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

12th ANNUAL SYSTEMS ENGINEERING CONFERENCE

"Achieving Acquisition Excellence Via Effective Systems Engineering"

San Diego, CA

26 - 29 October 2009

Agenda

Tuesday, October 27, 2009

PLENARY SESSION 1 - INTRODUCTION & OPENING REMARKS

- Mr. Bob Rassa, Director, Systems Supportability, Raytheon; Chair, Systems Engineering Division, NDIA

KEYNOTE ADDRESS

- Honorable Zachary J. Lemnios, Director, Defense Research and Engineering, Office of the Secretary of Defense (Acquisition, Technology and Logistics)

PLENARY SESSION 2 - SERVICE ACQUISITION EXECUTIVES
VIEW FROM THE TOP: HOW CAN SE SUPPORT PROGRAM EXECUTION?
Moderator: Mr. Terry Jaggers, Principal Deputy, Systems Engineering, Office of the Director, Defense Research and Engineering

- Mr. David G. Ahern, Director, Portfolio Systems Acquisition, Office of the Secretary of Defense (Acquisition, Technology and Logistics)
- Mr. Thomas E. Mullins, Deputy Assistant Secretary for Plans, Programs and Resources (SAAL-ZR), Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology)
- Mr. Christopher A. Miller, PEO for Command, Control, Communications, Computers and Intelligence (C4I), ASNRDA
- Mr. Randall G. Walden, Director, Information Dominance Programs, Office of the Assistant Secretary of the Air Force (Acquisition), AFRCO

LUNCH WITH SPEAKER IN THE REGATTA PAVILION

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

PLENARY SESSION 3 - TEST & EVALUATION EXECUTIVES
VIEW FROM THE TOP: HOW SE CAN SUPPORT DEVELOPMENTAL TEST AND EVALUATION?
Moderator: Mr. Jim O'Bryon, The O'Bryon Group; Chair, Test and Evaluation Division

- Dr. James N. Streilein, Technical Advisor, HQ Army Test & Evaluation Command
- Ms. Amy Markowich, Deputy DoN T&E Executive
- Colonel Dexter M. Sapinoso, USAF, Chief of Air Force Test and Evaluation Policy and Programs
- Mr. Christopher DiPetto, OUSD(AT&L)/DDR&E/DT&E

PLENARY SESSION 4 - *SE AND ACQUISITIONS REFORM: THE WAY AHEAD*
Moderator: Mrs. Kristen Baldwin, Office of the Director, Defense Research and Engineering

- Mr. Ross Guckert, Office of the Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT))
- Mr. Carl Siel, Office of the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RDA)CHSENG)
- Colonel Shawn Shanley, USAF, Chief Systems Engineer, Office of the Assistant Secretary of the Air Force for Acquisition, Science, Technology, and Engineering (SAF/AQR)
- Mr. Nicholas Torelli, Office of the Director, Defense Research and Engineering

WEDNESDAY, OCTOBER 28, CONCURRENT SESSIONS

TRACK 1
Systems Engineering Effectiveness - Bayview III

- 8851 - *Rapid Development and Integration of Remote Weapon Systems to Meet Operational Requirements*, Mr. Joseph Burkart, NSWC Crane, Small Arms Air Platform Integration
- 8893 - *Rapid Development,* Mr. Michael Gaydar, NAVAIR
- 8847 - *Tailoring the SE Process to Effectively Complement the SW Agile Development Process*, Mr. William Lyders, ASSETT Inc.
- 8902 - *Systems Engineering Leading Indicators: Insight into Effective Systems Engineering*, Mr. Gary Roedler, Lockheed Martin Corporation
- 9414 - *Correcting Deficiencies in the Systems Engineering of Tactical Weapons*, Mr. Marvin Ebbert, Raytheon Missile Systems
- 8948 - *Value Engineering Applications in Service Contracts*, Dr. Jay Mandelbaum, Value Engineering Applications in Service Contracts
- 8816 - *Mind the GAPs-a Systems Engineering Implementation of DoDI 5000.02*, Dr. Thomas Christian, U. S. Air Force
- 8990 - *Systems Engineering for Rapid Capability Development*, Mr. Thomas McDermott, Georgia Tech Research Institute
- 8974 - *Transforming Systems and Software Engineering Across an Enterprise*, Mr. Jeffery Wilcox, Lockheed Martin Corporation
- 8863 - *Using Requirements Compliance to Identify Gaps Between the Technical Solution and Requirements*, Mr. Frank Salvatore, High Performance Technologies, Inc.
- 8823 - *Win and Influence Design Engineers---Change Their Affordability DNA*, Mr. Tim Morrill, Raytheon Company

TRACK 2
Early System Engineering - Bayview II

- 8951 - *USAF View of NRC "Pre-A Systems Engineering" Study Committee Recommendations As Addressed By Levin-McCain (P.L. 111-23; "Weapon Systems Acquisition Reform Act of 2009"*), Mr. Jeff Loren, SAF/AQR (Alion Science & Technology)
- 8846 - *Air Force Materiel Command Early Systems Engineering*, Dr. Brian Kowal, USAF
- 9016 - *A Framework for Enhancing Forward-looking Capability Delivery Metrics*, Mr. Leonard Sadauskas, DoD CIO CT&S
- 9082 - *Including Environment, Safety, and Occupational Health (ESOH) Requirements in Joint Capabilities Integration and Development System (JCIDS) Documents*, Mr. Sherman Forbes, U.S. Air Force
- 8835 - *T&E Collaboration and Contributions during Early Program Acquisition*, Mr. Stephen Scukanec, Northrop Grumman Corporation Aerospace Systems
- 8795 - *Mission-based Test and Evaluation Strategy: Creating Linkages between Technology Development and Mission Capability*, Mr. John Beilfuss, U.S. Army Research Laboratory
- Panel Topic: 8924, 8925 , 8933 - *Early Systems Engineering in DoDI 5000.02*, Dr. Judith Dahmann, Ms. Lisa Reuss, Ms. Sharon Vannucci, Systems Engineering Directorate, ODDR&E
- 8949 - *Updated DoD 5000 and CJCS 3170 Policies: A Requirements to Acquisition Gap Analysis*, Mr. John Lohse, Raytheon Company
- 8813 - *Emerging Roles for Systems Engineering in Defense Decision Making; Better Aligning Requirements and Acquisition with the Budget and Security Environments*, Mr. Vincent Roske, Institute for Defense Analyses
- 9026 - *Early SE Determination of Best-Fit System Life Cycle Processes*, Dr. Barry Boehm, USC

TRACK 3 - Technology Maturity - Bayview I

- 8991 - *Systems Engineering for the Science & Technology Community*, Mr. Russell Menko, U. S. Army RDECOM/TARDEC
- 9017 - *Linking Systems Engineering Artifacts with Complex Systems Maturity Assessments*, Dr. Brian Sauser, Stevens Institute of Technology
- 8770 - *Incorporating Maturity Assessment into House of Quality for Improved Decision Support Analysis and Risk Management*, Mr. Pavel Fomin, U.S. Air Force
- 8798 - *The New Technology Readiness Assessment Process*, Dr. Jay Mandelbaum, Institute for Defense Analyses
- 8870 - *S&T Portfolio Maturity & Performance Analysis: The Concept of Critical Research Elements*, Mr. Has Patel, Infologic, Inc.
- 8879 - *TRL Vectors in IPPD-based Portfolio Management*, Mr. Michael Bartmess, General Dynamics/AIS
- 8963 - *Air Force Concept Maturity Assessment*, Mr. George Freeman, U.S. Air Force, Center for Systems Engineering
- 8900 - *DOD's Weapon System Portfolio: Are Results Getting Any Better?*, Mr. Michael Sullivan, U.S. Government
- 8894 - *Air Force Initiative – High Confidence Technology Transition Planning Through the Use of Stage-Gates – Update*, Mr. Randy Bullard, U.S. Air Force Materiel Command
- 8891 - *A comprehensive overview of techniques for measuring system readiness*, Mr. James Bilbro, JB Consulting International

TRACK 4 - Test and Evaluation of SOS - Mission I

- 8825 - *Test and Evaluation in a System of Systems Environment*, Mr. Edwin McDermott, 653 ELSW, Electronic Systems Center
- 8849 - *Joint Integration and Interoperability Lab (JSIIL)*, Mr. Steven Whitehead, SL, J8 Technical Director, USJFCOM
- 8935 - *Systems of Systems Systems Engineering and Test and Evaluation*, Dr. Judith Dahmann, Systems Engineering Directorate, ODDR&E/MITRE

TRACK 4 - Practical Systems Engineering - Mission I

- 9014 - *SAVI: Aerospace Platform Development and Certification Using Modeling and Simulation to "Integrate, then Build"*, Mr. Gregory Pollari, Rockwell Collins
- 8855 - *Certify and Fly Right: Preparing for DO-297 Certification*, Mr. Ketih Custer, Esterline Control Systems-AVISTA
- 8973 - *C-17 Transition to Criteria-based Airworthiness Certification*, Mr. Christian Stillings, USAF 516 AESG

TRACK 4 - Test and Evaluation - Mission I

- 8848 - *Integrated Testing: We Can Do It*, Dr. Beth Wilson, Raytheon Company
- 8882 - *Test & Evaluation Strategy for the Technology Development Phase*, Ms. Darlene Mosser-Kerner, OUSD(AT&L)/DDR&E/DT&E
- 8883 - *Test & Evaluation Products for the Systems Engineering Reviews*, Mr. Woody Eischens, OUSD(AT&L)/DDR&E/DT&E
- 8814 - *Joint Mission Environment Test Capability (JMETC), Lowering technical Risk by Improving Distributed Test Capabilities*, Mr. Chip Ferguson, JMETC
- 8901 - *Review Results of the NDIA/OSD Software Test Summit/Workshop*, Mr. Thomas Wissink, Lockheed Martin IS&GS

TRACK 5 - Human Systems Integration - Mission II

- 8998 - *Human Systems Integration – Ensuring the Human is Considered "Left of A"*, Col Larry Kimm, USAF, U.S Air Force
- 8885 - *Human Systems Integration (HSI) - Integrating Human Concerns into Life Cycle Systems Engineering*, Ms. Cynthia Shewell, Booz Allen

Hamilton

- 9012 - *Human Systems Integration: Defining and Validating a Framework for Enhanced Systems Development,* Dr. Matthew Risser, Pacific Science & Engineering Group
- 8975 - *What is Human Systems Integration (HSI) and why should we do it?,* Mr. Stuart Booth, Systems Engineering Directorate, ODDR&E
- 9042 - *Bounding the Human Within the System,* Mr. Michael Mueller, U.S. Air Force Center for Systems Engineering
- 8829 - *The Army Health Hazard Assessment Program's Medical Cost Avoidance Model,* Dr. Timothy A. Kluchinsky, Department of Army

TRACK 5 - System Safety - ESOH - Mission II

- 9095 - *Using Proposed MIL-STD-882 Change 1 For Hazardous Materials Management,* Ms. Karen Gill, Booz Allen Hamilton
- 8890 - *Building Safer UGVs with Run-time Safety Invariants,* Mr. Michael Wagner, Carnegie Mellon University, NREC
- Sherman Forbes, U.S. Air Force
- 882D - *Overview of Draft MIL-STD-882D With Change 1,* Mr. Bob Smith, Booz Allen Hamilton
- 9070 - *Improving Safety Technology Insertion in DoD Acquisition Programs,* Dr. Elizabeth Rodriguez-Johnson, Systems Engineering Directorate, ODDR&E
- 9094 - *DoD Green Procurement Program Update and Path Forward,* Mr. David Asiello, Office of the Secretary of Defense
- 9091 - *Environment, Safety, and Occupational Health (ESOH) Risk and Technology Requirements Reporting at Acquisition Program Reviews,* Ms. Lucy Rodriguez, Booz Allen Hamilton

TRACK 6 - System of Systems - Mission III

- 8898 - *Designing Collaborative Systems of Systems in support of Multi-sided Markets*, Mr. Philip Boxer, SEI
- 8892 - *SysML Strategies to Characterize and Analyze Systems of Systems*, Dr. Jo Ann Lane, University of Southern California
- 9041 - *On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems*, Dr. Jack Zentner, Georgia Tech Research Institute
- 9060 - *M&S Support for SoS SE,* Dr.Joann Lane, USC
- 8776 - *The Modular SOS Paradigm: an Availability Paradox?*, Mr. Peter Gentile, Northrop Grumman Corporation
- 8866 - *Extending FMECA to Systems of Systems,* Mr. Leopoldo Mayoral, Johns Hopkins University/APL
- *NDIA SoS Committee Report*, Dr. Judith Dahman, Systems Engineering Directorate, ODDR&E/MITRE
- 8960 - *A Distillation of Lessons Learned from Complex System of Systems Acquisitions*, Dr. Richard Turner, Stevens Institute
- 8784 - *Establishing a Departmental-Level Systems-of-Systems Engineering Management Construct for the Department of the Navy, Progress Report*, Mr. John Kevin Smith, Asst Sec of the Navy for RD&A, Chief Engineer
- 8942 - DoD Systems of Systems Update, Dr. Judith Dahmann, Systems Engineering Directorate, ODDR&E/MITRE
- 8961 - Engineering Systems of Systems: An Integration Perspective, Dr. Emmett Maddry, NSWCDD

TRACK 7 - Program Management - Palm I

- 8979 - *Boots on the Ground: Tactical Planning at Program Start Up,* Mr. Gerry Becker, Harris Corporation
- 8999 - *Program Signature Measurement*, Mr. James Thompson, Systems Engineering Directorate, ODDR&E
- 9103 - *The Economics of CMMI,* Mr. Geoff Draper, Harris Corporation
- 8995 - *Integrated Systems Engineering and Developmental Test and Evaluation,* Mr. Chris DiPetto, DUSD(A&T)/SSE
- 9021 - *Critical Success Factors for Milestone Review Risk Identification,* Dr. Barry Boehm, USC
- 9030 - *Lessons Learned in Motivating Software Engineering Process Group to Focus on Achieving Business Goals and Not on Just Achieving a Maturity Level,* Mr. Girish Seshagiri, Advanced Information Services Inc.
- 9003 - CMMI® for Executives, Mr. Geoff Draper, Harris Corporation
- 9034 - Sustainment and Continued Institutionalization of Best Practices and CMMI® at SPAWAR, Mr. Michael Kutch, SPAWAR Systems Center Atlantic
- 8791 - Cost and Risk Impacts of the New DOD 5000 Defense Acquisition Framework, Dr. Peter Hantos, The Aerospace Corporation
- 8895 - A Comprehensive Review of Maturity Assessment Approaches for Improved Defense Acquisition, Ms. Nazanin Azizian, The George Washington University

TRACK 8 - Net-Centric Operations/Interoperability - Palm II

- 8874 - *The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems,* Mr. John Palmer, The Boeing Company
- 9010 - *Network Enabled Weapons, A System Engineering Approach to Achieve Interoperabilty, Mr. Andrew Lieux,* Naval Air Warfare Center Weapons Division
- 8854 - *Human Interoperability Enterprise and Net Centric Operations,* Mr. Jack Zavin, ASD (NII)
- 8780 - *Net-Centric Best Practices,* Mr. Hiekeun Ko, JPEO-CBD - Software Support Activity
- 8788 - *Data sharing in a Stability Operations Community of Interest: Utilizing a pilot program to prove concepts and develop trust.*, Mr. Gerald Christman, Femme Comp Inc.
- 8853 - *C4I Architecture for Joint ASW*, Mr. Gregory Miller, Naval Postgraduate School
- 8929 - *Extending Net-Centric Quality of Service to Systems of Systems*, Maj Vinod Naga, USAF, Air Force Institute of Technology
- 9081 - *Testing in Service-oriented Environments*, Mr. Soumya Simanta, SEI
- 8913 - *Linking Interoperability and Measures of Effectiveness: A Method for Evaluating Architectures,* Dr. David Jacques, Air Force Institute of Technology

TRACK 8 - Speciality Engineering - Palm II

- 8944 - *DoD's Refocus on Specialty Engineering (Reliability, Availability and Maintainability; Producibility and Quality, Supportability, Safety and Human Systems Integration)*, Mr. Chester Bracuto, Systems Engineering Directorate, ODDR&E
- 9043 - *Implementing the Materiel Availability KPP in DoD acquisition programs—balancing life-cycle costs with warfighter needs,* Mr. Grant Schmieder, Systems Engineering Directorate, ODDR&E
- 8873 - *IUID enables streamlined acquisition and system engineering,* Mr. Robert Leibrandt, DoD UID Policy Office
- 8958 - *Security Systems Engineering,* Mrs. Kristen Baldwin, Systems Engineering Directorate, ODDR&E

THURSDAY, OCTOBER 29, CONCURRENT SESSIONS

TRACK 1 - Systems Engineering Effectiveness - Bayview III

- 8887 - *Achieving a Systems Engineering Culture in a Science and Technology Laboratory Environment,* Mr. Robert Rapson, Materials and Manufacturing Directorate, AFRL
- 8920 - *A Methodology for Assessing Systems Engineering Practices,* Ms. Lauren Levy, Johns Hopkins University/APL
- 9097 - *Acquisition ESOH Risk Management-How to Make It Work,* Mr. Bob Smith, Booz Allen Hamilton

TRACK 1 - Architecture - Bayview III

- 8831 - *Human-Centered Design in Systems Engineering: Human View Methodology,* Dr. Robert Smillie, SPAWAR
- 8830 - *Systems Engineering Needs of the DoDAF – Report of the Architecture Frameworks Working Group,* Mr. Joe Kuncel, Northrop Grumman Corporation
- 8824 - *Delivering DoDAF Version 2.0 to Architects and Systems Engineers for IT Systems and Services*, Mr. Walt Okon, Department of Defense, CIO, Enterprise Architecture
- 8971 - *Advancing Systems Engineering Practice using Model Based System Development,* Mr. Sanford Friedenthal, Lockheed Martin Corporation
- 9004 - *Evolving Systems Engineering through Model Driven Functional Analysis,* Dr. Mark Blackburn, Systems and

TRACK 2 - Logistics Systems - Bayview II

- 9063 - *An Integrated RAM Approach to System Design and Support,* Mr. Robert Finlayson, Johns Hopkins University/APL
- 9031 - *Supportability Lessons Learned with Line Replaceable Modules,* Ms. Heity Hsiung, Raytheon Company
- 8908 - *Successful First AESA Deployment through Application of System Engineering,* Mr. Scott Nichols, Raytheon Company
- 9039 - *Applying Systems Engineering to Fielded Weapon Systems and End-Items,* Mr. Michael Ucchino, AF Center for Systems Engineering
- 9008 - *Upgrade Fluid System Filter Element Monitoring To Increase Operational Reliability and Support Condition Based Maintenance Capability,* Mr. Gary Rosenberg, Constellation Technology Corportation
- 8834 - *Tailoring Systems Engineering for Technical Support of Legacy Products,* Mr. Joseph Skandera, BAE Systems
- 9092 - *The role of simulation in tracking mobile assets using RFID technology,* Mr. Swee Leong, National Institute of Standards and Technology

TRACK 3 - Modeling & Simulation - Bayview I

- 8939 - *Understanding the New DoD Instruction 5000.61: "DoD Modeling & Simulation Verification, Validation and Accreditation (VV&A)",* Mr. Michael Truelove, Systems Engineering Directorate, ODDR&E
- 8950 - *Live, Virtual, Constructive Architecture Roadmap: The Quest for Interoperability, Standards, and Reuse,* Dr. Gary Allen, Joint Training Integration & Evaluation Center
- 9048 - *Revisions to the Acquisition Modeling & Simulation Master Plan,* Mr. Stephen Swenson, Systems Engineering Directorate, ODDR&E
- 8759 - *A Systems Engineering Framework for Integrating M&S Development Best Practices,* Dr. Katherine Morse, Johns Hopkins University/APL
- 9052 - Best Practices in Contracting for Models, Simulations, and Associated Data, Mr. Dennis Shea, CNA
- 8947 - *Report on a Study on Management Concepts for Broadly-Needed Modeling and Simulation Tools in the U.S. Department of Defense,* Dr. James Coolahan, Johns Hopkins University/APL
- 8836 - *Producibility Modeling & Simulation Needs for Early Systems Engineering Evaluations of Alternative Design Concepts,* Dr. Al Sanders, Honeywell Aerospace
- 8810 - *Using Simulation to Define and allocate probabilistic Requirements,* Ms. Yvonne Bijan, Lockheed Martin Aeronautics
- 8923 - *Integration of Operational Simulations With Physics-Based Models For Engineering Analysis,* Mr. Stephen Guest, Lockheed Martin Aeronautics

TRACK 4 - Practical Systems Engineering - Mission I

- 8980 - *Using Model-driven Engineering Techniques for Integrated Flight Simulation Development,* Mr. Douglas Fiehler, Raytheon Missile Systems
- 9007 - *Technology Maturation for the Automated Aerial Refueling (AAR) Project*, Ms. Carol Ventresca, SynGenics Corporation
- 8880 - *Naval Postgraduate School Advanced Seabase Enabler Project: A Systems Engineering Case Study,* Mr. Lance Flitter, NSWC, Carderock Division
- 8946 - *Protecting the Mission, Preserving Legacy and Promoting Growth,* Ms. Patti Scaramuzzo, Lockheed Martin Corporation
- 9054 - *A-10 Avionics System Architecture Trade Study and Analysis (AVSATA) Program,* Mr. Richard Sorensen, KIHO Military Acquisition Consulting, Inc.
- 8976 - *A Systems Engineering Model for Roadmap Alignment,* Mr. Si Dok, U. S. Army TARDEC
- 9080 - *Rapid Systems Engineering of the MRAP Gunner Restraint System Saves Lives,* Ms. Michelle Bowen, JPO MRAP
- 9002 - *Key Considerations for Building Highly Available, Mission-Critical Systems,* Mr. Stephen Mills, GoAhead Software

TRACK 5 - Human Systems Integration - Mission II

- 8937 - *Integrating the Human into the system, integrating HSI Tools into Systems Engineering,* Dr. Jennifer Narkevicius, Jenius LLC
- 9064 - *Economics of Human Systems Integration: Early Life Cycle Cost Estimation Using HSI Requirements,* 2ndLt Kevin Liu, USMC, MIT
- *Proccess Management and tool selection to minimize risk of hand-arm vibration syndrome,* Mr. Sherman Forbes, U.S. Air Force

TRACK 5 - Systems Engineering Development Environment - Mission II

- 8945 - *Standards Based Development Environment,* Mr. Christopher Oster, Lockheed Martin Corporation
- 8922 - *The Role of DoD in Systems Engineering Standards and Models,* Mr. Donald Gantzer, Systems Engineering Directorate, ODDR&E
- 8844 - *The Power of the Spec: Understanding the Many Diverse Roles in SE of Good Specifications & Standards.",* Mr. Robert Kuhnen, U.S. Air Force

- 8967 - *Generating Visual and Interactive Output from System Engineering Tools*, Mr. John Schatz, Systems and Proposal Engineering Company
- 9015 - *Challenges and Benefits of applying ISO STEP*, Mr. Stuart Booth, Systems Engineering Directorate, ODDR&E
- 9059 - *Smallsat Conceptual Design Trade and Cost Modeling Tool*, Dr. Deganit Armon, Advatech Pacific, Inc

TRACK 6 - Enterprise Health Management - Mission III

- 8815 - *Applying Systems Engineering to Operational System Improvements*, Ms. Ryanne Gentry, Acquisition Logistics Engineering
- 8842 - *Applications in Integrated Diagnostics*, Mr. Jimmy Simmons, Georgia Tech Research Institute
- 8884 - *Tactical Wheeled Vehicle Integrated Diagnostics*, Mr Lawrence Osentoski, DRIVE Developments, Inc.

TRACK 6 - System of Systems - Mission III

- 8964 - *Software Assurance in a System of Systems World: Interoperability Challenges - Reports from the Field*, Dr. Carol Sledge, SEI
- 8969 - *An Introduction to Influence Maps: Foundations, Construction, and Use*, Mr. James Smith, SEI
- 9024 - *Dynamic Modeling of Programmatic and Systematic*, Dr. Brian Sauser, Purdue University
- 8915 - *System of Systems Challenges and Solutions: Case Study Insights*, Mr. John Colombi, U.S. Air Force Institute of Technology

TRACK 7 - Work Force Development - Palm I

- 8966 - *Improving Systems Engineering Curriculum Using a Competency-Based Assessment Approach*, Ms. Alice Squires, Stevens Institute of Technology
- 9088 - *Enhancing Systems Engineering Competencies in the Enterprise*, Mr. Gary Roedler, Lockheed Martin Corporation
- 8789 - *Achieving Acquisition Excellence via Improving the Systems-Engineering Workforce*, Dr. Kenneth Nidiffer, SEI
- 8926 - *Systems Engineering Workforce Development Update*, Dr. Don Gelosh, Systems Engineering Directorate, ODDR&E
- 9076 - *Assessing Systems Engineering Personnel Competency: Framework and Tool Experience*, Dr. Barry Boehm, University of Southern California
- 8943 - *Team SE Skill Set*, Mr. Charles Garland, U.S. Air Force Center for Systems Engineering
- 8956 - *Systems Engineering Approach to Workforce Development*, Mr. James Miller, U.S. Air Force
- 9046 - *Developing an Introductory Systems Engineering Practitioners Course: "Model-Based Systems Engineering (MBSE) With SysML"*, Mr. Joseph Wolfrom, Johns Hopkins University/APL
- 8878 - *Advanced Simulation Course for Army Simulation Management Professionals*, Dr. Gene Paulo, Naval Postgraduate School

TRACK 8 - Software Intensive Systems - Palm II

- 8977 - *Overview of DoD Software Engineering Initiatives*, Mr. Scott Lucero, Systems Engineering Directorate, ODDR&E
- 8820 - *Graduate Software Engineering Reference Curriculum (GSwERC)*, Ms. Nicole Hutchison, Analytic Services, Inc.
- 8739 - *Quality Assessment of Software-Intensive System Architectures and their Requirements (QUASAR*), Mr. Donald Firesmith, SEI
- 8812 - *A Systems Engineering Approach to Multi-Level Security in a Service Oriented Architecture*, Mr. Timothy Greer, Lockheed Martin Corporation
- 9104 - *Static Code Analysis: Best Practices for Software Assurance in the Acquisition Life Cycle*, Mr. Paul Croll, CSC
- 8996 - *Engineering Improvement in Software Assurance: A Landscape Framework*, Ms. Lisa Brownsword, SEI
- 8802 - *Open Source Technology for Enterprise Health Management*, Mr. Edward Beck, CSC
- 8901 - *Review Results of the NDIA/OSD Software Test Summit/Workshop*, Mr. Thomas Wissink, Lockheed Martin IS&GS
- 9506 - *Software Acquisition Management Practical Experience*, Mr. James Jones, SSAI

▸ CONFERENCE OVERVIEW

The NDIA Systems Engineering conference is focused on improving acquisition and performance of Defense programs and systems, including net-centric operations and data/information interoperability, system-of-systems engineering and all aspects of system sustainment. Convened in San Diego, CA, October 26-29, 2009, 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 the Under Secretary of Defense for Acquisition, Technology and Logistics, Office of the Director, Defense Research & Engineering/Systems Engineering.

▸ 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 & 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.

▸ CONFERENCE OBJECTIVES

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.

▸ 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, Systems Supportability, Raytheon;
Chair, Systems Engineering Division, NDIA,
rcrassa@raytheon.com,
(310) 985-4962

Meeting Planner:
Ms. Suzanne Havelis,
NDIA, shavelis@ndia.org,
(703) 247-2570.

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

▸ ATTIRE

Appropriate dress for this conference is business casual for civilians and class B uniform for military. During conference registration and check-in, each participant will be issued an identification badge. Please be prepared to present a picture ID. Badges must be worn at all conference functions.

▸ 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.

▸ CONTINUING EDUCATION UNIT CREDIT

NDIA is offering CEU credit options for the Systems Engineering Conference. For more information, please contact Ms. Suzanne Havelis at 703.247.2570 or shavelis@ndia.org.

▸ 2010 CALL FOR PAPERS INFORMATION

The primary objective of the 13th 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/1870

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 AGENDA

SUNDAY, OCTOBER 25, 2009

5:00 pm - 7:00 pm	**REGISTRATION FOR TUTORIALS AND GENERAL CONFERENCE**

MONDAY, OCTOBER 26, 2009

7:00 am - 6:00 pm	**REGISTRATION**
7:00 am - 8:00 am	**CONTINENTAL BREAKFAST (FOR TUTORIAL ATTENDEES ONLY)**
8:00 am - 12:00 pm	**TUTORIAL TRACKS**
9:45 am - 10:15 am	**MORNING BREAK (FOR TUTORIAL ATTENDEES ONLY)**
12:00 pm - 1:00 pm	**LUNCH (FOR TUTORIAL ATTENDEES ONLY)**
1:00 pm - 5:00 pm	**TUTORIAL TRACKS CONTINUED**
2:45 pm - 3:15 pm	**AFTERNOON BREAK (FOR TUTORIAL ATTENDEES ONLY)**
5:00 pm - 6:00 pm	**RECEPTION IN THE REGATTA PAVILION - OPEN TO ALL CONFERENCE ATTENDEES**

TUESDAY, OCTOBER 27, 2009

7:15 am - 7:00 pm	**REGISTRATION**
7:15 am - 8:15 am	**CONTINENTAL BREAKFAST IN THE REGATTA PAVILION**
8:15 am - 8:30 am	**PLENARY SESSION 1 - INTRODUCTION & OPENING REMARKS** ▸ Mr. Sam Campagna, *Director, Operations, NDIA* ▸ Mr. Bob Rassa, *Director, Systems Supportability, Raytheon*; *Chair, Systems Engineering Division, NDIA*
8:30 am - 9:30 am	**KEYNOTE** ▸ Honorable Zachary J. Lemnios, *Director, Defense Research and Engineering, Office of the Under Secretary of Defense (Acquisition, Technology and Logistics)*
9:30 am - 10:00 am	**MORNING BREAK IN THE REGATTA PAVILION**
10:00 am - 12:00 pm	**PLENARY SESSION 2 - ACQUISITION EXECUTIVES PANEL** ***View from the Top: How Can SE Support Program Execution?*** **Moderator:** Mr. Terry Jaggers, *Principal Deputy, Systems Engineering, Office of the Director, Defense Research and Engineering* ▸ Mr. David G. Ahern, *Director, Portfolio Systems Acquisition, Office of the Under Secretary of Defense (Acquisition, Technology and Logistics)* ▸ Mr. Thomas E. Mullins, *Deputy Assistant Secretary for Plans, Programs, and Resources (SAAL-ZR), Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology)* ▸ Mr. Christopher A. Miller, *PEO for Command, Control, Communications, Computers and Intelligence (C4I), U.S. Navy* ▸ Mr. Randall G. Walden, *Director, Information Dominance Programs, Office of the Assistant Secretary of the Air Force (Acquisition)*
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 27, 2009 - CONTINUED

1:30 pm - 3:15 pm

PLENARY SESSION 3 - TEST & EVALUATION EXECUTIVES PANEL

View from the Top: How SE Can Support Test and Evaluation?

Moderator: Mr. Jim O'Bryon, *The O'Bryon Group; Chair, NDIA Test and Evaluation Division*

- Dr. James N. Streilein, *Technical Advisor, HQ Army Test & Evaluation Command*
- Ms. Amy Markowich, *Deputy DoN T&E Executive*
- Colonel Dexter M. Sapinoso, USAF, *Chief of Air Force Test and Evaluation Policy and Programs*
- Mr. Christopher DiPetto, *Acting Director, DevelopmentalTest and Evaluation, Office of the Director, Defense Research and Engineering*

3:15 pm - 3:30 pm

AFTERNOON BREAK IN THE REGATTA PAVILION

3:30 pm - 5:15 pm

PLENARY SESSION 4 - SE AND ACQUISITION REFORM: THE WAY AHEAD

Moderator: Mrs. Kristen Baldwin, *Systems Engineering Directorate, Office of the Director, Defense Research and Engineering*

- Mr. Ross Guckert, *Office of the Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT))*
- Mr. Carl Siel, *Office of the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RDA)CHSENG)*
- Colonel Shawn Shanley, USAF, *Chief Systems Engineer, Office of the Assistant Secretary of the Air Force for Acquisition, Science, Technology, and Engineering (SAF/AQR)*
- Mr. Nicholas Torelli, *Systems Engineering Directorate, Office of the Director, Defense Research and Engineering*

5:30 pm - 7:00 pm

RECEPTION IN THE REGATTA PAVILION

WEDNESDAY, OCTOBER 28, 2009

7:00 am - 5:15 pm	**REGISTRATION**
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	**AWARDS LUNCH IN THE REGATTA PAVILION**
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 29, 2009

7:00 am - 3:00 pm	**REGISTRATION**
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 - 1:00 pm	**LUNCH IN THE REGATTA PAVILION**
1:00 pm - 3:00 pm	**CONCURRENT SESSIONS -** *Please refer to the following pages for session schedule*
3:00 pm	**CONFERENCE ADJOURNS**

MONDAY, OCTOBER 26, TUTORIAL SESSIONS

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	8819 - 1A8 - Tutorial: Rethinking Risk Management Ms. Audrey Dorofee, SEI/CMU	8819 - 1B8 - Tutorial: Rethinking Risk Management Ms. Audrey Dorofee, SEI/CMU	8877 - 1C8 - Tutorial: Best Practices in Modeling and Simulation Dr. Gene Paulo, Naval Postgraduate School	8877 - 1D8 - Tutorial: Best Practices in Modeling and Simulation Dr. Gene Paulo, Naval Postgraduate School
TRACK 7 Palm I	8785 - 1A7 - Tutorial: Agile Development in Defense Acquisition Dr. Peter Hantos, The Aerospace Corporation	8785 - 1B7 - Tutorial: Agile Development in Defense Acquisition Dr. Peter Hantos, The Aerospace Corporation	8801 - 1C7 - Tutorial: Integrating SE with Earned Value Management Mr. Paul Soloman, Performance-Based Earned Value	8801 - 1C7 - Tutorial: Integrating SE with Earned Value Management Mr. Paul Soloman, Performance-Based Earned Value
TRACK 6 Mission III	9078 - 1A6 - Tutorial: Organizational Implications of SoS Ms. Suzanne Garcia, SEI/CMU	9078 - 1B6 - Tutorial: Organizational Implications of SoS Ms. Suzanne Garcia, SEI/CMU	8782 - 1C6 - Tutorial: Technology Transition and the Defense Acquisition System Mr. William Decker, DAU	8782 - 1C6 - Tutorial: Technology Transition and the Defense Acquisition System Mr. William Decker, DAU
TRACK 5 Mission II	8984 - 1A5 - Tutorial: How to use Lean SE Processes to Save Time and Money Mr. Tim Olson, Lean Solutions Institute, Inc.	8984 - 1B5 - Tutorial: How to use Lean SE Processes to Save Time and Money Mr. Tim Olson, Lean Solutions Institute, Inc.	9072 - 1C5 - Tutorial: Leveraging the Defense Acq Program Support (DAPS) Methodology to Conduct Program Assessment Mr. Peter Nolte, Systems Engineering Directorate, ODDR&E	9072 - 1D5 - Tutorial: Leveraging the Defense Acq Program Support (DAPS) Methodology to Conduct Program Assessment Mr. Peter Nolte, Systems Engineering Directorate, ODDR&E
TRACK 4 Mission I	9035 - 1A4 - Tutorial: Collaborative Decision Making Dr. Tommer Ender, Georgia Tech Research Institute	9035 - 1B4 - Tutorial: Collaborative Decision Making Dr. Tommer Ender, Georgia Tech Research Institute	8931 - 1C4 - Tutorial: Role of Mentoring in Developing the Sys Eng Workforce Mr. Nicholas Torelli, Systems Engineering Directorate, ODDR&E	8931 - 1D4 - Tutorial: Role of Mentoring in Developing the Sys Eng Workforce Mr. Nicholas Torelli, Systems Engineering Directorate, ODDR&E
TRACK 3 Bayview I	8955 - 1A3 -Tutorial: Early Sys Thinking and Planning in WPN Sys Concept Phase Mr. Jeff Loren, SAF/AQR (Alion Science & Technology)	8955 - 1B3 -Tutorial: Early Sys Thinking and Planning in WPN Sys Concept Phase Mr. Jeff Loren, SAF/AQR (Alion Science & Technology)	9040 - 1C3 - Tutorial: Implementing the Materiel Availability KPP in DoD Acquisition Programs Mr. Grant Schmieder, Systems Engineering Directorate, ODDR&E	9040 - 1D3 - Tutorial: Implementing the Materiel Availability KPP in DoD Acquisition Programs Mr. Grant Schmieder, Systems Engineering Directorate, ODDR&E
TRACK 2 Bayview II	8779 - 1A2 - Tutorial: Mission Based Test and Eval Strategy: Case Study Mr. Christopher Wilcox, U.S. Army Test and Evaluation Command	8779 - 1B2 - Tutorial: Mission Based Test and Eval Strategy: Case Study Mr. Christopher Wilcox, U.S. Army Test and Evaluation Command	8818 - 1C2 - Tutorial: Integrated Testing Enhances SE Dr. Beth Wilson, Raytheon Company	8818 - 1D2 - Tutorial: Integrated Testing Enhances SE Dr. Beth Wilson, Raytheon Company
TRACK 1 Bayview III	8736 -1A1 - Tutorial: Framework of Engineering Architectures Mr. Donald Firesmith, SEI	8736 - 1B1 - Tutorial: Framework of Engineering Architectures Mr. Donald Firesmith, SEI	8992 -1C1 -Tutorial: SoS Quality Attribute Specification and Architecture Evaluation Mr. Michael Gagliardi, SEI	8992 -1D1 -Tutorial: SoS Quality Attribute Specification and Architecture Evaluation Mr. Michael Gagliardi, SEI

WEDNESDAY, 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 8 Net-Centric Operations/ Interoperability Palm II	**Mr. Jack Zavin**, *ASD (NII)*	8780 - Net-Centric Best Practices Mr. Hiekeun Ko, JPEO-CBD - Software Support Activity	8788 - Data sharing in a Stability Operations Community of Interest: Utilizing a pilot program to prove concepts and develop trust. Mr. Gerald Christman, Femme Comp Inc.	8853 - C4I Architecture for Joint ASW Mr. Gregory Miller, Naval Postgraduate School	TRACK 8 Net-Centric Operations/ Interoperability Palm II	**Mr. Jack Zavin**, *ASD (NII)*	8929 - Extending Net-Centric Quality of Service to Systems of Systems Maj Vinod Naga, USAF, Air Force Institute of Technology	9081 - Testing in Service-oriented Environments Mr. Soumya Simanta, SEI	8913 - Linking Interoperability and Measures of Effectiveness: A Method for Evaluating Architectures Dr. David Jacques, Air Force Institute of Technology
TRACK 7 Program Management Palm I	**Mr. Hal Wilson**, *Northrop Grumman Corporation* and **Ms. Dona Lee**, *Systems Engineering Directorate,*	9003 - CMMI® for Executives Mr. Geoff Draper, Harris Corporation	9034 - Sustainment and Continued Institutionalization of Best Practices and CMMI® at SPAWAR Mr. Michael Kutch, SPAWAR Systems Center Atlantic	9065 - Rapidly Implementing Lean CMMI® Processes That Meet Business Needs Mr. Tim Olson, Lean Solutions Institute, Inc	TRACK 7 Program Management Palm I	**Mr. Hal Wilson**, *Northrop Grumman Corporation* and **Ms. Dona Lee**, *Systems Engineering Directorate, ODDR&E*	8982 - Systemic Root Cause Analysis – Driving Improvements into the Acquisition Process Mr. Peter Nolte, Systems Engineering Directorate, ODDR&EE)	8791 - Cost and Risk Impacts of the New DOD 5000 Defense Acquisition Framework Dr. Peter Hantos, The Aerospace Corporation	8895 - A Comprehensive Review of Maturity Assessment Approaches for Improved Defense Acquisition Ms. Nazanin Azizian, The George Washington University
TRACK 6 System of Systems Mission III	**Dr. Judith Dahman**, *Systems Engineering Directorate, ODDR&E/ MITRE* and **Mr. John Palmer**, *Boeing*	NDIA SoS Committee Report Dr. Judith Dahman, Systems Engineering Directorate, ODDR&E/ MITRE	8960 - A Distillation of Lessons Learned from Complex System of Systems Acquisitions Dr. Richard Turner, Stevens Institute	8784 - Establishing a Departmental-Level Systems-of-Systems Engineering Management Construct for the Department of the Navy, Progress Report Mr. John Kevin Smith, Asst Sec of the Navy for RD&A, Chief Engineer	TRACK 6 System of Systems Mission III	**Dr. Judith Dahman**, *Systems Engineering Directorate, ODDR&E/ MITRE* and **Mr. John Palmer**, *Boeing*	8840 - Naval Systems of Systems Engineering Guidebook Update Ms. Melinda Reed, DoD (ASN RDA CHSENG)	8942 - DoD Systems of Systems Update Dr. Judith Dahmann, Systems Engineering Directorate, ODDR&E/ MITRE	8961 - Engineering Systems of Systems: An Integration Perspective Dr. Emmett Maddry, NSWCDD
TRACK 5 Human Systems Integration Mission II	**Mr. Stuart Booth**, *Systems Engineering Directorate, ODDR&E*	8975 - What is Human Systems Integration (HSI) and why should we do it? Mr. Stuart Booth, Systems Engineering Directorate, ODDR&E	9042 - Bounding the Human Within the System Mr. Michael Mueller, U.S. Air Force Center for Systems Engineering	8829 - The Army Health Hazard Assessment Program's Medical Cost Avoidance Model Dr. Timothy A. Kluchinsky, Department of Army	TRACK 5 System Safety - ESOH Mission II	**Mr. Sherman Forbes**, *U.S. Air Force*	9070 - Improving Safety Technology Insertion in DoD Acquisition Programs Dr. Elizabeth Rodriguez-Johnson, Systems Engineering Directorate, ODDR&E	9094 - DoD Green Procurement Program Update and Path Forward Mr. David Asiello, Office of the Secretary of Defense	9091 - Environment, Safety, and Occupational Health (ESOH) Risk and Technology Requirements Reporting at Acquisition Program Reviews Ms. Lucy Rodriguez, Booz Allen Hamilton

TRACK 4 Test and Evaluation Mission I	**Dr. Beth Wilson**, *Raytheon Company*	8848 - Integrated Testing: We Can Do It Dr. Beth Wilson, Raytheon Company	8882 - Test & Evaluation Strategy for the Technology Development Phase Ms. Darlene Mosser-Kerner, OUSD(AT&L)/ DDR&E/DT&E	8883 - Test & Evaluation Products for the Systems Engineering Reviews Mr. Woody Eischens, OUSD(AT&L)/ DDR&E/DT&E	TRACK 4 Test and Evaluation Mission I	**Dr. Beth Wilson**, *Raytheon Company*	8814 - Joint Mission Environment Test Capability (JMETC), Lowering technical Risk by Improving Distributed Test Capabilities Mr. Chip Ferguson, JMETC	8901 - Review Results of the NDIA/OSD Software Test Summit/ Workshop Mr. Thomas Wissink, Lockheed Martin IS&GS	
TRACK 3 Technology Maturity Bayview I	**Mr. Bill Nolte**, *WPAFB* and **Mr. James Malas**, *U.S. Air Force Research Laboratory*	8916 - System Readiness - Assessing Technical Risk Throughout the Lifecycle Mr. James Thompson, Systems Engineering Directorate, ODDR&E	8963 - Air Force Concept Maturity Assessment Mr. George Freeman, U.S. Air Force, Center for Systems Engineering	8900 - DOD's Weapon System Portfolio: Are Results Getting Any Better? Mr. Michael Sullivan, U.S. Government Accountability Office	TRACK 3 Technology Maturity Bayview I	**Mr. Bill Nolte**, *WPAFB* and **Mr. James Malas**, *U.S. Air Force Research Laboratory*	8894 - Air Force Initiative – High Confidence Technology Transition Planning Through the Use of Stage-Gates – Update Mr. Randy Bullard, U.S. Air Force Materiel Command	8833 - Communicating Risk: Air Force RI3 Methodology Mr. John Cargill, AF Cost Analysis Agency	8891 - A comprehensive overview of techniques for measuring system readiness Mr. James Bilbro, JB Consulting International
TRACK 2 Early System Engineering Bayview II	**Mr. John Lohse**, *Raytheon Company* and **Mr. Jeff Loren**, *SAF/AQR (Alion Science & Technology)*	Panel Topic: 8924, 8925 , 8933 - Early Systems Engineering in DoDI 5000.02 Dr. Judith Dahmann, Ms. Lisa Reuss, Systems Engineering Directorate, ODDR&E		Q&A: 8924, 8925 , 8933 - Early Systems Engineering in DoDI 5000.02 Dr. Judith Dahmann, Ms. Lisa Reuss, Systems Engineering Directorate, ODDR&E	TRACK 2 Early System Engineering Bayview II	**Mr. John Lohse**, *Raytheon Company* and **Mr. Jeff Loren**, *SAF/AQR (Alion Science & Technology)*	8949 - Updated DoD 5000 and CJCS 3170 Policies: A Requirements to Acquisition Gap Analysis Mr. John Lohse, Raytheon Company	8813 - Emerging Roles for Systems Engineering in Defense Decision Making; Better Aligning Requirements and Acquisition with the Budget and Security Environments Mr. Vincent Roske, Institute for Defense Analyses	9026 - Early SE Determination of Best-Fit System Life Cycle Processes Dr. Barry Boehm, USC
TRACK 1 Systems Engineering Effectiveness Bayview III	**Mr. Al Brown**, *The Boeing Company*	8816 - Mind the GAPs-a Systems Engineering Implementation of DoDI 5000.02 Dr. Thomas Christian, U. S. Air Force	8990 - Systems Engineering for Rapid Capability Development Mr. Thomas McDermott, Georgia Tech Research Institute	8974 - Transforming Systems and Software Engineering Across an Enterprise Mr. Jeffery Wilcox, Lockheed Martin Corporation	TRACK 1 Systems Engineering Effectiveness Bayview III	**Mr. Al Brown**, *The Boeing Company*	8863 - Using Requirements Compliance to Identify Gaps Between the Technical Solution and Requirements Mr. Frank Salvatore, High Performance Technologies, Inc.	8823 - Win and Influence Design Engineers---Change Their Affordability DNA Mr. Tim Morrill, Raytheon Company	8839 - Navy Systems Engineering Technical Review Process Ms. Melinda Reed, DoD (ASN RDA CHSENG)

WEDNESDAY, OCTOBER 28, CONCURRENT SESSIONS

TRACK	SESSION CHAIR	1:30 PM	2:05 PM	2:40 PM	TRACK	SESSION CHAIR	3:30 PM	4:05PM	4:40 PM
TRACK 8 Net-Centric Operations/Interoperability Palm II	**Mr. Jack Zavin,** *ASD (NII)*	8874 - The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems Mr. John Palmer, The Boeing Company	9010 - Network Enabled Weapons, A System Engineering Approach to Achieve Interoperabilty Mr. Andrew Lieux, Naval Air Warfare Center Weapons Division	8854 - Human Interoperability Enterprise and Net Centric Operations **Mr. Jack Zavin,** *ASD (NII)*	TRACK 8 Speciality Engineering Palm II	**Mr. Joel Moorvitch,** *Raytheon Company*	8944 - DoD's Refocus on Specialty Engineering (Reliability, Availability and Maintainability; Producibility and Quality, Supportability, Safety and Human Systems Integration) Mr. Chester Bracuto, Systems Engineering Directorate, ODDR&E	9043 - Implementing the Materiel Availability KPP in DoD acquisition programs—balancing life-cycle costs with warfighter needs Mr. Grant Schmieder, Systems Engineering Directorate, ODDR&E	8873 - IUID enables streamlined acquisition and system engineering Mr. Robert Leibrandt, DoD UID Policy Office 8958 - Security Systems Engineering Mrs. Kristen Baldwin, Systems Engineering Directorate, ODDR&E
TRACK 7 Program Management Palm I	**Mr. Hal Wilson,** *Northrop Grumman Corporation* and ***Ms. Dona Lee,*** *Systems Engineering Directorate, ODDR&E*	8979 - Boots on the Ground: Tactical Planning at Program Start Up Mr. Gerry Becker, Harris Corporation	8999 - Acquisition Program Technical Measurement Mr. James Thompson, Systems Engineering Directorate, ODDR&E	9103 - The Economics of CMMI Mr. Geoff Draper, Harris Corporation	TRACK 7 Program Management Palm I	**Mr. Hal Wilson,** *Northrop Grumman Corporation* and **Ms. Dona Lee,** *Systems Engineering Directorate, ODDR&E*	8995 - Integrated Systems Engineering and Developmental Test and Evaluation Mr. Chris DiPetto, OUSD(AT&L)/ DDR&E/DT&E	9021 - Critical Success Factors for Milestone Review Risk Identification Dr. Barry Boehm, USC	9030 - Lessons Learned in Motivating Software Engineering Process Group to Focus on Achieving Business Goals and Not on Just Achieving a Maturity Level Mr. Girish Seshagiri, Advanced Information Services Inc.
TRACK 6 System of Systems Mission III	**Dr. Judith Dahman,** *Systems Engineering Directorate, ODDR&E/MITRE* and **Mr. John Palmer,** *Boeing*	8898 - Designing Collaborative Systems of Systems in support of Multi-sided Markets Mr. Philip Boxer, SEI	8892 - SysML Strategies to Characterize and Analyze Systems of Systems Dr. Jo Ann Lane, University of Southern California	9041 - On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems Dr. Jack Zentner, Georgia Tech Research Institute	TRACK 6 System of Systems Mission III	**Dr. Judith Dahman,** *Systems Engineering Directorate, ODDR&E/MITRE* and **Mr. John Palmer,** *Boeing*	9060 - M&S Support for SoS SE Dr.Joann Lane, USC	8776 - The Modular SOS Paradigm: an Availability Paradox? Mr. Peter Gentile, Northrop Grumman Corporation	8866 - Extending FMECA to Systems of Systems Mr. Leopoldo Mayoral, Johns Hopkins University/APL
TRACK 5 Human Systems Integration Mission II	**Mr. Stuart Booth,** *Systems Engineering Directorate, ODDR&E*	8998 - Human Systems Integration – Ensuring the Human is Considered "Left of A" Col Larry Kimm, USAF, U.S Air Force	8885 - Human Systems Integration (HSI) - Integrating Human Concerns into Life Cycle Systems Engineering Ms. Cynthia Shewell, Booz Allen Hamilton	9012 - Human Systems Integration: Defining and Validating a Framework for Enhanced Systems Development Dr. Matthew Risser, Pacific Science & Engineering Group	TRACK 5 System Safety - ESOH Mission II	**Mr. Sherman Forbes,** *U.S. Air Force*	9095 - Acquisition ESOH Risk Management and HAZMAT Management Part I: Hazardouse Materials Management Plan Ms. Lucy Rodriguez, Booz Allen Hamilton	8890 - Building Safer UGVs with Run-time Safety Invariants Mr. Michael Wagner, Carnegie Mellon University, NREC	882D - Overview of Draft MIL-STD-882D With Change 1 Mr. Bob Smith, Booz Allen Hamilton

TRACK 4 Test and Evaluation of SoS Mission I	**Dr. Beth Wilson**, *Raytheon Company*	8825 - Test and Evaluation in a System of Systems Environment Mr. Edwin McDermott, 653 ELSW, Electronic Systems Center	8849 - Joint Integration and Interoperability Lab (JSIIL) Mr. Steven Whitehead, SL, J8 Technical Director, USJFCOM	8935 - Systems of Systems Systems Engineering and Test and Evaluation Dr. Judith Dahmann, Systems Engineering Directorate, ODDR&E/ MITRE	TRACK 4 Practical Systems Engineering Mission I	**Mr. Dana Peterson**, *DRS Technologies, Inc.*	9014 - SAVI: Aerospace Platform Development and Certification Using Modeling and Simulation to "Integrate, then Build" Mr. Gregory Pollari, Rockwell Collins	8855 - Certify and Fly Right: Preparing for DO-297 Certification Mr. Ketih Custer, Esterline Control Systems-AVISTA	8973 - C-17 Transition to Criteria-based Airworthiness Certification Mr. Christian Stillings, USAF 516 AESG
TRACK 3 Technology Maturity Bayview I	**Mr. Bill Nolte**, *WPAFB* and **Mr. James Malas**, *U.S. Air Force Research Laboratory*	8991 - Systems Engineering for the Science & Technology Community Mr. Russell Menko, U. S. Army RDECOM/TARDEC	9017 - Linking Systems Engineering Artifacts with Complex Systems Maturity Assessments Dr. Brian Sauser, Stevens Institute of Technology	8770 - Incorporating Maturity Assessment into House of Quality for Improved Decision Support Analysis and Risk Management Mr. Pavel Fomin, U.S. Air Force	TRACK 3 Technology Maturity Bayview I	**Mr. Bill Nolte**, *WPAFB* and **Mr. James Malas**, *U.S. Air Force Research Laboratory*	8798 - The New Technology Readiness Assessment Process Dr. Jay Mandelbaum, Institute for Defense Analyses	8870 - S&T Portfolio Maturity & Performance Analysis: The Concept of Critical Research Elements Mr. Has Patel, Infologic, Inc.	8879 - TRL Vectors in IPPD-based Portfolio Management Mr. Michael Bartmess, General Dynamics/AIS
TRACK 2 Early System Engineering Bayview II	**Mr. John Lohse**, *Raytheon Company* and **Mr. Jeff Loren**, *SAF/AQR (Alion Science & Technology)*	8951 - USAF View of NRC "Pre-A Systems Engineering" Study Committee Recommendations As Addressed By Levin-McCain (P.L. 111-23; "Weapon Systems Acquisition Reform Act of 2009") Mr. Jeff Loren, SAF/AQR (Alion Science & Technology)	8846 - Air Force Materiel Command Early Systems Engineering Dr. Brian Kowal, USAF	9016 - A Framework for Enhancing Forward-looking Capability Delivery Metrics Mr. Leonard Sadauskas, DoD CIO CT&S	TRACK 2 Early System Engineering Bayview II	**Mr. John Lohse**, *Raytheon Company* and **Mr. Jeff Loren**, *SAF/AQR (Alion Science & Technology)*	9082 - Including Environment, Safety, and Occupational Health (ESOH) Requirements in Joint Capabilities Integration and Development System (JCIDS) Documents Mr. Sherman Forbes, U.S. Air Force	8835 - T&E Collaboration and Contributions during Early Program Acquisition Mr. Stephen Scukanec, Northrop Grumman Corporation Aerospace Systems	8795 - Mission-based Test and Evaluation Strategy: Creating Linkages between Technology Development and Mission Capability Mr. John Beilfuss, U.S. Army Research Laboratory
TRACK 1 Systems Engineering Effectiveness Bayview III	**Mr. Al Brown**, *The Boeing Company*	8851 - Rapid Development and Integration of Remote Weapon Systems to Meet Operational Requirements Mr. Joseph Burkart, NSWC Crane, Small Arms Air Platform Integration	8893 - Rapid Development Mr. Michael Gaydar, NAVAIR	8847 - Tailoring the SE Process to Effectively Complement the SW Agile Development Process Mr. William Lyders, ASSETT Inc.	TRACK 1 Systems Engineering Effectiveness Bayview III	**Mr. Al Brown**, *The Boeing Company*	8902 - Systems Engineering Leading Indicators: Insight into Effective Systems Engineering Mr. Gary Roedler, Lockheed Martin Corporation	9414 - Correcting Deficiencies in the Systems Engineering of Tactical Weapons Mr. Marvin Ebbert, Raytheon Missile Systems	8948 - Value Engineering Applications in Service Contracts Dr. Jay Mandelbaum, Value Engineering Applications in Service Contracts

THURSDAY, OCTOBER 29, 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 8 Software Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* and **Mr. Scott Lucero,** *Systems Engineering Directorate, ODDR&E*	8977 - Overview of DoD Software Engineering Initiatives Mr. Scott Lucero, Systems Engineering Directorate, ODDR&E	8820 - Graduate Software Engineering Reference Curriculum (GSwERC) Ms. Nicole Hutchison, Analytic Services, Inc.	8739 - Quality Assessment of Software-Intensive System Architectures and their Requirements (QUASAR) Mr. Donald Firesmith, SEI	TRACK 8 Software Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* and **Mr. Scott Lucero,** *Systems Engineering Directorate, ODDR&E*	8812 - A Systems Engineering Approach to Multi-Level Security in a Service Oriented Architecture Mr. Timothy Greer, Lockheed Martin Corporation	9104 - Static Code Analysis: Best Practices for Software Assurance in the Acquisition Life Cycle Mr. Paul Croll, CSC	8996 - Engineering Improvement in Software Assurance: A Landscape Framework Ms. Lisa Brownsword, SEI
TRACK 7 Work Force Development Palm I	**Dr. Don Gelosh,** *Systems Engineering Directorate, ODDR&E* and **Mr. Mike Ucchino,** *U.S. Air Force Center for Systems Engineering*	8926 - Systems Engineering Workforce Development Update Dr. Don Gelosh, Systems Engineering Directorate, ODDR&E	9076 - Assessing Systems Engineering Personnel Competency: Framework and Tool Experience Dr. Barry Boehm, University of Southern California	8943 - Team SE Skill Set Mr. Charles Garland, U.S. Air Force Center for Systems Engineering	TRACK 7 Work Force Development Palm I	**Dr. Don Gelosh,** *Systems Engineering Directorate, ODDR&E* and **Mr. Mike Ucchino,** *U.S. Air Force Center for Systems Engineering*	8966 - Improving Systems Engineering Curriculum Using a Competency-Based Assessment Approach Ms. Alice Squires, Stevens Institute of Technology	9088 - Enhancing Systems Engineering Competencies in the Enterprise Mr. Gary Roedler, Lockheed Martin Corporation	8789 - Achieving Acquisition Excellence via Improving the Systems-Engineering Workforce Dr. Kenneth Nidiffer, SEI
TRACK 6 System of Systems Mission III	**Dr. Judith Dahman,** *Systems Engineering Directorate, ODDR&E/ MITRE* and **Mr. John Palmer,** *Boeing*	9083 - Requirements Engineering for Systems of Systems Mr. Soumya Simanta, SEI	8964 - Software Assurance in a System of Systems World: Interoperability Challenges - Reports from the Field Dr. Carol Sledge, SEI	8969 - An Introduction to Influence Maps: Foundations, Construction, and Use Mr. James Smith, SEI	TRACK 6 System of Systems Mission III	**Dr. Judith Dahman,** *Systems Engineering Directorate, ODDR&E/ MITRE* and **Mr. John Palmer,** *Boeing*	9024 - Dynamic Modeling of Programmatic and Systematic Dr. Brian Sauser, Purdue University	8903 - Global Earth Observation System of Systems (GEOSS) Mr. Lawrence McGovern, Northrop Grumman Electronic Systems	8915 - System of Systems Challenges and Solutions: Case Study Insights Mr. John Colombi, U.S. Air Force Institute of Technology
TRACK 5 Human Systems Integration Mission II	**Mr. Stuart Booth,** *Systems Engineering Directorate, ODDR&E*	8937 - Integrating the Human into the system, integrating HSI Tools into Systems Engineering Dr. Jennifer Narkevicius, Jenius LLC	9064 - Economics of Human Systems Integration: Early Life Cycle Cost Estimation Using HSI Requirements 2ndLt Kevin Liu, USMC, MIT	Process management and tool selection to minimize risk of hand-arm vibration syndrome Mr. Sherman Forbes, U.S. Air Force	TRACK 5 Systems Engineering Development Environment Mission II	**Mr. Al Brown,** *The Boeing Company*	8945 - Standards Based Development Environment Mr. Christopher Oster, Lockheed Martin Corporation	8922 - The Role of DoD in Systems Engineering Standards and Models Mr. Donald Gantzer, Systems Engineering Directorate, ODDR&E	8844 - The Power of the Spec: Understanding the Many Diverse Roles in SE of Good Specifications & Standards." Mr. Robert Kuhnen, U.S. Air Force

TRACK 4 Practical Systems Engineering Mission I	**Mr. Dana Peterson,** *DRS Technologies, Inc.*	8875 - Tomahawk Weapon System Development and Integration Mr. Gustavo Rivera, Naval Surface Warfare Center, Dahglren Division	8980 - Using Model-driven Engineering Techniques for Integrated Flight Simulation Development Mr. Douglas Fiehler, Raytheon Missile Systems	9007 - Technology Maturation for the Automated Aerial Refueling (AAR) Project Ms. Carol Ventresca, SynGenics Corporation	TRACK 4 Practical Systems Engineering Mission I	**Mr. Dana Peterson,** *DRS Technologies, Inc.*	8880 - Naval Postgraduate School Advanced Seabase Enabler Project: A Systems Engineering Case Study Mr. Lance Flitter, NSWC, Carderock Division	8946 - Protecting the Mission, Preserving Legacy and Promoting Growth Ms. Patti Scaramuzzo, Lockheed Martin Corporation	9054 - A-10 Avionics System Architecture Trade Study and Analysis (AVSATA) Program Mr. Richard Sorensen, KIHO Military Acquisition Consulting, Inc.
TRACK 3 Modeling & Simulation Bayview I	**Mr. Jim Coolahan, JHU/APL**	8939 - Understanding the New DoD Instruction 5000.61: "DoD Modeling & Simulation Verification, Validation and Accreditation (VV&A)" Mr. Michael Truelove, Systems Engineering Directorate, ODDR&E	8950 - Live, Virtual, Constructive Architecture Roadmap: The Quest for Interoperability, Standards, and Reuse Dr. Gary Allen, Joint Training Integration & Evaluation Center	9048 - Revisions to the Acquisition Modeling & Simulation Master Plan Mr. Stephen Swenson, Systems Engineering Directorate, ODDR&E	TRACK 3 Modeling & Simulation Bayview I	**Mr. Jim Coolahan, JHU/APL**	8759 - A Systems Engineering Framework for Integrating M&S Development Best Practices Dr. Katherine Morse, Johns Hopkins University/APL	9052 - Best Practices in Contracting for Models, Simulations, and Associated Data Mr. Dennis Shea, CNA	8947 - Report on a Study on Management Concepts for Broadly-Needed Modeling and Simulation Tools in the U.S. Department of Defense Dr. James Coolahan, Johns Hopkins University/APL
TRACK 2 Logistics Systems Bayview II	**Mr. Joel Moorvitch,** *Raytheon Company* and **Mr. Anthony Stampone,** *OSD-ATL*	9063 - An Integrated RAM Approach to System Design and Support Mr. Robert Finlayson, Johns Hopkins University/APL	9031 - Supportability Lessons Learned with Line Replaceable Modules Ms. Heity Hsiung, Raytheon Company	8908 - Successful First AESA Deployment through Application of System Engineering Mr. Scott Nichols, Raytheon Company	TRACK 2 Logistics Systems Bayview II	**Mr. Joel Moorvitch,** *Raytheon Company* and **Mr. Anthony Stampone,** *OSD-ATL*	8988 - How to Save Time and Money Using Lean Maintenance Processes Mr. Tim Olson, Lean Solutions Institute, Inc.	9039 - Applying Systems Engineering to Fielded Weapon Systems and End-Items Mr. Michael Ucchino, AF Center for Systems Engineering	9008 - Upgrade Fluid System Filter Element Monitoring To Increase Operational Reliability and Support Condition Based Maintenance Capability Mr. Gary Rosenberg, Constellation Technology Corportation
TRACK 1 Systems Engineering Effectiveness Bayview III	**Mr. Al Brown,** *The Boeing Company*	8887 - Achieving a Systems Engineering Culture in a Science and Technology Laboratory Environment Mr. Robert Rapson, Materials and Manufacturing Directorate, AFRL	8920 - A Methodology for Assessing Systems Engineering Practices Ms. Lauren Levy, Johns Hopkins University/APL	9097 - Acquisition ESOH Risk Management-How to Make It Work Mr. Bob Smith, Booz Allen Hamilton	TRACK 1 Architecture Bayview III	**Mr. Joe Kuncel,** *Northrop Grumman Corporation*	8831 - Human-Centered Design in Systems Engineering: Human View Methodology Dr. Robert Smillie, SPAWAR	8830 - Systems Engineering Needs of the DoDAF – Report of the Architecture Frameworks Working Group Mr. Joe Kuncel, Northrop Grumman Corporation	8824 - Delivering DoDAF Version 2.0 to Architects and Systems engineers for IT Systems and Services Mr. Walt Okon, Department of Defense CIO, Enterprise Architecture

THURSDAY, OCTOBER 29, CONCURRENT SESSIONS

TRACK	SESSION CHAIR	1:00 PM	1:35 PM	2:10 PM
TRACK 8 Software Intensive Systems Palm II	**Mr. Paul Croll,** *CSC* and **Mr. Scott Lucero,** *Systems Engineering Directorate, ODDR&E*	8802 - Open Source Technology for Enterprise Health Management Mr. Edward Beck, CSC	8901 - Review Results of the NDIA/OSD Software Test Summit/Workshop Mr. Thomas Wissink, Lockheed Martin IS&GS	9506 - Software Acquisition Management Practical Experience Mr. James Jones, SSAI 0000 - Implementing CMMI on a COTS Modification Effort Mr. Dave Castellano, U.S. Army
TRACK 7 Work Force Development Palm I	**Dr. Don Gelosh,** *Systems Engineering Directorate, ODDR&E* and **Mr. Mike Ucchino,** *U.S. Air Force Center for Systems Engineering*	8956 - Systems Engineering Approach to Workforce Development Mr. James Miller, U.S. Air Force	9046 - Developing an Introductory Systems Engineering Practitioners Course: "Model-Based Systems Engineering (MBSE) With SysML" Mr. Joseph Wolfrom, Johns Hopkins University/APL	8878 - Advanced Simulation Course for Army Simulation Management Professionals Dr. Gene Paulo, Naval Postgraduate School
TRACK 6 Enterprise Health Management Mission III	**Mr. Howard Savage,** *Savage Consulting* and **Mr. Chris Reisig,** *The Boeing Company*	8815 - Applying Systems Engineering to Operational System Improvements Ms. Ryanne Gentry, Acquisition Logistics Engineering	8842 - Applications in Integrated Diagnostics Mr. Jimmy Simmons, Georgia Tech Research Institute	8884 - Tactical Wheeled Vehicle Integrated Diagnostics Mr Lawrence Osentoski, DRIVE Developments, Inc.
TRACK 5 Systems Engineering Development Environment Mission II	**Mr. Al Brown,** *The Boeing Company*	8967 - Generating Visual and Interactive Output from System Engineering Tools Mr. John Schatz, Systems and Proposal Engineering Company	9015 - Challenges and Benefits of applying ISO STEP Mr. Stuart Booth, Systems Engineering Directorate, ODDR&E	9059 - Smallsat Conceptual Design Trade and Cost Modeling Tool Dr. Deganit Armon, Advatech Pacific, Inc
TRACK 4 Practical Systems Engineering Mission I	**Mr. Dana Peterson,** *DRS Technologies, Inc.*	8976 - A Systems Engineering Model for Roadmap Alignment Mr. Si Dok, U. S. Army TARDEC	9080 - Rapid Systems Engineering of the MRAP Gunner Restraint System Saves Lives Ms. Michelle Bowen, JPO MRAP	9002 - Key Considerations for Building Highly Available, Mission-Critical Systems Mr. Stephen Mills, GoAhead Software
TRACK 3 Modeling & Simulation Bayview I	**Mr. Jim Coolahan, JHU/APL**	8836 - Producibility Modeling & Simulation Needs for Early Systems Engineering Evaluations of Alternative Design Concepts Dr. Al Sanders, Honeywell Aerospace	8810 - Using Simulation to Define and allocate probabilistic Requirements Ms. Yvonne Bijan, Lockheed Martin Aeronautics	8923 - Integration of Operational Simulations With Physics-Based Models For Engineering Analysis Mr. Stephen Guest, Lockheed Martin Aeronautics
TRACK 2 Logistics Systems Bayview II	**Mr. Joel Moorvitch,** *Raytheon Company* and **Mr. Anthony Stampone,** *OSD-ATL*	8834 - Tailoring Systems Engineering for Technical Support of Legacy Products Mr. Joseph Skandera, BAE Systems	8837 - Injecting Requirements into Sustainment: UEWR RDA Mr. Jonathan Casey, Raytheon Integrated Defense Systems	9092 - The role of simulation in tracking mobile assets using RFID technology Mr. Swee Leong, National Institute of Standards and Technology
TRACK 1 Architecture Bayview III	**Mr. Joe Kuncel,** *Northrop Grumman Corporation*	9025 - Defining, Assessing, and Improving Architecture Competence Ms. Suzanne Garcia, Software Engineering Institute	8971 - Advancing Systems Engineering Practice using Model Based System Development Mr. Sanford Friedenthal, Lockheed Martin Corporation	9004 - Evolving Systems Engineering through Model Driven Functional Analysis Dr. Mark Blackburn, Systems and Software Consortium

2009 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 2009 awardees are:

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

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 Miller*
- Systems Engineering Individual Practitioner Award: *Mr. David Strimling*
- 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 SystemTeam*

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

DEPARTMENT OF DEFENSE AND THE NATIONAL DEFENSE INDUSTRIAL ASSOCIATION 2008 TOP 5 DEPARTMENT OF DEFENSE 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 2008 Top 5 Department of Defense Program Awards. The 2008 Program awardees are:

- *Wideband Global SATCOM: U.S. Air Force PM; Boeing Company Space & Intelligence Systems Group*
- *Joint Light Tactical Vehicle: U.S. Army/USMC PMs; BAE Systems Land & Armaments; General Tactical Vehicles; Lockheed Martin Systems Integration*
- *STRYKER Modernization: U.S. Army PM; General Dynamics Land Systems*
- *Broad Area Maritime Surveillance Unmanned Aircraft: U.S. Navy PM; Northrop Grumman Corporation*
- *Aviation Maintenance Training Continuum System: U.S. Navy PM; Raytheon Company; Paladin Data Systems Corporation*

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*

THANK YOU TO OUR PROMOTIONAL PARTNERS:

PTC provides product lifecycle management solutions designed to meet the requirements of the global aerospace and defense industry. These solutions enable digital automation of product development and program management processes, complete visibility and control over program information for secure, collaborative product development as well as dynamic publishing that allows you to produce vital service information directly in the standards-based formats – either in print or on the Web. PTC is an industry leader, serving the product development needs of the top 20 A&D companies. Further information is available at http://www.ptc.com/go/a-d.

At University of Phoenix, we've been thinking ahead for more than 30 years. In fact, we were founded in 1976 on an innovative idea: make higher education highly accessible for working students.

Still guided by this idea, University of Phoenix has helped transform the landscape of higher education in widely recognized ways.

Many of the conveniences that 21st-century students now take for granted—evening classes, flexible scheduling, continuous enrollment, a student-centered environment, practitioner faculty, online classes, online library, ebooks, computer simulations—were pioneered or made acceptable through University of Phoenix's efforts.
Configuration Management Data Management Coursework

This program exposes students to the most important principles concerning configuration management history, configuration identification, configuration change management, and data management. Courses are available over the internet through our Online Learning System (OLS) or, in small classes at select classroom locations as available.

To learn more contact University of Phoenix – Center for Professional Development at 1 (800) 325-1509 or via email – prodev@phoenix.edu.

LEAN SOLUTIONS INSTITUTE, Inc.
LEAN SOLUTIONS™ FOR YOUR ORGANIZATION

Lean Solutions Institute, Inc. (LSI) specializes in helping organizations to rapidly achieve measurable results by using benchmarking and Lean SolutionsTM (e.g., best practices to implement CMMI® in a lean way) to successfully improve client products and services. LSI helps organizations to measurably:

- Achieve ROI (e.g., 7:1)
- Increase productivity, performance and quality
- Reduce cycle time/schedule
- Reduce defects (e.g., post-release defects), rework and costs of poor quality
- Achieve world-class results (e.g., 70-90% defect removal efficiency or defects removed before test)

Systems engineering and software engineering have become more and more complex over the years. With this growing complexity, processes and procedures have become larger and more complex. Based on surveys, most organizations do not like their processes and procedures (e.g., including CMMI® Maturity Level 3-5 organizations) and they can have some of the following lean problems:

- Too large and complex (i.e., not lean or agile)
- Have non-value added activities
- Lack of visualization (e.g., pictures, diagrams, tables, charts, etc.)
- Difficult to use (e.g., poor usability)
- Lack of "chunking" which is a best practice for usability (7 plus or minus 2 principle)
- Lack of innovation
- Lack of "good metrics", not the right metrics, or not lean metrics

LSI has a patent pending approach for defining systems engineering and software engineering processes (e.g., CMMI® compliant processes) in a lean (e.g., short, usable, visual) way. Although this approach can be simple, it also scales up to handle complex processes (e.g., NASA processes). LSI uses "good diagrams" (i.e., process models) for putting the 5 W's (who, what, where, when, why) on one page. These visual one-page diagrams along with a page of support text typically replace about 25-30 pages of text. For example, lean CMMI® processes are typically about 20-25% of the size of a typical CMMI® implementation, and take half the time to implement (e.g., 1 year). In several CMMI® success stories (independently verified) using the LSI approach, organizations estimate that processes are about 20% of the size of sister business units with a similar CMMI® rated processes, and have achieved CMMI maturity levels half the time (or less).

LSI can help your organization achieve measurable results, reduce size and complexity, and improve processes and metrics to become much more lean, "value added", visual, and usable. LSI also uses an ISO/Baldrige approach to implementing CMMI®. LSI only does improvement and uses independent Authorized SEI Lead Appraisers to objectively verify LSI Lean SolutionsTM for CMMI®.

CMMI is a registered trademark of the U.S. Patent and Trademark Office by Carnegie Mellon University.

