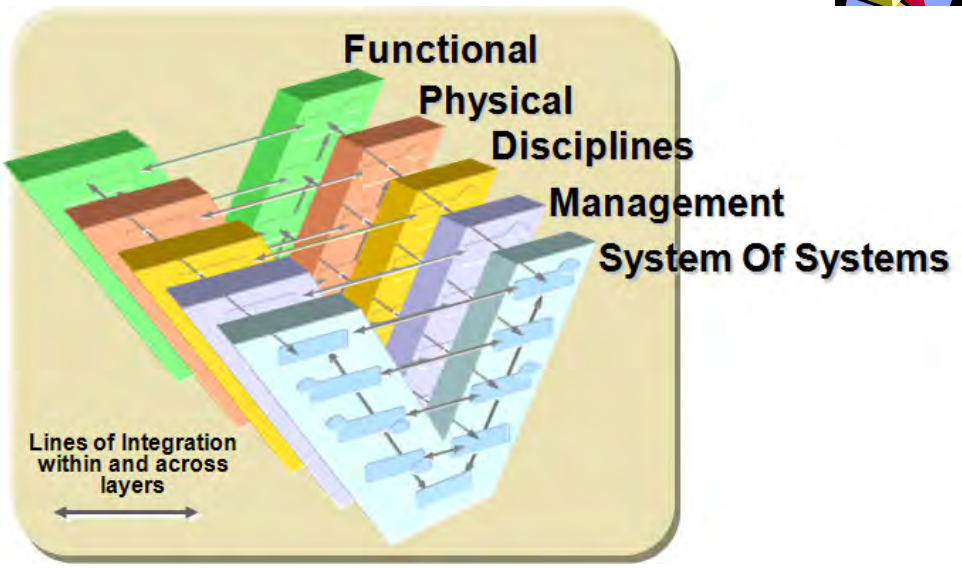


System	MTBSA (Point Estimates)		
	MS C (FY09)	Current (FY10)	Rqmt (CPD)
NIK	13	73	112
UAS	7.3	107	23
SUGV IQT	9.7	84	42
SUGV TT	9.7	339	42
T-UGS	38.9	595	127
U-UGS	24.3	503	105

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Integration Metrics
Focus on Developing

- Difficult to define
- Integration challenges are generally recognized late in the acquisition process



Metrics

- Availability depends on when system configuration is defined and application
  - System Interfaces (internal)
  - System of System Interfaces (external)
  - Mission Threads
- Relevant to all applications
  - Number of Integration Laboratories
  - Integration Progress

Context

- Type of systems/equipment (e.g., aircraft, ship, dismounted soldier) and a description indicating the complexity of the system being integrated.
- Types of Configuration items being integrated (e.g., vehicle, communications, sensors, weapons, software processes, etc.)
- Schedule duration in months (Critical Design Review to IOT&E)
- Engineering resources (e.g. man hours)specifically devoted to integration as documented in the IMP

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Negative Systemic Findings

Sep 2010

Top 10 Overall

1. Marginal program office staffing - 31% (seen on 31% of programs reviewed)
2. Progress is impeded by the lack of good communications between the Government and contractors. – 24%
3. Program has an inadequate system engineering process - 23%
4. Test schedule is aggressive/ success-oriented/ and highly concurrent - 23%
5. Current program budget is not sufficient to execute the proposed program – 20%
6. Requirements are not stable – 20%
7. Requirements are vague, poorly stated, or not defined – 20%
8. Requirements creep - 18%
9. Risk management tools and methodology are not sufficient - 18%
10. Incomplete or missing a systems engineering plan (SEP) – 17%

Focus area results

Category: Reliability

- Reliability is not progressing as planned or has failed to achieve requirements – 14%
- Reliability test program is needed – 14%; Reliability growth program not in place – 10%
- Reliability is currently based on analytical predictions and won't be demonstrated until late in program – 10%

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Partnering with Industry

- **Systems Development Performance Measurement Working Group**
  - Sponsored by NDIA SE Division in conjunction with PSM
  - Timeframe: Jan 2011, 6 month duration (short-term)

- **Objectives:**
  - Develop performance leading indicators that focus on readiness to proceed
  - Develop implementation solution space and mechanisms for measurement
  - Explore recommendations regarding developing industry benchmarks
- **Leverage data that is readily available**
- **Support DDR&E/SE Imperative:**
  - "Reduce cost, acquisition time and risk of our major defense acquisition programs"
- **Participation announcement forthcoming**

Get the right leading indicators in place to understand readiness – based on experience and risk

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Conclusions

- **Metrics**
  - Elegant systems engineering designs require us to augment intuition and judgment with quantitative means and effective analytical methods
  - Harness the right measures to help inform decisions
  - Industry, Academia, Agencies, Services have role in shaping quantitative methods and driving efficiencies into acquisition
- **Integration**
  - Integrate the information for better domain management /problem solving
- **Communication**
  - Effectively shape, share and disseminate results:
    - Updates to policy and guidance (e.g. SEP Prep Guide)
    - Conference, symposia, white papers, etc
- **Building Bridges**
  - Services, Industry, Acquisition Leadership, Academia

"Performance Management via Metrics". Program Mgt Track 2. Thur 10:50am

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

For Additional Information

Jim Thompson

ODDR&E/Systems Engineering

(703) 602.0851 | James.Thompson@osd.mil

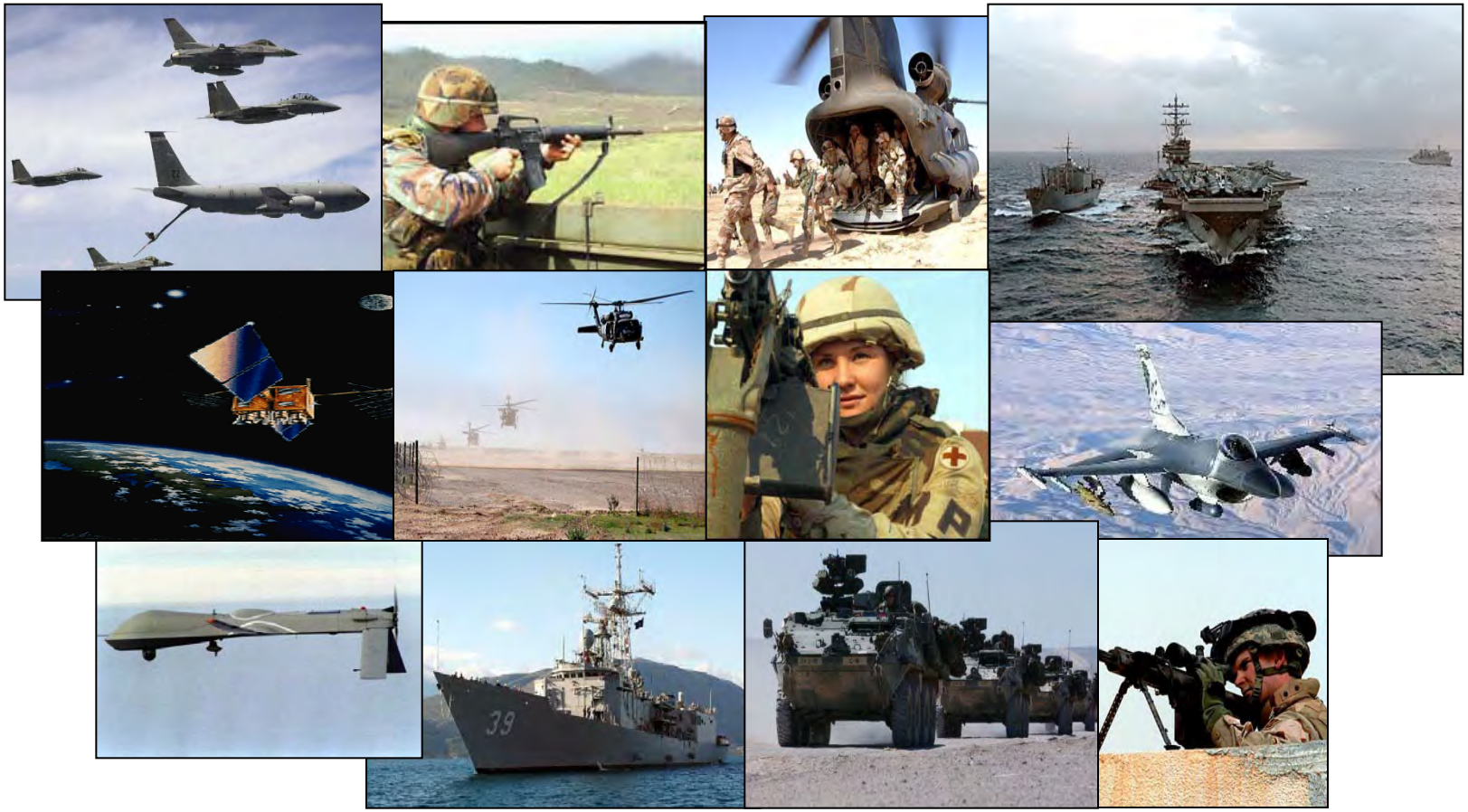
Laura Dwinnell

FASI

(703) 602.0851 | Laura.Dwinnell.ctr@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Systems Engineering: Critical to Program Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0072 applies.

Systems Engineering (SE) Project Metrics

Kalyani Tripathi, Systems Engineer
ARDEC- Systems Engineering Infrastructure
Kalyani.Tripathi@us.army.mil
973-724-9695

Need of SE Metrics

- Why do we need SE Metrics?
  - Determine how the projects are doing in regards to cost, schedule and performance
    - Provide feedback to projects
  - Determine the usefulness of SE Organizational Standard Processes (OSP)
    - Continuous improvement of current OSPs
- At the end of the day:
  - Want to help projects become more successful

Metrics

- Perform data collection and analysis for the following metrics on a quarterly basis and generate reports including recommendations

- List of Metrics:
  1. Requirements Stability
  2. Quality of Requirements
  3. Requirements Traceability
  4. Procedure Compliance
  5. Customer Satisfaction
  6. Process Tailoring
  7. Technical Performance Measures (TPMs)
  8. Project Deliverables
  9. Execution Per Roadmap
  10. Technical Reviews

Metrics

- Discuss the following metrics today:
  - **Requirements Stability**
  - **Quality of Requirements**
  - **Requirements Traceability**
  - **Procedure Compliance**
  - **Project Deliverables**
  - **Execution Per Roadmap**

Requirements Stability

Purpose

- Ensure projects are properly defining their requirements
- Ensure projects are not excessively modifying requirements after they have been reviewed and baselined
- Extreme fluctuations late in the program can indicate poor requirement development or management
- Show requirements trends over time on projects

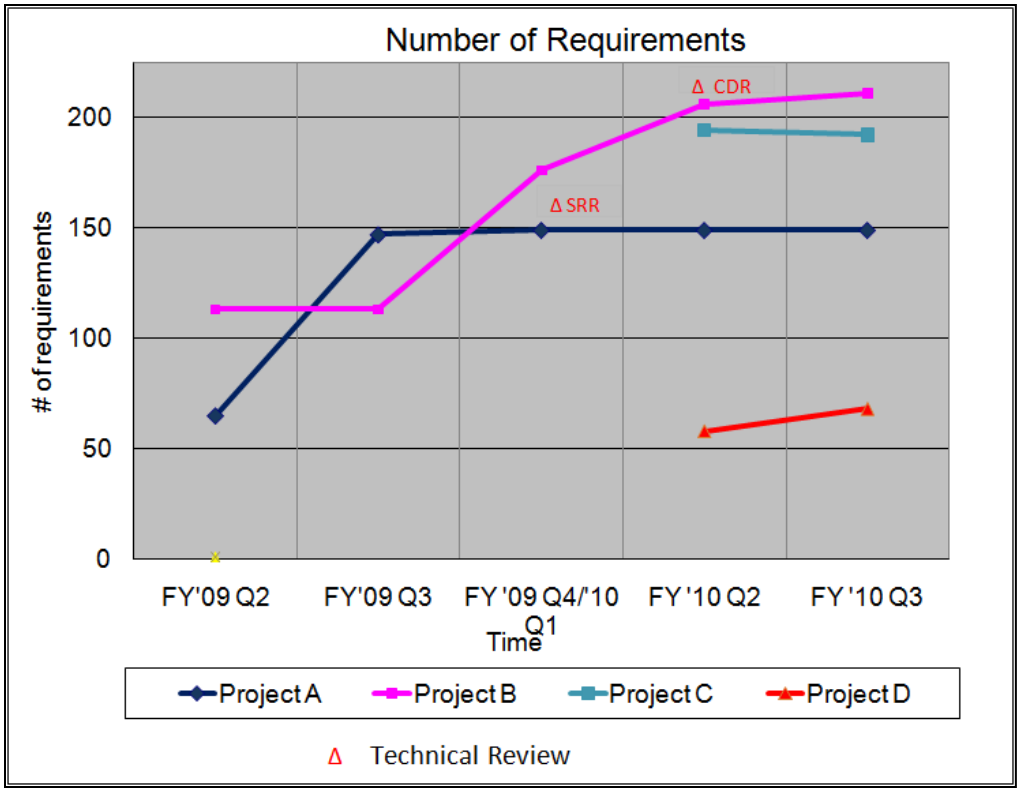
Collection Method

- Request SE leads to provide their requirements

Calculation Method

- Count the # of requirements
  - New requirements
  - Deleted requirements
  - Total Requirements

Requirements Stability Charts



Project Name	Total Number of Requirements				
	FY'09 Q2	FY'09 Q3	FY '09 Q4/'10 Q1	FY '10 Q2	FY '10 Q3
Project A	65	147	149	149	149
Project B	113	113	176	206	211
Project C				194	192
Project D				58	68

Project requirements stabilize over time

Findings & Actions

- Findings:
  - Requirements stability is critical to project success

- Actions:
  - Projects are now required to show requirements stability charts at all technical reviews after the FY'09 Q3

Quality of Requirements

Purpose

- Ensure that project requirements are being written in an acceptable manner
- Poorly written requirements is an early indication of issues

Collection Method

- Request SE leads to provide access to their requirements

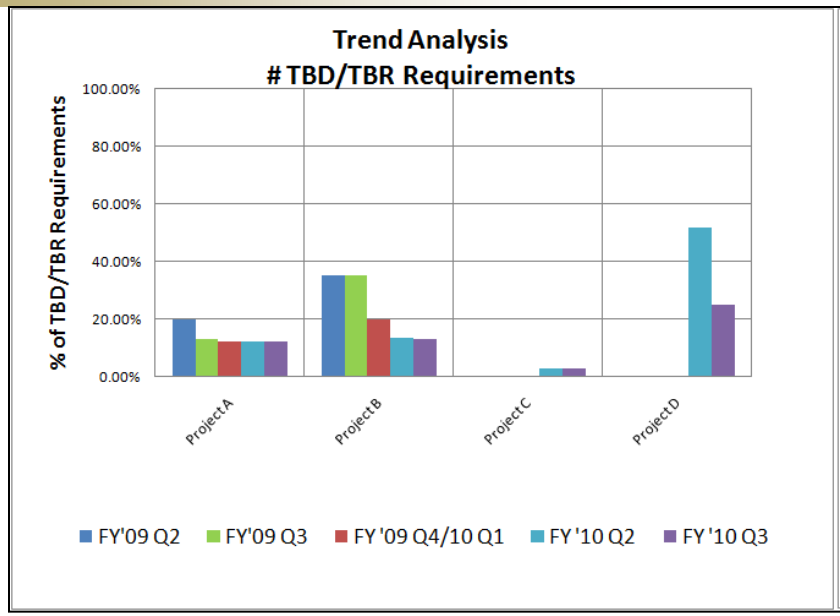
Calculation Method

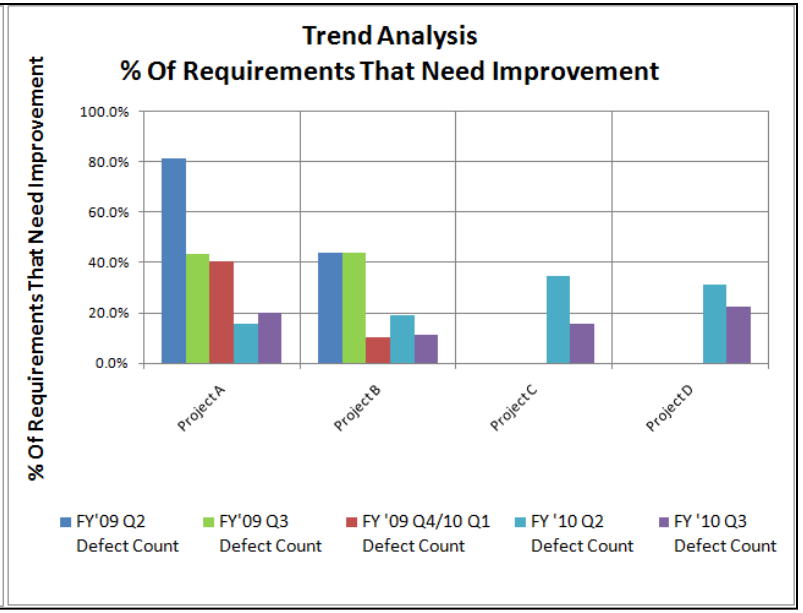
- Check the requirements for the following defect categories:

Achievable	Necessary and Sufficient	Expressed in terms of needs, not solutions	Complete
Verifiable	Consistent		Unambiguous

- Manually search a sample size of requirements [10-25% of total] to determine defects
- Count the number of To Be Determined (TBD)s, To Be Reviewed (TBR)s requirements

Quality of Requirements Charts





Analysis:

% of TBDs/TBRs are acceptable since these projects are still defining their requirements

Project A :12% - Same # from Q2'10 to Q3'10
Project B :14% - Same # from Q2'10 to Q3'10
Project C :3% - Same # from Q2'10 to Q3'10
Project D : 29% - **Decreased** from Q2'10 to Q3'10

Review 10~20% sample size of the Project requirements

Project A 6/30 –(20%) for Q3'10. (16%) for Q2'10)
Project B 6/54 – (11%) for Q3'10. (19%) for Q2'10)
Project C 5/32 – (16%) for Q3'10. (34%) for Q2'10
Project D 6/27 – (22%) for Q3'10. (31%) for Q2'10

Note: Projects are techbase so TBD/TBR is expected as the requirements are still evolving and some projects are still defining requirements.

Findings & Actions

- Findings:
  - Requirements were not well written and inconsistencies exists between projects
  - Tech base projects are expected to have some TBDs/TBRs
  - Positive Trend Observed
    - Quality of requirements have improved
    - TBDs/TBRs have decreased

- Actions:
  - Corrective actions were taken immediately such as:
    - Developed a Requirements Development best practices guide which includes characteristics of a quality requirement to write good requirements
      - ✓ Incorporated into the OSP
      - ✓ Trained the workforce
  - Feedback was provided to projects

Requirements Traceability

Purpose

- Ensure that all requirements are traced from higher to lower level and vice versa

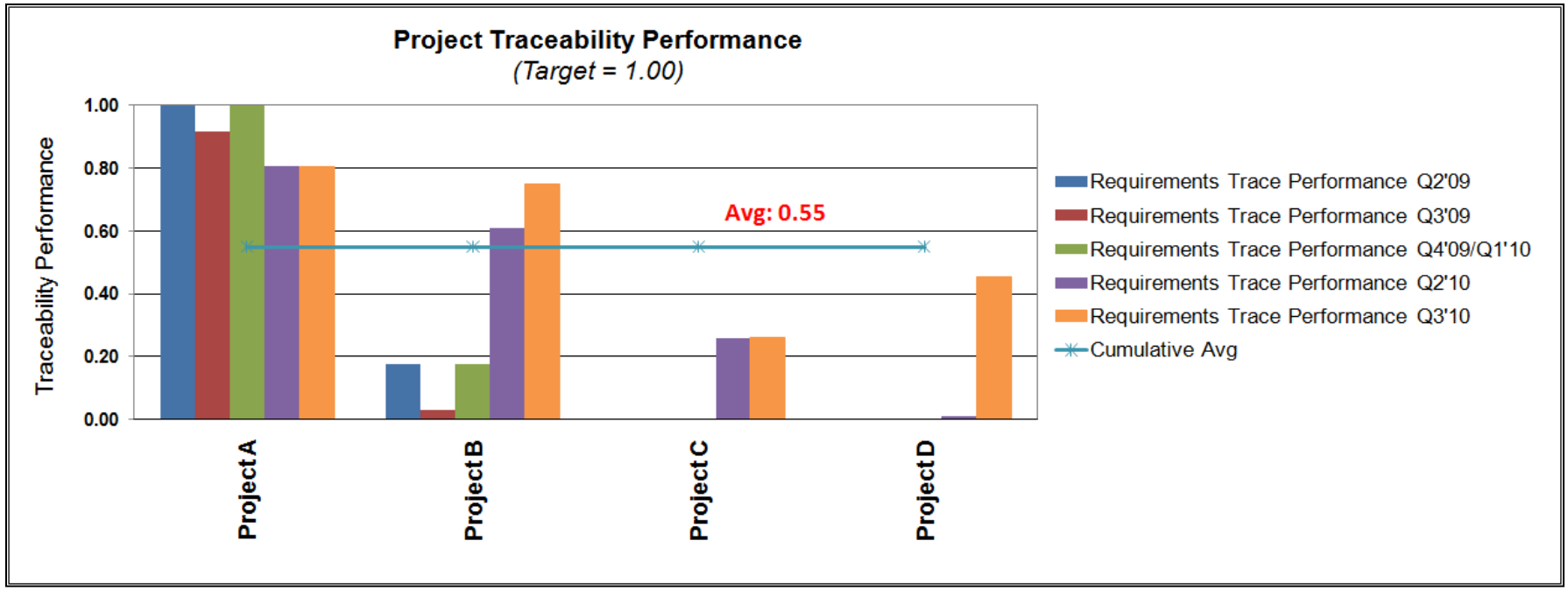
Collection Method

- Request SE leads to provide access to their requirements management tool (DOORS)

Calculation Method

- Conduct traceability analysis in the requirements management tool (DOORS)

Requirements Traceability Charts



Analysis:

- Overall Traceability has increased from Q2'10 to Q3'10.(42% to 57%)
- Project A has decreased traceability. It is an issue and was reported to the management.
- Project B and Project D (0 % to 46%) has increased traceability from Q2'10 to Q3'10

Findings & Actions

- Findings:
  - Requirements were not 100% traced from higher to lower level and vice versa
- Actions:
  - Provided guidance on using DOORS Tool for requirements.
  - Projects have improved on traceability once DOORS tool have been used
  - Keep encouraging project leads to put more effort into tracing their requirements
  - Ran reports in DOORS to check for In-links and Out-Links to verify traceability
  - Suggested and provided the traceability guidance document to use

Procedure Compliance

Purpose

- Ensure the procedures are followed as tailored by the project:
  - Requirement Management (RM)
  - Requirement Development (RD)
  - Configuration Management (CM)
  - Data Management (DM)
  - Technical Assessment (TA)

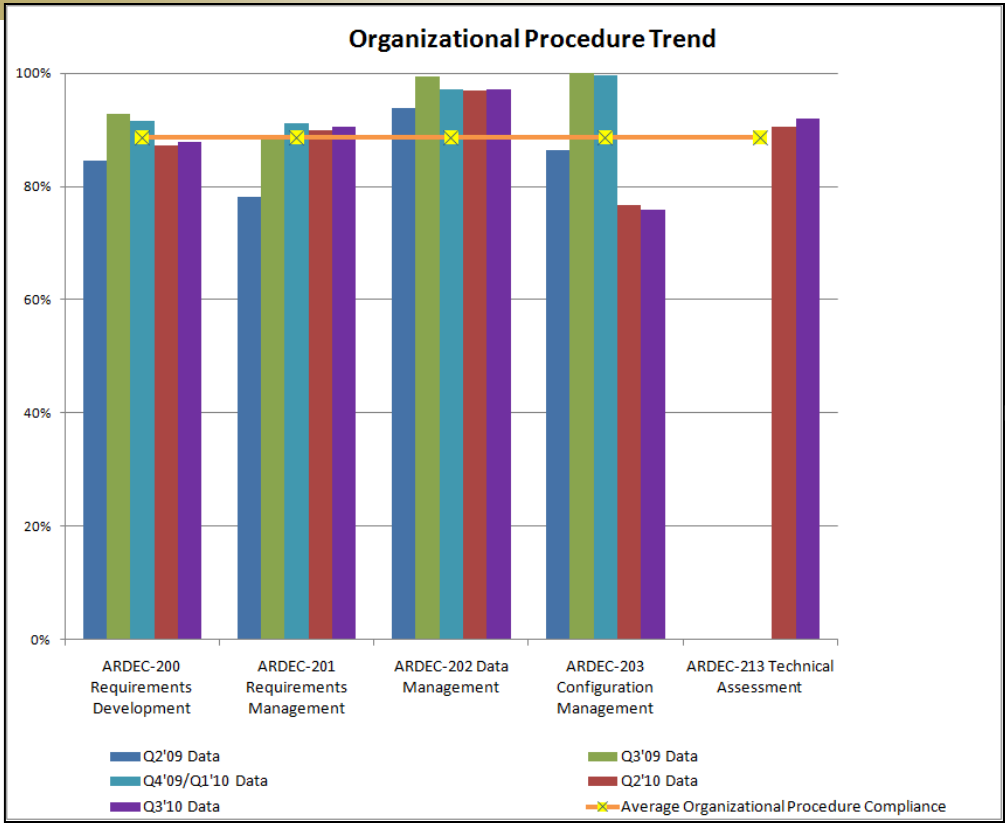
Collection Method

- Face to Face sessions with SE

Calculation Method

- Accept SE's input for compliance
- Two way communications with the SE to assess compliance
- Compliance is also verified with documentation

Procedure Compliance Charts



Project Procedure ComplianceQ3'10	Project A	Project B	Project C	Project D	Organizational Procedure Compliance
ARDEC-200 Requirements Development	97.92%	94.79%	87.50%	71.30%	87.88%
ARDEC-201 Requirements Management	100.00%	100.00%	98.33%	63.54%	90.47%
ARDEC-202 Data Management	98.13%	100.00%	100.00%	90.63%	97.19%
ARDEC-203 Configuration Management	80.00%	100.00%	71.00%	52.50%	75.88%
ARDEC-213 Technical Assessment	100.00%	100.00%	86.88%	80.83%	91.93%
Project Process Compliance	95.2%	99.0%	88.7%	71.8%	88.67%

Project Procedure ComplianceQ2'10	Project A	Project B	Project C	Project D	Organizational Procedure Compliance
ARDEC-200 Requirements Development	97.92%	93.75%	90.00%	67.71%	87.34%
ARDEC-201 Requirements Management	100.00%	100.00%	92.81%	66.67%	89.87%
ARDEC-202 Data Management	100.00%	100.00%	100.00%	87.50%	96.88%
ARDEC-203 Configuration Management	80.00%	100.00%	68.33%	58.33%	76.67%
ARDEC-213 Technical Assessment	100.00%	100.00%	80.91%	80.91%	90.45%
Project Process Compliance	95.6%	98.8%	86.4%	72.2%	88.24%

Analysis:

- Average Procedure compliance has almost stayed the same from Q2’10 to Q3’10. (88.24% to 88.67%)

Findings & Actions

- Findings:
  - None of the projects were 100% compliance with their project's processes
  - Early indication that some of the standard OSPs are not used efficiently

- Actions:
  - Provided Peer Review procedure, Technical Assessment procedure and Lessons Learned procedure to the project SE.
    - Reminded that the SE OSPs are available at the Process Assess Library (PAL)
  - Provided guidance on how to do Configuration Management Audits
  - Reviewed which OSPs may be required to be modified based on data collected
    - Some sections may not be required

Project Deliverables

Purpose

- Determine the “goodness” of SE deliverables

Collection Method

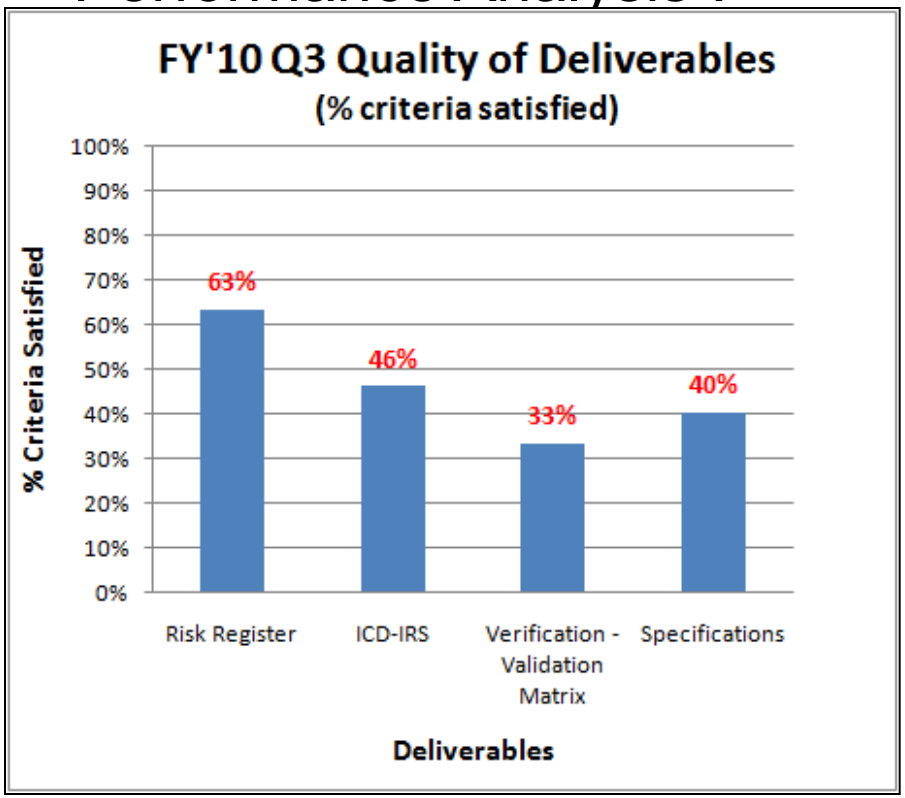
- Request project leads to provide deliverable

Calculation Method

- Independent Review based on pre established criteria checklist specific per deliverable
- Provided the pre-established criteria checklist to the projects

Project Deliverables Charts

Performance Analysis :



	Project A	Project B	Project C	Project D	Artifacts Reviewed	Criteria Satisfied
Risk Register	1		1	1	3	63%
ICD-IRS		1	1		2	46%
Verification - Validation Matrix				1	1	33%
Specifications			1		1	40%

Projects have partially satisfied the criteria of good deliverable

Findings & Actions

- Findings:
  - Project deliverable are not meeting the pre-established criteria of a good deliverable

- Actions:
  - Provided guidance documents on how to develop risk register, ICDs, Verification matrix to improve the quality of the current deliverables
    - ICD – provided the ICD template
    - Verification-validation matrix – provided an example
    - Specification – provided the requirements specification template
    - Risk Register – provided the Risk Register template

Execution Per Roadmap

Purpose

- Determine the project's SE task performance index (TPI)
- Find out if planned tasks are being accomplished according to the project roadmap schedule
- Ensure that all planned tasks get completed according to the schedule (TPI=1)

Collection Method

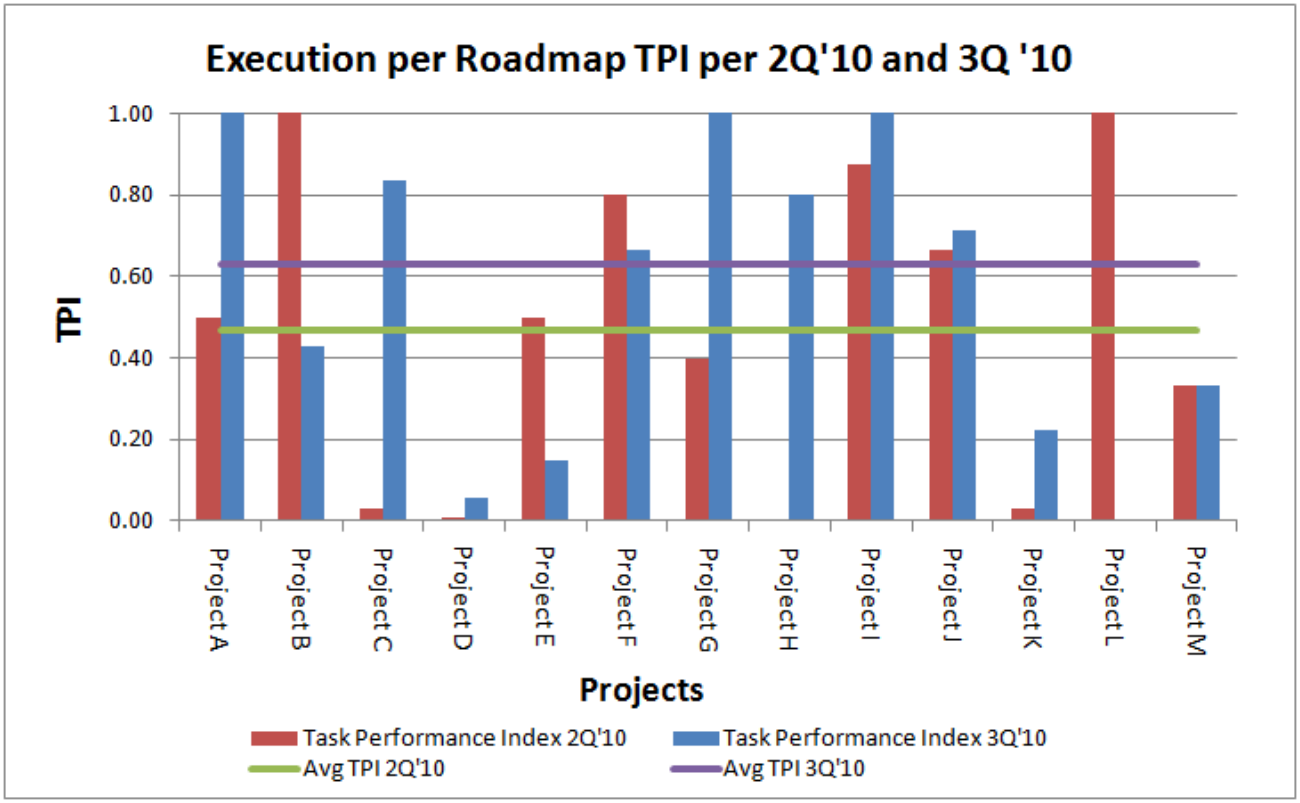
- Identify planned and completed tasks in the roadmap

Calculation Method

- Assess the latest 2 quarters roadmap to ensure tasks are completed according to their scheduled dates
- TPI = (Tasks Performed) (from quarter n)

  (Tasks Scheduled) (from quarter (n-1))

Execution Per Roadmap Task Performance Index



- Data analysis was done on 13 projects
- Avg TPI 2Q’10 - 0.47
- Avg TPI 3Q’10 – 0.63
- Avg TPI increased from 2Q’10 to 3Q’10

Findings & Actions

- Findings:
  - Planned vs. Accomplished tasks shows that tasks are accomplished but not 100%
  - Projects were not using the current version of roadmap tool
  - Some projects have gone back to the older version of the roadmap making it difficult for analysis

- Actions:
  - SE Lead will have to be very specific on updating Roadmaps
    - Very specific on dates to understand if a task is completed or not
    - Current status should indicate if a task has a new completion date
  - All the projects should use the latest version of Roadmap tool
  - Provided metrics data to project management - System engineering area lead
    - Early indication to track a technical review

Conclusions

- Provide early indication of potential issues
  - Corrective actions can be taken immediately when required
  - Markers for improvement in performance
- Sister Organization (PM) responsible for collecting data on overall project cost, schedule and performance metrics
  - Leverage their metrics data to assess SE Return on investment
  - Goal is to quantify the value of SE – Project performance vs. Project cost
- Value of SE OSPs can be assessed
  - SE documents can be improved to add more value to projects
- Lessons learned documented in the quarterly data analysis
  - Management supports continuing metrics collection
  - SE Metrics will evolve with time, to stay relevant to current project environment

Questions?

Value of Systems Engineering

Kerri Polidore, Systems Engineer
ARDEC- Systems Engineering Infrastructure
Kerri.polidore@us.army.mil
973-724-1983

BLUF

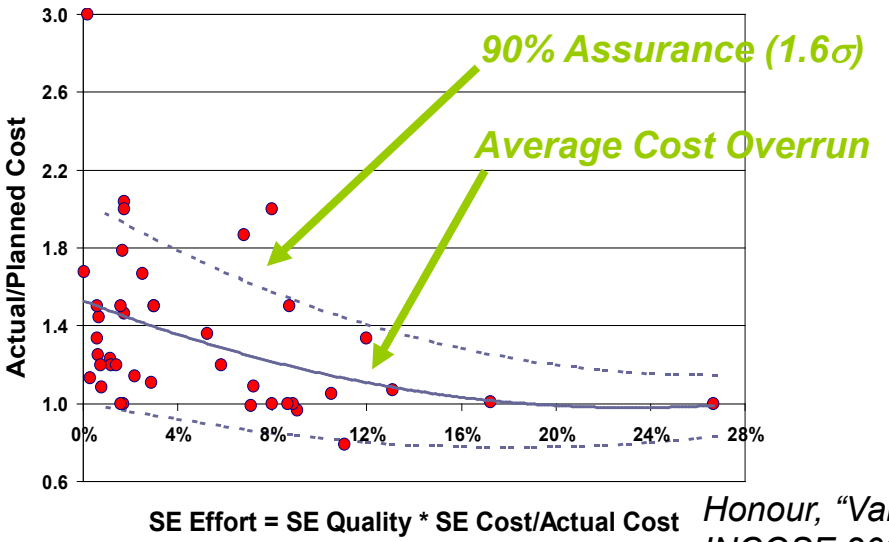
- "…there is a strong case to be made for a quantitative relationship between systems engineering investment and the quality of program performance." – Eric Honour, Value of Systems Engineering

How can we capture the value of Systems Engineering?

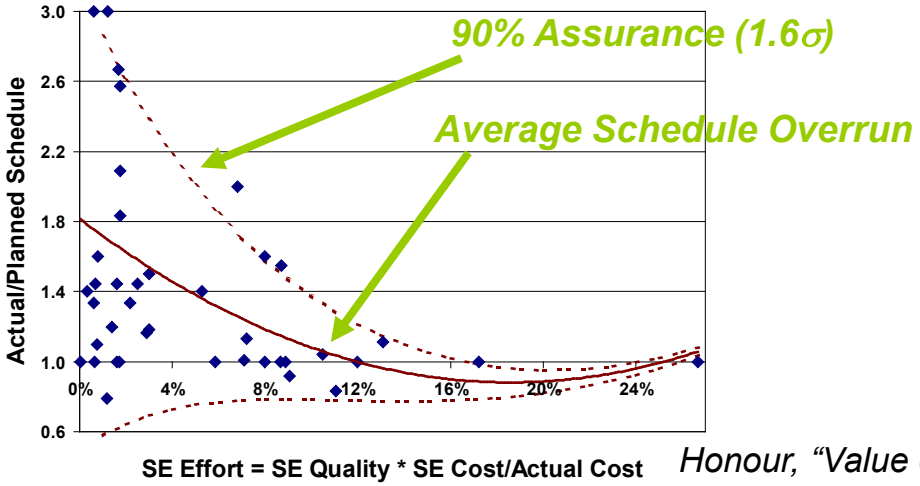
Goals & Strategy

Goal	Strategy
What information is available about the value of SE?	Research •INCOSE Value of SE & SE ROI •Qualitative findings •Quantitative findings
Determine Value of Systems Engineering on a given program at ARDEC	Use the Voice of the Customer/Interviews •Determine how much SE was done •How has SE benefited the program? •Where was there room for SE-related improvement?
Capture SE lessons learned to foster improvement	

Outside Findings- INCOSE



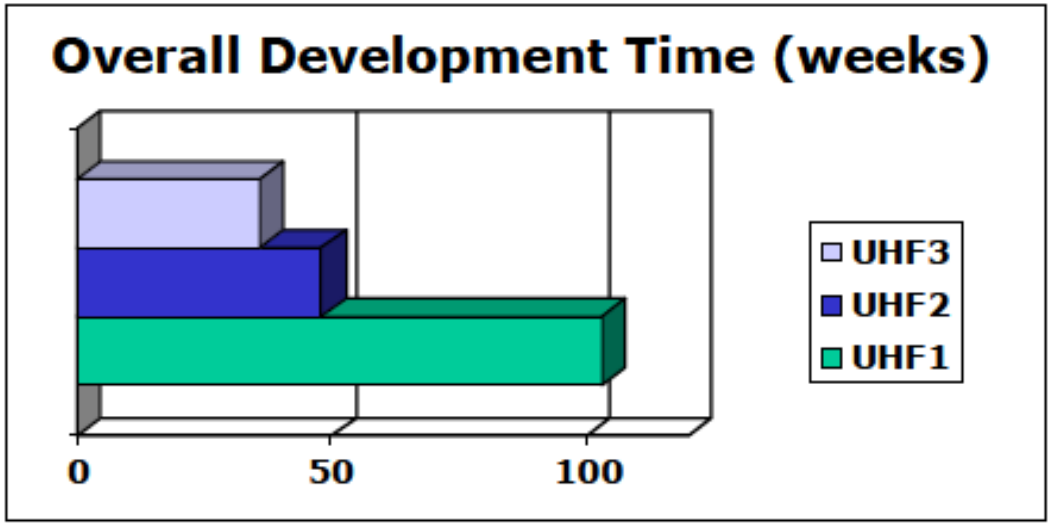
Honour, "Value of SE"
INCOSE 2004



Honour, "Value of SE"
INCOSE 2004

Malcolm Baldrige National Quality Award 2007 Award Recipient

Outside Findings- INCOSE



*

- Boeing study- Parallel development of 3 Universal Holding Fixture (UHF)
- UHF 3 was the most complex system
- More rigorous SE resulted in shorter durations between:
  - Requirements to subcontract RFP
  - Design to production
  - Overall development time
- Also superior quality of work (subjective)

* Honour, Eric C. Understanding the Value of Systems Engineering. Pg. 8. Honourcode, Inc.

Outside Findings- INCOSE

- Systems Engineering Return on Investment (ROI)
  - Follow up on Value of SE and SE Effectiveness research
- Interview a set of programs from participating organizations
- Formal, consistent interview format
- Gather data in regard to:
  - Funding method
  - Total program cost
  - Cost compliance (% over or under planned cost)
  - Schedule compliance (% over or under planned schedule)
  - Percentage of program cost used in SE effort
  - Subjective assessment of SE quality (scale of 1- poor to 10- world class)

Outside Findings- INCOSE

- Correlation between project success and ratio of effort on each area of SE to total SE effort
  - Verification/Validation
  - Technical Management/Leadership
  - Technical Analysis
  - System Implementation (integration)
  - System Architecting
  - Requirements Engineering
  - Scope Management
  - Mission/Purpose Definition
- Successful projects experienced cost overrun < 3%
  - ranging from 38% underrun to 1% overrun
- Unsuccessful projects ranged from 3% to 200% overrun

Outside Findings- INCOSE

- Unsuccessful projects, in comparison to successful projects, expended:
  - 50% less effort in mission definition
  - 33% less effort in requirements engineering
  - 33% less effort in scope management
  - 40% more effort in systems architecting
  - 60% more effort in implementation/integration
  - 25% more effort in verification/validation

Successful Projects Spent More Up Front

Outside Findings- INCOSE

- “These findings are consistent with the long-held anecdotal knowledge… that programs expending more front-end effort can expect to reduce overall cost and schedule”*

•Honour, Eric C. “Demographics in Measuring Systems Engineering Return on Investment (SE-ROI)”. INCOSE, 2009.

How does ARDEC measure up?

- Metrics
- Project Exit Interviews
- Lessons Learned

Metrics Overview

- Gather metrics on select projects during execution to monitor:
    1. Requirements Stability
    2. Quality of Requirements
    3. Requirements Traceability
    4. Procedure Compliance
    5. Customer Satisfaction
    6. Process Tailoring
    7. Technical Performance Measures(TPMs)
    8. Project Deliverables
    9. Execution Per Plan
    10. Technical Reviews

Overview of Exercise

- Interview SE and ARDEC Project Officer after project close-out
  - Gather feedback on all areas of our Organizational Standard Process (OSP)
  - Establish an informal dialogue to encourage anecdotal feedback as well

* Included personnel from both System Engineering and Project Management to ensure unbiased responses

Findings- Communication

- SE role in communication is huge
  - Synthesize information from all silos
  - Dialogue with customer/user to get the right requirements
    - Combination of the right information and the right tools
    - Ex: Tracing requirements is only useful when the right requirements are being traced!
  - Also a huge role in contractor management

Findings- Technical Planning

- Laying out the project plan from a SE perspective enables success
  - Metrics & measures communicate program status
  - Provide context to frame where a project is in its lifecycle

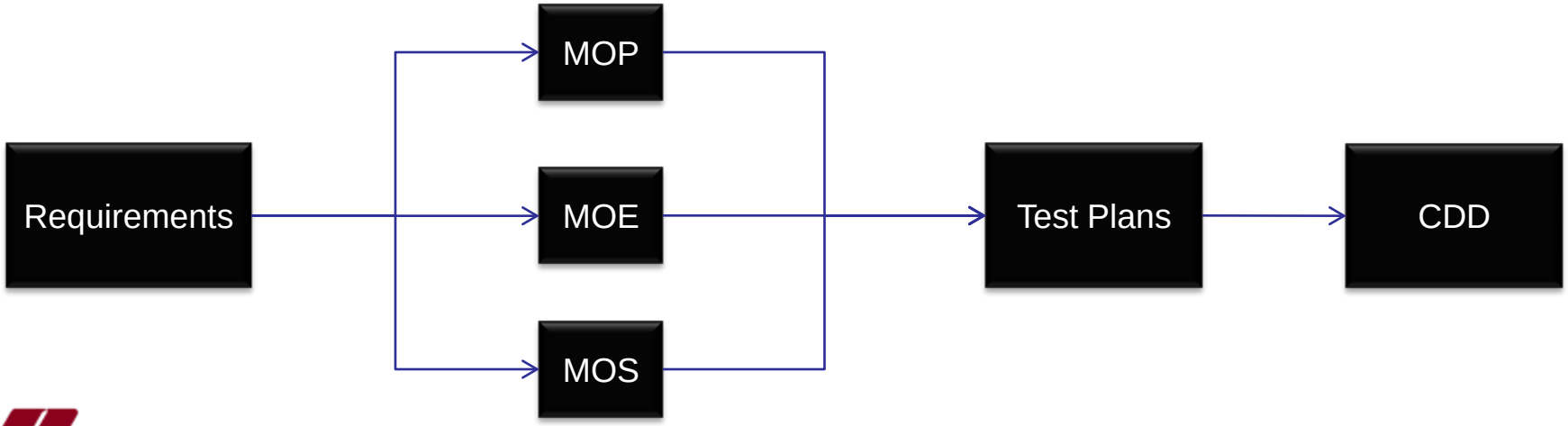
Findings- Requirements

- "Application of a tool for requirements management is critical"

- Use of DOORS as an SE tool
  - Limitations
    - Licenses- one SEL was the only IPT member with DOORS access
  - Benefits
    - Able to leverage DOORS database for numerous products and activities
      - Requirements Traceability
      - Verification plan

Findings- QFD

- Use of Quality Function Deployment (QFD) as a requirements tool
  - One program successfully implemented a QFD
    - Resulted in stable requirements through the program
    - Simplified writing the requirements document (i.e. Concept Development Document)



Findings- QFD

- Speaking to the SE and ARDEC Project Officer allowed for further discussion on successful QFD implementation
  - Gathered insight on:
    - Contracting the exercise
    - Roles and required participation
    - Leveraging the QFD to enable transition & communicate “readiness” to our acquisition partners

Findings- Risk Management

- SE's role in regard to Risk Management is pivotal
  - Communicate risk to management
  - Organize & understand variables affecting risk
    - Traditional cascading risk charts, risk matrix, risk register
    - Also implement quantitative risk analysis
      - Assess current design state

Findings- SE & Decision Making

- SE products aid in decision making
  - Removes emotion
  - Enables fact-based decisions & acquisition
  - Decision Analysis- builds consensus, defines alternatives, assigns priority
  - Example:
    - Feasibility study on one project showed that one alternative was feasible in a 10 year time frame, while another was not

Findings

- SE is commonly misunderstood
  - If tools are properly implemented, they provide a bridge to communicate with our Acquisition Partners
  - SE Products noted by projects to be especially helpful:
    - Feasibility study
    - QFD
    - Interface Control Documents (ICDs)
    - Risk matrix, associated products
    - Technology Readiness Level (TRL) tool

Findings- SE OSP

- Procedures and templates provide a useful framework for a SE
  - ARDEC SE OSP had not been established when one project began
  - SE had to research procedures and best practices on his own in order to implement the SE Process

Lessons Learned

- Stakeholder buy-in is key
  - Define acceptance criteria
  - Example:
    - Problems occurred on one project during testing as a result of undefined:
      - MOEs, MOPs, MOSs

Lessons Learned

- Establishing knowledge of and adherence to SE best practices is essential from the start of a project
  - Example:
    - Configuration Management: SE had little understanding of the process & the level of implementation appropriate for Technology Development
    - Not implementing from inception made it difficult to instantiate later on within the IPT
      - Resulted in rework during project close-out
- Inexperience is a big barrier to successful SE
  - Strong training base, weak in amount of experienced personnel

Takeaway- Value of SE

- Benefits within ARDEC
  - Open dialogue about the strengths and weaknesses of our organization and OSP after close-out allows for greater insight
    - Employees do not feel threatened
    - Project success is not threatened
    - Allow for greater understanding/documentation of lessons learned
  - Promotes SE within the organization
    - Justification for continued funding of SE Infrastructure
    - Greater understanding of what a SE can provide to a program

Takeaway- Value of SE

- Direction of Value of SE at ARDEC efforts
  - Enable robust analysis of the Value of SE by capturing more qualitative AND quantitative data
    - Continue to gather feedback from projects
      - Capture lessons learned
      - Improve ARDEC's SE OSP
      - Incorporate findings into Internal SE Training
    - Leverage cost, schedule & performance data collected by Project Management to correlate the SE Metrics we collect to project performance
      - Allow for more robust analysis of internal ROI

Conclusion

- "If you have a good systems engineer [on a program], the program goes great."
  - ARDEC Project Officer

- ARDEC projects implement SE and find utility in our SE OSP
  - Strive for Continuous Process Improvement (CPI)

Systems Engineering is beneficial in regard to project cost, schedule and performance

DoD Systems Engineering Policy and Guidance Update

Sharon Vannucci

ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Why New SE Policy and Guidance?

- **DoDI 5000.02 emphasis on early stages of pre-systems acquisition - prior to Milestone B (MS B)**
  - Reduce risk before making business commitment
  - Improve likelihood of being able to meet these commitments
- **Response to statutory direction (PL 111-23 [Weapon Systems Acquisition Reform Act of 2009] and others):**
  - Development planning
  - Additional certification requirements at MS A and B
  - Data Management Strategy
- **USD(AT&L) direction to assess the need for new reliability policy**
- **SecDef-directed efficiency initiative → USD(AT&L) Acquisition Document Streamlining Task Force**
- **Insights from DDR&E/SE acquisition program interaction**
  - Systems Engineering Plan (SEP) reviews
  - Program Support Reviews (PSR)
  - Systemic Root Cause Analysis (SRCA)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

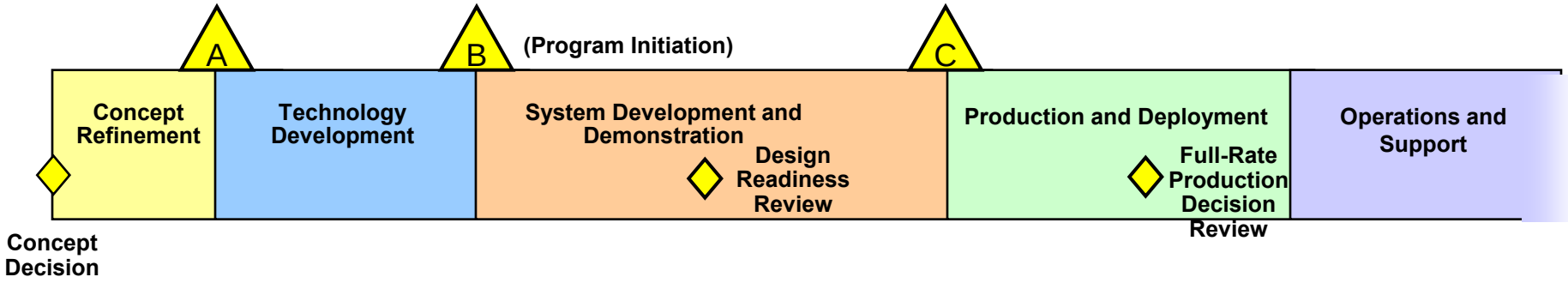
Outline

- **Policy Update**
  - Director of Systems Engineering Instruction 5134.dd (policy codification)
  - Development Planning (DTM 10-017) (new)
- **Guidance and Tools Update**
  - Systems Engineering Plan (SEP) Preparation Guide (update)
  - Program Protection Guide (update)
  - Defense Acquisition Guidebook Chapter 4 Systems Engineering (updated)
  - Technical Data Artifact Matrix (new tool)
  - Technical Review Sliderule (updated tool)
  - System Requirements Analysis Guide (new)
  - Technical Review guide (new)
  - Risk Management Guide (updated)
  - Incorporating SE in DoD Acquisition Contracts (planned update)

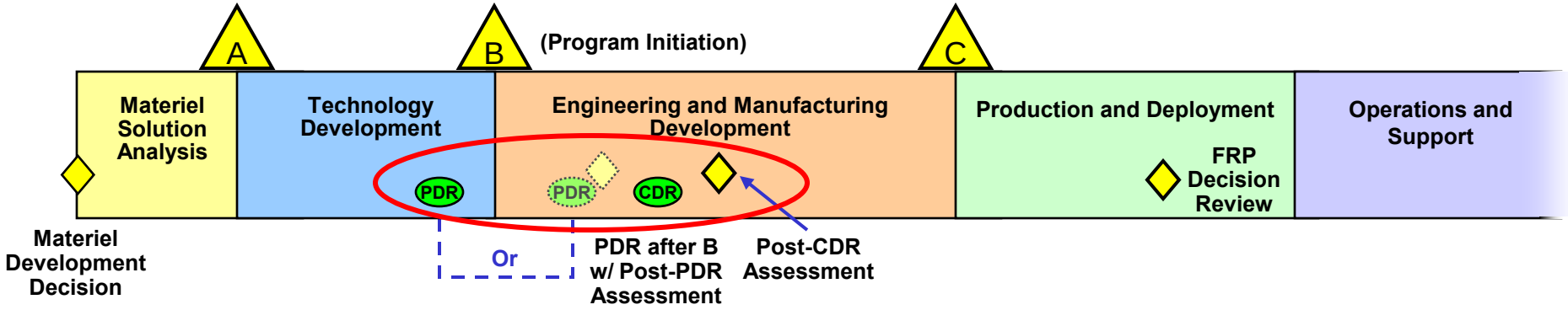
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Acquisition Lifecycle Comparisons –
A Systems Engineering Perspective

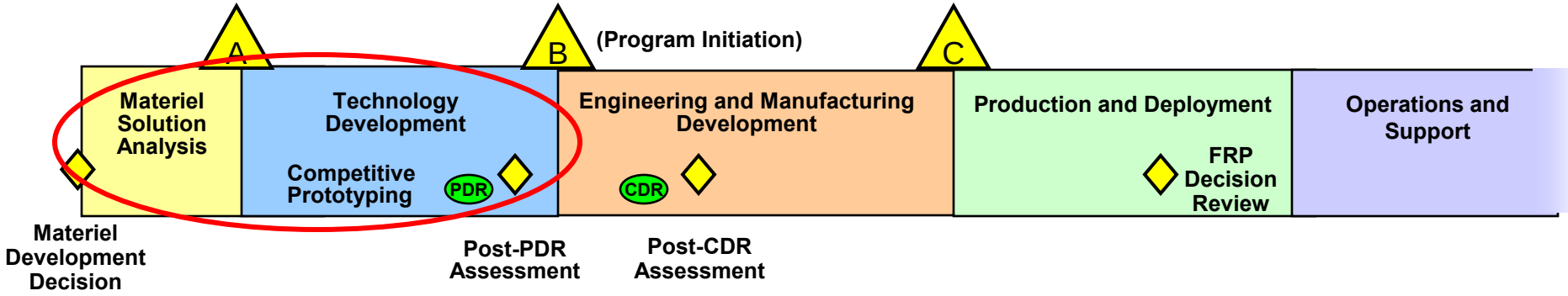
Defense Acquisition Management System, May 12, 2003



Defense Acquisition Management System, December 8, 2008



Defense Acquisition Management System, May 22, 2009 (post WSARA)



Development Planning
(New)

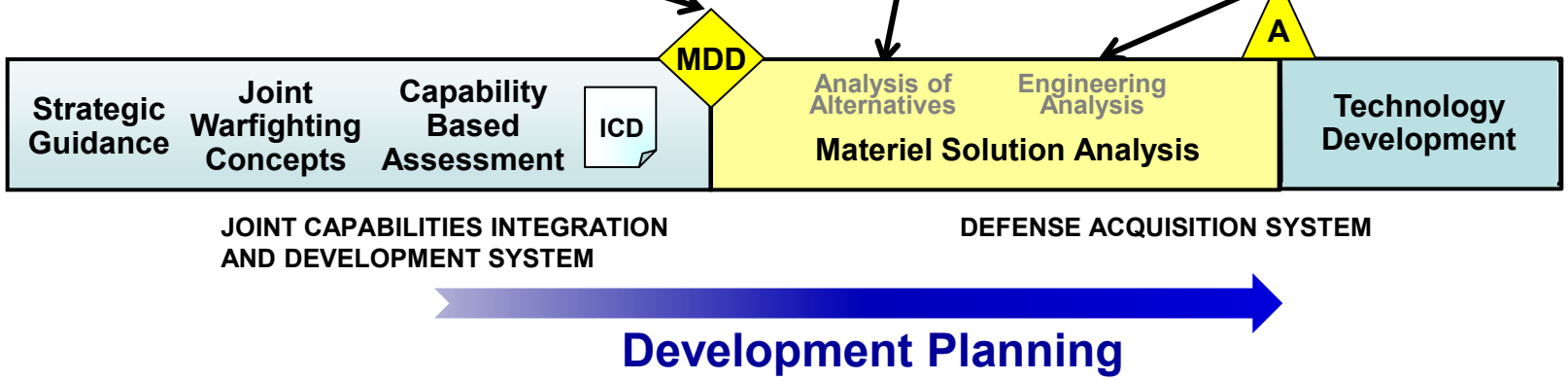
Development Planning Policy*

Oct 2010

- Enhanced technical entrance criteria for MDD
- Requires more complete technical preparation for acquisition entry

- DDR&E Engineering Engagement in the AoA
- Requires more thorough consideration of Systems of Systems impacts and technical risk drivers to cost and schedule in AoA recommendation

- Pre-Milestone A Engineering Analysis
- Prepares a focused plan for Technology Development risk reduction activities

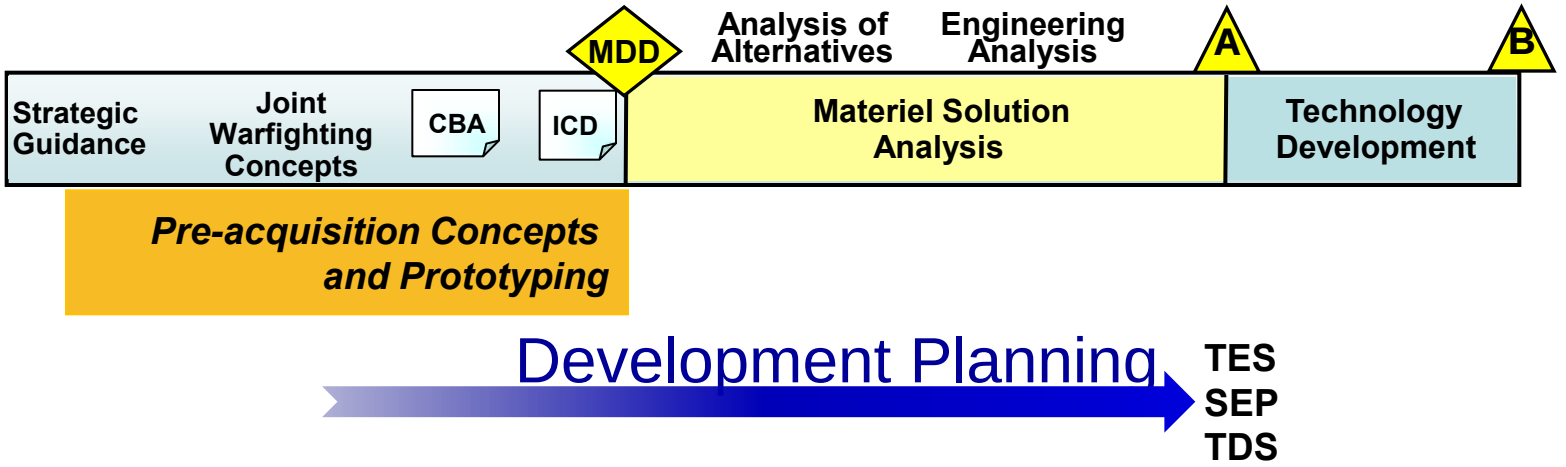


Development Planning is the upfront technical preparation to ensure successful selection and development of a materiel solution

* OUSD(AT&L) Memorandum of 13 September 2010, Subj: DTM 10-017, Development Planning to Inform Materiel Development Decision (MDD) Reviews and Support Analyses of Alternatives (AoA)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Development Planning Policy



Mandated policy at MDD:

1. The candidate materiel solution approaches have the potential to effectively address the capability gap(s), desired operational attributes, and associated dependencies.
2. There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data.
3. Consideration has been given to near-term opportunities to provide a more rapid interim response to the capability need.
4. The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirements as identified in the Defense Acquisition Guidebook (DAG).

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Development Planning Policy (con't)

Post-MDD DDR&E Engagement

- Cooperate with the Director, Cost Assessment and Program Evaluation, and, as agreed upon with that organization, serve as a standing participant and technical advisor in the development of AoA Study Guidance and on the AoA Study Advisory Group for potential programs under USD(AT&L) oversight to facilitate the consideration of technology and engineering risks for the alternatives under consideration.

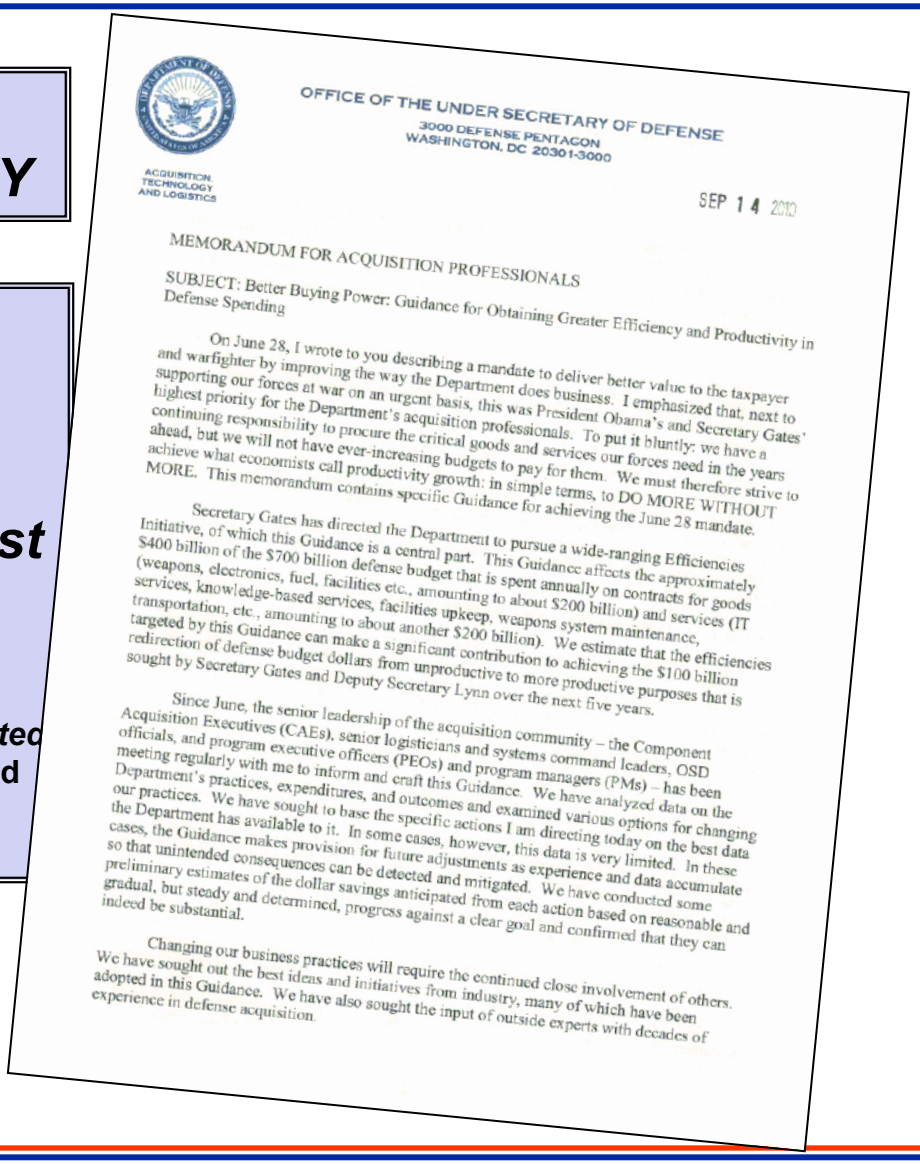
- Monitor and review the effectiveness of the policy in this DTM and develop additional development planning guidance as needed for incorporation into acquisition policy and the Defense Acquisition Guidebook.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Acquisition Documentation Streamlining: USD(AT&L) Direction of September 14, 2010

REDUCE NON-PRODUCTIVE PROCESSES AND BUREAUCRACY

- ***Review DAB documentation requirements to eliminate non-relevant content***
- ***Reduce by half, the volume and cost of internal and congressional reports***
  - ***… conduct a bottom-up review of all internally-generated reporting requirements .. by 1 March 2011*…*** **[required by DoD Instruction 5000.02] (Direction to Dir. ARA)**



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION, TECHNOLOGY AND LOGISTICS

SEP 14 2010

MEMORANDUM FOR ACQUISITION PROFESSIONALS

SUBJECT: Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending

On June 28, I wrote to you describing a mandate to deliver better value to the taxpayer and warfighter by improving the way the Department does business. I emphasized that, next to supporting our forces at war on an urgent basis, this was President Obama's and Secretary Gates' highest priority for the Department's acquisition professionals. To put it bluntly: we have a continuing responsibility to procure the critical goods and services our forces need in the years ahead, but we will not have ever-increasing budgets to pay for them. We must therefore strive to achieve what economists call productivity growth: in simple terms, to DO MORE WITHOUT MORE. This memorandum contains specific Guidance for achieving the June 28 mandate.

Secretary Gates has directed the Department to pursue a wide-ranging Efficiencies Initiative, of which this Guidance is a central part. This Guidance affects the approximately $400 billion of the $700 billion defense budget that is spent annually on contracts for goods (weapons, electronics, fuel, facilities etc., amounting to about $200 billion) and services (IT services, knowledge-based services, facilities upkeep, weapons system maintenance, transportation, etc., amounting to about another $200 billion). We estimate that the efficiencies targeted by this Guidance can make a significant contribution to achieving the $100 billion redirection of defense budget dollars from unproductive to more productive purposes that is sought by Secretary Gates and Deputy Secretary Lynn over the next five years.

Since June, the senior leadership of the acquisition community – the Component Acquisition Executives (CAEs), senior logisticians and systems command leaders, OSD officials, and program executive officers (PEOs) and program managers (PMs) – has been meeting regularly with me to inform and craft this Guidance. We have analyzed data on the Department's practices, expenditures, and outcomes and examined various options for changing our practices. We have sought to base the specific actions I am directing today on the best data the Department has available to it. In some cases, however, this data is very limited. In these cases, the Guidance makes provision for future adjustments as experience and data accumulate so that unintended consequences can be detected and mitigated. We have conducted some preliminary estimates of the dollar savings anticipated from each action based on reasonable and gradual, but steady and determined, progress against a clear goal and confirmed that they can indeed be substantial.

Changing our business practices will require the continued close involvement of others. We have sought out the best ideas and initiatives from industry, many of which have been adopted in this Guidance. We have also sought the input of outside experts with decades of experience in defense acquisition.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

SEP Preparation Guide
(Update)

- **Why the update**
  - Impacts from Public Law 111-23 and Directive-Type Memorandum (DTM) 09-027 – *Implementation of Weapon Systems Acquisition Reform Act of 2009* (Dec. 4, 2009)
  - Impacts from DoDI 5000.02
  - Lessons Learned from Major Defense Acquisition Program (MDAP) and Major Acquisition Information System (MAIS) Program
    - SEP reviews
    - Program Support Reviews (PSR)
    - Systemic Root Cause Analyses (SRCA)
- **To be streamlined as a key milestone deliverable**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

SEP Prep Guide:
PL 111-23 Impact on MDAPs

- DSE shall review and approve each SEP (MDAPs = ACAT ID and IC programs)
- Develop and track measurable performance criteria as part of SEPs
- Complete competitive prototypes
- Complete system-level PDR before MS B; provide report for MDA assessment
- SE role in development planning, lifecycle management, and sustainability

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

SEP Prep Guide:
DoDI 5000.02 Impact

- PDR and CDR are mandated with Post-review reports and MDA assessments
- "At completion of the system level [CDR], the PM shall assume control of the initial product baseline for all Class 1 configuration changes."
- "RAM shall be integrated within the [SE] processes, documented in the … SEP."
- IUID Implementation Plan
  - Summarized in MS A SEP
  - Included as an Annex to MS B and C SEPs

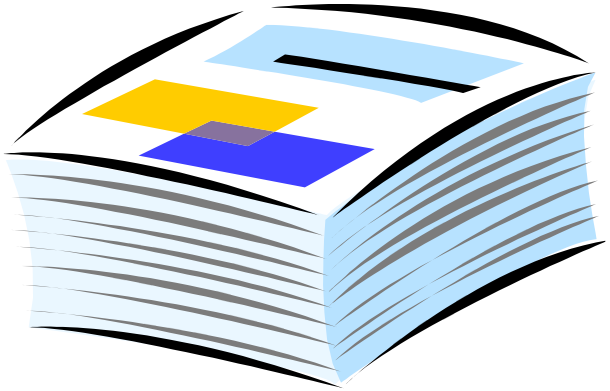
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Program Protection Plan (PPP)
(Streamlining Goals)

- **To provide one-stop shopping for program protection related acquisition documents**
  - PPP reviews provide a mechanism for communication, integration, and synchronization of protection activities throughout the DoD – from protecting technology investments during foreign military sales and international cooperation to preventing cyber attacks through secure designs and supply chain risk mitigation
- **To ensure that programs protect the US lead in technology AND prevent cyber attacks (supply chain and battlefield) on weapon systems**
  - Each have different purposes and threats, yet countermeasures for both are designed into the weapon system and often the same weapon system component so protection for both needs to be closely coordinated within the systems engineering process
  - Information Assurance, COMSEC, and Anti-Tamper are just a few of many **technology countermeasures** that should be layered in to the system design
  - Supply Chain Risk Mitigation are **acquisition activities** that the mitigate the risk to the system design including blind buys and preventing procurement of counterfeit components
- **To ensure that CPI is horizontally identified and protected across the Component Acquisition Executives**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

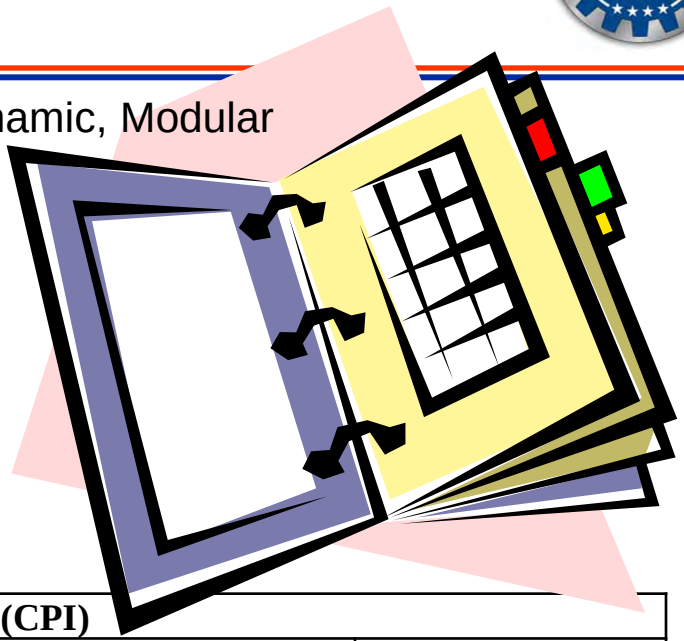
PPP Bulleted, Tabular Format



Verbose, Static, Essay

PPP Guide

Concise, Dynamic, Modular



Critical Program Information (CPI)				
Critical Program Information	*Impact of Loss* *(Low, Med, High)*	*Reason (for each change in status)*	*List Locations* *(Lab(s), PMO, Contractor Name(s), Test Site(s))*	*Status Dates (watch, new, removed)*
GPS		New: Critical warfighting component	PMO, Contractor X	New 6/2006
Radar FPGA		New: Target for hackers	PMO, Prime, Subcontractor Z	Watch 6/2007
Communication Card		Watch: US lead in technology Removed: No longer leading edge technology	N/A	New 4/1998 Removed 4/2007

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

DAG Systems Engineering (Updated)

DAG Section	Change
4.0.3 DoD Policy and Guidance on Systems Engineering	Director, Systems Engineering (DSE) approves all SEPs for DAB/ITAB programs and SEPs for ACAT IACs. SEPs due to DSE NLT 45 days prior milestone review
4.2.3.1.2 Technical Planning	Addressed technical scope of work, integrated plan, schedule, participants, and resources
4.2.3.1.3 Technical Assessment	Added technical reviews, measurements, and reporting requirements (EVM, DAES, and PDR Report)
4.2.3.1.5 Risk Assessment	Expanded discussion on five key activities (identification, analysis, mitigation implementation, and tracking) and added risk cube key activities
4.3.2.4.2.3 Preliminary Design Review	Updated to included WSARA language and additional clarification

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

DAG Systems Engineering
(Updated con't)

DAG Section	Change
4.2.3.1.3 Technical Assessment and Control	Added IAW ISO 15288
4.2.3.1.9 Measurement	Emphasizes renewed effort for metrics collection, analysis, and assessment
4.2.3.1.6 Configuration Management	Provides clarification to policy and update
4.2.3.1.7 Technical Data Management	Characterizes data types and technical review artifacts
4.3.2.4.2.3 Preliminary Design Review	Mandated for MDAPs with PDR Report to MDA and an MDA Assessment (new 2366b certification)
4.4.8 Human Systems Integration	Provides updates and clarifications
4.4.12 Parts Management, Materials and Processes	Includes mitigation for components made with lead-free solder
4.4.15 Reliability, Availability, and Maintainability	Update guidance to address new R&M policy

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Technical Data Artifact Matrix
(New Tool)

Maps availability of and defines technical data for the Data Management Strategy and other uses by technical reviews and key events

Data Types

1.0 System/Product Definition

- 1.1 Technical Requirements
- 1.2 Design
- 1.3 Manufacturing

2.0 System/Product Operation

- 2.1 Logistics Management
- 2.2 Material In-Service

3.0 Associated Information

- 3.1 Verification
- 3.2 Configuration Control
- 3.3 Other Associated Information

4.0 Software Maintenance and Support

5.0 Intelligence Mission

Technical Reviews/Events

- **SFR: System Functional Review**
- **PDR: Preliminary Design Review**
- **CDR: Critical Design Review**
- **TRR: Test Readiness Review**
- **SVR: System Verification Review**
- **FCA: Functional Configuration Audit**
- **PCA: Physical Configuration Audit**
- **FRPDR: Full Rate Production Decision Review**
- **IOC: Initial Operational Capability**
- **FOC: Full Operational Capability**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Technical Data Artifact Matrix
(New Tool con't)

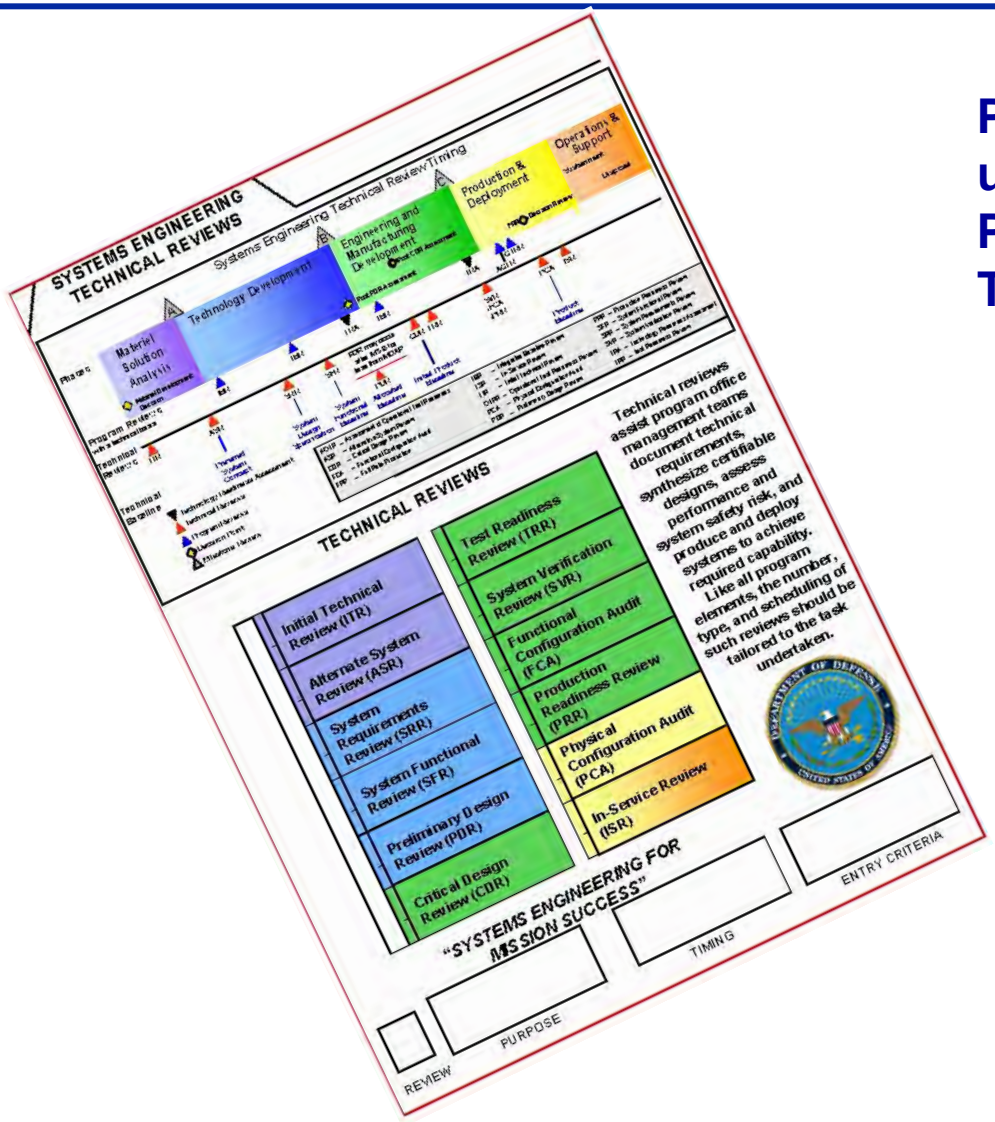
Data Types **Technical Reviews/Events**

Acquisition Milestones		MS A	MS B				MS C	FRP	DR	
	(X) Represents when technical data will be available by the system-level technica									
Data Management Strategy Data Types/ Technical Reviews		SFR	PDR*	CDR	TRR	SVR	FCA	PCA**	IOC	FOC
1.0 System/Product Definition Information										
1.1 Technical Requirements										
System Specification		X	X	X	X	X	X	X	X	X
Configuration Item (CI) Specifications			X	X	X	X	X	X	X	X
Interface Control Documents			X	X	X	X	X	X	X	X
Computer Software Configuration Item Specifications (CSCI)			X	X	X	X	X	X	X	X
Software Interface Requirements Specifications			X	X	X	X	X	X	X	X

Technical Data Artifacts Mapped by Technical Review

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Technical Review Sliderule
(Updated Tool)



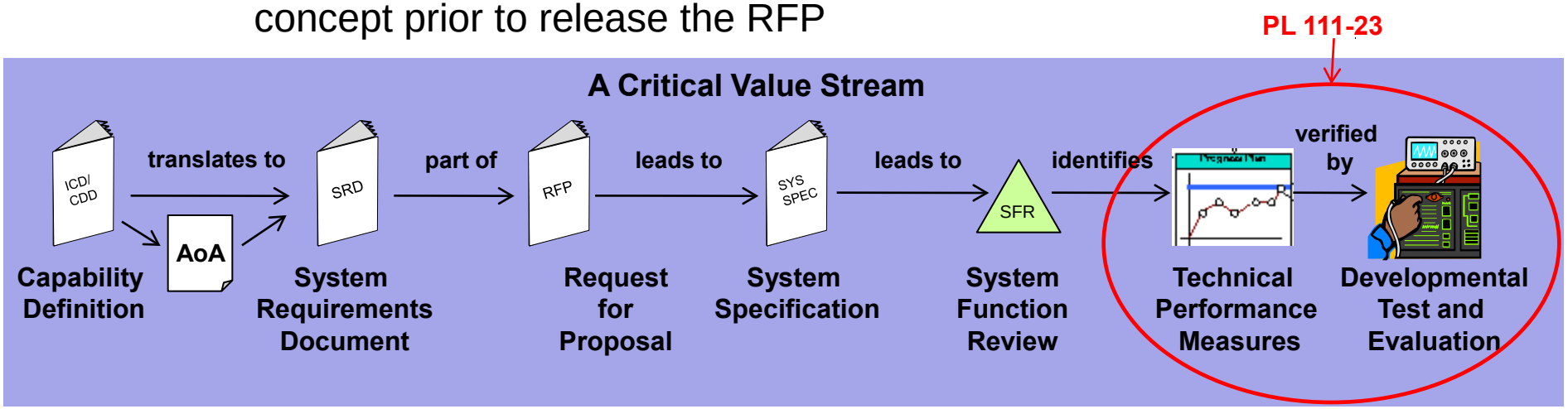
Popular quick reference tool, now updated to reflect DoDI 5000.02 and PL 111-23; describes the Purpose, Timing, and Entry Criteria for:

- **ITR: Initial Technical Review**
- **ASR: Alternate System Review**
- **SRR: System Requirements Review**
- **SFR: System Functional Review**
- **PDR: Preliminary Design Review**
- **CDR: Critical Design Review**
- **TRR: Test Readiness Review**
- **SVR: System Verification Review**
- **FCA: Functional Configuration Audit**
- **PRR: Production Readiness Review**
- **PCA: Physical Configuration Audit**
- **ISR: In-Service Review**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

System Requirements Analysis Guide (New)

- **What is System Requirements Analysis (SRA)?**
  - Structured approach to translating the user's need into a technical definition of the system
- **Why renewed emphasis in DoD System Requirements Analysis?**
  - Establish rigorous approach to translating user capabilities to technical requirements (System Requirements Document)
  - Expose as many risks and issues as possible to a preferred system concept prior to release the RFP



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

System Requirements Analysis Guide (New)

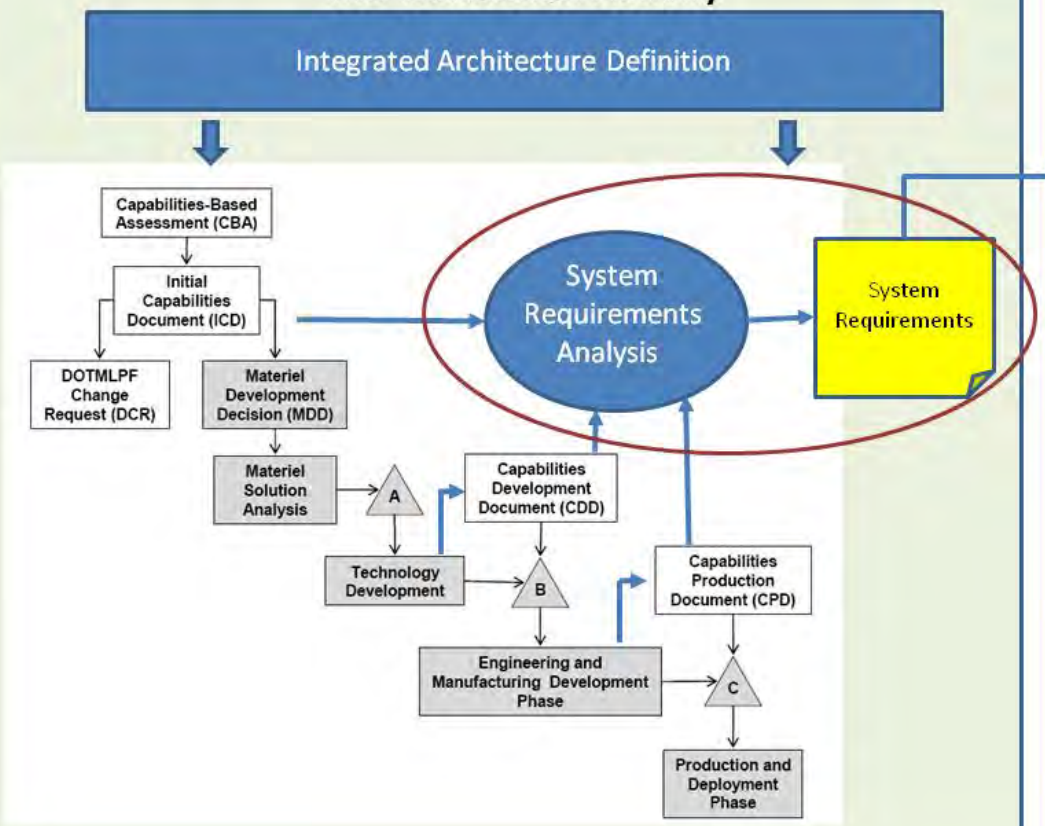
Objectives:

- Provide guidance to Government SEs in planning and executing the development of system requirements throughout the acquisition lifecycle
- Clarify the technical data expectations that supports technical baseline definition through (MS C) Initial Product Baseline
- Describe methods and techniques on how to "transform" requirements:
  - Capabilities ➡ System Requirements
  - System Requirements ➡ Subsystems Requirements
- Provide insights and references on "how" to develop a functional and physical architecture to support requirements definition and trade studies

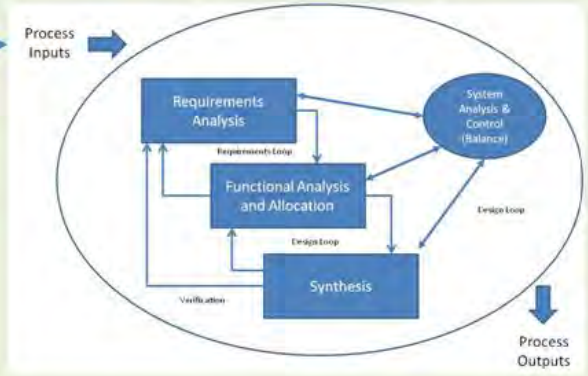
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

SRA Guide: Translation of Capabilities to Requirements

DoD JCIDS and System Requirements Analysis
" The Translation Activity"



Contractor Notional SE Process



Specifications

Sys Spec | Subsys Specs | Comp Specs | SRS

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Technical Review Guide
(New)

- **Preferred practices for conducting event-based technical reviews**
  - **Entry criteria**
  - **Role of Technical Authority (Chairing and Technical Review Boards)**
  - **Capture/management of action items**
- **Technical Review alignment with, and support of, key program activities and decision points (milestone decisions, competitive prototyping, source selection)**

➡ **Expected release, 2nd Quarter FY11**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Risk Management Guide
(Updated)

- Improved readability
- Improved risk example carried through the Risk Management processes
- Strengthened tie of Risk Mitigation Planning/Execution to IMP, IMS, and EVM
- Retains focus on Risk (vice Opportunity) management, as Risk Management continues to be a problem area noted in Program Support Reviews

➡ Expected release, 1st Quarter FY11

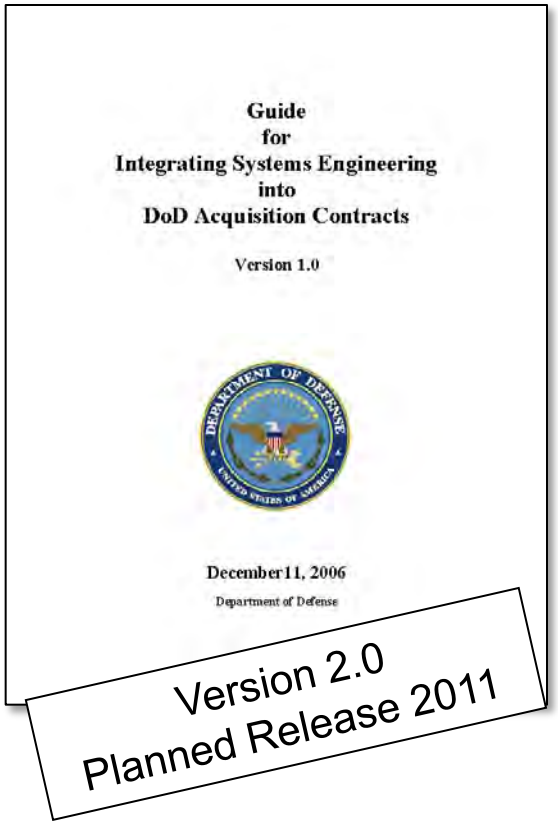
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Incorporating SE in DoD Acquisition Contracts (Update)

- WSARA Direction
- Latest Policy Updates inc. DoDI 5000.02
- Other DoD Focus Areas (e.g., R&M, M&S, MOSA)
- Lessons Learned from the Field

Approach

- Identify current guide areas impacted by WSARA and policy updates
- Capture feedback and lessons learned on utility of the current guide from DoD and industry stakeholders (program managers, contracting officers, systems engineers)
- Analyze RFPs developed since 2007 and identify usage trends
- Draft updates to guide
- Request feedback on draft from stakeholders
- Resolve comments and update draft
- Publish guide and execute outreach plan



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

To Learn More…

- **Development Planning (#10944)**
  Mike Duffey
  Wednesday, Oct 27, 8AM
  TRACK 4 Early Systems Engineering, Mission I

- **Systems Requirements Analysis Guide (#10812)**
  Sharon Vannucci
  Thursday, Oct 28, 9:10AM
  TRACK 1 Systems Engineering Effectiveness, Bayview I

- **Panel on SE Standards (#11107)**
  Sharon Vannucci, Moderator
  Thursday, October 28, 1:30PM
  TRACK 1 Systems Engineering Effectiveness, Bayview I

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

For Additional Information

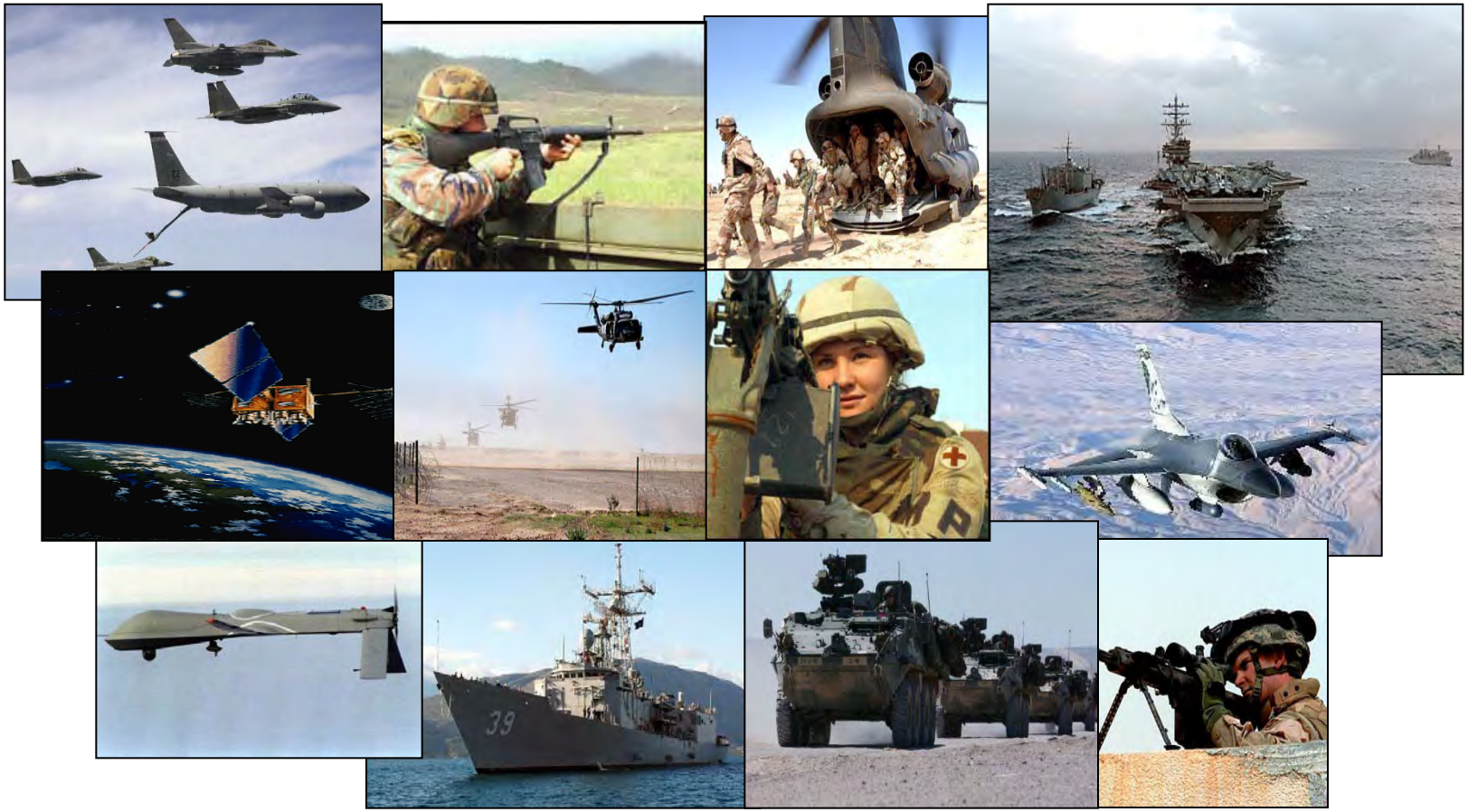
Sharon Vannucci

DDR&E/Systems Engineering

703-695-6364 | sharon.vannucci@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Systems Engineering: Critical to Program Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

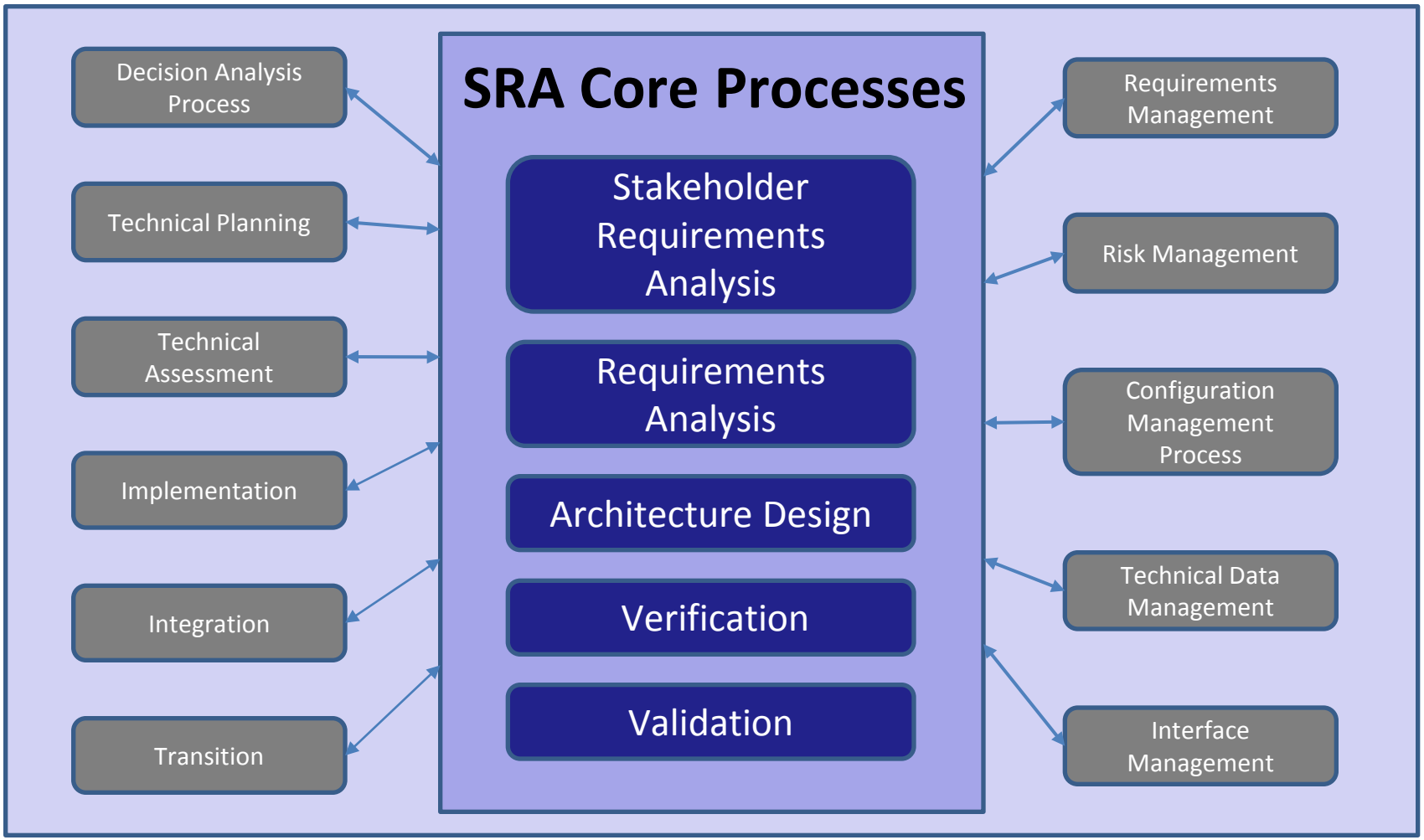
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Implications for Systems Engineering

- **Systems engineering is now recognized in law as inherently necessary in requirements definition, development planning, and early acquisition**
- **Need for and focus of *all* engineering in the "pre-acquisition" phases (Materiel Solution Analysis and Technology Development) is dramatically altered:**
  - **Earlier engineering involvement (well before Milestone A)**
  - **More government expertise to plan for and oversee requirements definition, technology maturation, and competitive prototyping leading to fully expressed system design (the allocated baseline) at the system-level Preliminary Design Review**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

SRA Guide: Overview and Key Thoughts



SRA core processes that provide the greatest influence in requirements definition

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0070 applies.

Synergies of DoD Systems Engineering and International Standards

Dr. Karen Richter

Institute for Defense Analyses (IDA)

Mr. Edward Bauer

US Army ARDEC

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Outline

- Relevant Standards Organizations
- Background of DoD and IDA Involvement
- Standards for Life Cycle Processes
- Synergy with DoD Activities
- Summary

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Relevant Standards Organizations

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Relevant International Standards Organizations

- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- ISO/IEC Joint Technical Committee 1 (JTC1), Information Technology
- ISO/IEC JTC1 Subcommittee 7 (SC7), Systems and Software Engineering
- Working Group 7 (WG7), Life Cycle Management

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

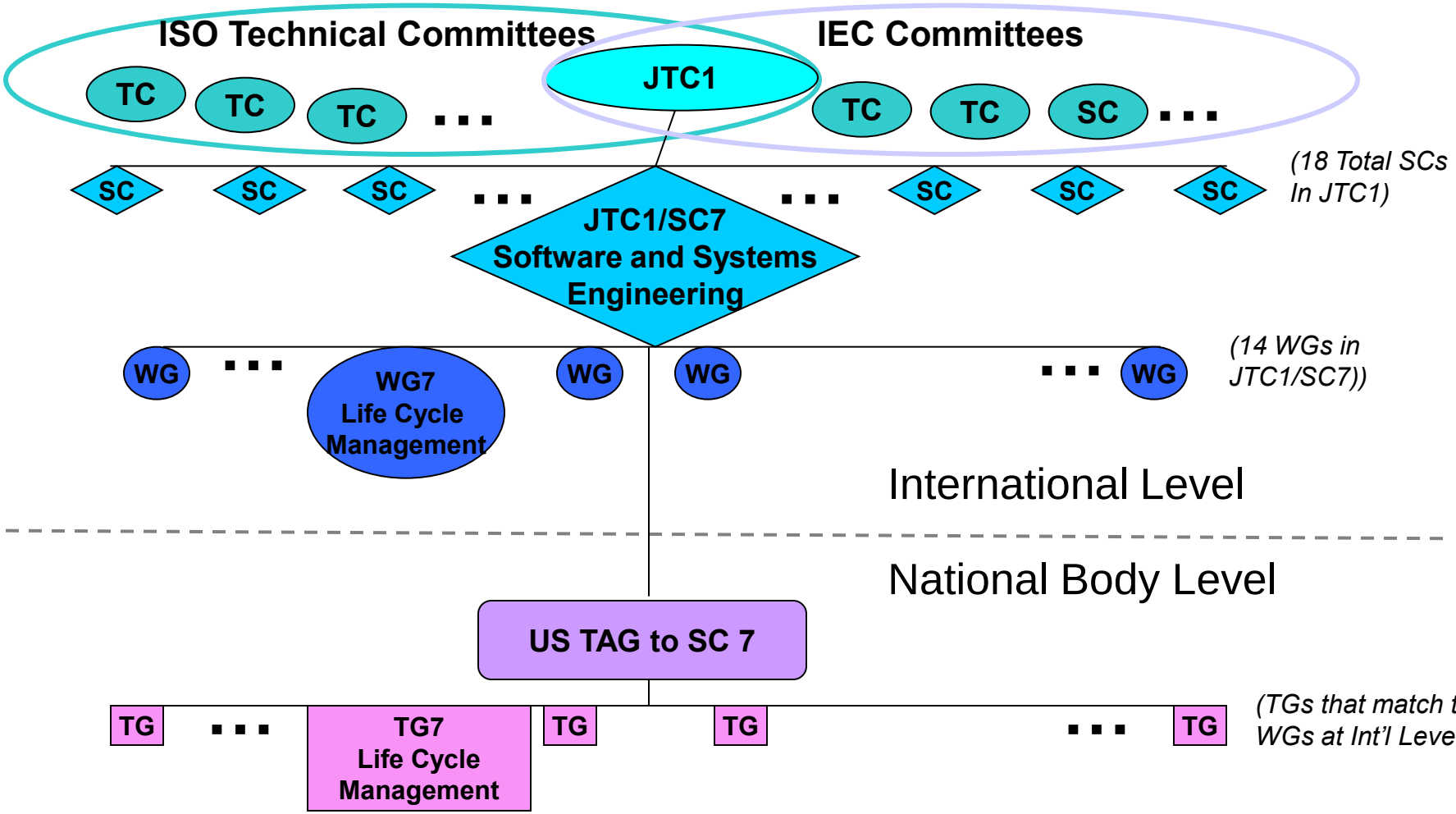
Relevant National Standards Organizations

- **U.S. National Body Technical Advisory Group (TAG)**
  - Administered by the Institute of Electrical and Electronics Engineers (IEEE)
- **Task Group 7 (TG7), Life Cycle Management**

Next slide shows the hierarchical relationship between these international and national organizations

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

ISO/IEC/TAG Hierarchy for JTC1



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Background of DoD and IDA Involvement

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

DoD and IDA Involvement

- **In 1994, SecDef Dr. William Perry issued a memorandum directing the use of performance and commercial specifications and standards in lieu of military specifications and standards, unless no practical alternative existed to meet the user's needs**
- **Shortly after the Perry memo was issued the Systems Engineering office, under the direction of Mr. Mark Schaeffer, became a member of the U.S. TAG**
  - U.S. Army ARDEC provides the alternate member who attends the meetings and does the work of the TAG

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

DoD and IDA Involvement, continued

- DoD's purpose in joining the TAG was to help ensure international commercial standards would meet the needs of DoD in the areas of systems and software engineering
- DoD also tasked the Institute for Defense Analyses (IDA) with participating in international standards organizations to help achieve DoD's goals for the use of commercial standards

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Standards for Life Cycle Processes

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Process Framework Standards

- **ISO/IEC 15288:2008 "Systems and Software Engineering – System Life Cycle Processes"**
- **ISO/IEC 12207:2008 "Systems and Software Engineering – Software Life Cycle Processes"**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

ISO/IEC 15288

- **Product of ISO/IEC JTC1, SC7, WG7**
- **Purpose**
  - A need existed for this standard
    - Increased system complexity due to hardware, software, human interaction
    - Absence of harmonization between relevant disciplines
  - Establish a common process framework for describing the life cycle of systems
- **Background/Status**
  - First published as an International Standard in 2002
  - 2008 version aligned with 12207
  - JTC1/SC7 has initiated efforts to harmonize and integrate all of the standards under its purview, consistent with 15288 as the framework standard
    - Resolution 629 at the Nagoya SC7 Plenary meeting in 2001

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

ISO/IEC 15288:2008 List of Processes

Process Purpose, Outcomes, Activities, and Tasks

Organization Project-Enabling Processes
Life Cycle Model Management
Infrastructure Management
Project Portfolio Management
Human Resource Management
Quality Management

Project Processes
Project Planning
Project Assessment and Control
Decision Making
Risk Management
Configuration Management
Information Management
Measurement

Agreement Processes
Acquisition
Supply

Technical Processes
Stakeholder Requirements Definition
Requirements Analysis
Architectural Design
Implementation
Integration
Verification
Transition
Validation
Operation
Maintenance
Disposal

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

ISO/IEC 12207

- **Product of ISO/IEC JTC1, SC7, WG7**
- **Purpose/Scope**
  - Establish a common framework for software life cycle processes
- **Background/Status**
  - Initial release, August 1995
  - 15288-aligned version published in 2008

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

ISO/IEC 12207:2008 List of Processes

Process Purpose, Outcomes, Activities, and Tasks

Organization Project-Enabling Processes
Consistent with 15288

Agreement Processes
Consistent with 15288

Project Processes
Consistent with 15288

Technical Processes
Qualification Testing
Installation
Acceptance Support
*In addition to 15288 Technical Processes

Software Reuse Processes
Domain Engineering
Reuse Asset Management
Reuse Program Management

Software Implementation Processes
Implementation
Requirements Analysis
Architectural Design
Detailed Design
Construction
Integration
Qualification Testing

Software Support Processes
Documentation Management
Configuration Management
Quality Assurance
Verification
Validation
Review
Audit
Problem Resolution

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Example Implementation Standards

- ISO/IEC 24748:2010, Technical Report "Systems and Software Engineering – Life Cycle Management" in four parts
- ISO/IEC 15939:2007 "Systems and Software Engineering – Measurement Process"
- ISO/IEC 16085:2006 "Systems and Software Engineering – Life Cycle Processes – Risk Management"
- ISO/IEC 16326:2009 "Systems and software engineering – Life Cycle processes – Project management"
- ISO/IEC 15289:2006 "Systems and Software Engineering – Content of Systems and Software Life Cycle Process Information Products (Documentation)"

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Four Parts of ISO/IEC 24748

- Part 1, Systems and software engineering – Guide for life cycle management
- Part 2, Systems and software engineering – Life Cycle Management – Guide for the application of ISO/IEC 15288
- Part 3, Systems and software engineering – Life cycle management – Guide to the application of ISO/IEC 12207 (Software life cycle processes)
- Part 4, Systems and software engineering – Life cycle management – Systems engineering management plan

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Synergy with DoD Activities

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

15288 Processes in the DAG and DAU Courses

- **Alignment of processes in Defense Acquisition Guidebook (DAG) and Defense Acquisition University (DAU) SE courses with ISO/IEC 15288:2008**

Technical Management

- Decision Analysis
- Technical Planning
- Technical Assessment
- Requirements Management
- Risk Management
- Configuration Management
- Technical Data Management
- Interface Management
- Measurement

Technical

- Stakeholder Requirements Definition
- Requirements Analysis
- Architectural Design
- Implementation
- Integration
- Verification
- Validation
- Transition

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

NATO Use of 15288

- **Adoption of ISO/IEC 15288**
  - NATO Life Cycle Management Group adopted ISO/IEC 15288:2002 as the standard for life cycle management
- **Alignment of NATO's processes with ISO/IEC 15288:2008**
  - Currently adopting ISO/IEC 15288:2008 processes
  - Plan to develop a NATO Standardization Agreement (STANAG) based on ISO/IEC 15288:2008 for ratification by NATO nations
  - Developing implementation guide for ISO/IEC 15288:2008 to add NATO-specific requirements

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

SEBoK Project

- **Coordination of Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) project with ISO/IEC TR 19759:2005, Software Engineering -- Guide to the Software Engineering Body of Knowledge (SWEBOK)**
- **WG7 members will serve as reviewers**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Verification and Validation Study Group (WG7)

- **Problem Statement**
  - Within SC7 product portfolio, a clear understanding of the relationships between the multitude of processes, activities, and tasks in the areas of V&V is missing
- **Issues to be Addressed**
  - Establishment of a high-level V&V environment consistent with life cycle process model
  - Understanding of the difference between the objective of evaluation and the evaluation techniques used to meet the objective
  - Consistent and economical terminology related to V&V
  - Relationships between various methods and techniques for V&V of products
- **Desired Outcomes**
  - Recommendations of ISO/IEC SC7 V&V environment
  - Recommendations on how existing and emerging standards (12207, 29119, etc.) can support the environment/process model and harmonization

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Summary

- Participate in ISO/IEC Standards development as a member of the U.S. National Body Technical Advisory Group (TAG)
- Participate in Study Groups (SGs) focused specifically on *harmonization* across life-cycle processes and relevant standards
- Alignment of Defense Acquisition Guidebook (DAG) with ISO/IEC 15288
- Alignment of NATO's quality management process with ISO/IEC 15288
- Coordination of Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) with ISO/IEC TR 19759:2005

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

What We Need from DoD Participants in Audience

- Need participants from other parts of DoD
- Need subject matter experts from the Services to review draft standards and technical reports

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

Thank you!

Questions?

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

For Additional Information

Dr. Karen Richter
Institute for Defense Analyses
703-845-2286 | krichter@ida.org

Mr. Edward Bauer
US Army ARDEC
973-724-7874 | edward.w.bauer@us.army.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0130 applies.

GAO
Accountability * Integrity * Reliability

Assessment of DOD Efforts to Implement WSARA Systems Engineering and Developmental Testing Requirements

Presentation by
Cheryl Andrew
Acquisition & Sourcing Management Team
U.S. Government Accountability Office

13th Annual Systems Engineering Conference
October 27, 2010

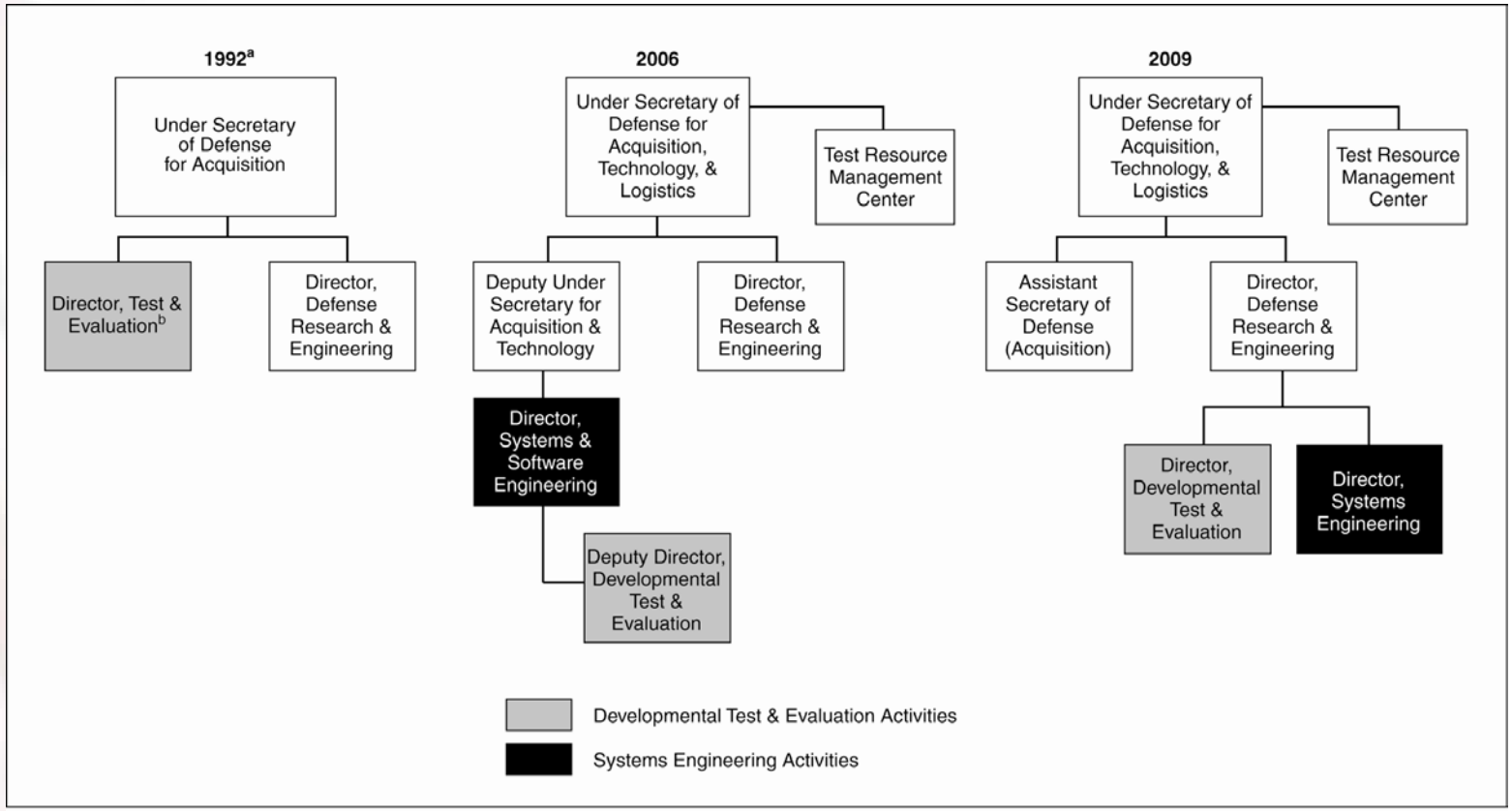
Agenda

- Background
- GAO Study Objectives
- Study Findings
- Conclusions
- Recommendations

Background

- Defense Science Board- May 2008
  - Operational testing results showed a dramatic increase in the number of systems not meeting suitability requirements
  - Caused by several factors, including
    - Lack of disciplined systems engineering process
    - Lack of a robust reliability growth program
    - Weaknesses in developmental testing
    - Acquisition workforce reductions
    - Limited government oversight
    - Increased weapon system complexity
    - Increased reliance on contractors

Background



Source: GAO presentation of Defense Science Board and DOD information.

Background

- Weapon System Acquisition Reform Act - May 2009
  - Places greater emphasis on activities occurring early in weapon system development
  - Created Director, Developmental Test and Evaluation and Director, Systems Engineering and requires directors to
    - Approve systems engineering and developmental testing planning documents,
    - Review, assess, and report on programs
    - Advocate for their respective workforces
    - Develop new policies for the conduct of these activities
  - Services were required to report on their plans to ensure they have an adequate number of trained personnel

GAO Study Objectives

- Determine the status of DOD's implementation of systems engineering and developmental testing WSARA requirements
- Obtain the views of experts on the placement of the new directors' offices within the Office of the Secretary of Defense
- Identify military service challenges in enhancing systems engineering and developmental testing activities

WSARA Implementation Status

- Some requirements have been fully implemented
  - Established Directors' offices
- Implementation of other requirements has begun but requires a sustained effort
  - Monitor and review major acquisition programs
  - Review military service organizations and capabilities and identify needed changes
  - Prepare joint annual report
  - Develop policies and guidance

WSARA Implementation Status

- Two provisions, one of which is discretionary, have not been completed
  - Joint guidance on development of detailed, measurable performance criteria to include in acquisition plans
    - Unclear whether the guidance will include criteria such as technology maturity, design stability, manufacturing readiness, concurrency, prototyping, and adequacy of resources
  - Option to permit the Director of Developmental Test and Evaluation to serve as Director of Test Resource Management Center
    - Possible consolidation is still being examined

Views on the Placement of the New Systems Engineering and Developmental Testing Offices

Experts offer varying opinions

- Director, DDRE and some others support current placement
  - Director, DDRE recognizes challenges, but believes they can be overcome
    - Stretches the role of and mission of DDRE
    - Strengthens organization's role in acquisition
  - Plans for the offices to perform both assessment and advisory roles

Views on the Placement of the New Systems Engineering and Developmental Testing Offices

Most current and former systems engineering and testing officials oppose placement

- Appropriately placed under Assistant Secretary of Defense (Acquisition) or Principal Deputy
- Mission of DDRE too focused on technology development
- Believe cultural change in DDRE would have to take place
    - Otherwise- no clout or resources to affect change
    - Most believe this cultural change will not occur

Military Service Challenges

- Identifying current and future systems engineering and developmental testing workforce
  - Services indicated they have adequate workforces to perform these activities in November 2009 self assessments;
  - However, personnel data reported by the services may not be entirely accurate
    - Systems Engineering numbers may be overstated
    - Developmental Testing numbers do not identify people who are conducting their primary work in another area
  - Director, Developmental Test and Evaluation disagreed with services in first joint annual report to Congress (March 2010)
  - Unclear how many people are needed to perform full scope of systems engineering and developmental testing activities

Military Service Challenges

- Placing greater emphasis on and creating a consistent approach for development planning activities
- Relying too much on contractors for test and evaluation activities
  - Could lead to inaccurate, misleading test results
- Training the large influx of new government personnel expected to be hired over the next 5 years
- Ensuring an adequate workforce is in place in both the short- and long-term
- Funding the upgrade of test facilities and instrumentation
- Addressing morale and retention issues

Conclusions

- Efforts to implement Reform Act requirements are progressing, but it will take time before results can be evaluated
- Present placement of the two new offices may present several challenges
- Determining best place of new directors' offices should be based on results
  - A comprehensive set of performance criteria have yet to be developed
  - Even with these, in order to improve outcomes, program managers need to be held accountable
- Military services may need additional staff and training resources

Recommendations

- Develop a comprehensive set of performance criteria to assess program risk
- Track extent to which program offices are adopting recommendations
- Directors and services need to work together to determine the appropriate number of personnel needed
- Develop plans to address training needs
- Report to Congress on the status of these efforts in future joint annual reports

Future GAO Efforts

- More in-depth examination of workforce and test range challenges
- Impact of WSARA on
  - DOD's approach to pre-milestone B activities
  - weapon system outcomes

GAO on the Web

Web site: http://www.gao.gov/

Contact

Chuck Young, Managing Director, Public Affairs, youngc1@gao.gov
(202) 512-4800, U.S. Government Accountability Office
441 G Street NW, Room 7149, Washington, D.C. 20548

Copyright

This is a work of the U.S. government and is not subject to copyright protection in the United States. The published product may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.

Improving Systems Engineering Effectiveness on the C-17 Program

Mr. Nick Mansur
Director C-17 Avionics/Flight Controls/Support Equipment IPT
Nick.Mansur@Boeing.com

Mr. Sivam Paramanathan
Sr Manager Systems Engineering
C-17 Air Vehicle IPT
Sivam.Paramanathan@Boeing.com

Mr. Christian Stillings
Lead Systems Engineer
ASC C-17 Division
A.Stillings@US.AF.MIL

Issues in Product Development

C-17 software-intensive projects often missed major milestones. Contributing factors determined at Joint Customer-Boeing off-sites were:

- **Significant requirements volatility after CDR**
- **Product defects found late – later than they could have been**
  - **High number of V&V anomalies late in test program**
- **Engineering culture did not embrace risk management**
  - **Some risks existed but went unidentified**
  - **Some mitigation steps didn't reduce risk level**
- **Value of metrics desensitized by measuring & reporting on everything**
- **Process deficiencies addressed symptom-by-symptom resulting in unnecessary complexity**

Reducing Requirements Volatility

- **What was done:**
  - **Method for assessing requirement quality developed**
    - » **Eight elements individually assessed: 1) inputs & triggers, 2) bounds & conditions, 3) outputs & effects, 4) performance spec, 5) verifiability, 6) traceability, 7) rationale/decision, 8) change impact analysis**
    - » **For each element, four criteria defined and rated: Poor (1), Low (2), Moderate (3), High (4)**
  - **Predictive metrics developed**
    - » **Plotted trend of multiple assessments for quality predicted when review can be conducted**
    - » **Standard adopted: Requirements sufficiently mature to proceed to milestone review when average quality score > 3.5**
- **What resulted:**
  - **Earlier discovery of problems with requirement statements**
  - **Increased collaboration between system and software developers**
  - **300% reduction in post-CDR volatility (from 12% to 4%)**

Improving Test Strategies

- **What was done:**
  - **Multi-level test strategy developed & established as a best practice**
  - **Integrated Systems, SW, HW, & Test engineering teams deployed on projects to review requirement correctness & testability**
  - **Greater emphasis placed on low level SW testing**
  - **Boundary & off-nominal robustness testing incorporated**
- **What resulted:**
  - **In general:**
    - » **Much greater collaboration among sub-teams**
    - » **Much quicker ramp up & response in facing problems & issues early on**
  - **On one project:**
    - » **1000% reduction in defects per test case; 600% improvement in system-level productivity; flight test completed with no major anomalies; avoided 2nd SW build, 2nd TRR, 2nd qual & flight tests; EAC savings of $1.7M & schedule savings of 3 months realized**
  - **At the program level:**
    - » **Opportunity realized for consolidating 4 project test plans into one with significant cost and schedule savings**

Improving Risk Management (1)

- **What was done:**
  - **Workshops conducted by risk SMEs with project teams**
    - » **Most complex projects selected: 8-10 hours/week, 3-4 weeks**
    - » **Reviewed & worked existing risks posted to risk database**
    - » **Risk process applied step by step**
    - » **Existing risk descriptions refined & revised**
    - » **Risk sources reviewed & new risks identified as needed**
    - » **Risk mitigation actions & plans scrutinized & revised or developed**
    - » **Mitigation tasks with no significant impact on risk reduction eliminated**
  - **Integrated mitigation plan with project schedule**
  - **Risk dictionary compiled**
    - » **Recurring patterns of risk identified from individual project risks and summarized & abstracted into common risk areas & sources**
    - » **Rationale: Common C-17 sources & areas much easier for domain engineer to work with than generic, difficult to interpret sources & areas**
    - » **Rationale: Commonalities in areas & sources lead to common handlings & similar mitigations**

Improving Risk Management (2)

- **What was done:**
  - **Lessons Learned database improved**
    - **Access improved providing wider view of projects with similar circumstances, aiding in risk identification & effective mitigation actions**
  - **Risk metrics developed**
    - **Metrics focused on risk / issue relationship (risk realized = issue)**
    - **First metric: Identification Effectiveness measured how many issues resulted from unidentified risks (expressed as %)**
    - **Second metric: Mitigation Effectiveness measured how many identified risks were realized as issues (expressed as %)**
- **What resulted:**
  - **Positive feedback from workshop participants**
    - **Key concepts clearer**
    - **Complex subjects better understood**
    - **Skills in executing process improved**
  - **Risk Dictionary defined**
  - **Formal guidelines for mitigation / schedule integration established**

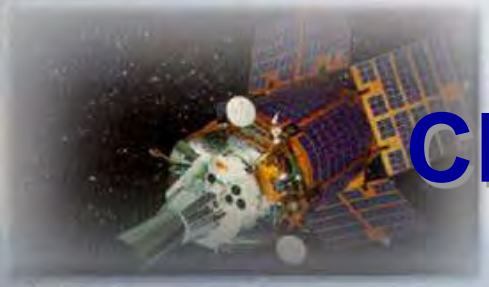
Improving Process & Metrics

- **What was done:**
  - **Developed list of "Things to Stop"**
    - » **Helped to shine light on processes without a customer and on products no one needed**
    - » **Forced questions to be asked about value vs. cost**
    - » **Questioned "required" data to defend data that was already defensible**
  - **Addressed processes holistically rather than symptom-by-symptom**
- **What resulted:**
  - **Eliminated requirement to gather and publish metrics & data with little or no value**
    - » **Helped everyone see what could be done, what's useful & what's not, and changed the culture as a result**
    - » **Increased understanding of key metrics**
    - » **Clearer understanding of "WHY" things are done**
  - **Eliminated multiple processes no longer deemed necessary**
    - » **Improved understanding of applicable processes**
    - » **Clearer understanding of "WHY" things are done**

Conclusion

- **Summary of Accomplishments**
  - **Requirements Management: Method for assessing requirement quality, early discovery & resolution of issues, increase in system-software collaboration**
  - **V&V: Multi-level test strategy best practice, integrated Systems, HW, SW, & Test sub-teams, early discovery & resolution of issues, increase in collaboration**
  - **Risk Management: Workshops as standard practice, effective mitigation plans integrated with project schedules, development of key risk metrics**
  - **Metrics & Process: Improved metrics & processes**
- **Key Results**
  - **Key Systems Engineering activities moved to the left**
  - **Schedule and cost savings realized**
- **Key Tools**
  - **Systems Engineering**
  - **Lean + Principles**
- **Ultimate Goal**
  - **DELIVERING FIRST-TIME QUALITY TO THE WAR FIGHTER SOONER RATHER THAN LATER**

ASN (RDA)
Chief Systems Engineer



Naval System Engineering Technical Review Process

NDIA Oct 2010

Paul T Dube
NUWC Newport
(401) 832-1648
Paul.Dube@navy.mil

Cleared for public release. Unlimited distribution

Agenda

- System Engineering Technical Review (SETR) Policy / Background
- SETR Relationship to PoPs and Gate Reviews
- Development of Engineering Functional Area SETR Criteria
- Worksheet for Critical Design Review (CDR) SETR Gate Review

Cleared for public release. Unlimited distribution

Systems Engineering Technical Review

- The Naval SYSCOM Systems Engineering Policy of 19 Jan 2010, establishes a common SETR process within the DON
  - A technical assessment to evaluate maturity
  - A framework for structured systems engineering management
  - Tailored according to the SEP approved by the MDA or the delegated authority
  - Chaired by technical authorities independent of the program, with participation by the PM
  - Engagement of stakeholders, peers, technical authorities, subject matter experts, and senior leaders

Programs are assessed continuously and results presented at SETRs

Naval SETR Handbook Update

- 10-months following approval of Naval SYSCOM SE Policy Instruction
- Update System-Specific Enclosures
  - Facilities and Infrastructure – NAVFAC
    - ★ Completed
- Ensure alignment with the latest references, such as
  - DOD Instruction 5000.2, 2 Dec 08
  - Gate Reviews; Alignment with 5000.2 expected Oct 09
- Include Information in support of Engineering Functional Areas (EFAs)
  - EFA's represent engineering domains common among all SYSCOMS
  - Established through existing SYSCOMS technical working groups
    - ★ Technical Warrant Holders
    - ★ SYSCOM Engineering Experts

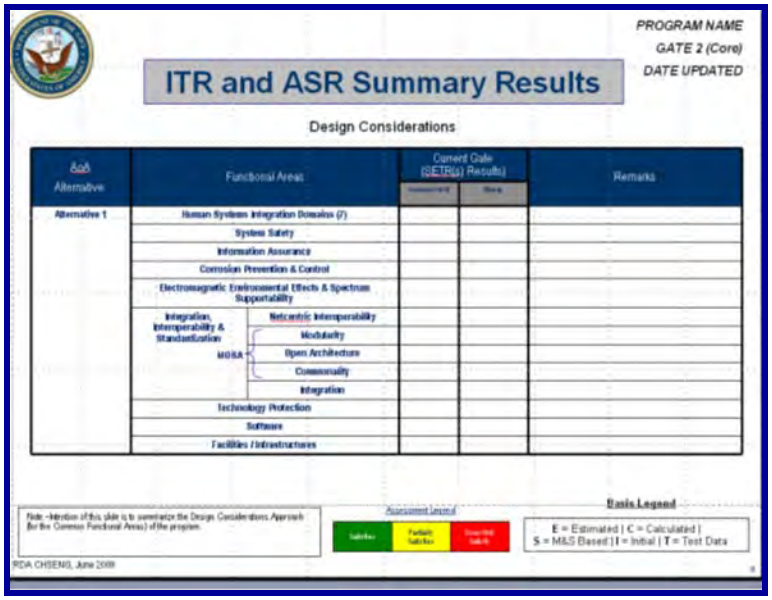
System Specific	POC	Lead
Platforms (NAVSEA) Ships Subs Carriers	Chris Paquette	Gail Goodman
Air (NAVAIR)	Mike Persson	
C4I (SPAWAR)	Dave Murray	
Land (MARCOR)	James Smerchansky	Bud Sawyer
IWS (NAVSEA) Surface IWS LMW IWS Subs IWS	Chris Paquette	Gail Goodman

Engineering Functional Areas
Open Architecture Enterprise Team (OAET)
Human Systems Integration Working Group (HSIWG)
Information Assurance Workforce Improvement Program (IA WIPT)
Software Engineering Working Group (SWWG)
Corrosion Prevention & Control
Safety Working Group, System Safety Advisory Board, Naval Executive Safety Board
Technology Protection
Interoperability and Integration Working Group
SE and PM Tasks

Linkage to PoPs/Gate Review

- Flag level issues highlighted in SETR Technical Review Board Recommendation
  - Program Technical Health, Readiness to enter next phase of development, Technical Risks, TRLs of CTEs
- Gate Backup Slide captures health of the Engineering Functional Areas (EFA's)
  - Drives need to have a mechanism to gauge success
- PM responsible for program execution BUT informed by SETR results

DoN Core Brief


PROGRAM NAME
GATE 2 (Core)
DATE UPDATED

ITR and ASR Summary Results

Design Considerations

Alternative	Functional Areas	Current Gate (SETR(s) Results)		Remarks
Alternative 1	Human Systems Integration Domains (7)			
	System Safety			
	Information Assurance			
	Corrosion Prevention & Control			
	Electromagnetic Environmental Effects & Spectrum Supportability			
	Integration, Interoperability & Standardization			
	MOSA: Netcentric Interoperability			
	MOSA: Modularity			
	MOSA: Open Architecture			
	MOSA: Commonality			
	MOSA: Integration			
	Technology Protection			
	Software			
	Facilities / Infrastructures			

Assessment Legend

Basis Legend

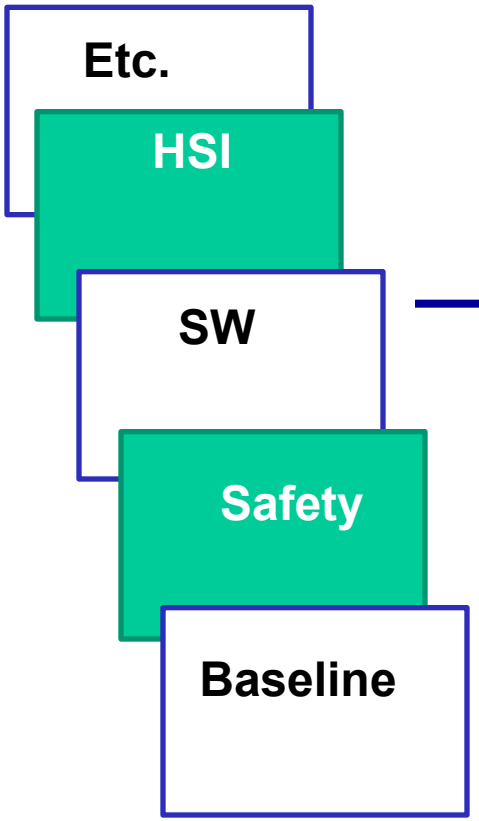
E = Estimated | C = Calculated | S = M&S Based | I = Initial | T = Test Data

RDA CHSENG, June 2009

Focus should be on developing SETR Criteria Questions and Goodness Metrics

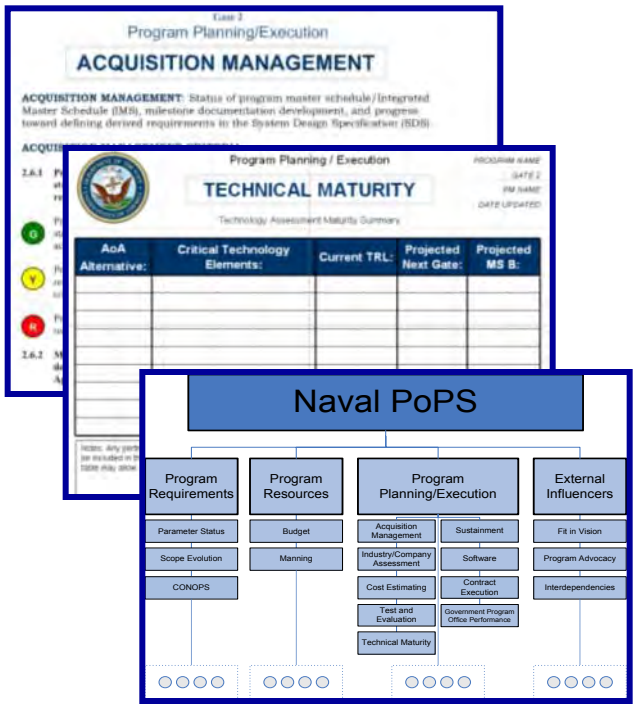
Inter-relationship of SETR, PoPS, and Gate Reviews

Systems Engineering Technical Review (SETR)



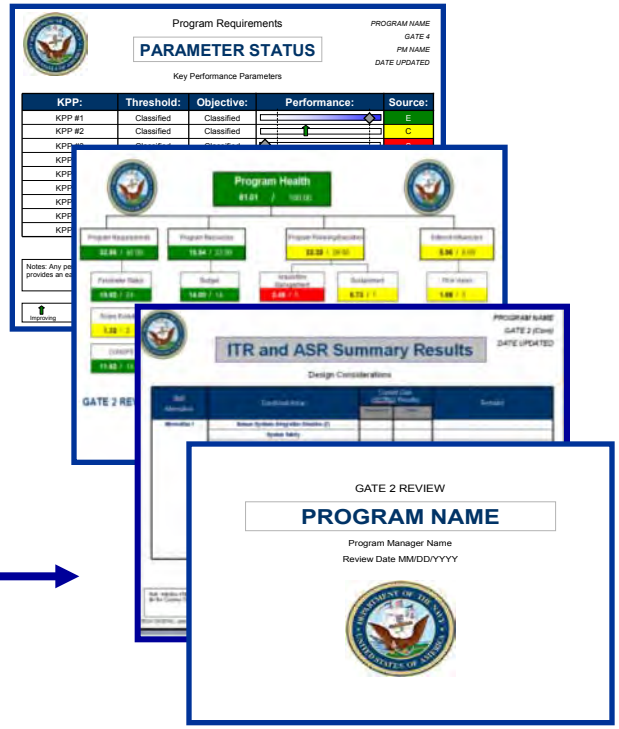
Technical maturity Assessment

Probability of Program Success (PoPS)



Holistic view of overall program health and readiness to proceed

DoN Gate Reviews



Detailed information germane to the Gate Decision

FY 10 Focus - Develop SETR Criteria

- Engineering Functional Area (EFA) teams defined mandatory / statutory and best practice products
  - Products were aligned to DOD 5000.2 milestones
- EFA's, developed SETR criteria specific to their Engineering domain which:
  - Establishes product maturity and health indicators
  - Includes requirements common among SYSCOM's
    - ★ Programs can tailor SYSCOM specific needs
    - ★ Programs can address additional elements to measure program performance and maturity
  - Guides in the preparation of SETR events
  - Guides reviewers in assessing SETR objectives
- Products and criteria organized into SETR Worksheets

Establish criteria to measure health and maturity of the program

FY 10 Focus - Develop SETR Criteria

- Total number of Criteria Statements Established
- April 19 – 20, 2010:
  - Two day Face to Face meeting among the SYSCOMS
  - Represented by Four review teams
  - Reviewed all statements and SETR Events and made recommendations

							Pre	Post										
CFA	ITR	ASR	SRR1	SRR2	SFR	SSR	PDR	PDR	CDR	IRR	TRR	FRR	SVR	OTRR	PRR	PCA	ISR	Total
I&I	14	24	45	15	23	24	27	19	25	4	12	3	8	12	4	1	3	271
Soft	5	11	14	21	28		31	101	108		30		31		29	15		424
Safety	10	18	13	3	26			39	32	3	18		11		14		10	197
IA	15	18	30		25		35		33		18							174
H. S. I.	2	5	5	2	10	2	23	4	20	5	12			10		2	1	103
CPC	4	2	4	5	3		7	7	7		5	1	5	2	3	1	3	59
Total	50	78	111	46	115	26	124	170	225	12	95	4	55	24	50	19	17	2458

Cleared for public release. Unlimited distribution

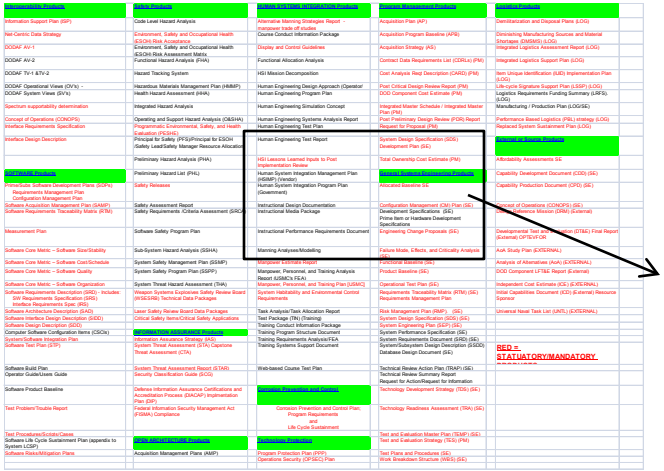
Purpose of CDR Worksheet

- Tool to be used by Programs to develop a set of SETR entrance and evaluation criteria based on DOD requirements and DON accepted standards
  - The tool provides a Red, Yellow, Green assessment that the program can use to assess readiness to proceed
- Provides the anticipated health and maturity of engineering functional areas common among SYSCOMS
- Worksheets will be maintained on Naval Systems Engineering Resource Center (NSERC) as an interactive tool for program use (https://nserc.navy.mil)
- Maintenance anticipated by Systems Engineering Stakeholder Group on an as needed basis
  - Includes (H.S.I, Software, Safety, Open Architecture, Information Assurance, Corrosion Prevention and Controls, Integration and Interoperability, Technology Protection)

Cleared for public release. Unlimited distribution

CDR Worksheet (Product List)

- Sample Section of Product List
  - Red - Mandated by Policy
  - Black - Best Practice/Common Engineering Products



Product List

	Human Engineering Test Report	System Design Specification (SDS) Development Plan (SE)
	HSI Lessons Learned Inputs to Post Implementation Review	Total Ownership Cost Estimate (PM)
	Human System Integration Management Plan (HSIMP) (Vendor)	General Systems Engineering Products
	Human System Integration Program Plan (Government)	Allocated Baseline SE
	Instructional Design Documentation	Configuration Management (CM) Plan (SE)
	Instructional Media Package	Development Specifications (SE) Prime Item or Hardware Development Specifications
	Instructional Performance Requirements Document	Engineering Change Proposals (SE)
	Manning Analyses/Modelling	Failure Mode, Effects, and Criticality Analysis (SE)
	Manpower Estimate Report	Functional Baseline (SE)

Cleared for public release. Unlimited distribution

CDR Worksheet (Product Table)

- Comprehensive list of mandated and best practice products associated with each Engineering Functional Area
- Identifies the Policy, Guidance and Standards associated with each product
- Provides stakeholder involvement recommendations
- Identifies the expected maturity of the product (Draft, Final, Updates) for each SETR event
  - Aligned to DOD 5000.2 and DON Gate Reviews

Product Description Cross Reference Table

I - Provides Input
I - Leads
R- Reviews
A - Approves
C - Concures

D- draft
F- Final
U- update

PROGRAM INITIATION AT MS B

TITLE	Description	Policy	Guidance	Standards	Stakeholders	SETR Review(s)-->	ITR	ASR	SRR1	SRR2	SFR	SSR	Pre PDR	IBR	Post PDR	CDR	IRR	TRR	FRR	SVR	OTRR	PRR	PCA	ISR
							1	A 2			3		B 4-5		6		6			C 6			6	
Interoperability Products																								
Information Support Plan (ISP)	The identification and documentation of information needs, infrastructure support, IT and NSS interface requirements and dependencies focusing on net centric, interoperability, supportability and sufficiency concerns. It should include force-level information exchange and processing, including TDLs	DODI 4630.8			Interoperability: L, A Software Safety Information Assurance Open Architecture H. S. I. Corrosion Prevention & Control Technology Protection					D			F			D				U		U	U	U

CDR Worksheet (Criteria Table)

- Organized and Categorized by SETR focus areas
- Worksheet contains more than 500 criteria elements

Note: Click on upper left Boxes [1] and [2] to expand and contract spreadsheet or use the [+] and [-] to expand sections individually

Priority	CRITICAL DESIGN REVIEW (CDR)	Common Functional Area	R	Y	G	U	NA	Program Comments	Independent Assessment Team Comments
	Tier 1 / Tier 2 / Tier 3 / Tier 4								
	SYSTEM REQUIREMENTS AND CAPABILITIES		0	0	0	0	0		
	DESIGN MATURITY								
	REQUIREMENTS ANALYSIS								
	REQUIREMENTS ALLOCATION								
	REQUIREMENTS MANAGEMENT								
	TEST EVALUATION AND CERTIFICATION OF PRODUCT		0	0	0	0	0		
	TEST PLANNING								
	SOFTWARE ENGINEERING								
	HUMAN SYSTEMS INTEGRATION								
	ENGINEERING PROCESSES, CONTROL AND ANALYSIS		0	0	0	0	0		
	SETR PLANNING/TECHNICAL REVIEW ACTION PLAN (TRAP)/Entry/Exit								
	INFORMATION ASSURANCE								
	PROCESS REVIEW								
	CONFIGURATION MANAGEMENT								
	RISK MANAGEMENT								
	TEST & EVALUATION								
	ARCHITECTURE								
	SOFTWARE ENGINEERING								
	MEASUREMENT & ANALYSIS								
	LOGISTICS								
	HUMAN SYSTEMS INTEGRATION								
	CORROSION PREVENTION AND CONTROL								
	PROGRAM MASTER SCHEDULE, EARNED VALUE AND COST		0	0	0	0	0		
	CRITCAL PATH								
	COST/SCHEDULE/PERFORMANCE/KEY PERFORMANCE PARAMETERS								
	COST ESTIMATE								
	SOFTWARE CORE METRICS								
	PROGRAM RISK PLANNING AND RISK ASSESSMENT		0	0	0	0	0		
	RISK PLANNING								
	RISK ASSESSMENT								

Sample Section of Criteria Table

- Provides evaluation criteria for expected health and maturity of the product
  - Directly tied to the Products List
  - Critical Information that goes into a product
  - Maturity expectations of important engineering studies
  - Tied to Policy, Guidance and Best Practices
- Contains an assessment tool and comments section

CRITICAL DESIGN REVIEW (CDR)				Common Functional Area						Program Comments	Independent Assessment Team Comments
Tier 1	Tier 2	Tier 3	Tier 4		R	Y	G	U	NA		
SYSTEM REQUIREMENTS AND CAPABILITIES					0	0	0	0	0		
	DESIGN MATURITY										
		System Engineering Plan (SEP)									
			Critical Technology Elements (CTEs) required to support the parameters in the ICD/CDD/CPD are at Technology Readiness Level (TRL) XX or above (based on mandatory levels from OSD); or if any CTE is below that mandatory TRL, a substitute mature technology is available that meets the user's needs.	Interoperability							
		Design Specifications									
			Are subsystem design specifications for each configuration item (H/W and S/W) complete?	Systems Engineering							

Cleared for public release. Unlimited distribution

Contact Information

Paul T. Dube

ASN(RD&A) Systems Engineering Support

Naval Undersea Warfare Center

Division Newport

1176 Howell Street

Newport RI 02841

401 832 1648

Cleared for public release. Unlimited distribution

Practical Agile Requirements Engineering

Presented to the
13th Annual Systems Engineering Conference
10/25/2010 – 10/28/2010
Hyatt Regency Mission Bay, San Diego, CA

Presented by:

Dick Carlson (richard.carlson2@boeing.com)

Philip Matuzic (philip.j.matuzic@boeing.com)

BOEING is a trademark of Boeing Management Company.
Copyright © 2009 Boeing. All rights reserved.

Agenda

- Introduction
- Classic Requirements engineering challenges
  - How Agile techniques address these challenges
- Overview / background of Agile software practices
- History and evolution of Agile software Requirements Engineering
- Work products and work flow of Agile Requirements Engineering
- Integration of Agile software Requirements Engineering in teams using Scrum
- Current status of the work and next steps

Copyright © 2010 Boeing. All rights reserved.

Introduction

- A large, software-centric program applied Agile techniques to requirements definition using the Scrum approach
- This presentation shows how systems engineering effectively applies Agile practices to software requirements definition and management
- An experience model created from the program illustrates how failures on a large software program evolved into significant process improvements by applying specific Agile practices and principles to practical requirements engineering

Copyright © 2010 Boeing. All rights reserved.

Requirements Reality

"The hardest single part of building a software system is deciding precisely what to build.

No other part of the conceptual work is as difficult as establishing the detailed technical requirements, including all the interfaces to people, machines, and other software systems.

No other part of the work so cripples the resulting system if done wrong.

No other part is more difficult to rectify later."

-Fredrick P. Brooks (1986),
"No Silver Bullet – Essence and Accident in Software Engineering"
Proceedings of the IFIP Tenth World Computing Conference: 1069-1076

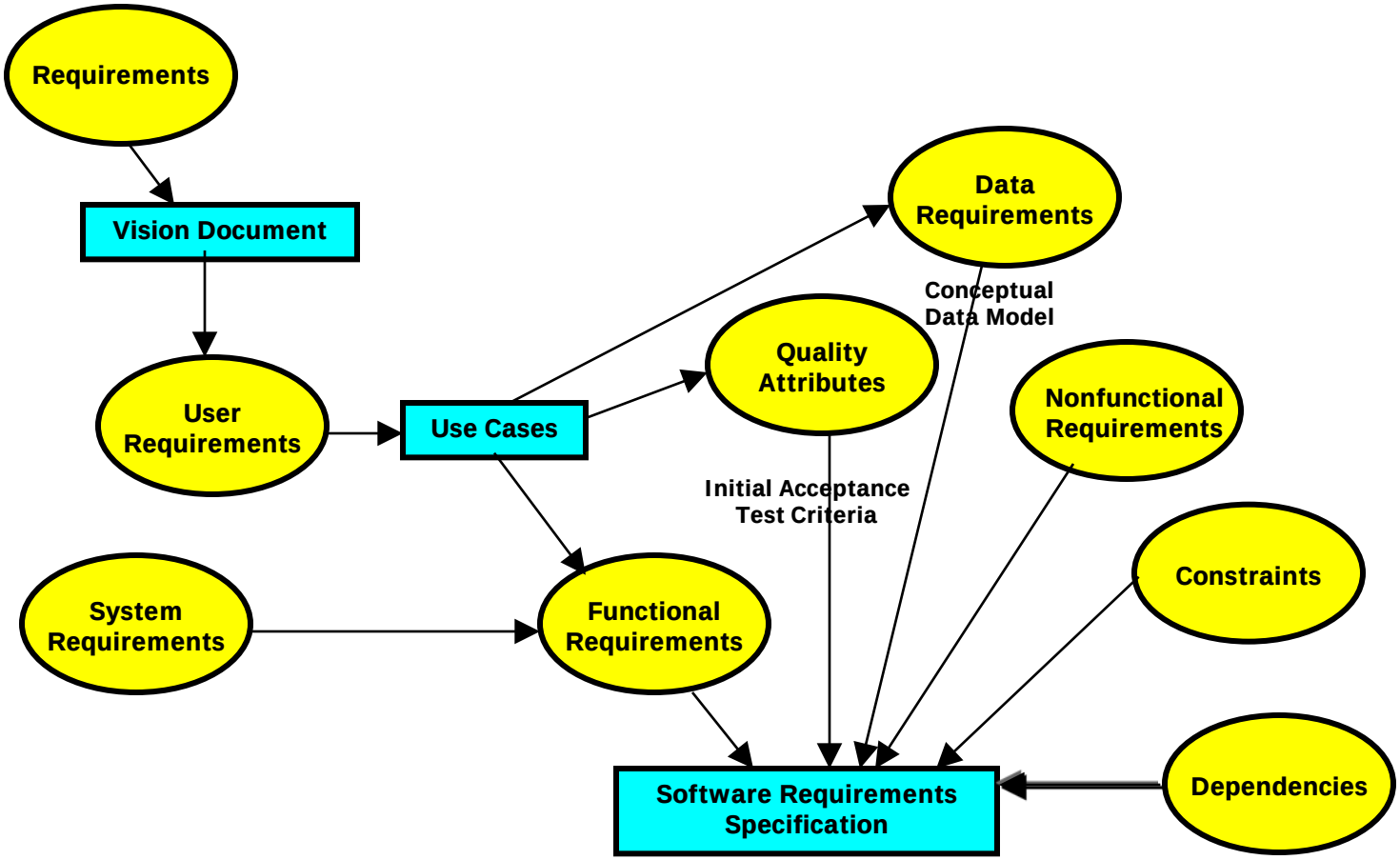
Copyright © 2010 Boeing. All rights reserved.

Traditional Requirements Problem

- **Requirements development is a communication problem**
- **Stakeholders and the development team typically do not have a clear understanding of the requirements as written**
- **Validation happens late in the life cycle**
- **Users see the product late in the process**

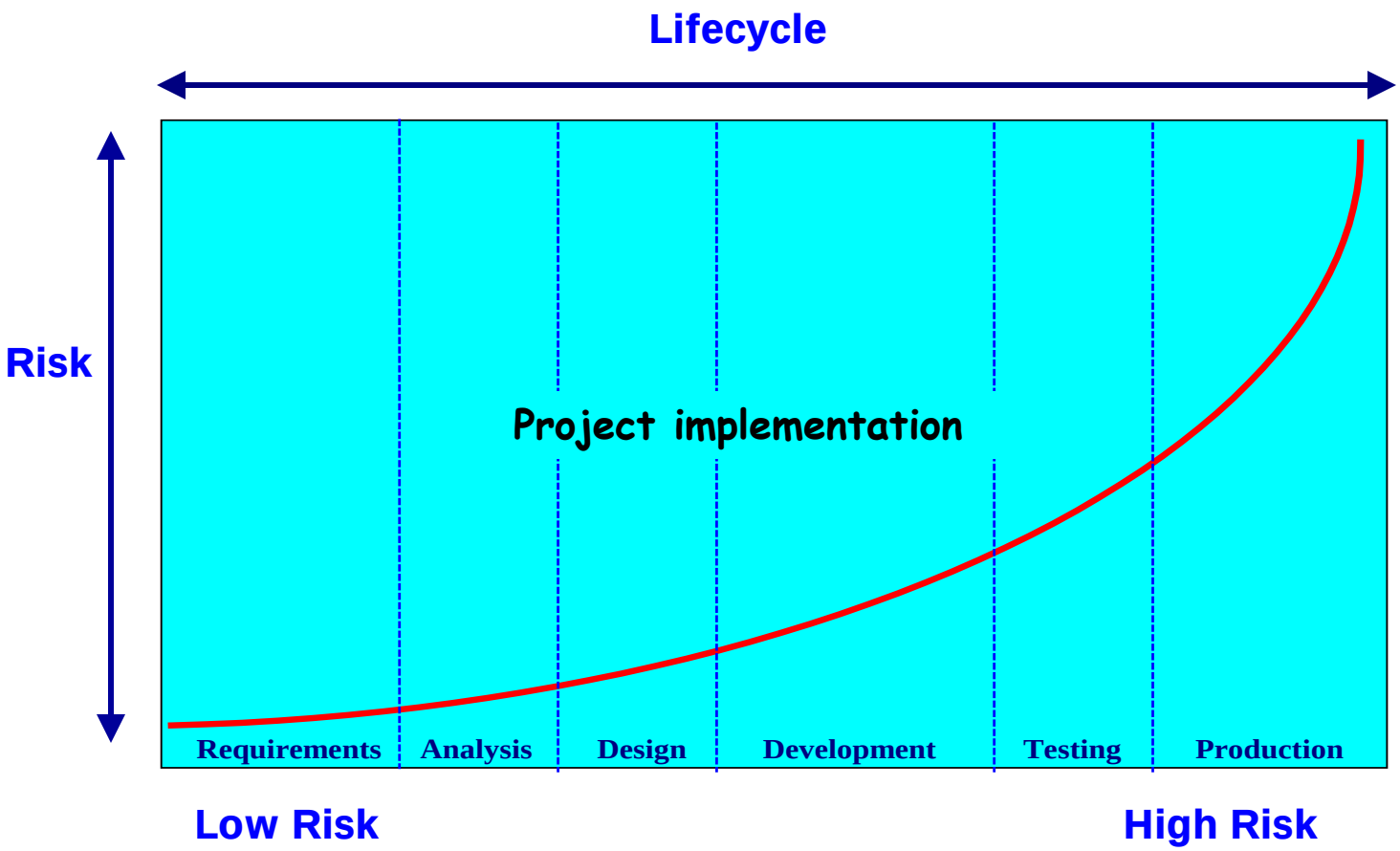
Copyright © 2010 Boeing. All rights reserved.

Traditional Requirements Engineering



Copyright © 2010 Boeing. All rights reserved.

Requirements Risk Abatement



Copyright © 2010 Boeing. All rights reserved.

Agile Principles and Practices

Principles:

- Customer Satisfaction
- Frequent Delivery/Deployment
- Motivated Team
- Technical Excellence
- Emergent Design
- Incremental development
- Embrace Change
- Collaboration
- High Bandwidth
- Sustainable Pace
- Simplicity
- Continuous Improvement

Practices:

- Close customer collaboration
- Daily stand-up meetings
- Planning and estimating
- Frequent feedback
- Short, daily standup meetings
- Short iterations
- Prioritized requirements
- Artifact reviews
- Self-organized teams
- Retrospectives

Source: Agile Alliance (http://www.agilealliance.org/)

Copyright © 2010 Boeing. All rights reserved.

Agile Requirements Development

- **Communications problem**
- **Requirements are developed and written as user stories (sometimes supported by Agile use cases)**
- **User stories shift the focus from writing to talking**
  - Written in a common language
  - Support iterative development
  - Brief description of functionality as viewed by the user
  - Written to convey functional requirements
  - Support participatory design
  - Emphasize user goals
  - Focus on the “what” – not the “how”

Copyright © 2010 Boeing. All rights reserved.

Requirements vs. User Stories

- **Traditional requirement "shall" statements**
  - "The system shall provide a user configurable interface for all user and system manager functions"
  - "The user interface shall be configurable in the areas of:
    - Screen layout
    - Font
    - Background and text color"

- **Corresponding User Story**
  - "As a system user or system manager,
  - I want be able to configure the user interface for screen layout, font, background color, and text color,
  - So that I can use the system in the most efficient manner"

Copyright © 2010 Boeing. All rights reserved.

Agile Systems Engineering

Copyright © 2010 Boeing. All rights reserved.

Agile SE Defined

- Definition: Agile Systems Engineering (SE) is an Agile project activity that defines and develops requirements, and creates a Product Backlog for an Agile Software Development project
- The Scrum framework is used to manage project teams
- The Product Backlog is prioritized by the Product Owner, and made available to the development team

Copyright © 2010 Boeing. All rights reserved.

Scrum Applied to Systems Engineering

- Scrum is a framework for managing a project that focuses on delivering the highest business value in the shortest time through the use of simple roles, artifacts, and ceremonies (or working sessions)

- A Scrum project is a series of 4 week iterations where fully developed requirements, functional analyses, and system-level architecture incorporating system decisions are demonstrated at each iteration completion

Source: Scrum Alliance (http://www.scrumalliance.org/)

Copyright © 2010 Boeing. All rights reserved.

More Scrum Practices

- Teams are self-organized and fully empowered to do whatever it takes to complete all iteration work
- The customer, users, and/or business needs set the priorities
- Scrum is simple and straightforward
  - Practices, artifacts, and rules are few and easy to learn
  - No complicated process descriptions
  - No individual assignments – team selects all work from the prioritized backlog

Copyright © 2010 Boeing. All rights reserved.

Systems Engineering Activities

- **Systems engineering includes consistent processes that produce specific and supportive artifacts —**
  - **To ensure integration with other engineering disciplines and domains**
  - **To ensure integration among disciplines/functions, design, manufacturing, supply chain, test, product support, etc.**
  - **To produce a system integrated among all systems and components**
  - **Applied over and addressing the entire lifecycle of the product from requirements development through operations and disposal**

Copyright © 2010 Boeing. All rights reserved.

Key Focus of Systems Engineering

- **Two key thrusts in program-level systems engineering domains:**
  1. **Engineering the system to define the technical solution, and**
  2. **Planning and control supporting program management**

- **Engineering the system requires:**
  1. **Requirements Analysis / Definition / Validation**
  2. **Functional Analysis and Allocation**
  3. **Design Synthesis**
  4. **Evaluation of Alternatives**
  5. **Requirements Verification**

Copyright © 2010 Boeing. All rights reserved.

Key SE Planning & Control

- **Planning and control requires:**
  - **Organizing and Planning (e.g. Organizing the program, and development of the SEMP, IMP/IMS)**
  - **Requirements Management**
  - **Interface Management**
  - **Baseline Definition and Management**
  - **Affordability**
  - **Decision Making (e.g. Risk Management, Trade Studies, TPMs)**
  - **Metrics Management**
  - **Reviews**

Copyright © 2010 Boeing. All rights reserved.

Bridging Agile Practices to SE

- **The benefits experienced by applying common Agile practices apply well to systems engineering activities.**
- **These Agile practices include:**
  - **Small, self-organized teams producing work products incrementally through a series of short iterations**
  - **Commitment by all team members and sponsors**
  - **Intense iteration planning sessions that identify what will be completed and how the team plans on completing it**
  - **Time-boxed daily standup meetings**
  - **Developed requirements and product backlog are reviewed**
  - **Team reflects what brought the highest value during the iteration through a retrospective that includes the entire team**

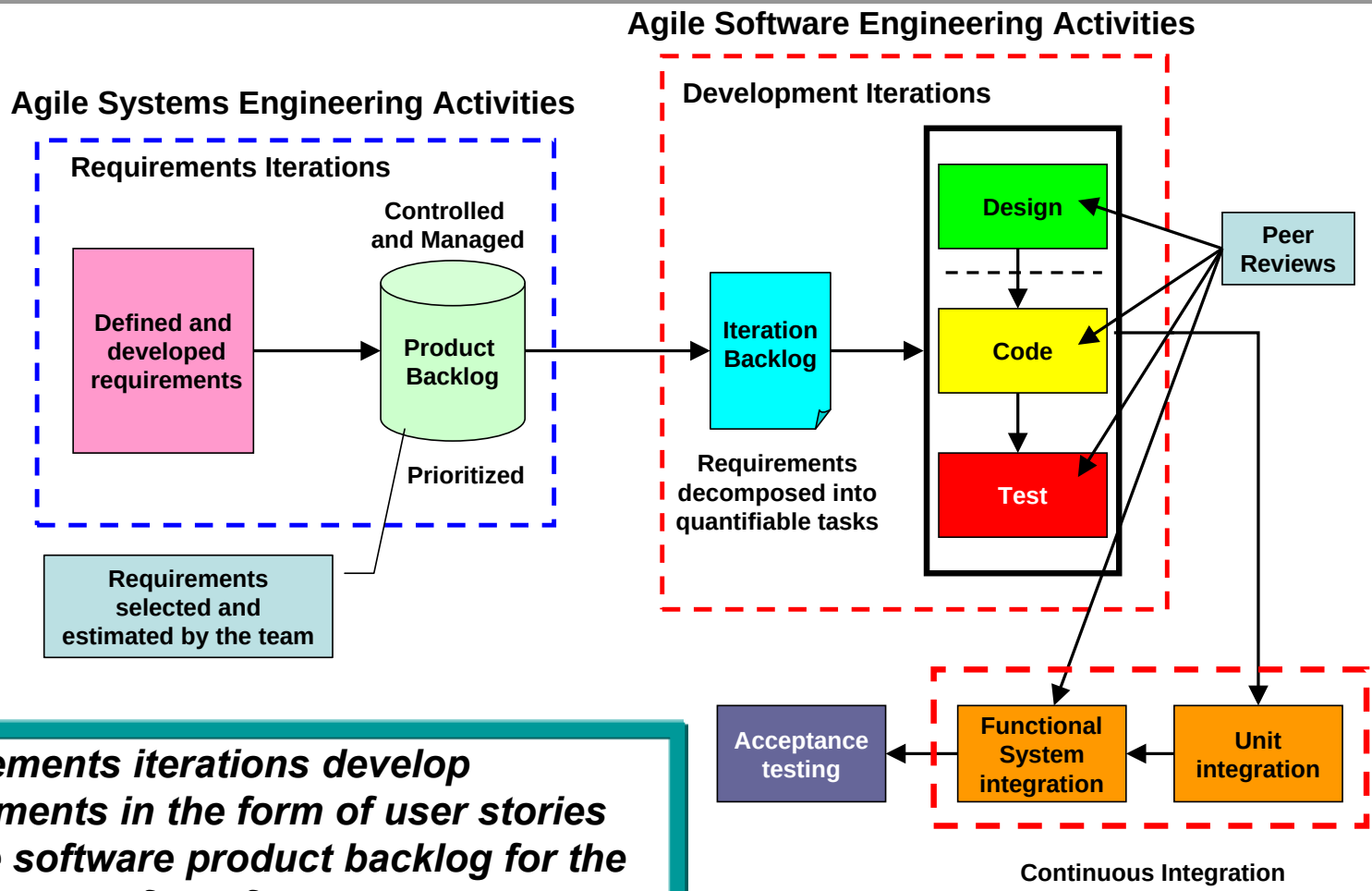
Copyright © 2010 Boeing. All rights reserved.

Agile SE for Integrated Engineering

- **The Agile systems engineering approach leverages integrated engineering by employing the same vocabulary and artifacts in an evolving, iterative approach**
  - **Software and systems engineers work collaboratively, consider alternatives, and take actions that lead to process change and improvement**

Copyright © 2010 Boeing. All rights reserved.

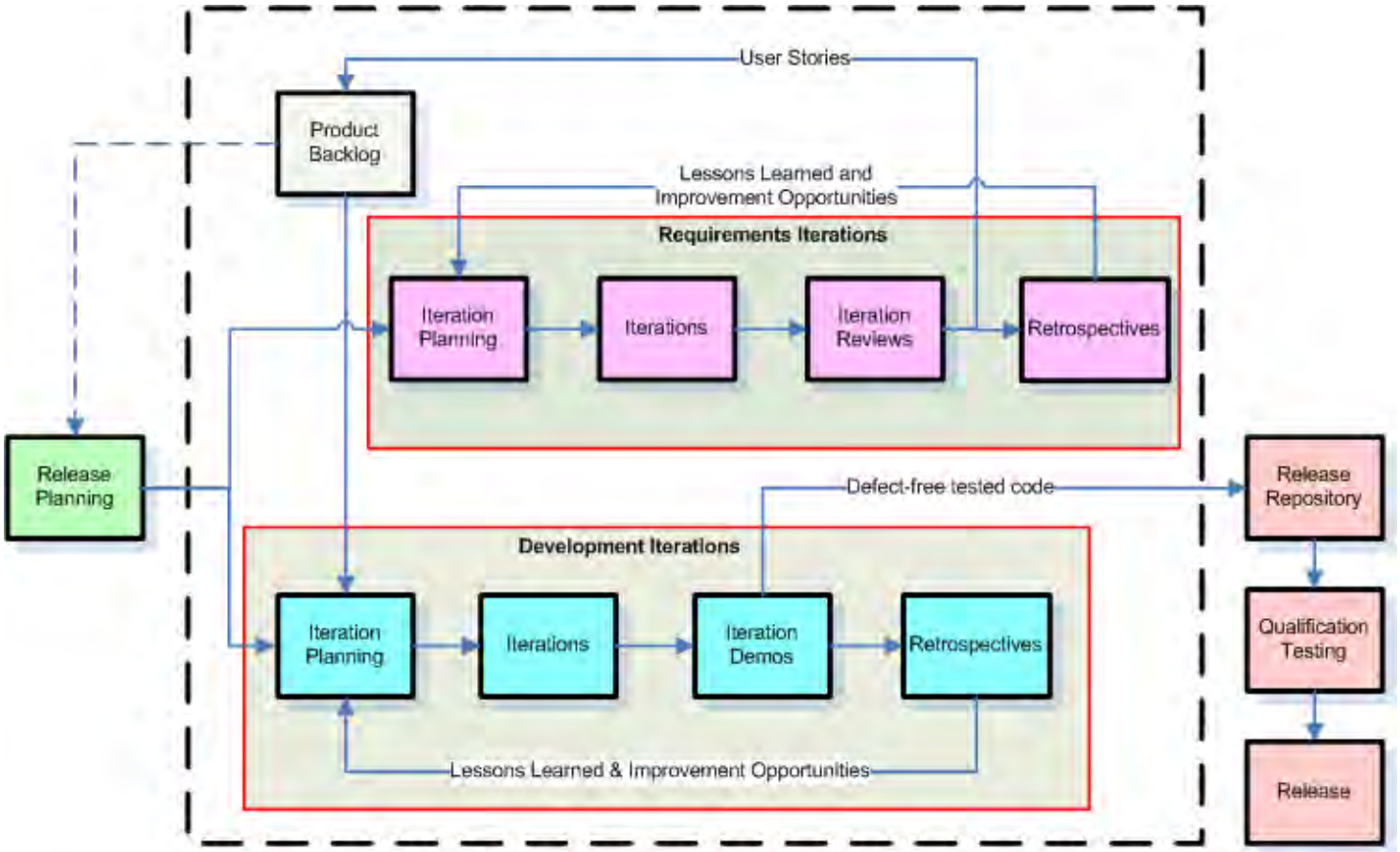
Boeing SE/SW Experience Model



Requirements iterations develop requirements in the form of user stories into the software product backlog for the development of a software system

Copyright © 2010 Boeing. All rights reserved.

SE/SW Collaboration Model



Systems and software engineers collaborate on release planning and the development of requirements written as user stories

Copyright © 2010 Boeing. All rights reserved.

Questions?

Copyright © 2010 Boeing. All rights reserved.

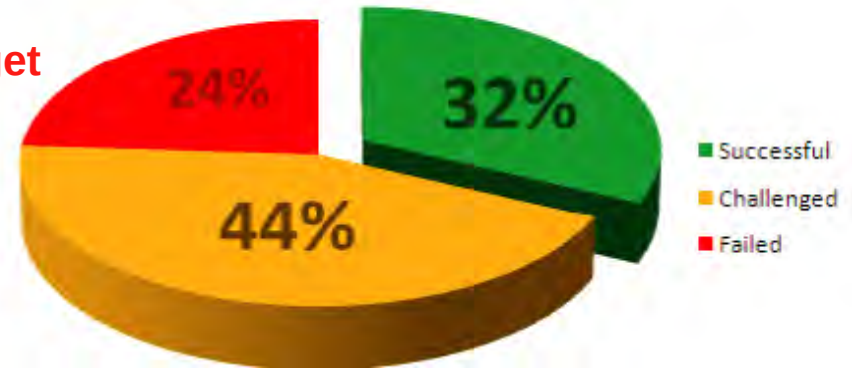
Back-up slides

Copyright © 2010 Boeing. All rights reserved.

Industry-wide High Project Failure Rates

- Backward Trend in Software Project Success
  - Failed and challenged projects hover around 70%
  - High failure rate due to inability to cope with change
  - Big projects exacerbate challenge and failure potential

- 2009 CHAOS Standish Chaos Report
  - **32% of software development projects were successful**
  - **44% challenged**
  - **24% failed to meet schedule or budget**

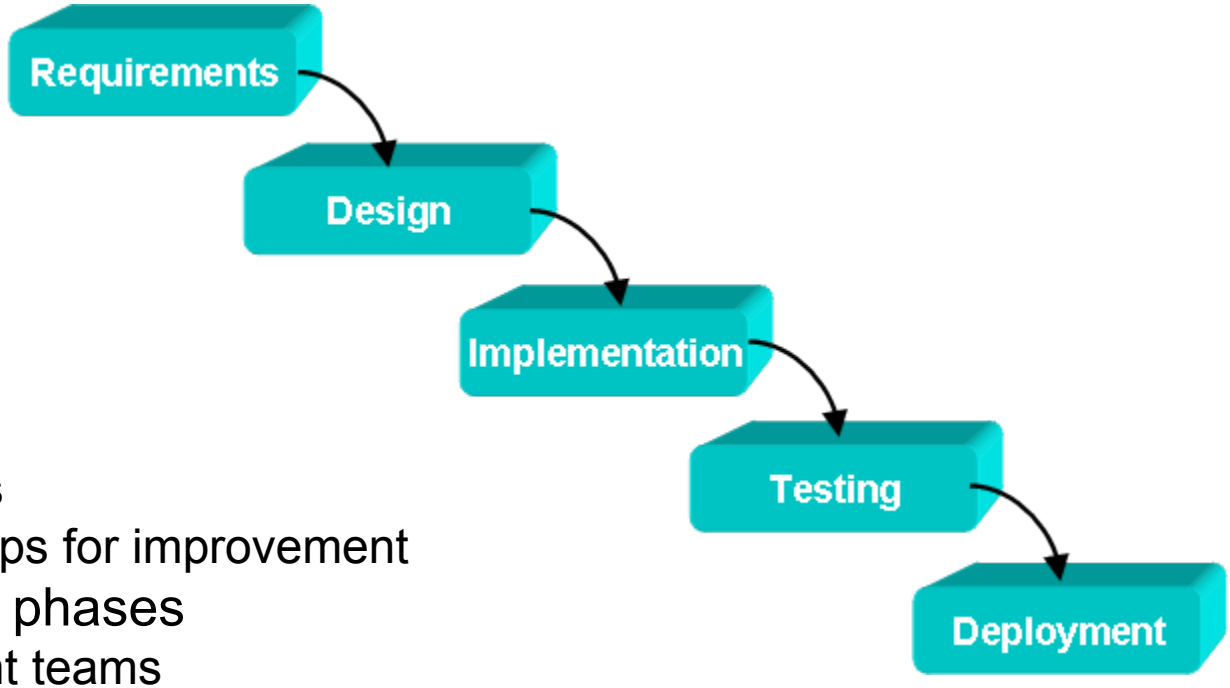


Johnson, J., et al. (2009), *Chaos Summary 2009*, Boston, MA: Standish Group International

Copyright © 2010 Boeing. All rights reserved.

Why Aren't the Successes Higher?

Historic processes were subjected to the weaknesses of the Waterfall model….

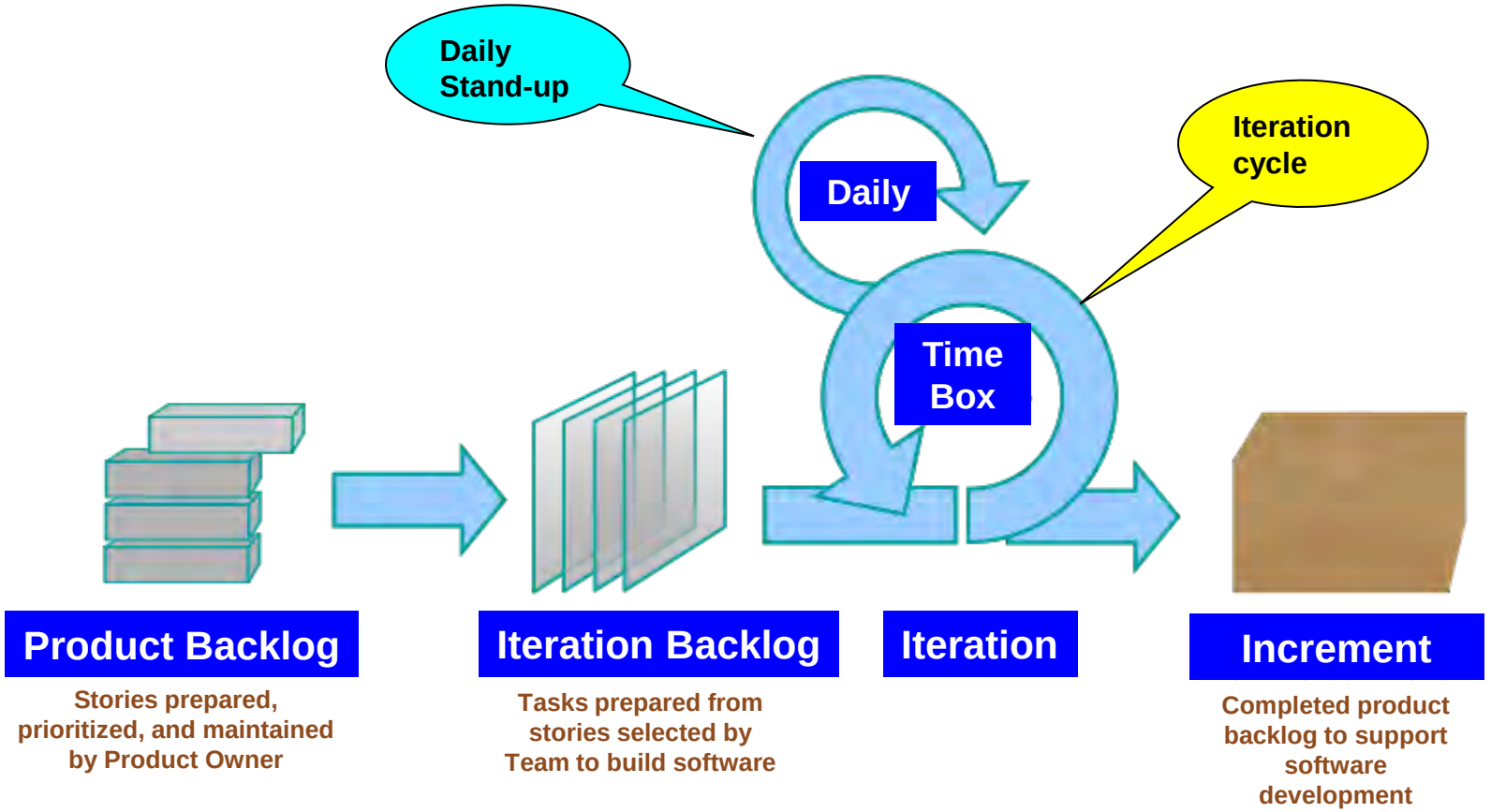


The Waterfall Model

- Has distinct phases
- Lacks feedback loops for improvement
- Includes sequential phases
- Handoffs to different teams
- Has an appealing air of simplicity
- Project managers like the easily tracked milestones

Copyright © 2010 Boeing. All rights reserved.

Scrum Framework



Copyright © 2010 Boeing. All rights reserved.

Scrum Values

- Scrum is based on a set of fundamental values that make up the backbone of its practices

  - **Commitment** – Be willing to commit to a goal
    - Scrum provides people all the authority they need to meet their commitments
  - **Focus** – Do what you said you will do
    - Focus efforts and skills on doing the work committed
  - **Openness** – Everything you do can be seen by everyone
    - Scrum is transparent by keeping everything about a project visible
  - **Respect** – Individuals are shaped by their experiences
    - It's important to respect the diversity of people who comprise a team
  - **Courage** – Have the courage to commit, act, be open, and expect respect
    - Celebrate and enjoy the journey

Source: Scrum Alliance (http://www.scrumalliance.org/)

Copyright © 2010 Boeing. All rights reserved.

Aeronautical Systems Center

Engineering for War Fighter Integration of Net-Centric Systems

Presentation to the 13th Annual Systems Engineering Conference

27 October 2010

Ms. Eileen Bjorkman
SAF/A6W
Pentagon, Washington DC
eileen.bjorkman@pentagon.af.mil

Mr. Timothy Menke
ASC/XRA (SIMAF)
Wright Patterson AFB OH
timothy.menke@wpafb.af.mil

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Overview

- Air Force Integrated Collaborative Environment (AF-ICE) Description
- Systems Engineering Process
- VV&A
- Air-to-Ground Integration Layer Exploration (AGILE) Live, Virtual, and Constructive (LVC) Venue
- AFICE today and tomorrow

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

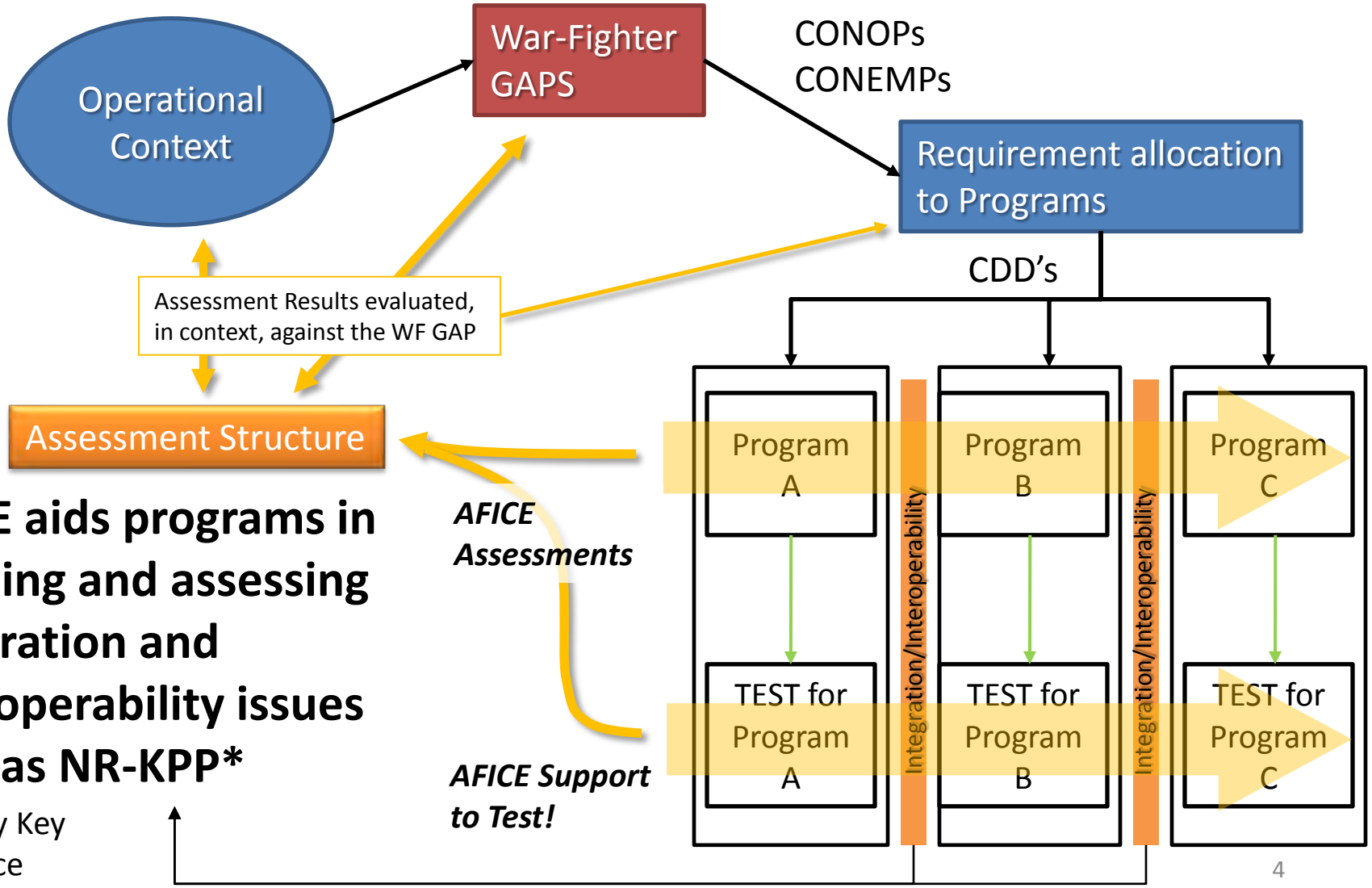
AFICE Objectives

- **Thorough testing with credible analysis** to deliver better products at reduced costs
- **An acquisition lifecycle-assessment approach** to leverage resources and expertise at distributed locations
- **An analytically based, system engineering process** to support traceability of war fighter requirements throughout the acquisition life cycle
- **Compose- able, reusable, non-duplicative** networked and instrumented infrastructure resources, consisting of LVC assets
- **Primary focus: Identify, categorize, assess, and report integration and interoperability gaps and seams**
- **Secondary mission: Assessment test-bed for risk-reduction activities for any program**

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Assess the "Seams"

Dominant Air Power: Design For Tomorrow…Deliver Today



AFICE aids programs in defining and assessing integration and interoperability issues such as NR-KPP*

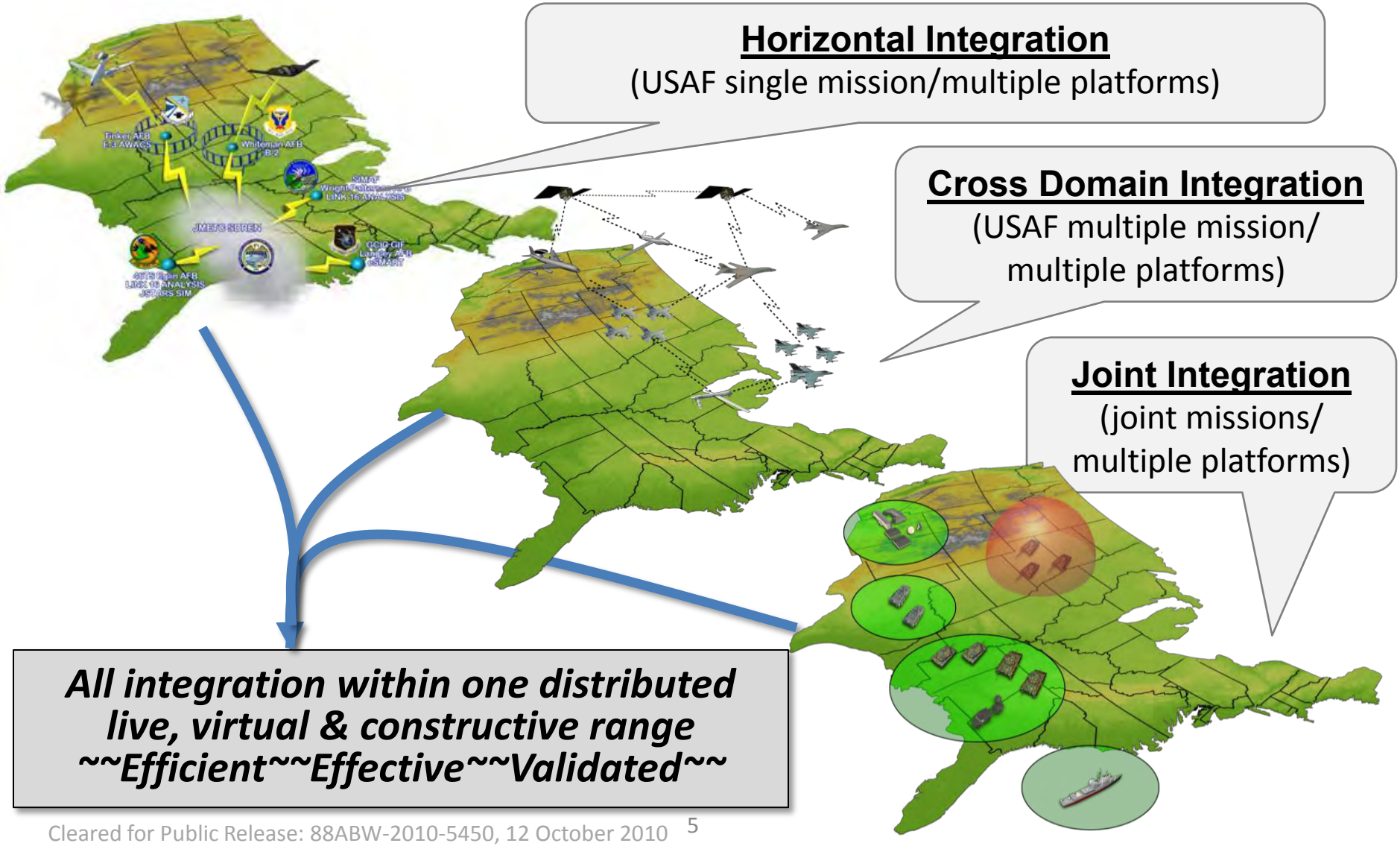
*Net-Ready Key Performance Parameter

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

AF-ICE Vision:

It's all about the integration

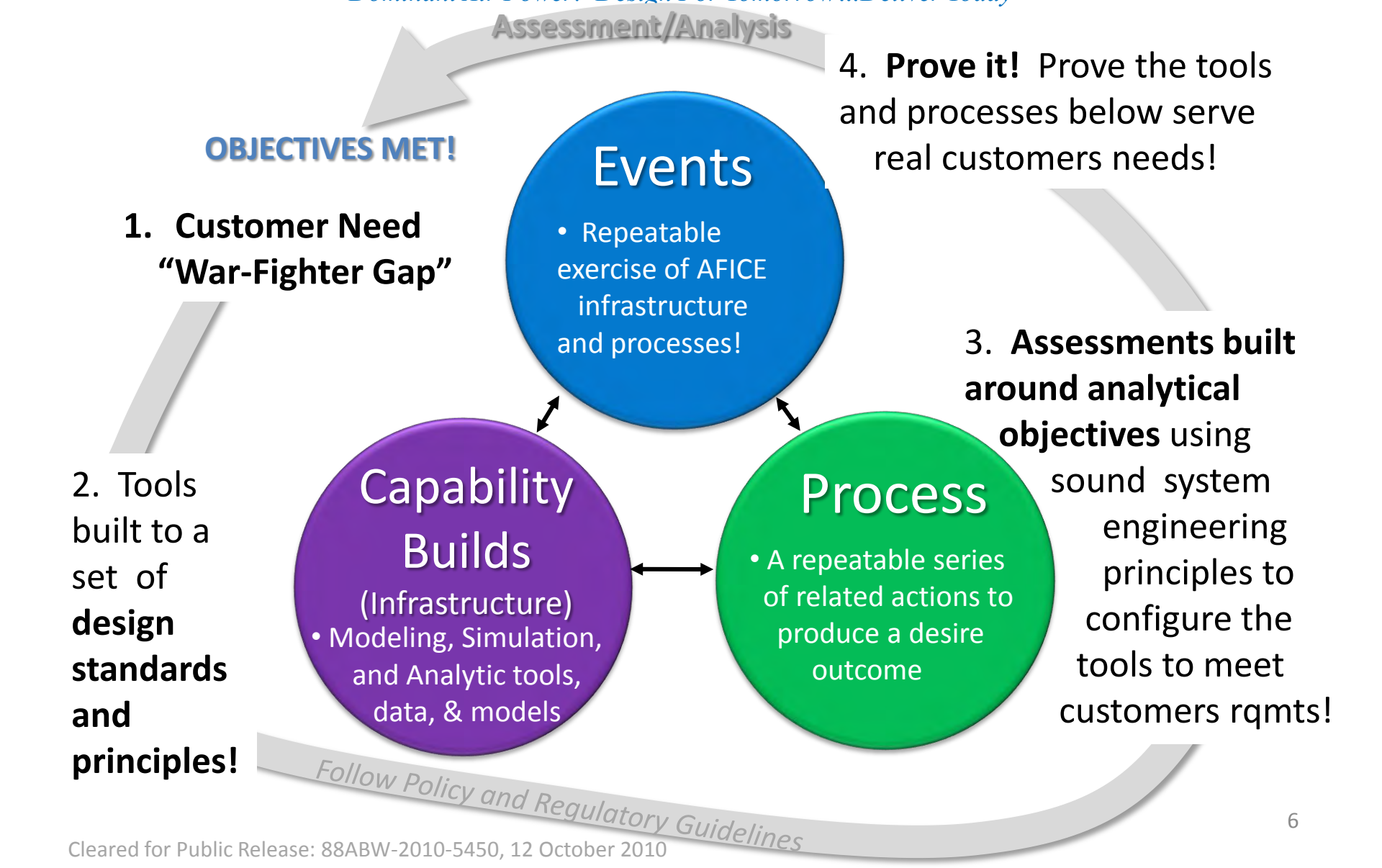
Dominant Air Power: Design For Tomorrow…Deliver Today



Investment Strategy

Three AFICE Key "Tenets"

Dominant Air Power: Design For Tomorrow…Deliver Today



Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

"M&S Battle-space"

Mapping between the real and virtual battle-spaces

Dominant Air Power: Design For Tomorrow…Deliver Today

Virtual Battlespace:
Computer representation of the actual battle-space!

End-to End Approach:
"Constructive" requirements & performance characterization investigation, leading to "Virtual" validation and verification performance assessments (aircrew in the loop)

Problem of interest is defined from the real battle space and "scoped" within study requirements (inside the LVC battle-space).

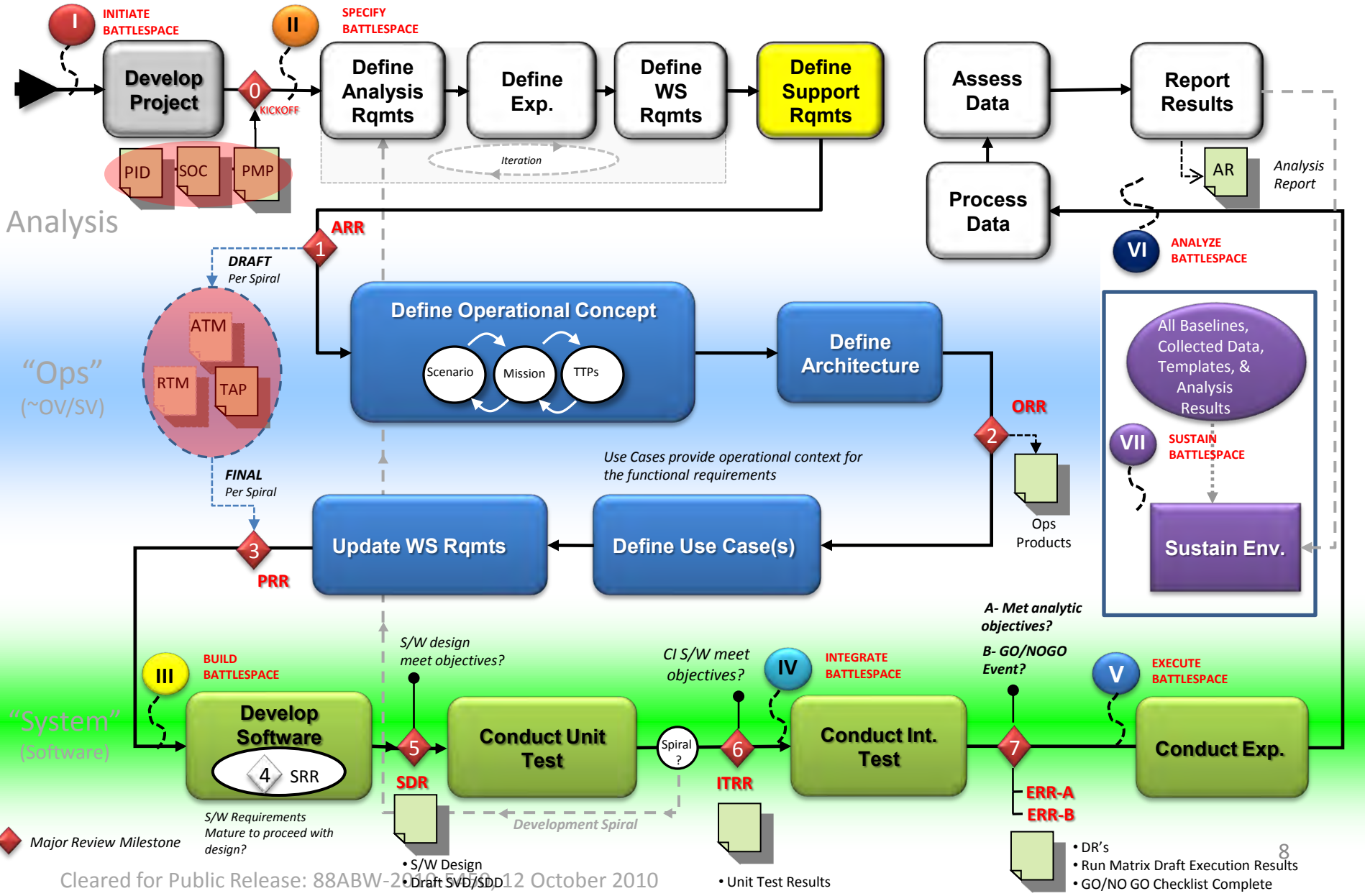
Analysis results provide insight into the trade space and are applied to the customer's decision making process to positively impact combat power!

Digital representation of key functional capabilities of the system(s) necessary to support the analytic objectives

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

FY11 SIMAF Master Event Process

SE embedded process in a product life-cycle, Updated 1 Oct 2010



Cleared for Public Release: 88ABW-2010-5490, 12 October 2010

Organization of Requirements

Functional Requirement Lexicon applied to all Projects

Dominant Air Power: Design For Tomorrow…Deliver Today

1.0 (C2): Command & Control
-Receive and respond to Messages for C2 assignments from C2 Nodes

2.0 (FM): Fly & Maneuver
-Aerodynamic Rqmts
- Max Speed Mach @ High Alt
-Combat Radius
- Range per Msn type
-Aerodynamic Model
- Degrees of Freedom model

3.0 (CM): Communicate
-Voice Radio
-Data Link Radio
-Message Sets

4.0 (UP): Understand, Predict, & React
-Virtual Cockpits with HOTAS
-OTW Displays
-Display Messages on Displays

5.0 (SD): Sense & Detect
-Radar: Type & Capabilities
-RWR: System Specific
-IFF: System Specific

6.0 (SC): Special Category

7.0 (LM): Launch Munitions
-Radar Missile, # needed
-IR Missile, # needed
-Jettisonable Centerline Tank

8.0 (EW): Electronic Warfare
- Internal Counter-measures system
-Chaff/flare dispenser

9.0 (DE): Directed Energy Attack

10.0 (IR): IR Attack & Support
-Chaff/Flare dispenser

11.0 (IN): Instrumentation

Key Takeaway: Requirement owners speak in the an organized and consistent language to the software developers! Reduces errors and Requirement Churn!

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

EAAGLES

Extensible Architecture for Analysis and Generation of Linked Simulations

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

- ❑ Capability-Based Design
- ❑ Electronic combat environment
- ❑ Robust air-to-air *and* air-to-ground
- ❑ Designed for hundreds of players
- ❑ *Proven* real-time architecture
- ❑ Optimized for the PC, yet platform independent
- ❑ Variable and Scalable Fidelity, Object Oriented
- ❑ Hardware: Dual to Networked PC "clusters"
- ❑ Hardware-in-the-Loop
- ❑ Distributed simulation via DIS, HLA, & TENA
- ❑ Government owned and managed software

OpenEAAGLES Simulation Framework

The EAAGLES framework is publically released and available via ***www.openeaagles.org***

Infrastructure Matters! Environment is engineered for real-time SoS assessments!

AFICE Distributed LVC Team

Mapping local processes

Dominant Air Power: Design For Tomorrow…Deliver Today

AFICE Lead IPT

- Integration Lead
  - Gov't Lead
  - Tech Lead
- Event Dir
  - Ops Lead
- LVC Lead
- Analysis Lead
- Infrastructure Lead
- Security Lead

PARTICIPATING LOCAL SITES IPTs

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

VV&A Problem Statement

- **The primary role of V&V is to reduce risk.**
  - The greater the risk, the more V&V are required.

- **Requirements and intended use must exist before V&V can be conducted**; acceptability criteria must be developed and documented:
  - Acceptability criteria should be agreed upon between the test manager and the accreditation authority.
  - Acceptability criteria are a measure of the risk the accreditation authority is willing to accept prior to conducting the test.

- **V&V is a never-ending process**
  - V&V continues during test execution. Information may need to be collected during actual test/event execution to ensure that the environment is correct, the simulations are running correctly, and the simulations are interacting with each other correctly.

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

VV&A Process Framework

Structuring the Project

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

Issue Category	Description (see notes page for more details)	Example Issue
Environment	Experimental design defines what needs to be represented in the environment: entities, databases, etc. at different locations may have inconsistent representations.	Environment database may vary across simulations and likely differs from a live asset on an open air range
Fidelity of models	May have improper simulation interactions due to differences in simulation fidelity. This can arise from desire to reuse existing resources without ensuring proper "fit."	"High fidelity" simulator may introduce additional factors and variables that confound test results
Data consistency	Network components introduce minor (and stochastic) latencies between transmittal and receipt of data between/among interacting entities.	May introduce improper simulation interactions if latencies are too high
Data collection and management	LVC data sets typically include multiple recording points, formats, and data rates; time reference standards become critical.	Time reference may be inconsistent due to transmission latencies
Infrastructure	Network protocols and hardware may impact quality of service and security.	How to handle lost data packets due to network performance
Administrative	V&V documentation at one location may not be sufficient for another location's test needs.	Inconsistencies in documentation or semantics

Step 1. Identify & Categorize VV&A Issues

Maturity Level	Use Characterization	Validation Referent	V&V Evidence
0	None	None	None
1	SME judgments	SME opinion of system behavior	SME judgment of completeness & accuracy
2	Representation requirements + primary use risks	SME opinion of system behavior	Inventory of completeness + SME judgment of accuracy
3	Level 2 + tolerable error characteristics & use risk estimates for errors & bounds	Quantitative estimate of system behavior & accuracy of estimate	Completeness & accuracy of evaluation results
4	Level 3 + tolerable uncertainties & sensitivities	Level 3 + uncertainty in behavior estimates	Level 3 + uncertainty evaluation results
5	Level 4 + mathematical derivation description	Level 4 + mathematical derivation description	Level 4 + mathematical proof

Step 2. V&V Maturity Levels

Consequence*	Probability that issue will lead to the consequences for the intended use*			
	Substantial	Moderate	Small	Slight
Catastrophic	4-5	4-5	3-4	3
Critical	4-5	3-4	3	1-2
Marginal	3	2-3	1-2	1
Negligible	2	1-2	1	1

- Numbers in boxes indicate desired V&V maturity level to support an accreditation decision
- Desired V&V maturity levels must be justified based on test objectives
- See notes page for more information

Step 3. V&V Risk Matrix

- Risk Level = V&V Maturity Required – V&V Maturity Achieved (or Achievable)

Risk Level	VV&A Type	Risk Description
5/Very High	Verification Failure	Model/simulation is specifically unable to meet requirement referent for intended use.
4/High	Negative Indication to Verify	V&V accomplished was inconclusive to fully determine verification requirement but data trends suggest model or simulation will fail compliance criteria for intended use.
2-3/Moderate	Failure to Verify	V&V accomplished failed to determine whether the model or simulation meets requirement referent for intended use.
1/Low Risk	Positive Indication to Verify	V&V accomplished was inconclusive to fully determine verification requirement but data trends suggest model or simulation may be compliant and is suitable for intended use.
<1/Very Low Risk	Verified	V&V accomplished indicates model or simulation is verified against the requirement referent for intended use.

Step 4. Determine Risk Level

- Provide a list of all potential issues identified by category and show the V&V maturity level desired and actually achieved to address each issue
  - The V&V maturity level must be supported with evidence!
  - Document each potential issue using the "V&V RISK ANALYSIS" outline on the next chart
- For each risk area identified, provide the chart depicted in Step 4, along with the following information:
  - Specific problem
  - The specific known potential consequences
  - Any additional risk mitigation or V&V activities that may take place before use of the simulation environment
  - A projected schedule and cost to raise the V&V Maturity to the desired level (if possible)

Step 5. Report Risk

VV&A Process Complete

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

VV&A Approach

Applying VV&A to AFICE LVC Distributed Assessments

- Apply template to selected potions of AGILE Fire III
- Report, by project, results to mock Accreditation Authority or Authorities
  - Include Assessed Risk Levels, Ability to mitigate Risk, and Resulting VV&A Risk levels per template
- Report , for entire event, results to mock “Event Accreditation Authority”
- Document lessons learned
- Collect VV&A documentation where applicable
- Provide feedback to further update the template
  - Assess applicability in whole or part (with new upgrades) in preparing for AGILE FIRE IV
- Document entire process as a Use Case

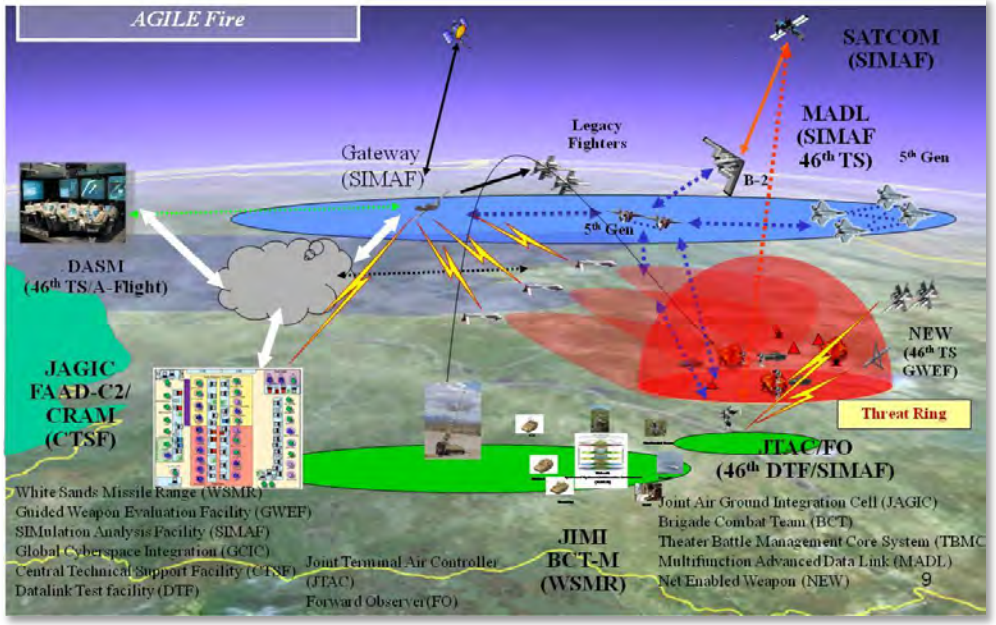
Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

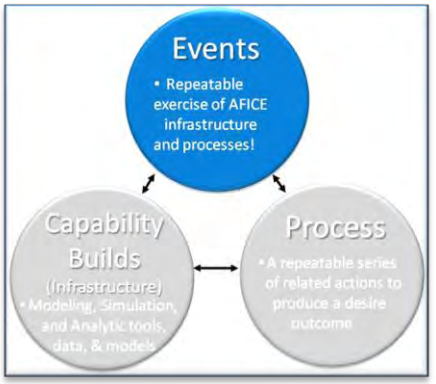
AFICE Venue

Unique Venue to support AFICE Objectives

Dominant Air Power: Design For Tomorrow…Deliver Today

- **Focus on the interoperability within and between space, air and ground communication layers**
- **Capture the requirements for emerging technologies/ interfaces to existing force structure in mission contexts.**
- **Support the customers by enabling a SOS environment to meet their Net Centric assessment needs!**
  - Requirements drive assessments
  - Analysis rooted in mission threads
  - Net Centric Focus to link their system performance to their operational partners





Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

AGILE II/III Description

Air and Ground Integrated Layer Exploration

Dominant Air Power: Design For Tomorrow…Deliver Today

- Multifunction Advanced Data Link (MADL)
  - AFMC/Electronic Systems Center (ESC), SAF/A6W
- Gateway
  - AFMC/ESC; Air Force Command and Control Integration Center (AFC2IC)
- AFATDS – TACP CASS
  - PM AFATDS/TACP-CASS/Ft Sill FSC
- Joint Air Ground Integration Cell (JAGIC)
  - ACC/A3D – USAF OPR
  - Joint and Combined Integration (JACI) – USA OPR
- Dynamic Air Space Management
  - AFMC/ESC-PM TBMCS/PM TAIS/PM AFATDS
- Counter – Rocket Artillery and Mortar (C-RAM)
  - PEO C3T/PD- CRAM
- Net-Enabled Weapon (NEW)
  - NEW Interoperability Working Group (NEWIG), SAF/A6W
- Capability Net Centric Test & Training (CNCTT)
  - 505th Command Control Wing (CCW)

AGILE III's Schedule

- AGILE III's next planning Conference is 26 to 28 Oct at WPAFB
- First Integration Spiral is December 2010

AGILE FIRE PHASE III adds 5 new projects

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Using AGILE

AGILE III and VV&A

- Part of OSD "VV&A Use Case" project tied to M&S Coordination Office High Level Task
- Used Networked-Enabled Weapon (NEW) as notional SUT
- Applied draft "Evaluation and Reporting Framework"
  - Risk-based framework
  - Pragmatic approach designed to achieve confidence in LVC environment while minimizing cost and schedule impacts
  - Focused on Live, Virtual, Constructive Distributed Environment (LVC-DE) for Test and Evaluation
- Reported results to mock Accreditation Authority (SAF/A6W SL) on 17 Aug 10
- Updated draft framework based on feedback
- **Reapply as Part of AGILE III, and IV in FY10**

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Formalizing AFICE

U.S. AIR FORCE

Air Force Integrated Collaborative Environment

Implementation Concept of Operations (CONOPS)

September 2010

Submitted by:

LAN CAWTHON, GS-15
Chief, Modeling & Simulation Policy Division
Directorate of Warfighting Systems Integration

Approved by:

WILLIAM J. BENDER, Brig Gen, USAF
Director, Warfighter Systems Integration
Office of Warfighting Integration and
Chief Information Officer

- **CONOPs signed by Brig Gen Bender (SAF/A6W) on 1 October 2010**
- **CONOPs establishes AFICE focus on program Integration and Interoperability**
- **Formalizes AFICE Governance**
  - *-Relationship to WFI GOSG*
  - *-Formation of an O-6/GS15 AFICE Advisory Group (AAG)*
  - *-Formation of an AFICE Users Group (AUG)*
- **CONOPS identifies a process for nomination of a War Fighter Gap**

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

AFICE and NR-KPP

Present and Future

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

- **Begin to formalize Interoperability assessments**
  - Consistent with existing test
  - Not duplicative
    - Focus on testing the capability in mission threads vice message compliance within the System
  - Work with the NR-KPP experts

AFICE Goal: Move beyond finding problems after system release to engaging with programs and supporting primes to discover interoperability problems before system release

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Summary

- AFICE uses a robust SE process to establish and maintain requirement traceability from analytic objectives through software development
- The resulting LVC environment is uniquely "engineered" for each customer based upon their analysis needs - Tied to a War Fighting Requirement
- **AFICE uses these environments to support integration and interoperability assessments based upon War-Fighter capability gaps**

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Contact Information

Ms. Eileen Bjorkman
Senior Advisor, Warfighting Systems Integration
SAF/A6W
Pentagon, Washington DC
eileen.bjorkman@pentagon.af.mil
(703) 588-5055, DSN 425-5055

Mr. Timothy Menke
Technical Director, Modeling and Simulation Division
ASC/XRA (SIMAF)
Wright Patterson AFB OH
timothy.menke@wpafb.af.mil
(937) 255-1276 (DSN 785)

Cleared for Public Release: 88ABW-2010-5450, 12 October 2010

Valuing System Flexibility via Total Ownership Cost Analysis

Barry Boehm, JoAnn Lane, USC

Ray Madachy, NPS

NDIA Systems Engineering Conference

October 27, 2010

Outline

- **Research Project Context**
- **Flexibility Definitions and Common Cases**
- **Total Ownership Cost (TOC) Results to Date**
  - **Advantages, Challenges, Strategies**
  - **TOC Analysis for Foreseeable Change**
    - **For individual systems**
    - **For families of systems**
  - **Conclusions and Candidate Extensions**
    - **Refined and extended model capabilities**
    - **Integration with alternative valuation models**

SYSTEMS ENGINEERING
Research Center

Research Project Context

- **Part of SERC Valuing Flexibility Research Task**
  - **For DDR&E Director of Systems Engineering Steve Welby**
- **Provide business cases for investing in system flexibility**
  - **Vs. buying more copies of less flexible systems**
- **Performed by multi-university team**
  - **Texas A&M, AFIT, NPS, USC, U. Virginia**
- **Using multiple analysis approaches**
  - **Knowledge Value Added, Option Hedging, Portfolio Analysis, Risk Analysis, Total Ownership Cost (TOC) Analysis**

Flexibility Definitions and Common Cases

- Working definition of "flexibility"
  - Ability to adapt cost-effectively to sources of change
- Foreseeable sources of change
  - Within single system: encapsulate sources of change
  - Across family of systems: use commonalities and variabilities
- Unforeseeable sources of change
  - Build in analysis of change traffic, adaptability
  - Build in system margins
- Classes of change effects
  - Capabilities, interfaces, levels of service, project constraints, improvement opportunities

Total Ownership Cost (TOC) Approach

- TOC Advantages, Challenges, Strategies
  - Representative examples
- TOC Analysis for Foreseeable Change
  - Model and tool for individual systems
    - Calibrated to TRW software data (3 systems)
    - Exploring calibration to NPS SHIPMAIN hardware data
  - Model and tool for families of systems
    - Calibrated to COCOMO II software data (161 projects)
    - Exploring calibration to AFIT modular munitions hardware data
- Candidate Extensions
  - Refined and extended model capabilities
    - Particular domains, tradeoff analyses, enterprise analysis
    - Effects of adaptation to unforeseeable change
  - Integration with alternative valuation models

TOC Advantages, Challenges, Strategies

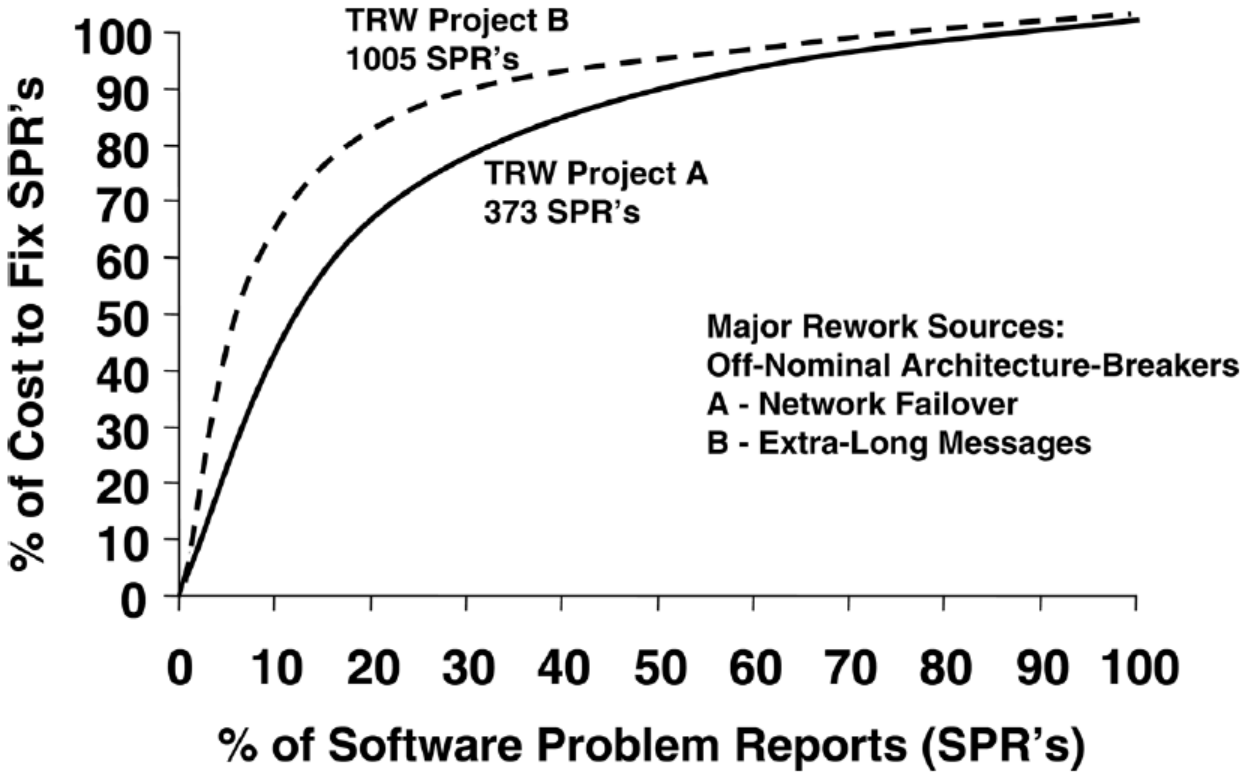
- TOC Advantages
  - Increasingly required (DoDI 5000.02, WSARA 2009)
  - Easy to understand across specialty domains
  - Clear cause-effect relationships, straightforward calibration
- TOC Challenges
  - Defining flexibility investment costs, resulting cost reductions
    - Rework and change-adaptation cost reductions a proxy for benefits
  - Predicting uncertain futures
- TOC Approach Strategies
  - Tailor analysis approaches to common situations
    - DoDI 5000.02 milestone reviews, make-or-buy decisions
  - Explicitly emphasize need to define evolution requirements
    - Not just snapshot capability, interface, KPP, project requirements
  - Start with simple models and tools, refine and extend as needed

Outline

- Research Project Context
- Flexibility Definitions and Common Cases
- Total Ownership Cost (TOC) Results to Date
  - Advantages, Challenges, Strategies
  - TOC Analysis for Foreseeable Change
    - For individual systems
    - For families of systems
  - Conclusions and Candidate Extensions
    - Refined and extended model capabilities
    - Integration with alternative valuation models

Point-Solution Architectures Cause Major Rework

Contracts: Nominal-case requirements; 90 days to PDR



SYSTEMS ENGINEERING Research Center

Projects A and B Major Rework Sources

- Change processing over 1 person-month = 152 person-hours

Category	Project A	Project B
Extra long messages		3404+626+443+328+244= 5045
Network failover	2050+470+360+160= 3040	
Hardware-software interface	620+200= 820	1629+513+289+232+166= 2832
Encryption algorithms		1247+368= 1615
Subcontractor interface	1100+760+200= 2060	
GUI revision	980+730+420+240+180 =2550	
Data compression algorithm		910
External applications interface	770+330+200+160= 1460	
COTS upgrades	540+380+190= 1110	741+302+221+197= 1461
Database restructure	690+480+310+210+170= 1860	
Routing algorithms		494+198= 692
Diagnostic aids	360	477+318+184= 979
TOTAL:	**13620**	**13531**

Project C: Architecting for Change

USAF/ESC-TRW CCPDS-R Project*

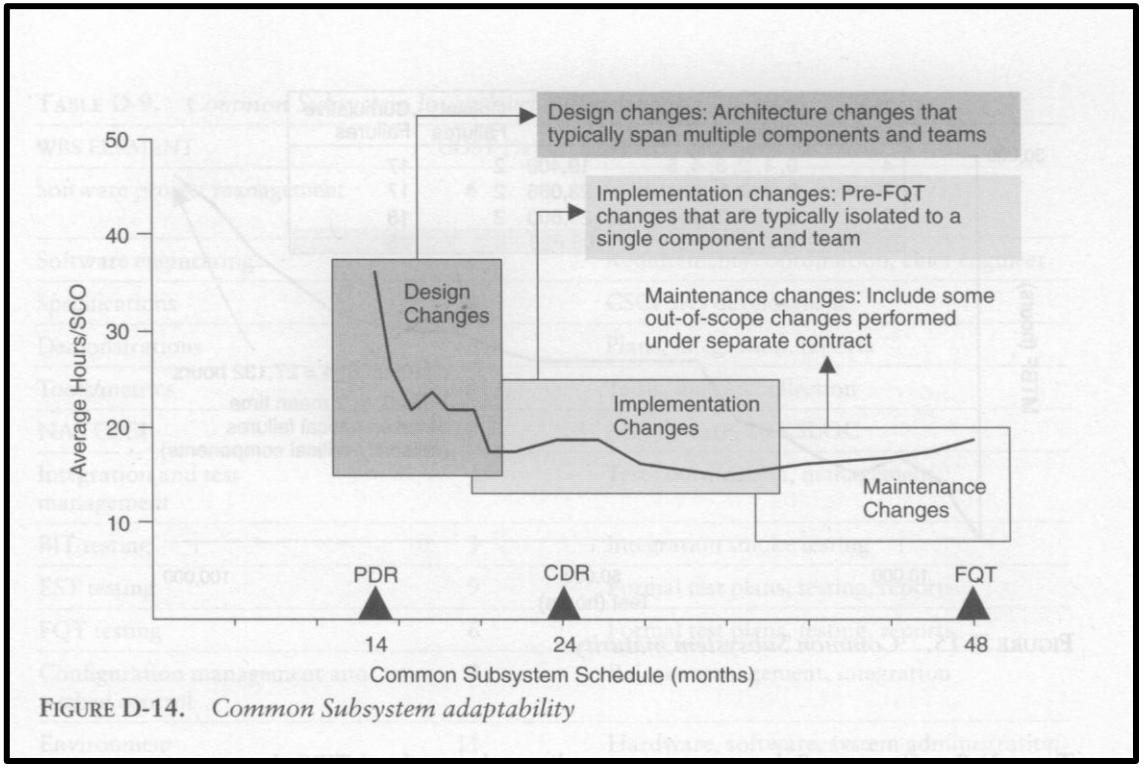


FIGURE D-14. *Common Subsystem adaptability*

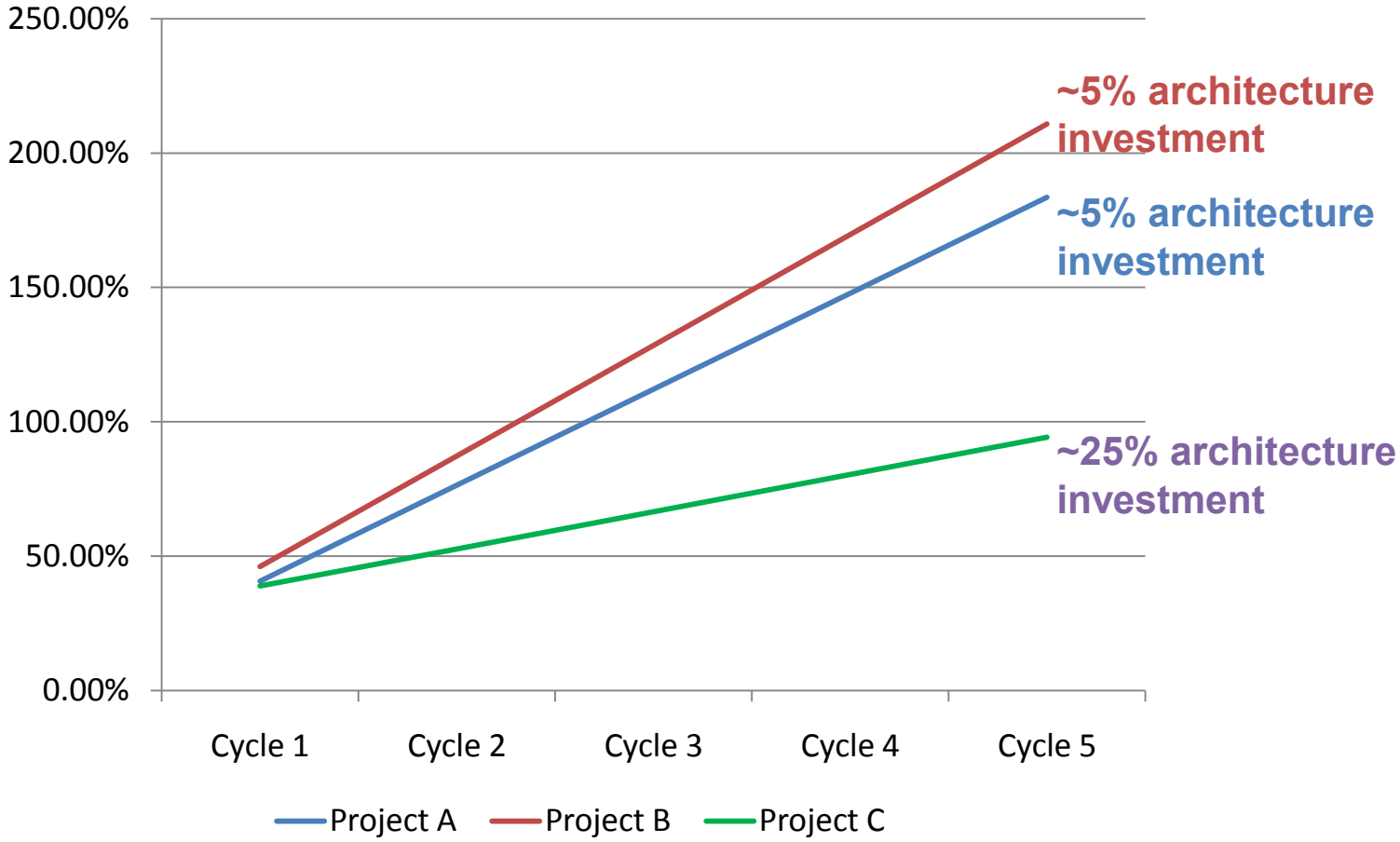
When investments made in architecture, average time for change order becomes relatively stable over time…

* Walker Royce, *Software Project Management: A Unified Framework*. Addison-Wesley, 1998.

Single-System TOC Model Example

	A	B	C	D	E
1	**Input Parameters**	**System**			
2		**A**	**B**	**C**	
3	Software Size (KSLOC)	100	100	355	
4	# Change Requests/Release	373	1005	1600	
5	# Change Requests (I&T only)				
6	# I&T Change Requests/Release/ > 1 PM	27	22		
7	# Total Change Requests/Release/ > 1 PM			16	
8	Change Request Fix Time (See assumption #2)	261	356	263	
9	Total Effort (Person Months)	731	865	1900	
10	% Arch, RESL	5%	5%	25%	
11	% Rework, RVOL	35.70%	41.16%	13.85%	
12					
13	**Cumulative Total Cost of Ownership**	Project A	Project B	Project C	
14	Cycle 1	40.70%	46.16%	38.85%	
15	Cycle 2	76.41%	87.31%	52.70%	
16	Cycle 3	112.11%	128.47%	66.55%	
17	Cycle 4	147.82%	169.62%	80.40%	
18	Cycle 5	183.52%	210.78%	94.25%	

Relative* Total Ownership Cost (TOC)



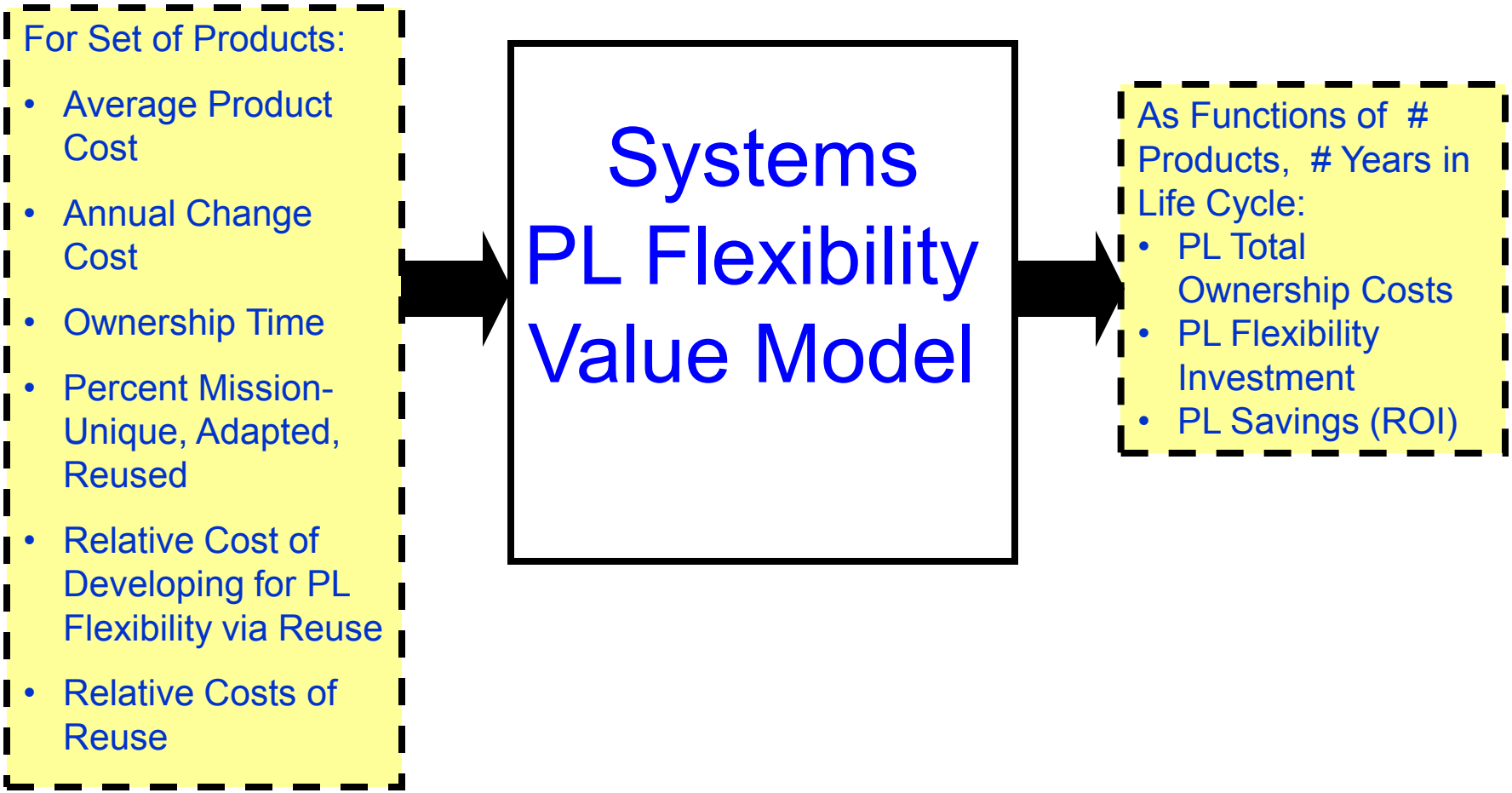
* Cumulative architecting and rework effort relative to initial development effort

Product-Line Flexibility Value Modeling

- USC and NPS collaborating on modeling value of investing in product-line flexibility with Return-On-Investment (ROI) and Total Ownership Cost (TOC) parametric models
  - System-level product line flexibility investment model
  - Software product line flexibility investment model.
  - Net present value (NPV) calculations included
- Models adapted from the Constructive Product Line Investment Model (COPLIMO*)
  - Special versions also developed for Daimler Chrysler and JPL

* Barry Boehm, A. Winsor Brown, Ray Madachy, Ye Yang, "A Software Product Line Life Cycle Cost Estimation Model," Proceedings of the 2004 International Symposium on Empirical Software Engineering, 2004

Systems Product Line Flexibility Value Model



SYSTEMS ENGINEERING
Research Center

Systems Product Line Results

Preferences

Systems Product Line Flexibility Value Model

Welcome SERC Collaborator

Open | Save | Save As

System Costs

Average Product Development Cost (Burdened $M)	5	Ownership Time (Years)	3
Annual Change Cost (% of Development Cost)	10	Interest Rate (Annual %)	7

Product Line Percentages		Relative Costs of Reuse (%)	
Unique %	40	Relative Cost of Reuse for Adapted	40
Adapted %	30	Relative Cost of Reuse for Reused	5
Reused %	30		

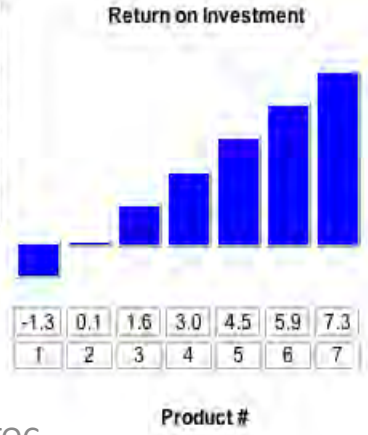
Investment Cost

Relative Cost of Developing for PL Flexibility via Reuse: 1.7

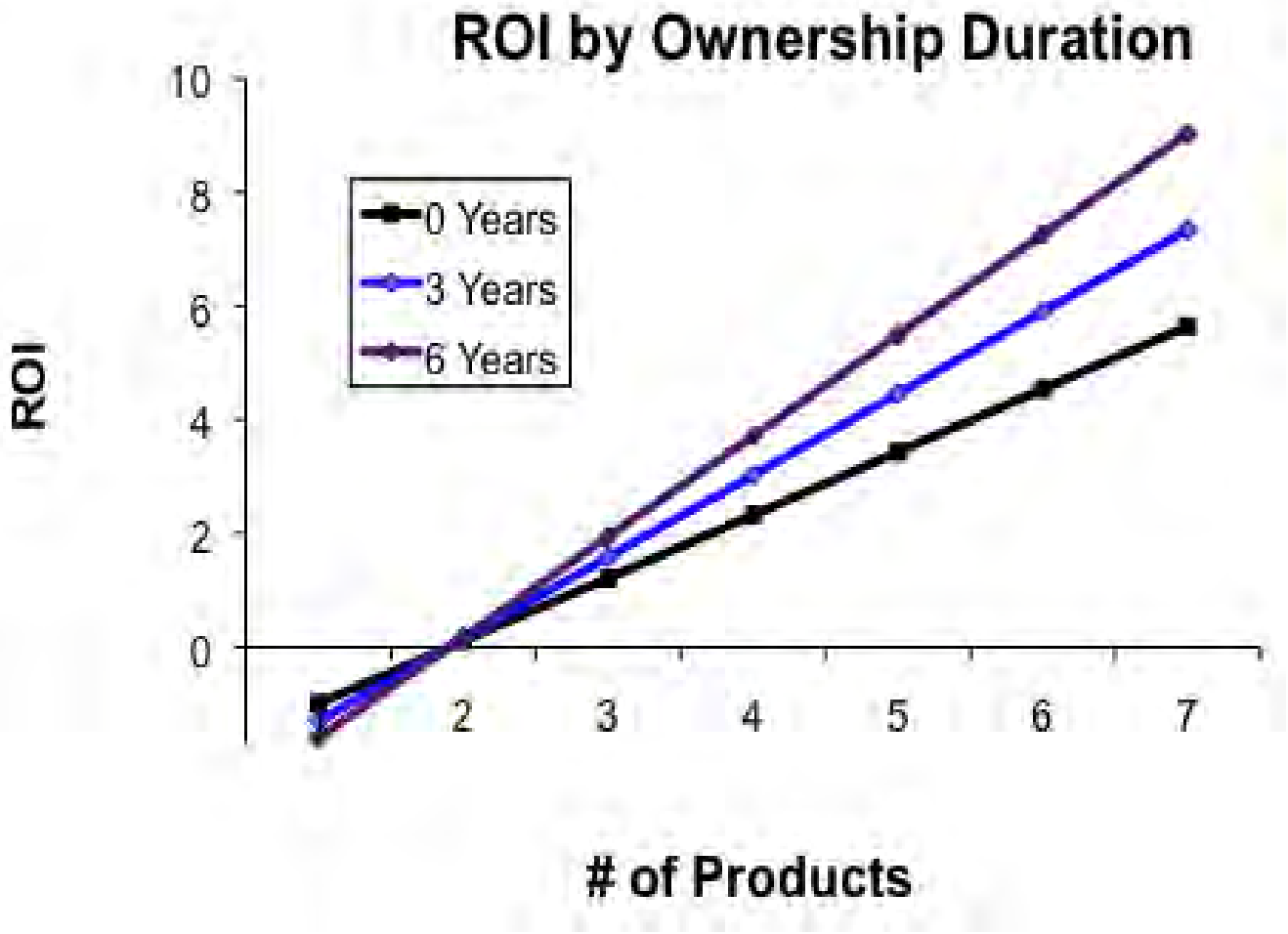
Calculate

Results

# of Products	1	2	3	4	5	6	7
Development Cost ($M)	$7.1	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
Ownership Cost ($M)	$2.1	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8
Cum. PL Cost ($M)	$9.2	$12.7	$16.2	$19.7	$23.1	$26.6	$30.1
PL Flexibility Investment ($M)	$2.1	$0	$0	$0	$0	$0	$0
PL Effort Savings	($2.7)	$0.3	$3.3	$6.3	$9.4	$12.4	$15.4
Return on Investment	-1.30	0.14	1.58	3.02	4.46	5.90	7.34



Sensitivity Analysis Example



Conclusions and Candidate Extensions

- TOC approach has several advantages
  - Increasingly required (DoDI 5000.02, WSARA 2009)
  - Easy to understand across specialty domains
  - Clear cause-effect relationships, straightforward calibration
- Important to determine evolution requirements
- Basic models available for foreseeable change
  - Individual systems, families of systems
  - Best to have calibration data
- Candidate Extensions
  - Refined and extended model capabilities
    - Particular domains, tradeoff analyses, enterprise analysis
    - Effects of adaptation to unforeseeable change
  - Integration with alternative valuation models

Procure-2-Pay Portal Pilot

Integrated Feasibility Assessment (IFA)

Lien Dinh
Chief Engineer, BTA DBSAE
lien.dinh@bta.mil

Agenda

- BTA DBSAE Mission and Vision
- Problem Statement and Requirement
- Integrated Feasibility Assessment (IFA) Overview
- Portal IFA Process
  - Project Strategy
  - Capability Analysis
  - Scoring Guidelines
  - Portal Analysis of Alternative (AoA) Options
  - Trends in User Provision and Portal Capabilities
  - Results, Implication, and Recommendations

DBSAE Mission and Vision

Deliver Business Capability to Warfighters

Be recognized as a World Class Acquisition Organization and Trusted Provider of Transformational Business Capabilities

Develop, operate, and drive successful implementation of Combat Support Business Enterprise Solutions for the Warfighter that deliver a solid Foundation for Sovereign Operations for the United States of America

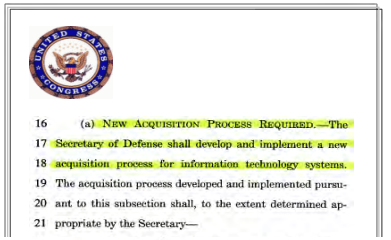
Accomplished through:

- **Transformation and Innovation**
- **Transitioning proven systems to sustainment**
- **A Trained, Agile and Ready Workforce;**
  - **Skilled**
  - **Motivated**
  - **Ethical**
  - **Diverse**

Rapid Acquisition On Schedule & On Cost

FY10 National Defense Authorization Act directs a "New Acquisition Process" based on DSB… must be designed to include:

- **Early and continued user involvement**
- **Multiple, rapidly executed increments or releases of capability**
- **Early, successive prototyping to support evolutionary approaches**
- **Congressional report in in 270-days**
- **Modular open-system approach**

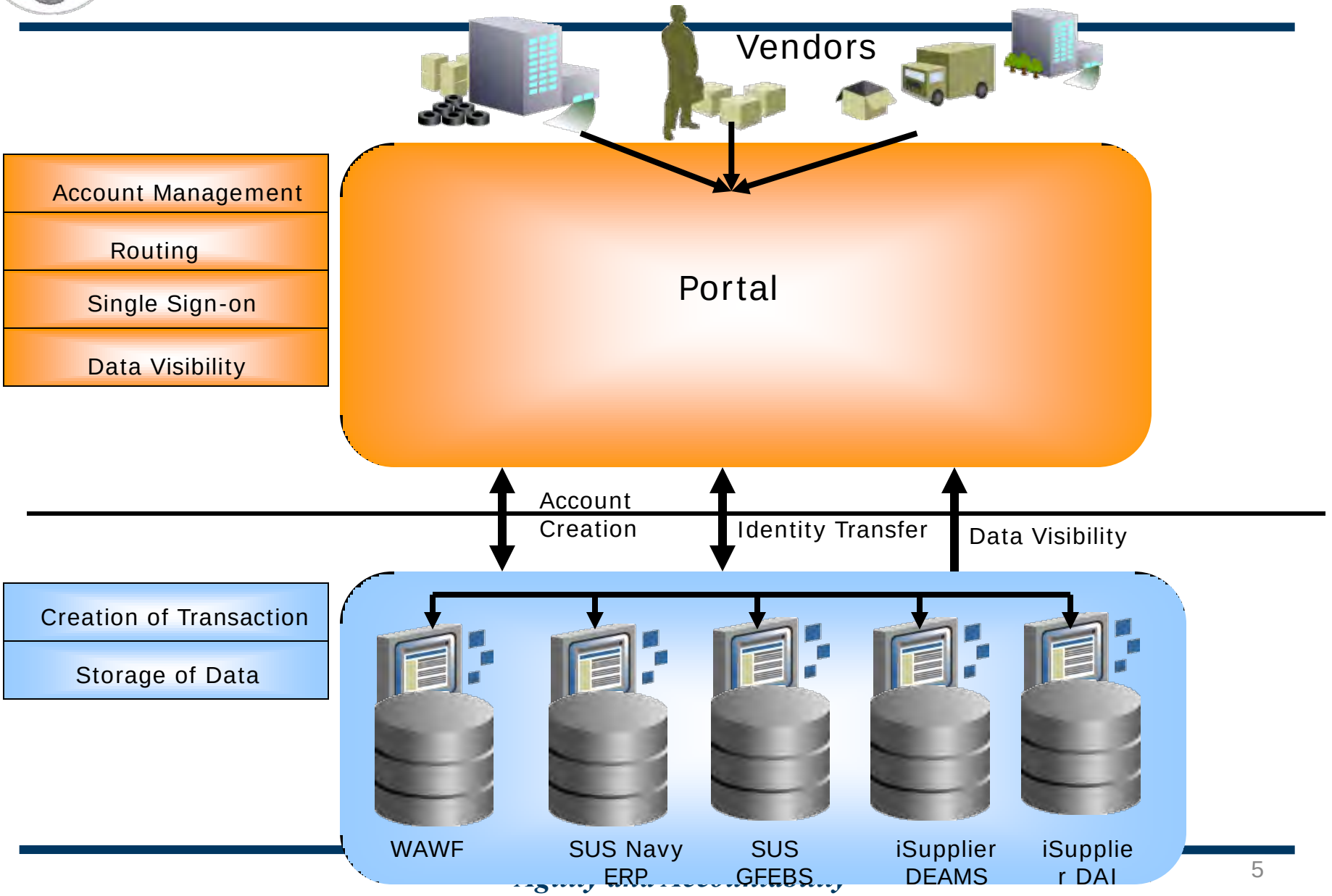


16 (a) NEW ACQUISITION PROCESS REQUIRED.—The
17 Secretary of Defense shall develop and implement a new
18 acquisition process for information technology systems.
19 The acquisition process developed and implemented pursu-
20 ant to this subsection shall, to the extent determined ap-
21 propriate by the Secretary—

Problem Statement

"Single Point of Entry for the vendor to access underlying systems for the purposes of receipt, acceptance, and invoicing."*

High Level Requirements View



Integrated Feasibility Assessment (IFA) Overview

What Is the IFA

Faster Technology to the Warfighter

The Integrated Feasibility Assessment (IFA) is an enterprise approach for assessing technology as it applies to mission/business capabilities' improvements.

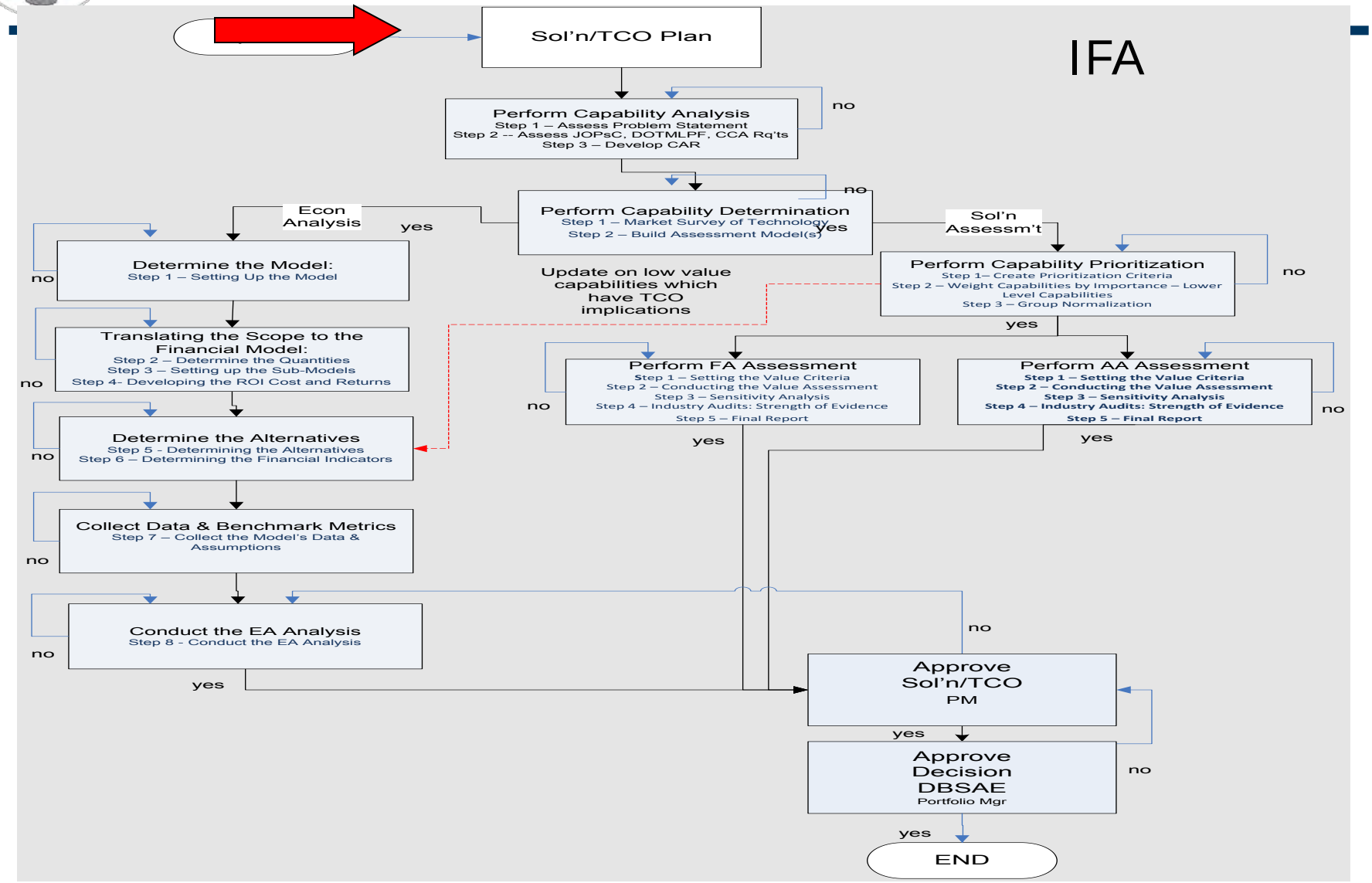
IFA is a methodology to:

- Increase the efficiency of solution assessments and reduce redundant pre-acquisition operational activities
- Increase the difficulty in approving non-optimal fielding and enterprise decisions
- Meet compliance with the Title 40 Clinger Cohen, DoD 5000.02 and BCL

IFA Assessment Process

Project Strategy (PS)	*Project Strategy (PS)* – the problem statement, which is the fundamental requirement of the IFA process, confirms the ability of the solution/ technology to satisfy the identified capabilities or gaps while providing a solution deemed "best value".
Capability Analysis (CA)	*Capability Analysis (CA)* — the CA identifies the requirements and capabilities for the program and further defines the problem statement and scope of the effort. Capabilities are defined at the Program level as a basis of the business case. This analysis ensures that there is sufficient data to understand the viability of technology and sufficient data to develop the Total cost of ownership (TCO) for the materiel solution.
Capability Prioritization (CP)	*Capability Prioritization (CP)* – The CP process is used to assess the comparative value of the capabilities to the various activities/roles (use case) of the organization. This process of elimination of low priority business case requirements increase the viability of a solution, reduce time/cost of implementation and decrease the failure risk.
Capability Determination (CD)	*Capability Determination (CD)* – The Capability Determination process defines "what" capability gaps are to be evaluated, and by "what" technologies. This is a process that creates groupings (tables) of capabilities and technology or solutions that satisfy the capability gaps. This is an important step, which establishes the plan for how the assessment will be conducted.
Feasibility Assessment (FA)	*Feasibility Assessment (FA)* — Feasibility Assessment is a process for analysis of emerging and innovative technology products regarding the degree to which they will satisfy the capabilities or gaps identified.
Economic Analysis (EA)	*Economic Analysis (EA)* — a minimal decision support process that identifies alternatives and provides business and technical arguments for selection and implementation to achieve stated organizational objectives. The Economic Analysis is a simplified Business Case Analysis, which provides an analytical and uniform foundation upon which sound decisions are made.

IFA FLOW DISGRAM



IFA Speeds Production of Statutory Documents

An Assembly Line Model with clear entry/exist criteria

JOPsC Rqt's Prioritization

Mission Capability	No	High Level Capability
2	1	Reduce time to deploy infrastructure
1	2	Reduce infrastructure cost
1	3	Improve Reliability, Availability Survivability (RAS)
4	4	Work within current Security Management Posture
		Provide support for AF Use C
1	6	Support SBC storage strategy
2	7	Support Infrastructure Requirements
1	8	Improved Manageability
1	9	Provide the same user experience (irrespective of client; rich or thin client).

Builds On

Functional/DOTMLPF Capabilities

	5e	Provide support for client type – Remote
	5f	Provide support for client type – Unmanaged
125	6	**Support SBC storage strategy**
	6a	Provide server-side storage of System data and/or system images
	6b	Provide server-side storage of enterprise data
	6c	Provide server-side storage of user data and/or system images
	6d	Provide server-side storage of user application
	6e	Provide server-side storage of enterprise data application
125	7	**Support Infrastructure Requirements**
	7a	Maintain current bandwidth/network loads (min 10 GB to max 100GB user profiles, 100 MB to the desktop)
	7b	Provide consistent capability, whether rich or thin, with differi on Active Directory rights/groups
	7d	Provide support for the Common Access Card (CAC)/DOD P Infrastructure (PKI) logon
150	8	**Improved Manageability**
	8a	Provide for remote manageability of desktop
	8b	Provide support for all business and mission applications, including bandwidth sensitive applications
	8c	Provide for a client computing environment solution that scales over the AF enterprise
	8d	Allow use of a diverse mix of hardware end devices in a heterogeneous environment
	8e	Increase IT service availability to the mobile/pervasive user
150	9	**Provide the same user experience (irrespective of client; rich or thin client).**

Builds On

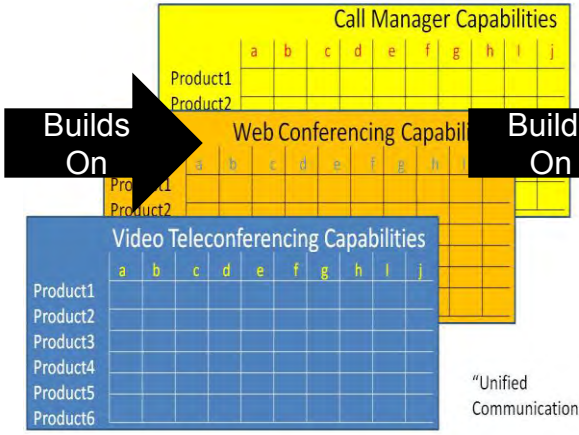
Capability

	5e	Provide support for client type – Remote	3
	5f	Provide support for client type – Unmanaged	5
125	6	**Support SBC storage strategy**	
	6a	Provide server-side storage of System data and/or system images	1
	6b	Provide server-side storage of enterprise data	1
	6c	Provide server-side storage of user data and/or system images	1
	6d	Provide server-side storage of user application	1
	6e	Provide server-side storage of enterprise data application	1
125	7	**Support Infrastructure Requirements**	
	7a	Maintain current bandwidth/network loads (min 10 GB to max 100GB user profiles, 100 MB to the desktop)	1
	7b	Provide consistent capability, whether rich or thin, with differing capabilities based on Active Directory rights/groups	1
	7d	Provide support for the Common Access Card (CAC)/DOD Public Key	1
150			1
		pplications, including bandwidth	4
		ution that scales over the AF	1
		evices in a heterogeneous	1
		se IT service availability to the mobile/pervasive user	2
150		**rovide the same user experience (irrespective of client; rich or thin client).**	1

UoM Objective

Builds On

Cap. Determination



"Unified Communications

Builds On

Feasibility/Architecture Assessments

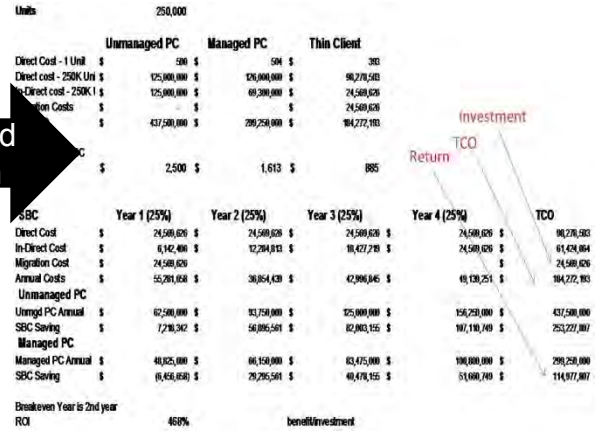
Value Factors	Reduce time to deploy infrastructure 15%	Reduce infrastructure cost 15%	Improve Reliability, Availability Survivability (RAS) 5%	Work within current Security Management Posture 5%	Provide support for AF Use Cases 5%	Support SBC storage strategy 13%	Support Infrastructure Requirements 13%	Improved Manageability 15%	Provide the same user experience (irrespective of client; rich or thin client). 15%	Sc
Softgrid	1.67	3.00	3.40	1.50	0.73	1.40	1.00	1.55	1.00	1.67
Ardent	2.33	3.15	3.40	3.00	1.53	1.40	1.33	2.11	2.00	2.23
ClearCube	1.67	2.23	1.30	2.50	2.07	1.40	2.00	2.78	4.00	2.48
Wyse	1.00	1.92	1.30	1.50	2.80	1.00	2.33	4.22	5.00	2.67
CCI/HP	1.67	2.23	1.30	2.50	2.07	1.40	2.00	2.78	4.00	2.83
Citrix	1.00	1.92	1.30	1.50	2.80	1.00	2.33	4.22	5.00	3.03

Blue = Essential	1 - 1.99
Green = Desirable	2 - 2.99
Yellow = Less Desirable	3 - 3.99
	4 - 5.00

Overall Score on each Product

Build On

Economic



Portal IFA Process

Project Strategy Capability Analysis Scoring Guidelines

Project Strategy

Objective	Stakeholders
Complete CAM process for P2P Portal Option 3 implementation, identifying potential implementation options within 30 business days.	•Vendors •EBPOC •Target Systems PMOs (ERP, WAWF, etc.) •BTA
Schedule and Status ***Completed CAM in 30 Business Days*** ▪Kickoff – 14 JAN √ ▪Problem Statement – 22 JAN √ ▪CAR – 29 JAN √ ▪Capability Prioritization – 5 FEB √ ▪*Snow – 12 FEB* ▪Market Research and Scoring – 19 FEB √ ▪AoA Completed – 26 FEB √ ▪Presentation of Results – 5 MAR	**CAM Participants** ▪Sponsor – BTA ▪Lead – BTA DBSAE ▪Participants – BTA TP&R; BTA EI; ▪Programs – DoD CIO Storefront, DKO/AKO, WAWF ▪Market Research – Provided by Gartner, Oracle, CA

P2P Capabilities

Level 1

Cap. No.	Capability Level 1	Description of Capability
1	**Notification to Human Users**	Ability for the system to deliver user account information or transactional information to recipients. The system should have the ability to notify users via email or other notification services.
2	**Data Visibility for Reporting**	Ability for the system to provide a mechanism for displaying information from all users authorized from each government organization
3	**Account management**	Ability for system to create a new vendor user account in the Portal. Vendor users will request access to the Portal in order to be routed to the appropriate target system for conducting business.
4	**Routing/ Workflow**	Ability to provide an automated routing service that will assist users in identifying the correct system to which a user should go and will establish a session on the correct system for the user. The portal must also provide user identity maintenance capabilities to accurately identify users and their access authorizations.
5	**Provide Presentation Layer for User**	Ability to provide a Presentation Layer, which will be responsible for the delivery and formatting of information to the application layer for further processing or display. Basic Requirements are: NIPRnet Presence , .mil Domain, Firewalls (Security requirements)
6	**Single Sign-On to Target System**	System shall provide Single Sign-On (SSO) services in support of accessing DoD ERP implementations (primarily Oracle Financials and SAP) and Wide Area Workflow (WAWF) target systems. The system should have the ability to eliminate further credential requests from each of the systems to which they need to connect, thereby enabling users to move among many systems in order to accomplish their various business objectives without signing on to each system individually.
7	**Data Storage**	Ability for the system to store user account information and transactional information and provide easy access to the data, which should be retrievable very quickly and transferable at a high speed.
Create Transaction Occurs at the ERP Level and falls outside the scope for this assessment		
8	**Creation of Transaction**	Ability for the system to allow the user to complete a "unit of work" which in the business world is known as a "business transaction". The system must allow the user to view and maintain records within the ERP environment using the standard Create, Read, Update or Delete operations. A transaction may deal with a single occurrence from a single database table or may deal with several occurrences from several database tables. It may only read from the database, or it may perform a number of inserts, updates and deletes within a single operation.

P2P Portal Capabilities

CAM Prioritization

Cap. No.	Capability Level 1	Capability Level 2	Level 1 Weight	Level 2 Weight
1	**Notification to Human Users**		**40**	
1.1		Notify User of Account & Transaction Status		20
1.2		Manage Notification Rules and Content		20
2	**Data Visibility for Reporting**		**100**	
2.1		Data Visibility through Reporting Capabilities		50
2.2		Search Transaction		50
3	**Account Management**		**225**	
3.1		User Provisioning for Web Page (Portlet)		72
3.2		Identity Management		72
3.3		Manage User Portlet Account		45
3.4		Web Page (Portlet) Role Management		36
4	**Routing/ Workflow**		**325**	
4.1		Determine Routing for Portlet Account Creation		163
4.2		Provide Service Interface Handle for Machine to Machine		163
5	**Provide Presentation Layer for User**		**125**	
5.1		Performance		25
5.2		Authenticate to the Portal		50
5.3		Authorize Access to Web Page		50
6	**Single Sign-On to Target System**		**150**	
6.1		Pass ID Credentials to Target Systems		100
6.2		Receive Acknowledgement of Target Systems Receipt of		50
7	**Data Storage**		**35**	
7.1		Store Data Related to Web Page (Portlet, Widget)		35
7.2		Store Data in Target Systems		N/A
8	**Creation of Transaction**		**N/A**	
8.1		Creation n of Transaction in Target System A1		N/A
		Total	**1,000**	**1,000**

Management View

Constraing Descriptions and Weights

Constraint Letter	Constraint	Description	Weight
		P2P Portal CAM Constraints	
A	Time To Market	Time to market (TTM) is the length of time it takes from a product being conceived until it is available for use - the time it will take for BTA to provide an end to end process fully implemented in the Enterprise Resource Planning (ERP) systems.	450
B	Vendor Buy-In	Vendor buy-in is essential to the success of the project and all stakeholders need to know what's happening, when it's happening and why it is happening. When all vendors involved understand and support the change initiative, then vendor buy-in has been achieved	200
C	DCMO Alignment	DCMO alignment is essential to the success of the project and all stakeholders need to know what's happening, when it's happening and why it is happening. When DCMO understand and support the change initiative, then DCMO Alignment has been achieved	150
		Performance Assessment Criteria	
D	Seamless Stakeholder Participation	Exists if the end-to-end business process enables all stages of the process to work smoothly together ensuring stakeholders (Business Process owners and users) support and comply with the business process operation to enable a successful enterprise. The typical unit of measure for Stakeholder Participation is the number of Desired uses against the number of Successful uses per unit of time.	N/A
E	Usability/Familiarity	Is the ability of business process stakeholders to make effective use of a business process upon demand. Characteristics of the business process are intuitive, uniform, and repeatable, ensuring the establishment of a process "comfort zone" such that all participants and stakeholders have a firm grasp on capabilities, expectations, hand-off requirements and process limitations. The existence of the process "comfort zone" encourages developing process execution proficiency. The typical unit of measure for Usability/Familiarity is the number of Attempted uses opposed to the number of Expected outcomes per unit of time.	100
F	Transactional Efficiancy	Is the demonstrated reliability and repeatability of a business process. The business process performs as expected, producing consistent results to an expected standard. The typical unit of measure for Transactional Efficiency is the number of Actual process uses against the number of Successful uses per unit of time.	N/A
G	Agility	Is the ability of process stakeholders to use a business process when wanted, with adaptability to change parameters within the process to allow modification as required to manage changing requirements and to assure process fulfillment. The typical unit of measure for Agility is the number of Desired process adjustments against the number of Successful process adjustments per unit of time.	100
H	Insight/Controls	Is the ability of enterprise managers and business process stakeholders to easily observe transactions, ensuring that they progress through the business cycle, promoting accuracy and completeness of data and the visibility of evolving requirements that produce reliable/timely information necessary to sustain process success and ensure adherence to policy. The typical unit of measure for Process Insight/Internal Controls is the number of Desired uses against the number of Expected uses per unit of time.	N/A
		Total	**1,000**

Scoring Guidelines

Scoring Value	Scoring Parameters
1	Mature Solution Meet Requirements with limited modification required
2	Mature Solution requires some modification
3	Mature Solution Requires modification in order to meet requirements
4	Immature Solution and may require modification OR Mature Solution requires significant modification
5	Solution was not shown to meet requirements

Portal IFA Process

Portal Analysis of Alternative (AoA) Options

Analysis of Alternative - Option A

CIO StoreFront

CAPABLITIES

1.0 Notification to Human User
- 1.1 Notify User of Status
- 1.2 Manage Notifications

2.0 Data Visibility for Reporting
- 2,1 Data Visibility Report Capabilities
- 2.2 Search Transaction

3.0 Account Management
- 3.1 User Provisioning for Web page
- 3.2 ID Management
- 3.3 Manage User Portlet Accounts
- 3.4 Web Page Role Management

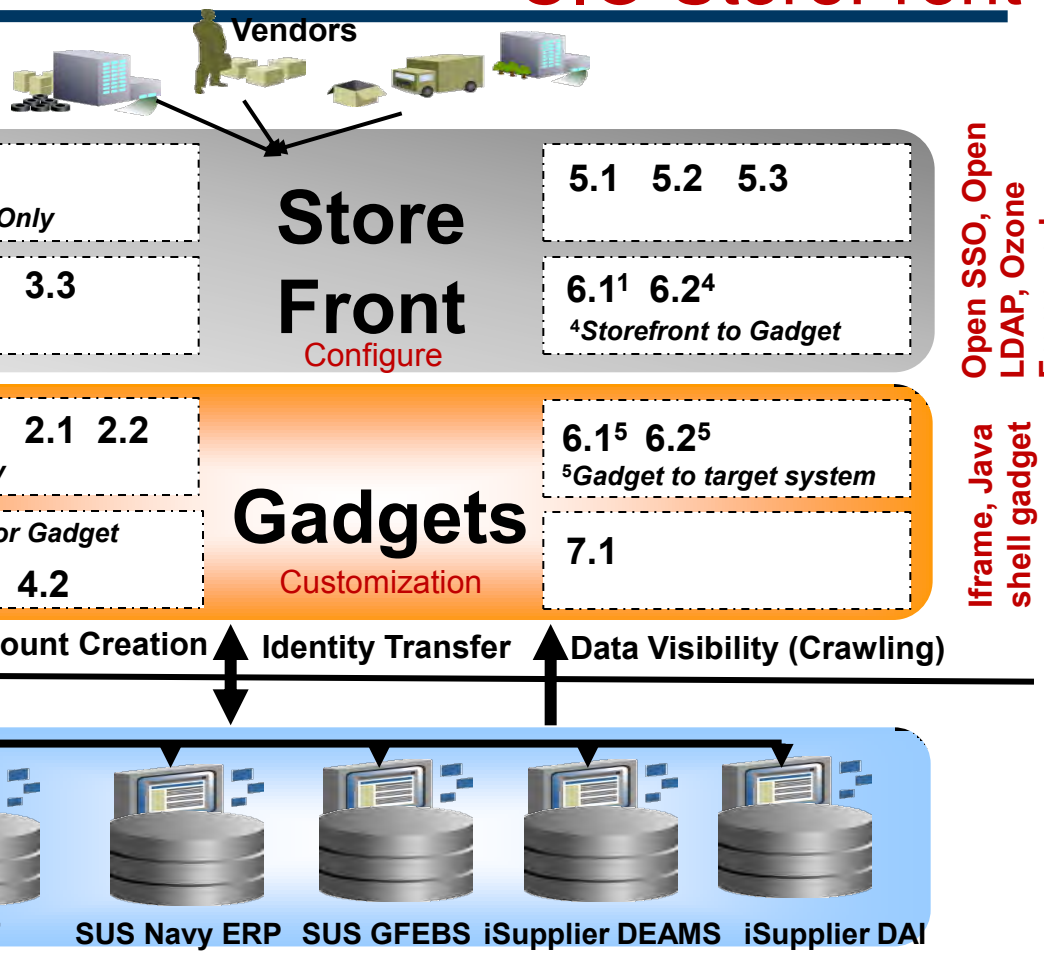
4.0 Routing/ Workflow
- 4.1 Routing for Account Creation
- 4.2 Service Interface Handler for M2M

5.0 Presentation Layer for User
- 5.1 Performance
- 5.2 Authenticate to Portal
- 5.3 Authorizes Access to Web Page

6.0 SSO on Target System
- 6.1 Pass ID credentials to Target System
- 6.2 Receive Acknowledgement from Target System

7.0 Data Storage
- 7.1Store Data related o Web Page

8.0 Creation of Transaction
- 8.1 Creation of Transaction in Target System



PRO
- Flexibility (Code Centric)
- Cost of Pilot
- Next Generation Pathfinder for "DKO"
- Thin layer Approach

CON
- Storefront schedule may not meet FY10 goal
- New solution not yet scaled
- Heavy programming requirement (Code Centric)

Analysis of Alternative – Option B2

WAWF Extenstion

CAPABLITIES

1.0 Notification to Human User
- 1.1 Notify User of Status
- 1.2 Manage Notifications

2.0 Data Visibility for Reporting
- 2,1 Data Visibility Report Capabilities
- 2.2 Search Transaction

3.0 Account Management
- 3.1 User Provisioning for Web page
- 3.2 ID Management
- 3.3 Manage User Portlet Accounts
- 3.4 Web Page Role Management

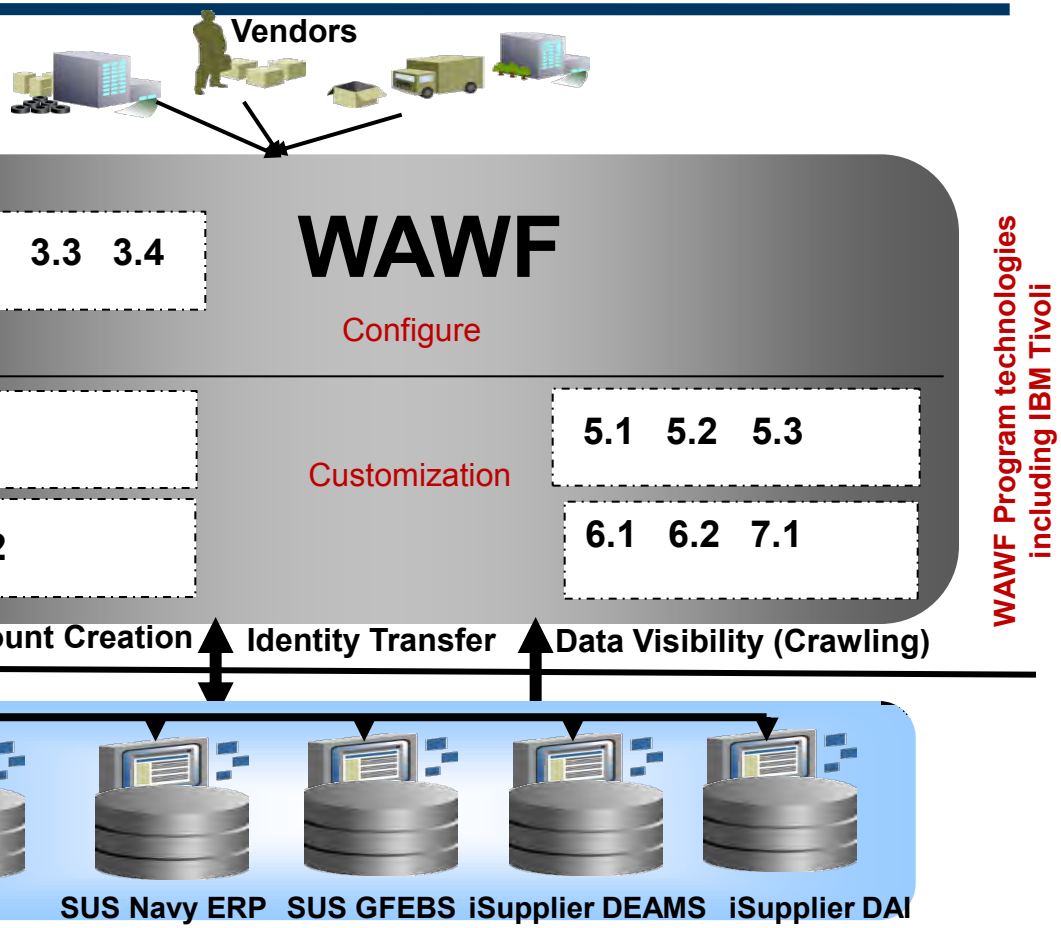
4.0 Routing/ Workflow
- 4.1 Routing for Account Creation
- 4.2 Service Interface Handler for M2M

5.0 Presentation Layer for User
- 5.1 Performance
- 5.2 Authenticate to Portal
- 5.3 Authorizes Access to Web Page

6.0 SSO on Target System
- 6.1 Pass ID credentials to Target System
- 6.2 Receive Acknowledgement from Target System

7.0 Data Storage
- 7.1Store Data related o Web Page

8.0 Creation of Transaction
- 8.1 Creation of Transaction in Target System



P R O
- Familiarity with Industry and User
- Familiarity with target system
- Gartner Magic Quadrant tool set for capability 3.0

C O N
- WAWF team development cycle
- New contracting
- Continuation of legacy code base with new extensions

Analysis of Alternative – Option C1

DKO

CAPABLITIES

1.0 Notification to Human User
- 1.1 Notify User of Status
- 1.2 Manage Notifications

2.0 Data Visibility for Reporting
- 2,1 Data Visibility Report Capabilities
- 2.2 Search Transaction

3.0 Account Management
- 3.1 User Provisioning for Web page
- 3.2 ID Management
- 3.3 Manage User Portlet Accounts
- 3.4 Web Page Role Management

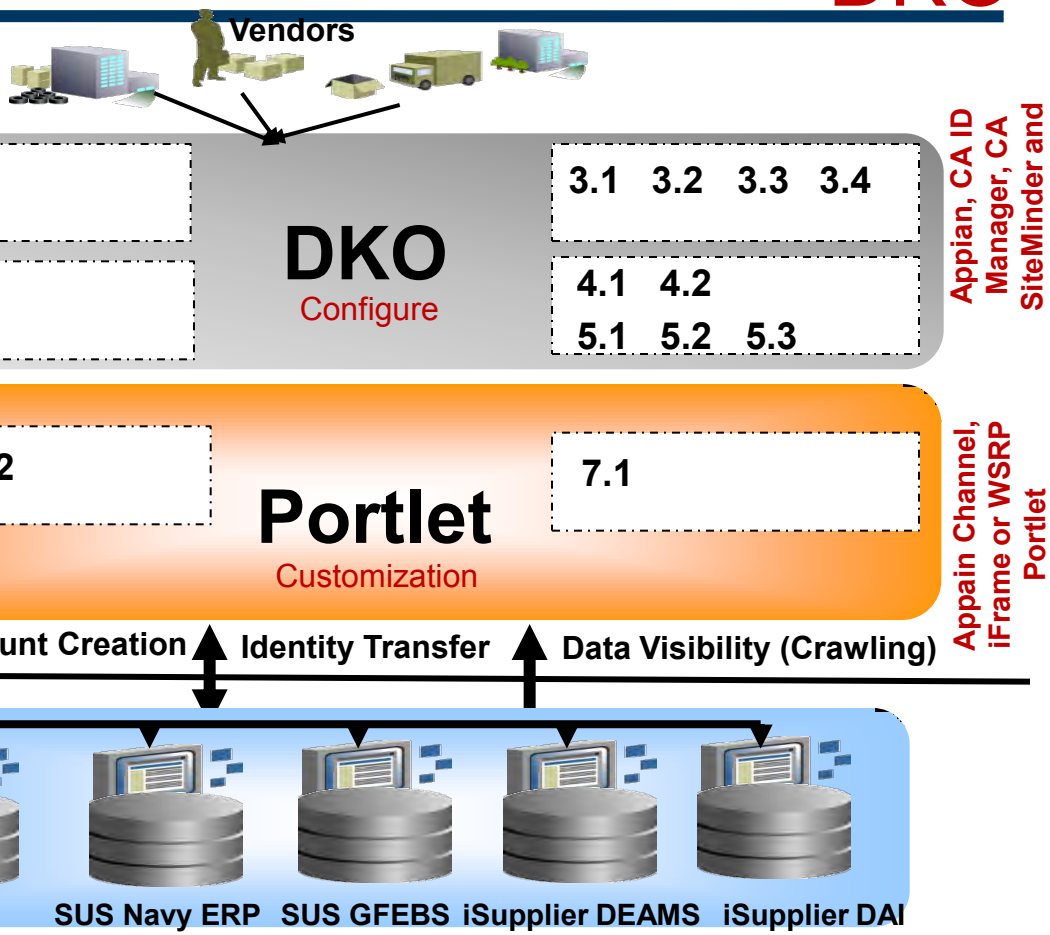
4.0 Routing/ Workflow
- 4.1 Routing for Account Creation
- 4.2 Service Interface Handler for M2M

5.0 Presentation Layer for User
- 5.1 Performance
- 5.2 Authenticate to Portal
- 5.3 Authorizes Access to Web Page

6.0 SSO on Target System
- 6.1 Pass ID credentials to Target System
- 6.2 Receive Acknowledgement from Target System

7.0 Data Storage
- 7.1Store Data related o Web Page

8.0 Creation of Transaction
- 8.1 Creation of Transaction in Target System



P R O
- Supported by DKO Team
- Aligns to DCMO Direction
- Mature technology

C O N
- Technology not acquired / deployed with P2P team
- New contracting

Analysis of Alternative – Option D

Hybrid: WAWF + DKO ID Mgmt

CAPABLITIES

1.0 Notification to Human User
- 1.1 Notify User of Status
- 1.2 Manage Notifications

2.0 Data Visibility for Reporting
- 2,1 Data Visibility Report Capabilities
- 2.2 Search Transaction

3.0 Account Management
- 3.1 User Provisioning for Web page
- 3.2 ID Management
- 3.3 Manage User Portlet Accounts
- 3.4 Web Page Role Management

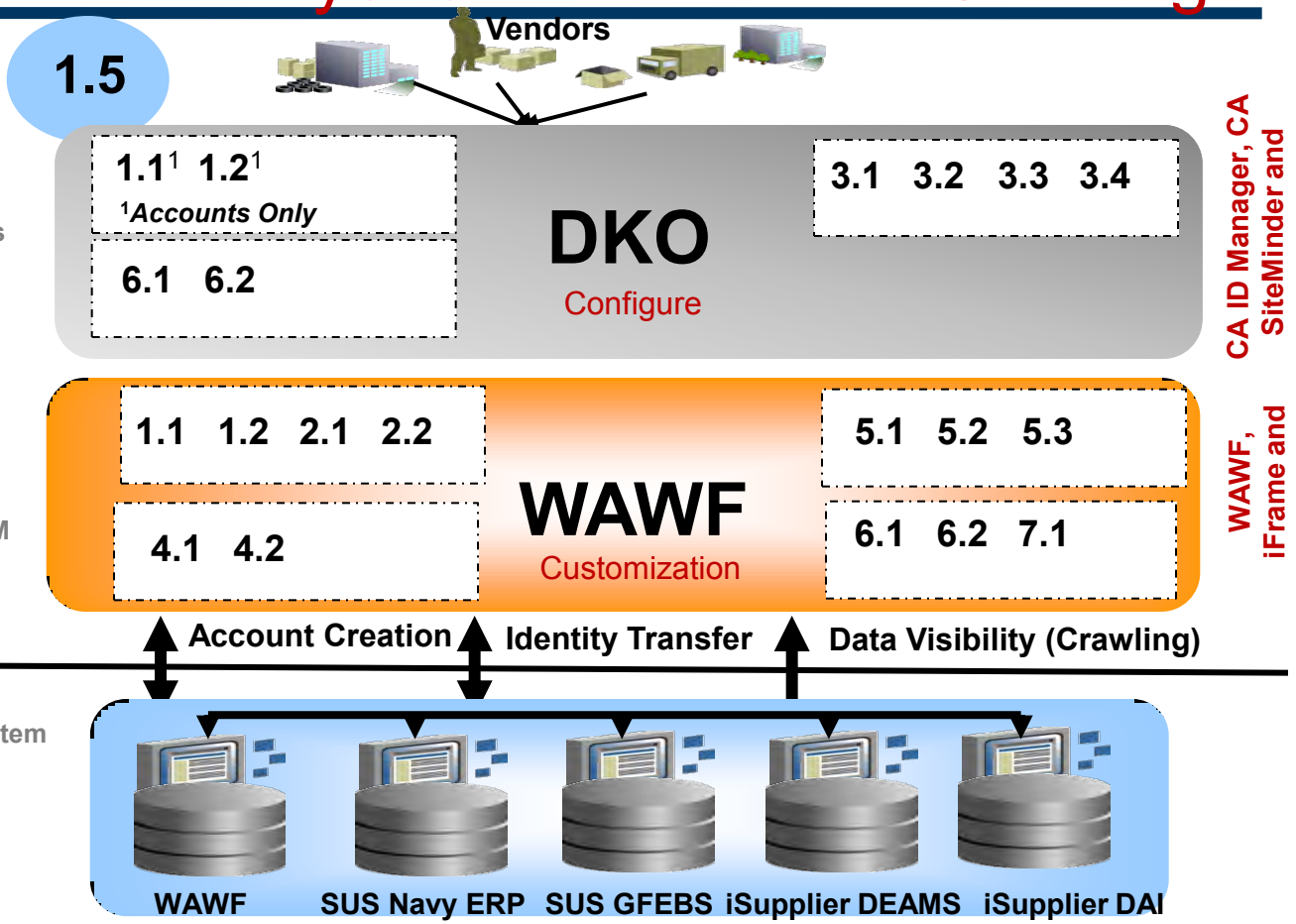
4.0 Routing/ Workflow
- 4.1 Routing for Account Creation
- 4.2 Service Interface Handler for M2M

5.0 Presentation Layer for User
- 5.1 Performance
- 5.2 Authenticate to Portal
- ~~5.3 Authorizes Access to Web Page~~

6.0 SSO on Target System
- 6.1 Pass ID credentials to Target System
- 6.2 Receive Acknowledgement from Target System

7.0 Data Storage
- 7.1Store Data related o Web Page

8.0 Creation of Transaction
- 8.1 Creation of Transaction in Target System



PRO
- Supported by DKO Team
- Aligns to DCMO Direction
- Vendor Buy-in from WAWF
- Provides for flexibility on P2P side
- Mature technology

CON
- Technology not acquired / deployed with P2P team
- New contracting
- Three+ parties involved (DKO, WAWF, P2P team)

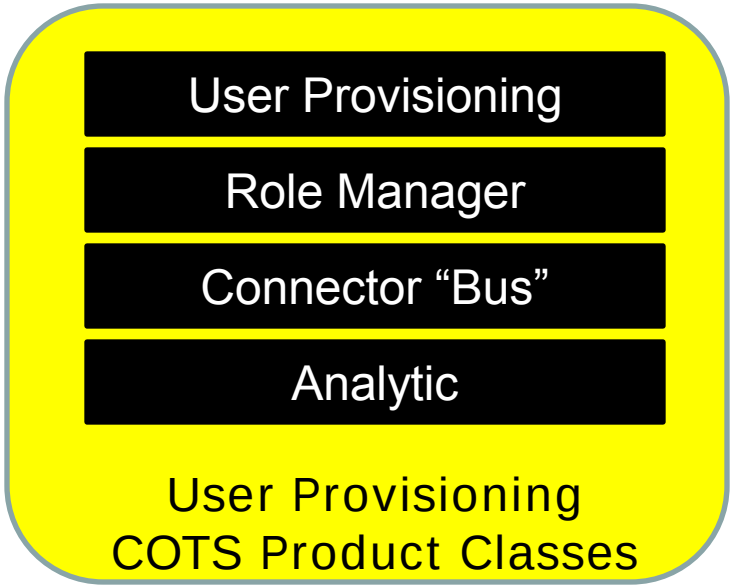
Portal IFA Process

Trends in User Provisioning and Portal Capabilities

Trends in User Provisioning
Technology & Approaches

Gartner –

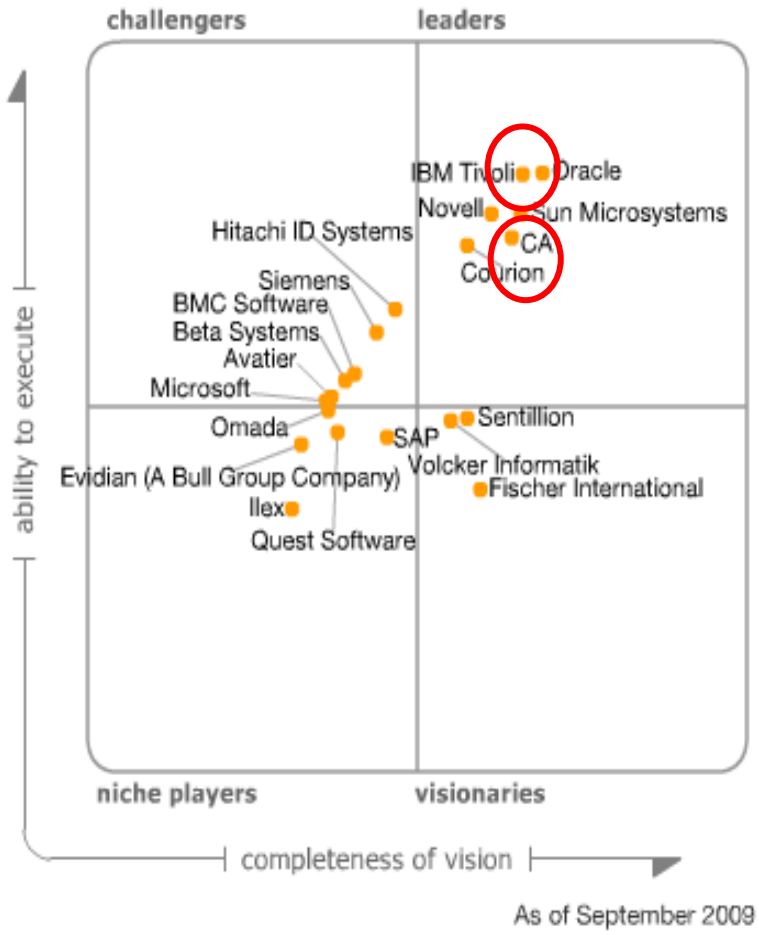
- Market has evolved since 2008 to a Commodity Market
- Early Product were not easy to use or configure
- 2010 products available at each layer and some Vendors have full stacks.
- Difficulty of implementation usually drives to a 75% solution
- 10,000 user implementation about $1 MIL ($50/user linear costs per user)



- **BTA P2P Portal Capabilities cover all Product Classes.**
- **Current DoD Implementation use only the User Identification Product**

Gartner Market Research

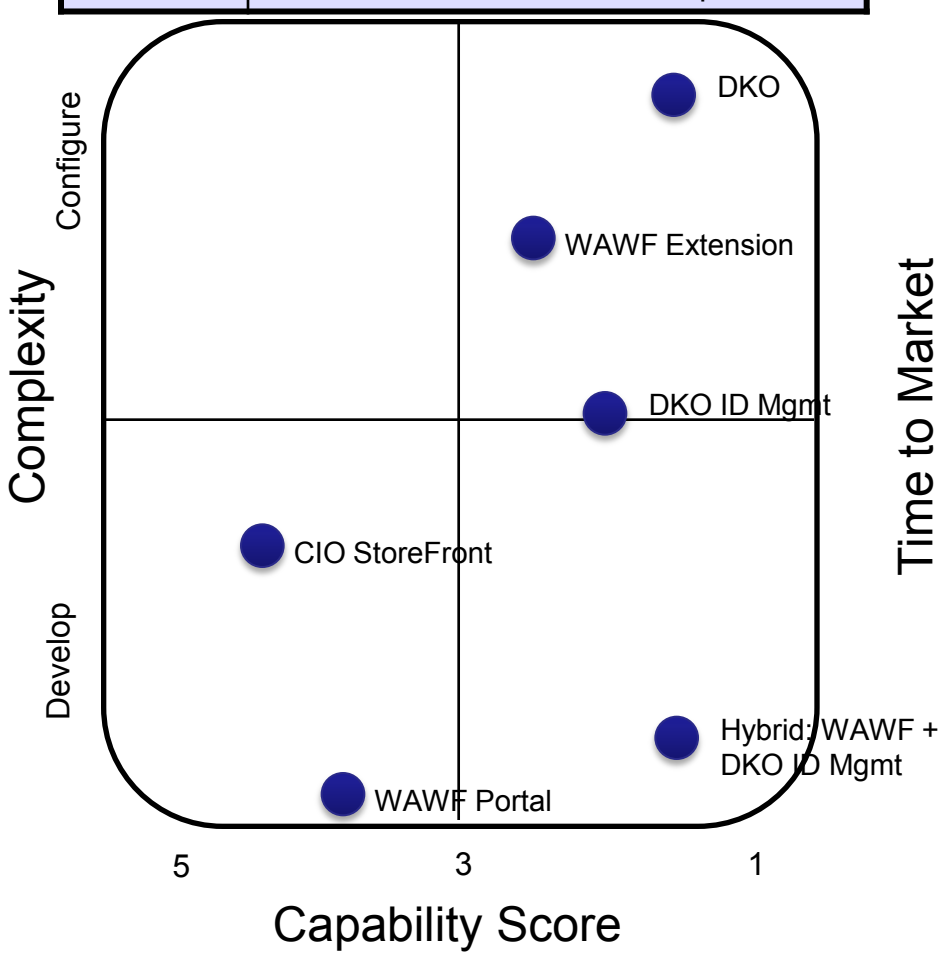
User Provisioning & Web Access Mgmt.

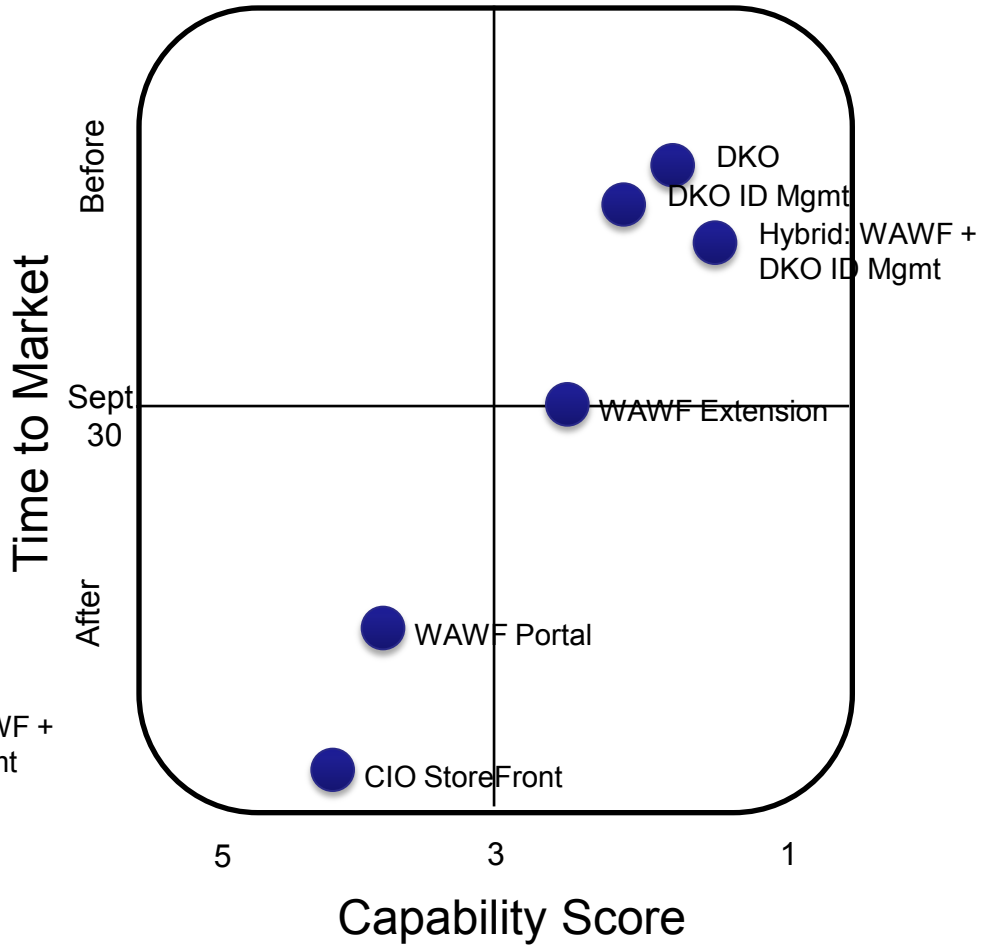


Magic Quadrants

Key

1	Mature Solution, Limited Modification
3	Mature Solution, Requires Modification
5	Solution not shown to meet requirements





Results, Implications, & Recommendations

P2P Portal AoA Results

IFA: Feasibility Assessment

Capabilities Scores

Key

1.0 – 1.9	Blue
2.0 – 2.9	Green
3.0 – 3.9	Yellow
4.0 – 5.0	Red

	1.0 Notification to Human Users	2.0 Data Visibility for Reporting	3.0 Account Management	4.0 Routing/ Workflow	5.0 Presentation Layer for User	6.0 SSO to Target System	7.0 Data Storage	8.0 Creation of Transaction	Total
Capability Weighting (%)	**4%**	**10%**	**23%**	**33%**	**13%**	**15%**	**4%**	**0%**	**100%**
Hybrid: WAWF + DKO ID Mgt	2.0	2.5	1.3	1.5	1.0	1.0	3.0	0.0	**1.5**
DKO	3.0	3.0	1.2	1.5	1.0	1.0	4.0	0.0	**1.6**
DKO ID Mgmt Only	5.0	5.0	2.4	1.5	1.0	1.0	4.0	0.0	**2.2**
WAWF Extension	2.0	2.5	1.3	3.0	1.4	5.0	1.0	0.0	**2.6**
WAWF Portal	4.0	4.0	4.0	4.0	3.8	4.0	3.0	0.0	**3.9**
CIO Storefront	4.0	5.0	2.6	5.0	2.4	5.0	3.0	0.0	**4.0**

P2P Portal AoA Results

IFA: Feasibility Assessment, Management View

Key	
1.0 – 1.9	Blue
2.0 – 2.9	Green
3.0 – 3.9	Yellow
4.0 – 5.0	Red

	Constraints								
	A. Time To Market	B. Vendor Buy-in	C. DCMO Alignment	D. Seamless Stakeholder Participation	E. Usability/Familiarity	F. Transactional Efficiency	G. Agility	H. Insight/Controls	TOTAL CONSTRAINTS
Weighting	**45%**	**20%**	**15%**	**0%**	**10%**	**0%**	**10%**	**0%**	**100%**
DKO	2.0	4.0	1.0	0.0	2.0	0.0	3.0	0.0	**2.4**
Hybrid: WAWF + DKO ID Mgt	2.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	**1.5**
DKO ID Mgmt Only	2.0	4.0	1.0	0.0	2.0	0.0	3.0	0.0	**2.4**
WAWF Extension	3.0	1.0	4.0	0.0	1.0	0.0	3.0	0.0	**2.6**
WAWF Portal	4.0	4.0	3.0	0.0	2.0	0.0	2.0	0.0	**3.5**
CIO Storefront	5.0	5.0	3.0	0.0	5.0	0.0	1.0	0.0	**4.3**

P2P Portal AoA Results

IFA: Capabilities and Constraints Details

Details

	1.0 Notification to Human Users	2.0 Data Visibility for Reporting	3.0 Account Management	4.0 Routing/ Workflow	5.0 Provide Presentation Layer for User	6.0 Single Sign-On to Target System	7.0 Data Storage	8.0 Creation of Transaction	TOTAL CAPABILITIES	A. Time To Market	B. Vendor Buy-in	C. DCMO Alignment	D. Seamless Stakeholder Participation	E. Usability/Familiarity	F. Transactional Efficiency	G. Agility	H. Insight/Controls	TOTAL CONSTRAINTS	TOTAL
Weighting	**4%**	**10%**	**23%**	**33%**	**13%**	**15%**	**4%**	**0%**	**100%**	**45%**	**20%**	**15%**	**0%**	**10%**	**0%**	**10%**	**0%**	**100%**	
DKO	3.0	3.0	1.2	1.5	1.0	1.0	4.0	0.0	**1.6**	2.0	4.0	1.0	0.0	2.0	0.0	3.0	0.0	**2.4**	**1.7**
Hybrid: WAWF + DKO ID Mgt	2.0	2.5	1.3	1.5	1.0	1.0	3.0	0.0	**1.5**	2.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	**1.5**	**1.5**
DKO ID Mgmt Only	5.0	5.0	2.4	1.5	1.0	1.0	4.0	0.0	**2.2**	2.0	4.0	1.0	0.0	2.0	0.0	3.0	0.0	**2.4**	**2.2**
WAWF Extension	2.0	2.5	1.3	3.0	1.4	5.0	1.0	0.0	**2.6**	3.0	1.0	4.0	0.0	1.0	0.0	3.0	0.0	**2.6**	**2.6**
WAWF Portal	4.0	4.0	4.0	4.0	3.8	4.0	3.0	0.0	**3.9**	4.0	4.0	3.0	0.0	2.0	0.0	2.0	0.0	**3.5**	**3.8**
CIO Storefront	4.0	5.0	2.6	5.0	2.4	5.0	3.0	0.0	**4.0**	5.0	5.0	3.0	0.0	5.0	0.0	1.0	0.0	**4.3**	**4.1**

1.0 – 1.9	Blue
2.0 – 2.9	Green
3.0 – 3.9	Yellow
4.0 – 5.0	Red

AoA Pro's & Con's

1.5	**Hybrid: WAWF + DKO ID Mgmt.**	Supported by DKO Team Aligns to DCMO Direction Vendor Buy-in from WAWF Provides for flexibility on P2P side Mature technology	Technology not acquired / deployed with P2P team New contracting Three+ parties involved
1.7	**DKO**	Supported by DKO Team Aligns to DCMO Direction Mature technology	Technology not acquired / deployed with P2P team New contracting
2.2	**DKO ID Mgmt.**	Supported by DKO Team Aligns to DCMO Direction Provides for flexibility on P2P side Mature technology	Technology not acquired / deployed with P2P team New contracting
2.6	**WAWF Extension**	Organizationally separate from WAWF Expandable in the future Familiarity with target system	WAWF team development cycle Technology not acquired / deployed with team before New contracting
3.8	**WAWF Portal**	Familiarity with Industry and User Familiarity with target system Gartner Magic Quadrant tool set for capability 3.0	WAWF team development cycle New contracting Continuation of legacy code base with new extensions
4.1	**CIO StoreFront**	Flexibility (Code Centric) Cost of Pilot Next Generation Pathfinder for "DKO" Thin layer Approach	Storefront schedule may not meet FY10 goal New solution not yet scaled Heavy programming requirement (Code Centric)

Decision Implications & Recommendations

Assumes Prototypes Aligns with Longer-Term Solution

• Prototype with least Complexity[1] to Build	DKO Hybrid
• Prototype Lowest Risk for Time To Market	DKO
• Prototype Alignment with the Market Trend	*Not Evaluated*
• Prototype with Highest Flexibility	StoreFront
• Prototype with Highest Stockholder Familiarity	WAWF Extensions
• Prototype Taking Advantage of Open Source	StoreFront

[1] Complexity defined as No. of Capabilities to be customized

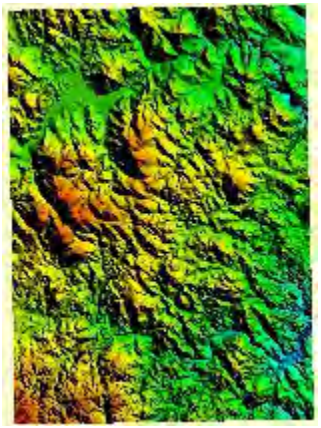
Geospatial Data Use in Modeling and Simulation

Tom Stanzione
VT MÄK
VP Advanced Technologies Division
(617) 876-8085 x109
tstanzione@mak.com

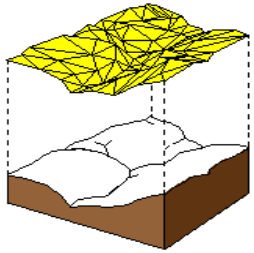
Overview

- Traditional Terrain Database Generation Process for M&S
- GIS-Enabled Modeling and Simulation (GEMS)
- Terrain Server Approach

M&S Terrain Database Generation Process

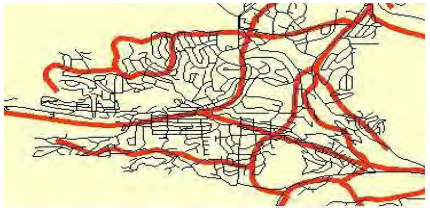


Digital Elevation Model (DEM)

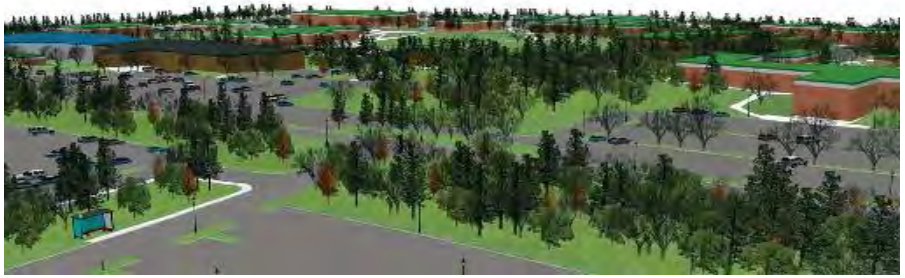


Creation of a Triangulated Irregular Network (TIN) from the elevation data.

Application of Imagery onto the surface of the TIN

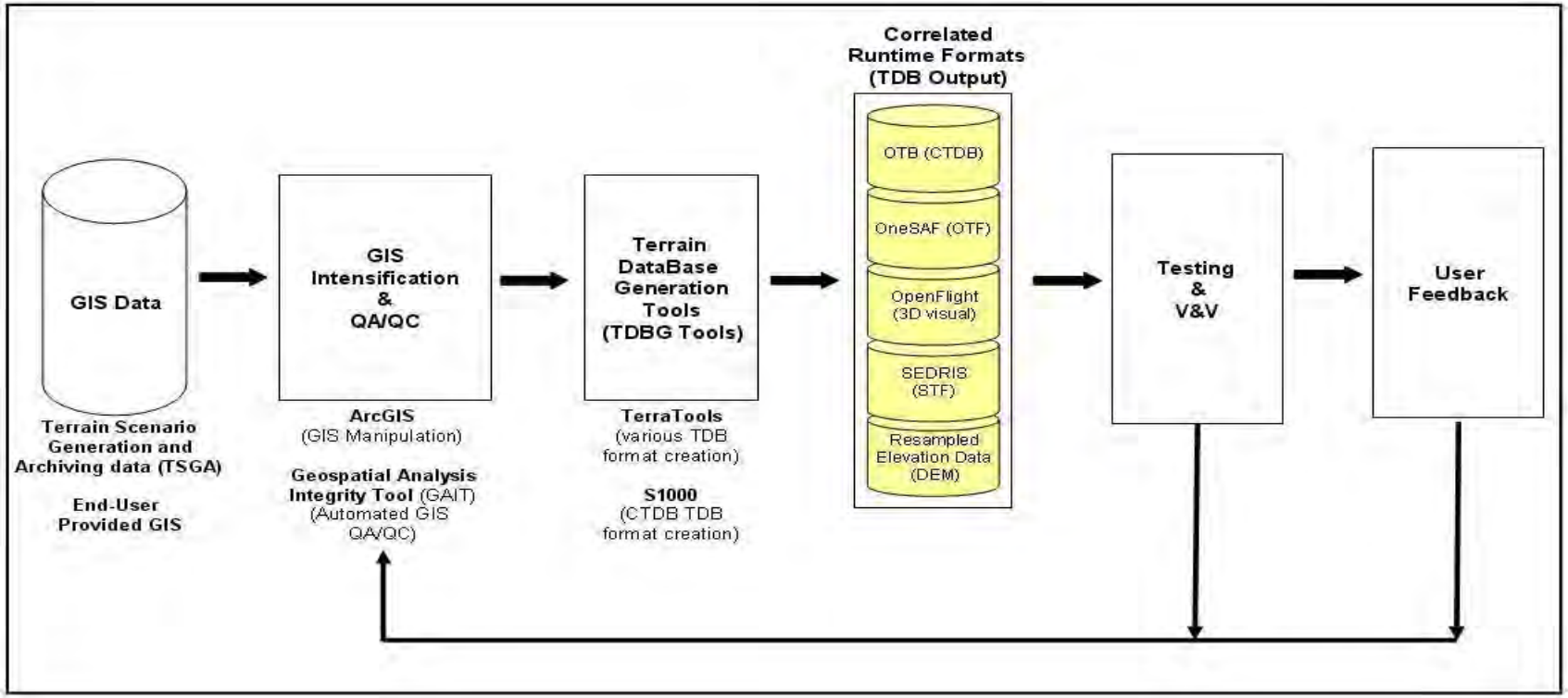


Collection and creation of Geospatial features (i.e. roads and buildings)



Completed database featuring elevation data, with overlaid imagery, and integrated GIS features compiled together into a synthetic environment.

Terrain Generation for M&S
Current Practice



Takes Time – Costs Money

Continuum of Terrain Database Approaches

Each Approach Has Merits

Geospatial Interoperability between M&S and Battle Command

Geospatial representations are quite different

- BC uses GIS-based geospatial data and mapping components
  - Raster elevation, imagery, vector features
- M&S uses proprietary, highly optimized run time terrain database formats
  - Specialized for each application

The GEMS project was started to address BC and M&S interoperability

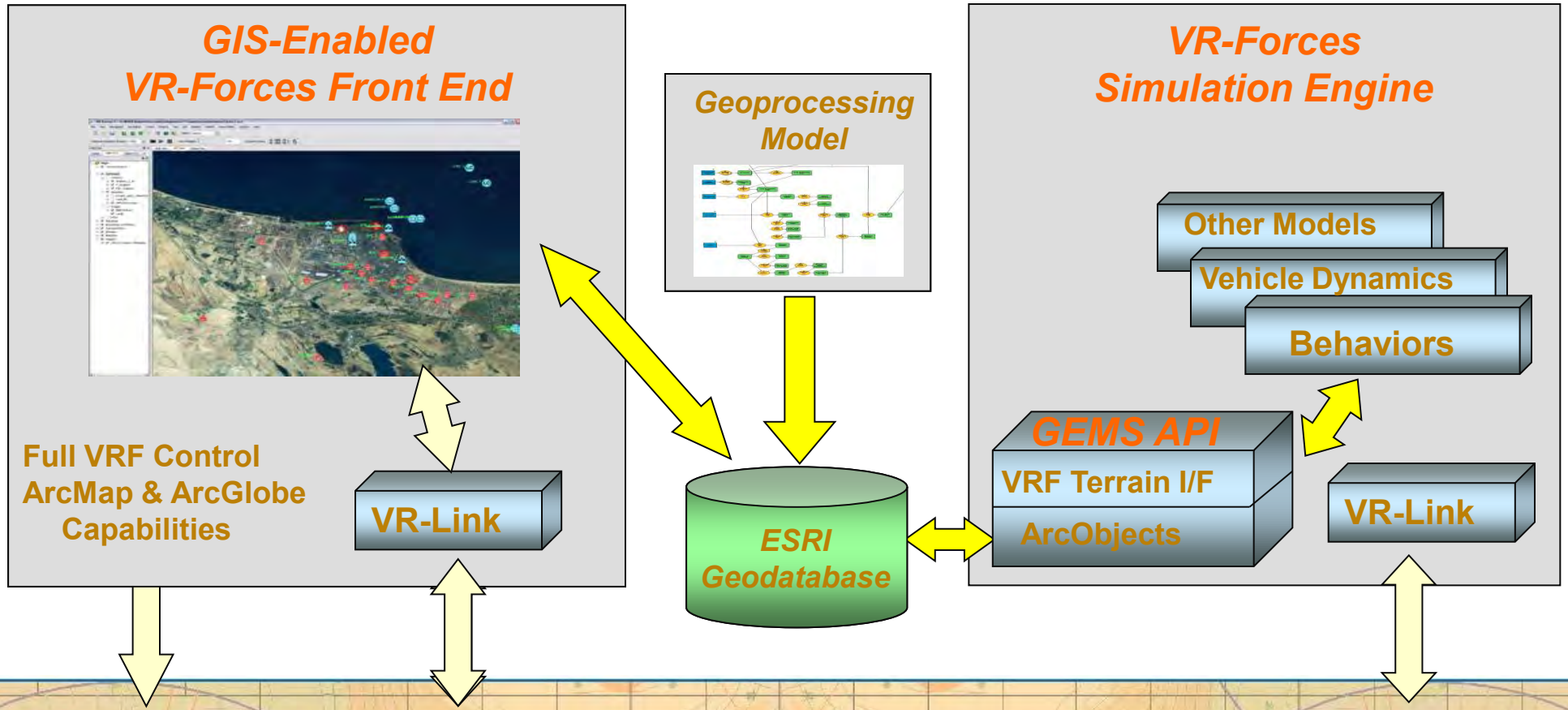
Army Geospatial Center bringing these domains closer together through use of common geospatial data, geospatial enterprise, and terrain analysis capabilities

- Leveraging GIS capabilities in Commercial Joint Mapping Toolkit (CJMTK)

GEMS - GIS Enabled M&S

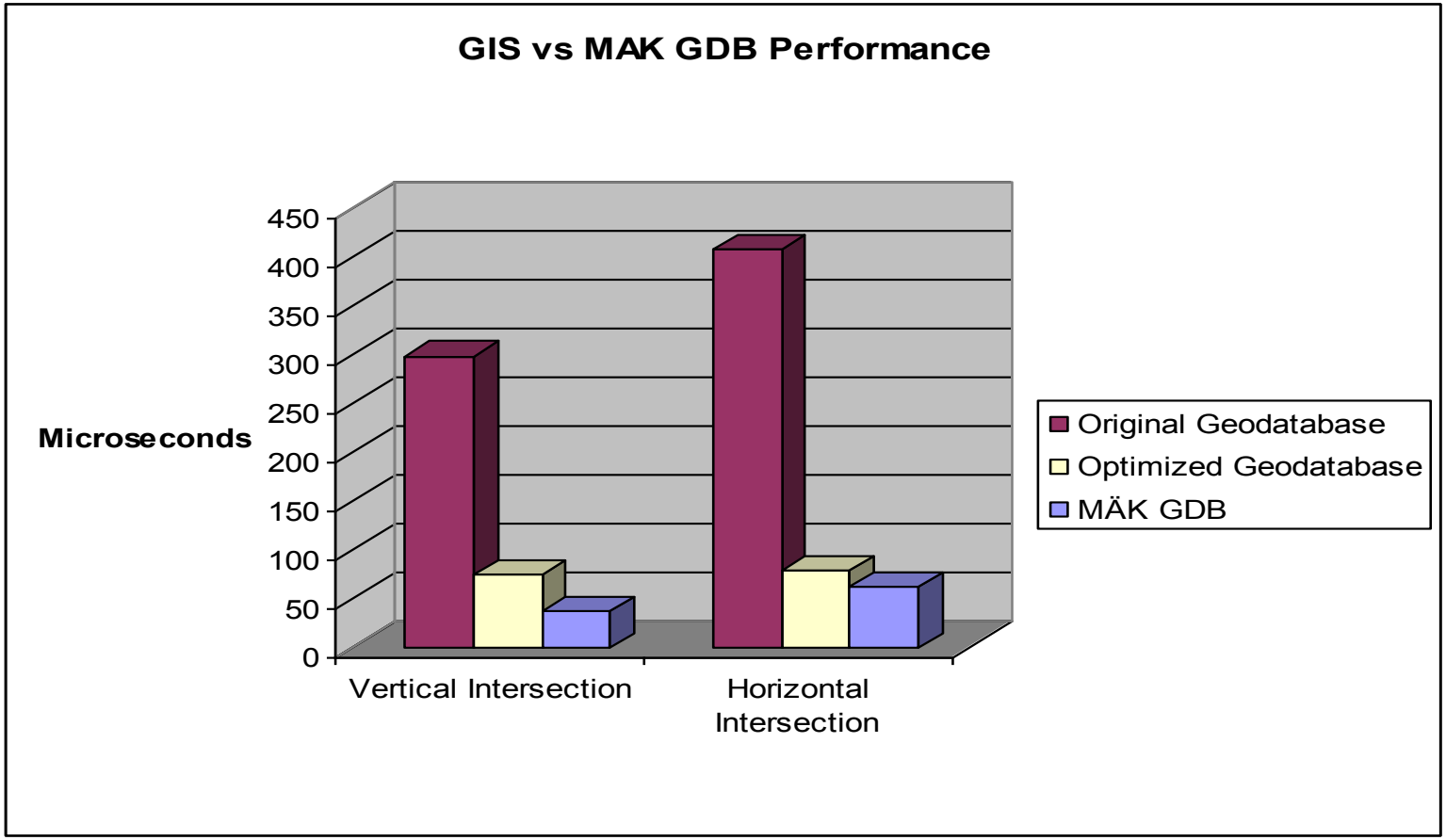
- GEMS is a technical architecture and set of functional components that allow M&S systems to run directly on operational geospatial data
- Started by TEC (now AGC) in 2006
  - Developed initial prototype using MÄK VR-Forces as simulation
- Continued with funding from US Army Simulation to C4I Interoperability (SIMCI) program in 2008
  - Added GIS enterprise capabilities
- Continued with funded by SIMCI and Army Modeling and Simulation Office (AMSO) in 2009 and 2010
  - Integrating GEMS capabilities into OneSAF
- Current SIMCI project to perform formal testing of OneSAF GEMS

GEMS Architecture



A company of VT Systems

GEMS Performance



GEMS API

Designed with integration into more than just VR-Forces in mind

Two layers

- ESRI (ArcObjects) specific layer for access to geodatabase
- Simulation application specific layer
  - Backward compatible to existing terrain APIs
  - Packages up result of queries for applications

GEMS Enterprise Capabilities

Used ArcServer to move from static, file geodatabase to distributed geodatabase

- Dynamic geodatabase
  - Changes to layers used by GEMS API as simulation is running
  - Content and extents
- Shared geodatabase between different simulation applications
  - Still using only VR-Forces back ends and front ends for prototype

Remote geoprocessing capabilities

- Terrain analysis queries that can be run on GIS server
- Demonstrated use of Web services in enterprise GIS environment

Enhanced the GEMS API to work in distributed environment

- Remote geoprocessing infrastructure
  - Asynchronous queries and results
- Modified VR-Forces models to demonstrate enterprise capabilities

GEMS in OneSAF

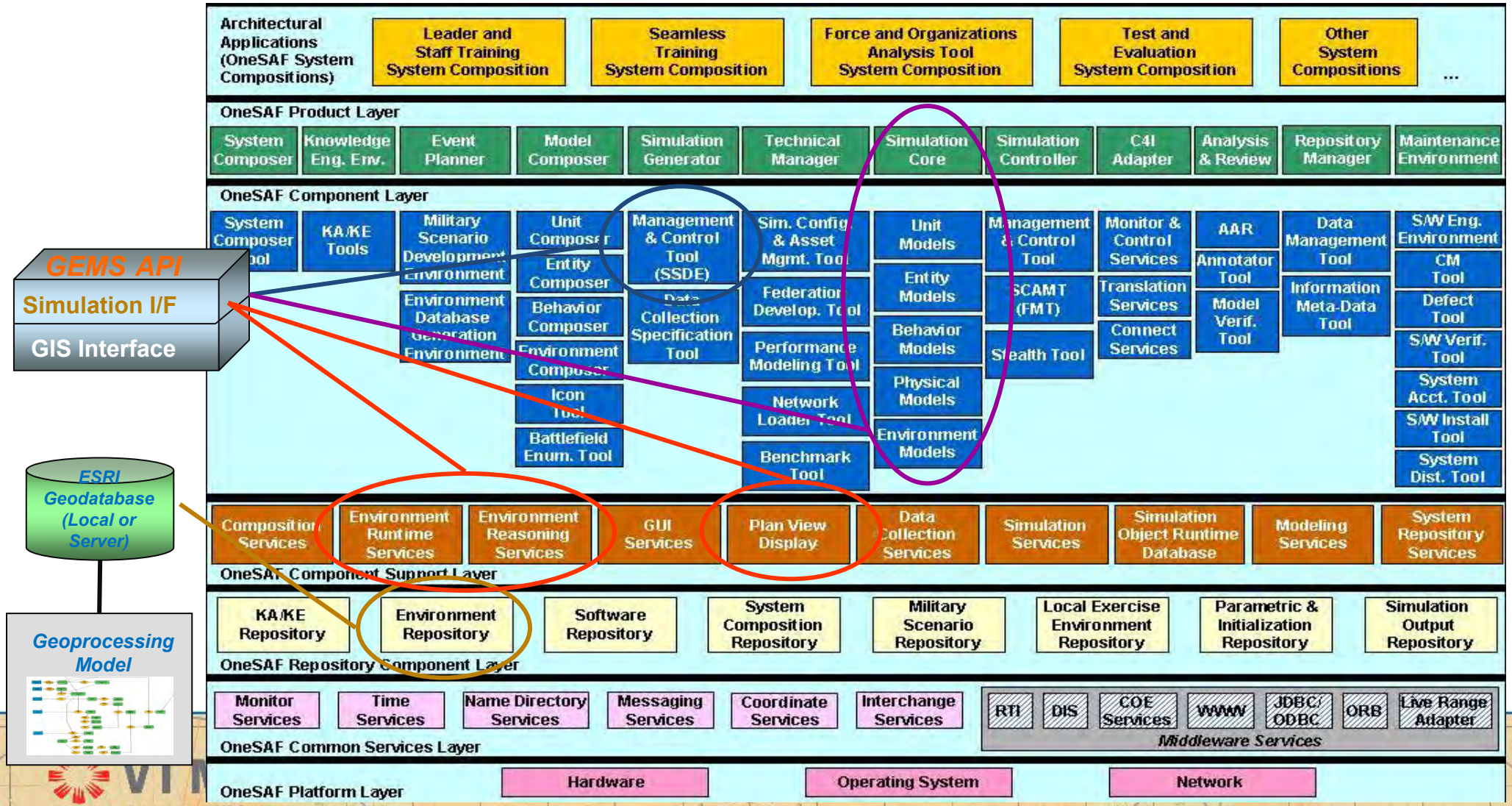
Examined OneSAF terrain API and determined design for GEMS API and geodatabase changes to support OneSAF

Integrated GEMS API into OneSAF

- Developed a OneSAF specific layer (plus)

Modified the OneSAF MCT (GUI) and behaviors to use GIS environment

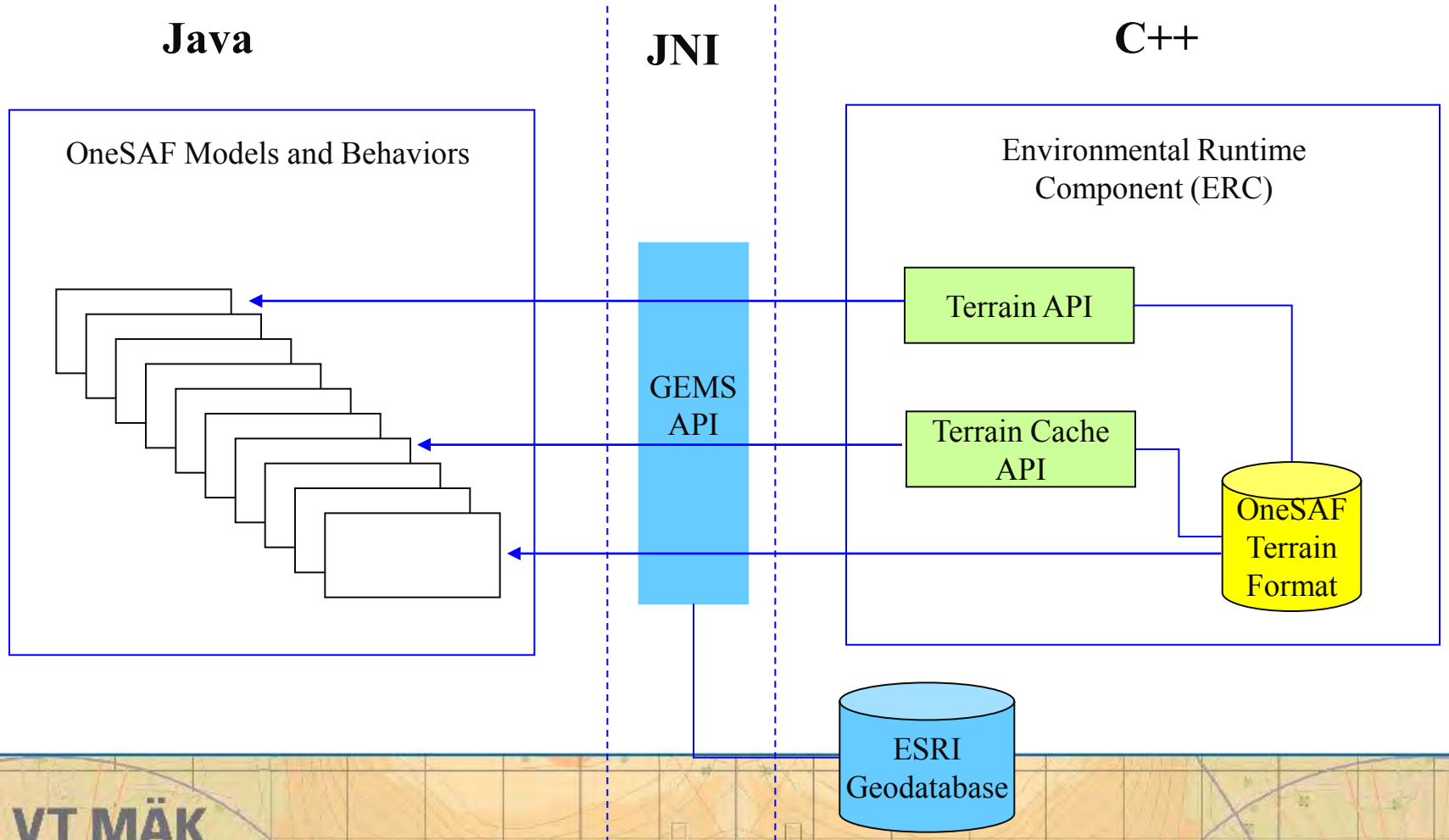
GEMS in OneSAF PLAF



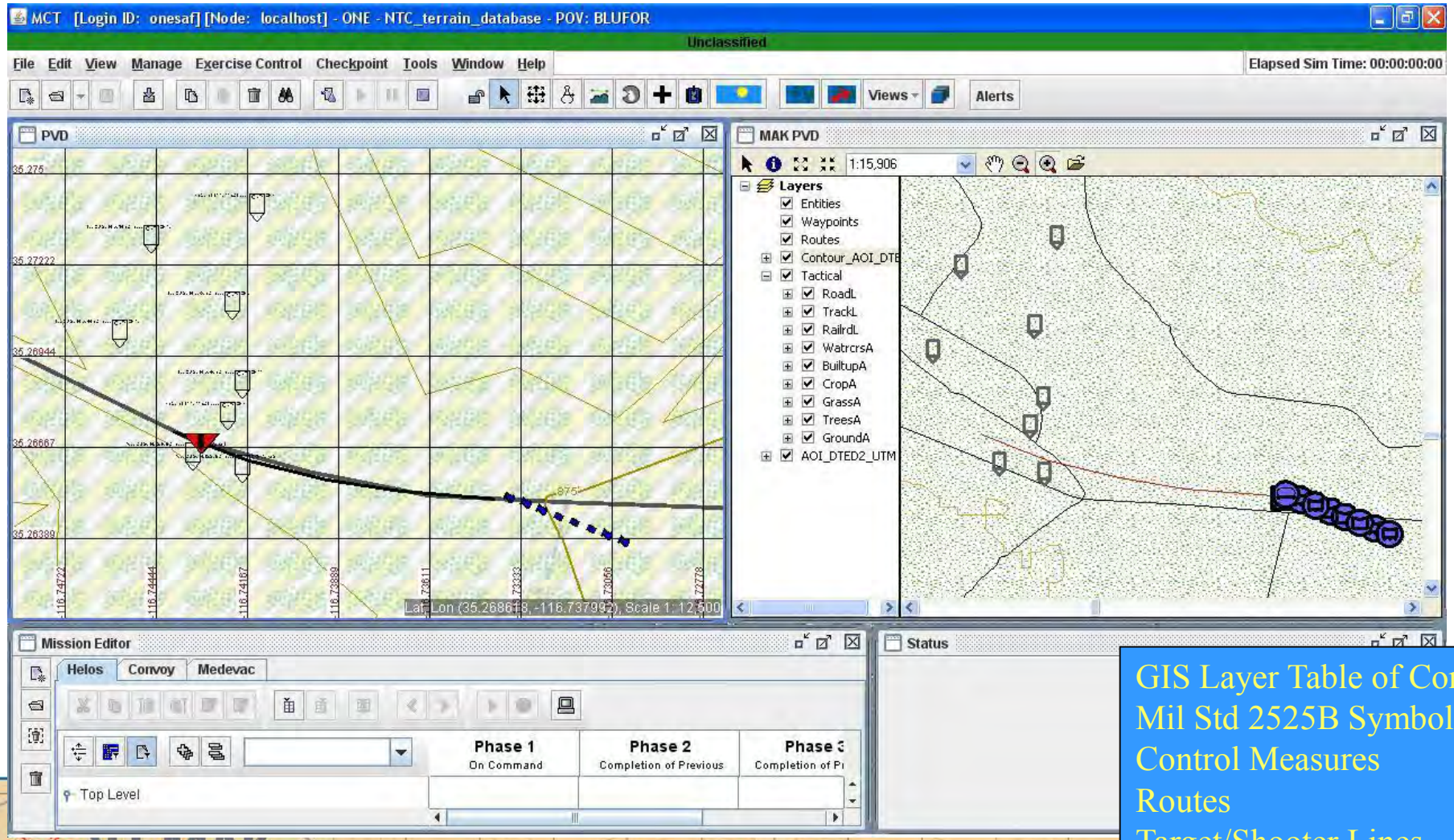
GEMS in OneSAF

- Running OneSAF models and behaviors on GIS data either locally or from server
  - Incremental loading of geospatial data into simulation
  - Caching and background loading of data
- Same operational data as used in C4I systems
  - Augmented with high resolution for simulation-specific purposes
- Can change geospatial data while simulation is running
- Can use GIS for remote terrain reasoning using operational algorithms
- Use GIS functions for geospatial data management and control in user interface

Design and Implementation Approach

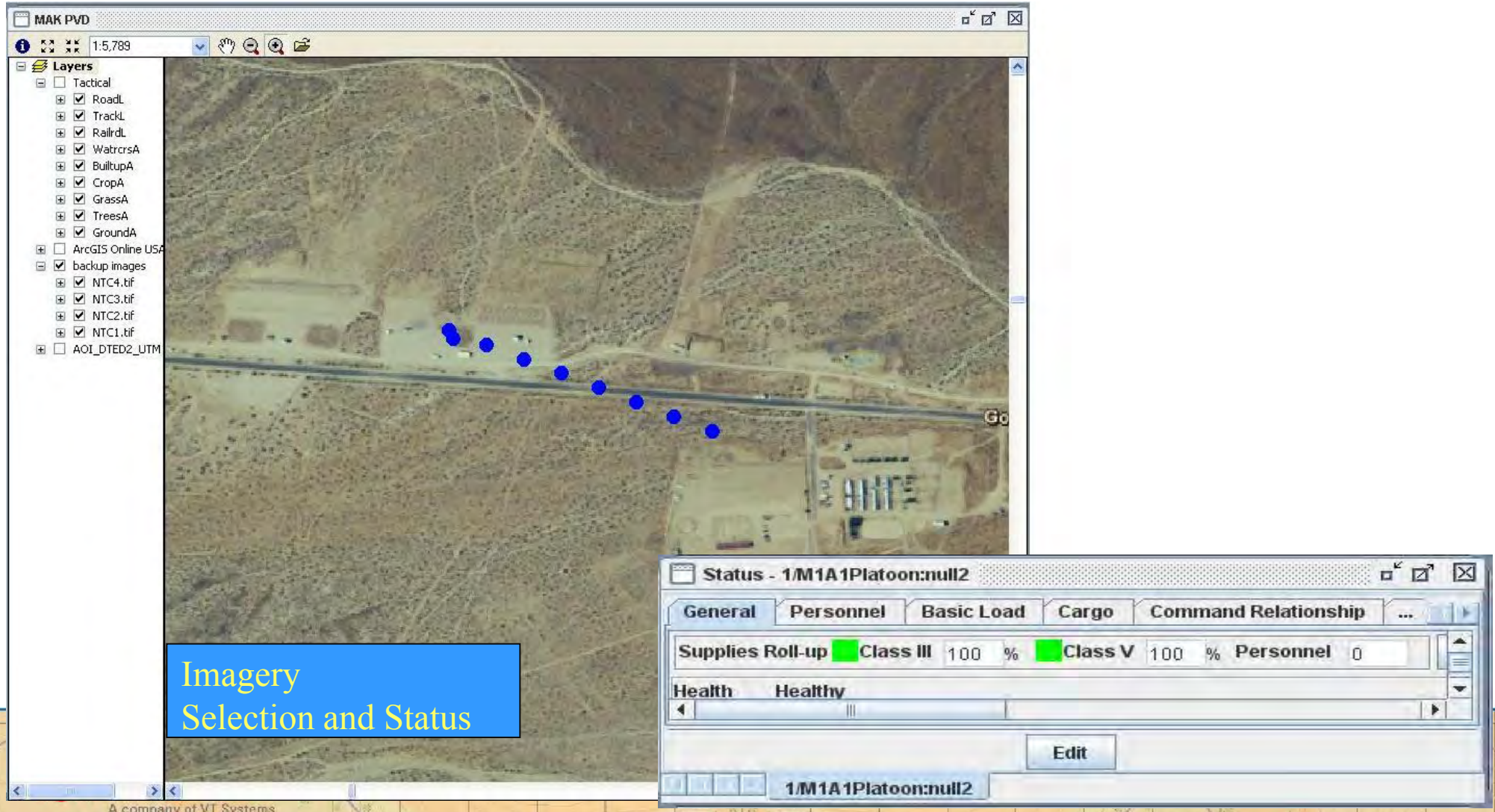


GIS Pane in MCT



GIS Layer Table of Contents
Mil Std 2525B Symbology
Control Measures
Routes
Target/Shooter Lines
Detonations

GIS Pane in MCT



OneSAF Behaviors using GIS

Route Generation in GIS
Movement and LOS using GIS terrain
Covered and concealed locations in movement behaviors

SIMCI FY 10 Project
Formal Testing of GEMS in OneSAF

More formal testing of GEMS OneSAF

- In cooperation with PM OneSAF
- Three test cycles
  - Increase complexity of scenarios and terrain

Updated GEMS API to work with OneSAF 4.0

- Came out in Spring 2010

Using standard ERC test routines for first test phase

  - Instrumented to collect performance metrics

Benefits of GEMS Approach

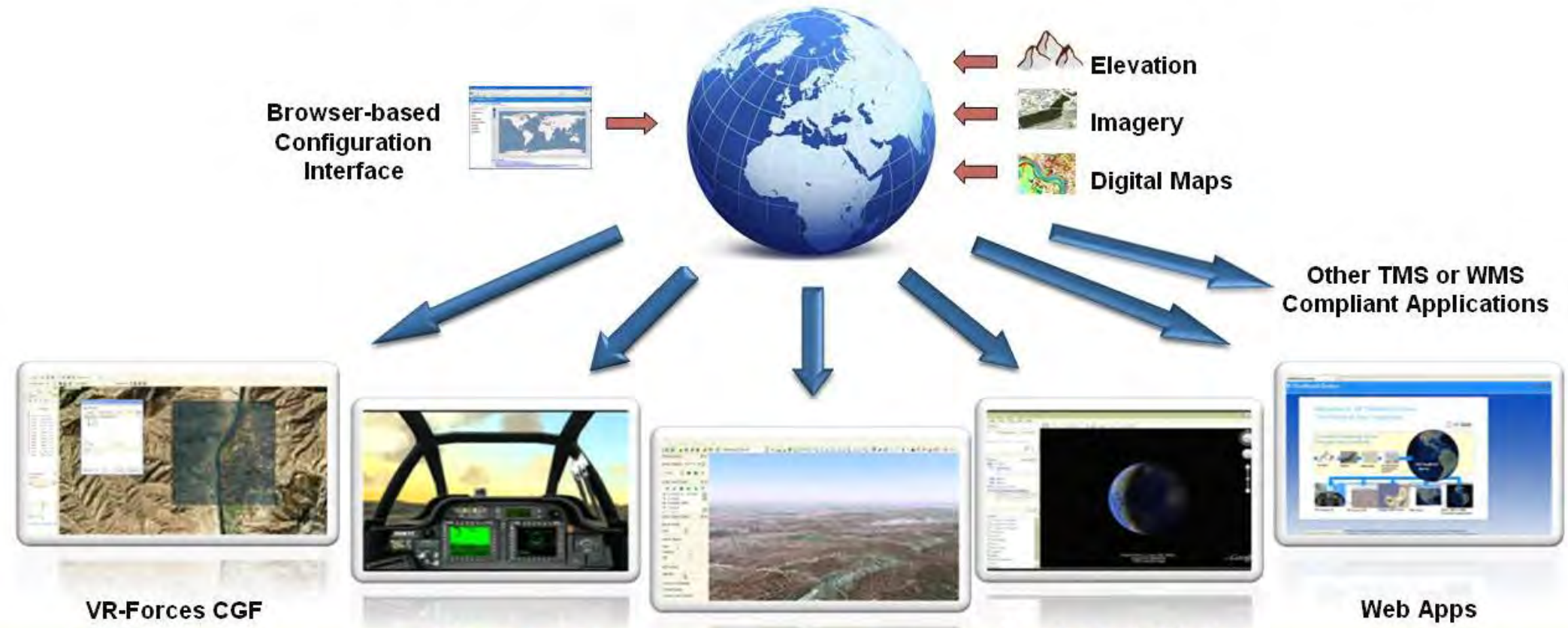
- Use operational geospatial data and terrain reasoning algorithms
- Reduce need for compiled run time simulation formats
- Dynamic geospatial data supported by server technology
- Enterprise GIS allows large area coverages of variable spatial resolution

Limitations of GEMS Approach

- Run time performance close to optimized terrain databases but not exceeded
  - Supports medium size scenarios, 80% of entities per simulation engine vs optimized TDB
- Some initial geoprocessing currently needed to obtain meet performance requirements
  - Working to move these to run time function as part of terrain paging
  - Convert elevation grids to TINs
    - This step no longer necessary – can generate terrain surface on the fly as portions are brought into the simulation
  - Expansion of linear and point features to areas

Terrain Server Approach (VR-TheWorld)

Correlated Streaming Terrain Through Open Standards



VR-TheWorld

Open-standards-based streaming terrain server

- WMS (OGC's Web Mapping Service)
- TMS (OSGeo's Tile Map Service)

VR-TheWorld Server

- Host terrain locally

VR-TheWorld Online

http://www.vr-theworld.com/

- 4TB of elevation and imagery

Summary

More options now for geospatial data in M&S

GIS tools in CJMTK and geospatial products from the AGC provide a powerful capability for improving M&S and BC interoperability

- Reduction in time and cost for geospatial data
- Increased currency and data correlation
- Facilitating embedded training in BC systems

Simulations decisions now based on same geospatial data and information as human decision makers

Questions?

Net Centric Principles

Hans Polzer
Lockheed Martin Corporation
703 416-2308 hans.w.polzer@lmco.com
NCOIC Net Centric Attributes Functional Team Chair

October 27, 2010

The NCOIC at a Glance

Members are Global Leaders:

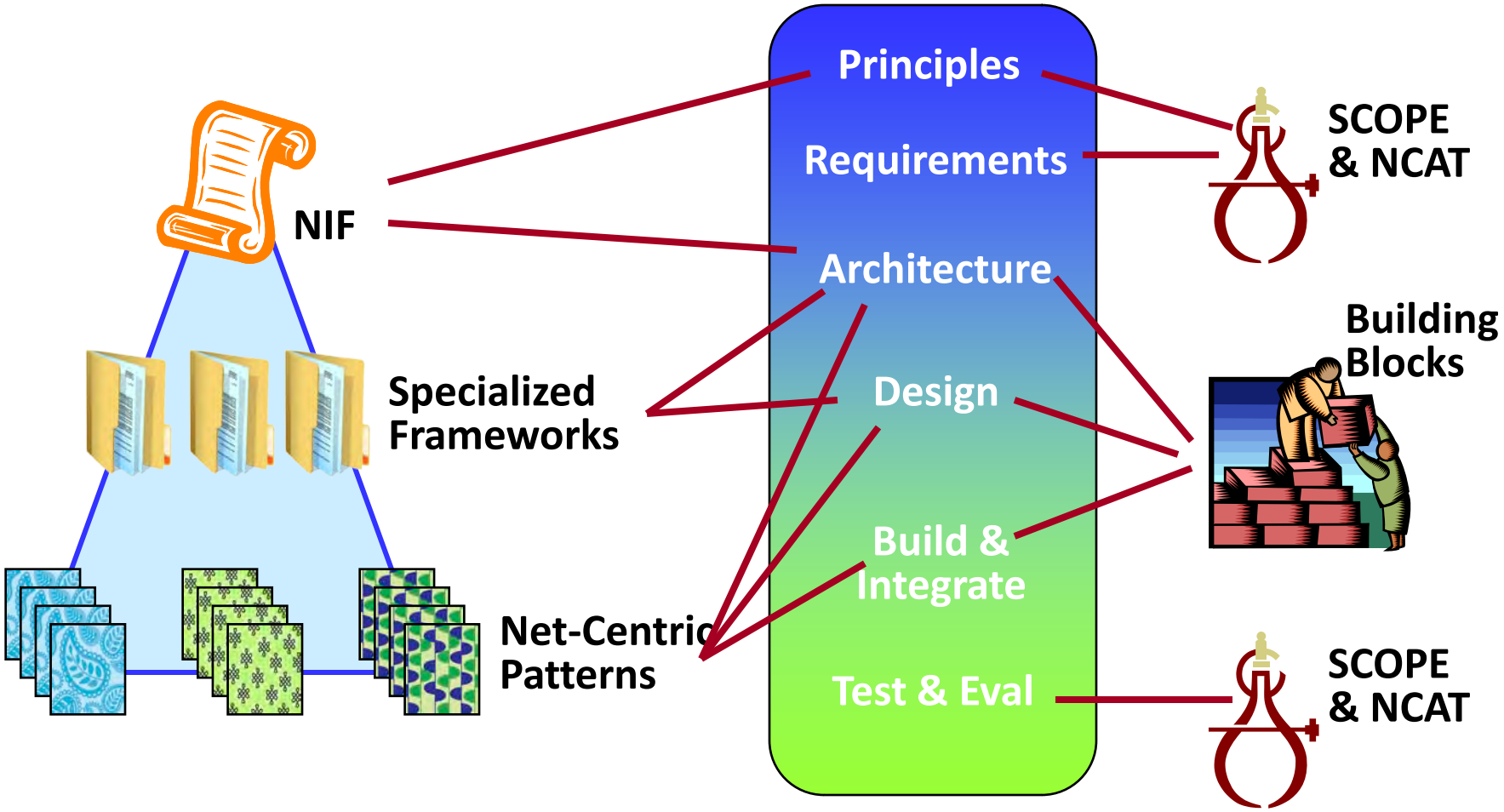
- Academic institutions
- Air Traffic Management providers
- Service providers
  - Consulting
  - Engineering
  - Logistics
- Defense suppliers
  - All military services
  - Multinational
- Government agencies
- Human service agencies
- Integrators
  - Commercial systems
  - Defense systems
- IT firms
  - Communications
  - Data management
  - Human-Machine interface
  - Information assurance
- Standards bodies

A global organization focused on an industry neutral approach to NCO adoption:

- Use of Open Standards in NCO domains
- Net-Centric Architecture Concepts and System Design Best Practices
- Tools for Evaluation and Assessment of Net-Centric Systems
- "Building Blocks" catalog of components compliant with NCOIC recommendations

Prescriptive Guidance On How To Build Interoperable, Network Centric Systems

Where Net Centric Principles fit into the NCOIC



The Essence of Net Centricity

- It's the opposite of system-centricity and enterprise integration
- It's about dynamic crossing of system and organizational boundaries to achieve objectives
  - Greater operational effectiveness through better use of what already exists – not just what you "own" or control
- It's not about the network – it's about who and what you can interact with via the network for your purposes when you need to
- It challenges existing business/acquisition and doctrinal paradigms and incentive models – more revolutionary than most realize
- It challenges system-centric system engineering and architecture paradigms
  - It similar to the relationship between ecology/evolution and biology
  - How do you engineer parts that support a variety of architectures?

Net Centricity – a full contact social sport

Key Definitions
Principles and Attributes

- Principle -- A basic generalization that is accepted as true and that can be used as a basis for reasoning or conduct.
- Attribute, property, dimension -- a construct whereby objects or individuals can be distinguished from each other
  - I.E., They are observable, and, ideally, measureable
- Characteristic, feature -- A prominent aspect of something; a distinguishing quality

- Simply put, ‘principles’ allow the selection of ‘attributes’ or ‘characteristics’ that are deemed useful for certain contexts
- ‘Characteristics’ or ‘Attributes’ are used to distinguish or select systems
- Thus, in identifying the core principles of net-centricity the goal is that these ‘principles’ may be used to select essential and relevant characteristics and attributes of net-centricity.

NET CENTRIC ATTRIBUTES

Net Centric Attributes

- Observable characteristics of systems, architectures, capabilities that exhibit net-centric behavior
- DoD develop a short set of high level attributes in the 2002-2004 timeframe
  - Somewhat refined since then
  - Supported by the Net Centric Checklist with more design/implementation-specific attributes
- ASD NII asked NCOIC to provide an industry perspective on the top level attributes last year
- This resulted in an NCOIC critique and recommended changes to the DoD attributes to improve their utility and applicability

DoD Net Centric Attributes

Attribute	Description
Internet & World Wide Web Like	Adapting Internet & World Wide Web constructs & standards with enhancements for mobility, surety, and military unique features (e.g. precedence, preemption) .
Secure & available information transport	Encryption initially for core transport backbone; goal is edge to edge; hardened against denial of service.
Information/Data Protection & Surety (built-in trust)	Producer/Publisher marks the info/data for classification and handling; and provides provisions for assuring authenticity, integrity, and non-repudiation.
Post in parallel	Producer/Publisher make info/data visible and accessible without delay so that users get info/data when and how needed (e.g. raw, analyzed, archived).
Smart pull (vice smart push)	Users can find and pull directly, subscribe or use value added services (e.g. discovery). User Defined Operational Picture vice Common Operational Picture.
Information/Data centric	Information/Data separate from applications and services. Minimize need for special or proprietary software.
Shared Applications & Services	Users can pull multiple applications to access same data or choose same apps when they need to collaborate. Applications on “desktop” or as a service.
Trusted & Tailored Access	Access to the information transport, info/data, applications & services linked to user’s role, identity & technical capability.
Quality of Transport service	Tailored for information form: voice, still imagery, video/moving imagery, data, and collaboration.

NCOIC Recommended Attributes

Title	Description
Media Independence	Information used, produced, published, or disseminated by the services or systems is decoupled from transport mechanisms.
Open-Ended Pervasive Accessibility	Ability of system(s) or service(s) to find, use, and control information (which requires an ability to identify and distinguish entities and the publication of information with minimal a priori constraints).
Open Standards Based	To support interoperability programs/projects, systems, and services must maximize the use of openly available and unencumbered technical and process standards that support media independence, pervasive accessibility, and trustworthy control of access to information and services.
Protected and Assured Transport Services	Program/project, system, or service makes use of existing specified assurance, protected, and defended transport services where feasible/available. Infrastructure systems provide specified assurance, protected, and defended transport services that are accessible and available wherever and whenever needed
Producer/Publisher Trust Relationships [with users and services]	Program, system, and/or service(s) has mechanisms for establishing and maintaining appropriate trust relationships with users and services on the network. Measures are taken to comply with any security labeling, data protection, and access control requirements entailed by the trust relationships and monitor the environment to ensure that conditions on which the trust relationships were established have not changed

NCOIC Recommended Attributes

Title	Description
Post Data/Information for Network Access	Program/project, system, and/or service(s) has made their products discoverable and accessible on the network in a manner and timeframe appropriate to the nature of the information/data.
Adaptive Information Access	Program/project, system, and/or service(s) has provided users and services access to information and data in ways most appropriate for their context while allowing them to negotiate access arrangements and understand the associated costs.
Information and Data Independence	Program/project and/or system has separated its information and data from applications and services (dependencies) and is provided with sufficient context (i.e., metadata) to enable users to use the information/data correctly for their purposes.
Tailored Resource Access	Service levels can be modified, tailored, or negotiated to meet needs as represented by identities, roles, and/or contexts.
Social & Cognitive Integration	Programs/projects and/or systems include measures of social and cognitive integration that facilitate their effective use.

Additional Recommendations

- Add non-technical attributes in the following areas:
  - Policy (legal, regulatory, political enablement)
  - Operational Scope (how much functionality is exposed on the net)
  - Organizational (e.g., portfolio management)
  - Cultural (e.g., dependency aversion, empowerment)
  - Business Model/Purpose – what motivates net centric behavior?
- Define an assessment context framework for tailoring and applying attributes to targets appropriately
  - Enterprise, Life Cycle Phase, Capability Type, Application Purpose
  - Follow-up report to be developed

NET CENTRIC PRINCIPLES

Net Centric Principles

- Review of DoD Net Centric Attributes raised awareness of implicit context assumptions
  - DoD acquisition planning context
- NATO had a similar but somewhat different set
- NCOIC had developed several sets of principles focused on net-centric architectures, services, patterns, and mobile network contexts
  - Some were statements of intended outcomes
- Needed a set of principles that transcended specific organizational and capability contexts

What makes something more or less net centric?

Net Centric Principles

Principle Name	Description
Dynamism	Entities should support dynamic behaviors and environments
Globalism	There should be no a priori bounds on the scope of applicability
Explicitness	An entity should make all information about its behavior on the net explicit
Symmetric and Reciprocal Behavior	Relations and entities should exhibit symmetric characteristics and behaviors – no a priori hierarchies
Entity Primacy	Entities have identity distinct from the contexts in which they participate

Net Centric Principles

Principle Name	Description
Ubiquitous Accessibility	Entities should have omnipresent or ubiquitous access to resources on the net (i.e., each other)
Explicit Relationship Management	Relations among entities should be explicitly represented and provide for negotiation, creation, change, and termination (dynamism)
Open World	Entity/concept representations should be extensible and service capacities scalable
Pragmatism	The ability to improve operational effectiveness is paramount and trumps the other principles

Examples and Implications

Principle	Examples	Implications
Dynamism	Service discovery and run-time binding; new COP contexts & sources	How to determine relevance and assurance cost of adaptability
Globalism	Security markings, multi-country language, entity, currency, etc. support	OK to have constrained scope but must advertise constraints on the net
Explicitness	Specifying units, frames of reference in service descriptions	More discoverable meta-data on systems/services and discovery logic
Symmetry/ Reciprocity	Peer to peer networking, authentication	Two-way authentication, dynamic hierarchies
Entity Primacy	Multiple vehicle IDs: VINs Lic No, Reg No, Fleet ID	Accommodate mapping IDs to other contexts

Examples and Implications

Principle	Examples	Implications
Ubiquitous Accessibility	Mobile networks, WiFi, WiMax everywhere	Avoid restriction to site specific or wired network provision mobile access
Explicit Relationship Management	Browser cookies, role assignment in orgs, supply chain members	Manage external systems explicitly and dynamicly
Open World	Extensible entity type schemas, multiple service instance designs	Avoid fixed address or attribute value sets, single service designs
Pragmatism	Not using country codes in phone numbers for US-only businesses, Y2K	Pragmatism itself can be dynamic, as seen in the Y2K example

APPLICATION CONTEXTS

Application Context

- The conditions under which principles and attributes are applied
  - Who, which institutions, in what environment
  - Enterprise context dimension
- The purpose of applying them
  - Requirements elicitation/exploration, affordability, operational effectiveness, compliance assessment
- The scope and type of what they are being applied to
  - System, domain/product line, vehicle, radio, capability, enterprise
- Where in the lifecycle are they being applied?
  - Concept development, system design, verification, post deployment evolution

Best Practices Assume a Specific Range of Application Contexts

Context Impact on Attributes

Context Dimension	Impact on Attributes
Enterprise/ Environment	The frames of reference used to represent entities and concepts including level of granularity and scope range (determines compliance attributes and values used)
Purpose	The importance of and possible scoring of specific attributes and attribute values
Operational Scope	The number and variety of domain-specific attributes and the complexity of scoring them and relating them to net-centric effects
Life Cycle Phase	The level of specificity and binding of attribute values to specific architecture and environmental elements
Others?	Open World principle suggests extensibility

Summary

- Past definitions of Net Centricity and Net Centric Attributes have been context-specific
- Difficult or inappropriate to apply in different contexts
- NCOIC has revised the DoD Net Centric Attributes to be generally applicable
- NCOIC has also developed a more basic set of Net Centric Principles
  - Context independence allows broad application
  - Help identify net centric architecture/pattern or design shortcomings
- Context dimensions provide guidance on how to apply principles and attributes

QUESTIONS?

For Additional Information

www.ncoic.org

Or Contact:

ncat-content@lists.ncoic.org

Net Centric Attributes Content WG email

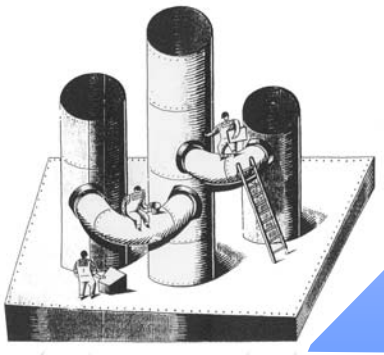
Content WG Chair: Todd Schneider, todd.schneider@raytheon.com

Net Centric Principles Draft available on request from Content Working Group

Australia
Canada
Denmark
Finland
France
Germany
Ireland
Israel
Italy
Netherlands
Poland
Romania
South Korea
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

Net-Enabled Future

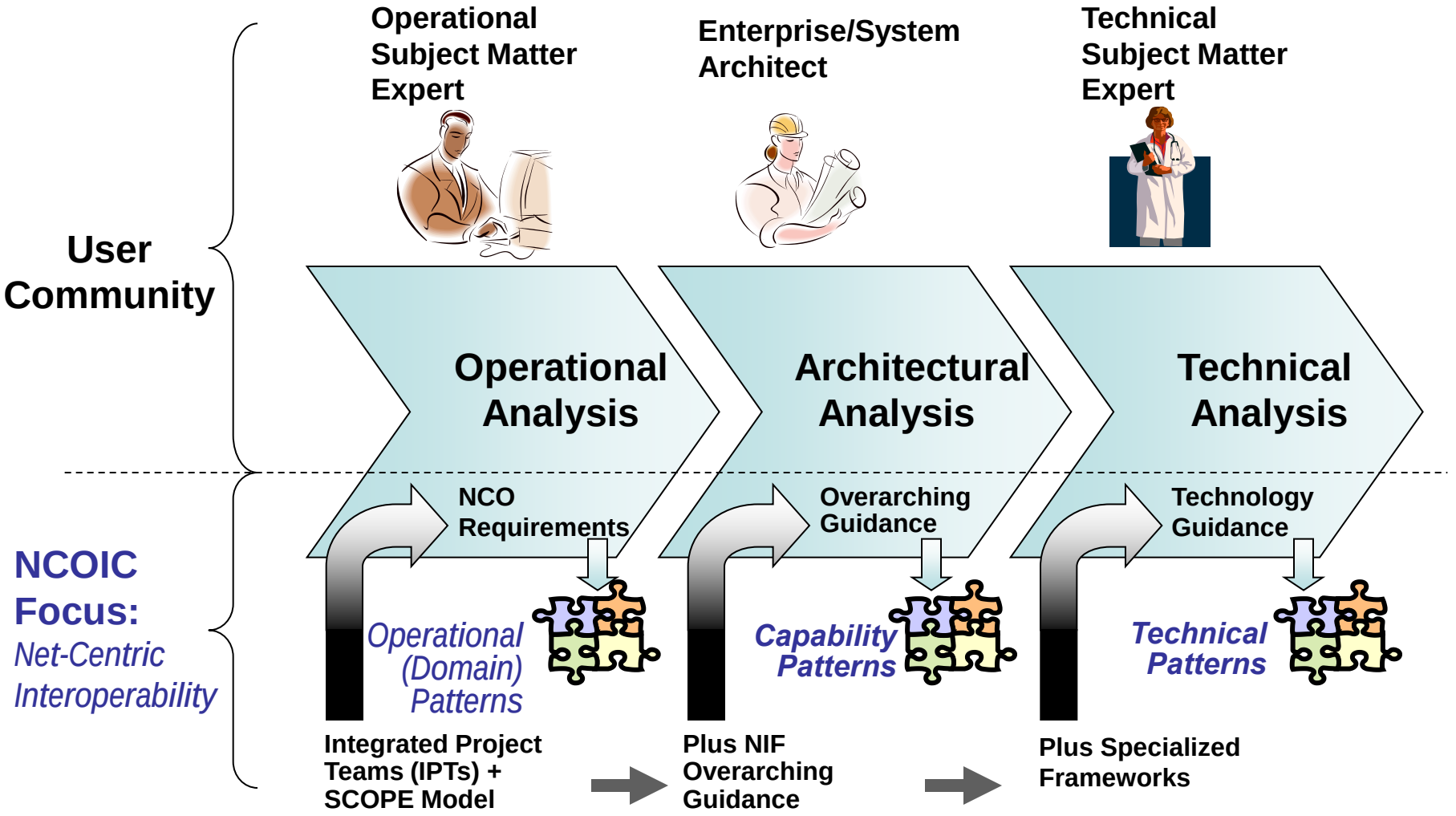
NCOIC



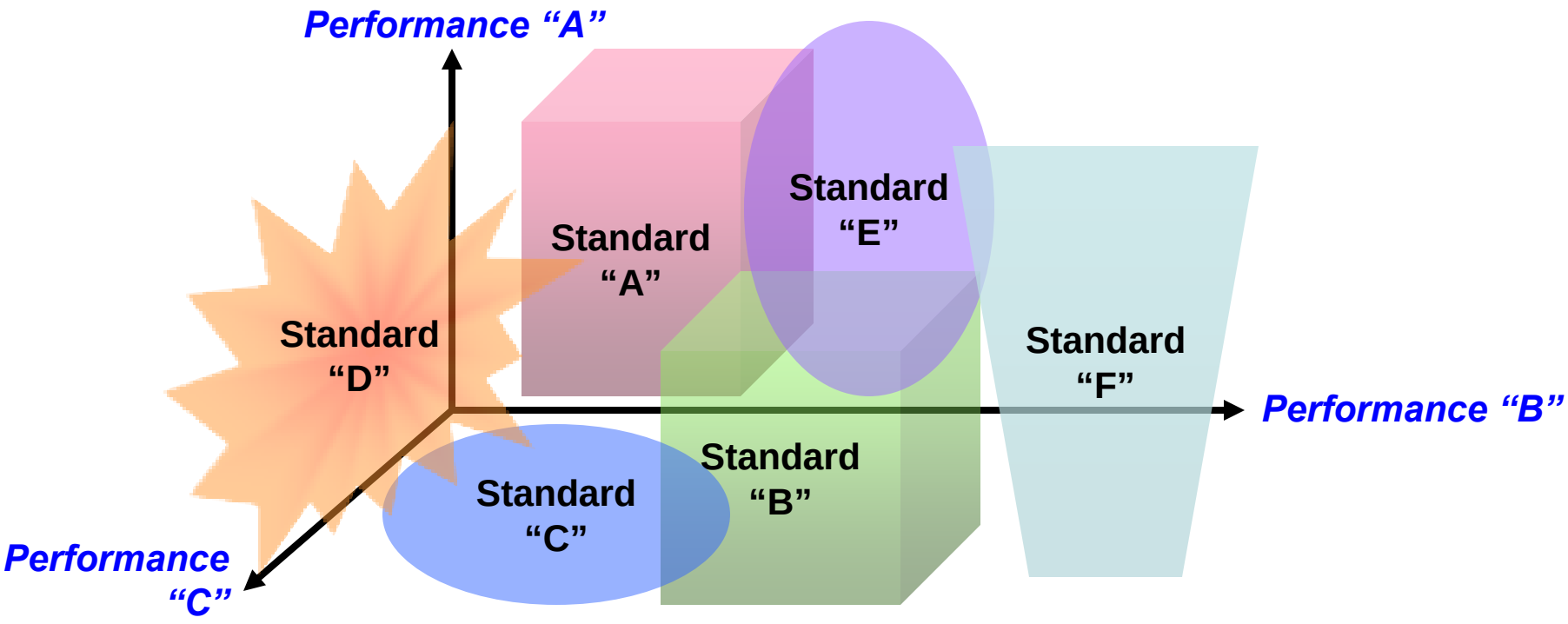
TODAY: Stovepiped Systems, Point-to-Point Networks

NCOIC Assists Customers in obtaining interoperable solutions:

NIF Guides Development of Net-Centric Systems



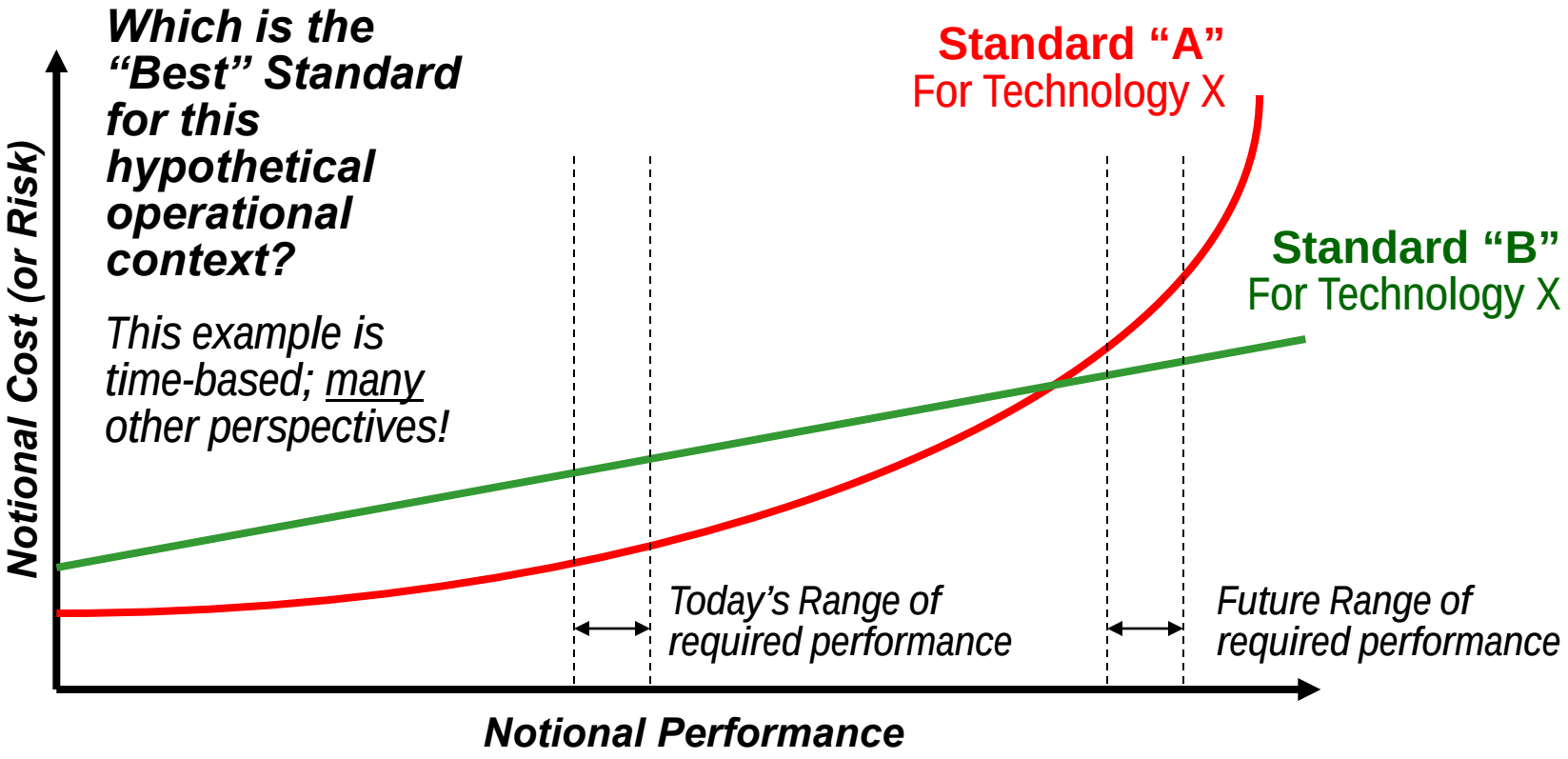
The Problem with Interoperability Standards



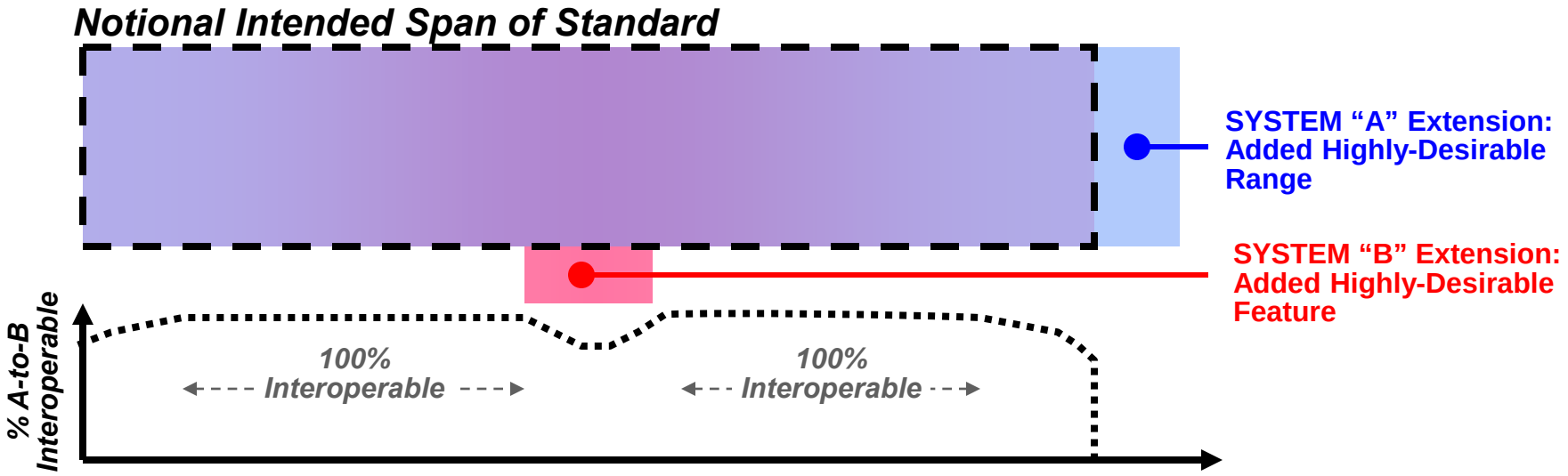
- Often the "BEST" Standard depends on the Mission
  - Real-World Condition! Often no *"One Size Fits All"*

The Problem with Interoperability Standards

- What is the appropriate level of NetCentricity for a given operational context? May impact selection of Standards!



The Problem with Interoperability Standards



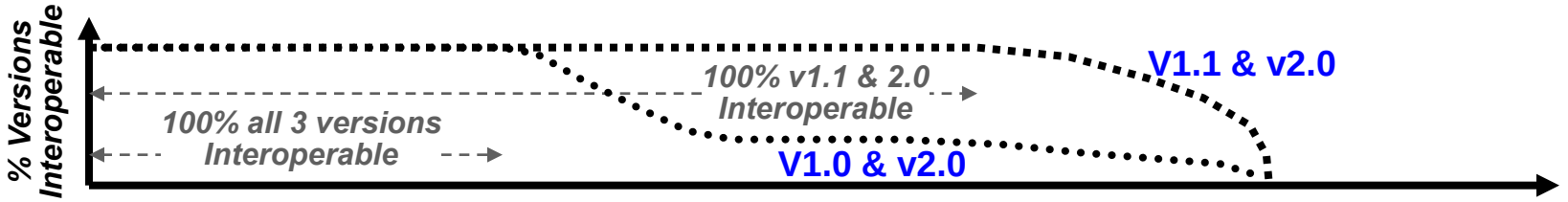
- "Bad" Standard, or "Bad" System Designs?
  - Real-World Condition!
  - In a System-of-Systems, cannot force systems to not use highly-desirable features when operating independently

The Problem with Interoperability Standards

ORIGINAL Standard v1.0

UPDATED Standard v1.1

NEW Standard v2.0: "Backward Compatible"



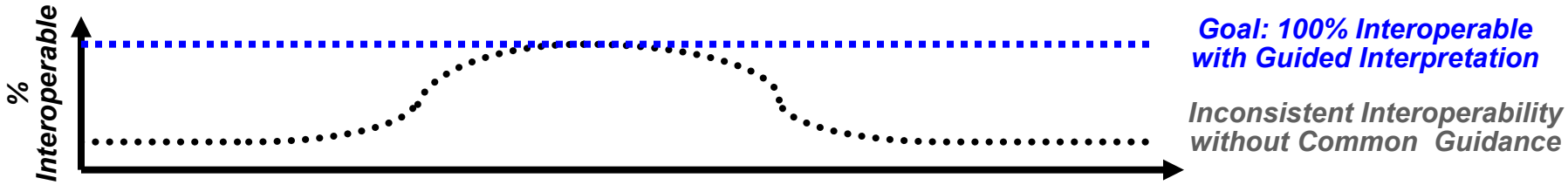
- Is Everyone Running the Same Version?
  - Real-World Condition!
  - In a System-of-Systems, cannot force Legacy systems to update to newest standard

The Problem with Interoperability Standards

Interpretation "A" of Standard

Interpretation "B" of Standard

GUIDED Interpretation of Standard



- Does Everyone Understand the Standard the Same Way?
  - Real-World Condition! (Not necessarily a bad Standard)
  - Different Languages; different Cultural backgrounds
  - Same Standard applied in different Operational Domains, implemented by designers with different levels of experience, different technical disciplines, different company rules

NDIA Systems Engineering Conference

27 October 2010

"Interoperability by Design"

An Alternative to Testing in Quality

Ken Hafner

C2 Chief Systems Engineer

Space and Naval Warfare Systems Command

858.537.0641

ken.hafner@navy.mil

Distribution Statement A: Approved for public release; distribution is unlimited (5 October 2010)

Agenda

- Background
  - Motivation
  - Technical Complexity
  - Programmatic Complexity
  - Prior Efforts and Constraints
  - Schedule Realities
- Current Status
- Solution Options
- Strategy
  - Leverage Current Direction
  - Provide Force Level Context
  - Implement Enabling Process
- Strategy Schedule Change
- Strategy Challenges
- Summary

Background – Past Motivators

1979 USS RANGER Message creates response to combat system integration problems, creates dedicated test facility

1998 USS HUE CITY and VICKSBURG issues result in NAVSEA interoperability lead with Distributed Engineering Plant dedicated test support. Interoperability improves in a number of areas

2005 Interoperability Certification Committee established to address continuing issues, standardize T&E and assessment process

1982 Lack of program readiness for integration test causes NAVSEA to establish software quality initiatives and development gates; integration gradually improves

2010 Interoperability characterized, but still deploying warfare systems with interoperability issues, still trying to test for success

The US Surface Navy has struggled with warfare system performance as they became digital, integrated within, and interoperable between platforms.

Background – Technical Complexity

	Platform 1	Platform 2	. . .	Platform i
Combat Direction System A	X			X
Combat Direction System n		X		
Navigation System A		X		X
Navigation System m	X			
Radar A	X	X		
Radar x				X
Sonar A		X		
Sonar y				X
Weapon A	X	X		
Weapon z				X

The Surface Navy procures subsystems and uses them in various combinations to compose the warfare system (of-systems) for various platforms. Warfare systems are not developed top-down and configurations are numerous.

Background – Programmatic Complexity

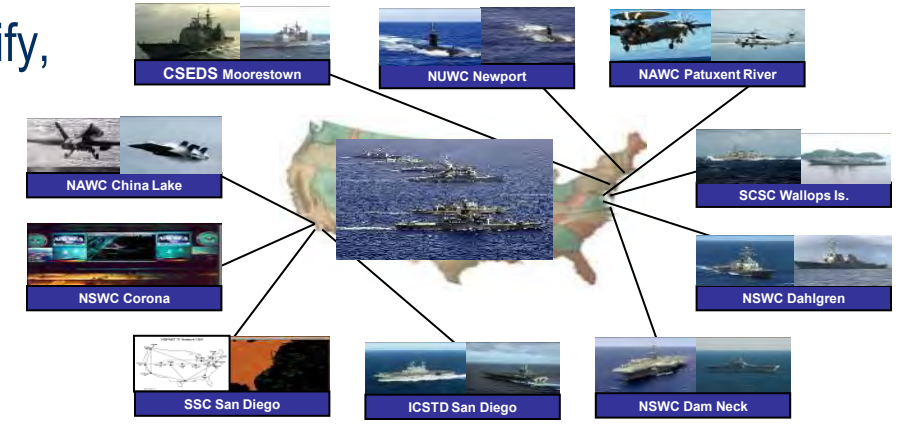
- Warfare systems composition is cross-SYSCOM and cross-PEO.
- Interoperable design today is a cooperative effort between PEOs and System Commands.
- Discovery of interoperability issues—even early in system design and development—may require prioritization of program issues given funding and schedule constraints.
- Authority higher than the Program Manager and PEO /SYSCOM is required to properly assess trade-offs and dictate resolution.

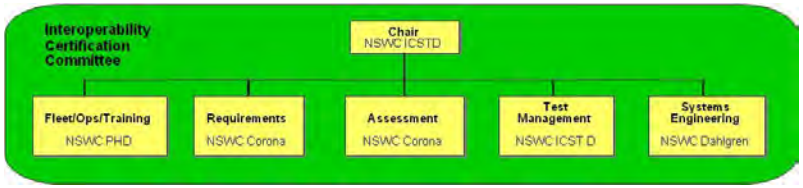
Warfare Systems

NAVSEA				SPAWAR		NAVAIR
ACDS	ESSM	NCDS/DDCN	TAS	NAVSSI	NGC2P	ADMACS
FODMS	NDDS	SPS-74	VLA	ADNS	NMT	IFF
ALIS	NFCS	SQQ-89	VLS	ADSI	SSEE/	JMPS
ASDS	GEDMS	SQS-53	ERDDS	AIS	COBLU/	MORIAH
AWS	GWS	NSSMS	SPS-67	CDF	TBMCS	TACAN
BEWT	HARPOON	NULKA	VMS	CANES	IBNS	SRQ-4
BFTT	PEP	SYS-2	DLS	CDLMS/C2P	JTT	TPX-42
BMD	IBS	RAM	SPS-49	CDLS	LINK11	TTWCS
BME	SACC-A	SSDS	WSN-7	Crypto	LINK16	MDS
CADRT	SGS/AC	TSSS	DBR	DCGS-N	NAVSSI	TCIP
SPS	SPS-73	SWAN	MK 38	DMR	ISNS	TTWCS
CDS/CEP	LRADDS	SLQ-32	SPS-48	EHF/TIP	HBSS	UPX-29
CEC	SM	USW-DSS	CV-TSC	EPLRS-DR	GCCS-M	
CIWS	MK 34	SPQ-9	MK 160			

Background - Prior Efforts

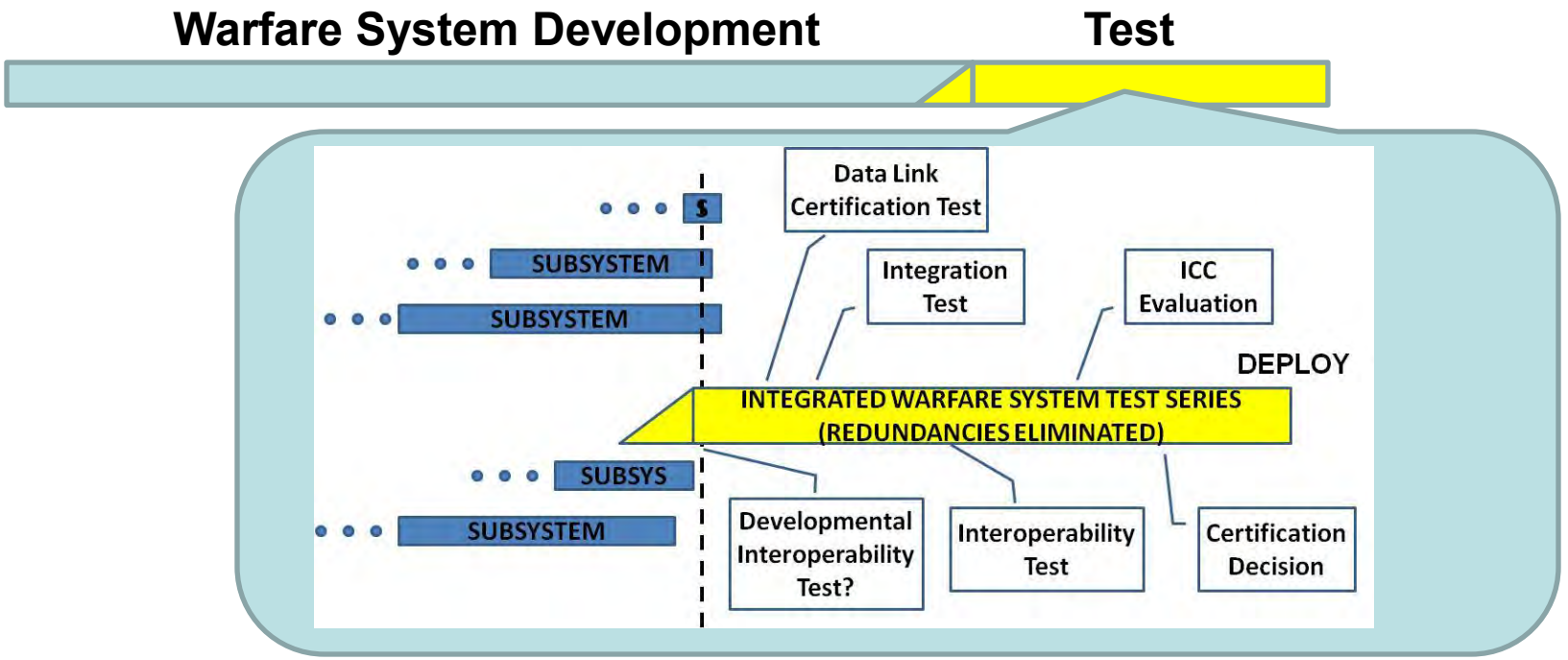
- Since 1998, OPNAV has funded the Strike Force Interoperability program to Asses, Certify, and **Improve** interoperability in the Fleet.
- SYSCOMs implemented a process to
  - Asses interoperability via a C5I Management Plan
  - Certify Warfare System interoperability via NWSCP
  - DEP and ICC improved assessment and characterization of interoperability issues.
- SYSCOM processes improved understanding of interoperability capabilities and limitations, but have not significantly **improved** interoperability
  - Discovered issues are not being fixed at a suitable rate due to technical and programmatic complexities
  - Operator workload is growing due to increasing number of "work-arounds" … and operator confidence decreasing.
- On-going budget cuts further compromise assessment and certification.





NWSCP = Naval Warfare Systems Certification Policy
DEP = Distributed Engineering Plant
ICC = Interoperability Certification Committee

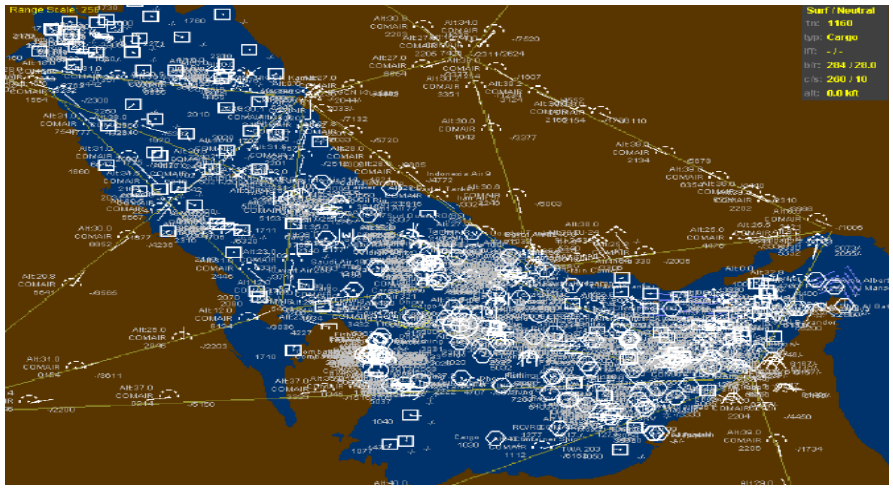
Background - Schedule Realities



All subsystems need to be complete enough to test. Delivery and support for each subsystem has to be synchronized with funding, schedule, and contract. Interoperability testing simply cannot be pushed earlier. There are also contract support issues for correction of problems identified after system acceptance.

Interoperability Challenge

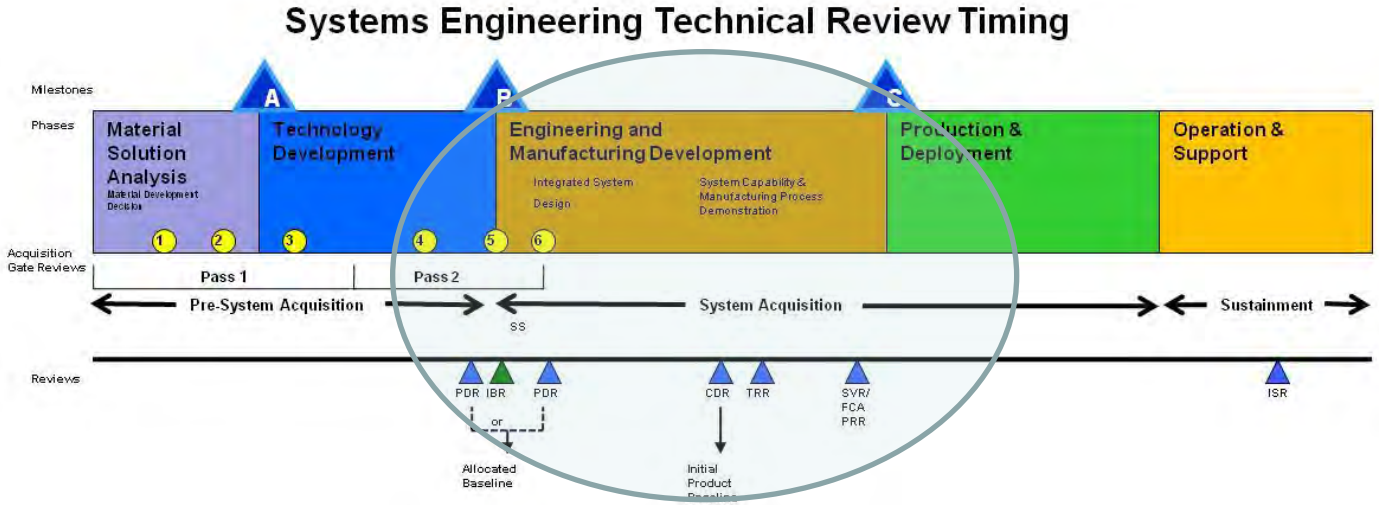
- Current subsystem design and engineering do not naturally lead to force interoperability.
- Because Navy surface warfare systems are composed after subsystem development, force interoperability gets addressed at that stage, almost always in warfare system or platform level test events.
- Efforts to effect interoperability design changes during development are frustrated by program funding, schedule, contract constraints, and program office imperatives.
- Efforts at interoperability testing earlier in warfare system development helped, but limit of early testing has been reached.



- *Fleet interoperability needs:*
  - ✓ *Complete, common, and accurate situational awareness picture*
  - ✓ *One track per object*
  - ✓ *Track number stability*
  - ✓ *Manageable picture with robust filtering*
  - ✓ *Intelligence information fused with tactical objects.*

Solution Approach

- The only approach remaining is to address interoperability as part of subsystem system engineering during development and upgrade.
- System design starts with operational requirements, but transitions to technical specification for procurement and development (Milestone B for new acquisitions).
- Interoperability issues tend to be operationally oriented, an area not familiar to most design engineers, and current instructions/requirements are vague.
- Interoperability awareness requires description of the interoperable context and injection of appropriate subject matter experts in the development process.



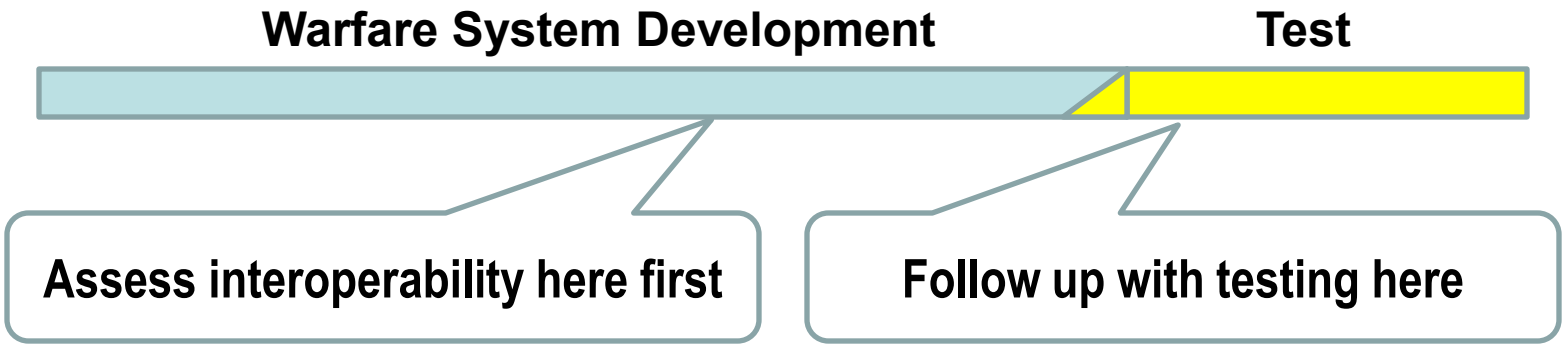
Strategy – What Is It?

- Stay within overarching direction and authorization (but clarify it).
- Provide usable fleet context for design and discussions.
- Establish processes to educate engineers on force-level interoperability influences, and monitor system development for compliance.

Strategy – Relationship to Testing

Interoperability engineering during development is a mental exercise focused by the operational context and supported by interoperability experts referencing system design documentation.

The context defined is similar to that used for interoperability testing. Design assessment flows smoothly into test.