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
8736	The Method Framework for Engineering System Architectures (MFESA)	Mr. Donald Firesmith
8739	QUality Assessment of Software-Intensive System Architectures and their Requirements (QUASAR)	Mr. Donald Firesmith
8759	A Systems Engineering Framework for Integrating M&S Development Best Practices	Mr. Robert Lutz Shon Vick Nathaniel Horner
8770	Incorporating Maturity Assessment into House of Quality for Improved Decision Support Analysis and Risk Management	Mr. Pavel Fomin Dr. Shahram Sarkani Dr. Thomas Mazzuchi
8776	The Modular SOS Paradigm: an Availability Paradox?	Mr. Richard Volkert
8780	Net-Centric Best Practices	Mr. Higgin Ko
8789	Achieving Acquisition Excellence via Improving the Systems-Engineering Workforce	Dr. Kenneth Nidiffer
8791	Cost and Risk Impacts of the New DOD 5000 Defense Acquisition Framework	Ms. Nancy Kern
8795	Mission-based Test and Evaluation Strategy: Creating Linkages between Technology Development and Mission Capability	Mr. Christophre Wilcox
8801	Integrating Systems Engineering with Earned Value Management	Mr. Paul Solomon
8810	Using Simulation to Define and allocate probabilistic Requirements	Dr. Henson Graves
8814	Joint Mission Environment Test Capability (JMETC), Lowering technical Risk by Improving Distributed Test Capabilities	Mr. Ryan Norman
8815	Applying Systems Engineering to Operational System Improvements	Mr. Charles Coogan
8816	MIND THE GAPs-a Systems Engineering Implementation of DoDI 5000.02	Ms. Janet Jackson Mr. William Mejias Mr. Ccharles Fabian
8818	Integrated Testing enhances System Engineering. Presentation topics address the conference objectives of "Interoperability & System Integration" and "SE Effectiveness"; and the Topic Session of "T&E	Ms. Darlene Mosser- Kerner
8819	Rethinking Risk Management	Mr. Christopher Alberts
8820	Graduate Software Engineering Reference Curriculum (GSwERC)	Dr. Arthur Pyster Dr. Richard Turner Ms. Kahina Lasfer
8823	Win and Influence Design Engineers---Change Their Affordability DNA	Ms. Diane Patane
8825	Test and Evaluation in a System of Systems Environment	Dr. Shahram Sarkani Dr. Thomas Mazzuchi
8831	Human-Centered Design in Systems Engineering: Human View Methodology	Dr. Holly Handley
8833	Communicating Risk: Air Force RI3 Methodology	Mr. Gregory Barnette
8834	Tailoring Systems Engineering for Technical Support of Legacy Products	Mrs. Virginia Doyle Mr. Derrick Min
8837	Injecting Requirements into Sustainment: UEWR RDA	Noah Van Fossan
8839	Navy Systems Engineering Technical Review Process	Ms. Susan Lashomb
8842	Applications in Integrated Diagnostics	Mr. Tim Palmer
8849	Joint Integration and Interoperability Lab (JSIIL)	Mr. Martin Westphal Mrs. Margery Frisby Mr. Randy Coonts

8853	C4I Architecture for Joint ASW	Baasit Saijid Matt LeTourneau Bill Traganza
8854	Human Interoperability Enterprise and Net-Centric Operations	Dr. S. Brown Dr. Beverly Knapp
8855	Certify and Fly Right: Preparing for DO-297 Certification	Mr. Keith Custer
8863	Using Requirements Compliance to Identify Gaps Between the Technical Solution and Requirements	Mr. Richard Swanson Mr. Edward Dooley
8866	Extending FMECA to Systems of Systems	Mr. Clayton Smith
8874	The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems	Ms. Alaka Shivananda Mr. Dennis Schwarz Mr. Marion Butterfield
8875	Tomahawk Weapon System Development and Integration	Mr. Tim Patrick
8878	Advanced Simulation Course for Army Simulation Management Professionals	Stephanie Few
8880	Naval Postgraduate School Advanced Seabase Enabler Project: A Systems Engineering Case Study	Mr. Robert Brooks Mr. Steven Schroeder Mr. Paul Rakow
8885	Human Systems Integration (HSI) - Integrating Human Concerns into Life Cycle Systems Engineering	Colonel Larry Kimm
8887	Achieving a Systems Engineering Culture in a Science and Technology Laboratory Environment	Dr. James Malas Mr. Bryan DeHoff Ms. Carol Ventresca
8890	Building Safer UGVs with Run-time Safety Invariants	Dr. Phil Koopman Dr. John Bares Mr. Chris Ostrowski
8892	SysML Strategies to Characterize and Analyze Systems of Systems	Mr. Tim Bohn
8894	Air Force Initiative – High Confidence Technology Transition Planning Through the Use of Stage-Gates – Update	Dr. Claudia Kropas-Hughes Ms. Sharon Fields
8895	A Comprehensive Review of Maturity Assessment Approaches for Improved Defense Acquisition	Dr. Shahram Sarkani Dr. Thomas Mazzuchi
8898	Designing Collaborative Systems of Systems in support of Multi-sided Markets	Dr. Nicholas Whittall
8900	DOD's Weapon System Portfolio: Are Results Getting Any Better?	Ms. Cheryl Andrew
8901	Review Results of the NDIA/OSD Software Test Summit/Workshop	Elizabteh Wilson
8902	Systems Engineering Leading Indicators: Insight into Effective Systems Engineering	Mr. Gary Roedler
8908	Successful First AESA Deployment through Application of System Engineering	Mr. Christopher Moore
8913	Linking Interoperability and Measures of Effectiveness: A Method for Evaluating Architectures	Dr. John Colombi
8915	System of Systems Challenges and Solutions: Case Study Insights	Dr. David Jacques
8916	System Readiness - assessing technical risk throughout the lifecycle	Mr. Jim Thompson
8920	A Methodology for Assessing Systems Engineering Practices	Mr. David McDonnell
8923	Integration of Operational Simulations With Physics-Based Models For Engineering Analysis	Dr. William Graves
8924	Key Early Systems Engineering Activities and Products Under the New DoDI 5000.02	Dr. Don Gelosh
8929	Extending Net-Centric Quality of Service to Systems of Systems	Dr. John Colombi Dr. Kenneth Hopkinson Dr. Michael Grimaila
8931	The Role of Mentoring in Developing the Systems Engineering Workforce	Dr. Don Gelosh

8933	Early Systems Engineering Planning: Milestone A Systems Engineering Plan	Dr. Judith Dahmann
8935	Systems of Systems Systems Engineering and Test and Evaluation	Mr. John Palmer Dr. JoAnn Lane Mr. George Rebovich
8942	DoD Systems of Systems Update	Dr. William Asrat
8946	Protecting the Mission, Preserving Legacy and Promoting Growth	Kerri Van Horne
8947	Report on a Study on Management Concepts for Broadly-Needed Modeling and Simulation Tools in the U.S. Department of Defense	Dr. Katherine Morse Mr. Randy Saunders
8950	Live, Virtual, Constructive Architecture Roadmap: The Quest for Interoperability, Standards, and Reuse	Dr. Amy Henninger
8955	TUTORIAL: Early Systems Thinking and Technical Planning in Weapon System Concept Development (HALF DAY)	Ms. Robin Wright
8960	A Distillation of Lessons Learned from Complex System of Systems Acquisitions	Arthur Pyster Kenneth Kepchar Ann Teford Mark Weitekamp
8963	Air Force Concept Maturity Assessment	Mr. Jeff Loren
8966	Improving Systems Engineering Curriculum Using a Competency-Based Assessment Approach	Dr. Wiley Larson
8967	Generating Visual and Interactive Output from System Engineering Tools	Steven Dam Chris Ritter
8973	C-17 Transition to Criteria-based Airworthiness Certification	Mr. Michael McKinney
8974	Transforming Systems and Software Engineering Across an Enterprise	Mr. Timothy Chaill
8976	A Systems Engineering Model for Roadmap Alignment	Mr. John Fitch Ms. Harsh Desai
8980	Using Simulink and Model-driven Engineering Techniques for Integrated Flight Simulation Development	Brett Collins Jesse Carlaftes
8982	Systemic Root Cause Analysis – Driving Improvements into the Acquisition Process	Mr. Jim Thompson Mrs. Laura Dwinnell
8990	Systems Engineering for Rapid Capability Development	Ms. Kathleen Harger
8992	1/2 Day Tutorial: System of Systems (SoS) Quality Attribute Specification and Architecture Evaluation	Mr. William Wood Mr. Timothy Morrow Mr. John Klein
8996	Engineering Improvement in Software Assurance: A Landscape Framework	Dr. Carol Woody Christopher Alberts Andrew Moore
8998	Human Systems Integration – Ensuring the Human is Considered "Left of A"	Ms. Bridget Simpkiss
8999	Program Signature Measurement	Mr. Gordon Kranz Mr. Christopher Miller Mr. Gerald Tarasek
9003	CMMI for Executives	Mr. Wendell Mullison
9004	Evolving Systems Engineering through Model Driven Functional Analysis	Mr. Sharad Kumar
9007	Technology Maturation for the Automated Aerial Refueling (AAR) Project	Mr. Jacob Hinchman Mr. Daniel Schreiter Mr. Ba Nguyen Mr. Jordan Adams
9010	Network Enabled Weapons, A System Engineering Approach to Achieve Interoperabilty	Mr. Wyane Willhite

9012	Human Systems Integration: Defining and Validating a Framework for Enhanced Systems Development	Alisha Belk Dr. Robert Smillie Major Andrew Gepp, USMC
9014	SAVI: Aerospace Platform Development and Certification Using Modeling and Simulation to "Integrate, then Build"	Dr. Don Ward
9015	Challenges and Benefits of applying ISO STEP	Mr. Charlie Stirk
9017	Linking Systems Engineering Artifacts with Complex Systems Maturity Assessments	Mr. Kenneth Michaud Mr. Richard Volkert Mr. Eric Forbes Dr. Joes Ramirez-Marquez
9021	Critical Success Factors for Milestone Review Risk Identification	Dr. Jo Ann Lane
9023	Department of Energy Office of Environmental Management's Technology Readiness Assessment (TRA)/Technology Maturation Plan (TMP) Process Guide and Plans for TRA Training	Dr. Stevem Krahn Mr. Kurt Gerdes Dr. Herbert Sutter
9024	Dynamic Modeling of Programmatic and Systematic Interdependence for System of Systems Acquisition	Dr. Brian Sauser Dr. Muharrem Mane Mr. Alex Gorod
9025	Defining, Assessing, and Improving Architecture Competence	Len Bass Paul Clements Suzanne Garcia Rick Kazman
9026	Early SE Determination of Best-Fit System Life Cycle Processes	Dr. Jo Ann Lane
9027	Department of Energy Office of Environmental Management's Technology Readiness Assessment (TRA) Process	Mr. Kurt Gerdes Dr. Steven Krahn Dr. Herbert Sutter
9031	Supportability Lessons Learned with Line Replaceable Modules	Mr. Joel Moorvitch
9034	SUSTAINMENT AND CONTINUED INSTITUTIONALIZATION OF BEST PRACTICES AND CMMI® AT SPAWAR	Mr. Michael Knox
9035	Enabling Collaborative Decision Making: A Process for Integrating Novel Systems Engineering Tools and Methods for Renewable Energy Portfolio Analysis	Mr. Thomas McDermott
9041	On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems	Dr. Tommer Ender Dr. Santiago Ballestrini-Robinson
9043	Implementing the Materiel Availability KPP in DoD acquisition programs—balancing life-cycle costs with warfighter needs	Mr. Pete Nolte Mr. John Quackenbush
9046	Developing an Introductory Systems Engineering Practitioners Course: "Model-Based Systems Engineering (MBSE) With SysML"	Mr. Michael Pafford
9054	A-10 Avionics System Architecture Trade Study and Analysis (AVSATA) Program	Mr. Adam Grimm Mr. Jerry Coates
9059	Smallsat Conceptual Design Trade and Cost Modeling Tool	Mr. John Carsten Mrs. Dana Sherrell Mr. Mike Paisner Mr. Mark Sutton
9060	Modeling and Simulation Support for the Systems Engineering of Systems of Systems (short title "M&S Support for SoS SE")	Dr. William Asrat
9064	Economics of Human Systems Integration: Early Life Cycle Cost Estimation Using HSI Requirements	Dr. Ricardo Valerdi
9065	Rapidly Implementing Lean CMMI Processes That Meet Business Needs	Mr. Tim Olson
9072	1/2 Day Tutorial - Leveraging the Defense Acquisition Program Support (DAPS) Methodology for Program Success	Mr. Peter Nolte

9076	Assessing Systems Engineering Personnel Competency: Framework and Tool Experience	Mr. Dan Ingold Dr. Paul Componation Dr. Richard Turner Ingold Dan
9078	Tutorial: Organizational Implications of Systems of Systems	Ms. Lisa Brownsword Mr. Patrick Kirwan
9080	Rapid Systems Engineering of the MRAP Gunner Restraint System Saves Lives	Mr. Michael Perricane
9081	Testing in Service-oriented Environments	Mr. Edwin Morris Mr. Sriram Balasubrama- niam
9083	Requirements Engineering for Systems of Systems	Mr. Edwin Morris Dr. Dennis Smith Grace Lewis Mr. Patrick Place
9094	DoD Green Procurement Program Update and Path Forward	Ms. Sandy Ross Ms. Christina Graven
9095	Acquisition ESOH Risk Management and HAZMAT Management Part I: Hazardouse Materials Management Plan	Mr. Sherman Forbes
9097	Acquisition ESOH Risk Management-How to Make It Work	Mr. Sherman Forbes
9103	The Economics of CMMI	Mr. Mike Campo
9104	Static Code Analysis: Best Practices for Software Assurance in the Acquisition Life Cycle	Mr. Paul Croll

Overview of Draft MIL-STD-882D w/CHANGE 1

NDIA Systems Engineering Conference
Track 5 - System Safety - ESOH
San Diego, CA

Robert E. Smith, CSP
Booz Allen Hamilton

Sherman G. Forbes
U.S. Air Force

October 28, 2009

Bottom Line Up Front (BLUF)

- MIL-STD-882D w/CHANGE 1, intended to
  - Be evolutionary, not revolutionary, change
  - Build on Acquisition policy advances since 2004
  - Improve standardization
  - Increase inclusion of health and environmental risk management
  - Emphasize integration into Systems Engineering
  - Support implementation of 8 Dec 08 DoDI 5000.02

Overview

- MIL-STD-882D – Overview and Problem
- DoD Policy and Guidance – The Response
- Drivers to Revise 882D
- Key Tenets in Revision Process
- Review of the Changes

MIL-STD-882D Overview

- MIL-STD-882D - Feb 2000
  - Converted to a performance-based standard practice
    - Required by the Military Specifications and Standards Report (MSSR) initiative to retain 882
    - Defined what is required, not how to
    - Task descriptions removed
  - Enabled Program Offices to put 882D on contract without approval
  - Government and Industry recognized need for creation of supporting guidance on how to effectively utilize

MIL-STD-882D – The Problem

- Neither Government or Industry provided the required support
- Confusion existed on lack of need for approval to require 882D
- No DoD Acquisition policy requirement to utilize 882D
- 12 May 03 DoDI 5000.2, Operation of the Defense Acquisition System, had limited and confusing guidance on safety, health, and environment risk management
- Perception and reality that DoD Acquisition policies and guidance did not support robust System Safety requirements
- Both System Safety and MIL-STD-882D atrophied

DoD Policy and Guidance – The Response

- 19 May 03 Secretary of Defense (SECDEF) policy memo "Reducing Preventable Accidents," 19 May 2003
- Sep 03 Defense Safety Oversight Council (DSOC) created to direct responses across DoD to SECDEF memo
    - DSOC originally established ten Task Forces to focus on variety of areas of mishap prevention
        - From aviation safety to deployments and operations
        - Acquisition and Technology Programs Task Force (ATP TF)
            - Stood up in January 2004
            - Chaired by office of the Undersecretary of Defense (Acquisition, Technology, and Logistics), Deputy Undersecretary of Defense (Acquisition and Technology), Director of Systems and Software Engineering

DoD Policy and Guidance – The Response

- ATP TF teamed with DoD Acquisition Environment, Safety, and Occupational Health (ESOH) IPT to integrate ESOH risk management into Systems Engineering using the DoD Standard Practice for System Safety, MIL-STD-882D
  - Developed a series of policy initiatives and implementation guidance to support that objective
- 23 Sep 04 AT&L memo "Defense Acquisition System Safety"
  - Specifically mandated use of MIL-STD-882D to manage ESOH risk as part of the Systems Engineering process
  - Requires Program Managers to report ESOH risk status and acceptance decisions at technical and program reviews

DoD Policy and Guidance – The Response

- Apr 05 Defense Acquisition University course CLE009, "System Safety in Systems Engineering"
  - First formal guidance on how to use MIL-STD-882D
  - Should have been developed in 2000 (along with other more detailed System Safety analysis guidance)
  - Mapped the 882D System Safety processes into the overall DoD Systems Engineering processes using the DoD SE Vee model
  - Vetted by environmental engineers, industrial hygienists, System Safety engineers, and Systems Engineers
  - Over 2000 personnel have now taken this course

DoD Policy and Guidance – The Response

- Nov 06 Defense Acquisition Guidebook
  - Much more detailed guidance on ESOH risk management
    - Using MIL-STD-882D
    - Integrating ESOH risk management into Systems Engineering
  - Explicitly mandated use of MIL-STD-882D
  - Moved ESOH guidance into Systems Engineering
  - Clearly delineated the overlapping areas between ESOH and Human Systems Integration (HSI)
  - Described the topics that the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) must address

DoD Policy and Guidance – The Response

- 21 Nov 06 AT&L memo "Reducing Preventable Accidents"
  - Required Program Managers at all program reviews to address
    - Status of each High and Serious ESOH risk
    - Compliance with applicable safety technology requirements
  - Included Program Offices in preparation of mishap reports
    - Required Program Offices to make recommendations for materiel mitigation measures to reduce the likelihood of reoccurrence of mishap
    - Focused on eliminating human error

DoD Policy and Guidance – The Response

- 7 Mar 07 AT&L memo “Defense Acquisition System Safety – ESOH Risk Acceptance”
  - Required formal acceptance of ESOH risks prior to exposing people, equipment, or the environment to a known system-related ESOH hazard
  - Mandated User Representative Formal Concurrence for High and Serious ESOH risk acceptance
- 8 Dec 08 DoDI 5000.02, "Operation of the Defense Acquisition System"
  - Incorporated all the ATP TF sponsored AT&L memos
  - Moved the ESOH discussion from HSI to Systems Engineering
  - Mandated use of MIL-STD-882D

Drivers to Revise 882D

- Desire to bring back the Task Descriptions from MIL-STD-882C to make them readily available for call out in contract documents
- Need to align with current OSD Acquisition Systems Engineering policy changes
- Standardize terminology and basic process elements to facilitate utilization
- Expand task descriptions to incorporate DoD ESOH perspective
- Add new tasks based on CLE009
- Support DoD strategic plans and goals

Key Tenets in Revision Process

- Retain performance-based, standard practice approach
- Minimize changes to those necessary to update the document and incorporate tasks
- Incorporate the tasks as optional, not mandatory
- Ensure each task is a separate and distinct activity
- Minimize transition from current version, to build on policy and implementation progress to date
- Ensure process usable by entire spectrum of DoD Acquisition programs
- Describe how to establish a collaborative ESOH effort using the System Safety process

Key Tenets in Revision Process

- Add subtitle to emphasize that 882D is used for assessing risks associated with environment and occupational health, not just risks related to safety
  - "ESOH Risk Management Methodology for Systems Engineering"
- Emphasize that MIL-STD-882D defines a process that exists as a part of the overall Systems Engineering process to
  - Provide coordinated ESOH inputs into Systems Engineering to minimize the environmental "footprint" of the system and improve safety of personnel and the system itself

Review of the Changes

- Update will not be a re-issuance, it will be a change revision, to retain 882D designation in DoD Acquisition policies
- Made the definitions, Section 3, mandatory to standardize terminology and to facilitate implementation of DoD ESOH risk acceptance policy
  - New and updated definitions
    - Emphasis on software safety related terminology
    - Emphasis on reducing confusion between Mishap, Hazard, and Risk
    - New or updated definitions include: Causal factor, Critical Safety Item, ESOH Technology Requirement, Environmental impact, Event risk, Hazard, Level of Rigor, Loss, Mishap, Mitigation measure, Risk, Safety-critical, Safety related, Safety Significant, Target risk, User, User representative *and more*

Review of the Changes

- Section 4 only other mandatory section with its eight steps
  1. Document the system safety approach
  2. Identify hazards
  3. Assess risk
  4. Identify risk mitigation measures
  5. Reduce risk
  6. Verify risk reduction
  7. Accept risk
  8. Manage Life-Cycle Risk

Review of the Changes

- Section 4 also
  - Emphasizes the identification and derivation of applicable ESOH technical requirements
  - Defines System Safety design order of precedence with five levels (vs. four levels in 882D) – added “Reduce risk through design alterations
- Risk assessment matrices and Software safety matrices (an addition of three tables) added to Section 4
  - Provide for a standard process for all developmental and sustaining engineering activities
  - May be tailored with formal approval in accordance with Component policy

Review of the Changes

- Matrix descriptions updated
  - For severity,
    - Dollar value on losses increased for today’s program dollars
    - Logarithmic progression applied
  - For probability
    - Additional guidance provided as notes to discuss use of quantitative or qualitative analysis and use of individual item or fleet/inventory
    - “Eliminated” level added

Review of the Changes

- Changed Task 102 from System Safety Program Plan to System Safety Engineering Plan
  - Emphasizes that System Safety is not a stand alone program, but one of many efforts integral to the Systems Engineering effort
  - Combines previous System Safety Program Plan and System Safety Management Plan into one task
- Added Task 105 Hazard Tracking System to provide guidance for the basic required elements of a hazard tracking system
- Added Task 107 Hazardous Materials Management Plan (HMMP)
  - Provides guidance on basic elements of a HMMP
  - Based on a Single Process Initiative

Review of the Changes

- Added Task 208 Functional Hazard Analysis to provide guidance for identifying and classifying the system functions and safety consequences of functional failures
- Added Task 209 Systems-of-Systems Integration and Interoperability Hazard Analysis to analyze the system within the context of it's systems-of-systems for emergent hazards not found in other hazard analyses
- Added Task 210 Environmental Hazard Analysis to support design development decision; support risk acceptance decisions for environmental hazards; provide the system specific data to support National Environmental Policy Act (NEPA) and Executive Order (EO) 12114 requirements

Conclusion

- MIL-STD-882D w/CHANGE 1, intended to
  - Be evolutionary, not revolutionary, change
  - Build on Acquisition policy advances since 2004
  - Improve standardization
  - Increase inclusion of health and environmental risk management
  - Emphasize integration into Systems Engineering
  - Support implementation of 8 Dec 08 DoDI 5000.02

Questions?

Robert E. Smith, CSP
Booz Allen Hamilton
1550 Crystal Drive, Suite 1100
Arlington, VA 22202-4158
703-412-7661
smith_bob@bah.com

Back Ups

MIL-STD-882 History[1]

- **MIL-STD-882 - July 1969**
  - First DoD System Safety standard
  - System Safety became mandatory on all DoD-procured products and systems
- **MIL-STD-882A - June 1977**
  - Centered on the concept of risk acceptance as a criterion for System Safety programs
  - Established categories for frequency of occurrence
  - Combined with long-standing hazard severity categories

1 Clifton Ericson II, A Short History of System Safety, Journal of System Safety, May-June 2006.

MIL-STD-882 History[1]

- **MIL-STD-882B - 30 March 1984**
  - Continued evolution of detailed guidance in both engineering and management requirement
  - Added emphasis on facilities and off-the-shelf acquisition
  - Addressed software in some detail for the first time
- **MIL-STD-882B, Notice 1 - July 1987**
  - Expanded software tasks
- **MIL-STD-882C - Jan 1993**
  - Integrated the hazard and software System Safety efforts
  - Removed individual software tasks
  - Combined software and hardware tasks

MIL-STD-882 History[1]

- **MIL-STD-882C, Notice 1 - Jan 1996**
  - **Corrected some errors and revised the Data Item Descriptions**
- **MIL-STD-882D - Feb 2000**
  - **Converted to a performance-based standard practice**
    - **Required by the Military Specifications and Standards Report (MSSR) initiative to retain 882**
    - **Defined what required, not how to**
    - **Task descriptions removed**
  - **Enabled Program Offices to put 882D on contract without approval**
  - **Government and Industry recognized need for creation of supporting guidance on how to effectively utilize**

Incorporating Maturity Assessment into the House of Quality for Improved Decision Support Analysis and Risk Management

George Washington University

The Department of Engineering Management and Systems Engineering

Pavel Fomin

I would like to take a moment to thank the men and women who over the last several years have been instrumental in shaping in the research that I am about to present before you today. Without their support, contribution, and unfaltering resolve to freely share information, this work would not have been possible.

George Washington University

Stevens Institute

Department of the Army

Department of the Air Force

Agenda

technology maturity track 8770

- Problem Statements
- Maturity Metrics
- Proposed Solution
- HoQ Overview
- Integration Approach
- Academic Example
- Conclusion

Problem Statements

new acquisition lifecycles without supporting methods

Characteristics of Modern Acquisitions
Evolving Requirements
System Emphasis
Globalization
International Competition
Prolonged Lifecycles
Complexity

Issue: Technology life cycles are outpacing system life cycles

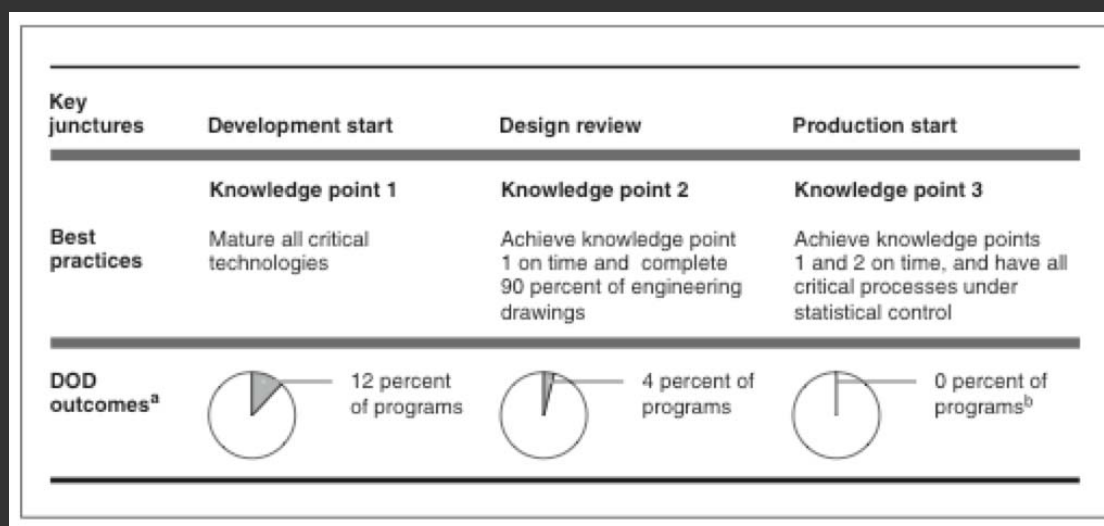
New Approaches / Philosophies
Cradle to Grave Life Cycle
Total Package Approach (TPA)
Technology Insertion
Introduction of Maturity Metrics

Issue: Lack of dynamic processes to account for new acquisition strategies, specifically with respect to maturity

Problem Statements

continued. GAO 2008 report

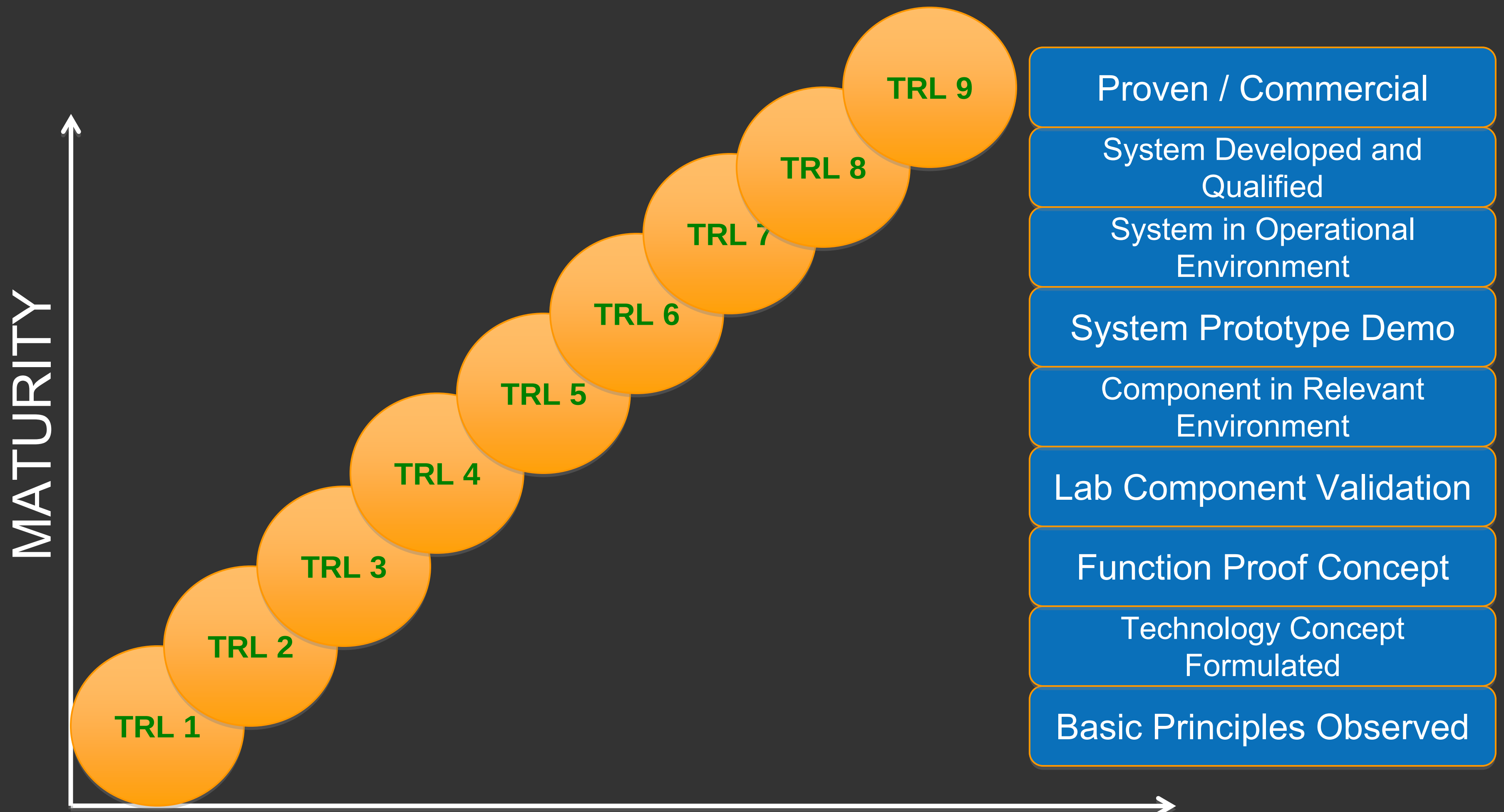
"None of the weapon programs we assessed had proceeded through system development meeting the best practices standards for mature technologies, stable design, and mature production processes—all prerequisites for achieving planned cost, schedule, and performance outcomes. In addition, only a small percentage of programs used two key systems engineering tools—preliminary design reviews and prototypes to demonstrate the maturity of the product's design by critical junctures. This lack of disciplined systems engineering, especially prior to starting system development, affects DOD's ability to develop sound business cases for programs and can contribute to contract cost increases and long development cycle times (GAO, 2008)."



Source: GAO analysis of DOD data.

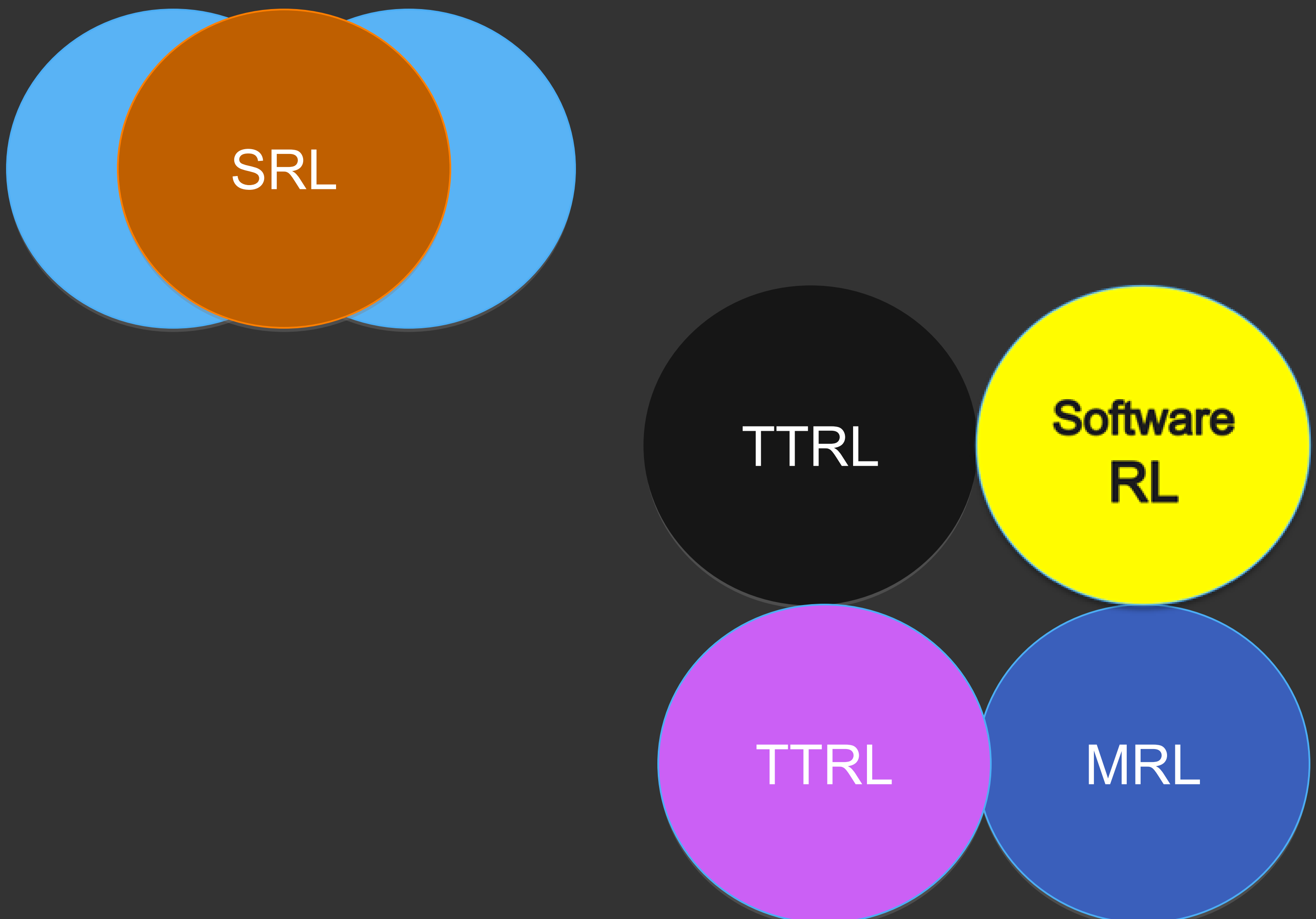
Problem Statements

continued. what about TRAs and TRLs?



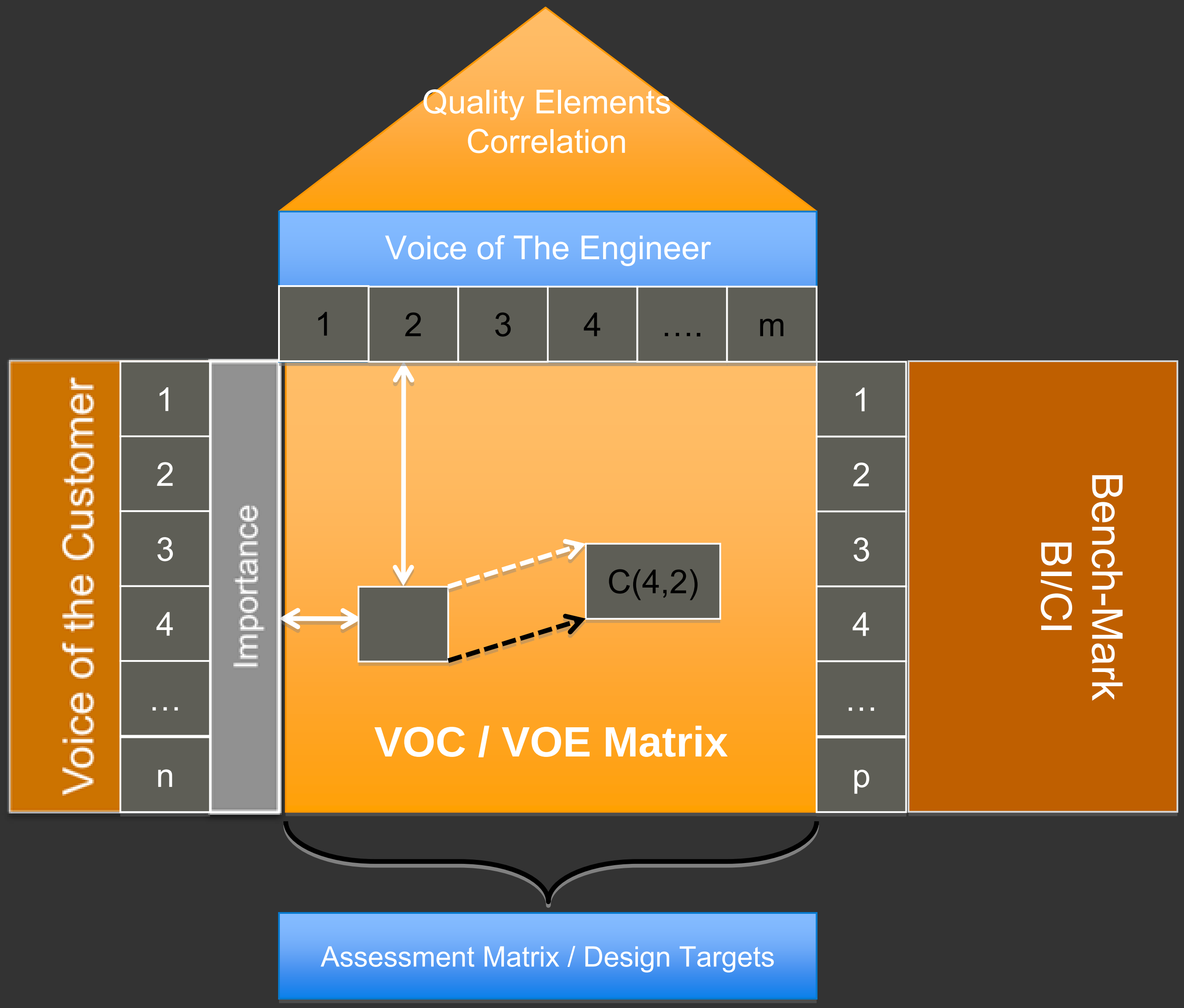
Maturity Metrics

are there more than just TRLs?



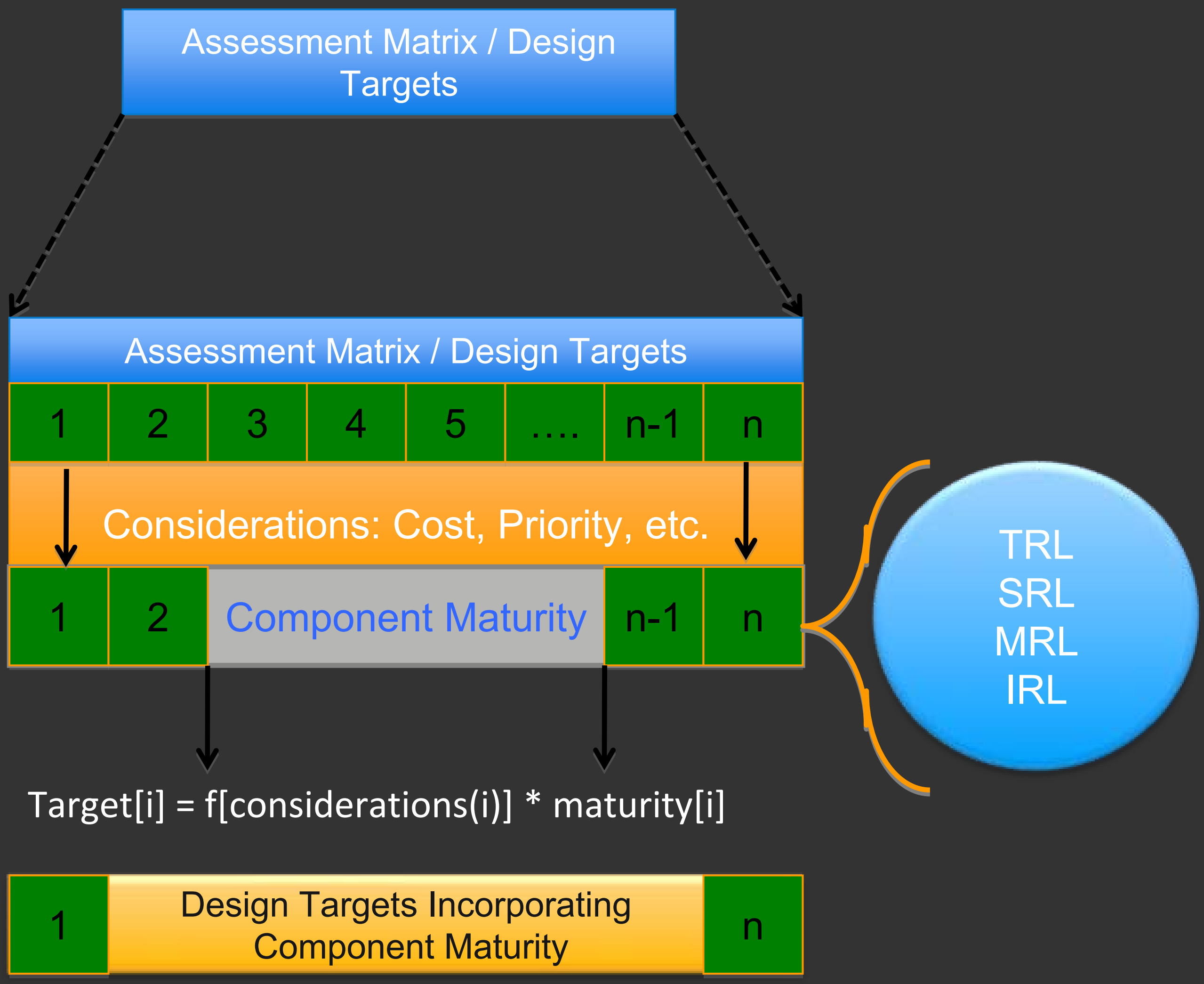
Proposed Solution

provide a process for maturity early in the acquisition life-cycle



Proposed Solution

integration approach into House of Quality



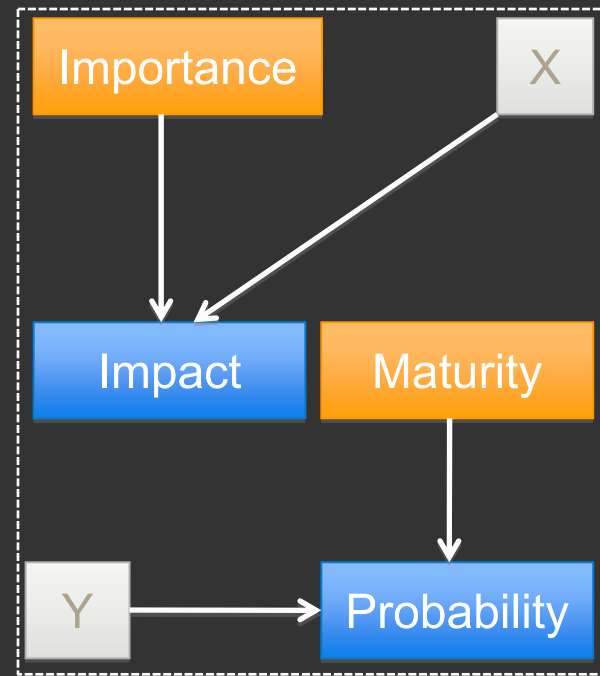
Integration Approach

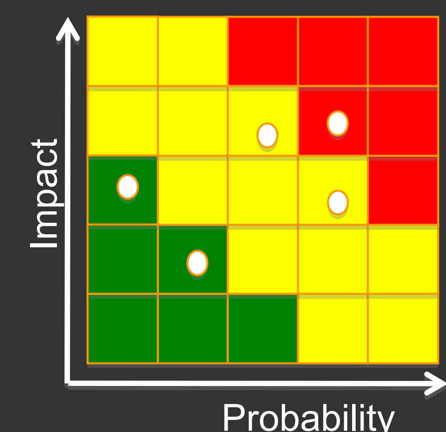
into the House of Quality

Target[i] = f[considerations(i)] * maturity[i]

Weighted Design Targets							
1	2	3	4	5	….	n-1	n

1	Consideration	Maturity	Importance
2	Consideration 2	TRL 4	8
3	Consideration 3	TRL 2	7
…	Consideration 4	TRL 9	3
n	Consideration n	TRL 8	2

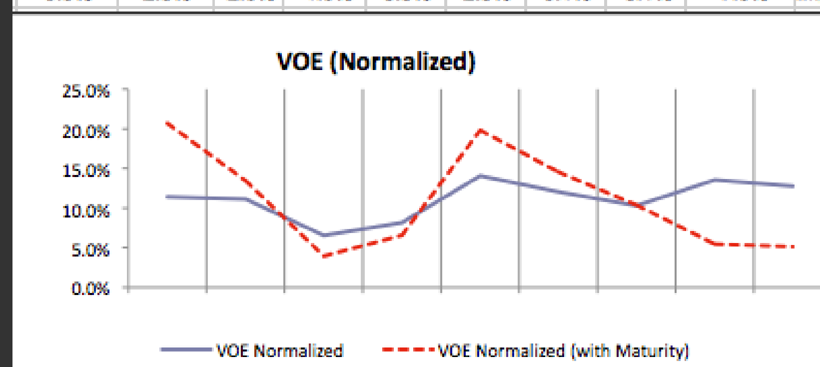




Academic

example

Voice of the Customer (VOC)	Importance	Engine	Single Speed Transmission	Supension	Production Facilities	Component Redundancy	Advanced Safety Features	Interior Microfabrics	LightWeight Body Materials	Modern Materiel Selection (Composites,
		Voice of the Engineer (VoE)								
Efficiency (Gas Mileage)	7	9	7	3	1	6	2	1	9	6
Interior (Size, Comfort, Durability)	9	1	1	5	1	6	3	9	6	6
Exterior (Performance over Time / Appeal)	5	3	1	1	1	6	3	1	6	6
Performance (Power Ratio, Stability, Balance)	7	6	6	3	1	6	3	1	6	3
Safety Features (Airbags, ABS, Traction Control)	8	2	3	1	1	6	9	1	3	4
Status Perception (Image / Appeal)	4	6	3	3	1	1	2	3	6	4
Environmental Responsibility	7	6	6	1	9	6	4	6	6	5
Customization (Individualism)	8	1	2	1	6	3	1	3	1	3
Cutting Edge Features	7	3	6	2	1	3	9	6	1	4
Costs (Initial and Sustainment)	8	6	5	3	6	6	6	4	6	5
VOE (Unscaled)		4.1	4.0	2.4	2.9	5.1	4.3	3.7	4.9	4.6
VOE (Normalized)		11.4%	11.1%	6.5%	8.2%	14.1%	12.0%	10.3%	13.6%	12.8%
Manufacturing Readiness		Removed For Simplicity								
Integration Readiness										
System Readiness										
Maturity Assessment (via TRL)		9	6	3	4	7	6	5	2	2
Weighed Maturity		37.0	24.1	7.1	11.8	35.5	26.1	18.6	9.8	9.2
VOE (Normalized with Maturity)		20.7%	13.5%	3.9%	6.6%	19.8%	14.6%	10.4%	5.5%	5.1%
Impact		9.3%	2.3%	-2.6%	-1.6%	5.8%	2.5%	0.1%	-8.1%	-7.6%



Conclusion

expected benefits

Incorporating component maturity assessment into the House of Quality is a disciplined approach for addressing maturity associated risk in complex system acquisition.

For a complete list of references and citations, please view the associated conference paper.

Reference Number: 8776
Session: System of Systems

The Modular SoS Paradigm

An Availability Paradox?

2009 NDIA Systems Engineering Conference
28 October 2008

Peter D. Gentile

NGC LCS MPI
Chief Engineer
& Technical Director

Richard Volkert

SSC-Pacific
PMS 420 LCS MP
Deputy Technical Director

Introduction

This Presentation will discuss :

- Modularity: what it is, Pros and Cons, how it is used on LCS
- Overview of extended systems
  - What's the concern
- Discuss Availability definitions: A_m, A_o, Mission Availability A_{om} alternative definition
- Discuss a strategy to address and manage the Availability Design of Modular SoS systems

Modular Systems Design

- Design Of Highly Modular Systems Is Expected To Quicken Development, Expand Mission Functionality And Reduce Cost
  - Complex SoS Architectures Have Multiple Levels Of Modularity
- Functional And Physical Modularity Coupled With Standard Software & Hardware Interfaces Enable New And Complex Functionality To Be Quickly Configured
  - Open Systems Design Approaches And Use Of COTS Enable Extended Systems Adaptation, Integration And Functional Growth
- Benefits Abound, But Challenges Remain, Good System Engineering Practices Are Vital To Realizing Open System/Modularity Benefits
- The Larger The System The More Challenging The Operational Availability - More Things To Fail – Longer Sequential Fault Trees

Modular Design, COTS, and Open System Concepts Enable Functional Expansion Across SoS, but care must be taken to achieve operational available to be of use to the Warfighter

Modularity Benefits

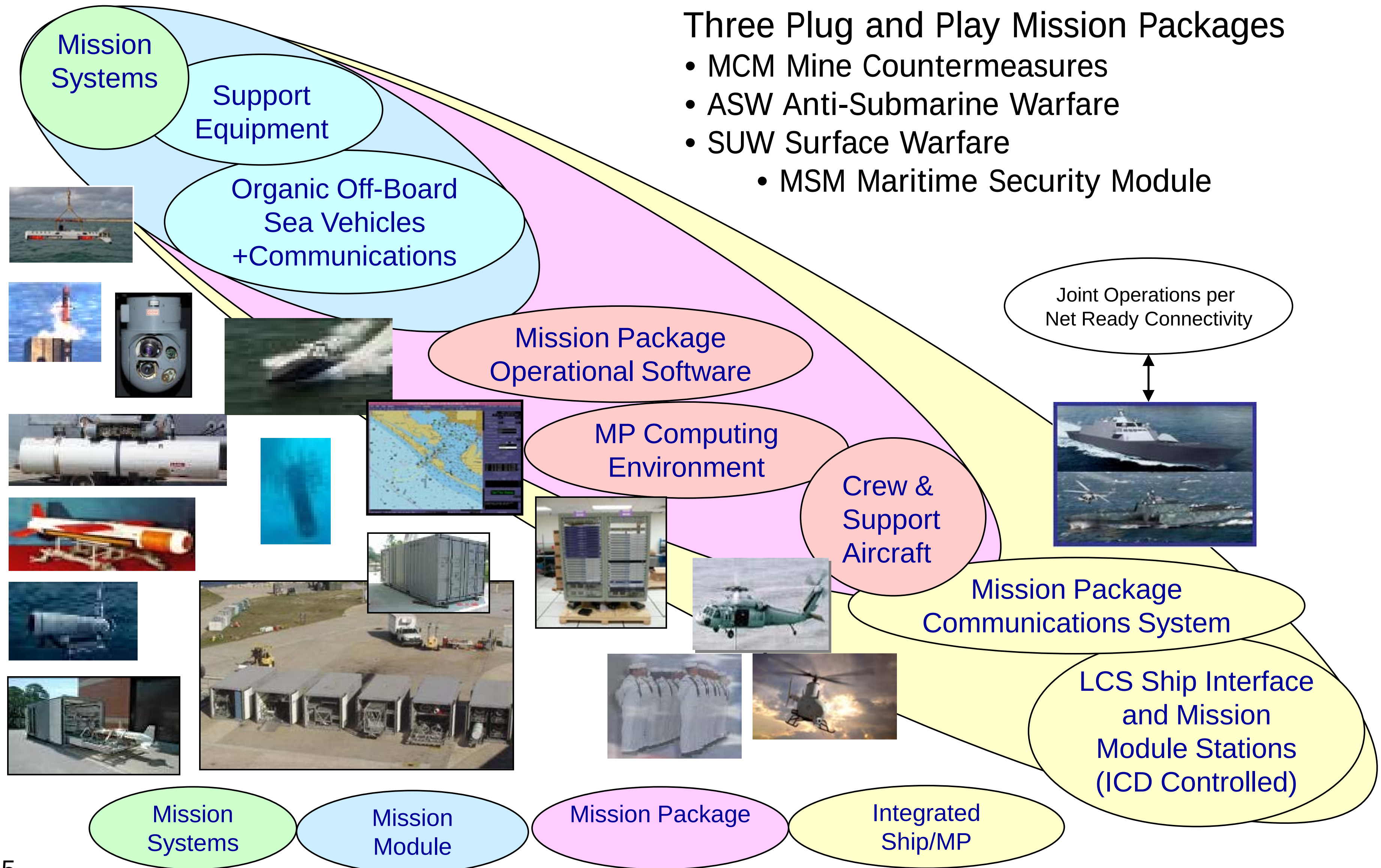
- Functional Modularity and Standard Software/Hardware Interfaces are all around us:
  - Cable and Satellite TV, cell, digital telephones
  - PC Plug and Play Hardware and Software, Networked gaming, Internet Cams, NetMeeting, WEBEX, Memory sticks, Portable hard drives, etc
- Open Systems Tools
  - SOA, XML, Java Wrappers, IP (data sharing), CORBA, P&S, Discovery
  - Plug and Play OS approach, simplified expansion of Functionality
  - Swap and Reuse of common modules built to common interface standards
  - Net Ready interconnectivity and functionality (SOA, SAS)
- LCS Modular Mission Systems Goals and Objectives
    - Plug and play sensors and I/O devices (e.g.: Modular 30mm Gun)
    - Plug and play mission software and hardware
    - Fast reconfiguration of functional and mission capabilities
    - Unmanned platforms, IP Multi-Vehicle Communications Network
    - Plug and Play Ship and Command Infrastructure

Open Systems Techniques and Mission Modularity Benefits Are Real

The LCS Levels of Modularity

Three Plug and Play Mission Packages

- MCM Mine Countermeasures
- ASW Anti-Submarine Warfare
- SUW Surface Warfare
  - MSM Maritime Security Module



SoS Modularity challenges

- Complex functionality can be quickly configured but extended systems have sustainability challenges, e.g.:
  - Internet applications subject to: overload, environmental disturbance, virus downtime, variable quality of service
  - Satellite communications exhibit environmental outages, and long term degradation, lack of physical security
- Availability issues require attention
  - The inherent reliability employing modular off-board systems is lower due to increased number or elements in the Reliability Block Diagram.
  - Additional Off-board deployed systems difficulties arises due to increase handling e.g. cyclic mission cycle, shipboard storage, shore refit/storage
- Redundancy or mission system diversity counters sustainability challenges
  - High availability operational requirements and real time system functions require derived Ao allocations and quality of service that support the operational need
  - Alternative mission equipment or CONOPS can help achieve mission availability

RMA and Fault Tolerance Design and Analysis are Essential Tools for SoS Modular Design

Generalized Implementation Characteristics For Classes Of Platforms

Characteristics of Implementation and System Integration	Fixed in-place Hardwired, Dedicated On-board systems	Manned Deployable Vehicles flexible/fixed Payload Stores Variations	Un-Manned Deployable Vehicles flexible/fixed Payload Stores Variations	Family of Modular Off -Board Systems with flexible P/L Station
Example systems:	DDG-1000, E2C, HUON Mine hunter, BAMS	e.g. F-35, F22 , B2, etc	e.g. Global-Hawk, Predator, etc	e.g. CVN/F with A/C, LCS with USV, VTUAV, UUV, SSUV, Helios
Complexity	high	high	high	high
Set-up before use: initialization	minimal	medium	medium	extensive
Pre-test, Pre-flight	automatic computer driven	automatic computer driven, some physical installation and verification	automatic computer driven, some physical installation and verification	extensive hands-on
Intrinsic Composition of Mission Equipment	Fixed Systems, stand alone systems	Fixed systems with Home base (ship or ground control)	Fixed systems with Home base (ship or ground control)	Off-Board systems linked to a Home base (ship or ground control)
Deployed external system, types	Minimal Deployed Systems other than: rockets, missiles, munitions, towed sonar	Payload stores, EMC decoys, refueling	Payload stores, EMC decoys, refueling	OOVs, payload Sensor Systems, munitions appendages, towed systems
Number of Make-Break Physical Interconnects Prior to Use	few	more	more	Many
Electrical connectors	Payload stores	<5/Station	<5/Station	Many
Required Software load and initializations, per mission (Steady State)	few, initialization and mission plans	few, initialization and mission plans	Focused mission plans	Software reconfiguration often
Data links	many interfaces, HI connectivity	flexible, HI-Medium connectivity	flexible, HI-Medium connectivity	Sea to Sea connectivity challenged
Communication Bandwidth	High	Hi - Moderate	Moderate	Moderate
Comparative Availability (Public sources)	.9 to .95	0.85 to .98 (Autonomic Logistics (AL))	0.85-.9	.8 to 0.85

Modularity Paradigm Challenges

Modularity Challenges That Require Attention

- The mission string is inherently less reliable because we increase the # of serial components in the mission/operational function
- Extended Unmanned systems set up time and potential for damage is increased because of the increased handling, and the deploy and recovery environment and handling systems design
- Infrastructure Over-head can be over whelming in the particular adaptation of modular P&P design approach (weight, extra services, handling operations, S/W & H/W overhead)
- Deployment of remote systems have security challenges (physical and data related)

**SoS Extends The Systems Reach,
But They Also Extend The Environmental Considerations And Exposure of Systems To Adversarial Threats**

Availability KPP

- Availability consists of two components;
  - Materiel and Operational Availability
    - A_m Materiel Availability is a readiness factor of all the systems required to execute a mission
    - Operational Availability (A_o) as based on MTBF, MTTR, MLDT
- These components provide availability from a fleet-wide perspective and operational unit/mission percentages respectively
- Mission Availability is a system characteristic that allocates A_{om} among the system End-to-End mission string as required for operations during deployment (CONOPS driven approach)

Functional expansion to multiple platforms such as unmanned vehicles or satellites requires focus on operational availability of the mission strings

Materiel Availability (A_m)

- Materiel Availability (A_m) provides the average percentage of time that the entire population of systems is materially capable for operational use during a specified period.
  - This can be expressed mathematically as the number of operational end items/total population.
  - Includes those temporarily in a non-operational status once placed into service (such as for depot-level maintenance). The total life cycle timeframe, from placement into operational service through the planned end of service life, must be included.

$$A_m = \frac{\textit{Number of End Items Operational}}{\textit{Total Population of End Items}}$$

At the equipment level we find insight for top level decision makers; what's impacting operations?

Materiel Availability (A_m)

- Am challenges in a SoS
  - Operational use during a specified period
  - Operational use may use a small percentage of the mission suite depending on the mission, e.g. for MCM; Mapping, identification, clearing.
  - Operational environment may call for a a smaller or larger subset of equipment to be used in a deployment

- Am indicates if the full package is ready for operational use
  - Gives little in the indication if systems in the package can support the deployment reliably

- Resilient/Persistent Technical Requirements Example
  - MCM Package Materiel Availability; Threshold: 0.64, Objective: 0.712
  - MPCE Materiel Availability Threshold: 0.90 Objective: 0.95

What's impacting operations could be biased

Classic Availability (A_o)

$$A_o = \frac{MTBF}{MTBF + MTTR + MLDT}$$

MTBF: *Mean Time Between Failure*

MTTR: *Mean Time to Repair*

MLDT: *Mean Logistics Delay Time*

$$*MLDT = MAdmDT + MOADT + MSRT$$

MSRT : *Mean Supply Response Time (index of system supportability)*
MOADT : *Mean Outside Assistance Delay Time (index of system supportability)*
MAdmDT : *Mean Administrative Delay Time (index of system supportability)*

***Mean Logistics Delay Time (MLDT)**
Operational Availability Handbook
OPNAVINST 3000.12A

At the box level we find insight for the hardware/software/reliability designers and engineers

A_m, A_o, Mission A_{om}, Comparisons

- **Am calculation for MCM mission, A_m =17/24 = 0.71**

Mission Package	Total # ships	Ship Am	# Ships Available	Deploy Duration (months)	Duration MP Embarked (months)	Total # MP	MP# Operating	MP# Maint	MP# RFI	MP Am
MCM	55	0.64	35	18	9	24	14	4	3	0.7

- **A_o = Classic Serial-Parallel String Solution**
  - **Yields System A_o = 0.95**
- **Mission A_{om} = 0.75 (average for CONOPS A)**
  - **Mission Availability avg. (Aom) = 19Days/(35-9)Days = 0.75**

Mission A_{om} provides operational assessment needed to cope, plan and improve critical elements in order to support demanding performance and operationally sustainable SoS

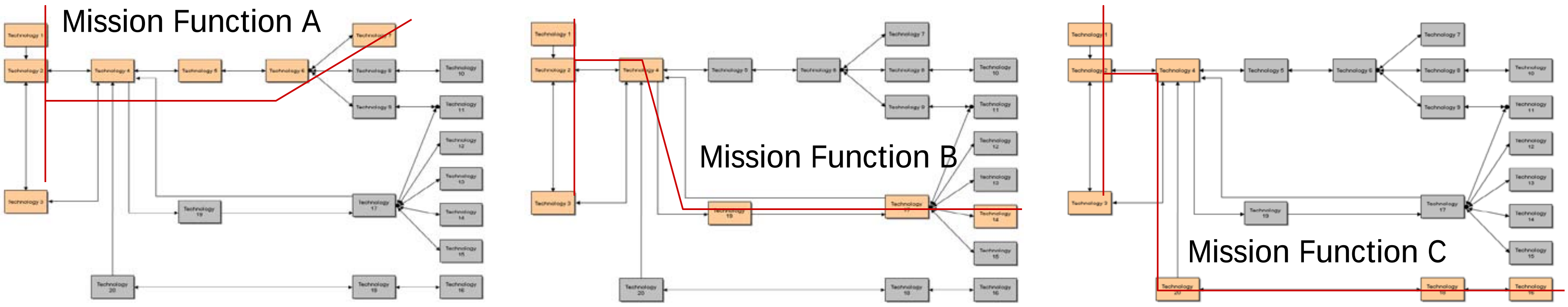
Mission Operational Availability (A_{om})

- Determining the optimum value for Mission Operational Availability requires a comprehensive analysis of the system and its planned use as identified in the CONOPS, including the planned operating environment, operating tempo, reliability alternatives, maintenance approaches, and supply chain solutions.
- Defining the SoS that will contribute to the mission will vary the Aom
  - Statistical combination of CONOPS and a blending the contributions of the equipment will identify the critical components and provide insight into which require shorter MTTR and MLD and higher MTBF

$$A_{om} = \text{System operational/Time Allocated for Mission}$$

Through mission string analysis we gain mission operational performance and sustainment insight linked to CONOPS

Mission Operational Availability "String" Analysis*



- Operational strings were analyzed to identify the components required to execute independent mission functions of the system
- An assessment of the string to achieve a Mission A_{om} contribution is made
- Common components (nodes) which form a critical function in more than one mission function are identified, operational time is calculated for each mission it touches over the deployment cycle
- Allocation of the Mission A_{om} forms an A_o requirement at the component (LRU) level

Complex systems often offer numerous options for conducting operations, but critical and commonly used/shared components must be available

* Notional Data Applied

MCM Mission String Analysis (CONOPS A Deployment)*

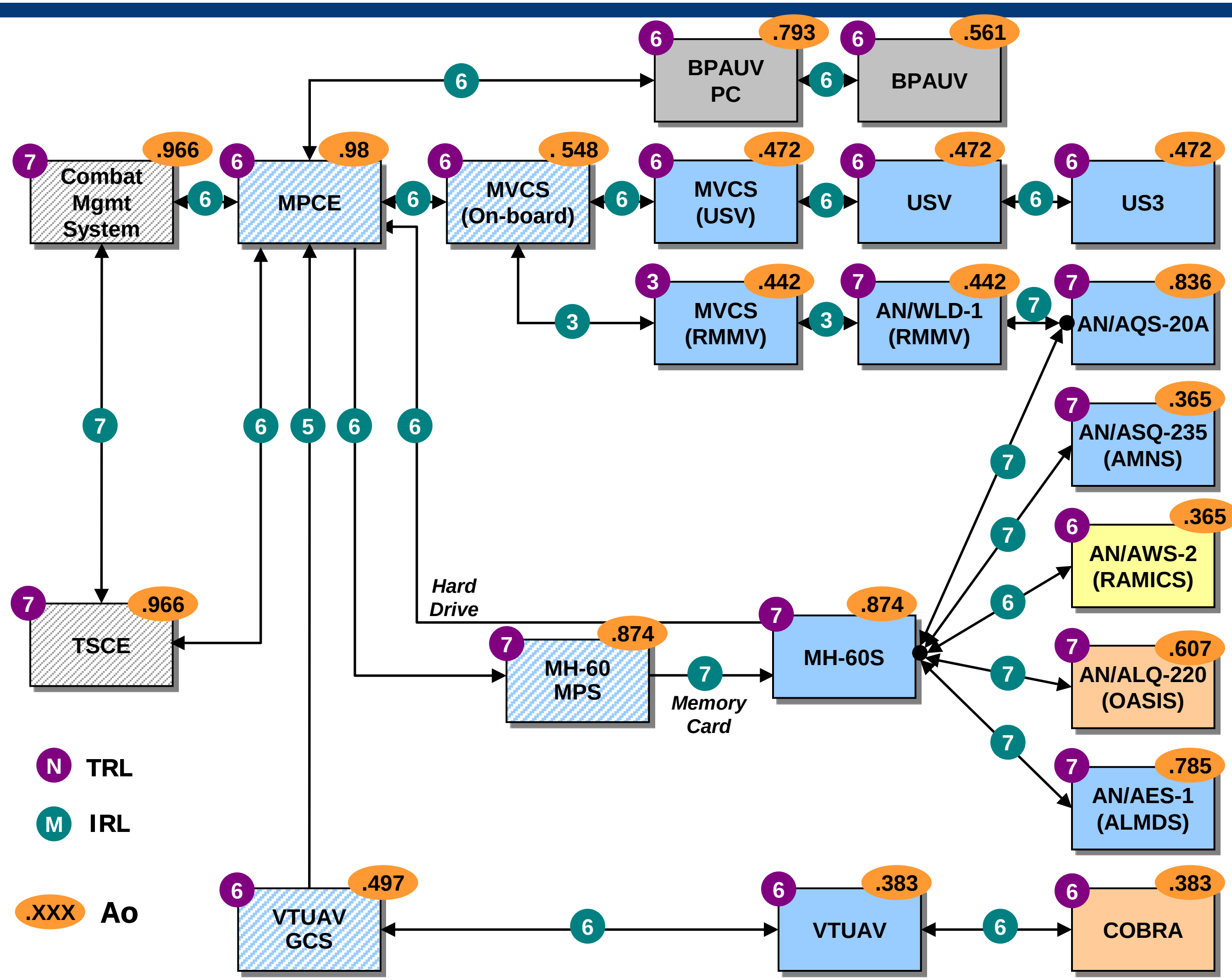
*** Notional Data Applied** Mission	Hunt Bottom & Volume Mines Deep Water to VSW		Hunt Near Surface & Floating Mines	Neutralize Bottom & Bottom Mines	Neutralize Near-SurfaceFloating Mines	Sweeping Mines		Detect Beach Zone Minefields	Clandestine Battlespace Preparation	Hunt Mines in VSW	Hunt Mines in SZ	Neutralize Mines in VSW	Neutralize Mines in SZ	Post data Analysis
Alternative CONOPS	Prime	BU				Prime	BU							
CMS (Includes Ship Up & Capable)	X	X	X	X	X	X	X	X	X	X	X	X	X	
TSCE	X	X	X	X	X	X	X	X	X	X	X	X	X	
MPCE	X	X	X	X	X	X	X		X					X
MVCS on board	X													
VTUAV GCS								X						
VTUAV								X						
COBRA								X						
MH-60		X	X	X	X		X			X	X	X	X	
MH-60 MPS		X	X	X	X		X			X	X	X	X	
AN/AES-1 (ALMDS)			X											X
AN/ALQ-220 (OASIS)							X							
AN/AWS-2 (RAMICS)					X									
AN/ASQ-235 (AMNS)				X										
AN/AQS-20A	X	X												X
AN/WLD-1 (RMMV)	X													
MVCS (on RMMV)	X													
US3						X								
USV						X								
MVCS (USV)						X								
BPAUV									X					
BPAUV PC									X					X
Mission Time* (example values, real values are classified)	20.93	40.00	35.00	12.00	12.00	25.00	50.00	14.00	40.00	X	X	X	X	70.00
Ship Deployment duration	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Explosive Ordnance Disposal (EOD) or Naval Special Clearance Team (NSCT) not provided by MP										X	X	X	X	

Mission Availability avg. (A_{om}) = 19Days/26Days = 0.75

Modular Diversity of the MCM suite enables options to mission execution

A_{om} is calculated as average of min/max mission operational

SoS (CONOPS A Deployment)*: MCM Mission Architecture Availability Allocation of A_o from A_{om}



Adapted from the MCM MP SRL Assessment Block Diagram

Extrapolate A_{om}=0.75 from 26 day to 18 month DD yields system A_o=0.95

* Notional Data Applied

Improving Modularity Benefits Realized Through

- Developing RMA performance expectations for these systems, based on mission analysis (completion time) and type of systems employed
- Using RBD's as a method for helping to pick technology insertion by looking at the impact across a mission area.
  - Allows resource focus on changes that increase number of mission systems or availability of the systems (which means better reliability, better maintainability, lower LDT). Increase number of mission systems or availability of the systems (which infers higher reliability, better maintainability, lower LDT).
- Designs should have as much BIT as possible, maybe even LAN based debug capabilities, (minimize handling to test RFU).
- Approaches to automatically verify interconnects should be used.
- Specifications should consider reparability in the modular sense, easy to find - quick to replace.
- If Crew size limitations are dictated, operations and maintenance approach should be simplified and standardized
- Incorporating prognostics technology which provides early prediction of expected failures via monitoring key component parameters and failure prediction algorithms (lower LDT)
- Alternative test and repair concepts; e.g. MSC support ship (lower LDT).

The Modular SoS Paradigm Summary

For a SoS Mission Availability Requires Continuous Risk Mitigation

- For SoS Allocate A_o based on Mission Operational Need and analysis, established MTBF may not meet the requirements
  - Identify the mission strings
  - ID Critical system nodes and connectivity points
  - Allocate Availability Goals
  - Define CONOPS alternatives that can achieve the mission timeline
  - Plan Availability Evolution (Technology Insertion or Obsolescence Opportunities)
  - Include any safety issues that could also drive A_o
- Balance modularity with fixed systems
  - Understand the development status of the systems
    - Weight new systems with SRL status
  - Collect data and project expectations against allocations
  - Harden the fixed systems but balance with cost benefit analysis
- Trade reliability improvement options with Program Cost and include RMA in the system roadmap to evolve A_o over the program LC
  - MTBF - design improvement, proper handling,
  - MTTR - modular construction, automated test equipment, Online MM,
  - MLDT - just-in-time spares, built in redundancy, prognostics

JPEO-CBD

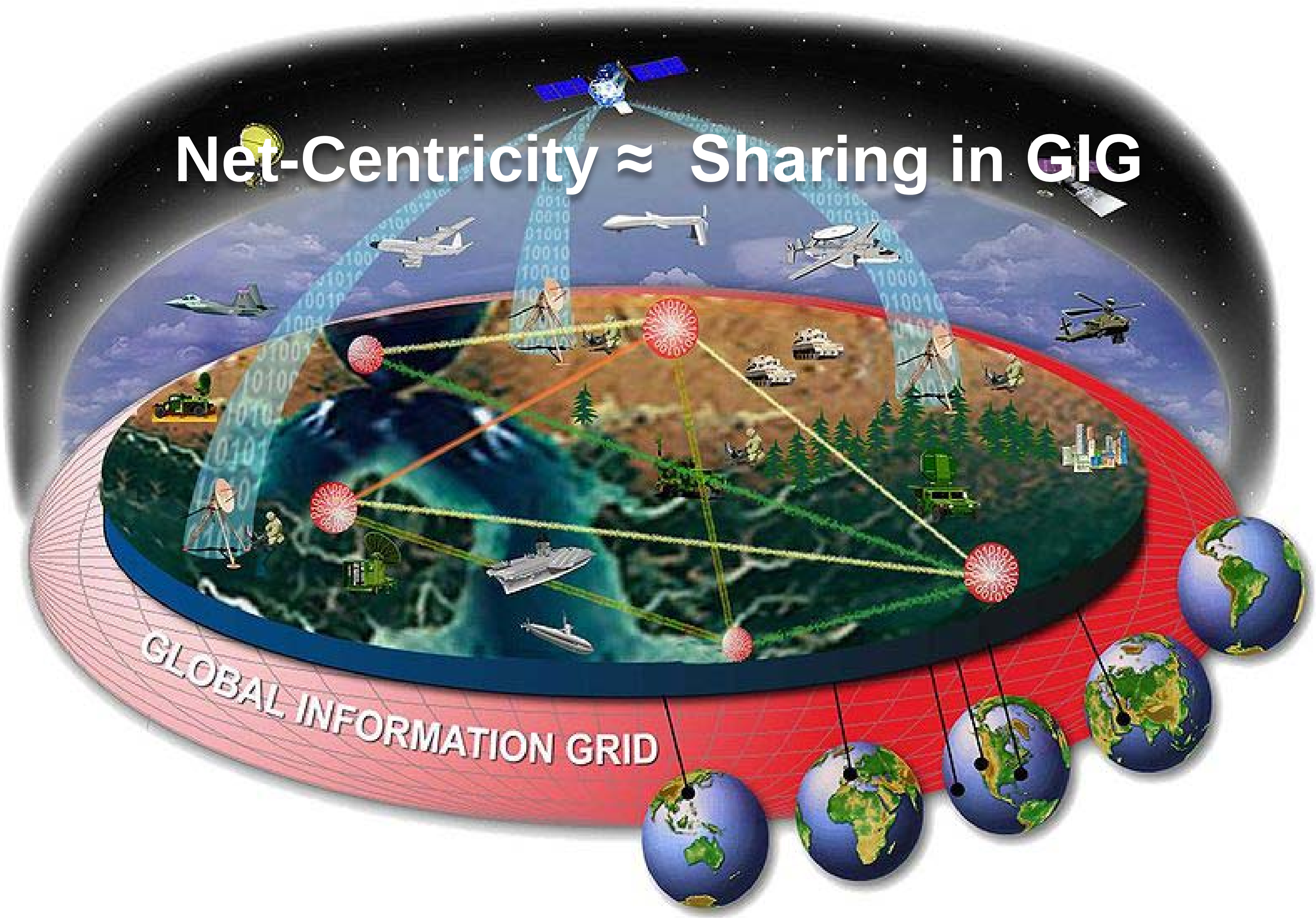
Net-Centric Updates and Case Studies

Oct 28, 2009

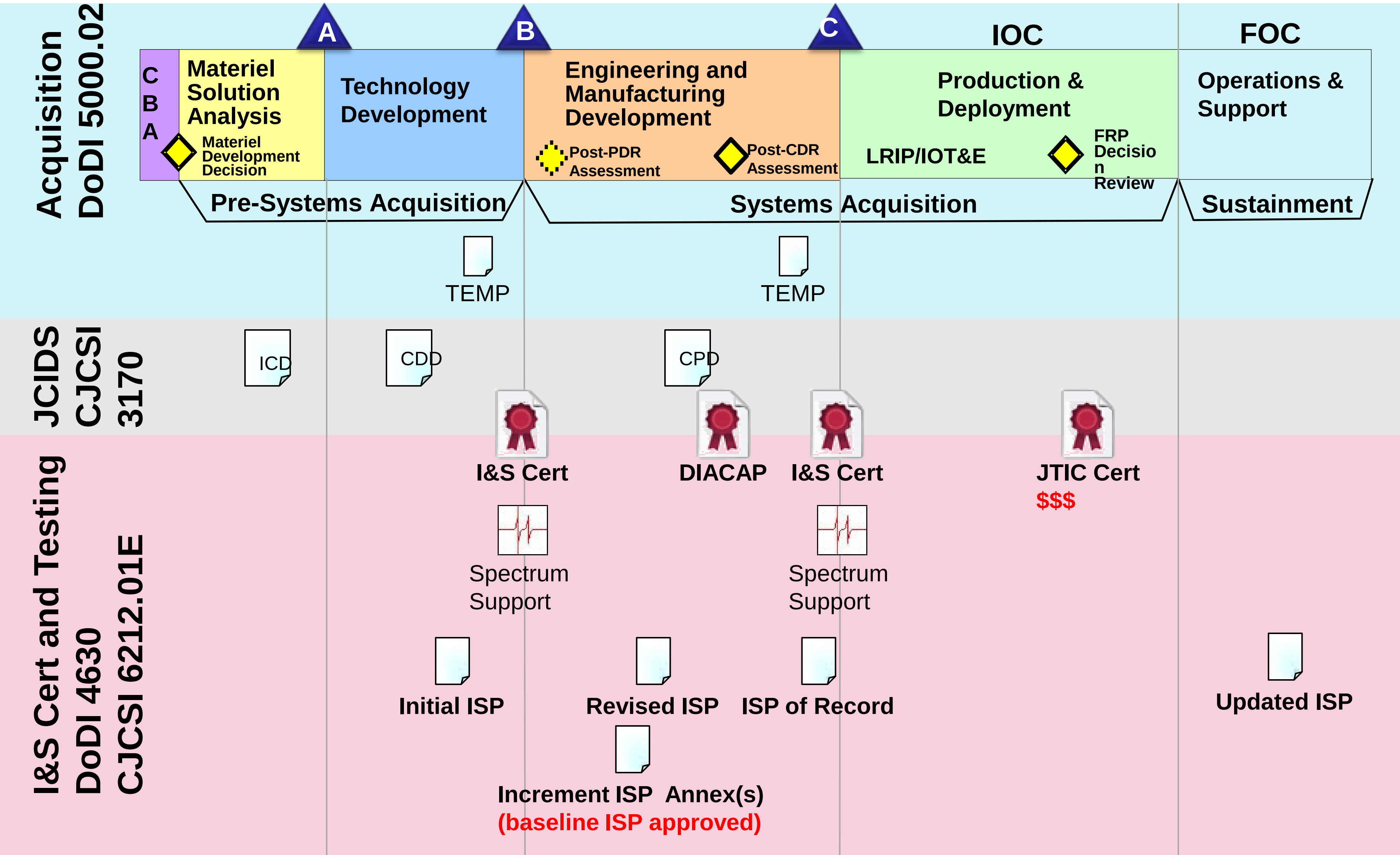
Donald Way
Lattice Government Services
619-553-7954
don.way@us.army.mil
dway@latticeincorporated.com

Hiekeun Ko, PhD
SPAWAR Systems Center Pacific
619-553-8013
hiekeun.ko@navy.mil

What is DoD Net-Centricity



Impacts on the DoD Acquisition



Net-Centric Compliance is Challenging

Policies

- DoDD 8320.02
- CJCSI 3170G
- NR-KPP
- CJCSI 6212E
- DoDI 4630.8
- DoDD 8500.1
- JROCOM 130-08
- UCore

Strategies

- NC Data Strategy
- NC Service Strategy
- NC IA Strategy

Architectures

- DoD IEA
- DoDAF 1.5
- DoDAF 2.0
- UPDM
- JCSFL

Tests

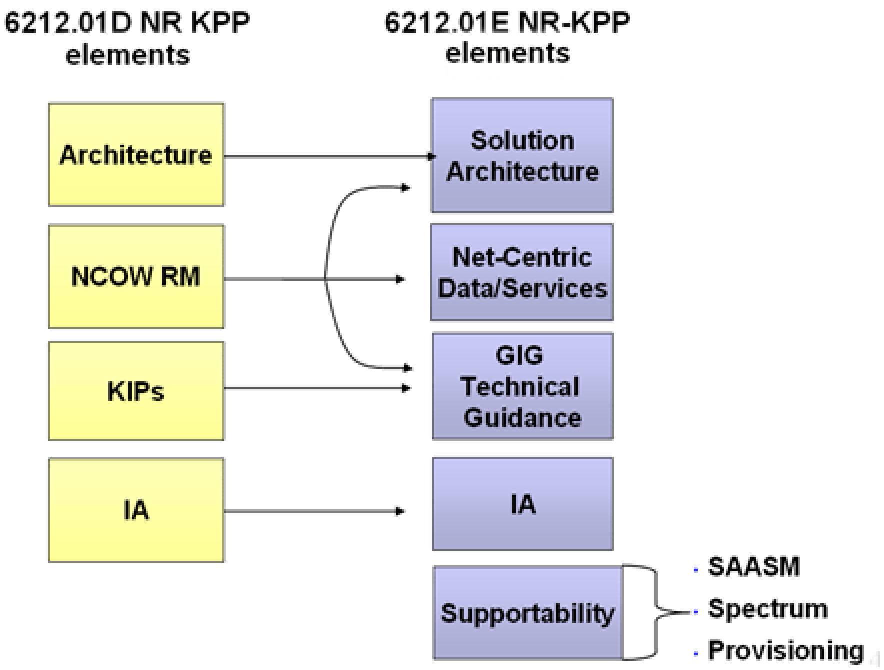
- JITC
- DICE
- JUICE
- CWID

Tools

- JCPAT-E
- DISR Online
- GTG Federation
- EISP
- DARS
- NCES
- MDR
- DDMS

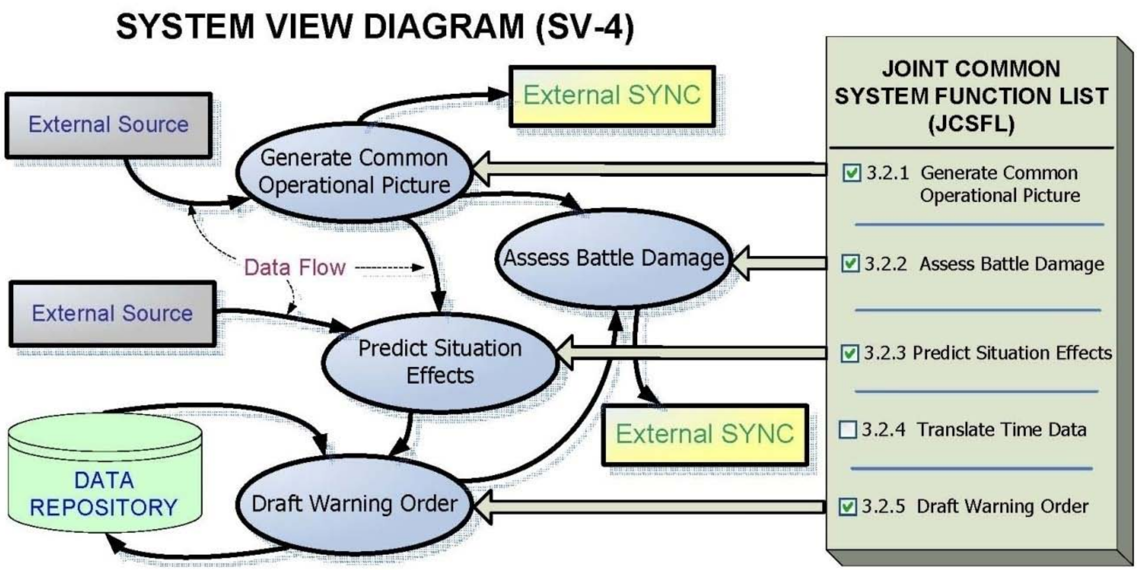
Net-Centric from CJCSI 6212.01E

Evolution of the Net-Ready Key Performance Parameters (NR-KPP)



Net-Centric Architecture

- Shifting from “Product-Centric” to “Data-Centric”
- Net-centric architecture compliance governed by **DoD IEA** business rules
- “All Views” (AV-1) diagram, must conform to DOD IEA standards and be maintained in the **DOD Architecture Registry System (DARS).**
- Introduces GIG Technical Guidance (GTG) as an emerging source for standard implementation (TV-1 and TV-2).
- Prescribes the use of JCSFL to describe functionality in a common lexicon.