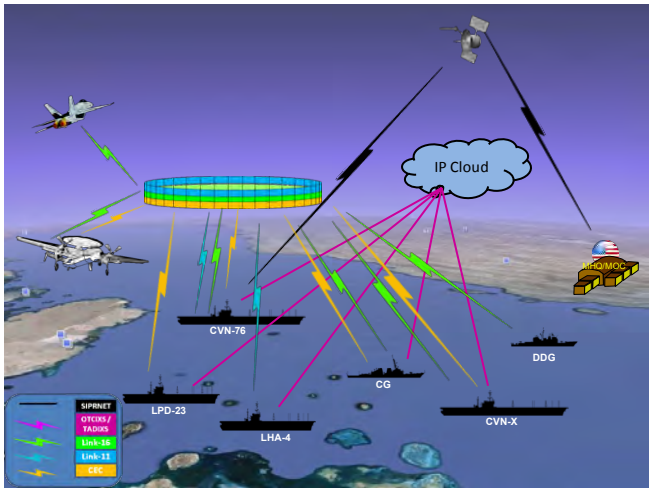
Strategy - Required Documentation

- Authorization already exists in instructions and directives.
- Directives that establish the minimum information required to support interoperability in Systems Engineering Technical Review (SETR):
  - Information exchange description that includes information originating from or being used on another platform
  - Cross-platform communication paths in system architecture
  - Explicit acknowledgement of redundant data paths or “duplicate” processing of Force data.
- Above interoperability detail needs to be reflected in both program and design documentation.
- Interoperability information is needed for legacy and legacy upgrades as well as for new systems.

Strategy – Context and Guidance

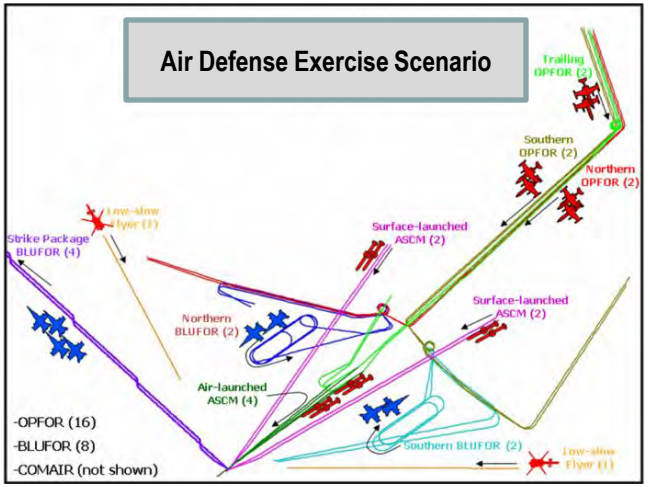
Reference Context

- Need "Reference Strike Group" to reduce scope of operational context for technical discussions
  - Define Strike Force makeup
  - Define communication architecture
- Describe scenarios for missions to be considered
  - Use same scenarios for test efforts
  - Limit to primary missions



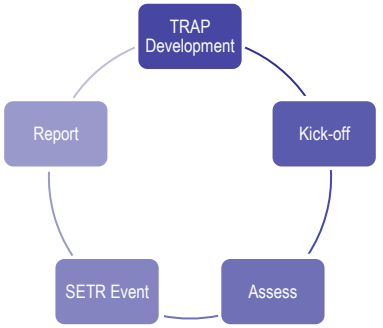
Provide guidance

- Concept of operations to provide operational context for technical discussions
- Guide to improve implementation to standards
  - Consistent interpretation
  - Lesson learned for best implementation practices
- Audit checklist in tutorial format
  - Systems Engineering use in advance of reviews
  - Interoperability Subject Matter Experts (SME) use during technical reviews



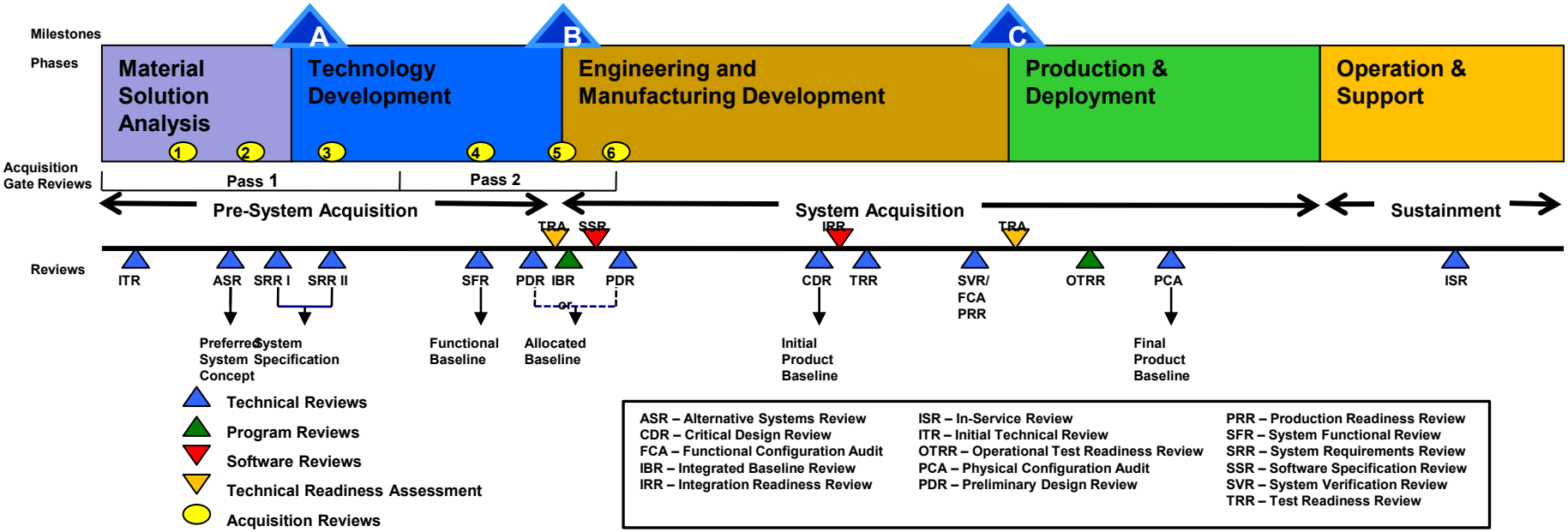
Strategy - Process

- Most SYSCOMs have effective Systems Engineering Technical Review (SETR) processes in place and staffed.
- Interoperability requires augmentation of SETR staff with interoperability Subject Matter Experts (SMEs).
- Interoperability SMEs need standardized documentation on which to base interoperability assessment.
- SETR will result in assessment of interoperability risk…conveyed in operational terms.
- Overarching authority for interoperability, working cross-SYSCOM/PEO, would be ideal.

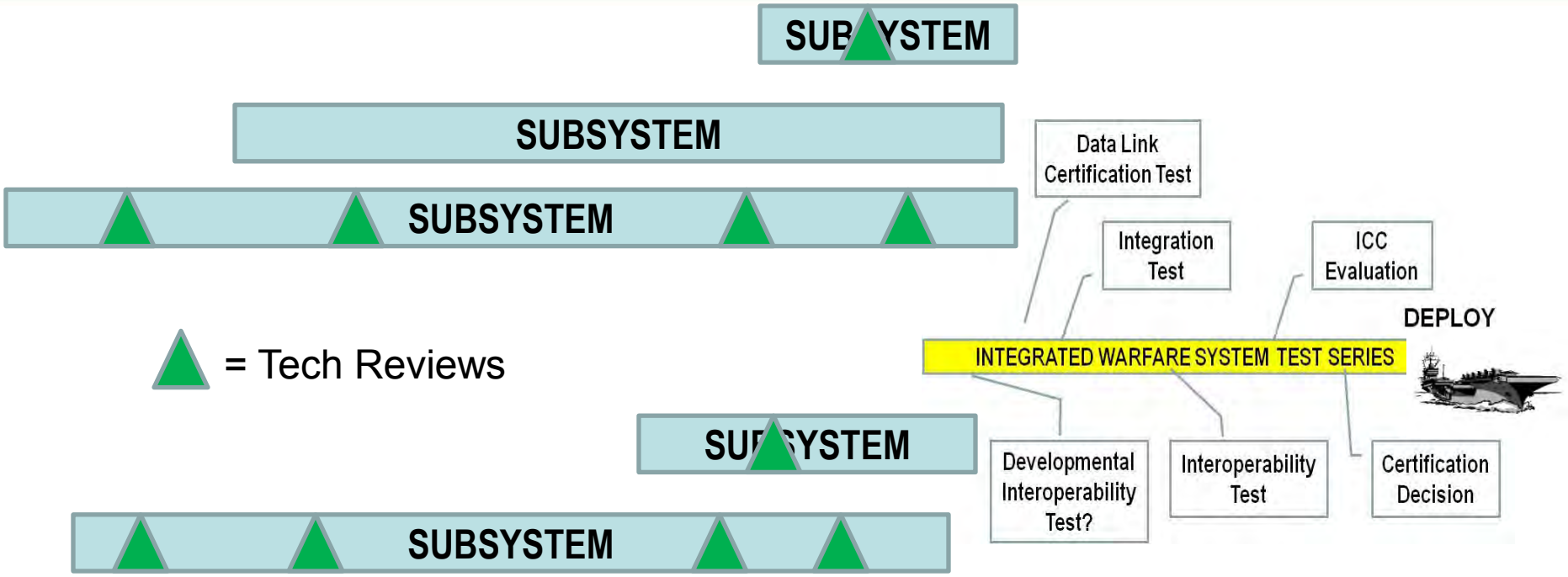


Strategy – Application Opportunities

- Utilize key design reviews
  - PDR, CDR, TRR, PRR, and ISR
  - Note that actual review dates are culmination of SME review and collaboration with Program Office
  - SETR team provides guidance, checklist, reference material, and expert support as required, including Fleet input.



Strategy - Results



This strategy moves interoperability forward in the overall schedule to permit time for issue correction in addition to identification…

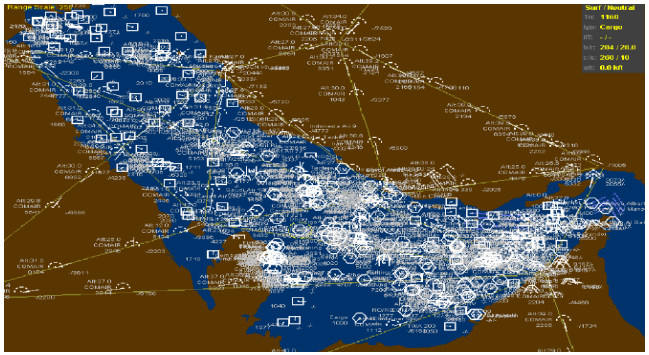
Because simply finding the problem is not enough.

Strategy - Challenges

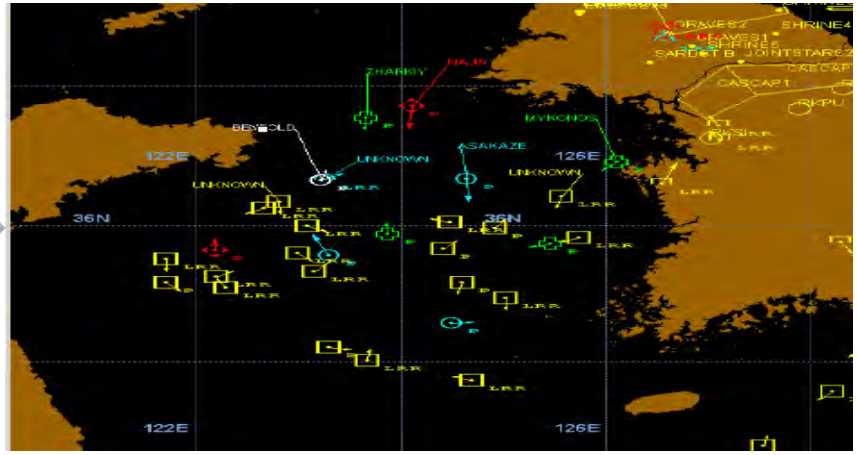
- Data Management
  - Many databases; non-uniform data and issue assessment
- Subject Matter Experts
  - Rare and in high demand
- Collaboration
  - Key to assessment process but everyone can't keep travelling
- Transition Time
  - Must allow for FYDP and contractual adjustments and process execution (ROI return not in same year as investment)
- Funding
  - Always tough but now we need to fund systems believed to have been already paid for
- Designating Overall Authority

Summary

- The Navy has maximized the utility of test for achieving interoperability in the surface force.
- Testing alone has proven inadequate to achieve desired fleet interoperability state.
- Aggressive interoperability systems engineering is the next (and only remaining) step to achieving fleet interoperability.



By Design



Institute for Defense Analyses
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

The Evolving Operational Environment as a Unifying Foundation for Systems Engineering and Acquisition Decision Making

Systemic Approaches to Enhancing SE, DT&E and OT&E in Defense Acquisition

Vince Roske
703 575 6632
vroske@ida.org

October 27, 2010

NDIA Systems Engineering Conference
Context for this Presentation

- Keynote: Lt Gen Scofield , USAF (Ret):
  - Enhancing the Acquisition process:
    - **Adequate understanding of the needed capability**
    - **Foundations for implementation**
    - Clarity in production and sustainment
    - **Enterprise Development Planning**
- Plenary Session 1: Mr. Thompson, DDR&E
  - Two themes:
    - Shorter Timelines
    - **Cognizance of program progress**

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

This Presentation: Systemic Enhancements

This Presentation Objectives and Conditions for Design and Test

Systemic* Categories

*www.ndma.com/resources/ndm1891.htm

Structures: (Organization, Processes & Products)	Culture: (Behavioral Patterns , Habits & Conventions)	Internal Economics:	Methods & Tools:	Metrics & Rewards: (System & Capability Oriented)
Defining **Objectives and Conditions** For SE & T&E	Concepts, Principles & Perspectives for **Objectives and Conditions** For SE & T&E	Facilities (Demand & Supply)	Derivation of **Objectives & Conditions**	Capability (Fielded, OT&E, DT&E & SE Phases)
Design, Test & Evaluation	Education & Training (Design , Test and Evaluation)	Personnel (Demand & Supply)		System Performance & Suitability (Fielded, OT&E, DT&E & SE Phases)
Configuration Management (Test Item)		Services Reimbursement		Design and T&E Processes & Products
Quality Control (Test Item & Test Processes)				
Data (Collection, Reduction & Use)				

Building Effective, Enduring Design and Test Paradigms

Example 1: Anti-ship Cruise Missile (CM) Inadequate SE Conditions

Objective: CM Survives target ship's close-in defensive engagement

Solution: A "Terminal Maneuver" to defeat ship defense system tracking algorithm

Approach to Design & Testing: M&S to support system design changes and to plan test event for terminal "pitch/ roll" maneuver using:

- Detailed, validated model of target ships to determine target RCS aim point
- Validated CM aerodynamics and target tracking/ flight control algorithms (CM designed for long range cruise)

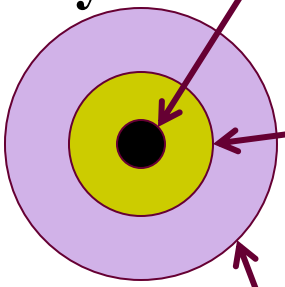
Symptom: CM departed controlled flight in the end-game, missed target, crashed

Cause: **Inadequate derivation of <u>Conditions</u>**: CM target seeker was polarized. *did not consider the*

- Used a two stage design process (culturally motivated)
  - Determine the aim point on the ship, what does the seeker see. Then to the aero-folks for
  - Make the CM maneuver hit the aim point
- **Failed to consider BOTH the "System Design" and Operational kinematics" implications together**
  - *A shift in RCS aim point due to **rolling** polarized seeker's perception of the target.*
  - *while* CM's attempted to maneuver and guide on the shifting RCS aim point => high speed stall

Example 2: Aircraft Self Defense System Design and Test

Desired Capability



Conceptual Depiction

Task Description

•Detect and defend A/C against ground launched IR-guided missiles

Task Performance Standards

•Capable of missile launch identification in any environment
•Low false alarm rate
•Spherical platform coverage
•Capable of jamming all major MANPADS missiles

Conditions: Operational Environment (DOTMLPF)

•Modular LRU configuration
•Capable of installation on nearly all rotary and low- and high-speed fixed-wing aircraft
•All climates, terrains, signature environments

Example 2: Inadequate SE & Test Conditions

- Detection System
  - Design validated (tested) on a **non-moving cable car**
  - Missile detection validated with **missile launches at "one" angle**
  - False alarm rate validated with modeling and simulation (M&S)
    - **Static, unrealistic IR background**

Example 2: Endemic Symptoms Consequences

- Excessive Weight
  - Capable of installation only on **very small number of high value larger rotary-wing platforms**
- Poor Reliability
  - Field revision for **vibration and temperature** variations not previously considered
  - Required substantial number of spares parts to account for **low reliability**
- Inadequate Effectiveness
  - **Limited platform coverage**!
  - **Reduced S/W Threat List to reduce excessive false alarm rate**!

Inadequate Performance and Suitability

Example 3: Endemic Symptoms
It's Not Just a System Problem

Lack of traction in Initiatives intended to enhance effectiveness of T&E

- Testing in Joint Environment (JTEM/CTM)
- VV&A of Test M&S
- Integrated DT/OT
- Design of Experiments (DOE)

SYSTEMICALLY
Why so little traction?
How can it be fixed?

Systemic Concepts: Two Objectives for DT&E

"And Design"

Defense ACQ Guidebook
Sec. 9.3.1
Developmental Test & Evaluation

- "Developmental Test (DT) provides the **verification** and **validation** of the **systems engineering** process and *must **provide confidence** that the **system design solution is on track to satisfy the desired capabilities**.*"
- "To ensure *that the system engineering verification and validation relates back to user required capabilities*, it is appropriate for government testers to:
- **observe** the contractor testing, conduct additional T&E, and, when appropriate,
- **facilitate early user involvement and contribution in the design and test processes**."

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

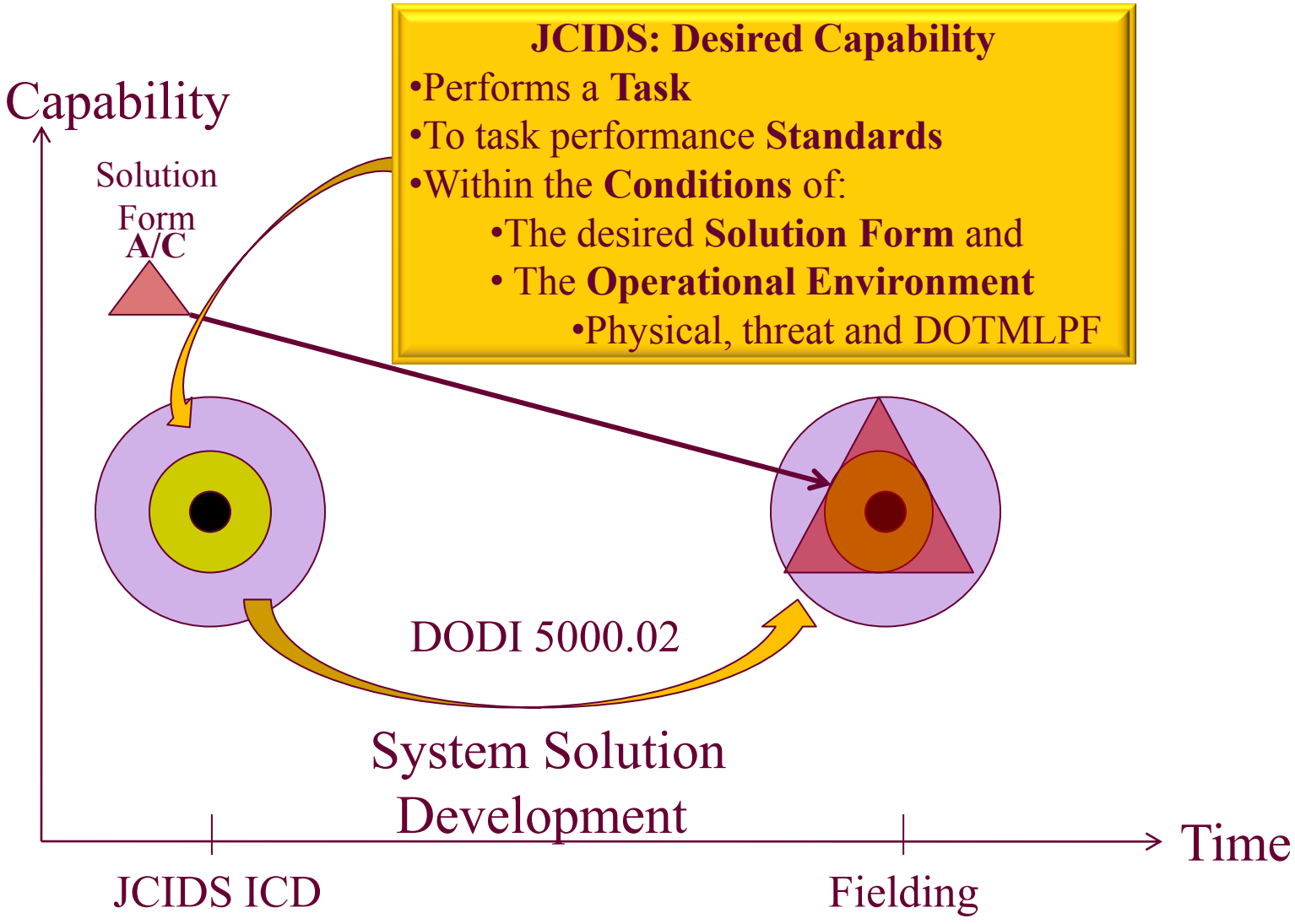
Provide **Verification** of the **systems engineering process** **"System does what it's design intended it to do"**

Test Objectives & Condition relate **performance** to **design** specification

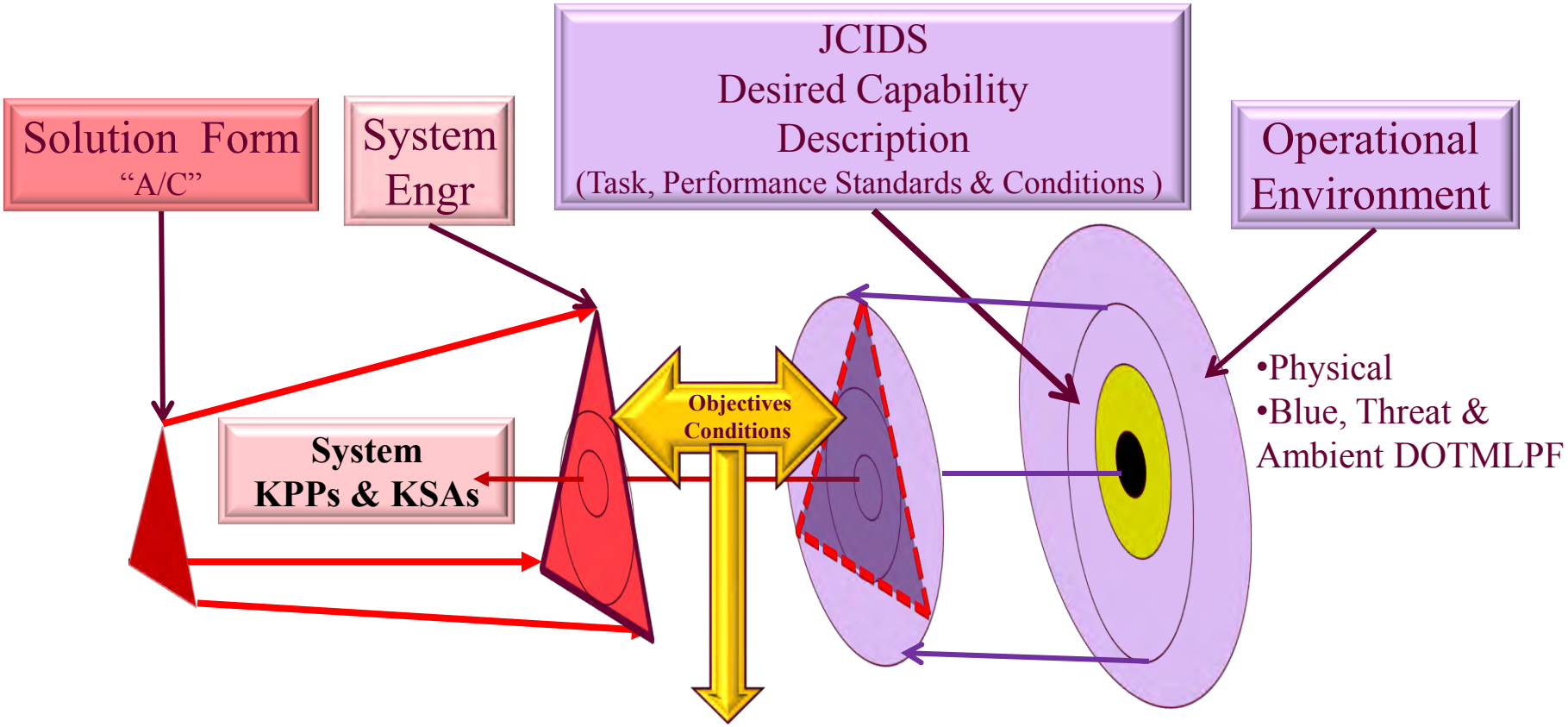
Provide **Validation** of the **systems engineering process** *"provide confidence that the **system design solution is on track to satisfy the desired capabilities"***

Test Objectives & Conditions relate **performance** to the desired **Capability**

Concepts: Solution Design

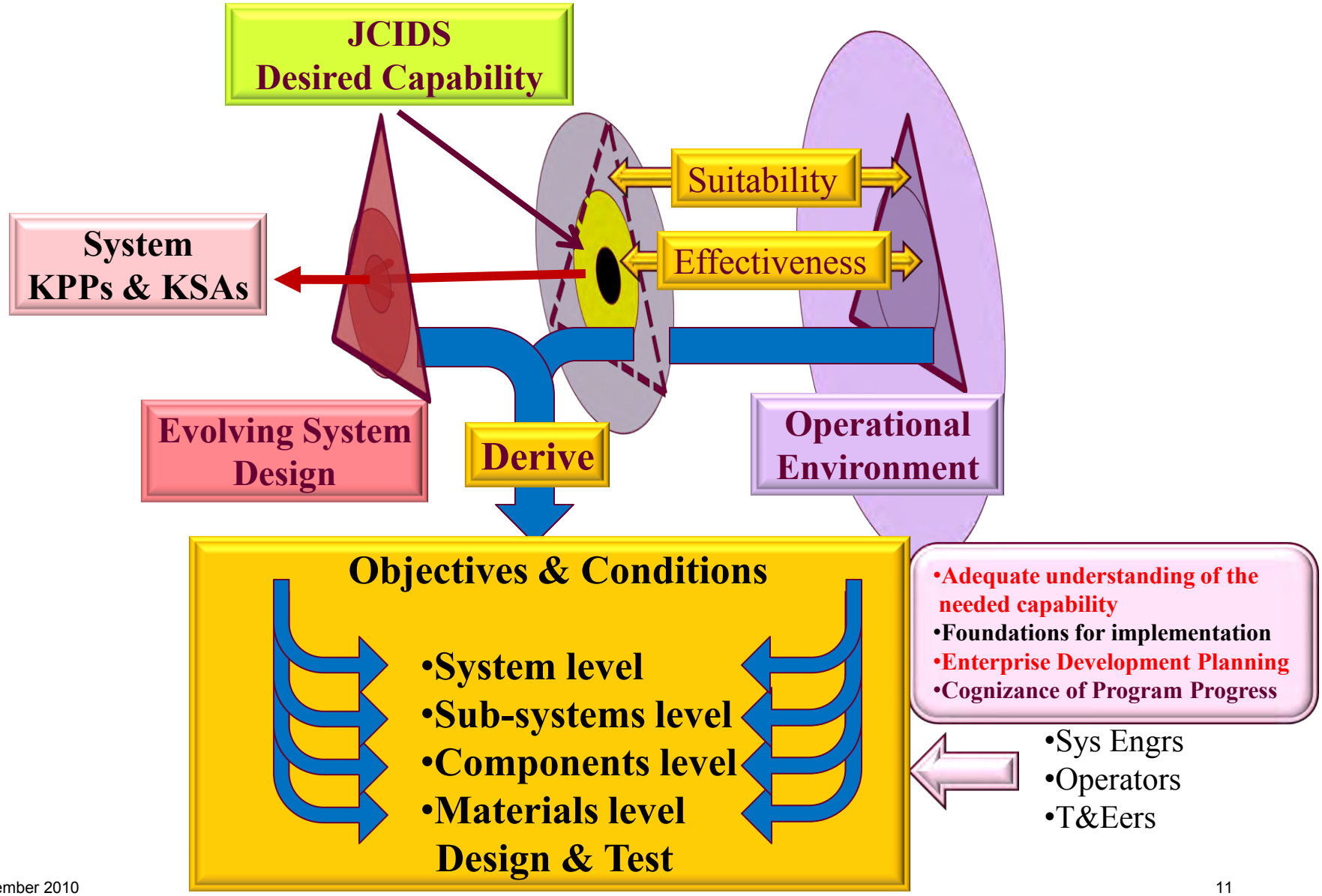


Concepts : Objectives & Conditions for Design and Testing

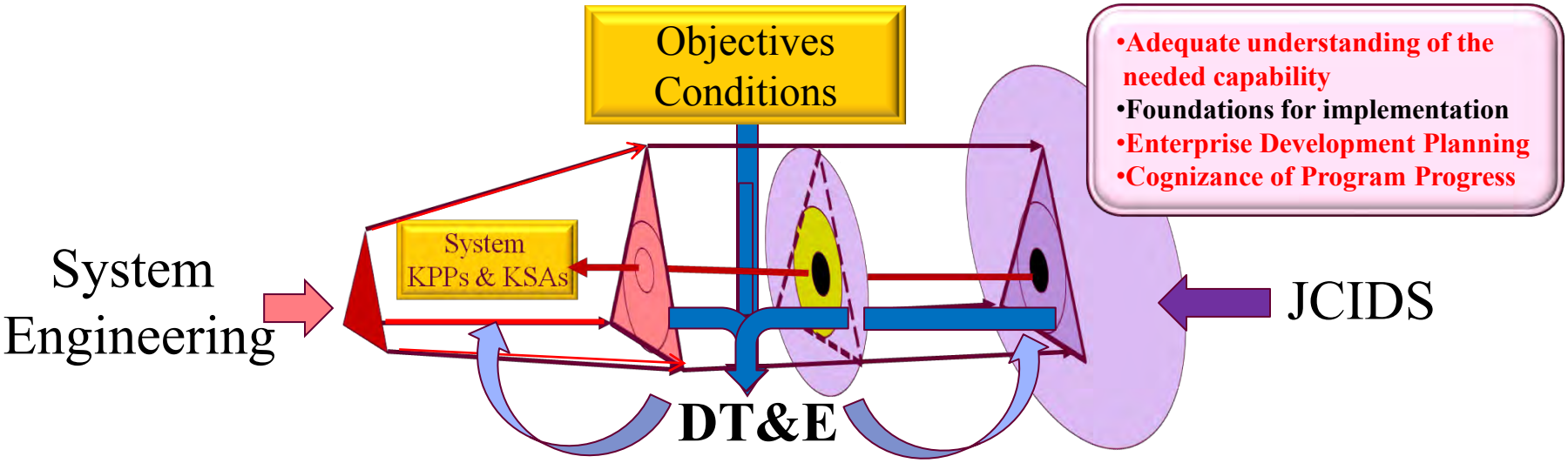


Objectives and Conditions
The devil is in the detail of how the
Design and the **Operational Environment**
interact
to provide the **Desired Capability**

Concept: Deriving Appropriate Test Objectives and Conditions



Concept: Relating System Performance to Desired Capability During Development



Verification
- Of Systems Engineering process
- *"System Works as **designed**"*

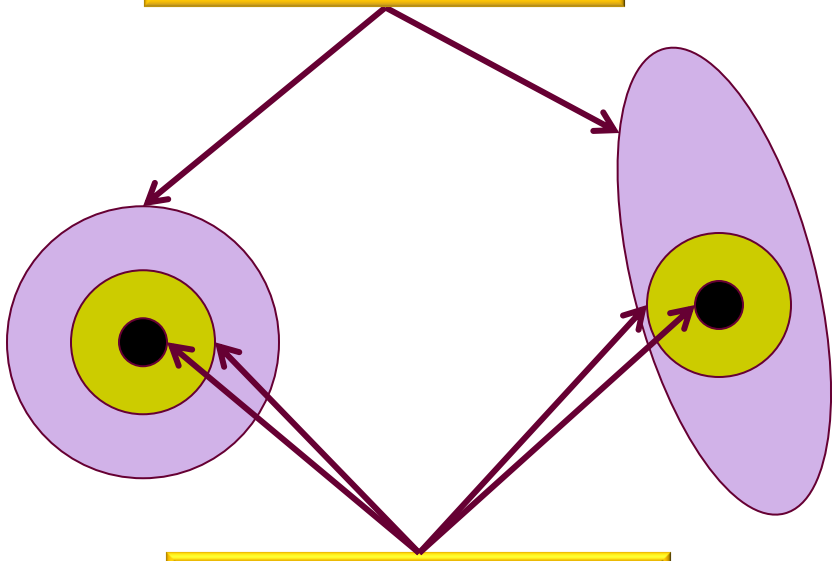
Validation
- Of Systems Engineering process
- *"Provide confidence that the system design solution is on track to satisfy the desired **capabilities**"*

Ensure Test Objectives & Conditions relate system performance to System Engineering **Design**

Ensure Test Objectives & Conditions relate system performance to the **Desired Capability**

Concepts: The Operational Environment as a Variable

Operational Environment (and perceptions of it) vary and change



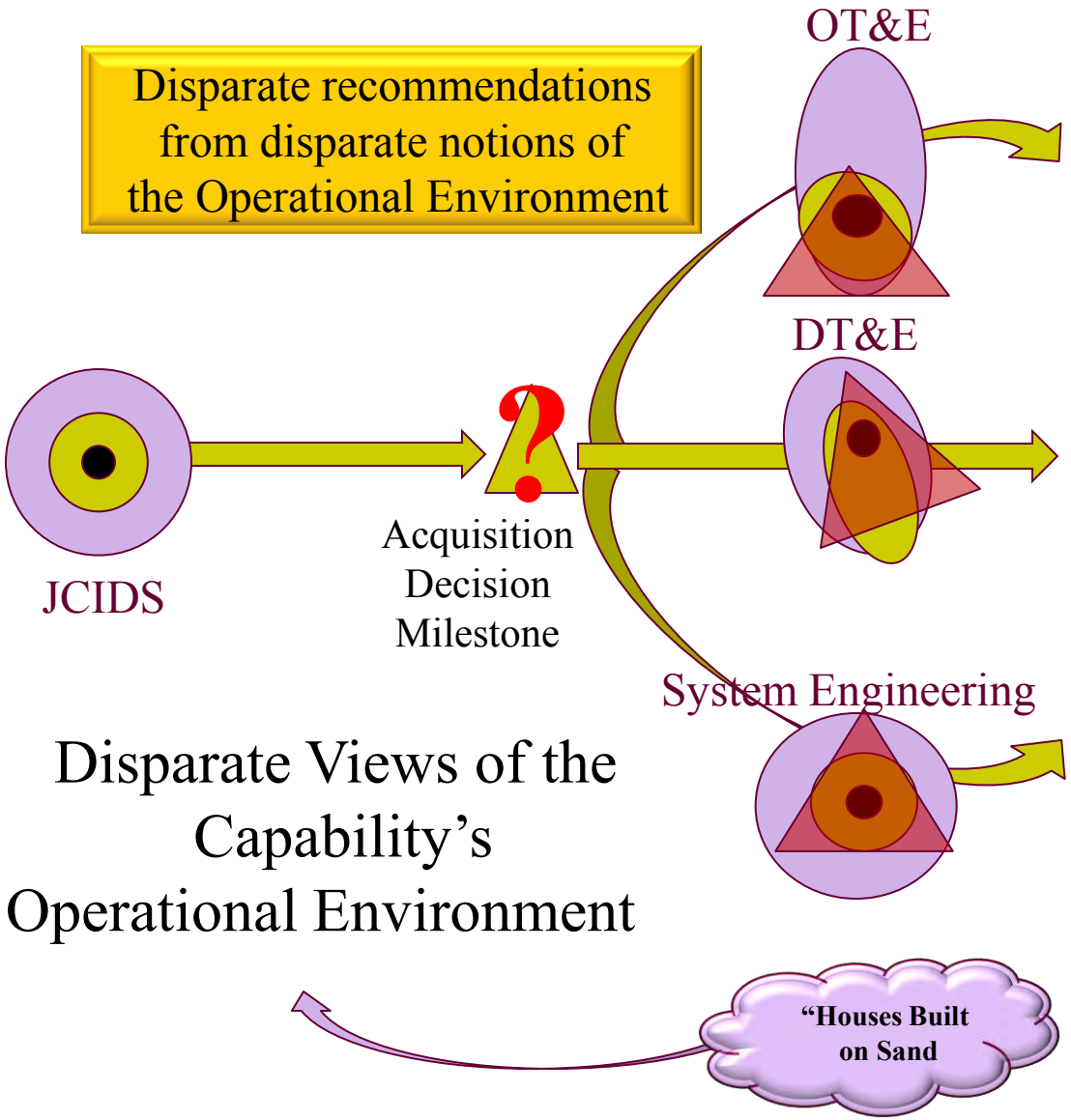
Task and task performance Standards & Conditions may remain unchanged

Rationally diverse motivations and perceptions; contribute to **disparate notions** of:
- WHAT in the Operational Environment is important to the design and test of the system, and
- HOW to describe the environment

Disparity in the Objectives and Conditions used for system design, test & evaluation

Symptoms of Systemic Tensions

Disparate recommendations from disparate notions of the Operational Environment

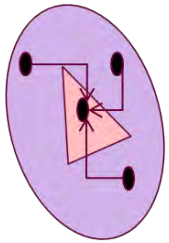


"Isn't Suitable, not Effective "
- Deficient RAM
- Does NOT meet KPPs

"System not adequately tested"
- System may not work as limited testing suggested; and
- Does system performance satisfy the desired capability?....Unknown

"Works as designed"

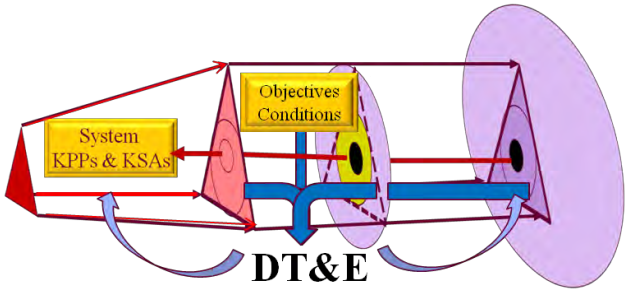
Why No Traction?



OT&E

Testing in Joint Environments (TIJE):

- **Differing perspectives on the Objectives and Conditions appropriate for Testing**
  - **Does not explicitly address the System Design**



DT&E

- System level
- Sub-systems level
- Components level
- Materials level

Design & Test Objectives & Conditions in appropriate scope and detail

M&S: For Acquisition and OT&E

Weak basis for M&S Design, Validation & Accreditation

- M&S tends to depict entities in *the way they would recognize themselves* ***(as blessed by entity owner)***
- Not representing entities in the way *they would interact with the* ***test item***
  - Eg. Model of a Tank signature could be just a *laser spot* –
    - A "valid" representation of the tank---as seen by the the sensor, NOT as the tank PMO sees the tank

Why No Traction?

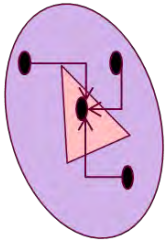
Evaluation-based Testing:

•**No consistent, persistent** analytic **Trade Space in which to** examine alternatives in design, system performance, cost constraints and resulting capability under conditions of the Operational Environment

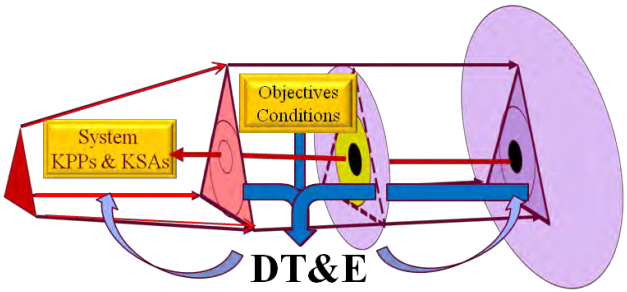
•**No "Baseline" Operational Environment** supporting use or maintenance of a trade space… No common basis for generating or comparing results of alternatives through the evolving development; consequently:

•Failed KPP? –so What?

Why No Traction?



OT&E



DT&E

•System level
•Sub-systems level
•Components level
•Materials level
Design & Test
Objectives & Conditions
in appropriate scope and detail

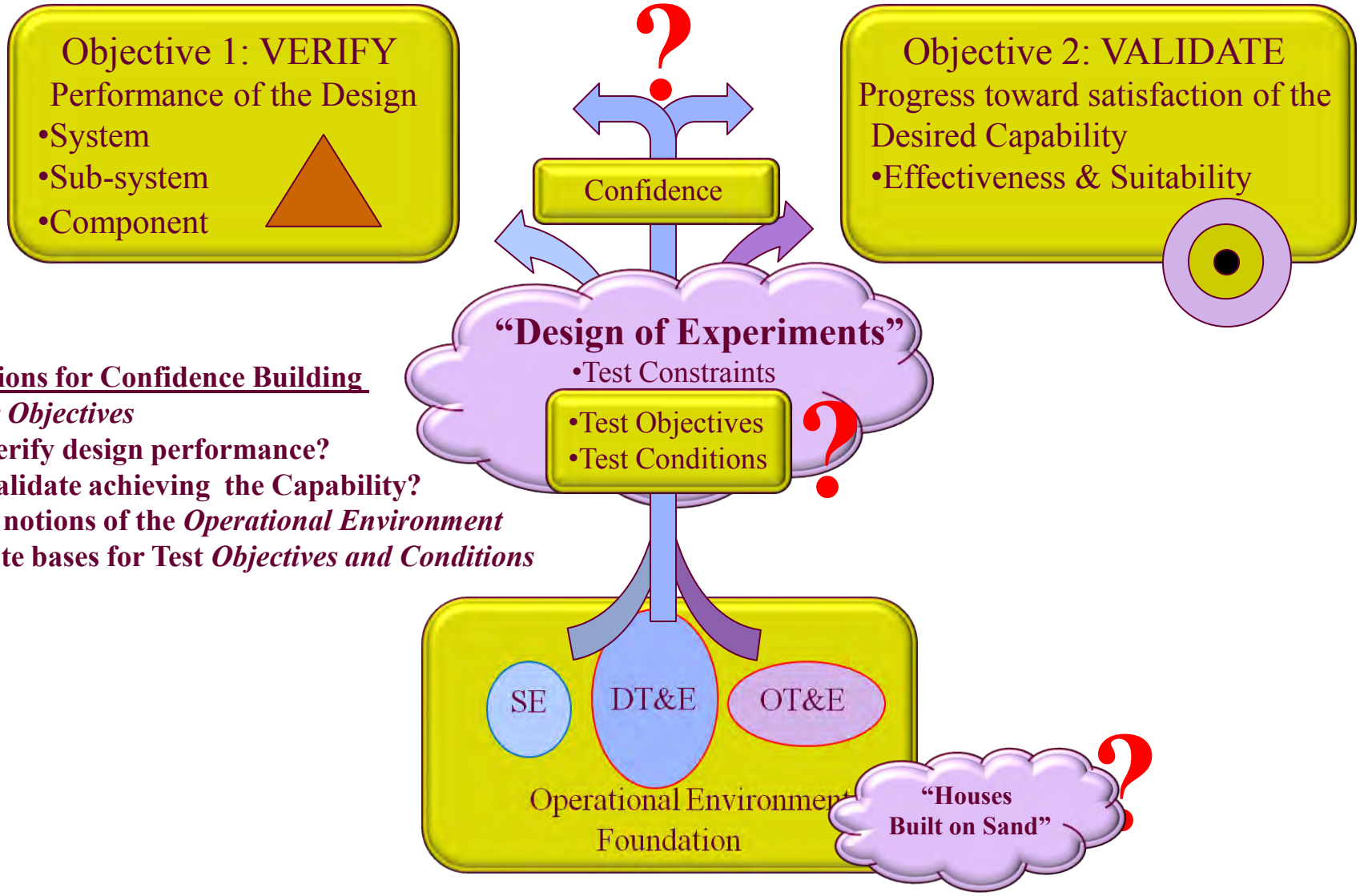
Integrated DT/OT:

Differing perspectives on Objectives and Conditions

- •OT Perspective: Tends to emphasize mission decomposition
  - •The system is a "given"
  - •Ops Environment **imposes** the Test Conditions on the system, sub-systems & components
- •Sys Engr & DT Perspective:
  - •The system Design is a maturing "variable"
  - •Test Objectives and Conditions are derived from the evolving **design's interaction** with the **Ops Environment** to provide the Desired Capability

Integrated DT/OT
A "Realistic" Operational Environment?
•Realistic to whom?
•Realistic for what?

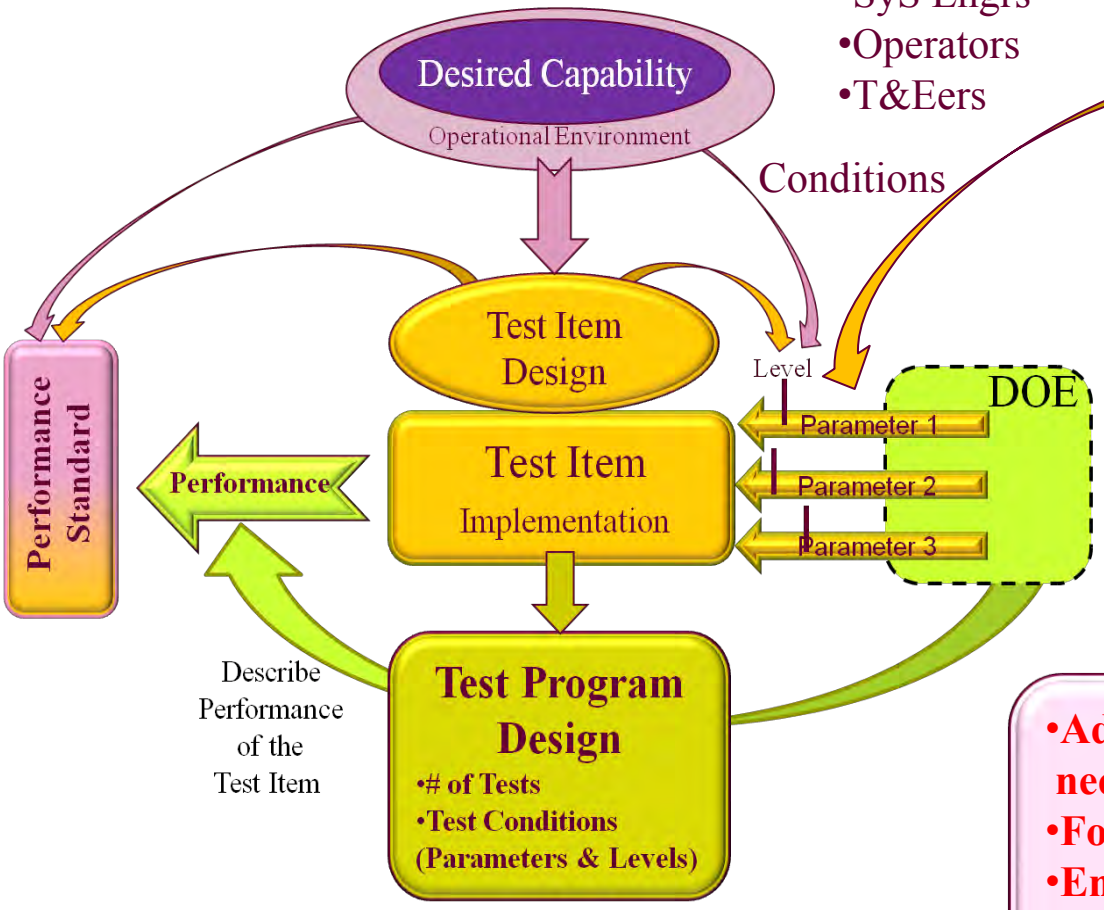
Design of Experiments(?) in Testing
Building Confidence & Understanding Risks



Foundations for Confidence Building

- **Unclear *Objectives***
  - **Verify design performance?**
  - **Validate achieving the Capability?**
- **Diverse notions of the *Operational Environment***
- **Disparate bases for Test *Objectives and Conditions***

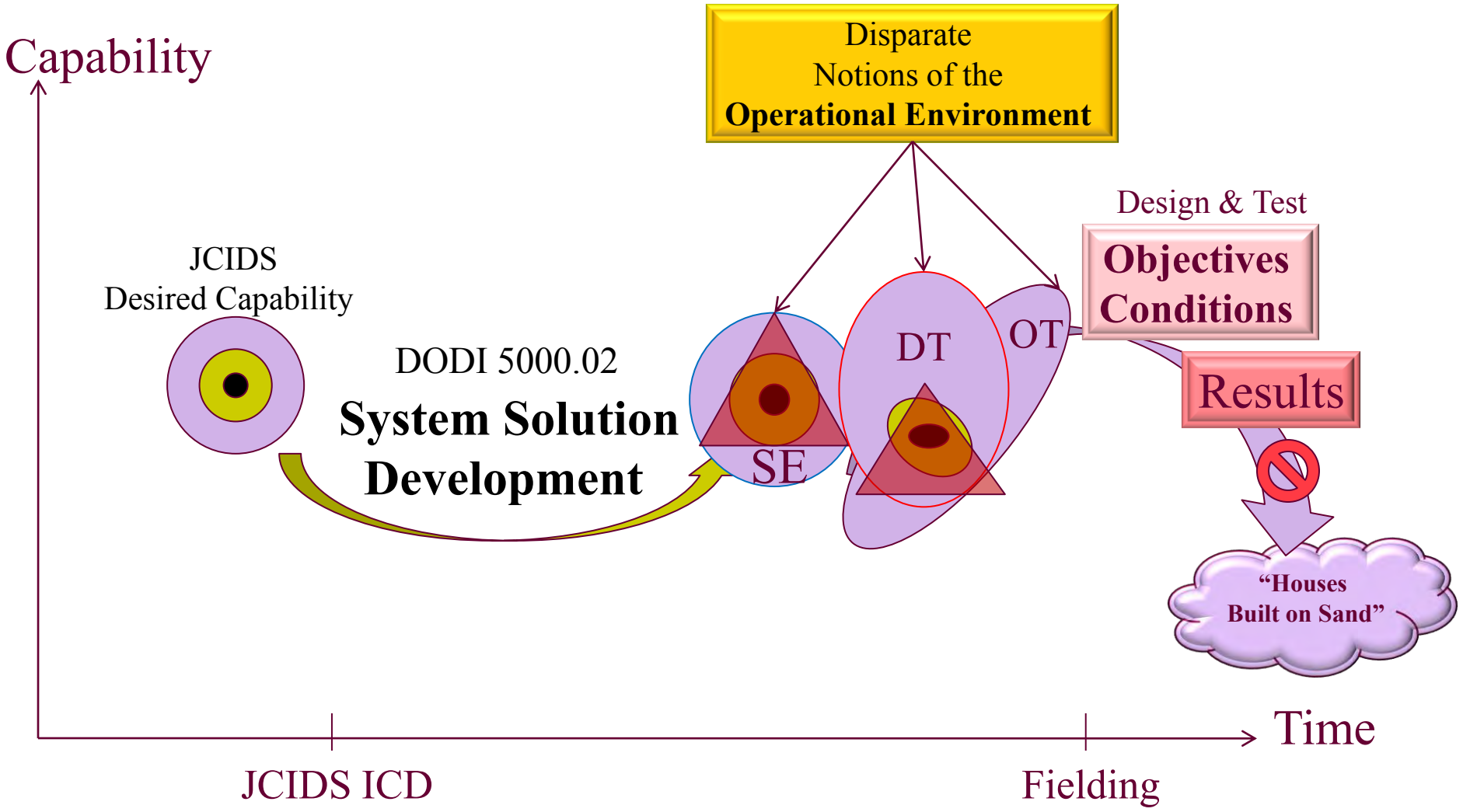
DOE as a "Foundation" for Systems Engineering AND T&E M&S



A Foundation For DOE AND Design and VV&A of M&S Of Conditions For Sys Engr & T&E

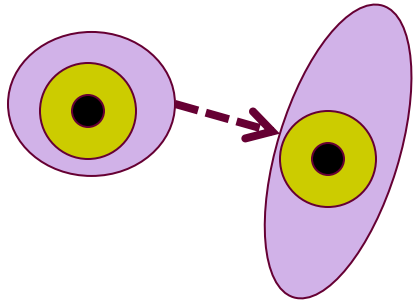
- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

Foundations: How to Provide A Strong Foundation For Deriving Design and Test Objectives and Conditions?



Systemic Solution Approach: New Guiding Concepts & Processes / New Collaborations

1. Establish an authoritative "Baseline" Operational Environment description for each Capability Solution

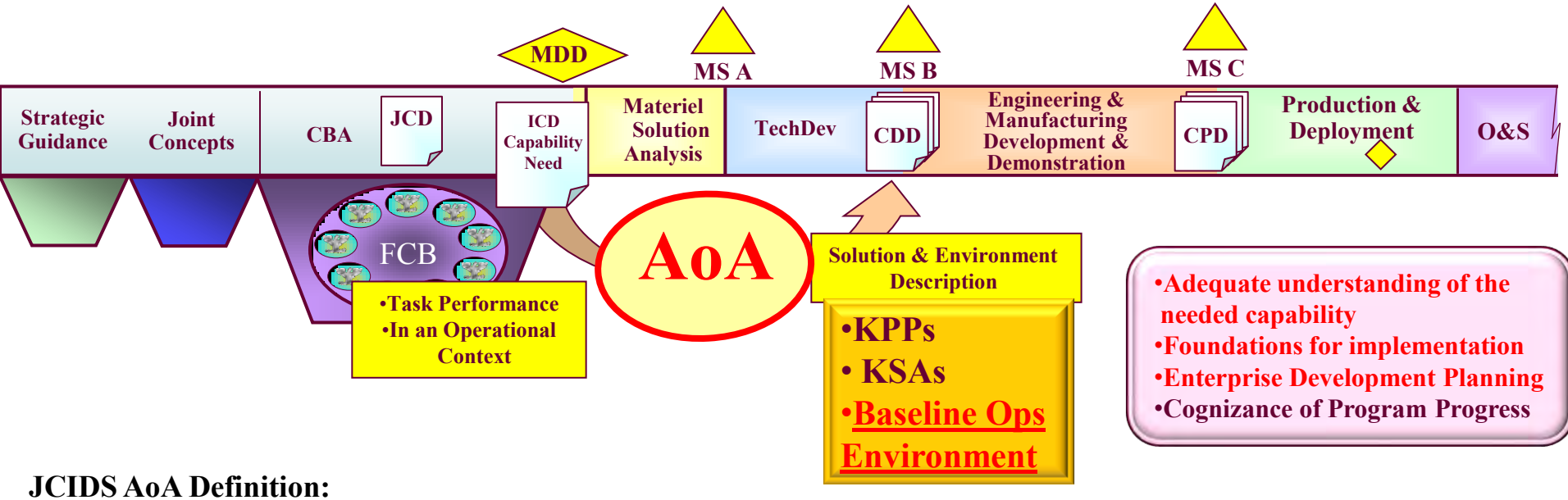


- Speaking with authority for the war fighter
  - Services & COCOM Input (?)
  - JROC Approved (?)
- For use by SE, DT&E, OT&E
  - A common baseline for **deriving** objectives and conditions
    - For use in the SEP, TES, TEMP, Test Plans, System Design, Capability Evaluation, RFPs, Contract Specifications

- **Implementation**
  - Ops Environment is initially in the ICD at the MDD
    - Is already refined and co-evolved with the emerging "Solution Approach" as a component of the AoA and reported in the AoA at MS B
  - Give the AoA Ops Environment description a **Purpose**: "Intended as a foundation for deriving Development Phase Design and Test Objectives and Conditions"
  - Give the AoA Ops Environment description **Authority**: JROC approve the AoA Solution Approach's Description of the Ops Environment with the KPPs and KSAs at MS B
  - Convey the "Baseline" Ops Environment description in System development RFPs
  - **Refine, and JROC approve as appropriate, the Ops Environment description as the System Design matures toward IOT&E and MS C**.

"Baseline" Description of the Capability's Operational Environment

Analysis of Alternatives (AoA)
Translates
A Desired Capability
Into
A "Solution Approach"
(A System Form with Performance Objectives & Conditions)



JCIDS AoA Definition:

"The evaluation of the performance, operational effectiveness, operational suitability, and estimated costs of alternative systems to meet a mission capability. ….The AoA is one of the key inputs to defining the system capabilities in the capability development document"

Systemic Solution Approach: New Oversight/ New Decision Making / New Collaborations

2. Establish oversight to ensure quality of the derivations of KEY Objectives & Conditions from the Capability's baseline Operational Environment

- Ensuring that KEY design and test Objectives and Conditions are appropriately derived "relevant" to:
  - The needed **Capability**
  - The **System Design** and
  - The **Operational Environment**

•SyS Engrs
•Operators
•T&Eers

- **Implementation:**
  - A collaboration among OT&E and AT&L (System Engineering , and DT&E)
  - Revise DODI 5000.02

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

Ensure that Objectives & Conditions are appropriate for KEY system design and testing and ultimately for Satisfying the Desired Capability

Systemic Solution Approach: New Principles, Concepts & Processes

3. Develop Concepts & Guidelines to guide the Derivation of appropriate Objectives & Conditions for system, sub-system, component and materials design & testing

- Relating the **Design**, the desired **Capability** and the **Ops Environment**
- Providing a broader and richer context for deriving appropriate performance Standards and Conditions at all levels of a system's development
- Facilitating effective **verification** of system performance and **validation** of the Systems Engineering process is on track to satisfy the desired capability

- **Implementation:**
  - Defense Acquisition University,
  - Defense Acquisition Guidebook,
  - Others (?)

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

Systemic Solution Approach: New Principles, Concepts & Processes

4. Provide Methods & Tools for Systems Engineering

- For rapid and agile excursions in the **"Trade Space"** of the ops environment, system **design & engineering**, system **performance**, **suitability,** capability **effectiveness**, and **cost**
- To identify and assess the **implications** of **test results** relative to:
  - System Performance, and
  - Desired Capability
- Answering "So What?" KKP issues
- Supporting Cost driven development of alternative KPPs and KSAs for JROC consideration & approval

•Adequate understanding of the needed capability
•Foundations for implementation
•Enterprise Development Planning
•Cognizance of Program Progress

Systemic Solution Approach: New Principles, Concepts & Processes

5. Provide Methods & Tools for Test & Evaluation

- Identify & explain **Design of Experiments** practices to produce test programs that enhance confidence in test results for use in:
  - **Verification** of system performance & suitability relative to the system Design, and
  - **Validation** that system engineering process is on track to provide the Desired Capability
- Providing a foundation for **VV&A** of M&S
  - For **Sys Engr** and **T&E**

- **Adequate understanding of the needed capability**
- **Foundations for implementation**
- **Enterprise Development Planning**
- **Cognizance of Program Progress**

BACKUP SLIDES

Summary: Systemic Approaches for Enhancing Objectives and Conditions for Design & Testing

APPROACHES

1. Authoritative Operations Environment "Baselines"

2. Appropriate Derivations of Objectives and Conditions that relate Performance to the Desired Capability's Performance Standard for System, Subsystem , and Components for Design, Test and Evaluation

3. SE, DT&E and OT&E Concepts, Guidance, Methods and Tools

ENABLING

Verification of the systems engineering process "System works as designed"

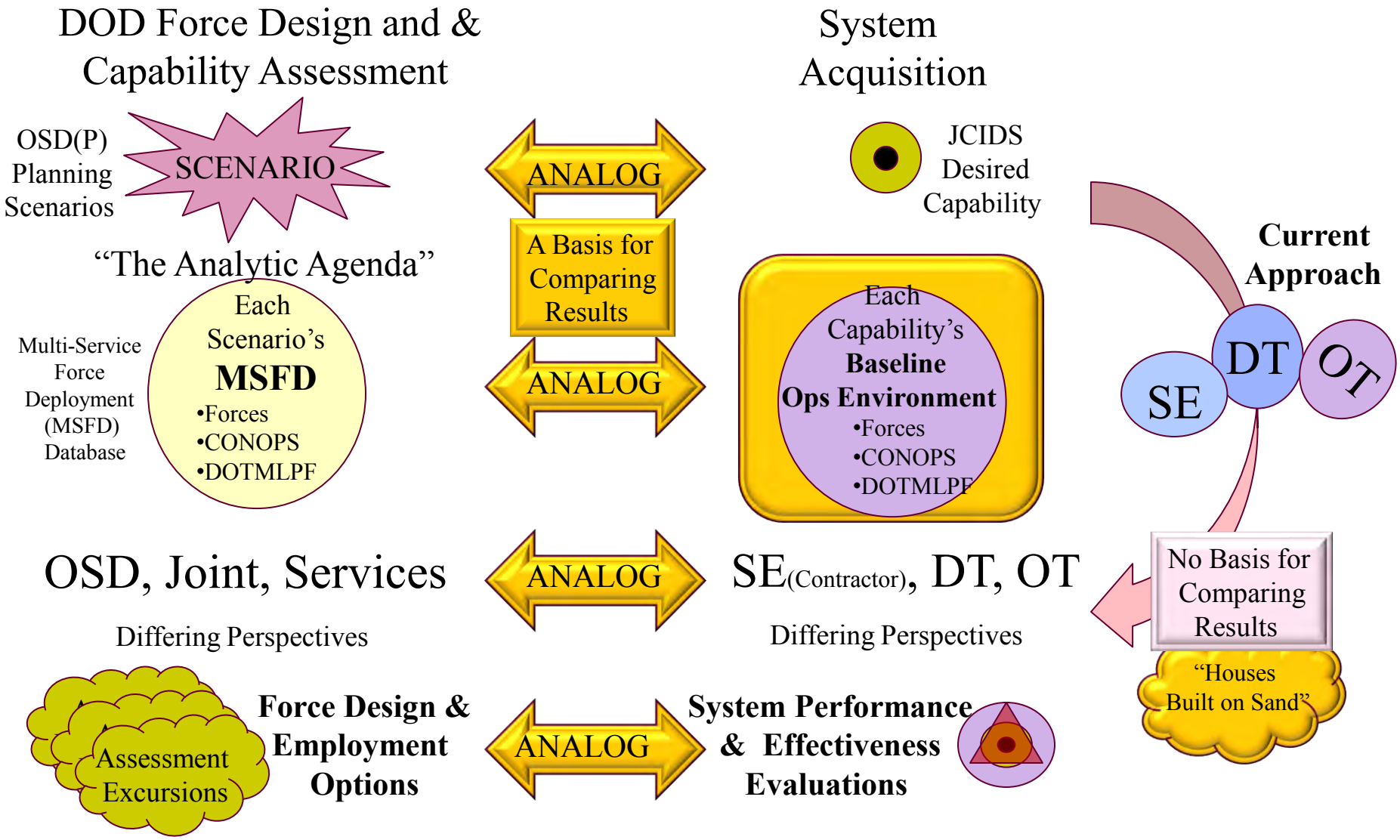
Test Objectives & Condition relate performance to design specifications

Validation of the systems engineering process and *must provide confidence that the system design solution is on track to satisfy the desired capabilities"*

Test Objectives & Conditions relate performance to the desired Capability

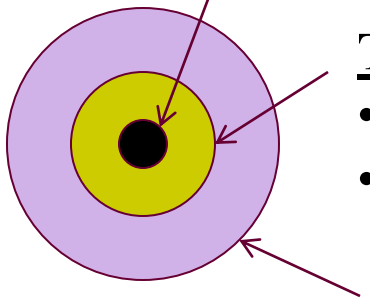
Traction in AT&L Initiatives
- VV&A of M&S
- Testing in Joint Environment
- Evaluation-based Testing
- Integrated DT/OT
- Design of Experiments

An OSD/ Joint Staff Precedent for Baseline Operational Environments



Concepts: A Capability as a Task with Associated Performance Standards & Operational Conditions

Capability = Task + Task Performance Standards + Conditions



Task Description

• Kill a hardened target

Task Performance Standards

•Pk xx%

•All weather, within xx minute of detection

Conditions: Operational Environment

•Threat: Order of Battle and Modes of Operation

•Physical: Climate, Terrain

•DOTMLPF:

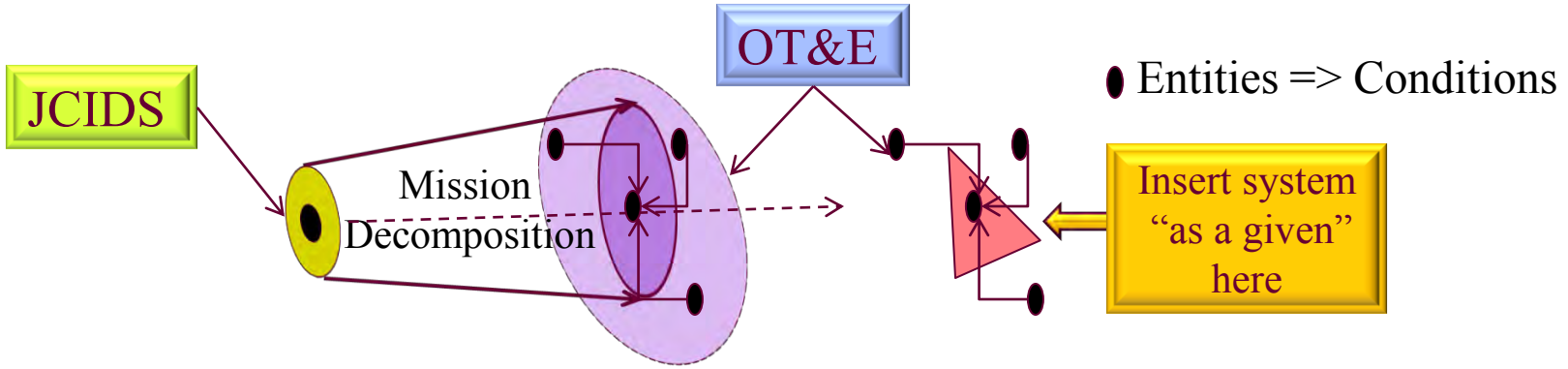
- Forces, Organization & C2 structure
- Logistics process, etc

•Desired "Form" of the Solution (A/C, MSL, truck, etc)

A "Conceptual" Depiction

Concept: Comparison of OT&E and Developmental Perspectives on Test Conditions

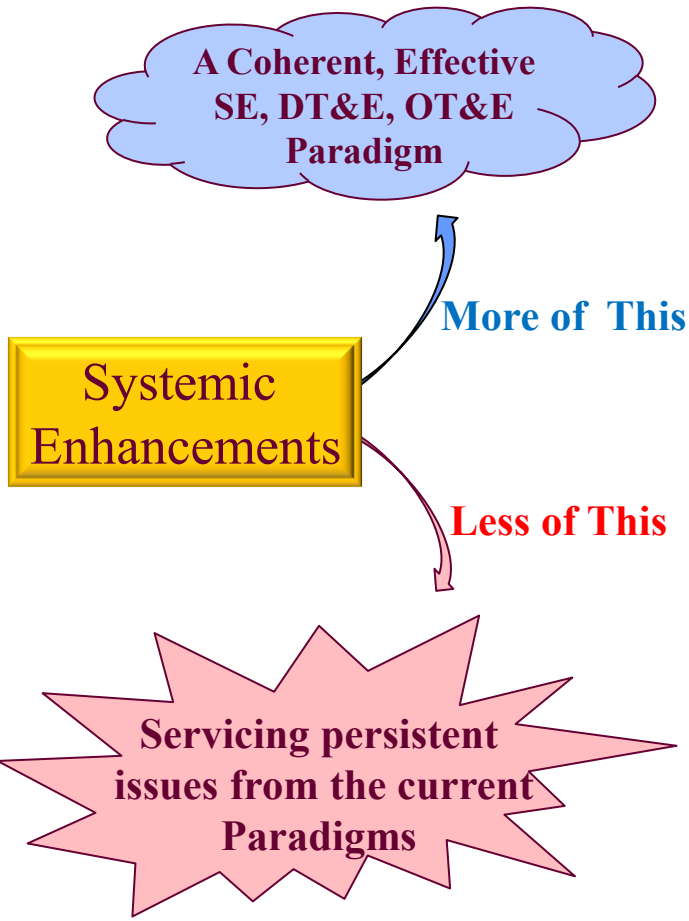
OT&E view for deriving Conditions tends toward a *mission decomposition* perspective which identifies **operational entities** (C2, threat, maintenance, etc) that interact with and affect the system's performance of the Desired Capability



OT&E view is "Necessary" but not "Sufficient" for deriving Effectiveness AND Suitability Objectives and Conditions for the sub-systems or component levels during System development and testing

- Design and Test Objectives and Conditions at those levels can change with the **evolving design**

Systemic v.s. Symptomatic Approaches



Systemic Approaches:

"Correcting conditions that cause persistent issues"

- Cultures, Structures, Internal Economics, Methods & Tools, Metrics & Rewards (www.ndma.com/resources/ndm1891.htm)
- Modes of change:
  - New guiding perspectives, principles, concepts
  - New processes and products
  - New Collaborations with new organizations on new challenges

Symptomatic Approaches:

"Reacting to recurring issues as they emerge"

- Low Reliability, inadequate testing, etc
- Performance arguments among processes
  - Inadequate testing
  - Inventing Requirements
- Routinely broken schedules and resources
  - Nunn-McCurdy cost breaches
  - Delayed Milestone Decisions

Example: A Systemic Challenge

"RAM deficiencies are endemic with big-ticket U.S. weapon systems, a problem that drives up operating and sustaining costs for ships, aircraft, and ground systems"

"Restoring Affordability and Productivity"

DOT&E to DUSD/AT&L: June 2010

Endemic Problem: RAM Deficiencies

Correction: Systemic "Process" Changes

- Implement **Configuration Management** (CM) and **Quality Control** (QC)
  - Provide the processes to identify, understand and resolve the sources of failure in the Reliability, Availability, Maintainability (RAM) relationship

Advancing Systems Engineering Through Use of Collaborative Space

G. Richard Freeman
Technical Director
Air Force Center for Systems Engineering

Alan R. Heminger, Ph.D.
Associate Professor
Air Force Institute of Technology

Overview

- Our Challenge
- Current Environment
- Desired Future State
- Research Findings
- Proposed Way Ahead

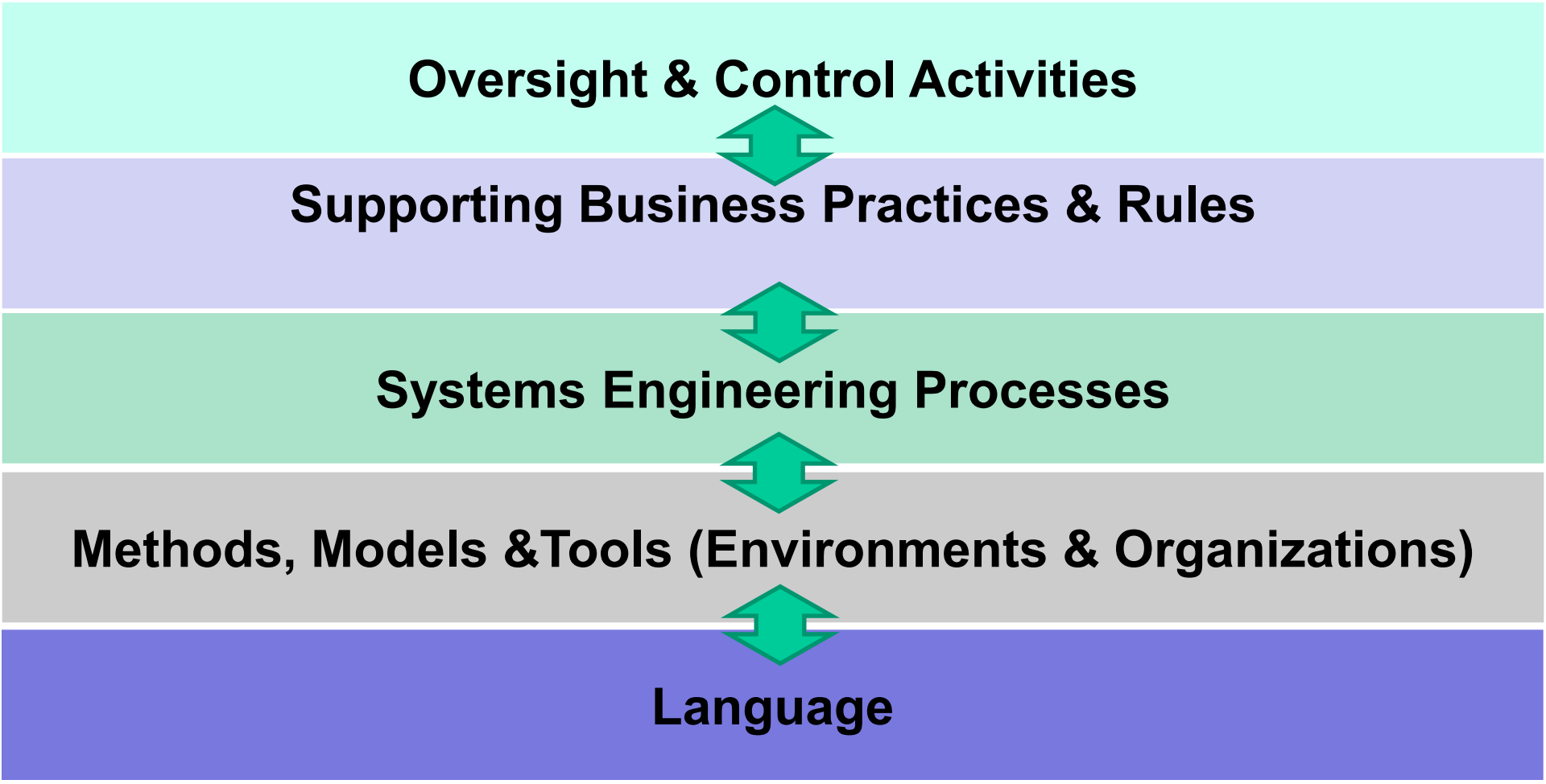
Our Challenge

- **There is a growing need for inter-organizational collaboration in Development Planning**
  - Weapon systems have become more and more complex, demanding expertise from multiple Product Centers
  - Congress and OSD have increased their focus on DP activities in continued attempts to improve the acquisition process

- **Capabilities to facilitate such collaboration are lacking**

Potential Enabler:
A Collaborative Systems Engineering Environment

Layered Framework



Investigation of Collaborative Capabilities in Product Centers

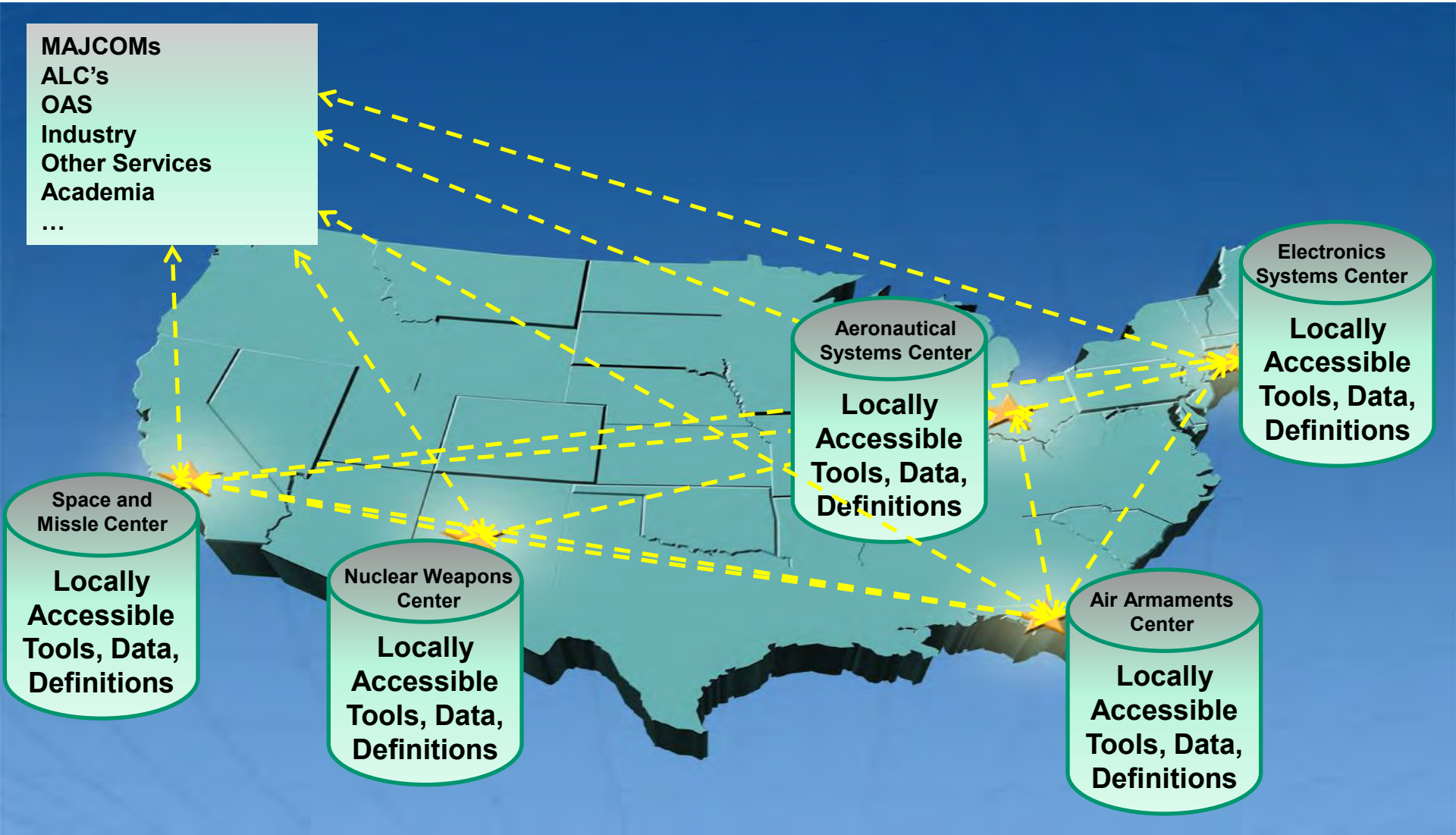
- Researchers from the Air Force Institute of Technology and the Air Force Center for Systems Engineering investigated Acquisition Product Centers to assess their needs for support of collaborative early systems engineering
- Both on site and paper investigation techniques were used

Research Findings

- People in the Centers are working very hard to address early systems engineering efforts, but they are working largely independently of each other
- This isolation tends to create a lack of commonality in understanding and implementation of early systems engineering
  - They use different
    - Processes
    - Standards
    - Nomenclature
    - Tools

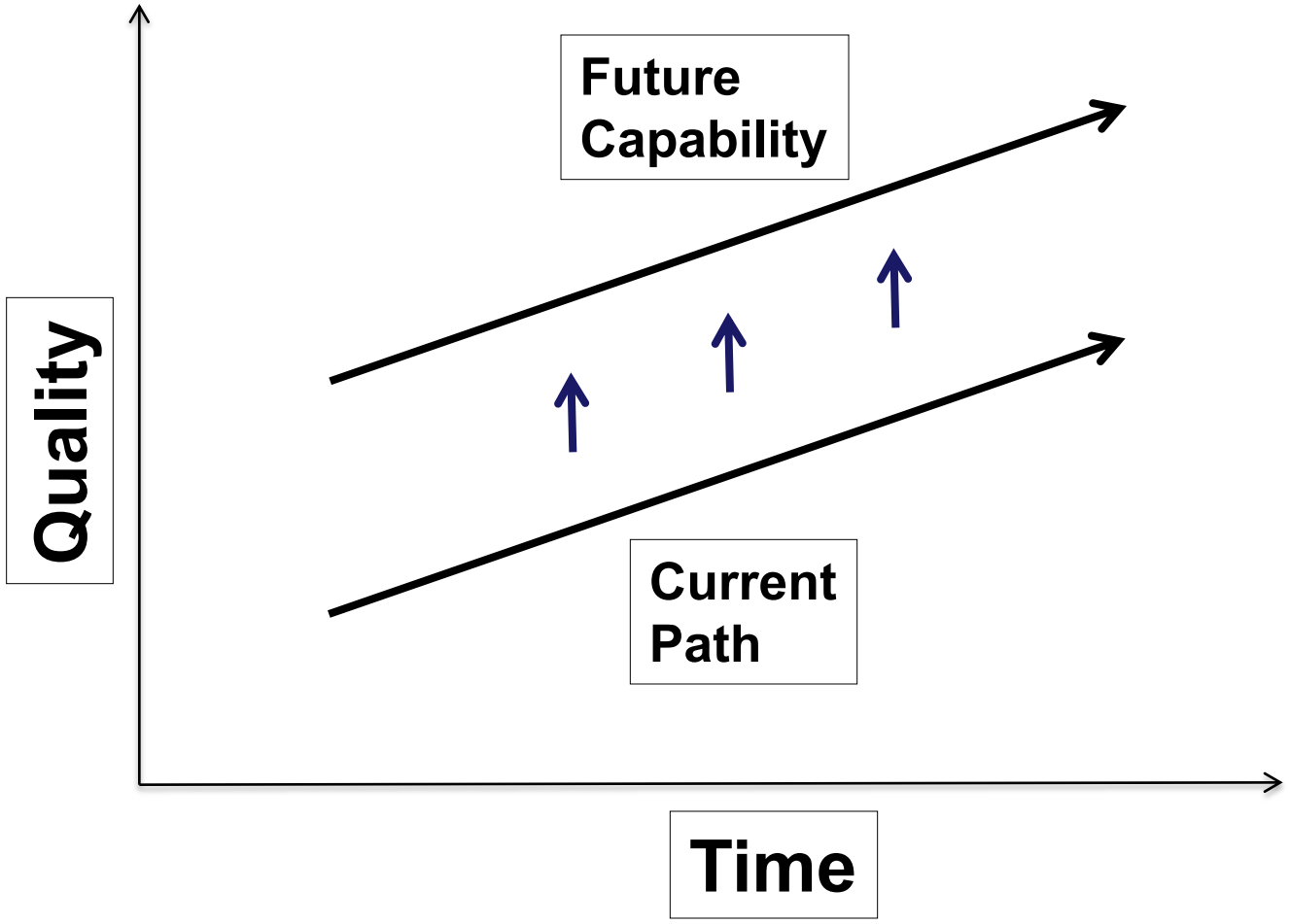
Current Environment

The AFIT of Today is the Air Force of Tomorrow.



Future Capabilities

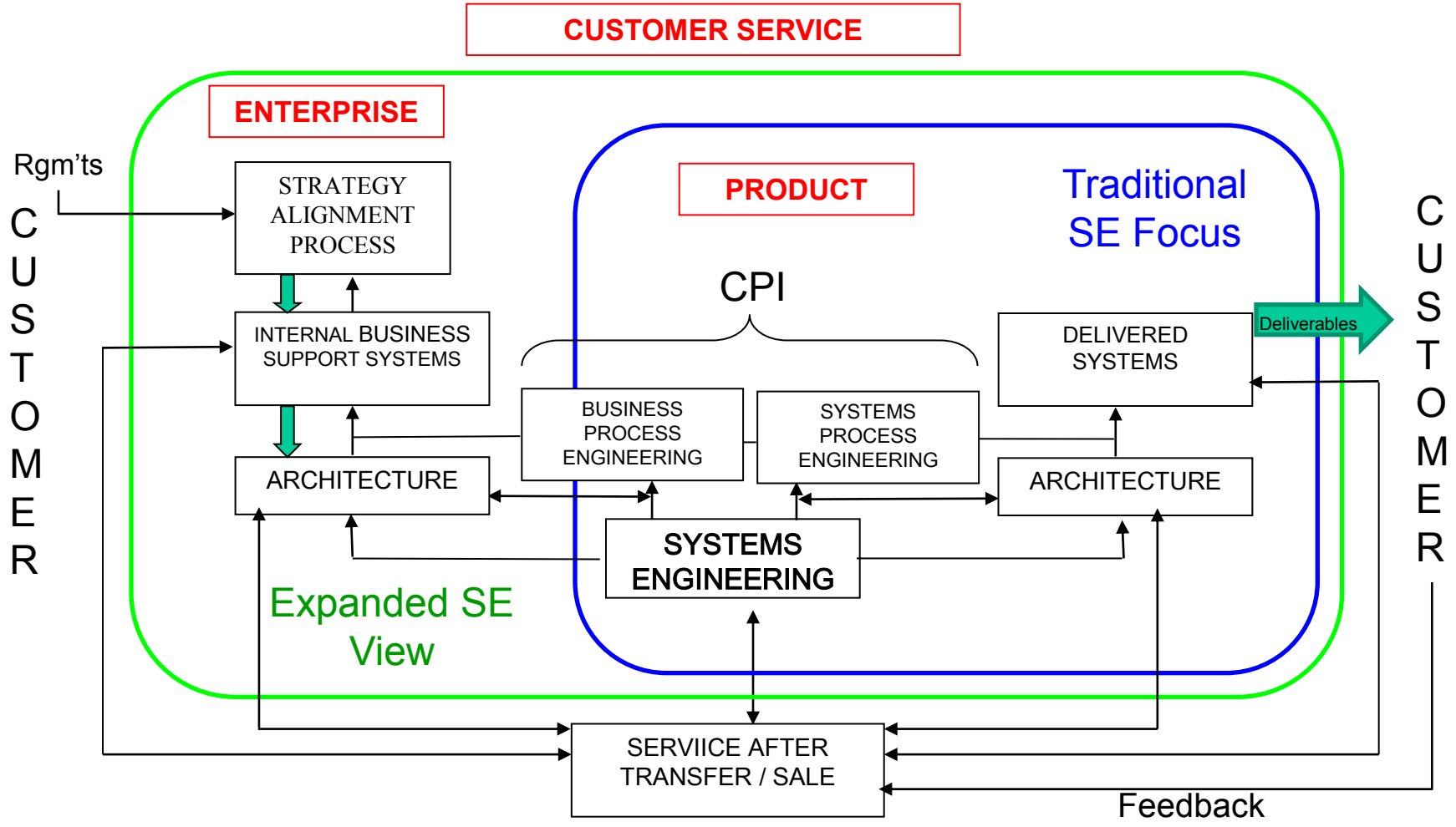
The AFIT of Today is the Air Force of Tomorrow.



INTEGRATING SYSTEMS ENGINEERING

PRODUCT, ENTERPRISE & CUSTOMER SERVICE VIEWS

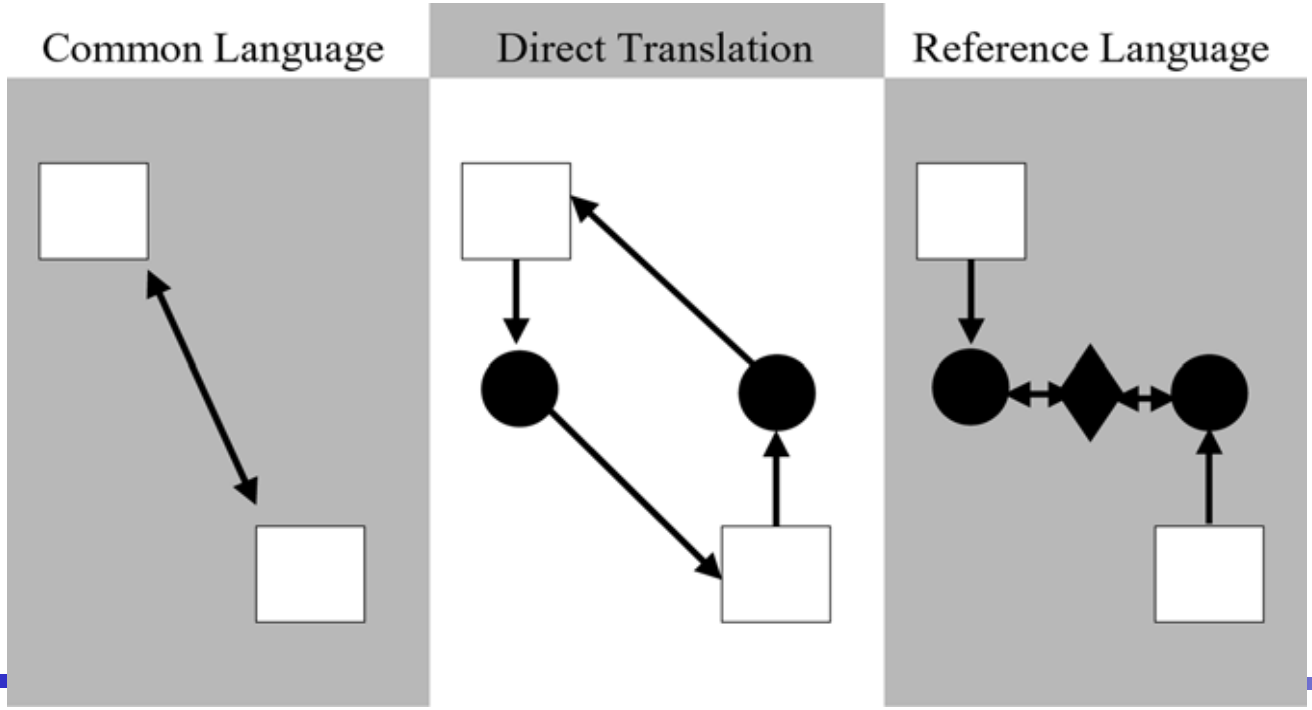
The AFIT of Today is the Air Force of Tomorrow.



Integrated Systems Engineering: Looking Beyond Traditional Realms

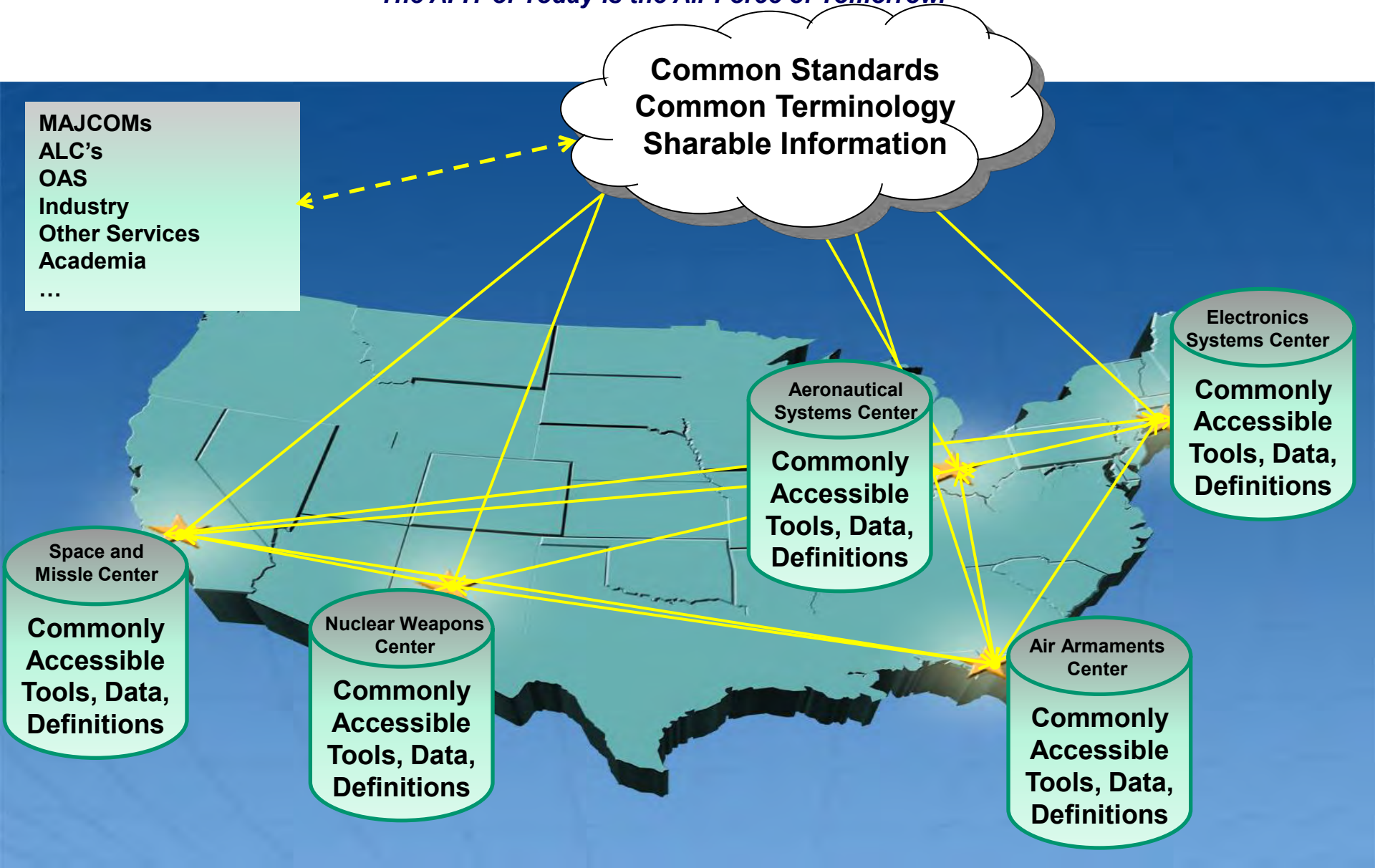
Interoperability

- In order for two entities to be interoperable, there must be clear communication of information from one entity to another.
- The product centers must use a common language to facilitate direct communication among each other

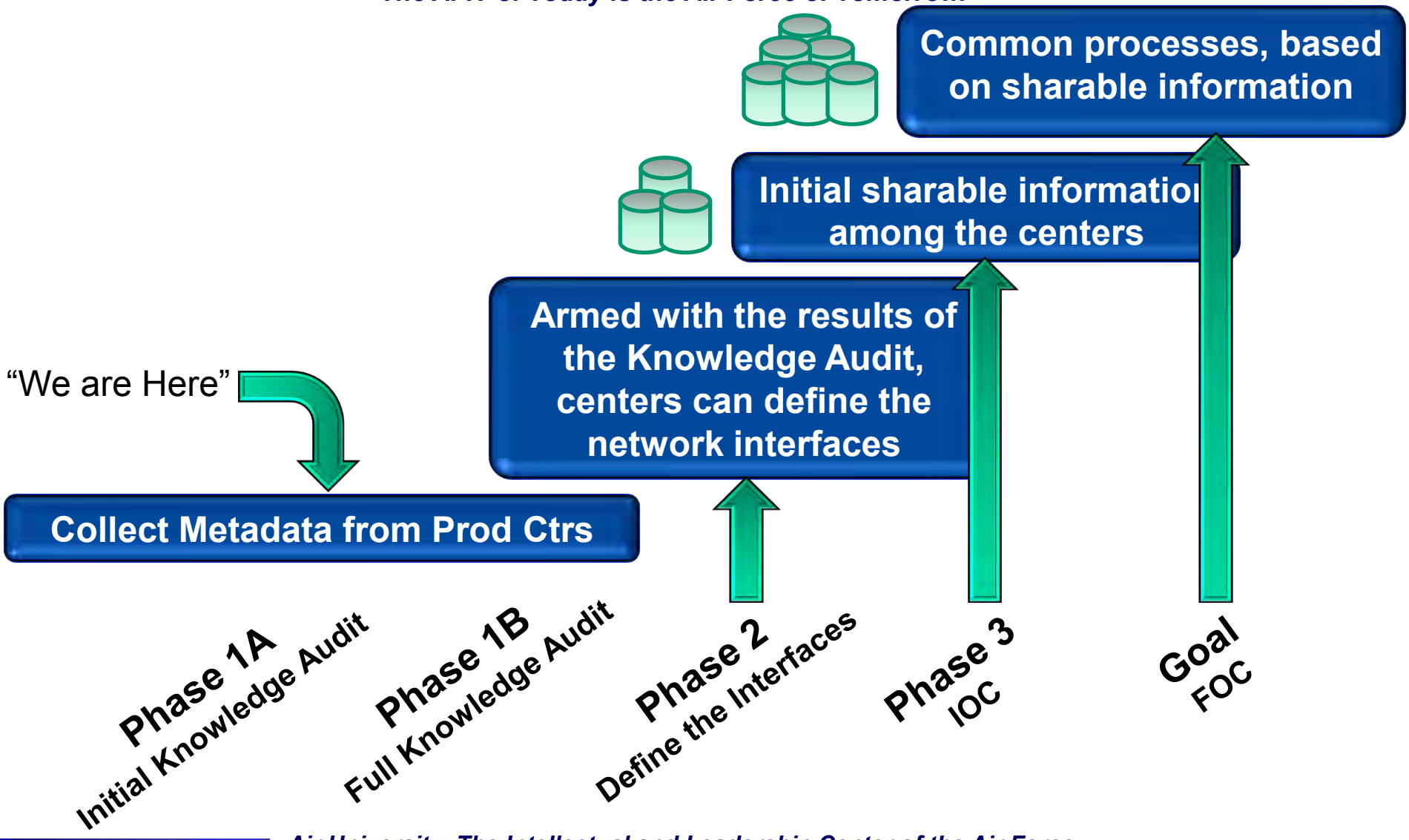


Desired Future State

The AFIT of Today is the Air Force of Tomorrow.



Proposed Way Ahead



Proposed Path Ahead

- **Phase 1B**
  - Inventory of available DP products and processes at Product Center DP organizations
  - Deliverable: Basis for establishing “as-is” architecture
- **Phase 2**
  - Define “to-be” architecture
  - Deliverable: network interfaces; proposed data solution
- **Phase 3**
  - Build/web enable relevant databases, building on common interfaces and data models
  - Deliverable: Information sharing capability
- **Goal**
  - Information sharing across product centers to support development of future weapons systems

What's Next

- CSE to facilitate work with Centers' XRs to develop formalized inter-center collaboration leading to:
  - Common terminology
  - Common processes & practices
  - Common tools & training
  - Collaborative mindset

AIR FORCE CENTER FOR SYSTEMS ENGINEERING
AIR FORCE INSTITUTE OF TECHNOLOGY

QUESTIONS ?

Systems Engineering Management and the Relationship of Systems Engineering to Project Management and Software Engineering

Barry Boehm, Ed Conrow, Ray Madachy,
Ken Nidiffer, Garry Roedler

www.bkcase.org

13th Annual NDIA Systems Engineering Conference

October 28, 2010

What is BKCASE?

- Project to create:
  - Systems Engineering Body of Knowledge
  - Graduate Reference Curriculum in Systems Engineering (GRCSE™ – pronounced “Gracie”)
- Started in September 2009 by Stevens Institute of Technology and Naval Postgraduate School with primary support from Department of Defense
- Project will run through 2012
- Intended for world-wide use

Our Partners

BKCASE

Under consideration

BKCASE Vision and Objectives

Vision

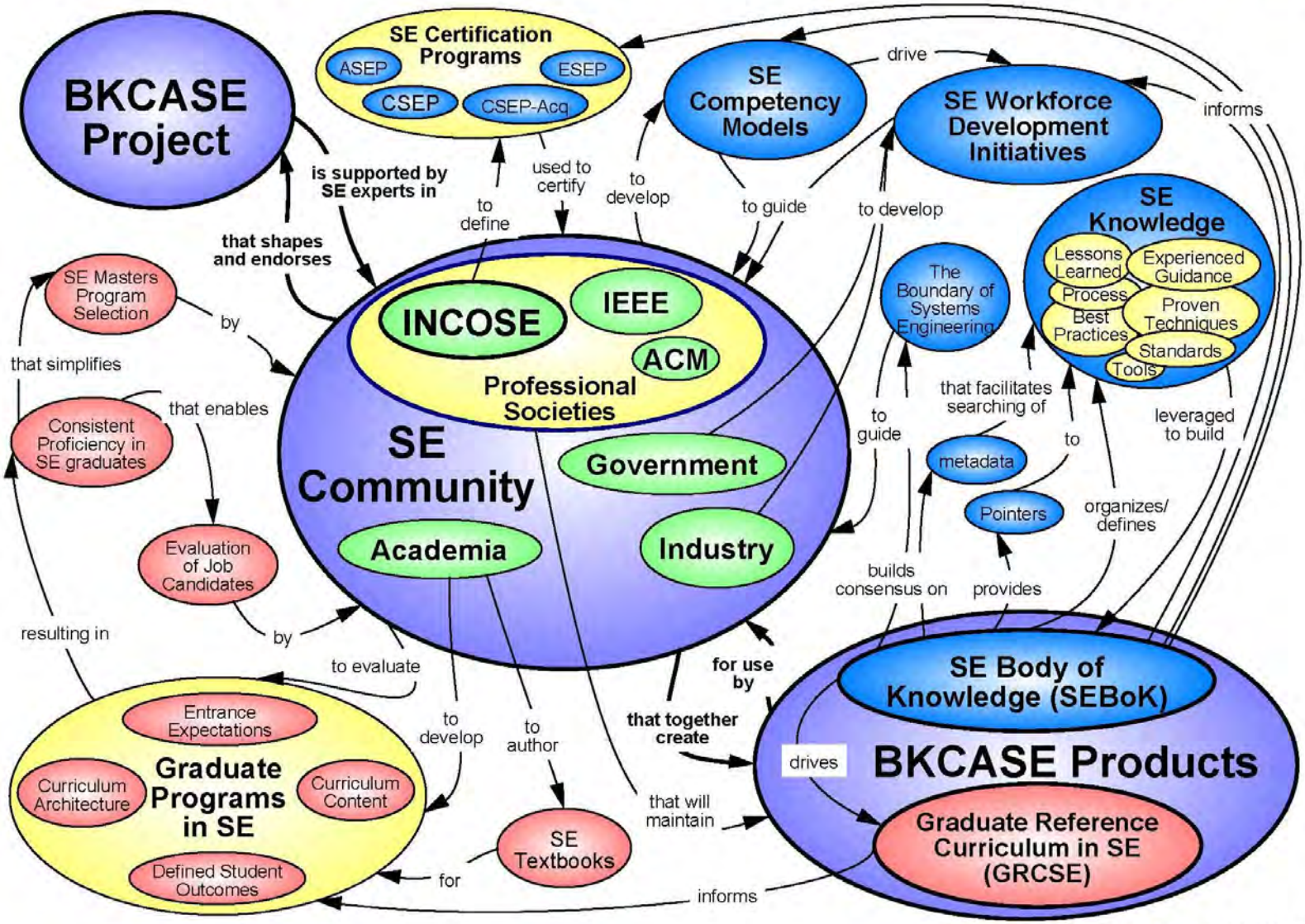
"Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE."

Objectives

1. Create the SEBoK and have it be globally recognized by the SE community as the authoritative guide to the body of knowledge for the SE discipline.
2. Create GRCSE and have it be globally recognized by the SE community as the authoritative guidance for graduate programs in SE.
3. Facilitate the global alignment of related workforce development initiatives with SEBoK and GRCSE.
4. Transfer stewardship of SEBoK and GRCSE to INCOSE and the IEEE after BKCASE publishes version 1.0 of those products, including possible integration into their certification, accreditation, and other workforce development and education initiatives.

BKCASE

Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE)



http://www.BKCASE.org/about-bkcase/bkcase-story/

SEBoK Value Proposition

1. There is no authoritative source that defines and organizes the knowledge of the SE discipline. Knowledge gap creates unnecessary inconsistency and confusion in understanding the role of SE and in defining SE products and processes.
2. Creating the SEBoK will help build community consensus on the boundaries of SE, including its entanglements with project management and software engineering.

Panel Focus

3. A common way to refer to SE knowledge will facilitate communication among systems engineers and provide a baseline for competency models, certification programs, educational programs, and other workforce development initiatives around the world.
4. Common ways to identify metadata about SE knowledge will facilitate search and other automated actions on SE knowledge.

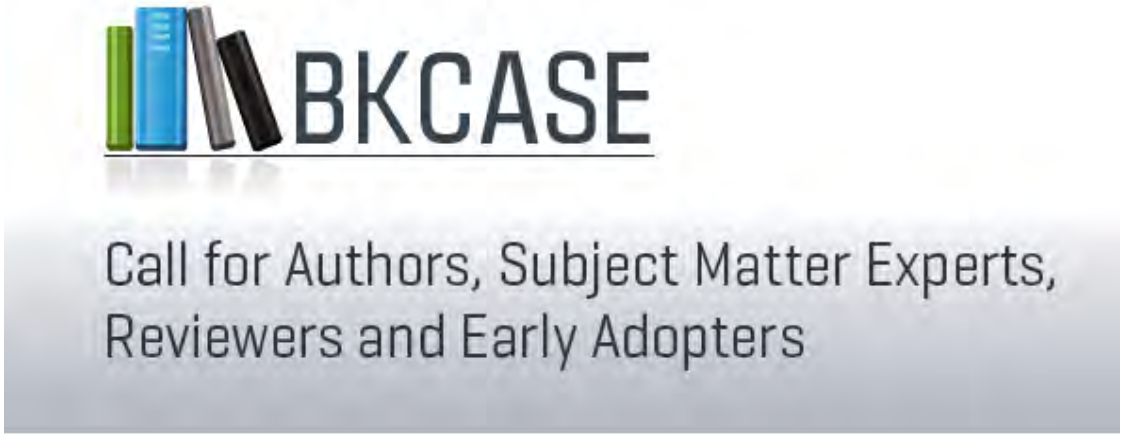
Systems Engineering Management Panel

- Panel will examine the approach and content of the Systems Engineering (SE) Management knowledge area, discuss the challenges and issues in developing an acceptable and concise representation of the knowledge, and ensure reasonable application to a wide range of domains.
- Consists of the experts who are authoring this chapter of BKCASE in SE Planning, Assessment and Control, Decision Management, Risk Management, Configuration Management, Information Management, and Measurement.

Author	Organization
Barry Boehm	University of Southern California
Ed Conrow	Management and Technology Associates
Ray Madachy	Naval Postgraduate School
Ken Nidiffer	Software Engineering Institute
Garry Roedler	Lockheed Martin

Challenges

- Complex systems bring many disciplines together and their boundaries are not always the same in different project environments. There is no one-size-fits-all way to define the details of where various SE management functions are performed.
- The advent of net-centric systems has made Software Engineering more critical to SE. Strong synergy exists between them, but there are key distinctions and management challenges between SE and Software Engineering.
- Covering multiple domains and industries for SE management.
- Individual management processes (e.g. Project Planning, Measurement, Risk Management) may require different approaches when distinguishing SE, Project Management and Software Engineering.



www.BKCASE.org

bkcase@stevens.edu

ISRAEL AEROSPACE INDUSTRIES

SYSTEMS MISSILES & SPACE GROUP

System Engineering Process Improvement using the CMMI in Large Space Programs

Revital Goldberg, Sarit Assaraf

Israel Aerospace Industries

13th Annual System Engineering Conference *25-28 Oct. 2010 San Diego CA.*

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Israel Aerospace Industries (IAI)

- Largest aerospace & defense company and the largest industrial exporter in Israel (> 15,000)
- Missiles, Satellites, UAVs, Avionics, Upgrades, RADARS, etc.
- Activities encompassing: Development, Production, Maintenance and Service of Aerospace Systems
- IAI divisions are certified for *ISO9000* and *AS9100*

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI Organizational Chart

Military A/C Group (3 Div.)	Commercial A/C Group (4 Div.)	BEDEK Aviation Group (3 Div.)	Headquarters Organizations	Engineering Group (2 Div.)	Systems Missiles Space Group (5 Div.)	ELTA Systems Group Ltd. (4 Div.)

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Process Improvement – WHY?

Watts Humphrey

"Software Process Program" founder at the

Carnegie Mellon's Software Engineering Institute:

"The *Quality of a System*

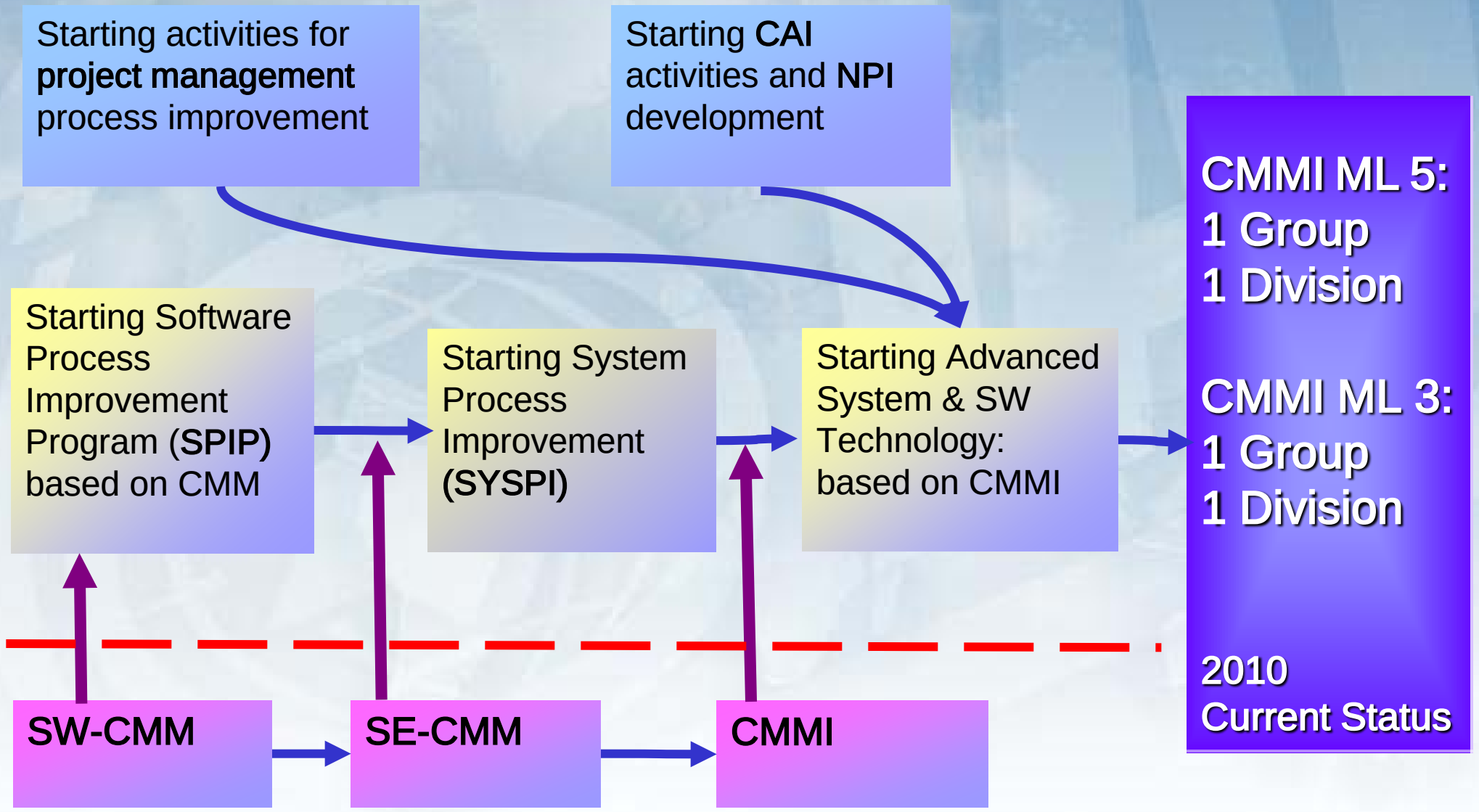
is Governed by

the *Quality of the Process*

Used to Develop it"

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI Process Improvement Path



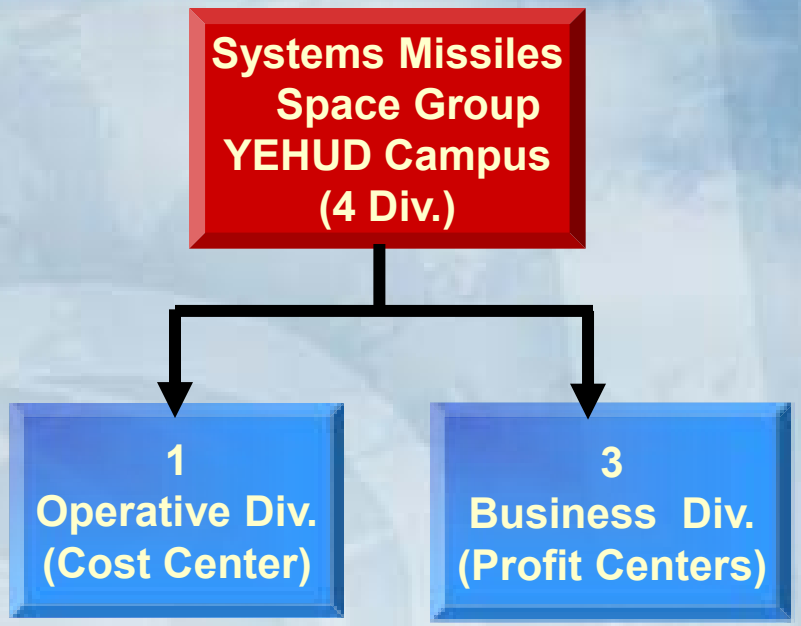
The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI Organizational Chart

Military A/C Group (3 Div.)	Commercial A/C Group (4 Div.)	BEDEK Aviation Group (3 Div.)	Headquarters Organizations	Engineering Group (2 Div.)	Systems Missiles Space Group (5 Div.)	ELTA Systems Group Ltd. (4 Div.)

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

CMMI & SEPG Program - Group Level (1)



- The CMMI implementation is ***managed as a program*** for process improvement at the group level

SAPIR – **S**tandard **A**nnual **P**rocess **I**mprovement **R**oadmap

- The ***management*** *concept* is based on the CMMI ORG and Support PAs

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

CMMI & SEPG Program - Group Level (2)

- Discipline based PITs - **P**rocess **I**mprovement **T**eams (Process Leader + Project Representatives)

  PM, SE, VVT, SW, HW, QA, CM, SAM, ORG ★

- Each PIT conducts meetings and activities, managed by PIT Leader ★
- **ORG PIT** comprises of all PITs Leaders ★
- **CMMI *Integrated plan*** consisting of all PITs' plans

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI Process Improvement Strategy

IAI Corporate Level

IAI VP Operations
Engineering & Development
CMMI Program Office

- Sponsorship
- Coordination
- Budget Allocation
- Process Assets Development
- Support and Implementation

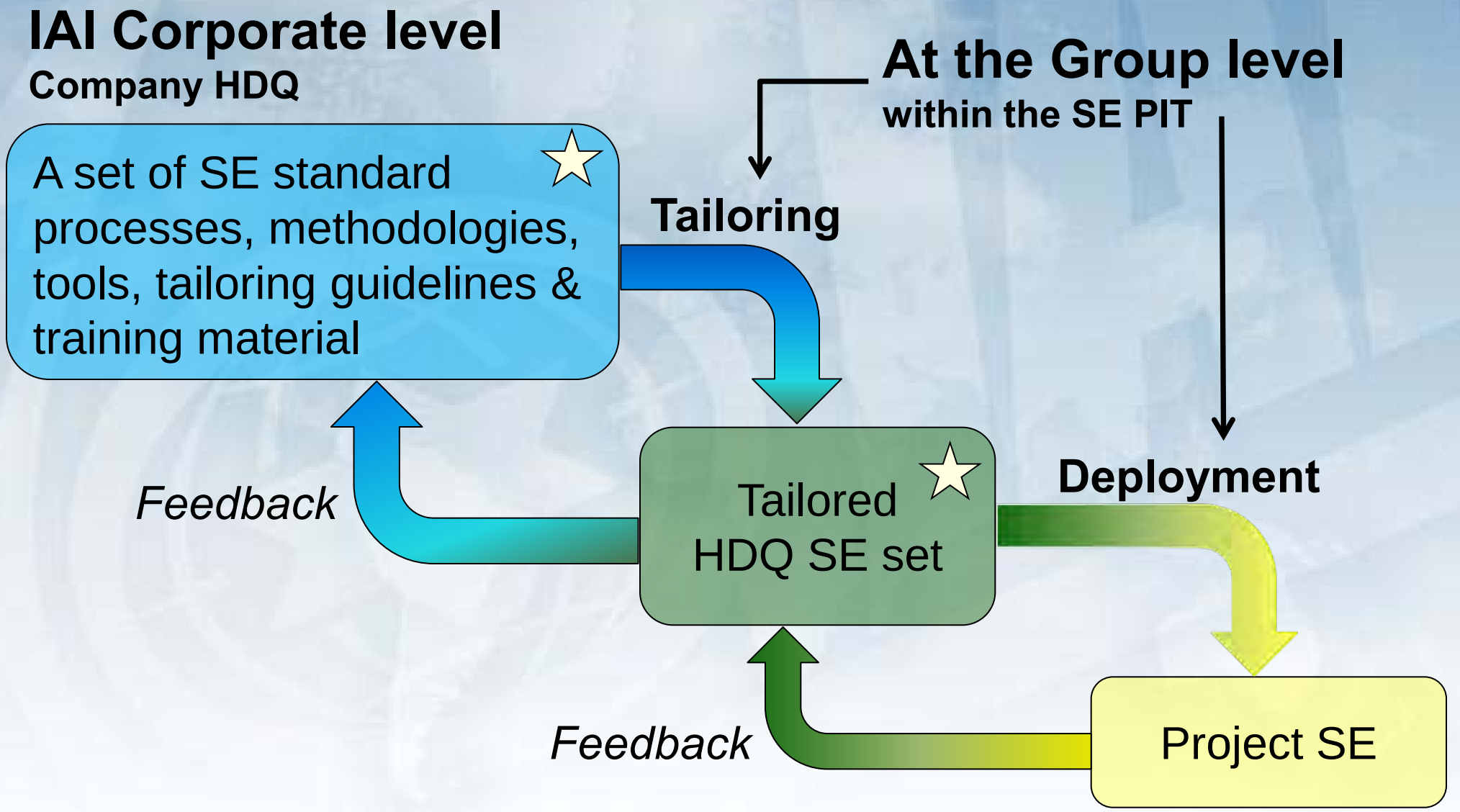
IAI Groups and Divisions

Process Improvement Activities

- Local Sponsorship
- Local Budget & Resources
- Process Assets Adaptation and Development
- Process Implementation
- Process Feedback

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Process Definition and Tailoring Method



The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Space systems

The Satellite Program = A System of Systems Program

Venus

Observation satellites

TECSAR
Synthetic Aperture Radar

EROS C

OPTSAT 3000

OFEQ

Shavit launch vehicles

Ground control stations

Communication satellites

AMOS 3

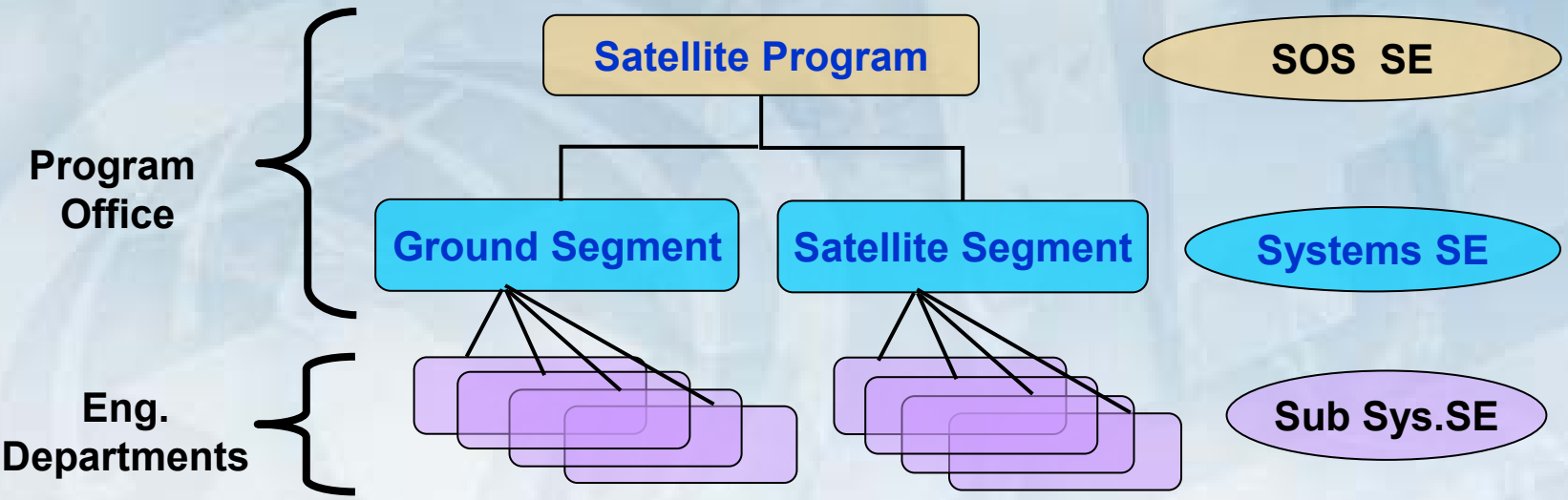
AMOS 1,2

AMOS 4
Advanced comm. Sat.

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI SPACE Programs Main Characteristics
Program Internal Structure (1)

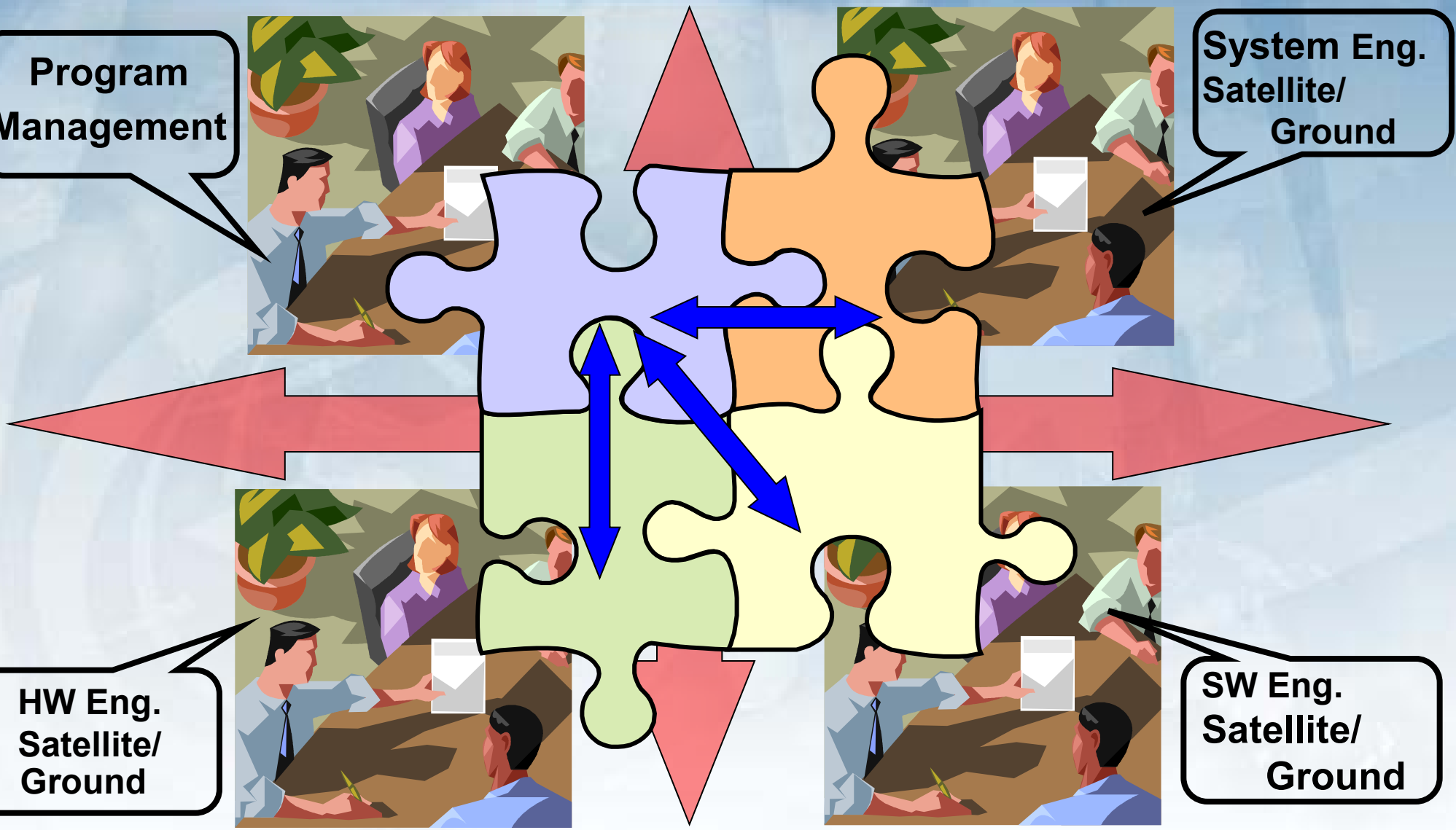
- **Decentralized SE at the group level –**
  The **SOS and the Systems SE** **are part of the program office**, also managing the Sub-Contractors.
  The **Sub Systems SE** **are part of the Engineering Departments**



- **Different views and meanings** of SE activities adequate to each level of the system: SOS, System, Subsystem.
- **Large project teams** (often, geographically dispersed)

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI SPACE Programs Main Characteristics
Program Internal Structure (2)



The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI SPACE Programs Main Characteristics
Program Internal Structure (3)

- **FORMAL *mutual commitment*** between the Program office and the Engineering Groups *supports implementation of*

  ***PP* SP3.3, *PMC* SP1.2, *REQM* SP1.2 & *IPM* SP2.2:**

  - The Program Office issues Internal Customer–Supplier Agreements
  - The Program Office allocates budget for the engineering groups against their commitment to supply adequate products on time

- The program establishes Integrated teams consisting of different disciplines (IPT = Integrated Product Teams)

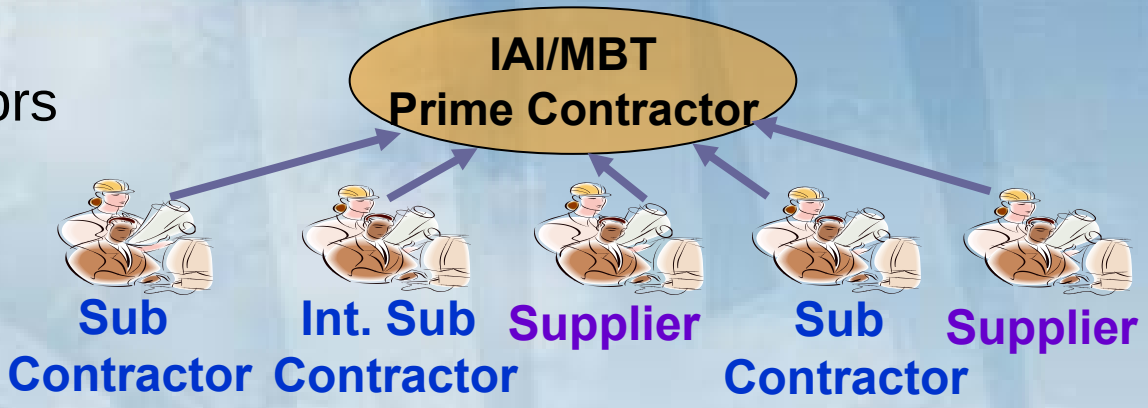
  CMMI V1.3 - New Version IPM & OPD

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI SPACE Programs Main Characteristics
Many Sub Contractors & Suppliers

- **Complex coordination**
  - Internal (IAI) sub contractors
  - External sub contractors
  - Suppliers

  Supports implementation of



IPM* SP2.1, SP1.5; *SAM* SPs; *TS* SP2.4; *DAR

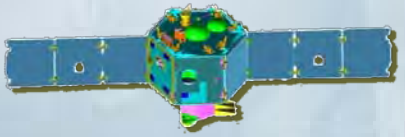
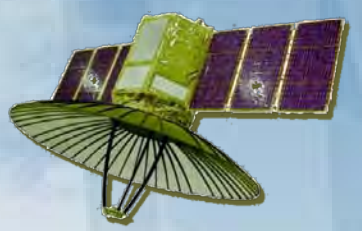
- **Complex System Integration aspects** – Integration Strategy planning requires special attention (***PI* SP1.1**):
  - Scheduling
  - Sub Contractors Monitoring
  - Interfaces definition correctness and completeness ***(TS* SP2.3, *PI* SP2.1)**
  - Integration Readiness Review ***(PI* SP3.1)**

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

IAI SPACE Programs Main Characteristics
The Satellite "Nature"

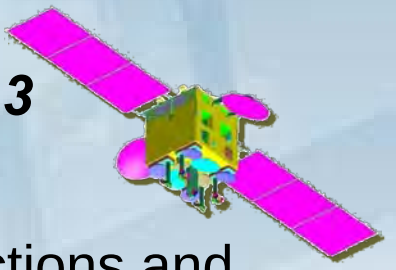
- **Each Satellite is "One of a Kind"**

  however …

  Verification & Validation are limited, especially by the ability to simulate the environmental conditions.

  *Support implementation of **VER** & **VAL** **SP1.1, SP1.2, SP1.3***



- **Once Launched –** Repair activities are limited to SW corrections and updates. Requires special attention to:
  - **Requirements validation** at early development stages ***(RD SP3.5)***
  - **Analysis of Failures** found on PI, VER & VAL stages ***(PI, VER SP3.2, VAL SP2.2)***
  - Special efforts in Engineering and Management activities to **minimize typical Space Programs risks** ***(RSKM)***

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Conclusions & Lessons Learned

- The IAI process deployment method relies on a Corporate Level processes definition, followed by Group/Division Level tailoring and implementation.

- The products and projects characteristics require special attention to the *RD*, *TS*, *PI*, *VER* & *VAL* process areas

- Using the internal Customer–Supplier Agreements and IPT's ensure
  - Better definition and management of the commitment
  - Integrated team work along the projects' life cycle

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

CMMI V1.2 Process Area Abbreviations

- **CAR** Causal Analysis and Resolution
- **CM** Configuration Management
- **DAR** Decision Analysis and Resolution
- **IPM** Integrated Project Management
- **IPPD** integrated product and process development
- **MA** Measurement and Analysis
- **OID** Organizational Innovation and Deployment
- **OPD** Organizational Process Definition
- **OPF** Organizational Process Focus
- **OPP** Organizational Process Performance
- **OT** Organizational Training
- **PI** Product Integration

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

CMMI V1.2 Process Area Abbreviations

- **PMC** Project Monitoring and Control
- **PP** Project Planning
- **PPQA** Process and Product Quality Assurance
- **QPM** Quantitative Project Management
- **RD** Requirements Development
- **REQM** Requirements Management
- **RSKM** Risk Management
- **SAM** Supplier Agreement Management
- **TS** Technical Solution
- **VAL** Validation
- **VER** Verification

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

Thank you

Revital Goldberg - rgoldberg@iai.co.il
Sarit Assaraf - sassaraf@iai.co.il

The information contained in this presentation is proprietary to MBT/IAI and may not be reproduced by any means or transmitted to any other party without the express written permission of MBT/IAI.

PUBLIC RELEASE

Understanding the Limits of SoS

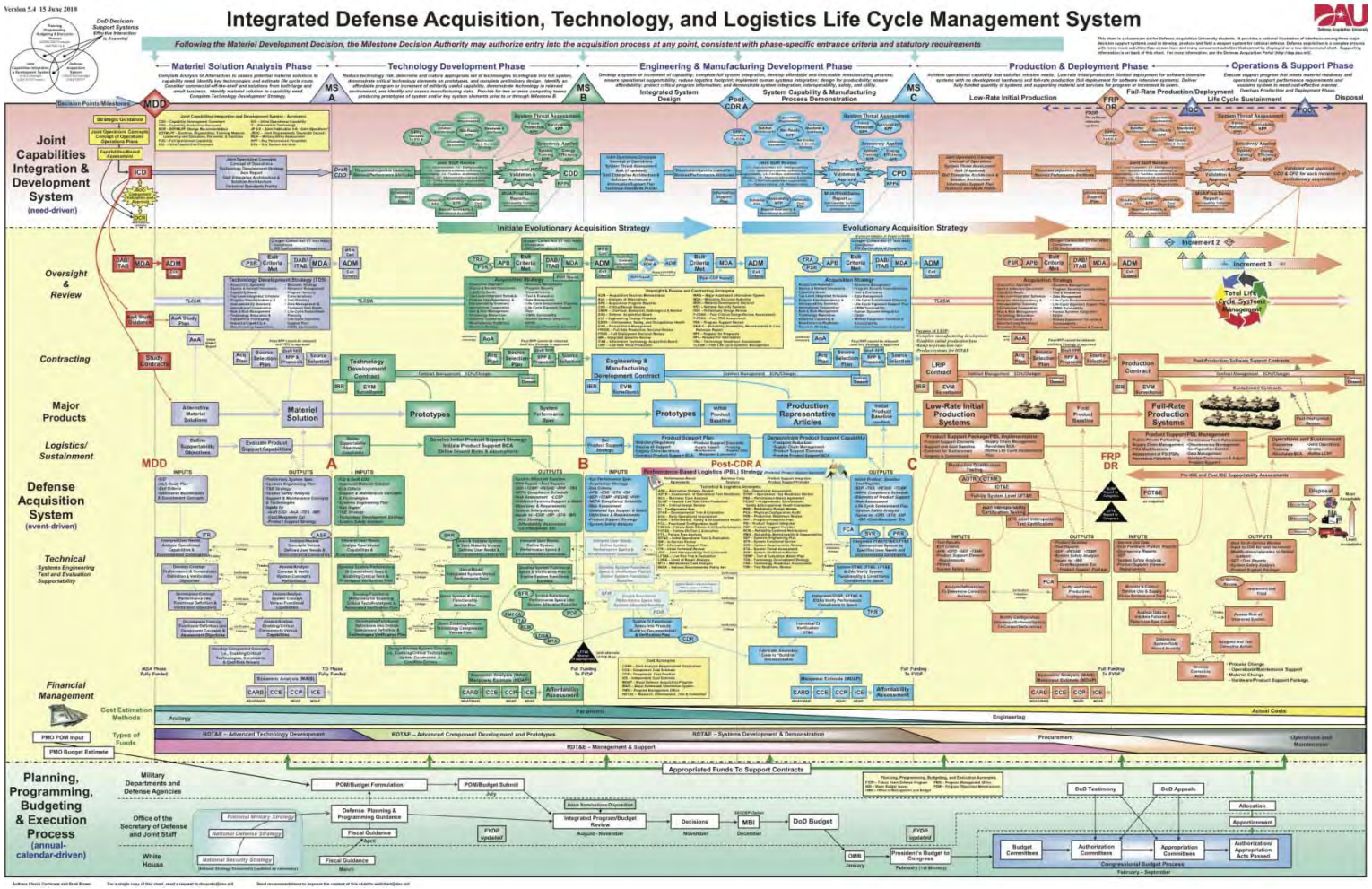
NDIA Systems Engineering Conference 2010

San Diego, CA
October 27, 2010

Table Of Contents

- Motivations
- Framework
- Examples

Motivations

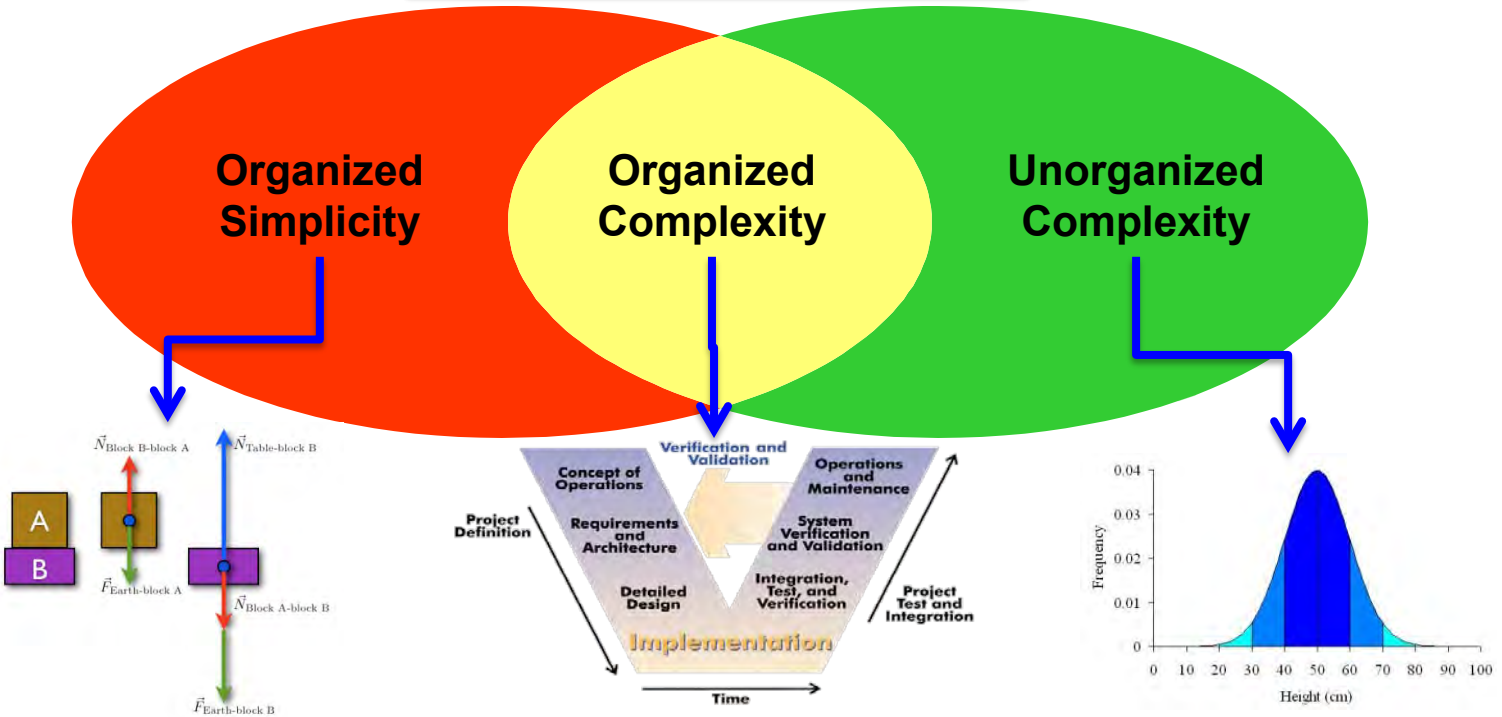


Source: Defense Acquisition University

Our technologies today are complex and highly coupled

- Tight coupling results when components are interdependent
- Complexity results when our tools fail to accurately predict system response

Types of Complexity



Controlled vs. Emergent Systems

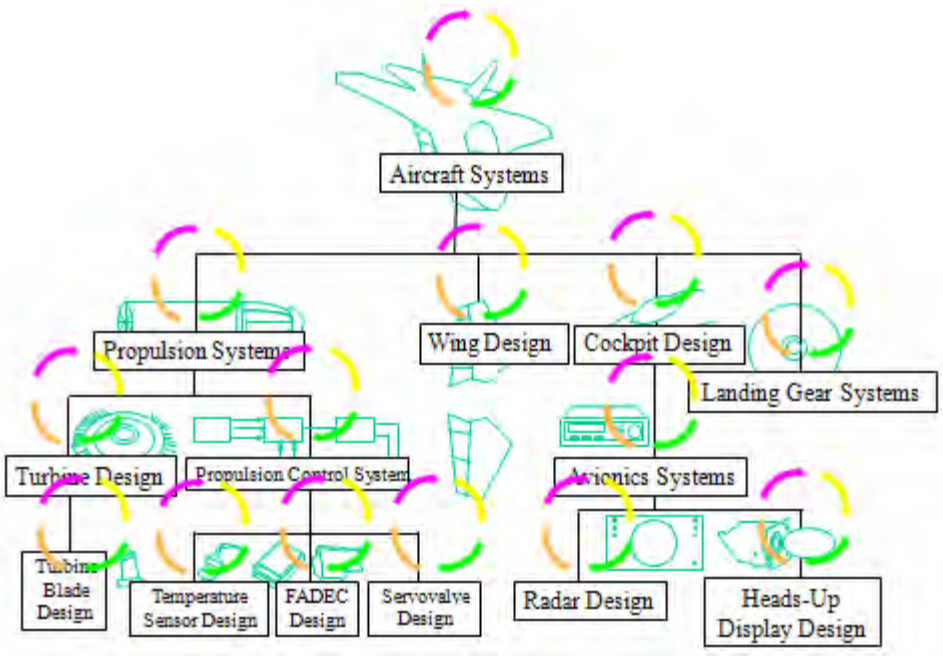
- Controlled systems
  - Militaries
  - Air traffic control
  - Multi-national corporations
  - Software, Hardware
- Emergent systems
  - Intelligence bureaucracy
  - Internet
  - Social networking
  - Biological swarming: Bees, ants, etc.

Background and Previous Research

- George Miller's "Magic Number 7" paper in 1956
  - Ability to differentiate one-dimensional stimuli accurate up to 6 items
  - Short-term memory can keep track of ~ 7 items
- McCabe's Cyclomatic complexity metric
  - Measures number of linearly independent paths through a program (loops)
  - General rule of thumb that software modules should be limited to metric of 10
- DARPA META Complexity Measure

$$C(n, A) = \sum_{i=1}^{n} \alpha_i + \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{4} \beta_k \alpha_{ijk} + \gamma \left[\frac{\log n}{\log 7} \right] E(A)$$

Previous Research



NSF Workshop: Design of Large-Scale Systems, Sept 2010

Item	~ # Parts	# Levels
Screwdriver (B&D)	3	1
Roller Blades (Bauer)	30	2
Inkjet Printer (HP)	300	3
Copier (Xerox)	2000	4
Automobile (GM)	10,000	5
Aircraft (Boeing)	100,000	6+

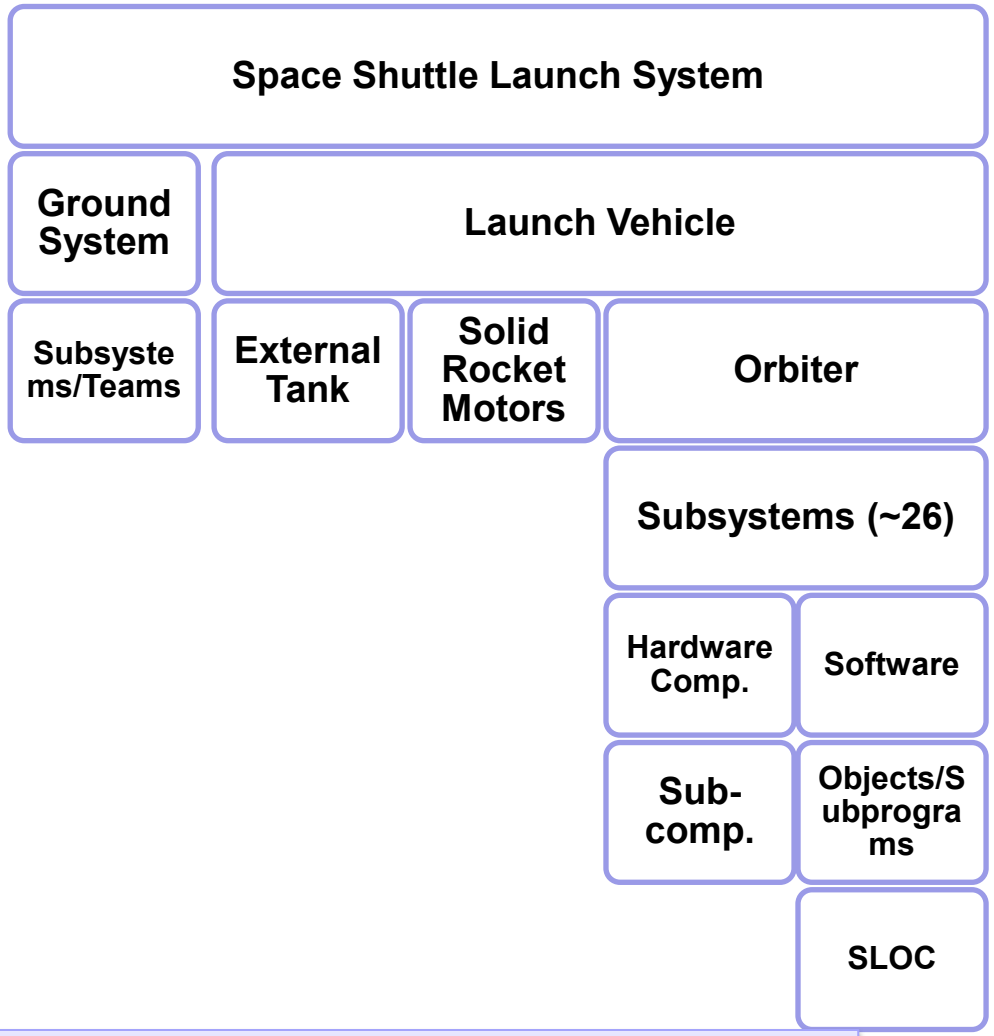
Source: Ulrich, K.T., Eppinger S.D. , Product Design and Development Second Edition, McGraw Hill, 2nd edition, 2000, Exhibit 1-3

Framework

- Survey systems of systems from a broad array of domains
  - Technical
  - Social
  - Biological
  - Political
- Count abstraction levels
- Count heterogeneous elements at each abstraction level
  - Functional
  - Attributes

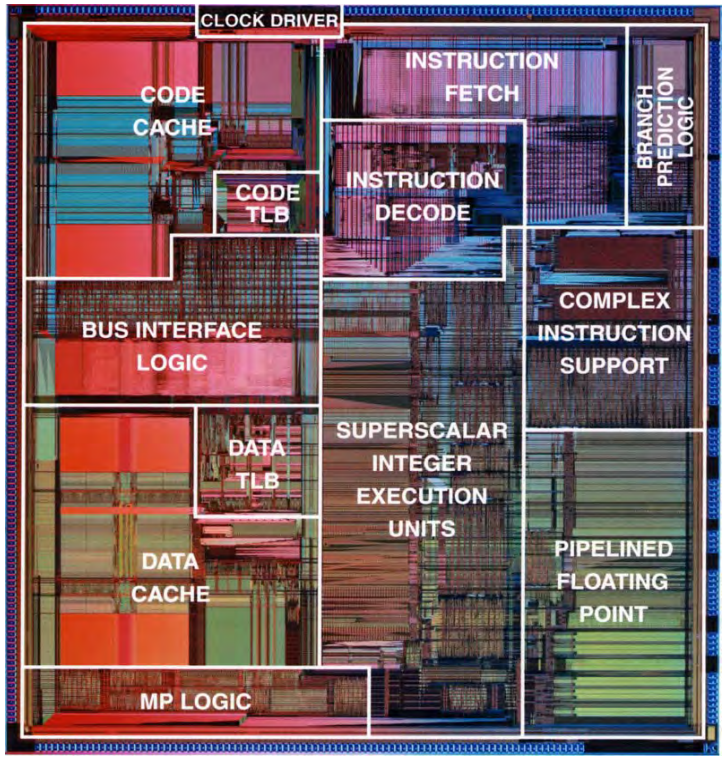
Launch System

Source: NASA



7 Levels – 2.5M parts, 2M SLOC

Microprocessor



Source: Intel Pentium Processor

Microprocessor

Components (ALU, FPU, Registers, etc.) (15 – 20)

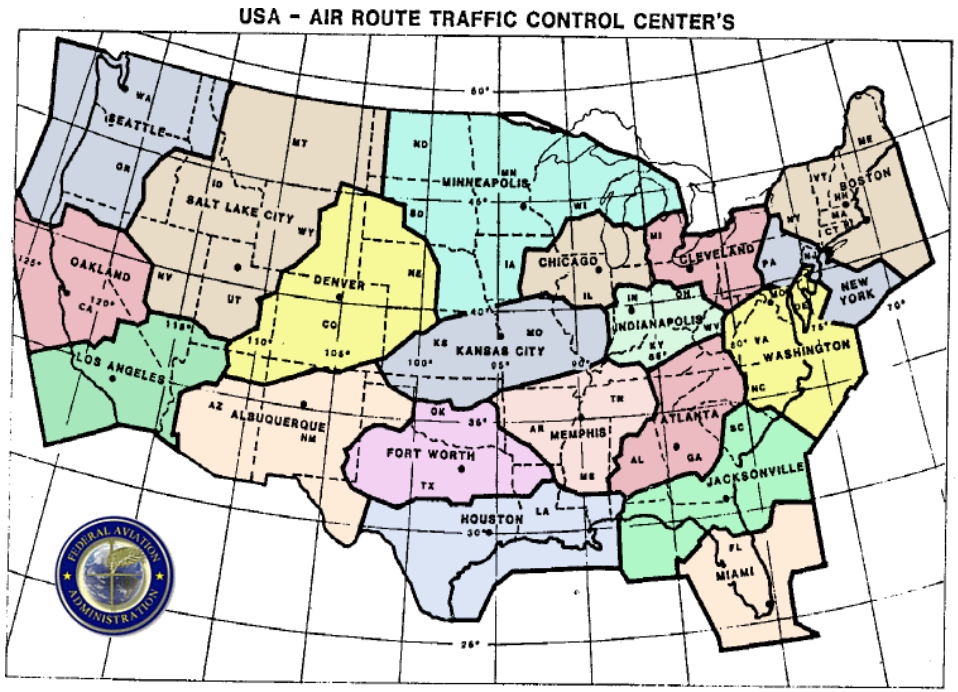
Logic Functions (NOR, AND, MUX, etc) (~20 types)

Transistors (2-30 per Logic Function, 2.3 Billion in 8-core Xeon Processor)

Substrates

5 Levels – 2.3B transistors

Air Traffic Control



Source: FAA

National Air-Traffic Control

Area Control Center (20 Centers)

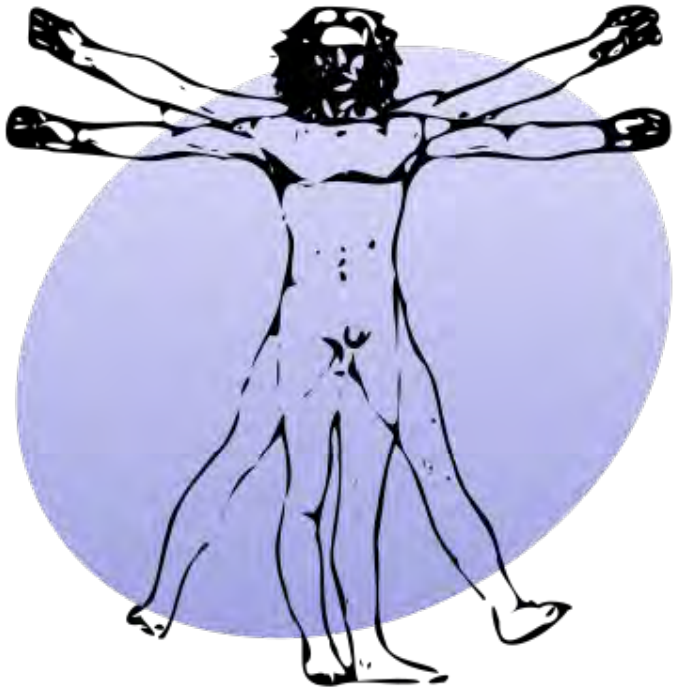
TRACON (Terminal Radar Approach Control Center) (830)

Airport Traffic Control (5200 Airports)

Air Control	Ground Control	Flight Data/Clearance Delivery	Apron Control	Ground Movement Control

5 Levels – 55,000 flights per day

Biological Systems



Source: Wikipedia

Human Body

Systems (11)

Organs (78)

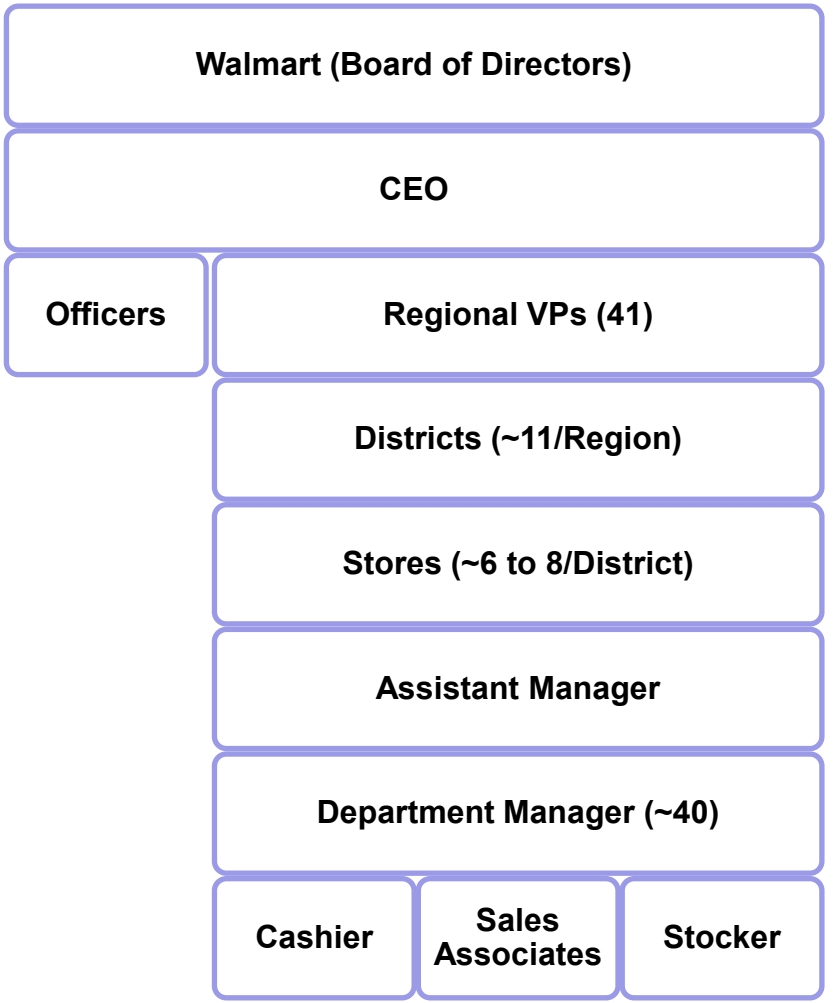
Tissue (4)

Cells (10 trillion)

5 Levels – 10T cells

WAL★MART

Source: Wikipedia



8 Levels – ~2M employees, 8500 Stores

Department of Defense

Secretary of Defense

Deputy Secretary of Defense

Office of the Inspector General of the Department of Defense

Office of the Secretary of Defense

Under Secretaries of Defense, Assistant Secretaries of Defense, and other specified officials

Department of the Army

Secretary of the Army

- Office of the Secretary of the Army
- The Army Staff
  - The Army

Department of the Navy

Secretary of the Navy

- Office of the Chief of Naval Operations
  - The Navy
- Office of the Secretary of the Navy
- Headquarters Marine Corps
  - The Marine Corps

Department of the Air Force

Secretary of the Air Force

- Office of the Secretary of the Air Force
- The Air Staff
  - The Air Force

The Organization of the Joint Chiefs of Staff

Chairman of the Joint Chiefs of Staff

- The Joint Staff

The Defense Agencies

- Defense Advanced Research Projects Agency
- Defense Business Transformation Agency
- Defense Commissary Agency
- Defense Contract Audit Agency
- Defense Contract Management Agency
- Defense Finance and Accounting Service
- Defense Information Systems Agency
- Defense Intelligence Agency
- Defense Legal Services Agency
- Defense Logistics Agency
- Defense Security Cooperation Agency
- Defense Security Service
- Defense Threat Reduction Agency
- Missile Defense Agency
- National Geospatial-Intelligence Agency
- National Reconnaissance Office
- National Security Agency/Central Security Service
- Pentagon Force Protection Agency

DoD Field Activities

- Defense Media Activity
- Defense Prisoner of War/Missing Personnel Office
- Defense Technical Information Center
- Defense Technology Security Administration
- DoD Education Activity
- DoD Human Resources Activity
- DoD Test Resource Management Center
- Office of Economic Adjustment
- TRICARE Management Activity
- Washington Headquarters Services

Combatant Commands

- US Africa Command
- US Central Command
- US European Command
- US Joint Forces Command
- US Northern Command
- US Pacific Command
- US Southern Command
- US Special Operations Command
- US Strategic Command
- US Transportation Command

Prepared by: Directorate for Organizational and Management Planning/Office of the Director, Administration and Management/Office of the Secretary of Defense May 2010

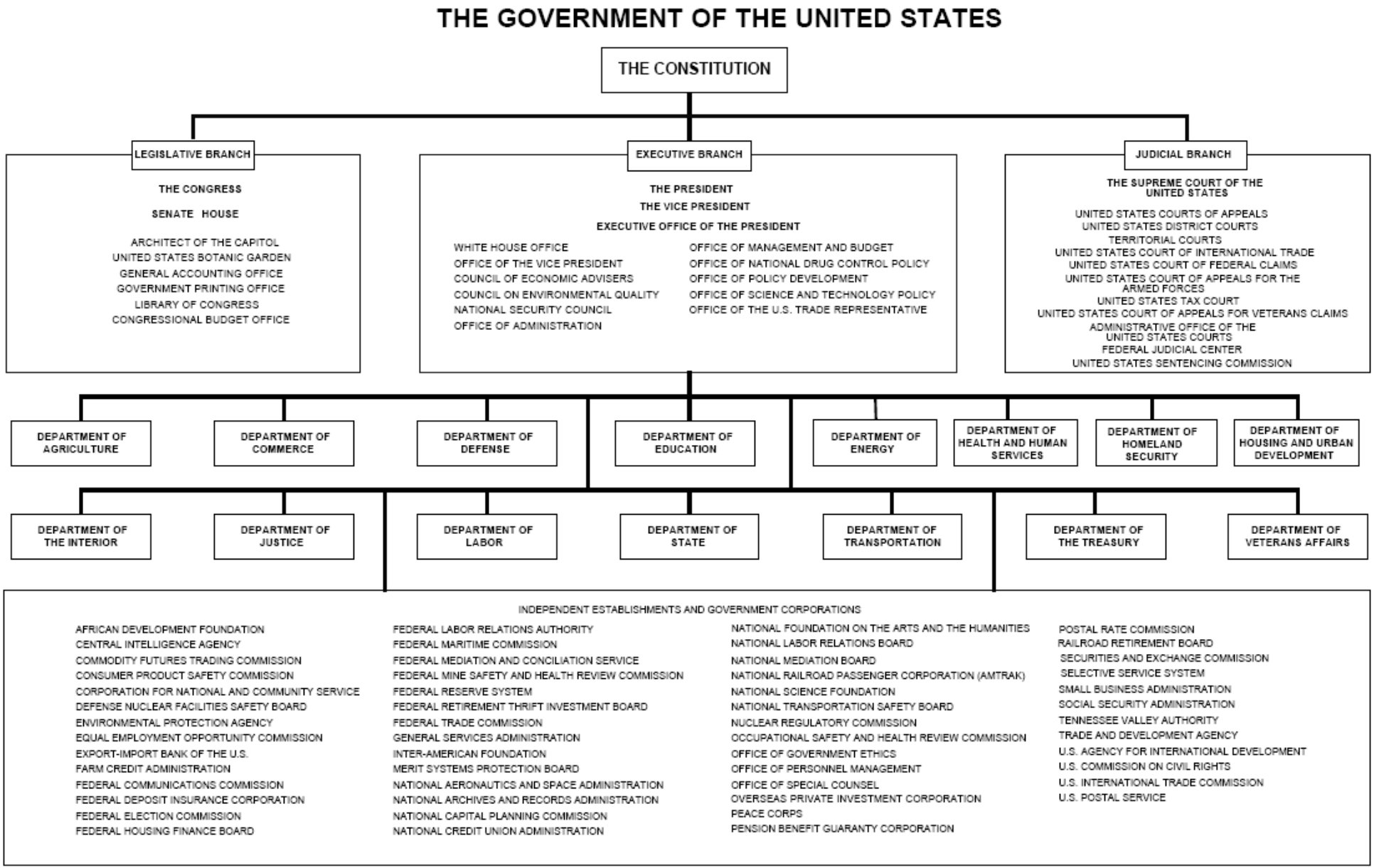
3+ Levels, 2.1M Personnel

US Air Force

Source: Wikipedia

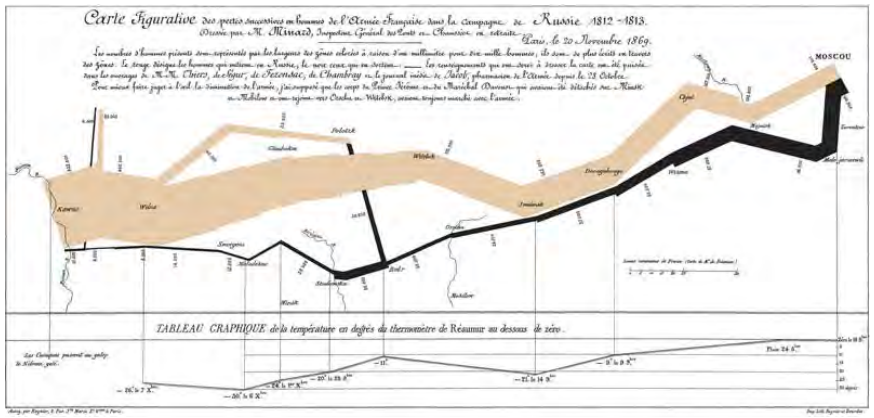
- **Air Force Headquarters**
- **Major Command (10)**
- **Numbered Air Force (24)**
- **Wing (243)**
- **Group**
- **Squadron (300)**
- **Flight**
- **Airman**

7 - 8 Levels – 330,000 personnel



3 Levels (+ x Levels) – 21M personnel

The Grande Armée



Napoleon			
Imperial Guard	Corps (5-7)		
	Artillery Brigade	Infantry Division (4k – 10k per Corp)	Calvary Division (2k to 4k per Corp)
		Brigade (2-3 per Corp)	Brigade (2-3 per Corp)
		Regiment (2 per Brigade)	Regiment (2 per Brigade)
		Infantryman (~10 per Regiment)	Cavalryman

6 Levels – 600,000 soldiers

Summary

- Miller's Magic Number 7 leads to maximum of ~960,000 parts
  - No clear limits
- Further research needed:
  - More surveys in a variety of systems
  - Interactions between Systems of Systems (i.e. Technical vs. Social)
- Emergent systems as opposed to controlled systems?

Key System of Systems Engineering Artifacts to Guide Engineering Activities

2010 NDIA SE Conference
San Diego, CA
October 2010

Dr. Jo Ann Lane, USC
Dr. Judith Dahmann, MITRE
George Rebovich, MITRE
Ralph Lowry, MTSI

Abstract

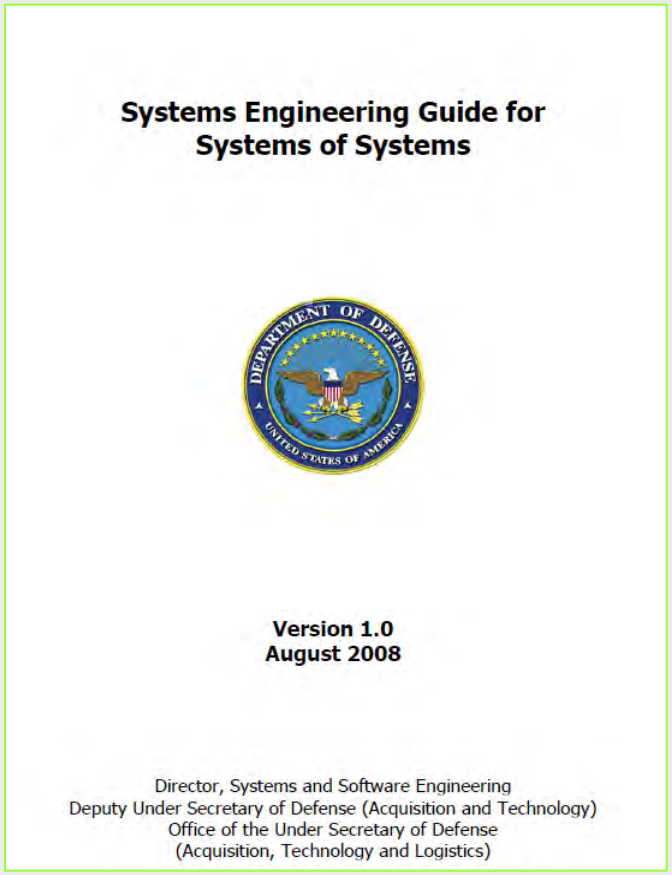
The recent Department of Defense (DoD) guidebook, *Systems Engineering for Systems of Systems,* analyzed 18 systems of systems (SoSs) and characterized SoS systems engineering (SE) using seven core elements, then expanded this research effort by identifying key engineering artifacts that are used to guide the SoS engineering activities. These key artifacts are used to capture and convey information to the various engineering teams both at the SoS and constituent system level as well as to guide cross-cutting engineering activities such as overall SoS performance, security, and flexibility to evolve quickly to meet new challenges.

This presentation reviews core SoS SE artifacts and how they are employed in the implementation of SoS SE. An 'implementers view' of SoS SE is presented showing how SoS SE artifacts support each step in SoS SE implementation.

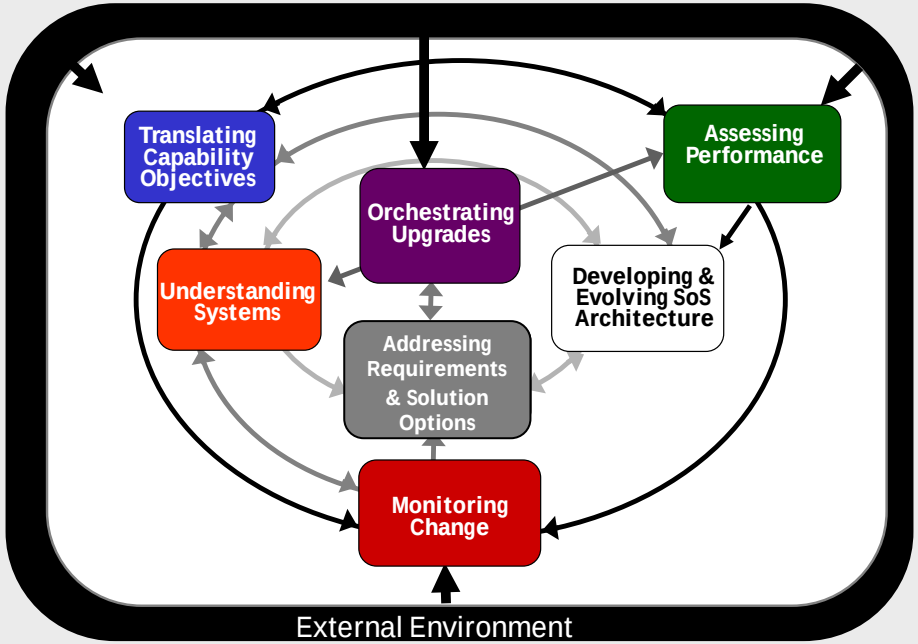
Background and Purpose

- Background
  - DoD SoS SE Guide provides a foundation for SoS SE
  - Current efforts have focused on translating guidance into 'implementers' view
  - Next step is to understand information needs critical to successful SoS SE decision making
- Purpose
  - Present an 'implementers view' of SoS SE ['the wave model']
  - Show how artifacts support engineering activities across the SoS SE implementation
- Key concepts
  - ***SoS Artifact:*** work products developed/composed from various sources by the SoS SE team, configuration managed at the SoS level, and used/ consumed by SEs at both the SoS and single system level in the process of developing, maintaining, enhancing, deploying, and assessing SoS capabilities
  - ***Relationship between SoS and single system artifacts:*** SoS SE engineers tend to use familiar SE artifacts, but have evolved them to support SoS needs

Foundations



Trapeze Model*

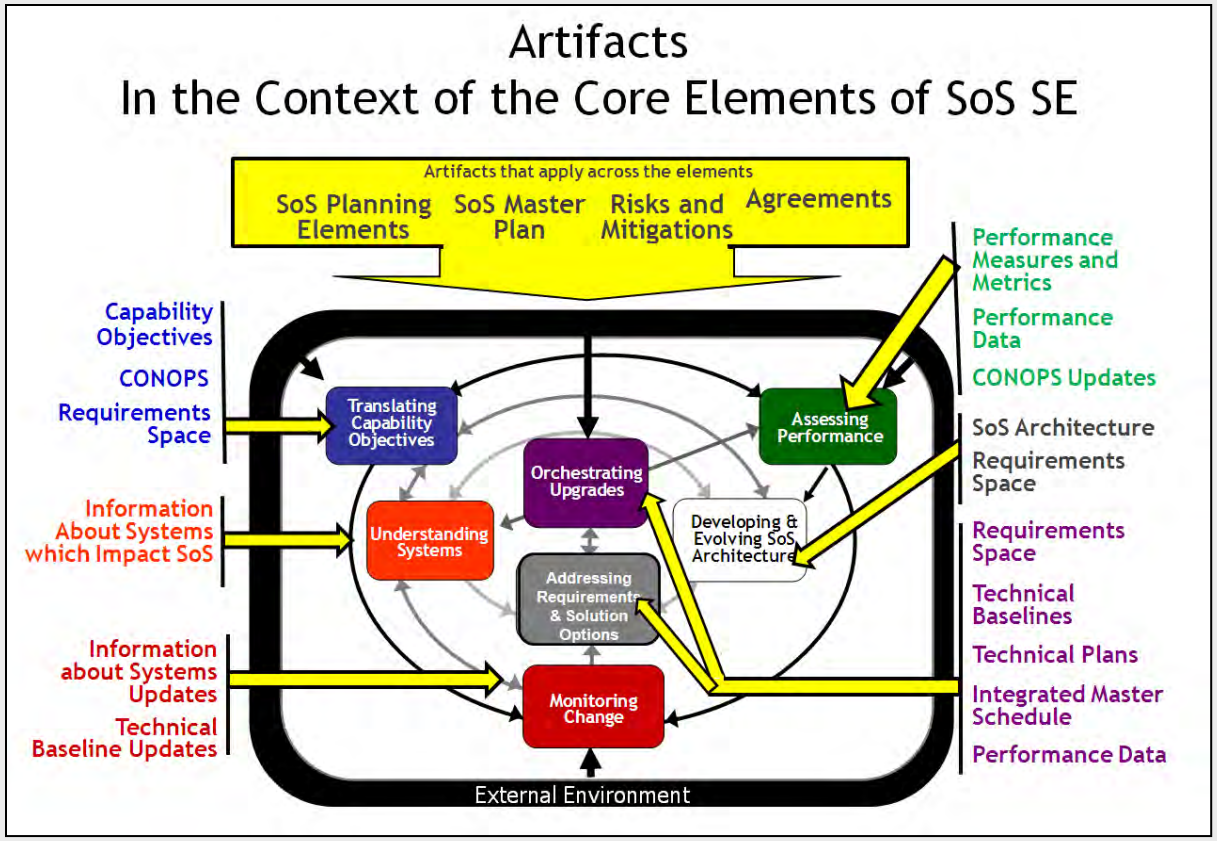


SE Model for SoS Based on 7 Core Elements of SoS SE

* Department of Defense, Systems Engineering Guide for System of Systems, Version 1.0, 2008.

Next Step: Provide guidance for implementation

SoS SE Artifacts



System Engineering Artifacts for SoS

Dr. Judith Dahmann and George Rebovich
MITRE
McLean, VA USA
{jdahmann, grebovich} at mitre.org

Dr. Jo Ann Lane
Department of Industrial and Systems Engineering
University of Southern California
Los Angeles, CA USA
joanne at usc.edu

Ralph Lowry
Modern Technology Solutions, Inc.
Alexandria, VA USA
ralph.lowry at mtsi-va.com

Abstract— This paper describes system of systems (SoS) systems engineering (SE) artifacts, compares and contrasts them with similar ones developed and used for individual systems, and explains how they are used to guide SoS engineering processes. The paper concludes with next steps for using SoS artifacts to continue maturing the understanding of SoS SE in an international cooperative effort with the United Kingdom, Australia, and Canada.

Keywords-component; system of systems, system of systems engineering, engineering artifacts

I. BACKGROUND AND MOTIVATION

The system of systems (SoS) systems engineering (SE) community is evolving SE processes to better apply SE to broadly defined SoS capabilities which span multiple systems. The knowledge from these efforts includes a greater awareness of SoS characteristics which create SE challenges, a recognition that some activities are unique to SoS SE, and ways to better employ fundamental SE processes in an SoS environment. Building on this knowledge, a United States (US) team is identifying key SoS SE artifacts (work products) and applying them to SE of SoS. The focus is on the critical information included in the artifacts rather than the documents. The objective is to develop a common set of concrete approaches to applying SE to SoS by understanding SE artifacts developed and used in SoS SE today.

II. SYSTEMS ENGINEERING FOR SYSTEMS OF SYSTEMS

With the increased emphasis on capabilities and networking, the US Department of Defense (DoD) is recognizing the criticality of effective and to and performance of SoSs to meet user needs. While acquisition processes continue to focus on systems, system requirements are increasingly based on assessment of gaps in user capabilities that require integration across systems. Thus, the role of systems engineering is expanding to the engineering of SoS that provide user capabilities. This dynamic is occurring in other arenas as well and in many beyond defense to include civilian and commercial enterprises.

Applying SE to SoS requires an understanding of the characteristics of SoS and their impact on basic SE processes which have traditionally been applied to the development of new, individual systems. An SoS is defined as a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities [1]. A primary interest in SoS SE concerns "acknowledged" SoS [2]. This type of SoS leverages existing system capabilities to address new needs while recognizing the programmatic and operational autonomy of the systems. Acknowledged SoS have top level objectives and governance and have SE teams working at the SoS level. These operate in concert with SE teams for the constituent systems. Acknowledged SoS are common in the DoD. Examples include the Single Integrated Air Picture, Ballistic Missile Defense System and Naval Integrated Fire Control Counter Air [3]. This paper is based on interviews with practitioners working in this environment conducted as part of the development of the DoD guide for SE of SoS [3] and the artifacts described here apply to acknowledged SoS. Future work will investigate their applicability other types of SoS.

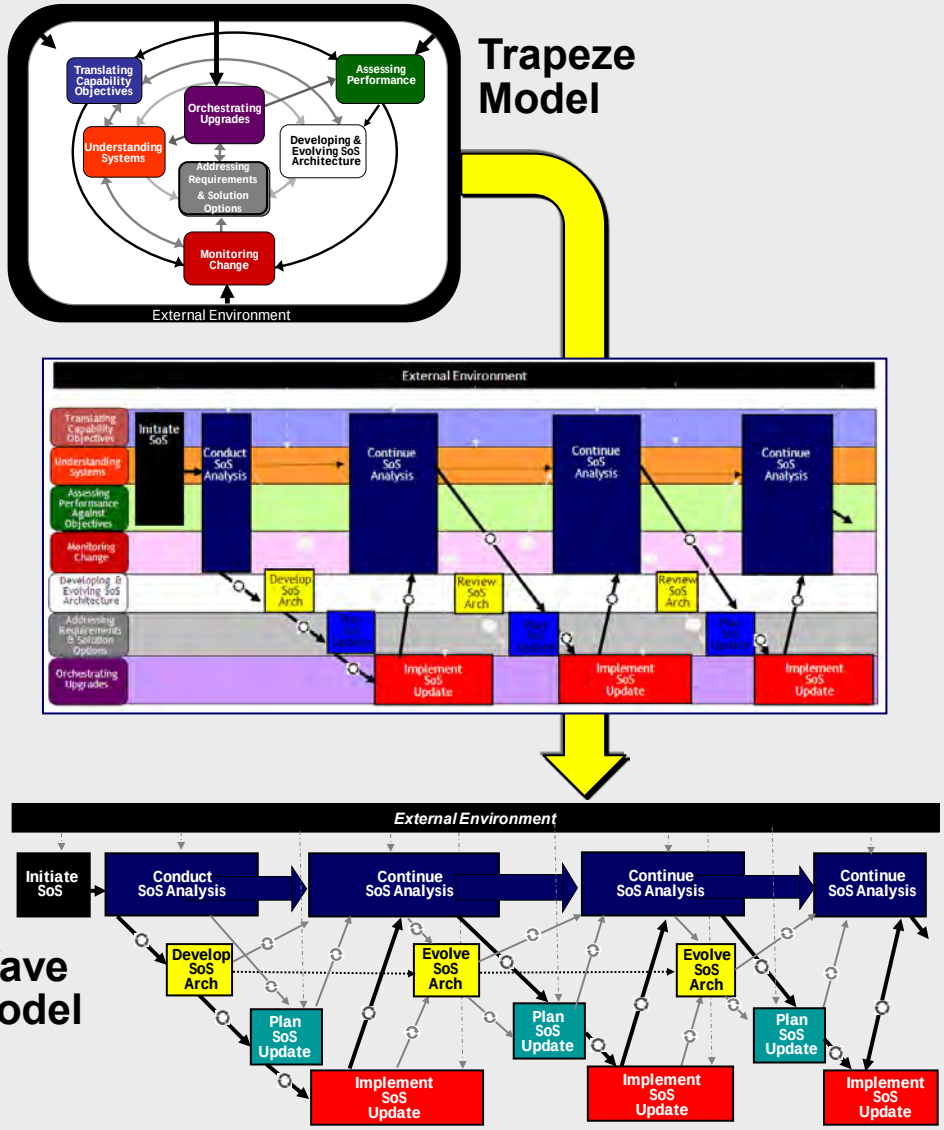
The analysis of SoS SE efforts in DoD today has identified a set of core elements of SE in an SoS environment. SoS systems engineers focus attention on the core elements as they evolve an ensemble of multiple existing and new systems to meet user capability objectives:

"In SoS SE, systems engineers are key players in the core elements of: (1) translating SoS capability objectives into SoS requirements, (2) assessing the extent to which these capability objectives are being addressed, and (3) monitoring and assessing the impact of external changes on the SoS. Central to SoS SE is: (4) understanding the systems that contribute to the SoS and their relationships, (5) developing an architecture for the SoS that acts as a persistent framework for (6) addressing SoS requirements and solution options. Finally, the SoS systems engineer (7) orchestrates enhancements to the SoS, while monitoring and integrating changes made in the systems to improve the performance of the SoS." [3]

Described in 2010 IEEE Systems Conference Paper

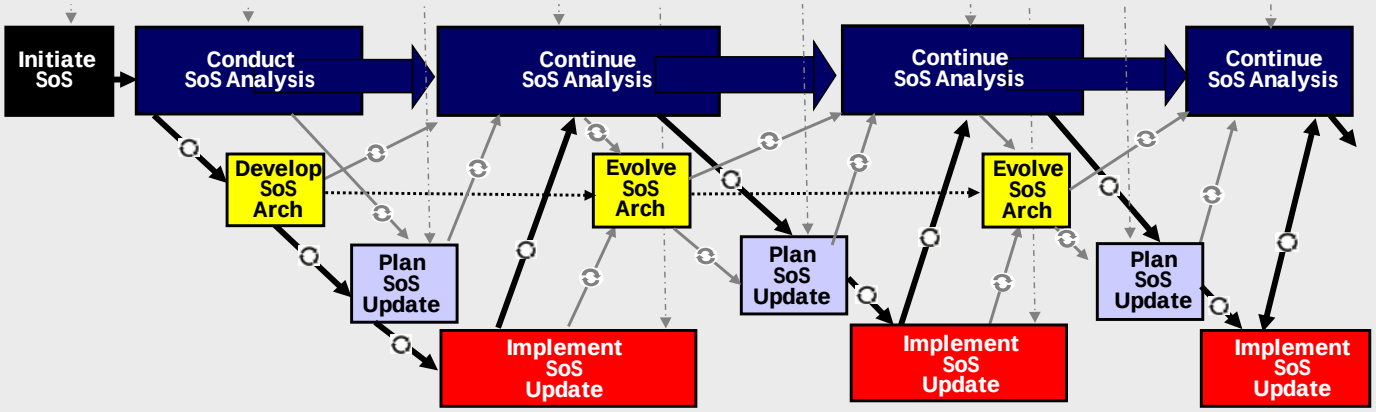
SoS SE Artifacts Developed as Part of an International SoS SE project under The Technical Cooperation Program (TTCP)

Practitioners View of SoS SE: Wave Model



- Trapeze Model
  - Presents the core elements of SoS SE and relationships
  - Provides a good 'conceptual' view of SoS SE
  - Not very useful to practitioner to help chart an implementation approach
- Wave Model
  - 'Unwinds' the trapeze model
  - Provide a view of SoS SE in terms of series of major steps in implementing an SoS SE process

Wave Model Elements



- Initiate SoS:

  Provides foundational information to initiate the SoS

- Conduct SoS Analysis:

  Provides analysis of the ‘as is’ and basis for SoS evolution

- Develop SoS Architecture:

  Develops/evolves the persistent technical framework for addressing SoS evolution and a migration plan identifying risks and mitigations

- Plan SoS Update:

  Evaluates SoS backlog , priorities, and options to define plans for the next SoS upgrade cycle

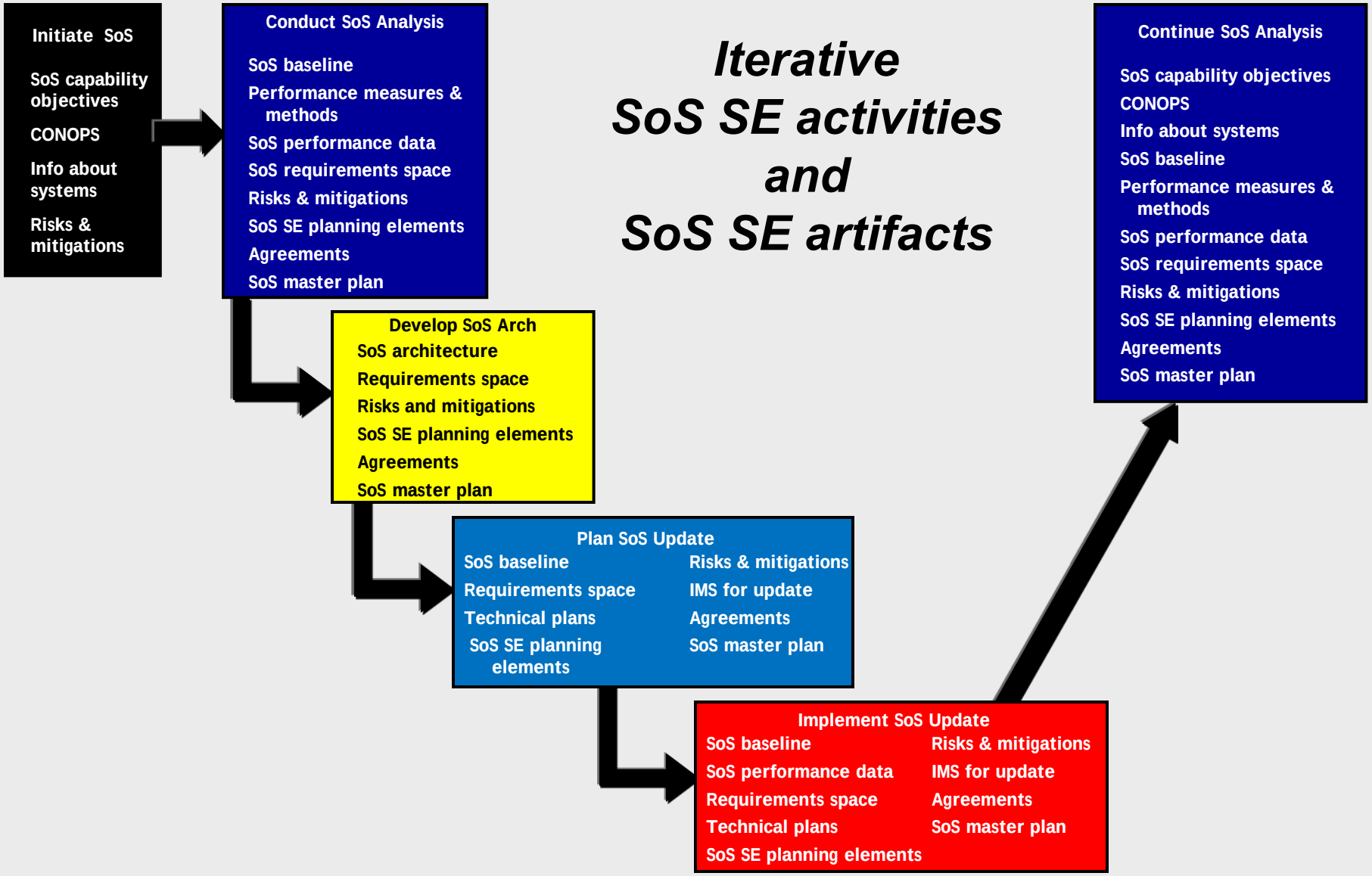
- Implement SoS Update:

  Oversees system implementations and plans/conducts SoS level testing, resulting in a new SoS product baseline

- Continue SoS Analysis:

  Ongoing SoS analysis revisits artifacts on the state and plans for the SoS as the basis for ongoing SoS evolution

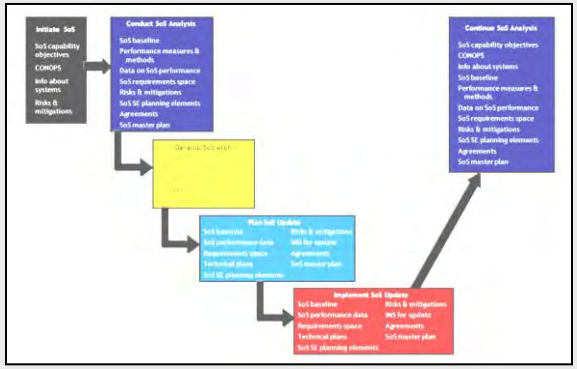
Artifacts Created or Changed at Each Step



Iterative SoS SE activities and SoS SE artifacts

Provide information needed to progress through the process

Artifact Logical Groups



- **SoS capability-related artifacts**
  - SoS capability objectives
  - SoS-level CONOPS
  - Requirements space
- **SoS technical artifacts**
  - SoS architecture
  - SoS performance-related artifacts
    - Performance measures and methods
    - Performance data
  - SoS technical baselines

- **System-related artifacts**
  - Information about systems that impact SoS capability objectives
- **SoS management and planning artifacts**
  - SoS risks and mitigations
  - Plans
    - SoS system engineering planning elements
    - Master plan
    - Technical plan(s)
    - IMS
  - SoS-level agreements

SoS Capability Related Artifacts

- **SoS capability objectives**: a statement of top level objectives for the SoS that describes the capabilities needed by the user, ideally based on some definitive or authoritative materials
- **SoS-level CONOPS:** describes how systems in the SoS will be employed in an operational setting and is developed collaboratively by the operational users and the systems engineers to describe the way users plan to operate and use material assets to achieve the objectives
- **Requirements space:** identifies the needed SoS functions independent of the systems within the SoS for various capability options; based upon the SoS capability/requirements backlog and SoS problem reports

Artifact	Initiate SoS	Conduct SoS Analysis	Develop SoS Arch	Plan SoS Update	Implement SoS Update	Continue SoS Analysis
SoS capability objectives	***Establishes*** to identify critical need(s) that provide justification for an acknowledged SoS	***Uses*** for initial analysis	***Uses indirectly*** through performance-related artifacts	***Uses*** to drive evaluation of alternatives and refine solution requirements	***Uses*** to focus SoS-level testing and assessment	***Updates*** to include new or changing needs; ***uses*** to continue SoS assessment
SoS-Level CONOPS	***Creates*** to provide context for critical need(s). Initial SoS CONOPS may be limited and focus only on current capabilities of interest	***Uses*** as part of initial analysis	***Uses indirectly*** through performance-related artifacts	***Uses*** to guide evaluation of alternatives and refine solution requirements	***Uses*** to guide SoS-level testing and assessment	***Updates*** to include changes to ways existing capabilities are employed and to incorporate new changes; ***uses*** to continue SoS assessment
SoS requirements space		***Establishes*** as part of the initial analysis	***Updates*** as new architecture needs are identified	***Identifies and tags*** requirements and problem reports in the requirements space to be implemented/fixed in the upgrade being planned	***Updates*** as capabilities, requirements, and problem fixes are implemented and tested	***Updates*** as new capability needs and problems are identified

SoS Technical Artifacts

- **SoS architecture**: persistent technical framework in which the systems interoperate as a system of systems; identifies SoS systems, key SoS functions supported by the systems, and relationships and dependencies as well as end-to-end functionality, data flow, and communications protocols
- **Performance measures and methods:** set of measure definitions and methods for collecting the measures that are a) traceable to the capability objectives established for the SoS and b) the basis for assessing overall performance of the SoS and guiding "continuous SoS improvement"
- **Performance data:** actual data collected to assess progress toward achieving SoS capability objectives
- **SoS technical baselines:** Consists of requirements, allocated, and product baselines at the SoS level

Artifact	Initiate SoS	Conduct SoS Analysis	Develop SoS Arch	Plan SoS Update	Implement SoS Update	Continue SoS Analysis
SoS architecture			***Documents*** initial "as is"; ***updates*** over time. Both "as is" and "to be" maintained	***Uses*** to plan updates	***Uses*** to guide implementation	***Uses indirectly*** as part of SoS analysis
Performance measures and methods		***Defines*** initial set of measures and methods	***Uses*** to identify and "build in" opportunities to measure architecture performance	***Uses*** to identify and plan mechanisms to measure SoS performance	***Uses*** to "build in" mechanisms to measure SoS performance	***Updates*** as SoS evolves
SoS performance data		***Captures*** initial data; initializes repository and performs initial analysis	***Uses*** to assess architecture and guide its evolution	***Uses*** results of analyses to guide planning for the next update cycle	***Updates*** with data generated & captured in testing; ***uses*** results of analyses to guide next update cycle	***Updates*** with data captured in performance assessments; ***uses*** results of analyses to identify problems for resolution or new requirements for the backlog
SoS technical baselines		***Creates*** initial SoS product baseline ("as is" baseline)	***Uses*** to guide architecture evolution	***Creates*** requirements and allocated baselines for update from requirements in the SoS requirements space	***Creates*** product baseline for update based on requirements that were implemented in the update cycle	***Updates*** product baseline based on non-SoS constituent system changes identified through monitoring activities; ***uses*** previous baselines to assess current status of SoS

System—Related Artifacts

- **Information about systems that impact SoS objectives**: programmatic and technical information about systems that reflects their ability to support SoS short and long term SoS capability objectives; used to assess various SoS capability options

Artifact	Initiate SoS	Conduct SoS Analysis	Develop SoS Arch	Plan SoS Update	Implement SoS Update	Continue SoS Analysis
Info about systems	***Captures*** initial information for analysis	***Uses*** to guide initial analysis activities	***Uses*** to evaluate architecture evolution options and to identify potential risks	***Uses*** to evaluate and select capability options for current update cycle and to identify potential risks	***Uses*** to guide risk monitoring activities	***Updates*** to reflect current system status as new releases of the constituent systems are deployed

SoS Management and Planning Artifacts

- **SoS risks and mitigations**: technical and programmatic risks at the SoS level that are identified and managed throughout the SoS SE process over time; may include system-level risks that potentially impact SoS capabilities
- **SoS systems engineering planning elements:** consists of information on general SoS battle rhythm/pacing of SoS upgrades (periodic or event-driven), SoS-level organizational structures, and SoS-level decision-making authorities and responsibilities, and SoS-level processes (e.g., configuration management, technical reviews)
- **SoS-level agreements:** formal and informal agreements that address roles and responsibilities of SoS participants at a broad level as well as specific commitments of participants in a development increment

Artifact	Initiate SoS	Conduct SoS Analysis	Develop SoS Arch	Plan SoS Update	Implement SoS Update	Continue SoS Analysis
SoS risks and mitigations	***Captures*** initial risks	***Updates*** as needed based upon analyses	***Updates*** as needed with architecture-related issues	***Updates*** as needed with planning-related issues	***Updates*** as needed with implementation-related issues	***Updates*** as needed based upon analyses
SoS SE planning elements		***Establishes*** initial elements	***Updates*** as needed as the SoS environment, tools, organizations, and vendors change	***Updates*** as needed as the SoS environment, tools, organizations, and vendors change	***Updates*** as needed as the SoS environment, tools, organizations, and vendors change	***Updates*** as needed as the SoS environment, tools, organizations, and vendors change
Agreements		***Establishes*** initial agreements	***Updates*** as roles of systems and vendors change over time	***Updates*** as roles of systems and vendors change over time	***Updates*** as roles of systems and vendors change over time	***Updates*** as roles of systems and vendors change over time

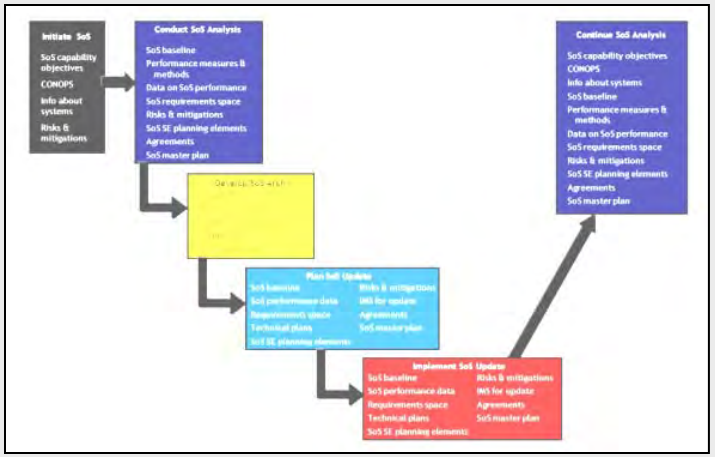
SoS Management and Planning Artifacts *(continued)*

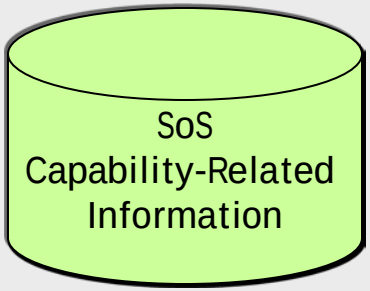
- **Master plan:** over-arching integrated plan that provides a top-level view across multiple SoS upgrade cycles; describes the longer-term SoS evolution strategy as well as the acquisition strategy for SoS capabilities that are incrementally developed and deployed
- **Technical plan(s):** includes plans for SoS implementation, integration, and test and are established for each development increment; SoS implementation plans include a high level description of requirements allocated to specific systems for current update cycle, roles and responsibilities for implementation, and details that elaborate upon IMS activities
- **Integrated master schedule:** single-increment IMS tailored to focus on key SoS SE activities, integration points , and milestones and incorporates or links to the system-level IMS elements related to the SoS activities

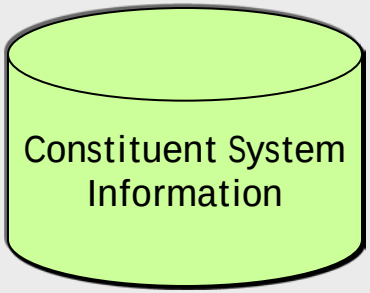
Artifact	Initiate SoS	Conduct SoS Analysis	Develop SoS Arch	Plan SoS Update	Implement SoS Update	Continue SoS Analysis
SoS master plan		***Establishes*** initial plan	***Updates*** as needed to reflect architecture evolution	***Updates*** as needed to reflect changing priorities and SoS evolution	***Updates*** as needed to reflect actual SoS evolution	***Updates*** as needed to reflect new needs, changing priorities, and SoS evolution
SoS technical plans			***Evaluates*** for potential architecture impacts	***Establishes*** for current update	***Updates*** as plans are executed and implementation progresses	***Uses*** to identify test-related information to support performance assessments
IMS for update			***Uses*** to schedule architecture re-assessments as architecture changes are completed	***Establishes*** for current update; incorporates SoS-related elements from constituent systems	***Updates*** as plans are executed and implementation progresses	***Uses*** to update master plan

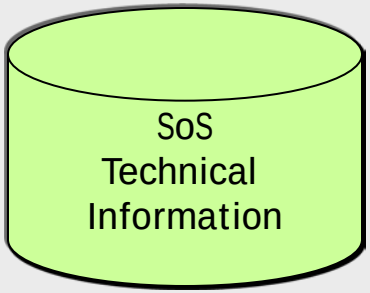
Summary

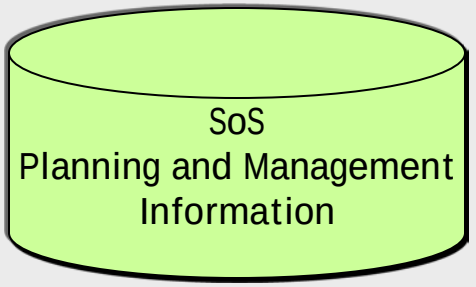
- **SoS SE artifacts:**
  Capture and convey information to the various engineering teams both at the SoS and constituent system level as well as to guide cross-cutting engineering activities
- **'Wave Model':**
  Provides an 'implementers view' of SoS SE
- **Artifacts support engineering activities across the SoS SE implementation:**
  Act as "information repositories" across SE teams at SoS and systems levels and across steps in the SoS SE implementation process
- **Next Steps:**
  Analyze how SoS artifacts are used by the constituent systems











Presenter's Contact Information

Dr. Jo Ann Lane
University of Southern California
jolane@usc.edu
858-945-0099

The Joint Land Component Constructive Training Capability: An SoS Success Story

Laura Feinerman (MITRE)
Timothy (Met) Metivier (USA CAC-T NSC)
Richard Weatherly (MITRE)
Mike Wright (USA PEO STRI)
Anita Adams Zabek (MITRE)

© 2010 The MITRE Corporation

MITRE

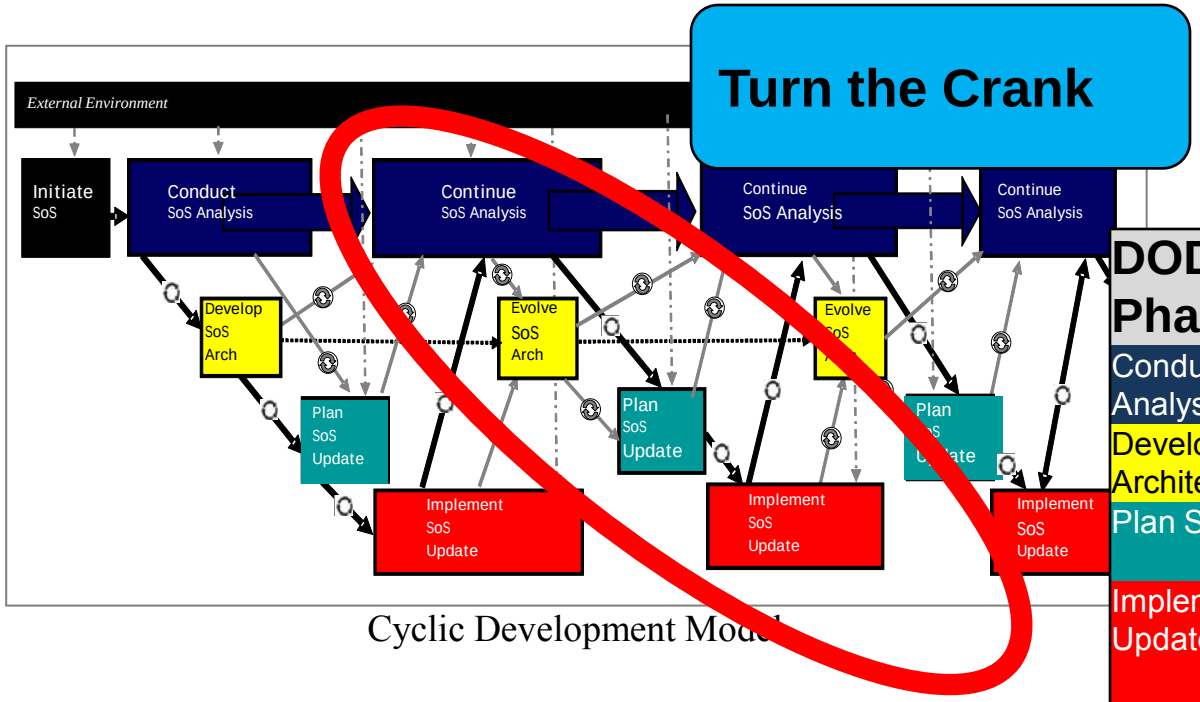
Approved for Public Release: 10-3067.
Distribution Unlimited

Outline

- Introduction to the Joint Land Component Constructive Training Capability (JLCCTC)
- Today's focus:
  - 'Steady State' System of Systems (SoS) operations
  - Provide overview of JLCCTC SoS process and artifacts
  - Identify key tenets of SoS SE in this example
- Topics not covered:
  - Initiating the SoS
  - Back plane planning

© 2010 The MITRE Corporation

SoS System Engineering Process



Cyclic Development Model

DoD SoS SE Guide Phases mapped to JLCCTC Phases

DOD SoS SE Phase	JLCCTC SoS Phase
Conduct SoS Analysis	Requirements
Develop SoS Architecture	Conceptual Development
Plan SoS Update	Design Development
Implement SoS Update	Develop Functionality
	Integrate and Test
	SoS Test
	Fielding

- *DoD Systems Engineering Guide for Systems of Systems*, Version 1.0, August 2008

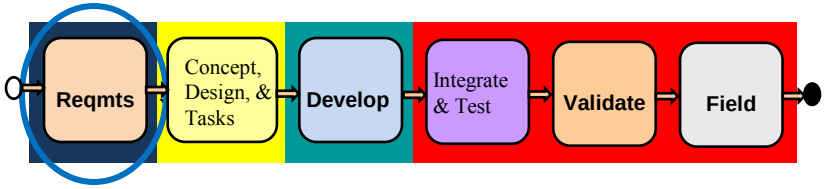
© 2010 The MITRE Corporation

JLCCTC SoS Characteristics

- The SoS components:
  - Must exchange information in a coordinated fashion
  - Are largely software
  - Have a long lead time and large price tag
  - Are owned by many organizations (multi Service, Nations)
  - Include both Programs of Record and Non-Programs of Record
- The SoS architecture
  - Includes common infrastructure software
  - Loosely couples the individual components
  - Includes legacy infrastructures and protocols
  - Requires a common data model for information exchange
- Changing and critical warfighter needs demand rapid response times

© 2010 The MITRE Corporation

Requirements Process



Understand and prioritize SoS needs.

Requirements collected from users and prioritized

- SoS SE groups Requirements by functional areas
- Contributing systems identified

SoS SE records decisions in Integrated Task List (ITL)

Requirements collected from component systems

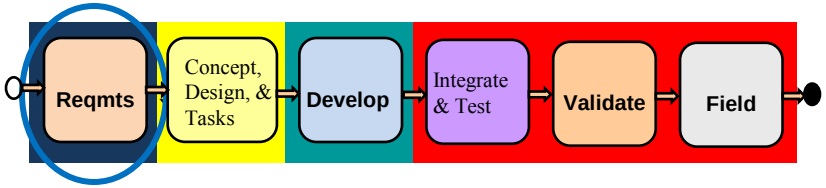
SoS SE's Requirements (Master Plan, infras-tructure, deferred, deficiencies)

Government only CCB

SoS SE key tenet for JLCCTC

© 2010 The MITRE Corporation

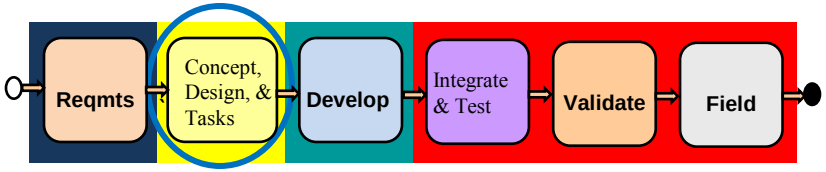
Requirements Artifacts



Guide Artifact Title	JLCCTC Title	Producer/User Context	Format
SoS Capability Objectives	Joint Land Component Constructive Training Capability (JLCCTC) Capability Production Document (CPD)	The JLCCTC Program uses a "System of Systems" approach for development. This approach will leverage the best functional capabilities of existing and developing simulation systems. At the same time, it incorporates new capabilities in a modular fashion, all of which, the Materiel Developer integrates into the simulation environment over time and as it 'makes sense' to do so. This approach works by retiring older technologies as newer technologies demonstrate an improved capability that results in increased training effectiveness and/or relevancy.	Word
SoS Requirements Space	TRADOC, NSC User SoS Requirements	Produced by the combat developer (TRADOC National Simulation Center) based on input from all users of the system	Word
SoS Requirements Space	Fielded Sites SoS Requirements	Produced by the users at the fielded sites.	Word, email
SoS Requirements Space	Non-Army User SoS Requirements (AFAMS, JFCOM JWFC)	Produced by the non-Army users of the SoS, including AF Agency for Modeling and Simulation, and JFCOM Joint Warfighting Center.	Word, email
SoS Requirements Space	Prior cycle deficiencies and carryovers	System problem reports (deficiencies) generated in prior cycle by systems engineer and the combat developer and end users using the fielded product. Carryovers recorded in prior cycle's ITL as incomplete tasks.	SPR tracking system, ITL
SoS Requirements Space	Architecture / infrastructure improvements	SoS requirements based on SE performance and stability testing or OS / COTS / GOTS upgrades, etc.	
SoS Requirements Space	SoS Information Assurance	The SoS is required to have an Authority to Operate (ATO) signed prior to fielding. This is accomplished through incremental steps throughout the development cycle, culminating in final Information Assurance steps taken at the Validation event.	Word

© 2010 The MITRE Corporation

Develop Concepts, Design, and Task Definition Process



Identify, evaluate, and select design options for addressing SoS needs.

SoS Concept Review

SoS Design Review

Govt only:
- go forward
- defer
- cancel

Record decisions in ITL

Functional Area Lanes

System Independent Conceptual Models

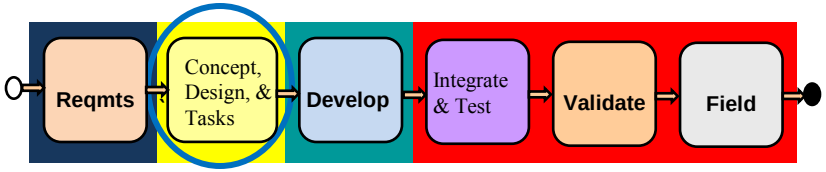
System Specific High Level Designs

Integration & Functional Development Plans & Tasks ==> ROM

SoS SE key tenet for JLCCTC

© 2010 The MITRE Corporation

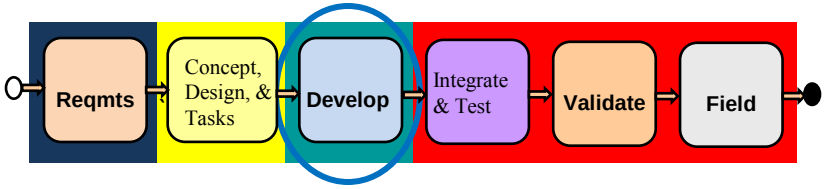
Concepts, Design, Task Definition Artifacts



Guide Artifact Title	Title	Producer/User context	Format
	Concept Session functional area briefings	Concept briefings are developed by SE, Users, and Developers to further describe the version requirements. These briefings are conceptual and do NOT identify specific systems.	PPT
SoS Architecture	SoS Architectures	SoS SE prepares a depiction of what systems are in the SoS for the current version, including information exchange architecture and security enclave. Prepared for each cycle during the Concept Development and Design phase.	PPT
SoS Architecture	SoS Data Exchange Model	SoS SE leads working groups in functional areas to develop the data exchanges between the systems. Candidate changes are reviewed by a technical board that assesses cost and performance impact to the individual systems and to the SoS, and are then entered into a database once approved. The SoS Data Exchange model modification process is led by the SE for each cycle during the Concept Development and Design phase. The model may evolve through later phases as the interface matures through system implementation and SoS integration activities.	OMT, FED files, and Word. Doc includes FOM and Federation Agreement info. HTML version of FOM.
SoS Architecture	SoS Data Exchange Vignettes	SoS SE leads working groups in functional areas to develop the patterns of interactions between the systems. These are documented as event trace diagrams and are called vignettes. Prepared by the SE for each cycle during the Concept Development and Design phase. These evolve through later phases as the interface matures through system implementation and SoS integration activities.	pdf, in Word docs (EMF).
SoS Architecture	C2 Spider Charts	These charts identify each SoS system that stimulates a C2 system or receives messages / direction from a C2 system, and the message format used.	

© 2010 The MITRE Corporation

Develop Functionality Process



Develop and manage the SoS architecture.

Synchronize and develop SoS updates

SoS Architecture evolves

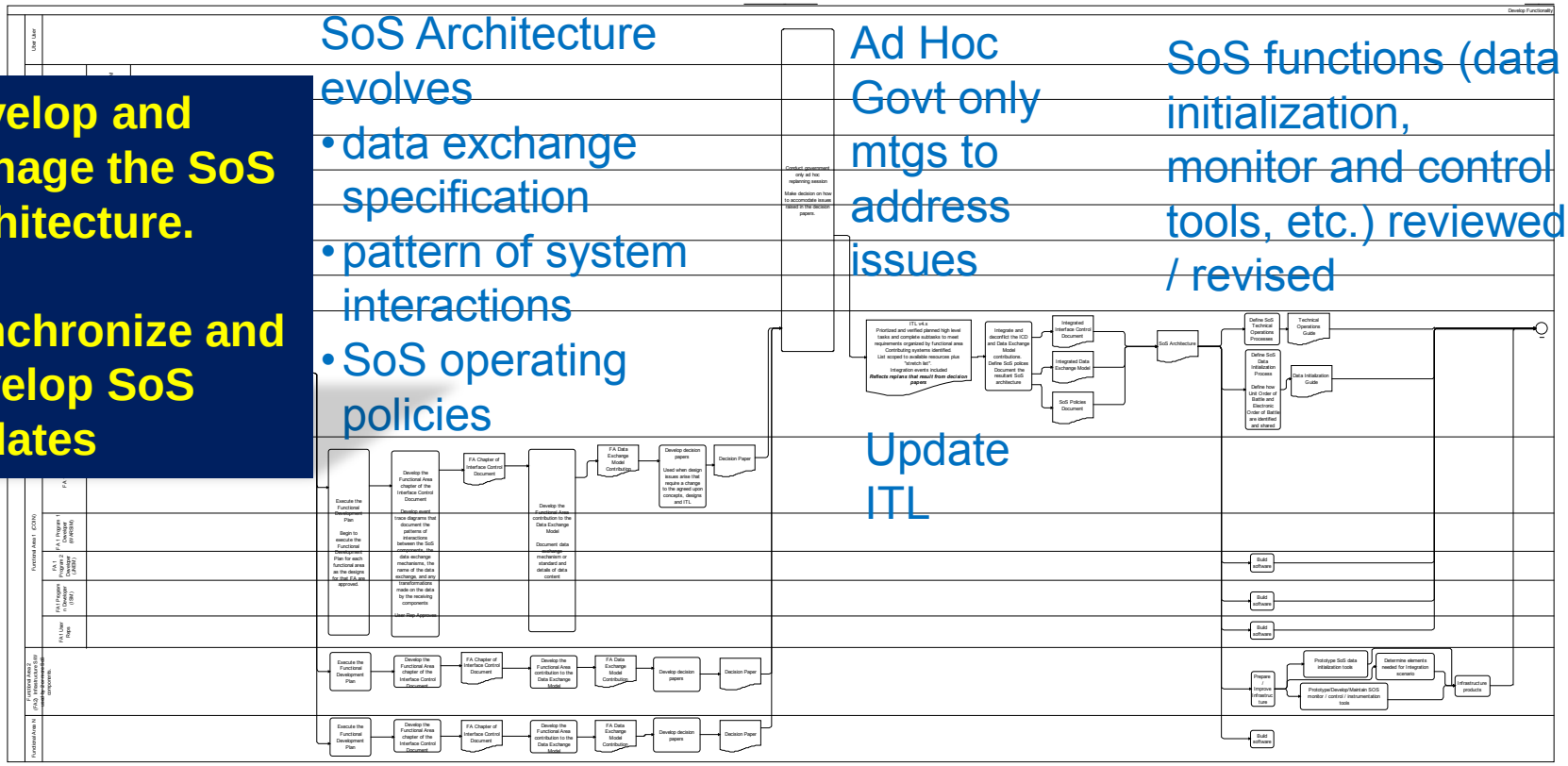
- data exchange specification
- pattern of system interactions
- SoS operating policies

Ad Hoc Govt only mtgs to address issues

Update ITL

SoS functions (data initialization, monitor and control tools, etc.) reviewed / revised

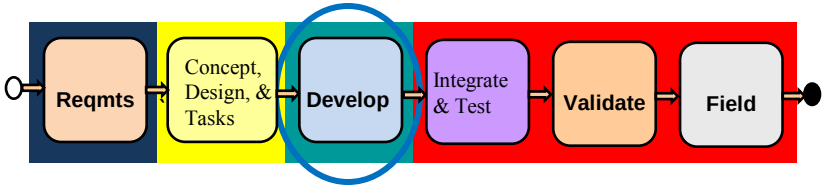
Software is built



© 2010 The MITRE Corporation

SoS SE key tenet for JLCCTC

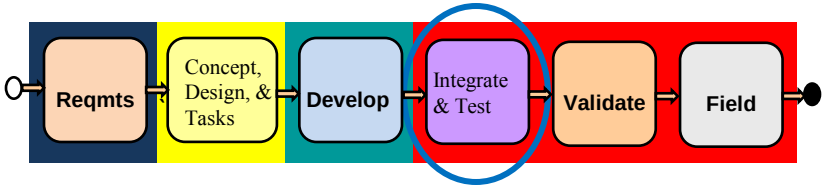
Develop Functionality Artifacts



Guide Artifact Title	Title	Producer / User Context	Format
SoS Baseline	Design Session functional area briefs	Functional Area (FA) design briefings evolve the concepts discussed for each requirement and begin to allocate functionality to systems. These are reviewed by the SE, System Developers and Proponents, and User. As information evolves it is captured in the ITL.	PPT
SoS Baseline	Integrated Task List	The ITL contains the planned enhancements and bug fixes for the version in development.	excel
SoS Baseline	SoS Architectures	Visio diagrams showing the SoS components, security levels, and interface protocols are revised to reflect current development plans.	Visio
SoS Baseline	SoS Data Exchange Model (FOM)	As each new interface is designed and allocated to components, the data exchange model is assessed for changes (generally additions) needed to deliver requested functionality. Changes to the data model are considered, reviewed by all SoS participants, including the SE, with a goal of minimal impact to all participants and the infrastructure while delivering new functionality.	OMT, FED files, published form: Word, pdf, HTML
SoS Baseline	Functional Vignettes	Each development cycle is broken into several integration events which are focused on one or more functional areas. Functional area improvements are decomposed by interfacing systems as well as the functionality each system can bring to a specific integration event. This information is captured in the ITL. Additional interface information is captured in object model and interface event trace diagrams. System developers and the FA SoS SE keep each other informed on progress, perceived impact to other Systems, SoS hw and SoS supporting sw (i.e.., MS SQL).	pdf, word
SoS Baseline	SoS Policies	Standards for interoperating as an SoS, e.g., data encoding, heart-beating, initialization procedures, system, network protocol and SoS continuity of operations procedures. Prepared by the SE for each cycle during the Concept Development and Design phase.	Word

© 2010 The MITRE Corporation

Integrate and Test Process

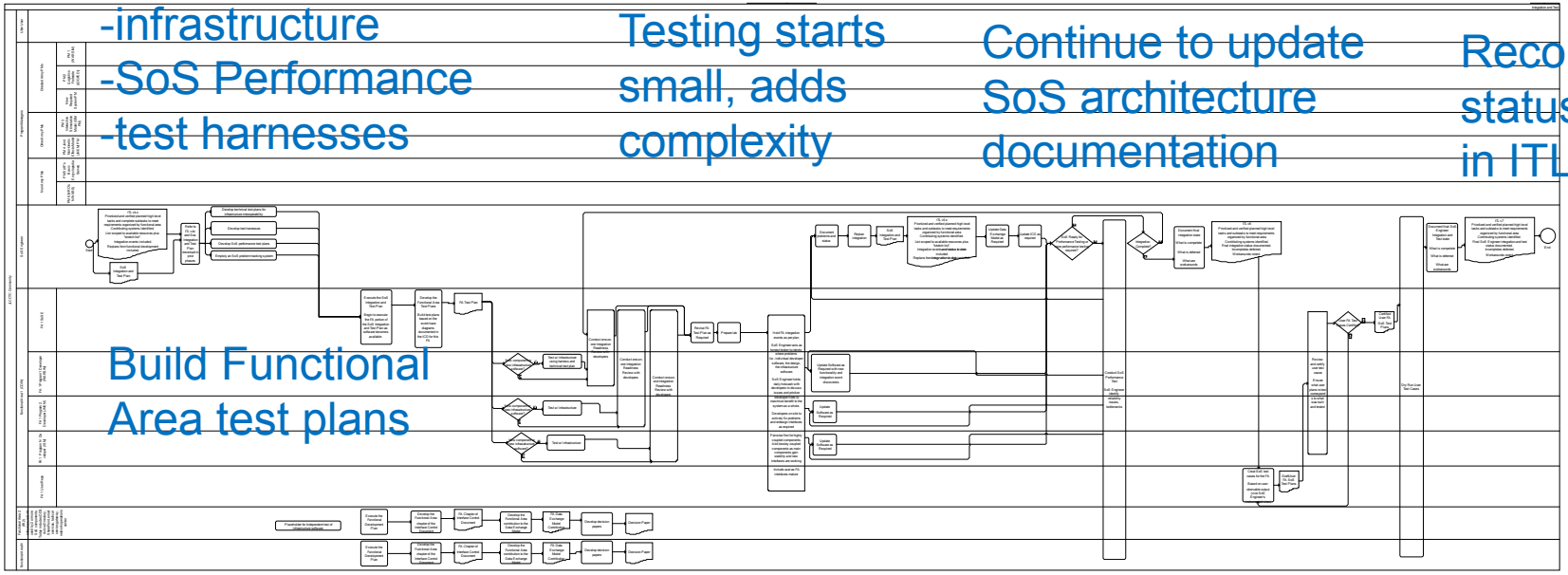


Prepare Test Plans/tools:
-infrastructure
-SoS Performance
-test harnesses

Testing starts small, adds complexity

Continue to update SoS architecture documentation

Record status in ITL



Build Functional Area test plans

Integrate and test SoS updates

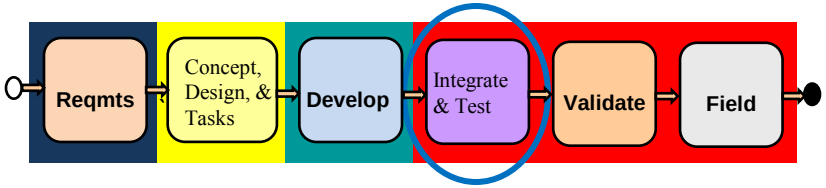
Conduct SoS performance test, IA tests, assess SoS completion

Review and dry run User Validation tests

© 2010 The MITRE Corporation

SoS SE key tenet for JLCCTC

Integrate and Test Artifacts



Guide Artifact Title	Title	Producer / User Context	Format
Tech Plans	Integration and Test Plans	For each Integration Event: the SE publishes a list of objectives for the event, the functional areas to be tested, the FOM data exchange model to be used, and the infrastructure (including information assurance plan) to be used at the event.	excel, word, ppt
Tech Plans	Integration Readiness Review Checklist	Based on Integration Event Plan and includes objectives for next integration event; hardware, software, and staffing expectations, Information Assurance (IA) lockdown testing and anticipated modifications, systems tested ability to run with current infrastructure and SoS inputs (data exchange model, databases, etc.) These are conducted by the SE with each anticipated System for the next integration event. This allows System developer to alert SE to current status (and any known issues) in private.	PPT
Tech Plans	Integration Readiness Reviews	SE conducts an Integration Event Readiness Review with each component developer participating in the integration event. The review includes the plans for each functional area scheduled to be integrated at the event, the status of that components contribution, the hw and software required by that component, and the ability of the component to execute in the integration event environment. The IRR provides an opportunity for the component developer to assure the SE of their readiness and/or alert the SE of any issues or concerns with the development of their component.	PPT, excel
Tech Plans	Integration Event HW, SW, IA, reqmts for lab	Prior to each event, the architecture of the event is drafted and updated as the IRRs are conducted. This product describes the hardware allocated to each component, the additional software products required by the component (e.g., MS SQL), the Information Assurance lockdown version, and any specific set up reqmts by each component.	excel
Tech Plans	Integration Event Results	The SE assesses the results obtained at the Integration Event and determines the impact to subsequent events, or if the cycle is concluding, identifies which requirements will not be met by the SoS test, and therefore will not be part of the released version.	

© 2010 The MITRE Corporation

Key Tenets of the JLCCTC SoS SE Process

- Understand and prioritize SoS needs.
- Identify, evaluate, and select design options for addressing SoS needs.
- Develop and manage the SoS architecture. Understand the breadth, significance, and power of proper architecture management.
- Synchronize and develop SoS updates.
- Integrate and test SoS updates.

© 2010 The MITRE Corporation

JLCCTC SoS SE Principles

- Focus on SoS capabilities beyond those of any single system's area of responsibility or expertise. Keep out of the rice bowl fights between systems.
- Focus on interfaces between systems, SoS infrastructure, and common services. These things cannot be addressed by a single system, each system is likely to have an opinion, some of them quite astute.
- Focus on technically feasible solutions and remain system agnostic.
- Rely on the expertise resident in a system's organization. Stay out of any single system's internal affairs unless invited.
- Be the scribe when everyone else is talking. Nuggets of truth are often buried in the noise.
- Make sure there is common access by all system developers to all critical documents. There should be no mysteries about the state of the SoS SE process.

© 2010 The MITRE Corporation

Features of the SoS Process

- Governance process addresses:
  - Intersection between components systems
  - Functionality within systems needed to address SoS capabilities
- Decomposition of the SoS into *functional areas*
  - As decoupled as possible in order to maximize parallel activities within a cycle
- Updated SoS design at each cycle
  - System independent conceptual models elaborating SoS requirements
  - Updated SoS *composition*
  - Updated SoS *infrastructure*
  - Updated SoS *data exchange model*
  - SoS vignettes describing the patterns of interactions between the systems in the new *composition*, using the updated *infrastructure*, and *data exchange model* to meet the requirements expressed in the conceptual models

© 2010 The MITRE Corporation

Demonstrated SoS Transition Success

Transitioned architecture

Replaced legacy with new systems

Accommodated new systems

Integrated new capabilities in response to changing world

© 2010 The MITRE Corporation

ASA(ALT) System of Systems Engineering Processes

NDIA Systems Engineering Conf 27 Oct 2010

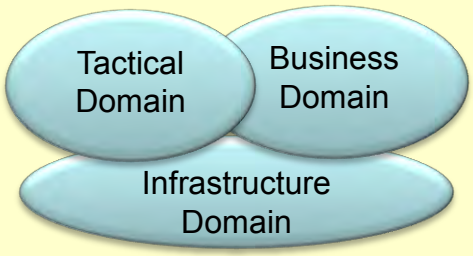
Mr. David E. Poole
ASA(ALT) SoSE
(703) 697-6901
david.poole@us.army.mil

Mr. David R. Castellano
Executive Director,
Weapons & Software Engineering Center
(973) 979-3002
david.r.castellano@us.army.mil

System of Systems Engineering (SoSE) – Environment

ASA (AL&T)

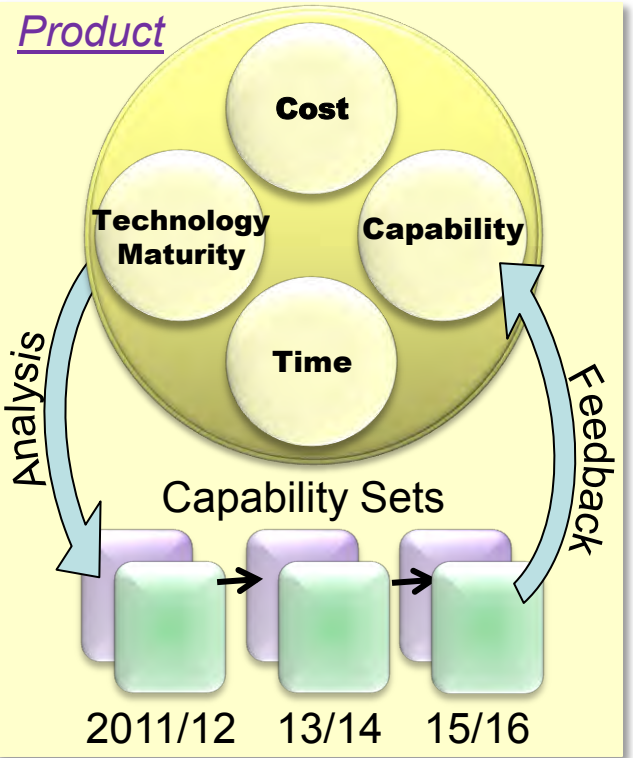
Scope



Mission

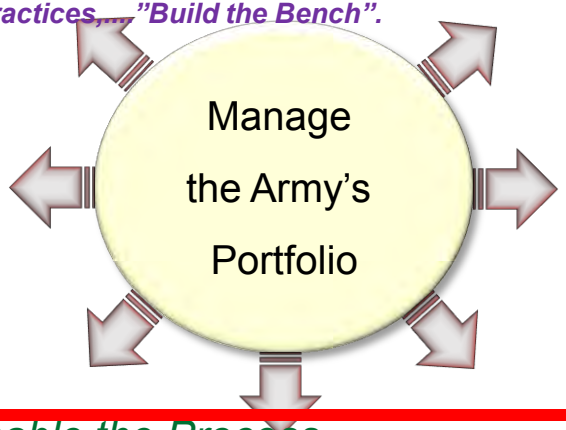
The Mission of ASA(ALT) SOSE:
Provide the Army's leadership and materiel developers with the necessary engineering/architectural products to manage and shape the Army's materiel portfolio, to ensure a System Engineering discipline across the Materiel developer community throughout the acquisition life cycle and grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,…"Build the Bench".

Product



Build the Bench

- Organize the Army Engineering Community
- Establish Technical Authority and engineering expertise/capability
- Pursue accreditation and certifications of organic workforce & organizations



Create Data Transparency

- Establish CM and an authoritative repository for products
- Establish a collaboration environment
- Establish a common operating environment for engineering Products

Enable the Process

- Establish the engineering process to deliver synchronized capability
- Establish the analytical structure with models & simulations
- Establish the engineering compliance structure/process for acquisition execution excellence
- Deliver engineering support to HQ staff and acquisition community

Manage the Portfolio

- Support the prioritization of capabilities within the portfolio
- Set the baseline architecture roadmap over time
- Support the resourcing process
- Synchronize and align the S&T, systems integration, test, and certification activities

Ver. 2.7

Vision Statement

At maturity o/a the end of FY 2012, the SoSE Directorate will provide the Army's leadership and Materiel Developers superior:

- ***Strategic level engineering and architectural products for both current and future configurations of each SoS domains (i.e. Networks, Mission Command, AVN etc.)***
- ***Automated tools necessary for tracking, managing and improving the technical cost, schedule and performance of SoS throughout their acquisition life cycle***
- ***Technical trades necessary for making informed SoS funding and programmatic decisions***
- ***Technical guidelines, protocols and standards for SoS life-cycle acquisition***
- ***Program reviews to develop, sustain and improve the cost, schedule and performance across the Systems Acquisition***
- ***SoS engineering organizational structure and processes to ensure consistence of SoS implementation across ASA(ALT)***
- ***Engineering policy, guides, best practices templates and metrics to insure SoS discipline across ASA(ALT)***
- ***Education and personnel development model to cultivate the SoSE capability across the Army***

Architectures & Analysis

ASA (AL&T)

Goals

- Establish a unified governance structure for system Architecture within ASA(ALT)
- Align the Architecture Products to support Army and Acquisition processes
- Align System Architecture capability within ASA(ALT)

Tasks: 1.4.1 Provide strategic level SoS engineering and architectural products .

1.4.1.1 Document and publish the current strategic level Systems architecture for each SoS.

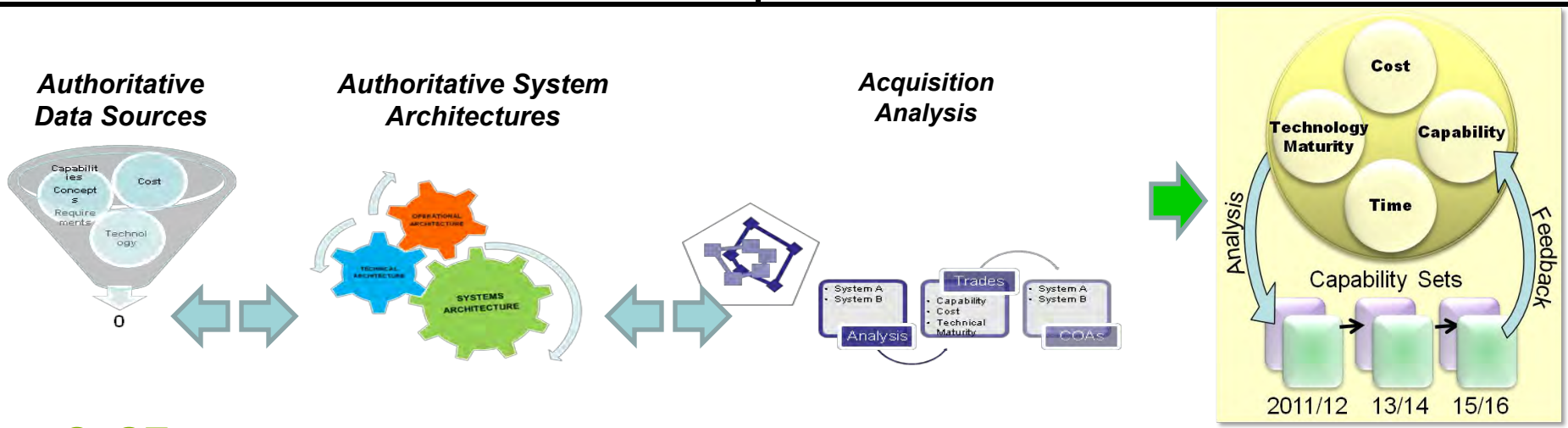
1.4.1.2 Develop and publish the future strategic level Systems architecture for each SoS at designated times in the future.

1.4.1.3 Develop and publish the strategic Systems Engineering Plan (SEP) for each SoS.

1.4.1.4 Establish and publish the standards and policies for SoS interfaces and data.

1.4.1.5 Identify, maintain and publish the official list of SoS and associated subsystems.

1.4.1.6 Provide input to the technical standards of performance for each SoS



Program Support & Mission Assurance

ASA (AL&T)

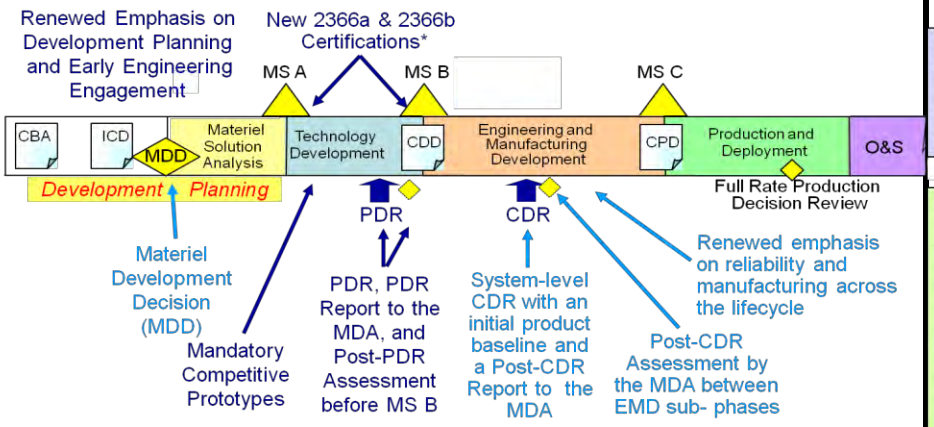
Goals

- **Systems Engineering support to Programs and Program Offices**
  - *Mentoring and Independent Assessment*
- **Establish Engineering policy, guides, best practices templates and metrics to insure SoS discipline across ASA(ALT)**

Tasks: ***1.4.2 Establish engineering policy, guides, best practices templates and metrics to insure SoS discipline across ASA(ALT)***

1.4.2.1 Address Legislative Mandates
1.4.2.2 Regulatory Responsibility
1.4.2.3 Provide Cadre of Engineering Expertise to support Acquisition Leadership
1.4.2.4 Deliver Independent Engineering Advice and Assessments to Acquisition Leadership
1.4.2.5 Provide Engineering Risk Assessment in support of MS Decisions

DOD 5000.2 Changing the Acquisition Landscape

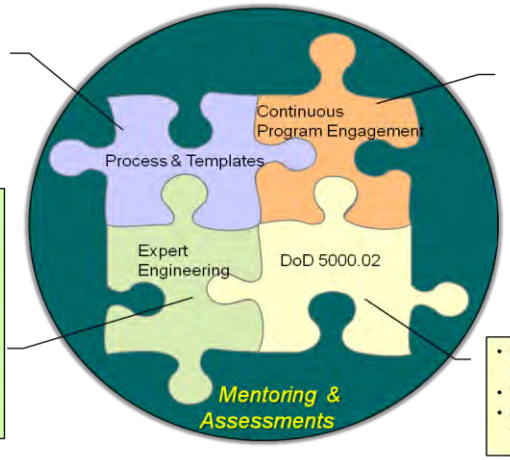


"Knowledge-based" Decision Making . . .making acquisition decisions with solid evidence and well understood risk

Program Support Reviews

- DAPS Methodology
- Templates, process flow diagrams, Training
- Questions
- Assessment Plans

- Program unique recommendations to PMs
- Expert engineering advice within programmatic context to Acquisition Leadership
- Systemic issues to acquisition community for improvements to greater Acquisition effort



- Sharper insight into real program issues and complexities
- Greater trust and openness developed w/programs
- Recommendations target the real issues at their root cause

- Assessments of Major Programs
- Program Monitoring
- Systemic Root Cause Analysis

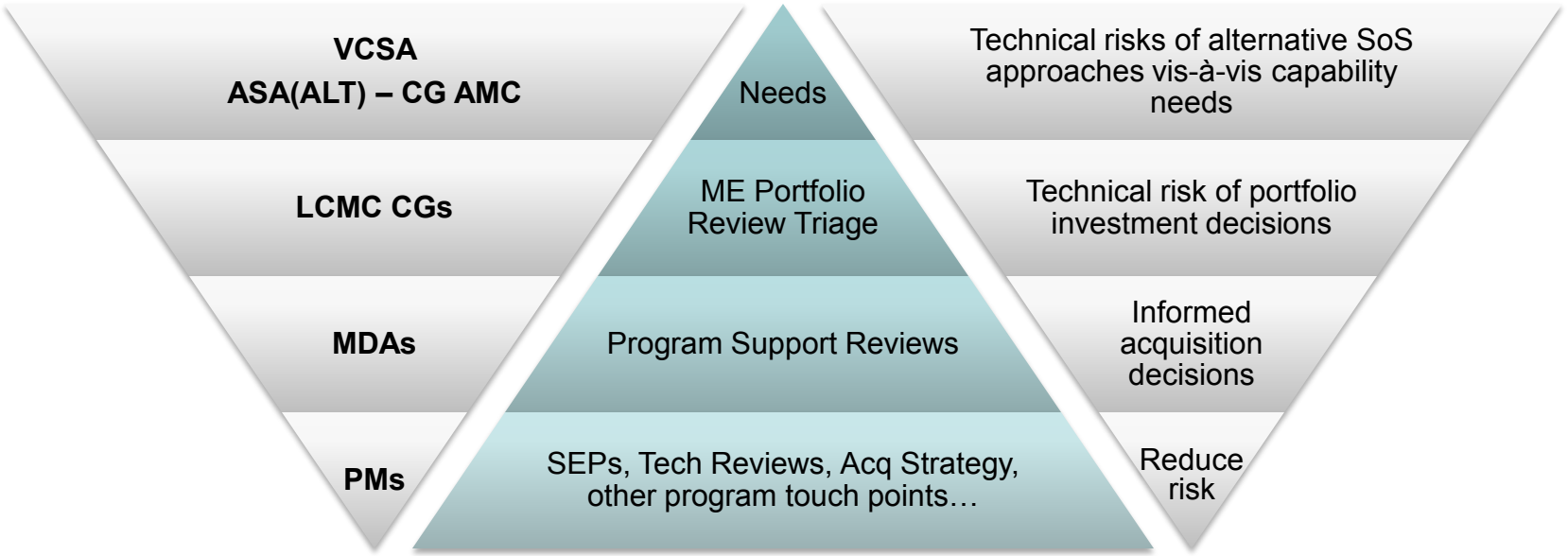
- **PM acceptance of 90% of all PSR recommendations**
- **Supporting >90% of all DABs, ITABS, OIPTs, IIPTs and SE WIPTS**

SoSE

DESIGN * DEVELOP * DELIVER * DOMINATE

The Army SoSE Approach to Program Support

ASA (AL&T)



- Four (4) COAs for Program Support (PS) management were considered; most effective option outsources Technical Agent role to RDECOM/ARDEC
- PS staff – Domain experts will be selected across Army elements to include RDECs
- Yearly cost ($12M est) to be shared across PEOs; recommend POM for outyears
- Start-up anticipated to be 6 months (initial staffing, methodology/templates/tools, etc)
- Leverages experience and methodology from OSD Major Program Support; acts on OSD's initiative to promulgate program support across Army/Services

Provides SE Leadership and Technical Oversight in Support of Planned Acquisition Programs

Build The Bench

Goals

- **Improving Component System Engineering Competencies**
  - *Growing Engineering Capacity across ASA(ALT)*
- **Establish Career path for SE & SoSE professionals**
- **Establish curriculum for SE & SoSE Discipline**
- **Establish Career field for SE/SoSE**

Tasks: Grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,....”Build the Bench”.

1.4.3.1 Assess current state of manning and certification/education in ASA(ALT) SE workforce
1.4.3.2 Identify SE workforce manning requirements
1.4.3.3 Identify SE workforce developmental plan and career progression
1.4.3.4 Establish an SE Career Field
1.4.3.5 Educate, certify and hire to development plan
1.4.3.6 Maintain database of SE workforce/ certification levels

Assess	ID Req’ts	Est Dev Plan	Est Career Field	Execute Plan	Cont Re-Assess

Organizing the SoS Space

ASA (AL&T)

ARMY ANALYTICAL FACTORY
G3/5/7 · G8 · G6 · ASA(ALT) · TRADOC & OTHER STAFF

LWN GOSC

AAE MilDEP

EXECUTIVE COUNCIL
DAS-M Chair *PEOs*

ENGINEERING OVERSIGHT COUNCIL (EOC)
SoSE Chair *DPEOs*

Acquisition Decision Authority

Configuration Steering Board

- *PEO*
- *SoSE*
- *S&T*
- *INTEGRATION*
- *RDECOM*
- *FFRDC*

AVIATION

BATTLE COMMAND

FIRES

TRANSPORT & NETOPS

SoSE Cross-IPT Integration WGs

Tactical Vehicle/ Sustainment

NETWORK INTEGRATION

MISSION COMMAND INTEGRATION

INTEG BASE DEFENSE

PLATFORM INTEGRATION

JOINT COMBAT ID

INTEL & SENSORS

Ground Combat Systems

SOLDIER

PEO TIER 2 SE GOVERNANCE

DOMAIN SE IPTs

Business

Chem / BIO

SIM & TRAINING

Authoritative Data Sources

Authoritative System Architectures

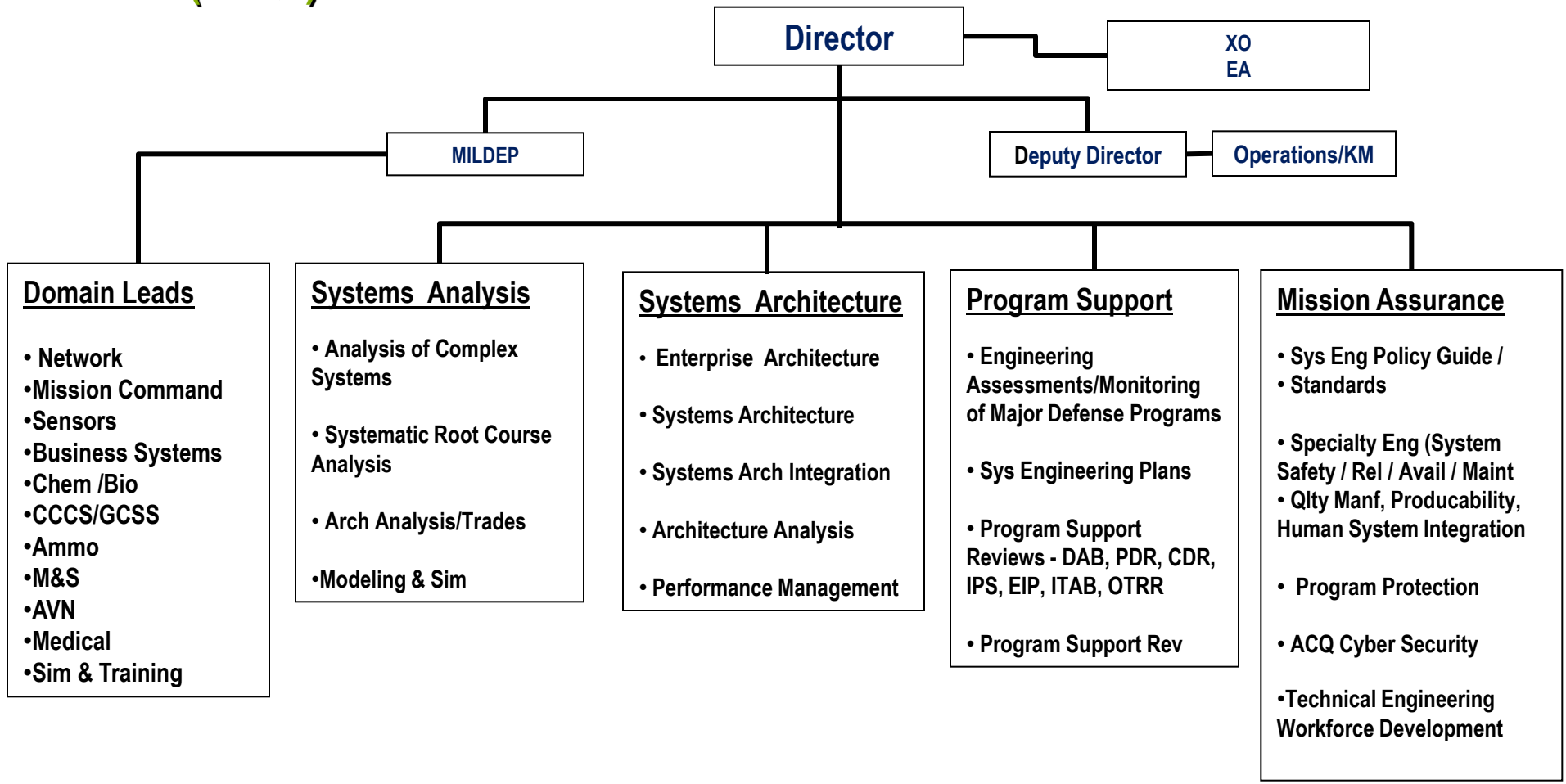
Acquisition Analysis

DESIGN ✷ DEVELOP ✷ DELIVER ✷ DOMINATE

SoSE

Army SoSE Organization

ASA (AL&T)



•- Domain Leads
•- GOV
•- RDECOM
•- FFRDC/Contractor

Providing Technical and SE Leadership & Oversight to ASA (ALT) in support of planned ongoing Acquisition Programs

Way Ahead / Challenges

- Leverage expertise across the community
- Pool resources to do more with less
- Establish engineering discipline across the community consistently
- Continuously look for engineering opportunities

ASA(ALT) System of Systems Engineering "Architecture" Developments

NDIA Systems Engineering Conf

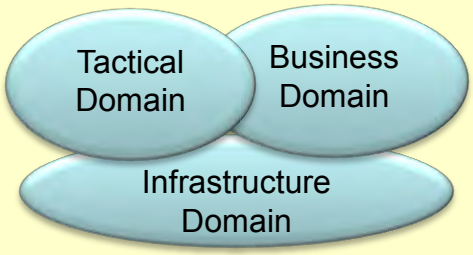
27 Oct 2010

Mr. David E. Poole
ASA(ALT) SoSE
(703) 697-6901
david.poole@us.army.mil

System of Systems Engineering (SoSE) – Environment

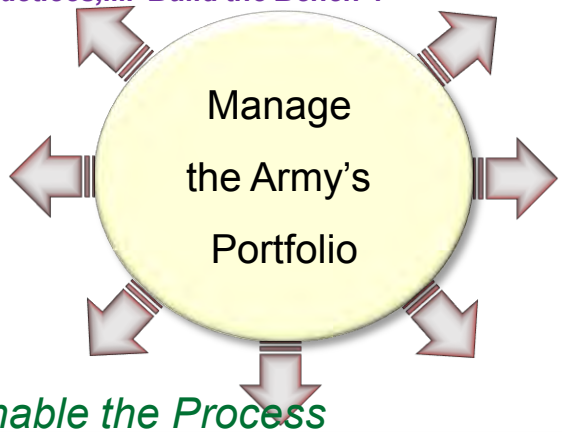
ASA (AL&T)

Scope

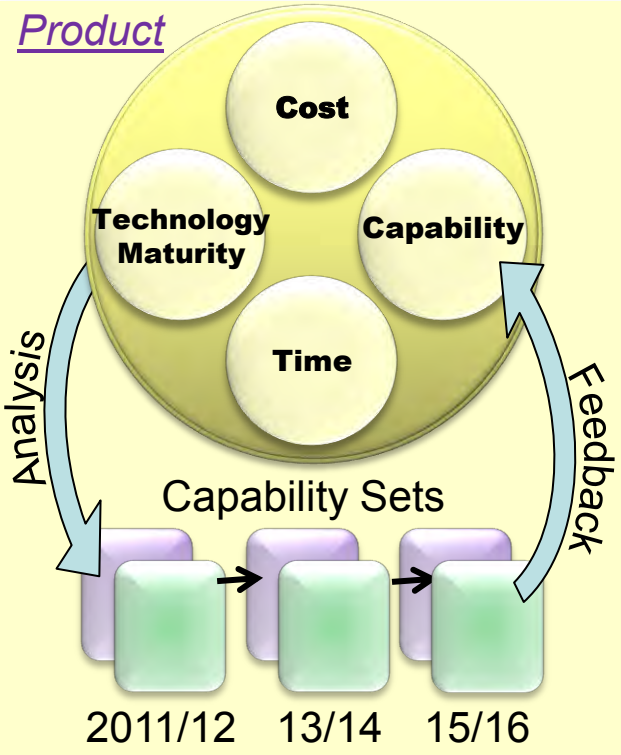


Mission

The Mission of ASA(ALT) SOSE:
Provide the Army's leadership and materiel developers with the necessary engineering/architectural products to manage and shape the Army's materiel portfolio, to ensure a System Engineering discipline across the Materiel developer community throughout the acquisition life cycle and grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,...."Build the Bench".



Product



Build the Bench

- Organize the Army Engineering Community
- Establish Technical Authority and engineering expertise/capability
- Pursue accreditation and certifications of organic workforce & organizations

Create Data Transparency

- Establish CM and an authoritative repository for products
- Establish a collaboration environment
- Establish a common operating environment for engineering Products

Enable the Process

- Establish the engineering process to deliver synchronized capability
- Establish the analytical structure with models & simulations
- Establish the engineering compliance structure/process for acquisition execution excellence
- Deliver engineering support to HQ staff and acquisition community

Manage the Portfolio

- Support the prioritization of capabilities within the portfolio
- Set the baseline architecture roadmap over time
- Support the resourcing process
- Synchronize and align the S&T, systems integration, test, and certification activities

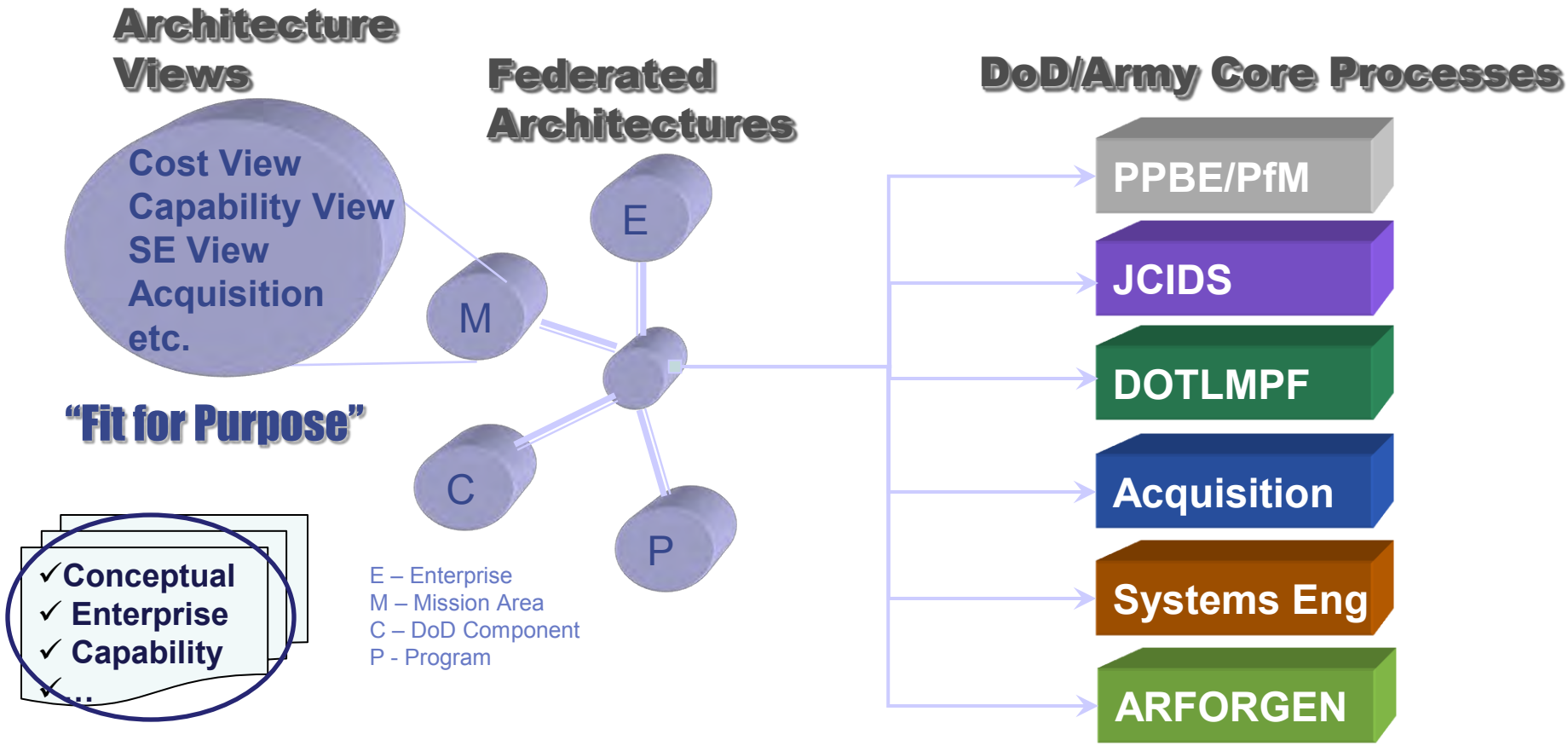
Ver. 2.7

ASA(ALT) SoSE Major Workload Areas*

- Performing SoS-level trades, developing and communicating recommendations to decision makers
- Integration of new systems into the SoSE process (i.e. CDRT, Mod strategy, etc.)
- Annual architecture development and integration efforts
- High priority ad hoc targeted trades
  - Same processes/tool/relationships

* 3 Sept 2009 – ESAT Key Outcomes and Path Forward

Making „Architecture" Relevant



Annual Programmed Plan Refinement

(Supported by Integrated Architectures)

ASA (AL&T)

Planning

Capability Gaps

13-14 COA Development

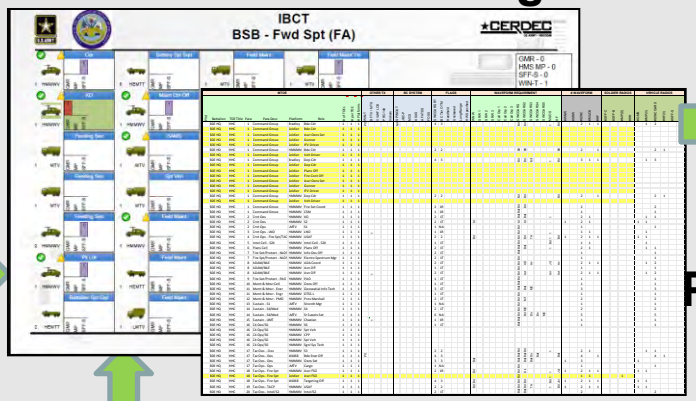
Force Structure

TRADOC 13-14 Requirements & Objectives

POR, COTS, and GOTS Solution Schedules

COAs

Proposed Changes to the Planned Program



Architecture Updates

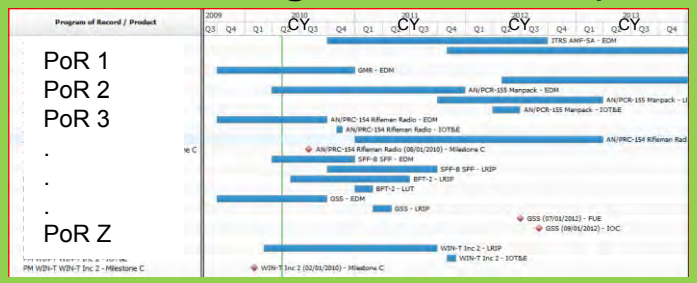
PEOs/PMs WSRs

Army Decisions

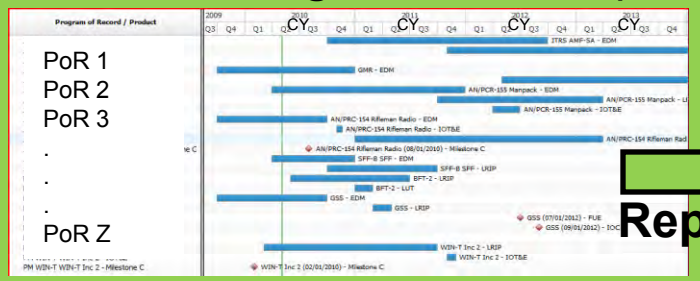
Army Decisions

Program

The Programmed Plan (FY 11-17)

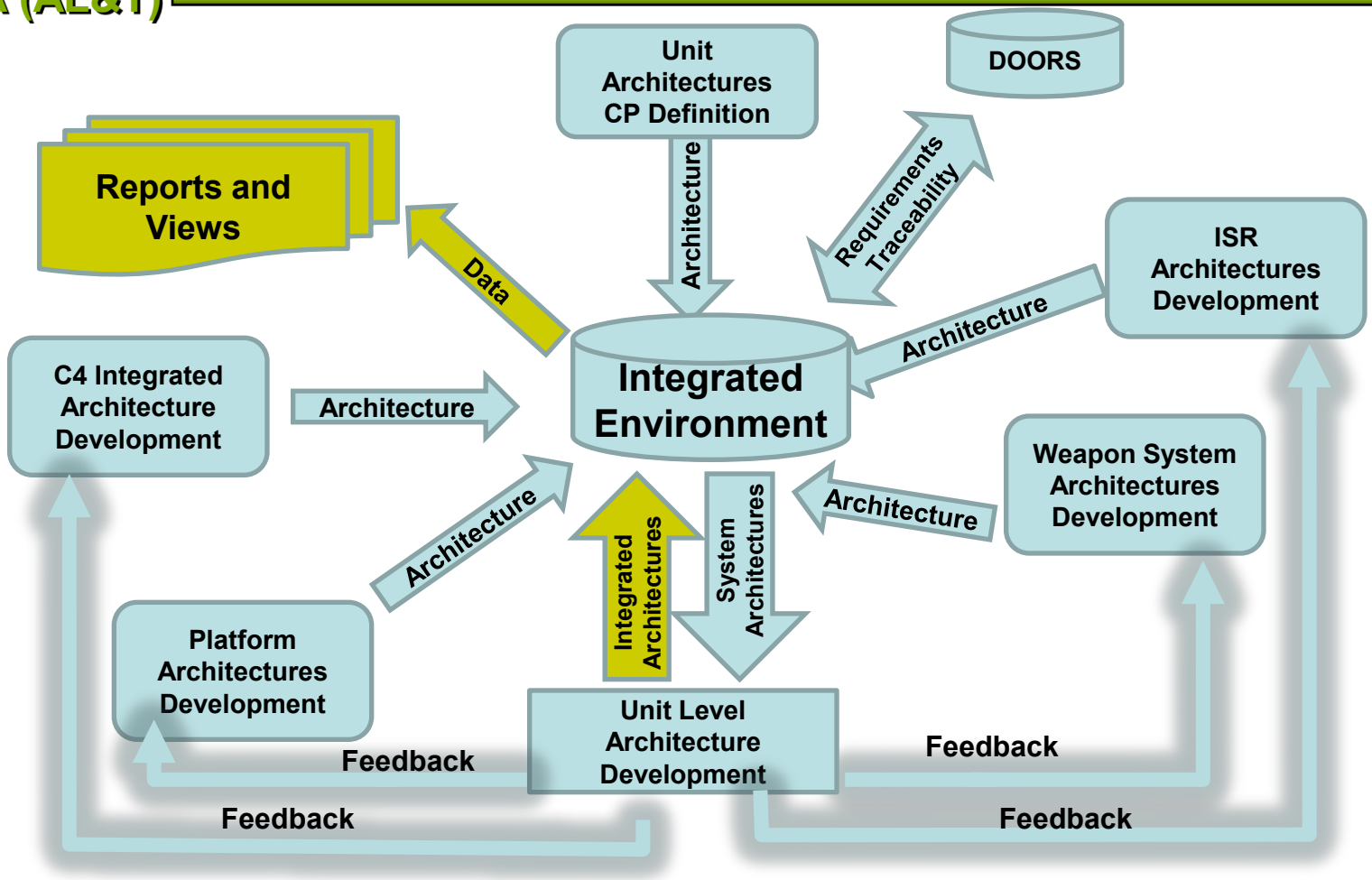


The Revised Programmed Plan (FY 11-17)



Repeat

Integrated Architecture Development Concept



Working with and across all PEOs

Using integrated systems architectures and analytical tools to perform holistic review of all acquisition portfolios that support the POM process

Architecture Application Schedule

ASA (AL&T)

Annual processes:

- Sept-May: define portfolios and architectures (C4ISR as start point)
  - Portfolio priorities and maturities are different—prioritize initial focus
  - Define interconnects across portfolios
  - Linkage of systems architectures with unit fielding timelines
  - Develop SOS SE Implementation Plan
  - Develop interaction processes between SOSE trades and TRADOC requirements process
  - Incorporates PIPs and obsolescence planning
- June: Cross-portfolio integration
- May-July: SOS trade activities
- Aug: Cross-PEO trade adjudication
- Sept: SoS decision point, SOS WSR preparation
- Oct: SoSE Weapon Systems Review portfolio position & issues
- Jan: SoSE Weapon Systems Review PoR recommended adjustments

In-parallel support to on-going activities:

- Continuous coordination with TRADOC associated with requirements
- CDRT impacts and integration

Systems-of-Systems Engineering for Army Transport

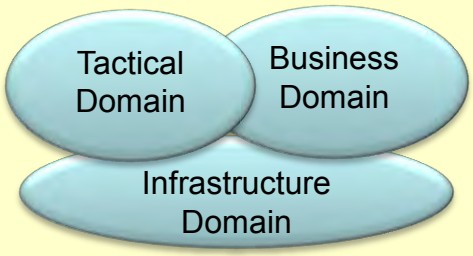
NDIA Systems Engineering Conf 27 Oct 2010

Mr. Terry Edwards
Director, ASA(ALT) SoSE
(703) 614-4540
terry.edwards@us.army.mil

System of Systems Engineering (SoSE) – Environment

ASA (AL&T)

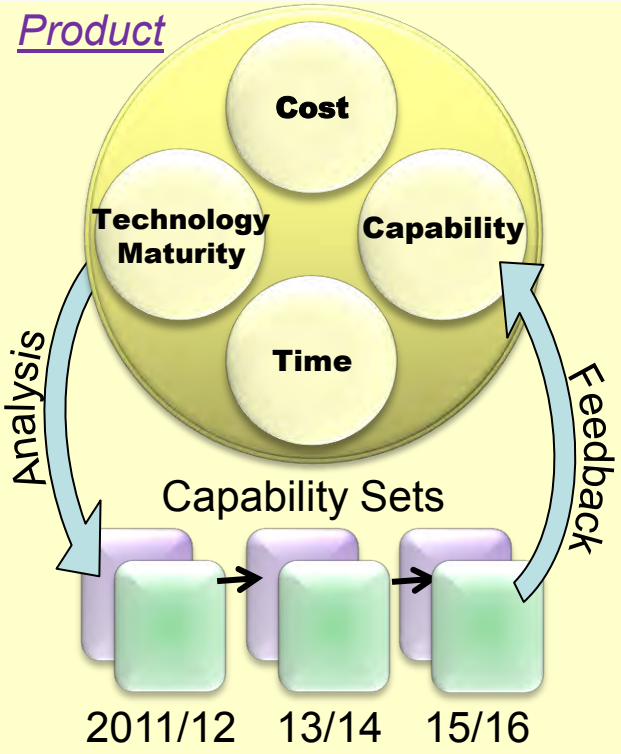
Scope



Mission

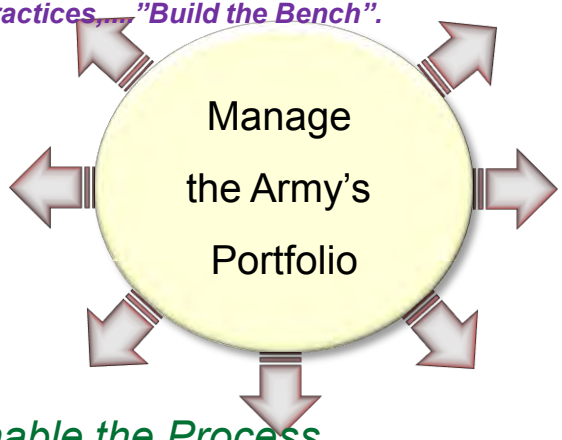
The Mission of ASA(ALT) SOSE:
Provide the Army's leadership and materiel developers with the necessary engineering/architectural products to manage and shape the Army's materiel portfolio, to ensure a System Engineering discipline across the Materiel developer community throughout the acquisition life cycle and grow the System Engineering capability within the Army – through education, engineering policy, guidelines and adoption of best industry practices,…"Build the Bench".

Product



Build the Bench

- Organize the Army Engineering Community
- Establish Technical Authority and engineering expertise/capability
- Pursue accreditation and certifications of organic workforce & organizations



Create Data Transparency

- Establish CM and an authoritative repository for products
- Establish a collaboration environment
- Establish a common operating environment for engineering Products

Enable the Process

- Establish the engineering process to deliver synchronized capability
- Establish the analytical structure with models & simulations
- Establish the engineering compliance structure/process for acquisition execution excellence
- Deliver engineering support to HQ staff and acquisition community

Manage the Portfolio

- Support the prioritization of capabilities within the portfolio
- Set the baseline architecture roadmap over time
- Support the resourcing process
- Synchronize and align the S&T, systems integration, test, and certification activities

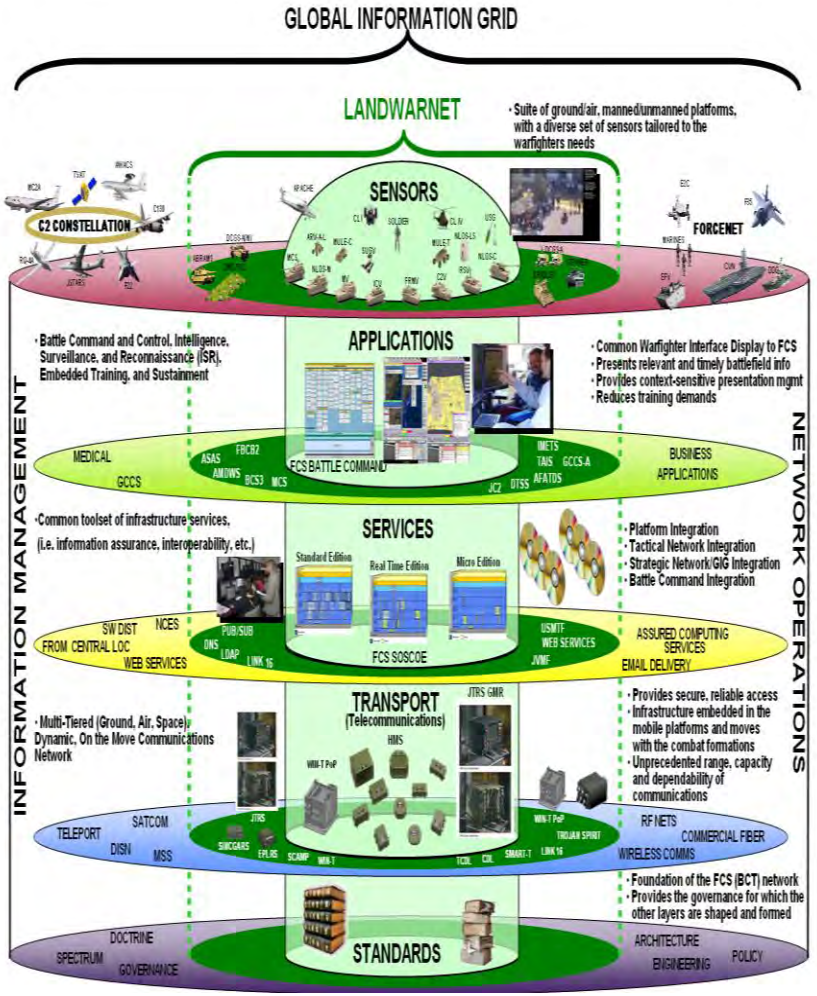
Ver. 2.7

The 'Network'

Typical 'Network' Layers
- Sensors
- Applications
- Services
- Transport
- Standards

Added
- Force Structure
- NETOPS

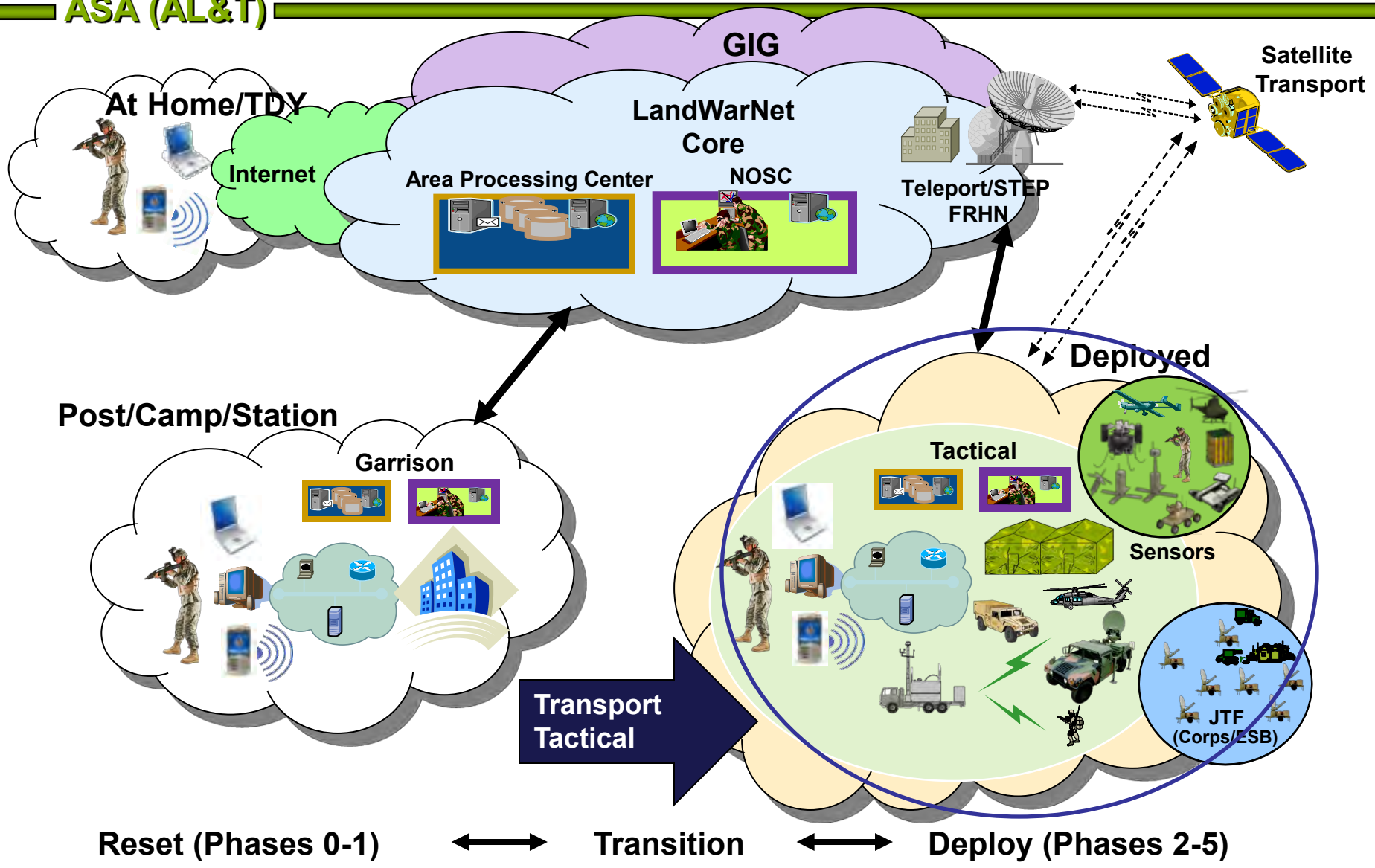
Transport Initial Focus



NETWORK = SENSORS + APPLICATIONS + SERVICES + TRANSPORT + STANDARDS + FORCE STRUCTURE + NETOPS

Army Network – Enterprise View

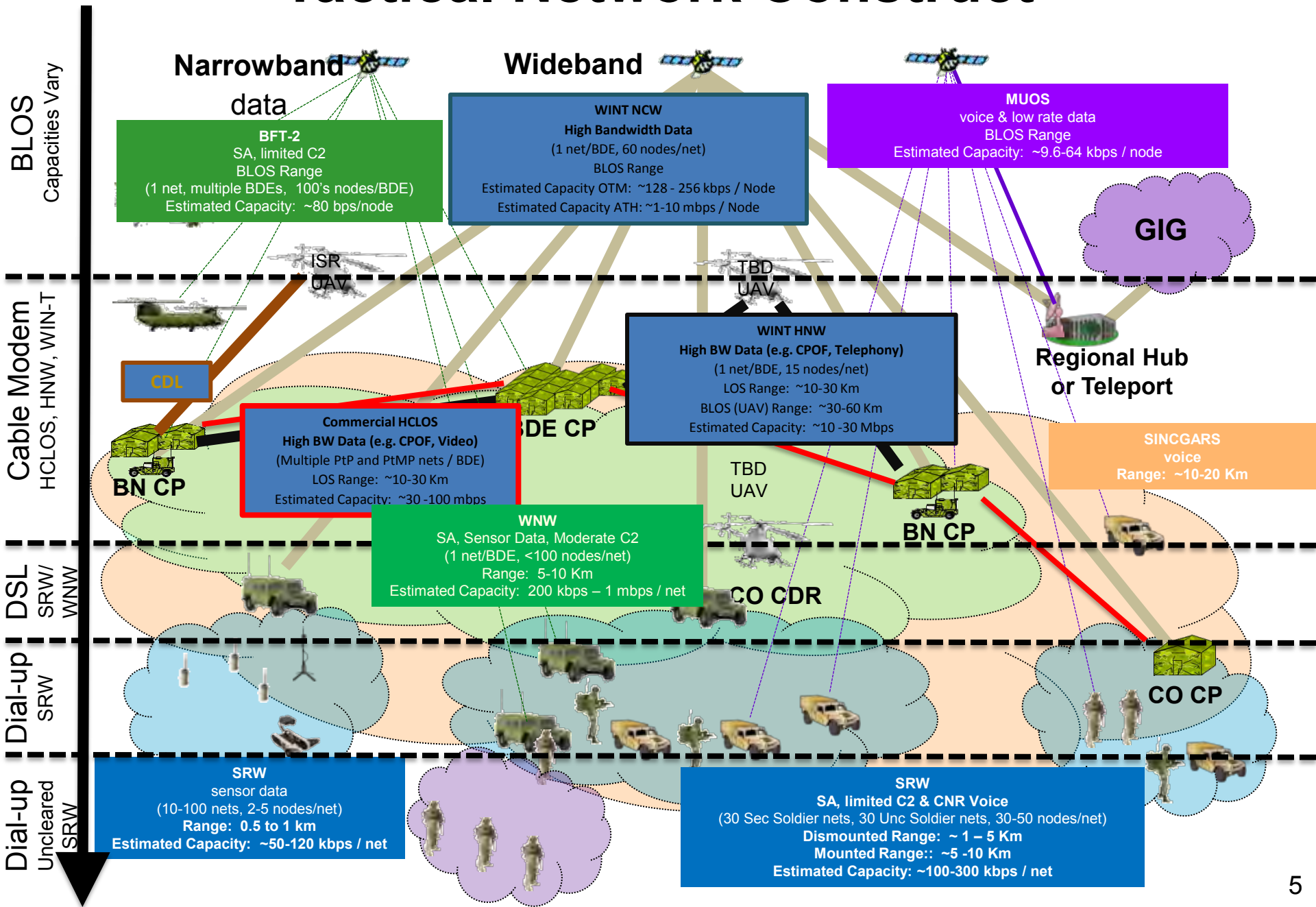
ASA (AL&T)



So

Always Accessible by The Soldier

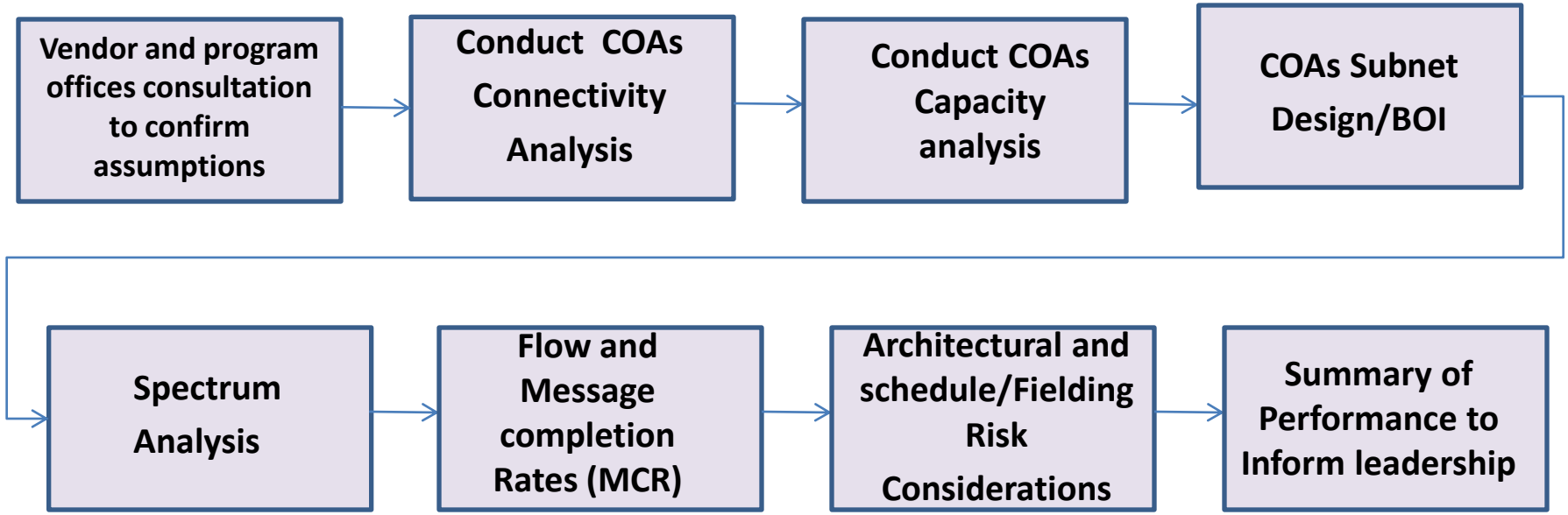
Tactical Network Construct



SoS Analysis Methodology Process

Quick Turn M&S Objectives

Provide a side by side comparison of COAs
Capture technical challenges and risks of fielding alternative radios PORs
Capture COA Schedule and Fielding Risks
Capture second and third order effects of selected Hybrid COAs



Typical Analysis Questions

ASA (AL&T)

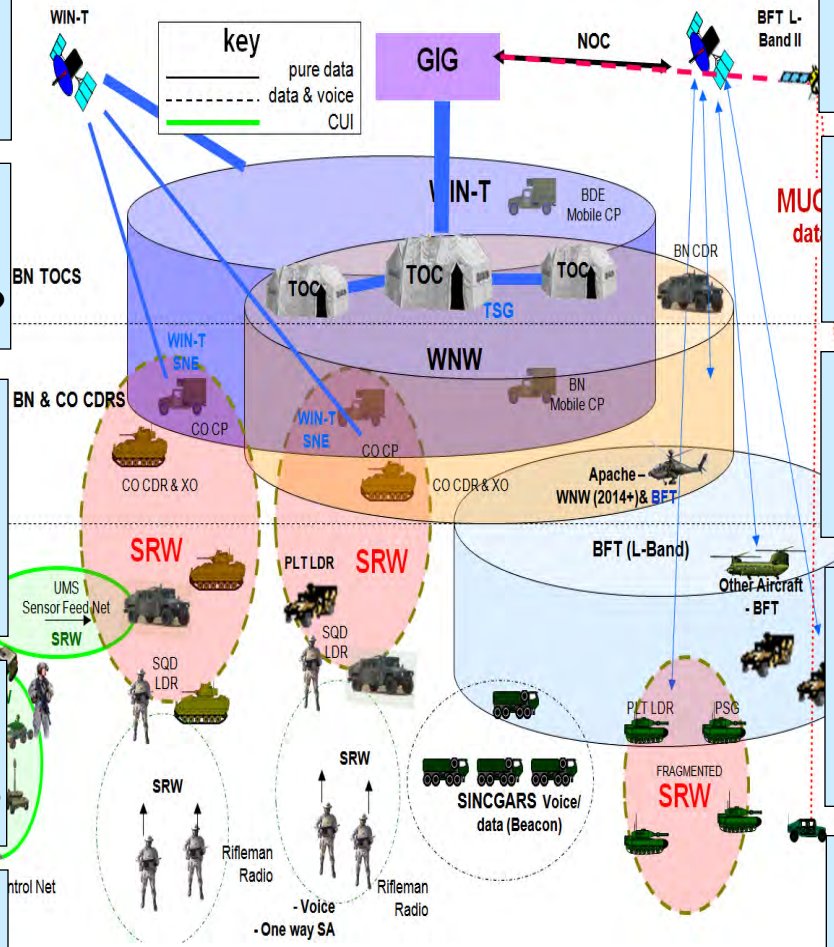
What is the right mix of SATCOM and terrestrial radios?

Will my network work if I reduce the amount of available spectrum?

What happens to my performance if I amplifier is decreased from 100 W to 50 W?

Will my network work if I reduce the amount of available spectrum?

Are dismounted soldiers within range to connect back to the network?



What altitude should my UAVs operate at?

How many UAVs do I need to heal the network?

Will the assumed traffic overload the network?

How far down in echelons should SATCOM terminals go?

How many simultaneous voice calls can my network handle?

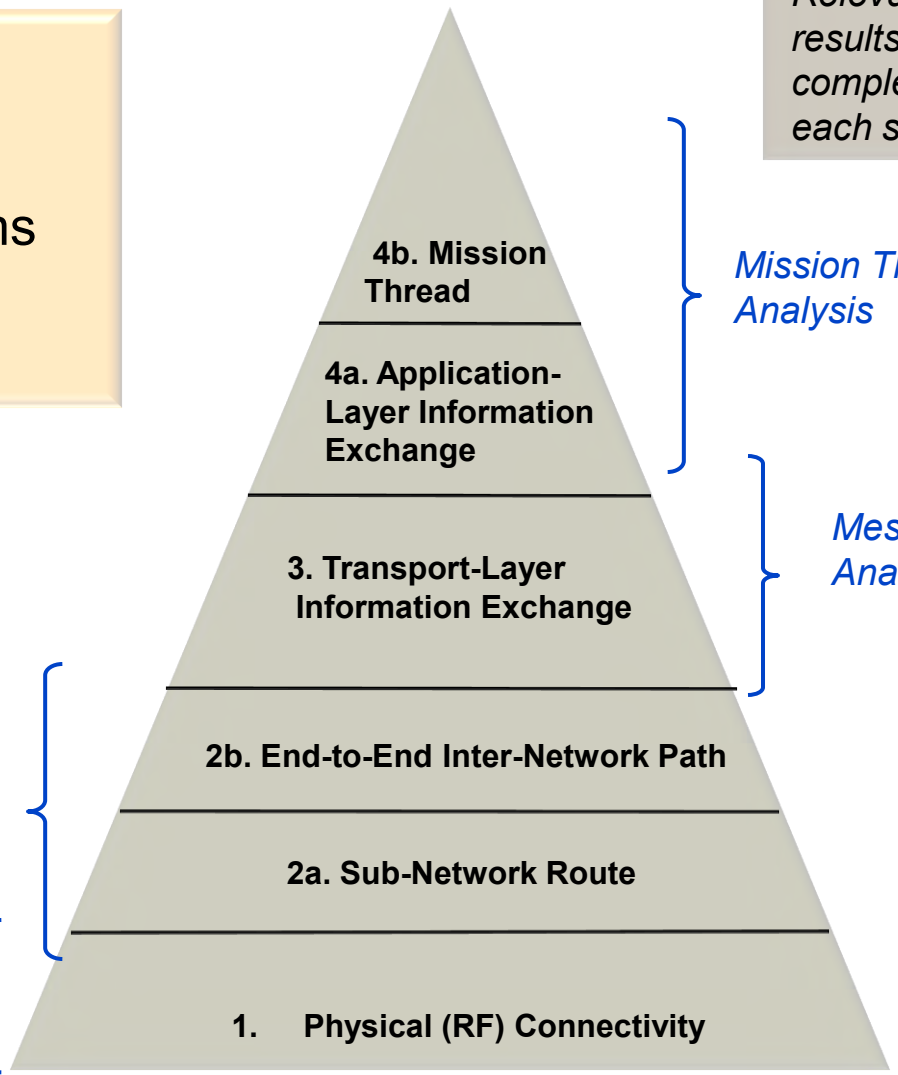
Connectivity, Capacity, and Thread Analysis

(A Layered Approach)

Performance Models

- Flow Simulation
- Communications Algorithms
- Stochastic Modeling

Relevant results at the completion of each step



Modular Analysis Approach facilitates Quick-Turn Analysis

Connectivity and Completion Rate Methodology

ASA (AL&T)

RF Link Closure - Link Budgets used to determine which links close

- Accounts for terrain and foliage
- Provides indication of achievable radio ranges

Network Loading - Use traffic profile to calculate load at each node/subnet

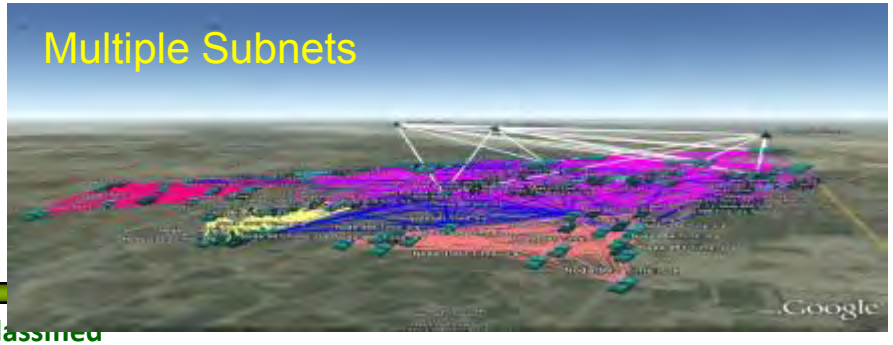
- Accounts for impact of relaying, frequency reuse, and priority
- Routing and other overheads are computed offline and decremented from waveform capacity
- Provides indication of network congestion and associated bottlenecks

Network Paths - Routing calculations determine path between any pair of platforms

- Accounts for unicast and multicast routing
- Accounts for RF link closure and heterogeneous subnet structure
- Provides network connectivity metrics

Completion Rate - Estimate fraction of data that is completed using preconfigured waveform capacities

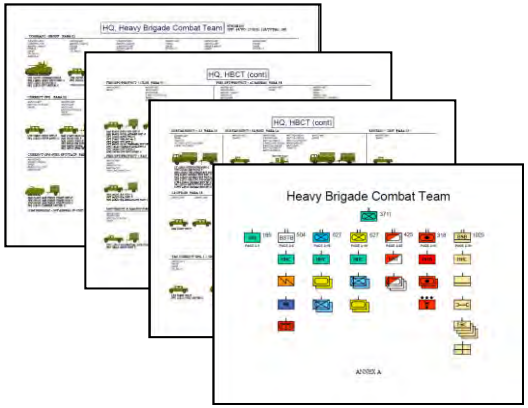
- Accounts for both terminal and subnet capacity limitations
- First order completion rate estimate

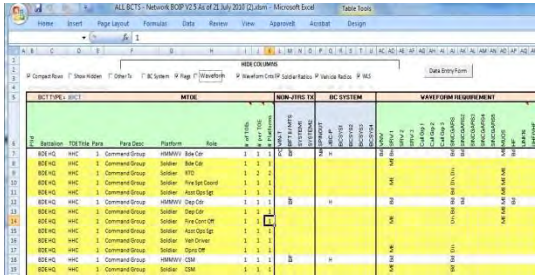


Network Basis of Issue Process

ASA (AL&T)

Force Structure and Platforms





Capture requirements, technical solutions, and radios (HW Mix)

Proponent Site Visits

- Identify Voice and Data requirements for all units

Capability Need

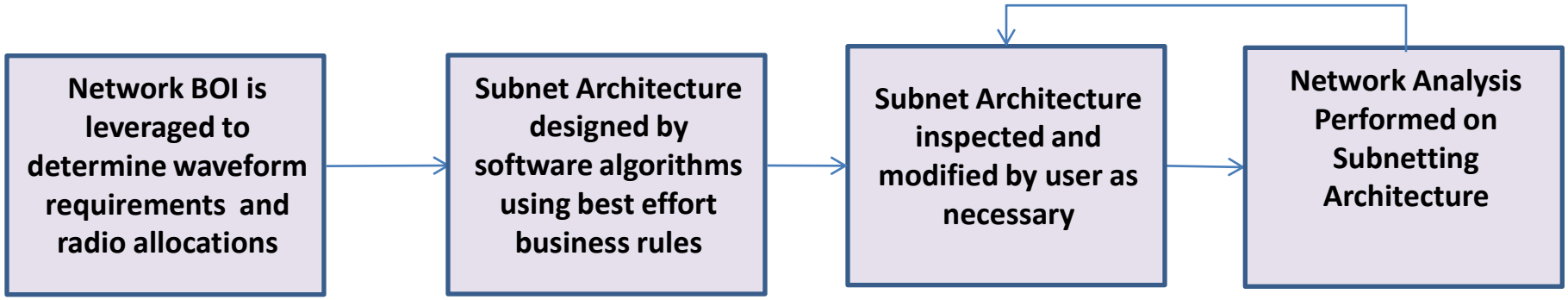
Technical Solutions

- Identify Waveforms to support requirements

- Identify HW mix to support Waveforms

Tradeoff Analysis

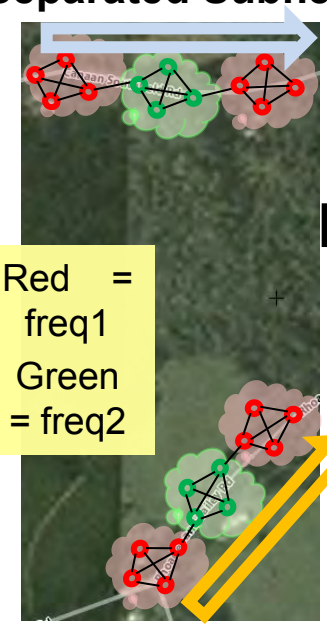
Subnet Design Process



- Subnet Design is based on several factors
  - Waveform limitations. (e.g. Scalability, Range, Netted Voice considerations)
  - Platform, Unit requirements, expected data dissemination flows
- Every subnet architecture must start with a Basis of Issue
  - Utilize Radio allocation and networking requirements to design subnet architecture
- Subnet Design is iterative
  - Analysis can uncover issues with subnet architecture implementations which will require modifications to subnet architectures

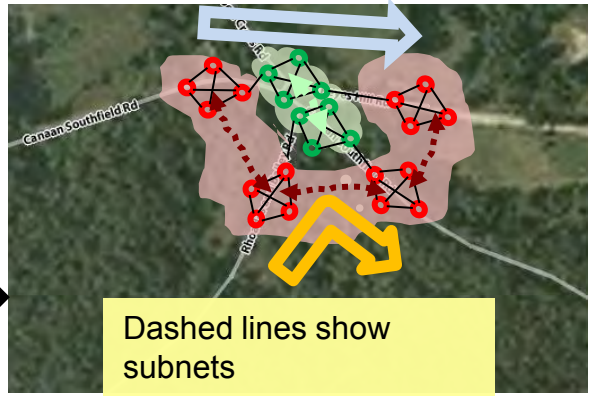
Spectrum Analysis

Separated Subnets



Red = freq1
Green = freq2

Co-located Subnets



Dashed lines show subnets
- Joining

or
- Interfering

- With sufficient spatial separation, Red & Green frequencies can be reused without sharing (overlapping) of bandwidth (i.e., spatial reuse)
- Depending on the waveform, as columns move within the same vicinity, platforms on the same frequency can *connect (e.g., a network join in the data plane), overlap (e.g., contention in the control plane), or interfere (e.g., noise at the physical layer)*
- More nodes must share the bandwidth of each frequency (more demand, same bandwidth) potentially resulting in an increase in message delays and losses

Analysis utilizes best case frequency reuse algorithm to determine number of channels needed (degree of reuse)

Starts all subnets on same frequency and calculates interference; moves one subnet at a time to new frequency until interference is manageable

Analysis is more than just a tool…

- Network analysis is much more than running a tool/simulation
  - Tools enable the systems engineer to perform their tasks
- A System engineer must understand the "big picture"
  - Identify system level tradeoffs
  - Make educated assumptions when necessary
  - Scope the analysis to the appropriate level
  - Provide recommendations to optimize net-centricity

- **A SoS engineer performs analysis with often lacking or incomplete data**
  - Agreeing upon the analysis inputs is often the most challenging part of analysis
  - Make assumptions where appropriate
  - Differentiate between essential data and non-essential data
  - Understand how abstractions and assumptions affect analysis results

Closing Remarks

- Keys to effective SoS analysis
  - Understanding System Requirements
  - Need subject Matter Expertise applied to analysis process
  - Employment of appropriate tools and techniques
  - Understanding latitude for system trades

Systems Engineering for Systems of Systems: Update

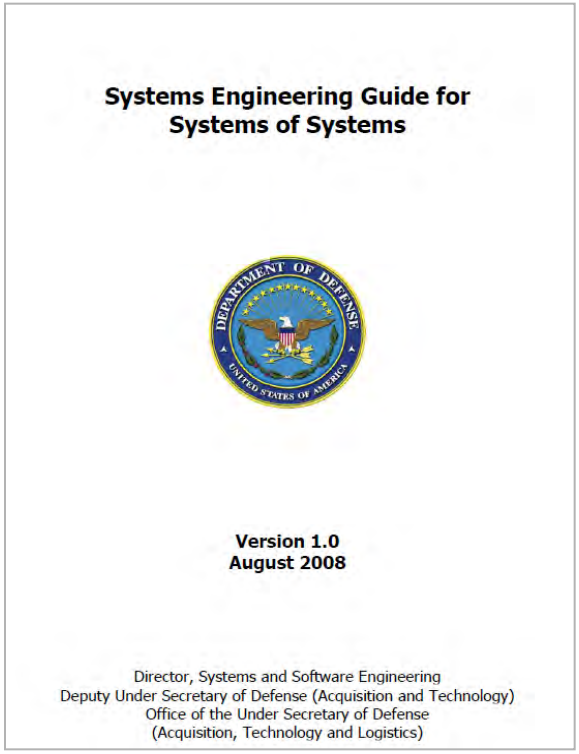
Dr. Judith Dahmann, MITRE

Systems Engineering Directorate

Office of the Director, Defense Research and Engineering

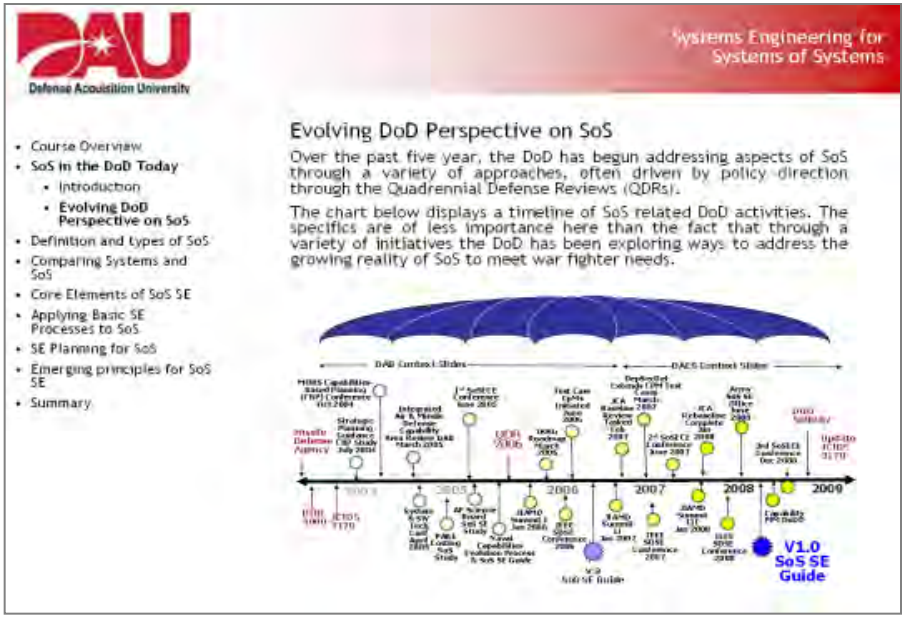
Background

- **DoD SoS SE Guide was published in late 2008 and is now being applied in a variety of settings across the DoD**
- **Current DDR&E SoS emphasis is on implementation, with major activities focus on**
  - Outreach
    - DAU Continuous Learning Module
    - NDIA SoS SE Committee, SharePoint and Webinars
  - Collaboration – TTCP and DoD SoS Initiatives
  - Initiatives to support SoS SE Implementation
    - SoS and T&E
    - SoS and Development Planning
    - SoS Artifacts
    - SoS 'Wave' Model
- **Next Steps**



UNCLASSIFIED

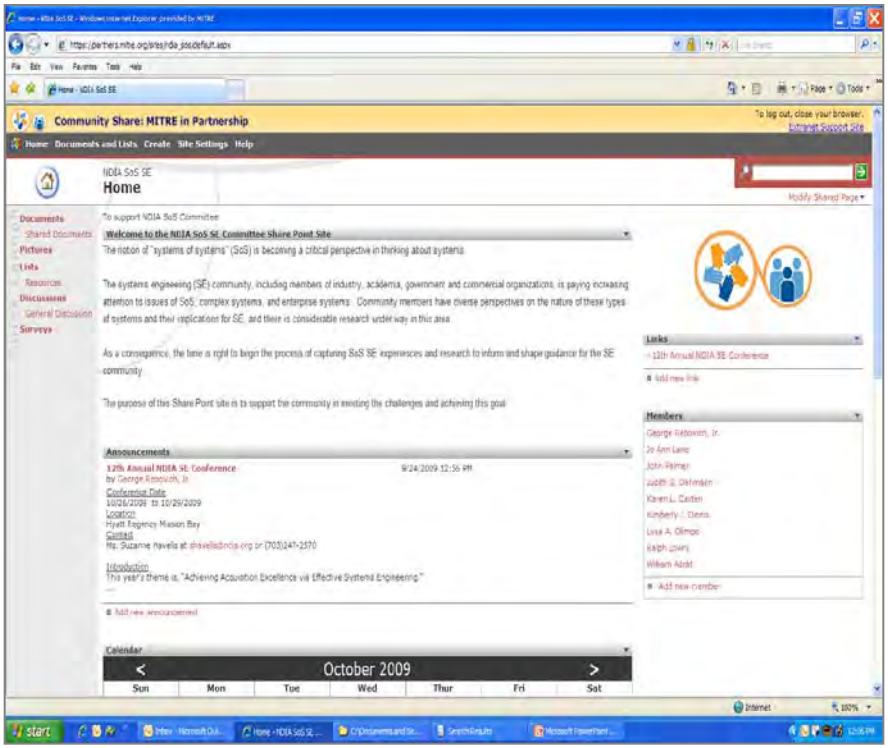
Outreach
SoS SE Continuous Learning Module



- Defense Acquisition University (DAU) provides education and training to US DoD workforce
- SoS SE Continuous Learning Module (CLM) is in development
  - Presents critical information from the SoS SE Guide
  - Online offering, 3-4 hour course
  - Expected to be available ~December 2010

UNCLASSIFIED

Outreach
NDIA SoS SE Committee



- National Defense Industrial Association (NDIA) Systems Engineering Division (SED)
  - Forum for industry, government and academic collaboration
- SoS SE Committee created in Feb 2009
  - Meet every 2 months (20-50 participants)
  - Identify areas of common interest; current focus
    - SoS and T&E
    - Approaches to SoS Assessment
  - Sponsor track at Annual NDIA SE Conference
    - Webinar Series

UNCLASSIFIED

Outreach
SoS SE Webinar Series

Systems of Systems Engineering Collaborators Information Exchange (SoSECIE)

Co-Sponsored by the
Director, Systems Analysis
DDRE Systems Engineering
And
National Defense Industrial Association (NDIA)
Systems Engineering Division
Systems of Systems Committee
Judith Dahmann,Mitre and John Palmer, Boeing Co-Chairs

- Twice monthly webinar on topics of interest to SoS SE Community
- Began with selected presentations from initial NDIA SE Conference SoS SE Track with added presentations from other venues
- Presentations are available on DDR&E Website and NDIA SoS SE Share Point Site

UNCLASSIFIED

Outreach
SoS SE Webinar Series

- **An Introduction to Influence Maps: Foundations, Construction, and Use**
  February 23, 2010**,** Jim Smith, SEI
- **On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems**
  March 9, 1010, J. M. Zentner, T. R. Ender, S. Balestrini-Robinson, Georgia Tech
- **A Distillation of Lessons Learned from Complex System of Systems Acquisitions**
  March 23, 2010, Richard Turner and Dinesh Verma, Stevens, Mark R. Weitekamp, ANSER, Ann Tedford, Federal Aviation Administration
- **Dynamic Modeling of Programmatic and Systematic Interdependence for System of Systems**
  April 13, 2010, Dan DeLaurentis, Purdue and Brian Sauser, Stevens
- **SysML Strategies to Characterize and Analyze Systems of Systems**
  April 27, 2010, Dr. Jo Ann Lane, USC and Tim Bohn, IBM
- **System of Systems Interoperability Challenges and Potential Approaches: Reports from the Field**
  May 25, 2010, Dr. Carol Sledge, SEI
- **Assurance Cases for Analysis of Complex System of Systems Software**
  June 8, 2010, Stephen Blanchette, Jr., SEI
- **System of Systems Artifacts**
  July 13, 2010, Dr. Judith Dahmann, Mitre
- **Accelerating System of Systems Engineering Understanding and Optimization through Lean Enterprise Principles**
  July 27, 2010, Dr. Jo Ann Lane, USC and Dr. Ricardo Valerdi, MIT

UNCLASSIFIED

Collaboration
US DoD and International

- The Technical Cooperation Program
  - Joint Systems Analysis Technical Panel 4: SE and Modernization SoS SE focus area with active interest by US, UK, Canada, and Australia
    - Focus on SoS SE Artifacts
    - Shared lessons learned from nations

- DoD Components and Agencies have been instituting SoS SE efforts or applying SE to SoS areas
  - DDR&E SE collaboration with these activities to
    - Share experiences
    - Identify areas of common interest
    - Understand experience with application of DoD SoS SE Guidance
    - Assist in developing component specific guidance

UNCLASSIFIED

Initiatives
SoS and T&E

- Topic of 2009 in NDIA SoS SE Committee
- IEEE SoSE Conference 2010 Paper : SoS and T&E Challenges
  - Distinct characteristics of systems of systems that impact their test and evaluation
  - Unique challenges and strategies
  - Recommendations drawn from experiences of active SoS SE practitioners
- Foundation for August 2010 SoS and T&E Workshop

Systems of Systems Test and Evaluation Challenges

Dr. Judith Dahmann
MITRE
McLean, Virginia USA
jdahmann at mitre.org

Dr. Jo Ann Lane
University of Southern California
Los Angeles, California USA
jolane at usc.edu

George Rebovich
MITRE
McLean, Virginia USA
rebovich at mitre.org

Ralph Lowry
Modern Technology Solutions, Inc.
Alexandria, VA USA
ralph.lowry at mti-va.com

Abstract—*A growing number of military capabilities are achieved through a system of system approach and this trend is likely to continue in the foreseeable future. Systems of systems differ from traditional systems in ways that require tailoring of systems engineering processes to successfully deliver their capabilities. This paper describes the distinct characteristics of systems of systems that impact their test and evaluation, discusses their unique challenges, and suggests strategies for managing them. The recommendations are drawn from the experiences of active system of system engineering practitioners.*

Keywords: System of systems engineering, test and evaluation, test techniques.

1 Background and Introduction

The United States (US) Department of Defense (DoD) recognizes the importance of systems of systems (SoS) in meeting user capability needs. The *DoD Guide for System Engineering of Systems* [1] SoS SEG defines SoS as a "collection of systems, each capable of independent operation, that interoperate to gather to achieve additional desired capabilities" SoSs differ from traditional systems in ways that require tailoring of systems engineering (SE) processes. The distinctive characteristics of SoS have implications for the application of test and evaluation (T&E) to SoS.

T&E for SoS has traditionally been addressed in the US DoD from the perspective of testing individual systems in an operationally realistic environment as well as certifying system interoperability. [2]. Here the focus is on T&E of the individual system in the larger context with attention on the issues of how to cost-effectively create the test environment.

More recently the US DoD has begun to shift from a system perspective to a capability perspective where the value to users is the collective effect of a set of systems rather than any one system. This leads to questions about how to define capabilities and how to integrate and test at the SoS level [1, 3, 4, 5].

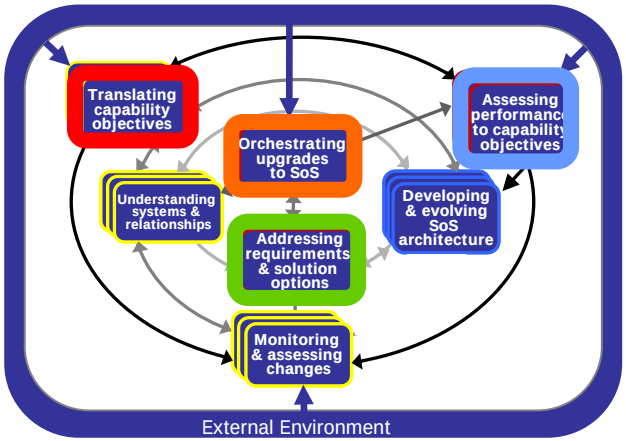
This paper looks at SoS and T&E from the perspective of systems engineering and addresses the questions: What are the critical characteristics of SoS that affect T&E? What are the T&E implications for SoS? The answers to these questions draw on the experiences of SE practitioners currently working in SoS, including those used as the basis for the SoS SEG [1]. This paper covers the characteristics of SoS as they impact T&E, and how aspects of T&E are addressed by the practice of SoS SE. Finally it discusses the implications for T&E of SoS, including specific challenges and the strategies currently employed to address them.

The focus of this paper is on '*acknowledged* SoS'. *Acknowledged* SoS have recognized objectives, a designated manager, and resources for the SoS; however, the constituent systems retain their independent ownership, objectives, funding, development and sustainment approaches. Changes to the constituent systems are agreed collaboratively between the SoS and the systems. Many SoS in the DoD today exhibit the characteristics of acknowledged SoS since the DoD has adopted a de facto strategy to maintain and leverage currently fielded systems to meet new and emerging needs wherever possible. For budgetary reasons, this is likely to continue well into the future.

This paper also applies to "mission-level" SoS where multiple platforms, information technology (IT) and other systems are brought together to meet large mission level capability objectives. Other SoS, such as platform-level SoS (integration of separately developed systems on a subsystem for instance) and IT-based SoS (where information across an SoS is managed as an enterprise asset), share some of the issues addressed here, but they have their own specific considerations, as well.

2 SoS Characteristics that Impact T&E

SoS present unique development challenges. These result from several factors, including broad based mission level SoS capability objectives, lack of control by the SoS over the constituent systems, and the dependence of SoS

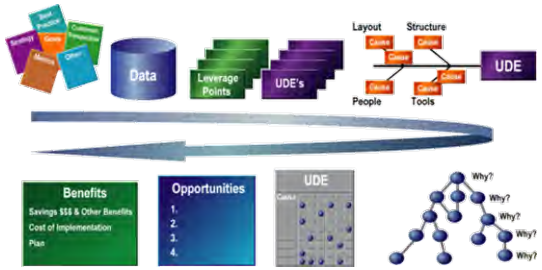


UNCLASSIFIED

Initiatives
SoS and T&E Workshop (1 of 2)

- Sponsored by NDIA SoS SE and DT Committees
- ~25+ participants from T&E and SoS Communities
- Facilitated by Martin Leek, Raytheon
- Developed insights into 5 issues identified prior to the workshop
- Identified 8 potential areas for action
- Selected 3 for follow up

Data Collection:
SoS White Paper
SE Conference Papers



Improvement Areas:
Strategic Initiatives
Collaborative Go-Do

Potential Problem Areas
1. *Future T&E for Systems brought together as SoS*
2. *Requirements*
3. *Metrics*
4. *Systems Changes*
5. *End to End Testing with systems not yet available*

Potential Causes
If we could only fix one thing, it would be _____

Leverage Matrix
Map Causes to problem areas

T&E in SE Track
10604 – T&E Issues for SoS
Wednesday 8AM
Palm II

NDIA
SoS SE Committee
DT&E Collaboration
August Workshop

August 2010

9/24/2010 1

UNCLASSIFIED

Initiatives
SoS and T&E Workshop (2 of 2)

Strategic Initiatives

- **Best Practices Model for SoS T&E**
  - Develop and validate T&E model for SoS as a
    - Continuous improvement process
    - Provides information on 'capabilities and limitations' of SoS to end users and feedback to SoS SE on areas for attention
    - Leverages various non-traditional methods for generating 'test type' data
  - Identify use cases and investigate as basis for assessing model
  - Objective is to publish a validated model as an SoS T&E community best practice

Focus for 2011 NDIA SoS SE

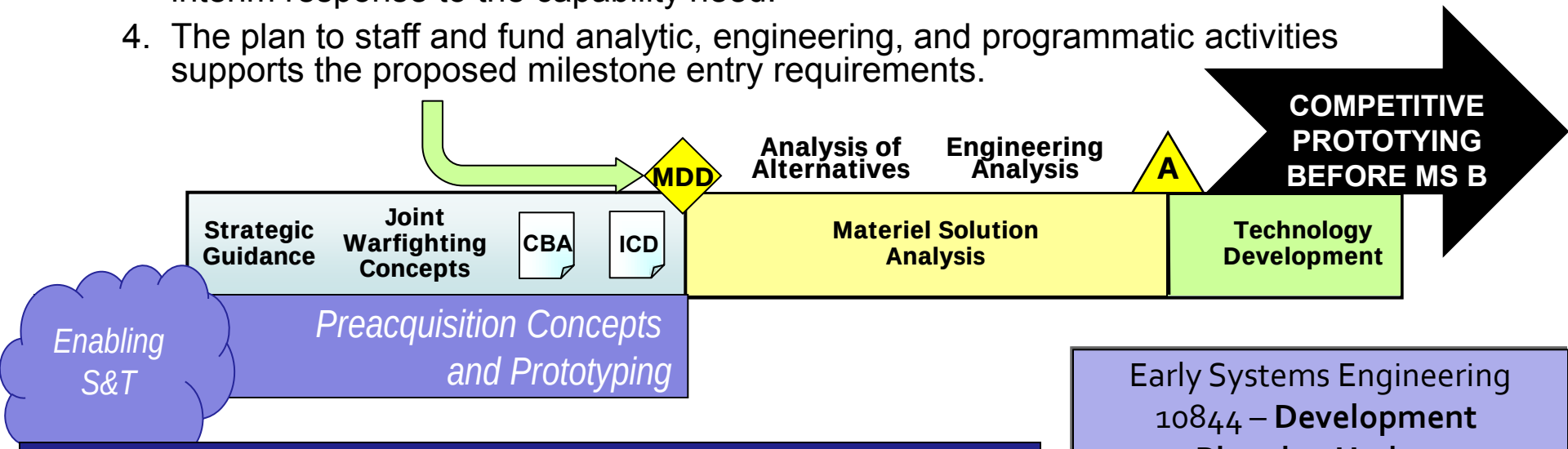
- **Radical Approach to SoS T&E**
  - Investigate the concept of replacing DT, OT, NR-KPPs, etc. with an overall SoS capability test.
- **SoS Governance**
  - Minimum set of characteristics that are required to govern SoS T&E efforts

UNCLASSIFIED

Initiatives
New Development Planning Policy

Development Planning Policy Memo (DTM 10-017) establishes new MDD Entrance Criteria

1. The candidate materiel solution approaches have the potential to effectively address the capability gap(s), operational attributes and **associated dependencies**.
2. There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data.
3. Consideration has been given to near term opportunities to provide a more rapid interim response to the capability need.
4. The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirements.



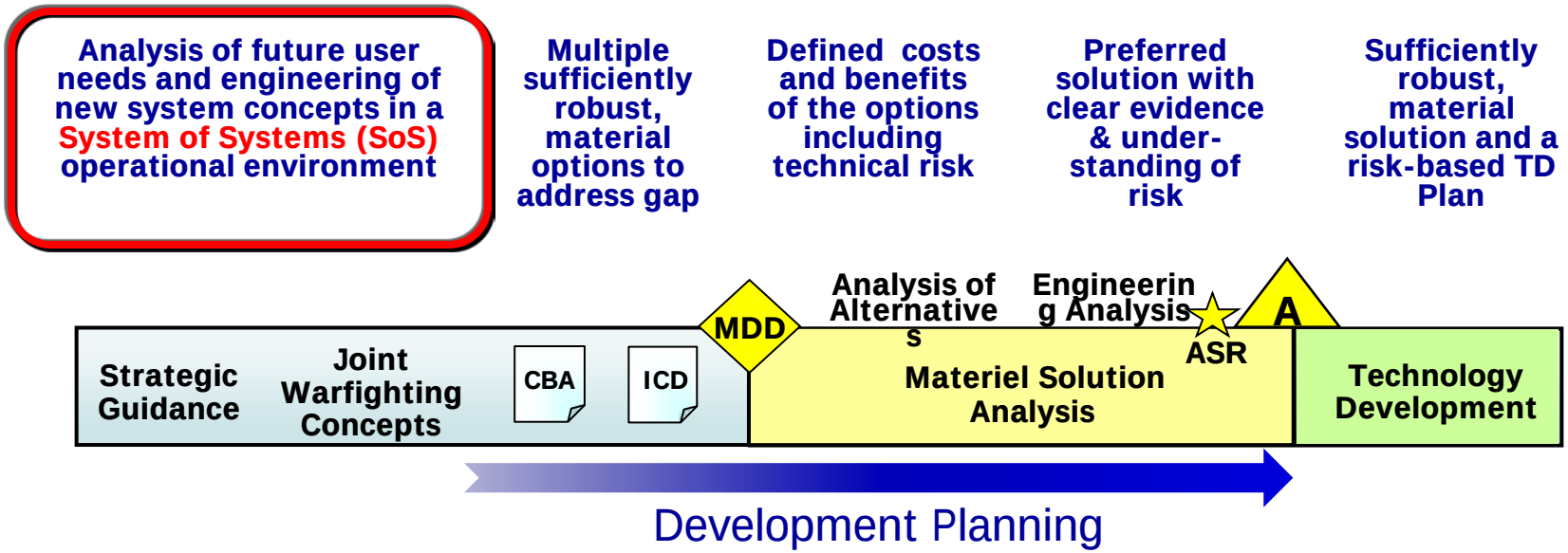
MDD is the lever to provide greater technical and engineering foundation for initiating an acquisition

Early Systems Engineering 10844 – **Development Planning Update**
Wednesday 8AM
Mission 1

UNCLASSIFIED

Initiatives
SoS in Development Planning

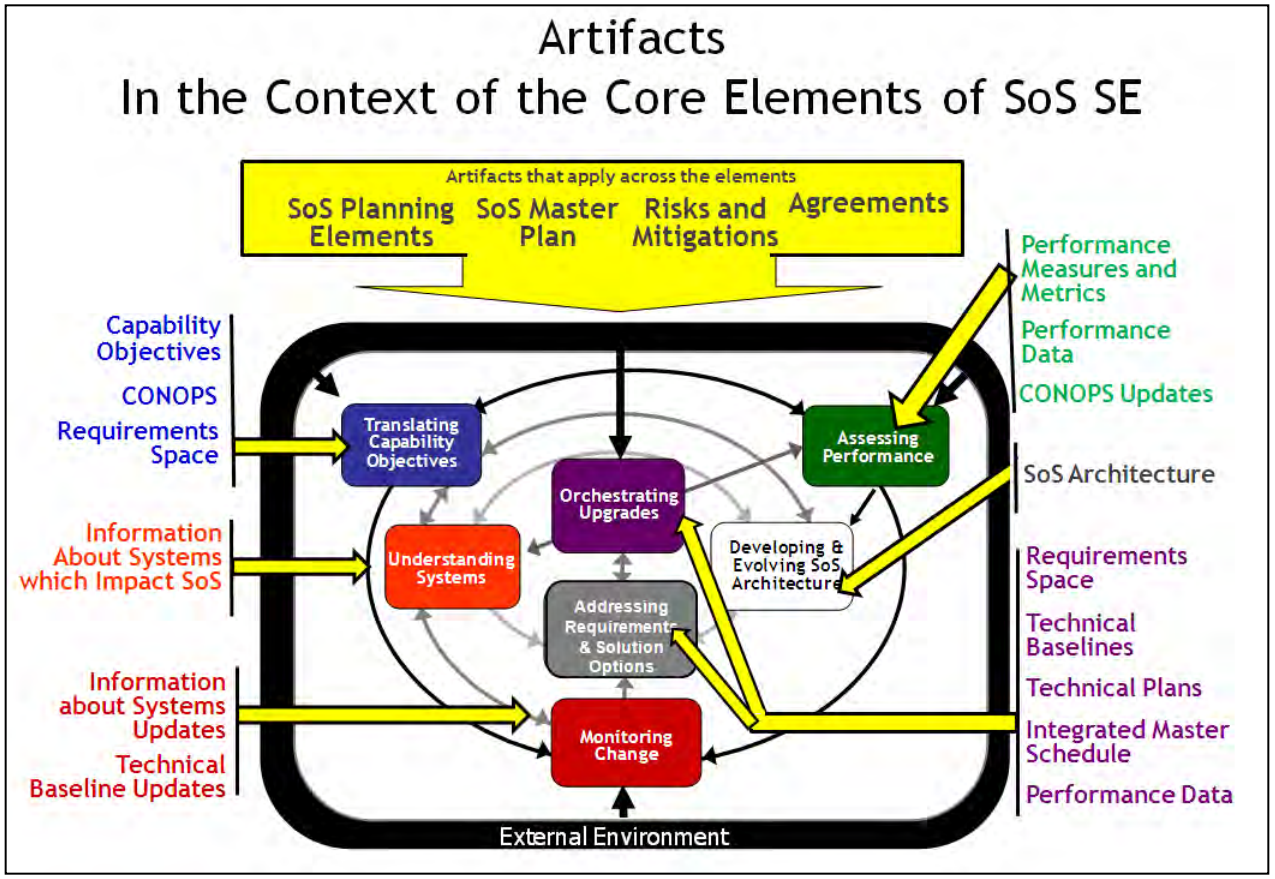
- Development planning activities span the lifecycle, including:



Development Planning is the upfront technical preparation to ensure successful selection and development of a materiel solution

UNCLASSIFIED

Initiatives
SoS SE Artifacts



System Engineering Artifacts for SoS

Dr. Judith Dahmann and George Rebovich
MITRE
McLean, VA USA
{jdahmann, grebovich} at mitre.org

Dr. Jo Ann Lane
Department of Industrial and Systems Engineering
University of Southern California
Los Angeles, CA USA
joanne at usc.edu

Ralph Lowry
Modern Technology Solutions, Inc.
Alexandria, VA USA
ralph.lowry at mtsi-va.com

Abstract— This paper describes system of systems (SoS) systems engineering (SE) artifacts, compares and contrasts them with similar ones developed and used for individual systems, and explains how they are used to guide SoS engineering processes. The paper concludes with next steps for using SoS artifacts to continue maturing the understanding of SoS SE in an international cooperative effort with the United Kingdom, Australia, and Canada.

Keywords-component; system of systems, system of systems engineering, engineering artifacts

I. BACKGROUND AND MOTIVATION

The system of systems (SoS) systems engineering (SE) community is evolving SE processes to better apply SE to broadly defined SoS capabilities which span multiple systems. The knowledge from these efforts includes a greater awareness of SoS characteristics which create SE challenges, a recognition that some activities are unique to SoS SE, and ways to better employ fundamental SE processes in an SoS environment. Building on this knowledge, a United States (US) team is identifying key SoS SE artifacts (work products) and applying them to SE of SoS. The focus is on the critical information included in the artifacts rather than the documents. The objective is to develop a common set of concrete approaches to applying SE to SoS by understanding SE artifacts developed and used in SoS SE today.

II. SYSTEMS ENGINEERING FOR SYSTEMS OF SYSTEMS

With the increased emphasis on capabilities and networking, the US Department of Defense (DoD) is recognizing the criticality of effective end to end performance of SoSs to meet user needs. While acquisition processes continue to focus on systems, system requirements are increasingly based on assessment of gaps in user capabilities that require integration across systems. Thus, the role of systems engineering is expanding to the engineering of SoS that provide user capabilities. This dynamic is occurring in other arenas as well and in many beyond defense to include civilian and commercial enterprises.

Applying SE to SoS requires an understanding of the characteristics of SoS and their impact on basic SE processes which have traditionally been applied to the development of new, individual systems. An SoS is defined as a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities [1]. A primary interest in SoS SE concerns "acknowledged" SoS [2]. This type of SoS leverages existing system capabilities to address new needs while recognizing the programmatic and operational autonomy of the systems. Acknowledged SoS have top level objectives and governance and have SE teams working at the SoS level. These operate in concert with SE teams for the constituent systems. Acknowledged SoS are common in the DoD. Examples include the Single Integrated Air Picture, Ballistic Missile Defense System and Naval Integrated Fire Control Counter Air [3]. This paper is based on interviews with practitioners working in this environment conducted as part of the development of the DoD guide for SE of SoS [3] and the artifacts described here apply to acknowledged SoS. Future work will investigate their applicability other types of SoS.

The analysis of SoS SE efforts in DoD today has identified a set of core elements of SE in an SoS environment. SoS systems engineers focus attention on the core elements as they evolve an ensemble of multiple existing and new systems to meet user capability objectives:

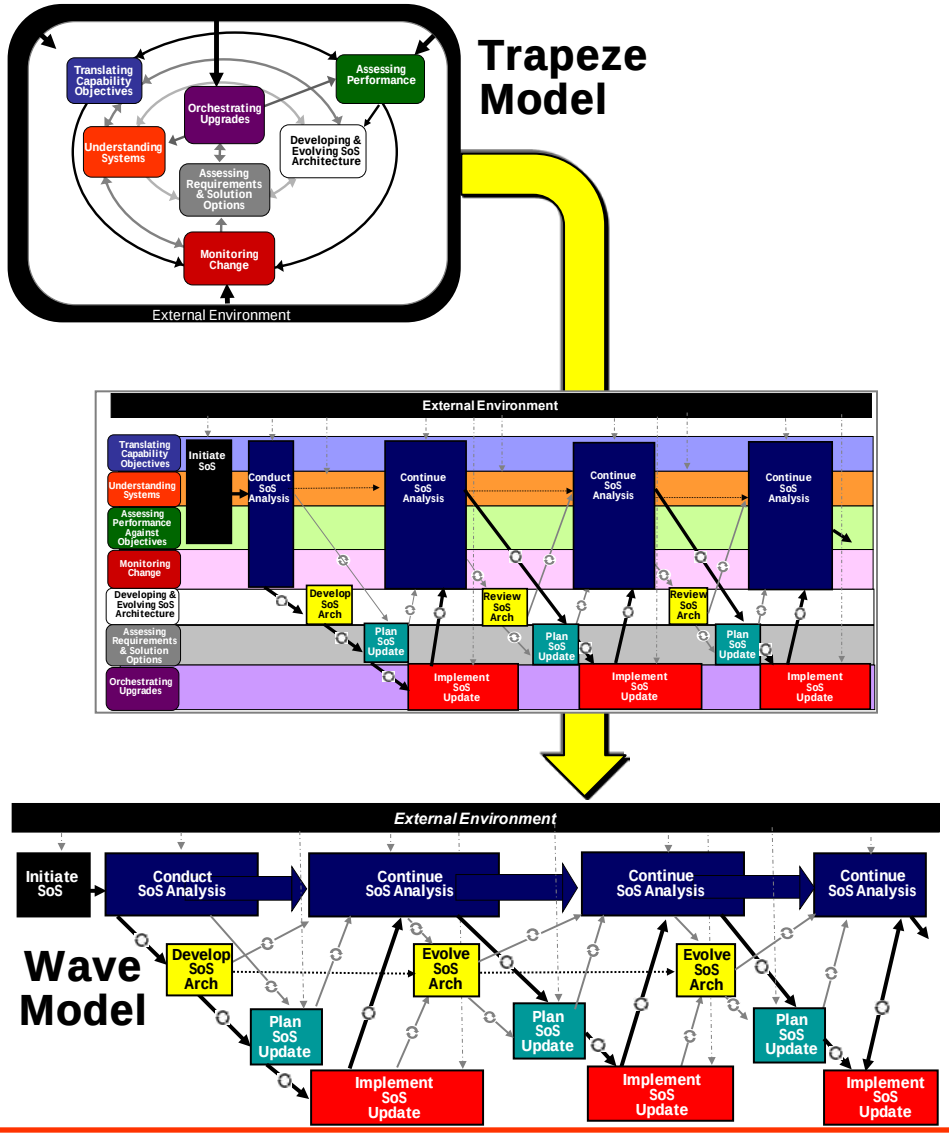
"In SoS SE, systems engineers are key players in the core elements of: (1) translating SoS capability objectives into SoS requirements, (2) assessing the extent to which these capability objectives are being addressed, and (3) monitoring and assessing the impact of external changes on the SoS. Central to SoS SE is: (4) understanding the systems that contribute to the SoS and their relationships, (5) developing an architecture for the SoS that acts as a persistent framework for (6) addressing SoS requirements and solution options. Finally, the SoS systems engineer (7) orchestrates enhancements to the SoS, while monitoring and integrating changes made in the systems to improve the performance of the SoS." [3]

Described in 2010 IEEE Systems Conference Paper

SoS SE Artifacts Developed as Part of an International SoS SE project under The Technical Cooperation Program (TTCP)

UNCLASSIFIED

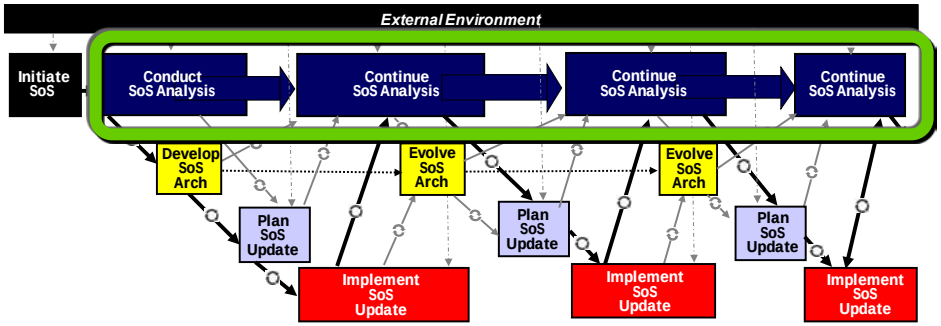
Initiatives
Implementers View of SoS SE



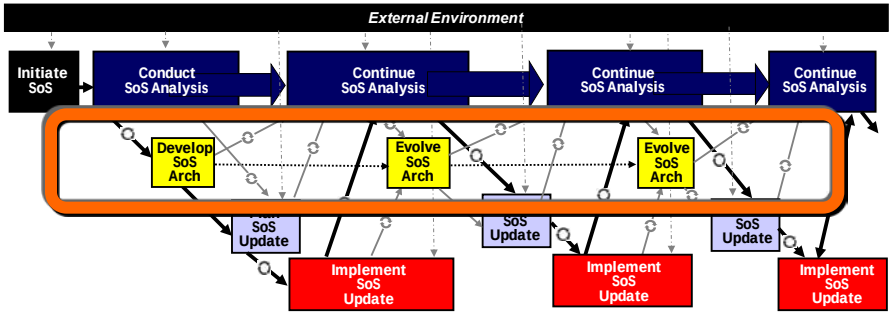
- Trapeze Model
  - Presents the core elements of SoS SE and relationships
  - Provides a good 'conceptual' view of SoS SE
  - Not very useful to practitioner to help chart an implementation approach
- Wave Model
  - 'Unwinds' the trapeze model
  - Provide a view of SoS SE in terms of series of major steps in implementing an SoS SE process
  - More intuitive for an implementer

UNCLASSIFIED

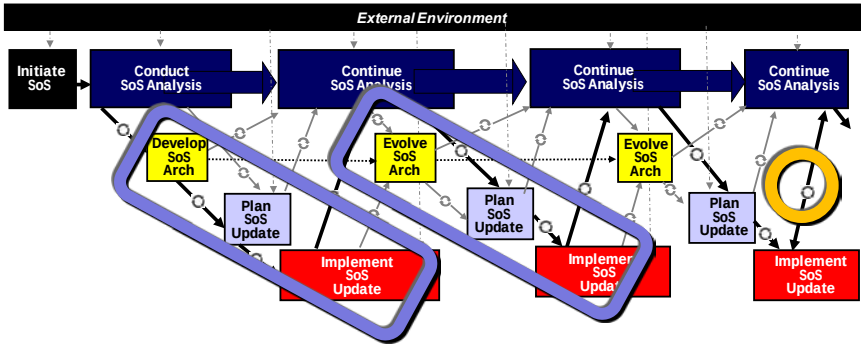
Implementer View – Key Features



Backbone of ongoing analysis



Architecture Evolution



Multiple overlapping iterations of SoS evolution

Forward movement with possible iterations

UNCLASSIFIED

SoS SE Activities At Each Step

Initiate SoS

Establish the foundation for the SoS SE including an understanding of objectives, key users, user roles and expectations, and core systems supporting capabilities

Conduct SoS Analysis

Establish initial 'SoS Baseline' based on the CONOPs including
- Measures of SoS performance
- Data on current performance
- Understanding how systems currently support SoS
- Risks and mitigations

Develop *initial* plans for the SoS engineering including
- Key planning element (Battle rhythm, organization, decision processes, roles and responsibilities)
- Agreements with critical players (users, constituent systems)
- SoS Master Plan

Continue SoS Analysis

Update 'SoS Baseline' based on
- Changes in objectives, CONOPs or external factors
- Results of the last SoS update
- Data on SoS performance
- Data on unanticipated factors
- Changes in systems
- Risks and mitigations

Update plans including
- Key planning element (Battle rhythm, organization, decision processes, roles and responsibilities)
- Agreements with critical players (users, constituent systems)
- SoS Master Plan

Develop SoS Arch

Develop the persistent technical framework for addressing SoS evolution and a migration plan identifying risks and mitigations

Evolve SoS Arch

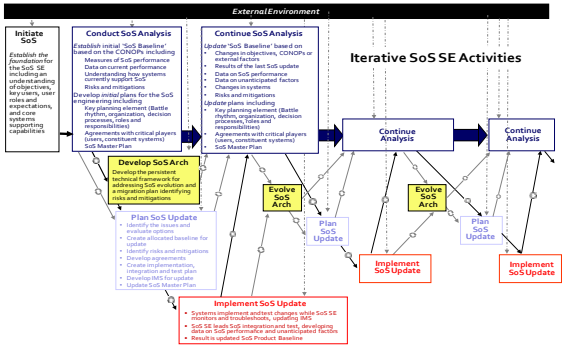
Plan SoS Update

- Identify the issues and evaluate options
- Create allocated baseline for update
- Identify risks and mitigations
- Develop agreements
- Create implementation, integration and test plan
- Develop IMS for update
- Update SoS Master Plan

Plan SoS Update

Implement SoS Update

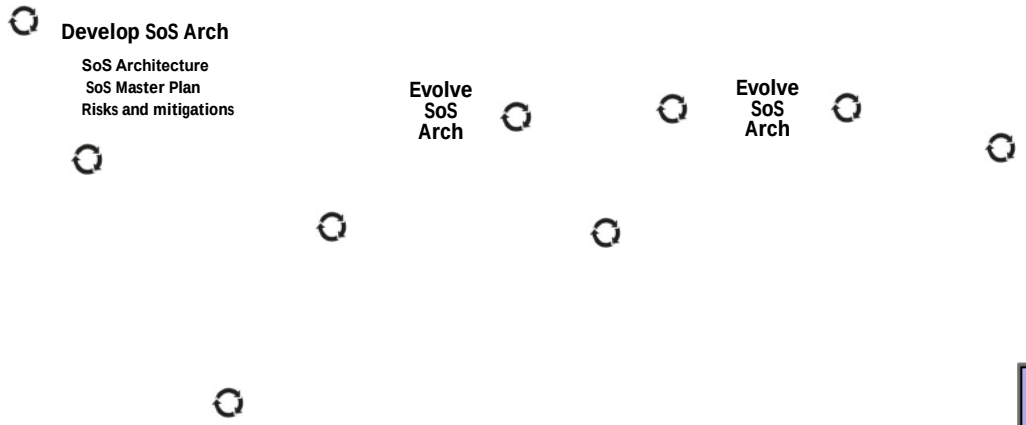
- Systems implement and test changes while SoS SE monitors and troubleshoots, updating IMS
- SoS SE leads SoS integration and test, developing data on SoS performance and unanticipated factors
- Result is updated SoS Product Baseline



- Understanding activities at each step provides a vehicle for implementation level guidance and support

UNCLASSIFIED

Initiatives
SoS SE Artifacts



Iterative SoS SE Activities and SoS SE Artifacts

- Artifacts can be usefully understood from a implementer perspective in terms of the role they play in each step in the SoS SE process

Systems of Systems
10806 – **Key SoS SE Artifacts To Guide Engineering Activities**
Wednesday 8:35 AM
Palm II

UNCLASSIFIED

Ongoing Initiative
Key SoS Acquisition Questions (1 of 3)

- Work in progress with NDIA SoS SE Committee to address a set of SoS questions posed by DDR&E Director, SE
- Two parallel actions
  - Examine how current guidance addresses questions
  - Set of presentations to committee on SoS analysis approaches
- Review and assessment now underway

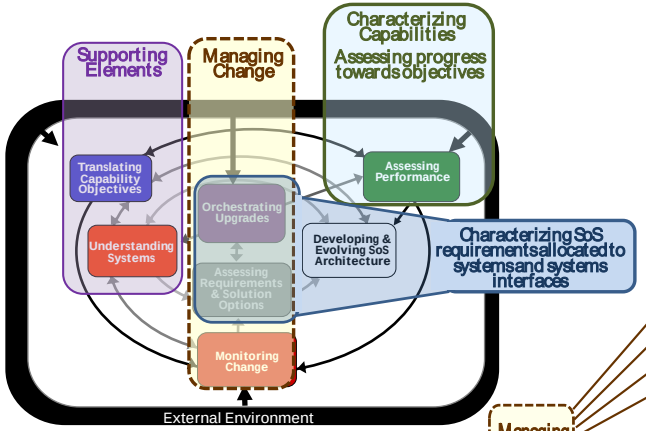
The acquisition community needs the ability to assess risk and review progress on programs where the significant capability is provided by investment in SoS, not by any one of the individual systems

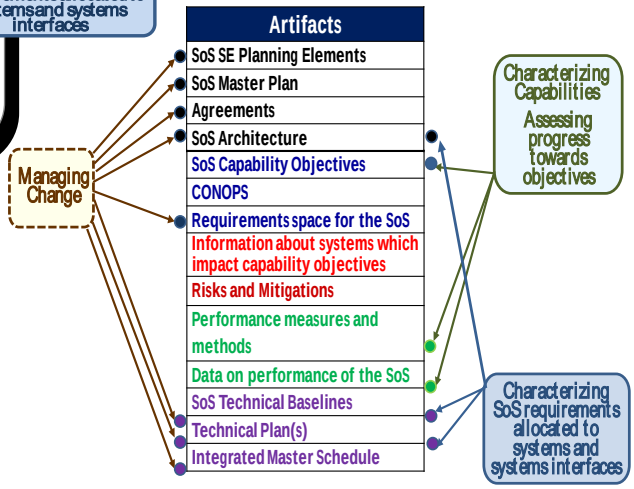
- How do we capture a coherent picture of the capabilities provided by a SoS?
- How do we characterize and capture the sub-allocated requirements, risks and interfaces visible at the individual program level that contribute to SoS level capabilities?
- How do we assess progress and risk associated with building toward these SoS capabilities?
- How do we manage change in a SoS environment, etc.?

UNCLASSIFIED

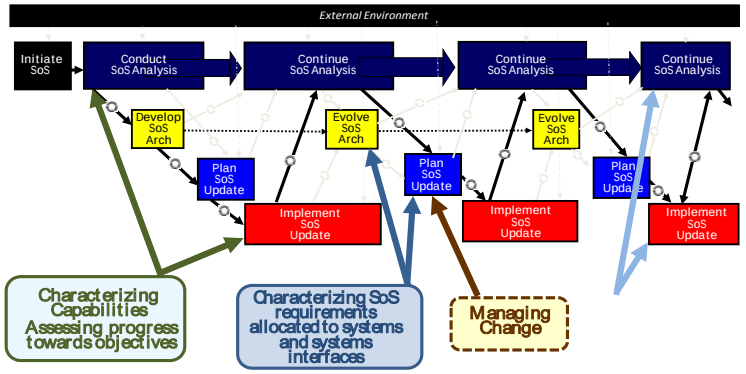
Ongoing Initiative
Key SoS Acquisition Questions (2 of 3)

- Mapped questions to current SoS SE guidance and research results
  - SoS SE Core Elements
  - SoS SE Artifacts
  - Wave Model





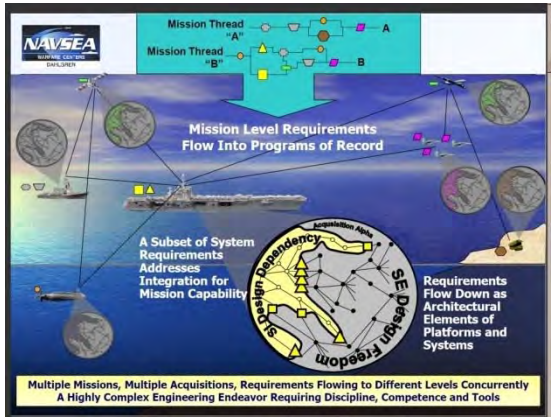
Original Welby Question	Elements of Questions	Direct Core SoS SE Elements	SoS SE Artifacts	Steps in the SoS SE Wave Model
How do we capture a coherent picture of the capabilities provided by a SoS?	**Characterizing Capabilities**	• Assessing Performance vs. Objectives	• Capability Objectives • Performance Metrics • Performance Data	• SoS Analysis • Implementing Upgrades
How do we assess progress and risk associated with building toward these SoS capabilities?	**Assess progress towards objectives**	• Assessing performance	• Capability Objectives • Technical Baselines • Master Plan	• SoS Analysis
How do we characterize and capture the sub-allocated requirements, risks and interfaces visible at the individual program level that contribute to SoS level capabilities?	**Characterizing** • **SoS rqts allocated to systems** • **Interfaces among systems**	• Developing and evolving arch • Addressing rqts and solution options • Orchestrating upgrades	• Architecture • Technical Baselines • Technical Plans	• Developing and Planning SoS Architecture • Planning Updates
How do we manage change in a SoS environment, etc.?	**Planned change**	• Addressing requirements and solution options • Orchestrating upgrades	• SoS SE Planning Elements • Agreements • Architectures • Requirements space • Information about systems which impacts the SoS • Master Plan • Technical Baselines • Technical Plans • Master integrated schedule • Risks and Mitigations	• Planning SoS Updates • Implementing Upgrades
	Uncontrolled change	• Monitoring and addressing change	• Risks and Mitigations	• SoS Analysis • Implementing Upgrades

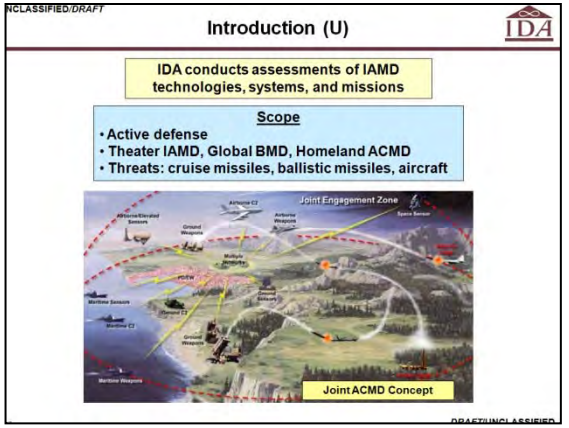


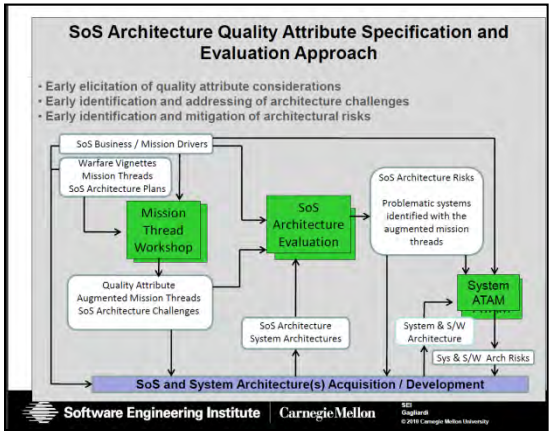
UNCLASSIFIED

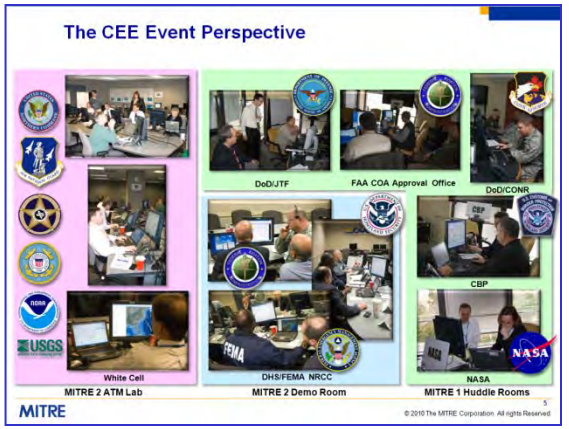
Ongoing Initiative
Key SoS Acquisition Questions (3 of 3)

- **NDIA Architecture Task Force Report**
  Joe Kuncel
- **Engineering Systems of Systems: An Integration Perspective**
  Emmet Maddry (NSWC Dahlgren)
- **SoS Quality Attribute Specification and Architecture Evaluation**
  Michael Galiardi (SEI)
- **Integrated Air and Missile Defense (IAMD) Studies**
  Dr. Joseph T. Buontempo (IDA)
- **Enabling Engineering of Complex Systems Through Simulation-Based Experimentation**
  Zach Furness (MITRE)









UNCLASSIFIED

Next Steps

- Continuing to work with the broader community through NDIA and TTCP to address growing interest and understanding of SoS and SE
- Continued technical work
  - To support DoD acquisition initiatives which call for a SoS perspective
    - SoS Acquisition Programs
    - Development Planning
  - To apply current understanding and learn from experiences with Component initiatives
  - To build guidance which supports the SoS SE practitioner
    - Wave model
    - Artifacts
    - Relationship to DoD acquisition
  - To address Director, SE questions

UNCLASSIFIED

Introduction to NCOIC Net-Centric Patterns

Mark K Bowler
Advanced Tactical Systems
Phantom Works
The Boeing Company
714.372.1956
mark.k.bowler@boeing.com

NIF Architecture Concepts Functional Team Chair

October 27, 2010

Approved for Public Release
Distribution Unlimited
NCOIC-NDIA-MB20101027

The NCOIC at a Glance

Members are Global Leaders:

- **Academic institutions**
- **Air Traffic Management providers**
- **Service providers**
  - Consulting
  - Engineering
  - Logistics
- **Defense suppliers**
  - All military services
  - Multinational
- **Government agencies**
- **Human service agencies**
- **Integrators**
  - Commercial systems
  - Defense systems
- **IT firms**
  - Communications
  - Data management
  - Human-Machine interface
  - Information assurance
- **Standards bodies**

A global organization focused on an industry neutral approach to NCO adoption:

- **Use of Open Standards in NCO domains**
- **Net-Centric Architecture Concepts and System Design Best Practices**
- **Tools for Evaluation and Assessment of Net-Centric Systems**
- **"Building Blocks" catalog of components & services compliant with NCOIC recommendations**

Prescriptive Guidance On How To Build Interoperable, Network Centric Systems

Unity of Effort
Different Domains, Similar Needs

Aviation IPT

C3 Interoperability IPT

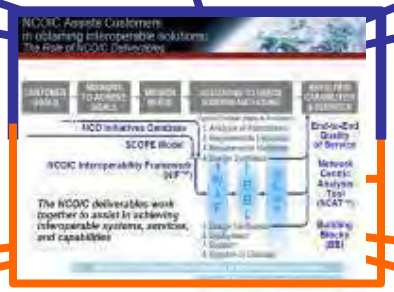
Net Enabled Emergency Response IPT

Maritime IPT

Cyber Security IPT

Operational Descriptions

Net Centric Patterns



Net Centric Principles & Attributes

Interoperability Frameworks

Net-Centric Attributes

- **SCOPE**
- **NCAT**

NCOIC Interoperability Framework

- **NIF & Concepts, Principles, Processes, PATTERNS**

Specialized Frameworks

- **Information Assurance**
- **Cloud Computing**
- **Mobile Networking**
- **System Management**
- **Semantic Interoperability**
- **Information, Services, etc.**

Building Blocks

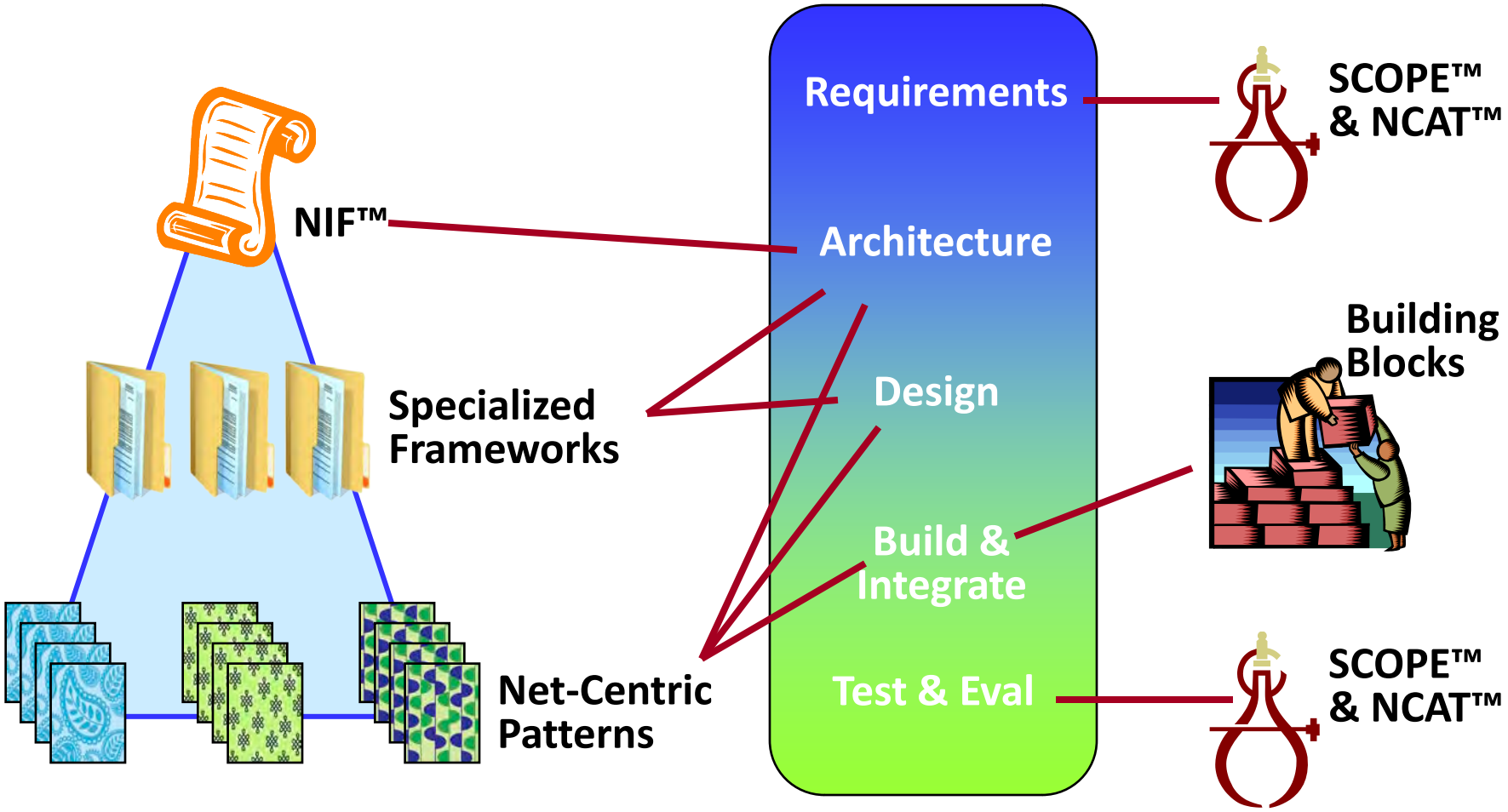
Modeling and Simulation

Systems Engineering and Integration

- **Test & Evaluation**
- **Lexicon**
- **Education & Outreach**

Functional Teams provide the technical expertise to serve customer domains.
The **Integrated Project Teams** provide operational information from customer domain perspectives.

Where Net-Centric Patterns fit into the NCOIC

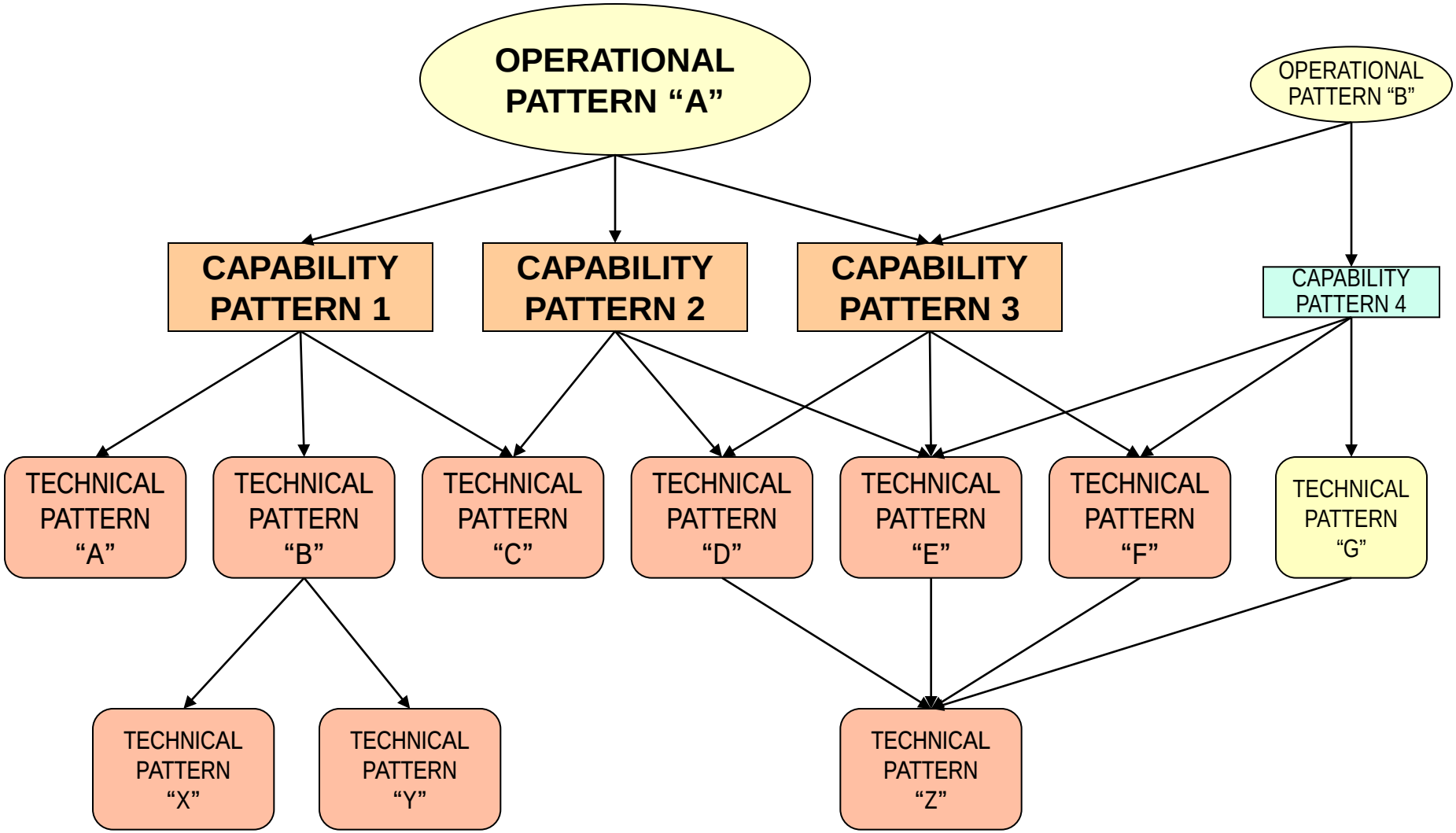


Why Patterns?

- **Standards alone do not guarantee interoperability… we also need guidance on architectural approaches, behaviors, design rules, design principles, etc**
- **Often the "best" Standard depends on the mission and performance requirements**
- **In a System-of-Systems, legacy systems cannot be forced to update to newest standard**
- **Does Everyone Understand the Standard the Same Way?**

NCOIC Net-Centric Patterns → A vehicle for prescriptive recommendations on which standards to use, how to use them, and other essential guidance

Three Types of Net-Centric Patterns



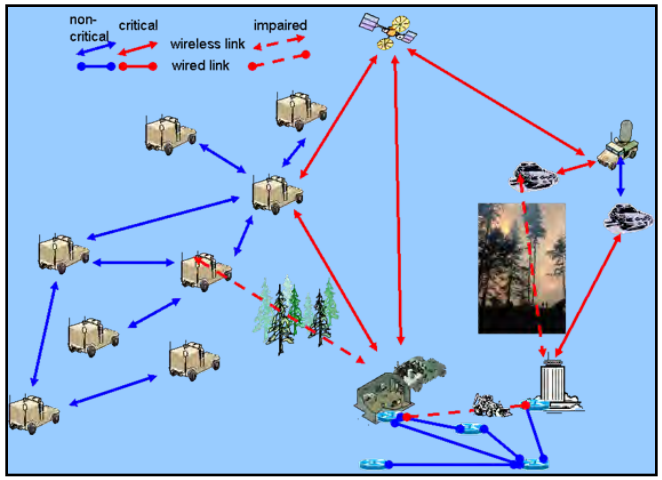
Typical use of NCOIC Resources

Activity	NCOIC Resource
Concept Development	▪ Specialized Frameworks ▪ **Operational Patterns**
Architecture Development	▪ NCOIC Interoperability Framework ▪ Specialized Frameworks ▪ **Capability Patterns** ▪ Network Centric Assessment Tool
System Design	▪ Specialized Frameworks ▪ **Technical Patterns** ▪ Network Centric Assessment Tool ▪ Building Block Catalog
System Assessments	▪ Network Centric Assessment Tool

Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

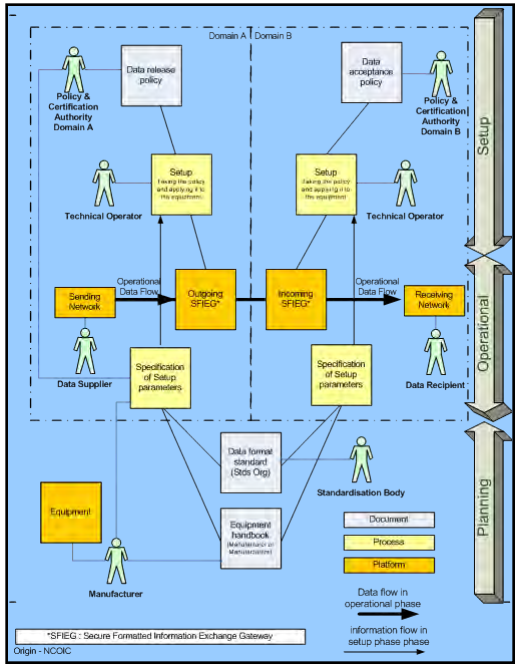
What is the problem being solved, and the context?



Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

Actors and interfaces involved in the NCP or otherwise required to implement it



Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

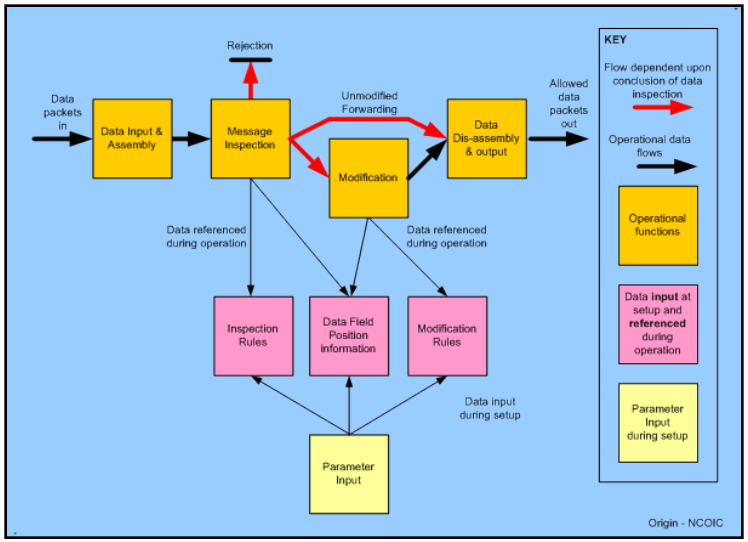
Pre-Conditions are prerequisites that must be in place before the pattern can be applied. If not met, the pattern cannot be successfully applied to the problem at hand.

Post-Conditions are the concrete results of applying the pattern. State what is the outcome of applying the pattern, including any limitations and/or consequences.

Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

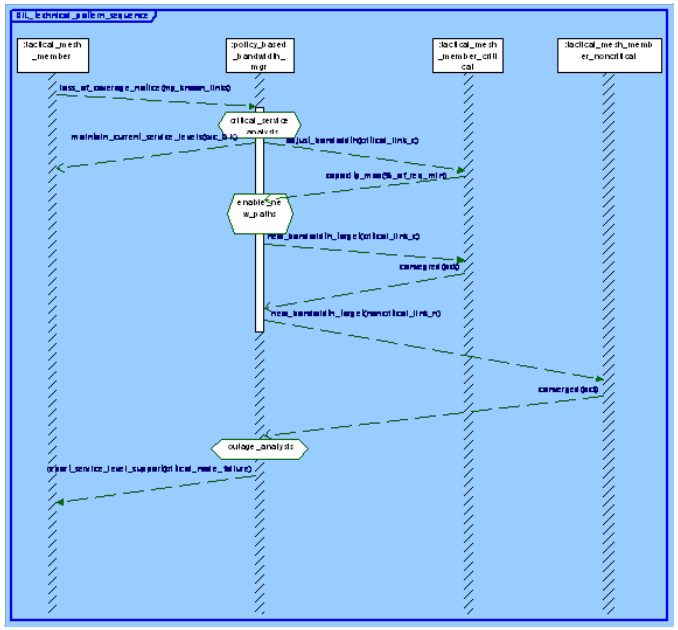
Graphical or textural description of any structure (architectures, etc) to be imposed on the solution



Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

Required behavior (dynamic interaction) of structure elements, actors, or interfaces. Includes "rules", principles, algorithms, etc.



Net-Centric Pattern Contents

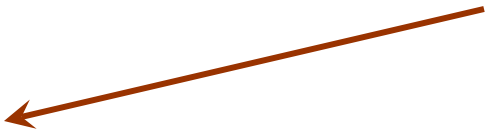
1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

Standard	Name and Number	Purpose	Notes
OSPFv2	IETF RFC 2328 (STD:54)	link state advertising on DIL links	When using IP technology
OSPF Traffic Engineering	IETF RFC 3630 Traffic Engineering (TE) Extensions to OSPF Version 2	traffic engineering to utilize DIL links	When using IP technology
IEEE 802.1D	Spanning Tree Protocol	link layer weighting of DIL links	When using COTS bridges
DAMA (MIL-STD-188-181)	181C - Interoperability Standard For Access To 5-kHz And 25-kHz Uhf Satellite Communications Channels	DAMA	When using UHF satellite communications technology
DAMA Control (MIL-STD-188-185)	185 - Interoperability UHF Milsatcom Dama Control System	DAMA control of DIL SATCOM links	When using UHF satellite communications technology

Detailed identification of all Standards required for implementation of the NCP

Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification



Non-Prescriptive information that may be of use to those using the NCP

Net-Centric Pattern Contents

1. Introduction and Problem Description
   - 1.1. Context
   - 1.2. Problem Statement
   - 1.3. Expected Benefits
2. Recommended Solution
   - 2.1. Actors
   - 2.3. Interfaces
   - 2.2. Pre-Conditions
   - 2.4. Structure
   - 2.5. Behavior
   - 2.6. Post-Conditions
   - 2.7. Standards
3. Additional information
   - 3.1. Lessons Learned
   - 3.2. Constraints & Opportunities
   - 3.3. Known Uses
   - 3.4. Potential Capability
   - 3.5. Related Patterns
   - 3.6. References
4. Verification

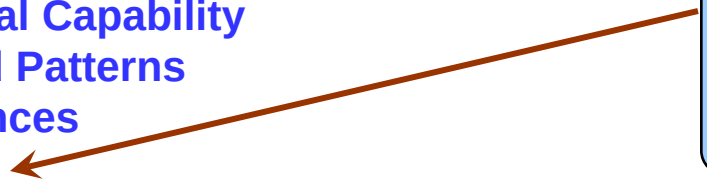


Table of detailed verification criteria for vendors wishing to certify that their product are compliant with the NCP

NCOIC Net-Centric Patterns

RELEASED

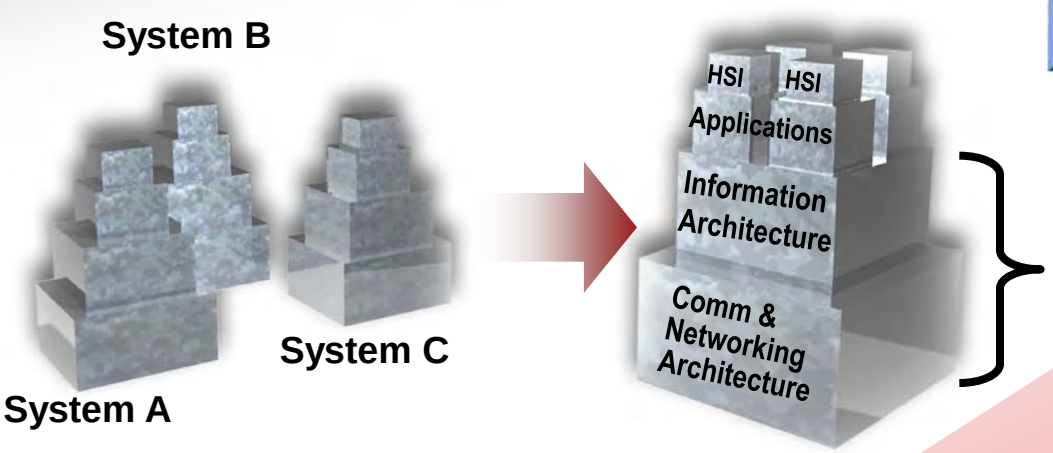
- SAGM Mobile Communication and Networking
- Legacy Services
- Design Phase Service Integration
- Information Dissemination Shared Database
- Land Force Tracking Gateway Network Centric
- All Hazards Alerts and Warnings
- Disconnected, Intermittent, Limited (DIL) Communications Management
- Simple and Extensible Email Services (SEES)
- Secure Formatted Information Exchange Gateway (SFIEG)
- Core Network Access

COMING SOON

- Flight Data Object Dissemination
- Live, Virtual, & Constructive Integrated Middleware Environment
- Net-Centric Cyber Simulation
- Access Network Discovery
- High Level Architecture (HLA)
- Distributed Interactive Simulation
- Services Interface Technical Pattern
- Resource Tracking Information Exchange
- More in work…

Operational Patterns
Capability Patterns
Technical Patterns

Value for the Customer



Future
- Integrated, ad hoc, interoperable solutions
- Global multi-domain System-of-Systems

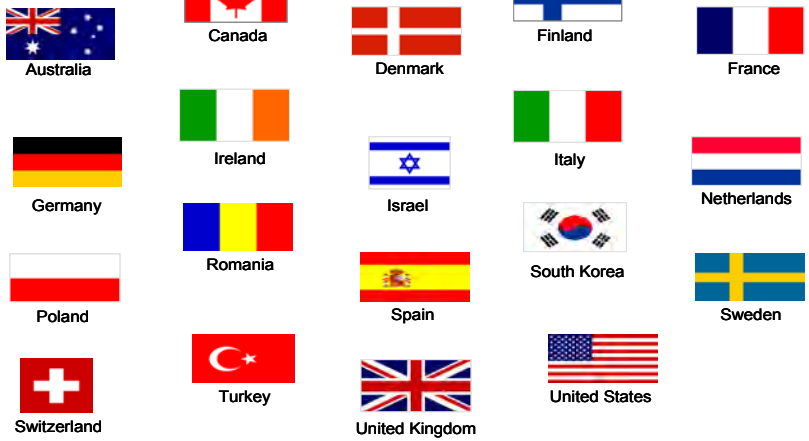
Present
- Technology exists, but not integrated
- Some transformational programs funded
- Lack of common approach
- Industry assistance required

Past
- Platform focused
- Performance driven
- Standalone

For Additional Information…

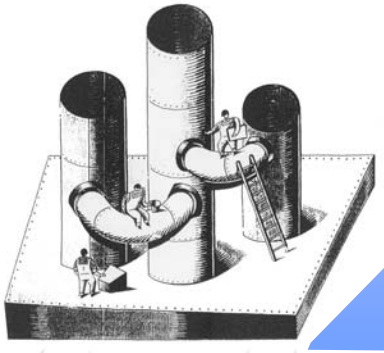
www.ncoic.org

Or Contact:
mark.k.bowler@boeing.com



Net-Enabled Future

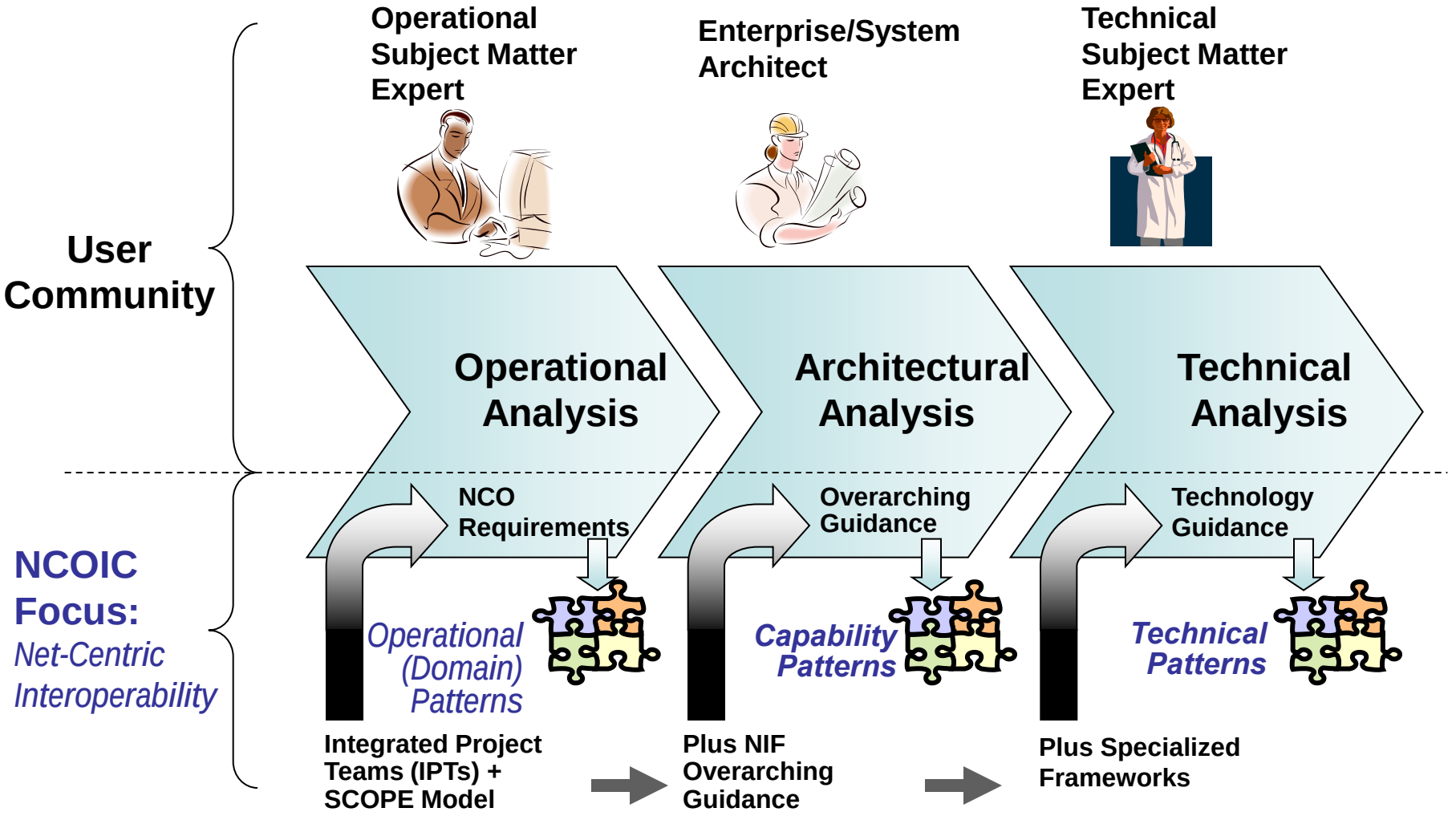
ncoic



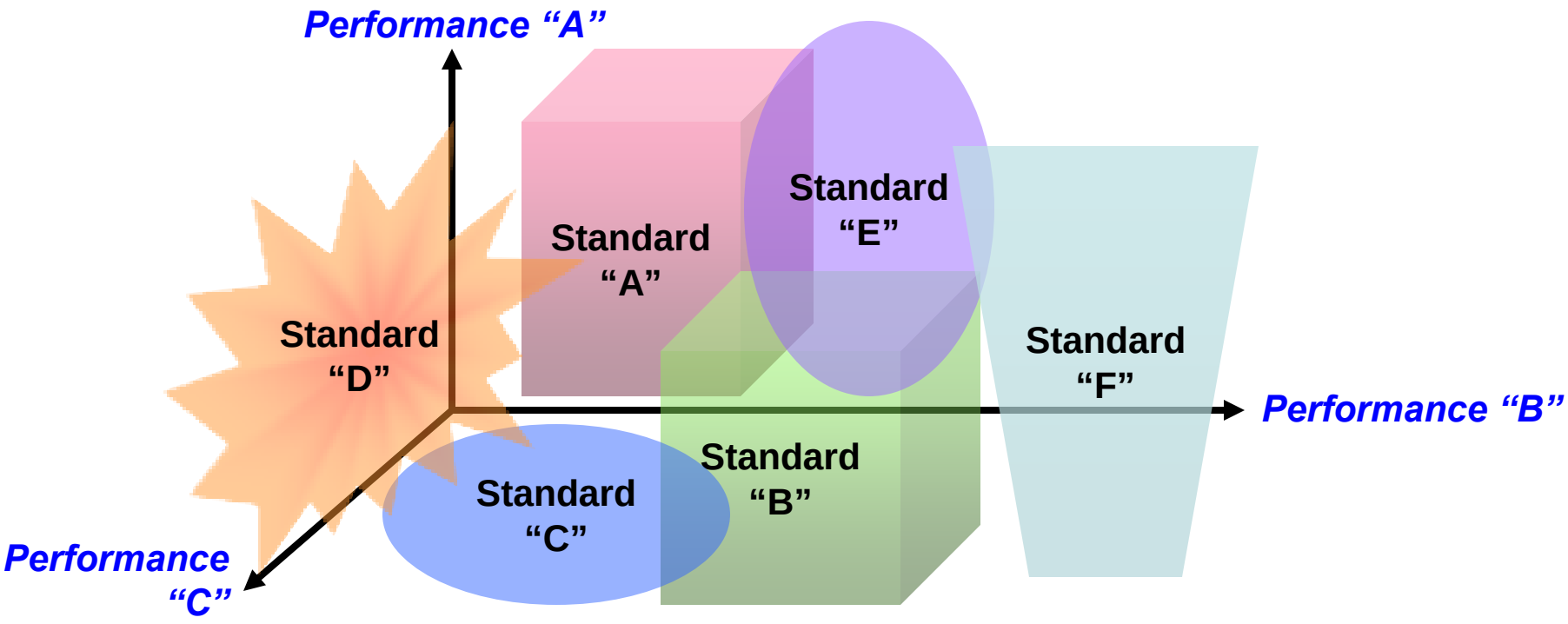
TODAY: Stovepiped Systems, Point-to-Point Networks

NCOIC Assists Customers in obtaining interoperable solutions:

NIF Guides Development of Net-Centric Systems



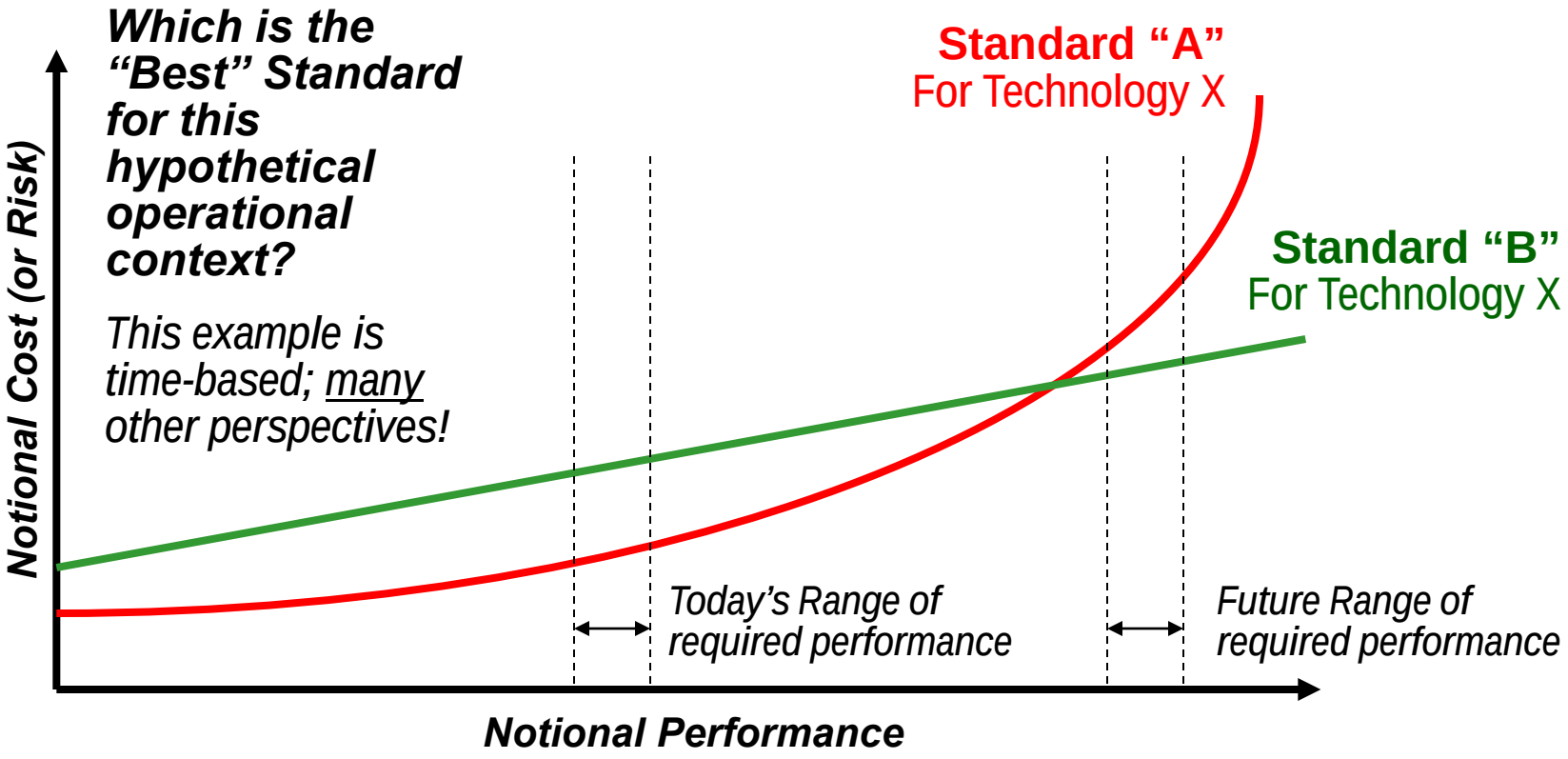
The Problem with Interoperability Standards



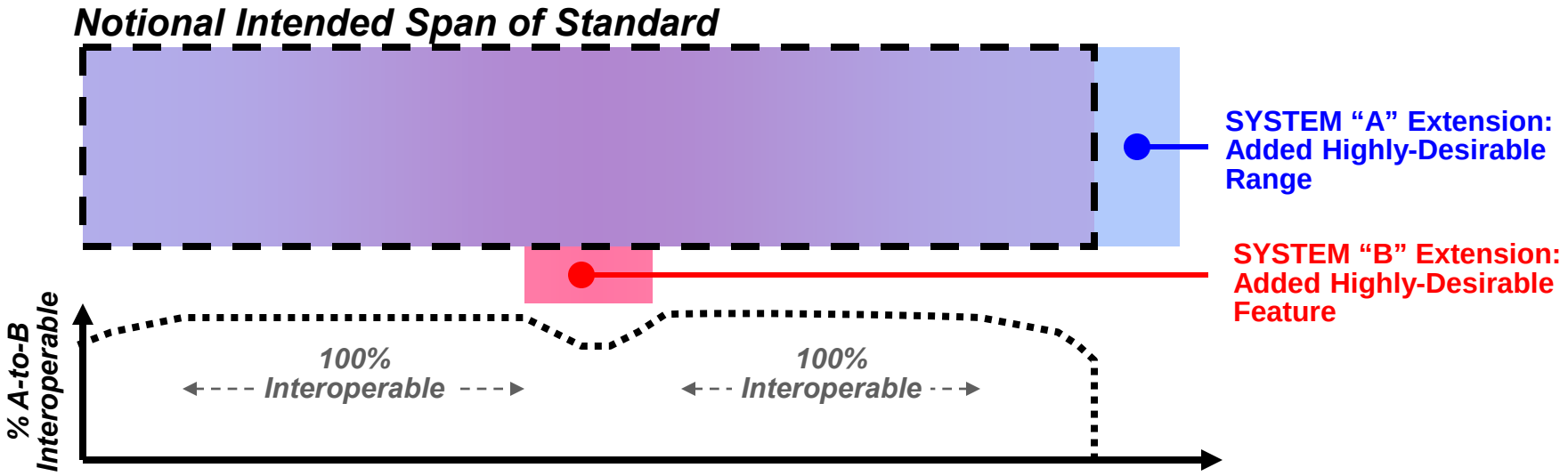
- Often the "BEST" Standard depends on the Mission
  - Real-World Condition! Often no *"One Size Fits All"*

The Problem with Interoperability Standards

- What is the appropriate level of NetCentricity for a given operational context? May impact selection of Standards!



The Problem with Interoperability Standards



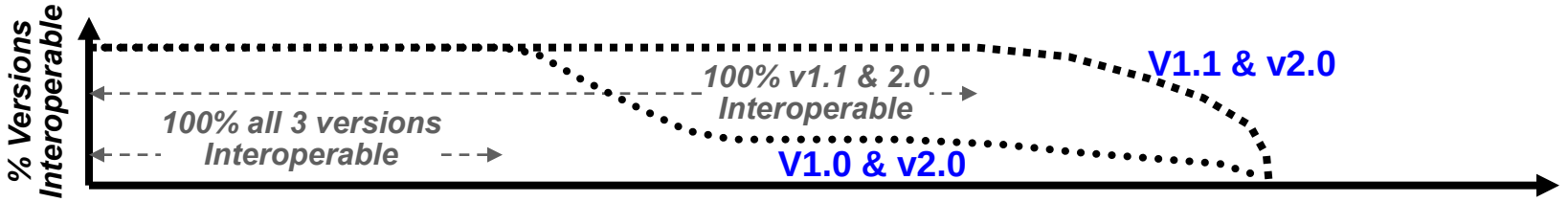
- "Bad" Standard, or "Bad" System Designs?
  - Real-World Condition!
  - In a System-of-Systems, cannot force systems to not use highly-desirable features when operating independently

The Problem with Interoperability Standards

ORIGINAL Standard v1.0

UPDATED Standard v1.1

NEW Standard v2.0: "Backward Compatible"



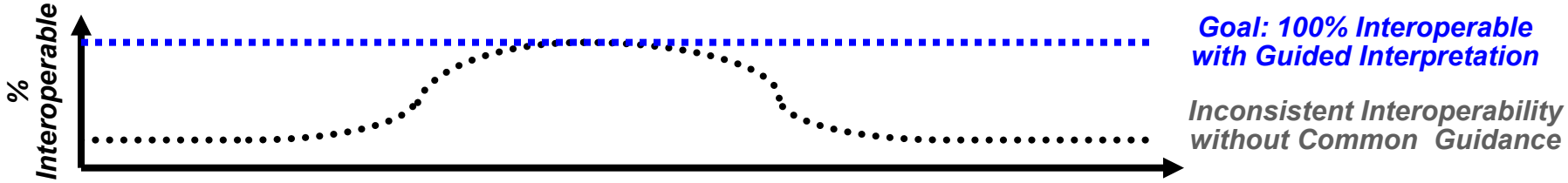
- Is Everyone Running the Same Version?
  - Real-World Condition!
  - In a System-of-Systems, cannot force Legacy systems to update to newest standard

The Problem with Interoperability Standards

Interpretation "A" of Standard

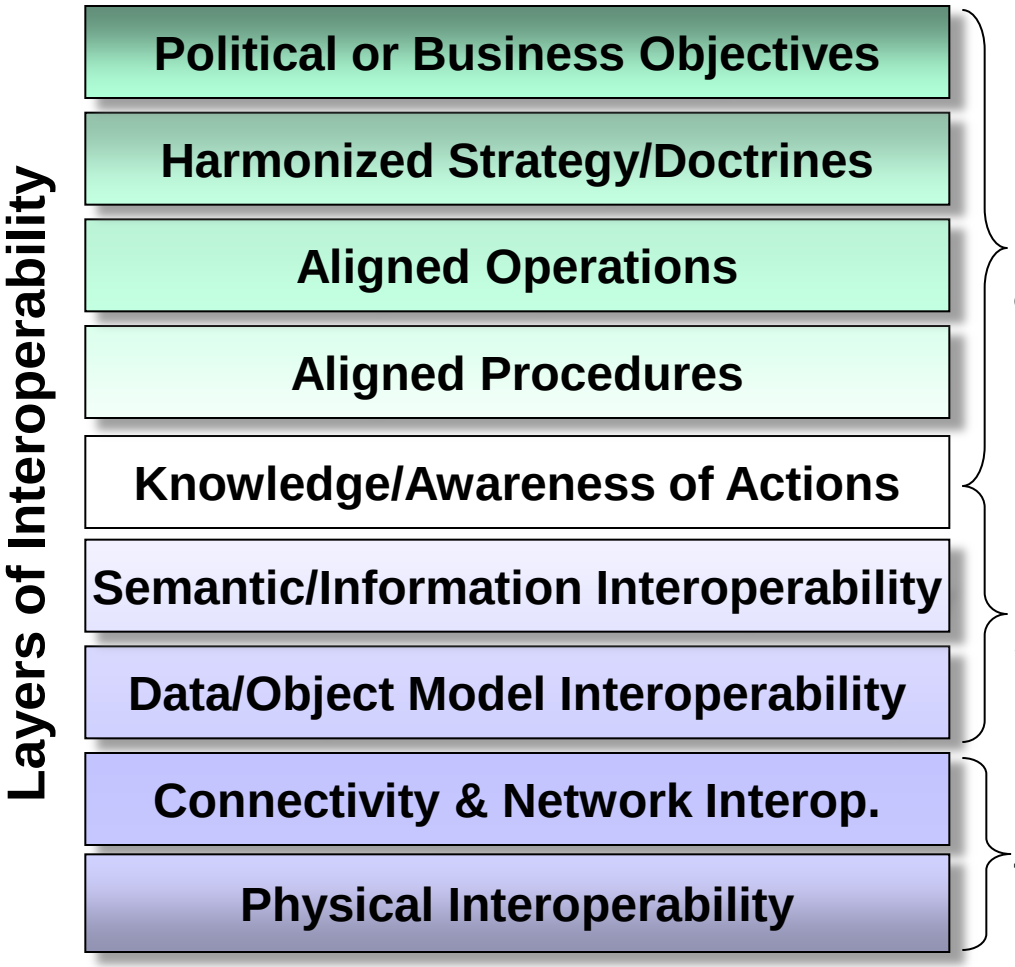
Interpretation "B" of Standard

GUIDED Interpretation of Standard

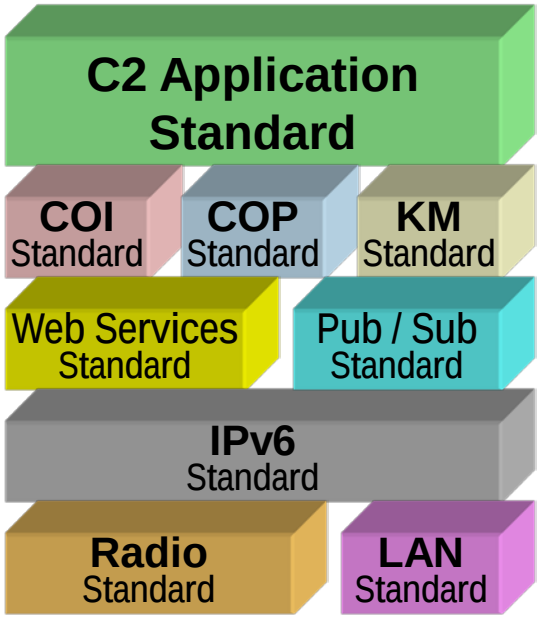


- Does Everyone Understand the Standard the Same Way?
  - Real-World Condition! (Not necessarily a bad Standard)
  - Different Languages; different Cultural backgrounds
  - Same Standard applied in different Operational Domains, implemented by designers with different levels of experience, different technical disciplines, different company rules

The Problem with Interoperability Standards



- Standards are Interdependent!
  - Standards for a layer often dependent on standards for lower layers



RDA CHSENG
MISSION ENGINEERING USE CASE
UNMANNED SYSTEMS

Helene Anderson
ASN(RDA) CHSENG
Mission Engineering Technical Support
Helene.Anderson@navy.mil

Presented to:
NDIA Annual SE Conference

October 27, 2010

Cleared for public release. Unlimited distribution

ASN (RD&A) CHSENG INTEREST

- Development of Unmanned Systems (UxS) to support Navy warfighting needs is still in its infancy
  - Unified management of requirements and acquisition has not happened for the **UxS**
- Since 2006, ASN(RDA) CHSENG has provided implementation guidance for Systems Engineering within a "System of Systems" architectural perspective. ASN(RDA) CHSENG has stressed the importance of applying Systems Engineering processes to the mission area system of systems.

- Unmanned Systems provide an opportunity for the application of Mission Area Systems Engineering principles and processes to define their operational effectiveness in Navy acquisition.

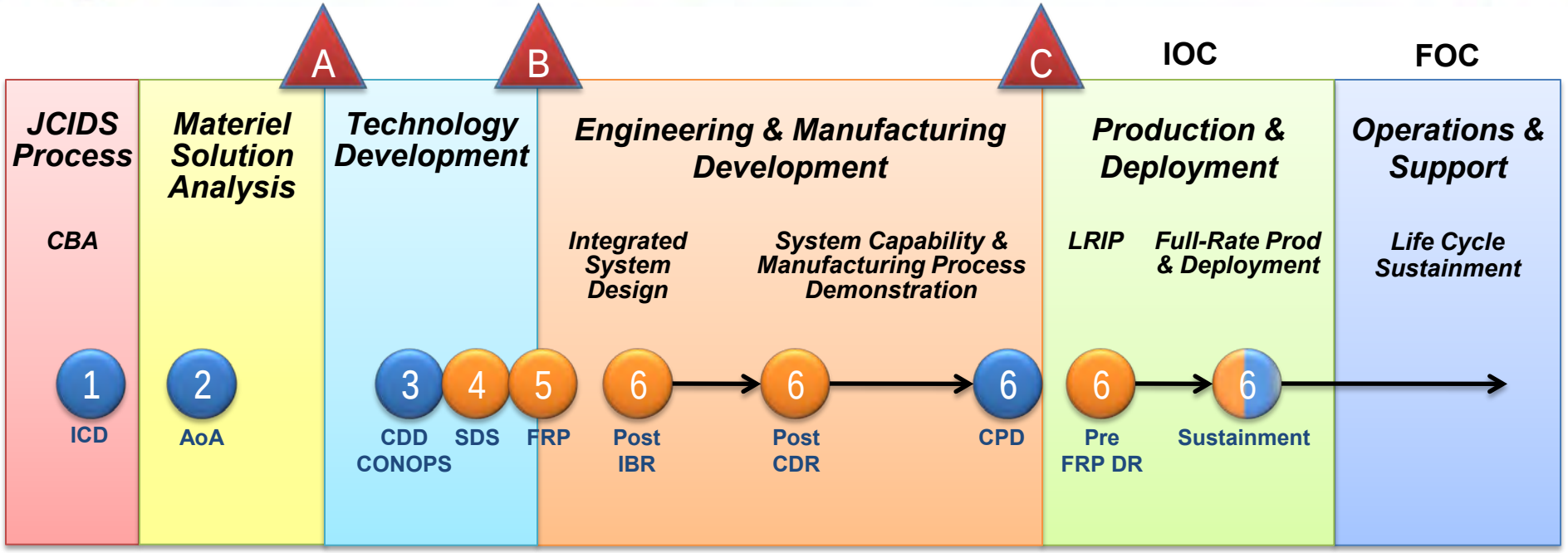
A DEMAND SIGNAL CREATES OPPORTUNITY

Demand Signal-

- **CNO Direction**
  - **Move Boldly:**
    - **Into Unmanned, machine autonomous technologies**
    - **Create a Fully-Integrated Intel, C2, Cyber & Networks Capability**
    - **Improve sea-based mid-range unmanned ISR capability**
    - **Sustain PR-11 increases in long-range persistent sea-based unmanned ISR and strike**
- **SECDEF Guidance for the Development of the Force**
  - **Ensure sea-based mid-range UAS in two locations in FY12, including sea-based ISR for the National Mission Force**
  - **NLT FY15, conduct CVN-based experiments with Navy-Unmanned Combat Air System**
  - **Assess the feasibility of accelerating Initial Operating Capability of CVN-based unmanned aircraft for strike and ISR missions**
- **Unmanned Vehicles are SECNAV's No. 2 Priority**

MISSION AREA ENGINEERING IN PROGRAM GOVERNANCE

RDA CHIEF SYSTEMS ENGINEER
ASN (RDA)



Underlying Mission, Platform and System Engineering Rigor

UxS Mission MOEs	UxS Development of Mission Threads	UxS Mission Experimentation	UxS Mission Requirements Allocation	Use of Live, Virtual, Constructive Training Environments	UxS Mission Information Dominance Roadmap

Today

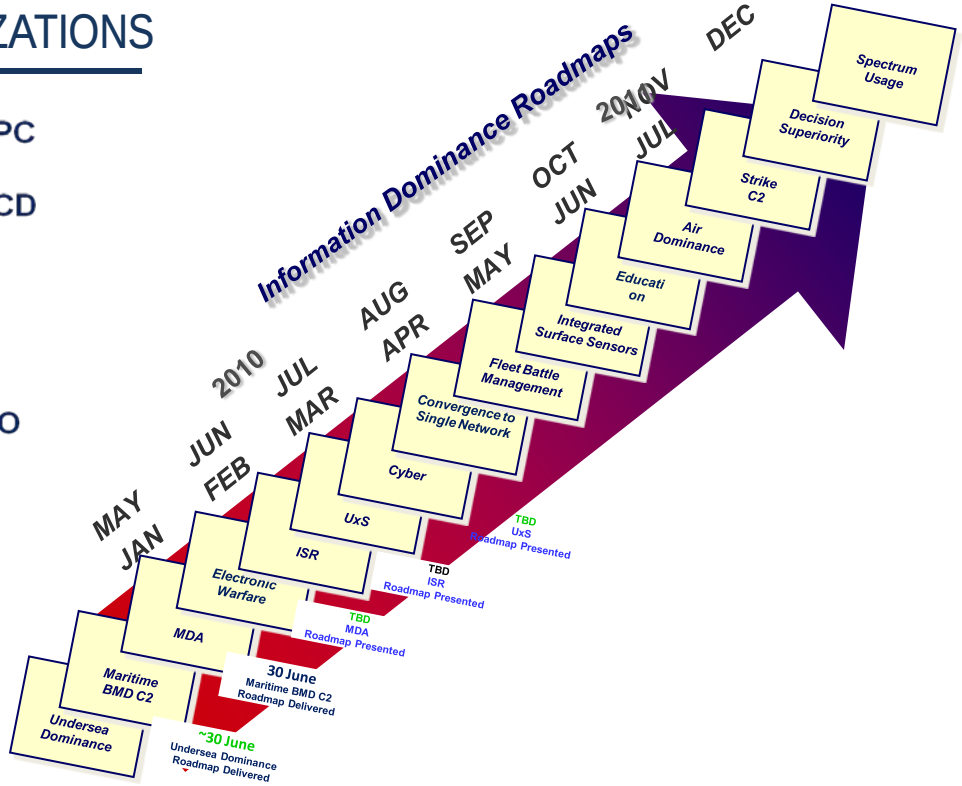
Alignment of Department's Engineering Efforts

CROSS FUNCTIONAL TEAM

- Unmanned Systems Cross Functional Team (CFT) established by OPNAV N2/N6 to support the development of the UxS Information Dominance Roadmap

PARTICIPATING TECHNICAL ORGANIZATIONS

- ASN RDA CHSENG
- NAVAIR 4.0
- SPAWAR 05
- NAVSEA 05
- MARCORSYSCOM
- NAWC WD
- NSWC DD
- NSWC DN
- NSWC PC
- NSWC CD
- NUWC
- ONR
- DON CIO
- NMSO



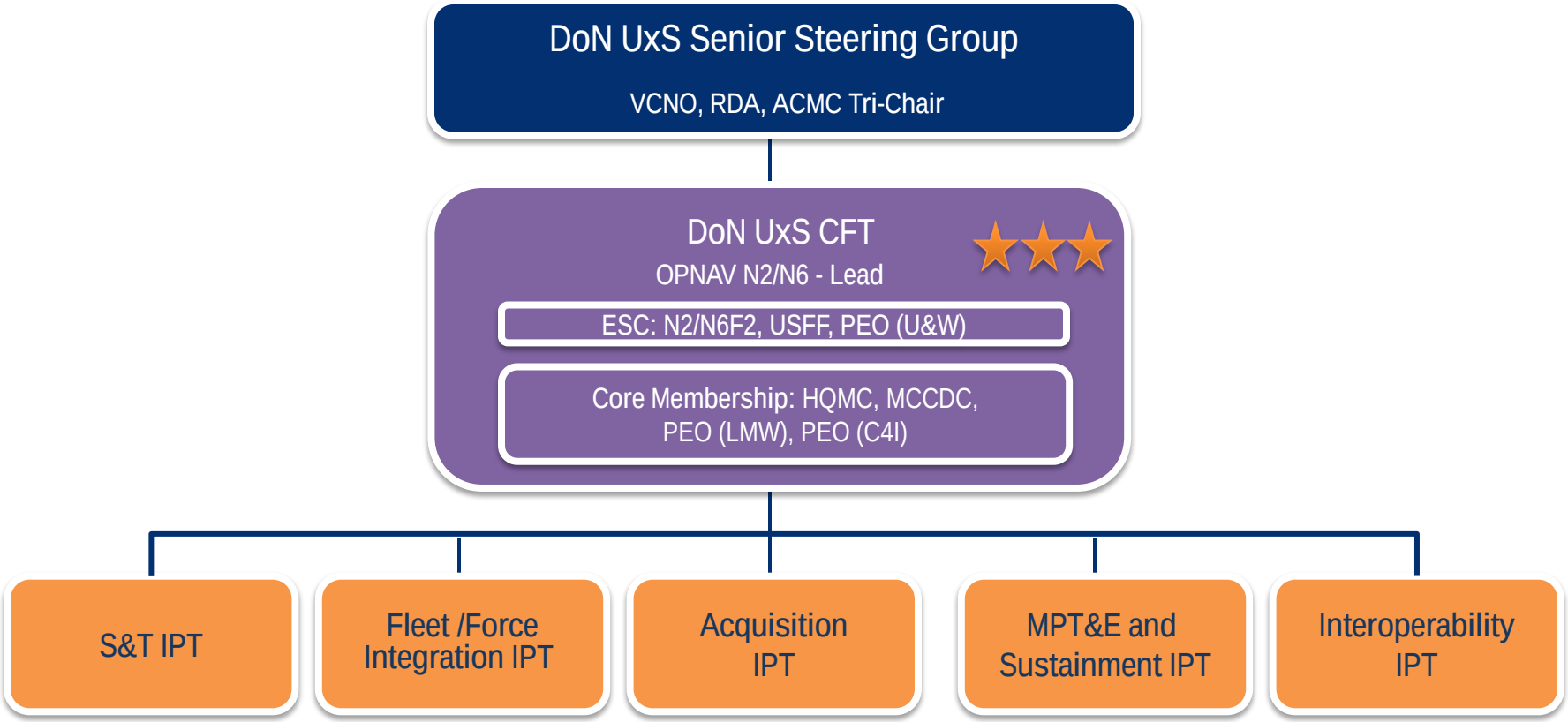
SYSTEM ENGINEERING CHALLENGES

- Current effort of CFT is an unfunded coalition of the "willing" – a Mission Engineering Consortium
  - RDA CHSENG is re-aligning existing tasking to begin work but will need to adapt and adjust resources to continue the work.
- Anticipated overhead budget cuts may jeopardize the coalition's strategic value:
  - Drives system and platform centric results as opposed to mission level perspective that can provide integrated alternative cost to capability options
  - Taxing programs to do this work creates unwanted bias
- Stakeholder organizations are hesitant to fully engage until Senior Leaders endorse way ahead and define resource priorities

Nevertheless, evolving mission capabilities to exploit UxS promises significant program savings at the Department level

PROPOSED CFT SCOPE WITH IPTS

RDA CHIEF SYSTEMS ENGINEER
ASN (RDA)



NAVAL UNMANNED SYSTEMS FUNCTIONAL CROSS WALK

RDA CHIEF SYSTEMS ENGINEER
ASN (RDA)

S&T IPT

GAP ANALYSIS

- Assess and prioritize Technology Gaps
- Develop a UxS S&T Roadmap to close technology gaps

FLEET/FORCE INTEGRATION IPT

SOLUTIONS ANALYSIS

- CONOPS development
- Develop Future Mission Threads and compare to "As Is" mission thread performance to better define the performance gap
- Develop a UxS Experimentation Campaign Plan integrated with USFF Sea Trial Campaign Plan. Evaluate UxS CONOPS and Future mission threads

INTEROPERABILITY IPT

PRODUCT IMPROVEMENT

- Develop "As IS" mission threads and assess performance gaps
- Develop / coordinate Interoperability standards (Joint, commercial)
- Develop Interoperability E2E testing process guide

MPT&E AND SUSTAINMENT IPT

ACQUISITION & PROGRAMMING

- Support the development of Non-materiel solutions
- Develop roadmaps for Training, Workforce Development and Sustainment

ACQUISITION IPT

- Transition technology provided by S&T IPT into rapid prototyping
- Take the outputs from the other IPTS and provide inputs to the POM process

ENGINEERING SUPPORT TO IPTs

- SYSCOM Field activity personnel offered as Deputy to IPT Leads
- Stakeholder organizations from the Mission Area Engineers and Technical Directors' Consortium offer dedicated participation for engineering and analysis support coordinated by the Deputy IPT Lead
- Technical breadth and depth of stakeholder team participants offers:
  - Solution recommendations thoroughly vetted to highlight mission impact vice bias towards platform protection or justification
  - Opportunities to leverage all of the varied communities prior investments
  - Mitigation of future interoperability stovepipes inherent in a collaborative engineering environment
  - Opportunities to limit future fiscal constraints from Contractor Furnished Equipment

NEXT STEPS

- Sufficient resources are on hand for initial pacing and phasing the standup of the IPTs. IPTs will be meeting in the next couple of months.

- Soliciting Navy sponsorship of a Limited Objective Experiment in late FY 11 to evaluate CONOPS for integrated manned and unmanned operations.

- The Mission Engineering Consortium is taking the opportunity to apply Department wide resources to SECNAV, CNO, and CMC priorities in Unmanned Systems

  - Apply Mission Engineering processes towards high priority tasking in Unmanned Systems (UxS) engineering
  - Aligns DON engineering competencies towards current efforts
    - UxS Cross Functional Teams
    - Information Dominance Roadmaps
    - PEO LMW and PEO U&W Programs
    - Warfare Center Technical Authorities

Provides Mission Level System Engineering and Analytical Rigor

Developing a Mission Architecture: From Mission Analysis to Executable Model

Liz O'Keefe
Jim Sierchio

26 October 2010

Copyright © 2010 Raytheon Company. All rights reserved (for Raytheon only slides).
Customer Success Is Our Mission is a registered trademark of Raytheon Company.

Approved for Public Release - SPR#1346

Raytheon

Outline

- Introduction
- JCIDS Mission Capability Analysis process
- Solution Architecture and Design development
- “PF2T2EA” Kill Chain Architecture
- Critical Architecture DoDAF products
- Key Architecture analysis results
- Architecture executable model
- Summary

Approved for Public Release - SPR#1346

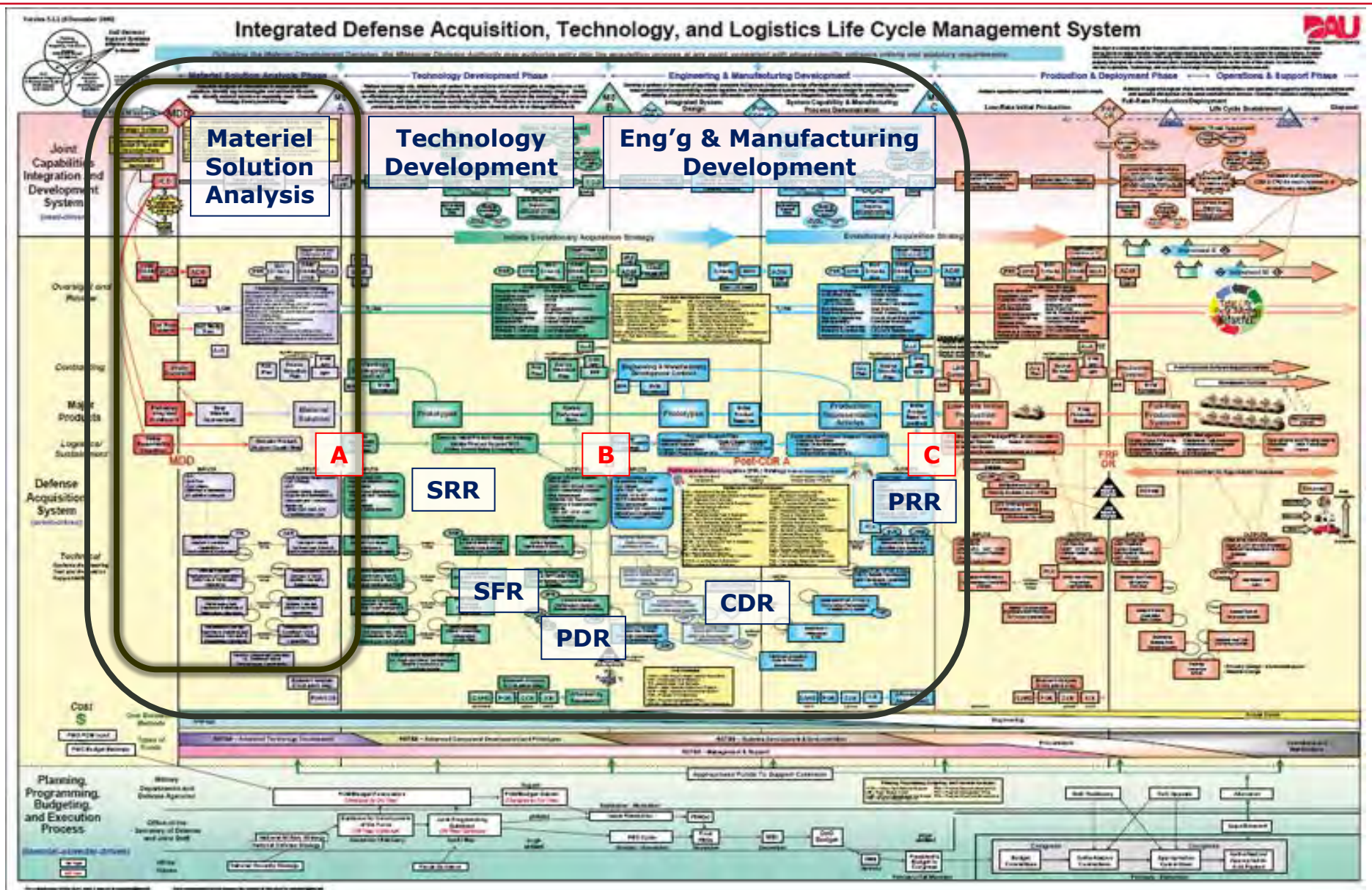
Introduction

- Mission analysis studies conducted per the Joint Capabilities Integration & Development System (JCIDS) process identified gaps in the Navy's ability to provide accurate, responsive "Fire Support from the Sea"
  - For Marine and Army forces operating ashore throughout conflict spectrum.
  - Gaps defined in the Marines' Joint Fires Initial Capabilities Document (ICD)
  - Included impact from use of MV-22 Osprey, which provides Marines ability to conduct vertical envelopment ops far beyond naval gunfire range.
- Navy interested in developing a refined system concept for an Affordable Weapon System (AWS) as a ship- and/or air-launched material solution
- Development of a mission solution necessitated developing an in-depth knowledge of the entire naval fire support "kill chain", and building an architecture expressing a comprehensive view of that kill chain
  - Architecture described AWS mission at the operational and system levels
- Team employed Raytheon Enterprise Architecture Process (REAP)

Approved for Public Release - SPR#1346

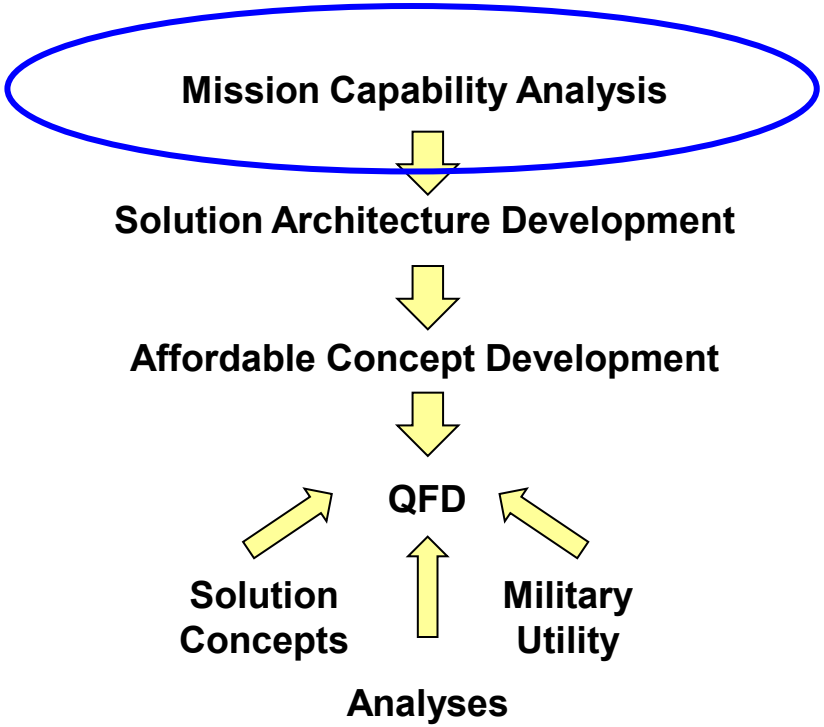
Development in the Acquisition Cycle - JCIDS and DoDI 5000.02

Raytheon



Mission Capability Analysis Process

One aspect of the AWS study was to determine the capabilities and associated tasks, conditions and standards required for Naval Surface Fire Support (NSFS) missions performed at standoff ranges.



MCA Identifies:

- Appropriate Mission Areas and Missions
- Scope of Mission area / Military Problem
- 2016 timeframe capability shortfalls

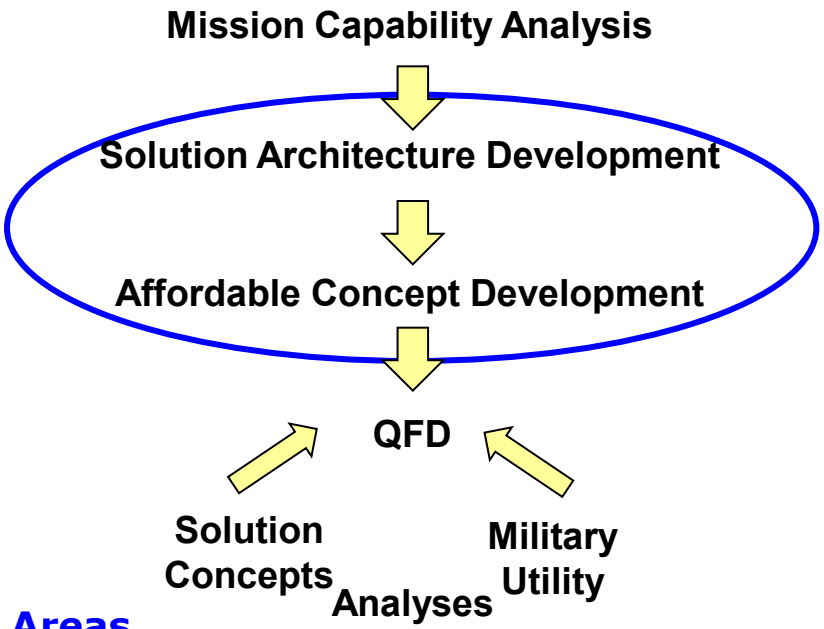
MCA Maps:

- Capabilities to Defense Strategies
- Relevant objectives to capability gaps
- Example Scenarios to mission areas

Focus on Identifying the Gaps

Solution Architecture & Design Development

- MOEs → System Capabilities → System Requirements
- Use of Existing Navy Surface Fires Infrastructure
- Detailed Architecture Definition beyond M/S A levels
  - DoDAF AV-1, AV-2, OV-1 thru OV-7 SV-1 thru SV-9)



Capabilities (CDD)
- KPPs, Mission Effectiveness

Requirements (SDS, EDD)
- Definitions of KPPs, KSAs, Other Targets, Environments

Operational Architecture
- Kill Chain & Operational Model

System Architecture
- Networks, Interfaces, Datalink, Systems, Functions, Function to Activity Mapping

Weapon System (WCS & Missile)
- Functionality
- Timeline
- End Game

Focus Areas

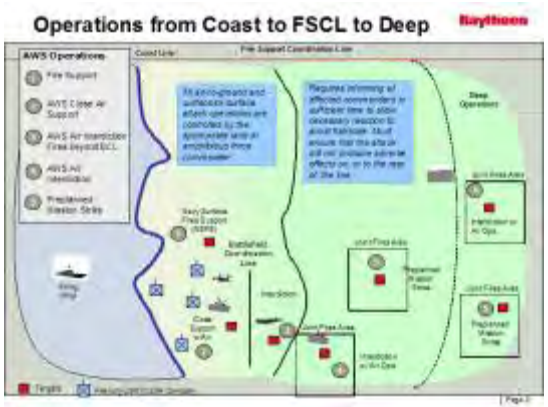
Architecture Flexibility wrt Preferred System Concept
System of Systems Interoperability & Functionality
Priority on Affordable & Useful → Achievable SoS Design → Exceptional Value to the Warfighter

Focus on Development of Solution Architecture & Concepts

Approved for Public Release - SPR#1346

Architecture Development - Methods of Discovery

AWS Operations & Control



"Where"

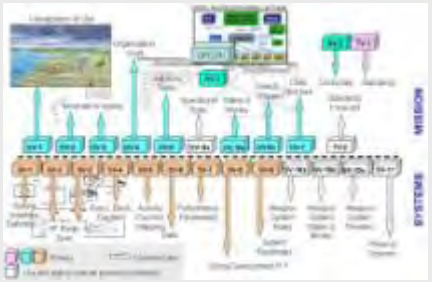
Military Situations "When"

Categories				
Support to National Level Special Operations	Noncombatant Evacuation Operations / Humanitarian Assistance / Disaster Relief	Gain Access and Shape the Battlespace	Forcible Entry	Sustained Operations Ashore
Irregular Warfare	Stability Operations	Gain Access	Decisive Operations	
SSSP Military Operations Other than War		MCO Wartime Operations		

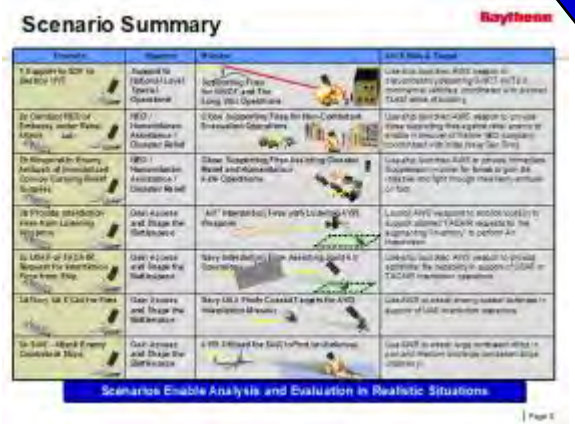
AWS Nodes "Who" "What"

Process & Documentation

Raytheon Enterprise Arch Process

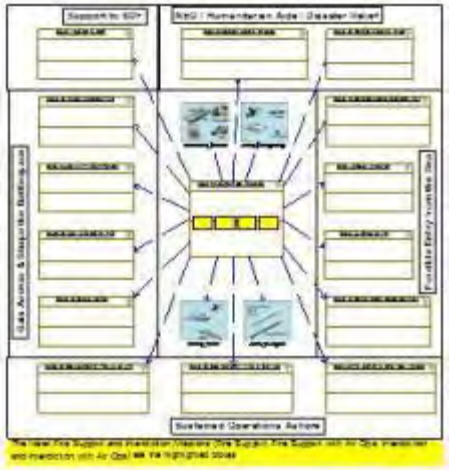


DoDAF



Joint Fires Scenarios "Why"

AWS Use Cases "How"

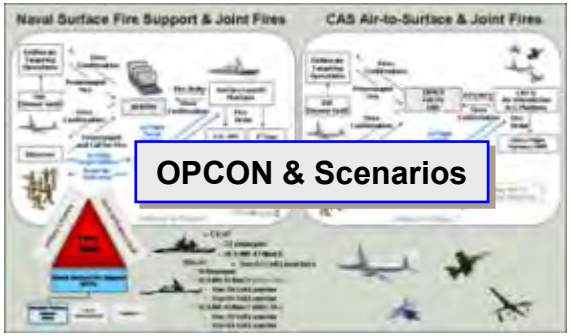


Discovery of "Where, When, Why, Who, What & How" for AWS

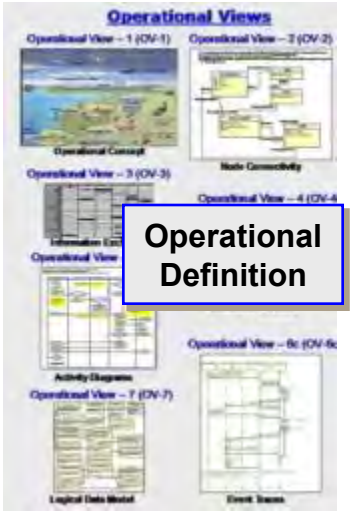
Defining the role of AWS and discovery of the Architecture

Approved for Public Release - SPR#1346

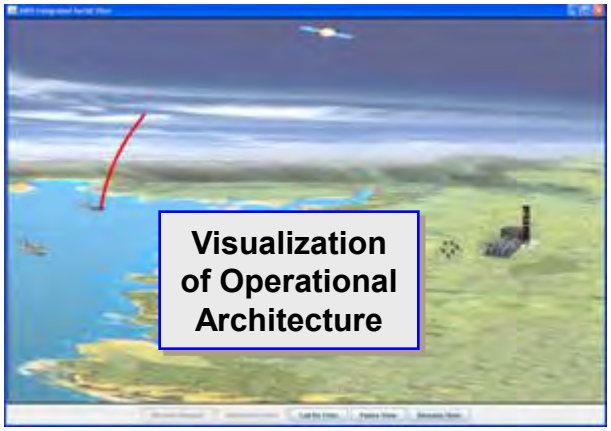
Architecture Development - Methods of Refinement



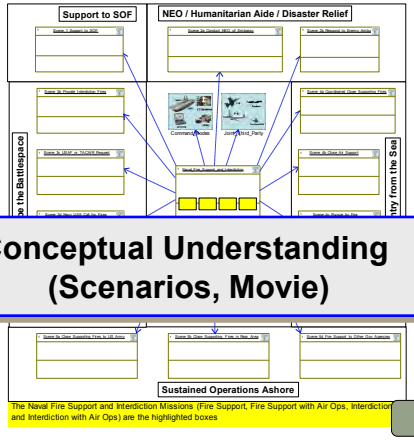
OPCON & Scenarios



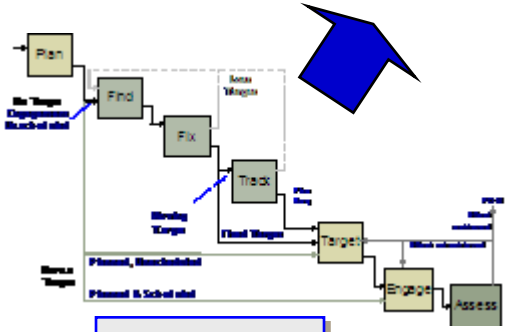
Operational Definition



Visualization of Operational Architecture



Conceptual Understanding (Scenarios, Movie)



Kill Chain Operations

System Definition

ICD

CDD

SDS

Capabilities Development

AFATDS/NFCS S/W Specs | NFCS/TTWCS Interface Specs | TTWCS/VLS/ MK-25/AWS Interface & Software Specs | MK-25 mod X Canister Spec | AWS Missile Spec

Notional Specification Tree

Requirements & Future Detailed Design

Operational understanding → System Development

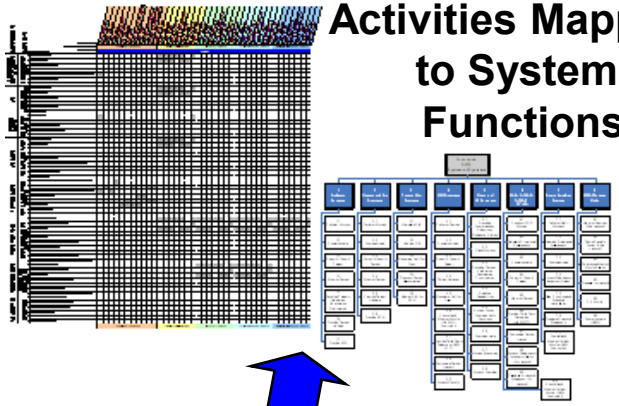
“PF2T2EA” Kill Chain Architecture

Operational Kill Chain

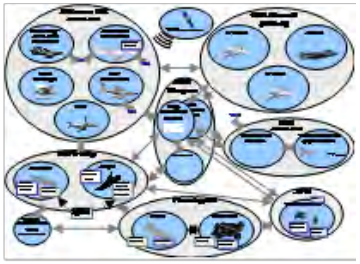
Executable Model

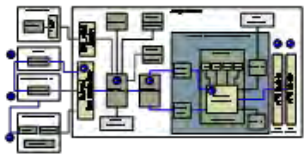
Studies & Design Decision Notebook

Operational Activities Mapping to System Functions



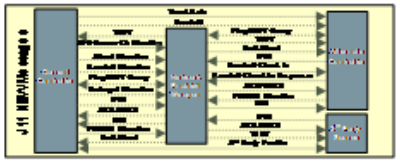
End Game





Networks & Communications

System Definition



Interfaces & Messages

System Operation → System Definition → System Design

AWS "To-Be" Operational Concept OV– 1

Affordable Weapon System for Navy Surface Fires Support & Joint Fires Operation

Raytheon

Operational Nodes & Info Exchange OV-2

Definitions of Node Swim Lanes Used for OV-5, 6b, 6c

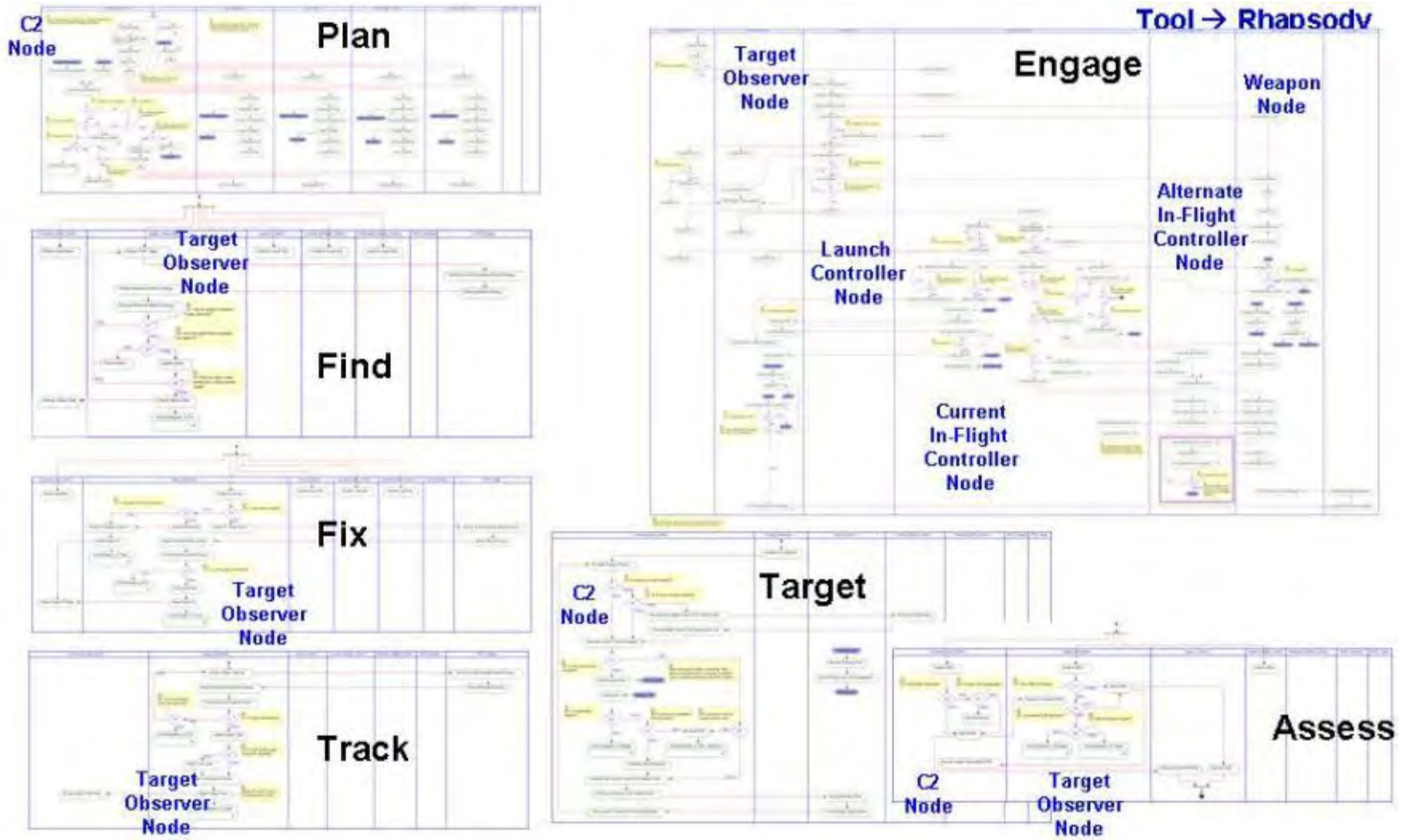
Command & Control	Target Observation	Launch Control	Current In-flight Control	Alternate In-flight Control	Weapon	Target
• Cmd Centers • Coord.Centers • Headquarters • FSCC, SACC ..	• FO/JTAC/ FAC(A) • Joint Intell. • NEW 3rd Party Target Source	• Aegis • Zumwalt • Maritime Air • LCS, UAV	• Net-Enabled Weapon In-Flight Controller	• Net-Enabled Weapon Alternate Controller	• AWS Missile	• Target of Interest
responsible for C2 functions	provides target information before, during and after the engagement	responds to CFF by preparing and launching missile	controls AWS missile during flight per NEW concept	different planned node that can become Current In-flight Control during flight	causes intended effect to battlefield	intended aimpoint object in Fires Mission

Operational Nodes perform activities of AWS Fires Kill Chain

Approved for Public Release - SPR#1346

Raytheon

Activity Diagrams OV-5s



Activity Diagrams show the Node participation in the AWS Kill Chain operations

Paths through the Kill Chain - Issues

Definitions

Planned – Specifically in the ATO (if required) and supporting relationships defined

Scheduled – Specific launch time defined

Plan

No Target

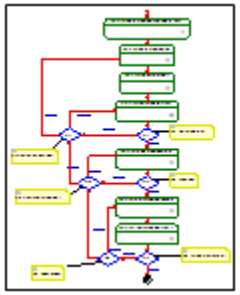
Find

Lost Target

Fix

Track

Engagement Unscheduled



Moving Target

Fixed Target

Target

Planned, Unscheduled

Have a Target

Planned & Scheduled

Response Time

Launch Platform Operations

C2

Missile Flight

Fire Req

Fire Order

Launch

EOM

Effect achieved

Effect not achieved

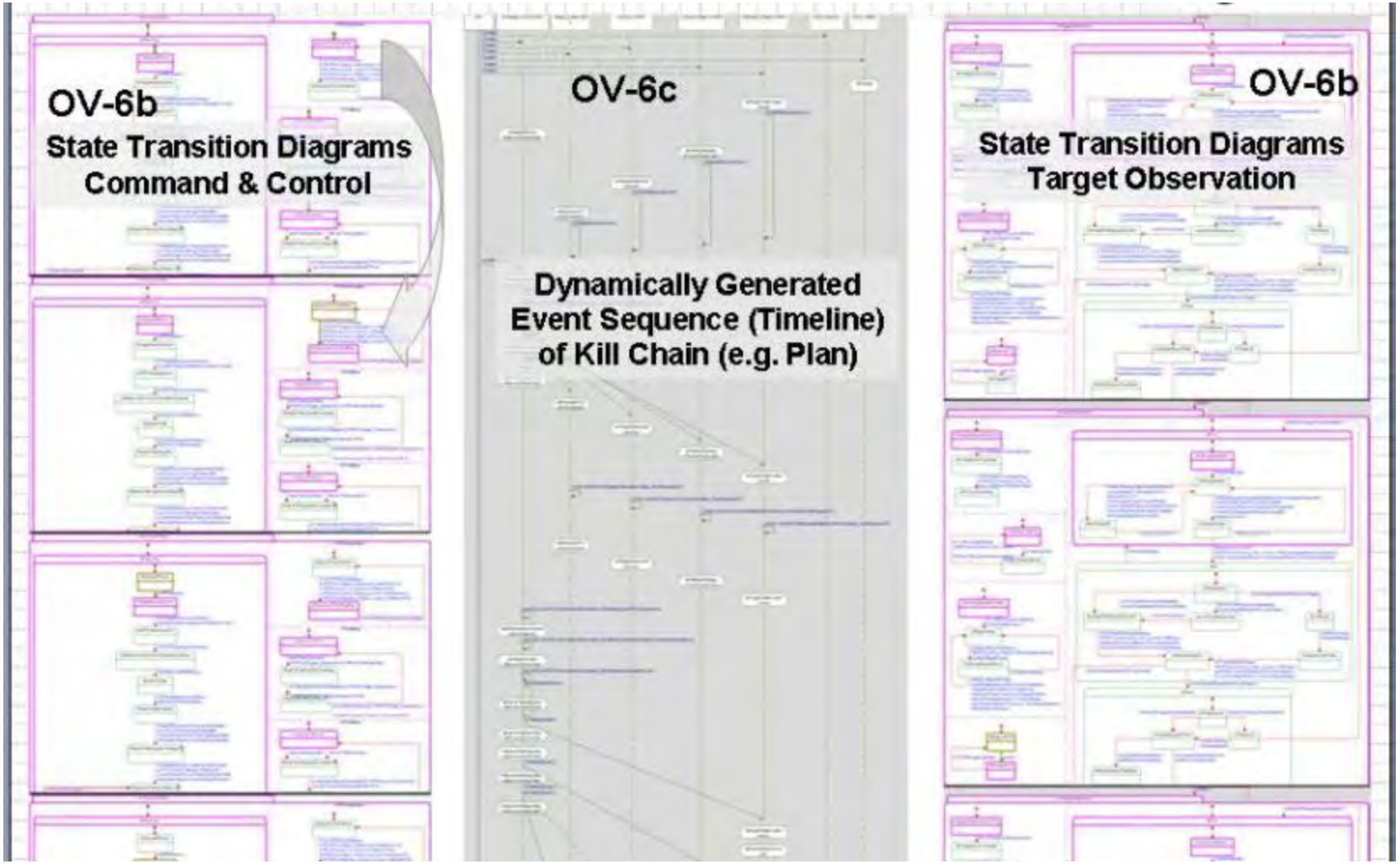
Engage

Assess

Call-For-Fire Supporting Fires focuses on Target & Engage

Raytheon

Execution of Kill Chain Operational Views



State Transitions and Event Sequences show dynamic interaction of AWS operations

Visualization of Operational Views

Enables Visualization and Verification of "what if" variations in AWS operations

Summary

- Described use of REAP to develop a Joint Fires and Naval Fire Support architecture based on P-F2T2EA kill chain model that emphasized:
  - Usability of the AWS
  - Affordability of development and deployment
  - Infrastructure and integration complexity
  - Desire for Net-Enabled Weapons (NEW) capability
- Showed operational- and system-level architecture products developed using IBM “Rhapsody” architecting tool, including an executable DoDAF model for sequencing, timeline analysis and mission visualization.
- Noted architecture analysis-derived mission and system requirements, and recommended C2 and fire support doctrine changes

Architecture available for use by other system developers

Biographies

- **Elizabeth M. (Liz) O'Keefe** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems, and has been with Raytheon and its legacy companies for 29 years. She has a BS degree from Clarkson University in Electrical Engineering (EE) - Communications and a MS degree in EE - Systems from California State University at Fullerton. Liz has worked in Radar Analysis, Systems Integration, Simulation, Engineering Processes, and Strategic Planning. She was Systems IPT lead for SM-3 Block I and then Chief Architect and Chief Engineer for SM-3 Strategic Architecture & Analysis (SA&A) and related Navy BMD programs, as well as Program Manager for the SM-3 SA&A and Low Cost Kill Vehicle programs. Liz was recently Chief Architect for the Affordable Weapon System and Net-Ready Key Performance Parameter Architecture Evaluator (NetRAE) Tool programs.

- **James G. (Jim) Sierchio** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems. He has been with Raytheon for 11 years, developing mission architectures and CONOPS for such BMD-related programs as Exo-Atmospheric Kill Vehicle, Multiple Kill Vehicle, and Sea-Based Terminal, the latter as Chief Architect. Jim is a retired Air Force Lieutenant Colonel, with a career spent in directed energy, space systems and BMD R&D, and technical intelligence. Jim has a BSE degree from Princeton University in Aerospace & Mechanical Sciences, a MS degree in Aerospace Engineering from the University of Dayton, an Engineer degree in Aeronautics & Astronautics from New York University, a MBA degree from Averett University, and a DBA from California Coast University.

Approved for Public Release - SPR#1346

BACKUP

Approved for Public Release - SPR#1346

Source Documents *(Primary References)*

REQUIREMENTS & SOURCES:

- Affordable Weapons System(s) Broad Agency Announcement, 3 July 2007
- Report to Congress on Naval Surface Fire Support, Director of Surface Warfare Office, CNO, March 2006
- Report to Congress, Chief of Naval Operations' Views & Recommendations of Naval Surface Fire Support, March 2006
- Report to Congress, Commandant of the Marine Corps' Views & Recommendations On Naval Surface Fire Support, March 2006
- Statement of Adm M.G. Mullen, CNO, Before the Senate Armed Services Sub Committee on Sea Power, 3 May 2007
- Joint Fires in Support of Expeditionary Operations in the Littorals, Initial Capabilities Document, Nov 2005
- Extended Range Munitions, Capabilities Development Document, Dec 2005
- Multi-Purpose Loitering Missile, Capabilities Development Document, Jan 2005
- GAO Report: "Issues Related to Navy Battleships," December 2005
- GAO Report: "Information on Options for Naval Surface Fire Support," November 2004
- GAO Report: "Improved Littoral War-Fighting Capabilities Needed," May 2001

CONCEPTS & DOCTRINE:

- Sea Power 21
- Naval Operations Concepts, 2006
- USMC Expeditionary Maneuver Warfare Family of Concepts,
  Operational Maneuver from the Sea MCCP-1 / Ship to Objective Maneuver / Sea Basing
- Marine Corps Operating Concepts for a Changing Security Environment, Second Edition, June 2007
- Supporting Arms in Amphibious Operations, NWP 3-09.11M
- Supporting Arms Coordination in Amphibious Operation s NTTP 3-02.2, May 2004
- Amphibious/Expeditionary Operations Air Control, NTTP 3-02.1.3, Sept 2005
- Ship to Shore Movement in Amphibious Operations, NWP 3-02.1
- Surface Ship Gunnery, NWP 3-20.32
- TST, Multi-Service Tactics, Techniques, and Procedures for Targeting Time Sensitive Targets.
  FM 3-60.1, MCRP 3-16D, NTTP3-60.1, AFTTP(I) 3-2.3
- MAGTF Planner's Reference Manual, August 2007
- Joint Pub 1-02 Definitions & Terminology
- Joint Pubs 3-XX Series
- Marine Corps Warfighting Pub 3-XX Series

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Findings and Recommendations from the NDIA/OSD Development Planning Working Group

John Lohse
Industry Co-chair
NDIA/OSD Development Planning Working Group
27 October 2010

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Agenda

- Background
- Development Planning Working Group Formation
- Industry Solicitation on Development Planning
- Development Planning Workshop Findings
- Development Planning Working Group Follow-on Activities
- Recommendations for Working Group Actions
- Next Steps
- Summary

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Background

Development Planning

NDIA SE Division Meeting
February 17, 2010

Mr. Michael Duffey
Deputy Director, Development Planning
Office of the Director for Systems Analysis
Systems Engineering Directorate
Office of Director, Defense Research and Engineering

Background

National Research Council

"Pre-Milestone A and Early-Phase Systems Engineering" Jan 2008

DoD 5000.02
December 2008

WSARA
May 2009

- **National Academies of Sciences Study**
  - All programs destined to fail without early [pre-MS A] systems engineering
  - Development planning can implement pre-MS A early systems engineering
- **DoD Acquisition Regulations (DoDI 5000.02) Update**
  - Increased focus on early pre-acquisition phases
  - Implication for added early systems engineering
- **Weapon Systems Acquisition Reform Act of 2009 (WSARA)**
  - Directs SE responsibilities to reinvigorate Development Planning

UNCLASSIFIED

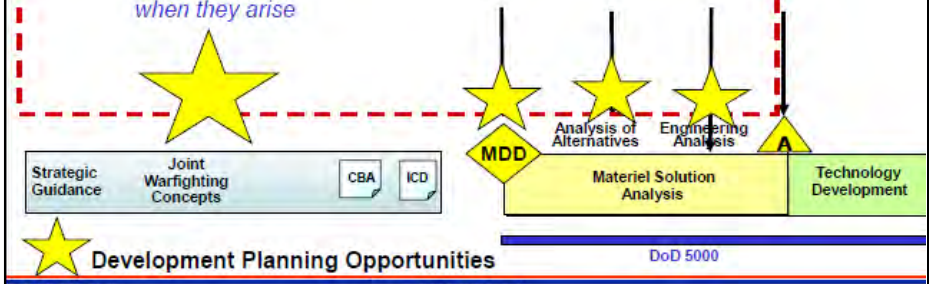
Development Planning Opportunities

Concept Development and Engineering

Focused SoS analysis and development of advanced systems concepts to support needs when they arise

Concept Evaluation and Refinement

Ensure optimal material solutions are identified with sound understanding of risks and opportunities



UNCLASSIFIED

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Background

DoD Systems Engineering

Mr. Stephen Welby
Director, Systems Engineering
Office of the Director, Defense Research and Engineering

DDR&E Imperatives

1. Accelerate delivery of technical capabilities to win the current fight
   - SE Focus: Support the current fight, manage risk with discipline
2. Prepare for an uncertain future
   - SE Focus: Grow engineering capabilities to address emerging challenges
3. Reduce the cost, acquisition time and risk of our Major Defense Acquisition Programs
   - SE Focus: Champion Systems Engineering as a tool to improve acquisition quality
4. Develop World Class Science, Technology, Engineering and Mathematics capabilities for the DoD and the Nation
   - SE Focus: Develop future technical leaders across the acquisition enterprise

Opportunities for engagement with NDIA Systems Engineering Division

Director, Systems Engineering Focus:
Champion Systems Engineering as a tool to improve acquisition quality

- Expand continuous engagement with Service acquisition efforts – provide mentorship and support to program offices
- Significant focus for FY2010: Institutionalize early Development Planning
  - Develop consensus across department on early Development Planning
  - Develop and Implement plan for reinvigorating early Development Planning; address policy and implementation, resourcing issues across department
  - Clarify Industry's role in Early Development Planning
  - Plan a workshop to define industry's role
    - Mission Analysis volunteered to participate
  - Convene a workshop to define industry role
    - Invite KOs and PMOs to participate
  - Kristen will provide overview current Pentagon work
- Evaluate current Systems Engineering policy and implementing guidance to identify opportunities to update and streamline current processes
- Support on an ad hoc review basis upon request

Development Planning Working Group Formation

- **OSD (DDR&E/SE) and NDIA (SE Div) agreed to form a Working Group to provide recommendations for how industry can support government Development Planning activities**
  - **Working Group formed with approximately 65 government/industry**
  - **WG Workshop held June 8 & 9 2010, in Alexandria VA (55 attendees)**

- **The objectives of the Working Group are to:**
  1. **Identify specific areas, activities and knowledge in the pre-milestone "A" timeframe where industry engagement could inform early technical analysis and engineering for DoD Acquisition Programs;**
  2. **Understand the available and potential mechanisms necessary to facilitate industry involvement in that early technical analysis and engineering;**
  3. **Recognize the issues, limitations, and questions and formulate recommendations to foster industry involvement in early technical analysis and engineering**

Development Planning Working Group Formation

- **The Working Group addressed the Development Planning scope of activities from two perspectives…**
  - **Pre-MDD**
  - **MDD to Milestone A**
- **The output of the Working Group will be a report to OSD DDR&E/SE identifying industry's potential role in supporting government Development Planning activities, specifically addressing the following:**
  - Identify how the government can engage with industry in early technical analysis and engineering
  - Identify the constraints industry engagement faces during early technical analysis and engineering and suggested recommendations
  - Identify the mechanisms Government can use to engage with industry during early technical analysis and engineering
  - Identify the key characteristics of DoD Policy & Guidance needed to enable industry engagement in early technical analysis and engineering

The underlying objective of this report is to identify the role industry can play in Development Planning in effectively starting the right acquisition programs

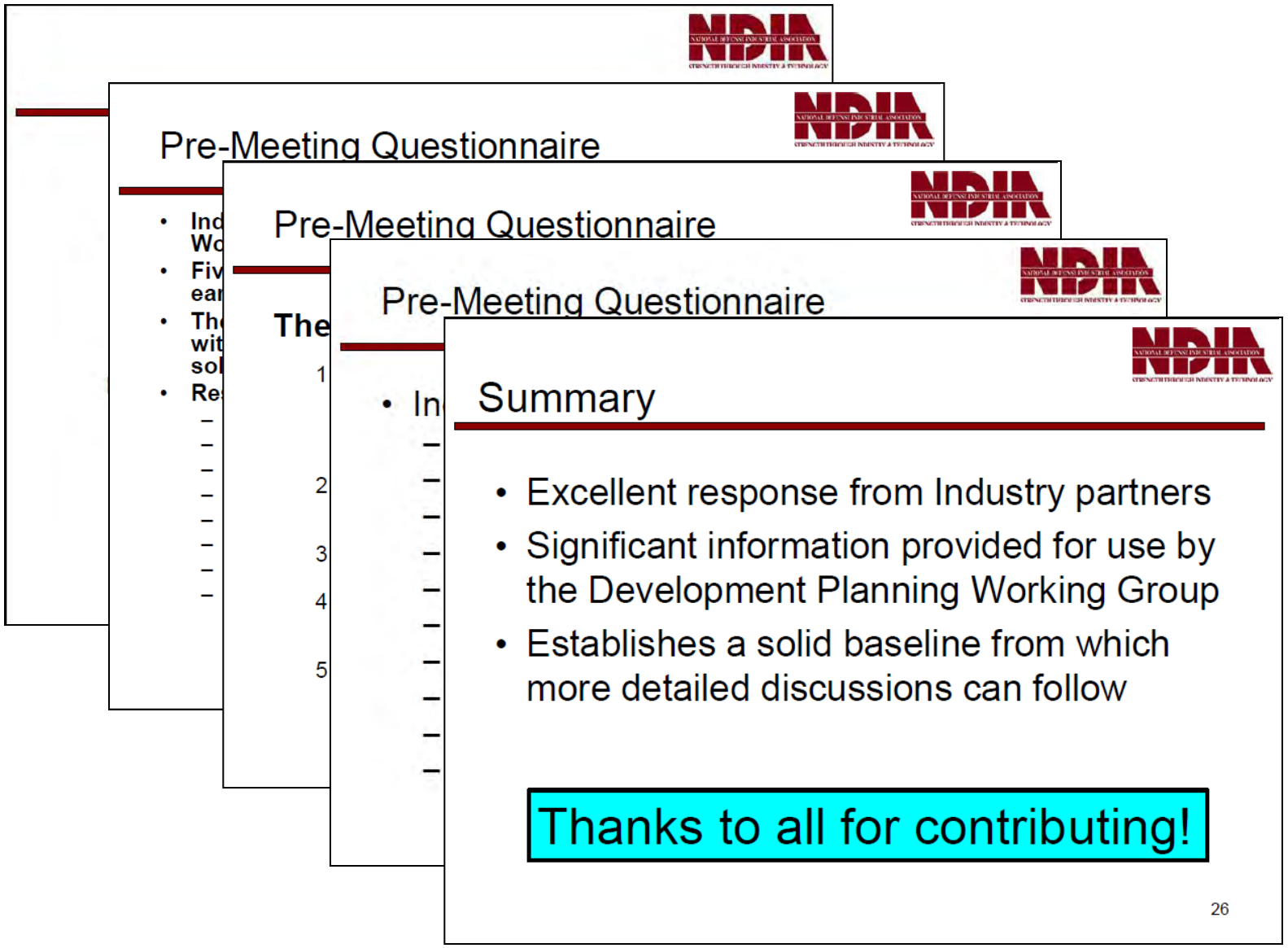
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Development Planning Working Group Formation

Key Motivator

- ***The Government decision-maker can make better and more informed decisions to achieve a balanced design of performance, schedule and cost including life cycle cost - i.e. what is practical and feasible - on a given program if they have more pertinent critical information of the type that Industry can provide.***

Industry Solicitation on Development Planning



NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Findings- Objective 1

Identify specific areas, activities and knowledge in the pre-milestone "A" timeframe where industry engagement could inform early technical analysis and engineering for DoD Acquisition Programs

- A-1:Industry knowledge can inform concept solution trade space and feasibility
- A-2: Industry input to Development Planning to support JCIDS Process would add value
- A-3: Early Industry engineering analysis would enhance the pre-MDD knowledge base
- B-1: Industry support in architecture development needed throughout Development Planning
- B-2: Industry can provide data and models, verified and validated by government, to inform independent government analysis in the AoA
- B-3: Industry support for engineering analysis during the initiation of program planning
- B-4: Industry support to the Gov't in assessing the state of technology
- B-5: Understanding of MDD/AoA Information enables Gov't/Industry collaboration to support MS-A

Findings- Objective 2

Understand the available and potential mechanisms necessary to facilitate industry involvement in that early technical analysis and engineering

- **Types of mechanisms (tools) is well understood**
  - Request for Information
  - Cooperative Research and Development Agreements
  - Study Contracts
  - Industry/Government Working Groups
  - Community of Practice
  - Mission-Domain Focused IDIQs
  - DTIC IRAD Database
  - Industry Days
  - Technology Demonstrations and Industry Driven Experiments
  - Broad Agency Announcements
  - Small Business Independent Research
  - Industry "pools" in theater and in acquisition
- **Process for government/industry collaboration to support pre-MDD & post-MDD activities needs to be defined**

*Defining a Development Planning process (**mechanism**) which incorporates these **tools** is part of the task at hand*

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Findings- Objective 3

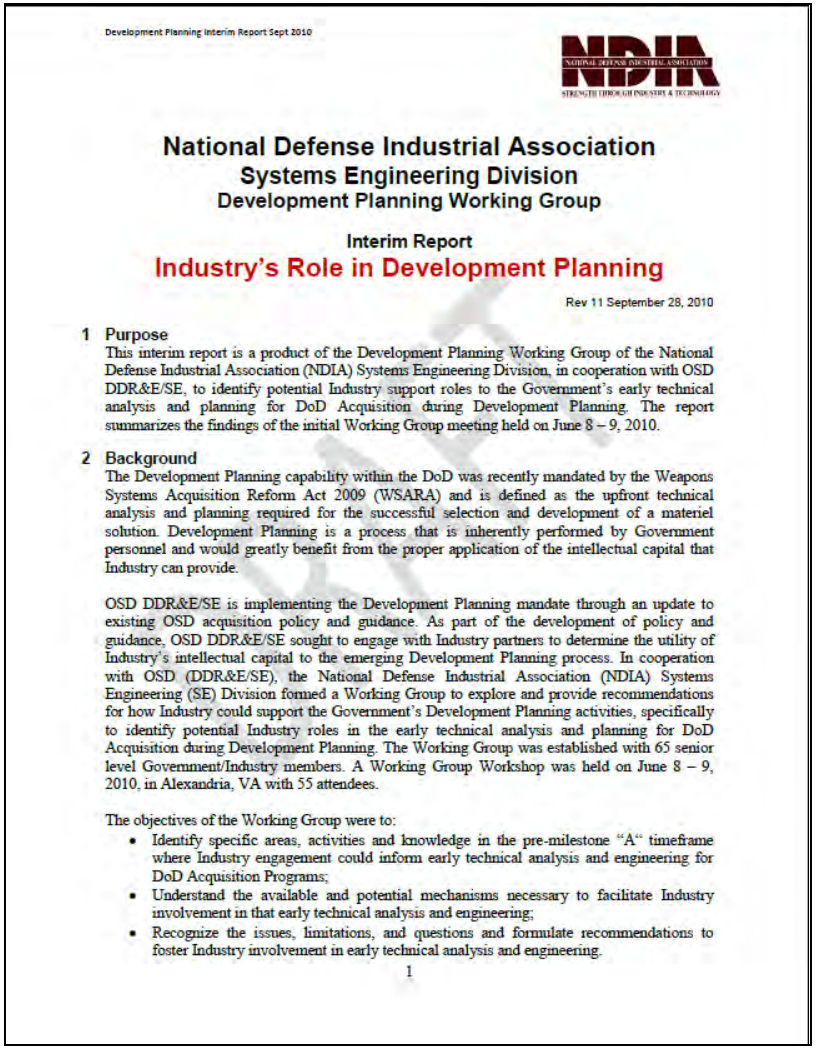
Recognize the issues, limitations, and questions and formulate recommendations to foster industry involvement in early technical analysis and engineering

- Organizational Conflict of Interest – interference with a contractor's ability to participate in subsequent competitions for development and production
- Industry cannot participate in "inherently governmental activity"
- Government reluctance to provide JCIDS products to industry
- Analytic Agenda requires classified access and limited distribution – possible other issues
- Industry input in the early phases of activity require the presence of technically competent government representatives to support technical exchanges
- Release and prioritization of capability needs and gap
- Industry activity in the early phases can be funded through industry investment to a point - establishing that threshold and identifying funding methods to support government needed industry investment in the early phases is a challenge
- Protection of industry intellectual property
- Industry reluctance to expose risks and opportunities in a pre-RFP environment (i.e., honesty and realism about industry capability can cost a contractor the contract)

Defining a Development Planning process which addresses these issues is part of the task at hand

Development Planning Working Group Follow-on Activities

- Briefed Mr. Welby, OSD, DDR&E, Director, Systems Engineering on July 28, 2010
- Received approval to continue Working Group effort
  - Generate a formal report
  - Provide recommendations on a detailed Development Planning process



Development Planning Interim Report Sept 2010

National Defense Industrial Association
Systems Engineering Division
Development Planning Working Group

Interim Report

Industry's Role in Development Planning

Rev 11 September 28, 2010

1 Purpose

This interim report is a product of the Development Planning Working Group of the National Defense Industrial Association (NDIA) Systems Engineering Division, in cooperation with OSD DDR&E/SE, to identify potential Industry support roles to the Government's early technical analysis and planning for DoD Acquisition during Development Planning. The report summarizes the findings of the initial Working Group meeting held on June 8 – 9, 2010.

2 Background

The Development Planning capability within the DoD was recently mandated by the Weapons Systems Acquisition Reform Act 2009 (WSARA) and is defined as the upfront technical analysis and planning required for the successful selection and development of a materiel solution. Development Planning is a process that is inherently performed by Government personnel and would greatly benefit from the proper application of the intellectual capital that Industry can provide.

OSD DDR&E/SE is implementing the Development Planning mandate through an update to existing OSD acquisition policy and guidance. As part of the development of policy and guidance, OSD DDR&E/SE sought to engage with Industry partners to determine the utility of Industry's intellectual capital to the emerging Development Planning process. In cooperation with OSD (DDR&E/SE), the National Defense Industrial Association (NDIA) Systems Engineering (SE) Division formed a Working Group to explore and provide recommendations for how Industry could support the Government's Development Planning activities, specifically to identify potential Industry roles in the early technical analysis and planning for DoD Acquisition during Development Planning. The Working Group was established with 65 senior level Government/Industry members. A Working Group Workshop was held on June 8 – 9, 2010, in Alexandria, VA with 55 attendees.

The objectives of the Working Group were to:

- Identify specific areas, activities and knowledge in the pre-milestone "A" timeframe where Industry engagement could inform early technical analysis and engineering for DoD Acquisition Programs;
- Understand the available and potential mechanisms necessary to facilitate Industry involvement in that early technical analysis and engineering;
- Recognize the issues, limitations, and questions and formulate recommendations to foster Industry involvement in early technical analysis and engineering.

1

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Recommendations for Working Group Actions

1) Explore opportunities for lessons learned from past successes involving industry and government collaboration in early phase acquisition
2) Define government and industry interpretations of the OCI legislation and rules
3) Clearly define the “inherently governmental activities”
4) Government and Industry ensure competent “up-front” involvement in Development Planning
5) Define government POCs within component Development Planning processes (domains, areas, expertise) to facilitate government/industry collaboration
6) Investigate the advantages, issues and challenges with each identified mechanism to facilitate recommended government/industry exchanges

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Next Steps

- Refine and resolve Findings/Recommendations into an integrated narrative with additional implementation detail
- Final report to be provided to OSD/DDR&E which clearly defines how industry can support government Development Planning activities
- Assist in initiating implementation of those recommendations considered viable by OSD through mechanisms included in specific recommendations

The underlying objective of this report is to identify the role Development Planning can play in effectively starting the right acquisition programs

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Summary

- The NDIA SE Division, in cooperation with OSD DDR&E/SE, formed a Development Planning Working Group to define potential Industry support roles in Development Planning
- A Development Planning Workshop was held on June 8 – 9, 2010
- Findings were presented to Mr. Welby on July 28, 2010
- Follow-on efforts being worked to provide Development Planning implementation details

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Questions?

Contact Information:
John Lohse
Raytheon Company
(520) 807-9156
jjlohse@raytheon.com

BACKUP

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

A-1:Industry knowledge can inform concept solution trade space and feasibility

- Industry can provide appropriate levels of government with critical information needed to help with pre-MDD information needs
  - Definition of the Concept Solution Space and associated technology assessments
  - Capability Trades in a Family of Systems context are needed with level of detail adequate to evaluate approaches to meeting a capability gap
- Benefits
  - Ensures a broad range of viable solutions are considered at MDD
  - Industry can identify what is achievable – or not - what the risks are, what the costs might be, and how long it might realistically take
- Mechanisms
  - TBD Development Planning process would establish information exchange mechanics
    - The current S&T environment provides some of this input, generally on a 1-on-1 basis
  - Component level Development Planning operating models need to be established
  - The existing DTIC IRAD dissemination site can inform government of current Industry advance developments and help provide additional critical S&T inputs
- Barriers/Issues
  - Must be done in a government-managed environment to obviate OCI* issues
  - Industry cannot actively participate in “inherently government activity”

***OCI: Organizational Conflict of Interest**

A-2: Industry input to Development Planning to support JCIDS Process would add value

- Decisions made at the MDD will benefit from more thorough and competent engineering analysis of potential concept
  - Critical information on feasibility, what is practical & plausible, risk, technologies available, costs, potential development schedules, and similar items to help in dealing with the overall trade space
- Benefits
  - More informed decision-making by government officials will allow for greater confidence and integrity in MDD inputs
- Mechanisms
  - Component level Development Planning operating models need to be established
  - Possible amendment to JCIDS (CJCSI 3170.01G) to formalize method for interacting with services Development Planners and Industry
- Barriers/Issues
  - JCIDS was not written to involve Industry or to facilitate informed information exchanges
  - Industry, working through the component Development Planning organizations, can provide critical information to government personnel for inclusion in JCIDS
  - Industry access to Analytical Baseline and Analytical Agenda would be needed
  - Potential OCI

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

A-3: Early Industry engineering analysis would enhance the pre-MDD knowledge base

- Pre-MDD activities will benefit from thorough and more competent engineering analysis by government
- Industry could assist in providing such to government through collaboration within the component Development Planning process
- Benefits
  - Pre-MDD work will have better data and focus resulting in better decision-making as process moves forward (i.e. what is practical & plausible)
  - Industry would gather additional feedback to help guide IRAD investments and refine technology investment strategies
  - Capitalize on past successes with technical collaboration between Industry & Government
- Mechanisms
  - OSD policy to encourage Service's Development Planning establish methodology which facilitates Industry interfaces, roles and responsibilities
  - Some funding may be required
- Barriers/Issues
  - Must not compromise OCI
  - Funding of efforts

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

B-1: Industry support in architecture development needed throughout Development Planning

- Gov't /Industry need alignment on the Mission Architecture, and collaboration on the transition to SoS and System architectures
- Benefits
  - Supports the transition to SoS and System capability definition
  - Creates Gov't/Industry alignment on SoS capability that will define Milestone A and Technology Development activities
  - Ensures identification of necessary enabling systems that need to be considered
- Mechanisms
  - Development Planning organizations collaborate with Industry on mission architecture dealing with common information on the Warfighter mission and corresponding needs
  - RFIs, CRADAs, and Study Contracts can be used to solicit a broad base of proprietary Industry responses
- Issues/Barriers
  - Protection of Industry IP once the architecture evolves into the potential SoS and System solution space
  - Potential OCI issues

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

B-2: Industry can provide data and models, verified and validated by government, to inform independent government analysis in the AoA

- The AoA will benefit from industry input on the models, tools, and data used by the Gov't to conduct the analysis
- Benefits
  - Gov't can validate their service models with further insight provided by Industry system models and architectures
  - Enables reusable concepts and higher fidelity models
  - Provides Gov't/Industry a shared understanding of mission parameters
  - Provides initial focus on affordability as a critical factor in the AoA
  - Provides tool/data/model configuration management and repository environment
- Mechanisms
  - Development Planning organizations identify the planned AoA tools and data, and Industry provided data on capability versus cost trades provides enhanced understanding in defining potential solution sets
  - RFIs, CRADAs, and Study Contracts can be used to obtain proprietary information on Industry models, tools, and data
- Issues/Barriers
  - Protection of Industry IP relative to Industry models, data, and tools, especially in a joint repository environment
  - Potential OCI issues

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

B-3: Industry support for engineering analysis during the initiation of program planning

- Post AoA engineering analysis is needed to shape initial program planning for the transition into Technology Development.
- Benefits
  - Industry information will help shape more realistic program planning and acquisition strategies accounting for cost/schedule/performance risks
  - Industry knowledge of the technical concepts and technology risks enable evolutionary acquisition with technology transition realism
  - Industry knowledge informs Gov't PMO or Development Planning organization as they build Milestone A documentation
  - Improved competition through cross Industry awareness
- Mechanisms
  - Development Planning organization or Gov't PMO establish the baseline of initial program planning documents
  - RFIs, CRADAs, and Study Contracts can be used to obtain proprietary information on Industry risks and opportunities relative to the Preferred System Concept identified by the AoA
- Issues/Barriers
  - Reluctance of Industry to share risks and opportunities in a pre-RFP environment
  - Protection of Industry IP relative to Industry risks and opportunities
  - Potential OCI issues

B-4: Industry support to the Gov't in assessing the state of technology

- It is critical to obtain credible assessments of the state of current and potential enabling technologies required to support the concept solution space prior to, during, and after the conduct of the AoA
- Benefits
  - Provides realism in technology assessment
  - Provides input on technology feasibility, and the capacity for growth/evolution
  - Supports TDS development relative to CTEs
- Mechanisms
  - Development Planning organization can assess applicable technologies
  - RFIs, CRADAs, and Study Contracts can be used to solicit a broad base of proprietary Industry responses on potential enabling technologies
  - Technology Demonstrations and Industry Driven Experiments can be used to assess and validate the current state of enabling technologies
  - The existing DTIC IRAD dissemination site can be used by Industry to post their IR&D efforts and by the Gov't to search on enabling technologies
- Issues/Barriers
  - Protection of Industry IP surrounding potential enabling technologies,
  - Potential OCI issues
  - Technology Demonstrations may require Gov't funding
  - Little Gov't feedback provided for Industry Driven Experiments

B-5: Understanding of MDD/AoA Information enables Gov't/Industry collaboration to support MS-A

- Increased sharing of MDD/AoA information to enable Gov't/Industry collaboration in refining the solution space to support MS A decision
  - Includes the AoA Study Guidance, the Acquisition Decision Memorandum defining Milestone A expectations, the AoA evaluation criteria/critical success factors, and the mission level MOEs.
  - This information needs to include technical, schedule, and budget constraints
- Benefits
  - The identification and potential refinement of these measures is critical to ensure meaningful MOEs with feasible parameters.
  - Allows Industry to inform Gov't on potential alternatives and risks (including disruptive and maturing technologies) which would drive evolutionary strategy
  - Aligns Gov't/Industry to Milestone A objectives and allows Industry to inform Gov't on potential objectives not considered in ADM
  - Aligns Gov't/Industry on the Warfighter needs (scenarios, threats, etc) and the measures against which the solution will be validated.
  - Industry can verify evaluation criteria/critical success factors are complete/balanced
- Mechanisms
  - Gov't/Industry Working Groups disseminate information to a broad Industry base and allow consolidated, non-proprietary Industry feedback
  - RFIs, CRADAs, and Study Contracts can be used to disseminate the information and solicit a broad base of proprietary Industry responses
- Issues/Barriers
  - Protection of Industry IP included in feedback
  - Potential OCI issues

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

C-1: Define clear guidelines for avoiding OCI

- OSD may need to provide additional clarification & guidance to Services regarding Organizational Conflict of Interest interpretations
  - Current FAR 9.505.2 provides all pertinent information
  - Additional clarification may be needed to facilitate collaborative environment
- Benefits
  - Would allow additional Industry participation in pre-MDD Development Planning activities, JCIDS process, and Material Solution Analysis activities
- Mechanisms
  - Could be included in OSD DDR&E Development Planning & Guidance
- Issues/Barriers
  - Current approach tends to be for government to use the lowest-risk interpretation, which typically causes exclusion of industry participation
  - Clear guidance on what type of industry involvement IS and IS NOT allowed, using examples, would help mitigate the current reluctance
  - NOTE we are not suggesting loosening the OCI provisions but clarifying them

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

C-2: Government leadership should ensure competent "up-front" involvement in Development Planning

- Ensuring that the best-available government engineering capability is involved with Development Planning will add integrity to the process
  - Growing losses of competent engineering personnel is problematic
  - Competent government engineering in the Development Planning process is essential and can be restored, and enhanced, with informed Industry inputs
- Benefits
  - Utilizing the best new/existing talent in Development Planning would add integrity to the process and allow for better decision-making
  - Industry inputs will be better utilized due to better understanding of technologies, inherent capabilities, risks, costs and what is practical and plausible
- Mechanisms
  - Services could consciously identify "best/brightest" and assign to Development Planning and related development activities as appropriate

C-3: Define Development Planning process for increased Gov't/Industry Collaboration

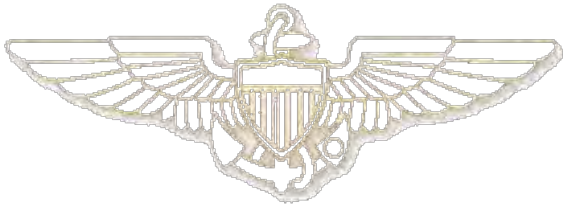
- Define attributes of a component Development Planning process which allows Government & Industry to facilitate increased collaboration
  - Examine existing component Development Planning processes
  - Identify important information exchange interfaces within each component process and between the appropriate stakeholders within the DoD
- Benefits
  - Will improve information sharing on advance developments, future military needs, and MDD information and documentation
  - NOTE: Industry believes this exists within DARPA, but is far less effective in the Services
- Mechanisms
  - Broad Agency Announcements (BAA)
  - Requests for Information (RFI)
    - Such need to remain open
- Issues/Barriers
  - BAAs and Open RFIs are costly
  - Industry would expect feedback from such

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

C-4: Identify and apply funding alternatives to support selected Development Planning activities

- Additional funding needed could come from Industry and/or Government for such things as additional engineering and technical analysis
- Benefits
  - Funded activities provide greater focus on specific needs
- Mechanisms
  - CRADAs (Cooperative Research and Development Activity)
  - Industry will self-fund certain activities if clear benefit to Development Planning is understood
  - SBIR (Small Business Independent Research) at MAJCOM level
- Issues/Barriers
  - S&T environment not funded/budgeted to “systemize”
  - Potential OCI issues, but careful boundary control can mitigate
  - CRADAs sometimes hard to implement; government help in visualizing mutual value will help

Suitability Impacts on Rapid Development



Michael Gaydar
Deputy Director Air Platforms, Systems Engineering

Roadmap

- Review of Quick Response Program Compared With A Program Of Record
- Characterizing System Requirements Through System Level Attributes
- Prioritizing System Attributes To Support Rapid Deployment
- Identifying Rapid Development Streamlining Of System Attributes
- System Architecting To Minimize Suitability Attributes Impact On Development Timelines
- Summary

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Rapid Development v. Rapid Deployment

The DOD 5000 series of instructions regulate government acquisition for ACAT I programs in a ***very deliberate*** and ***programmed manner. ..*** The rapid validation and resourcing of JUONs is a time sensitive process in support of a combatant commander involved in a combat-related ongoing operation. .. ***They should not involve the development of a new technology or capability***; however, the acceleration of an Advanced Concept Technology Demonstration (ACTD) or ***minor modification of an existing system*** to adapt to a new or similar mission is within the scope of the JUON validation and resourcing process.

-CJCSI 3470.01

- **Program Of Record-Long Term DOD Requirements**
  - CDD Requirements Originating Through JCIDS And Are Validated By JROC
  - Requirements Have Strategic View Of Capabilities
    - Stressing KPPs & Threshold Requirements Reflect Large Acquisition Efforts
    - Stressing Performance Thresholds Requires Additional Development Time
  - Time To IOC Is Dependent On Balancing Requirements
    - Total Ownership Costs (TOC) Are Minimized By Policy Direction
    - Longer Service Life Requires System Suitability
- **Direct Warfighter Response-Immediate Needs**
  - Supporting Tactical “Immediate Needs” Should Not Evolve Into Long Term Capability
  - Suitability Shortfalls Have A Short Lived Impact On System
  - Schedule Is KING
    - Performance Levels Constrained To Existing Technology
    - Existing Design Defines Suitability
    - Training Real Time And Hands-On

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Tasking

- **Compare Two Programs; Tiger Shark, A Rapid Deployment Program And STUAS, A CDD Tasked Program of Record (POR).**

Question 1: Tiger Shark Required Less Time And Staffing Resources To Field Than A POR. Why Did This Occur?

Question 2: Can Techniques Used In The Rapid Deployment World Be Adapted To Streamline POR Acquisition Efforts?

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Program Environments

Tiger Shark-

"USSOCOM Needed A Short Term, Stop Gap, ISR System For Approximately One Year."

STUAS-

"Marine Corps Was Looking To Field A System That Operators Liked And Was Supportable It For 20 Years."

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Tiger Shark vs STUAS Attributes Affecting Staffing

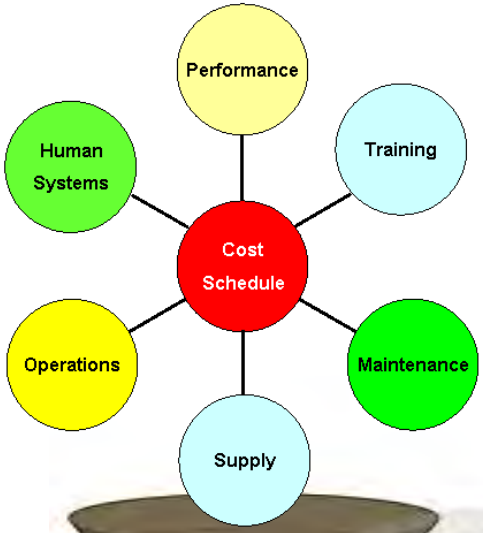
Factor	Tiger Shark	STUAS
Supportability	3-5 Yr Service Life, Contractor	20 Yr Service Life, Organic
Maturity of Technology	Non-Developmental	Sensor Development
Breadth of Design	Immediate Needs Focused	Multi-Service, Ground Segment
Complexity of Design	Sensor/Vehicle Integration	Stressing CDD
External Interfaces		
Interoperability	None	NET READY KPP
National Air Space	Combat or Range (CAT 3)	Sparsely Populated (CAT 2)
Ship Board Integration	NO	YES
ACAT Designation	None	YES
Competition/Sole Source	Pre-Negotiated Competitive	Source Selection Competition
Risk Tolerance	High	Medium To Low

Requirements Trade Space

Tiger Shark Guidance

STUAS JCIDS Guidance

300+ Requirements



BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Passing Grade

- **Operationally Effective**
  - User Performance Requirements and Capabilities
  - Evaluated In User Defined CONOPS Environments
  - Defined In System Key Performance Parameters (KPPs)
- **Operationally Suitable**
  - Compatibility With User Environment And Support Systems
  - Reliability and Maintainability Characteristics
  - Interoperability With Other Systems
  - Utilizes Establish Supply Chain
  - Reduces Total Ownership Cost (TOC)
  - Defined In System Key System Attributes (KSAs)

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Developing Attributes

- Attributes Should Represent Product Characteristics
- Traceable To OT&E Criteria
  - Operationally Effective: Does The Product Provide A Capability That Meets Performance Requirements?
  - Operationally Suitable: Is The Performance Available, Reliable, Supportable, Modifiable, and Cost Effective?
- Should Span Multiple Functional Engineering Disciplines
- Should Require Analysis And Final Verification By Technical Authorities

Varied Guidance On SE

DODI 5000.02 Enclosure 8 & 12	DAG Chapter 4.4	SECNAVINST 5000.02	NAVAIRINST 5000.24 SETR Handbook
Systems Engineering Across Life Cycle	System Engineering Design Consideration	CH 7 System Engineering and Human Systems Integration	Functional Areas
	Accessibility		
	Commercial Off-the-Shelf (COTS)		
Corrosion Prevention and Control	Corrosion Prevention and Control		
	Critical Safety Items (CSIs)	Aviation Critical Safety Items (CSIs) (7.3.7)	
	Disposal and Demilitarization		
	Diminishing Manufacturing Sources and Material Shortages (DMSMS)		
Environment, Safety, and Occupational Health (ESOH)	Environment, Safety, and Occupational Health (ESOH)	Environmental, Safety, and Occupational Health (ESOH) (7.3)	Safety
Programmatic Environmental, Safety and Occupational Health (ESOH) Evaluation (PESHE)	Programmatic Environmental, Safety and Occupational Health (ESOH) Evaluation (PESHE)	Safety and Health (7.3.3)	
	National Environmental Policy Act (NEPA)/Executive Order (EO) 12114 Compliance Schedule	National Environmental Policy Act (NEPA) and Executive Order (EO) 12114 Environmental Effect Abroad (7.3.2)	
	Networks and Automated Information Systems (AIS)		
	Environment, Safety, and Occupational Health (ESOH) Management Evaluation Criteria		
Mishap Investigation	Environment, Safety, and Occupational Health (ESOH) Risk Management		
	Environmental, Safety and Occupational Health (ESOH) Risk Reporting	ESOH Compliance (7.3.1)	
	Environmental, Safety and Occupational Health (ESOH) Risk Acceptance		
National Environmental Policy Act (NEPA)/ Executive Order (EO) 12114 Compliance Schedule Analysis	National Environmental Policy Act (NEPA)/ Executive Order (EO) 12114 Compliance Schedule Analysis		
	Unmanned Systems (UMS)		
	Green Procurement	Pollution Prevention (7.3.5)	
		Hazardous Materials Management (7.3.4)	
		Pollution Prevention (7.3.5)	
Mishap Investigation Support			
Human Systems Integration (Enclosure 8)	Human Systems Integration (HSI)	Human Systems Integration (HSI) (7.2)	Human Systems Integration
Human Factors Engineering		Human Factors Engineering (HFE) (7.2.3)	
Manpower		Manpower, Personnel, and Training (MPT) (7.2.2)	
Personnel			
Training			
Habitability		Habitability (7.2.5)	
Survivability		Personnel Survivability (7.2.4)	
Safety & Occupational Health			
		HSI in Acquisition (7.2.1)	

Varied Guidance On SE

DODI 5000.02 Enclosure 8 & 12	DAG Chapter 4.4	SECNAVINST 5000.02	NAVAIRINST 5000.24 SETR Handbook
Systems Engineering Across Life Cycle	System Engineering Design Consideration	CH 7 System Engineering and Human Systems Integration	Functional Areas
	Insensitive Munitions (IM)	Explosives Safety (7.3.6)	
	Interoperability	Interoperability and Integration (7.1.6)	Standardization and Interoperability
	Open Systems De	Open Architecture (7.1.4)	
Modular Open Systems Approach (MOSA)			
		(SOS & FOS) Standardization and Commonality (7.1.9.2)	
		T Design Considerations (7.1.6.1)	
		D Architecture Framework (DoDAF)/Global Information rid Technical Guidance (GTG) (7.1.6.2)	
		tem of Systems (SoS) or Family of Systems Integration eroperability Validation (7.1.6.3)	
		eroperability and Integration Support (7.1.6.4)	
		tem Performance for SoS and FoS Programs (7.1.9.1)	
	Parts Ma		
	Program Pr		
	Program		
	Critical Program I		
	Threats, Vulnerabi s, Risk sment		
			Information Assurance
	Quality and Producibility		
	Quality in Design	Quality (7.1.2)	
	Manufacturing Readiness	Manufacturing and Production (7.1.1)	
	Reliability, Availability, and Maintainability	Reliability, Availability, and Maintainability (RAM	intainability
	Software		e
Spectrum Supportability	Spectrum Management	Electromagnetic Environmental Effects (E3) an Supportability (7.1.13)	l Effects and Spectrum
	Standardization		
	Supportability	Acquisition Logistics and Sustainment (7.1	
	Supportability Analyses		
	Support Concept		
Data Management & Technical Rights	Support Data		
	Support Resources		
	Survivability and Susceptibility	Survivability (7.1.7)	
Unique Identification of Items (UID)	Unique Identification of Items (UID)		
Systems Engineer Plan (SEP)		System Engineering (7.1)	Sy g and Program Management Tasks
		Shipboard System Integration (7.1.8)	
		Performance Specifications (7.1.9)	
		Precise Time and Time Interval (PTTI) Support (7.1.10)	
		Geospatial Information and Services (GI&S) (7.1.11)	
		Natural Environmental Support (7.1.12)	
Systems Engineering Leadership			
Techncial Reviews			
Configuration Management			

No Mention Of Performance Parameters KPPs

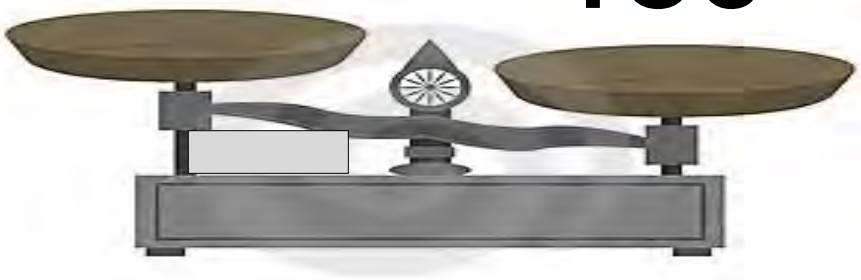
No Mention Of Total Ownership Cost TOC

System Attributes

Operationally Effective	Operationally Suitable
Performance (KPPs, KSAs)	**System Safety**
Human Systems Integration	**Environmental Impact**
Habitability	**Human System Integration (7 Domains)**
Survivability	Human Factors Engineering
Interoperability	Manpower
Air-Ship Integration	Personnel
Electromagnetic Environmental Effects (E3)	Training
Spectrum Supportability	Safety & Occupational Health
Netcentric Interoperability	**Interoperability & Standardization**
	OA
	Modularity
	Commonality
	Program Protection
	Critical Program Information (CPI)
	Critical Safety Items (CSI)
	Threats, Vulnerabilities, Risk Assessment
	Technology Protection
	Information Assurance
	OPSEC
	Producibility
	Ten Logistics Elements
	Maintenance Planning
	Supply Support
	Support & Test Equipment
	Manpower & Personnel
	Training & Training Devices
	Technical Data
	Computer Resource Support
	Packaging, Handling, Storage, and Transportation (PHS&T)
	Facilities
	Design Interface
	Facilities and Infrastructure
	Total Ownership Cost

KPPs/KSAs

TOC



Rapid Deployment System Attributes

Operationally Effective	Operationally Suitable
Performance (KPPs, KSAs)	**System Safety**
Human Systems Integration	**Environmental Impact**
Habitability	**Human System Integration (7 Domains)**
Survivability	Human Factors Engineering
Interoperability	Manpower
Air-Ship Integration	Personnel
Electromagnetic Environmental Effects (E3)	Training
Spectrum Supportability	Safety & Occupational Health
Netcentric Interoperability	**Interoperability & Standardization**
	OA
	Modularity
	Commonality
	Program Protection
	Critical Program Information (CPI)
	Critical Safety Items (CSI)
	Threats, Vulnerabilities, Risk Assessment
	Technology Protection
	Information Assurance
	OPSEC
	Producibility
	Ten Logistics Elements
	Maintenance Planning
	Supply Support
	Support & Test Equipment
	Manpower & Personnel
	Training & Training Devices
	Technical Data
	Computer Resource Support
	Packaging, Handling, Storage, and Transportation (PHS&T)
	Facilities
	Design Interface
	Facilities and Infrastructure
	Total Ownership Cost

Reduced Attribute Set Based On Minimum Set of Flexible Requirements For Short Lived Tactical Systems

No Threshold

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Critical Rapid Deployment Attributes

Operationally Effective	Operationally Suitable
Performance (KPPs, KSAs)	**System Safety**
Human Systems Integration	**Environmental Impact**
Habitability	**Human System Integration (7 Domains)**
Survivability	Human Factors Engineering
Interoperability	Manpower
Air-Ship Integration	Personnel
Electromagnetic Environmental Effects (E3)	Training
Spectrum Supportability	Safety & Occupational Health
Netcentric Interoperability	**Interoperability & Standardization**
	OA
	Modularity
	Commonality
	Program Protection
	Critical Program Information (CPI)
	Critical Safety Items (CSI)
	Threats, Vulnerabilities, Risk Assessment
	Technology Protection
	Information Assurance
	OPSEC
	Producibility
	Ten Logistics Elements
	Maintenance Planning
	Supply Support
	Support & Test Equipment
	Manpower & Personnel
	Training & Training Devices
	Technical Data
	Computer Resource Support
	Packaging, Handling, Storage, and Transportation (PHS&T)
	Facilities
	Design Interface
	Facilities and Infrastructure
	Total Ownership Cost

Rapid Deployment Attributes

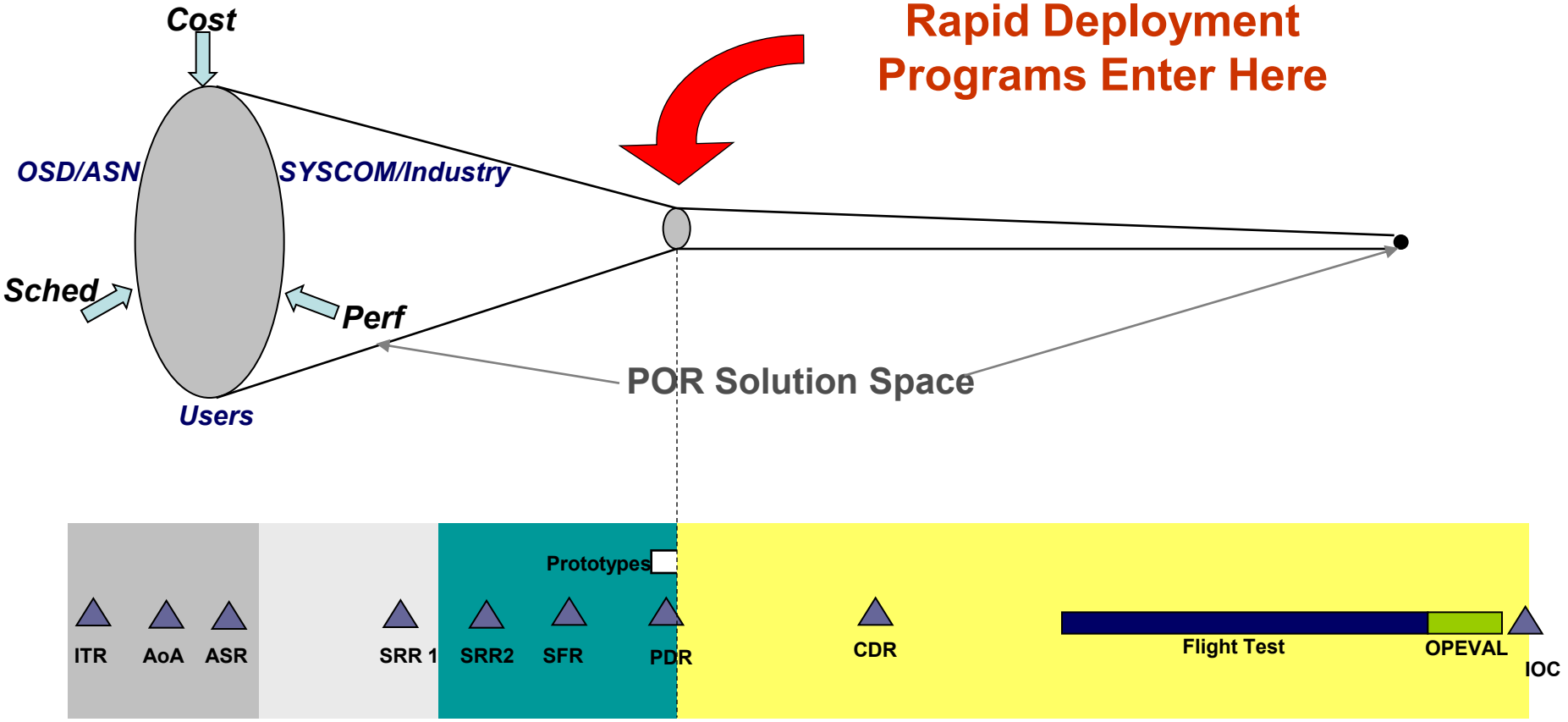
Defined Thresholds Exist

Thresholds Flexible

No Threshold

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Rapid Deployment Against SETR Timeline



BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Role of Engineering & Logistics Personnel

- **Engineering & Logistics Review Predictive Analysis To Evaluate Maturing Design**
  - Stressing Requirements Requires More Analysis
  - Suitability Requirements Are Balanced Across Breadth Of Design
- **Service Life (20-25 Year) Invokes JCIDS Sustainability Emphasis**
  - High Levels Of Reliability Over Service Life
  - Design Is Optimized To Reduce Total Ownership Cost (TOC)
  - Large Infrastructure Investments Are Evaluated
    - Fully Integrated, Multi-Service, Joint Infrastructure
    - Establishing Permanent Ground Control Segments
    - Multiple Operating Locations
    - Large Number Of Systems
    - Organic MX, Training, and Supply Support

Plan & Analyze

Short Lived Systems Reduce Planning and Analysis

Rapid Development Effectiveness Attributes

- **Performance Thresholds (Pre-MS B)**
  - Achievable With Existing Technology (Limited TD Phase)
  - Allow Performance Threshold To Adjust To Technology
  - Incremental Increases Through P3I
- **Open Architecture-Modular Or Federated Approach**
  - Integration Drives Complexity
  - Integration Works Against P3I
- **Avoid Desire To Control Everything**
  - Allow CDD To Spawn Multiple Programs
    - UAS Control Segments
    - UAS Air Vehicles
  - Manage Program Beyond System Boundaries

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Rapid Development Sustainment Philosophy

- **Identify Non-TOC Elements**
  - Balance Logistics Savings Against Development Cost
- **Avoid One Size Fits All Support Structure**
  - Current Support Of Sub-System May Be Good Enough
- **Define A Standardized Technology Insertion Cycle**
  - Manage Life Cycle Logistics Incrementally
  - Reduce Support Requirements By Life Limiting Components
  - Accept Technology Refresh As A Supportability Approach Along With Performance Improvements Benefits
  - Performance Improvements Have Value That Offset Cost
- **Assume Supportability Infrastructure Is Not Inflexible And Will Adapt To System Shortfalls**

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

Summary

- "Timing Is King" In Rapid Deployment
- DODI 5000.02 and JCIDS 3470.01 Identify Program Of Record Timelines As „Deliberate"
- System Development Timelines Driven By
  - State Of Technology
  - Suitability Requirements
- Architect System To Reduce Development Time
  - Open Architecture
  - Incremental Development or Technology Insertion
  - Modularize System To Reduce Supportability Impacts
- Support System Is Not Static

BACKUP

Rapid Deployment System Attributes

Operationally Effective	Suitable
Performance (KPPs, KSAs)	System Safety
Human Systems Integration	Environmental Impact
Habitability	Human System Integration (7 Domains)
Survivability	Human Factors Engineering
Interoperability	Manpower
Air-Ship Integration	Personnel
Electromagnetic Environmental Effects (E3)	Training
Spectrum Supportability	Safety & Occupational Health
Netcentric Interoperability	Interoperability & Standardization
	OA
	Modularity
	Commonality
	Program Protection
	Critical Program Information (CPI)
	Critical Safety Items (CSI)
	Threats, Vulnerabilities, Risk Assessment
	Technology Protection
	Information Assurance
	OPSEC
	Producibility
	Ten Logistics Elements
	Maintenance Planning
	Supply Support
	Support & Test Equipment
	Manpower & Personnel
	Training & Training Devices
	Technical Data
	Computer Resource Support
	Packaging, Handling, Storage, and Transportation (PHS&T)
	Facilities
	Design Interface
	Facilities and Infrastructure
	Total Ownership Cost

Rapid Warfighter Attributes

Defined Thresholds Exist

Thresholds Flexible

BRIEF DATE: ver 1.5
CONFIG. MGR: Michael Gaydar

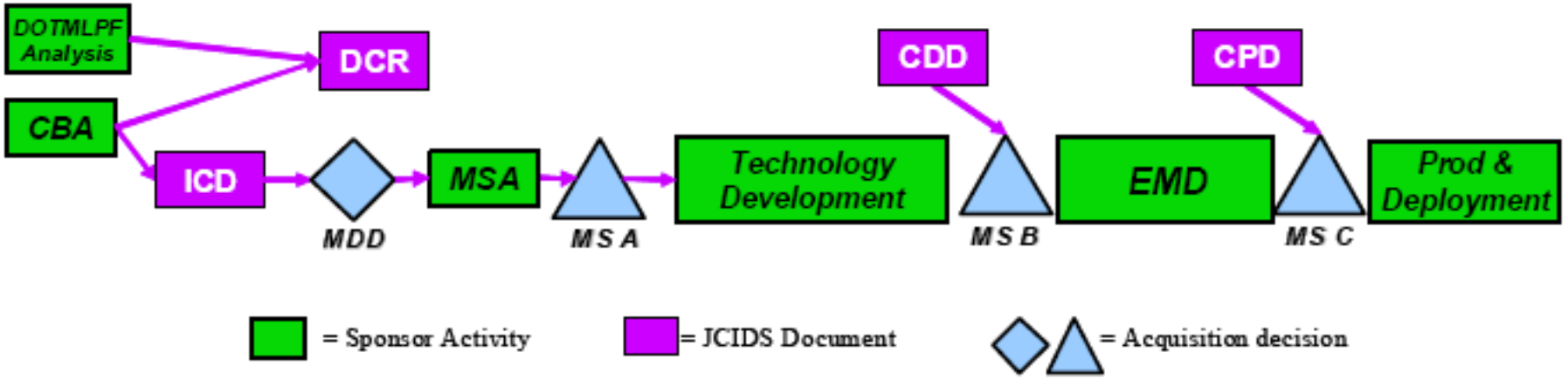
Early Systems Engineering to Achieve MS B

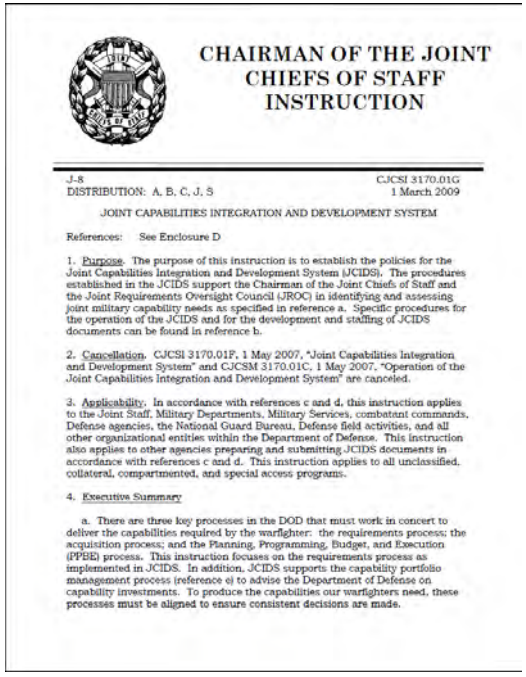
Michael Gaydar
Deputy Director Air Platforms, Systems Engineering

Early Systems Engineering Ground Rules

- Begins With MDD Decision
- Product Focused Approach
- Must Involve Engineers
  - Requirements Stability Is Outcome Of Early SE
- Must Demonstrate Achievable Technology
  - Requires TRL 6 Prior To MS B
  - Engineering Theory Pushed To Real World Capability
- Achieve Low Technical Risk
  - Medium Cost & Schedule Risk Environment
- Must Balance Cost, Schedule, & Performance
- Must Identify Sub-Systems Prior To MS-B
- CDD Finalized Just Prior To MS-B

DOTMLPF Analysis





CHAIRMAN OF THE JOINT CHIEFS OF STAFF INSTRUCTION

J-8 CJCSI 3170.01G
DISTRIBUTION: A, B, C, J, S 1 March 2009

JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM

References: See Enclosure D

1. Purpose. The purpose of this instruction is to establish the policies for the Joint Capabilities Integration and Development System (JCIDS). The procedures established in the JCIDS support the Chairman of the Joint Chiefs of Staff and the Joint Requirements Oversight Council (JROC) in identifying and assessing joint military capability needs as specified in reference a. Specific procedures for the operation of the JCIDS and for the development and staffing of JCIDS documents can be found in reference b.

2. Cancellation. CJCSI 3170.01F, 1 May 2007, "Joint Capabilities Integration and Development System" and CJCSM 3170.01C, 1 May 2007, "Operation of the Joint Capabilities Integration and Development System" are canceled.

3. Applicability. In accordance with references c and d, this instruction applies to the Joint Staff, Military Departments, Military Services, combatant commands, Defense agencies, the National Guard Bureau, Defense field activities, and all other organizational entities within the Department of Defense. This instruction also applies to other agencies preparing and submitting JCIDS documents in accordance with references c and d. This instruction applies to all unclassified, collateral, compartmented, and special access programs.

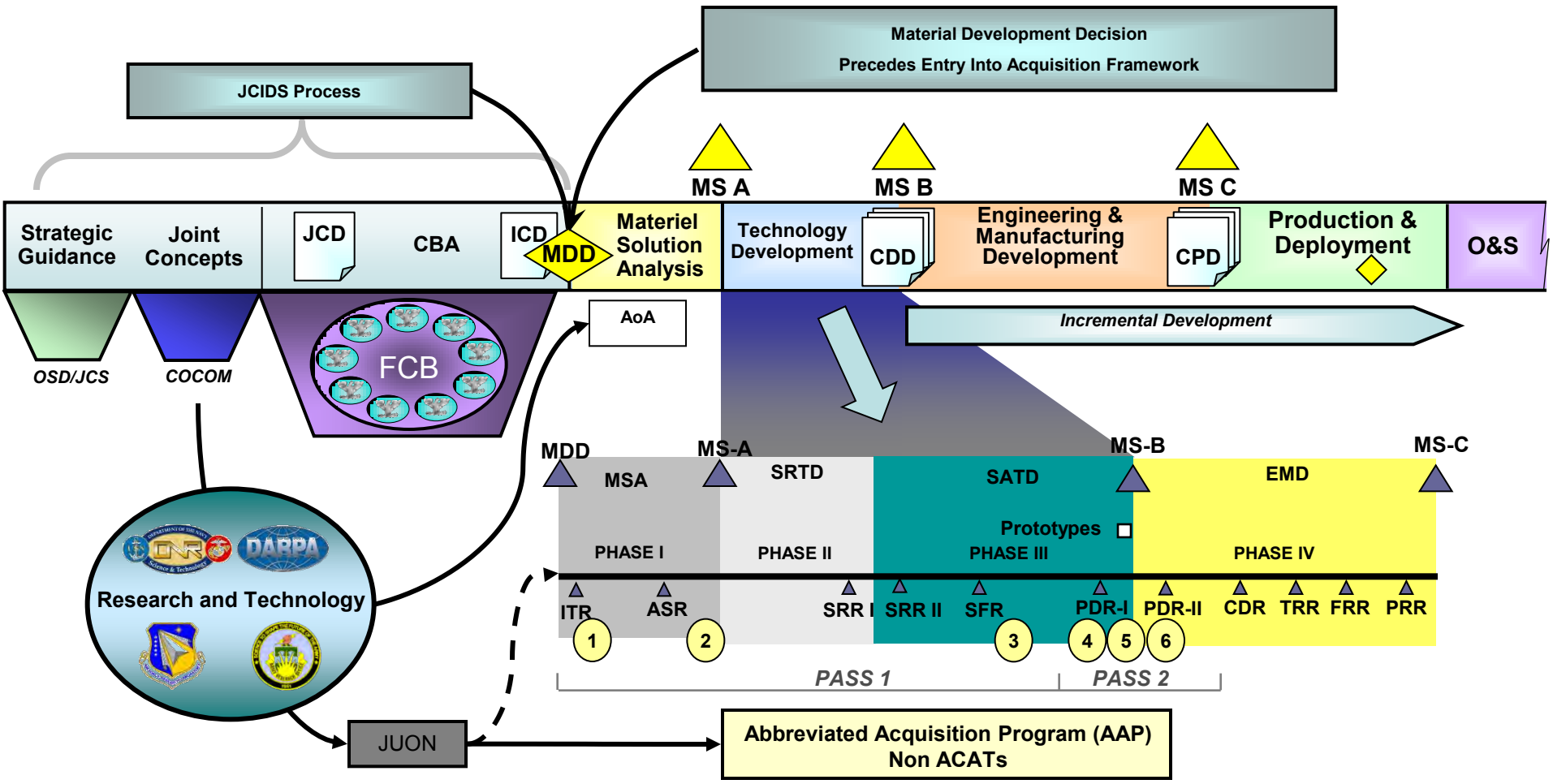
4. Executive Summary

a. There are three key processes in the DOD that must work in concert to deliver the capabilities required by the warfighter: the requirements process; the acquisition process; and the Planning, Programming, Budget, and Execution (PPBE) process. This instruction focuses on the requirements process as implemented in JCIDS. In addition, JCIDS supports the capability portfolio management process (reference e) to advise the Department of Defense on capability investments. To produce the capabilities our warfighters need, these processes must be aligned to ensure consistent decisions are made.

CJCSI 3170.01G Enclosure A

… ***When a materiel solution is required*** by an approved ICD, the milestone decision authority (MDA) determines the scope of the subsequent analysis of alternatives (AoA), the appropriate entrance milestone, and designates the lead component(s) in a Materiel Development Decision (MDD). ***The purpose of the Materiel Solution Analysis (MSA) phase is to assess potential materiel solutions*** and to satisfy the entrance criteria for the next program milestone as designated by the MDA. If the next phase per the MDA is Milestone (MS) A, then the ICD along with the results of the AoA form the basis for the MS A decision.

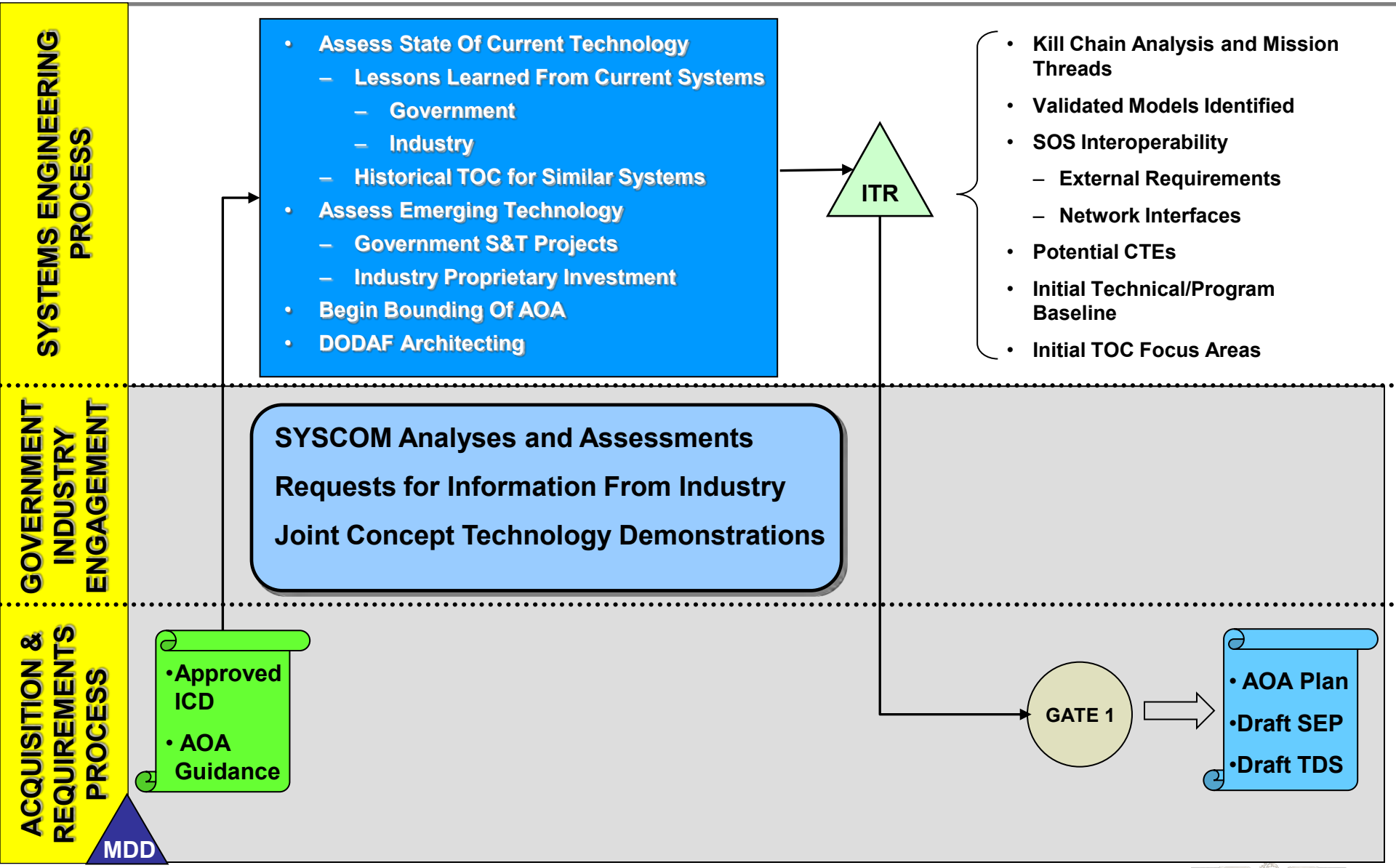
NAVAIR Engineering Process



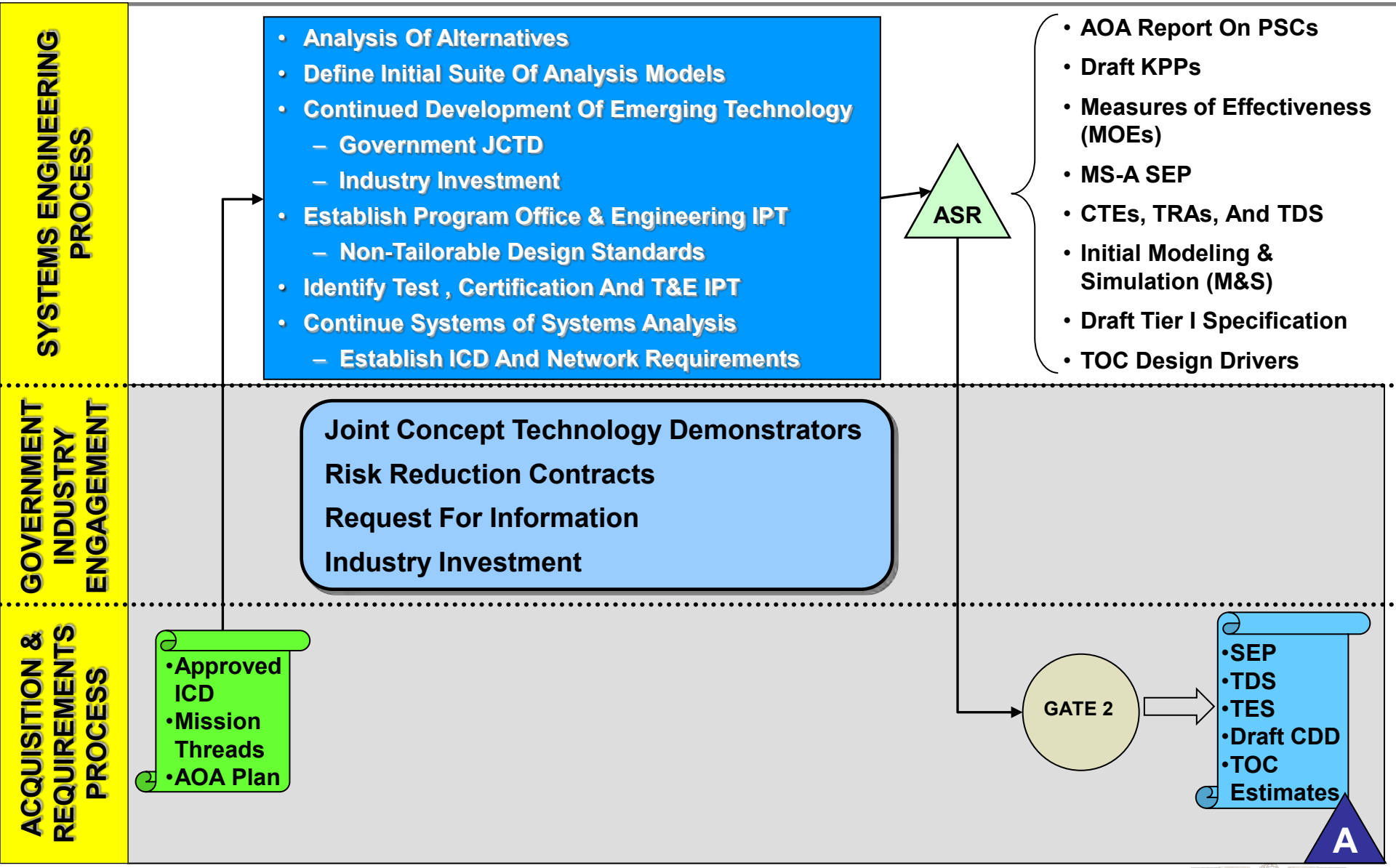
NAVAIR 4 Phase SE Process

- **Phase I – Materiel Solution Analysis (MSA)**
  - Establish initial set of Operational Capabilities and resolve to a Candidate Materiel Solution (aviation, ship, ground)
  - Broad focus to ensure all types of solutions receive appropriate consideration
  - Maximize leverage of gov't and industry knowledge base
- **Phase II – System Requirements & Technology Development (SRTD)**
  - Establish system performance requirements and detailed CONOPS
  - Develop critical technologies to support engineering final product
  - Relatively broad focus to maximize leverage of emerging technologies (stay ahead of the threat)
- **Phase III – System Architecture & Technology Demonstration (SATD)**
  - Complete the system architecture – requirements derivation and decomposition to subsystems
  - Demonstrate maturity of critical technologies
  - Narrowing focus down to a complete system architecture and preliminary design while allowing for optimization against cost and schedule
- **Phase IV –Engineering and Manufacturing Development (EMD)**
  - Complete the design, development and verification
  - Deliver the compliant weapon system to Operational Test/IOC

Phase I: MSA


SYSTEMS ENGINEERING PROCESS
GOVERNMENT INDUSTRY ENGAGEMENT
ACQUISITION & REQUIREMENTS PROCESS
• Assess State Of Current Technology
– Lessons Learned From Current Systems
– Government
– Industry
– Historical TOC for Similar Systems
• Assess Emerging Technology
– Government S&T Projects
– Industry Proprietary Investment
• Begin Bounding Of AOA
• DODAF Architecting
ITR
• Kill Chain Analysis and Mission Threads
• Validated Models Identified
• SOS Interoperability
– External Requirements
– Network Interfaces
• Potential CTEs
• Initial Technical/Program Baseline
• Initial TOC Focus Areas
SYSCOM Analyses and Assessments
Requests for Information From Industry
Joint Concept Technology Demonstrations
•Approved ICD
• AOA Guidance
MDD
GATE 1
• AOA Plan
•Draft SEP
•Draft TDS

Phase I: AOA


SYSTEMS ENGINEERING PROCESS
GOVERNMENT INDUSTRY ENGAGEMENT
ACQUISITION & REQUIREMENTS PROCESS
• Analysis Of Alternatives
• Define Initial Suite Of Analysis Models
• Continued Development Of Emerging Technology
– Government JCTD
– Industry Investment
• Establish Program Office & Engineering IPT
– Non-Tailorable Design Standards
• Identify Test , Certification And T&E IPT
• Continue Systems of Systems Analysis
– Establish ICD And Network Requirements
ASR
• AOA Report On PSCs
• Draft KPPs
• Measures of Effectiveness (MOEs)
• MS-A SEP
• CTEs, TRAs, And TDS
• Initial Modeling & Simulation (M&S)
• Draft Tier I Specification
• TOC Design Drivers
Joint Concept Technology Demonstrators
Risk Reduction Contracts
Request For Information
Industry Investment
•Approved ICD
•Mission Threads
•AOA Plan
GATE 2
•SEP
•TDS
•TES
•Draft CDD
•TOC Estimates
A

Phase II: TD Phase RFP

SYSTEMS ENGINEERING PROCESS

- Translation Of Draft CDD Into Tier I Specification By SMEs
  - Clearly Identify Design Standards
  - Define Certification Standards
- Technology Development Of CTEs
  - Required To Set Performance Thresholds
  - Establish Prototype Demo Requirements
- Establish Draft MS B Source Selection Criteria
  - Criteria For Design Evaluation In TD Phase

SRR-I

- Tier I Specification
- Draft CDD To Specification Traceability
- MOEs and MOPs
- Non-Tailorable Design Requirements
- Certification Requirements Defined
- Objective Trade Space Defined

GOVERNMENT INDUSTRY ENGAGEMENT

Joint Concept Technology Demonstrators
Risk Reduction Contracts
Request For Information
Industry Investment

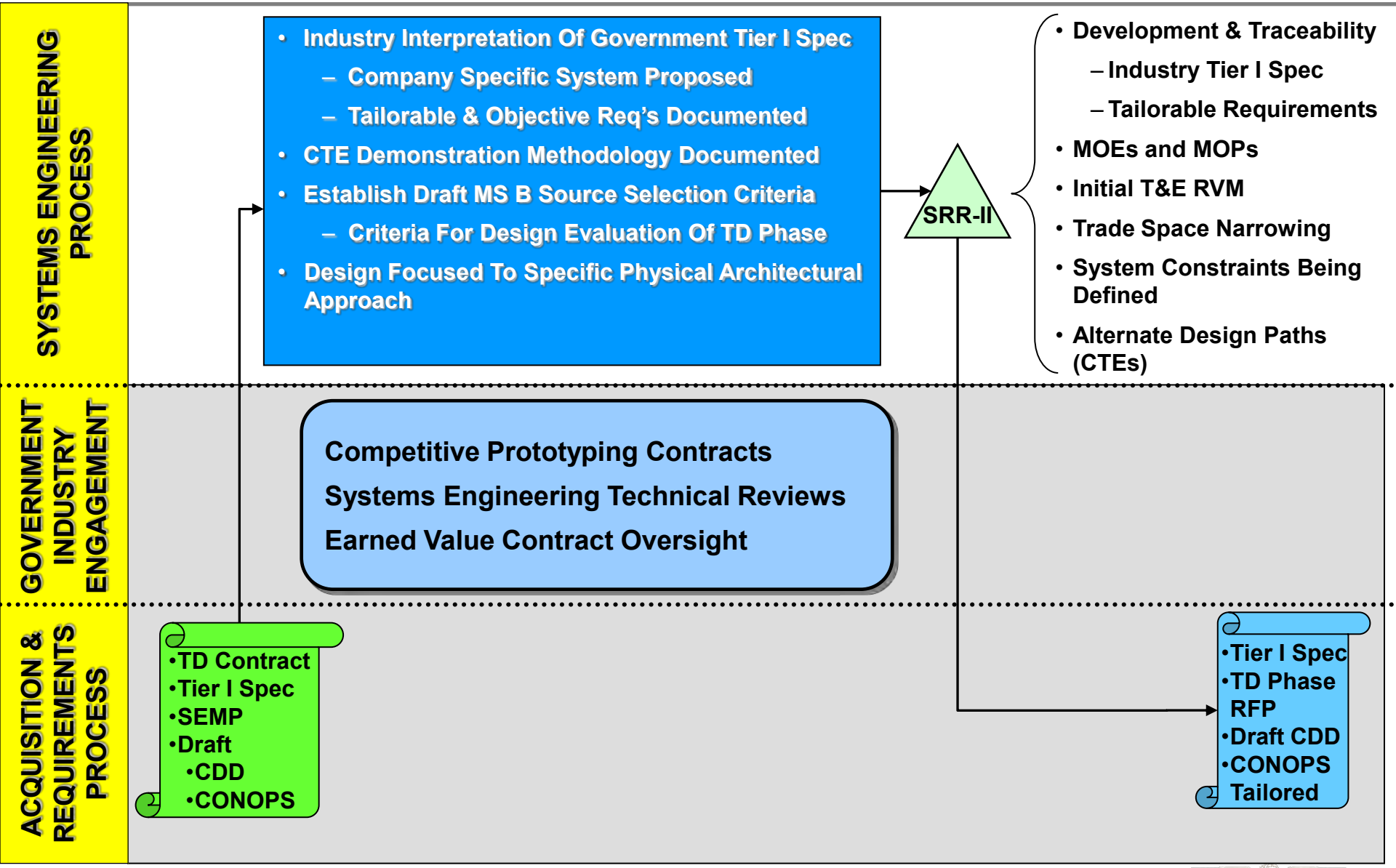
ACQUISITION & REQUIREMENTS PROCESS

- SEP
- TDS
- Draft
  - CDD
  - CONOPS
- TES

A

- Tier I Spec
- TD Phase RFP
- Draft CDD

Phase III: Tailored PSCs



Phase III: Finalize CDD

SYSTEMS ENGINEERING PROCESS

- Functionality Derived From CONOPS
- Maintainability & Logistics Requirements Flowed Into Design
- Functionality Partitioned Between System Segments
- Potential Subsystems Identified
  - Preliminary Architecture Defined
  - Subsystem Constraints Identified
- CDD Traceable To Candidate Subsystems

SFR

- Tier II Specification
  - Functional Traceability
  - CONOPS
  - CDD
- CDD Thresholds Evaluated
- CONOPS Finalized
- Preliminary Subsystems TPMs Identified
- TOC Design Drivers Identified

GOVERNMENT INDUSTRY ENGAGEMENT

Competitive Prototyping Contracts

Systems Engineering Technical Reviews

Earned Value Contract Oversight

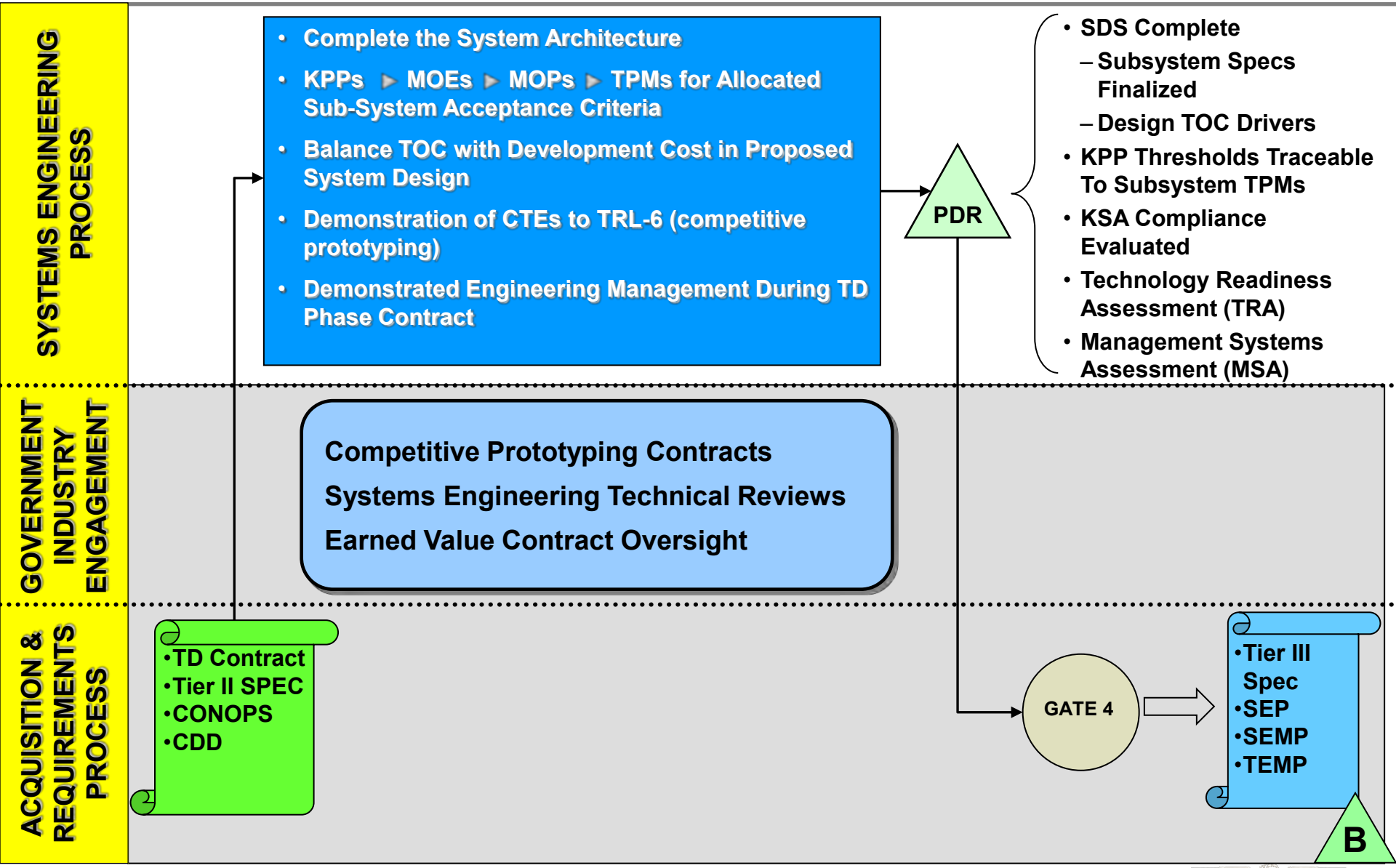
ACQUISITION & REQUIREMENTS PROCESS

- TD Contract
- Tier I Spec
- SEMP
- Draft
  - CDD
  - CONOPS

GATE 3

- CDD
- CONOPs
- TOC Drivers

Phase III: Pre-MS B PDR



Controlling Program Inertia

- **Recognize MS B As True Decision Point**
  - Only 3-5% Of TOC Expended By MS B
  - 95% Of System Money Leveraged At MS B
- **Not All Sunk Costs Are Wasted**
  - Technology Developed And Demonstrated
  - Potential Weapon Systems Architectures Explored
  - Demonstrated Performance vice Previous CPRs
- **Underlying System Engineering Approach Sound**

"If you find yourself in a hole, the first thing to do is stop digging"

– Will Rogers

Summary

- Early Systems Engineering Is The Front End Of The Traditional Tried & True SE Process
- Aligning Business And Acquisition Decisions
  - Decisions Are Based On Depth Of Knowledge
  - Stability Is Output Of Systems Engineering Not The Input
  - PDR Is The First Physical Manifestation Of A System In Development
- Evolving Guidance
  - To Shorten Post MDD Development Move Engineering Timeline To Left
    - MDD “the old MS-A?”
  - Technology Development Timelines Unpredictable
    - Existing Technology Deploys Quicker

Headquarters U.S. Air Force

Integrity - Service - Excellence

The ABCs of Concept Evolution:
A Better-Informed Materiel Development Decision for USAF Programs

NDIA Systems Engineering Division
Annual Conference
27 Oct 2010

Jeff Loren
SAF/AQRE (Alion Science & Technology)
703.254.2475
jeff.loren@pentagon.af.mil

U.S. AIR FORCE

U.S. AIR FORCE

KEY POINTS

- Setting the Stage
- Relationships Among Capability Planning, DP, SE, and Acquisition
  - Definitions in context
  - Why it's important
- Policy and Guidance
- Development Planning and Early SE
  - Support to AF planning and requirements
  - Concept Characterization & Technical Description (CCTD) principal elements
  - Visualizations
- Summary

U.S. AIR FORCE

The Situation

- The Functional Solutions Analysis (FSA) and the Analysis of Materiel Alternatives (AMA) no longer exist in either JCIDS or DoDI 5000.02

THIS MEANS THAT

- Neither the requirements community nor the acquisition community has explicit responsibility to either perform or resource these activities

BUT

- The intellectual integrity of these analyses is still required in support of pre-acquisition decisions
  - Materiel Development Decision (MDD)
  - Milestone A

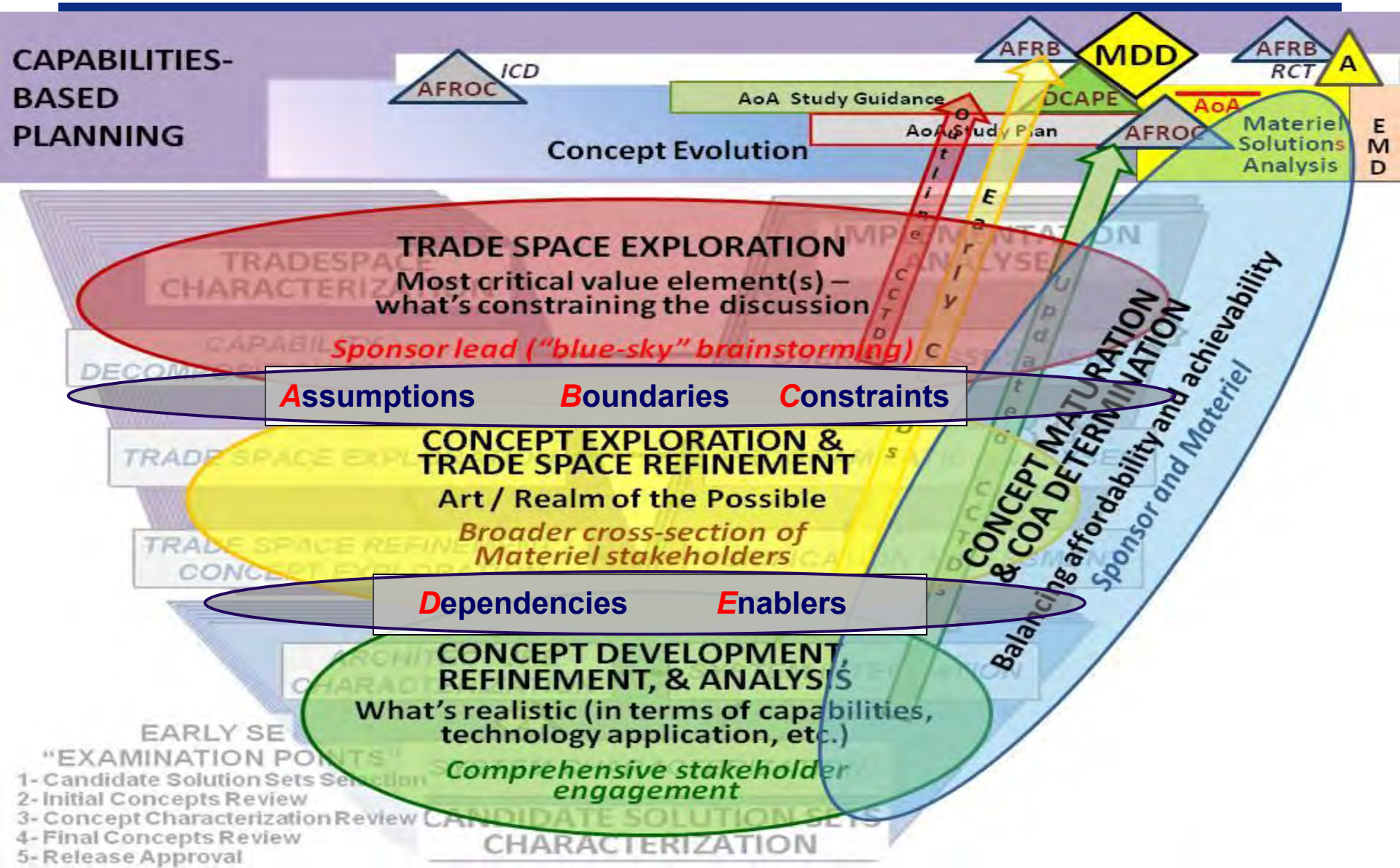
U.S. AIR FORCE

Shifting the Paradigm

- MDD (and Concept Decision before that) widely viewed as opportunity to decide "What are we going to acquire?"
- MDD is really an investment decision – "Do we need to acquire anything to address this capability need?"
  - An acceptable answer is "Not now; pursue S&T investment(s) and revisit the need in a few years"
  - Another acceptable answer is "More (or different utilization) of what we currently have"
- AoA Report provides information to ask "What could we realistically afford to think about acquiring?"
- Sponsor – with materiel support – develops COAs and proceeds to MS A with focus on "What are we going to start down the path to acquire?"

U.S. AIR FORCE

Capability Planning, DP, Early SE, and Acquisition



U.S. AIR FORCE

Definitions In Context

- **DEVELOPMENT PLANNING (DP)**
  - DP is the materiel contribution to Air Force capability planning
  - DP is a collaborative process bridging warfighter-identified capability needs to planning for acquisition of materiel solutions
  - DP includes analytically-based decision-quality assessments, studies, strategies, and options in pursuit of new capabilities
  - DP is generally executed by Product Center XR (Capability Planning / Development / Integration) offices
- **EARLY SYSTEMS ENGINEERING (Early SE)**
  - Early SE enables the technical elements of DP
  - Early SE looks like traditional SE
  - Early SE identifies technology alternatives

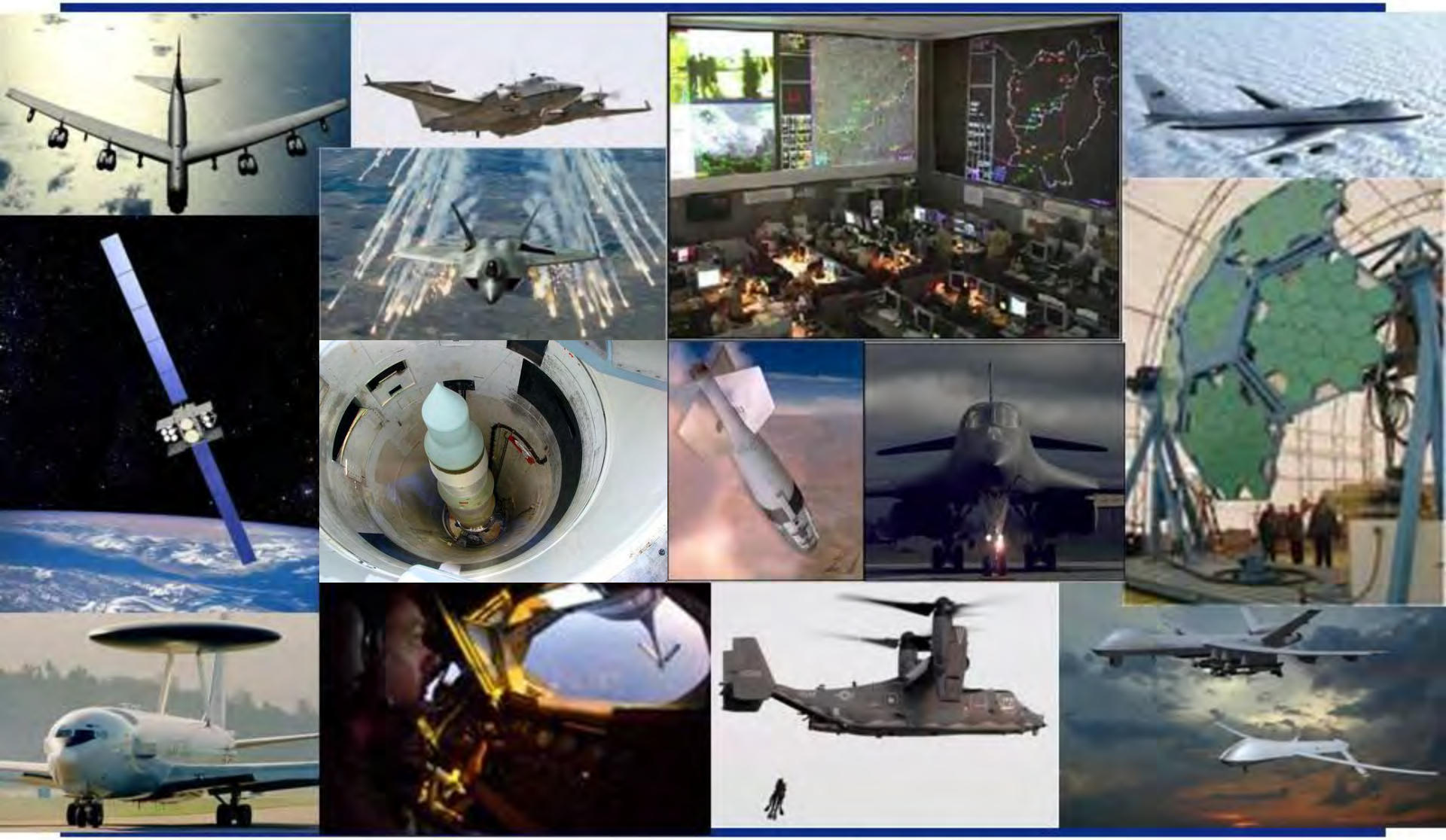
U.S. AIR FORCE

Why It's Important

- **Links JCIDS to acquisition**
  - Link CBA/P and development planning actions (coupling capability needs, enabling technologies, and system solutions)
  - Development of informed, feasible operational requirements
  - Leverage and inform technology planning and investments
  - Develop consistent mission-based system-of-systems approaches
  - Produce high-confidence strategies for timely, effective solutions
- **WSARA**
  - "JROC must vigorously challenge requirements, ... prioritize capabilities within JCA portfolios ... "
  - Concept descriptions for AoA guidance
  - Independent technology maturity assessments
- **SECAF/CSAF "Acquisition Improvement Plan"**
  - Task #2: Improve Requirements Generation Process
  - ... deliver products and services that perform on time, within budget

U.S. AIR FORCE

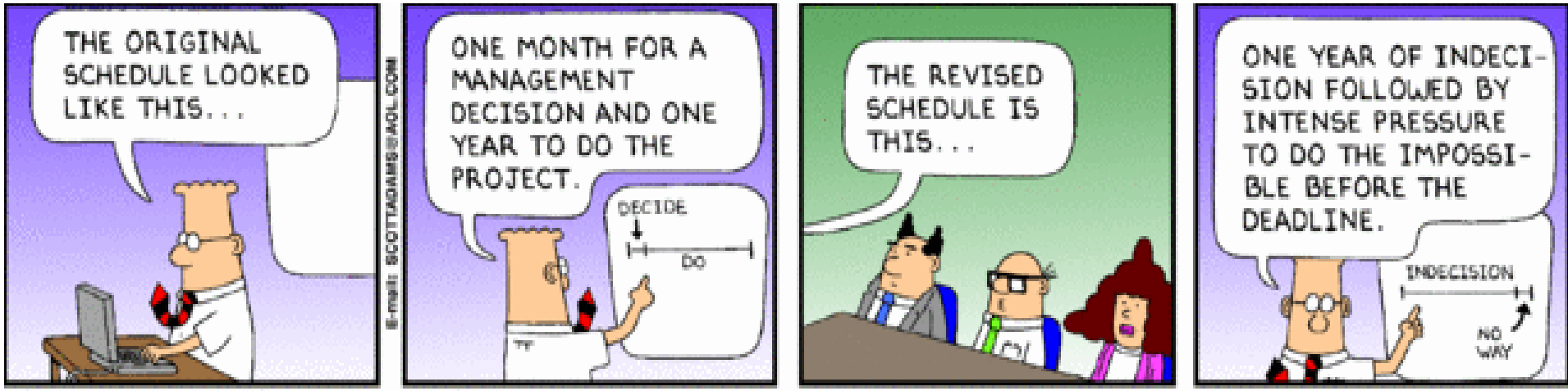
Why It's Important



U.S. AIR FORCE

Why we need early technical planning

c 2002 United Features Syndicate



U.S. AIR FORCE

MDD Information Needs – Forthcoming OSD Policy

The MDA must … decide whether an investment shall be made to fill the capability gap … Decisions must be based on effective development planning and a strong technical foundation. To support those decisions, the (MDA requires) evidence at the MDD Review (to) facilitate the determination that:

a. **The candidate materiel solution approaches have the potential to successfully address the capability gap(s) and associated dependencies, and desired operational attributes.**

b. **There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early *[AF add: studies, analyses,]* prototypes, models, or data.**

c. **Consideration has been given to near-term opportunities to provide a more rapid interim response to the capability need.**

d. **The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirement.**

U.S. AIR FORCE

AF Policy and Guidance

- **AFI 10-601 "Operational Capability Requirements Development"**
  - Updated Jul 10, added DP language including CCTD
- **AFI 63-101 "Acquisition and Sustainment Life Cycle Management"**
  - Interim Change adding ~10 instances of DP language (roles/ responsibilities, CCTD as MDD decision support product, etc.) currently in coordination
- **AFI 63-1201 "Life Cycle Systems Engineering"**
  - Interim Change adding DP language (as above, plus detailed 4-page Attachment) currently in coordination
  - To be completely revised/reissued; first draft to coordination Feb 11
- **Early SE Guide issued Mar 09**
  - Practitioner community has provided numerous suggestions and comments for updated content
- **DP Guide issued Jul 10**
- **CCTD Guide issued Oct 10**
- **Guides to be consolidated into official AF publication on DP**
  - Phase 1 (add Early SE content, incorporate CCTD Guide as Appendix, rescind Early SE Guide) start Nov 10
  - Phase 2 (complete content update and conversion) start Oct 11

U.S. AIR FORCE

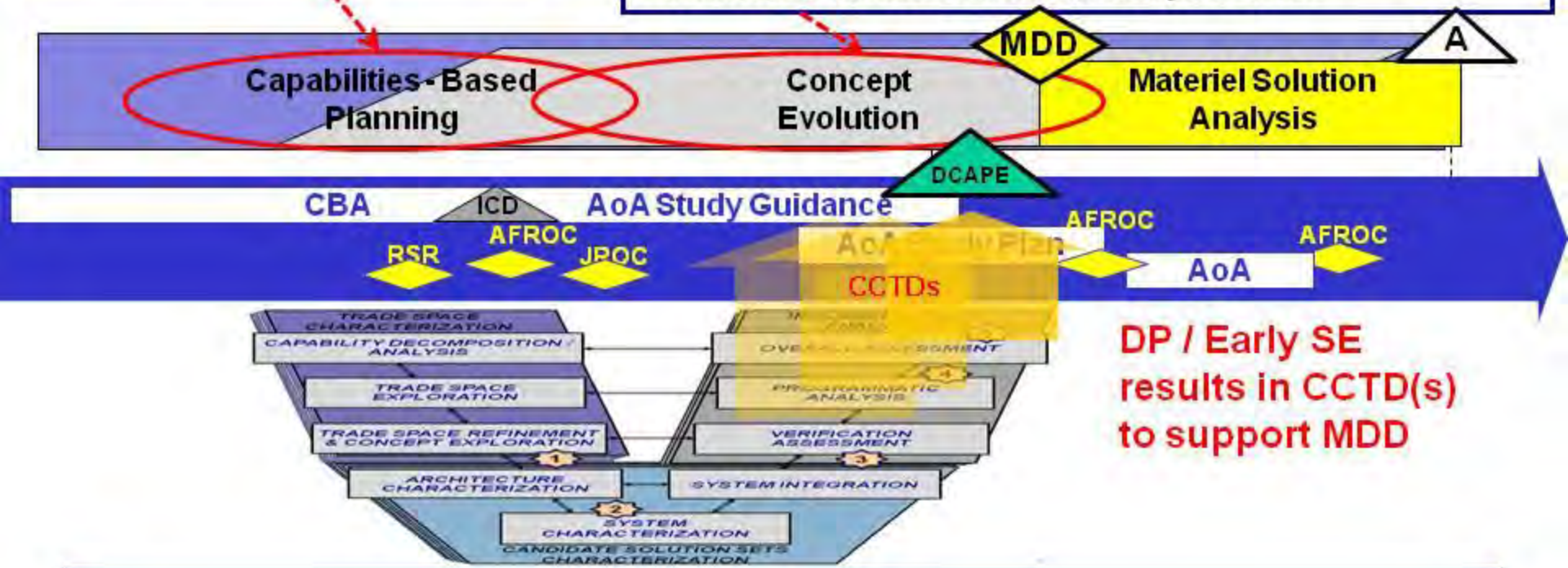
DP and Early SE Support to AF Planning and Requirements

SE involvement here should provide:

- An aid in identifying excess capabilities or shortfalls
- Early evaluation of technology feasibility against shortfalls
- Assistance in developing capability investment priorities

SE involvement here should provide:

- Evaluation of technical feasibility weighted against identified capability needs
- Use of M&S to evaluate alternatives and identify constraints
- Increased potential for validating / verifying concepts
- Improved concepts definition addressing performance, cost, schedule, and technological risk
- Guidance for Materiel Development Decision (MDD)
- A basis for Materiel Solutions Analysis / AoA



DP / Early SE results in CCTD(s) to support MDD

U.S. AIR FORCE

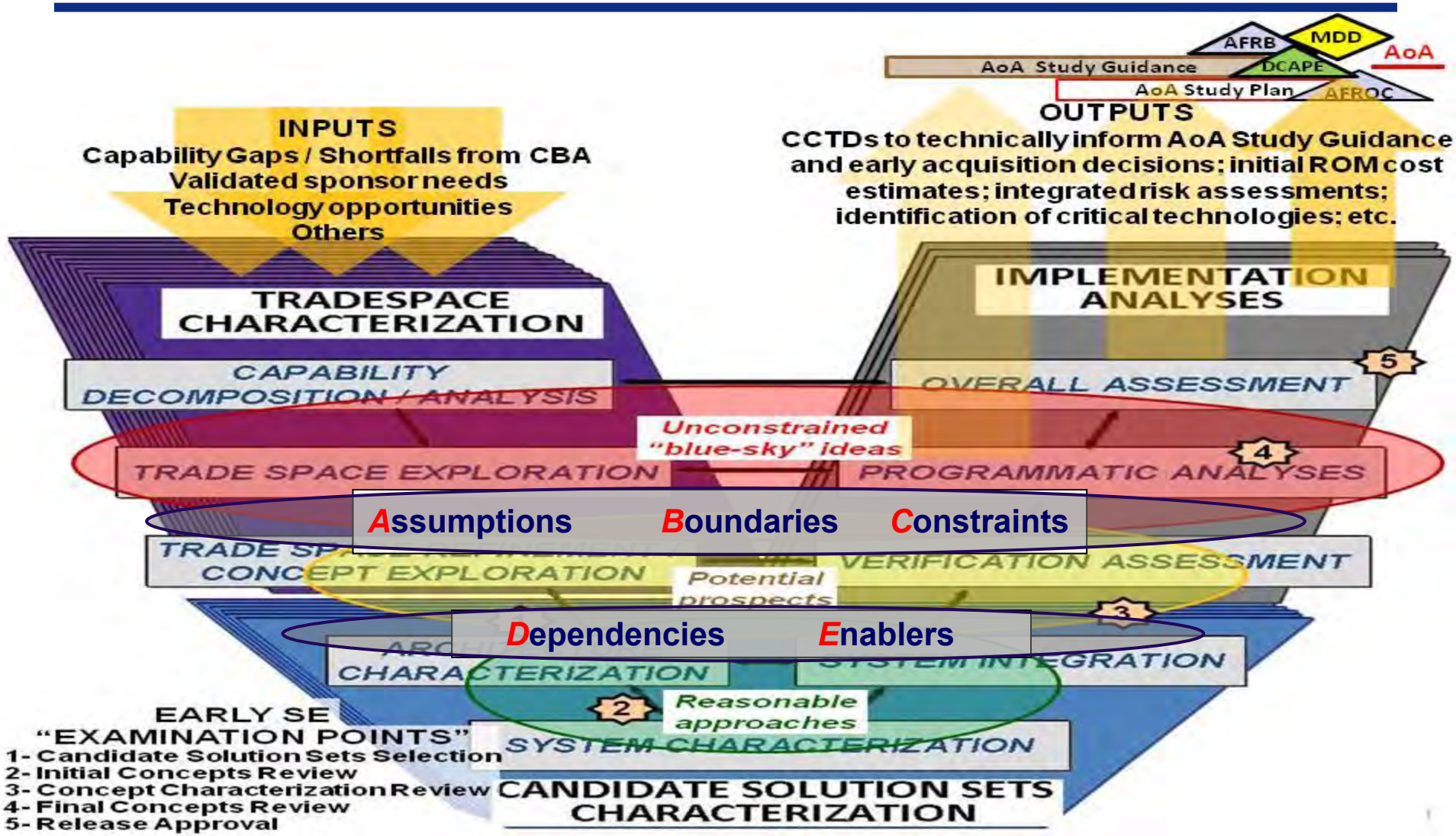
Concept Characterization and Technical Description (CCTD) Principal Elements

1. Mission / Capability Need Statement / CONOPS
2. Concept Overview
3. Trade Space Characterization
4. Evaluations (Studies, Analyses, Experiments)
5. Concept Characterization / Design — includes Critical Technology Elements
6. Implementation Analyses — includes Critical Technologies and Technology Maturation Approach
7. Risk Assessment and Decision-Certain Consequences
8. DOT_LPF Implications
9. Conclusions (Capability Description; Traceability to Need Statement)

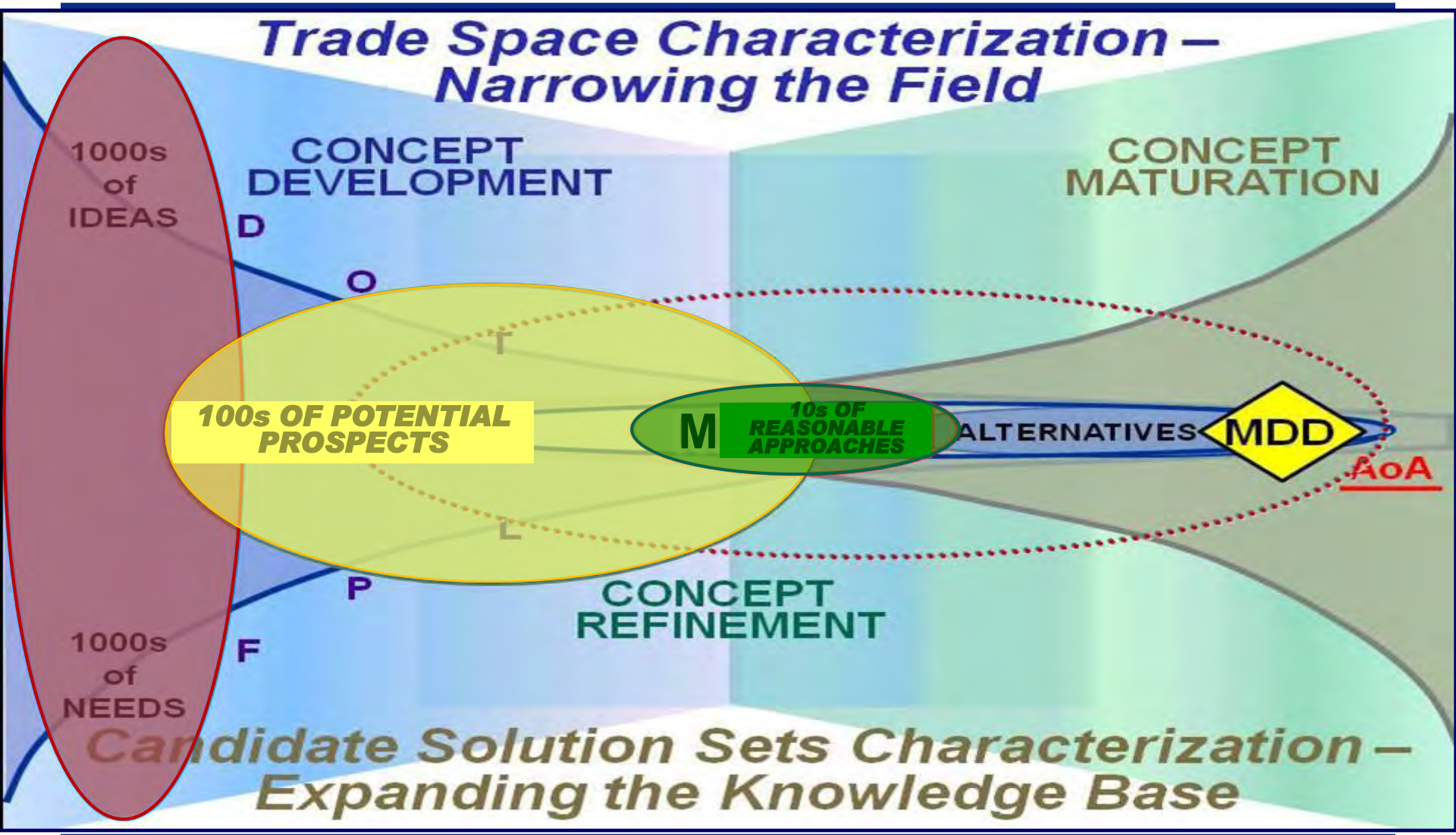
Tailored to meet MDD information needs
Tailored to timeline needed to support decision

U.S. AIR FORCE

Capability Planning, Development Planning, Early SE, and Acquisition



Venturi


Trade Space Characterization –
Narrowing the Field
1000s of IDEAS
CONCEPT DEVELOPMENT
CONCEPT MATURATION
D
O
T
100s OF POTENTIAL PROSPECTS
M
10s OF REASONABLE APPROACHES
ALTERNATIVES
MDD
AoA
L
P
CONCEPT REFINEMENT
1000s of NEEDS
F
Candidate Solution Sets Characterization –
Expanding the Knowledge Base

U.S. AIR FORCE

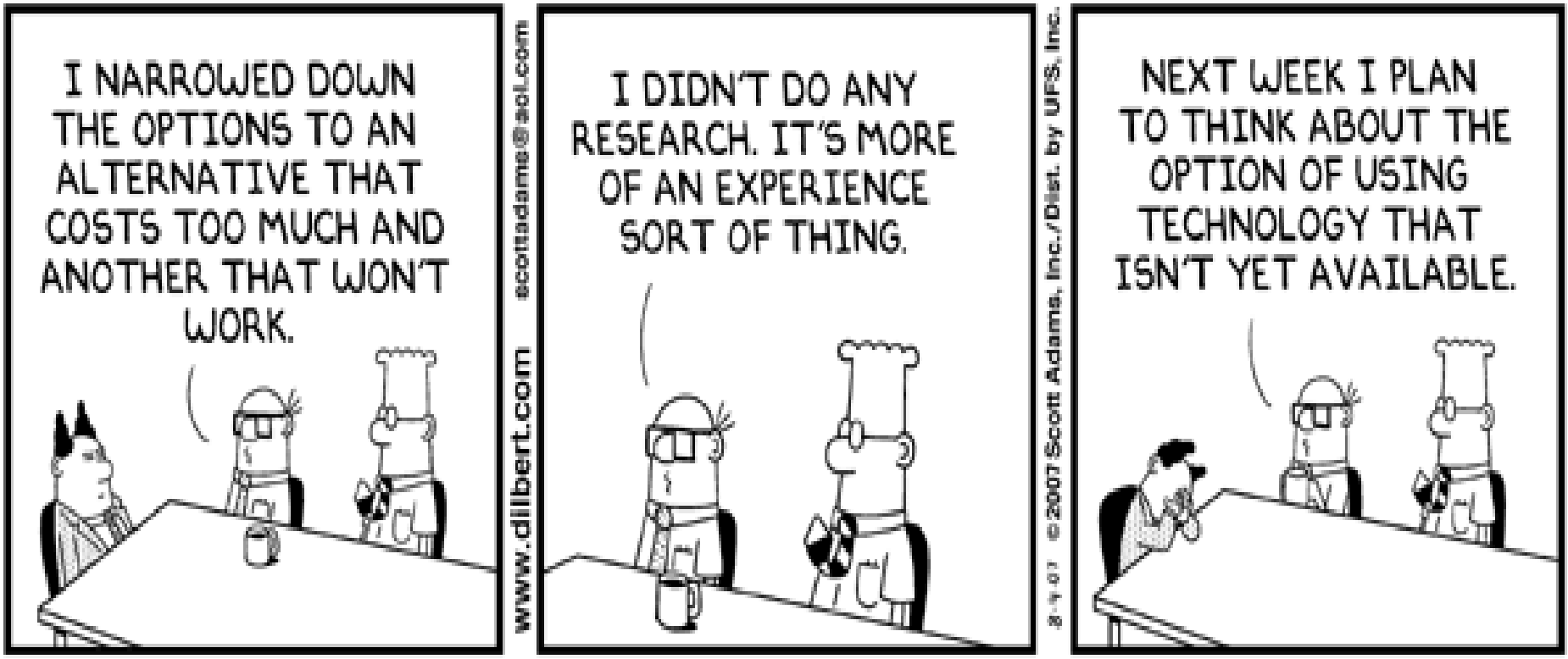
Summary

- Operational users want capability, not technology
  - Capability is provided by platforms and systems
  - Technology must be "systemized" to be useful
- DP ensures proper pre-acquisition analysis
  - Early SE facilitates DP
  - S&T informs and enables early SE
- CCTD is primary Early SE artifact that provides pre-acquisition decision support information
- AF policy will help institutionalize the best practices

"DO IT RIGHT, DO IT EARLY; DO IT EARLY, DO IT RIGHT"

U.S. AIR FORCE

Truth Hurts?



© Scott Adams, Inc./Dist. by UFS, Inc.

HPTi

Improving Success with Technology using an Organizational Epistemology – A Conceptual Decision Framework for Early SE

Dr. Chris R. Powell
Univ. of Wisconsin – Eau Claire
Sr. Technical Director, HPTi, Reston, VA

October 27, 2010

(c) Chris R. Powell
27 October 2010

Contact Info

- Dr. Chris R. Powell
  - High Performance Technologies, Inc. (HPTi)
- cpowell@hpti.com
- (715) 379-9696 (cell)

(c) Chris R. Powell

Agenda

- Frame SE/SoSE Problem as Knowledge Management (KM) issue
- Recent Research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- So What?
  - Model-Based SE Approach
  - Complex Systems Realization Framework

(c) Chris R. Powell

HPTi

Agenda

- Frame SE/SoSE Problem as Knowledge Management issue
- Recent Research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- So What?
  - Model-Based SE Approach
  - Complex Systems Realization Framework

(c) Chris R. Powe

HPTi

Fundamental SE/SoSE Issue

- OSD needs to reconcile tension between:
  - Increasing acquisition speed
  - Meeting more complex requirements
- *Contention*: This is significantly a knowledge structure and management issue

(c) Chris R. Powell

HPTi

Key Solution Factors

- Notion: Expedite time-consuming acquisition steps by providing and ensuring the following, starting early in the lifecycle:
  - Rigorous recording of assumptions, parameters, constraints, and other information through models, attributes, and metadata
  - Rigorous correspondence of artifacts across lifecycle steps/phases/etc. through common program taxonomy and ontology (e.g., model framework and metadata)
  - Quick, comprehensive testability of assumptions through simulation
  - Simultaneous, early, and ongoing consideration of engineering and program design issues to ensure risk prevention

Creation, discovery, structure and use of more precise, accurate knowledge

(c) Chris R. Powell

Agenda

- Frame SE/SoSE Problem as Knowledge Management issue
- Recent research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- So What?
  - Model-Based SE Approach
  - Complex Systems Realization Framework

(c) Chris R. Powell

HPTi

Research Problems

- Problem: IT Investments fail a lot (45-90%)
- Problem: (IT) Investment evaluation and justification is:
  - Highly subjective (executive "gut")
    - Basically, satisficing and bounded rationality
  - Imperfectly objective (reliance on overly constrained financial metrics)
- Problem: IT consideration requires extensive knowledge outside domain of business/mission process
- Problem: IT vendors lack appreciation for business/mission knowledge
- Need new framework for (IT) investment evaluation and justification:
  - Reconcile human nature
  - Oriented to Tacit Knowledge
  - Concept: "Set" knowledge to be satisficed and live within bounded rationality

Researching IT as a social problem rather than just a technical problem

(c) Chris R. Powell

HPTi

Key Issue – Contrast

- IT – the technology itself
  - Positivist
  - Natural science
  - Objective
  - Financial
  - Engineering/ Computer Science
- IS – IT in an organizational context
  - Phenomenological
  - Social
  - Subjective
  - "Soft"
  - Management
  - Socially-constructed
  - *Emergent*

IT frequently (and systemically) fails because of IT/IS contrast

(c) Chris R. Powe

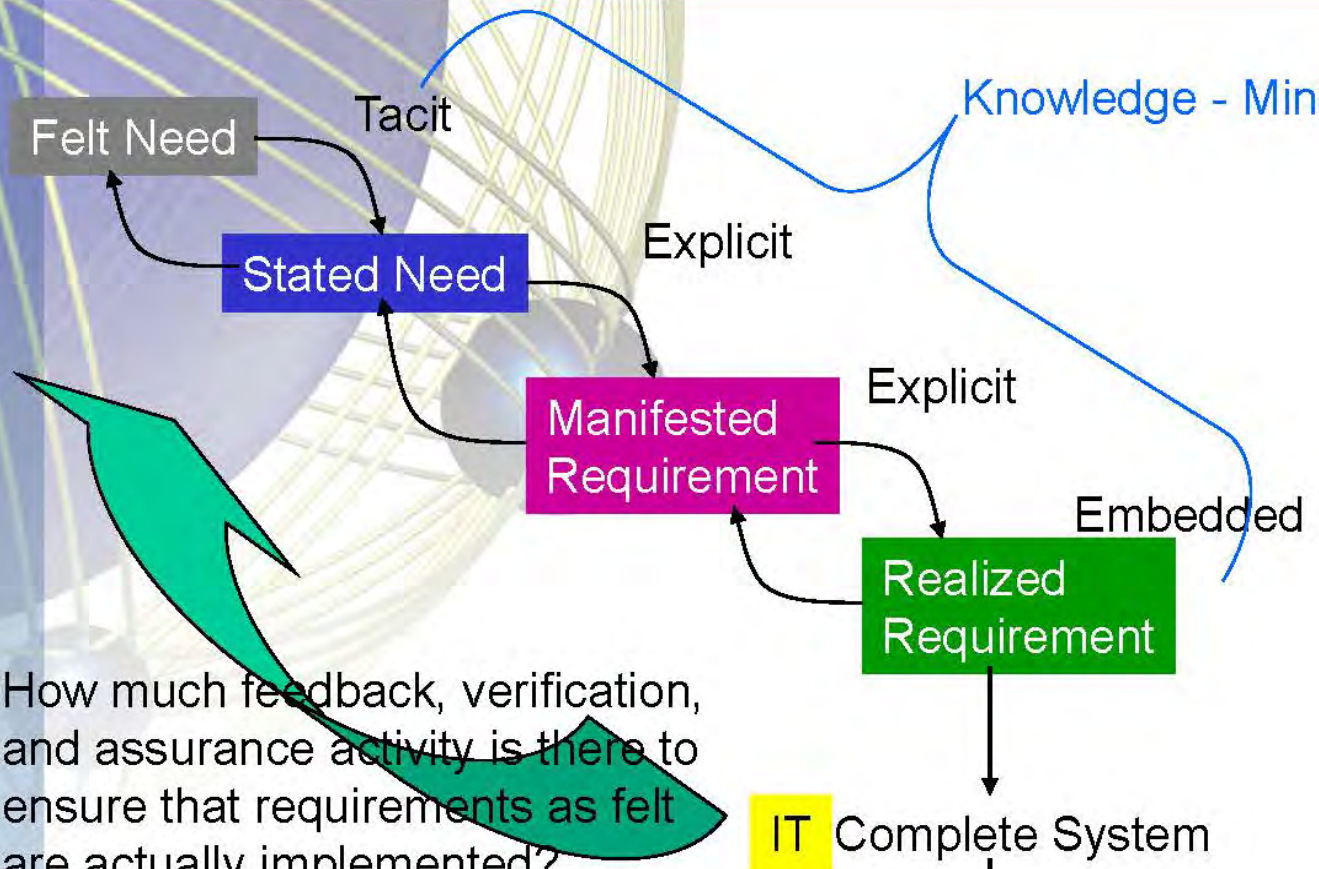
Abstract

- IT research should also focus on the socially constructed and emergent nature of IT as IS
- Structured dialog, (human felt needs AND technological aims), may improve the process of technology realization.
- Methodology
  - Analysis of IT/IS failure factors using case studies.
  - Pilot of a survey characterizes and tests elements of structured dialog through BPA (Business Process Analysis) tools
- Practical output: Conceptual decision framework

(c) Chris R. Powell

HPTi

Key Issue – Needs vs. Requirements



How much feedback, verification, and assurance activity is there to ensure that requirements as felt are actually implemented?
Very little.
Also, is any such activity structural? No.

(c) Chris R. Powe

HPTi

Problems to Concept Model

Problems

- Evaluation & Justification
  Highly Subjective
  Imperfectly Objective
- Knowledge Domain Mismatches
- High (IT) Investment Failure Rates (45-90%)

Argument

IT investment is not working with right knowledge for evaluation and justification, and doesn't reflect human nature in decision-making.

Hypothesis

A structured dialog technique can improve the process of IT project evaluation and justification.

Research Concept Model:

- Understand Failure Factors
- Focus human teams on these factors
- Efficiently facilitate dialog to "set" knowledge
- Evaluate dialog outcome
- Evaluate program outcome

(c) Chris R. Powe

HPTi

Research Methods

1. Case Studies (*hermeneutic circle*)
2. MetaInterpretation
3. Use and study tools to more systematically analyze IT requirements based on results of above (*positivist* angle)
4. Using survey, evaluate use of dialog to achieve shared meaning and concomitant impact on IT success/failure (*critical theory*) (Adorno, Habermas) (Giddens, Orlikowski, Foucault).
5. Finish *phenomenology* of IT wrt organizational epistemology through conceptual decision framework (Husserl, Heidegger, Ihde)

Probing: "Do what I mean, not (necessarily) what I tell you"

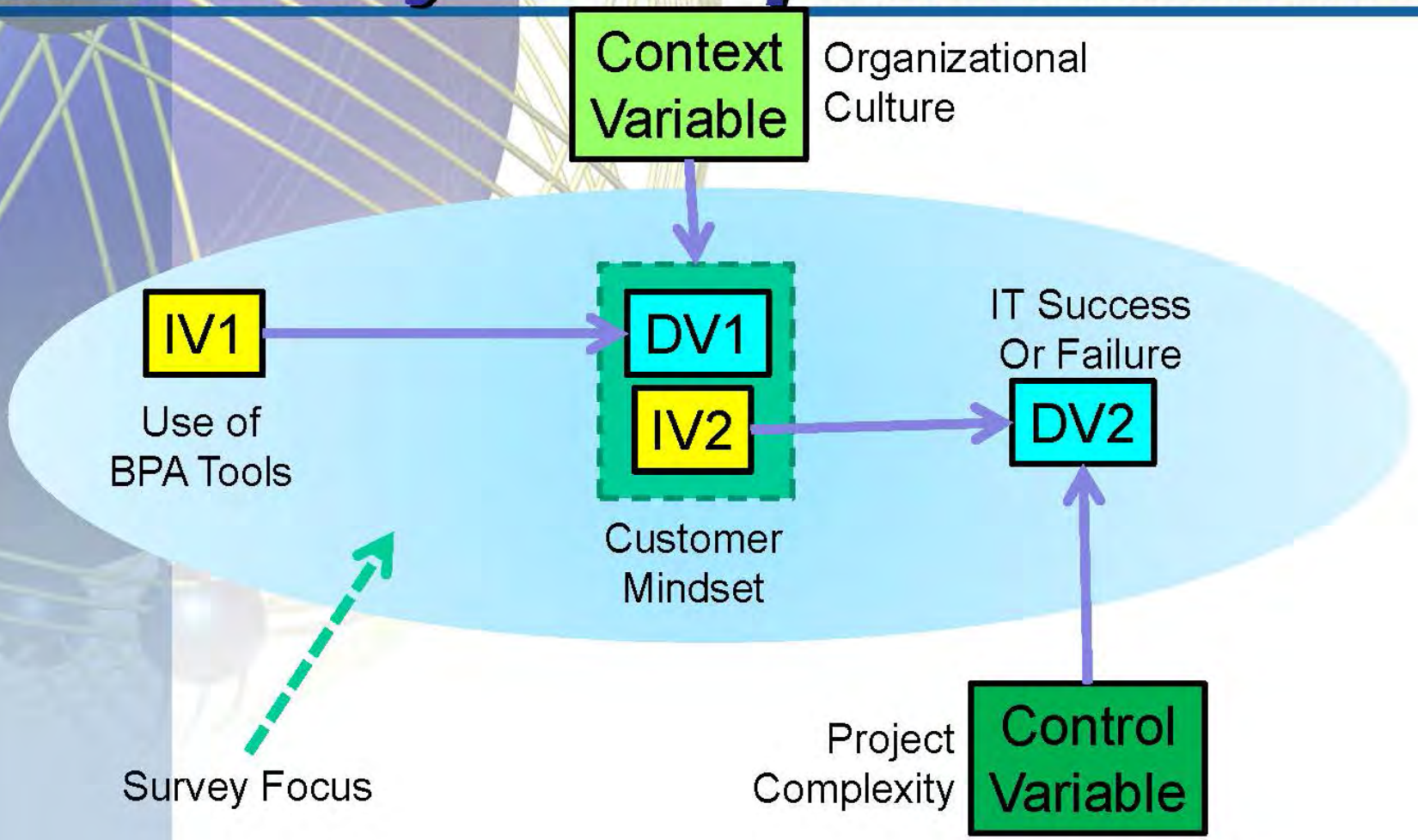
(c) Chris R. Powe

Case Study Findings: IT Failure – Core Root Causes & Relationship to Dialog

- Inexperienced management – Direct
- Inexperienced technical staff – Direct
- Minimal quality control – Indirect
- Unstable requirements – Direct
- Less than 5% component reuse – Indirect
- Generalists only – Indirect
- Ineffective development technologies – No
- Manual estimating – Indirect
- Manual planning – Direct
- Informal progress tracking – Direct
- Inexperienced clients – Direct
- Inadequate tool suites – Indirect

(c) Chris R. Powell

HPTi Survey Conceptual Framework



(c) Chris R. Powe

Results: Conceptual Decision Framework

- Clarification of the purpose of the new IT/IS system
- Improving team dynamics to enable better collaboration
- The production and use of shared meaning
- Creation and use of common language
- Shared experience
- Repetition and continuation of dialog
- Making a specific shared decision

(c) Chris R. Powell

Agenda

- Frame SE/SoSE Problem as Knowledge Management issue
- Recent research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- **So What?**
  - Model-Based SE Approach
  - Complex Systems Realization Framework

(c) Chris R. Powell

Agenda

- Frame SE/SoSE Problem as Knowledge Management issue
- Recent research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- So What?
  - **Model-Based SE Approach**
  - Complex Systems Realization Framework

(c) Chris R. Powell

Key SE Issues

- Lifecycle – current SE approach focused onspecific *program* level
  - Need approach that transcends lifecycle
- System – evolution from *platform* to *SoS*
  - Need approach that handles SoS attributes – adaptable, flexible, adjustable, dynamically defined, interoperable, *emergent*
- Architecture artifacts are typically text-based or pictorially one-dimensional
  - Need approach that handles system complexity

Systems are now out-pacing ability of current SE to keep up

(c) Chris R. Powell

HPTi

Key Factors

- New acquisition model
- Architecture-driven SE approach
- Visualization of dynamic, multiple system dimensions in context
- Modular, component-oriented design to enable system portability, extensibility, and address dynamic requirements
- Need to involve multiple COI/COP during system lifecycle
- Need to enable system adaptability and flexibility – to a series of unknown and new requirements

A Model-Driven Systems Engineering approach can address these factors simultaneously

(c) Chris R. Powell

Definitions

- **Model:**
  - Pattern, plan, representation, description
  - Shows main object, system, or concept and/or its workings
  - A model is an approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system (IEEE 610.12-1990), i.e. an *abstraction*.
  - A model usually offers different *views* in order to serve different purposes. A view is a representation of a system from the perspective of related concerns or issues (IEEE 1471-2000).
- **MBSE**
  - Formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases (INCOSE-TP-2004-004-02, Version 2.03, September 2007)

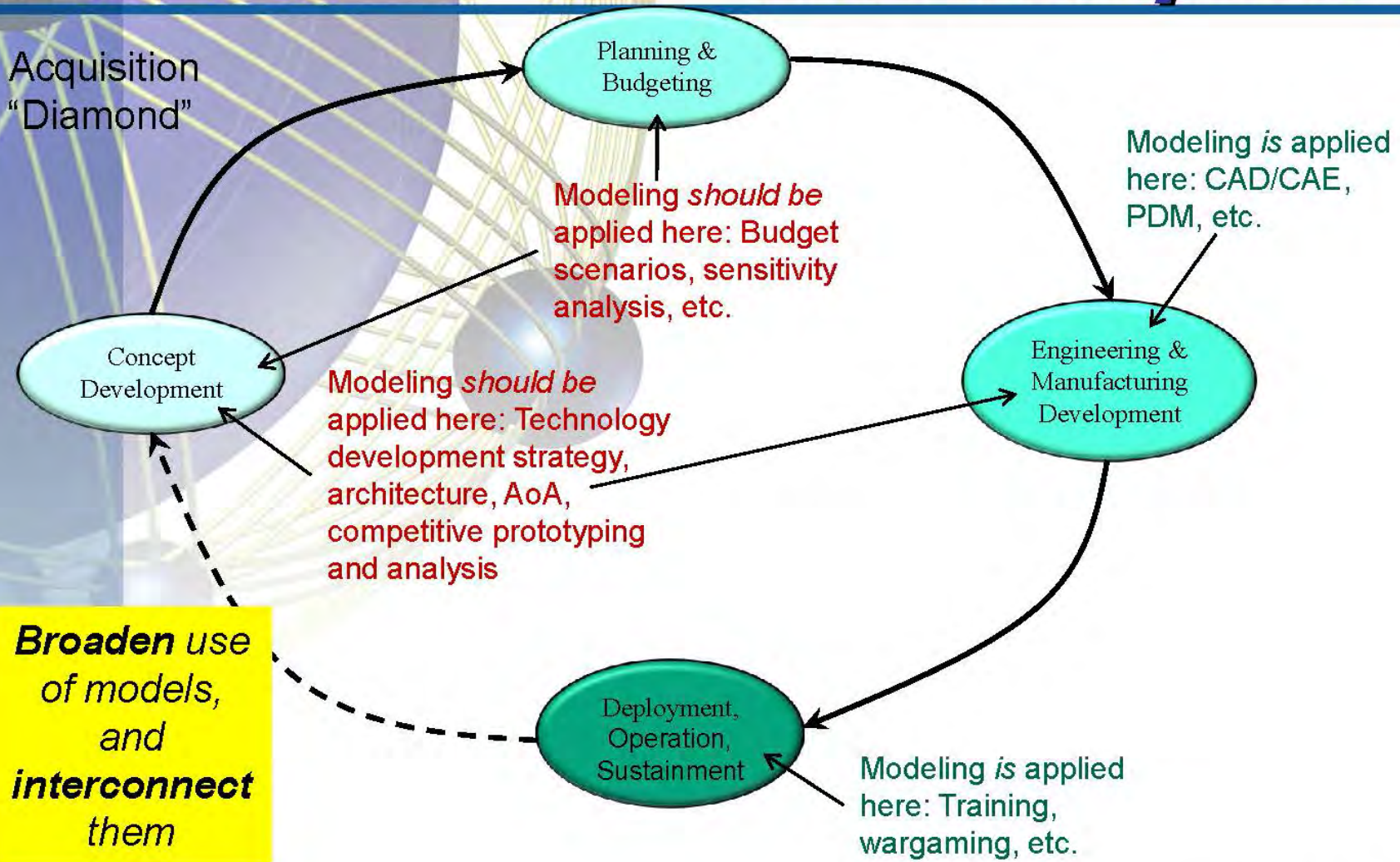
(c) Chris R. Powell

HPTi Operationalizing the Definition

- Model
  - Isolation of dependent and independent variables from a system
  - Exploration of complexity and its implications
  - Representation of reality
- Uses and Modes
  - Facilitating discussion – focusing on several attributes rather than entire system
  - Systems of models – which should be connected
  - Metamethodology –a process (modeling) that enables the process of SE
  - Efficiency and Speed – reduces circular discussion and runarounds
  - Quality – reliability and repeatability of SE results

(c) Chris R. Powell

DoD Perspective



(c) Chris R. Powell

HPT Practical Impact – Solution Factors

- Produce congruence across program
- Produce scenarios/vignettes for higher quality analysis across program
- Produce and use a common language across program
- Effective communications, within and outside of team
- Effective decision-making

Implement 7 factors from conceptual decision framework

(c) Chris R. Powell

HPTi

Agenda

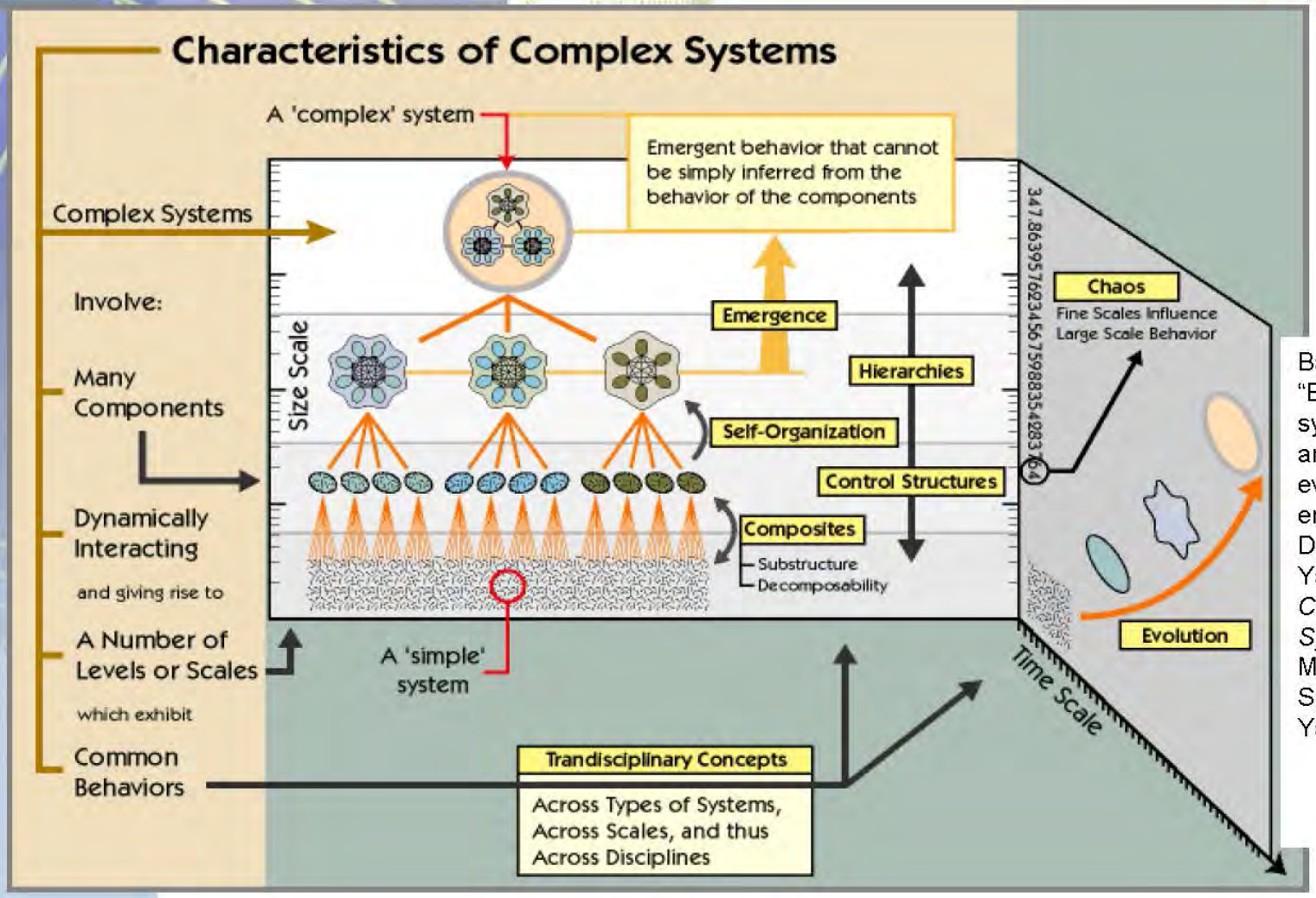
- Frame SE/SoSE Problem as Knowledge Management issue
- Recent research
  - KM in Technology Decision-Making
  - Conceptual Decision Framework for Improving Technology Success
- So What?
  - Model-Based SE Approach
  - **Complex Systems Realization Framework**

(c) Chris R. Powell

"The essence of tyranny is the denial of complexity". - Jacob Burkhardt

HPTi

What is a Complex System?



Bar-Yam, Yaneer, "Engineering complex systems: multiscale analysis and evolutionary engineering," in Braha, Dan, Ali A. Minai, and Yaneer Bar-Yam. *Complex Engineered Systems*. Cambridge, Massachusetts: Springer, 2006 [Bar-Yam 2006]

(c) Chris R. Powe

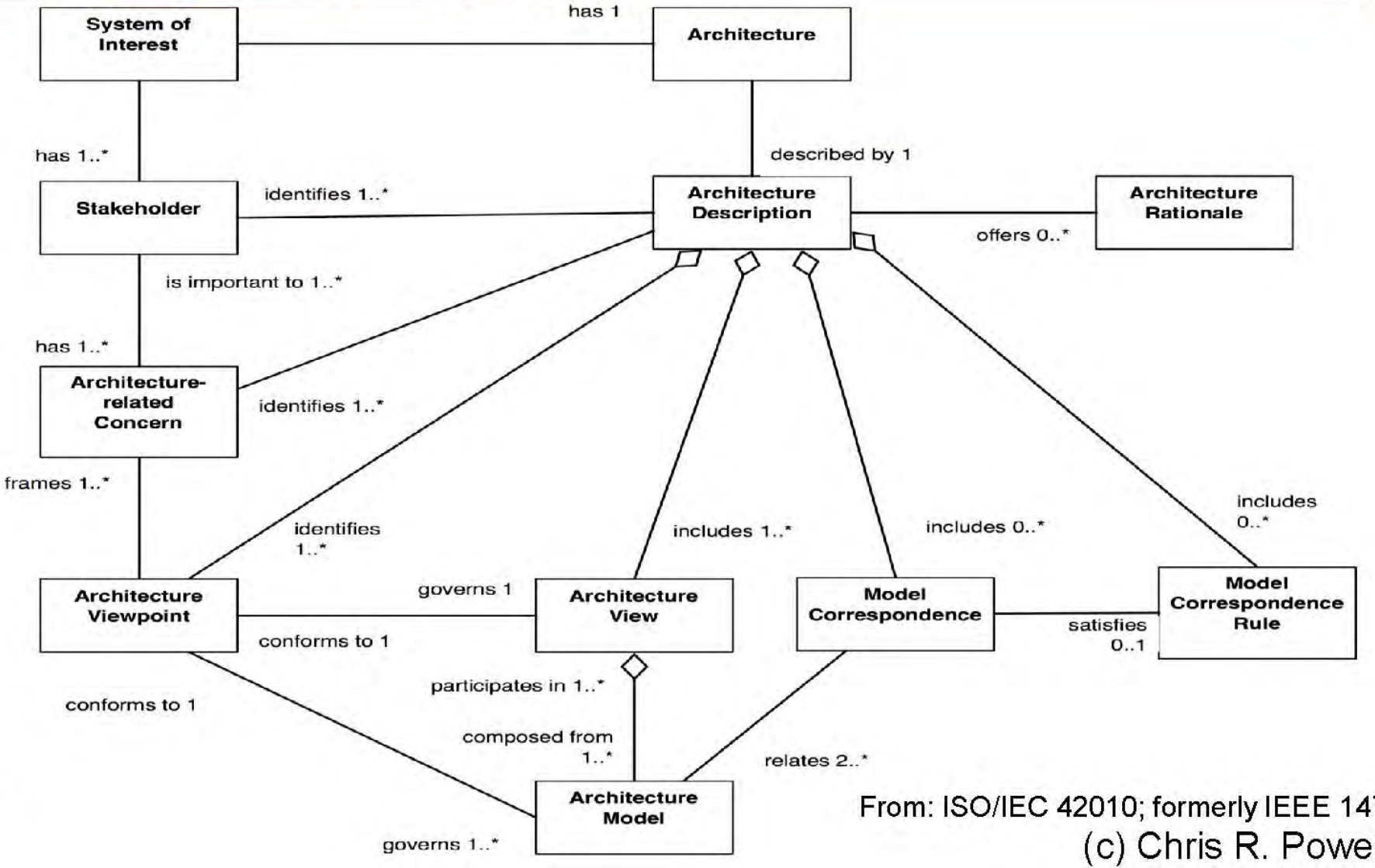
Key Aspects of Complex Systems

- Emergence: Emergence is related to the dependence of the whole on parts, the interdependence of parts, and specialization of parts. While studying the parts in isolation does not work, the nature of complex systems can be probed by investigating how changes in one part affect the others, and the behavior of the whole.
- Pattern formation: simple mathematical models capture pattern formation such as local activation / long range inhibition.
- Multiple (meta-) stable states: Small displacements (perturbations) lead to recovery, and larger ones can lead to radical changes of properties. Dynamics do not average simply.
- Multi-scale descriptions are needed to understand complex systems. Fine scales influence large scale behavior.
- It is difficult but not impossible to answer the question "How complex is it?"
- Behavior (response) complexity: To describe the behavior of a system we try to describe the response function: actions as a function of the environment. However, unless simplifying assumptions are made, this requires an amount of information that grows exponentially with the complexity of the environment.
- Contrasts. Complex systems often exhibit contrasting characteristics, including simplicity and complexity, order and disorder, random and predictable behavior, repeating patterns and change
- We cannot predict what a complex system will evolve into.

Sheard, Sarah. "Definition of the Sciences of Complex Systems." *INSIGHT* (volume 9 #1). Seattle, Washington: International Council on Systems Engineering, October 2006, p. 25.

(c) Chris R. Powell

Architecture & Modeling



From: ISO/IEC 42010; formerly IEEE 1471

(c) Chris R. Powell

Need for Architecture

HPTi

Mission Drivers

- Potential Mission ***Process*** Changes
- Potential Mission ***Performance*** Changes
- Potential Mission ***Data*** Changes
- Potential Changes in ***Collaboration*** or ***Interoperability***
- Potential New or ChangedMission ***Capabilities***

- Operational Impacts
- Personnel Impacts
- Training Impacts
- Support Impacts
- Infrastructure Impacts
- Related System Impacts

Changes to "what" gets done

Changes to "who" is involved

Changes to "where" things get done

Changes to "when" things get done

Changes to "how" things get done

Changes to "which" information is used

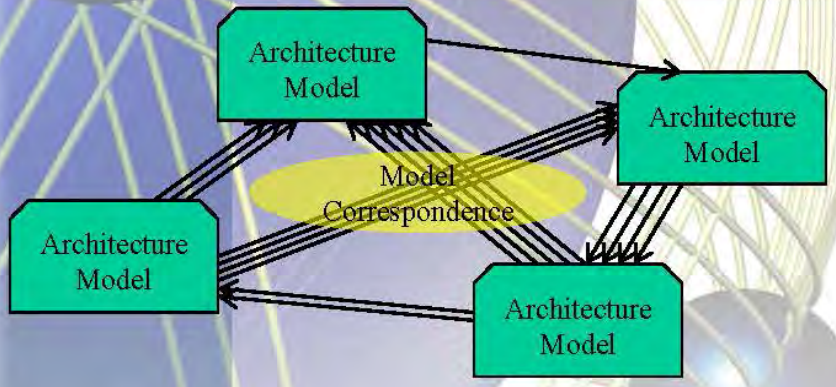
*Architecture qualifies and quantifies impacts and implications of system changes incorporated and desired in response to changing mission drivers – social **and** technical*

Potential problem – increasing system complexity can make characterizing these difficult or impossible up front. Architecture and modeling ensure adequate capability to respond to "unknown unknowns".

(c) Chris R. Powe

HPTi

Architecture Modeling



- Rigorous Identification & Evaluation of Assumptions and Constraints
- Pursue Early & Explicit Coupling of System Attributes, Aspects, and Factors
- Identification of Metadata and Context
- Establish Mutual Team Understanding and Shared Decision Making
- Identify Impacts and Implications
- Establish Adaptability and Flexibility to Handle Unknown and Emergent Properties

These modeling processes characterize and explore a system in human-friendly and knowledge-surfacing terms which enable system success.

- *Usage & Decision Modeling*
  - Concept Refinement Modeling
  - Operational Vignette Modeling
- *Technical Modeling*
  - Interface Specification & Modeling
  - Technology Modeling
  - Prototype Modeling
  - Emergent Properties Modeling
  - Testability Modeling
- *Program Modeling*
  - Requirements Modeling
  - Financial Scenarios & Sensitivity Analysis
  - EVM Criteria Modeling & Analysis
  - IMS/IMP Modeling
  - Risk Modeling & Prevention

(c) Chris R. Powe

HPTi Re-envisioning SE/SoSE as KM

- Maximize *efficient* involvement of OSD in programs to prevent risk
  - Leverage expertise and build more reachback
  - Tech transfer to Services
  - Continuous Engagement, Development Planning
- SE Research Agenda needed
  - Management & Technical concepts
- Manage programs as socio-technical systems
- Focus on knowledge discovery, creation, structure, and use
- Focus on human capital
- Change acquisition incentives to value contractor knowledge leverage – pattern catalog

(c) Chris R. Powell

QUESTIONS?

Development Planning

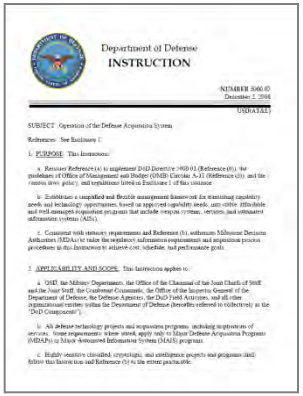
Michael Duffey
Office of the Director, Systems Engineering
Office of the Secretary of Defense

Pre-Acquisition Technology Development/Early System Engineering

National Research Council

"Pre-Milestone A and Early-Phase Systems Engineering" Jan 2008

DoD 5000.02
December 2008



Department of Defense
INSTRUCTION

NUMBER 5000.02
December 2, 2008
USD(AT&L)

SUBJECT: Operation of the Defense Acquisition System

References: See Enclosure 1

1. PURPOSE. This Instruction:

a. Reissues Reference (a) to implement DoD Directive 5000.01 (Reference (b)), the guidance of Office of Management and Budget (OMB) Circular A-11 (Reference (c)), and the various laws, policy, and regulations listed in Enclosure 1 of this Instruction.

b. Establishes a simplified and flexible management framework for translating capability needs and technology opportunities, based on approved capability needs, into stable, affordable, and well-managed acquisition programs that include weapon systems, services, and command and control systems (AIS).

c. Consistent with statutory requirements and Reference (b), authorizes Milestone Decision Authorities (MDAs) to tailor the regulatory information requirements and acquisition process procedures in this Instruction to achieve cost, schedule, and performance goals.

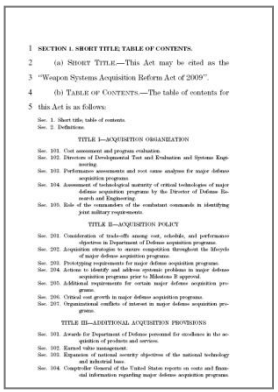
2. APPLICABILITY AND SCOPE. This Instruction applies to:

a. OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the Department of Defense (hereafter referred to collectively as the "DoD Components").

b. All defense technology projects and acquisition programs, including acquisitions of services. Some requirements in this issue apply only to Major Defense Acquisition Programs (MDAPs) or Major Automated Information System (MAIS) programs.

c. Highly sensitive classified, cryptologic, and intelligence projects and programs shall follow this Instruction and Reference (b) to the extent practicable.

WSARA
May 2009



SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Weapon Systems Acquisition Reform Act of 2009".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

Sec. 1. Short title; table of contents.
Sec. 2. Definitions.

TITLE I—ACQUISITION ORGANIZATION

Sec. 101. Cost assessment and program evaluation.
Sec. 102. Director of Developmental Test and Evaluation and Systems Engineering.
Sec. 103. Performance assessments and root cause analyses for major defense acquisition programs.
Sec. 104. Assessment of technological maturity of critical technologies of major defense acquisition programs by the Director of Defense Research and Engineering.
Sec. 105. Role of the commanders of the combatant commands in identifying joint military requirements.

TITLE II—ACQUISITION POLICY

Sec. 201. Consideration of trade-offs among cost, schedule, and performance objectives in Department of Defense acquisition programs.
Sec. 202. Acquisition strategies to ensure competition throughout the lifecycle of major defense acquisition programs.
Sec. 203. Prototyping requirements for major defense acquisition programs.
Sec. 204. Actions to identify and address systemic problems in major defense acquisition programs prior to Milestone B approval.
Sec. 205. Additional requirements for certain major defense acquisition programs.
Sec. 206. Critical cost growth in major defense acquisition programs.
Sec. 207. Organizational conflicts of interest in major defense acquisition programs.

TITLE III—ADDITIONAL ACQUISITION PROVISIONS

Sec. 301. Awards for Department of Defense personnel for excellence in the acquisition of products and services.
Sec. 302. Earned value management.
Sec. 303. Expansion of national security objectives of the national technology and industrial base.
Sec. 304. Comptroller General of the United States reports on costs and financial information regarding major defense acquisition programs.

- **National Academies of Sciences Study**
  - All programs destined to fail without early [pre-MS A] systems engineering
  - Development planning can implement pre-MS A early systems engineering
- **DoD Acquisition Regulations (DoDI 5000.02) Update**
  - Increased focus on early pre-acquisition phases
  - Implication for added early systems engineering
- **Weapon Systems Acquisition Reform Act of 2009 (WSARA)**
  - Directs SE responsibilities to reinvigorate Development Planning

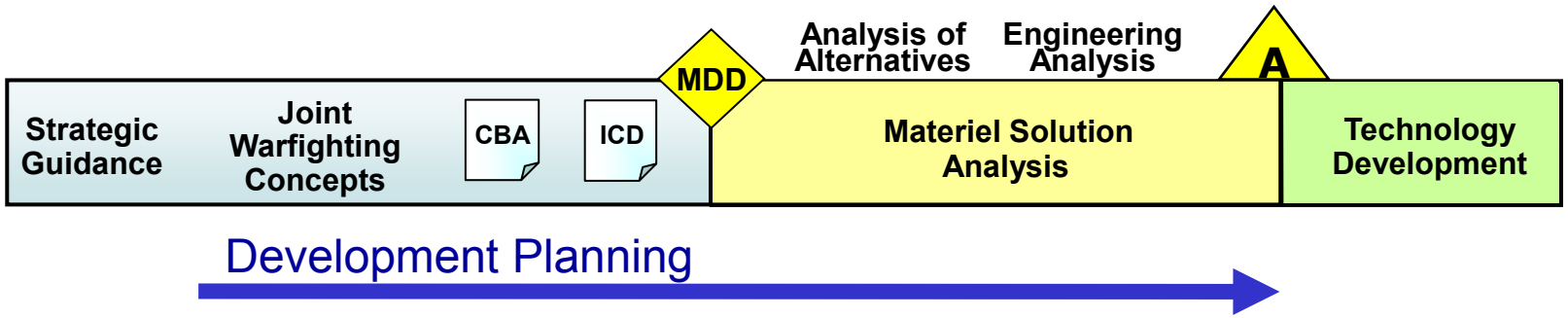
WSARA Development Planning Requirements

- ***Development Planning*** **is a new function identified in the 2009 legislation**
- **Specifically, SE is required to:**
  - Monitor and Review systems engineering and *development planning* activities of the major defense acquisition programs
  - Provide advocacy, oversight, and guidance to elements of the acquisition workforce responsible for systems engineering and *development planning*
  - Provide input on the inclusion of systems engineering requirements in the process for consideration of joint military requirements by the Joint Requirements Oversight Council
  - Periodically review the organizations and capabilities of the military departments with respect to systems engineering and *development planning* capabilities

DDR&E FY10 Development Planning Objectives

- **Establish Development Planning policy, guidance & criteria**
- **Establish capability to perform oversight**
- **Advocate tools, resources for development planning**

Development Planning



Development Planning is the upfront technical preparation to ensure successful selection and development of a materiel solution

Three Critical Impacts on Early Acquisition

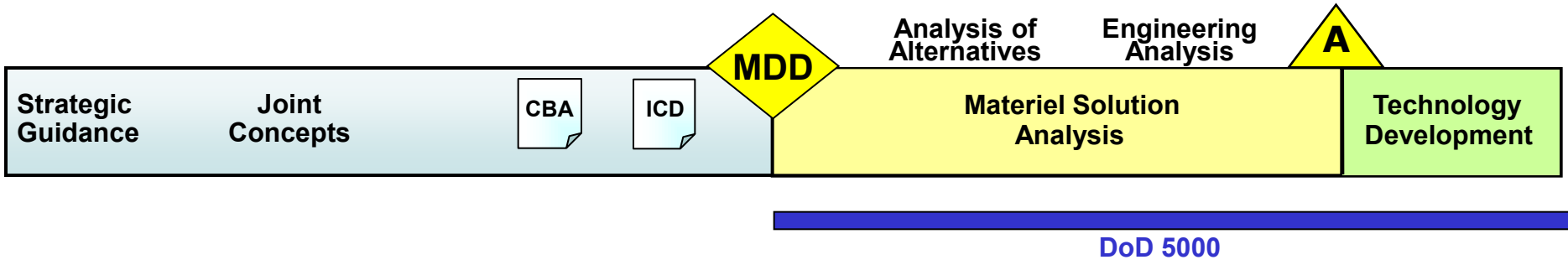
- **2009 Update to CJCSI 3170 eliminated the Functional Solutions Analysis (FSA) from the JCIDS, leaving a process gap in the identification of solutions for consideration in the AoA**

- **In September 2009, GAO issued a report entitled —ManyAnalyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options"**
  - "Department of Defense weapon programs often experience significant cost and schedule problems because they are allowed to start with too many technical unknowns and not enough knowledge about the development and production risks they entail."
  - GAO RECOMMENDATION: "[Secretary of Defense shall] establish specific criteria and guidance for how AoAs should be conducted, including how technical and other programmatic risks should be assessed and compared."

- **2008 DoDI 5000.02 Update drives greater technical work, including competitive prototyping and the Preliminary Design Review before Milestone B, creating greater demand for pre-Milestone A technical analysis and planning.**

Significant Technical Issues Pre-MS A

Issues	Implications
Lack of materiel engagement pre-MDD	• *Limited awareness of potential solutions* leading to missed solution opportunities and too narrow an AoA scope • *Limited understanding of user performance needs* and context, leading to cost/schedule growth due to lack of understanding of the CONOPS and user considerations • *Immature alternatives enter the AoA* leading to increased AoA time and cost due to evaluation of solutions that are not feasible
Program-focused analysis, when solutions will impact broad sets of systems and SoS	• Delivery of a system that *will not integrate*, or that has reduced benefit because of external system issues • Unanticipated costs due to needed *changes to other systems* in order to achieve capability objective
Insufficient engineering engagement between MDD and A	• Lack of engineering on preferred solutions leading to *poor planning for Technology Development* and technical issues leading development problems



Strengthening MDD Entrance Criteria

Material Development Decision (MDD)

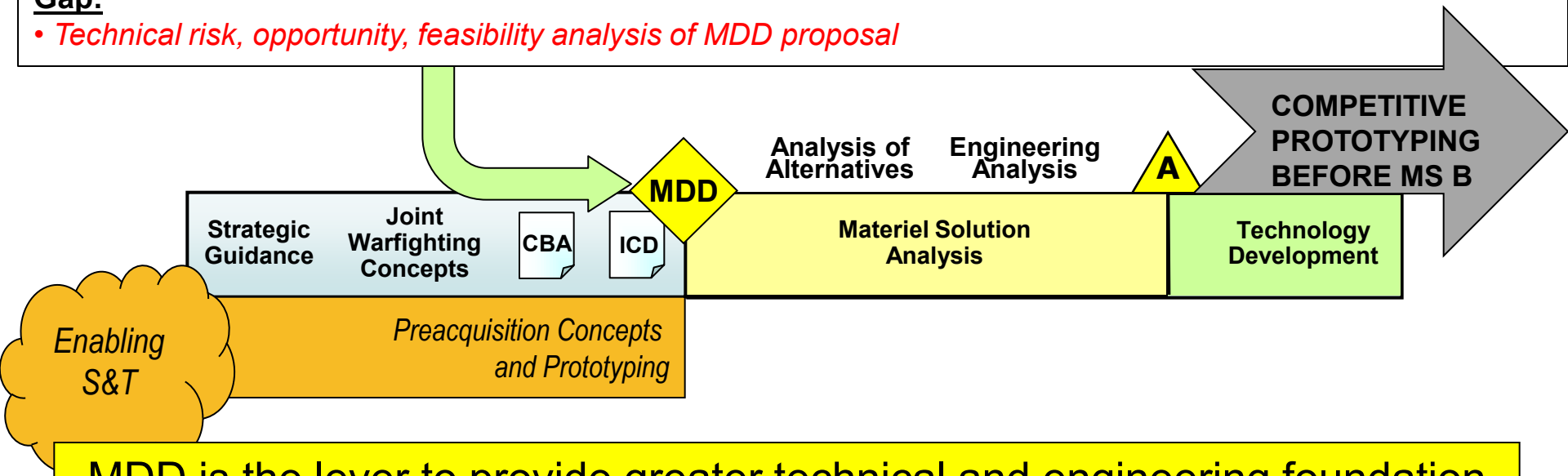
- Defined in DoDI 5000.02 as "the *formal entry point* into the acquisition process and mandatory for all programs"

MDD Entry Criteria:

- JROC approved *ICD*
- CAPE approved *AoA Study Guidance*
- DoD component presents approved ICD, preliminary concept of operations, a description of the needed capability, the operational risk, and the basis for determining that non-material approaches will not sufficiently mitigate the capability gap

Gap:

- *Technical risk, opportunity, feasibility analysis of MDD proposal*



MDD is the lever to provide greater technical and engineering foundation for initiating an acquisition

Development Planning Policy Memo (DTM 10-017)

MDD Criteria

1. The candidate materiel solution approaches have the potential to effectively address the capability gap(s), operational attributes and associated dependencies.
2. There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data.
3. Consideration has been given to near term opportunities to provide a more rapid interim response to the capability need.
4. The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirements.

Post-MDD DDR&E Engagement

- Cooperate with the Director, Cost Assessment and Program Evaluation, and, as agreed upon with that organization, serve as a standing participant and technical advisor in the development of AoA Study Guidance and on the AoA Study Advisory Group for potential programs under USD(AT&L) oversight to facilitate the consideration of technology and engineering risks for the alternatives under consideration.
- Monitor and review the effectiveness of the policy in this DTM and develop additional development planning guidance as needed for incorporation into acquisition policy and the Defense Acquisition Guidebook (Reference (d)).

Additional Evidence Requirements at MDD

The candidate materiel solution approaches have the potential to effectively address the capability gap(s), operational attributes and associated dependencies.

- *Common understanding of the root cause* of the gap between the operational analytical and acquisition communities
- Problem is *defined with adequate specificity* while maintaining *solution independence*
- *Associated dependencies*, to include other gaps, legacy systems, systems of systems baseline considerations and DOT_LPF implications
- Candidate materiel solution approaches have the potential to *effectively address the gap*
- The *urgency/priority of the gap*, including the operational community's requirements on schedule for deployment

There exists a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data

- Initial set of solutions have been drawn from the *entire solution space*
- A *broad range of solutions* is proposed for consideration to ensure the highest likelihood of success
- Evidence that demonstrates *technical feasibility* of proposed alternative solutions is presented, including prototypes, models or data
- Technical feasibility considers technical issues of new developments, updates to existing systems, and the *changes needed given the dependencies* of the proposed system

Additional Evidence Requirements at MDD

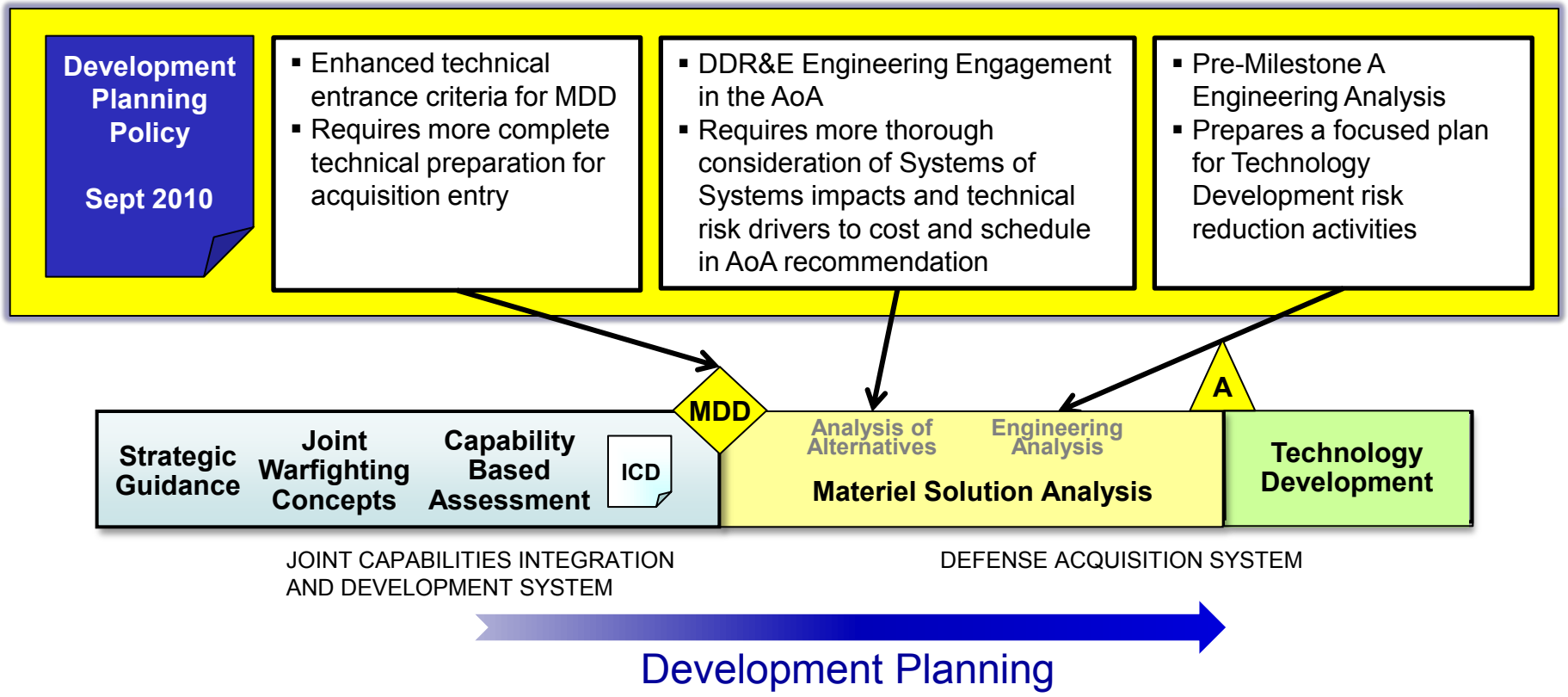
Consideration has been given to near term opportunities to provide a more rapid interim response to the capability need

- Provide evidence that consideration was given to *interim, more rapid solutions* to mitigate the impact of the capability gap while a system acquisition is underway
- Ensure that *incremental acquisition* has been considered to quickly deliver the solution to the warfighter and deliver added capability with follow-on increments

The plan to staff and fund analytic, engineering, and programmatic activities supports the proposed milestone entry requirements.

- Current DoDI 5000.02 policies mandates full funding of the AoA at the MDD
- Proposed Development Planning policy directs *DDR&E participation in oversight of the AoA* to support greater analysis of technical risk of proposed solutions
- Recent changes to DoDI 5000.02 require *greater pre-MS A engineering and programmatic planning* for the Technology Development phase in support of Milestone A requirements
- Requires evidence of *planning, funding and staffing* to adequately perform additional analysis and planning in the Materiel Solution Analysis phase

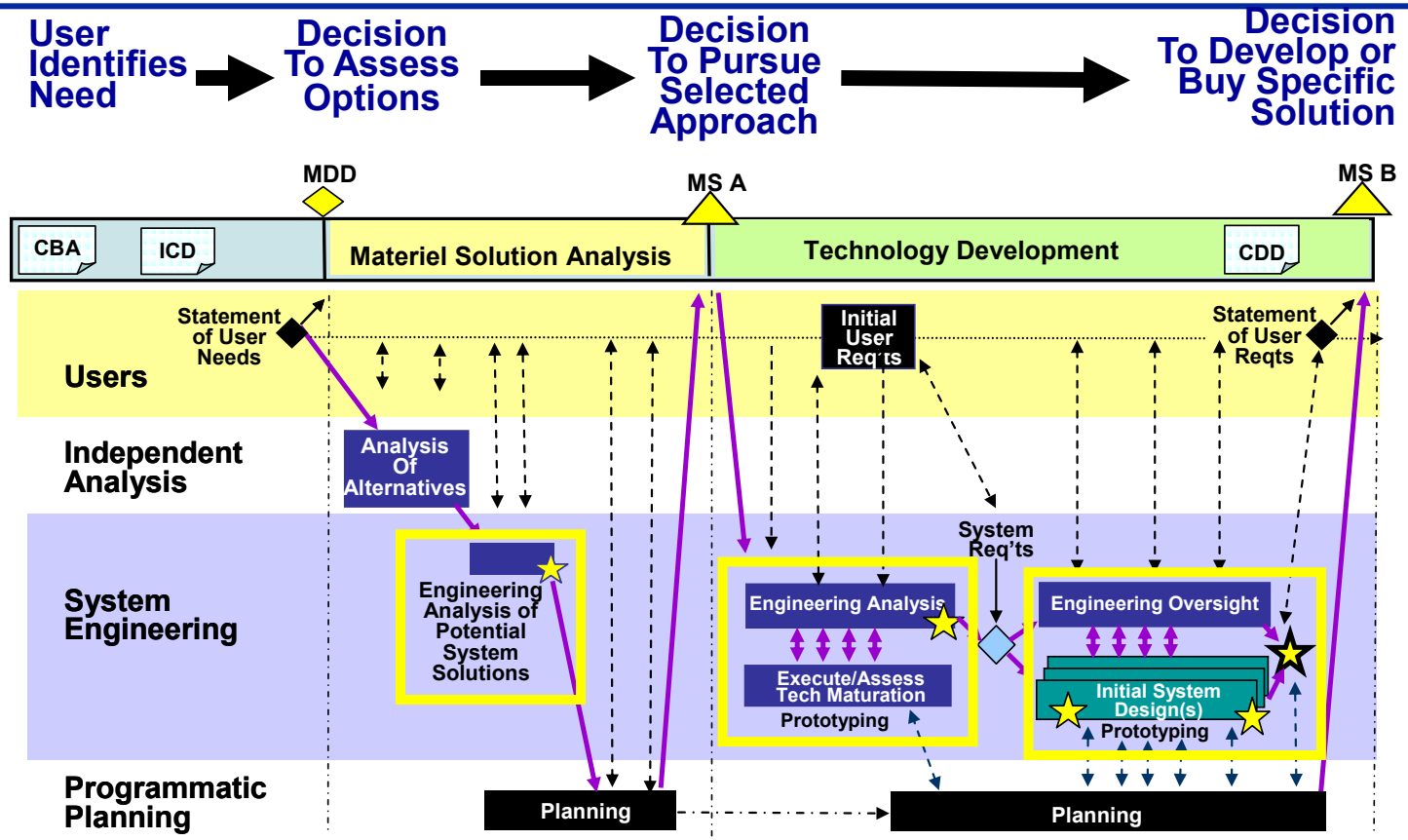
Summary



Development Planning policy drives earlier technical engagement to identify and reduce risk and start programs right

BACKUP

Critical SE Support to Program Formulation



During MSA and TD Systems Engineering Provides the Technical Foundation for Program Decisions

WSARA – Dir, SE Language

(b) DIRECTOR OF SYSTEMS ENGINEERING.—

(1) APPOINTMENT.—There is a Director of Systems Engineering, who shall be appointed by the Secretary of Defense from among individuals with an expertise in systems engineering and development planning.

(2) PRINCIPAL ADVISOR FOR SYSTEMS ENGINEERING AND DEVELOPMENT PLANNING.—The Director shall be the principal advisor to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology, and Logistics on systems engineering and development planning in the Department of Defense.

(3) SUPERVISION.—The Director shall be subject to the supervision of the Under Secretary of Defense for Acquisition, Technology, and Logistics and shall report to the Under Secretary.

(4) COORDINATION WITH DIRECTOR OF DEVELOPMENTAL TEST AND EVALUATION.—The Director of Systems Engineering shall closely coordinate with the Director of Developmental Test and Evaluation to ensure that the developmental test and evaluation activities of the Department of Defense are fully integrated into and consistent with the systems engineering and development planning processes of the Department.

(5) DUTIES.—The Director shall—

(A) develop policies and guidance for—

(i) the use of systems engineering principles and best practices, generally;

(ii) the use of systems engineering approaches to enhance reliability, availability, and maintainability on major defense acquisition programs;

(iii) the development of systems engineering master plans for major defense acquisition programs including systems engineering considerations in support of lifecycle management and sustainability; and

(iv) the inclusion of provisions relating to systems engineering and reliability growth in requests for proposals;

(B) review and approve the systems engineering master plan for each major defense acquisition program;

(C) monitor and review the systems engineering and development planning activities of the major defense acquisition programs;

(D) provide advocacy, oversight, and guidance to elements of the acquisition workforce responsible for systems engineering, development planning, and lifecycle management and sustainability functions;

(E) provide input on the inclusion of systems engineering requirements in the process for consideration of joint military requirements by the Joint Requirements Oversight Council pursuant to section 181 of this title, including specific input relating to each capabilities development document;

(F) periodically review the organizations and capabilities of the military departments with respect to systems engineering, development planning, and lifecycle management and sustainability, and identify needed changes or improvements to such organizations and capabilities; and

(G) perform such other activities relating to the systems engineering and development planning activities of the Department of Defense as the Under Secretary of Defense for Acquisition, Technology, and Logistics may prescribe.

Systems Engineering in S&T

A Bridge-Builder to Development Planning

Dr. Ken Barker
Chief Engineer

27 Oct 2010

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

Distribution A: Approved for Public Release, distribution unlimited (Approval given by local Public Affairs Office)

Overview

- SE for AFRL‟s S&TMission
- S&T Influences Across the Life Cycle
  - Emphasis on Development Planning
- SE Couples S&T and Development Planning

Systems Engineering in AFRL

- Enjoys Strong Support from Senior Leadership; Support from S&T Workforce is Growing
- Uniquely Tailored to AFRL's S&T Mission
  - SE Rigor Appropriate to S&T Program
- Recognizes that Technology Must be "Systemized" to Enable Capability
- Facilitates Technology Transition -- Turning Technology into War Winning Capabilities
- Enables Necessary S&T Influence Across Acquisition Life Cycle
- Forcing Function for Development Planning Activity
  - Which is a Forcing Function for S&T

SE Challenges in AFRL
(probably true in any DoD S&T organization)

- Terminology
  - Policy & guidebooks focus on Weapon System SE - require translation to S&T Mission
- Culture – a concern that SE discipline & rigor will:
  - Stifle innovation & creativity
  - Inhibit freedom to “push” technology not being “pulled” by documented capability need/gap

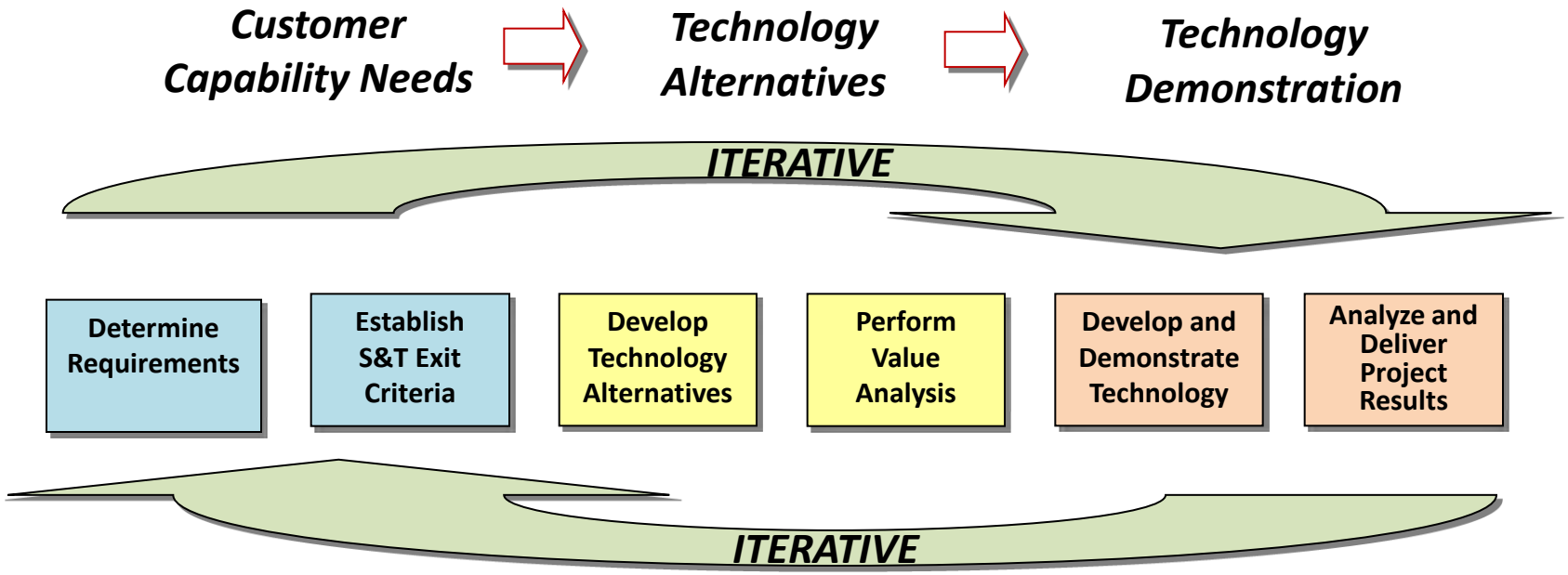
AFRL Leadership Committed to Strong SE in AFRL While Addressing These Challenges

Current AFRL Initiatives Support SE

- Formalized Role of Chief Engineer
  - AFRL-level and at each Technology Directorate
  - Responsible for Tailored SE in AFRL's Portfolio & Programs
    - Improved technology transition to AF systems
- Improved Responsiveness to Customer Needs
  - S&T Strategy…SES Capability Leads…Flagship Capability Concepts
- Consistent Participation on Development Planning (DP) & TRA Teams
- Relevant Training! (Lab 202, STM 303)

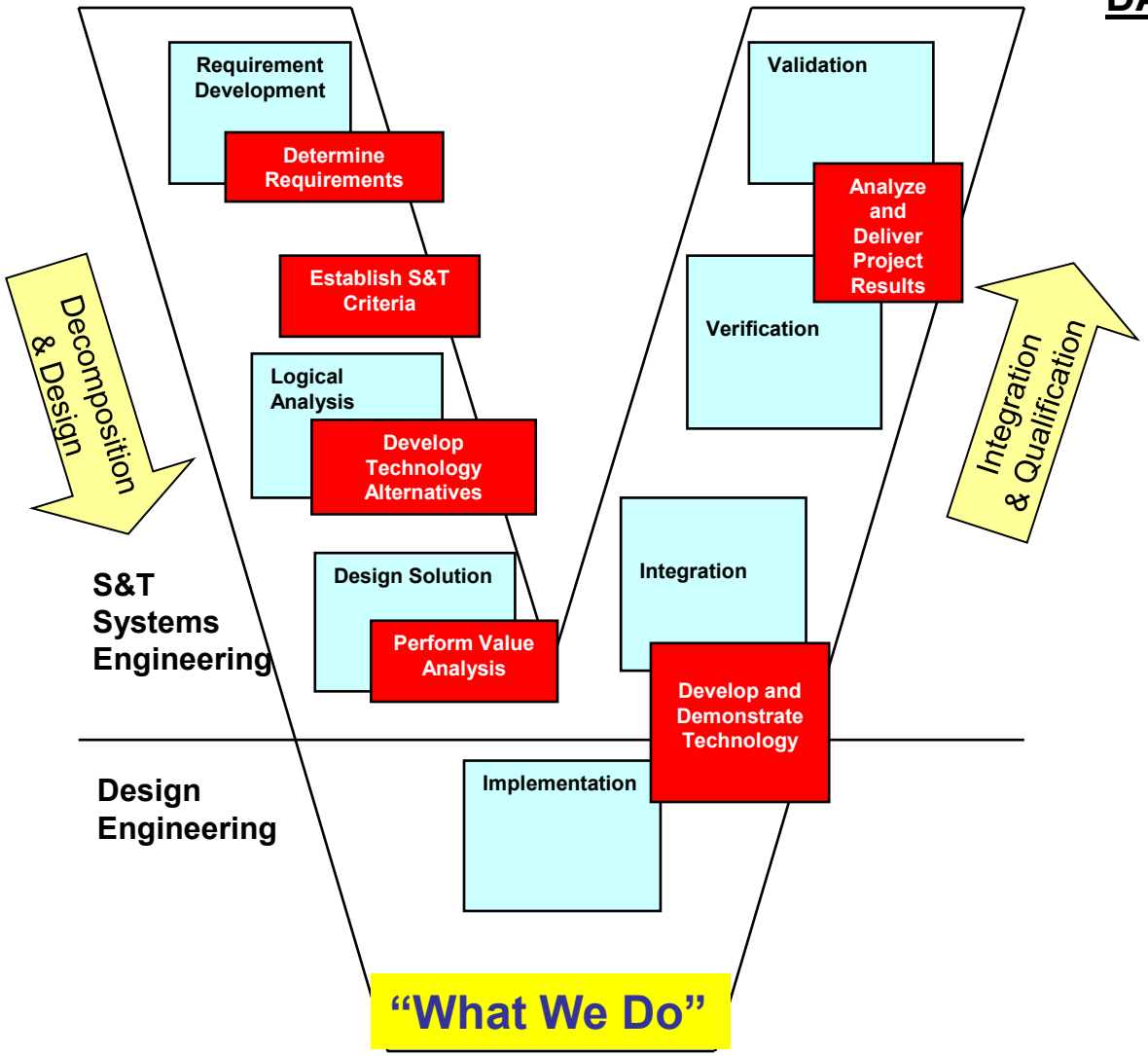
Appreciation for AFRL's Role & Responsibilities in SE Never Greater

AFRL"s Systems Engineering Process



- **SE in S&T is fundamental to:**
  - **Portfolio Development**
  - **Technology program planning, execution, transition**

AFRL"sS&T SE Process: Consistent With DAG SE Processes



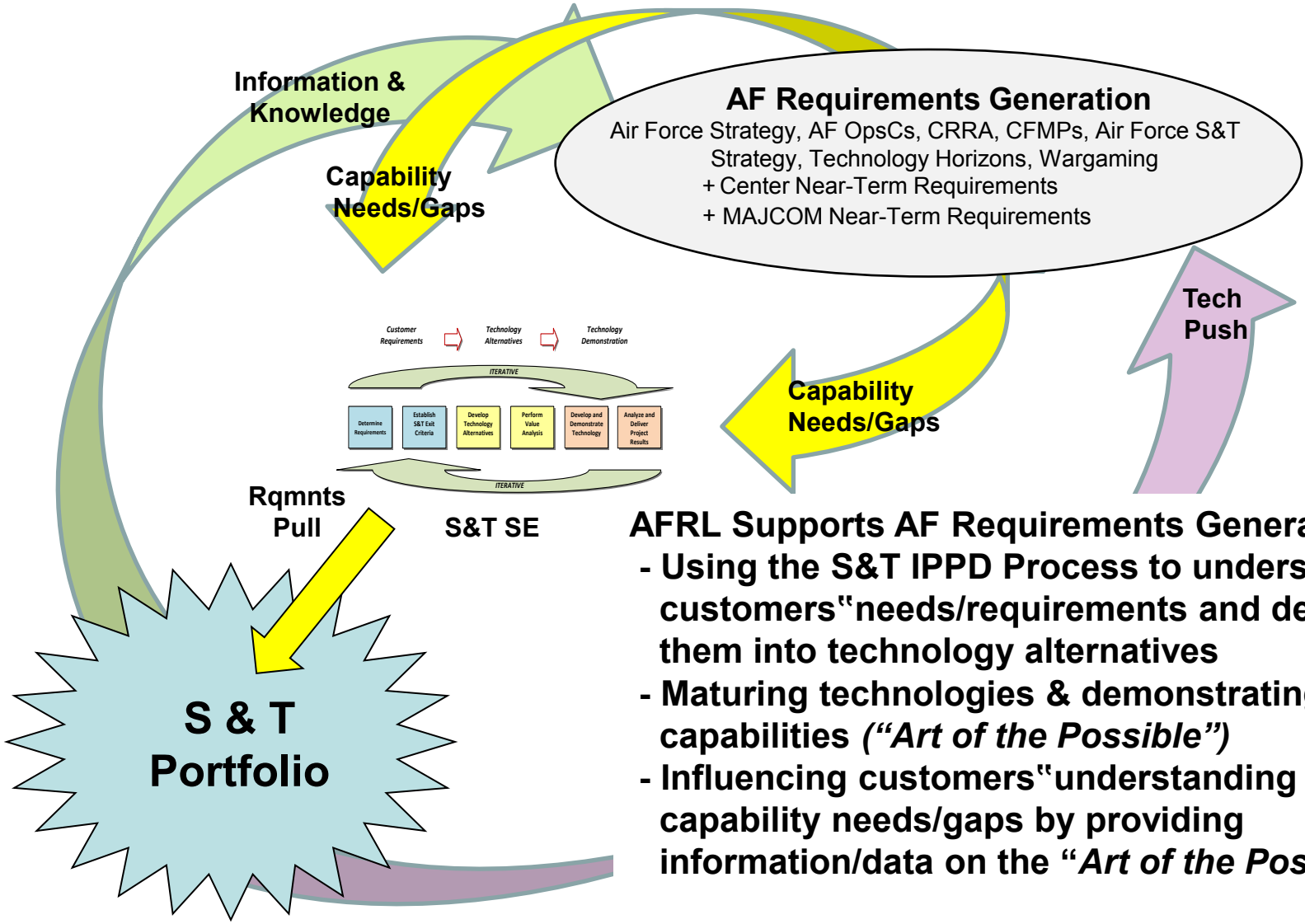
DAG Technical Mgmt Processes

- Decision Analysis
- Tech Planning
- Tech Assessment
- Requirements Mgmt
- Risk Mgmt
- Configuration Mgmt
- Data mgmt
- Interface Mgmt

"How We Do It"

S&T SE: And The Acquisition Life Cycle

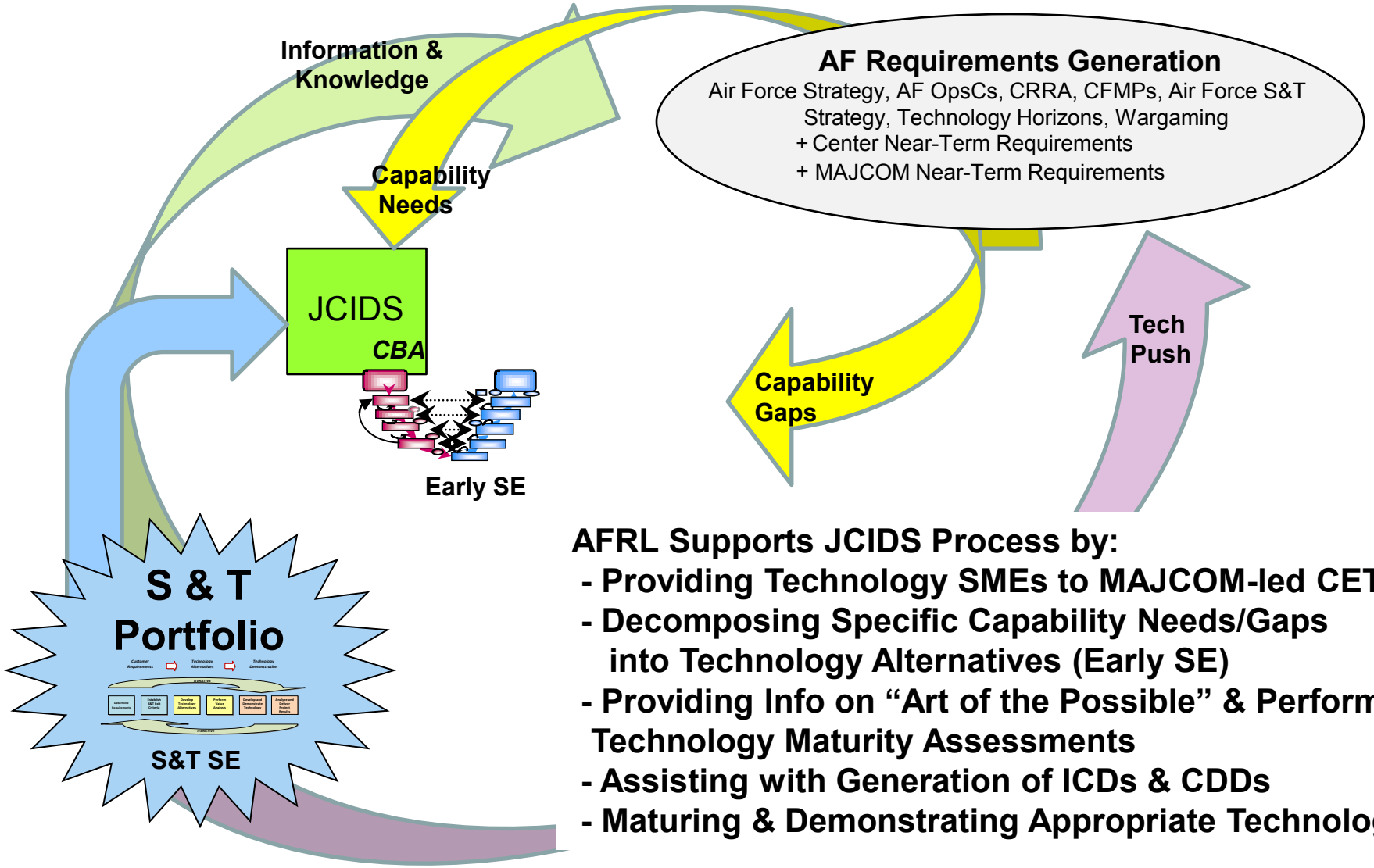
Warfighter Requirements Influence AFRL's S&T Portfolio



AFRL Supports AF Requirements Generation by:

- **Using the S&T IPPD Process to understand customers' needs/requirements and decompose them into technology alternatives**
- **Maturing technologies & demonstrating new capabilities *("Art of the Possible")***
- **Influencing customers' understanding of their capability needs/gaps by providing information/data on the "*Art of the Possible*"**

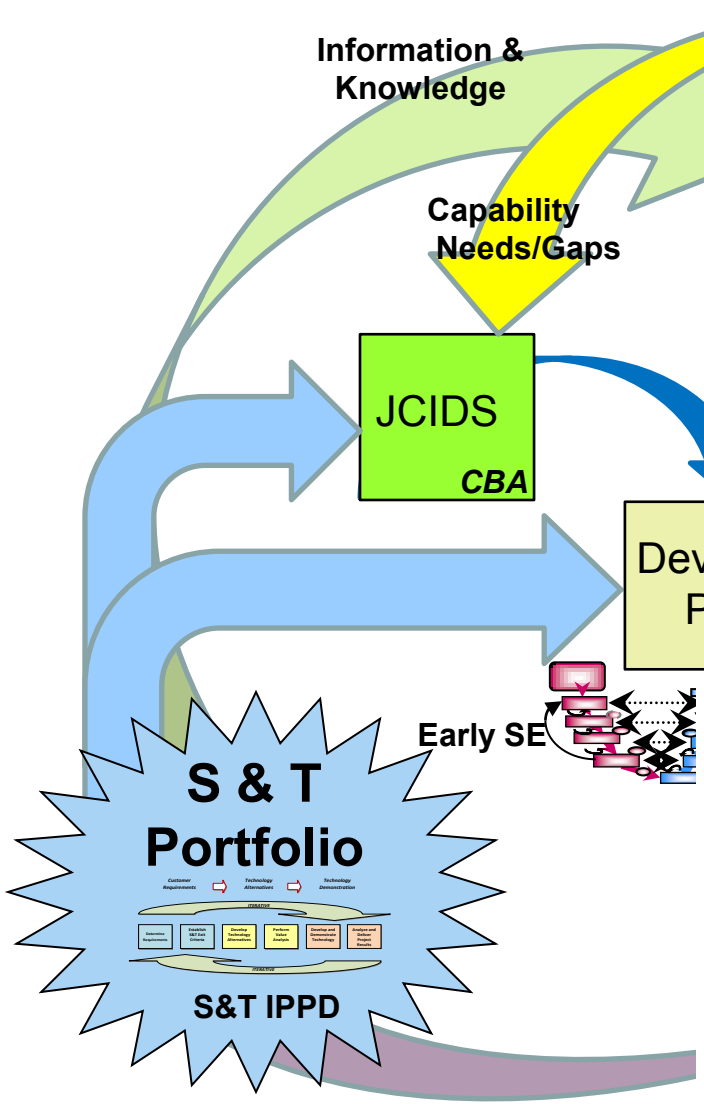
S&T SE: And The Acquisition Life Cycle



AFRL Supports JCIDS Process by:

- Providing Technology SMEs to MAJCOM-led CETs
- Decomposing Specific Capability Needs/Gaps into Technology Alternatives (Early SE)
- Providing Info on "Art of the Possible" & Performing Technology Maturity Assessments
- Assisting with Generation of ICDs & CDDs
- Maturing & Demonstrating Appropriate Technologies

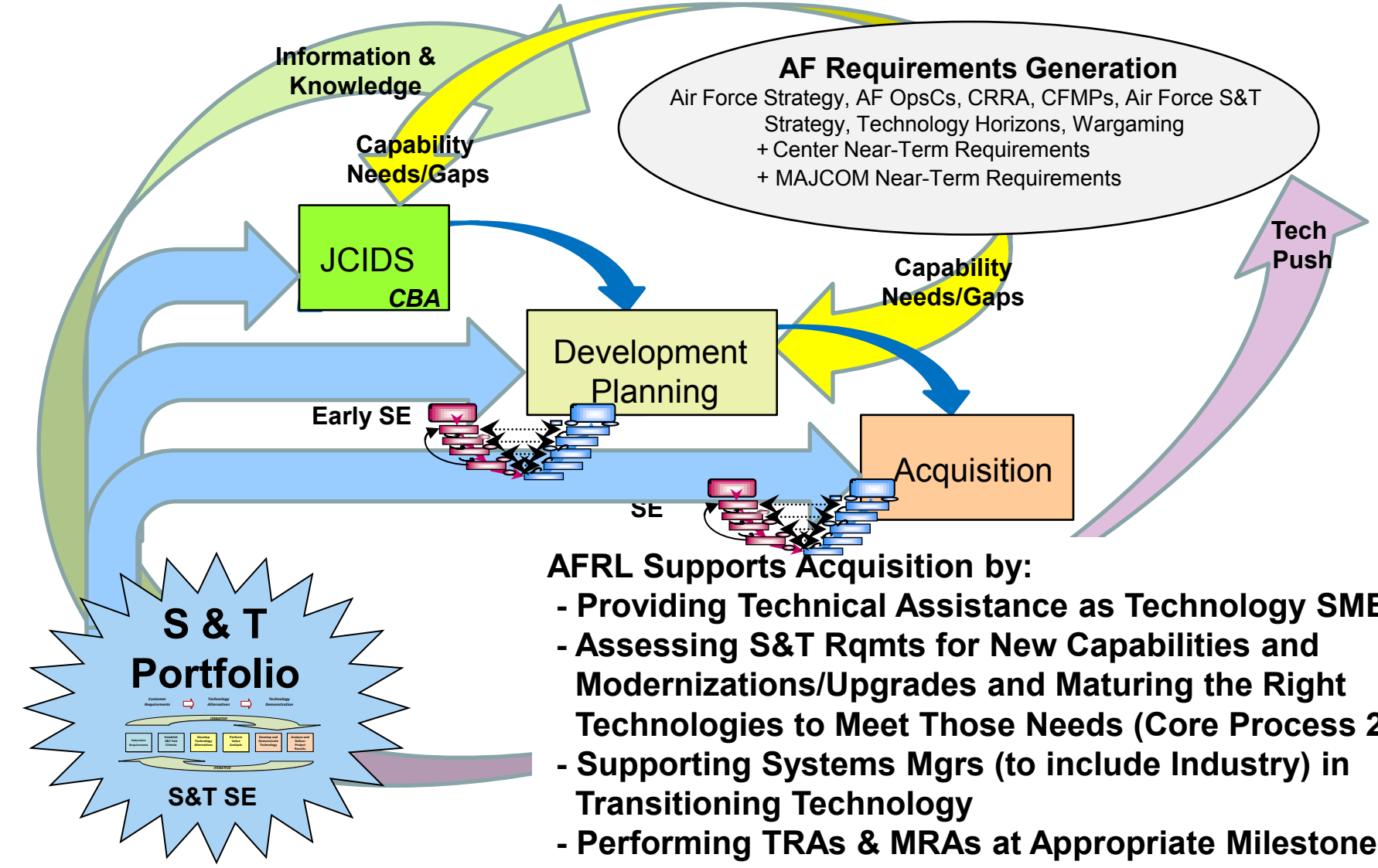
S&T IPPD: And The Acquisition Life Cycle



AFRL Supports DP by:

- **Providing Technology SMEs to XR-led DP Teams**
- **Further Decomposing Needs/Gaps into S&T Reqmts for Materiel Solutions**
- **Assisting with Analytical-Based Decision Assessments, Analysis of Alternatives, Studies and Strategies**
- **Performing Technology and Manufacturing Risk Assessments**
- **Helping Evolve the CCTD into the SRD**

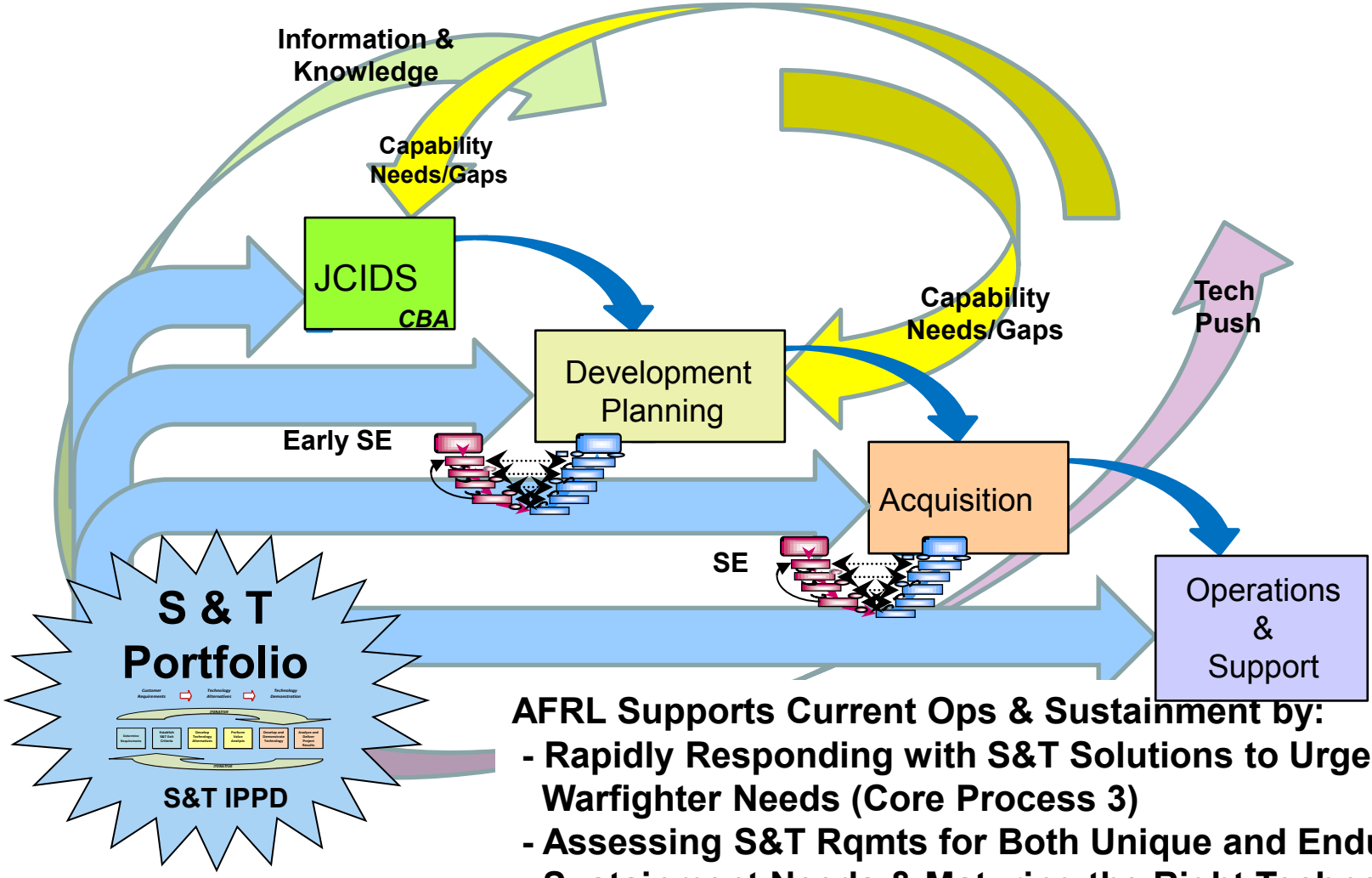
S&T IPPD: And The Acquisition Life Cycle



AFRL Supports Acquisition by:

- Providing Technical Assistance as Technology SMEs
- Assessing S&T Rqmts for New Capabilities and Modernizations/Upgrades and Maturing the Right Technologies to Meet Those Needs (Core Process 2)
- Supporting Systems Mgrs (to include Industry) in Transitioning Technology
- Performing TRAs & MRAs at Appropriate Milestones
- Maturing Manufacturing Processes

S&T IPPD: And The Acquisition Life Cycle

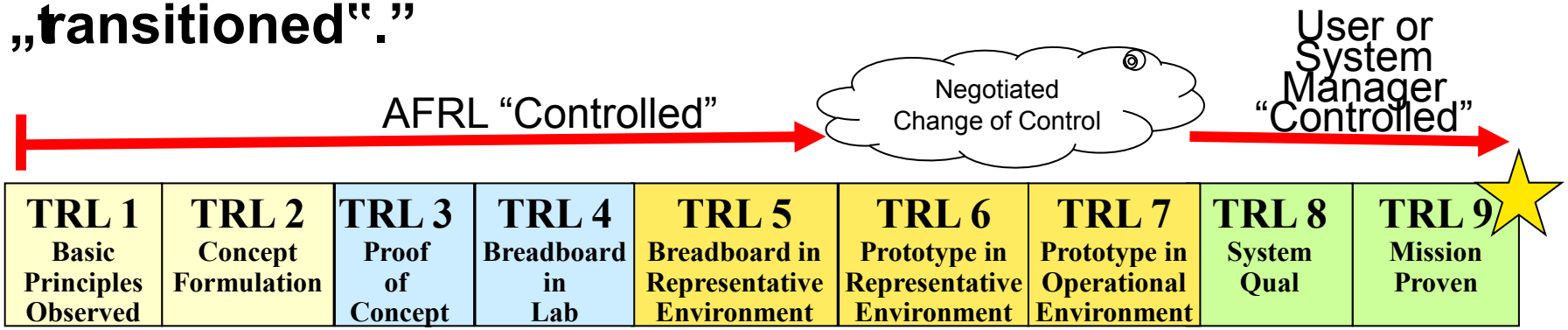


AFRL Supports Current Ops & Sustainment by:

- **Rapidly Responding with S&T Solutions to Urgent Warfighter Needs (Core Process 3)**
- **Assessing S&T Rqmts for Both Unique and Enduring Sustainment Needs & Maturing the Right Technologies to Meet Those Needs (Core Process 2)**
- **Providing Timely Forensic Analyses on Technical Issues**

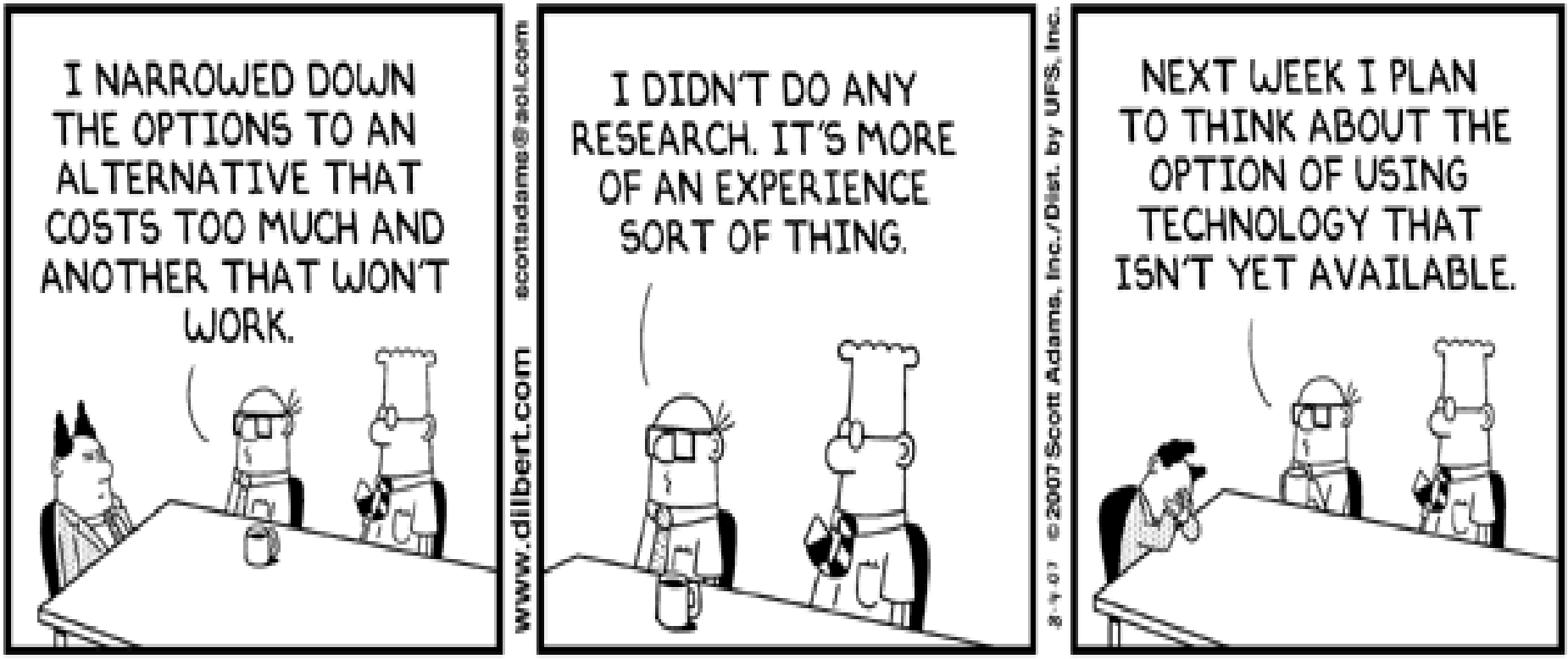
S&T SE:
Must Enable Transition

"Technology transition is a process where technology is developed in strong collaboration with managers and users of systems* with the intent to insert the matured technology into that system. The process is complete when the technology is operational (TRL 9) and supportable. Only at that point has the technology „transitioned".



* Weapon systems, manufacturing processes, analysis tools, and other systems intended to provide capability to an end user

Truth Hurts?

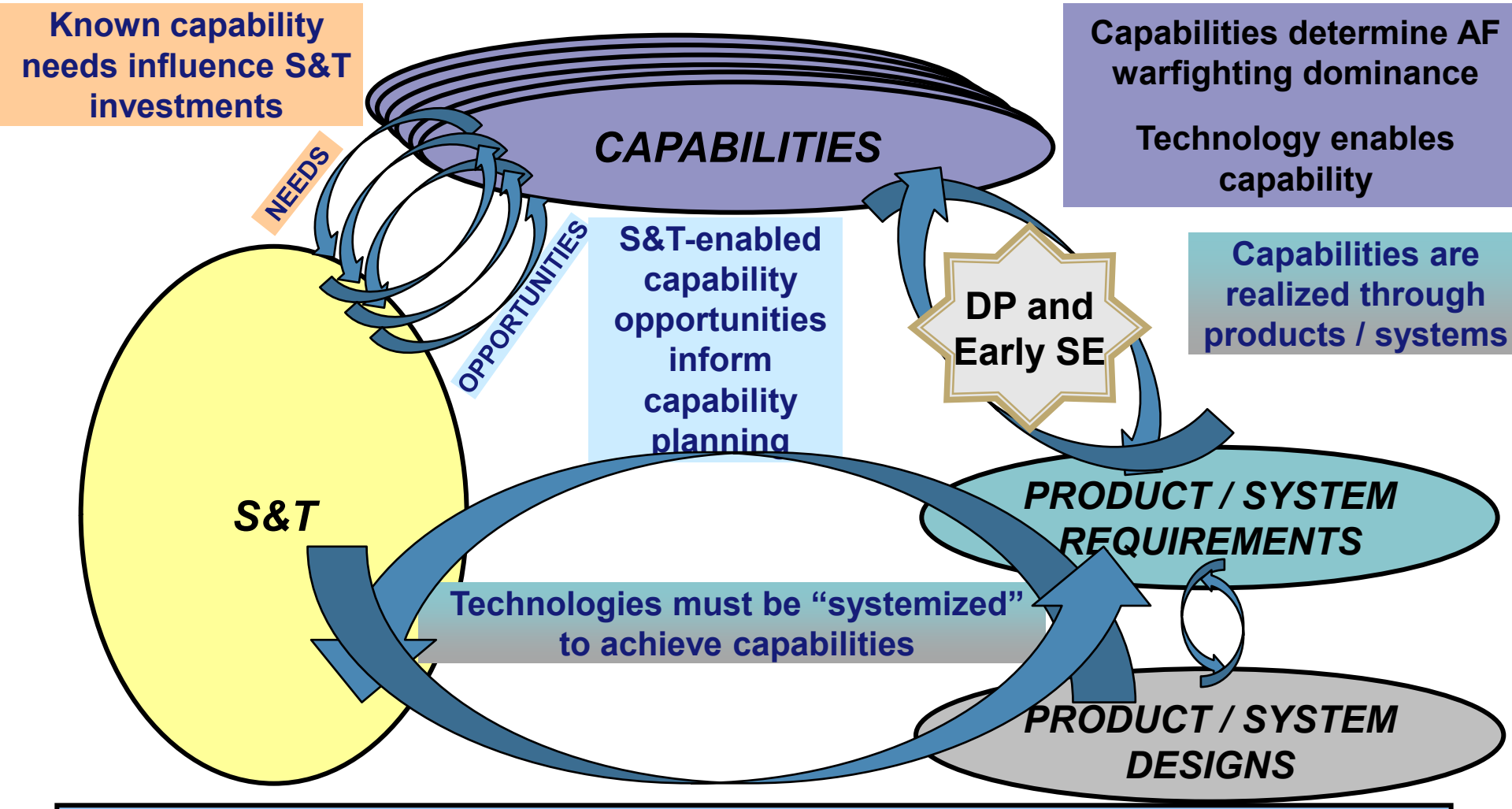


© Scott Adams, Inc./Dist. by UFS, Inc.

S&T Relationship to DP:
SE is the "Coupler"

- Refine warfighters' understanding of required capabilities
- Introduce warfighters to capability opportunities (often come from "Tech Push" efforts)
- Enable DP's SE "V" via insight into technology's "state-of-readiness" and risk of further maturing required technologies
- Focus S&T investments to ensure required technologies are properly mature for acquisition program (post MS A efforts)
- Ensure industry can respond to Program Office RFP with the necessary mature technologies

How It Works Together



SE and technical planning establish the connections between capability planning and S&T strategy

Summary

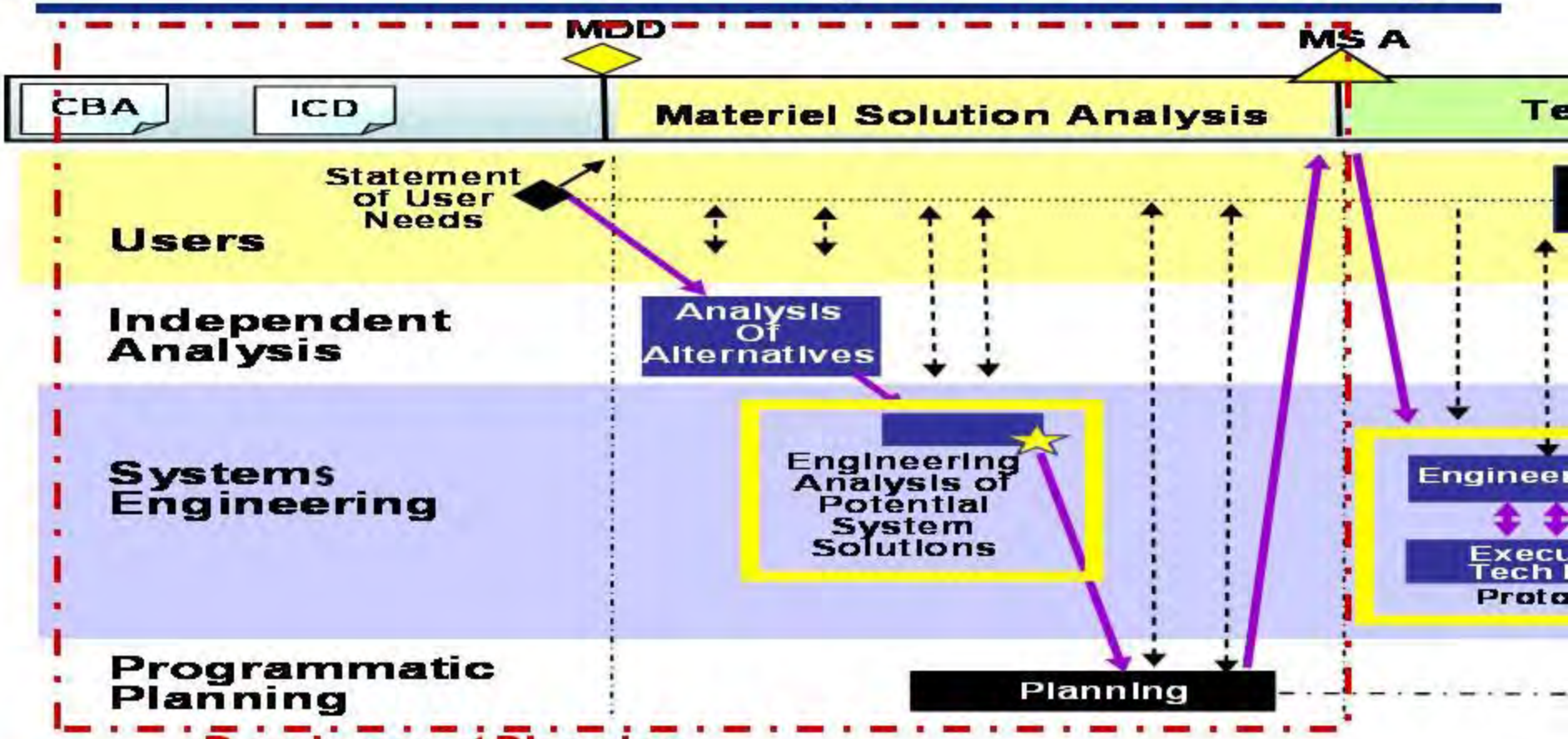
- Warfighters and end users want capability, not technology
- Capability is provided by platforms and systems
- Technology must be “systemized” to be useful
- DP ensures proper pre-acquisition analysis
- S&T informs and enables early SE
- Early SE facilitates DP
- SE facilitates technology transition beyond that required of DP

SE Can “Mechanize” the Interrelationship Between Development Planning and S&T

Backups

Year of the Air Force
Family

Development Planning



- DP begins before acquisition, and is integrated with CBA
- DP is a natural application of Systems Engineering processes
- DP provides robust concepts/alternatives/approaches for evaluation during MSA

Concept Characterization and Technical Description (CCTD) Principal Elements

1. Mission / Capability Need Statement / CONOPS
2. Concept Overview
3. Trade Space Characterization
4. Evaluations (Studies, Analyses, Experiments)
5. Concept Characterization / Design — includes Critical Technology Elements
6. Implementation Analyses — includes Critical Technologies and Technology Maturation Approach
7. Risk Assessment and Decision-Certain Consequences
8. DOT_LPF Implications
9. Conclusions (Capability Description; Traceability to Need Statement)

Tailored to meet MDD information needs
Tailored to timeline needed to support decision

CCTD and S&T CCTD Comparison

CCTD

- Acquisition (system) Based – Constrained by requirements
- Technical and analytical knowledge base document that captures data about a concept (prospective materiel solution) developed in response to gaps or shortfalls in operational concepts
- Prepared by the concept development organization (e.g., XR) with stakeholder inputs (i.e., Program Office, user, AFRL, etc.)
- Documents the pedigree of development actions and decisions as concept matures
- Informs AF leadership for decision making (e.g., AF Review Board before MDD & MS A; AFROC approval of AoA Study Plan and Report)
- Becomes source data/information for AoA documentation (e.g., Alternative Description or Technical Description Document (TDD))

CCTD IS NOT A REQUIRED MS DECISION DOCUMENT

S&T CCTD

- Technology Based – Unconstrained (can be tech push)
- Technical and analytical knowledge base document which captures data about a Capability Concept as a technology-enabler for future Capabilities
- Prepared by the appropriate Future Long Term Challenge (FLTC) Team with AFRL Technology Directorate (TD) technical support
- Highlights maturity of FLTC Capability Concept
- Instrumental to FLTC Chief and Senior AFRL Leadership decision making (e.g., POM inputs, resource postures, Mid- /Far-Term Demonstrations, etc.)
- Becomes source data/information for JCIDS Candidate Solution Sets and/or DP Programs

S&T CCTDs UNDER DEVELOPMENT in AFRL

QUESTIONS ?

Dr. Ken Barker
Chief Engineer
AFRL/XP
937-904-4409
Kenneth.barker@wpafb.af.mil

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

Distribution A: Approved for Public Release, distribution unlimited (Approval given by local Public Affairs Office)

Developing a Mission Solution: From Mission Gap Analysis to Preferred System Concept

Liz O'Keefe
Jim Sierchio
26 October 2010

Copyright © 2010 Raytheon Company. All rights reserved (for Raytheon only slides).
Customer Success Is Our Mission is a registered trademark of Raytheon Company.

Approved for Public Release - SPR#1345

Raytheon

Outline

- Introduction
- Development in the Acquisition Cycle
- Affordable Weapon System Study (AWS)
- Implementing JCIDS at RMS
- Mission Capability Analysis
- Solution Capability Analysis
- First Principles Analysis
- Quality Functional Deployment / Preferred System Concept
- Summary

Approved for Public Release - SPR#1345

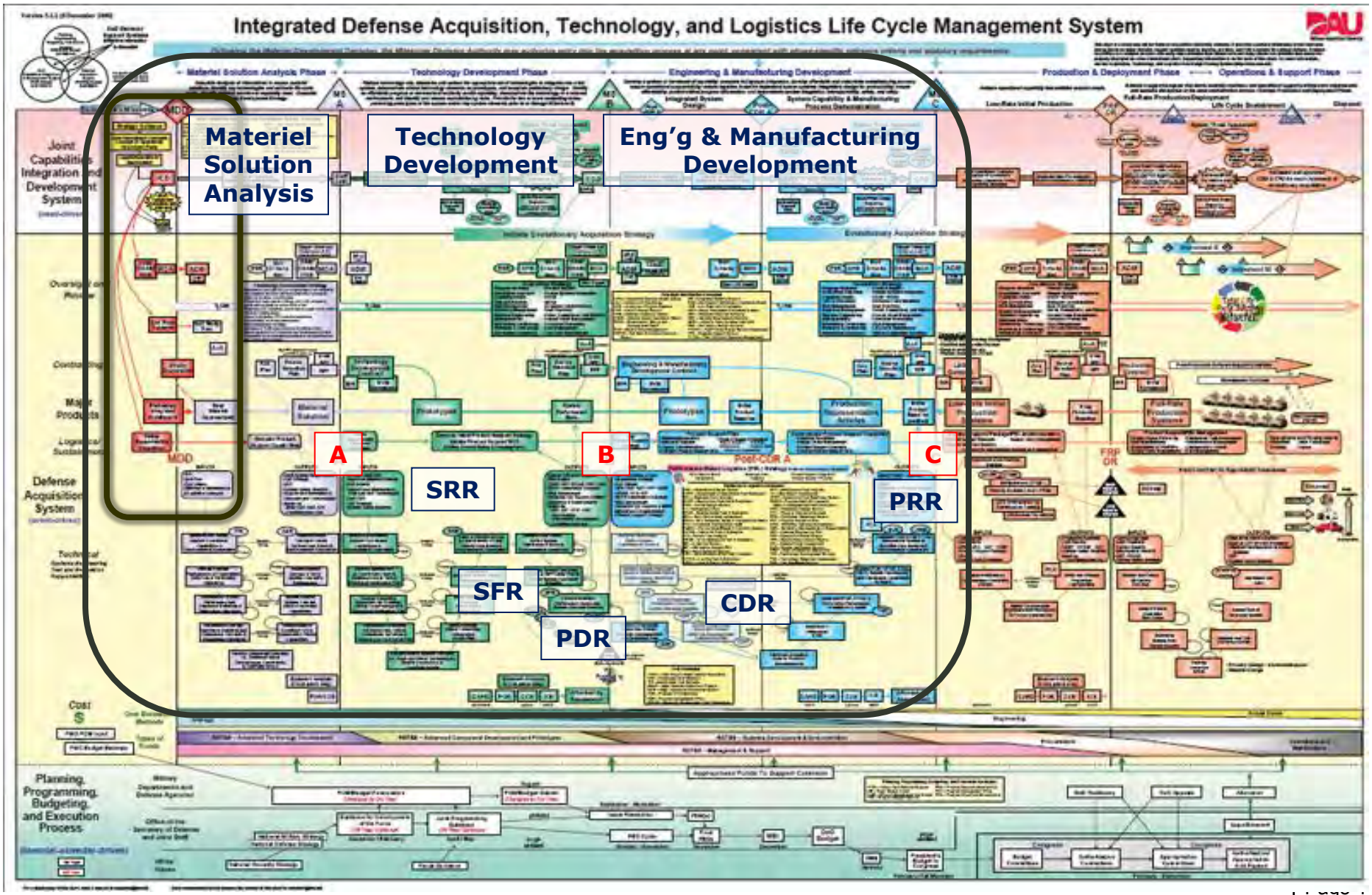
Introduction

- Mission analysis studies conducted per the Joint Capabilities Integration & Development System (JCIDS) process identified gaps in the Navy's ability to provide accurate, responsive "Fire Support from the Sea"
  - Marine and Army forces operating ashore throughout conflict spectrum
  - Gaps defined in the Marines' Joint Fires Initial Capabilities Document (ICD)
  - Included impact from use of MV-22 Osprey, which provides Marines ability to conduct vertical envelopment ops far beyond naval gunfire range
- Navy interested in developing a refined system concept for an Affordable Weapon System (AWS) as a ship- and/or air-launched material solution " for the 2016 timeframe
- AWS Team employed RMS Mission System Engineering (MSE) Process
  - Mission Capability Analysis (MCA) used to identify relevant Mission Areas and Missions, and then determine the 2016 timeframe capability shortfalls
  - Solution Capability Analysis (SCA) used to identify, rank and rate solution options, and map options against defense strategies and mission shortfalls.

Approved for Public Release - SPR#1345

Development in the Acquisition Cycle: JCIDS and DoDI 5000.02

Raytheon



Affordable Weapon System Study: Mission Capability Analysis Process

Raytheon

One aspect of the AWS study was to determine the capabilities and associated tasks, conditions and standards required for Naval Surface Fire Support (NSFS) missions performed at standoff ranges.

MCA Identifies:

- Appropriate Mission Areas and Missions
- Scope of Mission Area / Military Problem
- 2016 timeframe capability shortfalls

MCA Maps:

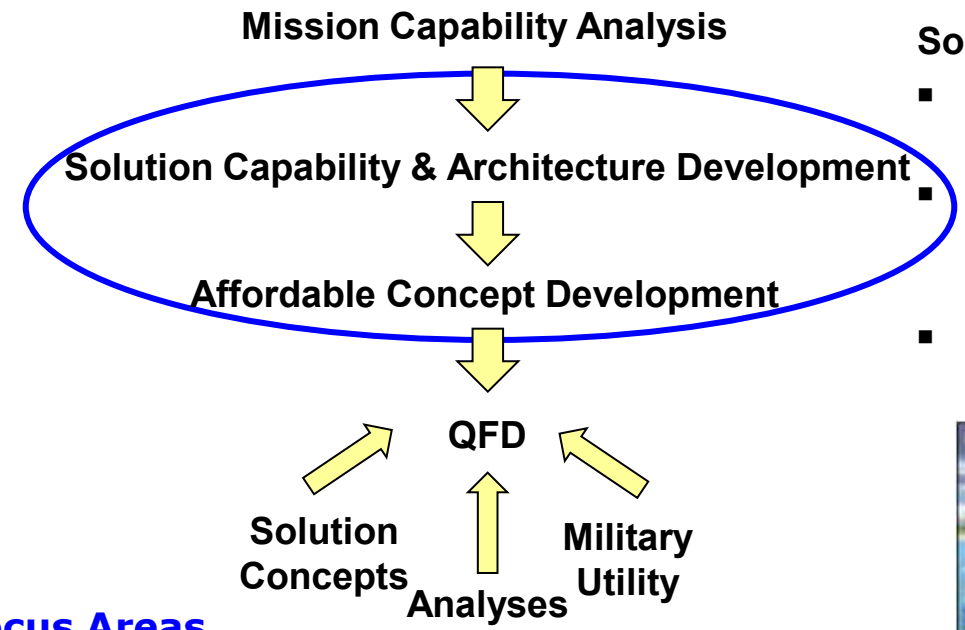
- Capabilities to Defense Strategies
- Relevant objectives to capability gaps
- Example Scenarios to mission areas

Focus on Identifying the Gaps

Affordable Weapon System Study: Solution Architecture & Design Development

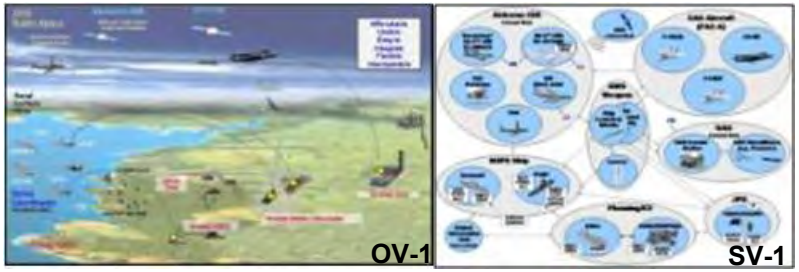
Raytheon

- MOEs → System Capabilities → System Requirements
- Use of Existing Navy Surface Fires Infrastructure
- Detailed Architecture Definition beyond M/S A levels
  - DoDAF AV-1, AV-2, OV-1 thru OV-7 SV-1 thru SV-9)



Solution Architecture includes:

- Operational Architecture
  - Kill Chain & Operational Model
- System Architecture & Solution Capabilities
  - Networks, Data Links, Systems, Functions, Interfaces, Function to Activity Mapping
- Weapon System (WCS & Missile)
  - Functionality, Timelines, End Game



Focus Areas

Architecture Flexibility wrt Preferred System Concept
System of Systems Interoperability & Functionality
Priority on Affordable & Useful → Achievable SoS Design → Exceptional Value to the Warfighter

Focus on Development of Solution Architecture & Concepts

Approved for Public Release - SPR#1345

Affordable Weapon System (AWS) Operational Concept OV– 1

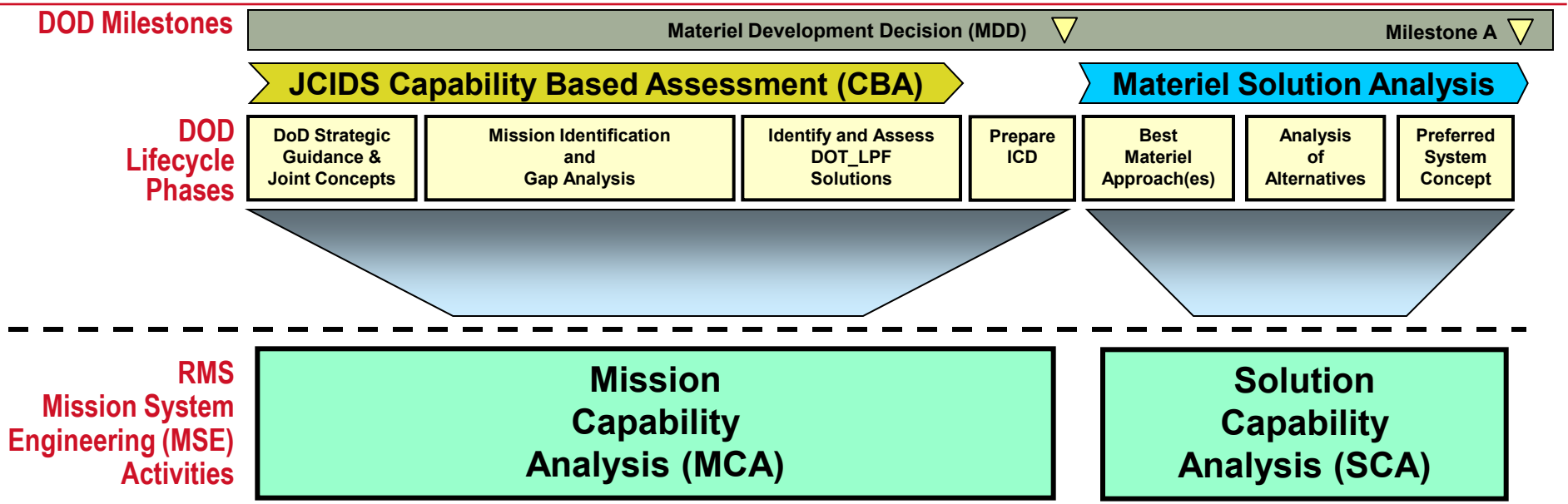
Raytheon

Affordable Weapon System for Navy Surface Fires Support & Joint Fires Operation

Approved for Public Release - SPR#1345

Implementing JCIDS at RMS: Mission System Engineering (MSE)

Raytheon



Implementing JCIDS at RMS: MSE Components

Raytheon

Mission Capabilities Analysis (MCA)

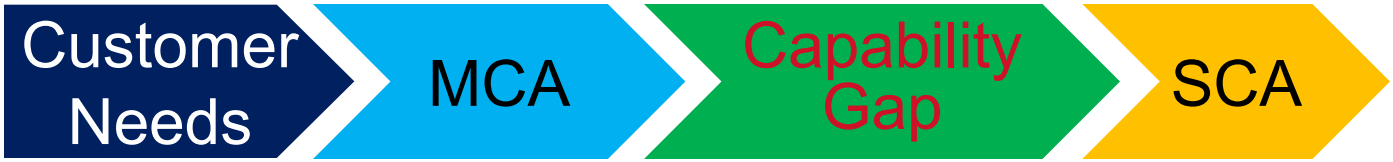
Analysis of mission areas and mission current and future capabilities

- Identifies
  - Mission Areas and Missions
  - Scope Problem
  - Relevant Timeframe
  - Capability Gaps
- Maps
  - Capabilities to Defense Strategies
  - Relevant Objectives to Capability Gaps
  - Example Scenarios to Mission Areas
- Includes
  - Mission Analysis
  - Capability Analysis
  - Gap Analysis

Solution Capability Analysis (SCA)

Analysis of solution space and capability gaps filled by candidate solutions

- Identifies
  - Solutions Ranked & Rated
  - Engagement Cost
- Maps
  - Options to Strategies
  - Solutions to Capability Gaps
  - Capability Gaps to Filled Gaps
  - Mission Weakness to Areas Fulfilled
- Includes
  - Tailored Analysis



Implementing JCIDS at RMS: Mission to Solution Relationship

Raytheon

MISSION CAPABILITIES ANALYSIS (MCA)

SOLUTION CAPABILITY ANALYSIS (SCA)

Mission Areas

Missions & Scenarios

Capability Attributes

Includes time frame and scope

Always keeping in Context of the Employment

Consider "ilities" – feasibility, operational suitability, affordability

Current Capability Assessment ☆

Mission Architecting Begins

Gap Identification ☆

Gap Descriptions and Weighting

DOT_LPF Analysis

Solution Space Analysis ☆

Solution Concepts ☆

Concept Capability Assessment ☆

How do the concept capabilities fill the gaps?

Concept Gap Analysis

What gaps still exist with the concept in place?

Rating/Ranking of Viable Concepts

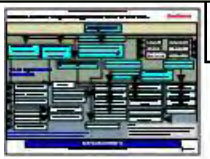
☆ Architecture

MSE is tailored to project status and growth needs

MCA Approach

MISSION CAPABILITIES ANALYSIS (MCA)

Mission Areas



Missions & Scenarios

Includes time frame and scope

Always keeping in Context of the Employment

Capability Attributes

Consider "ilities" – feasibility, operational suitability, affordability

Current Capability Assessment ☆

Mission Architecting Begins

Gap Identification ☆

Gap Descriptions and Weighting

- Perform Literature and Doctrinal Research
- **Review with Subject Matter Experts**
- Conduct Mission Analysis
- Summarize Findings
- Identify Capability Gaps
- Identify AWS Concept Trade Space

☆ **Architecture**

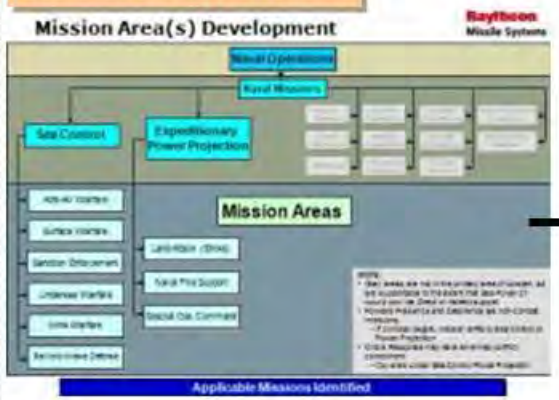
Review's Purpose:

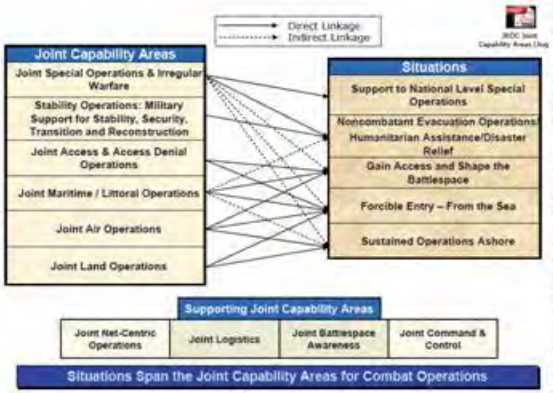
- **Capture mission breakdown for Naval Strike and Fire Support from Warfighter perspective.**
- **Focus on Mission Operations, Capabilities, and Mission Execution Cost**
- **Utilize Warfighter Subject Matter Experts with broad spectrum of user perspectives. Subject**

Subject Matter Experts Provide Key Input for Analysis

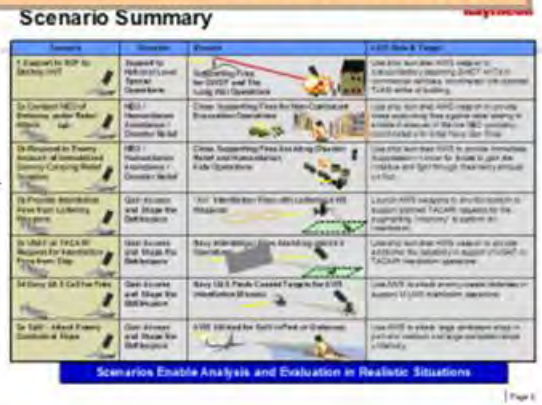
MCA Example

Missions Identified



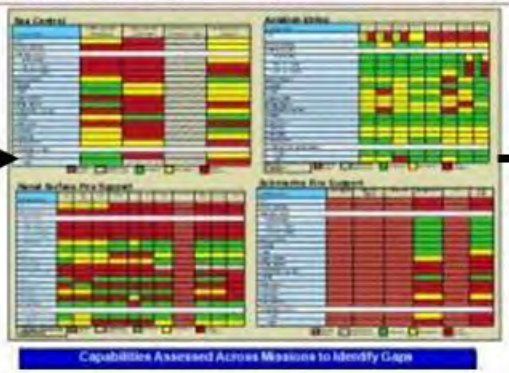


Reference Scenarios Identified and Used to Assess Missions

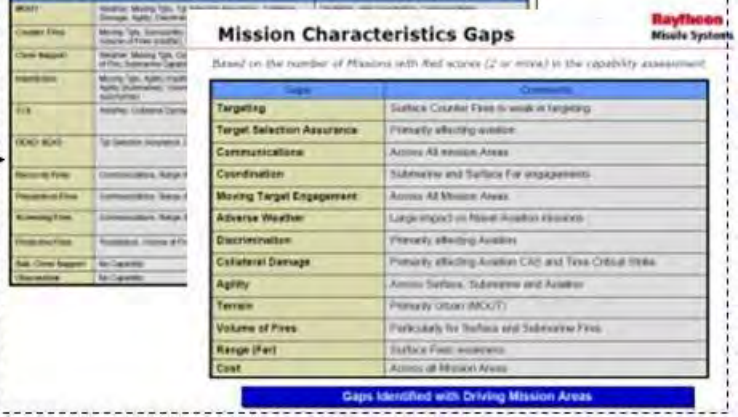


Assessed Capabilities Using Reference Scenarios

Identified Gaps



Gap Analysis Report



Mission and Mission Characteristics Gaps drive System Level Concept Development and Analysis

Approved for Public Release - SPR#1345

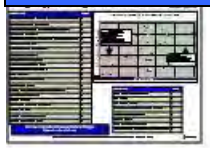
SCA Approach

- Rank Options
- Rate Options vs Gaps uncovered in MCA
- Cost Engagements
- **Map Options, Capability Gaps and Mission Areas**
- Includes tailored analysis to cover Identified Gaps

Mapping Purpose:
- **Options: determine extent to which Options are in line with Defense Strategies**
- **Capability Gaps: determine which Capability Gaps are fulfilled by other systems**
- **Mission Areas: determine extent to which Mission Area weaknesses are fulfilled**

SOLUTION CAPABILITY ANALYSIS (SCA)

Solution Space Analysis



Solution Concepts

Concept Capability Assessment

How do the concept capabilities fill the gaps?

Concept Gap Analysis

What gaps still exist with the concept in place?

Gap Descriptions and Weighting

DOT_LPF Analysis

Rating/Ranking of Viable Concepts

☆ **Architecture**

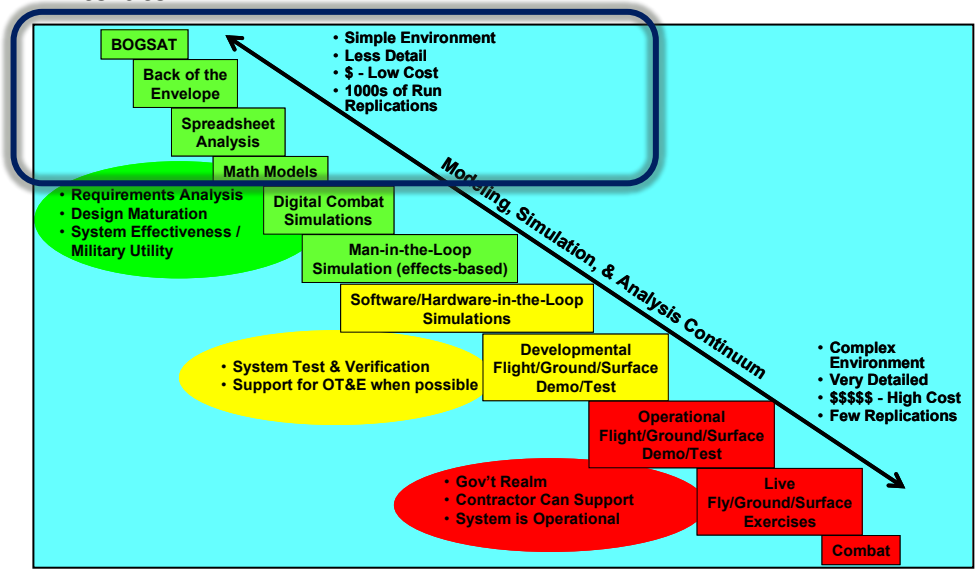
What Kind of Item Meets the Warfighter's Need?

First Principle Analysis

- **Purpose**
  - Support decision making
  - Begin design space bounding
  - Begin analysis plan development
- **Based on Top Level Understanding**
  - Operating Concepts
  - System Components
  - Interactions
- **What is it used for?**
  - Quick response and understanding at early stages of system development
  - Qualitative input to early business decision points
  - Sanity check comparison with higher order models
  - Design space development
  - Military utility analysis
  - Requirements development, balancing, influence
  - Op Con Validation
- **What it is not**
  - High Fidelity Level Models
  - Detailed Analysis
  - The Final Answer

- **How is it done?**
  - Understand the problem/question and level of fidelity
  - Identify components
  - Describe the interactions/effects in a computationally efficient manner
    - Mathematically
    - Model the system

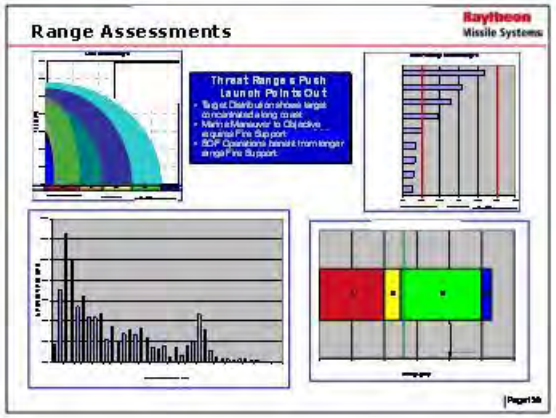
    ❖ Tools: Excel, Matlab, Pencil And Paper
  - Design experiments
  - Conduct experiments
  - Analyze results
  - Iterate

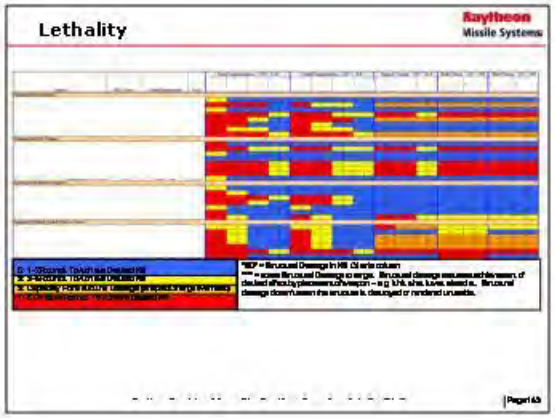


Just Enough Fidelity to Provide Early Insight

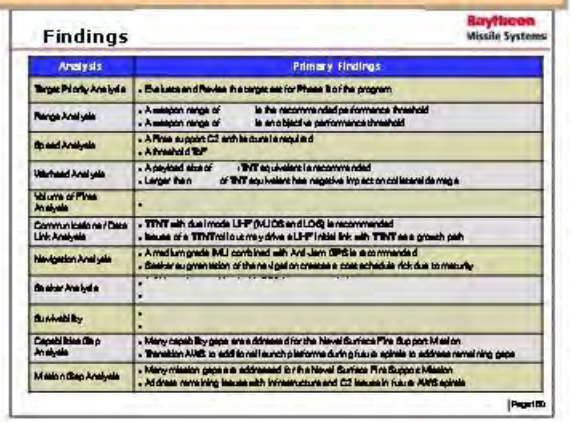
SCA Example

Solution Space Identified

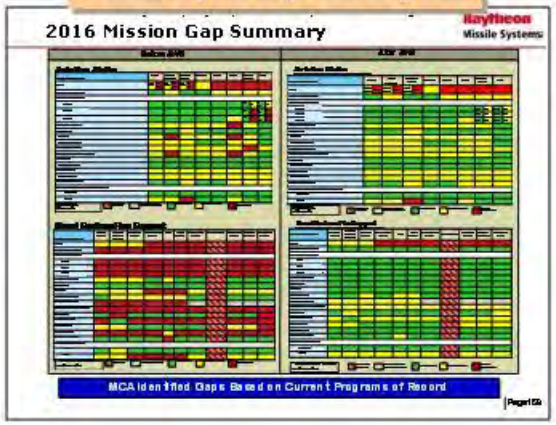




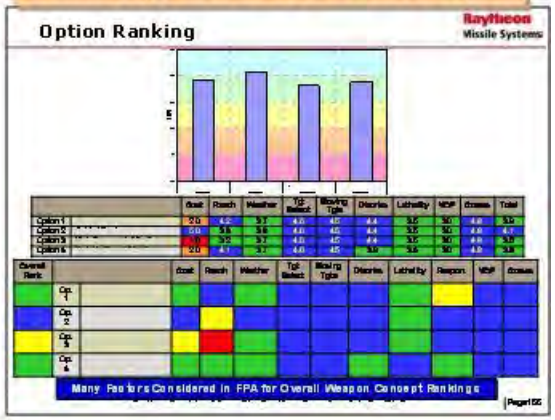
Concept Capability Assessment



Concept Gap Analysis



Ranking of Viable Concepts



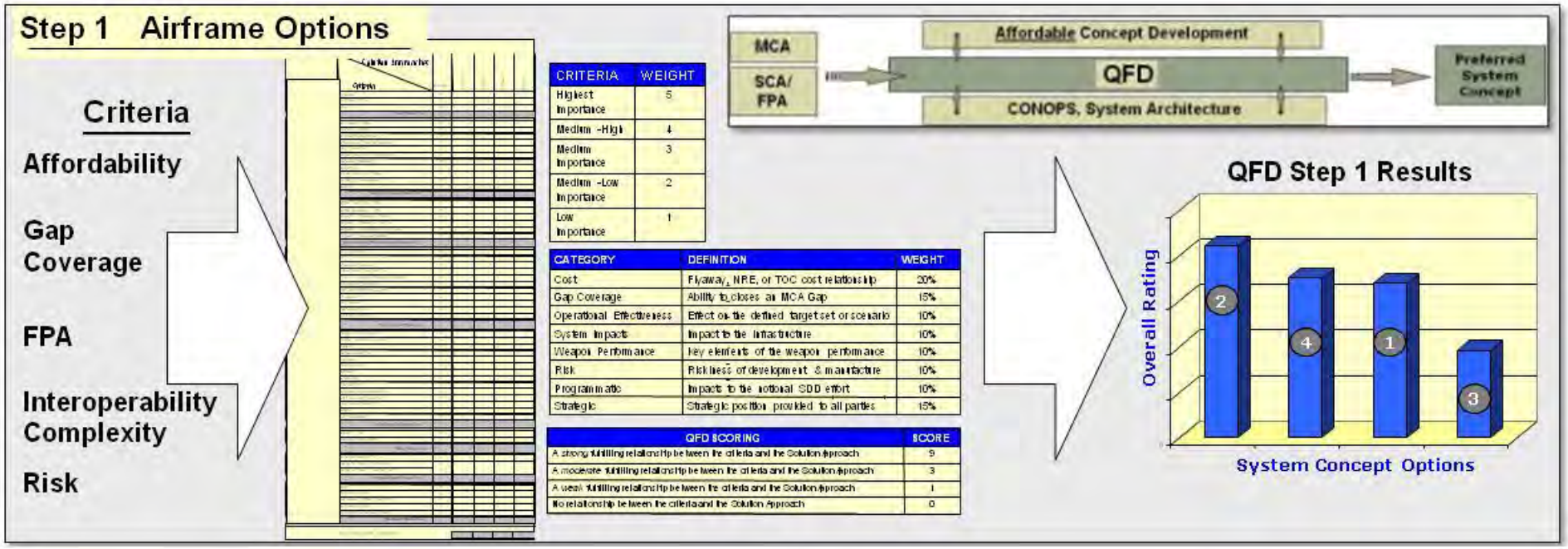
The Solution Concepts are Assessed for Ability to Fill Capability Gaps

Approved for Public Release - SPR#1345

Quality Function Deployment / Preferred System Concept Methodology

Raytheon

Step 1 Airframe Options

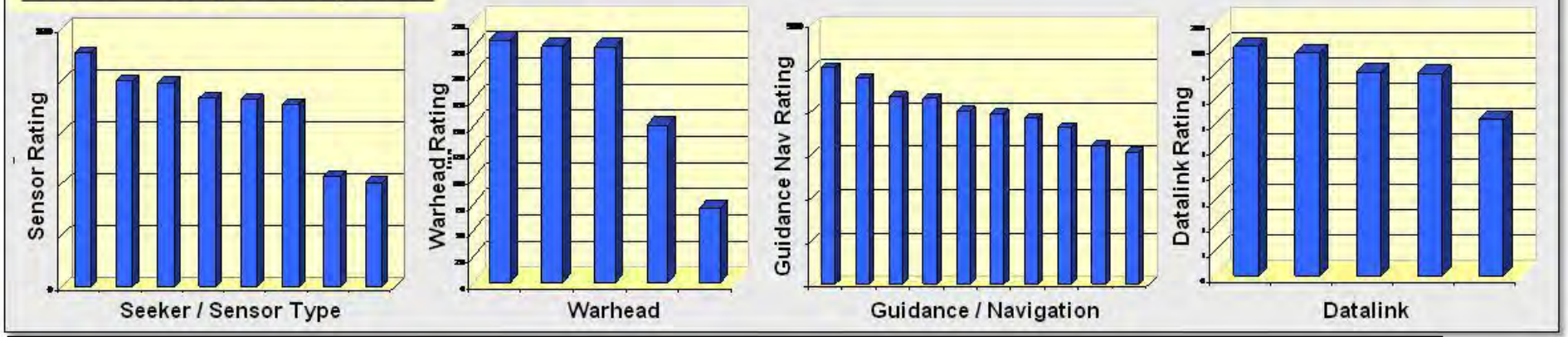


CRITERIA	WEIGHT
Highest Importance	5
Medium -High	4
Medium Importance	3
Medium -Low Importance	2
Low Importance	1

CATEGORY	DEFINITION	WEIGHT
Cost	Flyaway, NRE, or TOC cost relationship	20%
Gap Coverage	Ability to closes an MCA Gap	15%
Operational Effectiveness	Effect on the defined target set or scenario	10%
System Impacts	Impact to the infrastructure	10%
Weapon Performance	Key elements of the weapon performance	10%
Risk	Riskiness of development & manufacture	10%
Programmatic	Impacts to the notional SDD effort	10%
Strategic	Strategic position provided to all parties	15%

QFD SCORING	SCORE
A strong fulfilling relationship between the criteria and the Solution Approach	9
A moderate fulfilling relationship between the criteria and the Solution Approach	3
A weak fulfilling relationship between the criteria and the Solution Approach	1
No relationship between the criteria and the Solution Approach	0

Step 2 Subsystem Options



Option Preferred Due to Ability to Affordably Fill Mission Characteristic Gaps

Approved for Public Release - SPR#1345

Summary

- Raytheon uses Mission Analysis to Focus Selection of the Preferred System Concept on the Ability to Cover Gaps
  - Mission Capability Analysis
  - Solution Capability Analysis
- Mission Capability Analysis identifies Missions, Mission Gaps and Mission Characteristic Gaps
- Solution Capability Analysis bounds the Solution Space and assesses the Solutions Concepts for ability to fill the Capability Gap
- Results of the Affordable Weapon System Mission Analyses were key input to the QFD study and selection of the AWS Preferred System Concept – Airframe and Subsystems

Mission Analysis Enables Raytheon to Work Solutions Focused on Warfighter Need

Approved for Public Release - SPR#1345

Biographies

- **Elizabeth M. (Liz) O'Keefe** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems, and has been with Raytheon and its legacy companies for 29 years. She has a BS degree from Clarkson University in Electrical Engineering (EE) - Communications and a MS degree in EE - Systems from California State University at Fullerton. Liz has worked in Radar Analysis, Systems Integration, Simulation, Engineering Processes, and Strategic Planning. She was Systems IPT lead for SM-3 Block I and then Chief Architect and Chief Engineer for SM-3 Strategic Architecture & Analysis (SA&A) and related Navy BMD programs, as well as Program Manager for the SM-3 SA&A and Low Cost Kill Vehicle programs. Liz was recently Chief Architect for the Affordable Weapon System and Net-Ready Key Performance Parameter Architecture Evaluator (NetRAE) Tool programs.

- **James G. (Jim) Sierchio** is a Senior Principal Systems Engineer and Certified Architect at Raytheon Missile Systems. He has been with Raytheon for 11 years, developing mission architectures and CONOPS for such BMD-related programs as Exo-Atmospheric Kill Vehicle, Multiple Kill Vehicle, and Sea-Based Terminal, the latter as Chief Architect. Jim is a retired Air Force Lieutenant Colonel, with a career spent in directed energy, space systems and BMD R&D, and technical intelligence. Jim has a BSE degree from Princeton University in Aerospace & Mechanical Sciences, a MS degree in Aerospace Engineering from the University of Dayton, an Engineer degree in Aeronautics & Astronautics from New York University, a MBA degree from Averett University, and a DBA from California Coast University.

BACKUP

Approved for Public Release - SPR#1345

Source Documents *(Primary References)*

REQUIREMENTS & SOURCES:

- Affordable Weapons System(s) Broad Agency Announcement, 3 July 2007
- Report to Congress on Naval Surface Fire Support, Director of Surface Warfare Office, CNO, March 2006
- Report to Congress, Chief of Naval Operations' Views & Recommendations of Naval Surface Fire Support, March 2006
- Report to Congress, Commandant of the Marine Corps' Views & Recommendations On Naval Surface Fire Support, March 2006
- Statement of Adm M.G. Mullen, CNO, Before the Senate Armed Services Sub Committee on Sea Power, 3 May 2007
- Joint Fires in Support of Expeditionary Operations in the Littorals, Initial Capabilities Document, Nov 2005
- Extended Range Munitions, Capabilities Development Document, Dec 2005
- Multi-Purpose Loitering Missile, Capabilities Development Document, Jan 2005
- GAO Report: "Issues Related to Navy Battleships," December 2005
- GAO Report: "Information on Options for Naval Surface Fire Support," November 2004
- GAO Report: "Improved Littoral War-Fighting Capabilities Needed," May 2001

CONCEPTS & DOCTRINE:

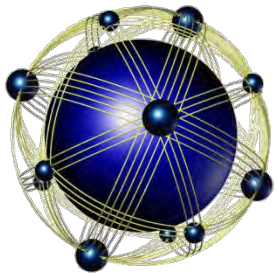
- Sea Power 21
- Naval Operations Concepts, 2006
- USMC Expeditionary Maneuver Warfare Family of Concepts,
  Operational Maneuver from the Sea MCCP-1 / Ship to Objective Maneuver / Sea Basing
- Marine Corps Operating Concepts for a Changing Security Environment, Second Edition, June 2007
- Supporting Arms in Amphibious Operations, NWP 3-09.11M
- Supporting Arms Coordination in Amphibious Operation s NTTP 3-02.2, May 2004
- Amphibious/Expeditionary Operations Air Control, NTTP 3-02.1.3, Sept 2005
- Ship to Shore Movement in Amphibious Operations, NWP 3-02.1
- Surface Ship Gunnery, NWP 3-20.32
- TST, Multi-Service Tactics, Techniques, and Procedures for Targeting Time Sensitive Targets.
  FM 3-60.1, MCRP 3-16D, NTTP3-60.1, AFTTP(I) 3-2.3
- MAGTF Planner's Reference Manual, August 2007
- Joint Pub 1-02 Definitions & Terminology
- Joint Pubs 3-XX Series
- Marine Corps Warfighting Pub 3-XX Series

Early Systems Engineering for Tech Base Projects

Richard Swanson

High Performance Technologies, Inc

October 27, 2010



Agenda

- Problems Faced by Tech Base
- Solution Theory
- Solution Implementation
- Solution Benefits
- Project Example
- Lessons Learned – SE for S&T

Problems Faced by Tech Base

- Tech Base Projects can be unsuccessful transitioning their technologies
  - Do no meet current warfighter needs
  - Unsure how to communicate the products usefulness
  - Unable to integrate in to the bigger picture
  - Projects are organized like science projects
    - Focus is on the feature or scientific breakthrough

Solution Theory

- **Improve Development Planning (SE Early)**
  - **Integrate tech base development projects to Capability Gaps**
    - JCIDS CBA artifacts
    - Other “approved” warfighter need sources
    - Specific (larger) program’s required capabilities
  - **Accurate, complete, verifiable alignment of project to DoD needs**

Solution Theory (cont.)

- Apply Requirements Engineering best practices to S&T
  - Discover functional needs to meet Gaps
  - Align technologies that satisfy these functions
  - Provide traceability for assessment & reporting
  - Provide starting point for Performance Requirements

Solution Implementation

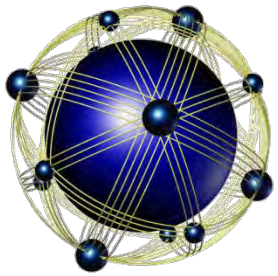
- Warfighter needs as a top level document
- Analyzed the needs to discover technology areas of interest
  - Not a solution
- Performed functional decomposition
- Aligned promising technologies

Captured in a Requirements Database

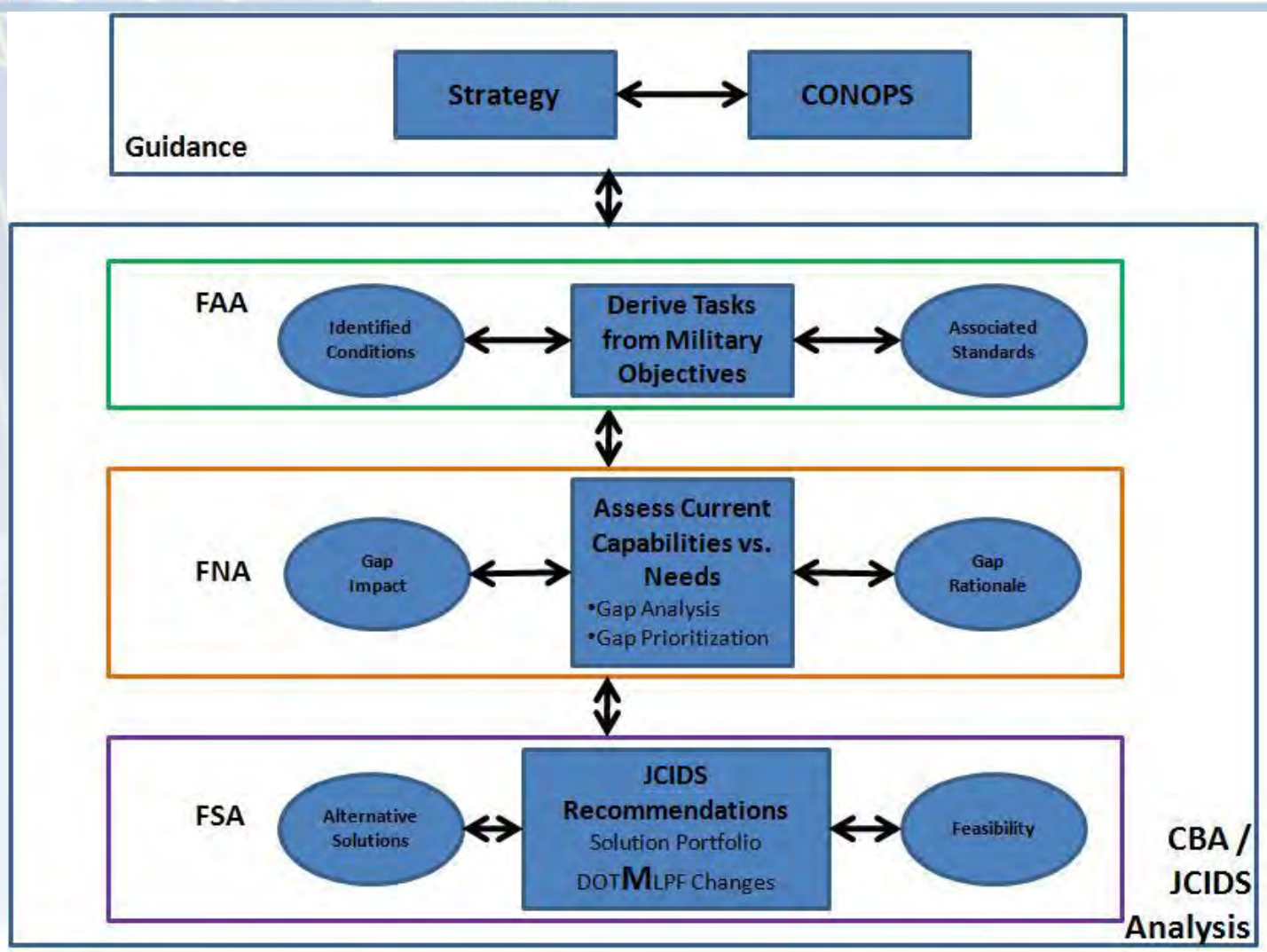
Solution Benefits

- S&T project focused on warfighter need from the beginning
- S&T project leadership able to “sell” themselves as critical technology for closing a Capability Gap
- S&T organizational leadership able to defend the project’s funding
- SE artifacts available for future customers

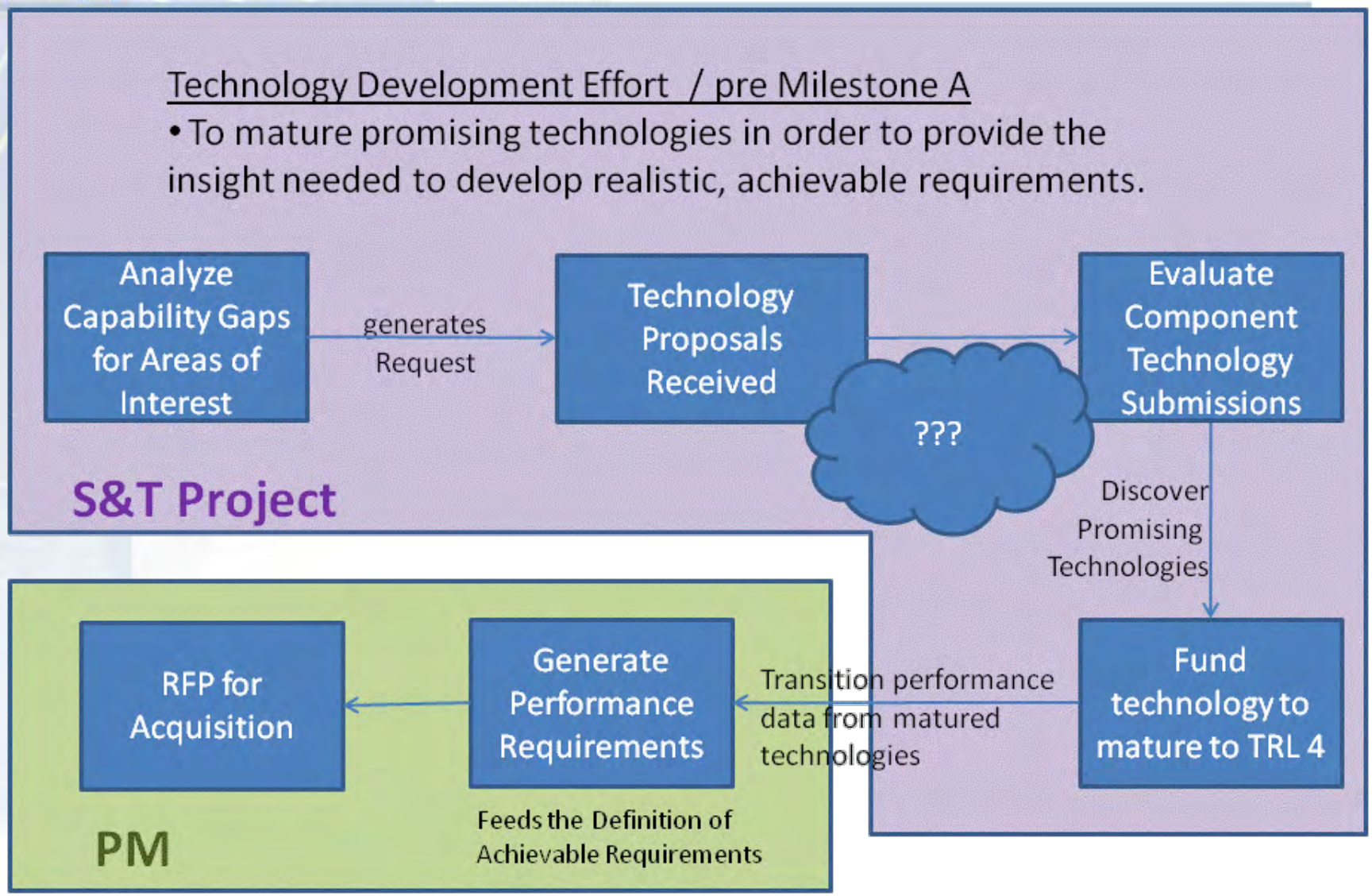
Project Example



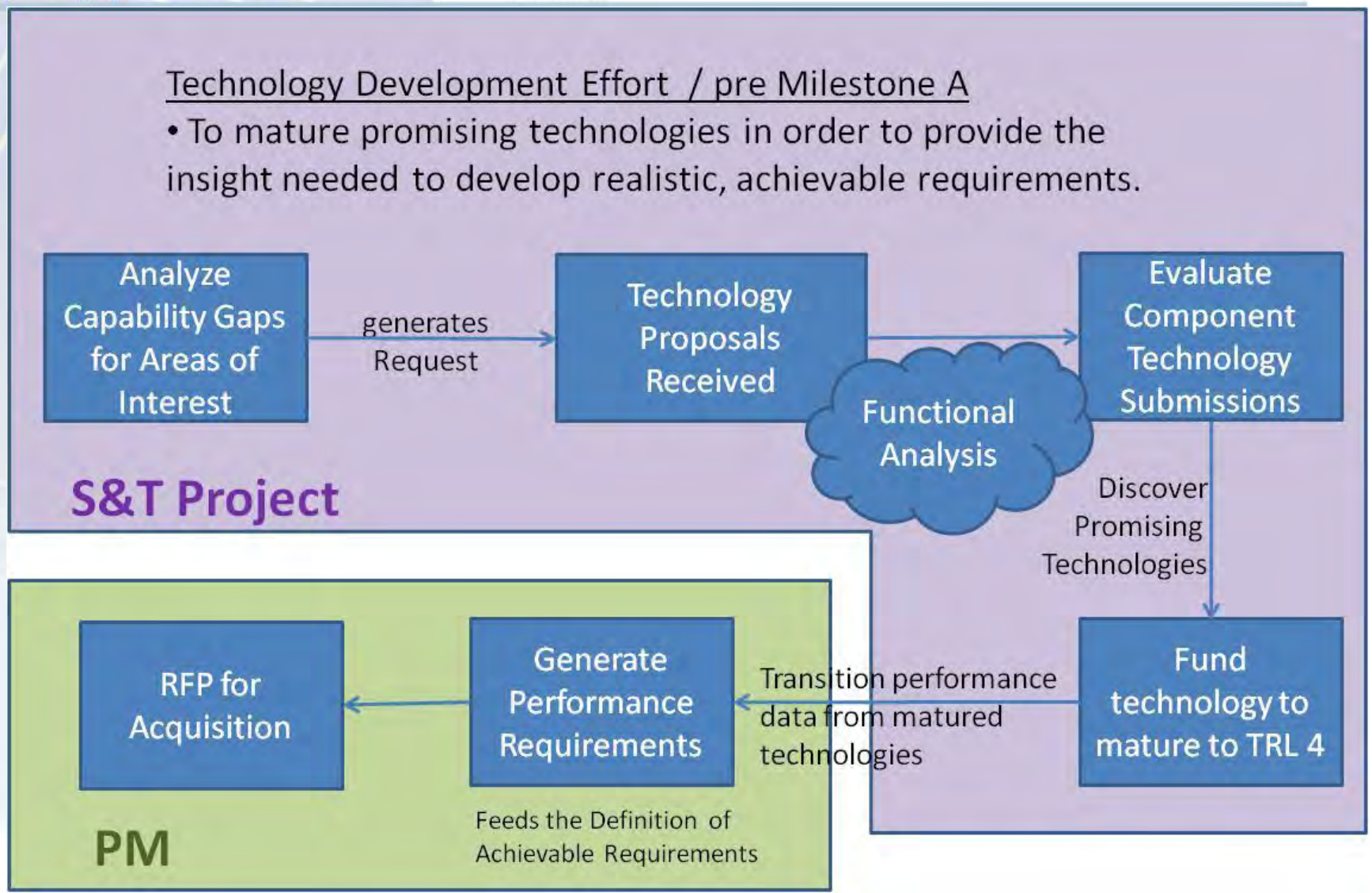
JCIDS CBA process



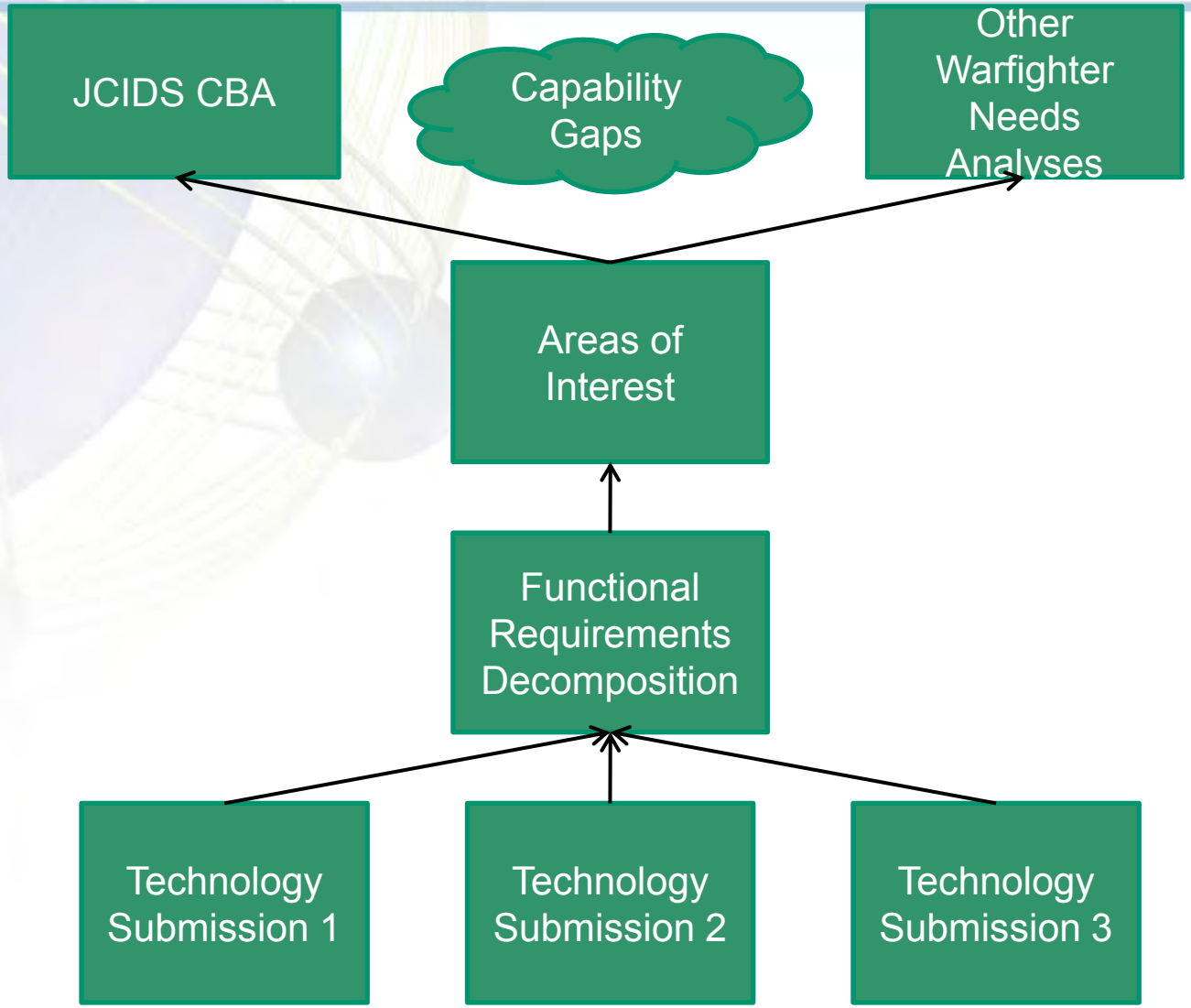
Example


Technology Development Effort / pre Milestone A
• To mature promising technologies in order to provide the insight needed to develop realistic, achievable requirements.
Analyze Capability Gaps for Areas of Interest
generates Request
Technology Proposals Received
???
Evaluate Component Technology Submissions
S&T Project
Discover Promising Technologies
RFP for Acquisition
Generate Performance Requirements
Transition performance data from matured technologies
Fund technology to mature to TRL 4
PM
Feeds the Definition of Achievable Requirements

Example (cont.)



Requirements Trace



Lessons Learned – SE for S&T

- **Just enough, Just in time MBSE**
  - Use MBSE to capture discussions and perform already scheduled tasks
- **Requirements (Capabilities) Capture**
  - Improves Senior Level Leadership Reviews
  - Project Knowledge Captured for Future Iterations
    - ✓ Rationale!
  - Impact Analysis becomes Possible
- **Application of Decision Analysis and Resolution**
  - Defendable Decisions

The Case for Considering Acquisition Program Executability Prior to Materiel Development Decision (MDD)

NDIA Conference Paper #11131

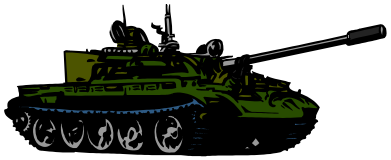
G. Laushine, H. Hayden

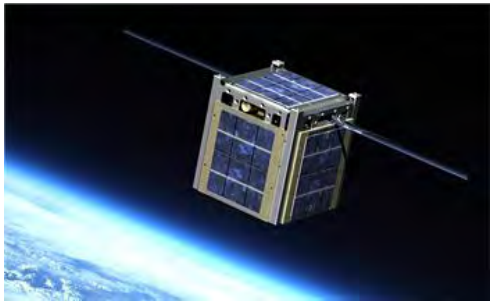
27 Oct 2010

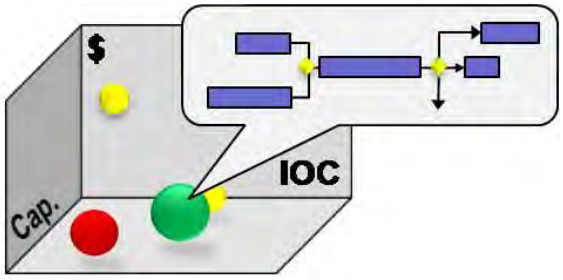
Assess Executability Before MDD?

"But I don't have a program yet!"

- **GAO continually emphasizes having sufficient knowledge, early in decision process**
- **Need to consider trade space of programs, not just a concept**





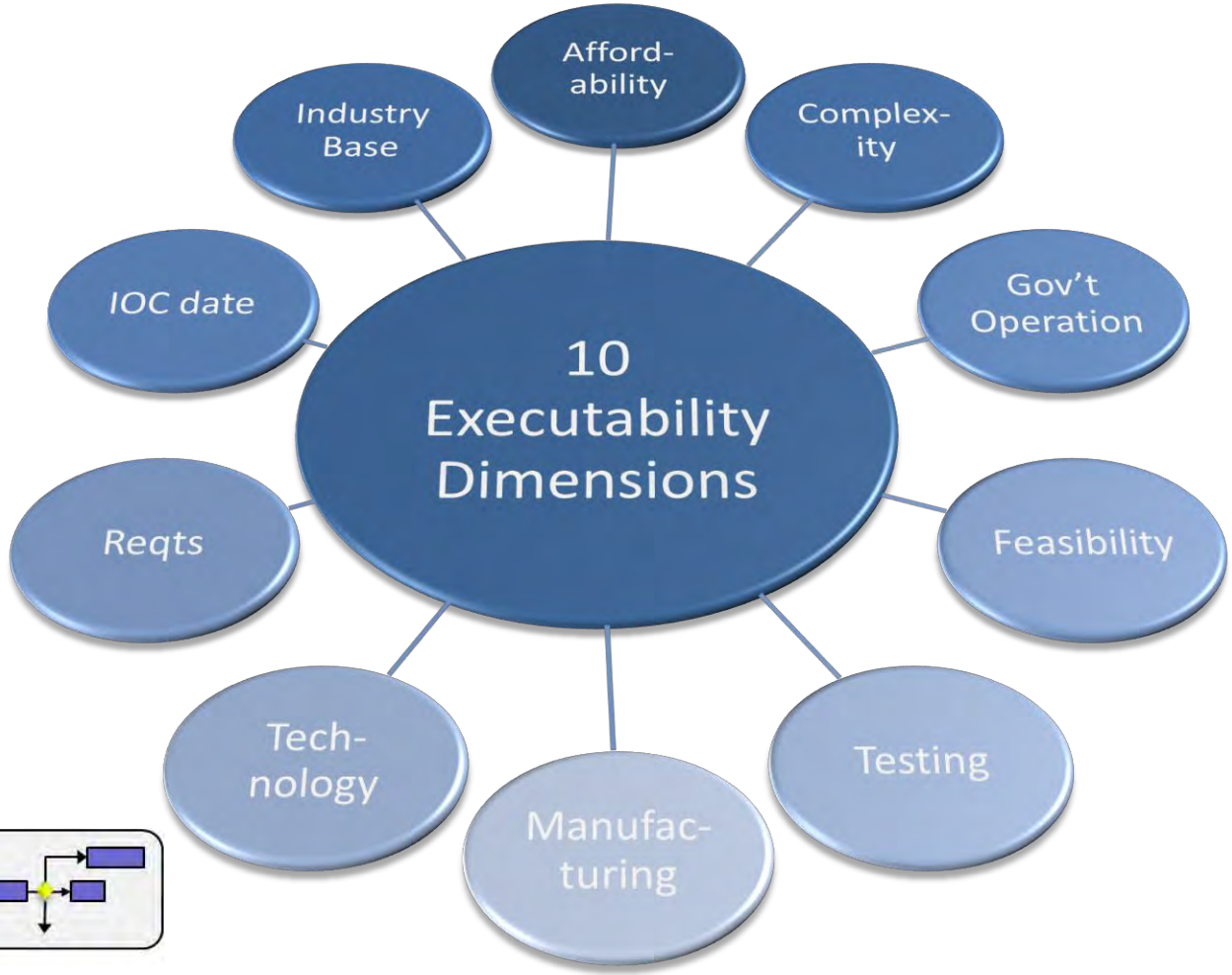


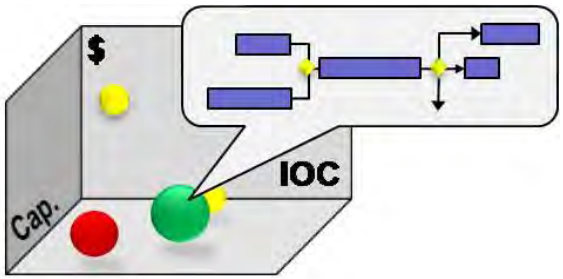
What is MDD Looking at?

All I need is requirements and AoA guidance, right?

- What Artifacts Do They Get?
  - ICD, AoA guidance
- What Decisions are really being made?
  - Do I have confidence that MSA will develop good info for a successful MS A decision?
    - Will we get a good Analysis of Alternatives (AoA)?
    - Will we get good Technology Development Strategies (TDSs)?
    - Is the MSA phase executable?
  - Do we need more info before we can review?
  - Should this effort be stopped?

Execution Considerations





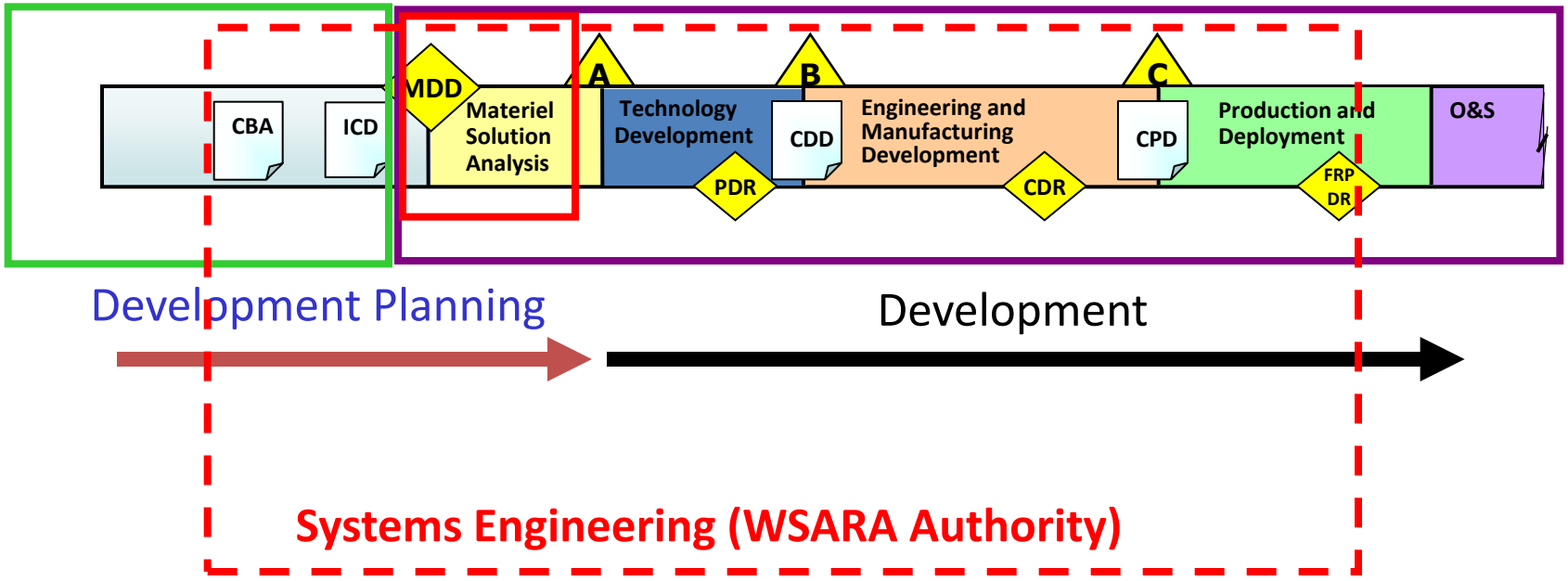
Current Approach is Required

But Not Sufficient to Avoid Breaches

JROC Authority (CJCSI 3170, Goldwater-Nichols)

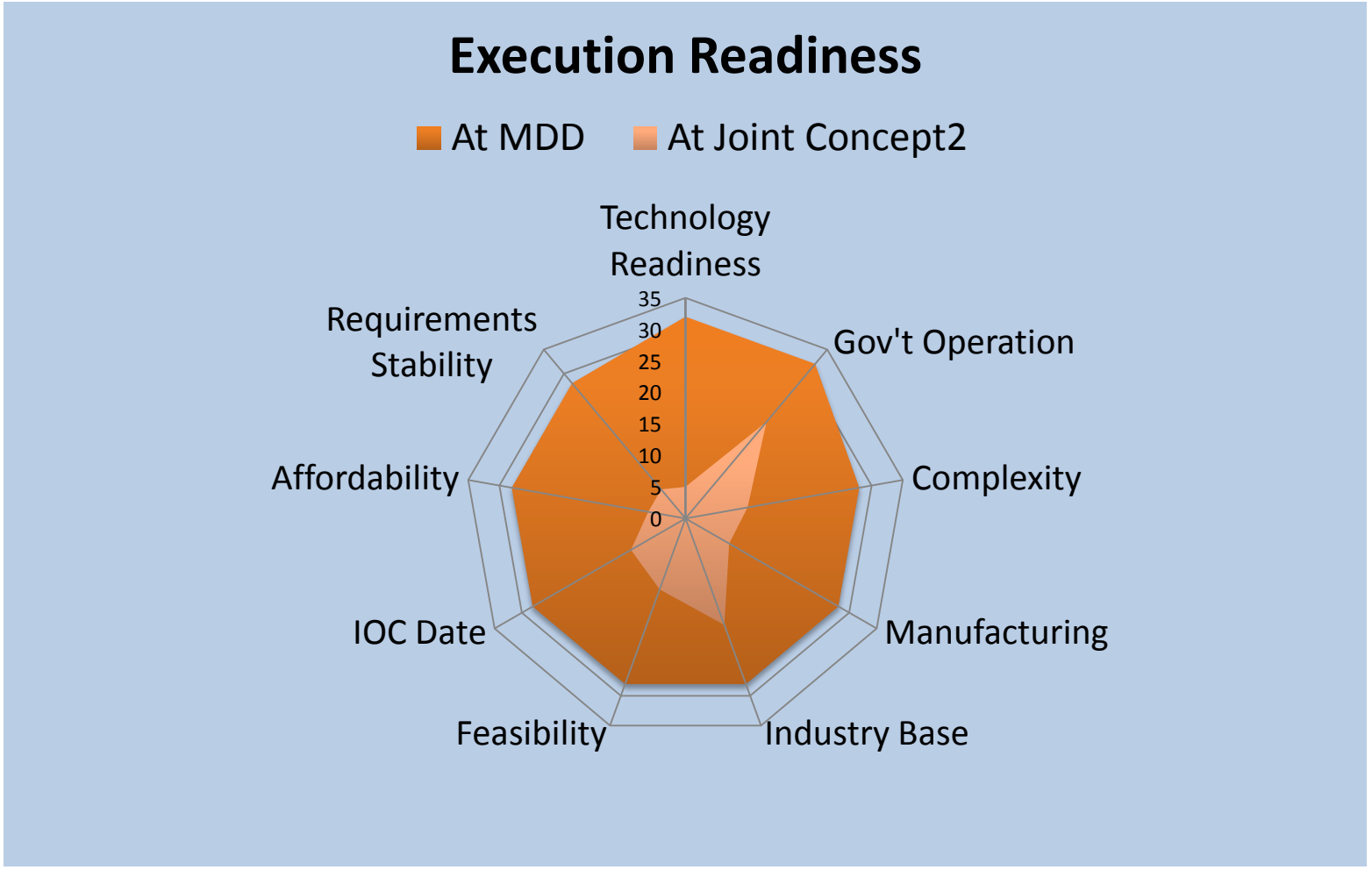
CAPE Authority (DoDI 5000.02, WSARA)

MDA Authority (DoDI 5000.02, Title 10)

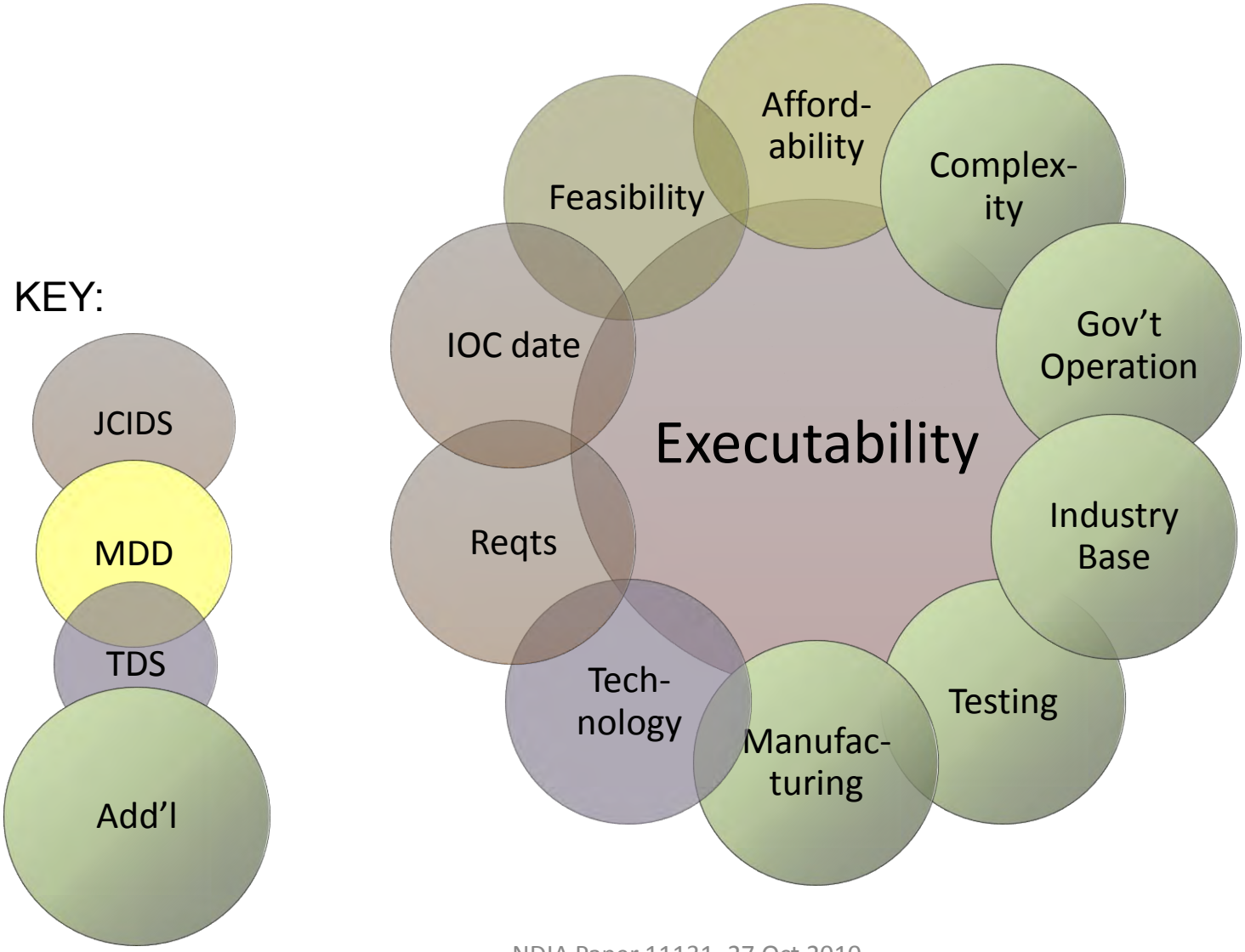


Hypothesis

A balanced look at execution considerations early on could help reduce number and magnitude of breaches



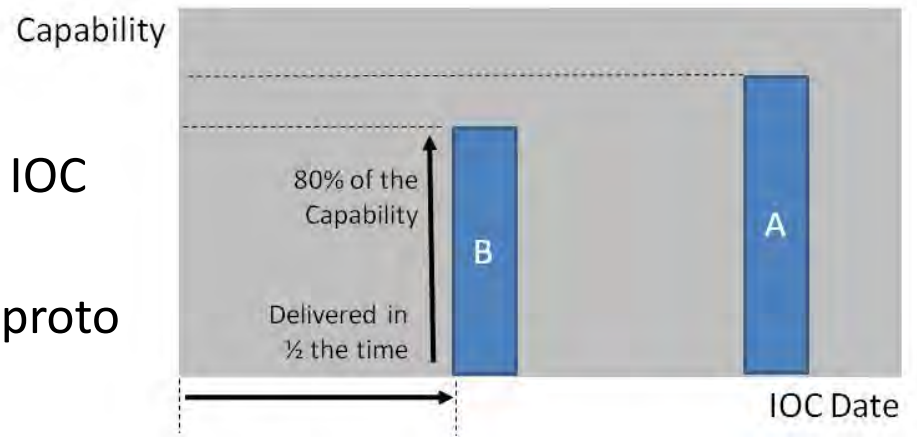
Executability Explored



JCIDS

JCIDS Focus

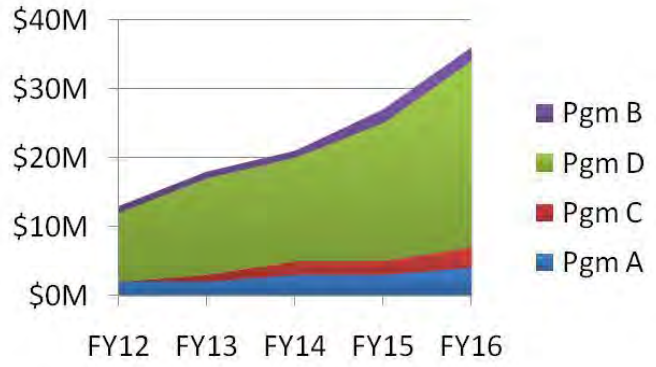
- Requirements
  - Clarity, stability, completeness
  - GAO Cited as a major reason for cost growth
- IOC Date
  - Need date vs. other achievable IOC dates for alternatives
  - Development path sequences (proto IMS)
  - True IOC Date achievable may not look as attractive as getting 80% of the capability in ½ the time



MDD

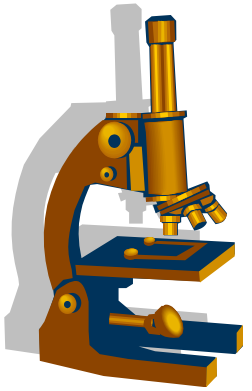
MDD Focus

- Affordability
  - Total costs affecting ability to keep stable funding
  - Large budget over time is more vulnerable than small budget needed over short time frame
  - WSARA (Terminating MDAPs)
- Feasibility
  - Practical ability to do
  - Wasted time and effort
  - Lost opportunity cost



TDS

TDS Focus

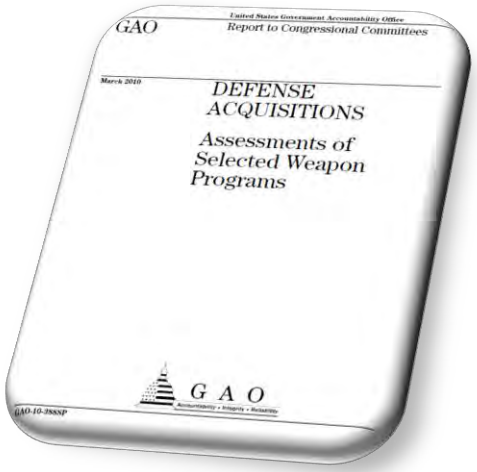


- Technology
  - The Known one
    - Identification of critical technologies in the alternative concept
    - Technology Readiness Levels (TRLs)
  - Why it matters
    - Major WSARA, DoD 5000 emphasis
    - Cited by GAO as major reason for cost growth

Add'l

Additional Considerations

- **Complexity**
  - Numbers of functions, modes, interfaces (especially how it integrates with the operational environment, infrastructure)
- **Government Operation**
  - Sufficient manning of program office work force
  - Geographically separated units, communication
- **Industry Base**
  - Expertise, capacity, availability to study, produce, supply, sources and backup sources



- **Testing**
  - What needs to be tested, and are there adequate test facilities?
- **Manufacturing**
  - Maturity of processes to efficiently produce sufficient units to standards, without defects

DoD Development Reality:
Challenges to Considering Executability Before MDD

- Organizational
  - Developers, Users, and funding sponsors usually separated
  - Fear of Technology Push
  - Linear Paradigm of JCIDS to DoD 5000.02
- Complexity (too much to deal with)
- Schedule Distractions
  - Budget cycle drives early decisions
  - Shift to rapid acquisition (no time)
- Requirements keep changing
  - Users want more
  - Threat picture keeps changing
- Resource Limitations

Summary

- **GAO continually emphasizes having sufficient knowledge early in the decision process**
- **Need to address all considerations at MDD in a balanced integrated perspective**
  - **Then focus on next action (TDS)**
- **Not all elements will present the same risk of breach, but all elements have potential risk**
  - **Bring developers in early to minimize total risk**
- **Acquisition strategy should be thought of as executability implementation**

An Integrated Perspective

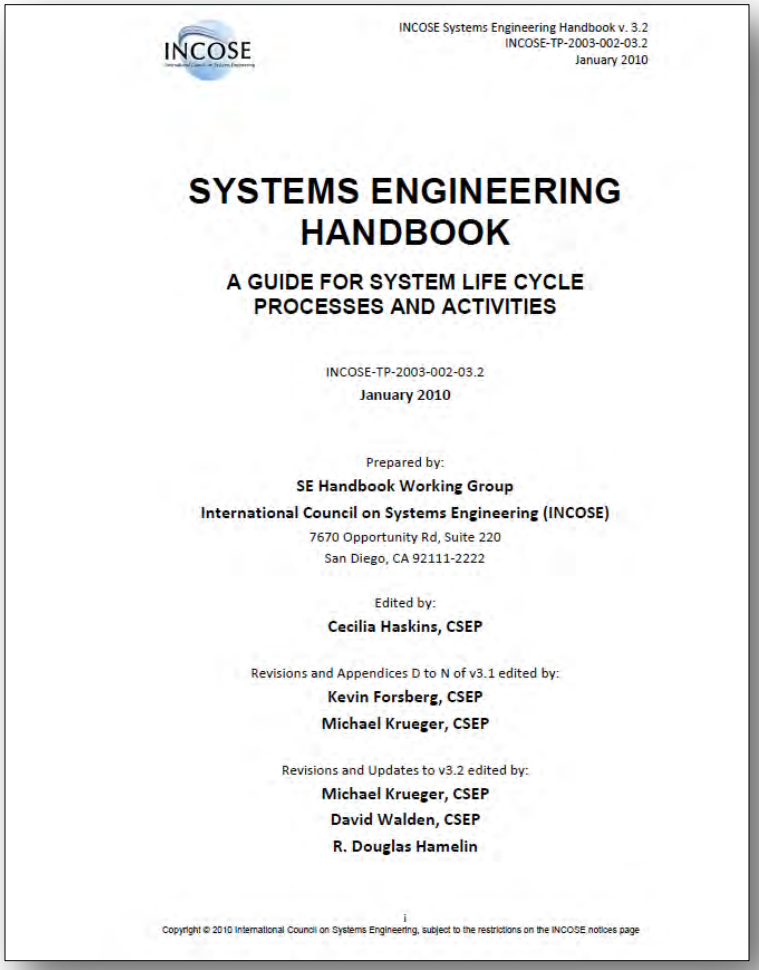
The Case for Considering Acquisition Program Executability Prior to Materiel Development Decision (MDD)

BACKUPS

Contact Info

Gregory Laushine
Science Applications International Corp. (SAIC)
(310) 936-4258
laushineg@saic.com

Accepted SE Practice:
Requirements and Developers work Together



INCOSE Systems Engineering Handbook v. 3.2
INCOSE-TP-2003-002-03.2
January 2010

SYSTEMS ENGINEERING HANDBOOK

A GUIDE FOR SYSTEM LIFE CYCLE PROCESSES AND ACTIVITIES

INCOSE-TP-2003-002-03.2
January 2010

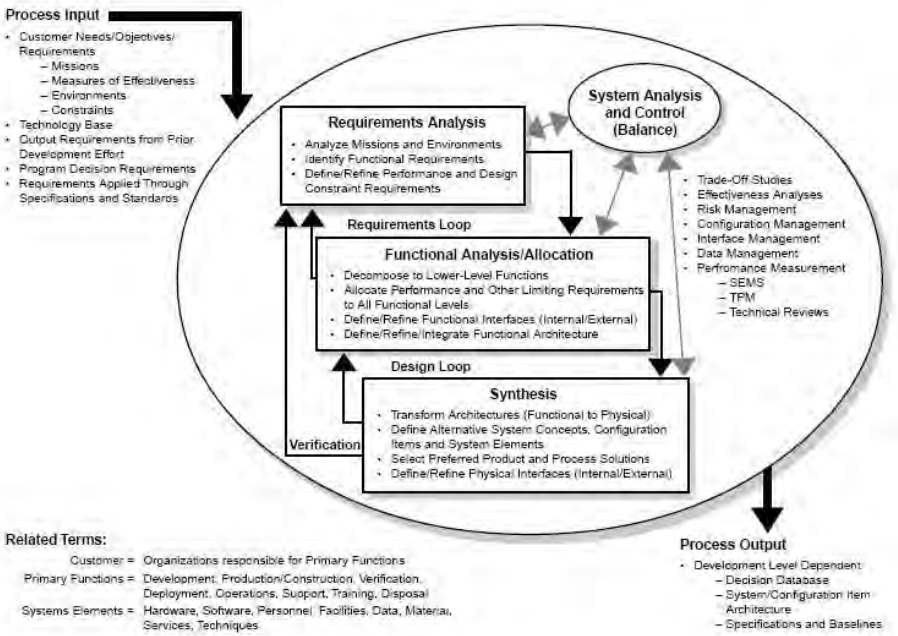
Prepared by:
SE Handbook Working Group
International Council on Systems Engineering (INCOSE)
7670 Opportunity Rd, Suite 220
San Diego, CA 92111-2222

Edited by:
Cecilia Haskins, CSEP

Revisions and Appendices D to N of v3.1 edited by:
Kevin Forsberg, CSEP
Michael Krueger, CSEP

Revisions and Updates to v3.2 edited by:
Michael Krueger, CSEP
David Walden, CSEP
R. Douglas Hamelin

i
Copyright © 2010 International Council on Systems Engineering, subject to the restrictions on the INCOSE notices page



NATO

OTAN

NATO
Consultation, Command and Control Agency

Distributed Networked Battle Labs (DNBL)

Briefing to NDIA

Meeting on 25th Oct. 2010

Michael Oberndorfner, Dr. Pascal Trouvé
NC3A / Battle Laboratory Services Team
pascal.trouve@nc3a.nato.int
Telephone: 31.70.374.3310

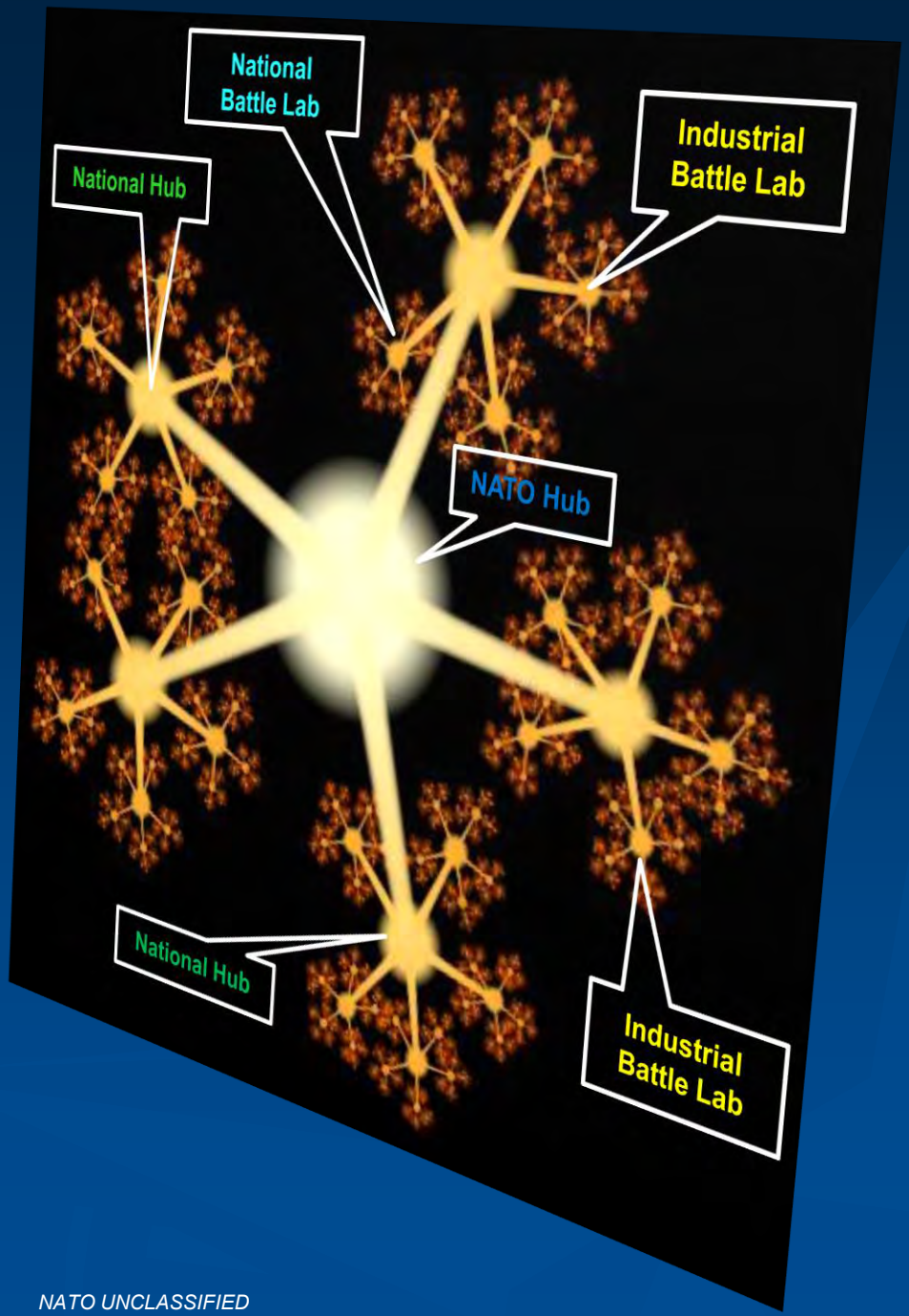
NATO C3 AGENCY

NATO

OTAN

Distributed Networked Battle Laboratories (DNBL)

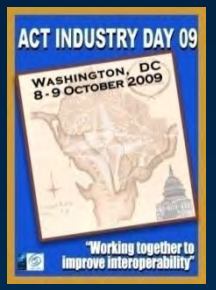
A Framework For Federation of Battle Labs



ALLIED COMMAND TRANSFORMATION

NATO C3 AGENCY

Overview



- **Initiative between ACT, NC3A, NIAG and Industry**
  - EADS, IABG, INDRA, SAIC, Selex, Thales
  - Nations involved in the Pilot Case (FRA, ITA, DEU,…)
  - Information to NC3Reps, NADReps
- **DNBL not a new lab/ reference facility**
  - Mechanism/framework for linking battle labs for NATO and nations' benefit
  - Integrates Industry into Concept Development and Experimentation process
  - Legal, procedural, security, and technical aspects
- **Leverages existing NATO, National and Industrial Battle Lab capabilities**

Motivation

- **For NATO:**
  - Compresses capability development cycle timescales
  - Improves effectiveness and interoperability of capabilities delivered to Operational Forces
  - Enables early adoption and implementation by Nations and Industries of NATO standards, and to benefit from best of the stream Industrial technologies and expertise
- **For Nations:**
  - Ensure coherency of their capabilities within NATO
  - Save cost, time, and risks management, in launching RFQs for implementation/compliance of/to NATO standards for their capabilities
- **For Industry:**
  - Access to real NATO data and systems, and gains knowledge of NATO standards / procedures
  - Increase technology reliability and to extend its applicability
  - Strengthen strategic positioning and anticipate competitive advantage in meeting military requirements

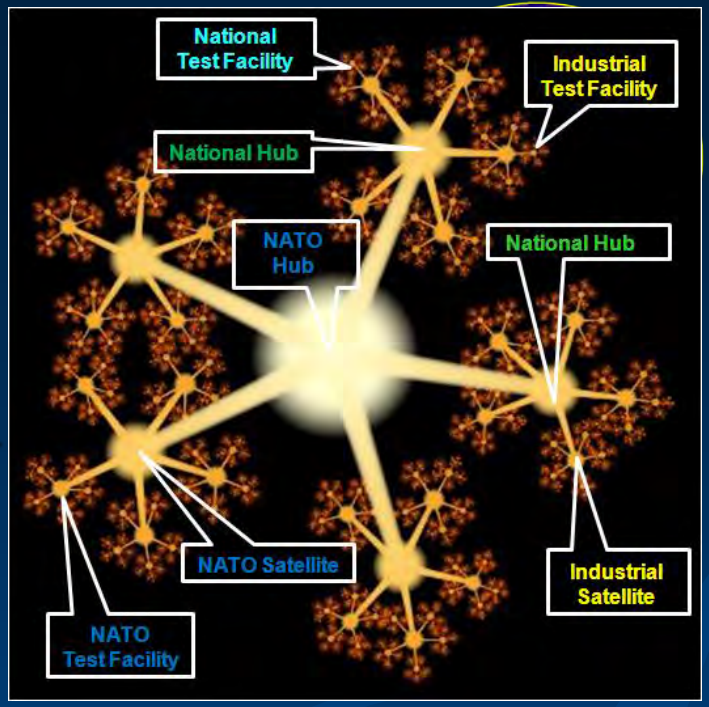
Expected benefits

1. Improvement of the level of interoperability awareness and capability assurance by networking of NATO, National, Industrial or academic laboratories and experts

2. Speed up the introduction, experimentation, verification and validation of new CONOPs, TTPs, standards, architecture design, implementations, systems, technologies, and thus compress capability engineering cycles

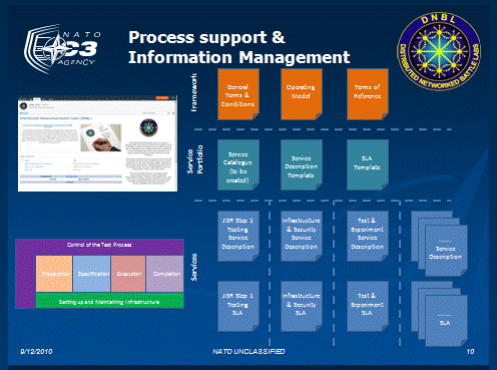
3. Increase the NNEC level of adoption and coverage, or operational fidelity, by completing the Federation-of-System testing capability, by making better use of existing facilities and knowledge across NATO, Nations, and Partners

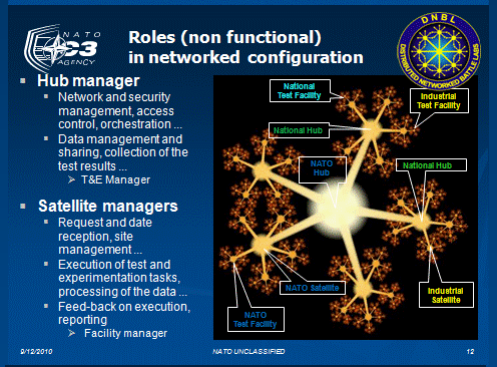
Framework views

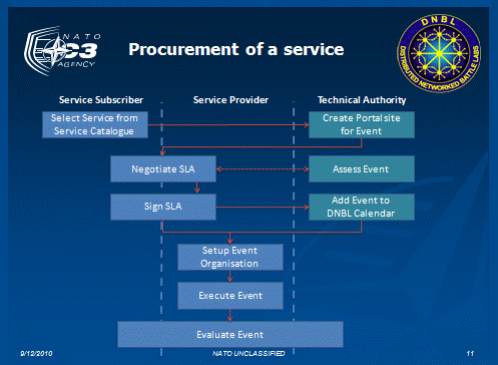


- **Management**
  - Executive board, Advisory Group,
  - DNBL Technical Authority
  - DNBL events: T&E Manager, Hub operator, Satellite cap.
- **Architecture**
  - Federation of Battle Labs Services
  - Clusters around NATO and National Hubs
- **User communities**
  - NATO, Nations, Industry, Academia
  - Support CD&E, Acquisition processes, NATO exercises, National exercises, multilateral events
- **Legal framework**
  - DNBL General Terms and Conditions
  - Service Level Agreement
- **Orchestration**
  - Common processes for distributed Experimentation, Testing, Verification and Validation
  - Minimum set of core services, each node services catalogue will develop over time
- **Network infrastructure , cross-domain security management**
  - Combined Federated Battle Laboratories Network (CFBLNet), VPN...
  - Public, Private, NATO Unclassified/Restricted/Secret...

Phase 1: business model and documentation baseline

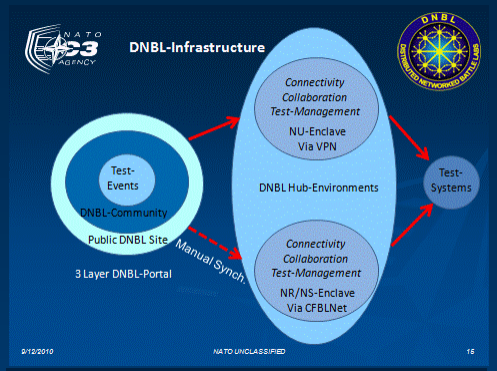


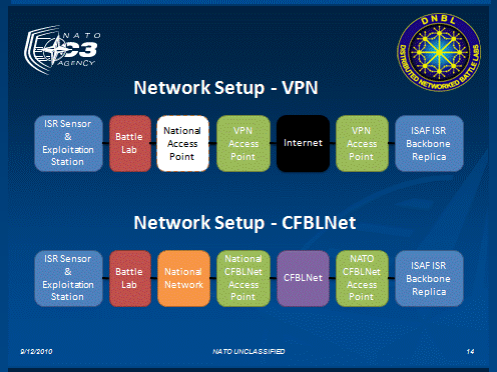


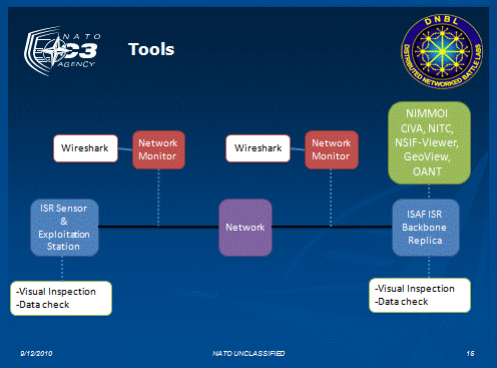


- **Testing as a Service**
  - Service description and SLA concepts
  - Event manager (any test sponsor, 1 of the 4 management authorities: TA, OA, SPA, IA)
  - Test & Experimentation manager
    - Test planning, tasks allocation, resource and risks management
    - Data preparation, configuration management
    - Execution monitoring of technical/system/operational scenarii
    - Results collation, assessment and reporting
  - Facility/Satellite managers
    - Service supplier, lab/site management ...
    - Execution of test and experimentation tasks
    - Processing of the data, feed-back on execution, reporting
  - Hub manager
    - Network and security management, access control, orchestration
    - Data management and sharing, collection of the test results ...
- **Process design**
  - Legal framework
  - Application as a DNBL member
  - Procurement of a service
  - Basic testing process

Phase 2: JISR experiments and infrastructure concepts







- **JISR/FMV step 1 testing**
  - Validation of Phase 1 concepts
  - Pre-deployment interoperability verification with national assets
  - Bi-lateral experiments run with FRA, ITA, DEU, soon with SWE, GBR
  - In parallel of SWE cooperation on networking battle labs and preparation of NFFI testing
  - And in parallel of CIAV WG Phase 1
  - Gained experience in setting test configuration within 2 days
  - Proved feasibility and effectiveness of DNBL approach, but not yet full efficiency of operating model
- **Network infrastructure**
  - CFBLNet enclaves or VPN
  - Single security domain (NU or NS)
  - Need to facilitate network discovery and monitoring during exercises
  - Need for more tools in support of the experimentation
- **Portal upgrade**
  - Increase information sharing
  - Need to manage communities around each event

Partial demonstration of initial DNBL concepts

Notional JISR Testing

National Assets
Live & Recorded Data

National
ISR System

NC3A Hub

Combined Federated
Battle Laboratory
Network
or
NU Virtual Private
Network

Supporting
Documentation
Detailed
Service
Descriptions
and SLAs

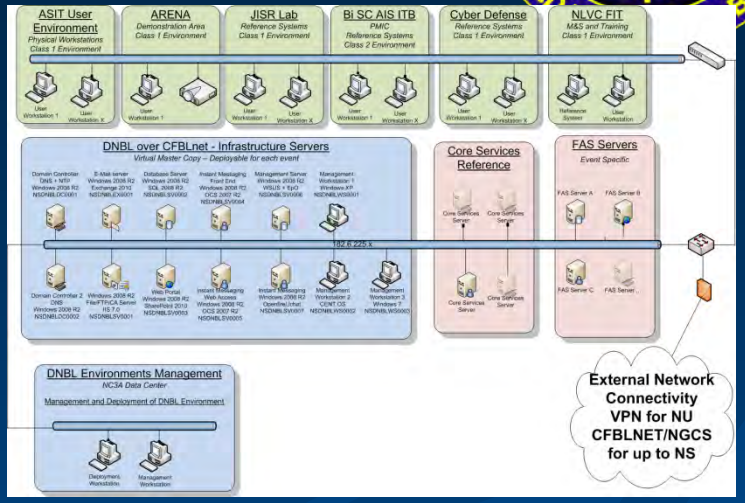
ISAF ISR
Backbone
Reference
Facility

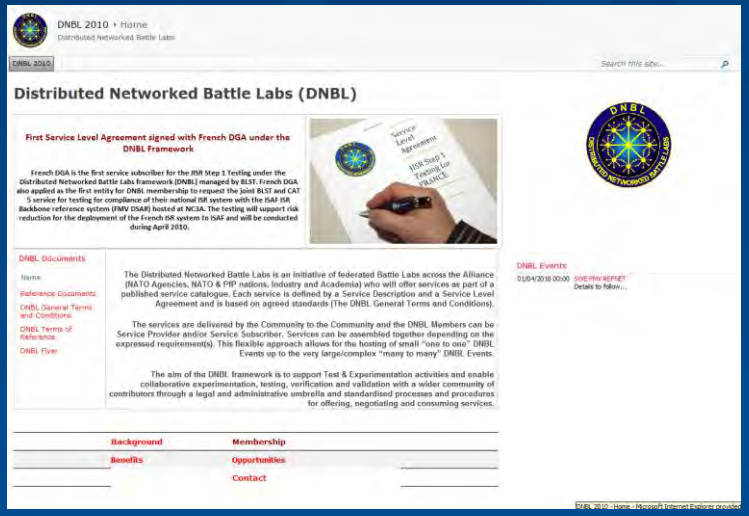
Compliance of Still Image, Full Motion Video, Ground Moving Target Standards and ISR Management Mechanisms

Distributed Networked Battle Lab

Phase 3: DNBL hub capability and support to exercises

- **A secured environment to run experimentations**
  - *Within NATO, Nations, Missions*
  - *With Industry and Academia*
  - *A means to collaborate and to raise trust between partners*
- **A virtual lab environment:**
  - *A means to capitalize*
    - *On test data, scenarii, results*
    - *On common processes*
    - *On sharing information and building knowledge*
  - *Over NU, NR and NS*
  - *Connected to the NC3A Labs and Data Centres*
  - *Scalable*
- **Managed collaborative space:**
  - Support desk
  - In configuration





DNBL Portal: https://dnbl.nc3a.nato.int

CWIX
Industry
NCSA
Combined Federated Battle Lab
CFBL
DNBL
DISTRIBUTED NETWORKED BATTLE LABS
Coalition Interoperability Assurance & Validation
CIAV
AFGHAN MISSION NETWORK
MAJIIC
NATO C3 AGENCY

Share to win

"The most essential force multiplier the Alliance can contribute is its ability to strengthen interoperability. ACT will continue to focus on advancing economical and technical solutions, like the „network of battlelabs", that enhance the interoperability of the Alliance"sforces across all functional domains."