Net-Centric Data Strategy

- Visible
- Accessible
- Understandable
- Institutionalized
- Trusted
- Interoperable
- Responsive to user needs

Net-Centric Service Strategy

- Provide
- Use
- Govern
- Monitor & Manage

Net-Centric Data / Service Exposure

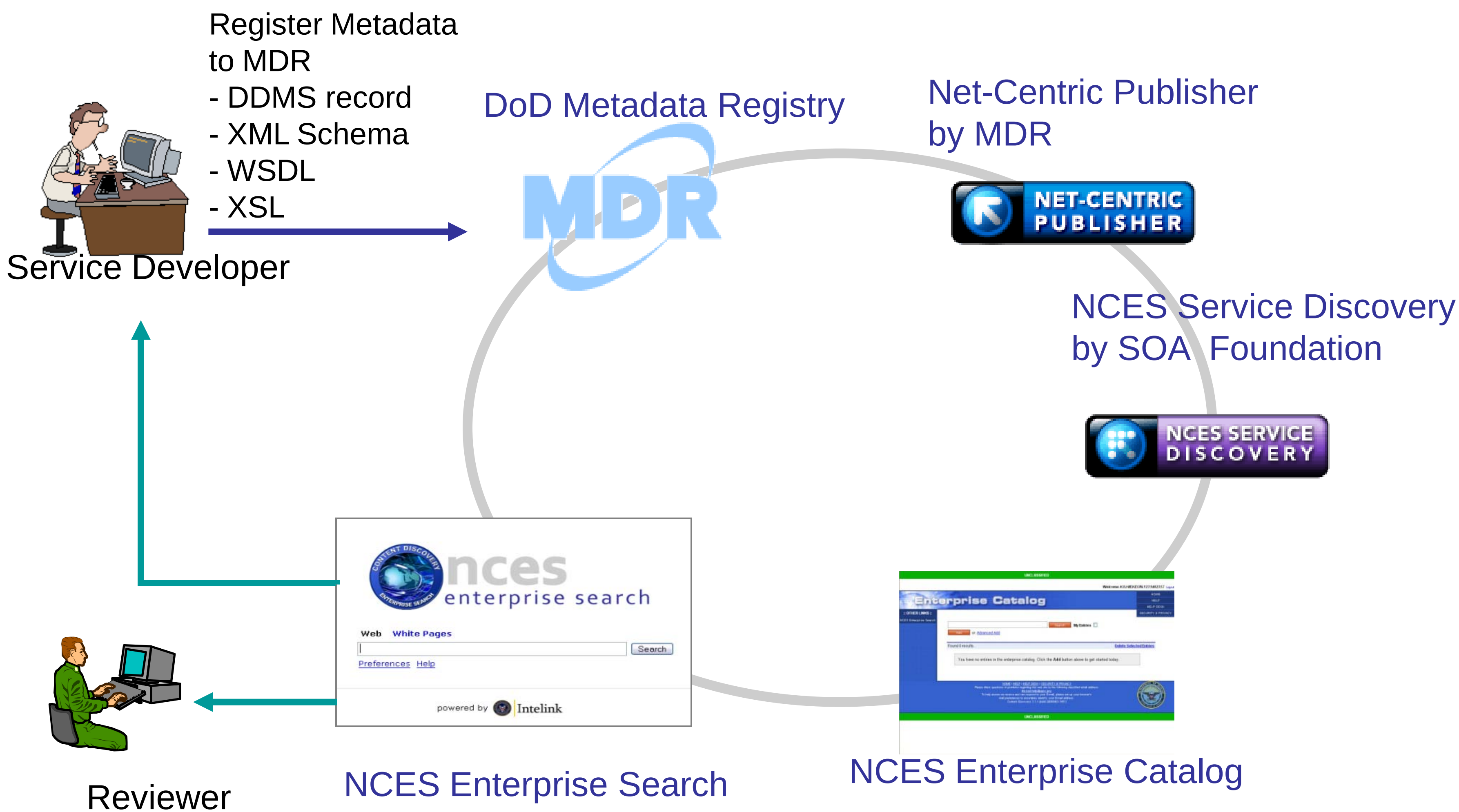
Data Exposure Status Criteria

1. Visible
   a. DDMS entry in an Enterprise Catalog
   b. Content search function that federates to NCES Federated search
2. Accessible
   a. Policy
      i. Written policy for transparent access to data
      ii. Policy addresses access from Federated Search
   b. Operational (Transparent Access)
      i. Federated Search results provide active link
3. Understandable
   a. Enterprise Search
      i. Search terms/keywords appropriate for Mission area or data type
      ii. Described data understandable to both anticipated and unanticipated user
      iii. Mission data maps back to search terms

Service Exposure Status Criteria

1. Visible
   a. XSD & WSDL in DoD Metadata Registry (MDR)
   b. Service end-points in Universal Description, Discovery and Integration (UDDI)
2. Accessible
   a. UDDI
      i. Transparent M2M access to operational data at the targeted security enclave
      ii. Service links to accessible WSDL definition
   b. Policy
      i. Written policy for transparent M2M access
      ii. Policy addresses unanticipated developer
3. Understandable
   a. Service Provider schemas & supporting documentation in MDR
   b. Service schemas conform to standard (COI approved) vocabulary

Service Registration/Discovery



Net-Centric Data / Service

- Design Net-centric data / services
  - Design effective information exchanges within and among declared COIs
  - Consider unanticipated users
- Implement Net-centric data / services
  - Reuse or leverage others
  - Implement and use core services (NCES SOA Foundation)
- Identify net-centric services and shared enterprise-level data
  - Verify that data and services are properly registered, visible, and accessible
  - Conformance testing for data / schema (e.g., proper XML format)
  - Verify correct provision and use of services / data and any related performance parameters (QoS, timeliness, etc.)
- Compliant with net-centric standards
  - SOA
  - XML, WSDL, SOAP, UDDI, etc

GIG Technical Guidance

- Establishes the policies and guidance to maintain a common technical foundation for the GIG throughout the DoD enterprise.
- GTG describes **GIG Enterprise Service Profile (GESP)** concepts and their relationship to operational requirements, as specified in the Capability Development Document (CDD), Capability Production Document (CPD), Information Support Plan (ISP) and technical views (TV).

- **DISA** recently introduced **GTG Foundation** (GTG-F) that facilitates, standardized, and streamlines the GIG Interoperability assessment process.
- **GTG-F** enables the gathering of compliance data including GIG Enterprise Service Profiles (GESPs), IT standards, guidance statements, metadata standards, and program data
- GTG-F makes the virtual ISP process more efficient by enabling **Enhanced ISP (EISP)** to feed ISP data into automated ISP Assessment Module (IAM)
- **GESP** Declaration (or KIP declaration, e.g., for pre-6212.01E documents) should be contained in CDD, CPD, ISP or NR-KPP package.

Net-Centric IA Strategy

- Protect Information
- Defend Systems & Networks
- Align GIG Mission Assurance
- Transform & Enable IA Capabilities
- Create an IA Empowered Workforce

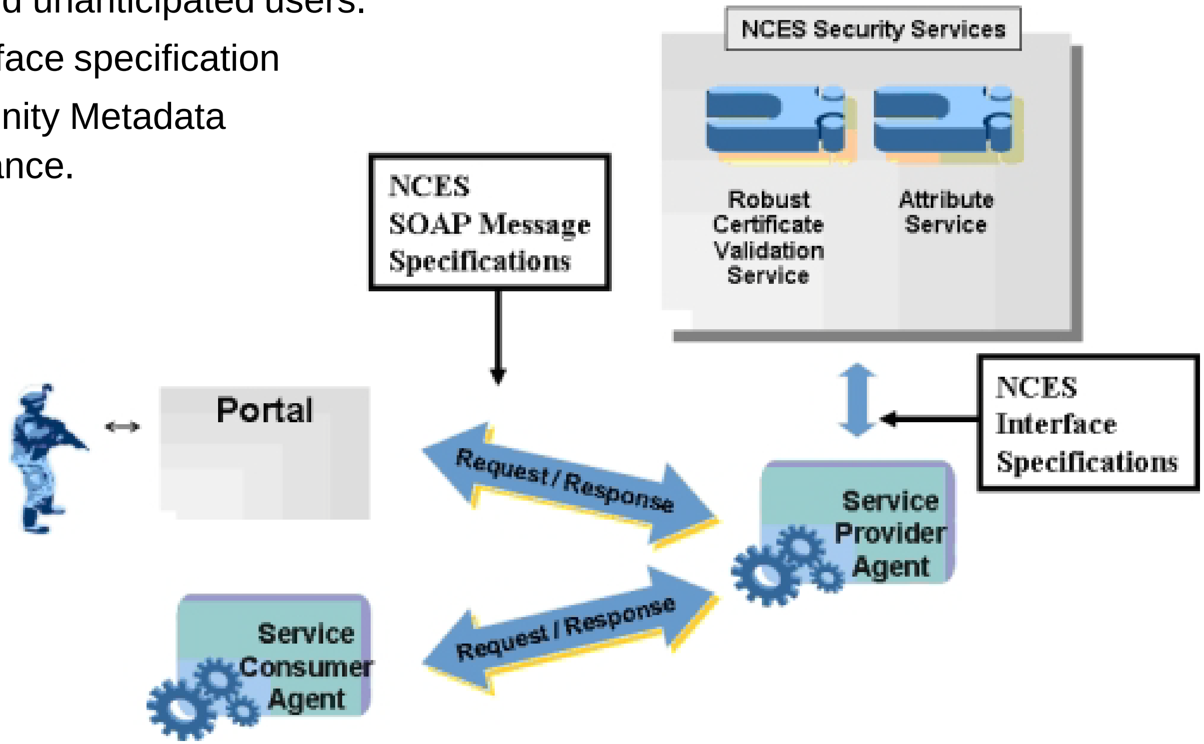
Net-Centric Service Security Standards

- Ensure security standards to protect service discovery by proper authentication and authorization mechanisms.
  - SOAP Security: WS Security, Industry (IBM, MS, and Verisign) and OASIS
  - Message Integrity: XML Signature, W3C
  - Message Confidentiality: XML Encryption, W3C
  - Access Control: XML Access Control Markup Language (XACML), OASIS

NCES – Core Enterprise Services

Service Security

- **NCES** provides the architecture for authentication, authorization, confidentiality, message integrity, non-repudiation, manageability, and accountability.
- Provides an enterprise Robust Certificate Validation Service **(RCVS)** to support effective authentication of both individuals and web services, with or without PKI.
- Provides an enterprise Attribute Service **(AS)** to support centralized retrieval of authoritative attribute values for individuals and unanticipated users.
- Provides a SOAP message interface specification
- Conforms to Intelligence Community Metadata Standards for Information Assurance.



Net-Centric IA

Accreditation / Certification

- Development Test stage
  - Verify the DIACAP process has been accomplished.
  - Review the System Identification Profile (SIP), Certification Report, Plan of Action and Milestones (POA&M) and the IATO, as applicable.
- Operational Test stage
  - Review the Comprehensive DIACAP Package.
  - Test configuration must mirror approved operational configuration (i.e., testing in a realistic IA environment)
  - Review OT report and verify IA compliance, as appropriate.
- Collect results of any IA accreditation, waivers, etc. for reporting in certification

Interoperability Testing

More emphasis on Integrated and Federated Testing

JITC

- **JITC** reviews testing already conducted as well as assessments prepared by independent testing organizations.
- **JITC** often performs its own testing and forwards test results to the Joint Staff, who validate the system's certification.
- Systems are generally certified for three years, after which they must be re-certified.

DICE

- JITC conducts **DoD Interoperability Communications Exercise (DICE)** in support of DoD Joint Interoperability testing, training, and exercise transformation initiatives 3 times per year.
- **DICE** is sponsored by the Joint Staff and U.S. Joint Forces Command (USJFCOM) and conducted by JITC

JUICE

- **Joint Users Interoperability Communications Exercise (JUICE)** formed in 1993 to answer the Army Secretary of Defense requirement for an organization to focus on Joint Interoperability across the DoD.
- Conducted by the Executive Agent Theater Joint Tactical Networks **(EA-TJTN)**
- Includes operational units, system developers, test and experimentation activities, life-cycle engineering organizations, and vendors) to examine and assess joint user-system interoperability in a robust simulated joint-task-force network functioning in a deployed environment.

Interoperability Test Events

- **Federated Test Events:** Testing shall include, when feasible, system-of-system and family-of-system (federated) live events to complete interoperability certification.

- **Federated Networks:** Maximum use of federated testing on federated networks (DREN, DISN, NIPR, SIPR) and federated tracking through the **Federated Development & Certification Environment (FDCE)** should be employed.

Leveraging operational tests:

- Interoperability tests of **Joint Mission threads** should be integrated throughout operational Testing. 6212.01E authorizes the use of Operational Assessments and Evaluation Reports (OAR/OER) to evaluate the operational effectiveness and validation of interoperability requirements.

- **JITC** reviews testing already conducted as well as assessments prepared by independent testing organizations. JITC often performs its own testing and forwards test results to the Joint Staff, who validate a system's certification. Systems are generally certified for three years, after which they must be re-certified.

Net-Centric Assessment
by JPEO-CBD Software Support Activity

- Identifies critical net-centricity items to assess the program during “Pre-Milestone C”
  - Program Schedule (Integrated Master Schedule (IMS) and detailed schedules as available)
  - DD 1494 Spectrum Supportability Certification OR Plan And Justification For Submission To USD(AT&L), ASD(NII), DOT&E, and The Chair, MCEB
  - Capability Production Document (CPD)
  - Updated NR-KPP
  - Certification and Accreditation Process Plan
  - J6 I&S Certification
  - Military Communications-Electronics Board **(MCEB)** Interim Certificate To Operate (ICTO) Request
  - Detailed Architecture Products Consistent With DoDAF Requirements
  - The Program RFP and Performance Specification
  - Database Creation Scripts For All Developed Databases
  - Interface Requirements Specification (IRS)

Net-Centric Assessment (con't)

- Mapping document that maps the program's data exchange requirements to a common **Data Model** or conforming **XML Schema**
- List of entities and attributes or XML types currently used by the program.
- **OV-7** and **SV-11** logical and physical data models
- All **XML** Schema files, including subsets.
- Web Service Description Language **(WSDL)** files for all defined Web Services
- All XML documents created/logged during system testing
- Signed System Security Authorization Agreement OR DIACAP derivative
- Signed Interim/Approval To Operate (I/ATO) letter
- Signed **Clinger-Cohen Act (CCA)** compliance statement, if required
- Signed Information Support Plan **(ISP)**
- Signed Cross Domain Appendix (CDA) (if required)
- Systems Engineering Plan **(SEP)**

Net-Centric Updated Resources
Best Sources of Standards and Information

- DAU Acquisition Community Connection
  - https://acc.dau.mil
- NCES Developer Community on DKO
  - https://www.us.army.mil/suite/kc/6998357
  - Is the best resource for the current concepts, direction and information on the Net-Centric initiative
- NESI-X
  - Net-Centric Enterprise Solutions for Interoperability () site at http://nesipublic.spawar.navy.mil/nesix/Frames, is a complete resource. Among other things the site offers developer support, guidance and best practices.

Case Study:
CBRN Data Model

- **The CBRN data model** is a realization of the **DoD net-centric data strategy** (NCDS) and facilitates interoperability and reuse by specifying a common data structure through the **CBRN COI.**
- **The CBRN Data Model** includes standardized, common, open tagged metadata in accordance with the Department of Defense **Discovery Metadata Specification (DDMS).**
- Developed using the Integration DEFinition for Information Modeling 1 eXtended (IDEF1X) format, as specified in the **Department of Defense (DoD) Information Standards Registry (DISR).**
- Lays the foundation for the creation of **XML tags** and schemas and assists in data quality checks for syntactic and logical consistencies. These XML tags to the CBRN namespace, and are registered in the DoD MDR.
- Built upon the North Atlantic Treaty Organization (NATO) **Joint Command and Control Information Exchange Data Model (JC3IEDM).**
- Expands the **JC3IEDM** to reflect all **Allied Tactical Publication (ATP) 45** NATO Nuclear, Biological, Chemical (NBC) message sets and related information elements.
- **CBRN Data Model v1.9** (2009) includes 569 entities, 5067 attributes, and 1811 physical relationships.
- **POC: Ms. Sheila Vachher**

  JPEO-CBD SSA Data Management, 703-933-3336, savachher@alionscience.com

Case Study:
CBRN Data Model (con't)

Other Benefits:

- Facilitates a common CBRN Domain Representation
- Enables Data Interoperability & Re-use
- Facilitates Interoperability:
  - Scalable and extensible
  - Specifies meaning and structure of data
  - Specifies relationships among data
  - Provides open standard basis for Data Exchange XML.
- Release 1.9 pilots the use of **Geospatial Markup Language (GML)** in the CBRN XML Schema Definition (XSD). **GML** is the mandated standard for geospatial representation in DoD IT Standards Repository (DISR) and in the **Universal Core (UCORE).** Still **GML** and **UCORE** have yet to be adopted into developing technologies by the greater DOD community. **Data Harmonization** efforts include:
  - Harmonization with the CBRN Common Sensor Interface **(CCSI),** ANSI N42.42, IEEE 1451 and OGC Sensor Web Enablement to include: Observations & Measurements, SensorML and TransducerML.
  - Defense Threat Reduction Agency **(DTRA)** and JPEO-CBD harmonization of Radiological / Nuclear data.
  - Harmonization with Department of Homeland Security **(DHS)** Chemical and Biological Alarm Summary.

Case Study:

CBRN Data Model (con't)

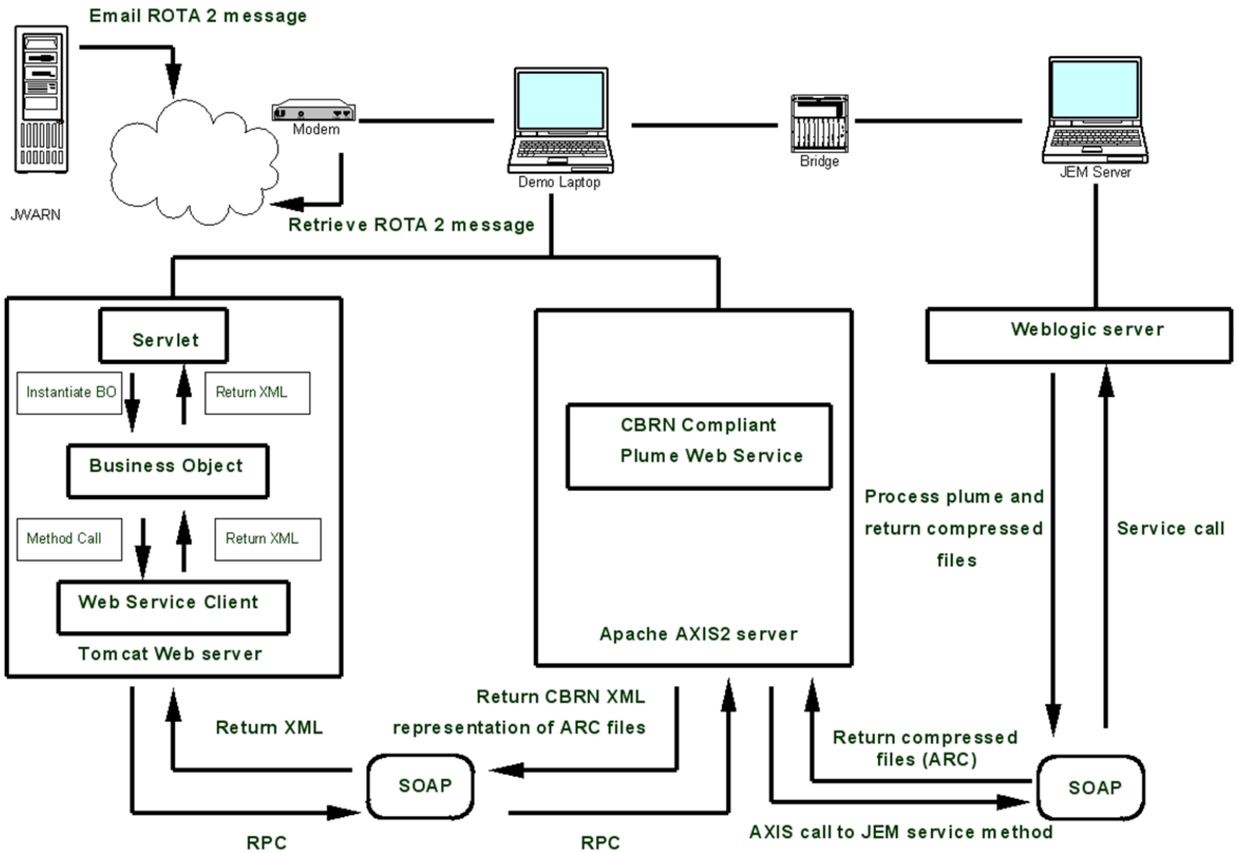


Diagram depicts the flow of a CBRN message through a data model compliant transformation in a web-server agnostic, SOA based system.

Case Study:
Joint Effects Model (JEM)

JEM Overview and Web Service Implementation

- **JEM** is a software simulation system employing advanced atmospheric transport and dispersion models to create high fidelity, hazard predictions of chemical, biological, radiological, and nuclear **(CBRN)** toxic materials to protect from airborne contamination.
- A web-based application utilizing **Web Services** in an **SOA** leveraging open eXtensible Markup Language **(XML)** -based standards and transport protocols to exchange data and encapsulate behaviors.
- Utilizes the Web Services Definition Language **(WSDL)** to expose service functionality and enable interoperation with various Weather and Visualization Services.

JEM's Net-Centric Weather Service

- **JEM** is capable of requesting, receiving and manually inputting meteorology and oceanography **(METOC)** data from local and strategic sources including: the Joint Weather Impact System **(JWIS, Air Force)** and the Defense Threat Reduction Agency's (DTRA) **METOC** Data Service **(MDS).**
- Within its delivery software for both **JWIS** and **MDS, JEM** communicates using the Host Name, User ID Name, User Password and Port Number; which allows immediate access to weather data via the NIPRNET and SIPRNET.
- **JEM** is one of the first applications to employ **JWIS Web Services**, that employs the METOC COI **Joint METOC Broker Language (JMBL)** as the XML interface and will also employ the **Joint Environmental Toolkit (JET).**

Case Study:

JEM (con't)

JEM Modeling Web Service

- **JEM** provides **modeling services** to other applications.
- The JEM **Modeling Web Service** acts as the intermediary between external applications and the JEM modeling application.
- Applications such as **JWARN** can request information and services from the Modeling Service using **SOAP** messages over **HTTPS**.

- **JEM Modeling Web Service** allows clients to submit modeling requests, check status of submitted jobs, and retrieve calculation results.

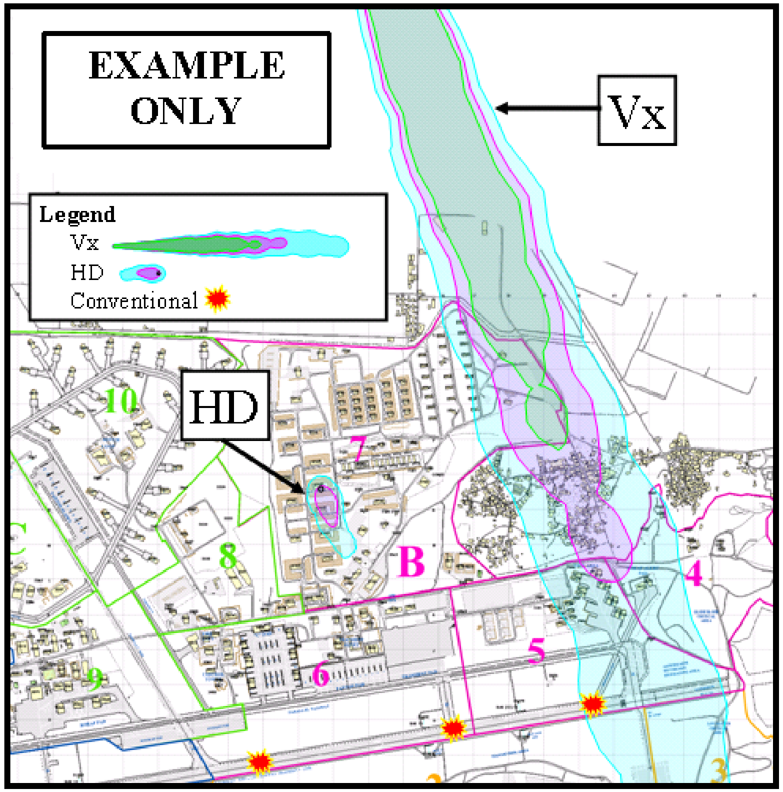
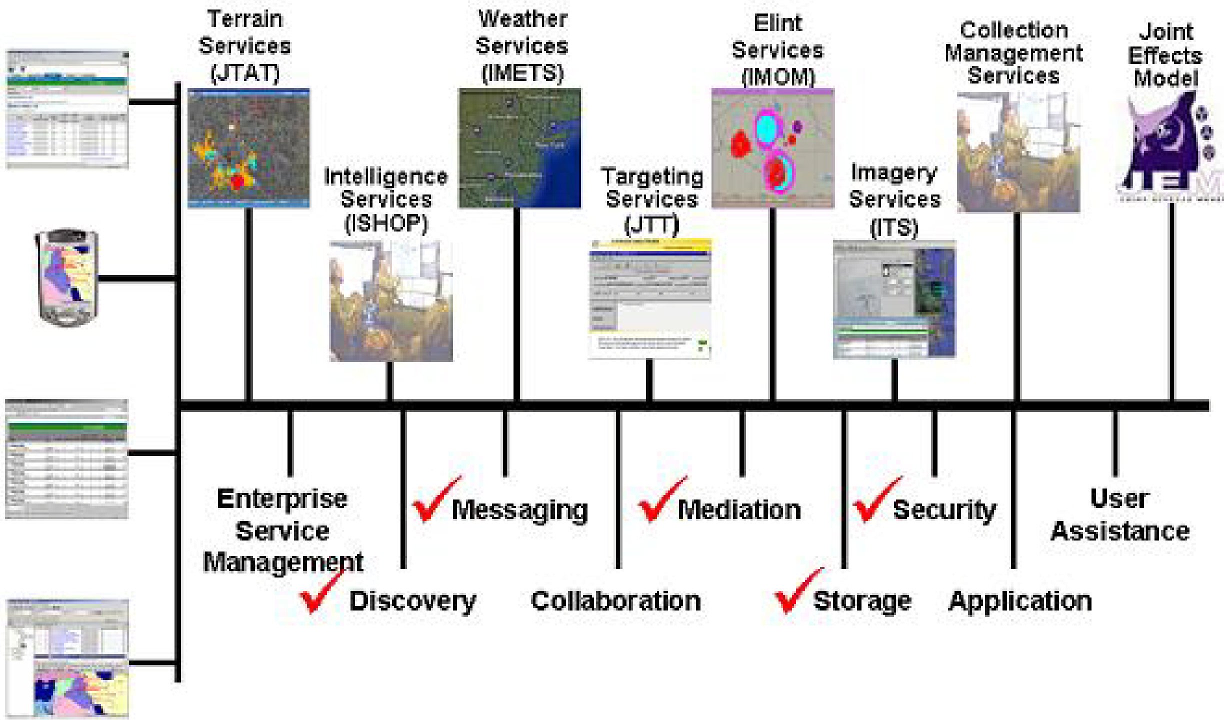


Diagram depicts a "Plume Model" generated from the JEM Modeling Web Service

Case Study:
JEM Web Service Relationships



Above describes the JEM's relationship to other peer applications that can utilize the JEM Modeling Service.

Case Study:

JEM Best Practices

- **Best practices in Net-Centric Development:**
  - A **CBRN Community of Interest (COI)** was developed along with an XML namespace (designed to DOD data and metadata standards) and registered with in **DOD Metadata Registry (MDR)**.
  - **JEM** is main contributor to **CBRN COI** and **CBRN Namespace**, also designed to metadata standards and registered in the MDR.
  - **JEM** is designed to be server “agnostic”. For Instance, JEM is hosted via the Battle Command Common **Services (BCCS)** platform, using an open-source/**JBOSS** configuration and is deployed on **GCCS** using **BEA’s Web Logic** application framework.
  - Test Interoperability with systems calling a JEM Web Service Interface “early and often”.
  - Designed to orchestrate multiple weather services in combination.

- **Best practices in Net-Centric Certification:**
  - Execute early and consistent contact with the **ASD/NII** staff to ensure that ISP development is in line with what was is expected by **J-6** and **J-3**
  - Promote tight coordination/ feedback loop with **JRO** engineers in **OV diagram** preparation**.**
  - Ensure that staff is skilled and has sufficient background to perform the required work.
  - Respond quickly to **JCPAT** feedback to keep process moving forward without delay.

Case Study

Joint Warning and Reporting Network (JWARN - Increment 1)

What is JWARN?

- **The Joint Warning and Reporting Network (JWARN)** is a fully fielded I&S and V&V completed software application that provides Joint forces with a comprehensive analysis and response capability to minimize the effects of Nuclear, Biological and Chemical **(NBC)** attacks.
- **JWARN** is also used in response to accidents and incidents involving Toxic Industrial Chemicals **(TICs)** and Toxic Industrial Materials **(TIMs)**.
- **JWARN** Enables an immediate and integrated response to threats of contamination by weapons of mass destruction through rapid warning and dissemination of Chemical, Biological, Radiological and Nuclear **(CBRN)** information.

Case Study

Joint Warning and Reporting Network (JWARN - Increment 1)

JWARN Functionality:

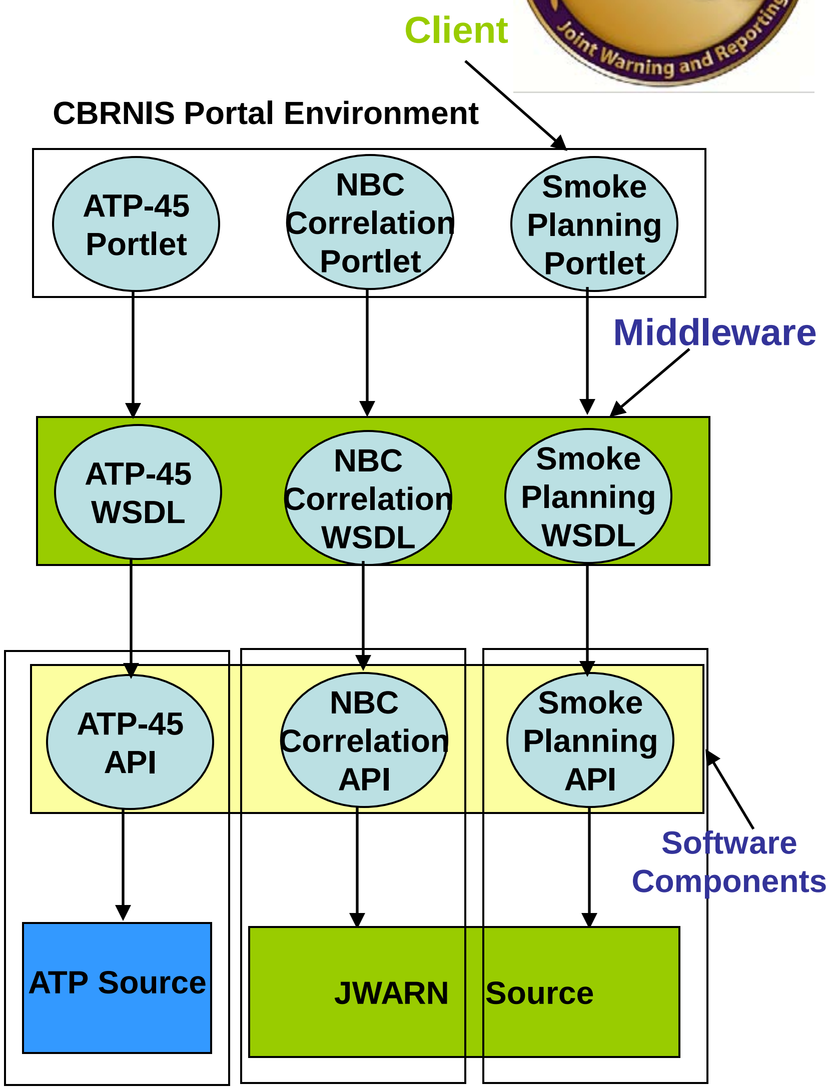
- Collects, generates, edits, and disseminates **NBC reports** and plots and provides a means of ensuring all addressees have received a sent message
- Provides application support for; **GCCS-M, GCCS-AF, GCCS-A, GCCS-J, FBCB2** (via message exchange) **and MCS, C2PC/JTCW**.
- Allows **NBC** reports (NBC-1/NBC-4) to be formatted and transmitted within 2 minutes and allows operator selection of automatic, delayed, or on-command sending of NBC reports
- Provides automated **sensor** interfaces for **M22(ACADA), ADM-300, AN/VDR2, M8A1, M21(RSCAAL), JSLSCAD, JCAD, JBPDS.**
- **Current Status: JWARN 1F (Block 1)** includes a worldwide distribution to all Theatres, Services and Bases and supports exercises in South Korea, Afghanistan, Iraq and within NATO activity areas.
- **JWARN Product Support provides:** Training events, Computer-Based Training, Quick Reference Guides for each C2 host and a 24/7 Call Center/Help Desk.

Case Study

Web-Enabled JWARN (WEJ)

JWARN Future Development of Web Enabled JWARN **(WEJ)** is to include full Net-Centric Interoperability and the following enhancements:

- **Cost Savings**
  - Facilitates code reuse.
  - Better adapts to changing environments.
  - Limited support required to deploy, field and train.
  - Easier to certify and test single component vs system. Process can also be automated.
  - Training costs are lower as web-based applications.
  - Administration costs are much lower since a limited number of servers need be maintained
- **Performance Improvements**
  - Utilizing load-balancing through server-side flexibility and scalability also greatly improves performance at minimal cost.
- **Ease of Use**
  - Consolidation of information can be delivered throughout the entire organization at any time and from any location in the world.
  - Decision makers can obtain information in real time.



Case Study

WEJ with ATP-45

What is ATP-45?

- A messaging format standard based on standard **NATO Allied Technical Publication ATP45** procedures used by CBRN hazard prediction software including JWARN and JEM.
- Allows the display NBC hazard areas resulting from the use of NBC weapon systems and dissemination devices over a geographic area. Creates a "plume" model.
- Is currently being updated to meet the latest dynamic technology and force protection requirements.
- The next version **ATP-45 Delta (D)** has been requested for delivery by December 2010**.** Current version is **Bravo (B)** and services have yet to adopt ATP-45 **Charlie (C)** versions.

Problems:

- Services and C2 Systems are slow to adopt new ATP-45 versions so CBRN applications must easily adapt to various C2 / ATP configurations. JWARN/JEM software must be "backward" compatible with MCS, FBCB2, C2PC, GCCS all legacy ATP-45 versions.
- For Instance, version **JWARN IF (Block 1)** uses an older version of the ATP-45 algorithm.
- Interfaces to this **ATP-45** algorithm (Bravo or Charlie) are tightly coupled to the data structures of each application and **Input AND Output Parameters (fields)** are also different.
  - –Bravo (JWARN Block 2) uses: **complex Report Object**
  - –Charlie (BNI demo code): uses: **actual "/" delimited AdatP3 string format**

Case Study
WEJ / ATP-45 (con't)

Solution:

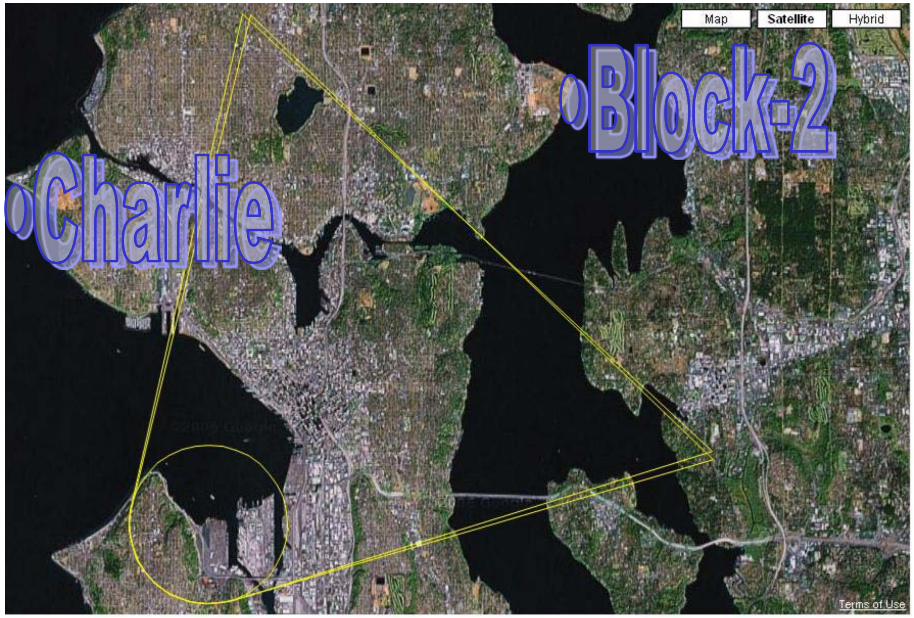
The ATP-45 Calculator Service Component was incorporated into the **WEJ** Hazard Prediction Service during software design and development. This calculator service supports backward compatibility and enables quick switching between various ATP-45 versions.

Hazard Prediction Components include:

- Get ATP-45 Bravo Hazard service.
- Get ATP-45 Charlie Hazard Service.

Planning/Calculation Components Include:

- Route Planning Service.
- Nuclear Planning Service.
- Smoke Planning Service.
- Flame field Expedients Planning Service.



This figure shows the results of both Bravo (Block-2) and Charlie (BNI) ATP-45 Calculations.

Case Study:
JEM / ATP 45

Problems:

- **JEM (B6P6**) used an older version of the “same” ATP-45 algorithm than JWARN (B321)
- Different versions of **JEM** called different versions of ATP-45 Bravo and Charlie algorithms

Solutions:

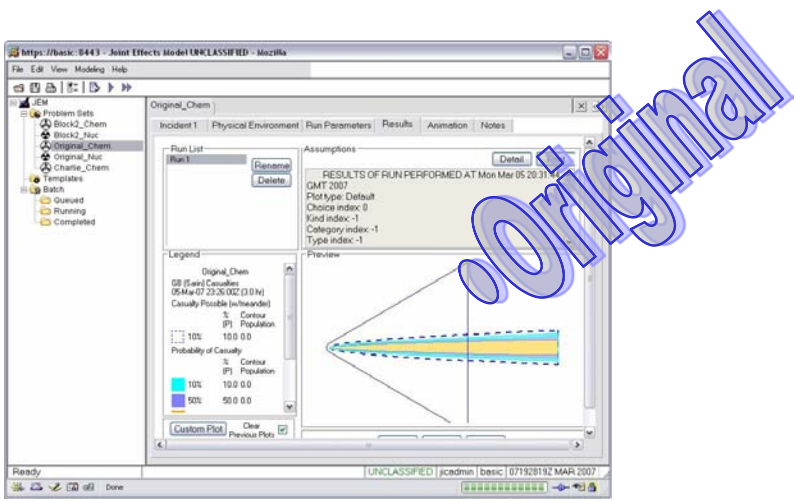
- Modifications to two java files that access common component rather than specific files (as is the older implementation)
  - Modification to build script in order to keep the ATP-45 service (application jar file) separate from the JEMSC.jar (data connector jar file)
  - Usage of a properties file to “switch” between algorithm versions at run-time rather than having to make code changes and recompile.
  - The **JEM code (B6P6)** was then updated to call this new API.
  - The **WEJ** project also developed a hazard prediction service which uses the ATP-45 algorithm. The corresponding code that calls this new API was also updated.

Case Study:
JEM / ATP 45 (con't)

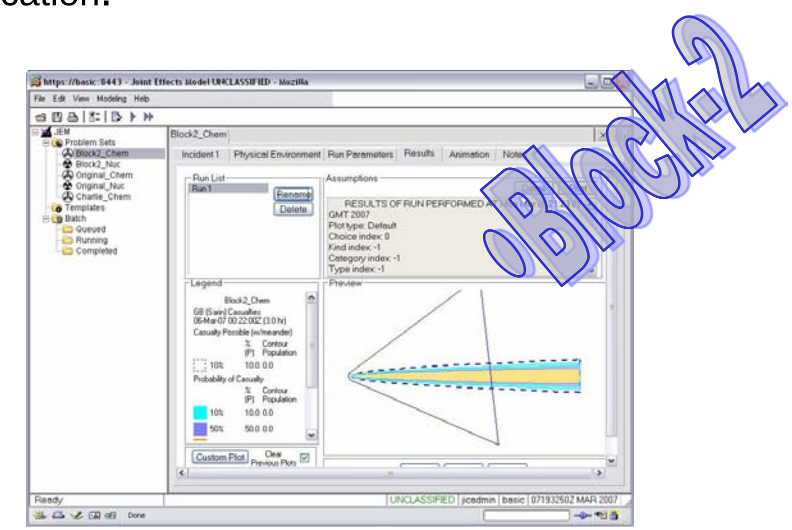
Solutions: (con't)

– The newly created component allowed the software to "substitute" calls to the **ATP-45 C** version of the algorithm (received as demo code from BNI) by adding an implementation of the interface for the new version.

– A properties file was also added so that this "switch" could be accomplished at run-time rather than having to edit / recompile the application.



JEM - Original Chem Hazard



JEM - Bravo (Block-2) Chem Hazard

Summary

- Start a new or join an existing Community of Interest (COI).
- Become familiar with latest NCES and GTG information and offerings.
- Coordinate Testing with JITC early and often while leveraging operational tests and federated test event.
- Apply new standards approximately six months after they are formally introduced into compliance documentation.

Case Study Summary:

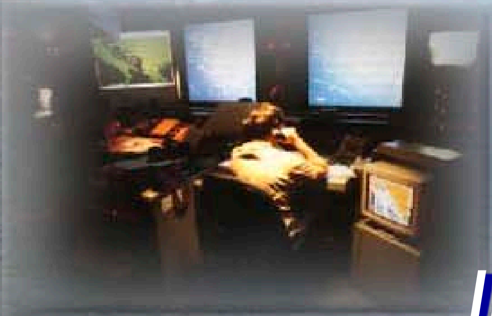
- CBRN Data Model facilitates interoperability and reuse by specifying a common data structure through the CBRN COI.
- JEM successfully obtained Interoperability with other systems by constantly calling their Net-Centric Web Service Interface during frequent and ongoing tests.
- A Net-Centric ATP-45 Calculator Service Component was incorporated into the WEJ Hazard Prediction Service during software development, allowing agile backward compatibility.
- JEM developed common components to switch between algorithms at runtime.

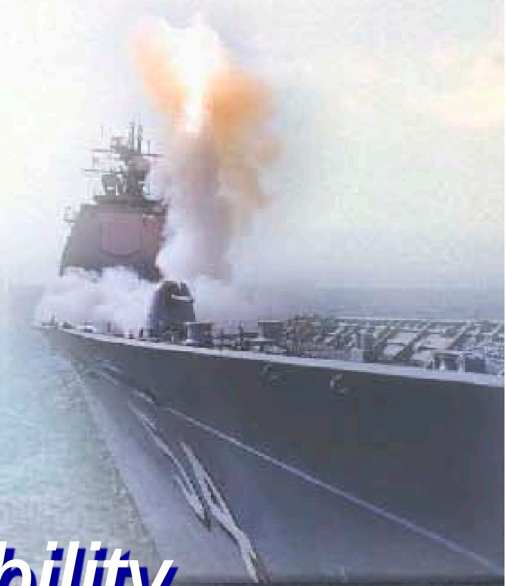
Acronym Lists

- CBRN – Chemical Biological Radiological and Nuclear
- CCA - Clinger-Cohen Act
- CDD – Capability Development Document
- COI - Communities of Interest
- CPD – Capability Production Document
- DARS – DoD Architecture Registry System
- DDMS – DoD Discovery Metadata Specification
- DIACAP - Defense Information Assurance Certification and Accreditation Process
- DICE - DoD Interoperability Communications Exercise
- DISR - DOD Information Technology Standards Registry
- EISP – Enhanced Information Support Plan
- GESP – GIG Enterprise Service Profile
- GIG – Global Information Grid
- I&S – Interoperability and Supportability
- ICD – Initial Capability Documentation
- ISP – Information Support Plan
- JC3IEDM - Joint Command and Control Information Exchange Data Model
- JCSFL – Joint Common Systems Function List

Acronym Lists (con't)

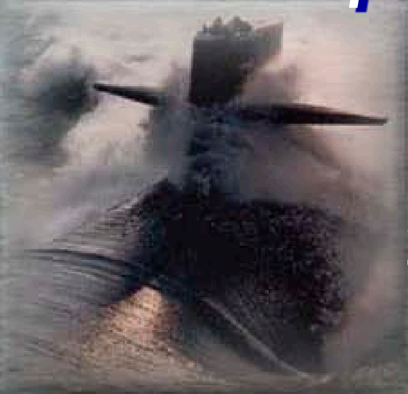
- JEM – Joint Effects Model
- JTRS – Joint Tactical Radio System
- JUICE - Joint Users Interoperability Communications Exercise
- JWARN – Joint Warning and Reporting Network
- METOC – Meteorology and Oceanography
- NCES – Net-Centric Enterprise Services
- NR-KPP – Net-Ready Key Performance Parameter
- SAASM – Selective Availability Anti-Spoofing Module
- SOAP – Simple Object Access Protocol
- TICs – Toxic Industrial Chemicals
- TIMs – Toxic Industrial Materials
- UDDI - Universal Description, Discovery and Integration
- UPDM – Unified Profile for DoDAF/MODAF
- XML - eXtensible Markup Language
- WEJ - Web Enabled JWARN
- WSDL - Web Service Description Language





ASN (RDA)
Chief Engineer

Net-Centric Integration & Interoperability Improvement in the Department of the Navy



28 October 2009

Mr. Carl Siel
ASN(RDA) Chief Engineer
carl.siel@navy.mil

Mr. J. Kevin Smith
Technical Director
ASN(RDA) Chief Engineer's Office
kevin.k.smith1@navy.mil

Unclassified

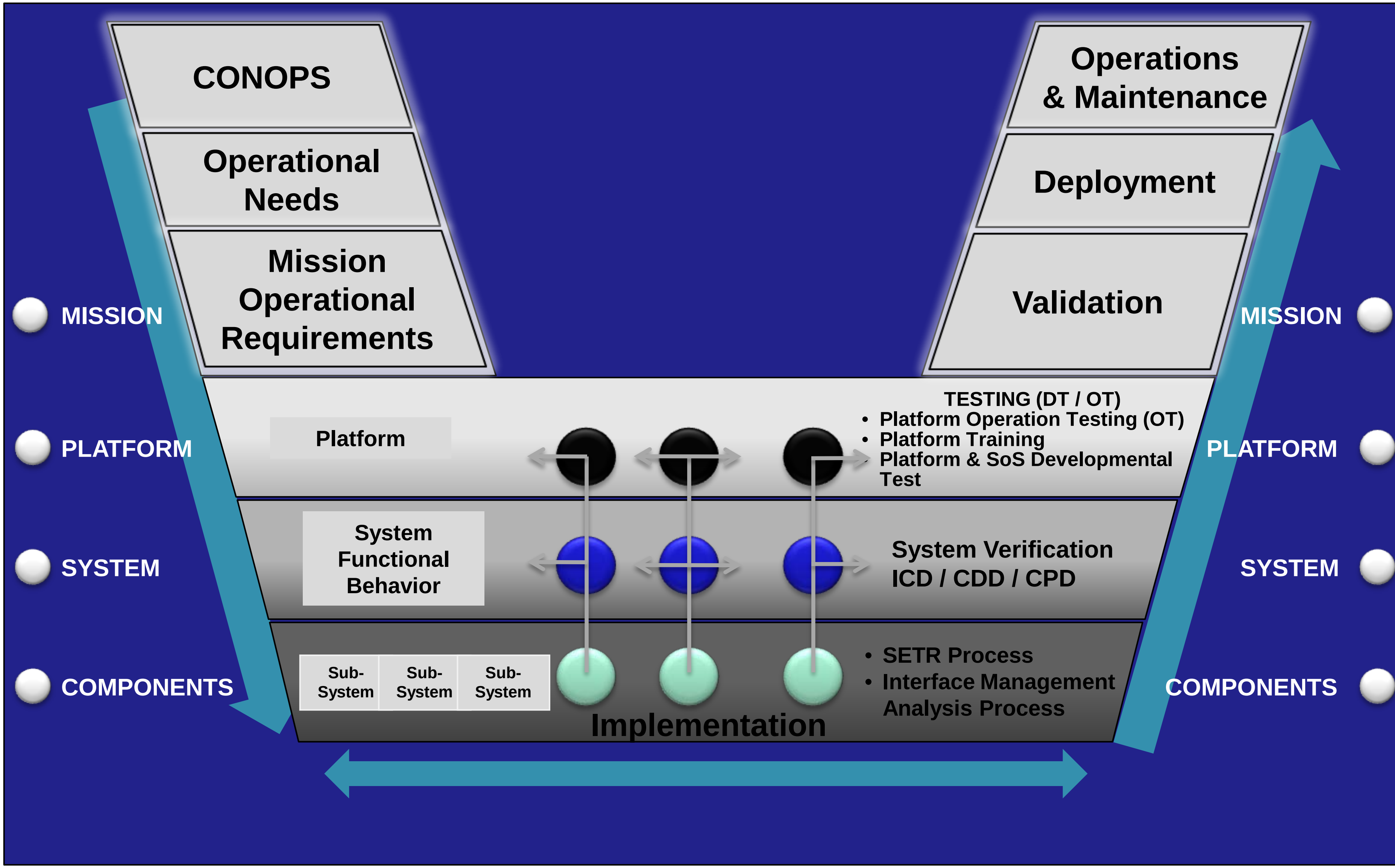
Purpose

- Provide a update on progress being made with Department of the Navy to improve integration, interoperability, and net-centricity across the Department of the Navy.

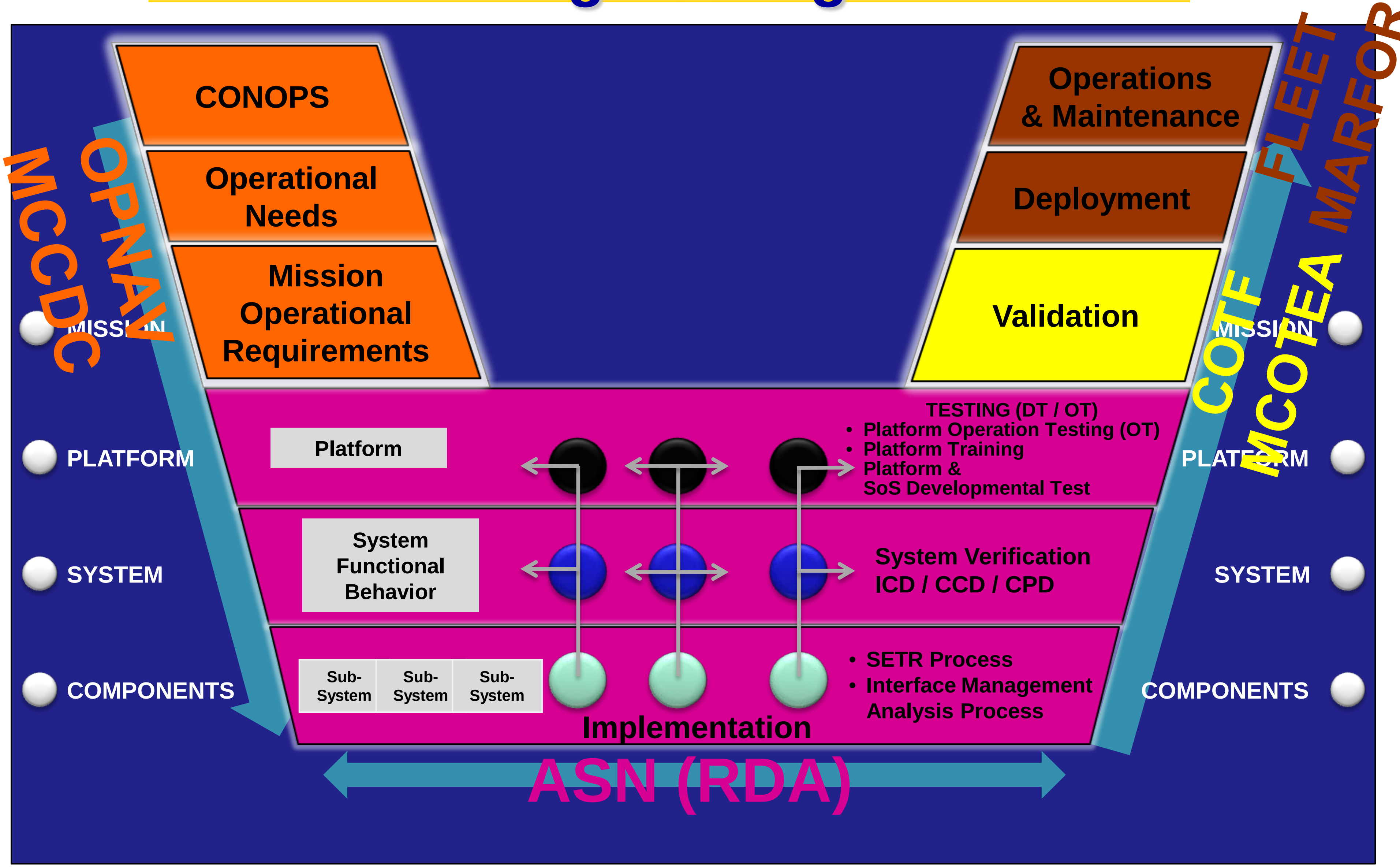
Background

- From February 2006 to September 2009, ASN(RDA) Chief Systems Engineer has been leading an initiative to improve the Department's approach to systems engineering of Net-Centric derived requirements.
  - ASN(RDA) CHSENG has assumed the role of systems-of-systems engineer at the Naval mission level.
  - PEO systems engineers and technical directors coordinate systems engineering within their organizations.
  - PMO system engineers have responsibility for program-level systems engineering.

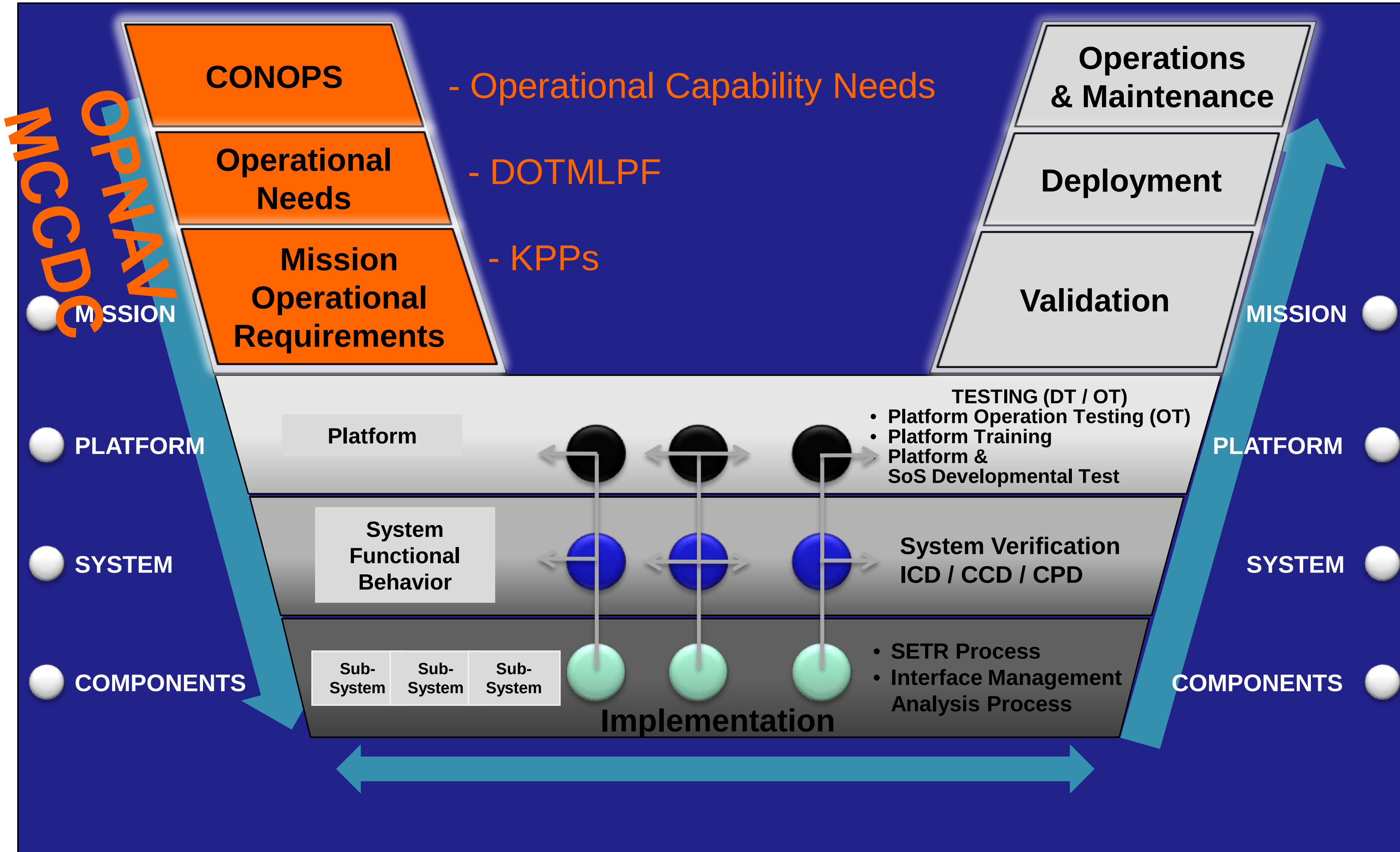
Mission Area System-of-Systems Engineering



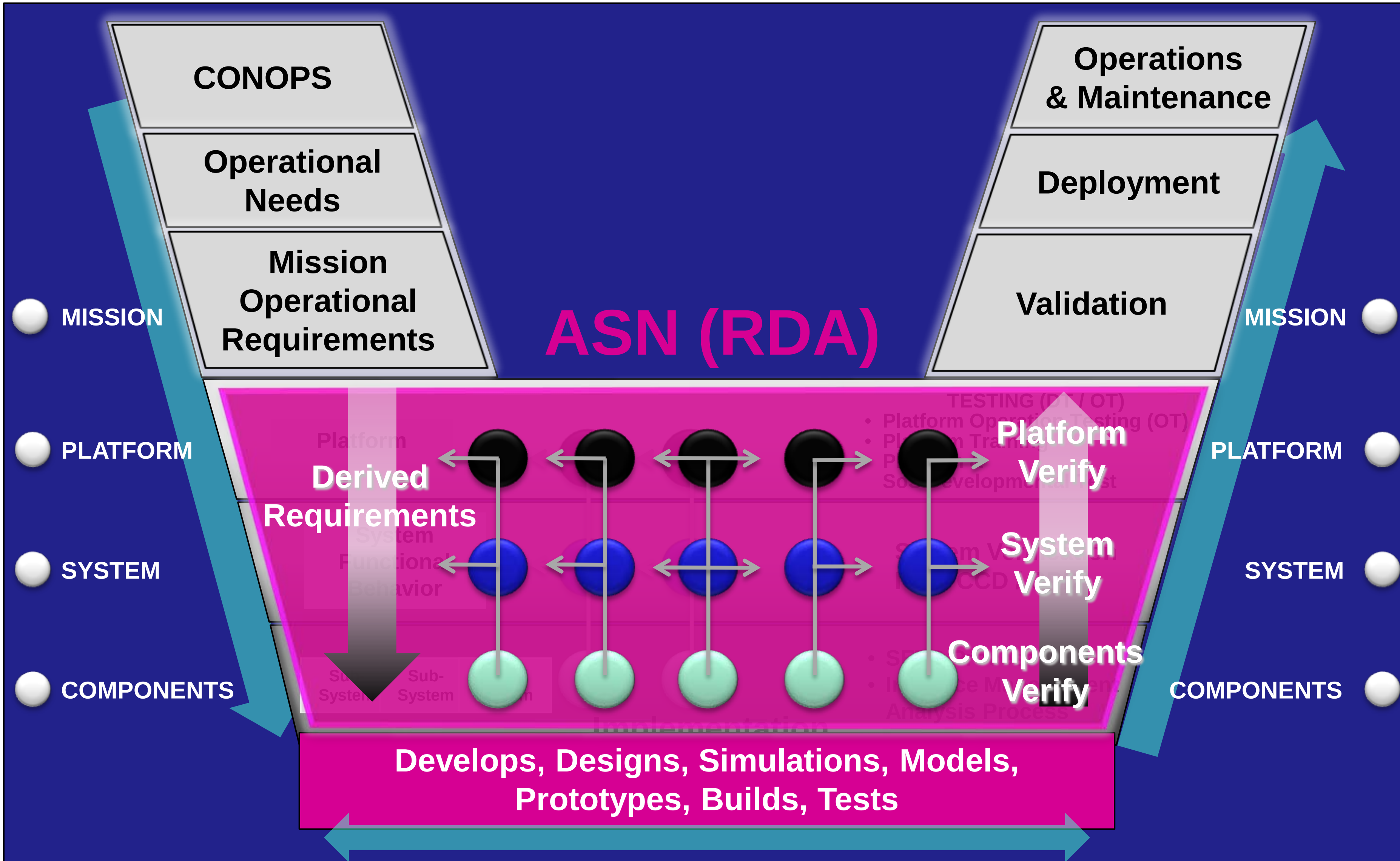
Mission Area System-of-Systems Engineering



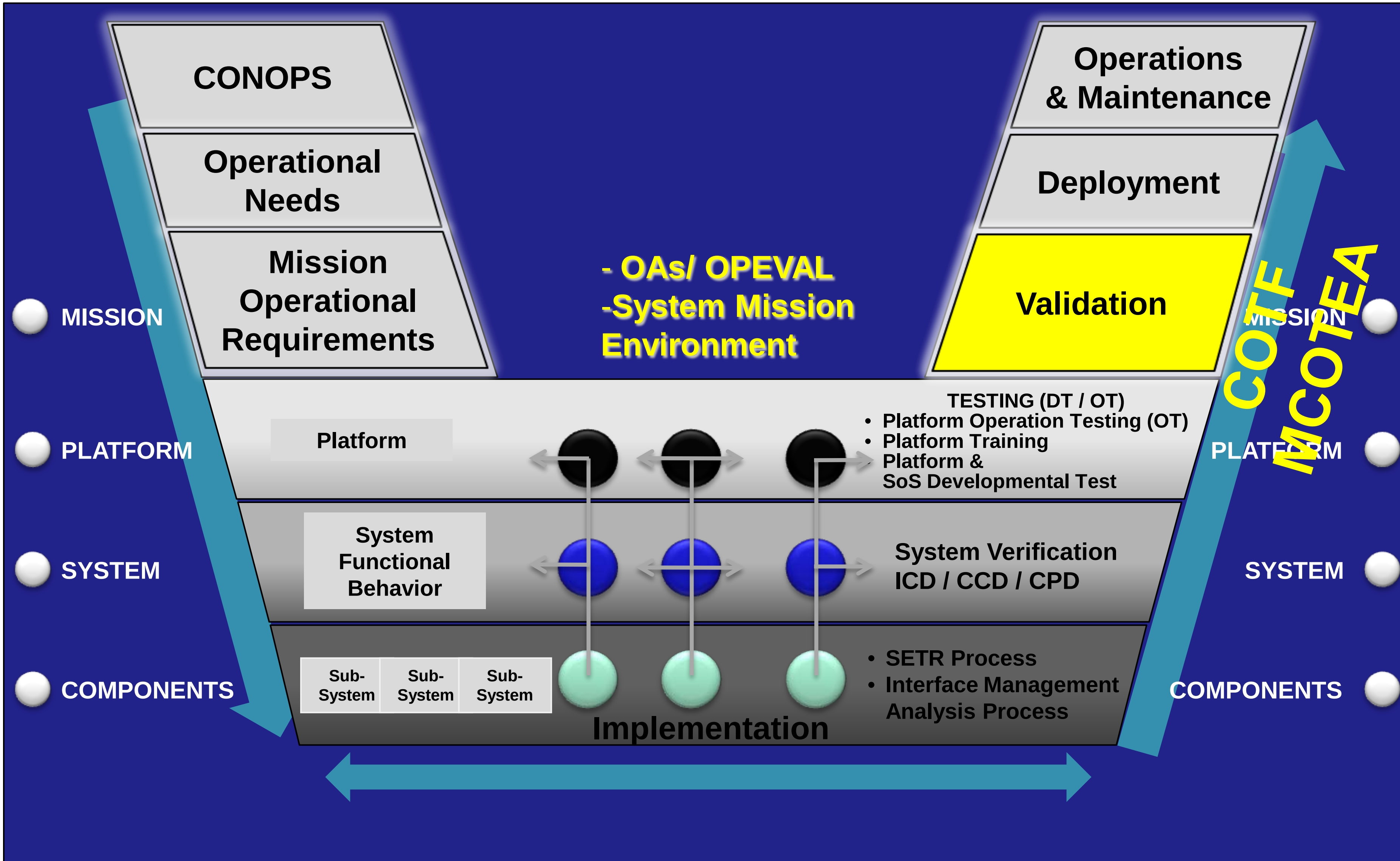
Mission Area System-of-Systems Engineering



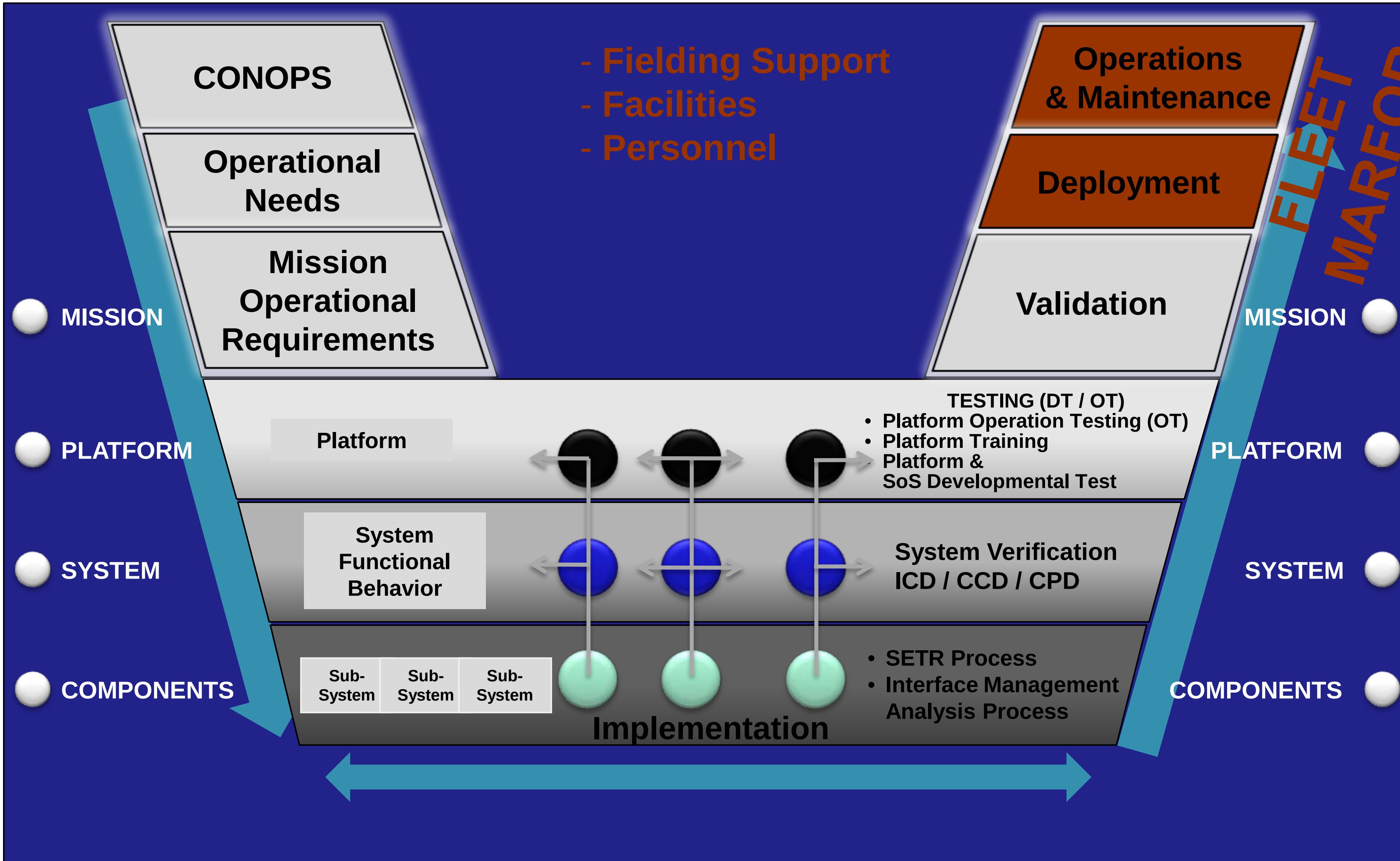
Mission Area System-of-Systems Engineering



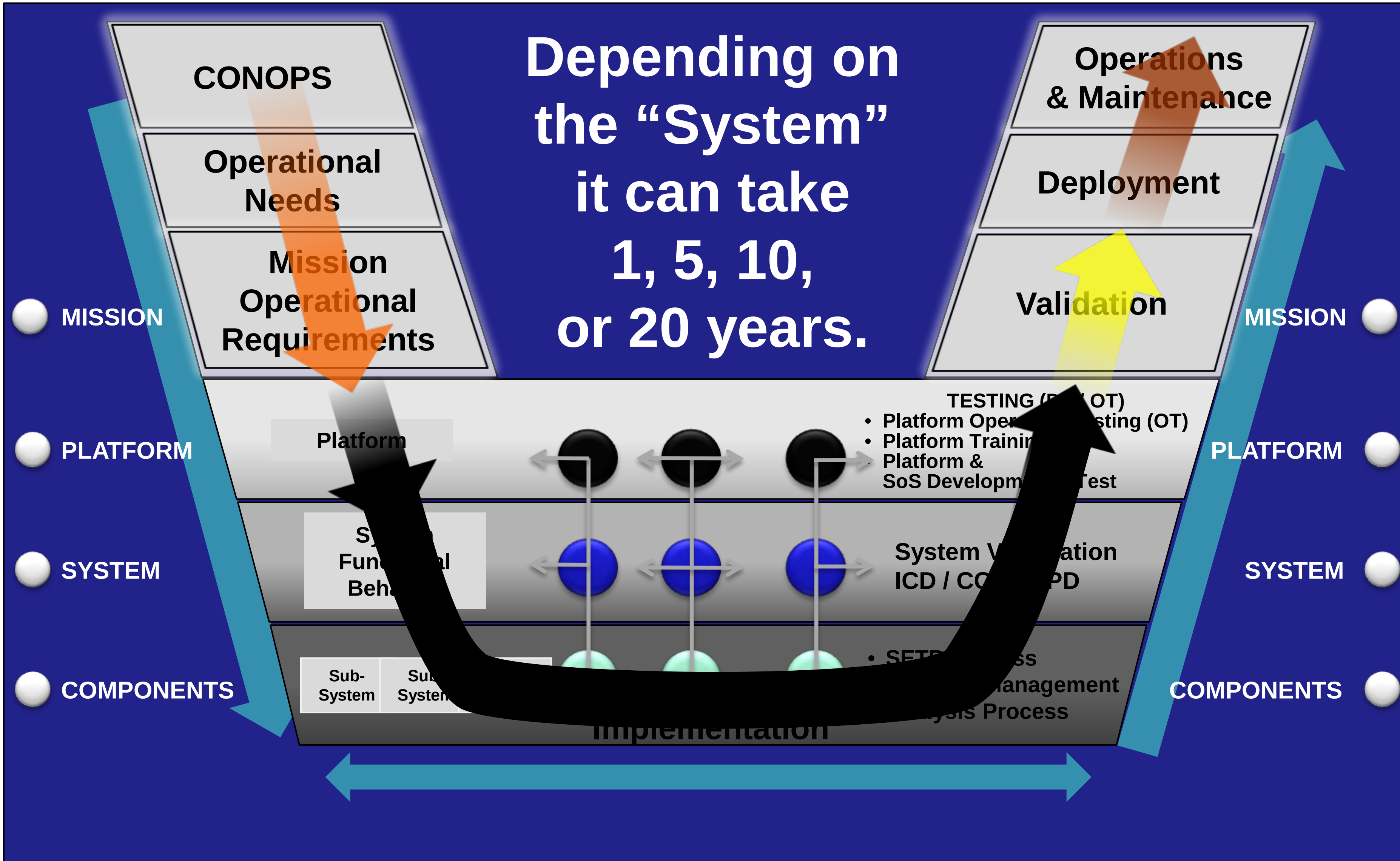
Mission Area System-of-Systems Engineering



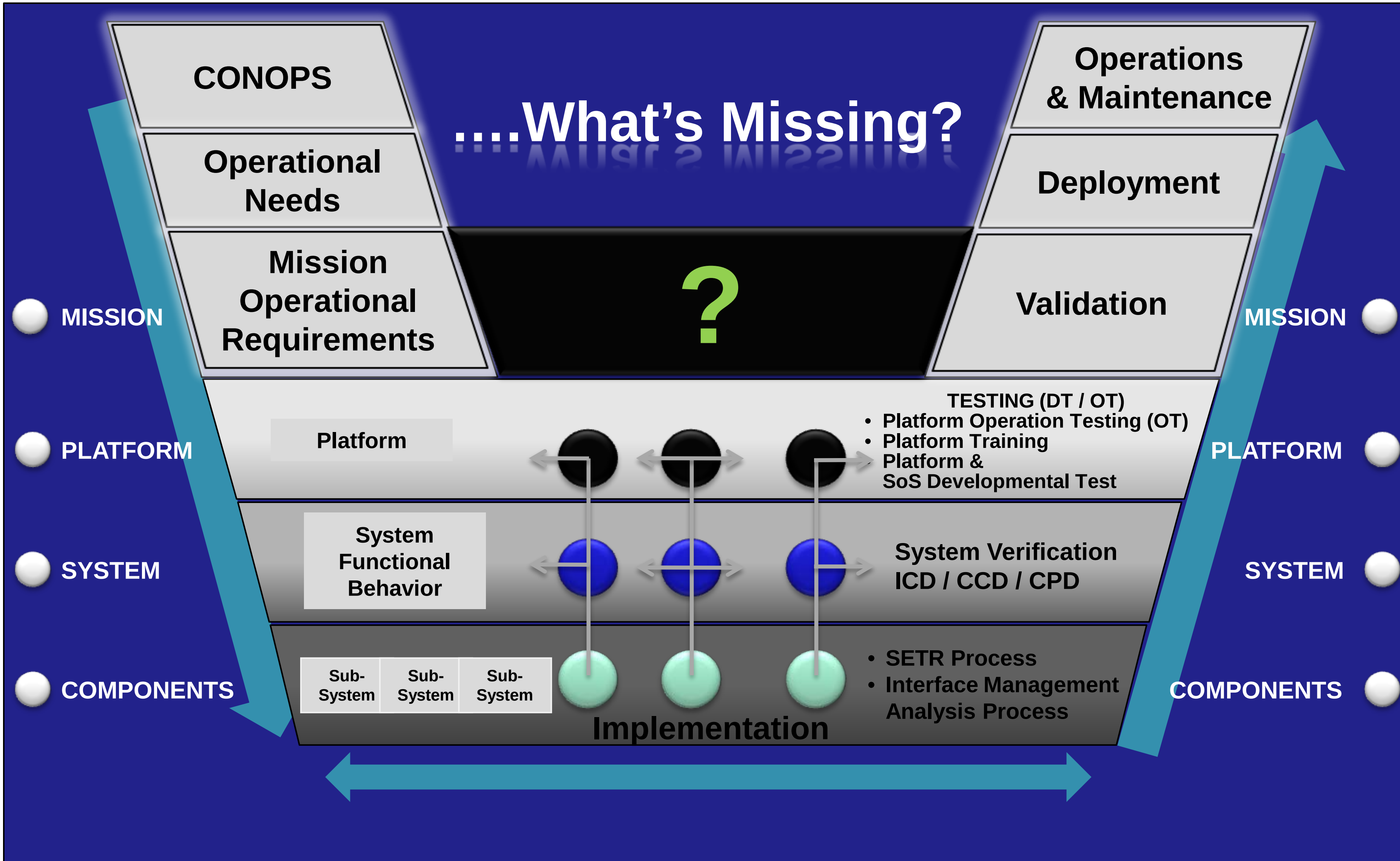
Mission Area System-of-Systems Engineering



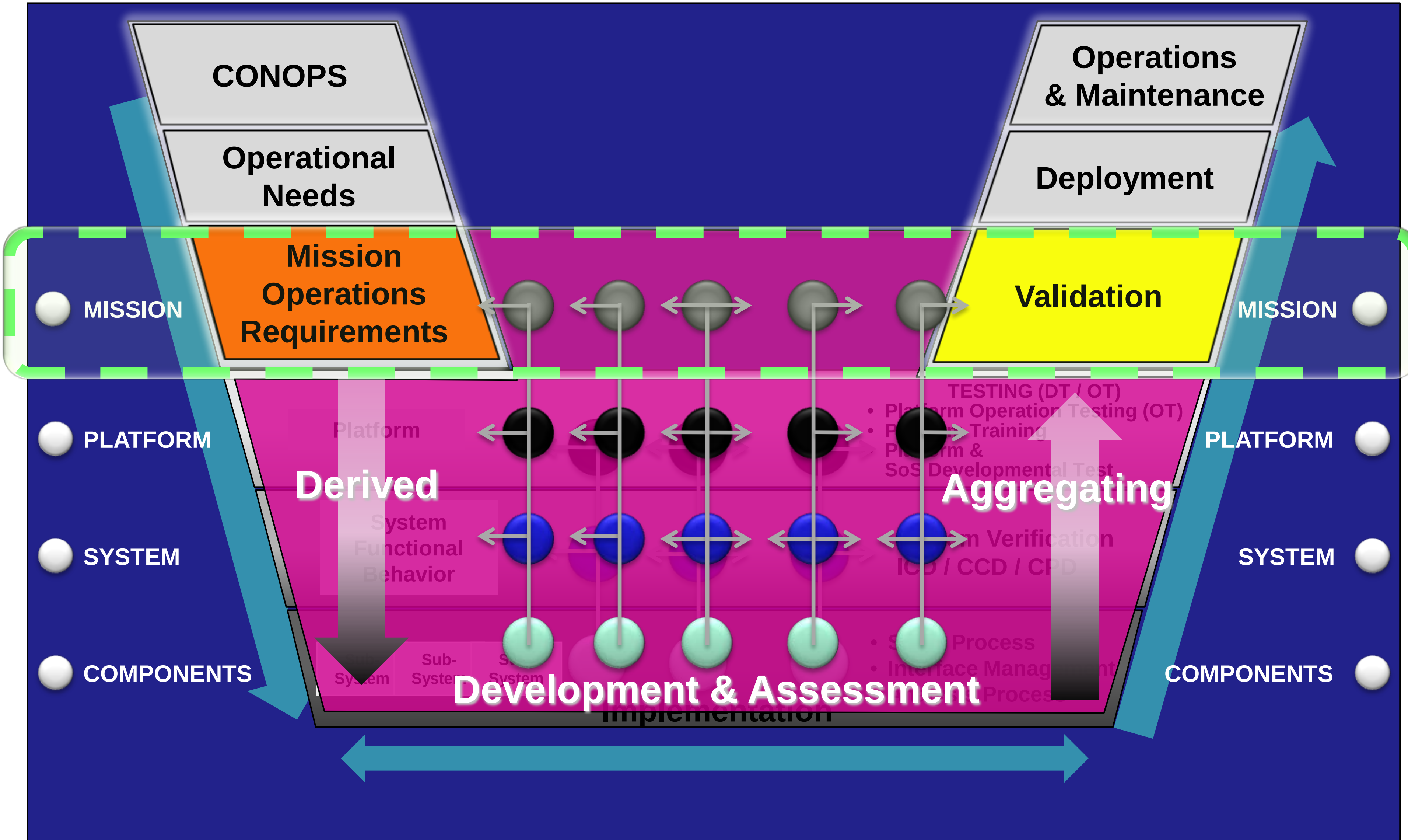
DoD 5000 Process



To Architect and Engineer the Naval Force...



Engineering at the Mission Level



RDA CHSENG Initiative

Net-Centric Integration & Interoperability

DON-Focused ISP Review

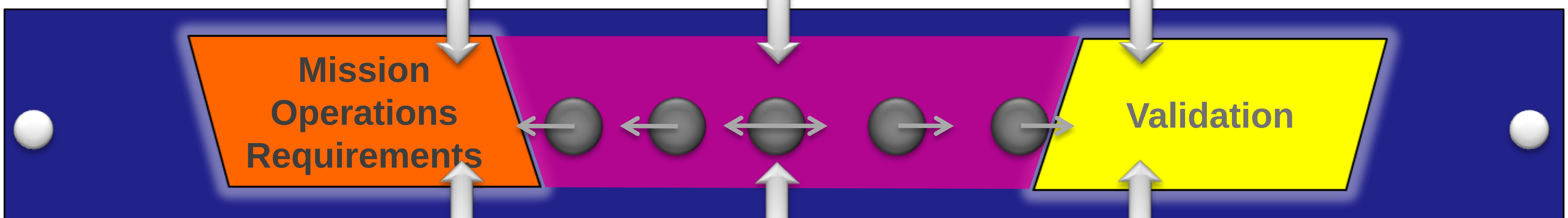
NR KPP Guidebook

DODAF Usability For Engineers

-DON Enterprise Architecture
-Architecture Common Data Elements
-Architecture Repository
-Architecture Hierarchy based on JCAs

Mission SoS Engineering Guidebook

Mission Area CHENG



Modeling and Simulation

- NMSO
- Large Scale Capability Assessment
- COTF

Analysis – Engineering – T&E Community Meta Data Strategy

Mission Threads

Mission Based Test Scripts

Use of Live Virtual Constructive Environment

Government Role as LSI

	Key Stakeholders	Gov't Role/ Responsibilities	Problem/ Challenge	Requirements	Strategy
Mission Force Focus	Joint Staff, FFC, Combatant CDR, OPNAV, RD&A	ID Capability Reqm'ts Provide SE rigor in Arch. & Reqm'ts Reqm'ts flowdown/ verification Reqm'ts Traceability	Ability to integrate mission capabilitities across muti missions, platforms, systems	Eng. mission capability in SoS arch., Allocating capability reqm'ts across PORs, SI reqm't in revieiws, T&E facilities	Clear Architectural Depictions Codify Mission Area Chief Engineers Test and Validation Facilities
SoS (Platform/Net Centric) Capability Focus	OPNAV, RD&A, PEO	Coord. SI across programs Decompose SI reqm'ts Validate sys performance Align evolving sys, tech,	Insufficient Govt Technical Insight Insufficient SI Requirements for optimum interoperability	Designs based on Govt defined Arch. Acq Strat., report SI activities at reviews, T&E facilities Contracting	Insight into sys development & SI implications Govt owns IP and sys arch. Access to SoS T&E Facilities Govt mechanism to track/report SI
System Functional Focus	PEO, SYSCOM	Integration approaches People, processes, facilities to maximize value across lifecycle	Knowledge to make SI decisions and lack of clear reqm'ts to maximize commonality	Processes, stds, specs & best Human Capital Capacity (TA) Contracting IP and Arch	Update technical processes (e.g. SETR) to address SI related information Intellectual Property Rights Assess Human Capital Capacity
Component End Item Focus	PM, SYSCOM, Industry	SI & Technical Authority People, processes, facilities Ensure industry compliance with SI reqm'ts	Insufficient Govt Insight	Facilities, Govt access to IP, Tech insight to execute "Smart Buyer" role, Hands on work	Contracting strategy and language to address IP Iincreased Govt activity in sys arch & specs Govt Rapid Prototyping (sustain knowledge base)

- Largest payoff is at the highest level, must technically launch the project correctly to avoid costly course corrections later in development/support
- Technical discipline (competency) is required at each level
- Quality SI information is essential to delivering mission capability through multiple PORs

RDA CHSENG
Mission Engineer Accomplishments

- DODAF Usability (On-going)
  - NetCentric I&I Management Plan: Kevin Smith, RDA CHSENG
  - Architecture Common Data Elements: Mark Econie, SPAWAR
  - Architecture Repository: Mark Econie; Pat Roche, SPAWAR
  - DON Enterprise Architecture: Mike Jacobs, DoN CIO, Kevin Smith, RDA CHSENG
- DON-Level ISP Review Process (Exists): Dr. Cheryl Walton; RDA CHSENG
- NR KPP Guidebook (Fall 2009): Dr. Cheryl Walton; RDA CHSENG
- Aggregation of Documentation (Fall 2009): Dr. Cheryl Walton; RDA CHSENG
  - Consolidated ISPs.
  - Restructured IA certifications.
- Mission SoS Engineering Guidebook (v1 Exists / v2 Spring 2010): Melinda Reed, RDA CHSENG

RDA CHSENG Mission Engineer Accomplishments (continued)

- Mission Area CHENG (On-going): Kevin Smith, RDA CHSENG
  - Segment Reference Architecture development.
  - Segment-to-Solution Architecture alignment.
  - JCIDS matching to Segment Reference Architectures

- Predictors of Program Success (POPS) (v1 Exists): Mike Yang, RDA CHSENG
  - Net-Centric parameters incorporated.

- Analysis / Engineering / T&E Meta Data Strategy (On-Going): John Moore, NMSO

- Large Scale CPA / CPE (Fall 2009): Tony Devino, RDA CHSENG
  - CFFC pre-deployment evaluations.
  - OPTEVFOR evaluations.

- Government Role as LSI (Initial Exists / Follow-On): Joan Johnson, NAVAIR

RDA CHSENG
Mission Engineer Plans

- DODAF Usability (On-going)
  - NetCentric I&I Management Plan: Kevin Smith, RDA CHSENG
  - Institutionalize Architecture Common Data Elements: Mark Econie, SPAWAR
  - Exercise Architecture Repository: Mark Econie; Pat Roche, SPAWAR
  - Populate the Segment Reference Architectures in the DON Enterprise Architecture: Mike Jacobs, DoN CIO, Kevin Smith, RDA CHSENG
  - Align DON SRAs to USJFCOM, Army, Air Force mission architectures: Kevin Smith, RDA CHSENG

- DON-Level ISP Review Process (Exists): Dr. Cheryl Walton; RDA CHSENG
  - Extend DON-level reviews to programs at ACAT III and below.

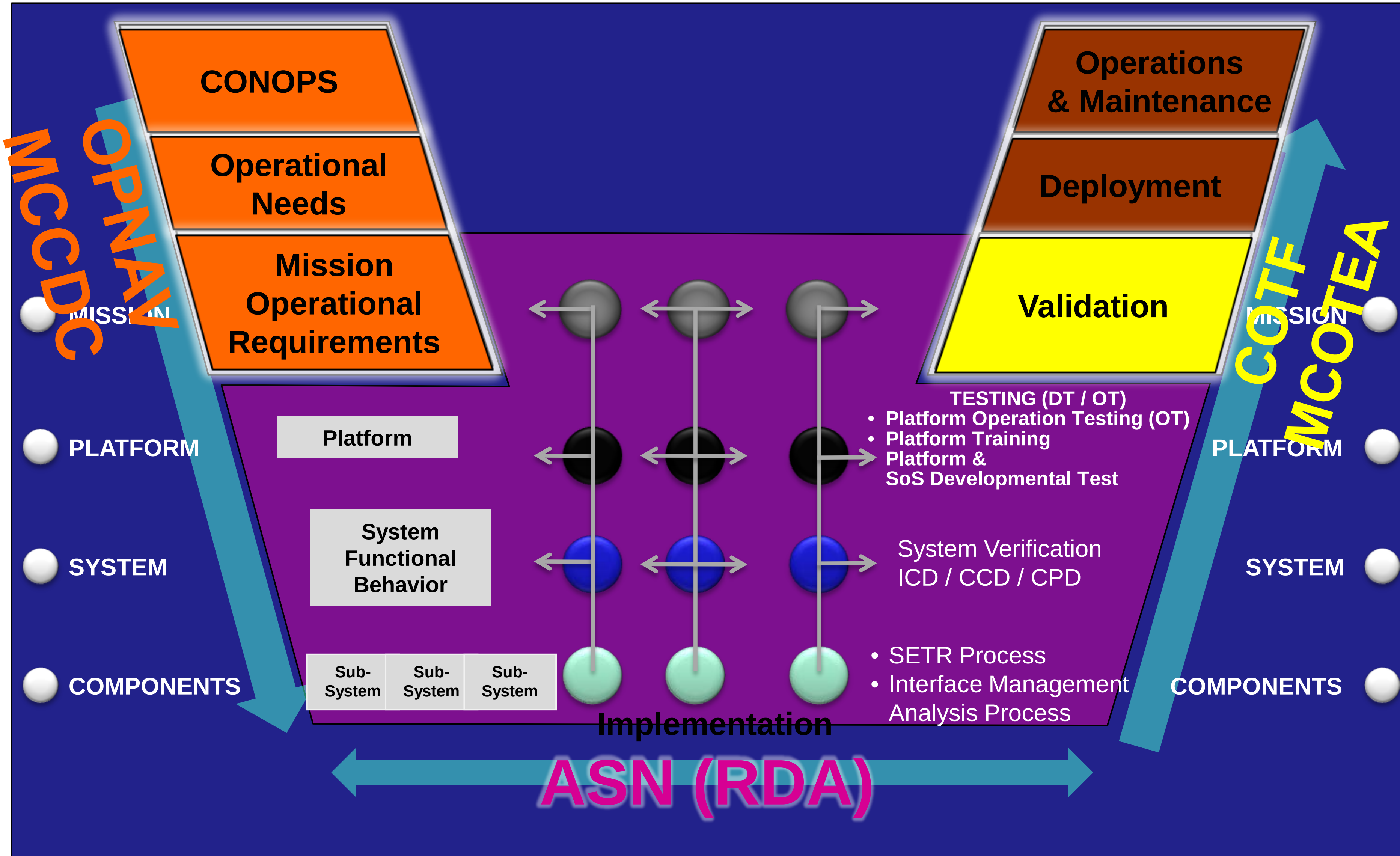
- NR KPP Guidebook (Fall 2009): Dr. Cheryl Walton; RDA CHSENG
  - Publish
  - Begin using OV data to quantify NR-KPP requirements at OPEVAL

- Aggregation of Documentation (Fall 2009): Dr. Cheryl Walton; RDA CHSENG Consolidated ISPs.
  - Implement platform-only ISPs

RDA CHSENG Mission Engineer Plans (continued)

- Mission Area CHENG (On-going): Kevin Smith, RDA CHSENG
  - Institutionalize MACE control of Segment Reference Architectures.
  - Continue Segment-to-Solution Architecture alignment during DON-level review of ISPs.
  - Institutionalize JCIDS matching to Segment Reference Architectures.
  - Export mission-level system-of-systems engineering to other Naval management processes:
    - Campaign and mission analyses.
    - Programming and Budgeting
- Predictors of Program Success (POPS) (v1 Exists): Mike Yang, RDA CHSENG
  - Update based on lesson learned.
- Analysis / Engineering / T&E Meta Data Strategy (On-Going): John Moore, NMSO
- Large Scale CPA / CPE (Fall 2009): Tony Devino, RDA CHSENG
  - Institutionalize CFFC pre-deployment evaluations.
  - Conduct initial OPTEVFOR system-of-system evaluation.

Summary



CONOPS
Operational Needs
Mission Operational Requirements
Operations & Maintenance
Deployment
Validation
OPNAV
MCCDC
COTF
MCOTEA
MISSION
PLATFORM
SYSTEM
COMPONENTS
Platform
System Functional Behavior
Sub-System
Sub-System
Sub-System
TESTING (DT / OT)
• Platform Operation Testing (OT)
• Platform Training
Platform &
SoS Developmental Test
System Verification
ICD / CCD / CPD
• SETR Process
• Interface Management Analysis Process
Implementation
ASN (RDA)

Abstract Reference #8788

Improving Stability Operations Data Sharing: Leveraging a COI Pilot to prove Concepts and Develop Trust

Gerard Christman, SMIEEE, FWAS
Sr. Systems Engineer, Contractor Support
Office of the Assistant Secretary of Defense
Networks and Information Integration

gerard.christman@ieee.org

Agenda

- Bottom Line Up Front
- Basis for this effort
- COCOM Demand Signals
- COI Charter
- COI Overview
- High level capability roadmap
- Problem Analysis: where to start, what to share
- Systems approach – Major Building Blocks
- The Pilot Team and the work process
- Scenario
- Basic Tenets
- Civ-Mil portal
- UMPC
- XForms
- Mobile Phone Application
- Next steps
- Additional Research

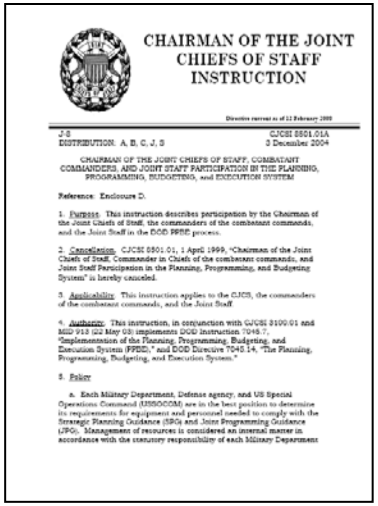
BLUF

- Purpose of the pilot initiative:
  - Proof of concept: net-centric sharing unclassified information services with partners
  - Demonstrate improved civil-military information sharing concepts and capabilities
  - Show: progress building relationships & capability
- Represents a start down the “To-Be” road - Identifies key components
- Approve recommendations for further work

What was the basis for this effort?

ASD(NII) Grimes

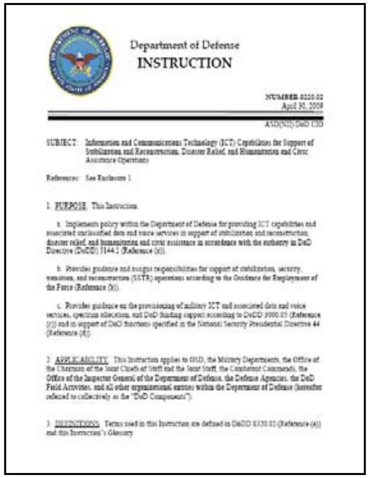
+



CHAIRMAN OF THE JOINT CHIEFS OF STAFF INSTRUCTION

COCOM IPLs

+



Department of Defense INSTRUCTION

OSD Policy Mandates

= **Get it started**

COCOM's Demand Signal for Solutions

- **(U) FY11-15 IPLs identify requirements for unclassified info sharing with coalition, interagency, international and non-governmental organizations as part of the Building Partnerships Portfolio:**
  - USAFRICOM – Building Partners Capability
  - USCENTCOM – Building Partnership Capacity
  - USEUCOM- Building Partner Capacity Planning and Execution
  - USJFCOM- DoD and Interagency Training and Capabilities (BP)
  - USNORTHCOM- Building Partnerships
  - USPACOM- Build Partner Capacity
  - USSOUTHCOM- Humanitarian Assistance and Disaster Response (Building Partnership Capacity)

COCOM IPL's reflect the need

COI Charter

- Get operators, technologists, academicians, civil, military
- Determine nature of the information sharing problem
- Frame high level capability roadmap
- Scope a pilot
- Get it done in a year
- Open source, open standards, license free
- Comply with net-centric data sharing policy

Stability Operations COI Overview

- More than DoD > USAID, DoS, UN, IOs, NGOs
- OCONUS Focus > Domestic response not examined
- Cyclone Nargis – final catalyst – summer 2008
- ASD (NII) recognized need to begin
- IIS solicited support from DoS HIU
- Concept approved by Information Mgmt Office of NII
- Kickoff 1 OCT 08
- 4 plenary sessions, 4 data working group, multiple pilot working group – now 250 members
- Consultation with SME's

What is a COI?

Community of Interest: A collaborative group of users that must exchange information in pursuit of its shared **goals, interests, missions, or business processes** and therefore must have shared vocabulary for the information it exchanges. - DoD Directive 8320.2

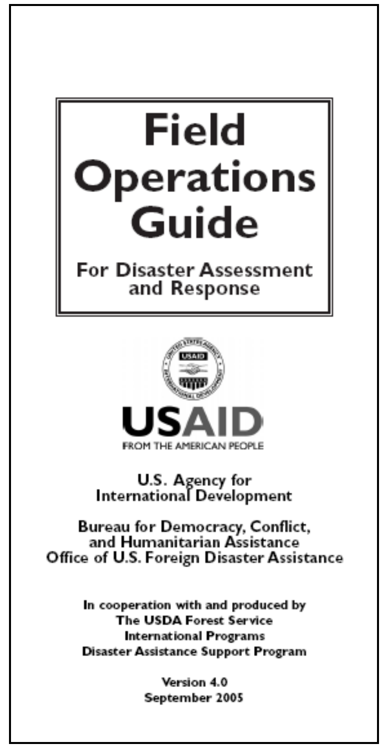
Key findings

High Level Capability Roadmap

1. Do **HADR Pilot** – illustrative of broader Stab Ops environment
2. Methodology should support **tailorable content** based on end-user role
3. **Geospatially coordinated information**
4. **Assessment reports based upon an agreed vocabulary**
5. Imagery + Assessment Report most useful>> **Food, Water, Shelter**
6. Role based access with a PKI solution – future consideration- get the basics done first
7. Information sharing capabilities must include **small form factors** i.e., 3G cell phones, smart phones, UMPC
8. **Open source** / open standard when and where practical- **no fees**
9. Examine **existing portals** – don't build anything new - integrate existing efforts
10. Leverage U-Core and STANAG 5525 >> Accessible, Visible, Understandable to programs of record >> abide by DoD policy
11. Common data model for the Community

Where to start and what to share?
HADR Assessments

- Victims / Displaced persons
- **Food**
- Nutrition
- Health
- **Water**
- **Shelter**
- Sanitation
- Agriculture & Livestock
- Search & Rescue
- Logistics
- Infrastructure


Field Operations Guide

For Disaster Assessment and Response

USAID
FROM THE AMERICAN PEOPLE

U.S. Agency for International Development

Bureau for Democracy, Conflict, and Humanitarian Assistance
Office of U.S. Foreign Disaster Assistance

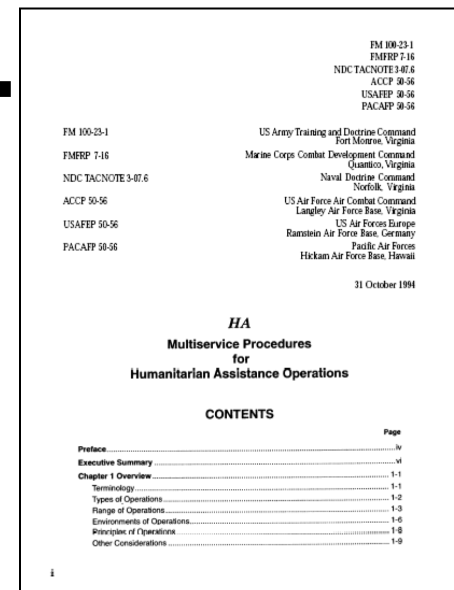
In cooperation with and produced by
The USDA Forest Service
International Programs
Disaster Assistance Support Program

Version 4.0
September 2005

Civil

+

FM 100-23-1


FM 100-23-1
FMFRP 7-16
NDC TACNOTE 3-07.6
ACCP 50-56
USAFEP 50-56
PACAFP 50-56

FM 100-23-1	US Army Training and Doctrine Command Fort Monroe, Virginia
FMFRP 7-16	Marine Corps Combat Development Command Quantico, Virginia
NDC TACNOTE 3-07.6	Naval Doctrine Command Norfolk, Virginia
ACCP 50-56	US Air Force Air Combat Command Langley Air Force Base, Virginia
USAFEP 50-56	US Air Forces Europe Ramstein Air Force Base, Germany
PACAFP 50-56	Pacific Air Forces Hickam Air Force Base, Hawaii

31 October 1994

HA

Multiservice Procedures for Humanitarian Assistance Operations

CONTENTS

	Page
Preface	iv
Executive Summary	vi
Chapter 1 Overview	1-1
Terminology	1-1
Types of Operations	1-2
Range of Operations	1-3
Environments of Operations	1-6
Principles of Operations	1-8
Other Considerations	1-9

i

Military

Major Systemic Considerations

- ✓ Collaborative Environment - Harmonieweb proponent - Chief, Collaboration Support/Portal Development & Implementation J6 Directorate, USJFCOM
  - ✓ Social media, collaboration space
  - ✓ List and Map views with RSS / GeoRSS content
  - ✓ MMS jpg
- ✓ Bridge – Civil-Military – C2 Data Services - Checkmate system, JIEDDO submission, sponsor TRADOC Program Integration Office – Battle Command
  - ✓ STANAG 5525 – NATO/MIP JC3IEDM semantics
  - ✓ U-Core
  - ✓ ABCS – MCS
  - ✓ SMS txt
- ✓ Internet Based Humanitarian Presence – generated internally- Google Maps Mashup- GeoRSS
- ✓ XForms – FWS Services (similar to USAID FOG & OFDA Form 82) Naval Undersea Warfare Center, Division Newport
  - ✓ W3C XML standard for web forms
  - ✓ Orbeon open source Xforms technology
  - ✓ Generates JC3IEDM messages for the C2 Data Service

The Pilot
Working Group Team

- C2 Data Services – **Leavenworth, Kansas**
  - Dave Vincent , Computer Science Corporation
- Dataswarm UMPC – **Leavenworth, Kansas**
  - Dr. Scott Bublin, Mobile Reasoning
- Cellphone-based reporting – **Fort Leavenworth, Kansas**
  - Bruce Montgomery, Combined Arms Center
- Harmonieweb – **Norfolk, Virginia**
  - DoD Unclassified HADR Portal – David McWee, Microlink
- Food Water Shelter Assessment Services- **Newport, Rhode Island**
  - Erik Chaum, Naval Undersea Warfare Center
- NGO Site – trusted HA partner – **Arlington, Virginia**
  - Sean McCarthy, FCI

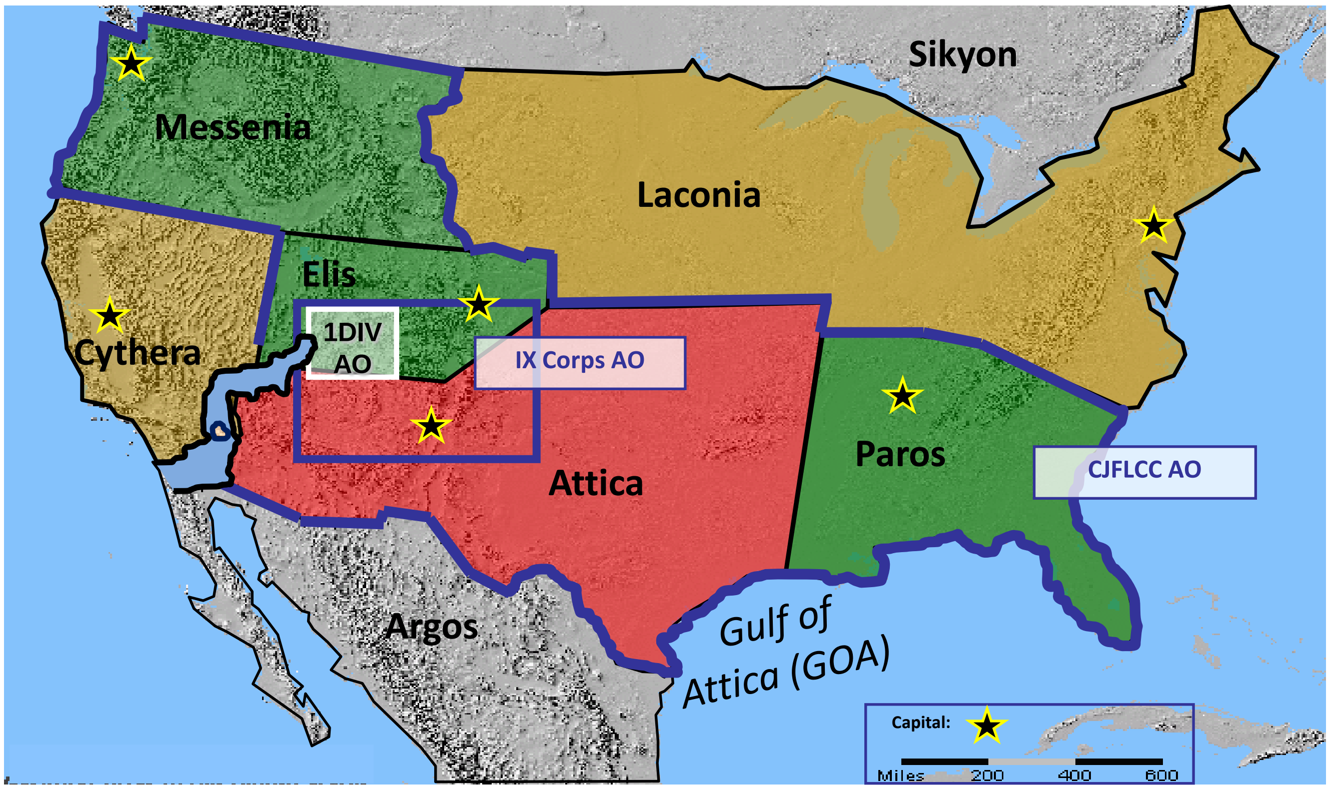
DCO Collaboration Tool

HADR Pilot Scenario

Caveat: The fictional Aegean region is overlaid on the US.
This is a by-product of exercise OMNI FUSION 2009.
This is coincidental and does not intend to imply a domestic focus.
The Stab Ops COI is focused on OCONUS operations.

Geography

Fictional Aegean Region

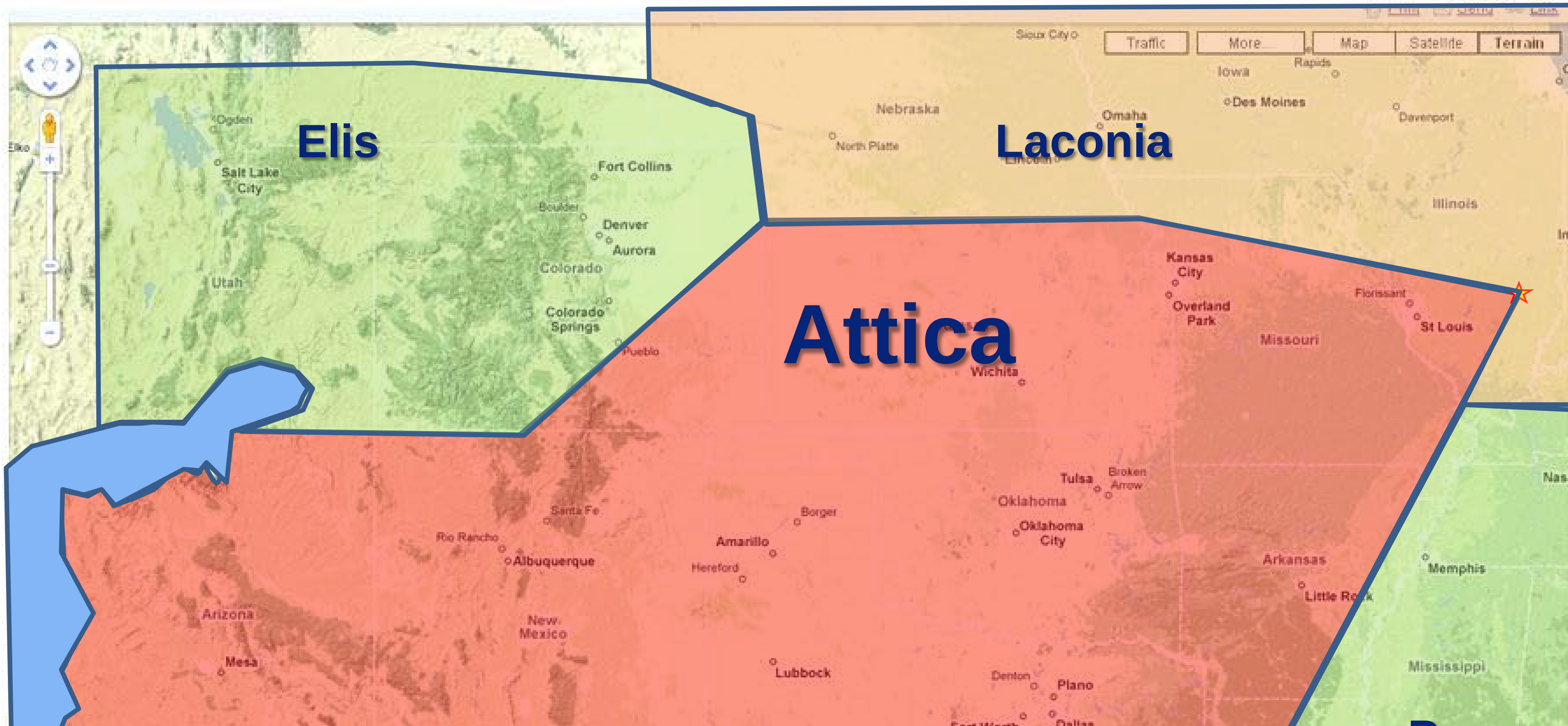


Belligerent state

State supporting Attica

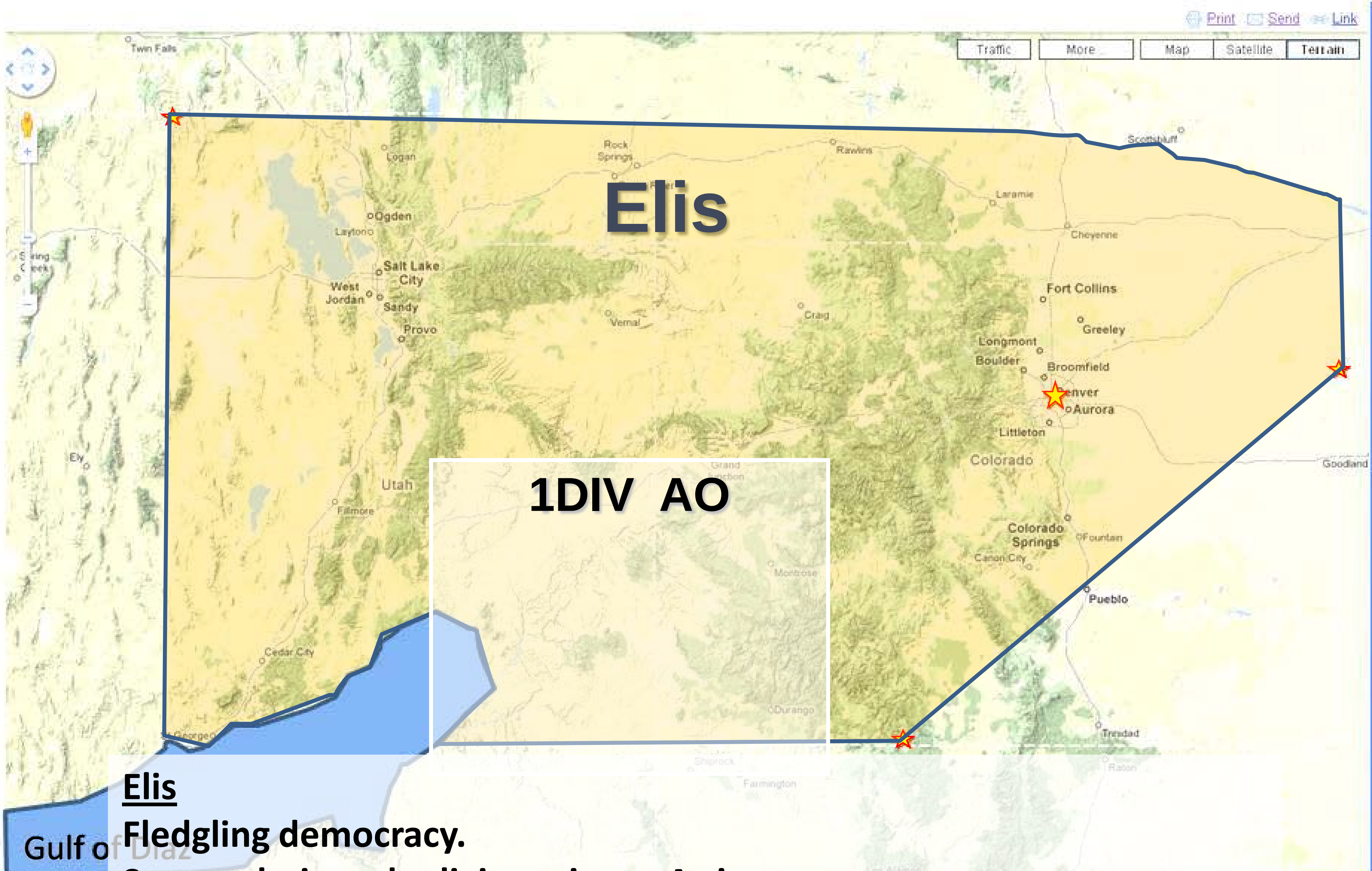
Neutral state

State supporting Coalition



<u>Attica</u>

- **Stable, prosperous society with popular support for dictatorship.**
- **Ethnic and religious diversity unified by political ideology.**
- **Strong economy: oil/gas, manufacturing, agriculture and mining.**
- **Popular dislike of Western cultures.**
- **Extensive economic and diplomatic ties to Laconia and extra-regional countries, to include arms imports.**
- **Asserting regional dominance.**



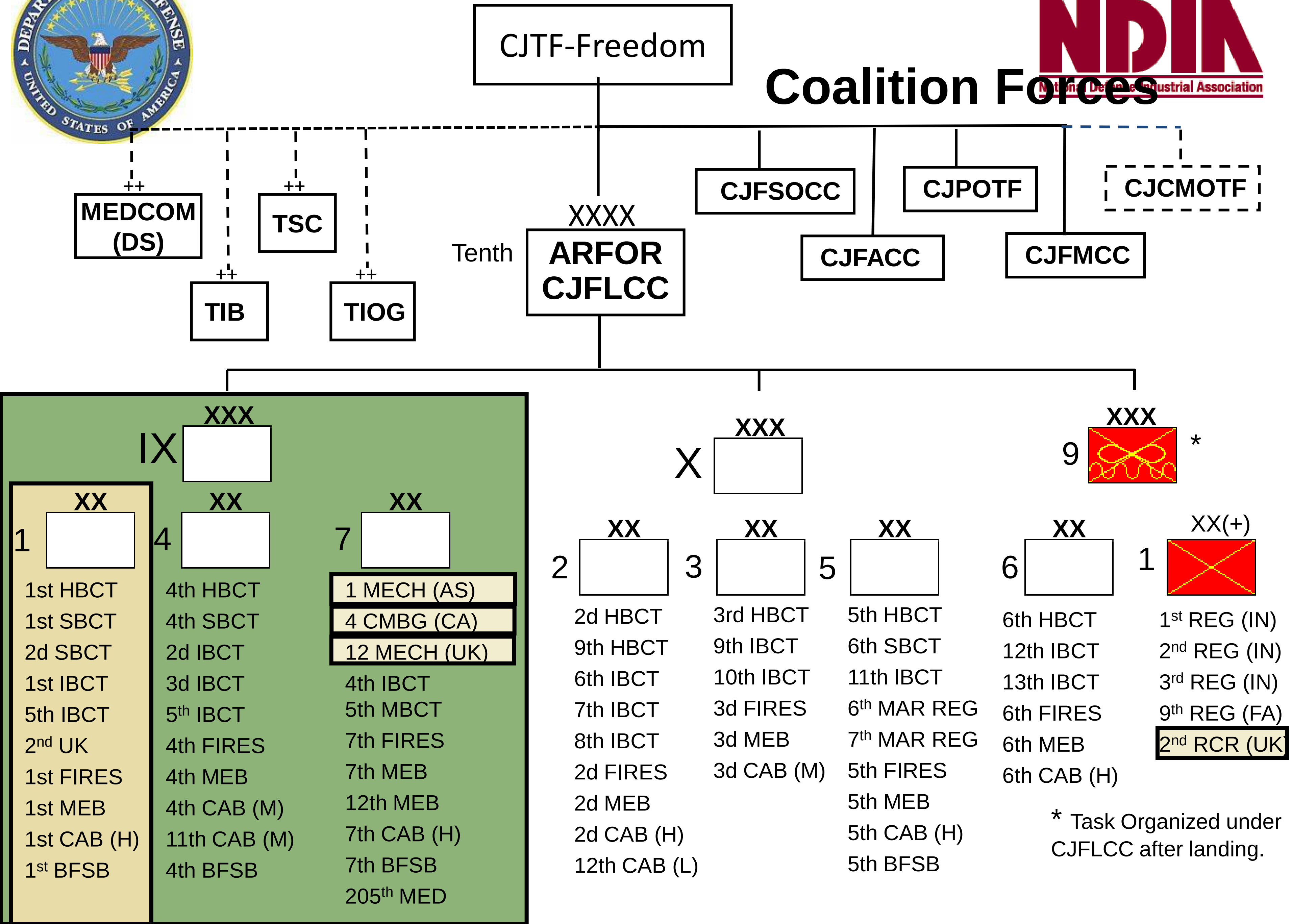
<u>Elis</u>

Fledgling democracy.

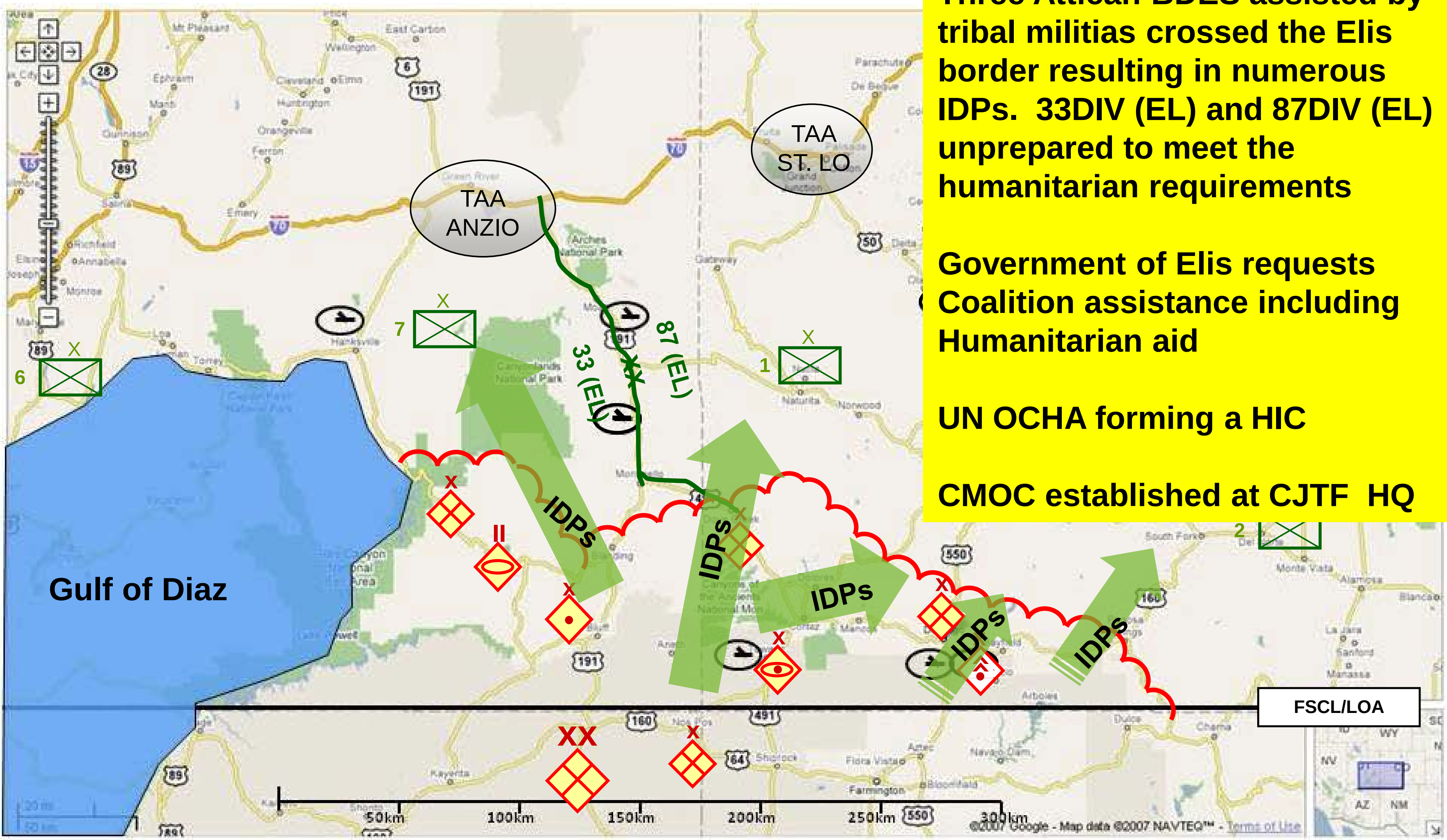
Some ethnic and religious ties to Attica.

Elis' relations with U.S. and West have created tension with Attica.

Coalition Forces



Situation



<u>Elis Border Incursion</u>

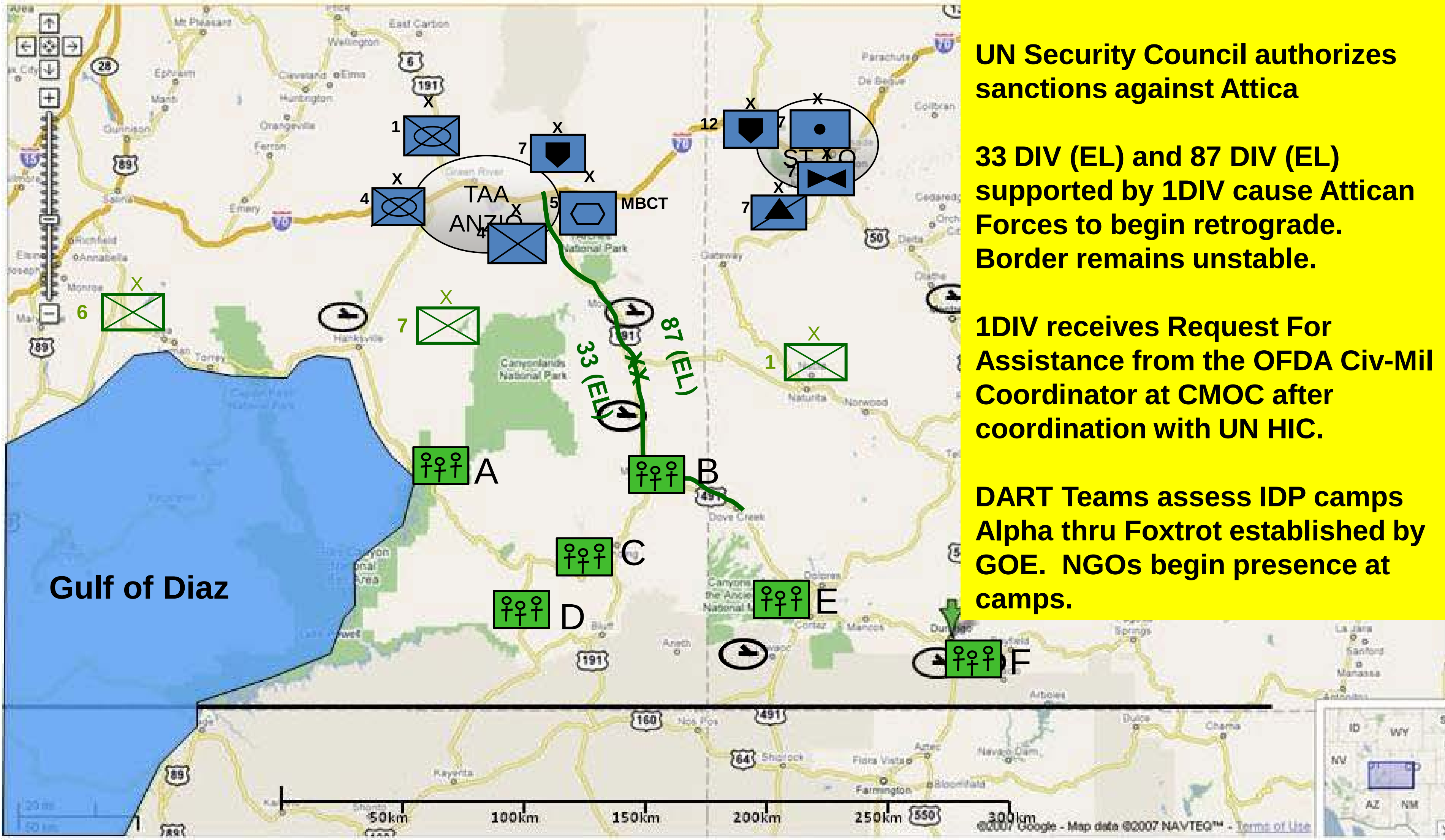
Three Attican BDES assisted by tribal militias crossed the Elis border resulting in numerous IDPs. 33DIV (EL) and 87DIV (EL) unprepared to meet the humanitarian requirements

Government of Elis requests Coalition assistance including Humanitarian aid

UN OCHA forming a HIC

CMOC established at CJTF HQ

Humanitarian Scenario



1DIV forces flow into TAAs

UN Security Council authorizes sanctions against Attica

33 DIV (EL) and 87 DIV (EL) supported by 1DIV cause Attican Forces to begin retrograde. Border remains unstable.

1DIV receives Request For Assistance from the OFDA Civ-Mil Coordinator at CMOC after coordination with UN HIC.

DART Teams assess IDP camps Alpha thru Foxtrot established by GOE. NGOs begin presence at camps.

= IDP camp

Key Basic Tenets

- Military supports USAID in HA efforts
- Military interactions with the NGO community will be coordinated with US country team, particularly OFDA disaster assistance response team (DART) representatives.
- The characteristics, missions, and capabilities of individual NGOs are diverse. All are involved in direct humanitarian aid with host populations. Each organization operates individually.
- NGOs provide the bulk of HA at the grassroots level.
- The military structure can provide logistics and security assistance to remote and unsecured areas.
- NGOs may operate in areas of high risk, where other organizations are hesitant to go. NGO assessments are often an excellent source of information on the HA situation.

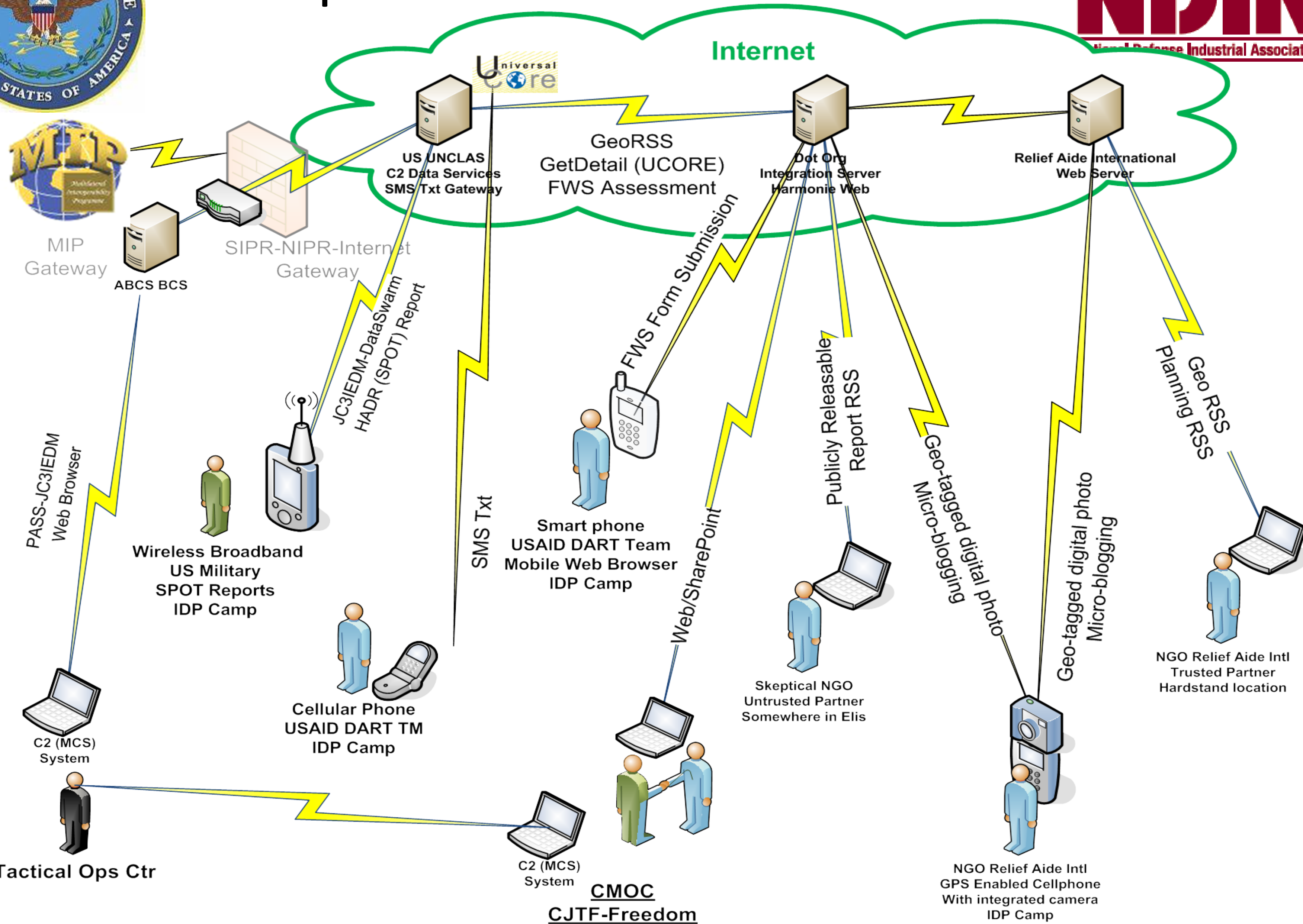
Scenario Assumptions

- Cellular Broadband Wireless Service covers AOR
- Some NGOs willing to collaborate in a federated approach
- Some NGOs unwilling to use portal but will exploit syndication
- US Country Team designee from OFDA in CMOC
- US-centric humanitarian response in 1 DIV AOR
- Permissive environment at IDP camps

Pilot Threads

- USAID OFDA DART Team member Bruce Montgomery uses Short Message Service to provide “Clear, concise, timely, practical, operational findings” of IDP Camp Alpha
- USAID OFDA DART Team member Bruce Montgomery uses the Mobileweb browser to access, populate, submit FWS assessment template.
- US Service member Scott Bublin uses handheld computer and wireless broadband to render aide-focused SPOT report at Camp Bravo.
- USAID Civ-Mil Country Team Designee Erik Chaum in CMOC completes FWS template (xForms) and coordinates with the military.
- Cooperative notional NGO, ReliefAide International, Sean McCarthy shares findings and geospatial information via syndication from Camp Charlie.
- ReliefAide member David McWee provides digital geo-tagged photo from Camp Charlie.
- ReliefAide member David McWee employs Social Media “Twitter” to “Tweet” [microblog] observations.
- Skeptical NGO wanting operational situation reports that are vetted as publicly releasable and available via syndication from HarmonieWeb

Pilot Operational View Architecture



Sign In

HARMONIEWeb.org

Home | Partner Organizations | Help Desk Status

Lists
- Links

Account
- Login
- Request an Account
- Lost Password Help

Partner Organizations
- Request Privileged Domain

Create HelpDesk Request

Help Desk Status

Login/Go to Portal

HARMONIEWeb.org is an internet accessible environment for the exchange of information across the civil-government boundary associated with Stability, Security, Transition and Reconstruction Operations or Humanitarian Assistance and Disaster relief.

External Links
- STAR-TIDES Program
- Reliefweb
- International Committee of the Red Cross
- Georgia

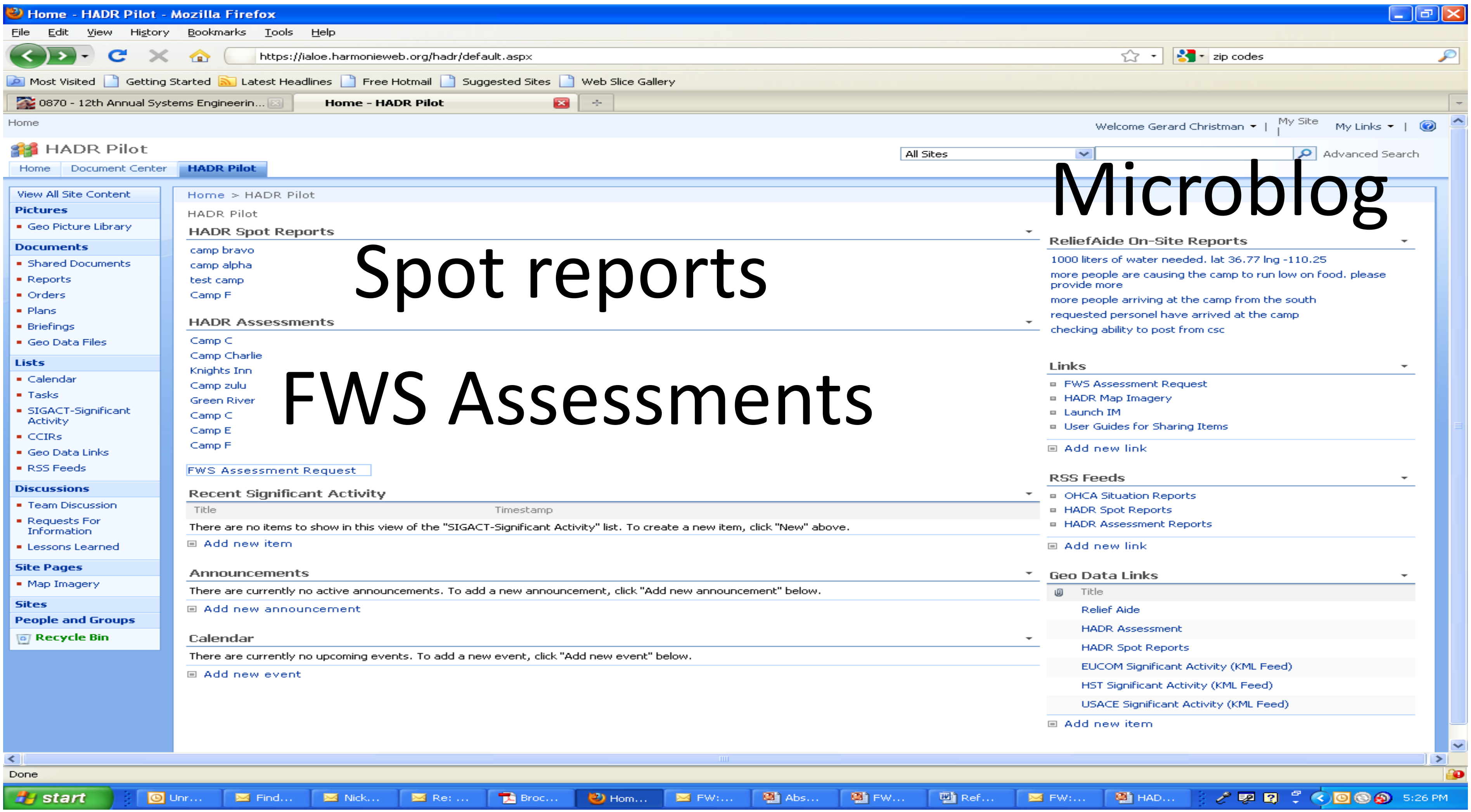
Documents
Getting Started in HARMONIEWeb

Disclaimer

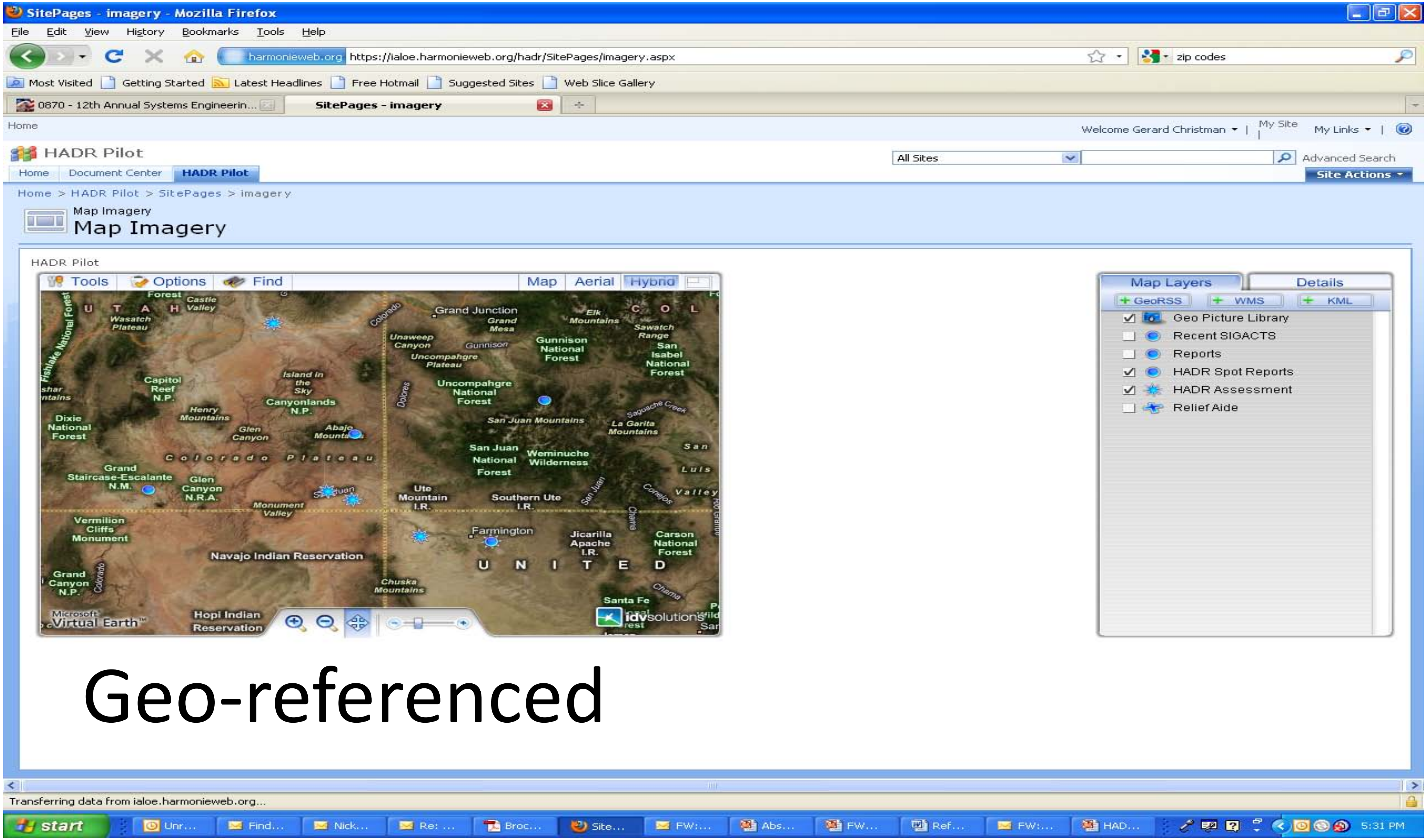
The views and information contained herein are the sole responsibility of the contributor and is not a reflection on either HARMONIEWeb.org or any sponsor organization.

Direct any comments to admin@harmonieweb.org

Civ-Mil portal



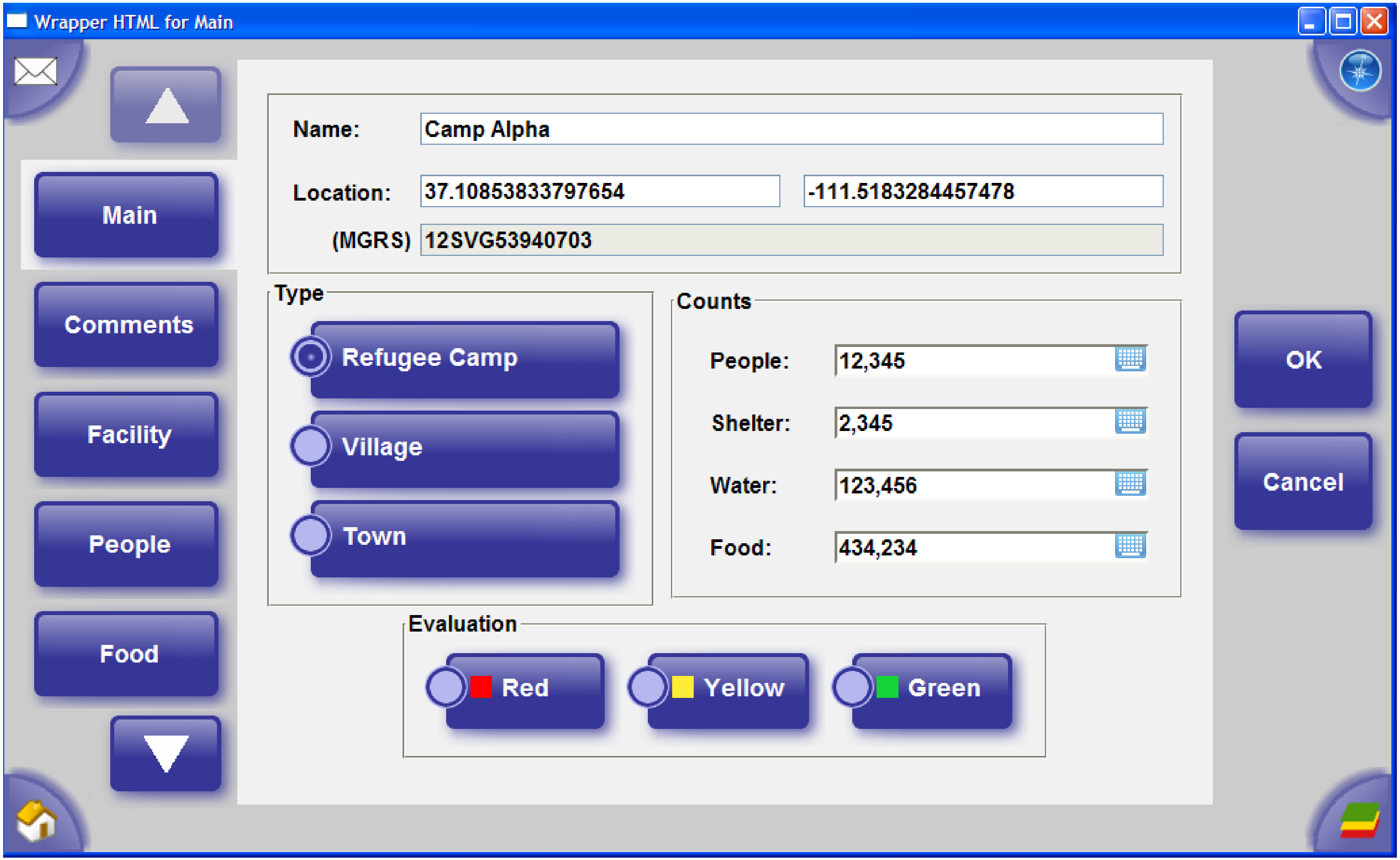
Civ-Mil portal

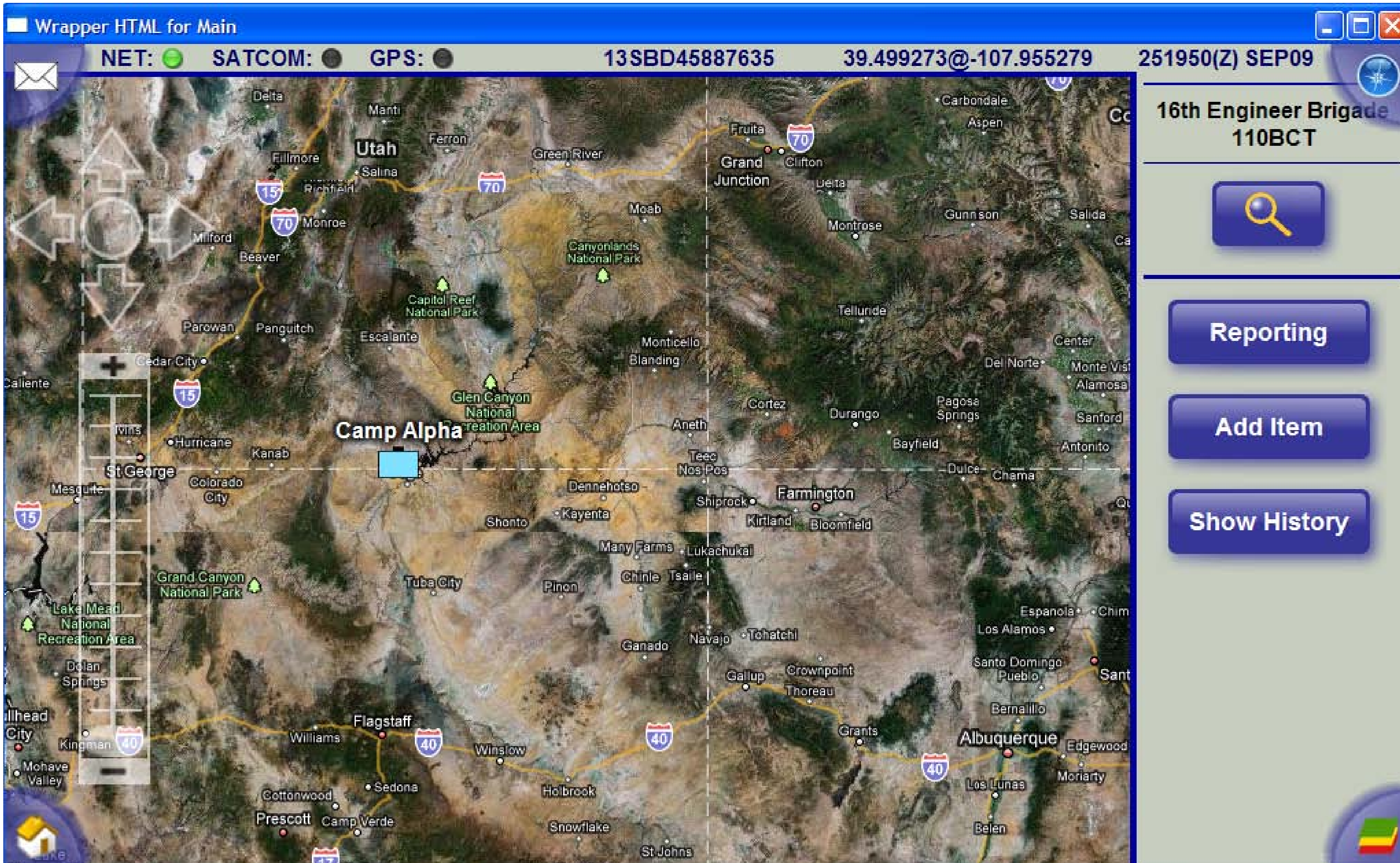


Geo-referenced

UltraMobile PC
UMPC

UMPC SPOT Report



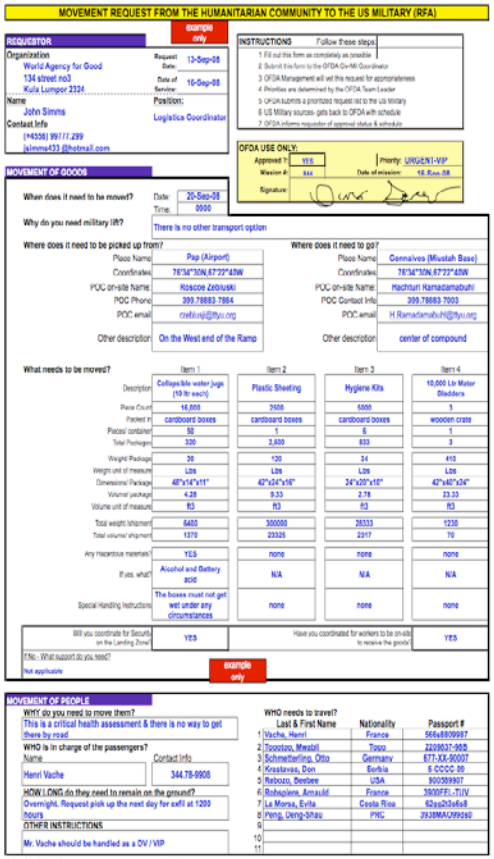

Wrapper HTML for Main
NET:
SATCOM:
GPS:
13SBD45887635
39.499273@-107.955279
251950(Z) SEP09
16th Engineer Brigade
110BCT
Camp Alpha
Reporting
Add Item
Show History

Food, Water, Shelter Assessment Requests

- Objective:
  - Provide a simple web-form and supporting services that can be used to report and coordinate FWS assessments and requests.
  - Ensure that FWS Assessment Requests can be understood by military C2 systems supporting HADR ops - STANAG 5525

- Implementation Approach:
  - W3C XForms standard and XML processing
  - Orbeon XForms technology

Paper to Network-Enabled



MOVEMENT REQUEST FROM THE HUMANITARIAN COMMUNITY TO THE US MILITARY (RFA)

example only

REQUESTOR

Organization: World Agency for Good, 134 street no3, Kula Lumpor 2334

Request Date: 13-Sep-08

Date of Service: 16-Sep-08

Name: John Simms

Position: Logistics Coordinator

Contact Info: (+4556) 99777.299, jsimms433@hotmail.com

INSTRUCTIONS Follow these steps

OFDA USE ONLY: Approved?: YES; Priority: URGENT-VIP

MOVEMENT OF GOODS

When does it need to be moved? Date: 20-Sep-08; Time: 0800

Why do you need military lift? There is no other transport option

Where does it need to be picked up from? Place Name: Pap (Airport); POC on-site Name: Roscoe Zebluski; Other description: On the West end of the Ramp

Where does it need to go? Place Name: Gonnaives (Mustah Base); POC on-site Name: Hachturi Ramadamabuhi; Other description: center of compound

What needs to be moved?

	Item 1	Item 2	Item 3	Item 4
Description	Collapsible water jugs (10 ltr each)	Plastic Sheeting	Hygiene Kits	10,000 Ltr Water Bladders
Piece Count	16,000	2500	5000	3
Packed in	cardboard boxes	cardboard boxes	cardboard boxes	wooden crate
Pieces/container	50	1	6	1
Total Packages	320	2,500	833	3
Weight Package	20	120	34	410
Weight unit of measure	Lbs	Lbs	Lbs	Lbs
Dimensions/ Package	48"x14"x11"	42"x24"x16"	24"x20"x10"	42"x40"x24"
Volume/ package	4.28	9.33	2.78	23.33
Volume unit of measure	ft3	ft3	ft3	ft3
Total weight/ shipment	6400	300000	28333	1230
Total volume/ shipment	1370	23325	2317	70
Any Hazardous materials?	YES	none	none	none
If yes, what?	Alcohol and Battery acid	N/A	N/A	N/A
Special Handling Instructions	The boxes must not get wet under any circumstances	none	none	none

MOVEMENT OF PEOPLE

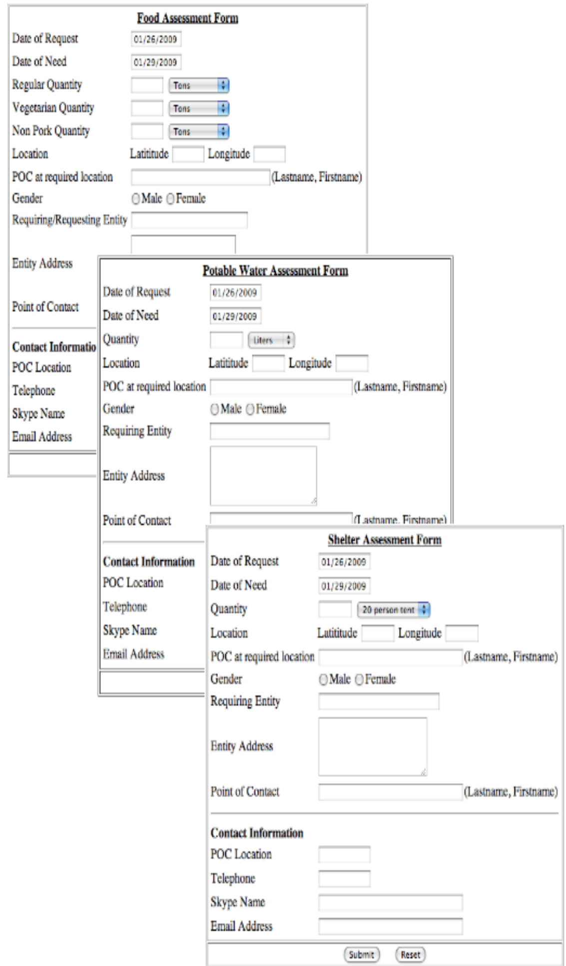
WHY do you need to move them? This is a critical health assessment & there is no way to get there by road

WHO is in charge of the passengers? Name: Henri Vache; Contact Info: 344.78-9908

HOW LONG do they need to remain on the ground? Overnight. Request pick up the next day for exfil at 1200 hours

OTHER INSTRUCTIONS: Mr. Vache should be handled as a DV / VIP

OFDA/OLU FORM 82



Food Assessment Form

Date of Request: 01/26/2009
Date of Need: 01/29/2009
Regular Quantity: Tons
Vegetarian Quantity: Tons
Non Pork Quantity: Tons
Location: Latitude, Longitude
POC at required location (Lastname, Firstname)
Gender: Male / Female
Requiring/Requesting Entity
Entity Address
Point of Contact
Contact Information
POC Location
Telephone
Skype Name
Email Address

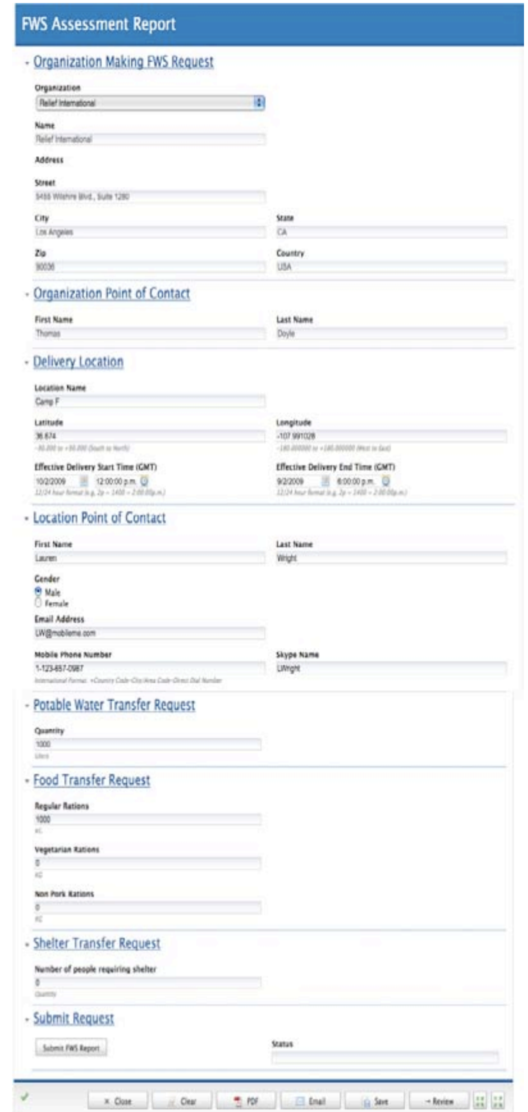
Potable Water Assessment Form

Date of Request: 01/26/2009
Date of Need: 01/29/2009
Quantity: Liters
Location: Latitude, Longitude
POC at required location (Lastname, Firstname)
Gender: Male / Female
Requiring Entity
Entity Address
Point of Contact (Lastname, Firstname)
Contact Information
POC Location
Telephone
Skype Name
Email Address

Shelter Assessment Form

Date of Request: 01/26/2009
Date of Need: 01/29/2009
Quantity: 20 person tent
Location: Latitude, Longitude
POC at required location (Lastname, Firstname)
Gender: Male / Female
Requiring Entity
Entity Address
Point of Contact (Lastname, Firstname)
Contact Information
POC Location
Telephone
Skype Name
Email Address
Submit | Reset

COI Notional FWS Forms



FWS Assessment Report

Organization Making FWS Request
Organization: Relief International
Name: Relief International
Address
Street: 5455 Wilshire Blvd., Suite 1280
City: Los Angeles; State: CA
Zip: 90036; Country: USA

Organization Point of Contact
First Name: Thomas; Last Name: Doyle

Delivery Location
Location Name: Camp F
Latitude: 36.674; Longitude: -107.991026
Effective Delivery Start Time (GMT): 10/2/2009 12:00:00 p.m.
Effective Delivery End Time (GMT): 9/2/2009 6:00:00 p.m.