Gen. S. Abrial, SACT
2 Dec. 2009

CONTACTING NC3A

NC3A Brussels

Visiting address:

Bâtiment Z
Avenue du Bourget 140
B-1110 Brussels
Telephone +32 (0)2 7074111
Fax +32 (0)2 7078770

Postal address:

NATO C3 Agency
Boulevard Leopold III
B-1110 Brussels - Belgium

NC3A The Hague

Visiting address:

Oude Waalsdorperweg 61
2597 AK The Hague

Telephone +31 (0)70 3743000
Fax +31 (0)70 3743239

Postal address:

NATO C3 Agency
P.O. Box 174
2501 CD The Hague
The Netherlands

Military Modeling & Simulation Systems Oriented Architecture Concepts Pilot

Gary W Allen, PhD

Joint Training Integration &

Evaluation Center (JTIEC)

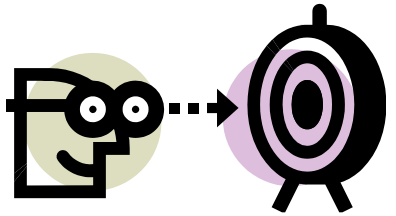
Anita Adams Zabek

The MITRE Corporation

Pilot Objectives

- **Goal**
  - **Provide the DoD M&S Community with:**
    - **Relevant information for decision makers**
    - **An education vehicle about SOA**
    - **A practical application of an LVC Architecture**

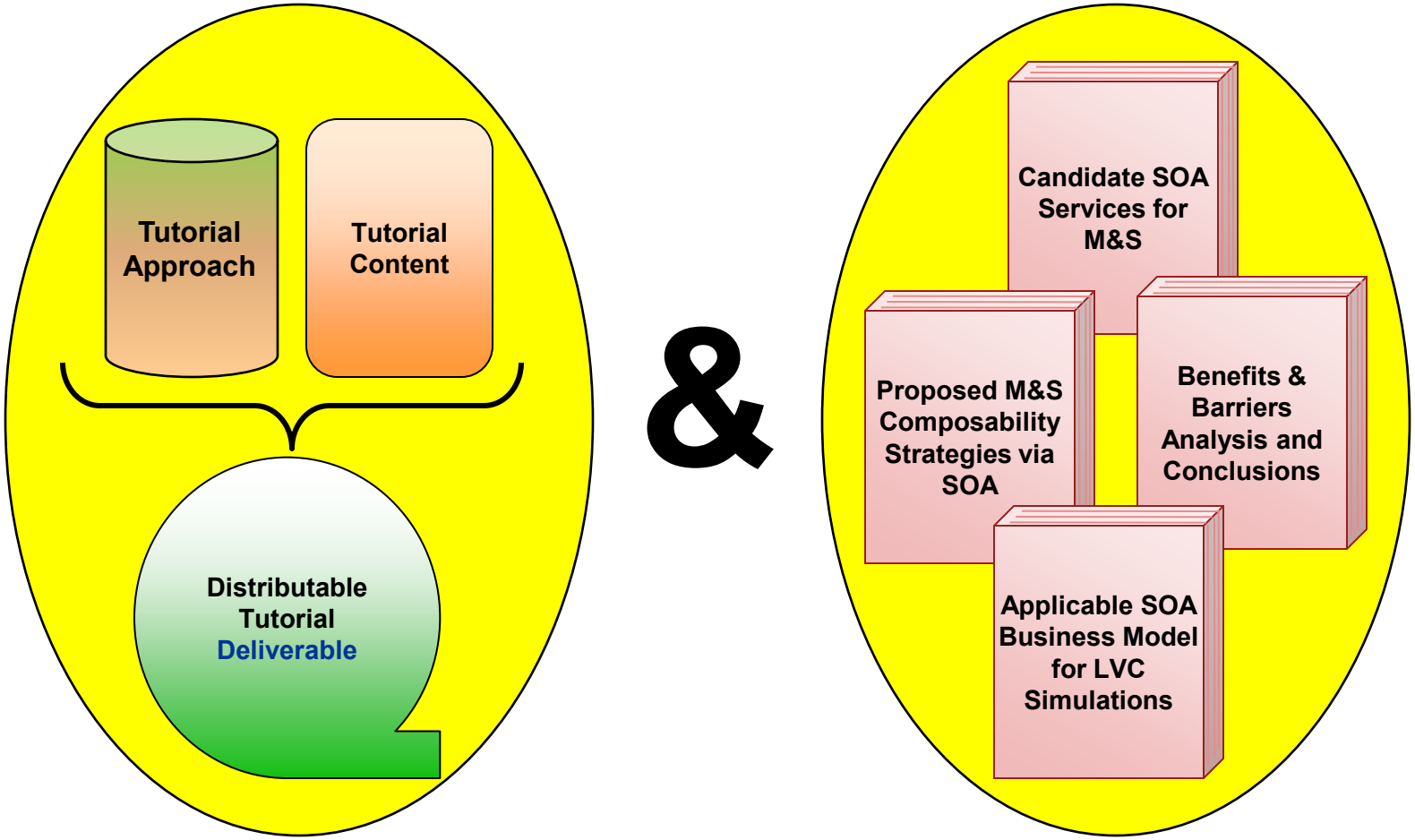
    that employs SOA commercial practices and technology



- **Approach**
  - **Examine SOA within context of DOD M&S environment**
  - **Design and produce a pragmatic tutorial**
  - **Provide the SOA framework to interoperate two disparate federations**

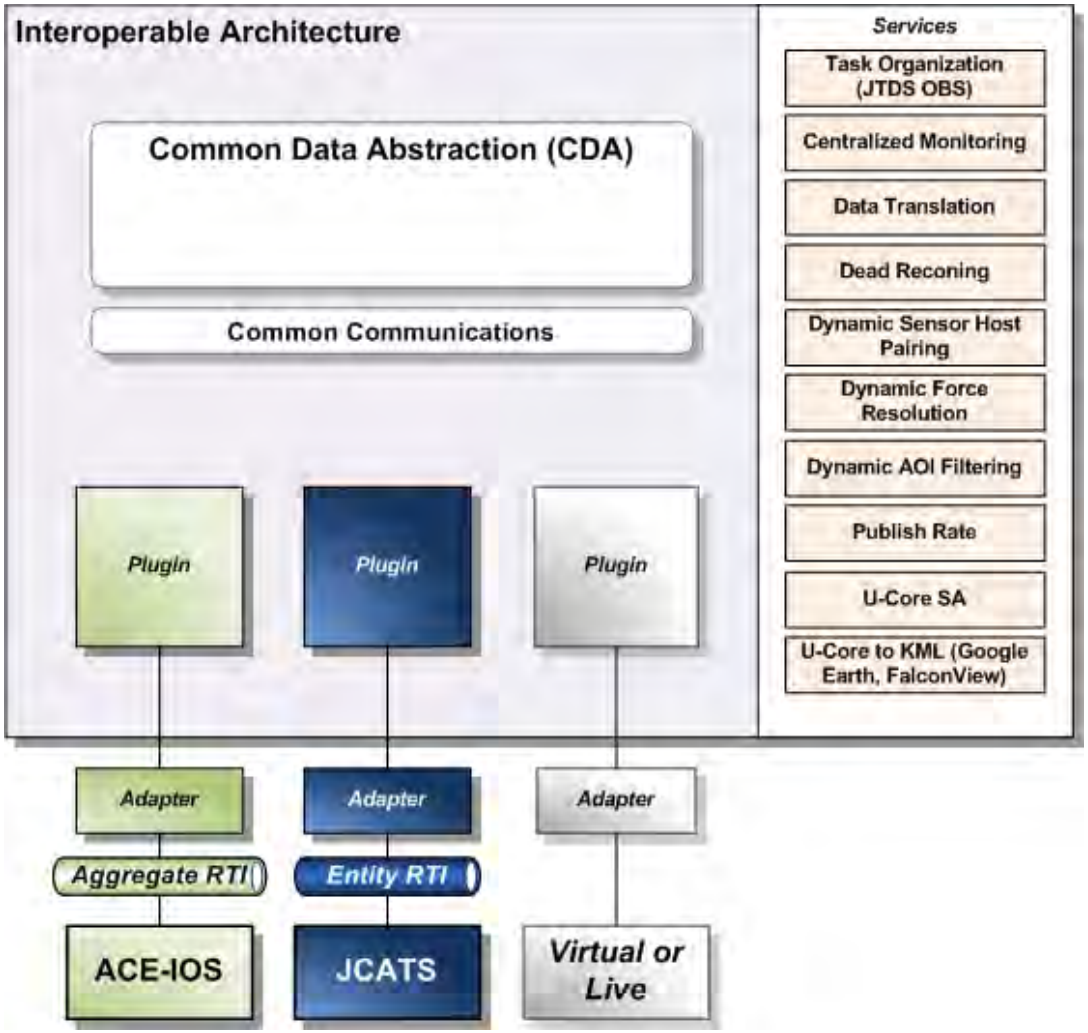
The technical approach, while incomplete with regards to Live and Virtual, never-the-less exercises the technology required to integrate all three in a non-trivial fashion

JHU/APL



EDUCATE **INFORM**

MITRE - Conceptual Pilot Architecture



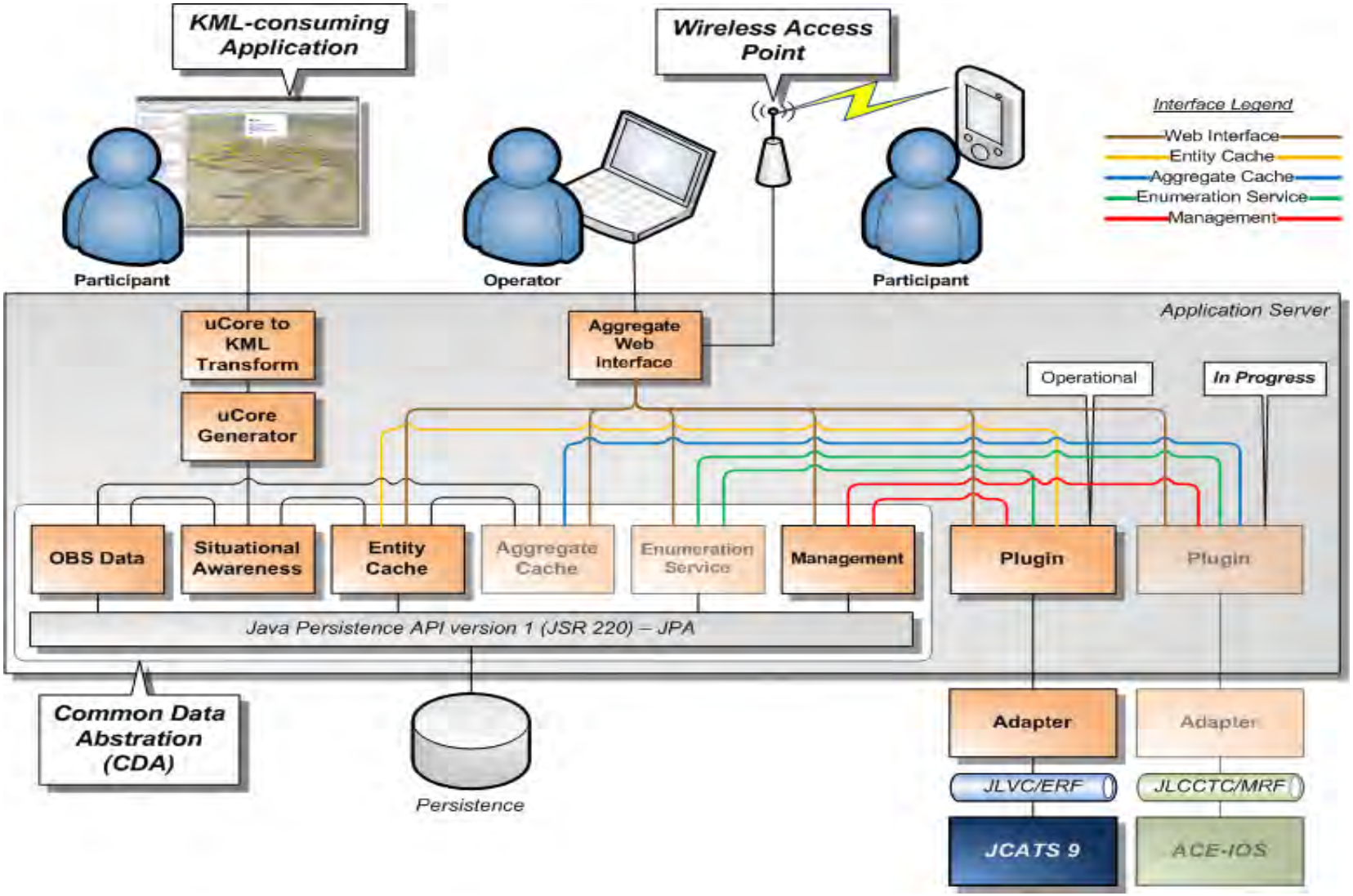
Process:

- **ID Common Services**
- **Decompose Federation (toggle off services that will be SOA based)**
- **Establish a SOA environment**
- **Compose federation around the SOA kernel**

Importance of the CDA

- The Common Data Abstraction (CDA) is a:
  - combination of public services
  - Has an underlying data model
  - Supports interoperability between two or more systems
- With the CDA all systems interface with a single external data model
  - The data model has a semantic and logical aspect
  - The underlying logical data model is accessed via public services
  - Allows changes to the underlying data model while maintaining the existing publicly defined interfaces
  - Supports addition of new public services to provide controlled access to new data

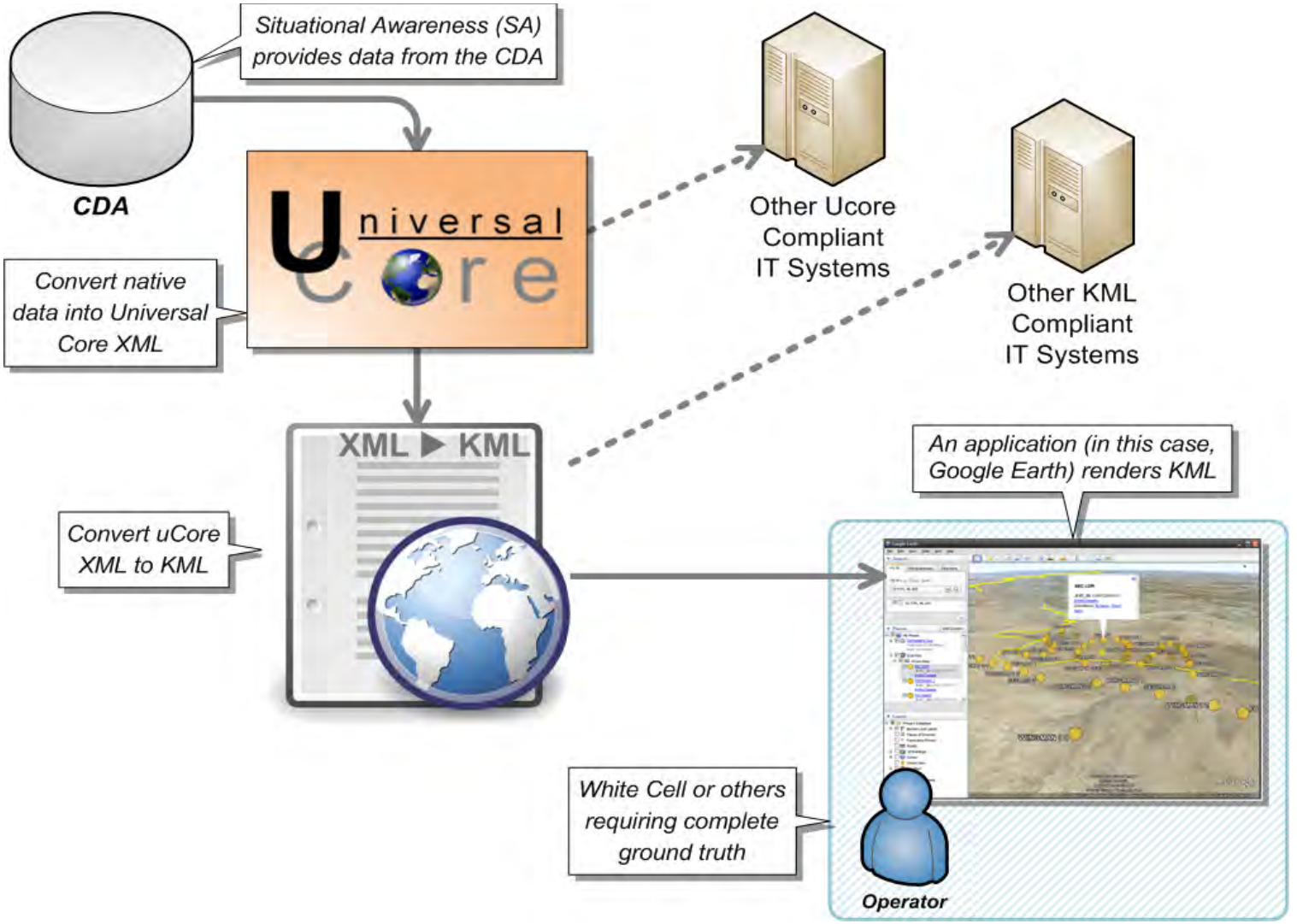
Evolved Pilot Architecture



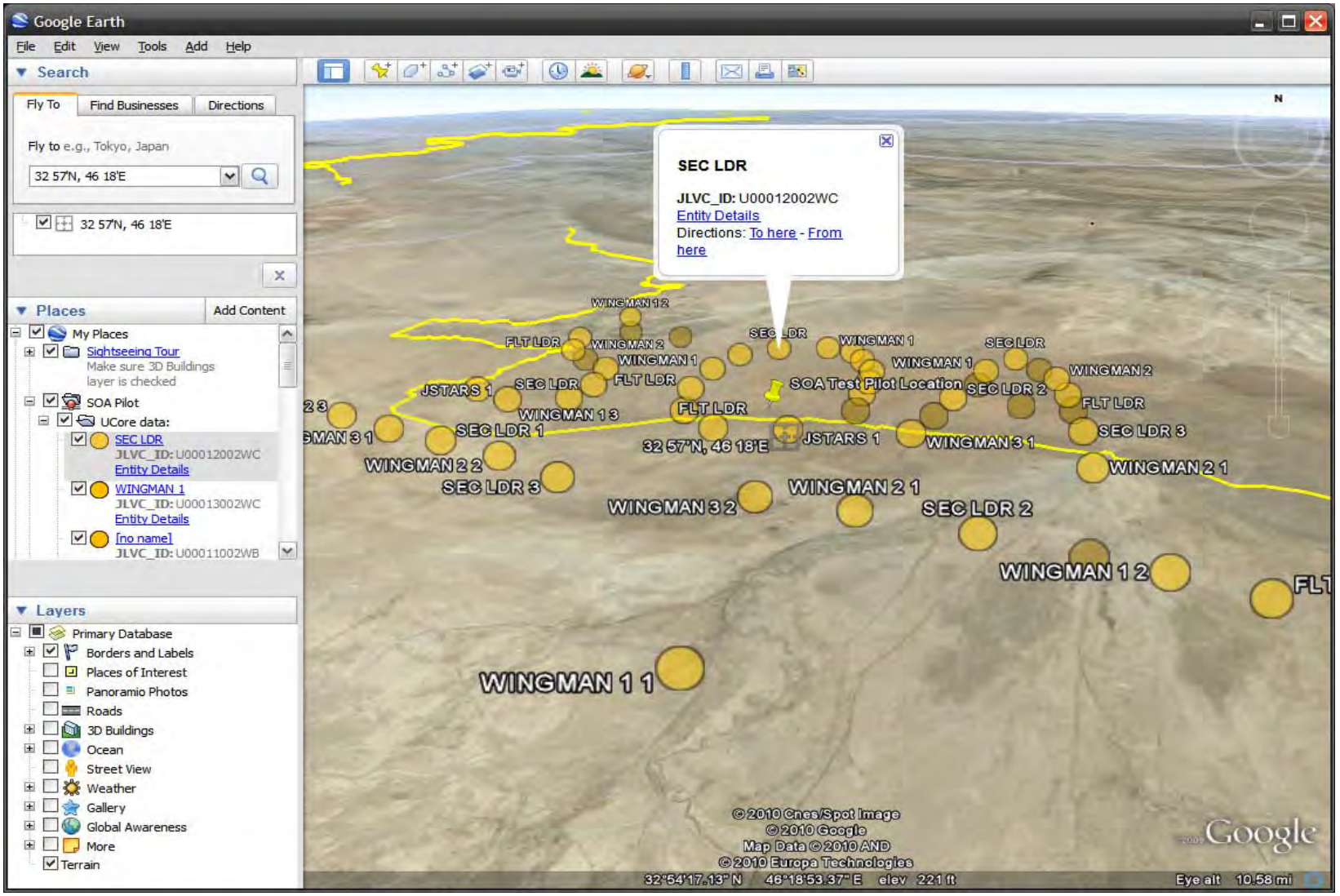
Implemented Services

- **Order Battle Services (OBS) Data**
  - Centralized service-based access to initialization data
- **Situational Awareness**
  - Provides centralized service-based access to ground truth
- **Entity Cache**
  - Provides centralized service-based storage and access of real-time entity information
- **Aggregate Cache**
  - Provides centralized service-based storage and access of real-time unit information
- **Enumeration Service**
  - Provides centralized service-based translation service from native to common data semantics
- **Management**
  - Provides centralized service-based storage of common participant system monitor and control information

SA to UCore to XML to KML to Google Earth



Google Earth: SA Feed



Summary

- Demonstrates SOA capabilities
  - Composition of services
  - Re-usability
  - Future flexibility
- Created a pilot that provides services using industry best practices
  - Order Battle Services (OBS) Data, Situational Awareness, Entity Cache, Aggregate Cache, Enumeration Service, Management
- The pilot is capable of reasonable performance with a non-trivial dataset
  - System easily support a 120K entity scenario on a Dell 690 quad-core workstation
  - Plugin/Adapter and Application Server on the same platform
  - Design provides for 'expedient adaptability'

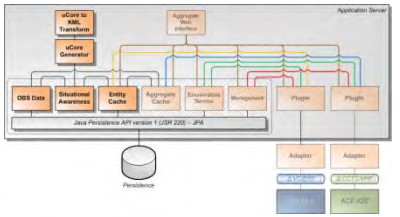
Potential Next Steps

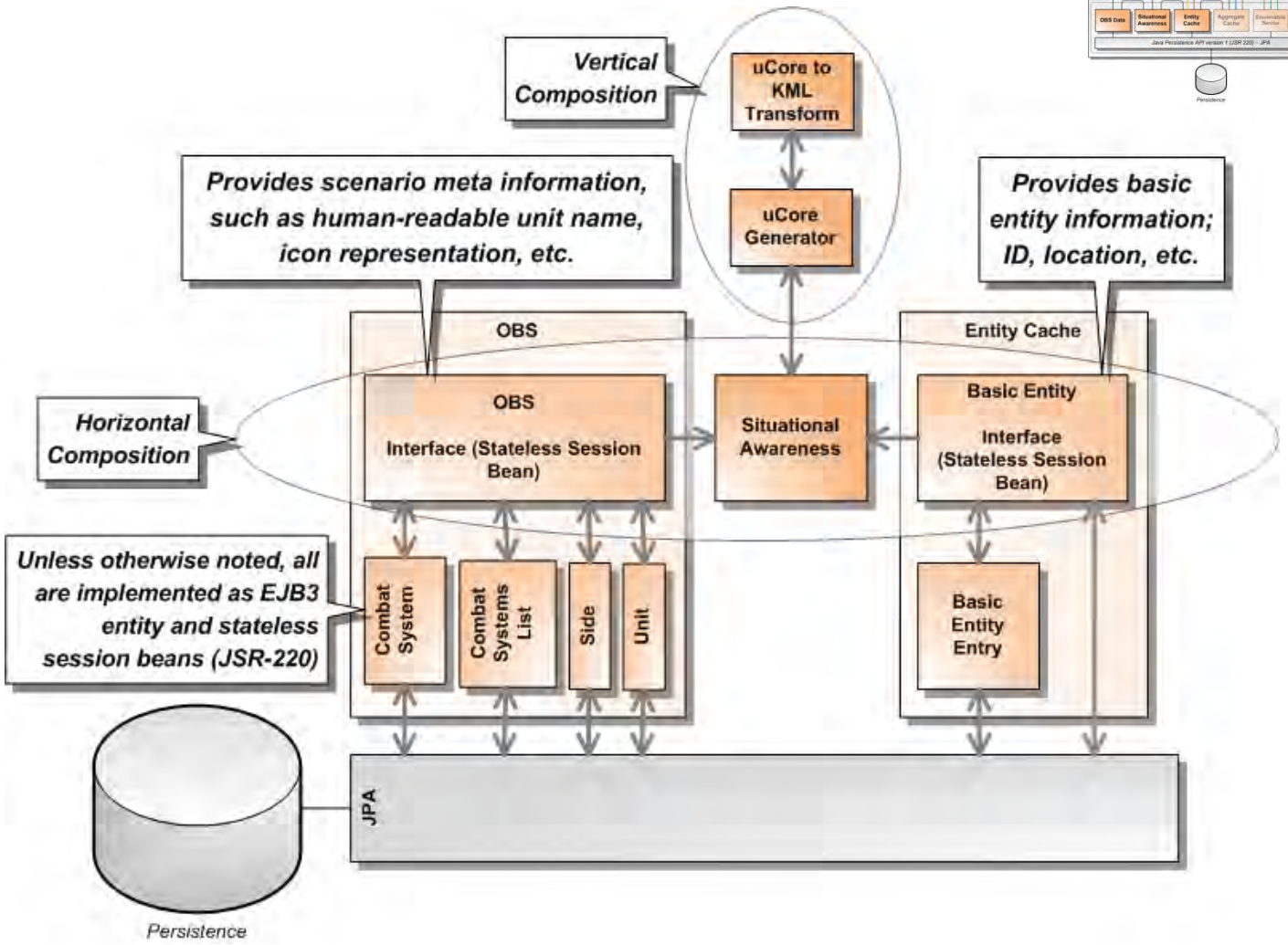
- Explore applicability to domains other than training
- Further performance testing and tuning
- Publish aggregate objects to the CDA to enable bidirectional exchange of aggregate and entity data
- Further refinement of the CDA
  - Enhanced scalability
  - Explore impact of more diverse endpoints

Gary W Allen, PhD
Joint Training Integration & Evaluation Center (JTIEC)
Orlando, FL
407-208-5607
Gary.allen@us.army.mil

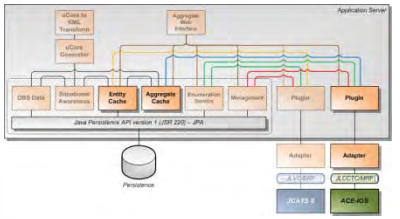
BACKUP

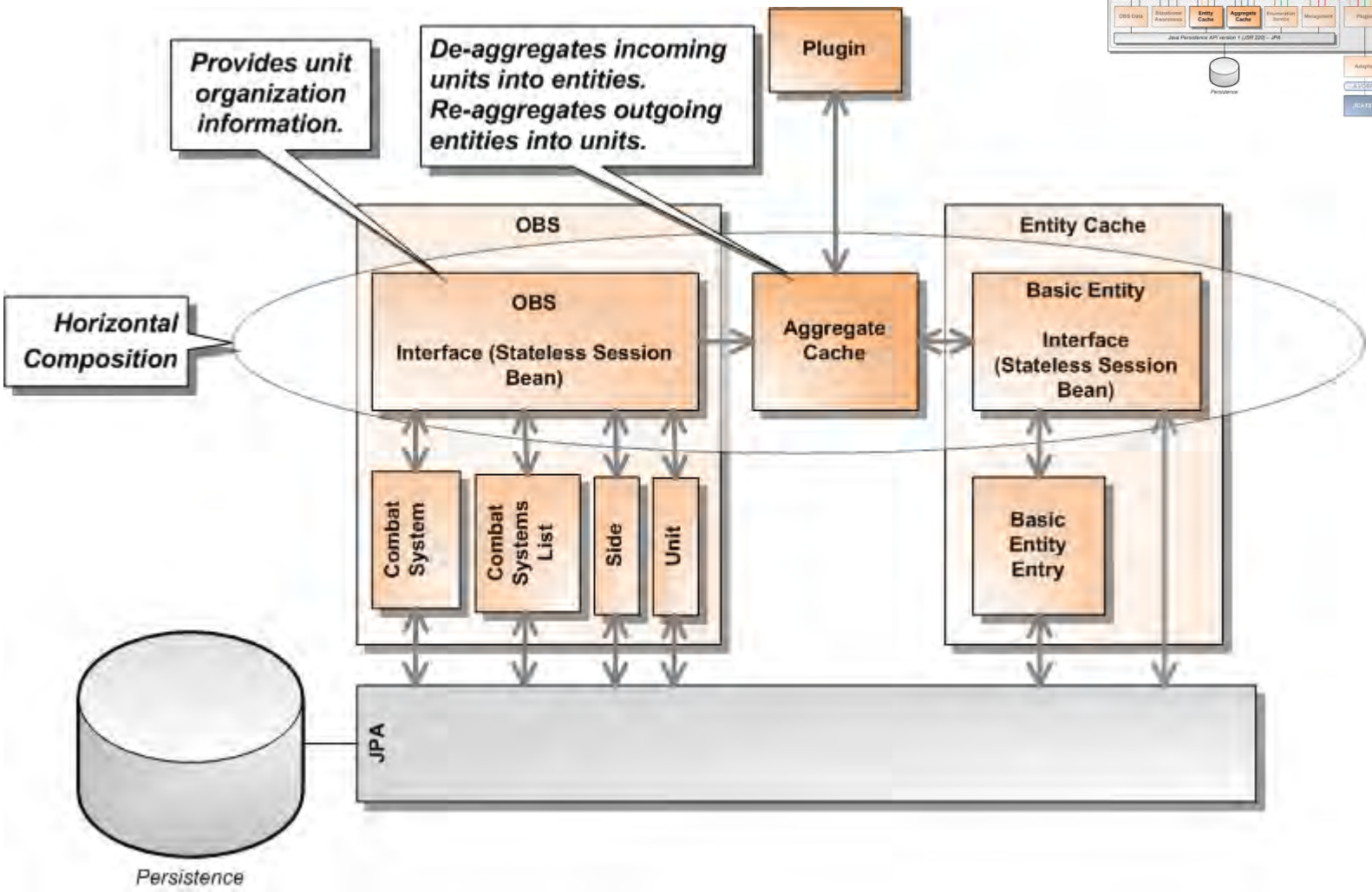
Service Composition within CDA



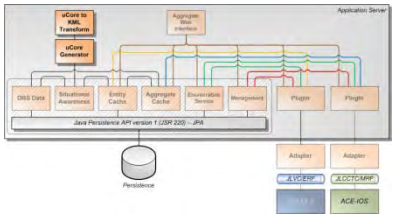


Aggregate Service Composition within CDA





Situational Awareness Feed Service Composition



UCoreGenerator

REST-based Servlet

EJB3 – JPA

Request: REST query
Response: UCore

Request: Dynamic bounding box
Response: KML

UCoretoKMLTransformer

REST-based Servlet

CDA
(Persistence)

EJB3 – JPA

EntityDetails

REST-based Servlet

Google Earth

Request: Embedded REST query
Response: HTML

Models & Simulations Development Best Practices

Katherine L. Morse, PhD

13th Annual NDIA Systems Engineering Conference

27 October 2010

APL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Presentation Outline

- Background
- Study Objectives and Major Technical Activities
- Literature Search
- Systems Engineering Framework
- Example – Develop Conceptual Model
- Example – Perform Product Validation
- Current Status

Background

- **The AMSWG included the following action in the Acquisition M&S Master Plan (AMSMP) published in April 2006:**
  - **ACTION 3-2. Define and foster sound practices for efficient development and evolution of credible M&S tools, incorporating user-defined requirements in a systems engineering approach with appropriate verification and validation.**
- **This study is funded by Office of the Director, Defense Research & Engineering - Systems Engineering/Systems Analysis**

AMSMP Rationale

- **Although the importance and use of modeling and simulation tools (models, simulations, and utilities) is expanding across the DoD, relatively few persons have a good grasp of the process and principles that should be followed when developing such tools.**
  - **The DoD has identified the Federation Development and Execution Process (FEDEP - IEEE 1516.3) as a recommended practice for distributed simulation federations using the HLA, but no equivalent best practice exists for the development of individual modeling and simulation tools.**
- **Whether conducting such a development or overseeing a contractor's efforts to do so, DoD acquisition professionals need to understand best practices for developing modeling and simulation tools.**

Study Objectives and Major Technical Activities

- Study Objectives
  - Identify effective practices for the efficient development and evolution of credible models and simulations
- Major Technical Activities
  - Conduct a literature search and survey of M&S tool developers to identify sound practices for M&S development
  - Develop an overarching systems engineering framework for describing the activities and tasks necessary for effective M&S development
  - Develop a plan for populating the SE framework with the appropriate process elements (activities and tasks), and for capturing best practices specific to chosen domain areas
  - Review the draft framework with organizations and individuals that can help ensure its correctness and appropriateness
  - Refine the core process document descriptions per the above reviews

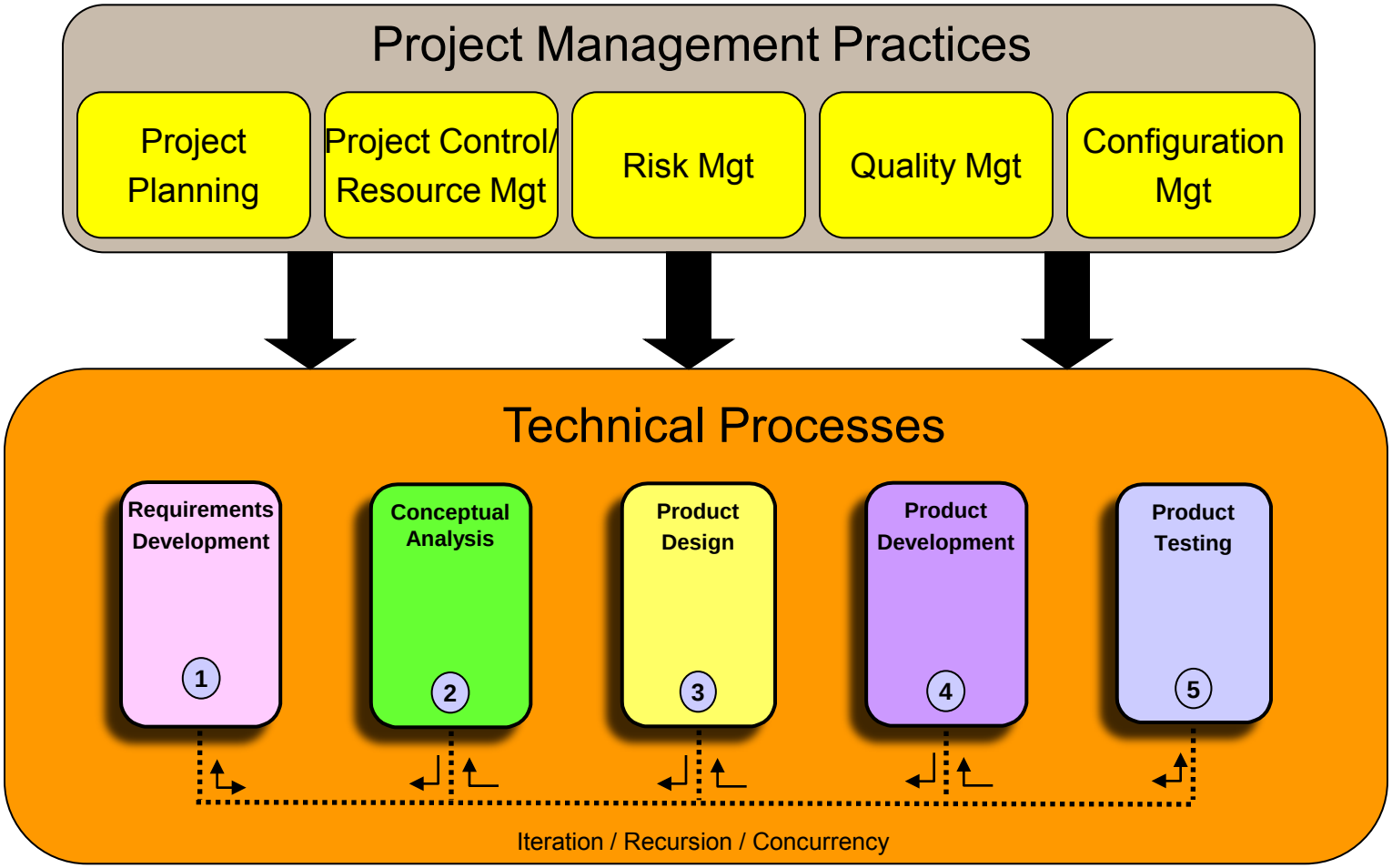
Literature Search

- Assembled bibliography of (mostly) journal and book sources
- Searched NDIA, Simulation Interoperability Workshop (SIW) and Interservice/Industry Training, Simulation & Education Conference (I/ITSEC) papers from the last 5 years
- Literature search and survey together resulted in approximately 116 practices for consideration
  - After removing practices that overlapped with the SE Framework itself, removing practices that weren't M&S specific, and merging similar practices, the team arrived at 50 best practices.

Systems Engineering (SE) Framework Inputs

- International Council on Systems Engineering (INCOSE) Handbook (v3.1)
- Electronic Industries Alliance (EIA) Processes for Engineering a System (EIA-632)
- Institute for Electrical and Electronics Engineers (IEEE) Standard for Application and Management of the Systems Engineering Process (IEEE-1220)
- International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) Systems engineering - System life cycle processes (ISO/IEC-15288)
- Military Standard - System Engineering Management (MIL-STD-499C)
- IEEE Federation Development and Execution Process (FEDEP) (IEEE 1516.3-2003)/Distributed Simulation Engineering and Execution Process (DSEEP) (IEEE P1730)
- Capability Maturity Model Integration (CMMI)

SE Process Overview



SE Framework Outline

- **Phase 1: *Requirements Development***
  - Activity 1: *Develop Stakeholder Requirements*
  - Activity 2: *Develop Product Requirements*
  - Activity 3: *Validate Requirements*
- **Phase 2: *Conceptual Analysis***
  - Activity 1: *Develop Conceptual Model*
  - Activity 2: *Validate Conceptual Model*
- **Phase 3: *Product Design***
  - Activity 1: *Perform Functional Analysis*
  - Activity 2: *Synthesize Design*
  - Activity 3: *Verify Design*
- **Phase 4: *Product Development***
  - Activity 1: *Establish Software Development Environment*
  - Activity 2: *Implement Product Design*
- **Phase 5: *Product Testing***
  - Activity 1: *Perform Product Verification*
  - Activity 2: *Perform Product Validation*
- ***Project Management Practices***
  - *Project Planning*
  - *Project Control/Resource Management*
  - *Risk Management*
  - *Quality Management*
  - *Configuration Management*

Phase 1: Requirements Development

- **Establish intent for model use.**
- **Use focus groups in simulation creation.**
- **Specify data content.**
- **Use survey methods to elicit Subject Matter Experts' (SMEs') knowledge.**

Phase 2: Conceptual Analysis

- Establish model focus by carefully choosing model behavioral aspects and data.
- Use a formal language for linking requirements to a conceptual model.
- Use a standard process for creating a conceptual model.
- Select computer scientists with domain expertise to be on the conceptual modeling team.
- Augment logical data models with semantics.
- Create a data dictionary.
- Include full simulation specification and context in a conceptual model for a simulation system.
- Format the conceptual model using a standard notation accessible to all stakeholders.
- Combine conceptual modeling with knowledge acquisition/knowledge engineering.
- Document a rationale for realistic output measures.
- Use a standardized conceptual model to mitigate stakeholder subjectivity in simulation design.
- Involve the decision-maker in the model development process.

Phase 3: Product Design

- Maintain a distinction between models and simulations.
- Use archived models and model components from an authoritative source.
- Select input data items based on a complete problem context.
- Define uncertainty models.
- Use design patterns in M&S.
- Balance modeling needs with data considerations.
- Design data storage and retrieval architecture.
- Consider availability of data sources when designing simulation.
- Group and separate data from models with varying resolution.
- Distinguish unknowns from unknowables.
- Use intelligent analytical approaches to handle unavailable or unknowable data.
- Adopt commonly accepted icons, symbols, shapes, and colors used to represent simulation entities, where possible.
- Evaluate a model's pedigree before (re)using it as a component.
- Create both an analysis data model and a logging data model to facilitate capture and use of simulation output data.
- Use standards where applicable.
- Separate data I/O interface from model code.
- Use a standardized logical data model and format for I/O data.
- Select output data items based on a complete view of simulation usage.
- Design models as components with loose coupling.

Phase 4: Product Development

- **Use scenario generation tools to promote consistency and efficiency.**
- **Choose the right architecting tool for static and dynamic aspects of the M&S application.**
- **Employ common random numbers in models.**

Phase 5: Product Testing

- **Collect referent information.**
- **Decompose qualitative SME input into quantitative indicators.**
- **Validate models against each intended use.**

Project Management

- Conduct engineering integration reviews.
- Include user domain representatives and external developers in peer reviews.
- Use SMEs throughout the development life cycle.
- Use Systems Engineering analysis and documentation.
- Use a standardized method of "packaging" for developing model components.
- Document model abstraction decisions.
- Keep data current.
- Establish a configuration management system.
- Document models and simulation data with metadata.

2.1 Conceptual Analysis - Develop Conceptual Model

A conceptual model is developed to identify those relevant entities within the M&S domain of interest that should be represented in the product to satisfy validated requirements. The conceptual model identifies the attributes of each entity that should be represented, the behaviors/performance of each, and the static and dynamic relationships among the entities. Algorithms should be specified where feasible.

- **Establish model focus by carefully choosing model behavioral aspects and data.**
- ***Use a formal language for linking requirements to a conceptual model.***
- **Use a standard process for creating a conceptual model.**
- ***Select computer scientists with domain expertise to be on the conceptual modeling team.***
- **Augment logical data models with semantics.**
- **Create a data dictionary.**
- **Include full simulation specification and context in a conceptual model for a simulation system.**
- **Format the conceptual model using a standard notation accessible to all stakeholders.**
- **Combine conceptual modeling with knowledge acquisition/knowledge engineering.**

Develop Conceptual Model – Sample Best Practices

- Use a formal language for linking requirements to a conceptual model
  - UML/SysML diagrams may be used for requirements analysis and conceptual modeling. Requirements and use case diagrams can be used to explore objectives. Activity, sequence, state machine, block definition, and parametric diagrams can model dynamic behavior traceable back to the requirements.
- Select computer scientists with domain expertise to be on the conceptual modeling team
  - Good conceptual modelers are computer scientists with domain expertise. If either skill is lacking, the conceptual modeler has difficulty building a model that bridges the gap between the real world and the computation space.

5.2 Product Testing - Perform Product Validation

The purpose of this activity is to ensure that the M&S application, when exercised for its intended use, will meet all of the operational needs articulated in the original stakeholder requirements. This may involve capability demonstrations or other such customer reviews, or could involve a trial-use period, whereby users report any faults/errors detected during normal use, for which corrective actions are defined and taken. Stakeholder satisfaction is the overriding goal of this activity.

- ***Collect referent information.***
- ***Decompose qualitative SME input into quantitative indicators.***
- ***Validate models against each intended use.***

Perform Product Validation – Sample Best Practices

- **Collect referent information.**
  - **Identify and collect appropriate referent information for validation of M&S results (test and experimental data and observations, laws of physics and theory, results from other M&S, SMEs, etc.) with explicit quantification of uncertainties related to that information.**
- **Decompose qualitative SME input into quantitative indicators.**
  - **Qualitative concepts used by SMEs may be decomposed hierarchically in a recursive fashion until all sub-components (called indicators) are quantitative. These quantitative indicators (called leafs) can be combined with weights to measure conformance. This allows comparisons of qualitative concepts.**
- **Validate models against each intended use.**
  - **Models must be validated against each intended use. If a previously-validated model is applied to new questions or new uses, it must be reevaluated in the new context.**

Status

- **The final report has been cleared for public release.**
  - **Send me an email if you would like a copy: katherine.morse@jhuapl.edu**
- **We're currently evaluating whether there's sufficient interest in the SISO Study Group to progress the report results to an open standard.**

Questions and Feedback

Systems Engineering Initiatives for Verification, Validation and Accreditation of DoD Models and Simulations

Philomena M. Zimmerman

ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Acquisition Community-led VV&A High Level Task (HLT) Summaries

V-AQ-2: "Risk Based Methodology for Verification, Validation and Accreditation (VV&A)" The degree of VV&A required is explicitly tied to both M&S use and the user risk incurred if the M&S does not provide accurate results. A methodology that tailors VV&A planning and implementation based on known risk factors will provide a framework in which VV&A implementation trade-offs can be made, information/fidelity requirements can be assessed, and a VV&A cost model can be developed.

V-C-2: "Improving VV&A Implementation" Increase VV&A implementation and enhance M&S credibility by transforming VV&A practices from current subjective methods into objective examples or use cases. Explore emerging technologies, standards, and applicable methods that could be applied to reduce costs, schedule, and improve reuse.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Verification, Validation, & Accreditation

(M&S PE Funded V-C-2 & V-AQ-2)

FY: 09-10

V-AQ-2

Risk Based Accreditation

FY: 10-11

V-C-2

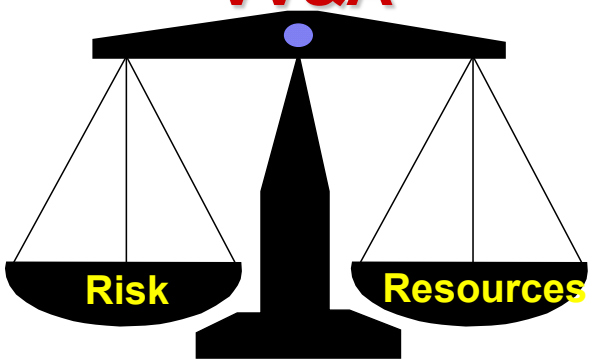
Improving VV&A Implementation

- Johns Hopkins APL
  - Improving VV&A Implementation
- Systems Engineering Research Center
  - VV&A Shortfalls & Needs
  - Complex Systems Modeling
- Pilot Implementations (SIMAF & NAVAIR)
  - VV&A/Distributed Joint VV&A/Vehicle Vulnerability
- Practitioners Forum
  - AMSWG VV&A Sub-Committee
  - ITEA LVC Sub-committee
  - "Gray Hairs" Study Support

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Risk-Based VV&A

(M&S PE Funded V-AQ-2)



Balancing the cost of knowing against the risk of assuming.

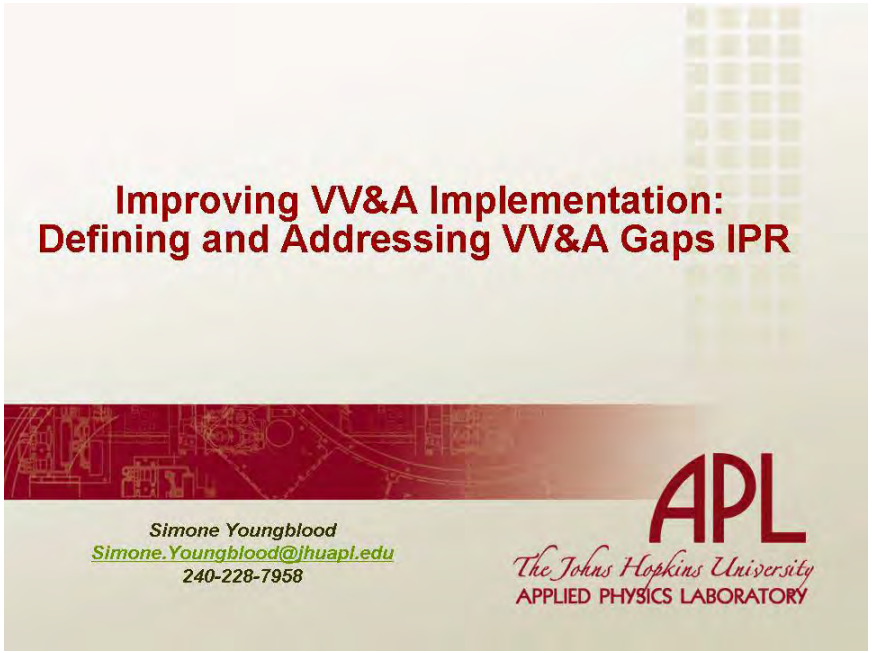
The purpose of this effort is to:

- **Improve Department of Defense (DoD) Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A) by establishing an effective risk-based methodology for VV&A.**

Since the cost of verifying and validating simulations is often high, V&V investments should be weighed against the risk of making a bad decision because of unreliable M&S results.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

JHU/APL VV&A Implementation:
Defining & Addressing Gaps
(M&S PE Funded V-C-2)



The purpose of the effort is to:

- **Support the identification of VV&A gap areas that inhibit effective implementation of VV&A processes;**
- **Develop supplemental capability required to implement the Risk-based Accreditation (RBA) methodology; and**
- **Evolve technology, in the form of automated tools and metadata specifications, that increase VV&A implementation efficiencies.**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Systems Engineering Research Center (SERC) VV&A Topic

(M&S PE Funded V-C-2)

Proposed SERC research topic:

Explore & promote a deeper understanding of emerging & current approaches, technologies, or practices underway within the academic community & gain a broader perspective on their potential applicability to the M&S community V&V needs

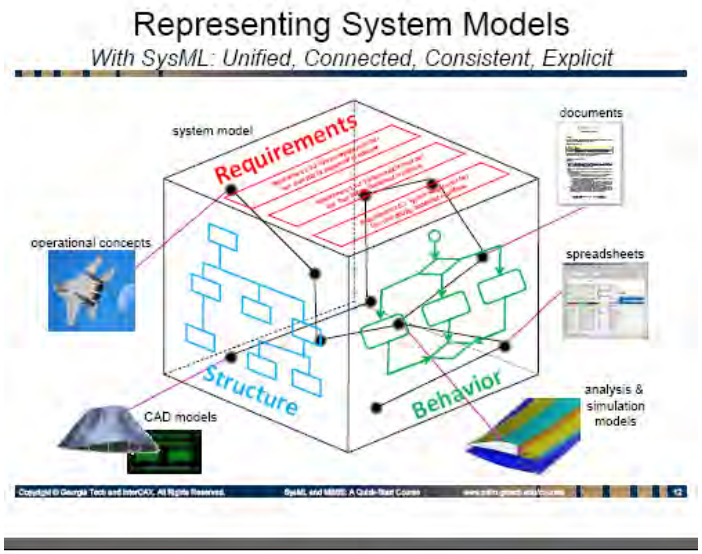
The 19 SERC university partners generated six responses, with selection of two proposals for implementation lasting 6 to 12 months

Two performers:
Georgia Institute of Technology
University of Alabama Huntsville

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Georgia Institute of Technology VV&A Study

(M&S PE Funded V-C-2)



Answers to Questions - II

- Who cares?
  - All M&S and VV&A stakeholders (given benefits below)
- If you're successful, what difference will it make?
  - Our approach provides the *Enabling Capabilities* seen in the table rows below, which produce the main *Primary Impacts* in the columns
  - Ex. Related earlier studies achieved 75% reduction in M&S time and enabled increased analysis intensity
  - We will endeavor to demo and quantify similar benefits in this SERC effort

Enabling Capabilities \ Primary Impacts	Reduced Time	Reduced Cost	Reduced Risk	Increased Understanding	Increased Corporate Memory	Increased Artifact Performance
Increased Knowledge Capture & Completeness			▪	▪	▪	▪
Increased Modularity & Reusability	▪	▪	▪	▪	▪	
Increased Traceability			▪	▪	▪	
Reduced Manual Re-Creation	▪	▪	▪			
Increased Automation	▪	▪	▪			
Reduced Modeling Effort	▪	▪				
Increased Analysis Intensity			▪			▪

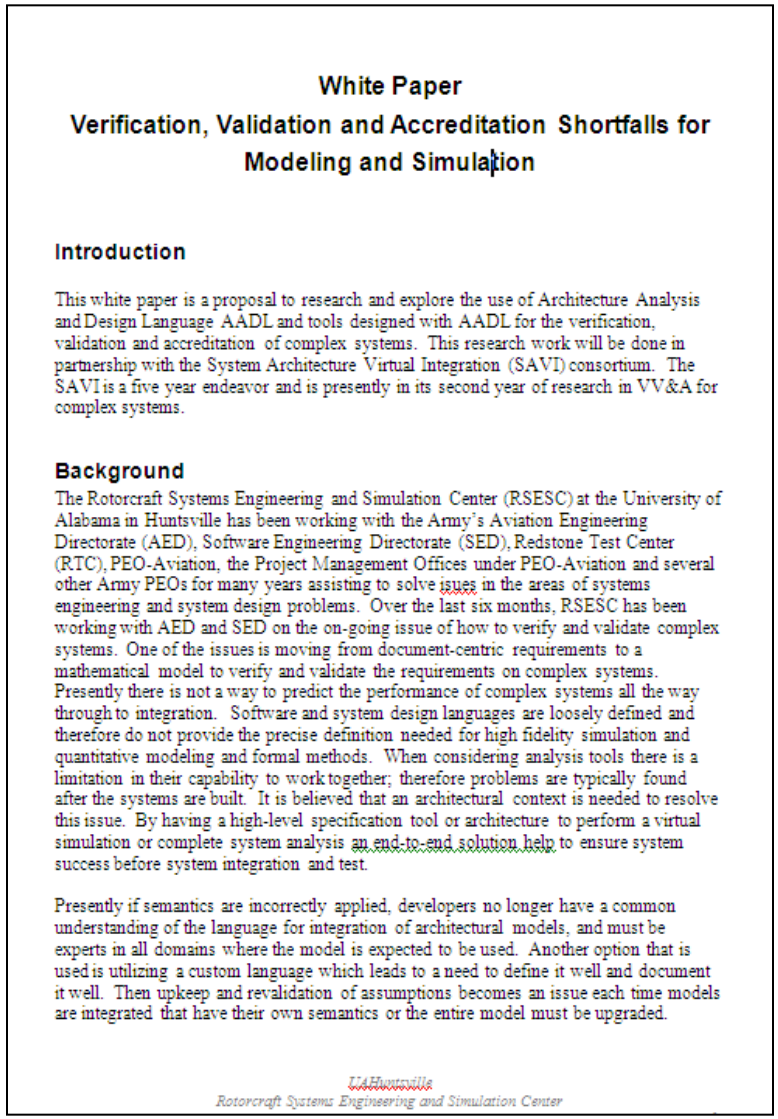
The purpose of this SERC effort :

- **Demonstrate how to address many of the gaps identified in this VV&A Research Topic by applying SysML and MBE/MBSE technology**
- **Engage practitioners in the DoD ecosystem to prioritize needs and to test resulting concepts**
- **Apply concepts in one or more key DoD test beds**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

University of Alabama at Huntsville VV&A Study

(M&S PE Funded V-C-2)



White Paper

Verification, Validation and Accreditation Shortfalls for Modeling and Simulation

Introduction

This white paper is a proposal to research and explore the use of Architecture Analysis and Design Language AADL and tools designed with AADL for the verification, validation and accreditation of complex systems. This research work will be done in partnership with the System Architecture Virtual Integration (SAVI) consortium. The SAVI is a five year endeavor and is presently in its second year of research in VV&A for complex systems.

Background

The Rotorcraft Systems Engineering and Simulation Center (RSESC) at the University of Alabama in Huntsville has been working with the Army's Aviation Engineering Directorate (AED), Software Engineering Directorate (SED), Redstone Test Center (RTC), PEO-Aviation, the Project Management Offices under PEO-Aviation and several other Army PEOs for many years assisting to solve issues in the areas of systems engineering and system design problems. Over the last six months, RSESC has been working with AED and SED on the on-going issue of how to verify and validate complex systems. One of the issues is moving from document-centric requirements to a mathematical model to verify and validate the requirements on complex systems. Presently there is not a way to predict the performance of complex systems all the way through to integration. Software and system design languages are loosely defined and therefore do not provide the precise definition needed for high fidelity simulation and quantitative modeling and formal methods. When considering analysis tools there is a limitation in their capability to work together; therefore problems are typically found after the systems are built. It is believed that an architectural context is needed to resolve this issue. By having a high-level specification tool or architecture to perform a virtual simulation or complete system analysis an end-to-end solution help to ensure system success before system integration and test.

Presently if semantics are incorrectly applied, developers no longer have a common understanding of the language for integration of architectural models, and must be experts in all domains where the model is expected to be used. Another option that is used is utilizing a custom language which leads to a need to define it well and document it well. Then upkeep and revalidation of assumptions becomes an issue each time models are integrated that have their own semantics or the entire model must be upgraded.

UAHuntsville
Rotorcraft Systems Engineering and Simulation Center

The purpose of this SERC effort :

- **Focus on verification & validation (V&V) of complex systems**
- **Identification of existing useful tools**

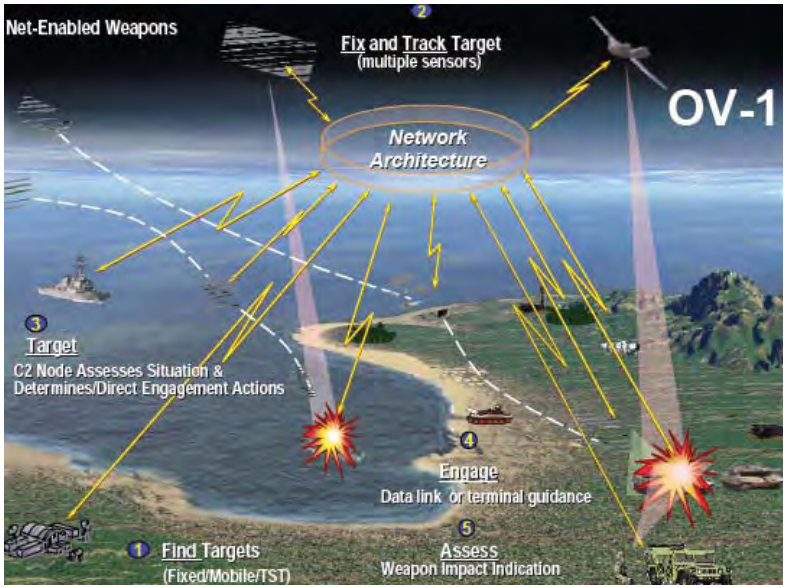
Leverages experience working the government customers in the Army Aviation Directorate, Software Engineering Directorate, Redstone Test Center, and PEO-Aviation.

Will benefit from insights resulting from Systems Architecture Virtual Integration (SAVI), an international industry consortium involving Boeing, Airbus, Lockheed Martin, BAE, FAA, SEI, etc

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

SIMAF VV&A of a Live, Virtual, Constructive (LVC) Environment Use Case

(M&S PE Funded V-C-2)



Joint Command and Control Joint Control For Net--Enabled Weapons from 7 March 2007 Col Richard W. Leibach, USAF Director JT&E presentation

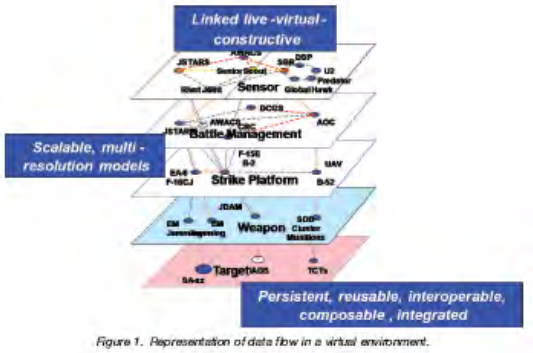


Figure 1. Representation of data flow in a virtual environment.

Tim Menke & W. Walter March, ITEA Journal 2009; 30: 469-472

Develop a Use Case for VV&A of a LVC Distributed Simulation Environment (DSE):

- **Document lessons learned from prior VV&A efforts related to LVC DSEs.**
- **Document applications of IEEE std 1516.4TM-2007; MIL-STD-3022 & Risk Based Approach for VV&A**
- **Consolidate documented best practices methodology for establishing acceptability criteria for DSE.**
- **Using the methodology; plan, conduct, & document a "use case" for VV&A of a LVC DSE.**
- **Insert another accredited simulation into the LVC DSE to re-verify, re-validate, & re-accredit the DSE.**
- **Recommend best practices for VV&A of a LVC DSE in a final report.**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Domain-relevant "Best of Breed" M&S Tool Suite VV&A NAVAIR Use Case

(M&S PE Funded V-C-2)

Multiple communities within the Department of Defense are interested in accelerating schedules, improving credibility, and reducing costs of technical execution of M&S support to decision-makers through tailored accreditation support

The scope of this effort was to:

- **Bring knowledge of existing VV&A "best practices" to funded implementation of credibility assessments of high-priority DoD M&S applications;**
- **Examine the practicality of leveraging Service-specific VV&A for domain-relevant Department-wide tool suite applications; and**
- **Identify Service-specific needs & estimate both cost-avoidance & incremental costs for plan to address.**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

VV&A Program Management & Integration

(M&S PE Funded V-C-2)

ACQUISITION MODELING & SIMULATION WORKING GROUP

VERIFICATION, VALIDATION, AND ACCREDITATION SUBCOMMITTEE

TERMS OF REFERENCE

May 14, 2010

Purpose

These terms of reference describe the purpose and structure of the Verification, Validation, and Accreditation (VV&A) Subcommittee. The subcommittee is subordinate to the Acquisition M&S Working Group (AMSWG). The terms of reference document the subcommittee's scope, stakeholders, roles, responsibilities, and general administrative functions; and will remain valid until cancelled by the AMSWG.

Scope

Contributions from the VV&A Subcommittee will support Action 4-5 in the Acquisition M&S Master Plan (AMSMP) and Goal 3 of the M&S Steering Committee's Strategic Vision for DoD M&S.

- AMSMP Action 4-5
  - Foster cost-effective VV&A
- Strategic Vision for DoD M&S (Goal 3)
  - Provide management processes for models, simulations, and associated data that include practical guidelines for their VV&A

The VV&A Subcommittee will:

- Coordinate with the AMSWG Chairman on proposed responses to Congressional inquiries regarding VV&A of models, simulations, and associated data used in the acquisition process
- Be the Acquisition Community conduit for sharing VV&A information by:
  - providing a virtual VV&A brain trust for the Acquisition Community
  - responding to requests for VV&A information from Acquisition Community members
  - establishing web access to pertinent VV&A information relevant to the Acquisition Community
- Conduct periodic technical interchange meetings to:
  - promote the importance of VV&A
  - make VV&A information available
  - be the "go to" place where VV&A information is shared and exchanged
  - identify Acquisition Community members' VV&A needs and issues
- Help evolve the practice of VV&A by:
  - Reviewing and commenting on VV&A studies
  - Providing input to the review and update of VV&A policy and standards

Membership

Participation is voluntary. Membership will comprise government organizations engaged in VV&A activities (implementation, policy, guidance, standards, etc.).

The VV&A Subcommittee is a coalition of the willing.

Help evolve the practice of VV&A by:

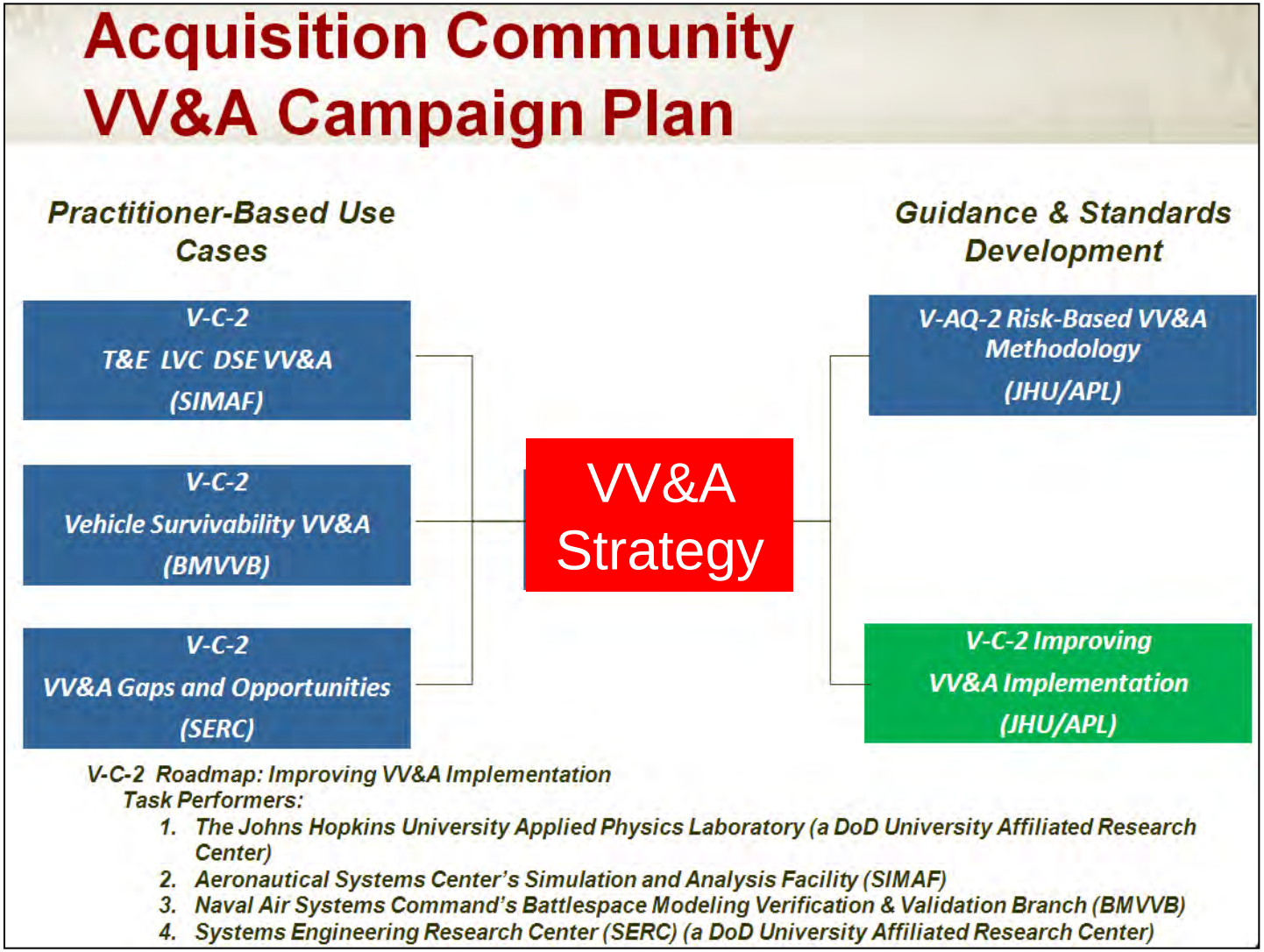
- **Reviewing and commenting on VV&A studies**
- **Providing input to the review and update of VV&A policy and standards**

Supported by:

- **ITEA LVC Sub-committee**
- **"Gray Hair" Support to Key Activities**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

How the VV&A Efforts Fit Together



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Key Acquisition M&S Contact Information

Acquisition Community Steering Committee Representative

- **Kristen Baldwin**, DDR&E/SE/SA
  (703) 681-7000, Kristen.Baldwin@osd.mil

Acquisition Modeling & Simulation Working Group Chair

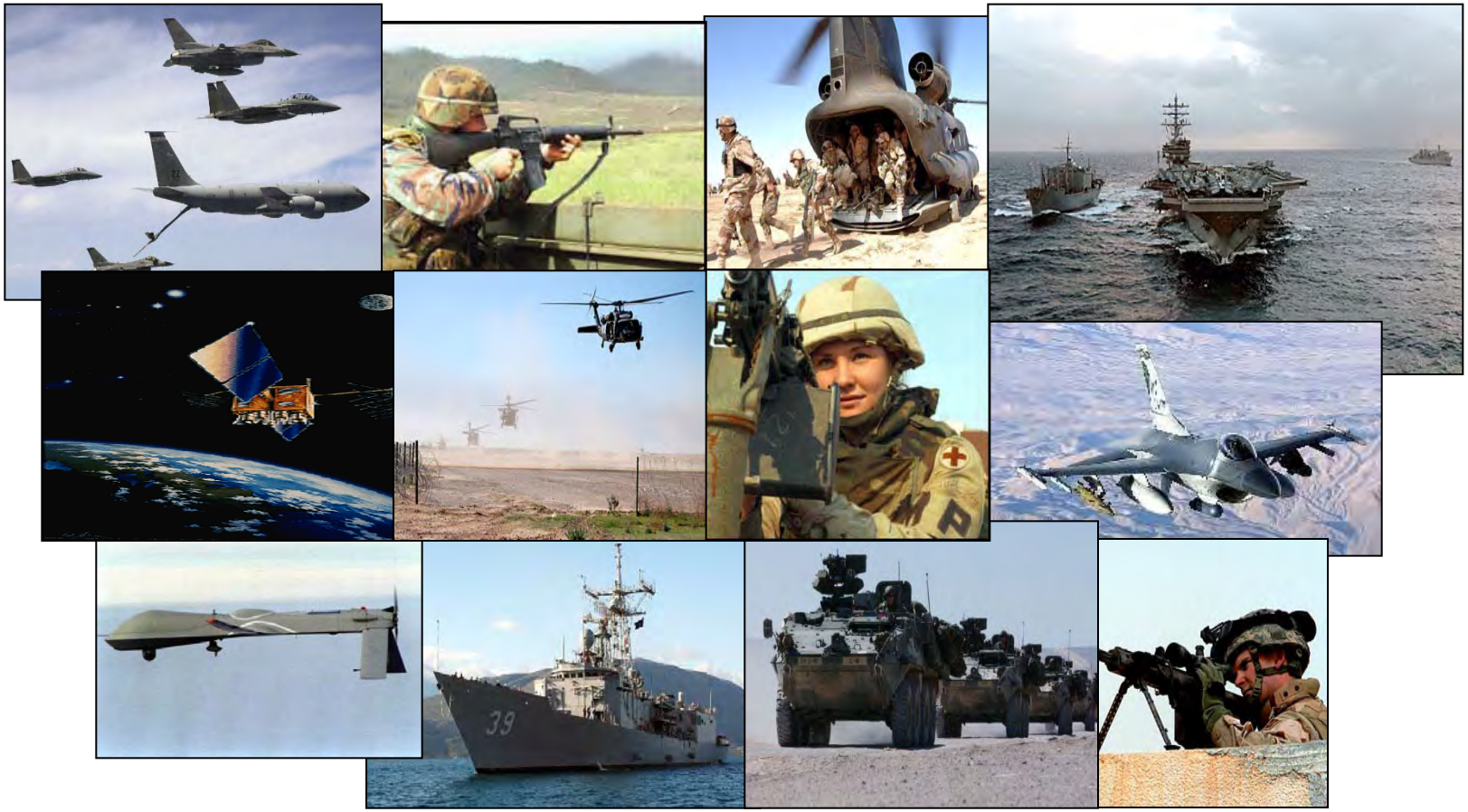
- **Philomena Zimmerman**, DDR&E/SE/SA
  (703) 681-6544; Philomena.Zimmerman@osd.mil

Acquisition M&S Team

- **Crash Konwin**, BAH Support to DDR&E/SE/SA
  (703) 681-6576; Kenneth.Konwin.ctr@osd.mil
- **Marcy Stutzman**, NGC Support to DDR&E/SE/SA
  (301) 317-9698; Marcy.Stutzman@ngc.com

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Systems Engineering: Critical to Program Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0047 applies.

Supporting Weapon Systems Assessments with Realistic Synthetic Environment Representations:

Where to Go for Authoritative Data

J. David Lashlee, Ph.D., CMSP
ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 October 2010 -- SR case number #11-S-0077 applies.

M&S in Weapon System Acquisition

"As dramatic advances in the supporting technologies made [Modeling and Simulation] more powerful and less expensive, and as declining resources and changing priorities made it essential to find better ways to develop and field new systems, the use of these tools and improved processes that exploit their contribution has expanded rapidly."

Study on the Effectiveness of M&S in Weapon System Acquisition
Director, Test, Systems Engineering, and Evaluation (1996)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topics

- Modeling and Simulation in Acquisition
- DoD Modeling and Simulation Governance
- Authoritative Source Data (Producers)
- M&S Synthetic Environment (Providers)
- Data Trade Space and Risk Mitigation

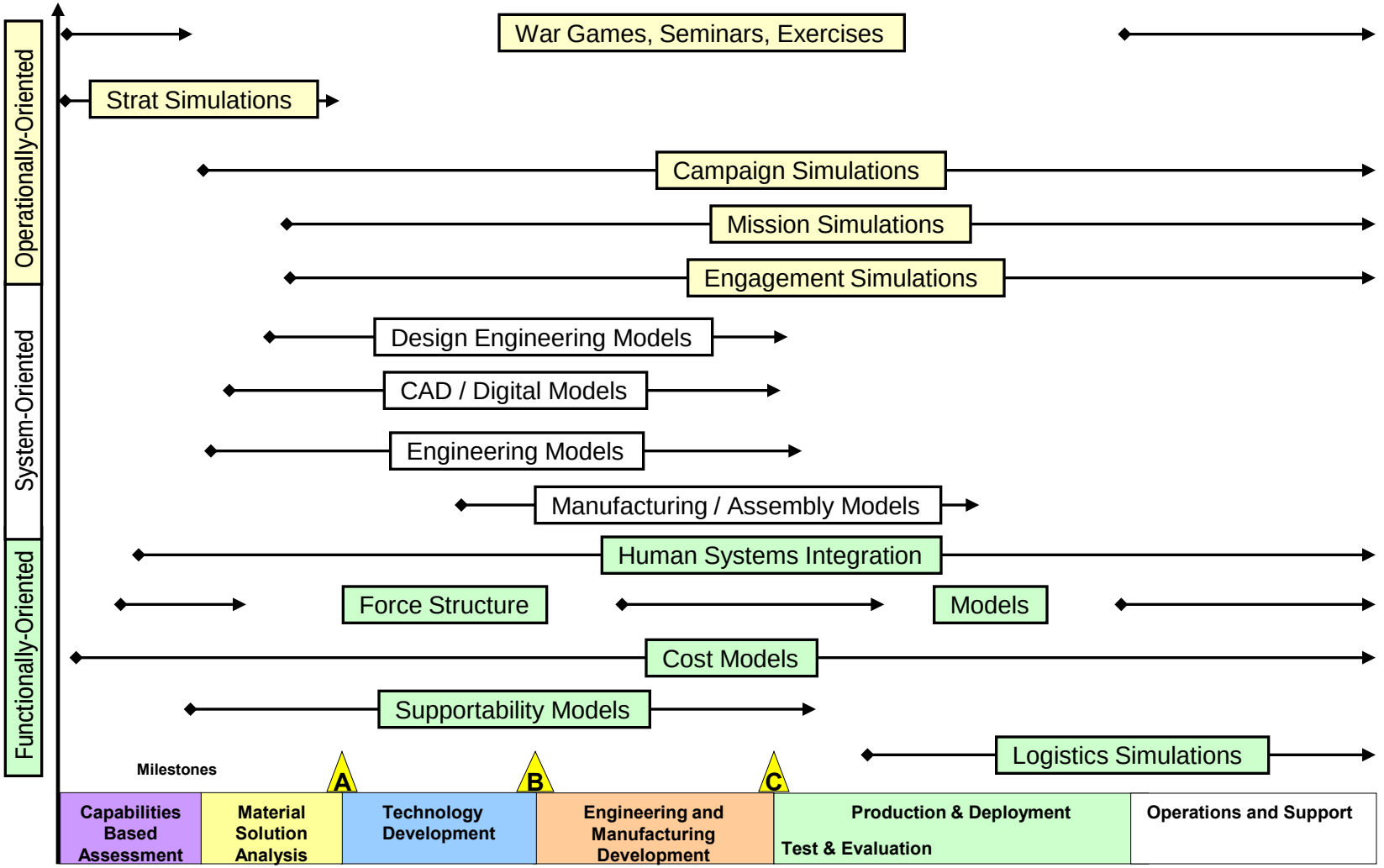
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topic

- **Modeling and Simulation in Acquisition**
- Modeling and Simulation Governance
- Authoritative Source Data (Producers)
- M&S Synthetic Environment (Providers)
- Data Trade Space and Risk Mitigation

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

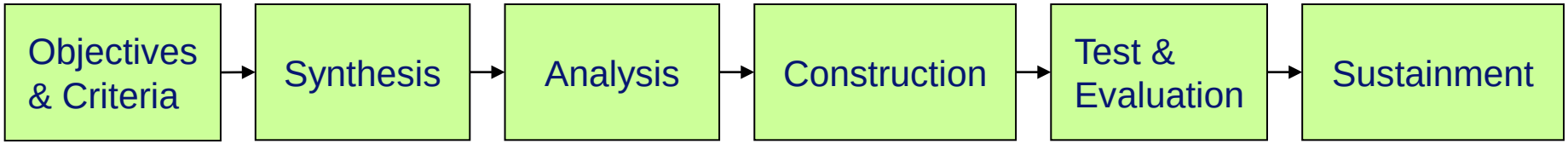
M&S in Acquisition



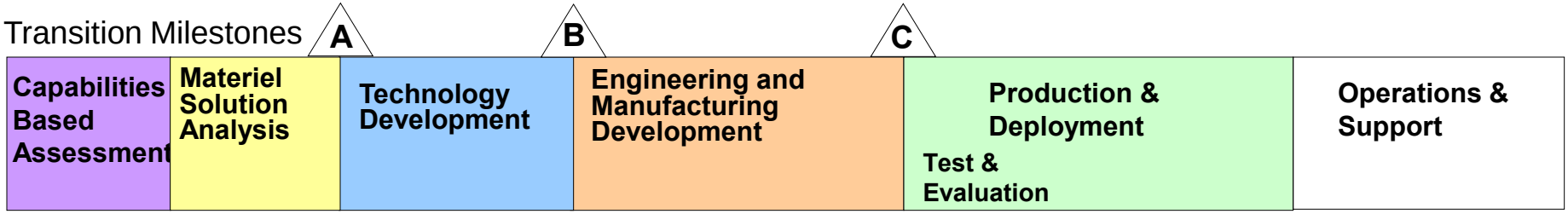
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Engineering Design & DoD Acquisition Life Cycle

Systems Engineering:

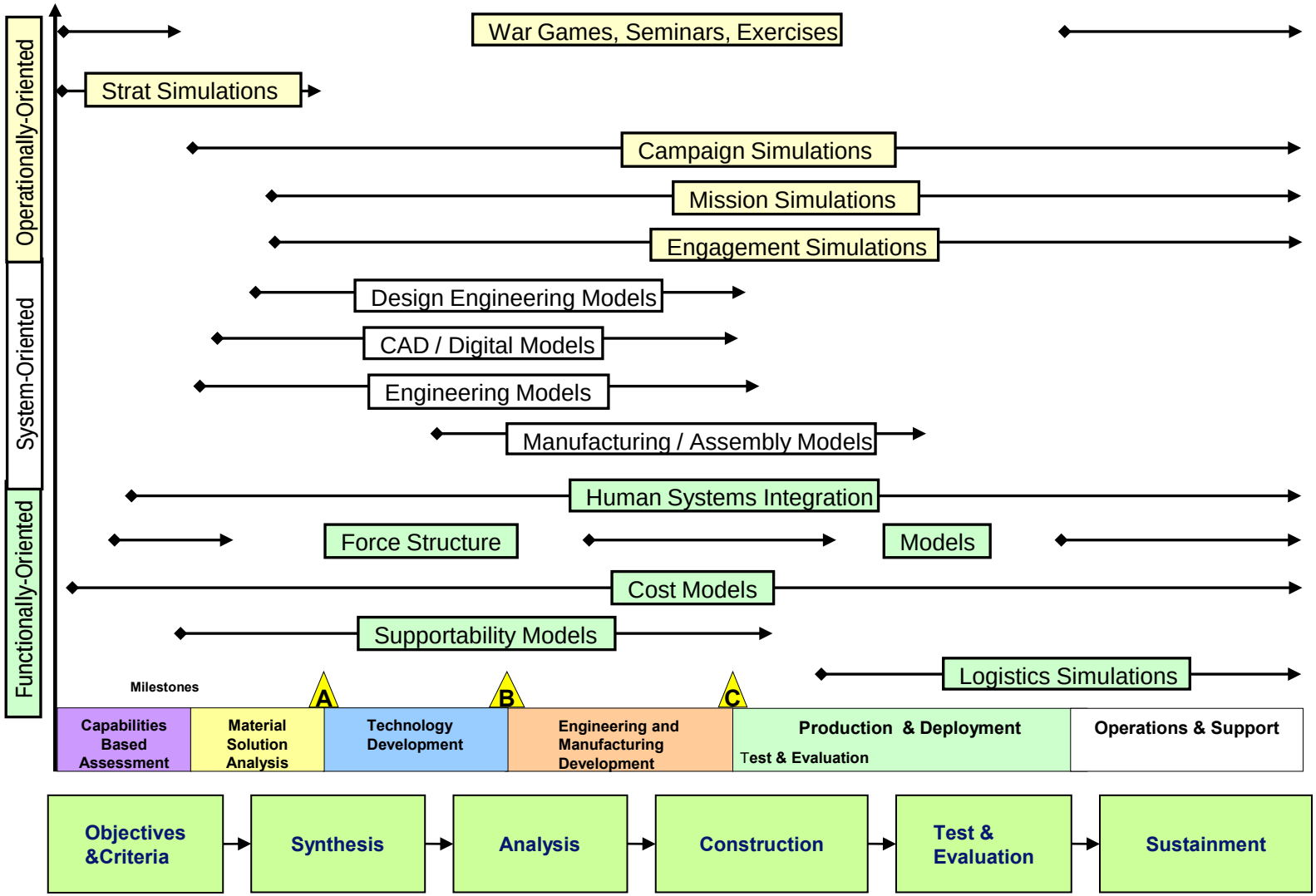


DoD implementation of Systems Engineering:



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

M&S in Acquisition



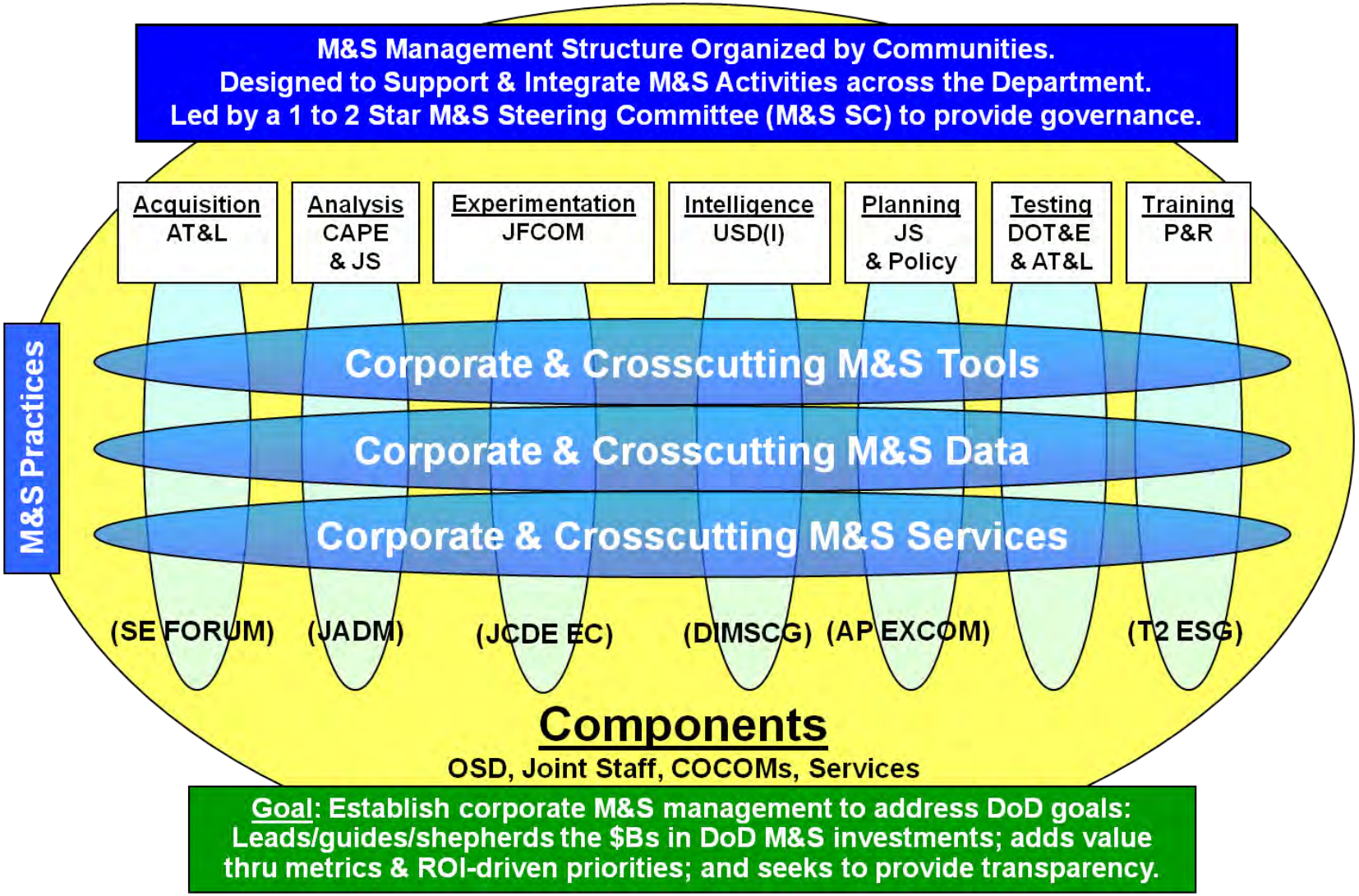
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topics

- Modeling and Simulation in Acquisition
- **Modeling and Simulation Governance**
- Authoritative Source Data (Producers)
- M&S Synthetic Environment (Providers)
- Data Trade Space and Risk Mitigation

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

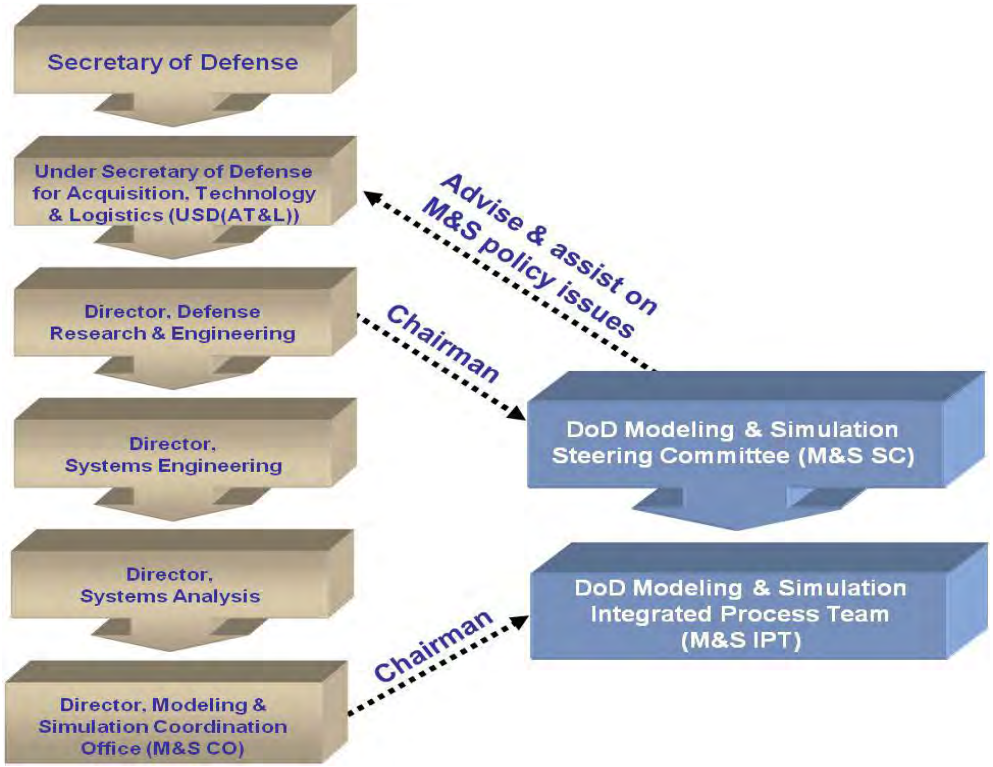
DoD M&S Governance



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

DoD M&S Governance

HR 487 Recognizes M&S as a National Critical Technology



- M&S Steering Committee (SC)
- M&S Integrated Process Team (IPT)
- M&S Coordination Office (M&S CO)
- M&S Information Analysis Center (MSIAC)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Modeling & Simulation Executive Agents (MSEA)

- **DoD MSEAs for the Natural Environment**
  - Air & Space Natural Environment: Dept. of the Air Force
  - Ocean: Dept. of the Navy
  - Terrain: National Geospatial-Intelligence Agency

- **MISSION: "Enable M&S developers and users to represent the natural environment and its effects rapidly, thoroughly, and consistently in a manner that promotes cost-effectiveness, ready access, interoperability, re-use, and confidence."**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Service M&S Organizations

Army Modeling & Simulation Office
– Arlington, VA

Navy Modeling & Simulation Office
– Washington, DC

Marine Corps Modeling & Simulation Management Office
– Quantico, VA

Air Force Agency for Modeling & Simulation
– Orlando, FL

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

M&S Community of Interest Data Management Working Group

- Improve M&S data sharing and reuse technical solutions and best practices
- Coordinate, develop, and register M&S discovery and structural metadata
- Develop extensions to existing Data Standards
- Identify, research, and resolve M&S data issues (policy, governance, business model, and technical) with the M&S CO, M&S IPT, and M&S SC
- Enable rapid discovery, access, integration, production, mediation, and sharing of trusted data between M&S and Operational systems
- Coordinate M&S data requirements with DoD data governance organizations
- Implement the DoD Net-Centric Data & Services Strategy

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topic

- Modeling and Simulation in Acquisition
- Modeling and Simulation Governance
- **Authoritative Source Data (Producers)**
- M&S Synthetic Environment (Providers)
- Data Trade Space and Risk Mitigation

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Authoritative Data Source

- **Definition**

  Authoritative Data Source (ADS)

  A data source whose products have undergone producer data verification, validation and certification activities (1)

- **General Characteristics**
  - Generates data through accredited data generation systems, often managed by a Government Office
  - Executes mission responsibilities to catalog, distribute, and maintain currency of information content
  - Generated in accordance with standards-based content specifications
  - Supported by a persistent user / customer needs assessment process

[1] "Data Abstraction." *Army Data Transformation. Web. 05 Aug. 2010. http://data.army.mil/ADSL_Data_abstraction.html.*

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Authoritative Planning Data

- **Planning Community Authoritative Data:**
  - Questionnaire distributed to members of Adaptive Planning Community
  - 57 ADS identified and rated based on importance, use, and value
  - 33 additional data sources/tools used by Planning Community were identified
  - Discovery metadata developed for 26 key data sources (on-going)
  - Examples of authoritative data shown below:

• Global Command and Control System – Joint (GCCS-J)	Joint Force Requirements Generator II (JFRG II)
• Global Decision Support System (GDSS)	Joint Operations Planning and Execution System (JOPES)
• Global Force Management Data Initiative (GFM-DI)	Meteorological and Oceanographic Environmental Databases
• Geospatial Infrastructure Data Environment (GIDE)	Ports and Airfields Consolidated Environment (PACE)
• Global Status of Resources and Training Systems (GSORTS)	Sustainment Generator (SUSGEN)
• Global Transportation Network (GTN)	Air Force World-Wide UTC Summary (AFWUS)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Environmental Representation Requirements Study

Problem:

- No DOD-wide Integrated Understanding of Environmental Data Requirements

Objectives:

- Characterize Environmental Data Requirements across M&S
  - 4 Services and Joint community
  - 7Communities enabled by M&S
- Characterize capabilities of environmental data producer/provider communities
- Identify and Prioritize Gaps in Support Capability
- Allow for More Informed Future Investment Decisions
- Ensure Future Projects are Aligned with Community Needs

Preliminary Findings - Consistent Environmental Issues:

- Environmental Data Discovery
- Data Consistency across Environmental Domains
- Dynamic Terrain
- Correlation of Environmental Data across Simulation Federates
- Time and Money Spent on Converting Source Data for Use in M&S Tools

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Authoritative Threat Data

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Authoritative Environmental Effects Data

Define Environmental Conditions

High Wind

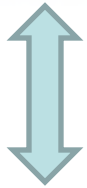
Clouds Develop

Precipitation Starts

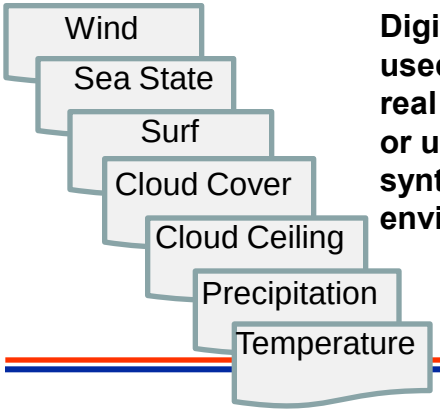
Terrain Gets Wet

Surf Builds

Ocean Waves Form



Mine Data Resources



Digital databases, used to describe real environment, or used to create synthetic environment

Deliver Required Impacts

High Waves Prevent Ship From Refueling. Noise From Waves Reduce SONAR Performance.

Plane Can't See Tank Through Clouds

High Surf Prevents Landing On Beach

Tank Gets Stuck In Mud

JFCOM ADS Directory

Need	Acronym	System	Acquisition_Authority	AA_PMO	Date_Available
TBM_GBM Early Warning_JAMD COI	AADC	Area Air Defense Commander	Navy	NAVSEA	4Q_FY09
Container ITV Information	ACAMS	Army Container Asset Management Systen	Army	AMC LOGSA	3Q_FY08
Arrival of Forces in Theater	ADAMS	Allied Deployment and Movement System	NATO		
Equipment Movement Information	ADAMS	Allied Deployment and Movement System	NATO		
Movement Schedules	ADAMS	Allied Deployment and Movement System	NATO		
Passenger Movement Information	ADAMS	Allied Deployment and Movement System	NATO		
Unit Movement Information	ADAMS	Allied Deployment and Movement System	NATO		
Blue Track	ADSI	Air Defense System Integrator	Navy	SPAWAR	
Electromagnetic Spectrum Management_Pl	AESOP	Afloat Electromagnetic Spectrum Operatio	Navy		
Army Equipment Locations	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	1Q_FY11
Army Fires Plans	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	4Q_FY09
Army Unit Consumables List	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	1Q_FY11
Army Unit Locations	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	4Q_FY09
Battle Damage Assessment Data	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	1Q_FY11
Fixed Targets	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	
GPS Impacts on Weaponeering	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	
Gray Track	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	
Mobile Targets	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	4Q_FY09
Red Track	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	
USMC Fires Plans	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	4Q_FY09
USMC Unit Locations	AFATDS	Advanced Field Artillery Tactical Data Sys	Army	PM BC	
Track Management_Association	AFCCIS	Air Force Command and Control Informati	Air Force		1Q_FY10
Air Force Unit Equipment List	AFEMS	Air Force Equipment Management System	Air Force	754 ELSG/LRE	2Q_FY13
Gray Track	AMDPCS	Air and Missile Defense Planning and Cont	Army	PEO-C3T PM C-R	1Q_FY09

The Joint ADS Directory provides a Systems / Tools view of the Authoritative Data, but does not include mapping to the organization responsible for producing the data.

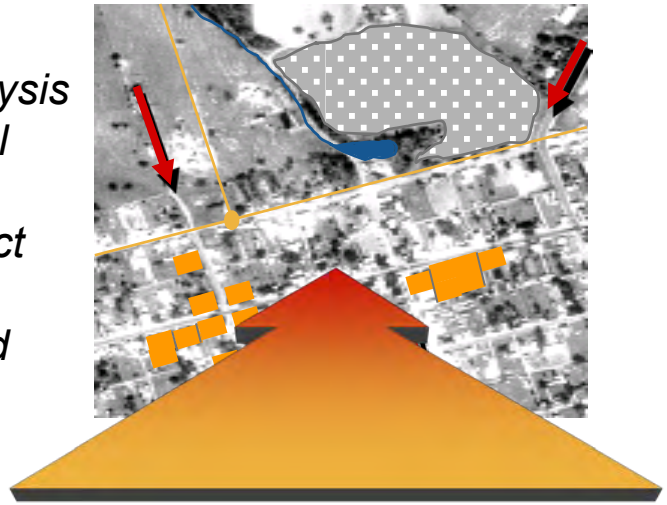
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Authoritative Geospatial Data

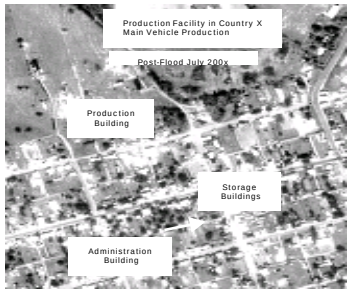
National Geospatial-Intelligence Agency (NGA)

GEOINT:

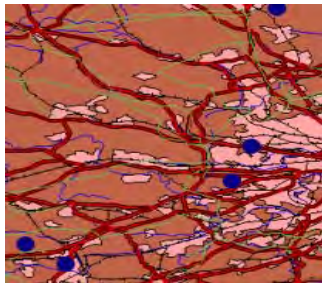
The exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the Earth. GEOINT consists of imagery, imagery intelligence, and geospatial information."



Imagery



Imagery Intelligence



Geospatial Information

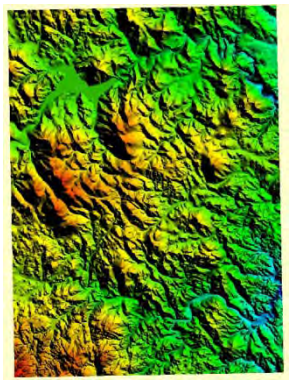
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topic

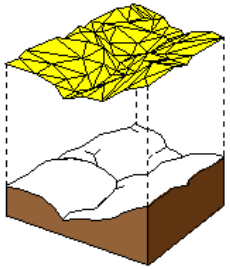
- Modeling and Simulation in Acquisition
- Modeling and Simulation Governance
- Authoritative Source Data (Producers)
- **M&S Synthetic Environment (Providers)**
- Data Trade Space and Risk Mitigation

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Synthetic Environment Generation



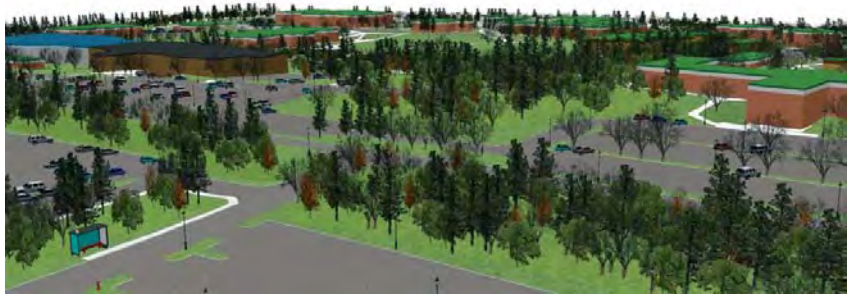
Digital Elevation Model (DEM)



Creation of a Triangular Irregular Network (TIN) from the elevation data.

Application of Satellite Imagery onto the surface of the TIN

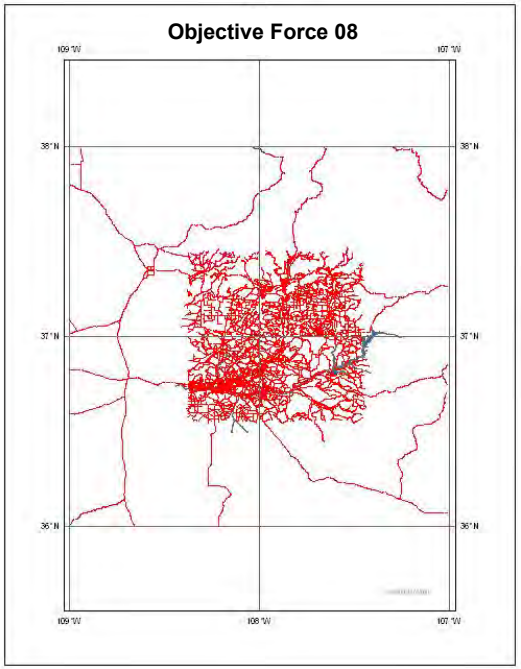
Collection and creation of Geospatial features (i.e. roads and buildings)



Completed database featuring elevation data, with overlaid imagery, and integrated GIS features compiled together into a synthetic environment.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

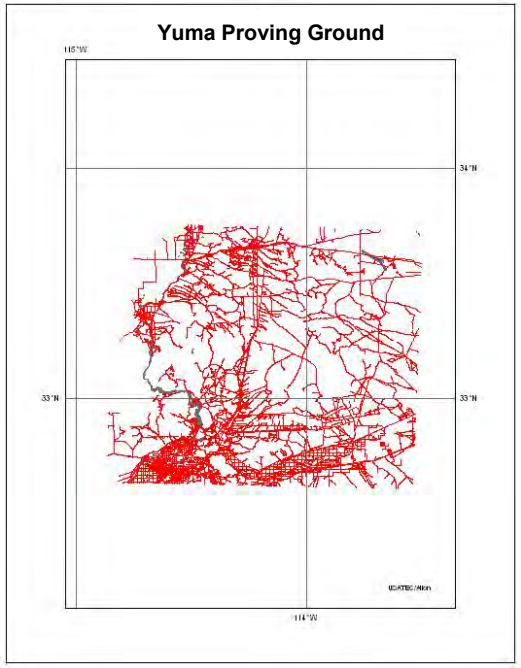
Synthetic Environments – Cost



Objective Force 08

Customer – TRADOC
Community – Analysis
Size – 4 Geotiles
Content – Geotypical
Time – 1 Month
Cost – $40K

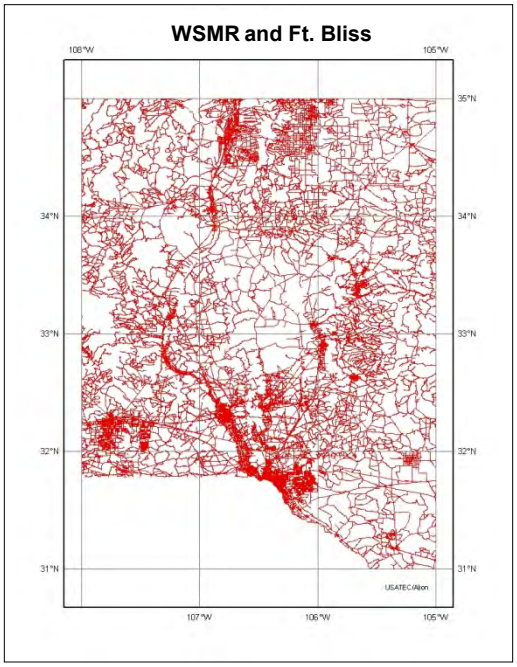
Priority = $
Insurance = $



Developmental Testing

Customer – ATEC
Community – Testing
Size – 1 Geotile
Content – Geospecific
Time – 1 Year
Cost – $280K

Geospecific Insets = $
High-Res Models = $



Test Article Database

Customer – Program of Record
Community – Acquisition
Size – 12 Geotiles (3 x 4 degrees)
Time – 3 Years
Cost – $1 Million

Geospecific Insets = $
High-Res Models = $
IFSAR Overflights = $
Enhanced DEMs = $
Multiple Formats = $

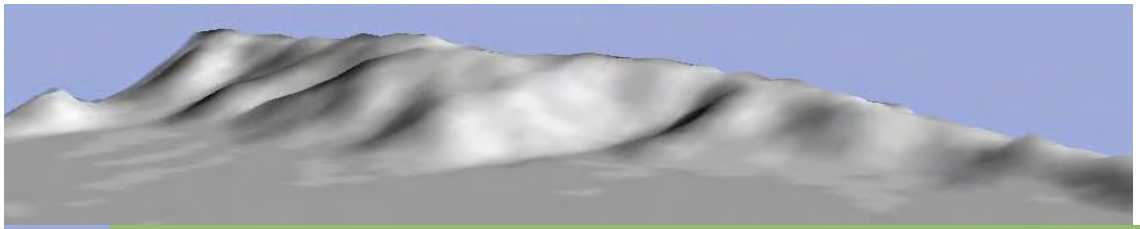
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Discussion Topic

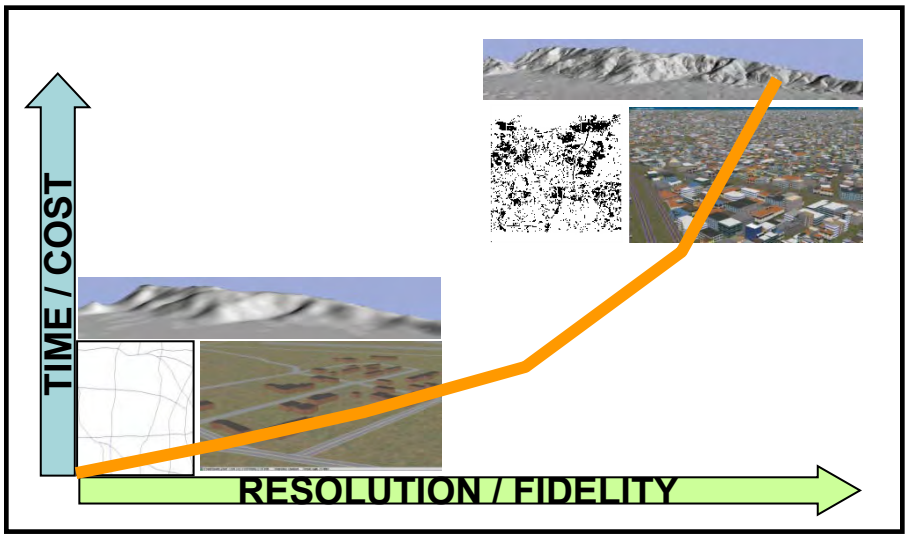
- Modeling and Simulation in Acquisition
- Modeling and Simulation in Governance
- Authoritative Source Data (Producers)
- M&S Synthetic Environment (Providers)
- **Environmental Data Trade Space and Risk Mitigation**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Geospatial Issue – Resolution



DTED1 ~ 90 m



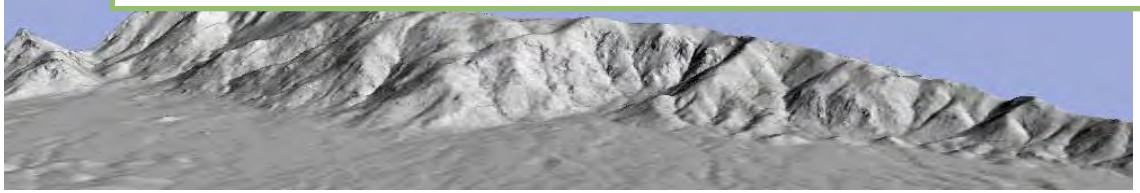
- Resolution vs Time / Cost

Elevation Data 1º Level (m)	Storage (MB)
0 (~900)	0.28
1 (~90)	2.8
2 (~30)	25.5
3 (~10)	230
4 (~3)	2067
5 (~1)	18600

30 m

10 m

3 m

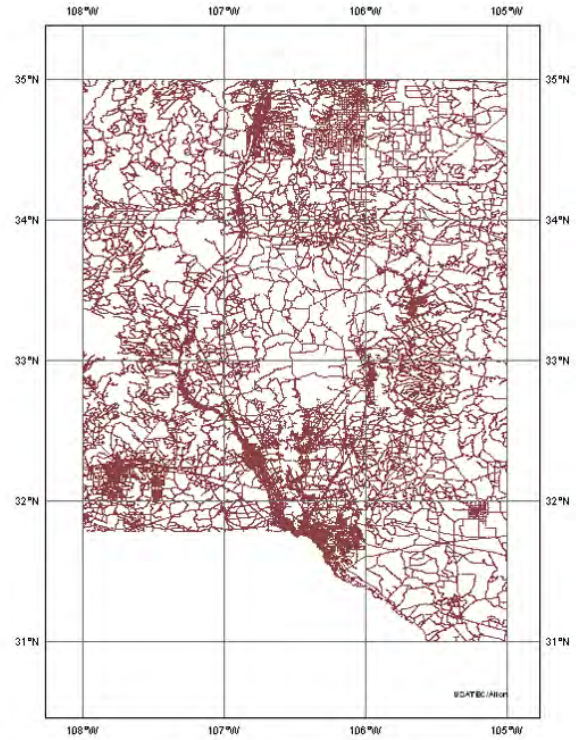


DTED5 ~ 1 m

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Geospatial Issues – Scale and Availability

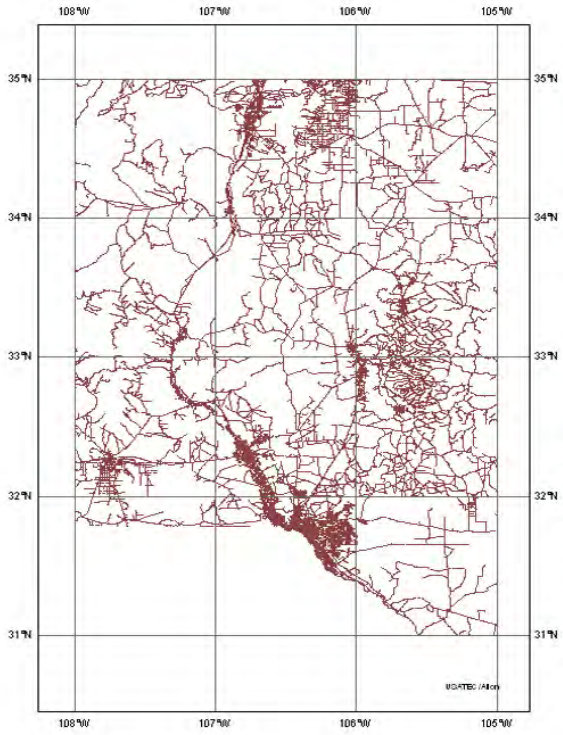
Test Article Database



Feature Type	Occurrences
All line segments	164357

Road Length	Measurement
Linear KM	69846.1

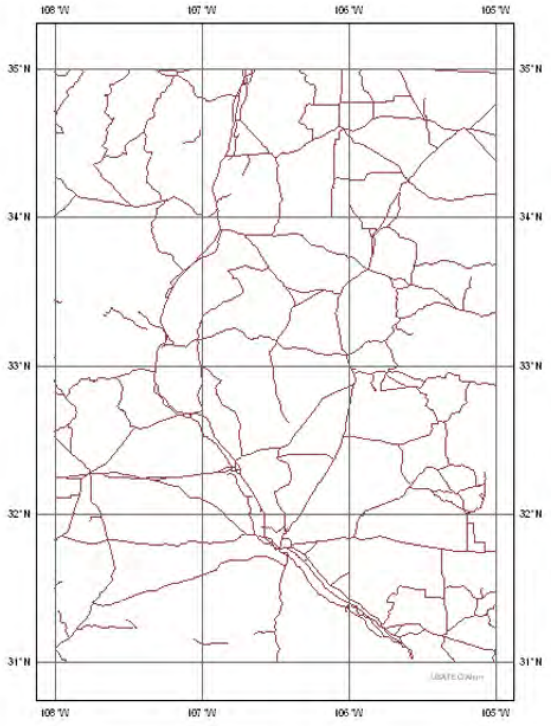
VMAP1



Feature Type	Occurrences
All line segments	59280

Road Length	Measurement
Linear KM	40116.3

VMAP0

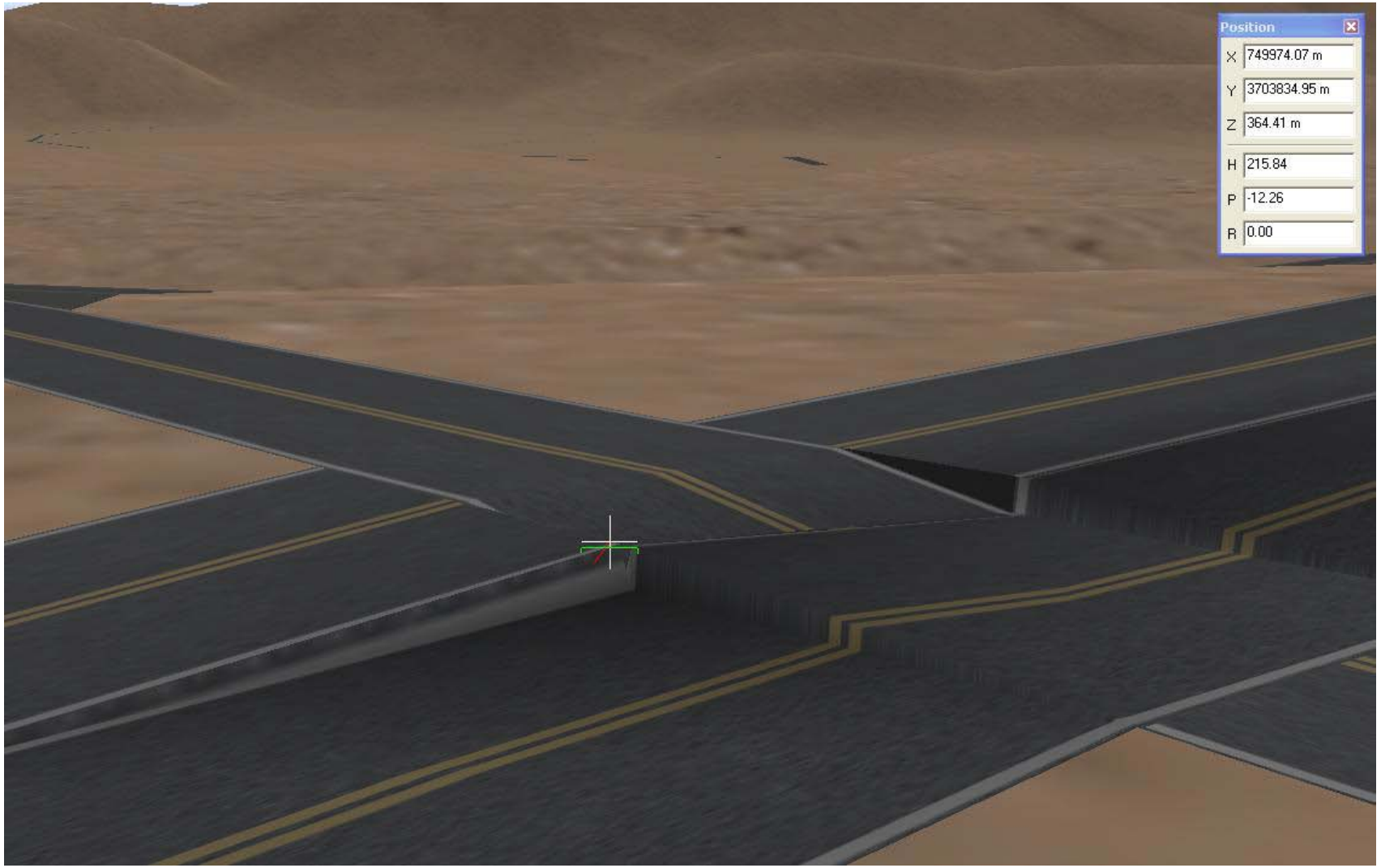


Feature Type	Occurrences
All line segments	632

Road Length	Measurement
Linear KM	7372.6

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

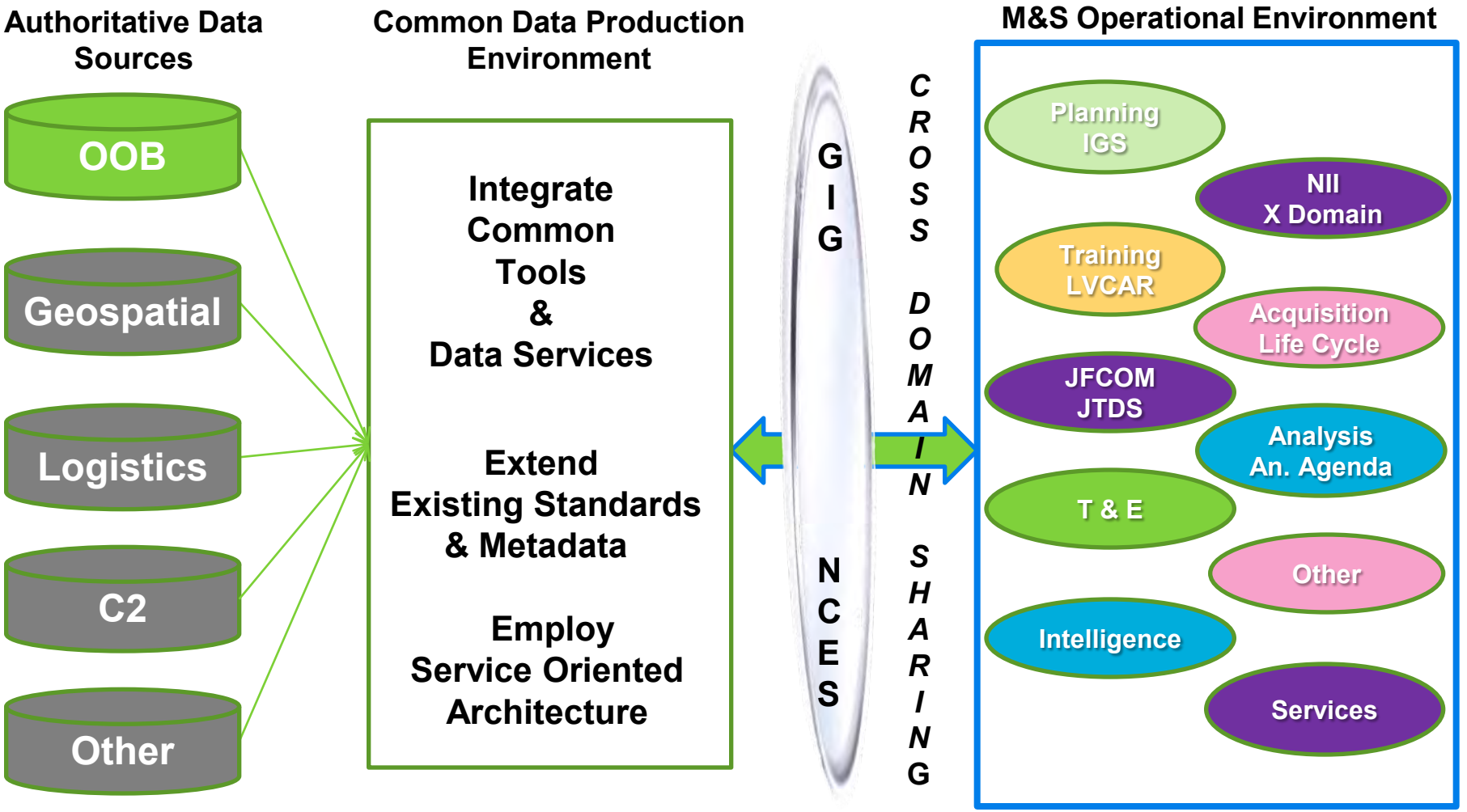
Geospatial Issue – Data Quality



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Rapid Data Generation

DoD M&S SC Governance



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

Summary

- **M&S is a *National Critical Technology***
- **M&S is *Applied Continuously Throughout the Acquisition Life Cycle***
- **M&S is *Used Extensively in Systems Engineering***
- **Many Organizations Produce Authoritative Data for Use in M&S**
- **Authoritative Data are Typically Not Simulation Ready**
- **Systems Engineering Often Requires Realistic Operational Environment Representations**
- ***Significant Cost-Benefit Trade Offs Exist*** (Geospatial Example):
  - Elevation data and imagery spatial resolution
  - Feature data content and coverage limitations, both spatial and attribute data
  - Model and simulation performance parameters

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

For Additional Information

J. David Lashlee
ODDR&E / Systems Engineering / M&S CO
(703) 681-6599 | david.lashlee@osd.mil

Dennis P. McGroder
Booz Allen Hamilton / M&S CO Support
(703) 681-6562 | dennis.mcgroder.ctr@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

DoD Net-Centric Data Strategy

- **DoD Directive 8320.02 "Data Sharing in a Net-Centric DoD":**
  - Establishes policies and responsibilities to implement data sharing, in accordance with "DoD Net-Centric Data Strategy" (DoD CIO, May 2003)
- **Key elements of policy:**
  - Data shall be made visible, accessible, and understandable to any potential user in the DoD to support mission objectives
  - Data assets shall be made visible by creating & associating discovery metadata for each asset
  - All metadata shall be discoverable, searchable, and retrievable using DoD-wide capabilities
  - Data assets shall be made accessible by making data available in shared spaces
  - Data assets shall be made understandable by publishing associated semantic and structural metadata in a federated DoD metadata registry
  - To enable trust, data assets shall have associated IA and security metadata, and an authoritative source for the data shall be identified when appropriate
  - Semantic and structural agreements for data sharing shall be promoted through communities (e.g., communities of interest (COIs)) consisting of data users (producers and consumers) and system developers
  - Data interoperability shall be supported by making data assets understandable and by enabling business and mission processes to be reused where possible
  - Data sharing concepts and practices shall be incorporated into education and awareness training and appropriate DoD processes

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 07 October 2010 -- SR case number #11-S-0071 applies.

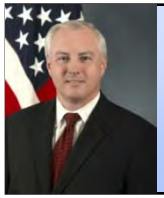
Understanding the Increasingly Important Role of Modeling and Simulation (M&S) in Department of Defense Acquisition

Philomena (Phil) Zimmerman
Acquisition Modeling and Simulation
ODDR&E/Systems Engineering

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.

Director, Systems Engineering



Director, Systems Engineering
Stephen Welby

Systems Analysis
Kristen Baldwin

Addressing Emerging Challenges on the Frontiers of Systems Engineering

- Analysis of Complex Systems/Systems of Systems
- Development Planning/Early SE
- Program Protection/Acquisition Cyber Security
- University and Industrial Engineering Research
- Modeling & Simulation Coordination

Major Program Support
James Thompson

Supporting USD(AT&L) Decisions with Independent Engineering Expertise

- Engineering Assessment / Mentoring of Major Defense Programs
- Program Support Reviews
- OIPT / DAB / ITAB Support
- Systems Engineering Plans
- Systemic Root Cause Analysis

Mission Assurance
Nicholas Torelli

Leading Systems Engineering Practice in DoD and Industry

- Systems Engineering Policy & Guidance
- Specialty Engineering (System Safety, Reliability / Availability / Maintainability, Quality, Manufacturing, Producibility, Human Systems Integration (HSI))
- Technical Workforce Development
- Standardization

Providing technical support and systems engineering leadership and oversight to USD(AT&L) in support of planned and ongoing acquisition programs

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.

Acquisition M&S Organizational Relationships

Industry

SISO

INCOSE

NDIA SE Division

SIW Forums

INCOSE MBSE WG

NDIA M&S Committee

Jim Coolahan, Chair
Jeff Bergenthal, Co-Chair

DoD Acquisition

Chair: Mr. Stephen Welby
OUSD(AT&L)/DDR&E/SE

Systems Engineering Forum

Acquisition M&S Working Group

Chair: Ms. Phil Zimmerman
OUSD(AT&L)/DDR&E/SE/SA

DoD M&S

Ms. Kristen Baldwin
Acquisition Member:
OUSD(AT&L)/DDR&E/SE/SA

M&S Steering Committee

M&S Integrated Product Team

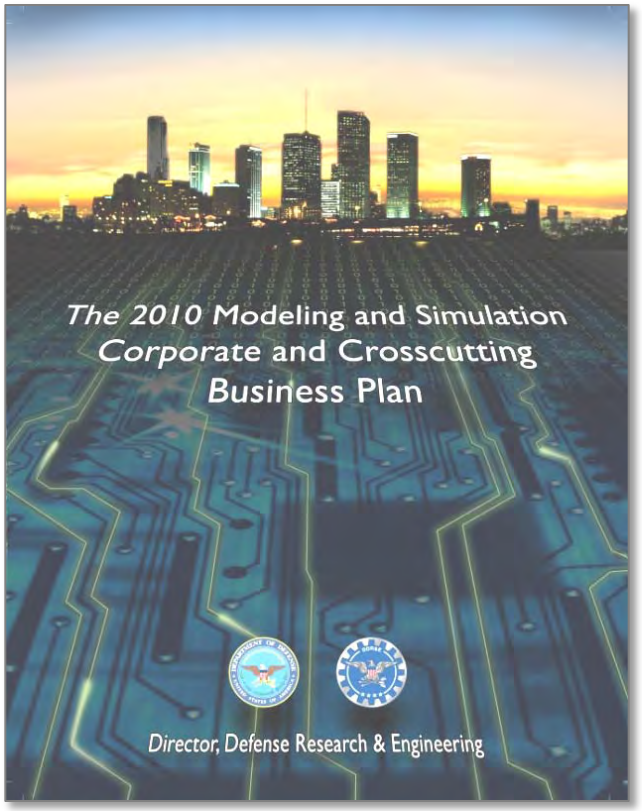
Ms. Phil Zimmerman
Acquisition Member:
OUSD(AT&L)/DDR&E/SE/SA

AMSWG Charter (SE Forum, 2006)

- **Assist PMs and acquisition professionals by improving the utility of M&S . . .**
- **Address common concerns, improve info flow, align technical initiatives, pursue cross-cutting issue resolution . . .**
- **Represent the acquisition community in DoD M&S deliberations . . .**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on XX Oct 2010 -- SR case number 10-S-XXXXXX applies.

2010 M&S Corporate and Crosscutting Business Plan



To be published Fall 2010

- **Improvements and Recommendations**
  - Collaborate with community leadership
  - Identify M&S gaps and areas for DoD-wide action, based on operational needs
  - Implementation and metrics to apply to M&S tools, data, and services investments for incorporation in separate Implementation Plan
  - Roadmap for management actions, technical strategies, and enterprise solutions
  - Corporate-level guidance
- **2010 Steering Committee Objectives**
  - M&S Interoperability
  - M&S Reuse

2010 Plan focuses on operational needs & M&S capabilities

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on XX Oct 2010 -- SR case number 10-S-XXXXXX applies.

2010 Summer Study to Shape Acquisition M&S Action Plan

2010 Summer Study Plan will respond to DDR&E Catalysts and DoD Systems Engineering Forum inputs:

- Immersive Virtual Environments for Concept Engineering
  - Leverage Rapid Tools Study; JTCOIC, Agile Fires, AF-ICE, Immersive Training Environment
  - Enhance warfighter needs and technology capabilities inputs to acquisition in collaboration with stakeholder communities
- M&S in support of System of Systems (SoS) Engineering
  - Use the SoS pilots as starting points
  - Support Integration of the Intelligence Community Threat M&S
- Model-based Systems Engineering
  - Leveraging ongoing Systems 2020, NDIA MBE efforts
- The Potential of Serious Games to the Acquisition Process

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on XX Oct 2010 -- SR case number 10-S-XXXXXX applies.

Discussion, Comments, Suggestions

- **What significant areas may be missing?**
- **What activities in your areas can be leveraged, augmented, accelerated?**
- **Who are the right technical points of contact to continue the technical interchange?**

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on XX Oct 2010 -- SR case number 10-S-XXXXXX applies.

Key Acquisition M&S Contacts

- **Acquisition Community Steering Committee Representative**

  Kristen Baldwin, ODDR&E/SE/SA

  (703) 681-7000, Kristen.Baldwin@osd.mil

- **Acquisition Modeling & Simulation Working Group Chair**

  Philomena (Phil) Zimmerman, ODDR&E/SE/SA

  (703) 681-6544; Philomena.Zimmerman@osd.mil

- **Acquisition M&S Team**

  Crash Konwin, Contractor Mission Support (Booz Allen Hamilton)

  (703) 681-6576; Kenneth.Konwin.ctr@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 20 October 2010 -- SR case number #11-S-0149 applies.
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on XX Oct 2010 -- SR case number 10-S-XXXXXX applies.

U.S. AIR FORCE

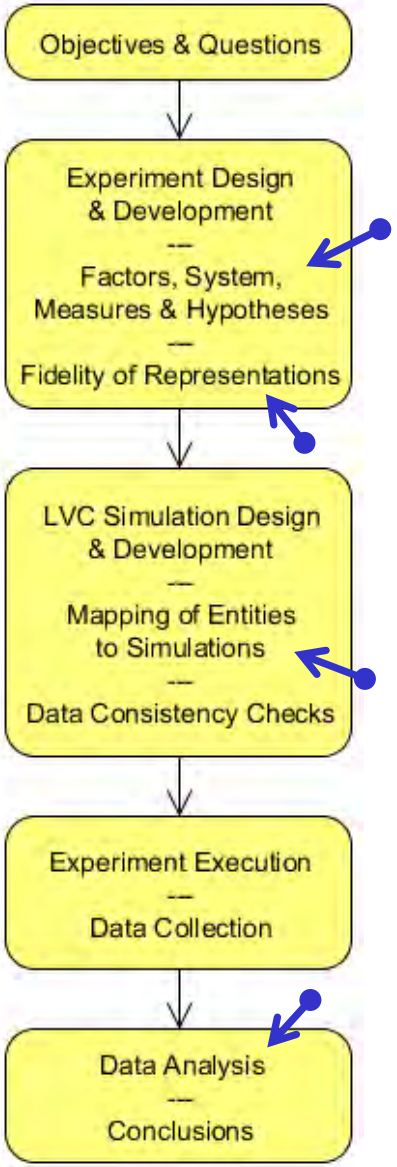
Leveraging LVC Simulations for Systems Analysis

NDIA
National Defense Industrial Association

13th Annual Systems Engineering Conference

Douglas D. Hodson, PhD
douglas.hodson@wpafb.af.mil
Simulation and Analysis Facility
Wright Patterson AFB

Agenda



- Verification & validation
- Experiment design
- Systems
- Entities as systems
- LVC systems
- Mapping entities to simulations
- Mention unique challenges
- Data analysis

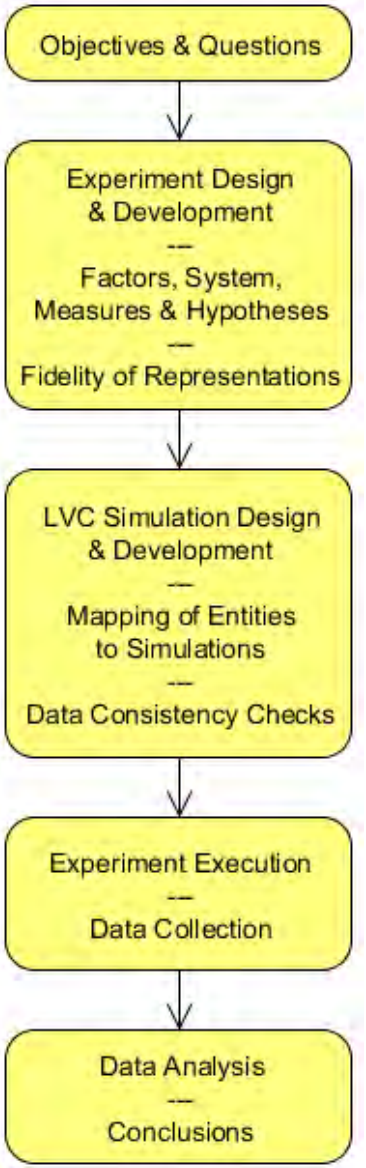
Definitions

- Validation (MIL-STD-3022)
  - The process of determining the degree to which a model, simulation, or federation of models and simulations, and their associated data are **accurate representations of the real world** from the perspective of the intended use(s)
- Verification (MIL-STD-3022)
  - The process of determining that a model, simulation, or federation of models and simulations implementations and their associated data **accurately represents the developer's conceptual description** and specifications

Verification & Validation for M&S

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today



Focus is on Defining a Valid Experiment

Focus is on Verifying the Simulated System Built Performs as Defined

Experiment Design

Experiment Design

- Define
  - Inputs (i.e., factors, causes)
  - System of interest
  - Outputs (i.e., measures, effects)
  - Hypothesis (i.e., basis for learning)
- Design experiment (i.e., fractional factorial, etc) to support statistical analysis
  - Randomization: statistical methods require that that observations (or errors) be independently distributed random variables
  - Replication: meaning an independent repeat of each factor combination
    - Allows experimenter to obtain an estimate of the experimental error
    - Allows experimenter to obtain a more precise estimate of the true mean response
  - Blocking: used to reduce or eliminate the variability of nuisance factors

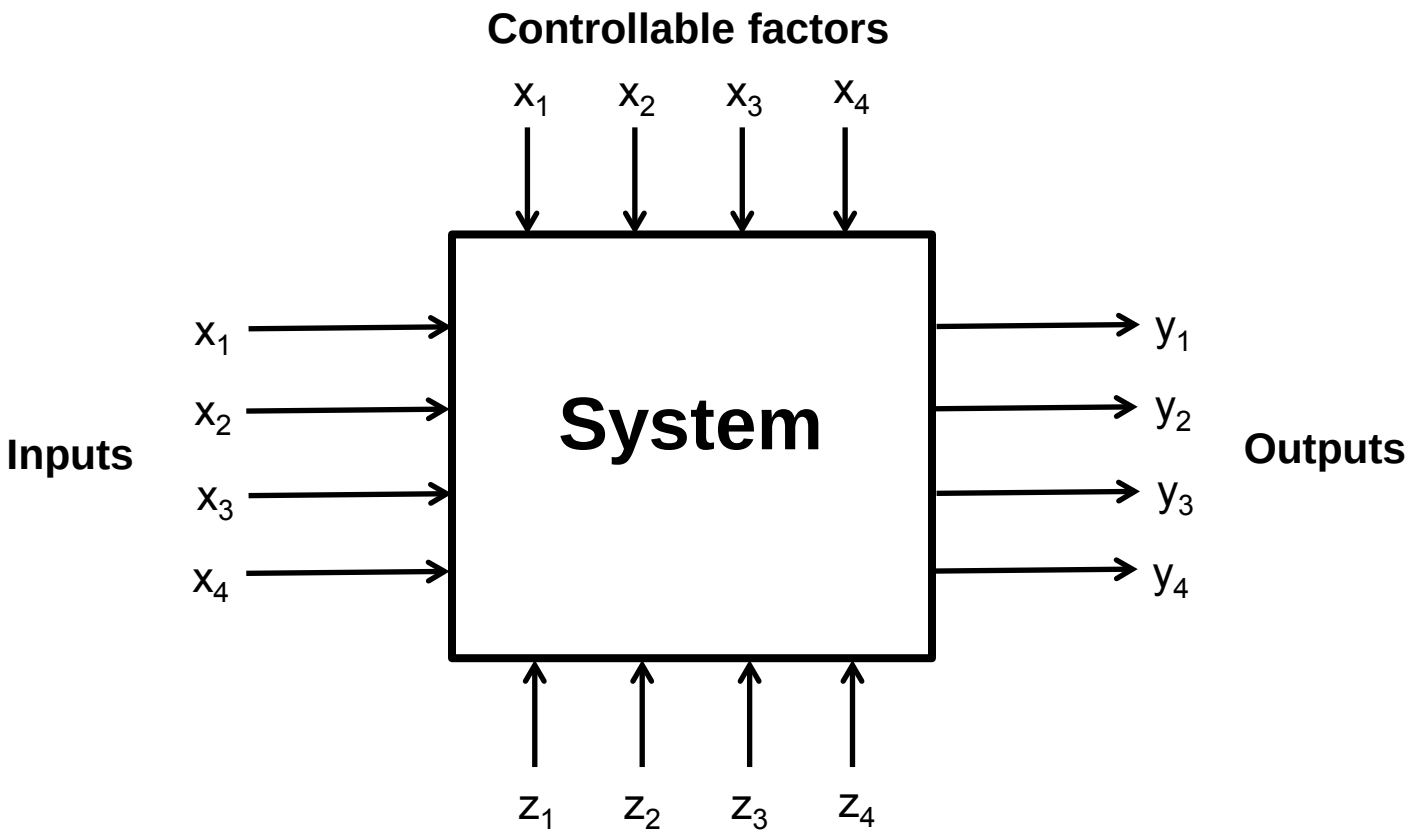
System of Systems (SOS)

- A collection of task-oriented or dedicated systems that pool their resources and capabilities together to obtain a new, more complex, "meta-system" which offers more functionality and performance than simply the sum of the constituent systems
- In other words, it's just a system
  - **Every system is a "system of systems,"** just as every system comprises interacting subsystems. The term "system of systems," is thus a tautology; not so much wrong, as an error in style revealing that the user of the term is unfamiliar with "systems"
- Nevertheless, we will differentiate a "system" from a "system of systems"
  - System will be associated with a platform level "entities" such as tanks, planes and ships
  - System of systems will be associated with a collection of entities performing a task

Experimental View of a System

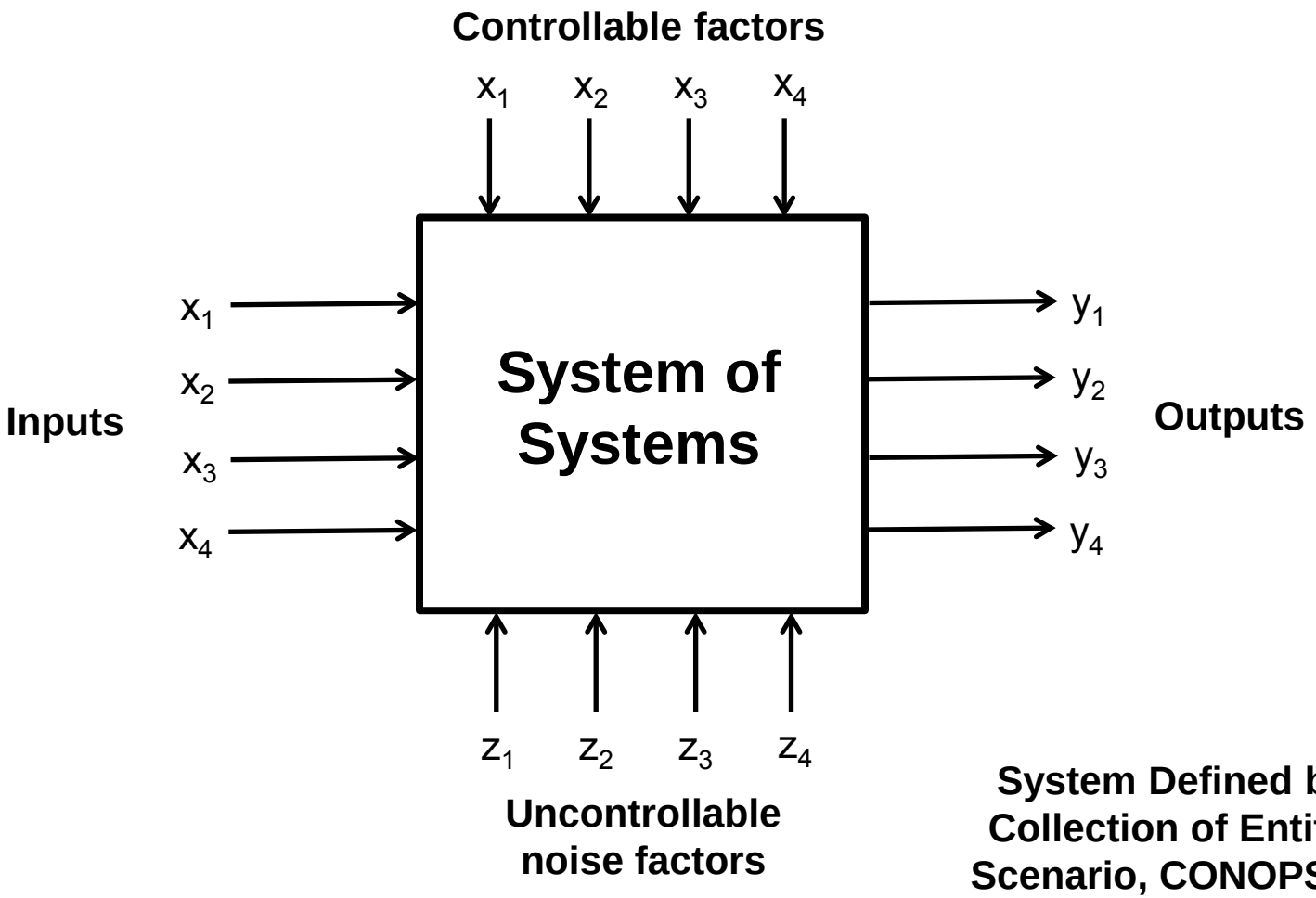
U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today



Inputs Relate to Experimental Factors (Causes), Outputs Relate to Measures (Effects)

Same for System of Systems



System Defined by a Collection of Entities, Scenario, CONOPS, etc

Entities as Systems

L-V-C Definitions

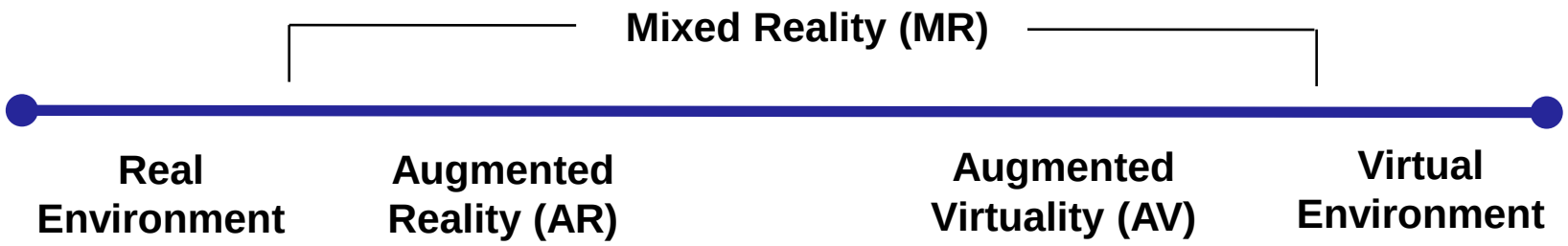
- Live Simulation
  - Real people operate real equipment
- Virtual Simulation
  - Real people operate simulated systems or simulated people operate real equipment
- Constructive Simulation
  - Simulated people operate simulated equipment
  - "Computer generated forces"

- "While categorizing simulations into three distinct classes is useful, in practice it is problematic because there is no clear division between these categories – the degree of human participation in the simulation is infinitely variable, as is the degree of system realism"
  - DoD 5000.59-M. Department of Defense Modeling and Simulation Glossary, 1998

Mixed Reality – "Degree of System Realism"

U.S. AIR FORCE

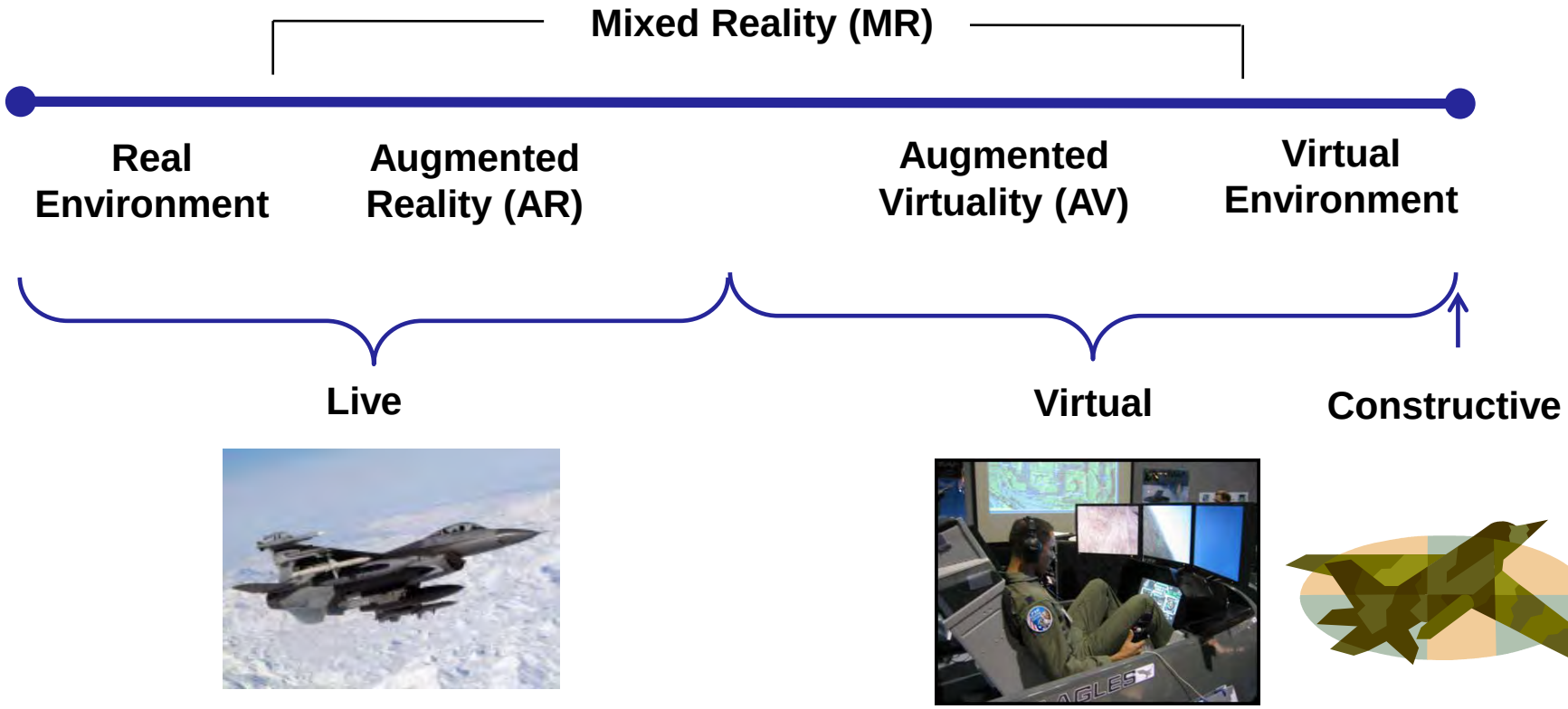
Dominant Air Power: Design For Tomorrow…Deliver Today



Reality-Virtuality Continuum introduced, Milgram, Takemura, Utsumi and Kishino

- Suggest leveraging the "reality-virtuality continuum" scale to couch Live, Virtual and Constructive elements in terms of "entities"
  - Don't view LVC's as collections of simulations
  - View LVC's as a collection (i.e., a set) of interconnected entities each interacted with a given level of mixed reality
  - The entities are systems, the collection is a system of systems
  - Bonus: this classification naturally fits distributed simulation interoperability paradigms and provides meaning to the term "system of systems"

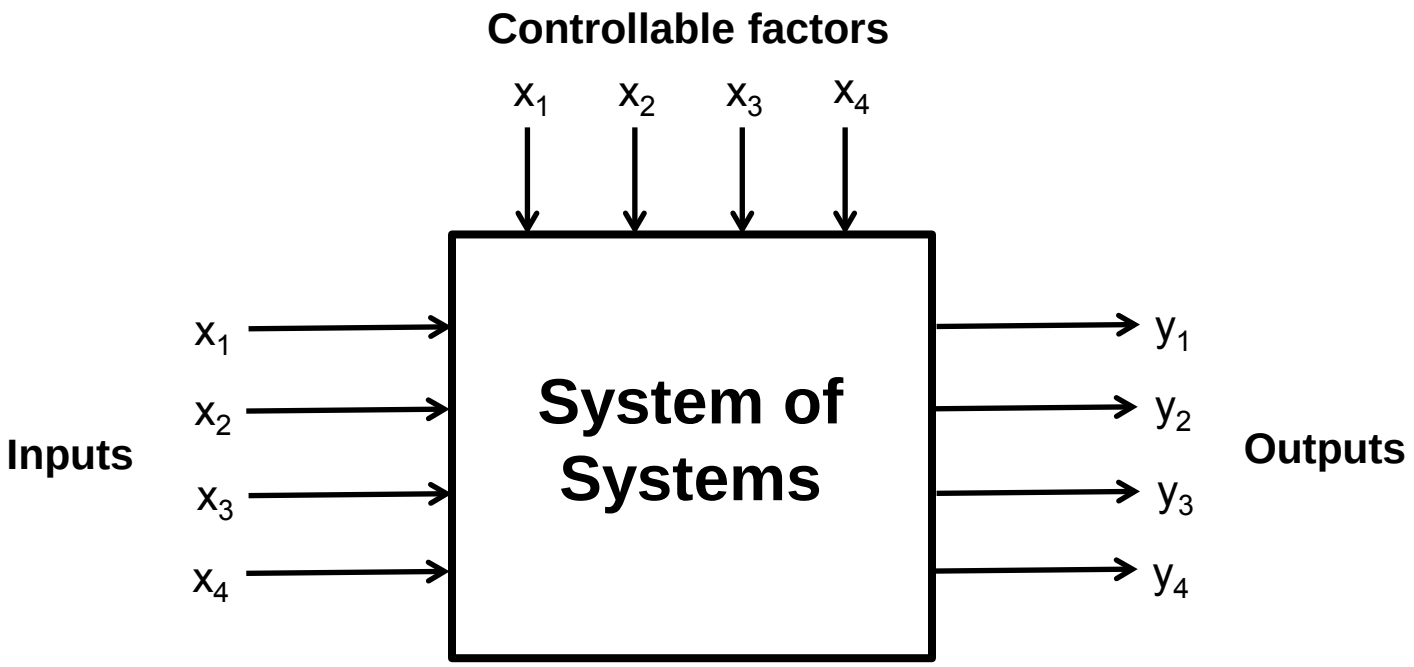
Classifying Entities as Systems



- Live, virtual and constructive entities are just interconnected systems to be analyzed like any other system (or SOS)

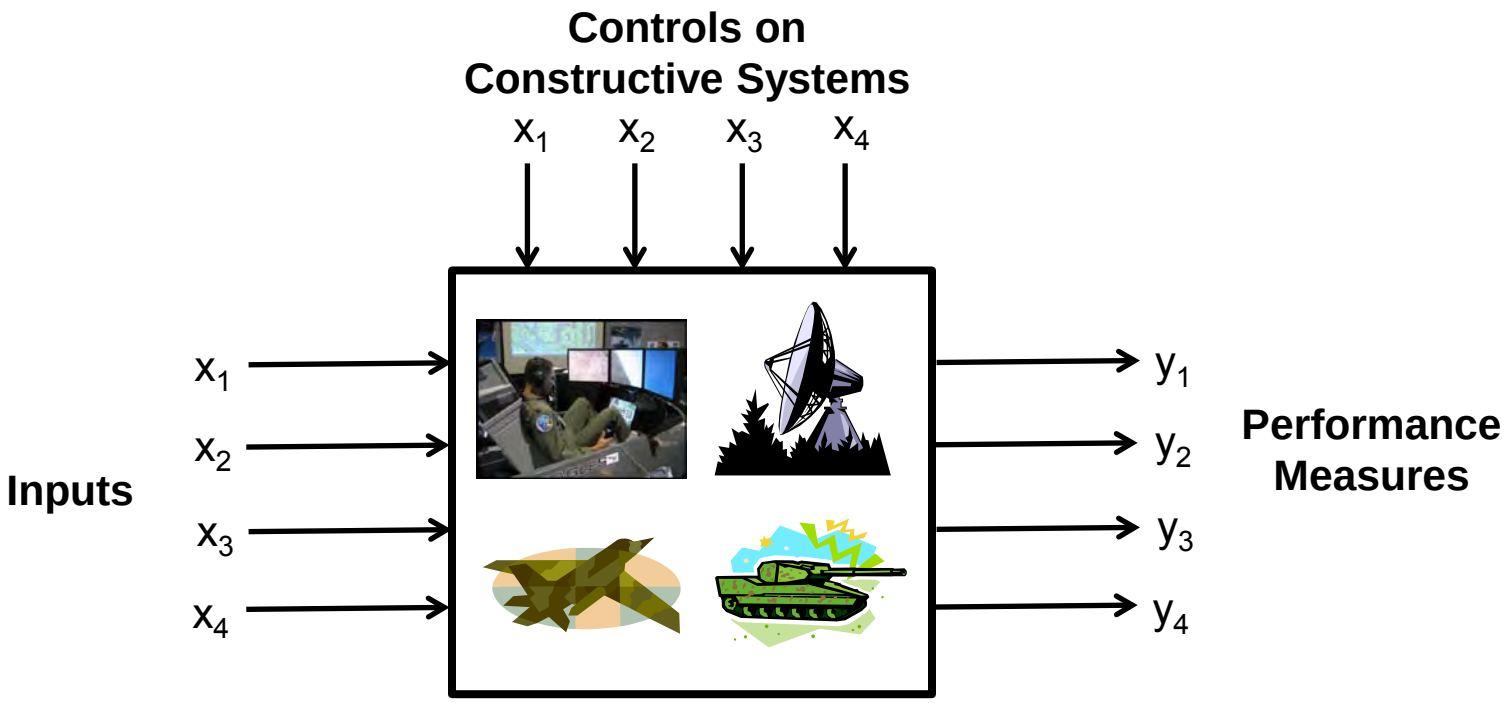
LVC Systems

Goal – Eliminate Noise Factors



- Uncontrollable noise factors should be minimized
- All factors "outside" the system under study should be controlled, meaning, as measurements (i.e., repetitions) of the system are taken, the conditions in which they are taken remain the same
  - Otherwise the experiment will become confounded

Example LVC System of Systems



- Constructive entities augment the study of virtual system

LVC Simulation Design, Development & Complicating Issues

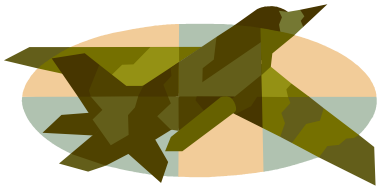
Conceptual Model

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

Live Entity

Virtual Entity



Constructive Entity

Simulation Specification

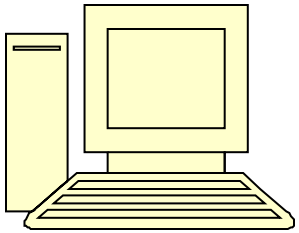
-Essential environments and scenarios
-Requisite number and types of entities
-Entity behavior, characteristics, attributes
-Fundamental interactions between entities
-Logical context of required processes
-Degree of fidelity involved

Entities Mapped to Simulations

U.S. AIR FORCE

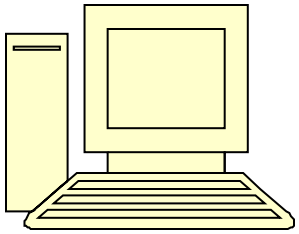
Dominant Air Power: Design For Tomorrow…Deliver Today

Live Entity

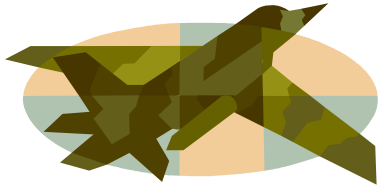


Sim0

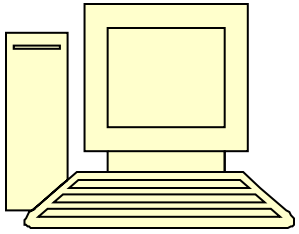
Virtual Entity



Sim1



Constructive Entity



Sim2

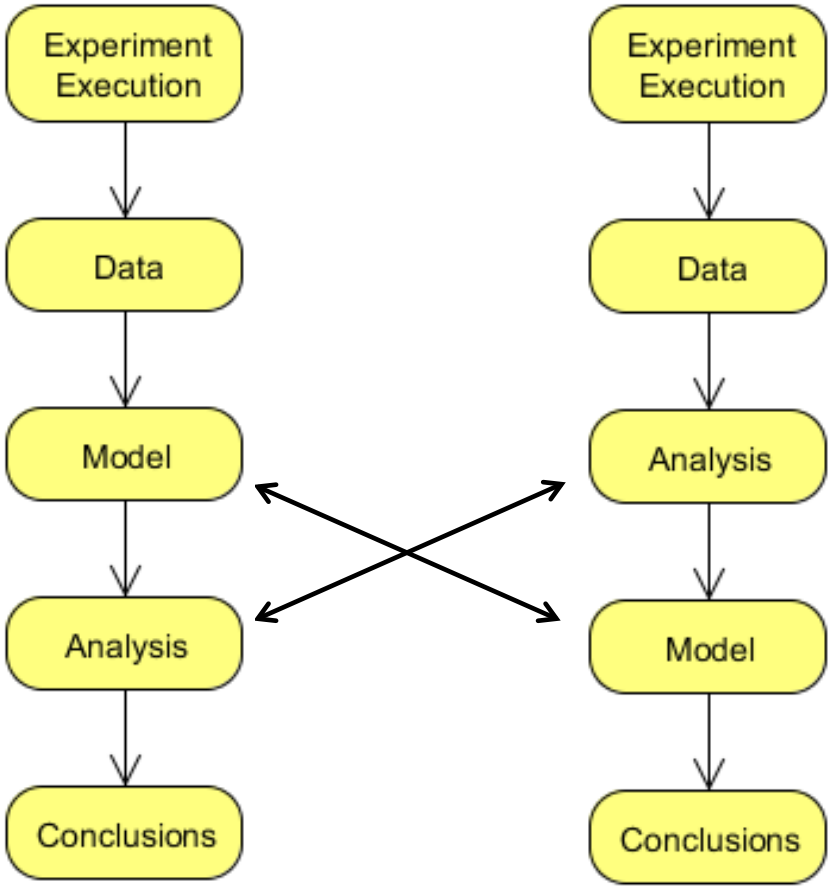
Challenges Unique to LVCs

LVC Challenges

- LVC challenges
  - Environment
  - Fidelity of models
  - Data consistency
  - Data collection and management
  - Infrastructure
  - Administrative

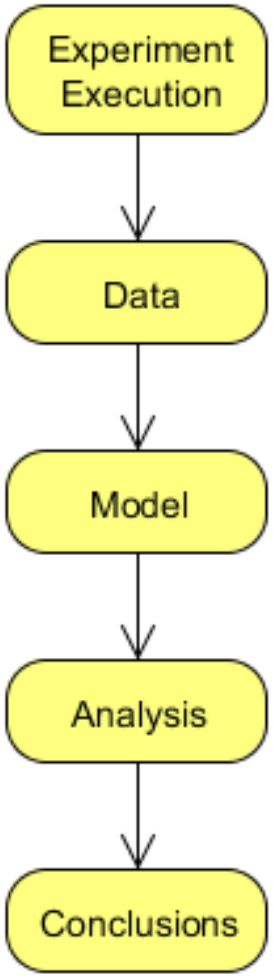
Data Analysis

Confirmatory verses Exploratory



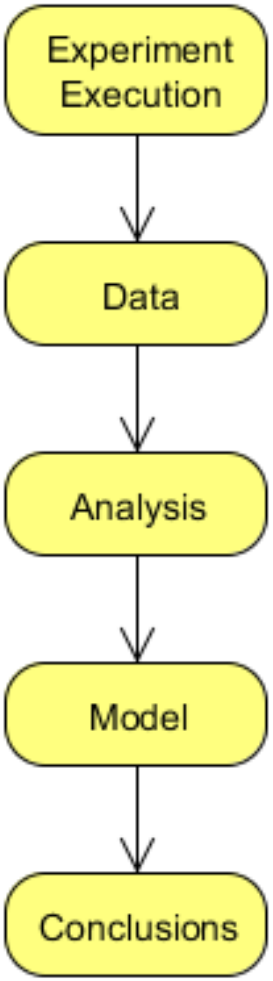
Confirmatory **Exploratory**

Confirmatory Data Analysis (CDA)



- Model
  - Imposes models on data. Deterministic models include, for example, regression models, and analysis of variance models
- Focus
  - Is on the model – estimating parameters of the model and generating predicted values from the model
- Techniques
  - Generally quantitative in nature – includes ANOVA, t tests, chi-squared tests and F tests.
- Rigor
  - Serve as the probabilistic foundation of science and engineering, they are rigorous, formal, and “objective”
- Data treatment
  - Techniques take all data and map it to a few numbers (“estimates”). Focus is on important characteristics. Some loss of information due to filtering process.
- Assumptions
  - Tests are usually very sensitive – meaning effects can be determined

Exploratory Data Analysis (EDA)



- Model
  - Data is used to suggest a model that best fits the data
- Focus
  - Is on the data – it's structure, outliers, and models suggested by the data
- Techniques
  - Generally graphical – includes scatter plots, box plots, histograms, etc
- Rigor
  - Do not share rigor or formality of CDA – they make up for lack of rigor by being very suggestive, indicative, and insightful about what the appropriate model should be
  - Techniques are subjective and depend on interpretation
- Data treatment
  - Uses all data – retain all "information"
- Assumptions
  - Makes little or no assumptions

Data Analysis Objectives

- Confirmatory
  - Confirm or falsify existing hypotheses
  - Establish cause/effect relationships
- Exploratory
  - Focuses on discovering new features in the data
  - Suggest hypotheses about the causes of observed phenomena
  - Assess assumptions on which statistical inference will be based

Examples

VS

- Mythbusters
  - Uses CDA
  - They build models, carefully design controlled experiments, collect data, analyze it, draw conclusions
  - Finally, they demo what they learned – usually blow something up
- Ghost Hunters
  - Uses EDA
  - They collect lots of data via cameras and other recording devices in an uncontrolled environment, they review tapes – look for interesting things
  - Finally, present what they saw – make guesses as to what is going on

Conclusions

- Designing LVC's for analysis does not require reinventing how to do simulation
  - It requires good experimental design considering the system being studied and an understanding of complicating issues
- Key best practice is to keep live assets and humans inside the "system under study" box
  - Minimize noise factors and control the environment
- LVC's present challenges due to distributed nature of simulation that must be considered
  - Addressing the challenges and documenting the steps to overcome them should produce higher quality, more valid LVC systems for accreditation

References

- "Design and Analysis of Experiments – 7th Edition", Douglas C. Montgomery
- "Theory of Modeling and Simulation – Second Edition, Integrating Discrete Event and Continuous Complex Dynamic Systems", Bernard P. Zeigler, Herbert Praehofer, Tag Gon Kim
- "Guide for Understanding and Implementing Defense Experimentation – GUIDEx", The Technical Cooperation Program
- "Code of Best Practice – Experimentation", Command and Control Research Program (CCRP)

Backups

System

- Definition
  - A regularly interacting or interdependent group of items forming a unified whole
- Characteristics
  - Structure: the inner constitution of a system
  - Behavior: its outer manifestation
- Internals
  - Includes its state and state transition mechanism

DIS Classification Scheme

- Practice for Distributed Interactive Simulation – Verification, Validation, and Accreditation (IEEE-Std-1278.4-1997)
- DIS exercises are intended to support
  - Virtual entities with computer-controlled behavior
    - Computer-generated forces
  - Virtual entities with live operators
    - Human in-the-loop simulators
  - Live entities
    - Operational platforms and test and evaluation systems
  - Constructive entities
    - Wargames and other automated simulations

Best Practice – Selected Quotes

Best Practice – System Definition

- Minimize noise factors
  - If people or live assets are included in the simulation environment, they must be “inside the box” (i.e., part of the system under study)
    - Both are rich sources of uncontrolled variance
    - If not inside the box, they will become noise factors
    - Affect the quality of collected data (i.e., limits ability to execute experimental replicates)
- Determining measures
  - If people or live assets are part of the system under test, then experimental measures should be associated with those “systems”
- Improving quality
  - Eliminate people “in-the-loop” if they are not associated with what is being measured
    - Circular argument, if they are not associated with what is being measured, then they are not part of the system under study… thus, they should be removed from the simulation as they will simply become noise factors

Best Practice - Fidelity

- The modern view is that validity actually means “fitness for purpose,” with the purpose being to execute the desired experimental design
- Simple models that provide useful insights are very often to be preferred to models that get so close to the real world that the mysteries of the world they intend to unravel are repeated in the model and remain mysteries

- High fidelity models can introduce confounding factors!

Best Practice - Design

- The tendency, especially in high-visibility experiments, to layer multiple concepts and capabilities into an experiment over time must be resisted
- One of the most common problems is the effort to "piggyback" transformational experiments onto training exercises
- Another common problem is introducing multiple experiments into a single venue, such that they actually *interfere with one another*
- *Experiments often lack a baseline or comparative structure. The lack of a baseline or comparison* between two meaningfully different alternatives violates a fundamental principle of experimentation

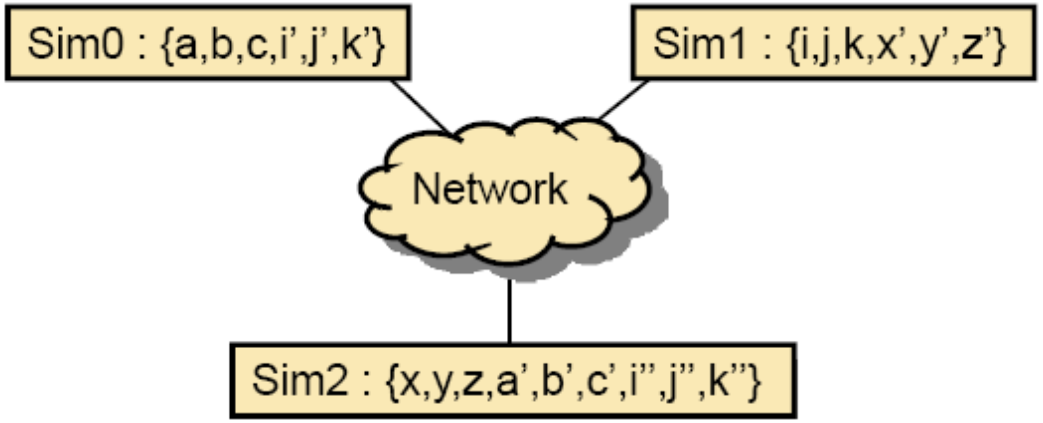
Best Practice - Human

- Train subjects adequately!
- *Failure to control for human subjects can create* problems in experiments
- Experimental designs that assume all subjects and teams are identical often fail to generate useful products because their results actually depend on the humans involved

Environment

- Environment requirements
  - Defined by experimental design
  - From the experimental design, what needs to be represented in the environment?
    - Entities/systems, subsystems, humans, datalinks, databases, etc
- Environment consistency examples
  - Environment not usually “standard” (e.g., not 15 degrees Celsius)
  - Environment database may vary across simulations and probably differs from a “live” distributed asset
  - Resolution and accuracy of environment database must be consistent with the simulation

State Space Inconsistencies



Distributed Simulation with Inconsistencies

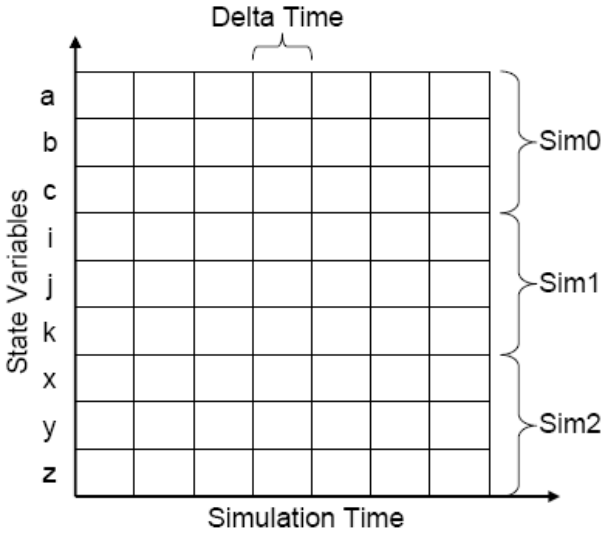
Fidelity of Models

- May have improper simulation interactions due to latency issues or differences in simulation fidelity, assumptions, etc
- Desire to interconnect an existing resource might over-shadow usefulness and/or “fit” of resource within the context of study/experiment
  - Inserting a “high fidelity” simulator, real system hardware or even a human into an experiment might be less appropriate than a simpler representation
  - In the worst case, the higher fidelity asset or model might confound the experiment by introducing new unwanted factors, thus significant sources of uncontrolled variance
- Fidelity should be based upon the design of experiments (or assessment)

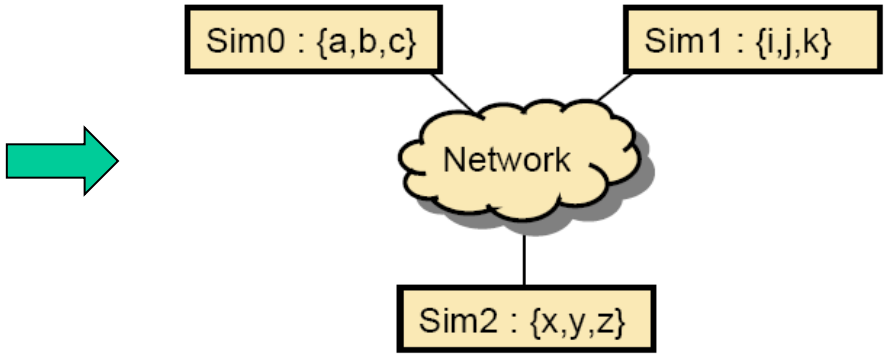
Data Consistency

- Meaning simulation state space consistency
  - The collection of data (state space information) from the simulation is the input to data analysis
- Accounting for data quality/consistency
  - While technology in the form of networks, interoperability protocols and standards enable the creation of complex distributed simulations, it cannot resolve data consistency issues that arise due to real-time execution issues
    - To improve the performance and scalability of LVC simulations, a trade between interaction performance and data consistency must be made (data consistency must be relaxed for live assets)
    - The class of problem defines consistency requirements

State Space Mapping Example



Single Simulation



Distributed Simulation

Data Management

- Focused on
  - Collection, reduction, analysis and archiving of event data
- Measures (e.g., MOPs, MOEs)
  - Defined early in the DOE process
  - Tailored to the DOE requirements
- LVC data recording
  - Local to individual applications and/or facilities
    - Multiple data recording points
    - Multiple and unique data recording formats
  - Consistency of LVC time references
    - Insert timing markers, which are global to the LVC event, into the individual data streams

Infrastructure

- Network protocol (DIS, HLA, TENA, etc)
- Network hardware
- Security
- Operations and experiment/event execution

Administrative

- MOAs between organizations
- Funding and Contracts
- Security and non-disclosure agreements
- Scheduling of facilities and range assets
- Scheduling of pilots and operators

The Modeling and Simulation Catalog for Discovery, Knowledge, and Reuse

Stephen Hunt
OSD CAPE Joint Data Support (SAIC)
Stephen.Hunt.ctr@osd.mil

The DoD Office of Security Review has cleared this report for public release
(Distribution A)
(Case No. 11-S-0097)

https://MSCatalog.osd.mil

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

The Goal: Visibility Across M&S Supported Communities

Visibility: Provide the capability to discover modeling and simulation resources (tools, data, and services) across DoD.

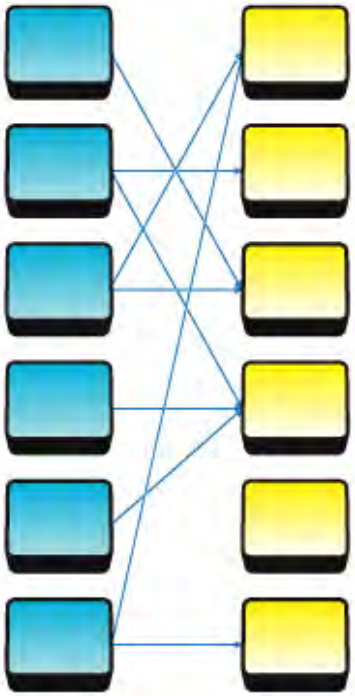
- Corporate visibility of DoD M&S resources enables reuse, improves efficiency, and helps identify high priority research areas
- More specifically, it will help us identify:
  - The M&S tools in use or in development in DoD
  - The degree to which a tool is generally accepted
  - The availability of data for existing M&S tools
  - The experts in particular tools, techniques or functional areas

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

Net-centric Vision

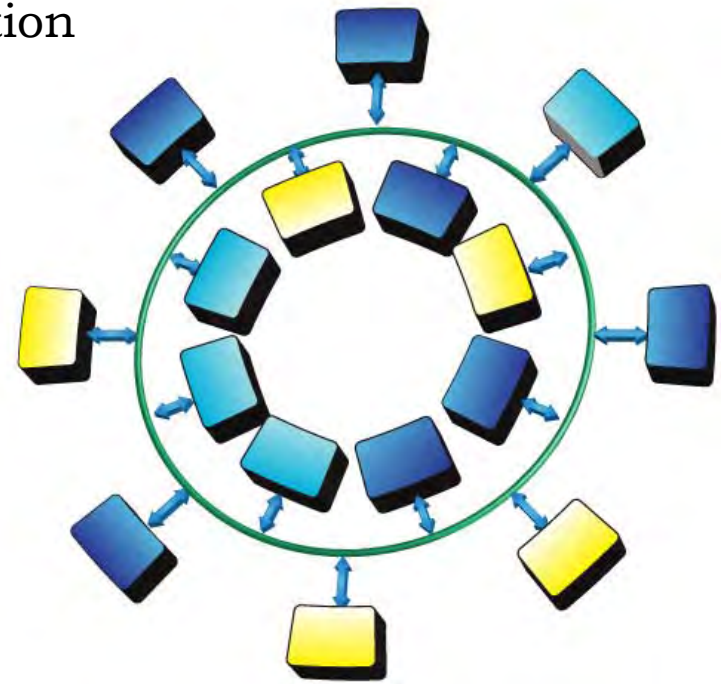
Before

- Pre-determined "point to point" connections within systems and applications on disparate networks
- Producer "pushes" information to predefined consumers



After

- Systems and applications are web-service enabled to expose their information
- Authorized known & unanticipated consumers "pull" or "subscribe to" what they need regardless of who produced the information

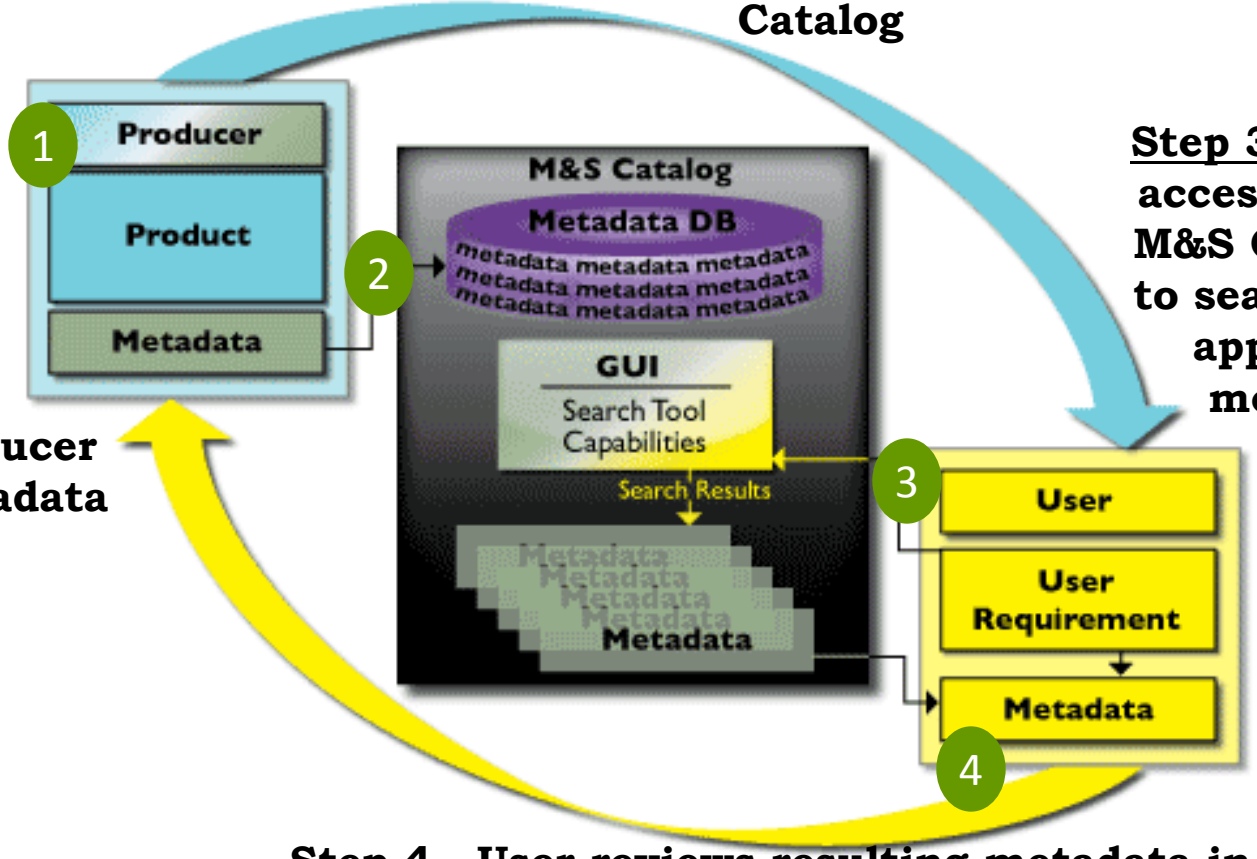


But how do you find it?

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

Discovery Process

Step 2 - Producer makes metadata electronically accessible to M&S Catalog



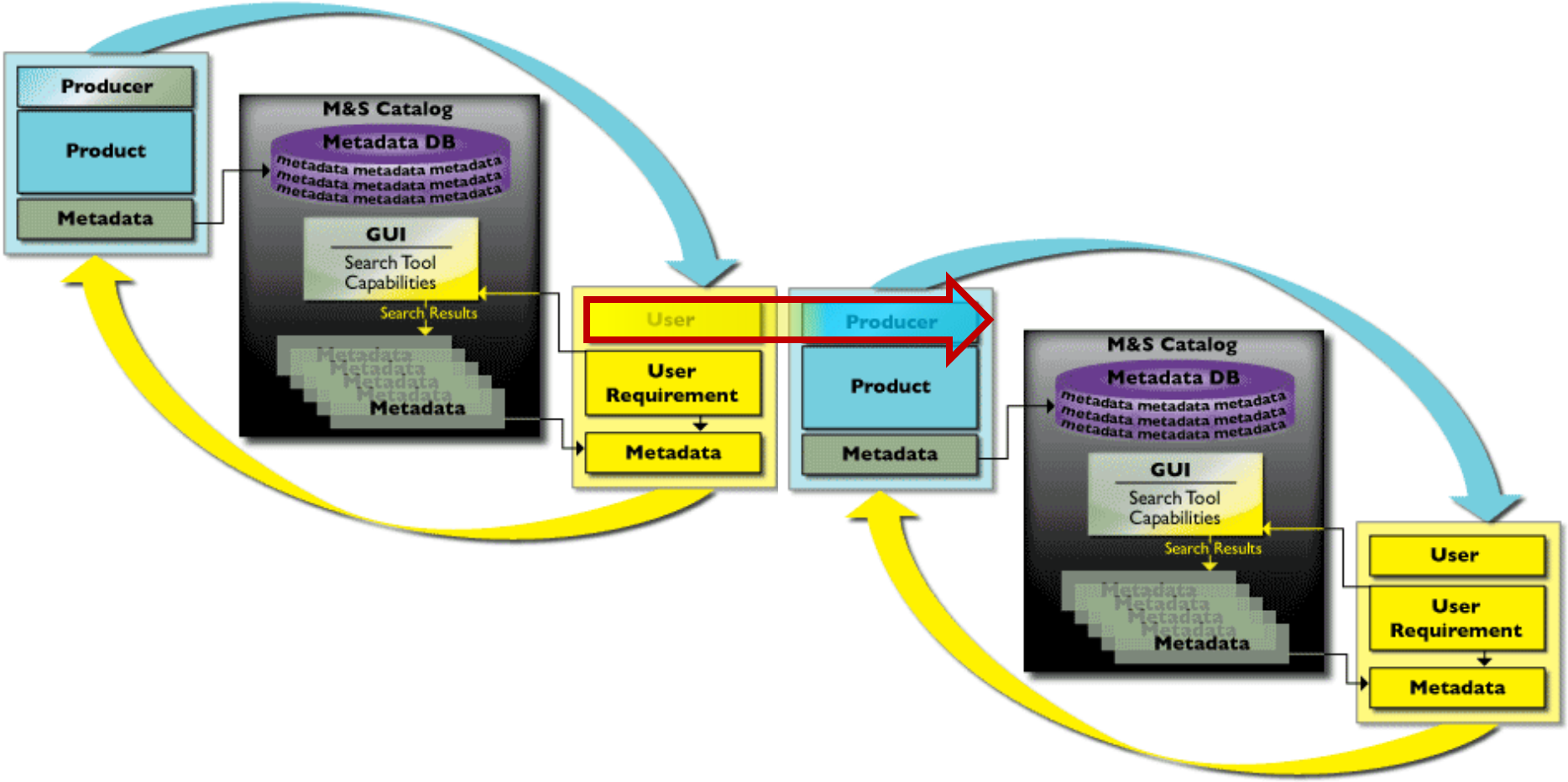
Step 3 - User accesses the M&S Catalog to search for applicable metadata

Step 1 -Producer creates metadata with all new products

Step 4 - User reviews resulting metadata in order to find the optimum product to meet requirements

User gains visibility into available resources to select best product and gains access to the product that best fulfills needs

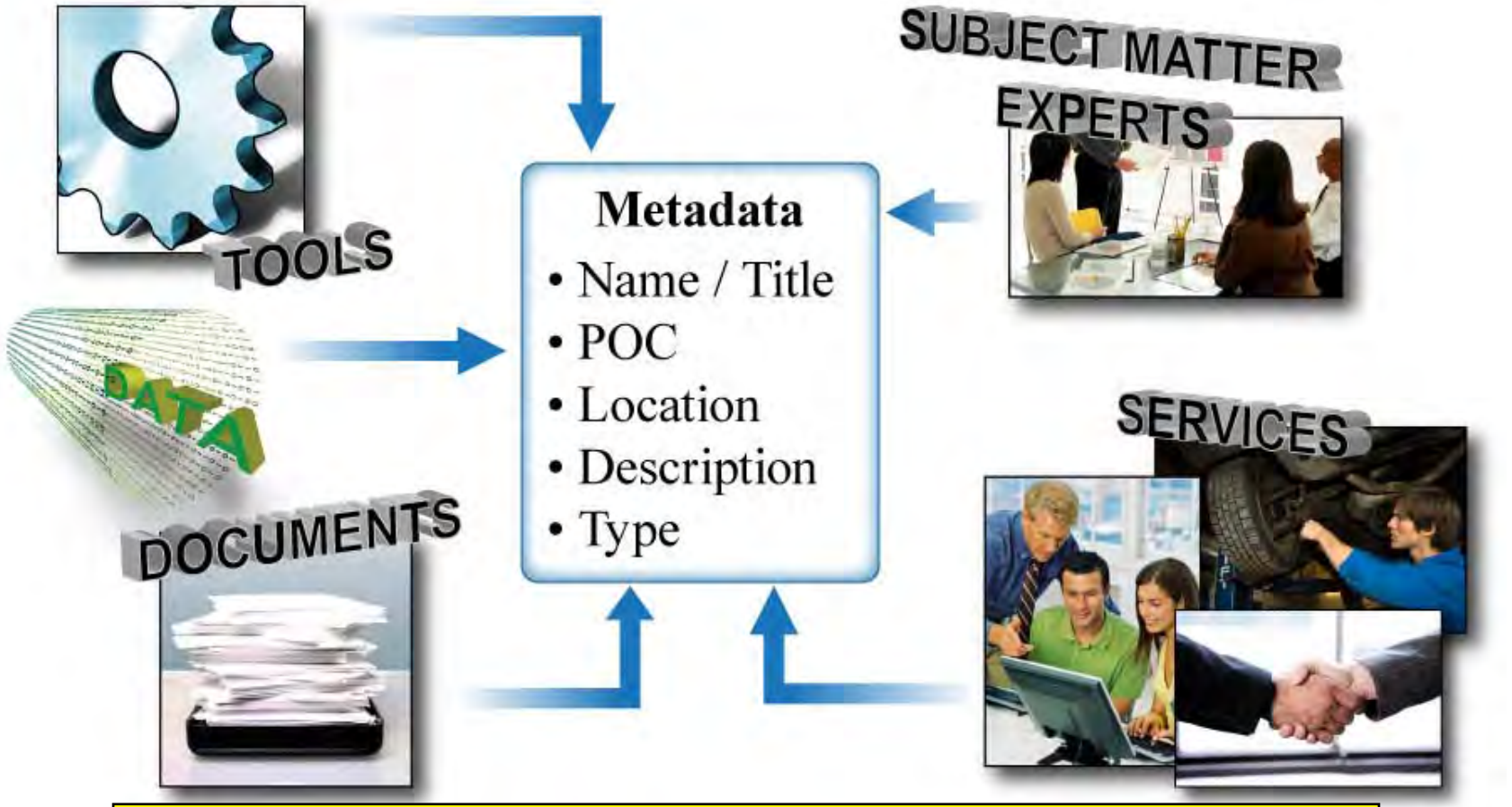
Discovery Circle of life



Users find products to complete their projects which becomes a new product to be advertised via the discovery process

- Visibility
- Net-centric Vision
- Discovery Process
- **Metadata**
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

Metadata is life blood of Discovery



Standardized metadata specifications:
DoD Discovery Metadata Spec (DDMS)
Communities of Interest DMS

Metadata is not new

Author
Title
Subject
Category
Kind of literature
Edition

973.9 Bur
What Ever Happened To The American Dream
Burkett, Larry
What Ever Happened To The American Dream
Moody Press / Chicago, IL, c1993
297 p. ; 24 cm.

ISBN 0802471757
Our founding fathers envisioned it as one of life, liberty, and the pursuit of happiness, as well as freedom to build a better future for one's family...

4 1. Economy, U.S 2. Finances (Money, Economics, Investments) I. Title

Keywords

Multiple Catalogs to search on different elements

973.9 Bur
Burkett, Larry
What Ever Happened To The American Dream
Moody Press / Chicago, IL, c1993
297 p. ; 24 cm.

ISBN 0802471757
Our founding fathers envisioned it as one of life, liberty, and the pursuit of happiness, as well as freedom to build a better future for one's family...

4 1. Economy, U.S 2. Finances (Money, Economics, Investments) I. Title

FINANCES (MONEY, ECONOMICS, INVESTMENTS)
973.9 Bur
Burkett, Larry
What Ever Happened To The American Dream
Moody Press / Chicago, IL, c1993
297 p. ; 24 cm.

ISBN 0802471757
Our founding fathers envisioned it as one of life, liberty, and the pursuit of happiness, as well as freedom to build a better future for one's family...

4 1. Economy, U.S 2. Finances (Money, Economics, Investments) I. Title

973.9 Bur
Burkett, Larry
What Ever Happened To The American Dream
Moody Press / Chicago, IL, c1993
297 p. ; 24 cm.

Media Type: Book, Hardback
ISBN 0802471757
LCCN 94108139
Published: 1993 $17.99

4 1. Economy, U.S 2. Finances (Money, Economics, Investments) I. Title

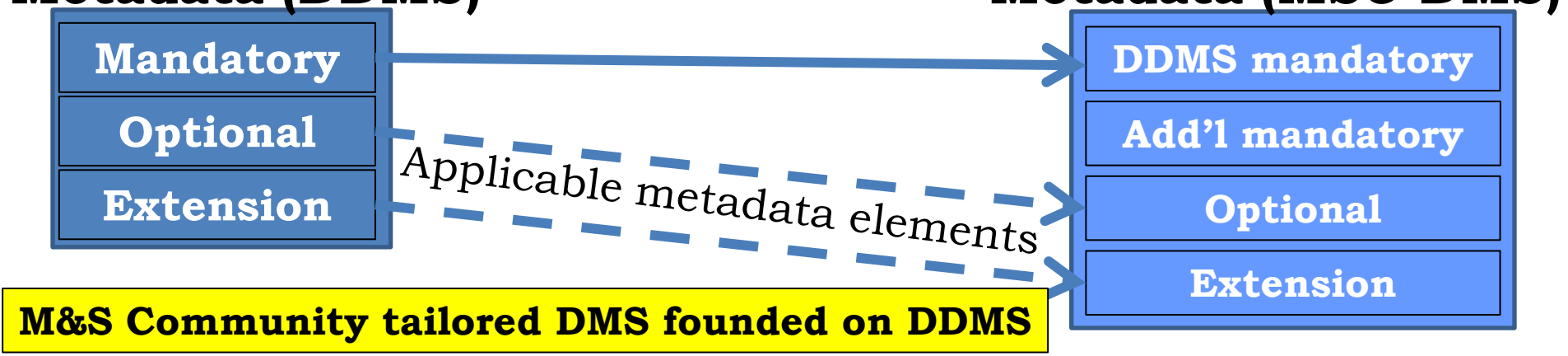
ECONOMY, U.S
973.9 Bur
Burkett, Larry
What Ever Happened To The American Dream
Moody Press / Chicago, IL, c1993
297 p. ; 24 cm.

ISBN 0802471757
Our founding fathers envisioned it as one of life, liberty, and the pursuit of happiness, as well as freedom to build a better future for one's family...

4 1. Economy, U.S 2. Finances (Money, Economics, Investments) I. Title

New technology enables easier access to metadata

M&S COI Discovery Metadata Schema (MSC-DMS) Elements



M&S Community tailored DMS founded on DDMS

Mandatory

- ✓ Title
- ✓ Type product
- ✓ Description
- ✓ Date of product
- ✓ Version
- ✓ Releaseability
- ✓ POC (Person)
- ✓ POC (Organization)
- ✓ Key words

Optional

- Acronym
- Document number
- Classification
- Associations
  - Studies
  - Tools
- Usages / purpose
- Media format
- Time period

Extensions

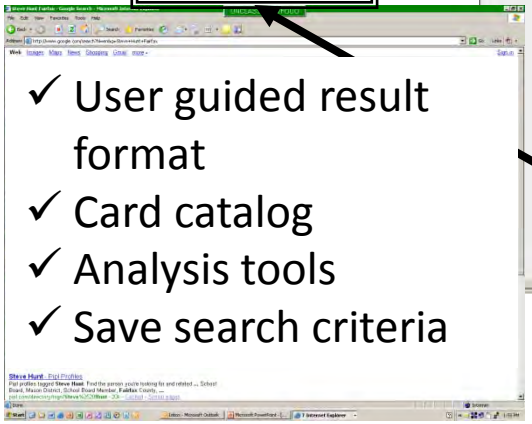
- Temporal Coverage
- Geospatial Coverage
- HLA Coverage
- Configuration Management
- VV&A Coverage

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- **M&S Catalog**
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

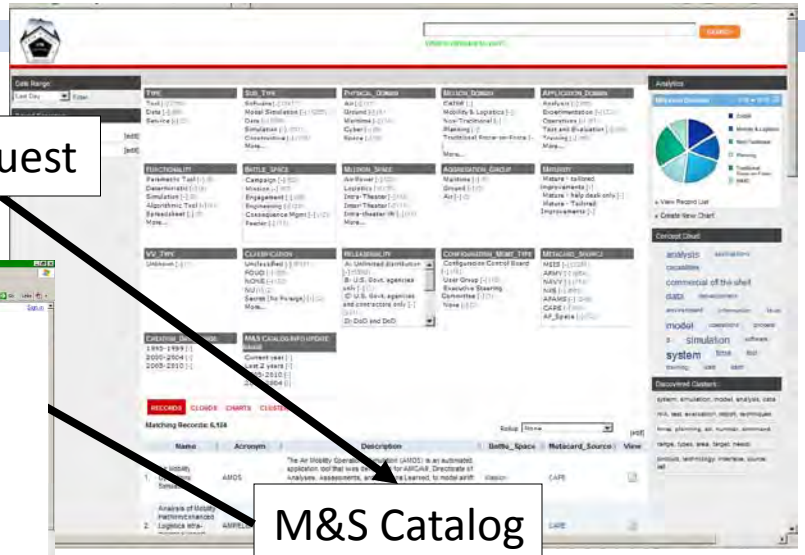
M&S Catalog Overview

Request

Response



- ✓ User guided result format
- ✓ Card catalog
- ✓ Analysis tools
- ✓ Save search criteria



M&S Catalog

- Key word search
- Faceted search
- Dynamic theme clouds
- Taxonomy driven
- Product related forum
- User product ranking
- Crawled website search

Minimize duplication and maximize currency by accessing sites as close as possible to the owner of the information

Metadata

Metadata

Metadata

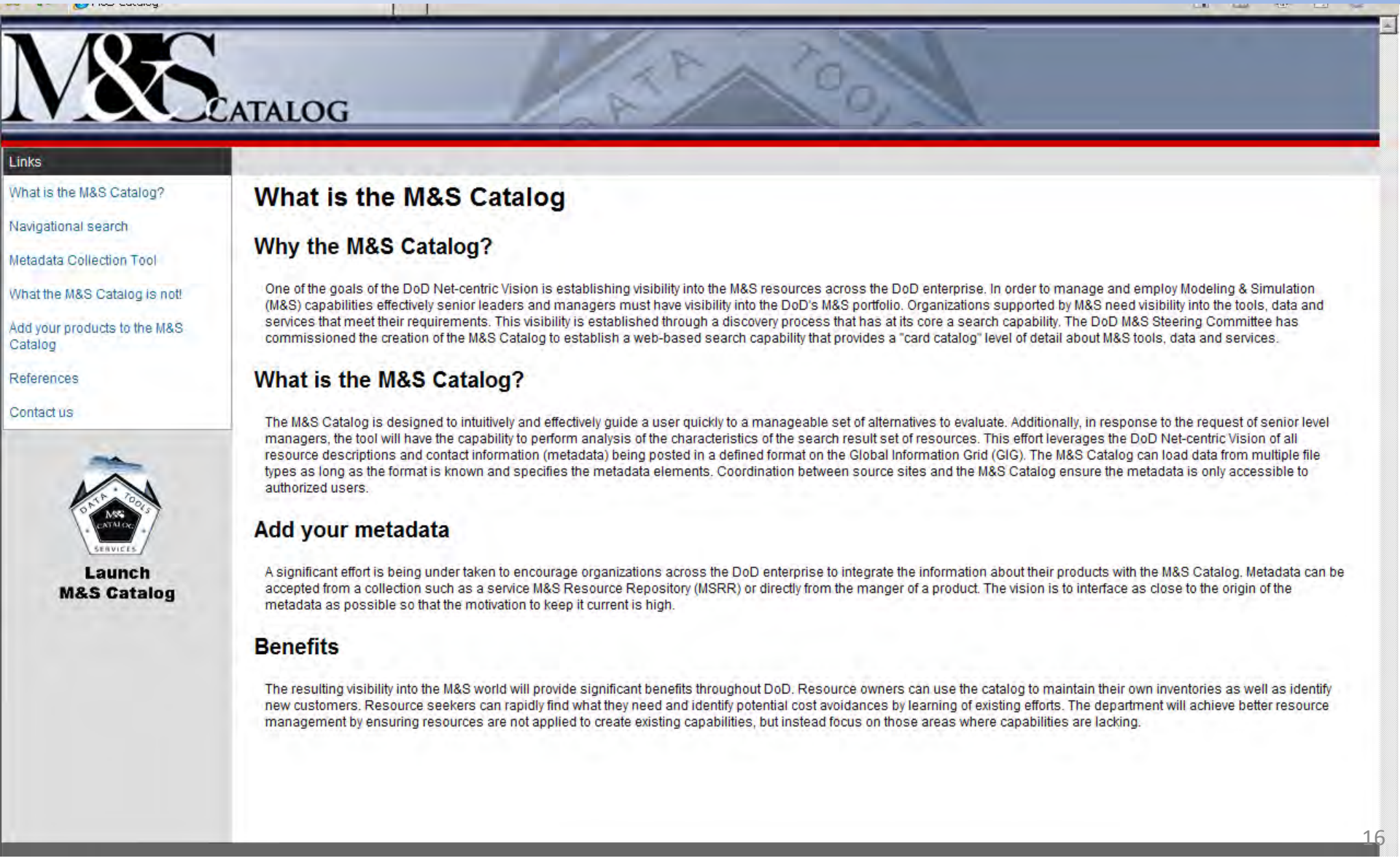
Metadata

Site 1 | Site 2 | Site 3 | Site N

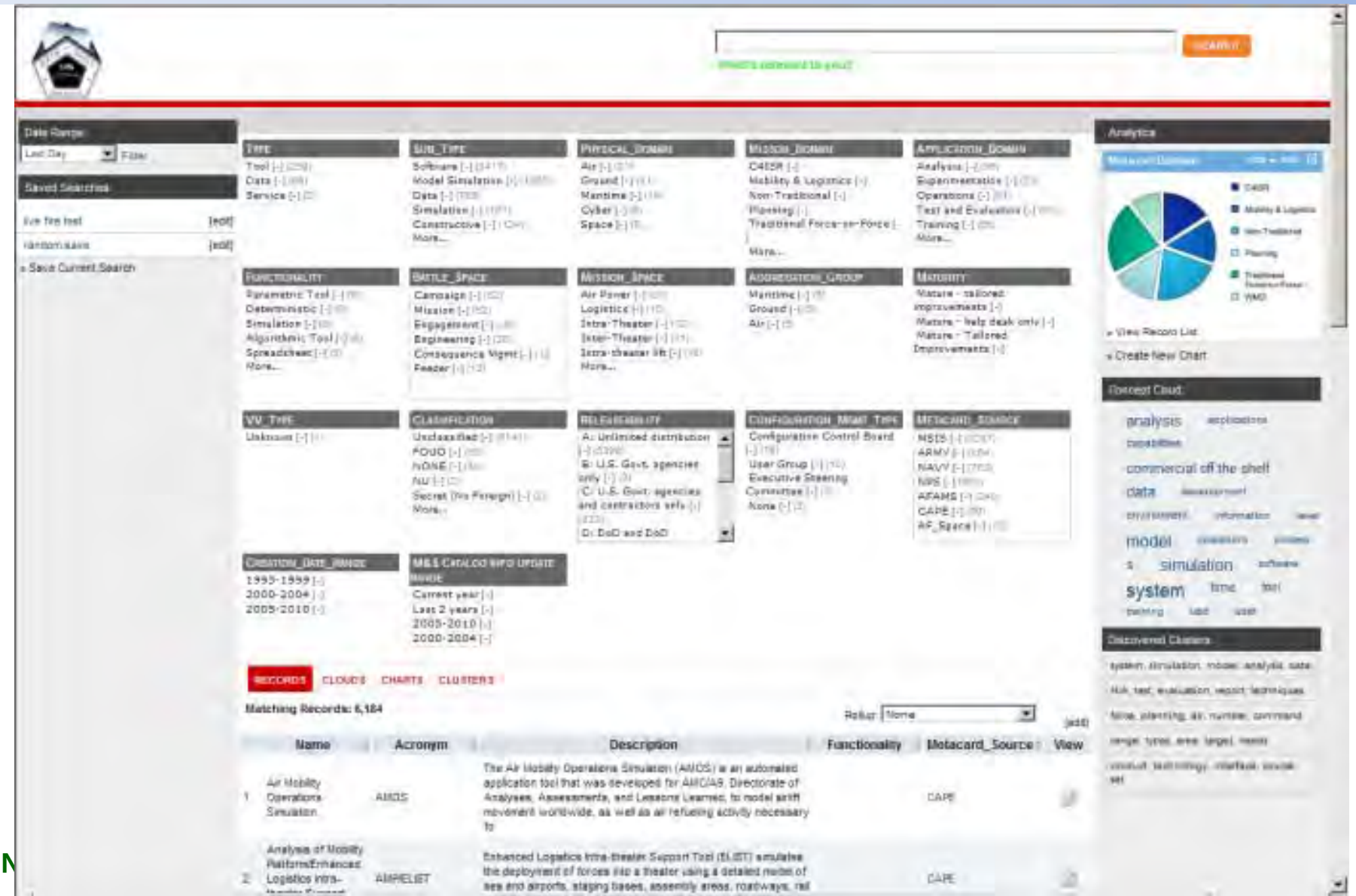
Tools | Data | Metadata Resource Sites | Services | SMEs

M&S Catalog can only find information that is made available online

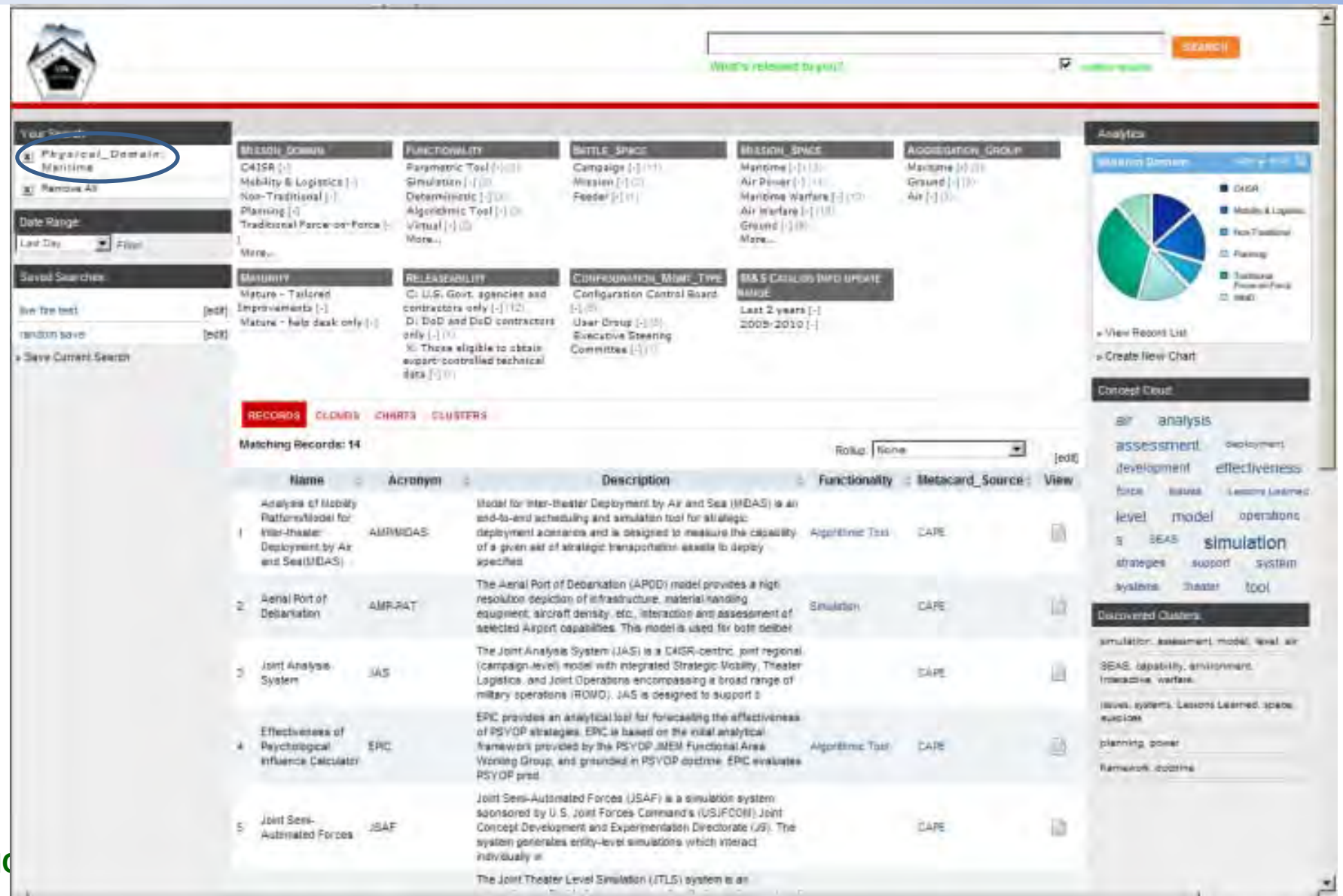
M&S Catalog Home Page



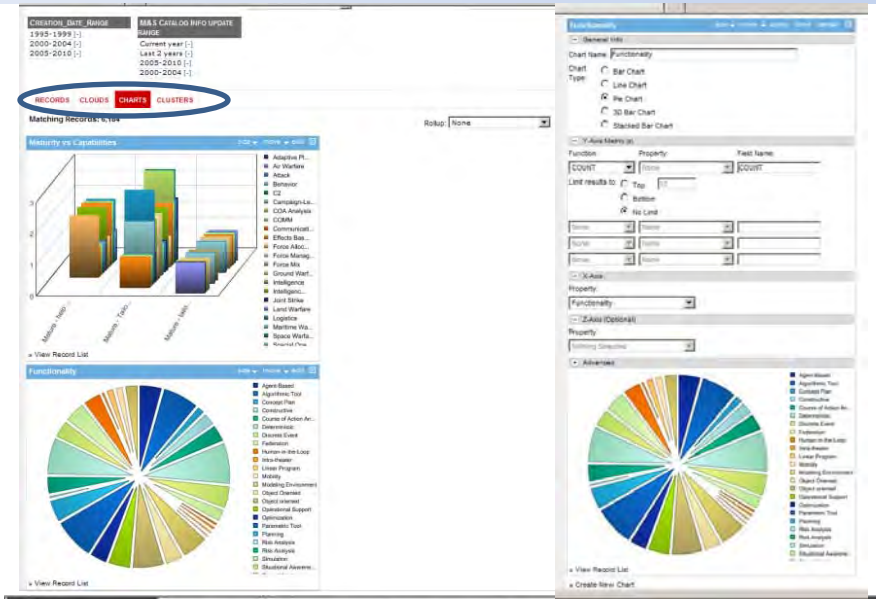
M&S Catalog Search

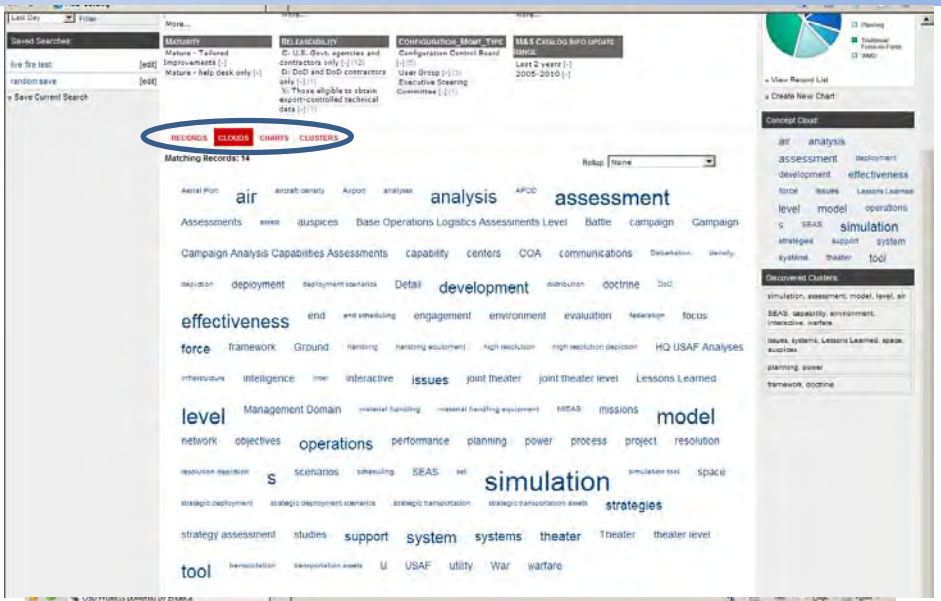


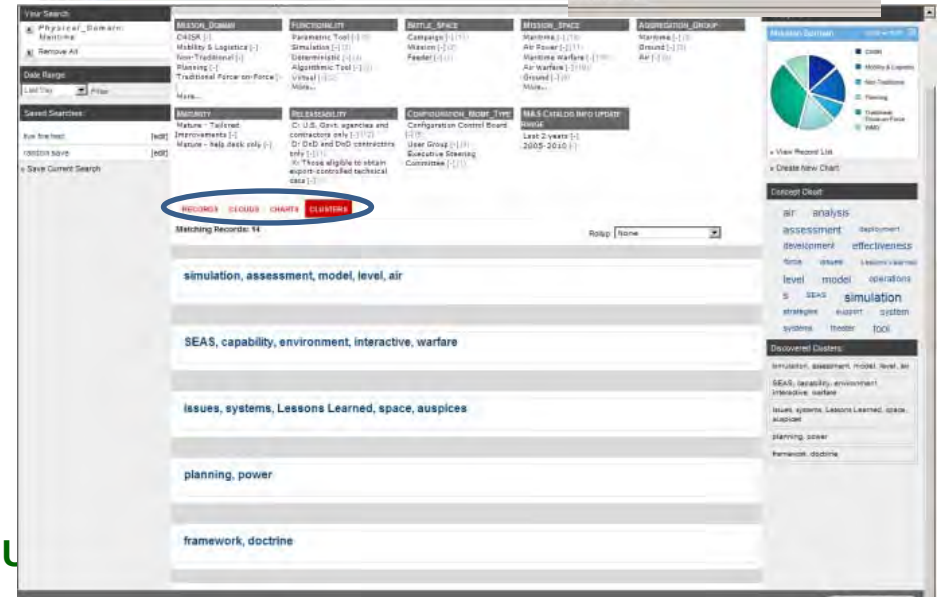
M&S Catalog Search
Maritime Selected



M&S Catalog Search
Additional Features







- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

Your Roles may be…

- **Senior Leader (Producer & User)**
  - Support the establishment and accessibility of metadata for all of your organization's products
  - Utilize the Catalog to support the management of your M&S resources
- **Producer** – provide asset metadata to the M&S Catalog
  - Make your data available to others to reuse or refine
  - Provide a mechanism to document and manage your own M&S resources
- **User** – provide feedback on content and usability
  - Identify the cost avoidance associated with Catalog use
  - Identify desired features and new sources
- **IT technician**
  - Comply with standards and schemas
  - Establish electronic connectivity between metadata & M&S Catalog
- **All M&S Practitioners** – help get the word out
  - Highlight the advantages of Catalog use in reports and briefings
  - Participate in professional meetings that address technology initiatives to improve the state of M&S

You may have multiple roles

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

Benefits

Producers
- Enable interoperability of tools and data formats & methods
- Establish authoritative standing
- More users of their product
- Greater benefit on investment to DoD

Users – Leadership & analyst / technician
- Improved management of M&S resources across the enterprise
- Rapid access to needed data, tools or services
- Reduced costs & time in fulfilling requirements
- Being able to reuse and build on existing vetted products

Technical
- Common discovery metadata schema
- COTS upload all file formats
- Web-based enables access
- Ability to accept metadata push enables network protections

Challenges

Who / What / Where / How ?

- Who is responsible for overseeing metadata creation or accuracy?
- What is motivation to create & maintain metadata?
- Where to put metadata?
- How to fund a search tool that supports all?
- How to create metadata in specific formats?
- How to describe that special something in metadata schema?
- How will the metadata be used by others?

Sharing vs. Security

- Information Assurance (IA)
  - –Firewalls, PKI certificates, Separation of public from private
- Personally Identifiable Information (PII)
- Aggregation of unclassified information can reveal classified info.

Motivation to Contribute

Top Down

- Leadership establish priority on creation, maintenance and sharing metadata
- Leadership resource level of effort and metadata creation, maintenance and sharing mechanism
- Inclusion of metadata in all deliverable
- Use of M&S Catalog Analytics to manage organizational products

Bottom up

- Increased visibility into products
- Increased users for product
  - Justification for funding
- Commenting and ranking along with user list provide pedigree
- Top ranking may lead to becoming authoritative source

Enabling

- Tools to minimize level of effort in creating, maintaining and sharing metadata

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- **Participation**
- Next steps

Your Participation Tasks

Producers
- Determine what products are to be advertised
- Integrate metadata with a discovery service (e.g., M&S Catalog)

Users – Leadership & analyst / technician
- Provide input into metadata format and taxonomy
- Encourage participation by producers

Technical
- Develop tools to automate metadata creation and integration
- Map metadata format to DoD metadata or COI specifications

Entire discovery process and net-centric vision is dependent on the creation of & access to metadata

Where we are now- Integrated Metadata Source Sites

(over 6184 records – 6085 unique tools)

	Major Sources	# of records
Original 3	AF MSRR	240
	Navy MSRR	753
	CAPE JDS	80
	AF SPC SARP	72
	ARMY MSRR	864
	DoD MSIS	3,281
	NAVAIR MFS	53
	Navy METOC OAML	61
	NPS MOVES	663
	PEO IWS	83

Can we add your organization's or activity's name to this list?

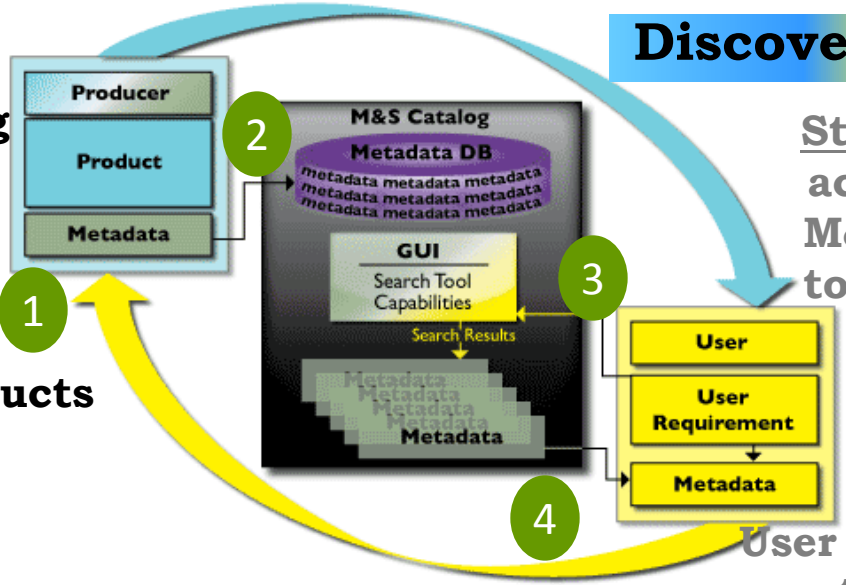
Potential New Source Sites

- In process of integration
  - USAF Logistics M&S
- Expressed interest
  - Army Electronic Proving Ground (ATEC)
  - Test and Training Enabling Architecture (TENA) Repository
  - USAF ASC/XRA-SIMAF (EAAGLES)
  - USMC PM TRASYS
  - NRL (interactive scenario builders)
  - Naval Air Warfare Center Training Sys Div (Submarine training group)
  - Los Alamos National Labs

M&S Catalog Source Integration

Step 2 - Producer makes metadata electronically accessible to M&S Catalog

Step 1 -Producer creates metadata with all new products



Step 3 - User accesses the M&S Catalog to search for applicable metadata

Step 4 – User reviews resulting metadata in order to find the optimum product to meet requirements

Organizational tasks to integrate in M&S Catalog:

1. Determine products to include in M&S Catalog
2. Develop or locate metadata for those products
3. Establish metadata in electronically accessible location
4. Integrate metadata location with M&S Catalog
   a. Map metadata to M&S Catalog data model
   b. Complete Data Exchange Agreement
5. Establish business model ensuring metadata accuracy and currency

- Visibility
- Net-centric Vision
- Discovery Process
- Metadata
- M&S Catalog
- Roles
- Benefits
  - ✓ Challenges
  - ✓ Motivations
- Participation
- Next steps

M&S Catalog Next Steps

Outreach

- Reaching out to interested source organizations
- Plan and conduct outreach to users

Improvements

- Integrate metadata from identified accessible new sources
- Develop and improve tools to help create and transform metadata.
- Develop mechanisms to enable a web service automated upload
- Establish Web 2.0 interactive functions
- Improve web site interoperability via user feedback
- Expand management analysis capabilities

Working to minimize effort required to create metadata & integrate with M&S Catalog

31

Summary

- The DoD M&S Catalog provides a window into the department's tools, data, and services
- The Visibility Project has achieved a proof of concept and is proceeding into stable operations using a commercial search engine
- How you can help:
  - **Provide us with the organizations or departments (& POC info) that generates /should generate metadata**
    - **Send an "email of introduction"**
  - **Encourage the creation of metadata with all new products and update information on existing tools**
    - **Fund the creation and maintenance of metadata**
  - **Encourage personnel to user the M&S Catalog**
  - **Provide feedback on tool usability, analytic capabilities & facetted search selection options**

Discovery is more of a business model than technical challenge

Questions??

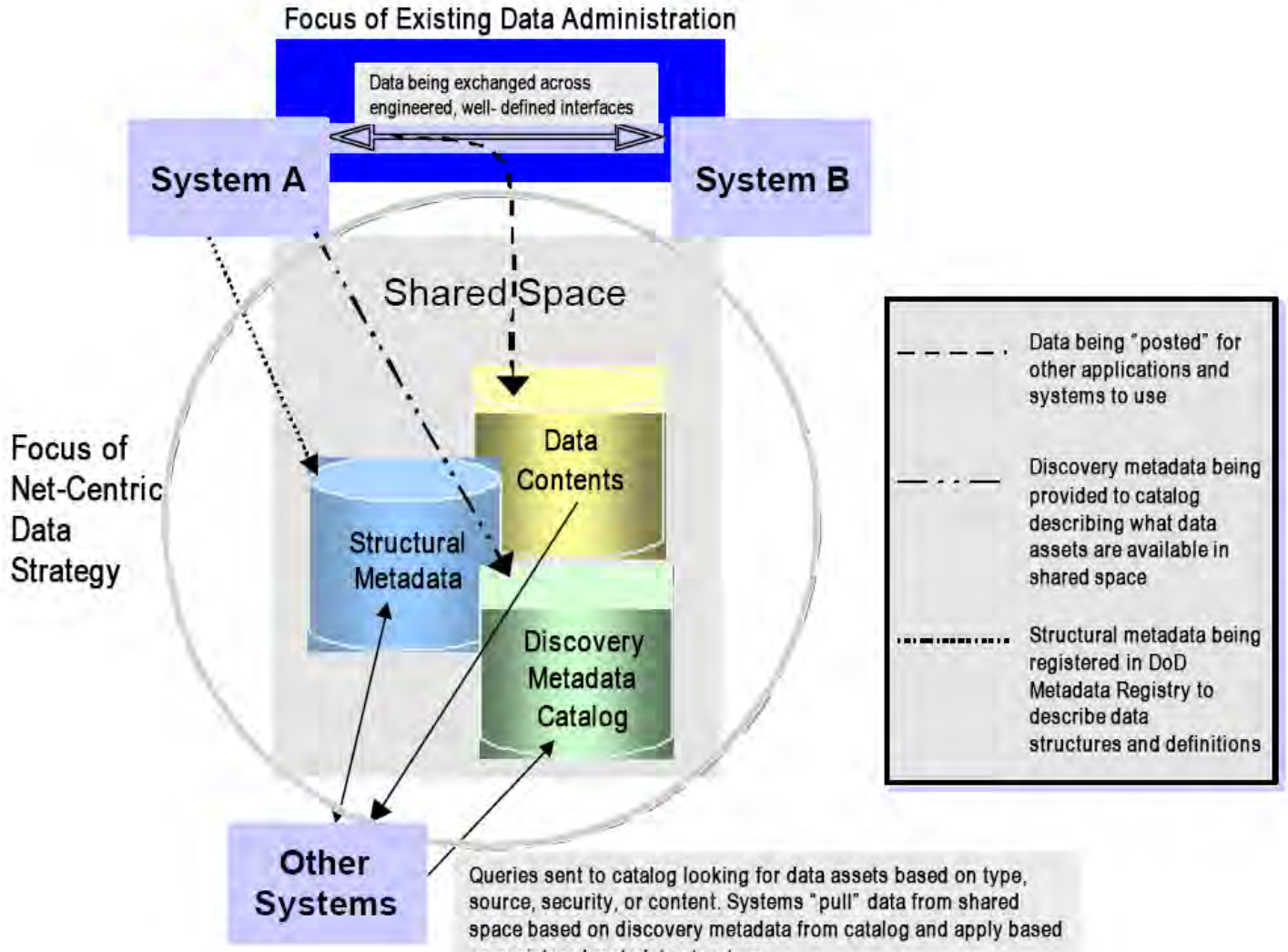
Answers – MSCatalog@osd.mil
https://MSCatalog.osd.mil

Back-up

https://MSCatalog.osd.mil

Net-centric Vision Change in Perspective

Figure 2. Scope of the Net-Centric Data Strategy



Net-centric Vision

2.1 DOD DATA VISION

- "All data is advertised and available for users and applications when and where they need it.
- "Users and applications "tag" data assets with metadata, or data about data, to enable discovery of data. Users and applications post all data assets to "shared" space for use by the Enterprise."

3.1.3 Create and Maintain Catalogs

- "Metadata catalogs will advertise the existence of shared data and will contain information about all data assets contained in the associated shared space (including databases, system output files, web pages, documents, and access services)."
- "COIs will establish and maintain catalogs. Each catalog may be organized according to the community-defined ontology. An Enterprise catalog will be established that links to community catalogs, effectively creating a 'catalog of catalogs.'"

Table C2.T2. Primary Responsibilities of COIs

- Identify data assets and information sharing capabilities, both operational and developmental, that should conform to the data strategy goals of DoD Net-Centric Data Strategy.
- Identify approaches to enable those data assets and information sharing capabilities to satisfy data strategy goals and to measure the value to consumers of shared data.
- Develop and maintain semantic and structural agreements to ensure that data assets can be understood and used effectively by COI members and unanticipated users.
- Register appropriate metadata artifacts for use by the COI members and others.
- Extend the DoD Discovery Metadata Specification (DDMS) (Reference (c)) as required to ensure that COI-specific discovery metadata is understandable for enterprise searches.

Net-centric Glue
Metadata

2.1.2 Metadata

- Metadata can be associated with all data in the Enterprise for the purposes of "advertising" data assets for discovery
  - Metadata that describes or summarizes key attributes and concepts of a data asset are used in the discovery process
  - This "discovery" metadata allows users and applications to quickly search through a wide range of data assets to identify those assets that are most valuable to support their needs

3.1.2 Associate Discovery Metadata With Data Assets

To facilitate discovery of data assets, users and applications will provide discovery metadata, in accordance with the DoD Discovery Metadata Standard (DDMS), for all data posted to shared spaces.

3.1.3 Create and Maintain Catalogs

At a minimum, the mandatory discovery metadata elements in the DDMS must be represented within metadata catalogs for any data asset posted to a shared space.

Table C2.T2. Primary Responsibilities of COIs

- Identify data assets and information sharing capabilities, both operational and developmental, that should conform to the data strategy goals of DoD Net-Centric Data Strategy.
- Identify approaches to enable those data assets and information sharing capabilities to satisfy data strategy goals and to measure the value to consumers of shared data.
- Develop and maintain semantic and structural agreements to ensure that data assets can be understood and used effectively by COI members and unanticipated users.
- Register appropriate metadata artifacts for use by the COI members and others.
- Extend the DoD Discovery Metadata Specification (DDMS) (Reference (c)) as required to ensure that COI-specific discovery metadata is understandable for enterprise searches.

Discovery Metadata

C4.2. MAKING DATA VISIBLE

C4.2.1. Activity Area Overview

C4.2.1.2. The discovery metadata may also include elements defined as COI extensions described in DoD Discovery Metadata Specification (DDMS).

- Elements are related to the subject matter of the data asset
- Necessary for specialist consumers in a particular subject matter to locate relevant data assets

C4.2.2. Implementation Activities

C4.2.2.5. Create a discovery capability containing discovery metadata

- The purpose of a discovery capability is to provide DDMS-formatted discovery metadata in response to federated searches
- Capability developers will then leverage the COI's discovery metadata in the discovery capability, allowing authorized users to discover the COI's data assets

C4.2. MAKING DATA VISIBLE

C4.2.1. Activity Area Overview

C4.2.1.1. Making data visible focuses on creating discovery metadata and deploying discovery capabilities that catalog data assets for users to find.

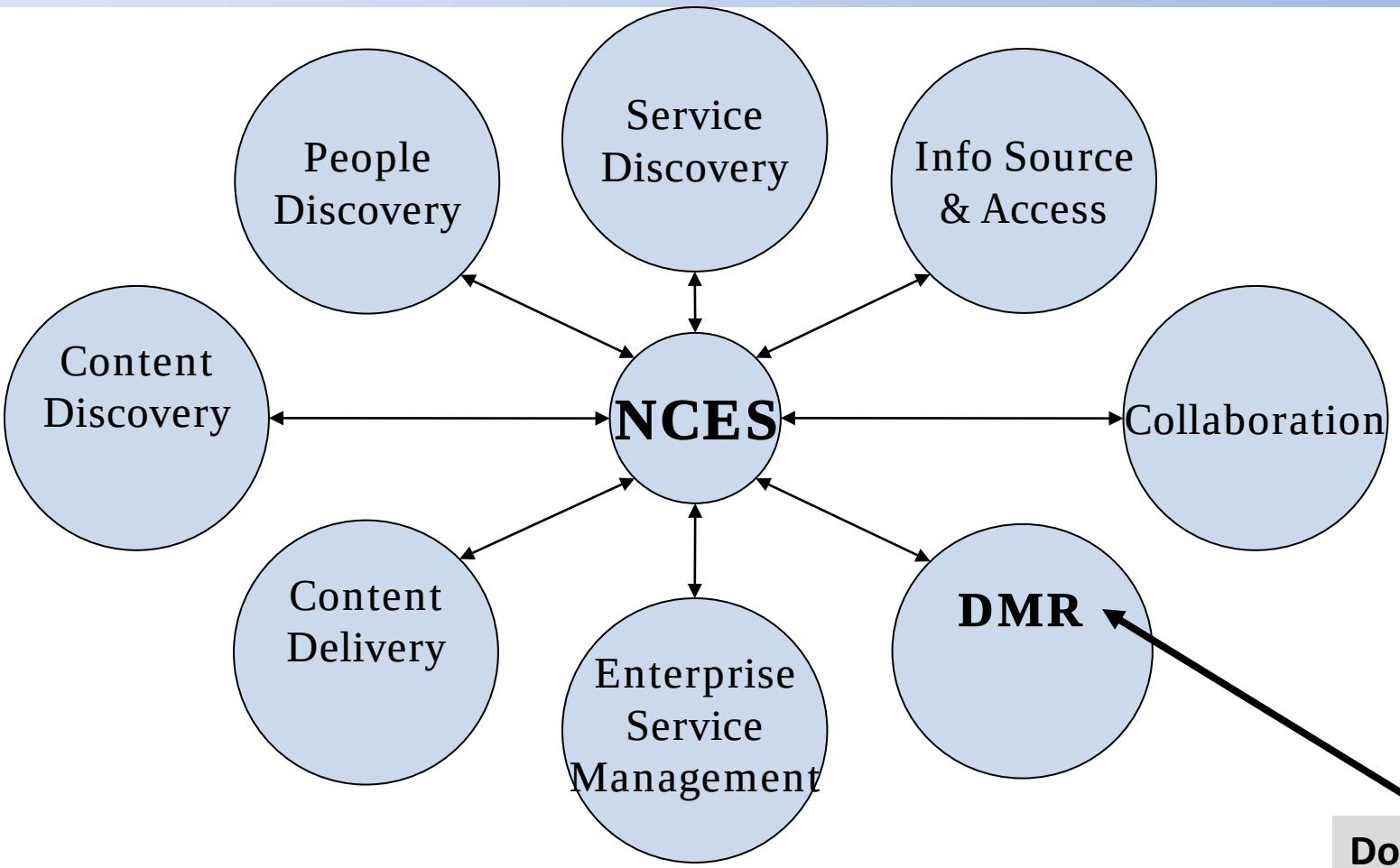
- The overall goal of data visibility is to enable DoD users to sift through the enormous volume and variety of DoD information holdings and quickly discover data assets that pertain to specific subjects of immediate interest.
- Enable consumers to find out who is responsible for specific assets, where the assets are located, what kind of data is available, and how to go about accessing them

C4.2.2. Implementation Activities

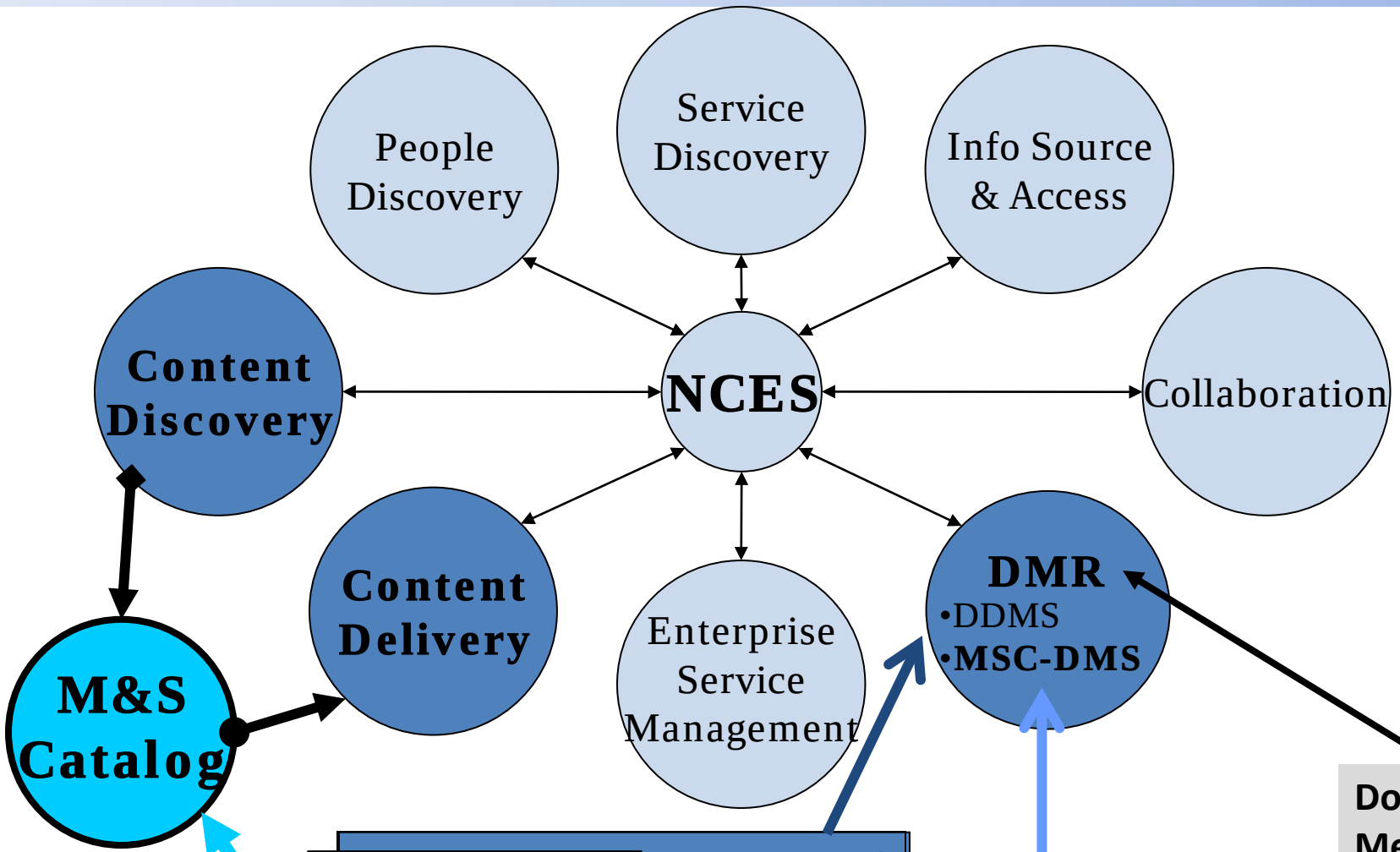
C4.2.2.5. Create a discovery capability containing discovery metadata.

- Identify the information and resources associated with providing a discovery capability that the COI can use for its discovery metadata
- Federated searches
- Allowing authorized users to discover the COI's data assets

DoD Net-centric Enterprise

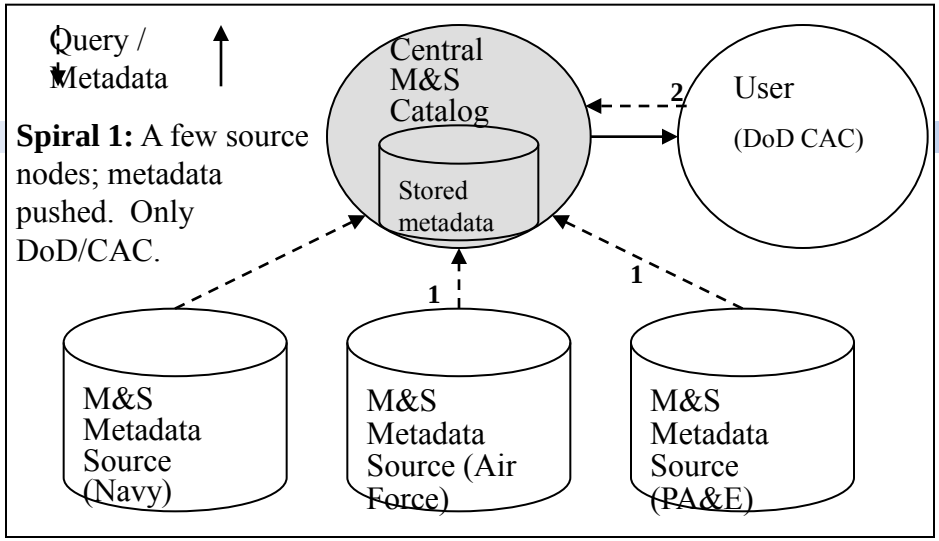


Placement in DoD Net-centric Enterprise

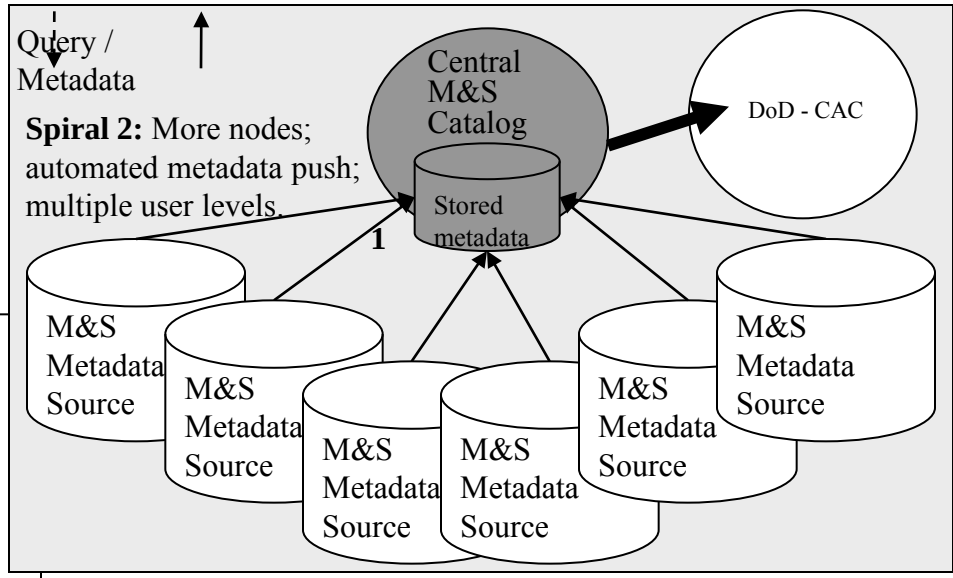


Prototype to Production

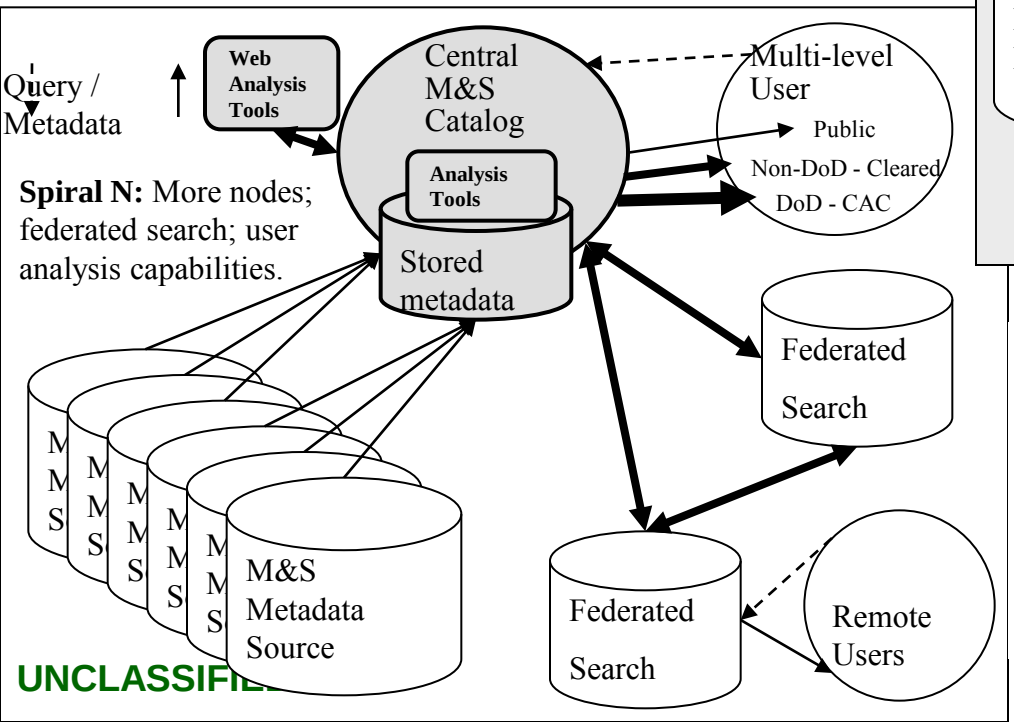
Spiral 1 (FY07/08)



Spiral 2 (FY09)



Spiral N

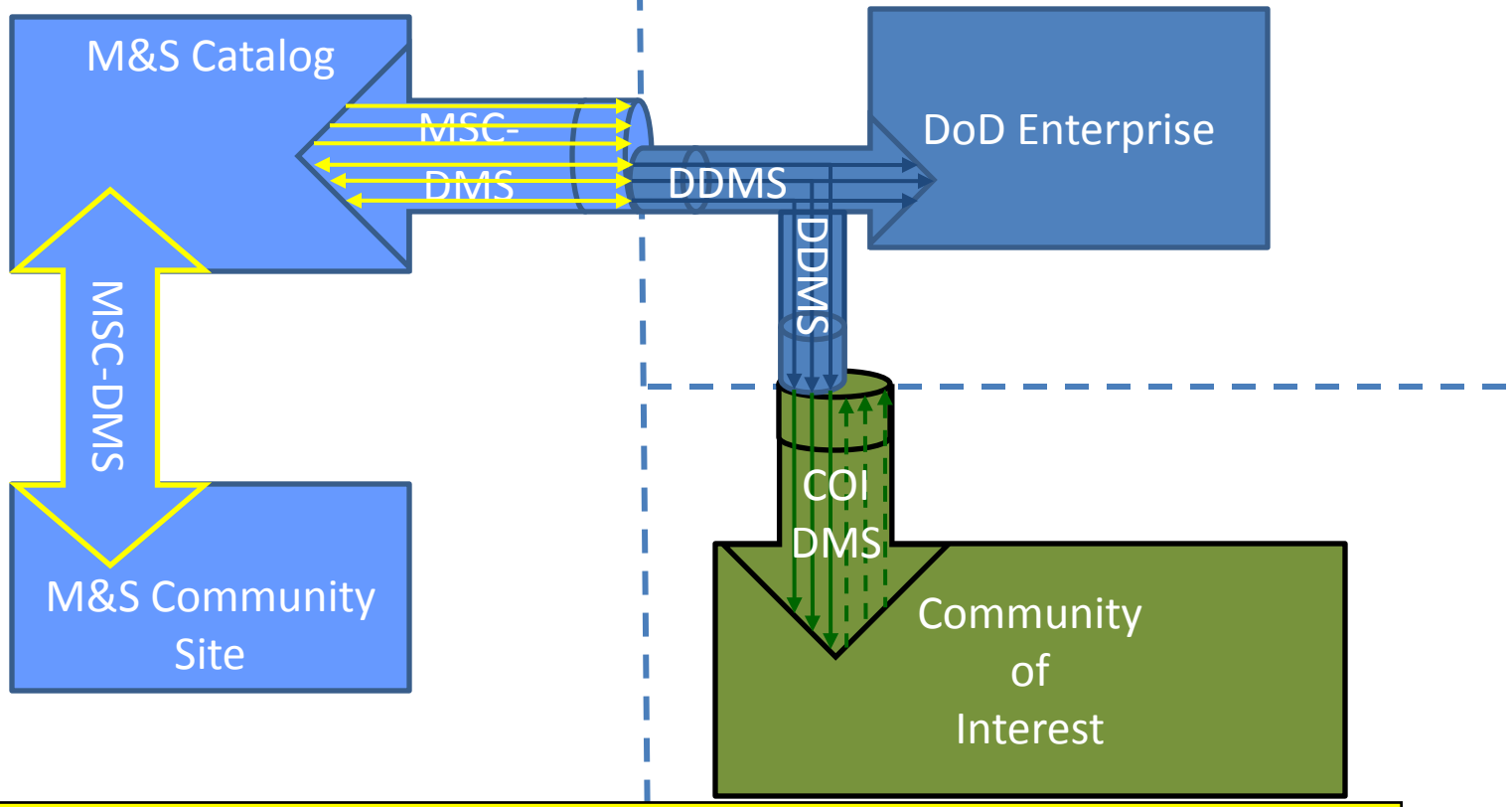


Spiral 1: Prototype concept demo

Spiral 2: Improve metadata foundation. More sources. Grow capabilities. Document search & discovery process. Governance. Sustainment.

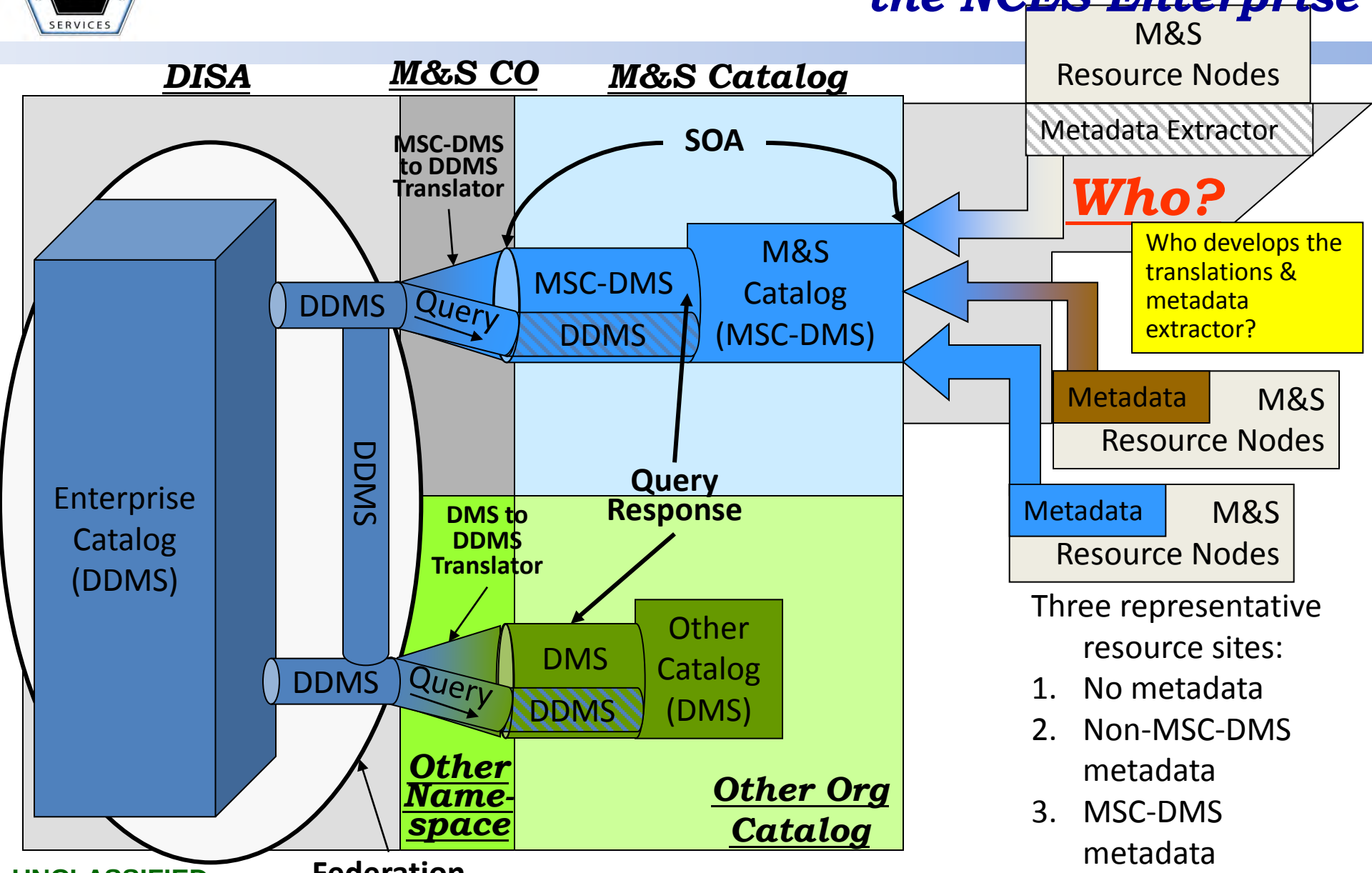
Metadata Translations in Federated Searches

- Federated search limited to DDMS metadata elements
- Translation to each CIO DMS is critical to the success of the enterprise



DDMS formatted Metadata is the metadata translator between communities of interest

Metadata Format Relationships M&S Catalog & the NCES Enterprise



Three representative resource sites:

1. No metadata
2. Non-MSC-DMS metadata
3. MSC-DMS metadata

Results of a Study on the Management of Broadly-Needed Modeling and Simulation Tools

NDIA Systems Engineering Conference
San Diego, CA

October 25-28, 2010

James E. Coolahan, Ph.D.
Katherine L. Morse, Ph.D.
Randy Saunders
Stephen W. Kay
Christopher L. Erdman

James.Coolahan@jhuapl.edu +1 240-228-5155
Katherine.Morse@jhuapl.edu +1 858-678-0629
Randy.Saunders@jhuapl.edu +1 240-228-3861
Stephen.Kay@jhuapl.edu +1 240-228-7325
Christopher.Erdman@jhuapl.edu +1 240-228-9531

The Johns Hopkins University
Applied Physics Laboratory
11100 Johns Hopkins Road
Laurel, MD USA 20723-6099

APL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

This document was cleared for public release (Distribution A)
by the DoD Office of Security Review (Case No. 10-S-2860).

Presentation Outline

- Study Background
- Study Objectives and Approach
- Information Gathering on M&S Tools and Management Approaches
- Categories of Tool Management Approaches
- Taxonomy for Assessing Success of Management Approaches
- Best Management Practices
- Recommended Action Items

Study Background

- **Many government-managed models and simulations are already used broadly, but typically suffer from several problems (e.g., lack of funding, lack of a stakeholder requirements management council, etc.)**
- **Study was initiated in October 2008 by the Director, Office of the Director of Systems and Software Engineering (D, SSE) in the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L))**
  - On behalf of the Acquisition M&S Working Group (AMSWG)
- **Study is an <u>initial</u> step in addressing Acquisition M&S Master Plan (AMSMP) Action 3-4 ("Centrally fund and manage the development of high-priority, broadly-needed M&S tools")**
  - Before embarking on such an initiative, it is prudent to objectively study DoD's current experience in the management of broadly-needed tools
    - Attempt to identify innovative approaches that could be leveraged to improve the cost-effectiveness of DoD M&S tools more broadly

Study Objectives

- **Identify best practices for managing broadly-needed M&S tools**
- **Based on these findings, recommend actions the U.S. DoD should take to improve its management of such M&S tools**

Study Approach

- Develop list of M&S tools used by multiple organizations not under the same chain of command or contract
- Survey M&S tool managers and users on management approaches
- Document and categorize management approaches for the tools identified
- Assess degree of success each tool management approach has had in avoiding certain problems
- Develop a taxonomy for assessing success of M&S tool management approaches
- Identify/develop best practices for managing broadly needed M&S tools
- Recommend actions DoD should take to improve its management of broadly-needed M&S tools
- Develop list of desirable characteristics of candidate tools to be used in pilot applications

List of M&S Tools with Responses to Tool Manager Survey (32 responses on 28 tools)

- Advanced Joint Effectiveness Model (AJEM)
- Advanced Testing Capability (ATC)
- Battle Command Management Service (BCMS)
- BRL-CAD
- Comprehensive Mine and Sensor Simulator
- Extended Air Defense Simulation (EADSIM)
- Hazard Prediction and Assessment Capability (HPAC)
- Intelligence Modeling and Simulation for Evaluation
- Joint Analysis System (JAS)
- Joint Conflict and Tactical Simulation (JCATS)
- Joint Communication Simulation System (JCSS)
- Joint Integrated Mission Model (JIMM)
- Joint Semi-Automated Forces (JSAF) (JFCOM version)
- Joint Theater Level Simulation (JTLS)
- Langley Standard Real-Time Simulation in C++ (LaSRS++)
- Model for Intratheater Deployment by Air/Sea (MIDAS)
- Naval Simulation System (NSS)
- One Semi-Automated Forces (OneSAF)
- OpenEaagles Simulation Framework
- ProtoCore
- Role Player Workstation
- RunTime Infrastructure (RTI) - MATREX
- RTI NG Pro
- Simulation Display (SIMDIS)
- SPIRITS
- Suppressor
- Synthetic Theater Operations Research Model (STORM)
- Threat Modeling and Analysis Program (TMAP)

Questions on the M&S Tool User Survey

Responder Information

1) Name 2) Rank/Title 3) Organization 4) Email Address 5) Phone Number

Requirements Management

6) How should user requirements be prioritized when funding and/or schedule are insufficient to meet all requirements?

Configuration Management

7) Is it critical to maintain a single source baseline, or are there circumstances under which multiple forks should be permissible? What criteria should be used to make this decision?
8) Identify good tool distribution mechanisms/methods (for source, executable, or both).
9) How frequent should releases be? Please describe the criteria upon which the frequency may depend, e.g. tool maturity, criticality of bug fixes.

Code Development

10) Should externally developed code (by users or others) be integrated into the code baseline?
11) How should conflicts between modifications submitted by different users/co-developers be mediated?

Test Management

12) Should V&V be a formal part of the integration process?
13) What processes/products are critical prior to product release, e.g., regression testing, reference data?

Lessons Learned

14) Please describe any other management best practices that are critical to successful model management.

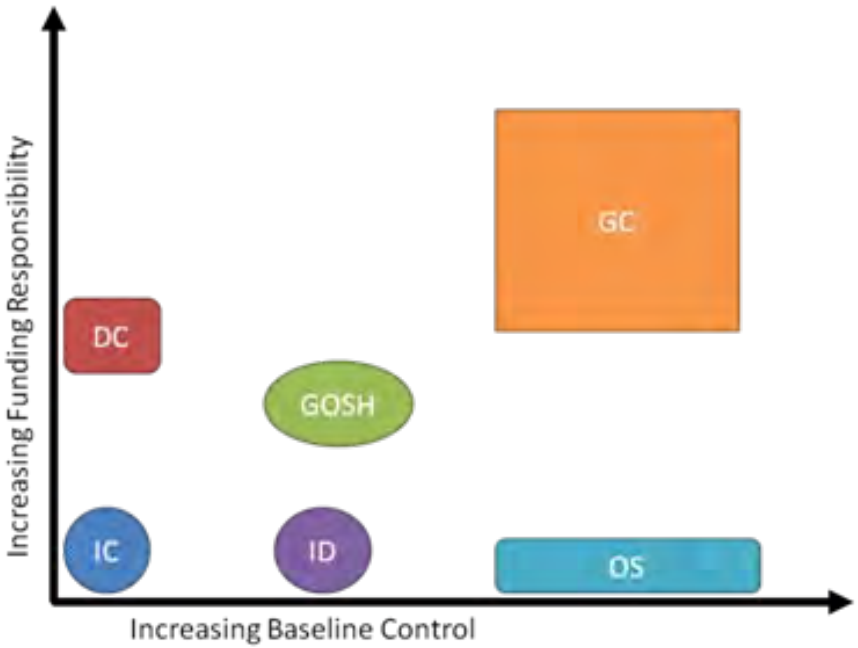
Categories of Tool Management Approaches (1 of 2)

- **Government Coordinated (GC)**
  - A single government office coordinates development of one version of the tool for all users. Government mechanisms, like MIPRs, are used to contribute funds. Developers (contractors or DoD employees) are paid and/or directed through a single coordinator.
- **Developer Coordinated (DC)**
  - A single development contractor coordinates one version of the tool for all users. Commercial mechanisms, like license fees or development contracts, are used to contribute funds from users.
- **Independent Development (ID)**
  - One or more developers (contractors or DoD employees) produce their own versions from a common tool baseline. Each user is free to select a version and/or developer.

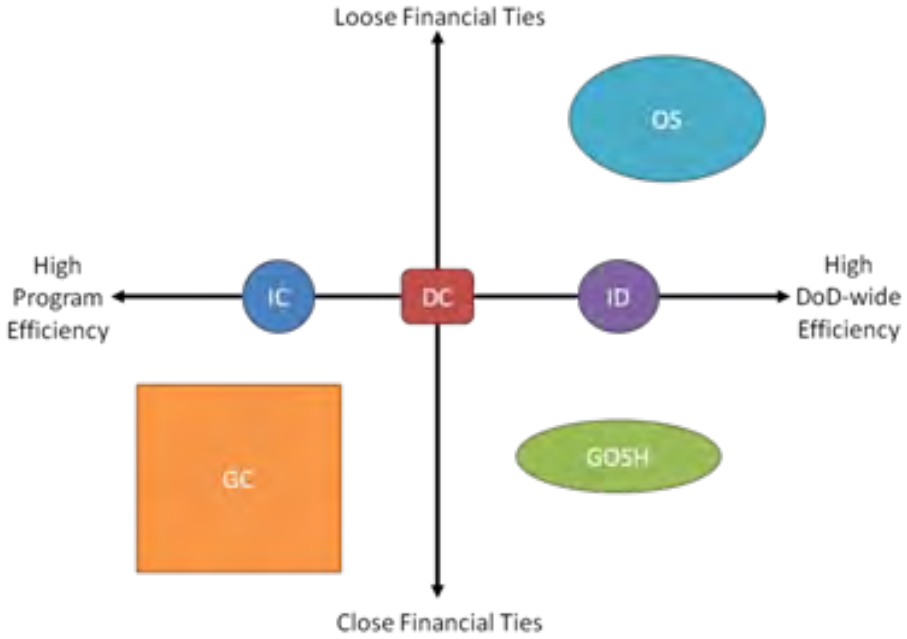
Categories of Tool Management Approaches (2 of 2)

- **Government Open Source Hybrid (GOSH)**
  - A government office authorizes certain developers (contractors or DoD employees) to participate in a shared source effort. Each user chooses a developer and all changes are constantly available to all participants.
- **Open Source (OS)**
  - One or more developers (contractors or DoD employees) participate in a shared source baseline. Each user chooses a version to use. No contractual relationship necessarily exists between users and developers.
- **Independent "Co-opetition" (IC)**
  - One or more developers (contractors or DoD employees) produce independent changes to a shared baseline. Each user chooses a developer, and the user determines if and when their changes are made available for inclusion in future baselines.

Comparison of Tool Management Approaches



Funding responsibility vs. baseline control



Efficiency vs. financial ties

Management Approach Success Criteria

High – The M&S tool manager is highly experienced in M&S tool management and committed to maximizing user value and utility. The M&S tool manager has sufficient funds to implement effective mechanisms to achieve these goals.

Medium – The M&S tool manager is experienced in M&S tool management and committed to providing user value and utility. The M&S tool manager may not have sufficient funds to implement all the mechanisms necessary to achieve these goals and must make choices about which mechanisms to implement.

Low – Either the M&S tool manager is inexperienced or has insufficient funds to maintain the M&S tool management mechanisms necessary to provide user value and utility.

Taxonomy for Judging Success of Approaches (1 of 2)

Integrating User-Developed Enhancements
High – The M&S tool manager has a structured, documented process for evaluating user enhancements and integrating them into the standard version. The process includes regression testing and mediation of differences between submitted changes.
Medium – Enhancements from a recognized set of sources are accepted and/or the framework allows for users to individually integrate their own plug-ins or libraries.
Low – Integration of externally-developed enhancements is on an ad hoc basis or not at all.

Model Accuracy (Verification & Validation)
High – Validation or testing of the fully integrated tool is required as part of the structured management process.
Medium – The tool manager accepts validation data where available, but does not require it.
Low – The tool management process does not include V&V.

Taxonomy for Judging Success of Approaches (2 of 2)

Meeting Foreseeable Needs
High – The M&S tool manager solicits inputs to future needs; the manager prioritizes requirements and integration activities to meet projected user community needs.
Medium – Priorities are set by a configuration control board; users may provide additional funding to meet their specific requirements.
Low – Projected user community needs are not considered in the requirements and integration process.

Customer Support
High – The M&S tool manager provides broad and responsive customer support including live support (help desk) and extensive documentation that supports understanding and use of the tool; the tool manager actively communicates with the user community.
Medium – The manager provides documentation beyond just a technical/user's manual and live support.
Low – The manager provides a technical/user's manual; live support is on an ad hoc basis.

Best Management Practices – by M&S Tool Management Areas

Twelve task categories, corresponding to success attributes, were derived for best management practices for M&S tools, which align with the following five overarching M&S tool management areas:

1. **Requirements Solicitation**
2. **Baseline Development**
3. **Testing, Quality Assurance, and Verification and Validation (V&V)**
4. **Baseline Maintenance**
5. **Customer Support**

Best Management Practices – Requirements Solicitation

- **Canvas Users for Needed Changes**
  - Develop website to enable users and external developers to document needed capabilities
  - Send hard copy questionnaires periodically
- **CCB-Approved Recommendations Implemented**
  - Establish a Configuration Control Board (CCB) that meets periodically (quarterly to annually), to review requirements for new capabilities
  - M&S Tool Manager should chair and facilitate CCB
  - CCB should determine implementation timeline
- **Justification for Excluding User Requirements is Promulgated**
  - CCB should provide to all its justification for not satisfying certain requirements
- **M&S Tool Manager Engages Users and External Developers**
  - Establish an online User Forum
  - Host periodic (perhaps monthly) teleconference to augment online forum
  - Host periodic face-to-face User Group Conferences

Best Management Practices – Baseline Development

- **Managing Divergence**
  - M&S Tool Manager should evaluate costs and risks of accepting externally-developed enhancements
  - If funding/scope exists to accept multi-source enhancements, a CCB of technical experts (see previous slide) is in order
  - In absence of sufficient funding, a plug-in framework could allow user enhancements without endangering code baseline stability
  - Any experimental excursion should have a plan, including M&S tool elements affected, and process for incorporating modifications in baseline
- **Incorporating Externally-Developed Enhancements**
  - Use CCB to assess desirability of submitted enhancements
  - Publish the process for assessing enhancements (criteria, schedule)
- **Coding Standards**
  - Include style guide, fidelity considerations, algorithm documentation

Best Management Practices – Testing, Quality Assurance, and V&V (1 of 2)

- **Quality Assurance Process**
  - Each release should have requirements at start, updated as needed
  - QA Plan (including V&V) should be developed soon after work begins
  - A test database should be developed that supports V&V
  - Design meetings/reviews should be conducted and documented
  - Testing should include unit testing prior to integration testing
  - Acceptance test cases should be documented with expected outcomes, and results compared; test cases to test known defects should be included
  - A QA report documenting test activities should be written for each release
  - Consider the following for experienced user base / co-development agreement:
    - User representatives / co-developers participation in review meetings
    - Supplemental testing by expert users prior to each release
  - Consider the following for models/simulations with multiple constituencies:
    - Supplemental validation testing by subject matter experts (SMEs)
    - V&V by an independent third party

Best Management Practices – Testing, Quality Assurance, and V&V (2 of 2)

- **Regression Testing**
  - When new releases are funded by users seeking new functionality, the M&S Tool Manager should obtain funding from these users for regression testing
  - The QA plan for each release should include regression tests evaluated for cost-effectiveness based on scope of modifications
  - For incremental developments, regression testing should be performed incrementally
  - Regression testing should include expected multiple operating system / computing system environments
  - In conjunction with new functionality, regression tests to ensure that the functionality is maintained in future releases should be developed
  - For a regression test program across multiple releases:
    - The M&S Tool Manager should advocate for a recurring funding stream to permit ongoing regression testing
    - A cumulative set of regression tests across all releases, with documentation of functionality each regression test is designed to address, should be maintained

Best Management Practices – Baseline Maintenance

- **Software Baseline Maintenance Funding**
  - The M&S tool manager needs to receive a funding stream for baseline maintenance that is:
    - Adequate for the required level of effort
    - Dependable
    - Dedicated to baseline maintenance

Best Management Practices – Customer Support

- **Technical Documentation**
  - Software engineering documentation should be a mandated part of the software development process; each release should include “release notes” documenting changes made to the previous release, including defects fixed and features added
  - User documentation should be produced by users of the tool rather than developers, and should include constraints, assumptions, and limitations
  - Mechanisms for discovery of the M&S tool and awareness of its capabilities need to be leveraged or developed
- **Help Desk**
  - Modern technology should be used to minimize cost (e.g., “virtual” help desk)
  - The first level of static information can be distributed via a website
  - The second level of dynamic information can be accessed via a website form or phone number
  - Queries without “off-the-shelf” answers can be forwarded to a list of expert developers and users

Recommended Action Items

- Publish and promulgate a Recommended Practices Guide for the management of broadly-needed M&S tools
- Identify and establish a limited number of short-term (up to two years in duration) pilot efforts for selected existing broadly-needed DoD-supported M&S tools, to verify the merits of the recommended best practices
  - See study report for specific actions to aid pilot programs
- Establish and maintain an effective M&S tool catalog / registry with metadata to support discovery and potential reuse of M&S tools
  - Note: this is underway in DoD, and considered important to the management of broadly-needed M&S tools

Questions

Backup Slides

M&S Tool Management Success Attributes (1 of 3)

M&S Tool Management Success Attributes: "The M&S Tool Manager …"	Meeting Foreseeable Needs	Integrating Externally-Developed Enhancements	Model Accuracy (V&V)	Customer Support
1. Successfully solicits recommendations from users for new capabilities.	X			
2. Actively communicates with, and engages, users / external developers on a consistent basis concerning tool efficacy and applicability.	X			X
3. Has a process for managing the tool baseline(s) that prevents irreconcilable divergence.	X	X		
4. Has implemented into the baseline tool enhancements agreed upon by a peer / user review process.	X	X		
5. Provides / publishes justification for not including any suggested tool enhancements that were not included in the new baseline tool.	X	X		X

M&S Tool Management Success Attributes (2 of 3)

M&S Tool Management Success Attributes: "The M&S Tool Manager …"	Meeting Foreseeable Needs	Integrating Externally-Developed Enhancements	Model Accuracy (V&V)	Customer Support
6. Has implemented a process to acquire and assess (using a peer / user review process) externally developed capabilities for inclusion into the baseline tool.		X		
7. Publishes a coding standards and style guide with which all externally developed capabilities are required to comply.		X		X
8. Has developed and implemented a quality assurance process that rigorously evaluates each new baseline tool implementation before final product release.			X	
9. Receives and expends the funds necessary to conduct verification and validation tests on all new enhancements, and thorough regression tests on all new baseline releases to ensure past functionality has not been compromised.			X	

M&S Tool Management Success Attributes (3 of 3)

M&S Tool Management Success Attributes: "The M&S Tool Manager …"	Meeting Foreseeable Needs	Integrating Externally-Developed Enhancements	Model Accuracy (V&V)	Customer Support
10. Updates the User's Guide and / or Technical Reference Manual with each baseline enhancement release, including constraints and limitations.			X	X
11. Receives consistent and adequate funding to conduct tool baseline maintenance, exclusive of baseline enhancements, to ensure the tool remains compatible with current software and hardware products used within the M&S community.				X
12. Provides timely customer support upon receiving a request for assistance (e.g., a competent and adequately staffed Help Desk).				X

National Defense Industrial Association
Systems Engineering Division
Modeling and Simulation Committee

Model Based Engineering Subcommittee

Interim Report

October 2010

Agenda

- Background / Charter / Subcommittee Membership
- MBE Definition and Model Characteristics
- Current State
- Elements of MBE “To Be” State
- Potential Benefits of MBE
- Initial Findings on Policy/Guidance and Contracting Mechanisms
- Next Steps

Grow engineering capabilities to address emerging challenges (con't)

Identify opportunities to leverage Model-based engineering practices to improve systems engineering productivity and completeness

- Do existing policies, guidance and contracting mechanisms hinder model-based collaboration?

Reinvigorate exploration and exploitation of Modeling and Simulation Systems Engineering enablers to assess and mitigate acquisition program risks

- Modeling & Simulation Committee to lead the initial investigation
- Coordinate work schedule with new Committee chair

Model-Based Engineering Subcommittee Charter

- Assess and promote Model Based Engineering (MBE) practices in support of the DOD capability acquisition life cycle*
  - Define Model Based Engineering (MBE)
  - Define how MBE is related to M&S
  - Identify the potential costs, risks, and benefits of MBE
  - Identify the potential limitations of MBE
  - Identify how MBE practices can be used in capability acquisition with a primary focus on Systems Engineering to include concept engineering, concurrent design, development, and manufacturing
  - Identify MBE approaches to assess and mitigate risks throughout the capability acquisition life cycle
  - Identify the issues and challenges with using MBE practices across the capability acquisition life cycle
  - Identify where/how existing policy, guidance and contracting mechanisms support/hinder Model Based collaboration across program/capability boundaries
  - Provide recommendations:
    - For changes in policy, guidance, and contracting mechanisms that could further support Model Based collaboration
    - For near-term opportunities to leverage MBE in capability acquisition
    - For areas of MBE research & development that may have high potential pay-off

* - Acquisition Life Cycle: All phases of the capabilities life cycle including research, development, Test & Evaluation, production, deployment, operations and support, as well as evolution of deployed systems in response to changes in their environment over time.

Model-Based Engineering Subcommittee

- Jeff Bergenthal (LM; subcommittee lead)
- Eileen Bjorkman (SAF/A6W; former AMSWG chair)
- Jim Coolahan (JHU/APL; SISO)
- Bill Espinosa (USN)
- Sandy Friedenthal (LM; INCOSE MBSE)
- Tony Pandiscio (Raytheon)
- Lou Pape (Boeing)
- Greg Pollari (Rockwell Collins; AVSI SAVI)
- Hans Polzer (LM; NCOIC)
- Jennifer Rainey (JHU/APL)
- David Redman (AVSI; AVSI SAVI)
- Mark Rupersburg (GDLS)
- Frank Salvatore (HPTI)
- Don Schneider (Foxhole Technology)
- Dennis Shea (CNA)
- Roddey Smith (NGC)
- Charlie Stirk (CostVision; PDES, Inc.)
- Steve Swenson (Aegis Technologies; SISO)
- Bill Tucker (Boeing)
- Mike Truelove (Army CAA)

MBE Definition

- **Model-based engineering (MBE):** An approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle.
- **Model:** A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. (DoD 5000.59 -M 1998)
- **Preferred MBE Practices:**
  - Models are scoped to purpose/objectives
  - Models are appropriate to the context (e.g. application domain, life cycle phase)
  - The models represent the technical baseline that is delivered to customers, suppliers, and partners
  - Models are integrated or interoperable across domains and across the lifecycle
- Core to MBE is the integration of descriptive/design models with the computational models.

Characteristics of Models Used in MBE

- Models apply to a wide range of domains (e.g. systems, software, electrical, mechanical, human behavioral, logistics, manufacturing, business, socio-economic, regulatory)
- Computer-interpretable computational model
  - Time varying (e.g. performance simulations, structural dynamic analysis)
  - Static (e.g. reliability prediction model)
  - Deterministic or stochastic (e.g. Monte Carlo)
  - May interact with hardware, software, human, and physical environment
  - Includes input/output data sets
- Human-interpretable descriptive models (e.g., architecture/design such as UML, SysML, UPDM, IDEF, electrical schematic, 3D CAD geometry, DODAF 2.0)
  - Symbolic representation with defined syntax and semantics
  - Repository based (i.e., the model is stored in structured computer format)
- Supporting metadata about the models including assumptions, versions, regions of validity, etc.
- MBE can also include the use of physical models (e.g. scale models for wind tunnels or wave tanks), but this is not the central focus.

MBE Current Activities

- Government
  - Systems 20/20 Initiative
  - DARPA META Projects
  - Navy, Army, Air Force all have programs and internal initiatives to deliberately drive engineering practices in the MBE direction
  - Air Force ICE project
  - Army MATREX
  - NIST MBE projects
  - OSD Mantech MBE projects
  - JPL
- Academia
  - Stevens, USC, Penn State, SERC
  - GTRI
  - GMU
  - JMU
  - JHU-APL

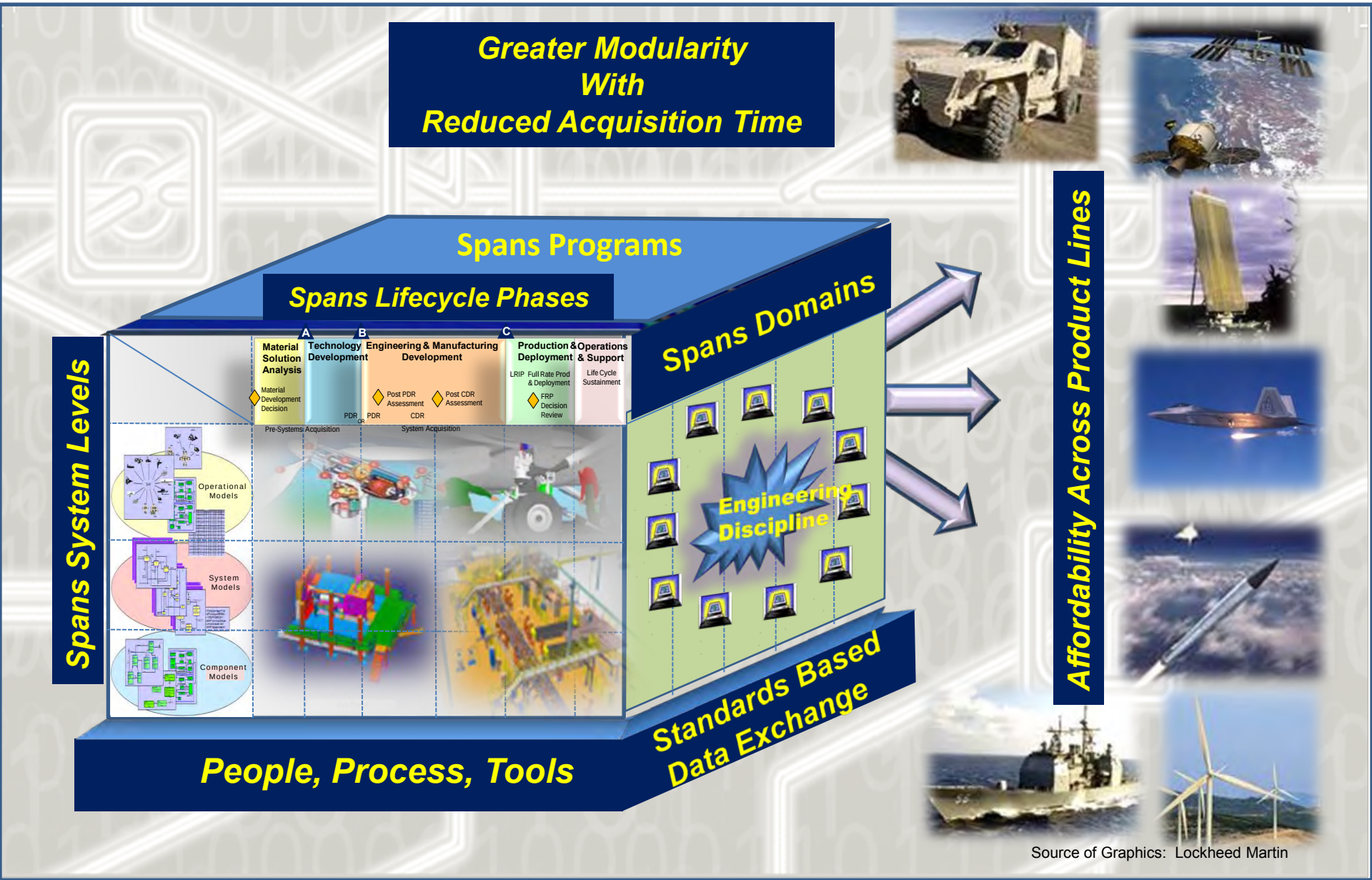
MBE Current Activities (cont.)

- Professional Organizations
  - INCOSE MBSE Initiative
- Standards Bodies
  - SISO Core Manufacturing Simulation Data Standard
  - PDES Data Interchange with STEP
  - OMG SysML
- Industry
  - AVSI SAVI Project in Aircraft Industry (Integration and Test)
  - All major players have various environment in use; even the best of these has limited collaboration capabilities.
- Tool Vendors
  - SysML/UML/UPDM/IDEF/ADL/BPML
  - CAD/CAE/CAM
  - Analysis
  - PLM/PDM
  - Etc….

MBE Current State

- Poor integration of simulations across the life cycle
- Limited reuse of simulation between programs
- Variation in modeling maturity and integration across Engineering Disciplines (e.g. systems, software, mechanical , electrical, test, maintainability, safety, security)
  - Mechanical/Electrical CAD/CAE fairly mature
  - Systems/Software/Test fairly immature
- Many MBE related activities across industry, academia, and standards bodies
- Evolving modeling standards (e.g., CMSD, Modeling Languages such as SysML, UPDM, Modelica, AADL)
- Tools are evolving towards an MBE paradigm and making progress towards greater tool to tool interoperability

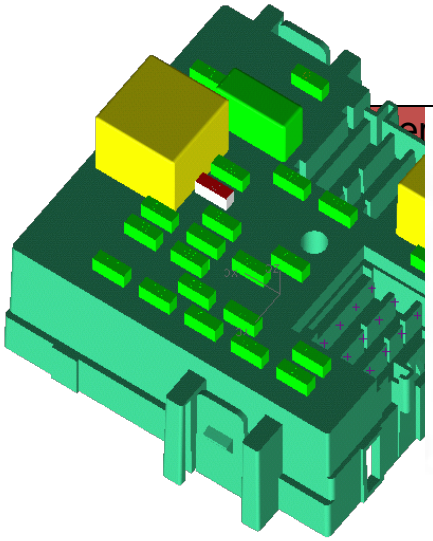
A Conceptual View of MBE "To Be" State

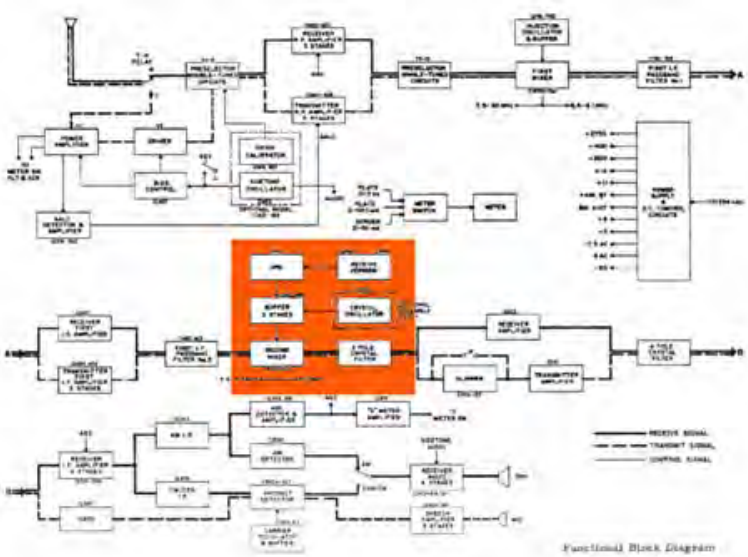


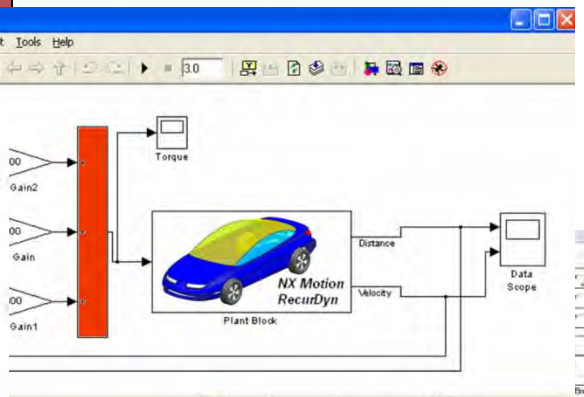
Source of Graphics: Lockheed Martin

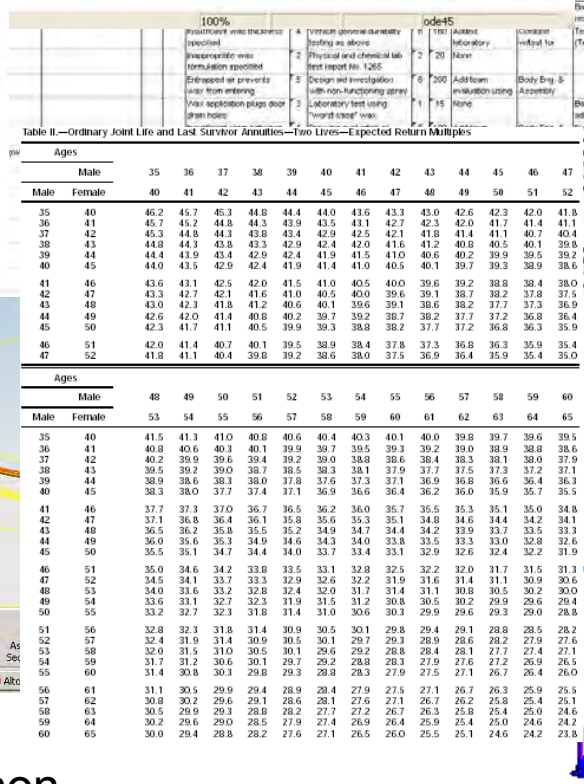
Example From INCOSE MBSE Initiative

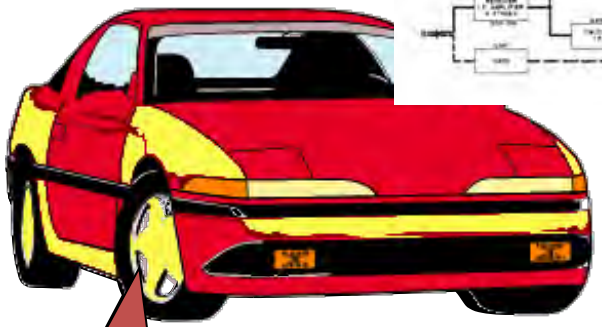
Hydraulic Fluid:
SAE 1
compli

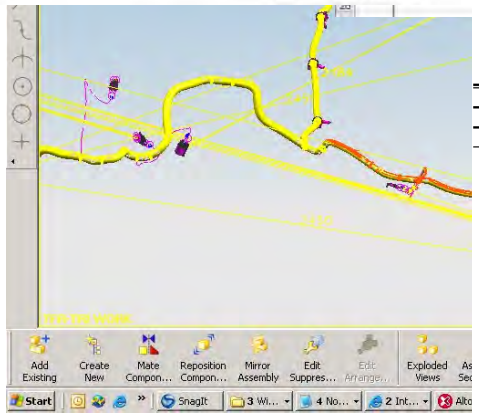












Minimum Turn Radius: 24 ft.
Dry Pavement Braking Distance
at 60 MPH : ~~110~~ ft. 90 ft

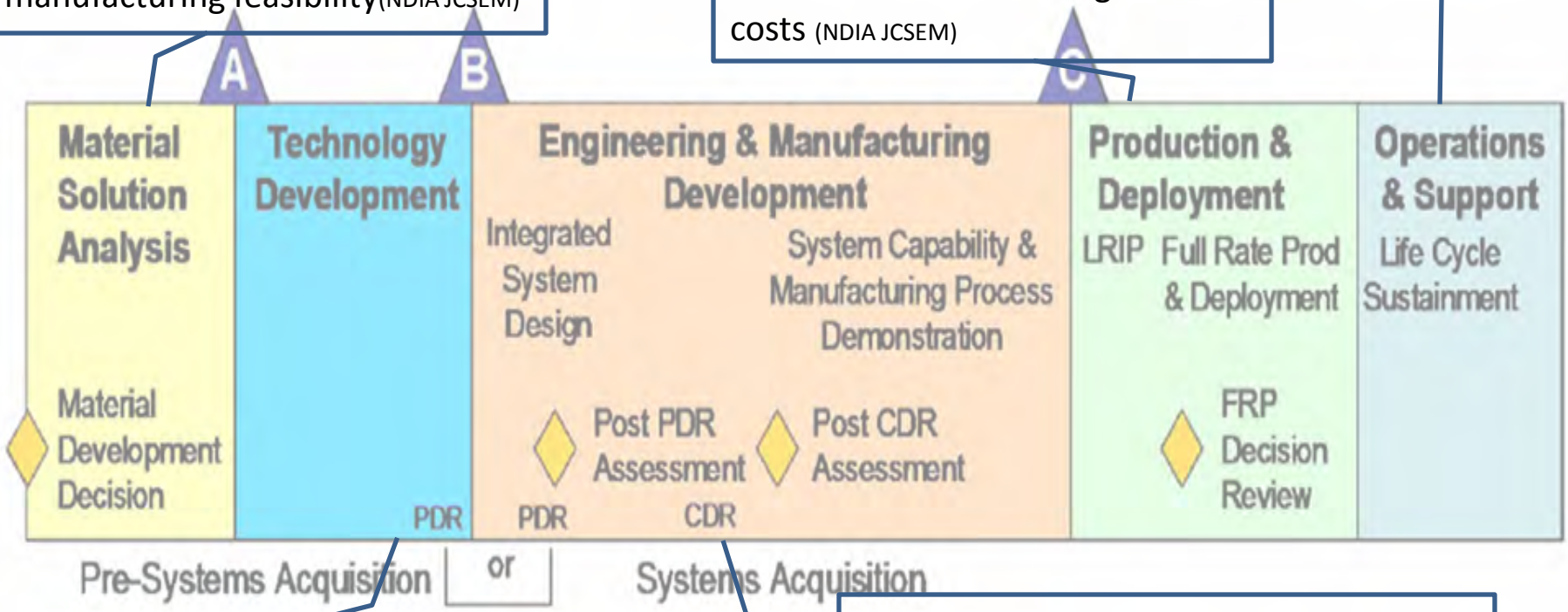
Provided by Mark Sampson

Potential Benefits of MBE

- Increased trade space (Boeing 787)
- Earlier evaluation of manufacturing feasibility (NDIA JCSEM)

- Reduced costs associated with complex product families (SWFTS)

- Reduced manufacturing related costs (NDIA JCSEM)



- Improved requirements (NRC, NRAC)
- Earlier risk identification and mitigation (NRC, NDIA JCSEM)
- Early evaluation of manufacturing processes (NDIA JCSEM)
- Increased trade space (Boeing 787)

- Earlier risk identification and mitigation (NRC, NDIA JCSEM)
- Concurrent and collaborative engineering (NRC, NRAC, NDIA JCSEM)
- Reduced defects and re-work costs (AVSI SAVI, NRAC, NRC)

Elements of MBE "To-Be" State

- Model-centric approach to engineering
  - Models are an integral part of the technical baseline
  - Models are explicit about their sources of "ground" truth
- Full life cycle application
  - Acquisition life cycle
  - For example: … -> Requirements → early validation → virtual integration → build/support
- Depth and breadth of the models
  - From SoS (System of Systems) down to component including the environment / context
  - Interoperable across User and Platform domains and engineering disciplines
  - Supply chain integration/exchange (global): customers, suppliers, partners
  - Potentially available for wider cross-enterprise use
- Implementation
  - Models based on descriptive metadata (model assumptions, versions, properties, validity ranges etc.)
  - Decentralized models that are stored and accessed with secure, reliable data exchange
  - Easier ability to find, access, and reuse models
  - Modeling languages based on formal semantics
  - Integrated model management (configuration, synchronization, change impact, etc.)
  - Modeling related standards that, as a minimum, support model interoperability
- Organizational / cultural
  - Knowledge, skills, ability
  - The way we do work and the value proposition(s) – individual and organizational
  - Breaking tradition

Gaps Identified That Will Need To Be Closed

- Policy/Processes/Methods
  - Policy / contracting mechanisms
  - Currently, models (other than CAD) are not part of the Technical Baseline
  - Model-based methods
- Tools/Technologies/Standards
  - Robust technology program for developing and transitioning technology to close specific gaps
  - Formal semantics
  - Model interconnect and interchange
    - Leverage efforts by INCOSE, AVSI, SISO, STEP PDES, OMG
- People
  - Workforce gaps across stakeholder communities
  - Acceptance of the use of models as a business practice
  - Model validation and confidence
- Infrastructure/Environment
  - Easy access to models / content developed by others
    - Inseparable from the business model
    - May be able to leverage the developing Defense Meta Data Standard
  - Lack of common, shared Operational Scenarios
  - Business model(s) that integrate the piece parts into a whole
  - Will take time to build up the set of available models that can be shared / reused across programs

Initial Policy Findings

- Existing OSD policies do not appear to pose any barriers to the implementation and use of MBE but does not appear to incentivize MBE. Guidance as referenced in the Defense Acquisition Guidebook is stronger and is supportive of the MBE concept.
- Army Acquisition Policy and Procedures has wording in place for "Simulation and Modeling for Acquisition, Requirements & Training" which is considered by some as a forerunner to MBE. Existing Army policy appears to be ready to accept MBE.
- Review of Air Force Policy found nothing that would preclude MBE from being implemented. Current Air Force policies will encourage MBE as a best practice.
- Review of Navy policy found no barriers to an increased use of M&S or the adoption of MBE concepts in the acquisition of Navy systems. Navy policy appears to be forward leaning in encouraging the use of MBE concepts and tools.
- There does appear to be more policy and guidance needed to address Model Based Contracting. Although there does not appear to be any explicit barriers to MBE within OSD or Services' policies and guidance, there are issues to be resolved with respect to contracting for MBE to ensure open and adequate competition and to protect the government from potential legal challenges.

MBE Subcommittee Next Steps

- Finalize analysis of potential MBE benefits, costs and risks
- Complete gap analysis
  - Policy / guidance / contracting mechanisms
  - Technical
  - Workforce
- Develop recommendations:
  - For changes in policy, guidance, and contracting mechanisms that could further support Model Based collaboration
  - For near-term opportunities to leverage MBE in capability acquisition
  - For areas of MBE research & development that may have high potential pay-off
- Prepare and brief final report in December 2010

Best Practices in Contracting for Models, Simulations, and Associated Data

Dennis Shea
Julianne Nelson

CNA
ANALYSIS & SOLUTIONS

Background: reasons for this project

OSD concerns:

- Desire to use existing M&S resources effectively
- Need for continued access to M&S resources over time and among programs
- Need to maintain existing M&S resources and acquire new resources as appropriate
- Need to adapt acquisition practices to changing IT state of the art
- Need to support recent OSD initiatives to streamline and improve DoD contracting practices
  - WSARA
  - “Better Buying Power” memo and subsequent guidance from OSD(AT&L)
  - Proposed revisions of DFARS treatment of intellectual property (DFARS Case 2010-D001 concerning DFARS Parts 212, 227, 246 and 252)

Example of the problem:

Text of the license rights section in an RFP management plan for M&S services:

"The **non-commercial** hardware, software, imaging and audio developed under this effort will be delivered to the Government with unlimited rights in accordance with DFARS 252.227-7014."

Note: ***no*** other data rights clauses are mentioned.

Unresolved issues:

- Is the contractor allowed to identify and use any ***commercial*** M&S resources? (and deliver with less than unlimited rights)
- Is the contractor allowed to identify and use ***pre-existing*** non-commercial M&S resources? (Under -7014, software developed in whole or in part with private funding is generally delivered with ***less*** than unlimited rights.)

Note: The DFARS clause cited applies ***only*** to software and software documentation (i.e., not hardware, imaging, audio or technical data generally).

CNA

Approach: emphasize the "*HOW*" rather than the "*WHAT*"

The *HOW*: the process of acquiring M&S assets by

- identifying needs
- developing solicitations
- selecting a vendor
- negotiating an agreement and
- monitoring contractor performance

Our approach: create support materials for DoD program staff

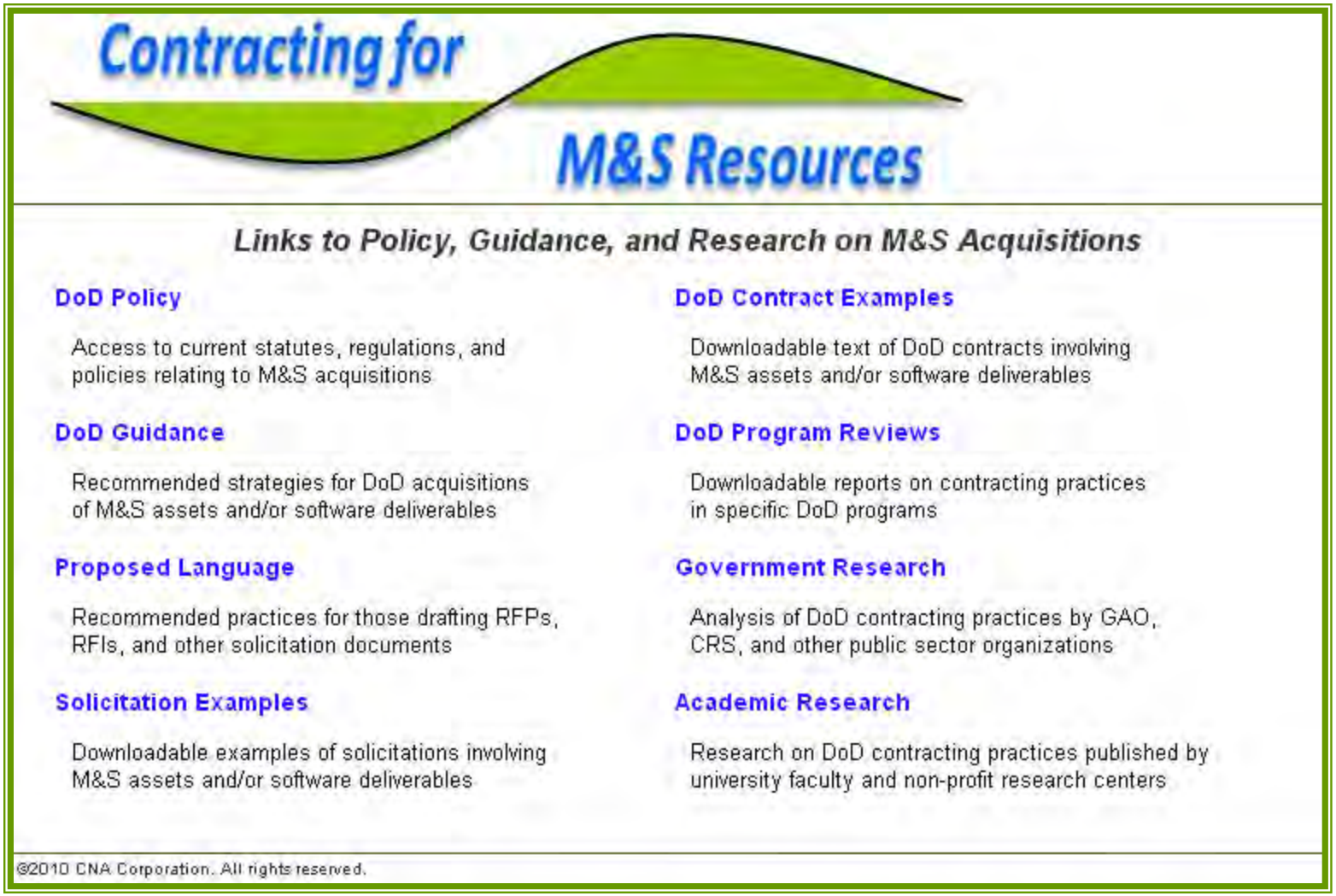
- that provide a synthesis of the laws, regulations, policy, and guidance on contracting for M&S resources
- that can be readily updated as these laws and policies evolve
- that provide access to focused guidance on specific aspects of the acquisition process (DP, SE, T&E, etc.)
- that provide concrete examples of contract language and acquisition strategies

CNA

Status quo – Brief M&S Co Online library

CNA

Deliverable: M&S contracting resources organized by topic



CNA

Next steps: add references to M&S CO web site

CNA

Best practices guide – table of contents

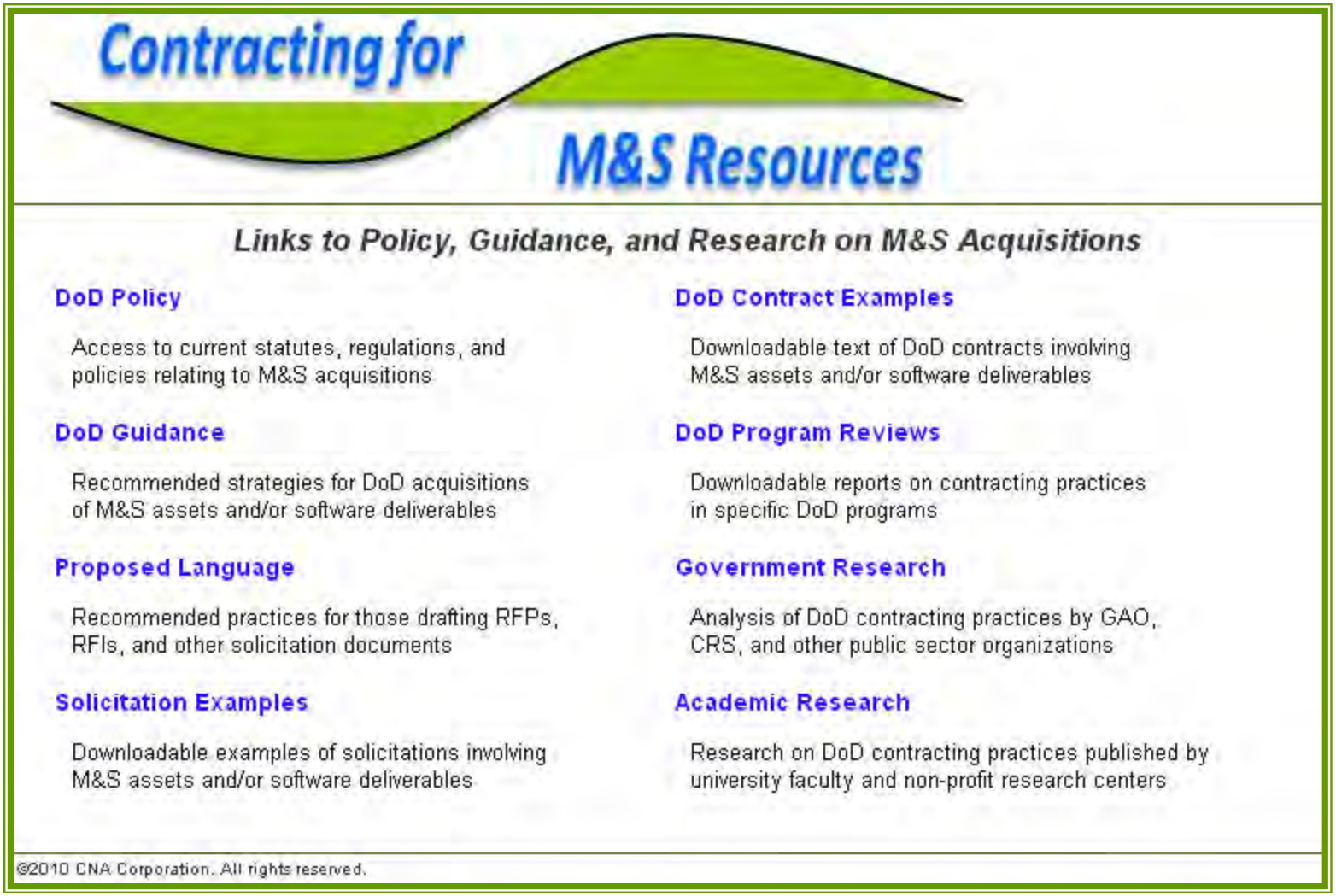
1 Introduction
2 Using M&S to enhance program efficiency
3 Developing M&S requirements
4 The "make-or-buy" decision for M&S capabilities
5 Solicitation planning and market research
6 Specifying contract deliverables
7 Rights to intellectual property in M&S
8 Financial incentives and contractor performance
9 Evaluating bids and awarding the contract
10 Conclusions and lessons learned
Appendix A: Roles for M&S within DoD
Appendix B: Twenty questions to plan a CBA
Appendix C: Solicitation examples
Appendix D: Requirements descriptions
Appendix E: Patent examples
Appendix F: Policy directives
Appendix G: Data rights clause examples
    Problematic data rights claims
    Tailored data rights clauses

CNA

Back-up slides:

M&S contracting web site

Deliverable: M&S contracting resources organized by topic

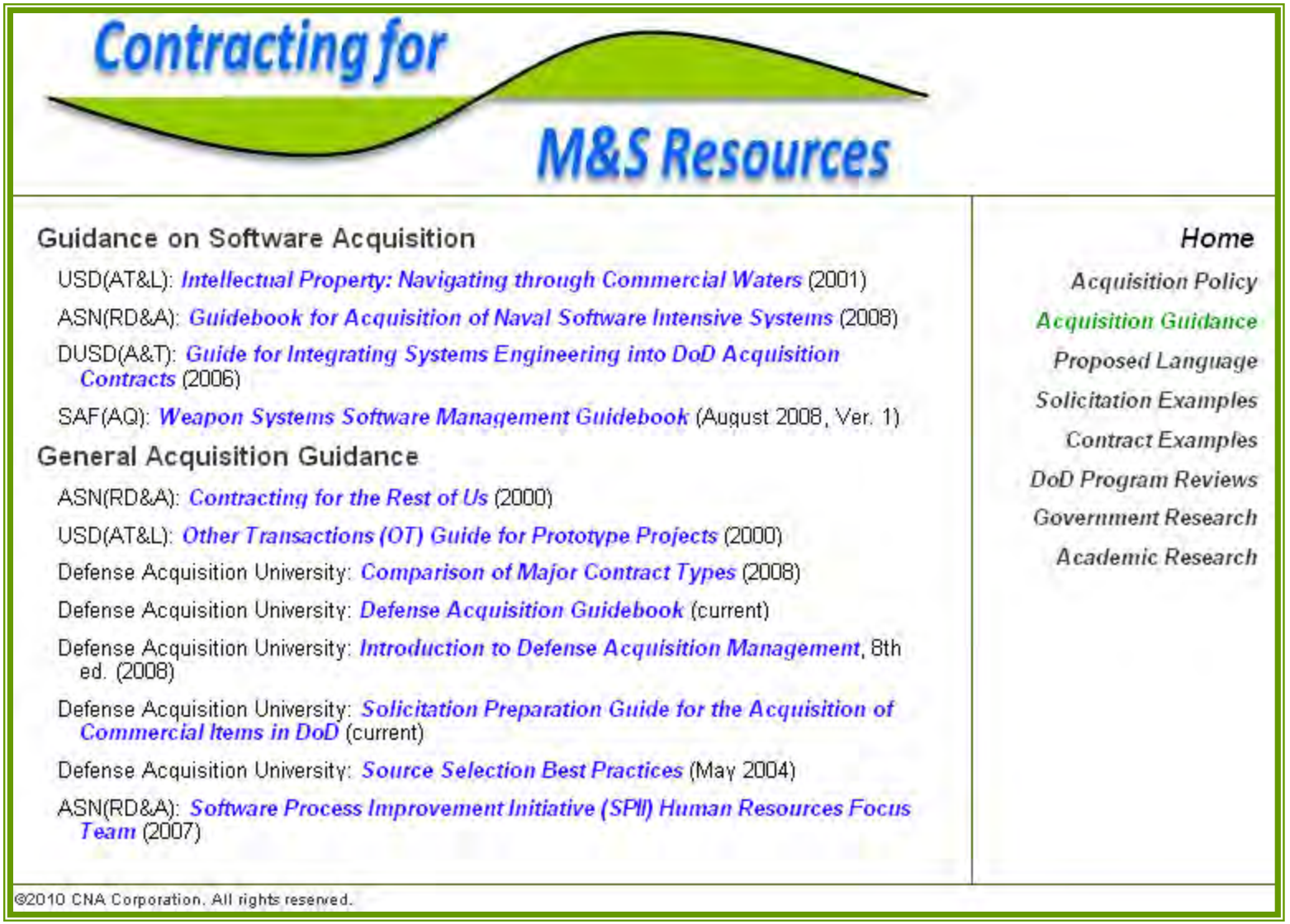


CNA

M&S policy references – with “mouse-over”

CNA

M&S contracting guidance



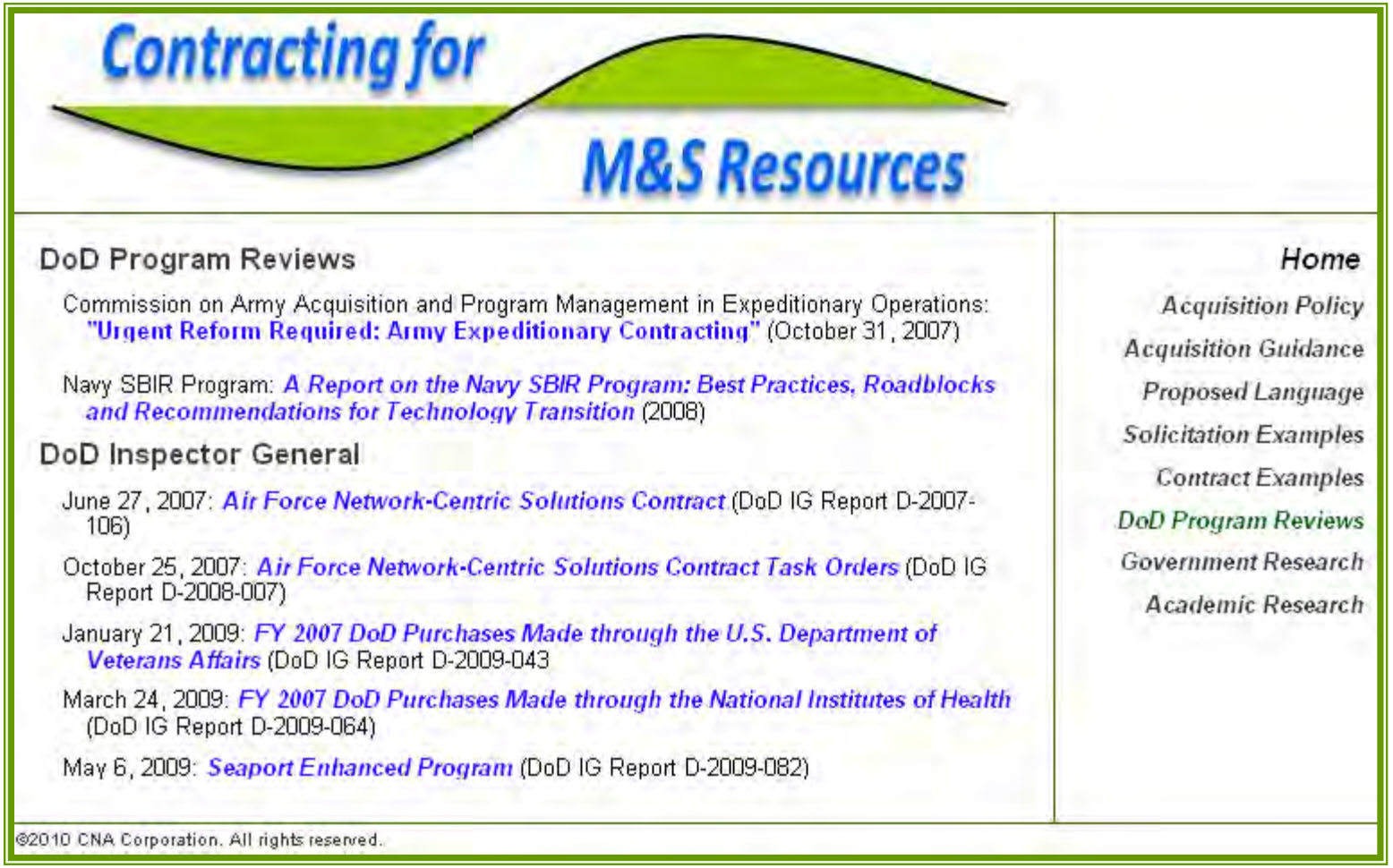
CNA

Proposed language for M&S contracts

Sample of solicitations involving M&S resources

Sample contracts involving M&S resources

Reviews of programs involving M&S



CNA

Government reports on IT and M&S contracting

Academic research on IT and M&S contracting

Back-up slides:

Contracting incentives web site

Next steps: add materials on contracting incentives

Backup slides:

Contracting language examples

Problematic language

Very broad data rights claims by the government:

Contract Example: 17.0. Proprietary Rights. All proprietary rights to all materials produced by Contractor personnel shall become the sole property of the US Government.

RFP Example: As such, no analysis or data provided under this contract shall constitute or be construed as company proprietary or owned by the contractor. Upon termination of the contract, all related hardware, software, data and materials shall become property of the United States Government and shall not be disclosed except upon written authority by the Task Order Manager (TOM).

Problematic language: inconsistent clauses

Contract example:

H-13 Software and data rights

H-13.I. The Government shall be provided with unlimited rights to all data and automated models developed in support of this contract in accordance with the policy expressed in DFARS 227.71, and the requirements of DFARS Clause 252.227-7015, **Technical Data - Commercial Items**, and DFARS Clause 252.227- 7013, Rights to Technical Data - Noncommercial Items. Proprietary models must not be used for any task order under this contract without the specific, written approval by the COR, prior to start of any work.

Problems:

- The commercial items clause (‘7015) cited above does ***not*** specify *unlimited* data rights for the government.
- All of the clauses cited explicitly ***exclude*** computer software (contrary to the implication of the section title).

CNA

Problematic language (continued)

Contract example:

H-14.2. DFAR22.227-7013 (June 1995) Rights in technical data and computer software shall apply to those monthly reports and other documents that are not characterized as "Special Works.“

Problems:

- Clause DFAR22.227-7013 does not exist.
- Clause DFARS 252.227-7013 does not apply to computer software.

CNA

Consistent language – scope of rights

RFP Example: **Technical Data Package/Rights** -

- **Provide the appropriate SOW tasking** in Annex F **for delivery of the technical data and rights sufficient to accomplish the objectives in SOO** paragraph 3.1.3.4 and, in this paragraph, demonstrate the extent to which the objectives can be met.
- **Provide a description of the level of data and rights** separately with regard to (a) meeting Title 10 U.S.C., Chapter 146, Section 2464, CORE logistics capabilities (CLIN 0101); (b) a competitively selected PBL support environment (CLIN 0102); and (c) the source data and data rights for a mission control system to enable use and modification for other UASs (CLIN 0103).
- For each, the Offeror **shall propose their approach for providing technical data** from both the prime and subcontractors, with sufficient rights and licenses provided to the Government. Specifically identify the data and the rights that will be provided, clearly identifying the additional data and rights to be provided that are above what will be provided as part of the effort under CLINs 0002 and 0202. Also, if any, identify data and rights that are required to meet the objectives but will not be provided.

CNA

Consistent language – classifying deliverables

RFP Example: **Intellectual Property Deliverable Restrictions**.

For each task order to be issued under the contract, the Contractor shall identify, prior to award of the affected task order(s) to the best of its ability, noncommercial and commercial technical data and computer software that it intends to deliver with restrictions on the Government's right to use, release or disclose such identified technical data and/or computer software.

CNA

Consistent language – Cost of data rights

RFP Example: 7.2.2.9 Software Parametric Data.

…Software costs shall be included in the Basis of Estimate (RFP Section J Attachment 18), including, license costs for COTS items, and costs for providing Government unlimited rights for software developed by the offeror and its suppliers.

Lessons learned (best practices) thus far:

- Request appropriate level of data rights (don't ask for the universe!)
- Use contract language that recognizes the contractor's copyright ownership
- Discuss data rights issues at the beginning of the contract
- Plan for a smooth transition at the end of a contract (avoid a hostage crisis)
- Consider a registration process to inform others on data rights previously obtained

CNA

RFP and contract examples

- Air Force M&S Training Toolkit (Pre-Solicitation FA8731-10-R-0001)
- TRADOC Support: *(*Contract No: GS-00F-0014N)
- Modeling And Simulation and Analytically Based Warfare Analyses (Solicitation N00024-09-R-3145)
- Marine Corps Studies System (Solicitation M00264-06-D-0006)
- NMCI Transition Plan
- System Development and Demonstration (SDD) Phase for the Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS) Program (Solicitation 00019-07-R-0001)
- Engineering Technical And Support Services For Naval Warfare Center And Other NAVSEA Field Sites (Solicitation N00178-04-R-4000)
- F-16 Mission Training Center (MTC) Program (Solicitation FA8621-07-R-6291)
- BLCSE TECHNICAL SUPPORT EFFORT – Solicitation W912SU-07-R-0002

CNA

Backup slides on data rights

Data rights for project involving OneSAF

- 3.3.1 Within scope of TICC and BEST activities (paragraph 3.1.1 above) the contractor shall modify, integrate and/or install simulation-independent HLA Middleware software packages, Gateways, Adaptors or Interfaces, permitting existing BLCSE simulations to interact with 3CE and/or Lead System Integrator (LSI) federates. Middleware, Gateways, Adaptors and Interfaces not provided as GFE **will be developed and delivered with complete documentation, operating instructions, and with complete government proprietary rights.** OOS-based or developed, or other GFE available, Middleware, Gateways, Adaptors and Interfaces will be utilized unless prior written agreement is received from COTR that no OOS or other GFE Middleware, Gateways, Adaptors and Interfaces are available or suitable to the integration task.

Data rights for project involving NSS, STORM

RFP Example: As such, no analysis or data provided under this contract shall constitute or be construed as company proprietary or owned by the contractor. Upon termination of the contract, all related hardware, software, data and materials shall become property of the United States Government and shall not be disclosed except upon written authority by the Task Order Manager (TOM).

CNA

Plans and Status of the CREATE-SHIPS Project: Enabling Required Naval Warship Performance Throughout the Acquisition Lifecycle

Myles Hurwitz

DoD HPC Modernization Program Office

NDIA 13th Annual Systems Engineering Conference

San Diego, CA

27 October 2010

Distribution Statement A: Approved for public release; distribution is unlimited

Computational Research and Engineering Acquisition Tools and Environments (CREATE) Goal

- **Enable major improvements in DoD Acquisition Engineering Design and Analysis Processes, by developing and deploying scalable physics-based computational engineering software products to:**
  - Replace empirical design based on historical data and experimental testing with physics-based computational design validated with experimental testing
  - Detect and fix design flaws early in the design process before major schedule and budget commitments are made
  - Develop optimized designs for new concepts
  - Begin system integration earlier in the acquisition process
  - Increase acquisition program flexibility and agility to respond to rapidly changing requirements
  - Enhance the productivity of the DoD engineering workforce
  - Establish an organic capability to develop and deploy physics-based computational engineering software within the DoD

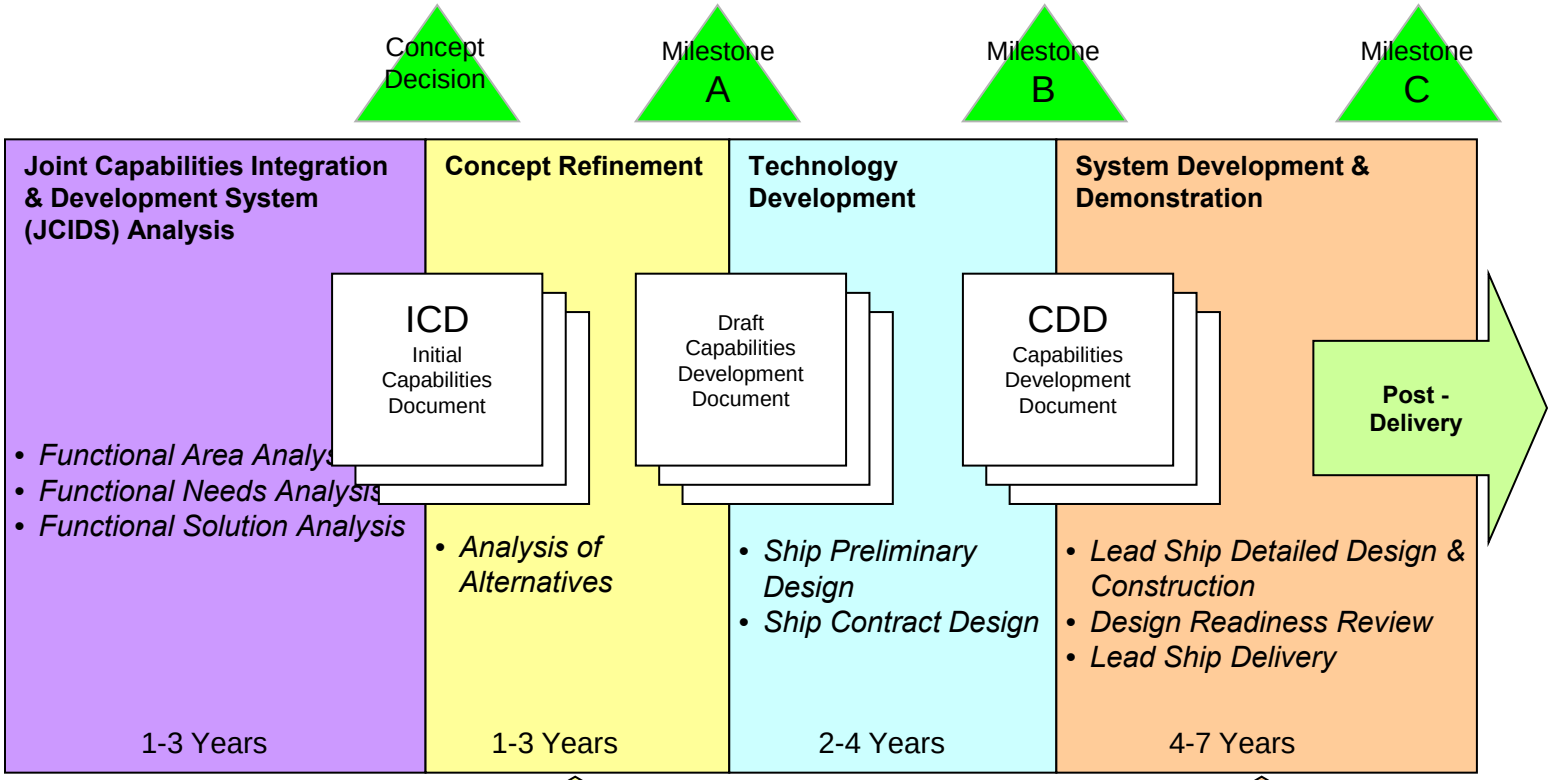
Distribution Statement A Applies, see cover page for specifics

CREATE-Ships Project Objective

- **Primary goal:**
  - develop the engineering software required to support a reconfigurable ship design and acquisition process that will enable the Navy to develop cost-effective ship designs on schedule and within budget, and that will perform as required and predicted.
- **Overall approach:**
  - develop, using high performance computing engineering tools, an optimized total warship design through properly designed hull, mechanical, and electrical systems integrated with combat and other mission systems earlier in the acquisition process than is possible today.
  - **Time to solution**
    - Scalability for high end codes
    - Embarrassingly (pleasantly) parallel for early stage codes exploring the feasible design space

Distribution Statement A Applies, see cover page for specifics

Acquisition Process – Use HPC and Full-Physics-Based Tools in the Ship Design Process for Complex Systems Evaluations



Distribution Statement A Applies, see cover page for specifics

Typical Definition and Evaluation Processes Through Contract Design

Geometry Definition	Selection of Other Ship Design Analyses
Hullform Design	Airflow Analysis
Compartmentation and Arrangements	Combat Systems Engineering
Structural Definition	Communications Systems Analysis
Location of Key Components	Control Systems Engineering
Routing of Key Distribution Systems	Deck Systems Engineering
Hydrodynamics	Deckhouse Systems Engineering
Resistance and Powering Analysis	Electromagnetic Engineering
Seakeeping and Loads Analysis	Hull Girder Ultimate Strength Analysis
Maneuvering Analysis	Fluid Systems Engineering
Dynamic Stability Analysis	FEA Structural Analysis
Damage Stability Analysis	Manning Analysis
Propulsor Performance Analysis	Power Systems Analysis
Survivability	Propulsion Systems Analysis
Susceptibility	RM&A Analysis
Acoustic Signature Analysis	Steering and Maneuvering Controls
Infrared Signature Analysis	Structural Cost and Producibility Assessment
Magnetic Signature Analysis	Total Ship Cost Analysis
Radar Cross Section Analysis	Underway Replenishment Analysis
Vulnerability – UNDEX-Shock/Damage	Weapons Handling and Aircraft Support
Recoverability	Weight and Moment Analysis

- From D. Billingsley – former NAVSEA lead for design tools, and
- From H. Fireman presentation to CREATE, 6 Apr 2007

Distribution Statement A Applies, see cover page for specifics

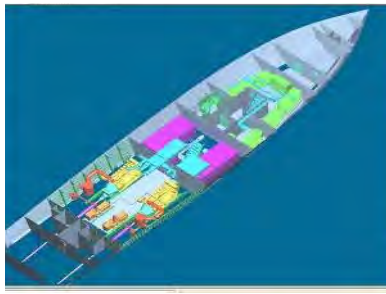
The CREATE-Ships Project

- **Addresses three primary challenges**

1. **Survivability analysis for severe events**
   - **Shock/Damage Product**
     - **Lead: Dr. E. Thomas Moyer (NSWC-Carderock)**

2. **Hydrodynamics analysis of new, innovative ship design improvements to existing designs**
   - **Hydrodynamics Products (2)**
     - **Lead: Dr. Joseph Gorski (NSWC-Carderock)**

3. **Timely/confident design tradeoffs in the earlier stages, when life-cycle costs are locked in**
   - **Rapid Design and Integration Product**
     - **Lead: Mr. Seth Cooper (NAVSEA)**



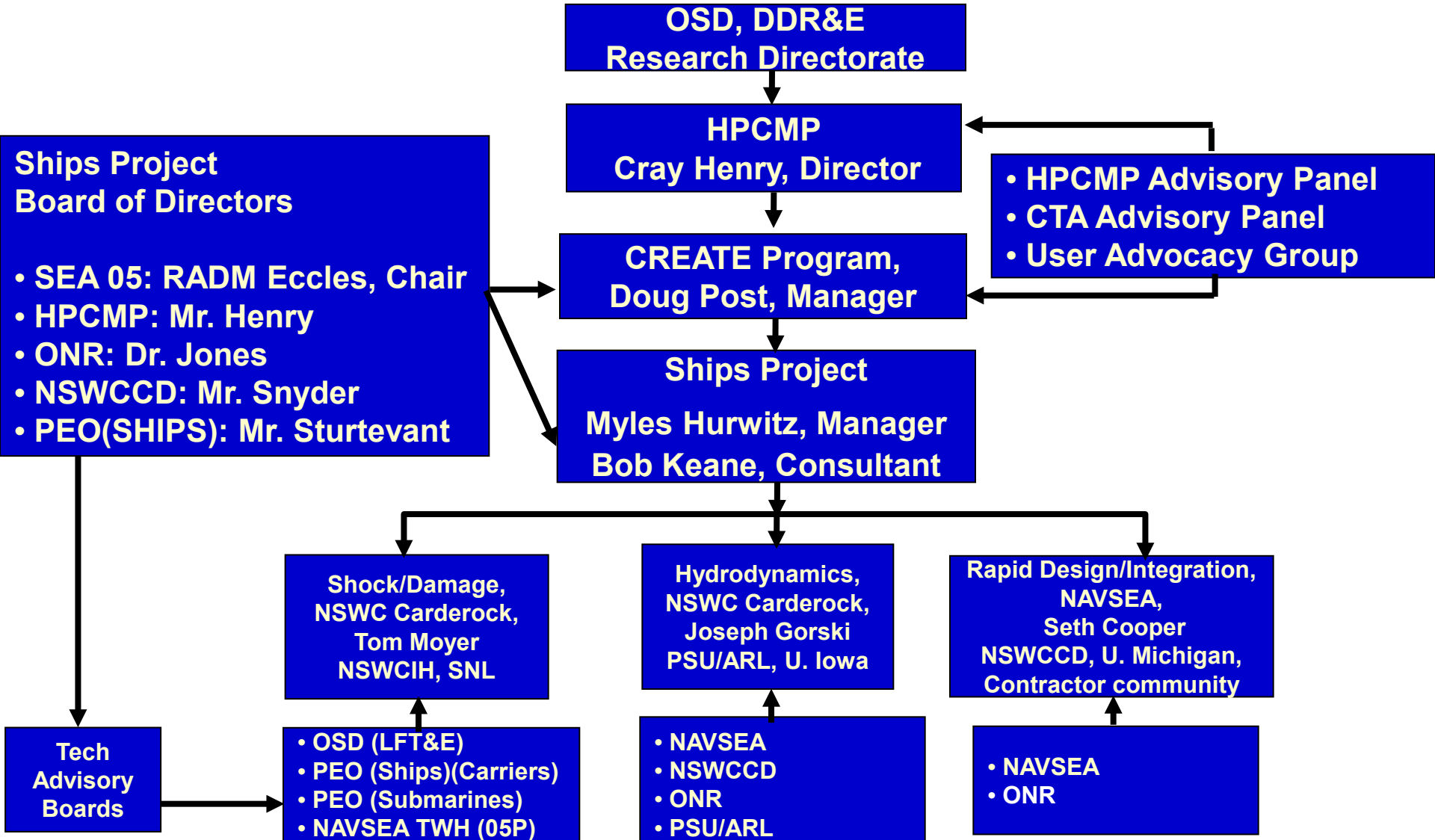
Distribution Statement A Applies, see cover page for specifics

COMNAVSEA Memo: 4 Feb 08 Functionality and Timeliness Objectives – (Reaffirmed Oct 2010 by NAVSEA Chief Engineer for Naval Systems Engineering

- **"This memorandum establishes high-level capability goals for NAVSEA design synthesis and analysis tools in order to guide development efforts within the Navy and for the DoD sponsored CREATE …"**
- **Joint Capabilities Integration & Development (JCIDS)**
  - "… capability to generate and analyze hundreds of ship concepts to a rough order of magnitude level within a period of **weeks or months**"
- **Concept Refinement**
  - "…accurately portray cost versus capability trade-offs, including uncertainty analysis, for dozens of ship concept options within a **six-month** period of performance"
- **Technology Development**
  - "… completion of a design iteration in **8 to10 weeks**, including insight as to changes needed for the next design iteration. Within the time allocated during a design iteration, analysis tools must comprehensively analyze all aspects of a Navy ship design …"
- **Interoperability with LEAPS (product model data repository and software integrator)**
- **Adhere to rigorous VV&A process**

Distribution Statement A Applies, see cover page for specifics

CREATE-Ships Project Governance



Distribution Statement A Applies, see cover page for specifics

CREATE-Ships Objectives for Shock/Damage

- **Develop robust capability to predict the response of surface ships & submarines to underwater explosion (UNDEX) loading for:**
  - **System/Component Environments**
  - **Structural Response & Damage**
  - **Scenarios**
    - **Stand-Off UNDEX**
    - **Close-In UNDEX**
    - **SURFEX (e.g., USS Cole)**
    - **AIREX**
- **Interface w/ Ship State Modeling in earlier stages of design with tools such as:**
  - **ASAP/ARM (Advanced Survivability Assessment Program/Advanced Recoverability Module)**
  - **FASST (Fully Automated Ship Shock Tool – fast computational model preparation)**

Distribution Statement A Applies, see cover page for specifics

Requirements & Use Cases

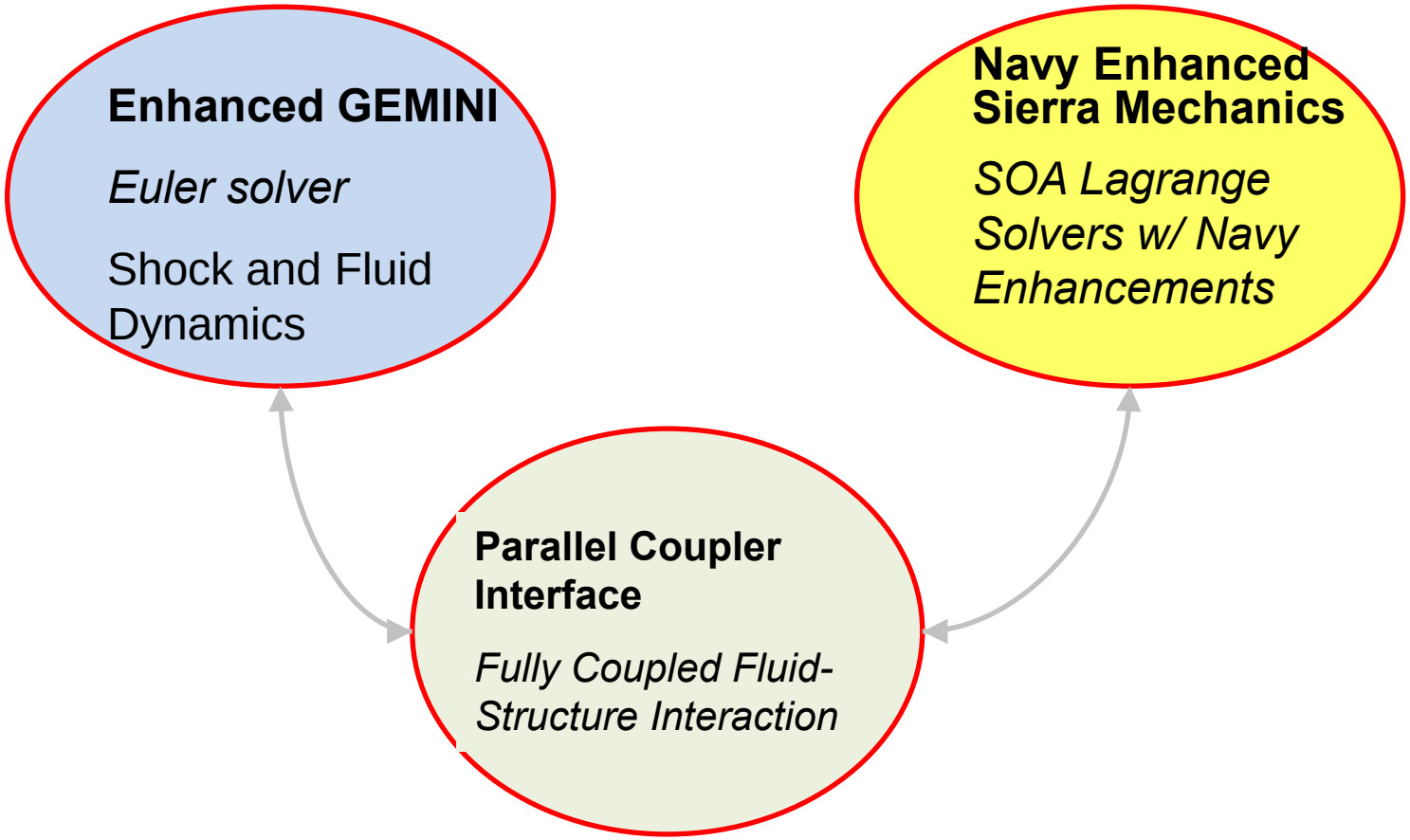
- **Define Development Plan & Requirements Based On Six (6) Use Cases**
  - UC I => Ship Response To Standoff UNDEX Where Structure Remains Predominantly Elastic (minimal damage)
  - UC II => Ship Response to UNDEX Causing Moderate Structural Damage
  - UC III => Ship Response To UNDEX Causing Severe Structural Damage (including SURFEX)
  - UC IV => Ship Response To AIREX Causing Moderate Structural Damage
  - UC V => Ship Response To AIREX Causing Severe Structural Damage
  - UC VI => Ship Response To Unconventional Weapon Attacks

Distribution Statement A Applies, see cover page for specifics

USS Cole – 12 Oct 2000

Distribution Statement A Applies, see cover page for specifics

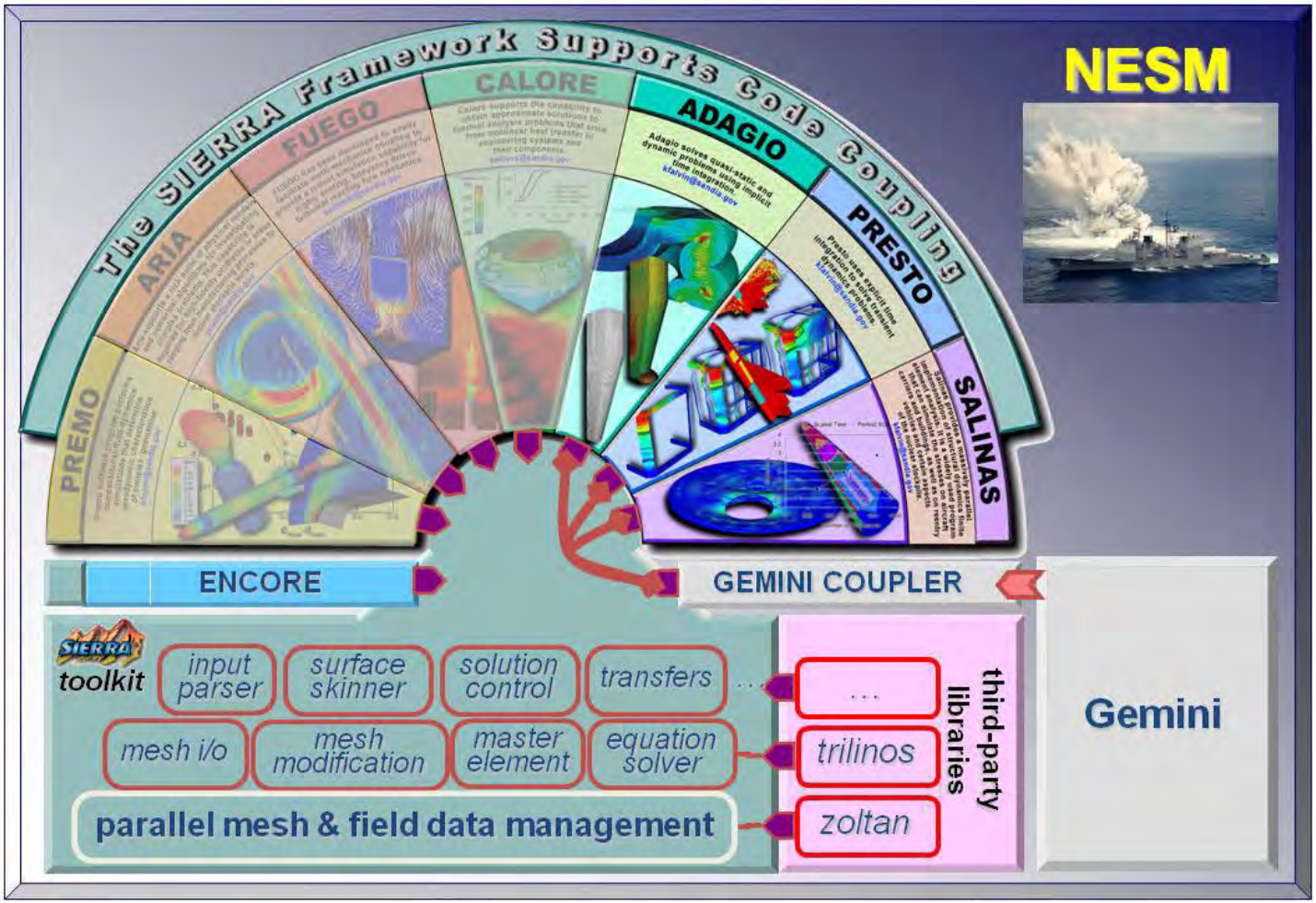
Evolving Capability - NESM/DYSMAS II



HYDROCODE FOR SIMULATION OF UNDERWATER EXPLOSION EFFECTS

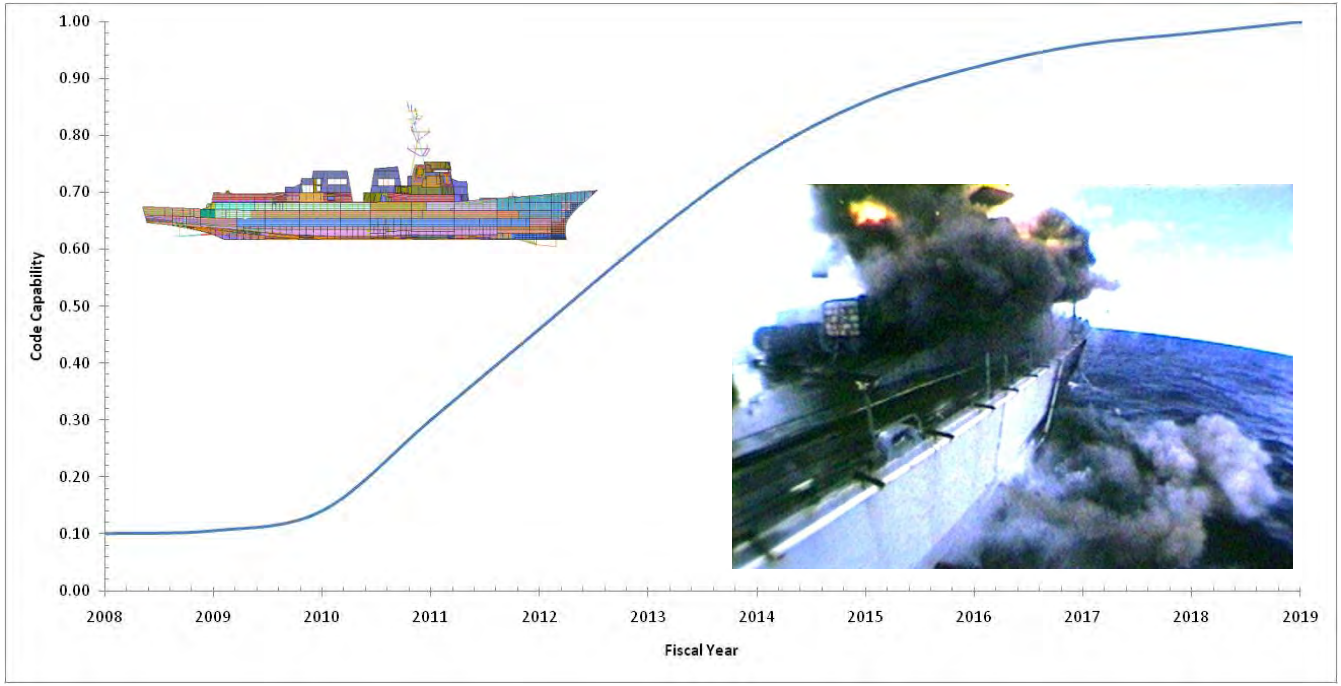
DYSMAS (Dynamic Systems Mechanics – Advanced Simulation)

NESM In The Sierra Framework



Distribution Statement A Applies, see cover page for specifics

NESM 12 Year Roadmap



- FY-08 => Planning, Start UC I
- FY-09 => UC I Development
- FY-10 => UC I Improvement
- FY-11 => UC I Production
- FY-12 => UC II Improvement
- FY-13 => UC II Production
- FY-14 => UC III Production
- FY-15 => UC IV Development
- FY-16 => UC IV Improvement
- FY-17 => UC IV Production
- FY-18 => UC V Production
- FY-19 => UC VI Production

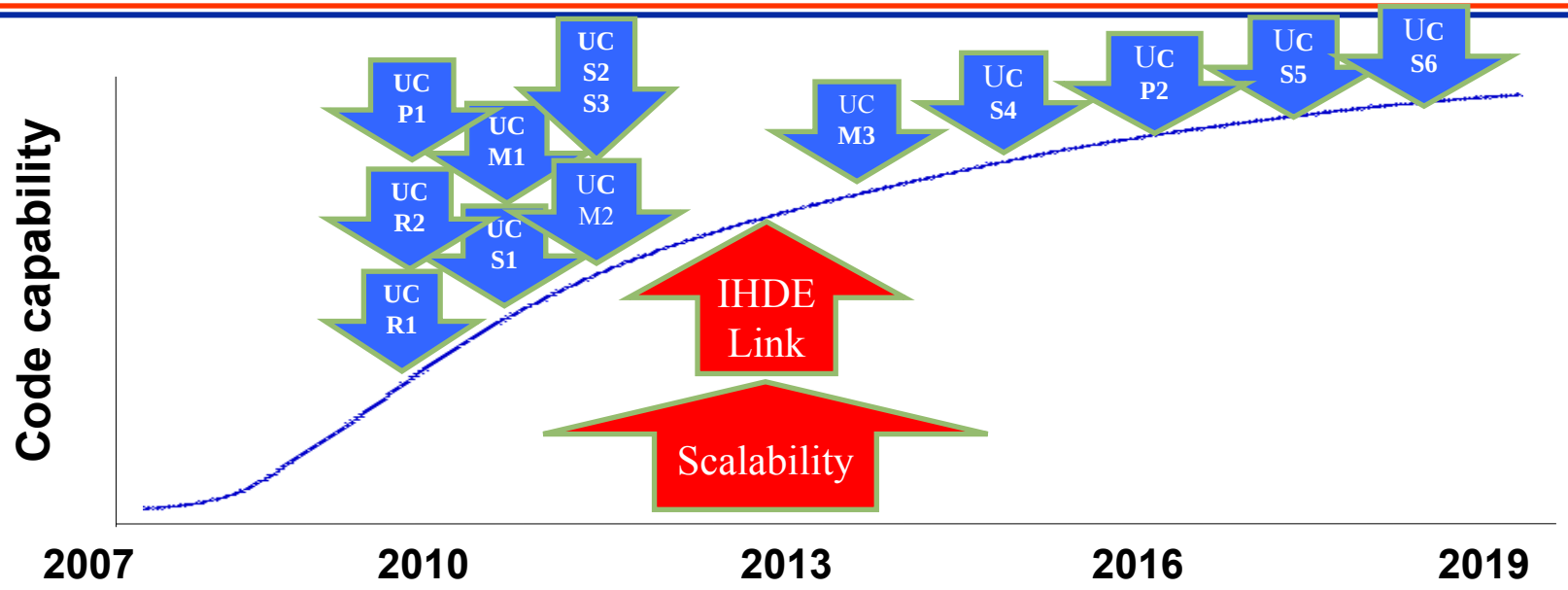
Distribution Statement A Applies, see cover page for specifics

CREATE-Ships Objectives for Hydrodynamics

- **Provide the US Navy community with a suite of analysis methods that can be used to impact design and analysis**
  - Existing and evolving semi-empirical methods for fast turnaround needs
  - Use of existing high-end methods where appropriate, within required timeframes
  - New CREATE-developed high-fidelity capability with a minimum of empiricism
- **Provide an integrated user design environment for using these different levels of fidelity methods by users in both the design and analysis domains**
  - Simultaneously optimize and evaluate different disciplines (e.g., resistance, powering, maneuvering, seakeeping)

Distribution Statement A Applies, see cover page for specifics

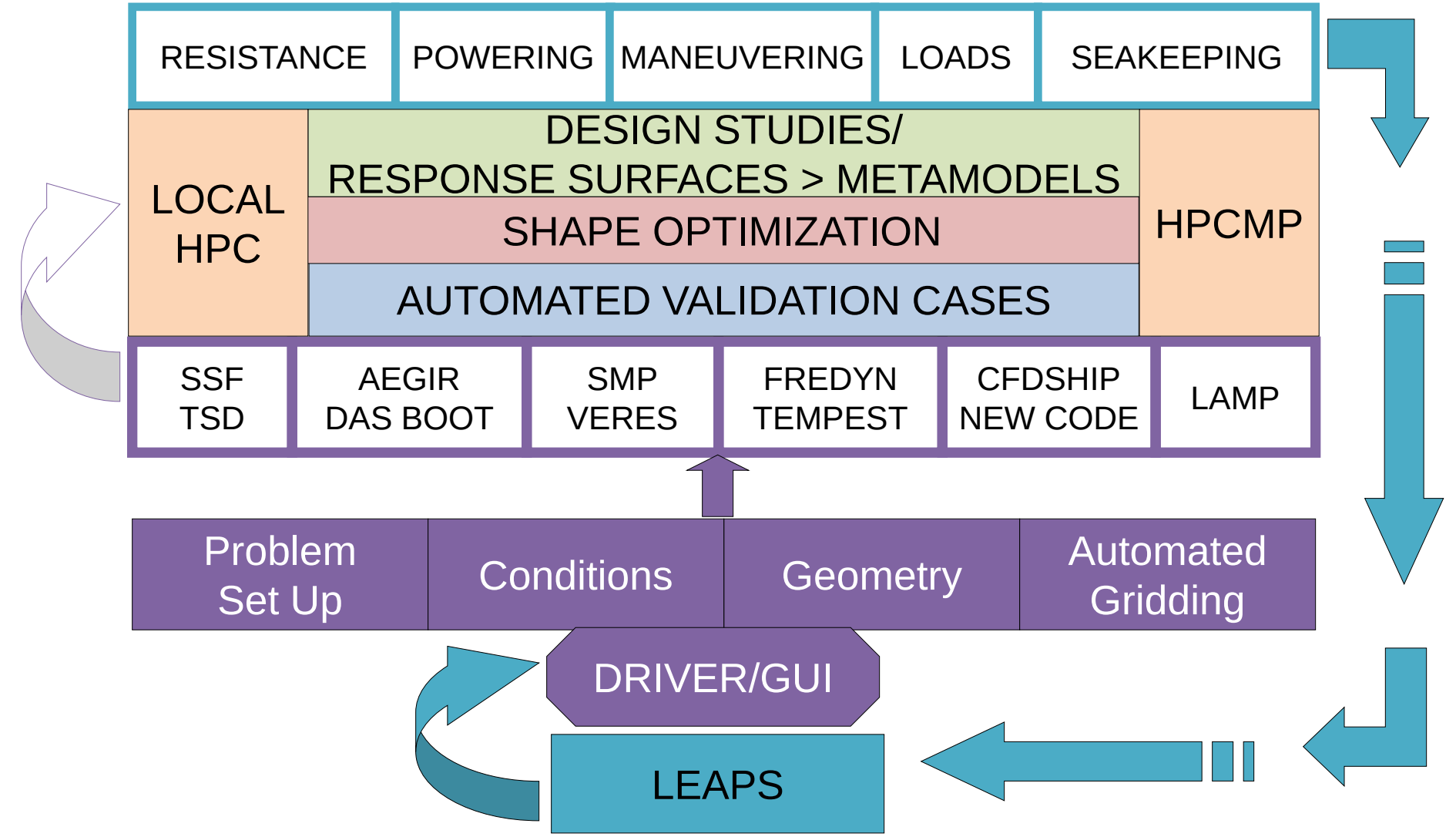
NavyNS Development Roadmap



- Resistance Related
  - UCR1: Hull with fixed ship sinkage and trim
  - UCR2: Hull with computed sinkage and trim
- Powering Related
  - UCP1: Body force model for propulsor
  - UCP2 : Full propulsor modeling
- Maneuvering Related (motions in calm water)
  - UCM1: Rotating arm steady turning motion
  - UCM2 : Planar Motion Mechanism (PMM)
  - UCM3 : Moving appendages and controller
- Seakeeping Related (involves waves)
  - UCS1 : Prescribed trajectory in regular waves
  - UCS2: Hull responds to regular waves
  - UCS3 : Prescribed trajectory in irregular waves
  - UCS4 : Predicted motions with moving appendages in waves
  - UCS5: Seaway loads with one way coupling to structures code
  - UCS6: Seaway loads with two way coupling to structures code

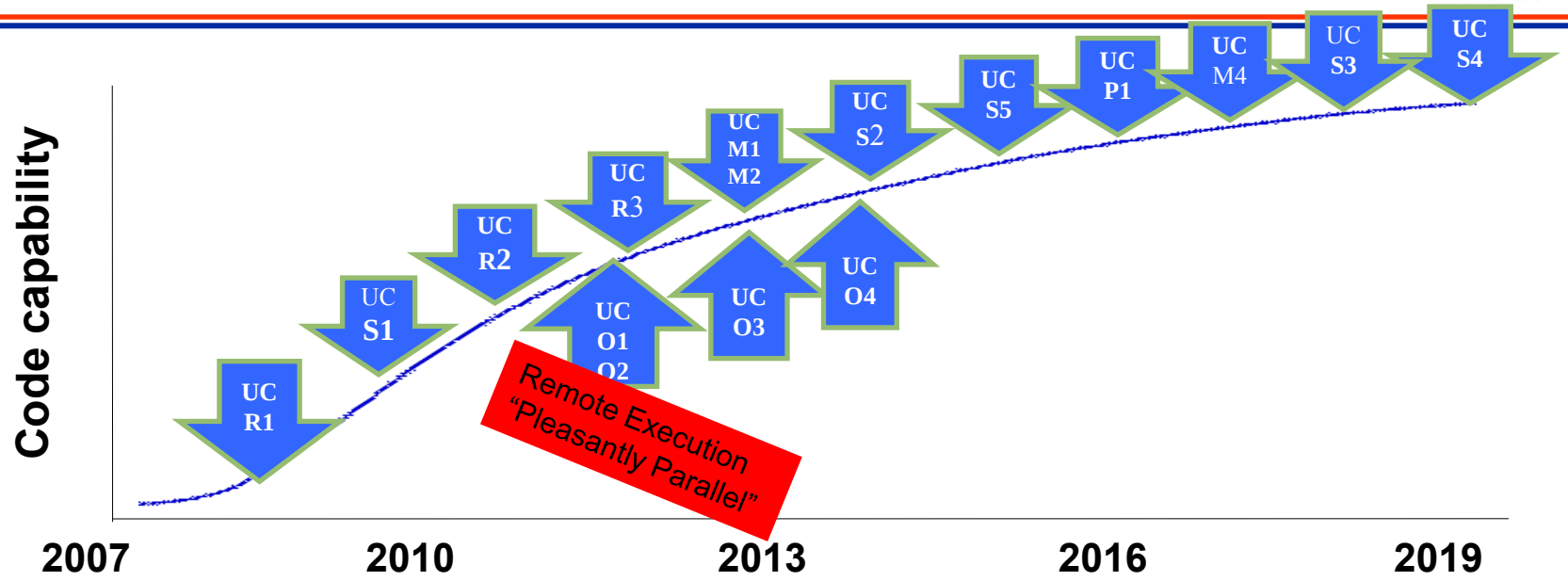
Distribution Statement A Applies, see cover page for specifics

Integrated Hydrodynamics Design Environment



Distribution Statement A Applies, see cover page for specifics

IHDE Development Roadmap



- Resistance Related
  - UCR1: Bare Hull thin ship theory
  - UCR2: Bare hull with the BEM
  - UCR3: Bare hull with RANS
  - UCR4: Fully appended hull with RANS
- Powering Related
  - UCP1: Body force model for propulsor
- Maneuvering Related
  - UCM1: Empirical based models
  - UCM2: Bare hull steady turns
  - UCM4: turning circles, overshoots, zig-zag
- Seakeeping Related
  - UCS1: Inviscid codes in the frequency domain
  - UCS2: Inviscid code in the time domain
  - UCS3: RANS at specified headings
  - UCS4: RANS predictions with moving appendages
  - UCS5: Seaway loads with inviscid code
- Optimization Related
  - UCO1: Single objective optimization for resistance
  - UCO2 : Single objective optimization for seakeeping
  - UCO3 : Multi-objective optimization
  - UCO4 : Multi-objective optimization for user-specified parameters

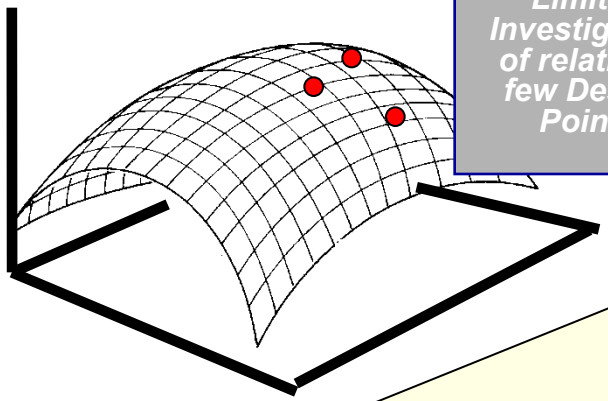
Distribution Statement A Applies, see cover page for specifics

CREATE-Ships Objectives for Rapid Design and Integration (RDI)

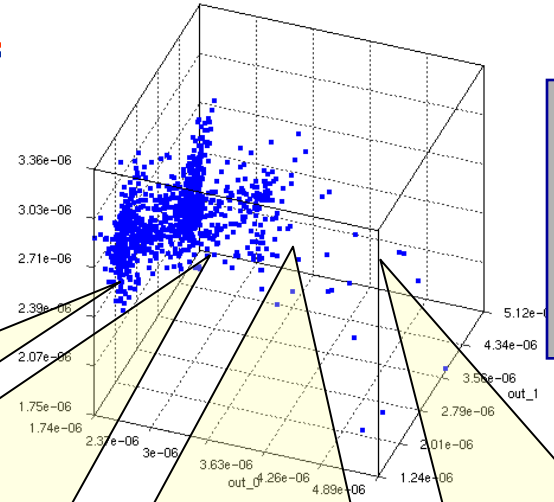
- Comprehensively explore alternative design solutions while there is still a maximum range of options available
- Provide greater definition for each ship in a range of possible design solutions
- Perform detailed, physics-based and HPC-based analysis early on in the design cycle for each ship in a range of possible design solutions

Distribution Statement A Applies, see cover page for specifics

Design Space Exploration

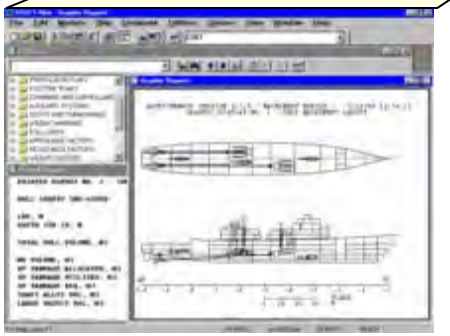


From… Limited Investigation of relatively few Design Points

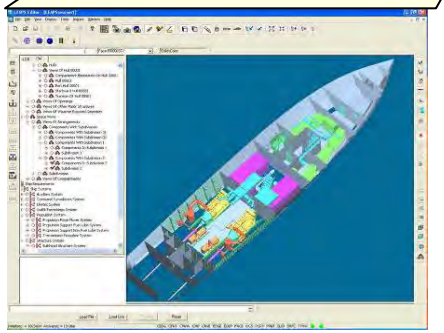


To… Full Investigation of Concepts throughout the Design Space

HPC Enables Exhaustive Exploration by:

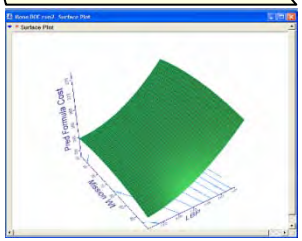


Generating *The Space*



Exploring *The Space*

Evaluating *The Space*

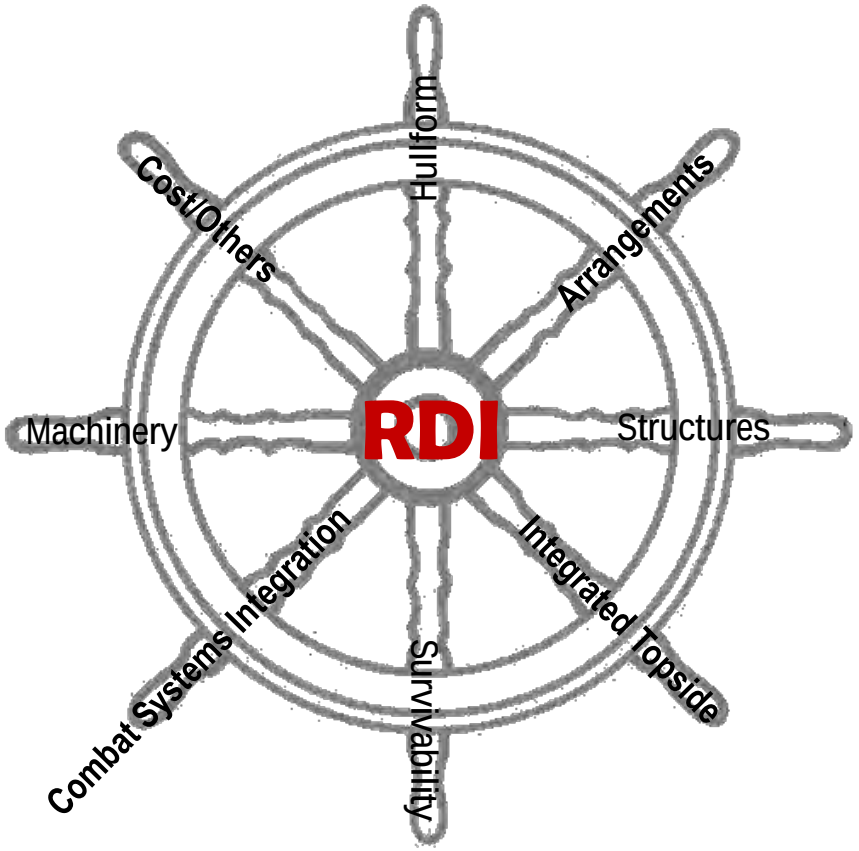


and ***Visualization***

Distribution Statement A Applies, see cover page for specifics

Rapid Design and Integration Enabling Concepts

- **Design Space Exploration, Optimization and Visualization**
  - Hullform Transformation
  - Hullform Generation
  - Arrangements (Interior and Topside)
  - Behavior Models/Response Surfaces/Neural Nets/Kriging
  - Multidisciplinary Optimization
- **Standard Product Model Data Structure**
  - Analysis Activity Integration



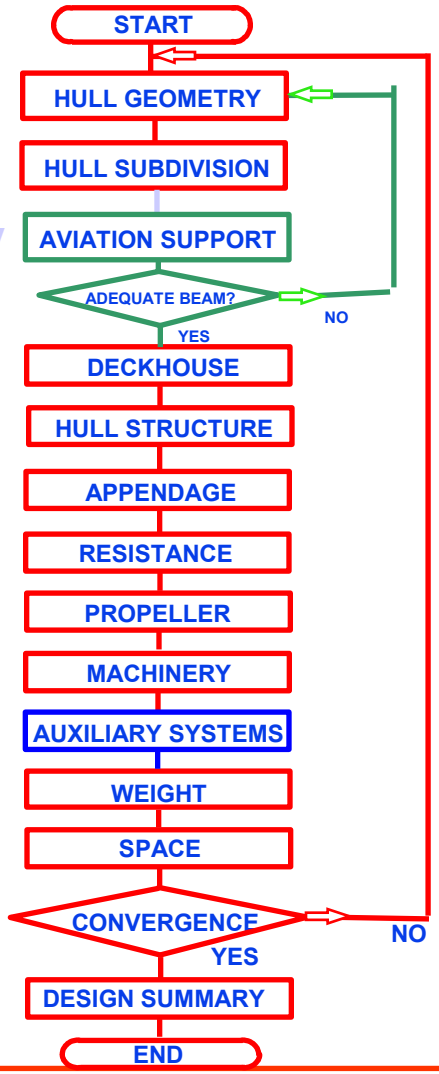
Distribution Statement A Applies, see cover page for specifics

Migrate traditional ship design spiral synthesis approach to multi-disciplinary optimization approach, using behavior models as surrogate analysis modules

INPUT SECTION

- PAYLOADS
- OTHER MISSION REQUIREMENTS
- TECHNOLOGIES
- MANNING

SYNTHESIS SECTION

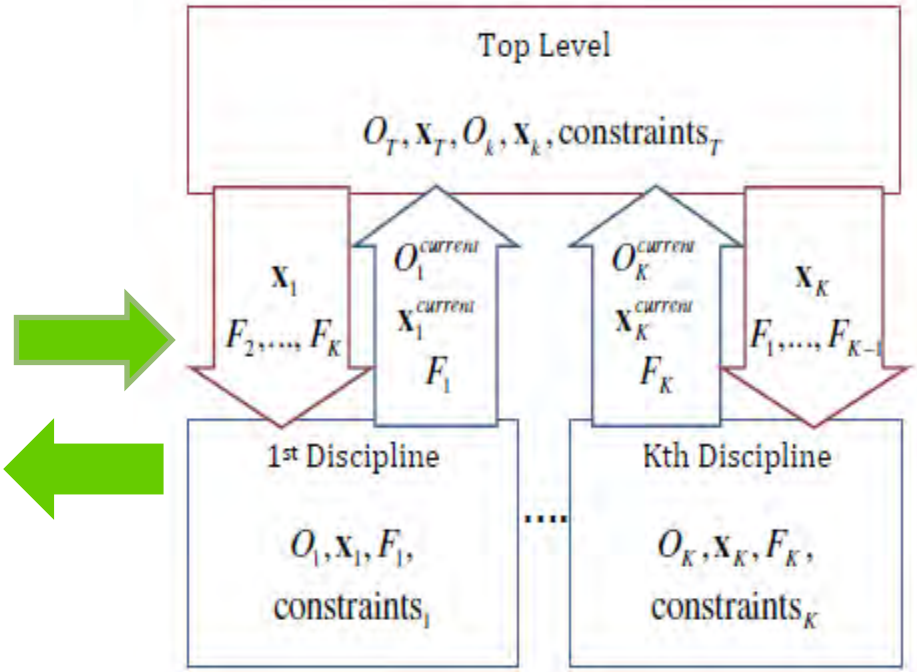


MONOCV only

MONOSC only

ANALYSIS SECTION

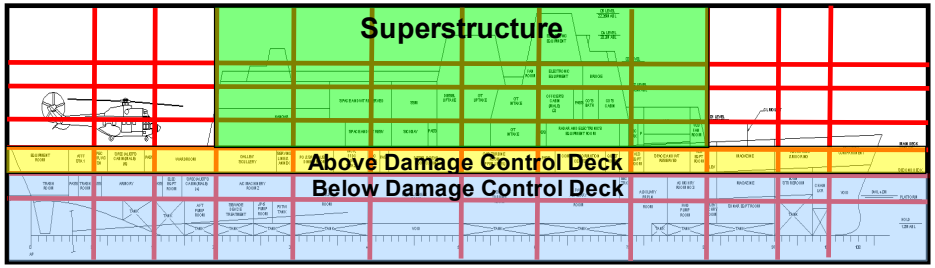
- PERFORMANCE
- HYDROSTATICS



Distribution Statement A Applies, see cover page for specifics

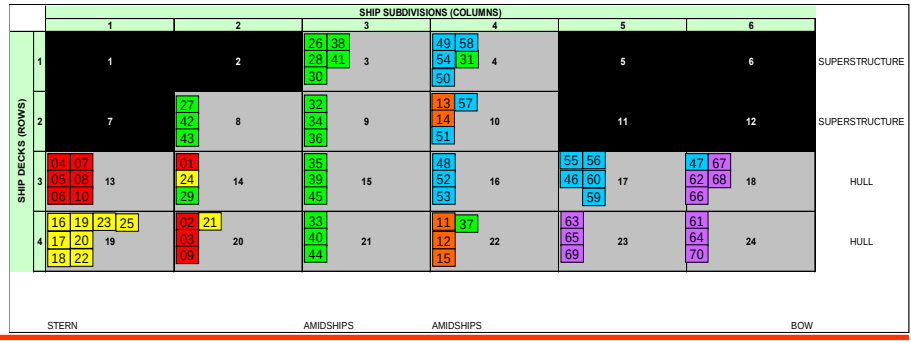
Intelligent Ships Arrangements (U. of Michigan): Ninth International Marine Design Conference -2006 (funded by ONR)

Fuzzy Global Location Preference Map Example: **Space A prefers to be either just forward or aft of amid ships and above the damage control deck within the hull.**



Superstructure				0.00	0.0	0.0	0.0	0.1	0.00			
				0.00	0.0	0.0	0.0	0.2	0.00			
				0.00	0.1	0.3	0.3	0.3	0.00			
				0.00	0.1	0.5	0.5	0.5	0.1			
Below Damage Control Deck	0.05	0.2	0.6	0.9	0.6	0.6	0.9	0.6	0.4	0.2	0.1	0.05
Below Damage Control Deck	0.05	0.05	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.05
	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.00

- **17 Zone-deck/70 compartment results**
  - Combinatorial Search Space 17^{70} = 1.35E+86
  - Unknown global optimum – too large for full enumeration in practical amount of time



Distribution Statement A Applies, see cover page for specifics

RDI Use Cases

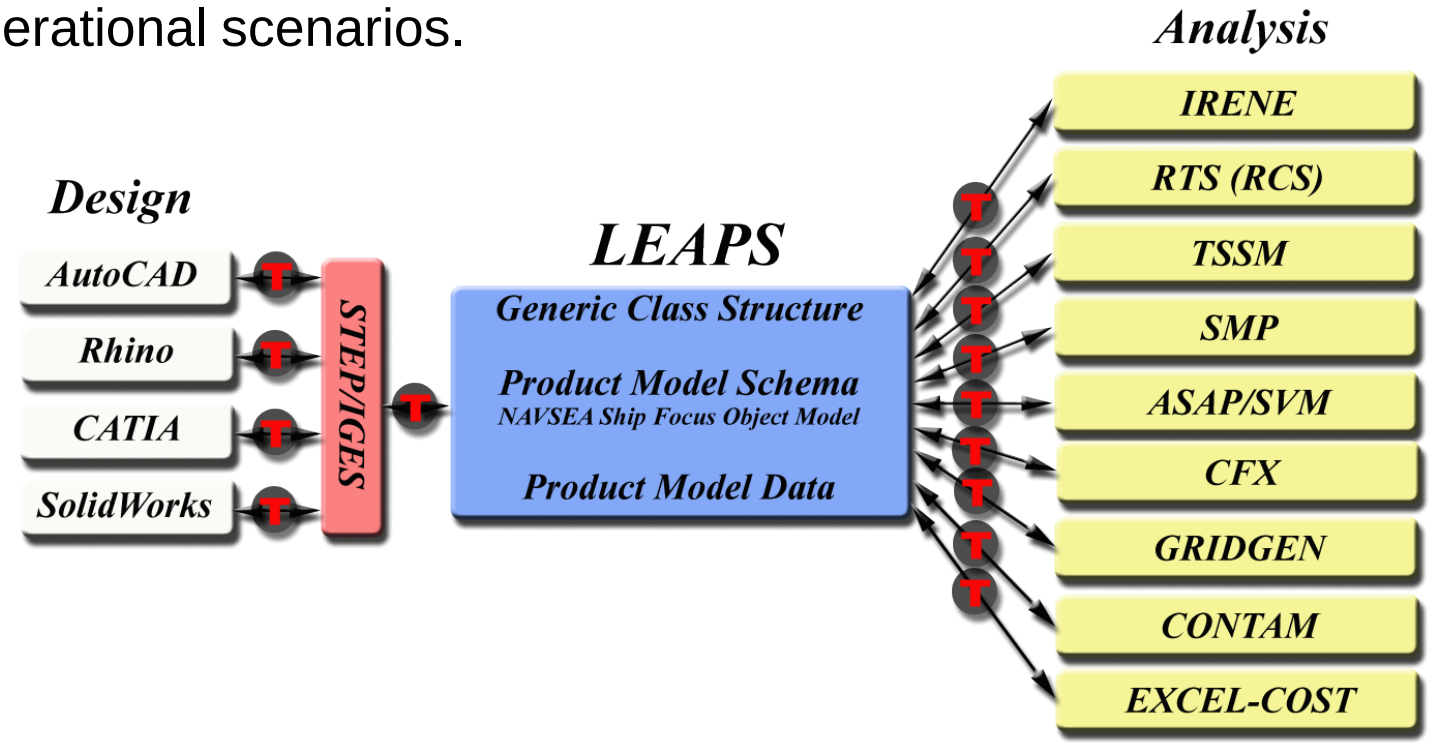
Use Cases	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs	Number of Ship Designs
ASSET Synthesis	100+	100+	100+	100+	100+	100+	100+	100+	100+	100+
Hullform Transformation		1	100+	100+	100+	100+	100+	100+	100+	100+
Hullform Generation				1	100+	100+	100+	100+	100+	100+
Hullform - Intact and Damaged Stability	1	1	1	100+	100+	100+	100+	100+	100+	100+
Hullform - Resistance Analysis	1	1	1	1	1	100+	100+	100+	100+	100+
Hullform - Maneuvering Analysis					1	100+	100+	100+	100+	100+
Hullform - Seakeeping Analysis		1	1	1	1	100+	100+	100+	100+	100+
Hullform - Structural Analysis					1	1	1	1	1	1
Arrangement - Internal Compartments (Outside in)					1	100+	100+	100+	100+	100+
Arrangement - Component Placement						1	1	100+	100+	100+
Arrangement - Routing of Distributed Systems							1	1	100+	100+
Arrangement - Internal Compartments (Inside out)									1	100+

Distribution Statement A Applies, see cover page for specifics

What is LEAPS?

The NAVSEA Product Modeling Environment

*L*eading *E*dge *A*rchitecture for *P*rototyping *S*ystems, is the product model repository used by the Naval Sea Systems Command. LEAPS is based on an extensible information meta-model. It is designed to provide product model data to support modeling and simulation tools used by Navy Ship Designers. The current focus is concept studies, analysis of alternatives, and operational scenarios.



Distribution Statement A Applies, see cover page for specifics

Product Model Data
A Simple Definition

Product Model data is the combination of 3D geometry and non-graphic attributes to define ship objects such as a piece of equipment, deck, bulkhead, etc. Product Model data can be organized to define interim products and ultimately the entire ship.

Part & System Definition (Caterpillar 3512, Starboard Main Engine, Propulsion System)

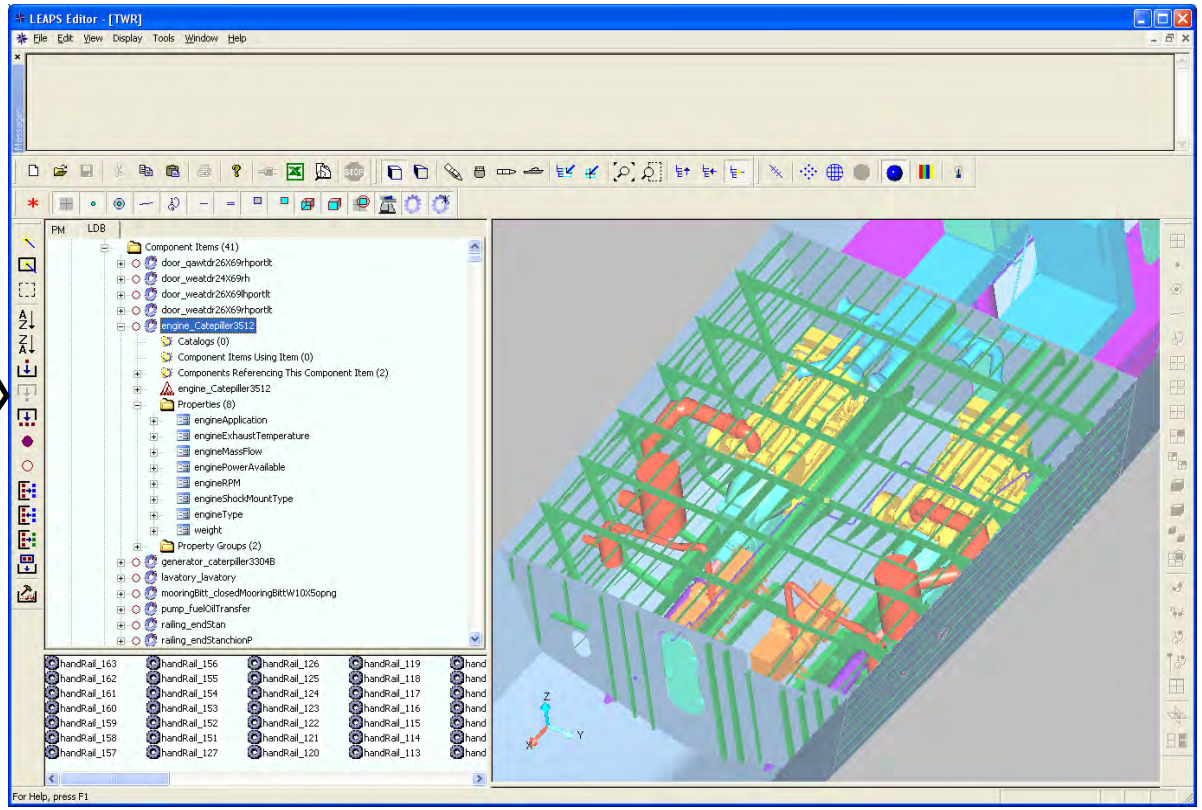
Design Definition (12 cylinder 4 stroke diesel engine)

Physical (Geometry, material connections, etc.)

Engineering Definition (1175 HP, 6464kg, 170mm bore, 190mm stroke)

Process Definition (Starting instructions, shaft alignment)

Logistics Support (FGC, SCLSIS, etc.)

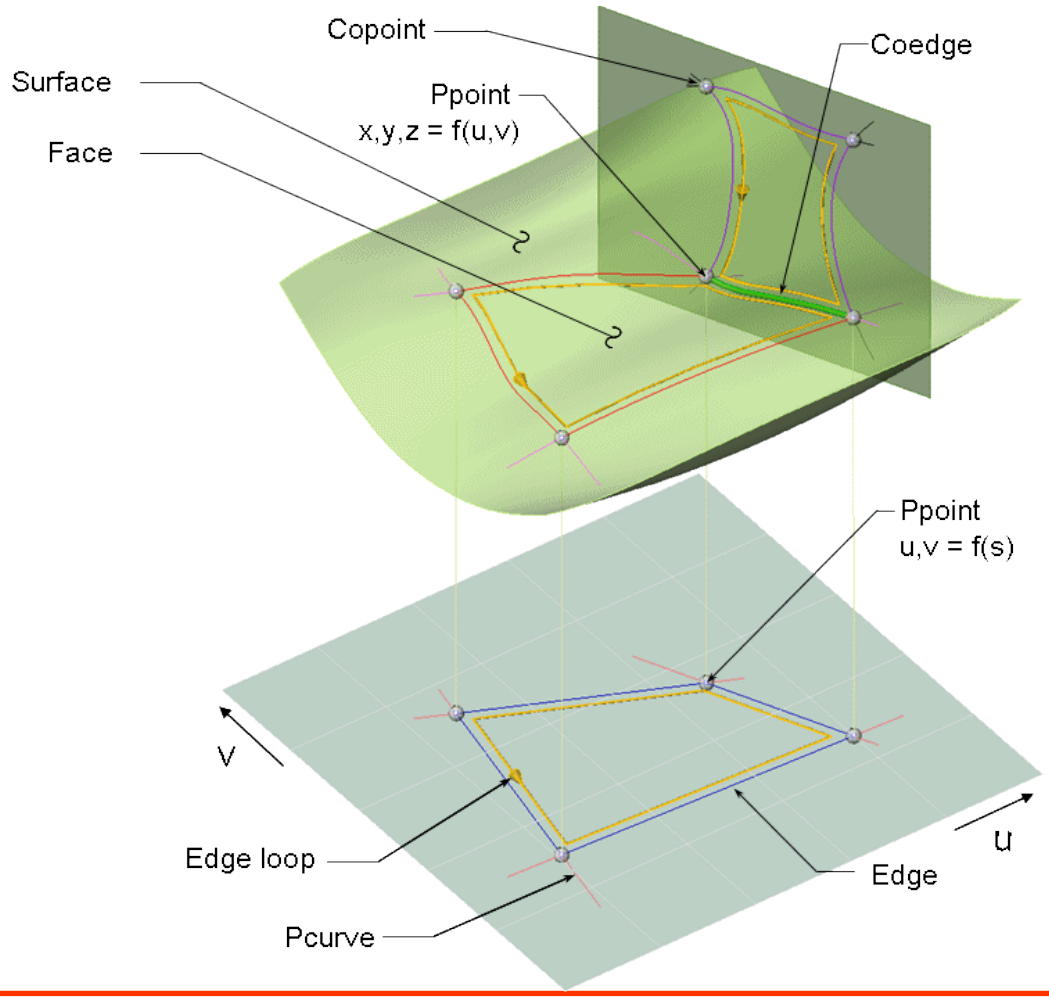


Advocates anticipate substantial economies from Product-Model-based design, construction, and service-life support activities due to better integration and reduction of engineering effort to locate, verify, and transform information.

Distribution Statement A Applies, see cover page for specifics

Geometry Object Structure
Entities and Topology

Solid	A manifold BREP (boundary representation) solid defined by a single OrientedClosedShell
Surface	An untrimmed 3D NURBS surface used to define any shape.
Oriented ClosedShell	A set of Face objects that form a closed shell that is oriented.
Face	A region of a surface represented as a trimmed NURBS surface.
EdgeLoop	A set of connected Edge objects that form a closed loop that is not self intersecting. This loop is also oriented.
Edge	A region or segment of a Pcurve. The collection of contiguous Edges is used for composing paths, loops, or topological boundaries.
Pcurve	A parametric curve defined by means of a 2D curve in the parameter space of a surface.
Ppoint	A parametric point lying on a Pcurve object.
Coedge	The relationship between two or more Edges. The CoEdge is used to allow traversal across Surfaces or Faces and defines explicitly an association between two or more Surfaces or Faces.
CoPoint	The Cartesian Location equivalent for a list of Ppoint objects.

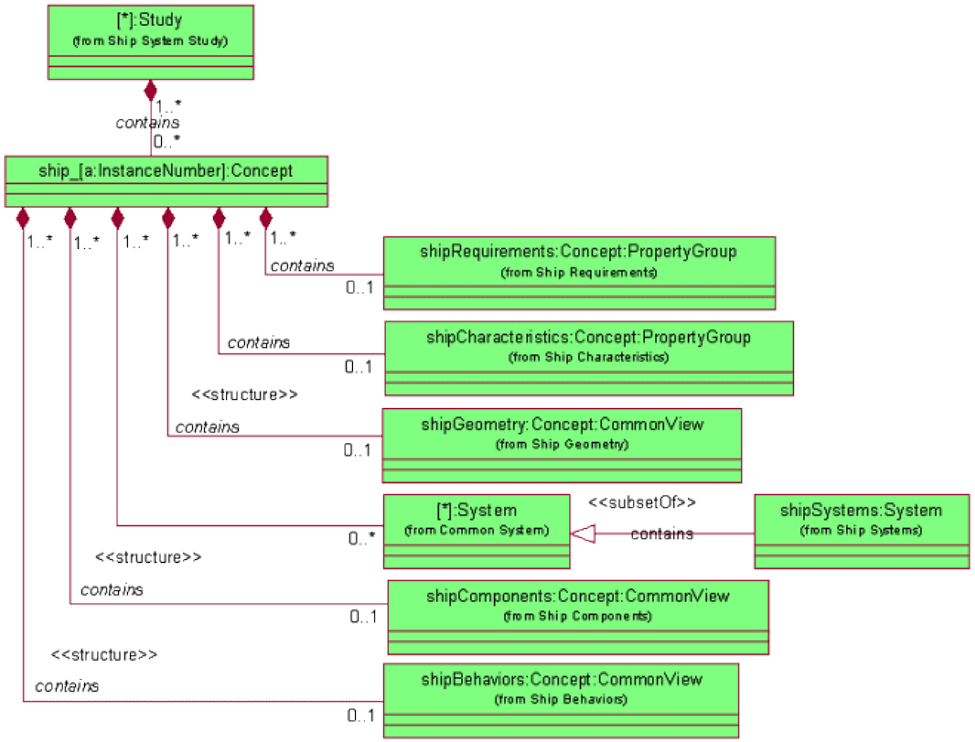


Distribution Statement A Applies, see cover page for specifics

What is LEAPS?
Geometry is just a small part

Geometry is important as it provides the spatial definition and is critical in supporting visualization. However it is important to realize geometry is no more relavent to the Product Model Definition of a ship than any other non graphical attribute.

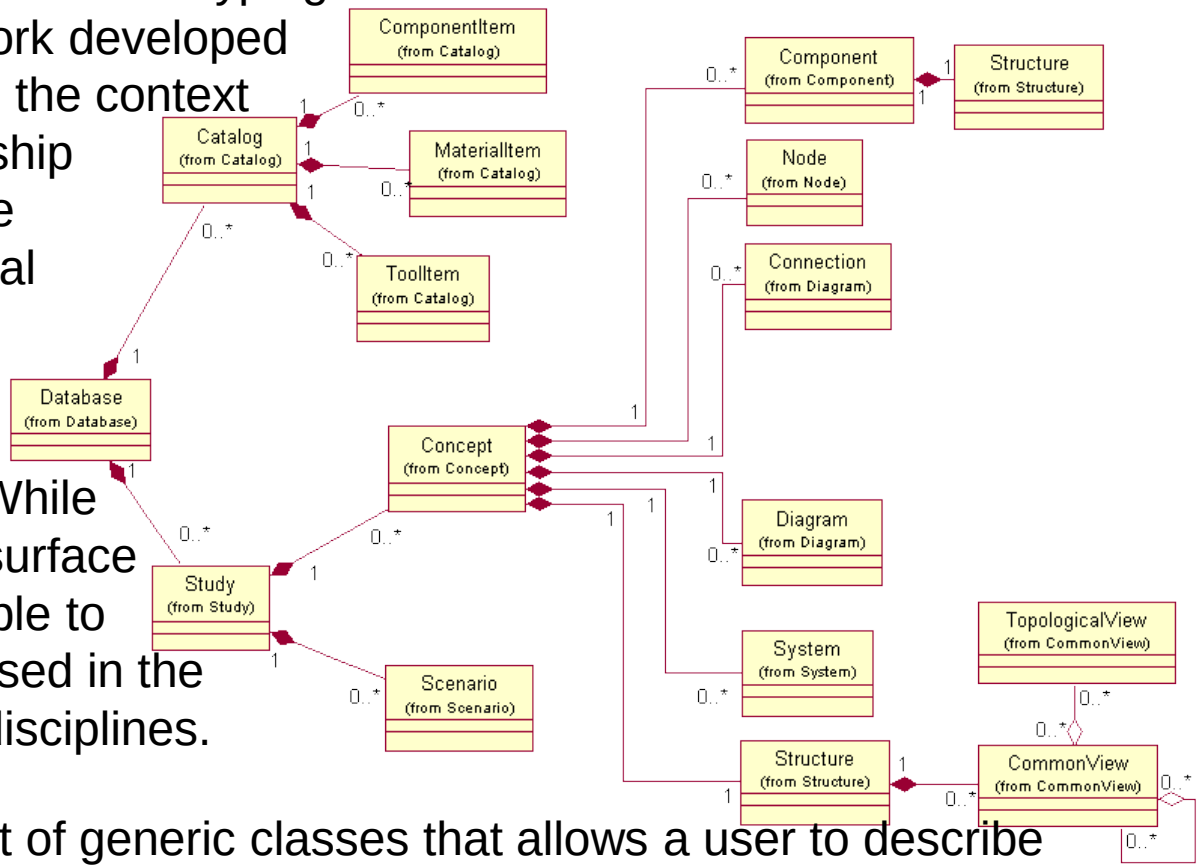
- Requirements are a property group that capture information that can be obtained from an AoA, ICD, and other high level program document.
- Characteristics are a property group that capture conditions related to the total ship. Examples of characteristics are curves of form, hydromechanics, mission profile, and stability.
- Systems are a combination of components, connections, subsystems, and functional relationships.
- Components are a collection of geometry and characteristics. Components can have multiple representations, and may have a system equivalent.
- Behaviors are a collection of geometry, conditions, environmental definition, and results.



Distribution Statement A Applies, see cover page for specifics

What is LEAPS?
The meta model

The Leading Edge Architecture for Prototyping Systems (LEAPS) is a framework developed to support virtual prototyping in the context of conceptual and preliminary ship design and analysis. Due to the complexity and diversity of naval ship design and analysis, the LEAPS architecture takes a "meta model" approach to product model development. While originally developed for naval surface combatants, LEAPS is applicable to other products and has been used in the aviation and urban structures disciplines.



The LEAPS MetaModel is a set of generic classes that allows a user to describe physical and/or functional representations of objects and methods that can be applied to the development of the NAVSEA Ship product model.

Distribution Statement A Applies, see cover page for specifics

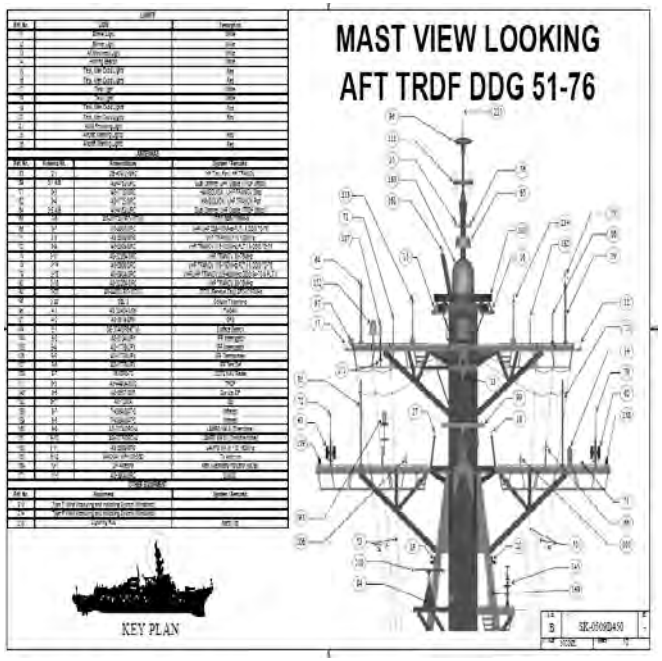
CREATE-SHIPS Interactions with Other CREATE Projects

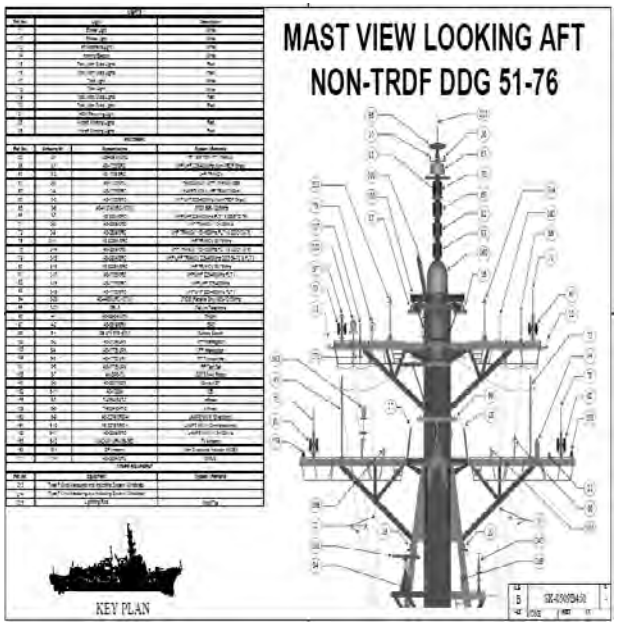
- RF Antennas: CREATE-RF
- Air Vehicles: CREATE-AV
- Mesh/Geometry: CREATE-MG

Distribution Statement A Applies, see cover page for specifics

Interactions with CREATE-RF

Our Topside Real Estate Reality





Numerous antennas competing for limited space and coverage result in a complex electromagnetic environment (EME), presenting a challenge for effective topside integration and maintaining the topside baseline.