Location Point of Contact
First Name: Lauren; Last Name: Wright
Gender: Male / Female
Email Address: LW@mobileme.com
Mobile Phone Number: 1-123-657-0987; Skype Name: LWright

Potable Water Transfer Request
Quantity: 1000

Food Transfer Request
Regular Rations: 1000
Vegetarian Rations: 0
Non Pork Rations: 0

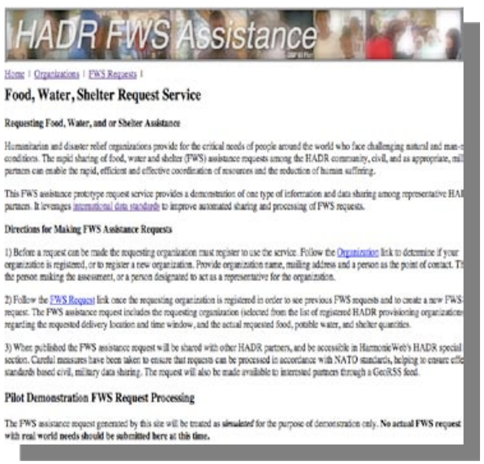
Shelter Transfer Request
Number of people requiring shelter: 0

Submit Request
Submit FWS Report; Status

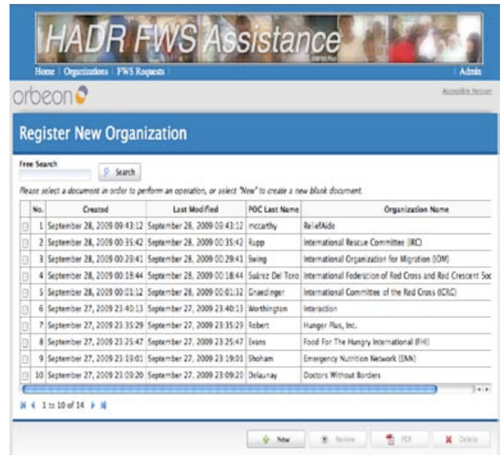
Close | Clear | PDF | Email | Save | Review

Deployed FWS Form (XForm Technology)

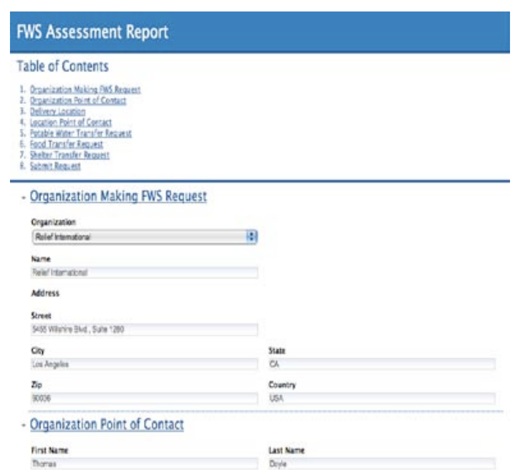
FWS Services & Pages



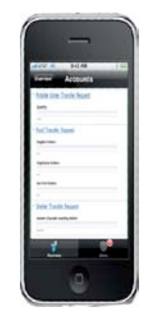
Overview & Instructions



Register Organizations

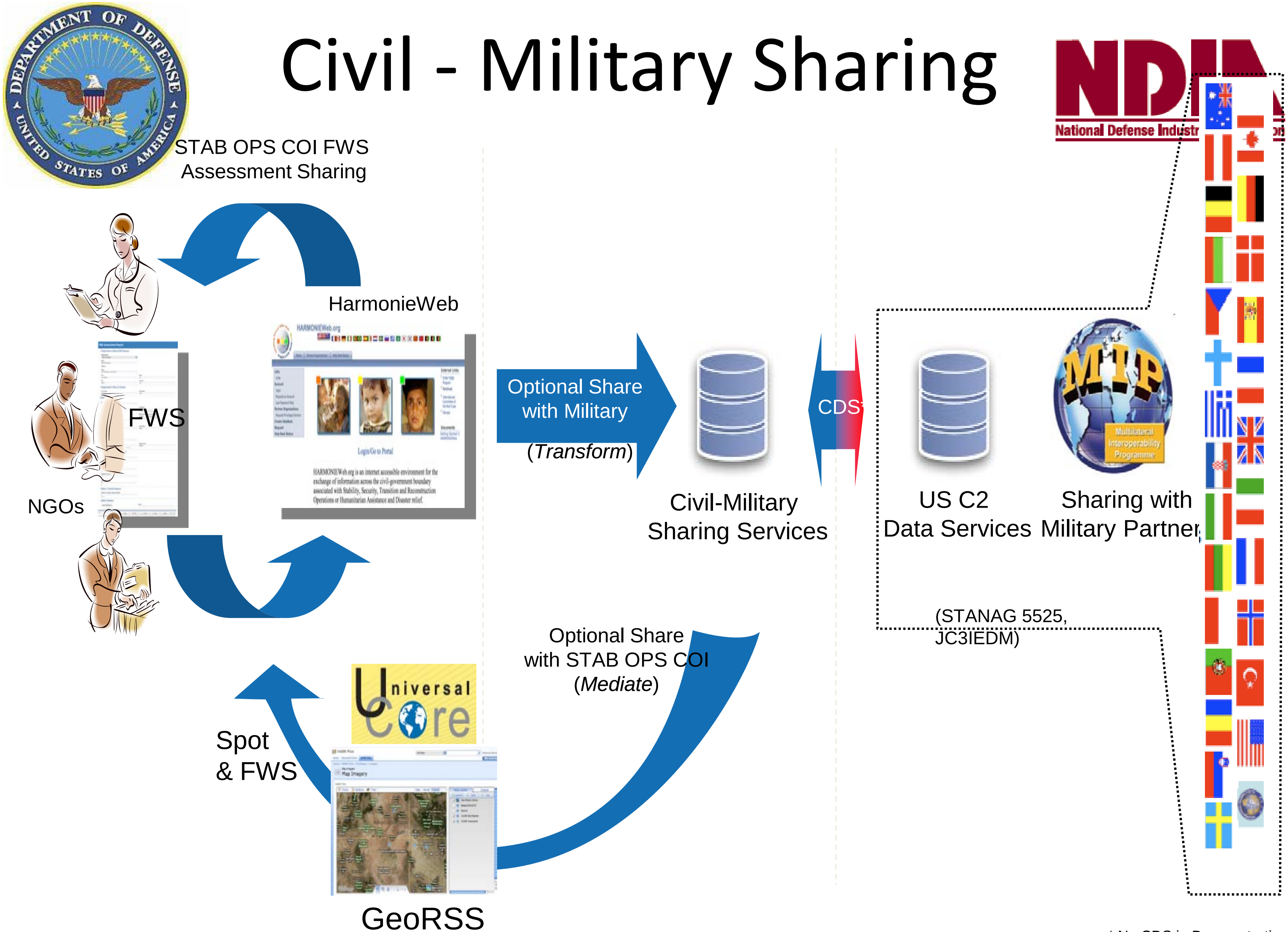


FWS Assessment Request



PC or SmartPhone

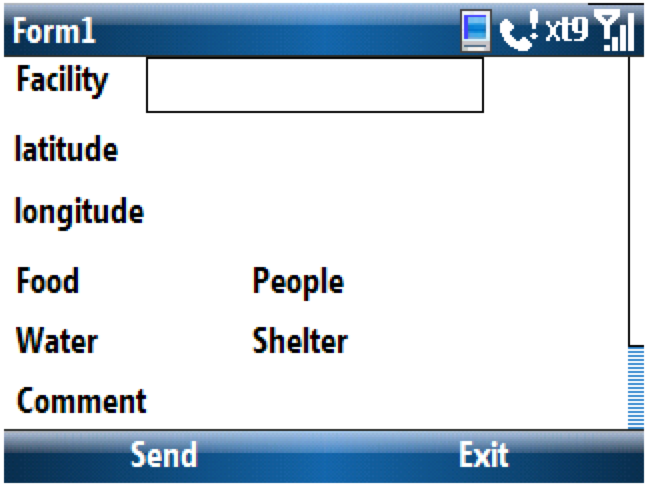
Civil - Military Sharing



* No CDS in Demonstration

Mobile phone app

- 3.3B mobile phones worldwide
- Windows Mobile 6.0
- Food, Water, Shelter



Leverage existing Committees for Governance

National Defense Industrial Association

Prescribed methodology

Mission Area & Domain Portfolio Managers

Executive Board (FO/GO) Chair or Co-Chair

- Promote & review COI activities
- Resolve cross-COI discrepancies

Steering Committee Forum (Chair or Co-Chair)

- Ensure appropriate participation
- Act as primary COI POC
- Track milestones & success criteria

Joint Implementation Working Group (Appropriate Lead/Co-Lead)

- Define & implement high level COI capability roadmap and schedule milestones
- Stand up Pilot WG as needed
- Synchronize COI products with existing processes (e.g., JCIDS, Acquisition, PPBE)

Data Management Working Group (Appropriate Lead/Co-Lead)

- Develop shared vocabulary for a given problem area in accordance with the DoD Net-Centric Data Strategy

Pilot Demonstration Working Group (Appropriate Lead/Co-Lead)

- Develop repeatable process to demonstrate COI products (e.g, COI vocabulary)
- Leverage core enterprise services
- Execute as risk reduction for next Pgm of Record (PoR) spiral

Additional Working Groups as needed

Building further consensus

- Shared Process
  - Coordinated: Relief Aid, Transportation, Security, Health
- Shared Service
  - Situation & Assessment Reporting, Coordination, Request
- Shared Data needs
  - **Victims/Displaced persons**
  - ✓ Food
  - **Nutrition**
  - **Health**
  - ✓ Water
  - ✓ Shelter
  - **Sanitation**
  - **Agriculture & Livestock**
  - **Search & Rescue**
  - **Logistics**
  - **Infrastructure/facilities**

Synchronizing with other existing processes

Tightly Couple with ISIP Focus Area 6

- Establish a set of web-service specifications to drive the net-centric development of functionality common to civil support and SSTR operations built on DoD Core Enterprise Service (CES) standards

- Establish various authentication and access standards/mechanisms to allow DoD and its external mission partners, both planned and unanticipated, to achieve an appropriate level of access to information concerning civil support and SSTR operations

- Develop standards for control measures to ensure the integrity and protection of information

- Establish data exchange standards to facilitate the sharing and integrating of information from across the various portal instantiations

- Develop a common look-and-feel among civil support/SSTR portals to facilitate ease of use and to reduce training requirements

- Leverage solutions developed by the combatant commands

Synchronizing with other existing processes

Leverage existing Civil Affairs Assessments

IKE w/GATER

Mobile GATER

Desktop GATER

Online GATER

UROC Centralized Geodatabase

Graphic Visualization

Tabular Visualization

Synchronizing with other existing processes

Integrate into JFCOM **Joint Concept Development** and **Experimentation**

- **JFCOM** is the DoD lead agency
  - Identifies major challenges facing the joint warfighter, to include combined and interagency operations; projects change year-to-year based on Warfighter Challenges prioritized by the COCOMs
  - Projects solve challenges in terms of doctrine, organization, training, materiel, leadership and education, personnel, facilities and/or policy changes
- Limited Objective Experiment (LOE)
  - Proposed solution is introduced into a simulated environment to observe its effect; prove/disprove an hypothesis by comparison to a baseline solution or to an observable standard.

  FY10 Experiments:

    - **Comprehensive Approach Interagency Concept (CAIC).** Problem statement: "The Joint Force Commander lacks a common concept to synchronize the diverse efforts of U.S. Government agencies, IOs, and NGOs into an integrated effort in response to crises and conflicts."

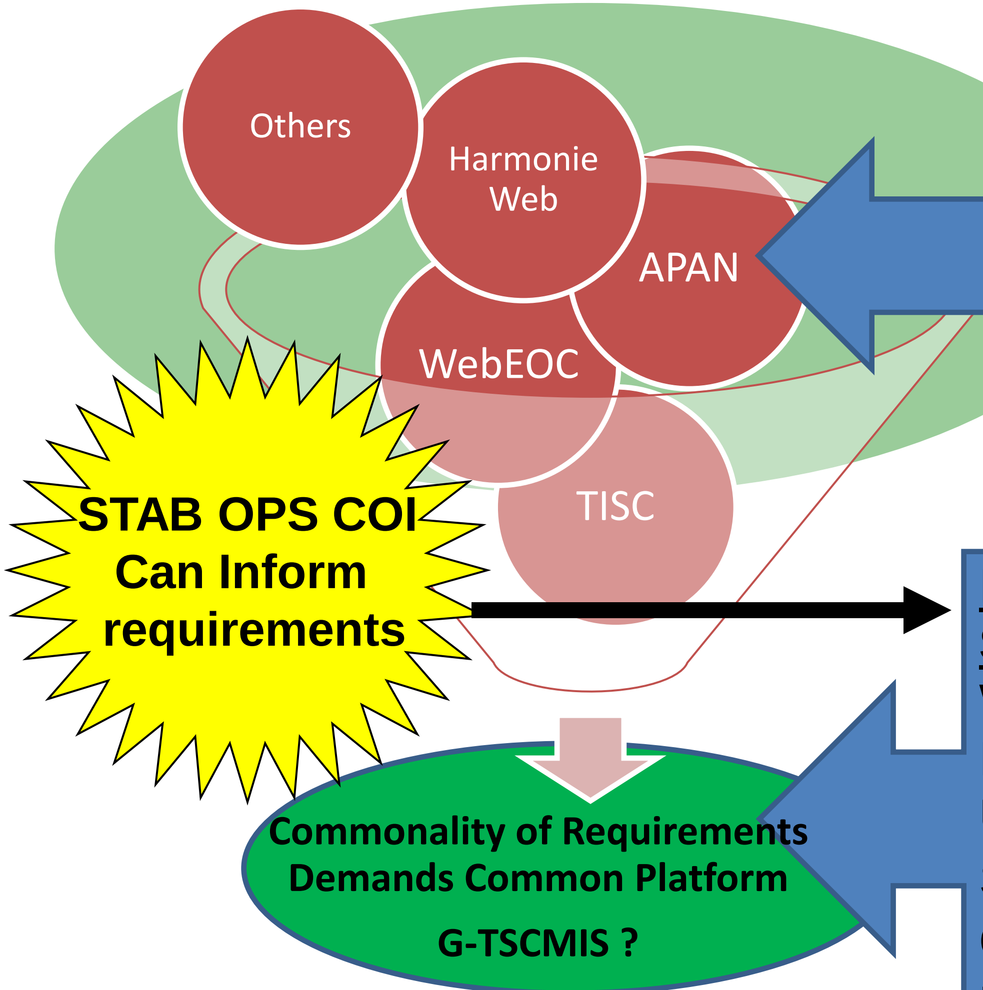
Synchronizing With Other Existing Processes

Integrate into **Army Experimentation** at BCBL-L TALON STRIKE/OMNI FUSION 10

- Plan, Prepare and Execute the TALON STRIKE/Omni Fusion 10, Exercise/Experiment, as the lead US Battle Lab
- Serve as Experiment Director for event
- Host/Conduct Initial and Final Planning Conferences, Co-Host Mid-Planning Conference in the UK
- Provide lab facility for the US DIV (Pope Hall) and US BCT (potentially from the National Simulations Center) role players
- Staff EXCON/HICON and support personnel for event

Synchronizing With Other Existing Processes

Shape Global Theater Security Cooperation Management Information Services Concept



<u>Today: Disparate Regional Solutions:</u>

Does Not Meet Existing Policy

No Data Discovery

Funding Inefficiencies

Difficult to Access by Ad Hoc User

Does not meet BP or TSC Reqmts

Stab Ops; HA/DR; HCA; IW

<u>Future: Department Wide **Unclas Info Sharing** Core Platform:</u>

Whole of Government Approach

Managed Outside NIPR

Un-Anticipated Users

Satisfy Theater Security Cooperation **Stab Ops; HA/DR; HCA; IW; Interagency**

Dynamic Data Discovery

May Need to Update Data Policy

Synchronizing With Other Existing Processes

Leverage STANAG 5525 and MIP Semantics

Engage NATO OTAN ALLIED COMMAND TRANSFORMATION

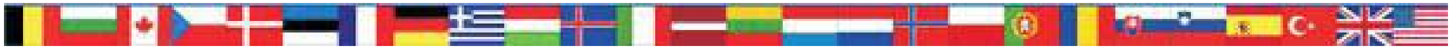
To implement MIP **semantics (STANAG 5525)**

OMG SOPES

At the NATO Civil-Military Fusion Centre

Your reachback to Civil-Military resources for complex crises

To promote information sharing amongst ISAF PRTs-



Members following the standard and their C2 POR

FULL MEMBERS	
CAN	TacC2IS
DEU	HEROS-2/1
DNK	DACCIS
ESP	SIMACET
FRA	SICF, SIR
GBR	ATacCS/ComBAT
ITA	SIACCON
NLD	ISIS
NOR	NORTaC/NORCCIS
SWE	ISMARK, SLB
TUR	TACCIS
USA	MCS

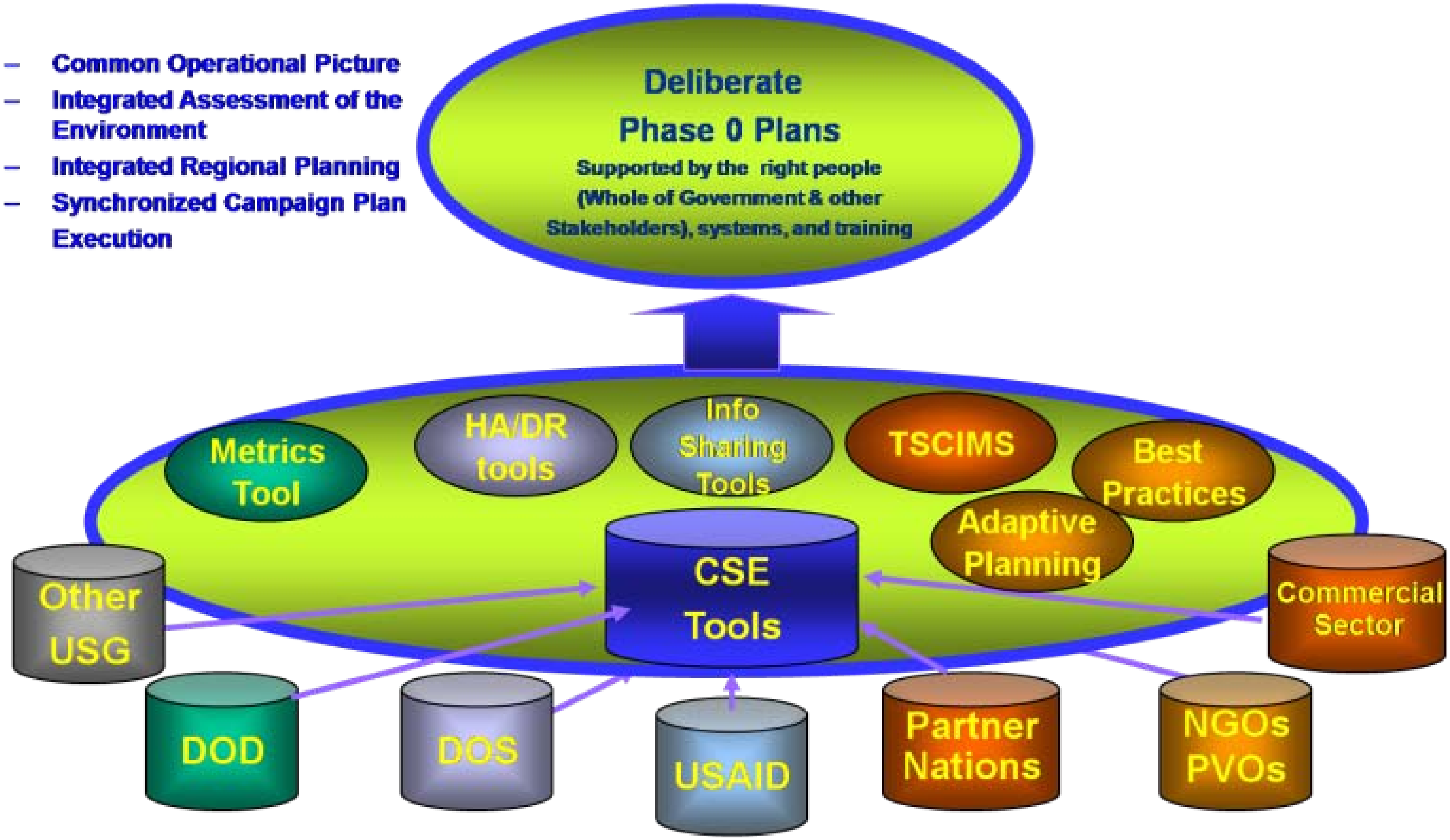
ASSOCIATE MEMBERS			
ACT	BiSC-AIS-LC2IS	HRV	CAF
AUS	JCCS, BCSS	HUN	HAVIR
AUT	PHOENIX	LTU	TAVVIS
BEL	ISIS	POL	SZAFRAN / C3IS Jasmine
BUL	FICIS	PRT	SICCE
CHE	FIS HE	ROU	SIAAB
CZE	GF-TCCS	SVK	C2SYS
FIN	FINACCIS	SVN	SITAWARE
GRC	HARCCIS		

* Country codes according NATO STANAG 1059 Ed 8.

Synchronizing With Other Existing Processes

Integrate effort into Cooperative Security Joint Capability Technology Demonstration Program

- Common Operational Picture
- Integrated Assessment of the Environment
- Integrated Regional Planning
- Synchronized Campaign Plan Execution



Further Efforts and Research

1. Leverage existing bodies involving IA partners for Governance
2. DASD (PS&SO) and OASD(NII) IIS couple COI with ISIP focus area 6
3. Authorize further systems integration, expand data modeling efforts, develop processes and CONOPS.
4. Leverage existing CA module for Assessments
5. Authorize Joint Experimentation and Concept Development – Comprehensive Approach Interagency Concept
6. Endorse experimentation w/Army at BCBL-L Exercise Talon Strike/Omni Fusion 10
7. Report outcomes to inform requirements of G-TSCMIS Concept
8. Authorize engagement of NATO ACT to leverage STANAG 5525 (MIP Semantics) and LC2IS
9. Integrate effort into Cooperative Security Joint Capability Technology Demonstration Program

References

1. *Data Sharing in a Net-Centric Department of Defense* [Department of Defense Directive 8320.02]. (2004, December 2). Retrieved October 8, 2009, from U.S. Department of Defense website: http://www.dtic.mil/whs/directives/corres/pdf/832002p.pdf

2. *Information and Communications Technology (ICT) Capabilities for Support of Stabilization and Reconstruction, Disaster Relief, and Humanitarian and Civic Assistance Operations* [Department of Defense Instruction 8220.02]. (2009, April 30). Retrieved October 8, 2009, from U.S. Department of Defense website: http://www.dtic.mil/whs/directives/corres/pdf/822002p.pdf

3. Orbeon XForms. (n.d.). *XForms*. Retrieved October 8, 2009, from http://www.orbeon.com/

Cost and Risk Impacts of the New DOD 5000 Defense Acquisition Framework

Dr. Peter Hantos and Nancy Kern
The Aerospace Corporation

NDIA 12th Annual Systems Engineering Conference
27 October 2009

Acknowledgements

- This work would not have been possible without the following:
  - *Reviewers*
    - John Lang
    - Suellen Eslinger
    - Dr. Leslie Holloway
  - *Sponsors*
    - Marilee Wheaton
    - Rosalind Lewis
    - Mary Rich
  - *Funding Source*
    - The Aerospace Corporation's Independent Research & Development

Objectives

- Highlight some consequences of selected changes in the DOD 5000.02 Policy
  - *The focus of inquiry is centered around the changes impacting the Technology Development phase of the acquisition life cycle*
- Use life cycle modeling and cost estimation research results to facilitate the analysis

Outline

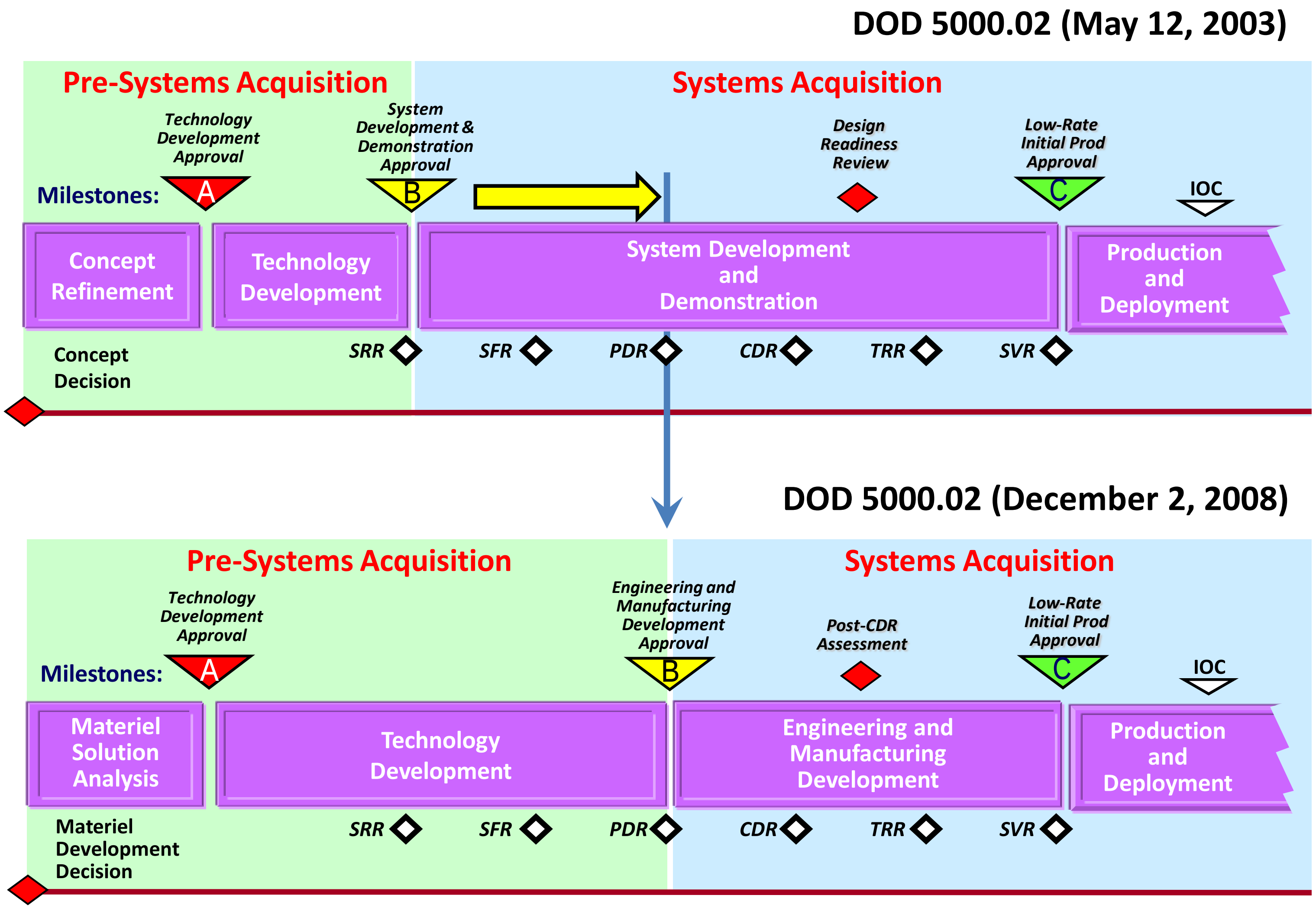
- Major Changes in the Technology Development phase
- Research Methodology
- Constructive Systems Engineering Cost Model (COSYSMO)
- Effort Distributions for the “Old” and the “New” DOD 5000.02
- Analysis
- Conclusions
- Acronyms
- References

Major Changes in the Technology Development Phase*

- “The Technology Development Strategy and associated funding shall provide for two or more competing teams producing prototypes of the system and/or key system elements prior to, or through, Milestone B”
  - *The new policy explicitly calls for competitive prototyping*
- Preliminary Design Review (PDR) conducted for candidate designs and PDR report provided to the Milestone Decision Authority (MDA) at Milestone B
  - *The new policy substantially expands the scope of the Technology Development phase*
- For Major Defense Acquisition Programs (MDAPs) Milestone B certification needs to be provided to the congressional defense committees
  - *The new policy substantially increases the weight and visibility of the Milestone B decision*

**** Source: [DOD 2008]***

PDR Conducted at Milestone B



The Rationale Behind the Changes

- Selected aspects of the discussed changes were proposed earlier in the 2006 Defense Acquisition Performance Assessment (DAPA) report*:
  - *For Acquisition Category (ACAT) I and II programs, create contract terms and conditions that require formal subcontractor level competition instead of internal make-or-buy assessments by the prime*
    - According to the report, this higher level of visibility would allow the government to better understand the technical and management risks of the prime contractor's plans
  - *Reposition the Milestone B decision to occur at PDR*
    - According to the report, the maturity of the designs at this phase would allow more realistic program cost determination
    - Industry and Government would be in a better position to agree on a high confidence cost estimate for the desired capability
    - Source Selection Authorities would have a competitive range available to consider the proposals' affordability

Source: [DAPA 2006]

Research Methodology

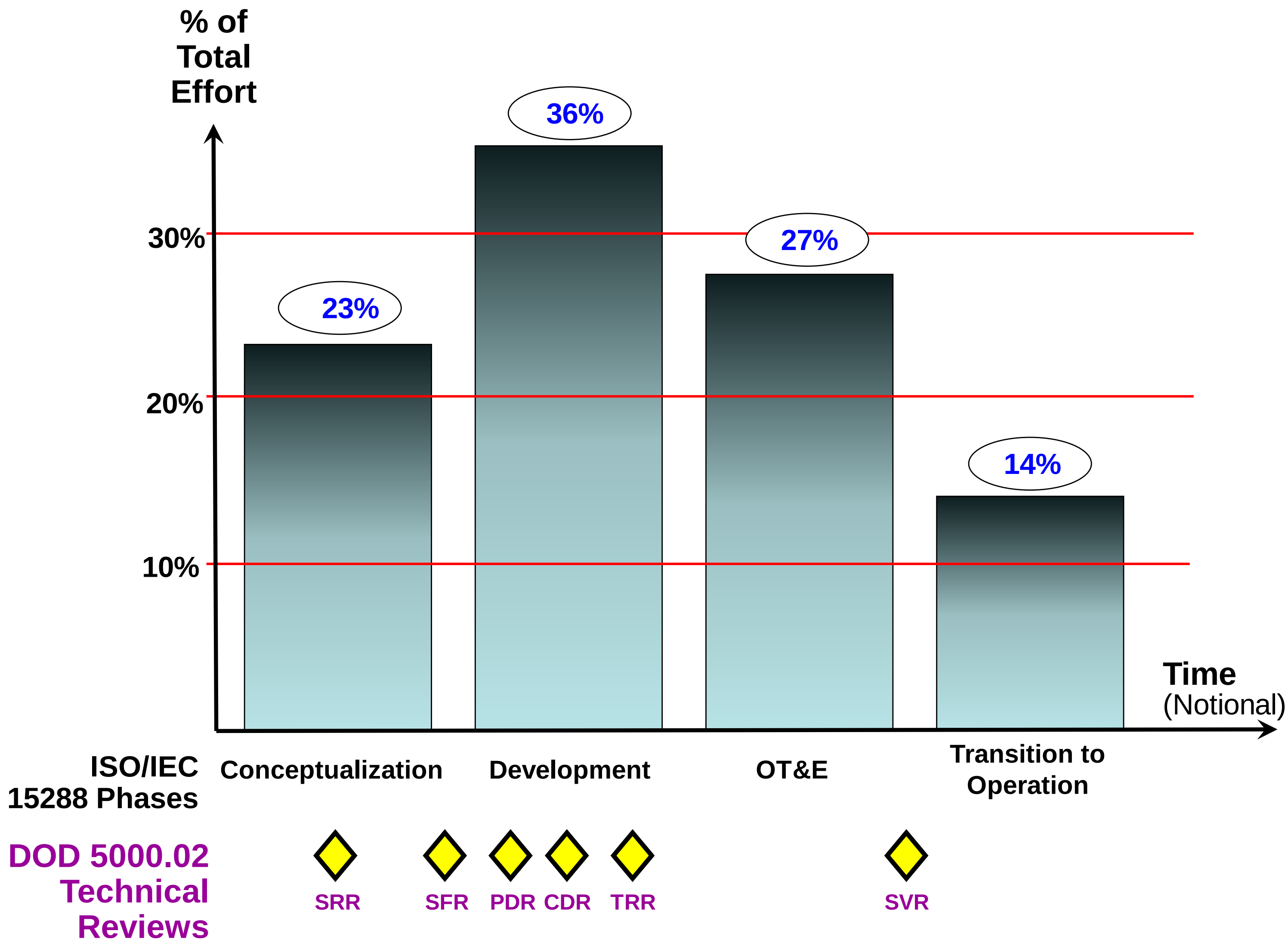
- Determine the systems engineering effort distribution using the Constructive Systems Engineering Cost Model (COSYSMO)
- Map the DOD 5000.02 Technical Reviews to the systems engineering standard's life cycle phases
- Using the COSYSMO effort distribution, model the total systems engineering effort for an acquisition using a two-contractor example, for both the old and the new versions of the DOD 5000.02 acquisition life cycle models
- Evaluate results, generalize for more than two competing contractors

Detour: COSYSMO

- What is COSYSMO?
  - *COSYSMO is a parametric estimation model to estimate how much systems engineering effort, in terms of person months, should be allocated for successful conceptualization, development, and testing of a large-scale system [Valerdi 2008]*
  - *Originally developed at the University of Southern California*
  - *COSYSMO adapted the ISO/IEC 15288 standard's phases* as the underlying life cycle model*

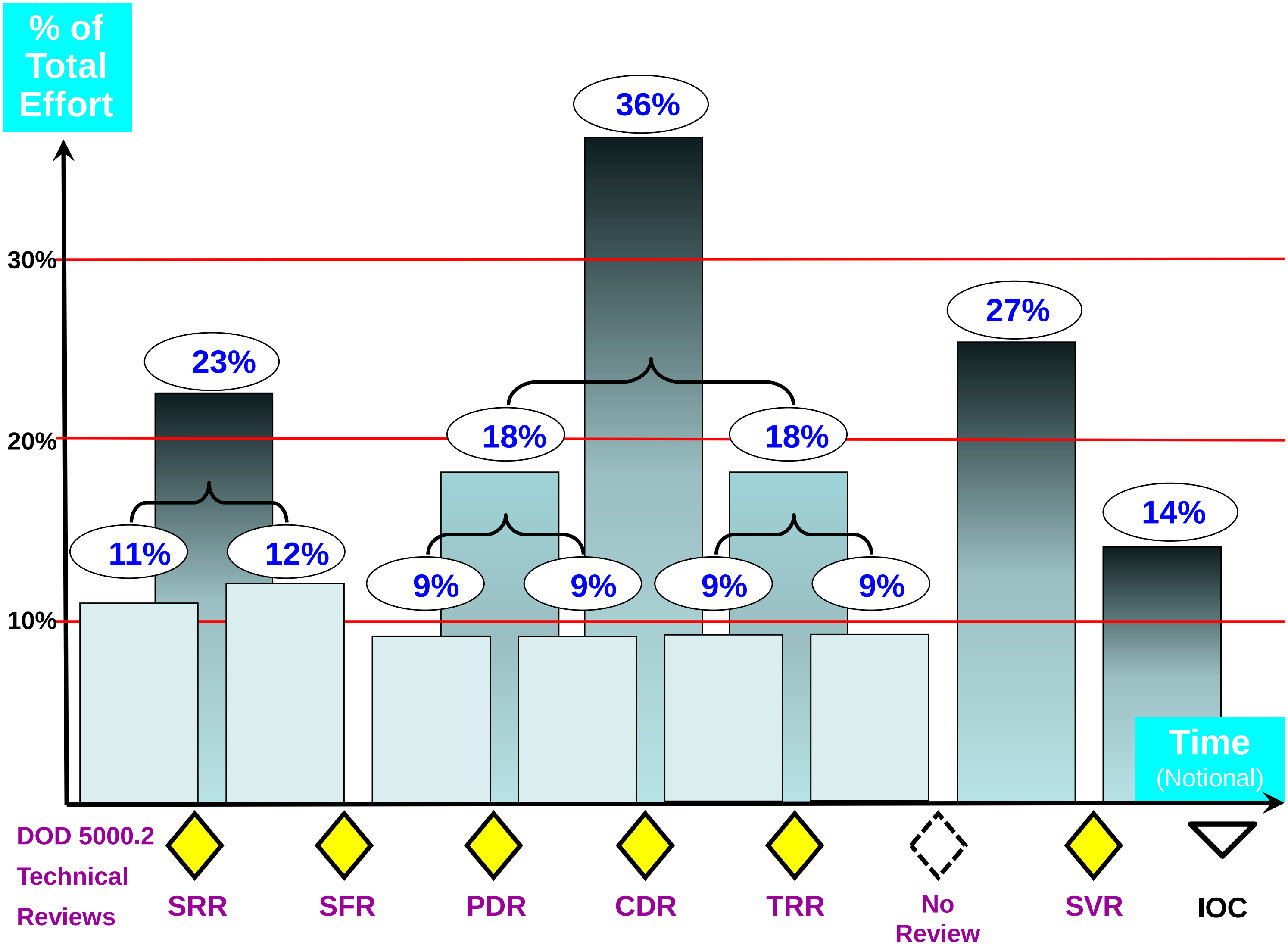
**** For more details on the standard see [ISO/IEC 2002]***

COSYSMO Systems Engineering Effort Distribution*



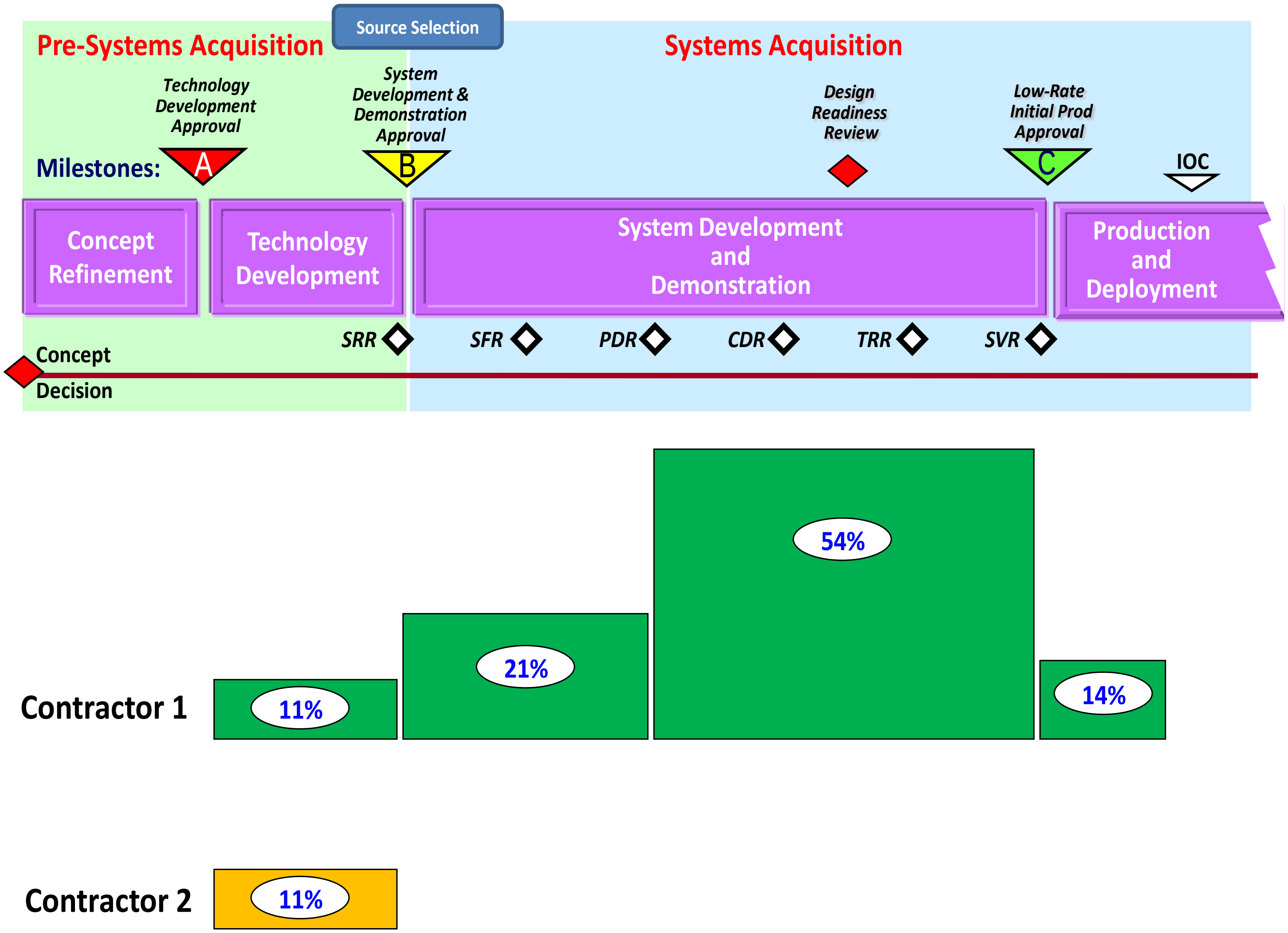
For sake of simplicity, standard deviation of effort values is not shown

Approximation of Effort Between Technical Reviews



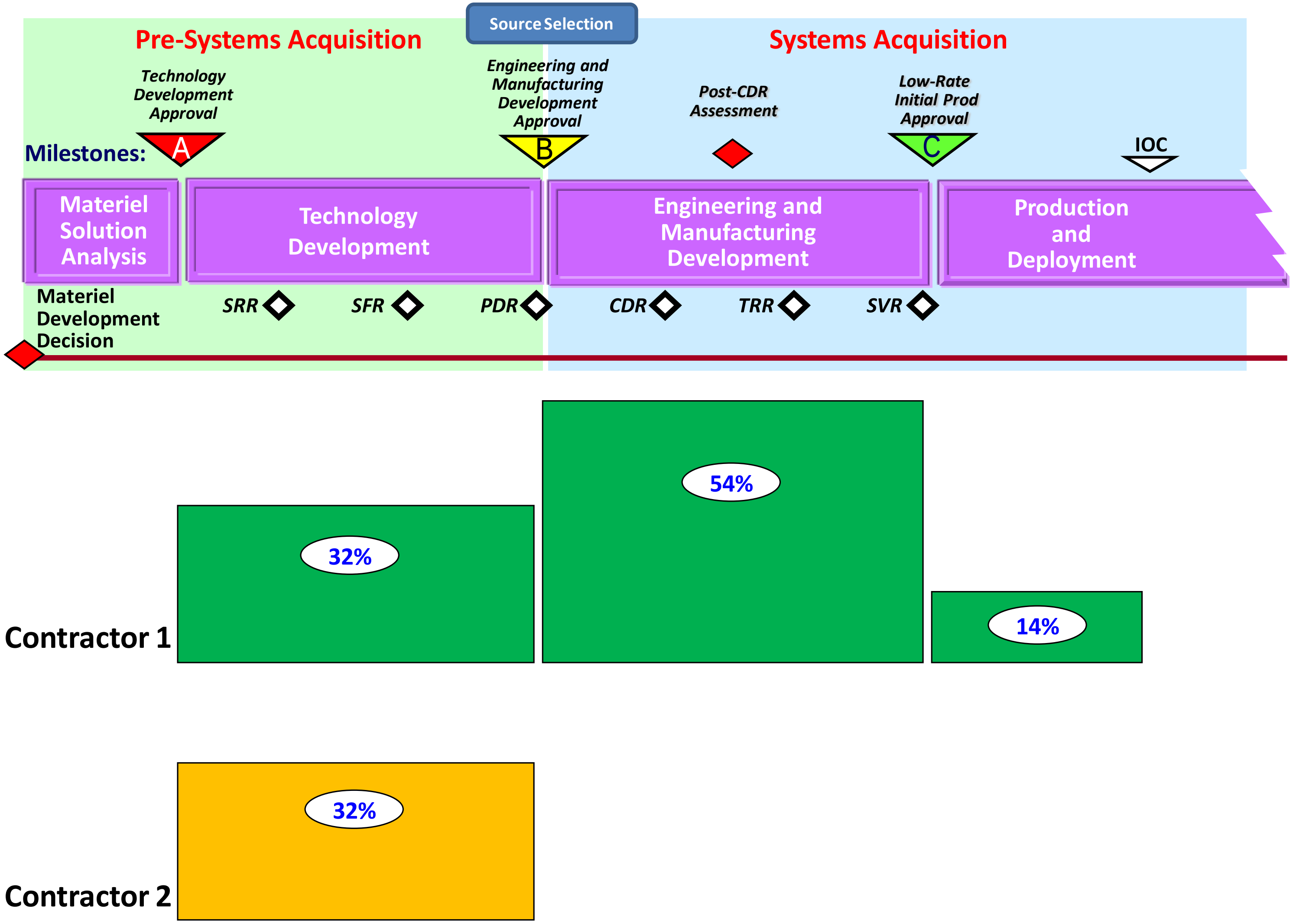
This approximation is not part of either the standard or COSYSMO

Effort Distribution for DOD 5000.02 (May 12, 2003)



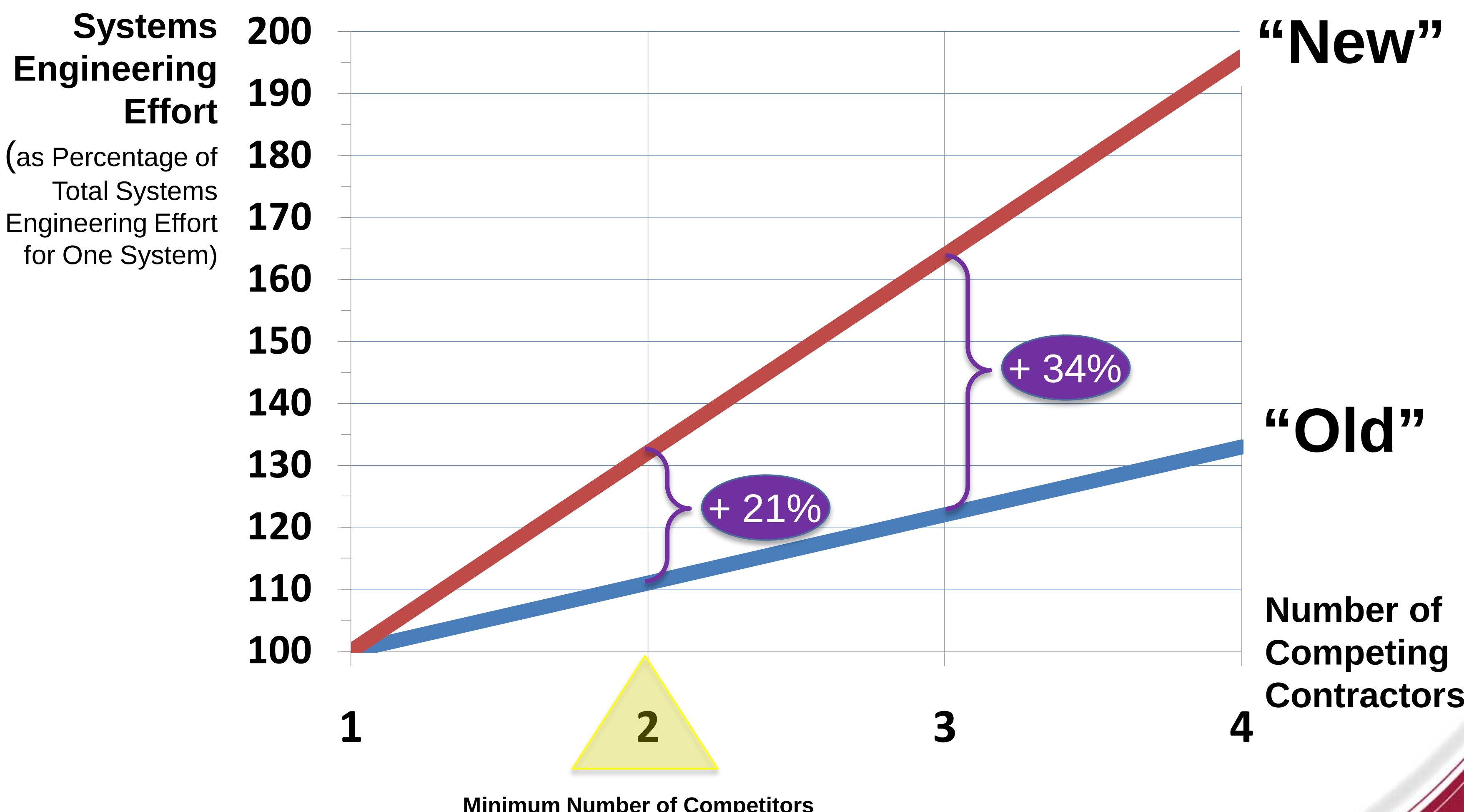
Note that the minimum effort for the overall acquisition is 111% of a single system's total effort since at least two contractors must compete

Effort Distribution for DOD 5000.02 (December 2, 2008)



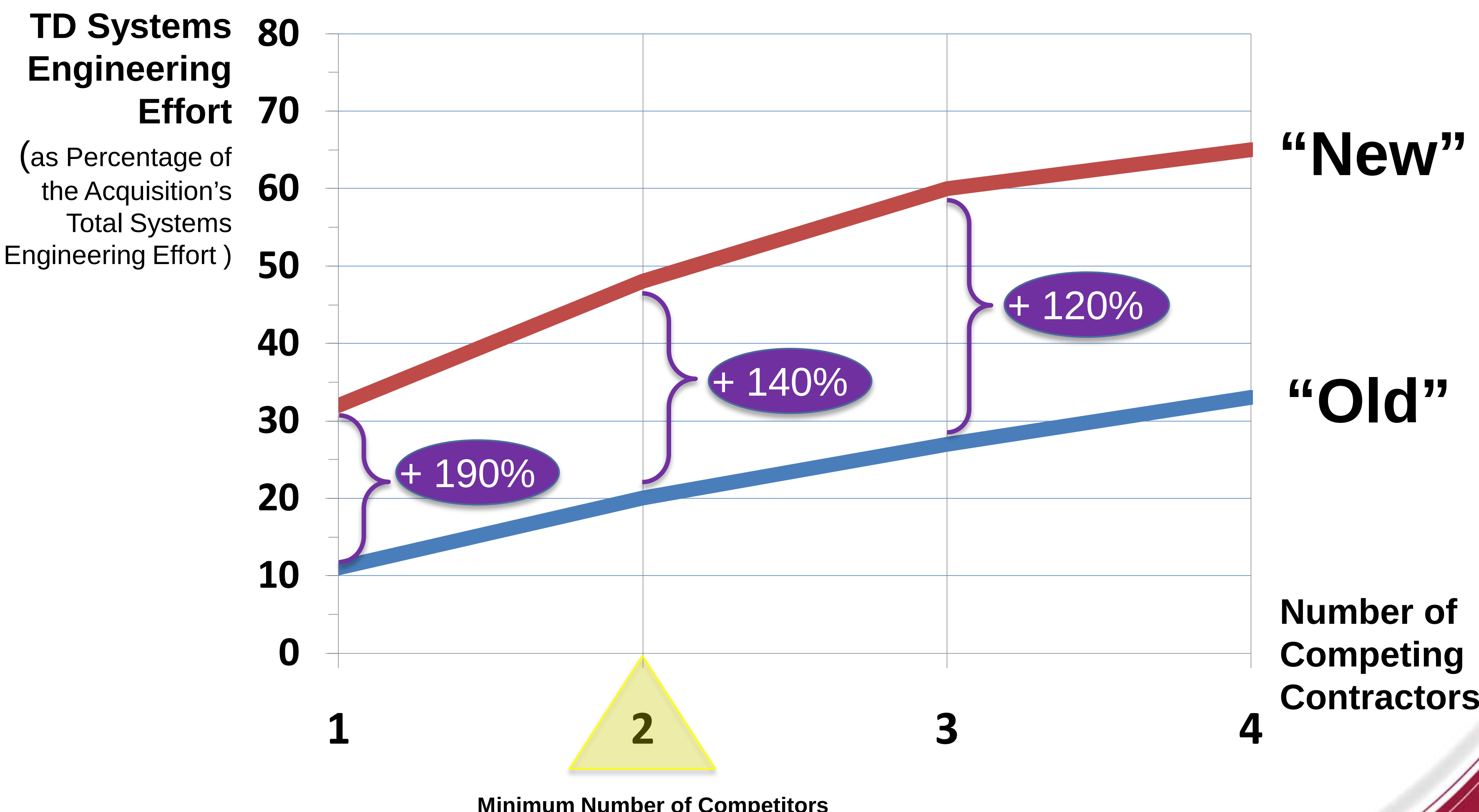
See analysis of impact on the following slides

Contractors' Systems Engineering Effort



Moving Milestone B increases the overall Systems Engineering effort

Technology Development Systems Engineering Effort



Analysis

- DOD and Government Accountability Office (GAO) Perspective
  - *Cost*
    - Since the program baseline is now established after PDR, the cost and duration of acquisitions might be expected to decrease
    - However, the overall cost of acquisitions, particularly the costs associated with the initial systems engineering effort involving multiple contractor teams, may significantly increase
    - Note: If the initial costs are <u>not</u> significantly increasing, that would mean that each team is receiving less funding than they would have received to get through PDR prior to the policy change. How can they be expected to do more risk reduction up front with less money up front?
    - The balance between Pre-Acquisition and System Acquisition has changed; the weight of Technology Development has increased
      - *Cost Analysis Improvement Group (CAIG) estimates, budgeting plans and budgeting effectiveness evaluations need to take this into account*
  - *Program Risk*
    - The longer, extended TD phase is likely to have multiple impacts:
      - *Reduction in rework at the back-end of the development life cycle, resulting from more extensive effort at the front-end*
      - *Reduction of program risk, but probably at increased cost and schedule*

Analysis (cont.)

- Program Executive Officer (PEO) Perspective
  - *Program Office effort, leading up to and carrying out source selection, will significantly increase*
    - Program office staffing plans need to take this into account
    - However, due to the financial reality, most likely the government team will just be spread thinner
    - A special challenge in such a competitive environment is that the government team cannot freely communicate with the contractor teams due to fear of protest for steering a contractor to a desired solution.

Conclusions

- Results of modern systems engineering research, particularly COSYSMO, are very useful in evaluating the impact of acquisition processes
- The analysis of selected features of the new DOD 5000.02 showed some of the potential consequences of the instituted changes
- To minimize these consequences, systems engineering analysis should be carried out with consideration of the potential positive and negative impacts
- Various scenarios have been analyzed as part of this research, but actual cost/schedule impacts remain to be seen
  - *The vision for systems during the Pre-A phase may be quite vague; consequently, estimates based on that vision have high levels of uncertainty*
  - *In addition to technical considerations, the gauging of TD funding will be based on various component and/or higher level negotiations*
  - *Both under- and over-estimation of resources for TD can put the program in jeopardy at the MS A and B decision points*

Acronyms

ACAT	Acquisition Category
CAIG	Cost Analysis Improvement Group
CDR	Critical Design Review
COSYSMO	Constructive Systems Engineering Cost Model
DAPA	Defense Acquisition Performance Assessment
DOD	Department of Defense
IEC	International Electrotechnical Commission
IOC	Initial Operational Capacity
ISO	International Organization for Standardization
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
PDR	Preliminary Design Review
SFR	System Functional Review
SRR	System Requirements Review
SVR	System Validation Review
TD	Technology Development
TRR	Test Readiness Review

References

DAPA 2006	Defense Acquisition Performance Assessment Report, March 2006
DOD 2008	Department of Defense Instruction on the Operation of the Defense Acquisition System, Number 5000.02, 2 December 2008
ISO/IEC 2002	ISO/IEC 15288:2002(E) Systems Engineering – System Life Cycle Processes
Valerdi 2008	The Constructive Systems Engineering Cost Model (COSYSMO), VDM Verlag Dr. Mueller, 2008

Use of Trademarks, Service Marks and Trade Names

Use of any trademarks in this material is not intended in any way to infringe on the rights of the trademark holder. All trademarks, service marks, and trade names are the property of their respective owners.

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Mission-Based Test & Evaluation Strategy: Creating Linkages between Technology Development and Mission Capability

NDIA Systems Engineering Conference

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

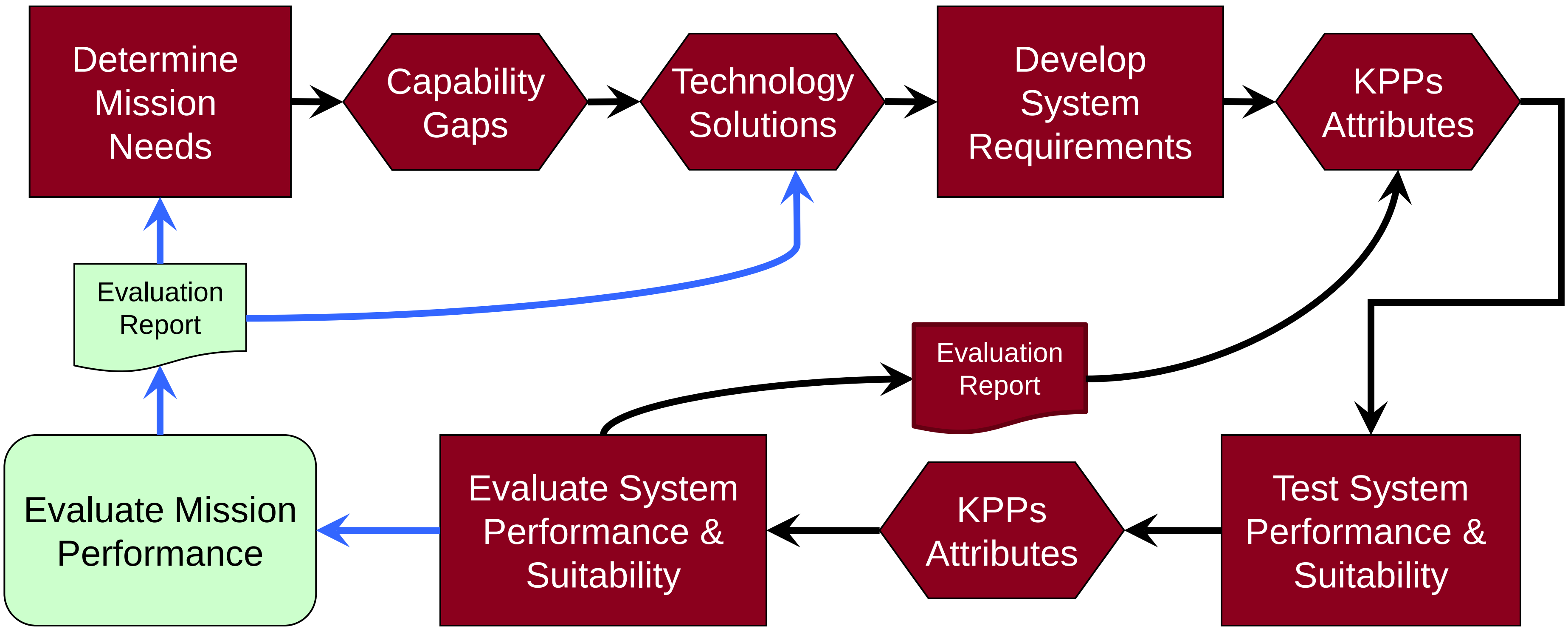
Mr. John Beilfuss (ARL)

Mr. Chris Wilcox (ATEC/AEC)

28 October 2009

Key Issue

Acquisition Process Paradigms: Traditional; Proposed

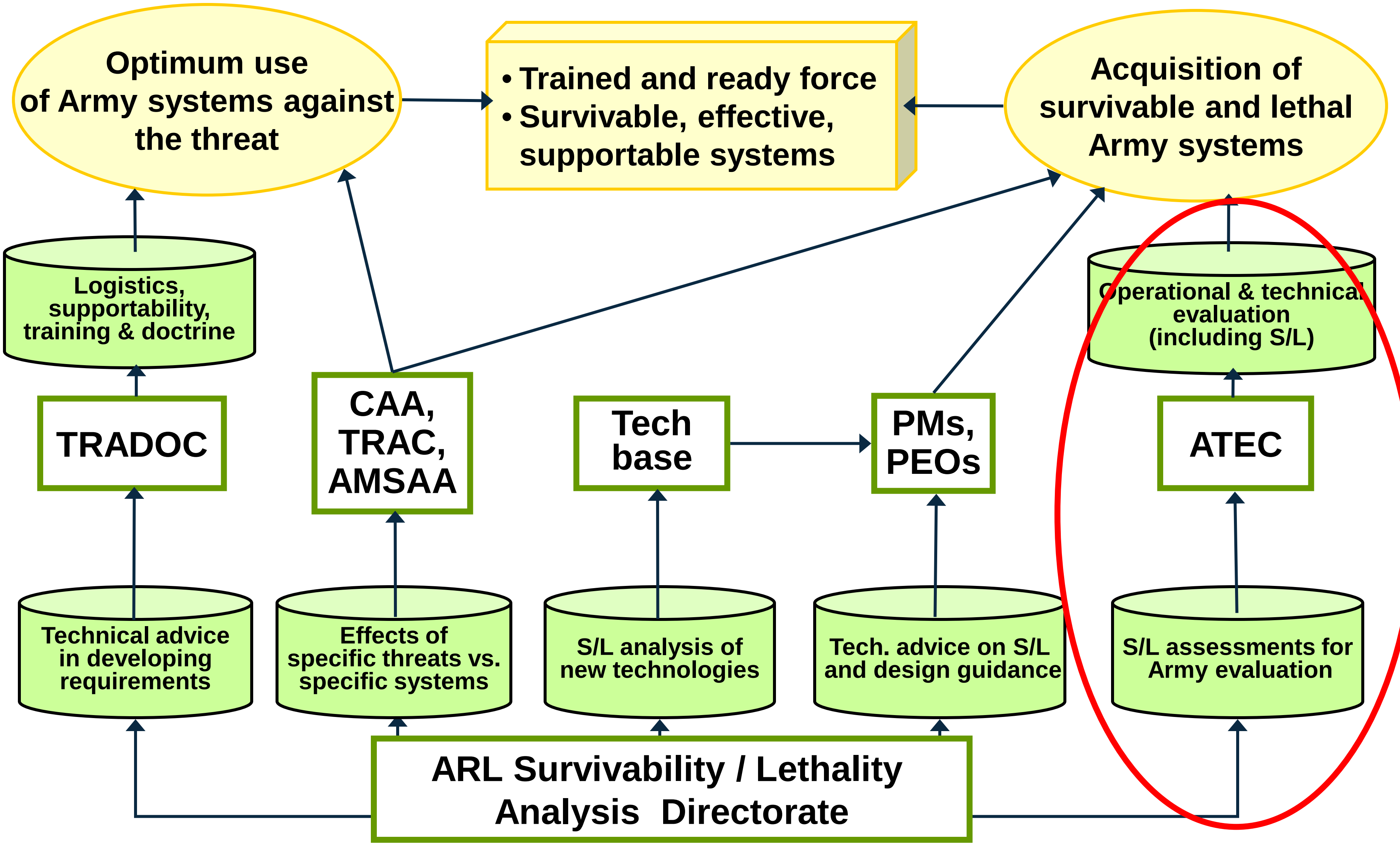


Leaves the "So What" question;
How does the technology/system help the Warfighter?

Completes the Feedback Loop to Mission Needs

KPP: Key Performance Parameter

Consumers of SLAD products: How we fit in



Purpose

- **Inform S&T community** of the effort to design and implement a ***mission-based test and evaluation (MBT&E)*** methodology.
- **Create awareness** of an opportunity for better transition of technology to PMs
- **Solicit questions and comments** from peers to help improve the MBT&E methodology.

- **MBT&E is a product of ATEC[1], ARL, AMSAA** and has been coordinated with acquisition, T&E, and user communities.
- **Note:** ARL/SLAD is a provider of survivability/lethality/vulnerability assessment data to ATEC/AEC. Our products to ATEC now have a capabilities dimension.

[1] Program lead is Mr. Chris Wilcox of Army Evaluation Center

Agenda

- **What is MBT&E**?
- **Why** was MBT&E developed?
- **What does MBT&E provide**?
- **How** is MBT&E implemented?
- **Where** is MBT&E headed?
- **What** is the potential impact on Army Technology Objectives?

<u>Mission-Based Test and Evaluation</u>

is a methodology that focuses T&E on the mission task **capabilities** provided to the warfighter. It provides a ***<u>framework</u>*** and ***<u>procedure</u>*** to:

- **link materiel system attributes to the operational capabilities;**
- **examine the SoS required to enable the operational capability; and**
- **enable synergistic use of all available data sources.**

Why was MBT&E developed?

- Prepare for networked system-of-systems evaluation
- Address Acquisition Initiatives
  - Capability-based acquisition
- Apply MBT&E to all evaluation programs
- Provide “feedback” to capabilities integration and development
- Draw from capability documents as basis for the evaluation strategy

“We will continue to examine and challenge our most basic institutional assumptions, organizational structure paradigms, policies, and procedures to better serve the Army.”

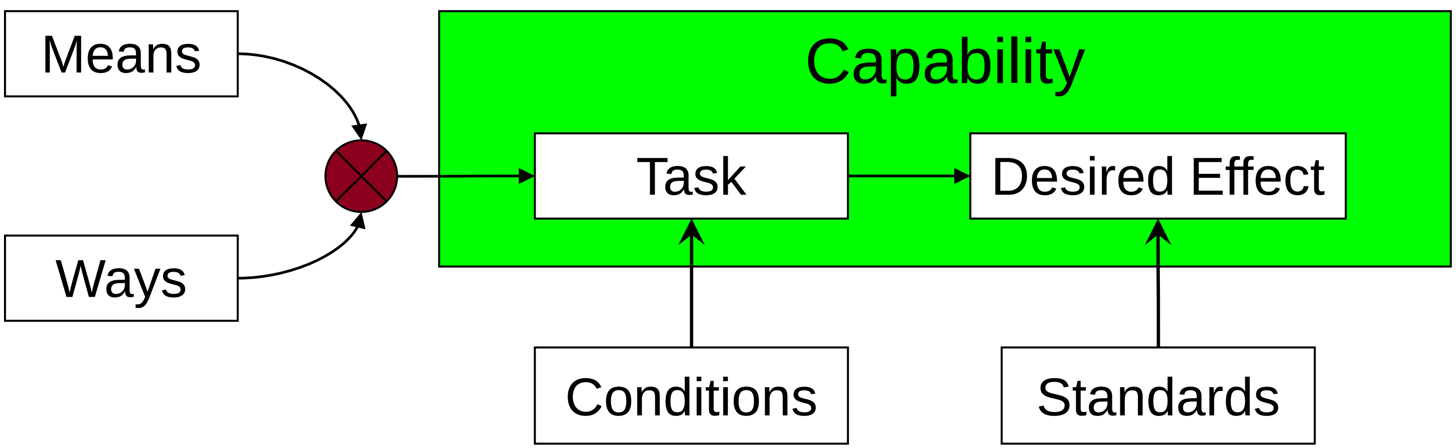
CG, ATEC Commander’s Priorities for FY 10-15

Definitions

Term	Definition	Reference
Mission	An assignment (task) with a purpose that provides direction to a command under prescribed conditions.	CJCS 3500.04C
Essential	Constituting the intrinsic, fundamental nature of something	Webster New World Dictionary
Task	A discrete event or action, not specific to a single unit, weapon system, or individual that enables a mission or function to be accomplished.	Cliff Whitcome Naval Postgraduate School
Conditions	Conditions are variables of the environment that affect the performance of tasks. Conditions include the physical, military, and civil environment	Joint mission essential task list development handbook CJCS.
METL	A document that provides the major input to planning, executing, and assessing joint training. A commander's list of priority joint tasks, derived from plans and orders, along with associated conditions and measurable standards.	Joint mission essential task list development handbook CJCS.
UJTL	A comprehensive integrated menu of functional tasks, conditions, measures, and criteria supporting all levels of the Department of Defense in executing the National Military Strategy. This document translates missions into tasks.	CJCS 3500.04C

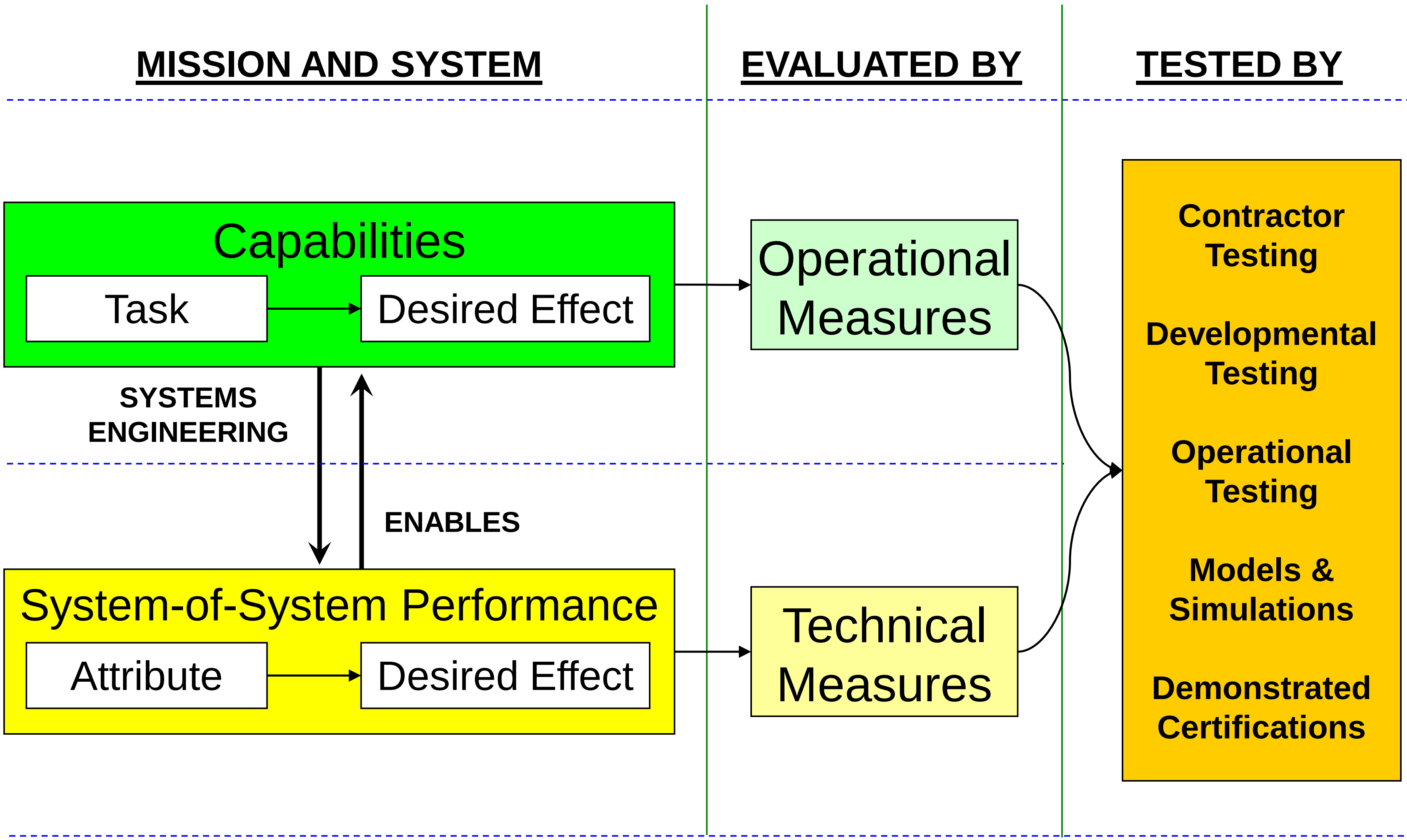
Capability[1] – The ability to achieve a **desired effect** [or result, outcome, or consequence of a task[2]] …

- under specified **standards and conditions**
- through a combination of **means and ways**
- to perform a set of tasks.

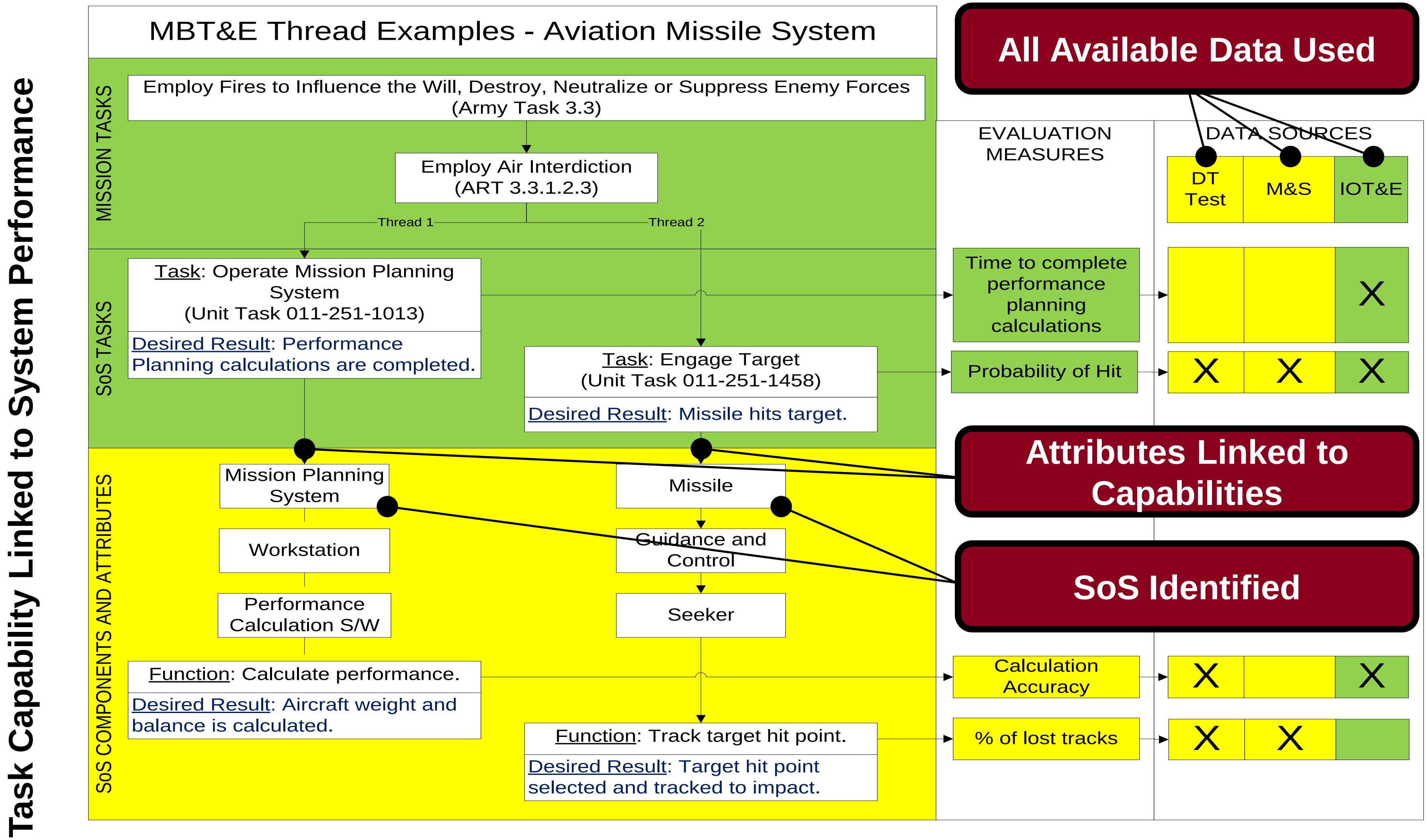


1. CJCSI 3170.01F, May 2007
2. Taken from JP 1-02, Mar 2007, definition of effect.

MBT&E Framework



MBT&E Framework Example



Capability and Performance Linked to Integrated T&E

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

MBT&E Process

- Process divided into steps.
- Steps divided into 5 major purpose areas.

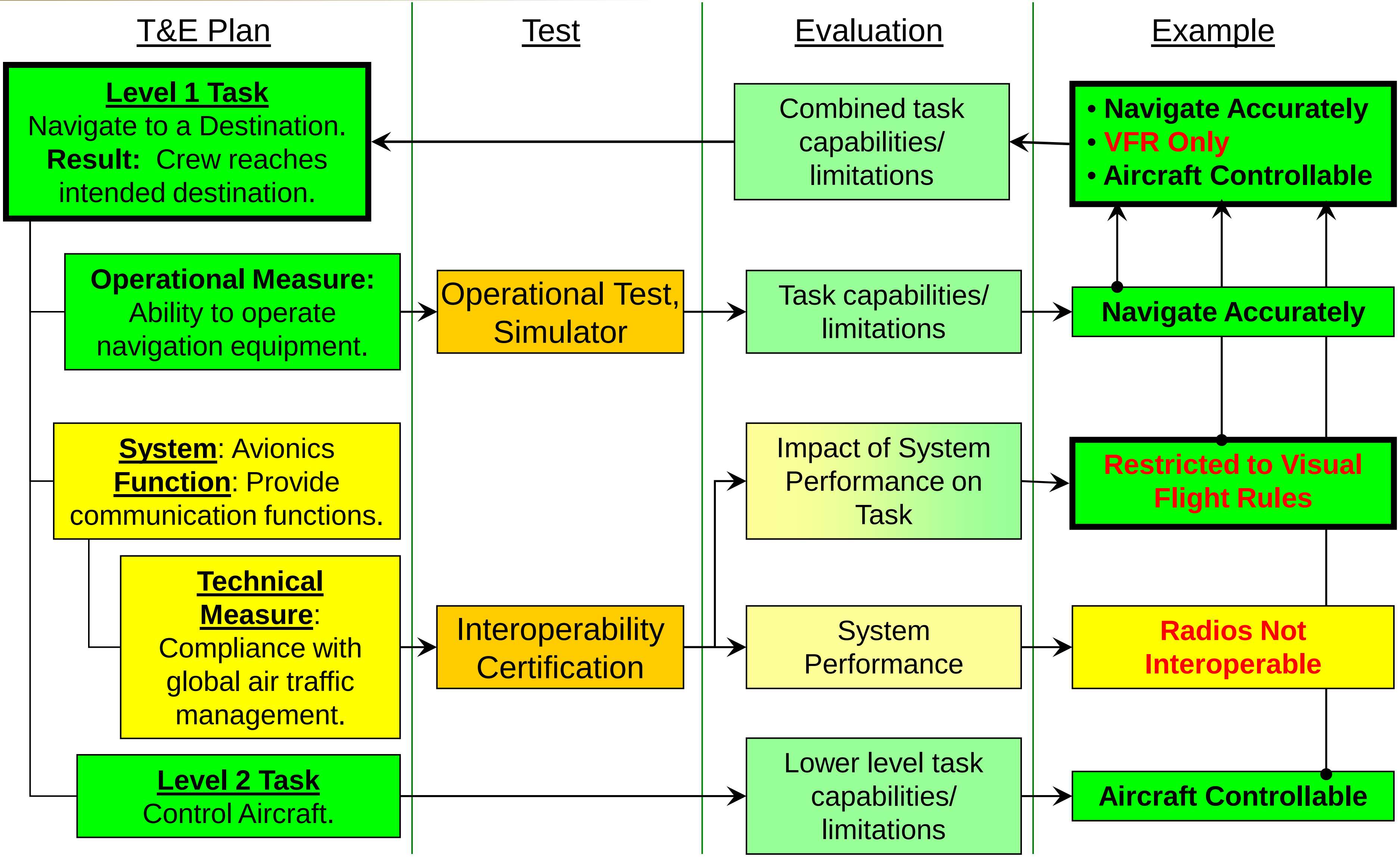
UNDERSTAND THE MISSION	• Mission and task context.
UNDERSTAND THE SYSTEM	• Materiel components and attributes.
	• **Linkages between** mission and materiel.
DESIGN THE TEST AND EVALUATION	• Test design and evaluation measures.
DETERMINE THE RESULTS	• Execute test and evaluation.
REPORT THE RESULTS	• Format and report the results.

What does MBT&E provide?

Reports on:

- Operational capabilities and limitations
- Materiel system performance and effect on operational capabilities as specified in:
  - FAA: Functional area analysis
  - FNA: Functional need analysis
  - FSA: Functional solution analysis
- Effectiveness, suitability and survivability based on task

Report Example



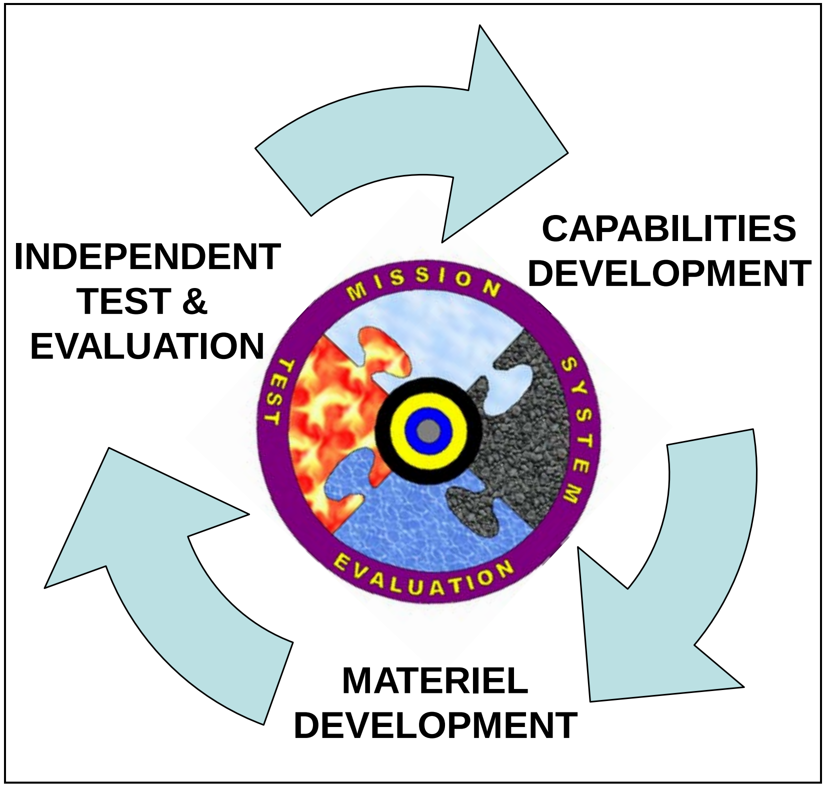
How is MBT&E Implemented?

Preliminary Design →	**Feb 08**: 1st MBT&E Summit	← Begin Pilot Projects (3)
80% Design →	**May 08**: Community review	← Add Pilot Projects (10)
Final Design →	**Aug 08**: 2nd MBT&E Summit	← Ongoing Pilots
Published Procedure →	**Dec 08**: Procedure Review	
	Jan 09:	← ***New T&E Concepts Using MBT&E***

Lessons Learned:
- MBT&E framework providing context of operational capability.
- MBT&E process is executable with current personnel skill set.
- Efficiencies can be increased through:
  - Improved tools (templates, IT, training, etc.); and
  - Combat and materiel developer participation.

Where is MBT&E headed?

- Synchronize with capabilities-based analysis.
- Synchronize with systems engineering.
- Collaborative environment.
- Pilot programs ongoing
  - Paladin
  - JLTV
- Address technology development and maturation



Paladin Example

EFD			System(s)	
CREW				
	c1	Commander Incapacitated	Commander	
	c3	Driver Incapacitated	Driver	
	c6	Gunner Incapacitated	Gunner	
	c7	Loader Incapacitated	Loader	
CATASTROPHIC LOSS				
	k1	Fuel/Ammo	Ammunition	OR
			Fuel Fire	
MOBILITY				
	m1.1	Reduced Maximum Speed 0-10%	Turbocharger System	OR
			Supercharger System	OR
			Two Intermediate Roadwheels	
	m1.2	Reduced Maximum Speed 10-50%	Road Wheel Left 1 System	OR
			Shock Absorber Right Rear System	OR
			Shock Absorber Right Front System	OR
			Shock Absorber Left Rear System	OR
			Shock Absorber Left Front System	OR
			Track Tensioner Right System	OR
			Track Tensioner Left System	OR
			Road Wheel Right 1 System	

Technology Functions Linked to Warfighter Tasks

Task #	Crew				Cat	Mobility							
						M1			M2			M3	
	C1	C3	C6	C7	K1	M1.1	M1.2	M1.3	M2.2 / 2.2.1	M2.3	M2.4	M3.2	M3.4
ART 3.3.1 Conduct Lethal Fire Support													
ART 3.3.1.1 Conduct Surface to Surface Attack													
1 Establish Firing Capability at Firing Position													
2 Conduct Emergency Missions													
3 Conduct Direct Fire													
4 Process Fire Missions													
5 Conduct Indirect Fire Missions													
6 Perform Fire Missions in Degraded Mode on the M109A6													

Joint Light Tactical Vehicle Example

Technology Functions Linked to Warfighter Tasks

SYSTEM FUNCTION

Move	Transp	Maintain / Sustain	Net Ready	Payload	Survive/ Safety	Protect	**CDD Risk**
Low		Medium				High	High

Mission
IBCT Ground Tactical Mobility

Mission Function	Mission Function Risk
ART 1.0: The Movement and Maneuver War-Fighting Function	High

Functional Task/ Sub Task	Move	Transp	Maintain / Sustain	Net Ready	Payload	Survive/ Safety	Protect	Functional Task- Sub Task Risk
ART 1.1							N/A	
ART 1.1.1	N/A			N/A				
ART 1.1.1.3							N/A	
ART 1.1.2								
ART 1.1.2.2	N/A							
ART 1.2:			N/A		N/A			
ART 1.2.1			N/A	N/A	N/A	N/A	N/A	

What is potential impact to Army Technology Objectives?

How does this impact an ATO? A mission-based evaluation may measure operational performance instead of technology performance.

- Technology programs feed programs of record
  - Consider planning for a mission-based evaluation with metrics
    - Ability of the technology to provide a capability to perform a set of tasks
    - Non-technical metrics
  - Improve the connection between the mission, tasks, and the technology objectives
  - Recognize the customer cares about performance of the mission
  - Influence a test strategy during the ATO process
  - Involve evaluators during the ATO planning and execution
  - Influence technology transfer agreements with PMs

Course of action

At Milestone A, the PM shall submit a Test and Evaluation Strategy (TES) that describes the overall test approach for integrating developmental, operational, and live-fire test and evaluation and addresses test resource planning.

The TES shall include a test plan that addresses *Technology Development* phase activity, including the identification and management of technology risk, and the evaluation of system design concepts against the preliminary mission requirements resulting from the Analysis of Alternatives.

Test planning shall address the T&E aspects of competitive prototyping, early demonstration of technologies in relevant environments, and the development of an integrated test approach.

The Milestone A test plan shall rely on the Initial Capability Document as the basis for the evaluation strategy.

Ref: DoDI 5000.2; Dec 2008

Guidebook specifies T&E strategy

- PM is required to Sync T&E Strategy with Technology Development Strategy and System Engineering Plan
- Addresses how component technologies being developed will be demonstrated in a relevant environment
- Identifies technology risk
- Identifies evaluation of system design concepts against preliminary mission and sustainment requirements.
- Supports the technology transition into the program
- Considers development, demonstration, production, and deployment
- Should take a mission-oriented approach
- Identifies key system attributes that support key capabilities in ICD.
- Enhances success in validating performance

Ref: DAU Defense Acquisition Guidebook; SE chapter 9

Summary

- MBT&E methodology has been developed
- Positive results and path forward toward increased efficiencies
- MBT&E aligns the efforts of the capabilities developer, materiel developer, and independent T&E
- Early integration of mission-based thinking supports technology transition to PMs

Questions?

The New Technology Readiness Assessment (TRAs) Process

12th Annual NDIA Systems Engineering Conference
October 28, 2009

Dr. Jay Mandelbaum

Institute for Defense Analyses

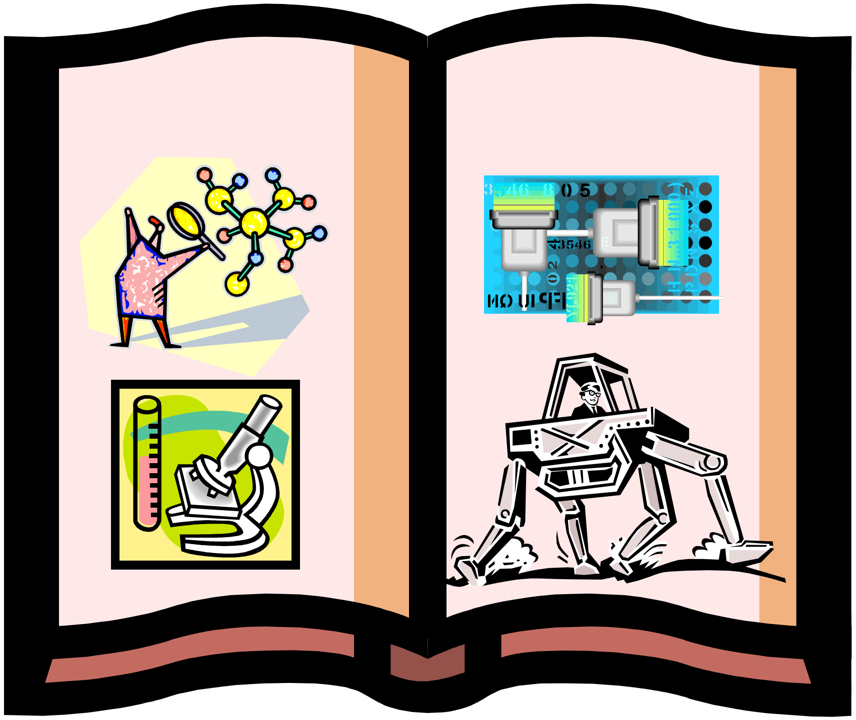
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

Outline

- TRA Background
- TRA Importance
- Policy and Statutory Changes Since 2005 Deskbook
- Principal TRA Process Changes Reflected in 2009 Deskbook

What is a TRA?

- **Systematic, metrics-based process that assesses the maturity of Critical Technology Elements (CTEs)**
  - **Uses Technology Readiness Levels (TRLs) as the metric**
- **Regulatory information requirement for *all* acquisition programs at MSs B and C**
  - **Submitted to DRD for ACAT ID and IAM programs, including space programs**



≠ Not a risk assessment

≠ Not a design review

≠ Does not address system integration

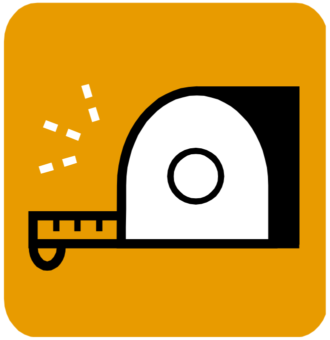
Critical Technology Element (CTE) Defined

A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (within acceptable cost and schedule limits) *and if the technology element or its application* is either new or novel or in an area that poses major technological risk during detailed design or demonstration.

CTEs may be hardware or software at the subsystem or component level

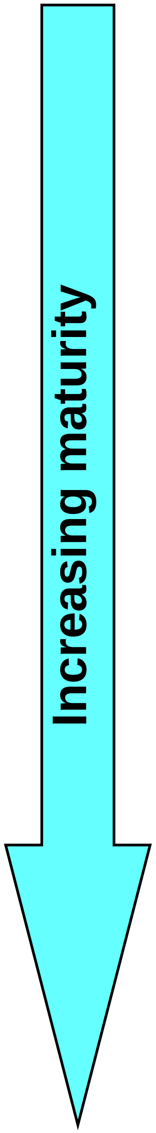
TRL Overview

- **Measures technology maturity**
- **Indicates what has been accomplished in the development of a technology**
  - **Theory, laboratory, field**
  - **Relevant environment, operational environment**
  - **Subscale, full scale**
  - **Breadboard, brassboard, prototype**
  - **Reduced performance, full performance**



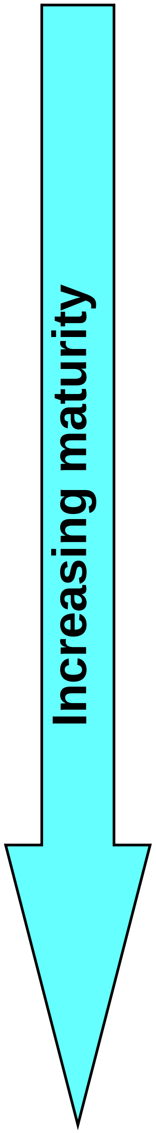
- **Does not indicate that the technology is right for the job or that application of the technology will result in successful development of the system – or how hard the application might prove.**

Hardware TRLs

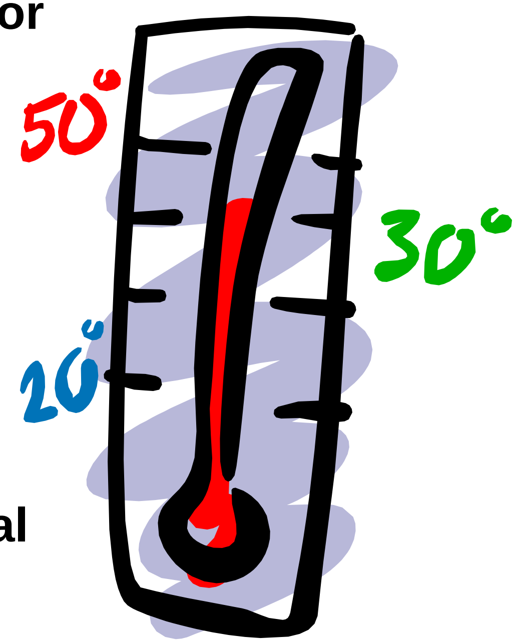


1. Basic principles observed and reported
2. Technology concept and/or application formulated
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Component and/or breadboard validation in a laboratory environment
5. Component and/or breadboard validation in a relevant environment
6. System/subsystem model or prototype demonstration in a relevant environment
7. System prototype demonstration in an operational environment
8. Actual system completed and qualified through test and demonstration
9. Actual system proven through successful mission operations

Software TRLs



1. Basic principles observed and reported.
2. Technology concept and/or application formulated.
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Module and/or subsystem validation in a laboratory environment, i.e. software prototype development environment
5. Module and/or subsystem validation in a relevant environment
6. Module and/or subsystem validation in a relevant end-to-end environment
7. System prototype demonstration in an operational high fidelity environment
8. Actual system completed and mission qualified through test and demonstration in an operational environment
9. Actual system proven through successful mission proven operational capabilities



Process Overview

PM responsibility

Collect data

Set schedule

PM responsibility
Coordinate with S&T Exec
Keep DRD informed

Identify CTEs

IRT (Independent Review Team appointed by S&T Exec) responsibility in conjunction with program

Coordinate CTEs

Component S&T Exec Responsibility;
DRD must concur

Assess CTEs; prepare TRA

IRT responsibility
PM funds it and provides tech support

Coordinate and submit TRA

S&T Exec coordinates
Acquisition Executive submits

OSD review

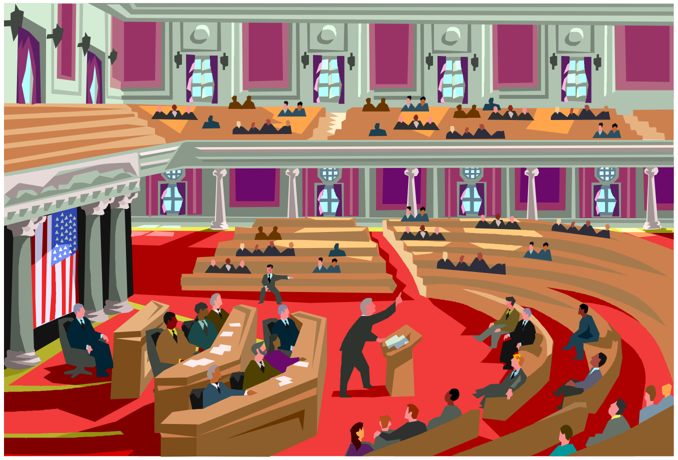
DRD responsibility

Outline

- **TRA Background**
- **TRA Importance**
- **Policy and Statutory Changes Since 2005 Deskbook**
- **Principal TRA Process Changes Reflected in 2009 Deskbook**

Why is a Milestone B TRA Important? (1 of 3)

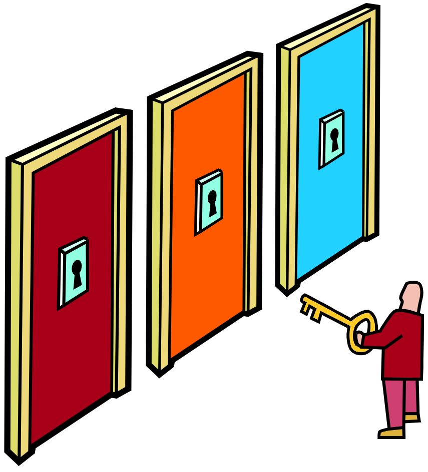
- The Milestone Decision Authority (MDA) uses the information to support a decision to initiate a program
  - Trying to apply immature technologies has led to technical, schedule, and cost problems during systems acquisition
  - TRA established as a control to ensure that critical technologies are mature, based on what has been accomplished



- Congressional interest
  - MDA must certify to Congress that the technology in programs has been demonstrated in a relevant environment at program initiation
  - MDA must justify any waivers for national security to Congress

Why is a Milestone B TRA Important? (2 of 3)

- **The PM uses the expertise of the assessment team and the rigor and discipline of the process to allow for:**
  - **Early, in depth review of the conceptual product baseline**
  - **Periodic in-depth reviews of maturation events documented as verification criteria in an associated CTE maturation plan**
  - **Highlighting *(and in some cases discovering)* critical technologies and other potential technology risk areas that require management attention (and possibly additional resources)**
- **The PM, PEO, and CAE use the results of the assessment to:**
  - **Optimize the acquisition strategy and thereby increase the probability of a successful outcome**
  - **Determine capabilities to be developed in the next increment**
  - **Focus technology investment**



Why is a Milestone B TRA Important? (3 of 3)

- **For Information Technology (IT) systems, which rely heavily on off-the-shelf components, TRAs have increased management's focus on finding CTEs that relate specifically to IT issues (e.g., interfaces, throughput, scalability, external dependencies, integration, and information assurance)**
  - **Since many IT systems have experienced problems in these areas, the TRA has proven useful in understanding potential problems earlier in the process, when solution options are easier to adopt and less costly to implement**

Why is a Milestone C TRA Important? (1 of 2)

- Reflects the resolution of any technology deficiencies that arose during EMD
- Serves as a check that all CTEs are maturing as planned especially any new CTEs identified in EMD
- Documents successful developmental test and evaluation (DT&E)
- Avoids technology driven OT problems: OT should focus on “effective and suitable”
- Confirms expansion of performance envelope to “operational” environment – generally a broader environment than can be tested in OT

Why is a Milestone C TRA Important? (2 of 2)

- For MAIS programs, or software intensive systems with no production components
  - Examines plans for maintenance and upgrades to ensure that no new CTEs are involved
  - Determines whether algorithms will transfer successfully when host platforms are moved and full-scale applications are initiated in a real operational environment
  - Identifies where new Milestone Bs are needed for future releases to initiate efforts to improve performance and determines the architectural changes necessary to support these future releases
  - Checks technology component of information assurance before deployment
  - Ensures that the operational environment for systems to deploy has included duress

Outline

- TRA Background
- TRA Importance
- Policy and Statutory Changes Since 2005 Deskbook
- Principal TRA Process Changes Reflected in 2009 Deskbook

Technology Maturation Policy Leading to Milestone A

"…the lead DoD Component(s) shall prepare an AoA study plan to assess preliminary materiel solutions, *identify key technologies*, and …"

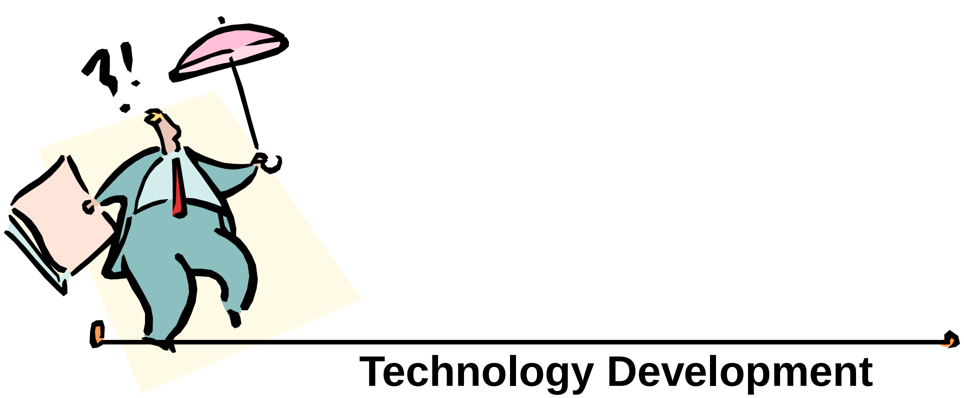
"… The purpose of the AoA is to assess the potential materiel solutions to satisfy the capability need documented in the approved ICD. The AoA *shall assess the critical technology elements (CTEs) associated with each proposed materiel solution, including technology maturity*, integration risk, manufacturing feasibility, *and, where necessary, technology maturation and demonstration needs* …"

(DoDI 5000.02, Encl 2, para 4.c.(5 & 6))

Technology Maturation Policy Leading to Milestone B is Unambiguous (1 of 3)

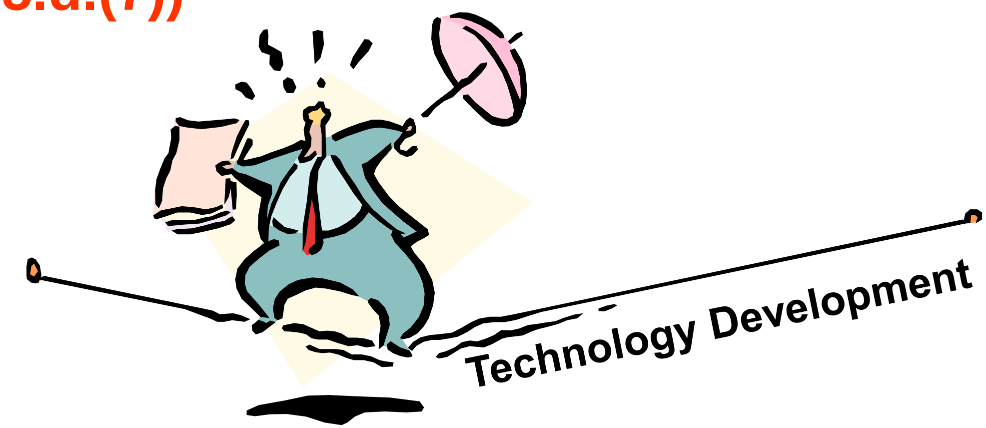
"PMs shall reduce technology risk, demonstrate technologies in a relevant environment, and identify technology alternatives, prior to program initiation" (DoDD 5000.01, Encl 2, para E1.1.14)

The TRA complements, but does not diminish, the PM's responsibility to pursue risk reduction efforts prior to program initiation at Milestone B



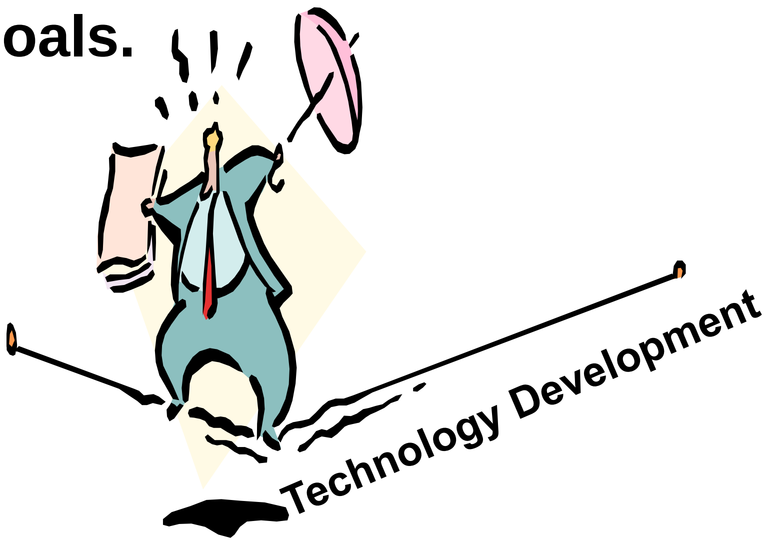
Technology Maturation Policy Leading to Milestone B is Unambiguous (2 of 3)

"The project shall exit the Technology Development Phase when an affordable program or increment of militarily useful capability has been identified; the technology and manufacturing processes for that program or increment have been assessed and demonstrated in a relevant environment; manufacturing risks have been identified; a system or increment can be developed for production within a short timeframe (normally less than 5 years for weapon systems); or, when the MDA decides to terminate the effort … A Milestone B decision follows the completion of Technology Development."
(DoDI 5000.02, Encl 2, para 5.d.(7))



Technology Maturation Policy Leading to Milestone B is Unambiguous (3 of 3)

"The management and mitigation of technology risk, which allows less costly and less time-consuming systems development, is a crucial part of overall program management and is especially relevant to meeting cost and schedule goals.



Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition. Technology developed in S&T or procured from industry or other sources shall have been demonstrated in a relevant environment or, preferably, in an operational environment to be considered mature enough to use for product development (see the "Technology Readiness Assessment (TRA) Deskbook" (Reference(n)). Technology readiness assessments, and where necessary, independent assessments, shall be conducted.

If technology is not mature, the DoD Component shall use alternative technology that is mature and that can meet the user's needs." (DoDI 5000.02, Encl 2, para 5.d.(4))

Prototyping and Competition Policy Provides Technology Maturation Safeguards

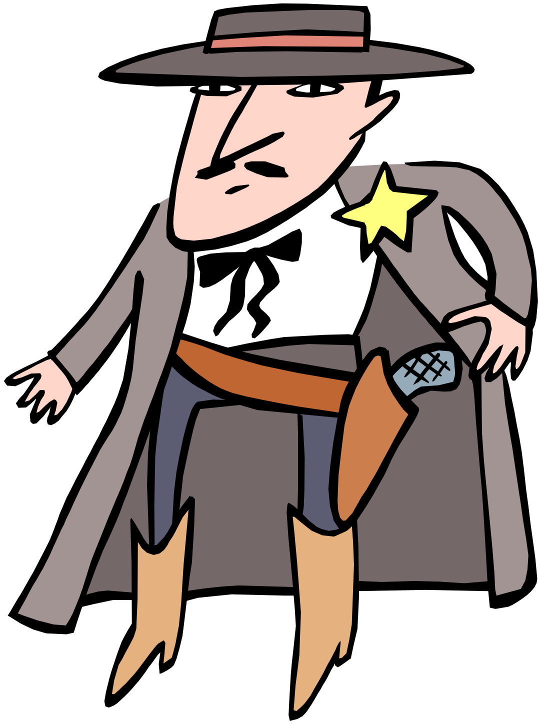
"Evolutionary acquisition requires . . . Technology development preceding initiation of an increment shall continue until the required level of maturity is achieved, prototypes of the system or key system elements are produced, and a preliminary design is completed. . . ."
DoDI 5000.02, Encl 2, para 2.b

"The TDS and associated funding shall provide for two or more competing teams producing prototypes of the system and/or key system elements prior to, or through, Milestone B. The prototypes shall be representative platforms reflecting the maturity of technologies and integrated system performance consistent with expected capability."
DoDI 5000.02, Encl 2, para 5.c.(9)

- Promotes maturity via
  - More rigorous relevant environment demonstrations
  - More comprehensive evidence of maturity
  - Fewer technical problems in the final design
  - Using prototypes for accelerated life-cycle tests
  - Providing insight into production issues

RFP Policy Provides Technology Maturation Safeguards

"**Final RFPs for the EMD phase, or any succeeding acquisition phase, shall not be released, nor shall any action be taken that would commit the program to a particular contracting strategy, until the MDA has approved the Acquisition Strategy.** **The PM shall include language in the RFP advising offerors that (1) the government will not award a contract to an offeror whose proposal is based on CTEs that have not been demonstrated in a relevant environment and (2) that offerors will be required to specify the technology readiness level of the CTEs on which their proposal is based and to provide reports documenting how those CTEs have been demonstrated in a relevant environment" (DoDI 5000.02, Encl 2, para. 6.c.(4)).**



Open Dialogue and Feedback on AT&L Policy (AT&L memo 24 Aug 2007)

- **Policy**
  - **“Structure all planned competitions with one or more feedback and dialogue points prior to receipt of final proposals”**
  - **“All ongoing competitions should be reviewed with a bias toward incorporating feedback and dialogue sessions before receipt of final proposals”**

- **Results of the Dialogue**
  - **A high quality well understood proposal**
  - **Allows the acquisition team to well explain, and for industry to understand, the fundamental factors which determine the outcome of the competition**
  - ***Provides multiple inputs for the government to define the required relevant environment for candidate CTEs, and to clarify criteria with contractors***

• • • The Policy is Reflected as a Statutory Requirement for Certification

Title 10 US Code 2366b:

Major defense acquisition programs: certification required before Milestone B or Key Decision Point B approval:

CERTIFICATION. A major defense acquisition program may not receive Milestone B approval, or Key Decision Point B approval in the case of a space program, until the milestone decision authority certifies that • • •

the technology in the program has been demonstrated in a relevant environment as determined by the Milestone Decision Authority on the basis of an independent review and assessment by the Director of Defense Research and Engineering;

Certification submitted with the first Selected Acquisition Report for the program

• • • and for Milestone B Certification Changes

(1) The program manager for a MDAP that has received certification under subsection (a) shall immediately notify the milestone decision authority (MDA) of any changes to the program that –

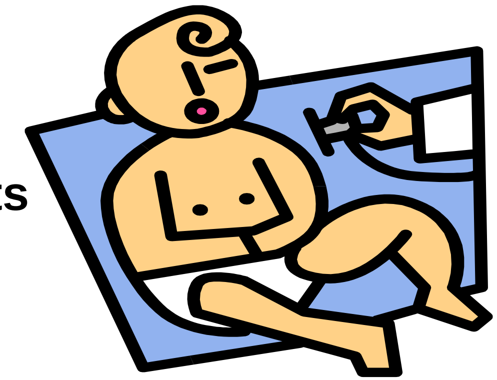
- (A) alter the substantive basis for the certification of the MDA relating to any of the components of such certification
- (B) Otherwise cause the program to deviate significantly from the material provided to the milestone decision authority in support of such certification

(2) Upon receipt of information under para 1, the MDA may withdraw the certification concerned or rescind MS B approval (or KDP B approval in the case of a space program) if the MDA determines that such certification or approval is no longer valid

Outline

- **TRA Background**
- **TRA Importance**
- **Policy and Statutory Changes Since 2005 Deskbook**
- **Principal TRA Process Changes Reflected in 2009 Deskbook**

DoD Practices to Support the Statutory Requirements (1 of 2)

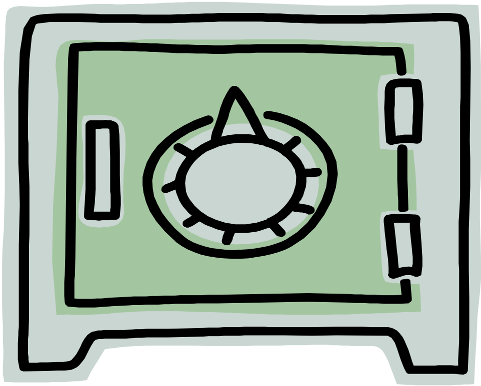


- Early evaluations of technology maturity (prior to Milestone A)
  - To provide a basis for modifying the requirements if technological risks are too high
  - To support the development of TMPs that show how all likely CTEs will be demonstrated in a relevant environment before preliminary design begins at the full system level
  - To refine the TDS
  - To inform the test and evaluation (T&E) community about technology maturity needs
  - To ensure that all potential CTEs are included in the program’s risk management database and plan
  - To articulate external dependencies on technology base projects and define specific technologies, technology demonstration events, and exit criteria for the technology to transition into the acquisition program

DoD Practices to Support the Statutory Requirements (2 of 2)

- **USD(AT&L) practice**
  - **Programs will not be initiated at MS B with immature technologies**
  - **The same standards apply to all acquisition programs**
- **As directed by 10 USC 2366b, DDR&E will provide technical advice based upon an independent review and assessment to the MDA in support of certification**
  - **For MDAPs, MAIS, and space systems the approved TRA process, as found in the DoD TRA Deskbook, and report will be the basis of that advice**
  - **DDR&E approved TRA process takes precedence over other guidance in situations where conflict would arise, pending future modification**

TRA Processes Designed to Support This Technical Advice (1 of 2)



- **Safeguards in place to provide the DDR&E with the confidence necessary to assure the MDA that certification can be made**
  - **To make the TRA support the certification, it must draw upon the best technical information available**
    - **As such, a generic TRA not based on the planned technical solution is not acceptable**
    - **The TRA must be based on the technologies in the system**
  - **The identification and assessment of CTEs must be performed by subject matter experts**
    - **These experts must be independent of the program (DDR&E concurrence required)**
    - **DDR&E has final say on CTE list**

TRA Processes Designed to Support This Technical Advice (2 of 2)

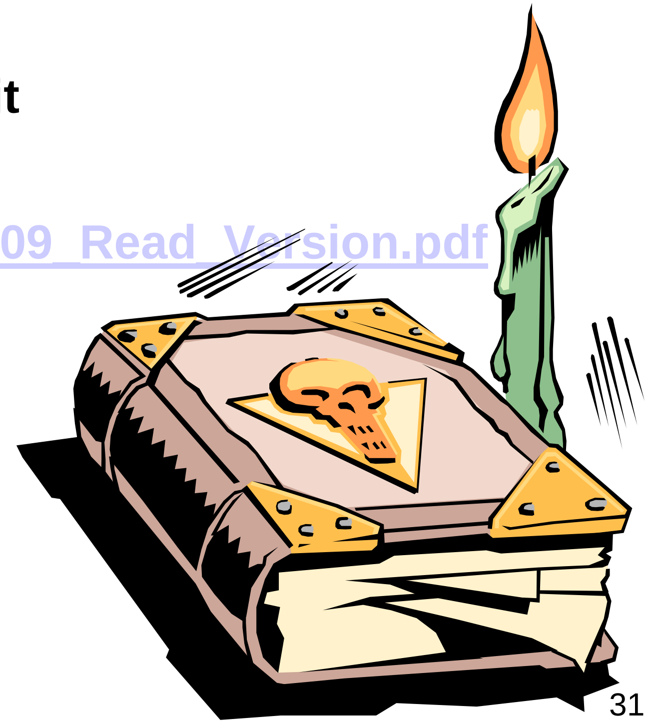
- **Assurance that technologies have been demonstrated in a relevant environment by the winning EMD Phase contractor**
  - **To initiate programs with mature technologies, the source selection process should include a focus on technical maturity**
  - **TRAs must be performed on all the competitors in a source selection**
- **ADM language establishing conditions for CTE insertion after Milestone B**
  - **To initiate programs with mature technologies, immature CTEs may be pursued in a parallel development effort, if approved maturation plans submitted with the TRA—** ***on ramp vice off ramp for preferred approaches with undemonstrated technologies***

Basis of Technology Maturity Assessments Throughout Acquisition

	Milestone A	Milestone B	Milestone C
Basis of CTE Identification	Early evaluation of technology maturity	Current level of design and CDD requirements	Planned LRIP article (or limited deploy-ment version of an IT system), prior TRAs, and final design
CTE Identification Status	Potential CTEs	CTEs – actual technologies in a preliminary design	CTEs of planned LRIP articles (or limited deployment version of an IT system)
Assessment Method	Evaluated in early evaluations of technology maturity and TMPs	Assessed in Mile-stone B TRA	Assessed in Milestone C TRA
Documentation	Informal submission to DRD and corresponding updates to TDS appendix	Milestone B TRA	Milestone C TRA

References and Resources

- **Defense Acquisition Resource Center http://akss.dau.mil/darc/darc.html**
  - **DoD Directive 5000.01 (DoDD 5000.01), *The Defense Acquisition System*, dated Dec 2, 2008**
  - **DoD Instruction 5000.02 (DoDI 5000.02), *Operation of the Defense Acquisition System*, dated Dec 2, 2008**
  - ***Defense Acquisition Guidebook***
- ***DAU Continuous Learning Module CLE021***
  - **https://learn.dau.mil/html/clc/Clc.jsp to browse it**
- ***TRA Deskbook***
  - **http://www.dod.mil/ddre/doc/DoD_TRA_July_2009_Read_Version.pdf**
- **Institute for Defense Analyses**
  - **Dr. Dave Sparrow dsparrow@ida.org**
  - **Dr. Jay Mandelbaum jmandelb@ida.org**
  - **Dr. Michael May mmay@ida.org**



BACKUP

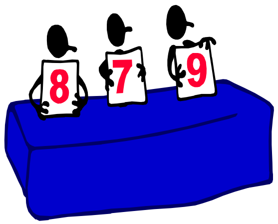
PM Roles and Responsibilities

- Plans and funds the program's risk reduction activities to ensure that CTEs reach the appropriate maturity levels
- Informs the Component S&T Executive of the need to conduct a TRA
- Funds the TRA evaluation for his program
- Designates a responsible individual in the program office to organize all TRA activities
- Prepares a draft TRA schedule and incorporates the approved version in the program's IMP and IMS
- Suggests to the Component S&T Executive the subject matter expertise needed to perform the TRA
- Familiarizes the IRT with the program
- Identifies possible CTEs for consideration by the IRT
- Provides evidence of CTE maturity to the IRT for its assessment, including contractor data
- Provides technical expertise to the IRT as needed
- Drafts the section of the TRA report containing a brief description of the program (program/system overview, objectives, and descriptions)

Component S&T Executive Roles and Responsibilities

- Directs the conduct of the TRA
- Coordinates on the TRA schedule
- Nominates SMEs to be on the IRT
- Provides the DRD with the credentials of all prospective IRT members and with sufficient information to confirm their independence from the program
- Trains IRT members on the TRA process
- Reviews the TRA report and prepares the TRA report cover memorandum, which may include additional technical information deemed appropriate to support or disagree with IRT findings
- Sends the completed TRA to the CAE for official transmittal to the DRD and furnishes an advance copy to the DRD
- Maintains continuity in the IRT membership for all TRAs conducted over the life of a program, to the maximum extent possible

IRT Roles and Responsibilities



- **Keeps the Component S&T Executive and the DRD informed on progress throughout the entire TRA process**
- **Develops a list of CTE candidates in conjunction with the program**
- **Assesses the TRLs for all CTEs**
- **Prepares (or oversees the preparation of) elements of the TRA report including (1) the IRT credentials and (2) IRT deliberations, findings, conclusions, and supporting evidence.**
  - **The assessment process should not be constrained to a validation of a "program-developed" position on the TRL**

DRD Roles and Responsibilities

- Concurs with the TRA schedule
- Concurs with the composition of the IRT
- Reviews the candidate CTE list and identifies any changes necessary to form the final CTE list. Additions to the list can include any special interest technologies that warrant the rigor of the formal TRA process
- Exercises oversight by monitoring and evaluating the TRA process and reviewing the TRA. On the basis of that review, a TRA revision may be requested or the DRD may conduct its own Independent Technical Assessment (ITA).
- Sends the results of its TRA review to the appropriate OIPT and/or the DAB
- Provides the DDR&E recommendations concerning certification
- Recommends technology maturity language for an ADM, noting, in particular, conditions under which new technology can be inserted into the program

An Enhanced Analysis of Alternatives (AoA)

A Mission-Oriented, Evaluation-Based Framework for Defense Test & Evaluation

Highlighting
Emerging Roles for Systems Engineering
in
Defense Decision Making
Abstract # 8813

Vince Roske
Institute for Defense Analyses
vroske@ida.org
703 575 6632

Emerging Needs for an Enhanced AoA

Scenario - Mission Need- -System Design- System Performance - Suitability - Mission Effectiveness & Cost

Aligning and Informing Defense Decision Making

- **CJCSI 3170.01G , JCIDS, 1 March 2009** "All **JROC Interest programs** with approved CDDs and CPDs **must return to the JROC if they experience a cost growth** of 10 percent over their current baseline or 25 percent over their original baseline as defined in the Acquisition Program Baseline. Information system programs must return to the JROC if they experience a cost growth of 15 percent or more over their approved baseline. **The JROC will assess whether the cost growth is a result of the validated KPPs and if so whether or not an adjustment to the KPPs is appropriate to mitigate the cost growth."**
- **Capstone Concept for Joint Operations (CCJO) 15 January 2009 :** "Adopting this concept has significant implications for the way the Services organize, man, train, and equip the units that compose the joint force." "The common theme to all these implications is creating greater adaptability and versatility across the force to cope with the uncertainty, complexity, unforeseeable change, and persistent conflict that will characterize the future operating environment." …**the growing importance of understanding:**

  (1) **limitations to flexible use of a system**, and

  (2) the *"complementarity* **factors that enable multiple services to perform (or not) the supporting tasks that enable a system to do its mission** and consequently affect flexibility and limitations in joint force effectiveness".
- **Acquisition**:
  - Early and More Frequent Program Reviews Beginning Pre-milestone A
  - Mission Oriented, Evaluation-Based Test Programs
- **T&E:**
  - Early Engagements by T&E with JCIDS and ACQUISITION
  - Integrated DT / OT Planning *(DT/OE)*Test in Joint Environments
- **Joint Commander:** Informed on System:
  - Effectiveness and Suitability
  - Flexibility and Limitations in Use
  - Flexibility and Limitation in Support

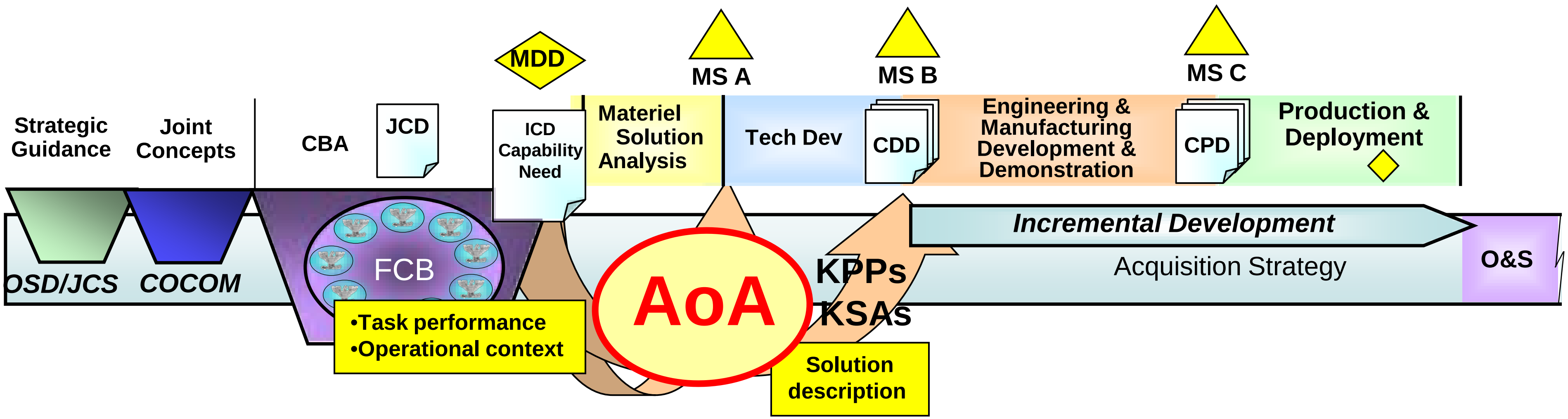
•Cost vs Capability
•Flexible Use

Observation 1.
SE informs JROC / JCIDS concerning system deign and cost implications of revised capability requirements

Observation 2
SE informs commanders concerning flexible use and support of System

Role of the Analysis of Alternatives (AoA)

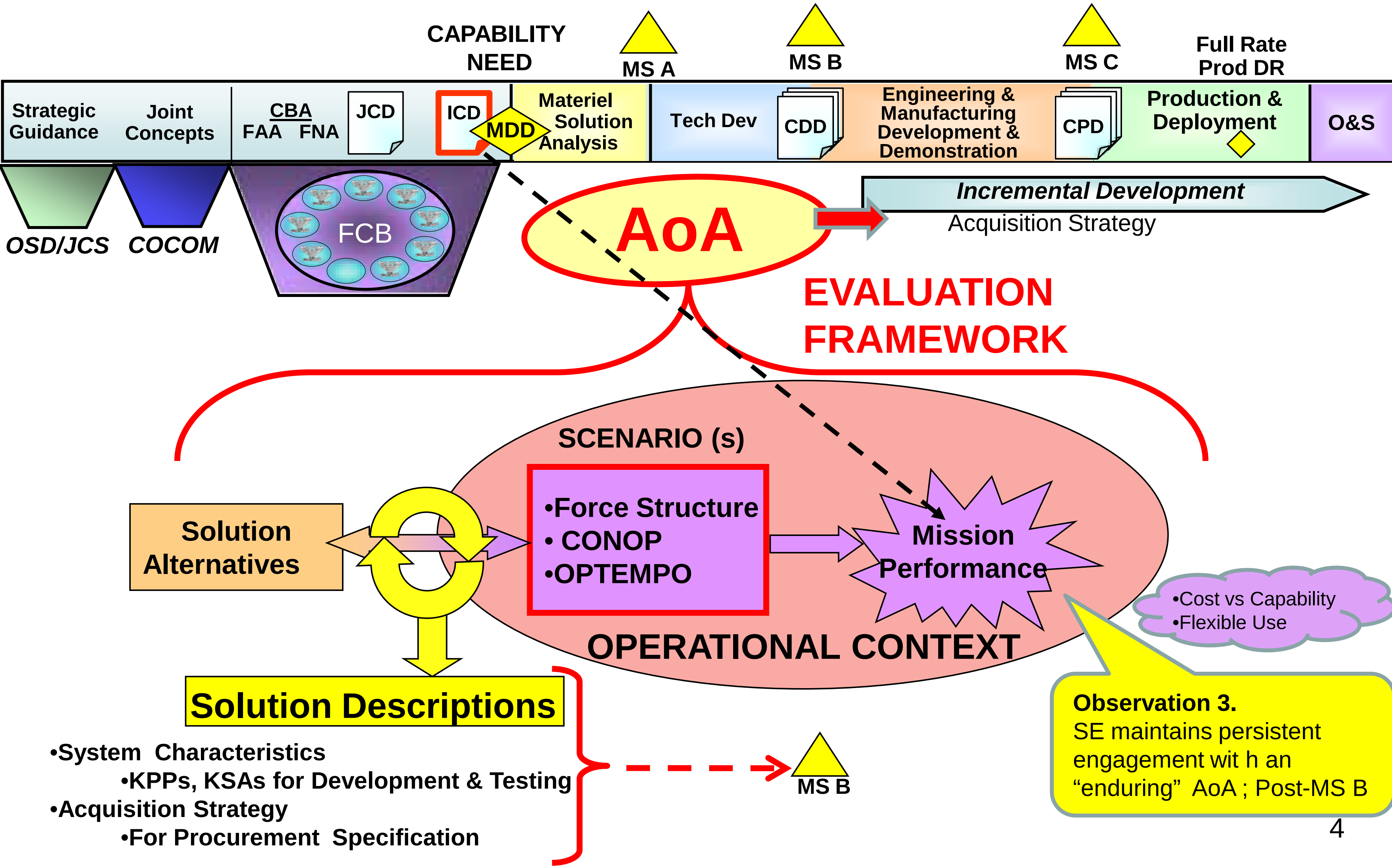
Analysis of Alternatives (AoA)
Translates tasks to be performed in an operational context into a system "solution" for acquisition



JCIDS definition of AoA:
"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 (CDD)"

Insights Needed to Build a TEMP

AoA Methodology



A Review of AoAs

- **Reviewed AoAs**
  - AoAs Done Between 2003 and 2008 AND Done for DOT&E Oversight List Programs
- **Implications for T&E:**
  - Each Contains a Description of an **Operational Context** Potentially Useful to T&E Planning
    - Scenario, Forces, Objectives CONOPS, Climate, OPTEMPO, etc

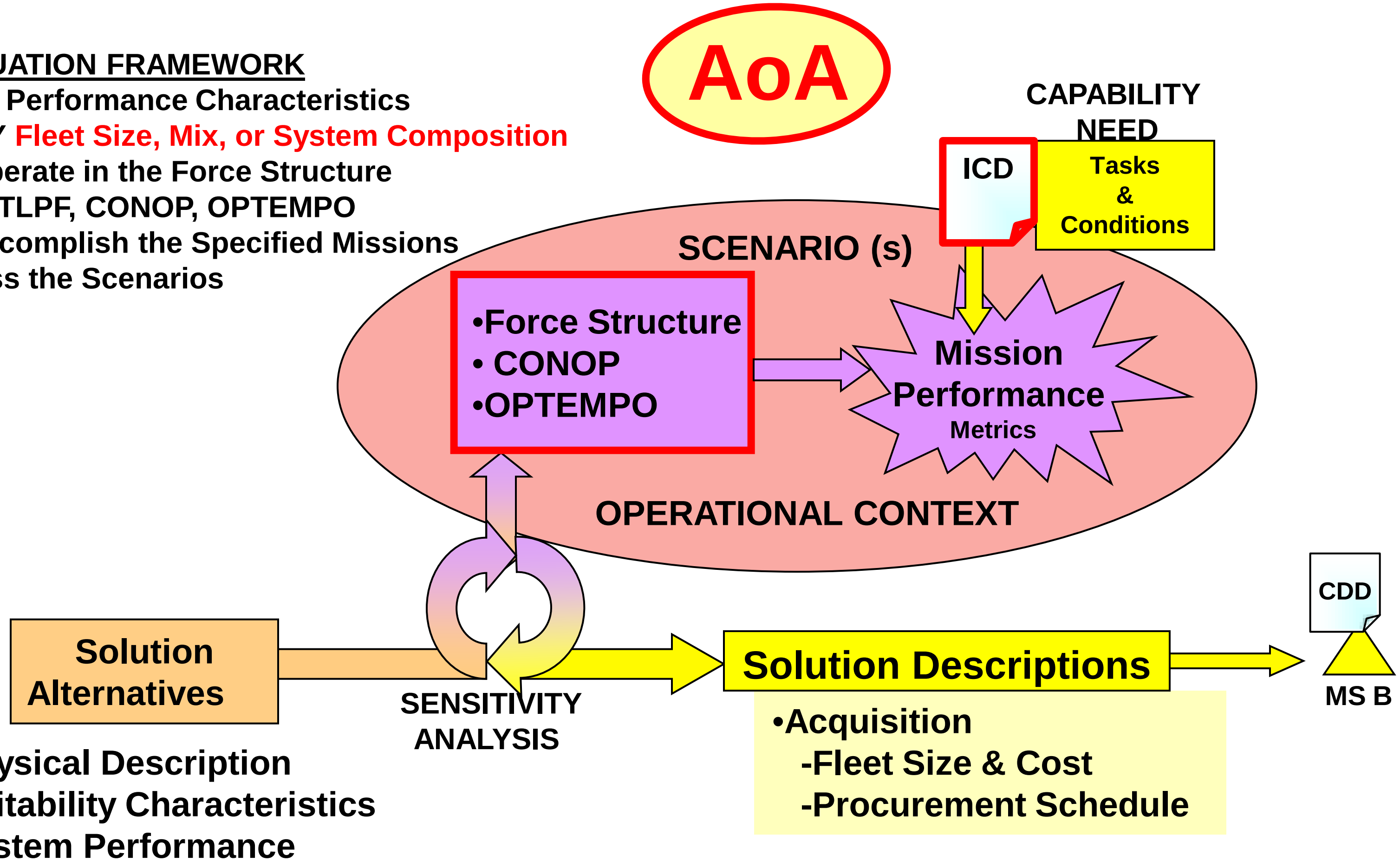
  - Each includes a **"Sensitivity Analysis"** (SA) Relating System Performance to Mission Accomplishment

    HOWEVER: SAs do NOT Generally Relate Variations in Systems' Characteristics Performance to Mission Effectiveness
    - SAs Treat Performance Characteristics as "Fixed";
    - SA used to Derive System Fleet Size or System Configurations of Fixed Components for "Mission Accomplishment" Across Varied Scenarios
      - AoA Informs a System Acquisition Strategy
        - » A "Packing Algorithm" Paradigm: "How Many "Systems as Defined" are Needed, by When, and at What Cost for Mission Success
      - **AoA Does NOT Recognize T&E as a Customer**
        - » T&E Examines System and Component Characteristics Performance relative to Mission Effectiveness measures
      - AoA cannot readily address revisions of Design or Performance levels
        - » SA varies the number of system, not their performance, vs the Mission.

Analysis of Alternatives (AoA)
Requirements-Based

<u>EVALUATION FRAMEWORK</u>

- **Fixed Performance Characteristics**
- **VARY Fleet Size, Mix, or System Composition**
- **To Operate in the Force Structure**
  - **-DOTLPF, CONOP, OPTEMPO**
- **To Accomplish the Specified Missions**
- **Across the Scenarios**

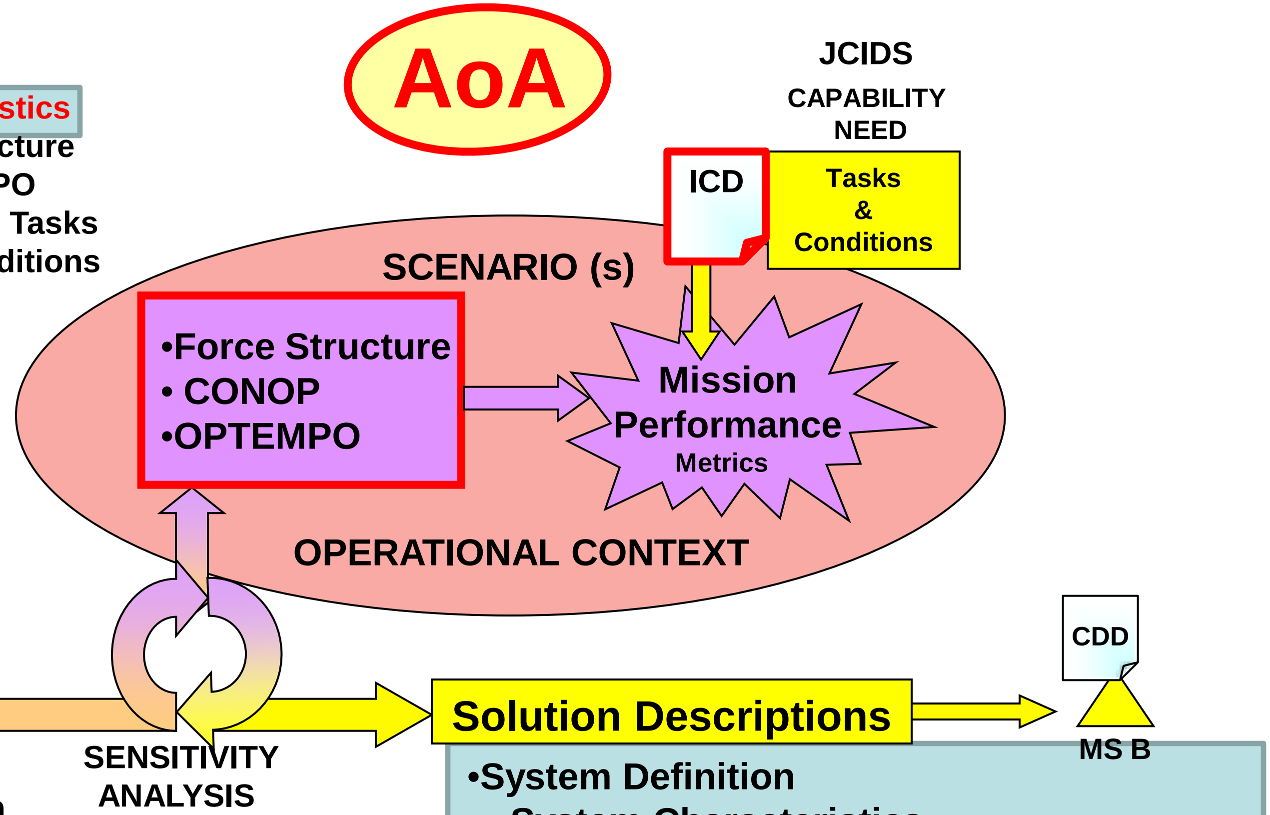


AoA Performed by JROC Designated (Service) Sponsor

An Enhanced Analysis of Alternatives (AoA) Capability-Based

EVALUATION FRAMEWORK

- **VARY the System Characteristics**
- **To Operate in the Force Structure**
  - **DOTLPF, CONOP, OPTEMPO**
- **To Accomplish the Specified Tasks**
- **Across the Scenarios & Conditions**



Solution Alternatives

- **System Type/Form**
- **VARY Characteristics**
  - **Physical**
  - **Performance**

AoA Performed by JROC Designated (Service) Sponsor

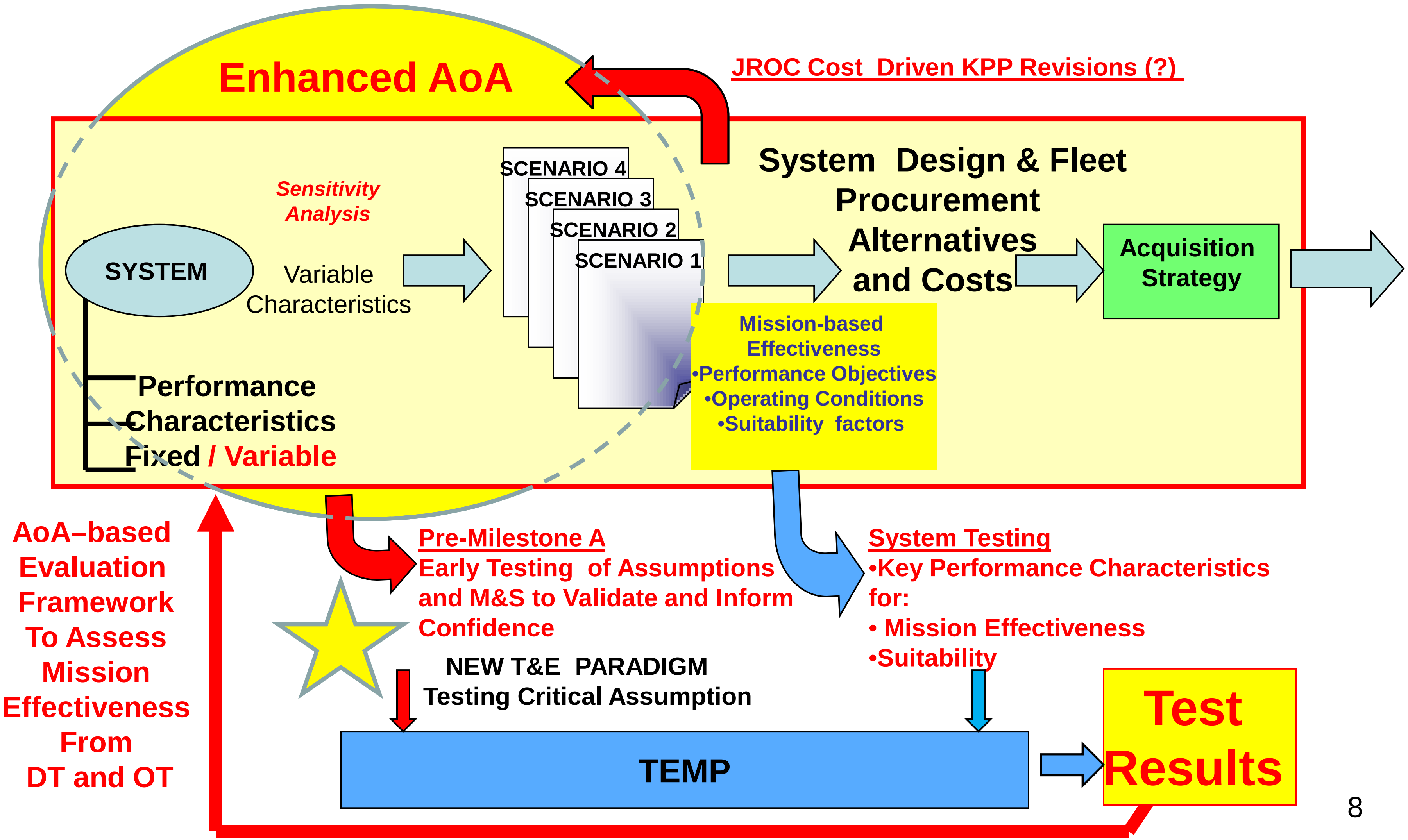
- **System Definition**
  - **System Characteristics**
    - **Priorities & Performance**
  - **Context & Conditions for Testing**
    - **T&E Planning (Evaluation Based)**
    - **RFP (Sections L & M) Input**
- **Acquisition**
  - **Fleet Size & Cost**
  - **Procurement Schedule**

Role of the Enhanced AoA

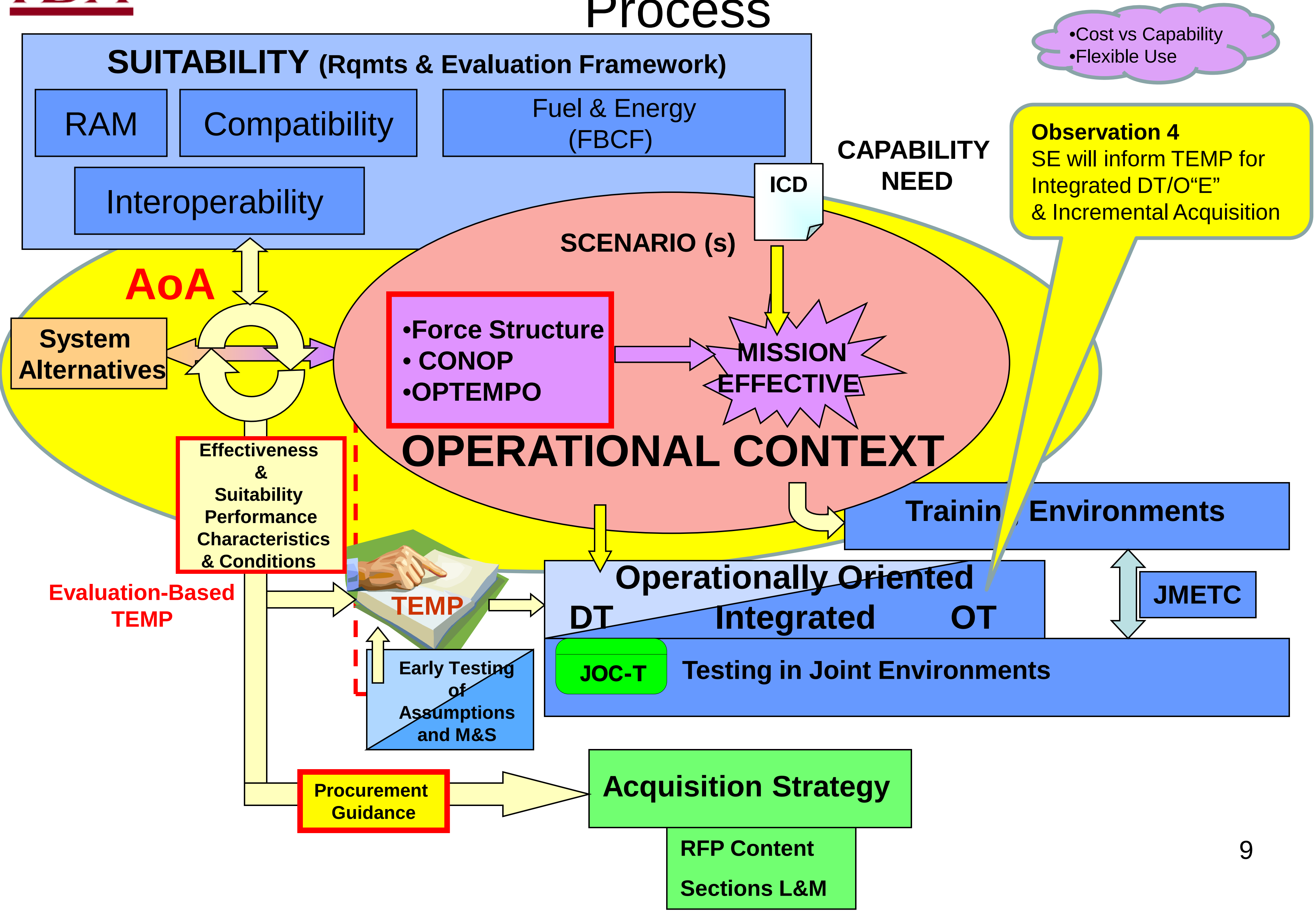
T&E Informs Confidence in Acquisition and Employment

By

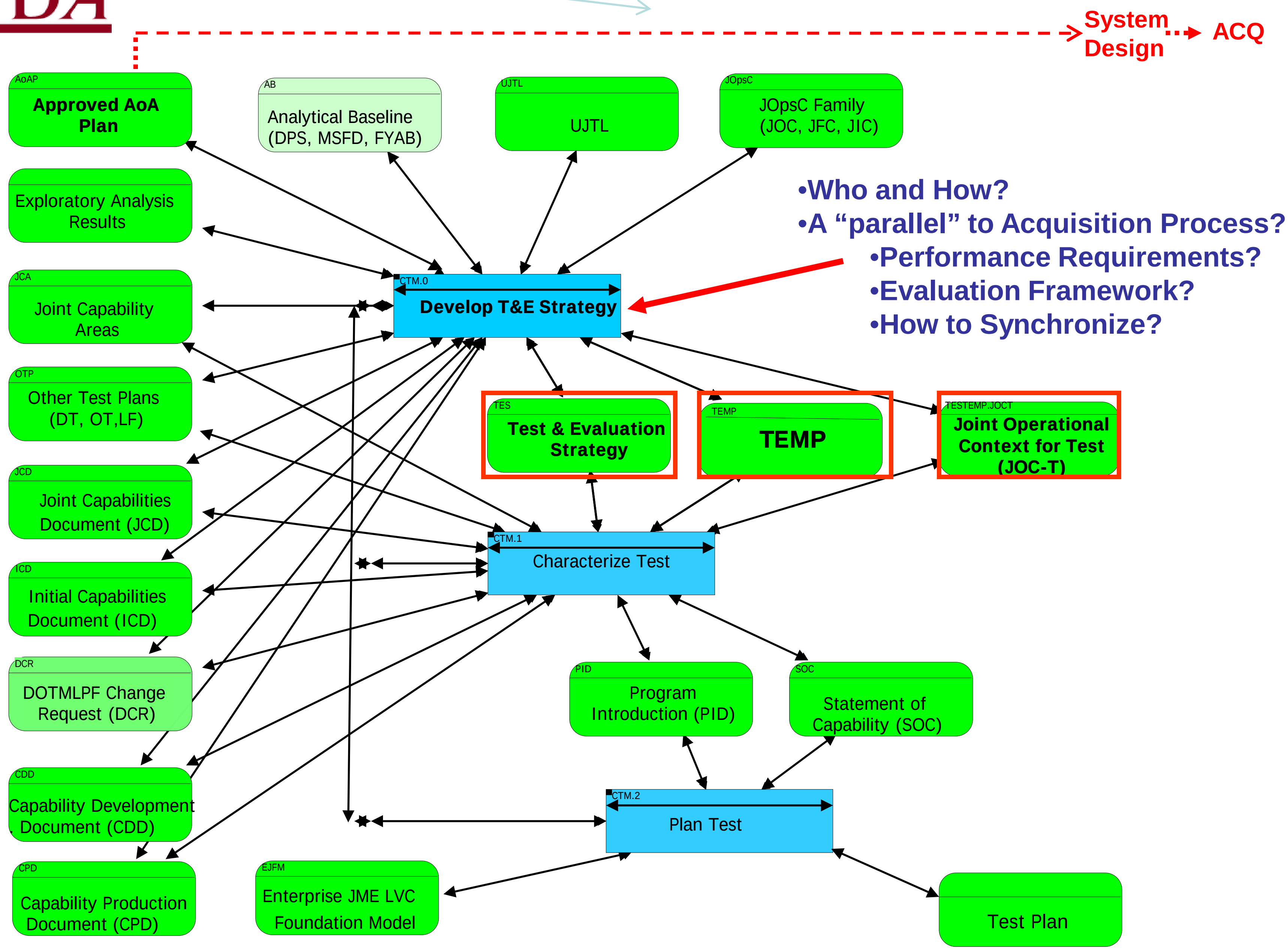
Test Results Evaluated in the AoA Framework



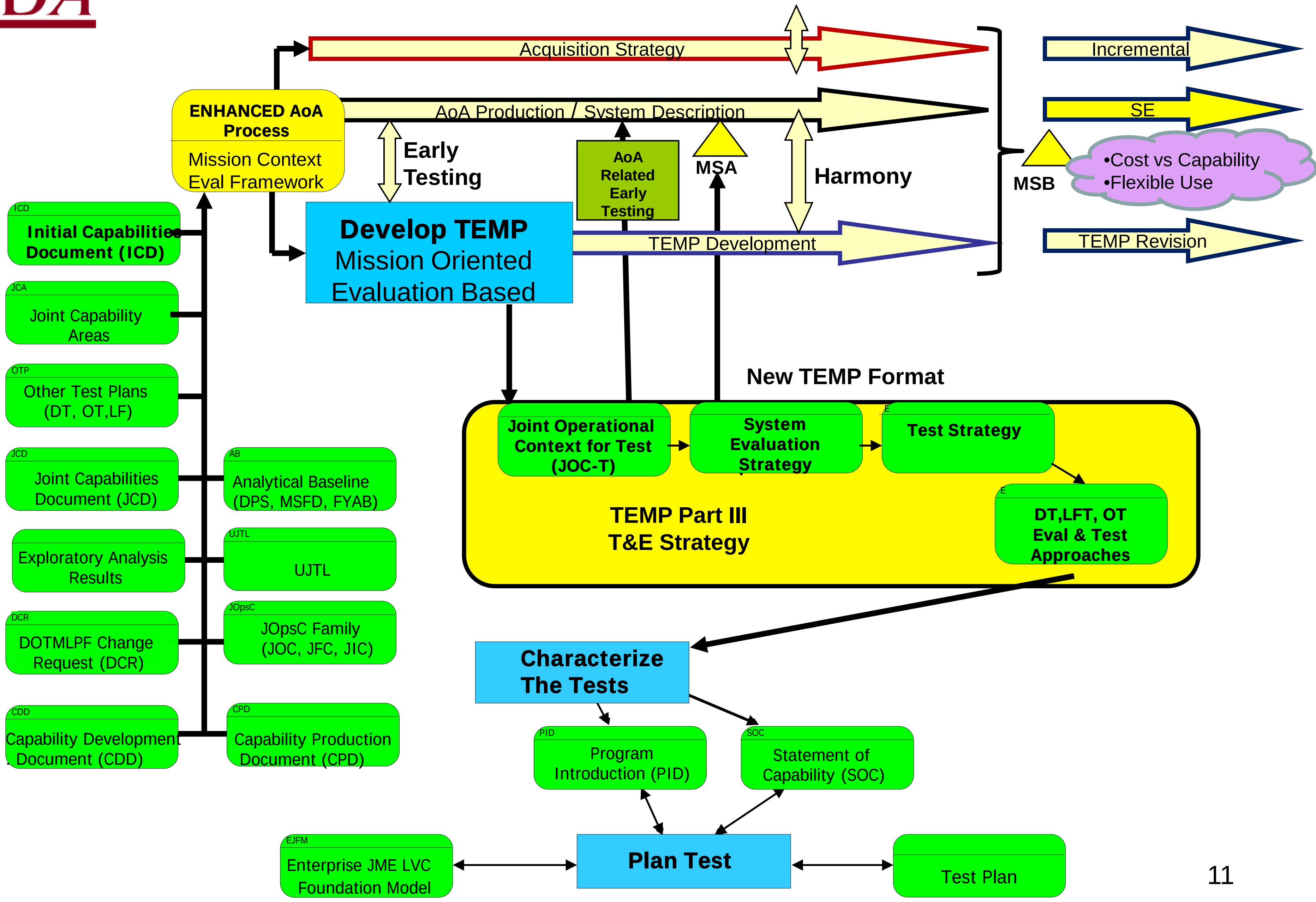
An Enhanced AoA an Integrating Process



Benefits to T&E: Capability Test Method (CTM)



Benefits to T&E: Enhanced CTM



Benefits to T&E: An Emerging TEMP Format

Part I Introduction	Part II Test Program Management & Schedule	Part III Test & Evaluation Strategy	Part IV Resource Summary

Part I – Introduction

Brief Purpose of TEMP

Brief Mission Description

Brief System Description
- -System Threat Assessment
- -Program Background
- -Key capabilities
  - -Key Interfaces
  - -Cert Rqmts
  - -Sys Engr Rqmts

•AoA Overview (T&E Perspective)
- -AoA System/Mission Evaluation Approach
- -AoA's Basis for Test Planning
- -AoA as Basis for evaluation of Test Results

•Acquisition Strategy Overview
- -Milestone Information Needs
- -System Maturity Schedule

Part II – Test Program Management & Schedule

T&E Management

Organization
T&E Data Base Rqmts
Deficiency Reporting
TEMP Updates
Integrated Test Program Schedule

Part III – Test & Evaluation Strategy

•Evaluation Strategy

Testing's Role in System/Mission Effectiveness Evaluation
- •How the AoA informs the Test Planning
  - -Provides Context for Performance Objectives and Operational Contexts for Testing
  - - Provides the Evaluation framework for:
    - -Mission Effectiveness Assessment
    - -Comparison to Current Capability
    - -Test Support to ACQ Decisions
- •How Test Results are used in the AoA Framework ACQ and Operational Decision Making

•Test Strategy

The Approach to Supporting the Evaluation Strategy
- - DT & OT Objectives from Evaluation Strategy
- - Joint Operational Context for Test (JOC-T)
- - AoA Assumptions/ M&S Validation Testing
- - Integrated DT & OT Planning Guidance

-M&S, Test Limitations

•Live Fire Evaluation Approach
- -Test Objectives, M&S, Test Limitations

•Certification for IOT&E

•Operational Evaluation Approach
- -Operational Test Approach
- -M&S, Test Limitations

•Other Certifications

•Reliability Growth

•Future T&E Activities

Part IV – Resource Summary

Introduction
- -Test Articles
- -Test Sites & Instrumentation
- -Test Support Equipment
- -Threat Representations
- -Test Targets & Expendables
- -OPFOR Test Support
- -M&S and Test-beds
- -Joint Operational Test Environment
- -Special Requirements

Federal, state, Local Rqmts

Manpower/ Personnel Training

Test Funding Summary

Describing an Evaluation-Based Test Program

Benefits from an Enhanced AoA

- **Enhanced Confidence in ACQ Decision Making**
  - Early Testing of Key AoA Assumptions and Representations
    - Responsive to pre-Milestone A Program Reviews
    - Tasking and Resource Planning in the TEMP for:
      - To validate Assumptions and M&S
      - For M&S DT and OT Planning and Test Events
  - MDAs and Field Commanders Better Informed on System Performance, Deficiencies Significance & Mitigation

- **More Effective and Efficient Test Programs**
  - Evaluation Based
    - Testing integral to the AoA/ Evaluation Process
    - Testing Focused on Most Important Performance Characteristics and Conditions
    - Test Results Designed for Evaluation in the AoA Framework
      - System Performance, Suitability and Mission Effectiveness
  - Mission Oriented
    - AoA's Authoritative Operational Context used to Derive Operational Environments for Testing
    - Context Facilitates Integrated DT/OT Planning; Operational Evaluation of DT …(DT/OE)
    - AoA Context Defines common Test and Training Environments

Harmonizing T&E and Acquisition Decision Support

System Design, Cost / Effectiveness Evaluation, Acquisition Strategy, and Test Program

Characteristics of an Enhanced AoA

•Cost vs Capability
•Flexible Use

- **A Persistent Analytic Activity**
  - Relates the Key System Performance Characteristics to Mission Effectiveness and Cost
  - Usually Animated by the JCIDS/ ICD; but sometimes as part of the CBA or sooner within a Service ; Enduring through Milestone B; may extent through Milestone C & System Life Cycle
  - Initially Focused on Selecting among Alternative Materiel Solution Approaches
  - **(Enhanced)** Develops and Maintains the Operational Oriented Evaluation "Trade Space" to Support Acquisition & Operational Decision Making
- **Informing:**
  - **JCDIS, ACQ, and Joint Commanders**
    - Sensitivity of Mission Effectiveness and Costs to Variations in the Performance Levels of Mission and Suitability Related System Characteristics
  - **JCIDS** (Determination and /or Adjustment of System KPPs and KSAs)
  - **Acquisition** (MDA & PM)
    - A Systems Engineering "Trade Space" and the Acquisition Strategy)
    - Numbers of Systems; O&M and Logistics Implications; Procurement Schedules; Design , Effectiveness and Cost Tradeoffs
  - **T&E** (DT and OT) ; Informs on:
    - Operational Conditions and Test Objectives Aligned with Mission Effectiveness
    - Mission Effectiveness Oriented Analytic Framework for Evaluating Test Results:
    - Key Assumptions and Representations (M&S and others) Requiring Testing to Enhance Confidence in the System Design
  - **Field Commanders;** Informs on:
    - Flexibility and Limitations in Use and Support of the System

Summary Observation
SE will Inform this new
DYNAMIC

Observation 5
A new & persistent paradigm
for responsive SE

Joint Mission Environment Test Capability
(JMETC)

Test Resource Management Center

Briefing for:

The National Defense Industrial Association Systems Engineering Conference 2009

Lowering Technical Risk by Improving Distributed T&E Capabilities

Mr. Chip Ferguson
JMETC Program Manager
28 October, 2009

NDIA Systems Engineering Conference

"The DoD seeks to improve the acquisition process and overall program execution to provide greater, more effective and reliable warfighting capability, at affordable cost and within schedule"

"Strong emphasis on systems engineering throughout the life cycle of the program…is a key enabler of successful programs"

The Joint Mission Environment Test Capability (JMETC) is the DoD Best Practice for providing the Infrastructure and Support needed for Distributed T&E throughout a program's life cycle

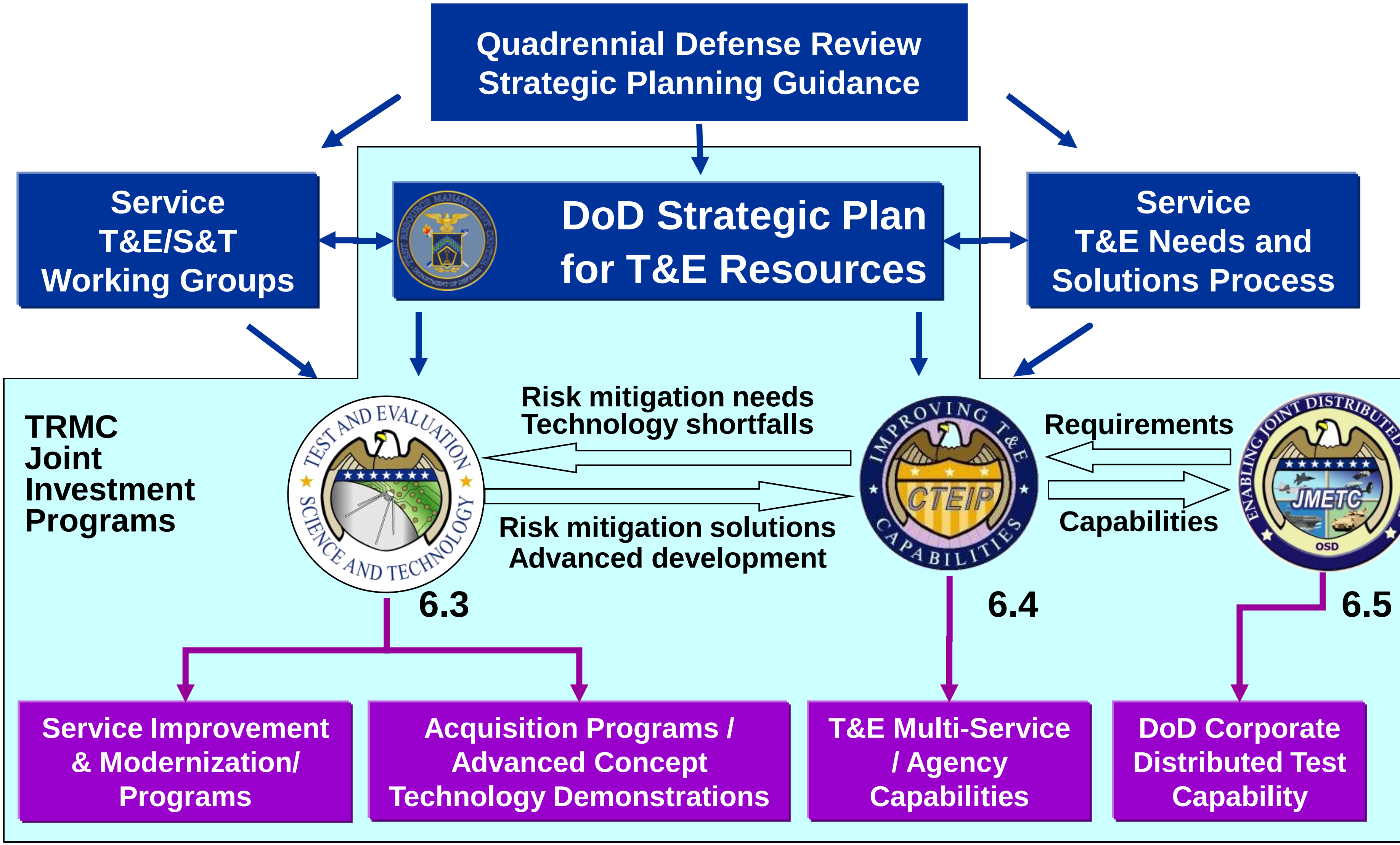
Bottom Line Up Front

For the Acquisition and T&E Communities, JMETC:

- **Lowers the cost to integrate systems together**
- **Decreases the time to integrate systems together**
- **Lowers the cost to develop new systems**

JMETC's unique total package capability allows the T&E customer to minimize the technical risk associated with planning for and providing the distributed test infrastructure so that they can truly focus on test requirements

Relationship within TRMC
Synergy through Aligned Investment



TRMC Investment Programs Overview

T&E/S&T

- Established in FY2002
- Develops technologies required to test future warfighting capabilities
- 6.3 RDT&E funds
- ~$95M / year
- 7 current focus areas
  - Directed Energy
  - Hypersonics
  - Netcentric Systems
  - Unmanned Systems
  - Multi-Spectral Sensors
  - Non-intrusive Instruments
  - Spectrum Efficiencies

CTEIP

- Established in FY1991
- Develops or improves test capabilities that have multi-Service utility
- 6.4 RDT&E funds
- ~$140M / year
- 47 current projects
  - 25 projects developing core Joint capabilities
    - 2 projects improving interoperability test cap.
  - 8 projects improving threat representations used in testing
  - 14 projects addressing near-term OT shortfalls

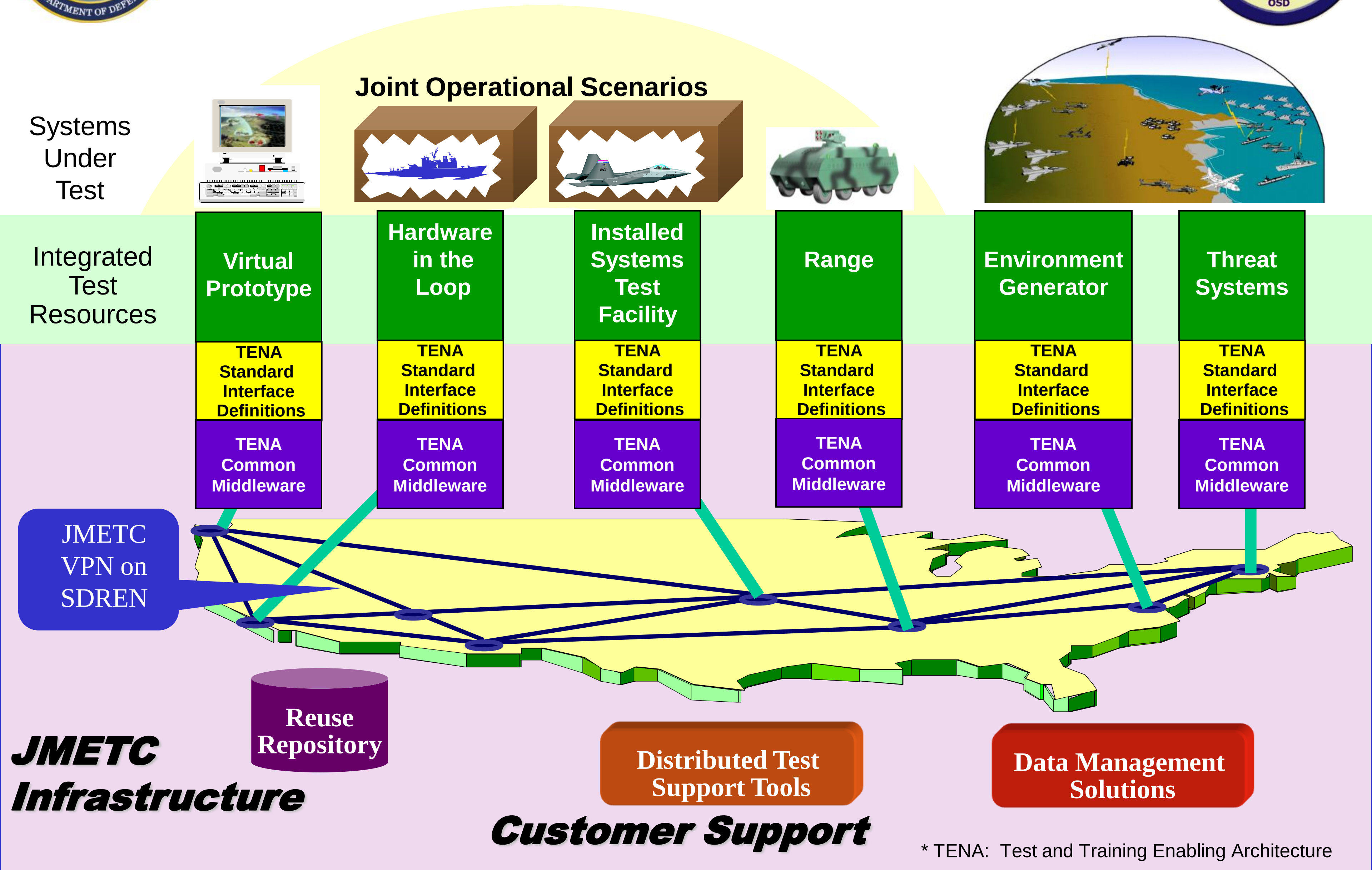
JMETC

- Established in FY2007
- Provides corporate infrastructure for distributed Joint testing
- 6.5 RDT&E funds
- ~$10M / year
- 32 current sites
  - Expanding to 44 sites
- Maintains
  - Network connections
  - Security agreements
  - Integration software
  - Interface definitions
  - Distributed test tools
  - Reuse repository

The JMETC Mission

JMETC provides the DoD T&E Community the resident distributed test *expertise* and the persistent modern *network infrastructure* needed for the connection and use of distributed live, virtual, and constructive resources to conduct the DT&E and augment the OT&E of joint systems and systems-of-system.