Distribution Statement A Applies, see cover page for specifics

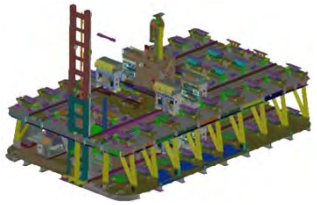
Interactions with CREATE-AV

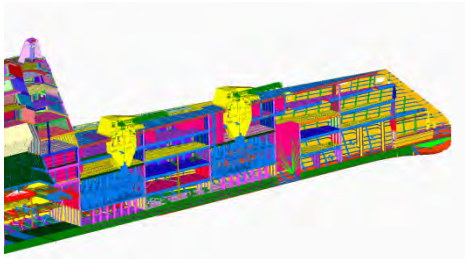
- **Dynamic Interface**

Distribution Statement A Applies, see cover page for specifics

Interactions with CREATE-MG

- **Mesh and Geometry (MG)**
  - Geometry clean-up and de-featuring
  - Multi-scale model integration
    - Large numbers of surfaces to be "cleaned and de-featured" prior to meshing – and then integration with other large numbers of surfaces
  - Accurate/fast meshing for hydro boundary layers
  - Adaptive Mesh Refinement to allow as much "hands-off" capability to ship designers as possible





Distribution Statement A Applies, see cover page for specifics

The CREATE-AV Project

Dr. Robert L. Meakin

CREATE-AV Project Manager

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

PROJECT MISSION

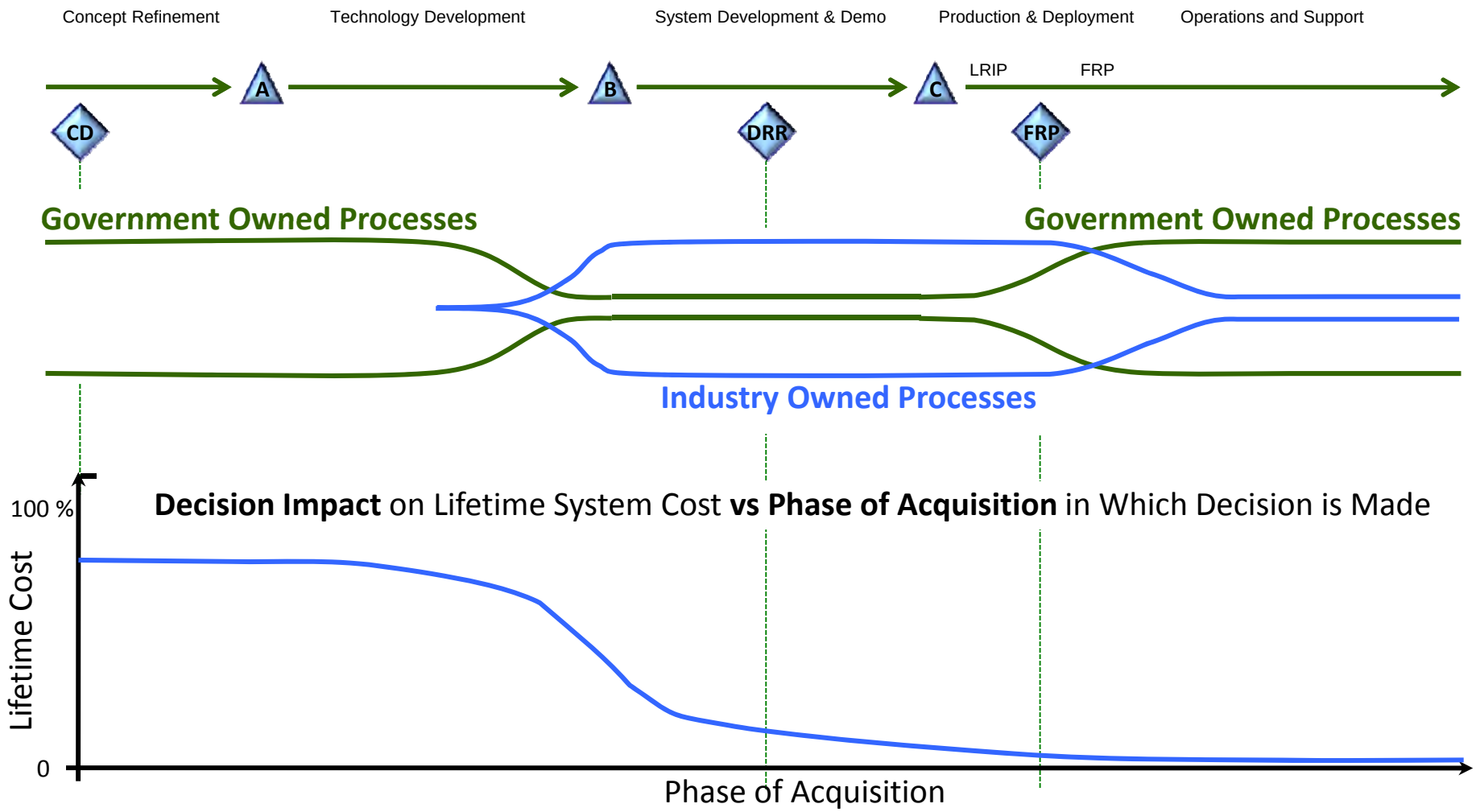
Develop and deploy a set of CBE Software Products that enable…

- **Increased capacity** of the acquisition engineering workforce of the services,
- Reduced workload through **streamlined** and more efficient acquisition **workflows**, and
- **Minimized need for rework** due to early detection of design faults or performance anomalies,

through exploitation of the capacity of next generation computer resources.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

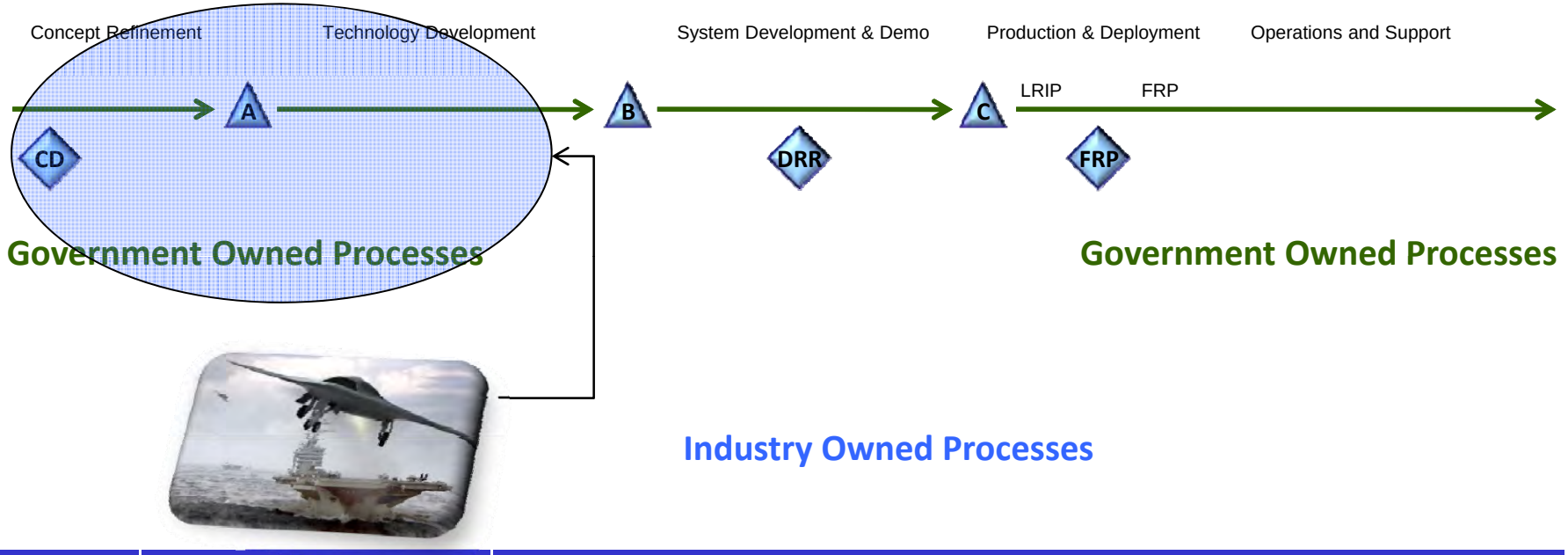
Ownership of Processes & Potential for Decision Impacts



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EARLY-PHASE EXAMPLE

1 of Targeted Set of Government Owned Engineering Processes

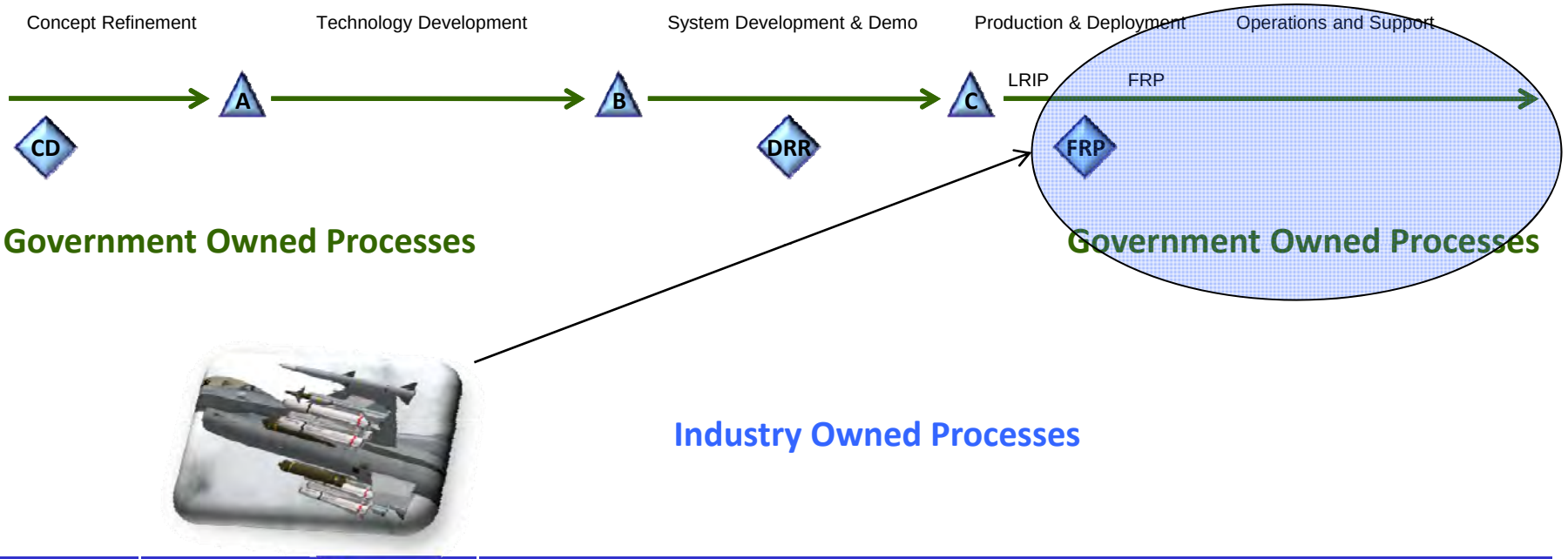


ID	Process Name	Use Case
AV-026	**Navy Conceptual Design** Process	Rapidly produce physics-based, optimized conceptual designs in days to weeks. Quantification of design concept performance and sensitivity to new technology. (Benefits: Better decision data at the earliest phases of acquisition have potential to positively impact all subsequent acquisition costs.)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

LATE-PHASE EXAMPLE

1 of Targeted Set of Government Owned Engineering Processes

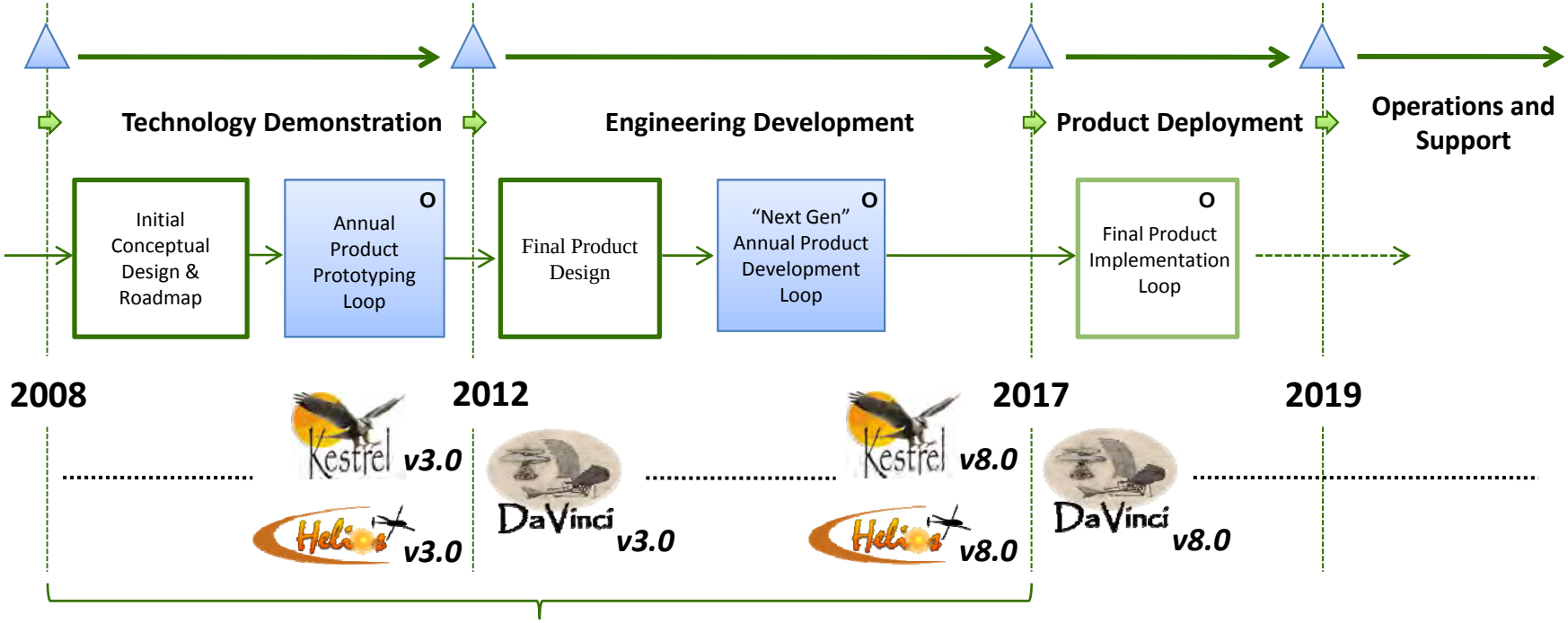


ID	Process Name	Use Case
AV-006	Store Compatibility Cert Recommend for **Store Separation** Air Force	Evaluate separation characteristics of all store combinations for a given aircraft. The number of configurations necessary to analyze is growing exponentially. (Benefits: Expansion of flight envelope / improve effectiveness & reduce cost of test programs)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

PRODUCT DEPLOYMENT SCHEDULE

ANNUAL release cycle – increasing functionality, physical accuracy, computational efficiency, usability



Deploy to targeted government workforce for **DoD owned** acquisition engineering processes. **Engage industry via technical advisory boards and professional societies.**

Expand industry involvement via Beta-test events

Full deploy to government and industry for DoD acquisition engineering

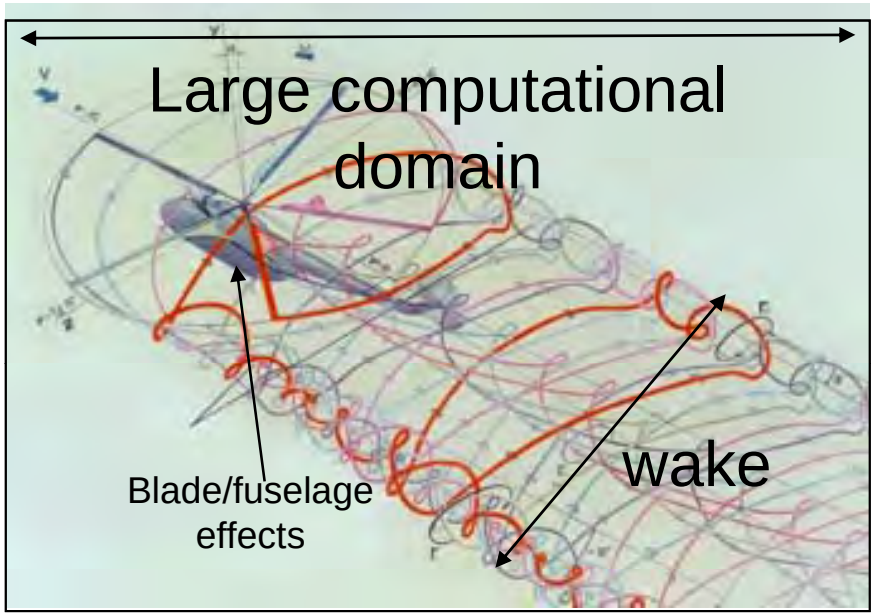
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

A LOOK AT ONE OF THE CREATE-AV PRODUCTS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

PHYSICS-BASED DRIVERS OF HELIOS DEVELOPMENT

- **Multiple scales**
  - Large computational domain
  - Small scales in boundary layers
  - Vortical structures in wake
- **Fluid-structure coupling**
  - Rotor blade aeroelasticity
  - Trim and pilot controls
- **Complex fluid dynamics**
  - Highly unsteady flowfield
  - Shock waves on advancing rotor
  - Dynamic stall on retreating rotor
- **Interactional aerodynamics**
  - Rotor/fuselage, main rotor/tail rotor
- **Numerical modeling**
  - High-order accuracy
  - Grid adaptation
  - Unsteady low Mach preconditioning



- **Other complexities**
  - Complex geometry
  - Bodies in relative motion

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

PHYSICAL ACCURACY TARGETS

Year / Measures	Metric 2008	2009	2010	2011	2012	2013	2014	2015	2016	Metric End of CREATE/AV
pp: Peak-to-Peak Vb: Vibratory Ph: Phase Mg: Magnitude Bp: Blade passage	SoA	Conventional Geometries			Capability/% Error in Accuracy			Advanced / Arbitrary Geometries		Vision for 10 Yrs
Airloads	pp 6% Vb 20% Ph 20%									pp 1% Vb 3% Ph 3%
Structural loads	pp 35% Vb 40% Ph 20%									pp 3% Vb 5% Ph 5%
Stress / Strain	-None-									Prediction
Hub loads	Mg 40% Ph 20%									Mg 5% Ph 5%
Fuselage Frequencies up to 40 Hz	Bp1 20% Bp2 40%									Bp1 5% Bp2 5%
Vibration Pilot/co-pilot seat Selected stations	-None- Mg 100% Ph 100%				Acro – tail boom impingment			Fuselage Dynamic Coupling		Prediction Mg 10% Ph 10%

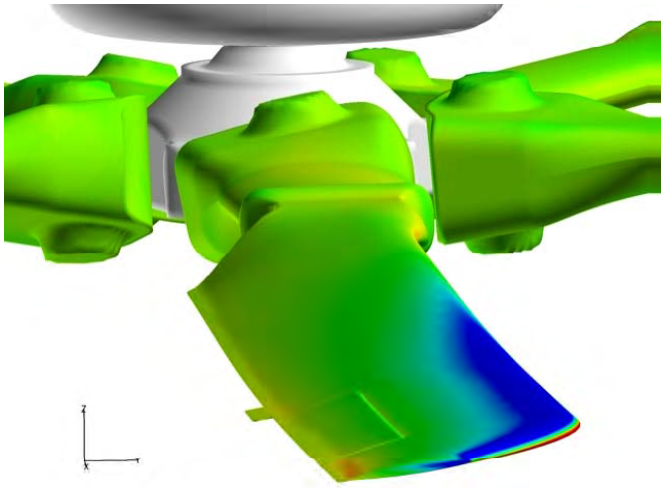
	Goal	Engineering Tool	Physics-Based Model
Forward flight performance	1%	4%	20%
Hover performance	0.5%	2%	2% (but flow-field not correct)
Airloads (c_n/c_m), without mean	1%	10% / 35%	6% / 20%
Airloads (c_n/c_m), with mean	1%	10% / 35%	15% / 40%
Blade loads (flap / chord / torsion)	3%	20 / 35 / 25%	20 / 35 / 25%
Vibration	10%	100%	Not available
Stability (fraction critical damping)	0.002	0.02	Not available
Noise	3 dB	10 dB	15 dB

From: ***Johnson and Datta 2008***

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

HELIOS v3.0 (RAINIER) CAPABILITIES

- **Full Rotorcraft configurations**
  - Fuselage + multiple rotors, tail rotor, etc.
    - Resolution of time-step mismatch problem between main rotor and tail rotor (high tail rotor-RPM results in very small global time steps for main rotor simulation)
  - Free-flight trim with CFD-based fuselage loads
- **General control surfaces**
  - Support for integral/conformal control surfaces (single grid with re-meshing or mesh motion)



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

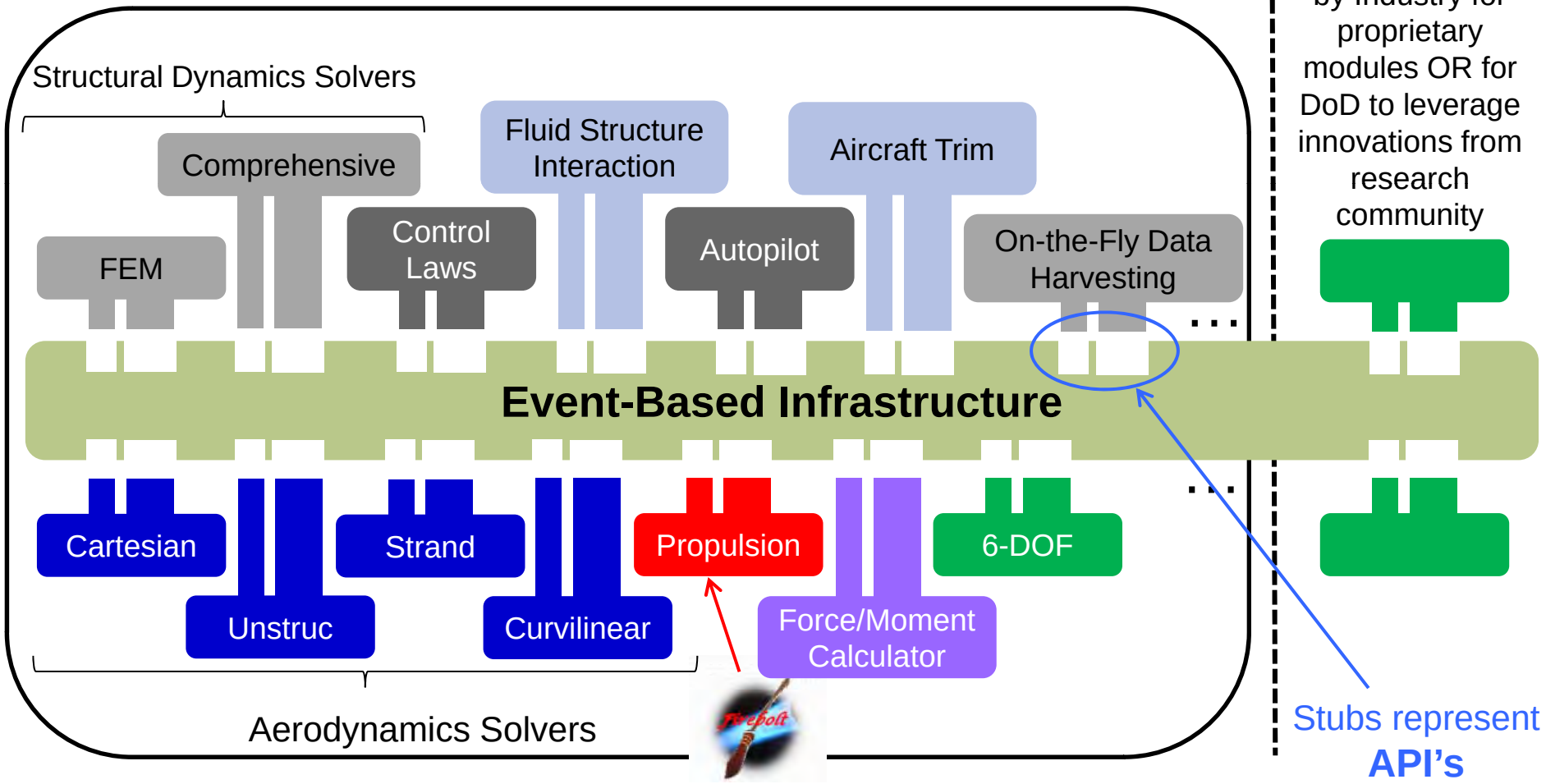
- **Engine module integration for propulsion effects**
  - 0-D engine model from CREATE-A/V Firebolt program)

- **Store Separation with 6-DOF motions**
  - Most of this software will be adapted from existing Kestrel modules using published interface definitions
    - Prescribed mesh motion
    - Rigid mesh motion
    - Mesh deformation
    - 6-degree of freedom body motion

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SOFTWARE ARCHITECTURE (Helios AND Kestrel)

"Light-Weight" Infrastructure – Highly Scalable and Modular (available as executable)



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

REMARK

Frameworks versus Infrastructures

Both offer compelling development and maintenance advantages for multi-physics software products, but differ in method of delivery. It is important to recognize that the choice of one over the other is a development decision (as opposed to a *management* decision).

Both are intimately intertwined with the multi-physics product.

Framework: written to be GENERIC to meet diverse needs and are shared by multiple software products.

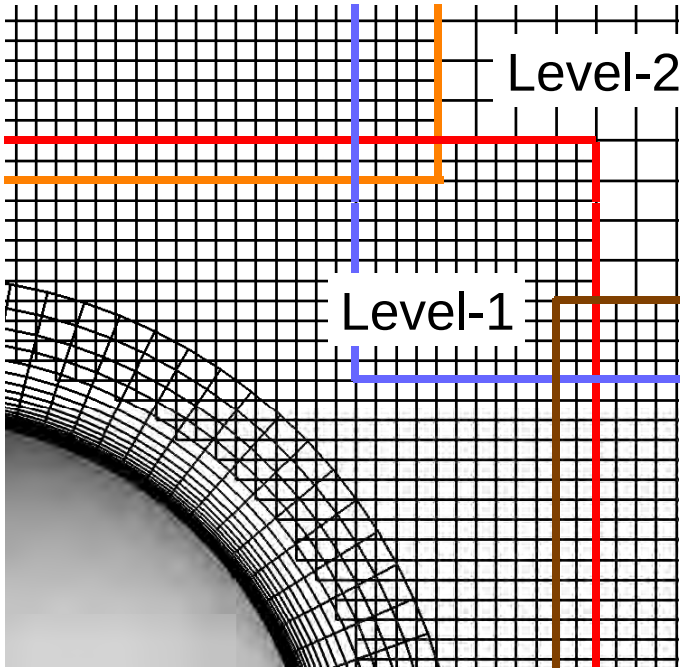
Infrastructure: developed for single product and target specialized needs.

Given the targeted long-life and operational constraints on CREATE-AV CBE products, an "infrastructure" path has been chosen by our principal developers.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SOME KEY HELIOS TECHNOLOGIES

Dual-Mesh (aka near-body/off-body spatial partitioning)



off-body
(overlapping uniform Cartesian grids of variable levels of refinement)

near-body
(overlapping curvilinear grids)

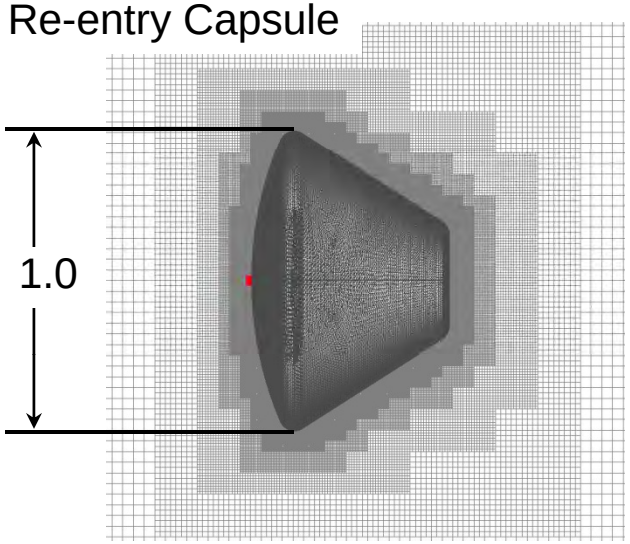
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Dual-Mesh: Why do it?

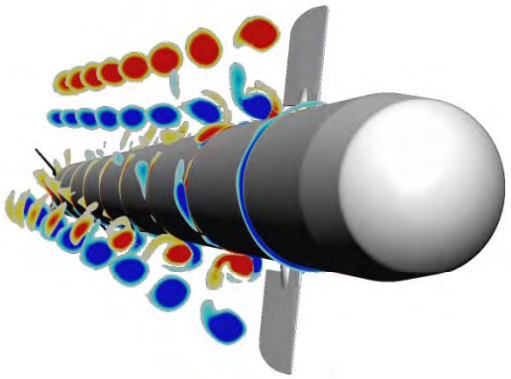
Ideally, use uniform Cartesian grids all the way to the vehicle surface. However, resolution required for viscous boundary layer is prohibitive.

Spacing Requirement*	Δ_{min}	N_{total}
NB/OB Transition	1.0×10^{-2}	$1.86 \times 10^{+6}$
Inviscid Wall	5.0×10^{-3}	$5.89 \times 10^{+6}$
Viscous Wall	1.0×10^{-6}	**$8.43 \times 10^{+12}$**
* assumes Re = $2.5 \times 10^{+6}$ and an AMR Factor = 2		

Re-entry Capsule



spinning missile w/ dithering canards



Combined with overset mesh technology, Dual-Mesh enables arbitrary relative motion between bodies, or components of multi-component bodies.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Adaptive Mesh Refinement (AMR)

Technology Drivers

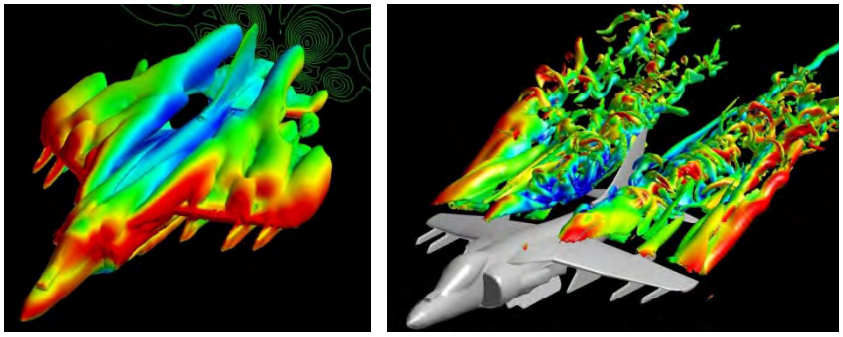
- Physical accuracy (sufficient for aircraft design analysis)
- Timeliness (on-schedule delivery of design analysis results)

CREATE-AV Examples

Legacy technology: static mesh, 2nd order accuracy in space and time

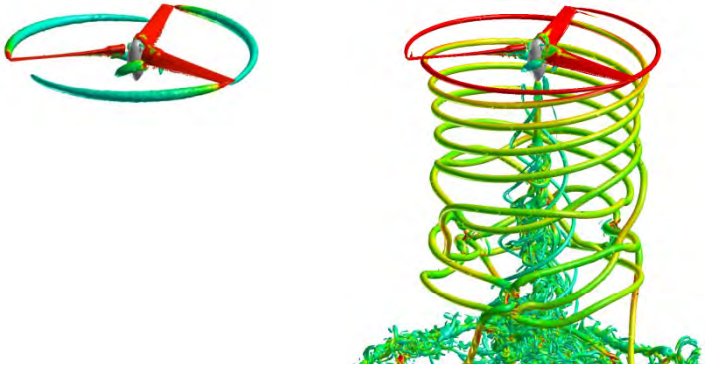
Deficiencies: rapid loss of fidelity of flow physics (e.g., vortices and shocks) away from aircraft surfaces, leading to loss in ability to predict downstream physics evolution and possible impacts to aircraft and interactional (aero-structural) dynamics

AV-8B



legacy AMR via Helios product

¼-scale V-22 rotor



legacy AMR via Helios product

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

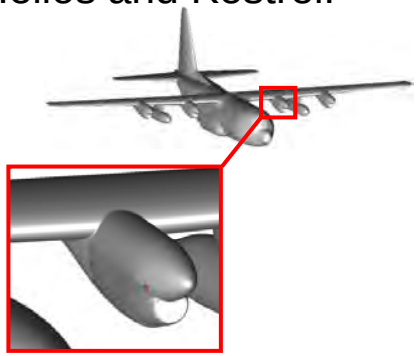
Strand Technology

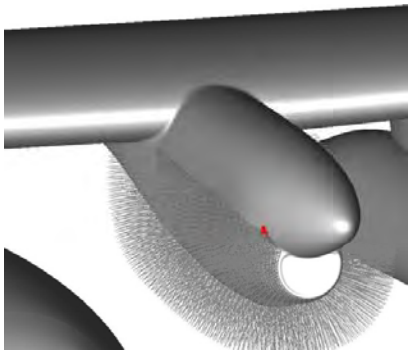
Technology Drivers

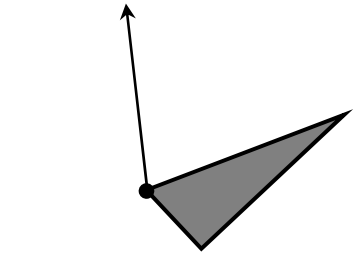
- Timeliness (automation of mesh generation)
- Timeliness (automation and scalability of domain connectivity)
- Timeliness/Physical accuracy (computational efficiency and scalability of aerodynamic solvers)
- Processor architecture (small memory footprint maps well to hierarchical memory architectures, e.g., multi-core, GPU)

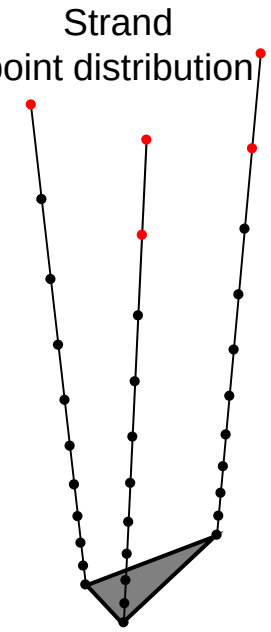
CREATE-AV Example

This is a new meshing paradigm introduced in 2007 by current members of the CREATE-AV technical staff. The technology is being matured in the Helios product and will be deployed through both Helios and Kestrel.



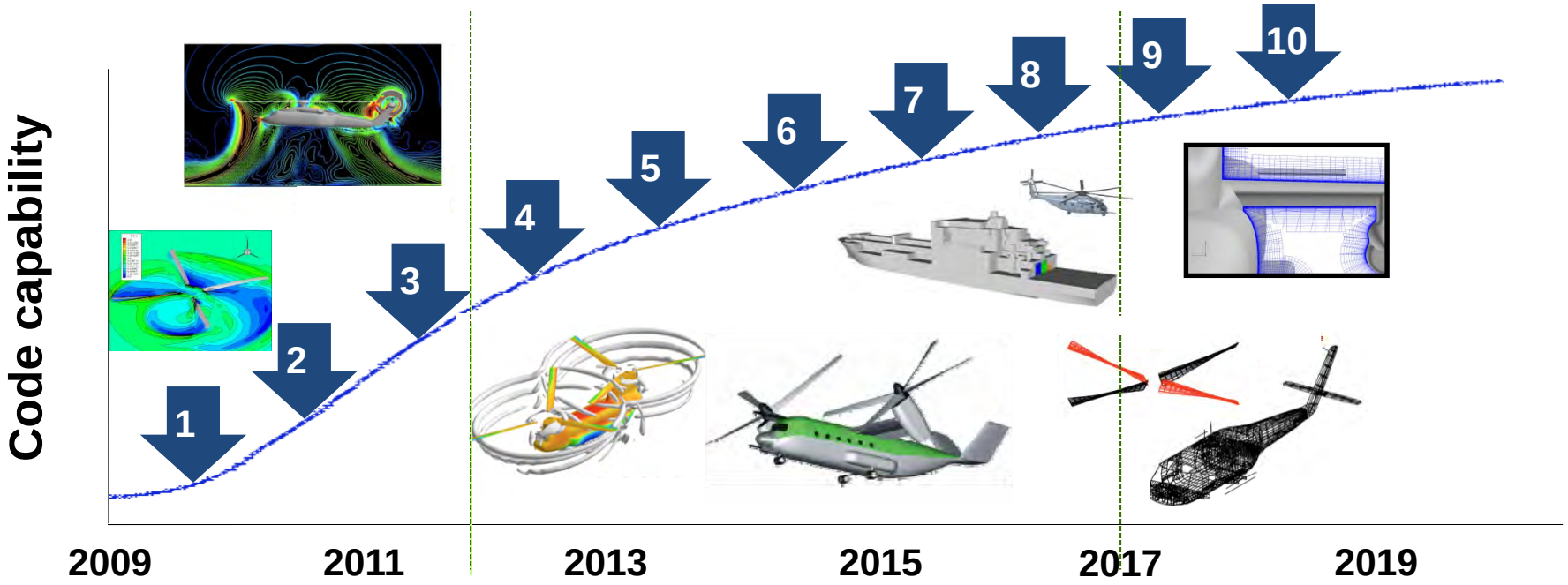






DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Helios CAPABILITY RELEASE SCHEDULE



1) Isolated rotor with CFD-CA Coupling; momentum disk
2) Fuselage+rotor free flight trim; maneuver; ground
3) Multiple rotors; propulsion; store sep
4) Strand solver, 3DFEM-rotor, multi-body dynamics, vtm
5) Multiple vehicles, hot, high, heavy, ship deck; time-spectral, high-fidelity engine model
6) Brownout; immersed boundary; 3DFEM-fuselage
7) Sea-state; icing; engine plume
8) Design Optimization; micro vehicles; acoustic module; improved models
9) Design Optimization; improved models
10) Design optimization; Improved models

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FINAL OBSERVATIONS

- Careful review of defense acquisition engineering workforce processes and workflows has been used to identify capabilities that can be delivered by CBE and next generation computer resources to positively impact defense acquisition.
- Plans to deliver highest impact capabilities have been developed and are being implemented.
- Quickly evolving threats increasingly require quick (with known uncertainties) engineering responses. CBE and HPC provides a means of addressing this challenge in a scalable way.
- Greatest potential for long-term positive impact on defense acquisition?
  - **Early-phase workflows** (an ability to generate physics-based decision data in a timely way during conceptual design is paradigm changing)
- Greatest potential for immediate impact on warfighters?
  - **Sustainment-phase workflows** (e.g., flight clearance, modified/new configuration/loading certification, launch and recovery envelop generation, envelope expansion, mishap investigation, among many others).

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

The Computational Research and Engineering Acquisition Tools and Environments (CREATE) Program

Dr. Douglass Post

Chief Scientist, DoD High Performance Computing Modernization Program

NDIA Systems Engineering Conference
San Diego, CA, 24-27 Oct 2010

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

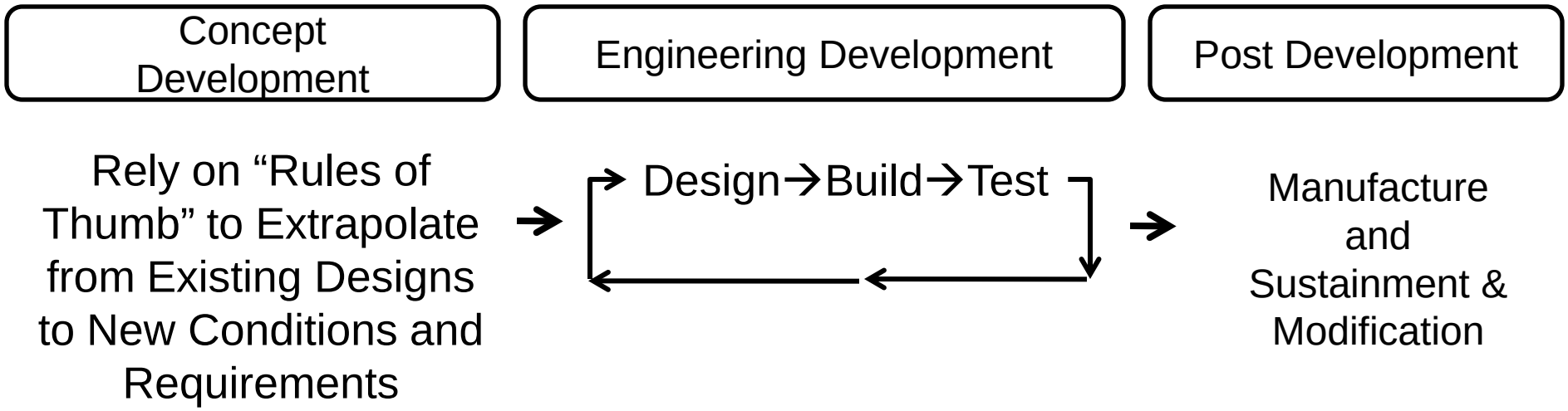
CREATE Program Concept
A Vision for Improving Acquisition

- **CREATE Goal: Enable the US to maintain a competitive advantage in weapons systems**
- **Enable innovation and reduce system development time**
  - Produce optimized designs early in the acquisition process with fewer defects and design flaws
  - Reduce testing requirements and rework thereby enabling faster system development and deployment
- **How?**
  - Supplement physical testing with multiphysics-based predictions from the beginning of the conceptual design and analysis process through deployment and sustainment
  - Develop and deploy production quality design and analysis software that is adaptable and maintainable
  - Develop and deploy multi-physics based Computational Engineering tools that exploit the 10^{15} growth in computer power since 1945
- **CREATE is a long term program**
  - Funding started in FY2008, $45M for first 3 years
  - Sponsored by OSD HCPMP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

The Classic Product Development Process (what the DoD uses now)

- Productivity gains for Concept and Engineering Development have lagged gains in manufacturing

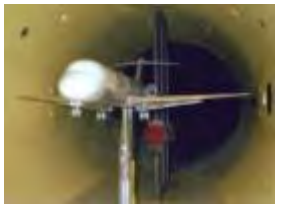


Since 1700s

Some Productivity Gains	Some Productivity Gains	Enormous Productivity gains

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Present Product Development Process: Iterated Design → Build → Test Cycles



Requirements → Design → Build Physical Product → Test Physical Product → Manufacture and Sustainment

(Many) Design iterations

- **Long time to deployment**
  - **Requires many lengthy and expensive design/build/test iteration loops**
  - **Process converges slowly, if at all**
  - **Process is rigid, not responsive to new requirements**
  - **Design flaws discovered late in process leading to rework**
  - **Systems Integration happens late in process**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

A Paradigm Shift in Industrial Product Development Is Happening

- **Past :**
  - Repeated Design→Build→Test Cycles
- **Present:**
  - Occasionally Augment Design→Build→Test with Limited Single-Physics Analysis by Use of Research or Commercial Codes
- **Future:**
  - Design Through Analysis, Multi-Physics Design and Analysis with Supercomputer Power
  - Repeated CAD→Mesh→Analyze Cycles Followed by a Few Design→Build→Test Cycles

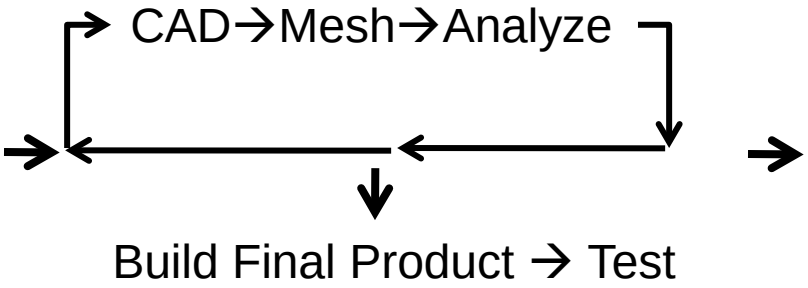
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Multiphysics-Based Software Can Enable Rapid Product Innovation

Use virtual prototypes at every stage of the acquisition process

Concept Development	Engineering Development	Post Development

Multi-physics based software tools allows use of the laws of nature to extrapolate to new conditions and needs



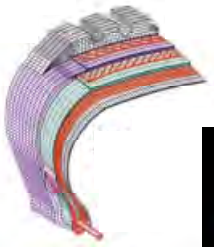
Manufacture And Sustainment & Modification

21st Century Result

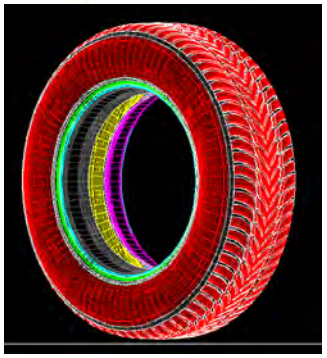
Large Productivity Gains	Large Productivity Gains	Additional Productivity gains

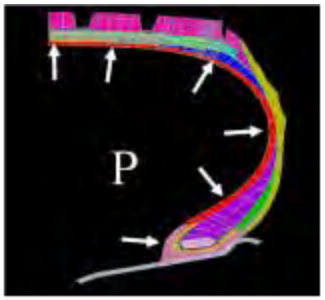
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Industry is Beginning to Adopt this Paradigm.



GOODYEAR





Inflation and Seating

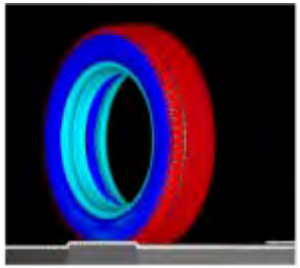
Hydroplaning Tests

Flight Radial

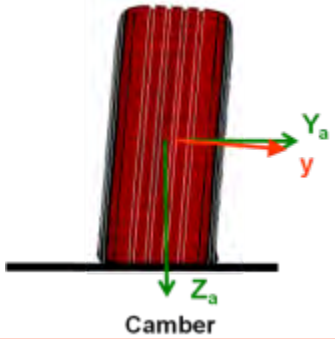
Requirements → Design and Mesh Virtual Product → Analyze and Test Virtual Product → Build and Test Physical Product → Market

Design iterations

- Reduced time to market from 3 years to less than 1 year
- Increased new products delivery from 1 every 3 years to 5 per year



Running Over Obstacles



Camber

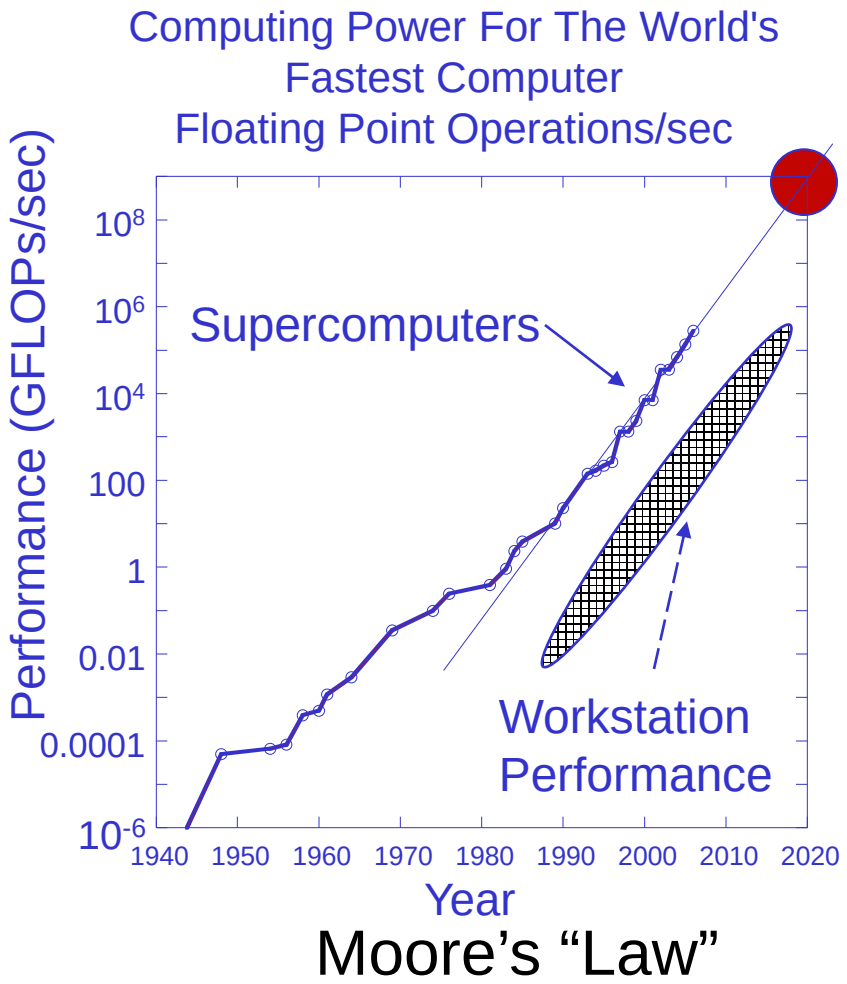
Fortera TripleTred

L. K. Miller, *Simulation-Based Engineering for Industrial Competitive Advantage, 2010, Computing in Science and Engineering,* ***12, 14-21***

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unl

Growth in Computers Since 1945 Provides Unparalleled Problem Solving Power

- **The 10^{15} increase in computer power since 1945 can enable us to develop and deploy codes during the next decade that are much more powerful than past tools:**
  - **Utilize accurate solution methods**
  - **Include all the effects we know to be important**
  - **Model a complete system**
  - **Complete parameter surveys in hours rather than days to weeks to months**
- **In ~ 10 years, workstations will be as powerful as today's supercomputers**
- **Greatest opportunities for 2020 (and 2010) include large-scale codes that integrate many multi-scale effects to model a complete system**



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

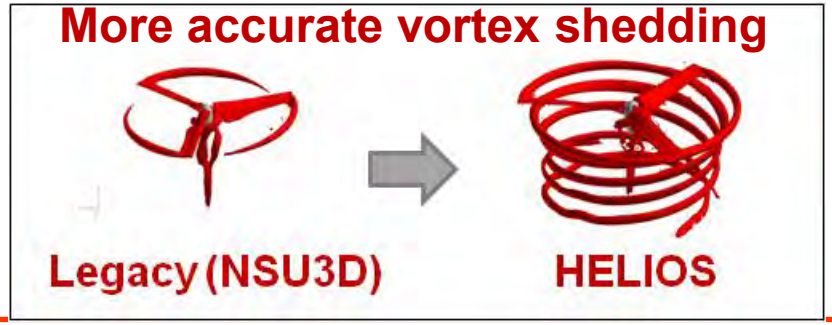
CREATE – Four Projects, Ten Products
Conceptual Design → Sustainment

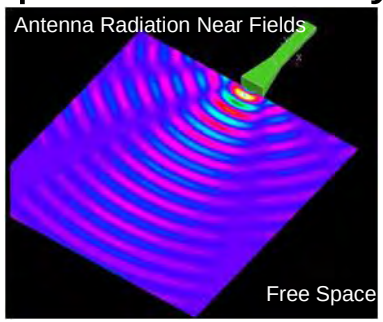
- **Air Vehicles**
  - **DaVinci -** Rapid conceptual design
  - **Kestrel -** High-fidelity, full vehicle, multi-physics analysis tool for fixed-wing aircraft
  - **Helios -** High-fidelity, full vehicle, multi-physics analysis tool for rotary-wing aircraft
  - **Firebolt -** Module for propulsion systems in fixed and rotary-wing air vehicles
- **Ships**
  - **RDI -** Rapid Design and Synthesis Capability—Partnership with ONR and NAVSEA
  - **NESM -** Ship Shock & Damage-prediction of shock and damage effects
  - **NAVYFOAM -** Ship Hydrodynamics-predict hydrodynamic performance
  - **IHDE -** Environment to facilitate access to Naval design tools
- **RF Antenna**
  - **SENTRI -** Electromagnetics antenna design and integration with platforms
- **Meshing and Geometry**
  - **Capstone -** Components for generating geometries and meshes

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
10-S-1202 & 10-S-2364

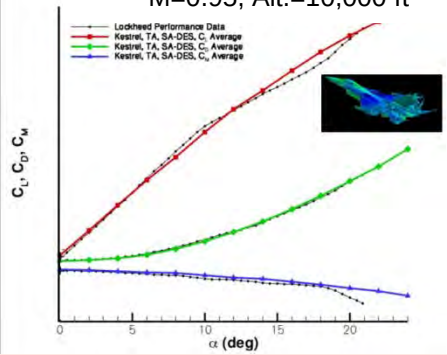
Two Years After Program Start (FY08), CREATE Began Delivering Usable Software.

- 5 beta releases in CY09 with good V&V and ~ 150 beta testers:
  - Helios 1.0—accurate calculation of rotorcraft vortex shedding
  - Kestrel 1.0—Rigid body CFD fixed wing AV with preliminary aeroelastics
  - SENTRI 1.0 and 1.5—initial RF antenna design and analysis
  - NESM 0.1—initial ship shock vulnerability analysis for underwater explosions
  - IHDE 1.0—initial user interface for ship hydrodynamics
- 10 releases planned for CY10 and each succeeding year
- Helios 2.0, Kestrel 2.0, SENTRI 2.0, NESM 1.0 and IHDE 2.0 plus:
  - Rapid design: RDI 1.0 for Ships, DaVinci 1.0 for Aircraft plus SENTRI 2.0
  - Components: Capstone 1.0 for geometry and mesh, Firebolt 1.0 for gas turbines
  - Detailed ship hydrodynamics NavyFoam 2.0 (seakeeping, drag, resistance,…)
- Continuing to build product teams, and develop and improve software engineering and project management processes and practices
- Developing approaches to improve scalability





Kestrel vs. F-16 Flight Data
M=0.95, Alt.=10,000 ft



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Critical Factors for Success

- **HPCMP analyzed what worked and what didn't**
  - A new, complex software application is an invention
  - Invention requires experienced teams with domain science & engineering, and computational skills
  - Success requires stable support from the sponsor
  - Development approach must achieve the right balance between flexibility & agility and project structure and management, between risk taking and risk avoidance,…
  - Requires sound software engineering practices tailored for computational engineering
- **Success also requires:**
  - Stable sponsor support,
  - Strong customer focus,
  - An inventive development team with excellent domain science and computational skills,
  - V&V, and
  - High performance computers
- **HPCMP applied these principles to CREATE**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

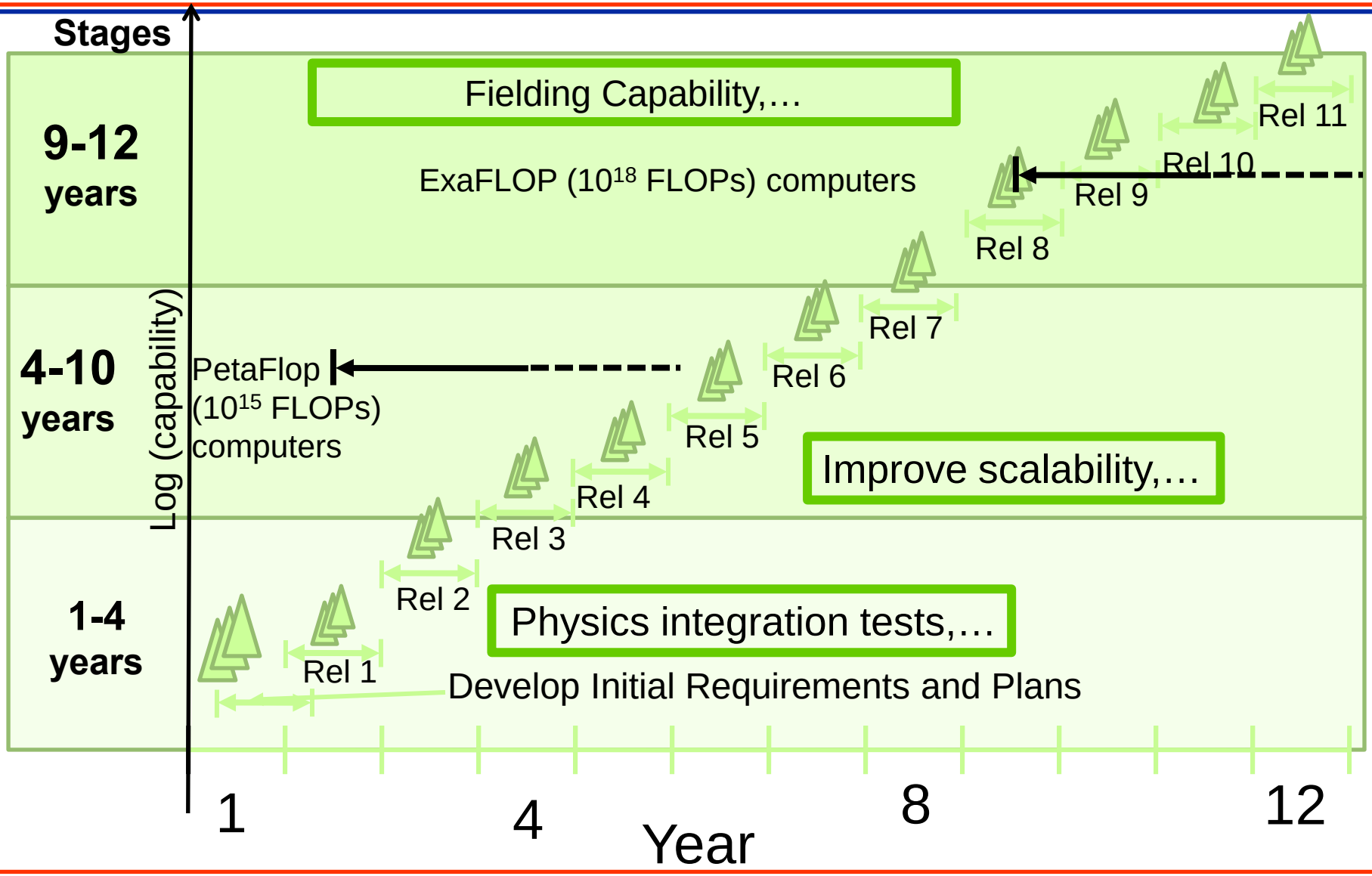
CREATE Emphasizes Software Engineering for a 30 Year Product Life

Software Engineering Practices and Processes

- **Goal is maintainable, extensible, portable and reliable software products developed with the right balance of agility and flexibility and short and long term planning**
  1. Requirements Management and Stakeholder Engagement
  2. Software Quality Attributes
  3. Design and Implementation
  4. Software Configuration Management
  5. Verification and Validation of CREATE Products
  6. Software Release
  7. Customer Support
- **Documents: Initial Capabilities Document +….**
  - Three Manuals: Technical, Developer, User
  - Plans: Test (V&V), Risk, Project and Product Development (EVMS),…
- **Agile development methods such as SCRUM**
- **Annual releases to engage users early and get their feedback**

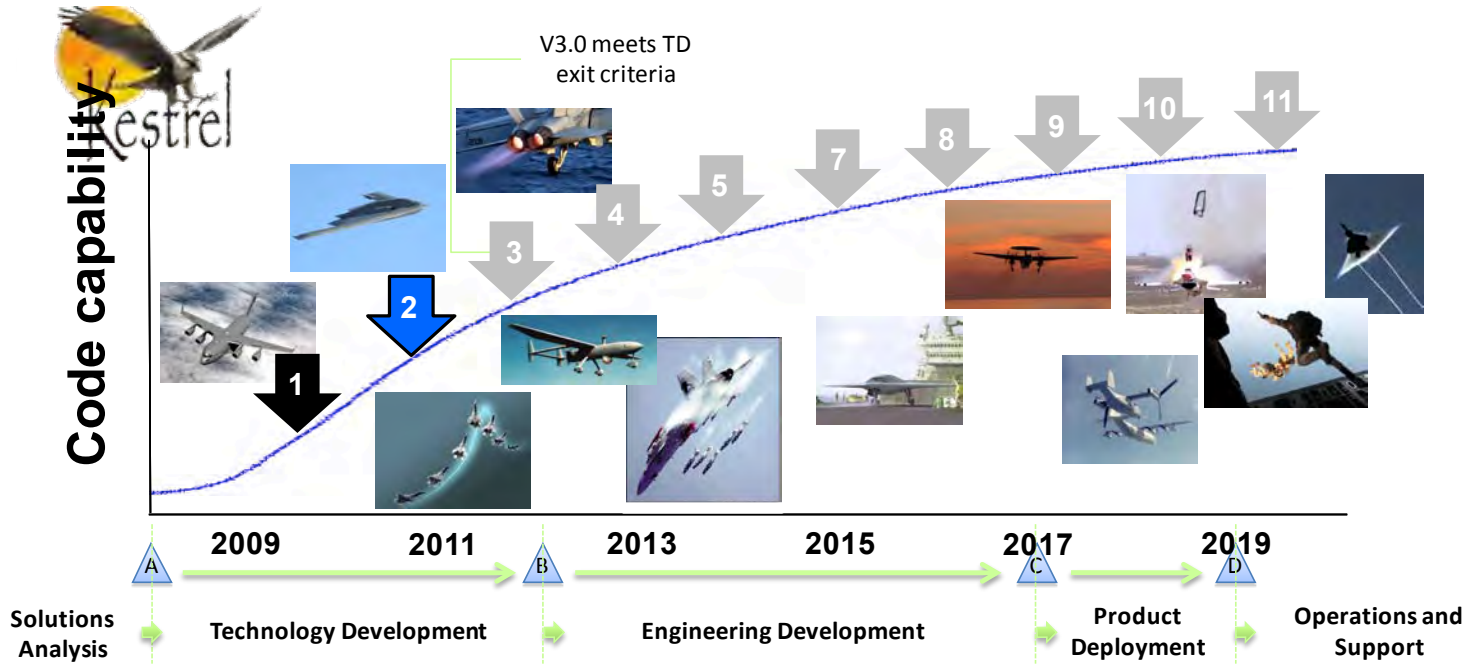
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Incremental Development and Deployment in Annual Releases



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Each Product Team Delivers New Capability Annually Following a Roadmap!



1) Arbitrary complete aircraft (rigid) for low-subsonic through high supersonic flight and steady or unsteady regimes.
2) Add capability to accommodate movable control surfaces, aero-structure interaction (flexible aircraft), and prescribed maneuvers.
3) Add capability to simulate arbitrary multi-body relative motion (e.g., simulation of store separation events subject to applied aerodynamic loads), dynamic propulsion effects, and to accommodate flight control systems (FCS) .
4) Add capability to accommodate autopilot, dynamic engineering models of fans, rotors, propellers, and significant physical accuracy upgrades.

.
.
.

11) Sustained Kestrel Product Capability. Full-vehicle, multi-physics design analysis and mission planning tool – enables scalable practices and is highly parallel, modular, maintainable, extendable, and introspective.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE – Radio Frequency (RF) Product Component

- **SENTRI enables antenna design integrated with platforms**
  - Able to calculate multiple antenna arrays for small- and large-scale systems (small UAVs → ships)
- **Staged capability**
  - Rapid design – coarse resolution with fast, first-order codes for small antenna systems
  - Detailed design, high-resolution complex antenna systems integrated with large platforms
  - Enabled by improved computational algorithms (n^3 → n log n scaling improvement)

Small
Less Complex

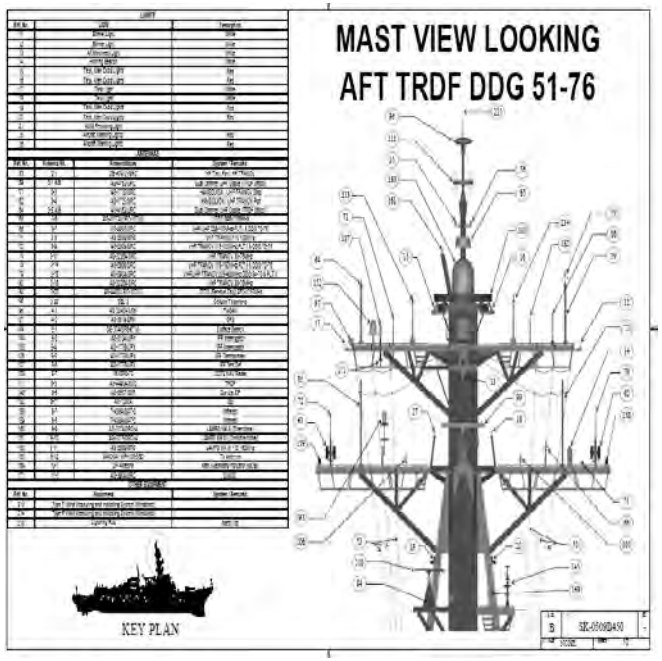
→

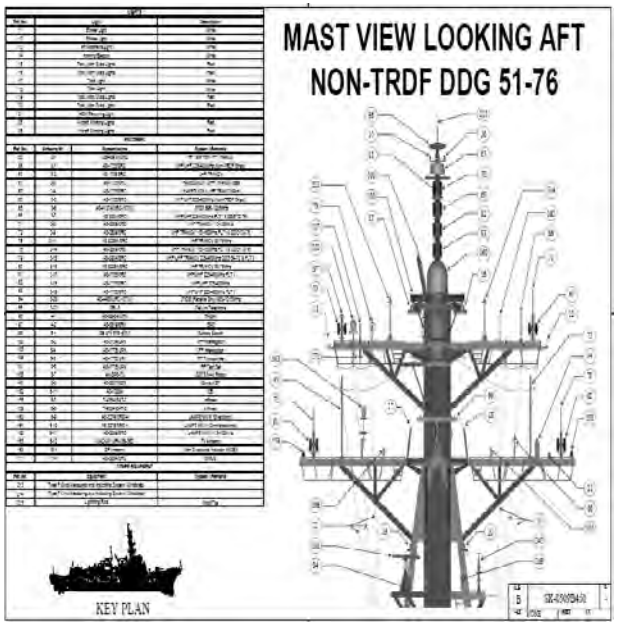
Larger
Highly Complex

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Ships, airplanes, and land vehicles have complex antenna requirements

Co-site interference is a major issue.





Numerous antennas competing for limited space and coverage result in a complex electromagnetic environment (EME), presenting a challenge for effective topside integration and maintaining the topside baseline.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SENTRI 1.0 – RF Antenna Design

Development Approach
Product Roadmap

CREATE RF

SENTRI v1.0 and v1.5

First Iteration → Multiple Functions for Wide Applicability

SENTRi

Antenna Modeling
- Patch, Notch, Horn, Spirals (Applications: Radar, Communication, GPS)
- Phased Array Antennas
- Cavity Backed Antenna (Approximate In-Situ Analysis)

Periodic Structures
- Frequency Selective Surfaces
- Circuit Analog Absorbers
- Metamaterials
- Infrared Filters / Absorbers

Microwave Circuits
- Power Splitting
- Material Measurement
- Filters
- Circulators

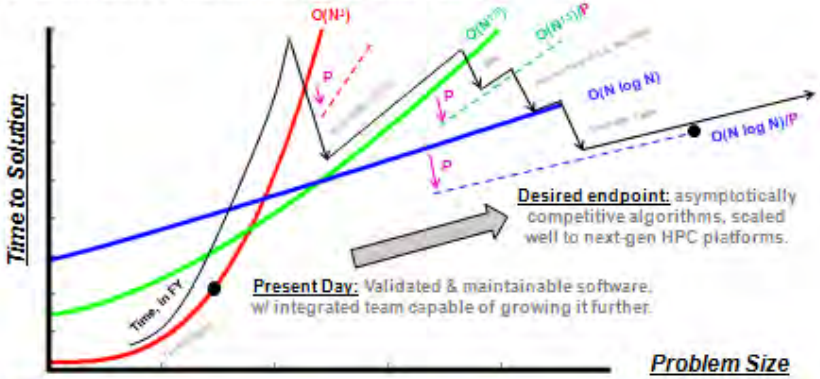
Radar Cross-Section Prediction

Development Approach
Technical Approach

CREATE RF

Finite Element – Boundary Integral Methods Chosen for: Accuracy, Reduced Volume Meshing, Adaptability → No Free Lunch → O(N³) Complexity

HPC cannot alone overcome poor asymptotic scaling.



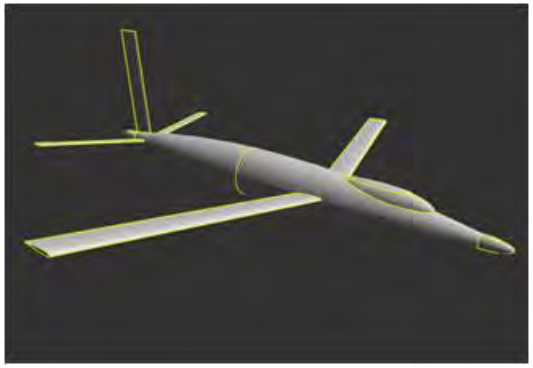
FY10 Technical Push – FAST SOLVERS – will reduce N^3 solve to $N^{1.5}$
FY11+ → N1.5 to N log N

- **SENTRI 1.0 → deliver initial capability, now in beta testing**
- **SENTRI 1.5 → refactored SENTRI 1.0 to enhance software quality**
- **Strong V&V program (SENTRI 1.0 benchmarked against current CEM design codes & extensive verification and validation tests)**
- **SENTRI 2.0→Begin improving scaling**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

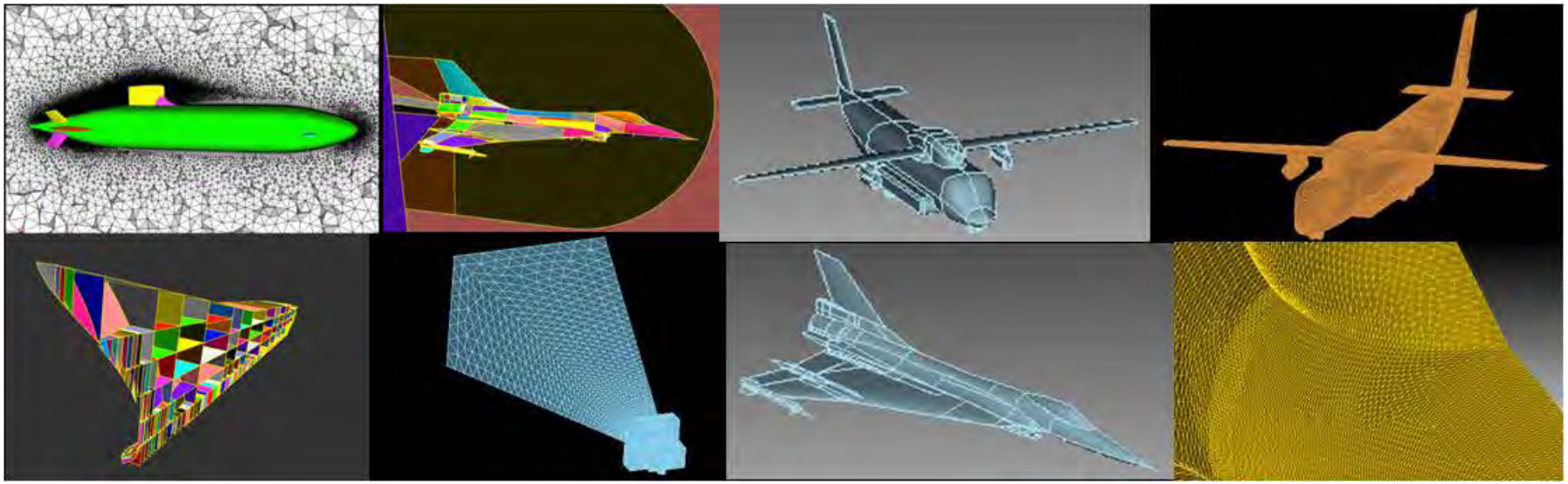
CREATE – Meshing and Geometry (MG) Components: CAPSTONE

- **CAPSTONE**
  - Collection of components that enable rapid generation of the geometry and mesh representations needed for all phases of acquisition engineering (conceptual, preliminary, detailed design, and operational support)
  - Emphasis is on geometry as key representation of product



Enable parametric, associative geometry and meshes in AV: DaVinci, Ships: RDI

Produce analyzable representations for complex and detailed analysis



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE Designed to Support the Government and Contractor Engineering Workforce

- **CREATE tools will enable government engineers to develop and explore design concepts, and oversee engineering development, manufacturing and sustainment**
- **CREATE tools will enable industry to participate in concept development, and improve engineering development, manufacturing and sustainment**
- **CREATE beginning to engage with industry through NDIA to identify how industry can use the CREATE tools to improve DoD acquisition**
  - Please share your perspectives and thoughts with us
- **Improve product innovation and reduce product development time**
- **Issues:**
  - Provide equal access to all potential contractors
  - Retain US competitive advantage in weapon system development

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Two Examples Out of Four Projects

- **Air Vehicles—Dr. Robert Meakin**
  - **DaVinci -** Rapid conceptual design
  - **Kestrel -** High-fidelity, full vehicle, multi-physics analysis tool for fixed-wing aircraft
  - **Helios -** High-fidelity, full vehicle, multi-physics analysis tool for rotary-wing aircraft
  - **Firebolt -** Module for propulsion systems in fixed and rotary-wing air vehicles
- **Ships—Mr. Myles Hurwitz**
  - **RDI -** Rapid Design and Synthesis Capability—Partnership with ONR and NAVSEA
  - **NESM -** Ship Shock & Damage-prediction of shock and damage effects
  - **NAVYFOAM -** Ship Hydrodynamics-predict hydrodynamic performance
  - **IHDE -** Environment to facilitate access to Naval design tools

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Backup slides

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Meshing and Geometry Project → Tools for AV, Ships and RF

Product: CAPSTONE

Core

API and library components for core framework, geometry and mesh representations and algorithms, attribution modeling

Provides:

- APIs for writing external meshing and add new higher-level functionality plugin(s)
- Access to Mesh Modification capability (refinement, coarsening, local-remeshing)
- Runtime access to geometry

Front-end

Provides geometry preparation and mesh generation

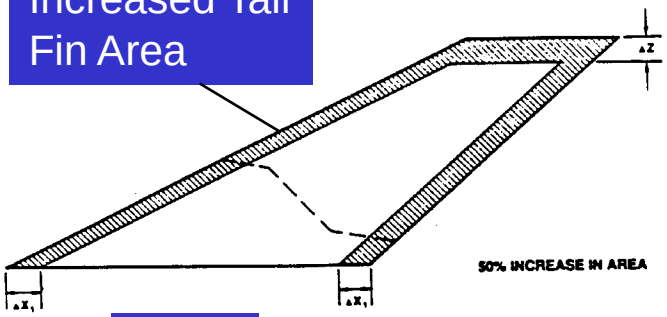
- Support graphical user interface (GUI), command-line, and scripting interfaces for end-user
- Provides traditional pre-processor capabilities for end-users
- Specialized application plugins (e.g. mesh implant for Ships)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

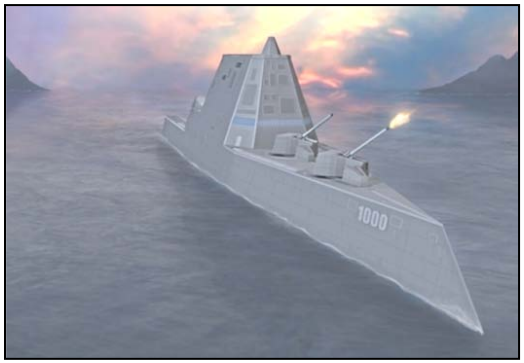
Problem: DoD Weapon Systems Design Process Is Not Effective

- **Tailfin design problems for:**
  - F-100, F-102, F-105, F-7U, F-11F, F-16, F-117
  - All needed to increase tail fin size between 25% to 50% after initial design
- **For stealth, DDG-1000 was built with a new hullform that sloped *in* rather than *out* as do all prior hullforms, but "Is New U.S. Destroyer Unstable?" Defense News Headline-04/02/07**
- **Lessons Learned:**
  - Can't base radically new designs on "rules of thumb" empirically based scaling of historical experience
  - Physics-based design tools required for new concepts

Increased Tail Fin Area



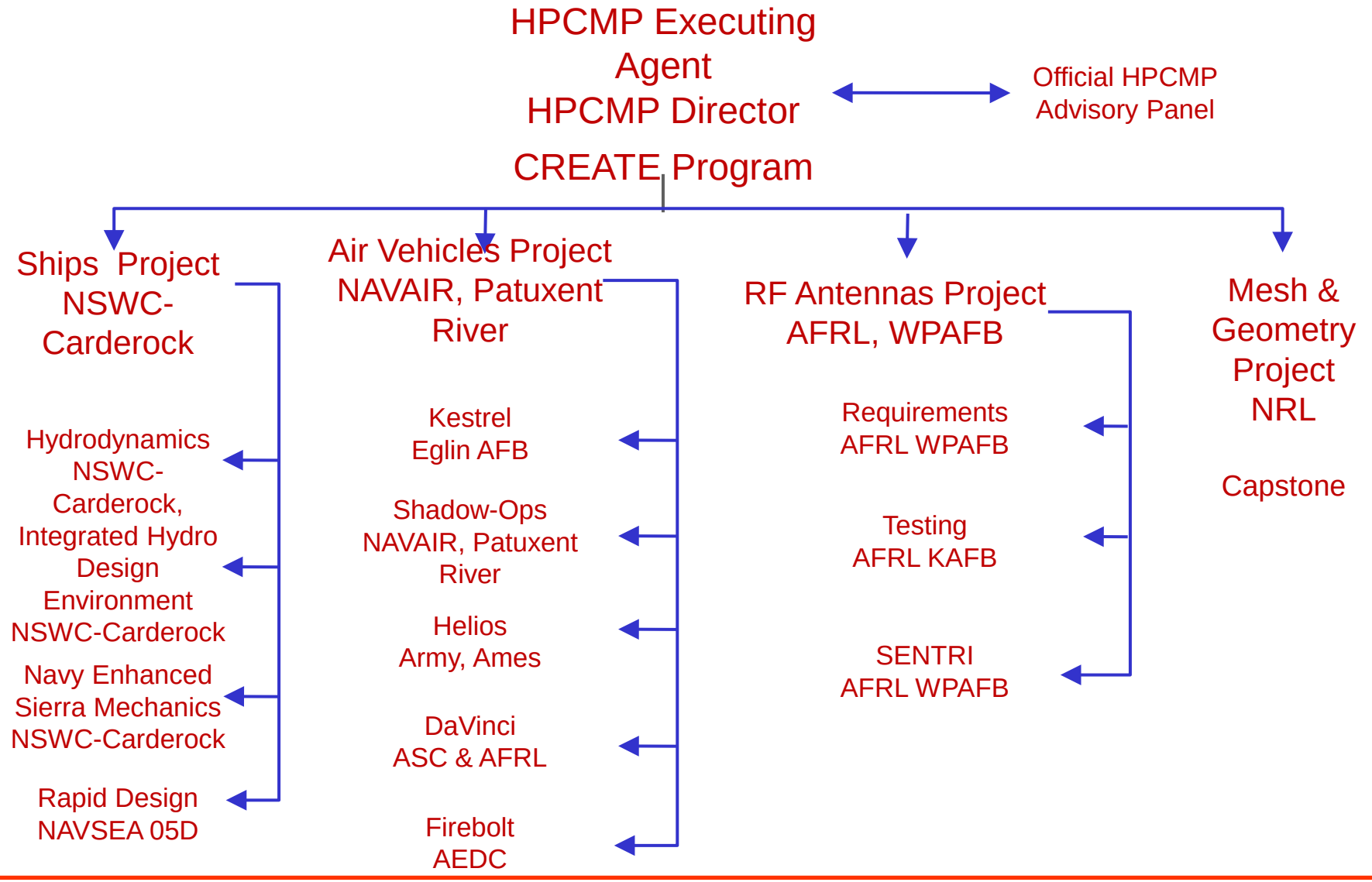
F-117



DDG-1000

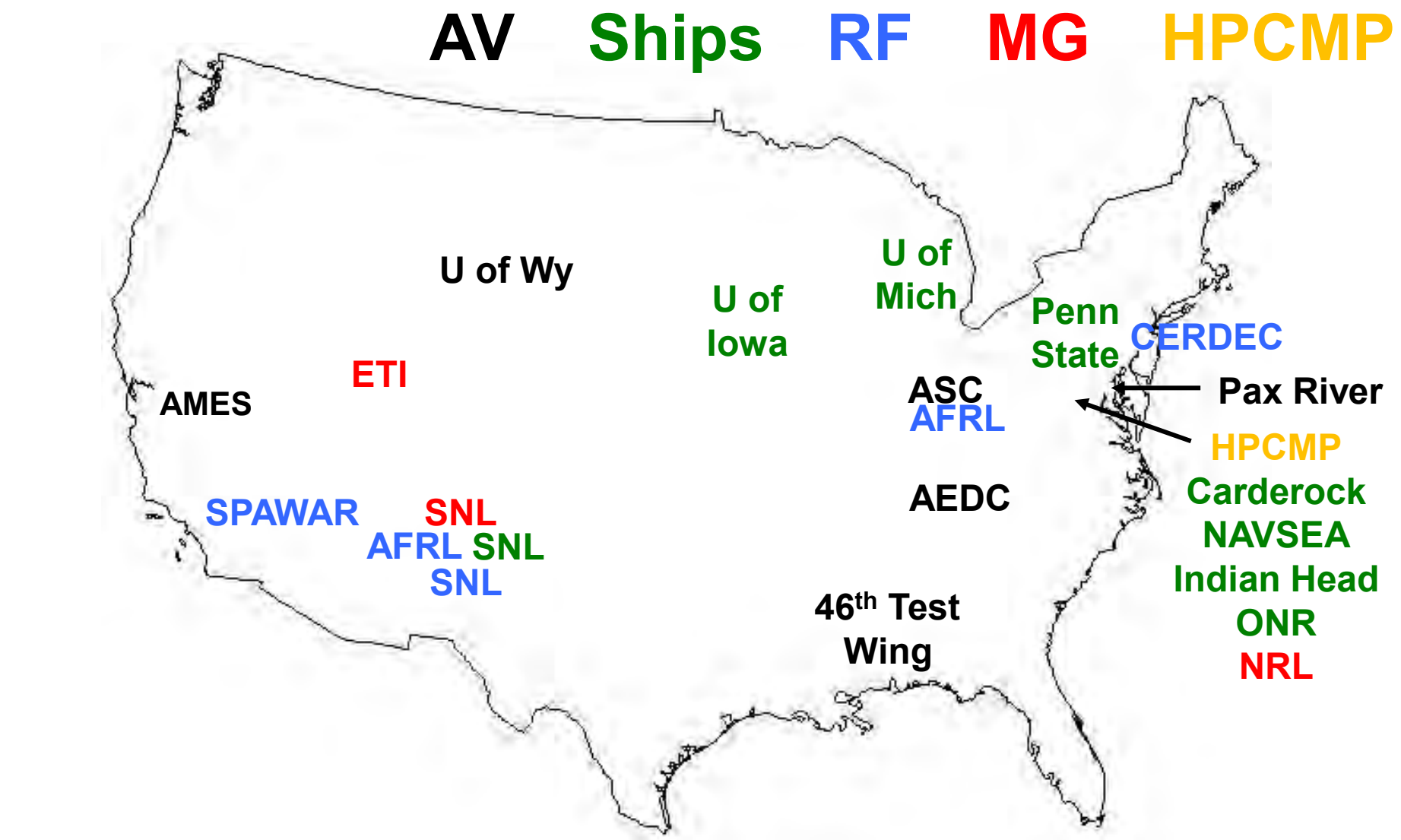
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE is a Tri-Service Program



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE is a Multi-Institutional and Multi-Service Program



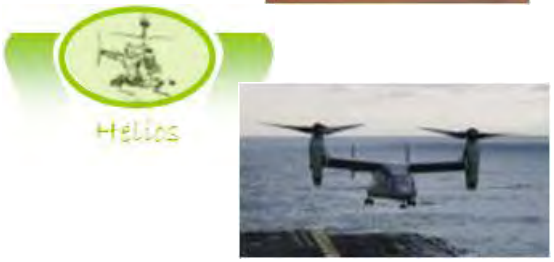
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE – Air Vehicles (AV) Product Components

- **DaVinci**
  - Targets early-phase acquisition engineering (conceptual design)

- **Kestrel**
  - High-fidelity, full-vehicle, multi-physics analysis tool for arbitrary fixed-wing aircraft

- **Helios**
  - High-fidelity, full-vehicle, multi-physics analysis tool for arbitrary rotary-wing aircraft

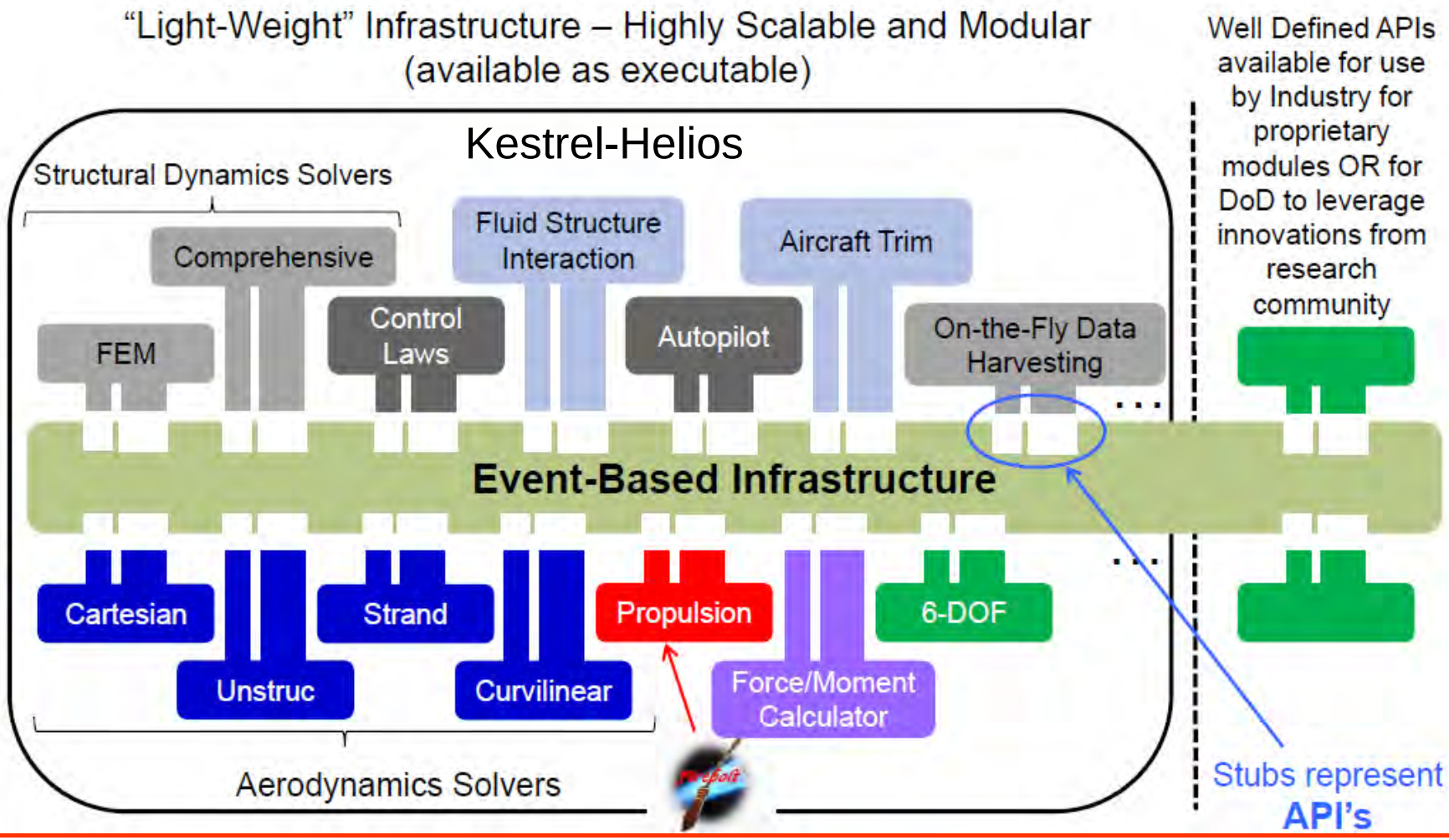


- **Firebolt**
  - Module for propulsion systems in fixed and rotary-wing air vehicles

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

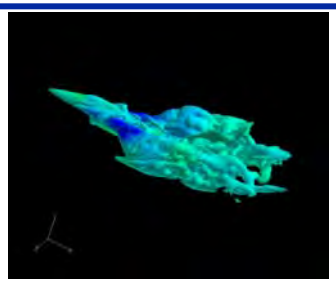
Solving the hard

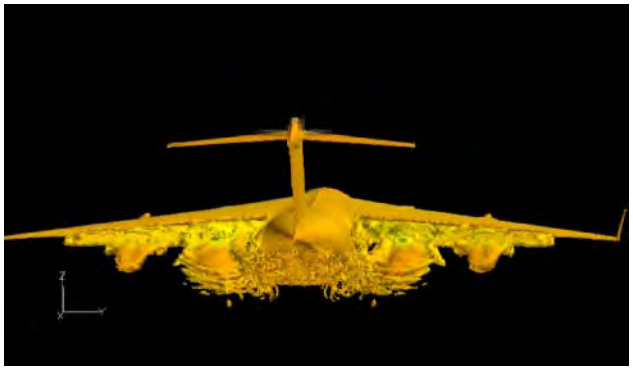
Use of Lightweight Infrastructures Facilitates Rapid Integration of Physics Capability



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

AV: Kestrel 1.0—Fixed Wing Aircraft





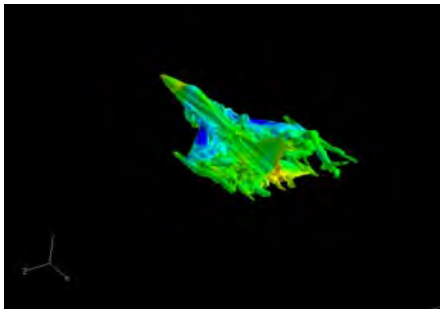
Spiral One Phase One Capability

1 - Static Rigid Body Aircraft

- Single Mesh
- Steady, Unsteady
- Inviscid, Viscous, Laminar, Turbulent

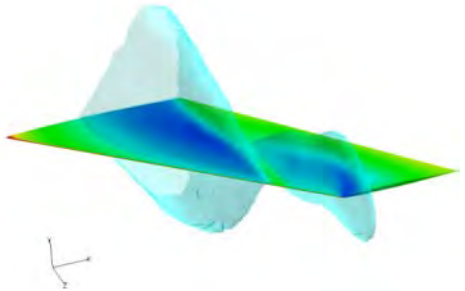
2 - Dynamic Rigid Body Aircraft

- Single Mesh
- Rigid Body Motion
- Arbitrary Motion file built externally
- Pitch, Yaw, Roll, Sinusoid or constant rate and hold in KUI
  - body axis and stability axis



3 - Flexible Wing

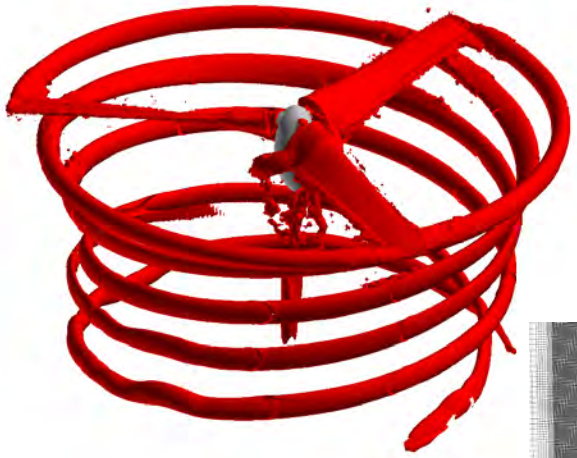
- Static Position Single Mesh Aeroelastic
- 2nd Order Temporal Coupling
- Structural Solver
  - Modal solver and mode shape forced motion
- Algebraic Mesh Deform with 3-4 method choices (Surface Influence, Delaunay, Hybrid)

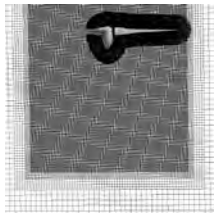


DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

AV: Helios 1.0 (Whitney)--Rotorcraft

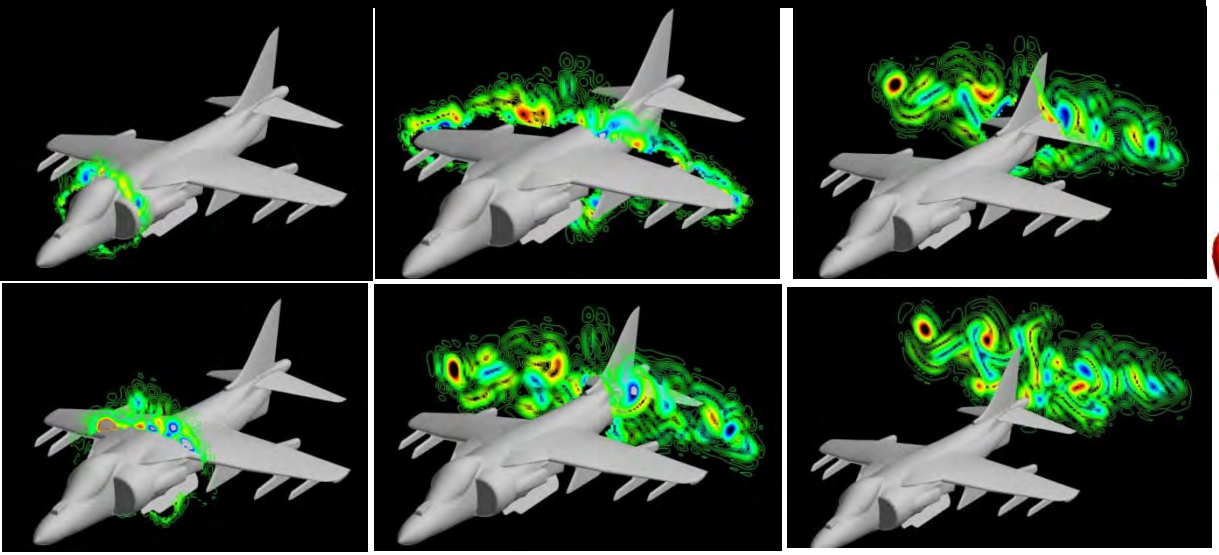
- **Helios v.1.0 (Whitney) Release Capabilities**
  1. Fuselage aerodynamics
  2. Fuselage with actuator disk model for rotor
  3. Isolated rotor in ideal hover
  4. Isolated rotor in forward flight with structural dynamics and trim
  – Stand-alone-NSU3D & Helios models also supported

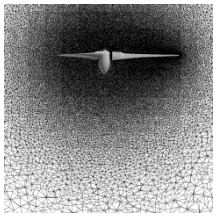




HELIOS

Helios predicts AV-8B tail fatigue due to vortex shedding





NSU3D

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CREATE – Ships Product Components

- **Rapid Design Capability and Design Synthesis**
  - Rapid development, assessment, and integration of candidate ship designs to avoid cost versus capability mismatches
  - Partnership with ONR & NAVSEA

FY03 OPNAV Sponsored Cruiser Concept

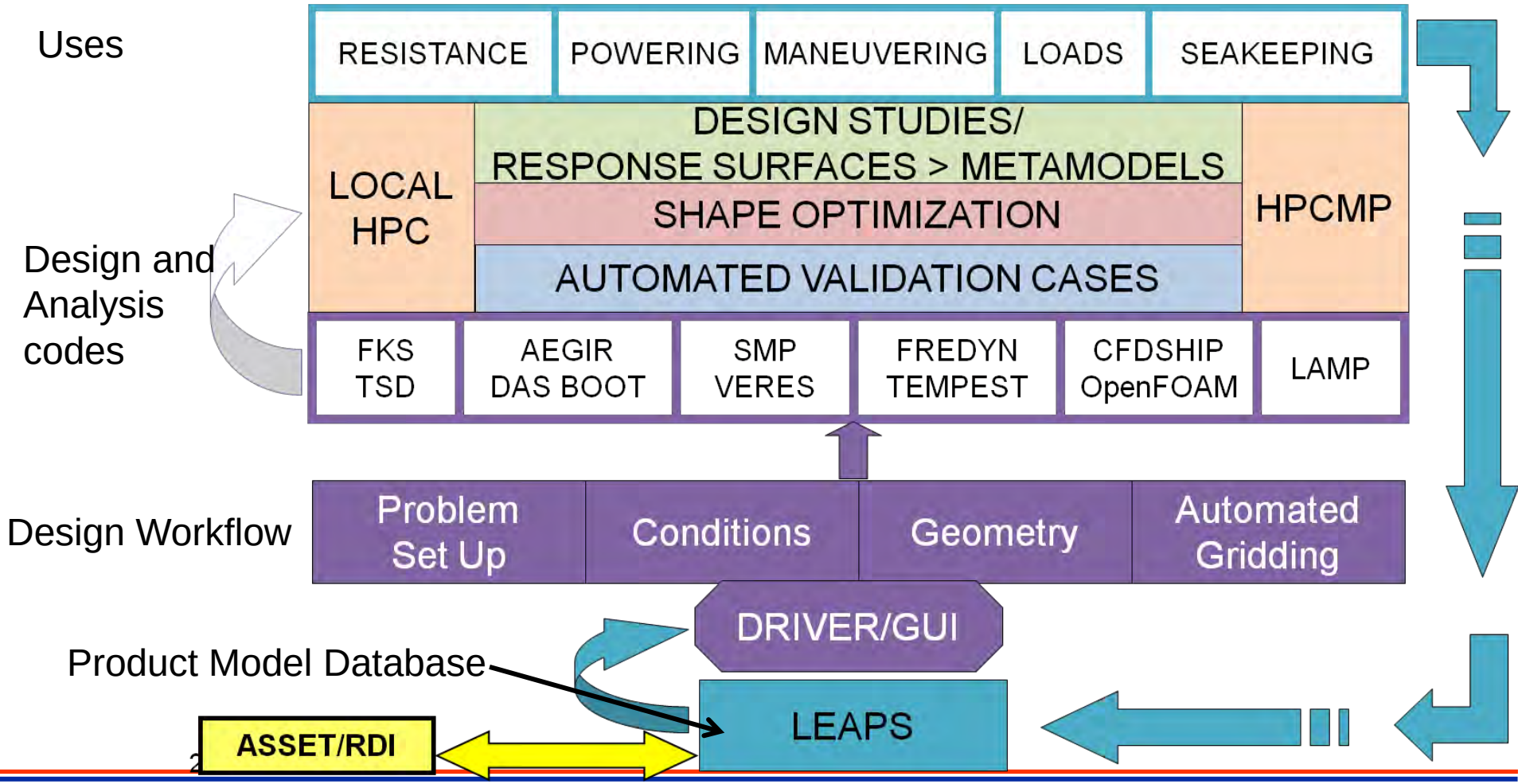
- **Ship Shock & Damage**
  - Provide analysis of shock and damage effects and reduce need for tests to assess ship shock and damage effects

- **Ship Hydrodynamics**
  - Accelerate and improve all stages of ship hydrodynamic design (seaway loads, sea keeping, resistance…)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

IHDE 1.0 – Ships: Integrated Hydro Design Environment

- Four Use Cases: 1. Resistance, 2. Powering, 3. Maneuvering, 4. Seakeeping



DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Use Cases Are Good for Capturing Requirements and Guiding Development

- **Ship Shock software (Navy Enhanced Sierra Mechanics, NESM) analyzes ship vulnerability**
- **NESM 12-year Product Development Plan & Requirements Based On Six (6) Use Cases**
  - UC I → Ship Response To Standoff UNDEX Where Structure Remains Predominantly Elastic (minimal damage) (FSST)
  - UC II → Ship Response to UNDEX & SURFEX Causing Moderate Structural Damage
  - UC III → Ship Response To UNDEX & SURFEX Causing Severe Structural Damage (including SURFEX)
  - UC IV → Ship Response To AIREX Causing Moderate Structural Damage
  - UC V → Ship Response To AIREX Causing Severe Structural Damage
  - UC VI → Ship Response To Unconventional Weapon Attacks
- **Sandia National Laboratory participation provides structural mechanics software (Sierra Mechanics Suite) to achieve good scalability**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Meshing and Geometry Project → Tools for AV, Ships and RF

Product: CAPSTONE

Core

API and library components for core framework, geometry and mesh representations and algorithms, attribution modeling

Provides:

- APIs for writing external meshing and add new higher-level functionality plugin(s)
- Access to Mesh Modification capability (refinement, coarsening, local-remeshing)
- Runtime access to geometry

Front-end

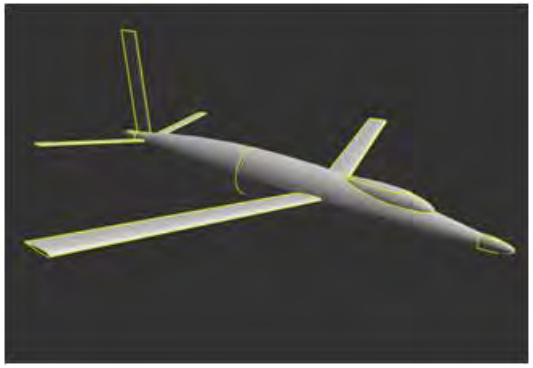
Provides geometry preparation and mesh generation

- Support graphical user interface (GUI), command-line, and scripting interfaces for end-user
- Provides traditional pre-processor capabilities for end-users
- Specialized application plugins (e.g. mesh implant for Ships)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

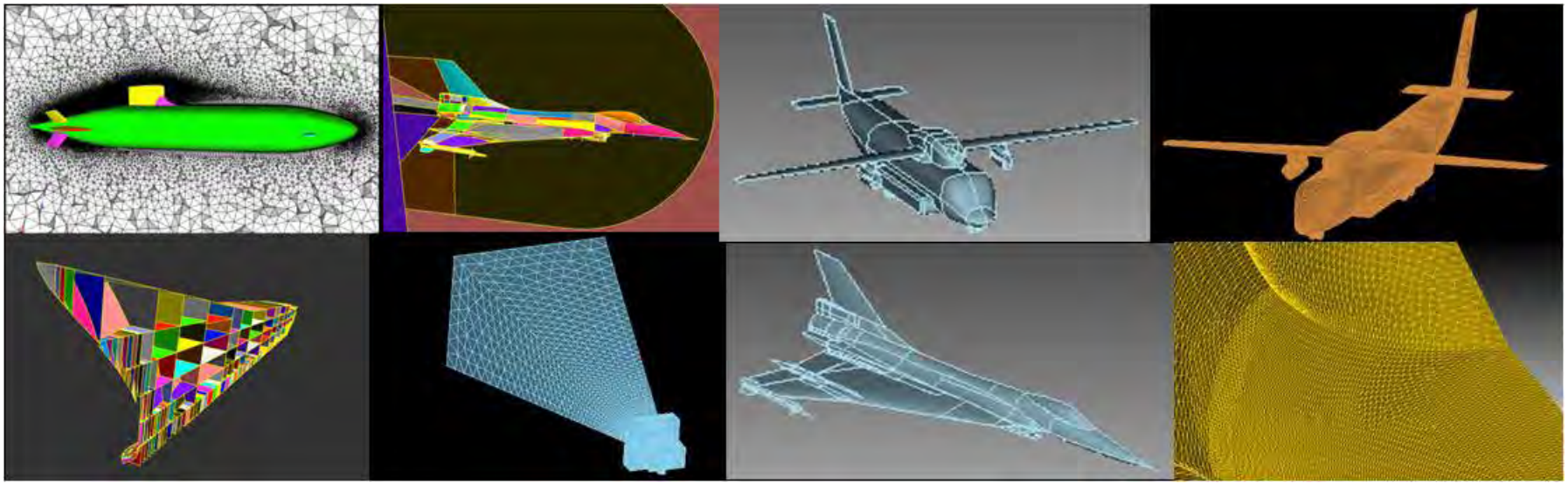
CREATE – Meshing and Geometry (MG) Components: CAPSTONE

- **CAPSTONE**
  - Collection of components that enable rapid generation of the geometry and mesh representations needed for all phases of acquisition engineering (conceptual, preliminary, detailed design, and operational support)
  - Emphasis is on geometry as key representation of product



Enable parametric, associative geometry and meshes in AV: DaVinci, Ships: RDI

Produce analyzable representations for complex and detailed analysis

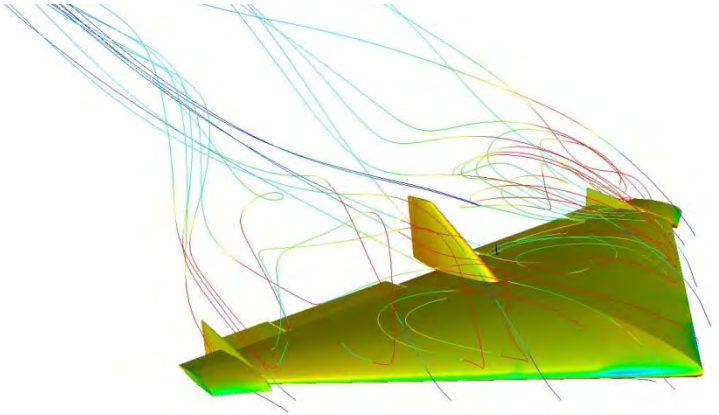


DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Another Early Success → Improved Flight Certification Process for Marine Corps UAV

- **Problem: Expensive and lengthy UAV flight certification for small-vendor designs due to physical testing required for flight data.**
- **Solution: Joint Navy and CREATE Air Vehicles Shadow-Ops STUAS project used computational engineering tools to rapidly and cheaply develop the flight certification database.**
- **Benefits to DoD Aircraft Programs**
  - **Reduced time and cost by eliminating the need for physical model testing**
  - **Enabled industry competitiveness through quick Services assessment of many vendor designs**
  - **Provided unbiased performance data to STUAS Program Office for assessment of contractor vehicles**
- **Six new vendors are now able to compete for UAV contracts**

8 foot wingspan

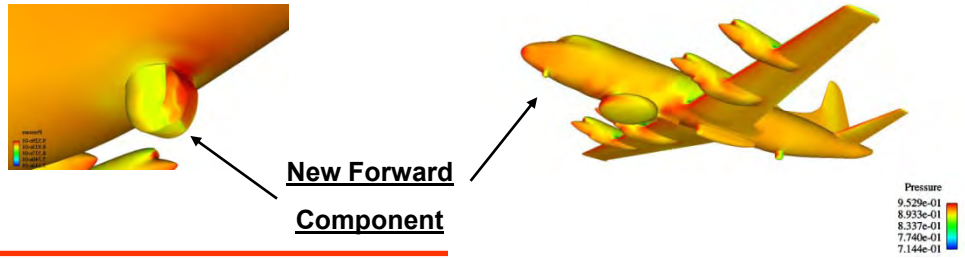


Engineers: Drs. Theresa Shafer / Gary N. McQuay - PMA-263 STUAS/Tier II UAS

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Early Success: Rapid Deployment of EP-3E

- **Shadow-Ops: CREATE staff use computational tools to support acquisition programs → provide experience and establish connections and value**
- **Performed CFD analysis of impact of electronic countermeasure pod for EP-3E flight clearance--Not sufficient time for conventional process (flight tests)**
  - **Eliminated construction cost of wind tunnel model and tests and need for contractor flying quality report.**
  - **Provided aircraft flying qualities characteristics within required time frame.**
  - **Provided data required to issue flight clearance in time for direct deployment.**
- **Reduced overall program cost and time.**
- ***Only* 1 flying qualities flight test required – Saving between 3-4 flight tests.**
- **System was deployed in the forward theatre in less than four months instead of twelve**



DEPARTMENT OF THE NAVY
PROGRAM EXECUTIVE OFFICER
AIR ASW, ASSAULT AND SPECIAL MISSION PROGRAMS
47123 BUSE ROAD, BUILDING 2272, SUITE 162
PATUXENT RIVER MD 20670-1547

IN REPLY REFER TO

May 15, 2008

Dr. Robert Meakin
CREATE-AV Program Manager
HPCMPO
10501 Furnace Road
Lorton, VA 22079

Dear Dr. Meakin:

SUBJECT: HPC CREATE-AV EP-3E CFD SUPPORT FOR FLYING QUALITIES ASSESSMENT AND CERTIFICATION

I wish to extend my thanks for the support your program, CREATE-AV, provided recently to certify the airworthiness of a new modification to the EP-3E aircraft. The computational support supplied by the Shadow Ops team provided the required computational data to the NAVAIR Flight Dynamics Branch to help issue a safe-for-flight clearance, from a flying qualities perspective, without the need of a costly, time consuming wind tunnel test. This accelerated the database development on the order of months and saved the program office hundreds of thousands of dollars. In addition, the data and subsequent flying qualities analysis, performed by Flight Dynamics Engineer, Ms. Ryan Fitzgerald, was sufficient to limit the flight test program to only one flight. This further reduced flight test time by several weeks, saving the program tens of thousands of dollars and allowing the EP-3E program to deploy this capability in the forward theater in support of the Global War on Terror (GWOT).

The creation of the Shadow Ops area of the overall CREATE-AV program is ideally suited to support DOD acquisition programs. It is an excellent venue to develop a working relationship between the computational engineering community and existing DOD aircraft programs. We are looking forward for future projects, and seeing how we can improve upon this process even further.

Sincerely,

LCDR Ryan Batchelor
EP-3E/Special Mission Class Desk, PMA-290E
22347 Cedar Point Rd
Bldg 2185, Floor 3, Room 3190-B1
Patuxent River, MD 20670
301-757-5684

POC: Ms. Ryan Fitzgerald, FQ Engineer NAVAIR 4.3.2.5

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Deployment of MBSE processes using SysML

October 2010

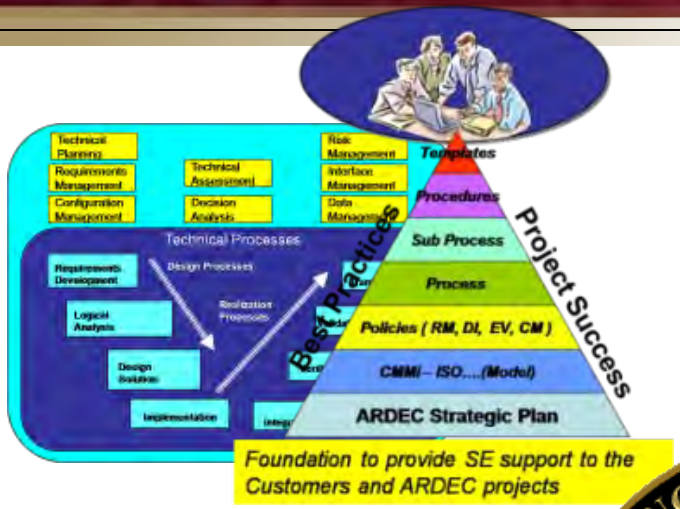
Tom Alameda
US ARMY – ARDEC
973.724.5012
Tom.alameda@us.army.mil

Tim Tritsch
High Performance Technologies, Inc
732-292-9819
ttritsch@hpti.com

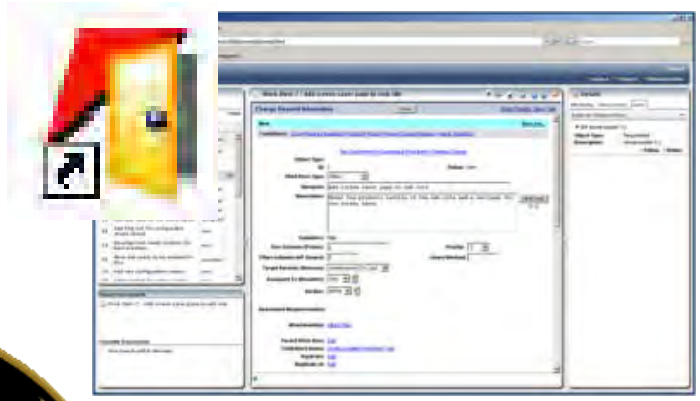
Topics

- Current SE at ARDEC Infrastructure
- Why move to MBSE?
- MBSE Gap Analysis
- Anticipated Benefits
- Three Pilot Projects
- Outreach
- Lessons Learned
- Summary

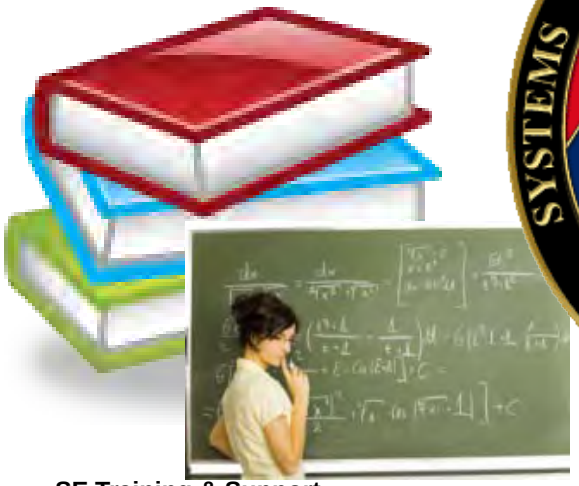
ARDEC Systems Engineering Infrastructure



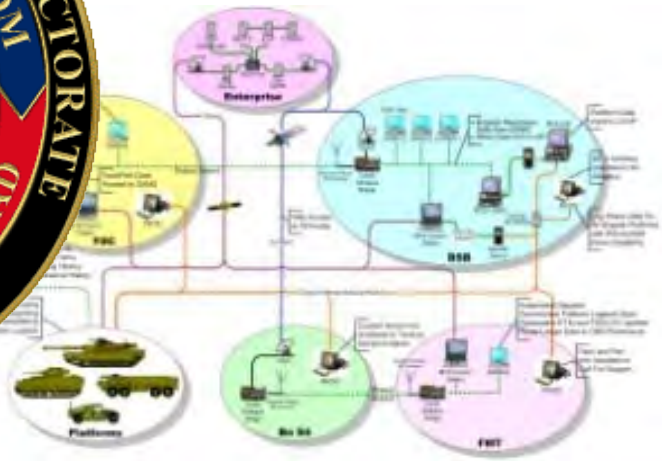
SE OSP Documents



SE Tool Suite



SE Training & Support



Collaboration Tools/Environment

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARDEC Systems Engineering Infrastructure

ARDEC Systems Engineering (SE) Directorate has developed a core competency in SE processes and the tools and training to facilitate the application of the systems engineering best practices on projects.

SE Process

- SE Organization Standard Process (OSP) – ARDEC's systems engineering best practices captured and documented in Policies, Processes, Procedures and Templates. OSP available online to workforce. Metrics and measures defined, collected, and analyzed to facilitate continuous improvement of OSP

SE Tool Environment

- Maintain a central database for all supported ARDEC and PM programs
- Virtual terminal servers to facilitate collaboration for IPTs distributed across the country
- Includes access to RM, CM, modeling, architecture and publishing tools.

SE Training

- Develop key training in tools and processes that allow IPT members to perform effective Systems Engineering on projects.
  - Tools training
  - Process training
  - Customized SE practice area workshops

Weapons Systems Acquisition Reform Act (WSARA) 2009:

Mandates SE applied to DoD programs

"The key to successful acquisition programs is getting things right from the start with sound systems engineering, cost-estimating, and developmental testing early in the program cycle."

–Senator Carl Levin (D-MI), Chairman, Senate Armed Services Committee

"This legislation is needed to focus acquisition and procurement on emphasizing systems engineering; more effective upfront planning and management of technology risk; and growing the acquisition workforce to meet program objectives."

–Senator John McCain (R-AZ), Ranking Member, Senate Armed Services Committee

Unanimously Approved by House and Senate!

Why ARDEC's MBSE Initiative

To Develop in-house Model-Based Systems Engineering (MBSE) Capability to include Methodology, Tools, Training, and SMEs

- Formalizes the practice of systems engineering through the use of models
- Broad in scope
  - Integrates with multiple modeling domains across lifecycle from SoS to component
- Results in quality/productivity improvements & lower risk
  - Rigor and precision
  - Communications among system/project stakeholders
  - Management of complexity
- Encourage and facilitate integrated architectures in projects
  - Logical/Functional Architectures
    - Better understanding of interfaces
    - Better understanding of system behaviors and operations
  - More effective and efficient system development

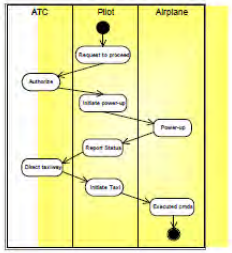
MBSE Gap Analysis

- **Goal:** To identify ARDEC needs related to MBSE using community knowledge as baseline against our SE process
- **Purpose:**
  - Understand the concept of system models
  - Establish a common lexicon for ARDEC MBSE
  - Identify tasks needed to begin the transition from the traditional document centric SE approach to a more model centric approach
  - Explain community-understood benefits of implementing MBSE
  - Identify challenges to ARDEC in adopting MBSE by understanding existing capabilities and where MBSE gaps exist
  - To suggest a path forward that will be implemented into the overall MBSE initiative

Past

Document centric

Future

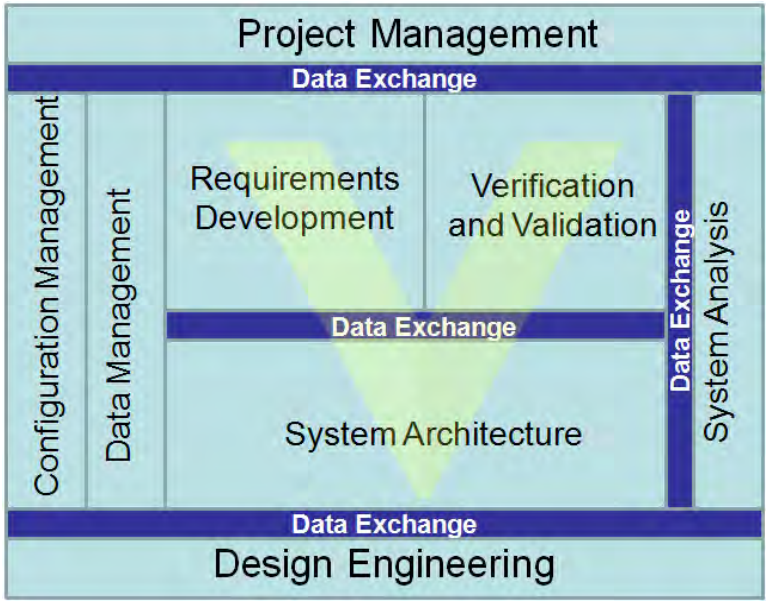


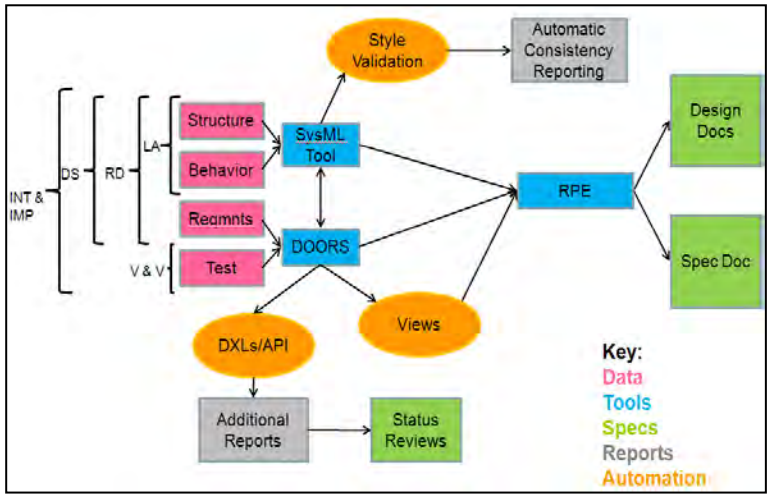
Model centric

Outputs of the MBSE Gap Analysis

- MBSE defined for ARDEC: formalized application of modeling to support the SE process throughout the entire lifecycle
- Defined an initial MBSE environment
  - Overall MBSE objective: enable M&S throughout the development lifecycle
  - Near term goal is to focus on the core SE activities (Requirements Development, Logical Analysis, and Design Solutions)
- Proposed an initial operating concept based on ARDECs existing capabilities
- Created a Gap Matrix which identifies:
  - "Present State" and "To Be State"
  - Gap Type (Process, Methods, Tools, Environment, People, or Technology)
  - Plan of Action, Dates, Resources, and Deliverables

Results from the Gap Analysis created the foundation for the activities of the MBSE Initiative





Automating the SE Process

The benefits of combining Requirements Management and MBSE activities are many. Combining these activities help the SE to:

- Formalize the design process
- Build more accurate and complete system descriptions
- Construct a consistent vocabulary for the system
- Improve requirements traceability and design rationale
- Reuse designs
- Manage Non-functional and Performance Requirements
- Perform impact analysis from anywhere in your design

SysML – How did we get here?

- **History of SysML**
  - 2001: INCOSE call to modify UML for application to MBSE
  - 2001: OMG Systems Engineering Domain Special Interest Group formed
  - 2003: UML for Systems Engineering RFP developed by INCOSE, issued by OMG
  - 2003: SysML Partners formed, author “Open SysML”
  - 2006: Multiple proposal “Merge” effort by OMG
  - 2007: OMG SysML 1.0 issued as a UML “Profile”
  - 2010: Ver 1.2 released

Three Pilot Projects

- Engagement Targeting System for Soldiers
  - Integrates with weapon to provide NLOS targeting
  - Stand-alone and Cooperative Engagement modes of operation
  - Requires interaction with both soldier and supporting infrastructure to complete mission requirements
  - *SysML model helpful for identifying and codifying functional dependencies on other systems, visualization of system functional boundaries*
- Programmable Artillery Round
  - Strict sequential interaction of components
  - Multiple mission scenarios each with multiple activity paths
  - *SysML provided visibility to required system and component logic*
- Automated Vehicle Health Management
  - Integrated ground vehicle health reporting and monitoring
  - Condition-Based Monitoring for preventive maintenance
  - Integrated Electronic Technical Manuals
  - *SysML models identified functional, communication, and interface components of the complex system/subsystem*.

Outreach

- Community Involvement
  - Participation in INCOSE MBSE and Model Usability Working Groups
    - Attended both IW and IS
    - Gained exposure to current state of practice
    - Trends
    - Current Issues
  - Attendance at local INCOSE SysML Seminar
- Inclusion of External SME's
  - Sandy Friedenthal, SysML Partners – asked questions like:
    - "What problem are you trying to solve?"
    - "Did you really need sequence diagrams (vice activity diagrams) to visualize interactions"
  - Dr. Robert Cloutier, Associate Prof., Stevens Institute of Technology
    - "Why the rush to identify blocks?"

The hunt for best practices

Lessons Learned - Methodology

- SysML is a large and complicated language
  - To improve efficiency, remove parts that are irrelevant to your processes, model purposes and system make-up
- Address Islands of SE Responsibilities
  - Model artifacts often cross-cut organizational boundaries
  - Full benefits only realized when everybody is motivated to play in the same sandbox
- No One Source of Know How
  - Every situation is unique
  - Use Multiple references, toolkits and training for guidance
- Which behavior diagrams and when?
  - Benefits
  - Must Maintain Consistency Across Different Views
    - The more views you use, the greater the effort will be to accomplish this

Lessons Learned - ROI

- You don't make money the first time
- Model for a purpose (or Purposes)
- Purposes need to be managed like requirements
  - Never miss an opportunity to remind stakeholders what they are
  - Make sure everybody is on board of they change
- Success Requires Formalized SE Processes
  - that may not exist.
- Incorporate the use of SysML and MBSE in SEP
  - Include artifact production from model against project milestones

Lessons Learned - Language

opaque
subclass
stereotype
metaclass
binding
metamodel
primitive
alias
namespace
dependency
instance
association
polymorphism
delegation
inheritance
meta object facility
class
package
superclass

Early on, even the most experienced Systems Engineer will struggle to be productive

Lessons Learned – Tool/ Tool Selection

- Selection Made with Trade-off Analysis
  - Features uncovered after selection made
- For Pilots, Specific Tool Selected Not Seen As Important
  - Emphasis on learning language
  - Chose to use same tool on each project
- Process/Methodology Script Experience
  - Automated features may put you in a box that is inappropriate for your project
- Tools Use Different File Structures, Effects:
  - Model CM
  - Integration with Engineering Repositories
- SysML compliancy
  - Temptation to leave in features not part of SysML profile, adding complexity
- Different levels of consistency maintenance
- What is the definition of “executable”?
  - Behavior timeline
  - Design budgets (static and dynamic)

Summary

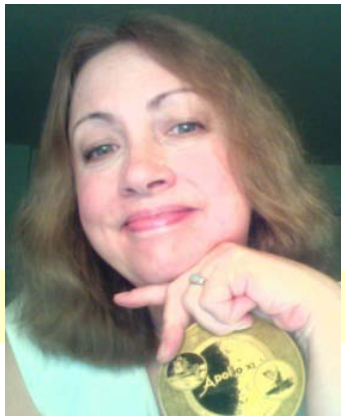
- Fundamentals of Systems Engineering reinforced through the creation of models
- Improvement seen in communications among system/project stakeholders
- Efficiencies not yet realized, require SysML proficiency at outset
- “Reverse Engineered” pilot projects -
  - Good for learning SysML
  - Helpful in support of developing processes
  - Missed opportunity to influence final outcome
- Model for a Purpose - *Begin with the end in mind!*

Realizing the Vision: Innovative Practices to Enhance the Capability Of the Systems Engineering Workforce

Dr. Janice Ziarko
The MITRE Corporation

NDIA 13th Annual Systems Engineering Conference
October 2010

©2010-The MITRE Corporation. All rights reserved



Dr. Janice A. Ziarko

jziarko@mitre.org

Dr. Ziarko is the MITRE Institute's Technical Program Asst. Manager, and the Program Manager for MITRE's Federal Employee Fellowship Program, S*Eworks* Program, and on-site JHU MSSE Degree Program. The MITRE Institute is the corporate education, training, and professional development group operating under the auspices of Human Resources at The MITRE Corporation, which manages five Federally Funded Research and Development Centers (FFRDCs). She is responsible for developing and delivering programs to meet the systems engineering and technological needs of the Corporation.

Her management and education experience span more than 30 years. She has been a practicing systems/software engineer since the late 80s. Her work and academic experience includes programs and advanced research projects for Treasury/IRS, DoD (OSD, Army, Navy), NASA, EPA, GSA, Department of Interior, and the USPS. She is an Adjunct Faculty at the Johns Hopkins University Applied Physics Laboratory, Whiting School of Engineering, where she teaches systems engineering. Dr. Ziarko holds a M.S. in Information Systems and a Ph.D. in Public Administration from American University in Washington D.C. concentrating on Technology Transfer, Open Systems, and Science and Technology Policy.

Our History at MITRE

- The MITRE Corporation is a non-profit organization
  - Founded in 1958 to provide engineering and technical services to the U.S. Air Force
  - Successfully expanded these services to a broad and diverse set of sponsors within the U.S. government and internationally

MITRE Today

- Today, The MITRE Corporation manages five Federally Funded Research and Development Centers (FFRDCs)
  - Department of Defense
  - Federal Aviation Administration
  - Internal Revenue Service and Department of Veterans Affairs
  - Homeland Security (Systems Engineering Development Institute)
  - Judiciary Engineering and Modernization Center (JEMC)
- The MITRE Institute is the corporate education, training, and professional development group operating under the auspices of Human Resources at The MITRE Corporation

Is This Systems Engineering?

Is this Systems Engineering?

- The SE discipline is coming into its own
  - Yet there is no consensus on the state of the discipline
- Some consensus on SE fundamentals and standards
  - ISO15288, EIA632, CMMI, etc.
- No consensus on advanced topics
  - Enterprise Systems Engineering, System of Systems Engineering, etc.

The
BIG
Picture
ISS007E05379

Systems Engineers Changed the World

- In the last 50 years…
  - We engineered systems that changed the world
  - We created a capable engineering workforce in the public and private sectors

- For the future…
  - We'll continue to enhance the capability of the systems engineering workforce
  - We'll continue to improve and create more innovative practices to sustain the systems engineering workforce

Public Managers and Systems Engineers

- For public managers leading major systems acquisitions and projects in the federal government, the systems engineer in the public, non-profit or private sectors is a critical asset
  - The role of the public manager and systems engineer is interwoven
  - Programmatic, technical, social and ethical considerations are involved in the decisions they make together to design and deploy systems and advanced technologies
- Many federal agencies have noted their public managers and engineers are spread too thin to effectively manage existing acquisitions

Source: Janice A. Ziarko, Mixed Contracting of Service Delivery in Federal Agencies and Bureaus: A Study in Inter-organizational Network Structure and Program Effectiveness, 2006.

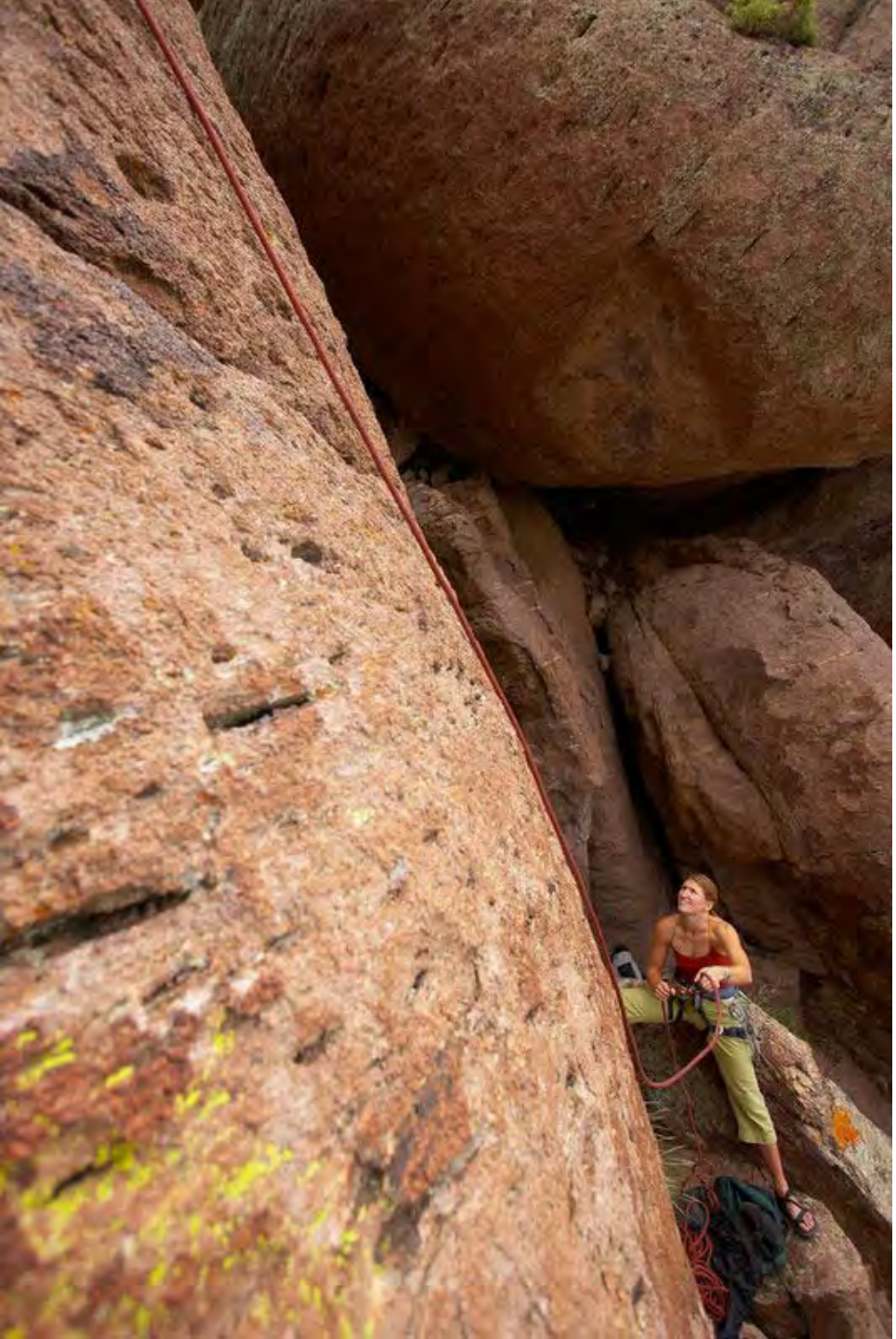
Federal SE Workforce - A Short Supply

"*The presence of experienced, domain-knowledgeable systems engineers on the development team — on both the government and the industry sides — is a critical factor in the success of any Air Force acquisition program. However, … the depth of systems engineering talent in the Air Force has declined owing to policies … that shifted the oversight of SE functions increasingly to outside contractors, as well as to the decline of in-house development planning capabilities in the Air Force.*

The result is that there are no longer enough experienced systems engineers to fill the positions in programs … particularly within the government. As acquisition programs continue to evolve from individual systems to systems of systems, this shortage will only become more acute."

Source: Air Force Study Board, Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Acquisition, Ch. 3, 2008.

Where Are We Headed?



Challenges for SEs On the Job

- Complex Technical Problems
- Interagency Politics
- Security Issues
- Small Budgets/Tight Schedules
- Greater Expectations
- Complex Operational Issues
- Technical Maturity
- Government Mandates
- Managing Risk/Uncertainty
- And more…

MITRE

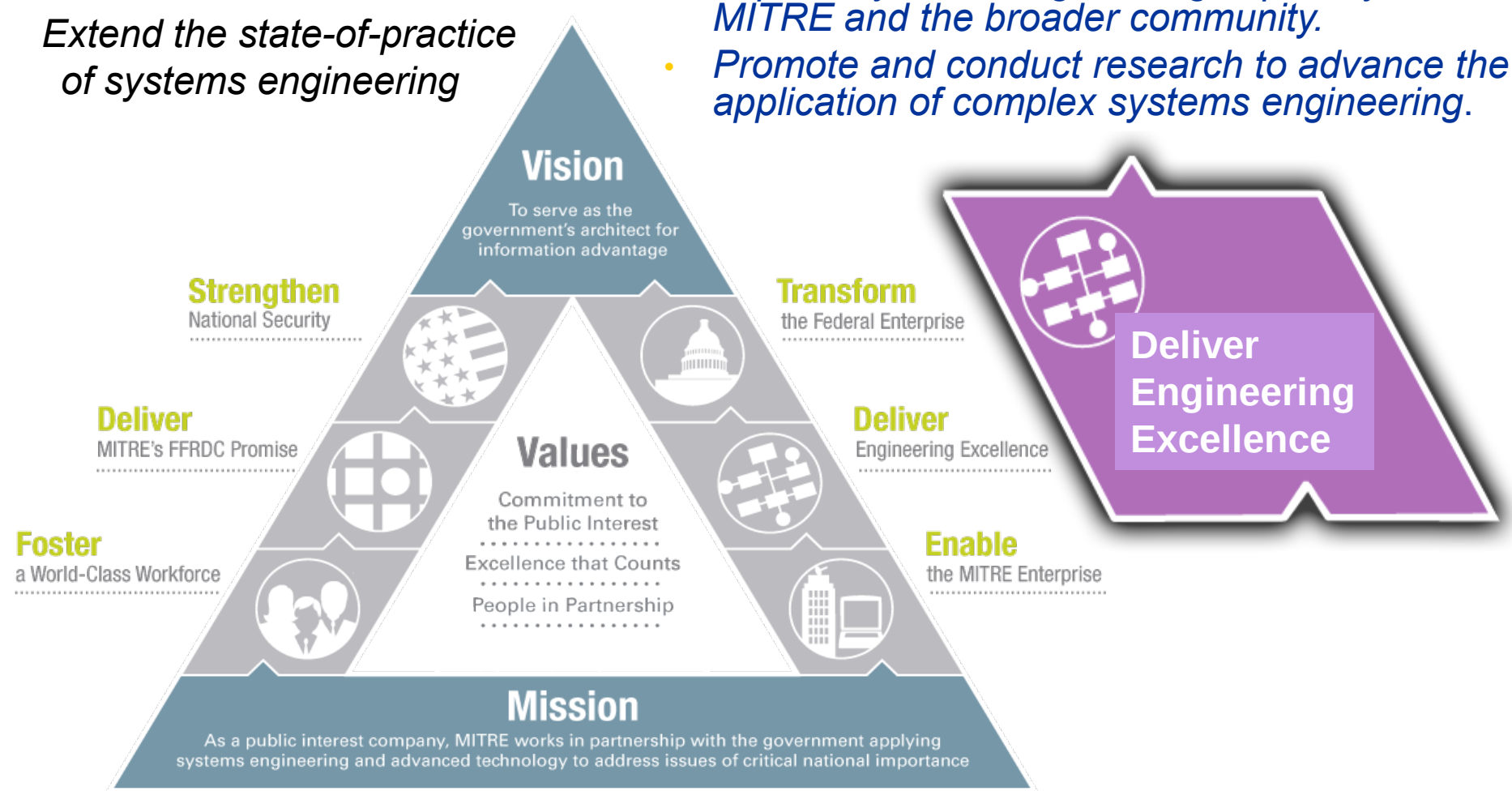
MITRE's Strategic Framework

Goal Objective

Extend the state-of-practice of systems engineering

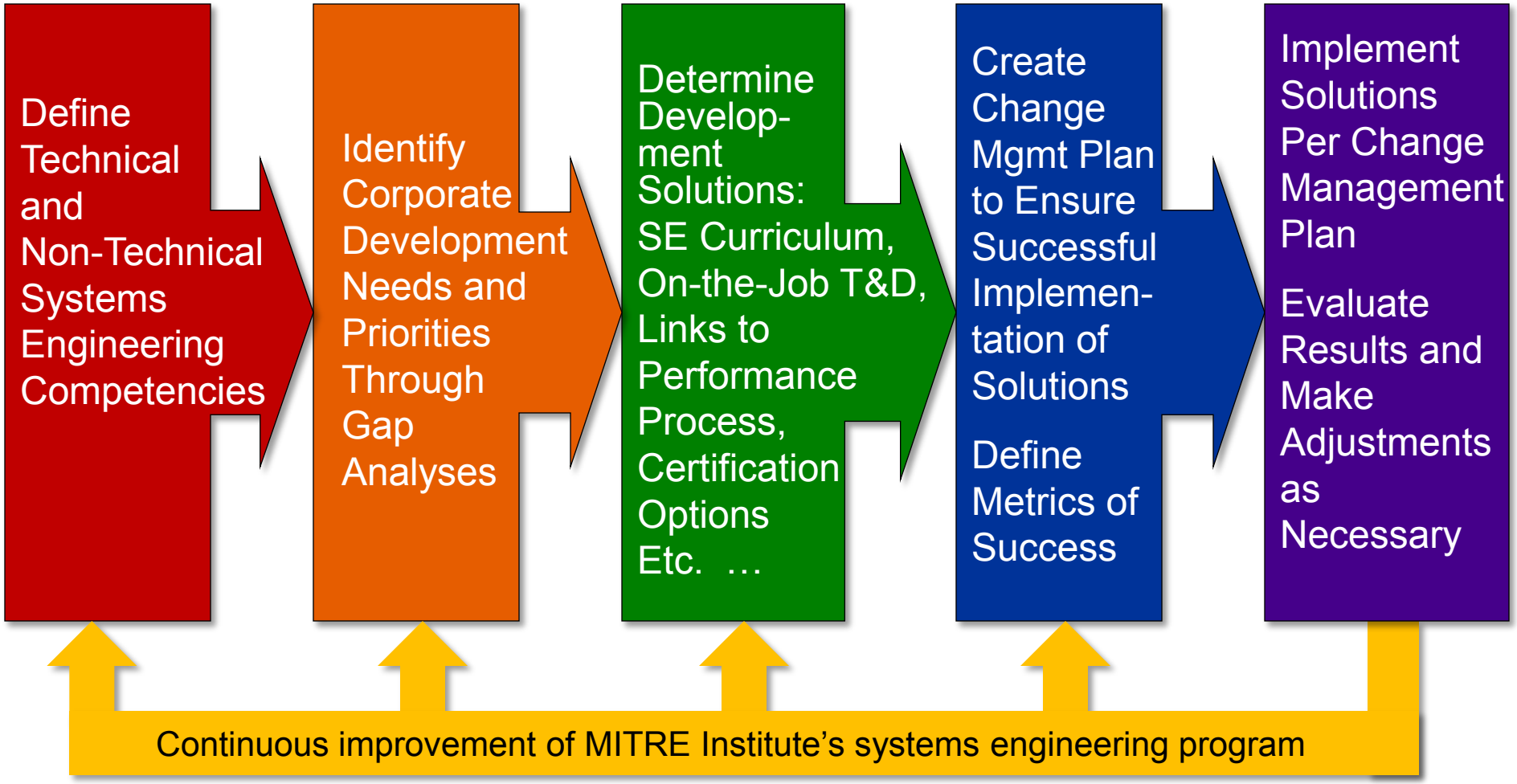
Strategy

- *Expand systems engineering capability across MITRE and the broader community.*
- *Promote and conduct research to advance the application of complex systems engineering.*



MITRE

MITRE's Strategic Approach to Enhance SE Workforce Capability



What Can We Do?
NASA

We Can Manage and Engineer Systems

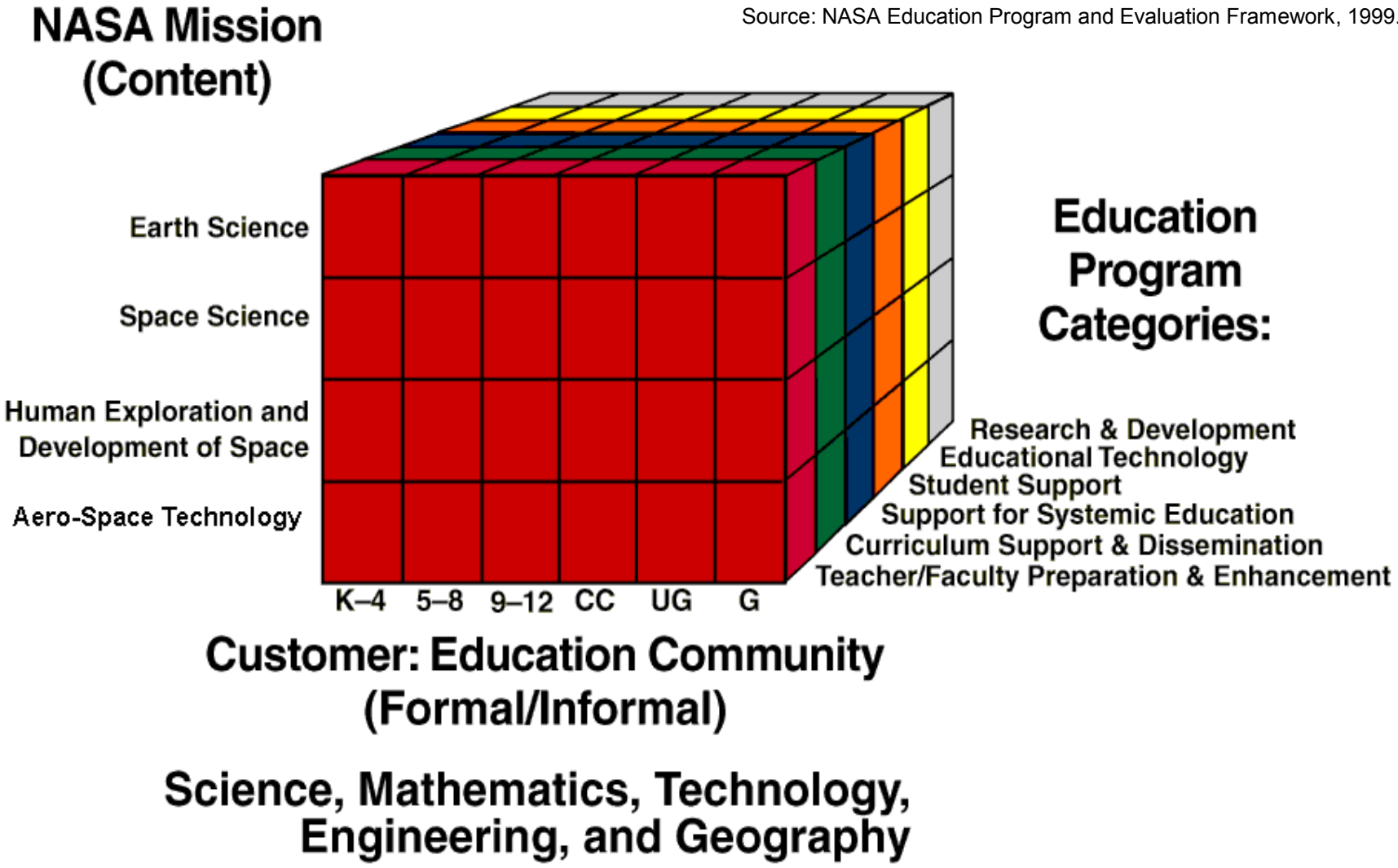
- Federal government systems acquisitions are focused on acquiring suppliers to design, develop, and field government systems
- When systems were initially created, their purpose may have been focused on functions such as accounting or environmental management, or as an integration of computing and network architectures in agency environments
  - These systems may have evolved into more integrated systems interfacing with multiple other systems in today's internet and intranet rich information environment
- This mosaic of interconnected and interoperable complex systems must be engineered and managed

We Can Create Innovative Practices

- Federal Programs are essential to deliver assets to local, State, regional and national education efforts in science, technology, engineering and mathematics
- Hiring, Recruitment, and Development is a life long commitment which begins with School Age Children
- SE Competency Models drive Individual Development
- Education, Training and Development Solutions are instrumental for SE Workforce Development
- Partnerships and Fellowships enrich Development for SE Practitioners

NASA's Innovative Education Program

Source: NASA Education Program and Evaluation Framework, 1999.



MITRE

NASA's Education Program and Evaluation Framework

- Integrates three components
  - Content, Customer, and Program category
- Content (knowledge) based on the NASA mission is a fundamental component of any education activity
  - Strategic Enterprises: Aero-Space Technology, Human Exploration and Development of Space, Earth Science, and Space Science
- Customer is the formal and informal education community
  - Content is tailored to meet customer expectations
  - Reaches kindergarten through graduate level education communities that comprise customer segments
- Program category is the manner in which education activities are provided to the customer

Six NASA Education Program Categories

- Teacher/Faculty Preparation and Enhancement
  - Provides NASA facilities, resources, information, and programs to advance the knowledge and skills of educators and faculty
  - Delivers professional development experiences and research opportunities for K–12 educators and higher education faculty
- Curriculum Support and Dissemination
  - Develops, utilizes, and disseminates *science, mathematics, technology, engineering, and geography* instructional materials (based on NASA's mission)
  - Supports the development of higher education curricula
  - Products are disseminated through a physical presence in each State, electronic networking resources, teacher/faculty workshops, and partnerships with organizations involved in systemic education reform

Six NASA Education Program Categories

- Support for Systemic Improvement of Education
  - Establishes partnerships to deliver assets to education efforts via collaboration with stakeholders (local, State, regional, and national)
- Student Support
  - Provides students with facilities, resources, information, experiences, programs, and research opportunities
- Educational Technology
  - Researches and develops products and services that facilitate the application of technology to enhance the educational process
  - Addresses the development of innovative learning tools, strategies, and teacher training
- Research and Development
  - Promotes collaborations with the academic community to enrich graduate education and research

We Can Recruit and Develop

- From a National perspective, recruitment and development begins in K-12 grades
  - Attract students to science, technology, engineering, and mathematics
  - Reinforce the value of public service and positive contributions of career civil servants
  - Deal with social issues (declining literacy rates, glass ceiling, etc.)
- Change begins with individuals and organizations
  - Planed activities (science fairs, field trips, children to work days)
  - Visit facilities (Wallops Island, Moffett Field, GSFC, etc.)
  - Teach children and adults in academic and professional settings
  - Development continues through adulthood
  - Continuously improve performance and capability

MITRE

We Can Utilize Competency Models

- SE Competency Models Drive Individual Development
  - Technical Acumen is a must for systems engineering
  - So are communications and team-building skills
  - Leadership and Management skills are crucial in the mix
- Corporate Assessments against Competencies Examine Staff Capability and Manager's Needs
  - Assessment of Incoming Students to Corporate T& D Program
  - Customize Their Program with an On-the-Job Project
  - Contributes to Performance and Development Plans for each Employee
- SE Competency Models Drive Curriculum Development for T&D Programs at all Levels of Proficiency

MITRE

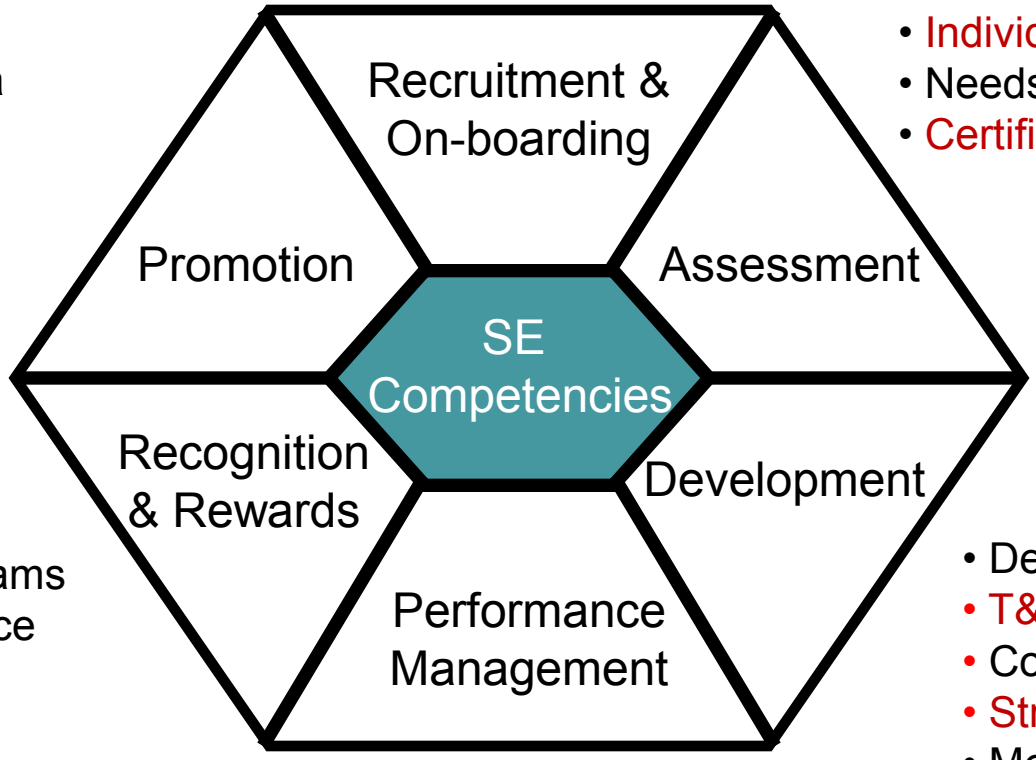
The Value of Competencies

Integration into Organizational Programs & Processes

- Job Descriptions and Sourcing
- Interviewing and Hiring
- Orientation and Assimilation

- Promotion Criteria
- Talent Reviews
- Career Planning

- Individual Assessment
- Needs Analysis
- Certification

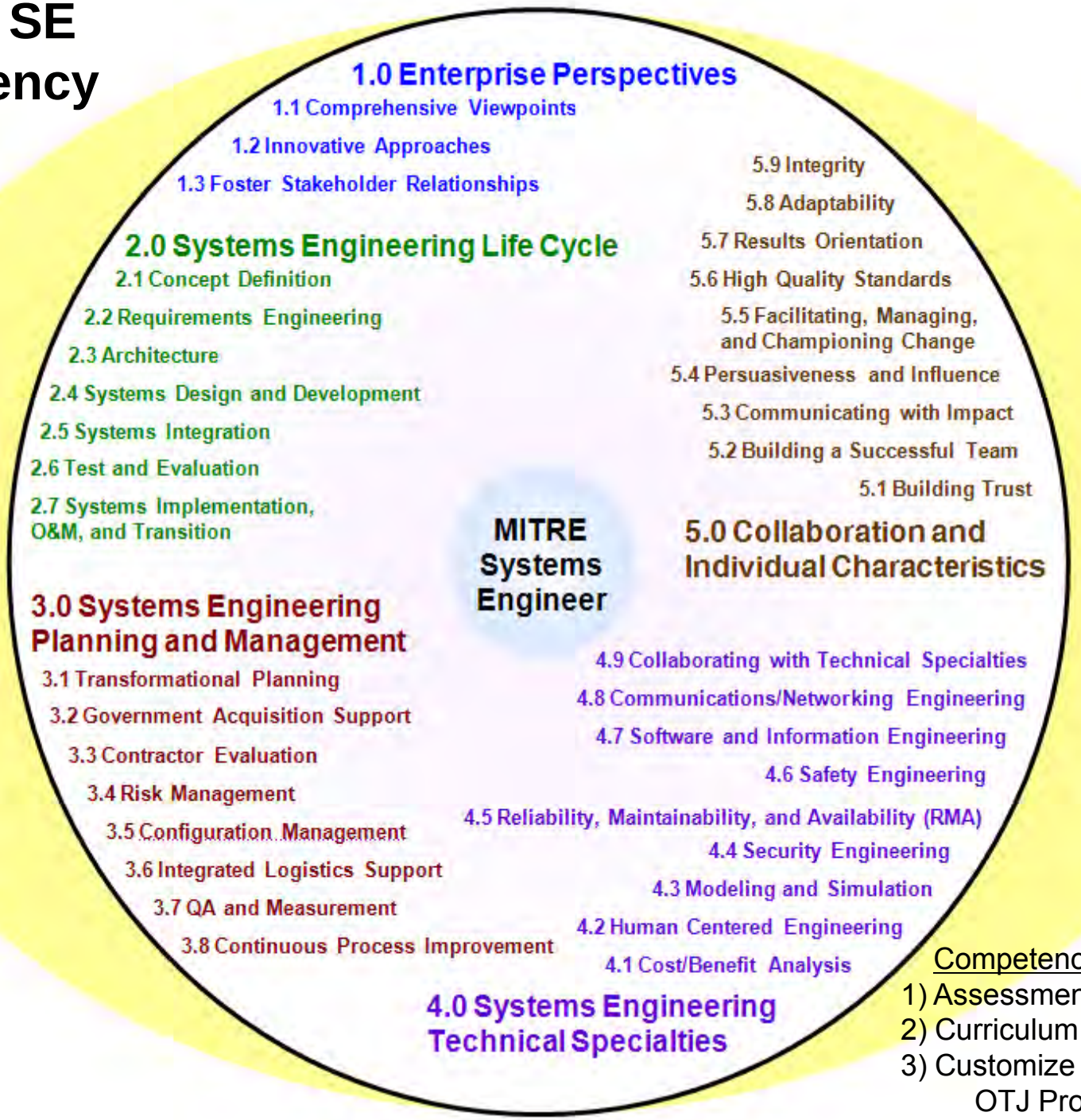


- Recognition Programs
- Pay for Performance

- Degree Programs
- T&D Programs
- Conferences
- Stretch Assignments
- Mentoring Practitioners
- Job Rotation

- Performance Goals and Feedback

MITRE's SE Competency Model



Competency Model Uses

1) Assessments 2007/2008
2) Curriculum Development
3) Customize Programs with OTJ Projects

We Can Implement Development Solutions

- Education, Training and Development includes
  - Academic foundation (degrees, certificate programs)
  - Professional development (courses, on-the-job, certifications, mentoring and coaching, links to performance)
- Multiple delivery options utilizing new technologies
  - In person, on-line broadcasts(live/recorded), distance learning
- The MITRE Institute is implementing a New Program

SEworks

Before SEworks

- The MITRE Institute had a large "Open" catalog approach
  - Continue to offer the Open Catalog for SE Development
  - Make improvements through staff and manager training surveys
  - Deliver ~ 500 course per fiscal year across a broad spectrum of systems engineering and advanced technology topics
  - Managers and staff pick and choose what they need for immediate future
- However, there was no long-term, strategic view of SE development
  - No clear articulation of what MITRE expects its SEs to know at specific proficiency levels or career levels
  - No clear expectations of what The MITRE Institute should be training SEs at specific levels of proficiency

Systems Engineering at MITRE

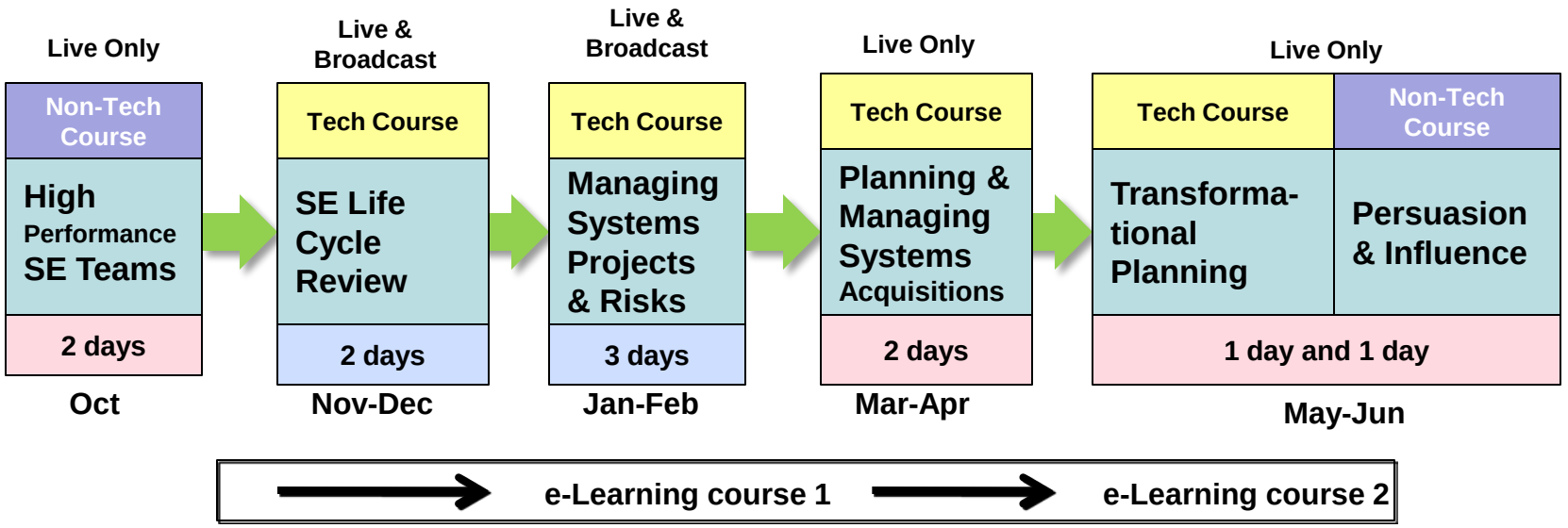
	Technical Competencies	Non-Technical Competencies	e-Learning & Vertical Integration
SEworks 1 Foundational	**Apply Rigor to SE Lifecycle Activities & Effectively Communicate & Collaborate**		
	Competency Model–Section 2 Concept, Requirements, Architecture, Design & Development, Integration, Test & Evaluation, and System Implementation	**Competency Model–Section 5** Teams, Communicating with Impact, Adaptability, and Results Orientation	**Competency Model–Section 4** HCE, CBA, M&S, and Security Eng. **Vertical Integration** ESE, Risk
SEworks 2 Intermediate	**Lead and Manage SE Activities & Build Successful Relationships with Stakeholders**		
	Competency Model–Section 3 Transformational Planning, Acquisition Support, Contractor Evaluation, Risk, Configuration Management, Logistics, QA, and Process Improvement	**Competency Model–Section 5** Teams, Trust, Quality Standards, and Persuasiveness & Influence	**Competency Model–Section 4** MA, SwEng., Comm\Netwking & Safety **Vertical Integration** ESE, Risk
SEworks 3 Expert	**Leverage SE in the Enterprise Environment & Influence Key Stakeholders to Transform the Enterprise**		
	Competency Model–Section 1 Comprehensive Viewpoints, Innovative Approaches, and Foster Stakeholder Relationships	**Competency Model–Section 5** Persuasiveness & Influence and Change Management	**Vertical Integration** Problems & Case Studies Set in Context of Life Cycle and Lead & Manage Enterprise Simulation

All Program Levels Will Include These Components

- Programs will last approximately 8-10 months & Video broadcast
- On-the-Job Project (2-3 competencies)
- Group Work & Networking with Other Center & Site Staff
- Training & Development Database Resources
- INCOSE Certification Option

MITRE

SEworks 2 Program



Technical Courses
TSE600 SE Life Cycle Review
TSE601/TSE604 Managing Systems Projects and Risks
TSE602 Planning & Managing Systems Acquisition
TSE603 Transformational Planning

Non-Technical Courses
DSE600 Building High Performance SE Teams
DSE601 Persuasion and Influence

Class size:
Groups of ~25, ~ 100 Students

Group Work and Project:

Group Work – Self-directed, virtual mentored teams; 1 hour at lunch every 2 weeks, or as directed by group
Project Work – "Give Back to Company" – group project or individual project for work program

We Can Form Partnerships and Fellowships

- Partnerships and fellowships between public, private, and non-profit organizations create opportunities for individuals to grow and excel
- MITRE's JHU MSSE Degree Program delivers on-site and distance learning MSSE degree programs to staff in areas of concentration
  - A Memorandum of Understanding forms the partnership
  - Six cohorts have been delivered, three more are planned
- MITRE's Federal Employee Fellowship Program delivers a senior leadership experience to selected federal employees
  - A Memorandum of Agreement with a sponsoring government organization assigns the federal fellow to MITRE for 4 - 12 months
  - A collaborative organization within MITRE enables a broad experience across federal agency work programs

For the Future…

For the Future…

- More focus on national policies to grow assets in science, engineering, technology, and mathematics
- More commitment to engaging young students in science, engineering, technology and mathematics
- More rigor in defining the SE discipline and competencies to enhance workforce capability
- More systematic delivery of SE education, training, and development
- More dedication to mentoring, coaching, and teaching engineers on the job and in the classroom

References

- *Air Force Study Board, Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Acquisition, Ch. 3, 2008.*
- *Chubb, J. E., and T. M. Moe, Politics, Markets and America's Schools. Washington, D.C: Brookings Institution, 1990.*
- *NASA Education Program, Implementation Plan for Education 1999-2005, (Washington, D.C.: U.S. Government, EP-1998 12-383-HQ, 1999, 7).*
- *Trudeau, Philip N., Ph.D., Design Considerations in Building a Corporate Systems Engineering Training and Development Program, 2010.*
- *Ziarko, Janice A, Ph.D., Mixed Contracting of Service Delivery in Federal Agencies and Bureaus: A Study in Inter-organizational Network Structure and Program Effectiveness, 2006.*

Undergraduate Systems Engineering Programs in the US

Dr. Don Gelosh
ODDR&E/Systems Engineering

Dr. Art Pyster
Stevens Institute of Technology

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

"A capable, qualified, and appropriately sized acquisition workforce will be key to achieving efficiency."

-- Dr. Ashton Carter
Under Secretary of Defense
for Acquisition Technology and Logistics

Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending **(***14 Sep 2010)*

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

What Does the DoD Expect from its Systems Engineering Workforce?

- **Breadth**
  - Awareness of and appreciation for other functional areas,
  - Understanding of the system lifecycle and processes
  - Knowledge of other engineering disciplines and how they integrate into the system solution
  - Knowledge of product domains
- **Depth**
  - Extensive expertise and experience in one or more engineering disciplines and in one or more product domains
- **Leadership**
  - Ability to motivate and inspire individuals and teams
  - Comfort in dealing with complexity
  - Focused on underpinning decisions with data
  - Capability to make tough technical decisions

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Motivation

Because the DoD needs many capable systems engineers, it is important to understand the size, focus, success, and challenges of undergraduate SE programs and help improve the impact of those programs.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

This Presentation Covers…

- Historical trends in US undergraduate Systems Engineering (SE) programs
- Results of a workshop held in April 2010 on US undergraduate SE programs – including recommendations

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

First a History Lesson…

- ***Historical trends in US undergraduate systems engineering (SE) programs***

- Results of a workshop held in April 2010 on US undergraduate SE programs – including recommendations

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Program Population Growth

There is healthy growth in the number of U.S. systems engineering programs at both the undergraduate and graduate levels

1999: 29 schools offered 58 programs at undergraduate and graduate levels – ***19 undergraduate programs***

2004: 75 schools offered 130 programs at undergraduate and graduate levels – ***43 undergraduate programs***

2009: 80 schools offered 165 programs at undergraduate and graduate levels – ***55 undergraduate program***

Brown, D. E. & Scherer, W. T. (2000). A comparison of Systems Engineering Programs in the United States. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 30(2), 204-212.

Fabrycky, W. J. and McCrae, E.A. (2005). Systems Engineering Degree Programs in the United States", in Proceedings of the 15th Annual International Symposium, INCOSE 2005, Rochester, NY, July, 2005 .

Fabrycky, W.J., "Systems Engineering: Its Emerging Academic and Professional Attributes", Proceedings of the 2010 American Society for Engineering Education Conference and Exposition, Lexington, KY, June 20-23, 2010.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Two Broad Types of Programs

- Systems-Centric: where the concentration is designated as SE; where SE is the intended major area
- Domain-Centric: SE education and training that integrates the best SE practices within the traditional engineering disciplines… SE with biological engineering, SE with industrial engineering, etc.

Useful, but not a perfect distinction – some programs have characteristics of both; e.g., Stevens has a master's of SE (SCSE), but offers a certificate in Space Systems SE (DCSE). Also, some programs integrate significant SE without using "systems engineering" in the name of their degree.

* Fabrycky, W.J., "Systems Engineering: Its Emerging Academic and Professional Attributes", Proceedings of the 2010 American Society for Engineering Education Conference and Exposition, Lexington, KY, June 20-23, 2010.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

2009 Program Distribution by Type

Type	B	M	PhD	Total
Systems Centric SE	11	31	14	56
Domain Centric SE w/ Biological Engineering	18	10	6	34
Domain Centric SE w/ Computer Engineering	7	5	3	15
Domain Centric SE w/ Industrial Engineering	17	17	13	47
Domain Centric SE w/ Management Engineering	1	2	0	3
Domain Centric SE w/ Manufacturing Engineering	1	8	1	10
Total	*55*	*73*	*37*	*165*

Parsing XX Systems Engineering important. Some programs are more about (XX Systems) Engineering rather than XX (Systems Engineering) – *more on this later…*

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

10-Year Trend

Type of SE Program	Degree Level	Brown & Scherer (2000)	Fabrycky (2010)	Increase Factor
Systems Centric	Bachelors	10	11	1.1
	Masters	10	31	3.1
	Doctorate	3	14	4.7
	Systems Centric	23	56	2.4
Domain Centric	Bachelors	9	44	4.9
	Masters	17	42	2.5
	Doctorate	9	23	2.6
	Domain Centric	35	109	3.1
All	Bachelors	19	55	2.9
	Masters	27	73	2.7
	Doctorate	12	37	3.1
All	All Degrees	58	165	2.8

Reference: Squires, A. (2010) DRAFT: Measuring the Value of Remote Online Systems Engineering Education, PhD Dissertation, Stevens Institute of Technology

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Program Growth is Not Uniform

- Over last decade, strong growth for some:
  - Undergraduate DCSE grew from 9 to 44 programs (~5x)
  - Graduate SCSE grew from 13 to 45 programs (~3.5x)
- Least growth in undergraduate SCSE programs - from 10 to 11
- Overall growth is close to 3x, but has slowed significantly in the last 5 years

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Why The Disparity in Growth?

- This disparity may reflect the belief by many that SE is inherently experiential-based.
- Perhaps undergraduates, who largely lack experience, best learn SE in the context of another engineering discipline/application domain (DCSE) rather than as a “pure” SCSE.
- Perhaps graduates, who often enter a program with substantial industrial experience, can succeed in either a DCSE or a SCSE program.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

And Now The Workshop…

- Historical trends in US undergraduate systems engineering (SE) programs
- ***Results of a workshop held in April 2010 on US undergraduate SE programs – including recommendations***

http://www.acq.osd.mil/se/docs/Undergraduate-Systems-Engineering-Program-Workshop-Report-Final.pdf

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

1st Undergraduate SE Workshop

Purpose: Examine the state of US undergraduate SE programs

Attendees: More than 60 professionals from academia, government, and industry

Venue: US Air Force Academy on April 7-8, 2010

Three goals:

- Explore the characteristics, successes, and challenges of US bachelor's degree programs in SE.
- Build a sense of community among US faculty who provide undergraduate SE programs.
- Develop high-level proposals for how to reinforce the strengths of those programs and address their challenges, thus increasing their value to students and prospective employers in a practical way.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Keynote Addresses

- *Department's Need for Young Systems Engineers*
  by Steve Welby, Director, SE, ODDR&E

- *Developing Our Systems Engineers*
  by Charles Toups, VP/GM Network and Tactical Systems, Boeing

- *US Air Force Academy Systems Engineering*
  by Lt Col Paul Lambertson, Director, SE

- *BKCASE Project and an Analysis of US Undergraduate Programs in SE*
  by Art Pyster, Stevens Institute of Technology

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Panel Sessions

1. *What are Best Practices in Teaching SE to Undergraduates?*

   Panelists: Michael Smith, Drew Hamilton, Seshadri Mohan, Armen Zakarian

2. *Should SE Degrees Only Be Offered at The Graduate Level?*

   Panelists: Dinesh Verma, Dennis Barnabe, Thomas Mazzuchi, Timothy Trainor, Brian Wells

3. *How Much Classical Engineering and Domain Focus Should Be in a Bachelor's Degree in SE?*

   Panelists: Don Taylor, Paul Coffman, Brian Gallagher, Brett Peters, Ariela Sofer

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Breakout Sessions

1. What are the primary undergraduate education requirements for SE personnel in government program offices?

2. What are the top 5 challenges to successful bachelor's degree programs in SE and how should those challenges be addressed?

3. Within the first four years after graduation, what should someone with a bachelor's degree in SE know and be capable of doing on the job?

4. How much classical engineering (general, industrial, mechanical, electrical, etc.) and application domain focus (telecommunications, naval, medical, etc.) should be in a bachelor's degree in SE?

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

State of the US

1. Strong Demand
2. Distinction Lessens Over Time
3. Real Engineers
4. Systems vs. Domain Centric
5. Distinction Is Fuzzy
6. Industrial vs. Systems Engineering
7. Top 4 Challenges
8. Program Offices Are No Different

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Strong Demand

- Both industry and government have a strong demand for trained, experienced systems engineers
- Prefer those who can:
  - think holistically about complex problems
  - are comfortable with the increasing complexity of systems that address those problems
  - can manage the uncertainty and complexity of the environment in which those systems are being built
  - can respond to demands to shorten the time to deliver systems to the field

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Strong Demand - Recommendation

Conduct research to understand the demand in both the defense community and the broad U.S. economy for graduates of undergraduate systems engineering programs

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Distinction Lessens Over Time

- Companies routinely hire engineers with bachelor's degrees in disciplines other than SE and develop them into systems engineers
- They hire engineers with bachelor's degrees in SE, but in far fewer numbers
- New hires are apprentices, not journeymen or experts.
- During first 2 years after graduation, distinction between SE and non-SE degree is sharpest
- After 4 years of work experience, there is little distinction between engineers who learn SE on the job and those who first learn it as an undergraduate

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Distinction Lessens Over Time - Recommendation

Conduct research to understand the jobs that graduates with a bachelor's degree in SE hold during their apprenticeship period, to understand the competencies valued most by employers during that period, and to understand the relative performance of those with an SE degree and those with an engineering degree other than SE

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Real Engineers

- Undergraduate SE programs generally produce “real” engineers
- Programs are Accreditation Board for Engineering and Technology (ABET) accredited
- Curricula incorporate classical engineering courses in physics, circuits, mathematics, mechanics, chemistry, etc.
- Graduates of these programs generally are prepared to sit for the Fundamentals of Engineering Exam required in most states to become certified as Engineers in Training

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Real Engineers - Recommendation

Conduct research to understand how many graduates of SE programs go on to become certified Engineers in Training and eventually certified Professional Engineers. Determine why graduates seek or forgo certification

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Systems vs. Domain Centric

- There are dozens of undergraduate programs that include the phrase “systems engineering” in their titles.
- All but 11 do so in combination with other disciplines
- No study has looked in detail at what is being taught in the Domain Centric SE programs to understand the balance between SE and the domain in the programs.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Systems vs. Domain Centric - Recommendation

Conduct additional research to understand what SE is being taught in Domain Centric SE programs and where the graduates are being employed

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Distinction is Fuzzy

- Distinction between Systems Centric and Domain Centric SE programs is not as sharp as the names imply.
- Systems Centric programs generally require students to specialize in an application area such as finance, or in an additional discipline such as electrical engineering.
- The effect is that the Systems Centric programs are often a hybrid of a “pure” program in systems engineering and a Domain Centric program.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Distinction is Fuzzy - Recommendation

Hold a workshop to sharpen the understanding of the similarities and differences between Systems Centric and Domain Centric SE programs

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Industrial vs. Systems Engineering

- Distinction between Industrial Engineering (IE) and SE is unclear.
- I&SE Department website at Texas A&M states “Industrial engineers deal with **systems**. They can design, implement or improve integrated systems comprised of people, materials, information or energy.”
- Similar to SE & OR Department website at GMU - “Systems Engineers determine…most effective ways …to use all of a given system's components -- people, machines, materials, information, and energy. Systems engineers plan, design, implement and manage complex systems that assure performance, safety, reliability, ...”

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Industrial vs. SE - Recommendation

Hold a workshop to sharpen the understanding of the similarities and differences between Industrial Engineering and SE

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Top Four Challenges

- Understanding and meeting customers needs within curriculum constraints,
- Sustaining technical and societal relevance
- Incorporating sufficient real-world problem solving into the curriculum
- Identity-communications-community of practice

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Top 4 Challenges - Recommendation

Hold a workshop to elaborate more fully on these challenges and develop a sharper roadmap to address them

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Program Offices Are No Different

- Undergraduate educational requirements for systems engineers who will work in U.S. government program offices are quite similar to those who graduate from a “typical” Systems Centric SE program
- For example, graduates should first be an engineer, then be a systems engineer
- They should be educated in systems analysis, requirements management, life cycle choices, trade-off analysis, and other concepts typically taught in Systems Centric SE programs

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

2nd Undergraduate SE Workshop

- Up to 100 people
- Add more industrial participation outside the defense/aerospace sectors and adding more representation from DoD program offices and product center chief engineers
- Directly address one or more earlier recommendations

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

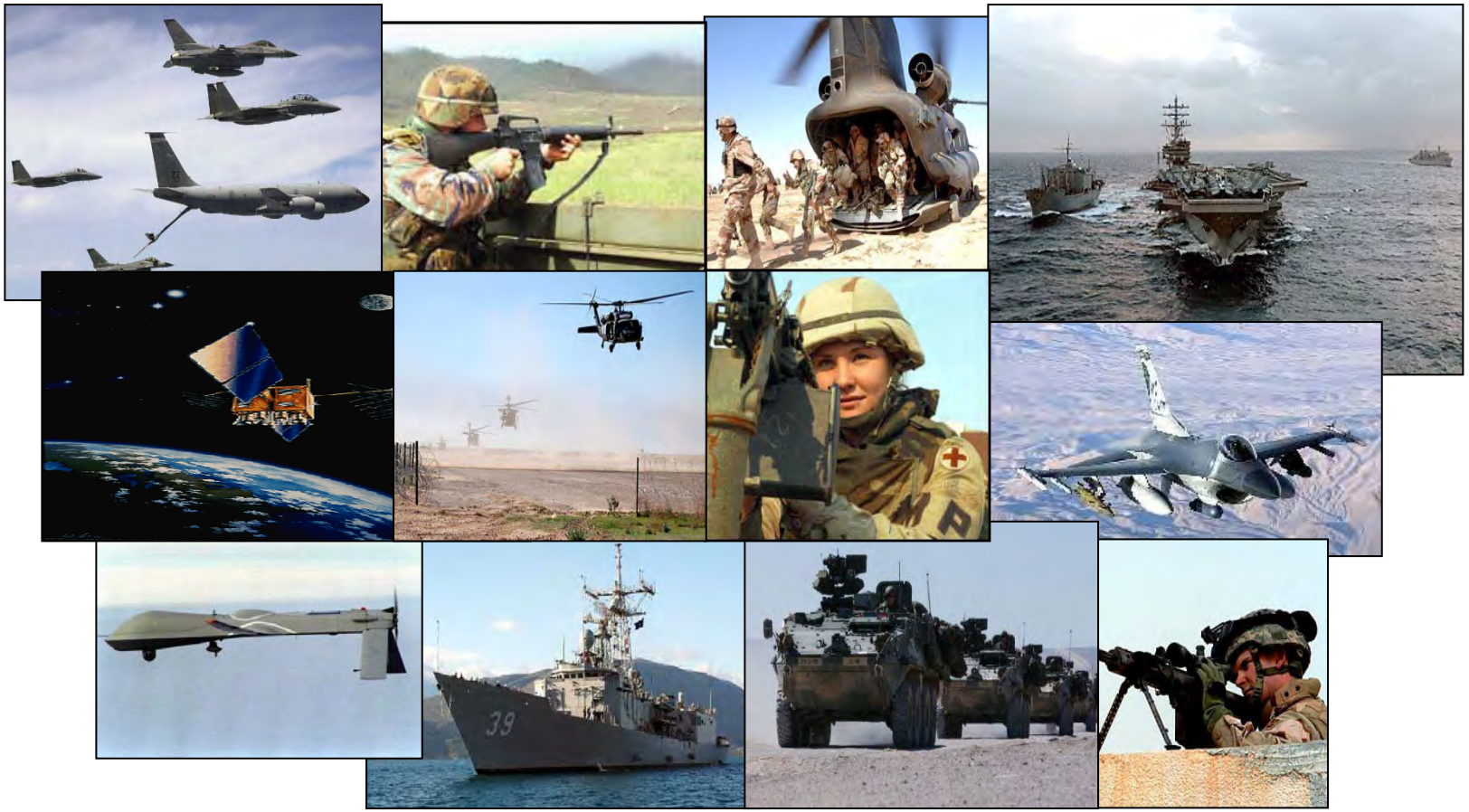
For Additional Information

Dr. Don Gelosh
ODDR&E/Systems Engineering
donald.gelosh@osd.mil

Dr. Art Pyster
Stevens Institute of Technology
art@pyster.com

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

Systems Engineering: Critical to Program Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 08 Oct 2010 -- SR case number 11-S-0042 refers.

The Body of Knowledge and Curriculum to Advance Systems Engineering Project

Art Pyster, *Stevens Institute of Technology*
Dave Olwell, *Naval Postgraduate School*

NDIA Systems Engineering Conference
San Diego, California
October, 2010

Agenda

1. BKCASE background and objectives
2. Systems Engineering Body of Knowledge status and plans
3. Graduate Reference Curriculum on Systems Engineering status and plans
4. Questions

Agenda

1. ***BKCASE background and objectives***
2. Systems Engineering Body of Knowledge status and plans
3. Graduate Reference Curriculum on Systems Engineering status and plans
4. Questions

How We Got Here

In Spring 2007, 3 phase effort was proposed:

1. A reference curriculum* for graduate software engineering with the “right” amount of systems engineering
2. A reference curriculum for graduate systems engineering with the “right” amount of software engineering
3. A fully interdisciplinary reference curriculum for systems and software engineering

*A reference curriculum offers recommendations on outcomes at graduation, entrance expectations, curriculum architecture, required knowledge, and possibly objectives. Recommendations are expected to be tailored. They do not specify course offerings or packaging.

You Are Here…

DONE — *Phase 1.* A reference curriculum for graduate software engineering with the "right" amount of systems engineering

NOW — *Phase 2.* A reference curriculum for graduate systems engineering with the "right" amount of software engineering

FUTURE — *Phase 3.* A fully interdisciplinary reference curriculum for systems and software engineering

Phase 1 Primary Products

- Graduate Software Engineering 2009 (GSwE2009): Curriculum Guidelines for Graduate Degree Programs in Software Engineering
- GSwE2009 Companion Document: Comparisons of GSwE2009 to Current Master's Programs in Software Engineering
- GSwE2009 Companion Document: Frequently Asked Questions on Implementing GSwE2009

iSSEc

Integrated Software & Systems Engineering Curriculum (iSSEc) Project

Graduate Software Engineering 2009(GSwE2009)

Curriculum Guidelines for
Graduate Degree Programs in Software Engineering

GSwE 2009

Version 1.0

September 30, 2009

Unlimited Global Distribution

© 2009 Stevens Institute of Technology

i

Endorsed by INCOSE, NDIA SE Division, Brazilian Computer Society

Originally sponsored by DoD. Now sponsored by the IEEE Computer Society and ACM

www.GSwE2009.org

What is BKCASE?

- Project to create:
  - Systems Engineering Body of Knowledge
  - Graduate Reference Curriculum in Systems Engineering (GRCSE™ – pronounced “Gracie”)
- Started in September 2009 by Stevens Institute of Technology and Naval Postgraduate School with primary support from Department of Defense
- Project will run through 2012
- Intended for world-wide use

What is the SEBoK?

Describes the boundaries, terminology, content, and structure of SE that are needed to systematically and consistently *support and enable:*

Task Name	Task Description
Inform Practice	Inform systems engineers about the boundaries, terminology, and structure of their discipline and point them to useful information needed to practice SE in any application domain
Inform Research	Inform researchers about the limitations and gaps in current SE knowledge that should help guide their research agenda
Define Curricula	Define the content that should be common in undergraduate and graduate programs in SE
Certify Professionals	Certify individuals as qualified to practice systems engineering
Decide Competencies	Decide which competencies practicing systems engineers should possess in various roles ranging from apprentice to expert

Guide to the literature, not all the content of the literature

What is in GRCSE?

- ***Guidance for Constructing and Maintaining the Reference Curriculum:*** the fundamental principles, assumptions, and context for the reference curriculum authors
- ***Entrance Expectations:*** what students should be capable of and have experienced before they enter a graduate program
- ***Objectives:*** what students should be able to achieve 3 to 5 years after graduation based on what they learn in program
- ***Outcomes:*** what students should achieve by graduation
- ***Architecture:*** the structure of a curriculum to accommodate core material, university-specific material, and elective material
- ***Core Body of Knowledge:*** material that all students should master in a graduate SE program

Not specific courses. Not specific packaging. Adaption and selective adoption expected and encouraged.

BKCASE Vision and Objectives

Vision

"Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE."

Objectives

1. Create the SEBoK and have it be globally recognized by the SE community as the authoritative guide to the body of knowledge for the SE discipline.
2. Create GRCSE and have it be globally recognized by the SE community as the authoritative guidance for graduate programs in SE.
3. Facilitate the global alignment of related workforce development initiatives with SEBoK and GRCSE.
4. Transfer stewardship of SEBoK and GRCSE to INCOSE and the IEEE after BKCASE publishes version 1.0 of those products, including possible integration into their certification, accreditation, and other workforce development and education initiatives.

BKCASE™

Our Supporters

Under consideration

Under consideration

BKCASE™

Authors as of October 2010

Author	Organization
Rick Adcock	Cranfield University, UK
Johann Amsenga	Eclipse RDC, South Africa
Erik Aslaksen	Sinclair Knight Merz, Australia
John Baras	University of Maryland, US
Barry Boehm	University of Southern California, US
John Brackett	Boston University, US
Aaron Eng Seng Chia	National University of Singapore, Singapore
Edmund Conrow	Management and Technology Associates, US
Paul Croll	Computer Sciences Corporation, US
Cihan Dagli	Missouri University of Science and Technology, US
Heidi Davidz	UTC Pratt & Whitney, US
Joseph J. Ekstrom	Brigham Young University, US
Marcia Enos	Lockheed Martin, US
Dick Fairley	IEEE, US
Alain Faisandier	Association Francaise d'lingeniere Systeme, France
Tim Ferris	University of South Australia, Australia
Kevin Forsberg	Center for Systems Management, US
G. Richard Freeman	Air Force Institute of Technology, US
Sanford Friedenthal	Lockheed Martin, US

BKCASE™

Authors as of October 2010

Author	Organization
Richard Frost	General Motors, US
Brian Gallagher	Northrop Grumman, US
Edward Ghafari	ICES in US
Tom Hilburn	Embry-Ridlle Aeronautical University, US
Nicole Hutchison	Stevens Institute of Technology, US
Scott Jackson	University of Southern California, US
Ken Kepchar	Federal Aviation Administration, US
Naohiko Kohtake	Keio University , Japan
Mike Krueger	ASE Consulting, Australia
Harold “Bud” Lawson	Lawson Konsult AB, Sweden
Yeaw lip “Alex” Lee	Defence Science and Technology Agency, Singapore
Ray Madachy	Naval Postgraduate School, US
James Martin	Aerospace Corporation, US
Greg Mayhew	The Boeing Company, US
Andrew McGettrick	Association for Computing Machinery, UK
Ken Nidiffer	Software Engineering Institute, US
Dave Olwell	Naval Postgraduate School, US

BKCASE™

Authors as of October 2010

Author	Organization
Daniel Prun	Ecole Nationale de l'Aviation Civile (ENAC), France
Art Pyster	Stevens Institute of Technology, US
Garry Roedler	Lockheed Martin, US
Jean-Claude Roussel	EADS, France
Sven-Olaf Schulze	Berner & Mattner, Germany
Seiko Shiraska	KEIO University, Japan
Hillary Sillitto	Thales Group, UK
John Snoderly	Defense Acquisition University, US
Alice Squires	Stevens Institute of Technology, US
Massood Towhidnejad	Embry-Riddle Aeronautical University, US
Guilherme Horta Travassos	Federal University of Rio de Janeiro, Brazil
Mary VanLeer	Arkansas Scholarship Lottery, US
Qing Wang	Institute of Software Chinese Academy of Sciences, China
Brian Wells	Raytheon, US

Rules for BKCASE Activities

1. Products generated by the authors, not the sponsor or partners
2. Even though the Department of Defense is the sponsor, it does not have any authority over the content of the products, nor are the products slanted towards defense systems development and acquisition
3. Volunteer authors do the bulk of the writing
4. Core Team from Stevens and Naval Postgraduate School provides stable labor and direction
5. Core Team responsible for final integration, technical editing, and clean up of products

Agenda

1. BKCASE background and objectives
2. ***Systems Engineering Body of Knowledge status and plans***
3. Graduate Reference Curriculum on Systems Engineering status and plans
4. Questions

SEBoK 0.25 Table of Contents

1. Introduction
2. System Concepts and Systems Thinking
3. SE Overview
4. Generic Life Cycle Stages
5. Service SE
6. Enterprise SE
7. Enabling SE in the Organization
8. SE Management
9. System Definition
10. System Realization Fundamentals
11. System Deployment and Use
12. System Life Management
13. SE Agreement
14. Cross-Cutting Knowledge
15. SE Competencies
16. SE Applications/Case Studies
17. References
18. Glossary

State of SEBoK 0.25

1. Version 0.25 released for limited review on September 15, 2010
   - 0.25 is prototype; 0.5 for early adopters; 1.0 for everyone
2. 656 pages long, 15 out of 16 chapters drafted, lots of very good material – more than expected at this point
3. Uneven maturity, too aerospace/defense, too process-oriented
4. More than 200 reviewers signed up – hoping for > 1000 comments – direction, topics, style, references, …
5. Reviews due December 15, 2010
6. All review comments will be adjudicated and adjudication published

State of SEBoK 0.25

7. Case studies planned for early 2011 – domain-dependent material
8. Pointers to more than 700 books, articles, and websites divided into two broad categories: primary references and additional references/ readings.
9. Primary references are for anyone who wants to understand the most important information the chapter covers.
10. Additional references/ readings are noteworthy contributions or specialized writings that would selectively be of interest to readers.

Review Questions

1. Is stated purpose of the SEBoK correct?
2. Is intended audience of the SEBoK correct?
3. Is scope of the SEBoK correct; i.e., does SEBoK cover the right topics?
4. How would you improve the writing about any specific topic? Did we leave off an important concept or discuss a concept poorly?

Review Questions

5. Did we properly identify all the primary references for a topic? The additional references and readings? Are there references or readings missing? If so, please identify them.

6. Did we properly identify all the correct glossary terms? Were important terms left out or are the definitions incorrect or incomplete?

7. How well does the SEBoK currently satisfy its stated purpose?

8. The BKCASE Team plans to convert the SEBoK into a wiki-based format. What are the considerations for this format? What capabilities should be expected from this structure?

Agenda

1. BKCASE background and objectives
2. Systems Engineering Body of Knowledge status and plans
3. ***Graduate Reference Curriculum on Systems Engineering status and plans***
4. Questions

GRCSE Value Proposition

1. There is no authoritative source to guide universities in establishing the outcomes graduating students should achieve with a master's degree in SE, nor guidance on reasonable entrance expectations, curriculum architecture, or curriculum content.

2. This gap in guidance creates unnecessary inconsistency in student proficiency at graduation, makes it harder for students to select where to attend, and makes it harder for employers to evaluate prospective new graduates.

3. GRCSE will fill that gap, becoming the "go to" reference to develop, modify, and evaluate graduate programs in SE.

GRCSE is being created analogously to GSwE2009 – in fact, using GSwE2009 as the starting text

Version 0.25 expected on December 17, 2010

GRCSE 0.25 Draft Contents

Title - Chapters
1. Introduction
2. Guidance for the construction and maintenance of GRCSE
3. Expected objectives when a graduate has 3-5 years' experience
4. Expected outcomes when a student graduates
5. Expected student background when entering master's program
6. Curriculum architecture
7. Core body of knowledge (CorBOK)
8. Assessment
9. Anticipated GRCSE evolution

Title - Appendices
App A. Summary of Graduate SE-centric SE programs in 2010
App B. Bloom's taxonomy of educational objectives
App C. Systems engineering competency frameworks
App D. Assessment and learning outcomes
References
Glossary
Index

Early Draft Decisions /Challenges

Challenge	Early Decision for GRCSE 0.25
Should GRCSE scope include Domain-Centric SE programs or just Systems-Centric programs?	Systems-Centric only
How much experience should be expected of program entrants?	At least 2 years of practical experience in some aspect of SE
Focus on traditional product SE or on services and enterprise SE as well?	All 3 – product, services, and enterprise SE
One set of outcomes and objectives or several sets, reflecting the range of SE educational practice?	One set

Decisions will be revisited for GRCSE 0.5

Early Draft Decisions /Challenges

Challenge	Early Decision for GRCSE 0.25
Expect an undergraduate degree in engineering, physical science, or mathematics?	Yes
Program be ABET accreditable or accommodate a range of program focuses	?
How much content should be standardized?	No more than 50%
Learn SE abstractly or in the context of an application domain	In context of application domain

Decisions will be revisited for GRCSE 0.5

If We Are Successful…

SEBoK will strongly influence the INCOSE SE Handbook Version 4, the INCOSE SE Professional Certification Program, DoD SE competency efforts, will highlight places where research is needed, become a standard reference for practitioners, and improve the quality and richness of communication among systems engineers worldwide.

GRCSE will clearly distinguish between graduate and undergraduate education in SE and influence the content of both undergraduate and graduate SE programs worldwide.

BKCASE™

Interested in helping? We need reviewers, subject matter experts, and a few more authors

www.BKCASE.org

bkcase@stevens.edu

Version 0.25 available December 17, 2010 - prototype
Version 0.5 available December 2011 – early adopters
Version 1.0 available December 2012 – general use

Agenda

1. BKCASE background and objectives
2. Systems Engineering Body of Knowledge status and plans
3. Graduate Reference Curriculum on Systems Engineering status and plans
4. ***Questions***

NDIA 10853 Panel: In search of the Principles of SE (BKCASE)

Rick Adcock, Cranfield University

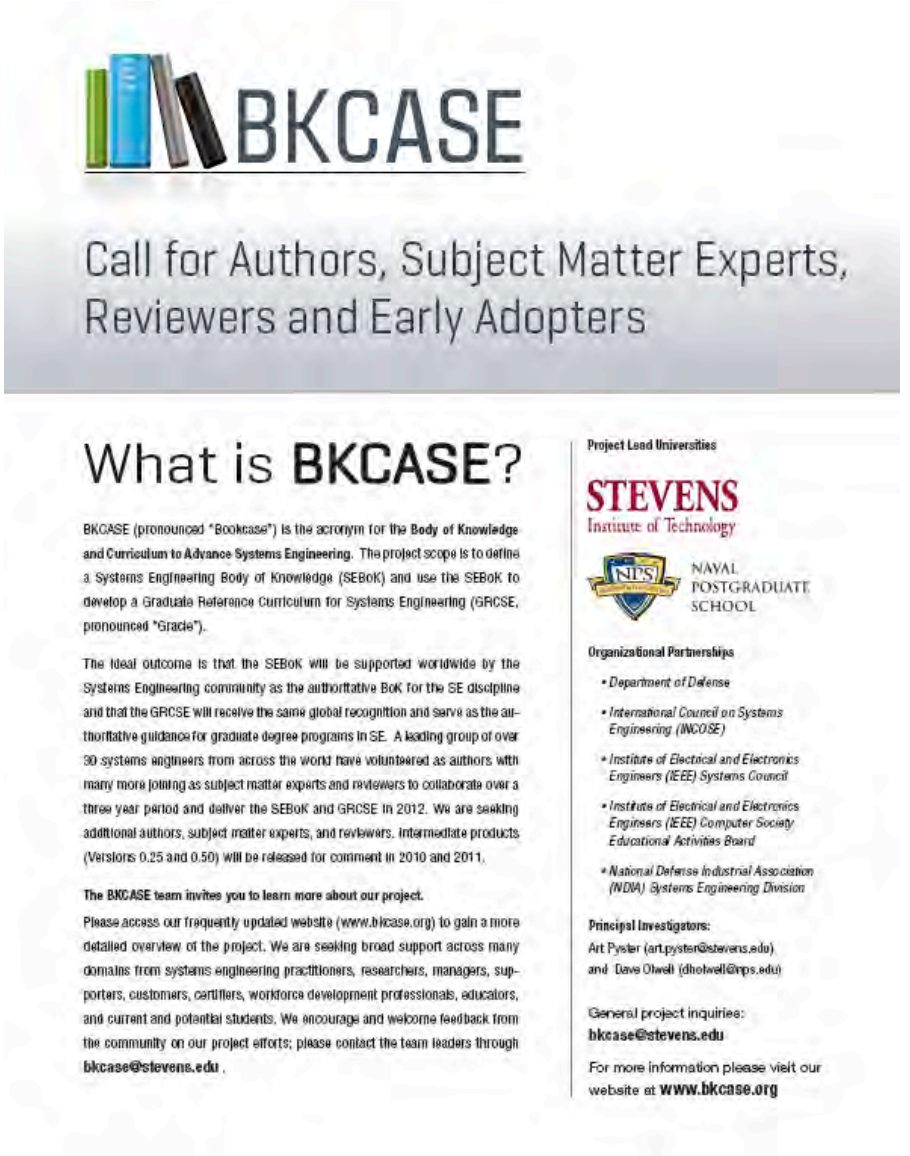
Head of SE Defence Academy of the UK

Panel

- Rick Adcock
- Art Pyster
- Don Gelosh
- Rich Freeman
- Barry Boehm

What is BKCASE?

- Project led by Stevens Institute of Technology and Naval Postgraduate School who are creating two primary products:
  - Body of Knowledge in systems engineering (SEBoK)
  - Graduate Reference Curriculum in Systems Engineering (GRCSE)
- Started in September 2009 and will run through 2012
- Intended for world-wide use
- Not intended to be used directly for accreditation



BKCASE

Call for Authors, Subject Matter Experts, Reviewers and Early Adopters

What is **BKCASE**?

BKCASE (pronounced "Bookcase") is the acronym for the **Body of Knowledge and Curriculum to Advance Systems Engineering**. The project scope is to define a Systems Engineering Body of Knowledge (SEBoK) and use the SEBoK to develop a Graduate Reference Curriculum for Systems Engineering (GRCSE, pronounced "Gracie").

The ideal outcome is that the SEBoK will be supported worldwide by the Systems Engineering community as the authoritative BoK for the SE discipline and that the GRCSE will receive the same global recognition and serve as the authoritative guidance for graduate degree programs in SE. A leading group of over 30 systems engineers from across the world have volunteered as authors with many more joining as subject matter experts and reviewers to collaborate over a three year period and deliver the SEBoK and GRCSE in 2012. We are seeking additional authors, subject matter experts, and reviewers. Intermediate products (Versions 0.25 and 0.50) will be released for comment in 2010 and 2011.

The BKCASE team invites you to learn more about our project.

Please access our frequently updated website (www.bkcase.org) to gain a more detailed overview of the project. We are seeking broad support across many domains from systems engineering practitioners, researchers, managers, supporters, customers, certifiers, workforce development professionals, educators, and current and potential students. We encourage and welcome feedback from the community on our project efforts; please contact the team leaders through **bkcase@stevens.edu** .

Project Lead Universities

STEVENS Institute of Technology

NPS NAVAL POSTGRADUATE SCHOOL

Organizational Partnerships

- *Department of Defense*
- *International Council on Systems Engineering (INCOSE)*
- *Institute of Electrical and Electronics Engineers (IEEE) Systems Council*
- *Institute of Electrical and Electronics Engineers (IEEE) Computer Society Educational Activities Board*
- *National Defense Industrial Association (NDIA) Systems Engineering Division*

Principal Investigators:
Art Pyster (art.pyster@stevens.edu)
and Dave Olwell (dholwell@nps.edu)

General project inquiries:
bkcase@stevens.edu

For more information please visit our website at **www.bkcase.org**

BKCASE Vision and Objectives

Vision

"Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE."

Objectives

1. Create a SEBoK that is globally recognized by the SE community as the authoritative BoK for the SE discipline.
2. Create a graduate reference curriculum for SE (GRCSE – pronounced "Gracie") that is globally recognized by the SE community as the authoritative guidance for graduate programs in SE.
3. Facilitate the global alignment of related workforce development initiatives with SEBoK and GRCSE.
4. Transfer stewardship of SE BoK and GRCSE to INCOSE and the IEEE after BKCASE publishes version 1.0 of those products, including possible integration into their certification, accreditation, and other workforce development and education initiatives.

Agenda

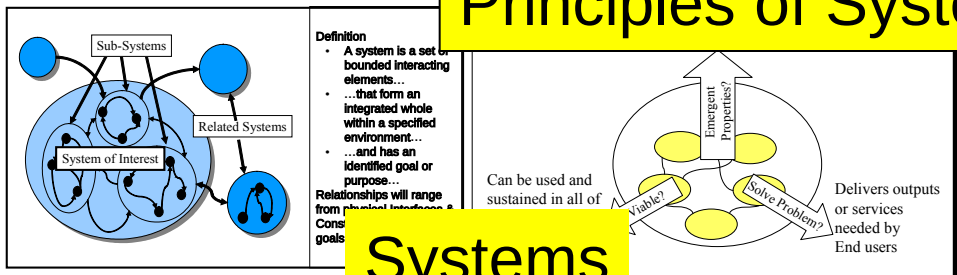
- Questions:
  - Why should DoD (and other nations) be interested in a Systems Engineering BoK?
  - What is the value of Systems Engineering in Defense?
  - How does Systems Engineering relate to other disciplines it?
  - What Systems Engineering skills do we need to make this happen?

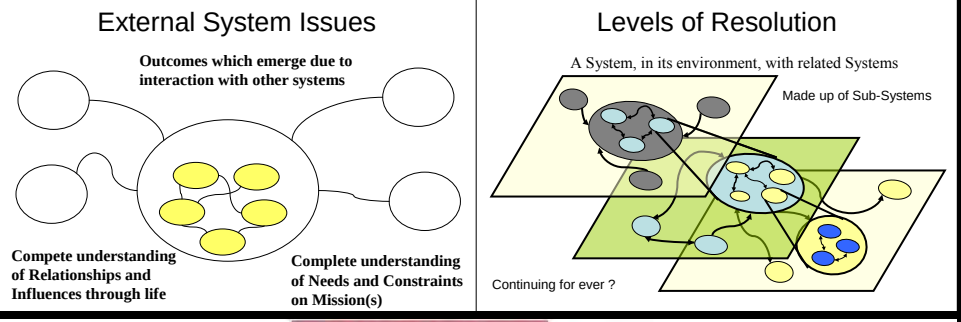
Principles

- What does it mean to apply Engineering to a system?
- Two definitions of Engineering:
  - The application of scientific knowledge to practical problems, or the creation of useful things.
  - To (cleverly) arrange for something to happen.
- Systems Engineering is traditionally associated with the first of these, as applied to Product Development
- We may also need to consider the second when we look at the wider application of Systems Engineering to Enterprise Success.

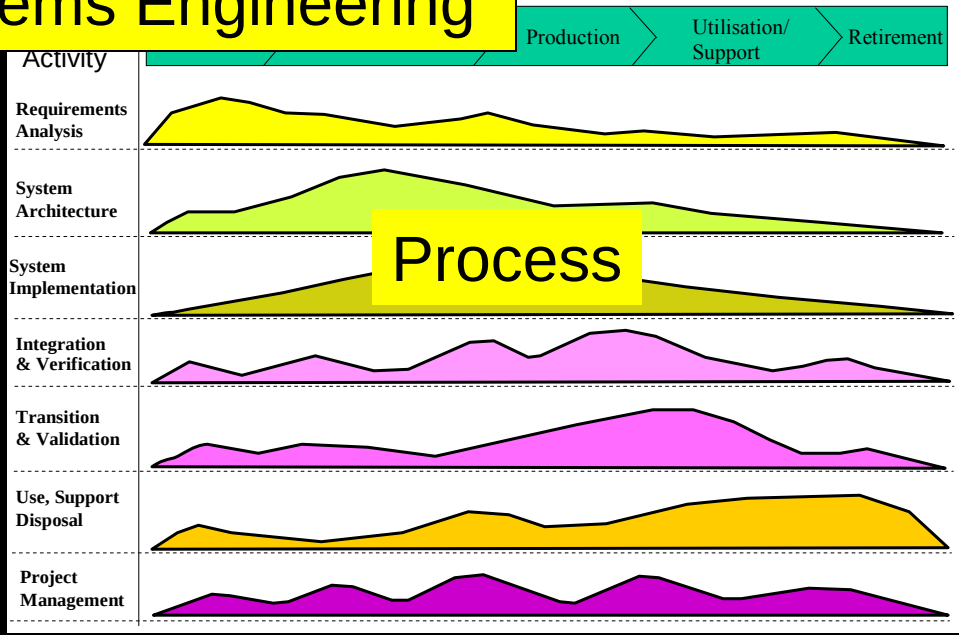
Principles of Systems Engineering

Systems

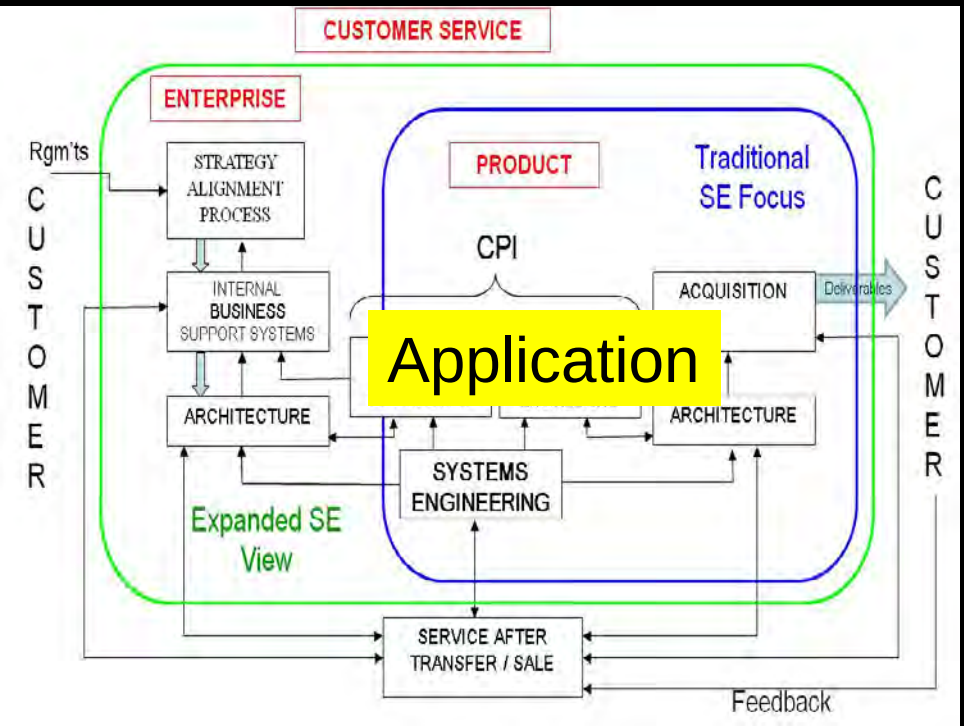




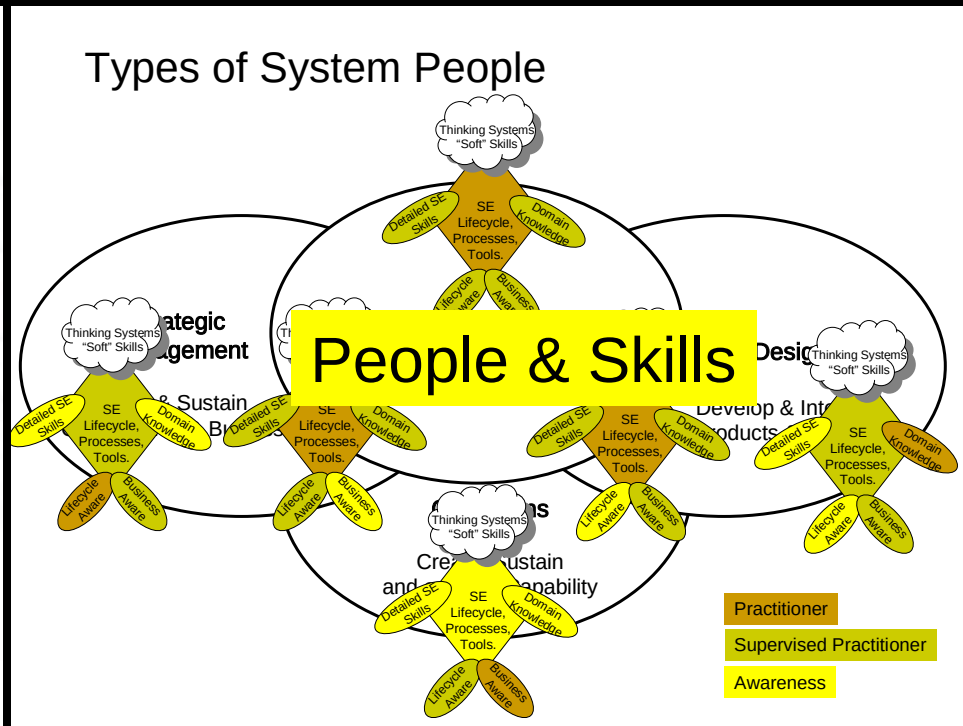
Process



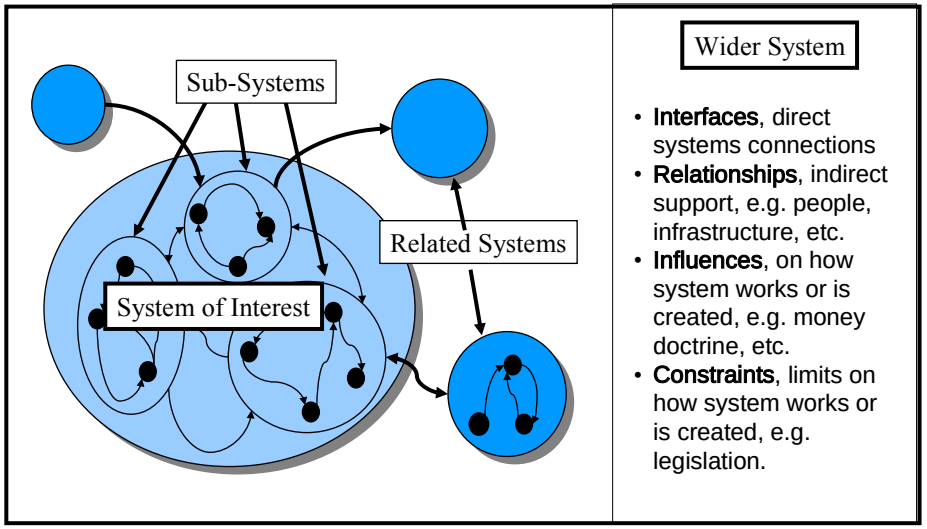
Application



People & Skills



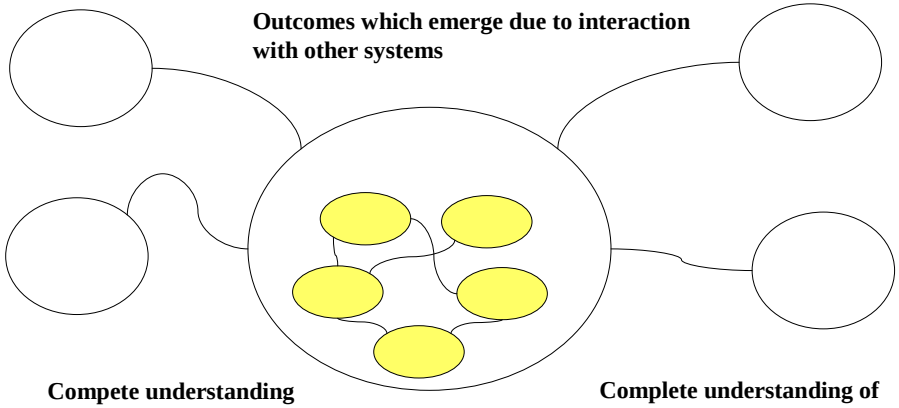
System



Wider System

- **Interfaces**, direct systems connections
- **Relationships**, indirect support, e.g. people, infrastructure, etc.
- **Influences**, on how system works or is created, e.g. money doctrine, etc.
- **Constraints**, limits on how system works or is created, e.g. legislation.

External System Issues



Outcomes which emerge due to interaction with other systems

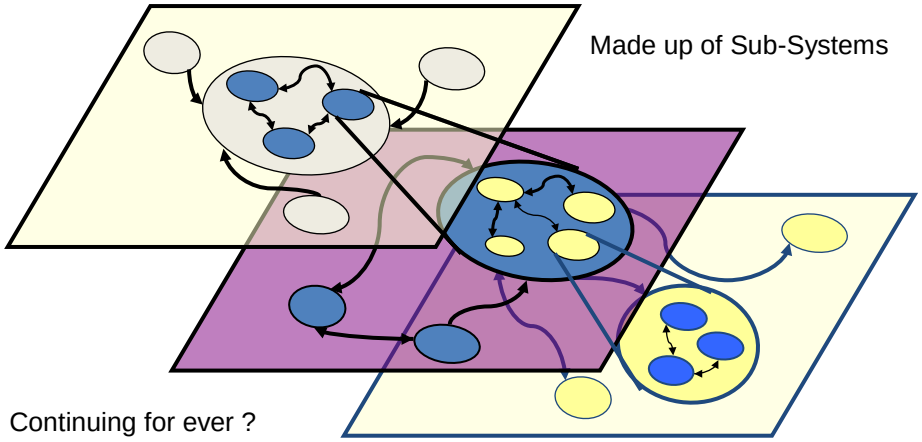
Compete understanding of Relationships and Influences on Life

Complete understanding of Needs and Constraints on Mission

Levels of Resolution

A System, in its environment, with related Systems

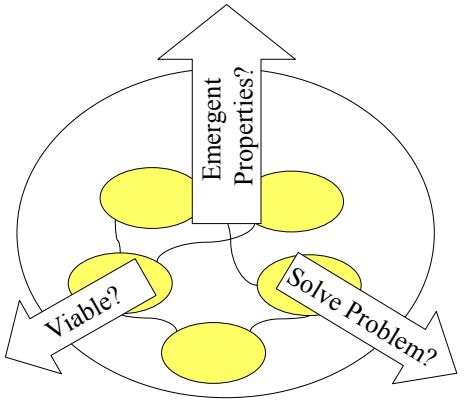
Made up of Sub-Systems



Continuing for ever ?

Internal System Issues

Properties of the whole which emerge due to interaction between elements



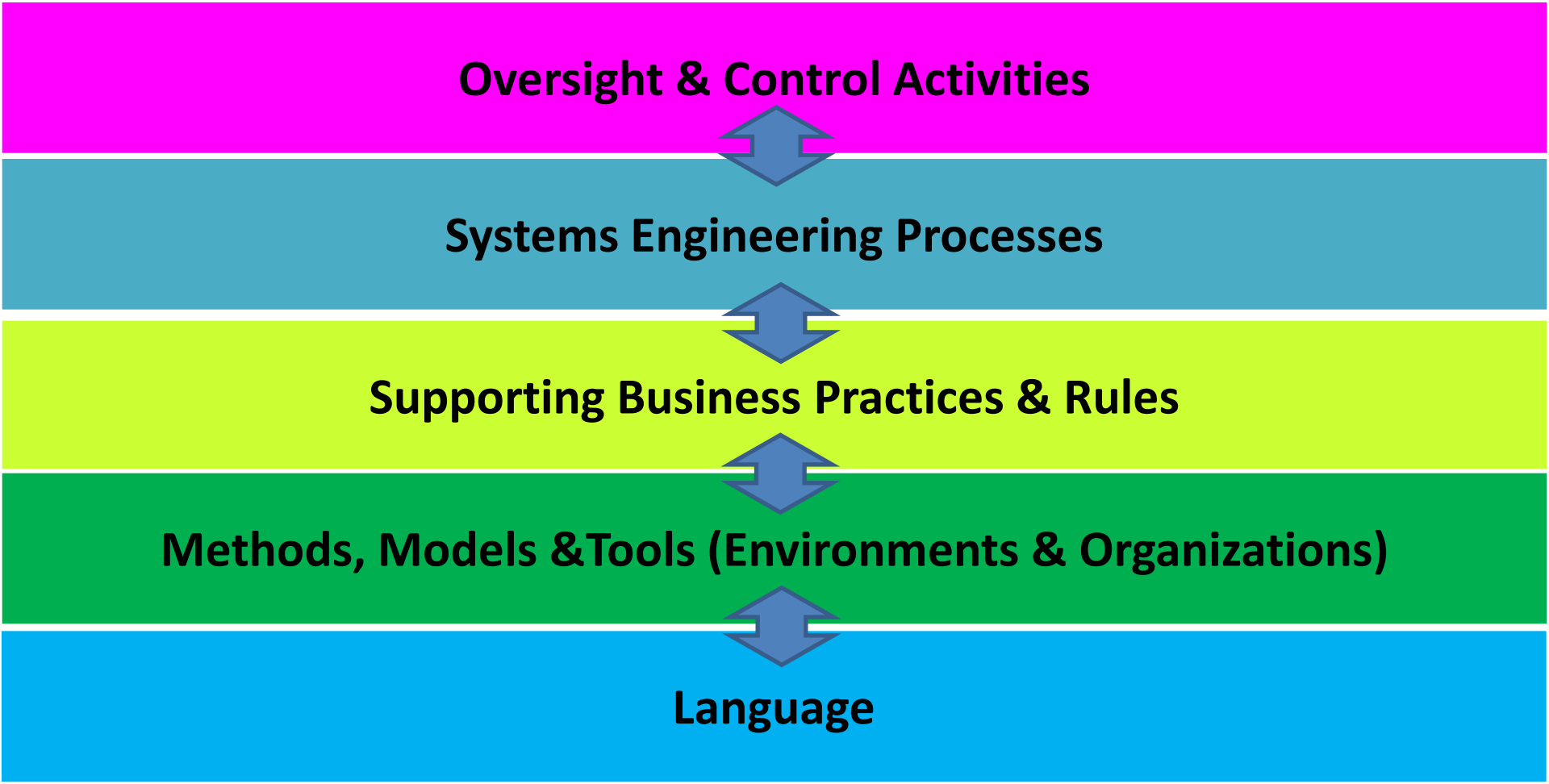
Can be used and sustained in all of its potential environments, through its life

Delivers outputs or services needed by End users

Systems Approach

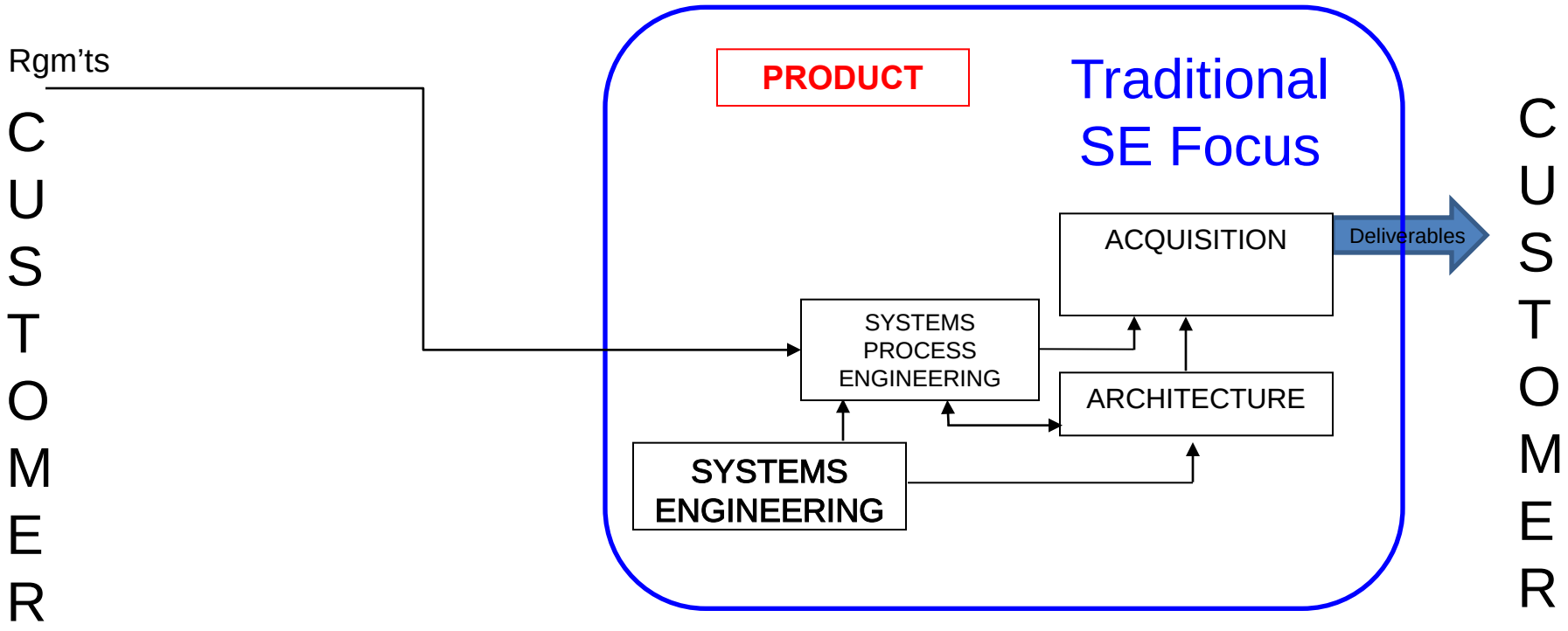
- Taking a systems approach to engineering expands the scope of scientific knowledge to include systems science or systems thinking.
- This approach will seek to
  - define problems, constraints and measures of success outside the boundary of a system of interest and
  - select and combine system elements and relationships inside the boundary in the context of wider system view.
  - It is fundamental to this view of engineering that it is both iterative and recursive in nature.
    - It includes iterative cycling between problem understanding in a wider system context, solution creation within a bounded context and solution insertion and use back in the wider context.
    - We can recursively use this system of interest, wider context approach to tackle problems at several levels of abstraction to deliver solutions to real world problems.
  - To do this we will need ways of assess and dealing with the different properties which arise from combinations of system elements at a number of levels of abstraction.

Layered Framework



Systems Engineering

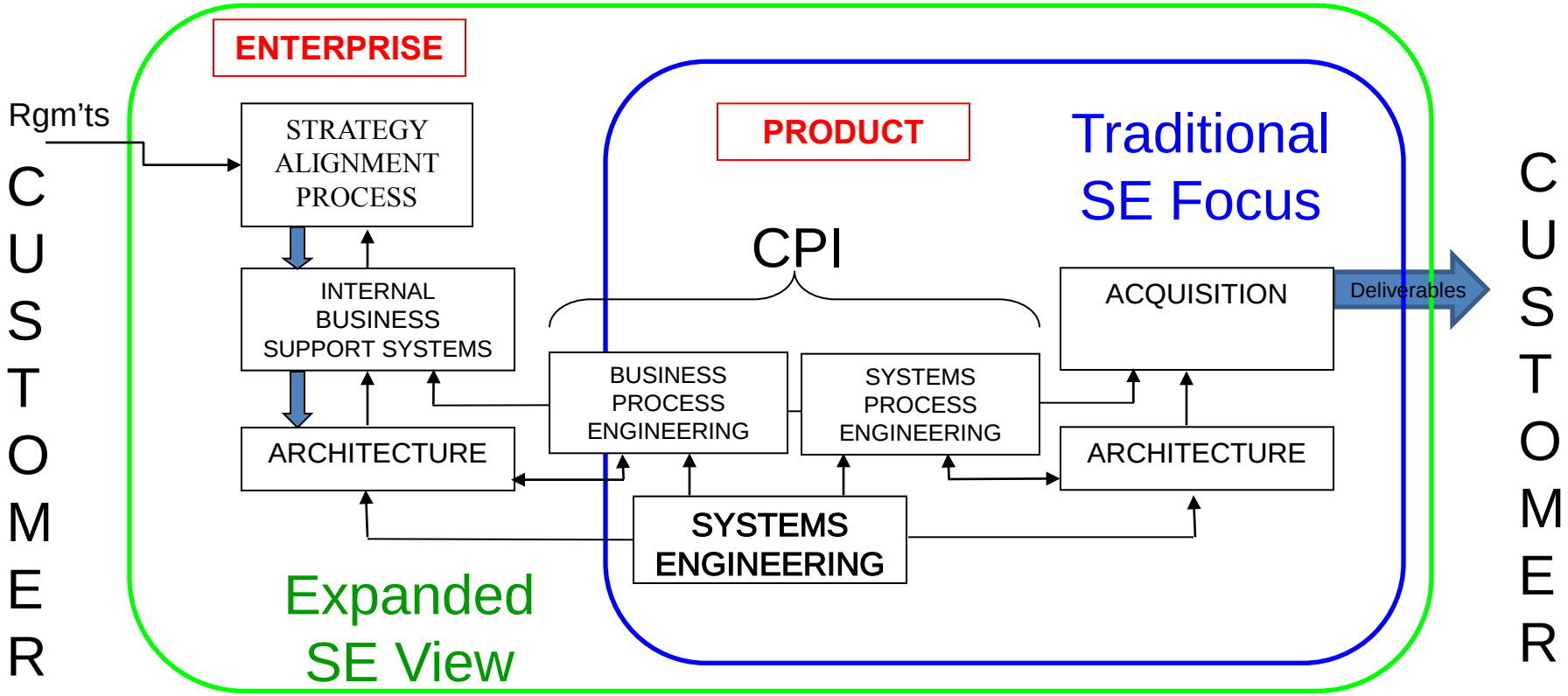
Product, Enterprise & Customer Service View Model



Integrated Systems Engineering: Looking Beyond Traditional Realms

Systems Engineering

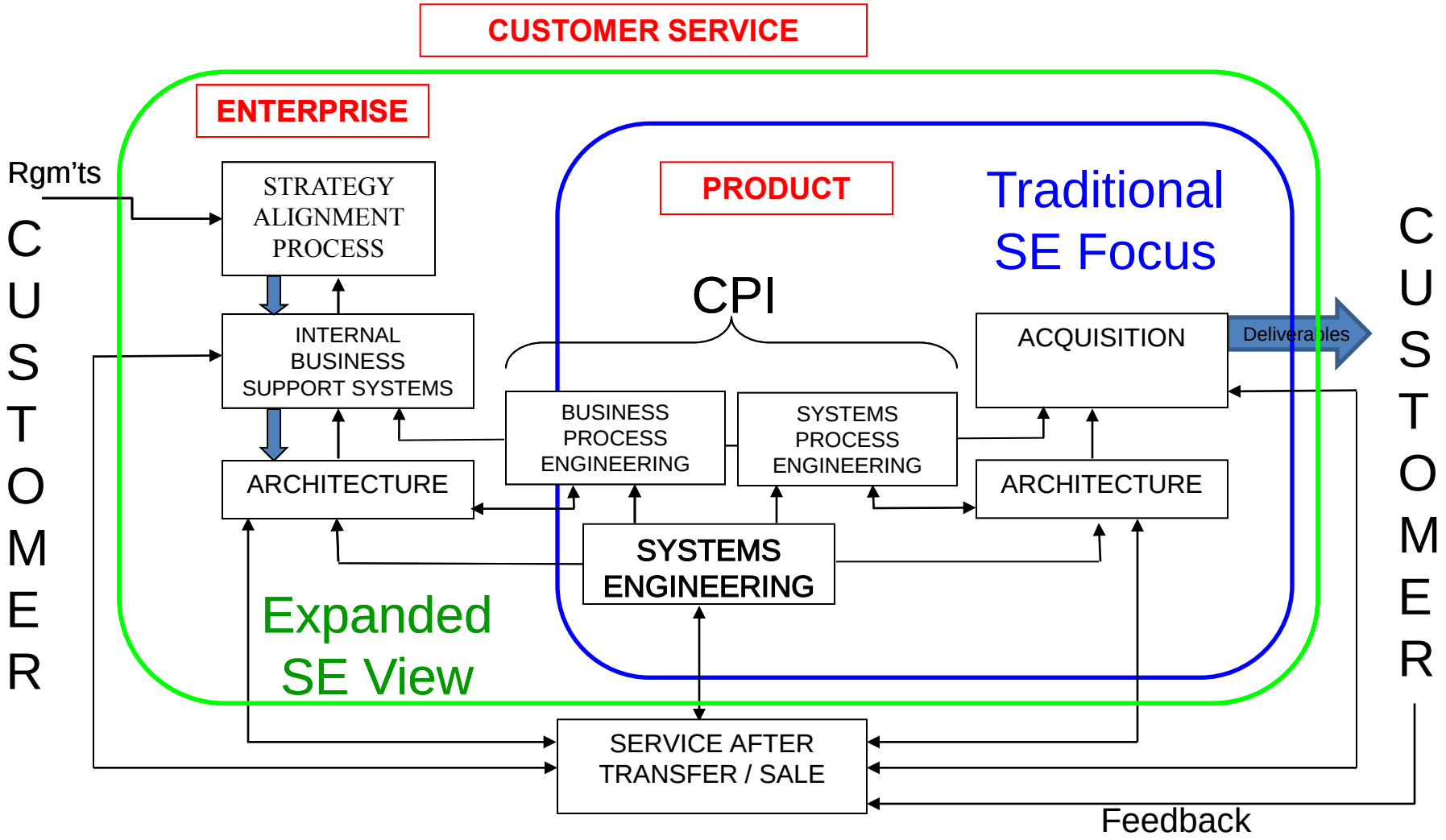
Product, Enterprise & Customer Service View Model



Integrated Systems Engineering: Looking Beyond Traditional Realms

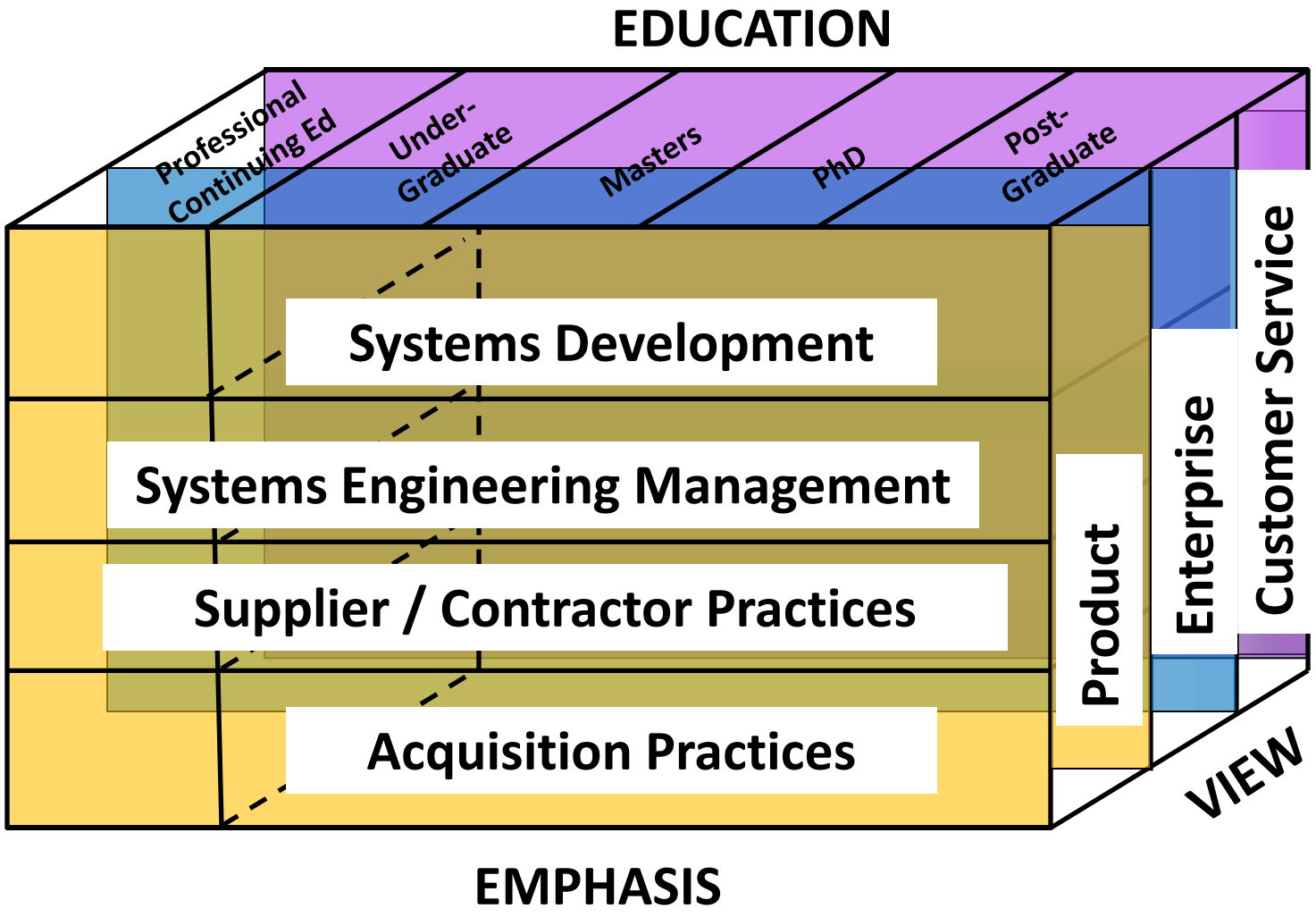
Systems Engineering

Product, Enterprise & Customer Service View Model

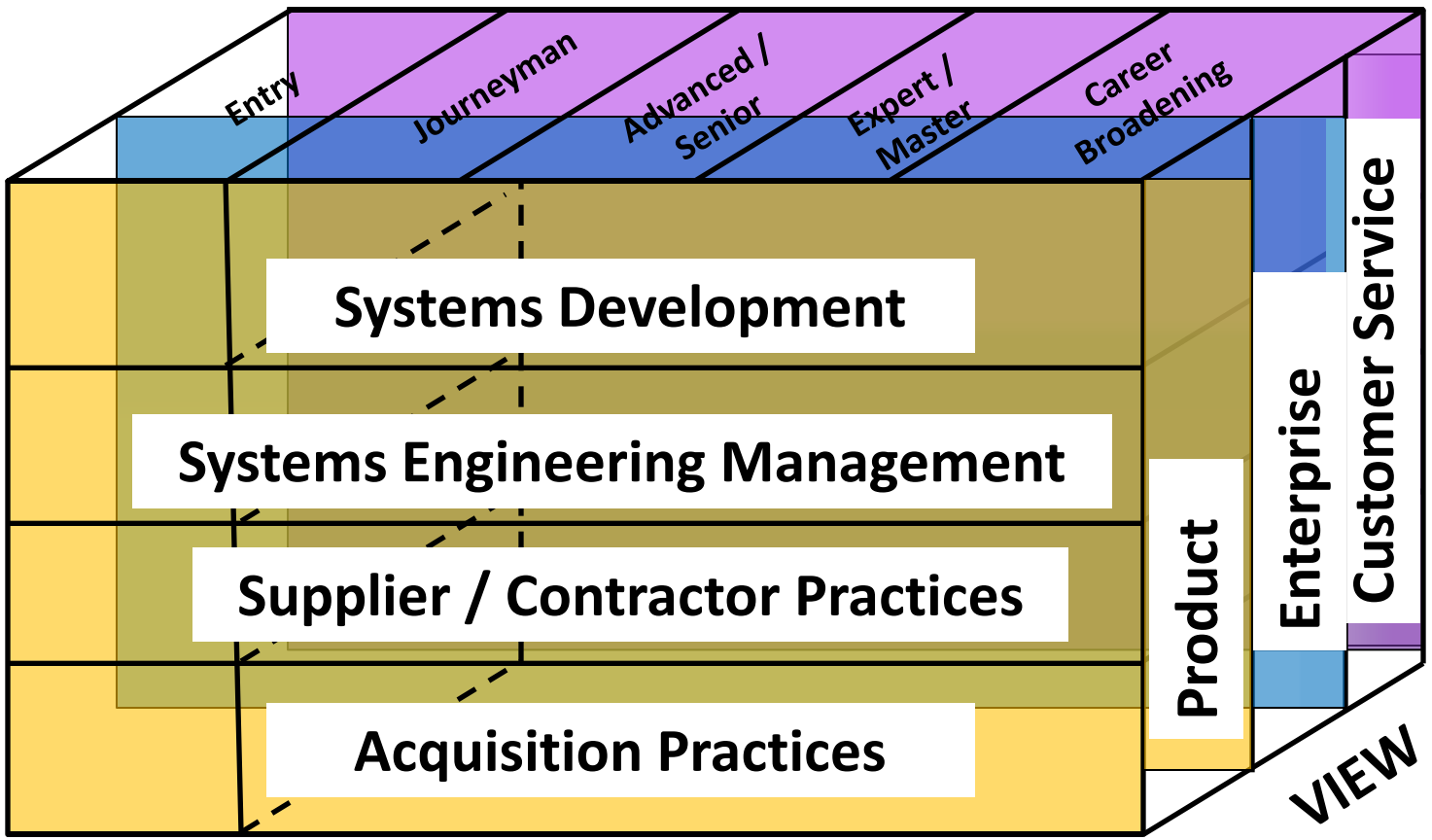


Integrated Systems Engineering: Looking Beyond Traditional Realms

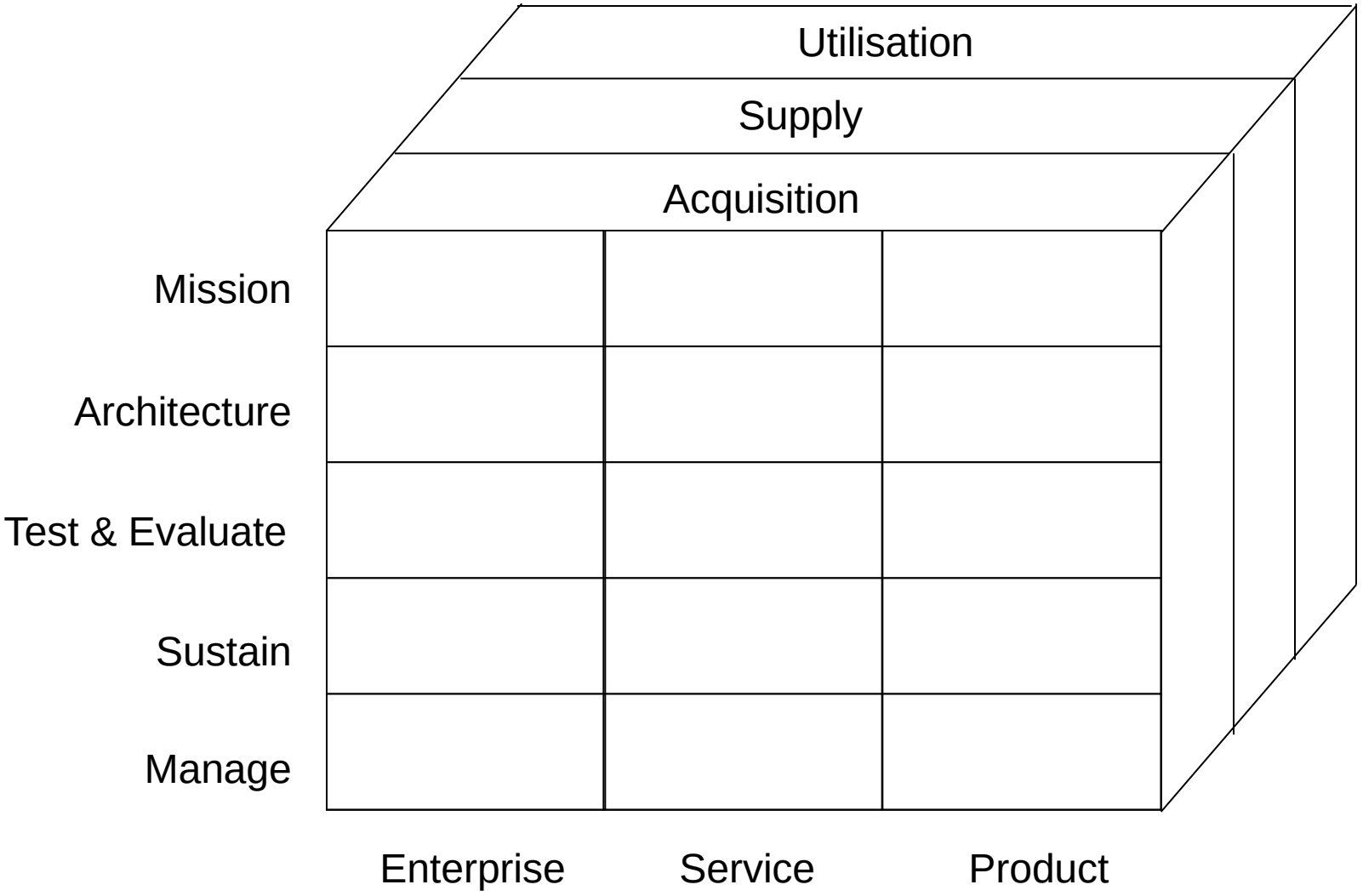
Competency Requirements Reference Cube



Competency Requirements Reference Cube

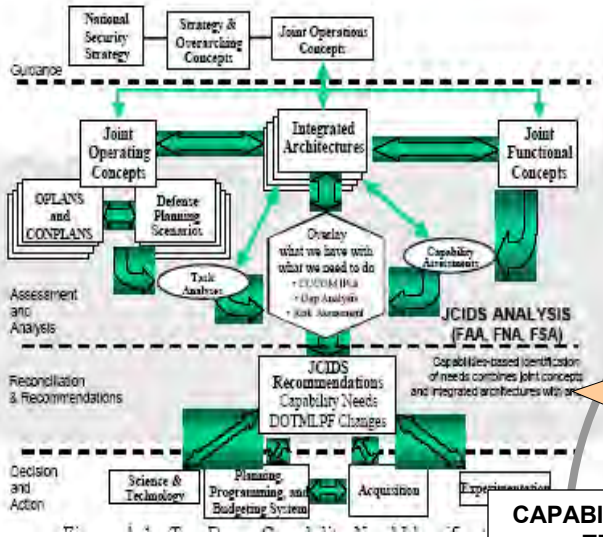


Systems Engineering Roles



Systematic Approach for Warfighting Capability

JCIDS



On-Going Operations

- Combatant Commands IPLs
- Operational Lessons
- Operational Need Statements

MROC PROCESS

FORCE CAPABILITY DEVELOPMENT

CAPABILITY FIELDING & TRANSITION

Expeditionary Force Development System (JCAID PNT FWD)

DOTMLPF REQUIREMENTS

PRIORITIZATION & RESOURCING

User Needs & Technology Opportunities

PPBES

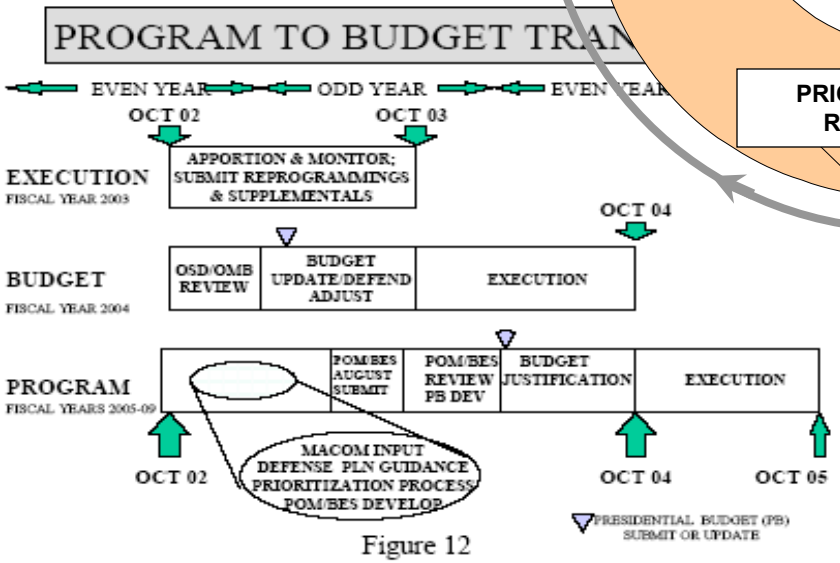
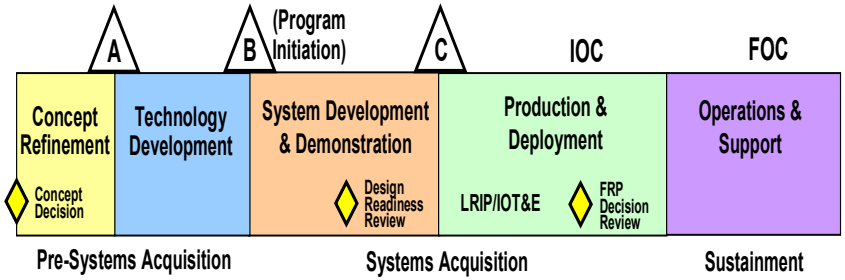


Figure 12

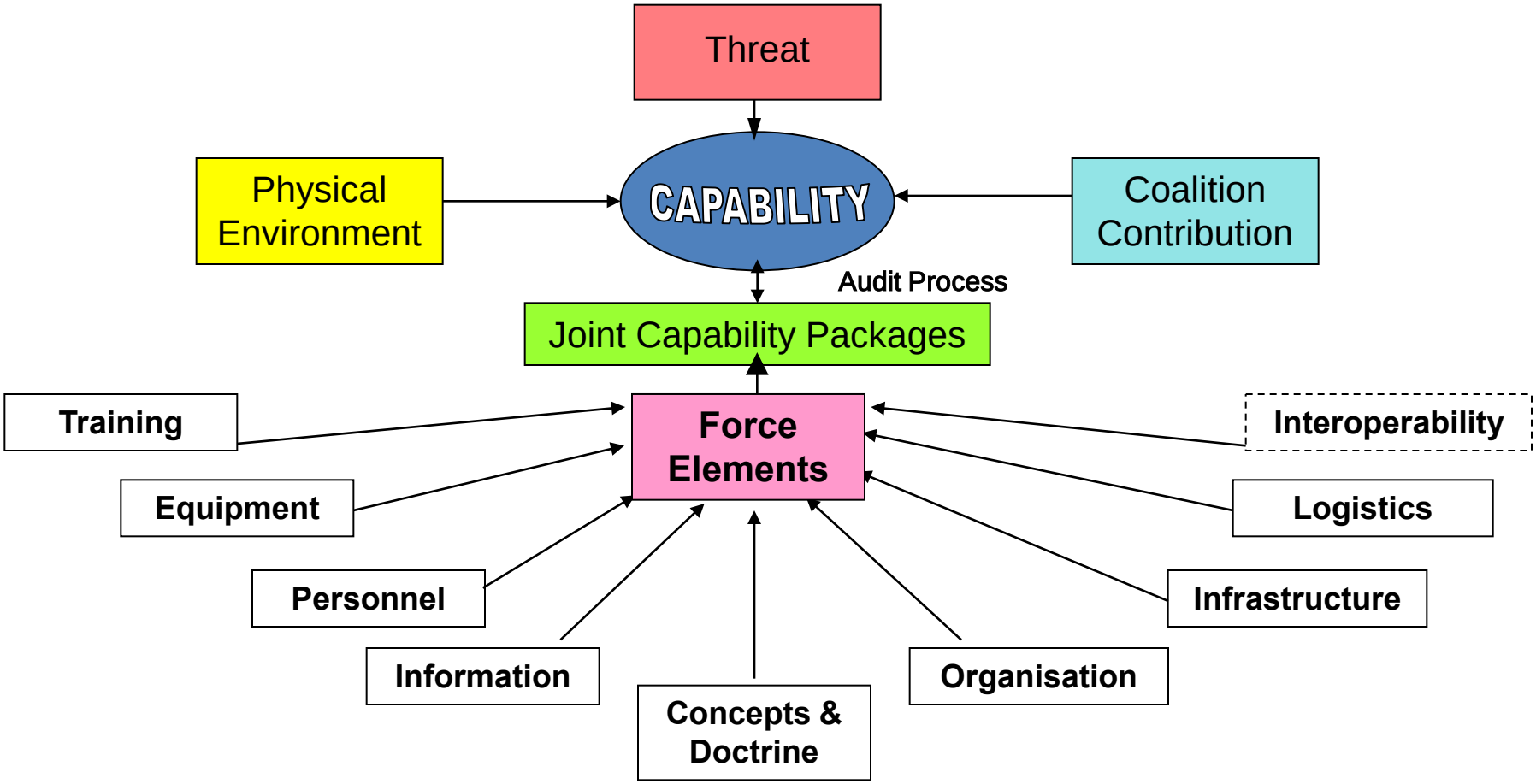
Acquisition

- *Process entry at Milestones A, B, or C*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*



Defence Capability

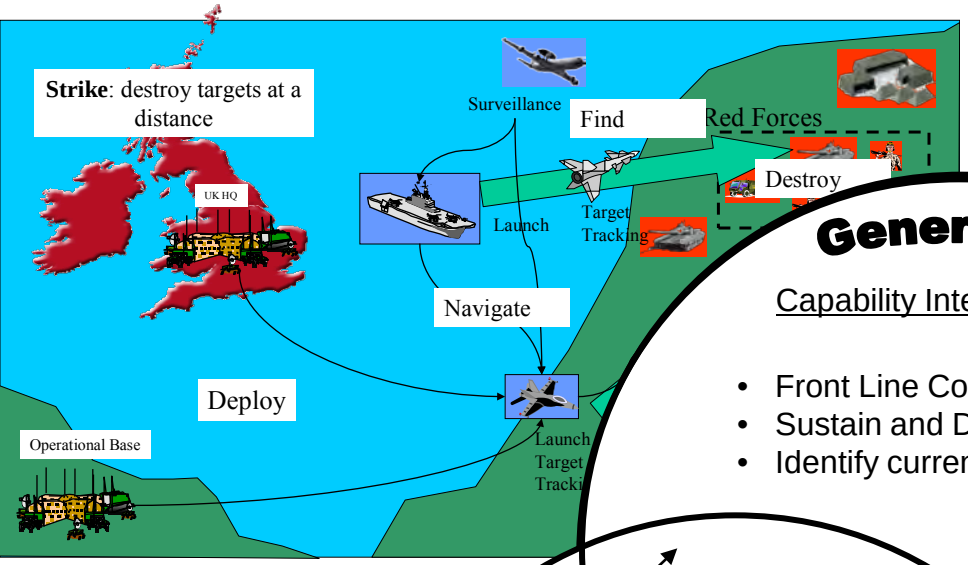
"The enduring ability to generate a desired operational outcome or effect, relative to the threat, environment and the contributions of coalition partners"



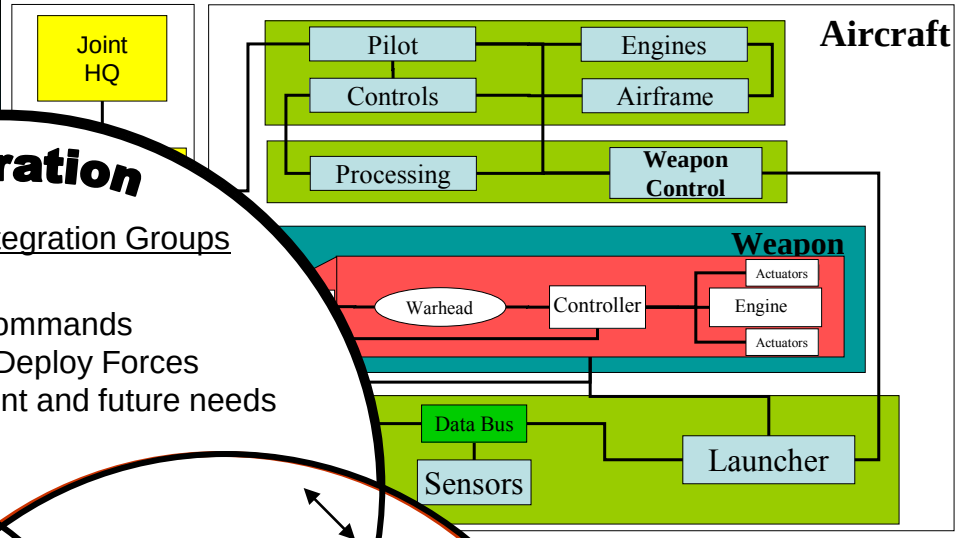
MOD Acquisition Operating Framework

© Crown Copyright 2009

Operational Scenarios



Operational Interfaces



Generation

Capability Integration Groups

- Front Line Commands
- Sustain and Deploy Forces
- Identify current and future needs

User feedback on Capability shortfalls and opportunities

Integration of new and/or changed capability

Capability Management

Sponsors Programmes
Owns Capability Requirements
Programme Initiation
Acceptance

Planning

Capability Planning Groups

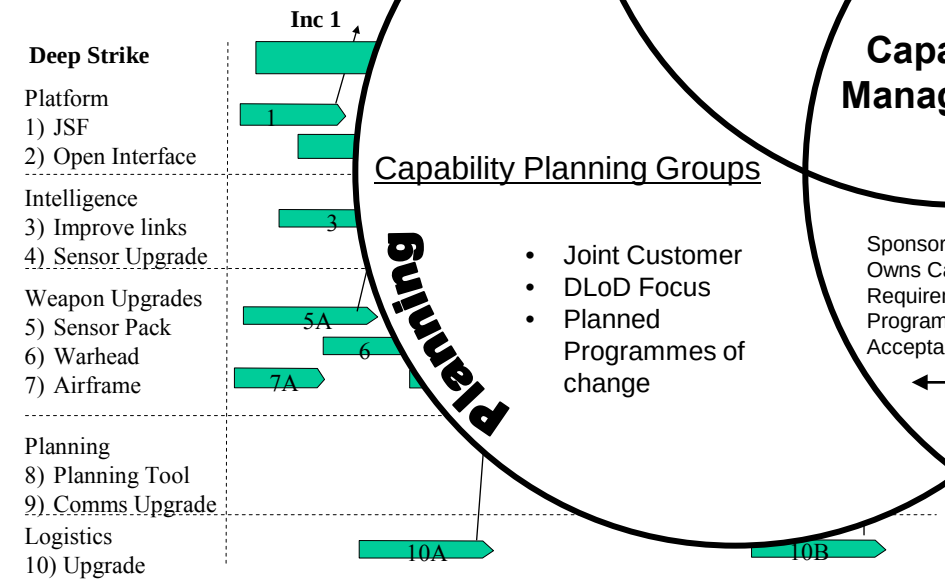
- Joint Customer
- DLoD Focus
- Planned Programmes of change

Delivery

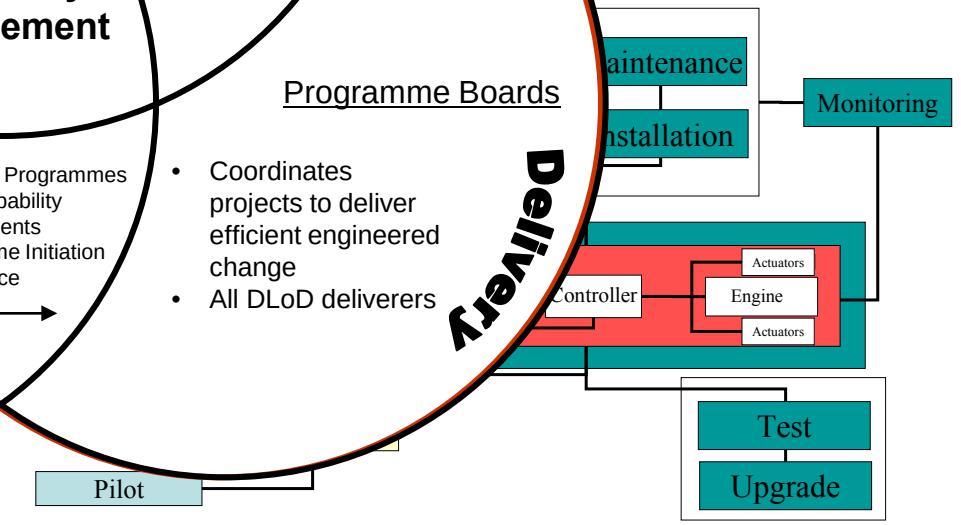
Programme Boards

- Coordinates projects to deliver efficient engineered change
- All DLoD deliverers

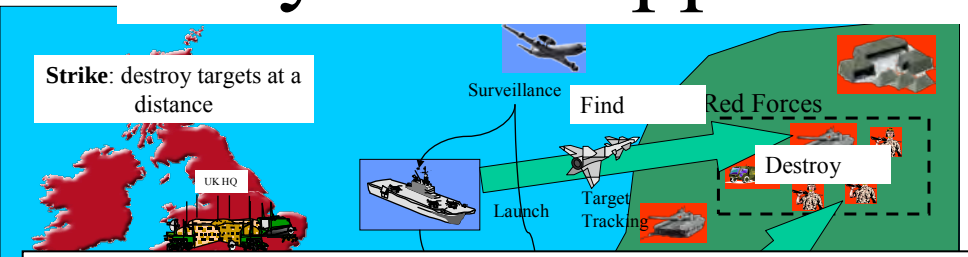
Deep Strike U

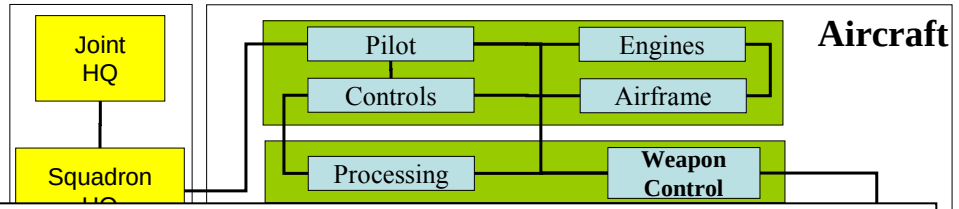


terfaces



A Systems Approach to Complex Problems





Strategic Management

Plan & Sustain
Organisation & Business

Systems Engineering

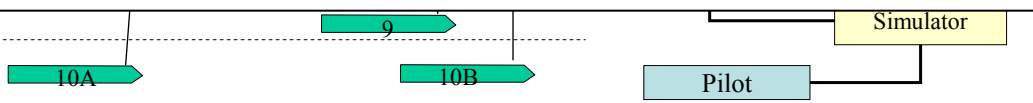
Design

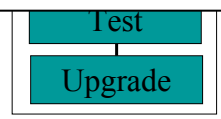
Develop & Integrate
Products & Services

Operations

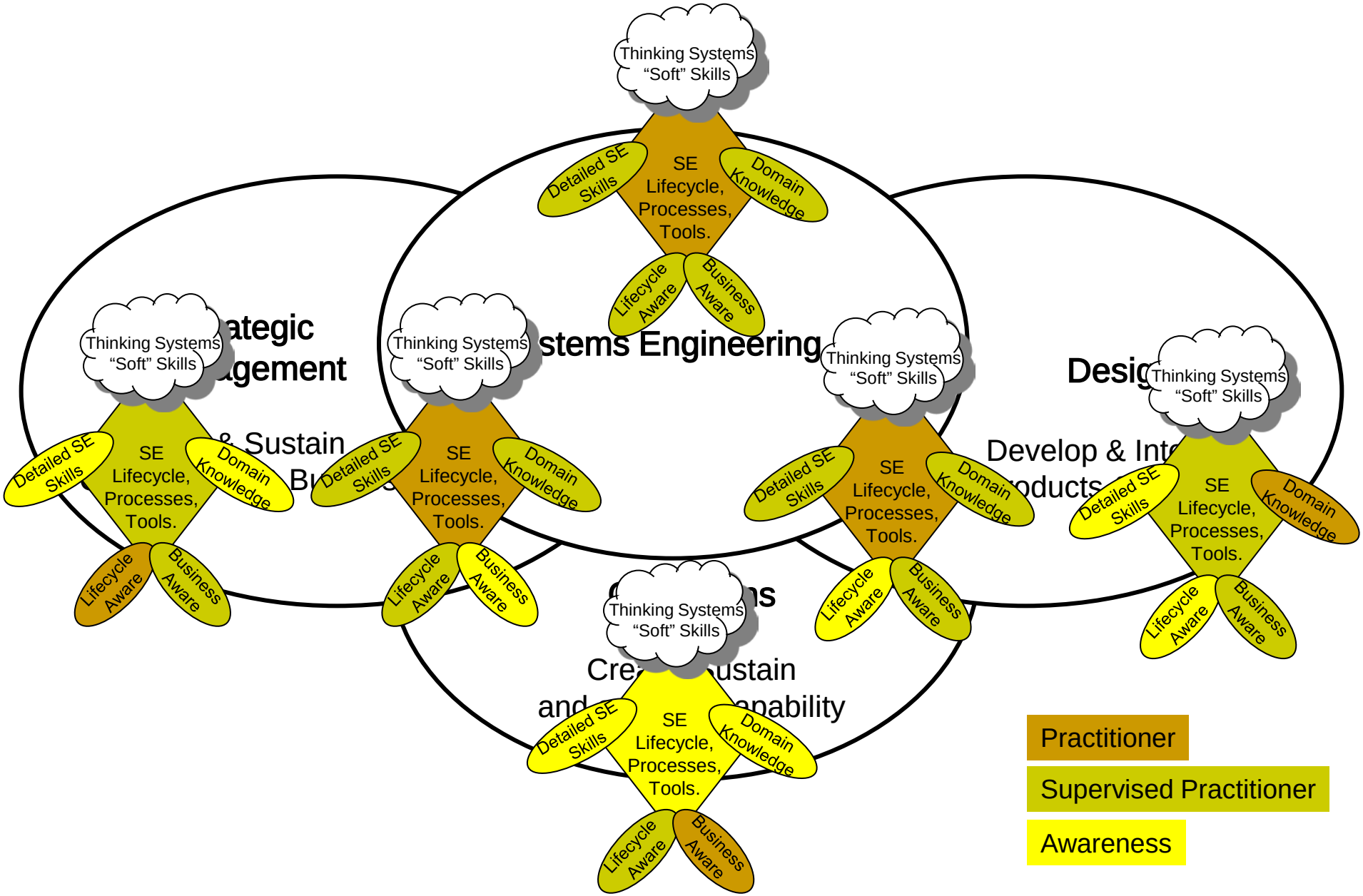
Create, Sustain
and execute Capability

9) Comms Upgrade
Logistics
10) Upgrade





Types of System People



Questions

- Questions through Chair please
- I will share questions around the panel
- If you stick to asking questions, we will try to giving concise answer

National Defense Industrial Association

Improving the Systems Engineering Workforce for the Department of Defense and Industry

NDIA Systems Engineering Division
Education & Training Committee Co-Chairs

Dr. Don Gelosh, CSEP-Acq
ODDR&E/Systems Engineering

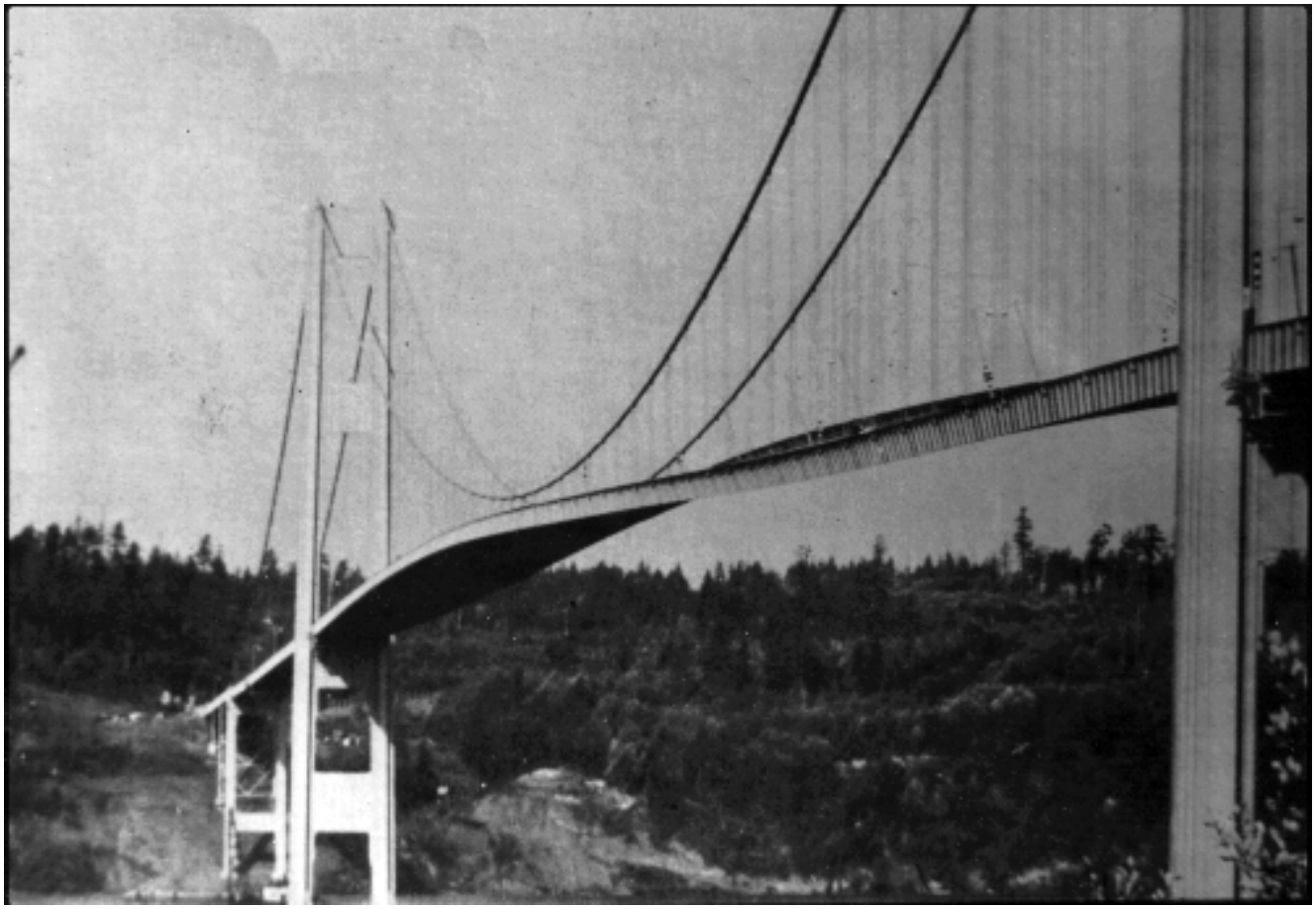
Dr. John R. Snoderly, D.P.A., CSEP
Defense Acquisition University

Mr. Doug Westphal
Scitor Corporation

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

National Defense Industrial Association

Avoiding Engineering Failures with Competent Systems Engineering



Tacoma Narrows Bridge Collapse, 7 November, 1940
Barney Elliott; The Camera Shop, Usable under fair-use principles only.

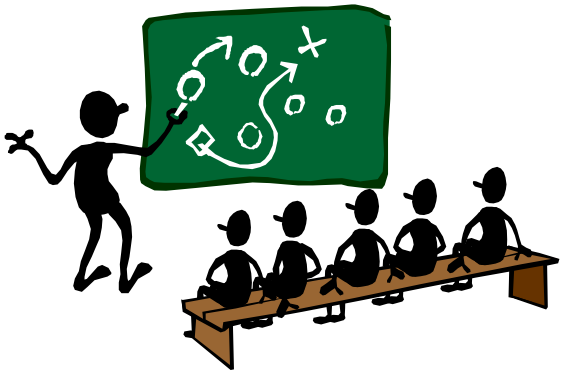
NDIA SE Division
Education and Training Committee

Objectives:

- Identify defense industrial base SE workforce challenges
- Explore how DoD policy and investments can aid in maintaining/growing critical capabilities
- Explore how we can attract, foster, and develop future DoD engineering leaders
- With the increased focus on government in-sourcing, explore how we can rapidly mature future program chief engineers

Approach

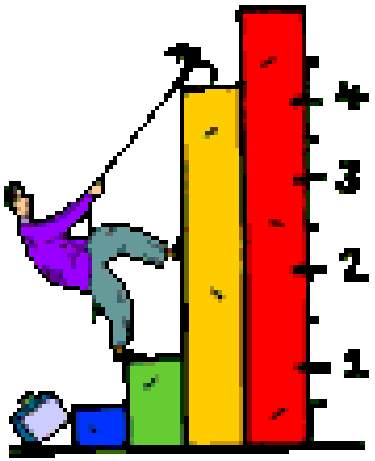
- Identified and analyzed the challenges
- Identified barriers to addressing challenges
- Identified enablers to addressing challenges
- Developed proposed solutions to leverage enablers and overcome barriers
- Formulated actionable recommendations



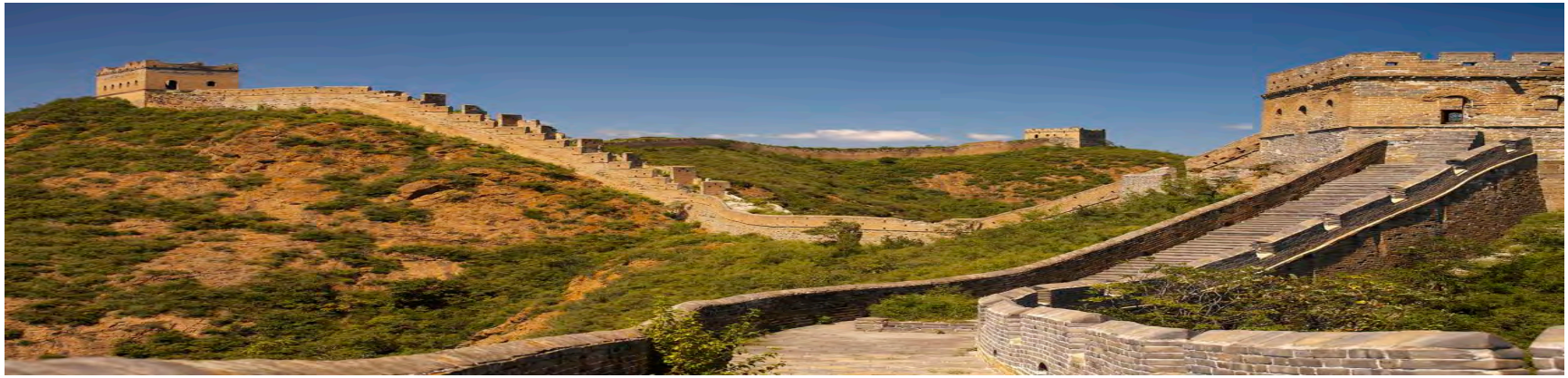
Workforce Challenges

How do we:

- Increase the number who enter the SE discipline?
- Identify the right mix of competencies and capabilities in the SE workforce?
- Increase the speed at which systems engineers mature?
- Increase the ability to deploy systems engineers more optimally within organizations?
- Attract and retain high caliber engineering leaders?



Barriers



Both Government and Industry:

- Children in the U.S. do not find STEM exciting
- Movement of people between government and industry is inhibited by conflict of interest rules
- In most organizations, pay and benefits encourage systems engineers to become program managers
- No agreement on the right amount of breadth vs. depth within a domain
- No agreement on the right amount of domain-specific vs. generic systems engineering
- Presumption that systems engineers are grown through “scar tissue” which can only be acquired through many years of experience

Barriers (Continued)

Both Government and Industry:

- Rotational assignments are hard to achieve in some cultures
- Scarce funding and overhead to support training
- Scarce availability of subject matter experts to support as trainers and mentors
- Managers tend to hold on to their best people

Government Only:

- Pay and benefits within government are not generally as attractive as those in industry
- Long hiring process

Enablers

- Many federal, state, local government, industry's active STEM investments and efforts
- Virtual technologies and approaches such as Webinars, on-line education, social/collaboration networks
- The Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE), which will establish an international guide to the body of knowledge for the SE field and a graduate reference curriculum for SE
- The International Council on Systems Engineering (INCOSE) professional certification program for systems engineers
- Joint industry/government training
- Making it easier to move between the government and industry without introducing any conflict of interests issues
- Moving work without moving people

Committee Proposed Solutions

- Leverage and integrate the use of remote technology to educate or collaborate
- Develop Joint Case studies and make them available to both government and industry
- Leverage BKCASE effort and SE Competency Frameworks
- Invest in gaming and other virtual technologies to rapidly simulate experiences
- Leverage IRAD/research projects to the greatest extent possible
- Promote application of SE in the sustainment of existing systems
- Establish rotational assignments within existing programs
- Establish rotational assignments with adjacent sectors, e.g. air traffic control, homeland security, and the census
- Establish policy on how to enable systems engineer exchanges between government and industry

Example Industry Solutions

General Electric Aviation

F414-GE-400 engine (U.S. Navy photo by Mass Communication Specialist Seaman Stephen W. Rowe/Released)

- Select proven engineering colleges & universities programs
- Recruit interns/co-ops only from programs
- Hire entry level engineers only from best of available interns/co-ops
- Run through company training programs
- Edison Engineering Development Program
  - Two year entry-level program consisting of at least three rotation assignments
  - Assignments are engineering projects and may include Systems, Design, Quality, and Validation
  - First year coursework includes advanced engineering topics to develop technical skills
  - Second year coursework includes corporate leadership topics to develop business skills
  - Program members are encouraged (if not required) to earn credit towards an MS degree in Engineering while on program
- Benefits: Less turnover, higher competent workforce, higher worker and employer satisfaction

Example Industry Solutions (Continued)

BAE Systems

- Engineering Leadership Development Program
  - Similar to GE's Edison Engineering Development Program

U.S. Army M3A3 Bradley Fighting Vehicle System (U.S. Air Force photo by Staff Sgt. Jason Robertson/Released)

Lockheed Martin

- "Engineering Leadership Development Program (ELDP) is an entry-level technical leadership program designed to develop a pipeline of future engineering leadership talent enterprise-wide"
  - Rotational Assignments
  - Technical Development Curriculum
  - Leadership Development
  - Leadership Development Conferences
  - Mentoring & Networking

F22 Langley AFB (Photo courtesy of Lockheed Martin)

Other Existing Solutions

DoD can provide an incentive for industry to grow and develop its engineering workforce

- **Increase allowable profit on DoD contracts**
  - A company's investment to hire and develop its workforce's abilities, experience, and professional credentials support an argument for higher profit when DoD contracting officials apply weighted guidelines on profit on DoD contracts

- **Industry Volunteer and Financial Support of their own STEM and / or other STEM Initiatives**

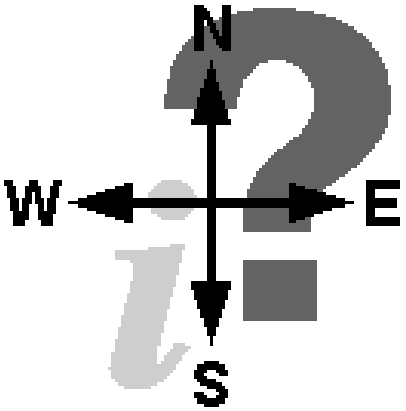
Recommendations

- Continue supporting the DDR&E STEM Initiative Goals:
  - Inspire, Develop, Attract and Deliver
- Develop and Support More:
  - Co-Op/Intern Programs
  - Mentoring Programs
  - Rotational Assignment Programs
- Provide more opportunities for workforce development initiatives between government and industry

Recommendations (Continued)

Encourage the provision, adoption, development, and use of:

- Joint government and industry case studies and other lessons learned documents
- Distance Learning Courses
- Systems Engineering Experience Accelerator, when complete
- The Guide to the Systems Engineering Body of Knowledge, when complete
- The Graduate Reference Curriculum for Graduate Systems Engineering, when complete



Questions?

NDIA
National Defense Industrial Association

For Additional Information:

Dr. John R. Snoderly
Defense Acquisition University
john.snoderly@dau.mil

Mr. Doug Westphal
Scitor Corporation
dwestphal@scitor.com

Dr. Don Gelosh
ODDR&E/Systems Engineering
donald.gelosh@osd.mil

AFEI nTsa PSA WIDF

School of Systems&Enterprises

Leveraging Remote Online Education for SE Competency Development

NDIA SE Conference, October 2010

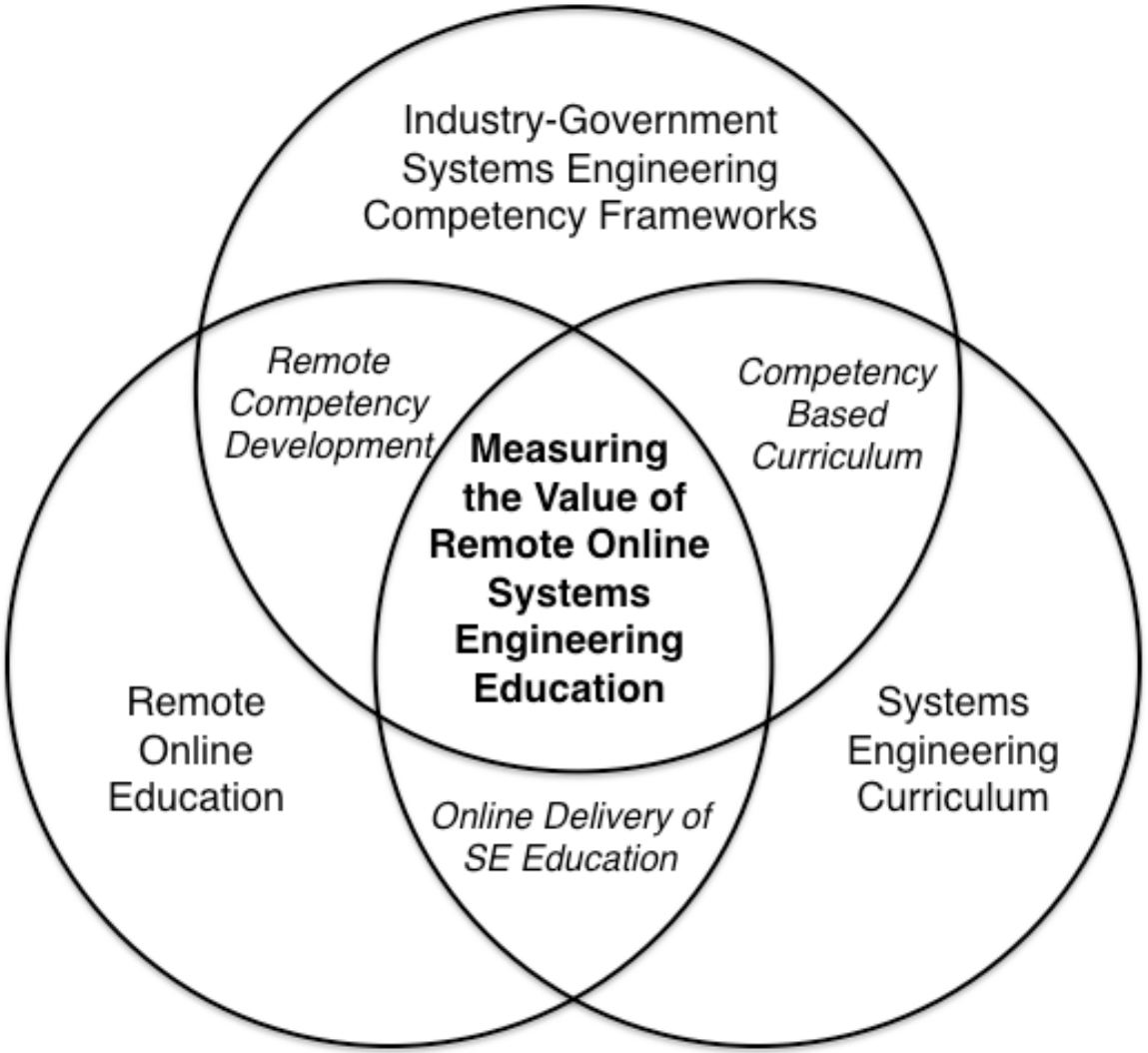
Alice Squires
alice.squires@stevens.edu

The Problem

According to the NDIA SE Division, one of the top five systems engineering issues for the Department of the Defense (DoD) is:

"The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and defense industry." (NDIA SE Division, 2010)

Problem Space

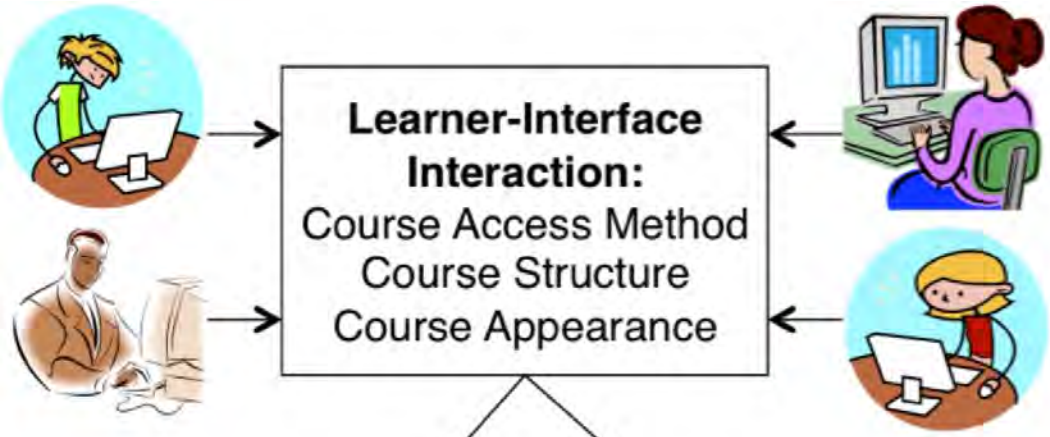


The Problem Continued…

BUT

The impact of remote online systems engineering education and training on student learning is not well known or understood.

Remote Online Classroom Architecture



Learner-Interface Interaction:
Course Access Method
Course Structure
Course Appearance

Learner-Content Interaction:
Visual
Verbal
External

Learner-Instructor and Learner-Learner Interaction:
Classroom Discussions
Team Discussions
One-on-One Discussions
Instructor Feedback to Learner
Learner Course Evaluation

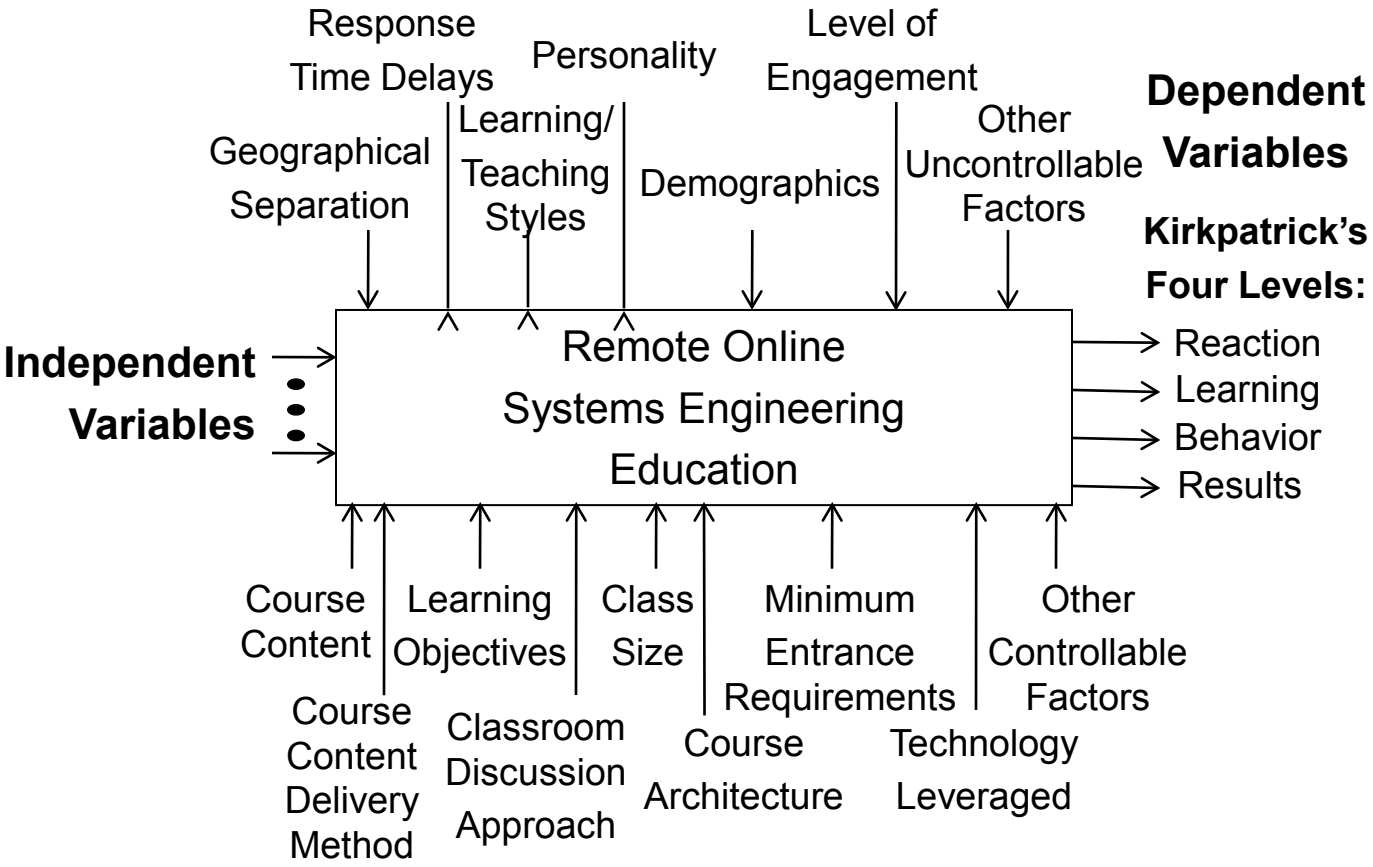
Early Systems Engineering Remote Online Education Research

- Squires, Pennotti & Verma (2006): case study - impact of audio lectures on student satisfaction and learning
  - 1 course, 7 instantiations, 131 students. Findings:
    - Audio lectures related to an increase in student satisfaction
    - No noticeable difference in student learning
- Squires & Pennotti (2007): which components of remote online learning impacted student satisfaction
  - 12 courses, 37 instantiations, 379 of 438 evals. Findings:
    - Top correlation: frequency and detail of faculty feedback
- Squires & Cloutier (2010): impact of classroom discussions on student satisfaction
  - 22 courses, 32 instantiations, 445 of 485 evals. Findings:
    - Classroom discussions related to student satisfaction, whether or not the faculty participated in those discussions

Current Version of Overall Framework

Uncontrollable Factors*

**These 'uncontrollable' factors apply to both Instructors and Students*



Controllable Factors

Research Hypotheses

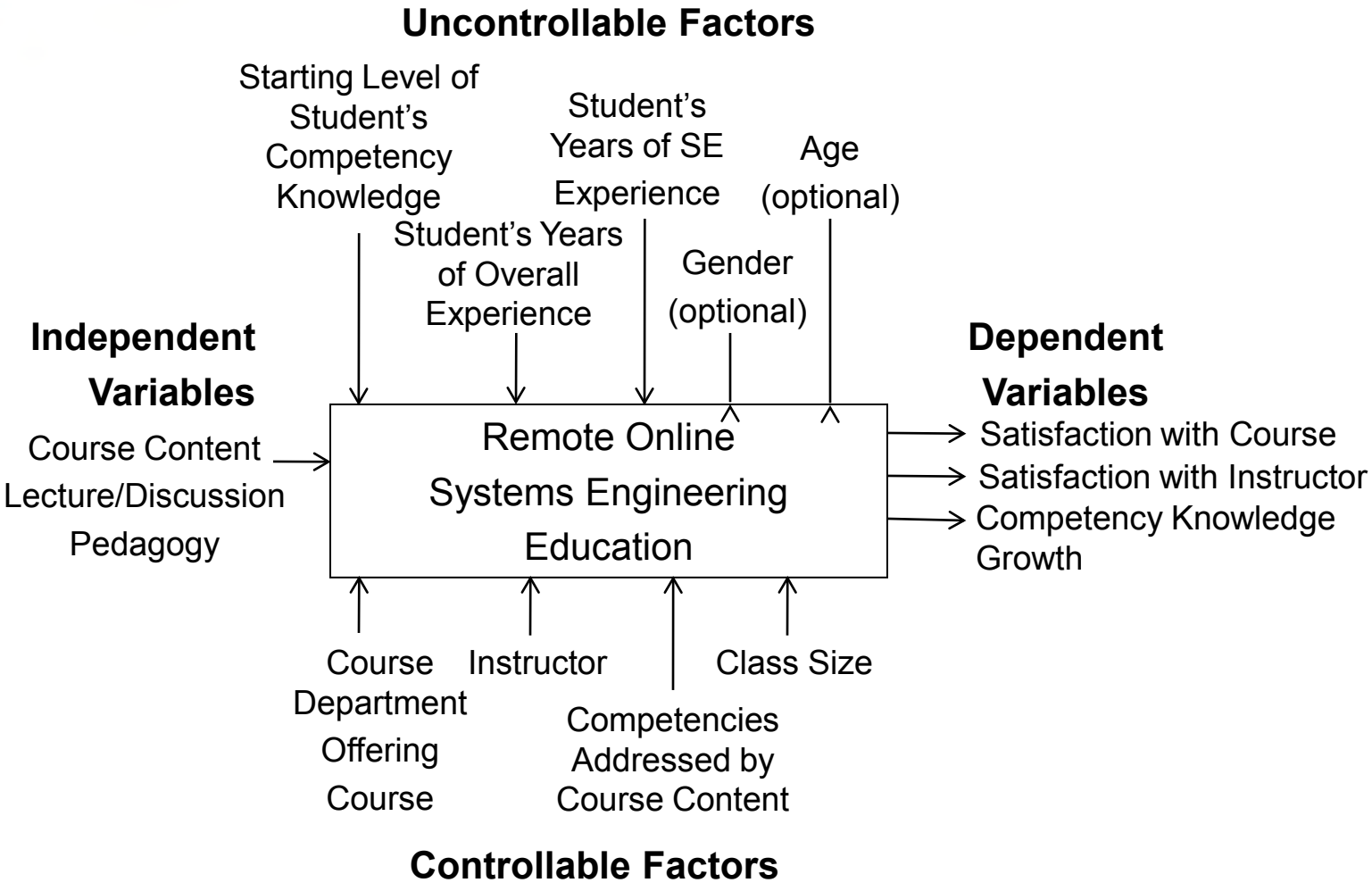
1. A student's level of satisfaction with a successfully completed remote online class…

2. A student's level of satisfaction with the instructor of a successfully completed remote online class…

3. The change in a student's perceived level of knowledge of systems engineering competencies, after successfully completing a remote online class,…

   …is related to the pedagogical approach used by the instructor to deliver lectures and discuss course content during the delivery of the course.

Research Experiment and Additional Data



Operational Definitions: Student Satisfaction with Instructor and with Course

- Self reported by students through a survey.
- Degree to which they agree or disagree with the following two statements:
  - The instructor was an effective teacher.
  - This was an excellent course.
- Equally spaced values on a 0 to 100 scale:
  - Strongly Agree = 100
  - Agree = 75
  - Neither Agree or Disagree = 50
  - Disagree = 25
  - Strongly Disagree = 0

NASA/Industry (APPEL, 2009) Model (1 of 3)

1.0 Concepts and Architecture	1.1 Form Mission Needs Statement
	1.2 Describe System Environments
	1.3 Perform Trade Studies
	1.4 Create System Architectures
2.0 System Design	2.1 Define/Manage Stakeholder Expectations
	2.2 Define Technical Requirements
	2.3 Logically Decompose System
	2.4 Define System Design Solution
3.0 Production, Product Transition and Operations	3.1 Implement the Product
	3.2 Integrate System
	3.3 Verify the System
	3.4 Validate the System
	3.5 Transition the System
	3.6 Conduct Operations

NASA/Industry (APPEL, 2009) Model (2 of 3)

4.0 Technical Management	4.1 Plan Technical Effort
	4.2 Manage Requirements
	4.3 Manage Interfaces
	4.4 Manage Technical Risk
	4.5 Manage Configuration
	4.6 Manage Technical Data
	4.7 Assess Technical Product and Process
	4.8 Manage Technical Decision Analysis Process
5.0 Project Management and Control	5.1 Oversee Technical Acquisition
	5.2 Manage Resources
	5.3 Manage Contracts
	5.4 Manage/Implement Systems Engineering

NASA/Industry (APPEL, 2009) Model (3 of 3)

6.0 Organizational Environments	6.1 Understand Organizational Structure, Mission, Goals
	6.2 Apply PM/SE Procedures and Guidelines
	6.3 Manage External Relationships
7.0 Human Capital Management	7.1 Manage Technical Staff Organization and Performance
	7.2 Manage Team Dynamics
8.0 Security, Safety and Mission Assurance	8.1 Organize Security
	8.2 Organize Safety and Mission Assurance
9.0 Professional and Leadership Development	9.1 Coach and Mentor Protégés
	9.2 Communicate Highly Effectively
	9.3 Lead Teams and Organizations
10.0 Knowledge Management	10.1 Capture, Organize and Distribute Knowledge

Student Survey

1. Welcome! Provides general direction, expressed thanks
2. Experience: years of overall and systems engineering specific [required]; student and work status [optional]
3. Education: Background
4. Course Completed: used to confirm in population. Data for course, types of course content delivery and discussion used, student's overall satisfaction with course and instructor.
5. Competency Level: most intensive (and takes the longest time) page of the survey. Data for competency knowledge growth in 37 competencies.
6. Final Page: Optional data on age range and gender.

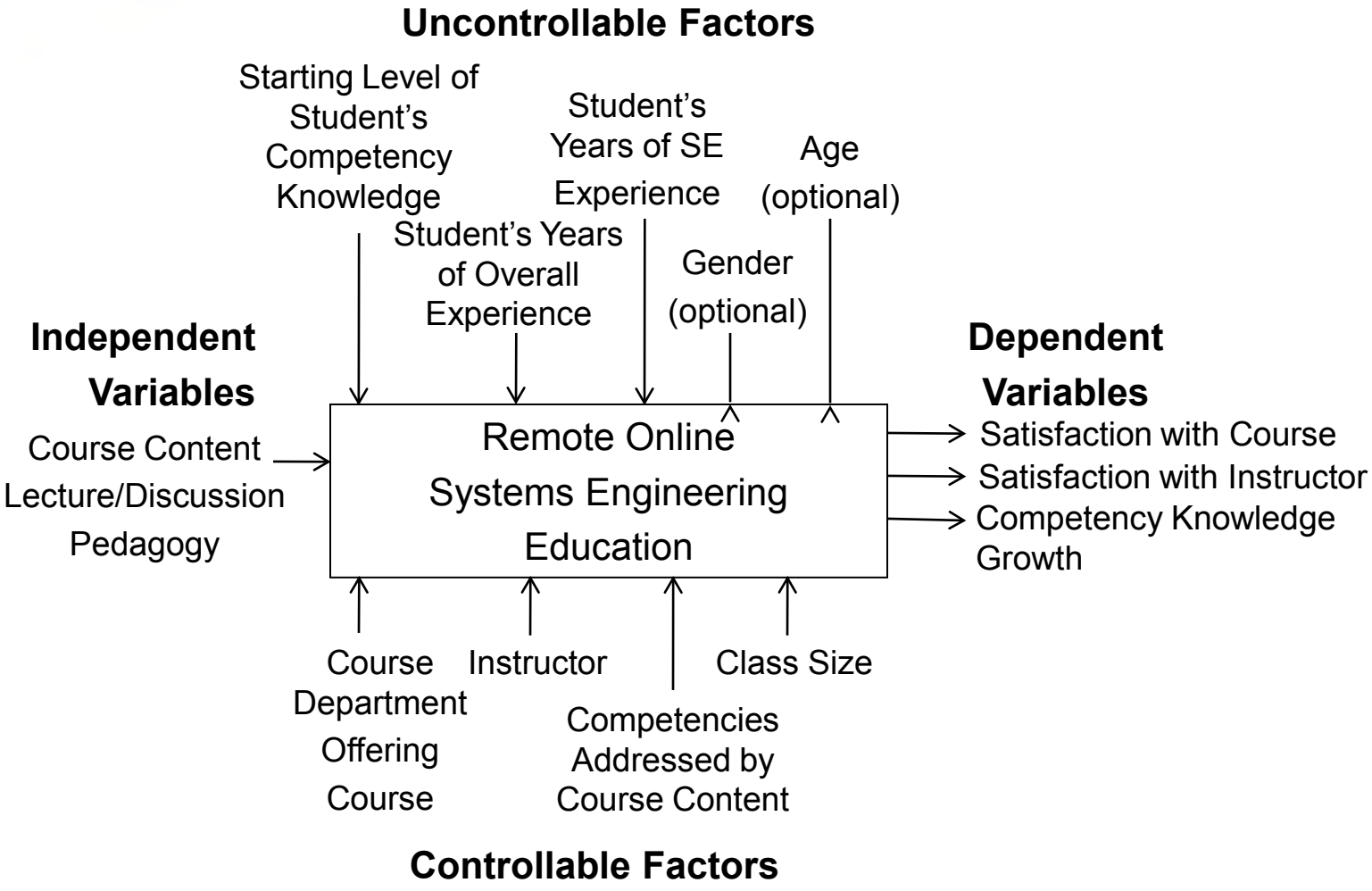
Instructor Survey

1. Welcome! General direction, expressed thanks
2. Course Taught: Information on course, types of course content delivery and discussion used.
3. Competency Level: Data for instructor's perception of which 37 competencies are covered in the course and at what level of knowledge.
4. Final Page: Thanks and final comments.

Population

- Students that completed one or more Stevens Webcampus courses in the Spring 2010 semester in:
  - Systems Engineering (includes space, security, enterprise)
  - Engineering Management
  - Software Engineering
- 422 student enrollments / 349 students:
  - 281 students (80.7%) in one Webcampus course
  - 62 students (17.8%) in two Webcampus courses
  - 3 students (0.9%) in three Webcampus courses
  - 2 students (0.6%) in four Webcampus courses
- 21 courses, 27 sections, 21 different instructors

Research Experiment and Additional Data



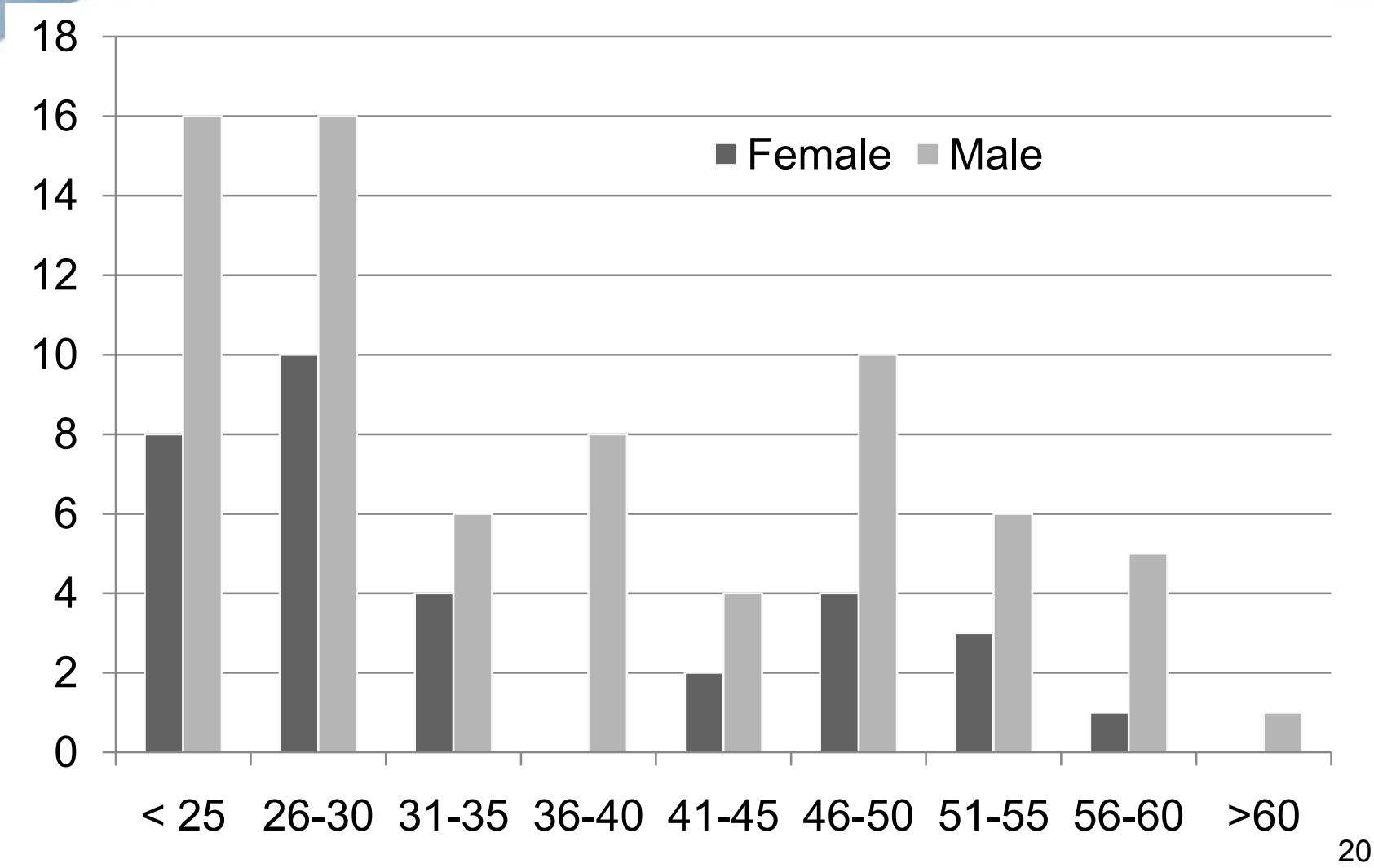
Analysis: Return Rates

Confidence Level:	**99%**	**95%**	**90%**
Constant z_N (two-sided):	**2.58**	**1.96**	**1.64**
Response Distribution (p):	**50%**	**50%**	**50%**
Finite Population (Pop):	**422**	**422**	**422**
Target Return Rate:	**20%**	**20%**	**20%**
Sample Size, SPLIT Sample:	42.2	42.2	42.2
Confidence Interval/Margin of Error (CI):	18.9%	14.3%	12.0%
Student Satisfaction Return Rate:	**37.7%**	**37.7%**	**37.7%**
Sample Size, SPLIT Sample:	79.5	79.5	79.5
Confidence Interval/Margin of Error (CI):	13.0%	9.9%	8.3%
Competency Knowledge Return Rate:	**25.35%**	**25.35%**	**25.35%**
Sample Size, SPLIT Sample:	53.5	53.5	53.5
Confidence Interval/Margin of Error (CI):	16.5%	12.5%	10.5%

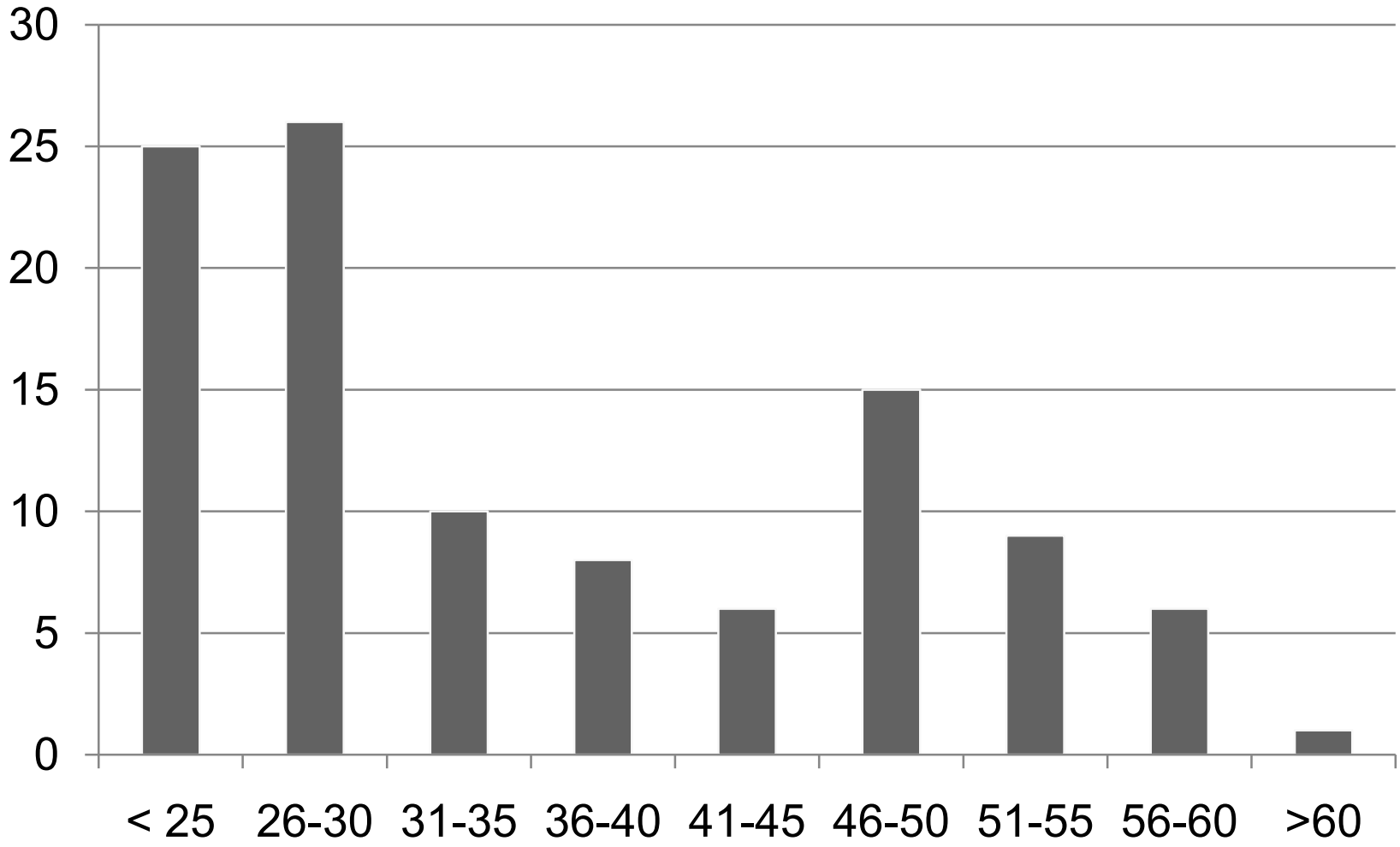
Return Rate 'Spread'

- Education and Experience: 159 student enrollments
  - Systems Engineering – 99 (62%)
  - Engineering Management – 40 (25%)
  - Software Engineering – 20 (13%)
- Plus Competency: 107 student enrollments
  - Systems Engineering – 70 (65%)
  - Engineering Management – 26 (24%)
  - Software Engineering – 11 (10%)
- Instructor Survey Return: 100%
  - Systems Engineering – 15 Courses, 12 instructors
  - Engineering Management – 7 Courses, 5 instructors
  - Software Engineering – 5 Courses, 4 instructors

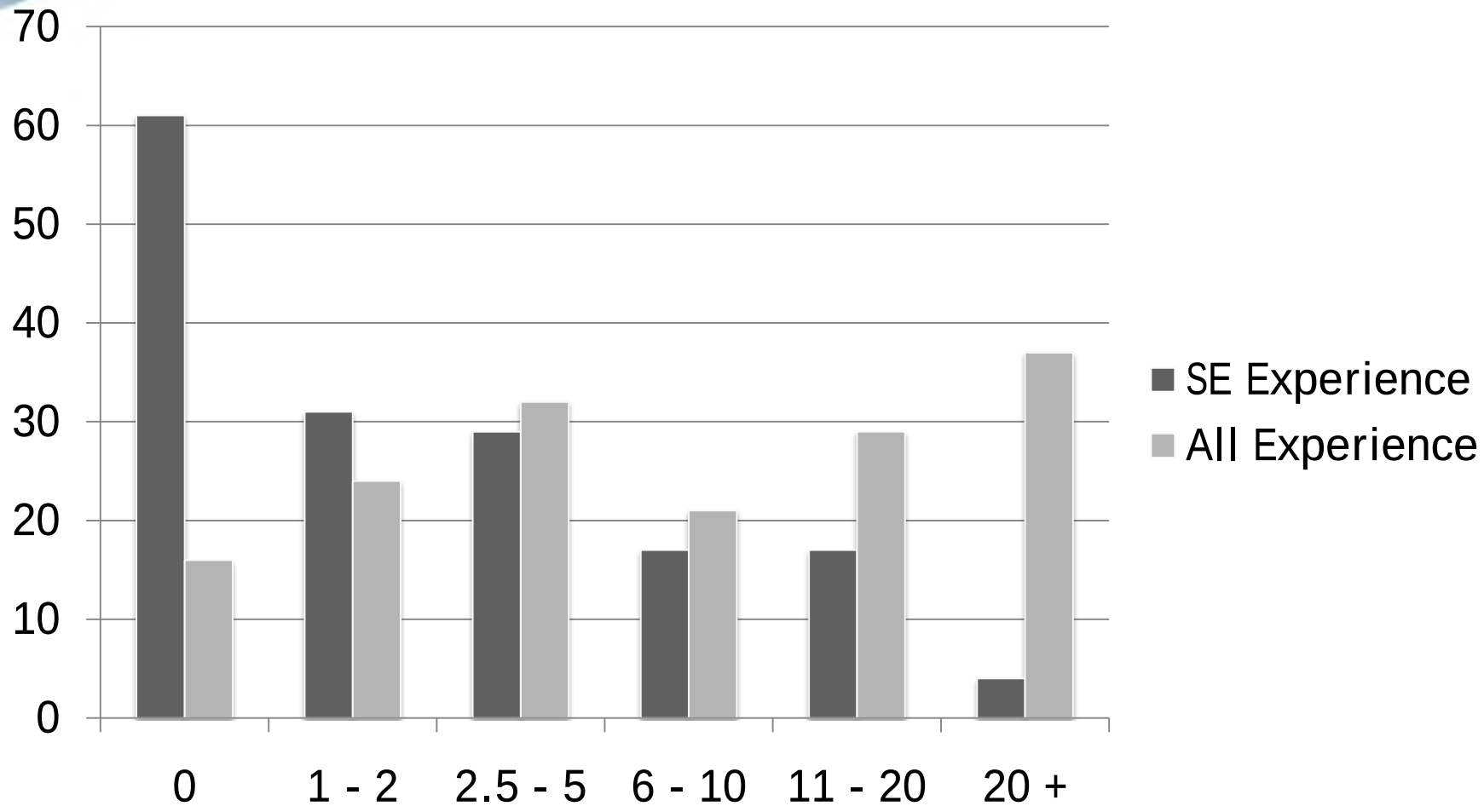
Sample: Age and Gender



Look Familiar?



Overall Experience/SE Experience



Preliminary Findings: Age/Gender/Experience

- Age:
  - About half are under 30 years.
  - About one-sixth are 30 – 40 years.
  - About one-third are over 40 years.
- About 70% Male, 30% Female
- Net Experience:
  - 10% have no professional experience
  - 38% have no SE Experience
  - 25% have 2 years or less of experience
  - 50% have 2 years or less of SE experience
  - Almost half have 5 years or less of experience in general
  - Over 75% have 5 yrs or less SE experience

Operational Definition: Competency Knowledge Growth

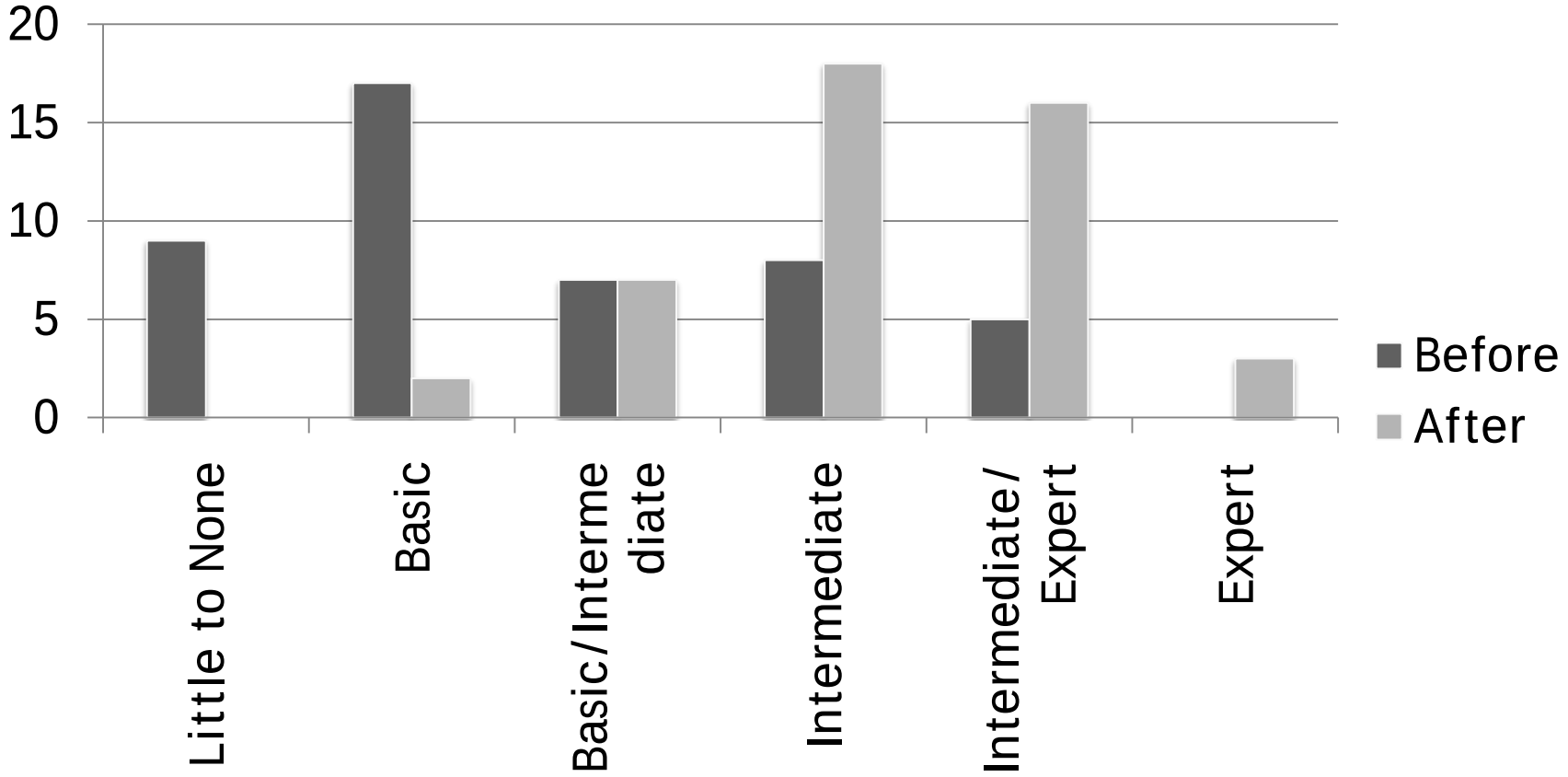
- Assumption: a change in the level of knowledge in a particular area of competency reflects learning.
- Self reported by students through a survey.
- Levels of knowledge are defined as:
  - Basic: You are able to understand a discussion about and follow directions related to the competency.
  - Intermediate: You are comfortable making decisions about and leading discussions related to the competency.
  - Expert: Many others look to you for knowledge about the competency.

Competency Knowledge Selections

- Students (and instructors) were asked to rate whether the competency was covered in the course (Yes or No).
- And what the level of competency was that the student had (or should have) coming into the course (before) and after successfully completing the course (after)
- The selections were:
  - Little to No knowledge
  - Basic level
  - Between Basic and Intermediate
  - Intermediate level
  - Between Intermediate and Expert
  - Expert knowledge

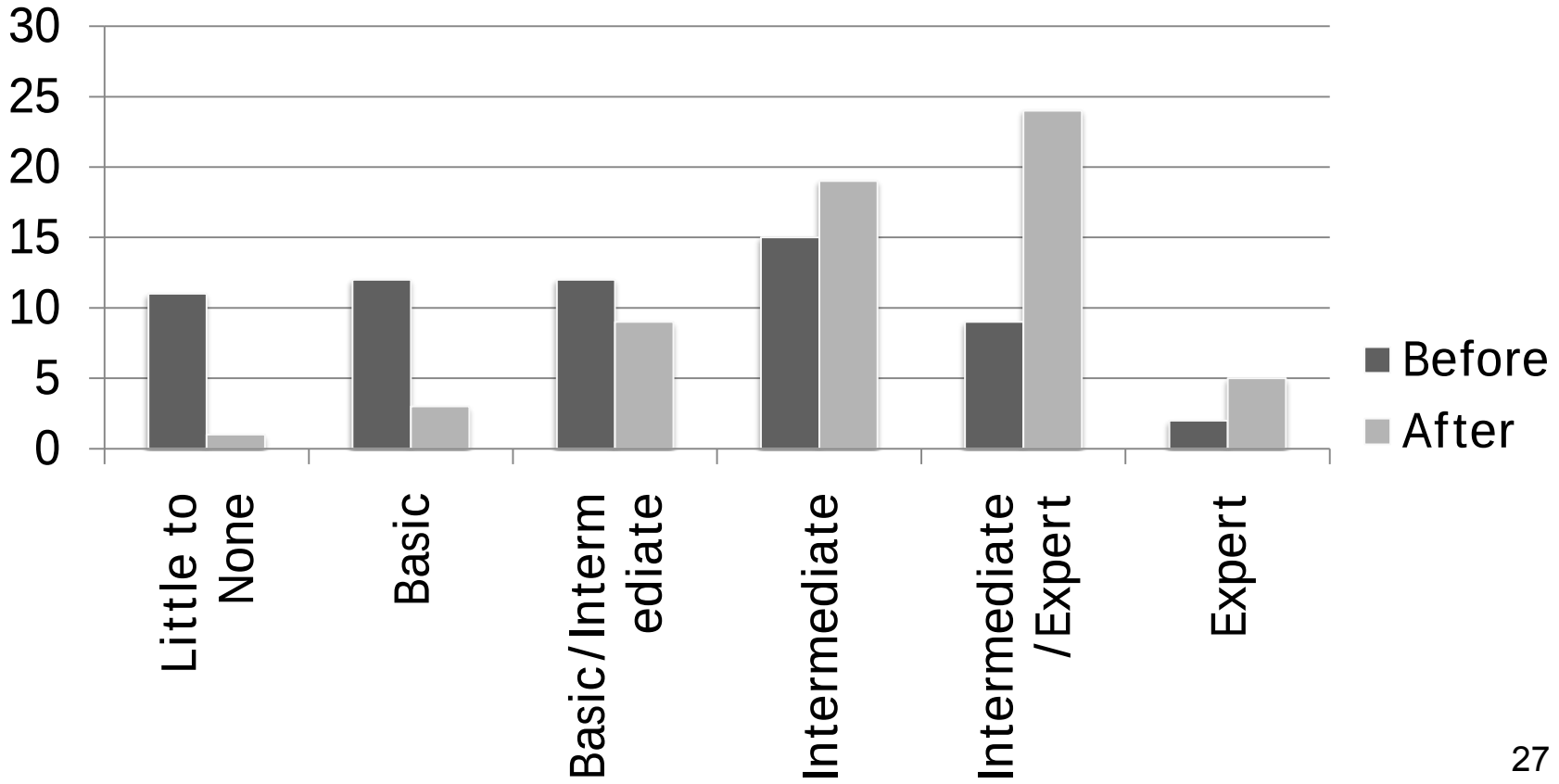
Concepts and Architecture: Form Mission Needs Statement

- Covered in Course? 43% said 'Yes'



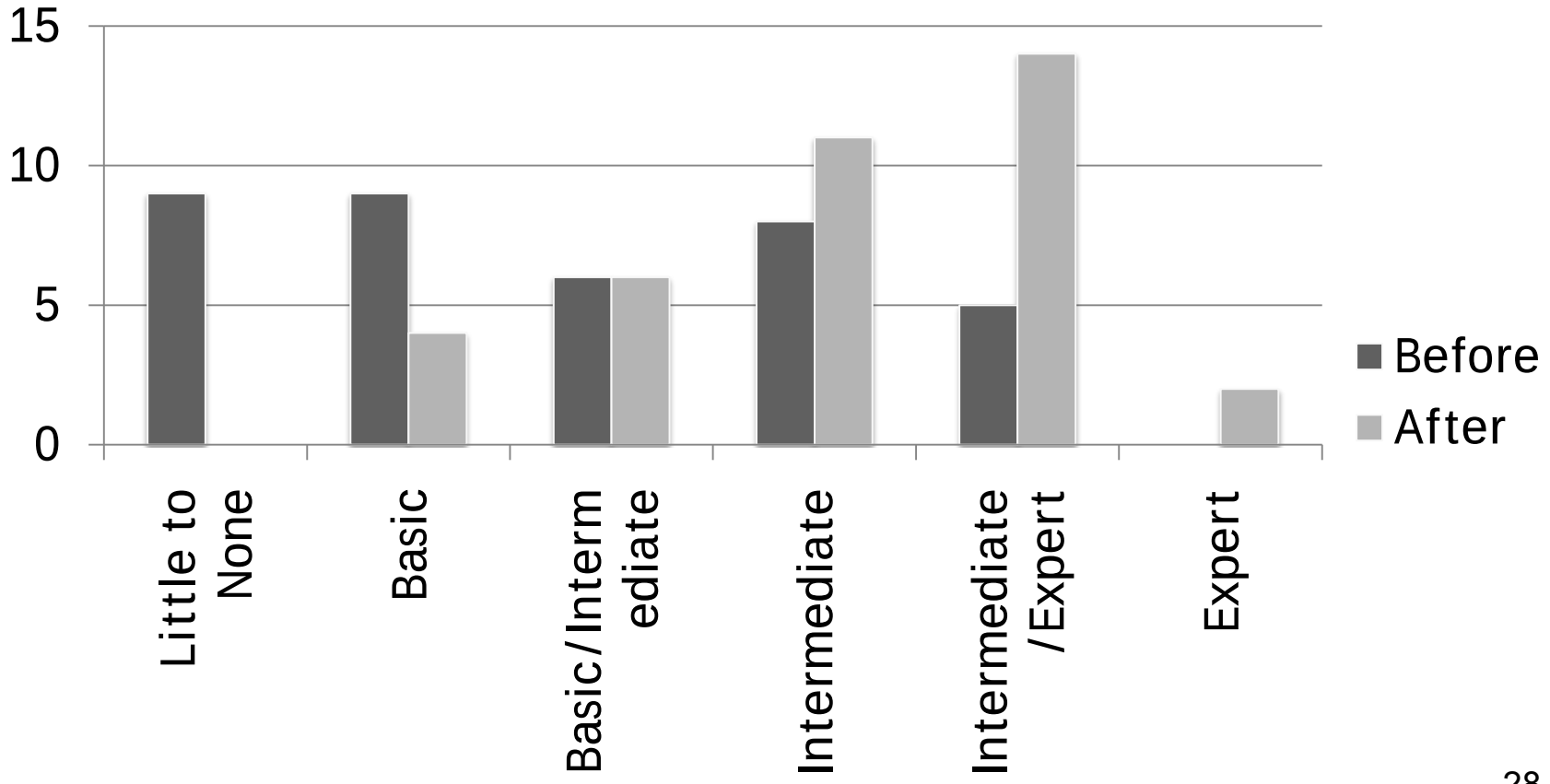
Concepts and Architecture: Describe System Environments

- Covered in Course? 57% said 'Yes'



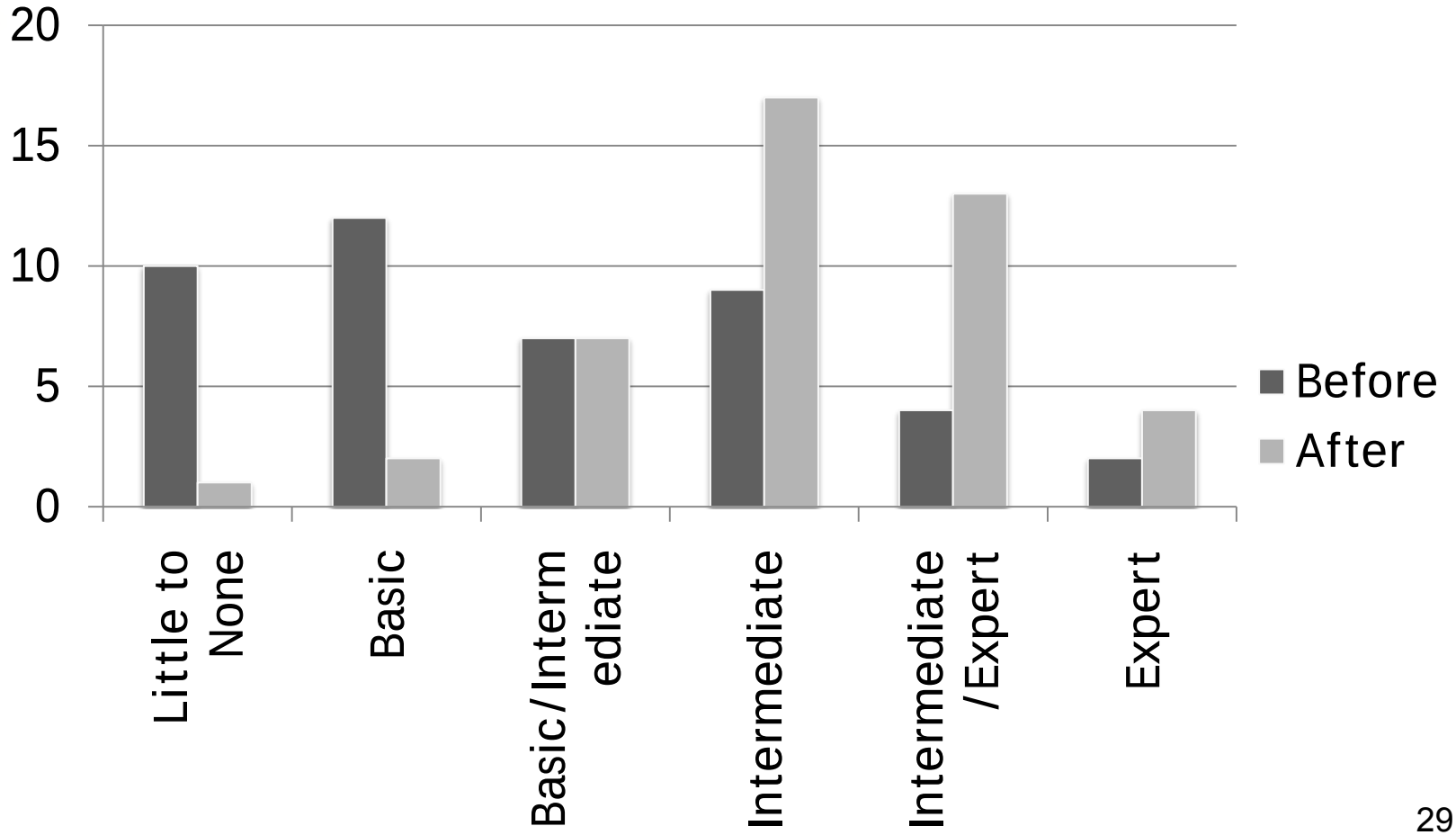
Concepts and Architecture: Perform Trade Studies

- Covered in Course? 35% said 'Yes'

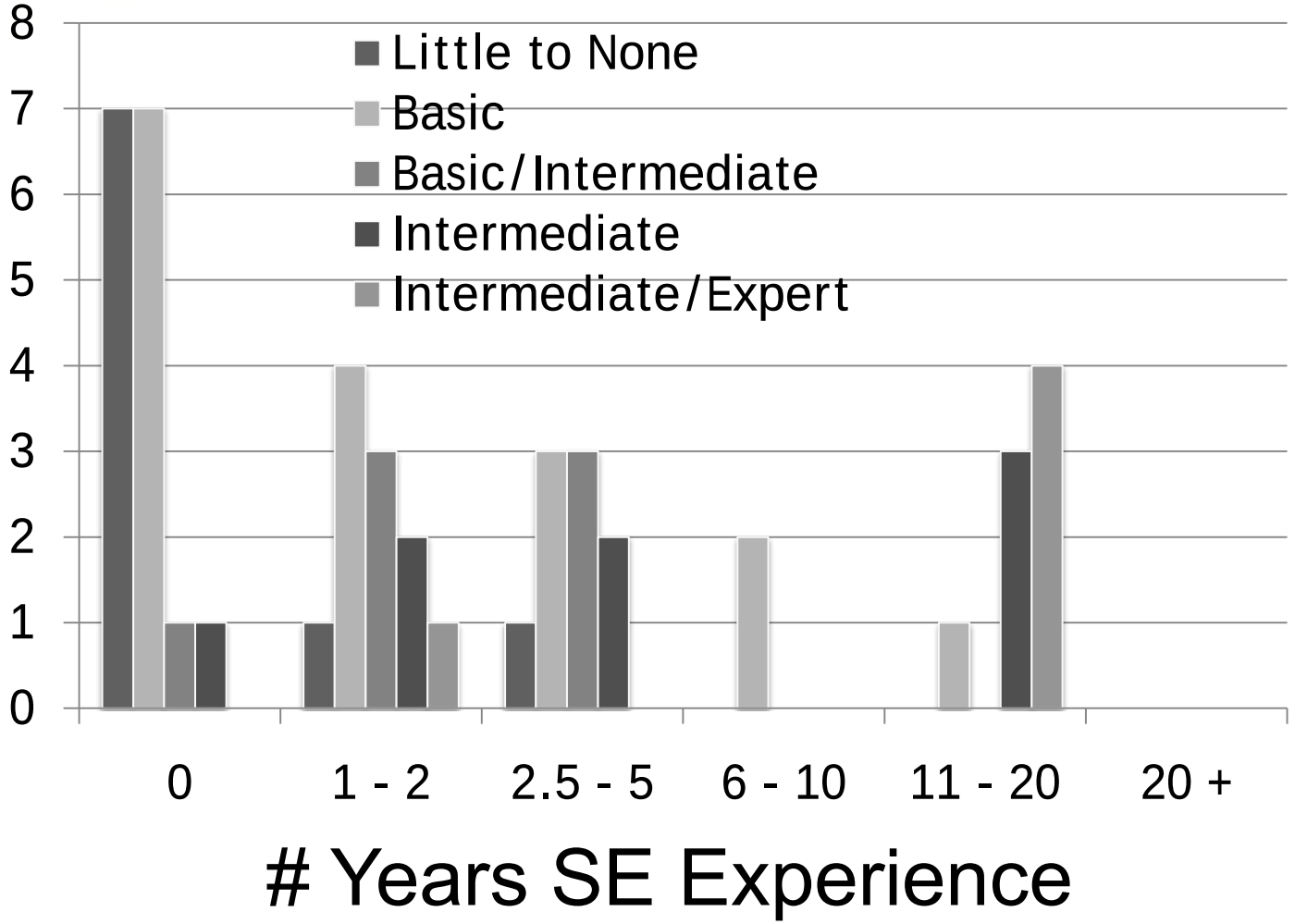


Concepts and Architecture: Create System Architectures

- Covered in Course? 41% said 'Yes'



Example Competency Roadmap: Form Mission Needs Statement



Preliminary Findings: Competency

- Students (and instructors) had different perceptions as to what competencies were covered in a particular course.
  - There was some general agreement in many cases.
- When a student felt that a particular competency was covered in the course content, they also felt that their level of knowledge in that competency tended to increase in general with the following noted:
  - The lower the level of perceived knowledge ‘before’ resulted in a larger increase from before to after, especially when the level started at ‘little to no knowledge’ or ‘basic knowledge’.
  - In some cases the perceived level did not change, but primarily when the level was ‘Intermediate’ or above.

Research Objectives (1 of 2)

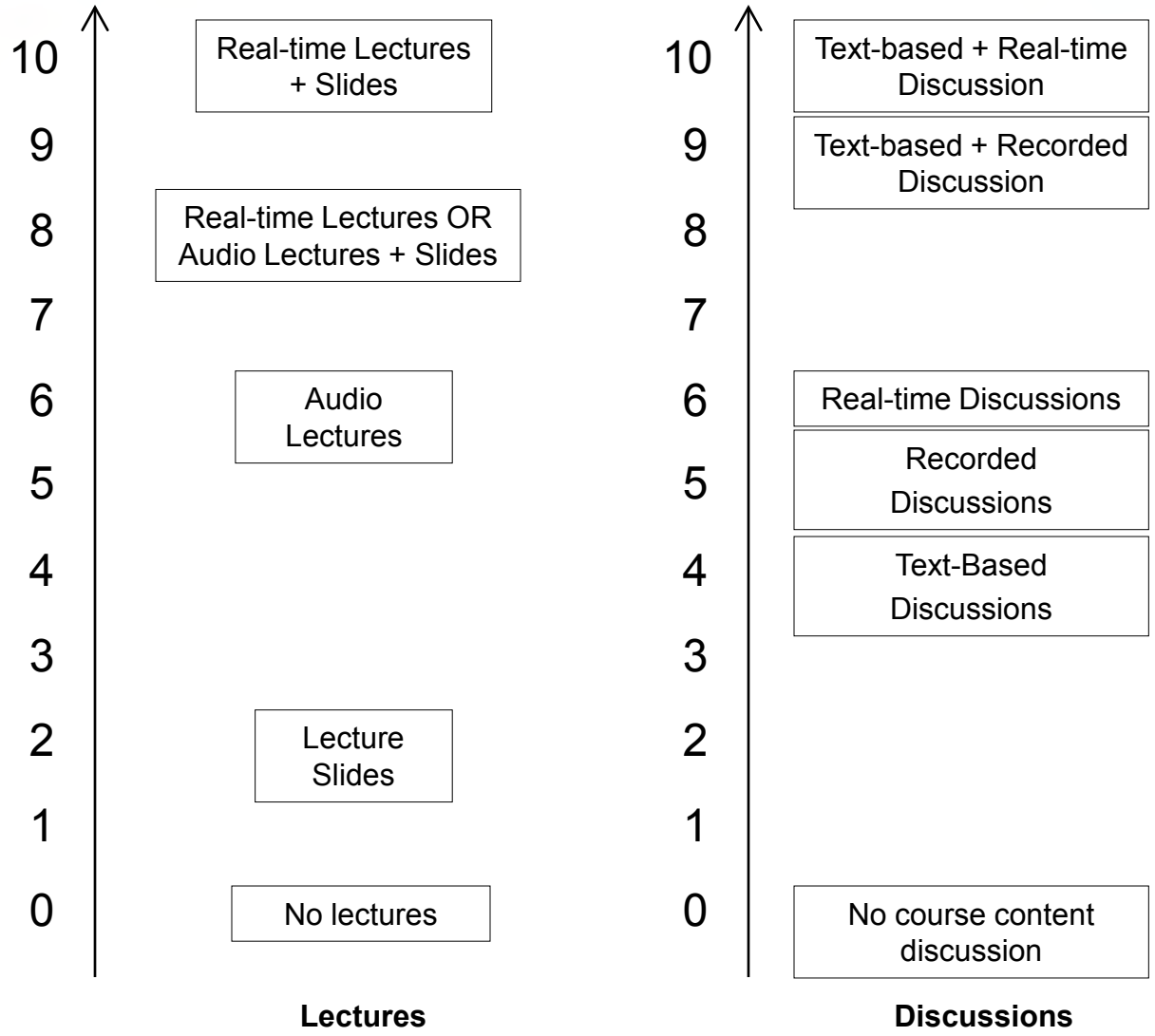
- To broaden awareness of both the need to assess remote online systems engineering education, and the challenges associated with this endeavor.
- To provide empirical evidence of the impact on student learning of systems engineering competencies when using specific pedagogical approaches to deliver course lectures and run classroom discussions in a remote online classroom.
- To provide empirical evidence of the impact on student satisfaction with the learning experience. Other observed impacts will be noted for possible future investigation.

Research Objectives (2 of 2)

- To further develop a robust design based framework that is intended to be extensible going forward to other modalities of systems engineering education as well as related educational domains.
- To continue the effort to identify the driving factors for measuring success in achieving an increase in student systems engineering competency development through remote online education.
- To test, validate, and assess the feasibility of a specific research approach for measuring student learning of systems engineering competency.

Backup Slides

Operational Definition: Course Content Lecture/Discussion Pedagogy



Frequency Values Defined

- Frequency of lectures /discussions range from 0 to 10:
  - Never = 0
  - A Few Times During Course = 2
  - Every Other Week = 5
  - Almost Weekly = 8
  - Weekly = 10
- The possible range of values for the sum of all possible methods used to deliver lectures multiplied by the possible frequency that method was used, is 0 to 100.
- Similarly, the possible range of values for discussions is 0 to 100.

Example: Lecture Values

Real-Time (Wt = 8)	Recorded (Wt = 6)	Slides (Wt = 2)	Value
Weekly	--	Weekly	100
Every Other Week	Every Other Week	Weekly	90
--	Weekly	Weekly	80
Every Other Week	Every Other Week	Never	70
Every Other Week	Never	Every Other Week	50
Few Times A Course	Every Other Week	Few Times A Course	50
Never	Every Other Week	Weekly	50
Never	Few Times A Course	Weekly	32
Few Times A Course	Never	Never	16
Never	Never	Few Times A Course	4
Never	Never	Never	0

Example: Discussion Values

Real-Time (Wt = 6)	Recorded (Wt = 5)	Text-Based (Wt = 4)	Value
Weekly	--	Weekly	100
Every Other Week	Every Other Week	Weekly	95
--	Weekly	Weekly	90
Every Other Week	Every Other Week	Never	55
Every Other Week	Never	Never	30
Few Times A Course	Few Times A Course	Few Times A Course	30
Never	Few Times A Course	Every Other Week	30
Never	Never	Never	0

Course Content Pedagogy (CCP) Value Defined

- Combines course content lectures and discussions
- Normalizes from 0 to 100
- Equally weighted (50% each)

$$CCP = 0.5 * \sum_{i=1 \text{ to } 3} F_i * L_i + 0.5 * \sum_{j=1 \text{ to } 3} F_j * D_j$$

- Where
  - F = Frequency
  - L = Lectures
  - D = Discussions

Example: Course Content Pedagogy

Course Content Pedagogy Used	CCP Value
Real-Time Weekly Lectures, Weekly Lecture Slides are Posted, Real-Time Weekly Discussions, Weekly Text-Based Discussions	100
Every Other Week: Real-time Lectures/Discussions, Lecture Slides are Posted, Text-Based Discussions	50
Recorded Weekly Lectures, Weekly Lecture Slides are Posted	40
Weekly Lecture Slides are Posted, Weekly Text-Based Discussions	30
Weekly Lecture Slides are Posted	10

Competency Knowledge Growth Value Defined (1 of 2)

- A transition at the higher levels (above intermediate) represents a greater step than a transition at the lower levels (below intermediate).
- Weighted values defined on a scale of 0 to 100 (LCK):
  - 0 - Little to No knowledge
  - 10 - Basic level
  - 30 - Between Basic and Intermediate
  - 50 - Intermediate level
  - 75 - Between Intermediate and Expert
  - 100 - Expert knowledge

Competency Knowledge Growth Value Defined (2 of 2)

- Competencies 'covered' in course (CIC):
  - Perspective of instructor through instructor survey
  - Perspective of students through student survey
- For those competencies 'covered', before and after levels of competency attainment collected from students (self perception) for all 37 competencies.
- Final competency knowledge growth value: difference between value 'after' course completed (CKA) less value 'before' course started (CKB):

$$CKG = CKA - CKB, \text{ where}$$

$$CKA = \sum_{i=1 \text{ to } 37} CIC_i * LCKA_i \quad \text{and} \quad CKB = \sum_{i=1 \text{ to } 37} CIC_i * LCKB_i$$

Example: Course 'Covers' Ten Competencies

	Before	After
Competency 1	Basic	Basic
Competency 2	Basic/Intermediate	Intermediate
Competency 3	Basic	Basic/Intermediate
Competency 4	Intermediate	Intermediate
Competency 5	Intermediate	Intermediate/Expert
Competency 6	None	Basic
Competency 7	Expert	Expert
Competency 8	Basic/Intermediate	Basic/Intermediate
Competency 9	Basic	Basic/Intermediate
Competency 10	None	Basic

CKB Value: 290

CKA Value: 395

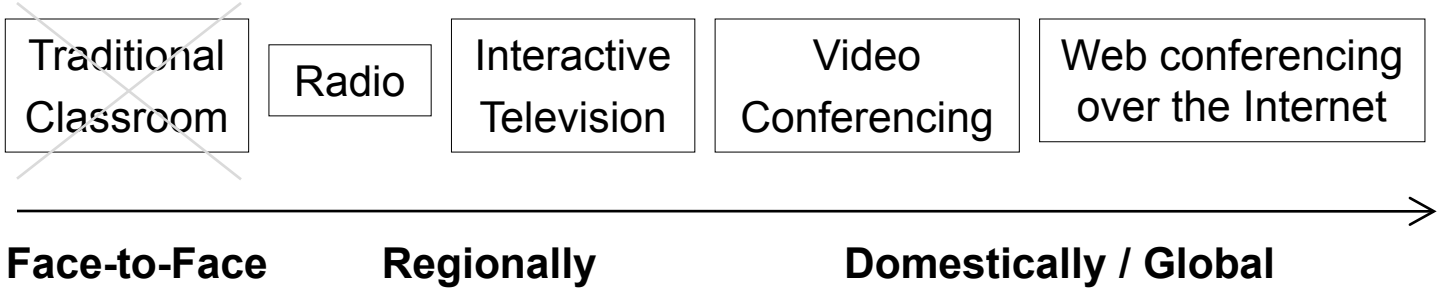
CKG Value: 105

Systems Engineering Education

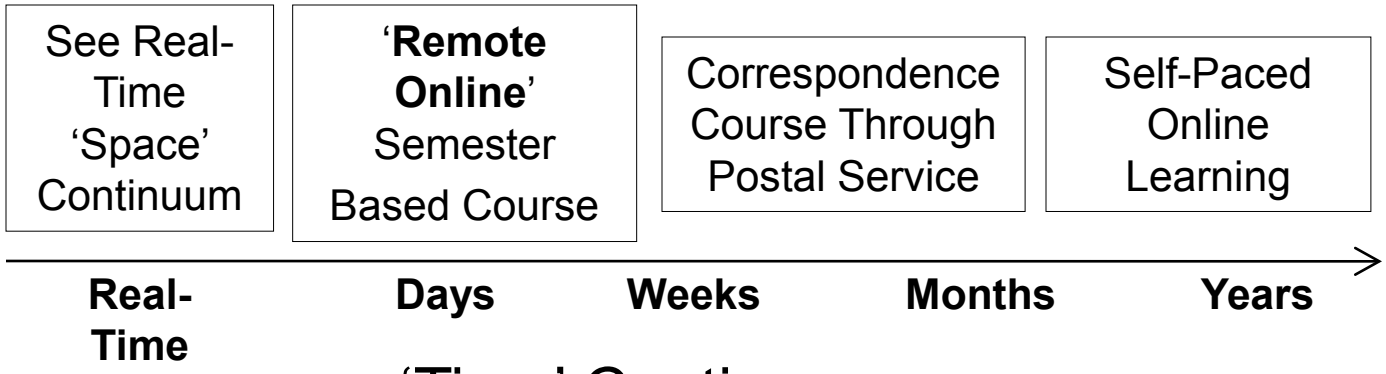
Type of SE Program	Degree Level	Brown & Scherer (2000)	Fabrycky (2010)	Squires (2010a)* Remote Online	2000 to 2010 Increase Factor
Systems Centric	Bachelors	10	11	*	1.1
	Masters	10	31	14	3.1
	Doctorate	3	14	*	4.7
	Systems Centric	23	56	14	2.4
Domain Centric	Bachelors	9	44	*	4.9
	Masters	17	42	4	2.5
	Doctorate	9	23	*	2.6
	Domain Centric	35	109	4	3.1
All	Bachelors	19	55	-	2.9
	Masters	27	73	18	2.7
	Doctorate	12	37	-	3.1
All	All Degrees	58	165	18	2.8

*Only Remote Online Masters Degrees investigated; however, no evidence of completely remote online SE undergraduate or PhD degrees found during investigation.

Remote Online: Subset of Distance Education



Real-time 'Space' Continuum



'Time' Continuum

[Distance Education] Evaluation Frameworks

Community of Inquiry (COI) Framework	An instrument for measuring social presence, teaching presence and cognitive presence in computer mediated conferences (online discussions)
Learner Interactions Model	Focused on interactions between learner-content, learner-instructor, learner-learner and learner-interface
Interaction Analysis Model	Groups analysis of computer mediated conferencing interaction into sequential knowledge development phases leading to newly constructed meaning
The Unfolding Model	Combines scientific quantitative approaches and qualitative research methods resulting in multiple perspectives for evaluating processes and outcomes in distance education.
Kirkpatrick's Four Levels	An approach for evaluating training programs that assesses the training through four levels: 1) student reaction to the training, 2) student learning, 3) change in student behavior on-the-job, and 4) the results or bottom line impact to the organization.
Bloom's Taxonomy for the Cognitive Domain	Used to categorize the level of cognition from amongst six levels, each of which builds on obtainment of the previous level, as follows: 1) Knowledge, 2) Comprehension, 3) Application, 4) Analysis, 5) Synthesis, and 6) Evaluation.

Publication Strategy (1 of 2)

Authored Titles	Authors	Venue	Status
The Effect of Incorporating Verbal Stimuli in the Online Education Environment: An Online Case Study	Alice Squires Mike Pennotti Dinesh Verma	Proceedings from ASEE 2006 Annual Conference, Chicago, Illinois, June 18-21, 2006.	Peer-reviewed, Presented, Paper Published 2006
Measuring the Value of Course Components in the Online Classroom	Alice Squires Mike Pennotti	Proceedings from ASEE 2007 Annual Conference, Honolulu, Hawaii, June 24-26, 2007	Peer-reviewed, Presented, Paper Published 2007
Mapping Space-Based Systems Engineering Curriculum to Government-Industry Vetted Competencies for Improved Organizational Performance	Alice Squires Wiley Larson Brian Sauser	Systems Engineering Journal	Accepted; Paper published, 2010, 13(3)
Improving Systems Engineering Curriculum Using a Competency-Based Assessment Approach	Alice Squires Wiley Larson	International Journal of Intelligent Defence Support Systems: Special Issue on Systems Engineering Education	Accepted; published in 4th issue, 2009.
Evolving the INCOSE Reference Curriculum for a Graduate Program in Systems Engineering	Alice Squires Rob Cloutier	Systems Engineering Journal	Accepted; Paper published, 2010, 13(4)

Publication Strategy (2 of 2)

Authored Titles	Authors	Venue	Status
Developing a Strategy to Measure Systems Engineering Competency Knowledge Development in the Remote Asynchronous Online Classroom	Alice Squires Rob Cloutier	Proceedings of the 8th Annual CSER 2010, Stevens Institute of Technology, Hoboken, New Jersey, USA, March 17-19, 2010	Peer-reviewed, Presented, Paper Published 2010
Evaluating the Effectiveness of Classroom Discussion Approaches Used in the Remote Delivery of Systems Engineering Education	Alice Squires Rob Cloutier	Proceedings of the ASEE 2010 Annual Conference, Lexington, KY, June 20-23, 2010.	Peer-reviewed, Presented, Paper Published 2010
Comparing Perceptions of Competency Knowledge Development in Systems Engineering Curriculum: A Case Study	Alice Squires Rob Cloutier	Proceedings of the ASEE 2011 Annual Conference, Vancouver, CA, BC, June 26-29, 2011.	Submitted abstract
Leveraging the Remote Online Classroom for Building Systems Engineering Competency Knowledge: A Detailed Case Study	Alice Squires Rob Cloutier	Systems Engineering	TBD
Measuring the Value of Systems Engineering Education in the Remote Online Environment	Alice Squires Rob Cloutier	Journal of Engineering Education	TBD

GRCSE and GSwE2009: Educational Advancements to Support Government and Industry

Nicole Hutchison
Massood Towhidnejad
Guilherme Travassos
John Brackett
Rick Adcock

Outline

- Introduction
- State of Practice
- Industry/Government Needs
- Comparison/Contrast of GRCSE Approaches

Background

- Begun in May 2007 at Stevens Institute of Technology
- Sponsored by DoD Director of Systems and Software Engineering
- Three products planned:

1. A modern reference curriculum for a master's degree in software engineering that integrates an appropriate amount of systems engineering (GSwE2009)
2. A modern reference curriculum for a master's degree in systems engineering that integrates an appropriate amount of software engineering (GRCSE)
3. A truly interdisciplinary degree that is neither systems nor software engineering – it is both

Problem

- Lack of consistency in current programs in both SE and SwE
  - Lack of consistency makes it difficult for industry and government bodies to understand the expectations when hiring an individual with an master's degree in either SE or SwE
- This is a gap that may be filled by a set of recommendations designed to improve the overall state of master's programs in these areas

iSSEc Project Goals

- The iSSEc project has to:
  - Define the current state-of-the art in master's level education for their respective disciplines
  - Define industry and government needs in these areas
  - Identify gaps between the state of the art and needs which may be addressed by education
  - Incorporate ways to address these gaps in project products

Examining the State of Practice

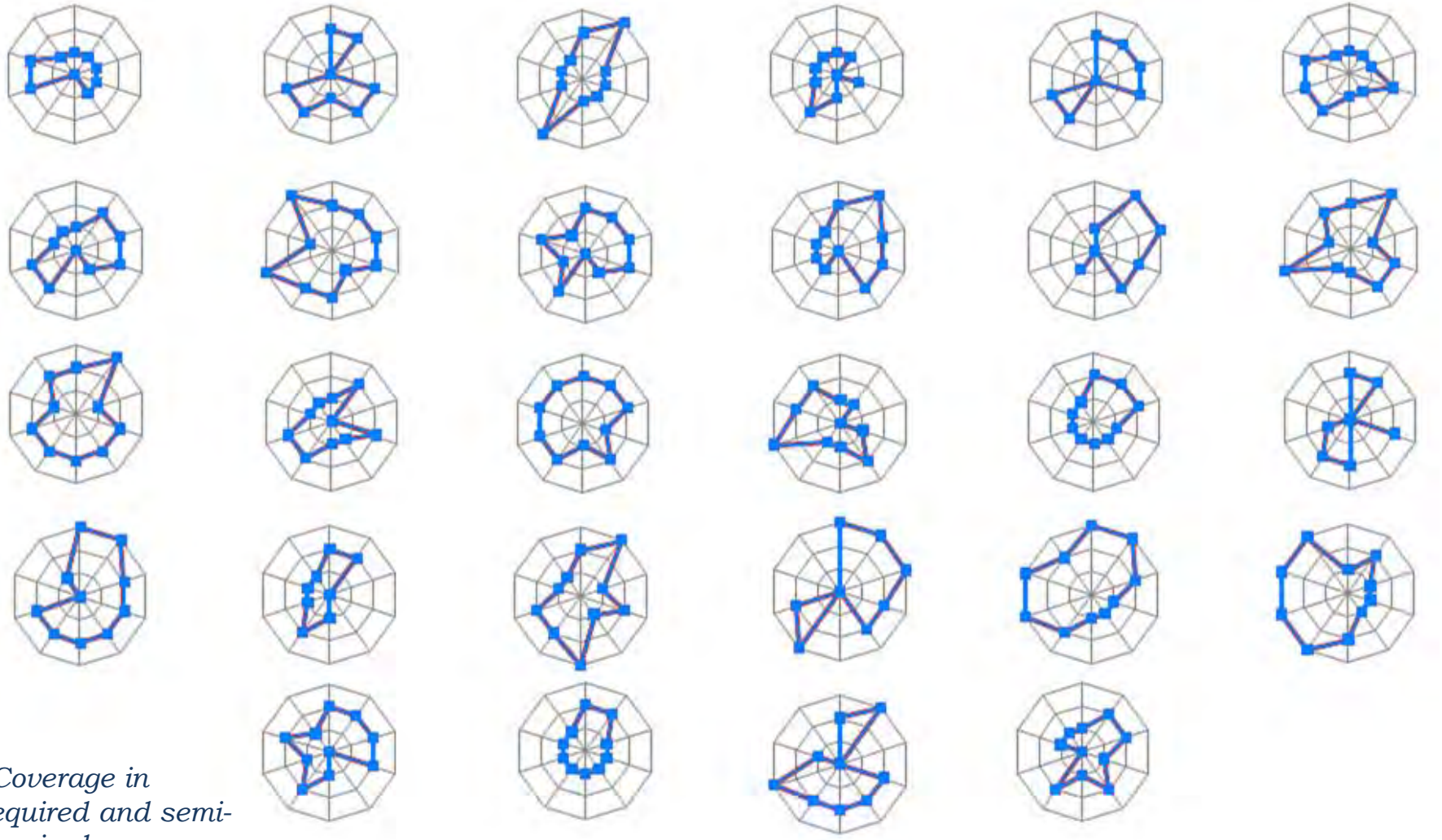
- Both Phase 1 and Phase 2 conducted surveys to determine the current state of master's level education in their respective fields
  - SWe Curriculum (2007) study surveyed 28 schools
  - SE Curriculum study (2010) surveyed 36 schools

- Both surveys collected:
  - Basic data about the university, program, etc.
  - The type of degree offered
  - Any specialized program focus
  - Thesis/Credit requirements
  - Required coursework
  - Entrance Requirements

School Survey Results

- Both surveys showed the same general pattern in SwE and SE:
  - Lack of consistency, structure and requirements degree programs
  - Several different types of degrees offered
  - Lack of consistency in entrance expectations
- Both are structured to allow tailoring at the program/university level while addressing shortcomings or inconsistencies in current programs

SWEBOK coverage* in 2007 across 28 SwE MS programs



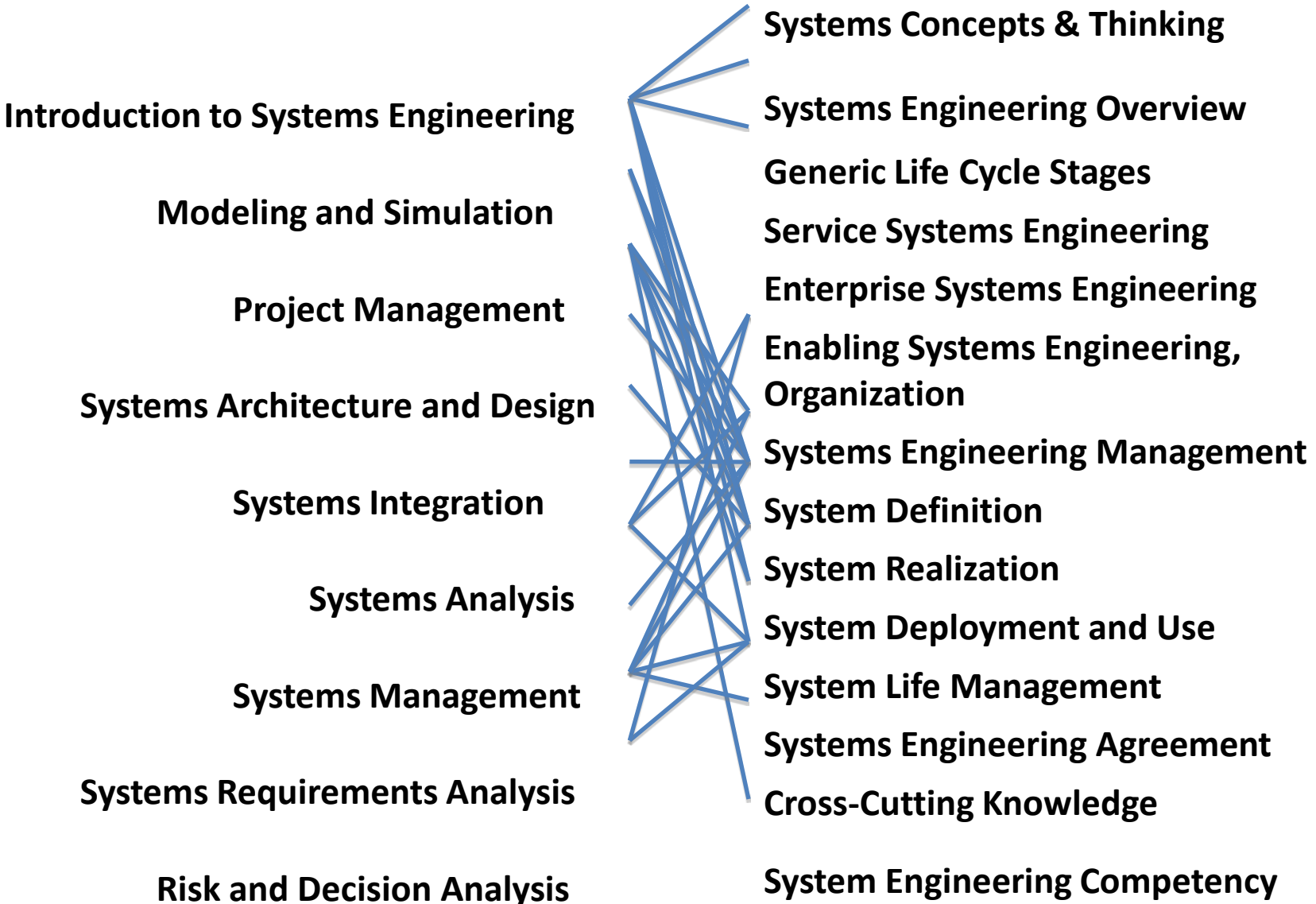
**Coverage in required and semi-required courses*

SEBOK coverage* in 2010 across 36 SE MS programs

Top 10 Courses Identified within the Program	
Introduction to Systems Engineering	56%
Modeling and Simulation	53%
Project Management	38%
Systems Architecture and Design	38%
Systems Integration	34%
Systems Analysis	25%
Systems Management	25%
Systems Requirements Analysis	25%
Risk and Decision Analysis	25%
Probability and Statistical Analysis	19%

**Coverage in required and semi-required courses*

SEBOK coverage* in 2010 across 36 SE MS programs



Industry & Government Needs

- Both GRCSE and GSwE2009 author teams include industry experts who could help identify areas requiring improvement
- OSD provided an overview of the gaps for both SwE and SE

A Common Approach

- Generic structure which provides:
  - recommendations as to student background upon program entry
  - a common set of foundational knowledge
  - a common framework for understanding the knowledge, skills, and abilities addressed by a program
- Neither curriculum prescribes exactly how a program should be structured

What does a Reference Curriculum cover?

- ***Guidance for Constructing and Maintaining the Reference Curriculum:*** the fundamental principles, assumptions, and context for the reference curriculum authors
- ***Objectives:*** *what a successful graduate should be able to contribute to a prospective employer within 2-3 years*
- ***Entrance Expectations:*** what students should be capable of and have experienced before they enter a graduate program
- ***Outcomes:*** what students should achieve by graduation, may vary depending on Objectives
- ***Architecture:*** the structure of a curriculum to accommodate core material, university-specific material, and elective material
- ***Core Body of Knowledge:*** material that all students should master in a graduate SE program, for different Objective/Outcomes

Phase 1 Graduate Software Engineering

1. Understand the current state of SwE graduate education (November 2007)
2. Create GSwE2009 0.25 (formerly GSwERC) with a small team, suitable for limited review (February 2008)
3. Publicize effort through conferences, papers, website, etc (continuous)
4. Create GSwE2009 0.50 (formerly GSwERC) suitable for broad community review and early adoption (October 2008)
5. Create GSwE2009 1.0 suitable for broad adoption (2009)
6. Transition stewardship to professional societies (2009)
7. Foster adoption world-wide (2009 and beyond)

Phase 1 Graduate Software Engineering

- Graduate Software Engineering 2009 (GSwE2009): Curriculum Guidelines for Graduate Degree Programs in Software Engineering

- GSwE2009 Companion Document: Comparisons of GSwE2009 to Current Master's Programs in Software Engineering

- GSwE2009 Companion Document: Frequently Asked Questions on Implementing GSwE2009

Endorsed by INCOSE, NDIA SE Division, Brazilian Computer Society

Originally sponsored by DoD. Now sponsored by the IEEE Computer Society and ACM

www.GSwE2009.org

GSwE2009 Release & Governance

- Version 1.0 was released to the international SwE community Sept. 30, 2009.
  - Delivered to US DoD OSD
  - Delivered to ACM EB, IEEE CS, INCOSE, and CAT
  - The document is available online at www.gswe2009.org/curriclum/recommendations/document.pdf
- **The ACM EB and IEEE CS have agreed to sponsor GSwE2009, and are now the GSwE2009 stewards**
- **INCOSE, the NDIA SE division, and the Brazilian Computer Society have endorsed GSwE2009**
- Author team is maintaining a small volunteer body to provide periodic updates of FAQ and comparisons materials with website support including forums, wikis, and other open collaboration structure.
- Implementation workshops at conferences, summer faculty workshops, and other activities would promote adoption. The CAT is currently seeking assistance from the NSF to support these workshops.

Phase 2 Graduate Systems Engineering (GRCSE)

- Unlike Software Engineering, Systems Engineering does not have an existing Body of Knowledge upon which a reference curriculum can be base.
- The Body of Knowledge and Curriculum Architecture for Systems Engineering (BKCASE) project will advance both BoK and Curriculum in parallel
- Even though the Department of Defense is the sponsor, it does not have any authority over the content of the products, nor are the products slanted towards defense systems development and acquisition
- A group of Volunteer authors do the bulk of the writing, and facilitate contribution and review from the wider community. A Core Team from Stevens and Naval Postgraduate School provide leadership, product integration, technical editing.

GRCSE Value Proposition

1. There is no authoritative source to guide universities in establishing the outcomes graduating students should achieve with a master's degree in SE, nor guidance on reasonable entrance expectations, curriculum architecture, or curriculum content.

2. This gap in guidance creates unnecessary inconsistency in student proficiency at graduation, makes it harder for students to select where to attend, and makes it harder for employers to evaluate prospective new graduates.

GRCSE is being created analogously to GSwE2009 – in fact, using GSwE2009 as the starting text

Version 0.25 expected in December 2010

GRCSE 0.25 Draft Contents

Title - Chapters
1. Introduction
2. Guidance for the construction and maintenance of GRCSE
3. Expected Objectives
4. Outcomes at Graduation
5. Expected student background
6. Curriculum architecture
7. Core body of knowledge (CorBOK)
8. Assessment
9. Anticipated GRCSE evolution

Title - Appendices
App A. Summary of Graduate SE-centric SE programs in 2010
App B. Bloom's taxonomy of educational objectives
App C. SE Competency Frameworks
App D. Assessment
References
Glossary
Index

Provides guidance on how to build a course, not specific courses.
Adaption and selective adoption expected and encouraged.

Similarities between GSwE2009 and GRCSE

- SE and SwE are distinct disciplines with rich body of knowledge, practice, and theory, drawing upon a common foundations from a wide variety of sources.
- Both SE & SwE curricula must appropriately recognize the inter-connections between them and other with science, management and engineering specialties, and make reference to appropriate Bodies of Knowledge in their own and related disciplines.
- The principal purpose of each is to provide tailorable recommendations for developing and improving curricula; NOT as a basis for accreditation.
- They are intended to be International in scope.
- Both describe professional degrees concentrated on enhancing the skills and knowledge of practicing systems engineers. They include some generic guidance on the expected skills and experience of students entering such a masters program.

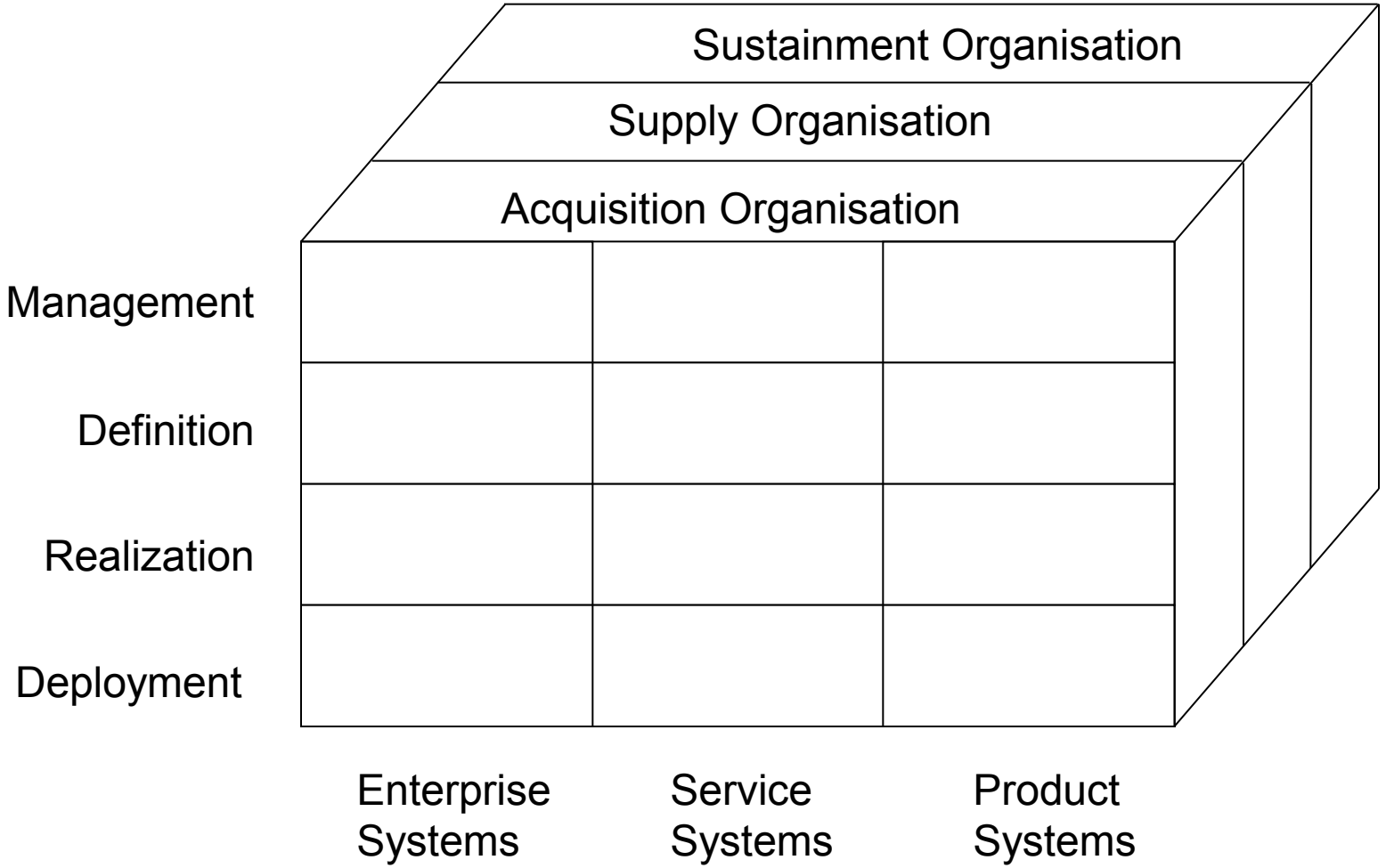
Similarities between GSwE2009 and GRCSE

- At the heart of each are the fundamental skills, attributes and knowledge that all graduates of SE/SWe masters degree program must possess, Blooms Taxonomy is used to identify appropriate levels of knowledge in different Knowledge Areas.
- These including technical and non technical skills, the application of both theory and practice and the ability to continue life long learning.
- Both go beyond expected knowledge to give a flexible architecture and significant guidance examples on how to build high quality programs.
- They attempt to respect the flexibility and uniqueness of existing programs and the need for university and domain specific content. Both cover the normal number of credits for a masters degree.
- They recognize the need to constantly review and update curriculum as both customer/student needs and knowledge and technology evolves.

Differences between GSwE2009 and GRCSE

- Systems Engineering has a very wide domain of application, often closely tied to domain practice, and can be used at many levels of an Enterprise.
- A section on Curriculum Objectives has been included in GRCSE to identify some of the roles Systems Engineering graduates might fulfill.
  - These roles will be defined by the type of Systems Engineering done and the kind of organization it is done in
  - Discussion of possible Systems Engineering Roles over page
- GRCSE provides guidance on the creation of Curricula for Professional Masters Programs. Thus it also will have Cognitive and Behavioural Outcomes to help produce Graduates able to conduct these roles within the extended enterprise.

Systems Engineering Roles: Influence on Objectives



Differences between GSwE2009 and GRCSE

- The current proposal (for GRCSE 0.25) is for a three levels of Knowledge/Outcomes:
  1. Core Knowledge, which all graduates must have
  2. Extended Core Knowledge, related to potential roles
  3. Elective or University Specific Knowledge
- Number 2 above is new to GRCSE, the exact roles and related Knowledge areas are still to be finalised.
- GRCSE will also tackle some of the wider education issues which GSwE2009 did not have time to consider

The curriculum author team

- Rick Adcock, Cranfield University and INCOSE representative, UK
- Edward Alef, General Motors, USA
- Bruce Amato, Department of Defense, USA
- Mark Ardis, Stevens Institute of Technology, USA
- Larry Bernstein, Stevens Institute of Technology, USA
- Barry Boehm, University of Southern California, USA
- Pierre Bourque, Ecole de Technologie Superieure and co-editor of 2010 SWEBOK update, Canada
- John Brackett, Boston University, USA
- Murray Cantor, IBM, USA
- Lillian Cassel, Villanova and ACM representative, USA
- Robert Edson, Analytic Services Inc., USA
- Richard Fairley, Colorado Technical University, USA
- Dennis Frailey, Raytheon and Southern Methodist University, USA
- Gary Hafen, Lockheed Martin and NDIA, USA
- Thomas Hilburn, Embry-Riddle Aeronautical University, USA
- Greg Hislop, Drexel University, and IEEE Computer Society representative, USA
- David Klappholz, Stevens Institute of Technology, USA
- Philippe Kruchten, University of British Columbia, Canada
- Phil Laplante, Pennsylvania State University, Great Valley, USA
- Qiaoyun (Liz) Li, Wuhan University, China
- Scott Lucero, Department of Defense, USA
- John McDermid, University of York, UK
- James McDonald, Monmouth University, USA
- Ernest McDuffie, National Coordination Office for NITRD, USA
- Bret Michael, Naval Postgraduate School, USA
- William Milam, Ford, USA
- Ken Nidiffer, Software Engineering Institute, USA
- Art Pyster, Stevens Institute of Technology, USA
- Paul Robitaille, Lockheed Martin, USA
- Mary Shaw, Carnegie Mellon University, USA
- Sarah Sheard, Third Millenium Systems, USA
- Robert Suritis, IBM, USA
- Massood Towhidnejad, Embry-Riddle Aeronautical University, USA
- Richard Thayer, California State University at Sacramento, USA
- J. Barrie Thompson, University of Sunderland, UK
- Guilherme Travassos, COPPE/Federal University of Rio de Janeiro, Brazil
- Richard Turner, Stevens Institute of Technology, USA
- Joseph Urban, Texas Tech University, USA
- Ricardo Valerdi, MIT & INCOSE, USA
- David Weiss, Avaya, USA
- Mary Jane Willshire, Colorado Technical University, USA

BKCASE Author Team

- Rick Adcock, Cranfield University, UK
- Erik Aslaksen, Sinclair Knight Merz, UK
- John Baras, University of Maryland, US
- Richard Beasley, Rolls Royce, UK
- Barry Boehm, University of Southern California, US
- John Brackett, University of Boston, US
- Aaron Eng, Seng Chia National University of Singapore in Singapore
- Edmund Conrow, Management and Technology Associates, US
- Paul Croll, CSC, US
- Cihan Dagli, Missouri University of Science and Technology, US
- Heidi Davidz, UTC Pratt & Whitney, US
- Joseph J. Ekstrom, Brigham Young University, US
- Marcia Enos, Lockheed Martin, US
- Dick Fairley, International Electronics and Electrical Engineering(IEEE)
- Alain Faisandier, Association Francaise d'lingeniere Systeme in France
- Tim Ferris, University of South Australia in Australia
- Kevin Forsberg, Center for Systems Management, US
- G. Richard Freeman, Air Force Institute of Technology, US
- Sanford Friedenthal, Lockheed Martin, US
- Richard Frost, General Motors Corporation, US
- Brian Gallagher, Northrup Grumman, US
- Edward Ghafari, ICES Corporation, US
- Tom Hilburn, Embry-Riddle Aeronautical University, US
- Nicole Hutchison, Stevens Institute of Technology, US
- Scott Jackson, University of Southern California, US
- Ken Kepchar, Federal Aviation Administration, US
- Naohiko Kohtake, KEIO University in Japan
- Mike Krueger, ASE Consulting, US
- Harold "Bud" Lawson, Lawson Konsult AB in Sweden
- Yeaw lip "Alex" Lee, Defence Science and Technology Agency in Singapore
- Ray Madachy, Naval Postgraduate School, US
- James Martin, Aerospace Corporation, US
- Greg Mayhew, The Boeing Company, US
- Andrew McGettrick, Association for Computing Machinery, US
- Ken NiDiffer, Software Engineering Institute, US
- Dave Olwell, Naval Postgraduate School, US
- Daniel Prun, Ecole Nationale de l'Aviation Civile (ENAC) in France
- Art Pyster, Stevens Institute of Technology, US
- Garry Roedler, Lockheed Martin, US
- Jean-Claude Roussel, EADS in France
- Sven-Olaf SchulzeBerner & Mattner in Germany
- Seiko Shiraska, KEIO University in Japan
- Hillary Sillitto, Thales Group, UK
- John Snoderly, Defense Acquisition University, US
- Alice Squires, Stevens Institute of Technology, US
- Massood Towhidnejad, Embry-Riddle Aeronautical University, US
- Guilherme Horta Travassos, Federal University of Rio de Janeiro (UFRJ) in Brazil
- Mary VanLeer, Arkansas Scholarship Lottery, US
- Qing Wang, Institute of Software Chinese Academy of Sciences in China
- Brian Wells, Raytheon, US

Questions?