JMETC Enables Distributed Testing



JMETC Leadership & Governance

JMETC
Chain of Command

Honorable
Dr. Ashton B. Carter
USD (AT&L)

Dr. John B. Foulkes
Director, Test Resource Management Center (TRMC)

Derrick Hinton
Principle Deputy, TRMC
Deputy Director, JIPP

Chip Ferguson
JMETC Program Manager

George Rumford
Senior Technical Advisor

JMETC
Governance

Testing in a Joint Environment Roadmap Senior Steering Group

- Senior DoD Leaders
- Charter signed 26 Oct 07

JMETC Advisory Group

- Service/Agency reps
- Regularly held meetings to discuss/review plans, common issues, needed studies, etc.

JMETC Users Group

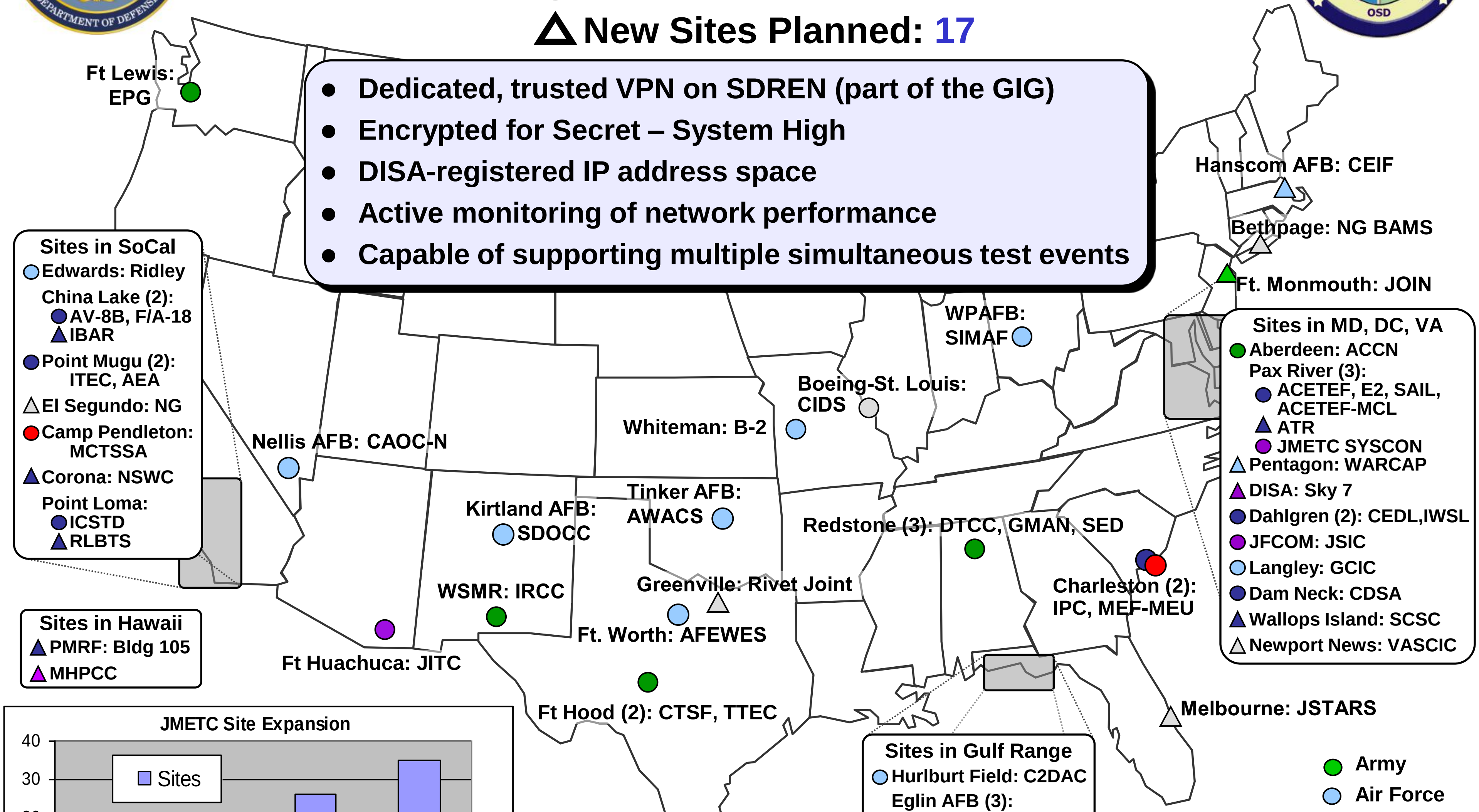
- Technical representatives of customers and test resource owners
- Nine meetings held to date
- ~185 participants/meeting

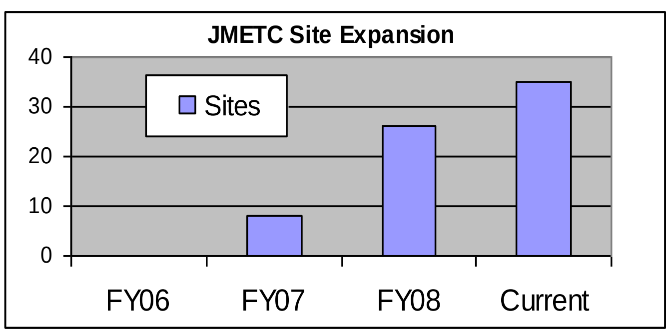
JMETC Connectivity

○ Functional Sites: 38

△ New Sites Planned: 17

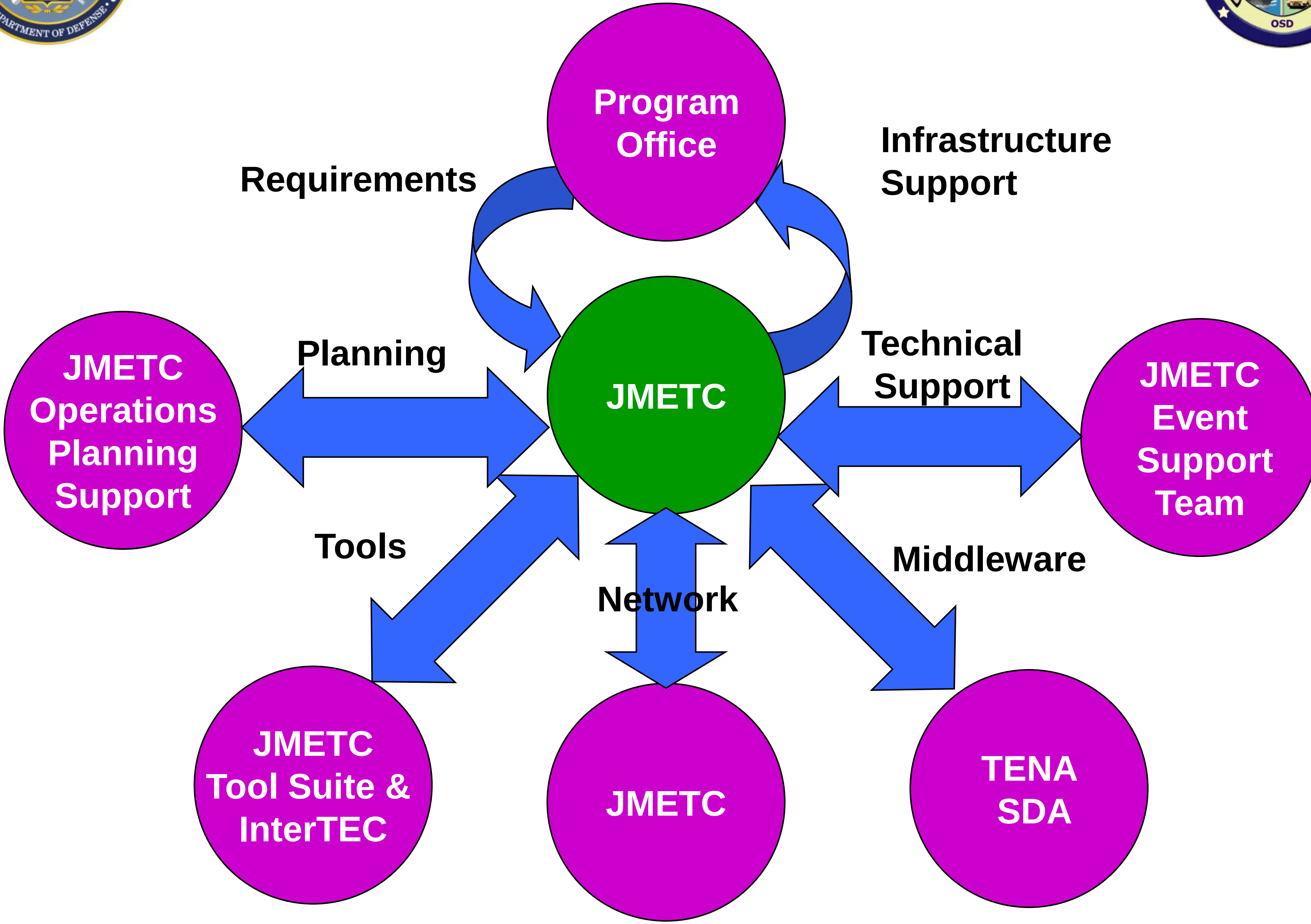
- Dedicated, trusted VPN on SDREN (part of the GIG)
- Encrypted for Secret – System High
- DISA-registered IP address space
- Active monitoring of network performance
- Capable of supporting multiple simultaneous test events



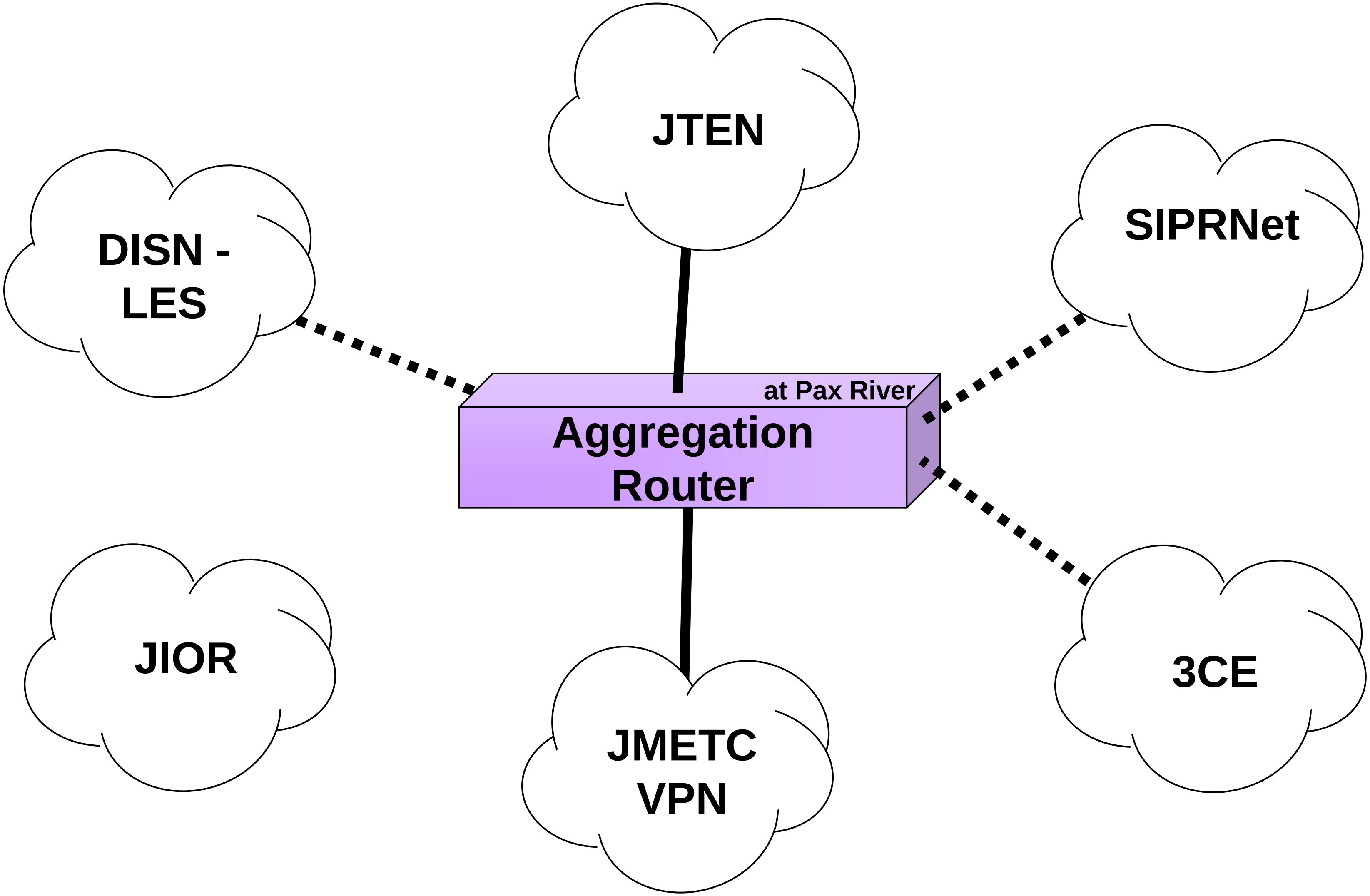


As of 15 Sept 2009

JMETC Support: Major Programs



Network Aggregation
Bridging Networks



Joint Mission Environment Test Capability (JMETC) FY 09 Accomplishments

FY 09 JMETC Customers

- Broad Area Maritime Surveillance System (BAMS)
- Joint Surface Warfare (JSuW) JCTD
- Multi-Service System-of-Systems Test Bed (MSSTB)
- Joint Expeditionary Force Experiments (JEFX)
- Air Force Integrated Collaborative Environment (AF-ICE)

JMETC Accomplishments

- Expanded network from 32 to 38 sites with additional 19 planned
- Transitioned AF-ICE network operations to JMETC VPN
- Improved customer utilization of persistent distributed test environment
- Enhanced and optimized JMETC site local infrastructure
- Added JITC certified tools for Joint Planning Network certification testing
- Collected issues and best practices for implementing DIACAP
- Reuse Repository Data Expansion

Insight Gained by the DoD

- Identification of Air Force Initiatives ready for warfighter transition
- Tactical UAS deployment in the National Airspace
- Employment of Net-Enabled Weapons
- Timeliness of C2 processes
  - Joint Fires
  - Time Sensitive Targeting Cycle
  - Joint Close Air Support
  - Combat ID
- Ability to encrypt airborne and ground IP networks
- Improvements in Joint Airborne Network Integration:
  - Network Management
  - Network Interoperability
- Ability to simulate Link-16 networks for optimization and re-planning of assets with limited to no connectivity
- Successful Bridging of Win-T and DDS networks
- Assessment of technical risks for FY10 Joint Track Manager Demo

FY10 JMETC Support Schedule

Customer	Event	Dates
Air Force	Persistent Fire 01	October 08 – December 09
Air Force	JEFX 10-1/Spirit Ice	October 09 – April 2010
Air Force	JEFX 10-2	8-13 February 2010
Air Force	JEFX 10-3	10-23 April 2010
Navy	Correlation/Decorrelation Interoperability Test (C/DIT) Integration Events (Continuous)	September 2010
Air Force	Battlefield Airborne Comm. Node (BACN) JUON (DT/OT)	March - October 2010
Air Force	Agile Fire 10-2	25-29 January 2010
Air Force	Agile Fire 10-3	June 2010
JFCOM	United Endeavor 10-1	February – April 2010
Navy	BAMS LVC DE	October 09 – December 09
CTEIP Activity	**Event**	**Dates**
InterTEC	Tool Development & Test	FY07 – Present (Periodic)
TENA SDA	Release 6 Testing	October 08 – Present (Periodic)
Discussions for Future Teaming		
Gerald R. Ford Class (CVN-21)	Joint Strike Fighter (JSF)	JIAMDO/Joint Track Manager
Brigade Combat Team (BCT) Modernization	Multi-Function Adv Data Link (MADL)	Multi-Mission Maritime Aircraft (MMA)

JMETC Update

- Program is growing
  - More events…VPN being used every day
  - More sites…38 functional sites with 17 more planned
  - Relevant to the T&E community…Users Group Attendance
  - JMETC Infrastructure is Valued by T&E Community
    - ❖ Air Force/AF-ICE to JMETC VPN
    - ❖ Planning to move ATIN to JMETC VPN
    - ❖ In discussion to move Navy DEP to JMETC VPN
    - ❖ 12 sites have paid their own way onto JMETC VPN
- Working with Acquisition Programs
  - Navy, Pax River, ACETEF: CVN-21, MMA, BAMS…
  - Air Force SAF/XCDM and 46th TW, Eglin AFB: MADL, MALD, SDB…
  - Army: BCT Modernization Program
  - Joint: JFCOM J8-led JC2 Partnership

JMETC Users Group

The JMETC Users Group is designed to establish a structured dialog across the User Community to foster better Testing of Joint Requirements

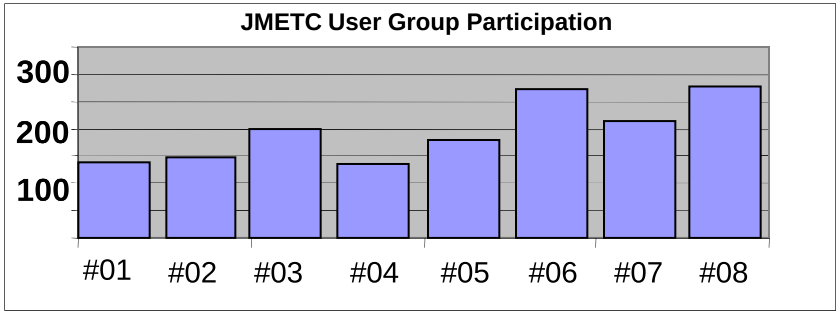
- **Identify core infrastructure requirements and use cases**
- **Discuss available solutions, tools, and techniques**
- **Identify opportunities to partner and collaborate**

Current Initiatives include:

- **Streamlining the Network Accreditation process**
- **Cross-Domain Solutions**
- **West Coast Aggregation Router**
- **Mobile Node Capability (Transportable Node)**

The Users Group continues to grow

Next Users Group meeting: Feb 2010, Orlando, FL.



JMETC Initiatives

- Streamlining the Network Accreditation process
  - DoD Information Assurance Certification and Accreditation Process (DIACAP) Implementation Tiger Team
- Cross-Domain Solutions
  - Unified Cross Domain Management Office (UCDMO)
  - Information Operations Range (IO Range)
- West Coast Aggregation Router
- Mobile Node Capability (Transportable Node)

Summary

- **JMETC supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads**
  - **JMETC is being built based on customer requirements**
  - **JMETC event support can be tailored to customer needs**
  - **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**
- **Leading Track at 2010 LVC Conference, El Paso TX, 11-14 Jan, "*Future Trends and Needs for Distributed T&E Infrastructure*"**

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

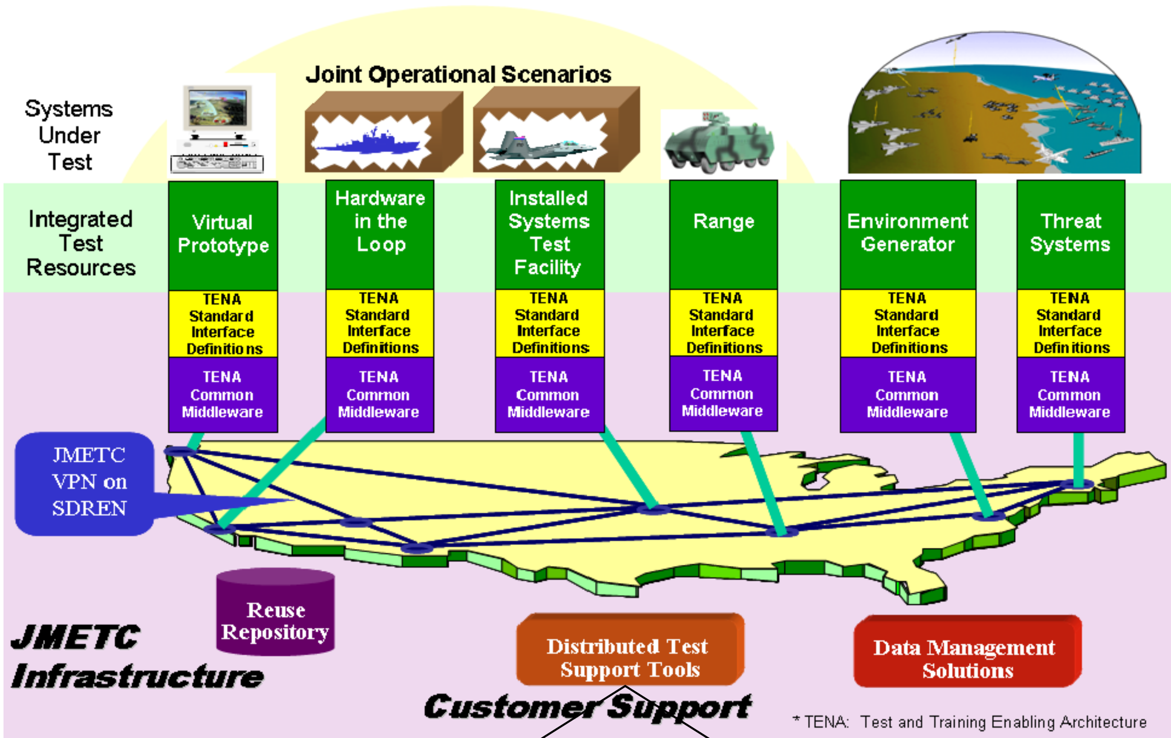
JMETC Website: www.jmetc.org

BACK UP

SLIDES

JMETC - JTEM - InterTEC

Differences from a JMETC Perspective



Joint Test & Evaluation Methodology (JTEM)

- 2005-09 JT&E (DOT&E): Transitioning
- Developed <u>recommended</u> Joint LVC test <u>methods</u>

JMETC

- Persistent infrastructure and technical support
- AT&L-TRMC: 2007-POM

InterTEC

- JMETC Distributed Test Tools include TENA, <u>InterTEC</u> and Service tools
- InterTEC produces tools necessary to test Net-Ready KPP's. <u>Certified</u> by JITC for interoperability testing
- CTEIP project (AT&L-TRMC)

JMETC, InterTEC and JTEM have unique roles

Aeronautical Systems Center

Dominant Air Power: Design For Tomorrow…Deliver Today

U.S. AIR FORCE

Mind The Gaps – A Systems Engineering Implementation of DODI 5000.02

12th Annual NDIA SE Conference
26-30 Oct 09

Authors:
Dr. Tom Christian, SL, ASC/EN
Ms. Janet Jackson, Chief, Systems Integration, ASC/ENSI

Overview

- **Purpose**
- **Background**
- **ASC Engineering Assessment**
- **Summary**

Purpose

- **To present ASC/EN's unique approach to implement current policy DODI 5000.02**

Background

- **DoDI 5000.02 released in Dec 2008**
- **Directed by ASC Director of Engineering to identify local policy impacts and implementation**
- **Conducted a preliminary assessment in early 09 and recommended an offsite for a gap analysis**
- **Held an ASC engineering offsite in Mar 09**
  - Members: Engineering Senior Leaders, Wing DOEs, ASC/EN division chiefs/tech directors, XR, AQ DOEs, and ASC/AQ staff

Background

- **Promulgated across AF to raise awareness**
  - Resulted in other functionals to do the same

- **Presented results at the SAF/AQR ILCM Tech Forum and HQ AFMC Engineering Council in May 09**

ASC/EN Assessment

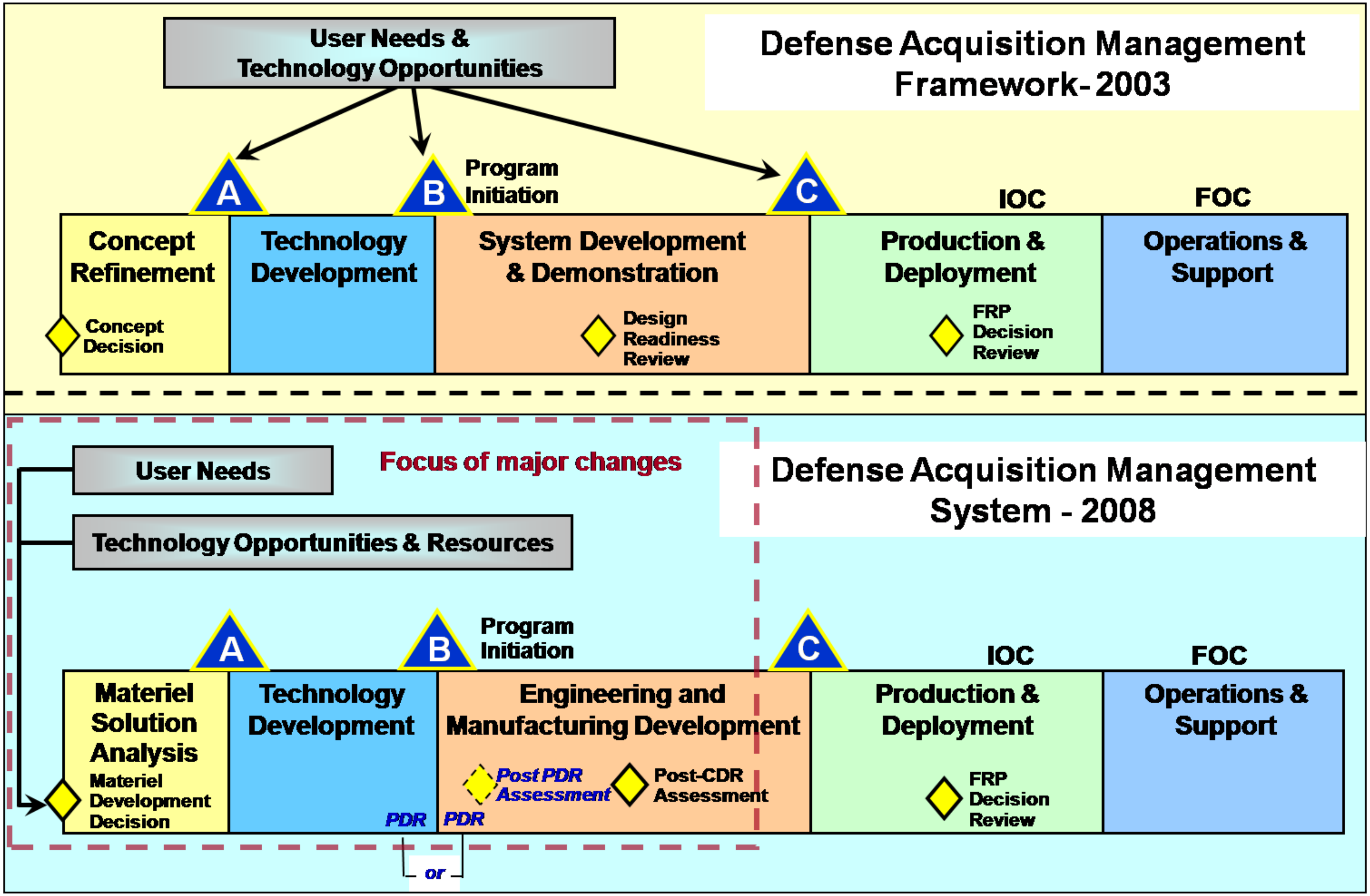
ASC/EN Assessment Approach

- **Evaluated 5000.02 changes for each Milestone and Phase**
- **Identified gaps (processes/tools/training) between DoDI 5000.02 and current ASC systems engineering processes/toolset**
- **Consolidated and prioritized gaps**
- **Outbriefed to ASC Director of Engineering in Mar 09**

Goal: To meet statutory and regulatory requirements

5000.02 Major Changes

Dominant Air Power: Design For Tomorrow…Deliver Today



Requirements Flow-Down

- **OSD**
  - DoDI 5000.02
  - DAG being updated
- **AF**
  - AFPD 63/20-1 and AFI 63-101, 63-1201
  - D&SWS initiatives
  - SAF/AQ policy memos
- **HQ AFMC**
  - AFMCI 63-1201
  - AFMC policy memos
- **ASC**
  - PEO Memos
  - ASC/EN SE Toolset

5000.02 Key Emphasis for Engineering

- **More Robust Systems Engineering**
  - Emphasis much earlier in life cycle
  - More robust Analysis of Alternatives (AoA)
  - Manufacturing emphasis
- **Technical Risk Reduction**
  - Competitive prototyping
- **Independent SME Reviews**
- **Additional Program Documentation**
  - Technology Development Strategy
  - PDR assessment report
  - CDR assessment report

Prioritized Gaps

Near Term Efforts:

- **Engineering Manpower Strategy**
  - PDR Bfr MS B Gap: No manpower allocations to execute TD phase objectives (i.e., prototyping/PDR)
  - PDR Bfr MS B Gap: Independent SME manpower driver, to include RFP prep, source selection support, and other predecessor PDR reviews (i.e., SRR)
  - EMD Gap: Independent SME manpower driver (EN HO and Wings)
- **MDD Gap: No technical planning document exists to guide early systems engineering activities – ASC/EN and XRE**
- **TD Gap: RAM strategy not uniformly implemented across all programs**
- **TA Gap: Lack of EN-corporate process for TRA/MRAs**
- **EMD Gap: No template for PDR/CDR Reports**

Long Term Efforts:

- **MS A Gap: No template for Technology Development Strategy (TDS)**
- **TR Gap: Lack of definition for "independent SME"**
- **MDD Gap: Lack of formalized process for engineering SME reach-back support**
- **MSA AoA Execution Gap (process): Lack of formalized process for engineering SME reach-back support**
- **MSA Gap: New requirement (SAF/AQR/AFMC/EN) to develop Organizational SEP (O-SEP) or Operating Instructions (OIs)/training**
- **TD Gap: Lack of decision analysis guidance on determining requirements for maturity of critical technologies and/or competitive prototyping**
- **TD Gap: No template for Data Management Strategy**

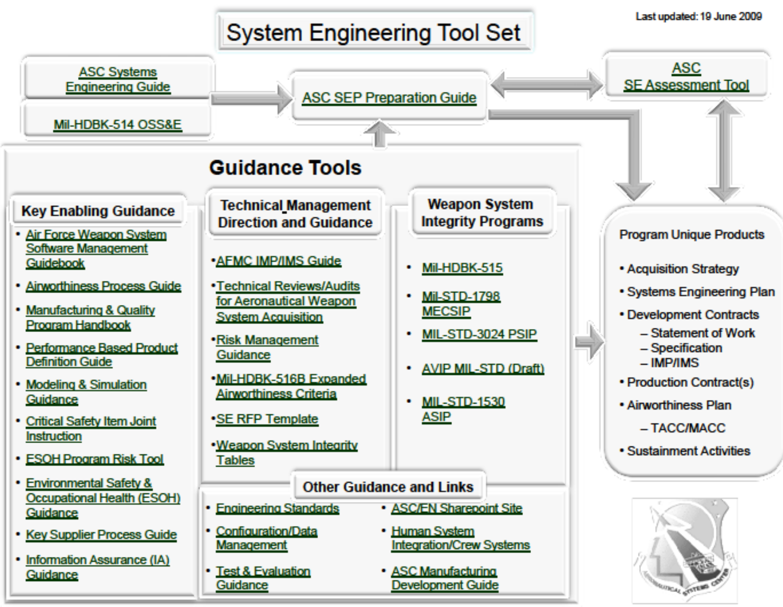
U.S. AIR FORCE

Summary

Dominant Air Power: Design For Tomorrow…Deliver Today

- **Better understanding of 5000.02 impacts**
- **Focusing on near term efforts**
- **Still in flux – additional guidance will follow**
  - Weapon Systems Acquisition Reform Act of 2009, dated May 09
  - Will implement as additional guidance becomes available

- **May drive additional manpower**



Win and Influence Design Engineers--- Change Their Affordability DNA

Authors:

Timothy G. Morrill
Sr. Principal Electrical Engineer
Design Performance, Architecture and Testability Department
Raytheon Missile Systems
1151 E. Hermans Road
Tucson, AZ 85756
520-545-8291
tgmorrill@raytheon.com

S. Diana Patane
Sr. Systems Engineer, II, Cost Engineering
Affordability and Robust Design Methodologies Department
Raytheon Missile Systems
1151 E. Hermans Road
Tucson, AZ 85756
520-794-2583
S_Diana_Patane@raytheon.com

Introduction

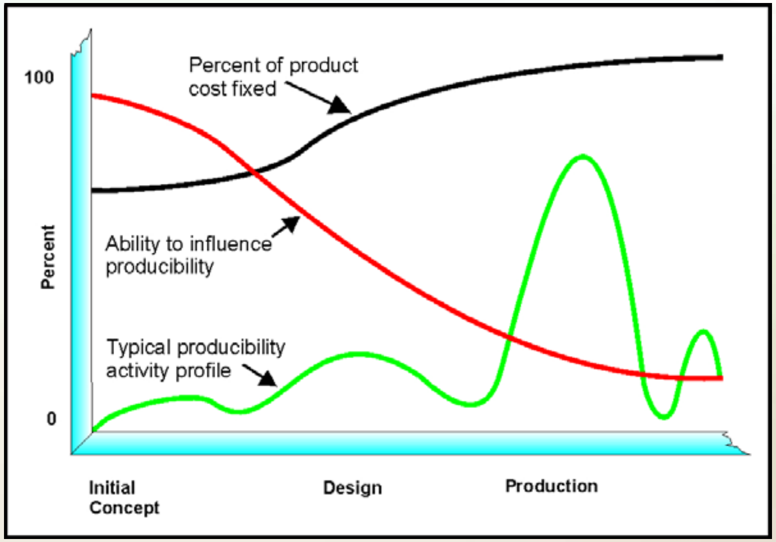
•Develop a plan that will enable design engineer to include producibility and affordability as well as other "specialty" engineering into the design process

•Specialty engineering is usually flowed to the team as an edict

- •Thou shalt be producible!
- •Thou shalt be testable!
- •Blah.. Blah.. Blah..   "Generic" trap

•"As a design engineer why should I care about producibility or any other 'ilities'?"

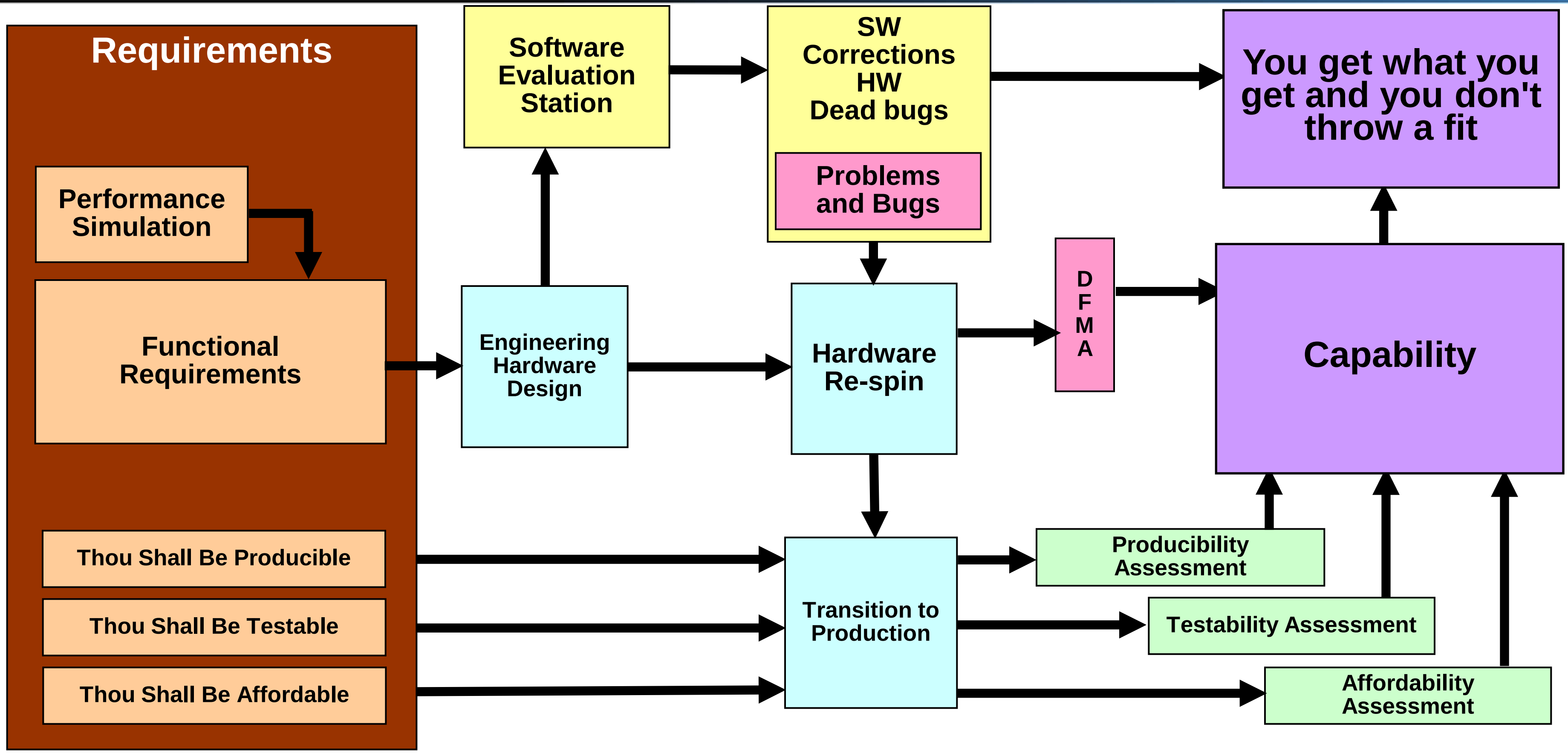
- •Functional requirements are verifiable
- •Environments are verifiable
- •How do I verify an illity?



NRE in a good design is the same as the NRE in a bad design

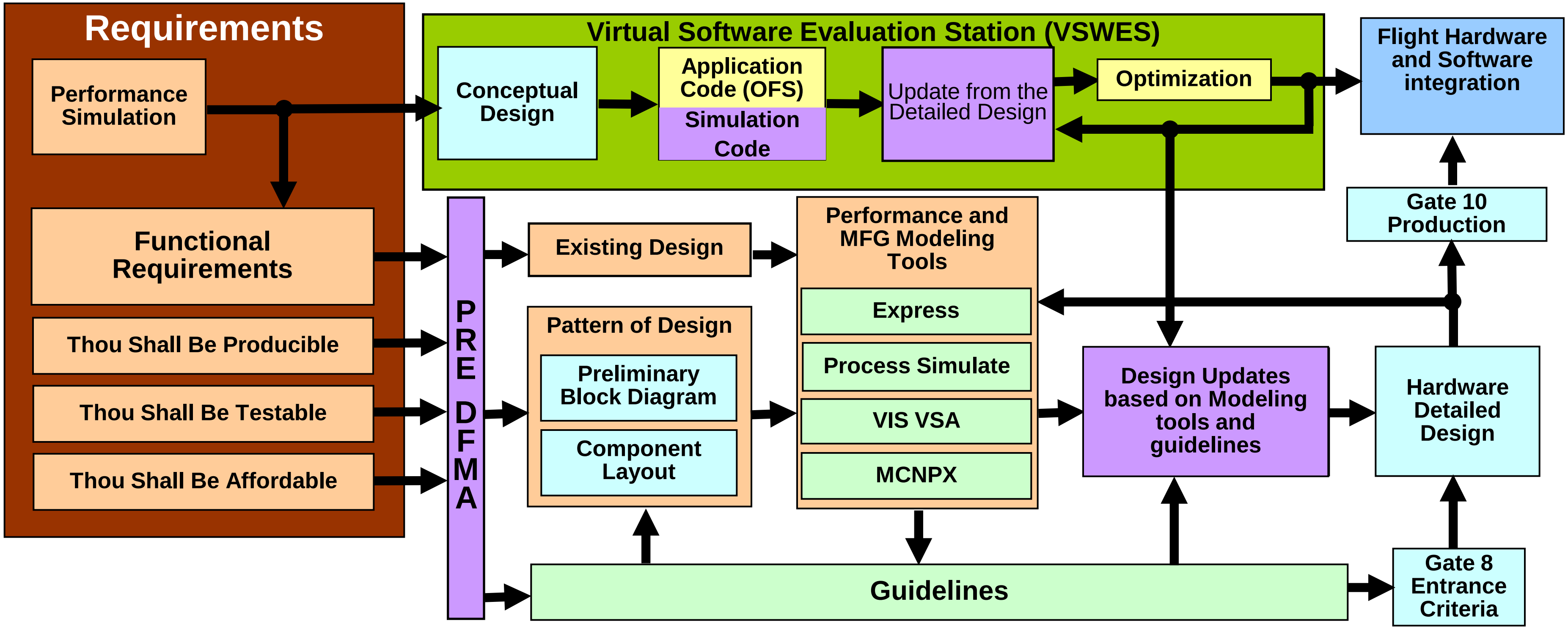
- If I can’t verify it, then it shouldn't be a requirement
  - Shifting requirements drive the cost during this phase
  - Specialty engineering is difficult or impossible to quantify
  - A good design should incorporate specialty engineering
  - The cost impact during development is minimal
  - Hardware Development takes time and costs money
- It has to become part of the process
  - Philosophical vision of the product (clearly communicated)
  - Understanding of the Life cycle of the product
  - Assessment of the cost drivers within the life cycle (this is product specific)
  - Discipline within the design community
- Identify product characteristics that historically drive producibility
  - Limit or eliminate Key Product Characteristics (KPCs)

Traditional Method



- **Engineering Hardware Design**
  - Supports Software Development
  - Initial Requirements Evaluation
  - Initial Hardware Evaluation
  - Ignore Specility Engineering as NVA for engineering design
- **Hardware Re-spin**
  - Correct problems found by SW
  - Updates to Requirements
  - Capability assessment for speciality engineering
- **Transition to Production**
  - Incorporation of assessment recommendations
  - Design Verification testing
  - Cost Increase For Transition to Production
  - Usually abandoned because its to expensive
- **Actual Hardware Design**
  - Incorporates recommendations from DFMA as long as performance is not impacted
  - The Design is assessed for Capability with respect to specialty engineering
  - You get what you get

Design Optimization Approach



- **PRE DFMA**
  - Disciplines that represent the Life Cycle of the product
  - Generate or tailor design guidelines applicable to the program
  - Communicate the accountability to all involved with the product
  - Vision, Philosophy, Heuristics
- **Hardware Development**
  - Create a Conceptual design to drive the VSWES
  - Establish the baseline design from either an existing design or the accepted pattern
  - Analyze the baseline design and trade studies
  - Preliminary Design Traditional DFMA
  - Use the guidelines to gate the Detailed Design
- **Design Optimization**
  - Designed to be compliant to the requirements and the guidelines
  - Continue to analyze the design
  - Feedback recommendation into the detailed design
  - Update the VSWES model to the detailed design
  - Use a CIL/HIL to FQT software
- **Flight Hardware Design**
  - Designed to be compliant to the functional requirements
  - Optimized to incorporate specialty engineering

Raytheon

Summary

- Specialty Engineering is difficult if not impossible to quantify
- Specialty Engineering is cheaper up front
- Define the "Ilities" for your product early and make it a priority
  - The product life cycle and the Concept of operations (ConOps) need to be understood
  - ConOps should help to identify major cost drivers
  - Identify what the customer cares about
    - Affordability, Maintainability, Durability
  - Identify what the enterprise cares about
    - Producibility, Testability, Modularity
  - Don't fall into the "generic" trap
- Use a PRE DFMA before the start of preliminary design to establish guidelines and run rules for the designers
- Use the guidelines to gate through the process

Summary – Cont’d

- **Model the baseline or conceptual design with the manufacturing tools as well as the performance tools as soon as you can to establish a baseline and to create stretch goals.**
- **Use the data from the models to resolve the trade studies during preliminary design and to identify the metrics you need to evaluate progress**
- **Update the models as the design is refined**
- **Know your requirements and avoid Key Product Characteristics**
- **Traditional DFMA as you progress to detailed design**

“ilities” must be controlled by the process and enforced from the top down

Backup Slides

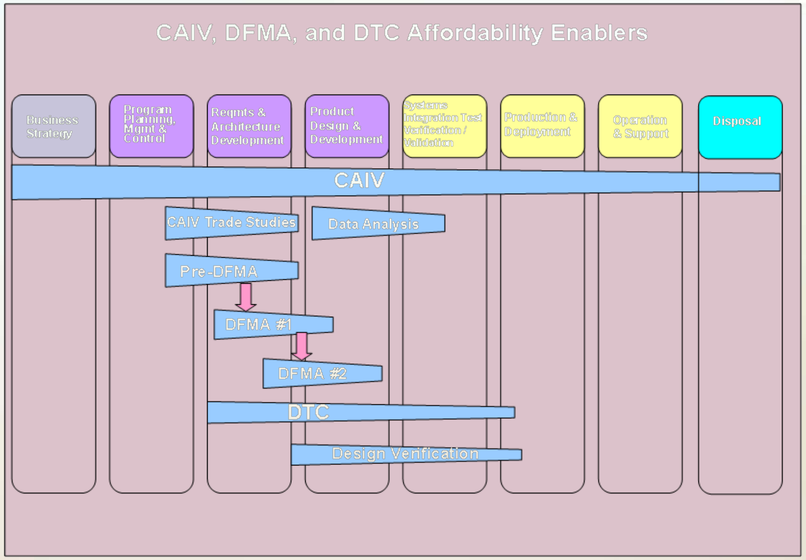
Affordability Enablers

- **Cost as an Independent Variable (CAIV),**
- **Design to Cost (DTC),**
- **Design for Manufacture and Assembly (DFMA),**
- Statistical Design Analysis (Design for Six **σ**),
- Digital Lean Manufacturing, and
- Statistical Process Control.

CAIV & DTC

- CAIV starts a first design decision

- DTC engages as requirements and architecture develop



Test and Evaluation in a System of Systems Environment

A Case Study of the Air Force Modeling & Simulation Training Toolkit (AFMSTT)

Edwin P. McDermott

and

Sharam Sarkani, PhD, PE

Thomas A. Mazzuchi, DSc

Notes

- This presentation is an extract of work being submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Systems Engineering at The George Washington University
- This presentation has been cleared for public release by the Electronic Systems Center, Hanscom AFB, Massachusetts
- The opinions expressed here are solely those of the principal author

Outline

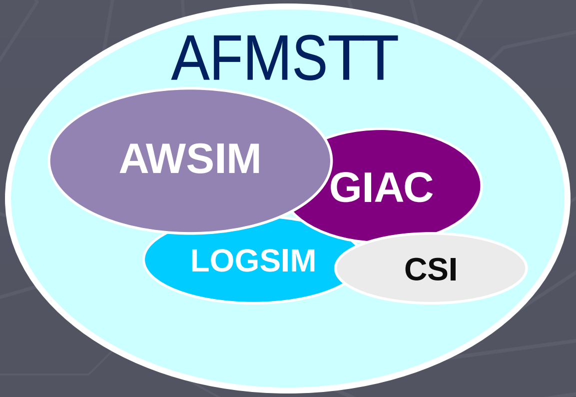
- What is AFMSTT?
- Why is AFMSTT interesting relative to SoS T&E?
- What has AFMSTT done to make it work?
- Layered T&E Strategy
- Lessons learned that could be applied elsewhere
- Some fortunate circumstances
- Recommendations for further research
- Postscript

What is AFMSTT?

- The Air Force Modeling and Simulation Training Toolkit (pronounced “AFF’ mist”)
- Software program over 15 years old (written mainly in ADA & C++ > 2M SLOC)
- Significant human control/inputs/interaction (approximately ten model controllers)
- Provides a constructive air picture for battle staff training during major exercises and experimentation

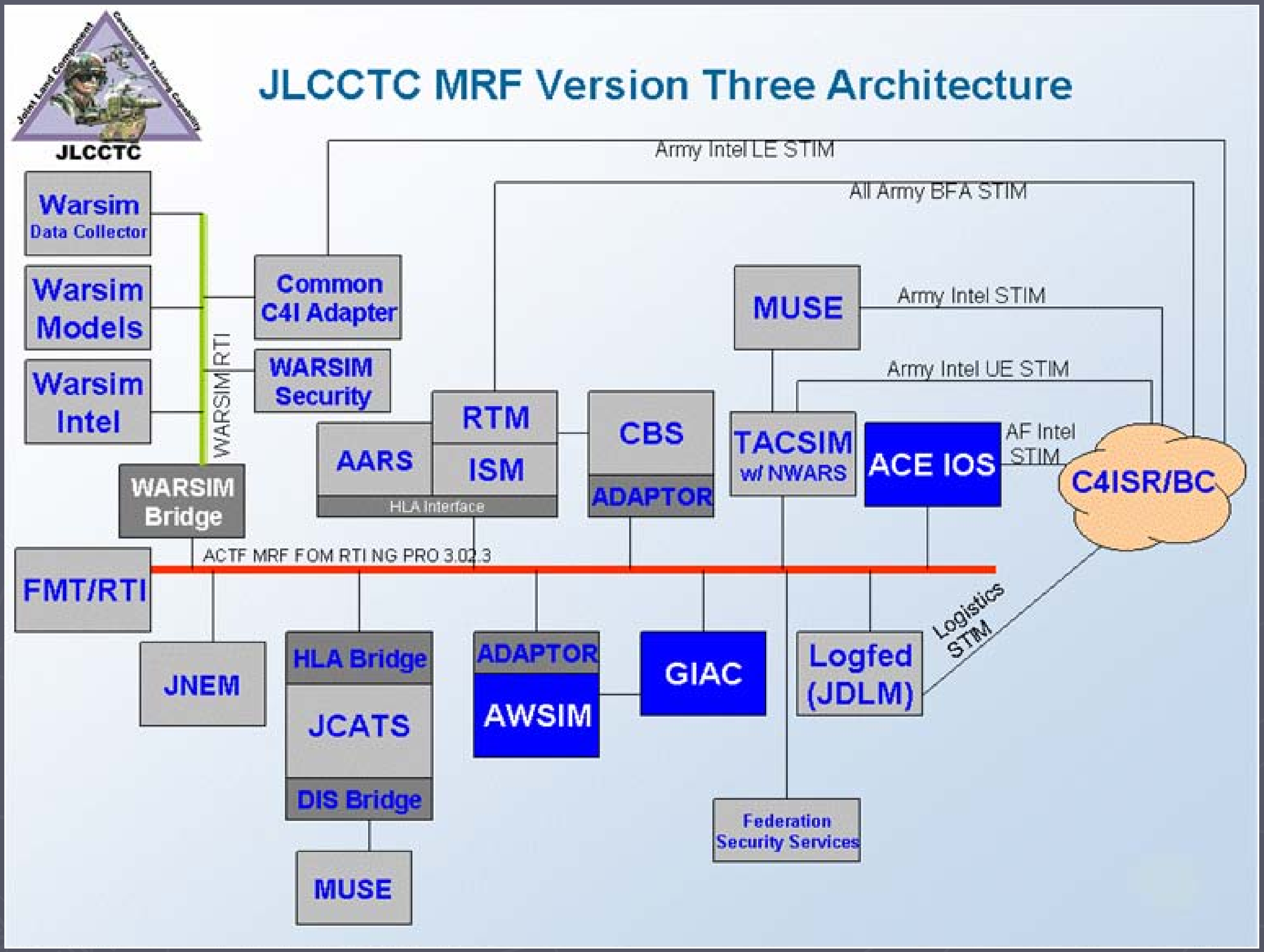
AFMSTT Components

- Air Warfare Simulation (AWSIM) – sim engine
- Graphical Interface Aggregate Controller and Data Server (GIAC) – displays air picture
- C2 System Interface (CSI) – external links
- Logistics Simulation (LOGSIM) – injects realistic logistics constraints & behaviors



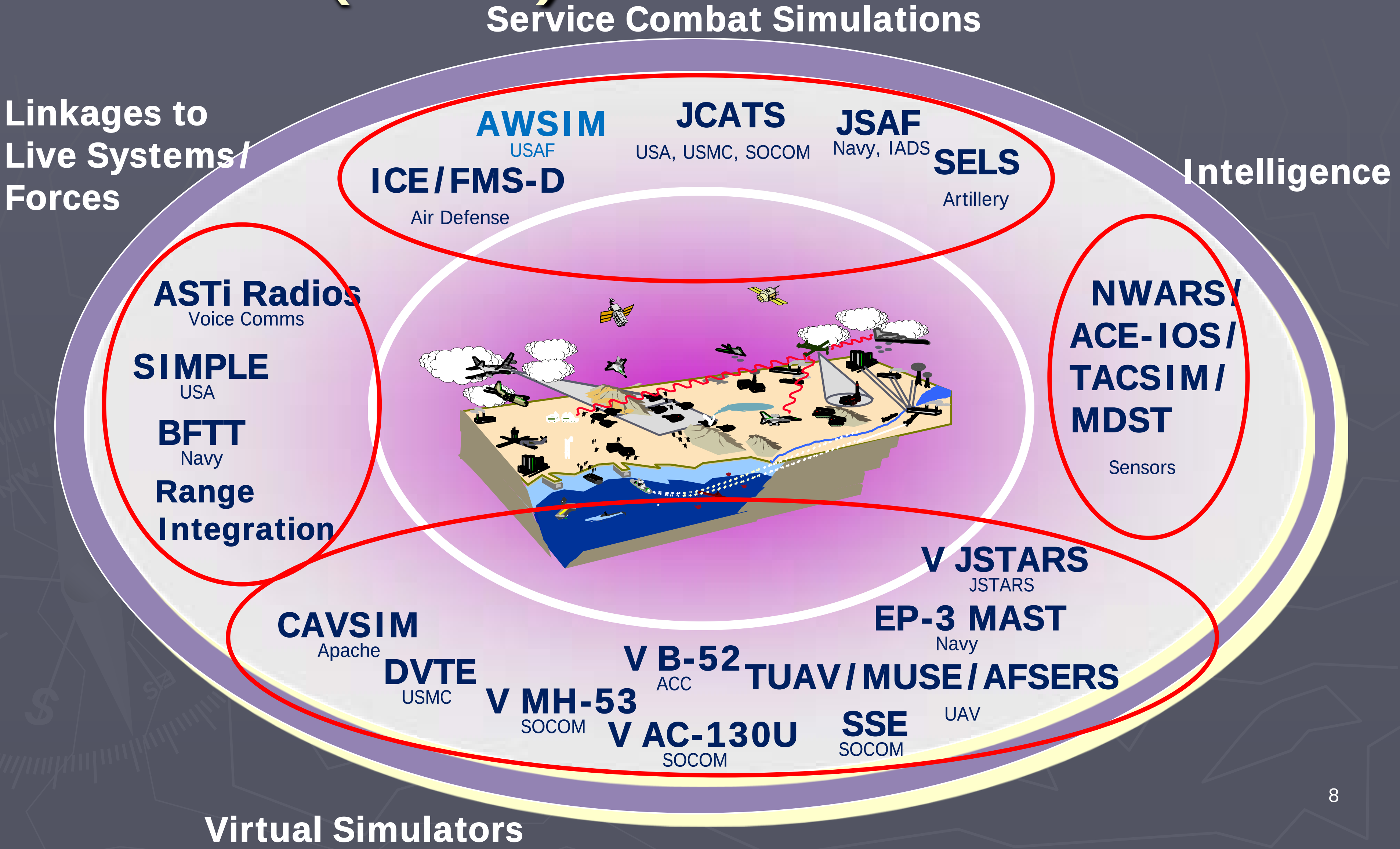
Why Is AFMSTT Interesting? (relative to T&E in a SoS)

- AFMSTT functions in several complicated federations and interacts with many systems not under a common governance system – the *essence* of System of Systems
- AFMSTT has been undergoing constant evolution since its inception with nearly continual modification



From *Common Standards, Products, Architectures and/or Repositories (CSPAR) Baseline Document*, Version 1.0, 16 Oct 06, US Army PEO Simulation, Training & Instrumentation

Joint Live Virtual Constructive (JLVC) Environment



What has AFMSTT Done to Make It Work?

- Constant attention to federated environment
- Integrated Test Team of Program Office (V&V), Using Command/Representative (AF Agency for Modeling and Simulation), JFCOM & Contractor along with others as required
  - Developer using Agile software development
  - “Test-driven development methodology”
- Intimately close-coupled and “layered” testing almost continuously

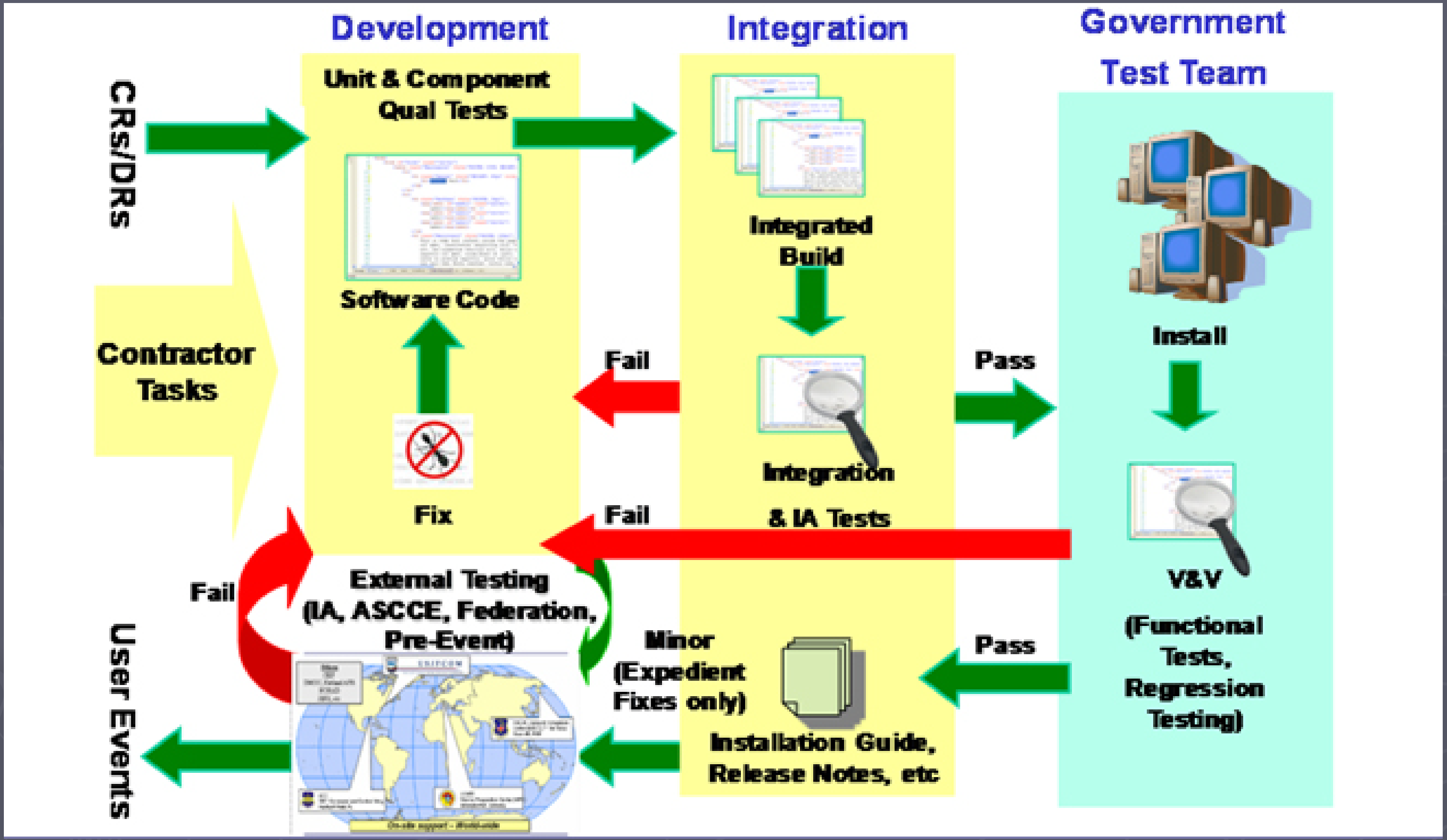
Layered Testing

- Contractor Testing
  - Unit & Component QA Testing – nightly/automated
  - System Integration Testing – weekly
  - IA Testing (in-plant & by 46 TS) – every 30 days
  - Extensive shared repertoire of test scripts and cases used to ID critical interfaces/functions (Note: These are constantly evolving/being updated!)
- Government Validation & Verification (V&V) – every 3 months done in C2 Enterprise Integration Facility @ Hanscom AFB

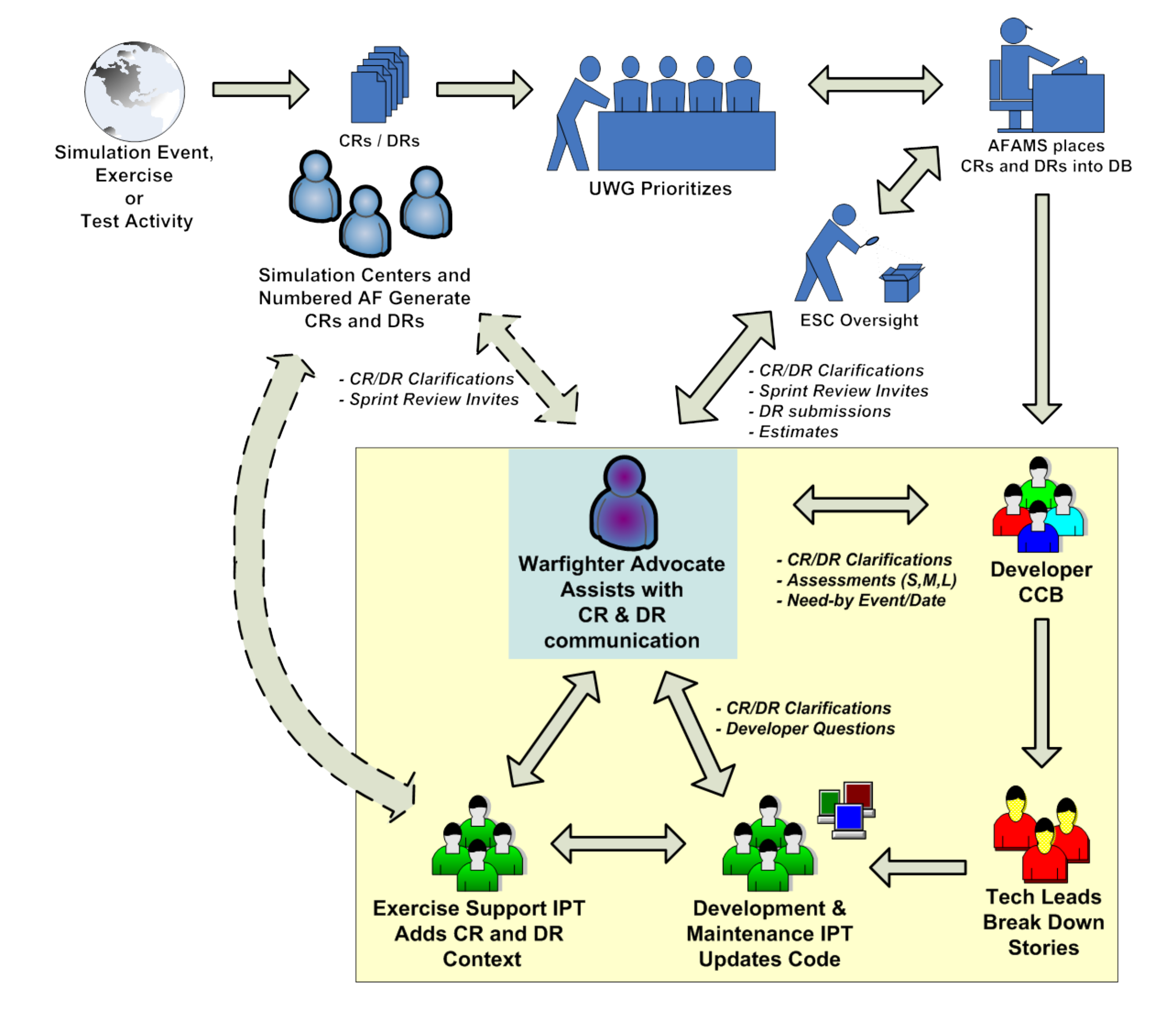
Layered Testing (cont)

- External Testing
  - Air, Space & Cyber Constructive Environment (ASCCE) – test harness against ACE baseline
  - Federation Testing (JLVC & JLCCTC) – every six months but can be done before major exercises
  - Formal External IA – Air Force Communications Agency – Note: AFMSTT *first* legacy system to receive full ATO from AFCA!
  - Event Preparation Testing – two-week "rehearsals" (bug fixing) before major events

Layered Testing



Agile Development Framework



Lessons Learned
(with potential for other systems)

- Constant awareness of SoS environment, focus on configuration control (both systems & interfaces)
- Proactive risk management of important interfaces
- Layered, incremental testing can identify most problems early, when easily fixed
- Employment of realistic test environments (fed tests)
- Pre-planned pre-event rehearsal time periods and allotted time for fixing bugs
- Closer user involvement reduces “stuff nobody really wants” which decreases test requirements

Observations

- Increased cost of testing has driven a desire for “the perfect test” and “complete knowledge”
- Complexities of SoS have made this unrealistic and unachievable! (in *both* cost & time)
- AFMSTT has gone in *exactly the opposite direction* with more testing at lower levels = SUCCESS!
- The Certification and Accreditation (C&A) and Test and Evaluation (T&E) processes need to function much more efficiently in concert/combination

Fortunate Circumstances

- The AFMSTT primary mission is to function within a large federated system of systems
  - Not all systems do so regularly
- Small-dollar program, avoided many large formal documentation requirements
  - LCMP incorporates most aspects of SEP, TEMP, etc. into widely used, concise living document
- Popular User Base & linkage to Joint National Training Capability (JNTC) forces incremental delivery

Recommendations for Further Research

- Additional case studies
- Identify and investigate other large system-of-systems federations
- Work towards a set of principles for SoS T&E and develop a methodology
  - Roadmap for SoS/Net-Centric Approaches
  - Likely that a family of approaches will be needed (large/small federations, hardware/software systems)

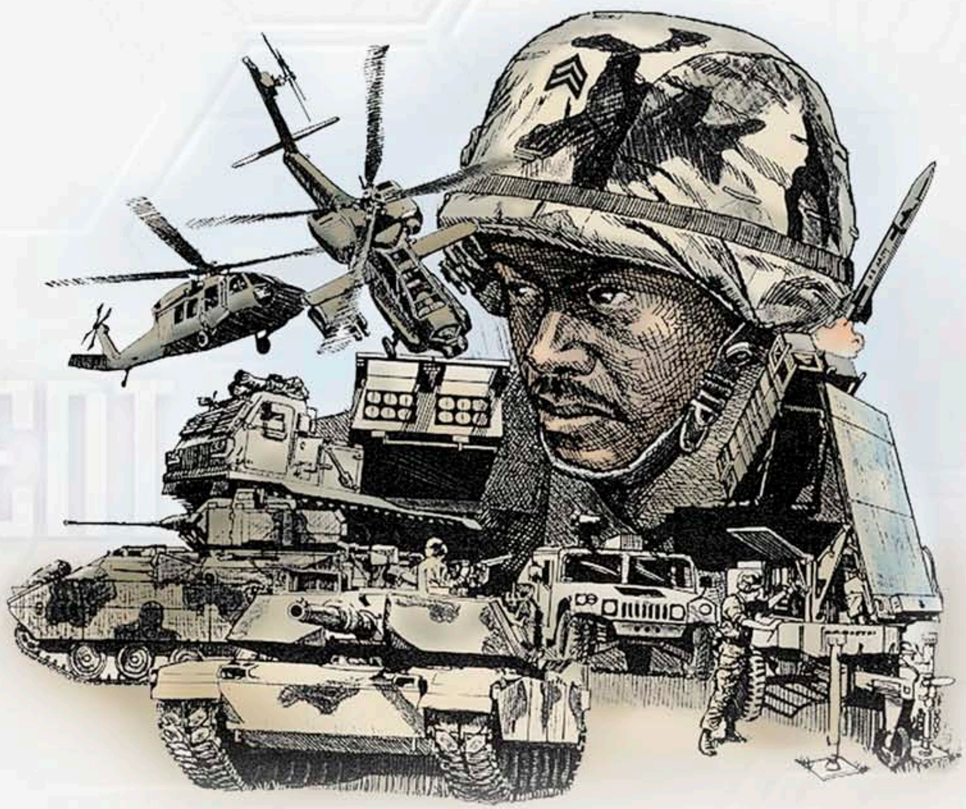
Postscript

- DoD Exercise budget decreasing
  - Fewer dollars for major exercises
  - Fewer dollars for programs like AFMSTT
  - Modernization on Horizon – funding challenges
- Since no contract lasts forever, AFMSTT is preparing to recompete development
  - The “documentation gatekeepers” have struck!
  - AFMSTT program office now dedicating personnel to writing documents (that so far have been unnecessary)

Questions?

Army Health Hazard Assessment Program:

Medical Cost Avoidance Model



AJ Kluchinsky

Manager, Health Hazard Assessment Program
United States Army Center for Health Promotion and Preventive Medicine

NDIA SE Conference: San Diego, **28 Oct 09**

USACHPPM
Readiness thru Health

Manpower and Personnel Integration

Health Hazard Assessment

Training

System Safety Engineering

Human Factors Engineering

Personnel

Manpower

Soldier Survivability

Health Hazard Assessment

PRIMARY OBJECTIVE:

- To identify, assess, and provide recommendations to eliminate or control health hazards associated with:
  - ***weapon platforms***
  - ***munitions***
  - ***equipment***
  - ***clothing***
  - ***training devices***
  - ***other materiel systems***

Health Hazards

SPECIFIC OBJECTIVES:

1. Preserve and protect the health of the SOLDIER.
2. Improve SOLDIER performance and enhance SYSTEM effectiveness.
3. Enhance READINESS - Reduce health hazards causing training/operational restrictions.
4. Reduce SYSTEM design retrofits needed to control or eliminate health hazards.
5. Reduce PERSONNEL COMPENSATION - Eliminate or reduce injury/illness attributable to health hazards from the use of Army materiel.

Proponent & Regulations

- Proponent:
  Army Surgeon General.
- Governing Regulations:
  - DOD 5000 Series.
  - AR 70-1, Army Acquisition Policy.
  - AR 40-10, Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process.
- Lead Agent (1995): USACHPPM.