- For more information on GSwE2009, see: www.gswe2009.org

- For more information on GRCSE, see: www.bkcase.org

Contact information:

Nicole Hutchison
Staff Researcher, Systems Engineering Research Center
Stevens Institute of Technology
nicole.hutchison@stevens.edu

Overview Information in 2010 across 36 SE MS programs

Program Focus	
General Systems Focus; Systems Engineering; Systems Architecture; Systems Design; Systems Management	66%
Domain Specific	34%
Requirements for Admission	
Accepted Undergraduate Degrees in one or more of the following areas	
Engineering	88%
Science/Physics/Mathematics	81%
Other	30%
Under Graduate Performance	
Average GPA 3.0	60%
No Requirement	28%
No Response	12%
Related Work Experience	
Average 3 years	40%
No Requirement	44%
Company Sponsored	16%

Curriculum for the Life Cycle of the Systems Engineer

Carlee A. Bishop, PhD and Tommer R. Ender, PhD

Georgia Tech Research Institute

400 10th St., N.W., Atlanta, GA 30332

13th Annual Systems Engineering Conference

October 25-28, 2010

Overview

- The Need and Development
- The Life Cycle of the Systems Engineer
- Georgia Tech's Contribution to the Life Cycle
- Mentoring

The Need

- *"The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and the defense industry"*

  (Top 5 Systems Engineering Issues - NDIA 2006)
- *"We have jobs going begging in systems engineering right now."* (Boeing)

  (ICPA Market Study - Georgia Tech 2005*)
- *"Every company is short of systems engineers. Really good systems engineers are worth their weight in gold."* (Raytheon)

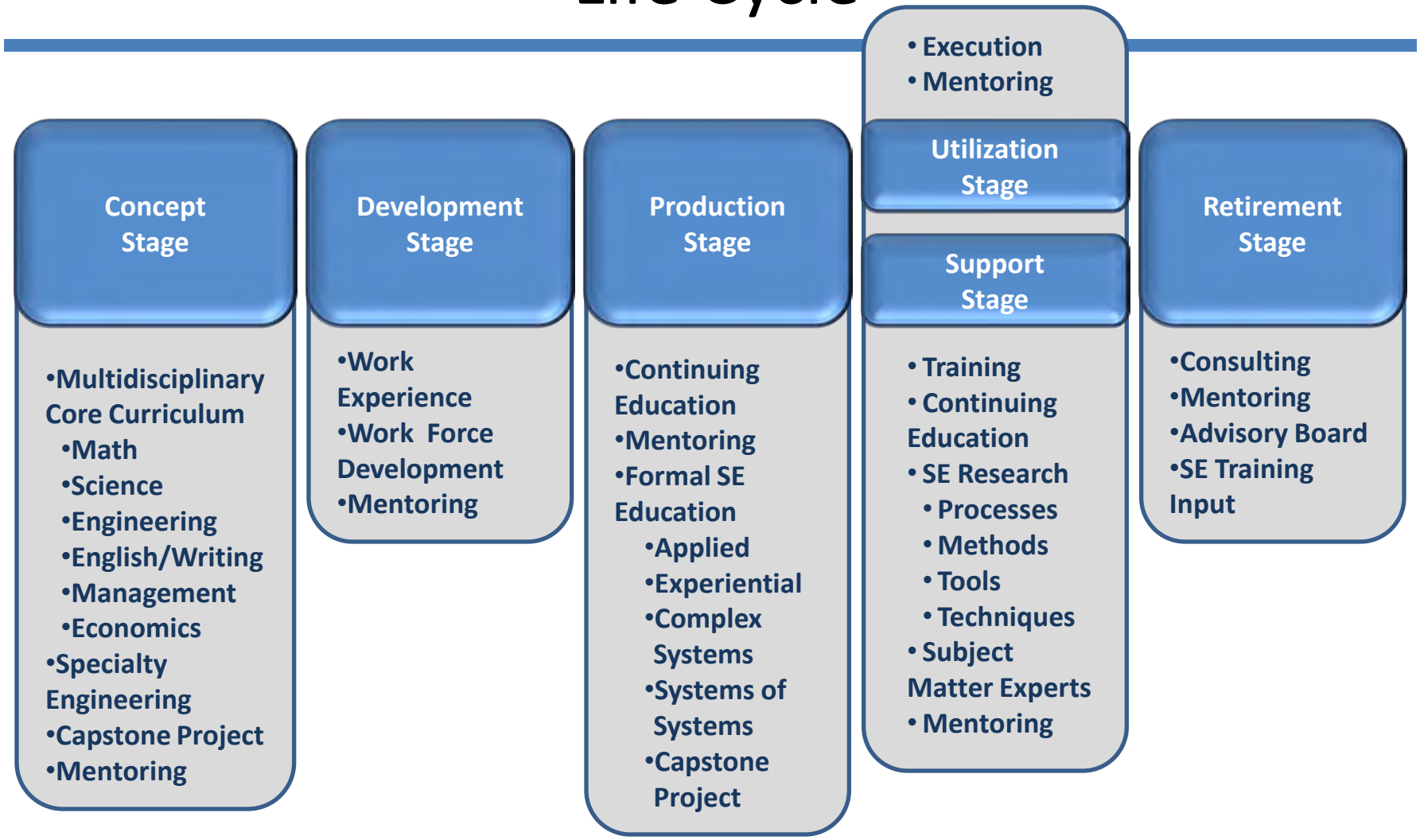
  (ICPA Market Study - Georgia Tech 2005*)

* >2400 respondents

The Development

- **Life Cycle Approach**
  - Systems engineering stresses a focus on the life cycle of a system
  - Training/educational programs must address the entire life cycle of the systems ENGINEER
- **Holistic Approach Proposed**
  - Purposeful development of the systems engineer from early undergraduate education through retirement
  - Employment of programmed activities at each stage of their career

The System Engineer Life Cycle



Georgia Tech's SE Lifecycle Contribution

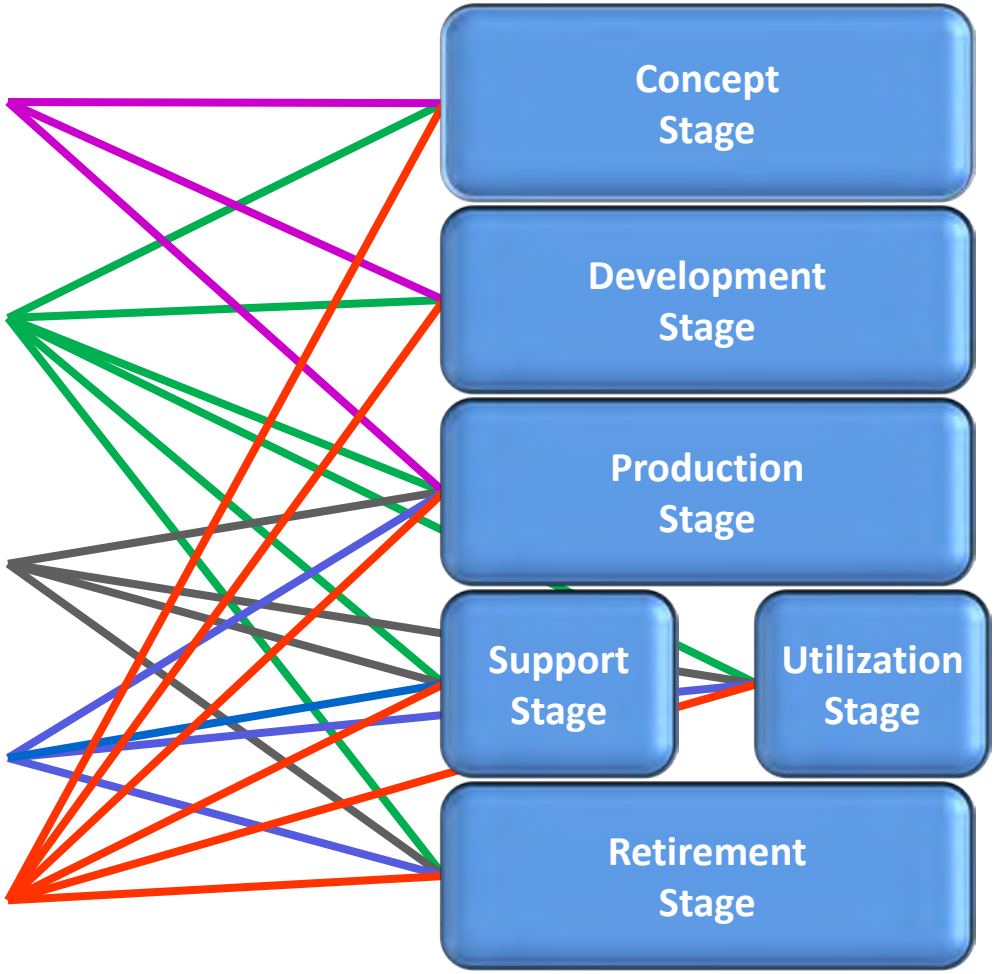
Undergraduate Engineering Programs

Systems Engineering Education Initiative

Systems Engineering Research

Consulting

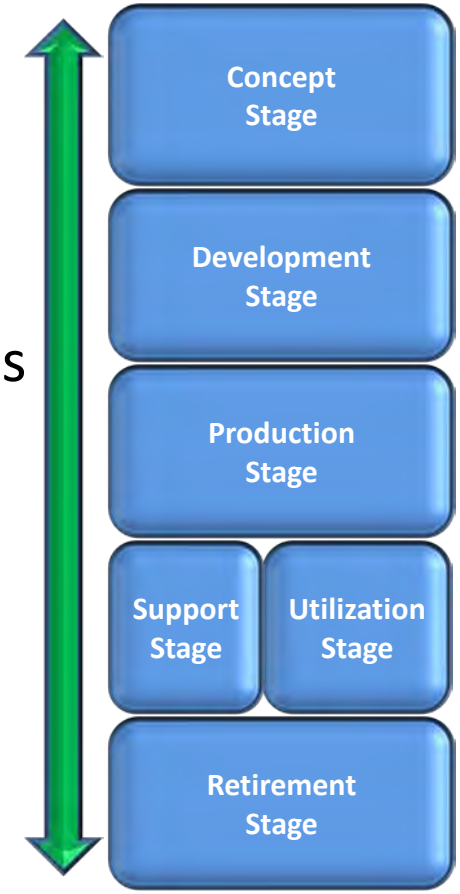
Mentoring



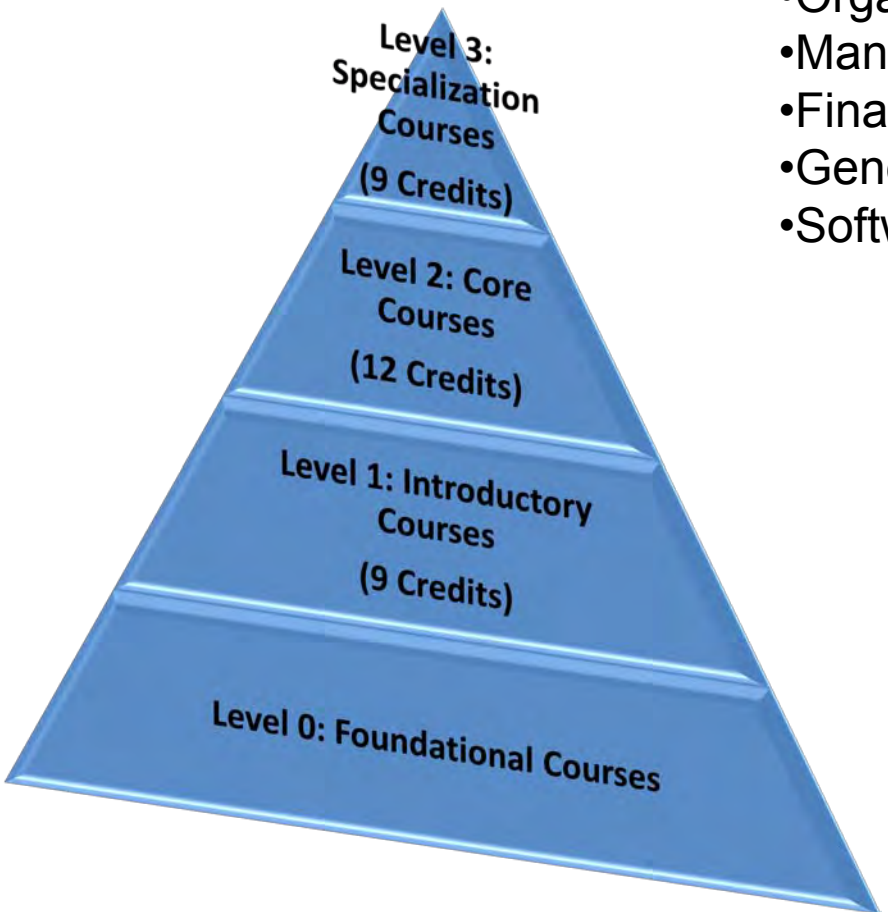
The SE Education Initiative

- Systems Engineering Research
  - Processes, Methods, Tools, Techniques
- Continuing Education
  - Short courses, Certificates, Custom programs
- Formal Systems Engineering Education
  - Professional Masters in Applied Systems Engineering (PMASE)

Life Long Learning Opportunities



INCOSE Reference Curriculum (2007)



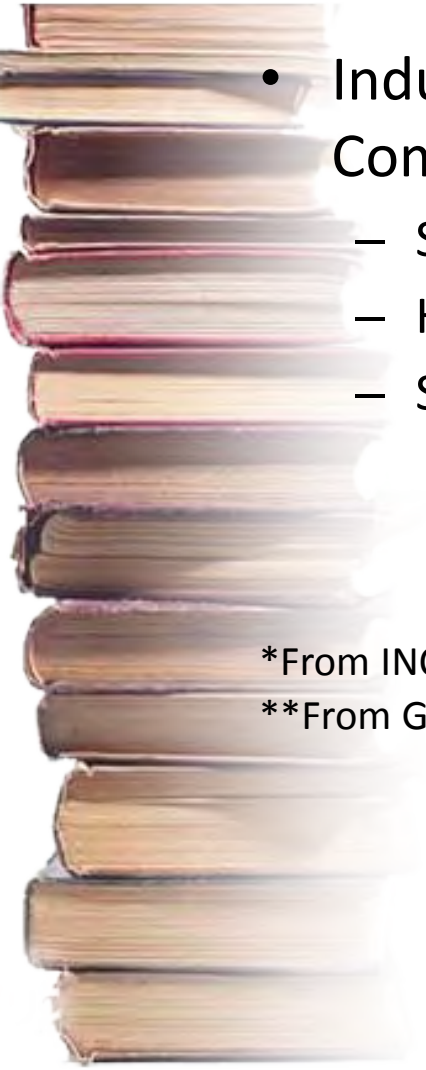
- Masters Project or Seminar
- Engineering Ethics & Legal Considerations
- Organizational Leadership
- Manufacturing, Production, & Operations
- Finance, Economics & Cost Est
- General Proj Mgt
- Software SE

- Decisions, Risks and Uncertainty
- Modeling, Simulation & Optimization
- Quality, Safety, & Systems Suitability
- System Integration & Test
- Systems Design & Analysis

- Intro to SE Mgt
- Fundamentals of SE

- Probability & Statistics
- General Mathematics

Stakeholder Inputs to Curriculum



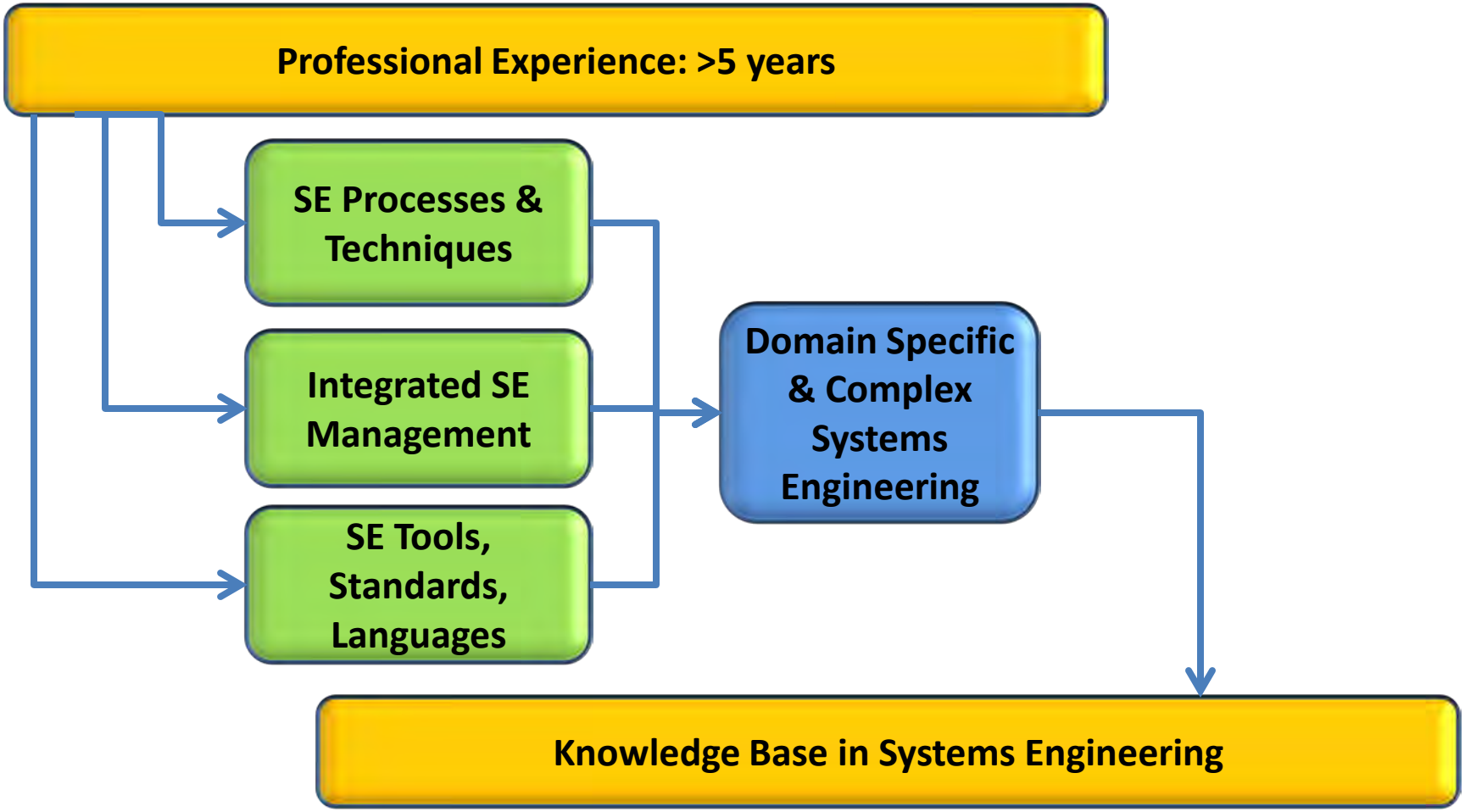
- Industry Required Competencies*
  - Systems Thinking
  - Holistic Life Cycle View
  - SE Management

*From INCOSE Reference Curriculum 2007

**From GT ICPA Market Study 2005

- Curriculum Interest**
  - Workplace applications
  - Interdisciplinary approach
  - System of systems oriented
- Domain Applications
- Core Courses
  - Systems Engineering Principles
  - Technical Program Management
  - System Modeling, Design, and Optimization
- Strong interest in:
  - Supply chain mgt / Logistics
  - Software
  - Business mgt
  - Information Systems
  - Integrated Engineering Design

The PMASE Program



The PMASE Curriculum

Core Curriculum

ASE 6001: Fund in Modern SE

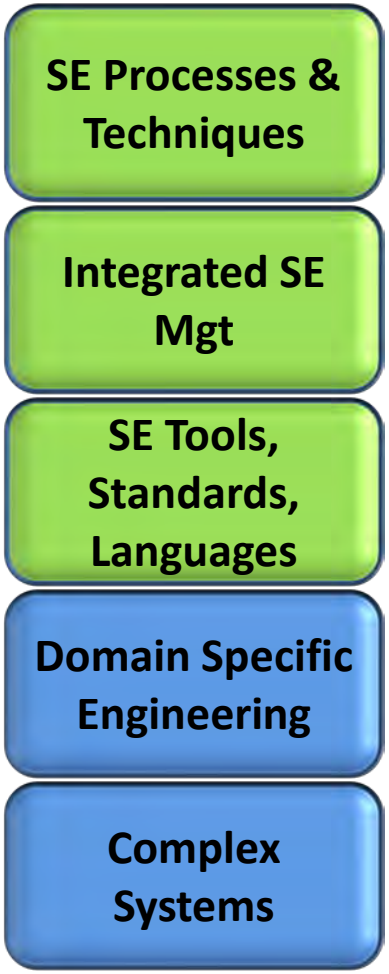
ASE 6002: Sys Design & Analysis

ASE 6003: M&S for SE

ASE 6004: Leading SE Teams

ASE 60X5: Advanced Topics in SE
- SysML
- HSI

ASE 6006: SE Lab



Complex Systems Curriculum

ASE 61X1: Domain Elective in Synthesis & Analysis
- Vehicles
- Sensors
- Info Systems
- HSI

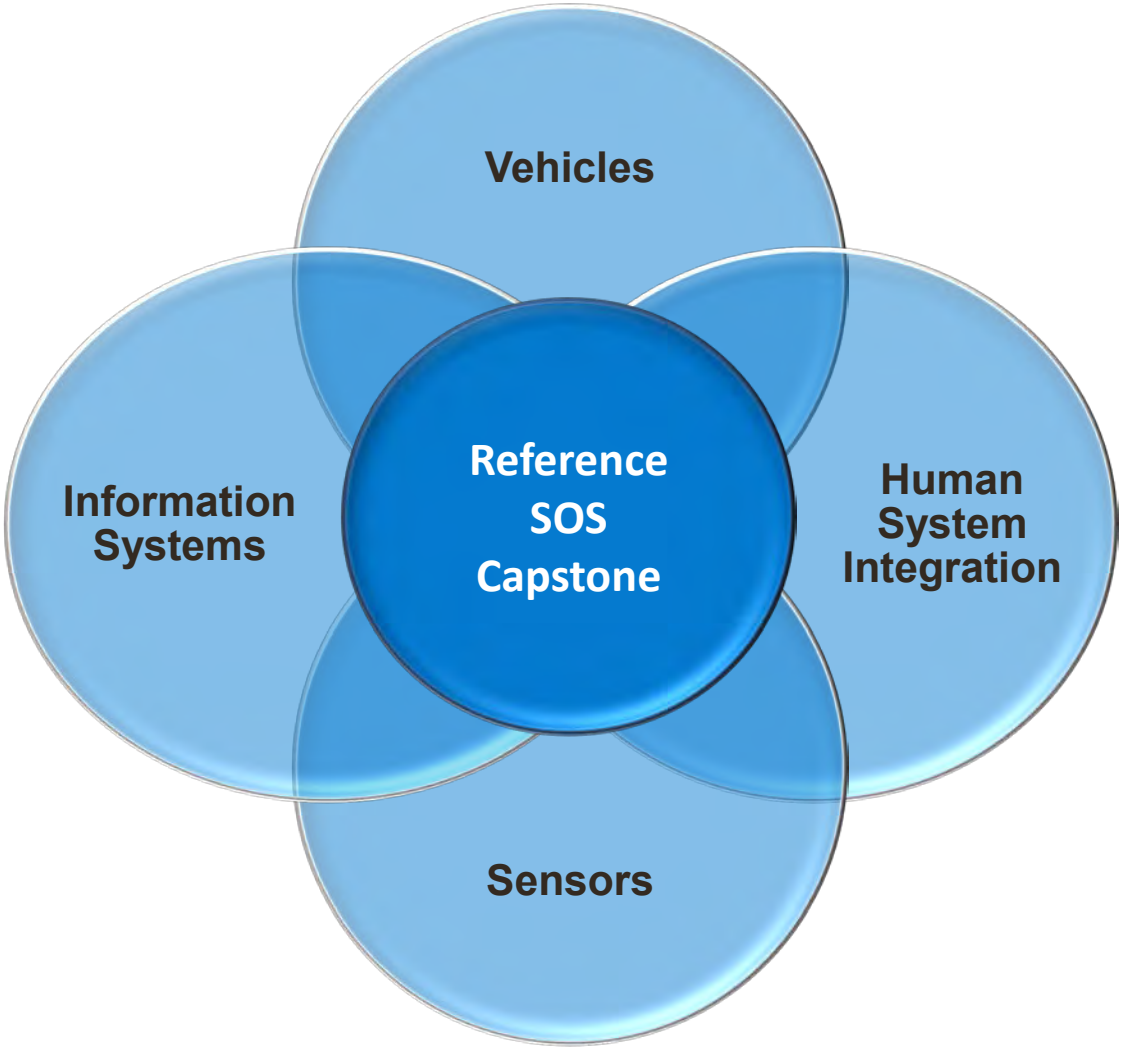
ASE 6102: SOS & Architectures

ASE 6103: Lifecycle & Integration

ASE 6104: Complex Systems Capstone

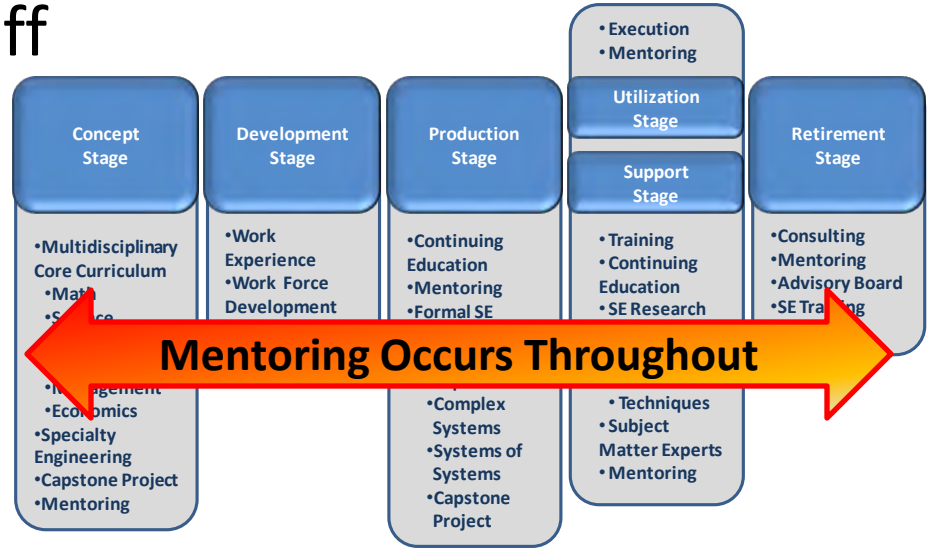
Complex System Capstone Project Development

- **Capstone course** in lieu of MS thesis
- Project developed through integration of **domain elective** courses
- Complex system carried through the SE lifecycle process

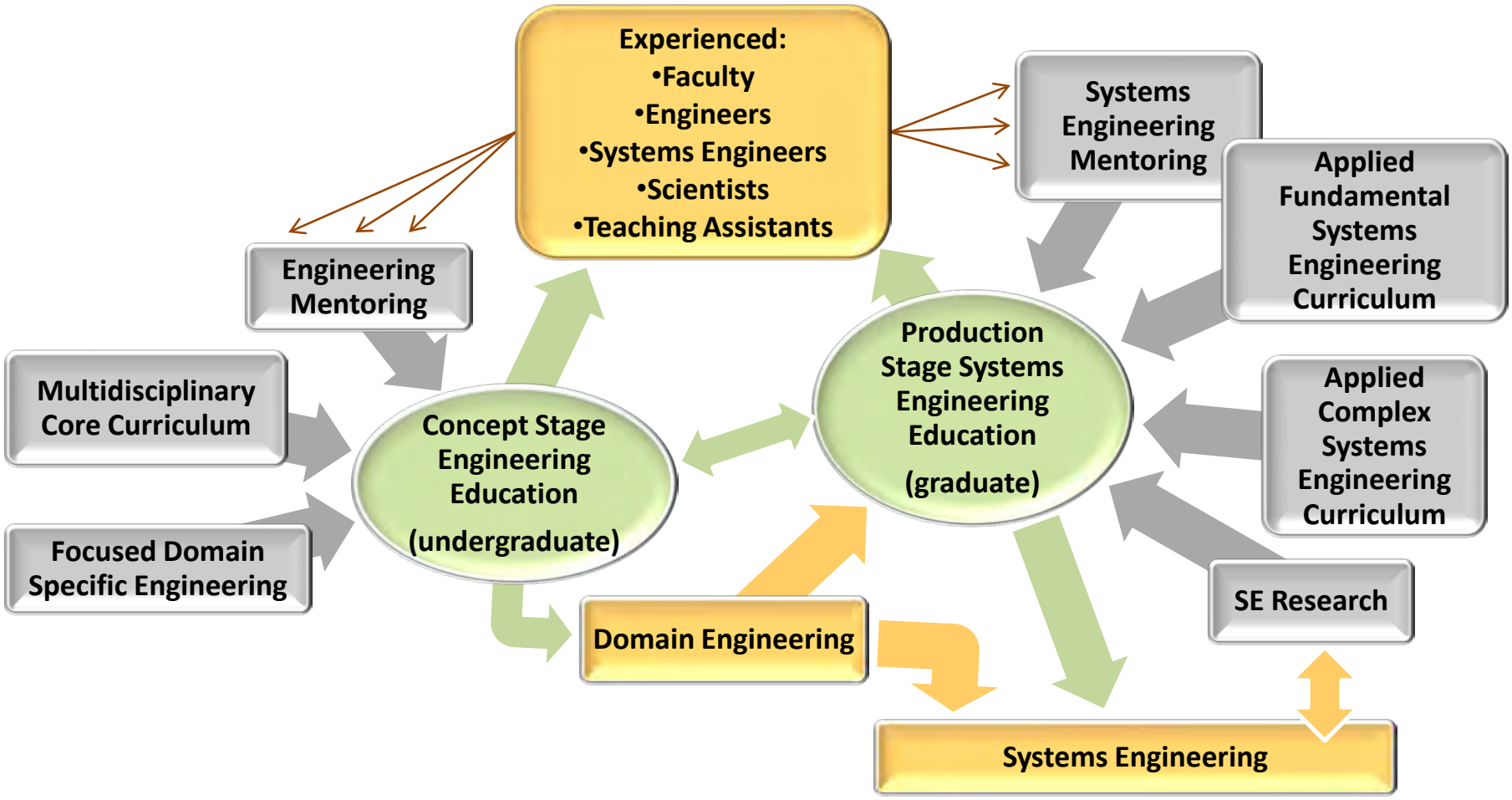


Mentoring Throughout the SE Lifecycle

- **Formal Mentoring**
  - Instructors / Faculty / Staff
  - Industry Participants
  - Researchers
- **Informal Mentoring**
  - Teaching Assistants
  - Graduate Research Assistants
  - Students from previous classes
  - Students in current class



Interaction Between Life Cycle Stages



Conclusions and Wrap Up

- The development of an effective systems engineer is…
  - a multifaceted and multi-disciplinary process conducted throughout the entire career of the engineer.
  - accomplished by developing the engineer according a ‘systems engineer’ lifecycle.
  - developed through distinct stages which result in the completion of major milestones.

- The GT Systems Engineering Initiative addresses the entire life cycle of the Systems Engineer

Questions/Comments

Carlee A. Bishop, PhD

Georgia Tech Research Institute

400 10th St., N.W.

Atlanta, GA 30332-0840

carlee.bishop@gtri.gatech.edu

Tommer R. Ender, PhD

Georgia Tech Research Institute

400 10th St., N.W.

Atlanta, GA 30332-0840

tommer.ender@gtri.gatech.edu

Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development

13th Annual NDIA Systems Engineering Conference
27 October 2010

Cecil Whitfield
PMS 420 Technical Director
cecil.whitfield@navy.mil

Richard Volkert
PMS 420 Deputy Technical Director
SPAWAR Systems Center Pacific
richard.volkert@navy.mil

Carly Jackson
PMS 420 Systems Engineer
SPAWAR Systems Center Pacific
carly.jackson@navy.mil

NDIA Systems Engineering Conference, 25 – 28 Oct 2010
Paper Reference Number: 11445
Session: Workforce Development Mission III

Statement A: Approved for Public Release, Distribution is Unlimited

Overview

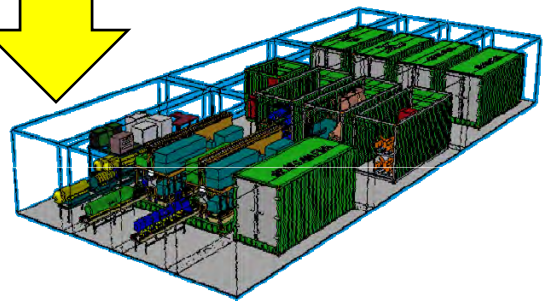
- Mission Module Definition, History, & Status
- Acquisition Approach
- Rapid Prototyping and other Advantages
- Transitioning to Production
- Lessons Learned
- Summary

Statement A: Approved for Public Release, Distribution is Unlimited

Littoral Combat Ship (LCS)

- **Optimized for warfighting in the littorals**
  - Unique designs for unique environment
  - Fast, maneuverable, shallow draft
- **Targeted at critical capability gaps**
  - Reconfigurable single-mission focus
  - Mines; small fast surface craft; diesel submarines
- **Modular Open Systems Architecture approach**
  - Flexible system for dynamic battlespace
  - Advanced unmanned air, surface, and underwater vehicles
  - Onboard sensors, weapons, command and control
- **Naval and Joint Force multiplier**
  - Operational flexibility for sea superiority and assured access
  - Integral member of future surface combatant family of ships
  - Fully netted with the battle force

Littoral Combat Ship Interface Control Document



Navy Need: small, fast delivery vehicle with integrated focused mission package

Statement A: Approved for Public Release, Distribution is Unlimited

Mission Packages Defined

MISSION MODULE
LCS MM Program - PMS 420

\+

CREW & SUPPORT AIRCRAFT

=

MISSION PACKAGE

Mission Systems + Support Equipment

Vehicles
- RMMV
- USV

Weapons
- 30MM Gun
- AMNS
- SSMM

Sensors
- ALMDS
- AQS-20A
- COBRA

Support Containers
Support Equipment
Standard Interfaces

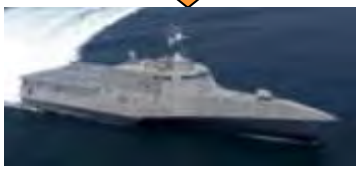
MPCE / MVCS Software

MPCE / MVCS Hardware

VTUAV

Crew Detachments
- Mission Modules
- Aviation

MH-60S

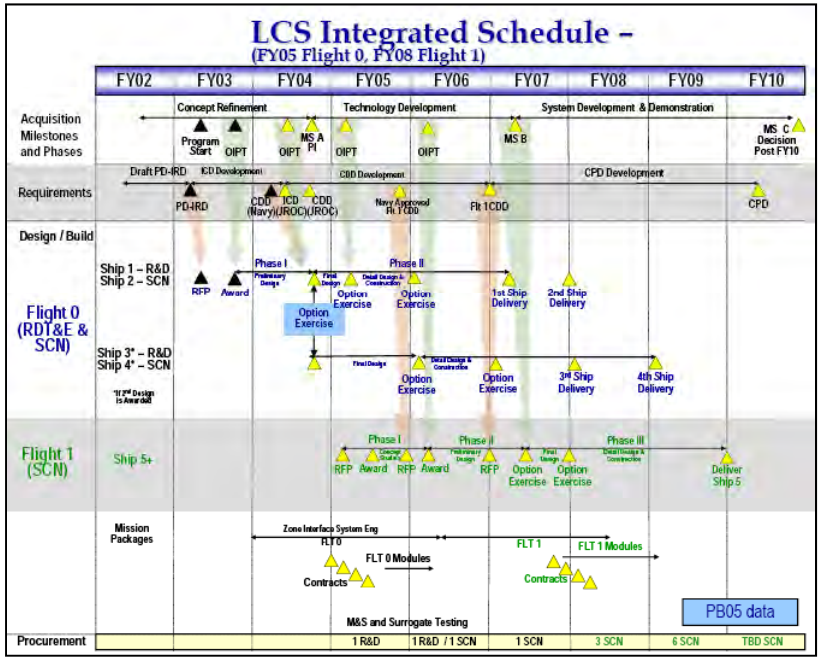


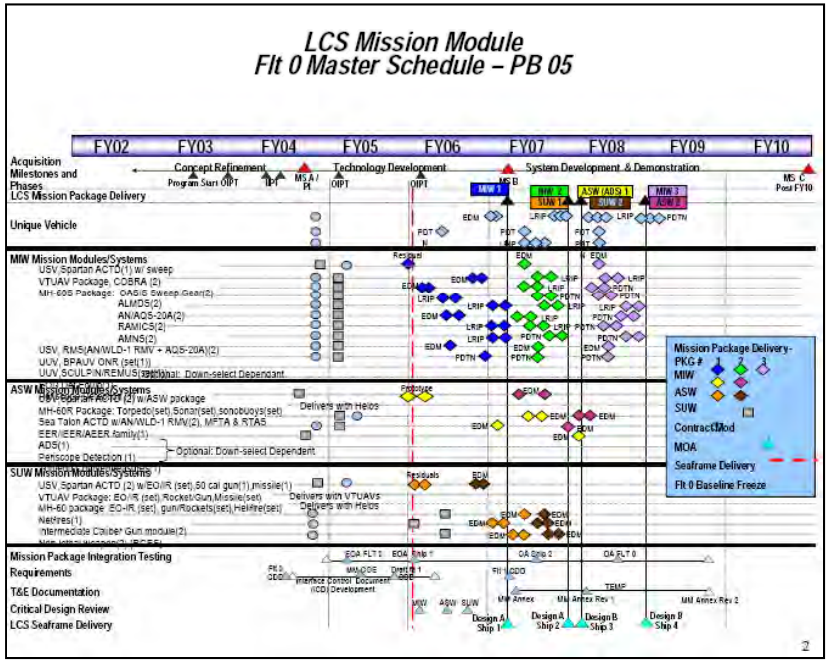
MPAS – Mission Package Application Software MPCE – Mission Package Computing Environment MVCS – Multi Vehicle Communication System

Statement A: Approved for Public Release, Distribution is Unlimited

Original Schedule – Experiment to Production

- **LCS Program Began with a Very Aggressive Approach to Seaframe and MP acquisition –** '04 MS A, '07 MS B, '10 MS C, 5th Flt 0 ship delivered in '09, first 5 Flt 1 ship deliveries in '08-'09, etc.
- **Flight 0 was to be an experimental Seaframe to explore the LCS concept, production needs were to be defined / developed in Flight 1** – initial experimental designs were pushed into production with more contractor furnished equipment (CFE) than any other Navy ship.
- **MPs were designed around a come as you are approach with an overly optimistic assumption of Mission System technology maturity** – e.g. system delays have pushed delivery of Flt 0+ capability from '07-'08 to '16 for MCM.





Statement A: Approved for Public Release, Distribution is Unlimited

LCS and MP Timeline Challenge

Milestones
System Deliveries/ Deployments
Specification/ Requirements Changes

2002
- Feb 02 – PMS 501 (PEO SHIPS) established

2003
- Mar 03 – PMS 420 (PEO LMW) established

2004
- Jan 04 – LCS Initial Capabilities Document
- May 04 – LCS Program Milestone (MS) A

2005
- May 04 – LCS Flt 0 CDD
- 05 – Sea Fighter enters service as an experimental littoral ship with modular capability
- Jul 05 – LCS Flt 0 BL 1.1 ICD

2006
- Oct 05 – LCS Flt 0 BL 1.2 ICD

- Sep 06 – LCS 1 Christening

2007
- Sep 07 – MCM MP 1 Delivery

2008
- Jun 08 – LCS Flt 0+ CDD
- Jul 08 – SUW MP 1 Delivery

- Dec 08 – LCS Program MS A Prime
- Sep 08 – ASW MP 1 Delivery
- Oct 08 – LCS 2 Christening

2009
- Dec 09 – LCS Flt 0 BL Rev A 1.2 ICD
- Aug 09 – MCM MP 2 Delivery

2010
- Feb 10 – LCS 1/SUW MP 1 Early Deployment
- Mar 10 – SUW MP 2 Delivery

2011
- Oct 10 – LCS Program MS B
- ... Mission Packages will achieve Flt 0+ Full Capability in:
  - MCM MP 7 (2016)
  - SUW MP 5 (2014)
  - ASW Spiral Bravo (TBD)
- Jul 11/12 – Mission Modules MS B/C

Statement A: Approved for Public Release, Distribution is Unlimited

PMS 420 Acquisition Approach Relies Heavily on using Navy Warfare Centers as Lead System Integrators (LSIs)

Participating Acquisition Resource Managers (PARMs):

Surface Warfare (SUW)	Mine Countermeasures (MCM)	Anti-Submarine Warfare (ASW)
PMS 420	PMS 495	PMS 420
PMA 266	PMA 266	PMA 266
PMA 299	PMS 406	PMS 406
	PMA 299	PMA 299
	PMS 403	

Warfare Centers are MP Lead System Integrators, and will assume TDA roles post MP development:

Surface Warfare (SUW)	Mine Countermeasures (MCM)	Anti-Submarine Warfare (ASW)
NAVSEA WARFARE CENTERS NSWC Dahlgren	NAVSEA WARFARE CENTERS NSWC Panama City	NAVSEA WARFARE CENTERS NUWC Newport
		SPAWAR Systems Center PACIFIC

Production and integration is handed off to Northrop Grumman for LRIP:

NORTHROP GRUMMAN

Statement A: Approved for Public Release, Distribution is Unlimited

Warfare Centers are Able to Rapidly Mature Prototype Concepts and Support Transition to Production via Existing Contract Vehicles

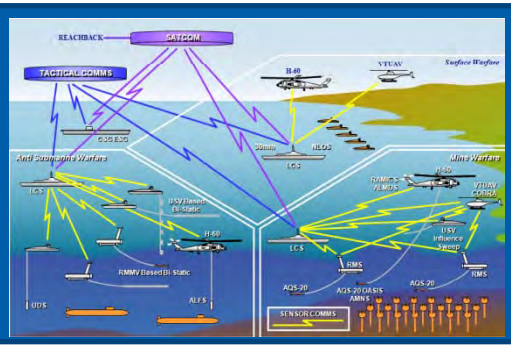
Statement A: Approved for Public Release, Distribution is Unlimited

Contract Modifications are not necessary for Warfare Centers to Implement Innovative Solutions

The "come as you are" approach baselined the ADS Mission Module Radio, however this solution went away when the Advanced Deployable System (ADS) was terminated.

SSC Pacific helped to initiate an SBIR for a Net-Centric Comms in FY04, which evolved into...

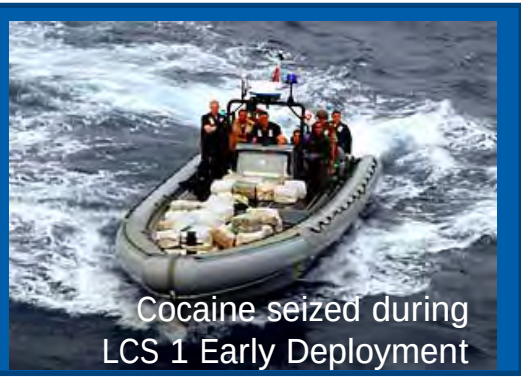
... the RT-1944/U a networked radio solution – ***a critical enabler of the LCS MM Concept.***



The Maritime Security Module was added to the SUW MP in Jun '08. NSWC DD and SSC Pacific answered the call, designing and building a prototype MSM for the LCS 1 Early Deployment (Feb '10).

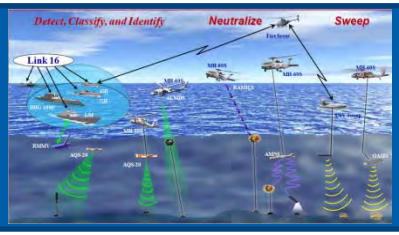
VBSS

Berthing


Cocaine seized during LCS 1 Early Deployment

NSWC PC is working to develop experimental tactics, such as the "pruning" technique to achieve minehunting KPPs.

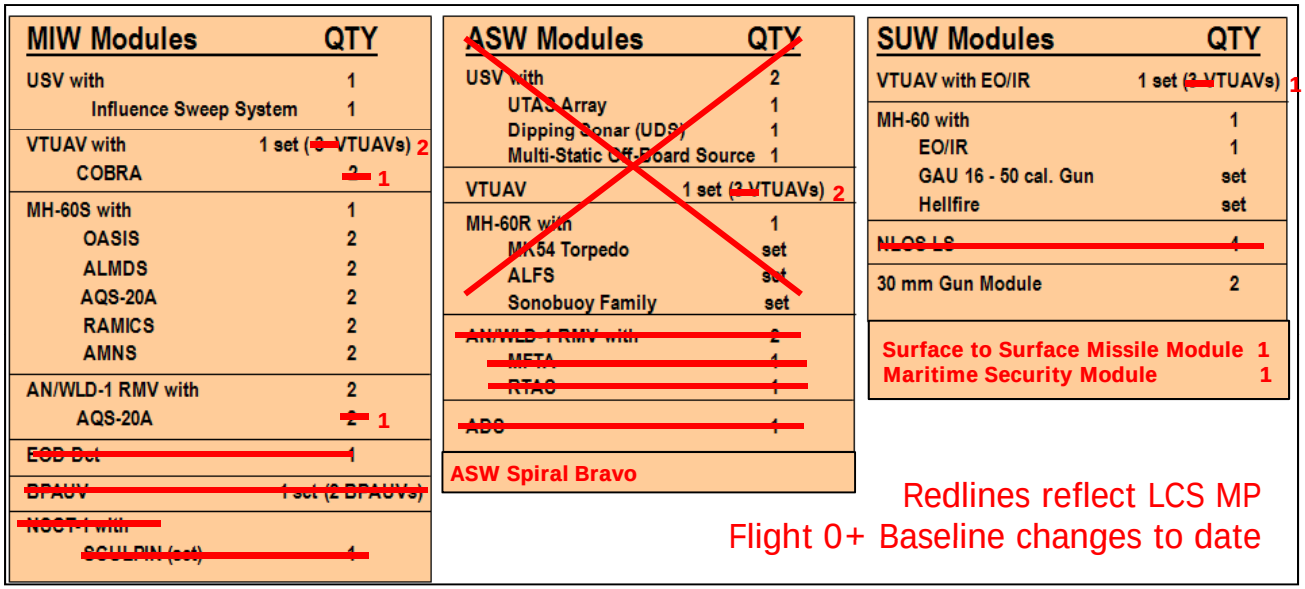
Using existing systems in different ways to improve performance without major system upgrades or modifications.



Statement A: Approved for Public Release, Distribution is Unlimited

Navy Warfare Centers are suited to meet the Aggressive MP Development Schedule and Respond to Changing Requirements

LCS MP Flight 0+ Baseline (circa 2005):



	Pros:	Cons:
Warfare centers are not bound by contracts, less formal "funding documents" are used to define tasks.	Labs can adjust early and often to design changes with less cost/ schedule impact.	Less accountability, scrutiny, insight into delivered products.
Design Expertise	Labs are experienced with rapid prototyping and can leverage existing contracting mechanisms, facilities, etc.	Lab designs are not production-ready. Engineering drawings are delivered to Industry with red, green, and blue lines.

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Implement Commonality Amongst Disperse Product Lines

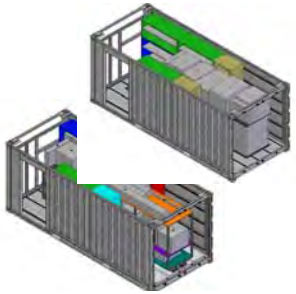
Mission Package Computing Environment (MPCE) H

MPCE provides local IT infrastructure and interfaces with the TSCE on the seaframe.

Multi-Vehicle Communication System (MVCS) HW/SW

MVCS establishes a common interface for UxV data links and network comm services.

Aviation Support Containers



Common Aviation SCs across MPs

Common Cradle

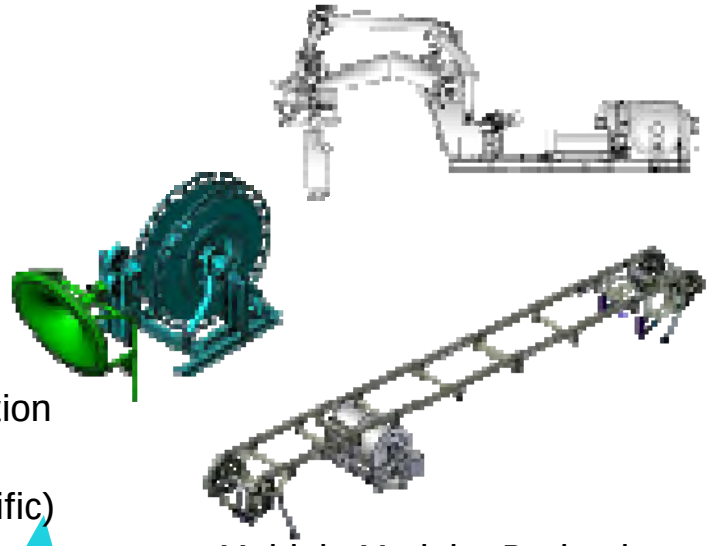
Adjustable support frames to interface with ASW USV (tri-hull) and MCM USV (monohull) and Navy Standard 11-m RHIB

- Three separate capability areas would typically be administered via 3+ separate contracts.
- Using the Warfare Centers as LSIs gives the freedom to implement commonality without multiple contract modifications.

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Contract Vehicles Enable Rapid Prototyping

- ASW MP System Performance Specification
- ASW USV SSS
- BAA (SSC Pacific)
- Source Selection
- Contract Award



Multiple Modular Payloads

Systems Engineering must be rigorous to support Rapid Development AND the Transition to Production:

- Contract Vehicles must be in place to enable Rapid Prototyping.
- System/Sub-system Specification Documents must be fully developed.
- The USV needed to support multiple, modular, payloads, the LSI must actively manage the interfaces well and constantly.

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Elegant Engineering vice Producibility
A Tale of Two Aviation Support Container Designs

Base Support Container:

MH-60S (MCM) Support Containers:

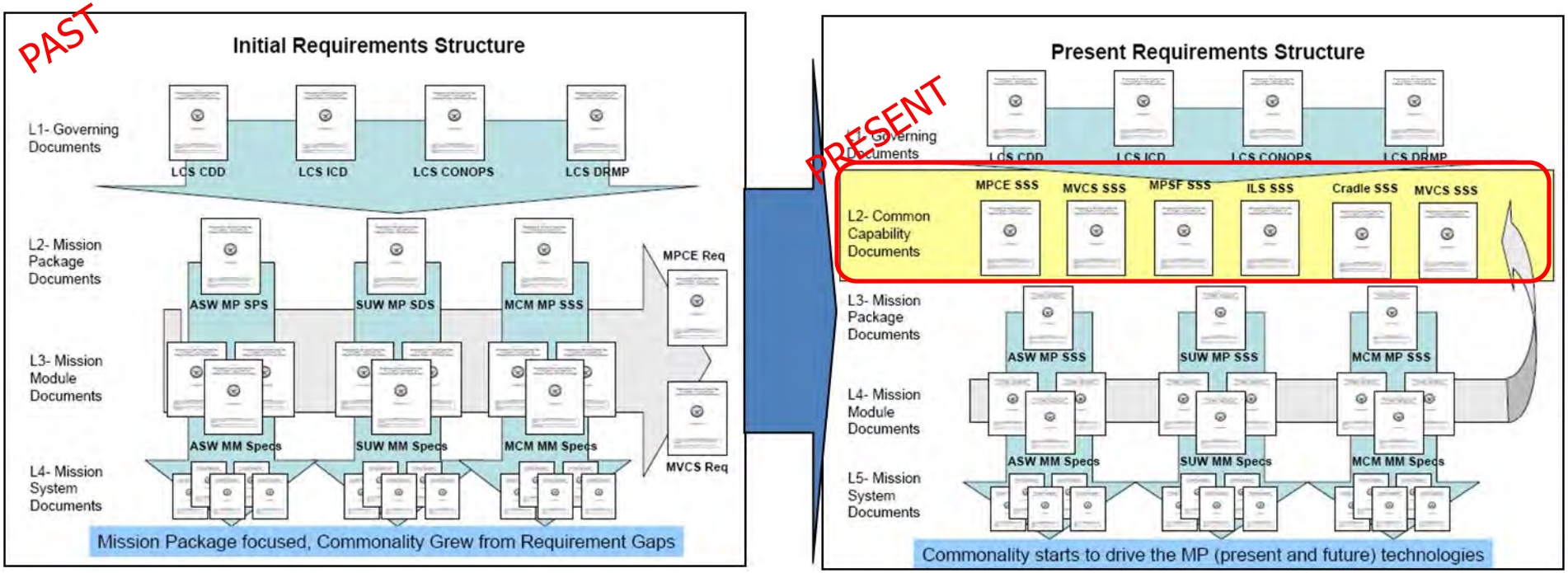
- **Automated, mechanized shelving**
- **External access to heavy items**

MH-60R (ASW) Support Containers:

- **Open Shelf Design**
- **Reconfigurable Shelving**
- **Low Maintenance → Low LCC ($)!!**

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Implement Effective Requirements Management and Drive Towards Commonality Early in the Design Process



- Establishment of a Cross Organization Requirements Database
- Enforced CM process involving all SE stakeholders
- Implementation of a Cultural Change towards Common Solutions

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Define and Control the Technical and Processes from the Start

- Requirements Management
  - **Originally Bottom Up:** Each warfare center developed separate Specification documents (one each a SRS, SPS, SSS) with little to no coordination or commonality
  - **Morphing into Top Down:** Level II Spec documents are developed. Each warfare center is reworking their Specification documents into a SSS in accordance with a DID.
- Systems Engineering
  - Define SE process up front and implement (ESOH, Safety, CM, IA, etc.)
  - Each warfare center used their local expertise and business rules to implement ESOH, Safety, CM, and IA for the prototype Mission Packages.
    - e.g. Each warfare center developed separate Systems Engineering Plans. PMS 420 recently developed an overarching SEP document, providing coordinated guidance and alleviating the warfare centers need to produce separate documents.
  - As PMS 420 enters T&E phases and nears production phases, PMS 420 had to define and implement up a centralized ESOH, Safety, CM , and IA processes, many of which are still maturing.

Statement A: Approved for Public Release, Distribution is Unlimited

Lessons Learned: Prepare for the Transition to Production

- Define CM processes up front and implement.
  - If left uncoordinated, Warfare Centers will use local business rules to develop separate Configuration Management Plans and Databases.
    - As PMS 420 enters T&E phases and nears production phases, PMS 420 defined and implemented up a centralized CM processes, providing coordinated guidance/repository and alleviating the warfare centers need to produce separate documents/ maintain separate databases.
  - Engineering drawings are delivered from warfare centers with red, blue, and green lines.
    - Significant rework is needed to rework the drawings into production-ready products and to represent the as-built configurations.
- System/Sub-system Specification Documents must be fully developed.
  - Typically the only technical document provided to system developers – part of the SOWs.

Statement A: Approved for Public Release, Distribution is Unlimited

Summary: Lessons Learned

- Implement Commonality Across Disperse Product Lines
  - Reduces cost and schedule
- Contract Vehicles Must be in Place to Enable Rapid Prototyping
  - Warfare centers
- Motivate Labs to Design toward Producible Designs – Minimizes Redesign
- Implement Effective Requirements Management and Drive Towards Commonality Early in the Design Process
  - Establishment of a Cross Organization Requirements Database
  - Enforced CM process involving all SE stakeholders
  - Implementation of a Cultural Change towards Common Solutions
- Define and Control the Technical and Processes from the Start
  - Implement Effective Requirements Management
  - Define and Implement Common SE Processes up front

Statement A: Approved for Public Release, Distribution is Unlimited

Questions?

Statement A: Approved for Public Release, Distribution is Unlimited

Back-up

Statement A: Approved for Public Release, Distribution is Unlimited

Abstract

Conference: 13th Annual NDIA Systems Engineering Conference, Oct 25 – 28 2010, San Diego, CA.

Authors: Rich Volkert (SSC Pacific), Carly Jackson (SSC Pacific), Cecil Whitfield (PMS 420)

Title: The Use of Navy Warfare Centers as Lead System Integrators: Lessons Learned from Mission Module Development

Abstract: Over the last several decades, the nature of acquisition has seen significant changes. The delivery of capabilities has shifted from a systems focus to the development and fielding of system-of-systems (SoS). The defense industry has seen significant consolidation while experiencing one of the largest military buildups in US history. The governments acquisition workforce has declined due to aging and reductions in force following the ending of the cold war. Acquisition efforts have been under significant pressure to deliver products faster and in an environment that's under severe fiscal and performance pressure. One of the results of these pressures and a changing business philosophy resulted in the government outsourcing of the role of Lead Systems Integrator (LSI) to Prime Contractors for major defense projects in the 80's and 90's. Due to several of these programs suffering major acquisition challenges, the decision was made to return this span of control to within DoD. This policy was directed in the Defense Authorization Act. The question then became that with the decline in the acquisition workforce over the last several decades was the government up to accepting the challenge and could it produce? The Littoral Combat Ship (LCS) Mission Modules Program Office (PMS 420) provides an opportunity to see some of the challenges and advantages of retaining the LSI role within the government and to identify areas where investment are required to assist the government in effectively accomplishing this role. The briefing will review the history of how the warfare centers became involved in the development of the Mission Packages, the roles and responsibilities assigned to those centers, and how those roles and responsibilities have changed as the Mission Modules program has matured. The advantages and challenges of using a warfare center to assist in rapid development activities will be reviewed and the challenges of transitioning roles as efforts mature from development and integration to production is presented.

Statement A: Approved for Public Release, Distribution is Unlimited

From a System to an Acknowledged System of Systems

Table 2-1. Comparing Systems and Acknowledged Systems of Systems

Aspect of Environment	System	Acknowledged System of Systems
Management & Oversight		
Stakeholder Involvement	Clearer set of stakeholders	Stakeholders at both system level and SoS levels (including the system owners), with competing interests and priorities; in some cases, the system stakeholder has no vested interest in the SoS; all stakeholders may not be recognized
Governance	Aligned PM and funding	Added levels of complexity due to management and funding for both the SoS and individual systems; SoS does not have authority over all the systems
Operational Environment		
Operational Focus	Designed and developed to meet operational objectives	Called upon to meet a set of operational objectives using systems whose objectives may or may not align with the SoS objectives
Implementation		
Acquisition	Aligned to ACAT Milestones, documented requirements, SE with a Systems Engineering Plan (SEP)	Added complexity due to multiple system lifecycles across acquisition programs, involving legacy systems, systems under development, new developments, and technology insertion; Typically have stated capability objectives upfront which may need to be translated into formal requirements
Test & Evaluation	Test and evaluation of the system is generally possible	Testing is more challenging due to the difficulty of synchronizing across multiple systems' life cycles; given the complexity of all the moving parts and potential for unintended consequences
Engineering & Design Considerations		
Boundaries and Interfaces	Focuses on boundaries and interfaces for the single system	Focus on identifying the systems that contribute to the SoS objectives and enabling the flow of data, control and functionality across the SoS while balancing needs of the systems
Performance & Behavior	Performance of the system to meet specified objectives	Performance across the SoS that satisfies SoS user capability needs while balancing needs of the systems

Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008

Statement A: Approved for Public Release, Distribution is Unlimited

System of Systems Challenges

SoS increases the complexity, scope, and cost of both the planning process and systems engineering, and introduces the need to coordinate inter-program activities and manage agreements among multiple program managers (PMs) as stakeholders who may not have a vested interest in the SoS. The problems that need to be addressed are large and complex and are not amenable to solution by better systems engineering alone. Without a solid governance and management approach for an SoS, independent authorities who oversee the multiple governance processes of DOD are unlikely to accept guidance from a systems engineer they do not control, placing the systems engineer in an untenable position in attempting to support an SoS. An administrative/governance structure that addresses these realities will enable SoS SE to be more effective in all phases of the processes as outlined in this document. This document acknowledges these issues but does not make any recommendations for changes to existing management and control structures to resolve inter-system issues,

Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008

Statement A: Approved for Public Release, Distribution is Unlimited

System of System (SoS) Organizational Challenges

OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY (RESEARCH, DEVELOPMENT AND ACQUISITION)

PEO STRUCTURE

ASSISTANT SECY OF NAVY (RDA)
Mr. Sean J. Stackley

Principal Military Deputy
VADM Dave Architzel
Principal Civilian Deputy
Mr. Jim Thomsen

JOINT	SSP			SPAWAR
PEO JOINT STRIKE FIGHTER (JSF) BGen David R. Heinz (USMC) (703) 602-7640	DIRECT REPORTING PROGRAM MANAGER STRATEGIC SYSTEMS PROGRAM (SSP) RADM Stephen Johnson (703) 601-9000 (703) 601-9001	PEO ENTERPRISE INFORMATION SYSTEMS RDML "Grunt" Smith (703) 602-9802	PEO C4I Mr. Chris Miller (619) 524-7358 (858) 537-8779	PEO SPACE SYSTEMS RDML Liz Young (703) 808-3000

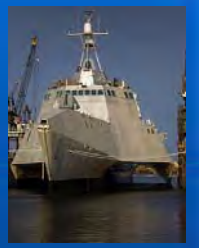
NAVSEA	NAVSEA		NAVSEA
PEO LITTORAL AND MINE WARFARE Ms. E. Anne Sandel (202) 781-3900	PEO SHIPS RADM William Landay (202) 781-2941	PEO INTEGRATED WARFARE [illegible] (202) 781-2984	PEO [illegible] (202) 781-4000	[illegible] RDML Michael McMahon (202) 781-2949

NAVAIR		NAVAIR	
PEO AIR ASW, ASSAULT AND SPECIAL MISSION PROGRAMS (PEOA) RDML Steven Eastburg (301) 757-5370 (301) 757-5372	PEO TACTICAL [illegible] PROGRAMS [illegible] RADM W. Mark [illegible] (301) 757-7 (301) 757-7	PEO UNMANNED AVIATION AND STRIKE WEAPONS (PEO U&W) RDML Bill Shannon (301) 757-6332	PEO LAND SYSTEMS Mr. William E. Taylor (703) 432-3370 (703) 432-4963

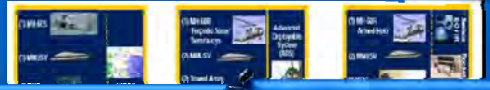
ASN(RDA) [illegible]

The LCS program office (PMS 501) exercises technical and programmatic oversight of the industry teams via a comprehensive team representing all systems engineering disciplines.

PMS 501: Littoral Combat Ships



PMS 420: LCS M[illegible]



PMS 403/406: Unmanned Maritime Vehicles

PMS 403 is responsible for the the RMMV.

PMS 406 is responsible for Unmanned Maritime Vehicles, incl. the MCM and ASW USVs.

PMS 495: Mine Warfare

PMS 495 is responsible for the acquisition of mine warfare systems.

PEO A (NAVAIR) is responsible for air ASW, assault & special mission programs.

PMA 299: MH-60 Helicopters

PMA 266: Unmanned Air Systems

PEO U&W (NAVAIR) is responsible for unmanned aviation and strike weapons.

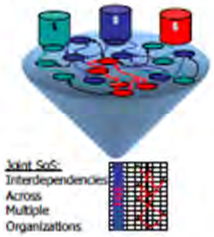
Statement A: Approved for Public Release, Distribution is Unlimited

23

SoS Management Challenges

Acknowledged System of Systems Challenges

- **Management and Oversight:** SoS systems engineers (SE) must be able to function in an environment where the SoS manager does not control all of the systems that impact the SoS capabilities and stakeholders have interests beyond the SoS objectives.
- **Management and Oversight:** SoS SE must balance SoS needs with individual system needs.
- **Implementation:** SoS SE planning and implementation must consider and leverage the development plans of the individual systems.
- **Implementation:** SoS SE must address the end-to-end behavior of the ensemble of systems, addressing the key issues which affect that behavior.



"The problems that need to be addressed are large and complex and are not amenable to solution by better systems engineering alone. Without a solid governance and management approach for an SoS, independent authorities who oversee the multiple governance processes of the DOD are unlikely to accept guidance from a systems engineer they do not control"

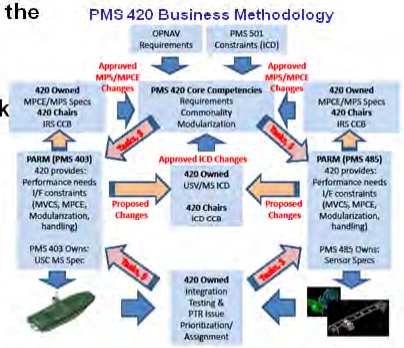
Ref: DoD System Engineering Guide for Systems of Systems, V1.0, Aug 2008 21

"Acknowledged" SoS have recognized objectives, a designated manager, and resources, but the constituent systems retain their independent ownership, objectives, funding, and development and sustainment approaches. It is one of four SoS types identified in *DoD System Engineering Guide for SoS, V1.0*, Aug 2008.

→ *Successful development and implementation of an "Acknowledged" SoS is dependent on collaboration between the SoS' and the constituent systems' SE and PM teams.*

How is the LCS Mission Module Program Addressing Acknowledged SoS Issues?

- **Ensuring System Maturity**
  - Monitoring the readiness of all technologies and integrations within the SoS environment
- **Enforcing Commonality**
  - Developing solutions which can work across the program to save time and money while increasing flexibility
- **Estimating SoS Availability**
  - SoS RMA defined: Am, Ao, Mission Availability, LCS MM perspective
- **Estimating SoS Performance**
  - Monitoring performance through KPPs/TPMs from a SoS persective



PMS 420 is working at the forefront of SoS acquisition developing novel methodologies that provide SoS technical and management insight.

Statement A: Approved for Public Release, Distribution is Unlimited

24

Australian Government
Department of Defence
Defence Science and Technology Organisation

Australia's Experience in Technology Risk Assessment

Dr David Wood
Director General Materiel Science Support
Defence Science and Technology Organisation
Department of Defence
+61-2-62652009
david.wood1@defence.gov.au

Presentation to NDIA Systems Engineering Conference 2010

Approved for public release

DSTO

AUS TRA ≠ US TRA

- **In the US**

  TRA = Technology Readiness Assessment
  - ***Not* a risk assessment**
  - ***Does not* address system integration**

- **In Australia**

  TRA = *Technical Risk* Assessment
  - ***Is* a risk assessment**
  - ***Includes* both system integration and integration of the system**

DSTO

Why the difference?

- US is the leading developer of military technology
  - So must risk manage the development of technologies
- Australia acquires most of our capabilities
  - Modifies equipment to meet our needs
  - Develops military technologies only in niche areas
  - Comes from various nations
  - Have to manage developmental options very differently from off-the-shelf

DSTO

Defence Procurement Review 2003 (the Kinnaird Review)

- **Defence was experiencing delays in a significant number of projects**
  - **Collins submarine, Sea Sprite helicopters, Jindalee over-the-horizon radar etc**
- **Review was commissioned to improve the acquisition of defence capabilities**

DSTO

Kinnaird outcomes

- **Review recognised the role of complex technology development in these delays and recommended that:**
  - **Defence consideration of new acquisitions to include *'comprehensive analysis of technology, cost and schedule risks'* and**
  - **'*Government needs to be assured that adequate scrutiny is undertaken …. by DSTO on technology feasibility, maturity and overall technical risk'.***
- **As a result, the Chief Defence Scientist (CDS) became responsible for providing independent advice to Government on technical risk for all acquisition decisions**

DSTO

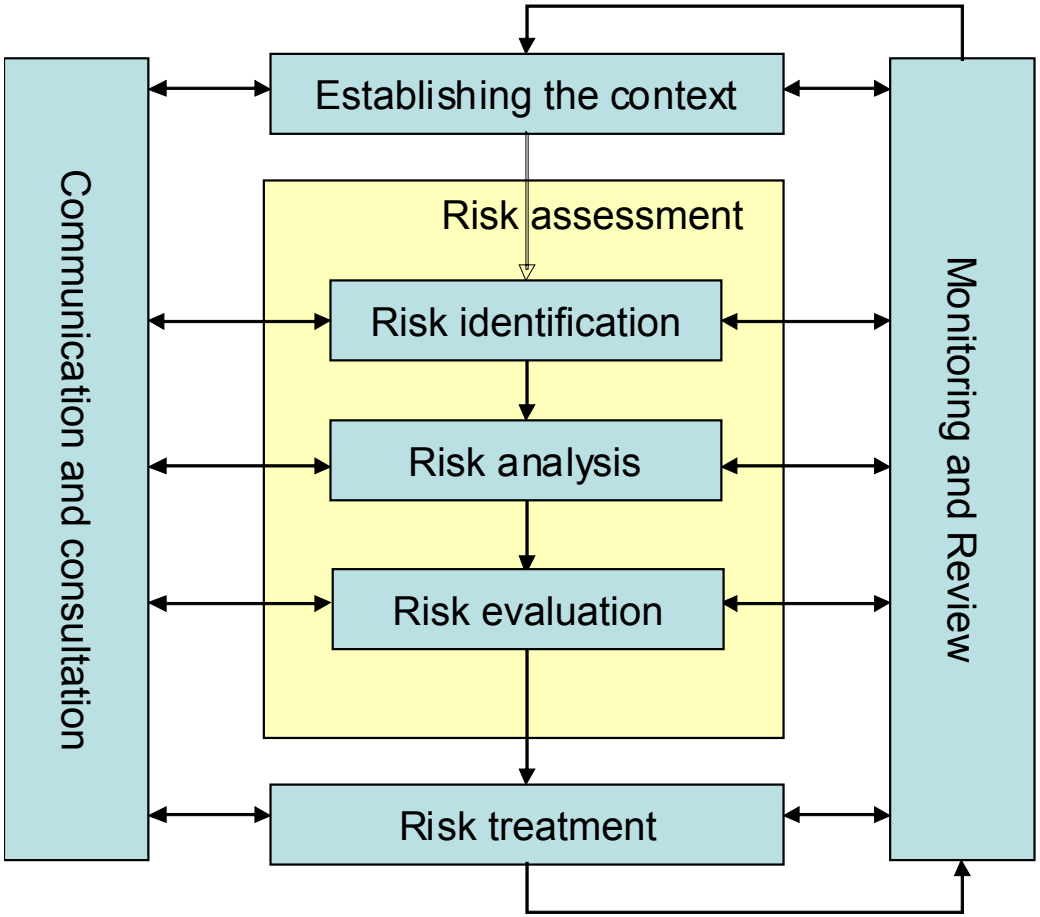
The Capability Development Process

- **Kinnaird Review also recommended the introduction of a formal two-pass process that ensures Government is well-advised in making decisions on Defence's major acquisition proposals**
  - **First pass sets the capability & options developed**
  - **Second pass seeks a decision on what option is to be acquired**

- **DSTO is required to provide a technical risk assessment at each pass which forms the basis for CDS to provide a technical risk certification to government**

DSTO

Risk management process



Risk management - Principles and guidelines, AS/NZS ISO 31000:2009

DSTO

Technical Risk Assessment

- **A systematic approach to identifying and assessing the technical risks for a major acquisition decision**
  - **Starts from risk management process**
  - **Draws on experience from UK Ministry of Defence and the US Department of Defence**
- **Aim is to inform decision-making and risk management**
- **Initial approach developed in 2004 and refined further with experience**
  - ***Technical Risk Assessment Handbook* currently in development**

DSTO

So What are *Technical* Risks?

- **Two types of risk**
  - **Immature technology will not be developed in time**
  - **And they may not be integrated into the system or Australian Defence Force**
- **Technology risk**
  - *the risk that the project will not achieve its objectives due to an underpinning technology not maturing in the required timeframe*
- **Technical risk**
  - *the risk that the project will not achieve its objectives due to risks which arise in the integration of critical technologies, and/or sub-systems dependent on them, or to the integration of the system into the ADF*

DSTO

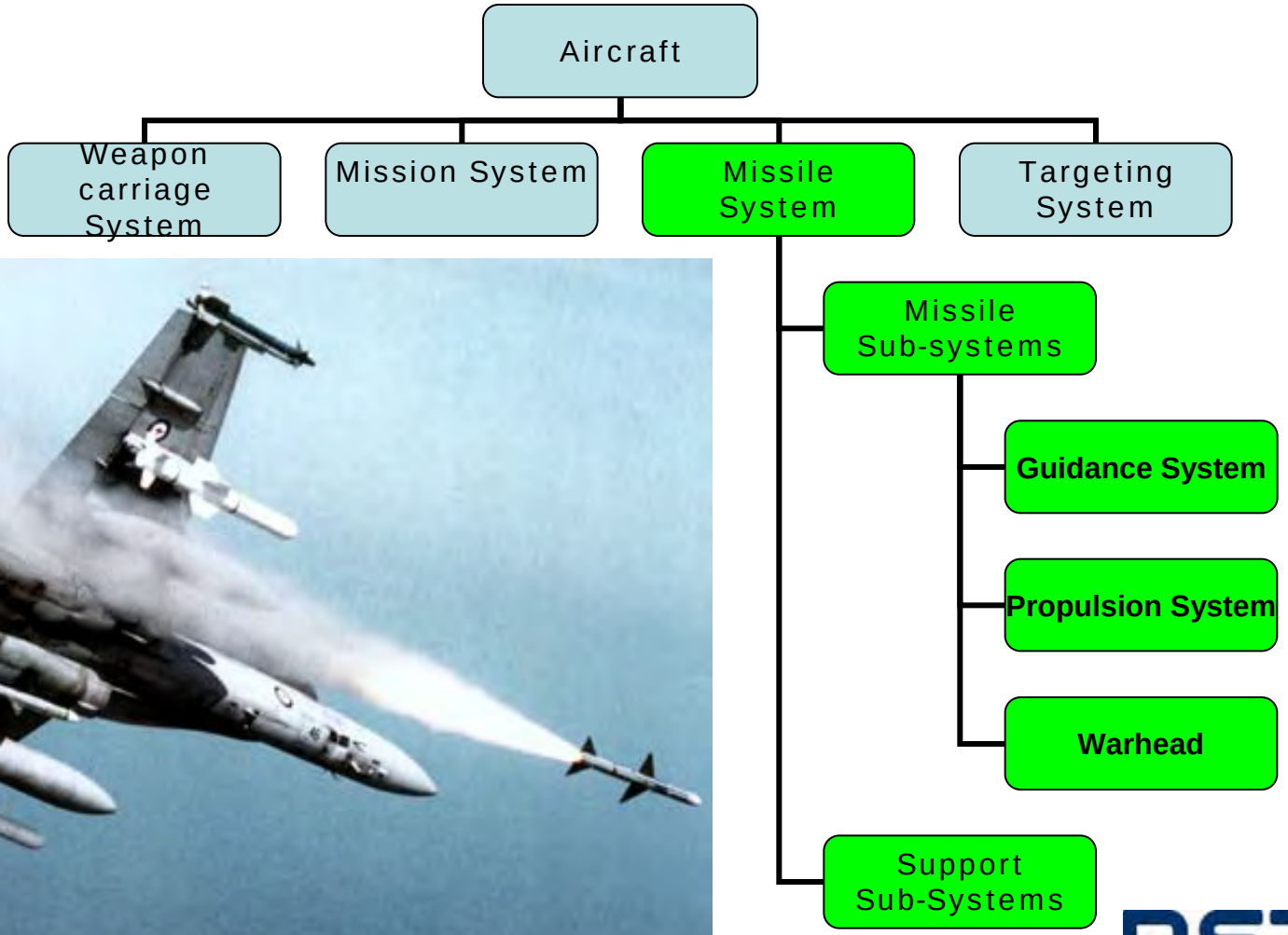
How are the technical risks assessed

- Use readiness levels to assess maturity
- Assess likelihood of not maturing in time based on
  - Are the technical requirements known?
  - What are the time and resources available?
  - What is the level of difficulty in maturing the technology?
  - Is this an extension of previously developed technology or is it leading edge technology?
  - Does the system use new technology or components?
  - Is a new manufacturing process or technique involved?
  - Do the developers have expertise in this area?
- Impact on project's objectives
  - Performance
  - Cost
  - Schedule
  - Supportability
  - Safety

DSTO

Project AIR1234 F/A-18 Missile

Use systems breakdown to identify technologies



DSTO

For technology maturity use TRLs
(From DoD TRA Deskbook)

Technology Readiness Description	Readiness Level
Basic principles of technology observed and reported.	1
Technology concept and/or application formulated.	2
Analytical and laboratory studies to validate analytical predictions.	3
Component and / or basic sub-system technology validated in a laboratory environment.	4
Component and / or basic sub-system technology validated in a relevant environment.	5
System sub-system technology model or prototype demonstration in a relevant environment.	6
System technology prototype demonstration in an operational environment.	7
System technology qualified through test and demonstration.	8
System technology qualified through successful mission operations.	9

DSTO

Technology risks example

Technology	TRL	Development required	Likelihood of technology not maturing in time	Impact on project's objectives	Risk
Battery	9	Same battery proven in service on another missile			Nil
Guidance set	5	Shock resistance still to be demonstrated	UNLIKELY (10-15%)	Moderate (Could delay schedule)	Low

DSTO

For technical maturity use System Readiness Levels

(adapted from TRLs by DSTO using MOD concept)

System Readiness Description	Readiness Level
Basic principles observed and reported.	1
System concept and/or application formulated.	2
Analytical studies and experimentation on system elements.	3
Sub-system components integrated in a laboratory environment.	4
System tested in a simulated environment.	5
System demonstrated in a simulated operational environment, including interaction with simulations of external systems.	6
Demonstration of system prototype in an operational environment, including interaction with external systems.	7
System proven to work in the operational environment, including integration with external systems.	8
Application of the system under operational mission conditions.	9

DSTO

Technical risks example

Sub-system	Technologies in each sub-system	TRL	SRL	Integration required	Likelihood of not being integrated in time	Impact on Project's Objectives	Level of Risk
Guidance System	Battery	9	5	Guidance set to be integrated	Less than likley	Moderate	MEDIUM
	Guidance set	5					
	etc						
etc							
System							
Missile System				To be integrated with aircraft mission system	Less than likely	Major	HIGH

DSTO

Summarising the Risks

Project AIR 1234 TRA Summary			
Likelihood	Consequence/Impact		
	Minor	Moderate	Major
More Than Likely		Seeker development	Warhead effectiveness
Less Than Likely	Weapon integration	GPS integration	
Unlikely	Missile development		
Overall Technical Risk Level	HIGH		

DSTO

Experiences

- TRAs have influenced decisions and management
- Distinguishing risks and issues
- Military/Commercial Off-the Shelf
  - Perceived as low risk
  - BUT can be technical risks in integration and in supportability
  - And can be issues if not demonstrated in mission conditions
- TRA as an input to risk management
  - Integrating TRA into project risk management and into the capability development process
- Consistency of assessment across TRAs
  - TRA Handbook being developed
- Human science risks
  - Included as a source of technical risk

DSTO

Next steps

- **Improving the risk assessment part**
  - **To date have used expert judgement**
- **Will examine potential to use other techniques where possible**
  - **e.g. probabilistic simulation modelling**
- **Formalise training in TRA**
  - **To cover both process and techniques**

DSTO

Thanks to

Mr Jim Smith, Dr Terry Moon, Dr John O'Neill, Dr Nigel McGinty, Dr Peter Dortmans, & Dr Axel Bender

Reference

Technical Risk Assessment of Australian Defence Projects (2004), *J. Smith, G. Egglestone, P. Farr, T. Moon, D. Saunders, P. Shoubridge, K. Thalassoudis and T. Wallace, DSTO-TR-1656.*

available from

http://dspace.dsto.defence.gov.au/dspace/bitstream/1947/4011/1/DSTO-TR-1656%20PR.pdf

DSTO

Adapting Systems Engineering Best Practices to Technology Development in Applied Research

NDIA 13th Annual Systems Engineering Conference

27 October 2010

Mr. Jeffrey Craver

Defense Acquisition University

Mr. Hossam Ahmed

DTRA-RD

Mr. Mike Ellis

DMD, LLC.

DISTRIBUTION STATEMENT A. **Approved for Public Release. Distribution Unlimited.**

Overview

- *Introductions*
- *Problem Statement (GAO et al.)*
- *Identify Govt Orgs Using/Interested in the Technology Program Management Model (TPMM)*
- *Solution Implemented through collaborators/piloting*
- *Benefits of Rooting Tech Development in TPMM*
- *Conclusion - Way Forward .....*

Demonstrate how one solution developed out of necessity at the Army Space and Missile Defense Command has captivated the attention of the Defense Acquisition University and changed the landscape for S&T

DMD

DISTRIBUTION STATEMENT A. **Approved for Public Release. Distribution Unlimited.**

Quantifying the Effects of Immature Technologies

According to a GAO review in 2005 of 54 DoD programs:

- **Only 15% of programs began System Design Decision [beyond Milestone B] with mature technology (Technology Readiness Level (TRL 6-7))**
  - Programs that ***attempted to integrate with immature technologies*** averaged ***41% cost growth*** and a ***13 month schedule delay***
- **At Critical Design Review, 58% of programs demonstrated design instability (< 90% drawings releasable)**
  - ***Design stability not achievable with immature technologies***
  - Programs ***without stable designs at CDR*** averaged ***46% cost growth*** and a ***29 month schedule delay***

Source: Defense Acquisitions: Assessments of Selected Major Weapon Programs, GAO-05-301, March 2005

[Follow-up reports by GAO in subsequent years have not indicated any significant change in the Findings]

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Reasons Why This Happens

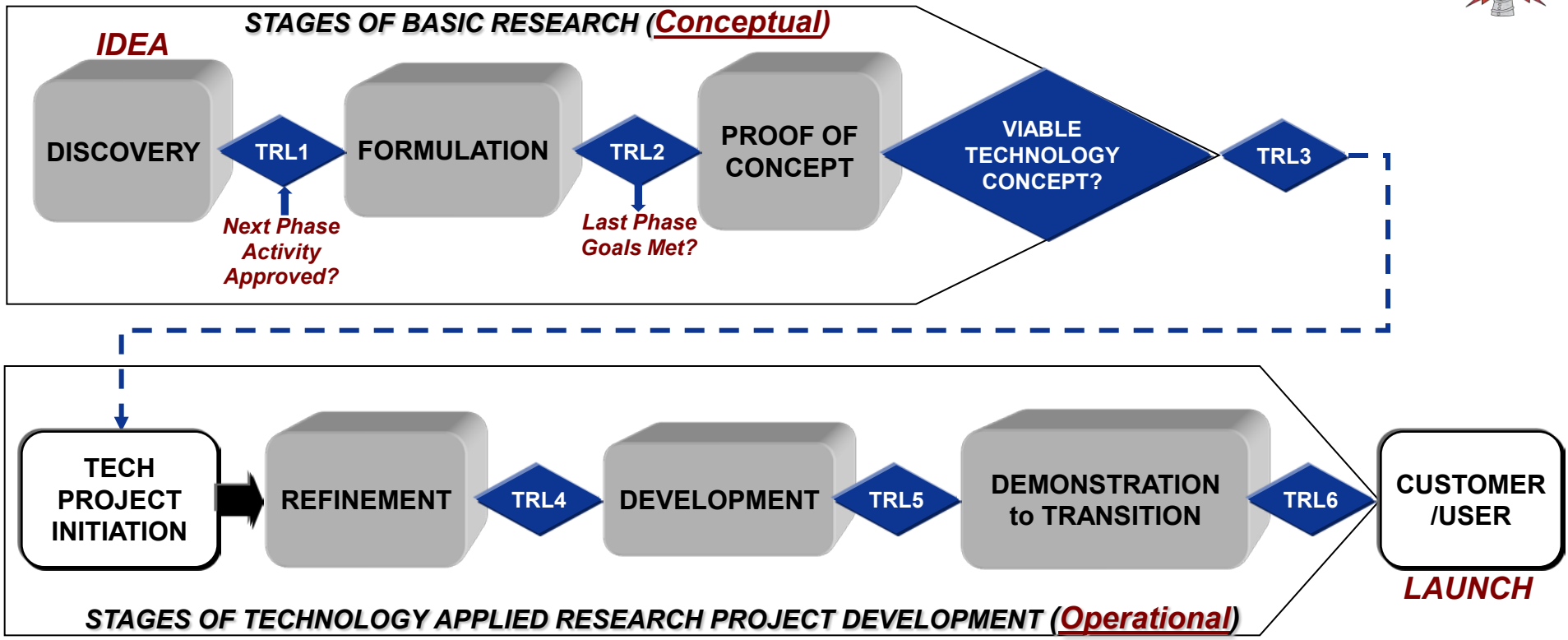
- ***Doctrine*** **Promotes delay**
  - **The DoD 5000 Directive calls for the first Assessment of the technology at MS-B (too late in the process to have any real effect on an immature technology)**
- ***Predisposition*** **of Viewpoints**
  - **Users know the requirements, Acquisition Managers know how to build things, and Technology Developers know how to invent.**
  - **A Forcing Function is needed to effectively cross those boundaries**
- ***Communications*** **Breakdown**
  - **Technology solutions selected to fill gaps need continual re-alignment to ensure development is on schedule and that the "right" problem is still being solved**
- ***Culture*** **Within the Technology Development Community**
  - **Tradition of Invention and scientific endeavor in the Technology Community *coupled with lack of Systems Engineering discipline* contributes to a lack of Transition Focus**
- ***Interpretation*** **Wide Enough to Drive a Humvee Through**
  - **TRL definitions are vague and sometimes too subjective which can lead to more questions than answers.**

One Conclusion: A System Engineering and Programmatic-based criteria set needs to be applied as a standard earlier in the process.

DMD

DISTRIBUTION STATEMENT A. **Approved for Public Release. Distribution Unlimited.**

SE Rigor Using Stage-Gate



Process Represented by:

- Distinct Blocks for ***Conceptual*** and ***Operational*** development paths that when combined, traverse from ***Idea*** to ***Launch***.
- Managed process of ***Defined Stages*** composed of ***Activities/Tasks*** that are evaluated as input criteria for planning/approval to ***proceed to the next stage***.
- Stages culminate in ***Decision Gates*** of measurable Exit Criteria used to evaluate technical accomplishment and technology readiness/maturity.

DMD

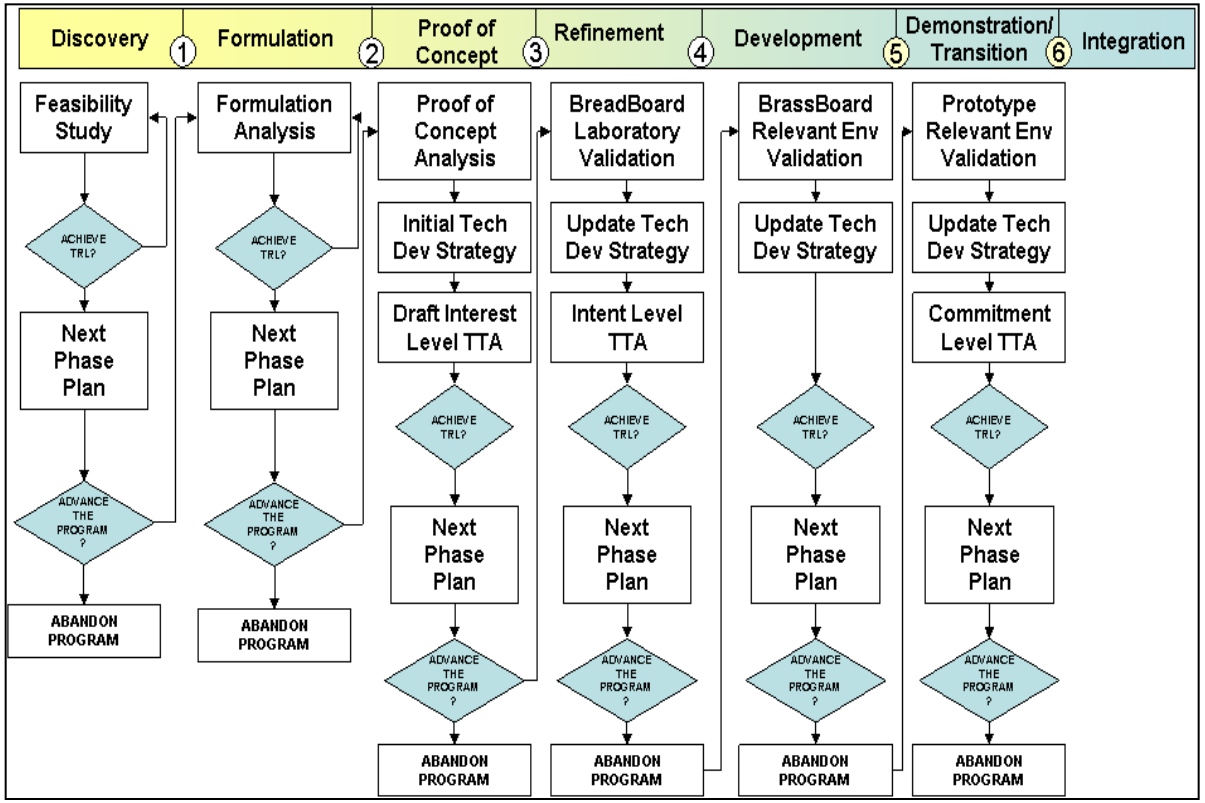
DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Functions Performed by TPMM

A TRL-Based, Stage Gate Model that:

- **Program Definition**
  - Identify Activities to consider
  - Identify Deliverable Documents
  - Provide guidance for Tailoring
  - Employ "Best Practice" Tools
  - Identify and Mitigate Risk
- **Transition Management**
  - Technology Transition
  - Technology Transfer
  - Technology Marketing
- **Maturity Assessments**
  - Establishes Entry/Exit Criteria
  - Provides a Framework for

Technology Maturity Assessments (TMA)

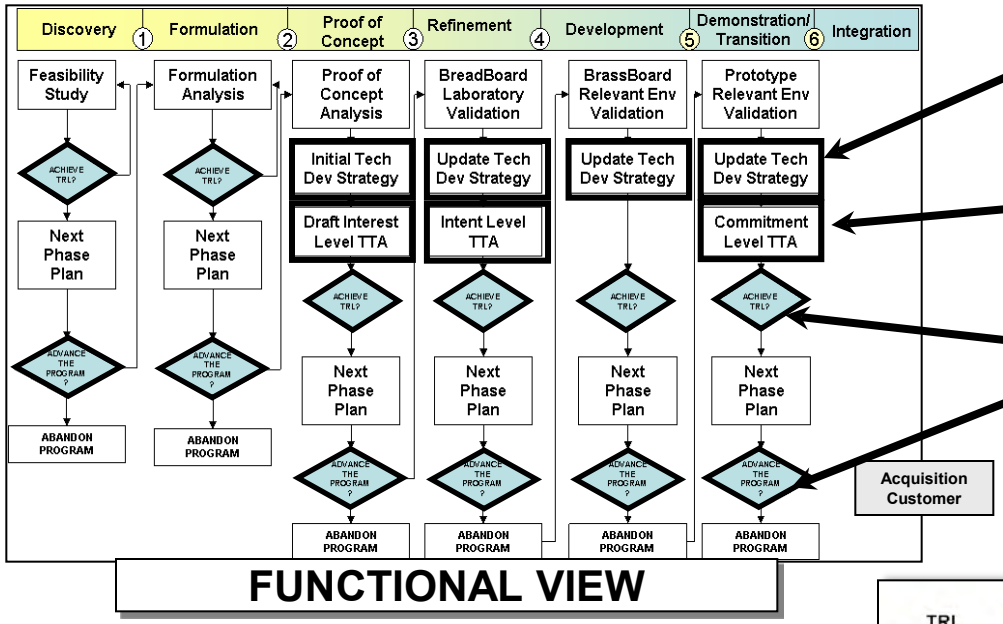


Legend:
TTA = Technology Transition Agreement
TDS = Technology Development Strategy

"TPMM: A Model Designed for Technology Development and Transition"

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Key Features of TPMM



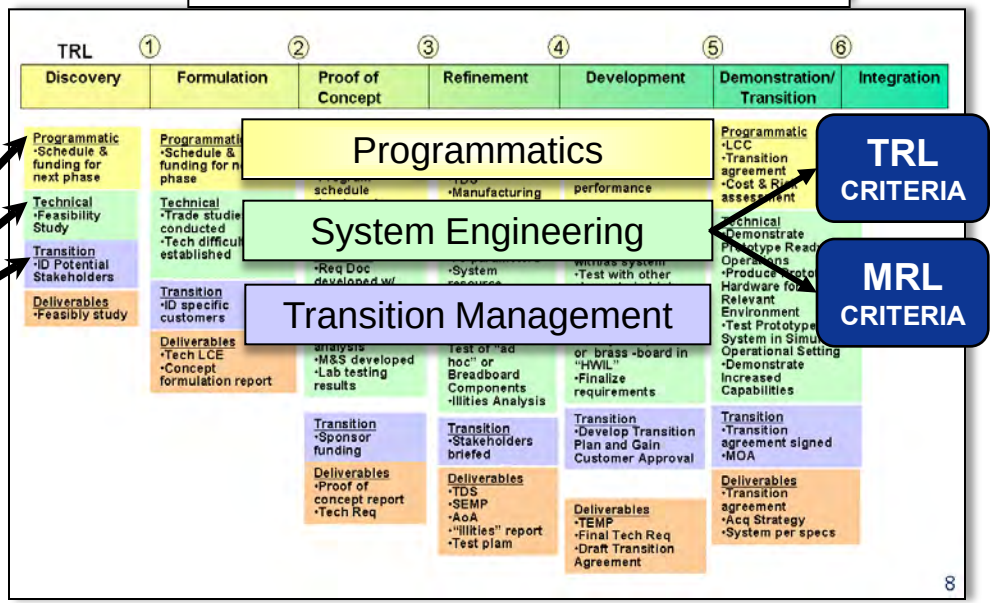
FUNCTIONAL VIEW

TDS establishes common language and vision

DAU adopted TTA

Program reviews include a TRA and a TAA

ARCHITECTURAL VIEW

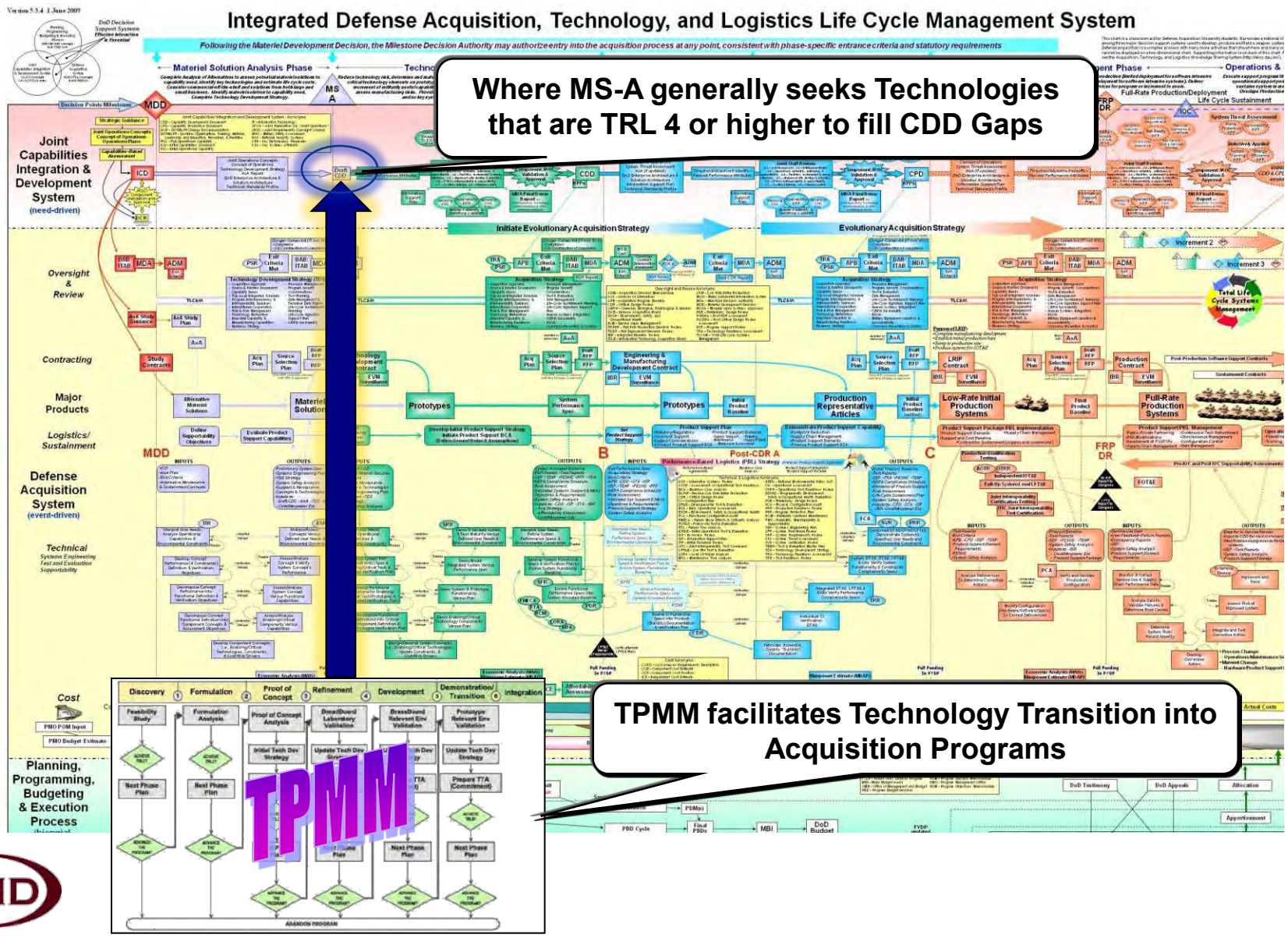


Multi-Dimensional criteria set provides a comprehensive TRL Assessment

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

TPMM Facilitates DoDD 5000.1 Alignment



Where MS-A generally seeks Technologies that are TRL 4 or higher to fill CDD Gaps

TPMM facilitates Technology Transition into Acquisition Programs

Technology Transition Alignment Mechanisms

Legend:
TTA = Technology Transition Agreement
TDS = Technology Development Strategy
CFAR = Concept Formulation Analysis Report
PoCP = Proof of Concept Plan
PoCR = Proof of Concept Report

MDD
Material Solution Analysis Phase
MS A
USER
Technology Development Phase
MS B
PM
Engineering & Manufacturing Development Phase

ICD
CDD DRAFT
CDD FINAL
TDS DRAFT
TDS FINAL
AS DRAFT
AS FINAL

Alignment Mechanisms
TTA
TDS TTA
TDS TTA
TRA

TRL 3 — PROOF OF CONCEPT — TMA
TRL 4 — REFINEMENT — TMA
TRL 5 — DEVELOPMENT — TMA
TRL 6 — DEMONSTRATION/ TRANSITION — TMA

Alignment Mechanisms
CFAR
TTA PoCP
TTA PoCR

TRL 1 — DISCOVERY — TMA
TRL 2 — FORMULATION (ANALYSIS OF ALTERNATIVES) — TMA
TRL 3 — PROOF OF CONCEPT — TMA

Basic Research (6.1)
Applied Research (6.2)
Advanced Technology Development (6.3)

INDUSTRY
ACADEMIA
DoD USERS
BA S&T
TECH XFER

DMD

Technology Maturity Assessment (TMA)

TPMM Defines The Process And Transition Mechanisms To Help Align Tech Programs With Capability Needs

Technology Transition Best Practices

- Repeatable processes
- Demonstrated to produce the desired result in more than one environment
- Easily adapted to other organizations (tailorable)
- Focuses on needs of users/recipients of technology
- Produces credible data for decision makers

Level	Best Practice	Status	Where used	Benefits
Personal – project level tool	TRL Quicklook checklist	Available for deployment now – easily tailored	DTRA, similar tools used in USAF, NASA	Consistent, credible, more objective TRL assessment
S&T organization	Technology Program Management Model (TPMM)	Process is mature – tool (TurboTPMM) pending C&A	SMDC, MDA, DTRA	Provides consistent, credible, data for portfolio management at S&T org.
Enterprise (S&T and PEO)	Technology Assessment Transition Management (TATM)	Process is mature – tool in use, undergoing C&A	PEO Aviation/AMRDEC, PEO Soldier, (JPEO Robotics – past)	Provides PEO reliable data on status/scheduling of S&T projects that will transition to PEO programs

DMD

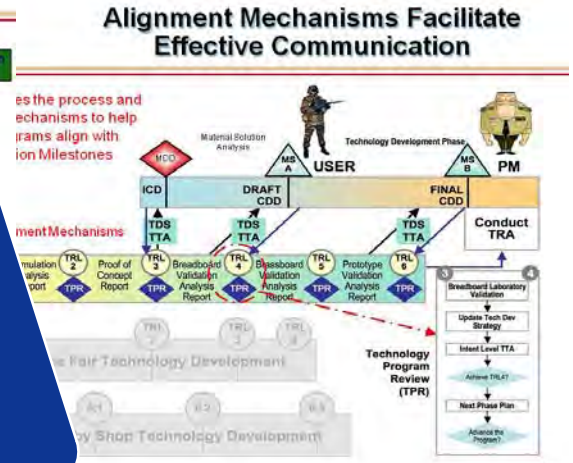
DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

DAU Courseware includes Best Practice Methodologies and Tools

Technology Program Management Model

- U. S. Army Space and Missile Defense Technical Center
- Logical methodology to guide technology managers through the planning and development of their projects
- Seven phases with exit criteria and deliverables
- Technology process reviews after each phase
- Currently in use by Missile Defense Agency, Defense Threat Reduction Agency, Department of Homeland Security, Air Force Research Laboratory and Defense Threat Reduction Agency

TPMM

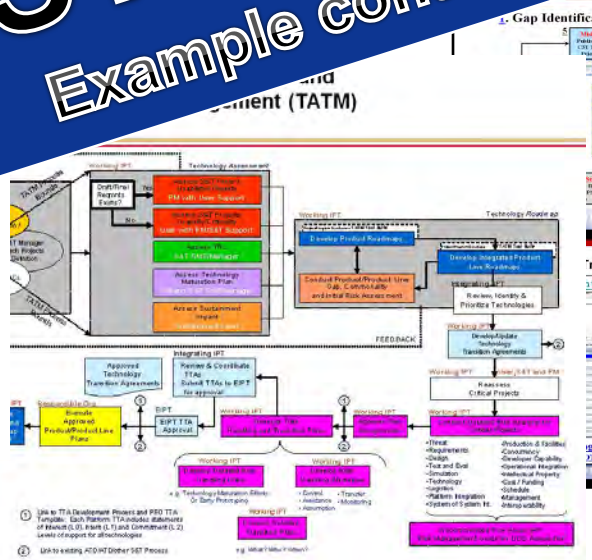


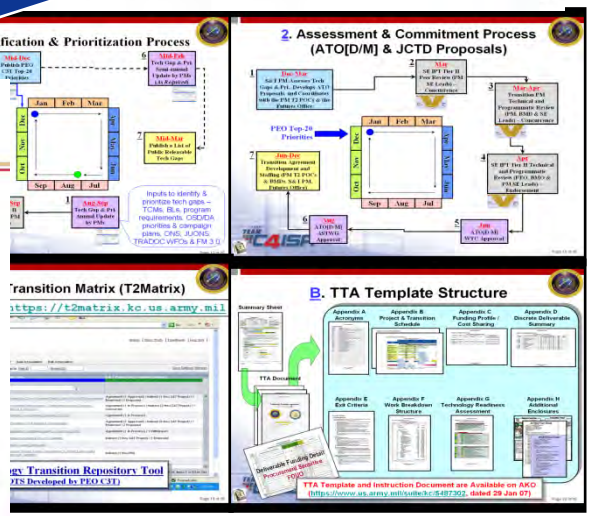
Technology Assessment and Tra… Management (TATM) Proces…

- Stable process agreed upon by AMRDEC and PEO Aviation
- User and sustainer are involved from start
- Technologies are judged on criticality and sustainability as well as technical maturity
- Identify where risk reduction efforts are needed
- Basis for Technology Transition Agreements

- DAU POC for TATM and TPMM: Mr. Jeff Craver, jeffrey.craver@dau.mil (256-895-3453) william.decker@dau.mil (256-895-3448)

TATM





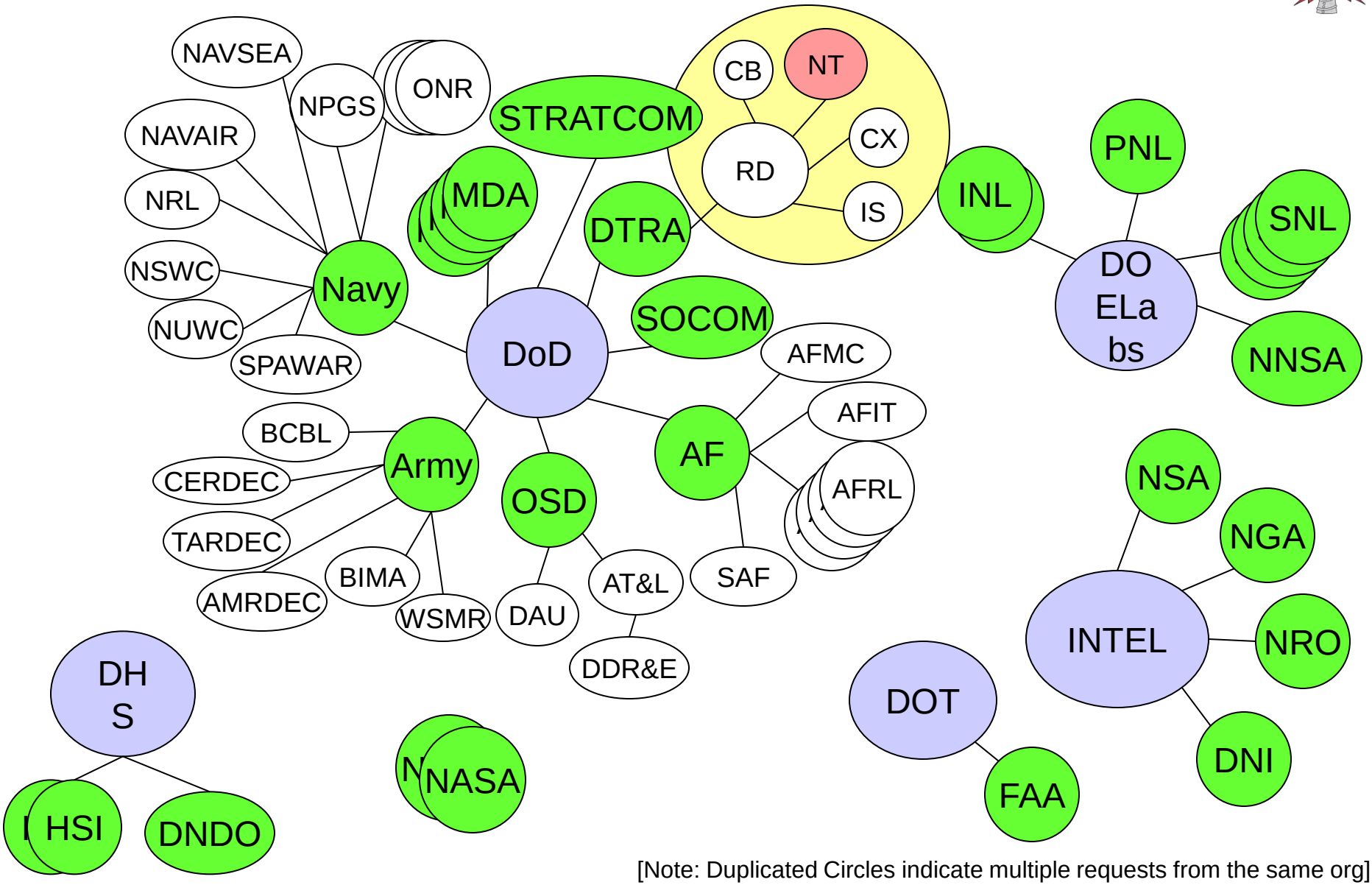
T2 MATRIX

Science and Technology Management

STM 202

Example content

Organizations Interested in TPMM



[Note: Duplicated Circles indicate multiple requests from the same org]

***DISTRIBUTION STATEMENT A*. Approved for Public Release. Distribution Unlimited.**

TPMM User Examples

Missile Defense Agency

- Kill Assessment Technology Program used TPMM to broker the inclusion of their technology concept into the C2BMC Element of the BMDS.

Department of Homeland Security

- Provided Basic Research technology maturity data (Entry/Exit Criteria, Phase Deliverables, and Activities) used to populate the Exploratory portion of their draft S&T RDT&E Process.

Air Force (AFMC at Wright-Patterson AFB)

- Supporting TD-1-13 Initiative: High Confidence Technology Transition Planning Through the Use of Stage-Gates (More later)

U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT)

- Vertical/horizontal Integration of Space Technologies and Applications (VISTA) Program
- Distributed Imaging Radar Technology (DIRT)
- All Weather RF Launch Detection (AWRFLD)

Defense Acquisition University (Huntsville Campus)

- Developing an interface between Technology Assessment and Transition Management (TATM tool used at PEO Aviation) and TPMM.

Defense Threat Reduction Agency (NTD Ft. Belvoir)

- Providing Engineering Analysis to initiate collaboration on a Technology Management Process Improvement effort designed to implement the TPMM in their Division S&T.

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

DTRA RD
TPMM Implementation Pilot

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Technology Development Challenges Facing DTRA-RD

Consistent *technology development planning*

- Requirements definition and refinement not applied consistently and effectively.
- Lack a common set of tools and standards to gauge technology maturity.

Improve *transitioning of technologies*

- Transition not always considered as part of Technology Development
- Limited Customer/User identification/involvement

Establish **"a management methodology that balances the portfolio by *Imposing Structure and Rigor* through the use of clear, well-defined and *Measurable Metrics*!"**
J. Heusmann DTRA-RD *(7 May 09)*

DMD

DISTRIBUTION STATEMENT A. **Approved for Public Release. Distribution Unlimited.**

Desired Technology Management Environment

- An environment that delivers technology-based solutions to a Program of Record in response to documented and validated capability gaps.
- An Environment where:
  - User capability needs are accurately and fully defined in the DTRA mission space and allocated to the appropriate directorate
  - Risk is reduced because the user is engaged at appropriate steps in the development process
  - Transition agreements and detailed roadmaps are jointly developed and committed to
  - Technologies/products are fully integrated, tested, and fielded
  - A set of common standards and metrics are established and applied to all technology development programs as applicable.
  - Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) needs of our transition partners are addressed early in the development process.

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

DTRA-RD TPMM Training

Discovery (1) Formulation (2) Proof of Concept (3) Refinement (4) Development (5) Demonstration/ Transition (6) Integration

TPMM Naked
Thurs, 28 Jan
0830-1000 hrs

TPMM and the Myth of the Grape Kool-Aid
Thurs, 25 Feb
1400-1530 hrs

TPMM - Combat Training
Weds, 17 Mar
1400-1530 hrs

Turbo TPMM
Weds, 3 Mar
1400-1530 hrs

Endorsed by Defense Acquisition University (DAU) as a "best practice"

DAU Defense Acquisition University

Technology Project Management Model (TPMM) Program

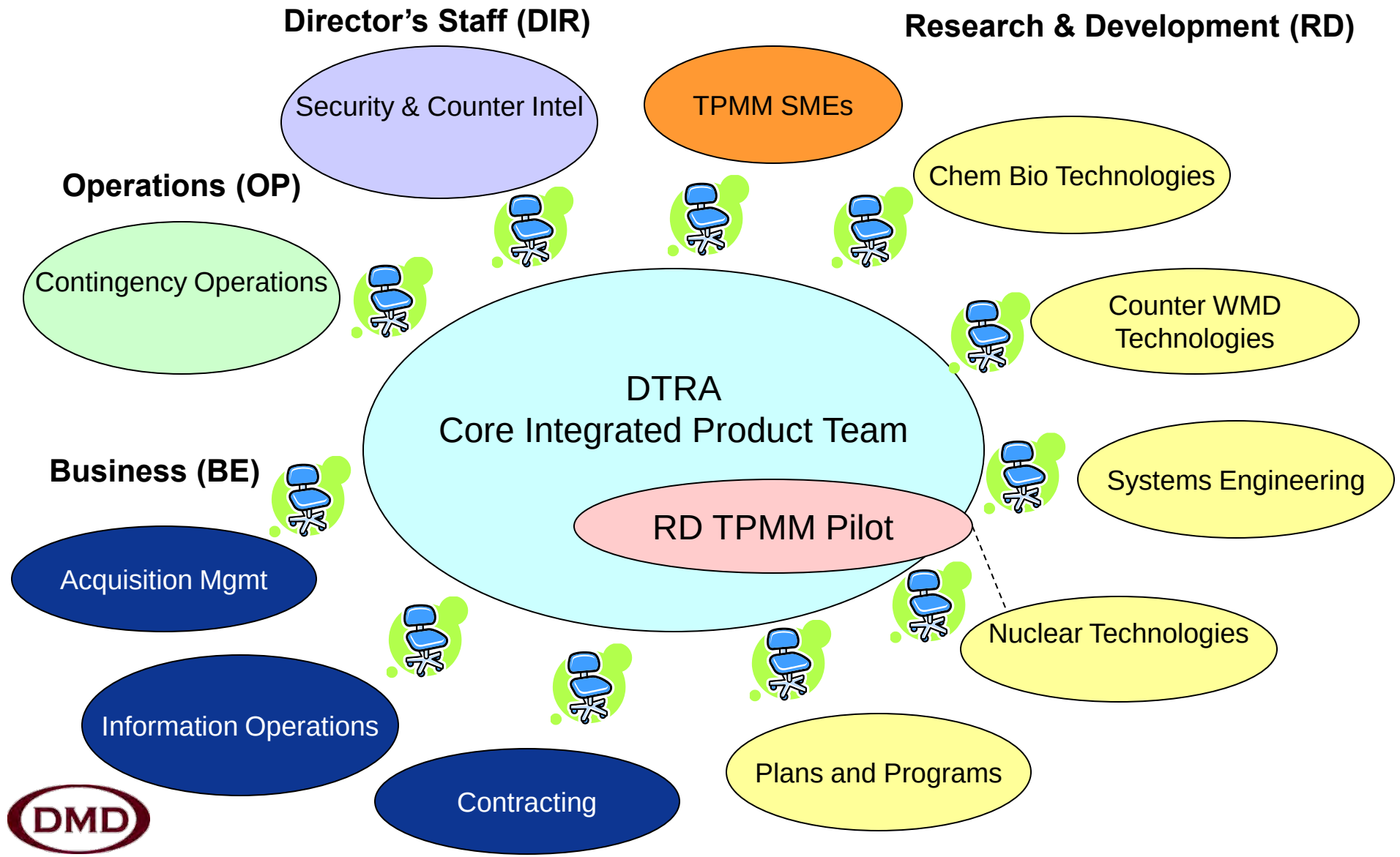
- Improves program execution
- Facilitates program review and prioritization
- Aligns capabilities and identifies gaps
- Reduces risk
- Improves investment decisions
- Can be tailored to meet organizational needs
- Defines key decision points to evaluate progress
- Incorporates organizational processes and systems
  Enhances documentation process
- Supports technology transition

Join Us As We Explore a Focused Approach To DTRA Technology Development

TPMM Pilot Underway in DTRA-RD-NT

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

DTRA TPMM IPT



DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

TPMM Pilots at DTRA-RD

Basic Research

- BA to identify TRL 2/3 opportunities (1 or 2 projects) that BA and NTD will develop a transition plan for FY11 execution .

Division TPMM Pilot

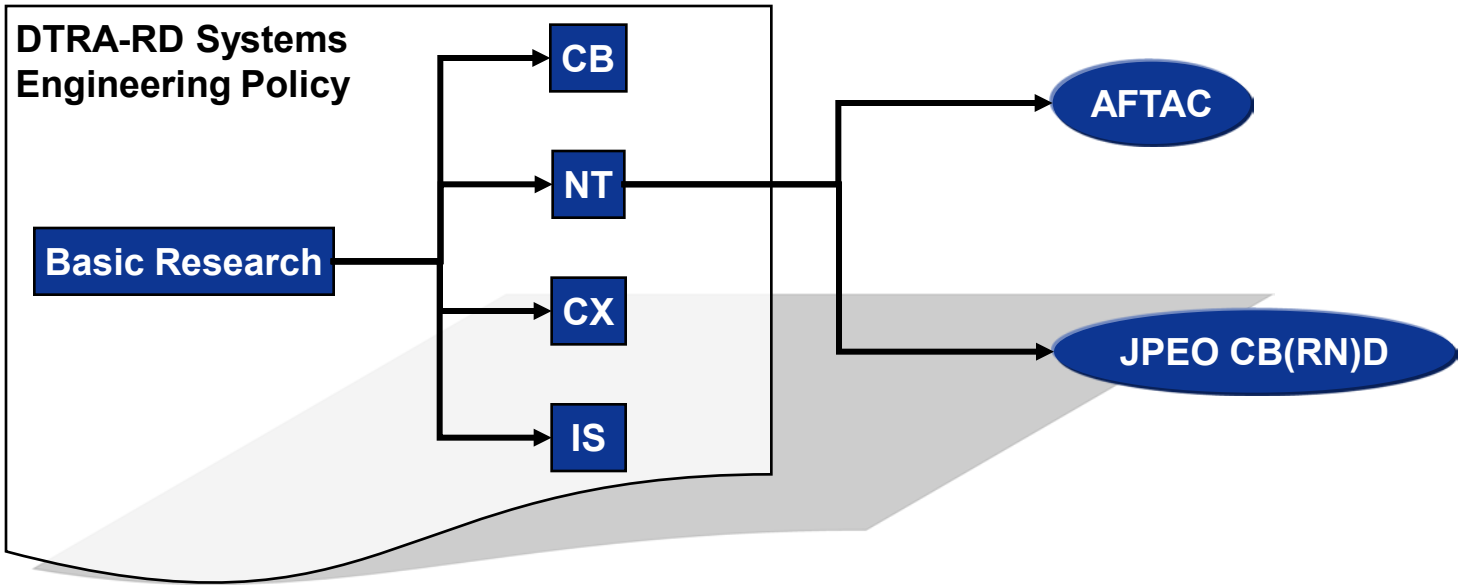
- Develop/Implement Standard Metrics for use in Measuring Progress using the DTRA/NTD Process. Perform ongoing Maturity Assessment for Detection Projects and Baseline in TPMM.

Systems Engineering

- Working DTRA-RD SE Policy and developing strawman Technology Maturity Assessment Process for in Formal Gate Reviews. Establishing DTRA Mission Space Requirements Pathway

Transition to Customer Pilot(s)

- Developing Generic Transition Process between JPEO CBD and DTRA-RD including Pilots
- Executing Technology Transition Agreement with AFTAC on a specific Technology Project



DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Basic Research to Applied Research Technology Transition

Exercises in Technology Transition:

- BA to NTD Transition Process White Paper drafted
- "Interest" developed for six Grant projects will down-select to 2-3 that are "Intended" for Applied Research
- Developing process deliverables and evaluation tools
  - **Modified TRL 2 Checklist**
  - **Introduce Tailored TPMM Deliverables:**
    - Technology Transition Agreement
    - Concept Formulation Analysis Report
    - Proof of Concept Plan
    - Proof of Concept Report

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Technology Transition to JPEO-CB(RN)D

- **Exercises Planned in Technology Transition:**
  - First transition will be for a JCTD component system that is beyond MS-B that is ready for “leave behind” but *not presently sustainable*.
  - Assist JPM RN to provide for DOTMLPF
  - Follow-on Transitions will be more traditional and engage with the formal Acquisition process at or about MS-A (TRL 4).
- **Implementing TPMM process Transition Deliverables and evaluation tools**
  - Updated TRL 4, 5, & 6 Exit Criteria Checklists
  - Introduce Tailored TPMM Deliverables:
    - Technology Transition Agreement
    - Technology Development Strategy
    - Phase Validation Plans/Reports
  - Investigating Existing Criteria for IRL/SRL 7-8 for use with mature Projects

DMD

***DISTRIBUTION STATEMENT A*. Approved for Public Release. Distribution Unlimited.**

TPMM Phase Deliverables – Applied Research to EMD

INTERNAL TRANSITION

TMA

BASIC RESEARCH → APPLIED RESEARCH

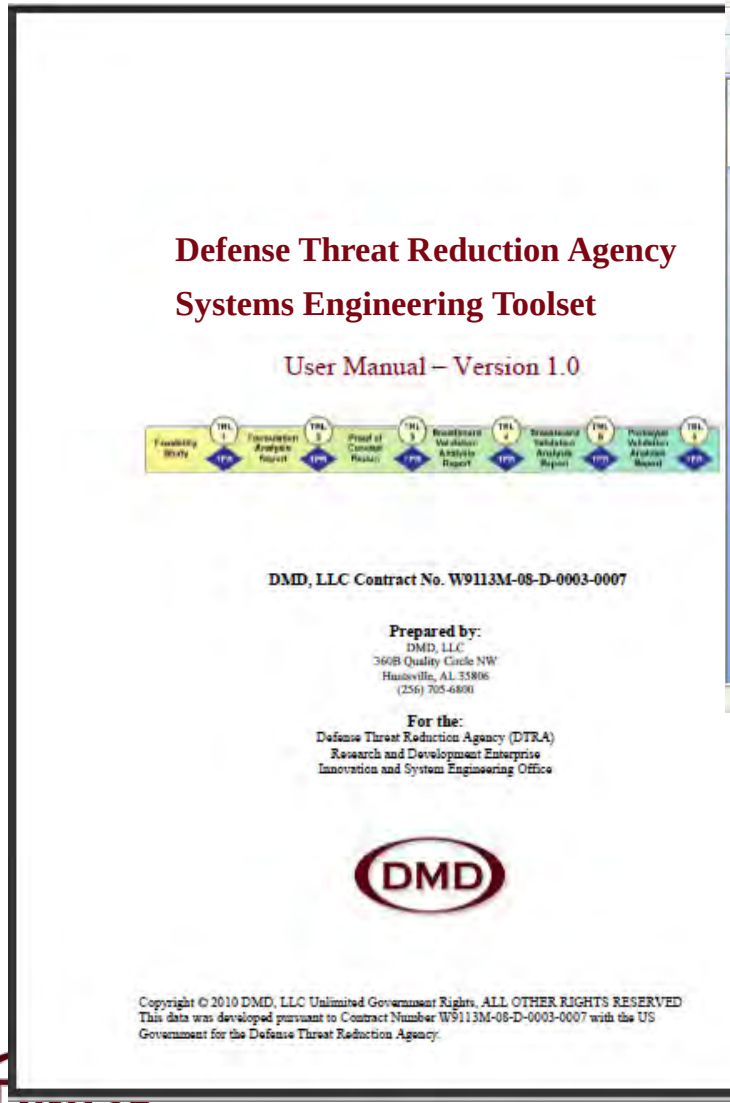
TRL	1	2	3	4	5	6
	Discovery	Formulation	Proof of Concept	Refinement	Development	Demonstration/ Transition	Integration
	•Programmatic •Schedule & funding for next phase	•Programmatic •Schedule & funding for next phase	**Programmatic** • Program cost Estimation • Pgm Schedule developed • Contract strategy	**Programmatic** • WBS • Cost Model • TDS • Manufacturing plan	**Programmatic** • LCcMP • WBS (+) • Cost & risk performance	**Programmatic** • LCC • Transition agreement • Cost & Risk assessment	
	•Technical •Tech Concept Developed •Industry Analysis •Academic Studies	•Technical •Trade studies conducted •Tech difficulty established •Alternatives analyzed	**Technical** • Req Doc developed w/ (ICD) • Cross tech • Proof of concept analysis • M&S developed • Lab testing results	**Technical** • SEP • F3 parameters • System resource allocations • Design constraints • Integrated Lab Test of "ad hoc" or Breadboard Components • Illities Analysis	**Technical** • Demonstrate components work with/as system • Test with other elements in HF Validation test • Develop high fidelity component or Brassboard "HWIL" • Final Requirements • Manuf/Prod Anal • Document ilities	**Technical** • Demonstrate Prototype Ready for Operations • Produce Proto Hardware for a Relevant Env • Test Prototype as System in Simulated Operational Setting • Demonstrate Increased Capabilities	
	•Transition •ID Potential Stakeholders	•Transition •ID specific customers	**Transition** •Sponsor funding	**Transition** •Stakeholders briefed (Customer/User)	**Transition** • Detailed Transition Planning and Gain Customer Approval	**Transition** •Transition agreement signed •MOA	
	Deliverables	**Deliverables**	**Deliverables**	**Deliverables**	**Deliverables**	**Deliverables**	
	•Feasibility Study	•Analysis of Technical Alternatives	Proof of Concept Report	Breadboard Lab Validation Report	Brassboard Lab Validation Report	Prototype Relevant Env Lab Validation Rpt	
	•Formulation Plan	•Formulation Analysis Report	Technology Development Strategy (TDS) Initial	TDS Update	TDS Update	TDS Final	
		•Proof of Concept Plan	Technology Transition Agreement (TTA) (Interest)	TTA (Intent)	TTA Update (Intent)	TTA Update (Commitment)	
			User Operational Requirements	User Performance Requirements	Manufacturing Plan [Draft]	Manufacturing Plan [Final]	
			Breadboard Lab Validation Plan	Brassboard Lab Validation Plan	Production/ILS Plan [Draft]	Production/ILS Plan [Final]	
					Prototype Relevant Env Lab Validation Plan	Transition Support Plan	

LEGEND

DTRA | JPEO | BOTH

DISTRIBUTION STATEMENT A. Approved for Public Release. Dist… …limited.

DTRA-RD TPMM SharePoint Tool


Defense Threat Reduction Agency

Systems Engineering Toolset

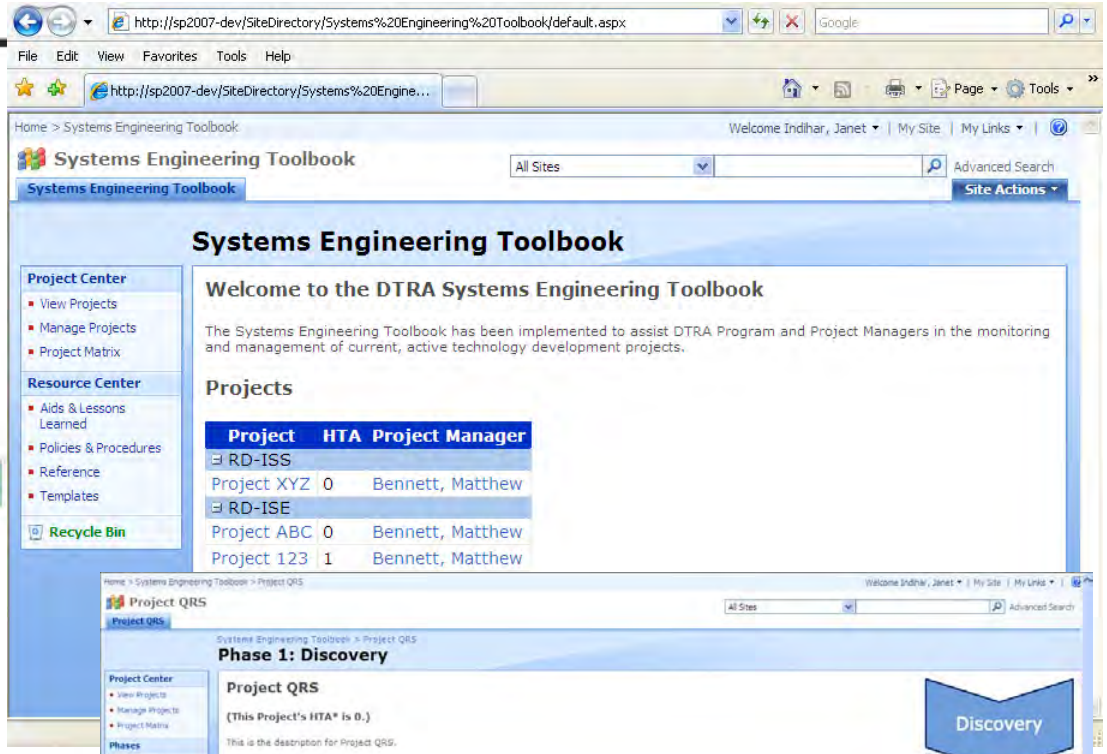
User Manual – Version 1.0

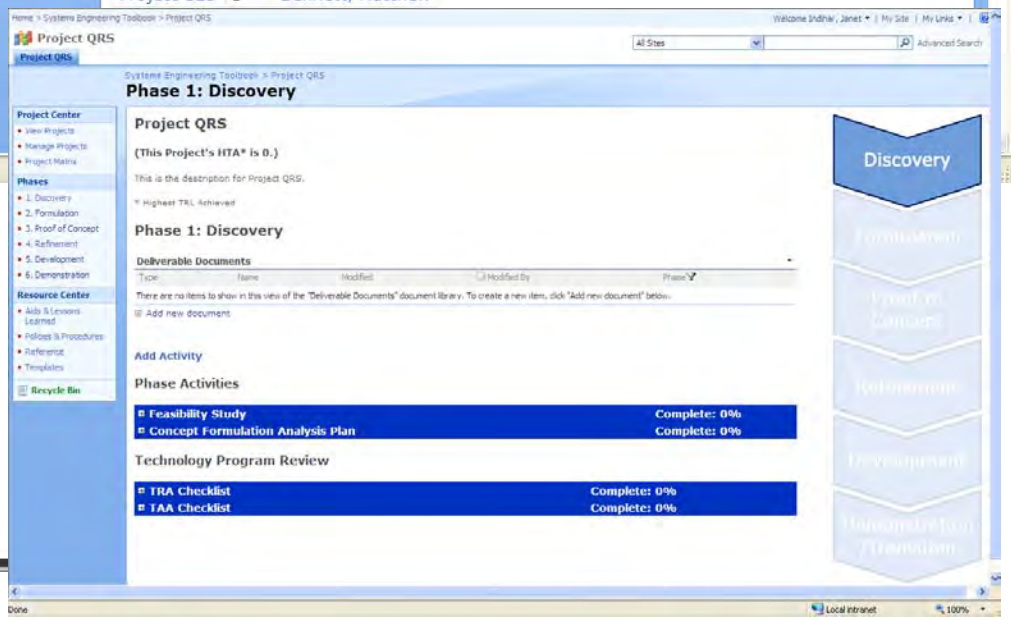
DMD, LLC Contract No. W9113M-08-D-0003-0007

Prepared by:
DMD, LLC
360B Quality Circle NW
Huntsville, AL 35806
(256) 705-6800

For the:
Defense Threat Reduction Agency (DTRA)
Research and Development Enterprise
Innovation and System Engineering Office

Copyright © 2010 DMD, LLC Unlimited Government Rights, ALL OTHER RIGHTS RESERVED
This data was developed pursuant to Contract Number W9113M-08-D-0003-0007 with the US Government for the Defense Threat Reduction Agency.





DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

TPMM Strategic Value

Status of Programs

- Standardizes Progress in Meeting TRL Maturity Goals
- Transition Agreements in place
- Successful Transitions over time
- Program Distribution by
  - TRL
  - Technology Domain
    - •Science Discipline
    - •Sponsor
  - Acquisition Customer
  - Funding

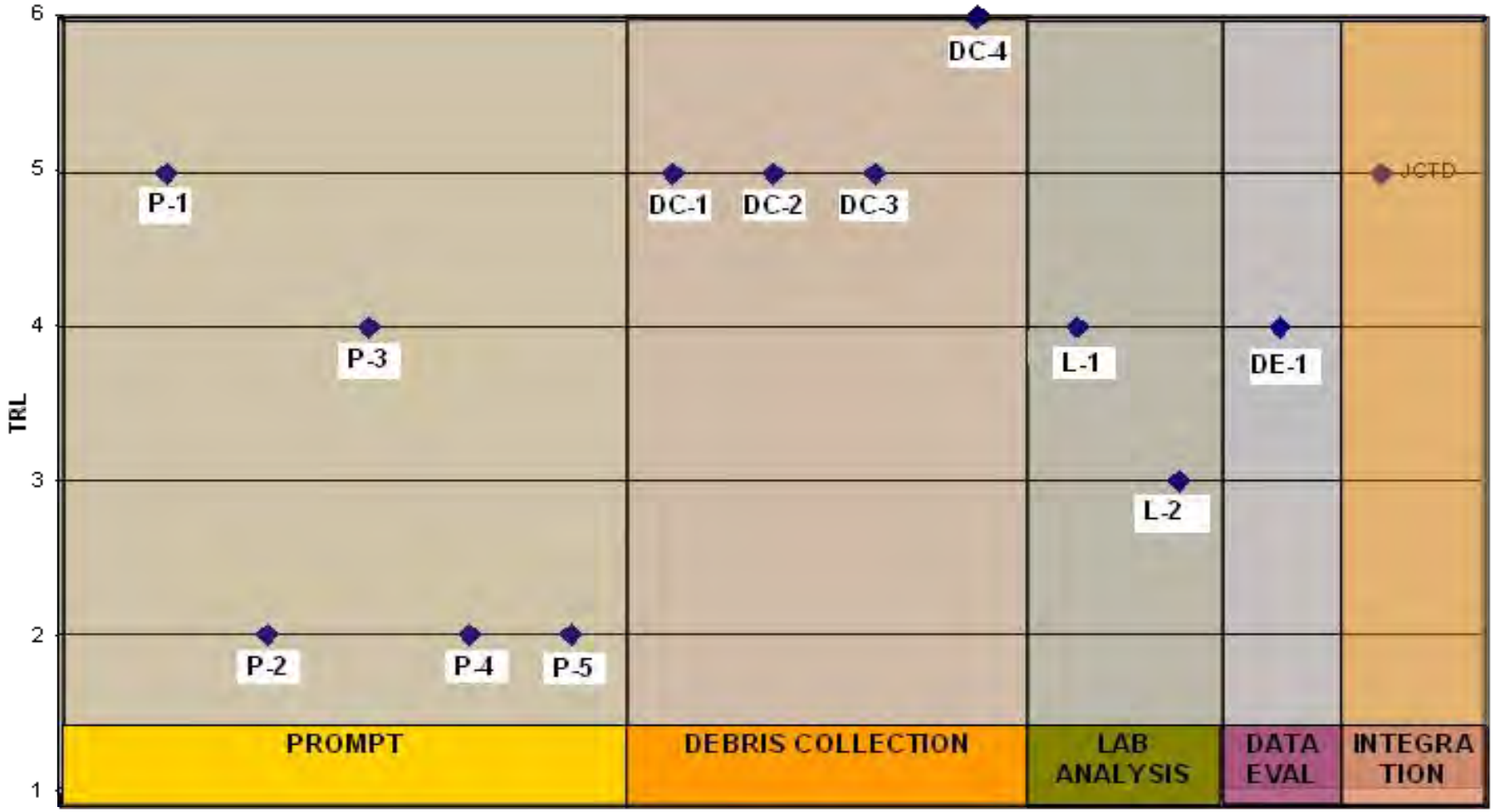
Facilitate Strategic Planning

- Technology Distribution and Prioritization
- Technology Development Gap Analysis
- Domain Analysis
  - Skill gaps / recruiting needs (Develop/Maintain technical skill set)
  - Diversified Portfolio Analysis
    - •Sponsor
    - •Science Discipline
- TTA Migration Status
- Develop POM/Budget Inputs
  - Substantiates Technology maturity and value

TPMM Provides a Metrics-driven Process that Supports Strategic Decision Making

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Technology Quicklook Maturity View: Forensics



DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

TPMM Outputs Support Decision Making

TPMM Output	Priority	1	2	3	4	5
Technology Advancement Degree of Difficulty (TAD^2)	1	Well Within	Within	Pushing the Science	Hard Push on Science	Breakthrough Required
Risk	1	100% Mitigated	< 100% > 75% Mitigated	< 75% > 50% Mitigated	< 50% > 25% Mitigated	< 25% Mitigated
Next TRL Achievement	1	Imminent (0-6 months)	Soon (6-12 months)	Ranged (12-18 months)	Far (18-24 months)	Horizon (>24 months)
TRL Roadmap to Transition	1	1 Year	2 Years	3 Years	4 Years	>4 Years
Technology Transition Agreement (TTA) Initiated	1	Commitment	Intent	Interest	Under Development	None
Phase Cost (Funding Objectives and Threshold Minimum)	1	< $500K	>$500K <$1M	>$1M <$2M	>$2M <$3M	>$3M
Measure of Effectiveness as a % improvement over existing capability/performance	1	>100%	< 100% > 75%	< 75% > 50%	< 50% > 25%	< 25%
Requirements Trace	1	Traceable to DTRA Mission	Traceable to RD-NT	Traceable to RD-NT-NTD	Level DoD Source	Not Traceable

- **A priority can be set for any given factor when one has more influence with the decision than another (i.e., where MoE is more important than cost but equal in relevance to TAD^2)**
- **TPMM outputs can be used to support investment decisions applied as follows:**
  - **A Project that totals [≥ 33] is in need of review for continuation**
  - **A Project that ranks [≥ 21 but ≤ 32] needs Management Oversight**
  - **A Project that totals [≥ 11 but ≤ 20] has moderate risk**
  - **A Project that totals [≤10] should be considered as well targeted and relatively Low Risk**

DMD

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Summary

- TPMM is an ***activity model*** for technology development that is partitioned into phases and gate-qualified using ***TRL***.
- TPMM is a ***best practice standard*** that expands TRL understanding to include ***detailed activities, exit criteria, and deliverables***.
- TPMM is a ***toolset*** used by the Tech Manager to ***plan, guide and measure*** a technology program's development maturity.
- TPMM is an ***alignment mechanism*** that promotes early focus on ***transitioning the technology*** to Acquisition Program Customers.
- TPMM acts as a ***common yardstick*** and provides the criteria for evaluating the ***Technology Development Strategy*** earlier.
- TPMM model provides ***a standard TRL criteria set*** for performing effective ***Technology Readiness Assessments*** at MS B

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

Contact/Consultation Information

Mr. Jeffrey Craver
Defense Acquisition University
South Region
Huntsville, AL 35807
E-mail: Jeffrey.Craver@dau.mil

Mr. Hossam Ahmed
DTRA-RD
Ft. Belvoir, VA
E-mail: Hossam.Ahmed@dtra.mil

Mr. Mike Ellis
DTRA-RD
(USASMDC/DMD, LLC)
Ft. Belvoir, VA
E-mail: Michael.Ellis_contractor@dtra.mil

US Government Personnel can request a copy of TPMM V2.pdf file at:
http://www.tpmm.info

DISTRIBUTION STATEMENT A. **Approved for Public Release. Distribution Unlimited.**

QUESTIONS?

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

NDIA EHM COMMITTEE Enterprise Health Management Technology Transition Task

27 Oct 2010
Presented by Chris Reisig
Boeing
Integrated Diagnostics
NDIA EHM Committee Co-Chair

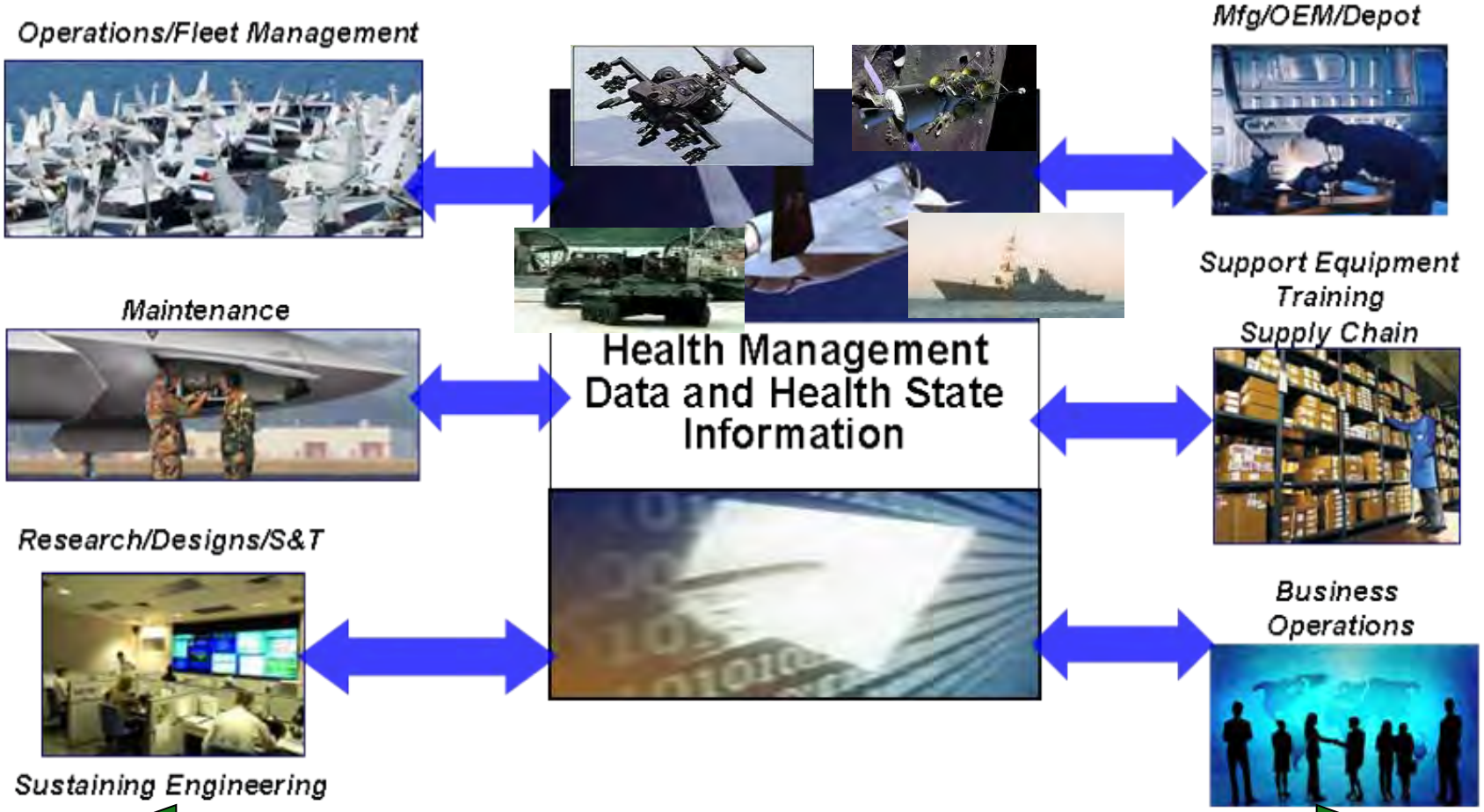
Enterprise Health Management – What is it

"The capability to make intelligent, informed, appropriate decisions across the Enterprise about design, logistics, maintenance and operational actions based on Health Management Data or Information, available resources, acquisition strategy, and operational demand."

Next Generation Enterprise Health Management Decision Support Solution Targeting Unprecedented Value, Affordability and Continuous Improvement

Key Attributes Include….
EHM as a Design Element; Proactive Advisory Generation Based on Health State; Autonomic; Planned Maturation; Near Real Time Updates; No False Alarms

EHM – Who's Affected



Product life cycle must be considered for applicable transition

Transformation Expected Across All Elements
Strong Commonality Across Platforms

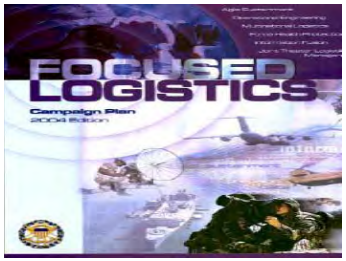
EHM – Who Promotes It

Shared Vision, Purpose & Barriers

Prognostics and Health Management

The capability to make intelligent, informed, appropriate decisions across the Enterprise about design, logistics, maintenance and operational actions based on HM information, available resources, acquisition strategy, and operational demand.

AFSO21
Air Force Smart Ops For The 21st Century

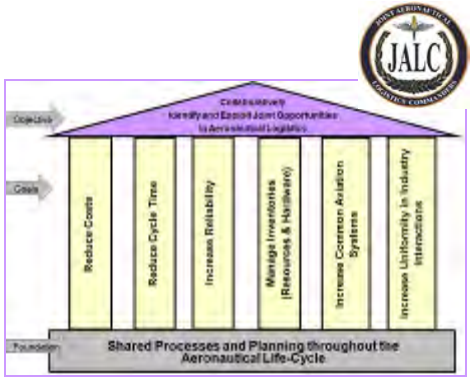


The proactive approach to managing fleet health

SLIM Mission Statement

Integrate WSIP, CBM+, RCM/MSG-3, RAM, MFOQA, EAVI, and AIP efforts. Standardize engineering processes/tools associated with improving system performance monitoring and assessment leading to proactive weapon system management and product improvement throughout the system lifecycle.

CBM+ is the application and *integration of appropriate processes, technologies and knowledge-based capabilities* to improve the *reliability and maintenance effectiveness of DoD systems and components*. At its core CBM+ is maintenance performed on evidence of need provided by Reliability-Centered Maintenance (RCM) analysis *and other enabling processes and technologies*.



Enterprise Health Management is the Common Denominator

The Bridge

Required for Efficiency and Effectiveness

Prognostics and Health Management

The capability to make intelligent, informed, appropriate decisions across the Enterprise about design, logistics, maintenance and operational actions based on HM information, available resources, acquisition strategy, and operational demand.

AFSO21

Air Force Smart Ops For The 21st Century

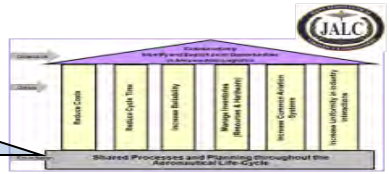
The proactive approach to managing fleet health

SLIM Mission Statement

Integrate WSIP, CBM+, RCM/MSG-3, RAM, MFOQA, EAVI, and AIP efforts. Standardize engineering processes/tools associated with improving system performance monitoring and assessment leading to proactive weapon system management and product improvement throughout the system lifecycle.

BUSINESS TRANSFORMATION

CBM+ is the application and *integration of appropriate processes, technologies and knowledge-based capabilities* to improve the *reliability and maintenance effectiveness of DoD systems and components.* At its core CBM+ is maintenance performed on evidence of need provided by Reliability-Centered Maintenance (RCM) analysis *and other enabling processes and technologies.*



Focused EHM Framework, Guiding Principles & Collaborative Alliance

Needs, Barriers, Expertise, Funding, Schedule, Data, Roadmaps

STAKEHOLDERS/SPONSORS

Policy & Requirements	**Technology Offices**	**OEM/Integrators**
Programs and Platforms	**Research Labs**	**Suppliers**
Warfighters	**Academia**	**Small Business**

The Fundamental Challenge

"Despite significant investment in technology-the uptake of CBM+ enabling technologies and emerging concepts like Enterprise Health Management (EHM) into operational forces is languishing due to significant gaps and barriers preventing effective technology transition."

ADUSD MP&P tasked NDIA to study the problem:

- **Review a framework for EHM developed by the JSF PHM Lead**
- **Assess and recommend a set of applicable guiding principles**
- **Use the proposed framework to identify common system level gaps and barriers to achieving CBM+**
- **Determine the need and desire for an overarching alliance of industry, government, academia, and professional societies to accelerate uptake of CBM+ capabilities into the Services' platforms.**

Task Activities

Near-term Actions	FY2008	FY2009	FY2010	FY2011
Task Initiated				
Refine Concept in Committee				
Conduct Workshop				
Refine Results and Prepare Report				
Results Briefed to Sponsors				

Strategic Focus Areas

Study identified nine Strategic Focus Areas vital to transition:

Strategic Focus Area	State Change Needed
EHM Systems Engineering Process and Framework	An EHM framework with SE process to derive holistic CBM+ solutions and drive transition.
Architecture	A reference model with tools to develop effective architectures.
Standards	Use of existing standards, and creation of new standards for EHM.
Alignment/Collaboration	Alignment/collaboration across industry, government and academia
Policy	Revise existing CBM+ DoD policy to add link to EHM framework.
Business Case/Communication	Cost modeling tools that link requirements, solution, CONOPS, KPPs, and LCC management objectives of the particular program.
Organization/ Leadership	An "overarching leadership structure" that effectively integrates the various elements of EHM.
Education	Training and educational resources for CBM+.
Test Environments and Guidelines	Test environment and guidelines to demonstrate validity and maturity of a given CBM+ approach.

Strategic Focus Areas Leadership

Strategic Focus Area (SFA)	Issue Description	Recommended Leader
1. EHM Systems Engineering Process and Framework	An EHM framework with SE process to derive holistic CBM+ solutions and drive transition.	Jim Dill(Chair), Phil Dussault(Deputy-chair)
2. Architecture	A reference model with tools to develop effective architectures.	Michael Mullins (Chair), Mark Hollins(Deputy-chair)
3. Standards	Use of existing standards, and creation of new standards for EHM.	Phil Dussault(Chair), Michael Mullins(Deputy-chair)
4. Alignment/Collaboration	Alignment/collaboration across industry, government and academia	Sonia Vohnout(Chair), Ron Newman(Deputy-chair)
5. Policy	Revise existing CBM+ DoD policy to add link to EHM framework.	Ron Newman(Chair), Dave Cutter(Deputy-chair)
6. Business Case/ Communication	Cost modeling tools that link requirements, solution, CONOPS, KPPs, and LCC management objectives of the particular program.	Paul Howard(Chair), Jim Dill(Deputy-chair)
7. Organization/ Leadership	An “overarching leadership structure” that effectively integrates the various elements of EHM.	Steve Desantis (Chair), Andy Hess(Deputy-chair)
8. Education	Training and educational resources for CBM+.	Ed Crow(Chair), William Decker (Deputy-chair)
9. Test Environments and Guidelines	Test environment and guidelines to demonstrate validity and maturity of a given CBM+ approach.	Mark Hollins (Chair), Kirby Keller (Deputy-chair)

Recommended Actions (Forward Strategy)

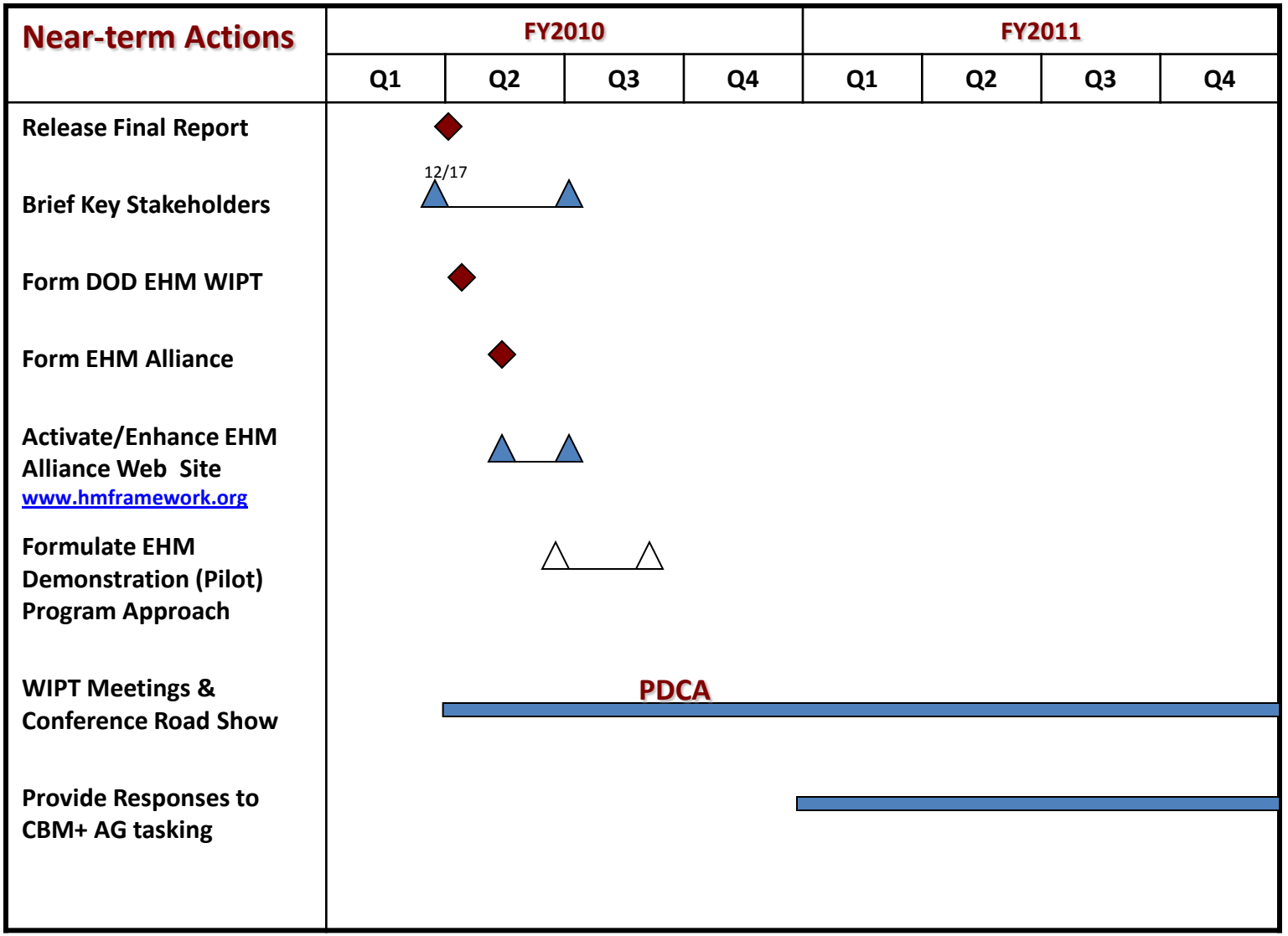
- ✓ **Form EHM WIPT under existing CBM+ Action Group (AG) to assess and align ongoing CBM+ initiatives, formalize EHM process and address Strategic Focus Areas identified**

- ✓ **Form an alliance among government, industry, and academia to collaborate and promote the transition of CBM+/EHM capabilities, and the adoption of the common EHM framework.**

- **Create an Enterprise Demonstration (Pilot) Program--integrating CBM+ components from the major ongoing programs, government labs, industry and academia, initiate an effort to demonstrate the effective benefits, implementation, and transition of a CBM+ enterprise solution based on the proposed EHM framework approach.**

- **Plan/do/check/adjust– to provide a measure of progress against the strategic focus areas and overall task progress**

Action Plan


Near-term Actions
FY2010
FY2011
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Release Final Report
12/17
Brief Key Stakeholders
Form DOD EHM WIPT
Form EHM Alliance
Activate/Enhance EHM Alliance Web Site
www.hmframework.org
Formulate EHM Demonstration (Pilot) Program Approach
WIPT Meetings & Conference Road Show
PDCA
Provide Responses to CBM+ AG tasking

The NDIA EHM Advisory Alliance – NEAA
Key Attributes

- **NEAA Organization Format**
  - Reports to the NDIA EHM Committee Chairs
  - Supports the OSD EHM WIPT
  - Tasks From the WIPT Approved by the EHM Chairs and the SED
  - Eleven Core Member Positions – one Chair with one DoD co-chair + three Classes of three Members Each. Class members recruited by chair
    - Initial class nominated 2010, term ends 2013
    - Second class nominated 2010 term ends 2014
    - Third class nominated 2010 term ends 2015
    - Staggered "nominations and commitment" 3 each year
    - Chairman serves for one year with no term limits
  - Class Tenure – three years.
  - NDIA Rules Govern All Tasking
- **Tasking Implementation Process**
  - Upon Approval of a WIPT Tasking, the task is assigned to an NEAA Task Leader (PM)
  - NEAA task leader forms a Task Group with Expertise Applicable to the Specific Tasking
    - Members Drawn From Academia, Industry, Government on an Ad Hoc Basis
  - Task Plan / Schedule / Deliverables Defined and Approved by NDIA EHM Chairs
  - Task Group Interacts With WIPT as Needed during Task Performance
  - Task Products Approved by EHM Chairs, SED, and Forwarded to WIPT

Questions?

DRIVE Developments, Inc.

National Defense Industrial Association

Promoting National Security Since 1919

13th Annual Systems Engineering Conference

"Achieving Acquisition Excellence via Effective Systems Engineering."

San Diego, CA

October 27th, 2009

"Unmanned Ground Vehicle Integrated Diagnostics"

Larry Osentoski, President & CEO

DRIVE Developments, Inc.

7314 Nineteen Mile Road

Sterling Heights, MI 48314

DRIVE Developments, Inc.

Corporate Overview

DRIVE Developments, Inc. is a high quality engineering solution provider. Our experience is strongly rooted in vehicular diagnostics and prognostics. This is evidenced in our **DIME (Diagnostic Information Management Environment)** product line which combines over 50 years of staff experience with hardware and software development within test facilities, **remote diagnostics and fleet management**.

The breadth of our capabilities also extend into other areas of vehicular engineering to include scientific test cell development, internet applications and plant monitoring systems.

We truly believe in the philosophy of "Lead, Follow or Get Out of the Way"

DRIVE Developments, Inc.

Business Highlights

- Michigan Small Business incorporated in July 2007
- Focused on Military and Commercial vehicle work
- Featured on The Economic Report with Greg Gumbel in Fall 08’
- Selected as one of “Michigan’s 50 Businesses To Watch for 2009”
- Selected as Prime on $500M / 5 year TARDEC OMNIBUS
- Selected as Crain’s Top 25 Defense Companies to Watch 2010

DRIVE Developments, Inc.

Overview :

This presentation will present an example of successful integration of diagnostics within a UGV platform that was delivered to US Forces Special Operations Command by DRIVE Developments, Inc. for use in riverine drug interdiction operations OCONUS.

The UGV, named **ARK**, is an Amphibious Robot that can travel at speeds up to 22 mph on land and up to 5mph in waterways. The vehicle is remote controlled and is interoperable with all Ethernet based military communications including but not limited to Wave Relay equipment.

DRIVE Developments, Inc.

ARK – Amphibious Remote Controlled Robot

DRIVE Developments, Inc.

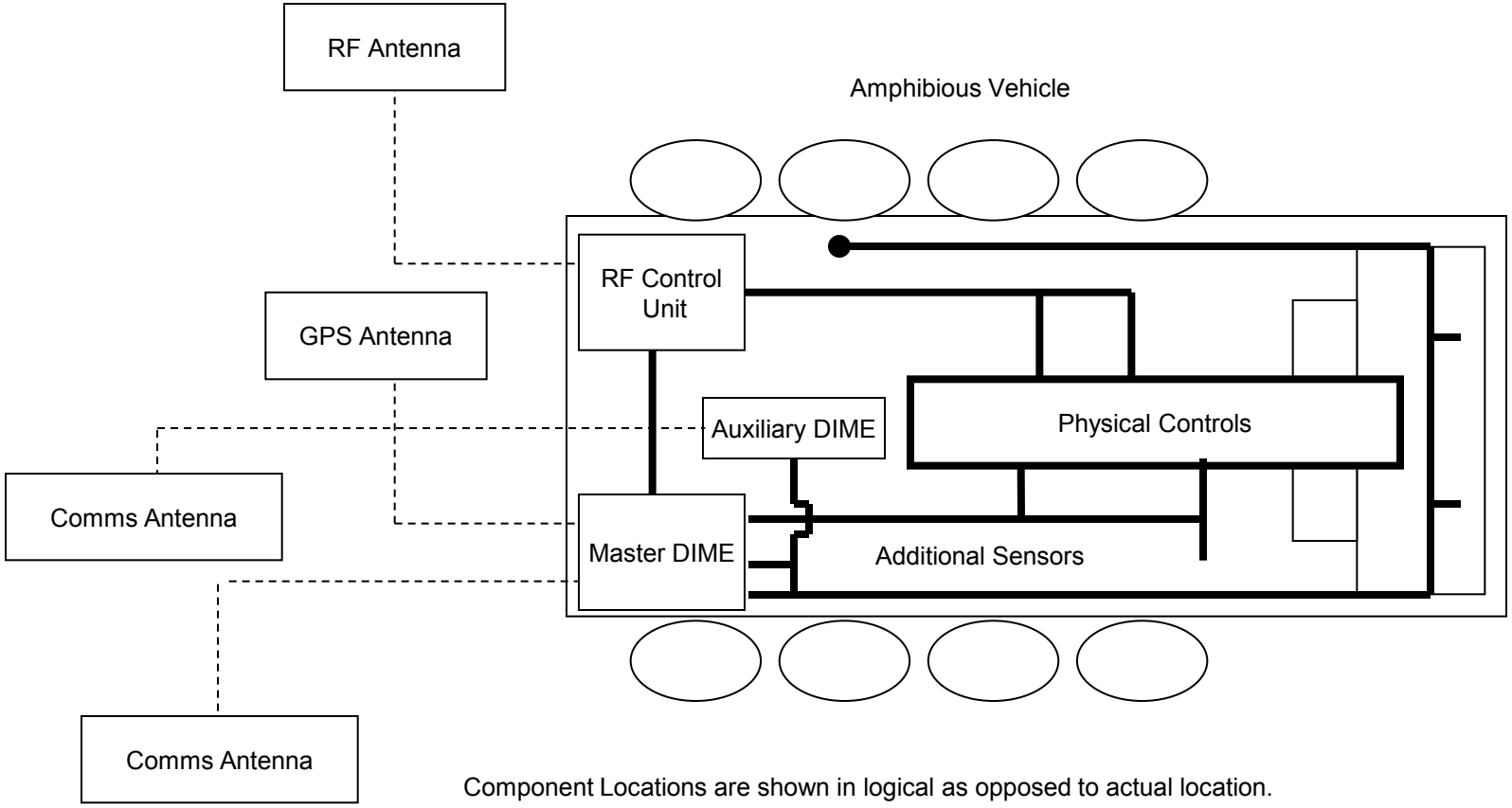
DRIVE Developments, Inc.

Features of ARK

- Resident CAN data bus which records vehicle activity and alerts operators and commanders of pending and current fault conditions
- GPS tracking
- Extensive on-board instrumentation and controls that provide a real time view into the current operation and long term duty cycle of the vehicle

DRIVE Developments, Inc.

ARK System
Hardware : *Logical System Block Diagram*



Component Locations are shown in logical as opposed to actual location.

DRIVE Developments, Inc.

SIDE VIEW ARK

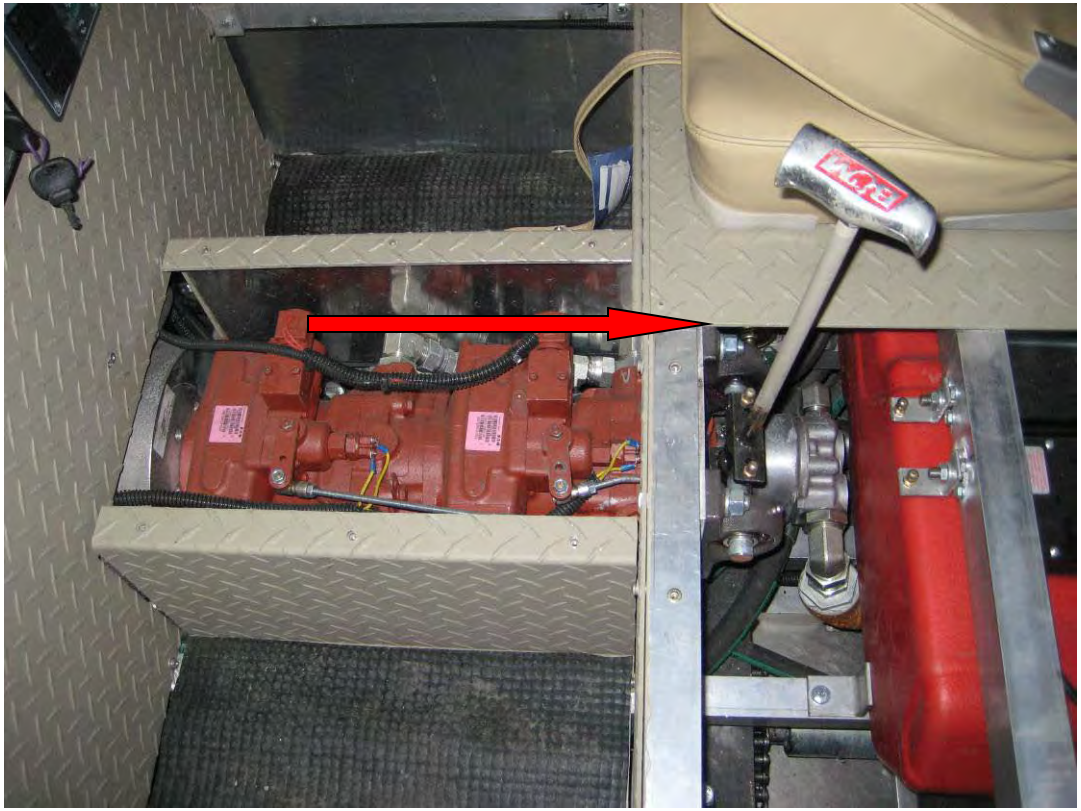
DRIVE Developments, Inc.

DRIVE Developments, Inc.

Onboard driver T-handle controls to override remote control system. Actuators free follow when driver overrides.

DRIVE Developments, Inc.

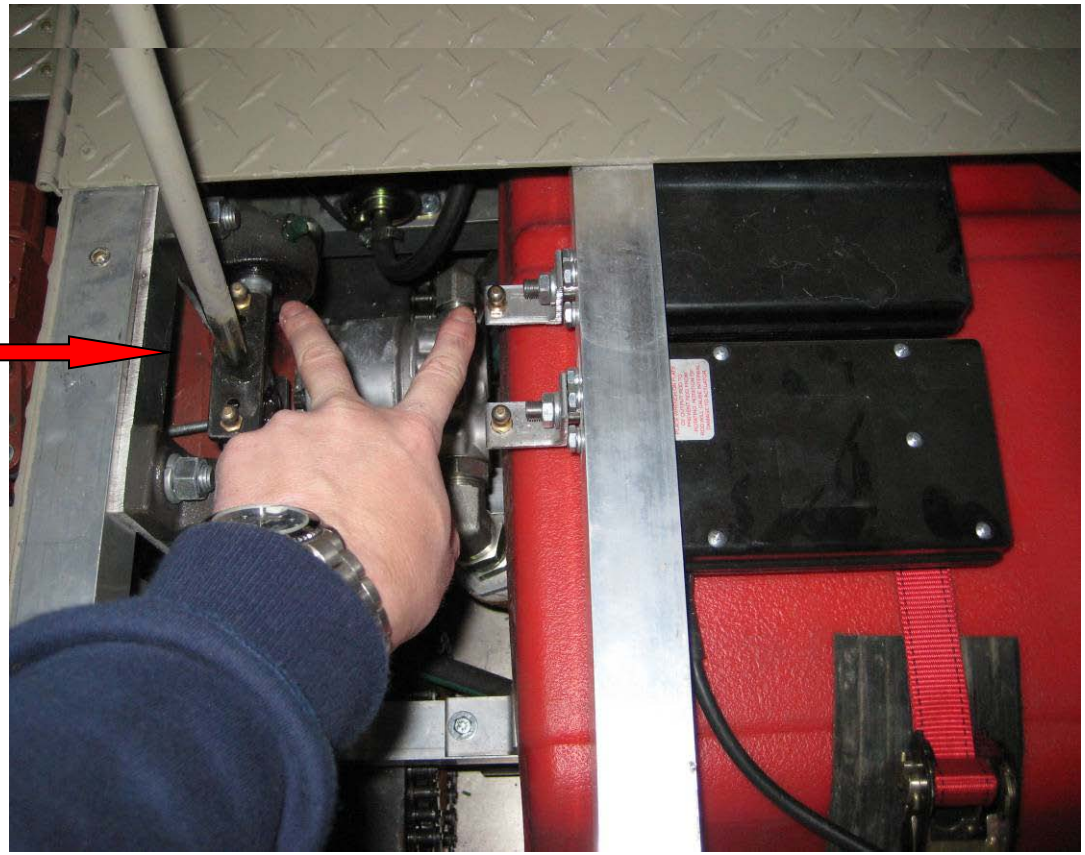
Onboard driver T-handle controls to override remote control system. Actuators free follow when driver overrides.



DRIVE Developments, Inc.

Onboard driver T-handle controls to override remote control system. Actuators free follow when driver overrides.

Two independent linkages manipulate all remote control motion via the two on board actuators



DRIVE Developments, Inc.

Hydrostatic driven outboard water propulsion

INSIDE CHASSIS VIEW

OUTSIDE CHASSIS VIEW

DRIVE Developments, Inc.

Upgraded Instrument panel

EStop Button

Fuel level gage

Remote enable switch

DRIVE Developments, Inc.

Instrument panel

The gauge is wired into the vehicles CAN network. The AUX DIME reads the gauge input and broadcasts the corresponding fuel level message. The MASTER DIME logs and reports the fuel level information to the portal system.

Fuel Level Gage controlled by DIME AUX Smart ECU on J1939 over CAN

DRIVE Developments, Inc.

Instrument panel

The E-stop is wired into the vehicle's control panel. When depressed all vehicle functions are cut off and power is removed from the system.

On board E-stop manually controlled by the operator.

DRIVE Developments, Inc.

Instrument panel

The switch is wired to the vehicle control systems and supplies power to the remote control unit. As a safety precaution changing modes during operation kills the engine. This prevents unwanted behavior when the actuators either take over or relinquish control.

Operator controlled remote control enable switch.

DRIVE Developments, Inc.

Hand Held Remote Control

Master and AUX DIME mounting: The DIME units and the remote control receiver electronics are mounted in NEMA enclosures as shown below.

AUX unit location.

DIME Master and Omnex Receiver location.

Situational Awareness : DIME Antenna

a) Dual WiFi / GPS antenna.
b) GPS antenna has active gain.
c) 2.4GHz Comms frequency supporting both 802.11b/g
d) Currently mounted on the hood of the vehicle to provide clear path to the sky for GPS.

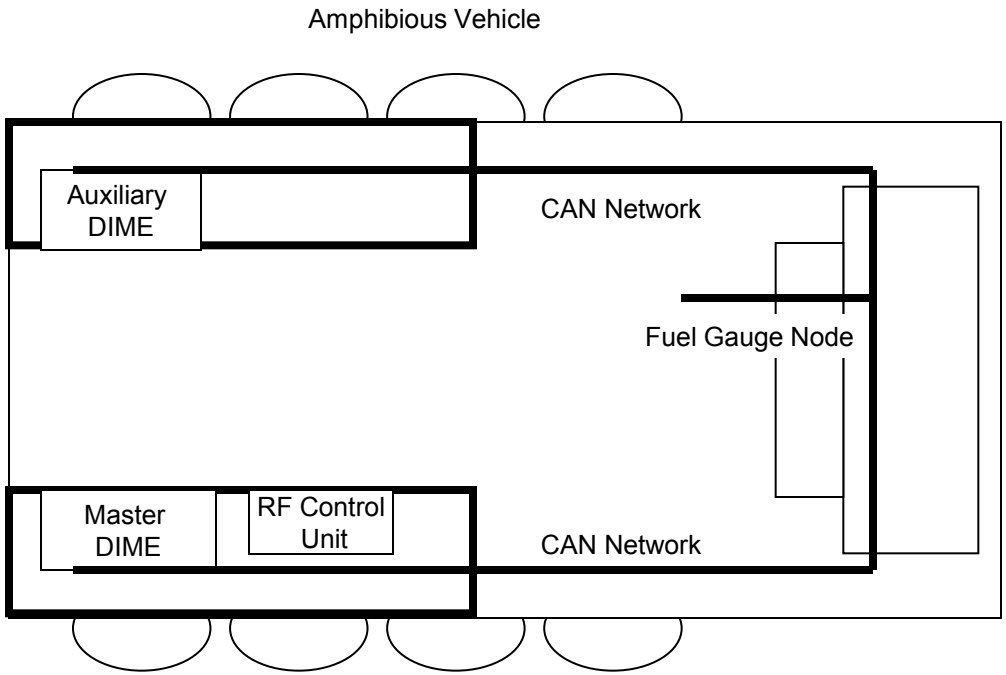
DRIVE Developments, Inc.

CAN J1939 Network

a) MASTER and AUX DIME CAN Controllers
b) AUX unit interfaces sensors and broadcasts CAN data providing network data.
c) MASTER unit collects data and reports to portal.
d) CAN J1939 Fuel gauge connects directly to the CAN network and receives messages.
e) The Network runs around the vehicle in a horseshoe pattern and allows for future connections and nodes.

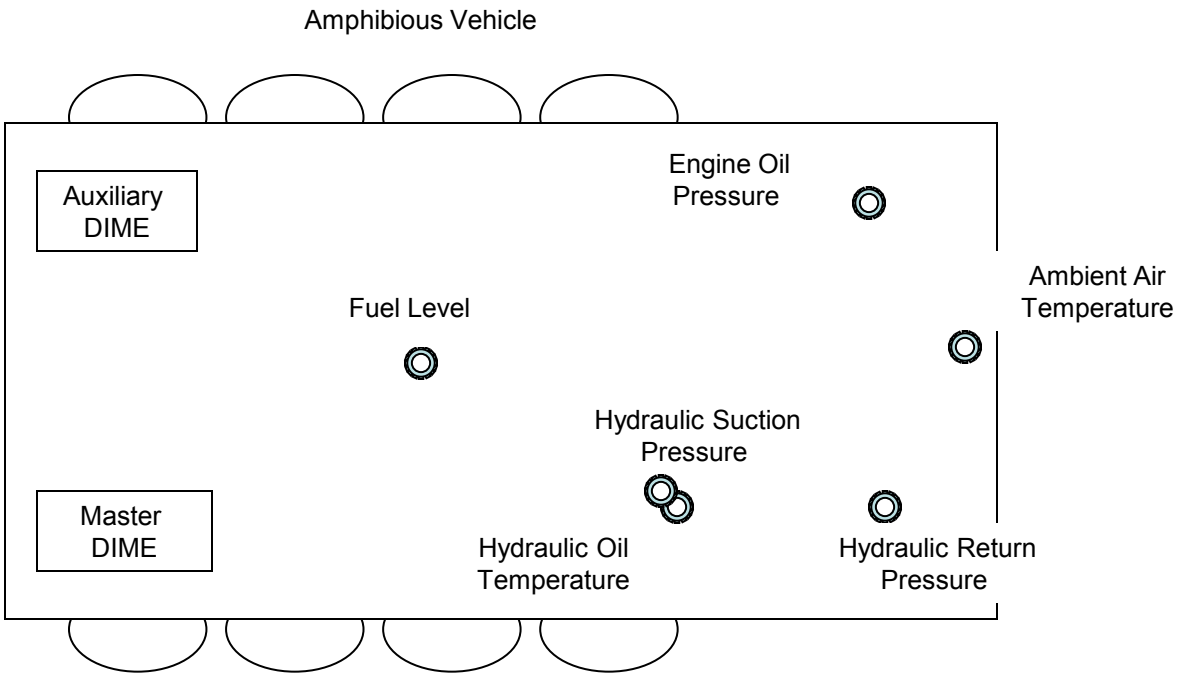
DRIVE Developments, Inc.

Situational Awareness : CAN J1939 Network



DRIVE Developments, Inc.

Situational Awareness : Sensor Locations



DRIVE Developments, Inc.

Situational Awareness : Integration

a) NEMA electronics enclosures mounted on each side of the vehicle.
b) DIME units and remote control receiving unit mounted within NEMA enclosures.
c) Power, ground and communications lines integrated.
d) Remote control integration complete with all functional testing passed.
e) CAN Network completed
f) Sensors wired to appropriate DIME units.
g) Communications/GPS antenna mounted.

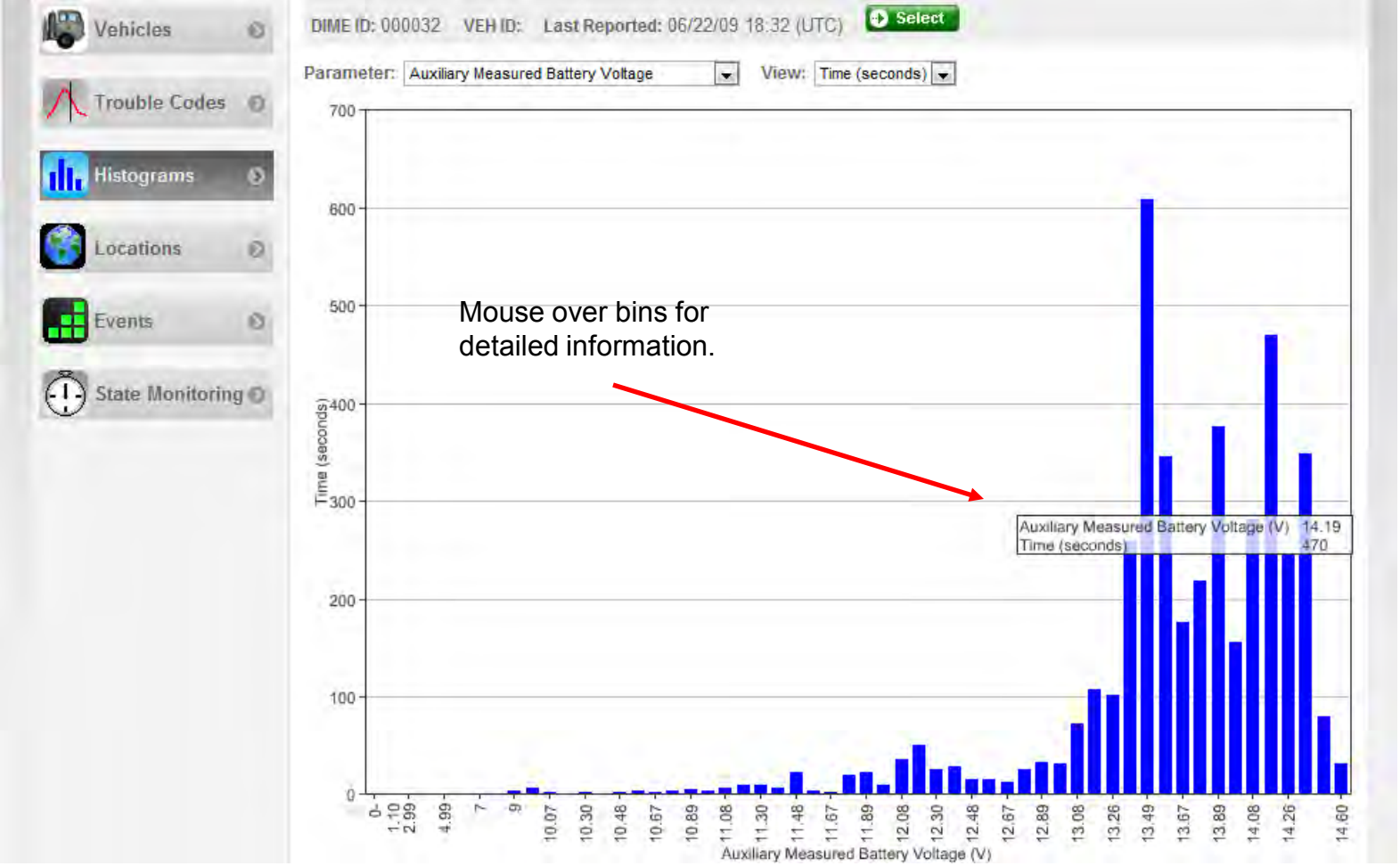
DRIVE Developments, Inc.

Vehicle Health & Situational Awareness

1. Application management features
    a. Remote firmware flash (MINT file)
    b. Remote Application flash (REED file)
2. Data Collection Types
   (Histograms, Time in State, Event Counters, Situation Awareness files, Event Window Files)
3. Data Collection Speed
    a. Bus speed for triggered or fault events
    b. 10 Hz (100ms) for non-time correlated data
4. Remote configuration - Proprietary data compression techniques enabling performance in low bandwidth Military environments.
5. System processing of data from multiple data bus sources (CAN, J1708, RS485) simultaneously.
6. Capable of storing data in emergency power loss situations.
7. BIST (Built In Self Test)

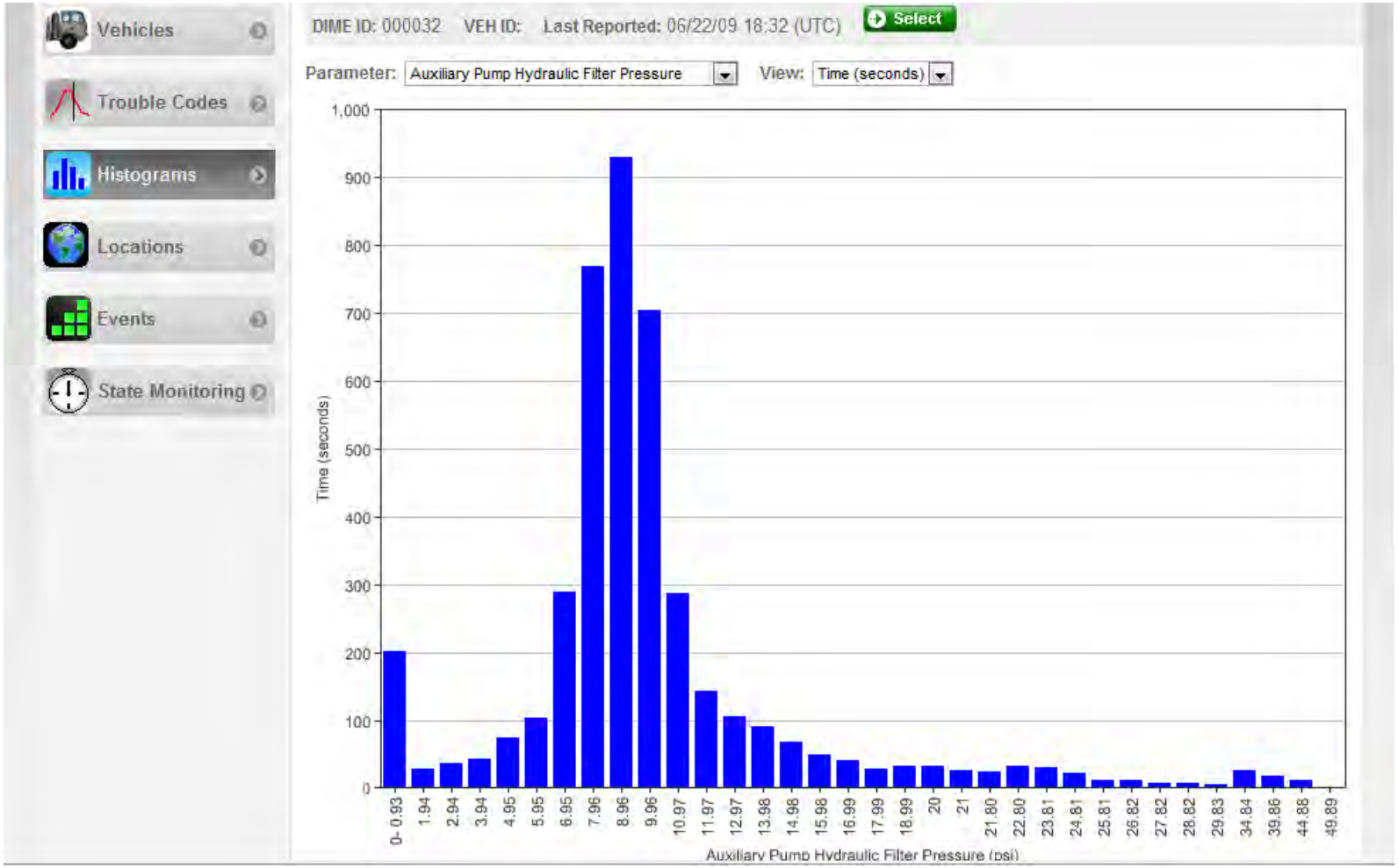
DRIVE Developments, Inc.

Auxiliary Measured Battery Voltage Histogram



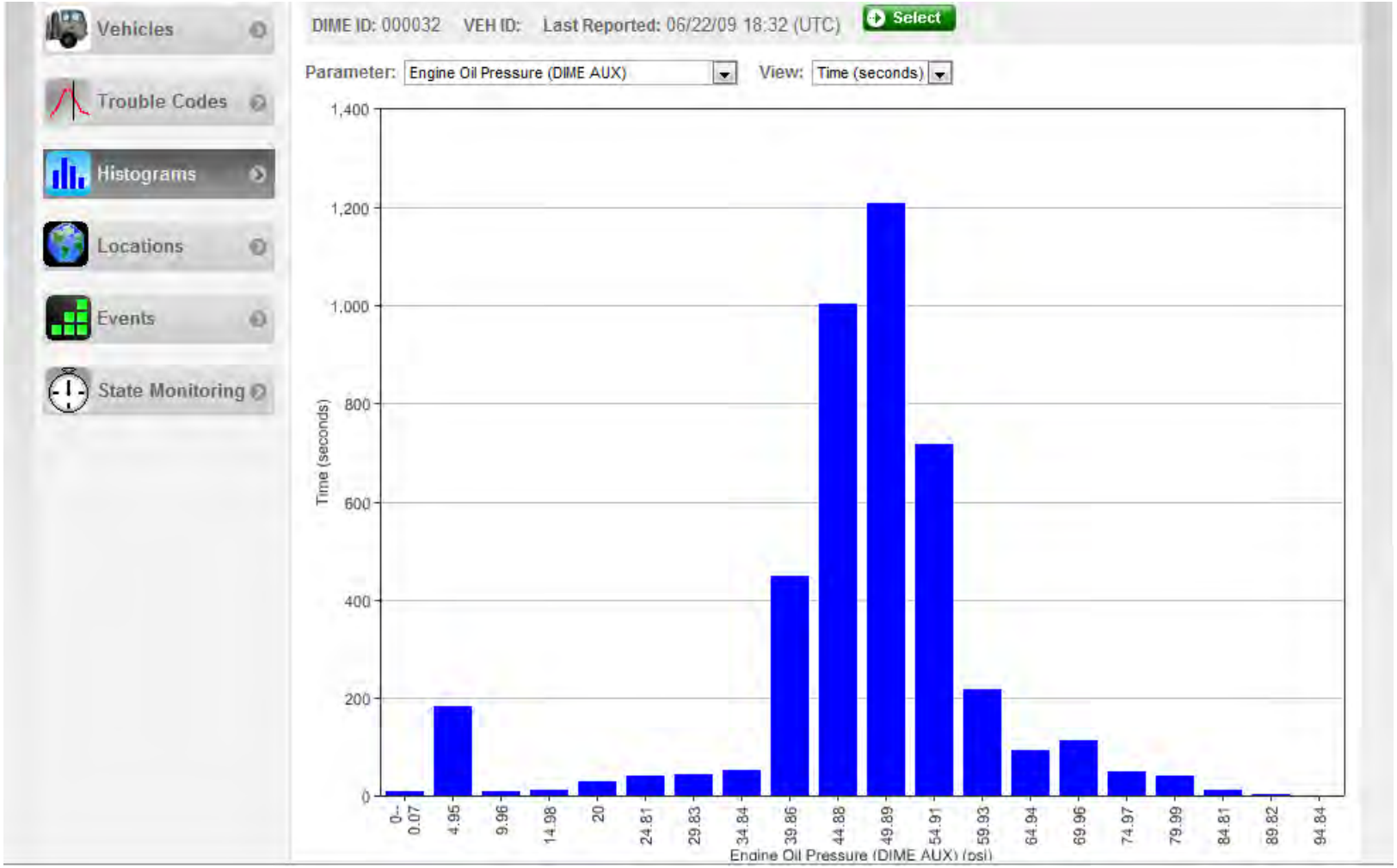
DRIVE Developments, Inc.

Auxiliary Pump Hydraulic Filter Pressure



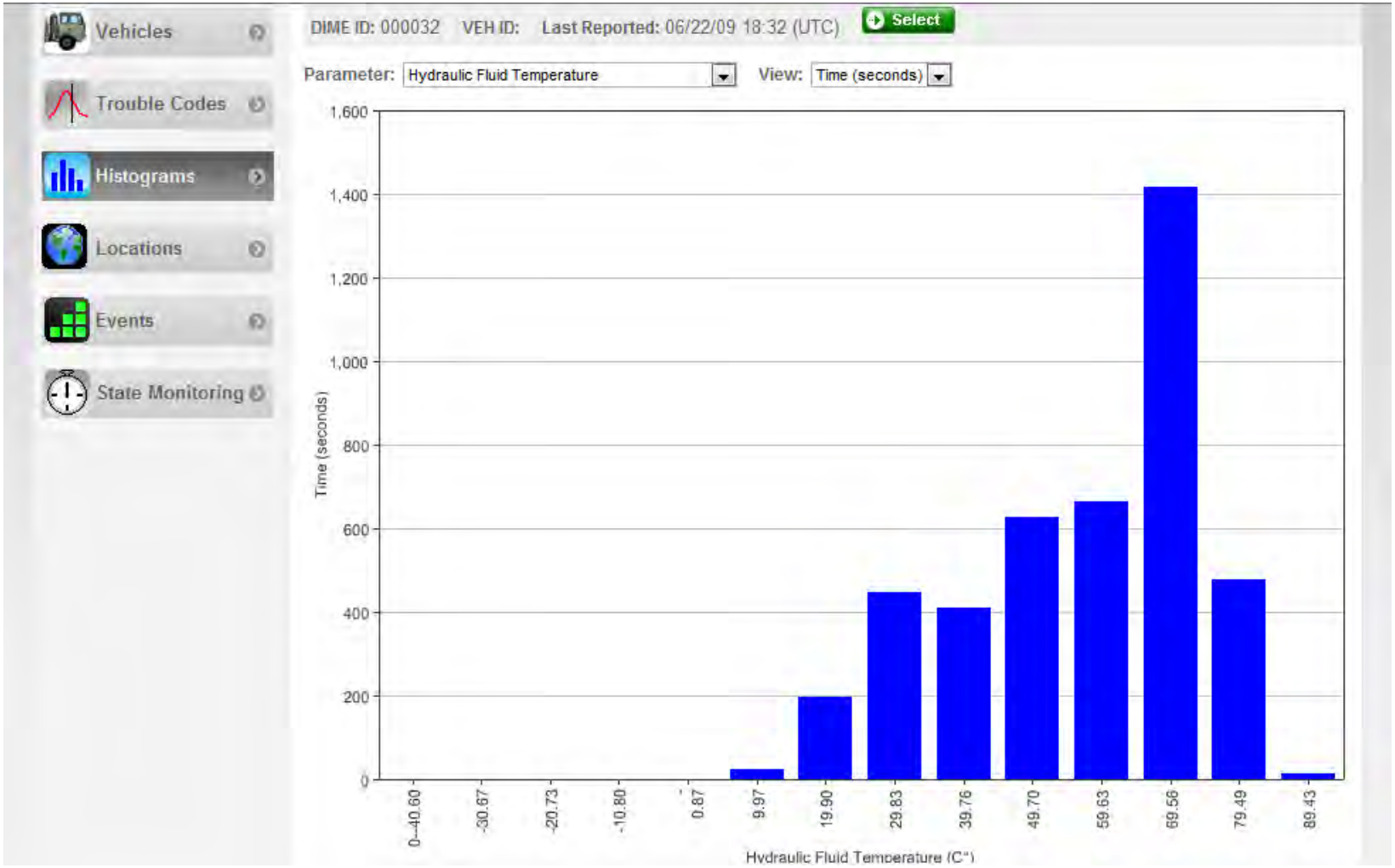
DRIVE Developments, Inc.

Engine Oil Pressure



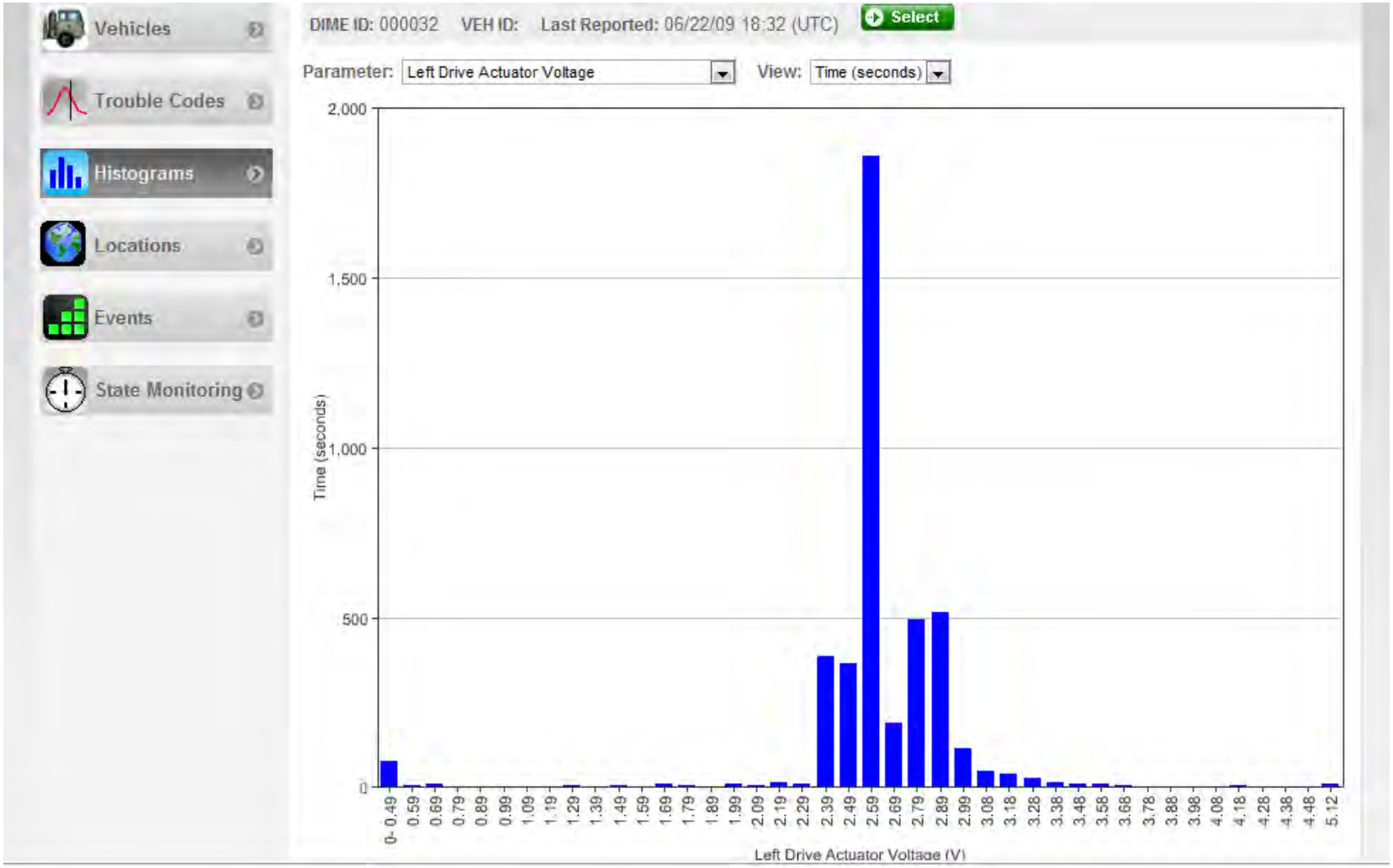
DRIVE Developments, Inc.

Hydraulic Fluid Temperature



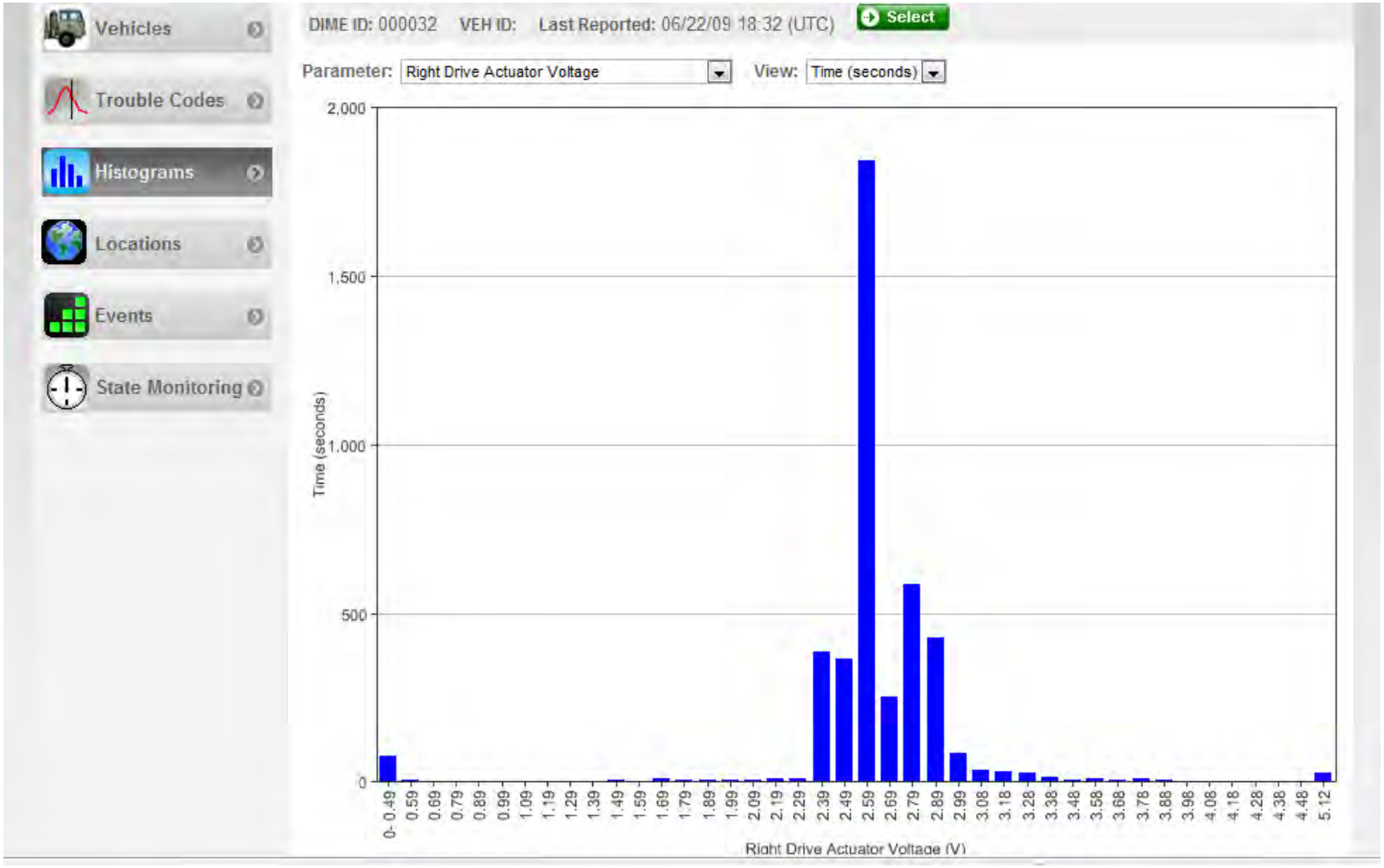
DRIVE Developments, Inc.

Left Drive Actuator Voltage



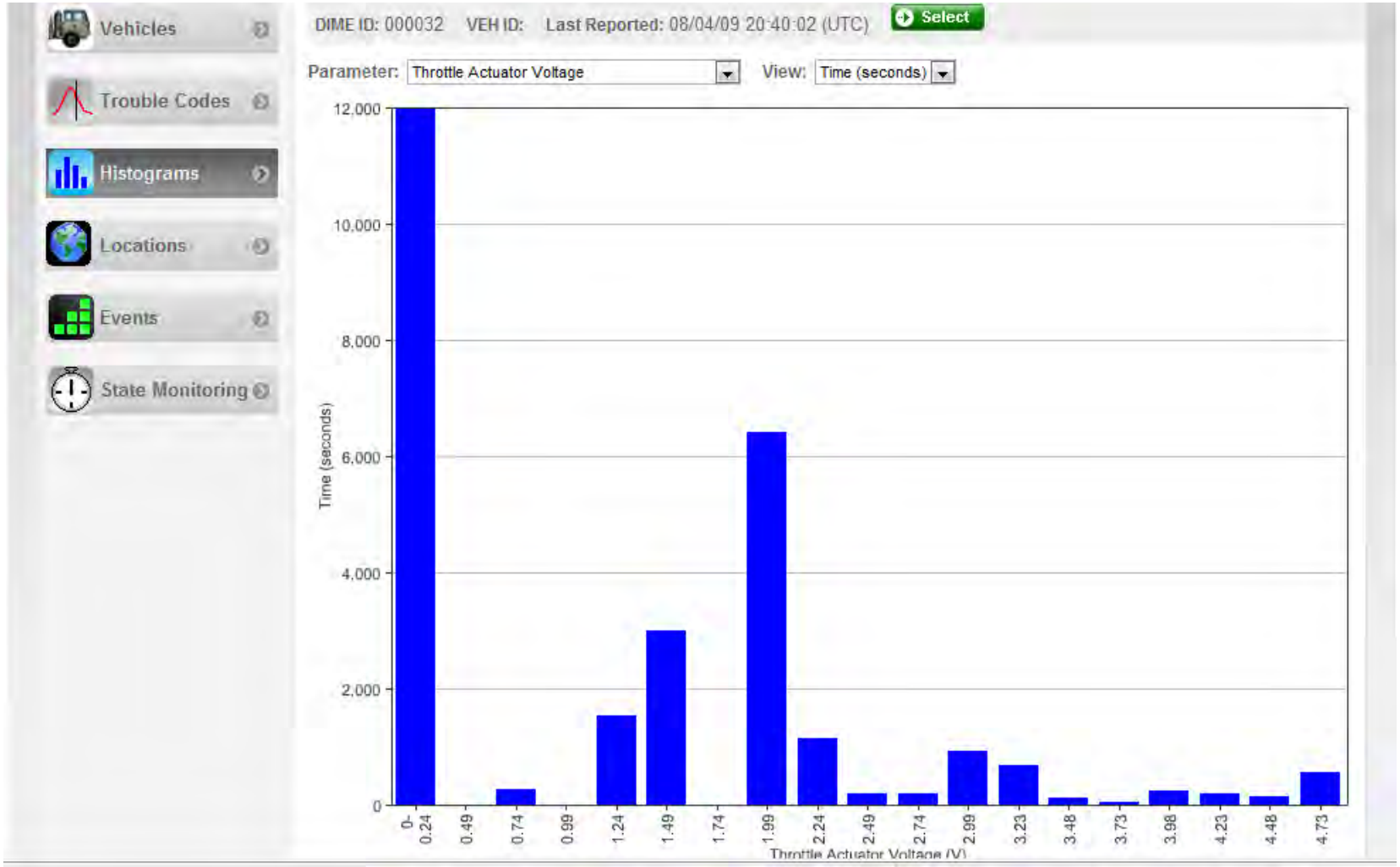
DRIVE Developments, Inc.

Right Drive Actuator Voltage



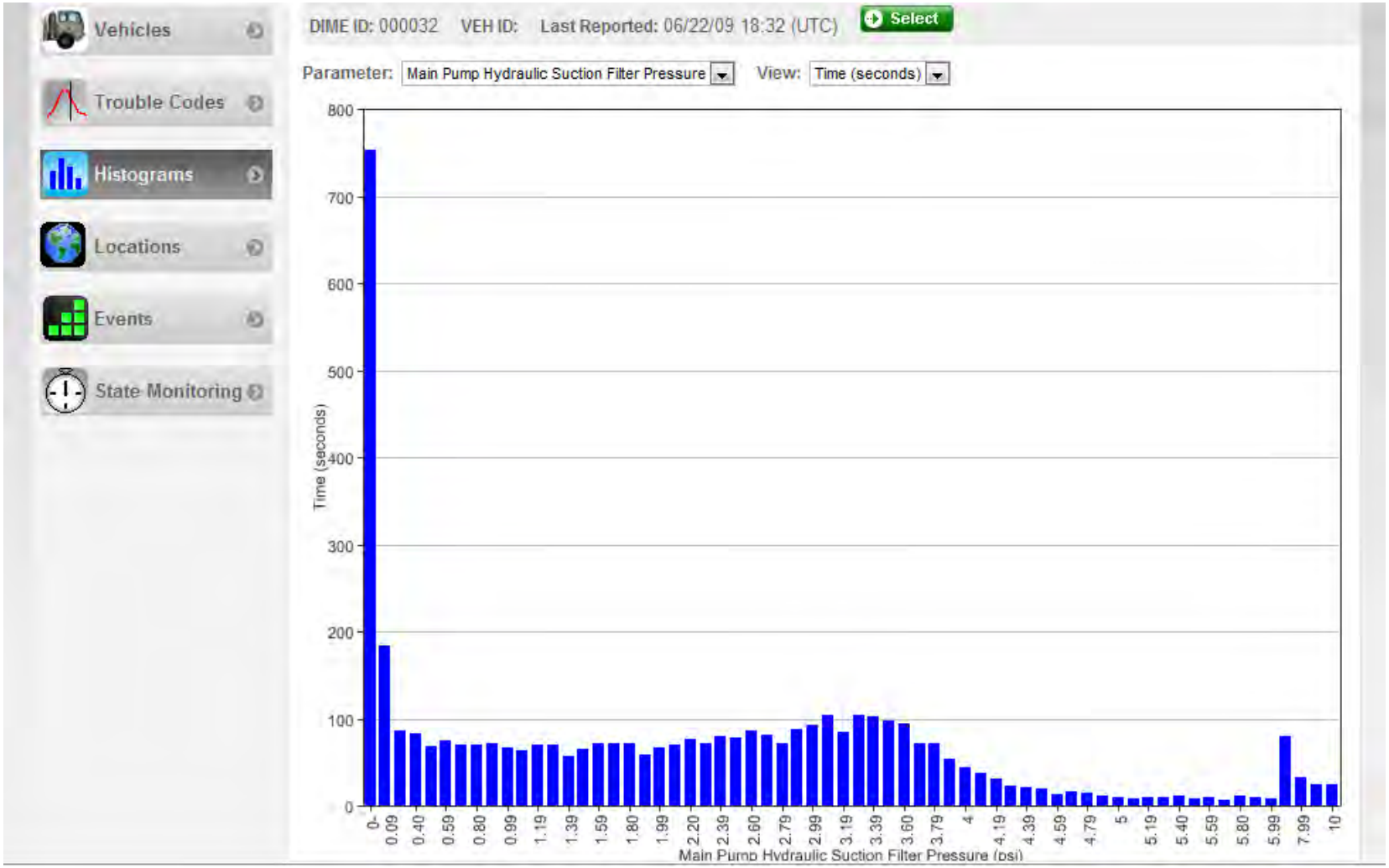
DRIVE Developments, Inc.

Throttle Actuator Voltage



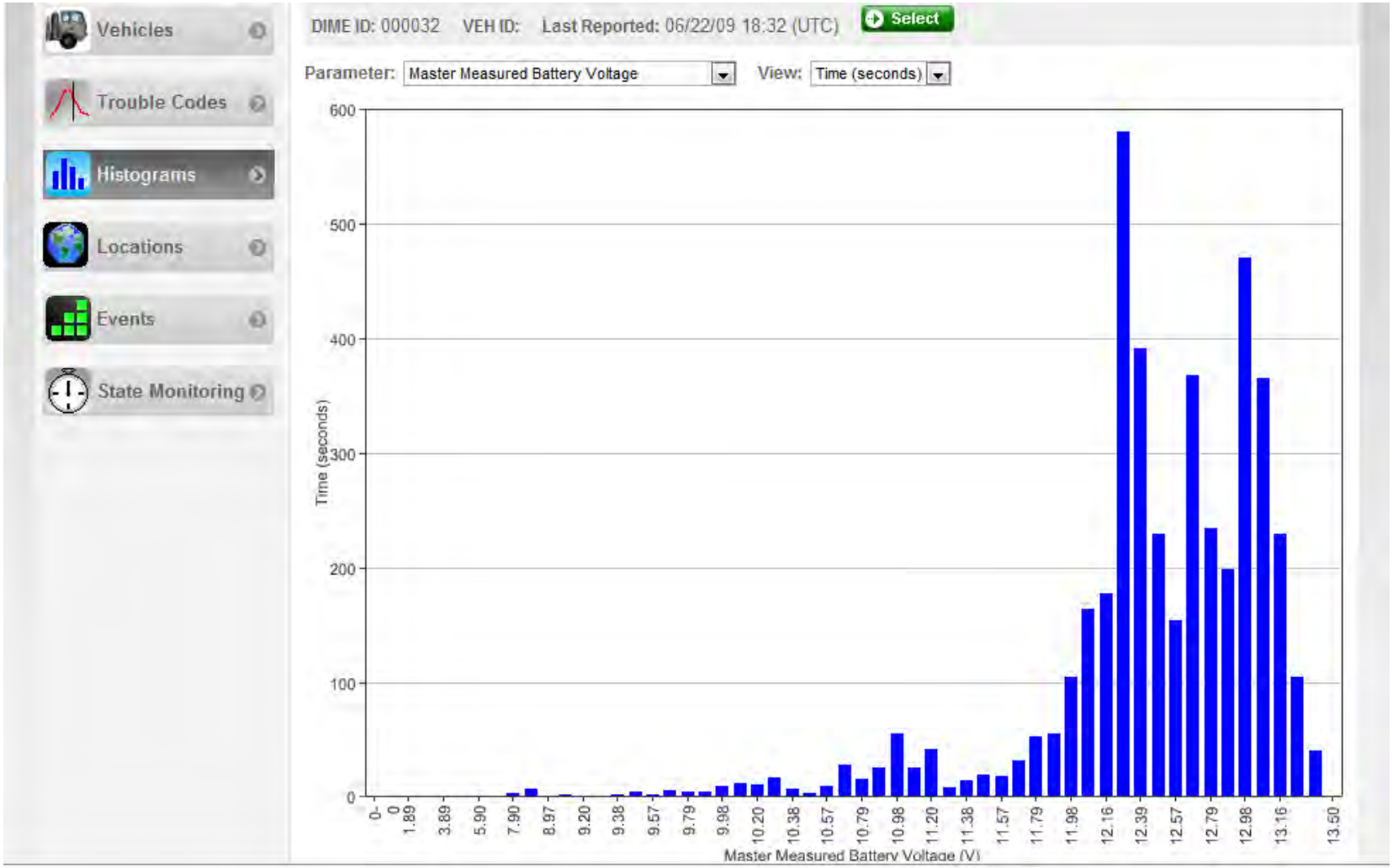
DRIVE Developments, Inc.

Main Pump Hydraulic Suction Filter Pressure



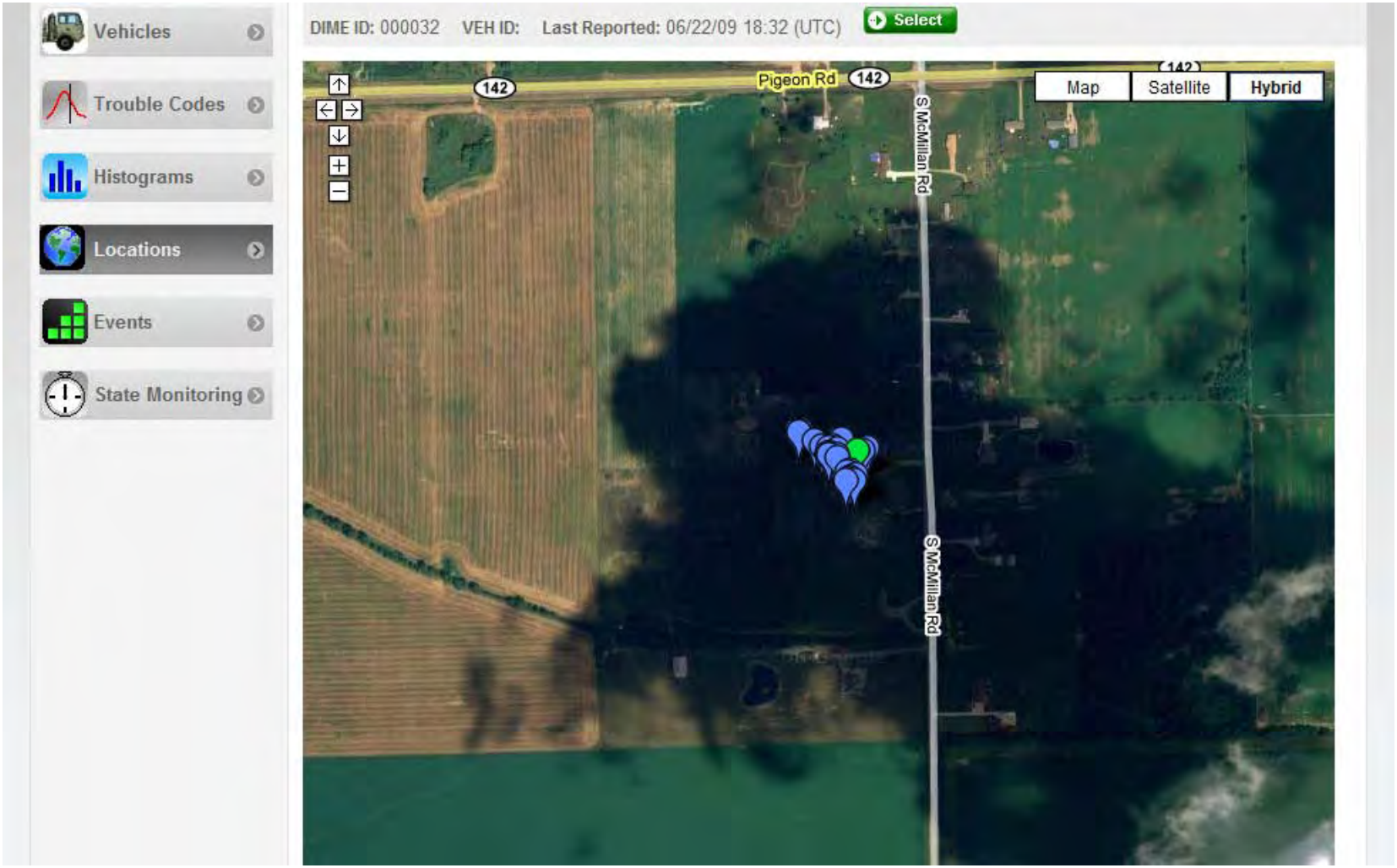
DRIVE Developments, Inc.

Master Measured Battery Voltage



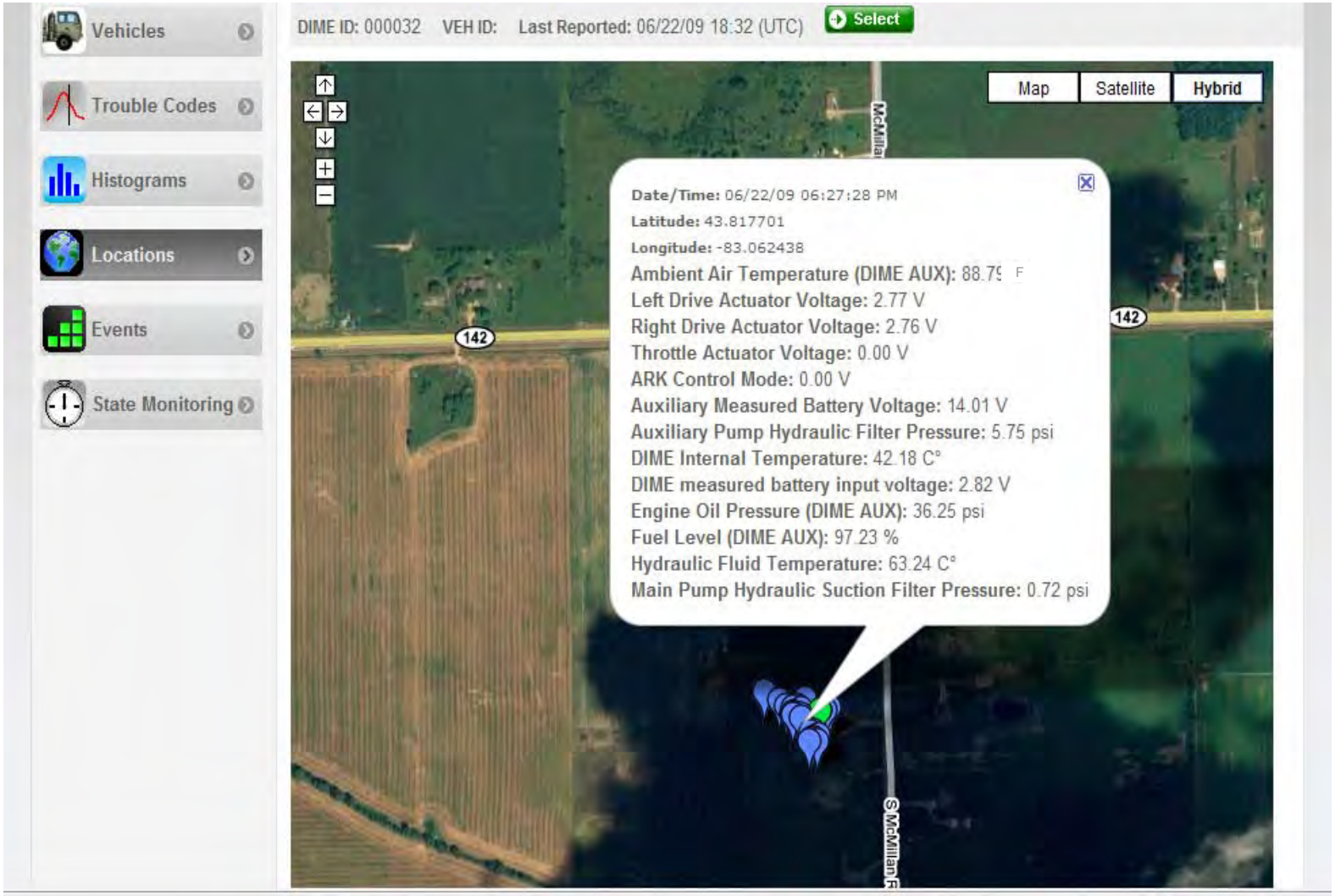
DRIVE Developments, Inc.

Situational Awareness View



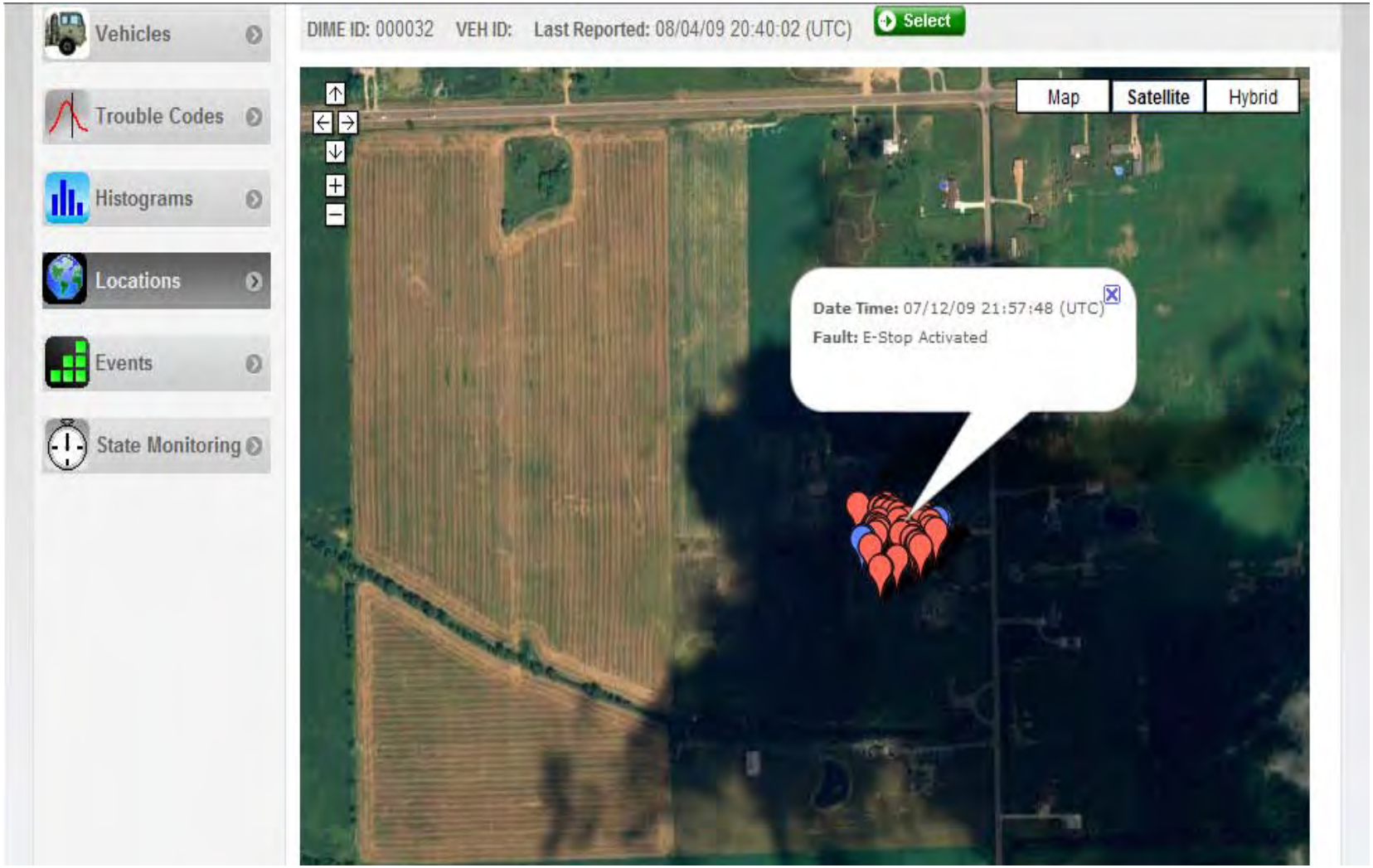
DRIVE Developments, Inc.

Situational Awareness View



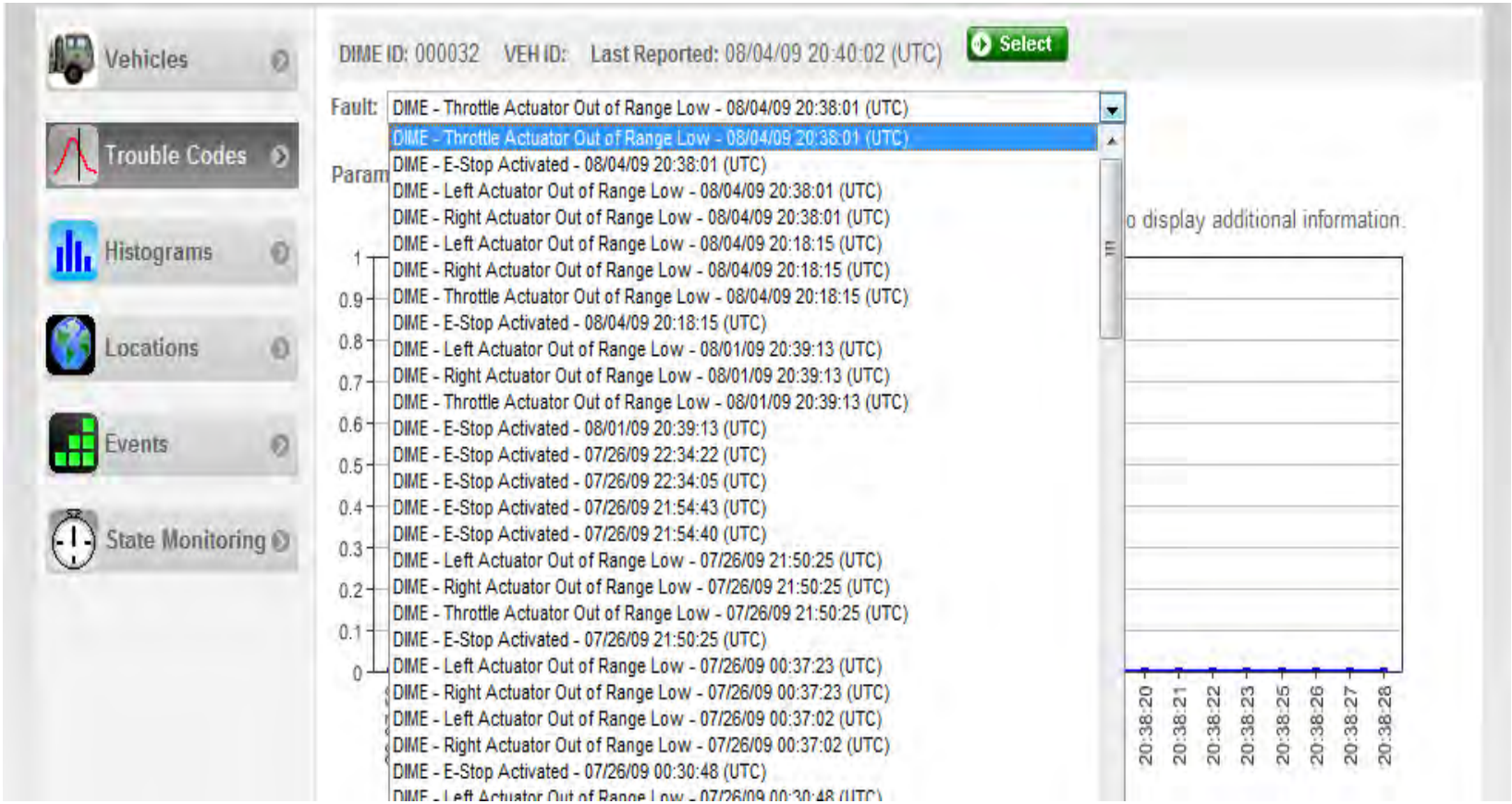
DRIVE Developments, Inc.

Situational Awareness View: Reported Faults



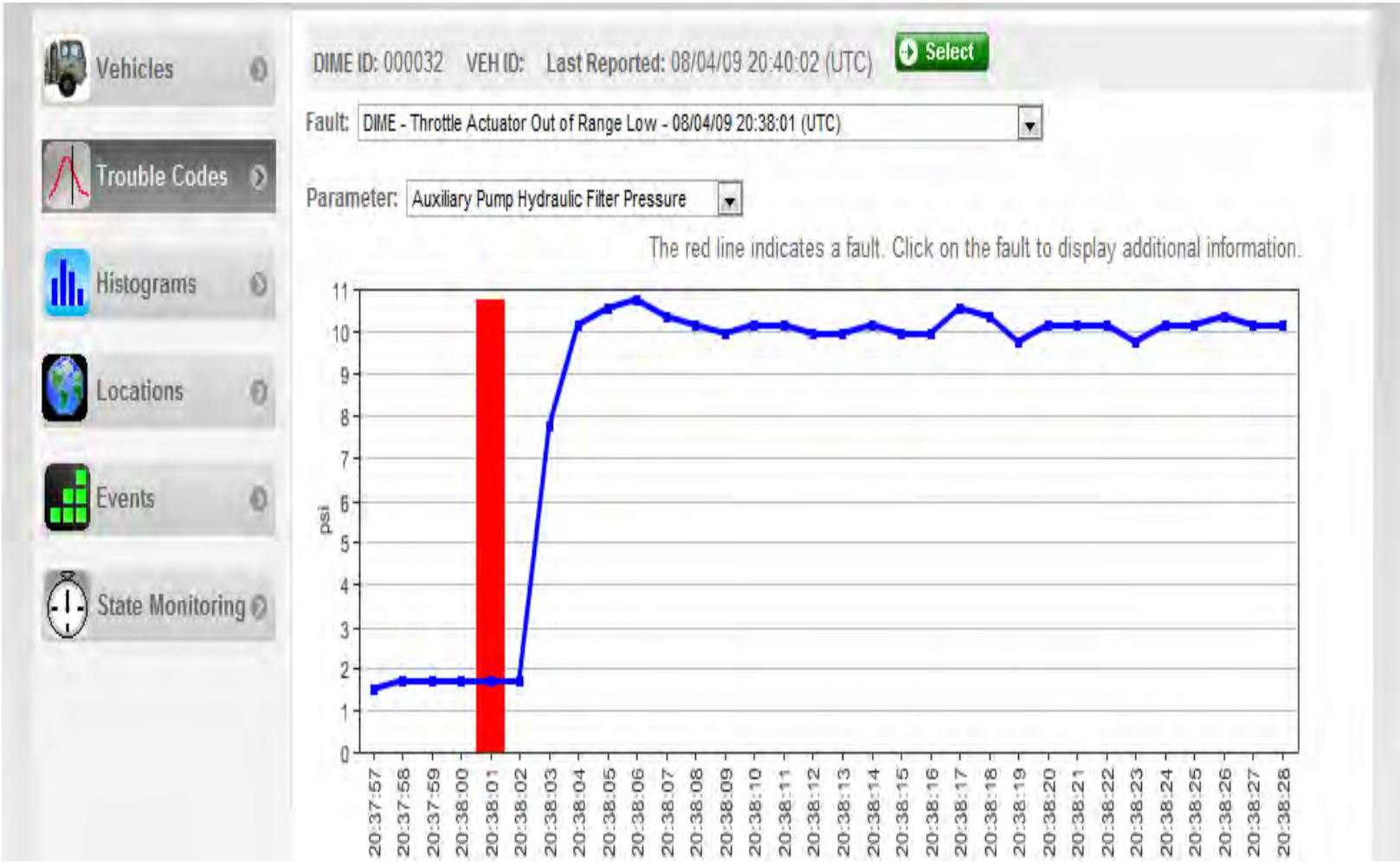
DRIVE Developments, Inc.

Reported Faults



DRIVE Developments, Inc.

Reported Faults Detailed Graph



DRIVE Developments, Inc.

Next Generation of the ARK :

The initial ARK vehicle has been tested at Avon Park, FL test facility with US Special Forces. DRIVE is currently developing the next generation of this vehicle that will include 360 degree real time day/night vision in addition to the integration of our new NICKEL product for diagnostic data bus monitoring within a wireless controller solution.

DRIVE Developments, Inc.

Our Family of DIME Products

Diagnostic **I**nformation **M**anagement **E**nvironment (DIME)

DRIVE Developments, Inc.

What is the DIME?

The DIME (**D**iagnostic **I**nformation **M**anagement **E**nvironment) is a **TRL 8** end-to-end **Lifecycle and Vehicle Health Management System** complete with on-board storage, GPS tracking, wired and wireless communication interfaces. DIME enables *Connected Vehicle* applications.

The system is capable of remotely updating and upgrading the system firmware and application code within seconds even in low communication bandwidth environments. This is accomplished via the DIME Data Management Center where data is stored, analyzed, distributed and displayed.

DRIVE Developments, Inc.

What is the DIME?

HARDWARE Features:

- Technical Readiness Level (TRL) 8
- **Ultra low power consumption (<25mW) in sleep mode with optional ZERO power draw configuration.**
- Low space and weight claim (approx 1.5 lbs)
- **Capable of start up and recording in less than 50ms**
- 802.11 b/g wireless interface
- 2 CAN channels capable of 1Mbps communications
- Ultra low cost hardware investment
- RS485 / RS422
- Capable of waking up from up to eight unique input sources (CAN Bias, CAN Activity, Ignition, J1708, RS232, RS422/RS485, External input, Real Time Clock)

DRIVE Developments, Inc.

What is the DIME?

HARDWARE Features continued:

- RS232
- Ethernet
- **GPS (Global Positioning System)**
- **Sensor interfaces (Analog and Digital)**
- Remote management / disablement of GPS/Wireless comms
- Wave Relay, Fortress, and CAISI compliant via Ethernet connection
- Forms the foundation for any diagnostic system for any vehicle platform.
- Compatible interface with mounted and mobile vehicle display systems.
- Disposable technology, low logistics footprint

DRIVE Developments, Inc.

What is the DIME?

Embedded Software Features:

- **Remote configuration**
- Data compression techniques enabling performance in low bandwidth Military environments.
- **System processing of data from multiple data bus sources (CAN, J1708, RS485) simultaneously.**
- Capable of storing data in emergency power loss situations.
- **BIST (Built In Self Test)**

DRIVE Developments, Inc.

THANK YOU

DRIVE Developments, Inc.
7314 19 Mile Road
Sterling Heights, MI 48314
248-613-6738
1-877-705-**DRIV**E

Larry Osentoski
President and CEO

Novel Approach for Overcoming Diagnostic Performance Limitations

NDIA Systems Engineering Conference

27 October 2010

Darrell Bartz
F/A/EA-18 Integrated Diagnostics
Boeing Defense, Space & Security - Global Services & Support

Accurate On-board Diagnostics Are Essential

- Many Avionic Weapon Replaceable Assemblies (WRAs) Cost In Excess Of $1,000,000 To Purchase.
- The Cost Charged To The Squadron's Operational Budget To Remove And Replace A WRA Is Significant Percentage Of The Purchase Price.
- Deployed Squadrons Must Be Able To Operate 24/7/365 With The Spare WRAs That They Are Allocated Locally.
- Recent Trends Toward Directed Two Level Maintenance Solutions Requires Accurate Organizational Level Diagnostics To Avoid Can-Not-Duplicates.
- When A Failure Cannot Be Isolated To A Single WRA The Ambiguity Group Must Be As Small As Possible.

Macro Diagnostic Dependencies

- Diagnostic solution planning for avionic systems establish hierarchical dependencies between:
  - Subsystem, System And Platform Diagnostic Elements
  - On-board And Off-board Organizational Diagnostic Elements
  - Organizational, Intermediate And Depot Maintenance Elements
- Each element contributes data to the subsequent elements thus creating information to establish an accurate and complete diagnostic solution
- When a diagnostic element cannot provide what is needed by the next level then diagnostic accuracy and completeness will be degraded unless an alternate source of the needed information can be established.

F-18 On-Board Diagnostic Environment

In a Federated System Architecture:

- Subsystems Have BIT And Testability Design Elements That Feed WRA Diagnostics
- WRA BIT And Testability Design Elements Feed System Or Aircraft Level Diagnostics
- Most Systems Report BIT Results To The Aircraft Level
- The Aircraft Processes BIT Data And Reports Failed WRAs To The Maintainers For Removal And Replacement

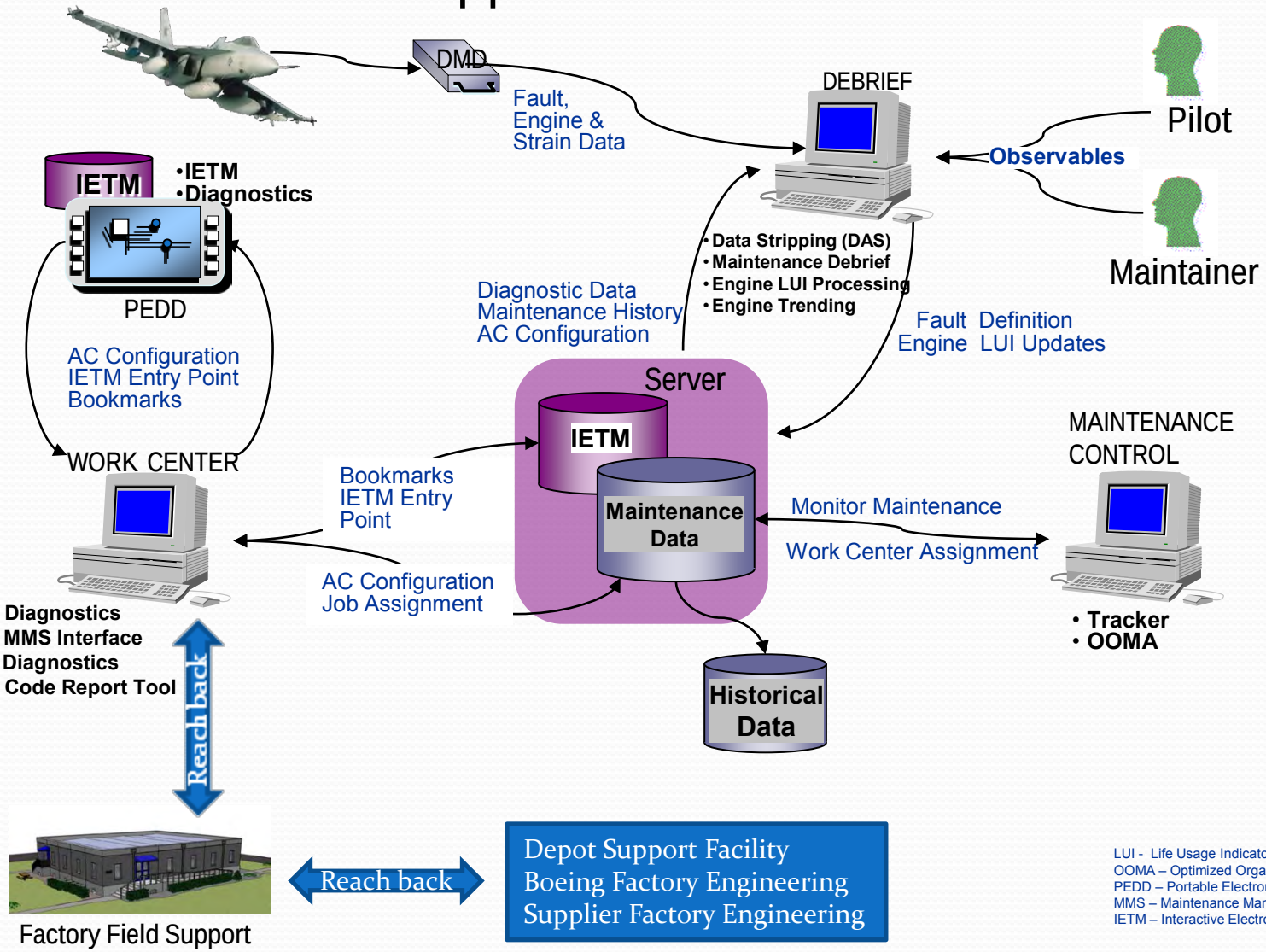
❖ *Aircraft Data Is Captured And Stored In A Digital Memory Device (DMD)*

Off-Board Organizational Diagnostic Resources

- Supplemental Off-Board Diagnostics
  - Flight Line Maintainer Experience and Expertise
  - Interactive Electronic Technical Manual (IETM)
    - IETMs provide technical guidance for the Flight Line Maintainer To Ensure Consistent Diagnostics
  - Organizational Level Support Equipment (SE)

- Other Available But Often Unused Resources
  - Aircraft Data Stored In The Digital Memory Device (DMD)
  - Historical Repair Data

Organizational Level Support Environment



LUI - Life Usage Indicator
OOMA – Optimized Organization Mx Activity
PEDD – Portable Electronic Data Device
MMS – Maintenance Management System
IETM – Interactive Electronic Technical Data

Description Of A Dysfunctional Diagnostic Solution

- A Major Existing Avionic System Was Transitioned From A Legacy Platform And Declared To Follow A Two Level (Organizational-To-Depot) Maintenance Approach.
  - The Decision Was Made To Save The Cost Of Establishing An I Level Facility.
  - Assumed That On-board Diagnostics Were Adequate To Meet Requirements.
- The On-Board Design Included Considerable Subsystem Diagnostics But WRA And System Level *Diagnostic Limitations* Resulted In Poor Isolation And Large Ambiguity Groups.
- Supplemental Off-Board Diagnostics Were Not Established To Compensate For The Poor On-Board Diagnostics Results.
- IETMs Directed Flight Line Maintainers To Remove and Replace The WRAs That The Aircraft Diagnostics Indicted.
  - Replacement Actions Often Resulted In The Same Repeated Failure Indications.
- This Led To A Shotgun Maintenance Approach Which Resulted In Even More Unnecessary WRA Replacements and Supply Chain Burden.

Money talks...but all mine ever says is good-bye

- A Significant Amount Of Unplanned Engineering Troubleshooting Was Required During Flight Test And OPEVAL To Resolve Failures That Were Hindering Progress On Completion Of Those Program Milestones.
- Squadron Budget Is Wasted By Replacing Good WRAs.
- With No Intermediate Maintenance Available to Screen Suspected Failed WRAs, Logistic Dollars Were Wasted Shipping Good WRAs Back To The Depot Maintenance Facility.
- Depot Testing Found Many Can-Not-Duplicates (CNDs) in the Returned WRAs. Depot Wasted Dollars Testing Good Boxes.
- An Increased Number Of Spare WRAs Were Purchased To Meet The Unplanned Demand.

➡ Integrated Diagnostics Team Exploited Aircraft Flight Data To Troubleshoot Failures During Flight Test And OPEVAL.

We Initially Attempted to Implement A Manual Analysis Process

Aircraft Failure Event
MSP Code(s)
Boeing Final Assembly
XOR
Boeing Field Support
Failure Report
IPT Team or ID Team
Identify Failed System
Assign Analyst
Assemble Available Data
Drawings and Diagrams for System of Interest
Supplier BIT Data
MU Flight Data
Record Code Report Tool
Translation & Association
Aggregation & Documentation
Human Analysis of Evidence
Repair Recommendation
4 Hours
24 Hours
4 Hours
8 Hours
Data Collection
Data Translation & Association
Documenting the Evidence
Evidence Analysis

Manual Failure Analysis Process

The Automated Process Made The Approach Feasible

Aircraft Failure Event

Boeing Final Assembly

XOR

Boeing Field Support

Failure Report

IPT Team or ID Team

AAD

MU Flight Data

Data Warehouse

HTML

Record Code Report Tool

Failure Analysis Process Using the BIT Quick View Tool

Drawings and Diagrams for System of Interest

Supplier Fail Analysis Data

Supplier BIT SW Data

Integrated Diagnostics

BIT Quick View Tool

Human Analysis of Evidence

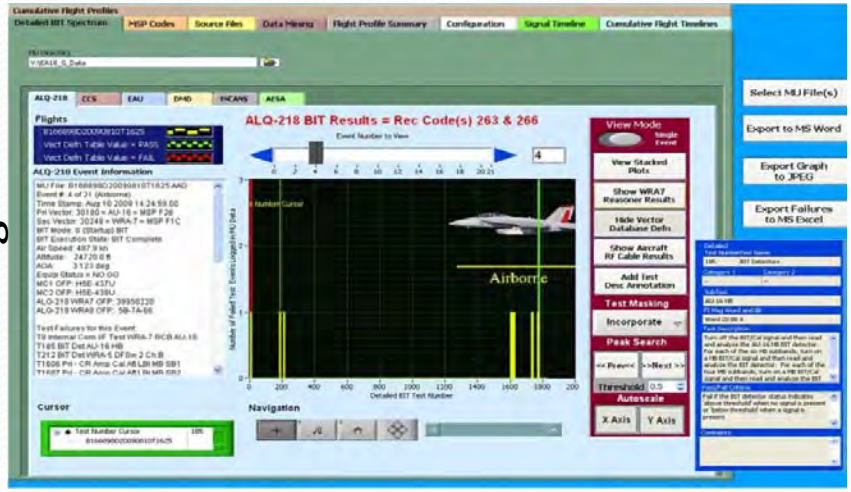
Repair Recommendation

2 Hours

Evidence Analysis

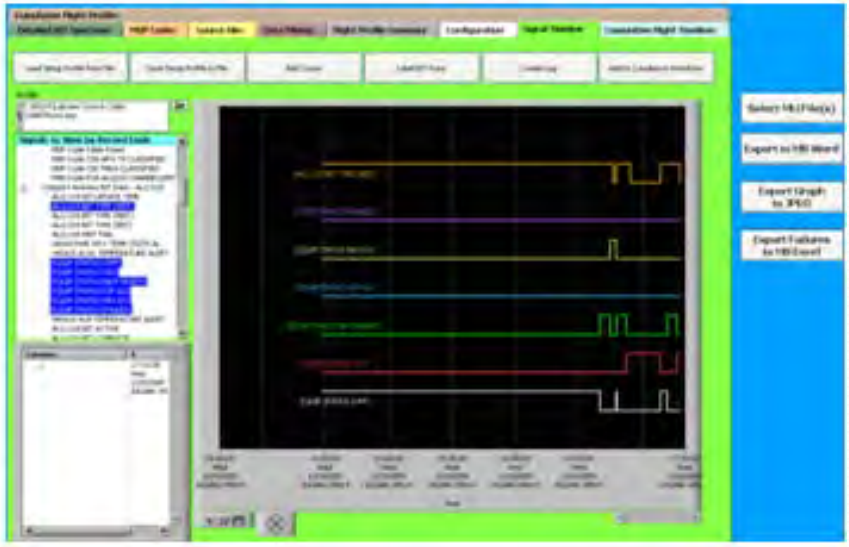
Aircraft Flight Data Clearly Summarized

BIT Failure Histogram

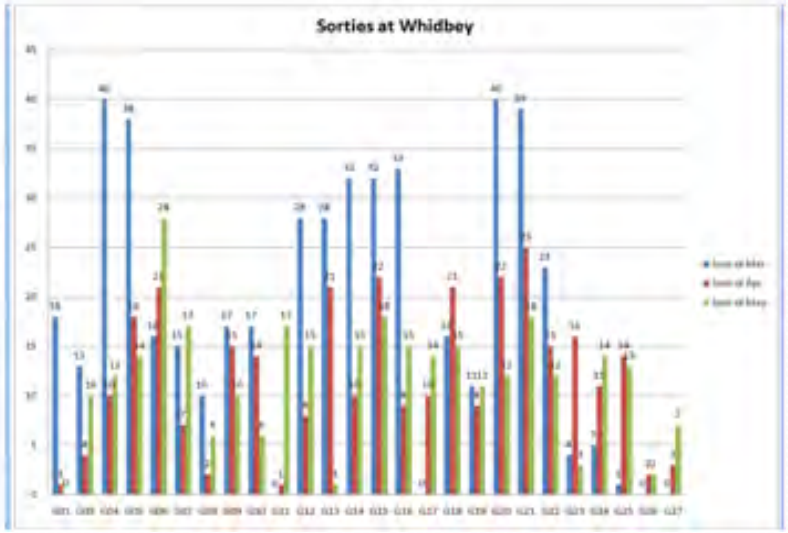


RF Cable Ambiguity Reduction

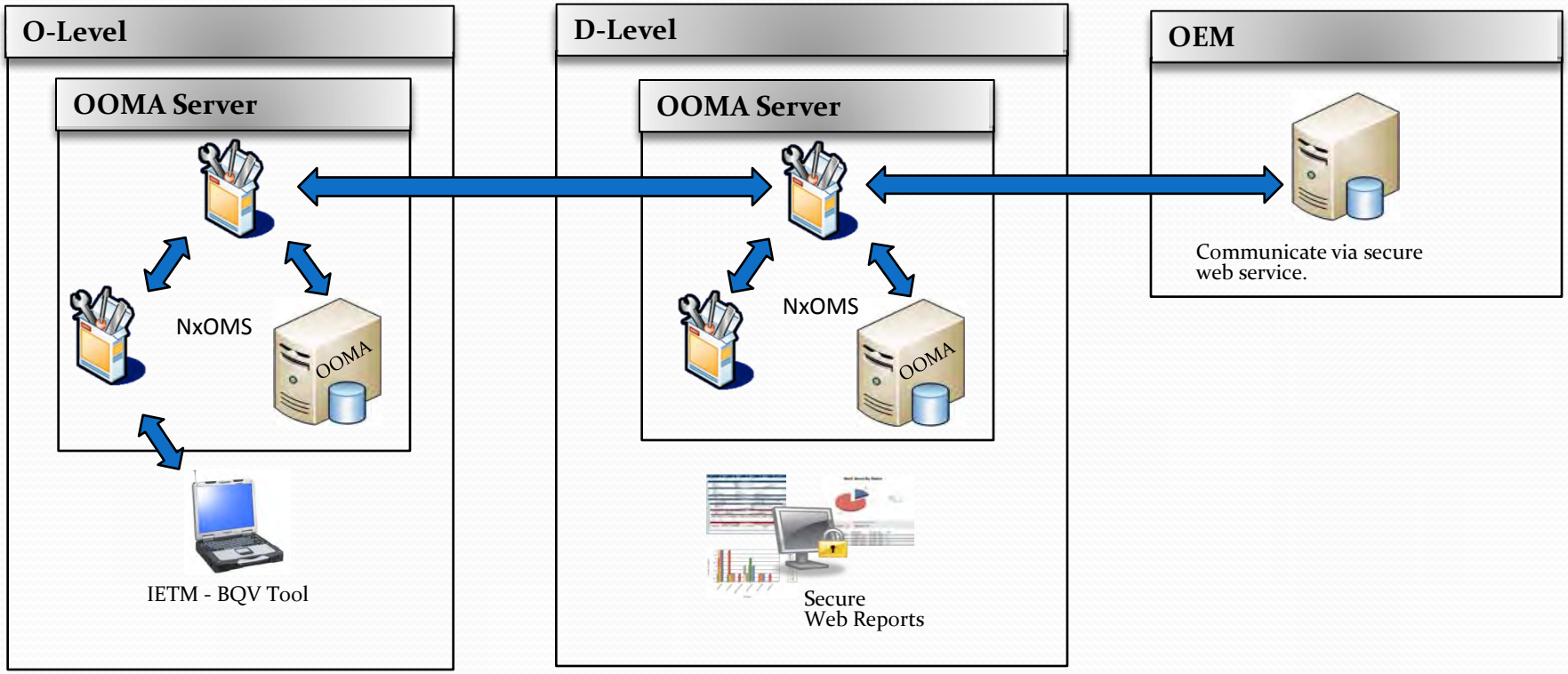
Signal Discrete Timeline



Historical Flight Data Mining Results



Data Flow Across Maintenance Levels



NXOMS – Next Generation Operations Management Software
BQV – BIT Quick View
IETM – Interactive Electronic Technical Data
OOMA – Optimized Organization Mx Activity

Program Cost Avoidance

- Significant Cost Avoidance Has Been Realized From Support Of STL Ramp Support And BIT Maturation Analysis.
  - Production Problems Are Handled By A Phone Call To Engineering Experts Who Analyze The Issue Using BQV And Suggest Maintenance Actions.
  - Process Has Resulted In Lean Support With Accurate Solutions Resulting In Lower Production Man-hours.
- Aircraft BIT Failure Reports Being Sent Back To The Supplier Have Resulted In Quicker Repairs Or Decision Making That Effect Repair Processes In House.
- BIT Maturation Data Collection Has Been Automated.

An Assessment of Acquisition Outcomes and Potential Impact of Legislative and Policy Changes

Presentation by
Travis Masters, Sr. Defense Analyst
Acquisition & Sourcing Management Team
U.S. Government Accountability Office

National Defense Industrial Association
13th Annual Systems Engineering Conference
San Diego, CA
October 2010

Presentation Objectives

- **Provide observations** on the Department's efforts to manage its 2009 portfolio of major weapon system programs, performance of newer programs, and ability to deliver to the warfighter on time
- **Analyze outcomes** and knowledge attained at key junctures in the acquisition process for a subset of the 42 programs primarily still in development
- **Gather data on other factors** that might impact program stability and outcomes such as: cost estimating, requirement setting, software management, and program office staffing
- **Provide an update** on any impacts from DOD acquisition policy changes and Congressional acquisition reform legislation

GAO
Accountability * Integrity * Reliability

Observations on DOD's Fiscal Year 2009 Major Defense Acquisition Program Portfolio

- DOD's major defense acquisition portfolio grew to 102 programs in July 2009 - a net increase of 6 programs since December 2007.
- Eighteen programs in the portfolio are newly designated major defense acquisition programs. The total acquisition cost of the thirteen new programs with cost data is over $72 billion.
- Twelve programs with a cost of $48 billion, including $7 billion in cost growth since their first estimate, left the portfolio. If FCS is included, these numbers increase to $179 billion and $48 billion respectively.
- The lack of complete Selected Acquisition Reports in 2009 precluded a definitive analysis of the overall cost and schedule performance of the portfolio.

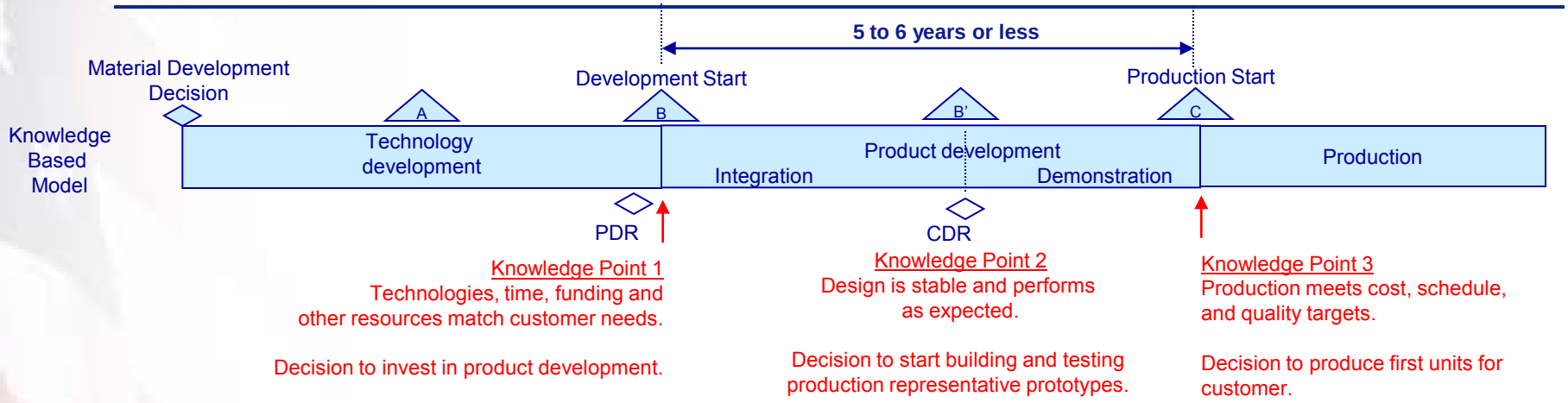
Observations on DOD's Fiscal Year 2009 Major Defense Acquisition Program Portfolio

- The Secretary of Defense's fiscal year 2010 budget recommended canceling or curtailing all or part of at least a half dozen major defense acquisition programs, including CSAR-X, DDG 1000, FCS, and VH-71.

	Weapon system	Secretary's comments
Recommended terminations	VH-71 Presidential Helicopter	Plan to develop options for new program
	Combat Search and Rescue Helicopter	Plan to reexamine requirements
	Next-Generation Bomber	Will not initiate new development program without better understanding of requirements and technology
	Future Combat Systems–Manned Ground Vehicles	Plan to reevaluate requirements, technology, and approach before relaunching and recompeting program
	Transformational Satellite	Plan to buy two more AEHF satellites as alternative
	Ballistic Missile Defense–Multiple Kill Vehicle	Plan to reexamine requirements; no mention of new program
Recommended end of production	C-17	Recommended ending production at 205 aircraft
	DDG 1000	Recommended ending production at 3 ships
	F-22	Recommended ending production at 187 aircraft.

Source: GAO analysis of DOD data.

A Knowledge-Based Approach is Key to Successful Program Outcomes



- Model provides framework for incremental, time certain (development constrained to 5 to 6 years or less), and knowledge-based approach to weapon system acquisitions.
- Success requires structured, disciplined application and adherence to model.
- Knowledge points align with key investment inflection points.
- Controls are in place for decisions makers to measure progress against specific criteria and ensure managers capture key knowledge before moving to next phase.

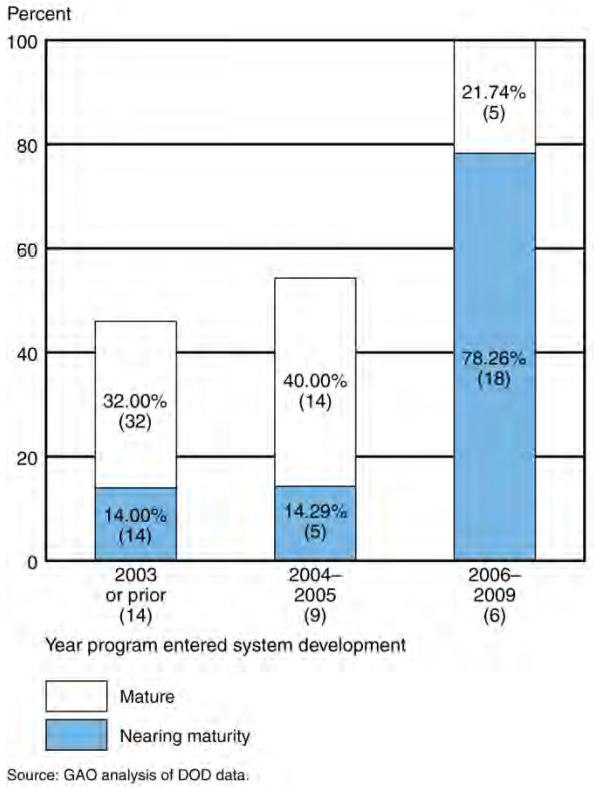
Programs Conducting Early Systems Engineering Have Better Outcomes

- Early systems engineering, ideally before a program enters development, is critical to ensuring that requirements are achievable and designable.
- We have previously reported that programs conducting key systems engineering events prior to development start experienced, on average, lower cost growth and shorter delays in achieving initial operational capability.
- Only 1 of the 37 programs in our 2010 assessment that held PDR did so before development start. The remaining programs, on average, held the review 30 months after development start.
- Preliminary design review now required prior to development start under the Weapon System Acquisition Reform Act of 2009.

Newer Programs GAO Assessed Are Starting with Higher Levels of Technology Maturity

- Since 2003, there has been an increase in the maturity of critical technologies at development start.
- All 6 programs entering system development from 2006 to 2009 had their critical technologies demonstrated in at least a relevant environment, in accordance with the DOD and statutory criteria.
- However, only 4 of the 29 programs in our 2010 assessment that provided data started development with fully mature critical technologies.

Maturity of Critical Technologies at Milestone B



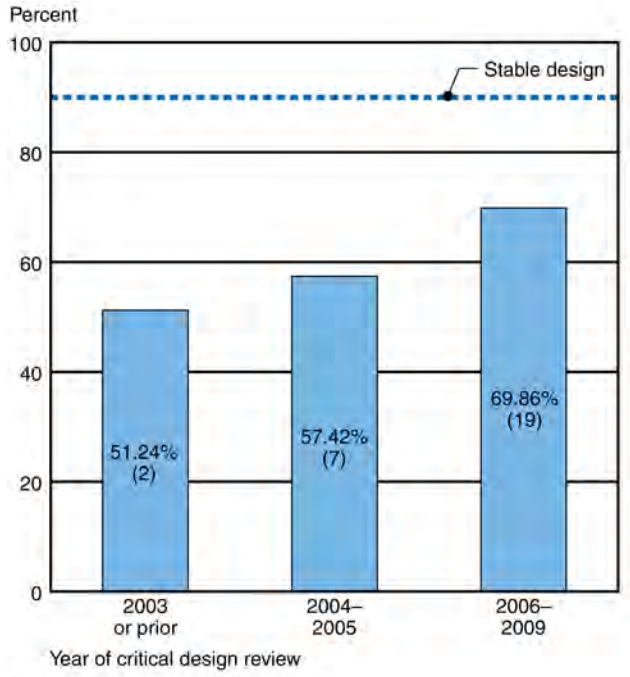
Source: GAO analysis of DOD data.

Note: Number of programs and technologies in parentheses.

Programs Holding Design Reviews in Recent Years Reported Having More Knowledge

- Since 2003, the average percentage of design drawings releasable for programs at the critical design review has steadily increased.
- However, designs, on average, are still far from stable and concurrent technology development increases the risk subsequent design changes and rework.
- Of the 28 programs in our 2010 assessment that held a critical design review, only 8 reported having a stable design.

Average Percent of Releasable Design Drawings at Critical Design Review



Source: GAO analysis of DOD data.

Note: Number of programs in parentheses.

Programs Are Not Testing Prototypes in Time to Prove Out Designs and Performance

- Programs should test integrated prototypes before critical design review to demonstrate that the design is capable of meeting requirements.
- Only 4 of 33 programs in our 2010 assessment tested or planned to test an integrated prototype before critical design review. The remaining programs reported that they will test these prototypes, on average, 31 months later.

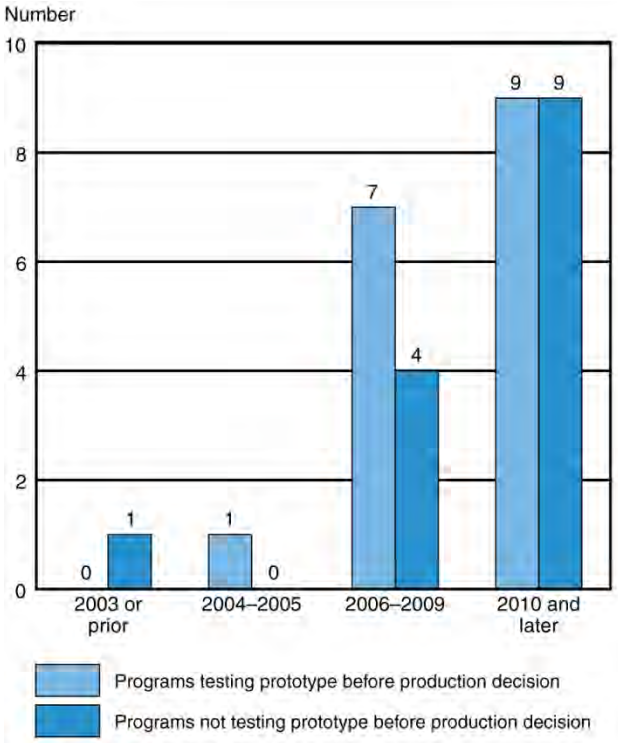
	Year of critical design review				
	2003 or prior	2004-2005	2006-2009	2010 or later	All programs
Number of programs testing before critical design review	1	0	3	0	4
Number of programs testing after critical design review	3	6	15	5	29
For programs testing after critical design review, average number of months from design review to prototype test	74	29	27	18	31

Source: GAO analysis of DOD data.

Programs Are Not Demonstrating Performance or Manufacturing Processes Before Production

- Programs should test production representative prototypes before production start and bring critical manufacturing processes into statistical control.
- Only 17 of the 31 programs in our 2010 assessment that reported a production date have tested or planned to test a production representative prototype before production.
- Only 7 programs in our 2010 assessment had identified their critical manufacturing processes.

Programs Testing Production Representative Prototype Before and After a Production Decision



Source: GAO analysis of DOD data.

Observations on Other Factors That Can Affect Program Execution

- **Requirements:** Of the 42 programs in our 2010 assessment, 23 programs reported at least one change to a key performance parameter and 9 programs experienced at least one change to a key systems attribute since development start.

- **Software:** Seventeen of the 28 programs that reported software data estimated that software lines of code had grown by 25 percent or more since development start. The average lines of code growth was 92 percent.

- **Program office staffing:** Nineteen of 50 programs that responded to our staffing questions were able to fill all authorized positions. As a result, program offices reported that program management and oversight had been degraded, contracting activities had been delayed, and program management costs had increased as contractors were used to fill gaps.

Observations on Other Factors That Can Affect Program Execution

- Programs' reliance on non-governmental personnel continues to increase in order to make up for shortfalls in government personnel and capabilities.

Program Office Composition for 50 DOD Programs

	Program management	Engineering and technical	Contracting	Other business functions	Administrative support	Other	Total
Military	28%	7%	6%	3%	2%	5%	8%
Civilian government	40%	41%	74%	45%	18%	24%	40%
Total government	67%	47%	80%	48%	20%	29%	49%
Support contractors	32%	43%	20%	50%	78%	70%	45%
Other nongovernment	0%	9%	0%	3%	2%	1%	6%
Total nongovernment	33%	53%	20%	52%	80%	71%	51%

Note: Totals may not add due to rounding.

Source: GAO analysis of DOD data.

GAO
Accountability * Integrity * Reliability

New DOD Policies Could Improve Outcomes

- **Recent department initiatives may help focus on joint warfighter needs**
  - Functional COCOMs given greater voice in requirements process.
  - Preferred materiel solutions no longer identified in initial capability proposals, giving greater emphasis to trade-off analysis via AOAs.
- **New Capability Portfolio Management framework could facilitate more strategic investment choices**
  - Portfolio managers provided key input in recent budget cycle, but they do not have decision-making authority.
- **More discipline and up-front knowledge in early acquisition phases could put programs on more stable footing**
  - Early Materiel Development Decision required for all programs.
  - Preference for incremental development, with baselines for each increment.
  - PDR required before system development start.
  - Competitive prototyping required as part of technology development phase.
  - Configuration Steering Boards established to control requirements creep.

Weapon System Acquisition Reform Act Stresses Cost and Performance Assessment

- **Elevates the role of cost assessment and program evaluation**
  - Duties of Director, Cost Assessment and Program Evaluation (CA&PE) include reviewing cost estimates, conducting independent cost estimates, and approving the choice of baseline cost estimates for all ACAT ID programs.
  - Director, CAPE, will also formulate study guidance for analysis of alternatives.
- **Emphasizes importance of systems engineering and developmental test**
  - Established Directors of Developmental Test and Evaluation and Systems Engineering to oversee policy and guidance and approve test and systems engineering plans.
  - Requires services to periodically assess their capabilities in these areas.
- **Increases oversight and reporting on cost estimating, systems engineering, developmental test, program performance, and technology maturity.**
- **Stresses importance of competition throughout the acquisition cycle.**

GAO
Accountability * Integrity * Reliability

Programs Have Begun to Implement DOD's Revised Acquisition Policies

- **Programs in our 2010 assessment have begun to implement acquisition reforms that could improve cost and schedule outcomes.**
  - Competitive prototyping – 8 of 10 pre-major defense acquisition programs in our assessment reported planning to develop competitive prototypes of the proposed weapon system or key system elements prior to Milestone B.
  - Early systems engineering – 7 of 10 pre-major defense acquisition programs in our assessment have already scheduled a preliminary design review before Milestone B.

- **Only a few programs in our 2010 assessment reported holding configuration steering board meetings in 2009.**
  - For 7 programs that held meetings in 2009, none reported that the board approved a requirement change or significant technical change.
  - One program presented de-scoping options to the board and had those approved to help maintain cost and schedule.

GAO
Accountability * Integrity * Reliability

Questions?

Performing Software Feasibility Analysis on Major Defense Acquisition Programs

Mr. James Thompson
Director, Major Program Support
ODDR&E/Systems Engineering

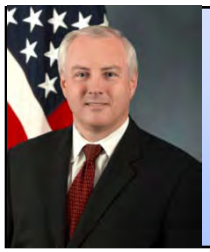
Mr. Christopher Miller
SAIC

Ms. Angela Lungu
QSM

13th Annual NDIA Systems Engineering Conference
San Diego, CA | October 27, 2010

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Mission Context



Director, Systems Engineering
Steve Welby

Systems Analysis

"Weapon Systems Acquisition Reform Act of 2009"

S.454-10; d.(1): The development and tracking of detailed measurable performance criteria as part of the systems engineering master plans…

S.454-10; d.(3): A system for storing and tracking information relating to the achievement of the performance criteria and objectives specified…

S.454-12; SEC. 103.b.(4): Evaluating the utility of performance metrics used to measure the cost, schedule, and performance of [MDAPS], and making such recommendations …to improve such metrics.

Major Program Support
James Thompson

- Program Support Reviews
- Systems Engineering Plans
- Program Technical Auditing
- OIPT/DAB Support
- DAES Database Analysis and Support
- Performance Measurement
- Systemic Root Cause Analysis

Mission Assurance

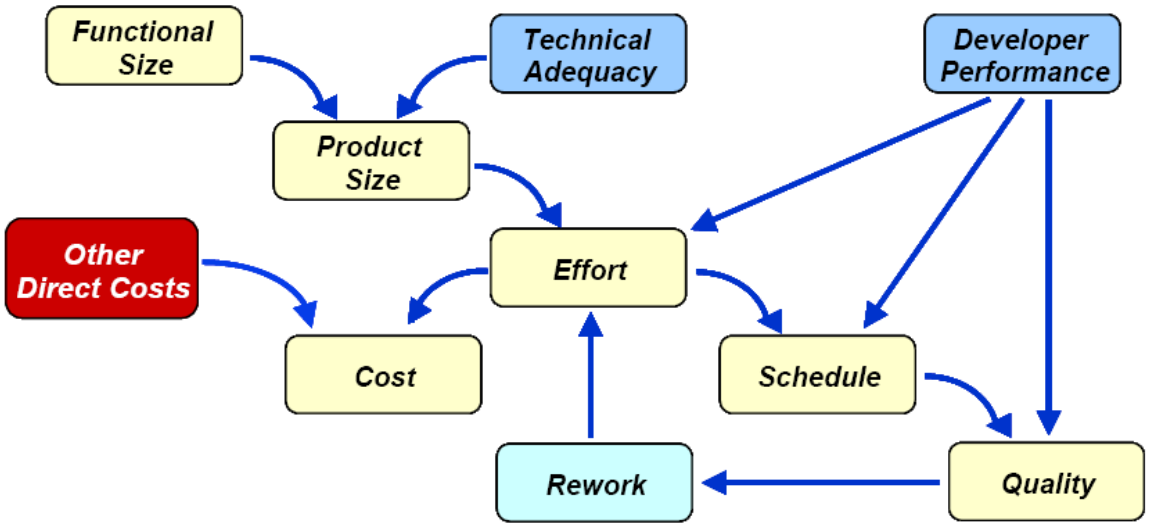
Software Performance Measurement and Analysis

- DAPS 4.5 Software
- Data Collection based on Best Practices
- Parametric analysis used to assess program feasibility and establish benchmarks

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Initial Metrics Data Call

- **Metric**
  - Sizing (for each build, broken down by new/modified/reused, in SLOC)
- **Numerical Context (for each build)**
  1. Peak staffing
  2. Effort hours
  3. Duration (start and end dates, both planned and actual)
  4. Software reliability target (Mean Time to Defect, MTTD) or actual defects discovered



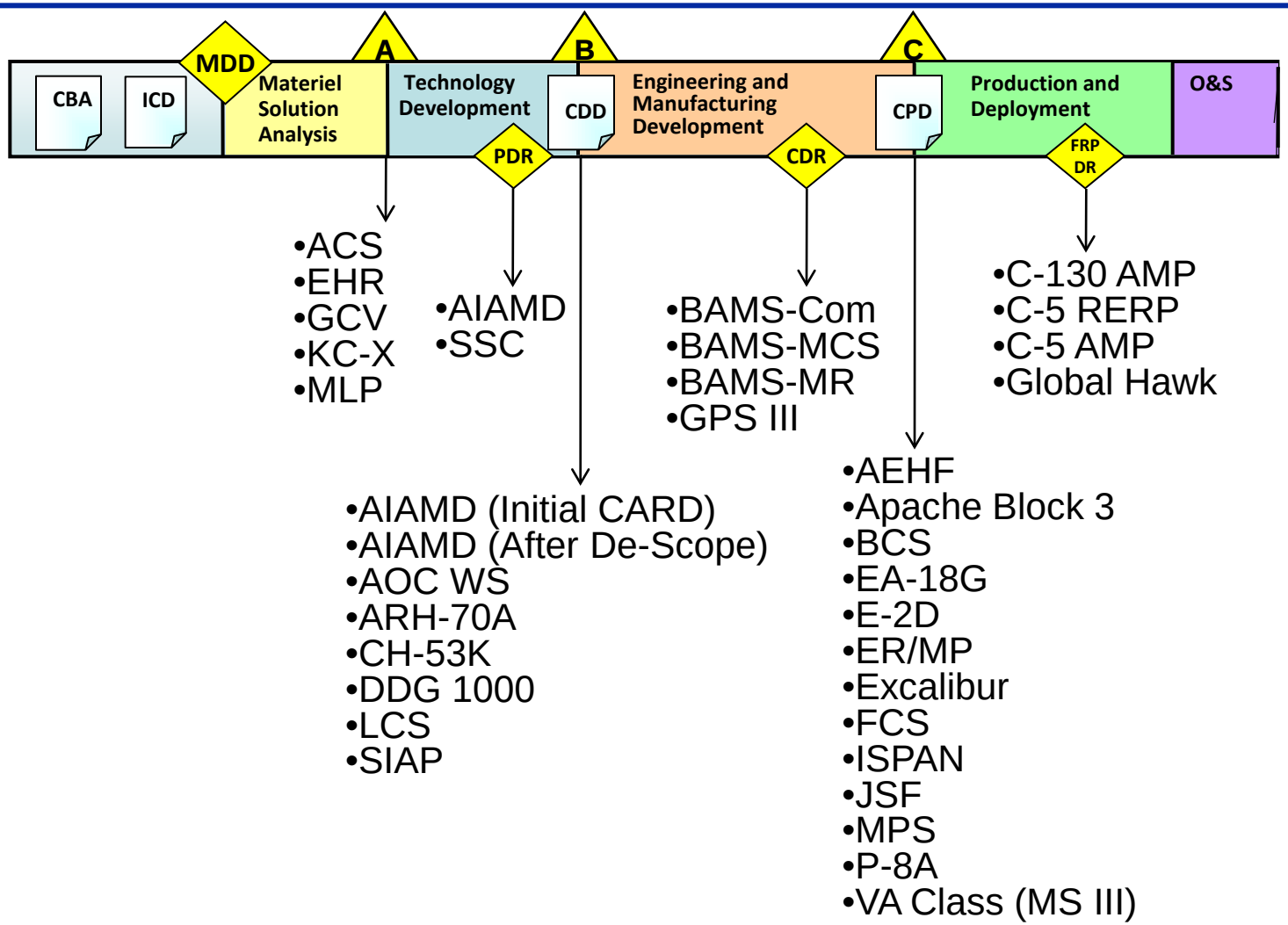
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Initial Metrics Data Call

- **Descriptive Context (Background)**
  - System type (business, scientific, real time (e.g., avionics))
  - Program briefs that explain the software effort and any discussion of functionality included in each build or release (and which builds are customer releases vs. engineer builds), as well as Software Development Plan (explains their metrics collection plan).
  - Any metrics from previously completed builds/releases
  - Listing of the key PSR event dates (e.g., initial review dates, final brief, etc.)
- **Expected Sources**
  - CARD and Software Resources Data Report (SRDR) appendixes (2630-1 or 2630-2, 2630-3)
  - Software Development Plan (SDP)
  - Contract Deliverables (CDRLs) that contain monthly software performance data
  - Integrated Master Schedule (IMS) if software is shown
  - Integrated Master Plan (IMP)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

40 Software Program Analyses Completed/Ongoing (2008-2010)



DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Existing Lifecycle Metric Sources

Anticipated Software-Related Actions By Program Phase

Notes for reading this matrix:

Software-related documents are in bold text

Specific metrics that should be included in the source documents are indented and italicized

	Pre-MS A	Pre-MS B	Pre-MS C	Pre-FRP	Post-FRP
Program briefs explaining program software effort	YES	YES	YES	YES	YES
CAPE-approved Contract CSDR Plan (SRDRs and standard software metrics DIDs, as listed in CDRL)	NO	YES			
CARD (with Initial Government Report SRDR, DD 2630-1) (Initial CARD due earlier of 180 days prior to OIPT or 60 days prior to RFP) (Final CARD due earlier of 45 days prior to OIPT or 60 days prior to RFP release)(DTM 09-027 now requires at MS A)	YES	YES			
Estimated/Planned Integrated Master Plan listing key software/program events	YES	YES			
DD 2630-1: Initial Government Report SRDR (estimate) (due same time as draft CARD to OSD, see above) (usually included in CARD)	YES	YES			
Estimated sizing for each build, broken down by new/modified/reused, in raw, logical Source Lines of Code(SLOCCO), function points, implementation units, requirements, or otherstandard sizing unit					
Estimated peak staffing by 'increment'	YES	YES			
Estimated Start/End dates by 'increment'	YES	YES			
Estimated software reliability threshold (MTTD)	YES	YES			
System type (e.g., avionic, engineering)	YES	YES			
DD 2630-2: Initial Developer Report SRDR (Required at start and completion of each 'increment')	NO	NO			
Planned sizing for each build, broken down by new/modified/reused, in raw, logical Source Lines of Code(SLOC), function points, implementation units, requirements, or other standard sizing unit					
Monthly software metrics CDRLs (actuals)(see CAPE-approved contract CSDR plan)	NO	NO	YES	YES	YES
Actual sizing (and re-planned sizing, if changed since submission of DD 2630-2 or since last review) for each build, broken down by new/modified/reused, in raw, logical Source Lines of Code(SLOC), function points, implementation units, requirements, or other standard sizing unit					
Actual peak staffing by 'increment'	NO	NO	YES	YES	YES
Actual effort by 'increment'	NO	NO	YES	YES	YES
Actual start/end dates by 'increment'	NO	NO	YES	YES	YES
Actual software reliability (MTTD)	NO	NO	YES	YES	YES
Actual software defects discovered/open and closed defects, by 'increment' and by category (e.g., P1, P2, P3)	NO	NO	YES	YES	YES
DD 2630-3: Final Developer Report SRDR (60 days after completion/delivery)(for each 'increment')	NO	NO	NO	YES	YES
Final/actual sizing (and re-planned sizing, if changed since last review) for each build, broken down by new/modified/reused, in raw, logical Source Lines of Code(SLOC), function points, implementation units, requirements, or other standard sizing unit					
Final/actual peak staffing by 'increment'	NO	NO	NO	YES	YES
Final/actual effort by 'increment'	NO	NO	NO	YES	YES
Final/actual start/end dates by 'increment'	NO	NO	NO	YES	YES
Final/actual software reliability (MTTD)	NO	NO	NO	YES	YES
DD 2630-3 Final Developer Reports SRDRs for previous	YES	YES	YES	YES	YES
requirements, or other standard sizing unit					
Final/actual peak staffing by 'increment'	YES	YES	YES	YES	YES
Final/actual effort by 'increment'	YES	YES	YES	YES	YES

Currently Leveraging Existing Metrics and Data Sources

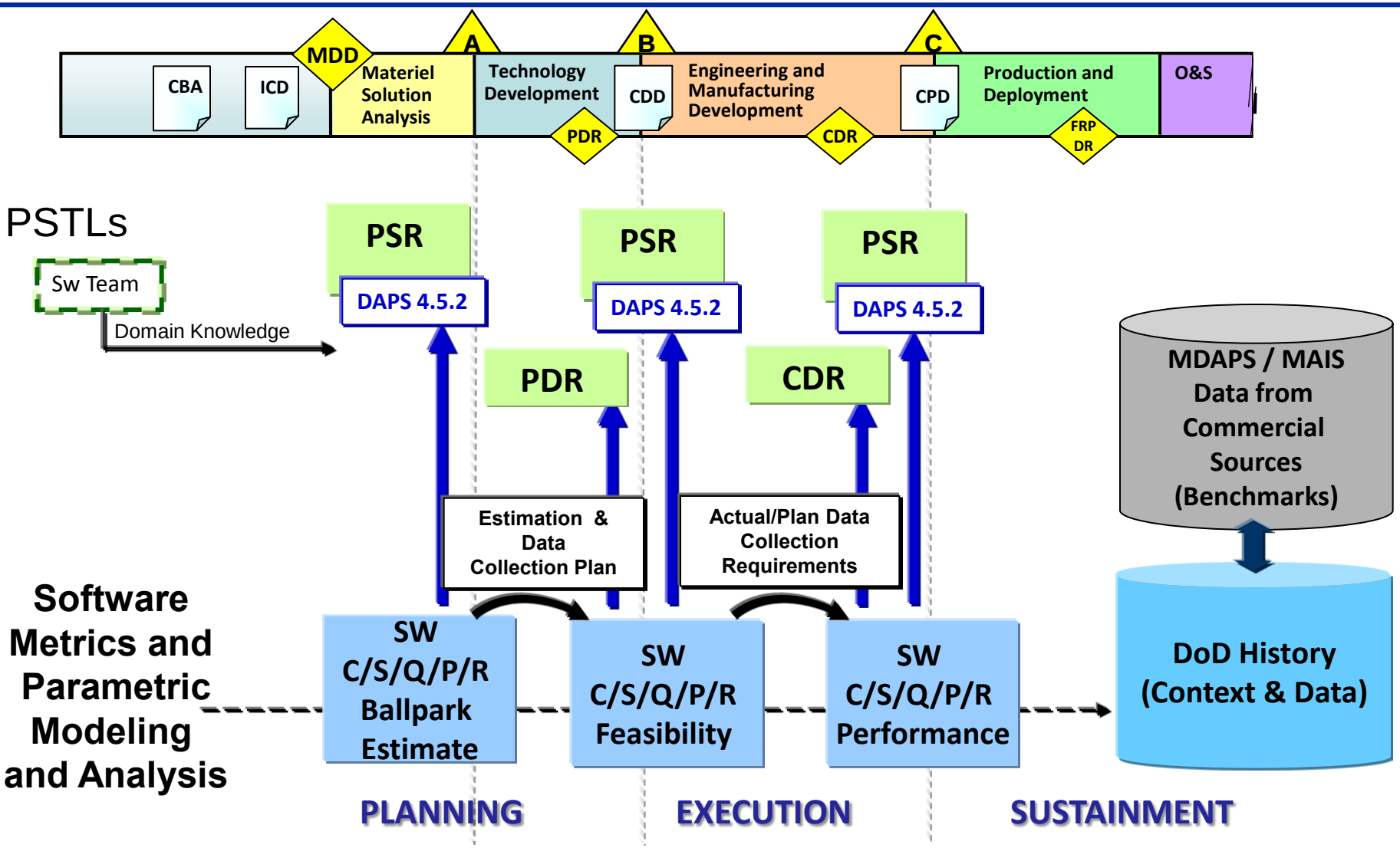
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Sample Metrics Collected, Normalized, and Modeled

- **Metrics are captured as reported by the Program (as Program Artifacts)**
  - Identify internal inconsistencies within Program metrics
  - Identify data gaps, and omissions
  - Data validation is necessary to conduct analysis
- **Metrics are normalized to enable parametric modeling and benchmark analyses**
  - Normalization provides ability use parametric models to assess feasibility
  - Software development effort assessed based on probability of success
- **Data compiled into historical repository to support benchmark analyses**
  - Normalized data allows for benchmarking
  - Unified data set provides ability to assess software performance across portfolios of programs

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Analysis Across the Acquisition Lifecycle



C/S/Q/P/R – cost, schedule, quality, performance, & risk

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Software Analysis and Insight

- **MS A: Ballpark Estimate / Feasibility analysis**
  - Is the program's plan to estimate the software adequate? Is the Acquisition strategy adequately accounting for the software development aspects?
  - What information (granularity) is missing or inadequate at this point in the program? Has the program identified the software metrics/data reporting requirements for the TD & EMD?
- **MS B: Independent Estimate / Plan Feasibility Analysis**
  - Are the software planning artifacts mature enough to support an estimate? What is the probability of meeting the delivery date?
  - How does their software plan compare to similar programs WRT size, complexity, schedule, staffing, & effort/cost?
  - Has the program adequately incorporated data collection & metrics reporting into the RFP and contract deliverables to support OSD program performance assessments?
- **MS C: Benchmark / Software Reliability Assessment**
  - Based on the performance data to date, what is the probability the program will deliver on time and on schedule?
  - What is the software defect density? And how does it compare to other similar programs? Does the data indicate a software quality issue?
- **Nunn-McCurdy/Special Emphasis:**
  - Is the Program's performance typical? (i.e., was the breach due to inadequate funding/planning or is the breach due to poor performance)?

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Example A/Pre-MS B: "Trade Space"

Program Office received trade space analysis

Enabled the program office to select initial planning options in the feasible trade space

Scenario Comparison (80% Assurance)

Scenario Assumptions	ESLOC	Cost	Schedule	PI	Remarks
Program Plan	--	$25M	60 mo	--	Program allocated $25M for software; 60 months schedule is not software driven.
1. Optimized Solution	**538K**	$76M	86 mo	12.1	Historical industry average; assumes no ESLOC growth; **cost overrun 300%; schedule adds 2.1 yrs**
2. Fixed Cost	538K	**$25M**	114 mo	12.1	Constrained to $25.2M budget; **schedule runs 4.5 yrs late**
3. Fixed Schedule	538K	$370M	**60 mo**	12.1	Constrained to 5-yr schedule; **cost is 14.7 times greater than total budgeted**
4. Typical Program Size Growth	**700K**	$105M	97 mo	12.3	Size growth (80% industry projects typically grow 30% from PDR to delivery); slightly improved productivity index assumed; **cost over 420% of budget; schedule takes 3 yrs longer**
5. Reduced Functionality	**216K**	$25M	58 mo	12.1	Limited functionality/size with budget and schedule constrained
6. Increased	538K	$25.2M	60 mo	**16.0**	Increased PI (2 standard deviations higher than
7. Increased Productivity/ Size	**700K**	$39M	62 mo	**16.0**	Increased PI (only 2.2% of industry has achieved that PI)

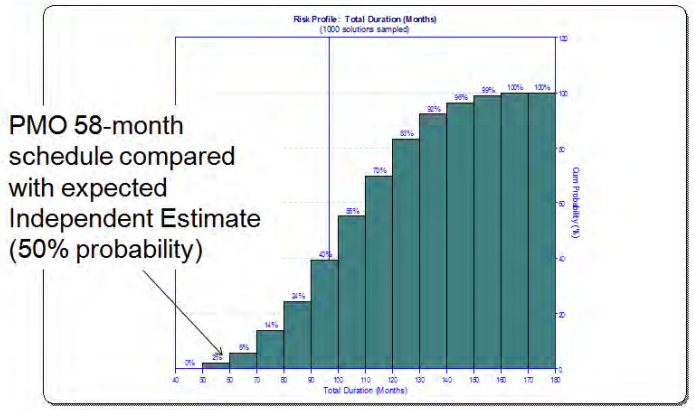
XXX *= Value constrained (held constant) in scenario run*
PI = Productivity Index, to include environmental factors for efficiency
ESLOC = Effective Logical Source Lines of Code

Interrelationships among size, effort, staffing, duration, and productivity allow decision-makers to see the impact of existing program constraints

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Example A/Pre-MS B: Feasibility

PMO Schedule Probability Compared with Independent Estimate



Excursions (What-if Analysis)

- We performed several excursions (what-if scenarios) to assess whether corrective action can be taken to increase probability of success.
- Each excursion is compared to the planned schedule and budget as well as the Independent Estimate.

What-if Scenario	Primary Objective
Excursion 1: Increase Budget	Meet Functionality and Schedule
Excursion 2: Reduce Functionality	Meet Budget and Schedule
Excursion 3: Defer Release 2 and Patriot	Meet Schedule and Budget
Excursion 4: Reduce Quality	Meet Schedule
Excursion 5: Extend Schedule	Meet Functionality, Budget and Quality
Excursion 6: Combination	Compromise of the Above Constraints

- **Feasibility analysis of the proposed Government estimate/plan indicated a 7% probability of meeting schedule**
- **Excursion analysis showed Program Office feasible options**
- **Program Office "de-scoped' and revised plan was assessed near 50% probability of meeting schedule; reducing overall cost & schedule risk to the program**

Excursion 2 Summary: Reduce Functionality

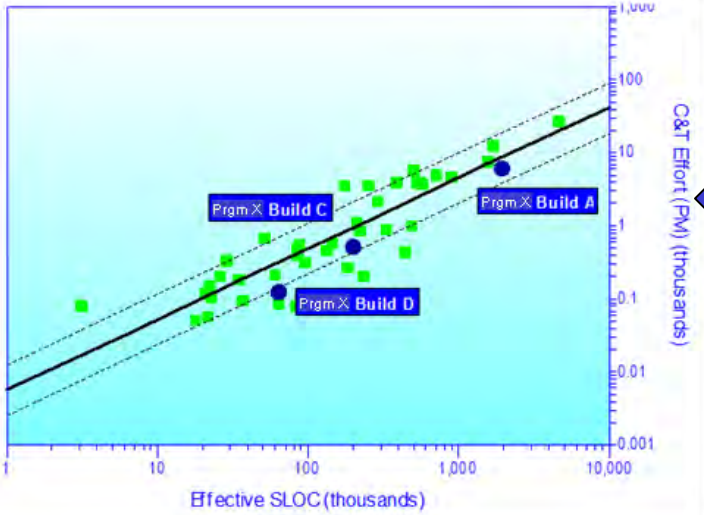
Excursion	Staff Months (Rel 2, System 1)	Release Date (Rel 2, System 1)	% change from Plan Staff Months	% change from Ind. Estimate Projection Staff	Defect Rate change from Ind. Estimate Projection (Rel 2, System 1)	ESLOC (Rel 2, System 1)
Excursion 2 (Rel 2, System 1)	4892, 3763	Apr 2014 (Aug 2013 C&T), Aug 2013	0%	0%	1.4x, 1.2x	425,000, 543,000
Ind. Estimate Projection w/ System 2	4892, 3763	Oct 2016, Mar 2015	0%	0%	1x, 1x	1,099,000, 925,000
Current Plan (Rel 2)	4892	Aug 2013	0%			1,099,000, N/A

- Objective: Reduce functionality to reach plan release date of Aug 2013.
- Result: 40% of release 2 and 59% of System 1 could be delivered on scheduled date. Integration would require additional 8 months.
- Pros: Deliver code to integration on planned release date.
- Cons: Deliver less functionality, slightly worse quality.

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

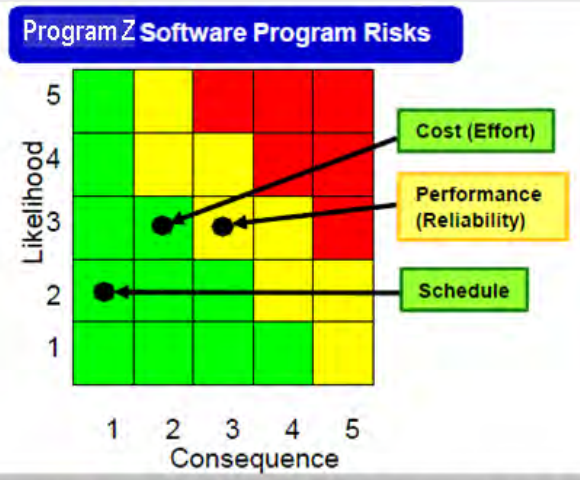
Example MS B: Plan Feasibility

- Similar AT&L projects shown in green
- **Program X Builds in blue**
- Plot provides solid center line of AT&L project and 1 standard deviation dotted line
- View all four views concurrently to gain insight:
  - Size vs Effort
  - Size vs Staffing
  - Size vs Productivity parameter
  - Size vs Schedule



Scatter plot shows feasibility of planned builds compared to other similar AT&L programs

Risk areas identified based on statistical distance from historical program performance



Although consistent with AT&L projects, potential risk due to large size and increased defects, impacting reliability and, to lesser degree, schedule (fixing instead of coding).

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Example MS C: Software Reliability Modeling

1 Reconstruct current/adjusted plan using actual reported metrics

2 Compare and quantify performance to date with similar programs

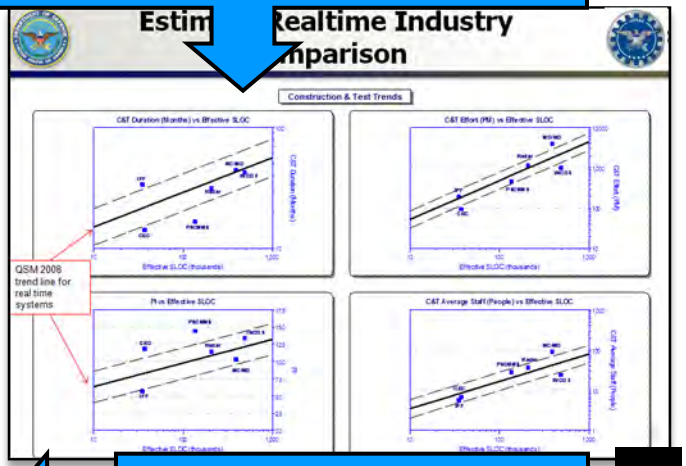
3 Using reported defects, calibrate model

4 Forecast if acceptable software reliability will be achieved by release date compared to similar programs

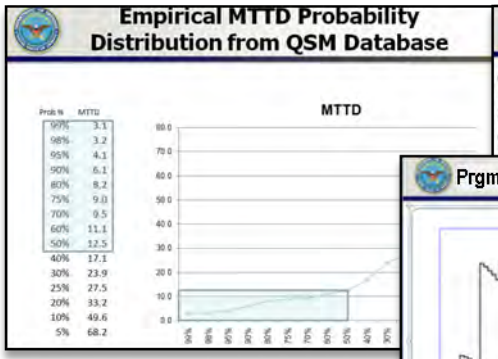
SLIM-Estimate Reconstruction

Component Name	ESLOC	Rqts. Start Date	FQT Completion Date	Peak Staffing	PI
Subsystem 1	135,000	11/2005	08/2007	37.0	14.4
Subsystem 2	486,690	04/2004	12/2008	32.3	13.4
Subsystem 3	207,600	04/200	07	49.0	11.4

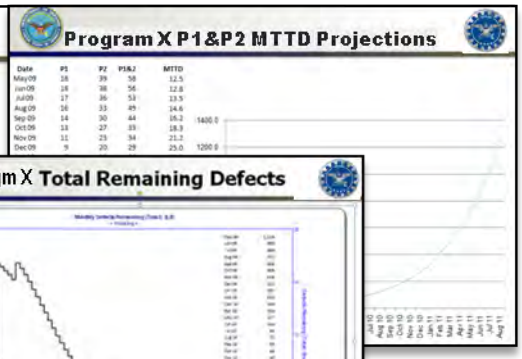
Estim Realtime Industry mparison



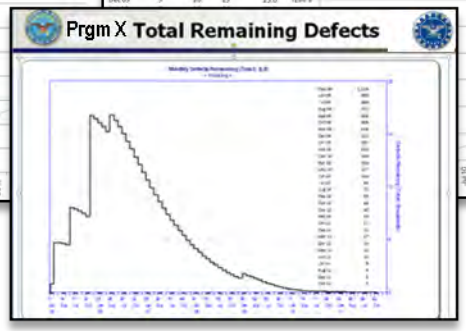
Empirical MTTD Probability Distribution from QSM Database



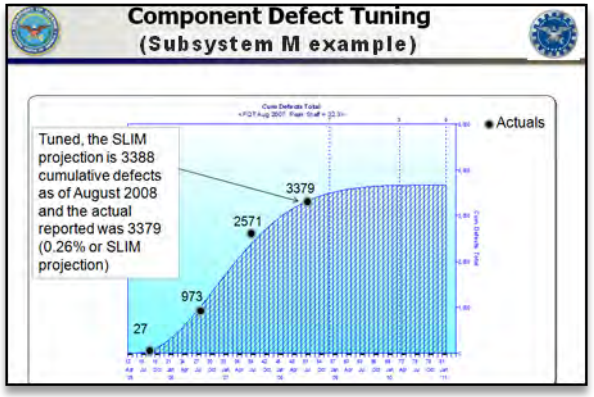
Program X P1&P2 MTTD Projections



Prgm X Total Remaining Defects

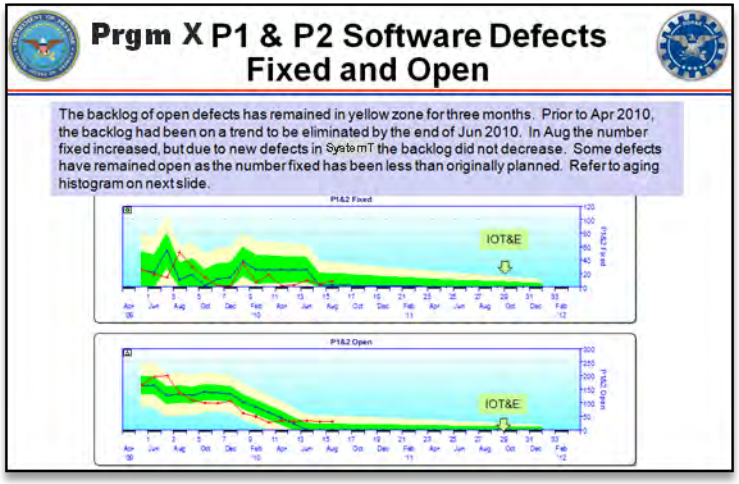


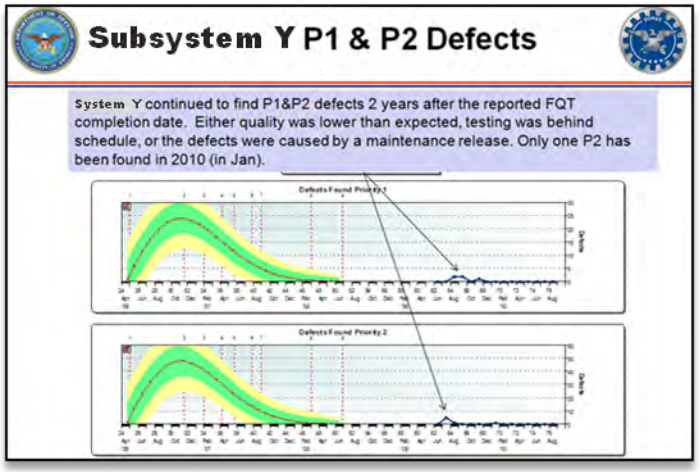
Component Defect Tuning (Subsystem M example)



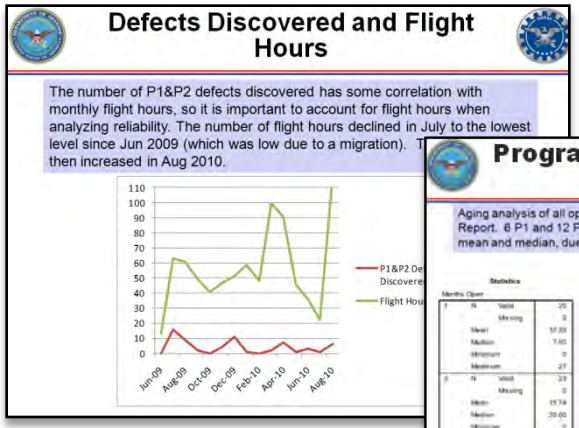
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

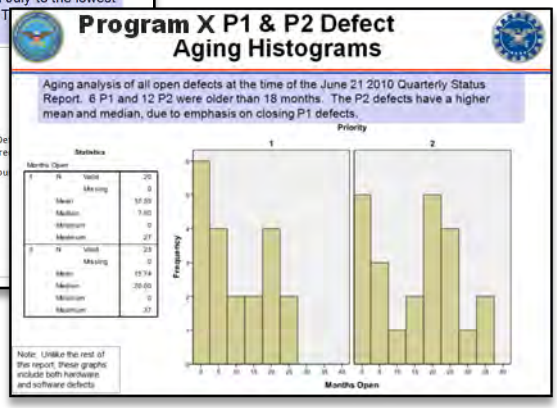
Example Continuous Defect Monitoring





Continuous monthly monitoring provides detailed insight into projected reliability, highlighting any unusual backlog or defect discovery, down to subcomponent level





DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Software Observations

- **Summary findings from our parametric analyses of software intensive programs at OSD AT&L:**
  - Lack of software reliability requirement
  - Missing core metrics needed for monthly tracking / forecasting
  - Inadequate program level estimation and probability assessment
  - Too much schedule compression (high staffing and risk of poor quality)

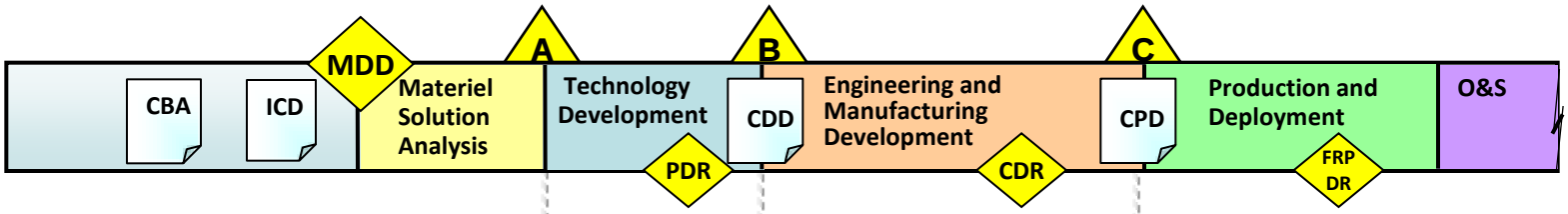
DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Path Forward

- **Leveraging existing metrics and data sources**
  - From many potential metrics; initial data call is limited to 5 fundamental metrics which should naturally exist based on existing acquisition policy and guidance.
  - Normalized and validated metrics provide a basis to model the software development effort and provide insight into overall software development feasibility
- **Extending and maturing metric-based oversight**
  - Time Sensitive
    - Measures collected during program interactions (e.g., PSRs)
    - Metrics collected to support specific decisions (e.g., Program's 'readiness to proceed')
  - Milestone Driven
    - Metrics collected based on a Milestone or Technical Review
    - Metrics provide a static or 'snapshot' of program as of a specific date/time
  - Periodic Data Collection
    - Metrics collected to show trends or 'movement'
    - Frequency
      - Monthly (e.g., defect modeling)
      - Quarterly (e.g., requirements stability)
      - Annually (e.g., inputs to congressional report)

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Summary of Software Data, Analysis, & Lifecycle Decision Support



Program Artifacts	CARD ConOps SRDR-1	Sys Spec SDP SRDR-2	Monthly Status Test Plan SRDR-3
SW Data/ Metrics	**Domain (Context)** Ballpark Size, Constraints • Schedule, • Budget, etc.	Planned: • Size • Schedule • Staffing/Effort • ***SW Reliability***	Actual: • Size • Schedule • Staffing/Effort • Defects • Test Points
Parametric Analysis Objectives	Feasible Trade Space? Alternatives?	Realistic plan? Assumptions - Productivity - Amount of Reuse - Existence of SW Reliability Rqmt	Program health check: • Actual vs. Plan • Forecast to Complete • SW Reliability Modeling

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

For Additional Information

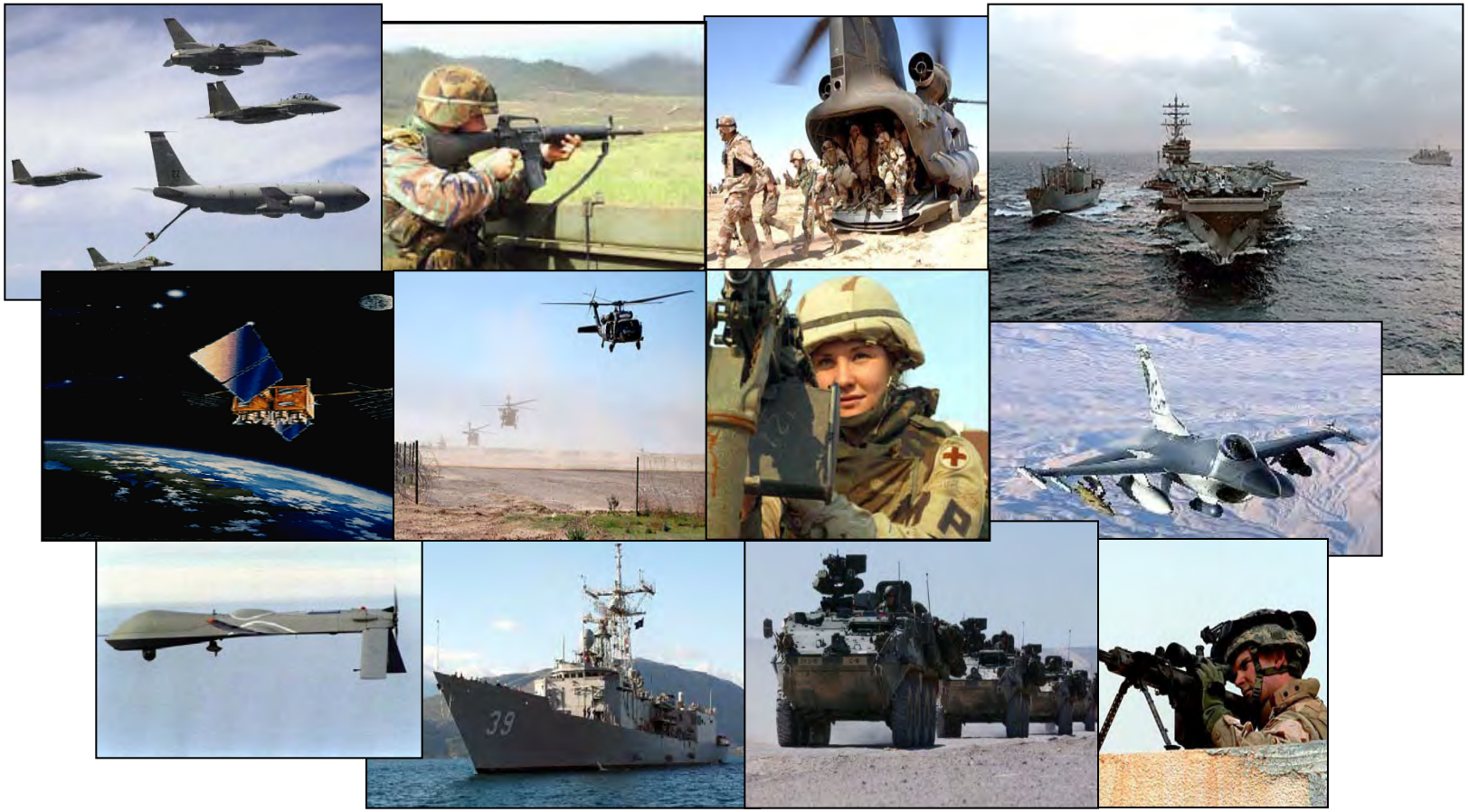
Jim Thompson
ODDR&E/Systems Engineering
(703) 602.0851 | James.Thompson@osd.mil

Chris Miller
SAIC
(703) 412.3689 | christopher.miller.ctr@osd.mil

Angela Lungu
QSM
(703) 749.3826 | angela.lungu.ctr@osd.mil

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Systems Engineering: Critical to Program Success



Innovation, Speed, and Agility

http://www.acq.osd.mil/se

DISTRIBUTION STATEMENT A -- Cleared for public release by OSR on 19 October 2010 -- SR case number #11-S-0105 applies.

Enterprise Health Management Committee

Howard Savage

October 27 2010

NDIA SE Conference

NDIA

- **A**merica's leading Defense Industry association promoting National Security
- **ADVOCATE:** Cutting-edge technology and superior weapons, equipment, training, and support for the War-Fighter and First Responder
- **PROMOTE:** A vigorous, responsive, Government – Industry National Security Team
- **PROVIDE:** A legal and ethical forum for exchange of information between Industry and Government on National Security issues
- **Motto**: Strength through Industry and Technology

EHM COMMITTEE

- Interchange forum for government and industry
- Accepts task from DoD
- Workshops and conferences
- A primary objective of the committee is to determine how to reduce the total ownership cost of weapon systems

EHM Committee

Formerly Known as: Integrated Diagnostics

- Name Changed in 2009:
  - To better serve our Sponsor's needs the ID Committee is expanding its scope to view the ID Process end to end or (in today's vernacular) as an Enterprise.
  - The explicit use of "Management" rather than "Monitoring“ in EHM conveys the idea of focus on the issues that serve the user by improving the application of monitoring to the areas that are important to him - managing the health of weapons to assure mission completion versus just telling him something is breaking.

Enterprise Health Management – What is it

"The capability to make intelligent, informed, appropriate decisions across the Enterprise about design, logistics, maintenance and operational actions based on Health Management Data or Information, available resources, acquisition strategy, and operational demand."

Next Generation Enterprise Health Management Decision Support Solution Targeting Unprecedented Value, Affordability and Continuous Improvement

Key Attributes Include….
EHM as a Design Element; Proactive Advisory Generation Based on Health State; Autonomic; Planned Maturation; Near Real Time Updates; No False Alarms

Past Activities

- Actions From TMDE (Army)
  - Diagnostic Requirements
    - White Paper Issued
  - Infra-Structure Requirements to facilitate Maintenance Data Management
  - Further Define Maturation Process
    - Maintenance Data Capture and usage
- Work with the System Engineering Division to “Fix BIT”
  - Lou Kratz’s statement at the System Engineering Conference
- Networking for Government and Industry

Electronic Prognostic Task

- Accomplishments
  - Report and Information Briefings Complete
    - Results Briefed to Dave Pauling
    - Briefed expected levels of Benefits to Chuck Silva
      - Reduced LCC = 15%
      - Reduced False Alarm Removals = 40%
      - Improved Availability = 25%

      (based on CASREP Data)
    - OSD CBM AG performed detailed analysis of a System
- Follow-on Activities
  - Funding for R&D areas identified in study being pursued

Other Activities

- Marines – Autonomic Logistics
  - Gene Morin requesting ROI help on Vehicle Health Management
- Product Support Analysis Team (PSAT)
  - Identify future requirements for Life Cycle Product Support
- EHM Technology Transition task
  - Workshop Completed
  - Final Report presented to sponsor
  - Report recommendation being addressed with CBM+ AG

Test and Evaluation Issues for Systems of Systems: Sleepless Nights to Sominex

Beth Wilson, Raytheon
Tom Wissink, Lockheed Martin
NDIA Developmental Test and Evaluation Committee

Judith Dahmann, MITRE
John Palmer, Boeing
NDIA Systems of Systems Committee

Sleepless Nights: Test and Evaluation for SoS

- **Systems of Systems Topics Discussed in 2009:**
  - Compiled list of "what keeps me awake at night" topics for SoS
  - Test and evaluation for SoS topped the "Sleepless Nights" list
- **NDIA SoS and DT&E Committees Worked Jointly in 2009:**
  - Identified key T&E challenges for SoS
  - White paper described 5 top issues
  - Presented at 2009 NDIA SE Conference in joint SoS/T&E track
- **Focus for 2010: Joint Workshop**
  - Define a path from Sleepless Nights to Sominex
  - Evaluate challenges and underlying issues
  - Transition specific issues into strategic initiatives
- **Workshop Held August 17th**
  - 3 Strategic Initiatives
  - 1 Collaborative Go-Do

Workshop Defined Path to Sominex

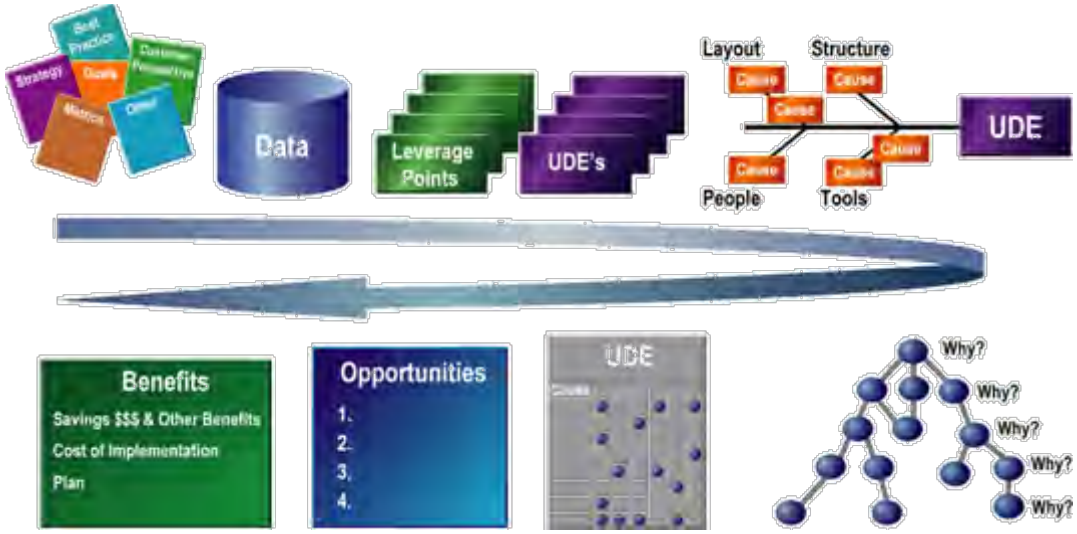
Reminder from 2009: T&E Challenges for SoS

1) **Future T&E:** If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?
2) **Requirements:** If 'requirements' are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?
3) **Metrics:** What is the relationship between SoS metrics and T&E objectives?
4) **Systems Changes:** Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?
5) **End to End Testing:** How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results? What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

White Paper was Starting Point

Facilitated Workshop: The Technique

Data Collection:
SoS White Paper
SE Conference Papers



Potential Problem Areas

1) Future T&E for Systems brought together as SoS
2) Requirements
3) Metrics
4) Systems Changes
5) End to End Testing with systems not yet available

Potential Causes

If we could only fix one thing, it would be _____

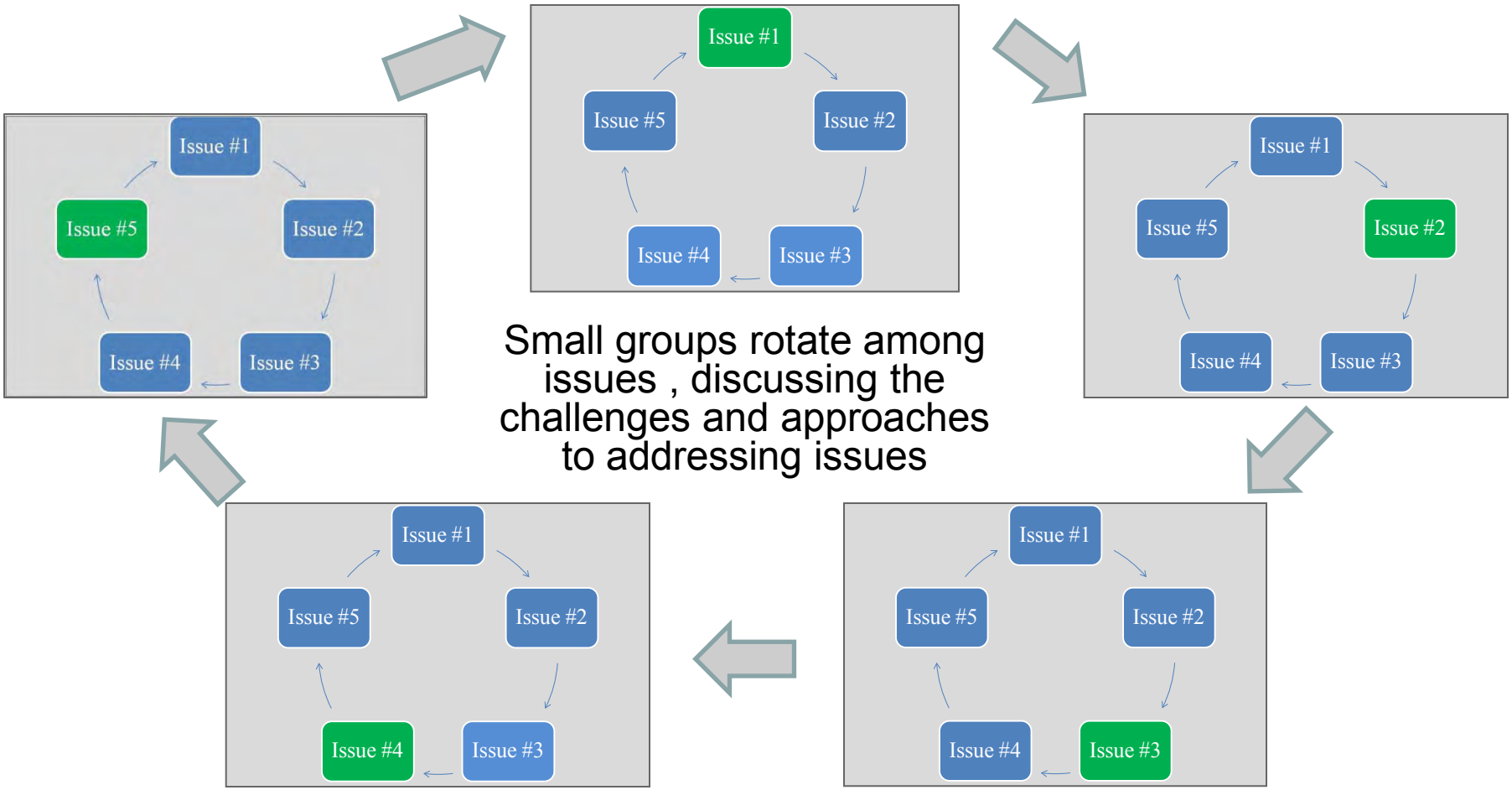
Improvement Areas:
Strategic Initiatives
Collaborative Go-Do

		Cable	Tasks	Setup	Testing	Security
Facility	Signal cables wrong length or incorrect	X		X		
	Power/Cooling connections	X		X		
	Safety interconnect	X				
	Test equipment			X		
	Equipment in NFR	X		X		X
Schedule Dependencies	Signal cable delivery	X	X			
	REX/NBDC/SDP availability		X		X	
	REX array availability		X		X	
	Test results prior to string integration				X	
	Detailed tasks for integration/prep	X	X	X	X	
Security	Classified shipment					X
	Classified workstations					X
	Classified field returns					X
Integration Test Conduct	Procedures incomplete or incorrect		X	X	X	
	SDP emulator				X	
	Work-arounds required	X	X	X	X	X

Leverage Matrix
Map Causes to problem areas

Transition from Problem Space to Solution Space

Facilitated Workshop: Carousel Brainstorming



Brainstorm Undesired Effects Aligned with Each Issue

Facilitated Workshop: Action Development

Leverage Matrix

	Issue #1	Issue #2	Issue #3	Issue #4	Issue #5
Initiative A	X		X		
Initiative B		X			
Initiative C	X			X	X
Initiative D			X		
Initiative E					X

Approaches to addressing the issues are recast as initiatives and collaborative activities

Strategic Initiatives

- Problem Statement
- Examples of Problem
- Candidate Vision Statement
- Participants
- Action Plan
  - Output Products
  - Deadline for Completion

Collaborative Activities

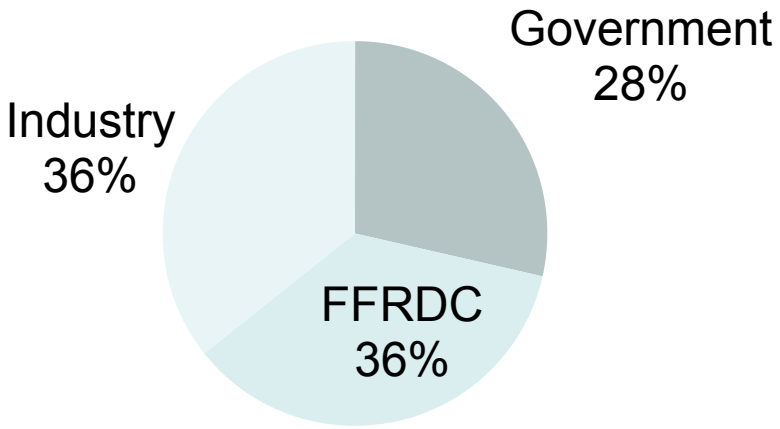
- Collaborative Go-Do Activity
- Participants
- Action Plan
  - Output Products
  - Timeline for Completion

Define Strategic Initiatives and Collaborative Activities

Facilitated Workshop: Attendees

Mr. Robert Aaron	Army	Government
Col (Ret) Suzanne M. Beers	MITRE	FFRDC
Dr. William D. Bell	MITRE	FFRDC
Mr. Aumber Bhatti	MITRE	FFRDC
Clyneice Chaney	MITRE	FFRDC
Mr. Peter H. Christensen	MITRE	FFRDC
Mr. David W. Coleman	MITRE	FFRDC
Dr. Judith S. Dahmann	MITRE	FFRDC
Ms. Indira Deonandan	MIT	Government
Mr. John W. Diem	OSD/ MSCO	Government
Mr. Mark E. Fenicle	DoD	Government
Mr. Tanya Gobel	SAIC	Industry
Mr. Robert Heilman	DOD	Government
CDR (Ret) Bryan Herdlick	JHU APL	Government

Dr. JoAnn Lane	USC CSSE	Industry
Mr. Steven S. Lee	DoD	Industry
Mr. Marty Leek (Facilitator)	Raytheon	Industry
Mr. Favio L. Lopez	Army	Industry
Mr. John R. Palmer	Boeing	Industry
Mr. George Rebovich Jr.	MITRE	FFRDC
Mr. Frank J. Serna	Draper	Industry
Mr. Michael Shanahan	USMC	Government
Dr. Carol A. Sledge	SEI	FFRDC
CDR (Ret) James D Smith II	SEI	FFRDC
Mr. Thomas Wissink	Lockheed Martin	Industry
Mr. Jack Zavin	OSD NII/DoD CIO	Government
Dr. Janice A. Ziarko	MITRE	Industry
Ms. Robin E. Ziradinovic	SAIC	Industry



Workshop Results

- **Strategic and Tactical Initiatives Identified**
  - **Consensus among participants**
  - **Willing leadership**

- **Three Strategic Initiatives:**

  1. **Best Practices Model for SoS T&E**
  2. **Radical Approach to SoS T&E**
  3. **SoS Governance**

- **One collaborative 'Go-Do'**

  1. **SoS SE Policy and Guidance**

Initiatives Identified with Action Plans

Collaborative Go-Do: SE Policy and Guidance

Ensure that guidance for SoS SE (DoD SoS SE Guide) is recognized and employed on growing number of SoS

- **Good Results:**
  - **Most participants are aware of current DoD guidance on SoS SE**
  - **A number have applied the guidance with good results**
- **The current guidance is 'soft':**
  - **Provides recommended approaches to addressing SE for SoS**
  - **Core elements of SoS SE reflected in the discussions of the workshop issue groups as things which need to be done to address the issues**
- **No requirement to follow this guidance:**
  - **An obstacle to success is that there is no requirement to follow this guidance**
  - **Without this, the imperative, the authority and resources needed to successfully address technical issues critical to employing SoS SE to enable user capabilities is missing**

Recognize and Employ SoS Guidance

Strategic Initiative #1: Best Practices Model for SoS T&E

SoS T&E as a continuous improvement process supporting capabilities and limitations information for end users and feedback to the SoS and system SE teams toward evolution of the SoS

- **Lead:** Rob Heilman and Judith Dahmann
- **Product :** Description of "best practice" model, supporting evidence based on use cases, from DoD and beyond (if possible); (non government, commercial) with an assessment of efficacy and applicability of the model including degree of confidence
- **Who/Customer:** DDR&E, SE/DE, TRMC
- **When:** Oct 2010 – Dec 2011
- **How/Activities:**
  - **Oct – Dec 2010: :** Form team; Review with customers to determine interest in product; Develop plan, present plan at strategic planning meeting, and circulate model draft as baseline
  - **Jan – Aug 2011:** Identify use cases and schedule presentations/exchanges as part of committee meetings
  - **Sept – Dec 2011:** Assess model against use case data; Synthesize and evaluate

Define Best Practices Model

Strategic Initiative #2: Radical Approach to SoS T&E

Rethink T&E of systems in an operational context and systems interoperability away from system testing toward integrated 'capability' SoS testing

Investigate the concept of replacing DT, OT, NR-KPPs, etc. with an overall SoS capability test. Take results to end user. Sell concept to DOT&E and acquisition communities

- **Lead:** Tom Wissink
- **Product:** Report describing a process to achieve "capabilities test"
- **Who:** DT&E/OT&E communities & certification & acquisition groups, force providers
- **When:** November 2010 start (6-9 months completion)
- **How:** Series of Workshops

Define SoS Capability Test

Strategic Initiative #3: SoS Governance

Identify the process by which we can change and influence the governance of SoS

Mature/improve templates (AT&L) – defined minimum set of characteristics that are required to govern SoS T&E efforts

- **Lead:** Robert Aaron and James Smith
- **Product** : ID the process to influence governance
  - ID what is Governance, minimum set
  - Rationale
- **Who:** Audience → Stakeholders → Supporters
- **When:** Milestones:
  - **Info Oct 25-28 SE Engineering Conference Paper**
  - **Mid Jan 2010 draft**
- **How:** Briefs – Feb → June
- **Issues:** Coalition partners; Other NDIA groups

Define Characteristics of Successful SoS T&E

Summary

- **Successful Workshop with SoS and T&E Practitioners**
- **Framework Established for Continuing Collaboration**

- **Top 5 T&E Issues for SoS:**
  1. **Future T&E for SoS programs not currently program of record**
  2. **Requirements that become the basis of T&E for SoS**
  3. **SoS Metrics that relate to T&E objectives**
  4. **System changes that impact SoS performance and T&E objectives**
  5. **End to End Testing of SoS elements**

- **Initiatives to Develop T&E Solutions for SoS:**
  1. **Define a best practices model**
  2. **Define SoS capability test**
  3. **Define characteristics of successful SoS T&E**
  – **Recognize and employ existing guidance for SoS (DoD SoS SE Guide)**

Transition Discussion from Challenges to Solutions

BACKUP

Details on T&E Issue Discussions

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Discussion

- **Restatement of issue:**
  - How do we define, articulate, and enforce the relationship between the SoS and the constituent systems?
  - How does T&E support/help this?
- **Governance/Roles/Stakeholders**
  - Need a shepard (architect?) and support from users
  - Need to educate stakeholders
  - What are rules of governance?
  - What are the regulations, standards, and policies?
  - Need to obtain resources (funding, test assets, time)
  - SoS leadership focus: architecture views, who "owns"
  - Potential conflicts between SoS and constituents
  - Business case for PMs to do SoS
- **SoS T&E Focus**
  - SoS T&E operationally driven (vs. DT-ish)
  - SoS edge of the envelop
  - What is an AoA of SoS?
  - Emergent behaviors (good and bad)
  - SoS resource consumption (e.g. data pipeline)
  - Continual assessment (joint exercises, deployments)
  - How to define test strategies to efficiently continuously test?
  - How do we help the T&E process help the SoS work?
- **Understand SoS Capabilities**
  - What is the SoS expected to do?
  - Define and articulate relation between SoS and systems
  - Flexible composition
  - Artfully sub-optimize the systems in favor of the SoS
  - System performance bounds are not rigid in real operation
  - Candidate solution: SoS requirements document with annex for each constituent system (what is constituent contribution to SoS capability)

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Approach to addressing issue

- Define a minimal set of SoS governance characteristics of a successful acknowledged SoS
  - Roles/resources
  - Rules/regs/standards/policies
  - Managing conflicts
  - Establishing cooperation of constituent systems
  - Includes responsibility to define SoS capabilities, architecture, and associated test strategy
  - Concept of continual change and test in operational and training environment
  - Lean management, taking advantage of available opportunities
  - Recognize the large number of SoS across the DoD, and the fact that many systems support multiple SoS.anf the potential impacts of governance

Issue #2 If "requirements" are not clearly up front from a SoS, what is basis for T&E of an SoS?

Discussion

- Requirements vs expectations; Mission objective vs. technical requirements
- Mission threads linked to capability strands as architecture model
- Who/what has responsibility for architecture/requirement- another DOD layer?
- Standards for participating or acceptance of each system into SoS
- Requirements model for architecture encompassing time, space changes
- SoS level requirement T&E at program or SoS level balance?
- T&E of aggregation of systems level requirements (SOS level TEMP)
- Integrated development environment/ reference architecture as model
- Need operations/architecture view of SoS that individual systems must plug into- need someone responsible for this
- Prioritization of SoS capabilities at high (OSD) level required to permit constituent PM to manage development and delivery. With funding at SoS
- Measure and baseline SoS capability thru T&E w/o requirements. Where do we get metrics?
- Must have an "enforcer" capability manager - carrots and sticks
- Measure SoS capabilities when changes to SoS Baseline
- CONOPs vs innovative use of systems in face of changing threat
- Move from paper to 4 dimensions to capture SoS capabilities requirements.
- Use of modeling tools of SoS components delivered with each component to communicate requirements
- Capability flow down to systems, demo meeting systems capability

Issue 2: If "requirements" are not clearly defined up front for a SoS, what is basis for T&E of an SoS?

Approach to addressing issue

- The DOD needs a top-down (architecture, requirements, context, expectation) flow-process to systems within the SoS
- Needs authority & funding to enforce capability fulfillment
- Needs to be flexible enough to meet changing needs and threats and CONOPS/operator innovation.
- Determine the right balance between system test to sos- test to SOS level test

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Discussion

- SoS T&E is focused on continuous improvement of the SoS (as compared to system T&E which is focused on the field, fix, or don't field decision)
- Continuous SoS T&E requires
  - Stable/consistent metrics
  - Consistent approach to defining evolving baseline
  - A way to deal with emergent behavior (technical, organization, human) – positive or negative
  - Need to leverage wide range of opportunities for test environments
  - Continuous improvement means continuous testing ; Built in test instrumentation for feedback from field
- SoS metrics
  - Do not address discrete behaviors of systems (as do system metrics)
  - Do address end to end performance across systems in SoS toward capability objectives of the SoS
- What is objective of T&E for an SoS?
  - Development information on capabilities and limitations of SoS to inform end users and ongoing SoS evolution (as compared to system T&E which is assessment of whether system meets requirements)
- SoS T&E customers?
  - End user and SoS SE team (as compared to system T&E where aquisition community is the customer)
- SoS T&E should be risk driven: focus on areas of risk to SoS or systems

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Approaches to addressing issue

- Characterize SoS T&E as continuous improvement, document the approach and share with the community
- Radically change how we look at testing given the growing prevalence of SoS
  - Concepts of DT and OT don't really fit
  - Inefficient to address systems in operational SoS environment on a system by system basis (OT today)
  - Continue to test individual systems to assess whether we have developed what we asked for
  - Create a new approach to OT, by cross systems support for testing capabilities

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Discussion

- To address these issues you need to fix
  - Define the SoS and its performance objectives
    - Constituent systems that are part of the SoS
    - Which parts of the constituents contribute to the SoS objectives
  - Describe the current and future state of the changing systems (Baselines)
  - Assign ownership of SoS performance objectives
  - Big challenge; leadership issue, etc
    - More collaborative approach for stakeholders of SoS
- Emergent behavior – interaction of systems, humans, system and organization along with constant change of the parts
- Bounds of human impact
  - Operator – leader – mission
  - The people side of systems
- Training and development of the evaluators (and the end users)
- Expensive to assess if capabilities are realized (hard to do)
  - Doing more with less?
  - Disconnect thinking and reality?
- Leadership understanding of SE and SoS
  - Is there competency to make decisions and know the impact and implications?
    - Trades without know the desired outcome can be achieved
  - Evaluation on an SoS basis vs individua;l systems and their acquisitions
  - Timing and who benefits (lack of rewards systems)
  - Accountability for SoS
- Continued improvement, assessment, and alignment because objectives have changed
  - More data from fielded systems
- Connections to fielded side of the house (doesn't deal well with change)
- "Measurement system' for system
  - Analysis of impacts
  - M&S?
  - Risks; "we are not sure but…" with some mitigation
  - Regression testing and configuration of SoS
  - Comparative analysis

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Approaches to addressing issue

- Influence assigning leadership responsibility and ownership of defined SoS capability and associate performance objectives
- Establish incentives of constituent systems to collaborate and achieve SoS performance objectives
- Map SoS capabilities and performance objectives to constituent systems (under configuration control)
- Continual assessment, improvement, and realignment is required (incremental approach) focused on end user)
- Create a guidance framework for emergent behaviors of changing to be measured and managed

Issue 5

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Discussion

- Trying to assemble all piece parts for T&E
- So many variables that can impact T&E outcome
- Reliance on other programs (e.g., JTRS) for capabilities that can slip in schedule or are never delivered
- Spanning "use-case" space with a reasonable set of resources and schedule
- Need defined set of requirements (but, of course, this is part of the problem space)
- What does a T&E strategy look like?
- How account for "the network" and stresses to it?
- DoD should require programs to share/ make transparent to other programs their development, DT and other data (obstacles: proprietary/security)
- Recommend ways to systems instrument to enable post-fielding collection of "test" data
- Operations, exercises, training
- DoD should develop a common approach to accounting for "the network" as a constituent of all SoSs for purposes of T&E
- DoD articulate purpose of SoS T&E
  - Is it a capability demo ("what do we have?")
  - Is it a classical check against requirements?
  - The real purpose of SoS T&E is to answer:
    - Is the new capability operationally useful (whether or not it "met" requirements); what are risks?
  - How can the new capability be used?
  - What further changes are required?

Issue 5

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Approach

- **M&S of piece parts that are not yet ready to be tested (but issues between M&S for individual system performance versus effects-based M&S) – potential solution to issue #1.**
- **Architectures and synchronizing them an enabler of T&E (provides well-defined baseline; can measure deltas against the baseline)**
- **Combinatorial test & design (suggested as potential solution to issue #2).**
- **Model-test-model approach suggested for way to accommodate emergent behavior**
- **Field exercises – instrumentation to collect data**
- **Training as a T&E opportunity**
- **No SoS requirement => no TEMP for SoS capabilities => no SoS T&E funding. Therefore need a capability (SoS) focused, cross-system, integrated test schedule that builds to a graduation-level event. (some disagreement re. existence of such an event). Push SoS T&E to fleet/operators as proof of IOC (need fleet experimentation funding).**

2010 Strategic Plan for DoD T&E Resources

27 October 2010

Dr. Suzanne V. Strohl
Test Resource Management Center
Deputy Director, Strategic Planning Division

Discussion

- National Defense Authorization Act
- Strategic Plan Law and Guidance
- Strategic Plan Purpose
- Products and Effects of the Strategic Plan
- Strategic Plan Systems Engineering Requirements Traceability Process
- Strategic Plan Systems Engineering Approach
- Systems Engineering Approach Example – Space
- Domains and Focus Areas
- Questions

National Defense Authorization Act
(FY2003) (Public Law 107-314)

Established
TRMC

- DoD Field Activity
- Direct Report to USD(AT&L)
- ★★★ SES Director

Oversee
T&E Budgets

Major Range & Test Facility Base (MRTFB);
Other T&E Facilities
Within & Outside DoD

Biennial 10-Year Strategic Plan for DoD T&E Resources

Annual T&E Budget Certification

Military Departments & Defense Agencies

Administer
Centrally-Funded T&E
Investment Programs

CTEIP
T&E/S&T

Strategic Plan
Law and Guidance

U.S. Code
Title 10, Section 196 (d)

> "…**The strategic plan shall be based on a comprehensive review of the test and evaluation requirements** of the Department and the adequacy of the test and evaluation facilities and resources of the Department to meet those requirements…."

DoDD 5105.71

> "6.2.2.2. **The strategic plan shall be based on a comprehensive review of the Department's T&E requirements** …"

Strategic Plan for DoD T&E Resources

- Ensure adequate T&E capability and capacity with optimum effectiveness and efficiency to support the testing of future warfighting capabilities
- Assess T&E Resources from DoD T&E, non-DoD Government, Commercial, Academia, and International
- Include requisite Workforce, Infrastructure, and Funding resulting in a T&E Capability, by means of the T&E Processes

NOTE: 2010 Strategic Plan awaiting signature by USD(AT&L) on September 15, 2010

Products and Effects of the Strategic Plan

Strategic Plan

- T&E Requirements
- Performance Measures
- T&E Facility and Resource needs
- Investment needs
- Budgetary Resource needs

Inform Congress for Appropriations and Legislation

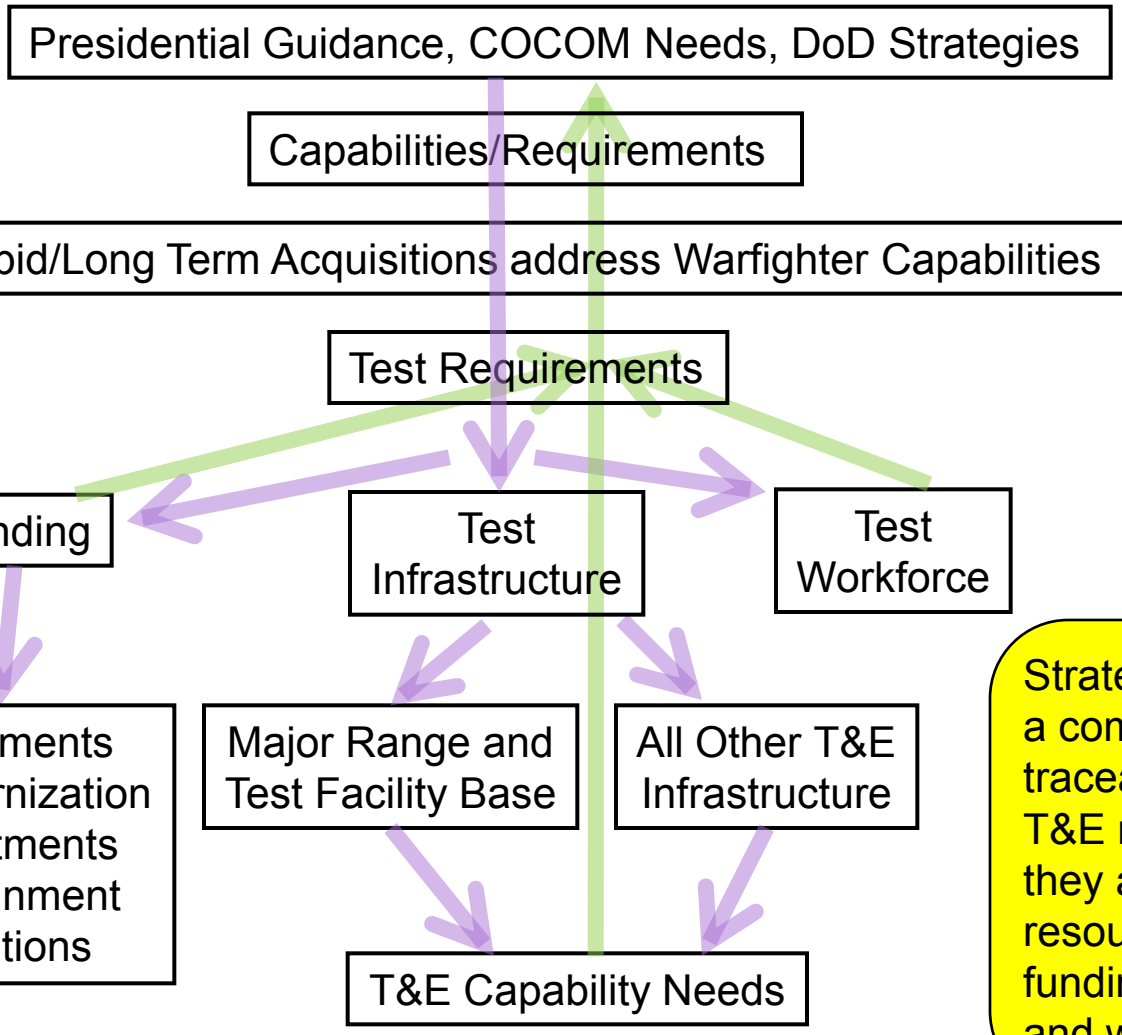
T&E Operations and Investments

T&E Budget Certification

Investments

Strategic Plan Traceability

Comprehensive Systems Engineering Review Process



Strategic Plan provides a comprehensive and traceable review of T&E requirements as they affect T&E resources, including funding, infrastructure, and workforce.

Strategic Plan
Systems Engineering Approach

Institutionalize approach establishing a standard to link:
Warfighter requirement needs → testing → back to mission capability

Stakeholder & Interests

OSD, Executive, DIA, S&T	AT&L, COCOMs	DT&E, DOT&E, Experts	SE, MDAP, T&E Users	Services, OMB, CAPE, Congress
What are the emerging trends and threats?	What are the capability requirements and warfighter needs?	What tests are needed given likely missions and future demands?	What resources and facilities are required to facilitate T&E?	What investments are being made to fulfill resource demands?

Global Context & Challenges	Warfighter Missions / Needs	T&E Capability Requirements	T&E Resource Enablers	Programs & Investments
Threats & Trends Strategic Objectives Complex Operating Environments	Technology Development (ACTD) Acquisition	Current (available) vs. Future Need (for current acquisition programs and future warfighter needs)	Funding Infrastructure Skill sets Processes	T&E S&T Service POM CTEIP

Systematically Map End-to-End

Partial / illustrative depiction

Step 1

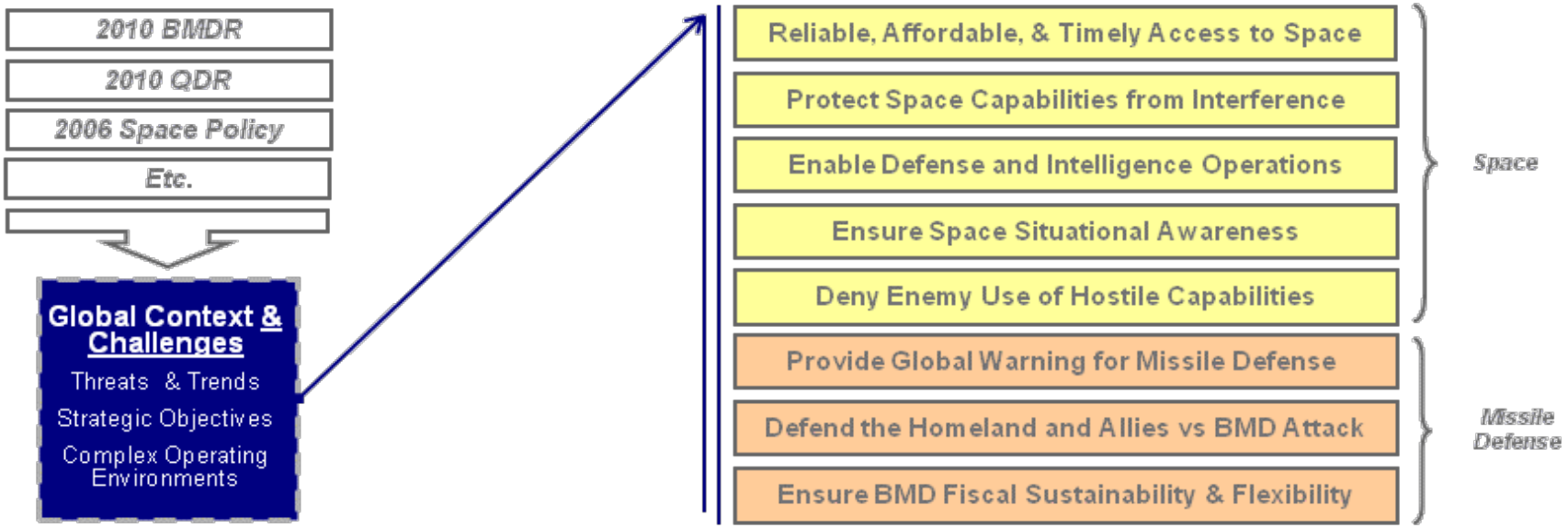
Example: Space

National Strategy to Strategic Objectives Mapping

Step 1: Use national strategic documents to extract, decompose, and communicate major strategic objectives.

Various national strategic documents (DoD, Executive) identify and sometimes prioritize US strategic thrusts, important global trends, and possible threats to national security.

Example Process for Space and Missile Defense



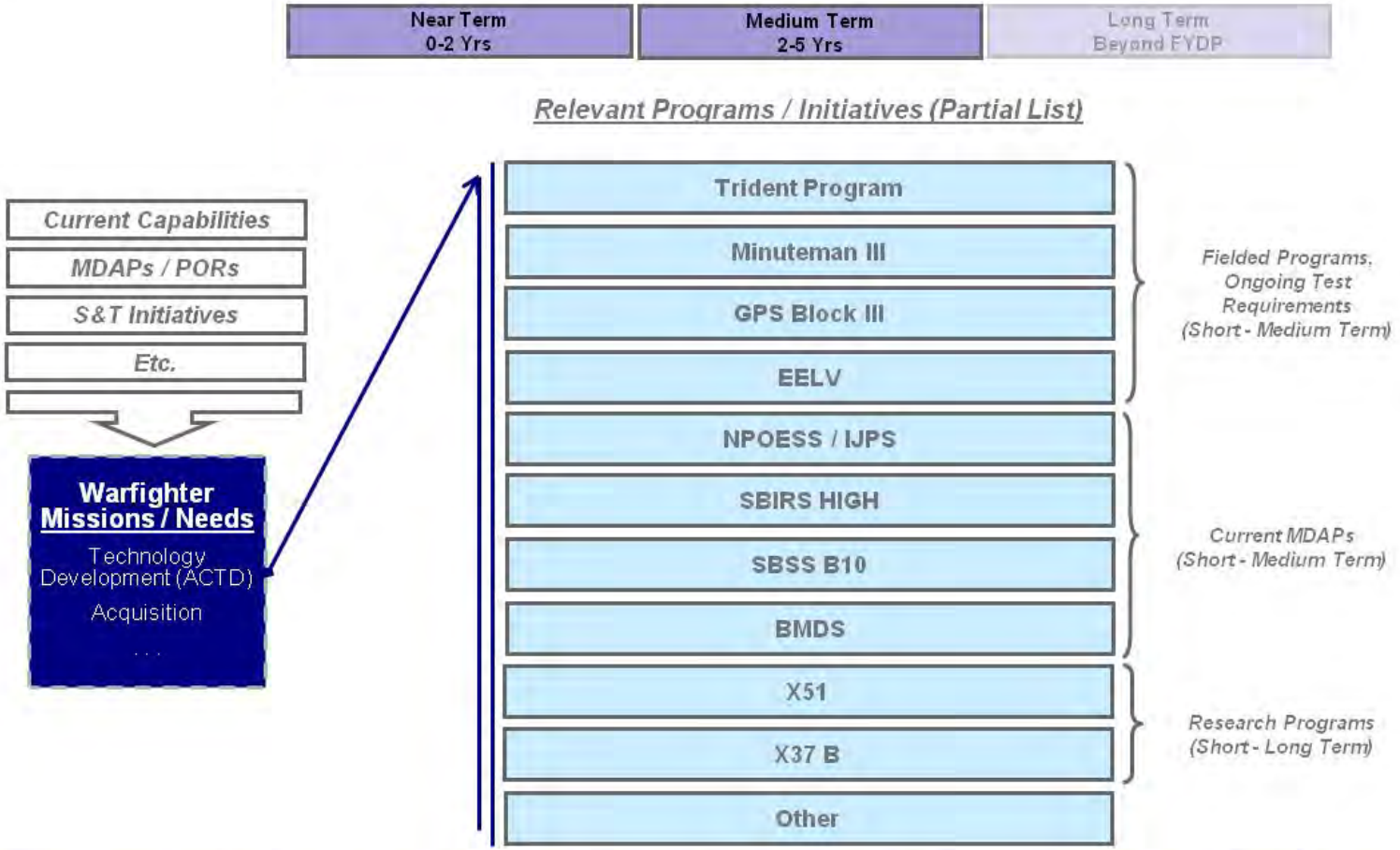
ILLUSTRATIVE LISTING (PARTIAL)

Step 2

Example: Space

Testing Resource Driver Identification

Step 2: Identify the major drivers (programs, technologies, initiatives, etc) which determine potential required test capabilities, by time period.



Short-term and medium-term priorities will tend to be driven primarily by current programs for some areas

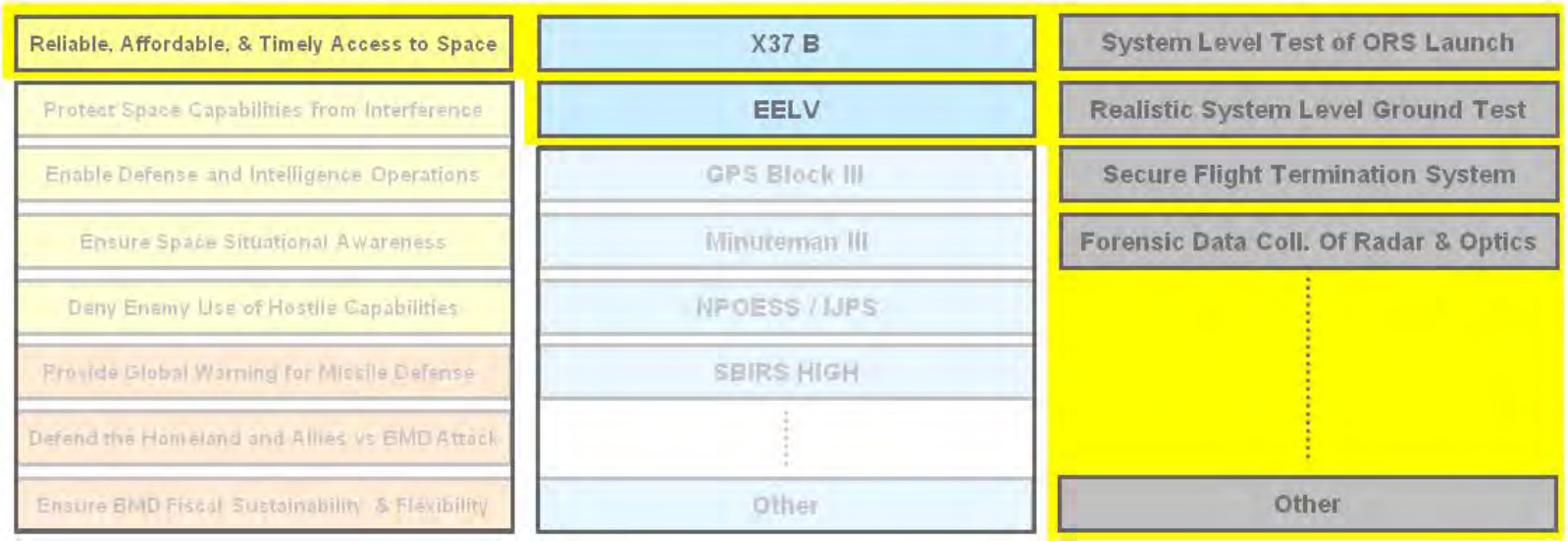
Step 3

Example: Space

T&E Capability Identification & Mapping

Step 3: Map strategic objectives to warfighter needs/programs to determine T&E capability requirements.

Warfighter missions/needs most likely support at least one strategic objective. T&E capabilities for each need (or program) may be identifiable based on tactical roadmaps, TEMPS, and so forth.



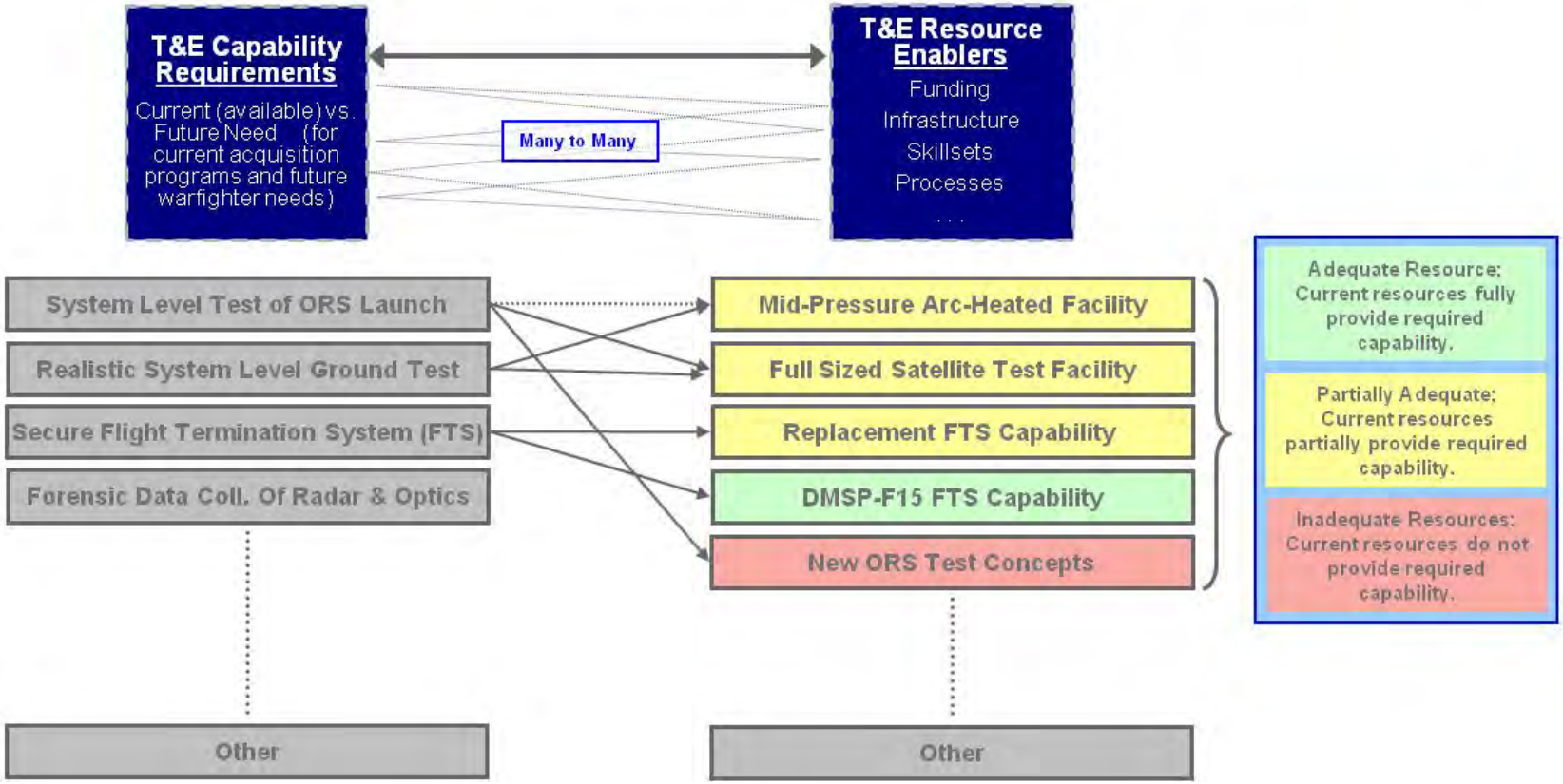
Step 4

Example: Space

Capability Resource Assessment

Step 4: Identify T&E resources required to completely fulfill the T&E capability requirements. Separate out current and needed capabilities.

Capabilities present resource requirements in terms of infrastructure, processes, and manpower. Capabilities may either be adequately, partially, or inadequately resourced.

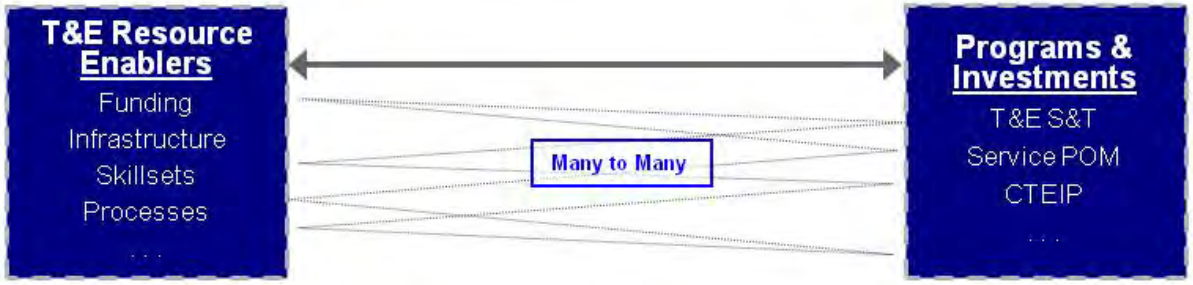


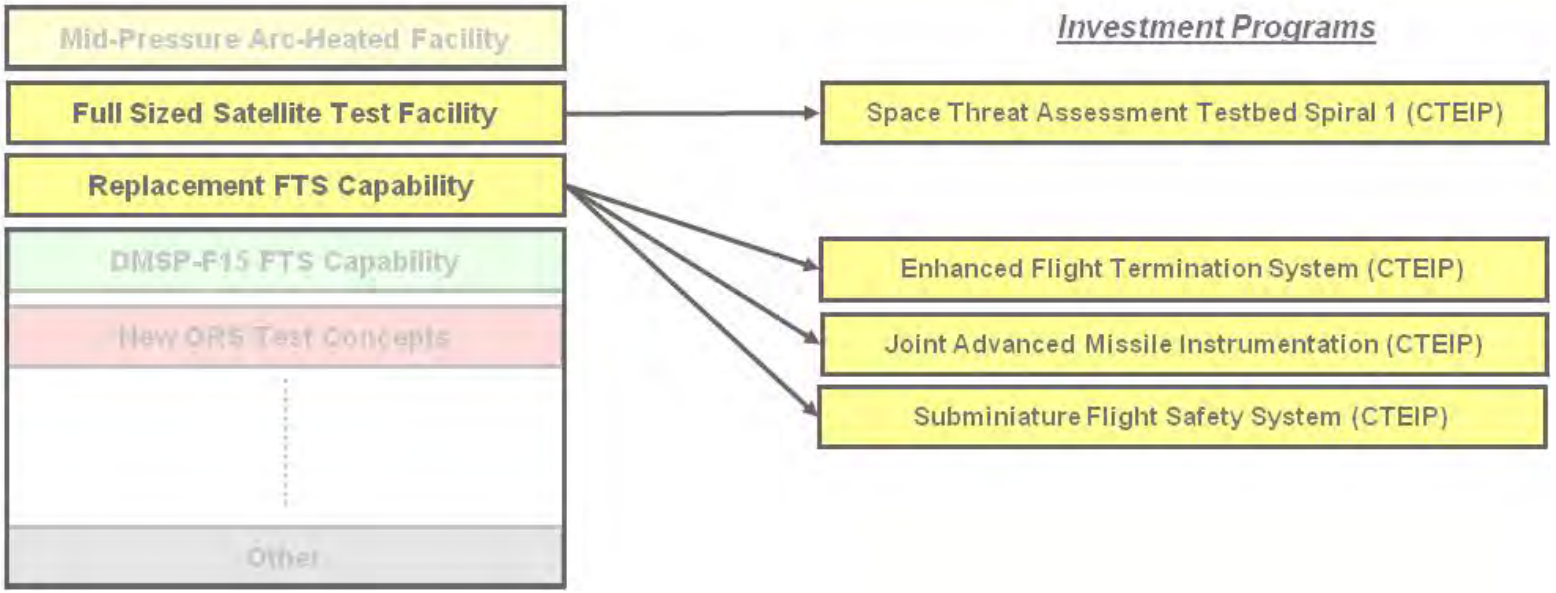
Step 5

Example: Space

Current Investment Assessment

Step 5: Map T&E Resource needs with relevant investment programs (CTEIP, TE/ST, Services) and the expected availability.

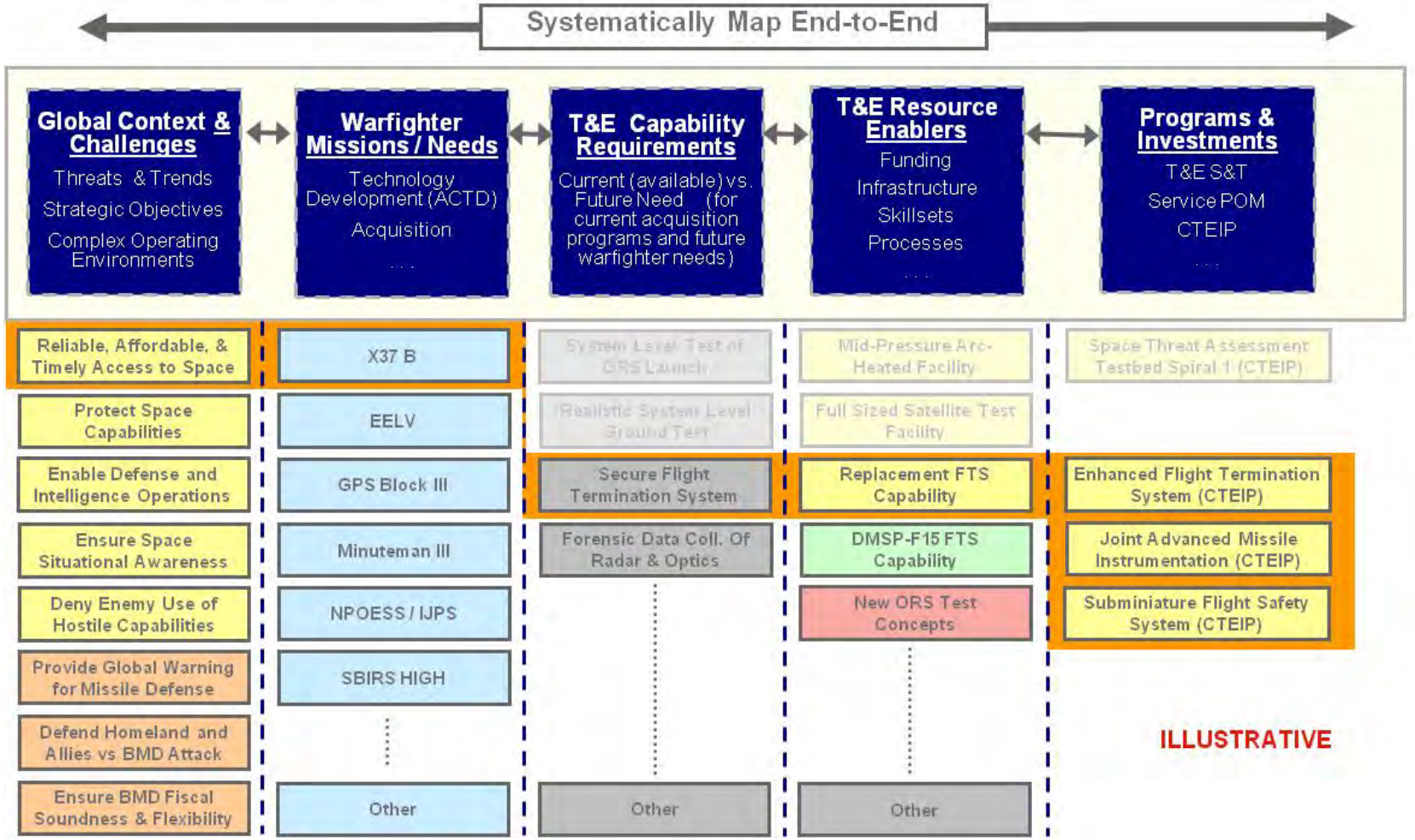




Example: Space

An Integrated Approach

One strategic objective, reliable access to space, provides an example of the disciplined integrated approach.



Formation of Work Groups

Strategic Plan Approach

Institutionalize approach establishing a standard to link:
Warfighter requirement needs → testing → back to mission capability

Stakeholder & Interests

OSD, Executive, DIA, S&T	AT&L, COCOMs	DT&E, DOT&E, Experts	SE, MDAP, T&E Users	Services, OMB, CAPE, Congress
What are the emerging trends and threats?	What are the capability requirements and warfighter needs?	What tests are needed given likely missions and future demands?	What resources and facilities are required to facilitate T&E?	What investments are being made to fulfill resource demands?

Global Context & Challenges	Warfighter Missions / Needs	T&E Capability Requirements	T&E Resource Enablers	Programs & Investments
Threats & Trends Strategic Objectives Complex Operating Environments	Technology Development (ACTD) Acquisition	Current (available) vs. Future Need (for current acquisition programs and future warfighter needs)	Funding Infrastructure Skill sets Processes	T&E S&T Service POM CTEIP

Systematically Map End-to-End

Partial / illustrative depiction

Domain & Focus Area Work Groups

Domains and Focus Area Work Groups

- Develop each domain/focus area
  - Collect T&E requirements
  - Assess current T&E capability to support those requirements
  - Identify any known T&E resource gaps
  - Guide review of current capability for certification
- Regularly held meetings
- Led by TRMC Strategic Planning Focus Area POCs
  - Focus areas nominated by Service, Defense Agency, or OSD
  - SP Focus areas determined by February of the odd year
- Comprised of Service SMEs, OSD Agencies (DDR&E, DOT&E, DT&E, DISA, DARPA, etc…), and Academia

Areas of Focus

- **Strategic Plan Work Areas**
  - Domains
    - Air, Land, Sea & Cyberspace Combat; Space and Missile Defense
  - Focus Areas
    - Artificial Intelligence, Biometrics, Counter-IED, Electronic Combat/Directed Energy, Environments, Hypersonics, Joint Capability Testing, Net-Centric, Nuclear Weapons Effects, Spectrum Management and Stewardship, Targets and Threats, Unmanned and Autonomous Systems
- **Future Areas**
  - International, Intelligence, Sensors and Intelligence Surveillance & Reconnaissance, Medical, Science and Technology

Strategic Plan for DoD T&E Resources Questions

Dr. Suzanne V. Strohl
Office of The Secretary of Defense (AT&L)
Test Resource Management Center
1225 South Clark Street
Crystal Gateway 2, Suite 1200
Arlington, VA 22202

703-601-5242
suzanne.strohl@osd.mil
suzanne.strohl@osd.smil.mil

Evolution of the Tomahawk Land-Attack Missile Operational Test Launch Methodology

Angelica Lilly
443-778-3209
The Johns Hopkins University
Applied Physics Laboratory
Angelica.Lilly@jhuapl.edu

NAVAIR Public Release 10-1289
Distribution: Statement A - Approved for public release; distribution is unlimited

APL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

Ref: 13th Annual National Defense Industrial Association Systems Engineering Conference, 25-28 October 2010

Agenda

- Background
- Goals
- Tactical Tomahawk Block IV
- Overview of Operational Test Launch (OTL) Program
- Evolution of Methodology
- Lessons Learned
- Summary

Background

- The Tomahawk Weapon System (TWS) has been traditionally viewed as a strategic asset whose employment has been directed by the National Command Authority, rather than controlled by Fleet, Task Force, or Combatant Commanders
- The system test office of the Tomahawk Weapon System program (PMA-280) has actively been engaged in the planning and transition of the Tomahawk Land-Attack Missile (TLAM) Operational Test Launch (OTL) program to promote increased operational realism in testing
- This evolution of methodology from “tester-centric” participation to more “user-centric” participation is to integrate new tactics, techniques, and procedures (TTPs) with a stable weapon system, and to augment our traditional role of identifying issues

Goals

- The goals of the presentation are to provide:
  - examples of the transformation of the OTL program, with a focus on the Tactical Tomahawk Block IV missile, as a path forward in the program's evolution to achieve improved operations and ease-of-use
  - useful information to identify areas in which to inject additional operational realism to more accurately accomplish programmatic objectives
  - lessons learned to assist other weapon system programs in the successful evolution to a more operationally realistic test and evaluation program

Tactical Tomahawk Block IV

- **The Tactical Tomahawk Block IV missile provides increased capabilities with the introduction of a new communications system, using a two-way ultra-high frequency (UHF) satellite data link:**
  - **In-flight redirection**
  - **Missile health and status feedback**

Ref: Jane's Online (Defence Equipment and Technology Intelligence Centre)

Overview of Operational Test Launch (OTL) Program

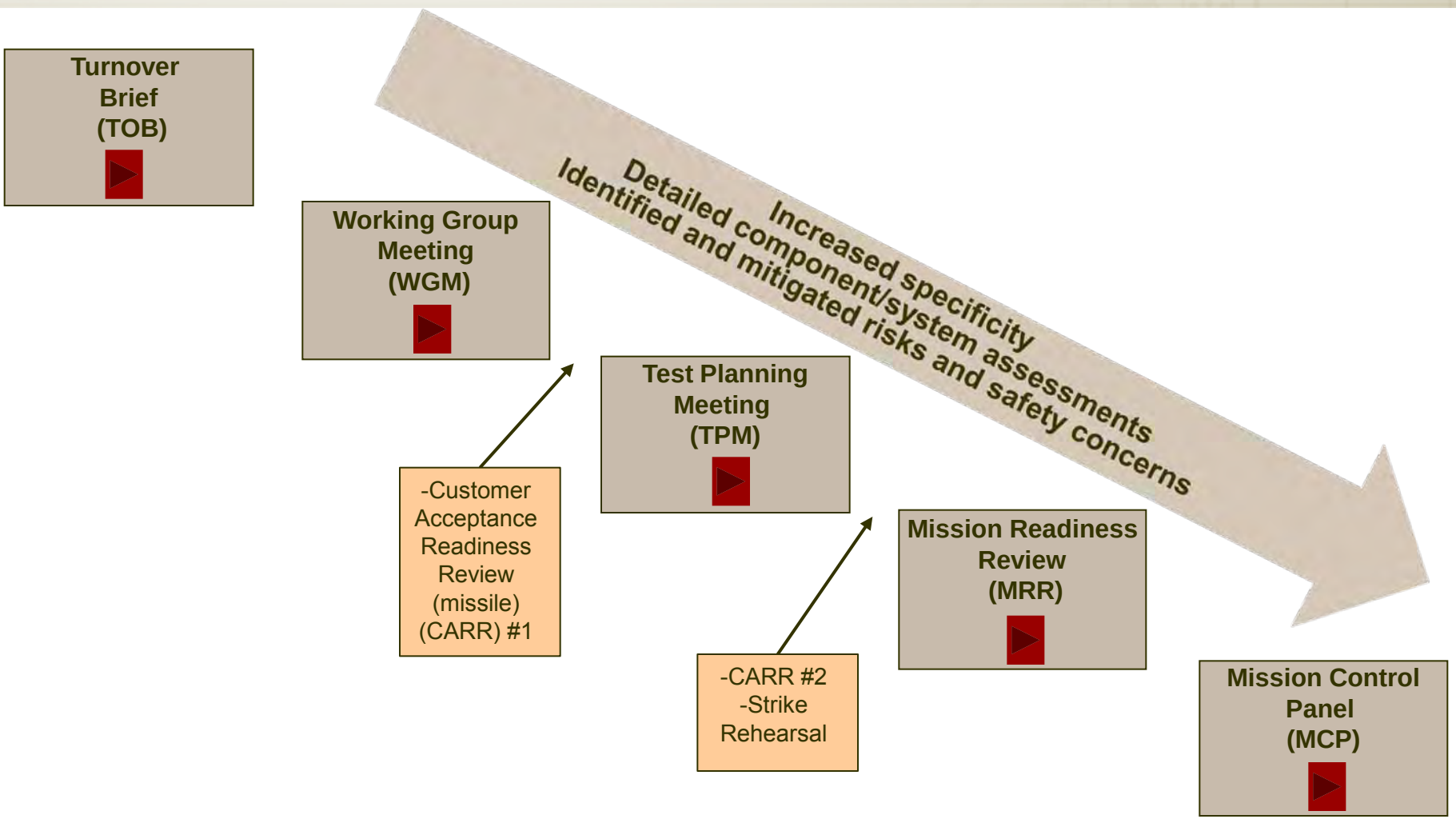
- The OTL Program is a follow-on test and evaluation (FOT&E) program established by the Chief of Naval Operations (CNO)
- A robust test planning and execution process is employed to assess the readiness and effectiveness of the TWS through several annual launches of fleet-representative weapons

OTL Planning Process

- Flight test planning begins with the Turnover Brief (TOB), during which test interfaces and preliminary objectives are identified and utilized to establish the initial mission architecture
- Additional planning meetings address mission generation and test weapon preparation, solidify test objectives, and assess test team readiness to conduct the OTL
- Flight test planning is completed upon receipt of Flag-level approval for the conduct of the test launch at the Mission Control Panel (MCP)

Ref: "Tomahawk Flight Test and Evaluation Directive," PEO(U&W) Inst 3960, 02 November 2009

OTL Planning Process Details



Evolution of Methodology

- Numerous enhancements in command and control (C2) planning, communications, and strike execution have been introduced while preparing for and conducting recent OTLs to more accurately reflect existing user operating procedures

- Lessons learned in these three areas have identified specific steps to continue promoting the evolution of the OTL program toward more operationally realistic test and evaluation

Command and Control (C2) Planning

Previous Approach	Enhancements
• Cruise Missile Support Activities (CMSAs) plan all OTL missions	**•Fleet mission planners used for OTL mission planning, when feasible**
• Mission planning worksheet generated by test team and provided to planning organization to direct mission creation	• Target Information Package (TIP) provided by representatives of Commander, Operational Test and Evaluation Force (COTF) to initiate mission •Missions planned via Mission Planning Requests
• Strike execution test plans developed by the Johns Hopkins University Applied Physics Laboratory (JHU/APL) to provide test-specific scripting to all participants	**• Strike Organization (STKORG) develops and adheres to Pre-Exercise (Pre-Ex) message for test conduct, utilizing Standard Operating Procedures (SOPs)**
• Preplanned mission and/or retarget route(s) employed	• Real-time mission and retarget route generated, when feasible

Communications

Previous Approach	Enhancements
• Consistent use of the same satellite footprint for the communications network	• Variety of satellite footprints used for the communications network, when feasible
• Active participation by test team in conducting pre-test communications checks	**• Test team participants monitor STKORG conduct of pre-test communications checks**
• Test team and STKORG communicate in a single Secure Internet Protocol Router (SIPR) chat room during test conduct, with test team interacting through chat “whispers”	• Multiple SIPR chat rooms established during test conduct to reduce test team interference in STKORG activities
• Test team representatives relied upon to troubleshoot and resolve issues with weapon system configuration settings	**• Test team representatives assist STKORG only if successful OTL execution is threatened**

Strike Execution

Previous Approach	Enhancements
• **Strategic C2 represented in STKORG**	• **Operational C2 reflected in STKORG, through use of simulated Maritime Operations Centers (MOCs), as feasible**
• Strike Folder created by test team and provided to Tasking Authority (TA) with additional test-specific system employment guidance	• Strike Folder created by TA strike team in accordance with SOP
• Electronic Strike Package (ESP) with test team provided parameters, created by TA and reviewed by test team representatives before distribution	• ESP created by TA, with minimal input from and/or review by test team, prior to distribution
• **Hardware-in-the-Loop (HWIL) device operated by test team during Strike Rehearsal**	• **STKORG utilizes a resident Strike Rehearsal Tool to lead Strike Rehearsal**

Lessons Learned

- As the OTL program transitions toward a more operationally realistic test and evaluation program, several lessons learned have been documented which relate to:

  - C2 Planning
  - Communications
  - Strike Execution

C2 Planning

- User C2 operational concepts should be included in test events to fulfill user needs and to promote increased operational realism
- C2 planning should be conducted under operational timeline and constraints
- User participants should be involved early on in the C2 planning for test events

Communications

- STKORG participants should utilize pre-defined and/or widely utilized procedures and diagnostic tools to evaluate communications status
- Firing Units should ascertain communications status prior to getting underway
- User communications requirements should be clarified prior to test events and distributed via standard operational methods

Strike Execution

- STKORG participants should review SOPs for the applicable area of responsibility (AOR) for test events
- STKORG participants should review applicable weapon system documentation (i.e., technical notes, technical bulletins, users guides, etc.) in preparation for test events
- Ample weapon system training should be provided when turnover of Fleet personnel occurs

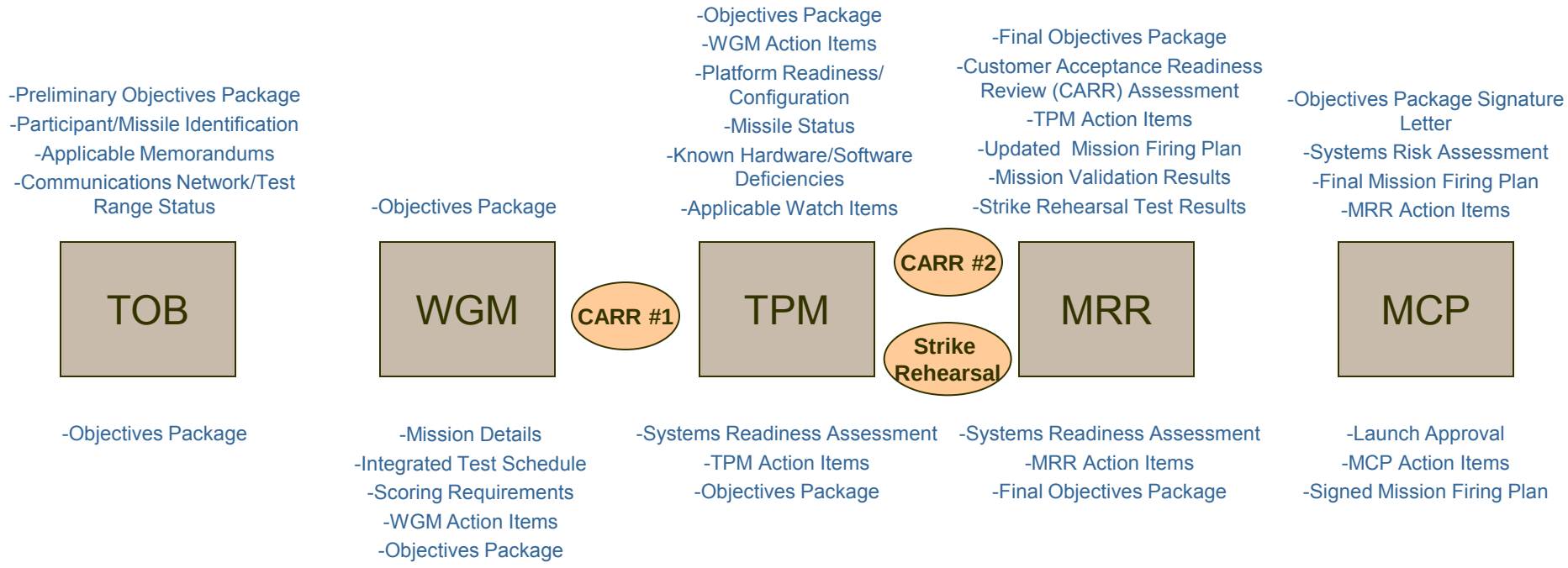
Summary

- By evaluating potential weapon system employment scenarios identified by users in CNO-directed FOT&E, the Tomahawk Weapon System OTL program has evolved toward a more operationally representative test and evaluation program
- Collaboration between PMA-280 and users has validated novel TTPs, improved weapon system utility, and expanded war-fighter capability
- Lessons learned from recent changes in OTL planning, communications, and strike execution can be adopted by other weapon system programs to promote a more operationally realistic test and evaluation program

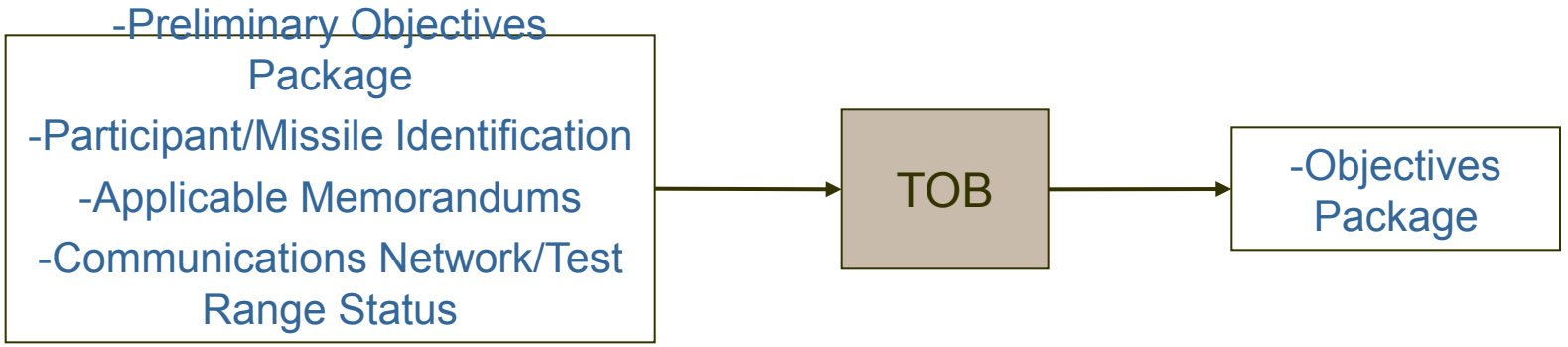
Questions?

Backup Slides

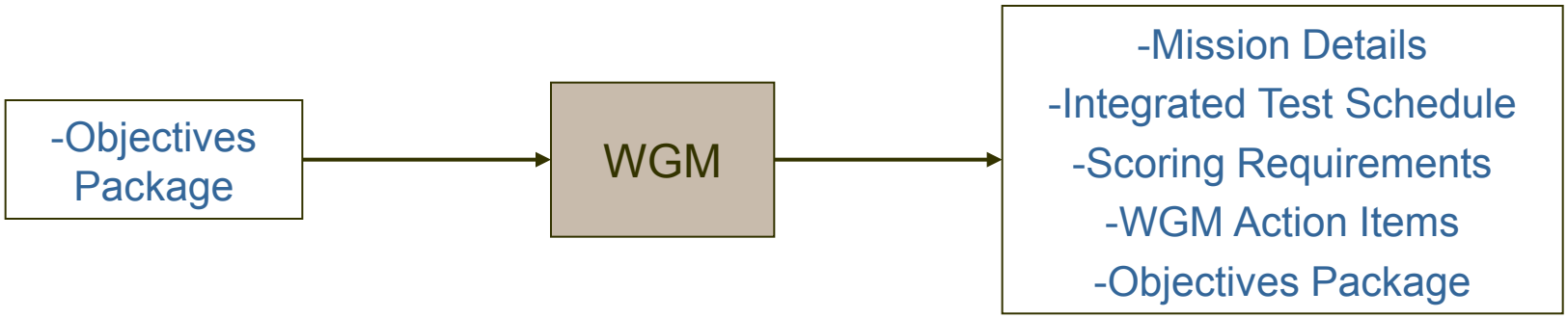
Flight Test Planning with Products



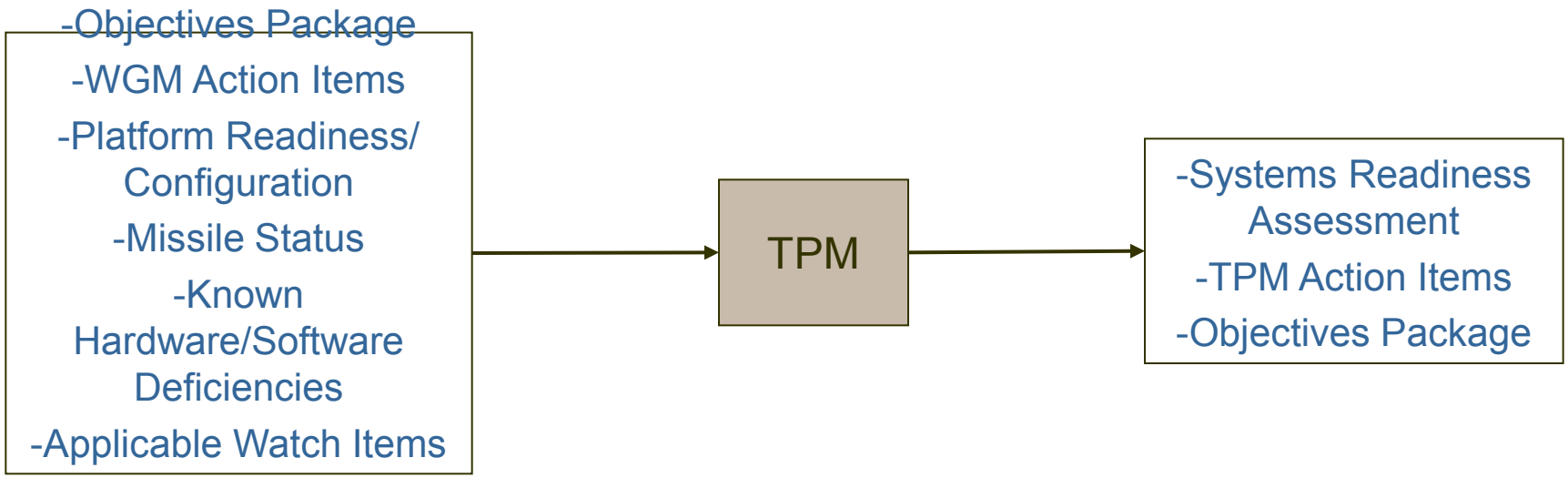
Turnover Brief Products



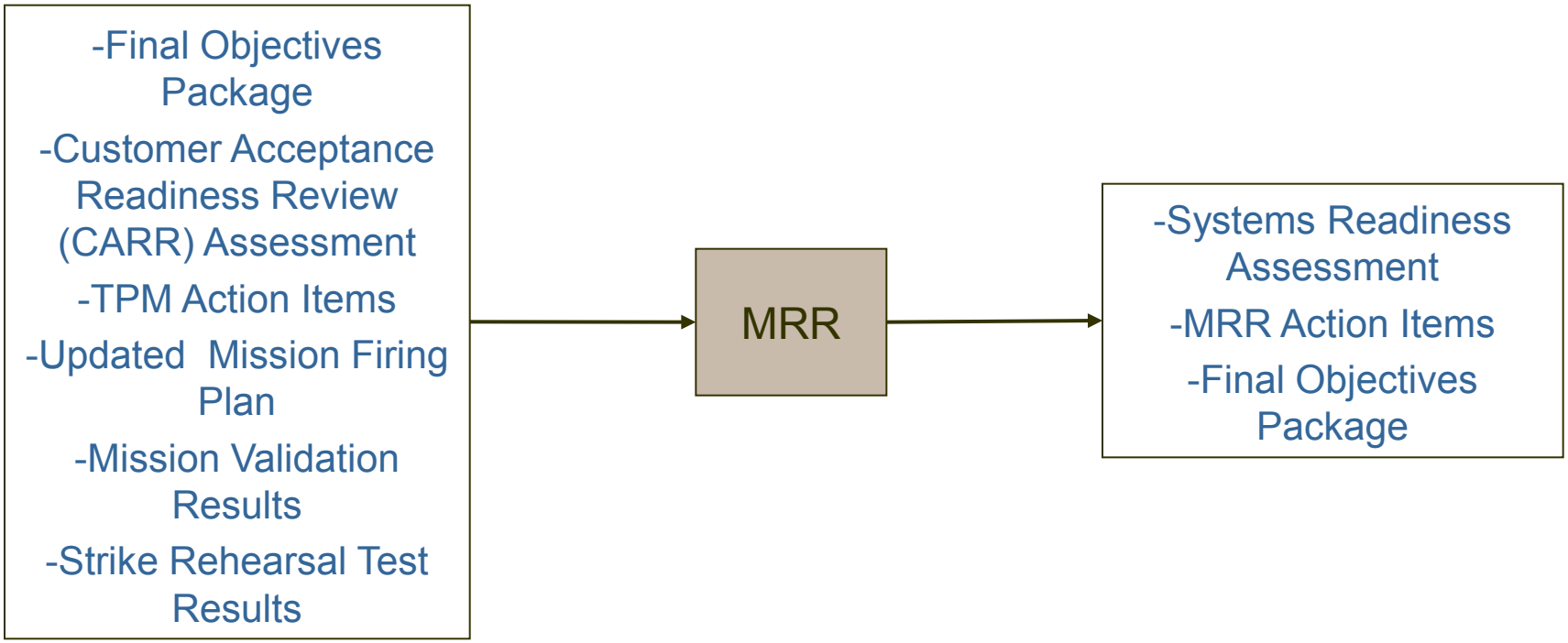
Working Group Meeting Products



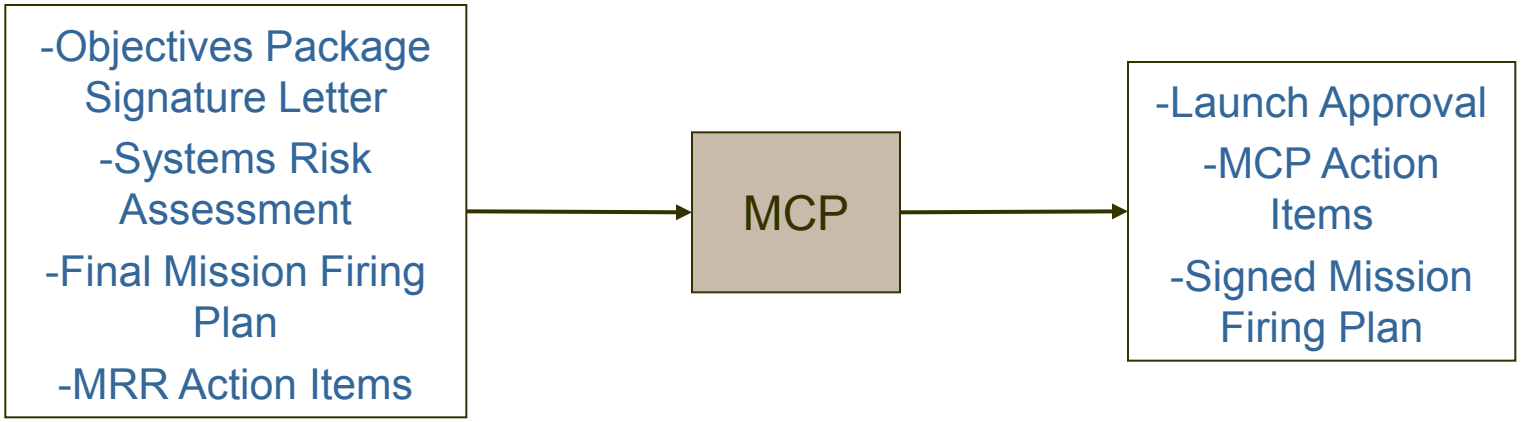
Test Planning Meeting Products



Mission Readiness Review Products



Mission Control Panel Products



JOHNS HOPKINS
UNIVERSITY

Applied Physics Laboratory

TRANSFORMATIONAL TIMES

"Driving Operational Solutions"

Test and Evaluation (T&E) Methodology for Business Systems

27 October 2010

Dr. Aaron Drew
Senior Systems Engineer

How it all Started…

- **Two Documents**
  - **DBSAE T&E White Paper**
  - **Integrated Test and Evaluation Methodology for Business Systems**
- **The documents posed questions about the testing of business systems opposed to weapon systems**

Testing Challenges

- **Tools**
  - Effectively Manage Data
  - Automate Test Tools
  - Use Checklists and Templates
- **Time**
  - Conduct event (not time) based T&E
  - Integrate Testing and Development
- **Talent**
  - Address risk with “Risk Leadership”
  - Adjust strategies based on COTS and custom development
- **Transition**
  - *Deliver* capability to the warfighter
- **Tradition**
  - Overcome rigid and inflexible approaches to testing

Integrated Business Testing Requires Transformation!

Transforming Testing!!!

Improve Product Quality and Predictability

- Focus on Single Programs (not Enterprise)
- Test Activities Often Duplicated
- Lack of Common Test Tools
- Lack of Focus Early in the Program
- Business IT Tested Like Weapon Systems
- Decision Makers Lack Early Indicators

- Establish Centralized Testing Environments
- Merge Development & Ops Testing
- Reuse of Tools and Test Events
- Integrate Teams Prior to Development
- Create Business IT Testing Processes
- Early Visibility Improves ROI

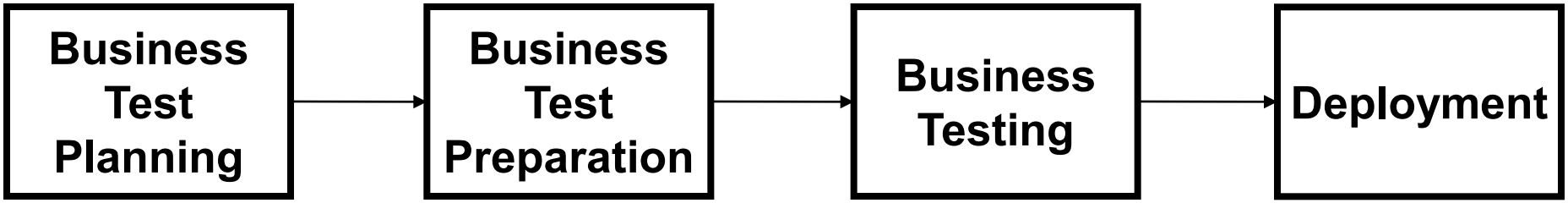
Goal: Greater insight throughout the program lifecycle!

5 T&E Approaches

- **Testing as a Service (TaaS)**
- **Signed DOT&E Letter**
- **Integrated Testing Team (ITT Charter)**
- **Shared Resources, specifically a T&E expert**
- **Smaller iterative testing and releases**

Business Testing Methodology

Business Testing Overview



Purpose:

- Establish a business testing framework to guide test and evaluation in PMOs
- Identify requirements and key stakeholders, assess testability of requirements. Establish test cases, schedule, funding, and key documents. Assess system risk and minimize testing within mature components (e.g. COTS).
- Activate discrepancy reporting processes, evaluate training materials, and establish test environment
- Conduct testing, identify discrepancies, evaluate
- Transition capability to operations

Testing as a Service

Overview

- Programs currently required to pay high upfront costs when acquiring T&E capabilities, this limits their adoption, restricts information sharing, and creates islands of unused capabilities
- Establishing a “Test as a Service” option provides programs an opportunity to lease an established capability, share costs and best practices, and maximize utilization of the tools

Bottom Line Upfront

- Cost estimates for licensing and hosting shows savings for small programs using TaaS:
  - Performance: Savings of ~$211K – 50% over 5 years
  - Test management: Savings of ~$94K – 55% over 5 years
- TaaS cost structure rewards advance planning
- Centralization of T&E management provides greater opportunities to influence T&E processes
- Policy obstacles are:
  - JITC cost re-imbursement structure and limitations of RDT&E funding
  - Absence of a standard, pre-approved Memorandum of Agreement based on established rates

Reduces Cost to Small Programs

- **Performance testing**
  - Licensing and hosting for a basic (HP) test package (ability to generate/monitor 1K VUs) for 5 years
  - Current (program restricted) approach:
    $418K + functional expertise
  - TaaS (enterprise focused) approach:
    5 years x 6 months / year x $12K /month =
    $206K + functional expertise
- **Test Management Support**
  - Licensing and hosting for a basic (HP) test package (ability to generate/monitor 1K VUs) for 5 years
  - Current (program restricted) approach:
    $166K
  - TaaS (enterprise focused) approach:
    $72K

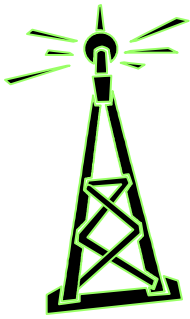
Programs Enabled to Purchase Only the Capabilities They Need - Effective Planning Minimizes Program Costs

Increases JITC Influence

- **JITC becomes better positioned to become a (the) business test authority**
  - Increased visibility across multiple programs
  - Economical offerings pull programs towards JITC
- **JITC can promote standardization of Test & Evaluation activities with creation and administration of templates and reports**

ITT Charter

Starting Integrated Testing (by Program)



- **Form the ITT**
  - **Establish a Charter based on Standard Template**
  - **ITT planning**
  - **Define the T&E Strategy that addresses a Business System Model**
  - **Participate in the Design Process to ensure a Testable Outcome**
  - **Participate in the RFI/RFQ and follow-on competitive planning processes to ensure testing considerations are included**
  - **Identify and communicate Risks to the Risk Management Team**
  - **Participate in drafting the Tailored Information Support Plan**

Sections

- **Mission**
- **References**
- **Purpose**
- **Membership (Program & JITC)**
- **Responsibilities**
- **Deliverables**
- **Meetings**
- **Duration**

Shared T&E Resource

Business Systems ≠ Weapon Systems

Business "IT" Acquisition Speed bumps

DOT&E Letter

DOT&E Letter

OFFICE OF THE SECRETARY OF DEFENSE
1700 DEFENSE PENTAGON
WASHINGTON, DC 20301-1700

OPERATIONAL TEST AND EVALUATION

SEP 14 2010

MEMORANDUM FOR DEPUTY UNDER SECRETARY OF THE ARMY, TEST & EVALUATION COMMAND
DEPUTY, DEPARTMENT OF THE NAVY TEST & EVALUATION EXECUTIVE
DIRECTOR, TEST & EVALUATION HEADQUARTERS, U.S. AIR FORCE
TEST AND EVALUATION EXECUTIVE, DEFENSE INFORMATION SYSTEMS AGENCY
COMMANDER, ARMY TEST AND EVALUATION COMMAND
COMMANDER, OPERATIONAL TEST AND EVALUATION FORCE
COMMANDER, AIR FORCE OPERATIONAL TEST AND EVALUATION CENTER
DIRECTOR, MARINE CORPS OPERATIONAL TEST AND EVALUATION ACTIVITY
COMMANDER, JOINT INTEROPERABILITY TEST COMMAND

SUBJECT: Guidelines for Operational Test and Evaluation of Information and Business Systems

To support agile acquisition of Information and Business Systems, the attached guidelines may be substituted in place of the traditional operational test and evaluation approach described in DoD Instruction 5000.02 of December 8, 2008, *Operation of the Defense Acquisition System*.

It is expected a large portion of the test strategy for Information and Business Systems will utilize an integrated test approach. The degree of independent operational testing appropriate for each software increment or capability can be tailored by using the risk analysis described in the attached guidelines. The guidelines also permit delegation of test plan approval using the same criteria. These guidelines do not apply to weapons systems or strategic and tactical command and control systems.

Signed September 14, 2010

Synopsis

- **Business Systems and Weapon Systems are separate**
- **A risk analysis is conducted by the lead OTA**
  - This determines the degree of risk and impact on the mission accomplishment.
  - The risk assessment looks at the impact of a capability failing to be operationally effective, suitable, and survivable/secure.
  - There are 4 categories the risk analysis will address.
    - Technology and Software Development, Integration &Deployment, Training, Utilization & Management, and IA
- **There three levels of Operational Assessment**

Iterative Testing and Releases

Examples

- **P2P Portal**
- **Performance Data Automation (PDA)**
  - **As driven by the metrics in the SMP**
- **Enterprise Information Web (EIW)**
  - **PoDs released every 60-90 days.**

Testing for Business Systems

Early Planning -- The way ahead to establishing integrated T&E

- **Design Integrated T&E Models based on Risk**
  - **Account for risk in an applied framework**
  - **System maturity influences testing activities**
  - **Risk leadership requires accepting appropriate risk**
- **Develop an inclusiveness across the four disciplines of T&E**
  - **Developmental Testing, Information Assurance, Interoperability, Operational Testing working cooperatively vice independently**
- **Establish an Integrated Test Team (ITT) early**
  - **Membership extends beyond testing disciplines**
  - **Includes functional proponent and the program office**

Questions

Dr. Aaron J. Drew
Senior Systems Engineer
Defense Business System Acquisition Executive
Business Transformation Agency

Aaron.Drew@bta.mil
571-481-8403

NORTHROP GRUMMAN

GUARDING THE INTENT OF THE REQUIREMENT

13th Annual Systems Engineering Conference
Hyatt Regency Mission Bay San Diego
October 25-28, 2010

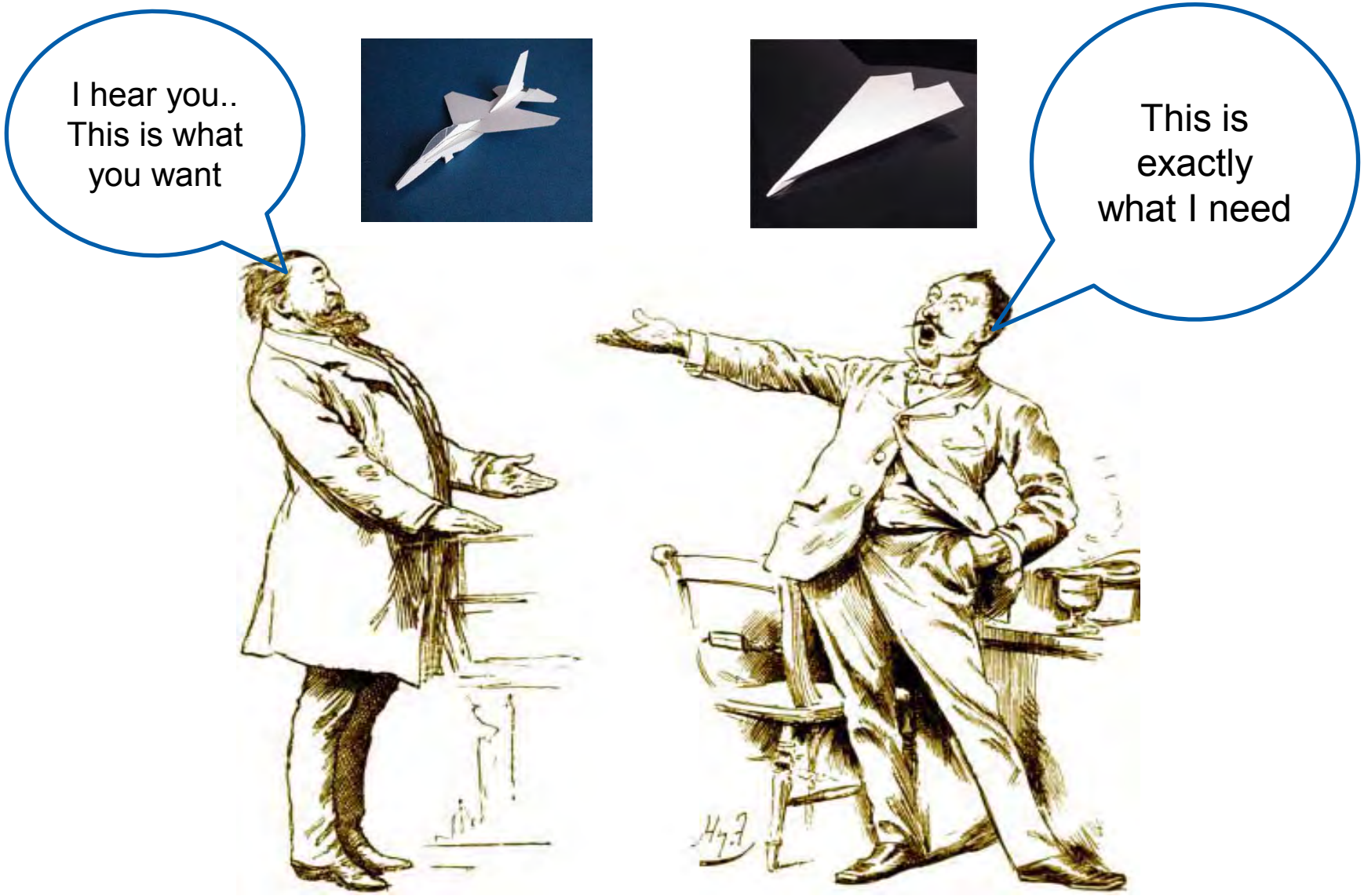
Stephen J Scukanec
Flight Test and Evaluation
Aerospace Systems
Northrop Grumman Corporation

Eric N Kaplan
Mgr. Projects and Processes
Flight Test and Evaluation
Aerospace Systems
Northrop Grumman Corporation

Cleared For Public Release 10-1223

The Challenge – Avoid Creating a product Which Neglects the Warfighter's Needs

NORTHROP GRUMMAN



Cleared For Public Release 10-1223

Establishing the Intent

NORTHROP GRUMMAN

JCIDS

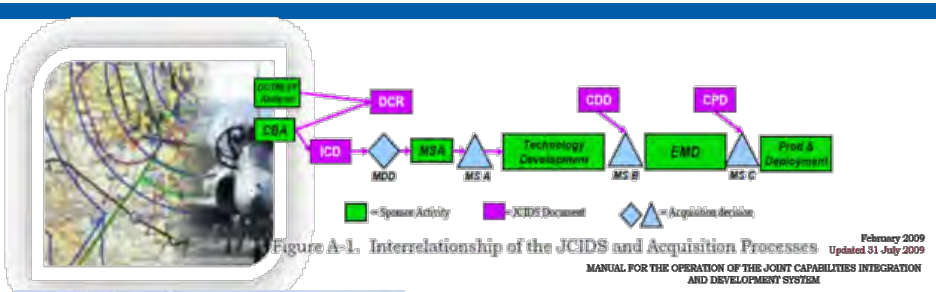
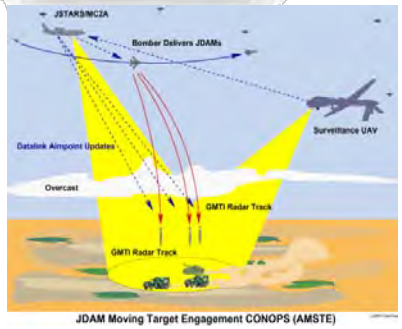


Figure A-1. Interrelationship of the JCIDS and Acquisition Processes

February 2009
Updated 31 July 2009

MANUAL FOR THE OPERATION OF THE JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM

CONOPS

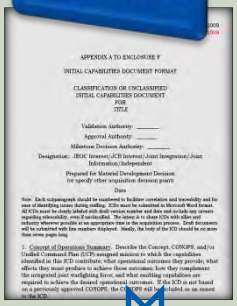


JDAM Moving Target Engagement CONOPS (AMSTE)

Mission needs result from assessments of current and projected capability requirements. Mission needs may establish a new operational capability, improve an existing capability, or exploit an opportunity to reduce costs or enhance performance. MIL-HDBK-245D

Rqmts

ICD

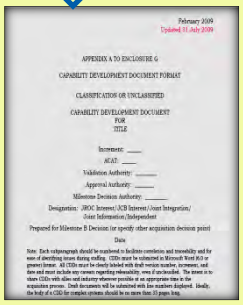


Test

TES

Test & Evaluation Strategy *(TES) is an early Test and Evaluation (T&E) planning document that describes the T&E activities starting with Technology Development and continuing through EMD into Production and Deployment.*

CDD



TEMP

Test and Evaluation Master Plan
The TEMP documents the overall structure and objectives of the Test and Evaluation (T&E) program. ….The TEMP identifies the necessary Developmental Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E), and Live Fire Test and Evaluation (LFT&E) activities.

This Is What is Needed

Template - ICD - JCIDS Manual - 31 July 2009.docx

https://acc.dau.mil/CommunityBrowser.aspx?id=29065

Cleared For Public Release 10-1223

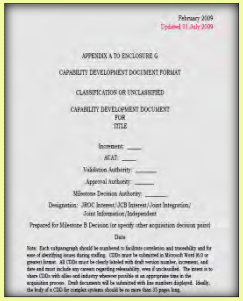
Flowing the Intent

NORTHROP GRUMMAN

Rqmts

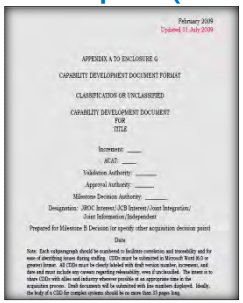
- **Capabilities**
  - Performance / Function / Interface
  - KPPs
- **Design Requirements**
  - Translation of the capabilities to Design Requirements
- **Formal Proof**
  - Agreed to Verification Activities

CDD



TEMP

System Spec (Contr)



Verification Plan

Integrated Test Program

Test

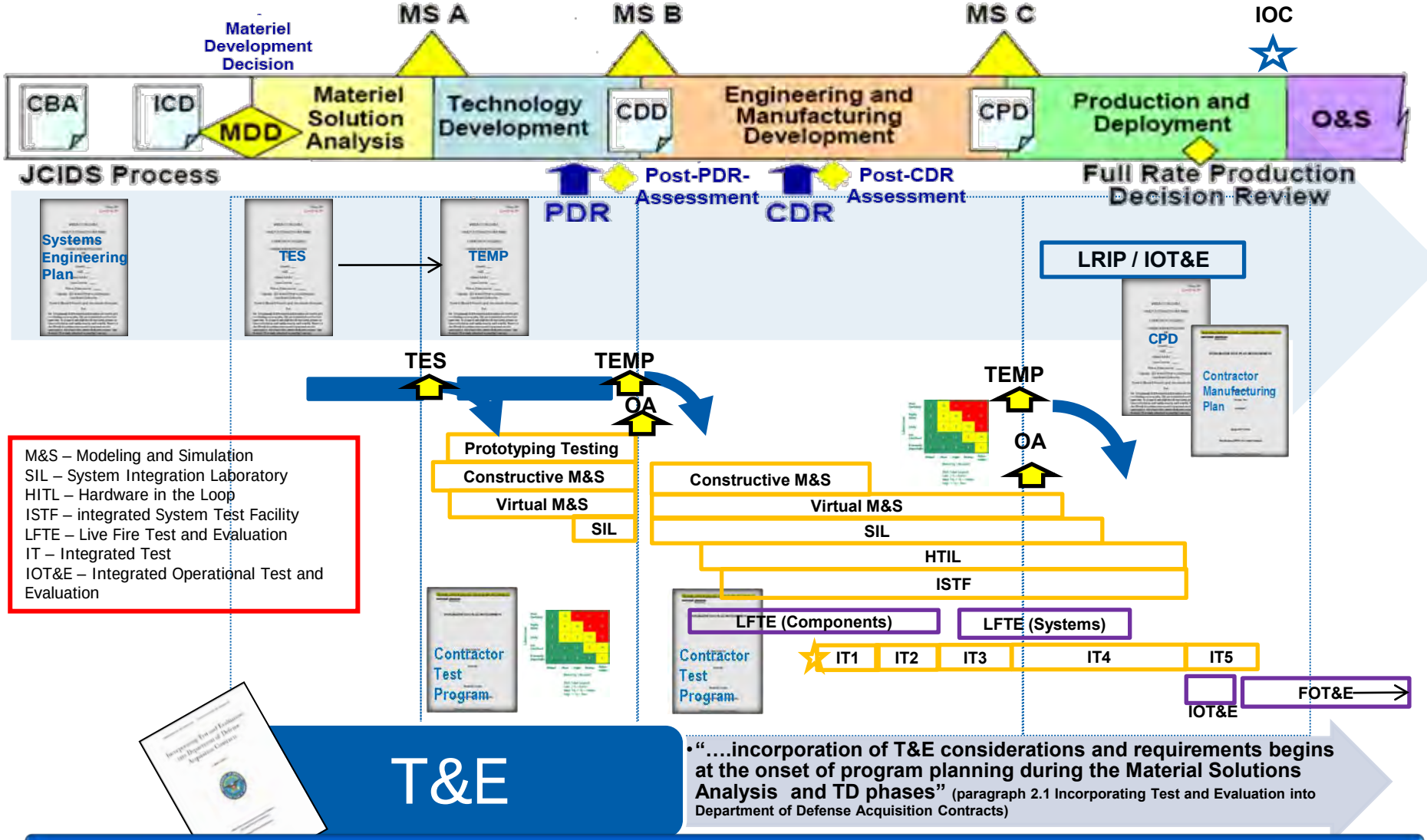
- **Integrated Test Program and Strategy**
  - Total Test Approach, Environment, Needs
- **Documented Coordinated Contractor Test Program**
  - Definition of the Test Program (Formal and Informal) Activities Through Product Development

A Testing Program Aligned to the Intent of the Warfighter Needs

Cleared For Public Release 10-1223

Guarding the Intent - A Lifecycle Look

NORTHROP GRUMMAN

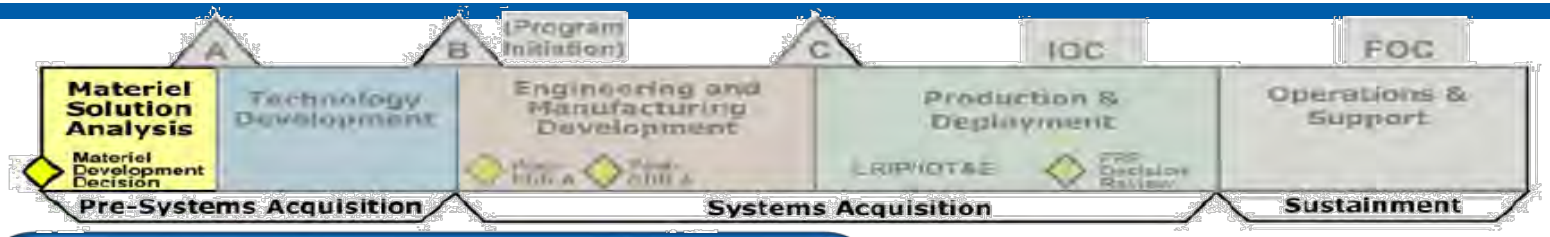


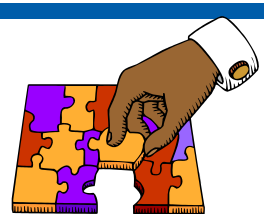
Intent must be maintained throughout the programs lifecycle to ensure warfighter need is provided

Cleared For Public Release 10-1223

Pre-Milestone A Pitfalls & Solutions

NORTHROP GRUMMAN





A lack of clear communication between those setting requirements and those in the acquisition process turning requirements into acquisition plans and contract specifications.

HOUSE ARMED SERVICES COMMITTEE PANEL ON DEFENSE ACQUISITION REFORM *FINDINGS AND RECOMMENDATIONS* March 23, 2010

"The Act [WSARA 2009] recognizes that 'unrealistic performance expectations' and 'immature technologies' are among the root causes of trouble in defense programs,"

DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

"… early stages of an acquisition program are in many ways the most critical. It is in the early stages that investments must be made in systems engineering, in acquiring technical data rights to support competition and system sustainment, and in robust developmental testing"

HOUSE ARMED SERVICES COMMITTEE PANEL ON DEFENSE ACQUISITION REFORM *FINDINGS AND RECOMMENDATIONS* March 23, 2010

Solutions

Fund The Program Correctly
Establish A robust Systems Engineering Community
Government / Industry Working Groups
Technical Reviews
Coordinated Capabilities– ICD
Contract Language Supporting Integrated Testing
TES – Test Strategy

5000.02

"The test and evaluation community can, during the requirements-setting process, identify such potential problems early in the life of programs."

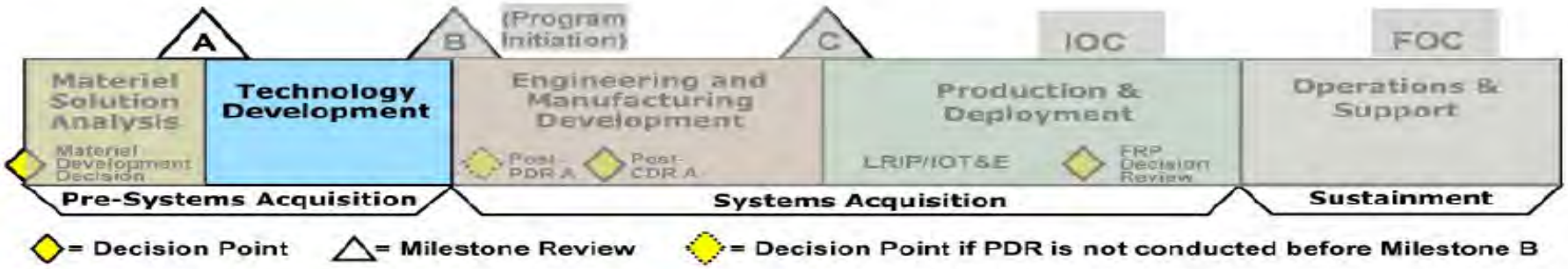
DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

Starting a program right is essential to program success

Cleared For Public Release 10-1223

Technology Development Phase Pitfalls & Solutions

NORTHROP GRUMMAN



'….and 'immature technologies' are among the root causes of trouble in defense programs'

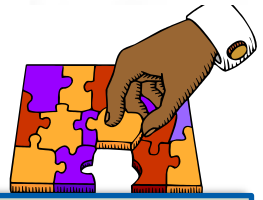
DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

Technology Development and Risk Assessment lacks Connectivity to Operational Mission "immature technologies" entering EMD

Former DOT&E Director Charles McQueary Feb 2008 NDIA

5000.02

Solutions



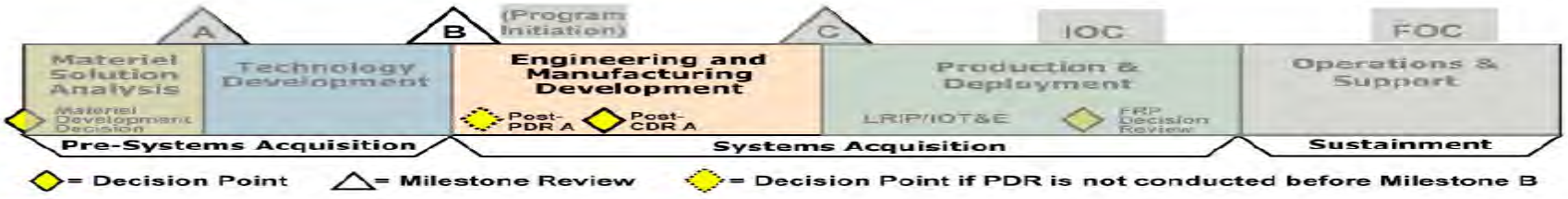
- **A sound Technology Development Plan (TRL Maturation)**
- **A coordination between the TES and TEMP**
- **A capability Development Document that details the operational performance parameters for the anticipated system**
- **Test Planning establish Integrated Test Plans accounting for Risk Related Activities**
- **Implement Integrated Test Concept WIPT / CTF**

Technology Development must be performed within the intended operational environment

Cleared For Public Release 10-1223

Engineering and Manufacturing Development- Pitfalls & Solutions

NORTHROP GRUMMAN



Requirements Creep - preclude destabilizing requirements changes 5000.02 Dec 08

PROCESS Charles "Pete" Adolph NDIA May 2010

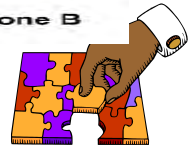
" What is important to the user is strengths and weaknesses, capabilities and limitations, not specification compliance."

Section 231 Report to Congress Core T&E Principles - 2007

Verify technical design throughout normal operating envelope ASAP Fly Before You Buy

PROCESS Charles "Pete" Adolph NDIA May 2010

Solutions



- Early and effective employment of systems engineering, applied in accordance with a well-structured Systems Engineering Plan.
  - Technical reviews that align capabilities to specifications
  - Identify potential management risks and issues in a timely manner.
- Configuration Steering Boards used to avoid requirements creep
- Integrate DT and OT test activities
- Evaluations shall include a comparison with current mission capabilities
- Use of WIPT / CTF concept ensuring Alignment of Government and Contractor Test Plans
- Contractors Development of a Modeled Executable Test Program that demonstrates excitability and accounts for the operational environment
- Coordinated data Sets to support OA's

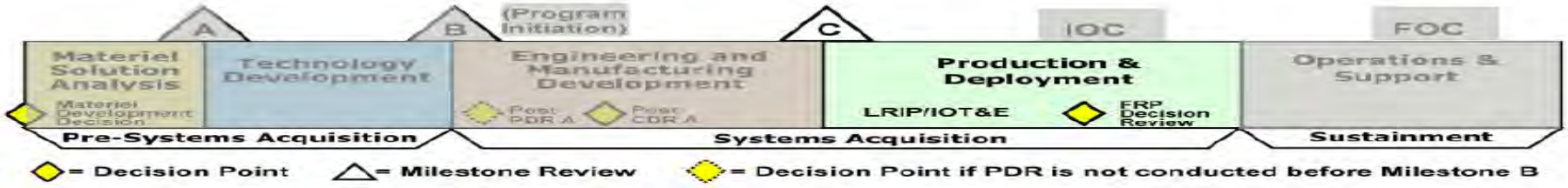
Integrated Testing

Avoid Mindless Specification Verification / Test as you will Fly
Share the Data

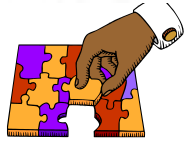
Cleared For Public Release 10-1223

Production and Deployment Pitfalls & Solutions

NORTHROP GRUMMAN



Solutions



Requirements Creep - preclude destabilizing requirements changes 5000.02 Dec 08

PROCESS Charles "Pete" Adolph NDIA May 2010

Incomplete OA Assessments Prior to Authorization to LRIP / Production

Former DOT&E Director Charles McQueary Feb 2008 NDIA

- Updated TEMP and Comprehensive Capabilities Product Document (CPD)
- Contractor Production Plan consistent with CPD
- ATP's test with proper environment where applicable
- Implement Block update acquisition policy "Evolutionary Acquisition"

5000.02

Build what you Intended – No More – No Less

Cleared For Public Release 10-1223

Lessons Learned

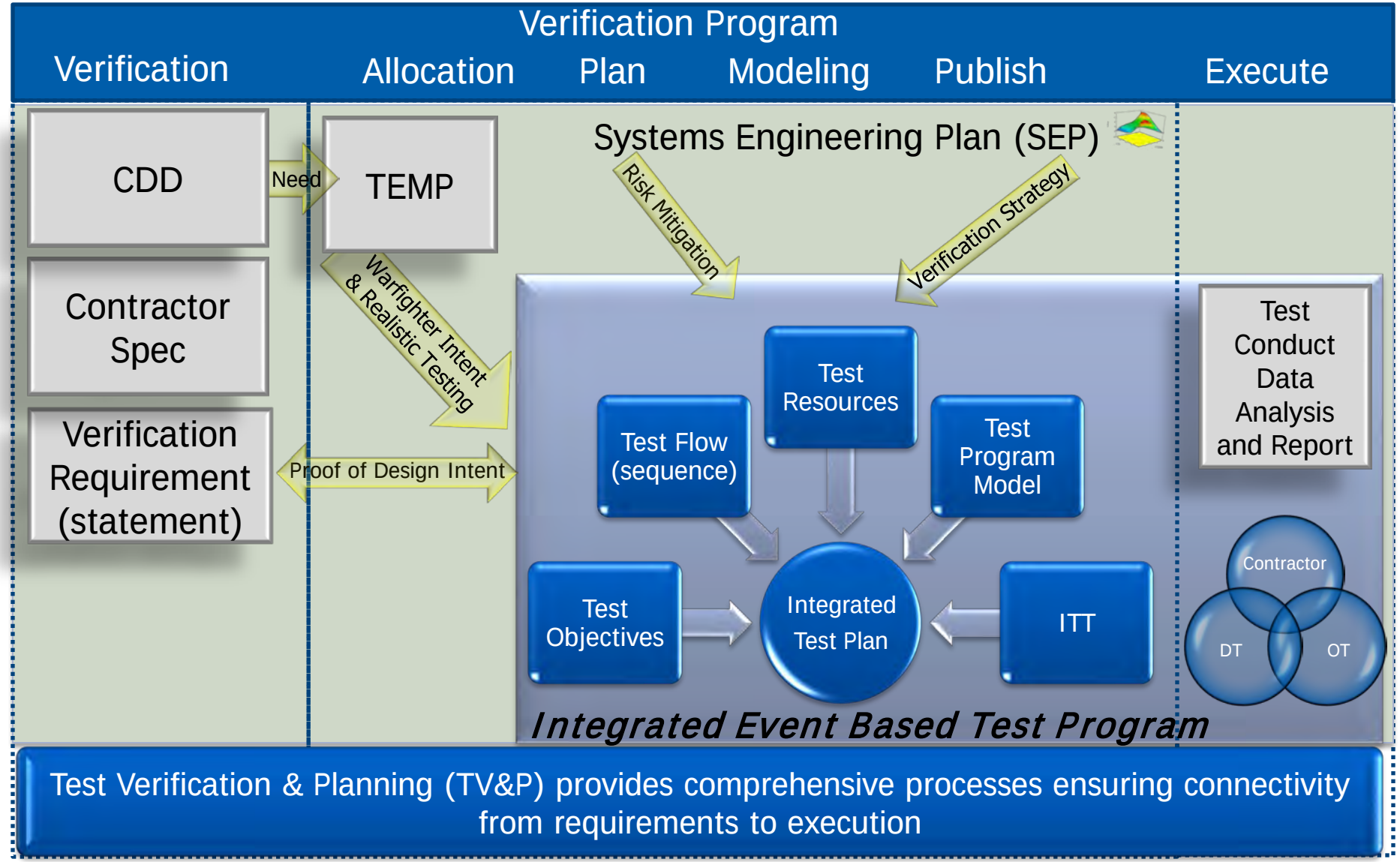
NORTHROP GRUMMAN

Program Problem	Issue	Fix
Incomplete and Ambiguous Requirements	Lack of Early Program Skill Mix inside SEIT prevented complete requirements Set Definition	Introduce and Program for Complete SEIT Skill including Specialty Engineering and Test and Evaluation Personnel Establish Early Verification Program
Risk program not aligned with realistic operational environments	Technology development inconsistent with needs	Test Plan Integrated with SEP established Risk program waterfalls, planned early Contractor Test Program Integrated with TES and TEMP
Test Plan Intent not used during EMD	Test Plan not maintained throughout the EMD test program	Collaborative Test Plan Model Maintained throughout the Program Lifecycle (SE Model Tools Used to support Collaboration and Modeling) Contractor Test Plan Aligned with Requirements Verification and TEMP though SE traceability tool set
Data Rights Not Negotiated	Prevents OA using early test data	Good Contract Language and Propriety Information Agreements Established Early in a Program

Maintaining the Original Intent Delivers the Right Product to the Warfighter

Cleared For Public Release 10-1223

Test Verification and Planning Overview



Cleared For Public Release 10-1223

Test Verification and Planning Guarding the Intent
A Contractor's Look at A Hybrid Solution

NORTHROP GRUMMAN

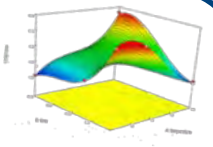
CDD, Requirements, TES TEMP, Risk Plan, Product Architecture, SEP, Program Management Plan

Test Verification &Planning

Integrated Test Team, Verification Requirements, Test Unique Requirements, Test Planning, Test Plan Modeling and Schedules, Architectural Refinement

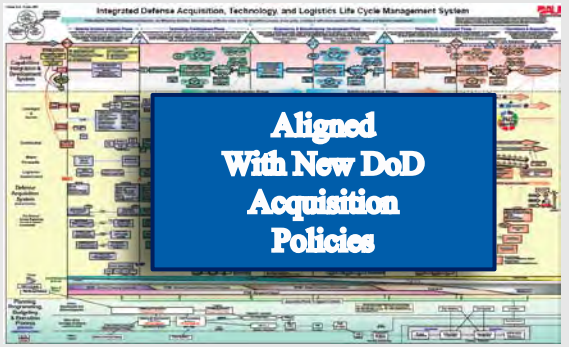
Team Products

- **Test Plan Strategy Developed and aligned with the TES and TEMP**
- **Test Strategy Coordinated and Optimized with ITT**
- **Major Range Coordination / Long Lead Planning Requirements Established**
- **Integrated T&E Strategy and Approach Addressing the Total Program Lifecycle**
- **Event Driven, Measurable Modeled Test Approach Logically Sequenced and Optimized**
- **Operationally Realistic Environments and Measurements Defined**
- **Verifiable Requirements with Established Completion Criteria**
- **Unique Test Requirements Needed to Complete the System Design Requirement Set**
- **Integrated Test Plan aligned with Program Risk Plan**



Program Values

- **Early Test Plans and Facilities Definitions.**
- **Requirements Based on Tested Architecture**
- **Streamlined Testable Architecture**
- **Event Based Test Schedule Developed**
- **Integrated Risk Program**
- **Scientific and Statistical methods applied to Test Plan**
- **Verifiable Requirements &Verification Statements Developed**
- **Test Unique Design Requirements Developed.**
- **Embedded Operational Realism in Test Program**
- **Support to Operational Sustainment Assessment As Required**



TV&P Ensure Intent is Captured in the Verification Program

Cleared For Public Release 10-1223

Conclusions:

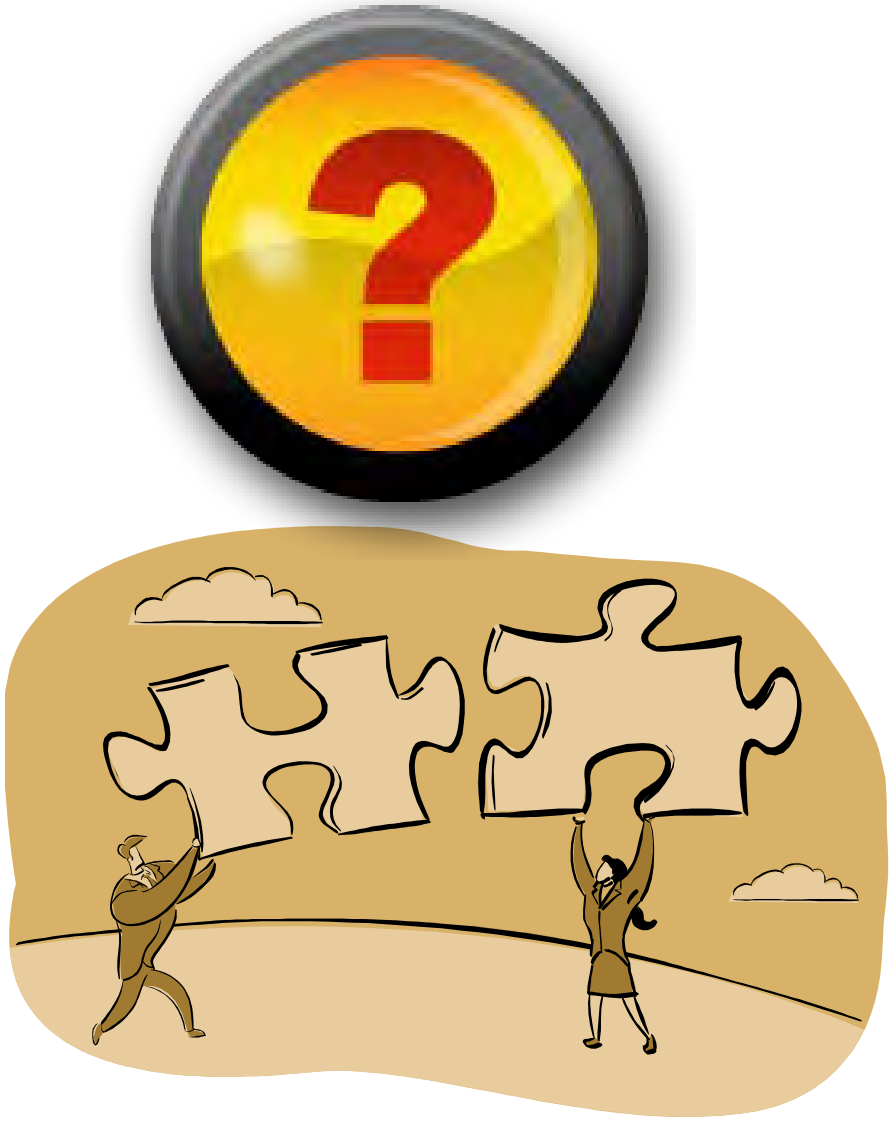
NORTHROP GRUMMAN

- Maintaining the original intent of the product is mandatory for the warfighter's success.
- Intent is sourced from multiple places
  - Mission Statement, TES , TEMP, OPSCON / CDD
- Avoid the temptation to complete requirements verification to the “Letter of the Spec”
  - The Product’s Operational Performance is the Warfighter’s Need.
- Tools and processes exist today to help avoid these pitfalls.
  - Modeled Test Plan
  - Modeled Tests
  - Coordinated Working Groups
  - Data Plan supporting a Program’s Lifecycle including early will help offset total program costs
- Too many programs are only driven by cost and schedule at the expense of performance
  - PMs must embrace the idea of Integrated Testing
  - Ensure Programs start with the proper skill mix

Attention to the intent must be maintained throughout the program’s lifecycle

Cleared For Public Release 10-1223

Questions



Cleared For Public Release 10-1223

Contact Information

Steve Scukanec
"The Test Guy"
Flight Test and Evaluation
Aerospace Systems
Northrop Grumman Corporation
Stephen.Scukanec@NGC.com
310-350-3156

Eric N Kaplan
Mgr. Projects and Processes
Flight Test and Evaluation
Aerospace Systems
Northrop Grumman Corporation
Eric.Kaplan@NGC.Com
310-505-2901

Cleared For Public Release 10-1223

Joint Mission Environment Test Capability (JMETC): Effective T&E by Improving Distributive Test Capabilities

Ryan Norman

Deputy Program Manager – Systems Engineering

Ryan.Norman@osd.mil

October 27, 2010

DoD Acquisition Today

- Systems, Systems of Systems, and Families of Systems are all designed, developed, and assembled disparately
  - Result: “Good” Integration and T&E are exponentially more difficult
  - System Evaluation is holistic under Joint Capabilities Integration Development System (JCIDS)
  - Coincidentally, acquisition programs run over budget
- Weapon Systems Acquisition Reform Act of 2009
  - Creation of Developmental T&E (DT&E) and Systems Engineering (SE) organizations
  - Competitive Prototyping Required
  - Feedback needed early in the development process to ensure that capability-based requirements are met

Distributed testing is essential for creating cheaper, faster, and more rigorous test environments that reduce program risk

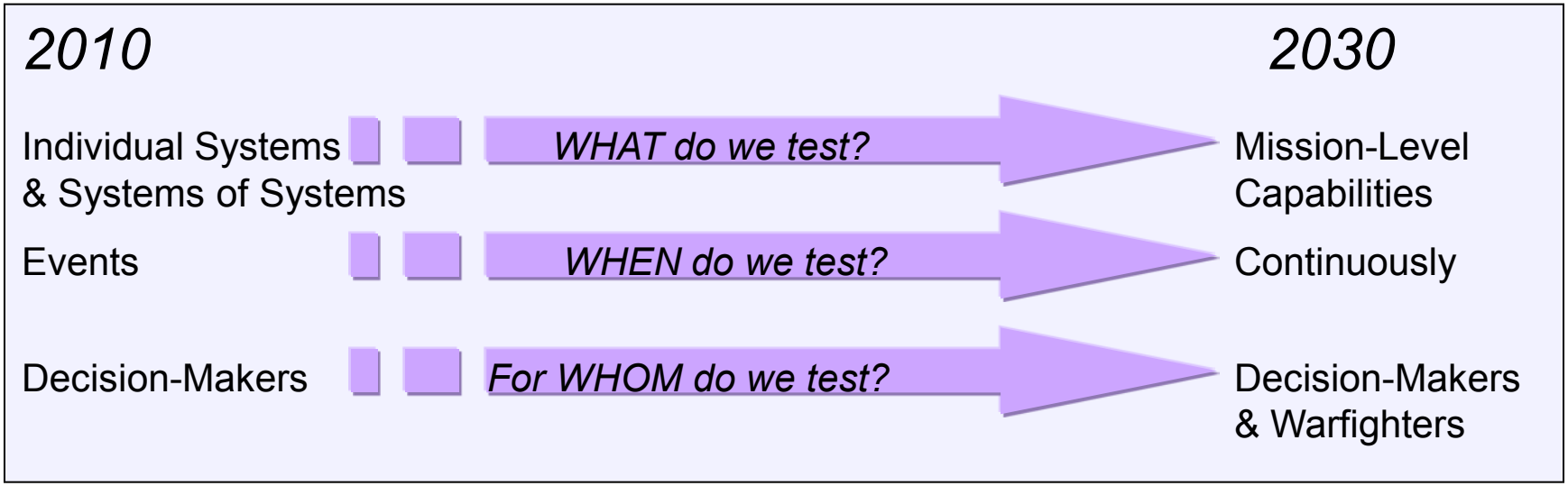
The JMETC Mission

JMETC provides the ***persistent infrastructure (network, integration software, tools, reuse repository)*** and ***technical expertise*** to integrate live, virtual, and constructive systems for test and evaluation in a Joint systems-of-systems (SoS) environment

Test Resource Management Center
Future T&E Process

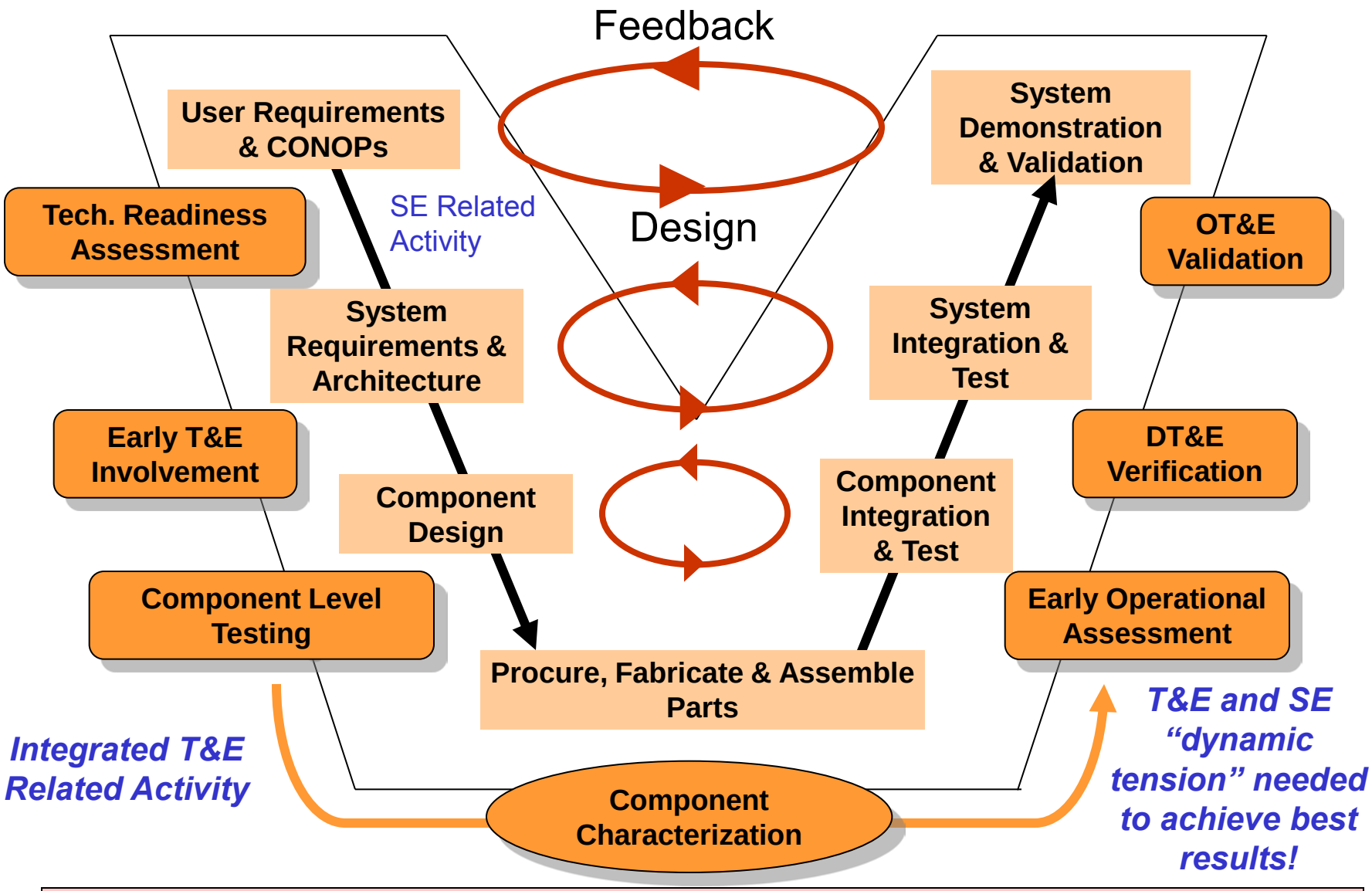
The DoD T&E process must evolve to be:

- Agile
- Streamlined
- Affordable
- Continuous



Goal: Distributed, Integrated Testing and Training

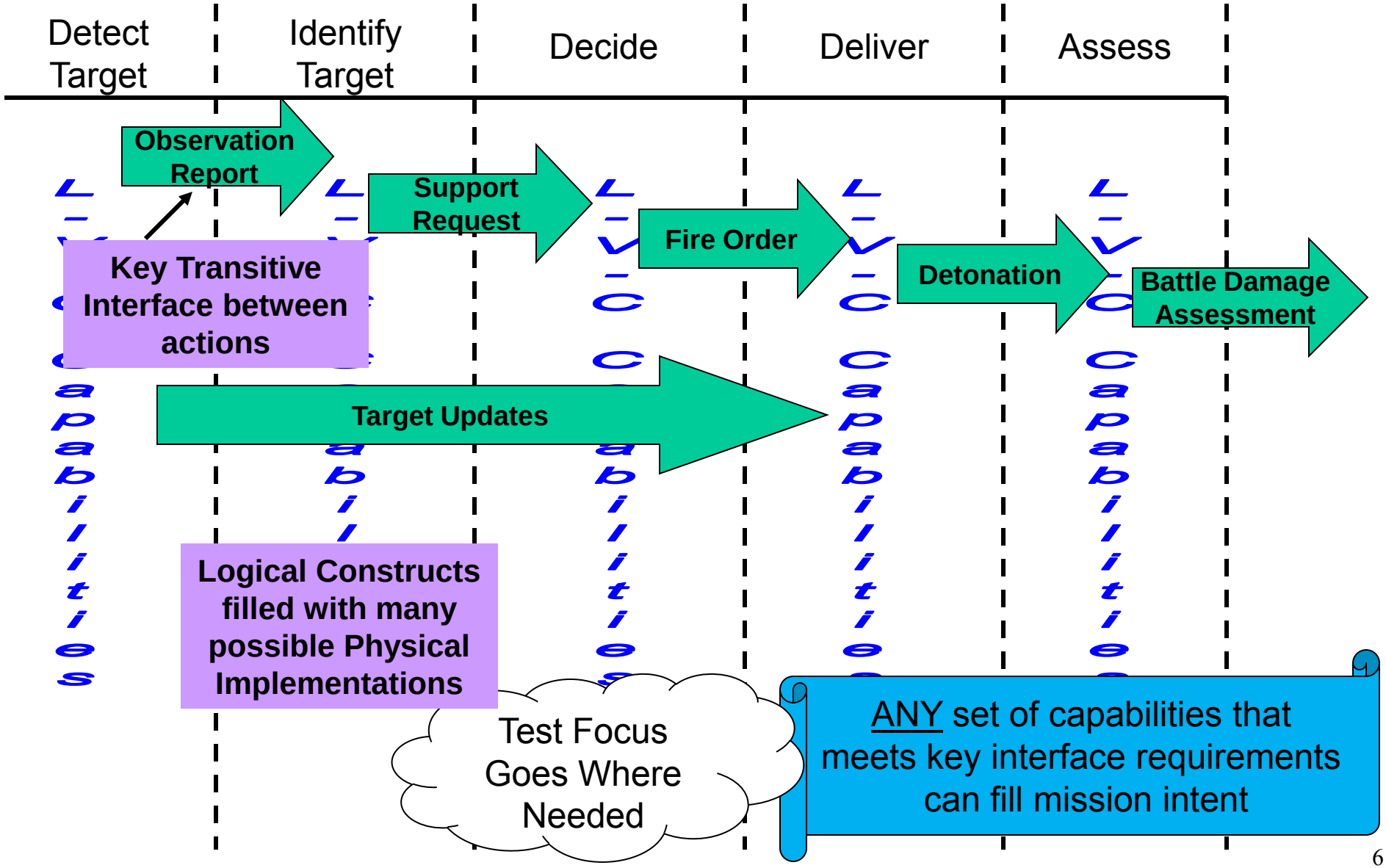
Distributed T&E Supports Systems Engineering (SE)



T&E Integral to System Reliability Program & Overall Performance Verification

L. Weiss 2009

JCAS Example: Enabling Persistence in Design Across Multiple Joint Mission Thread Configurations



JMETC Benefits Acquisition Programs, Testers, & Evaluators

- Enables early verification that systems work in a Joint Environment
  - Test whether systems work well together
- Supports all aspects of testing
  - Rapid acquisition, Developmental Test, Operational Test, Interoperability Certification, Net-Ready Key Performance Parameters testing, Joint Mission Capability Portfolio testing
- Helps find problems early in acquisition – when they are less costly to fix
  - Customers have run as many as 20 independent test runs in a day and fixed interoperability issues overnight
- Reduces acquisition time and cost
  - Readily-available, persistent connectivity with standing network security agreements
  - Common integration software for linking sites
  - Accredited test tools for distributed testing
- Support to Acquisition Programs
  - Expertise to integrate distributed test facilities

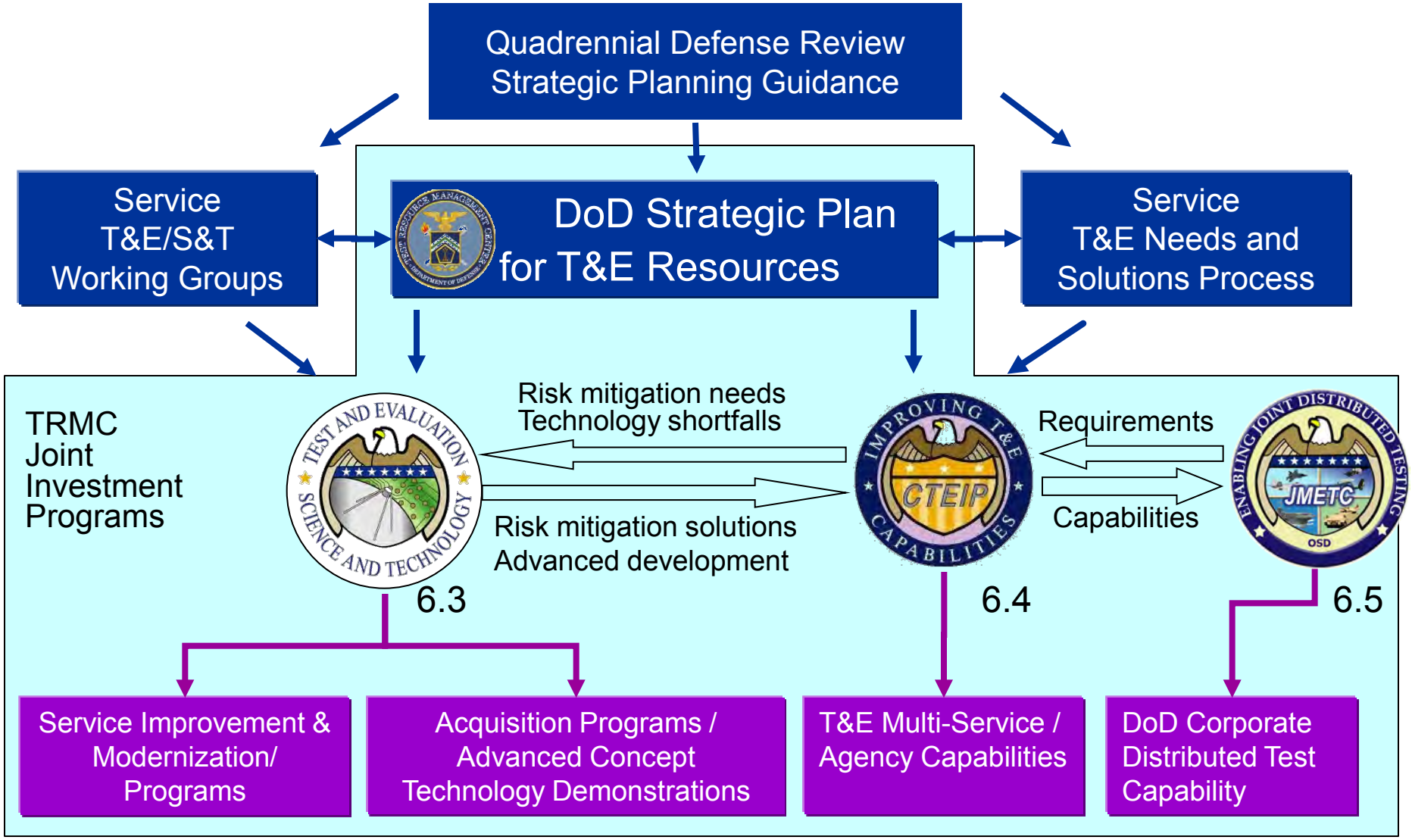
JMETC is identified in T&E Master Plans (TEMPs) as the distributed infrastructure to be used to conduct Joint testing

Distributed T&E Example: JIAMDO JSI & C/DIT 10

- Joint Integrated Air & Missile Defense Organization (JIAMDO) sponsored programs addressing full scope of System Track Management
  - Joint Sensor Integration (JSI) Goal: Integrate national, theater, and tactical sensors and processors to better utilize existing sensor inputs
  - Correlation / DeCorrelation Interoperability Test (CDIT) Goal: All-Service & Coalition Integration of Track Management to fully realize existing capabilities
- JMETC Infrastructure Serves as Joint Development Testbed
  - Identify Joint and Multi-mission architectural issues as they apply within: Net Centric Operations, Battle Management, Command and Control (C2), and Intelligence, Surveillance, and Reconnaissance (ISR)
  - Integration behavior anomalies are discovered, modifications made and retested in real time
  - Modified Infrastructure as needed to support testing
    - Changed scenario files, Test Roles, IFF loads, Participants, etc. without need for re-integration

Rapid Testing / Rapid Turnaround / Rapid Progress!

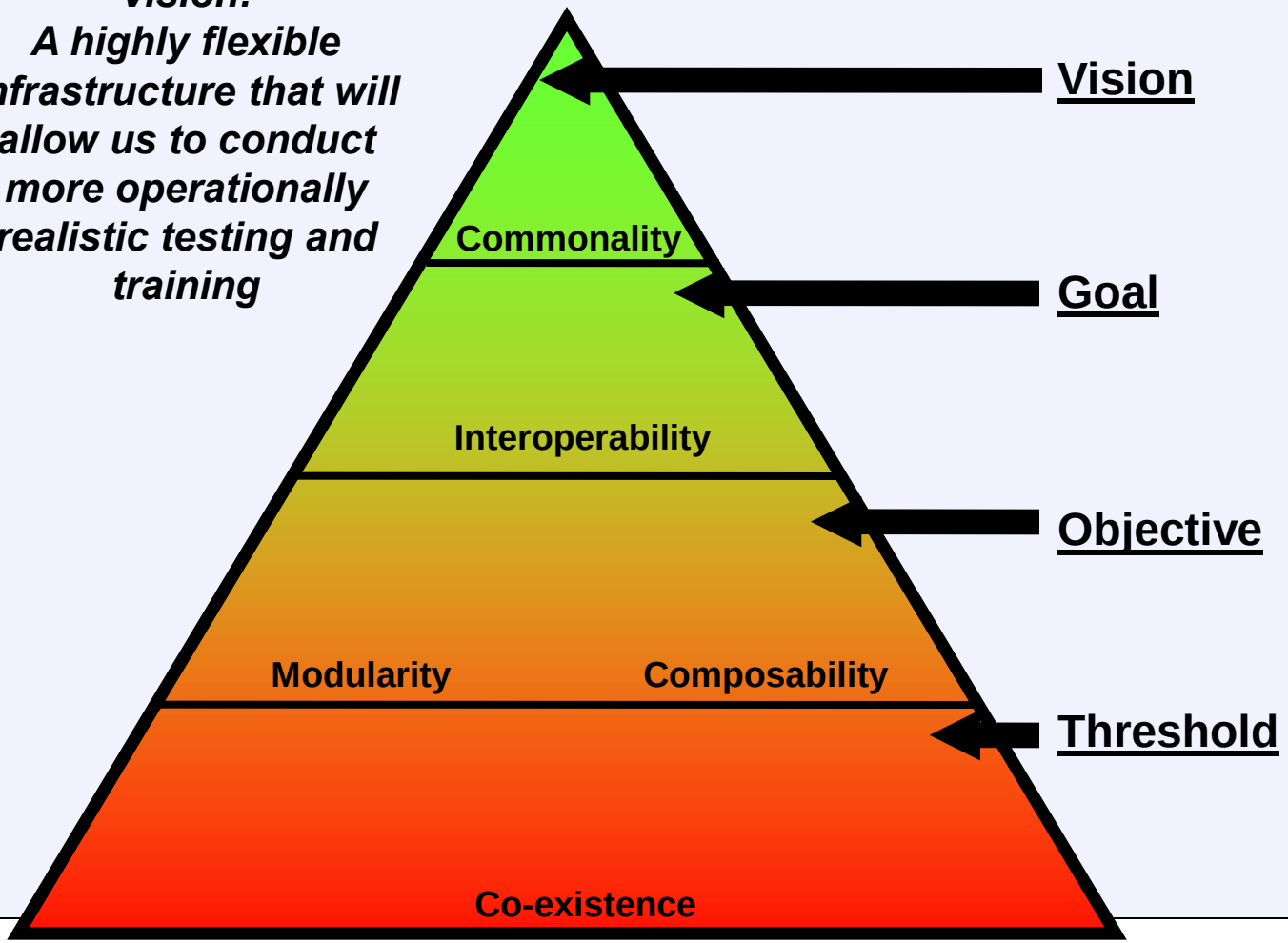
Relationship within TRMC
Synergy through Aligned Investment

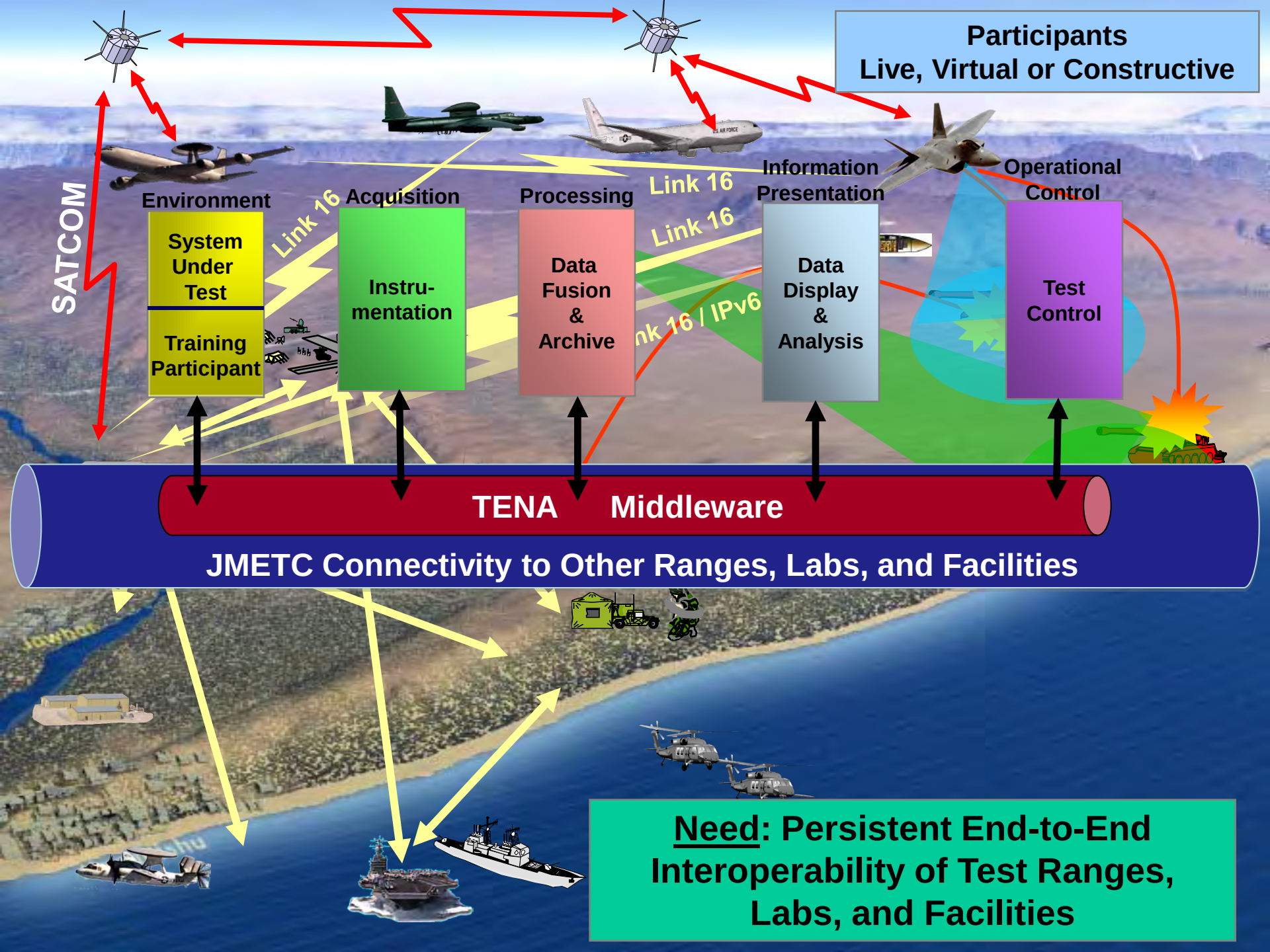


A TRMC Perspective:

Vision for a Common Test and Training Infrastructure

Vision:
A highly flexible infrastructure that will allow us to conduct more operationally realistic testing and training




Participants
Live, Virtual or Constructive
SATCOM
Environment
System Under Test
Training Participant
Link 16
Acquisition
Instru-mentation
Processing
Data Fusion & Archive
Link 16
Link 16
Link 16 / IPv6
Information Presentation
Data Display & Analysis
Operational Control
Test Control
TENA Middleware
JMETC Connectivity to Other Ranges, Labs, and Facilities
Need: Persistent End-to-End Interoperability of Test Ranges, Labs, and Facilities

JMETC Infrastructure Overcomes Common Distributed T&E Challenges

Challenge:	JMETC Enables Through:
• Site Interconnectivity	→ JMETC Network on SDREN
• No common enabling transport architecture	→ TENA Middleware
• Interface Incompatibility Across Distributed Applications	→ TENA Standard Object Models
• Inconsistent Tools	→ JMETC "Best of Breed" Process
• Test Participant Collaboration	→ Reuse Repository
• Analysis of Disparately Stored Data	→ Data Management Solutions

TENA: Test and Training Enabling Architecture

JMETC Connectivity

- Functional Sites: 57
- New Sites Planned: 6
- Connection Points to Other Networks: 4

- Dedicated, trusted connectivity on SDREN (part of the GIG)
- Encrypted for Secret – System High
- DISA-registered IP address space
- Active monitoring of network performance
- Capable of supporting multiple simultaneous test events

Boeing: Tukwila
Keyport: NUWCD
Ft Lewis: EPG

Hanscom AFB: CEIF
Bethpage: NGC BAMS
Ft. Monmouth: JOIN

Dugway Proving Ground
WPAFB: SIMAF
Schriever AFB: JEWL
Whiteman: B-2
Boeing: Berkeley
Nellis AFB: CAOC-N
Tinker AFB: AWACS
Redstone (5): DTCC, GMAN, SED-Patriot, SED-THAAD, SED-FAAD
Charleston (2): IPC, MEF-MEU
WSMR: IRCC
Greenville: Rivet Joint
Ft Huachuca: (2) JITC, JTDL
Ft Hood (2): CTSF, TTEC
Melbourne: NGC JSTARS

Sites in SoCal
- Edwards: Ridley
- China Lake (3): AV-8B, F/A-18, IBAR
- Point Mugu (2): ITEC, AEA
- El Segundo: NGC B-2
- Camp Pendleton: MCTSSA
- Corona: NSWC
- Point Loma: RLBTS, SSC-PAC
- West Agg Rtr.

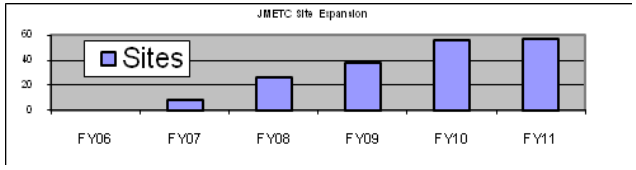
Sites in Hawaii
- PMRF: Bldg 105
- MHPCC

Site in Alaska
- Ft. Greely: CRTC

Sites in Gulf Range
- Hurlburt Field: C2DAC
- Eglin AFB (4): AOC, DTF, GWEF, KHILS

Sites in MD, DC, VA
- Aberdeen: ACCN
- Pax River (5): ESTEL E2C/D, ACETEF, SAIL, ACETEF-MCL, ATR
- JMETC SYSCON
- East Agg Rtr.
- Pentagon: WARCAP
- DISA: Sky 7
- Dahlgren (2): CEDL,IWSL
- JFCOM: JSIC
- Langley: (2) GIIF, TDLITC
- Norfolk: COMOPTEVFOR
- Norfolk:C2F Mitscher Ctr
- Dam Neck: CDSA
- Wallops Island: (2) SCSC, SSDS
- Newport News: NGC VASCIC

- Army
- Air Force
- Navy
- Marines
- Joint
- Industry



As of 18 Oct 2010

JMETC Uses TENA to Integrate Sites

(Can gateway to existing DIS and HLA simulations)

- TENA is:
  - Developed, upgraded, and sustained by CTEIP and JNTC
  - Middleware that provides a single, universal data exchange solution
  - Common for test and for training (core standard in JMETC and JNTC)
  - Available for download at www.tena-sda.org for free
- TENA provides:
  - Interoperability among range systems, hardware-in-the-loop laboratories, and simulations in a quick, cost-efficient manner
  - A capability to rapidly and reliably develop LVC integrations
  - A set of community-agreed object models that define the data elements used in LVC integrations – maximizes reuse from event to event
  - An auto-code generator to drastically reduce TENA incorporation time
- Newest version of TENA (version 6.0) provides:
  - Advanced data filtering (only data of interest sent over the wire)
  - Improved fault tolerance and embedded diagnostics
  - Downloadable on the TENA Website

JMETC Has Realized Benefits from Using TENA

- **Lowers the cost to integrate systems together**
  - Systems have been made TENA-compliant for under $20K
- **Decreases the time to integrate systems together**
  - Auto-code generator creates C++ interface (50K+ SLOC) in hours
  - Legacy systems upgraded to TENA compliancy in < 1 week
  - HLA-compliant display system made TENA-complaint in 1 day
- **Lowers the cost to develop new systems**
  - New systems can use middleware (1.5M+ SLOC) & existing object models for free
  - New systems do not need to develop multiple interfaces to various range protocols
- **Lowers cost of upgrades through gradual deployment**
  - TENA can be gradually deployed (system by system) at DoD Ranges and Laboratories rather than requiring all systems be redesigned
  - Easy incorporation of existing/legacy systems
- **Improves reliability of integrating systems together**
  - Consistency checker to verify every system has compatible versions installed
  - More reliability from reusing systems from one event to the next
  - Auto-code generator ensures that every system has same baseline of source code
  - Standard, validated algorithms (such as coordinate translations or unit conversions) are embedded in TENA rather than burden software applications of managing and performing translations

TENA is an Open Architecture

- SEI defines an Open System as "a collection of interacting software, hardware, and human components designed to satisfy stated needs with interface specifications of its components that are fully defined, available to the public, maintained according to group consensus, in which the implementations of the components conform to the interface specifications."
- TENA is maintained according to a consensus of its users assembled as the TENA Architecture Management Team (AMT)
  - TENA Architectural Specification is publicly defined and available on the web
  - TENA Middleware Specification (API) is publicly available on the web
  - TENA Object Model is publicly available and downloadable without restriction
    - » An Event Designer can create or modify object models for a given event to satisfy their particular event requirements
- TENA Middleware exists and is being used to support real events
  - Built on open source software – CORBA ACE/TAO
  - Government owned, without proprietary software
  - Studying possible open source release

TENA Upgrade Support Offer

- **The TENA team is available to offer advice and assist any organization looking to use TENA**
  - **Advice on overall design approach and trade-offs to consider**
  - **Recommended Object Models to reuse**
  - **Recommendations on how to design new Object Models**
  - **Implementation / Code Designs Reviews**
  - **Awareness of similar systems and lessons learned**
  - **Hands-on training classes on TENA capabilities**
  - **Hands-on training classes on using "TIDE" (a TENA Development Tool)**
    - » **Eases developing TENA interface**
    - » **Assists incorporating different Object Models**
    - » **Upgrade utility for HLA applications migrating to TENA**

Opportunity to Get Assistance in Using TENA

E-mail request to: feedback@tena-sda.org

Distributed T&E Community Growth Areas

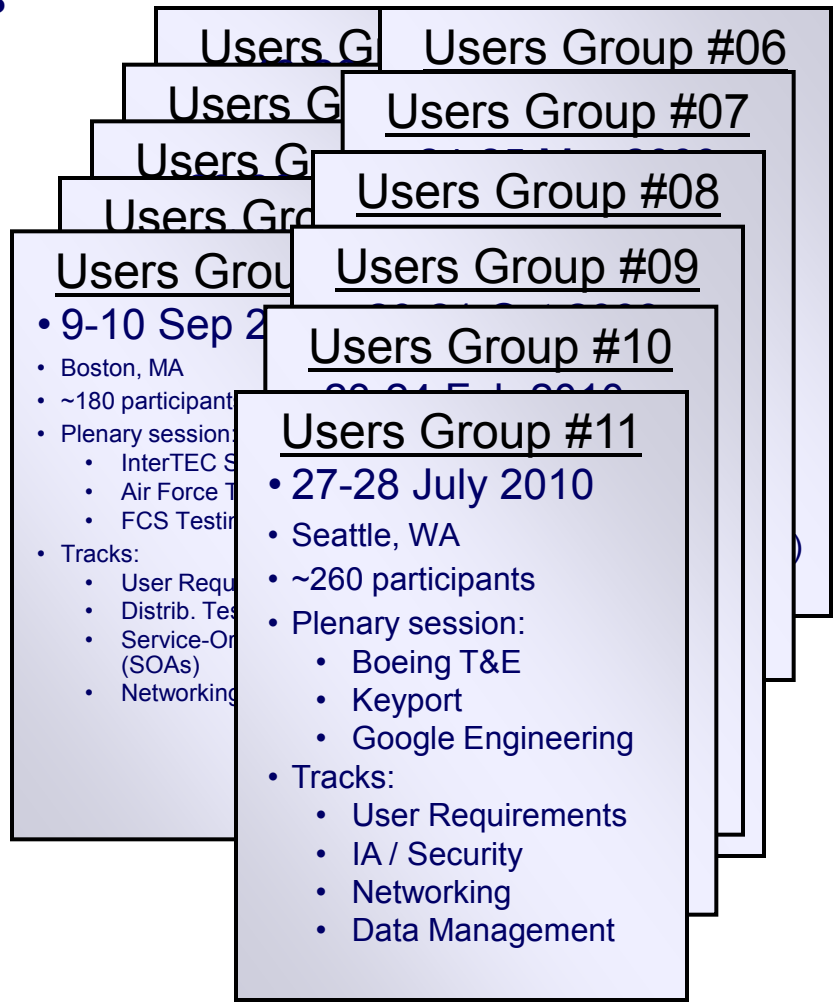
- "Good" Test & Analysis Plans are critical to a successful distributed **test**
- Software and Network Configuration Management must be taken more seriously in distributed test environments
- Elimination where possible of Protocol Converters and Gateways as single points of failure
- Continued emphasis in community on “test early and often”
- Community is getting really good at quickly collecting and storing lots of test data. What are we going to do with it?

JMETC Users Group Meetings

- **Identify core infrastructure requirements and use cases**
- **Identify, investigate, & resolve issues**
- **Identify opportunities to collaborate**
- **Discuss available solutions, tools, and techniques**
- **Share lessons learned**

Next JMETC Users Group Meeting:

- Scheduled for 13-14 December
- Location: San Diego, CA
- Potential Tracks:
  - User Requirements
  - Information Assurance / Security
  - Data Management
  - Networking
  - Tools
  - Software Interface



Summary

- JMETC supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads
- JMETC and TENA are being built based on customer requirements
  - JMETC Network on SDREN established and expanding
  - TENA the enabling architecture (commonality with Training)
  - Gateway devices available to convert legacy systems to TENA
  - Common tools used extensively at many sites
  - Constructing Reuse Repository based on user requirements
- JMETC is partnering with Service activities and leveraging existing capabilities
- JMETC is coordinating with JFCOM to bridge test and training capabilities
- JMETC Users Group provides an open forum to present emerging requirements as well as new technologies & capabilities

JMETC Program Points of Contact

JMETC Program Manager:	**Chip Ferguson** chip.ferguson@osd.mil 703-601-5274
JMETC Principal Deputy PM:	**Bruce Bailey** bruce.bailey@osd.mil 703-601-5208
JMETC Lead Operations Planning:	**Marty Arnwine** martemas.arnwine@osd.mil 703-601-5215
JMETC Senior Technical Advisor:	**George Rumford** george.rumford@osd.mil 703-601-5233
JMETC Lead Systems Engineer:	**Ryan Norman** ryan.norman@osd.mil 703-601-5277

JMETC Website: https://www.jmetc.org

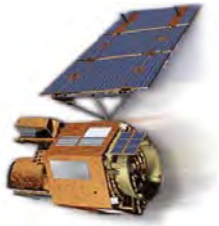
Questions?

Ryan Norman
Deputy Program Manager – Systems Engineering
Ryan.Norman@osd.mil

CSC
NORTH AMERICAN PUBLIC SECTOR

Rationalizing Governance, Engineering Practice, and Engineering Economics in the System and Software Assurance Trade Space

Paul R. Croll
Fellow
CSC
pcroll@csc.com



Outline

- The Governance Challenge
- Governance for System and Software Assurance
- Quality Characteristics in Engineering Trades
- System and Software Assurance Engineering Economics and Risk Management
- Rationalizing Governance, Engineering Practice, and Engineering Economics

CSC

NORTH AMERICAN
PUBLIC SECTOR

The Governance Challenge

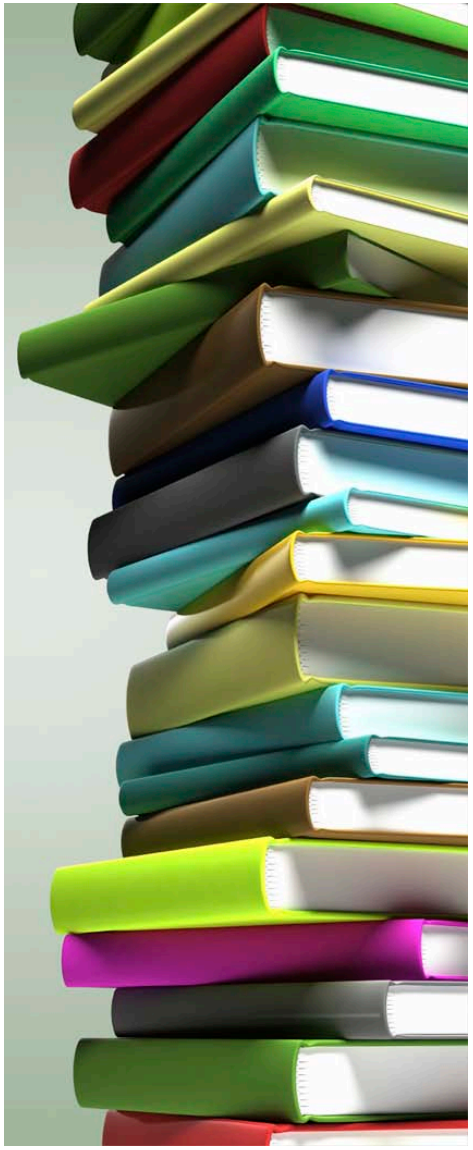
Trade Space Constraints

- Engineering systems and systems of systems (SoSs) is about trade-offs
- Generally such trade-offs focus on quality attributes associated with architecture, design, and implementation [1]
- From a system and software assurance perspective, the trade space is often constrained by a myriad of governance documents that may include public law, regulatory agency directives, both acquiring and supplying organizations' policies and procedures, as well as standards and best practices.
- These numerous documents may in some cases be duplicative in their reporting requirements, or may even conflict with each other. They not only constrain trade-offs, but directly impact system cost.

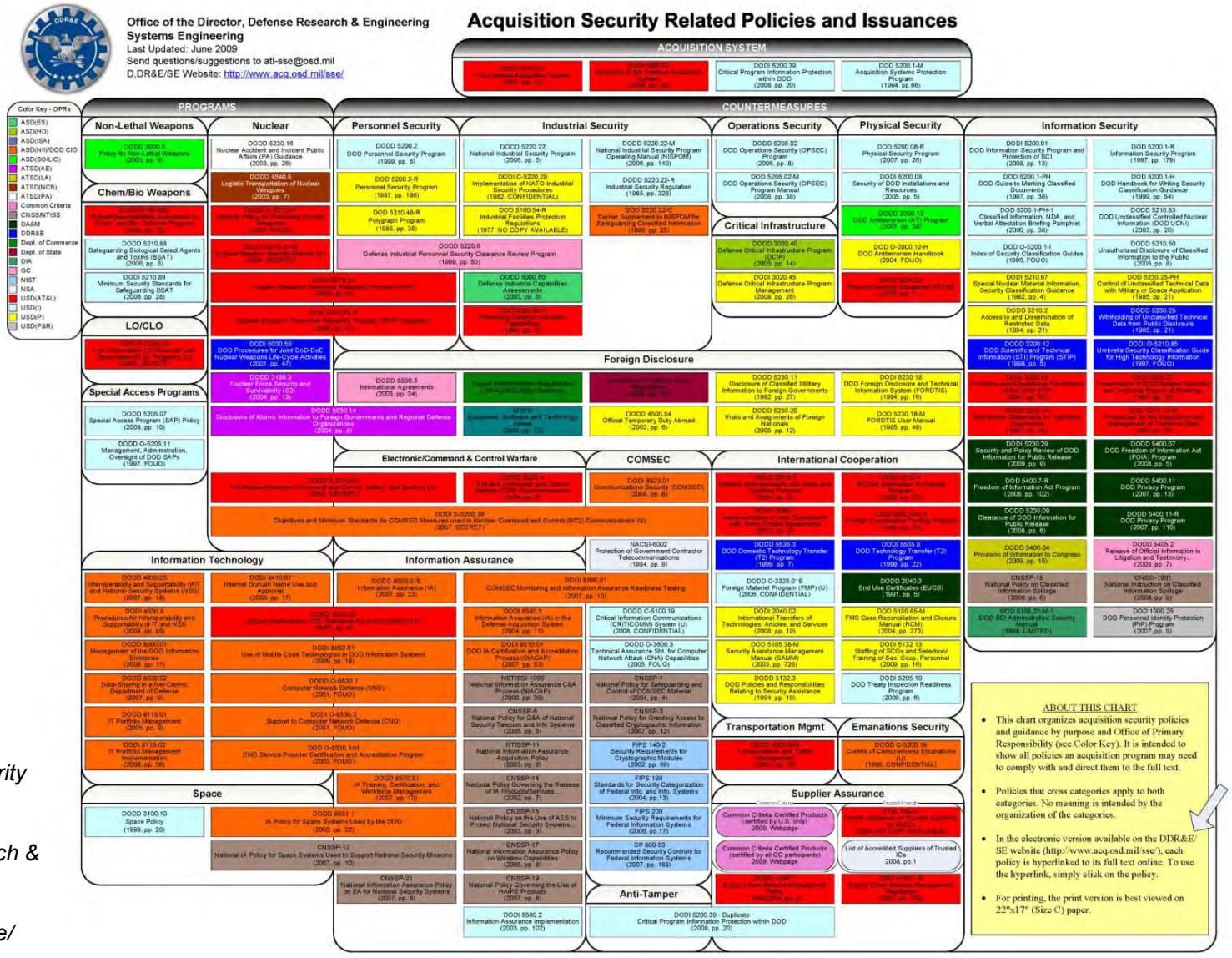
.

Governance Context

- In the U. S. Federal marketplace alone, there are over two hundred governance documents related to system and software assurance
  - An example for the US DoD is provided on the next slide
- A recent U. S. Congressional Budget Office review [2] estimated the cost of implementing the Federal Information Security Act of 2008 (FISMA) alone, designed to improve information security throughout the federal government, at US $40 million in 2009 and about US $570 million over the 2009-2013 period.
- These external governance requirements drive internal governance structures that must be both responsive and cost-effective, while providing value to all stakeholders



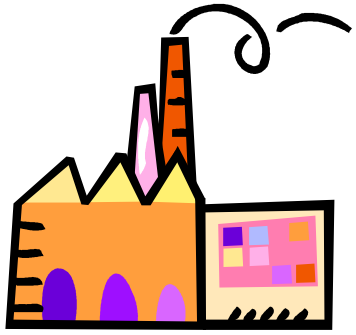
Example: US DoD Compilation of Security-Related Policy and Guidance



Source: Acquisition Security Related Policies and Issuances, Office of the Director, Defense Research & Engineering Systems Engineering, http://www.acq.osd.mil/sse/

Governance Classes

- In performing the engineering trades associated with system and software assurance, governance documents of various classes define compliance and conformance requirements that may constrain the trade space. These may include:
  - Legal and regulatory requirements
  - Industry standards
  - Client-imposed requirements
  - Internal guidelines



Compliance vs. Conformance

- There is a difference between compliance and conformance [3]
  - Compliance refers to mandatory adherence to laws, rules, and regulations
  - Conformance refers to voluntary adherence to standards and best practices.
- Compliance requirements and conformance objectives are addressed as part of an organization's business strategy through the development and promulgation of an internal governance structure consisting of:
  - Policies
  - Procedures
  - Standards
  - Practices
- These are aligned with external compliance and conformance drivers

CSC

NORTH AMERICAN
PUBLIC SECTOR

Governance for System and Software Assurance

IT Governance Defined

- The Information Security and Control Association (ISACA) defines governance as:
  - *The set of responsibilities and practices exercised by the board and executive management with the goal of providing strategic direction, ensuring that objectives are achieved, ascertaining that risks are managed appropriately and verifying that the enterprise's resources are used responsibly* [4]
- Brotby [5] suggest five basic outcomes of information security governance:
  - Strategic alignment of information security with business strategy
  - Security risk management
  - Resource management related to the effective deployment of security knowledge and infrastructure
  - Performance measurement through information security governance metrics
  - Value delivery through optimization of information security investments

System and Software Assurance Defined

- These suggested outcomes may be generalized to engineering for system and software assurance.
- System assurance is defined as *the justified confidence that the system functions as intended and is free of exploitable vulnerabilities, either intentionally or unintentionally designed or inserted as part of the system at any time during the life cycle* [6].
- Similarly, software assurance is defined as *the level of confidence that software is free from vulnerabilities, either intentionally designed into the software or accidentally inserted at anytime during its lifecycle, and that the software functions in the intended manner* [7].

IT Governance Generalized to System and Software Assurance

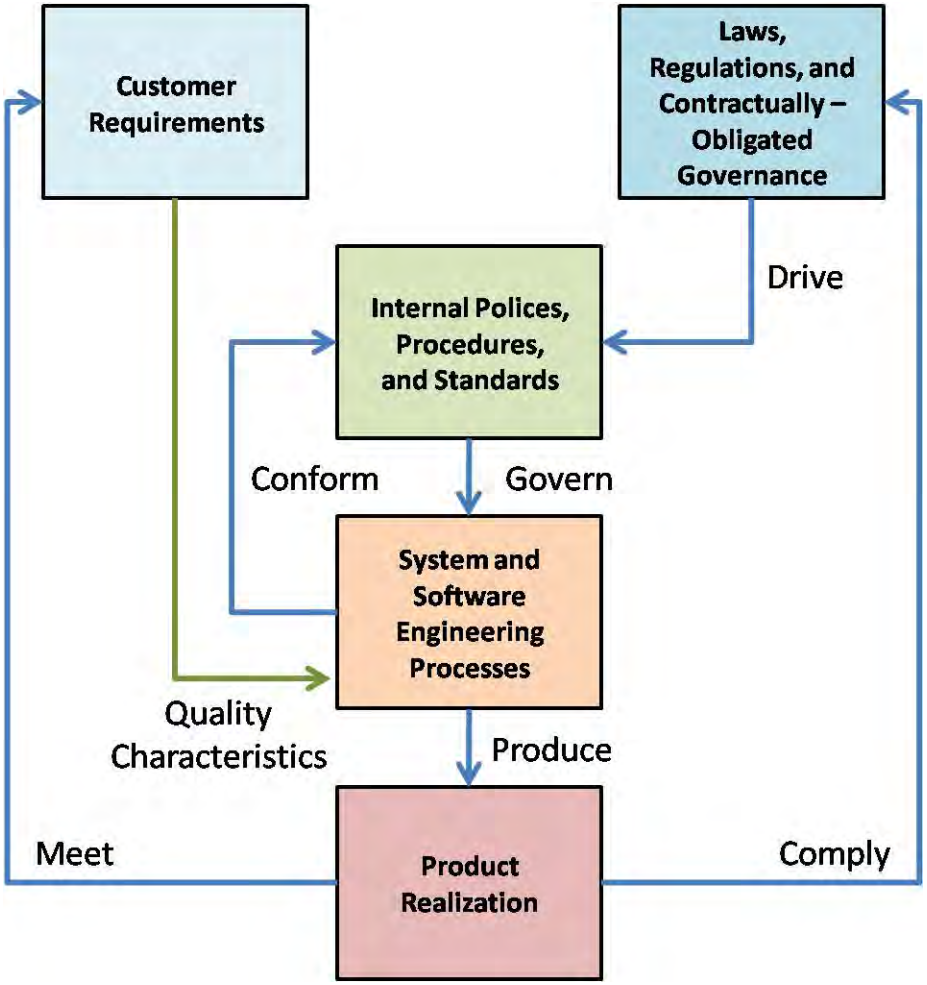
- ***Strategic alignment with business strategy*** implies that
  - Organizational policies and enforcement mechanisms are in place to support effective engineering for system and software assurance
  - Costs and benefits are well understood
- ***Security risk management*** implies that
  - Security-related risks are identified and managed at all stages of the engineering life cycle
  - Such risks are communicated appropriately to stakeholders.
- ***Resource management*** implies that
  - Qualified, properly trained engineers are available throughout the engineering life cycle to adequately address systems and software assurance concerns
- ***Performance measurement*** implies,
  - For engineering processes, that they are meeting their targets for architecture and design resiliency, secure coding practices, and freedom from vulnerabilities
  - For the products produced, that the product meets its quality requirements
- ***Value delivery*** implies that
  - The value proposition associated with both the investment made in the engineering processes for system and software assurance, and the costs associated with architectural and design decisions, show clear benefit to both the organization, the acquirer and the users of the system

Security Governance Framework

- Brotby [5] further suggests that an effective security governance framework generally consists of:
  - A security risk management methodology
  - A security strategy linked with business objectives
  - An effective security organizational structure
  - Security policies that address control and regulation in the context of the security strategy
  - Security standards defining compliance with policy
  - A process for monitoring of compliance and for providing feedback on risk mitigation
  - A process for periodic evaluation and update of the governance framework in the context of changing risks and organizational objectives.

Governance in the Engineering Life Cycle

- **Customer requirements** for the system, defining the system's quality requirements, set the expectations for the system. It is against these quality requirements that engineering trades will be made.
- **Applicable laws, regulations, and other contractually-obligated governance** set the constraints bounding the engineering this trade space.
- **Internal policies, procedures, and standards** institutionalize external governance requirements (as well as business best practices) and drive the engineering processes for producing systems and software
  - Internal quality reviews will generally include reviews of conformance of a project's engineering processes to these established policies, procedures, and standards.
- **Engineering processes** produce the product by trading off internal governance requirements along with customer quality requirements, to facilitate optimization among quality characteristics and compliance with external governance requirements.



CSC

NORTH AMERICAN
PUBLIC SECTOR

Quality Characteristics in Engineering Trades

Customer Defined Quality Requirements

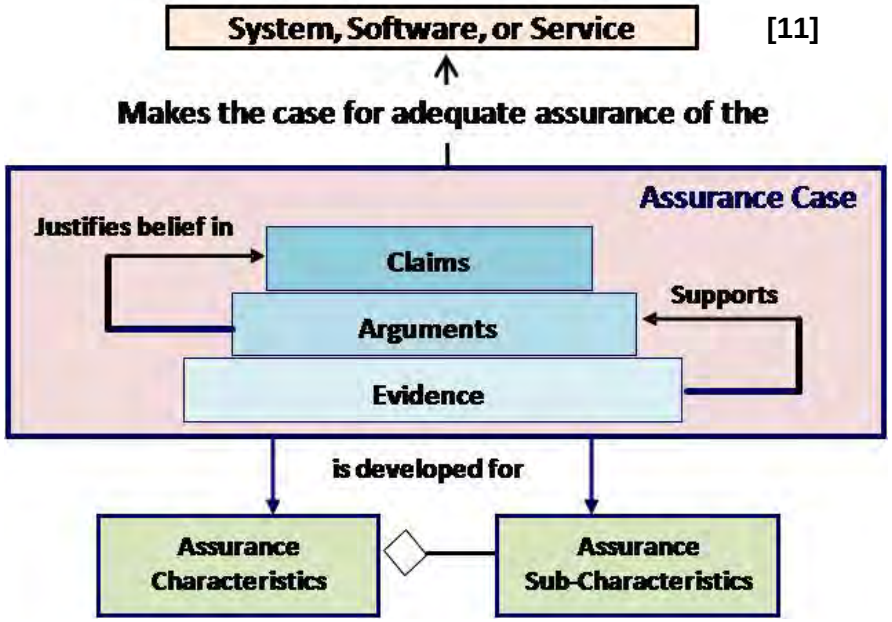
- Quality characteristics drive system and software architecture and design.
- Firesmith [8] describes two classes of quality characteristics important to the system and software assurance trade space:
  - Internal quality characteristics
  - External quality characteristics
- Internal characteristics are described as characterizing an internally visible quality of a system or architectural component when it is in the process of being developed, modified, or retired
  - Internal quality characteristics are of primary interest to developers and maintainers
- External characteristics are described as characterizing an externally visible quality of a system or architectural component when it is deployed and in service in its operational environment
  - External quality characteristics are of primary interest to users and operators
- Quality requirements in the trade space are specified in terms of these quality characteristics
- *Compliance with governance documents*, as is *security*, is only one of many quality characteristics which must be addressed when making architectural and design trades

A Quality Attribute Approach to System and Software Engineering Trades

- This approach [1] ensures that:
  - Customer quality requirements will have been distilled into drivers which will have shaped the system architecture and design.
  - Tradeoffs will have been made to optimize the realization of important quality characteristics, in concert with customer expectations.
  - The level of confidence that the resultant system will meet those expectations will be known.
  - Customers will be knowledgeable of any residual risk they are accepting by accepting the delivered system.
- The NDIA guidebook on Engineering for System Assurance [6], suggests using system assurance requirements, design constraints and system assurance critical scenarios for trade-off analysis, and documenting the results in an assurance case

The Assurance Case

- A detailed explanation of the recommended structure of an assurance case may be found in [9], and a discussion of its contents in [6] and [10].
- Claims made about a system's assurance characteristics must be supported by rational arguments to justify their belief
- In order for these arguments to be accepted, they must in turn be supported by sufficient evidence
- The assurance case is the means for communicating to stakeholders the degree of assurance achieved, with what confidence level, and with what residual risk



CSC

NORTH AMERICAN
PUBLIC SECTOR

System and Software Assurance Engineering Economics and Risk Management

Software Assurance Economic Models

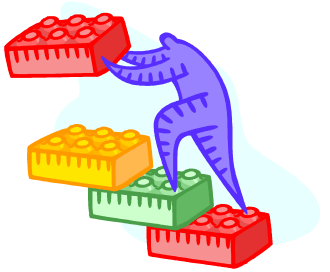
- Bailey et al [12] discuss four categories of IT valuation models, and thirteen specific models, that might be adapted assessing the cost and value of software assurance.
- Those most familiar in engineering and IT environments include:
  - ***Investment-Oriented Models*** like Microsoft's Rapid Economic Justification framework [13];
  - ***Cost-Oriented Models***, like Total Cost of Ownership [14];
  - ***Environmental/Contextual-Oriented Models***, like Balanced Scorecard [15]; and
  - ***Quantitative Estimation Models***, like CoCoMo II with Security Extensions [16]
- However, there is no one widely accepted model for determining the cost/benefit of investment in software assurance [17] [18]

Assurance Risk Management – Balancing Assurance Costs

- NIST Special Publication 800-30, *Risk Management Guide for Information Technology Systems* [19] describes risk management for IT systems as a process that balances the operational and economic costs of protective measures to achieve mission-essential security capabilities
- NIST Special Publication 800-27, *Engineering Principles for Information Technology Security (A Baseline for Achieving Security), Revision A* [20], recognizes that elimination of all risk is not cost-effective
  - *A cost-benefit analysis should be conducted for each proposed control. In some cases, the benefits of a more secure system may not justify the direct and indirect costs. Benefits include more than just prevention of monetary loss; for example, controls may be essential for maintaining public trust and confidence*

  Principle 5: Reduce risk to an acceptable level

- MacKessy [21] posits that a "hierarchy of risk" framework, providing a flexible, multidimensional schema for analyzing quantitative and qualitative risk may be useful in address related classes of risk in the business enterprise



Risk Hierarchy for System and Software Assurance

- Legal and Regulatory Risk
  - This class of risk addresses risks associated with failures regarding compliance with legal or regulatory requirements
  - Consequences may include fines, civil or criminal prosecution, prohibitions against provision of products to the market place.
- Operational Risk
  - This class of risk addresses both external and internal risk
    - External risks associated with failures of provided products in their operational environments,
    - Internal risks associated with failures in the engineering processes producing such products.
  - Consequences may include delivered exploitable vulnerabilities that result in harm to users, their systems, or their data
- Reputational Risk
  - This class of risk is linked with legal and regulatory, operational, and competitive risk
  - It addresses risks associated with damages to the organization's reputation in the market place resulting from legal and regulatory breaches and operational failures
  - Consequences include loss of standing in the market place and mistrust on the part of current and potential customers.
- Competitive Risk
  - This class of risk addresses risks associated with loss of stature with respect to competitors.
  - Consequences include loss of market share and potential difficulty entering new markets.
- Financial Risk
  - This class of risk addresses risks associated with monetary loss
  - Consequences include loss of revenue, negative impact on stock prices, and diminishing shareholder confidence.
- Strategic Risk
  - This class of risk is linked with all the other risk classes below it in the hierarchy
  - It addresses risks associated with failures to meet the strategic goals and objectives of the organization

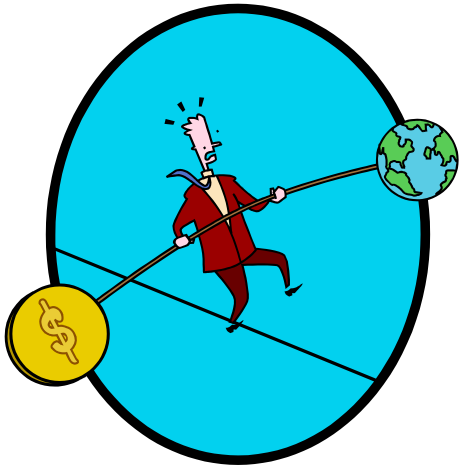
Value Delivery

- *Value delivery* implies that the value proposition associated with both the investment made in engineering processes for system and software assurance, and the costs associated with architectural and design decisions, shows clear benefit to both the organization and the acquirer and users of the system
- Value addresses the relationship between stakeholder needs and the resources used to satisfy them. Stakeholders will have different perceptions about what constitutes value
  - Value in the eyes of a regulatory agency may be viewed as compliance with directives
  - The organization's CEO and its shareholders may view value in terms of profit and market position
  - Acquirers or users of a system may perceive value in terms of expected performance and freedom from exploitable vulnerabilities
- The challenge is to understand and reconcile these differences without any negative impact on quality requirements.

CSC

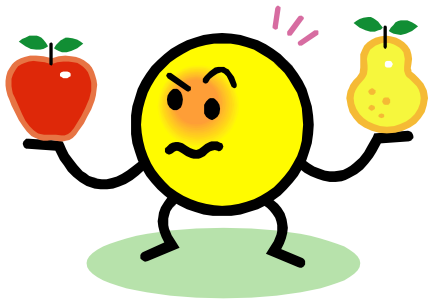
NORTH AMERICAN
PUBLIC SECTOR

Rationalizing Governance, Engineering Practice, and Engineering Economics



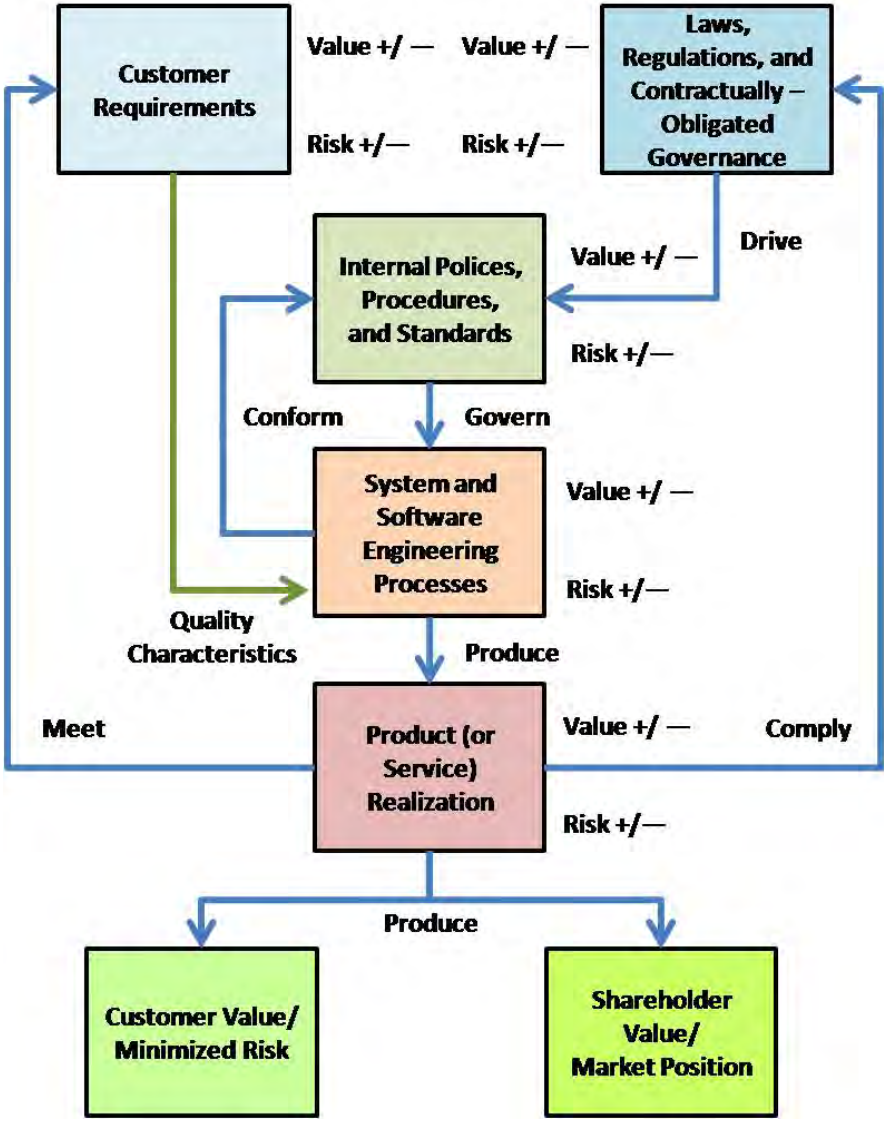
Rationalizing Governance, Engineering Practice, and Engineering Economics

- The previous discussion has touched on governance in the engineering life cycle, quality characteristics and their use in making engineering trades, models for assessing the cost and value of software assurance, assurance risk management, and value delivery
- The literature surveyed is abundant with models, equations, and checklists but comes to no consensus on the “best” approach for system and software assurance
- Several of the references cited provide more information for comparison of governance requirements as well as methods, tools, and techniques [5], [6], [8], [12], [18], and [22]
- The figure on slide 14, described earlier as depicting governance in the engineering life cycle, may be annotated to illustrate the touch points for rationalizing governance with risk and value



Rationalizing Governance in the Engineering Life Cycle

- Although simplistic, this figure depicts the necessary consideration of positive and negative impacts on value and risk throughout the engineering life cycle and the ultimate delivery of value to both the customer and the organization's shareholders
- Understanding of this value chain should be an integral part of an organization's approach to engineering projects
- This includes the impacts of external laws, regulations or other contractually-obligated governance requirements on internal policies procedures and standards that in turn govern the organization's engineering processes, as well as the impacts of those processes on the value chain.



Key Rationalization Questions

- How does compliance with a particular external governance requirement impact organizational risk and value delivery?
- Where multiple external compliance requirements exist, have I examined their overlaps and chosen a compliance strategy that optimizes compliance while minimizing risk and maximizing value?
- Have I added value and reduced risk to my engineering processes through the policies, procedures, and standards I've adopted in compliance with those external governance requirements?
- Does my product provide value in the market place while limiting risk to acquirers and users?

Further research is needed to produce both qualitative and quantitative tools to facilitate such rationalization

References – 1 of 2

[1] P. Croll. Quality Attributes – Architecting Systems To Meet Customer Expectations, Proceedings of the 2nd Annual IEEE International Systems Conference. New York: Institute of Electrical and Electronics Engineers, April 2008.

[2] U. S. Congressional Budget Office. Congressional Budget Office Cost Estimate – S.3474, FISMA Act of 2008. Washington, DC, October 27, 2008.

[3] Tashi. Regulatory Compliance and Information Security Assurance, Proceedings of the 2009 International Conference on Availability, Reliability and Security. New York: Institute of Electrical and Electronics Engineers, 2009

[4] ISACA. CISM Review Manual, Information Security and Control Association, 2008.

[5] K. Brotby. Information Security Governance, A Guide for Boards of Directors and Executive Management, 2nd ed. ITGI, 2005.

[6] National Defense Industrial Association (NDIA) System Assurance Committee. Engineering for System Assurance. Arlington, VA: NDIA, 2008.

]7] Committee on National Security Standards. CNSS Instruction No. 4009, National Information Assurance Glossary, Ft. Meade, MD, Revised 2006.

[8] D. Firesmith, P. Capell, D. Falkenthal, C. Hammons, D. Latimer, and T. Merendino. The Method-Framework for Engineering System Architectures (MFESA): Generating Effective and Efficient Project-Specific System Architecture Engineering Methods. Boca Raton, FL: Auerbach Publications, 2009.

[9] ISO/IEC JTC1/SC7, CD 15026-2.4, Systems and software engineering — Systems and software assurance — Part 2: Assurance case. ISO, Geneva Switzerland, July 2009.

[10] J. Goodenough, H. Lipson, and C Weinstock. Arguing *Security - Creating Security Assurance Cases*. Pittsburgh, PA: Carnegie Mellon University, 2008. https://buildsecurityin.us-cert.gov/bsi/articles/knowledge/assurance/643-BSI.html#

[11] P. Croll. *Practices Make Perfect – Leveraging Your Engineering and Management Practices to Meet the Software Assurance Challenge*, 20th Annual Department of Defense Systems and Software Technology Conference, 2008.

References – 2 of 2

[12] J. Bailey, A. Drommi, J. Ingalsbe, N. Mead, and D. Shoemaker. Models for Assessing the Cost and Value of Software Assurance. Pittsburgh, PA: Carnegie Mellon University, 2008. https://buildsecurityin.us-cert.gov/daisy/bsi/articles/knowledge/business/684-BSI.html

[13] Microsoft. Rapid Economic Justification, Enterprise Edition: A Step-by-Step Guide to Optimizing IT Investments that Forge Alliances Between IT and Business. Redmond, Washington: Microsoft Corporation, 2005

[14] R. West, and L Daigle. Total Cost of Ownership: A Strategic Tool for ERP Planning and Implementation. Boulder, Colorado: EDUCAUSE Center for Applied Research, Research Bulletin, Volume 4, Issue 1, 2004.

[15] W. Van Grembergen and S. De Haes. Measuring and Improving IT Governance Through the Balanced Scorecard, Information Systems Control Journal, Volume 2. Information Systems Audit and Control Association Inc., 2005.

[16] E. Colbert and B. Boehm. Cost Estimation for Secure Software and Systems, USC-CSSE-2008-811. Los Angeles, California: Center for Systems and Software Engineering, University of Southern California, 2008. http://csse.usc.edu/csse/TECHRPTS/2008/usc-csse-2008-811/usc-csse-2008-811.pdf

[17] J. Allen. Making the Business Case for Software Assurance (SWA). SEPG Conference, 2009.

[18] A. Arora, et al. Estimating Benefits from Investing in Secure Software Development. Pittsburgh, PA: Carnegie Mellon University, 2008. https://buildsecurityin.us-cert.gov/daisy/bsi/articles/knowledge/business/267-BSI.html

[19] G. Stoneburner, A. Goguen, and A. Feringa. NIST Special Publication 800-30, Risk Management Guide for Information Technology Systems. Gaithersburg, MD: National Institute of Standards and Technology, 2002.

[20] G. Stoneburner, C. Hayden, and A. Feringa. NIST Special Publication 800-27, Engineering Principles for Information Technology Security (A Baseline for Achieving Security), Revision A. Gaithersburg, MD: National Institute of Standards and Technology, 2004.

[21] J. MacKessy. The Hierarchy of Risk A New Approach To Risk Management, The Investment Professional, Vol 2, No. 3. New York: The New York Society of Security Analysts, Inc., 2009.

[22] R. Venkataraman and J. Pinto. Cost and Value Management in Projects. Hoboken, New Jersey: John Wiley & Sons, Inc., 2008.

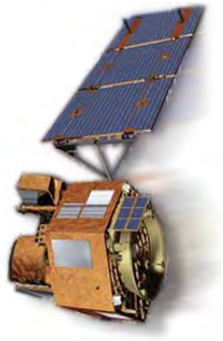
For More Information . . .

Paul R. Croll
CSC
10721 Combs Drive
King George, VA 22485-5824

Phone: +1 540.644.6224

Fax: +1 540.663.0276

e-mail: pcroll@csc.com



NAVSEA
WARFARE CENTERS
DAHLGREN

Strategic Enterprise Testing and Evaluation Approach

National Defense Industrial Association

13th Annual Engineering Conference

28 October 2010

Harriette Tullos-Banks

Eileen McConkie

Naval Surface Warfare Center, Dahlgren Division

Approved for public release; distribution is unlimited.

The views expressed in this brief are those of the authors and do not reflect the official policy or position of the Department of the Navy, the Department of Defense, or the U.S. government.

Purpose

- Demonstrated in this presentation is a concept for a Strategic Enterprise Test and Evaluation (SET&E) process that integrates all test organizations into a single process.
- Our intent is to show the relationship between a well-defined SET&E process and a reduction in Total Ownership Cost (TOC).

Definitions

SET&E:

Knowledge sharing and best practices in all T&E aspects; systematically and purposefully aligning users and T&E centers' integration efforts to deliver effective T&E capacity and capabilities by optimizing test resources through leveraging performance results across program with common architectures and/or systems.

TOC:

The sum of all financial resources necessary to organize, equip, train, sustain, and operate military forces sufficient to meet national goals in compliance with all laws; all policies applicable to the Department of Defense (DoD); all standards in effect for readiness, safety, and quality of life; and all other official measures of performance for DoD and its components.

Reduce the cost of delivering warfighter capability

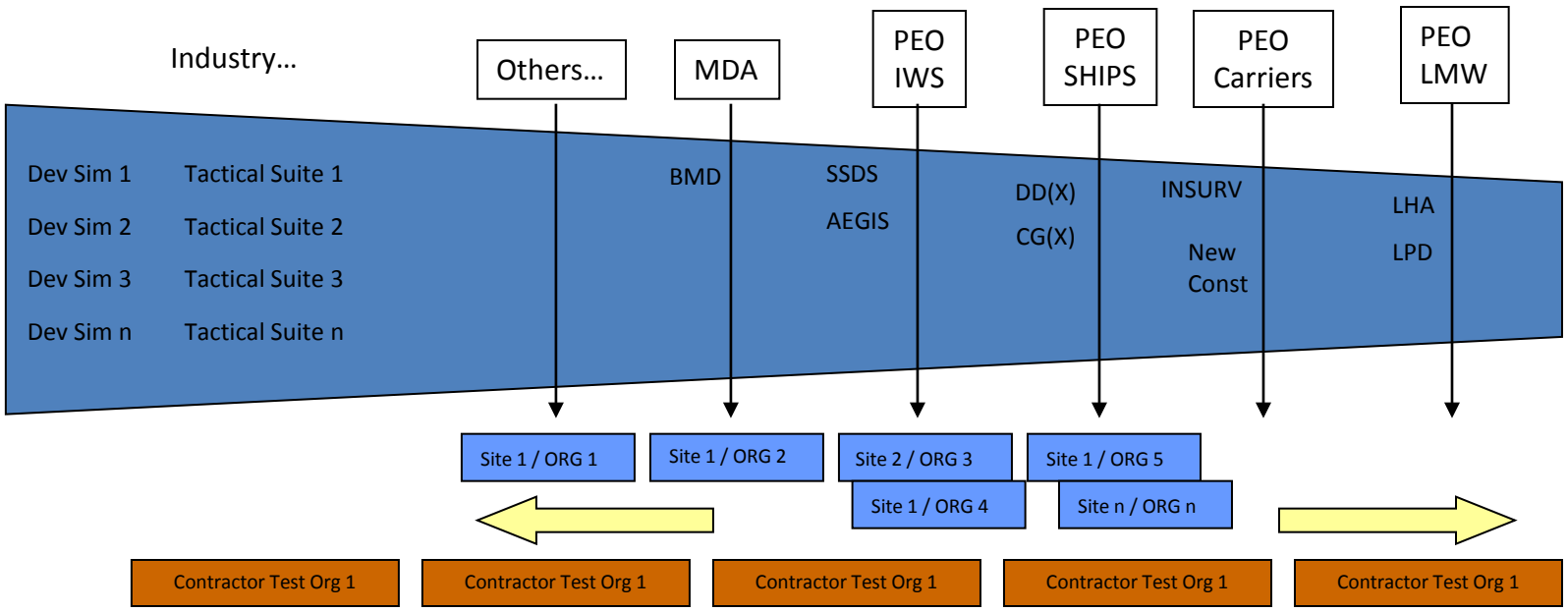
Current State

- **Overlapping T&E Infrastructure**
  - Redundant test capabilities and test facilities
- **Limited Coordinated Efforts**
  - Collect or provide T&E requirements
  - Perform planning, scheduling, and execution
  - Conduct testing
  - Perform integration
  - Develop products
- **Funding Similar Efforts for Different Ship Classes**
  - Duplicating key component of systems

Redundant facilities and infrastructure are significant budget drivers

Duplicate Processes Example

Current State



Ideal State

Development Suite	Development and Integration Test Lab	Shipboard Representative Systems	At-Sea Testing

MDA: Missile Defense Agency
PEO: Program Executive Office
IWS: Integrated Warfare Systems
LMW: Littoral Mine and Warfare

BMD: Ballistic Missile Defense
SSDS: Ship Self-Defense System
INSURV: Inspection and Survey

Future State

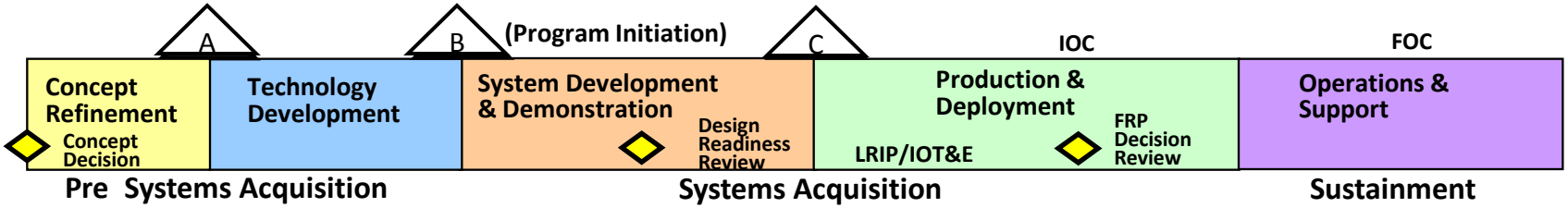
- **Reduce TOC by Better Coordinating Facilities and Infrastructures**
- **SET&E Introduces a Process for Coordinating Facilities and Infrastructures**
  - **Integrated test team**
    - **Understand task, schedule, requirements**
    - **Move toward common processes and automation**
    - **Blend at-sea and land-Based test teams**
  - **Consolidated test facilities and test approach**
    - **One development site**
    - **One integration site**
    - **One configuration management site**
    - **Consistent tools**

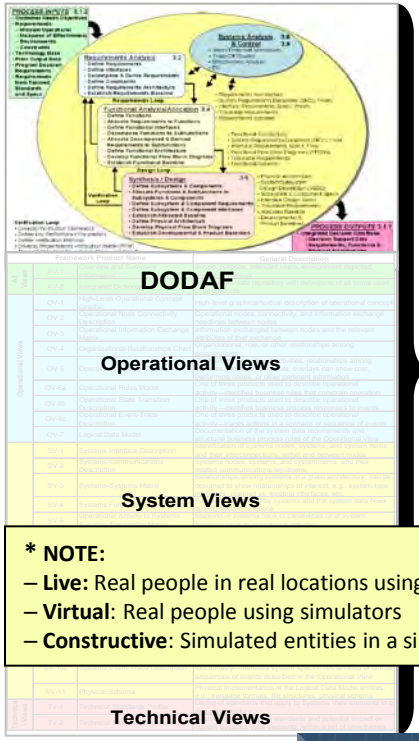
The teams should design, develop, and test with active customer participation.

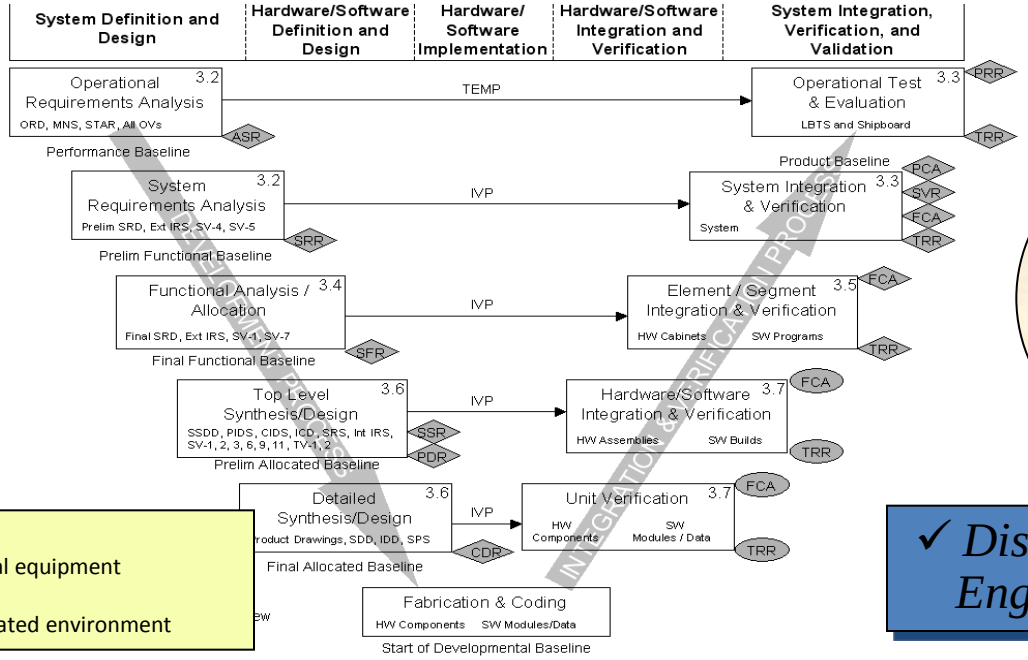
Leverage Systems Engineering Process Changes To Affect Test Process and Approach

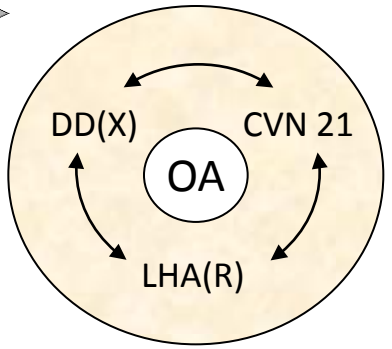
**Test like you fight through application of live, virtual and constructive test and training environments*

Test & Evaluation Policy Revisions Memo dated 22 Dec 07









*** NOTE:**
- **Live:** Real people in real locations using real equipment
- **Virtual**: Real people using simulators
- **Constructive**: Simulated entities in a simulated environment

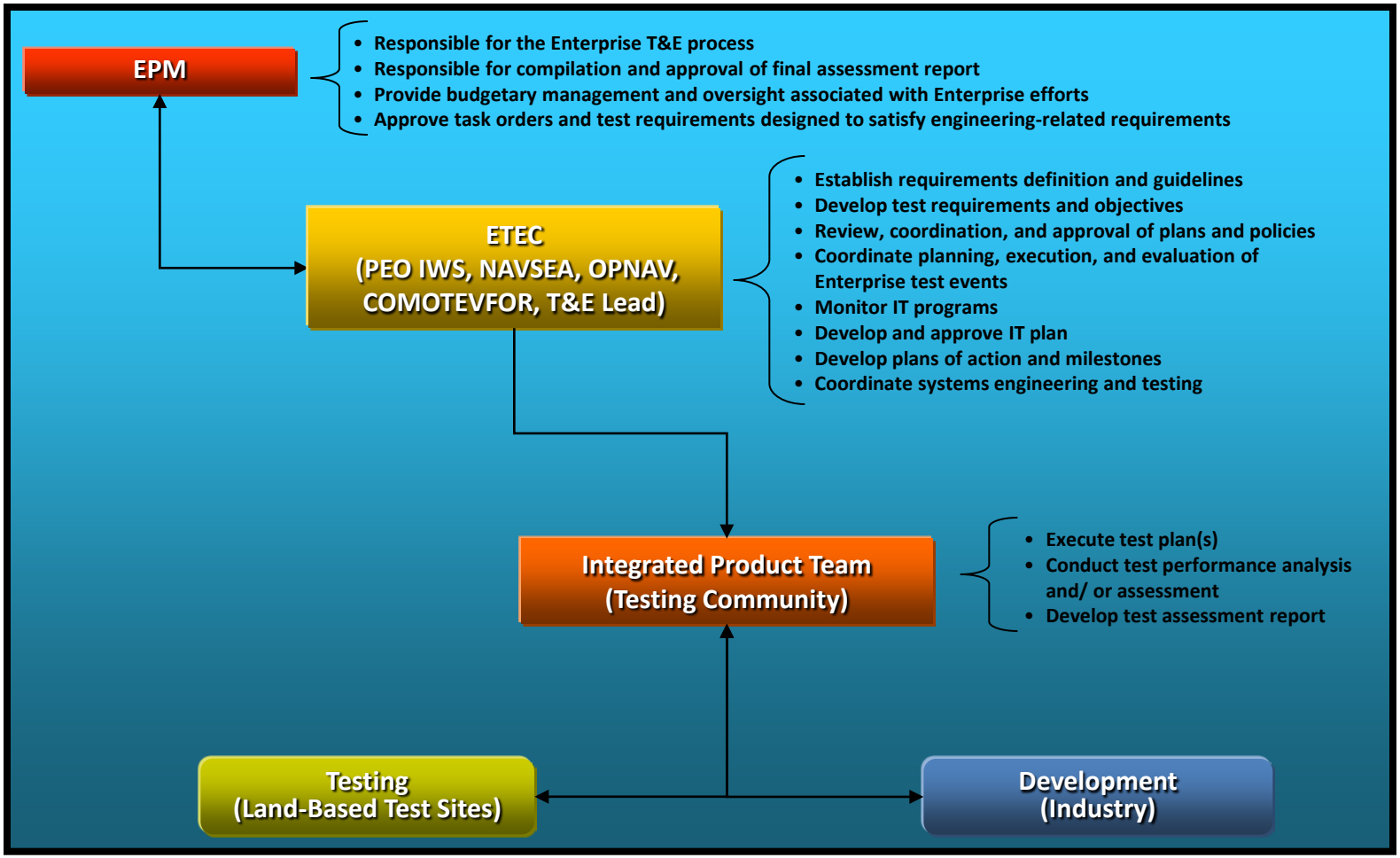
✓ *Disciplined Systems Engineering Process*

Excerpted and modified from Proceedings of the First Annual NCOSE Conference, Forsberg and Mooz, 1990; and Visualizing Project Management, Forsberg, Mooz, Cotterman , ©2000 by John Wiley & Sons, Inc.

We must change from an approach that is optimized by program and platform to one that can solve the challenges of integrated systems that cross many platforms and functions

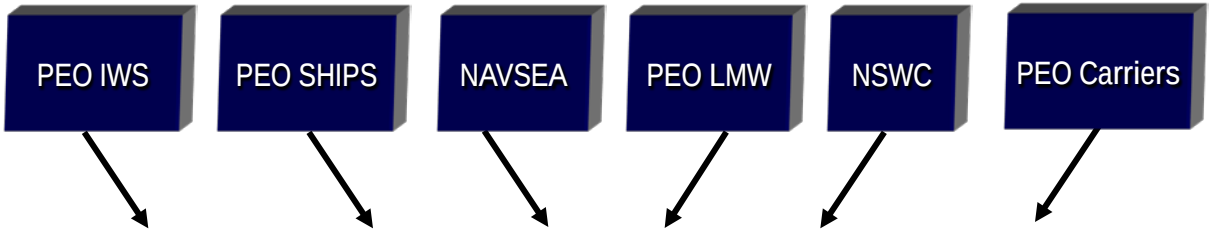
ASN(RDA) Reorganization Message dated November 11, 2002

Proposed SET&E Process

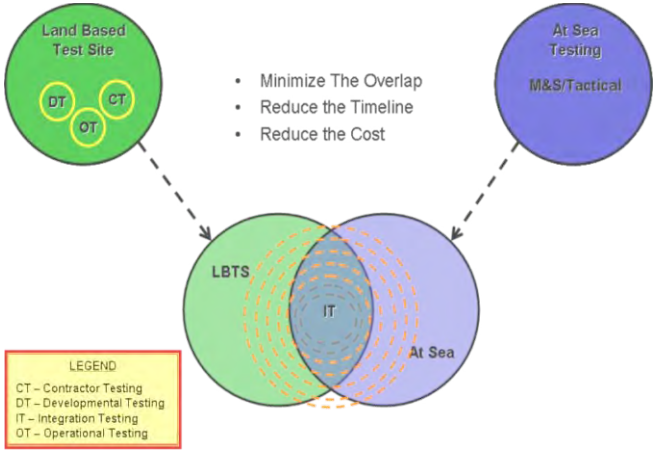


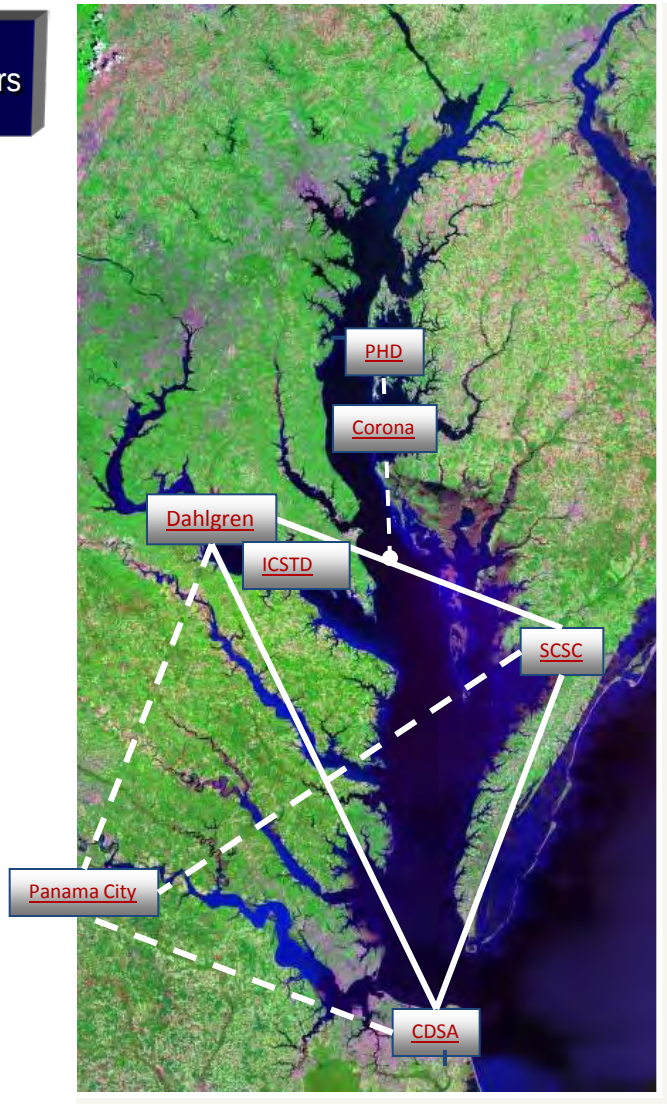
Effective test engineering across the surface Navy enterprise

SET&E Participants



- Single Team for Warfare/Combat System
  - Providing Integration Support and Evaluation of Key Warfare System Elements
  - Land Based Testing and Certification
    - Facilitate *unified* overall land-based test efforts
    - Develop and execute configuration management plan
    - Partner with SCSC, CDSA, Corona, ICSTD
    - Supported by at-sea test team (PHD)
      - Surge to meet land-based test needs
      - Corona detachment at SCSC provides added analysis support
  - At-Sea Testing
    - Facilitate across the at-sea test efforts
    - Supported by land-based test team
      - Surge to meet at-sea needs



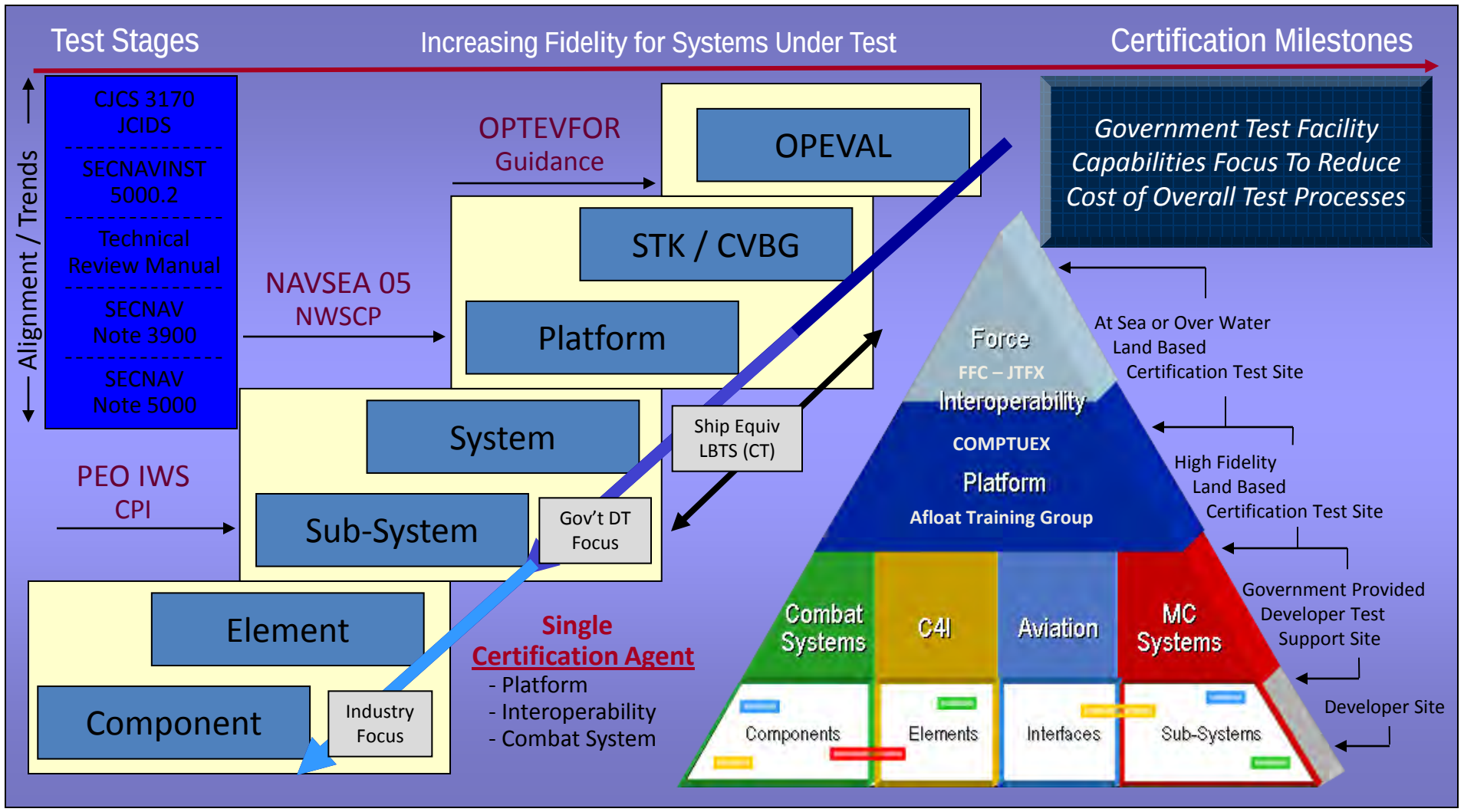


SET&E Products

- Enterprise T&E Instruction, in Compliance with Department of the Navy guidelines
  - Enterprise T&E goals and objectives
  - T&E guiding principles
  - DoD T&E process
- Enterprise T&E Plan of Action and Milestones
- Modeling and Simulation Master Plan
- Test Assessment Report
- Test Objectives
- Integrated Test Plan Document

NAVSEA
WARFARE CENTERS
DAHLGREN

Future State - A Fully Integrated Test Approach



Overarching Test Process Alignment To Cost Optimize Test Capabilities and Processes

Questions?

NORTHROP GRUMMAN

Systems Engineering and User Needs

Strategies and Tactics for the Evolving System Acquisition Environment

National Defense Industrial Association

13th Annual Systems Engineering Conference

October 27, 2010

Dr. W. David Reese, CSEP

Dr. Conrad B. Monson

Systems and Specialty Engineering

Northrop Grumman Electronic Systems

Agenda

NORTHROP GRUMMAN

- The Human Engineering (HE) element of Systems Engineering (SE)
- HE in the System Life Cycle
- Benefits of incorporating HE early
- Misperceptions of the value of HE
- Lessons learned from real programs
- HE in the multi-dimensional SE environment
- Summary

Human Engineering (HE) in Military Systems Acquisition*

NORTHROP GRUMMAN

- Involves engineering human interfaces to integrate personnel into the design and ensures user needs are considered throughout the system development process

- Often used synonymously with Human Factors Engineering
  - Understand the human factors or capabilities (i.e., cognitive, physical, sensory, and team dynamics)
  - Integrate capabilities into system design for optimal system performance
    - Characterize work to be performed
    - Create effective, efficient, and safe human hardware/software interfaces

- Encompasses Human Systems Integration (HSI)
  - Technical and management processes for integrating human considerations within and across all system elements
  - Focuses on key domains effecting humans including Human Factors, Manpower, Personnel, Training, Safety, Habitability, Survivability

* Adapted from Mil Standard 46855, Dept. of Defense Handbook *Human Engineering Program Process and Procedures*

User Needs – The Indispensible Compass for Systems Engineers

NORTHROP GRUMMAN

- All Engineering efforts can ultimately be traced to user needs
  …*and users tend to be human*

- Engineers can often be narrowly focused
  - Optimized solutions for a particular engineering discipline
  - Only a limited focus interfaces that integrate engineering disciplines
  - Lose sight of the global or overall perspective

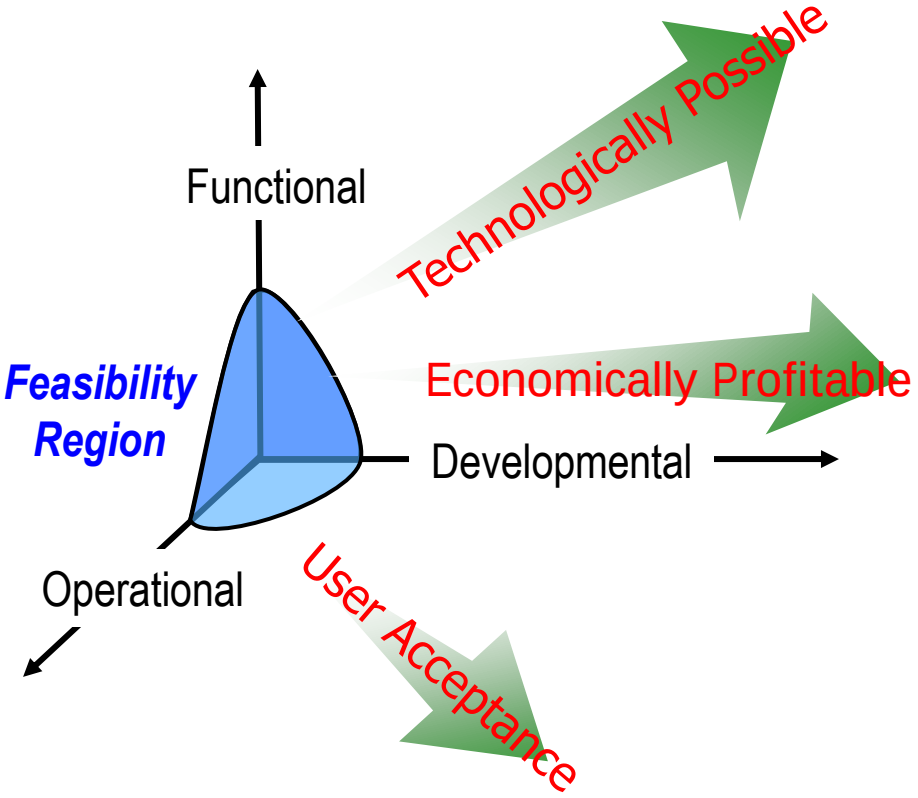
- System Engineering should optimize designs across engineering disciplines and multiple developmental dimensions

- Meeting user needs is key to driving correct design decisions
  - Human Engineering identifies those needs and helps develop designs to meet those needs

HE is Part of a Multi-dimensional Systems Engineering Approach

NORTHROP GRUMMAN

- Systems Engineers must address competing challenges across multiple engineering dimensions in seeking fully integrated designs
- HE effort to address user needs can often be shortchanged during the Developmental Phase because impacts are not seen until the Operational Phase



Benefits of incorporating HE early

NORTHROP GRUMMAN

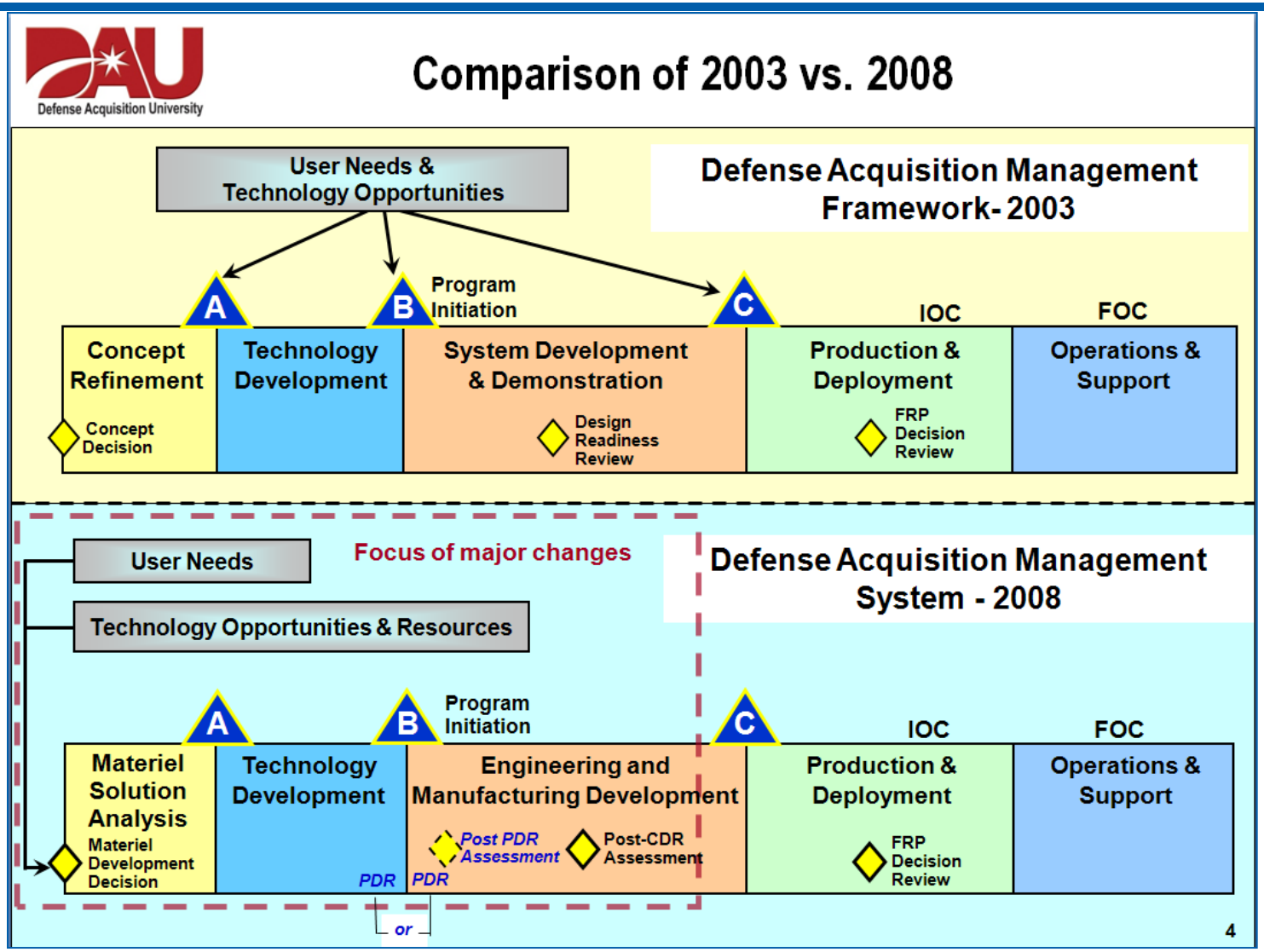
- Excluding user needs from early trades may —fatally flaw design decisions
- As system designs mature, changes to accommodate user needs become more costly
  - Significant re-work to address requirement failures and user dissatisfaction
- Although difficult to retro-fit systems after the fact, it may be necessary for legacy system extensions or reuse in new systems—especially if legacy system did not adequately address user needs in its design

Misperceptions About the Value of HE

NORTHROP GRUMMAN

- Customers, managers, business developers, and even end users will overlook the criticality of conducting HE early and in development
- Common misperceptions:
  - User needs cannot be understood until user performance data can be collected
  - Users can adapt to designs
  - More training will overcome deficient designs
  - Hardware and software engineers can adequately address user needs without support from HE specialists
- Primary HE challenge: Stakeholder buy-in to commit finite project resources to HFE
  - Stakeholders should have accurate estimates of LCC associated with meeting user needs
  - Stakeholders need to understand risks associated with delaying HE efforts

DoD Acquisition Focus on Up Front User Needs



*Source: Bradford Brown, *DoD Instruction 5000.02 Operation of the Defense Acquisition System Statutory and Regulatory Changes*, 8 December 2008, Defense Acquisition University

HSI Mandate from DoD

NORTHROP GRUMMAN

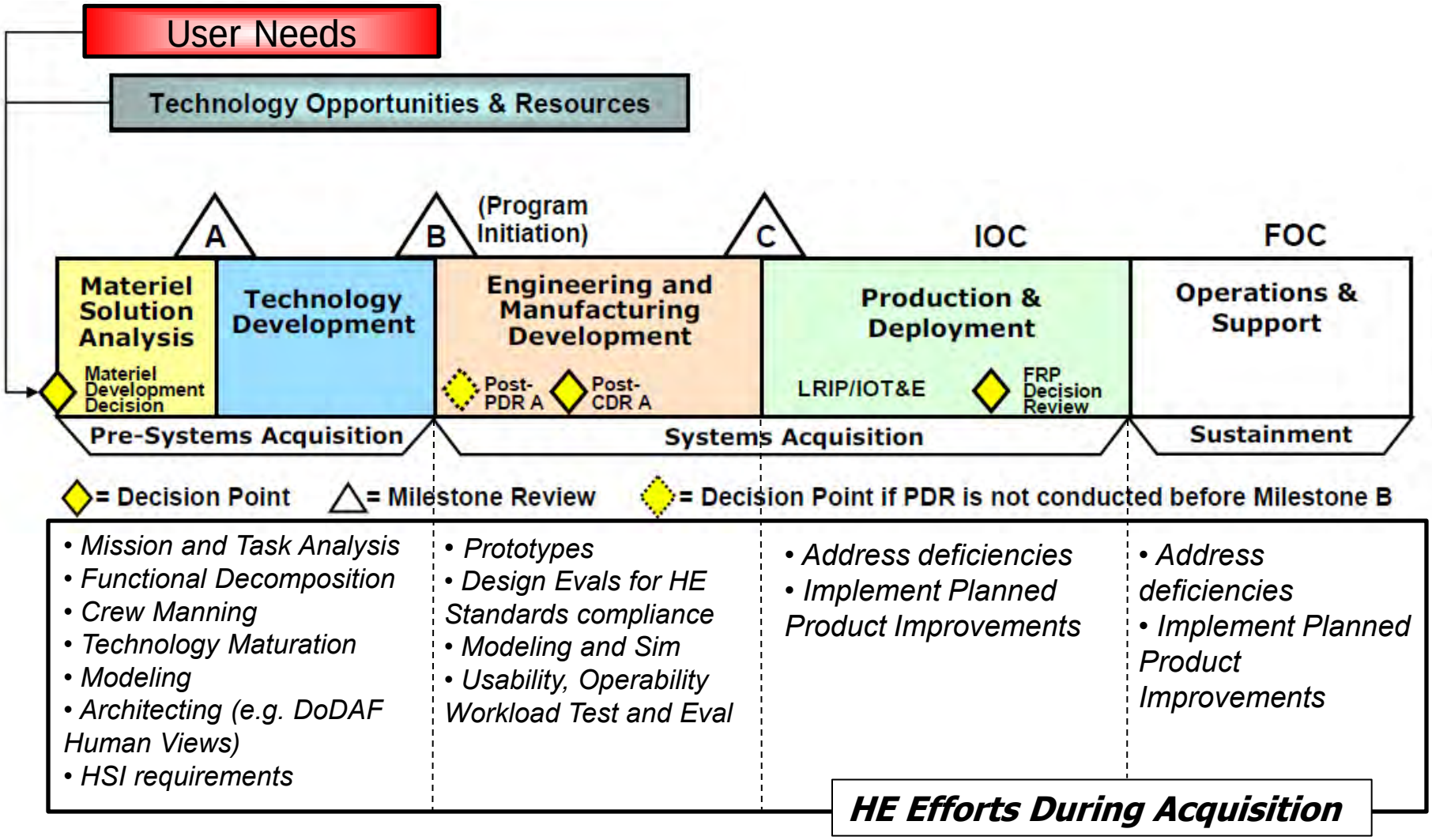
Department of Defense

INSTRUCTION NUMBER 5000.02 December 8, 2008

USD(AT&L) SUBJECT: Operation of the Defense Acquisition System

'The PM shall have a plan for HSI in place early in the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system" (from Enclosure 8)

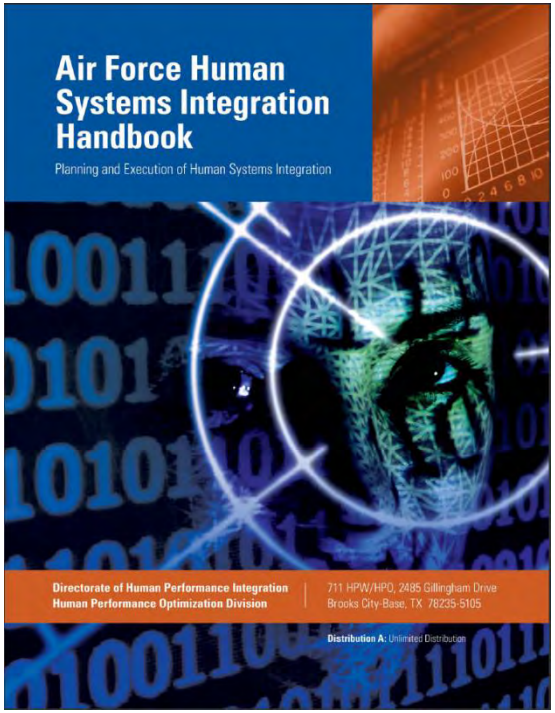
HE Activities Within the Acquisition Process



Source: Enclosure 2, DoDI 5000.02, December 8, 2008

HE Benefits to Life Cycle Costs

- Air Force estimated that after a system is fielded, 80% of all LCC are related to Human System Integration
  - 40-60% are related to Manpower, Personnel and Training
- Ensuring user needs are addressed early in the design could
  - Dramatically reduce LCC
  - Ensure LCCs are not unnecessarily inflated
    - e.g., Greater numbers of maintainers needed to cover deficiencies in design



"Because human performance exerts such a significant effect on system effectiveness, the only question is whether HSI will be paid for most affordably in advance, or at much greater expense after a newly fielded system reveals significant problems."

Source: U.S. Air Force Human Systems Integration Handbook, Sept 16, 2008

Human Engineering in Current Programs

NORTHROP GRUMMAN

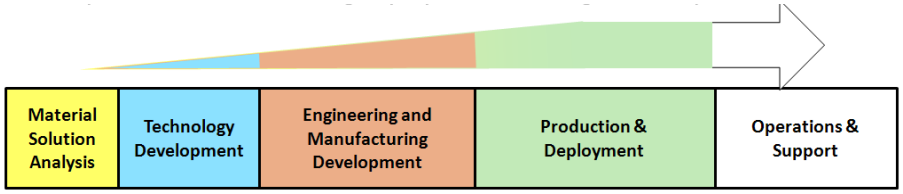
- Recent experience on a variety of sensor system programs highlighted the multi-dimensional context of the HE effort
  - Spanned several acquisition phases (Full EMD to small IRAD development efforts)

- Experience showed understanding user needs was one key to success
  - If that understanding is not part of an HE effort early in the development process, it must be obtained at greater expense later
  - “Standard” HE practices had to be tailored to address HE constraints and ensure user needs are addressed
- Relatively small HE efforts can help avoid costly oversights
  - Developed a “70%” solution via agile process utilizing on-call HE expertise as needed

Program #1 – Full Engineering and Manufacturing Development Effort

NORTHROP GRUMMAN

Life Cycle Focus (bias towards later phases)



Tailored HE Effort

- Through performance modeling and extensive stakeholder involvement, addressed user needs even though late in development
  - Identified within-scope GUI redesigns
- Performed extensive usability, operability and workload testing

Description and Constraints

- SoS Development
  - Added new missions and more demanding operator conditions to legacy missions
  - Added new sensors to increase fidelity, amount and timeliness of data
- HE Constraints
  - Heavy legacy component reuse
  - Limited HE in early development

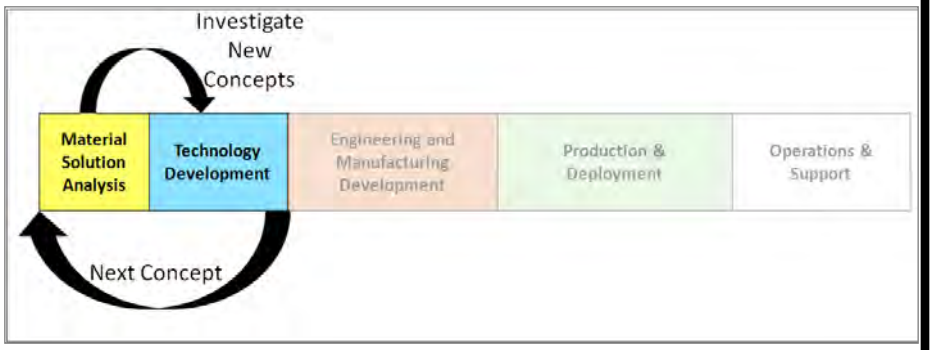
Results and Lessons Learned

- Predicting operator performance through modeling was essential to influencing design decisions
- Extensive stakeholder involvement through formal and informal meetings helped identify GUI modifications that would support usability and would be acceptable to operators

Program #2 – Applied Research to Create System Enhancements

NORTHROP GRUMMAN

Life Cycle Focus



Tailored HE Effort

- HE effort potentially benefited primarily R&D developers and analysts
- GUIs could improve efficiency of complicated or often repeated R&D-related tasks
- Visualization of data processing (e.g., missile tracks across a globe) could significantly aid developers in understanding code behavior

Description and Constraints

- R&D lab evaluating utility of new sensors and algorithms for missile defense
- HE constraints or unique attributes
  - Focused on rapid prototyping, evaluation and analysis (no need for highly polished interfaces optimized for time or accuracy)
  - System, per se, never stops evolving
  - R&D advances, when operationalized, become part of a highly automated system within a larger SoS
  - Little or no operator interactivity

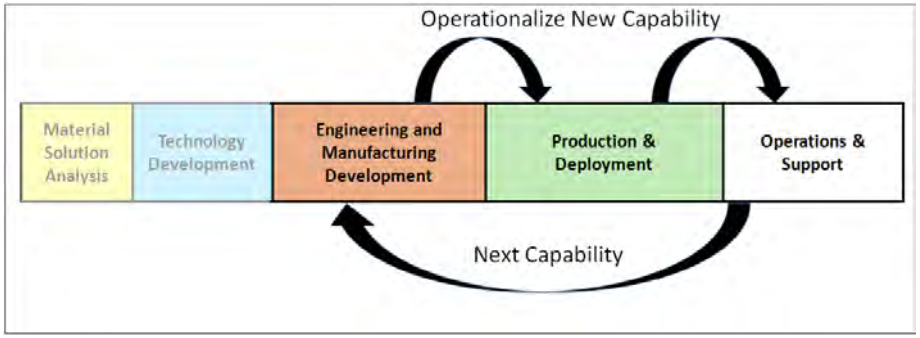
Results and Lessons Learned

- GUIs and visualization tools were ultimately incorporated into the R&D environment, but their earlier introduction would have yielded even greater benefit
- Systems Engineers must consider potential contributions of HE early and often, even in development of system enhancements involving little end user/operator interactivity

Program #3 –Rapid Deployment of System Enhancements to the Operational Environment

NORTHROP GRUMMAN

Life Cycle Focus



Tailored HE Effort

- Customer amenable to HE enhancements
- HE efforts would primarily benefit developers, maintainers and analysts
- GUIs could be developed to reduce errors associated with complicated maintenance tasks

Description and Constraints

- Operationalize* use of new sensors and algorithms for missile defense
- HE constraints or unique attributes
  - Little or no operator interactivity
  - Part of a highly automated system within a larger SoS
  - System stability, maintainability and robustness of paramount importance
  - Limited customer requirements for tangible HE artifacts

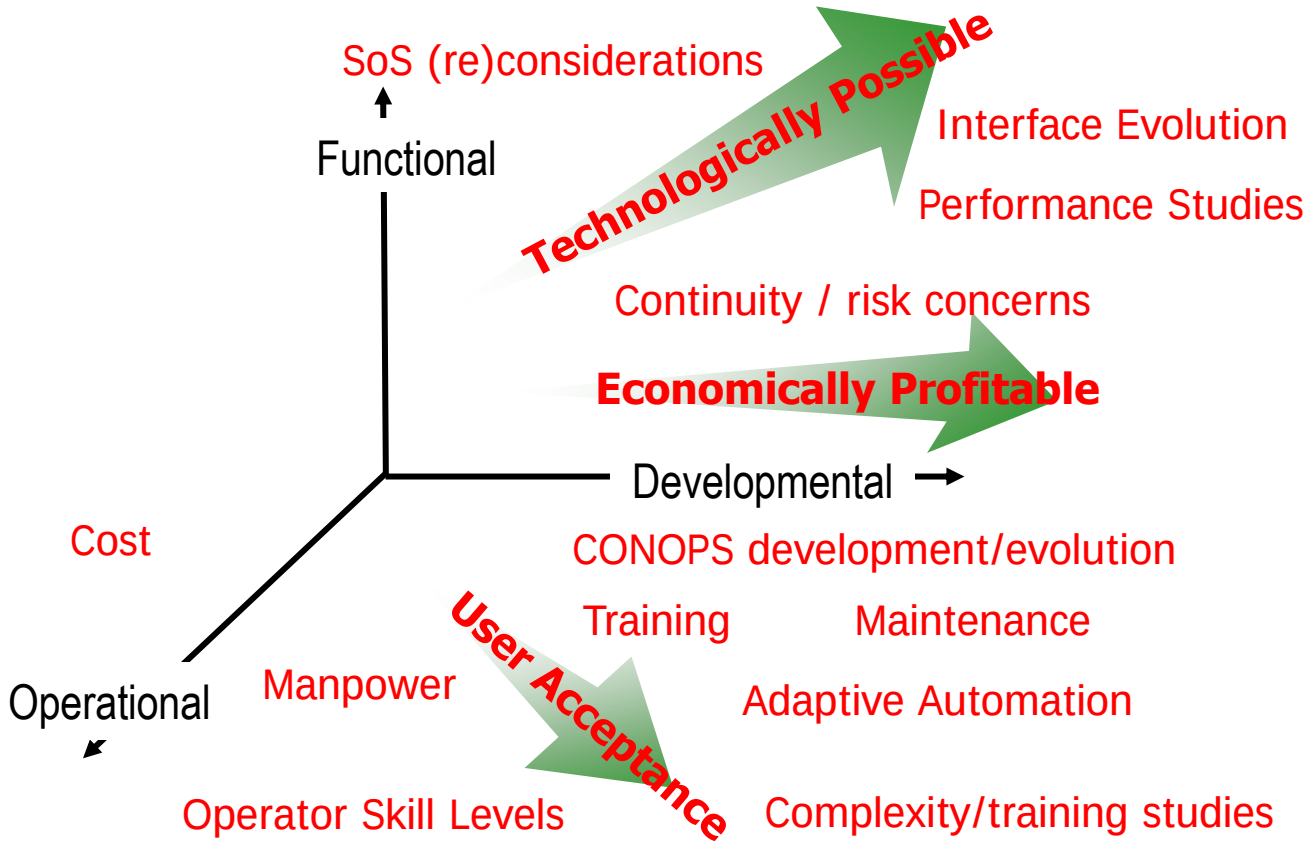
Results and Lessons Learned

- GUIs, primarily geared toward system maintainers, were agreed to by the customer and incorporated into deliveries—however, lack of involvement by HE domain experts resulted in designs that violated some HE interface guidelines
- GUIs were also used to more efficiently accomplish V&V
- HE can add surprising value to system design and development—even in highly automated systems

* test, harden and document prototype code, V&V, and integration with other SoS components

HE Within the Multi-Dimensional Systems Engineering Perspective

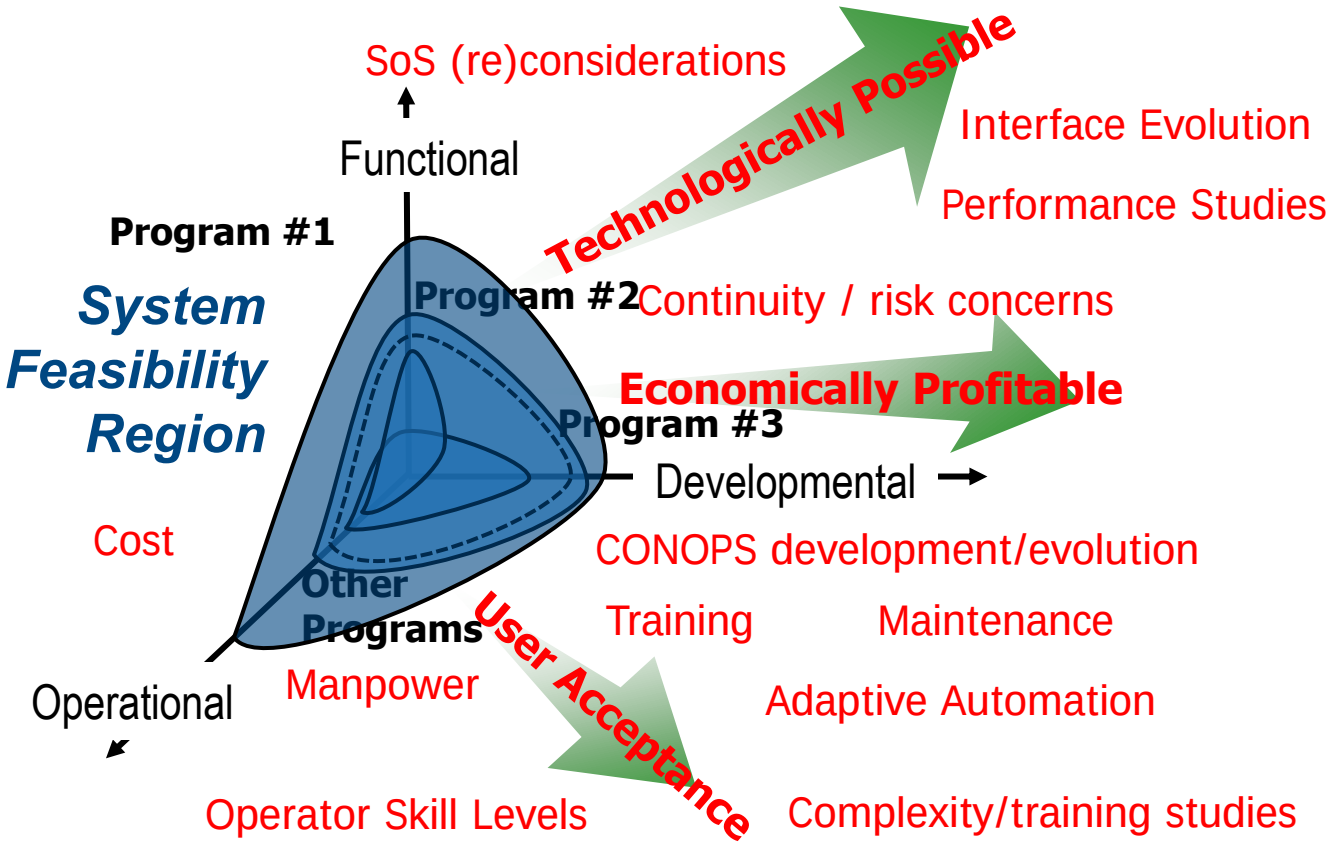
NORTHROP GRUMMAN



There are a full range of HE activities that can be conducted in each engineering dimension

HE Within the Multi-Dimensional Systems Engineering Perspective

NORTHROP GRUMMAN



HE effort in each dimension defines a System Feasibility Region that accounts for user needs

Summary

NORTHROP GRUMMAN

- HE is critical in satisfying user needs and adds the most value when applied early in a system's life cycle
- DoD acquisition process is increasing emphasis on early consideration of user needs and HE
- HE impacts each dimension of a systems engineering effort
- Automated systems benefit from HE
- Even small inputs from HE experts help avoid future design challenges

Headquarters U.S. Air Force

Integrity - Service - Excellence

Assessment of Human Systems Integration in Air Force Acquisition

U.S. AIR FORCE

NDIA Systems Engineering Conference
San Diego CA
27 October 2010

Col Larry Kimm
Mr. John Maziarz

U.S. AIR FORCE

Overview

- Air Force HSI Office (AFHSIO)
- Summary of Previous Work
- Current Effort
- Closing Comments

HSI
HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

AFHSIO Objectives

- Integrate HSI into functional domains
  - Into the AT&L life cycle management framework
  - Build AF team to equip, enhance, sustain the warfighter
- Institutionalize HSI as a way of doing business
  - Increase total system performance
  - Decrease total ownership costs
- Sustain HSI in systems acquisition
  - Collaboration w/ OSD, Sister Services, Industry and Academia
  - Improve support to programs
- Improve HSI
  - Feedback and lessons learned from the operational, logistics and acquisition communities
  - Demonstrate value added to the Air Force

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

AFHSIO's Role in Meeting HSI Objectives

- Facilitate and advocate integration of HSI into the Integrated Life Cycle Management (ILCM) framework and AF policies and guidance to comprehensively implement, assess, and improve HSI
- Develop and deliver comprehensive HSI education and training, tools, technology and methods to support Program Executive Officers (PEO), Program Managers (PM), Systems Engineers, and others involved in requirements development, acquisition and sustainment
- Provide expert advice, real-time assistance, and implementation strategies of HSI
- Support the development, communication and implementation of HSI initiatives

HSI
HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

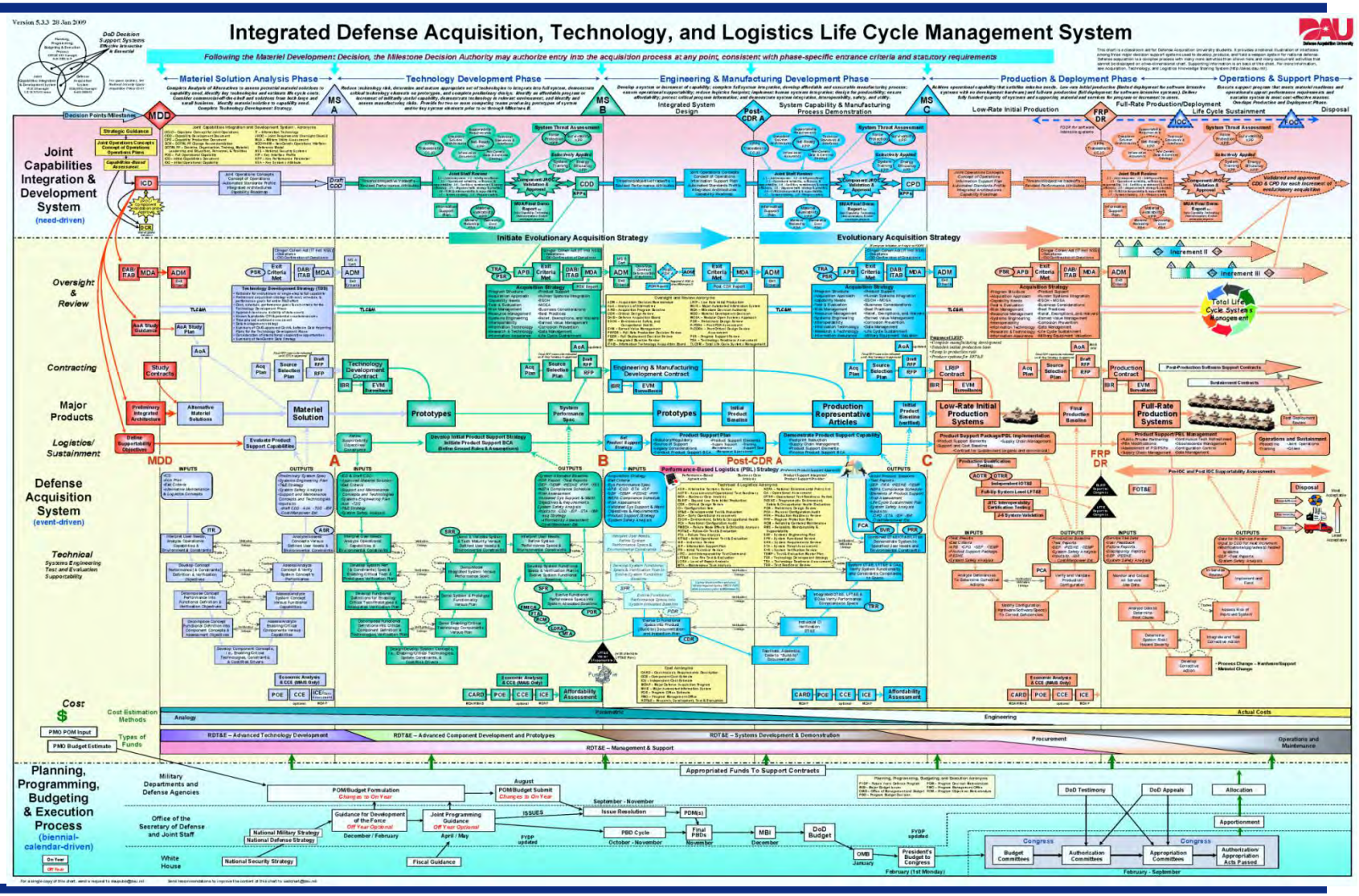
Summary of Previous Work

- Objective: Integrate HSI considerations and processes into the Acquisition, Technology and Logistics Life Cycle Management Framework to equip and sustain Airmen
- Develop a product to:
  - Facilitate systems engineers' understanding of what HSI domain experts bring to the table
  - Help HSI domain experts understand their role in the acquisition process
  - Assist domain and systems engineering integration on HSI issues

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Take this…



U.S. AIR FORCE

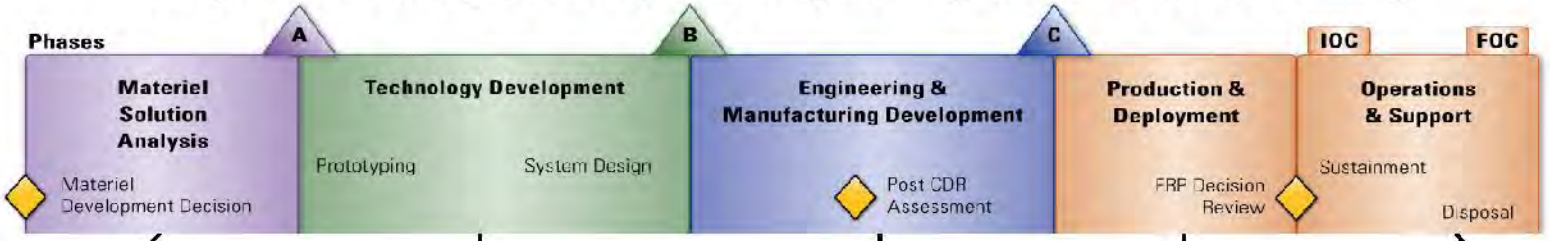
…and this…

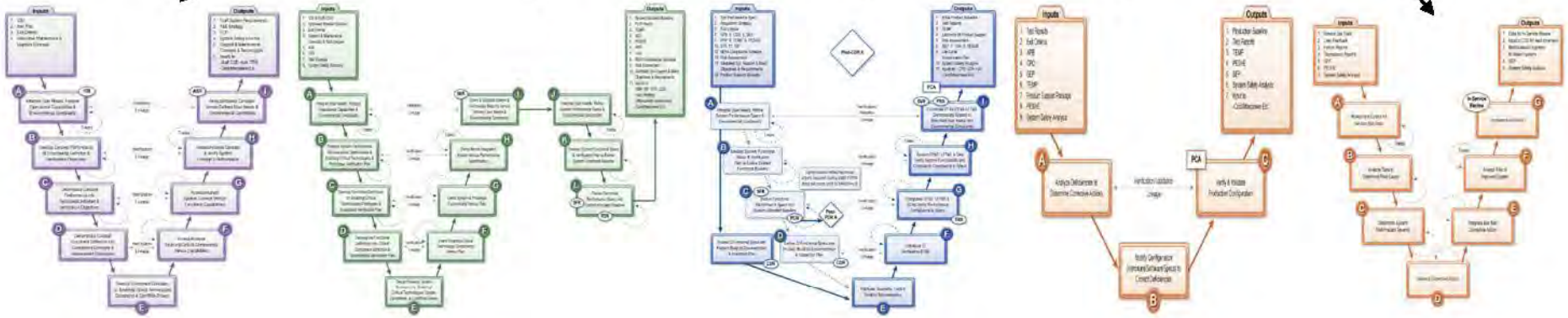
1. Manpower
2. Personnel
3. Training
4. Environment
5. Safety
6. Occupational Health
7. Human Factors
8. Survivability
9. Habitability

HSI HUMAN SYSTEMS INTEGRATION

…and do this!

Acquisition Life Cycle and Systems Engineering Technical Review Timing





U.S. AIR FORCE

Current Effort

- Direct application of previous HSI in Acquisition effort.
- Develop framework for identifying HSI related risks – process and product assessment. Examine in greater detail Air Force acquisition processes for life cycle management, systems engineering, and test and evaluation.
- Develop templates to aid in the implementation and subsequent assessment of HSI considerations in the acquisition and sustainment processes.
  - Air Force Life Cycle Management Plan (LCMP).
  - Systems Engineering Plan (SEP).
  - Test and Evaluation Strategy / Test and Evaluation Master Plan (TES / TEMP).
- Tie information to an executive dashboard – Status Board.

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Current Effort (continued)

- Carried out in conjunction and collaboration with the Air Force Research Laboratory's 711th Human Performance Wing
  - Investigate program management, systems engineering, and test and evaluation processes, policies, and guidance
  - Provide recommendations for inserting HSI language into these processes, policies, and guidance
  - HSI life cycle planning and execution integrated with three major acquisition domains
    - Program management – LCMP – life cycle program planning and execution
    - Systems engineering – SEP – life cycle system design and development
    - Test and Evaluation (T&E) – TES / TEMP – life cycle verification and validation

HSI HUMAN SYSTEMS INTEGRATION

AF Life Cycle Management Plan

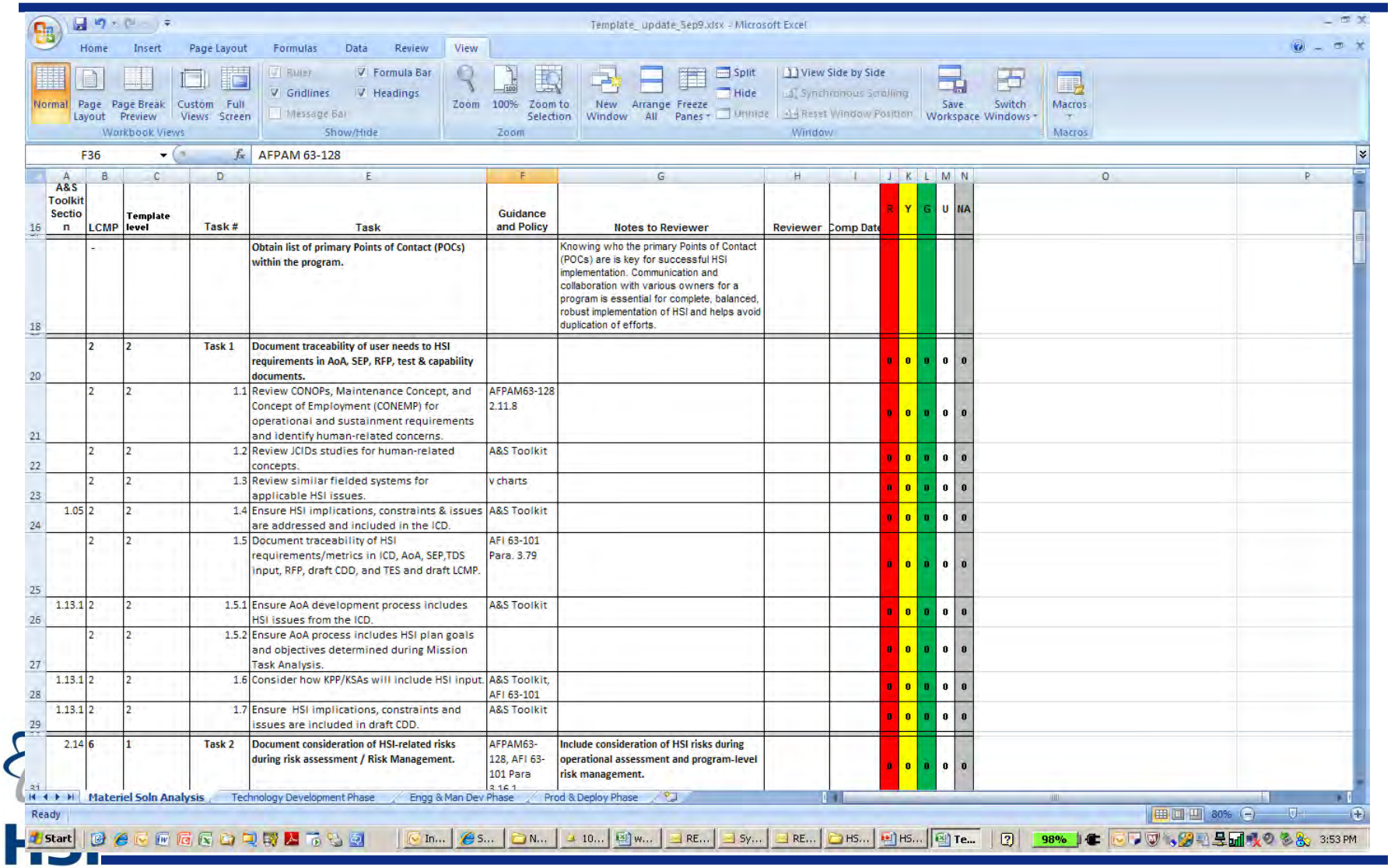
U.S. AIR FORCE

- **Document Purpose: The Life Cycle Management Plan (LCMP) is the integrated acquisition and sustainment strategy for the life of a system.**

HSI HUMAN SYSTEMS INTEGRATION

LCMP Template Screen Shot

U.S. AIR FORCE



Template_update_Sep9.xlsx - Microsoft Excel

Home | Insert | Page Layout | Formulas | Data | Review | View

Normal | Page Layout | Page Break Preview | Custom Views | Full Screen — Workbook Views

Ruler | Gridlines | Message Bar | Formula Bar | Headings — Show/Hide

Zoom | 100% | Zoom to Selection — Zoom

New Window | Arrange All | Freeze Panes | Split | Hide | Unhide | View Side by Side | Synchronous Scrolling | Reset Window Position | Save Workspace | Switch Windows — Window

Macros — Macros

F36 | AFPAM 63-128

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
16	A&S Toolkit Section	LCMP	Template level	Task #	Task	Guidance and Policy	Notes to Reviewer	Reviewer	Comp Date	R	Y	G	U	NA		
18		-			**Obtain list of primary Points of Contact (POCs) within the program.**		Knowing who the primary Points of Contact (POCs) are is key for successful HSI implementation. Communication and collaboration with various owners for a program is essential for complete, balanced, robust implementation of HSI and helps avoid duplication of efforts.									
20		2	2	Task 1	**Document traceability of user needs to HSI requirements in AoA, SEP, RFP, test & capability documents.**					0	0	0	0	0		
21		2	2	1.1	Review CONOPs, Maintenance Concept, and Concept of Employment (CONEMP) for operational and sustainment requirements and identify human-related concerns.	AFPAM63-128 2.11.8				0	0	0	0	0		
22		2	2	1.2	Review JCIDs studies for human-related concepts.	A&S Toolkit				0	0	0	0	0		
23		2	2	1.3	Review similar fielded systems for applicable HSI issues.	v charts				0	0	0	0	0		
24	1.05	2	2	1.4	Ensure HSI implications, constraints & issues are addressed and included in the ICD.	A&S Toolkit				0	0	0	0	0		
25		2	2	1.5	Document traceability of HSI requirements/metrics in ICD, AoA, SEP,TDS input, RFP, draft CDD, and TES and draft LCMP.	AFI 63-101 Para. 3.79				0	0	0	0	0		
26	1.13.1	2	2	1.5.1	Ensure AoA development process includes HSI issues from the ICD.	A&S Toolkit				0	0	0	0	0		
27		2	2	1.5.2	Ensure AoA process includes HSI plan goals and objectives determined during Mission Task Analysis.					0	0	0	0	0		
28	1.13.1	2	2	1.6	Consider how KPP/KSAs will include HSI input.	A&S Toolkit, AFI 63-101				0	0	0	0	0		
29	1.13.1	2	2	1.7	Ensure HSI implications, constraints and issues are included in draft CDD.	A&S Toolkit				0	0	0	0	0		
31	2.14	6	1	Task 2	**Document consideration of HSI-related risks during risk assessment / Risk Management.**	AFPAM63-128, AFI 63-101 Para 3.16.1	**Include consideration of HSI risks during operational assessment and program-level risk management.**			0	0	0	0	0		

Materiel Soln Analysis | Technology Development Phase | Engg & Man Dev Phase | Prod & Deploy Phase

Ready | 80% | Start | 98% | 3:53 PM

HUMAN SYSTEMS INTEGRATION

Integrity - Service - Excellence

U.S. AIR FORCE

LCMP Findings

- Along with the SEP, the LCMP can serve as vehicle to formalize and ensure the coordination, communication, and connectivity between the traditionally functional Air Force responsibilities such as manpower, personnel, training, and environment, safety, and occupational health
- The LCMP can serve as an HSI check point for the program. It can help the program manager (who is ultimately responsible for HSI throughout the lifecycle) ensure that the appropriate level of HSI planning is incorporated throughout the program
- HSI-related risks should be clearly identified, included among the other risks managed by the Program Manager, and documented in the LCMP

HSI
HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

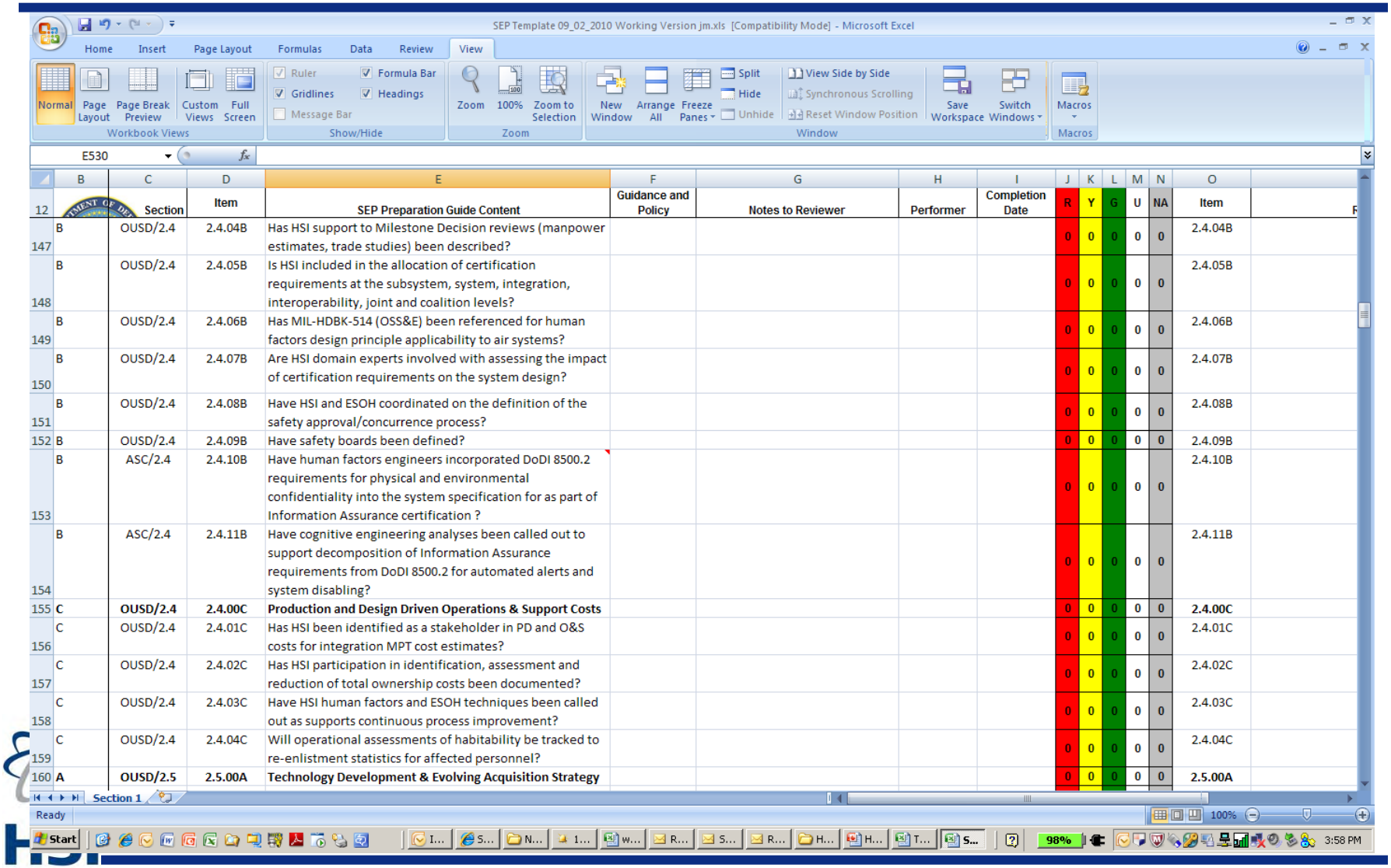
Systems Engineering Plan

- **Document Purpose: The purpose of the Systems Engineering Plan (SEP) is to help programs develop their systems engineering approach, providing a firm and well-documented technical foundation for the program. The SEP is a living document in which periodic updates capture the program's current status and evolving systems engineering implementation and its relationship with the overall program management effort.**

HSI HUMAN SYSTEMS INTEGRATION

SEP Template Screen Shot

U.S. AIR FORCE



	B	C	D	E	F	G	H	I	J	K	L	M	N	O
12		Section	Item	SEP Preparation Guide Content	Guidance and Policy	Notes to Reviewer	Performer	Completion Date	R	Y	G	U	NA	Item
147	B	OUSD/2.4	2.4.04B	Has HSI support to Milestone Decision reviews (manpower estimates, trade studies) been described?					0	0	0	0	0	2.4.04B
148	B	OUSD/2.4	2.4.05B	Is HSI included in the allocation of certification requirements at the subsystem, system, integration, interoperability, joint and coalition levels?					0	0	0	0	0	2.4.05B
149	B	OUSD/2.4	2.4.06B	Has MIL-HDBK-514 (OSS&E) been referenced for human factors design principle applicability to air systems?					0	0	0	0	0	2.4.06B
150	B	OUSD/2.4	2.4.07B	Are HSI domain experts involved with assessing the impact of certification requirements on the system design?					0	0	0	0	0	2.4.07B
151	B	OUSD/2.4	2.4.08B	Have HSI and ESOH coordinated on the definition of the safety approval/concurrence process?					0	0	0	0	0	2.4.08B
152	B	OUSD/2.4	2.4.09B	Have safety boards been defined?					0	0	0	0	0	2.4.09B
153	B	ASC/2.4	2.4.10B	Have human factors engineers incorporated DoDI 8500.2 requirements for physical and environmental confidentiality into the system specification for as part of Information Assurance certification ?					0	0	0	0	0	2.4.10B
154	B	ASC/2.4	2.4.11B	Have cognitive engineering analyses been called out to support decomposition of Information Assurance requirements from DoDI 8500.2 for automated alerts and system disabling?					0	0	0	0	0	2.4.11B
155	**C**	**OUSD/2.4**	**2.4.00C**	**Production and Design Driven Operations & Support Costs**					0	0	0	0	0	**2.4.00C**
156	C	OUSD/2.4	2.4.01C	Has HSI been identified as a stakeholder in PD and O&S costs for integration MPT cost estimates?					0	0	0	0	0	2.4.01C
157	C	OUSD/2.4	2.4.02C	Has HSI participation in identification, assessment and reduction of total ownership costs been documented?					0	0	0	0	0	2.4.02C
158	C	OUSD/2.4	2.4.03C	Have HSI human factors and ESOH techniques been called out as supports continuous process improvement?					0	0	0	0	0	2.4.03C
159	C	OUSD/2.4	2.4.04C	Will operational assessments of habitability be tracked to re-enlistment statistics for affected personnel?					0	0	0	0	0	2.4.04C
160	**A**	**OUSD/2.5**	**2.5.00A**	**Technology Development & Evolving Acquisition Strategy**					0	0	0	0	0	**2.5.00A**

HUMAN SYSTEMS INTEGRATION

Integrity - Service - Excellence

U.S. AIR FORCE

SEP Findings

- HSI needs to be integrated throughout the SEP. A separate HSI Plan or SEP HSI appendix will lead to suboptimal outcomes.
- The Chief Engineer's responsibilities should explicitly include HSI.
- The HSI IPT needs to be adequately staffed in accordance with the human considerations (situational awareness, decision making, physical demands, operating) of the capability being developed.

HSI HUMAN SYSTEMS INTEGRATION

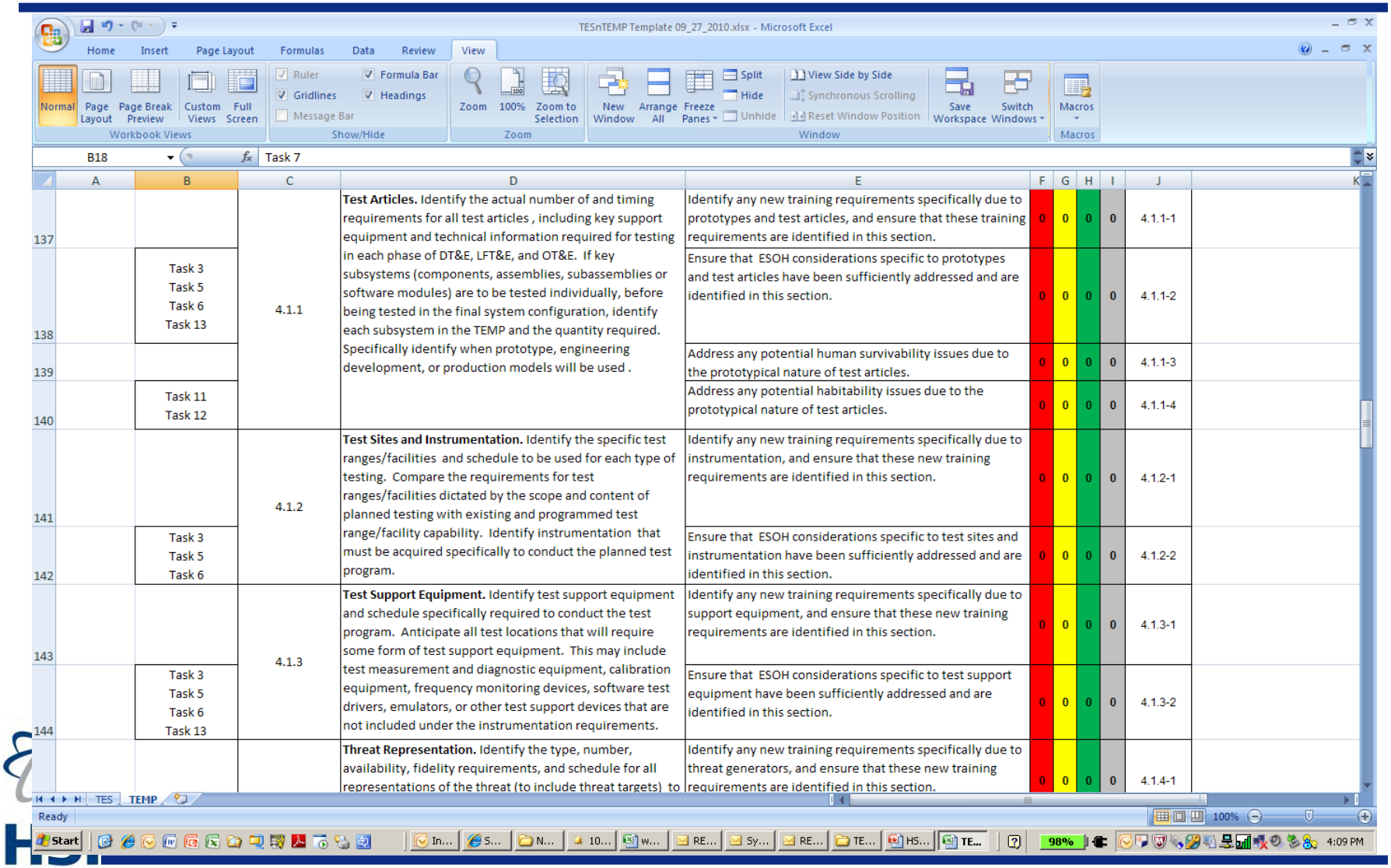
U.S. AIR FORCE

Test & Evaluation Strategy / Test & Evaluation Master Plan

- **Document Purpose: The Test and Evaluation Strategy (TES) describes the concept for tests and evaluations throughout the program life cycle, starting with Technology Development and continuing through Engineering and Manufacturing Development into Production and Deployment. It provides the basis for the Test and Evaluation Master Plan (TEMP). The TEMP describes the total test and evaluation planning from component development through operational test and evaluation into production and acceptance. It is an important document that identifies the required type and amount of test and evaluation events, along with their resource requirements.**

TES / TEMP Template Screen Shot

U.S. AIR FORCE



TESnTEMP Template 09_27_2010.xlsx - Microsoft Excel

Home | Insert | Page Layout | Formulas | Data | Review | View

Normal | Page Layout | Page Break Preview | Custom Views | Full Screen — Workbook Views

Ruler | Gridlines | Message Bar | Formula Bar | Headings — Show/Hide

Zoom | 100% | Zoom to Selection — Zoom

New Window | Arrange All | Freeze Panes | Split | Hide | Unhide | View Side by Side | Synchronous Scrolling | Reset Window Position | Save Workspace | Switch Windows — Window

Macros — Macros

B18 | Task 7

	A	B	C	D	E	F	G	H	I	J
137			4.1.1	**Test Articles.** Identify the actual number of and timing requirements for all test articles , including key support equipment and technical information required for testing in each phase of DT&E, LFT&E, and OT&E. If key subsystems (components, assemblies, subassemblies or software modules) are to be tested individually, before being tested in the final system configuration, identify each subsystem in the TEMP and the quantity required. Specifically identify when prototype, engineering development, or production models will be used .	Identify any new training requirements specifically due to prototypes and test articles, and ensure that these training requirements are identified in this section.	0	0	0	0	4.1.1-1
138		Task 3 Task 5 Task 6 Task 13			Ensure that ESOH considerations specific to prototypes and test articles have been sufficiently addressed and are identified in this section.	0	0	0	0	4.1.1-2
139					Address any potential human survivability issues due to the prototypical nature of test articles.	0	0	0	0	4.1.1-3
140		Task 11 Task 12			Address any potential habitability issues due to the prototypical nature of test articles.	0	0	0	0	4.1.1-4
141			4.1.2	**Test Sites and Instrumentation.** Identify the specific test ranges/facilities and schedule to be used for each type of testing. Compare the requirements for test ranges/facilities dictated by the scope and content of planned testing with existing and programmed test range/facility capability. Identify instrumentation that must be acquired specifically to conduct the planned test program.	Identify any new training requirements specifically due to instrumentation, and ensure that these new training requirements are identified in this section.	0	0	0	0	4.1.2-1
142		Task 3 Task 5 Task 6			Ensure that ESOH considerations specific to test sites and instrumentation have been sufficiently addressed and are identified in this section.	0	0	0	0	4.1.2-2
143			4.1.3	**Test Support Equipment.** Identify test support equipment and schedule specifically required to conduct the test program. Anticipate all test locations that will require some form of test support equipment. This may include test measurement and diagnostic equipment, calibration equipment, frequency monitoring devices, software test drivers, emulators, or other test support devices that are not included under the instrumentation requirements.	Identify any new training requirements specifically due to support equipment, and ensure that these new training requirements are identified in this section.	0	0	0	0	4.1.3-1
144		Task 3 Task 5 Task 6 Task 13			Ensure that ESOH considerations specific to test support equipment have been sufficiently addressed and are identified in this section.	0	0	0	0	4.1.3-2
				Threat Representation. Identify the type, number, availability, fidelity requirements, and schedule for all representations of the threat (to include threat targets) to	Identify any new training requirements specifically due to threat generators, and ensure that these new training requirements are identified in this section.	0	0	0	0	4.1.4-1

TES | TEMP

Ready

Start | 98% | 4:09 PM

HUMAN SYSTEMS INTEGRATION

Integrity - Service - Excellence

U.S. AIR FORCE

TES / TEMP Findings

- Air Force Test and Evaluation is sub-specialized by acquisition phase and product domain, making it difficult to uniformly integrate HSI into T&E.
- It is difficult, but not impossible, to write credible quantitative requirements and specifications that relate to a capability's human elements.
- T&E Personnel are familiar with methods and techniques for measuring human-related parameters, but requirements need to be in place.
- The T&E Framework provides an excellent opportunity to integrate HSI.

HSI
HUMAN SYSTEMS INTEGRATION

Top-Level Evaluation Framework Matrix

(DAG, Chapter 9 Notional Example)

U.S. AIR FORCE

Key Requirements and T&E Measures				Test Methodologies/Key Resources (M&S, SIL, MF, ISTF, HITL, OAR)	Decision Supported
Key Reqs	**COIs**	**Key MOEs/ MOSs**	**CTPs & Threshold**		
KPP#1:	**COI #1.** Is the XXX effective for…	**MOE 1.1.**	Engine thrust	Chamber measurement Observation of performance profiles OAR	PDR CDR
	COI #2. Is the XXX suitable for…		Data upload time	Component level replication Stress and Spike testing in SIL	PDR CDR
	COI #3. Can the XXX be…	**MOS 2.1.**			MS-C FRP
		MOE 1.3.			Post-CDR FRP
		MOE 1.4.	Reliability based on growth curve	Component level stress testing Sample performance on growth curve Sample performance with M&S augmentation	PDR CDR MS-C
KPP #2		**MOS 2.4.**	Data link		MS-C SR
KPP #3	**COI #4.** Is training….	**MOE 1.2.**		Observation and Survey	MS-C FRP
KSA #3.a	**COI #5.** Documentation	**MOS 2.5.**			MS-C FRP

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Closing Comments

- The effort to inculcate HSI guidance throughout acquisition processes will help to increase HSI awareness
- The templates are a new concept
  - They need refinement to make them more user-friendly
  - They need proof testing with program office subject matter experts before they can be used universally

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Final Questions?

HSI
HUMAN SYSTEMS
INTEGRATION

A Case Study of an Evolving ESOH Program – One Company's Perspective

A Presentation By:

General Dynamics – Electric Boat Corporation

Rick Milnarik – System Safety Engineering
Mike Parulis – Environmental Engineering

October 27, 2010

Presentation Agenda

- Objective
- Background Information
- An Evolving ESOH Program
- What…How…Who
- Examples
- Achievements
- Summary

Presentation Objectives

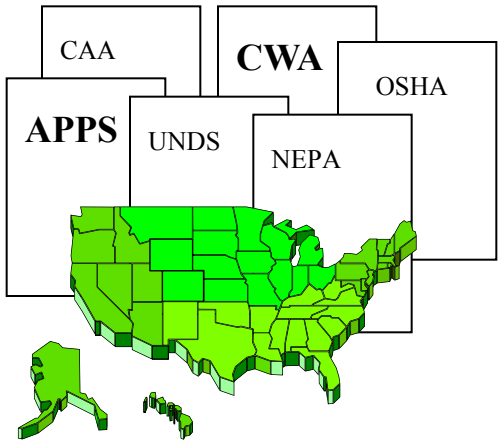
- Illustrate the evolution of the environment, safety & occupational health (ESOH) discipline and its place within Electric Boat.

- Emphasize that ESOH is part of an integrated systems approach, involving ESOH engineers, as well as shipyard, design and engineering organizations.

- Demonstrate, through a few examples, that ESOH is a natural fit in the Human System Integration (HSI) domain.

Background Information
Laws & Regulations Flowdown

Laws & Regulations



Department of Defense

INSTRUCTION

NUMBER 5000.02
December 8, 2008

USD(AT&L)

SUBJECT: Operation of the Defense Acquisition System

- **Ship Specifications**
- **Contract Requirements**
- **Program-specific HSI and ESOH Plans**

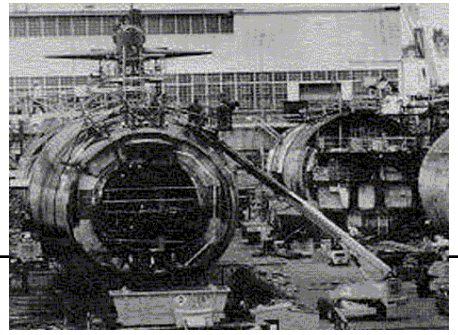
Background Information
The Life Cycle Approach

Operations

Manufacturing and Construction

DESIGN/BUILD/SUSTAIN

Maintenance and Overhaul



Ship and System Recycling/Disposal

Background Information - HSI Domains

Equips warfighters with the needed knowledge, skills & abilities

Training

Personnel Survivability

Provides that the warfighter will have all personal protection needed

Human Factors

Ensures that all aspects of the system are designed with full consideration of the inherent capabilities and limitations of the warfighter

Ensures that all aspects of the living and working spaces are designed with the warfighter in mind

Habitability

Environment

Design features that minimize the risks of illness, disability or death, and enhance job performance and productivity of the personnel that operate, maintain or support the system

System Safety

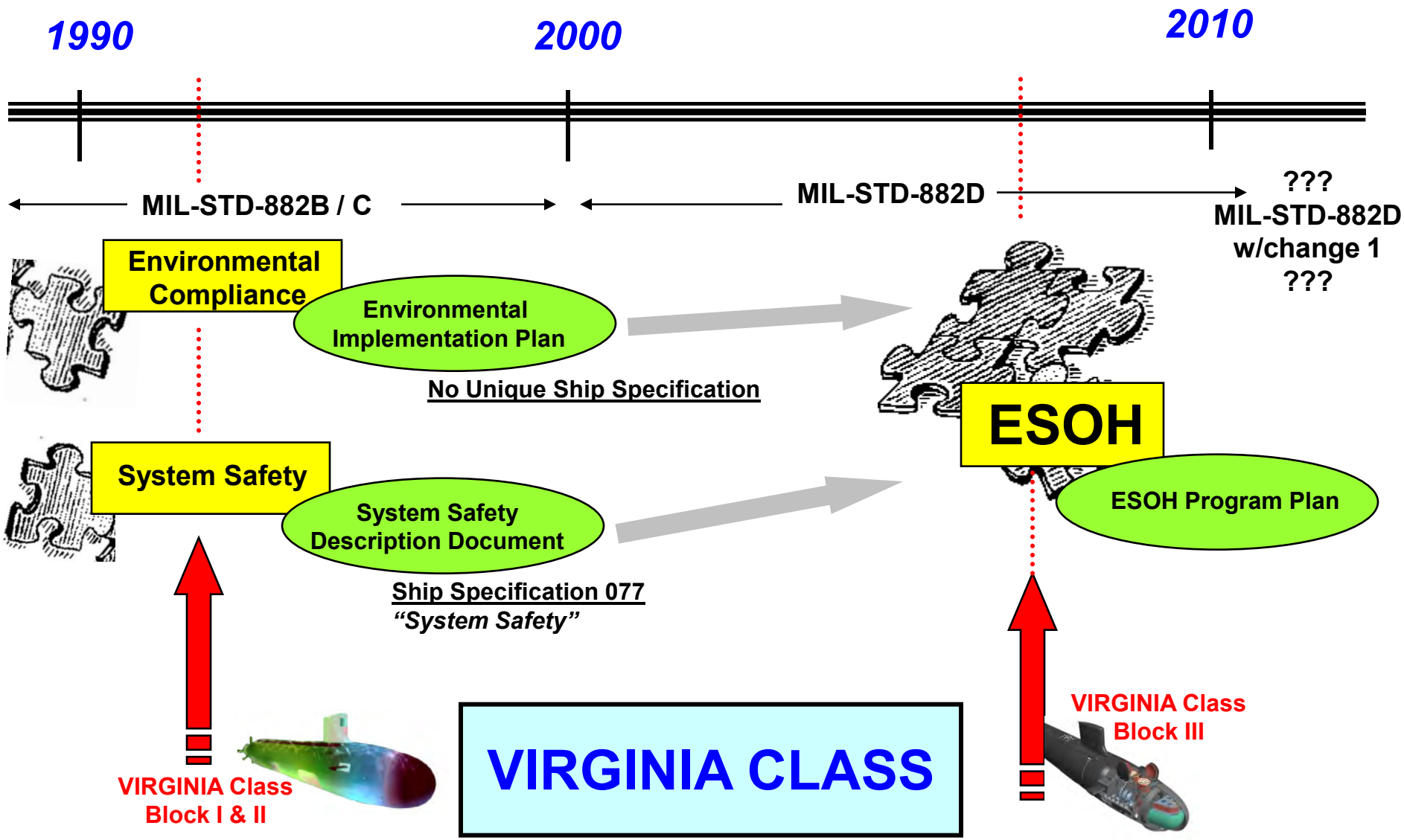
Occupational Health

Addresses all aspects of defining requirements for personnel as well as obtaining and retaining those individuals

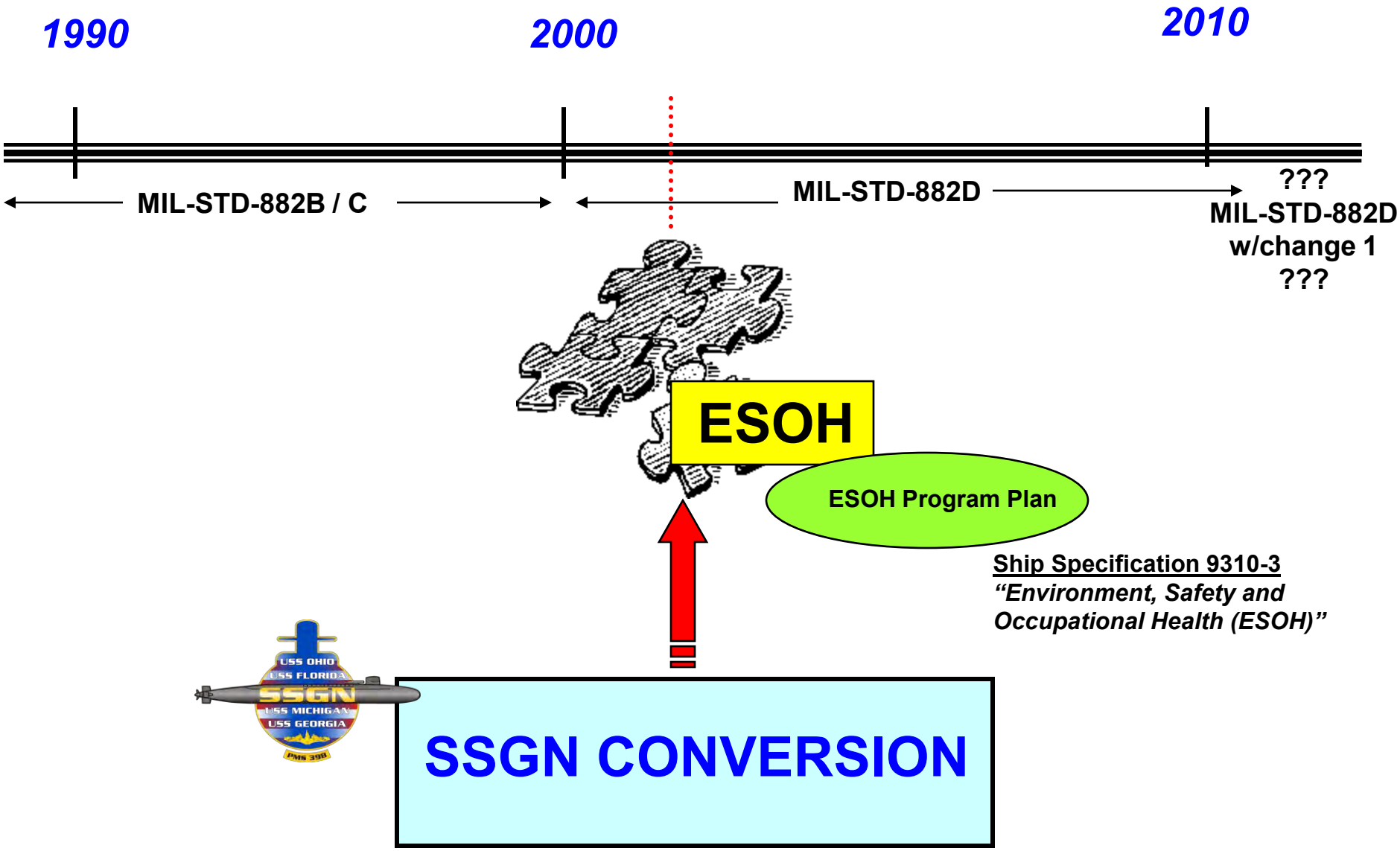
Personnel

Manpower

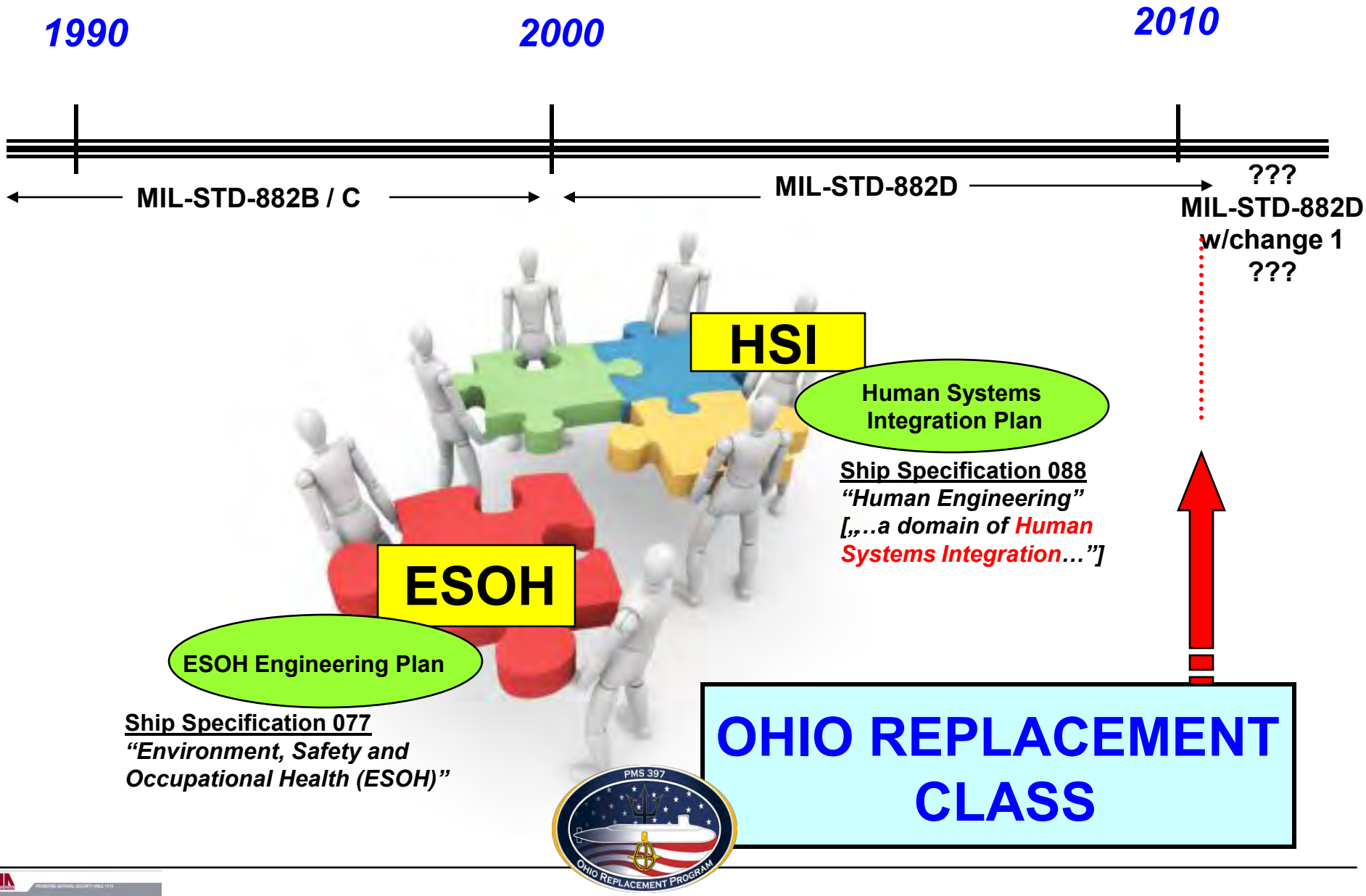
An Evolving ESOH Program – Overall Program Level Focus



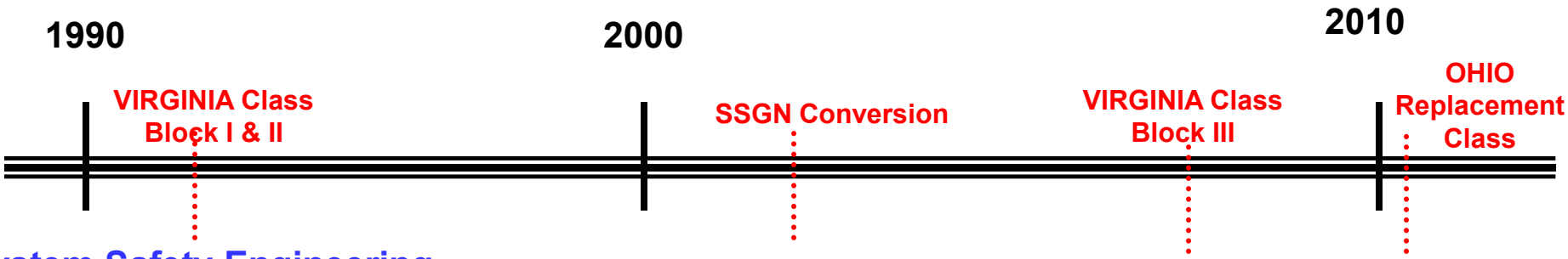
An Evolving ESOH Program – Overall Program Level Focus



An Evolving ESOH Program – Overall Program Level Focus



An Evolving ESOH Program – Organizational Structure



System Safety Engineering

D495 – TRIDENT Planning

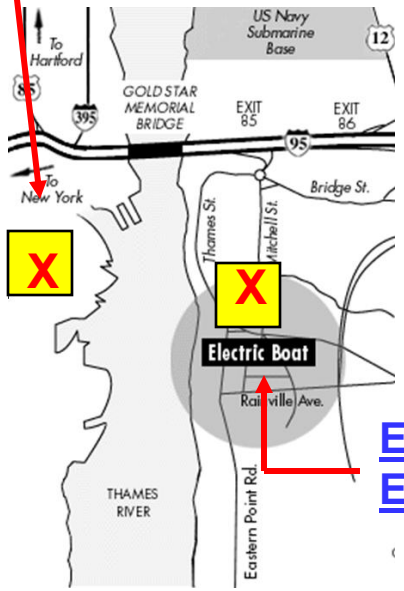
D428 – Electrical System Design

D411 – Life Cycle Engineering

Life Cycle Engineering

> Human System Engineering Programs

> RMA & ESOH



Human Factors Engineering

D427 – Power & Auxiliary System

D411 – Life Cycle Engineering

Environmental Engineering

D470 - Life Cycle Support

ESOH Engineering

ESOH Engineers are integrated into Design/Build/Sustain Teams to provide the ESOH perspective to help design out potential safety hazards and environmental impacts early in the design process.

Here's What ESOH Engineering Does…

Minimize / Eliminate Safety Hazards & Environmental Impacts:

- Carcinogens (lead, cadmium, beryllium, Cr^{+6})
- Mechanical/electrical/acoustic shock
- Ozone Depleting Substances -ODSs- (freon, 1,1,1-trichloroethane)
- Slips/trips/falls
- Volatile Organic Compounds -VOCs- (e.g., toluene, MEK, trichloroethylene)
- Ordnance detonation
- Toxic off-gassing products
- Unguarded rotating machinery

The Earlier in the Design that Hazards are Identified, the Easier it is to Implement Change in the Design

Here's How We Make It Happen...

Participate In Design Reviews and Product Development

Perform Hazard Analyses in Accordance With MIL-STD-882D

- Construction & Vendor Dwgs
- System Diagrams
- Test Procedures
- Standard Parts Library
- Tech Manuals & Ship System Manuals
- Planning Yard Alteration Work Packages

This Process Supports All Submarine Classes and Development Projects

Here's How We Make It Happen...

ESOH Filter Includes:

- Ship Spec Requirements
- NAVSEA Lists of Hazardous Materials
- Submarine Atmosphere Control Manual (ACM) Requirements
- Electric Boat SP 7-20 (Chemical Risk Reduction)
- Ammunition and Explosives Safety Regulations
- Human Engineering Design Standard Practice
- Weapon System Safety Guidelines Handbook

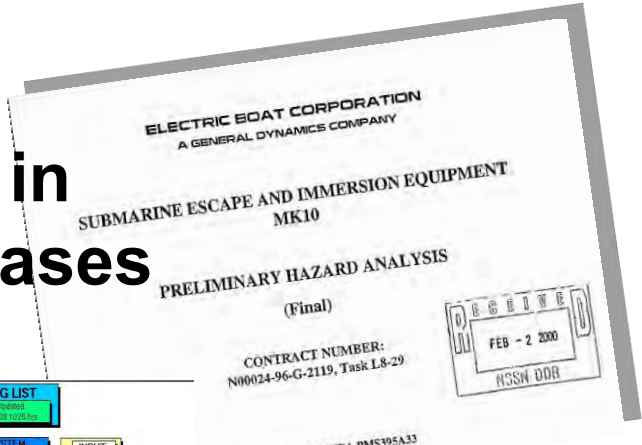
Identify ESOH Hazards and Mitigating Actions

- Environmental Impacts
- Safety Hazards

Here's How We Make It Happen...

Implement Mitigating Changes to Designs and Procedures

Document Results in Reports and Databases


ELECTRIC BOAT CORPORATION
A GENERAL DYNAMICS COMPANY

SUBMARINE ESCAPE AND IMMERSION EQUIPMENT
MK10

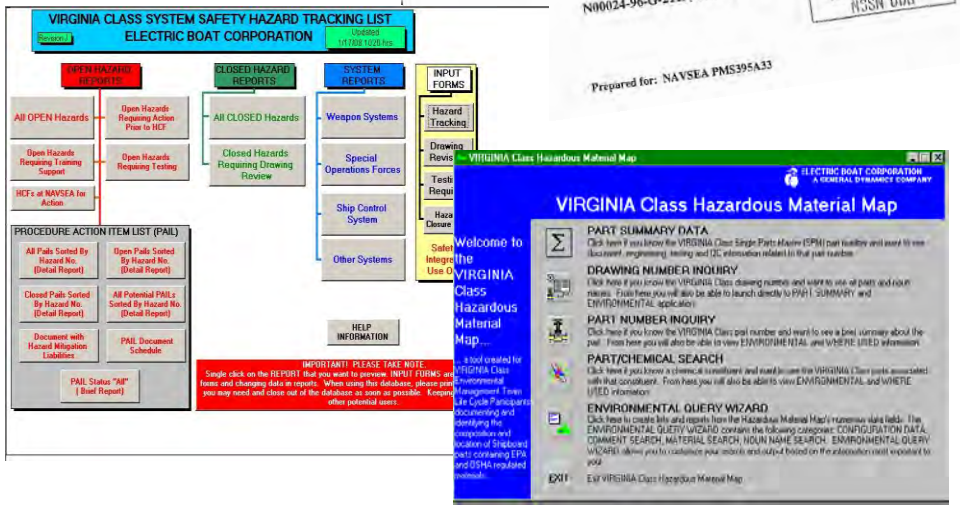
PRELIMINARY HAZARD ANALYSIS

(Final)

CONTRACT NUMBER:
N00024-96-G-2119, Task L8-29

RECEIVED
FEB - 2 2000
NSSN DOR

Prepared for: NAVSEA PMS395A33



Eliminate ESOH Hazards

- Unsafe Conditions
- Toxic Exposures
- HazMat Disposal

Example #1: Procedural Improvement

PROBLEM

Existing Tech Manual (TM) had No Beryllium Warning

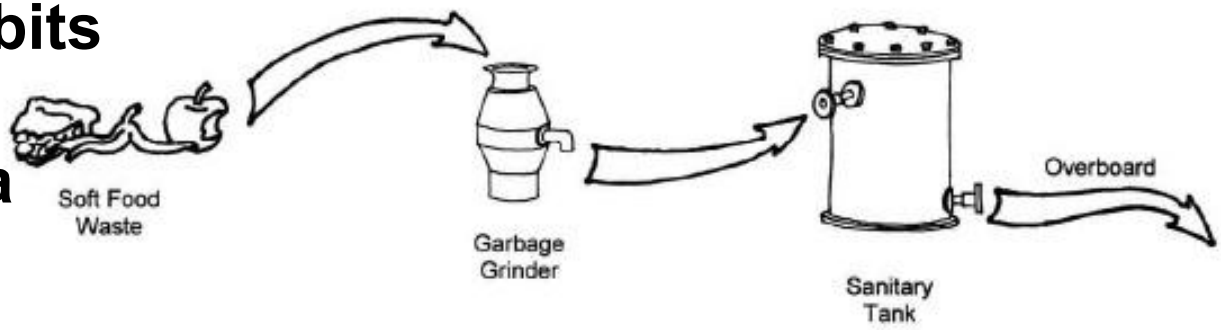
- ↗ VIRGINIA & SSGN hazmat
- ↗ DoD "Emerging Contaminant"
- ↗ Carcinogen

SOLUTION

During TM Revision, Added "WARNING" Statements at Each Step Involving Work on Beryllium Piece Parts

Example #2: VIRGINIA Class Plastics Waste Stowage

The Act to Prevent Pollution from Ships (APPS) Prohibits Navy Submarines from Disposing Plastics at Sea After December 31, 2008.



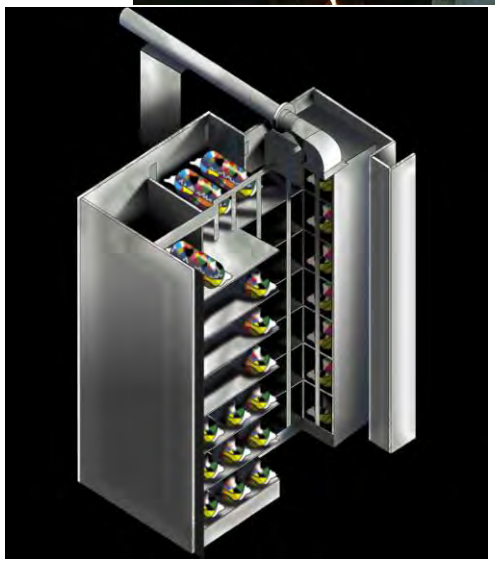
Stowage of Plastics Waste Creates a Potential Fire Safety Risk Due to the Concentration of the Plastics Waste Becoming Fire Sustaining Fuel.

Example #2: VIRGINIA Class Plastics Waste Stowage (Cont'd)

Testing was Performed to Assess Fire Characteristics of Burning Bags Filled With Plastics Waste

A Fire Risk Assessment per MIL-STD-882 was Performed

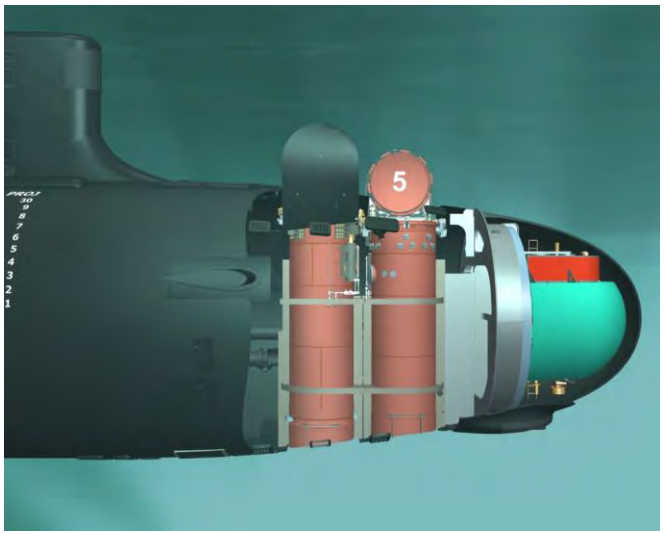
- No additional design changes were recommended in the stowage arrangement in the environmental space
- The risk was considered acceptable by the Fire Fighting System Design/Build Team and the NAVSEA Program Office.

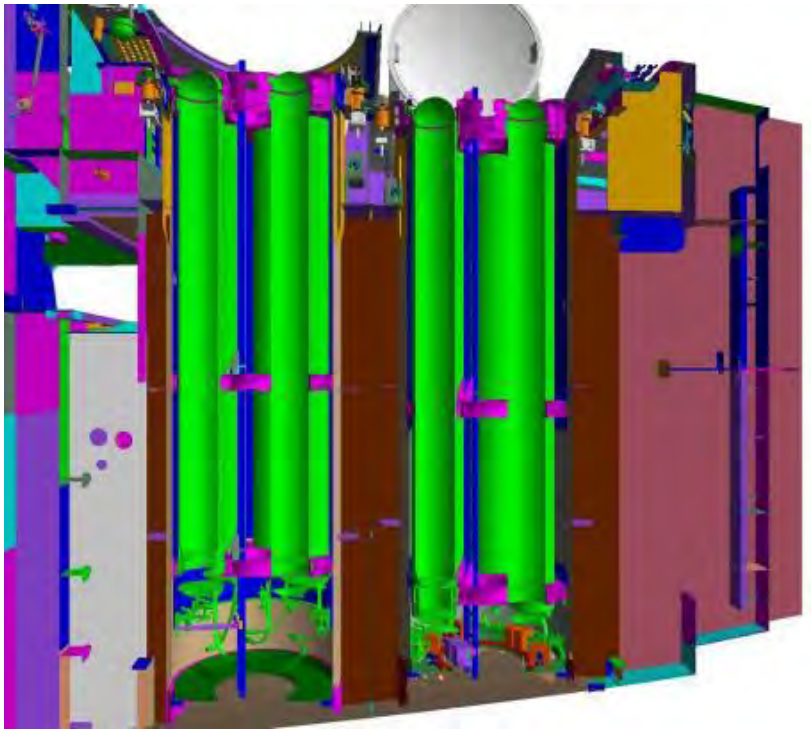


Example #3: VIRGINIA Payload Tube (VPT) Multiple All-Up-Round Canister (MAC) Center Access Ladder

Confined Space Safety Issues (Limited Access to Equipment and No Outside Ventilation) Documented in the VPT Preliminary Hazard Analysis (PHA).

No Access to the Payload Tubes From Inside the Ship Like SSGN Class



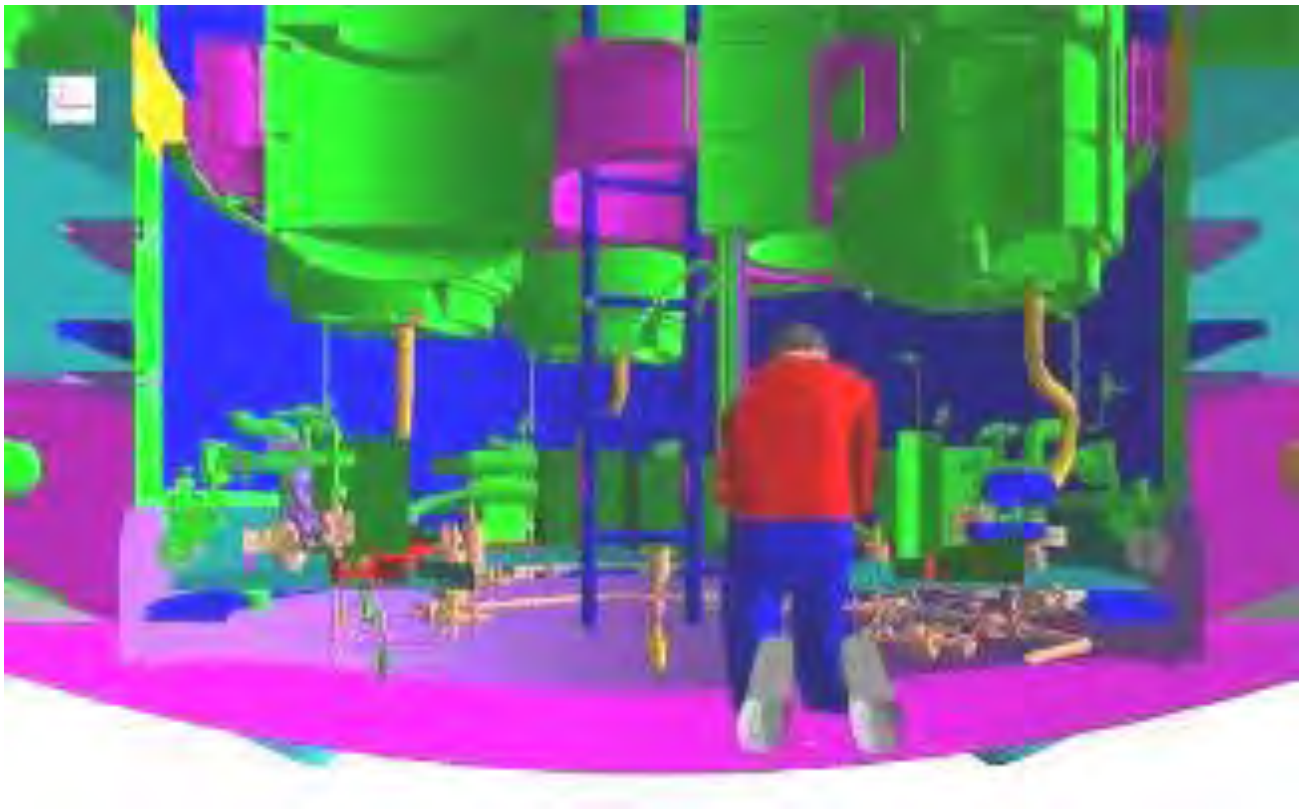


Example #3: VPT MAC Center Access Ladder (Cont'd)

Hazard Mitigation Includes:

Demonstrating Accessibility to Vital Equipment (Full Scale Wooden Mock-up)

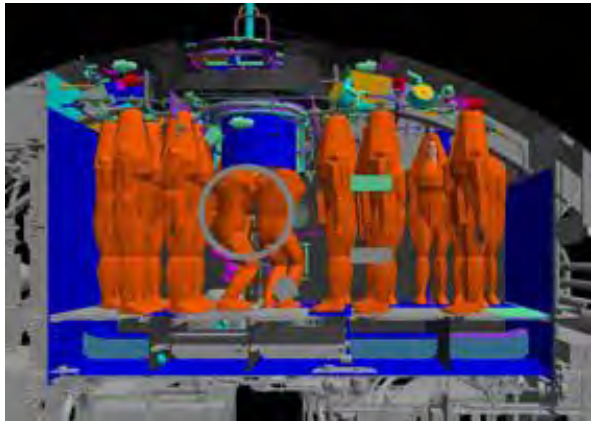
Providing Continuous Forced Air Ventilation to the VPT Through a Custom-built Center Cell Ladder



Example #4: Submarine Escape

Preliminary Hazard Analysis (PHA) on the Submarine Escape and Immersion Equipment (SEIE) MK 10 Made the Following Recommendation:

"Provide realistic MK10 S.E.I.E. pressurized ascent training for the submarine crews."



Example #4: Submarine Escape (Cont'd)

That Recommendation Resulted in Construction of the New Submarine Escape Trainer at SUBASE New London.

ESOH Program Achievements

A Successful Team Approach has resulted in:

- **1995-1997 Environmental Security Awards - VIRGINIA Class Excellence in Pollution Prevention by a Weapon System Acquisition Program (NAVSEA/CNO/DoD/DON)**
- **1998 EPA Stratospheric Ozone Protection Award to VIRGINIA Class Program**
- **2006 Dept of Navy Special Recognition for Excellence - awarded to SSGN ESOH Integrated Product Team**
- **2007 International System Safety Conference Award for Best Paper – "Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program"**

ESOH Success Recognized

Special Recognition by the Navy for Excellence in Safety in the Field of Acquisition

"The program emphasizes the integration of safety and environmental engineers into the design/build teams to add the element of objectivity into hazard analyses. This team exemplifies the benefits of the early integration of safety concerns into the acquisition process."

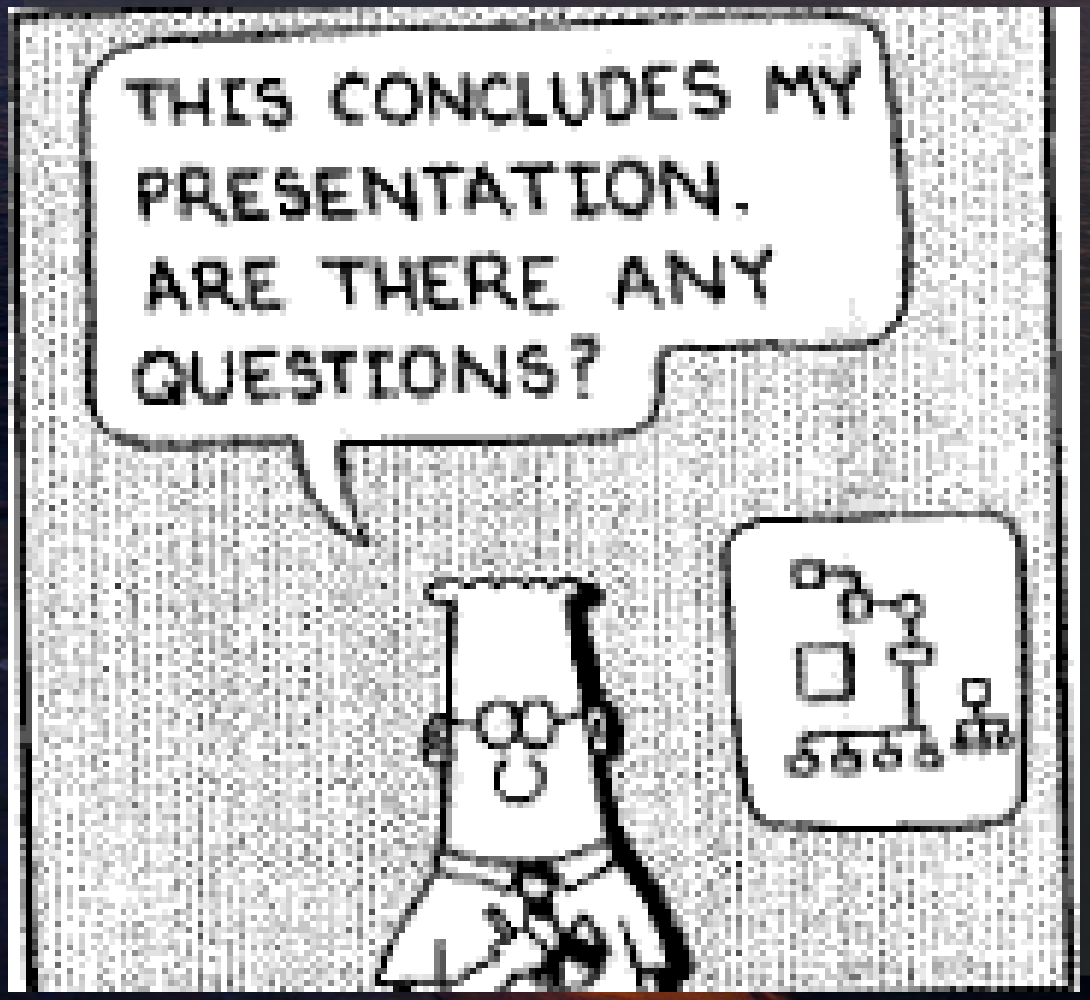
Hon. Donald C. Winter, Secretary of the Navy

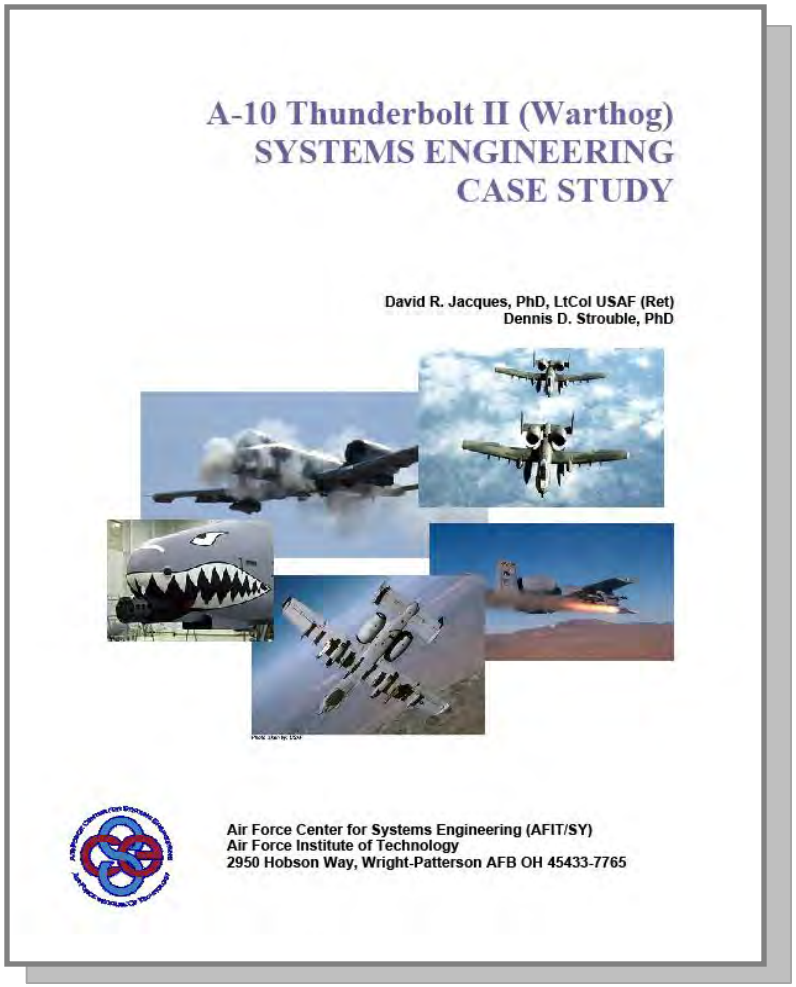
September 2006

Summary

- Performed ESOH tasks in a variety of successful projects and programs
- Successfully integrated environmental considerations into the System Safety approach described in MIL-STD-882D (DoD Standard Practice for System Safety)
- Continue to interface with Shipyard Safety, Fire Dept., Industrial Hygiene, vendors, Environmental Resources Management, and Design/Build/Sustain teams in ESOH tasks

ESOH is Part of the Integrated Systems Engineering Approach and Incorporates HSI Requirements


THIS CONCLUDES MY PRESENTATION. ARE THERE ANY QUESTIONS?



Human Systems Integration in Early Acquisition:

A Historical Example

(Based on A-10 Systems Engineering Case Study)

27 October 2010

Dr. Dave Jacques
Air Force Institute of Technology
(david.jacques@afit.edu)

Tenets of Acquisition Policy

1. System need shall be clearly established in operational terms, with appropriate limits, and shall be challenged throughout the acquisition process…Wherever feasible, operational needs shall be satisfied through the use of existing military or commercial hardware…
2. Cost parameters shall be established which consider the cost of acquisition and ownership… Practical tradeoffs shall be made between system capability, cost and schedule…
3. Logistic support shall also be considered as a principle design parameter…
4. Programs shall be structured and resources allocated to assure that the demonstration of actual achievement is the pacing function… Schedules and funding profiles shall be structured to accommodate unforeseen problems and permit task accomplishment without unnecessary overlapping or concurrency.
5. Technical uncertainty shall be continually assessed… Models, mock-ups and system hardware will be used to the greatest possible extent to increase confidence level.
6. Test and evaluation shall commence as early as possible. A determination of operational suitability, including logistics support requirements, will be made prior to large scale production commitments…
7. Contract type shall be consistent with all program characteristics, including risk…
8. The source selection decision shall take into account the contractor's capability to develop a necessary defense system on a timely and cost-effective basis…
9. Management information/program control requirements shall provide information which is essential to effective management control… Documentation shall be generated in the minimum amount to satisfy necessary and specific management needs.

Lessons from Vietnam

- Air Force largely unprepared for Close Air Support (CAS) mission
  - A-1, A-37 had insufficient payload, loiter
  - Incompatible comm with ground units

- Army doctrine evolving towards air mobile tactics
  - Increased reliance on armed helicopters
  - Initiated development of AH-56 Cheyenne

- Johnson-McConnell Agreement
  - AF retained CAS mission, but recognized role of Army helicopters for fire support
  - Army gave up large fixed-wing transports

Task Definition

Three Mission Tasks

- Close Support Fire (CSF)
- Armed Escort (AE)
- Armed Reconnaissance (AR)

- CSF and AE were considered complementary
- AR involved different weapons and target acquisition systems, considered a secondary A-X mission due to parallel development of AC-130 gunship

Mission Characteristics
(Now called attributes)

Only four key mission characteristics specified !

- ***Responsiveness*** considered not just speed, but basing locations, availability, loiter time over target, and ability to communicate with ground elements
- ***Simplicity*** emphasized ease of production, maintenance, and low cost
- ***Survivability*** concerns would drive redundancy, component placement, protection systems, maneuverability, targeting systems, et.al.
- ***Lethality*** made it clear that it was not an aircraft development effort, it was a weapon system development

- Mission characteristics drove performance parameters, which resulted in concept aircraft configurations
  - Alternatives evaluated against mission and cost effectiveness measures

Note: All four key mission characteristics for the A-X directly impacted HSI considerations

A-X Concepts

Requirements from Dec 1966 Requirements Action Directive

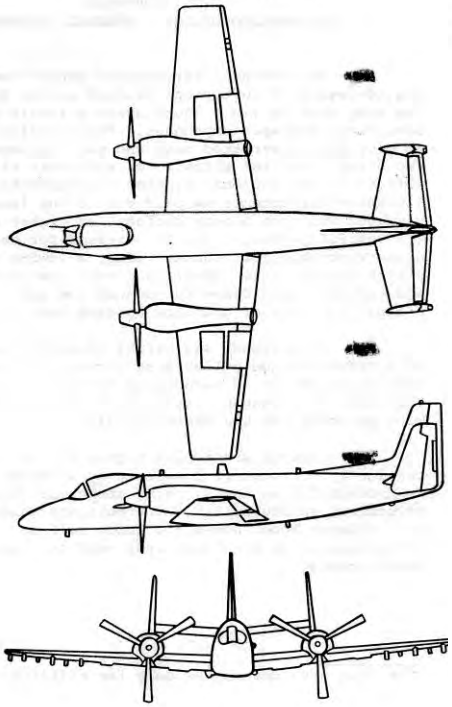
Performance Parameter	Desired	Required
Gross Weight (lbs)	22,500	30,000
Payload - Mixed Ordnance (lbs)	8,000	6,000
Combat Radius (nautical miles)	---	200
Loiter Time @ Combat Radius (hrs)	---	2
Min Maneuvering Speed @ 5000 ft (knots)	120	150
Turn Radius @ Combat Weight (ft)	1,000	2,000
Max Speed @ Sea Level w/ Ext. Ordnance (knots)	550	450

- Concept design studies conducted in 1967
  - Resulted in two government configurations, and four contractor configurations
- Concept determined to be feasible within existing technology
  - Most configurations used turbo-prop designs
  - Identified risk elements included gun/ammunition development and integration, and early IOC
  - Lean avionics packages defined to keep costs down
- Concept Formulation Package completed in 1968

A-X Concepts

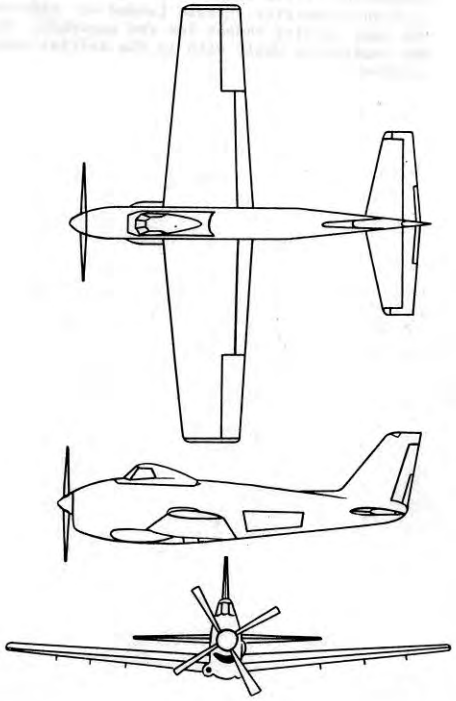
(U) GRUMMAN
RECOMMENDED DESIGN GENERAL ARRANGEMENT

(Figure UNCLASSIFIED)



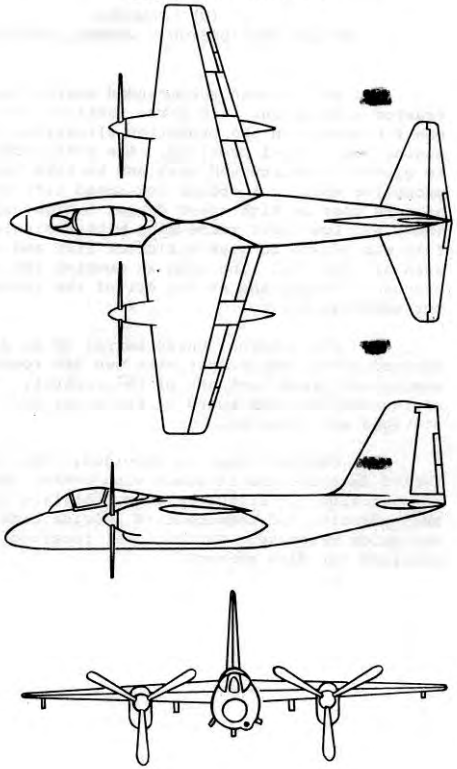
(U) GENERAL DYNAMICS
RECOMMENDED DESIGN GENERAL ARRANGEMENT

(Figure UNCLASSIFIED)



(U) McDONNELL DOUGLAS
RECOMMENDED DESIGN GENERAL ARRANGEMENT

(Figure UNCLASSIFIED)



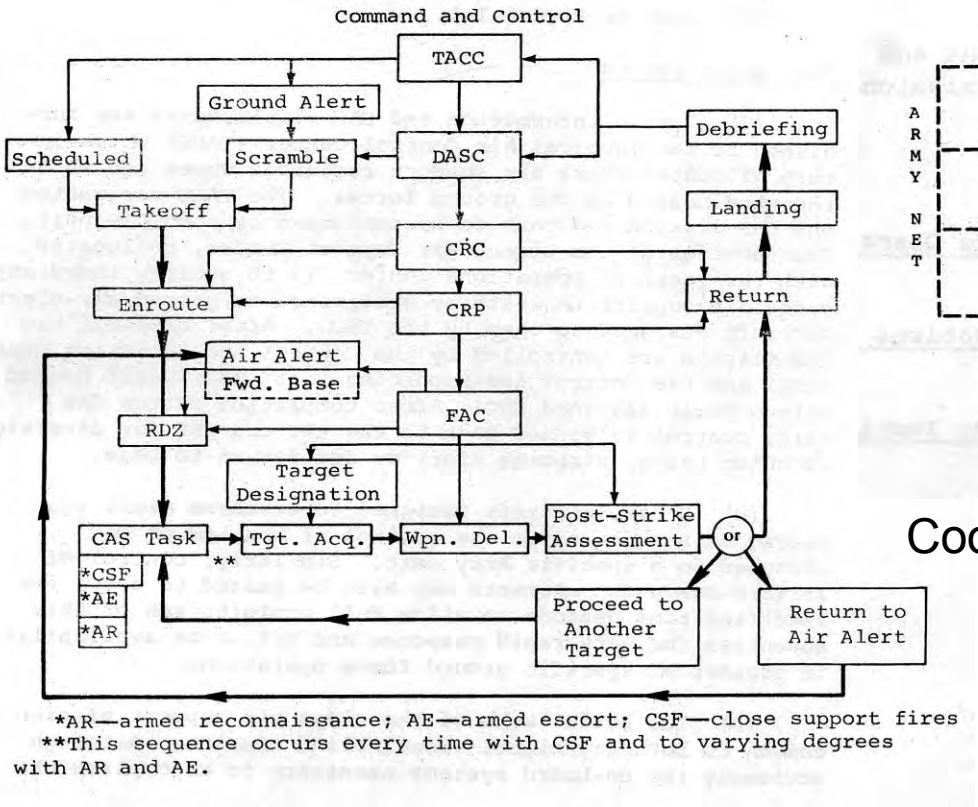
Notes: Significant design changes occurred during Concept Definition (now referred to as Materiel Solutions Analysis)

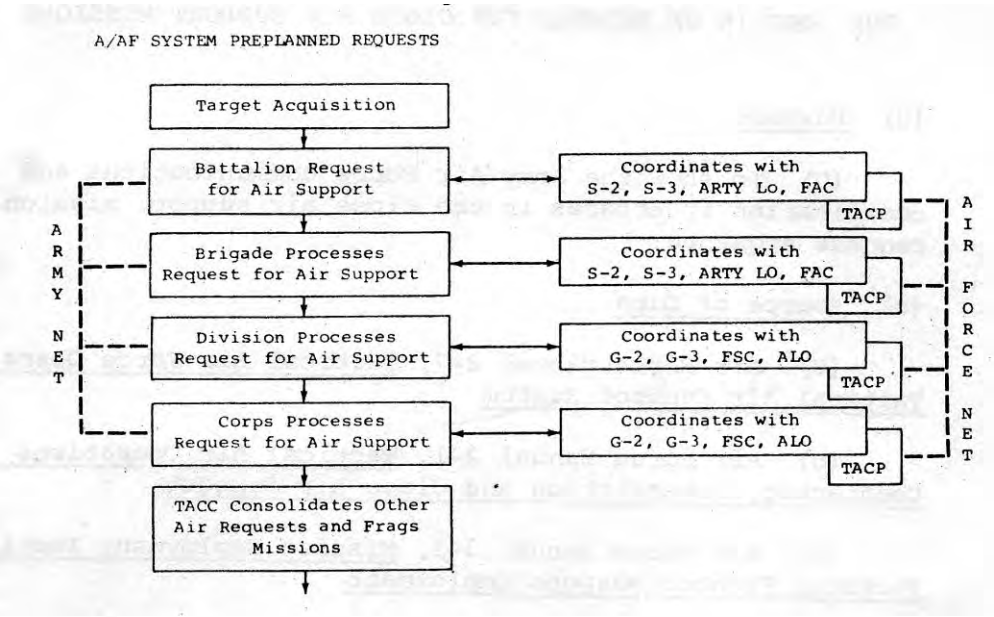
- Single or twin turboprop propulsion gave way to twin turbofan (leveraged Navy S-37 aircraft development)
- Payload essentially doubled to 16,000 lbs – led to aircraft size/cost growth

Key Mission Characteristics

- ***Responsiveness*** considered not just speed, but basing locations, availability, loiter time over target, and ability to communicate with ground elements
- ***Simplicity*** emphasized ease of production, maintenance, and low cost
- ***Survivability*** concerns would drive redundancy, component placement, protection systems, maneuverability, targeting systems, et.al.
- ***Lethality*** made it clear that it was not an aircraft development effort, it was a weapon system development

Responsiveness
The System of Systems Perspective





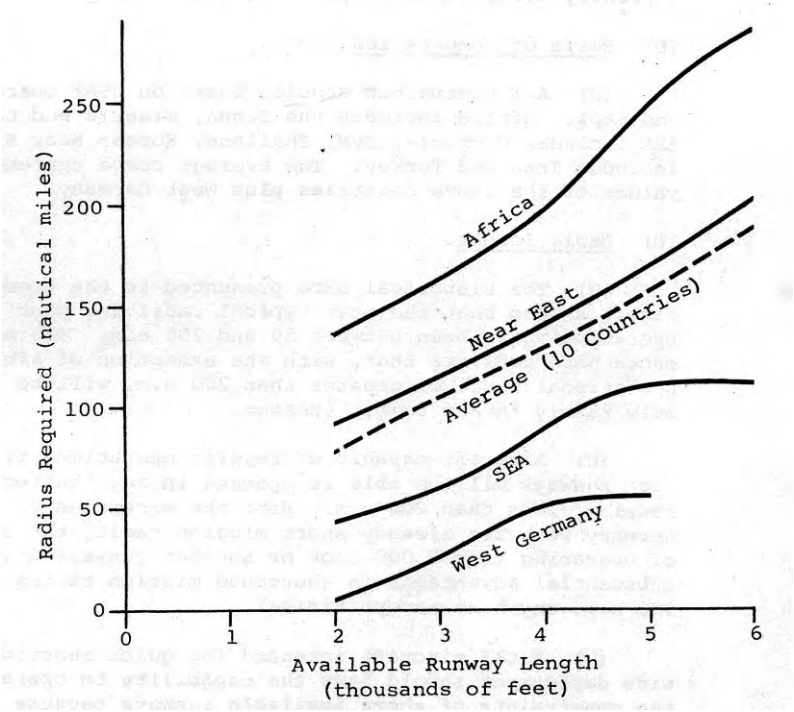
Coordination for Pre-Planned CAS Requests

The Tactical Air Control System (circa 1968)

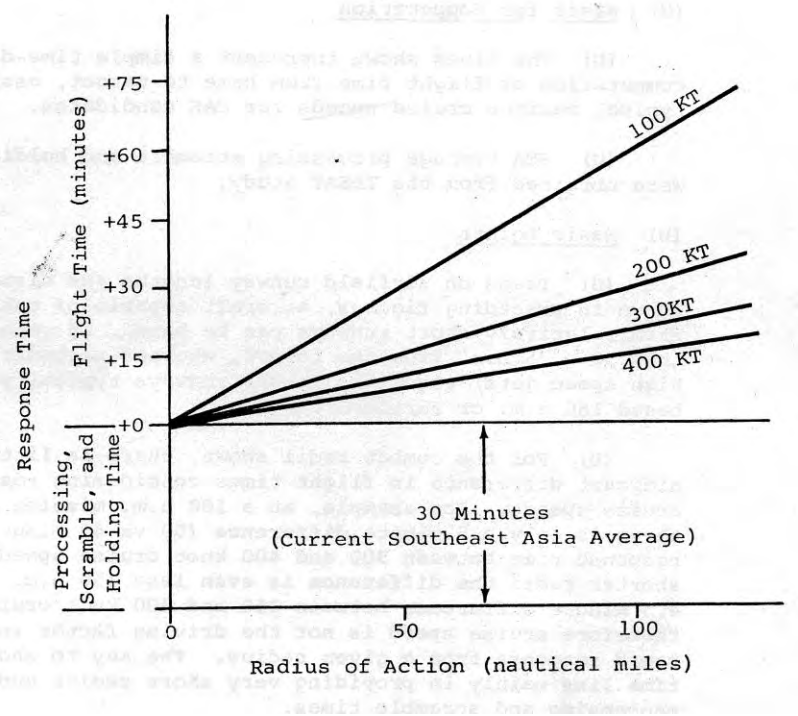
They defined human-human interface at the SoS/mission level

Responsiveness
The Importance of Basing

Combat Radius and Loiter Time Considerations



Radius Req'd for 90-Percent Geo-Area Coverage from Available Runways



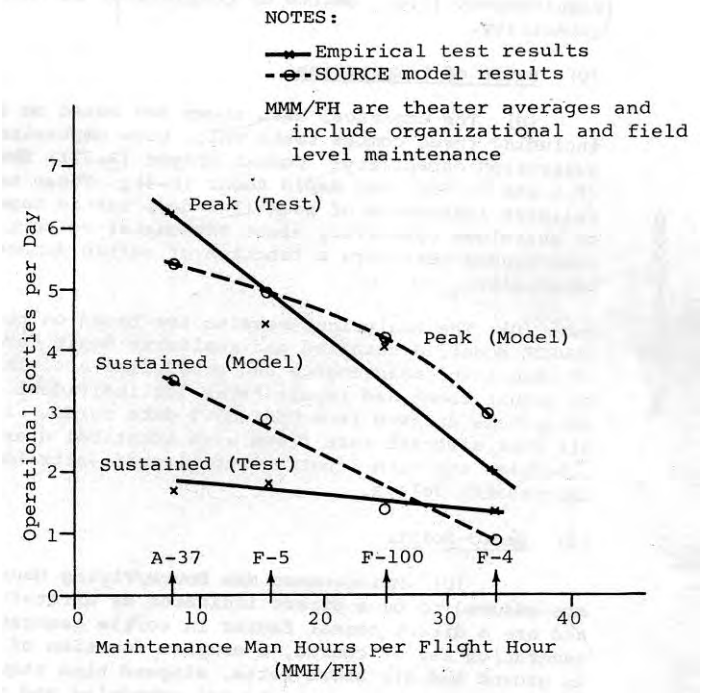
Response Time Versus Mission Radii and Cruise Speed

Key Mission Characteristics

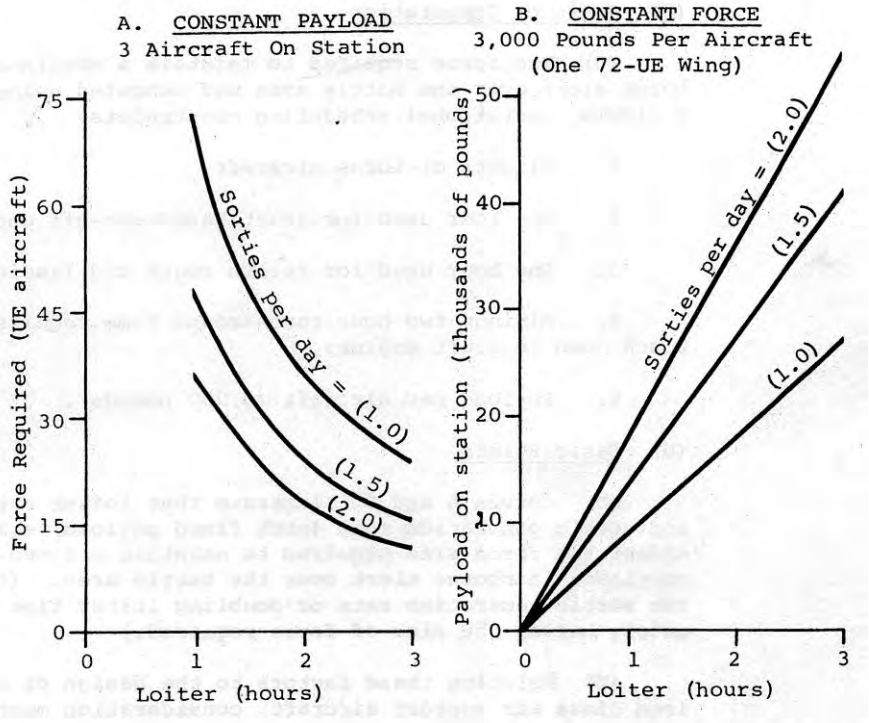
- ***Responsiveness*** considered not just speed, but basing locations, availability, loiter time over target, and ability to communicate with ground elements
- ***Simplicity*** emphasized ease of production, maintenance, and low cost
- ***Survivability*** concerns would drive redundancy, component placement, protection systems, maneuverability, targeting systems, et.al.
- ***Lethality*** made it clear that it was not an aircraft development effort, it was a weapon system development

Simplicity …
(… or is it more than that ?)

	AFM 26-3 PLANNING MMH/FH	ACTUAL SEA MMH/FH AVERAGE
F-4	30	33.2
*F-105	40	27.6
F-100	25	26.6
F-5	17	15.5
A-1	10	14.3
A-37	7	7.8



Maintenance Man Hours/Flight Hour for Vietnam era Aircraft



Impact of Loiter Time and Sortie Rate on Force Requirements

A-10 Maintenance Features

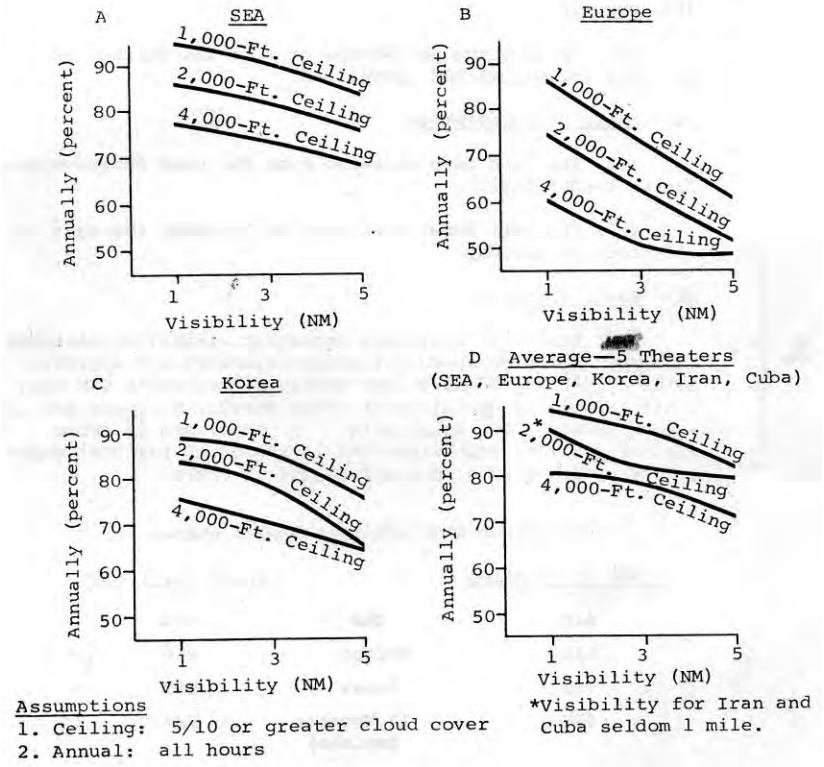
- Design simplicity, ease of access
  - e.g., designed for 30 minute engine replacement
- Low wing, high engine placement
  - Allowed for engine-on, quick turn re-arming
- Interchangeable left/right side components
  - Engines, landing gear, vertical stabilizers
- Non-load bearing wing panels
  - Damaged skin replaceable in the field
- Designed to be operable and serviceable from forward air bases
  - Including those with damaged runways

Simplicity
How much avionics?

A-X AVIONICS EQUIPMENT

"SKELETON" Below Minimum	"Lean" Minimum	"Lean" Plus 1st Add-On	"Lean" Plus 2d Add-On	"Lean" Plus 3d Add-On
VHF/FM (With Homer)	Doppler Navigator	Radar Added Functions	MTI to Radar	Maverick
UHF/AM (ADF)	Radar Ranger	Terrain Avoidance	Inertial Nav.	
IFF (A-G)	VHF/FM (Wigh Homer)	(Manual)	Night Sight	
Voice Scrambler	UHF/AM (ADF)	PPI Map	(Optical)	
Intercom	IFF (A-G)	Beacon Interrogation		
TACAN	Voice Scrambler			
UHF/ADF	Intercom			
Radio Altimeter	TACAN			
ILS	UHF/ADF			
Air Data Converter (Computer)	Radio Altimeter			
Attitude, Heading, Reference	ILS			
S-Band Radar Beacon	Air Data Converter (computer			
Continuous-Solution Stabilized Sight (Depressable Optical Sight)	Attitude, Heading, Reference			
	Continuous-Solution Stabilized Sight (Depressable Optical Sight)			
Gun Camera (2) Maurer 220	Gun Camera (2) Maurer 220			
Integrated Armament Control System	Integrated Armament Control System			
COSTS $127,780	$34,000	$10,000	$20,000	$16,000
Accumulative Costs	161,780	171,780	191,780	207,780
Weight (Pounds) 367	83	20	35	40
Accumulative Weight 367	450	470	505	545

Weather Suitability



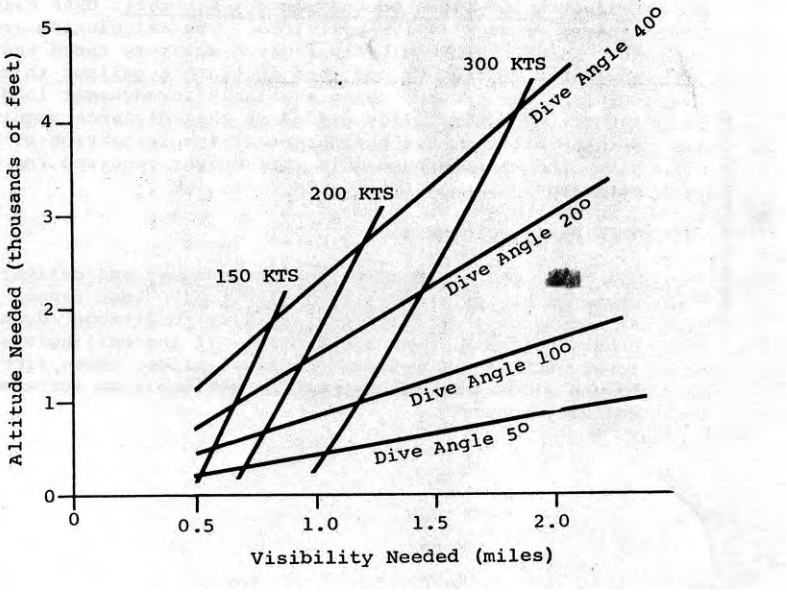
Assumptions
1. Ceiling: 5/10 or greater cloud cover
2. Annual: all hours

*Visibility for Iran and Cuba seldom 1 mile.

Availability of Weather Suitable for CAS Operations

Percent of time minimums better than—		
2,000 ft./3 miles		1,000 ft./1 mile
82%	SEA	95%
62%	Europe	86%
78%	Korea	88%
81%	(5 Theater Average)	94%

Assumptions
1. Time from point of alignment to pullout = 10 seconds
2. Pullout at ground level



Attack Profile Nomogram

Do you recognize this A/C?

A-10B

- Night/Adverse Weather
- Two seat (tandem)

- A-10A was simple enough to operate with a lone pilot
- Did good HSI from the operator perspective make a two seat variant unnecessary?

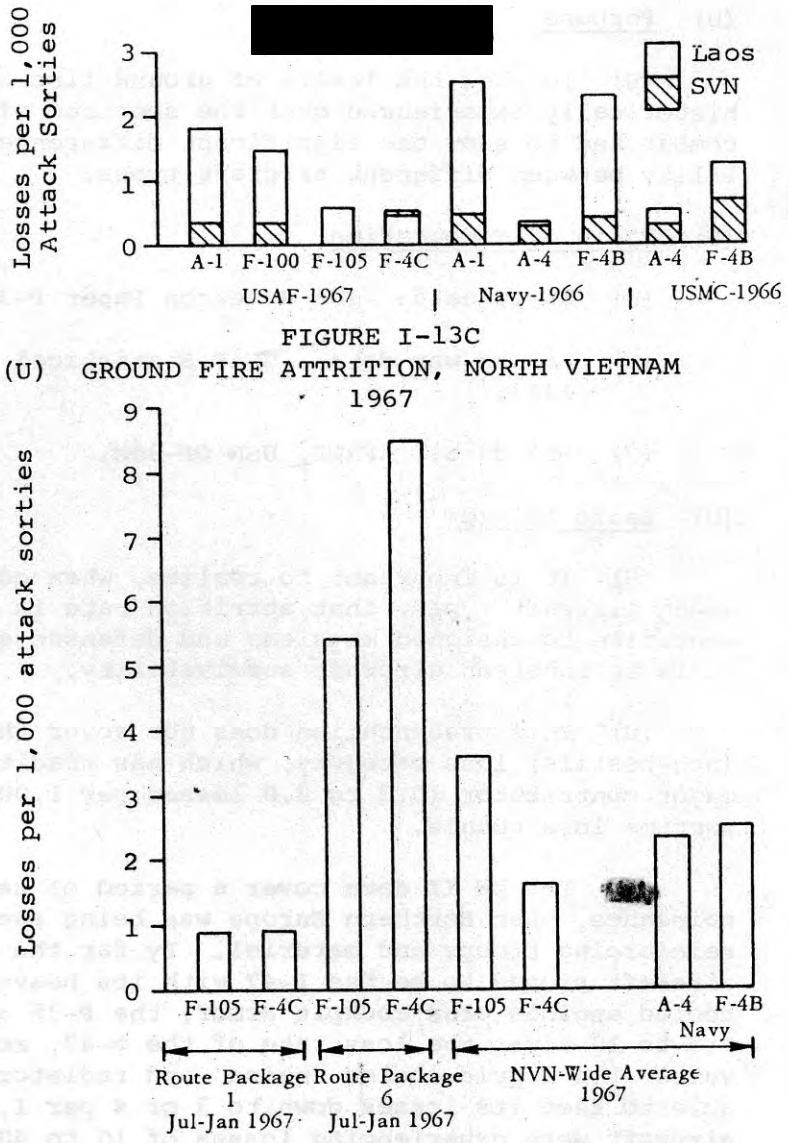
Impact of Avionics Decisions
A-10 Night Operations

- Night operations in Desert Storm
  - Pilots used IR Maverick seeker as night vision aid
- Success and survivability in night operations serve as a testament to other design features and skilled, innovative pilots
- Badly needed avionics upgrades came well after Desert Storm

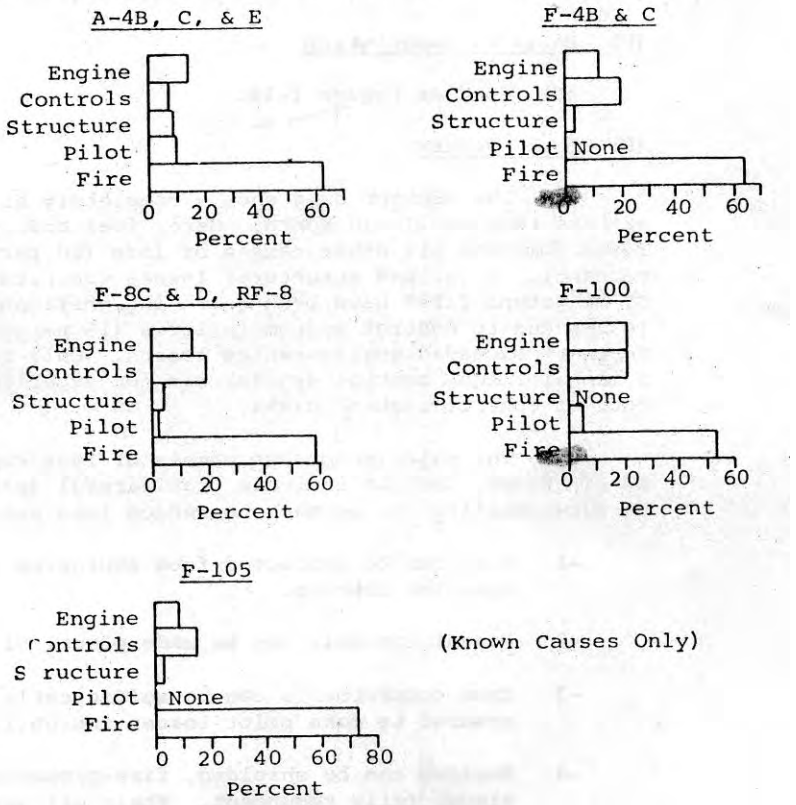
Key Mission Characteristics

- ***Responsiveness*** considered not just speed, but basing locations, availability, loiter time over target, and ability to communicate with ground elements
- ***Simplicity*** emphasized ease of production, maintenance, and low cost
- ***Survivability*** concerns would drive redundancy, component placement, protection systems, maneuverability, targeting systems, et.al.
- ***Lethality*** made it clear that it was not an aircraft development effort, it was a weapon system development

Survivability



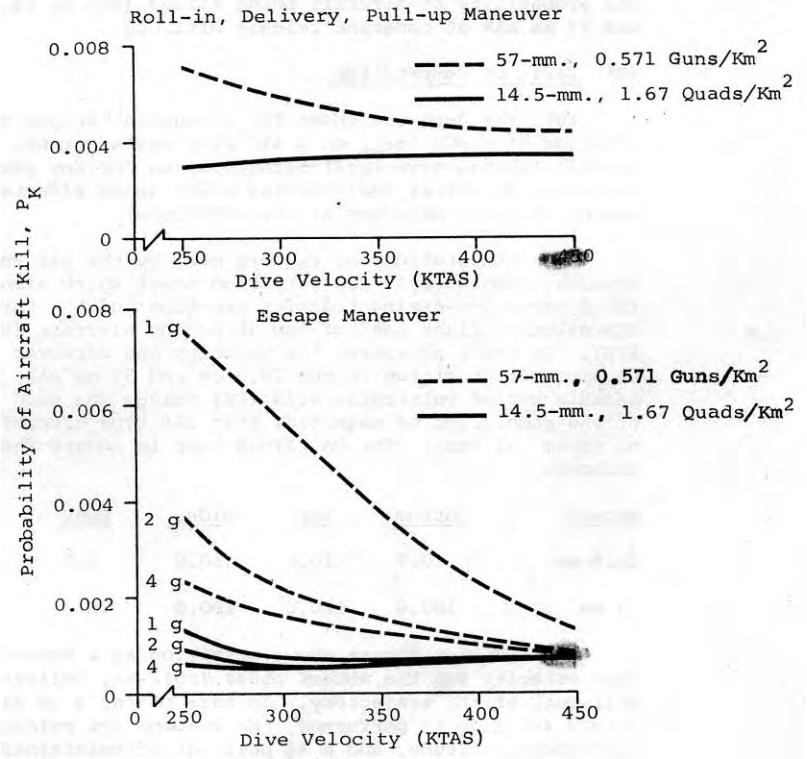
Ground Fire Attrition in South Vietnam and Laos



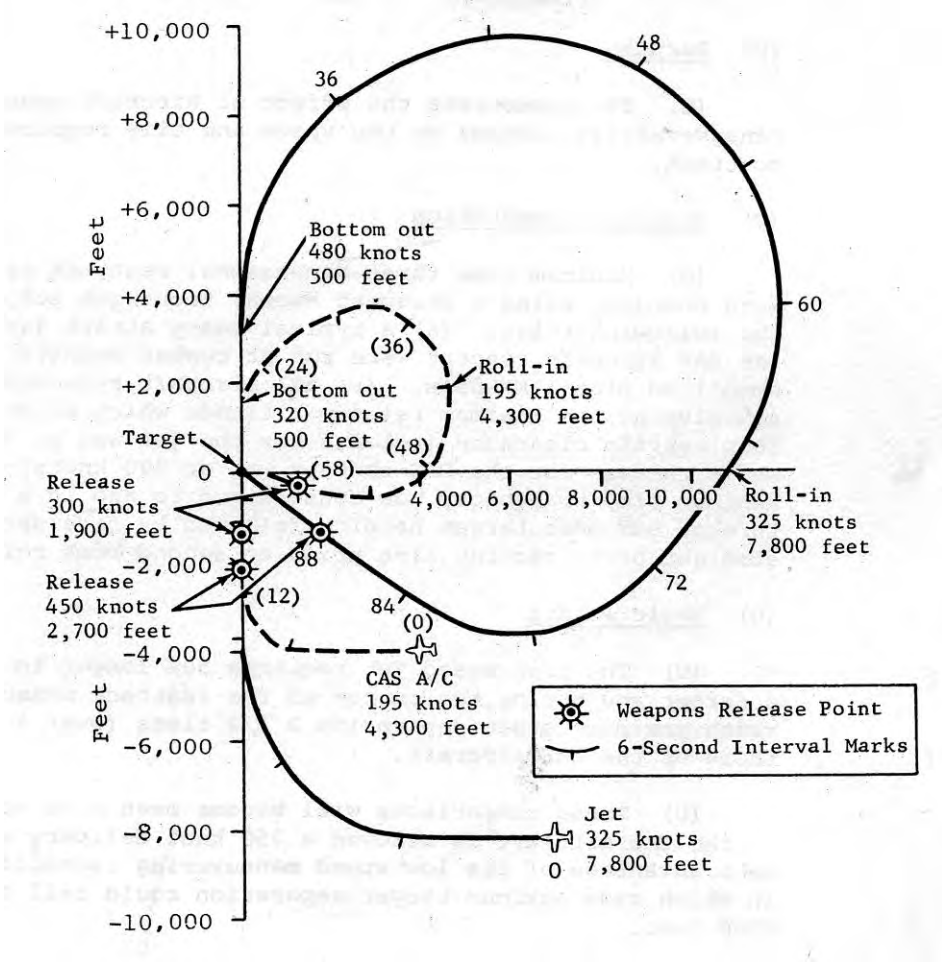
Cause of Aircraft Ground Fire Loss in Southeast Asia

Survivability

How to avoid being hit in the first place



Relative Aircraft Attrition Versus Velocity and Maneuver



Time and Space Required for Re-Attack Minimum time Trajectory

Survivability Features

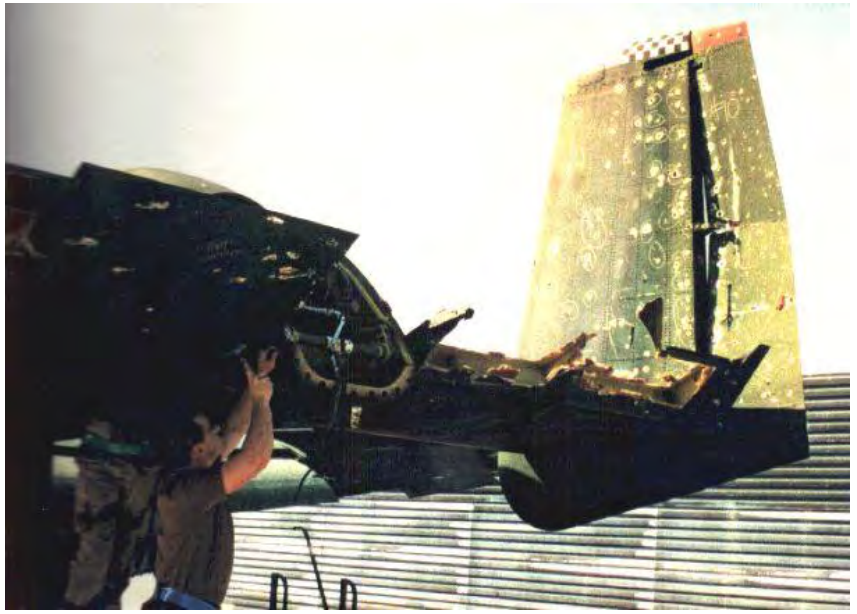
- Titanium “bathtub”
- Redundant wing spars
- Twin tail, oversized ailerons
- Redundant flight control with manual backup
- Two engines, widely separated
  - Placement provides partial shielding of IR signature
  - Protection from FOD, AAA fire
- Self-sealing fuel tanks, protected by fire-retardant foam
- Rugged landing gear design
  - Hinged toward rear – deployable without hydraulic power
  - Semi-protruding – accommodates gear-up belly landings

Demonstrated Survivability

- Capt Kim Campbell's aircraft takes hit(s)
- Loss of hydraulics for control
- Manual backup allows aircraft (and pilot!) to come home

Demonstrated Survivability

One of the Six A-10s Lost in Desert Storm.
"Wheels up, hard stick landing. Everyone said it couldn't be done, including the Flight Manual's and Tech Orders... pilot Capt Rich Biley proved'm wrong on 22 Feb 1991! … Capt Biley was unhurt during the crash." *



Repaired Aircraft 80-186
This Aircraft was damaged on three separate occasions during Desert Storm, the last one resulting in over 300 holes. The plane was repaired and continued to fly and fight.

*Web site: Pats-World.com, A-10 Thunderbolt II "Warthog" A-10 Battle Damage, http://www.pats-world.com/gulfwar/home.htm.

Key Mission Characteristics

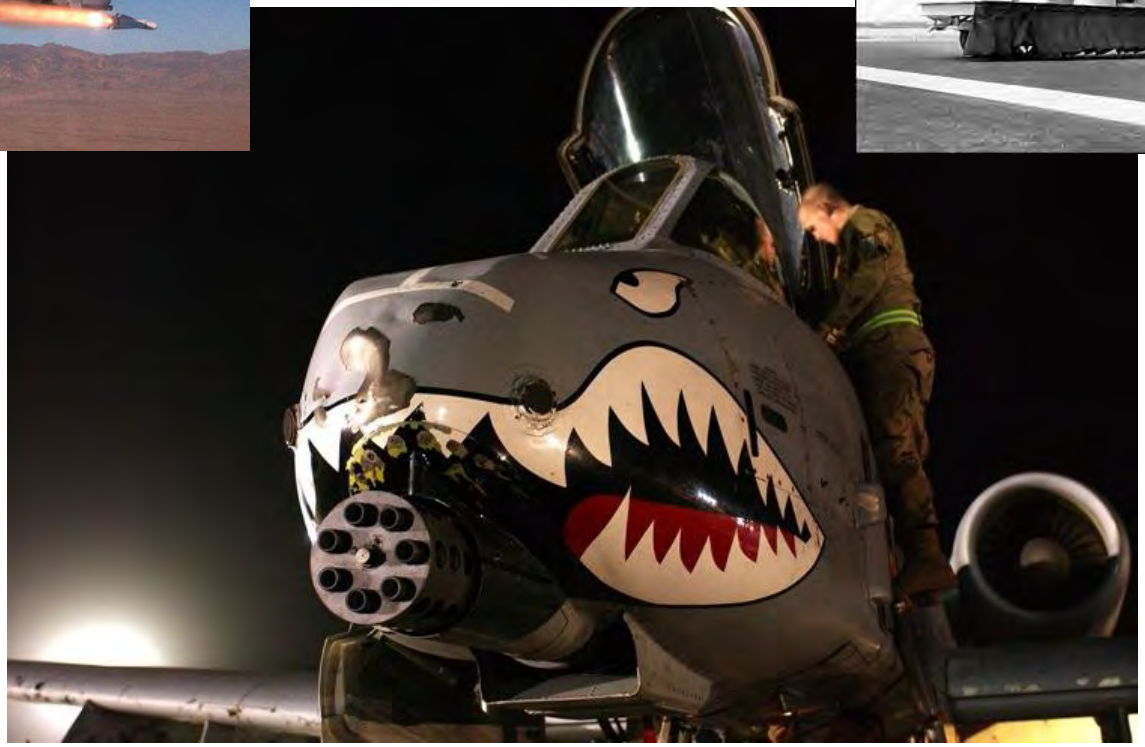
- ***Responsiveness*** considered not just speed, but basing locations, availability, loiter time over target, and ability to communicate with ground elements
- ***Simplicity*** emphasized ease of production, maintenance, and low cost
- ***Survivability*** concerns would drive redundancy, component placement, protection systems, maneuverability, targeting systems, et.al.
- ***Lethality*** made it clear that it was not an aircraft development effort, it was a weapon system development

Lethality

Was it sacrificed for other characteristics?

In a word …

NO!



- Aircraft designed around gun, and ability to bring gun to bear on targets
  - The relatively few augmentations to the avionics suite were associated with targeting aids for gun and Maverick

Good HSI on the A-10?

Generally, YES!

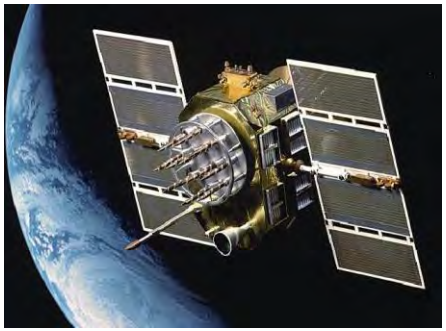
- HSI clearly evident in key characteristics driving the concept formulation effort
- All aspects of HSI as currently defined were clearly evident in the A-10 development
- Survivability and Maintainability of the system are especially notable

Shortcomings

- Minimal avionics made it marginally suitable for night operations – a human factors issue
- Depleted uranium shells raise environmental and safety concerns
- Lapses in sustainment throughout 1990's resulted in safety of flight issues
- Others?

Air Force Center for Systems Engineering Case Studies

Hubble Space Telescope



GPS (Global Positioning System)

F-111

C-5

Available as pdf downloads at:
http://www.afit.edu/cse/

TBMCS (Theater Battle Management Core Systems)

A-10

KC-135 Simulator

Global Hawk

Conclusion

- An often quoted statement:
  - Those who don't learn the lessons of the past are condemned to repeat them
- So are we learning them, or repeating them?

Questions?

Back-ups/Holding Area

Competitive Prototyping

- Recall acquisition tenet # 5
  - Technical uncertainty shall be continually assessed… Models, mock-ups and system hardware will be used to the greatest possible extent to increase confidence level.
- The A-X (termed A-10 after downselect) became a pilot program to demonstrate competitive prototyping on a major system development effort*

* The publication of DoD 5000 did not occur until a few months after the start of the A-X development program, but these policy ideas from the Office of the Secretary of Defense clearly influenced the A-X program formulation. In some respects, the A-X program was a test bed for considerations such as design-to-cost, supportability in design, and competitive prototyping.

A-X Prototyping

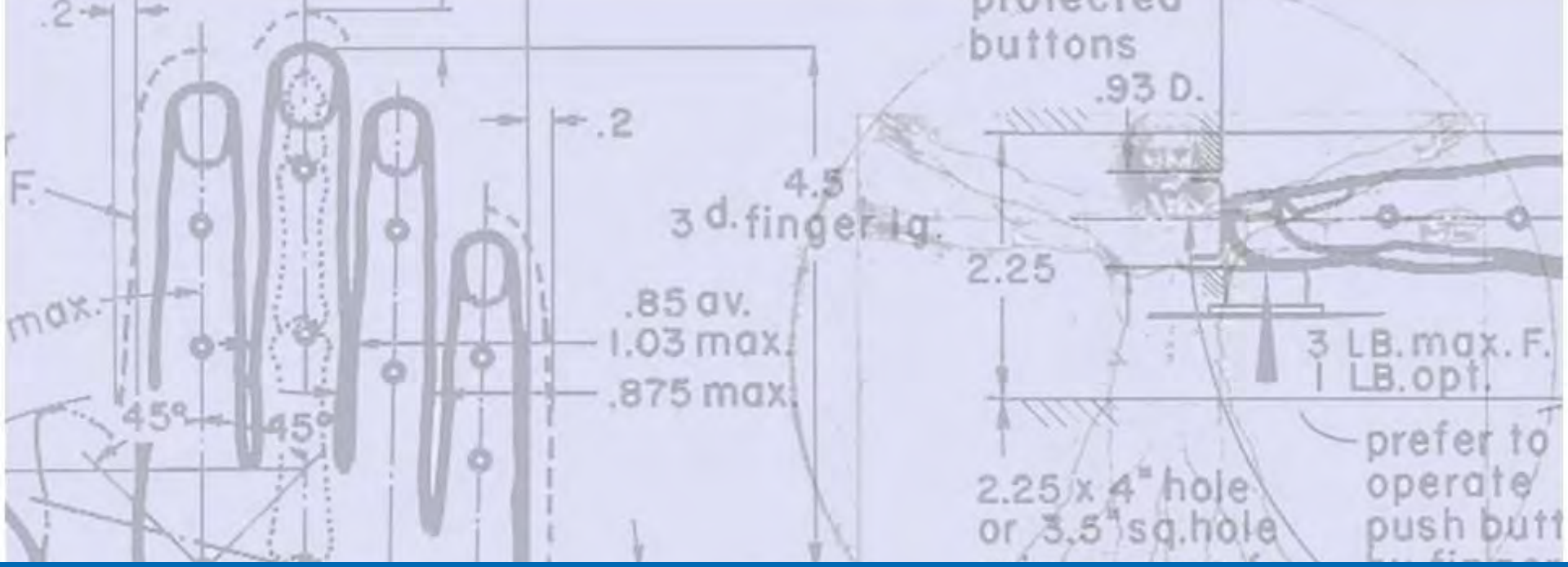
- A-X Pilot – Parallel Undocumented Development
  - Favored by DepSECDEF David Packard and AFSC/CC Gen Ferguson
  - Require minimal documentation during the competitive prototype phase to encourage innovation and initiative on the part of the contractor.
  - Expected to reduce technical risk and lead to a better source selection decision at the expense of higher RDT&E cost
- A-X was unique in this approach
  - F-X (later termed F-15), initiated in the same year, followed traditional “paper” Concept Definition approach to source selection

Competitive Prototyping on A-X

- Aircraft
  - Two competitors selected from six bidders for competitive prototyping phase
    - Northrop (YA-9) and Fairchild (YA-10)
    - Competitive fly-off by AF pilots after ~2.5 years in development
    - Downselect based on design, cost, risk, and flying performance
- Gun
  - Two competitors selected to design/build prototype guns
    - GE (GAU-8) and Philco-Ford (GAU-9)
    - Each competitor responsible for separate ammunition development
    - Competitive shoot-off after ~2.5 years in development; only GE was able to demonstrate a satisfactory gun system
- Ammunition
  - After gun downselect, GE directed to retain two ammunition subcontracts
  - Targeted downselect for ammunition was to be two years after IOC for first independent ammunition order; prior orders part of gun contract

A-X Competitive Prototyping Rationale and Outcomes

- Aircraft development was considered low risk, but gun development and integration was considered higher risk
  - Ammunition for gun was also considered higher risk
  - Ammunition cost was projected to make up 90% of the life cycle cost for the gun system
- Aircraft fly-off successful for both Northrop and Fairchild
  - Fairchild A-10 chosen based on cost, risk, and a “simpler” design for manufacture and maintenance
- Gun prototype demonstration eliminated Philco-Ford from consideration, and positively demonstrated feasibility and effectiveness of GE design
- Reports have suggested that extensive efforts in technology development and competition contributed to an 80% reduction in ammunition from the original cost estimate



HUMAN SYSTEMS INTEGRATION:
APPROACHES FOR DEVELOPMENTAL TESTING

Matthew Risser, Ph.D.

Alisha Belk, M.S.

Pacific Science & Engineering Group, Inc.

NDIA 13th Annual System Engineering Conference, October 25-28, 2010

HSI in Developmental Testing

- Developmental Testing (DT) assesses technical progress against critical technical parameters and allows for early operational assessments
  - DT can include multiple phases / events
- DoD policy and guidance helps to direct HSI involvement
  - DoD 5000.02 mandates that Human System Integration (HSI) be included in the Engineering Manufacturing Development phase of the acquisition process, which includes DT
  - HSI test planning should verify that the system can be operated, maintained, and supported by users in its intended operational environment, with the planned level of operator training (DAU DAG, 2010)
- DT is a valuable environment for HSI assessments and user-centered testing
  - Early, multiple opportunities, system integration and functionality, and can support operational workflows
- However, there is limited guidance on how to include HSI in DT events, the scope of what to test during each event, and how those results impact overall system performance

HSI in Developmental Testing: Challenges

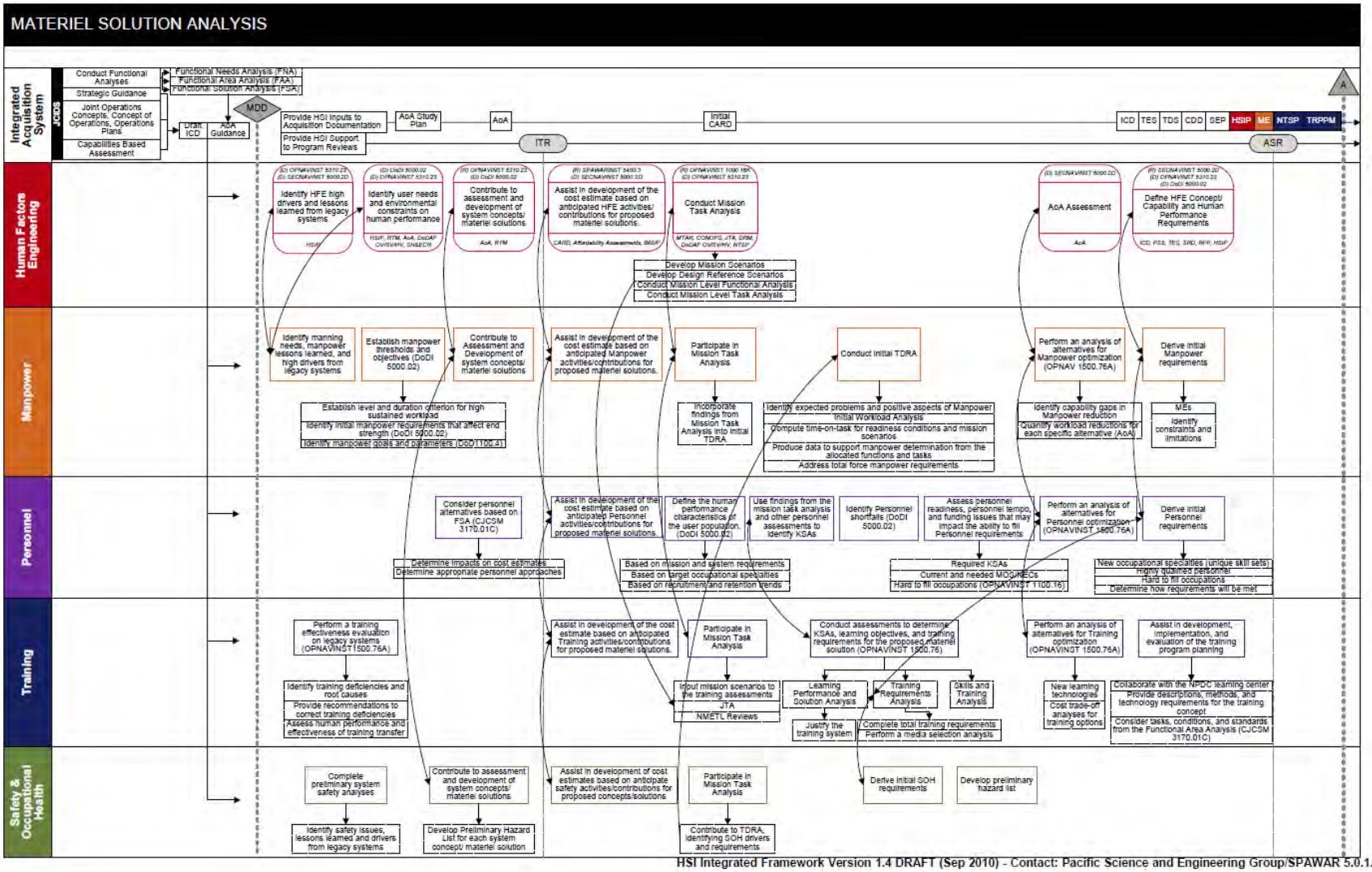
- HSI testing opportunities may only include components and subprocesses rather than total system performance
- Examples of traditional yet limited approaches to HSI testing:
  1. human performance evaluations on a mature or fielded system
  2. usability evaluations of discrete system functions without acknowledging their relationship to the larger, complex system – a “band-aid” approach
- While valid approaches, HSI testing in both instances is untimely because it is not aligned with the full sequence of planned engineering test activities
- Testing is rarely under the direction and control of HSI and therefore may limit opportunities for HSI tests
- HSI and DT processes require better integration so HSI results can contribute to development of early mitigation strategies
- There is a need to better define how HSI testing capabilities can support the test community
  - Process, procedures, products, and metrics

Defining a Process: HSI Support for Testing

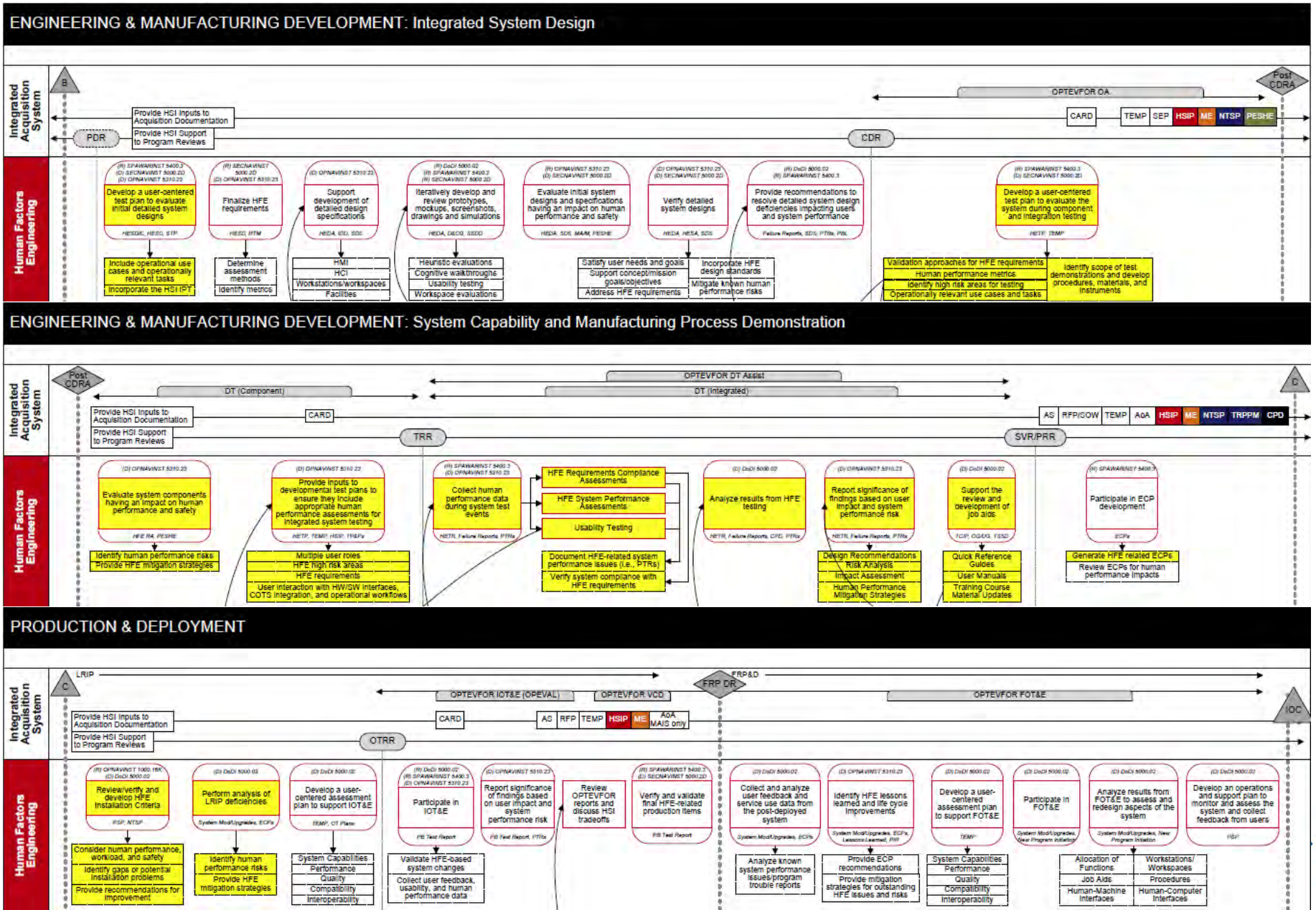
- An HSI Framework was developed to provide specific guidance on how to integrate HSI processes, products, and tools into the Defense Acquisition System.
- Using DoD guidance and policy documents as references, activities for all HSI domains were defined and mapped to each acquisition phase.
- The intent of the Framework is to provide a coordinating mechanism, aligned with the Acquisition Lifecycle, to support the Program Offices, program reviews, system engineering, and the HSI practitioner.
- It supports the consistent application of HSI processes, products, and tools within the acquisition community to mitigate human performance shortfalls and maximize system effectiveness.

HSI Framework Example

Materiel Solution Analysis phase includes rows for each HSI domain and a row for integrated acquisition events and documents. Inputs and outputs have been mapped onto each HFE activity.



HSI Framework: Test Activities Identified



HSI in Developmental Testing: Approaches

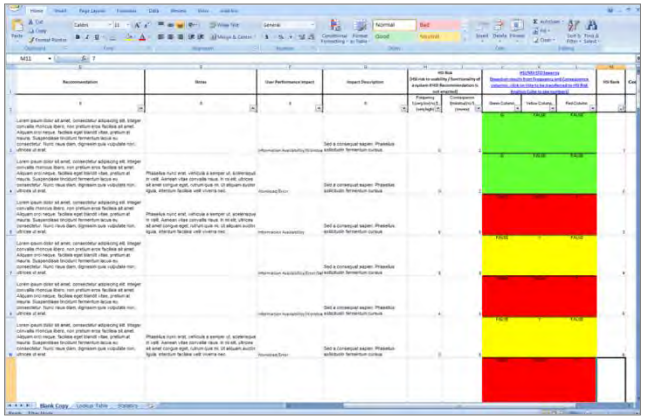
- Support the development of operationally based DT test plans and procedures
  - Directly supports subsequent Operational Testing (OT)
  - Resequencing traditional requirement-based test procedures can reveal system performance issues that would otherwise be discovered during OT and fielding
- Use a multi-phase and multi-source approach
  - Participate in multiple DT events and leverage findings to support each subsequent event
  - Leverage multiple data sources such as observations, interviews, expert assessments, performance measurements, analysis of logs, etc.
- Communicate HSI findings in a manner consistent with the engineering and test communities
- Perform expanded analyses to demonstrate impact on operational workflow and mission performance

HSI Role in Developmental Test Events

DT Event	HSI Role
Component Testing	HSI will **observe engineering component/unit tests** in order to obtain a more comprehensive understanding of the system and its individual components. Observations and **HSI requirements validation** results will be used to focus the scope of assessments for Functional Testing and develop/refine HSI test plans for System Integration and Developmental Testing. HSI-related issues uncovered by component testing will be documented and analyzed.
Functional Testing	HSI will **observe tests of functionality with representative users**. Observations of user performance and **HSI requirements validation** results will be used to refine test plans and materials for System Integration and Developmental Testing. HSI-related issues uncovered by functional testing will be documented and analyzed.
System Integration Testing	HSI will **perform assessments with representative users to evaluate usability and user performance** when using an integrated functional system. **Recommendations for conducting DT/OT** will be provided ensuring test plans include operational use cases, operationally relevant tasks/scenarios, and testable human performance metrics based on requirements. Any critical user performance and system functional issues identified will be noted and included in DT/OT assessments for further evaluation. In preparation for DT/OT, HSI will review the TEMP and provide inputs as needed.
Developmental / Operational Testing	HSI will p**erform assessments with operational users to evaluate user performance and operational suitability**. HSI test plans and materials developed and refined based on findings from previous test events will be used to support user evaluations. Results from DT/OT will be reported and recommendations for Engineering Change Proposals (ECPs) will be provided.

Communicating HSI Results and Impact

- HSI-specific findings should be assessed for their relevance and tracking of HSI-related items at the program level
- Report significance of findings based on user impact and system performance risks
  - Analyze HSI issues based on Frequency and Consequence to prioritize human performance risks
  - Results should include prioritized design guidance, human performance mitigation strategies, and/or risk and impact assessments
- Coordination of HFE and Training domains
  - DT findings will contribute to the development and review of job aids such as quick reference guides, user manuals, and training course material updates
  - Training solutions can be revised based on findings from integrated system demonstrations and pilot courses



CONSEQUENCE

FREQUENCY

	1 Minimal	2 Minor	3 Moderate	4 Significant	5 Severe	Total
5 Very High: ~90%	Low 0	Moderate 1	High 0	High 0	High 0	1
4 High: ~70%	Low 2	Moderate 5	Moderate 2	High 5	High 0	14
3 Moderate: ~50%	Low 1	Low 6	Moderate 5	Moderate 3	High 2	17
2 Low: 30%	Low 10	Low 4	Low 5	Moderate 3	Moderate 0	22
1 Very Low: ~10%	Low 1	Low 0	Low 0	Low 0	Moderate 0	1
Total	14	16	12	11	2	55

ANALYSIS OF HSI PROBLEM TRACKING REPORT (PTR) DISTRIBUTIONS AND POTENTIAL IMPACT ON OPERATIONAL WORKFLOW

HSI PTR Analysis

- Problem Tracking Reports (PTRs) are issues identified through DT events, assigned a severity code, prioritized, and tracked over time for their resolution
- Many “system” PTRs have human performance implications
- Naturally, program mitigation strategies and resources place emphasis on higher priority items
- Many HSI items may be identified as lower priority because they do not meet higher priority criteria and often have workarounds
- Individually, each HSI item may not be a significant concern
- But what is the impact on overall system performance when an operator must accommodate several workarounds or “nuisances” while executing their tasks?

Case Study: METMF(R) NEXGEN

- The Mobile Meteorological Facility (Replacement) Next Generation (METMF(R) NEXGEN) is a USMC mobile tactical meteorological system designed in a sheltered HMMWV
  - Up-armored sheltered HMMWV with tactical trailer
  - 4 modes of operation (Full, Limited, Remote, Stand-alone)
  - 3 racks of equipment, 3 displays, and 2 operator workstations
  - 5 major sensor systems with 25 cases
  - Multiple communication pathways
- HSI-related Key Performance Parameter (KPP): Full setup in 3-hours with 8 Marines and Limited setup in 1-hour with 2 Marines
- Sensors and components must be stored within a limited space and used safely and efficiently by operators and technicians within tight time constraints under various environmental conditions

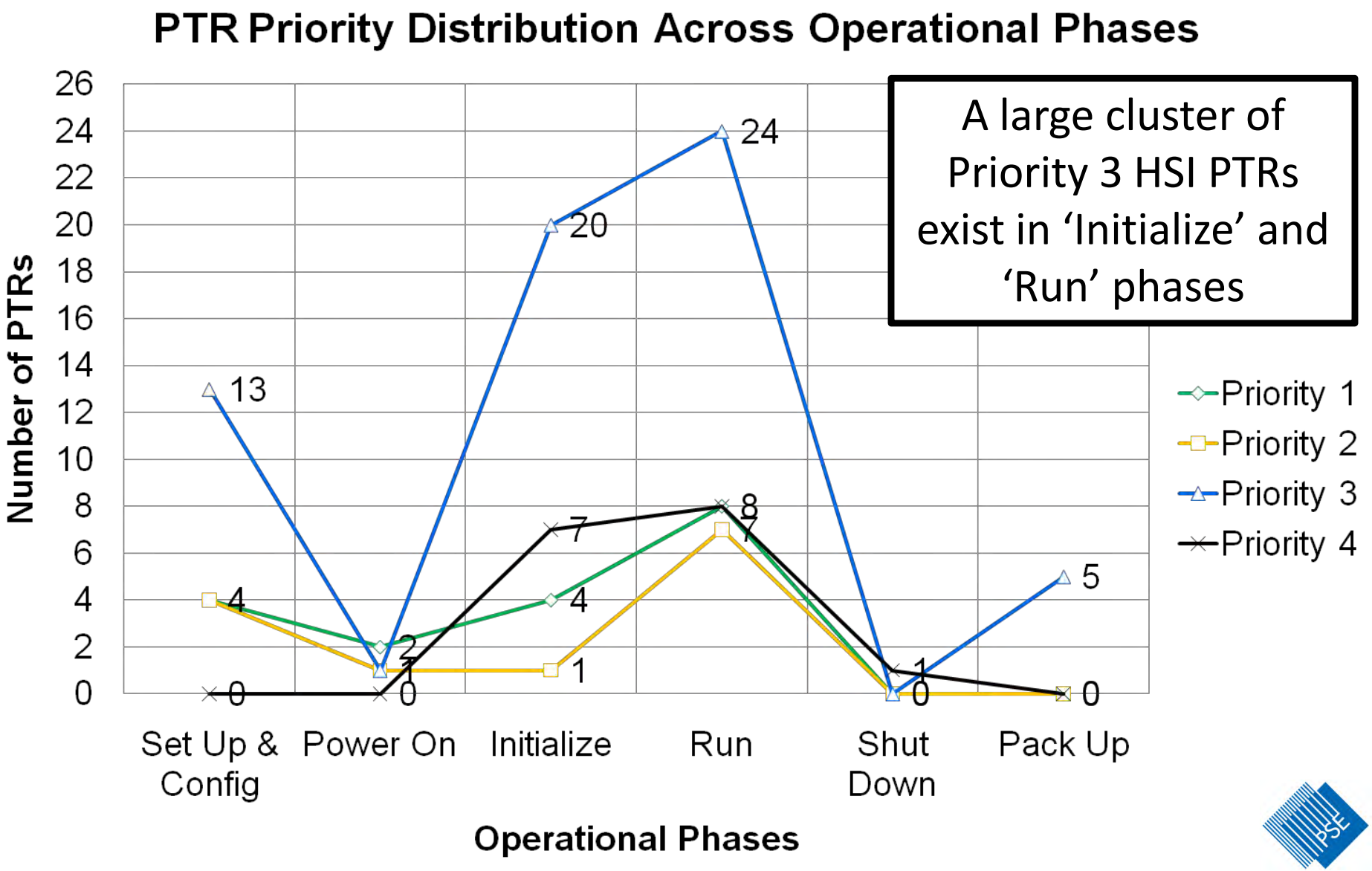
HSI PTR Analysis: Rationale

- A series of HSI DT analyses identified 110 human performance-related PTRs
  - 12 High, 57 Moderate, and 41 Low risk HSI PTRs
  - Priority categories were 1's (18), 2's (13), 3's (63), and 4's (16)
- Most HSI-related PTRs were of lower priority because workarounds were identified (e.g. usability items)
- However, human errors and workload can be additive
  - Several smaller issues can equal one large issue
  - Workload increases with each issue
  - Errors can have cascading consequences
- Analyses needed to determine impact on operational performance to scope future efforts – 2 analyses were performed:
  - PTR Frequency and Risk Distribution Analysis
  - PTR Expanded Error Analysis

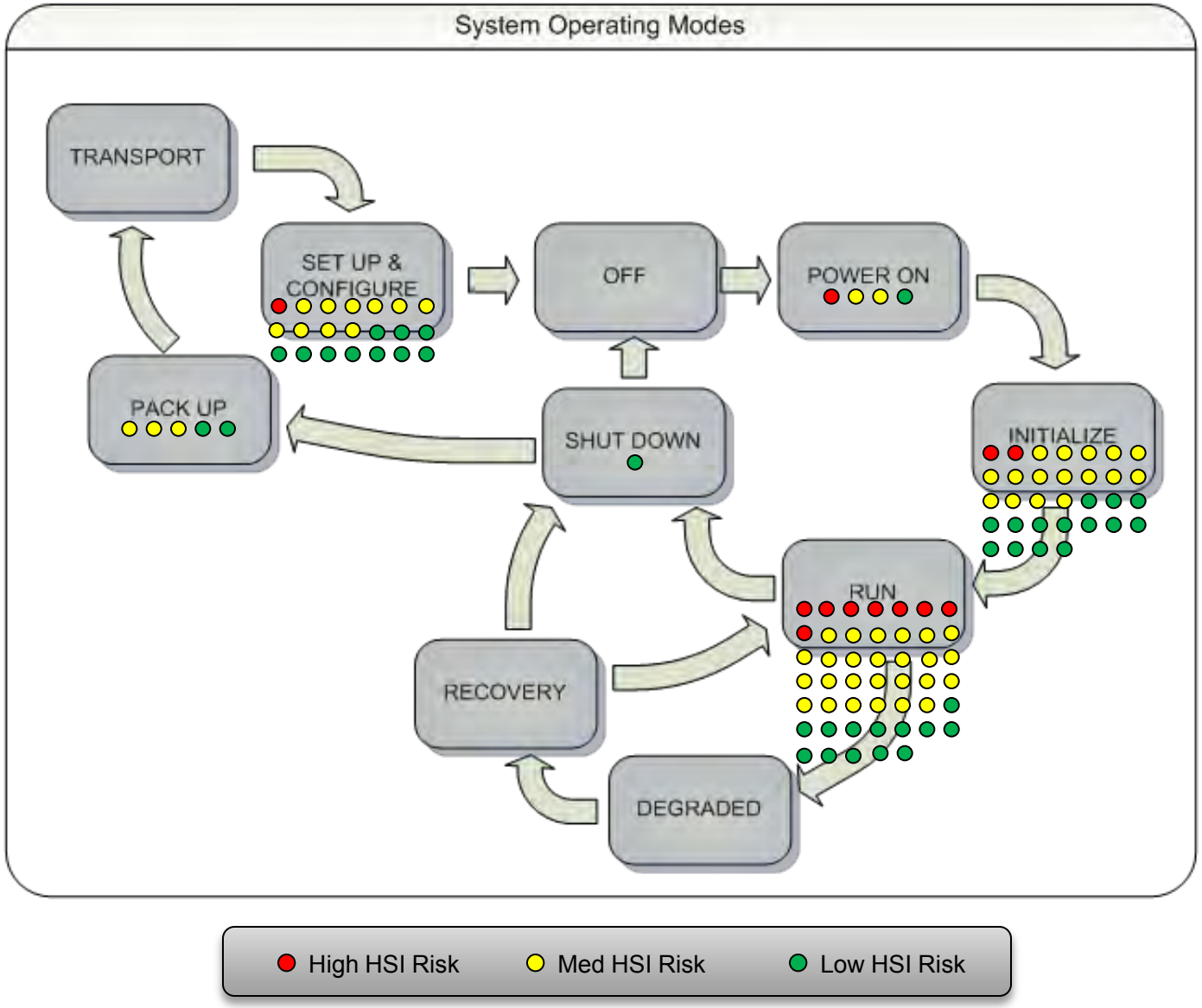
HSI PTR Distribution Analysis: Method

- Objectives:
  - Identify the impact of lower priority PTR clusters on operational phases
  - Determine the type and severity of human performance risks
  - Evaluate the distribution of HSI-related PTRs against operational workflow
    - Risk severity distribution (High, Medium, Low)
    - Risk type distribution (Error, Safety, Workload)
  - Identify the high-risk HSI PTRs based on the consequences of latent errors that may impact operational performance
- Method:
  1. Plotted HSI-related PTRs against operational workflow to identify low priority clusters
  2. Categorized HSI PTRs for type of risk (workload, safety, error)
  3. Based on analyses of Frequency and Consequence, derived and categorized HSI Severity (high, medium, low) using MIL-STD 882D risk matrix
  4. Matched HSI PTRs to System Operating Modes or other system components
  5. Plotted and analyzed clusters of risk type and severity within the operational workflow

HSI PTR Analysis: HSI Priority Distribution

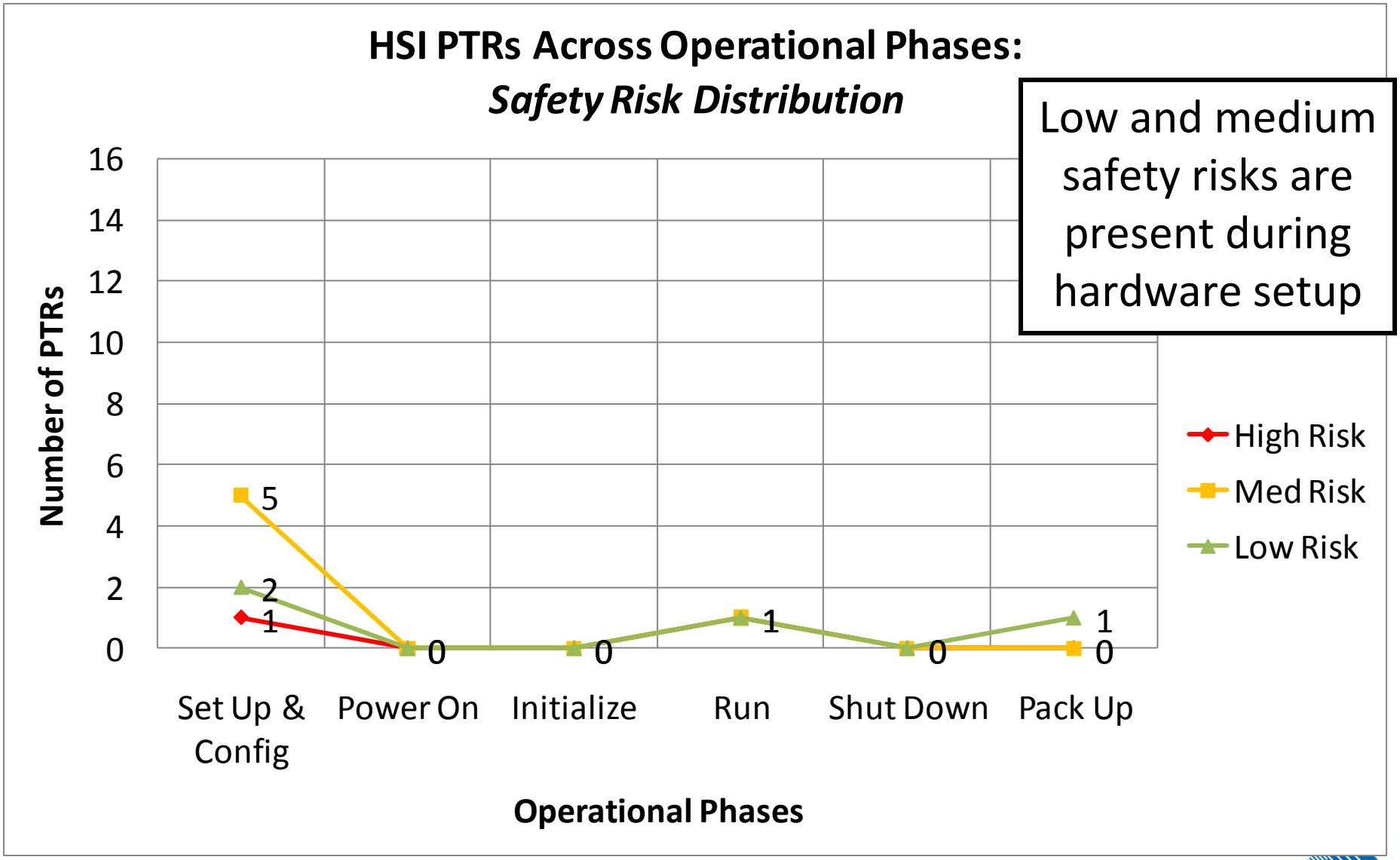


HSI PTR Analysis: HSI Severity Distribution

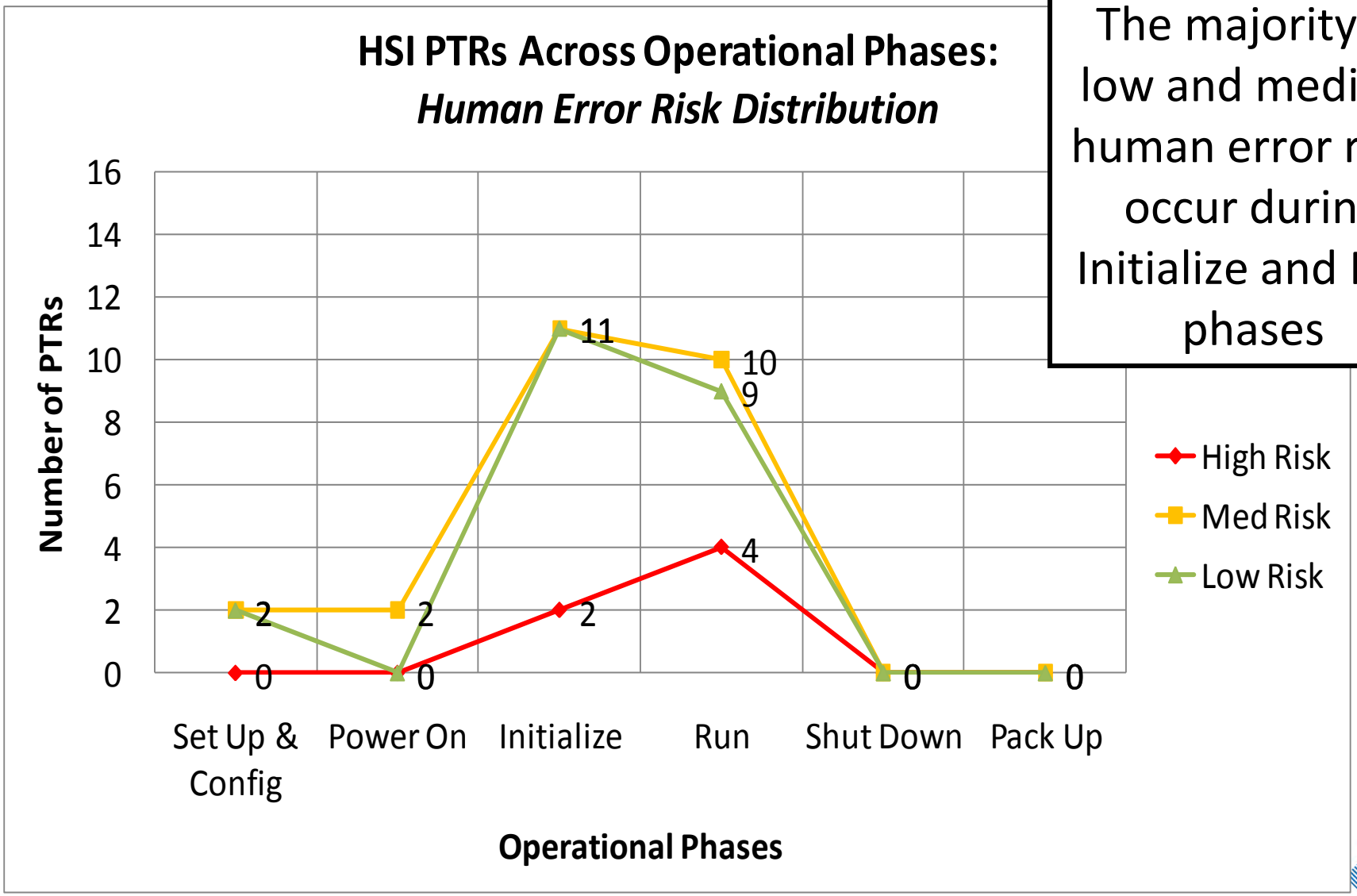


HSI risk severity plotted against workflow demonstrates significant clusters of low risk items during 'Initialize' and 'Run' – consistent with the PTR priority distribution

HSI PTR Analysis: Safety Distribution

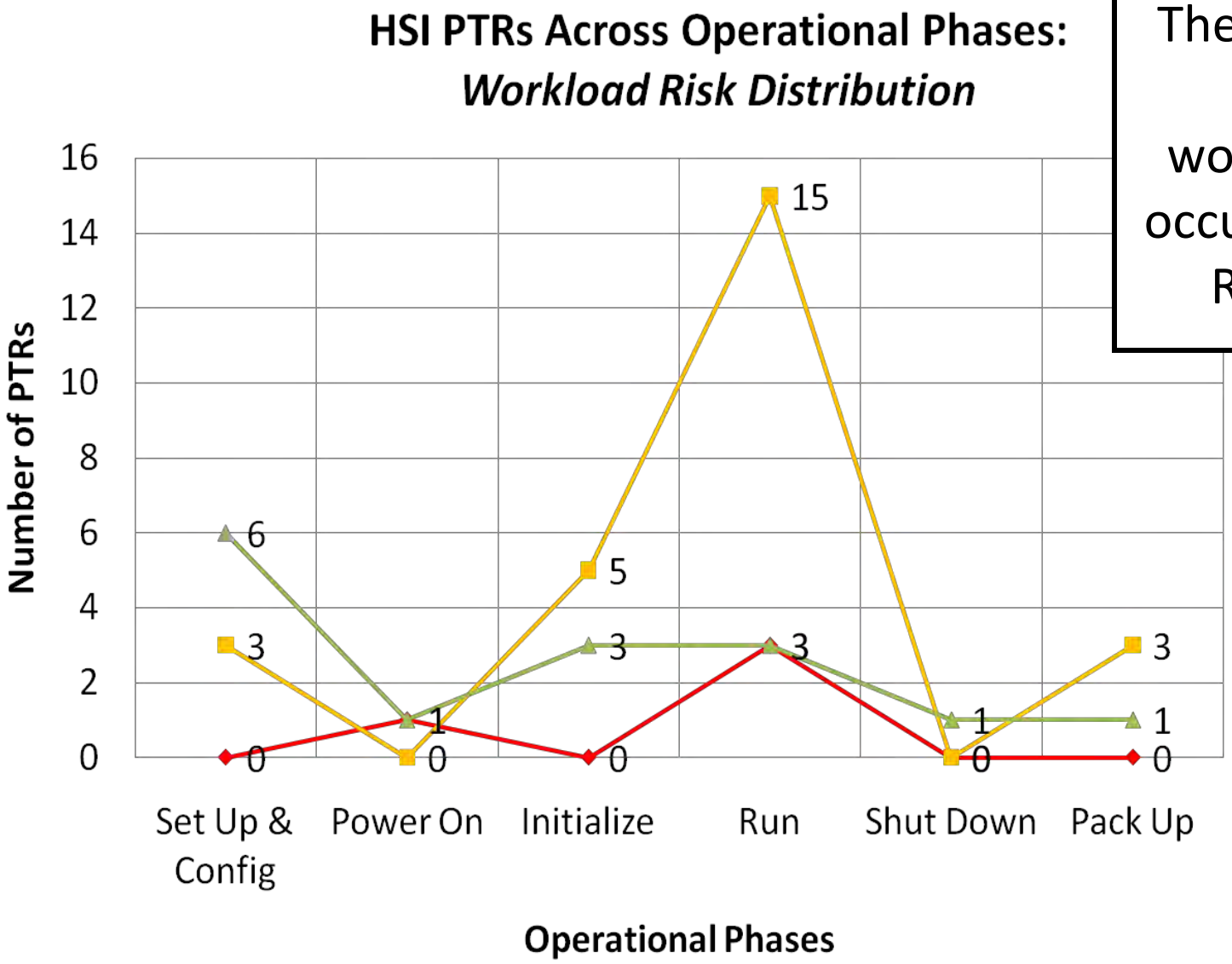


HSI PTR Analysis: Human Error Distribution



The majority of low and medium human error risks occur during Initialize and Run phases

HSI PTR Analysis: Workload Distribution



The majority of medium workload risks occur during the Run phase

Expanded Error Analysis: Method

- The 110 human performance-related PTRs were then analyzed in detail to estimate:
  - Whether the problem described was related to workload, performance (human error), or safety
  - The factors contributing to the problem
  - The likelihood the problem would occur
  - The probability the problem would be detected and corrected
- The time required to detect and correct each problem was also estimated.
- Issues in each category were then re-analyzed to identify a smaller set of those that could have significant consequences:
  - Delayed consequences – those that occur should the problem not be detected and corrected immediately
  - Cascading consequences – those that could generate additional error, safety, or workload issues

Expanded Error Analysis: Results

- Many PTRs were of lower priority because they were of low risk, easy to detect, and simple to correct.
- The analysis revealed 17 PTRs that may have delayed or cascading consequences
- Some (15) were of concern because they were associated with consequences that were difficult to detect or time-consuming to correct.
- A few (2) were of concern because they were associated with potential safety issues

HSI PTR Distribution Analysis Summary

- Conclusions:
  - This analysis method demonstrated that there may be increased human performance risks during specific phases in operational workflow
  - Lower priority PTRs were related to type of human performance risks (e.g., error and workload)
  - Clustering of lower priority PTRs can be additive – leading to a decrease in human performance, and increase operational performance risks
- Recommendations:
  - While its important to address high-priority items, some attention should be given to resolving clusters of lower priority human performance risk items that can have additive or cascading impacts on operational workflow
  - Priority should be given to the HSI-related PTRs (error and workload) that are difficult to detect and correct operationally
  - Use PTR clusters to generate cost effective ECPs (i.e., fix related items)
- Impact – The program successfully reassessed the PTR clusters to develop mitigation strategies

HSI in Developmental Testing: Summary

- HSI objectives during DT should ensure:
  - HSI tests and metrics adequately verify compliance with HSI domain requirements
  - HSI-related system and functional requirements, user needs, and operational mission objectives are met and training plans are adequate
- HSI should take a multi-phase and multi-source approach to align with existing test processes
- HSI testing should also identify any outstanding human performance risks (e.g. human error, increased workload, safety) that would negatively impact system reliability and operational performance
- Findings should be analyzed and prioritized to communicate specific human performance and operational impacts:
  - Low priority / severity issues can cluster to have additive or cascading impacts on operational workflow
  - Issues that are difficult detect or correct
- Results can be used to make trade-off decisions about risk acceptance versus engineering modifications proposed to improve the system prior to Operational Testing and fielding

Contact

For more information please contact:

Pacific Science & Engineering Group
9180 Brown Deer Rd
San Diego, CA 92121
(858) 535-1661
www.pacific-science.com

Matthew Risser, Ph.D.
risser@pacific-science.com

Driving Human System Integration into Common Industry Practice

Noreen McQuinn, Ph.D., Technical Fellow

noreen.mcquinn@boeing.com 714-330-1676

Why Human Systems Integration?

- HFE model is not sufficient to address complex systems design and government/defense increased emphasis on lowering life cycle costs
  - The human represents 70% of the variability of system effectiveness and 50-80% of the cost of a system
  - These percentages have changed little, especially for complex systems with large human component.
  - Addressing this variability and cost requires broader, systematic integration of HFE with a number of related disciplines (called domains)
- HSI is being mandated by the government
  - MANPRINT /HSI

HSI better addresses the human contribution to cost throughout the system life cycle

Acceptance of HSI in Acquisition Programs

- After 24 years of (Army) HSI, HSI still suffers a credibility and funding problem
- This paper discusses some of the reasons:
  - Government and industry maintain different interpretations and some misconceptions about Human Factors Engineering (HFE) versus HSI
  - HSI is not always properly accounted for in contract documentation to ensure inclusion in program efforts
    - SOW, Specs, CONOPS, etc
  - Established organizational structures separate HSI domains and prevent effective execution of HSI
  - Service branches have different levels of HSI maturity
  - HFE Standards are outdated, ambiguous, and insufficient

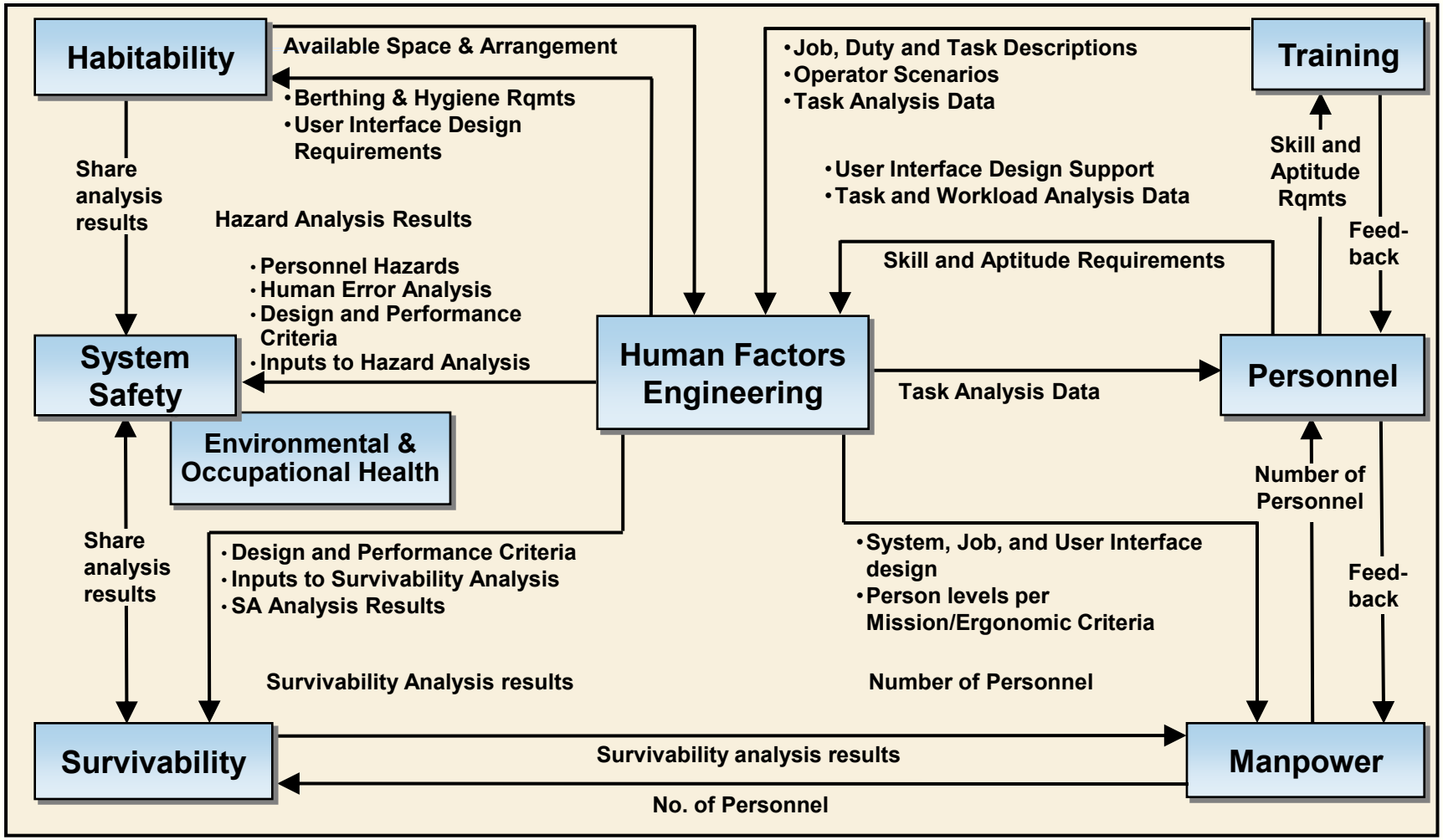
HSI has not achieved sufficient acceptance and influence in system design

Distinction between HFE and HSI

- Human Factors Engineering (HFE) is the application of human capabilities and limitations to the design, development and deployment of systems
  - HFE plays a central role in providing the scientific basis for design decisions…but it is not the whole story
- HSI is a Systems Engineering-based technical management activity integrating multiple domains, including HFE
  - These domains together capture most aspects of the human interface
  - Many of these domains have not traditionally worked closely together
    - Training
    - Manpower
    - Personnel (skill level),
    - Safety/Occupational Health
    - Habitability (Navy)
    - Personnel Survivability
    - Human Factors Engineering
- HSI coordinates these domains during Requirements Definition, Design and Development, Testing, Initial deployment, Fielding, and System Decommission

HSI is not another name for Human Factors!

Distinction between HFE and HSI (cont'd): Relationships among HSI domains



Human Factors Engineering remains a central element in the effective integration of the human with all other domains

Distinction between HFE and HSI (cont'd)

- Industry HFE and HSI specialists must continue to educate program management regarding distinctions
  - Recognize HSI in program effort from proposal through fielding
- Government must continue to educate management and practitioners
  - Naval Postgraduate School
  - Army Directorate

Industry and Government must work together to educate management and practitioners

Contractual Considerations

- HSI is often mentioned only briefly in contracts documents
- Sometimes an HSI program is specified, but deliverables are the Human Engineering DIDs!
- Human Factors is completely eliminated from the contract
- Without proper terminology, industry HSI specialists cannot influence the scope of HSI on the program
  - Without inclusion in appropriate documents, cannot create requirements necessary for budget and resources
  - HSI then lacks deliverables to document/ensure a robust effort

The Contract must include HSI to ensure adequate focus – no program is devoid of a human interface!

Contractual Considerations (cont'd)

- Specify HSI requirements, work tasks, or deliverables
  - However, maintain the traditional HFE effort as well
- Write HSI into RFP, SOW, WBS, Operational Requirements Document, Initial Capabilities Documents, CONOPS/TAD, HSIPP DID, and PDR/CDR Risk Assessment Checklists
- Define HSI milestones at a high enough level for IMP/IMS
  - HSI can be tracked, with associated risks and risk reduction efforts
  - This ensures that *sufficient time, resources, and visibility* will be allocated to HSI effort

"What gets measured gets done!"

Organizational Structure

- It is Impossible to reach across various disciplines without the proper management and process structure
- There is often a large organizational / process “distance” between
  - Training and HFE
  - Manpower, Personnel and Safety, HFE
  - Survivability and most other domains
- This requires a large leap across management chains to coordinate trade-offs
- The “Shared” decision maker is likely to be at a middle management or ranking officer level
- Few technical issues will be presented at that level
- Industry and Government HSI structure often quite different

Without a recognized organizational placement, HSI will not achieve the necessary coordination and cooperation

Organizational Structure (cont'd)

- HSI depends on a process-driven management structure
  - Represented across all IPTs with appropriate RAA
    - Enables HSI consideration of all user interface design decisions
    - Domains "do their job" but HSI integrates and levels requirements
  - Established early in acquisition, no later than SDD
  - HSI Management plan and process documented in SEMP
  - Contribute to early trade off and function allocation decisions
  - Sit on Engineering Review Board
  - Establish an HSI Audit Trail
  - HSI logs, coordinates, tracks, and documents HSI requirements, issues, and resolutions
- HSI effort would benefit from closer Industry and Government organizational alignment

Effective HSI design demands disciplined, integrated structure

Differing Levels of HSI Maturity among the Services

MANPRINT

- Established Policy
- Institutionalized Across Army
- Standardized Processes
- Centralized Functionality

NAVPRINT

- Relatively New
- Established Policies
- Based on MANPRINT
- Standard Processes being developed

AIRPRINT

- Under Development
- HSI Lead Identified

Each service is at a different phase of HSI development

Differing Levels of HSI Maturity among the Services (cont'd)

- Government/Armed services should work together to institutionalize HSI and represent a unified voice for warfighter/user
- Government and Industry should develop common terminology
- Industry must work with government to understand what is expected from an HSI program/effort

An integrated government voice could be a force of nature in establishing HSI

HFE as a Central Discipline to HSI

- HFE, as an integral part of HSI, remains an inexact science
- While there is a continual refinement of HFE tools, techniques and methodologies, most HFE effort remains in development and validation testing
  - Management is often unwilling to make the investment for early prototyping and testing
    - Analysis is often qualitative, crude, and early in program
    - Systems are often not mature enough for valid testing
    - Field testing is very expensive and too late to effect change
    - Late “fix-its”, end-user dissatisfaction/errors incur greater cost

Funding and system availability render HFE less effective

HFE as a Central Discipline to HSI (cont'd)

- Much of 1472 is guidance material, not a requirements document
- Invoking 1472 wholesale is an archaic method of imposing "requirements"
  - Not enough RFP/Proposal time or proposed design detail to tailor 1472 effectively
  - Even for actual requirements, most "over-define" the interface
  - Incomplete, at best, for User Interface considerations

MIL-STD-1472 provides great guidance, but it is insufficient to ensure effective human-centered design

HFE as a Central Discipline to HSI (cont'd)

- Apply MIL-STD-1472 selectively
  - Industry must work to the contract!
  - Over-application of 1472 creates paperwork nightmare
  - Under-application of requirements leaves industry HSI personnel no opportunity for adequate resources and focus
- Move toward performance requirements
  - Functional requirements can limit design; Cannot cover all possibilities
  - Performance and constraint requirements must be clearly defined

Government and Industry work together to better define HFE requirements and constraints

Summary

- Continue to educate practitioners within Industry and Government about HSI
  - Provide clear examples of HSI contributions to cost and safety
- Ensure that contracts include HSI in RFPs, SOW, Specs etc
  - But don't forget to include the HFE effort!
- Create process and structure to incorporate HSI in programs
- Branches come together to provide single and consistent HSI voice
- Continue to develop HFE requirements, constraints, performance measures, ensure adequate testing

Industry and government must work together to ensure an effective implementation of HSI

Headquarters U.S. Air Force

Integrity - Service - Excellence

Human Systems Integration Translation of Capabilities Requirements to Acquisition

U.S. AIR FORCE

Ms. Carol Blankenship
711 HPW/HPO
Ms. Lisa Kaminski
Booz Allen Hamilton
27 October 2010
Version 1

U.S. AIR FORCE

Overview

- Air Force HSI
- Objectives
- Approach
- Implementation
- Resources

HSI
HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI Defined

- "HSI is the integrated, comprehensive analysis, design and assessment of requirements, concepts and resources for systems with respect to Manpower, Personnel, Training; Environment, Safety & Occupational Health; Habitability, Survivability, and Human Factors Engineering (HFE)." – AFI 10-601
- "HSI considers all human-related domains in an integrated manner. It must be addressed throughout the life cycle, and must be consistently integrated into SE implementation to balance total system performance (hardware, software, and human)…" – AFI 63-1201

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI Domain Considerations

Human Factors Engineering	Manpower	Personnel	Training
-Compatibility of design with human performance capability/expectations -Human-System-Environment interfaces -Impact of design on skill, knowledge, & aptitudes requirements -Workload, situational awareness, and human performance reliability -Implications of mission, system, and human performance requirements -Design-driven human performance, reliability, effectiveness, efficiency, and safety performance requirements -Simplicity of operation, maintenance, and support -Costs of design driven human error or inefficiency	-Wartime/Peacetime manning requirements -Deployment considerations -Force structure -Operating strength -Manning concepts -Manpower policies -Future technology & human aptitudes -System MERs -A76 Considerations -BRAC Considerations -Life Cycle Cost Implications of Manpower decisions 	-Personnel Selection and Classification -Demographics -Knowledge, Skills, Abilities -Accession/Attrition -Career progression & retention rates -Promotion flow -Personnel/Training pipeline flow -Qualified personnel when and when needed -Projected user population/recruiting -Cognitive, physical, educational profiles - Life Cycle Cost Implications of Personnel decisions	-Training concepts and strategy -Training tasks/training development methods -Media, equipment, facilities -Simulation/Emulation -Virtual applications -Operational tempo -Training system costs, OSS&E, efficiency -Trainer currency -Training vs. Job Aids -Timeliness of delivery -Manpower and Personnel policy implications for training flow and costs

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI Domain Considerations

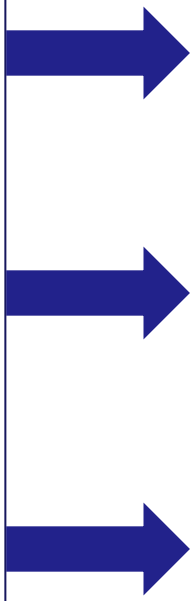
Habitability	Survivability	Environment	Safety	Occupational Health
-Physical living environment (e.g., berth, toilet, bath) -Support services (e.g. food, medical, clergy, recreation) -Impact on sustained mission effectiveness -Impact on recruitment of personnel -Impact on retention of personnel	-Threats -Operational arenas -Fratricide Identification Friend/Foe (IFF) -Potential damage to crew compartment & Personnel -Camouflage/ Concealment -Protective equipment -Medical injury Fatigue & Stress -Degraded mission -Long/short term	-Health hazards induced by systems, environment, or requirements -Areas of special interest including: -Mechanical -Acoustics -Biological & Chemical substances -Radiation -Oxygen deficiency & Air Pressure -Temperature & Weather -Shock & vibration -Laser protection	-Safety of design -Procedures – Normal & Emergency -Human error -Total System reliability & fault reduction -Total System risk reduction -Comprehensive Safety -Human -Flight -Weapon -Ground -NBC -Equipment -Environment -System	-Operational Health -Hazards -Environment -Systems -Health care -Diagnose, treat & manage illness & trauma -Heat, cold, hydration -Stress & Fatigue -Exercise & Fitness -Personal protection -Disease prevention (vaccines/hygiene)

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Domain-to-Attribute Interface

- Manpower
- Personnel
- Training
- Habitability
- Survivability
- Human Factors Engineering
- Environment
- Safety
- Occupational Health



Usability	•Operations •Sustainment	Support Training
Operational Suitability	•Utility •Interoperability •Survivability	Operability Dependability Habitability
Sustainability	•Serviceability •Availability •Dependability	Reliability Accessibility Maintainability

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

AF HSI Organizations

- AFHSIO
  - Located at SAF/AQ
  - Strategic HSI organization
  - Responsible for HSI policy, guidance, and oversight
- 711 HPW/HP
  - Located within AFRL
  - Tactical HSI organization
  - Responsible for HSI implementation and execution
- HSI Cells
  - Located at Air Combat Command, Air Mobility Command, Air Force Special Operations Command, Air Education and Training Command, and Air Force Materiel Command
  - Responsible for integrating and executing HSI

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

AF HSI Objectives

- *Integrate* HSI processes into the integrated Acquisition, Technology and Logistics Life Cycle Management Framework to equip and sustain the warfighter
- *Institutionalize* HSI as a way of doing business to increase total systems performance and decrease total ownership costs
- *Sustain* HSI through collaboration with partners in OSD, AF, sister services, industry and academia
- *Improve* HSI processes through metrics, feedback, and lessons learned from operational, logistics and acquisition communities

Increased HSI awareness and implementation

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Target for HSI in the AF

- Intent is to work HSI backwards through the acquisition process from Operations and Support to Pre-concept development
  - Reverse movement through Acquisition Life-cycle to become more involved pre-Milestone B
  - Early and frequent involvement throughout entire Life Cycle from concept to disposal
- Increased participation in JCIDS requirements development
  - Providing inputs for CBAs
  - Formal and informal inclusion in capabilities documents
  - Participation in HPTs
  - Participation in AoAs
- Coordination of HSI goals between AFHSIO, 711 HPW/HP and Major Commands

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI MAJCOM Objectives

- Integrate and Institutionalize HSI within each Air Force Major Command (MAJCOM)
- Develop HSI Cell to serve as HSI focal point
- MAJCOM Goals
  - Implement HSI through the entire system life cycle
  - Review Documents for HSI Inclusion
  - Participate in IPTs and Working Groups
  - Provide HSI expertise for MAJCOM programs

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI Approach

Policy – AFHSIO stood-up to impact DoD and AF policy

Support – 711 HPW/HP and MAJCOM Cells

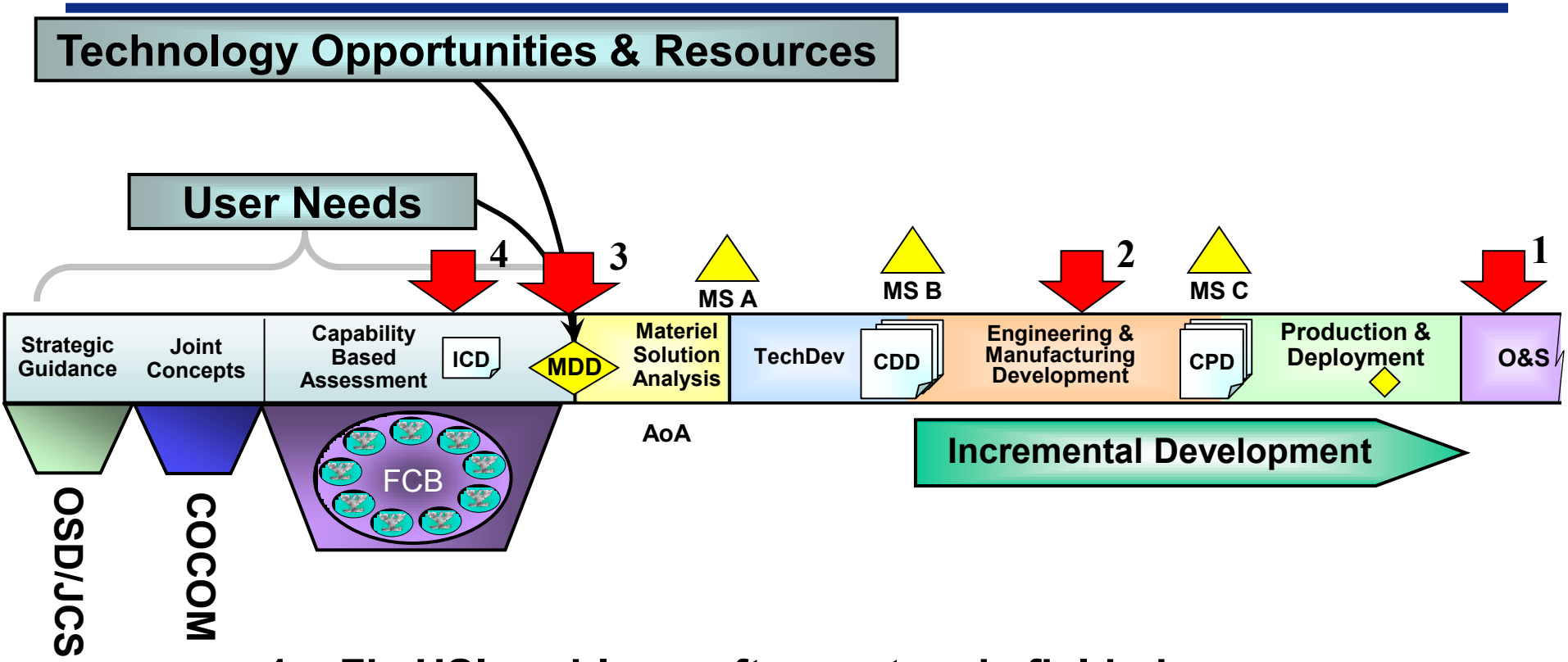
Approach – Influence acquisition process through analysis, requirements & design

Practice – Training, Program POC, IPT, Planning, Center WG, MAJCOM Cells

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI → Full Life Cycle



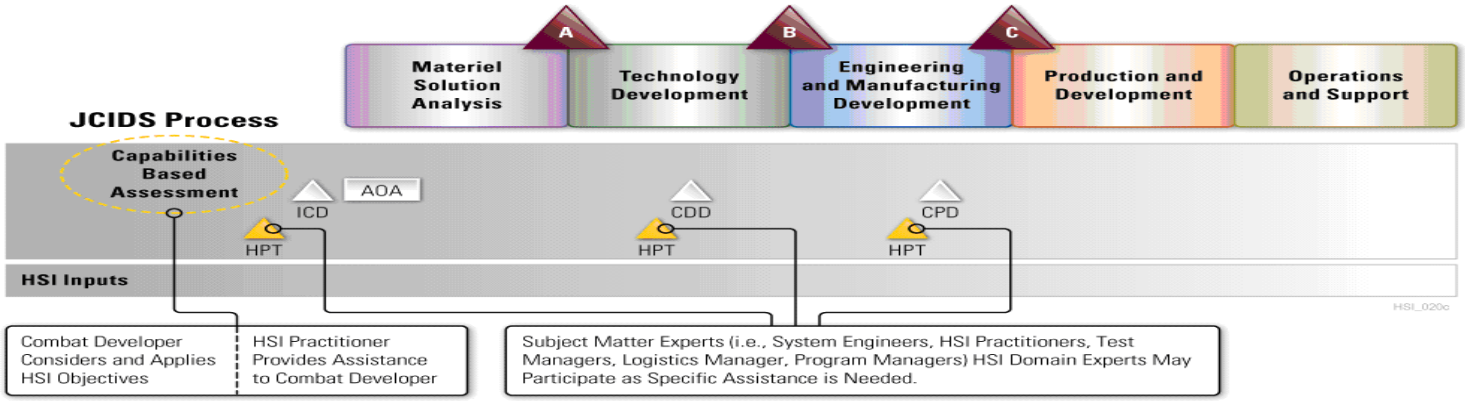
1 = Fix HSI problems after system is fielded
2 = Prepare for HSI support before the system is fielded
3 = Use HSI as a selection criteria/consideration (and cost)
4 = Make HSI part of the trade space to solve the gap/shortfall

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI in Operational MAJCOMS

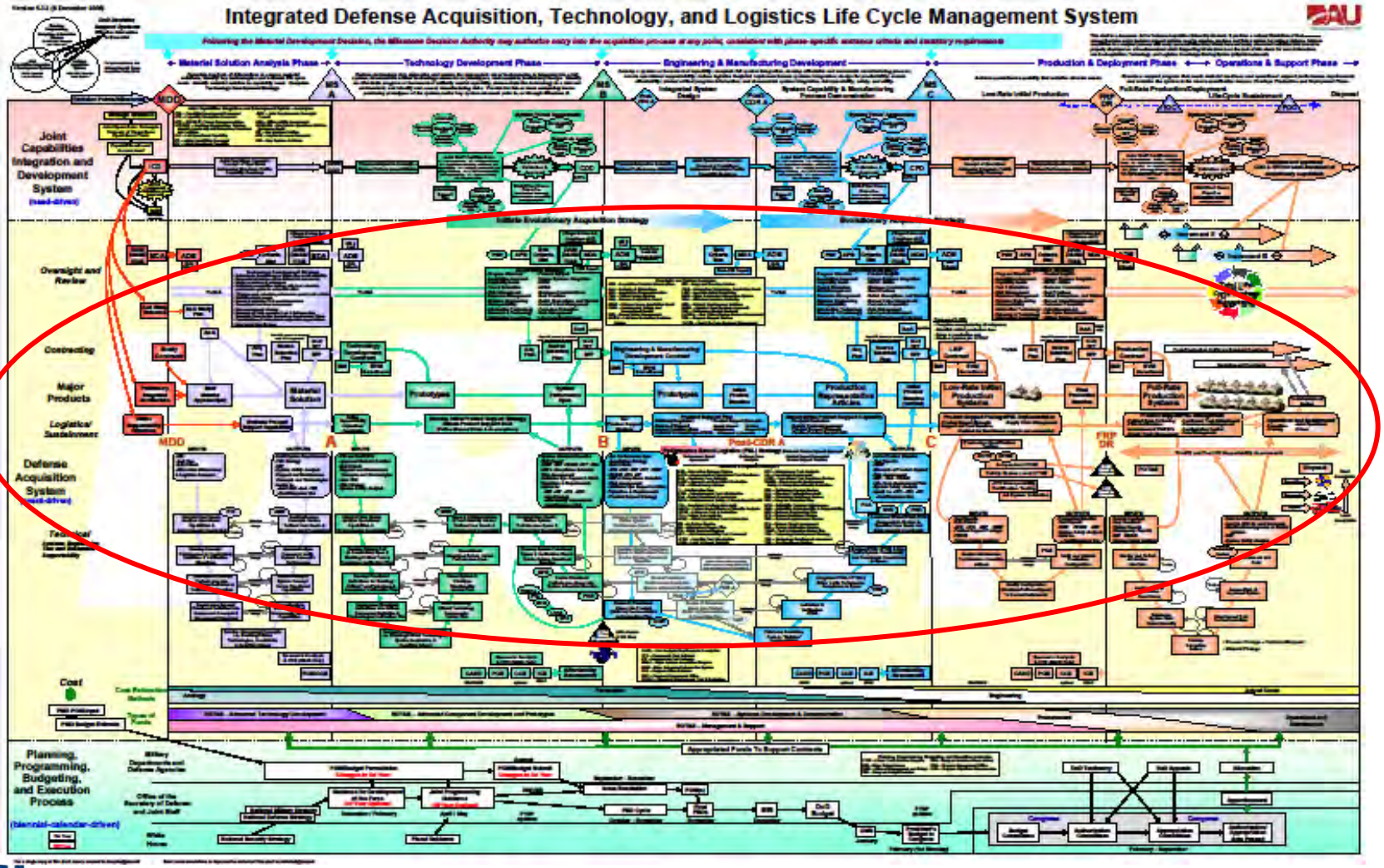
- Inclusion in Operational MAJCOM requirements processes
  - Working through the Requirements Process Owner and Requirements Managers
  - Inputs into capability requirements documents (ICDs, CDDs, and CPDs)
  - HSI inclusion in AoA Study Guidance
  - Participation on AoA Study Teams
  - Development of measurable human-related requirements



HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI in Acquisition



HSI
HUMAN SYSTEMS INTEGRATION

Integrity - Service - Excellence

U.S. AIR FORCE

HSI Challenge in Acquisition

Perception – Military HSI efforts are robust and exhaustive

Reality – Human Factors Research is an advanced subgroup of HSI

Problem – HSI is often minimized and pursued too late in the life cycle

Challenge – Consider the human early and frequently

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI in AFMC

- **Product Centers**
  - ***Acquisition***
  - Engineering Directorates
    - Systems Engineering processes/documents
  - Planning Directorates
    - Development Planning processes/documents
- **Logistics Centers**
  - ***Sustainment***
  - System Sustainment Managers/Engineers
    - System Modifications
- **Test Centers**
  - **Verification and Validation**
  - Safety Directorates
    - Safety/Occupational Health Testing
  - Engineering Directorates
    - Logistics and Human Factors Testing
- **Research Laboratory**
  - ***Research***
  - Technology Directorates
    - Systems Engineering and Human Performance

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI is Integral to SE

- HSI underpins Systems Engineering
- Enabling function for efficient system development
- Early inclusion results in better analysis, requirements, design, and ultimately a better end-state system
- Explores interrelationships (both internal and external) of process components
- Facilitates understanding system interactions/linkages
  - Mitigation of risks (limited understanding of system)
  - Produces “trade space” for designing and developing systems

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

HSI in Early SE

- Proper translation of human-related requirements into acquisition documentation
- Inclusion in the following processes/documents:
  - Development Planning (DP) efforts
  - Concept Characterization Technical Descriptions (CCTDs)
- HSI in „living" documents
  - SEP
  - LCMP
  - SRD
- Tools and processes
  - AoA training
  - Acquisition & Sustainment Toolkit (ASTK)
  - Human Readiness Levels
  - Systems Engineering Assessment Model (SEAM)

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Enabling Functions for HSI

- HSI community is coordinating with other enabling functions to further impact system design and provide cost savings
  - Logistics
  - Intelligence
  - Communications
  - Modeling and Simulation
- Similar goals and efforts to increase involvement in requirements and acquisition
- Early involvement decreases total ownership costs

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Continuing Efforts

- Integrate and sustain early and frequent involvement
- HSI planning throughout the system‟s life cycle by inclusion in and update of “living” documents
- Provide training to requirements, acquisition, and sustainment personnel and communities
- Enhanced tools and processes to include and assess HSI efforts

HSI HUMAN SYSTEMS INTEGRATION

U.S. AIR FORCE

Resources

- Tools and resources:
  - Public site: http://www.wpafb.af.mil/afrl/711hpw/hpi.asp
  - Closed site: https://wwwd.my.af.mil/afknprod/ASPs/CoP/ClosedCoP.asp?Filter=HP-HS-01
- Contact Information
  - AFHSIO: HSI.workflow@pentagon.af.mil
  - 711 HPW/HPO: 711hpw/hp.hsi.workflow@brooks.af.mil
  - 711 HPW/HP: Carol Blankenship carol.blankenship@wpafb.af.mil;
  - AFMC Cell Rep: Lisa Kaminski kaminski_lisa@bah.com; 937.781.2459

HSI HUMAN SYSTEMS INTEGRATION

Aeronautical Systems Center

Dominant Air Power: Design For Tomorrow…Deliver Today

U.S. AIR FORCE

ESOH in Systems Engineering Across the Entire Acquisition Life Cycle

(27 Oct 10)

Mr. Ted Grady
ASC/WNV
(937) 255-3578
Tedmond.Grady@wpafb.af.mil

Environment, Safety & Occupational Health (ESOH)

- **Impacts on Acquisition**
  - **More stringent ESOH regulations increase risk**
    - **Hexavalent Chrome Minimization**
    - **European REACH policy**
  - **O & M phase is ~60% of systems life cycle**
    - **ESOH costs can equal 20-30% of some O&M tasks**
  - **$1 = $10 of hidden hazardous materials costs**
    - **$10 in related costs over life cycle**
    - **Controls, monitoring, record keeping, disposals, etc.**
  - **DoDI 5000.02 lists several ESOH requirements**
    - **Across several disciplines & all life cycle phases**

ESOH Drivers

LAW — 42 USC 4321-4370d, 11001 et seq. & 13101 et seq.

EO — Executive Order 13423 Executive Order 12114

CFR — 10 CFR 30-36 49 CFR 172.101
40 CFR 112, 261.32, 279 & 1500-1508

DOD — DODD 4715.4 DODI 5000.02 DODD 6050.9

AFI — AF Instructions 32-7061, 7080, 7086

AF POLICY — SAF/AQ Policy Letter 94A-003
AF Policy Directive 32-70

Oc. & Environmental Health Exposure — **AFM 48-155**

AF Drivers

- AFPD 32-70 Environmental Quality
- AFPD 90-8 Environment, Safety, and Occ Health
- AFI 32-7110 Environmental Budgeting
- AFI 32-7080 Pollution Prevention Program
- AFI 48-145 Occupational Health Program
- 32 CFR 989 Environmental Impact Analysis Process
- AFI 63-101 Operations of Capabilities Base Acq Sys
- AFI 63-1201 Life Cycle Systems Engineering
- AFI 91-202 US Air Force Mishap Prevention Program
- MIL-STD-882D Standard Practice for System Safety

ESOH Risk

- **Minimized ESOH risk across life cycle**
  - **Prevent ESOH risk when possible**
  - **Manage ESOH risk when unavoidable**
  - **Def Acq Guidebook: three types ESOH risks**
    - **Adverse effects from routine system development, testing, training, operation, sustainment, maintenance and demilitarization/disposal**
    - **Mission readiness impacts from system failures or mishaps, including critical software failures**
    - **Impacts to program lifecycle cost, schedule and performance from ESOH compliance requirements**

ESOH Compliments Weapon System Goals

- **Two of ASC's Strategic Priorities**
  - Implement Integrated Life Cycle Management
  - Develop and Care for Our People
- **Engineering problems have ESOH solutions**
  - F-16 coatings drying faster improve PDM cycle
  - Hydraulic Fluid Purification increased MTBF
- **Ideally addressed in Systems Engineering**
  - Coordinate with program mangers, operators, users, testers, maintainers and manufacturers
  - Included ESOH in trade-offs with other "ilities"

ASC ESOH Risk Management

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

ESOH Risk Management

- **Institutionalize ESOH into Acq Process**
  - Requirements in Systems Requirements Document, Life Cycle Management Plan, Request for Proposal, Test Evaluation Master Plan, etc.
  - Summarize Strategy & Risk in Programmatic Environment, Safety & Health Evaluations (PESHE)
- **Institutionalize ESOH into Sys Engineering**
  - Summarize ESOH approach in Sys Eng Plan
    - Address ESOH risk in design reviews
    - Assess impacts of updates to laws/regulations
  - Seek material substitutions or identify needs
- **Work ESOH across entire life cycle**

ESOH into Acquisition & Systems Engineering Process

- **Acquisition Planning & Review**
  - EIAP, ODS Approvals, SEP, LCMP, ASP
- **Request for Proposal**
  - RFP (Sections H, I, L & M), SOO or SOW, CDRLs
- **Source Selection Evaluation**
  - Statement of Work and Integrated Master Plan
- **Design Reviews**
  - Alternative processes and/or material
- **Test & Evaluation Master Plan**
- **Modification Processes**
  - ECPs, Deviations and Waivers

Acquisition Strategy

- **Acquisition Strategy Panel**
  - ESOH ASP representative
  - ESOH template slide with calculate risk (i.e. ESOH Prg Risk Tool)
- **Life Cycle Management Plan**
  - Required to summarized ESOH Strategy
- **Programmatic Environment Safety and Health Evaluation (PESHE)**
  - Program office developed document
  - Summarizes ESOH Strategy & known risk
  - Required regardless of Acquisition Category

ESOH ASP Template Example

- Date of PESHE completion or recent update
- National Environmental Policy Act (NEPA) Compliance Strategy/Schedule & Coord. Status
- Ozone Depleting Substance (ODS) Use/ Waivers
- Hazardous Materials Use
  - Hexavalent Chrome Certification
- Demilitarization & Disposal Strategy

AFI 63-1201

Life Cycle Systems Engineering

- **ESOH Requirements**
  - Development, acquisition, and sustainment efforts must also address ESOH Integration
  - Integrate ESOH into the Sys Engineering process
    - Using MIL-STD-882D system safety practices
  - Identify basic ESOH strategy in Sys Eng Plan
  - PESHE elements in Risk Mgmt Plan, Integrated Master Plan, and Integrated Master Schedule
  - PESHE documents status of ESOH hazard identification, assessment, mitigation, verification, and residual risk
  - PESHE contains National Environmental Policy Act (NEPA) compliance schedule
  - Technical and program reviews must include ESOH risk management status

Systems Engineering Plan

- **The SEP should include a section on ESOH Management that documents the approach.**
  - **23 Sep 04 USD (AT&L) Memo**
    - **Incorporate DoDI 5000.2 requirements to integrate ESOH strategy into systems engineering**
  - **AFI 63-1201 Requires ESOH summary in SEP**

Request For Proposal

- **ESOH language should be included in the RFP (Sections H, I, L, & M)**
  - **ASC Templates for ESOH verbiage**
- **System Safety & HazMat Management Plans**
  - **National Aerospace Standard 411**
  - **MIL-STD-882D**
  - **Address hazardous material use/disposal, system safety hazards, occupational health concerns, and pollution prevention initiatives**

Source Selection

- **Examine Offeror's ESOH Program to determine if critical requirements are satisfied**
  - **Integrated Master Plan/Schedule**
  - **Draft System Safety or Hazardous Materials Management Plan**

Design Reviews

- **23 Sep 04, USD (AT&L) Memo**
  - **Identify, assess, and mitigate ESOH risks**
  - **Report residual risk at technical reviews**
- **Treat ESOH as a normal part of the Design Review (DR)**
  - **Address ESOH in PDR/CDR reports**
  - **ESOH checklist in DoD Acquisition Community Connection**
- **DoDI 5000.02 requires SME participation**

Design Review Considerations

- **Alternative processes and/or material**
  - **Reduce flow time**
  - **Increase cost savings**
  - **Provide P2 needs during annual data call**

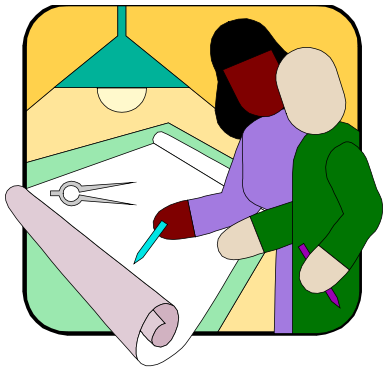
  - **Examples: Laser Stripping,O2 Line Cleaning, Flashjet®, High Performance Coatings**

Test Planning

- **NEPA Planning**
  - Coordinate with test organization to support their NEPA documentation requirements
  - Place NEPA data requirements on contract
- **Safety analyses document the hazards associated with operating the system**
  - List procedural controls needed during test
  - Safety design/mitigations often verified through tests
- **Early identification of requirements is necessary to properly scope the test effort**
  - Ex. High noise levels

Modifications

- **Contract Change Proposal (CCPs) and Engineering Change Proposal (ECPs)**
  - **SOW requires contractor to determine the ESOH impacts as part of the submittal process**
  - **If ESOH impacts unknown- contractor specify actions to identify, categorize, and minimize the potential impacts**
  - **Ideally, ESOH Rep on Configuration Control Board**



ESOH During All Life Cycle Phases

- Material Solutions Analysis
- Technology Development
- Engineering & Mnfg Development
- Production & Deployment
- Operation & Support
- Disposal

ESOH needs to be accomplished during all life cycle phases of weapon system acquisition

ESOH During Material Solution Analysis

- Identify ESOH requirements for AoAs
- ID responsibilities for ESOH integration
- Complete Preliminary Hazard List
  - For each concept
- Starting point for Hazardous Materials
  - EPA 31 Priority Chemical List
  - Ozone Depleting Substances
  - Chemical & Material Risk Management Directorate
    - Formerly MERIT

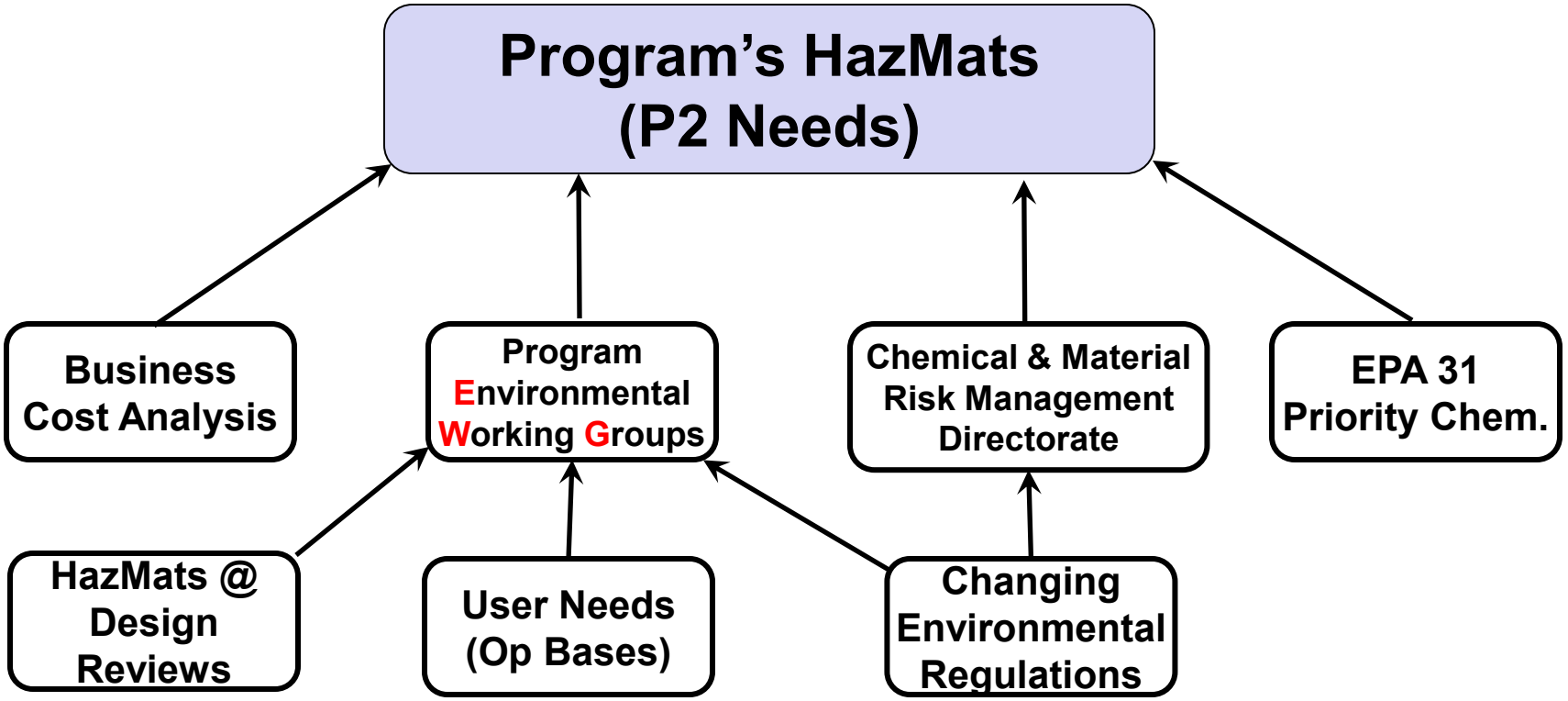
ESOH During Technology Development

- Strategy for integrating ESOH into Sys. Eng.
- Identify emerging ESOH technologies & hazards
- Update PESHE for Milestone B Review
  - SEP should have addressed ESOH @ MS A
- Summarize ESOH Risk at Pre-Milestone B PDR and in PDR Report
  - DoD Acq. Community Connect checklist

Identifying Hazardous Materials

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today



Recommend Program Office hold EWG or address ESOH matters through System Safety Group

ESOH During Engineering & Mnfg Development

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

- **Address ESOH in CDR & CDR report**
  - **DoD Acq. Community Connect checklist**
  - **Document Hazardous Materials**
- **Green Procurement**
- **Substitutions**
  - **Hexavalent Chrome and other P2 alternatives**
- **Flight Test NEPA**
- **Health Risk Analysis**
- **Document ESOH Risk in the PESHE**
  - **Updating for Milestone C**

ESOH During Production & Deployment

- Update PESHE for Full Rate Production DR
- Operational Base HazMat "Pharmacies"
- Depot Repair and PDM processes
- Coordination with Logistics
  - Green Procurement
- Bed Down NEPA
  - Encroachment, noise, waste streams, etc.
- Host Nations
  - REACH
- Sustain ESOH analysis for next increment
  - Or for similar systems

ESOH During Disposal

- List of Hazardous Material
  - Special considerations at AMARG
- Disposal Plan
  - Recycle
  - Special landfill requirements
  - De-militarization precautions

Aeronautical Systems Center Acquisition ESOH Tools

U.S. AIR FORCE

Dominant Air Power: Design For Tomorrow…Deliver Today

- **ESOH Programmatic Risk Model**
  - Lessons Learned
- **PESHE Templates**
  - PESHE Checklist
- **Other ASC Acquisition ESOH Tools**
  - ESOH Circular and NEPA Circular
  - NEPA Compliance Checklist
  - Environmental criteria for pre-award documents
  - Acquisition ESOH Training

Developed with System Safety, Occupational Health, and Environmental Subject Matter Experts

Aeronautical Systems Center Acquisition ESOH Training

Dominant Air Power: Design For Tomorrow…Deliver Today

- ENV 101 – Intro to ESOH in Acquisition
- ENV 110 – ESOH Programmatic Risk Model
- ENV 120 – Developing the PESHE
- Integration of ESOH into System Engineering for Weapon System Acquisition
  - SYS 196* (Complete)
    - Overview
  - SYS 197* (30 Aug 10)
    - Material Solutions Analysis – Technology Development
  - SYS 198* (TBD)
    - Eng Mfgr Development – Disposal

*AFIT Distance Learning Courses

Conclusion

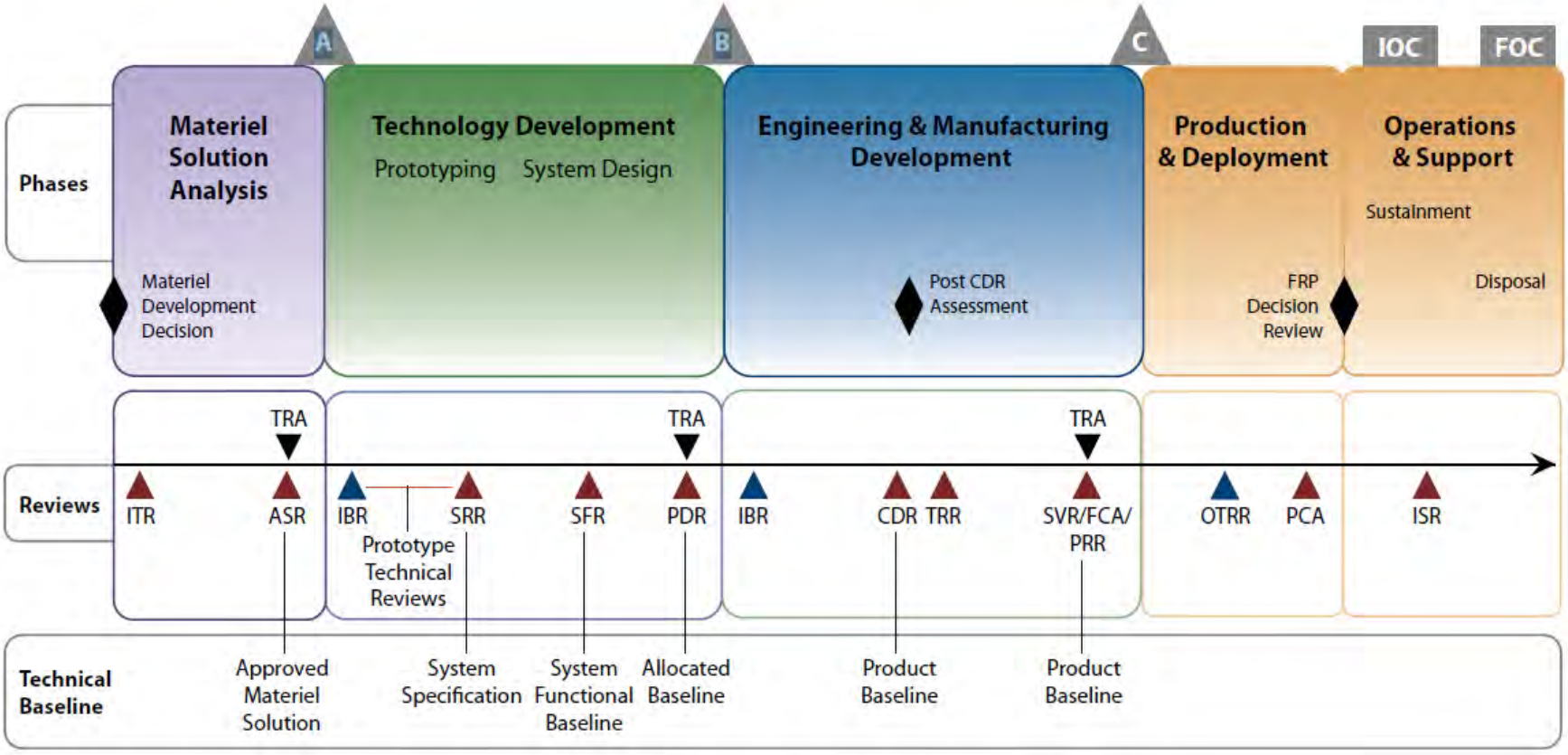
- **Establish ESOH strategy early in the acquisition life cycle to maximize risk reduction & cost savings**
- **There are ESOH efforts required across all phases of the acquisition life cycle**
  - **Document in acquisition planning/strategy**
  - **Implement through systems engineering**
- **Assess ESOH in systems engineering as part of other "ilities"**
  - **Existing sys eng process can easily be adjusted to incorporated ESOH considerations**

- **Backup Slides**

U.S. AIR FORCE

Life Cycle Overview

Dominant Air Power: Design For Tomorrow…Deliver Today



Acquisition Environment, Safety, and Occupational Health (ESOH)

– Follow Through After the Policy is Printed – ESOH in Acquisition

NDIA 2010 Systems Engineering Conference

October 27, 2010

Mr. David Asiello

Office of the Deputy Under Secretary of Defense

(Installations & Environment)

Outline

- Acquisition ESOH Mission
- The Policy
- Traditional Oversight
- Current Initiatives
- Path Forward

Acquisition ESOH Mission

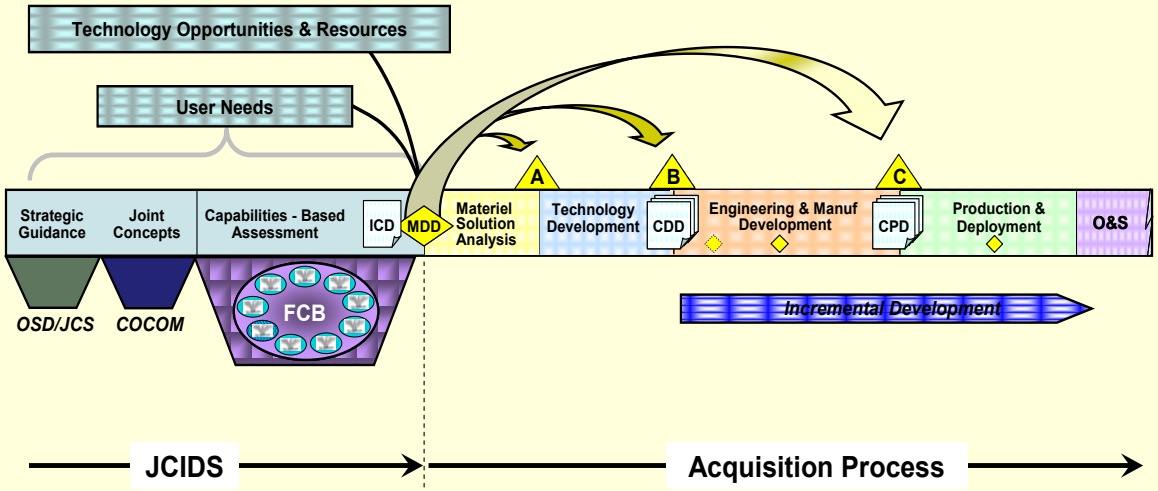
- **As part of sustaining its mission DoD is committed to avoiding**
  - Loss of life or serious injury to personnel
  - Damage to facilities or equipment
  - Harm to the environment and the surrounding community
  - System failure with adverse impact on mission capability or mission operability

"The mission of the Department of Defense is to provide the military forces needed to deter war and to protect the security of our country."

ESOH Acquisition in Policy

To accomplish our ESOH mission

- Use the System Safety methodology across ESOH disciplines to identify hazards and mitigate risks through the systems engineering process
  - ESOH refers to all individual, but interrelated, disciplines that encompass environment, safety, and occupational health
- Work throughout the Acquisition Life cycle / Framework



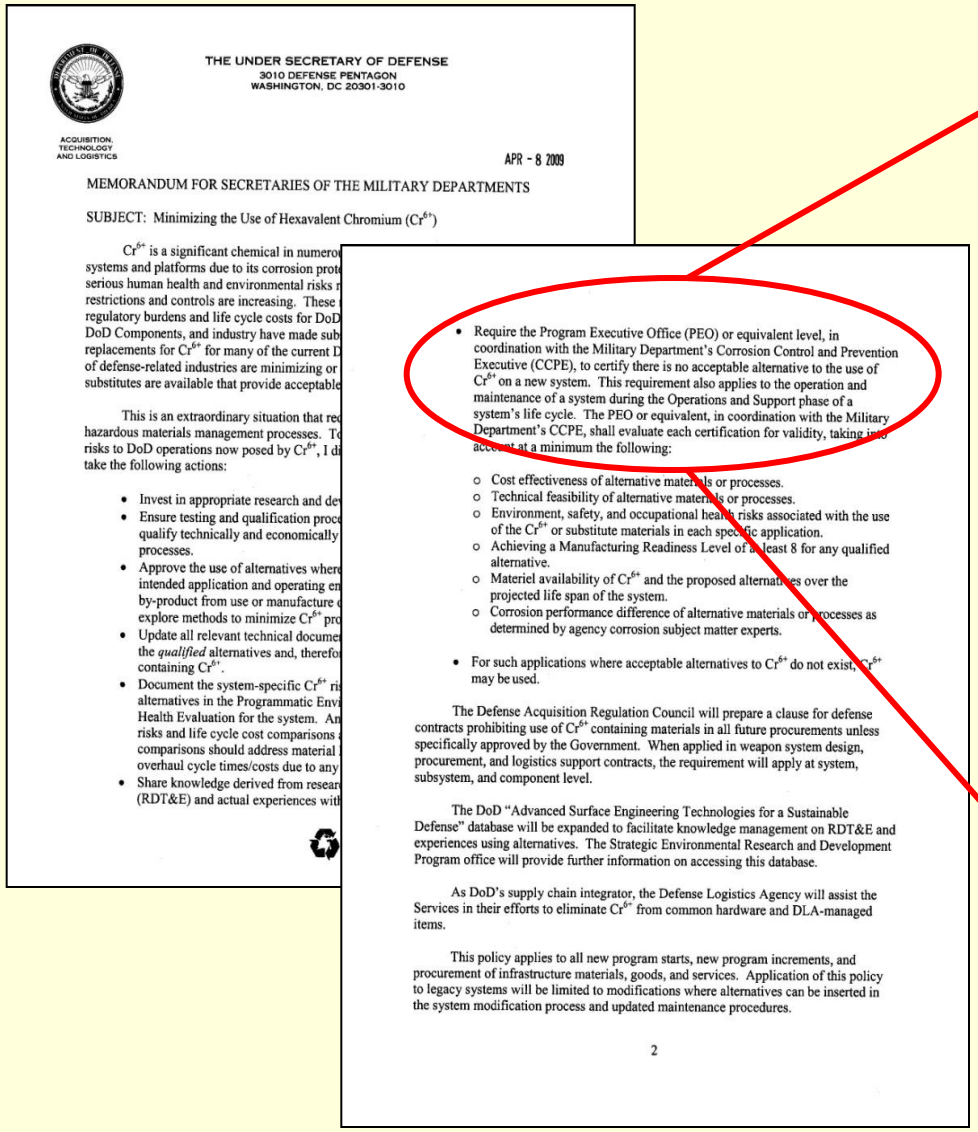
Policy & Guidance

- DoD Directive (DoDD) 5000.01, The Defense Acquisition System (May 12, 2003)
- DoD Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System (December 08, 2008)
- Defense Acquisition Guidebook, https://dag.dau.mil/
- Acquisition Community Connection, ESOH Special Interest Area, https://acc.dau.mil/esoh

Policy (DoDI 5000.02, E12.6)

- **Use MIL-STD-882D, *DOD Standard Practice for System Safety*, in all developmental and sustaining engineering activities**
- **The PM must report the status of all High and Serious ESOH risks and applicable ESOH Technology Requirements for program reviews and fielding decisions**
- **Prior to exposing people, equipment, or the environment to a known system-related ESOH hazards,**
  - Risks must be accepted by the appropriate authority
  - User concurrence for High and Serious risks.

Policy Memo: Minimizing the Use of Hexavalent Chromium



THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY AND LOGISTICS

APR - 8 2009

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS

SUBJECT: Minimizing the Use of Hexavalent Chromium (Cr^{6+})

Cr^{6+} is a significant chemical in numero systems and platforms due to its corrosion prot serious human health and environmental risks r restrictions and controls are increasing. These regulatory burdens and life cycle costs for DoD DoD Components, and industry have made sub replacements for Cr^{6+} for many of the current D of defense-related industries are minimizing or substitutes are available that provide acceptable

This is an extraordinary situation that re hazardous materials management processes. T risks to DoD operations now posed by Cr^{6+}, I di take the following actions:

- Invest in appropriate research and de
- Ensure testing and qualification proc qualify technically and economically processes.
- Approve the use of alternatives where intended application and operating en by-product from use or manufacture explore methods to minimize Cr^{6+} pro
- Update all relevant technical docume the *qualified* alternatives and, therefo containing Cr^{6+}.
- Document the system-specific Cr^{6+} ri alternatives in the Programmatic Envi Health Evaluation for the system. An risks and life cycle cost comparisons comparisons should address material overhaul cycle times/costs due to any
- Share knowledge derived from resear (RDT&E) and actual experiences wit

- Require the Program Executive Office (PEO) or equivalent level, in coordination with the Military Department's Corrosion Control and Prevention Executive (CCPE), to certify there is no acceptable alternative to the use of Cr^{6+} on a new system. This requirement also applies to the operation and maintenance of a system during the Operations and Support phase of a system's life cycle. The PEO or equivalent, in coordination with the Military Department's CCPE, shall evaluate each certification for validity, taking into account at a minimum the following:
  - Cost effectiveness of alternative materials or processes.
  - Technical feasibility of alternative materials or processes.
  - Environment, safety, and occupational health risks associated with the use of the Cr^{6+} or substitute materials in each specific application.
  - Achieving a Manufacturing Readiness Level of at least 8 for any qualified alternative.
  - Materiel availability of Cr^{6+} and the proposed alternatives over the projected life span of the system.
  - Corrosion performance difference of alternative materials or processes as determined by agency corrosion subject matter experts.
- For such applications where acceptable alternatives to Cr^{6+} do not exist, Cr^{6+} may be used.

The Defense Acquisition Regulation Council will prepare a clause for defense contracts prohibiting use of Cr^{6+} containing materials in all future procurements unless specifically approved by the Government. When applied in weapon system design, procurement, and logistics support contracts, the requirement will apply at system, subsystem, and component level.

The DoD "Advanced Surface Engineering Technologies for a Sustainable Defense" database will be expanded to facilitate knowledge management on RDT&E and experiences using alternatives. The Strategic Environmental Research and Development Program office will provide further information on accessing this database.

As DoD's supply chain integrator, the Defense Logistics Agency will assist the Services in their efforts to eliminate Cr^{6+} from common hardware and DLA-managed items.

This policy applies to all new program starts, new program increments, and procurement of infrastructure materials, goods, and services. Application of this policy to legacy systems will be limited to modifications where alternatives can be inserted in the system modification process and updated maintenance procedures.

2

"…the Program Executive Office (PEO) or equivalent level, in coordination with the Military Department's Corrosion Control and Prevention Executive (CCPE), to certify there is no acceptable alternative to the use of Cr6+ on a new system."

Traditional Oversight

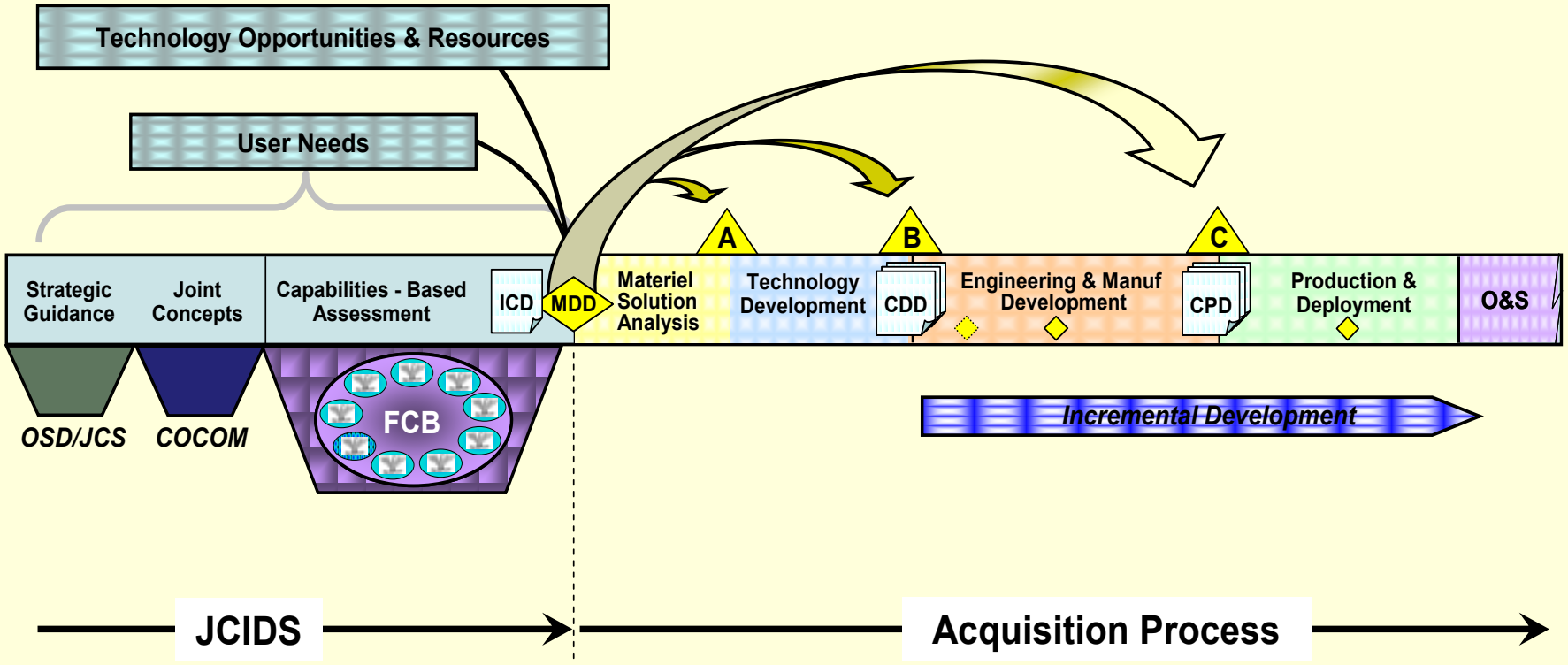
- **Document "Review-Centric" Approach**
  - Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE)
  - Acquisition Strategy (AS)
- **Pentagon Level Meeting Participation**
  - Overarching Integrated Product Team (OIPTs)

Weaknesses – Limited:

Insight into Implementation Effectiveness

Ability to Impact Early Decision Making

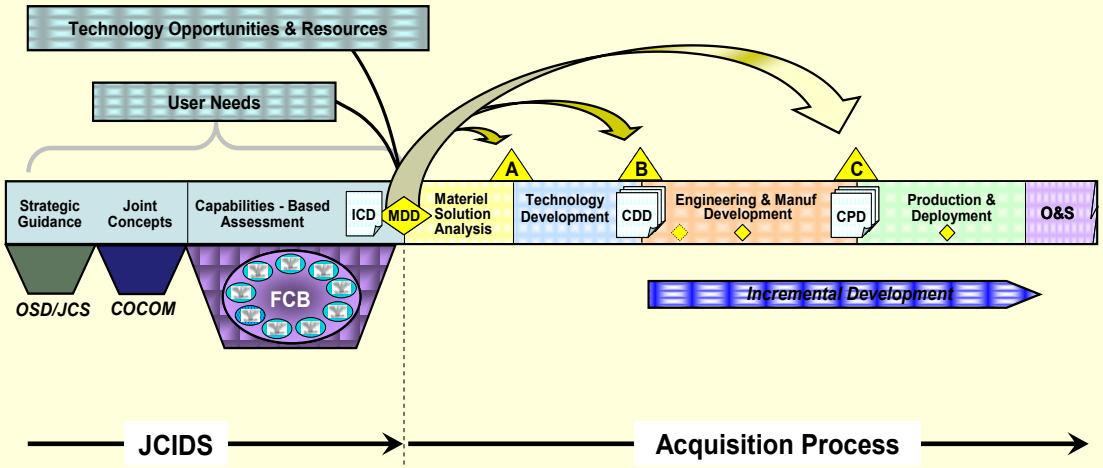
Defense Acquisition Management System



ESOH needs to be a consideration from conception to disposal

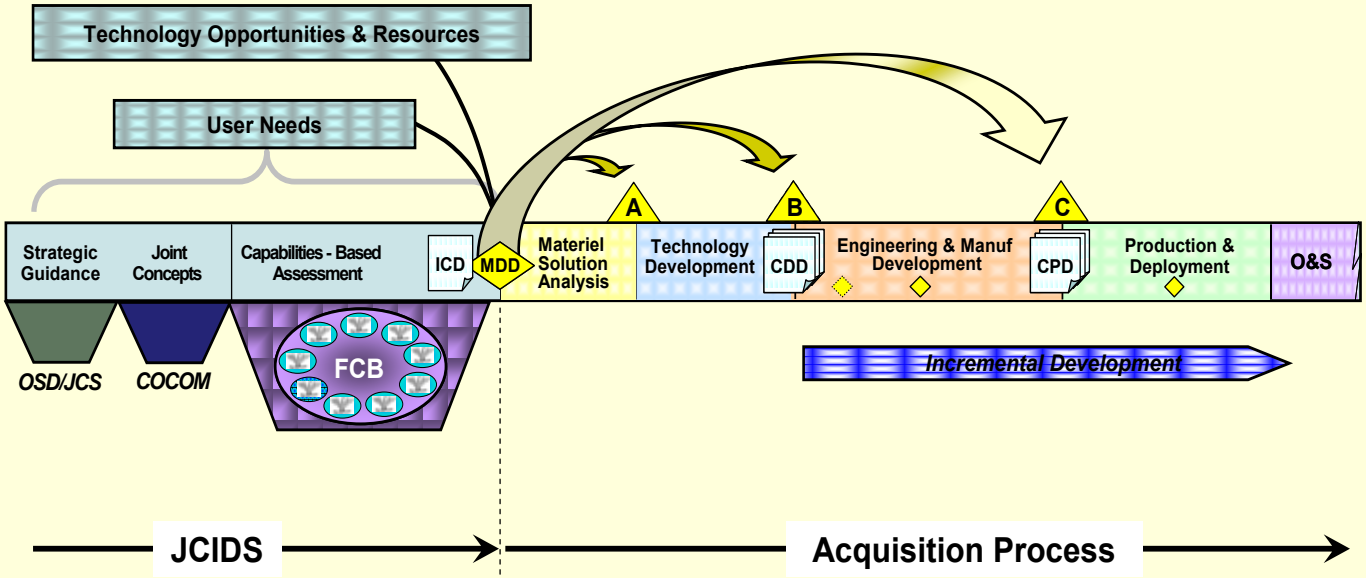
Current Initiatives Target the Entire Life Cycle Framework (1 of 2)

- ESOH in Joint Capabilities Integration & Development System (JCIDS)
- Environmental Sustainability Criteria used for decision making



Current Initiatives Target the Entire Life Cycle Framework (2 of 2)

- Expanded use of DFAR Clauses
- Expanded review of documentation
- **Participation in Program Support Reviews**



Program Support Reviews (PSRs)

- **Office of Director of Development, Research and Engineering (DDR&E) leads PSRs**
  - Mandated by DoDI 5000.02
  - Provides a Systems Engineering Focused Review
  - Examines multiple aspects of Program
  - Supports Defense Acquisition Board Decisions
- **ODUSD(I&E) is providing ESOH Subject Matter Experts and coordinating with DDR&E**

Participation in PSRs

- **Validate program compliance**
  - Determine accuracy of PESHE and fill in unknowns
- **Assess effectiveness of Acquisition ESOH policy**
  - Re-enforce reporting of High and Serious category ESOH risks
  - Compliance with ESOH technology requirements
  - DDR&E prefers this approach
- **Work closely with program teams**
  - Provide ESOH guidance and direction
  - Educate the work force
  - Establish an “ESOH network”

Participation

Example PSR ESOH Findings/Issues

- PESHE does not describe actual ESOH program execution
- Program Office „System Safety" and „ESOH" efforts not integrated
- Lack of emphasis on implementing ESOH mitigations
- Failure to address USD (AT&L) policy
- ESOH risk data and technology requirements not in PESHE

Path Forward

- **Implement a Five Year Strategy**
- **Continue to influence programs via oversight**
- **Improve effectiveness of the workforce**
  - Education
- **Program resources**
  - Continue to provide ESOH Subject Matter Experts for PSR's
- **Address root cause issues to ESOH risks**
  - Policy and Guidance
    - Improve content and timing of the PESHE
    - Incorporate into SEP, etc.
  - Work with DDR&E/SE to integrate ESOH design considerations earlier in the acquisition / SE process

ODUSD(I&E), Chemical & Material Risk Management Directorate

Mr. David Asiello
ESOH in Acquisition Lead
(703) 604-1874
David.Asiello@osd.mil

BACKUP SLIDES

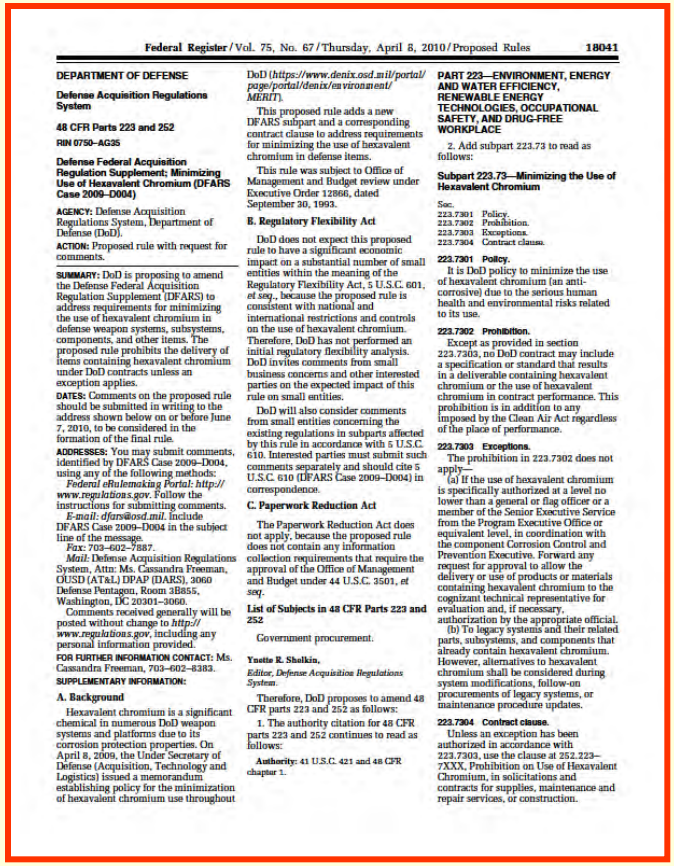
ESOH in JCIDS

- **ESOH Senior Leadership endorses all JCIDS documents**
  - ESOH communities have opportunity to provide inputs
  - Raise awareness with leadership
  - MILDEP's to set up internal process
- **Developing training to support ESOH SME participation**
- **Issue JCIDS ESOH Policy**
  - USD(AT&L) memo is ready to enter formal staffing

Factoring Sustainability into Acquisition Programs

- **Tool to help field, maintain, and upgrade weapons systems more rapidly and economically**
- **Identify sustainability factors to be considered and the appropriate decision point**
  - Use physical, chemical, and toxicity data to make smart choices
  - Possible weighting or scoring system for alternatives
  - Provide examples of the types of life cycle costs that need to be considered
- **Develop "Sustainability in Acquisition" guidance**
- **Construct training module**

Expanded Use of Defense Federal Acquisition Regulation (DFAR)



Federal Register / Vol. 75, No. 67 / Thursday, April 8, 2010 / Proposed Rules 18041

DEPARTMENT OF DEFENSE

Defense Acquisition Regulations System

48 CFR Parts 223 and 252

RIN 0750–AG35

Defense Federal Acquisition Regulation Supplement; Minimizing Use of Hexavalent Chromium (DFARS Case 2009–D004)

AGENCY: Defense Acquisition Regulations System, Department of Defense (DoD).

ACTION: Proposed rule with request for comments.

SUMMARY: DoD is proposing to amend the Defense Federal Acquisition Regulation Supplement (DFARS) to address requirements for minimizing the use of hexavalent chromium in defense weapon systems, subsystems, components, and other items. The proposed rule prohibits the delivery of items containing hexavalent chromium under DoD contracts unless an exception applies.

DATES: Comments on the proposed rule should be submitted in writing to the address shown below on or before June 7, 2010, to be considered in the formation of the final rule.

ADDRESSES: You may submit comments, identified by DFARS Case 2009–D004, using any of the following methods:

Federal eRulemaking Portal: http://www.regulations.gov. Follow the instructions for submitting comments.

E-mail: dfars@osd.mil. Include DFARS Case 2009–D004 in the subject line of the message.

Fax: 703–602–7887.

Mail: Defense Acquisition Regulations System, Attn: Ms. Cassandra Freeman, OUSD (AT&L) DPAP (DARS), 3060 Defense Pentagon, Room 3B855, Washington, DC 20301–3060.

Comments received generally will be posted without change to *http://www.regulations.gov,* including any personal information provided.

FOR FURTHER INFORMATION CONTACT: Ms. Cassandra Freeman, 703–602–8383.

SUPPLEMENTARY INFORMATION:

A. Background

Hexavalent chromium is a significant chemical in numerous DoD weapon systems and platforms due to its corrosion protection properties. On April 8, 2009, the Under Secretary of Defense (Acquisition, Technology and Logistics) issued a memorandum establishing policy for the minimization of hexavalent chromium use throughout DoD (*https://www.denix.osd.mil/portal/page/portal/denix/environment/MERIT*).

This proposed rule adds a new DFARS subpart and a corresponding contract clause to address requirements for minimizing the use of hexavalent chromium in defense items.

This rule was subject to Office of Management and Budget review under Executive Order 12866, dated September 30, 1993.

B. Regulatory Flexibility Act

DoD does not expect this proposed rule to have a significant economic impact on a substantial number of small entities within the meaning of the Regulatory Flexibility Act, 5 U.S.C. 601, *et seq.*, because the proposed rule is consistent with national and international restrictions and controls on the use of hexavalent chromium. Therefore, DoD has not performed an initial regulatory flexibility analysis. DoD invites comments from small business concerns and other interested parties on the expected impact of this rule on small entities.

DoD will also consider comments from small entities concerning the existing regulations in subparts affected by this rule in accordance with 5 U.S.C. 610. Interested parties must submit such comments separately and should cite 5 U.S.C. 610 (DFARS Case 2009–D004) in correspondence.

C. Paperwork Reduction Act

The Paperwork Reduction Act does not apply, because the proposed rule does not contain any information collection requirements that require the approval of the Office of Management and Budget under 44 U.S.C. 3501, *et seq.*

List of Subjects in 48 CFR Parts 223 and 252

Government procurement.

Ynette R. Shelkin,

Editor, Defense Acquisition Regulations System.

Therefore, DoD proposes to amend 48 CFR parts 223 and 252 as follows:

1. The authority citation for 48 CFR parts 223 and 252 continues to read as follows:

Authority: 41 U.S.C. 421 and 48 CFR chapter 1.

PART 223—ENVIRONMENT, ENERGY AND WATER EFFICIENCY, RENEWABLE ENERGY TECHNOLOGIES, OCCUPATIONAL SAFETY, AND DRUG-FREE WORKPLACE

2. Add subpart 223.73 to read as follows:

Subpart 223.73—Minimizing the Use of Hexavalent Chromium

Sec.
223.7301 Policy.
223.7302 Prohibition.
223.7303 Exceptions.
223.7304 Contract clause.

223.7301 Policy.

It is DoD policy to minimize the use of hexavalent chromium (an anti-corrosive) due to the serious human health and environmental risks related to its use.

223.7302 Prohibition.

Except as provided in section 223.7303, no DoD contract may include a specification or standard that results in a deliverable containing hexavalent chromium or the use of hexavalent chromium in contract performance. This prohibition is in addition to any imposed by the Clean Air Act regardless of the place of performance.

223.7303 Exceptions.

The prohibition in 223.7302 does not apply—

(a) If the use of hexavalent chromium is specifically authorized at a level no lower than a general or flag officer or a member of the Senior Executive Service from the Program Executive Office or equivalent level, in coordination with the component Corrosion Control and Prevention Executive. Forward any request for approval to allow the delivery or use of products or materials containing hexavalent chromium to the cognizant technical representative for evaluation and, if necessary, authorization by the appropriate official.

(b) To legacy systems and their related parts, subsystems, and components that already contain hexavalent chromium. However, alternatives to hexavalent chromium shall be considered during system modifications, follow-on procurements of legacy systems, or maintenance procedure updates.

223.7304 Contract clause.

Unless an exception has been authorized in accordance with 223.7303, use the clause at 252.223–7XXX, Prohibition on Use of Hexavalent Chromium, in solicitations and contracts for supplies, maintenance and repair services, or construction.

EXAMPLE:

- Minimizing Use of Hexavalent Chromium (DFARS Case 2009–D004)
- Published in Federal Register April 8, 2010

Expanded Review of Documentation

- **In addition to PESHE and AS, reviewing**
  - Analysis of Alternatives
  - Technology Development Strategy
  - Systems Engineering Plan
  - Life Cycle Sustainment Plan

More effectively influencing the Systems Engineering process

Program Support Reviews (PSRs)

- **Office of Director of Development, Research and Engineering leads PSRs**
  - Mandated by DoDI 5000.02
  - Provides a Systems Engineering Focused Review
  - Examines multiple aspects of Program
  - Supports Defense Acquisition Board Decisions
- **ODUSD(I&E) is providing ESOH Subject Matter Experts and coordinating with DDR&E**

Abstract Reference Number: #10584

Enterprise Architecture Model-Driven Simulation

Rob Byrd
Chief Enterprise Architect
719-235-4408
robert.byrd@serco-na.com
Visit us at: http://ea.serco-na.com/

Serco is a leading provider of professional, technology and management services focused on the federal government. We advise, design, integrate and deliver solutions that transform how clients achieve their missions. Our customer-first approach, robust portfolio of services and global experience enable us to respond with solutions that achieve outcomes with value.

For more information about Serco's solutions:

Serco Inc.
1818 Library Street
Suite 1000
Reston, VA 20190
t: 703.939.6000
www.serco-na.com

Introduction

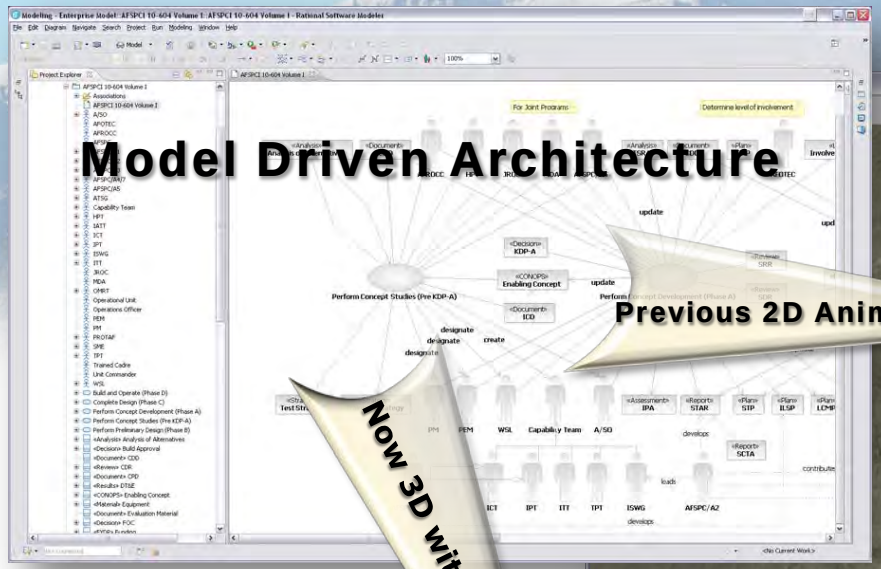
- Enterprise Architecture Challenges
- The Vision…
- Introduce enterprise architecture strategy to task using the Unified Profile for MODAF and DoDAF (UPDM)
- Discuss enterprise architecture process
  - The object-oriented method…
- Demonstrate Enterprise Architecture Model-Driven Simulation

Some significant challenges…

- Effectively defining, modeling, and communicating enterprise complexity
- Ensuring required operational capabilities drive system development – linking capabilities directly to enterprise components
- Identifying and managing enterprise and program boundaries
- Recognizing reusable operations and components to reduced ownership cost
- Coping with change (threats, missions, operations, organizations responsibilities, technology, etc.)

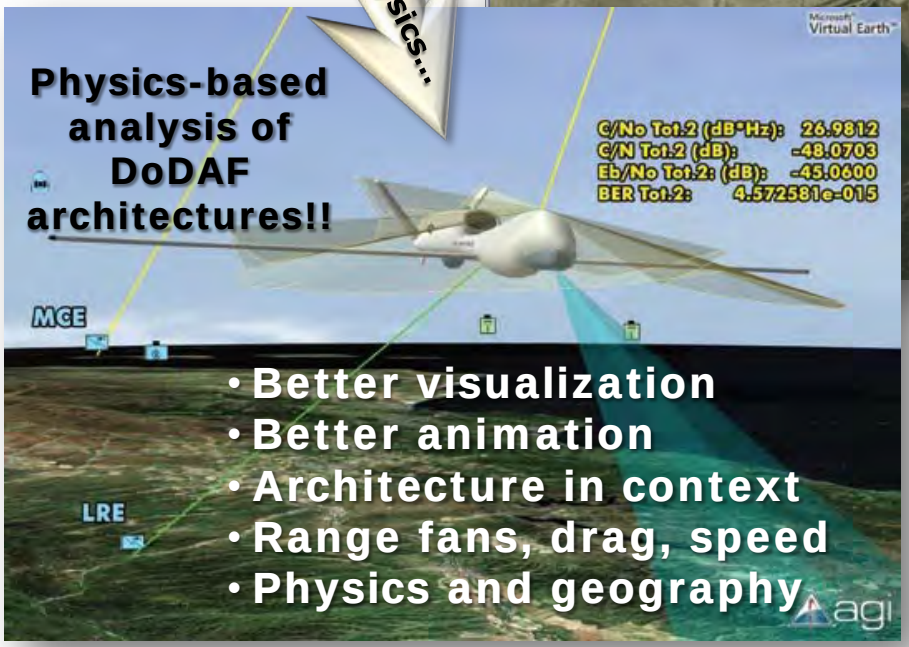
The Vision…

Model Driven Architecture



Previous 2D Animation…

Now 3D with physics…



Great value in integrating Enterprise Architecture with AGI's analysis and visualization tool…

serco

Strategy to Task

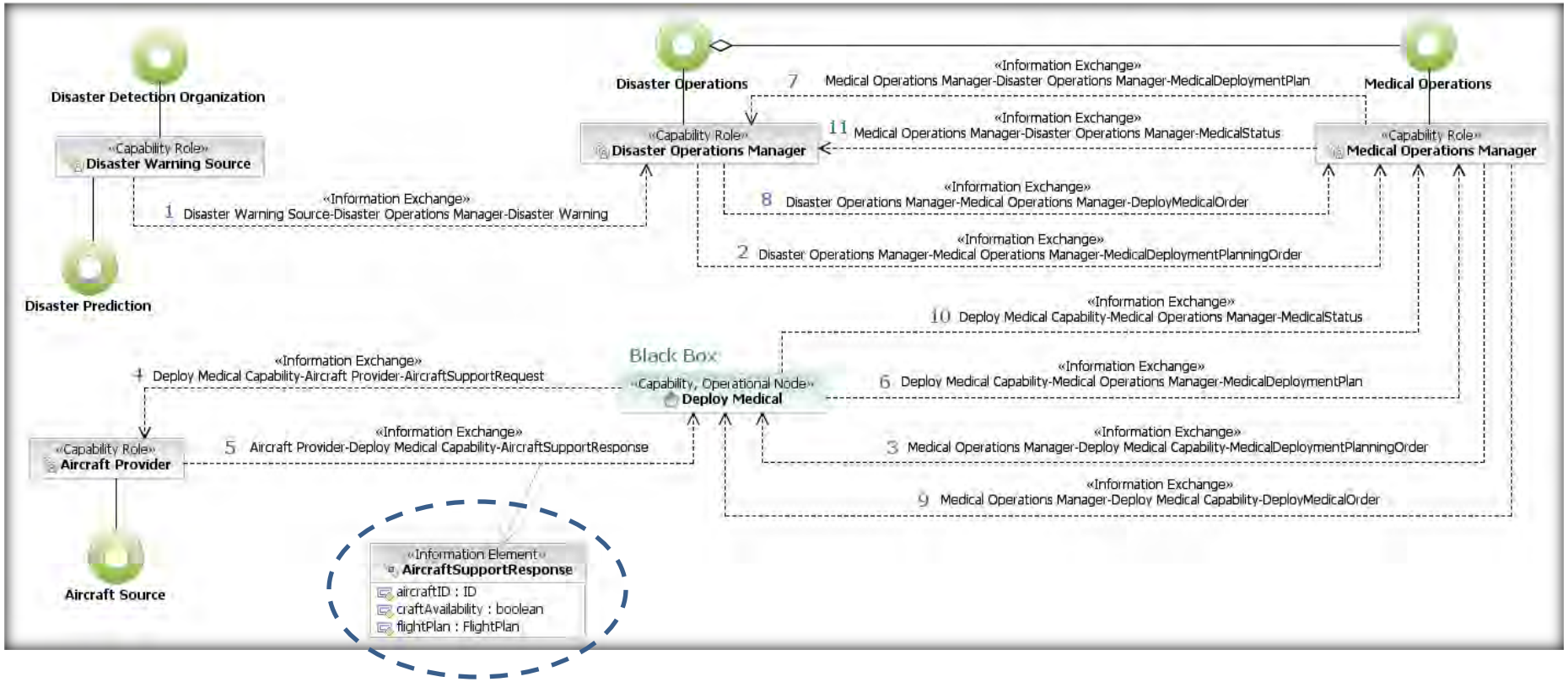
Discussion includes the Unified Profile for MODAF and DoDAF (UPDM) using IBM's UML Profile for Integrated Architecture (UPIA)

* Model courtesy of Tom Folk, the MITRE Corporation

serco

Context Diagram – Information in Context

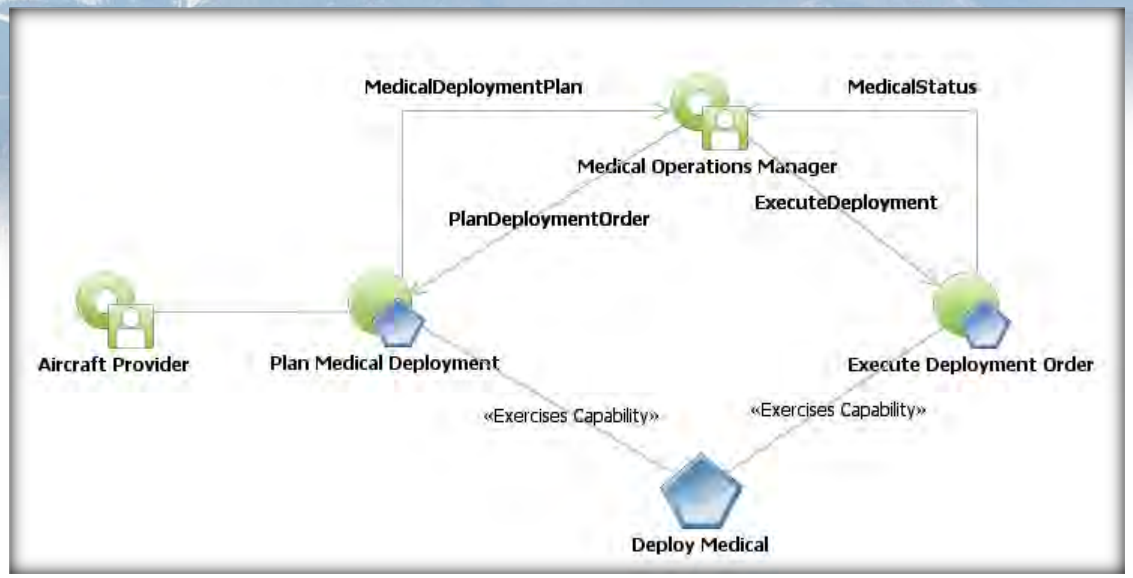
- Method to think through the process and identify important information elements
- Identifies roles and operational nodes
- Identifies UML use cases (Capability Usage) by recognition of important objects
- Assigns information responsibility to capability



*** Model courtesy of Tom Folk, the MITRE Corporation**

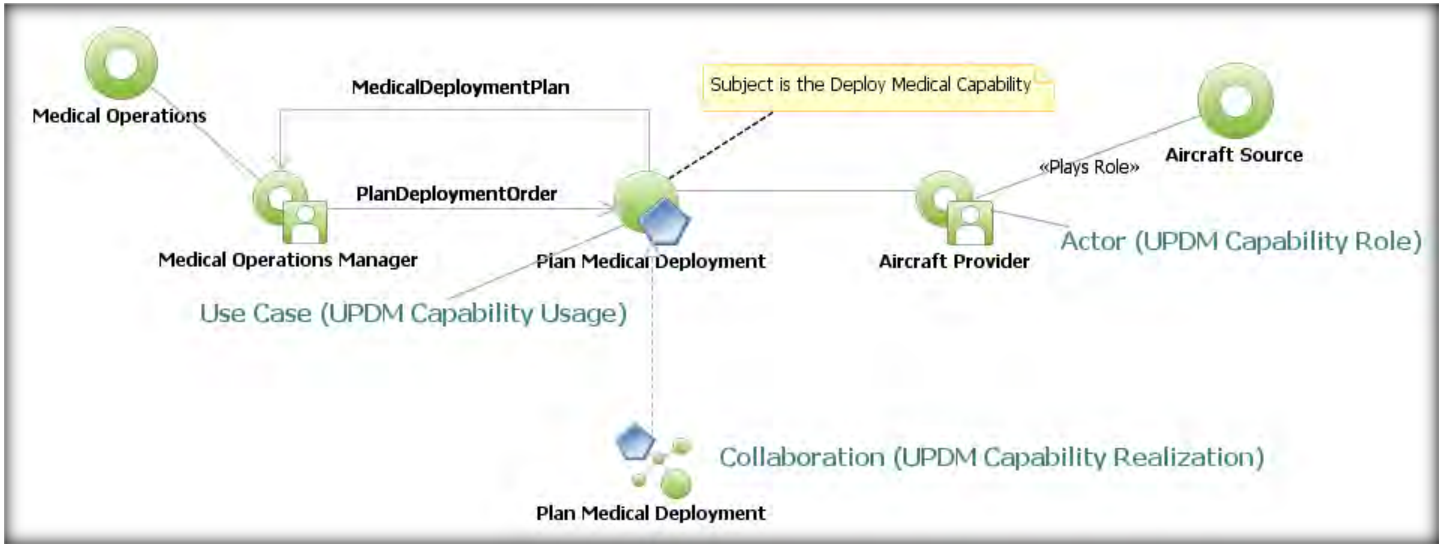
serco

UML Use Cases Exercise Capability



Use Case:

- Defines scope
- Evolves operational concept
- Indentifies triggering objects
- Produces value-based objects
- Defines roles and responsibilities
- Packaged for reuse…



*** Model courtesy of Tom Folk, the MITRE Corporation**

serco

Assign Operational Tasks to Interfaces

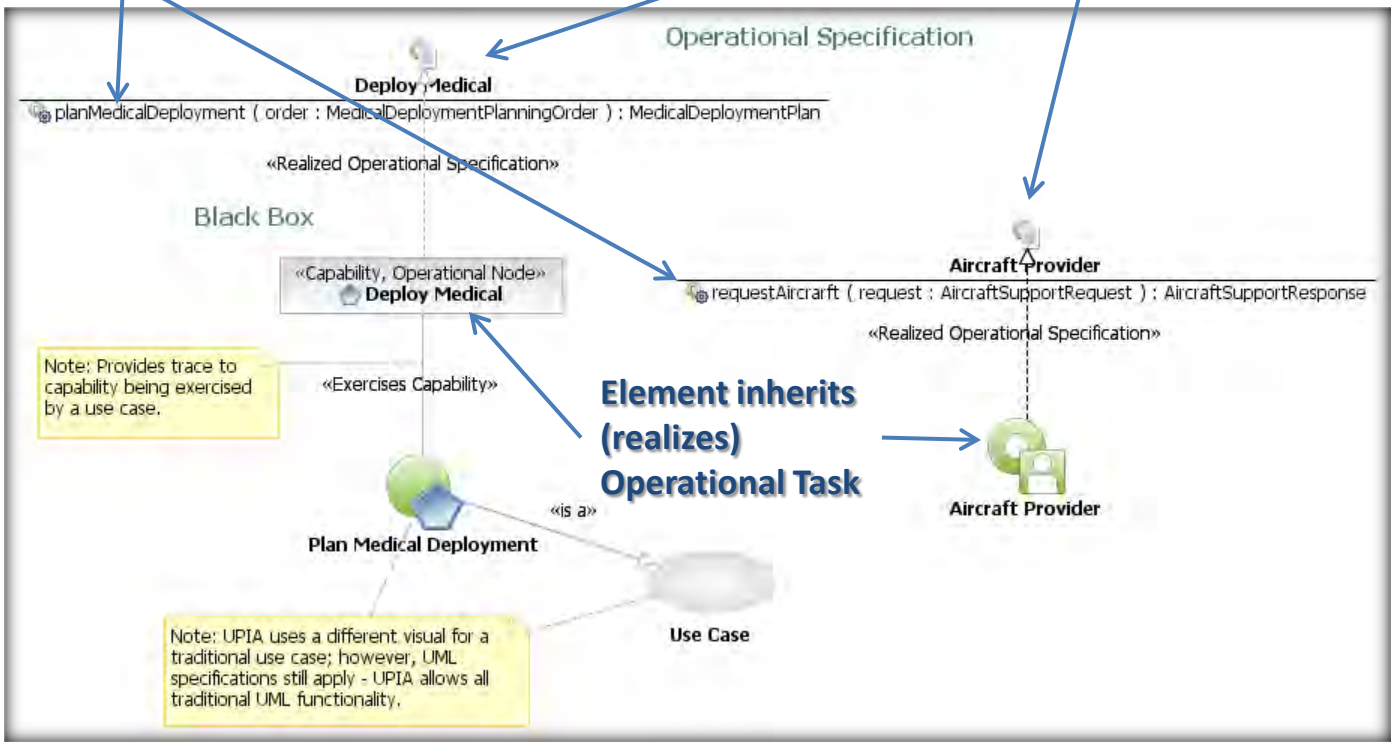
Note: The Context Diagram is useful in identifying responsibility of operational tasks i.e., which role owns the task

Interface Realization:

- **In UPDM operational interfaces equal Operational Node Specifications**
- **Binds important objects to Operational Task**

Operational Task

Operational Node Specification

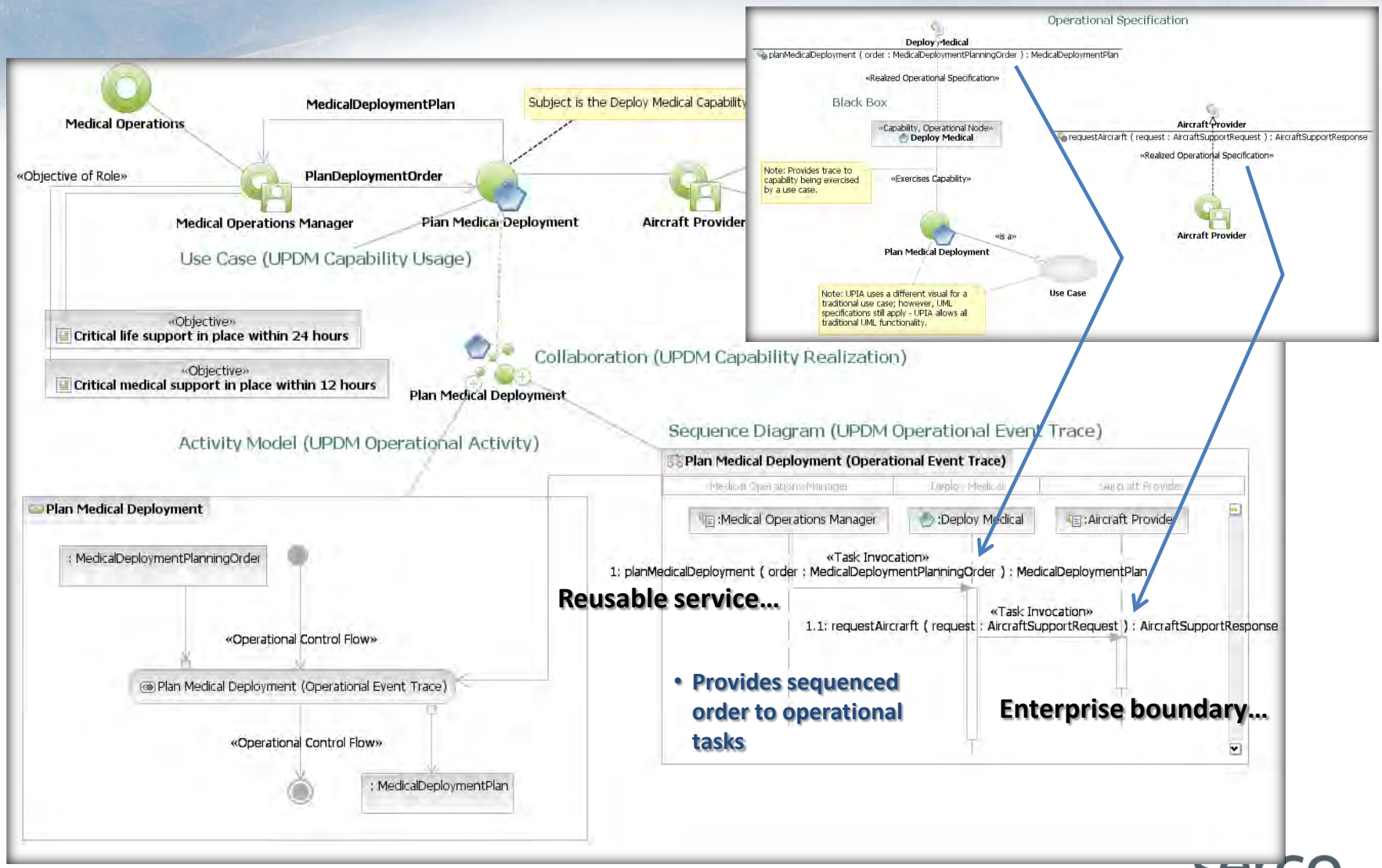


*** Model courtesy of Tom Folk, the MITRE Corporation**

serco

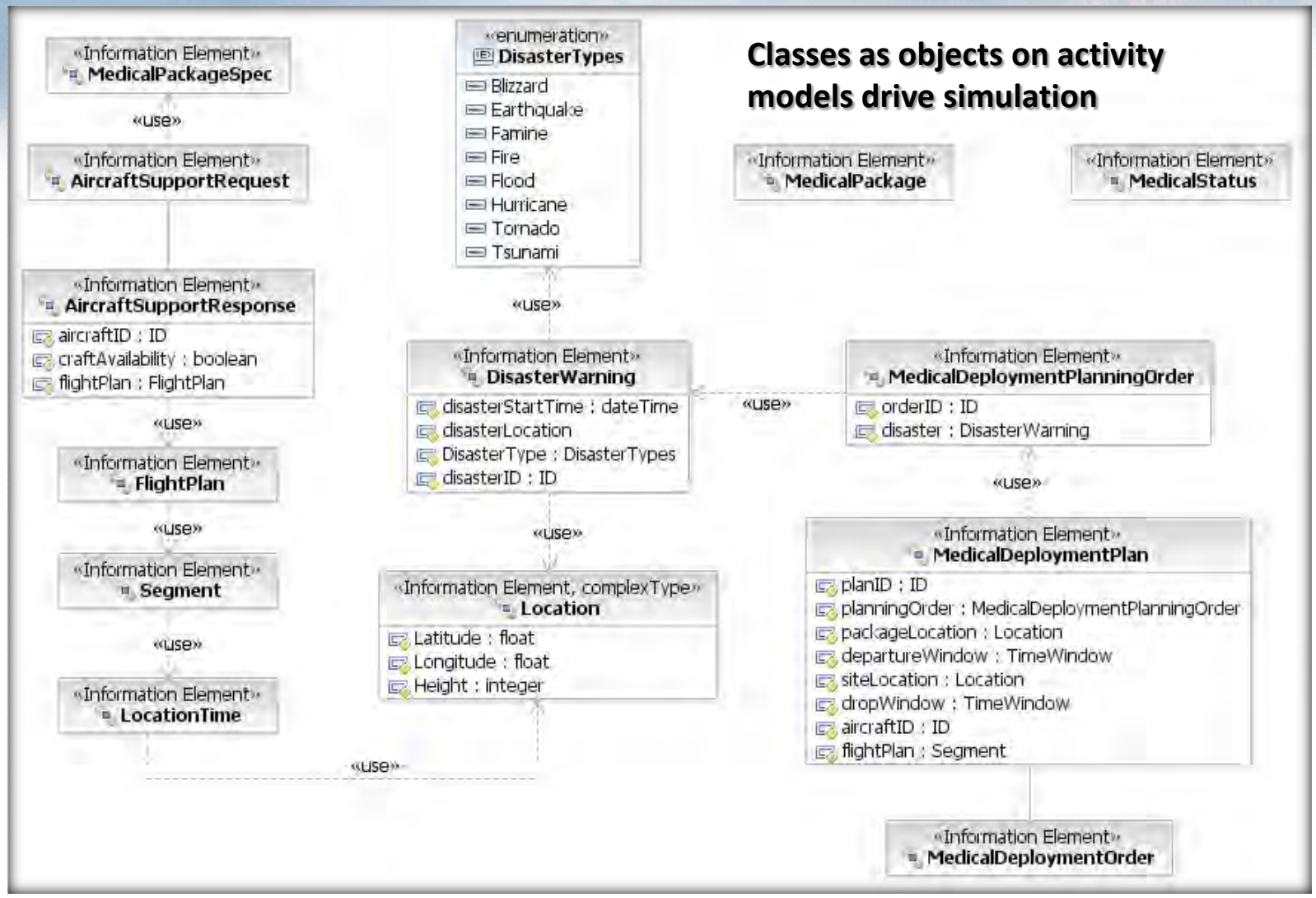
UPDM Capability Realization

- Provides the details of the Capability Usage (UML Use Case)
- Includes Operational Activity and Operational Event Trace



* Model courtesy of Tom Folk, the MITRE Corporation

Provides Logical Data Model Framework



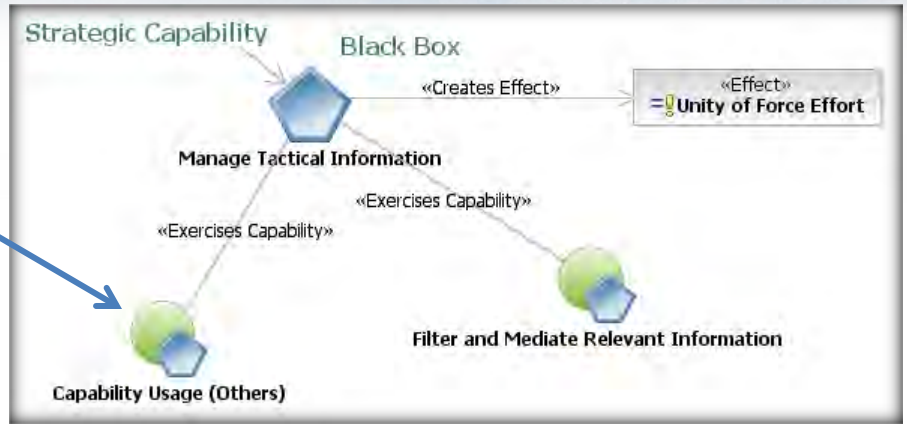
*** Model courtesy of Tom Folk, the MITRE Corporation**

serco

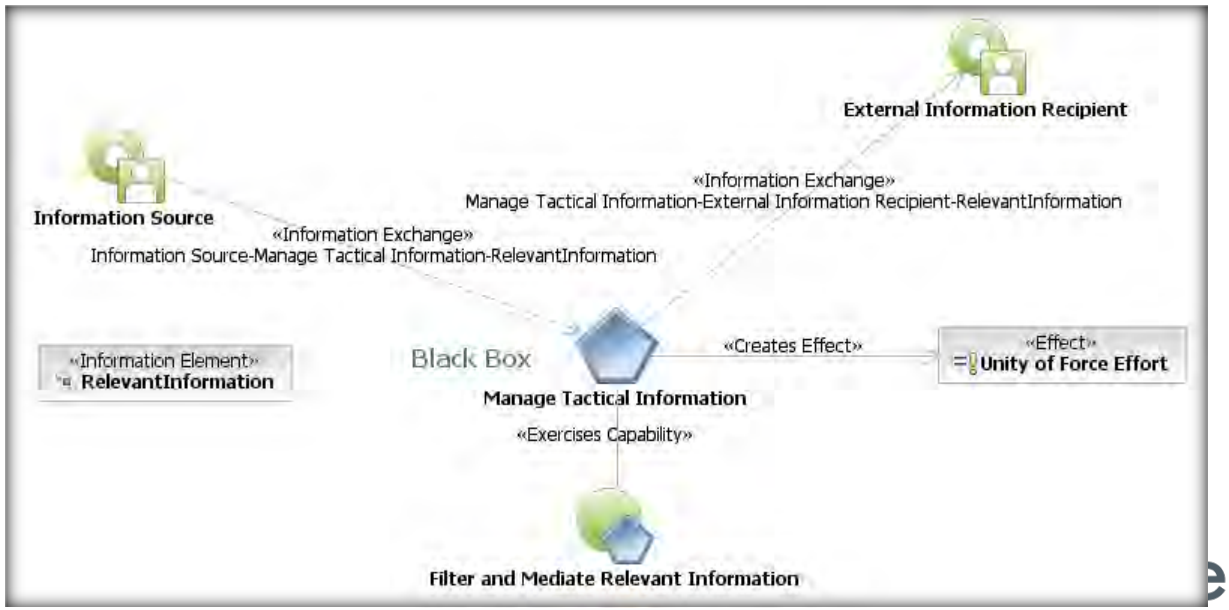
Another Example…

Note: Capabilities may require one to many Capability Usages to produce the desired effect

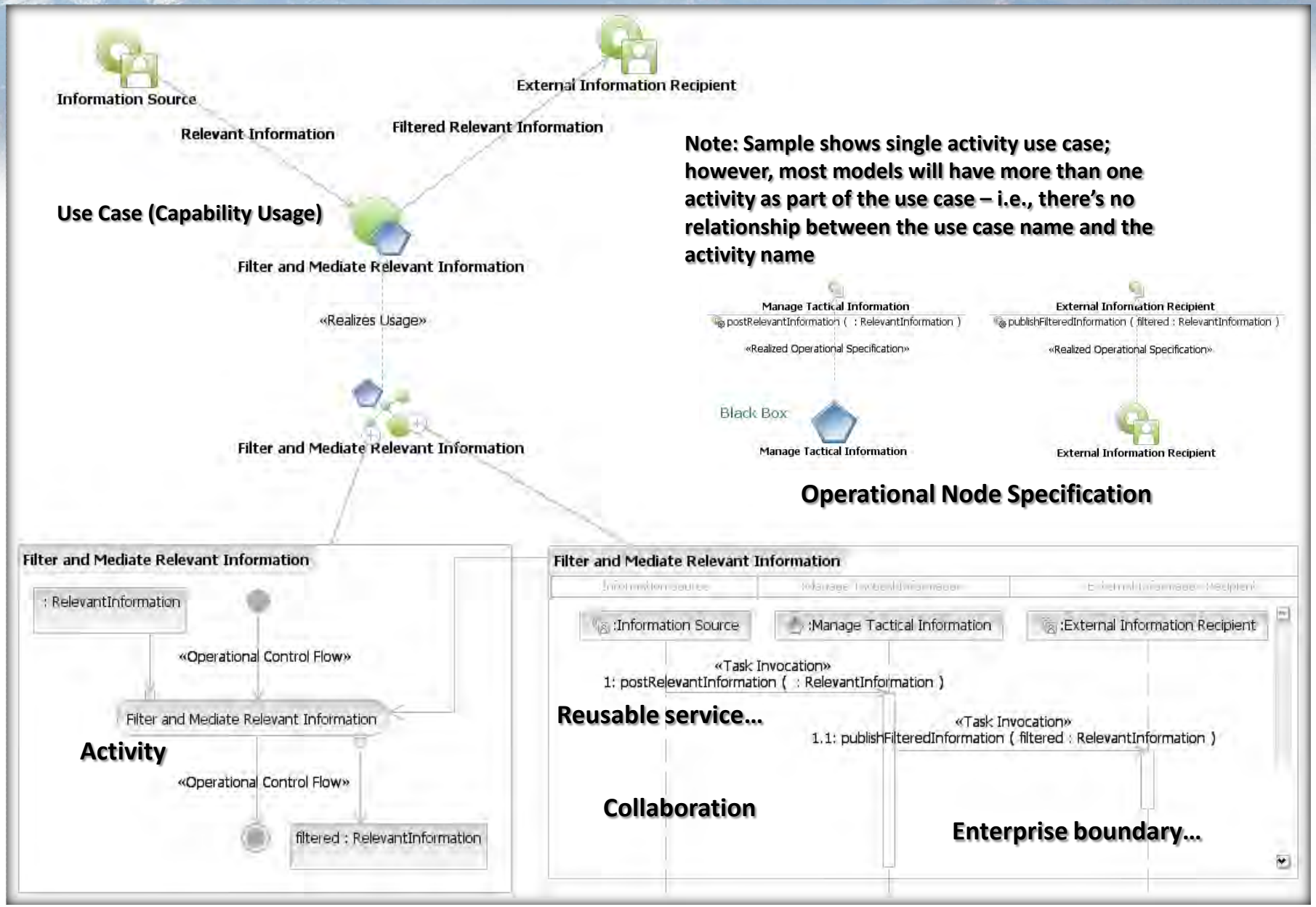
Capability View



Context Diagram

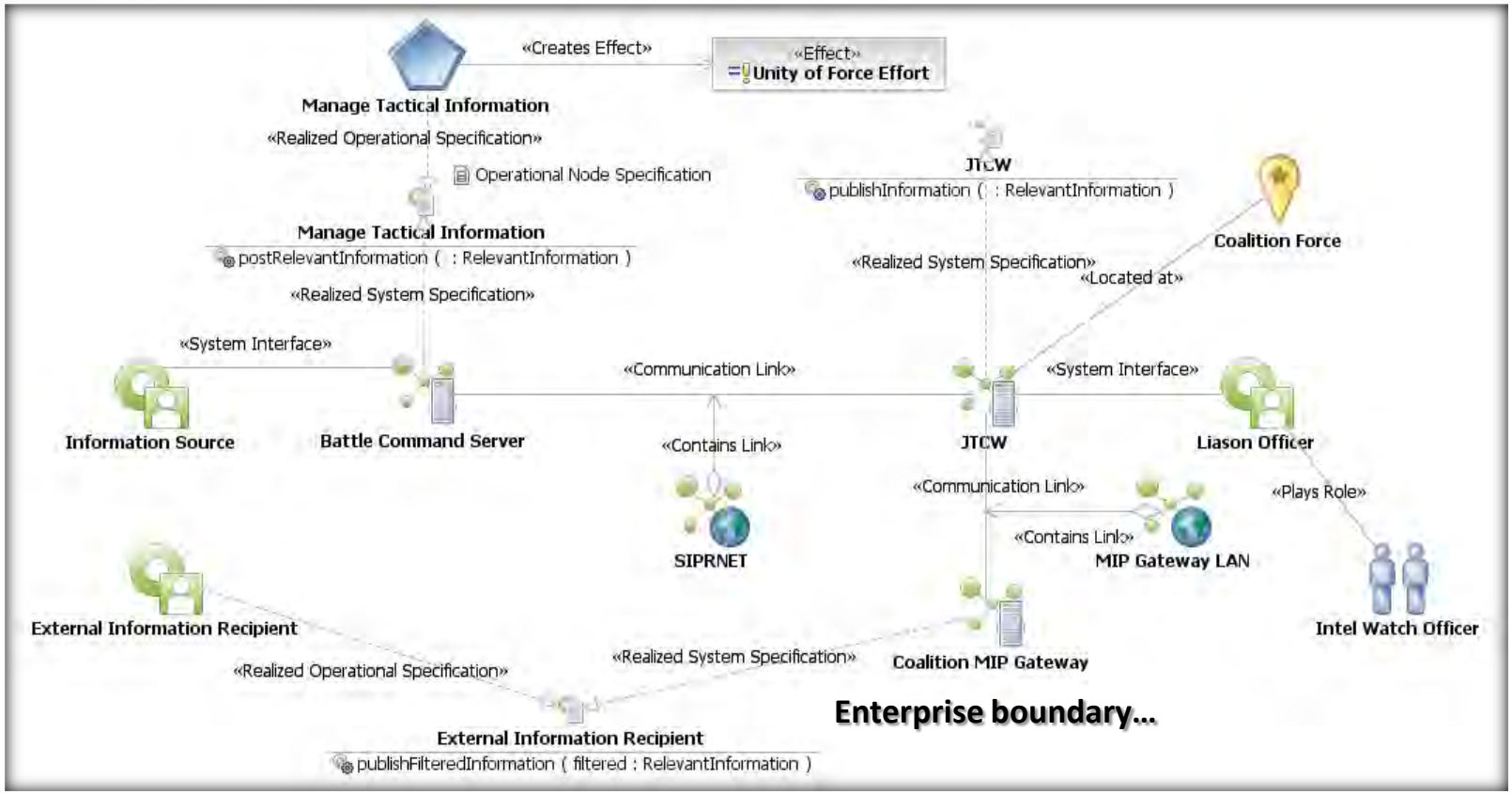


Use Case Model

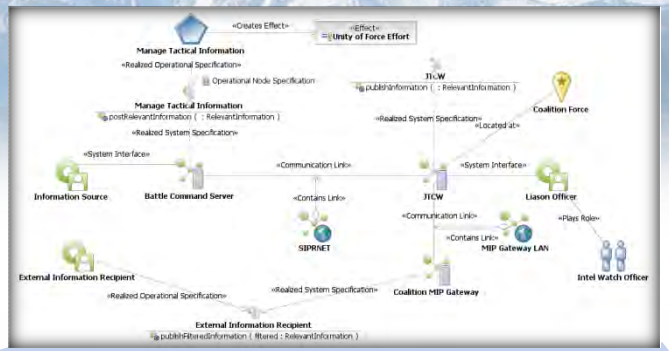


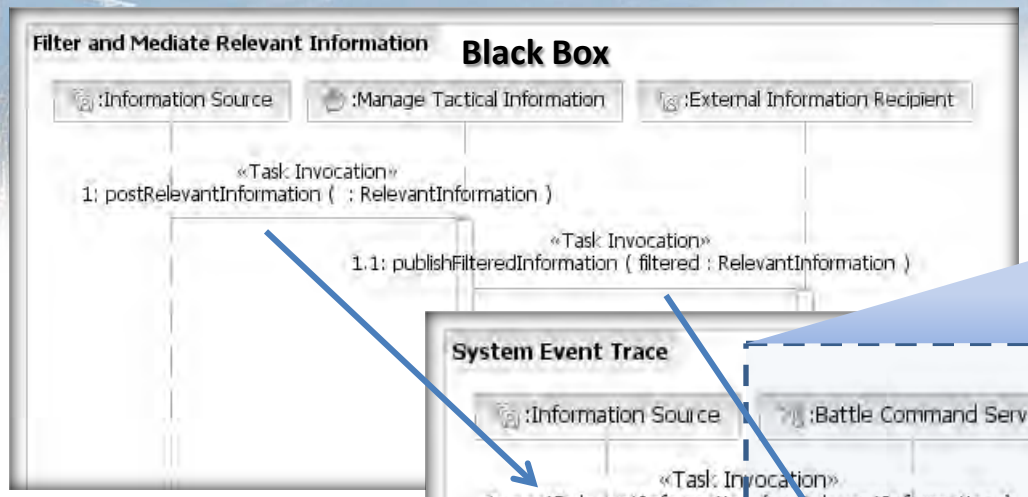
System View…

- Describes infrastructure elements such as communications links, locations, etc.
- Identifies system interface specifications
- Introduces new roles necessary to implement the capability

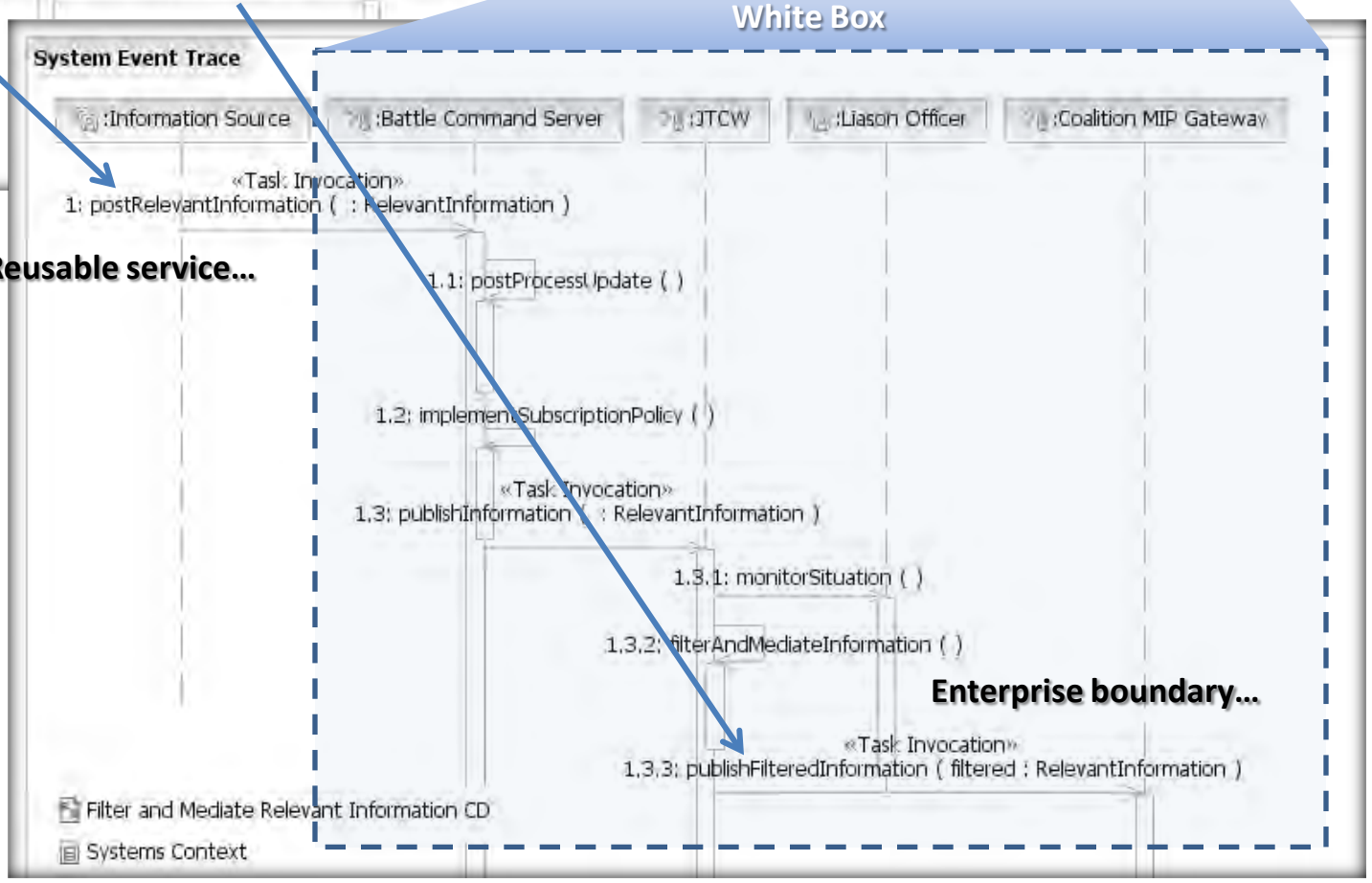


System Event Trace





White Box



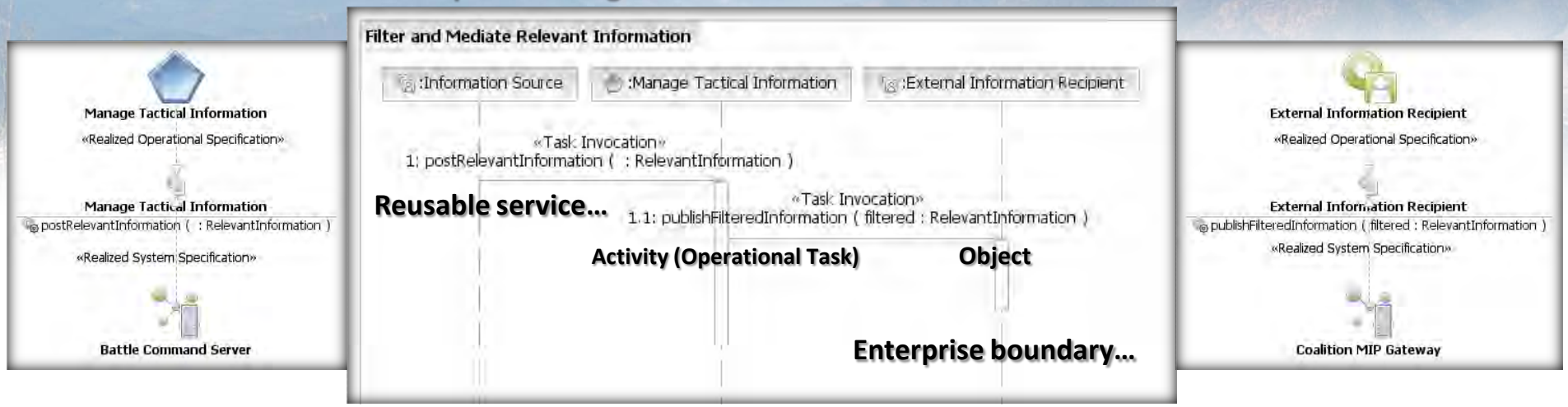
Reusable service…

Enterprise boundary…

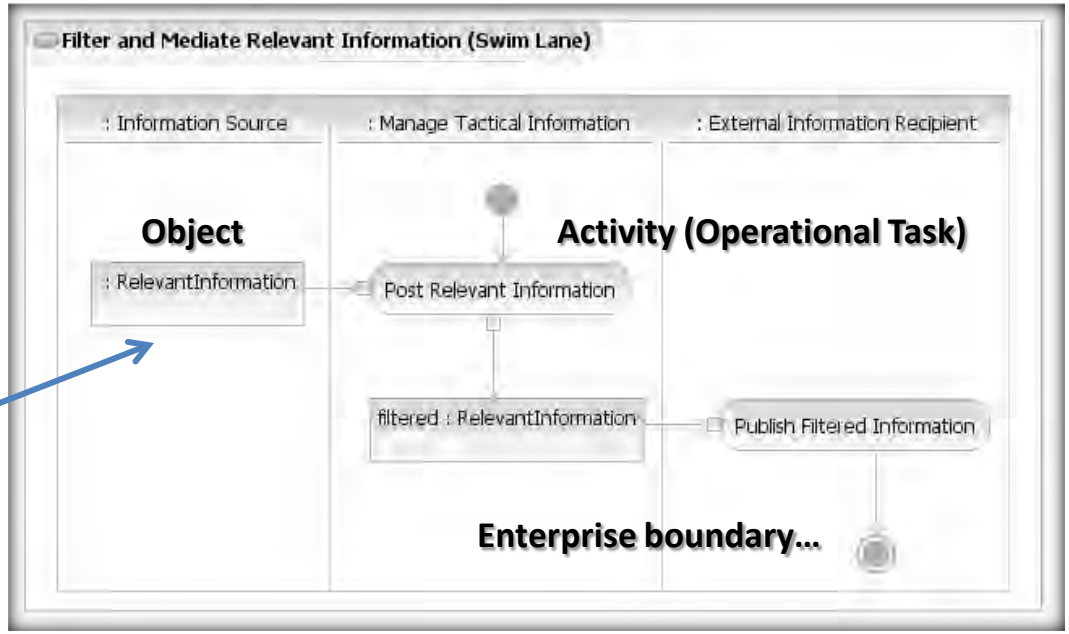
Notice that the edges of the model are the same!

Sequence and Activity Model Comparison

Sequence Diagram



Activity Diagram (Swim Lane)



Sequence Diagram

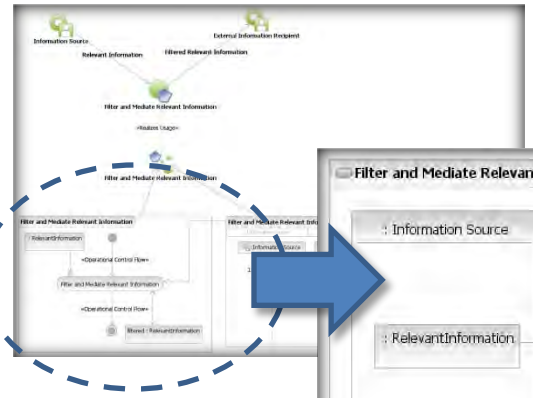
- Provides traceable interface to system
- Allows management of important interfaces
- Provides a way to establish service agreements between interested participants

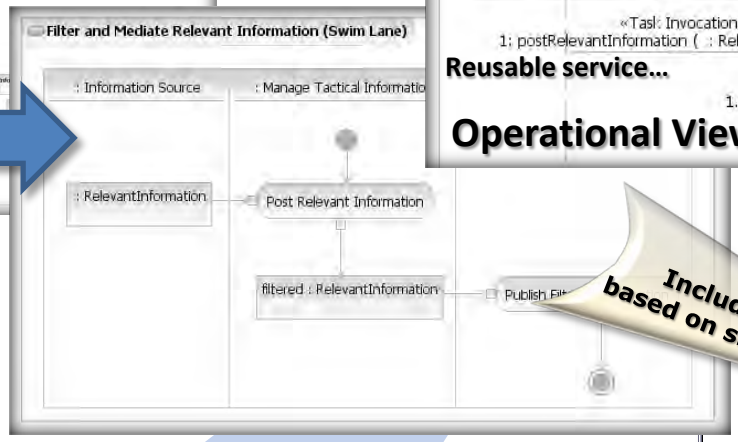
Note: Action step implied at start

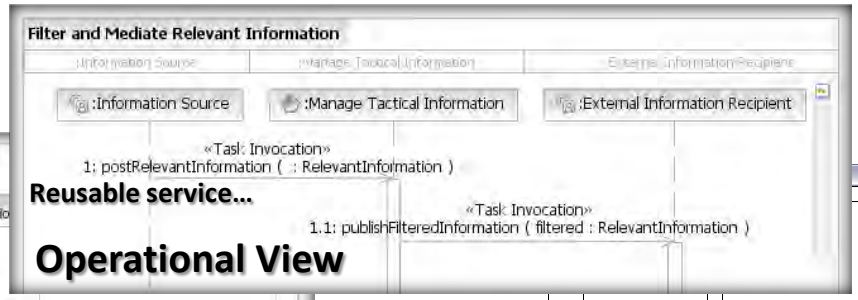
Activity Diagram

- Interfaces are implied
- More easily understood by non architects
- Provides best framework for animated simulations
- Demonstrates objects moving through process

serco



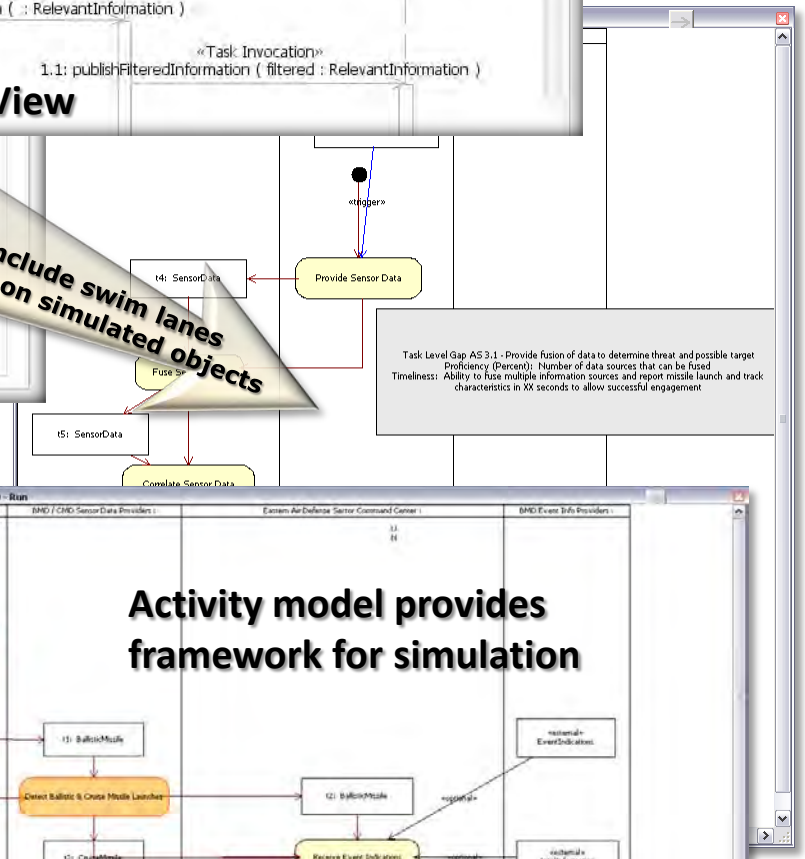




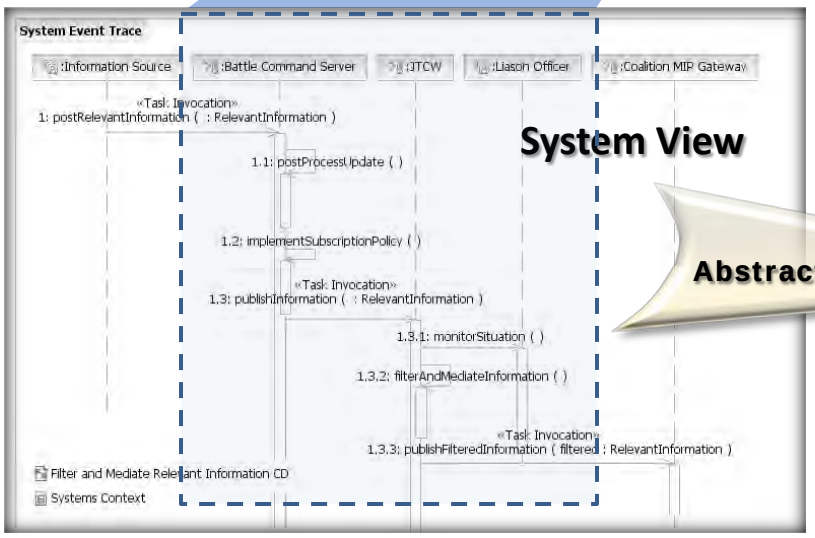
Reusable service…

Operational View

Include swim lanes based on simulated objects

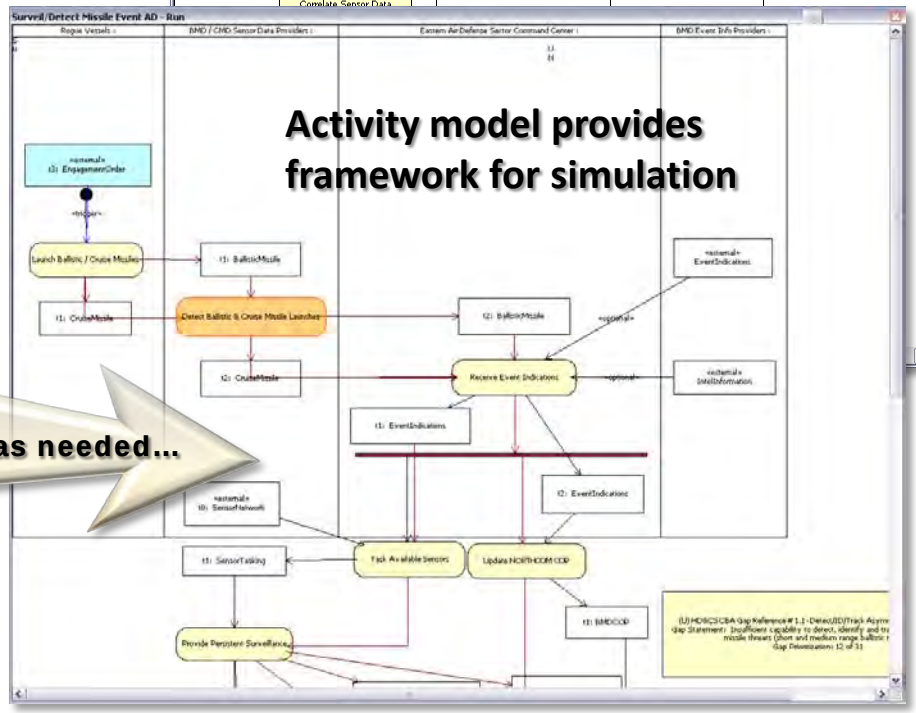


- Activities are containers for modeled behavior
- Represent underlying services realized by systems
- Object flow can be simulated

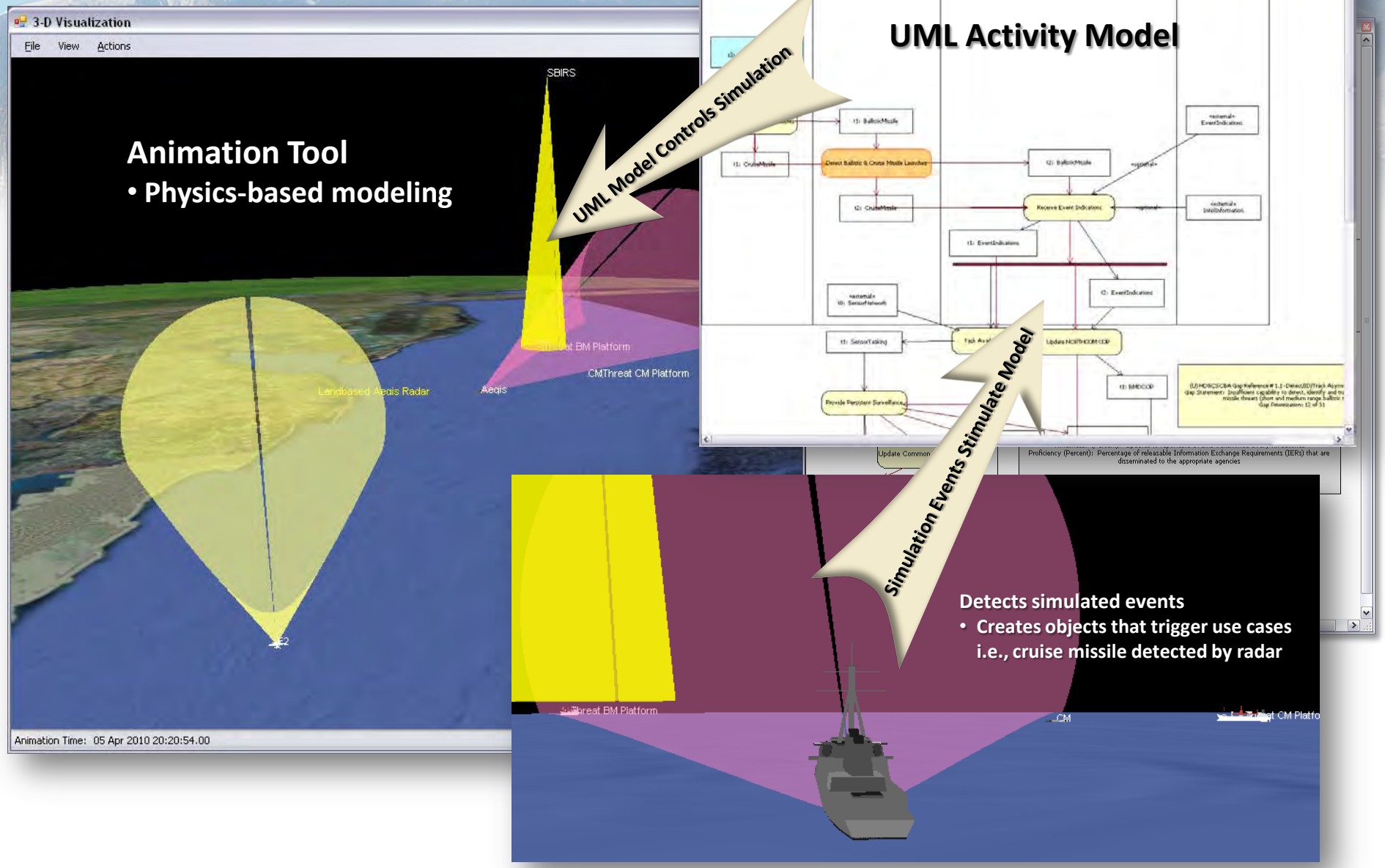


System View

Abstract as needed…



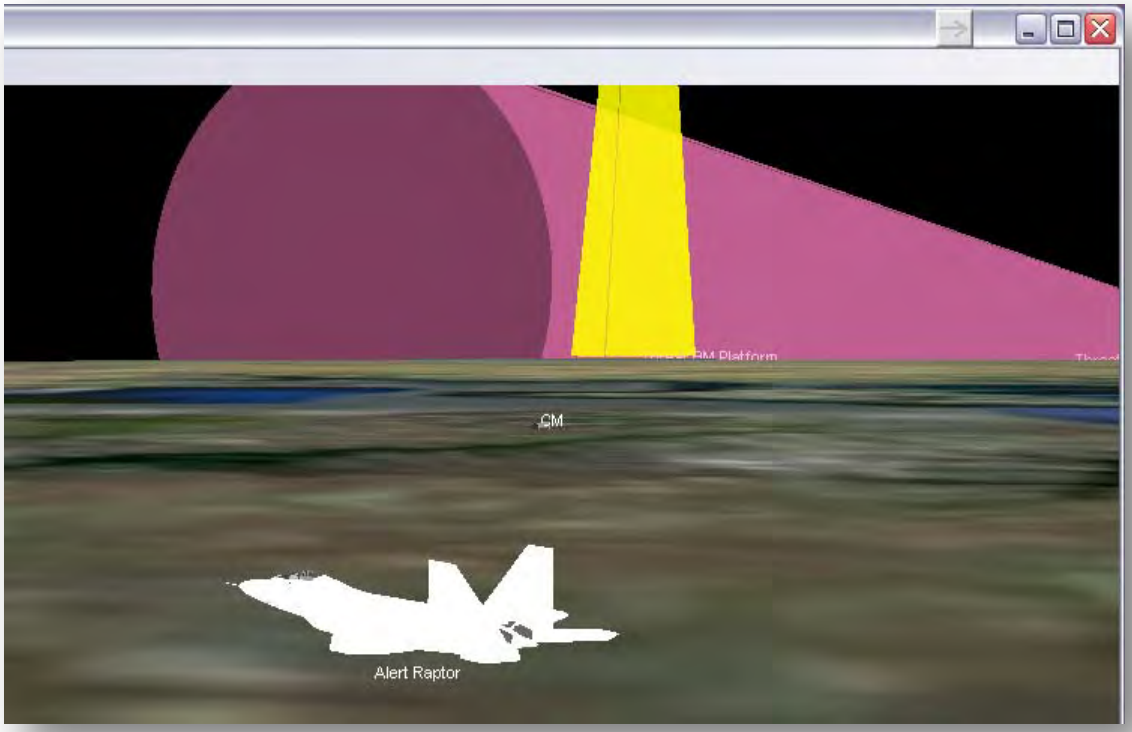
Model Driven Simulation



serco

Summary…

- Validates and verifies architecture operational concept with stakeholders
- Understood by leadership and the non architect
- Develops reusable information and services in context of use
- Basis for trade studies based on system implementation considerations
- Provides framework for gap analysis and performance considerations
- Fully traceable to national military strategy
- Provides leadership with an architecture to manage technical portfolio



serco

Engineering Design Analysis (Physics of Failure)

Gary S. Drake

October 27, 2010

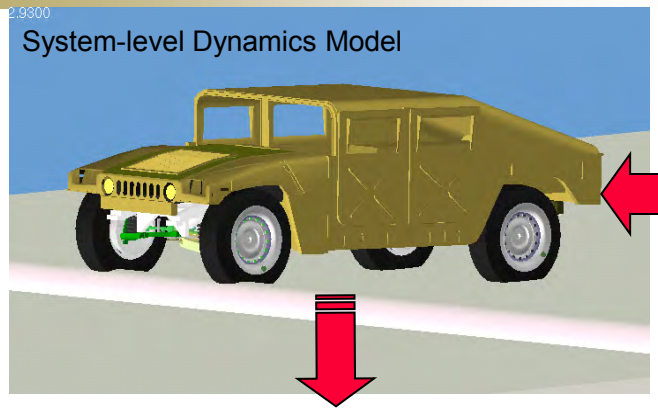
Approved for Public Release: Distribution is Unlimited

AMSAA
Excellence in Analysis

Why Physics of Failure?

- Army needs better approaches to identify potential reliability problems early so the appropriate actions can be taken
- Testers, Evaluators, Program Managers need the best tools to enable a T&E that gets the most out of every test
- Physics-of-Failure (PoF) M&S aids test evaluation by revealing the underlying physics that explain system performance – helps identify “root-causes” of test and field failures
- PoF in use by private sector –broader application of PoF can help achieve materiel reliability levels to those achieved by commercial sector

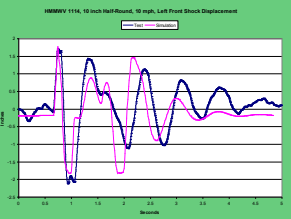
Mechanical PoF Overview



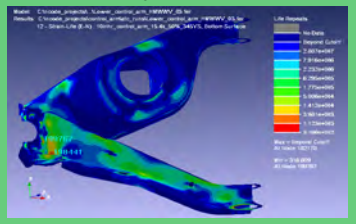
Live Data from Instrumented Tests

Strains, Accelerations, Displacements

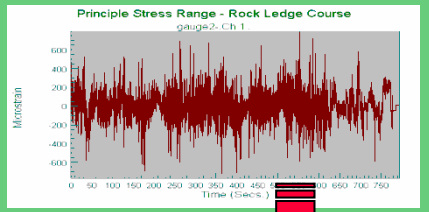
Loads, Accelerations



Finite Element Analysis (FEA)

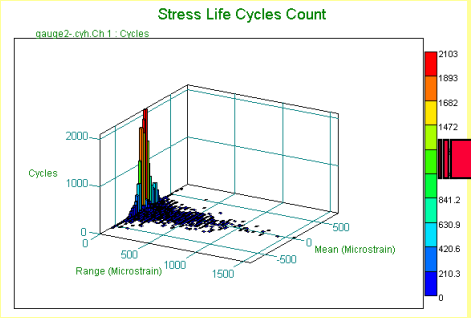


Strain Time History

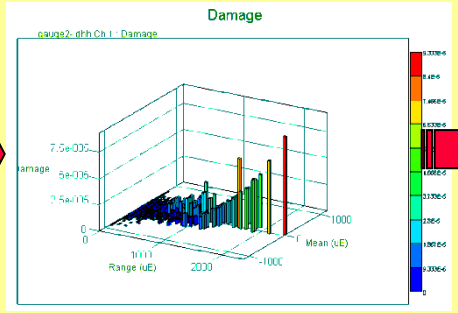


FEA tools, e.g. Abaqus, ANSYS, NASTRAN

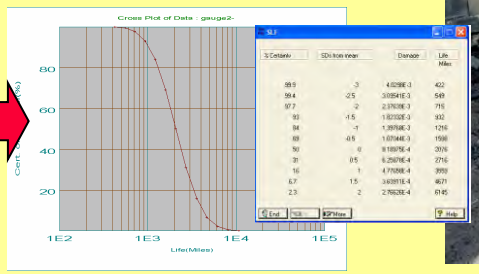
Rainflow Cycles Count



Damage Cycles Count



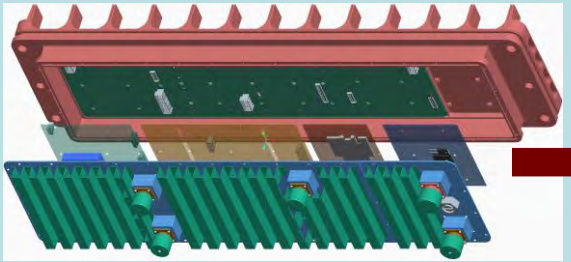
Component Life Prediction

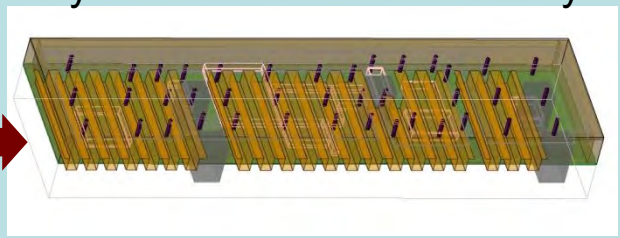


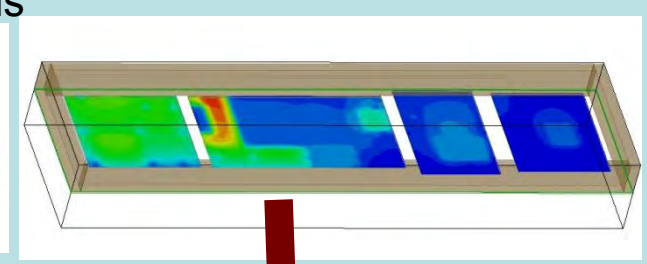
Computational fatigue analysis using nCode tools, BS7608, or similar standards

Electronics PoF Analysis Overview

System-Level Thermal Analysis

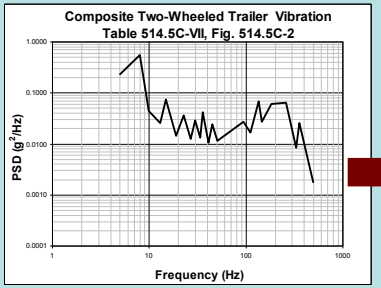


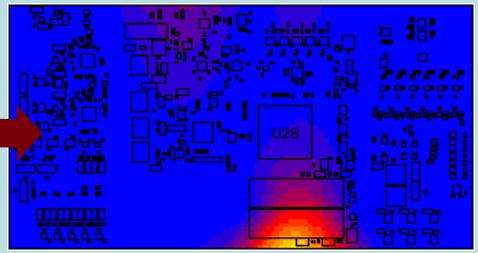




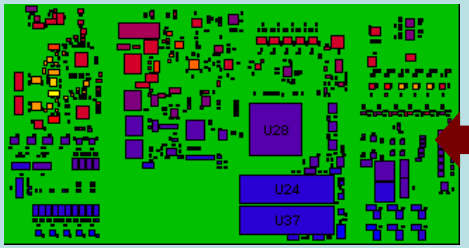
Board-Level Analysis

Mechanical Loads



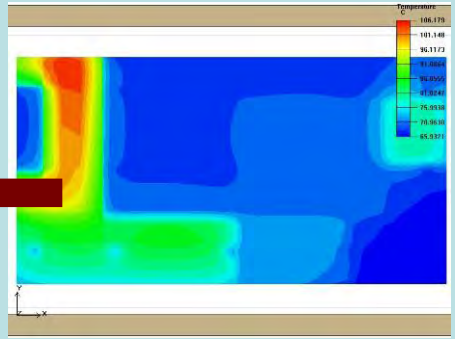


Board Displacement

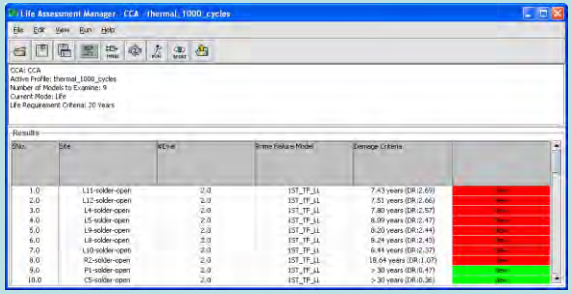


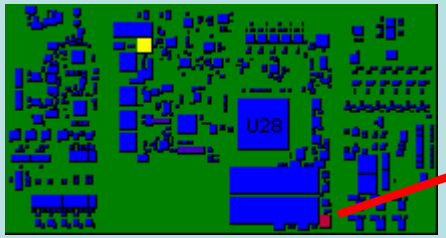
Thermal Overstress Analysis

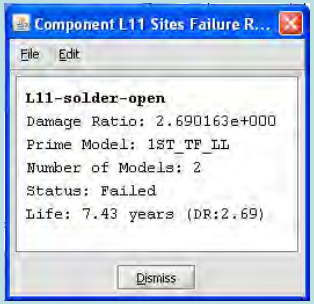
Thermal Loads



Component Life Estimates







Electronics Physics of Failure

- **Physics of Failure (PoF) -** Is used to model dominant failure mechanism(s) and is aimed at eliminating failures through redesign

- **Benefits of Physics of Failure**
  - Determine if component will last in field
  - Find life limiting failures in fielded products
  - Determine root cause of failures
  - Improve design prior to testing
  - Analyze impact of design changes
  - Use models for prognostics
  - ***Identify simple inexpensive design changes***
  - ***Decrease O&S costs***

- **Physics of Failure lessons learned**
  - ***Apply early in the design process***
  - Can significantly reduce testing
  - Very high return on investment
  - Refine model as design changes

- **University of Maryland (UMD) CALCE Electronics Products Systems Center (EPSC) Tools**
  - ***CalcePWA***
  - CalceFAST
  - CalceEP

- **CirVibe**

- **Solder Reliability Solutions (SRS)**

- **Finite Element Analysis (FEA) Software**
  - ***Patran/Nastran***
  - ANSYS
  - Pro Mechanica

- **Computational Fluid Dynamics (CFD) Software**
  - ***ICEPAK***

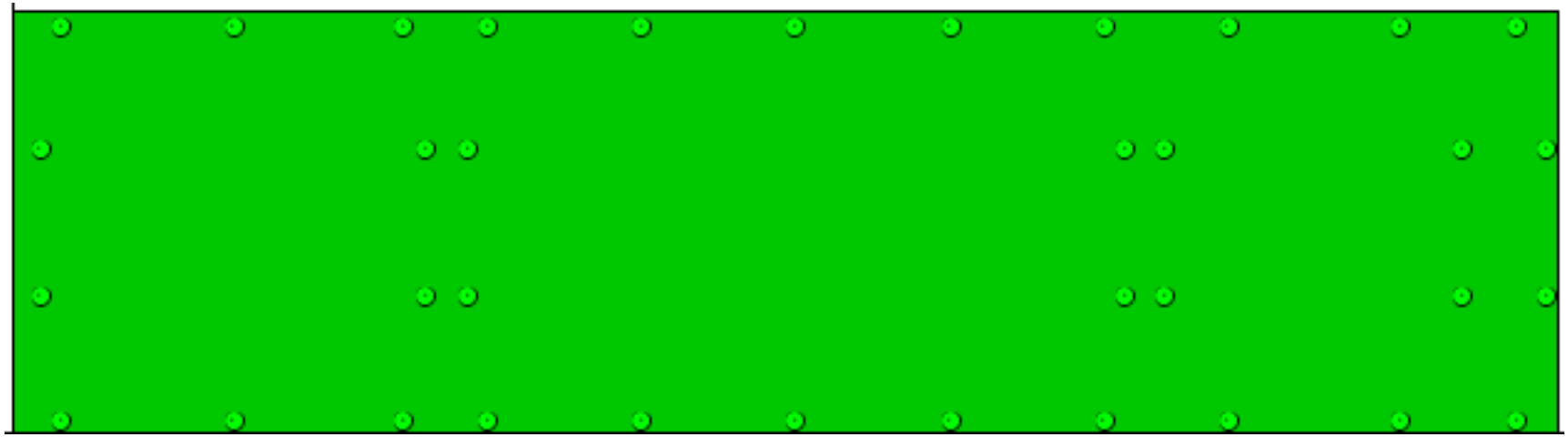
Analyses Performed

- **LRU Thermal Analysis**
  - Determines temperature profile within enclosure
- **CCA Thermal (Overstress) Analysis**
  - Determines temperatures of components & compares results to rated temperatures
- **CCA Modal Analysis**
  - Determines natural frequencies of circuit boards
- **CCA Random Vibration Response Analysis**
  - Determines displacement & curvatures of circuit boards based on random vibration input
- **CCA Shock Response Analysis**
  - Determines displacement, curvature and strain of circuit boards from specified shock pulse

Life Assessments Performed

- **CCA Shock Survivability Assessment**
  - Determines whether circuit board and components will survive given shock pulse
- **CCA Vibration Fatigue Life Assessment**
  - Estimates fatigue life of component solder-joints and leads based on input from vibration analysis
- **CCA Thermal Fatigue Life Assessment**
  - Estimates fatigue life of component solder-joints and leads based on thermal cycles (loading)
- **CCA Combined Fatigue Life Assessment**
- **CCA Thermal Plated-Through Hole Fatigue Life Assessment**
  - Estimates through hole & via plating fatigue life based on thermal cycles

Apply Early In The Design Process



CCA dimensions: 567 x 154 x 2.337 mm
Board thickness: 2.337 mm

Modeled PWB Layers: 6

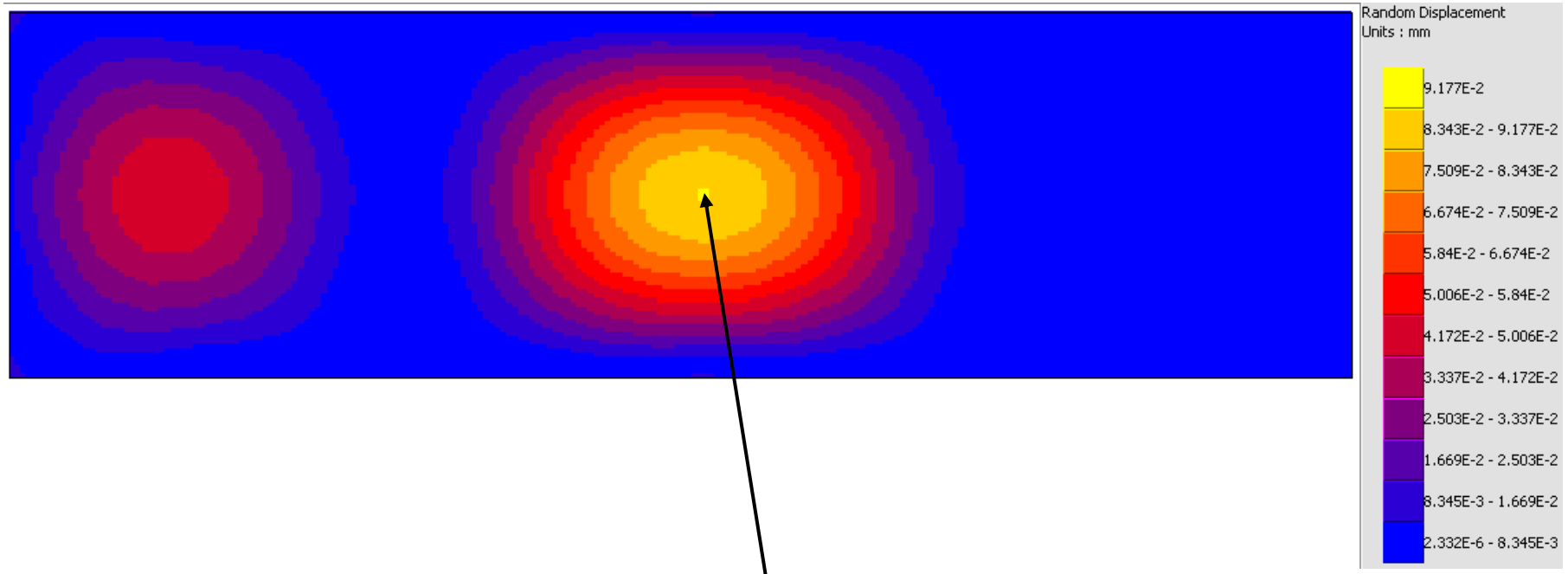
Board materials: Epoxy glass laminate (FR-4) with copper metallization

Boundary Conditions Legend:

S - Simple Support at single node, usually representing fastener (screw)

Damping factor: 0.05

Random Vibration Displacement Results

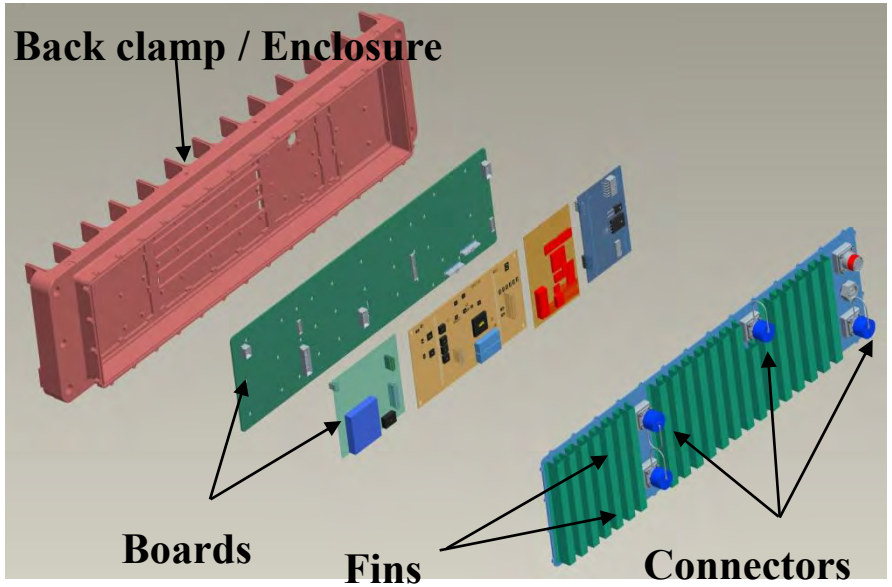


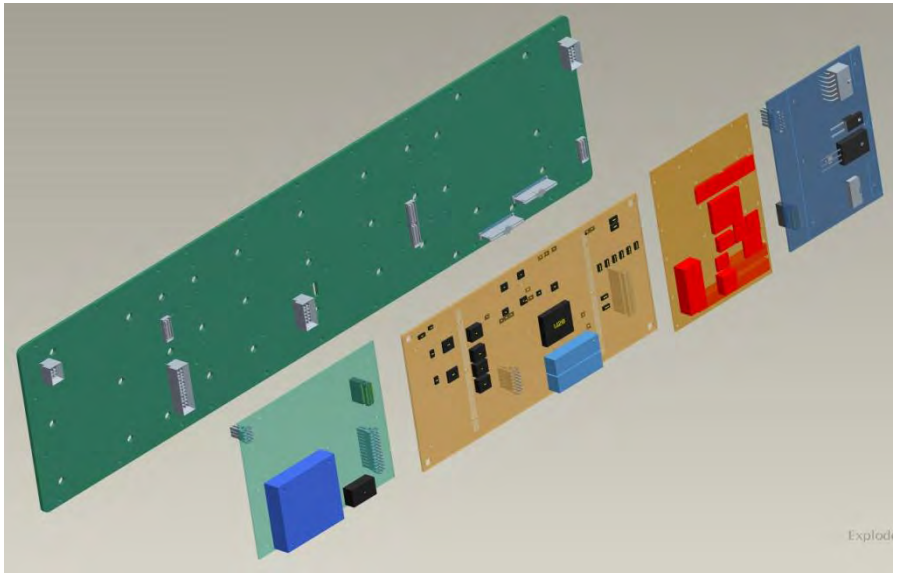
Max displacement:
0.09177 mm

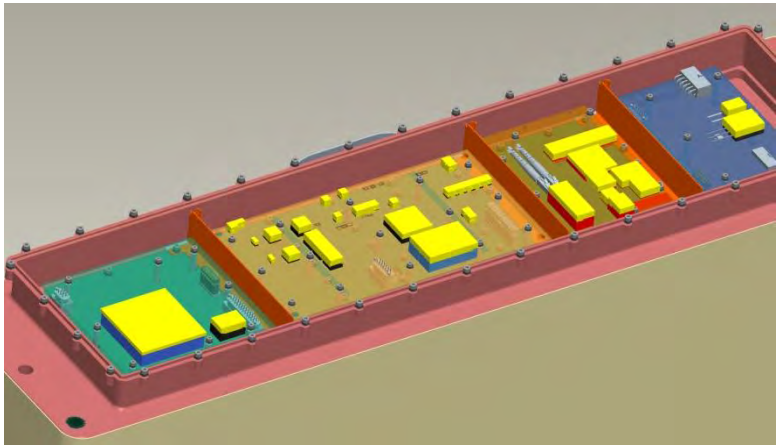
Avoid Large/Tall
Leadless Components

EXAMPLE of Electronic Chassis Thermal Analysis and CCA PoF Analysis

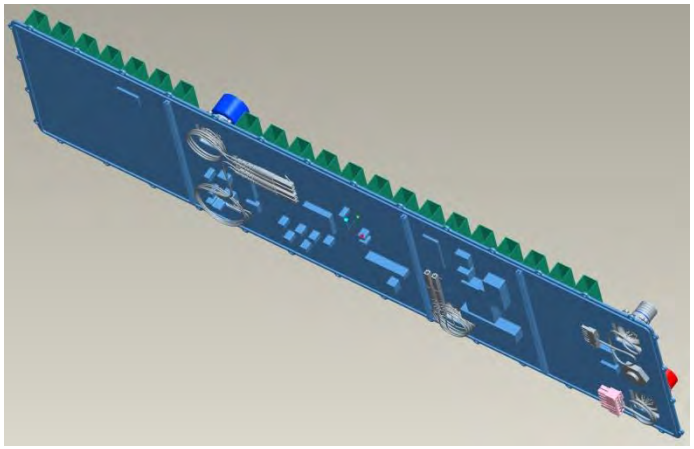
Electronic Chassis Thermal Analysis Pro-E model





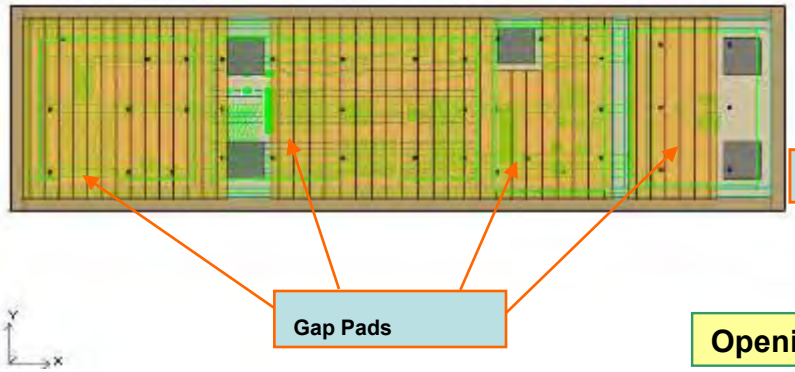


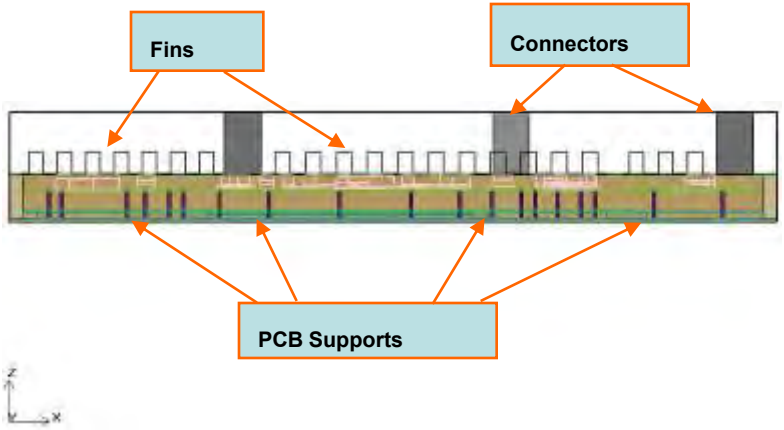
Thermal interface material / gap pad shown in yellow

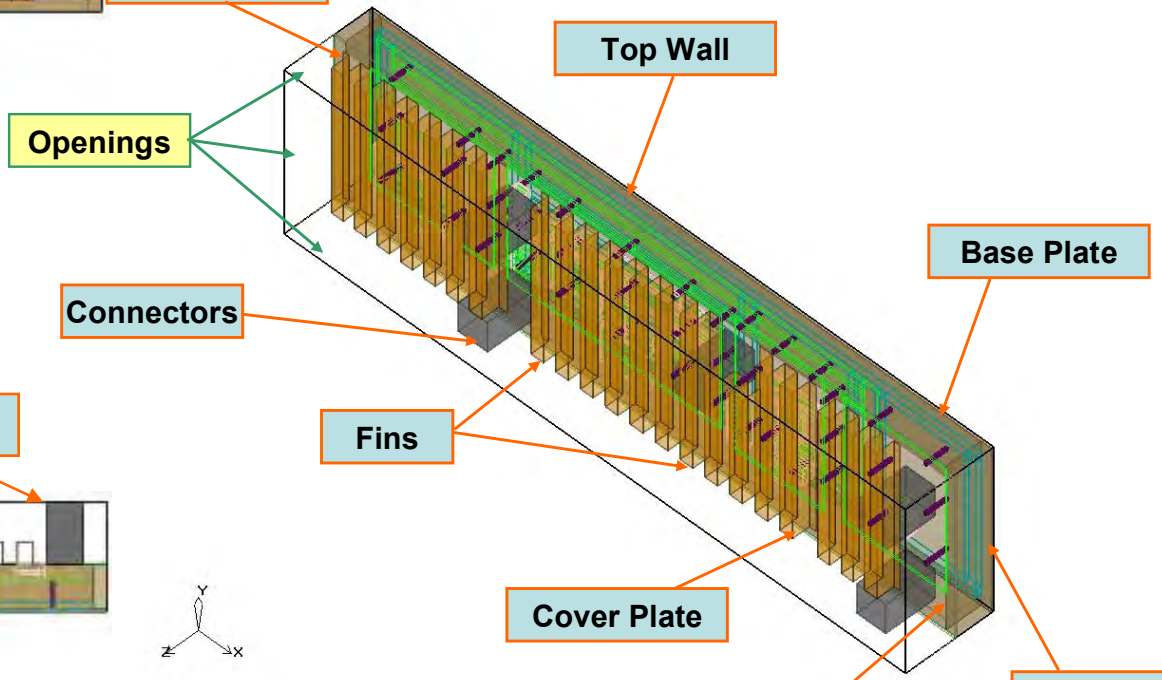


Redesigned aluminum posts

Finished ICEPAK Model







Gravity:
Y-Direction

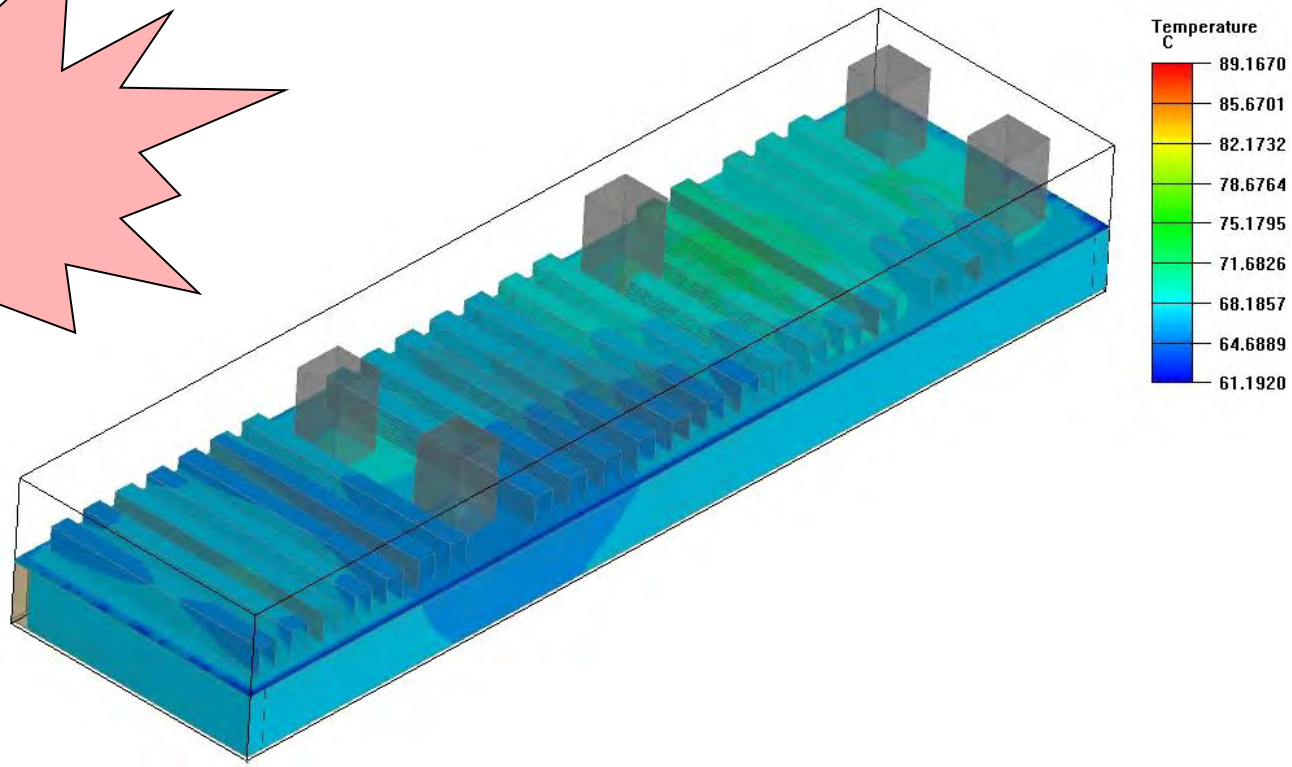
Results: Overall

Airflow through (and around) cover plate and fins calculated by ICEPAK

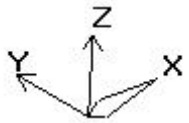
Applied Heat Transfer Coefficient Values:

- Left Wall: 4.45 W/m^2-K
- Right Wall: 4.45 W/m^2-K
- Top Wall: 5.639 W/m^2-K
- Bottom Wall: 2.771 W/m^2-K

Natural Convection Cooling

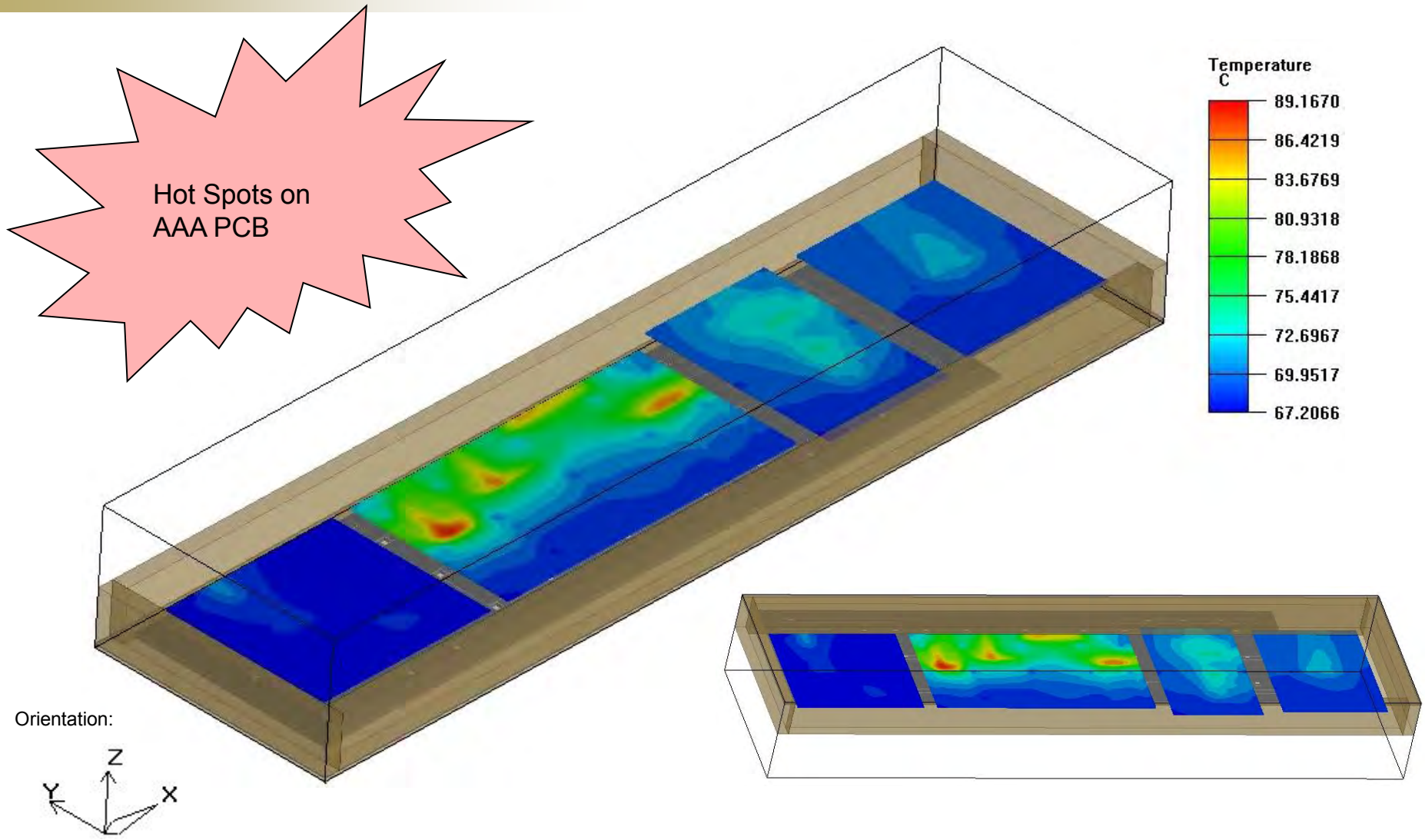


Orientation:



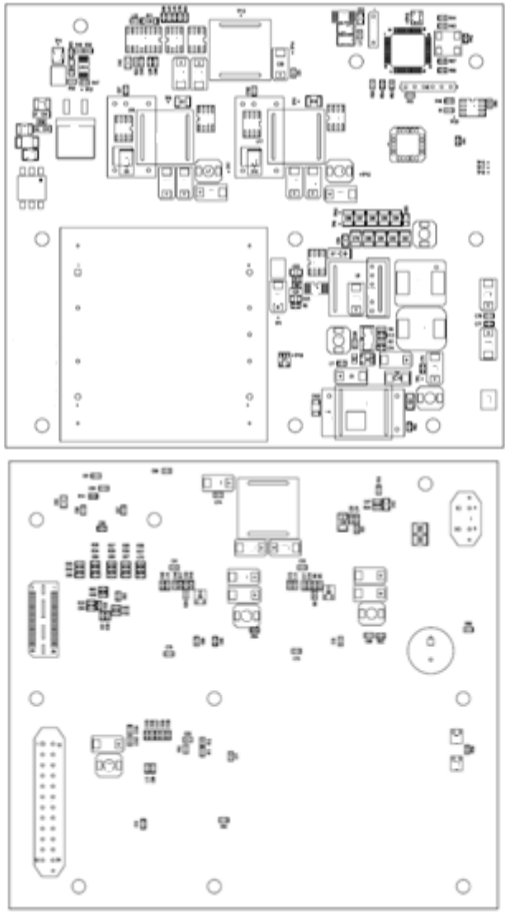
- Maximum temperature of 89.2ºC located within the enclosure on the AAA PCB

Results: PCB Temperatures

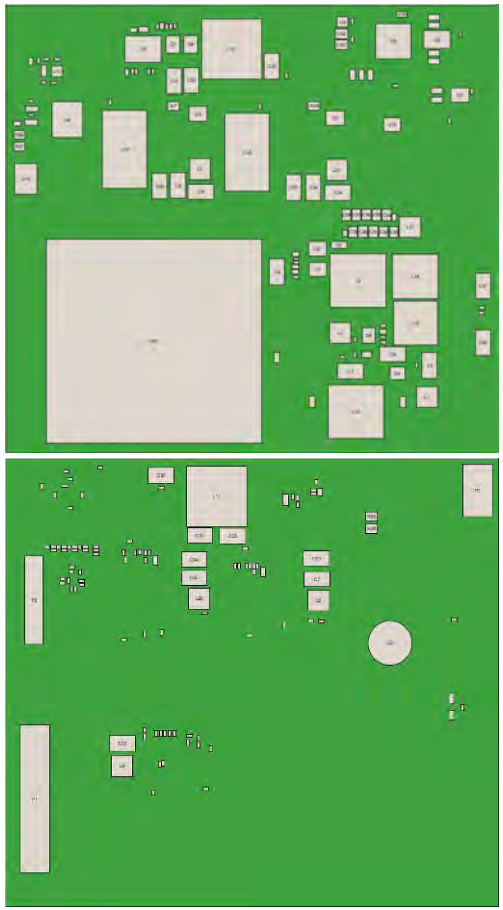


- Maximum temperature of 89.2ºC at all the PCB's located on the AAA PCB

CCA Modeling



Component Placement Drawing



CalcePWA Model

CCA dimensions: 139.7mm x 127mm x 1.534mm

Modeled PWB Layers: 11 total
(6 signal/power/gnd)

Board materials: Epoxy-glass laminate (FR-4) with 50% copper metallization on each signal/power/ground layer

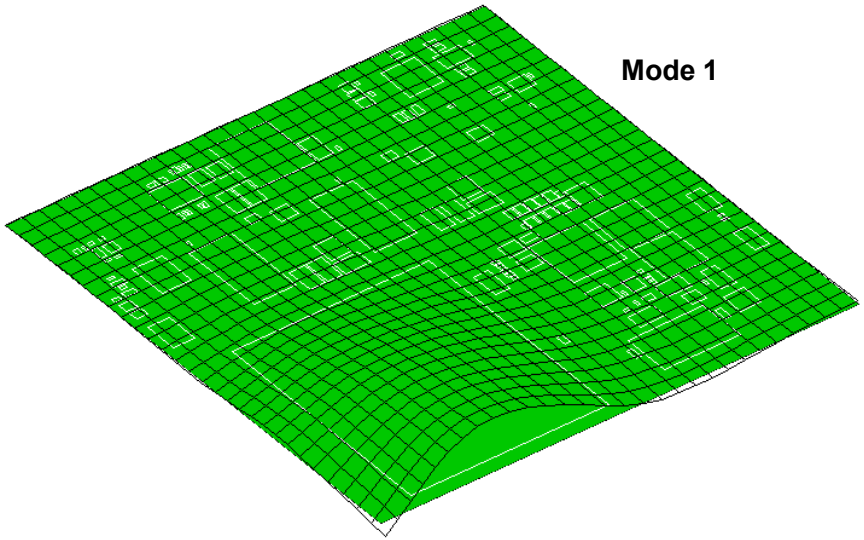
- Layers 1,3,5,7,9,11 - 1 oz Cu

Components:

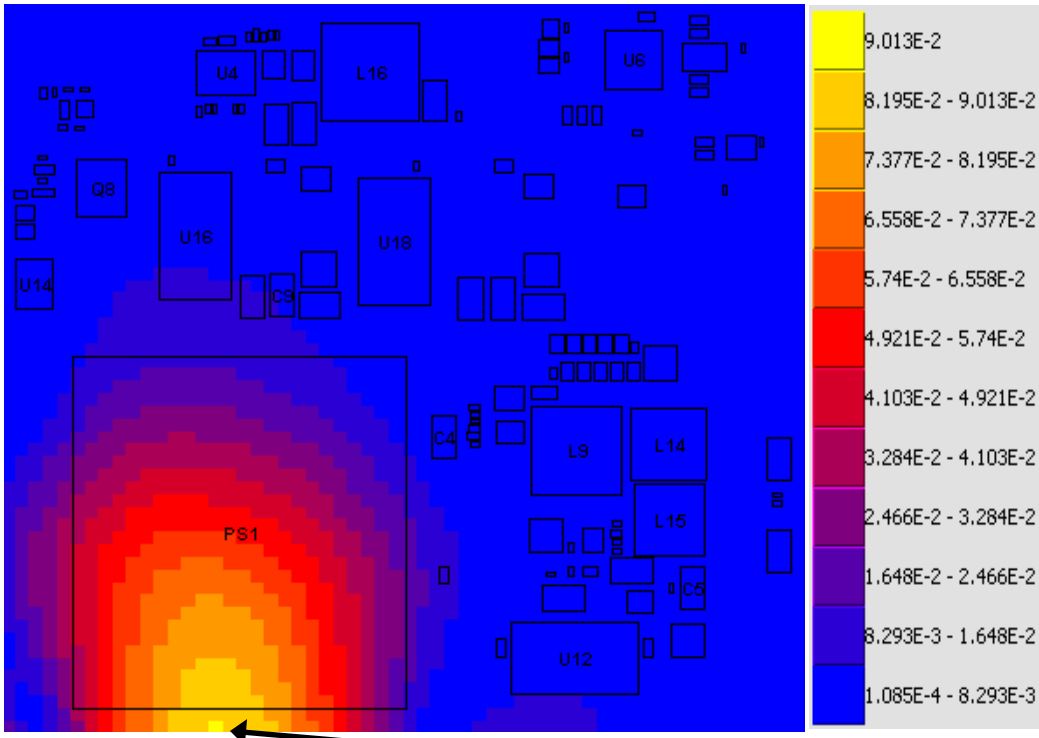
- Leadless ceramic capacitors
- Leadless ceramic resistors
- SMT Power Inductors
- SOPs, SOICs, SOTs, TQFP
- Axial-leaded diodes
- Radial-leaded inductors
- Tantalum capacitors
- Aluminum electrolytic capacitors
- Power Converter (DC/DC)
- Schottky Diodes

Modal / Random Vibration Response

Mode	1	2	3
Frequency (Hz)	272	517	581



Mode 1

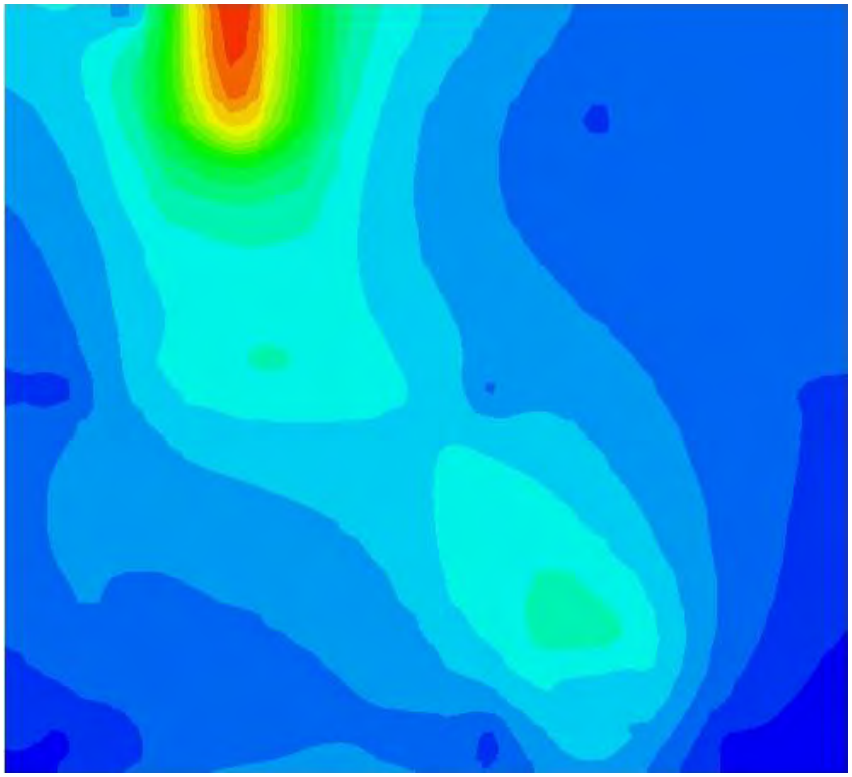


Two wheeled trailer

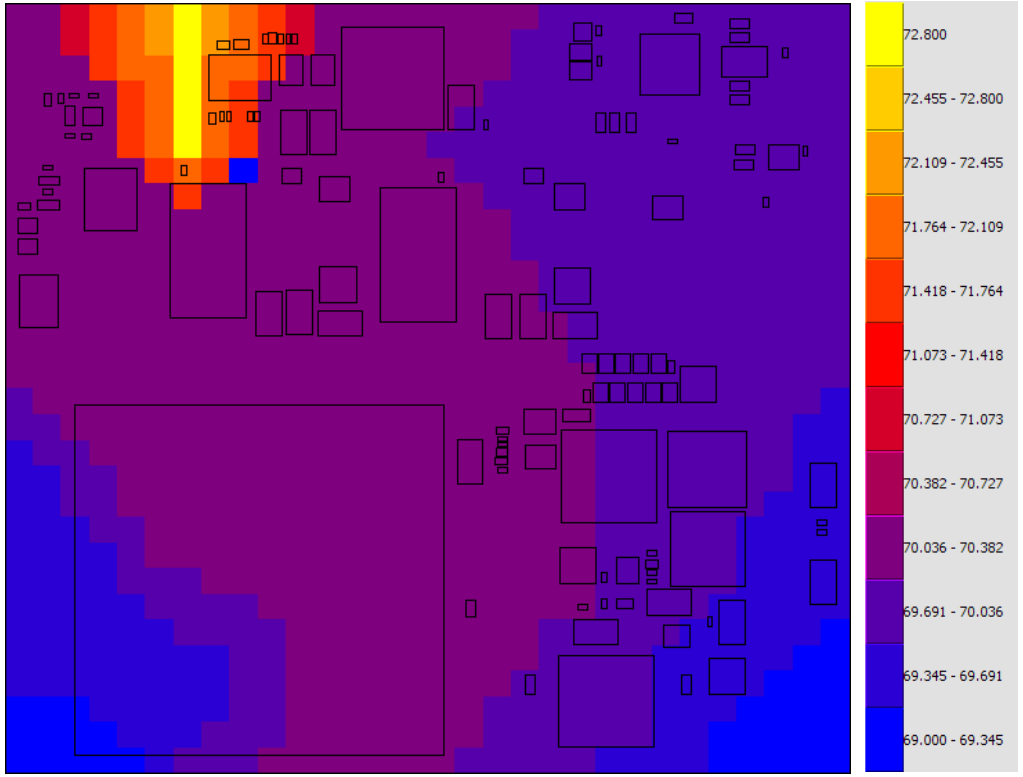
0.09013mm

Maximum displacement of 0.09013mm due to Composite Two-Wheeled Trailer vibration exposure

CalcePWA Thermal Fatigue Setup

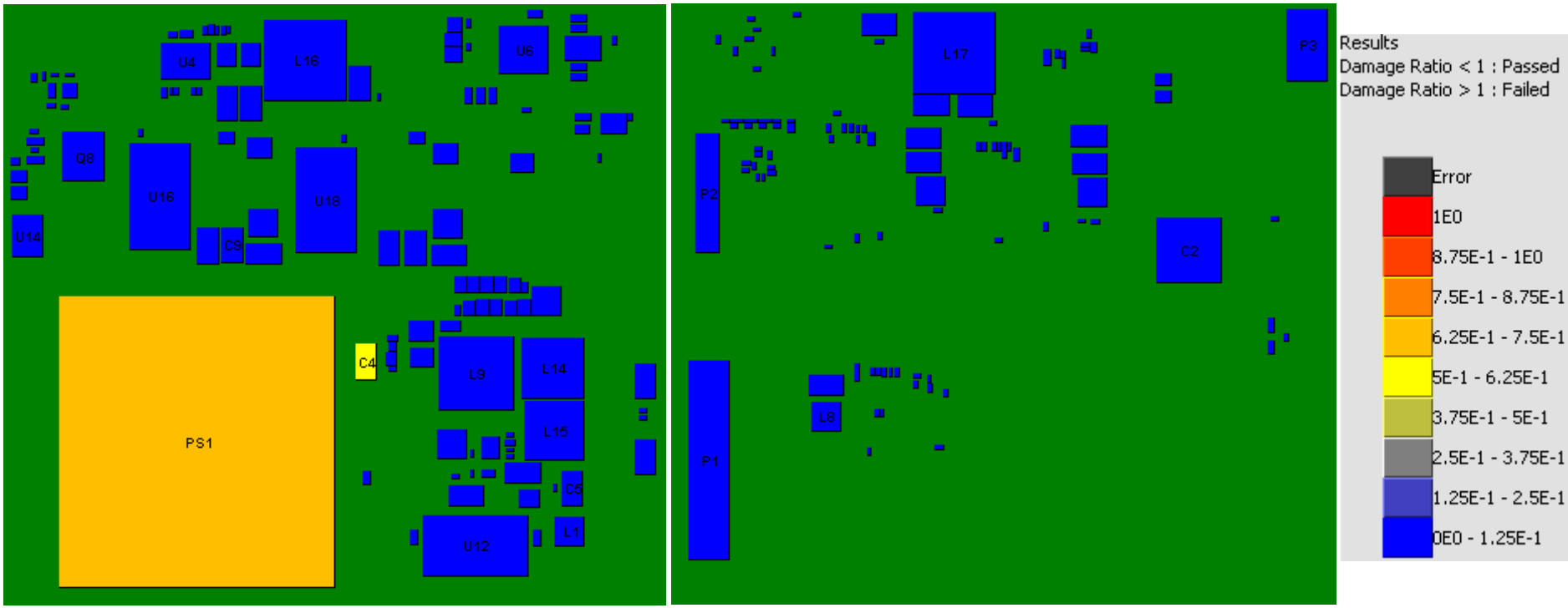


ICEPAK Thermal Analysis Results



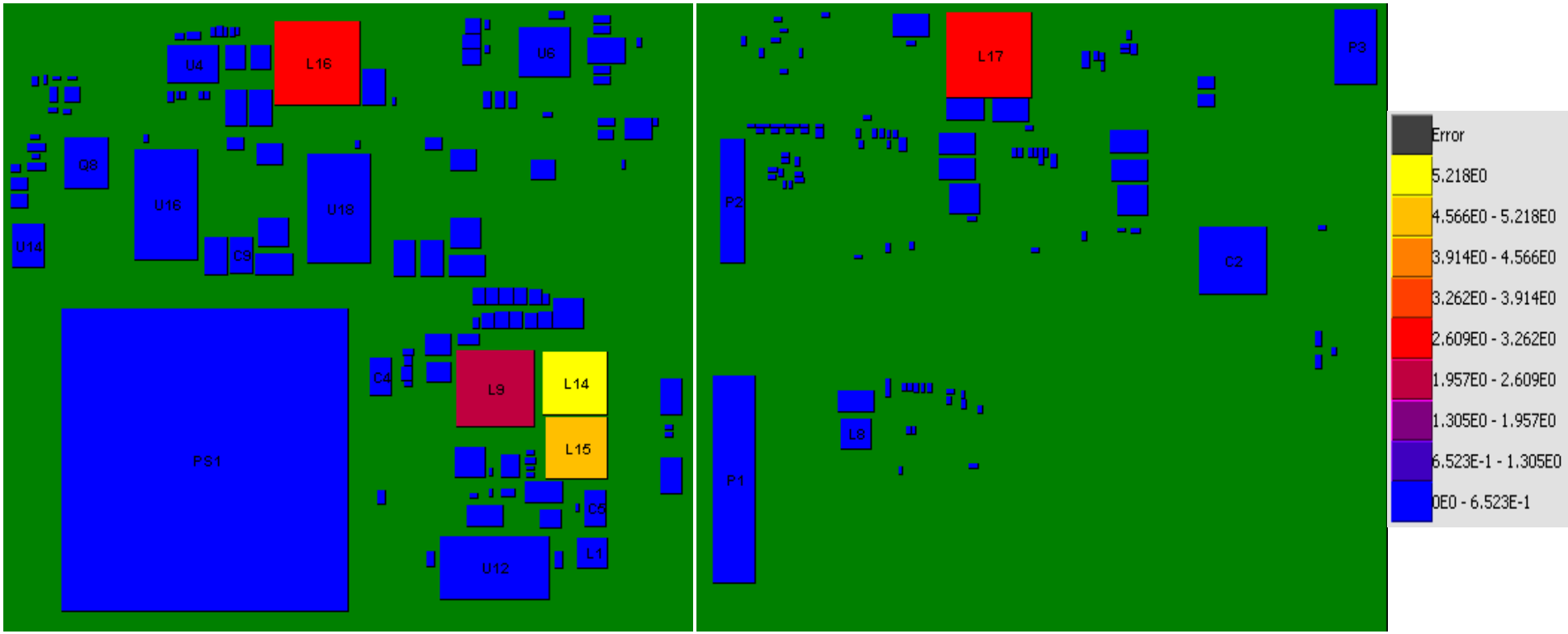
CalcePWA Substrate Temperature

Life Estimate due to Vibration Loading Only



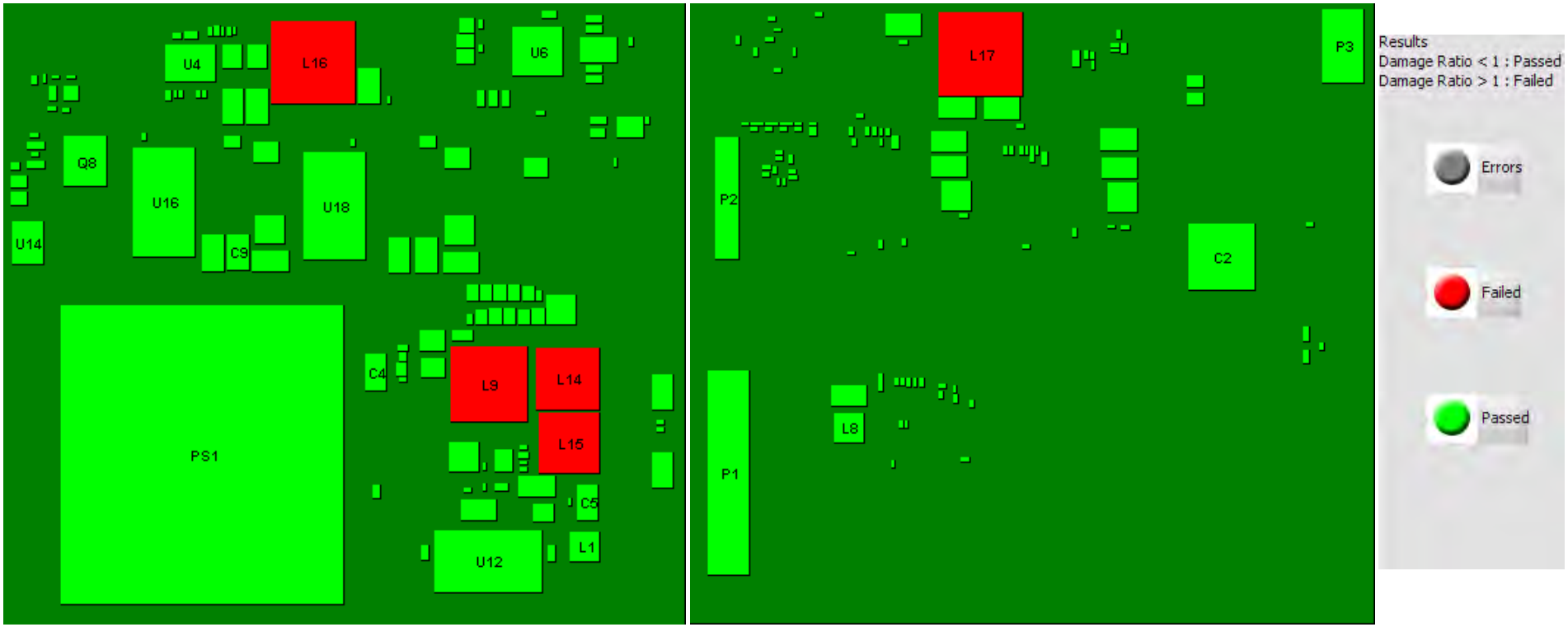
- **DC/DC Converter PS15 expected to accumulate the most damage over lifetime from vibration loading (DR = 0.64)**
- **Tantalum capacitor C45 expected to accumulate the second most damage over lifetime from vibration loading (DR = 0.55)**

Life Estimate due to Thermal Loading Only



- **Inductor L145 expected to accumulate the most damage over lifetime from 210 annual thermal cycles (DR = 5.22)**
- **Inductors L95, L155, L165, and L175 expected to receive significant damage over lifetime from 200 annual thermal cycles (DR>1)**

Life Estimate due to Combined Thermal & Vibration Loading



Components L95, L145, L155, L165, and L175 have life estimates of less than 20 years due to combined vibration loading and thermal cycling (50th Percentile)

Worst-Case Component Life Estimate Combined Loading

Temperature cycles on/off per year wartime	Components Name	Part	Damage Ratio	Thermal Fatigue life (Years)
200	L145	Inductor	3.54	5.66
	L155	Inductor	3.24	6.18
	L165	Inductor	2.21	9.05
	L175	Inductor	2.17	9.20
	L95	Inductor	1.56	12.78
200-500	L145	Inductor	7.42	2.69
	L155	Inductor	6.79	2.95
	L165	Inductor	4.63	4.32
	L175	Inductor	4.55	4.39
	L95	Inductor	3.26	6.13
	C45	Inductor	0.68	29.41
500-1000	L145	Inductor	12.81	1.56
	L155	Inductor	11.70	1.71
	L165	Inductor	7.93	2.52
	L175	Inductor	7.80	2.56
	L95	Inductor	5.55	3.60
	C45	Capacitor	0.76	26.31
	PS15	DC/DC Converter	0.64	>30
	L25	Inductor	0.60	>30

Life requirement Criteria : 20 Years

Reliability Improvement Suggestions

Board	Ref. Des.	Package Type	Failure Mechanism*	Possible Solution
A	L99999	SMT Power Inductor	TSJF	• Use equivalent through-hole versions of inductors L9, L14 - L17 with compliant spacer or kinked leads. Tie down body of component. • Select equivalent component with known CTE and re-run analysis. Make recommendation based on result.*** • Perform component testing to determine actual CTE. Re-run analysis. Make recommendation based on result.***
A	L145678	SMT Inductor	TSJF	Same as above.
A	L152345	SMT Inductor	TSJF	Same as above.
A	L161212 L171819	SMT Power Inductor	TSJF, SHCK	Same as above. • Perform component shock test using representative solder processes. ***
A	PS145	DC/DC Converter	TSJF**, SHCK	• Add PWB mounting screws in four corners of device. • Attach PS1 base to PWB with compliant cement (such as RTV).***
B	L2093	SMT Inductor	TSJF	Same as L9 Power Board.
B	P40167	Surface Mount High-Speed Header	TSJF	• Use equivalent through-hole version. • Perform component testing. Re-run analysis. Make recommendation based on result.***
C	L41,L51, L121, R21, C11111	SMD Components	VSJF	• Add support (standoff) to PWB at high deflection region. • Use equivalent through-hole version with looped (or kinked) lead. Tie down body of component.***
C	L200, L30	Through-Hole Chokes	TSJF**	• Add compliant spacer or kink leads. Tie down body of component.

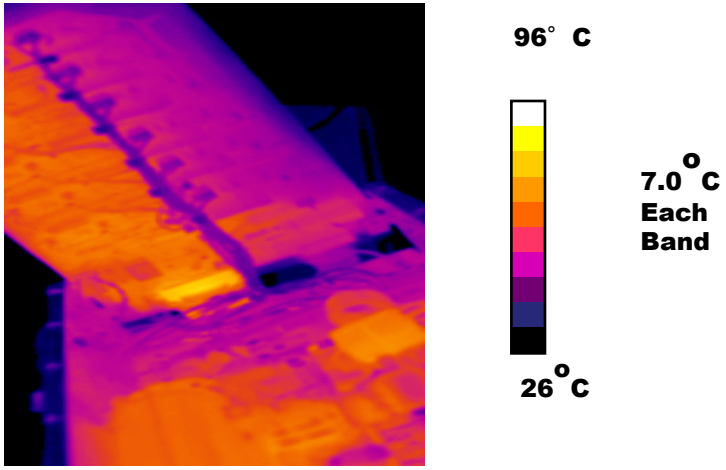
* - Failure mechanism: TSJF = Thermal Solder-Joint Fatigue, VSJF = Vibration Solder-Joint Fatigue, SHCK = Shock

** - Out-of-Plane Thermal Expansion ***- Alternative

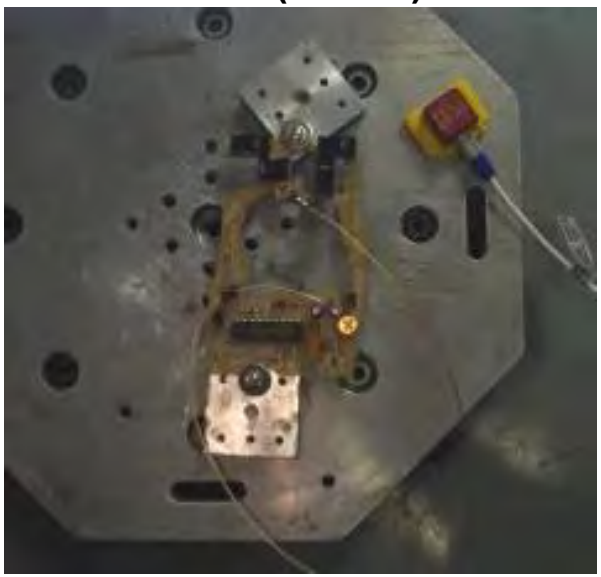
Survey Testing

- Used to refine/verify analysis predictions
- Used to determine interaction of multiple circuit card assemblies & chassis

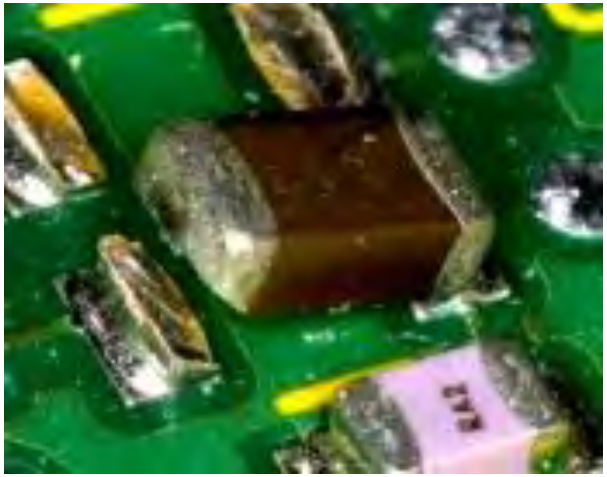
Thermal



Vibration (Modal)



Shock



Thermal/Modal Survey Testing

- Thermal analysis predicts component temperatures and identifies components to monitor
- Thermal test measures actual component temperature using thermocouples, thermal imaging, or both

- Modal / Random Vibration analyses predict card natural frequencies and identify locations of maximum deflection for accelerometer placement
- Modal test measures actual CCA & Chassis natural frequencies

Contact Information

Gary Drake

(410) 278-3122

U.S. Army Materiel Systems Analysis Activity

gary.s.drake@us.army.mil

First Steps in the Development of an Architecture Framework for a Product Development Process

Presenter: Jeffery L. Williams, PhD Candidate

Co-author: Jerrell T. Stracener, PhD

SMU | Bobby B. Lyle School of Engineering

Research Foundation

- This presentation is based on my PhD research to develop a methodology an model to optimize the design of an organization (a complex system) for developing an Aerospace & Defense (A&D) system

- An organization is a function of the Product Development Processes and the goals & objectives of the end item system

- Therefore, the initial research is focused on the application of an Architecture Framework for a Product Development Process and its impact on the design of the organization

Where does the need for an Architecture Framework come from?

- Today's A&D systems are becoming increasingly more complex
- Today's defense acquisition process is a complex phase-gated process that forces A&D system developers to **continually restructure** its organizations in order to respond to changing demands
- Each A&D system developer needs to **redefine itself** at the start of each acquisition phase (and at key decision points within a phase) in order to accomplish the objectives of that phase in the most efficient manner possible
- In the Systems Engineering Journal, Vol. 12 No. 1 2009 p69-90, Tyson R. Browning identified Product Development Process (PDP) as a "kind of complex system" and he discussed the need for research regarding the application of Architecture Frameworks (AFs) to the development of PDPs.[1]

Response to the Need

Conway's Law

- Melvin Conway stated in his paper, *How Do Committees Invent?*[2]
  - Any organization that designs a system (defined more broadly here than just information systems) will inevitably produce a design whose structure is a copy of the organization's communication structure.
- My research is focused on the design of organizations for the development of A&D systems.
  - These organizations are complex systems that are continually adapting and modifying their needlines in order to operate efficiently

If an AF can be defined for an organization in the PDP, then it may be possible to determine a method to optimize the design of that organization.

Purpose of this Paper

1. To address the question:

   Why do we care about developing an Architecture Framework for a Product Development Process (PDP)?

   The basic need of any system developer is determine the best application of resources that will minimize program cost and schedule while successfully executing the program.

2. The objective of this research is to determine if the same methods used to design a system can be used to design the organization following the PDP

3. In order to describe how the PDP influences the characteristics of the organization we will use the Department of Defense Architecture Framework (DoDAF) modeling methodology.

Why use DoDAF V2.0?

1. DoDAF V2.0 is the "overarching, comprehensive framework and conceptual model enabling the development of architectures to facilitate the ability of DoD managers at all levels make key decisions more effectively …"[3,pES-1]
2. The DoDAF is widely used by organizations developing system solutions for the DoD
   - Developers of A&D Systems are most likely to be the first to see the need to optimize the design of the their organizations
3. Version 2.0 added missing viewpoints necessary for modeling an evolving organization
   - Capability Viewpoint
   - Data Information Viewpoint
   - Project Viewpoint

DoDAF V2.0 is a common methodology that architects already know!

How do we Tailor DoDAF V2.0?

- The 6 steps used to tailor DoDAF V2.0 [3, p62]
  1. Define Stakeholders
  2. Document the decisions made by the stakeholders
  3. Define information requirements for decisions
  4. Define DoDAF artifacts that support Stakeholder decisions
  5. Align information requirements to the data sets for decisions
  6. Develop architectural artifacts

Use of the Zachman Framework (ZF) [4]

- By mapping the stakeholders onto the ZF it helps us to:
  - Understand each stakeholder's needs
  - Address the six interrogatives

ENTERPRISE ARCHITECTURE - A FRAMEWORK ™

	DATA *What*	FUNCTION *How*	NETWORK *Where*	PEOPLE *Who*	TIME *When*	MOTIVATION *Why*	
SCOPE (CONTEXTUAL) *Planner*	List of Things Important to the Business ENTITY = Class of Business Thing	List of Processes the Business Performs Function = Class of Business Process	List of Locations in which the Business Operates Node = Major Business Location	List of Organizations Important to the Business People = Major Organizations	List of Events Significant to the Business Time = Major Business Event	List of Business Goals/Strat Ends/Means=Major Bus. Goal/ Critical Success Factor	SCOPE (CONTEXTUAL) *Planner*
ENTERPRISE MODEL (CONCEPTUAL) *Owner*	e.g. Semantic Model Ent = Business Entity Reln = Business Relationship	e.g. Business Process Model Proc. = Business Process I/O = Business Resources	e.g. Logistics Network Node = Business Location Link = Business Linkage	e.g. Work Flow Model People = Organization Unit Work = Work Product	e.g. Master Schedule Time = Business Event Cycle = Business Cycle	e.g. Business Plan End = Business Objective Means = Business Strategy	ENTERPRISE MODEL (CONCEPTUAL) *Owner*
SYSTEM MODEL (LOGICAL) *Designer*	e.g. Logical Data Model Ent = Data Entity Reln = Data Relationship	e.g. "Application Architecture" Proc. = Application Function I/O = User Views	e.g. "Distributed System Architecture" Node = I/S Function (Processor, Storage, etc) Link = Line Characteristics	e.g. Human Interface Architecture People = Role Work = Deliverable	e.g. Processing Structure Time = System Event Cycle = Processing Cycle	e.g., Business Rule Model End = Structural Assertion Means = Action Assertion	SYSTEM MODEL (LOGICAL) *Designer*
TECHNOLOGY MODEL (PHYSICAL) *Builder*	e.g. Physical Data Model Ent = Segment/Table/etc. Reln = Pointer/Key/etc.	e.g. "System Design" Proc = Computer Function I/O = Screen/Device Formats	e.g. "System Architecture" Node = Hardware/System Software Link = Line Specifications	e.g. Presentation Architecture People = User Work = Screen Format	e.g. Control Structure Time = Execute Cycle = Component Cycle	e.g. Rule Design End = Condition Means = Action	TECHNOLOGY CONSTRAINED MODEL (PHYSICAL) *Builder*
DETAILED REPRESENTATIONS (OUT-OF-CONTEXT) *Sub-Contractor*	e.g. Data Definition Ent = Field Reln = Address	e.g. "Program" Proc = Language Stmt I/O = Control Block	e.g. "Network Architecture" Node = Addresses Link = Protocols	e.g. Security Architecture People = Identity Work = Job	e.g. Timing Definition Time = Interrupt Cycle = Machine Cycle	e.g. Rule Specification End = Sub-condition Means = Step	DETAILED REPRESENTATIONS (OUT-OF CONTEXT) *Sub-Contractor*
FUNCTIONING ENTERPRISE	e.g. DATA	e.g. FUNCTION	e.g. NETWORK	e.g. ORGANIZATION	e.g. SCHEDULE	e.g. STRATEGY	FUNCTIONING ENTERPRISE

Zachman Institute for Framework Advancement - (810) 231-0531

First Primary Stakeholders & Their Decisions

1. **Planner:** Program Managers & Executive Leadership
   - The Planner's decisions are based on the scope of the effort and its impact on the enterprise
   - Mapping of the Planner's decision needs to the 6 interrogatives & DoDAF V2.0

Stakeholder	What	How	Where	When	Who	Why
Planner	Business Entity	Business Function	Location	Event (IMP)	The Org.	Goals & Strategies
Planner	DIV-1	OV-5a	OV-2	CV-3 PV-1	OV-4	AV-1 CV-1 OV-1

Second Primary Stakeholders & Their Decisions

2. **Owner:** Program Manager, Chief Engineer, Manufacturing & Logistics Leads
   - The Owner's decisions are based on the definition of the enterprise responsible for execution
   - Mapping of the Owner's decision needs to the 6 interrogatives & DoDAF V2.0

Stakeholder	What	How	Where	When	Who	Why
Owner	Relation ships of Business Entities	Process Models	Logistics of Execution	Master Schedule	Resource Groups	Business Plan or RFP
Owner	DIV-2 AV-2	OV-5b OV-6a OV-6b	OV-2	OV-6c CV-3 CV-4 CV-2 PV-2	OV-3 OV-4	AV-1 CV-1 PV-3

Third Primary Stakeholders & Their Decisions

3. **Designer:** Chief Engineer, Manufacturing & Logistics Leads
   - The Designer's decisions based on defining the day-to-day operations of the organization
   - Mapping of the Designer's decision needs to the 6 interrogatives & DoDAF V2.0

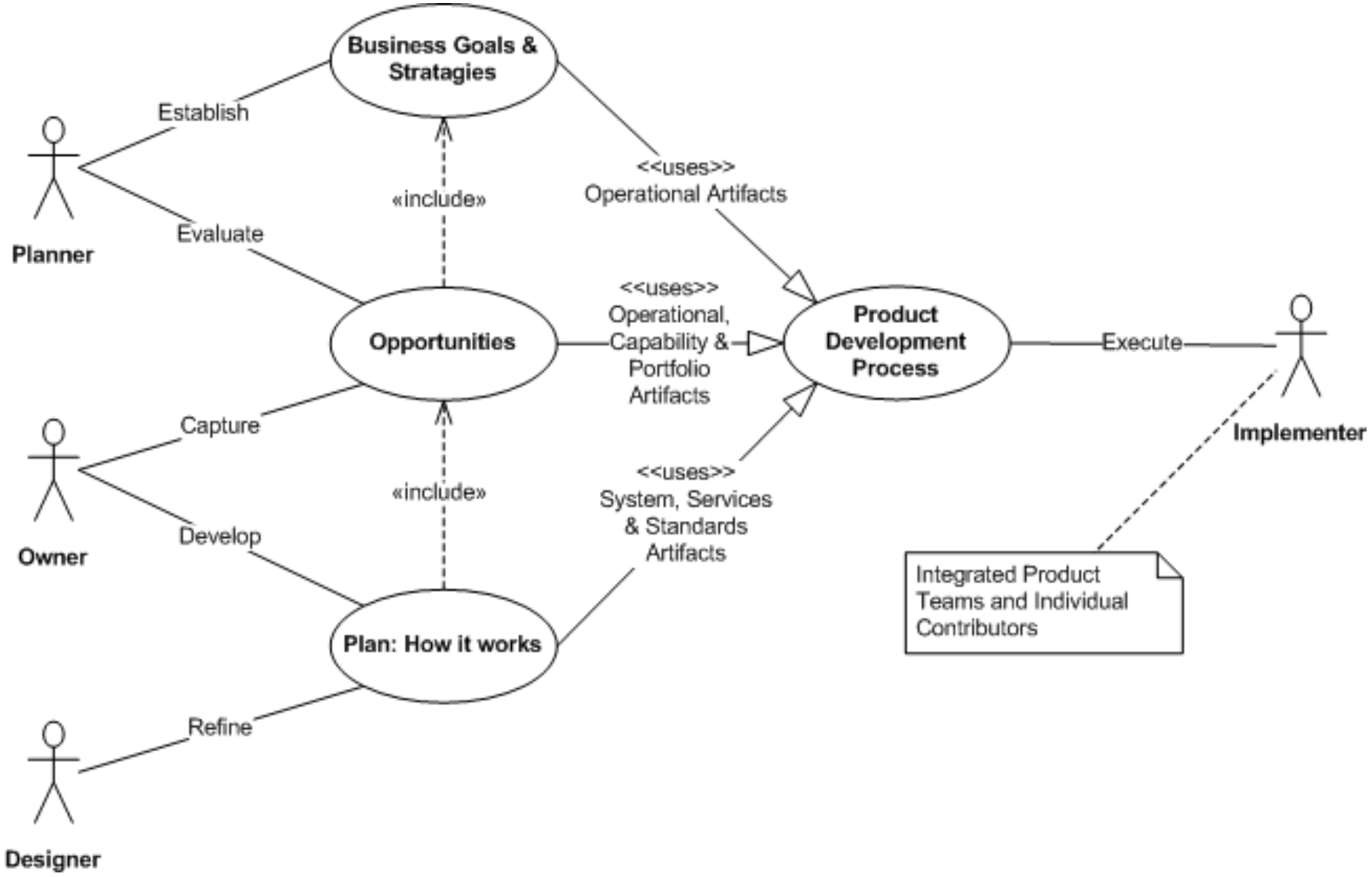
Next Slide

Third Primary Stakeholders & Their Decisions

Stakeholder	What	How	Where	When	Who	Why
Designer	Data Products	Exchange of DPs	Org Network	Sequence	Org. Resources Rq'd - Nos.	SOWs, CLINS, & Processes
Designer	DIV-3 SV-1 SvcV-1 SV-3 SvcV-3a SvcV-3b	SV-4 SvcV-4 SV-5a SvcV-5a SV-5b SvcV-5b SV-6 SvcV-6 SV-7 SvcV-7 SV-10b SvcV-10b StdV-1	SV-2 SvcV-2	SV-10c SvcV-10C CV-5	OV-2 SV-6 SvcV-6	StdV-2 SV-10a SvcV-10A CV-6 CV-7

Note 1: Select either a System or Service view of the organization
Note 2: SV-6 & SvcV-6 emphasis is on data & products flowing from/to org. needs
Note 3: OV-2 definition is expanded at this level

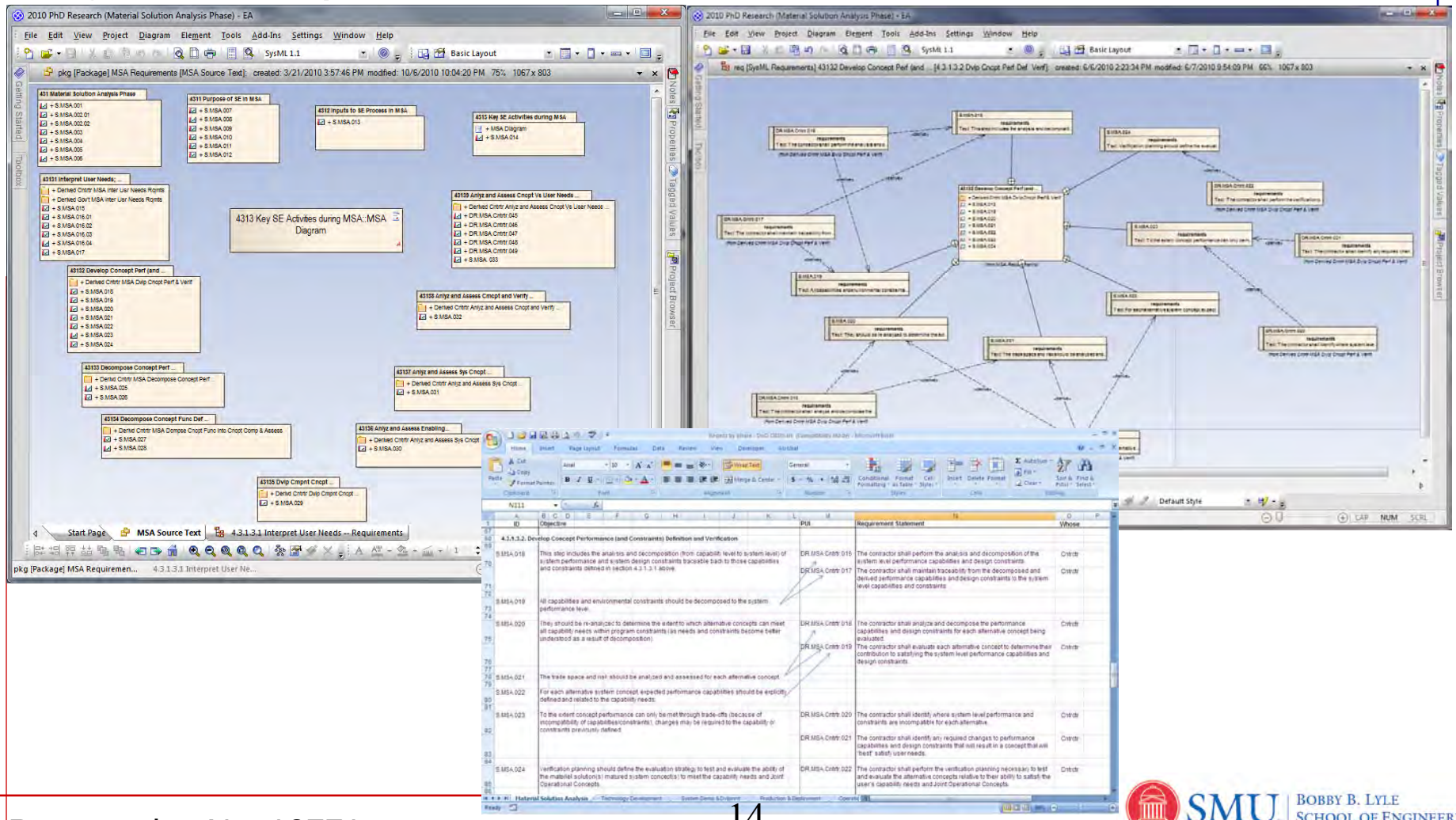
A Use Case Example for Developing a PDP



SMU Bobby B. Lyle School of Engineering

Definition of Scope of First Application

- Analysis of Material Solution Analysis Phase to define generic requirements for a SOW



SMU BOBBY B. LYLE SCHOOL OF ENGINEERING

Mapping of Requirements to AF Artifacts

Requirement	OV-5a	OV-5b	SvcV-5	SV-5a	SV-5b
DR.MSA.Cntrtr.001	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.002	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.003	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.004	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.005	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.006	↑	↑	↑	↑	↑
DR.MSA.Cntrtr.007	↑	↑	↑	↑	↑

The requirements derived from the description of the MSA phase in the Defense Acquisition Guidebook (DAG)[5] map to those artifacts associated with defining the activities to be performed.

Next Step

- Develop example artifacts to guide an application of the process
  - In work, initial artifacts are being created in the modeling environment
- Identification of program to support creation of an applied architecture
  - Initial discussions with an Aerospace & Defense developer were initiated on 8 Oct 2010
- Development of the resultant network model to optimize the program execution for the given constraints
- Analysis of the optimized network model to determine ideal organizational structure

Summary

- An initial evaluation of the DoDAF 2.0 indicates that it has sufficient breadth to support the development of a System Architecture of a Product Development Process

- The Viewpoints of the DoDAF 2.0 provide artifacts that address each of the decisions the primary stakeholders must address

- Final Observation – An extrapolation from Conway's Law
  - If an AF is not used to produce a System Architecture of an organization in the PDP, design flaws imposed on the organization will reflect the weaknesses of both the structure and process model of the enterprise.

References

[1] *The Many Views of a Process: Toward a Process Architecture Framework for Product Development Processes*, System Engineering Vol. 12, No. 1, 2009, p69-90.

[2] *How Do Committees Invent?,* Datamation, April 1968. Copy available at: http://www.melconway.com/Home/Committees_Paper.html

[3] *DoD Achitecture Framework Version 2.0, Volume 1: Introduction, Overview, and Concepts, Manager's Guide*, 28 May 2009. The DoDAV C2 guides are available at: http://cio-nii.defense.gov/sites/dodaf20/index.html

[4] *The Zachman Enterprise Framework™* . Available at: http://zachmaninternational.com/index.php and https://apps.adcom.uci.edu/EnterpriseArch/Zachman/

References

[5] *Defense Acquisition Guidebook*. Available at: https://dag.dau.mil/Pages/Default.aspx

Other papers of interest not references

The Use of Zachman Framework Primitives for Enterprise Modeling, Gundars Osvalds, Senior Principal Member of Technical Staff, Litton/TASC, 26 October 2000

A framework for information systems architecture, J.A. Zachman, IBM Systems Journal, Vol 26, No. 3, 1987.

Backup Slides

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
AV-1: Overview and Summary Information	Describes a Project's Visions, Goals, Objectives, Plans, Activities, Events, Conditions, Measures, Effects (Outcomes), and produced objects.
AV-2: Integrated Dictionary	An architectural data repository with definitions of all terms used throughout the architectural data and presentations.
CV-1: Vision	The overall vision for transformational endeavors, which provides a strategic context for the capabilities described and a high-level scope.
CV-2: Capability Taxonomy	A hierarchy of capabilities which specifies all the capabilities that are referenced throughout one or more Architectural Descriptions.
CV-3: Capability Phasing	The planned achievement of capability at different points in time or during specific periods of time. The CV-3 shows the capability phasing in terms of the activities, conditions, desired effects, rules complied with, resource consumption and production, and measures, without regard to the performer and location solutions.
CV-4: Capability Dependencies	The dependencies between planned capabilities and the definition of logical groupings of capabilities.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
CV-5: Capability to Organizational Development Mapping	The fulfillment of capability requirements shows the planned capability deployment and interconnection for a particular Capability Phase. The CV-5 shows the planned solution for the phase in terms of performers and locations and their associated concepts.
CV-6: Capability to Operational Activities Mapping	A mapping between the capabilities required and the operational activities that those capabilities support.
CV-7: Capability to Services Mapping	A mapping between the capabilities and the services that these capabilities enable.
DIV-1:Conceptual Data Model	The required high-level data concepts and their relationships.
DIV-2: Logical Data Model	The documentation of the data requirements and structural business process (activity) rules. In DoDAF V1.5, this was the OV-7.
DIV-3: Physical Data Model	The physical implementation format of the Logical Data Model entities, e.g., message formats, file structures, physical schema. In DoDAF V1.5, this was the SV-11.
OV-1: High-Level Operational Concept Graphic	The high-level graphical/textual description of the operational concept.
OV-2: Operational Resource Flow Description	A description of the Resource Flows exchanged between operational activities.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
OV-3: Operational Resource Flow Matrix	A description of the resources exchanged and the relevant attributes of the exchanges.
OV-4: Organizational Relationships Chart	The organizational context, role or other relationships among organizations.
OV-5a: Operational Activity Decomposition Tree	The capabilities and activities (operational activities) organized in a hierarchal structure.
OV-5b: Operational Activity Model	The context of capabilities and activities (operational activities) and their relationships among activities, inputs, and outputs; Additional data can show cost, performers, or other pertinent information.
OV-6a: Operational Rules Model	One of three models used to describe activity (operational activity). It identifies business rules that constrain operations.
OV-6b: State Transition Description	One of three models used to describe operational activity (activity). It identifies business process (activity) responses to events (usually, very short activities).
OV-6c: Event-Trace Description	One of three models used to describe activity (operational activity). It traces actions in a scenario or sequence of events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
PV-1: Project Portfolio Relationships	It describes the dependency relationships between the organizations and projects and the organizational structures needed to manage a portfolio of projects.
PV-2: Project Timelines	A timeline perspective on programs or projects, with the key milestones and interdependencies.
PV-3: Project to Capability Mapping	A mapping of programs and projects to capabilities to show how the specific projects and program elements help to achieve a capability.
SvcV-1 Services Context Description	The identification of services, service items, and their interconnections.
SvcV-2 Services Resource Flow Description	A description of Resource Flows exchanged between services.
SvcV-3a Systems-Services Matrix	The relationships among or between systems and services in a given Architectural Description.
SvcV-3b Services-Services Matrix	The relationships among services in a given Architectural Description. It can be designed to show relationships of interest, (e.g., service-type interfaces, planned vs. existing interfaces).
SvcV-4 Services Functionality Description	The functions performed by services and the service data flows among service functions (activities).

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SvcV-5 Operational Activity to Services Traceability Matrix	A mapping of services (activities) back to operational activities (activities).
SvcV-6 Services Resource Flow Matrix	It provides details of service Resource Flow elements being exchanged between services and the attributes of that exchange.
SvcV-7 Services Measures Matrix	The measures (metrics) of Services Model elements for the appropriate time frame(s).
SvcV-8 Services Evolution Description	The planned incremental steps toward migrating a suite of services to a more efficient suite or toward evolving current services to a future implementation.
SvcV-9 Services Technology & Skills Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future service development.
SvcV-10a Services Rules Model	One of three models used to describe service functionality. It identifies constraints that are imposed on systems functionality due to some aspect of system design or implementation.
SvcV-10b Services State Transition Description	One of three models used to describe service functionality. It identifies responses of services to events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SvcV-10c Services Event-Trace Description	One of three models used to describe service functionality. It identifies service-specific refinements of critical sequences of events described in the Operational Viewpoint.
StdV-1 Standards Profile	The listing of standards that apply to solution elements.
StdV-2 Standards Forecast	The description of emerging standards and potential impact on current solution elements, within a set of time frames.
SV-1 Systems Interface Description	The identification of systems, system items, and their interconnections.
SV-2 Systems Resource Flow Description	A description of Resource Flows exchanged between systems.
SV-3 Systems-Systems Matrix	The relationships among systems in a given Architectural Description. It can be designed to show relationships of interest, (e.g., system-type interfaces, planned vs. existing interfaces).
SV-4 Systems Functionality Description	The functions (activities) performed by systems and the system data flows among system functions (activities).
SV-5a Operational Activity to Systems Function Traceability Matrix	A mapping of system functions (activities) back to operational activities (activities).

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SV-5b Operational Activity to Systems Traceability Matrix	A mapping of systems back to capabilities or operational activities (activities).
SV-6 Systems Resource Flow Matrix	Provides details of system resource flow elements being exchanged between systems and the attributes of that exchange.
SV-7 Systems Measures Matrix	The measures (metrics) of Systems Model elements for the appropriate timeframe(s).
SV-8 Systems Evolution Description	The planned incremental steps toward migrating a suite of systems to a more efficient suite, or toward evolving a current system to a future implementation.
SV-9 Systems Technology & Skills Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future system development.
SV-10a Systems Rules Model	One of three models used to describe system functionality. It identifies constraints that are imposed on systems functionality due to some aspect of system design or implementation.
SV-10b Systems State Transition Description	One of three models used to describe system functionality. It identifies responses of systems to events.

DoDAF 2.0 Definitions[3, p23-26]

Model	Description
SV-10c Systems Event-Trace Description	One of three models used to describe system functionality. It identifies system-specific refinements of critical sequences of events described in the Operational Viewpoint.

Integrity - Service - Excellence

Product Lifecycle Management (PLM) for Systems Engineering support within Expeditionary Combat Support System (ECSS)

NDIA 13th Annual Systems Engineering Conference
27 Oct 2010

Ms. Segrid Harris-Wright, AF/A4IT
Com: 937-904-0855
E-mail: segrid.harris-wright@wpafb.af.mil
Mr. Ron Krugman, CSC
Mr. Edwin W. Kincaid, OC-ALC/ENSN

U.S. AIR FORCE

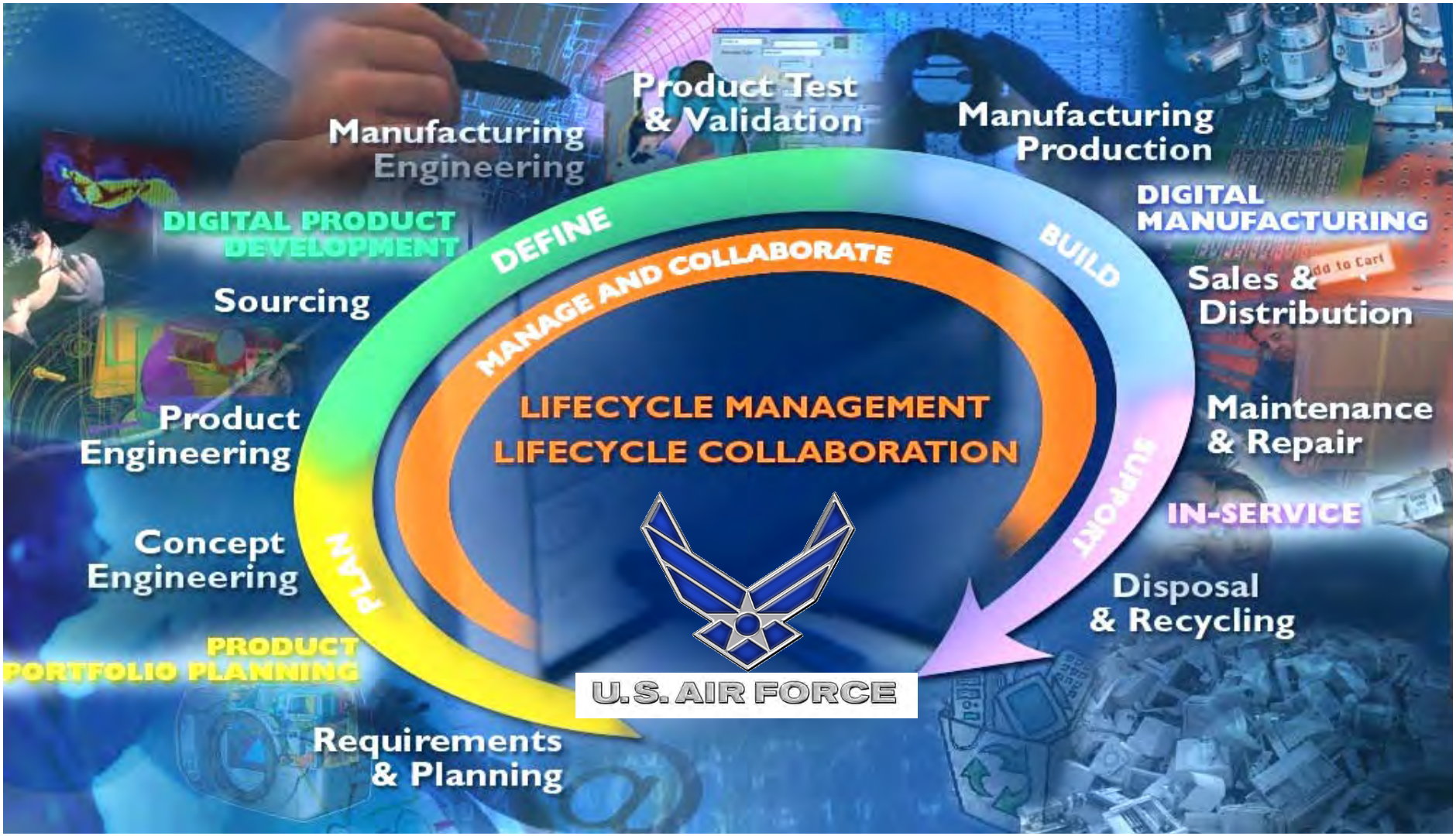
U.S. AIR FORCE

Outline

- **AF System Engineering Drivers**
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- Configuration Management and CMII
- Problem Reporting
- Engineering BP Processes
- System Engineering Benefits/Summary

U.S. AIR FORCE

The Total Weapon System Lifecycle



AF Acquisition Improvement Plan (AIP) & WSARA

U.S. AIR FORCE

Acquisition Improvement Plan

- Revitalize the Air Force acquisition workforce
- Improve requirements generation process
- Establish clear lines of authority and accountability within acquisition organizations
- Instill budget and financial discipline
- Improve Air Force major systems source selections

Weapon System Acquisition Reform Act (PL 111-23) Sec. 102 Directors of Developmental Test and Evaluation and Systems Engineering

(a) In General

§ 139d. (b) (5) Director of Systems Engineering shall

(D) provide advocacy, oversight, and guidance to elements of the acquisition workforce responsible for systems engineering, development planning, and lifecycle management and sustainability functions;

(E) provide input on the inclusion of systems engineering requirements in the process for consideration of joint military requirements by the Joint Requirements Oversight Council …

(b) Developmental Test and Evaluation and Systems Engineering in the Military Departments

(1) Plans. -- The(SAE) … shall develop and implement plans to ensure the military department … has provided appropriate resources for …

(B) Development planning and systems engineering organizations with adequate numbers of trained personnel in order to

(i) support key requirements, acquisition, and budget decisions made for each major defense acquisition program prior to Milestone A approval and Milestone B approval through a rigorous systems analysis and systems engineering process; …

(iii) identify systems engineering requirements, including reliability, availability, maintainability, and lifecycle management and sustainability requirements, during the Joint Capabilities Integration Development System process, and incorporate …into contract requirements …

Secretary of Defense Direction

U.S. AIR FORCE

Chief among institutional challenges facing the Department is acquisition."

"First, this department must consistently demonstrate the commitment and leadership to stop programs that significantly exceed their budget or which spend limited tax dollars to buy more capability than the nation needs…

Second, we must ensure that requirements are reasonable and technology is adequately mature to allow the department to successfully execute the programs…

Third, realistically estimate program costs, provide budget stability for the programs we initiate, adequately staff the government acquisition team, and provide disciplined and constant oversight.

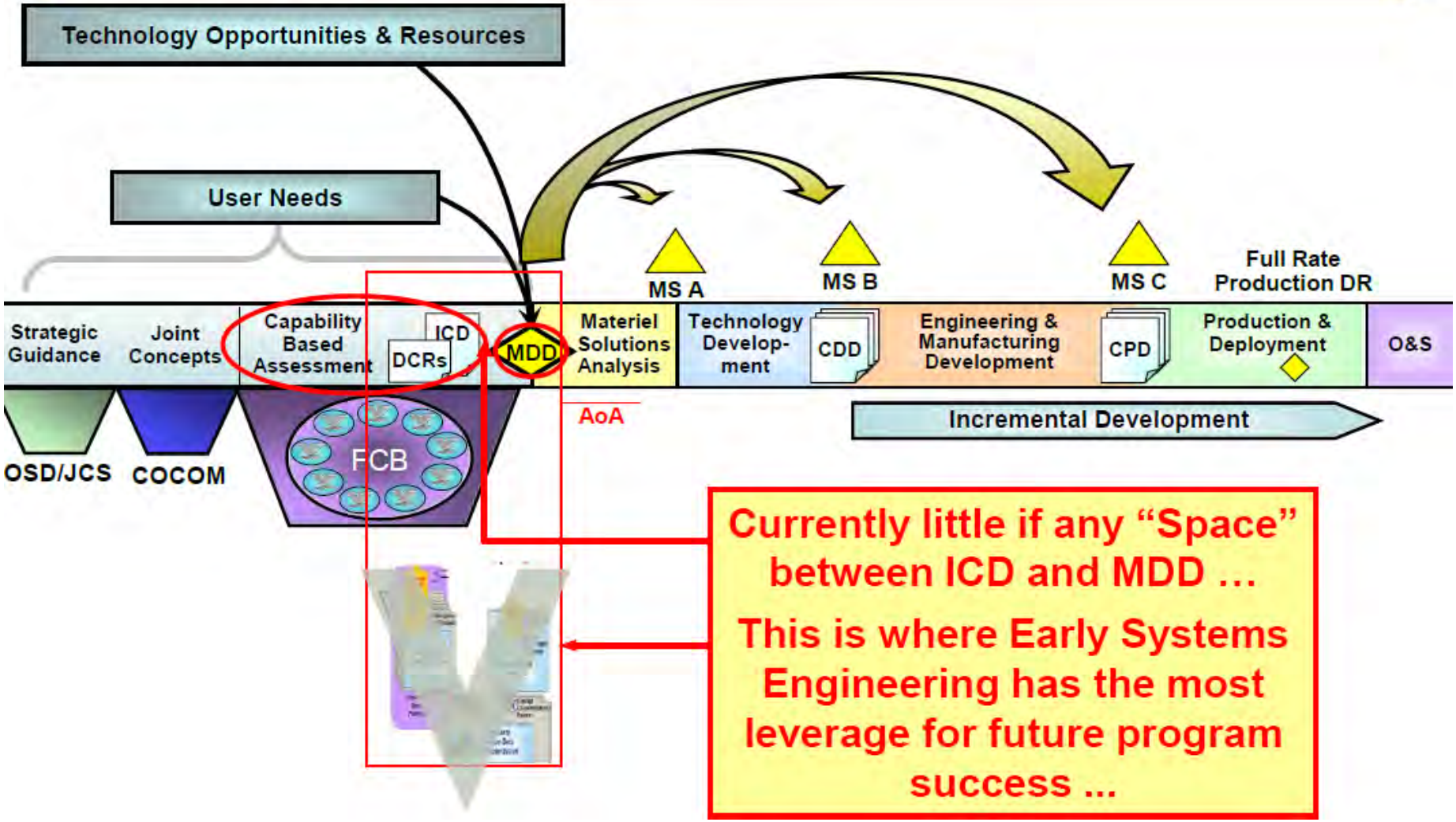
We must constantly guard against so-called "requirements creep," validate the maturity of technology at milestones, fund programs to independent cost estimates, and demand stricter contract terms and conditions."

Secretary of Defense Robert M. Gates

U.S. AIR FORCE

Current State

Filling the Gap Between CBA and MDD



U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- **ECSS and PLM Overview**
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- Configuration Management and CMII
- Problem Reporting
- Engineering BP Processes
- System Engineering Benefits/Summary

U.S. AIR FORCE

What is ECSS?

- **ECSS and PLM initiatives are part of the eLog21 transformation campaign that will integrate Air Force supply chain operations**

eLog21:

Expeditionary Logistics for the 21st Century (eLog21) campaign, will transform Air Force Logistics to improve support of the War fighter.

ECSS:

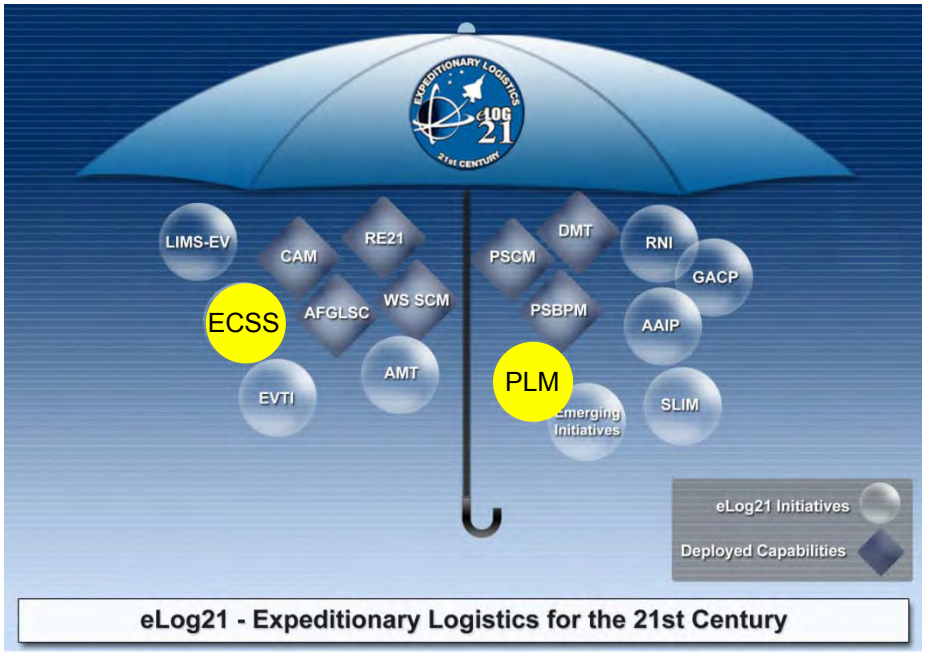
Cornerstone for eLog21. The eLog21 initiatives will be enabled by ECSS not just because ECSS provides a common IT infrastructure, but because ECSS will transform the way the Air Force Logistics community does business

Enterprise Resource Planning (ERP):

ECSS is AF Logistics ERP. A commercial, off-the-shelf (COTS) software product for horizontal integration of business operations

Product Lifecycle Management (PLM):

Process of managing the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal



U.S. AIR FORCE

ECSS PLM Overview

- Is an enabling technology based on **industry's best practices** to support total lifecycle systems management
- Provides a closed loop, **CMII compliant process**
- Provides a **single authoritative source** with effective configuration management of product information
- **Tracks configurations** and attributes of a weapon system and its subassemblies and components
- Accurately **captures the design** from initial concepts to the as-built, as-operated and as-maintained configurations
- Assures the **data is available** for all users facilitating cost effective sustainment of USAF combat capabilities
- Facilitates **reuse of information** for future acquisition efforts such as major system modifications

U.S. AIR FORCE

PLM's Roles

D&SWS Business Intelligence

Weapon System/Program Performance Scorecards

Service Requests

AQ

- DOD 5K
- Programs
- Budgets
- Quality
- Schedule
- Cost

- Requirements
- DODAF
- Capabilities
- Testing
- Life cycle Plans
- Re-use
- Performance
- Compliance
- RISK

Source

- Contracts
- Purchase order
- Purchase Request
- Indirect sourcing

- Technical Specs
- Manufacture Sources
- **Technical Packages**
- Product Quality
- KPP/KPA

Del/Rtn

- Inventory
- Warehousing
- Distribution
- Logistics
- Transport

- **Supplier integration**
- Warranty
- Materials Handling
- Storage Specs
- Kitting

Make/Repair

- Asset Configuration
- Work Order Planning
- Resource Mgmt
- Maintenance History
- Serialization
- Equipment & Facilities
- Asset mgmt.
- Work Plan & Execute

- Bills of Material
- Maintenance Programs
- Engineering Drawings
- Engineering Specs
- **Technical Orders & TCTO's**

- Assistance Request
- **Configurations & Modifications**
- Job Standards & Controls

Plan

- Demand Plan
- Supply Plan
- Deployment Planning
- Resource & Equipment Planning

- **Obsolescence**
- Resources,
- Facilities, & Equipment
- Capacity Factors

SLIM

- Structures
- Engines
- Electronics
- RCM
- CBM+

- Root-Cause
- **Reliability**
- **Performance**

Core ERP Processes

PLM

U.S. AIR FORCE

ECSS Operational Model

Teamcenter PLM

SIEMENS

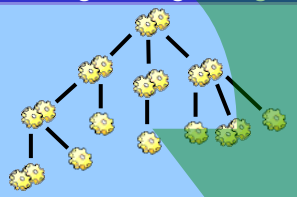
Propulsion System
Airframe
Landing Gear System
Main Landing Gear
Avi
Hydraulics
Flight Controls
Main Landing Gear
Nose Landing Gear

Engineering Change Mgmt

Shock Strut
Piston Assy
PN: 526895-11
Cage: 66254

Configuration Change Request

Master Engineering Configuration



Information Transfer

- Item Ownership
- ✓ Engineering Master Configuration Data
- ✓ Serialized Constituent Components (Parts and part attributes)
- ✓ Supporting Technical Documentation

Oracle Product Suite

Maintenance Planning and Execution

Enterprise Resource Planning/Execution

Advanced Planning and Scheduling

ORACLE

U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- **PLM and SE Sustainment Challenges**
- ECSS Blueprinting
- Configuration Management and CMII
- Problem Reporting
- Engineering BP Processes
- System Engineering Benefits/Summary

U.S. AIR FORCE

Bottom Line Up Front

- The Air Force requires new end-to-end Sustainment Engineering capabilities within the core ECSS functionality
- The architecture for PLM will use a two-system approach
  - Engineering community Teamcenter
  - Logistics community Oracle
- The scope of PLM covers activities after Milestone C
- ECSS Planning and Maintenance require Bills of Materials
  - PLM provides configuration management of BOMs

U.S. AIR FORCE

PLM & SE Challenges Today

Lack of Enterprise Config Mgmt Process

- Each weapon system has unique configuration management processes

No Common Intelligent Product Data Formats

- Product data formats and systems to manage product data are not standardized

Not Buying the Correct Data

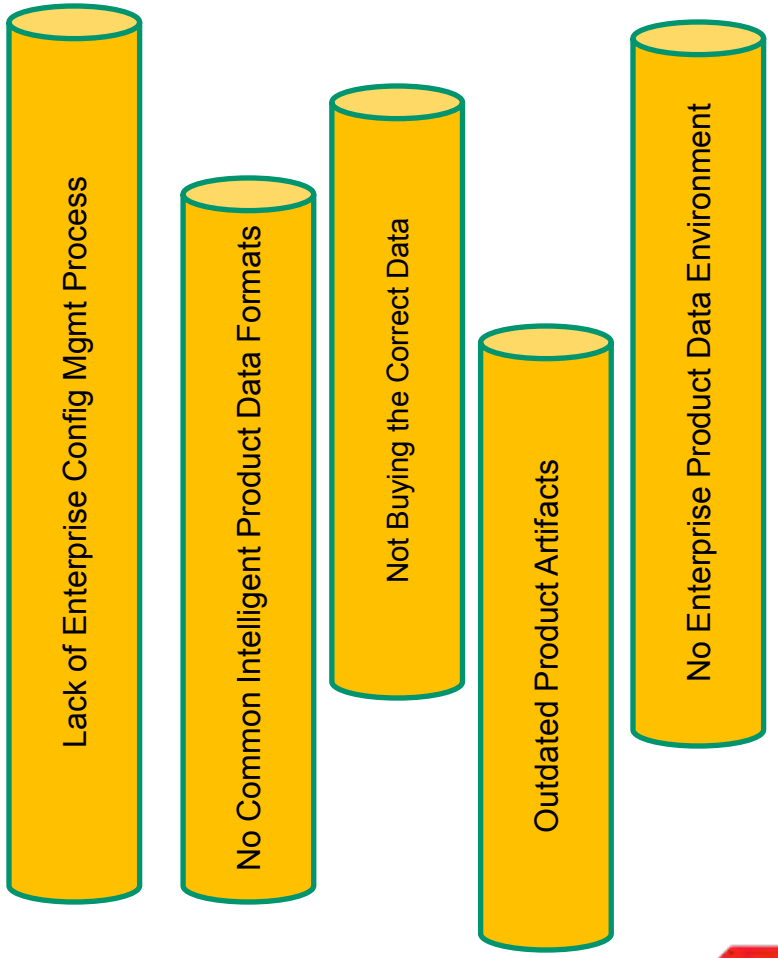
- Rights to technical data are not considered to reduce lifecycle costs
- Not buying complete data

Outdated Product Artifacts

- Product data is primarily image-based formats even when OEMs are utilizing 3D CAD models and structured content

No Enterprise Product Data Environment

- Silos of data exist; no enterprise visibility



ECSS PLM SE for the Future

U.S. AIR FORCE

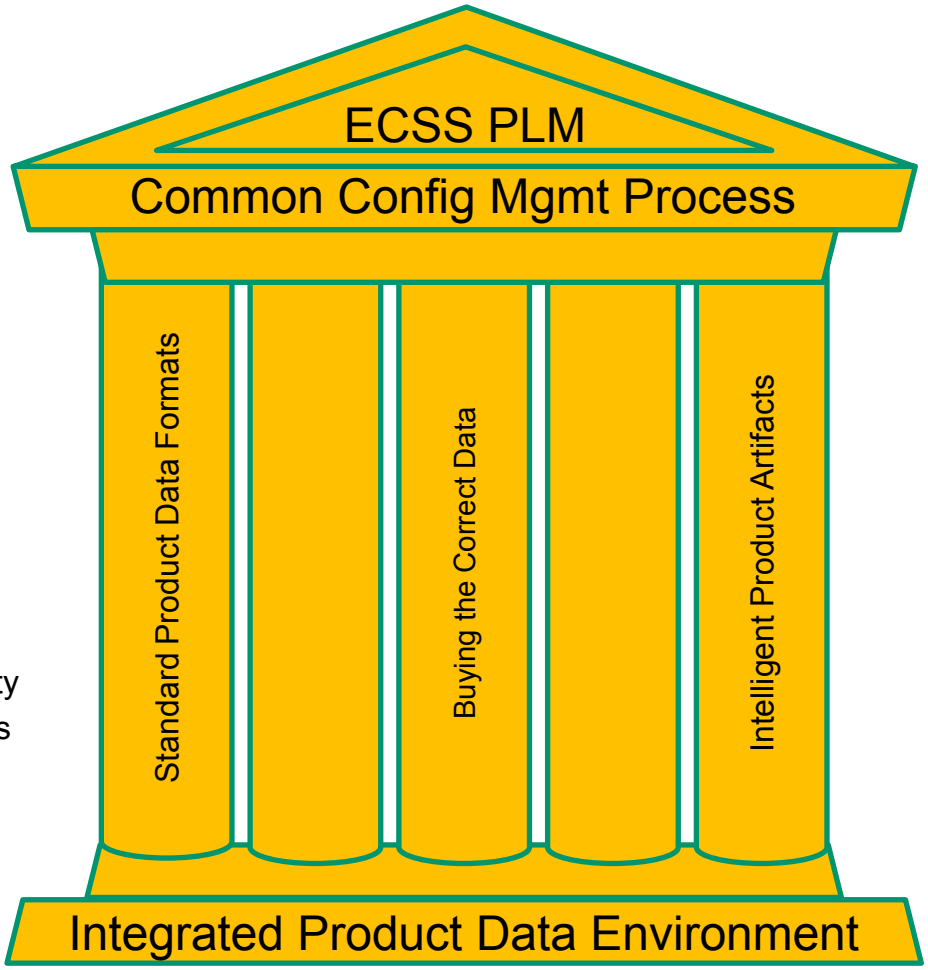
Common Config Mgmt Process
- Single CMII Based Product Management Process
- Standardized Practices and procedures

Standard Product Data Formats
- Common Product Data Exchange with Vendors
- Standardized Data across Weapon Systems

Buying the Correct Data
- Adopt A&D industry standards
- Reduction in OSS&E Costs

Intelligent Product Artifacts
- Database driven Functional Capability
- Integrated Artifact Data Relationships

Integrated Product Data Environment
- Accurate, timely and efficient data management
- Product Data (CAx, BOM, and Content)
- Common Functional Interface



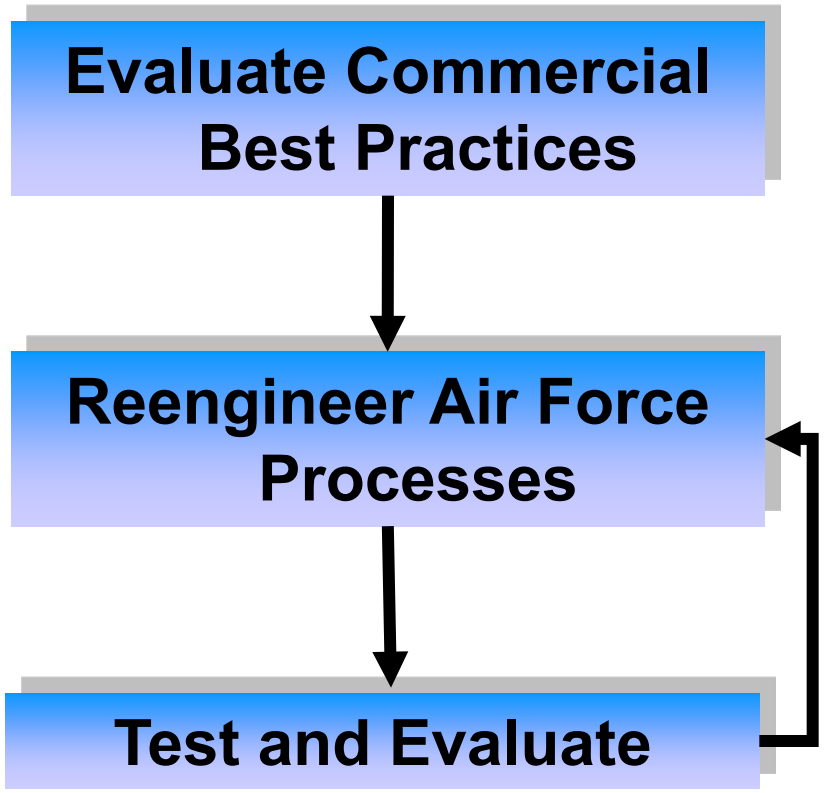
U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- **ECSS Blueprinting**
- Configuration Management and CMII
- Problem Reporting
- Engineering BP Processes
- System Engineering Benefits/Summary

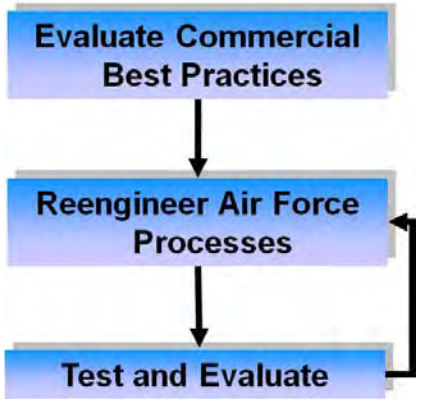
U.S. AIR FORCE

ECSS Blueprinting Process



ECSS Blueprinting Process

U.S. AIR FORCE



Objectives:

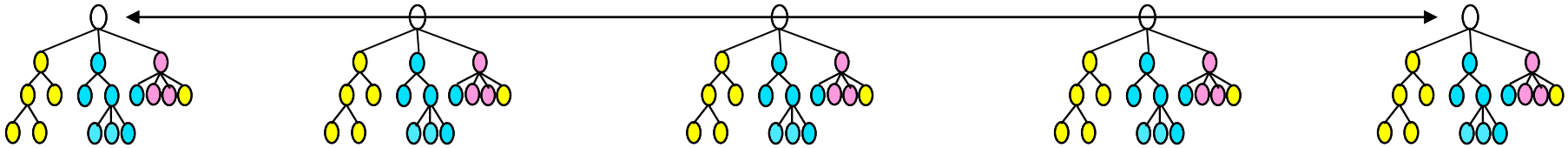
- Core SE Processes in Place and Practiced
  - Requirements
  - Project Management
  - SE "V" Model
- Provide Repeatable SE "Best Practices" Process
- Improve Program Performance & Reduce Technical Risk
- Implement Industry Best Practices
  - CMMI
  - CMII
  - ISO/IEEE
  - INCOSE
  - Defense Acquisition Guidebook
  - PMBOK
- Incorporate US Government SE and related Standards
  - AFI 63-1201 Life Cycle Systems Engineering & OSS&E
  - MIL-STD 499B Systems Engineering
  - AF SEAM

U.S. AIR FORCE

PLM Premise

– *The primary objective of PLM in the logistics domain is to establish a single-source of authoritive product data via integrated Bill of Material Configuration Management through the product lifecycle.*

Engineering | Provisioning | Advanced Planning And Scheduling | Supply Chain Management | Maint/Repair and Overhaul



Integrated Engineering Change Control Process

Revision-controlled weapon system documentation

- Engineering Drawings
- System Specifications
- Technical Orders
- Product Support Documentation
- Parts and Items Data
- Deficiency Reports
- Maintenance Plans
- Safety Data
- Operational Requirements
- Acquisition Documentation
- Air Worthiness Documentation
- OSS&E Documentation

U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- **Configuration Management and CMII**
- Problem Reporting
- Engineering BP Processes
- System Engineering Benefits/Summary

U.S. AIR FORCE

PLM And Derived Configurations

Derivative Configurations (BOMs)

Engineering/Master Configuration
(Supports Engineering)

Product Structure Breakdown

C-130

- Propulsion System
- Airframe
- Landing Gear System
  - Main Landing Gear
    - Main Landing Gear
    - Nose Landing Gear
      - Shock Strut Piston Assy
- Avionics
- Hydraulics
- Flight Controls

PLM

Model/Serialized Specific Configuration
(Supports Provisioning, APS, SCM)

Product Structure Breakdown

C-130H

- Propulsion System
- Airframe
- Landing Gear System
  - Main Landing Gear
    - Main Landing Gear
    - Nose Landing Gear
      - Shock Strut Piston Assy
        PN: 526895-11
        Cage: 66254
- Avionics
- Hydraulics
- Flight Controls

Aircraft/Tail Number Specific Configuration
(Supports MRO)

Product Structure Breakdown

C-130H Tail Number 2245

- Propulsion System
- Airframe
- Landing Gear System
  - Main Landing Gear
    - Main Landing Gear
    - Nose Landing Gear
      - Shock Strut Piston Assy
        PN: 526895-11
        Cage: 66254
        SERNO: 114245
- Avionics
- Hydraulics
- Flight Controls

ERP/MRO/APS

Increased Granularity

What is in CMII?

CMII is an integration of configuration management and other closely related activities as shown below.

CMII

Configuration Management:	*Ensures that configurations conform to released requirements;*
Requirements Management:	*Ensures that documented requirements are clear, concise and valid;*
Release Management:	*Ensures that documents are authorized and released prior to use;*
Change Management:	*Keeps released documents and data up to date;*
Data Management:	*Ensures data bases are accurate and deliverable data is secure;*
Records Management:	*Retains traceability of work and proof that work products conform;*
Document & Library Control:	*Protects knowledge assets and prevents unauthorized changes;*
Enabling Software Tools:	*Serve to enhance overall process reliability and efficiency.*

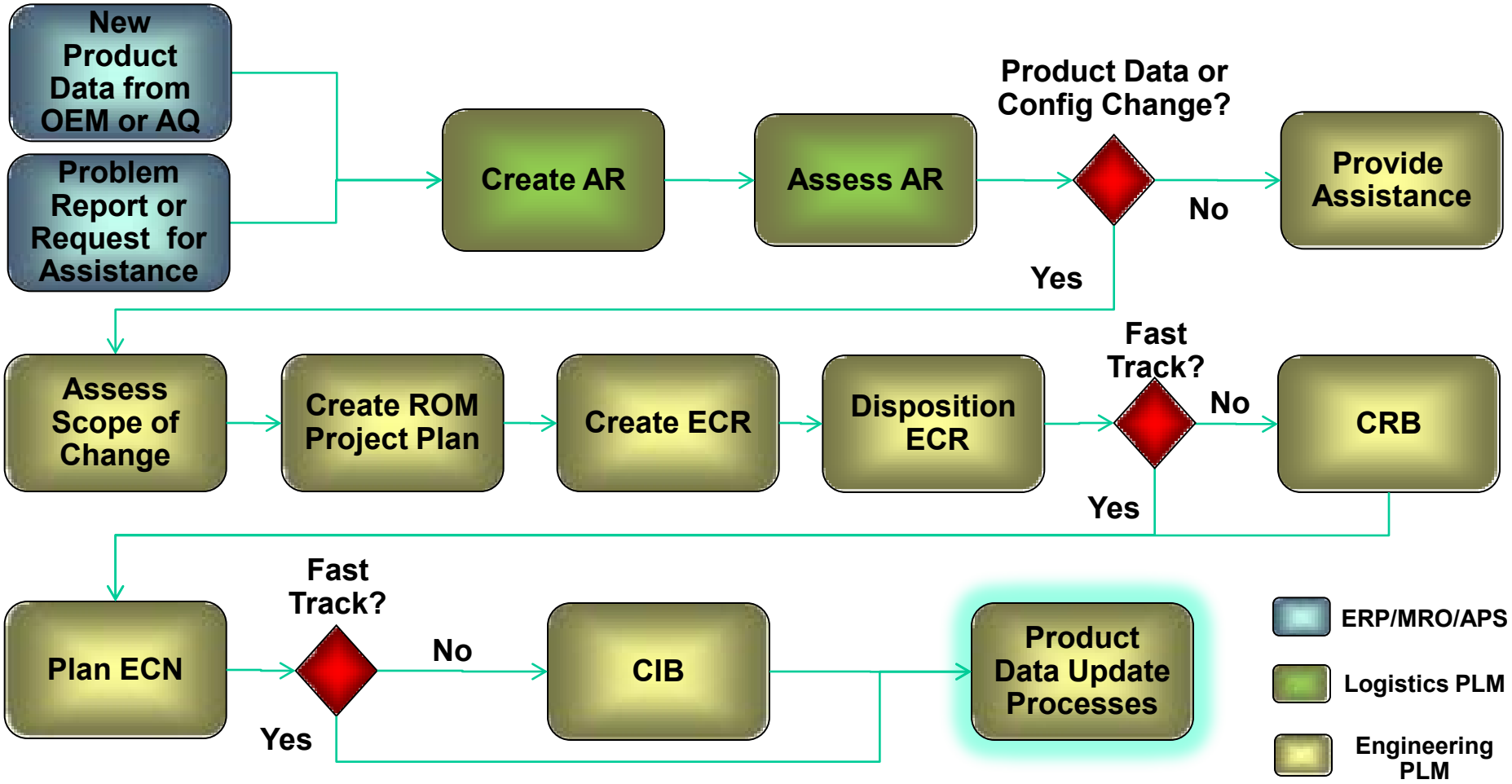
U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- Configuration Management and CMII
- **Problem Reporting**
- Engineering BP Processes
- System Engineering Benefits/Summary

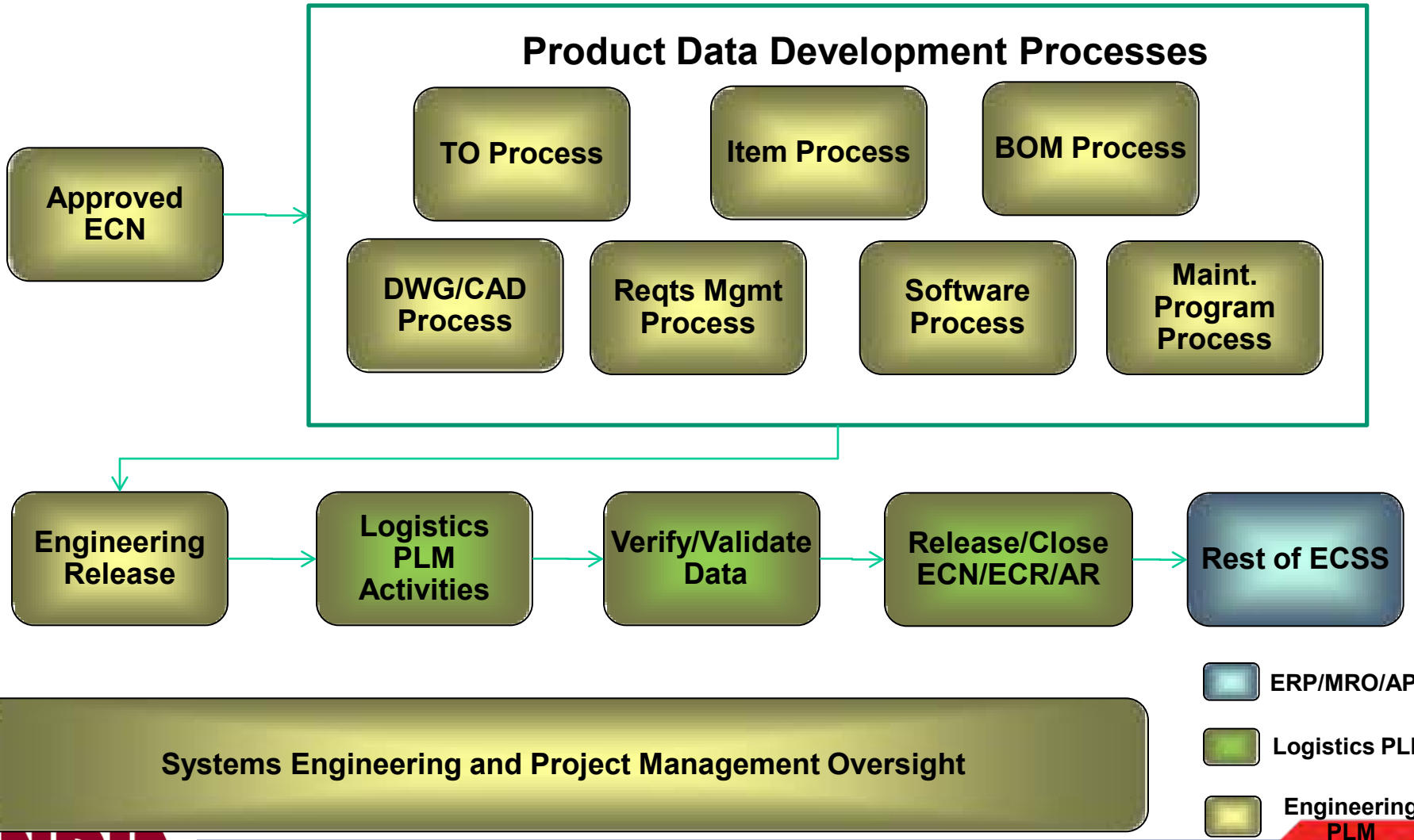
U.S. AIR FORCE

PLM Process Model: Change Management



U.S. AIR FORCE

PLM Process Model
Product Data Update and Release



U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- Configuration Management and CMII
- Problem Reporting
- **Engineering BP Processes**
- System Engineering Benefits/Summary

U.S. AIR FORCE

Ensure SE Processes & Techniques

- Implement Weapon Systems Acquisition Reform Act 2009
  - Focus is on AF Sustainment (After Milestone C)
  - Some ALC Engineering Projects will be supported pre Milestone C
    - Local and AFRL collaborated R&D Projects
    - ALC Managed implementing Major Command Modification directed Projects
- Provide SE Processes tailored as needed to support sustainment activities
  - Maintenance Requests
  - Deficiency Reports
  - Airworthiness
  - Product Improvements

Ensure OSS&E

- **Implementation of AFMCI 63-1201 (OSS&E and Life Cycle Systems Engineering)**
  - ***Operational Safety**, **Suitability** and **Effectiveness** (OSS&E)* **defines a process for establishing and preserving the safety, suitability, and effectiveness of Air Force systems and end-items over their entire operational life by preserving technical integrity via prudent use of disciplined engineering practices**
  - ***Disciplined Engineering Process* - A disciplined engineering process must be implemented to ensure that activities such as operational use, configuration changes, maintenance repairs, and part/software substitutions or upgrades do not degrade OSS&E characteristics over the operational life of the system or end-item**

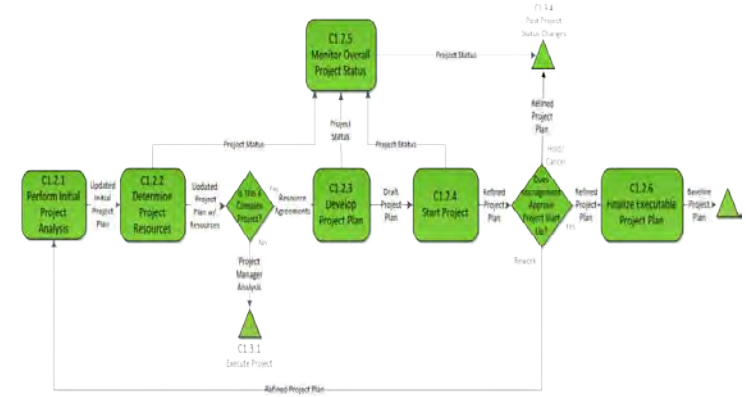
U.S. AIR FORCE

AF Systems Engineering Assessment Model (SEAM)

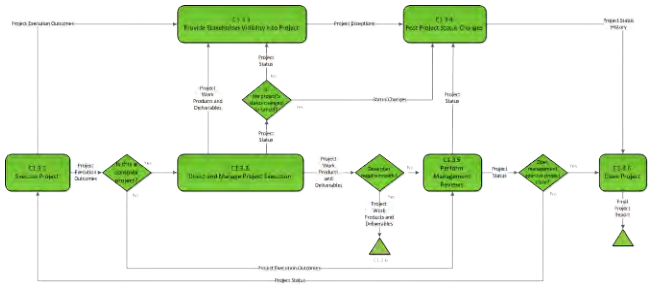
- **Definition of AF Systems Engineering Assessment Model:**
  - **A single AF-wide tool which can be used for the assessment and improvement of systems engineering processes in a program/project.**
- **Applying SEAM Model Goals**
  - **Ensure a Consistent Understanding of SE**
  - **Ensure Core SE Processes are in Place and Being Practiced**
  - **Document repeatable SE "Best Practices" across AF**
  - **Identify Opportunities for Continuous Improvement**
  - **Clarify Roles and Responsibilities**
  - **Improve Program Performance & Reduce Technical Risk**

U.S. AIR FORCE

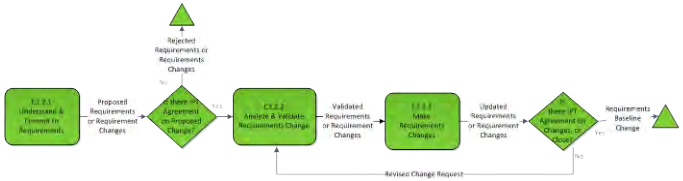
Supporting SE Processes



- Project Management – Planning
  - Scope
  - WBS
  - Cost Estimates

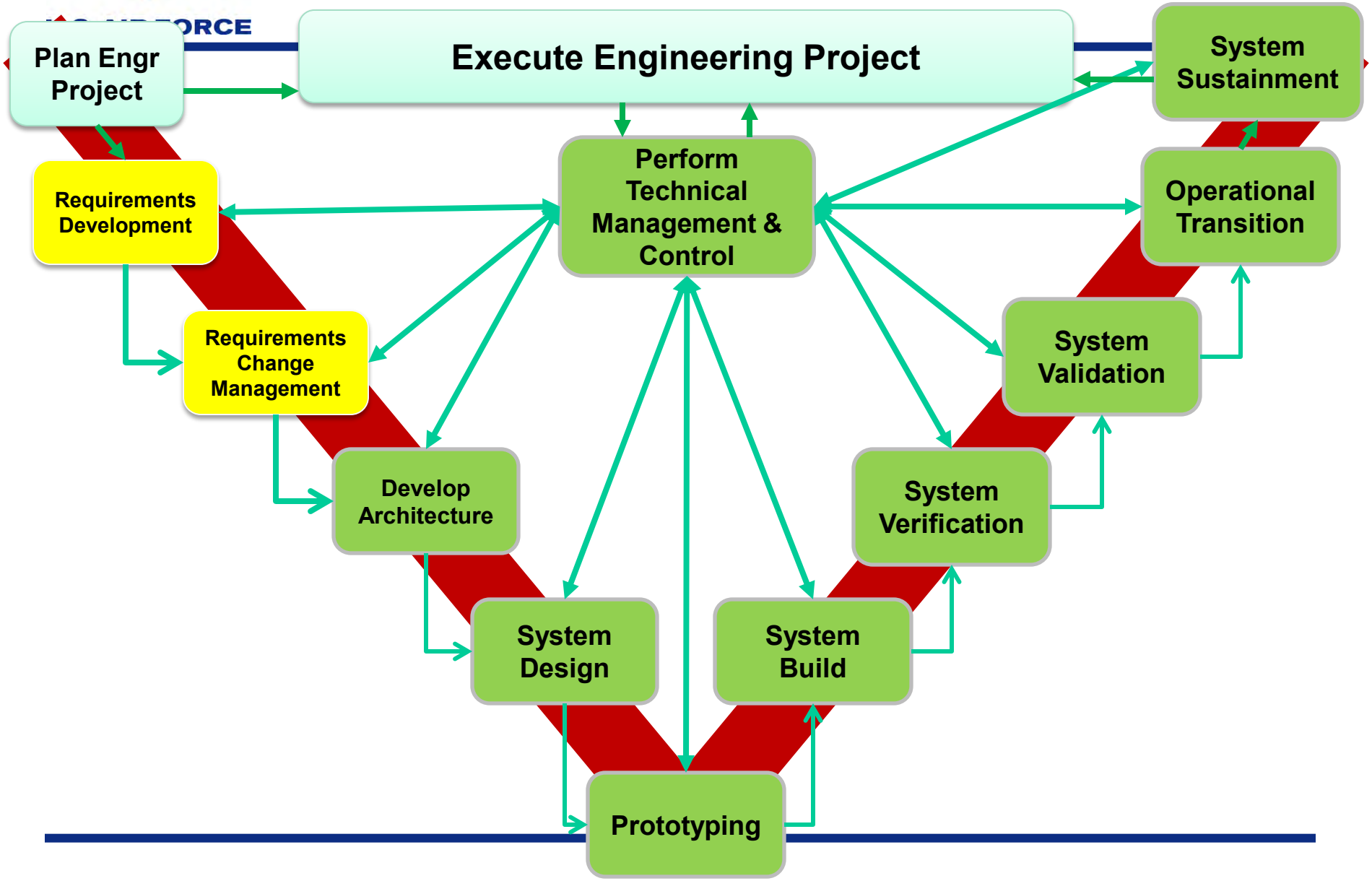


- Project Management – Execute
  - Monitor
  - Schedule
  - Performance



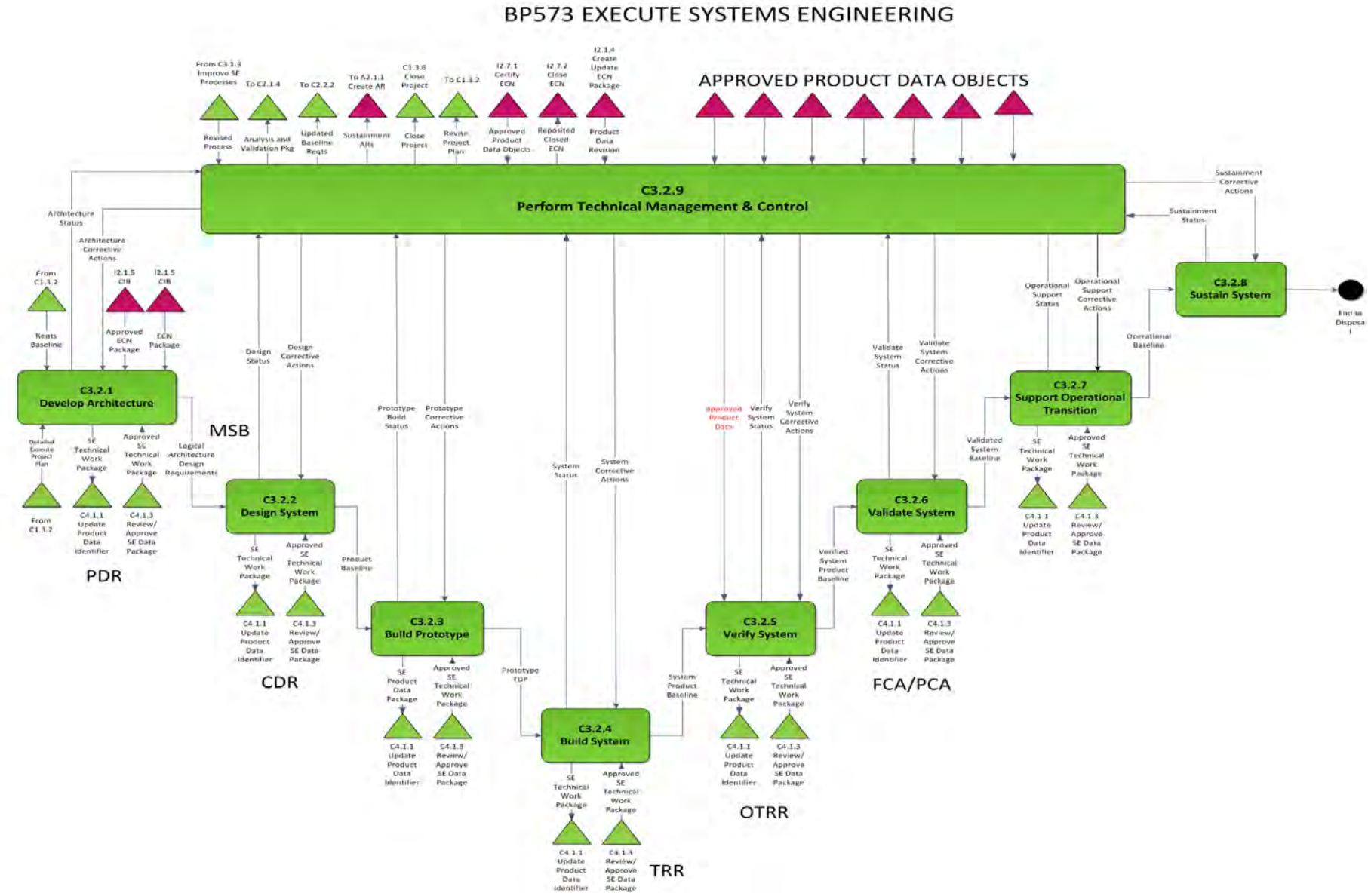
- Requirements Change Management
  - Manage Requirements Baseline
  - Traceability
  - Change Rational

ECSS PLM System Engineering "V"



U.S. AIR FORCE

Execute System Engineering



ECSS PLM System Engineering "V"

U.S. AIR FORCE

ECSS/PLM SE Process focus is on Sustainment Support

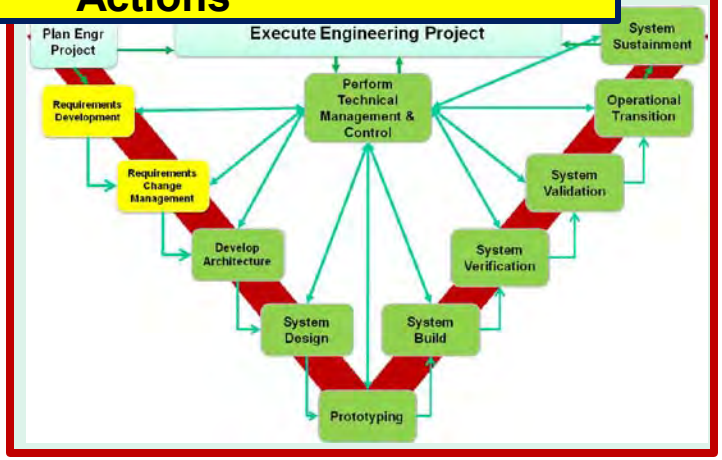
A | B | C | IOC | FOC

Materiel Solution Analysis	Technology Development	Engineering and Manufacturing Development	Production & Deployment	Operations & Support

Tech Insertion and R&D Projects

Can Support → Support to MAJCOM on Major Mods

Primary Focus → ALC SPO Managed Mods/Corrective Actions

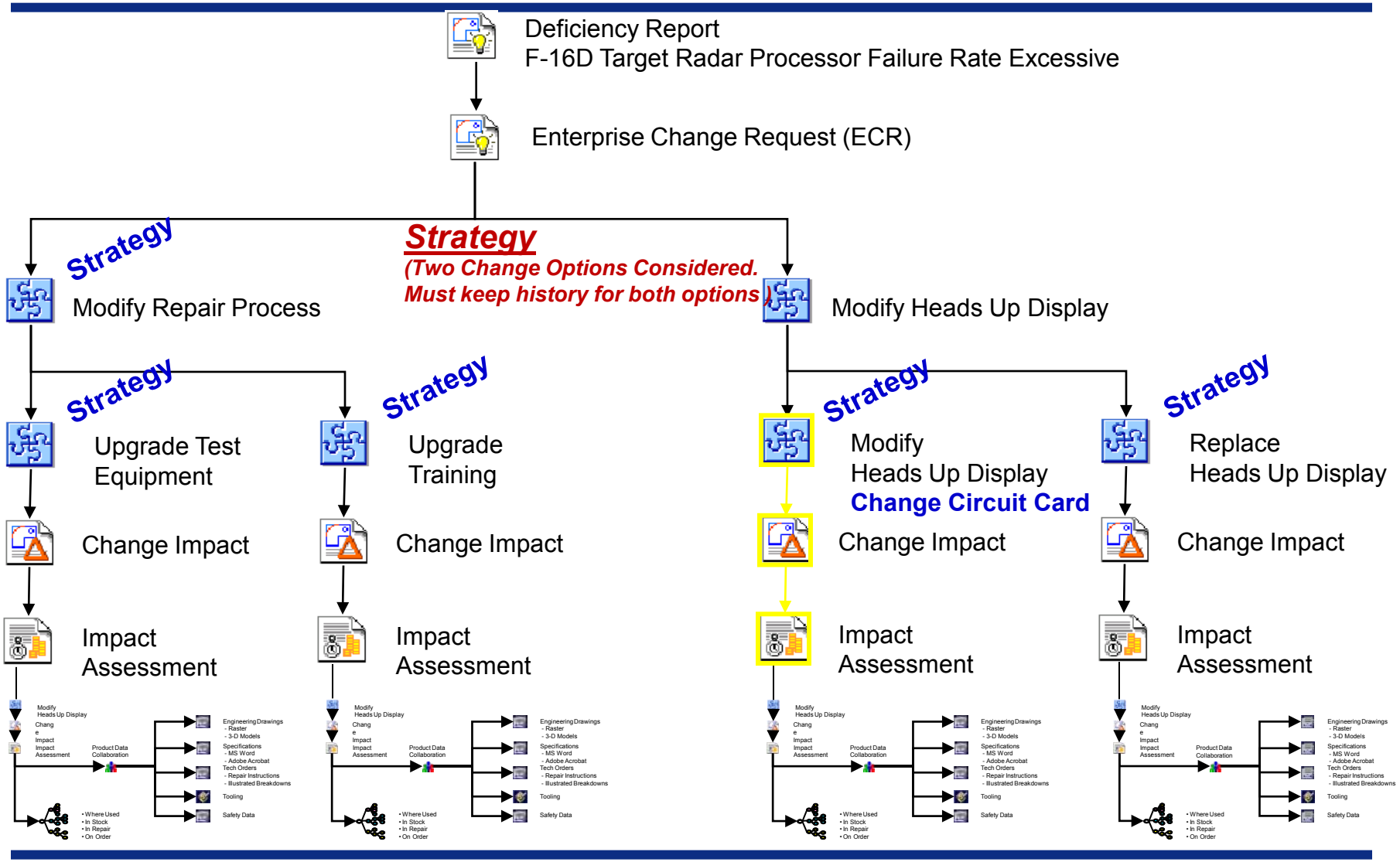


SE Sustainment "V" Supports Product Data examples below:

- Initial Technical Review (ITR)
- Alternative Systems Review (ASR)
- Systems Requirements Review (SRR)
- System Functional Review (SFR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Post-PDR Assessment (Post-PDRA)
- Post-CDR Assessment (PCDRA)
- Test Readiness Review (TRR)
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Production Readiness Review (PDR)
- Operational Test Readiness Review
- Physical Configuration Audit (PCA)

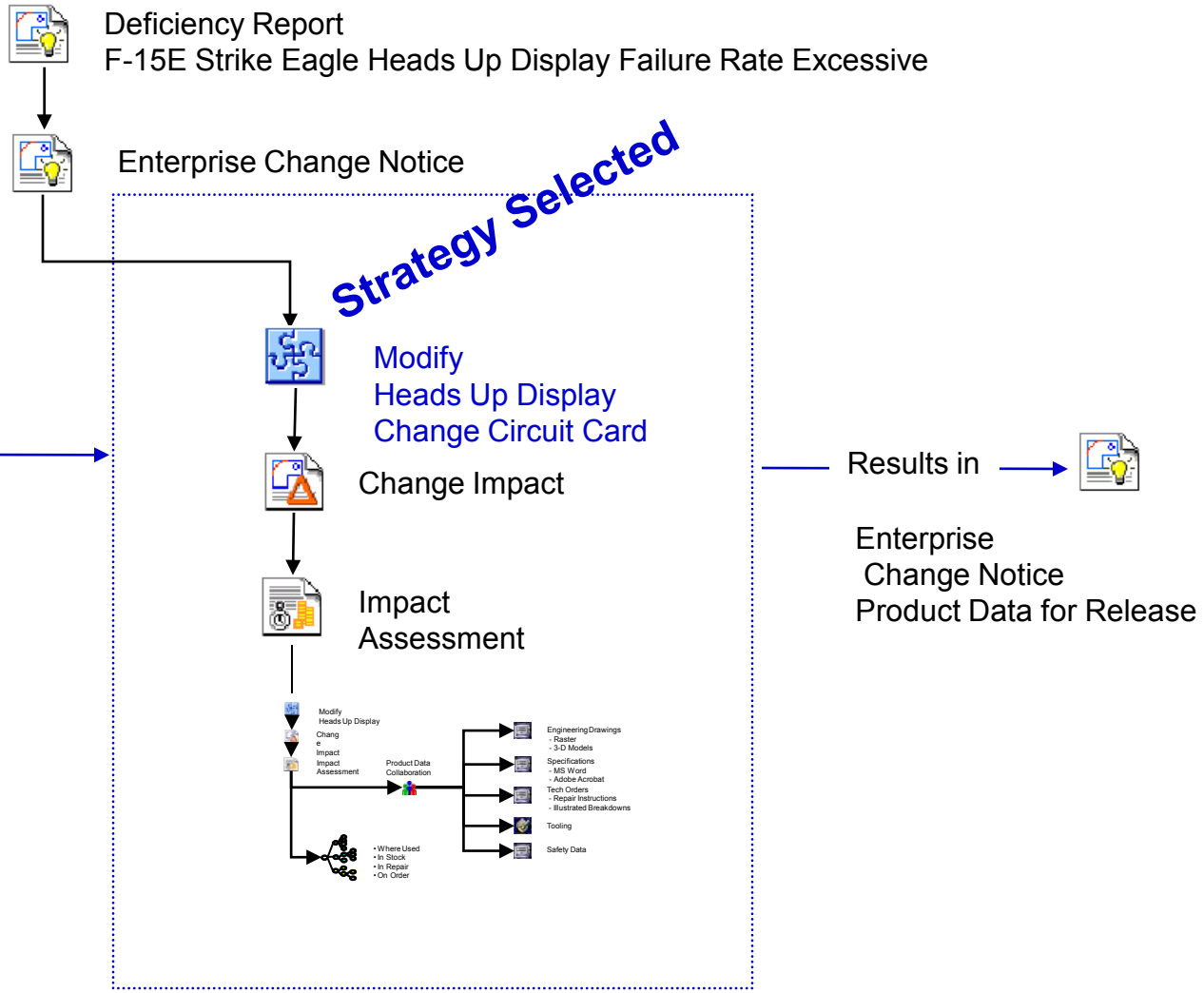
U.S. AIR FORCE

Example: Repair or Modify Enterprise Change Request



U.S. AIR FORCE

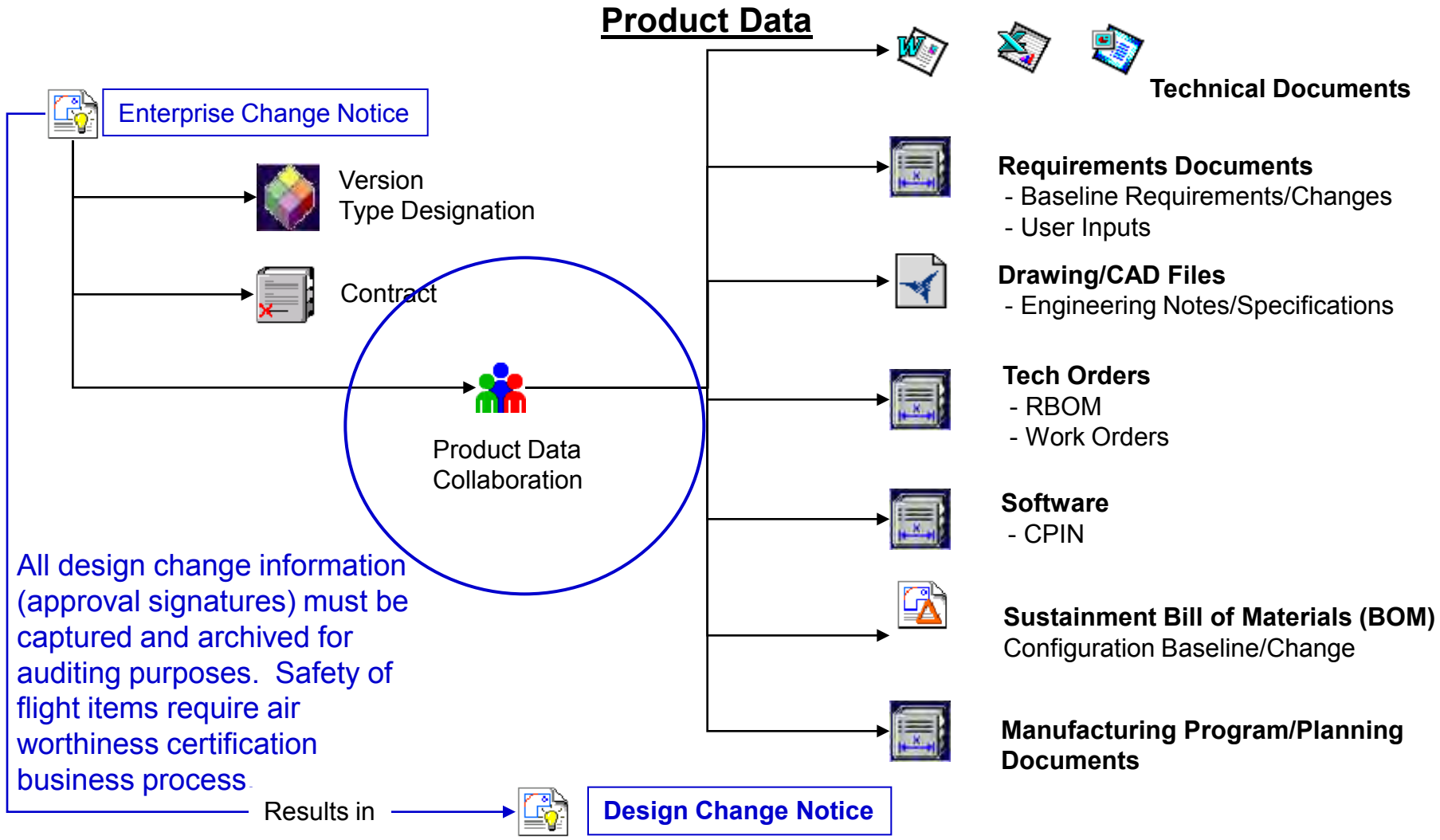
Example: Enterprise Change Notice (ECN)



It is crucial to capture the change decision process for reuse in implementing the change, future change considerations and configuration auditing purposes.

U.S. AIR FORCE

Example: Enterprise Change Notice (ECN)



U.S. AIR FORCE

Outline

- AF System Engineering Drivers
- ECSS and PLM Overview
- PLM and SE Sustainment Challenges
- ECSS Blueprinting
- Configuration Management and CMII
- Problem Reporting
- Engineering BP Processes
- **System Engineering Benefits/Summary**

U.S. AIR FORCE

Benefits of ECSS/PLM SE Implementation

- Accumulation of accurate project execution history data (cost, performance, etc.) facilitates improved budgeting and financial management of future projects.
- Overall, better engineering project execution control will contribute to higher weapon systems availability.
- Standard documented process support for formal training (vs. on-the-job learning) will improve the quality of the workforce and reduce worker training time.
- Capability to track product design and build results to the customer requirements baseline.
- Capability to link specific requirement elements to their specific engineering project plan tasks, work products and related technical artifacts.

U.S. AIR FORCE

Benefits of ECSS/PLM SE Implementation

- Collaborative stakeholder interaction, feedback and conflict resolution over warfighter needs, expectations, constraints, and limitations.
- Continuous process improvement and implementation of standardized, common, and repeatable processes across the Air Force organization.
- Reduced overall systems engineering work effort and costs with an optimal balance of performance and total ownership cost will be achieved.
- Standard processes will provide improved performance metrics, cross organizational visibility and accountability for OSS&E results.

U.S. AIR FORCE

Summary

- ECSS and PLM initiatives are part of the eLog21 transformation campaign that will integrate Air Force supply chain operations
- The scope of PLM covers activities after Milestone C
- The primary value provided by PLM is a comprehensive, single source of authoritative product data that supports Provisioning, Planning, and Repair activities
- PLM SE Implementation meet the goals/objectives of
  - WSARA
  - AF SEAM
  - AFMCI 63-1201

U.S. AIR FORCE

Questions & Answers

Questions

U.S. AIR FORCE

LEADING EDGE TECHNOLOGY
WORLD CLASS SUSTAINMENT
WAR-WINNING SYSTEMS

NDIA Life Cycle Affordability Project

27 October 2010

Jerry Cothran
J.S. Moorvitch

NDIA
National Defense Industrial Association

Purpose

To define and recommend an approach to institutionalize Operations and Support (O&S) cost reduction as an overarching priority objective influencing the broader issues of Affordability and Life Cycle Cost (LCC) reduction throughout acquisition, operation, and sustainment of DOD defense systems

Background

- 2010 is the “Year of Affordability” focus for DoD
  - Sec Gates Remarks at Eisenhower Library
  - Sect. 805 2010 NDAA: “maximize value to the Department of Defense by providing the best possible product support outcomes at the lowest operations and support cost”
  - 28 June 2010 USD/AT&L Memo: “Restore Affordability to our programs and activities”
  - OSD PSAT: “Make life cycle affordability a core business process”

NDIA
National Defense Industrial Association

Background

- LCS Committee held a joint DoD-Industry workshop 27 April 2010
- 40+ in attendance (including OSD Logistics/SE leadership)
- Identified 23 life cycle LCC/Affordability issues (root causes, potential solutions)
- Consolidated into 4 Core Issues
- Gap analysis vs. current OSD initiatives

AFEI NTSA PSA WIDS

National Defense Industrial Association

PSAT Recommendations

Product Support Business Model:

Define the overall strategy that drives cost-effective performance and capability for the Warfighter across the weapon system life cycle and enables most advantageous use of an integrated defense industrial base

Industrial Integration Strategy:

Align and expand the collaboration between Government & Industry that produces best value partnering practices

Governance:

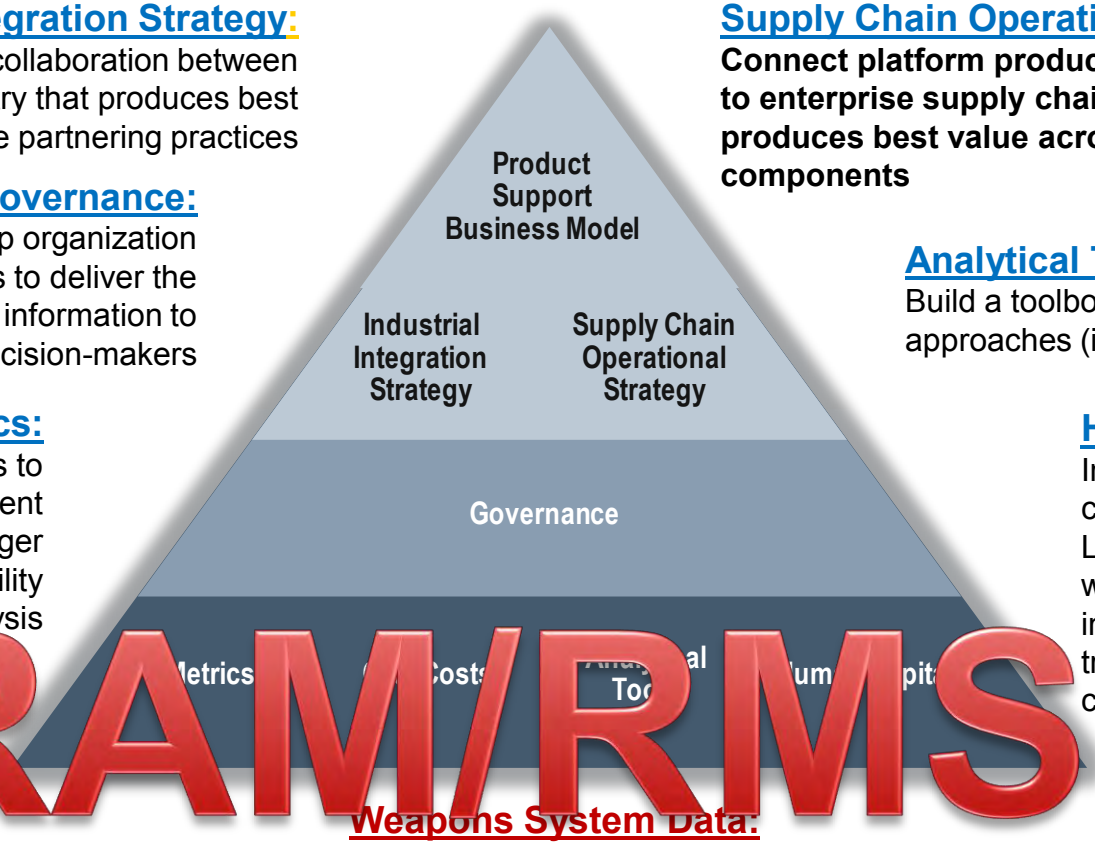
Strengthen and develop organization and mgmt processes to deliver the right sustainment information to decision-makers

Metrics:

Use existing metrics to catalyze sustainment strategies and trigger continuous supportability analysis

O&S Cos[illegible]s:

Improve [illegible] cost visi[illegible]ty and influe[illegible]ce



Supply Chain Operational Strategy:

Connect platform product support strategies to enterprise supply chain approaches that produces best value across the DoD components

Analytical Tools:

Build a toolbox of analytical approaches (including BCA)

Human Capital:

Integrate Product Support competencies across the Logistics and Acquisition workforce domain to institutionalize successful tra[illegible] of [illegible] outcome-based culture

Weapons System Data:

Define, collect, report, and manage the data we need to drive effective Life Cycle Product Support

OSD Affordability Initiative

- Response to Carter memo
- Established Senior Integration Group (SIG) with 5 issue teams
- Affordability Task Force led by ADUSD/MR (Randy Fowler); co-chaired by RDML Randy Mahr (Navy PEO(T)) and SES Darlene Costello (AT&L/PSA/NW)
- NDIA LCS findings prominently folded into ATF analysis and initial recommendations
- NDIA membership on AFT core team

NDIA LCC/Affordability Recommendations

- Narrow RAM/RMS focus “with intent”
- Other issue areas well-covered by PSAT
  - TOC/LCC, O&S cost, governance, BCA, partnerships, sustainment metrics, …
- RAM/RMS conspicuous by absence
- Huge gap in OSD policy on fielded operational systems
- Need for detailed, actionable recommendations

NDIA
National Defense Industrial Association

Recommendations

- Fielded Operational Systems
  - RAM/RMS focus throughout the life cycle
  - Leverage SLEP, MOD, Upgrade opportunities
    - Identify Cost, Reliability drivers through standard SE RAM/RMS methodologies
    - Prioritize, invest, resolve
- Acquisition Programs
  - Require conduct and outcomes of RAM-C analysis to be institutionalized into the Acquisition decision process
  - RAM-C in requirements

AFEI NTSA PSA WIDS

NDIA
National Defense Industrial Association

Results

- Recommendations submitted to OSD by NDIA leadership (Sep 2010)
- Folded into PSAT implementation team actions
- Working through PSAT BCA and O&S IPTs

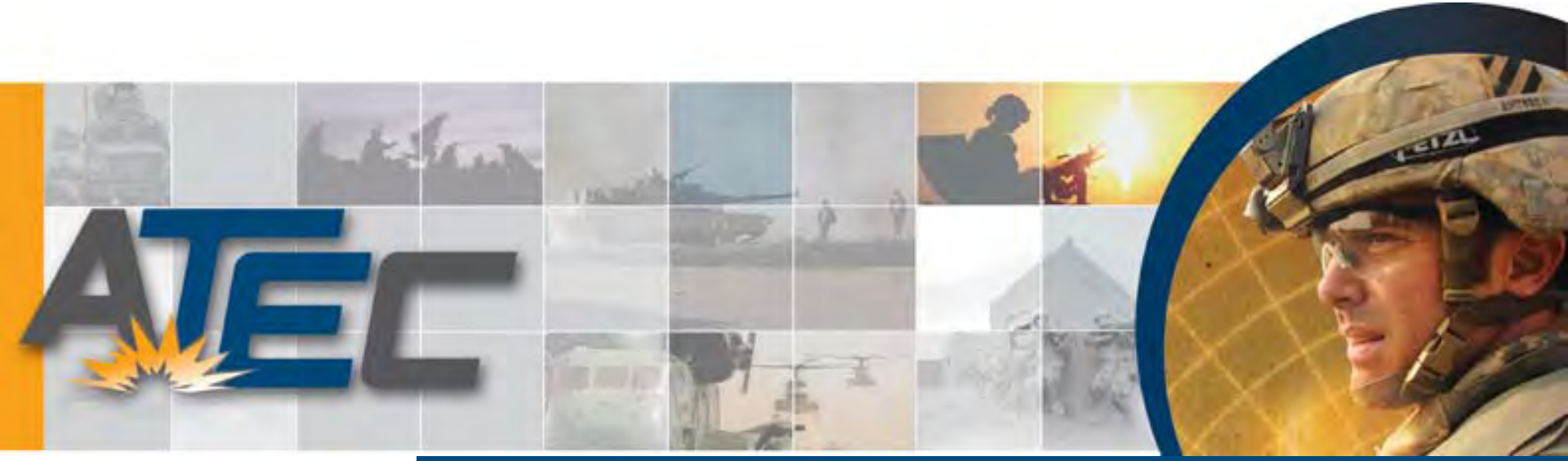
AFEI nsa PSA WIDS

NDIA
National Defense Industrial Association

Summary

- NDIA is clearly influencing OSD Affordability efforts and recommendations
- The environment is ripe for making tangible change
- RAM/RMS activities and emphasis are a proven approach to reducing O&S/Life Cycle cost
- We must leverage this opportunity

AFEI nsa PSA WIDS



Incremental Logistics Demonstration Strategy

Jeff Gilbert
US Army Test & Evaluation Command
US Army Evaluation Center
Integrated Logistics Support Directorate
27 October 2010

Army Proven
Battle Ready

Introduction

- A Logistics Demonstration (Log Demo) is conducted by the Program Manager during the acquisition process to evaluate the readiness the System Support Package (SSP)
  - Includes both remove/replace and diagnostics/prognostics elements of field level maintenance, both operator and maintainer
  - Conducted as a standalone (status quo) or incremental
- Incremental Log Demos:

  (1) Influence both supportability and design

  (2) Reduce risk for operational testing

  (3) Provide the Program Manager, evaluator, and other stakeholders additional data to support milestone decisions
  - Concept: Increments of Log Demo during acquisition
  - Data Collection and tracking tools available

Purpose of the Logistics Demonstration

- The Log Demo provides data to evaluate:
  - Supportability
  - Adequacy of maintenance planning
  - Technical publications
  - Logistics data
  - Training and training devices.
  - Manpower and Personnel Integration (MANPRINT)
  - Test, measurement, and diagnostic equipment
  - Common and unique tools
  - Spares and/or repair parts

The Log Demo is required on all acquisition programs using representative soldiers (MOS) and is a primary data source for the ATEC evaluation

Components of the Log Demo

Physical Teardown

- Soldier Operator Tasks per TM including PMCS
- Soldier Maintainer Tasks per TM (predominately Field level)
- All Tools, equipment, facilities, TMDE, TMs (electronic/hardcopy), packages/kits and itemized lists needed to perform tasks

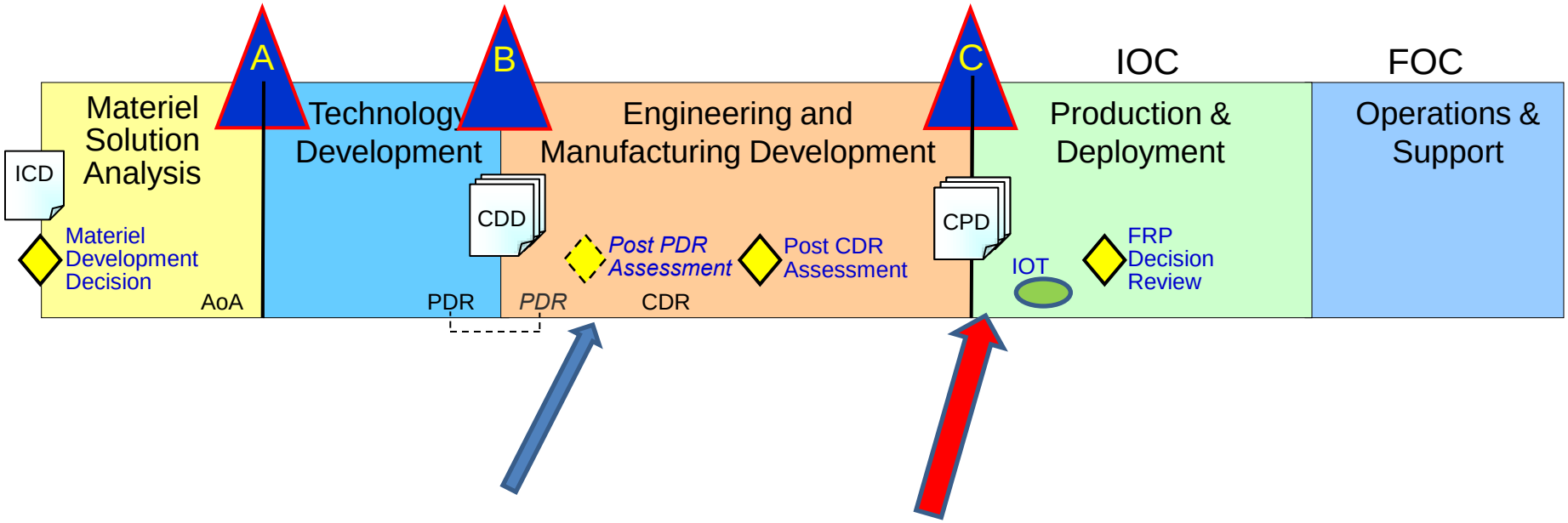
Events may be combined or separate

Maintainability Demo

- Fault Insertion List, and appropriate Diagnostic/ Troubleshooting procedures and equipment
- Address 100% of all known critical faults, introduced into the equipment individually according to the failure modes, effects, criticality analysis (FMECA).
- Critical faults are those that result in critical or catastrophic failures that may cause severe injury, major system damage, or weapon system loss as defined in MIL-STD-1629 and MIL-STD-882.
- Additional faults will be selected through a random process weighted to represent predicted failure rates. MIL-HDBK-470 may be used as a reference to determine fault insertion sample size and methodology.
- Faults must be introduced in a safe manner as to not cause damage to the test system.
- Conducted as an integrated system, or system of systems, to the extent it is necessary to fault isolate, perform maintenance, and verify that faults are corrected.

Log Demo in Acquisition

Generally LD is conducted during EMD or PD phase and prior to the Initial Operational Test

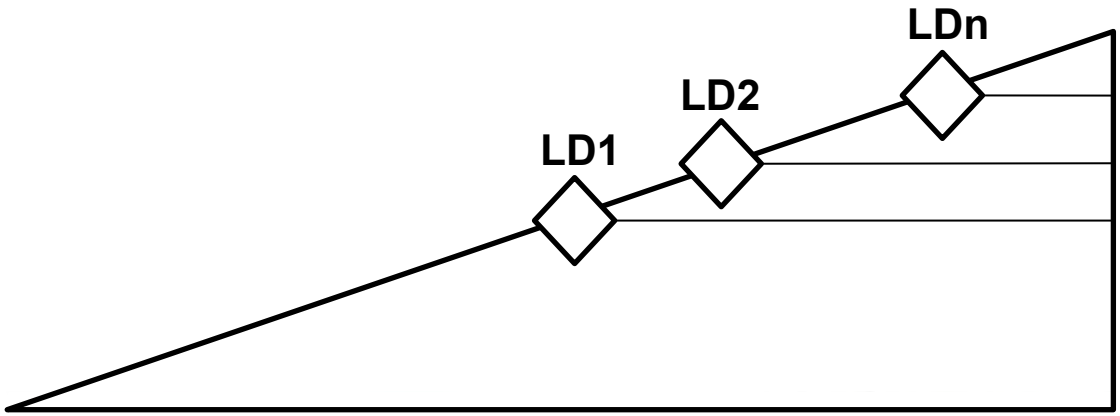


Incremental LDs are conducted during the EMD phase and on into PD Phase

Final LD is typically conducted before IOT using LRIP assets.

Army Proven
Battle Ready

Value of the Incremental Log Demo

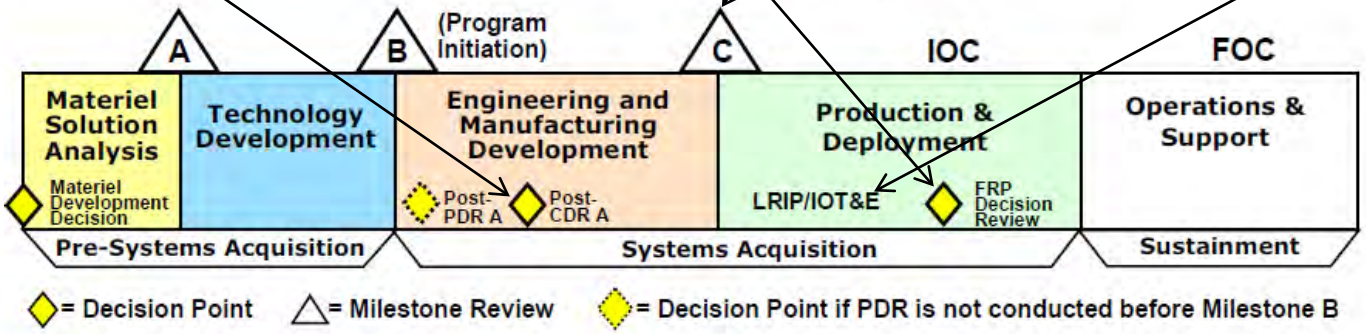


Maturity of System Support Package

Influence supportability AND design

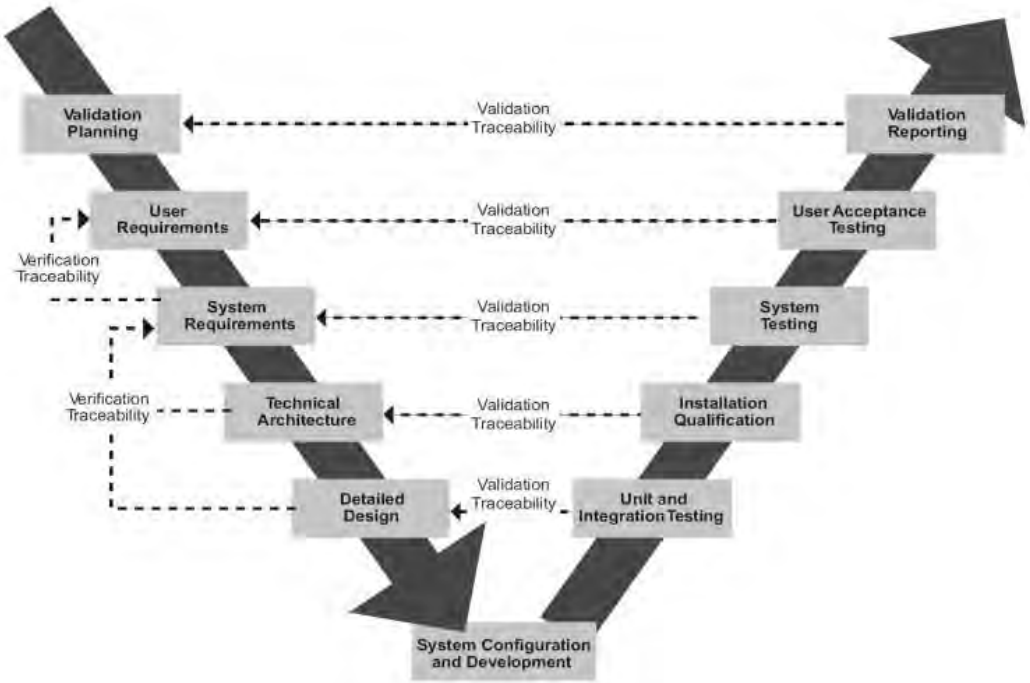
Provides information to support milestone evaluations

Reduces risk for operational testing



Army Proven
Battle Ready

Influence of Supportability and Design

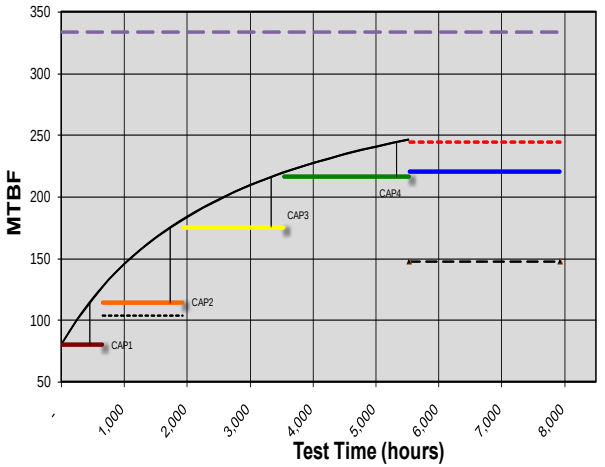


- Log Demo supports the Systems Engineering Process
- Subsystem, system, and User testing
- Validation of user requirements
  - Two level maintenance
  - Tools/test equipment
  - Manpower/personnel
- Validation of System Requirements
  - Startup & operating procedures
  - Mean time to repair
  - Built in test

Incremental Log Demo provides the feedback mechanism to evaluate and influence design

Design for Reliability & Maintainability

- Data from Log Demo is used to assess task level mean time to repair (MTTR)
- Time estimate includes:
  - Identification of symptom (fault)
  - Troubleshooting
  - Removal and replacement
  - Validation that symptom is remedied
- Compare MTTR with weighted MTTR from developmental and operational testing (DT/OT)
- Validates supportability data and maintenance allocation chart estimates
- Reliability growth planning curve identifies hardware maturity for conduct of Log Demos
- DT/OT identifies failure modes to be addressed in maintainability demonstration



Example Reliability Growth Planning Curve

Army Proven
Battle Ready

Support to Milestone Decisions

- Test & Evaluation
  - The Army Test & Evaluation Command (ATEC) encompasses all phases of testing; experimentation, developmental, operational & evaluation
  - Coverage of everything from rifles to Missile Defense (except medical and uniforms)
  - Testing and Evaluating over 400 systems, with 1100 test events worked daily
  - ATEC Forward Operational Assessment Teams in Iraq & Afghanistan
- Logistics Demonstrations
  - Serve as a primary data source for the ATEC evaluation
  - Provide logistics data used to form ATEC position for suitability of system (i.e. how supportable, maintainable, and costly…)
  - Informs key decision makers of suitability risks to assess cost, schedule, and performance

Incremental Log Demo allows influence to each milestone decision

Reduces risk for Operational Testing

- OT is conducted using to assess effectiveness, suitability, and survivability in an operational environment using representative Soldiers
- Systems must stay operational to meet test objectives
- If maintenance concept is immature or unproven going into OT
  - Excessive downtime may result
  - System may require contractor support
  - May result in longer test window or costly follow-on testing

Incremental Log Demos are a means to validate the maintenance concept prior to OT

Log Demo Assessment

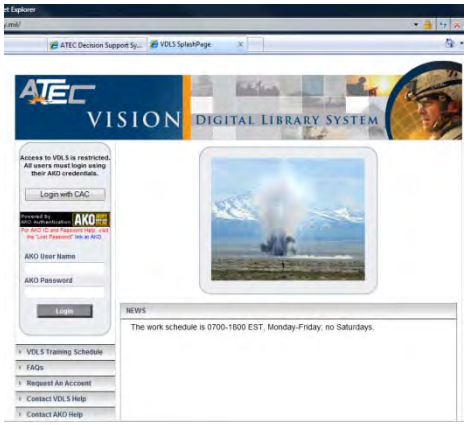
- Program Manager summarizes these results in the Log Demo report, and ATEC will provide in the evaluation report
- Tasks that are changed or unproven require demonstration in future events
- Trends will show reduction of issues with technical data, design, and execution over the Log Demo increments
- Reduced burden for testing late in acquisition process

Example

	Log Demo 1	Log Demo 2		Log Demo N
Tasks demonstrated	25%	40%		50%
Required TM update	15%	10%		5%
Required design change	10%	5%		0%
Required Execution change	5%	3%		0%

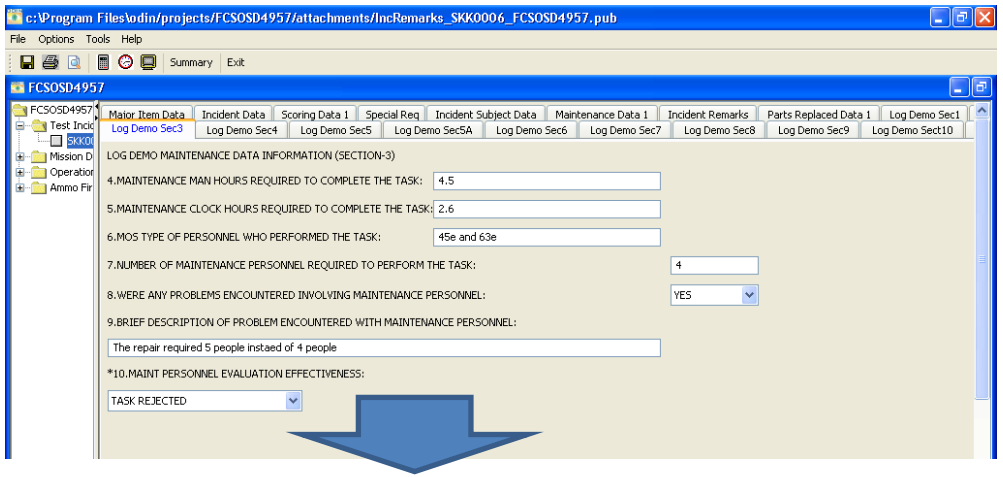
Data Collection Tools

- Test Incident Report (TIR)
  - Log Demo tasks are traditionally documented via the PMs own data collection system
  - ATEC (with PEO Integration) has developed a Log Demo Supplemental Data Form annex to the TIR
  - Stored in ATEC Vision Online Digital Library (VDLS)
  - Data query tools & centralized data storage
- Maintenance Task Tracking Tool
  - Tracks the completion status of an incremental LD
  - Extracts Log Demo data from VDLS, imports a data file into Powerlog-J, and runs a LD status report
  - Tracks configuration changes using LMI data (LCN, ALC, CAGEC, Reference Number) and Log Demo task completion using maintenance task analysis
  - Developed by LOGSA in support of PEO Integration, implemented as feature of Power-Log J, release 1.7.1, Nov 2009.



TIR Supplemental Form

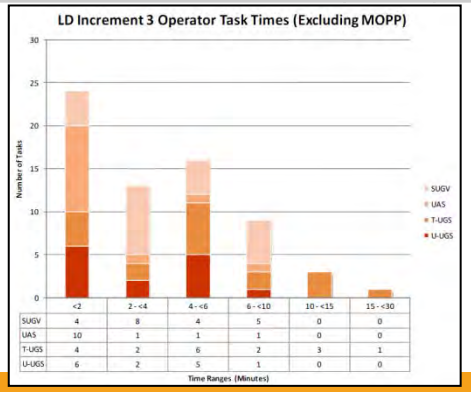
Step 1: Data collector inputs data into supplemental form within Observer Data Input Nexus (ODIN)



Supplemental Form Focus Areas:
-Manpower/Personnel
-BIT/BITE
-Technical Manuals
-Training
-Tools
-Supply/Spares
-Design

Step 2: Evaluation of data via query tools/excel

PROJ NUMBER	SYSTEM	DATE	TASK_TITLE	TIME	DESCRIPT_FAULT	BIT DETECT	MOS	TASK ACCPT
FCSS1E4670	T-UGS	6/7/10	MDAT FAIL MESSAGE	9M 50S	MDAT FAIL MESSAGE	YES	11 BRAVO	TASK ACCEPTED (WITH COMMENTS)
FCSS1E4670	UAS CLASS 1	6/8/10	E-FUELER NOT FLOWING FUEL	.119	INSUFFICIENT FUEL IN FUEL CONTAINER	NA	11B	TASK ACCEPTED
FCSS1E4670	SUGV	6/8/10	MAIN TRACK SLIPS, COMES OFF, OR POSSIBLE BURNING SMELL	0.105	MAIN TRACK STRETCHED OUT OF SHAPE	NO	11B10, 11B20	TASK ACCEPTED



Step 3: Reporting of results in reports and evaluation products

Army Proven
Battle Ready

MTTT Status Report

LCN Nomenclature	LCN	LCN Type	ALC	TM FGC	Reference Number	CAGE	Item Name	UOC
COMPUTER, DESKTOP	D	P	00	00	D-2400V1	3XAU1	COMPUTER, DESKTOP	D24

Task Code	Task Identification	Task LD Status	LD Passed Date	Diagnostics	Diagnostics LD Date	Removal	Removal LD Date	Installation	Installation LD Date	Operational Check	Operational Check LD Date	Others (clean, adjust, calibrate, PMCS)	Others LD Date
2GCAAAA	DEBUG SOFTWARE	Pass	02/20/2009 14:25:00	Completed	02/20/2009 10:00:00	Completed	02/20/2009 10:00:00	Completed	02/20/2009 12:30:00	Completed	02/20/2009 14:25:00	N/A	02/20/2009 14:25:00

TIR Number	Revision Number	Log Demo Date	Diagnostics	Removal	Installation	Operational Check	Others (clean, adjust, calibrate, PMCS)
B0001		02/20/2009 10:00:00	Completed	Completed			
B0002		02/20/2009 12:30:00			Completed		
B0003		02/20/2009 14:25:00				Completed	N/A

Task Code	Task Identification	Task LD Status	LD Passed Date	Diagnostics	Diagnostics LD Date	Removal	Removal LD Date	Installation	Installation LD Date	Operational Check	Operational Check LD Date	Others (clean, adjust, calibrate, PMCS)	Others LD Date
BGCAAAA	TEST USING SYSTEM DIAGNOSTICS												

TIR Number	Revision Number	Log Demo Date	Diagnostics	Removal	Installation	Operational Check	Others (clean, adjust, calibrate, PMCS)

Task Code	Task Identification	Task LD Status	LD Passed Date	Diagnostics	Diagnostics LD Date	Removal	Removal LD Date	Installation	Installation LD Date	Operational Check	Operational Check LD Date	Others (clean, adjust, calibrate, PMCS)	Others LD Date
DGCAAAA	SET-UP OR ADJUST SYSTEM CONFIG	Pass	02/23/2009 08:25:00	N/A	02/23/2009 08:25:00	N/A	02/23/2009 08:25:00	N/A	02/23/2009 08:25:00	N/A	02/23/2009 08:25:00	Completed	02/23/2009 08:25:00

TIR Number	Revision Number	Log Demo Date	Diagnostics	Removal	Installation	Operational Check	Others (clean, adjust, calibrate, PMCS)
B0004		02/23/2009 08:25:00	N/A	N/A	N/A	N/A	Completed

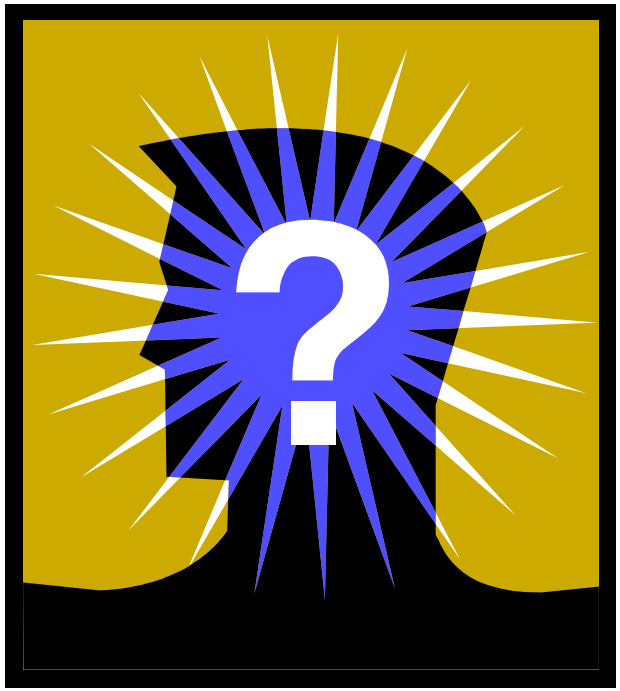
Task Code	Task Identification	Task LD Status	LD Passed Date	Diagnostics	Diagnostics LD Date	Removal	Removal LD Date	Installation	Installation LD Date	Operational Check	Operational Check LD Date	Others (clean, adjust, calibrate, PMCS)	Others LD Date
NGCAAAA	FAULT LOCATE LOCKUPS AND												

Army Proven
Battle Ready

Challenges to the Incremental LD Process

- Managing LDs around major design updates
- Training for data collectors and use of after action reviews
- Availability of Soldiers and training requirements
- Cost and benefit for:
  - Commercial and non-developmental items
  - Systems requiring little maintenance
- Log Demo entrance criteria and acceptance
  - Validated Technical Manuals
  - “Go with changes” vs. “No-Go” tasks
- Task tracking of system configuration and task completion

Questions????



Thank You!

Army Proven
Battle Ready

16

The Role of Enterprise Architecture Updates in Guiding Decentralized Organizations

John Schatz

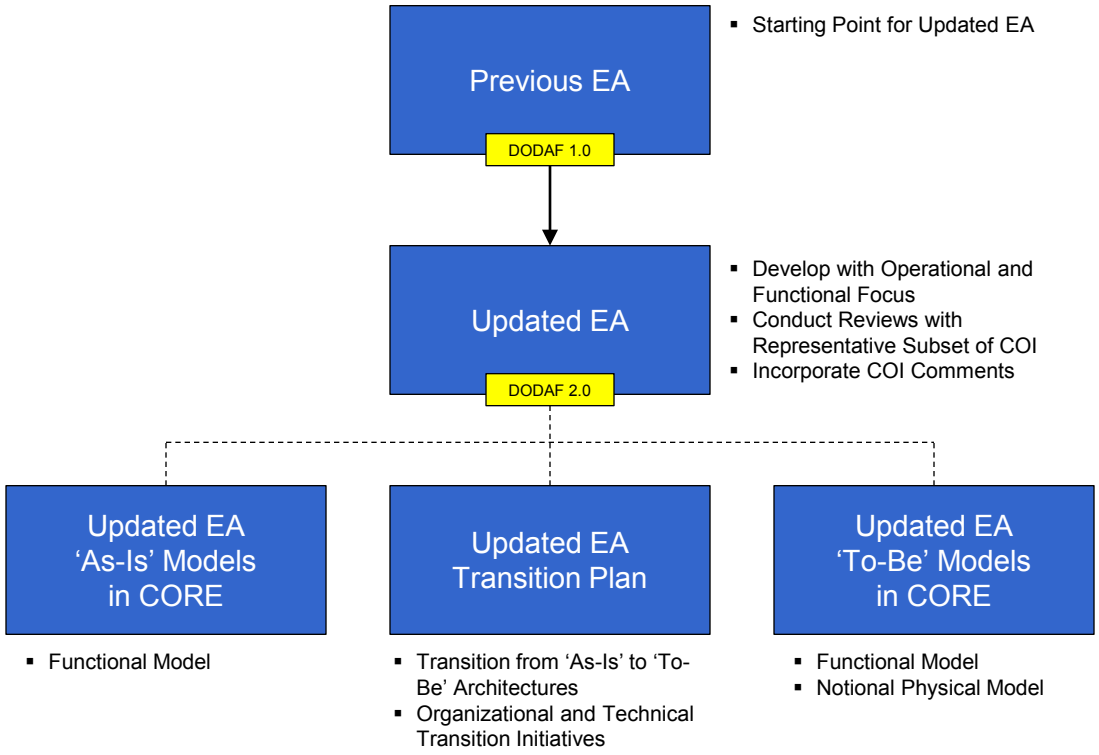
SPEC Innovations

Overview

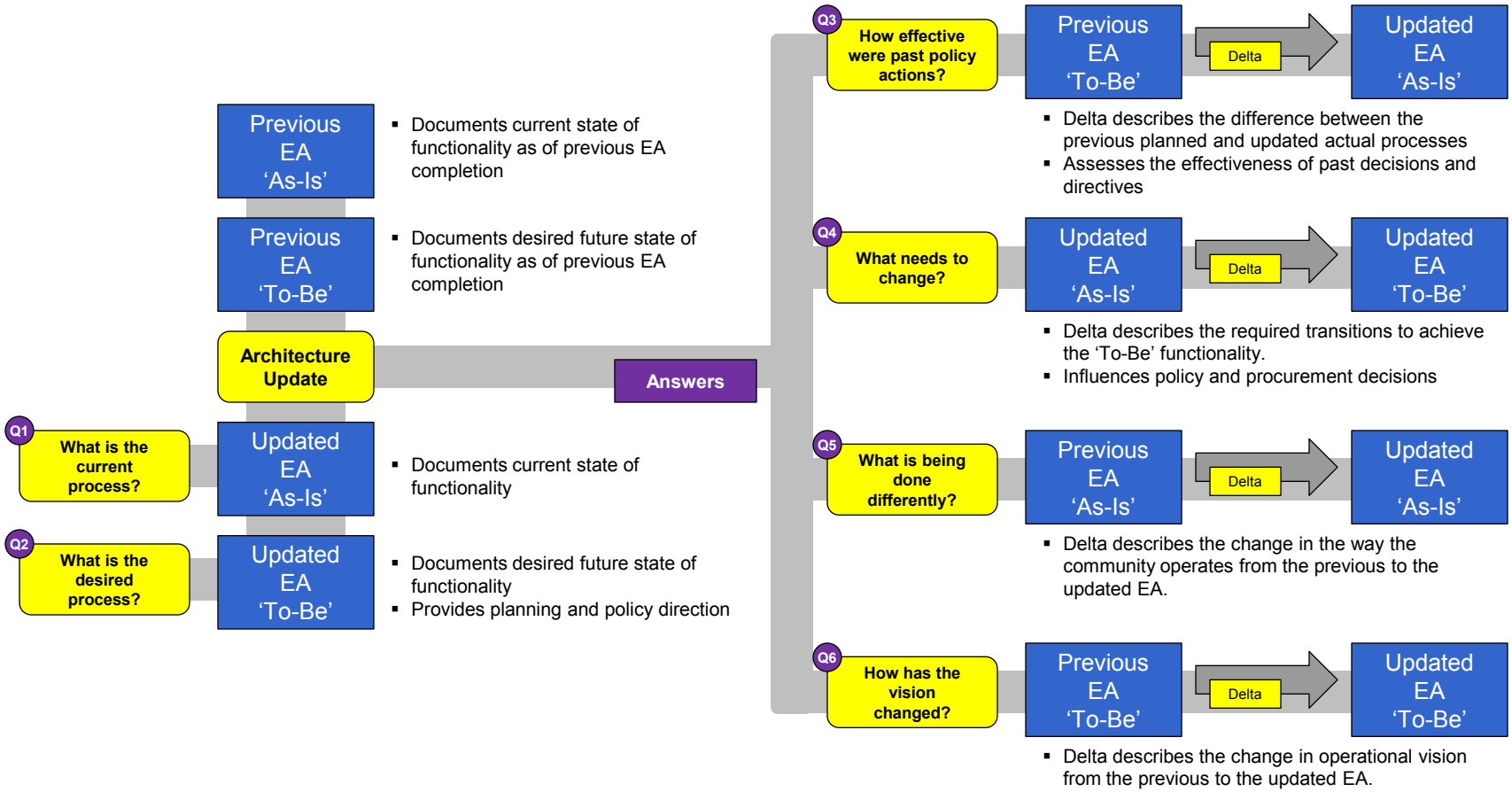
- Enterprise Architecture and Systems Study Interrelation
- Systems Study Methodology
- Systems Study Data Manipulation
- Summary
- Backup Slides

ENTERPRISE ARCHITECTURE AND SYSTEMS STUDY INTERRELATION

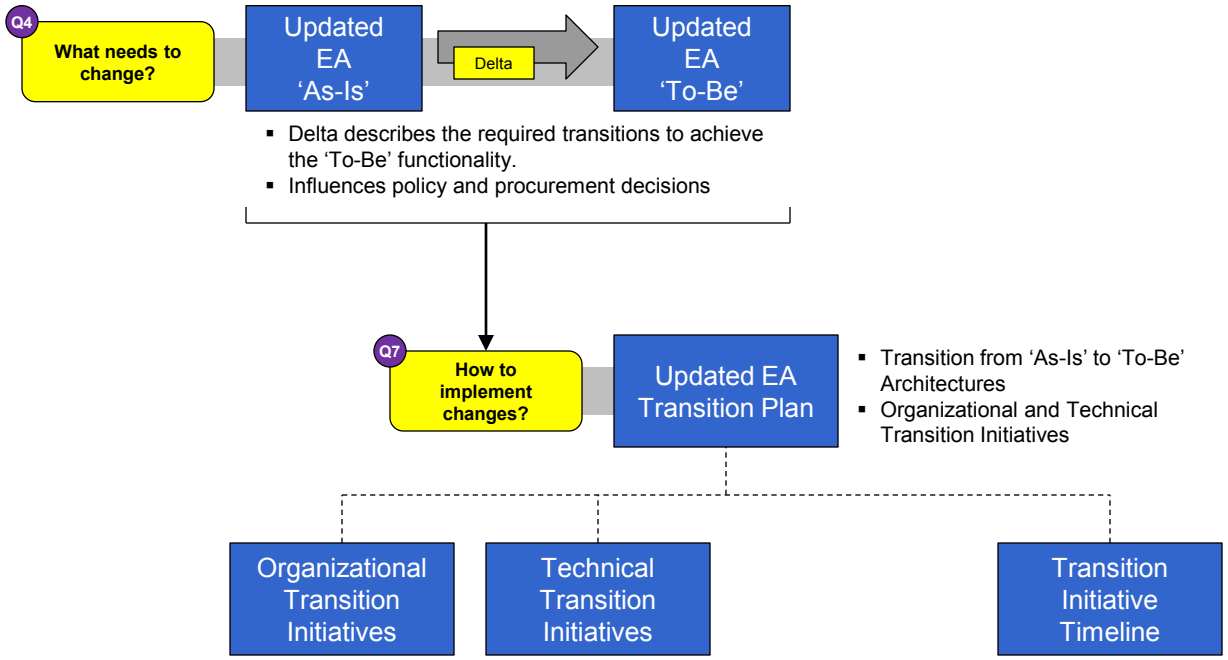
Enterprise Architecture (EA)



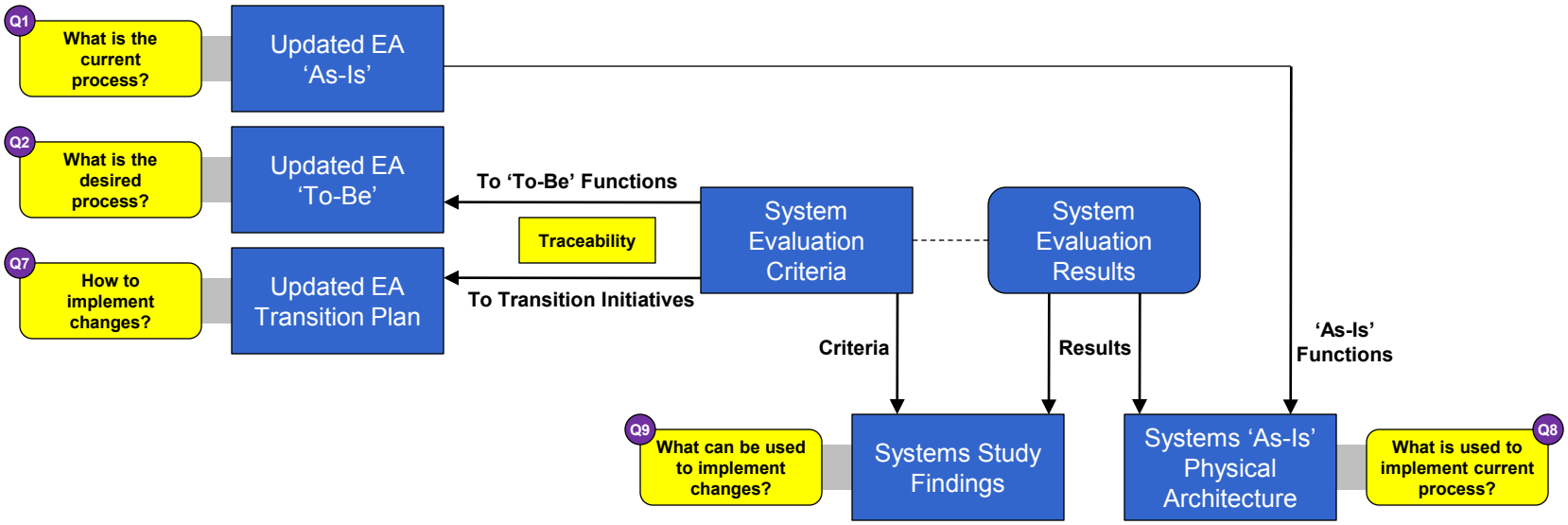
Why Update the EA?



EA Transition Plan



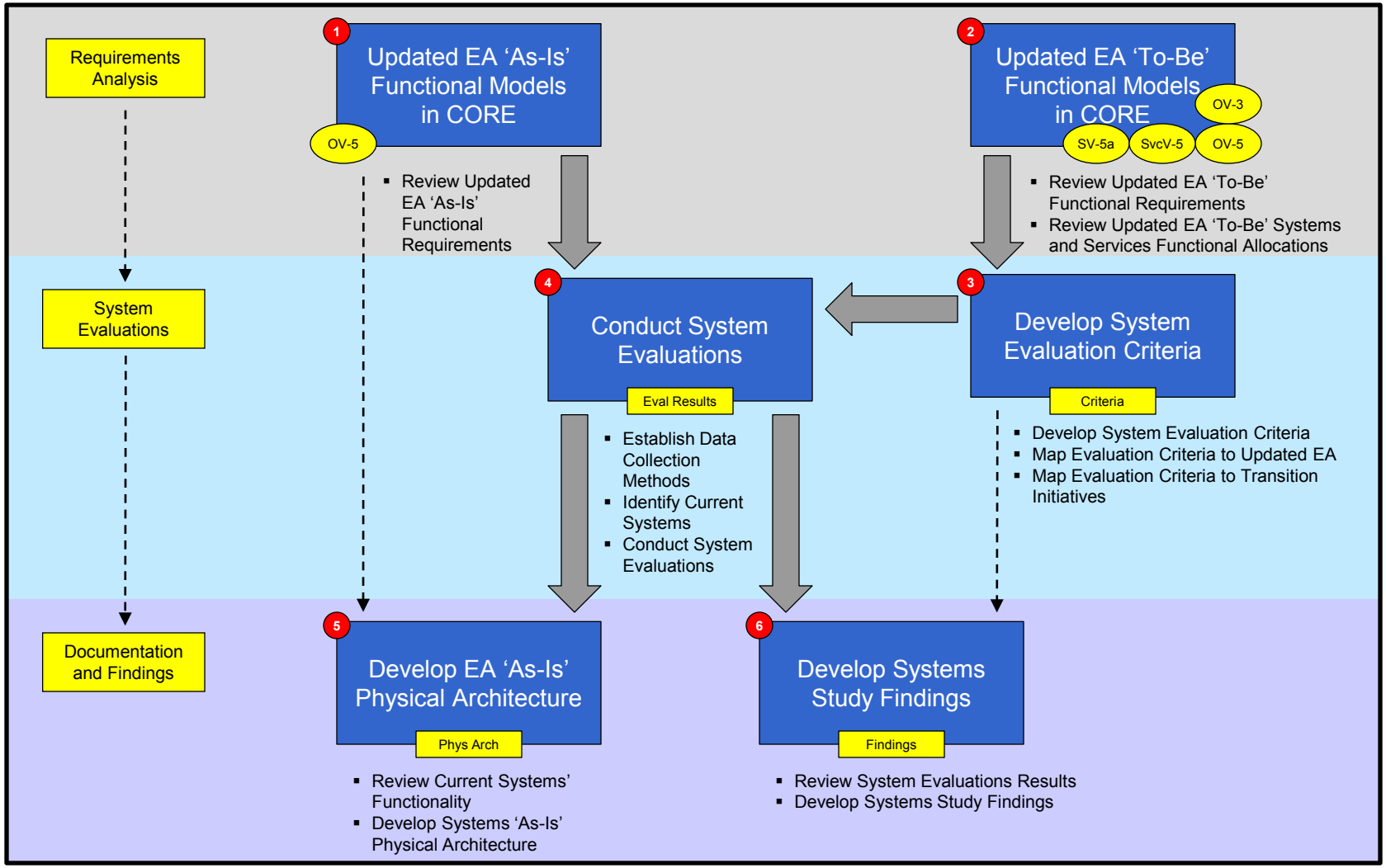
EA to Systems Study



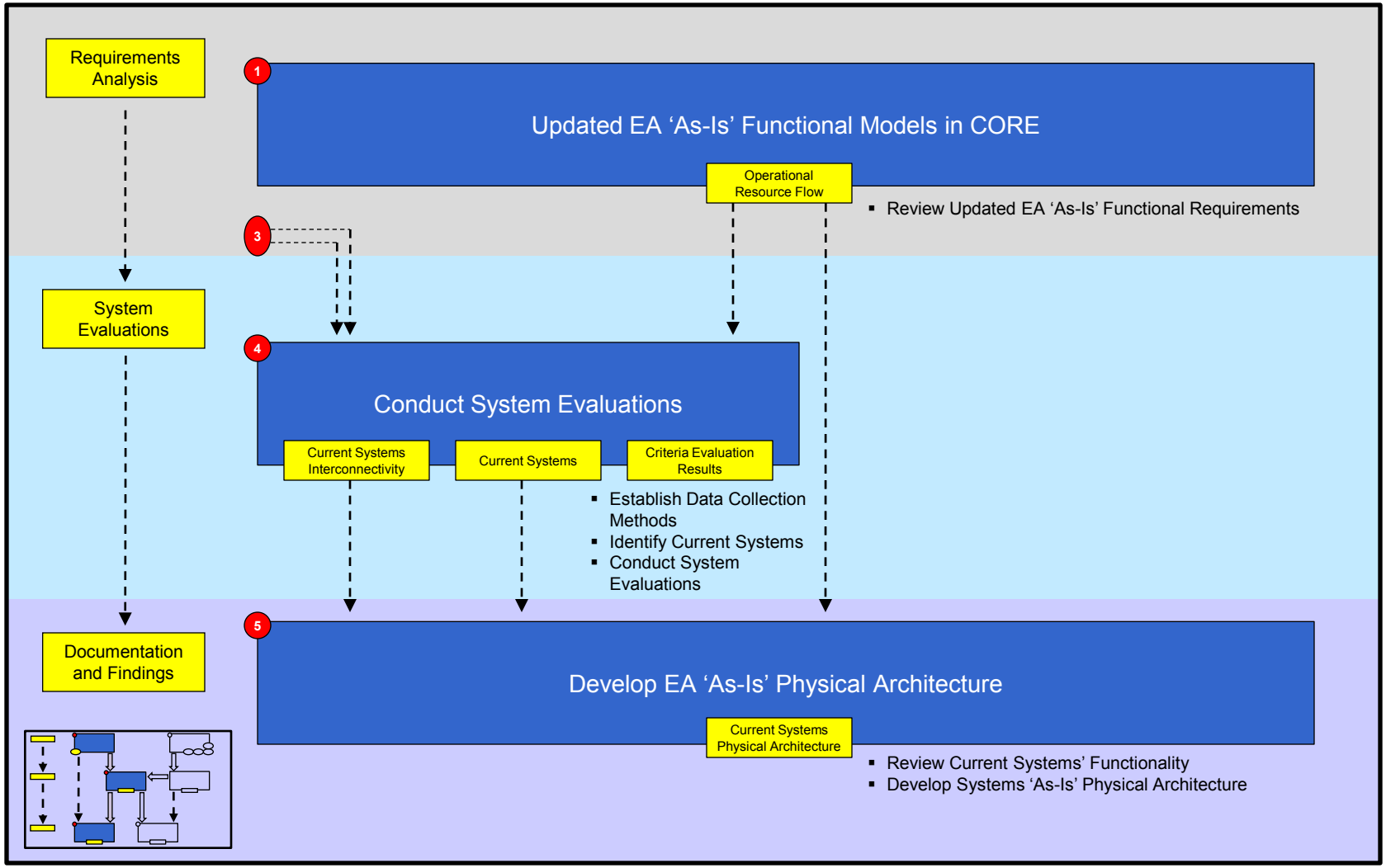
The Systems Study Findings will show how existing systems might be leveraged to implement the desired processes and changes as defined in the Updated EA.

SYSTEMS STUDY METHODOLOGY

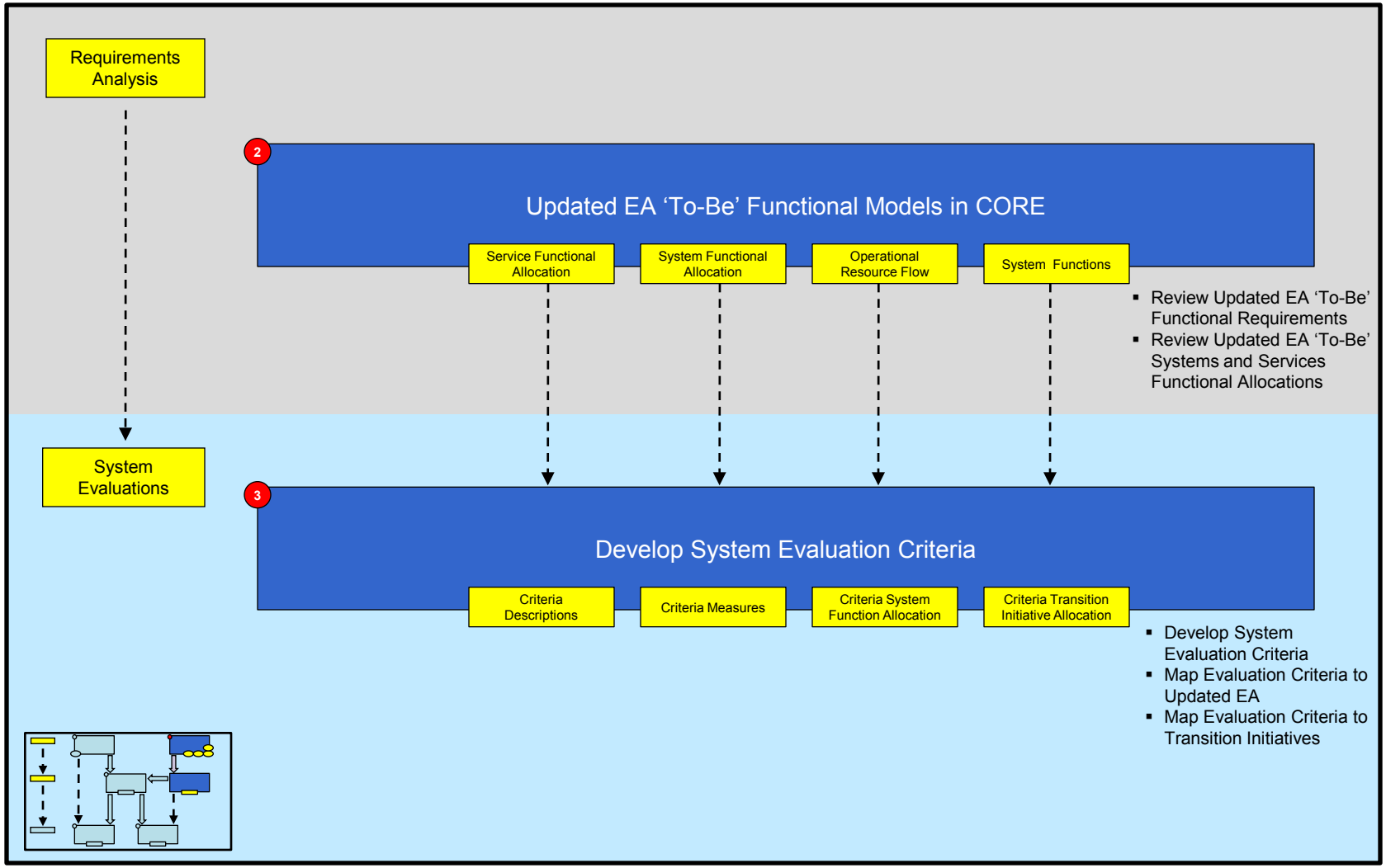
Systems Study Path Forward



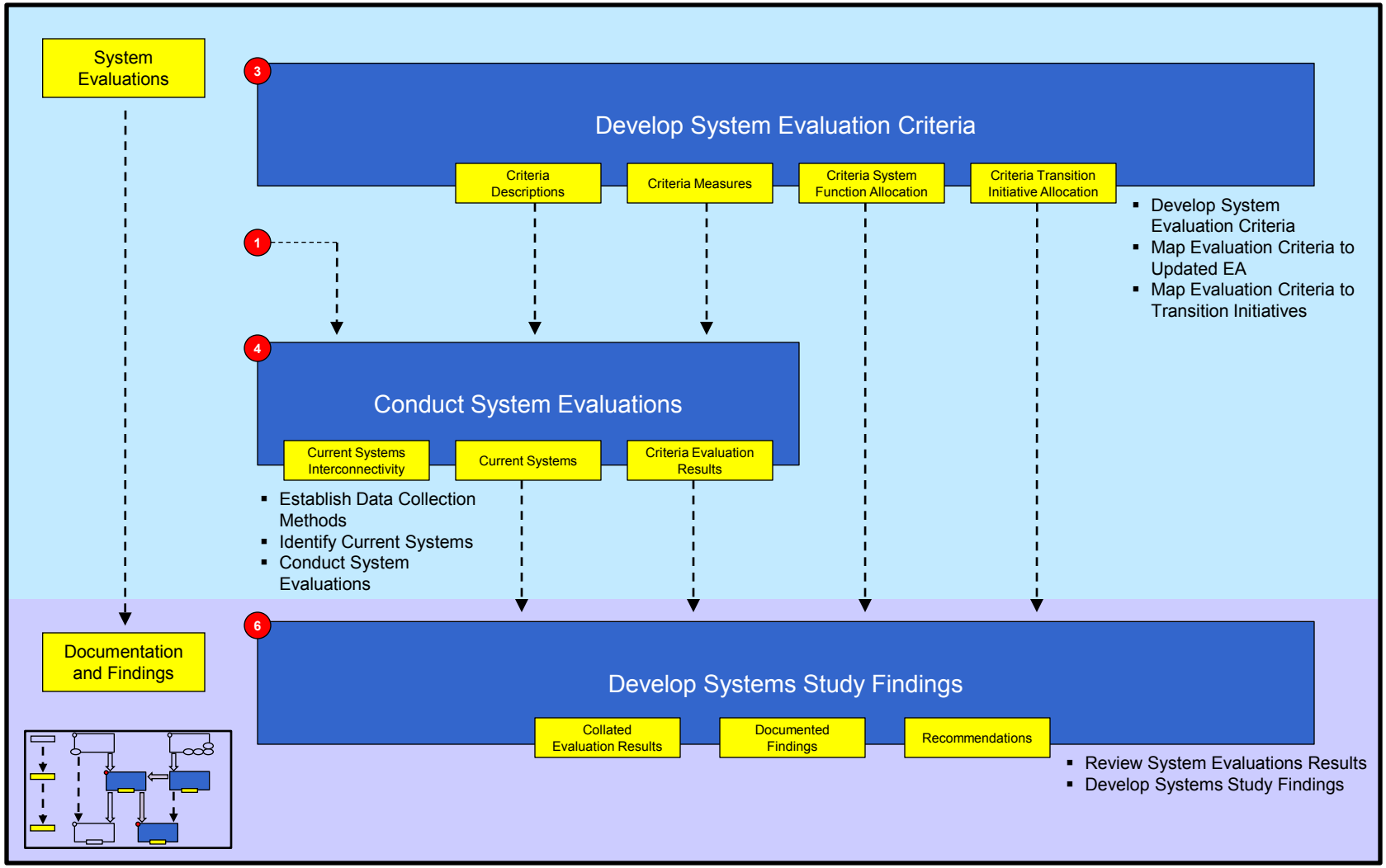
Systems Study Path Forward



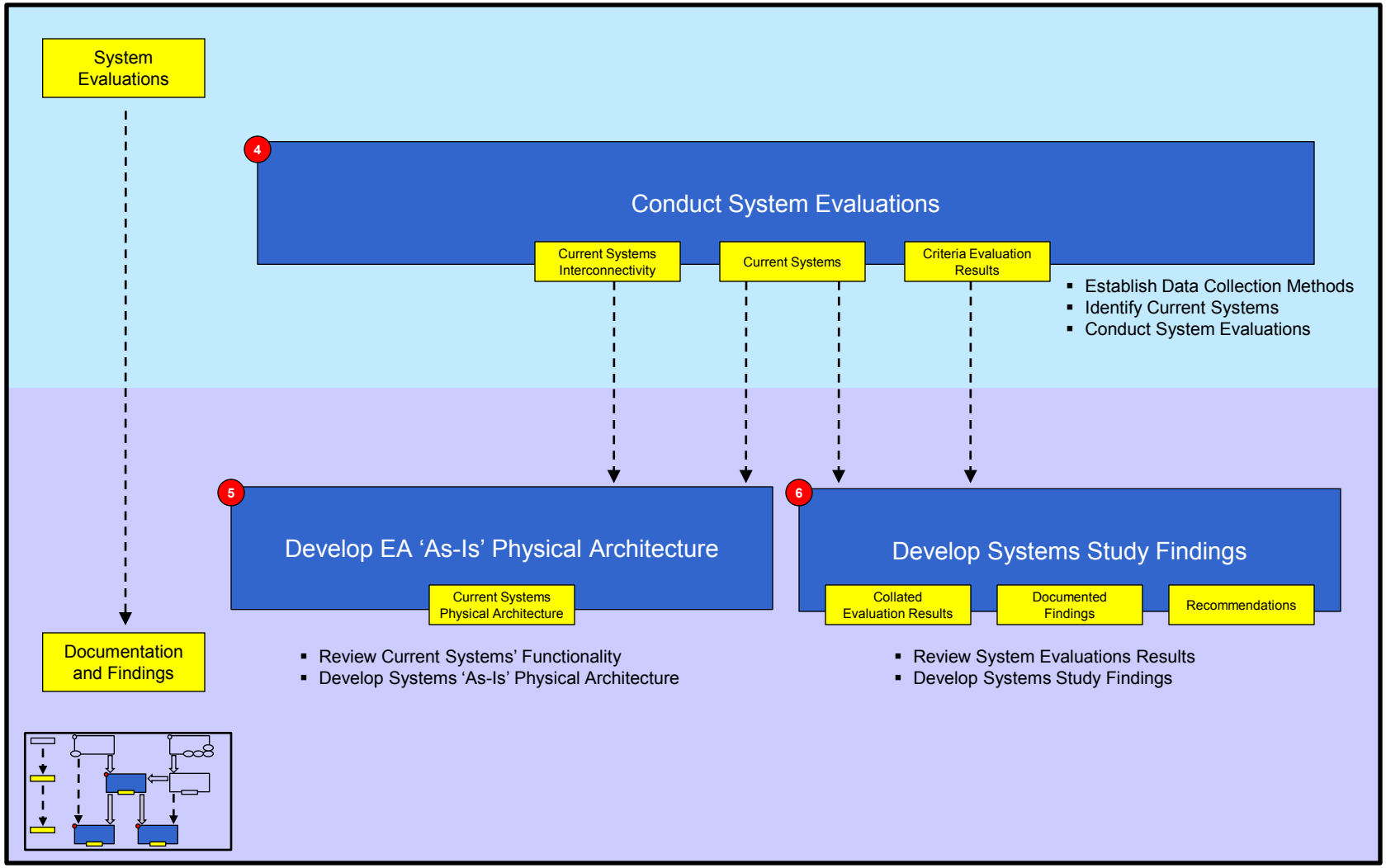
Systems Study Path Forward



Systems Study Path Forward

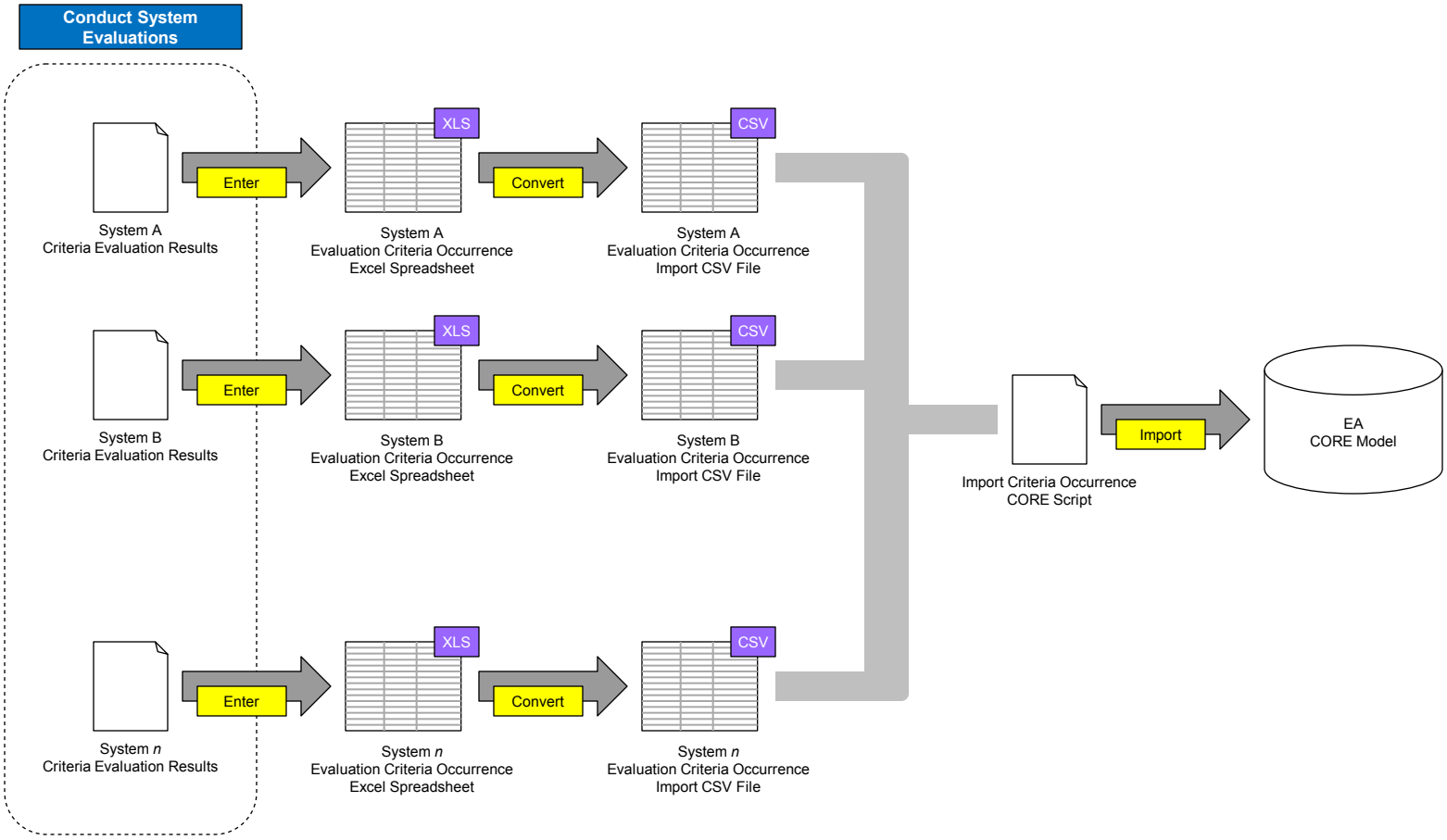


Systems Study Path Forward

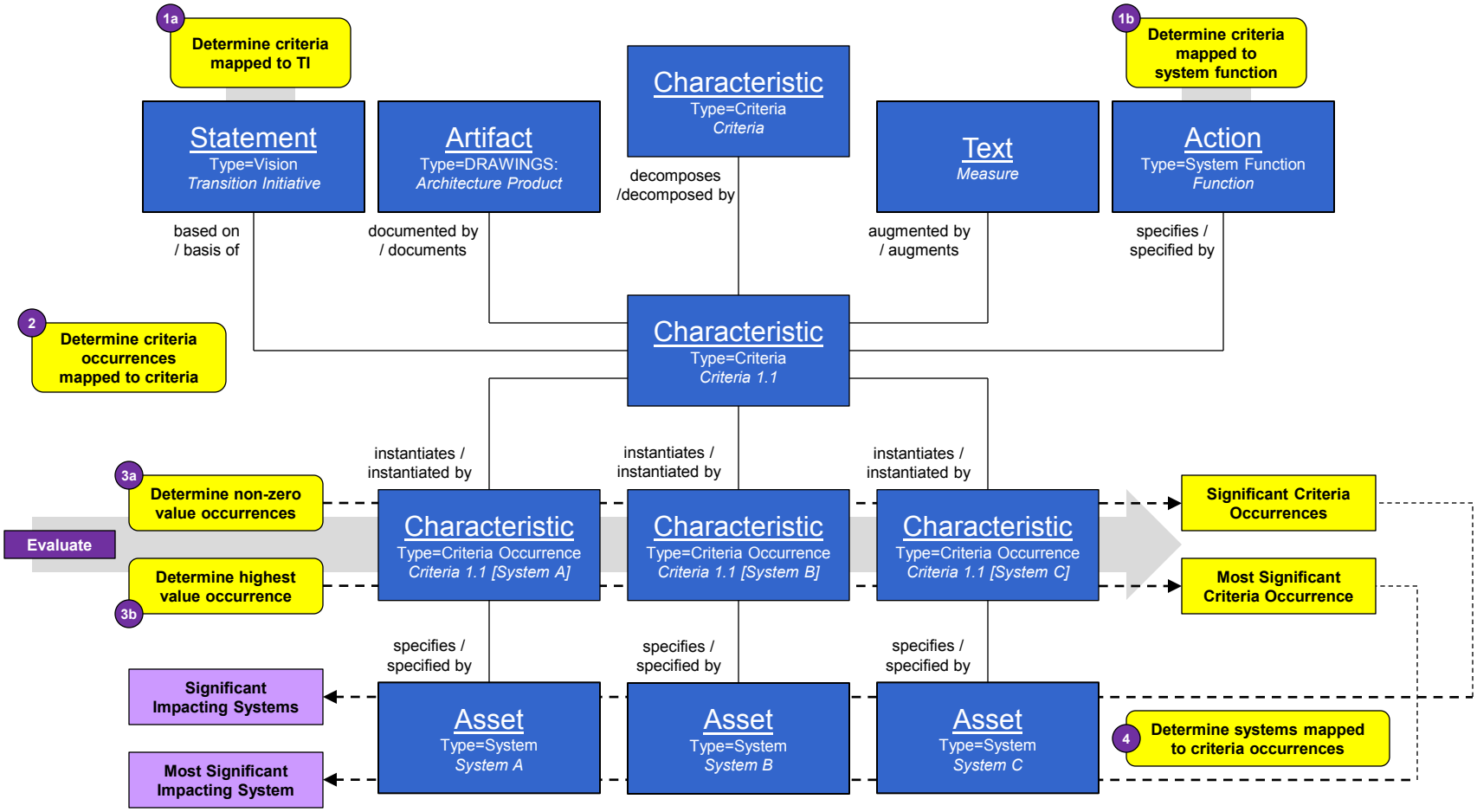


SYSTEMS STUDY DATA MANIPULATION

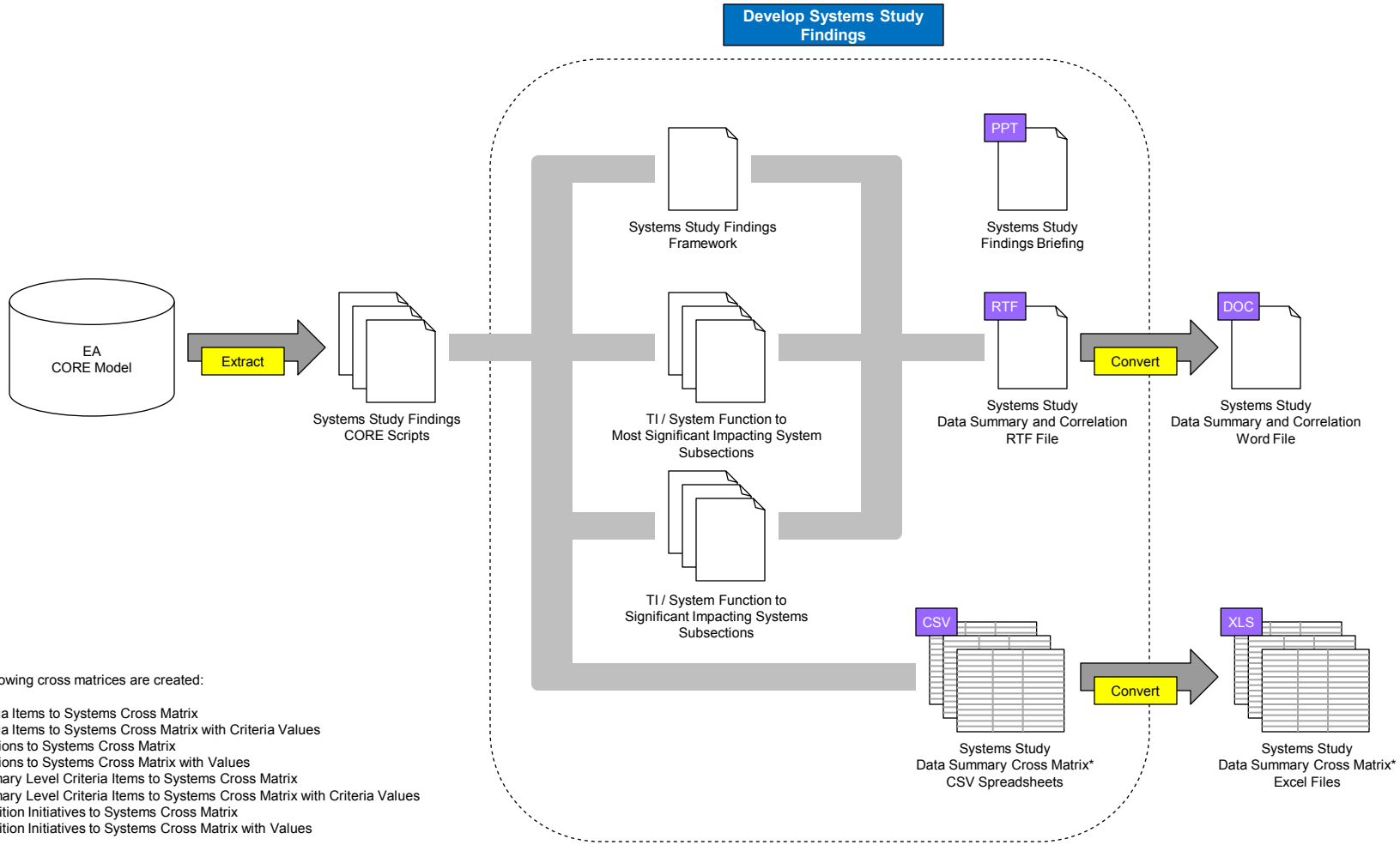
Criteria Evaluation Results Data



Determining Systems Potentially Impacting Changes



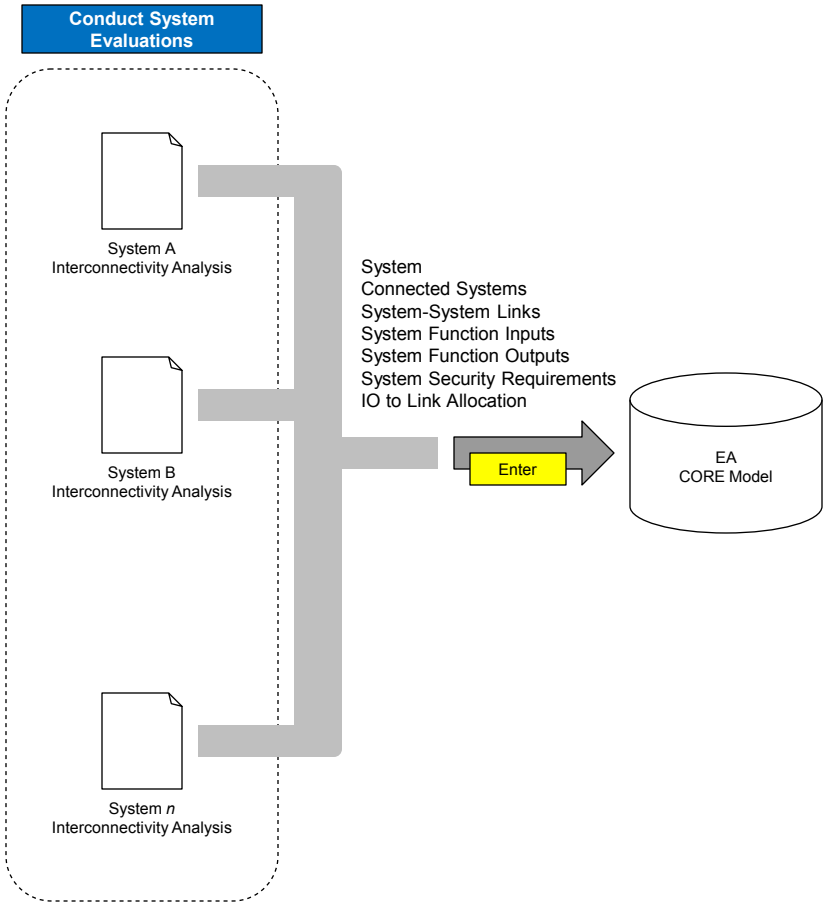
Findings Document Creation



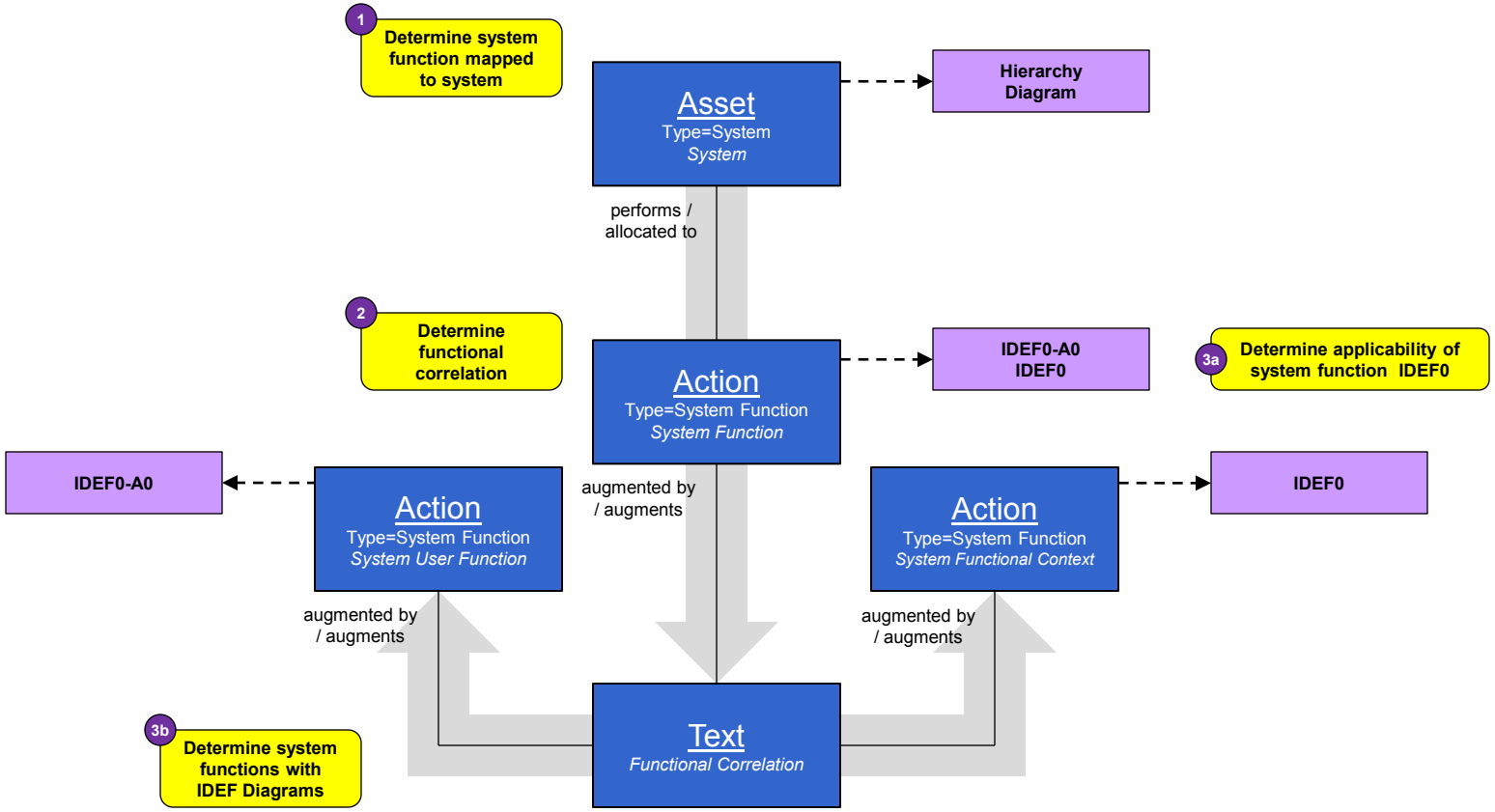
* The following cross matrices are created:

Criteria Items to Systems Cross Matrix
Criteria Items to Systems Cross Matrix with Criteria Values
Functions to Systems Cross Matrix
Functions to Systems Cross Matrix with Values
Summary Level Criteria Items to Systems Cross Matrix
Summary Level Criteria Items to Systems Cross Matrix with Criteria Values
Transition Initiatives to Systems Cross Matrix
Transition Initiatives to Systems Cross Matrix with Values

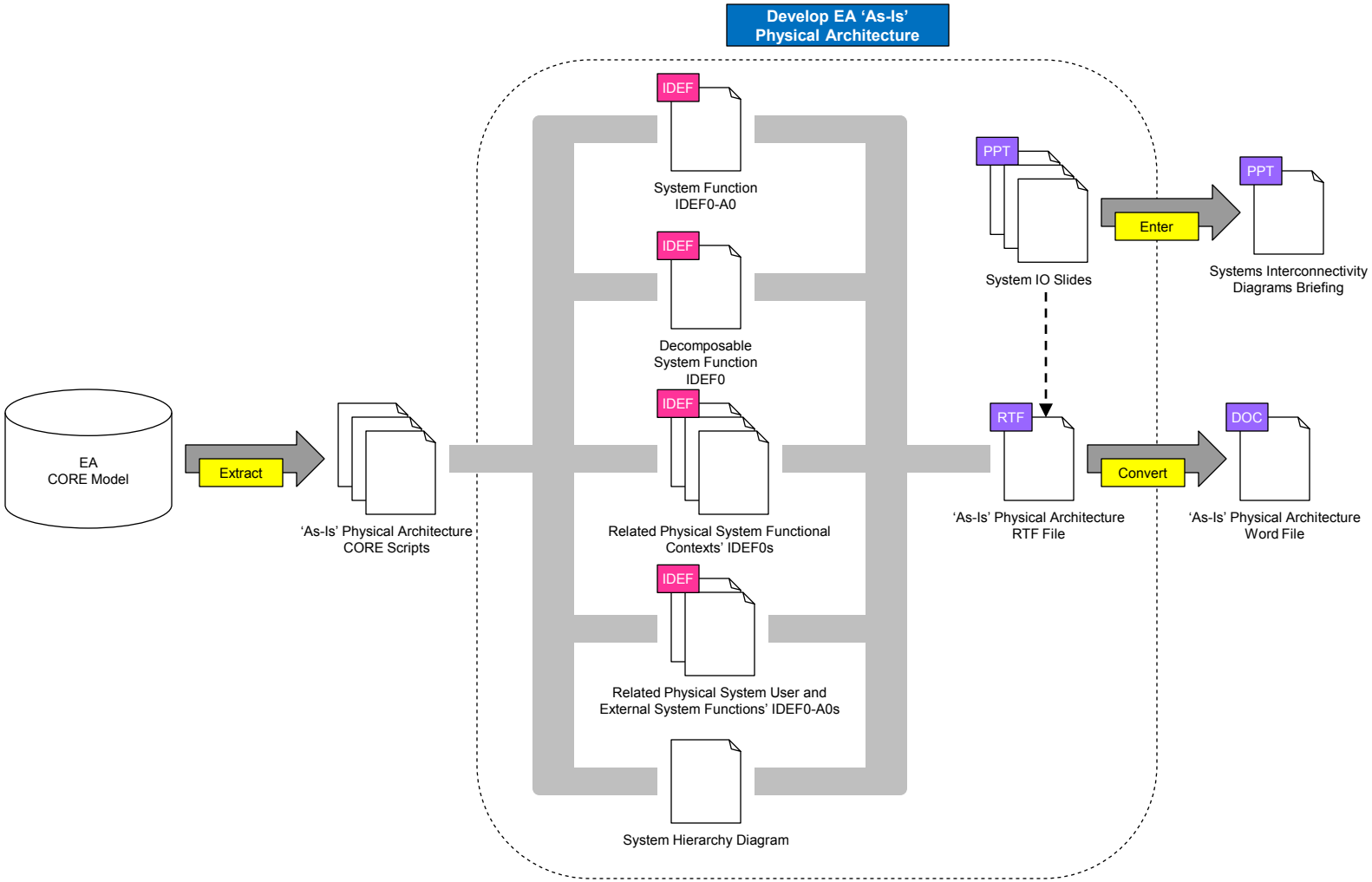
System Interconnectivity Data



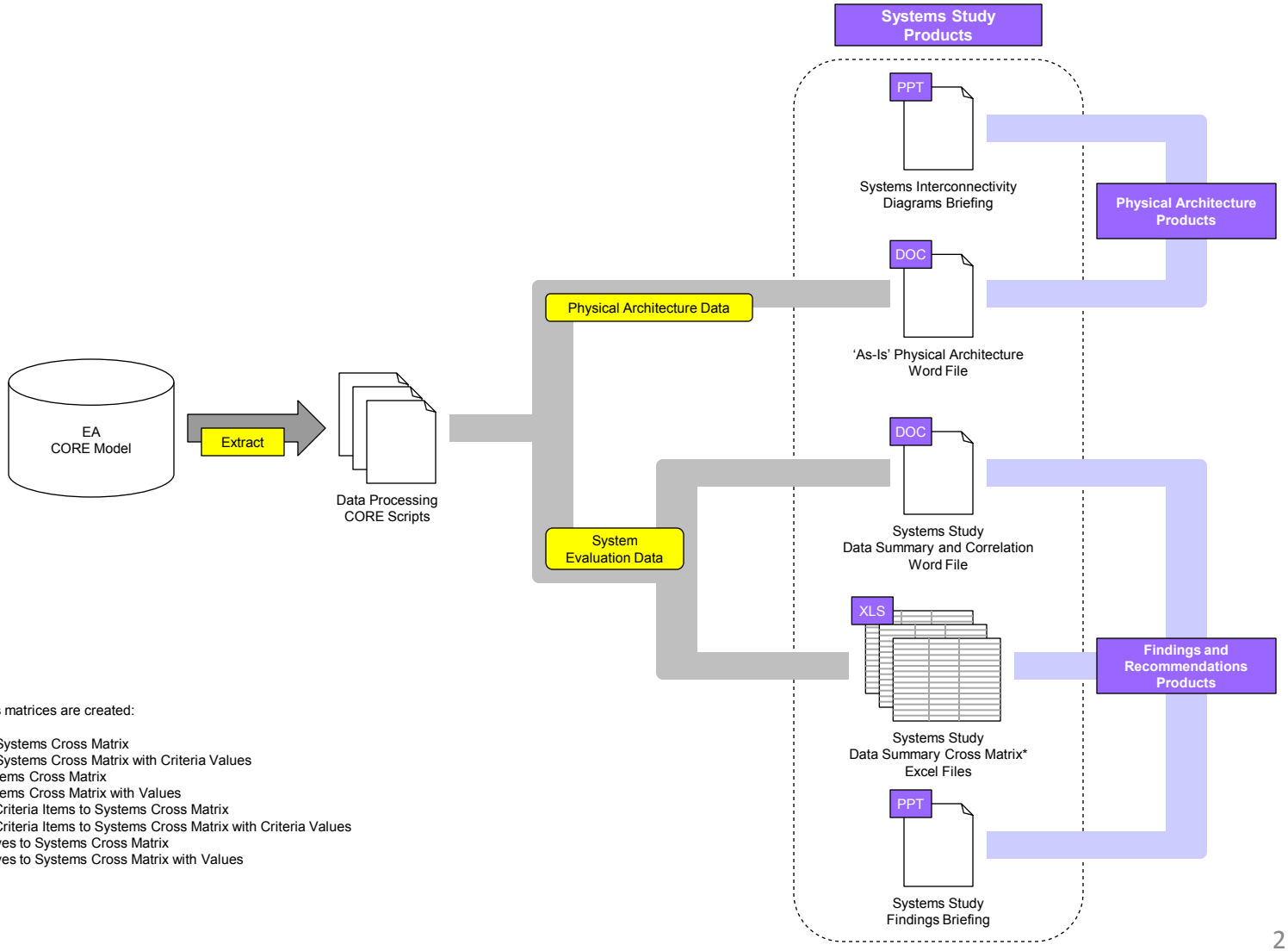
Physical Architecture Model Rendering



Physical Architecture Document Creation



Systems Study Product Creation



* The following cross matrices are created:

Criteria Items to Systems Cross Matrix
Criteria Items to Systems Cross Matrix with Criteria Values
Functions to Systems Cross Matrix
Functions to Systems Cross Matrix with Values
Summary Level Criteria Items to Systems Cross Matrix
Summary Level Criteria Items to Systems Cross Matrix with Criteria Values
Transition Initiatives to Systems Cross Matrix
Transition Initiatives to Systems Cross Matrix with Values

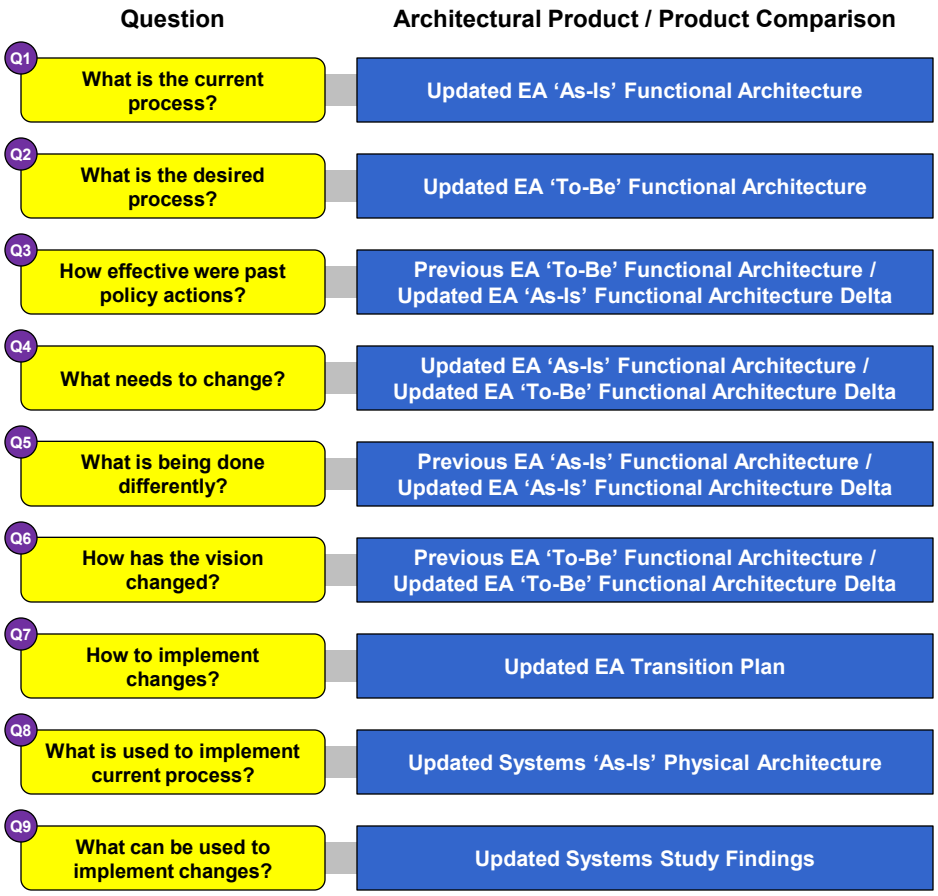
SUMMARY

Summary

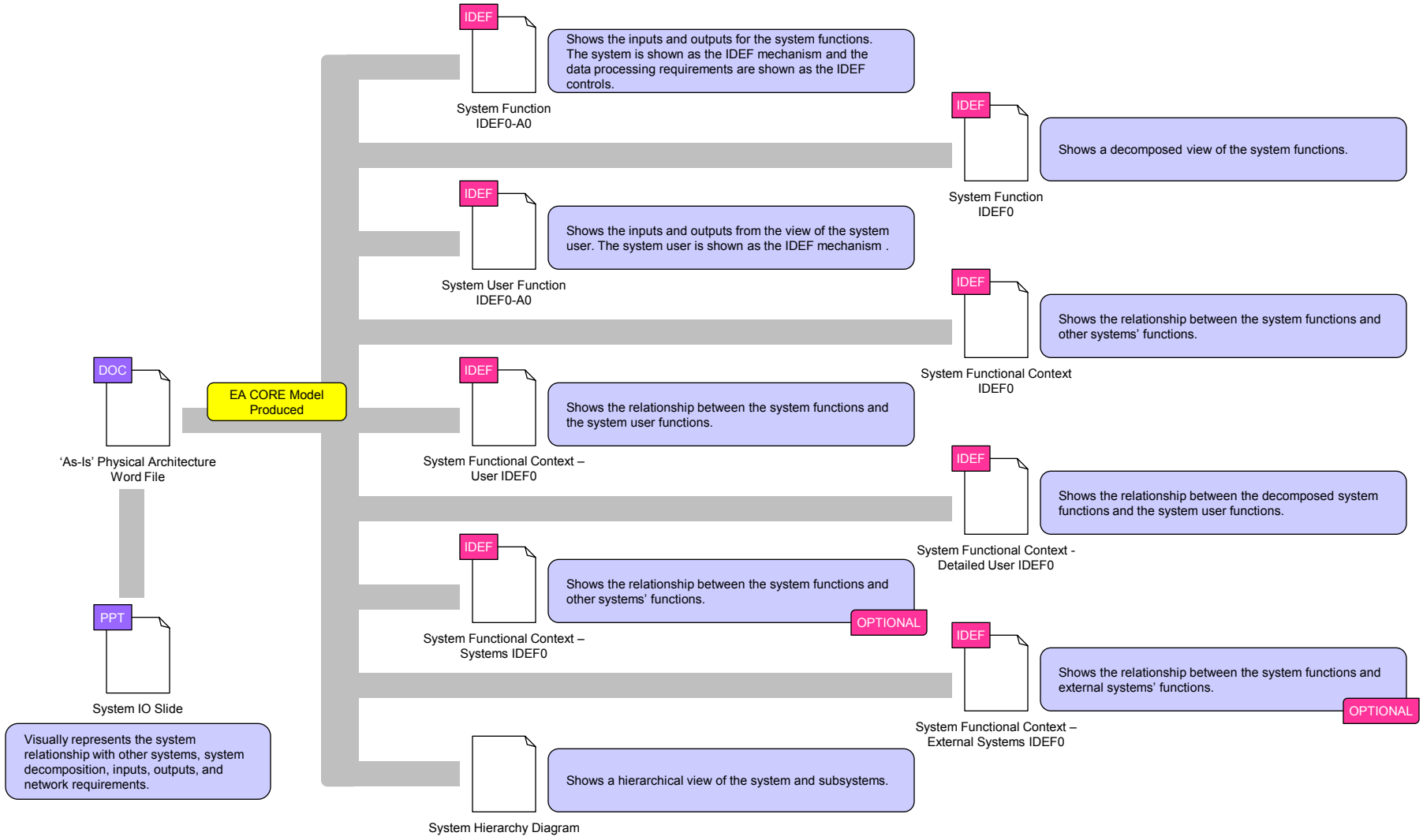
- Enterprise Architecture (EA) updates answer questions regarding the state and direction of the enterprise.
- Systems Study findings show how existing systems might be leveraged to implement the desired processes and changes as defined in the Updated EA.
- Systems Study data should be stored in the architecture database and mapped to the EA and Transition Initiatives.

BACKUP SLIDES

Enterprise State and Direction Questions



Physical Architecture Diagram Summary



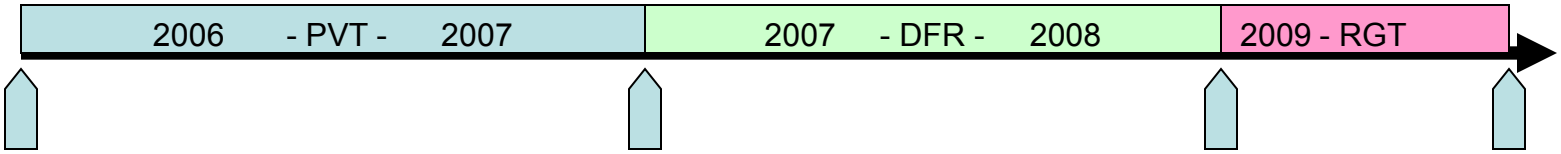
Stryker NBCRV Reliability Growth

Dmitry Tananko, Ph.D.
Sharad Kumar
Carl Elliott
Michael Staniszewski

Agenda

- Sections
  - Production Verification Testing (4/2006-7/2007)
  - Design For Reliability (12/2007-12/2008)
  - Reliability Growth Testing (4/2009-11/2009)
  - Conclusion

Time Line



Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Product Verification Test (PVT)

- April 2006 through July 2007
- NBCRV ORD requirement is 1000 MMBSA
- NBCRV Hardware / Software (w/o Government Furnished Equipment) requirement is 2000 MMBSA

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

PVT Results

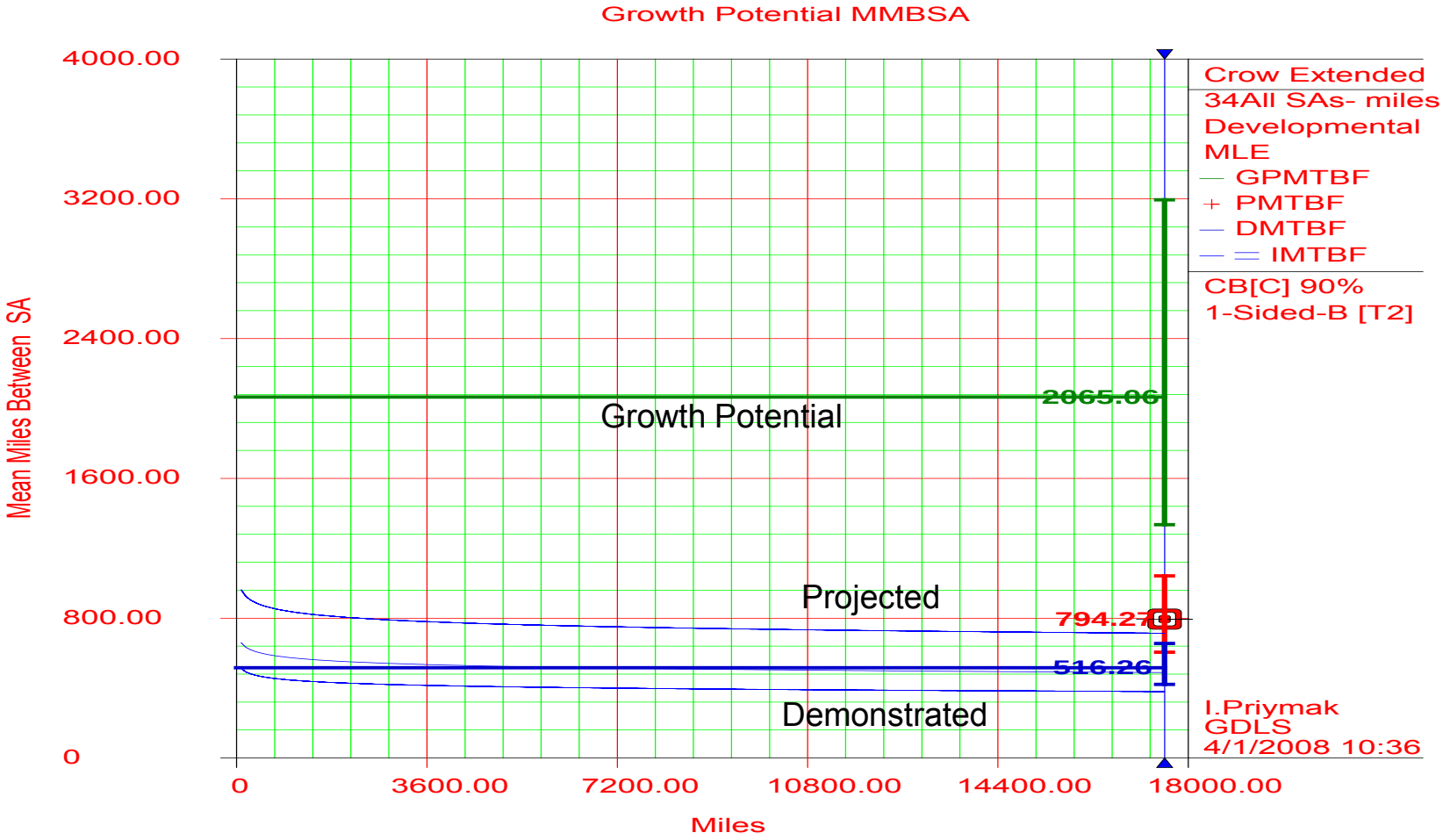
- PVT (Production Verification Test) / Durability testing
  - Stopped at ~70% of planned 24,000 mile RAM test
  - Multitude of CFE (Contractor Furnished Equipment) HW/SW System Abort's
  - Slightly over a half of the requirements demonstrated during PVT
  - No growth during PVT / Durability testing
  - Testing was halted due to low Reliability

NBCRV PVT was halted due to Low Reliability

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Reliability Growth Analysis

ReliaSoft's RGA 6 PRO - RGA.ReliaSoft.com



Beta (hyp.)=1.0000, Beta=1.0564

PVT was halted due to Low Reliability

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Post-PVT Discussion - DFR

- **Execute a System Engineering based Reliability Growth Program to satisfy User Requirements**
- **Exit Criteria:**
  - **Off Ramp based on demonstration of an instantaneous 1,333 MMBSA with 70% confidence**
  - **Demonstration of a point estimate of 1,333 MMBSA or better over 14K Miles**

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

What is DFR?

- DFR is Design for Reliability
  - Up front use of Reliability Tools to influence design
  - Infusing a mindset in the design process that promotes striving for improved Reliability
  - Produce a higher growth potential of design
- A change in attitude
  - Aggressive use of Reliability principles
  - Commitment to the DOD directive of Reliability Growth
- DFR tools:
  - Boundary Diagram
  - P-Diagram (Parameter Diagram)
  - DFMEA (Design Failure Modes Effects Analysis)
  - FTA (Fault Tree Analysis) / Prediction
  - DVP&R (Design Verification Plan and Report)

Up Front Use of Reliability Tools to change the Growth Potential of a Design

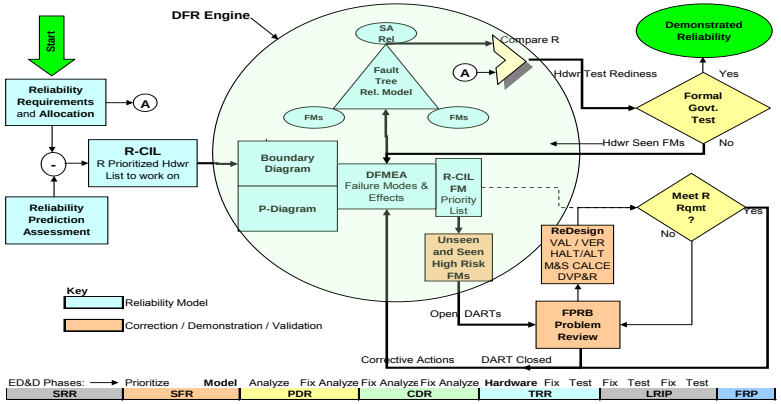
Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

New Reliability Standard ANSI/GEIA-STD-0009 Objectives

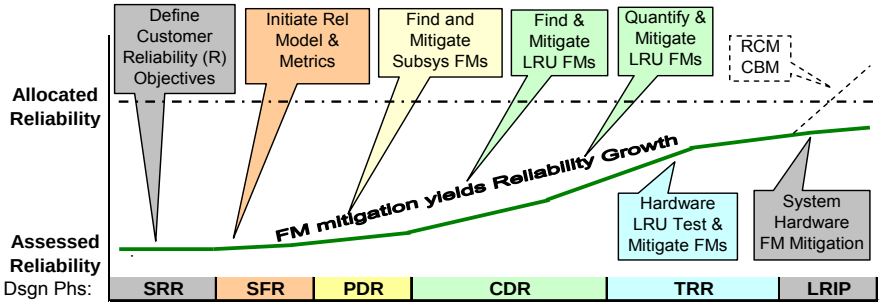
Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

DFR Quad Chart

ED&D Process to Grow R - Identify & Mitigate FMs

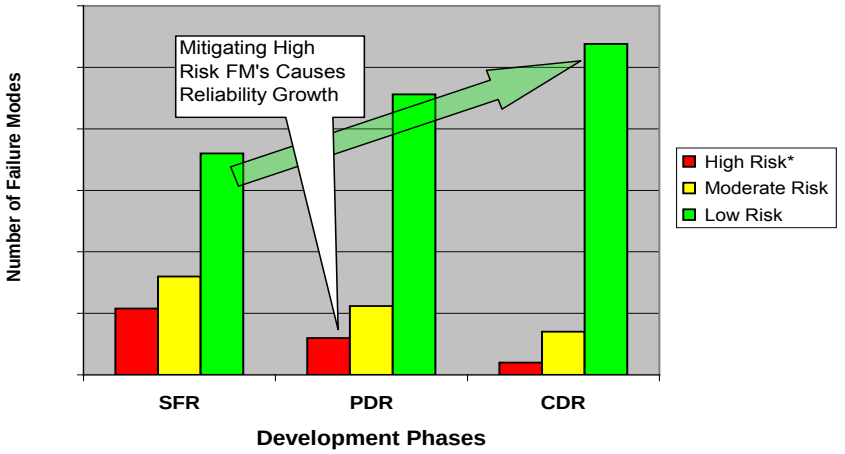


DFR - Mitigation of Potential FMs yields Reliability Growth



GDLS Dev Phase	GEIA R Standard Objectives	DFR Activities	DFR Tools	Reliability Deliverable
SRR	1. Customer / User Requirements and Constraints.	Understand and define Customer Reliability (R) Objectives	Required Rel. Assess Rel. R-CIL	Customer Requirements Constraints List
SFR		Define "R" constraints Initiate R Growth Program Plan Initiate System R model	Sys FTA / RBD Trade Studies Sys DFMEA	Reliability Model & Metrics System R-CIL
PDR	2. Design and Redesign for Reliability - DFR (Proactively assess, improve and optimize reliability)	Model subsys to LRU level. Qualitatively find high risk FMs Mitigate critical FMs to grow R	B-Diag P-Diag LRU DFMEA RCIL-DVP	Reliability Subsystem and LRU R-CIL
CDR		Identify root causes of FMs Quantitatively identify and Mitigate critical FMs to grow R	DVP Early Detection FM Mitigation	Reliability LRU FM & CA R-CIL
TRR		Early hardware FM detection Demonstrate & Mitigate Mitigate Subsys FMs to grow R	PQT FM Mitigation Validate Relibility	Reliability Hardware FM R-CIL
LRIP	3. Produce Reliable Systems / Products	Early Sys R demonstration Failure Analysis (FA) and write corrective actions (CA) grow R	FRACAS (Detect & Mitigate)	Reliability Subsys & Sys Hrdwr R-CIL
FRP	4. Monitor & Assess User Reliability	Actively Assess R TAF TAF Capture R growth opportunities for FRP	FRACAS Monitor R Growth	Vehicle Verification & Hdwr FM R-CIL

Manage Reliability Growth with Metrics



Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Top Level DFR Summary

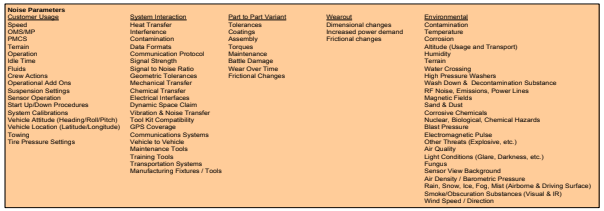
- Major steps toward start of design and test
  - Hardware Reliability – Design for Reliability Methodology
    - Boundary Diagrams
    - Parameter Diagrams
    - Design FMEA (Failure Mode and Effect Analysis)
    - Incident Screening Team
    - Failure Prevention Review Board (FPRB)
    - Steering FPRB
  - Operational Reliability
    - Personnel/Maintainer/Operator Training
    - Manuals
  - Quality/Manufacturing
    - Vehicle Shake down
    - Process FMEA
    - Vendor/Supplier Training

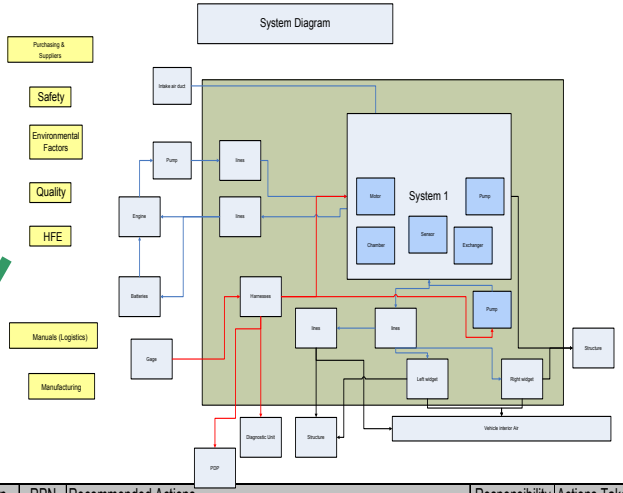
Three Major Areas to Facilitate Reliability Growth Potential

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

DFMEA

- **Center Piece of the DFR Process**
  - DFMEA uses the Boundary Diagram and P-diagram as a jump off point for analysis
  - DFMEA allows for Risk assessment
  - DFMEA targets candidates for redesign
  - DFMEA feeds and compliments the Fault Tree Analysis
  - DFMEA feeds the DVP&R



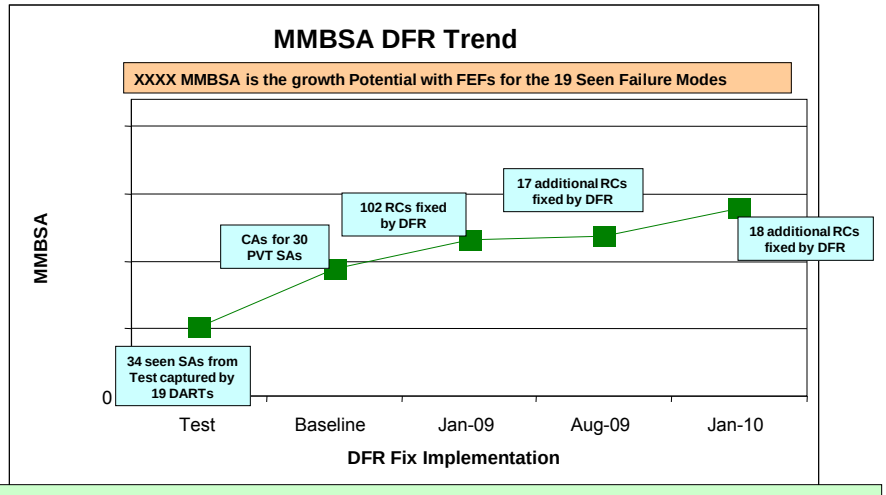


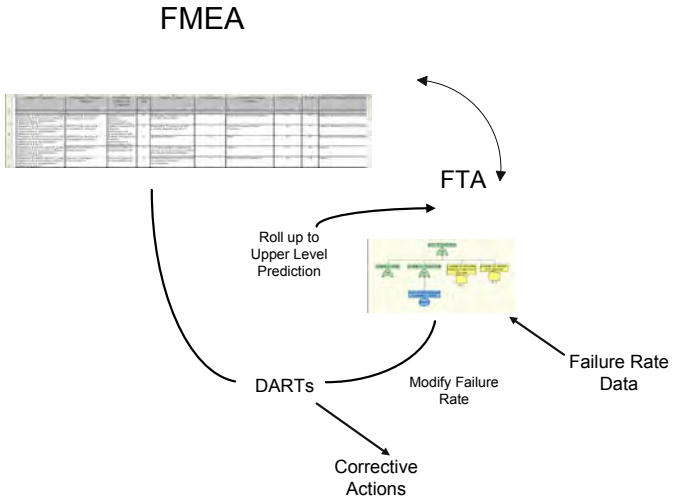
Item / Function	Potential Failure Mode	Potential Effect of Failure	Severity	Classification	Root Cause	Occurance	Current Design Controls	Detection	RPN	Recommended Actions	Responsibility & Target Date	Actions Taken
Failure of item	Item won't operate	delay mission start	3		Root Cause from P-diagram	2	Preventative	1	6	Redesign item	name and date	
Failure of item	Item won't operate	delay mission start	3		Root Cause from P-diagram	2	Preventative	1	6	Redesign item	name and date	
Failure of item	Item won't operate	delay mission start	3		Root Cause from P-diagram	1	Preventative	5	15	Redesign item	name and date	
Failure of item	Item won't operate	Stop mid mission	5		Root Cause from P-diagram	4	Preventative	5	100	Redesign item	name and date	
Failure of item	Item won't operate	Stop mid mission	5		Root Cause from P-diagram	4	Detection	4	80	Redesign item	name and date	
Failure of item	Item won't operate	Stop mid mission	5		Root Cause from P-diagram	2	Detection	5	50	Redesign item	name and date	
Failure of item	Item won't operate	Stop mid mission	5		Root Cause from P-diagram	2	Detection	5	50	Redesign item	name and date	
Failure of item	Item won't operate	Stop mid mission	5		Root Cause from P-diagram	2	Detection	5	50	Redesign item	name and date	

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Fault Tree Analysis

- **Fault Tree Analysis (FTA)**
  - Top-down analysis identifies failure modes of parts that could cause System Abort (SA)
  - Failure Definition Scoring Criteria (FDSC) for Production Verification Testing (PVT) used to guide tree contents
  - Failure modes identified during Failure Modes Effects Analysis (FMEA) included in Fault Tree
  - Failure Rate Data from known sources used in





FTA results predict failure to meet RGT entrance criteria (see Oct. '07 PM OSD brief)

Approved for Public Release; Distribution Unlimited; GDLS approved, Log No. 2010-104, dated 10-01-10

Screening Team Work Flow Progress

IST: Filter ~2500 Root Causes found during DFMEA

NBCRV SUB SYSTEM	ROOT CAUSES					Corrective Actions
	Root Causes	RPN >39	DFR IST Reviewed	DFR IST Approved	DFR IST Rejected	
Subsystem 1	37	8	8	6	2	5
Subsystem 2	177	22	23	17	6	4
Subsystem 3	54	13	13	0	13	0
Subsystem 4	35	3	3	3	0	2
Subsystem 5	23	6	6	3	3	3
Subsystem 6	192	12	13	4	9	2
Subsystem 7	833	142	65	37	28	5
Subsystem 8	90	30	30	21	9	2
Subsystem 9	290	118	116	33	83	10
Subsystem 10	137	69	71	22	49	5
Subsystem 11	121	46	46	17	29	7
Subsystem 12	70	56	58	14	44	
Subsystem 13	185	5	5	2	3	
Subsystem 14	34	3	3	0	3	
Subsystem 15	128	19	18	2	16	
Subsystem 16	19	3	3	3	0	1
Total	**2425**	**555**	**481**	**184**	**297**	**55**
		Progress	87%			

FPRB: Filter > 50 Corrective Actions proposed by Engineering

NBCRV SUB SYSTEM	Corrective Actions	Current Corrective Actions		
		FPRB Reviewed	FPRB Approved	FPRB Rejected
Subsystem 1	5	5	4	1
Subsystem 2	4	4	3	1
Subsystem 3	0	0	0	0
Subsystem 4	2	2	1	1
Subsystem 5	3	3	2	1
Subsystem 6	2	2	2	0
Subsystem 7	5	5	3	2
Subsystem 8	2	2	1	1
Subsystem 9	10	10	8	1
Subsystem 10	5	5	4	1
Subsystem 11	7	7	8	1
Subsystem 12	6	6	4	2
Subsystem 13	2	2	2	0
Subsystem 14	0	0	0	0
Subsystem 15	1	1	0	1
Subsystem 16	1	1	1	0
Total	**55**	**55**	**43**	**13**
		Progress	100%	

Steering Committee: Final Filter on Corrective actions

NBCRV SUB SYSTEM	Corrective Actions	Current Corrective Actions		
		SFPRB Reviewed	SFPRB Approved	SFPRB Rejected
Subsystem 1	4	4	4	0
Subsystem 2	3	3	2	1
Subsystem 3	0	0	0	0
Subsystem 4	1	1	1	0
Subsystem 5	2	2	2	0
Subsystem 6	2	2	1	1
Subsystem 7	3	3	3	0
Subsystem 8	2	2	1	1
Subsystem 9	8	7	6	1
Subsystem 10	4	4	3	1
Subsystem 11	6	6	6	0
Subsystem 12	4	4	3	1
Subsystem 13	2	2	1	1
Subsystem 14	0	0	0	0
Subsystem 15	0	0	0	0
Subsystem 16	1	1	1	0
Total	**42**	**41**	**34**	**7**
		Progress	98%	

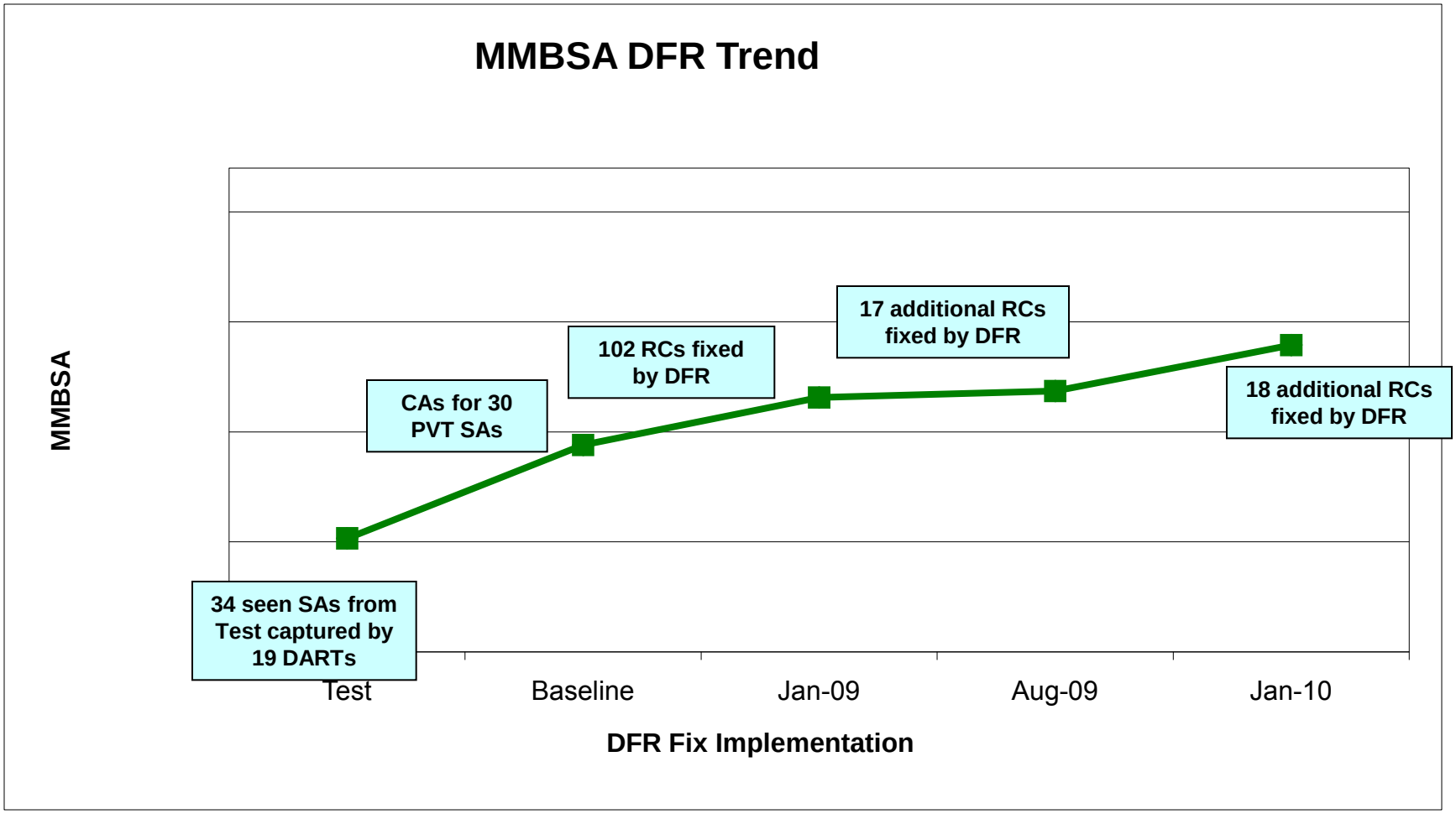
Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Summary of DFR

- DFR is a Two step process
  - Discover Failure Modes
  - Mitigate Failure Modes
- Statistical and Engineering Analysis
  - Calculate Reliability using Fault Tree Model
  - Fix it using Failure Prevention Review Board (Corrective Actions)
  - Using the NBCRV FDSC (Failure Definition and Scoring Criteria) 15 vehicle systems were chosen as candidates for improving the vehicle
    - DFMEAs were then performed on those systems concentrating on System Abort Failure Modes
  - Discovered near 2.5k root causes of failure modes which cause System Aborts
  - Those failure modes were screened and selectively addressed by corrective actions through FPRB
  - 230 root causes fixed with Design changes
  - Predicted MMBSA (Mean Miles Between System Abort) of approximately 1150 to start Reliability Growth Test (RGT) based on Fault Tree Analysis

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

FTA Results Using Corrective Action Cut-in Timeline



Fault Tree Showed an RGT start around 1150 MMBSA

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Operational Reliability

- Training of crews and maintainers
  - Classes were conducted by GDLS certified trainers
    - OPNET November '08 Classroom and then Vehicle
    - RGT delta teach: 2/20/09-2/26/09
    - FLMNET CCS delta teach: 3/16-3/20 2009

- Technical Manuals (TMs)
  - TMs delivered: 2/02/09
  - Items that did not make the February drop were made into ERRATA sheets and sent to be incorporated into the Manuals
  - Vendor TMs delivered in Jan. '09.

Operational Failures Mitigated by Training and Improved Manuals

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Quality and Manufacturing

- PFMEA's conducted by major suppliers
  - CCOPS supplier
  - Harness supplier

- Production quality
  - 2009 vs 2006 – Number of defects reduced by 15 times.

Production Quality along with Supplier Quality addressed

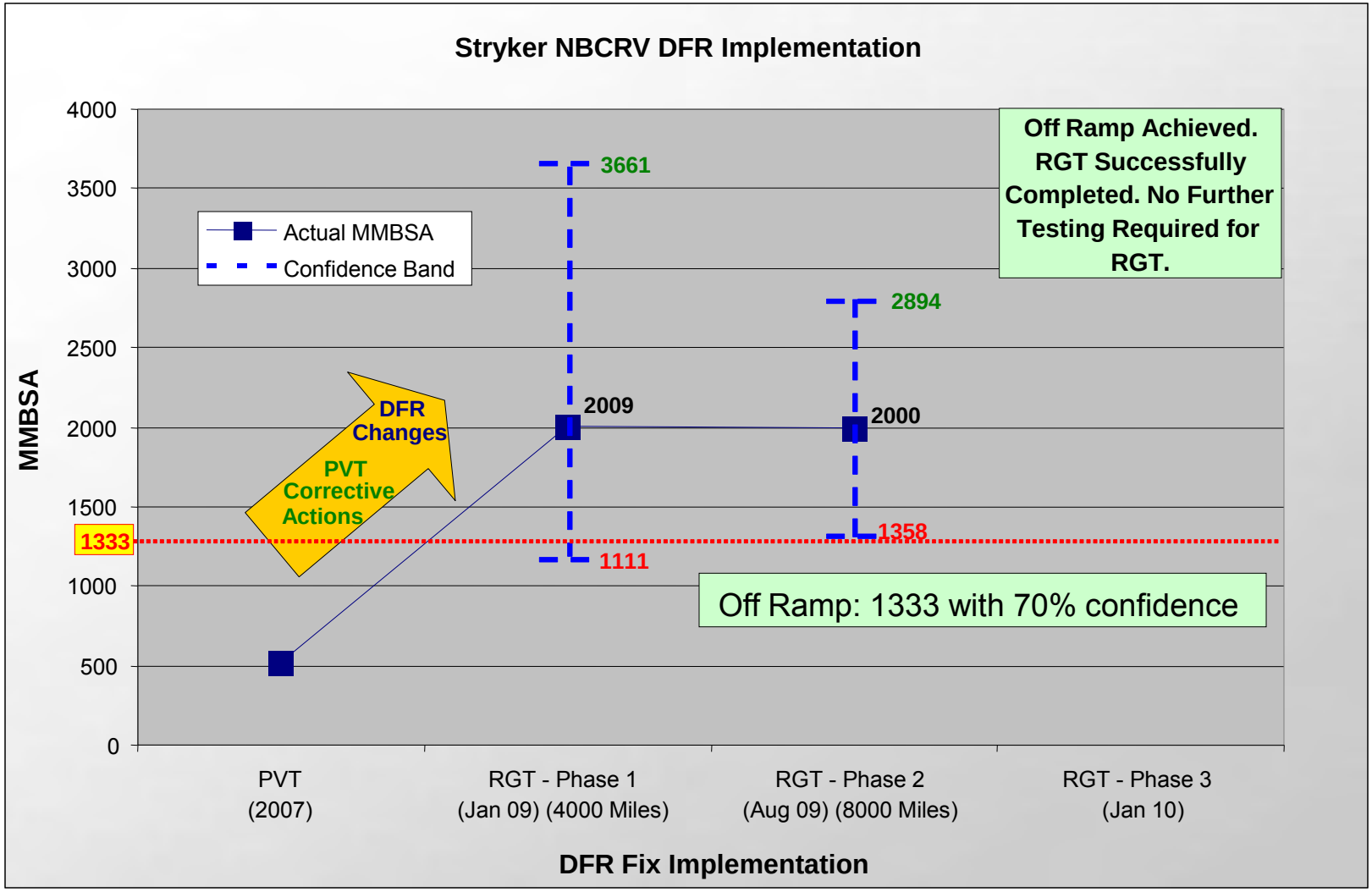
Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Reliability Growth Test Parameters

- April 2009 through November 2009
- 14000 miles
  - Phase I - 4000 miles / Phase II - 4000 miles / Off Ramp Opportunity / Phase III – 6000 miles
- Off-ramp opportunity at 8000 miles
- Shakedown
  - 400 before start of test
  - 100 after insertion points
  - Failures during shakedown not scored if they were directly attributable to DFR modifications

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Graph PVT to RGT Comparison



Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

SUMMARY

- NBCRV PVT/Durability was halted due to poor reliability
- The Design For Reliability resulted in a drastic jump in Reliability that was demonstrated in RGT
- RGT was ended early (8k miles vs. 14k miles) because the Reliability Requirements (1333 MMBSA) were exceeded with Confidence.

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10

Corresponding Author:
Dmitry Tananko, PhD
Manager, Reliability Department
General Dynamics Land Systems
tanankod@gdls.com
(586) 634-5071

Approved for Public Release, Distribution Unlimited, GDLS approved, Log No. 2010-104, dated 10-01-10