Health Hazard Categories Addressed by the HHA Program

ACOUSTIC ENERGY
- **Impulse Noise**
- **Blast Overpressure**
- **Steady-state Noise**

BIOLOGICAL SUBSTANCES
- **Field Sanitation & Hygiene**
- **Poisonous Plants & Animals**

CHEMICAL SUBSTANCES

RADIATION ENERGY
- **Radio Frequency/Ultrasound**
- **Laser/Optical Radiation**
- **Ionizing Radiation**

SHOCK
- **Rapid Acceleration/Deceleration**

TRAUMA
- **Sharp/Blunt Impact**
- **Musculoskeletal Trauma**

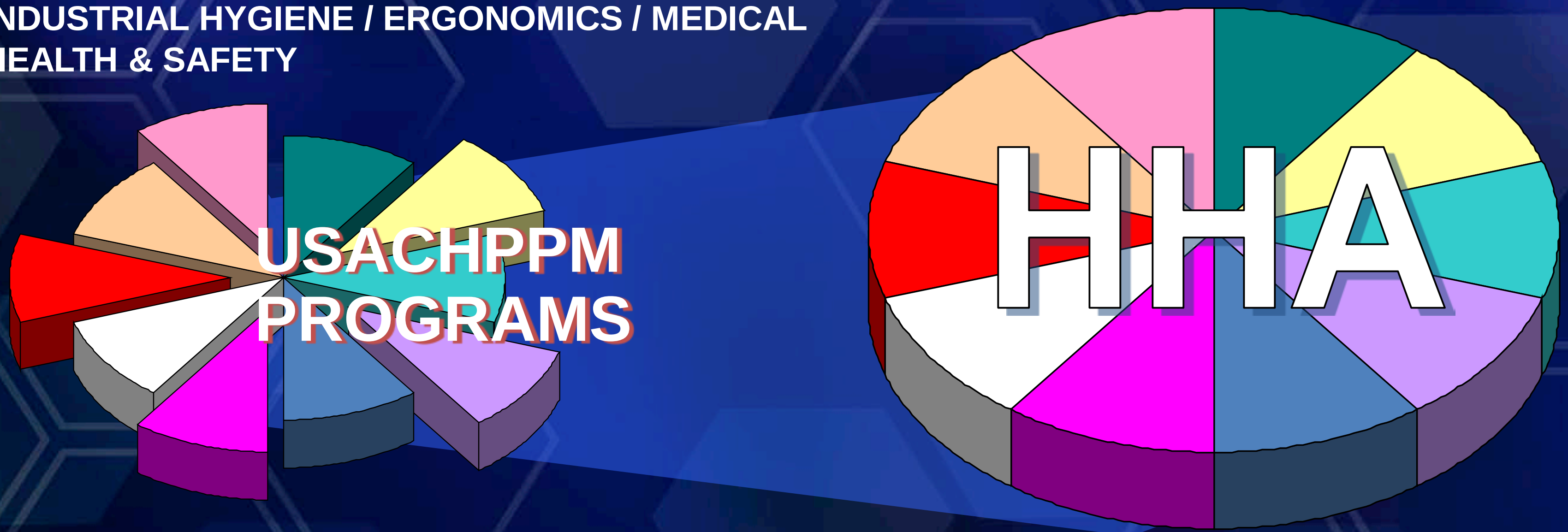
VIBRATION
- **Whole-body (multiple shock)**
- **Segmental**

TEMPERATURE EXTREMES
- **Heat/Cold**

OXYGEN DEFICIENCY
- **High Altitude/Confined Spaces**
- **Ventilation**

Matrixed USACHPPM Support

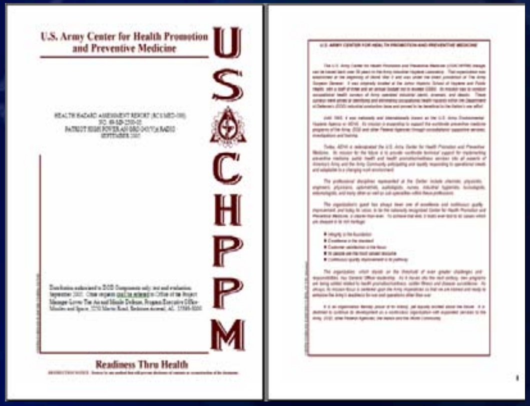
- ENVIRONMENTAL HEALTH ENGINEERING
- HEALTH HAZARD ASSESSMENT
- ARMY HEARING PROGRAM
- ENTOMOLOGICAL SCIENCES
- INDUSTRIAL HYGIENE / ERGONOMICS / MEDICAL HEALTH & SAFETY



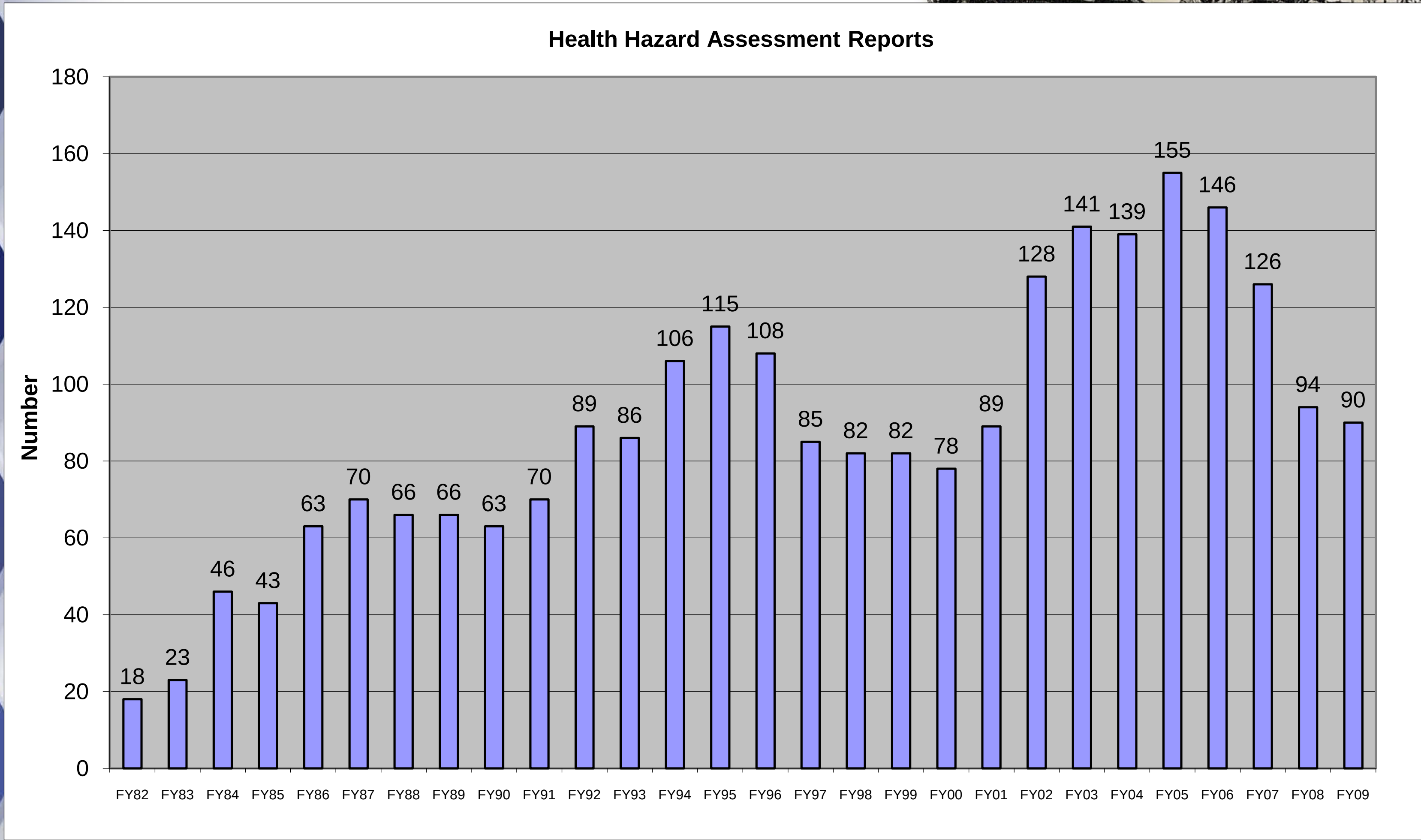
- HEALTH PHYSICS
- TOXICITY EVALUATION
- LASER-OPTICAL RADIATION
- RADIOFREQUENCY/ULTRASOUND
- OCCUPATIONAL MEDICINE

Mission Services

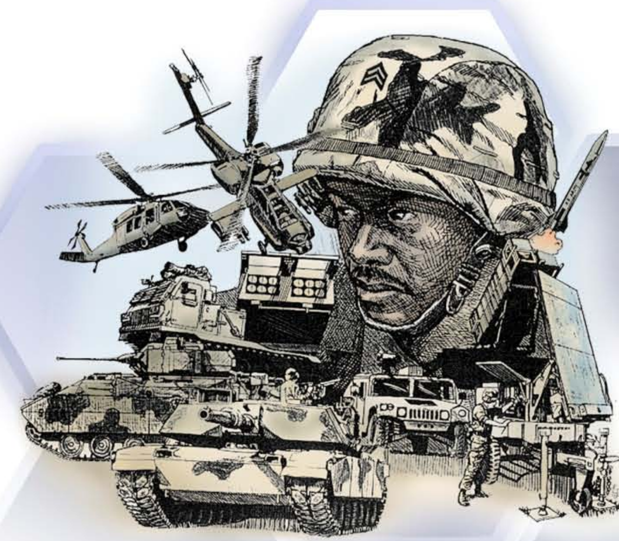
- Health Hazard Assessment Reports
- System Safety IPT Participation
- Manpower and Personnel Integration (MANPRINT) IPT Participation
- Acquisition Document Review
- Weapons Review Board & Committee Membership
- Uniformed Services University Support



Health Hazard Assessment Reports



Health Hazard Assessment Report

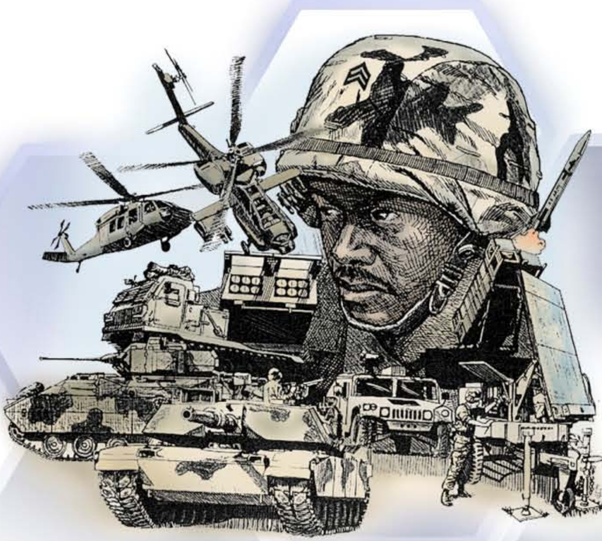


- Provides MATDEVs & CBTDEVs an estimate of OH risk associated with “normal use” of items.
- Not intended to provide an all-inclusive medical assessment or USAMEDD approval to use an item.
- Mishaps, accidents, or equipment failures resulting in injuries, although sometimes health-related, do not fall within the scope (Safety).

Health Hazard Assessment Report does not address….

- Environmental Quality (EIS)
- Safety (SAR)
- Survivability/lethality (SSV)
- Human Factors Engineering (HFE)
- System performance/effectiveness

Health Hazard Assessment Report Assessment Standards



- Applies OSHA 29 CFR 1910 and other non-DOD regulatory health standards to military-unique equipment, systems, and operations, insofar as practicable.
- OSHA Standards are generally designed for 8-hr exposures and may not be applicable for 24-hr exposures, multiple exposures, or short duration at high level exposures typical of military-unique applications.

Health Hazard Assessment Report

- When military-unique design, specification, or deployment requirements render compliance with existing OH standards infeasible or inappropriate, or when no standard exists for military-unique applications, the Army will use the health risk management process to develop military-unique OH standards.

Requesting a Health Hazard Assessment Report

- http://chppm-www.apgea.army.mil/
- Click on "Request USACHPPM Services"
- Complete the "Request for CHPPM Products and Services" form
- Upload/submit a signed memorandum on letterhead
- Upon acceptance, the HHA-PO:
  - contacts Client
  - develops project plan
  - sends SOW & MIPR Request
  - opens an official HHA project in the OPM Application
- Provide all data/test results and materiel system information relevant to HHA at least 90 working days in advance of the anticipated publication date.

HHA Program TDA

LCMC = Life Cycle Management Command
CECOM = Communications-electronics Command
PEO = Program Executive Office
JPEO = Joint Program Executive Office
C3T = Command, Control, Communications (Tactical)
EIS = Enterprise Information System
IEWS = Intelligence, Electronic, Warfare & Sensors
JTRS = Joint Tactical Radio Sets
AMCOM = Aviation & Missile Command
STRI = Simulation, Training, & Instrumentation
TACOM = Tank-automotive and Armaments Command
CS/CSS = Combat Support & Combat Service Support
GCS = Ground Combat Systems
JM&L = Joint Munitions & Lethality
FCS = Future Combat Systems
CBD = Joint Chemical & Biological Defense
EFV = Expeditionary Fighting Vehicale

Program Manager
Dr. Timothy Kluchinsky

Secretary
Ms. Rachel Mitchell

LCMC CECOM (+)
PEO C3T
PEO EIS
PEO IEWS
JPEO JTRS

Mr. Robert Gross

LCMC AMCOM (+)
PEO Aviation
PEO Missiles
PEO STRI

Mr. Robert Ehmann

LCMC TACOM
PEO CS/CSS
PEO Soldier
PEO GCS

Mr. Robert Batts

LCMC JM&L (+)
PEO Ammunition
PEO Integration

Mr. David Segure

JPEO CBD
PM EFV (U.S.M.C.)

Mr. Brett Huntington

	Total	Civilian	Military	Contractors
REQUIREMENTS	15	11	4	0
AUTHORIZATIONS	5	3	2	0
ON BOARD	7	7	0	0
			Source 0310 Approved TDA	

Health Hazard Assessment Project Officers & SMEs

- Review historical HH data on similar items.
- Review health surveillance and safety data.
- Review designs, use scenarios, exposure criteria & data.
- Make recommendations to control or eliminate HH.
- Assign a RAC & residual RAC when applicable.
- Support the PM's risk management decision process.
- Support acquisition Milestone Decision Reviews, safety releases/confirmations, materiel releases, and other events.
- 2010: Will provide an estimate of Medical Cost Avoidance.

HHA and Risk Management Model

Acquisition Program Manager

- Cost
- Performance
- Schedule

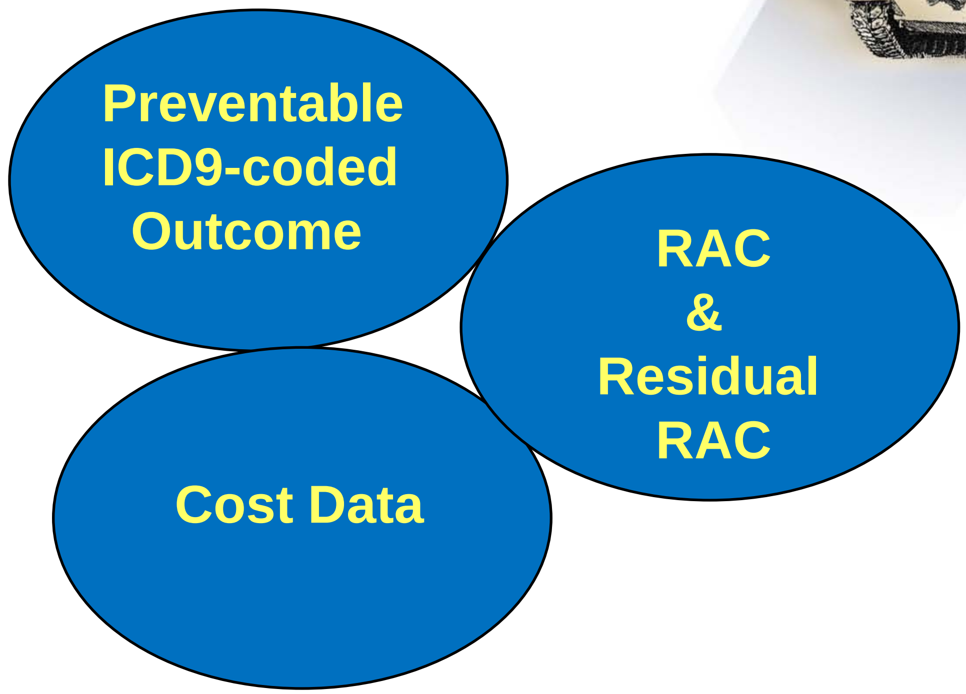
Medical Cost Avoidance

Preventable
ICD9-coded
Outcome

RAC
&
Residual
RAC

Cost Data

Medical Cost Avoidance



Medical Cost Avoidance

Preventable
ICD9-coded
Outcome

RAC
&
Residual
RAC

Cost Data

Health Hazard Categories Addressed by the HHA Program

ACOUSTIC ENERGY
- **Impulse Noise**
- **Blast Overpressure**
- **Steady-state Noise**

BIOLOGICAL SUBSTANCES
- **Field Sanitation & Hygiene**
- **Poisonous Plants & Animals**

CHEMICAL SUBSTANCES

RADIATION ENERGY
- **Radio Frequency/Ultrasound**
- **Laser/Optical Radiation**
- **Ionizing Radiation**

SHOCK
- **Rapid Acceleration/Deceleration**

TRAUMA
- **Sharp/Blunt Impact**
- **Musculoskeletal Trauma**

VIBRATION
- **Whole-body (multiple shock)**
- **Segmental**

TEMPERATURE EXTREMES
- **Heat/Cold**

OXYGEN DEFICIENCY
- **High Altitude/Confined Spaces**
- **Ventilation**





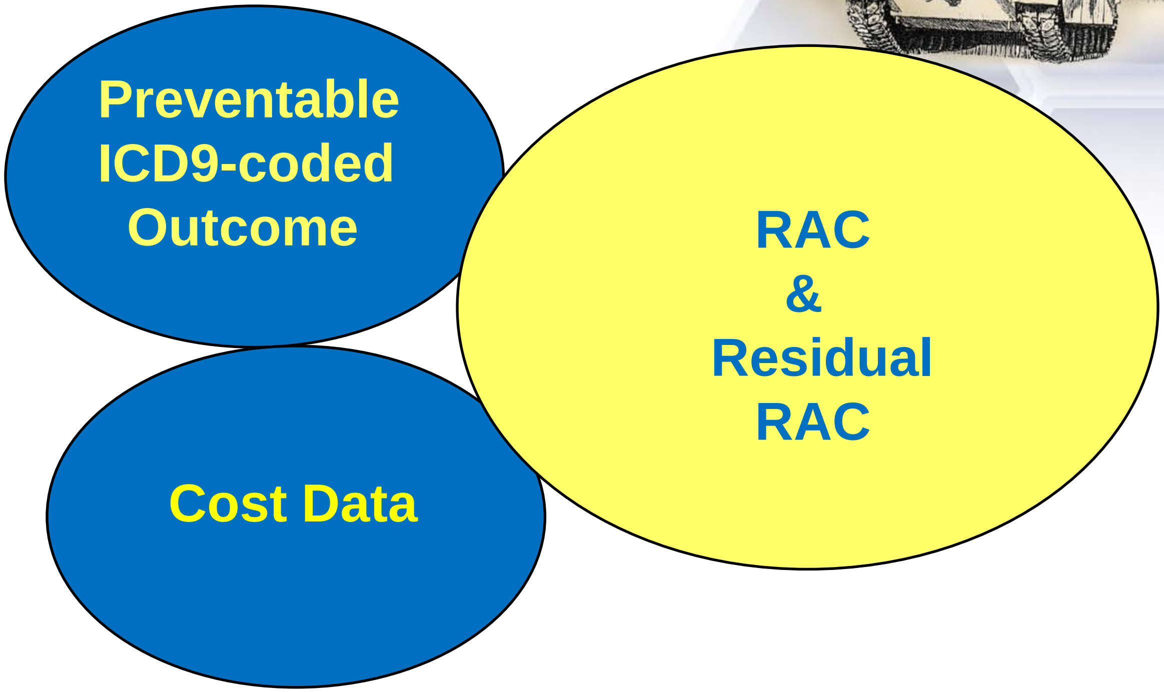
International Classification of Diseases (ICD-9) Categories Used in the Model

ICD-9 Category	ICD-9 Descriptor
001-139	Infectious and Parasitic Diseases
140-239	Neoplasms
240-279	Endocrine, Nutritional, and Metabolic Diseases, and Immunity Disorders
280-289	Diseases of the Blood and Blood-Forming Organs
290-319	Mental Disorders
320-389	Diseases of the Nervous System and Sense Organs
390-459	Diseases of the Circulatory System
460-519	Diseases of the Respiratory System
520-579	Diseases of the Digestive System
580-629	Diseases of the Genitourinary System
630-677	Complications of Pregnancy, Childbirth, and the Puerperium
680-709	Diseases of the Skin and Subcutaneous Tissue
710-739	Diseases of the Musculoskeletal System and Connective Tissue
740-759	Congenital Anomalies
760-779	Certain Conditions Originating in the Perinatal Period
780-799	Symptoms, Signs, and Ill-Defined Conditions
800-999	Injury and Poisoning
V01-V83	Supplementary Classification of Factors Influencing Health Status and Contact with Health Services

Veterans Administration Schedule for Rating Disabilities (VASRD) Codes used in the Model

VASRD Code	VASRD Descriptor
50	Bones and Joints Disease
60	Eye and Visual Acuity
61 & 62	Ear, Smell, and Taste
63	Systemic Disease
65	Nose and Throat
66	Trachea and Bronchi
67	TB, Lungs, and Pleura
68	Non-TB Diseases
70	Heart Diseases
71	Arteries and Veins
72 & 73	Digestive System
75	Genitourinary System
76	Gynecological
77	Hemic and Lymphatic
78	Skin
79	Endocrine System
80 - 87	Organic Disease Central Nervous System
89	Epilepsies
90 & 92	Psychotic Disorders
91 & 93	Organic Brain Disorders
94 & 95	Psychoneurological Disorders
99	Dental and Oral

Medical Cost Avoidance



Risk Assessment Codes

High ⟷ Low

Hazard Severity	Hazard Probability				
	A	B	C	D	E
I	1	1	1	2	3
II	1	1	2	3	4
III	2	3	3	4	5
IV	3	4	5	5	5

High ↕ Low

*AR 40-10

Hazard Severity Categories		
Numerical Designation	**Classification**	**Possible Hazard Outcomes**
I	**Catastrophic**	**May cause death or total loss of a bodily system**
II	**Critical**	**May cause severe bodily injury, severe occupational illness, or major damage to a bodily system**
III	**Marginal**	**May cause minor bodily injury, minor occupational illness, or minor damage to a bodily system**
IV	**Negligible**	**Would cause less than minor bodily injury, minor occupational illness, or minor damage to a bodily system**

Hazard Probability Categories			
Descriptive Word	**Level**	**Specific Individual Item**	**Fleet or Inventory**
Frequent	**A**	**Likely to occur frequently**	**Continuously experience**
Probable	**B**	**Will occur several times in the life of an item**	**Will occur frequently**
Occasional	**C**	**Likely to occur some time in the life of an item**	**Will occur several times**
Remote	**D**	**Unlikely but possible to occur in the life of an item**	**Unlikely but can reasonably be expected to occur**
Improbable	**E**	**So unlikely, it can be assumed occurrence may not be experienced**	**Unlikely to occur, but possible**

Risk Assessment Codes

High ⟷ Low

Hazard Severity	Hazard Probability				
	A	B	C	D	E
I	1	1	1	2	3
II	1	1	2	3	4
III	2	3	3	4	5
IV	3	4	5	5	5

High ↕ Low

*AR 40-10

Risk Assessment Codes

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	1	1	1	2	3
II (0.1)	1	1	2	3	4
III (0.01)	2	3	3	4	5
IV (0.001)	3	4	5	5	5

High ↕ Low

*AR 40-10

Risk Assessment Codes

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	1	1	1	2	3
II (0.1)	1	1	2	3	4
III (0.01)	2	3	3	4	5
IV (0.001)	3	4	5	5	5

High ↕ Low

*AR 40-10

Risk Assessment Codes

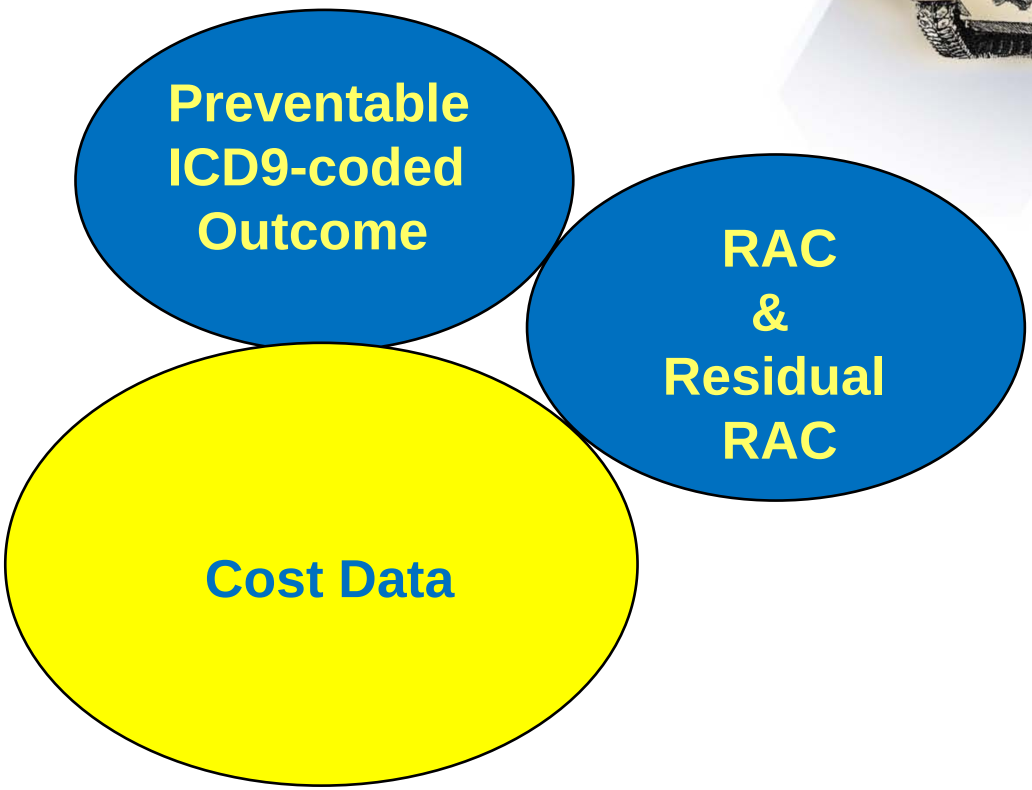
High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	1	1	1	2	3
II (0.1)	1	1	2	3	4
III (0.01)	2	3	3	4	5
IV (0.001)	3	4	5	5	5

High ↕ Low

*AR 40-10

Medical Cost Avoidance



Medical Cost Avoidance Model (MCAM)

Quantifies hazard specific costs by using the following data sources:

- MHS Direct Care and Population Data (M2)
- Army Physical Disability Agency Data
- Military Personnel Cost Data
- VA Disability Compensation Data

Medical Cost Avoidance Model (MCAM)

Quantifies hazard specific costs by using the following data sources:

- MHS Direct Care and Population Data (M2)
- Army Physical Disability Agency Data
- Military Personnel Cost Data
- VA Disability Compensation Data

M2 Beneficiary Population Data Elements Used in the Model

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
AGE	Pseudo Sponsor ID	Pseudo Sponsor ID
BENCAT	Bed Days Civilian Hospital, Total	Encounters, Total
DODOCC	Bed Days in ICU, Total	Full Cost, Total
FM	Bed Days, Total	Price, Total
FY	Convalescent Leave Days, Total	Variable Cost, Total
GENDER	Cooperative Care Days, Total	Age
MARSTAT	Dispositions, Total	APG, Med
PSUEDOID	Full Cost, Total	APG, Med Desc
FMP	Medical Hold Days, Total	APG, E&M
CTCHDMIS	Price, Total	APG, E&M Desc
CTCHNAME	Quarter Days, Total	APG Proc 1
RACEETH	RWP, Total	APG Proc 2
GRADE	Sick Days this MTF, Total	APG Proc 3
SERVICE	Supplemental Care Days, Total	APG Proc 4
RACE	Variable Cost, Total	Beneficiary Category
	Admission Date	Catchment Area ID
	Beneficiary Category	Catchment Area Name
	Catchment Area ID	Diagnosis 1
	Catchment Area Name	Diagnosis 2
	Diagnosis 1	Diagnosis 3
	Diagnosis 2	Diagnosis 4
	Diagnosis 3	Disposition Code
	Diagnosis 4	E&M Code
	Diagnosis 5	FY
	Diagnosis 6	FM
	Diagnosis 7	FMP
	Diagnosis 8	Gender
	Disposition Status Code	Inpatient Indicator
	FY	Marital Status
	Diagnostic Related Group (DRG)	MEPRS (3) Code
	FM	Patient Category
	Procedure 3	Sponsor Pay Grade
	Procedure 4	Sponsor Service
	Procedure 5	Tmt Parent DMIS ID
	Procedure 6	Tmt Parent DMIS Name
	Procedure 7	Tmt Service Clinic
	Procedure 8	

M2 Beneficiary Population Data Elements[a] Used in the Model

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
	Pseudo Sponsor ID	
	FMP	
	Race	
	Sponsor Pay Grade	
	Sponsor Service	
	Tmt Parent DMIS ID	
	Tmt Parent DMIS Name	
	Service Date	
	Clinical Service, Admitting	
	Clinical Service, Dispositioning	
	Clinical Service, Second	
	Clinical Service, Third	
	Length Of Stay	Procedure 1
	Age	Procedure 2
	Gender	Procedure 3
	Marital Status	Procedure 4
	Patient Category	Pseudo Sponsor ID
	Procedure 1	Race

Notes:
[a] Data Sources for Beneficiary Population data included Defense Enrollment Eligibility Reporting System (DEERS), Standard Inpatient Data Record (SIDR), and Standard Ambulatory Data Record (SADR)

Medical Cost Avoidance Model (MCAM)

Quantifies hazard specific costs by using the following data sources:

- MHS Direct Care and Population Data (M2)
- Army Physical Disability Agency Data
- Military Personnel Cost Data
- VA Disability Compensation Data

Army Physical Disability Agency (APDA) Data

- Obtained from APDA in 2001.
- Contained decisions of 1980-1999.
- Used to determine disability-related percentages for:
  - Degree of Disability
  - Disposition Category
    - Fit for Duty
    - Separation
    - Permanent Disability Retirement
    - Temporary Disability Retirement

Medical Cost Avoidance Model (MCAM)

Quantifies hazard specific costs by using the following data sources:

- MHS Direct Care and Population Data (M2)
- Army Physical Disability Agency Data
- Military Personnel Cost Data
- VA Disability Compensation Data

Table 6-1-7

Army Population by Rank and AMCOS Lite Personnel Cost[a]

Military Pay Grade	Population	AMCOS Lite Personnel Cost	Total Personnel Cost for Grade
O-10	10	$229,450	$2,294,500
O-9	40	$207,210	$8,288,400
O-8	103	$192,086	$19,784,858
O-7	147	$234,309	$34,443,423
O-6	3,805	$195,119	$742,427,795
O-5	9,124	$197,795	$1,804,681,580
O-4	14,035	$160,565	$2,253,529,775
O-3	24,264	$118,844	$2,883,630,816
O-2	9,553	$98,082	$936,977,346
O-1	6,704	$81,330	$545,236,320
WO-5	419	$140,503	$58,870,757
WO-4	1,598	$125,569	$200,659,262
WO-3	3,553	$110,467	$392,489,251
WO-2	4,624	$94,659	$437,703,216
WO-1	2,070	$79,841	$165,270,870
E-9	3,439	$143,011	$491,814,829
E-8	11,232	$117,761	$1,322,691,552
E-7	37,573	$106,787	$4,012,307,951
E-6	56,197	$92,299	$5,186,926,903
E-5	74,076	$78,084	$5,784,150,384
E-4	118,874	$62,944	$7,482,405,056
E-3	61,607	$55,054	$3,391,711,778
E-2	31,705	$52,975	$1,679,572,375
E-1	16,521	$50,255	$830,262,855
CADETS	4,101	$18,221	$74,724,321
Total Officer	84,150		$10,561,012,490
Total Enlisted	411,224		$30,181,843,683

Notes:
[a] AMCOS Lite data included major cost categories of Military Personnel-Account (MPA); Operations & Maintenance, Army (OMA); and Other. More specific breakouts within these categories were listed in AMCOS and included under the MPA Category: military compensation, officer acquisition costs, other benefits, permanent change of station costs, retired pay accrual, separation costs, special pays, and training; under the OMA Category: medical support costs, morale, welfare and recreation costs, and officer acquisition costs; and under the Other Category: training.

Medical Cost Avoidance Model (MCAM)

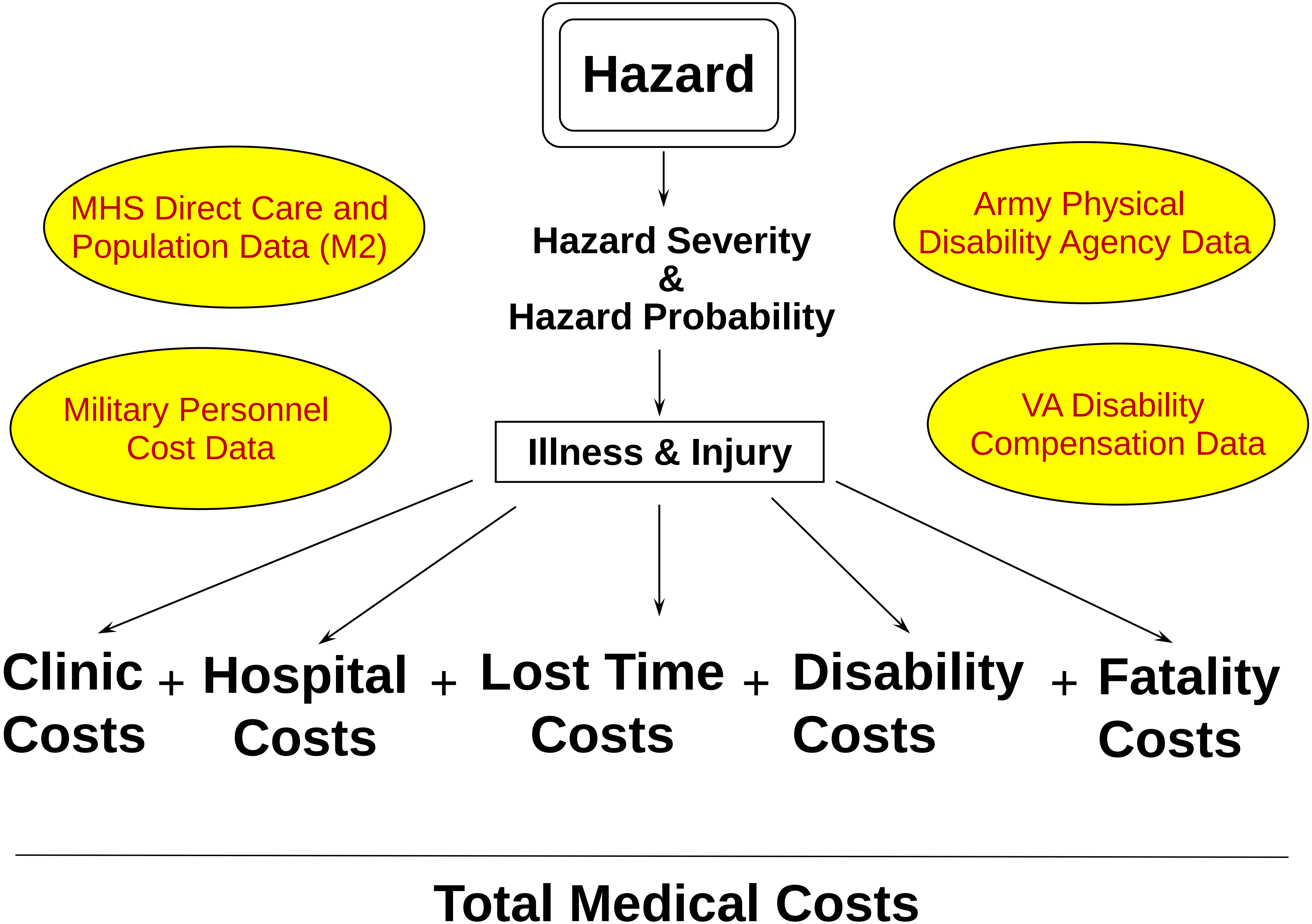
Quantifies hazard specific costs by using the following data sources:

- MHS Direct Care and Population Data (M2)
- Army Physical Disability Agency Data
- Military Personnel Cost Data
- VA Disability Compensation Data

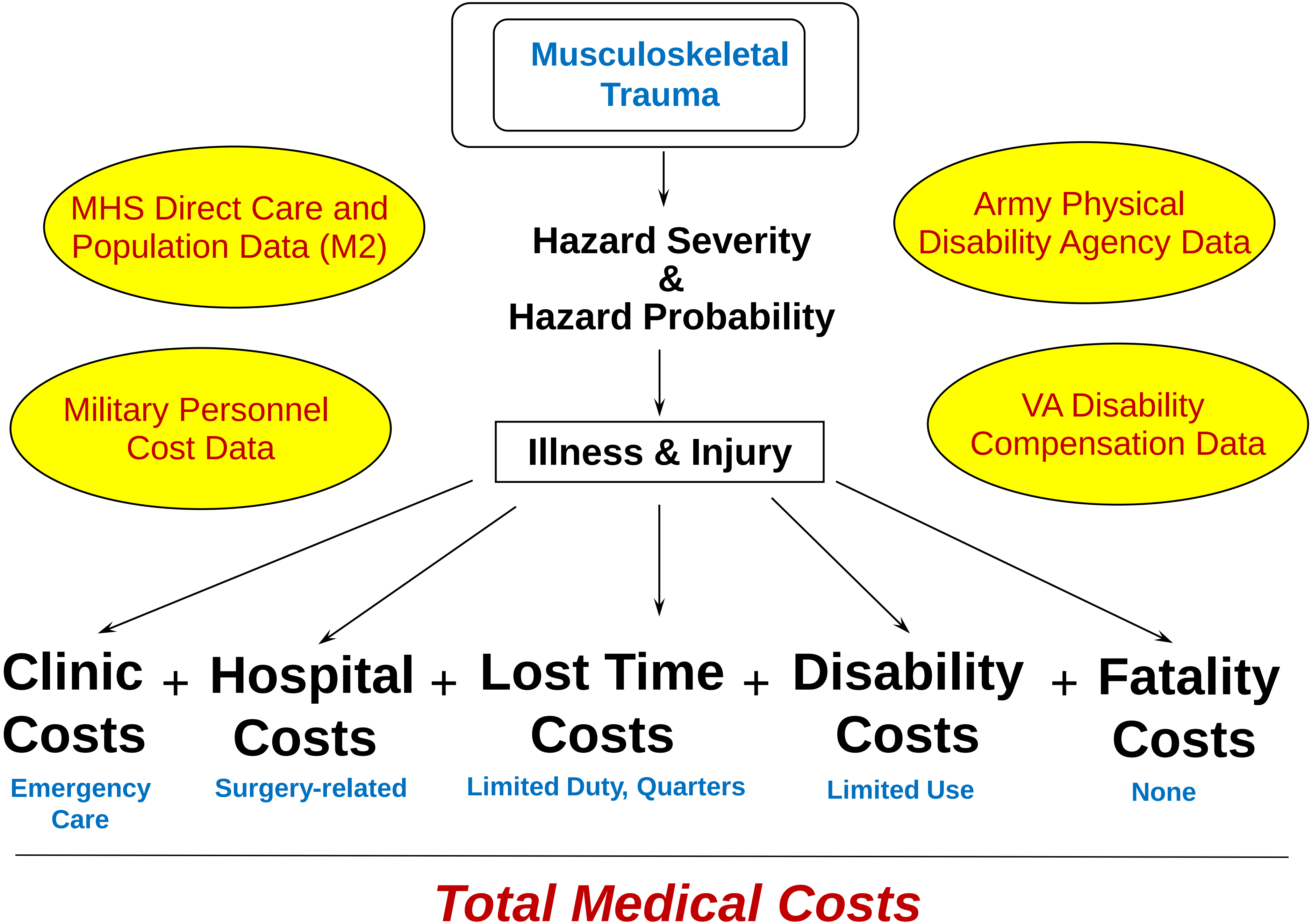
Veterans Affairs Compensation Rate Table

Percentage[a]	Rate[b]
10%	$106
20%	$205
30%	$316
40%	$454
50%	$646
60%	$817
70%	$1,029
80%	$1,195
90%	$1,344
100%	$2,239

Notes:
[a] Degree of disability
[b] Monthly rate of compensation

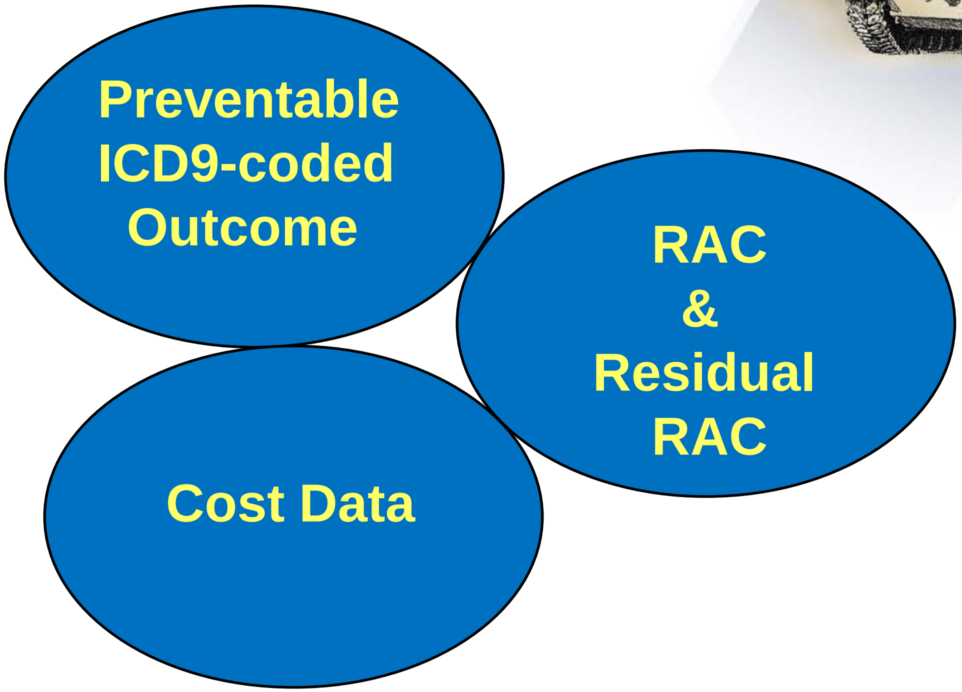


Hazard
Hazard Severity
&
Hazard Probability
MHS Direct Care and Population Data (M2)
Military Personnel Cost Data
Army Physical Disability Agency Data
VA Disability Compensation Data
Illness & Injury
Clinic Costs
+
Hospital Costs
+
Lost Time Costs
+
Disability Costs
+
Fatality Costs
Total Medical Costs



Musculoskeletal Trauma
MHS Direct Care and Population Data (M2)
Army Physical Disability Agency Data
Hazard Severity & Hazard Probability
Military Personnel Cost Data
VA Disability Compensation Data
Illness & Injury
Clinic Costs + Hospital Costs + Lost Time Costs + Disability Costs + Fatality Costs
Emergency Care
Surgery-related
Limited Duty, Quarters
Limited Use
None
Total Medical Costs

Medical Cost Avoidance



Overall Cost Elements, Type, Description, and Source

$$C_T = C_c + C_h + C_l + C_d + C_f$$

Cost Element	Type	Description	Source
C_T	Variable	Overall costs related to unabated health hazards	Calculated by model application
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_h	Variable	Cost of hospitalization (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_l	Variable	Cost of days of lost time	Calculated by model application
C_d	Variable	Cost of disability	Calculated by model application
C_f	Variable	Cost of fatalities	Calculated by model application

Overall Cost Elements, Type, Description, and Source

$$C_T = C_c + C_h + C_l + C_d + C_f$$

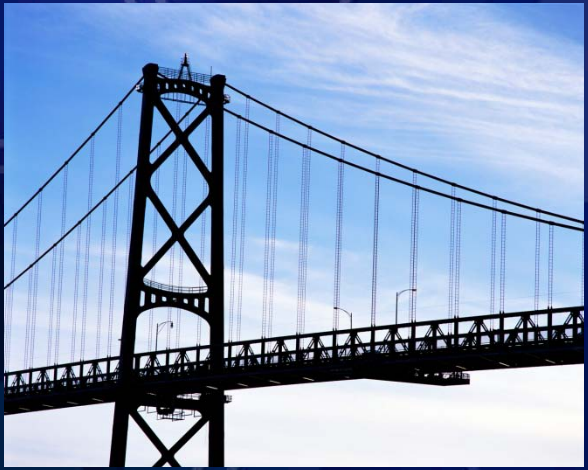
Cost Element	Type	Description	Source
C_T	Variable	Overall costs related to unabated health hazards	Calculated by model application
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_h	Variable	Cost of hospitalization (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_l	Variable	Cost of days of lost time	Calculated by model application
C_d	Variable	Cost of disability	Calculated by model application
C_f	Variable	Cost of fatalities	Calculated by model application

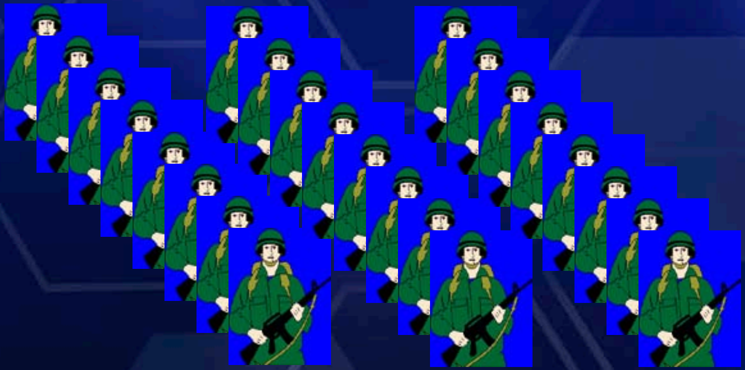
Clinic Cost Elements, Type, Description, and Source

$$C_c = P_e \times N_s \times N_{ps} \times S_k \times I_c \times C_a \times N_v$$

Cost Element	Type	Description	Source
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Clinic visit incidence for injury/illness	Model application (Calculated from M2 clinical data)
C_a	Constant (for each hazard)	Average clinic visit cost (includes associated pharmaceutical and laboratory costs)	Model application (Calculated from M2 clinical data)
N_v	Constant (for each hazard)	Number of clinic visits per injury/illness (includes follow-up visits within 30 day initial visit)	Model application (Calculated from M2 clinical data)

Example





117 Bridge Systems

24 Soldiers/system

N = 2808 Exposures

Health Hazard Categories Addressed by the HHA Program

ACOUSTIC ENERGY
- **Impulse Noise**
- **Blast Overpressure**
- **Steady-state Noise**

BIOLOGICAL SUBSTANCES
- **Field Sanitation & Hygiene**
- **Poisonous Plants & Animals**

CHEMICAL SUBSTANCES

RADIATION ENERGY
- **Radio Frequency/Ultrasound**
- **Laser/Optical Radiation**
- **Ionizing Radiation**

SHOCK
- **Rapid Acceleration/Deceleration**

TRAUMA
- **Sharp/Blunt Impact**
- **Musculoskeletal Trauma**

VIBRATION
- **Whole-body (multiple shock)**
- **Segmental**

TEMPERATURE EXTREMES
- **Heat/Cold**

OXYGEN DEFICIENCY
- **High Altitude/Confined Spaces**
- **Ventilation**

*Measuring **Baseline** Costs*: Musculoskeletal Trauma*

High ⟷ Low

Hazard Severity (High ↕ Low)	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$3,184	$1,769	$708	$35	$4
II (0.1)	$318	$177	$71	$4	$0
III (0.01)	$32	$18	$7	$0	$0
IV (0.001)	$3	$2	$1	$0	$0

*Each cell depicts the average medical costs per Soldier exposure

*Measuring **Total Annual** Costs*: Musculoskeletal Trauma*

High ⟷ Low (Hazard Probability)

High ↕ Low (Hazard Severity)

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$8,904	$4,967	$1,987	$99	$10
II (0.1)	$894	$497	$199	$10	$1
III (0.01)	$89	$50	$20	$1	$0.1
IV (0.001)	$9	$5	$2	$0.1	$0.01

*Thousands of dollars: n = (117 Systems) (24 Soldier/system) = 2808 Soldiers

Health Hazards Risks for the Bridge

Worst Case

Health Hazard Category	Hazard Type (n)	Risk Assessment Code (HS, HP)	Residual Risk Assessment Code (HS, HP)	Medical Costs Avoided 1-Year
Trauma	Musculoskeletal (n=24)	2 (II, C)	5 (IV, C)	$196,686
				Total = $196,686

*Measuring **Total Annual** Costs*: Musculoskeletal Trauma*

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$8,904	$4,967	$1,987	$99	$10
II (0.1)	$894	$497	$199	$10	$1
III (0.01)	$89	$50	$20	$1	$0.1
IV (0.001)	$9	$5	$2	$0.1	$0.01

High ↕ Low

*Thousands of dollars: n = (117 Systems) (24 Soldier/system) = 2808 Soldiers

*Measuring **Total Annual** Costs*:*
Musculoskeletal Trauma

High ⟷ Low

Hazard Severity	Hazard Probability				
	A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	$8,904	$4,967	$1,987	$99	$10
II (0.1)	$894	$497	$199	$10	$1
III (0.01)	$89	$50	$20	$1	$0.1
IV (0.001)	$9	$5	$2	$0.1	$0.01

High ↕ Low

*Thousands of dollars: n = (117 Systems) (24 Soldier/system) = 2808 Soldiers

Health Hazards Risks for the Bridge

Worst Case

Health Hazard Category	Hazard Type (n)	Risk Assessment Code (HS, HP)	Residual Risk Assessment Code (HS, HP)	Medical Costs Avoided 1-Year
Trauma	Musculoskeletal (n=24)	2 (II, C)	5 (IV, C)	$196,686
				Total = $196,686

Health Hazards Risks for the Bridge
117 Systems

Health Hazard Category	Hazard Type (n)	Risk Assessment Code (HS, HP)	Residual Risk Assessment Code (HS, HP)	Medical Costs Avoided 1-Year
~~Trauma~~	~~Musculoskeletal (n=24)~~	~~2 (II, C)~~	~~5 (IV, C)~~	~~$196,686~~
Trauma	Musculoskeletal (Top Panel, n=5)	2 (II, C)	5 (IV, C)	$40,976
Trauma	Musculoskeletal (Bottom Panel, n=5)	5 (IV, C)	5 (IV, C)	0
Trauma	Musculoskeletal (Deck, n=2)	5 (IV, C)	None	$166
Trauma	Musculoskeletal (Long Ramp, n=7)	5 (IV, C)	5 (IV, C)	0
Trauma	Musculoskeletal (Junction Panel, n=5)	2 (II, C)	3 (III, C)	$37,251
				Total = $78,393

Total 1-year lifecycle costs for the unabated health hazards of the Bridge

Hazard Type	Outpatient	In-Patient	Lost time	Fatality	Disability	Total
WORST CASE						
Musculoskeletal (n=24)	$1,511	$4,285	$133,338	$0	$57,552	**$196,686**
ACTIVITY BASED						
Musculoskeletal (Top Panel, n=5)	$315	$893	$27,779	$0	$11,990	$40,976
Musculoskeletal (Bottom Panel, n=5)	$0	$0	$0	$0	$0	$0
Musculoskeletal (Deck, n=2)	$1	$4	$112	$0	$48	$166
Musculoskeletal (Long Ramp, n=7)	$0	$0	$0	$0	$0	$0
Musculoskeletal (Junction Panel, n=5)	$286	$811	$25,253	$0	$10,900	$37,251
						$78,393

Total 20-year lifecycle costs for the unabated health hazards of System X

Hazard Type	Clinic	Hospital	Lost time	Fatality	Disability	Total
Weapons combustion products	$338,000	$116,700	$44,724,400	$21,600	$3,919,400	$49,120,100
Fire extinguishing agents	$7,500	$2,600	$993,900	$500	$87,000	$1,091,500
Carbon dioxide	$400	$100	$49,700	$0	$4,400	$54,600
Impulse noise	$100	$1,100	$19,400	$0	$1,100	$21,700
Steady-state noise	$100	$1,100	$19,400	$0	$1,100	$21,700
Cold stress	$400	$0	$52,300	$0	$700	$53,400
Heat stress	$400	$0	$47,600	$0	$900	$48,900
Oxygen deficiency (ventilation)	$400	$1,200	$36,500	$0	$500	$38,600
Non-ionizing radiation	$100	$0	$9,700	$0	$200	$10,000
Ionizing radiation	$0	$0	$6,600	$0	$100	$6,700
						$50,467,200

Model Assumptions

- Clinic visit time = 2 hours.
- Limited (temporary restricted) duty duration = 15 days.
- Quarters duration = 3 days.
- Convalescent leave duration = 30 days.
- Limited duty = reduced productivity of 30%.
- Inflation factor = $(1.0204)^{\text{No. Yrs.}}$
- Fatality costs = $674,375.

Model Limitations

- Purchased care (Non-MHS) data is not included.
- Estimates based on worst-case crew position.
- Uses Army-based incidence rates, rather than military occupational specialty (MOS) incidence rates.
- Does not estimate materiel-related pollution prevention costs.
- Does not estimate abatement costs.
- Does not estimate costs to acquire and train replacements.
- Does not estimate family quality of life costs.

MCAM Peer Review

- Textbook of Military Medicine, Chapter X
- Injury Prevention Report No.12-HF-04MT-08
  - Defense Safety Oversight Council
  - *“Preventing Injuries in the U.S. Military: The Process, Priorities, and Epidemiological Evidence”*
- American Journal of Preventive Medicine (Jan 2010)

Questions?

NORTHROP GRUMMAN

T&E Collaboration and Contributions During Early Program Acquisition

NDIA Systems Engineering Conference
San Diego California October 26th – 29th 2009

Stephen J Scukanec
Flight Test and Evaluation
Aerospace Systems
Northrop Grumman Corporation

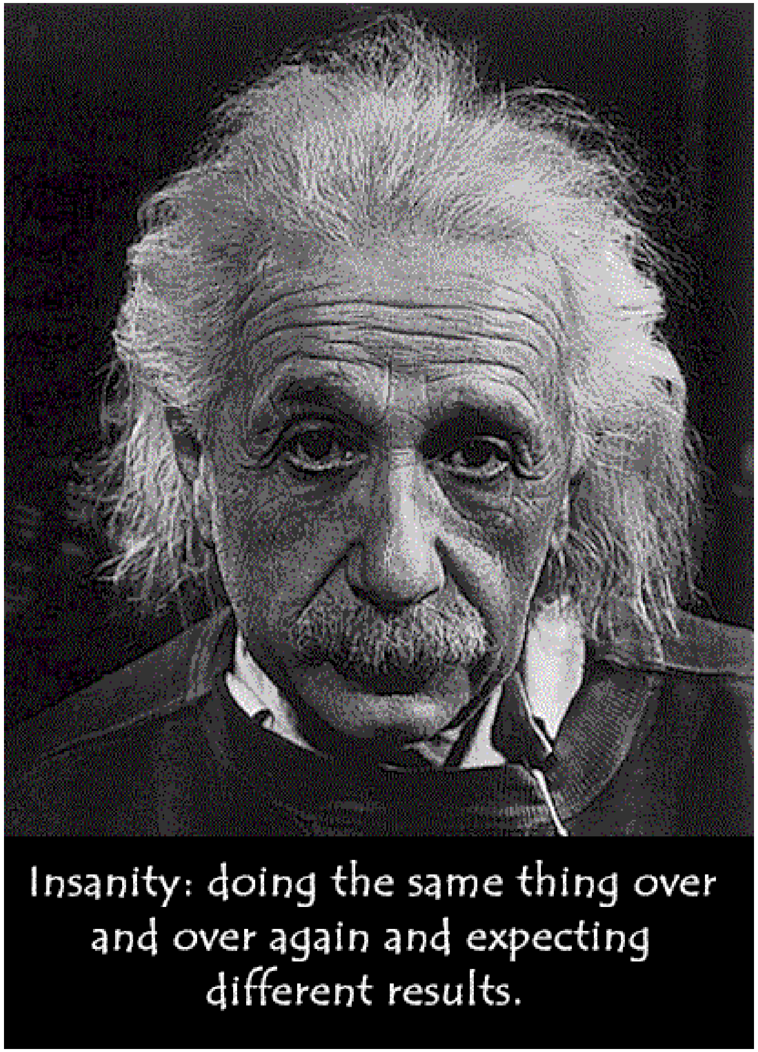
Background

Why Programs Fail

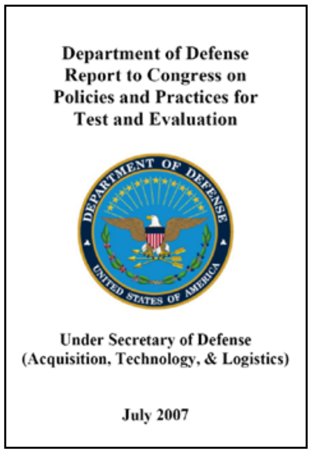
- My observations since last year…[1]
- Programs usually fail because we don't start them right:
  - Requirements instability/creep –not well defined, not understood
  - Inadequate early technical planning
  - Inadequate funding or phasing of funding to properly execute the program
  - Lack of schedule realism –success oriented, concurrent, poor estimation/planning
  - Lack of technical maturity or a credible back-up plan –"we're always optimistic"
  - Limited focus on life cycle issues
- What we need from you…[1]
  - Tell your leadership that Dr. McQueary and Dr. Finley are focused on starting programs right!
  - We are working daily to improve communication, both in DoD and with Industry
  - We are looking to improve competition and time to field capabilities

1 - The Honorable- James I. Finley- Deputy Under Secretary of Defense (Acquisition & Technology) - October 23, 2007 NDIA Systems Engineering Conference – Keynote Address

Insight


Insanity: doing the same thing over
and over again and expecting
different results.

Section 231 Report to Congress Core T&E Principles


Department of Defense
Report to Congress on
Policies and Practices for
Test and Evaluation

Under Secretary of Defense
(Acquisition, Technology, & Logistics)

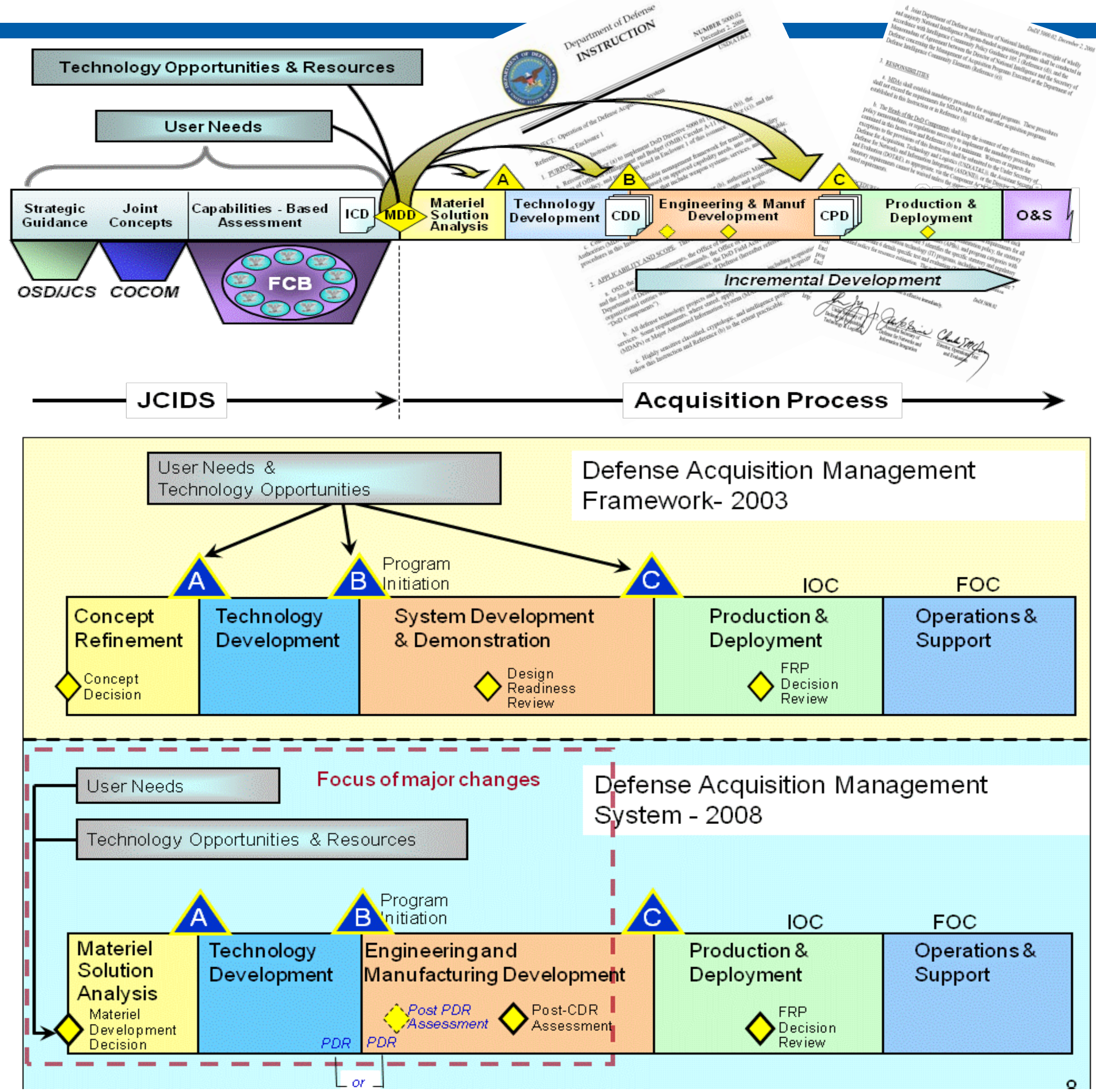
July 2007

DoD Report To Congress	Influence on T&E Program
“ What is important to the user is strengths and weaknesses, capabilities and limitations, not specification compliance.”	Avoid “Mindless Specification Verification”. Provide a Realistic Test Environment
“Along with the notion of experimentation is the consequence that testing and evaluation should be a continual process of information gathering for decision-making.”	Early Test and Evaluation Should be Conducted to Support the Early Program Milestones Including the Evaluation of the System Architecture and the Design and Not Just Focus on Verification and Acceptance
“In early testing, as a part of good systems engineering, the objective should not be a binary outcome but rather an exploration of system capabilities.”	Evaluate to and beyond the limits of the design. Ensure the Proper Environmental Effect are a Part of your Testing Program. Ensure data is Collected In Evaluation beyond the Pass Fail Borders

Reference :DoD Report to Congress on Policies and Practices for Test and Evaluation Contracts – July 2007

Major Attributes of Revision

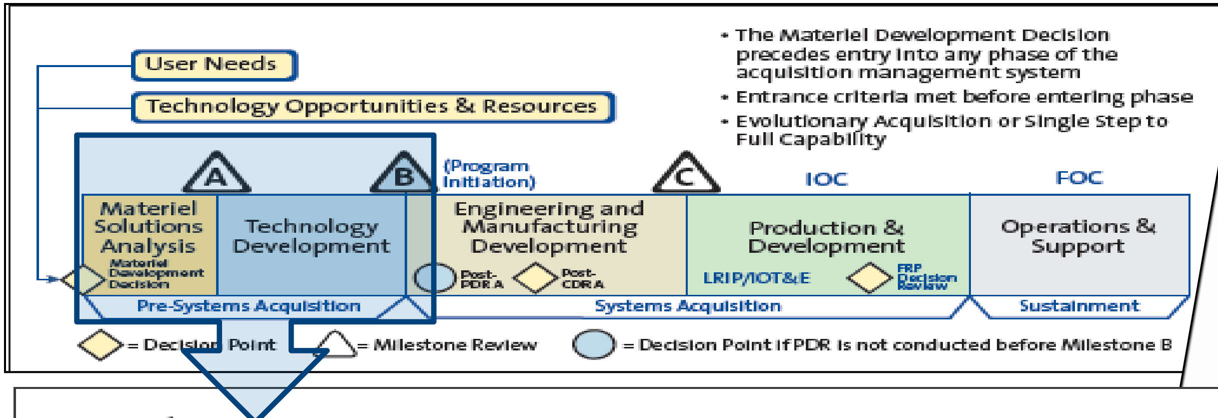
- **Earlier definition of scope, risk and cost**
  - **Mandatory entry point**
- **Risk Reduction**
  - **Competitive prototyping**
  - **Highly integrated T&E**
  - **Apply a rigorous System Engineering Discipline**
  - **Evolutionary acquisition <u>(NOT spiral development)</u>**
- **Enhanced Oversight**
  - **More/more frequent assessments**
  - **Peer reviews**
  - **Configuration Steering Boards**

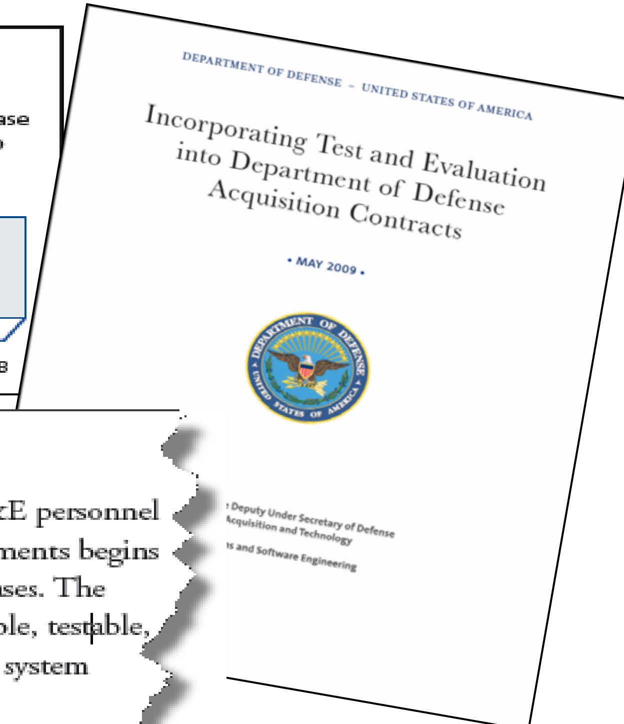


DOD Instruction 5000.02 Operation of the Defense Acquisition System

Incorporating T&E Into Programs

NORTHROP GRUMMAN





2.1 Planning

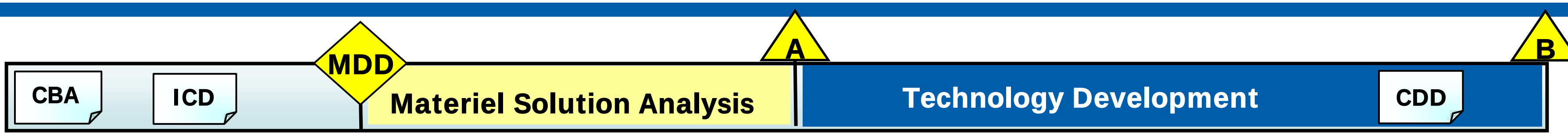
During the program life cycle it is critical that the PM, systems engineer, and T&E personnel recognize that early and consistent incorporation of T&E considerations and requirements begins at the onset of program planning during the Materiel Solutions Analysis and TD phases. The program acquisition strategy must be grounded in a technical approach with achievable, testable, and measurable performance requirements and reliability metrics embodied in viable system solutions that are within cost and schedule constraints.

Consistent incorporation of T&E considerations and requirements begins at the onset of program planning during the Materiel Solutions Analysis and TD phases.

This is not Business As Usual

What Can the Program Do To Incorporate These Changes?

NORTHROP GRUMMAN



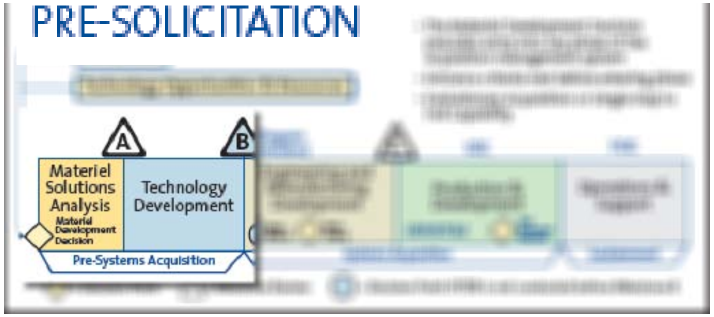
Activity	Systems Engineering	Test and Evaluation
Prototyping & Risk Reduction	**Prototyping (Technology and Design)**	**Early involvement of testers, …as a program conducts pre-system acquisition activities, especially prototype testing. The T&E Strategy should be consistent with and complementary to the Systems Engineering Plan (SEP).**
	TRL Maturation	**Include TRL Maturation plans in T&E Master Plan and TES**
	SE Support for Technology Risk Reduction	**The TES describes, in as much detail as possible, the risk-reduction efforts across the range of activities**
	Oversight of Competitive Designs	**Oversight of Competitive Test Programs, Facilities and Teaming Coordination as required**
	Risk Assessment	**Participate in Risk Assessment Activities**
Input to Acquisition/ Planning, CARD, Budget and Other	**SE in Contract Requirements**	**T&E in contract requirements**
	SE Input into the post-PDR Report, report to MDA, Acquisition Strategy, TEMP, CARD, and the ICE	**The SEP, SSP, RMP, and the resulting RFP should integrate the T&E policy directives and best practices from government and industry**
Evidence of Strong SE Activity	**PDR and Post-PDR Report and Assessment**	**PDR and Post-PDR Report and Assessment**
	Tech Reviews up to and including PDR	**Support technical reviews, Test Readiness Reviews, acceptance requirements, and schedule.**
	SEP	**TES and TEMP**
	Strong Reliability, Availability and Maintainability (RAM)	**Include RAM program in T&E Strategy**
Inputs to Requirements	**Systems Requirements Definition**	**Ensure T&E approach can satisfy Requirements verification approach**
	RAM and Sustainability	**Include RAM program in T&E Strategy**

Reference DAG Sections 4.3.1 and 4.3..2

Reference Incorporating Test and Evaluation into Department of Defense Acquisition Contracts • MAY 2009 • Sections 2 and 3

Additional T&E Activities Needed in the Pre-solicitation "Early" Phase

NORTHROP GRUMMAN



6 Important PM and team T&E Considerations When Beginning pre-solicitations activities

The PM and team, and the program, must be prepared to enter the EMD phase with cost, schedule, and expected system performance requirements balanced and synchronized. Six important PM and team T&E considerations when beginning pre-solicitation activities are as follows:

1. **Select a Domain – Experienced Contractor With Proven Performance**

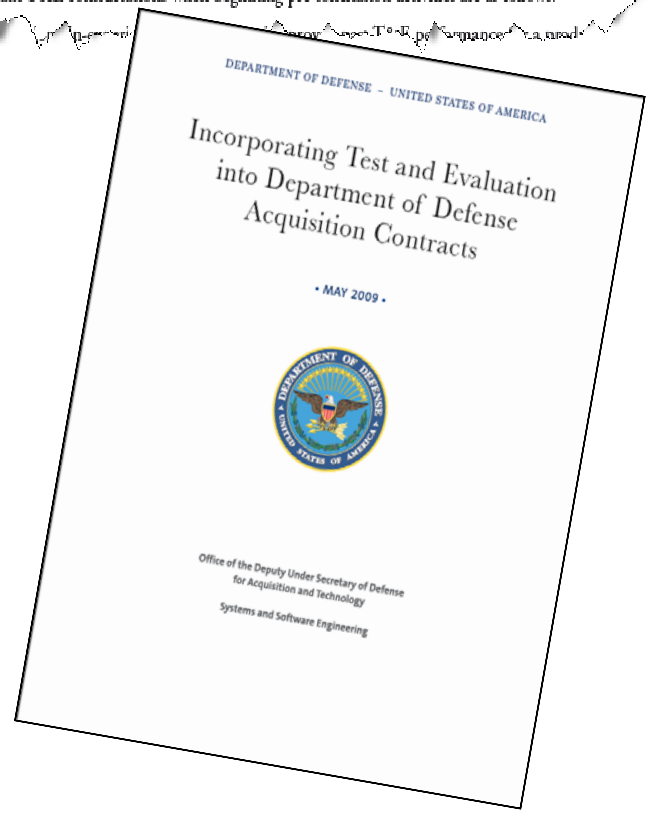
2. **The SEP, SSP, RMP, and the resulting RFP should integrate the T&E policy directives and best practices from government and industry.**

3. **Ensure the integrated T&E strategy and approach address the total life cycle of the program**

4. **Ensure the specific test ranges/facilities and test support equipment are identified for each type of testing.**

5. **Incorporate T&E requirements in budgets and cost estimates**

6. **Consider Joint Interoperability Test Command (JITC) interoperability and Net-Ready Key Performance Parameter (NR-KPP) certification**


DEPARTMENT OF DEFENSE – UNITED STATES OF AMERICA

Incorporating Test and Evaluation into Department of Defense Acquisition Contracts

• MAY 2009 •

Office of the Deputy Under Secretary of Defense for Acquisition and Technology

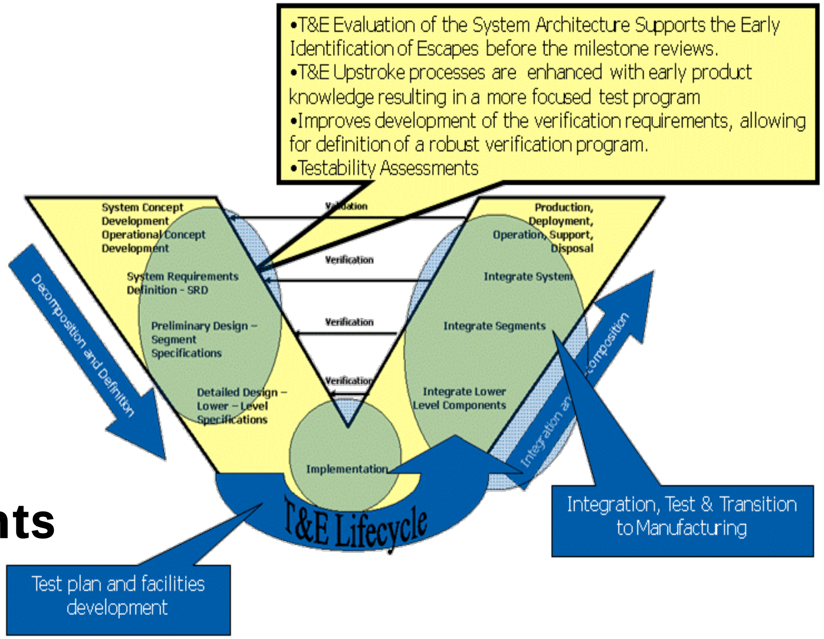
Systems and Software Engineering

Incorporating T&E into DoD Acquisition Contracts May - 2009

What Can T&E Do To Help The Process?

NORTHROP GRUMMAN

- Architecture Process
  - Test Architecture
    - Physical
    - Functional
- Requirements Process
  - Identify "Not Testable Requirements"
  - Develop Unique Test Requirements
    - Become Requirements "Owners" For Unique Testing Requirements Imposed on the Design
  - Provide T&E Skills in the Development of Verification Statements



Get Involved Early

9/29/2009 Cleared For Public Release 09-1777

Early T&E Activity Benefits

Architecture Development	
Activity	**Benefit**
Architecture Tested for •Errors / Holes •Limits •Testability	Evaluated System Architecture Prior to Requirements Development. Know that the System Architecture has already been "Tested"

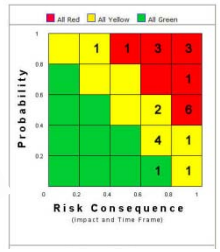
Requirements Development	
Activity	**Benefit**
Develop Unique Test Design Requirements	Ensure Complete Requirements Set is developed – No Late to need requirements developed for test program imposed late on the design
Provide skill mix for development of Verification Requirements	Complete and Concurred with Requirements Verification Criteria
Assess Requirements Verifiability	Complete Requirements Validation Check, Provide Independent Assessment of Requirements Verifiability at Program Reviews

T&E and SE Working Together to Achieve Early Program Milestones Benefits The Entire Program Lifecycle

Additional Early T&E Activity Established By Policy

NORTHROP GRUMMAN

3. Ensure the integrated T&E strategy and approach address the total life cycle of the program



- "What is important to the user is strengths and weaknesses, capabilities and limitations, not specification compliance."

b. The PM, in concert with the user and the T&E community, shall coordinate DT&E, OT&E, LFT&E, family-of-systems interoperability testing, information assurance testing, and modeling and simulation (M&S) activities, into an efficient continuum, closely integrated with requirements definition and systems design and development.

- **Align Early Test Planning with Program Risk Planning**
- **Conduct early Test Planning**
  - **Develop Flow Down of TES and TEMP to Test Program**
  - **Establish Major Test Range Coordination**
  - **Ensure the integrated T&E strategy and approach address the total life cycle of the program and include an event-based T&E approach that is not schedule-driven but consists of logically sequenced test events**
- **Develop Operational Based Test Parameters to be Applied to Verification Plan and Integrated Test Plan**
- **Coordinate the DT and OT Test Communities Early**

Starting Early on Lifecycle Planning and Coordination Supports Policy and Law

How Did We Do?

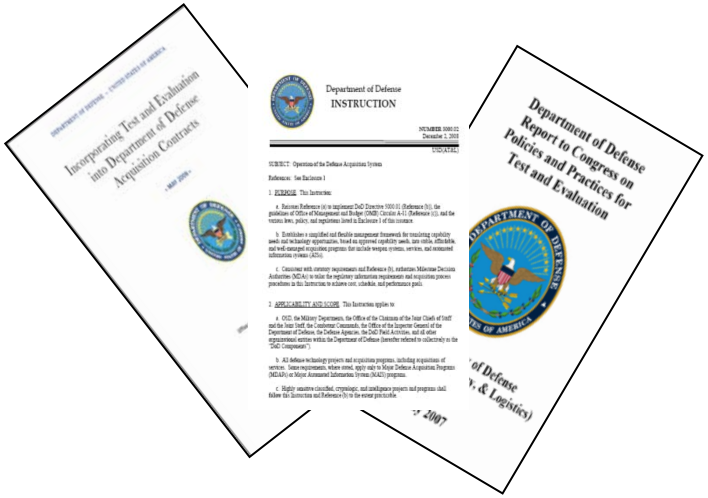
NORTHROP GRUMMAN

Problem	T&E Contribution to Solution
Requirements instability/creep –not well defined, not understood	T&E Skill Mix Can Support Architectural Evaluations and Requirements Development and Verification Criteria
Inadequate early technical planning	Integrated DT&OT – TES and TEMP integrated with Contractor Experience
Inadequate funding or phasing of funding to properly execute the program	Program Managers Must Account for Early T&E Skill Mix – T&E Skill must Contribute to Early Program Milestones
Lack of schedule realism –success oriented, concurrent, poor estimation/planning	Include an event-based T&E approach that is not schedule-driven
Lack of technical maturity or a credible back-up plan –“we’re always optimistic”	T&E Supports the Technology Development Phase and Risk Reduction Programs
Limited focus on life cycle issues	T&E Strategy, Planning, and Execution Must Address the Entire Program Lifecycle

T&E Skill Mix Contributions Early Help Ensure Program Success

9/29/2009 Cleared For Public Release 09-1777

Conclusions



- Policy and Law now <u>Mandate</u> Early and Integrated T&E Participation Within Acquisition Programs
- T&E Can Enhance and help Validate Early System Engineering Products
  - T&E Unique Skill Mix Can Aide In the Development of The Product Architecture and Requirements
- The Programs Lifecycle Must be Included Within the Requirements and Test Program
- Programs Can No Longer Minimize the Needs For T&E in Early Program Phases

Programs Must Ensure That T&E Is Integrated Early – Budgeted Early – Tasked Early

Early Systems Engineering Initiative

Dr Brian W Kowal
HQ AFMC/EN
28 October 2009

Purpose

- Status AFMC Early Systems Eng Initiative
- Summarize Recent Changes
- Identify Weak Areas
- Suggest Improvements

Topics

- Initiative Motivation
- Early Acquisition Process Studies
- Core Problems
- Opportunity and New Challenges
- History and Current Approach
- Shortfalls
- Possible Improvements

Initiative Motivation

- **GAO Defense Acquisitions Study – April 2009**
  - **MDAP initial capability delivery delay 22 months**
  - **Total acquisition cost increase 25%**

- **Weapons Systems Acq Reform Act of 2009**
  - **Overwhelming Congressional approval**
  - **Indicative of significant concern with DoD acquisition**

70-75% Cost Decisions Made Pre-MS A*

Richard Andrews, 2003, *An Overview of Acquisition Logistics*.

Core Problems

- Inadequate Milestone Information
  - Senior leadership cannot accurately assess concept
  - No process for defining/providing required data
  - Impacts acquisition decision process

- Analysis of Alternatives Take Too Long
  - Average AoA two years … max around six years
  - Inadequate/Insufficient pre-AoA Information

AFMC Opportunity

- Acquires Most AF Weapon Systems
- Manages $59B Annually (41% of AF Budget)
- Early Acquisition Process Involvement
- Systems Engineering Expertise

New Challenges

- **Joint Capabilities Integration and Development System (JCIDS) Changes**
  - **F-Studies eliminated**
  - **ICD no longer provides prioritized materiel solutions**
    - Rationale for a materiel solution
    - Increased AoA activity
- **DoDI 5000.02**
  - **New Materiel Development Decision Milestone (MDD)**
  - **New Materiel Solution Analysis Phase**

Little Guidance On Pre-MDD/Post ICD Acquisition Process

Specific Activities

- Pre-Acquisition Systems Engineering Process (PASEP) Study
- USAF Early Systems Engineering Guidebook
- Air Force Materiel Command Instruction 63-1201*
- Center for Systems Engineering Workshops

*Implementing Operational Safety, Suitability & Effectiveness and Life Cycle Systems Engineering

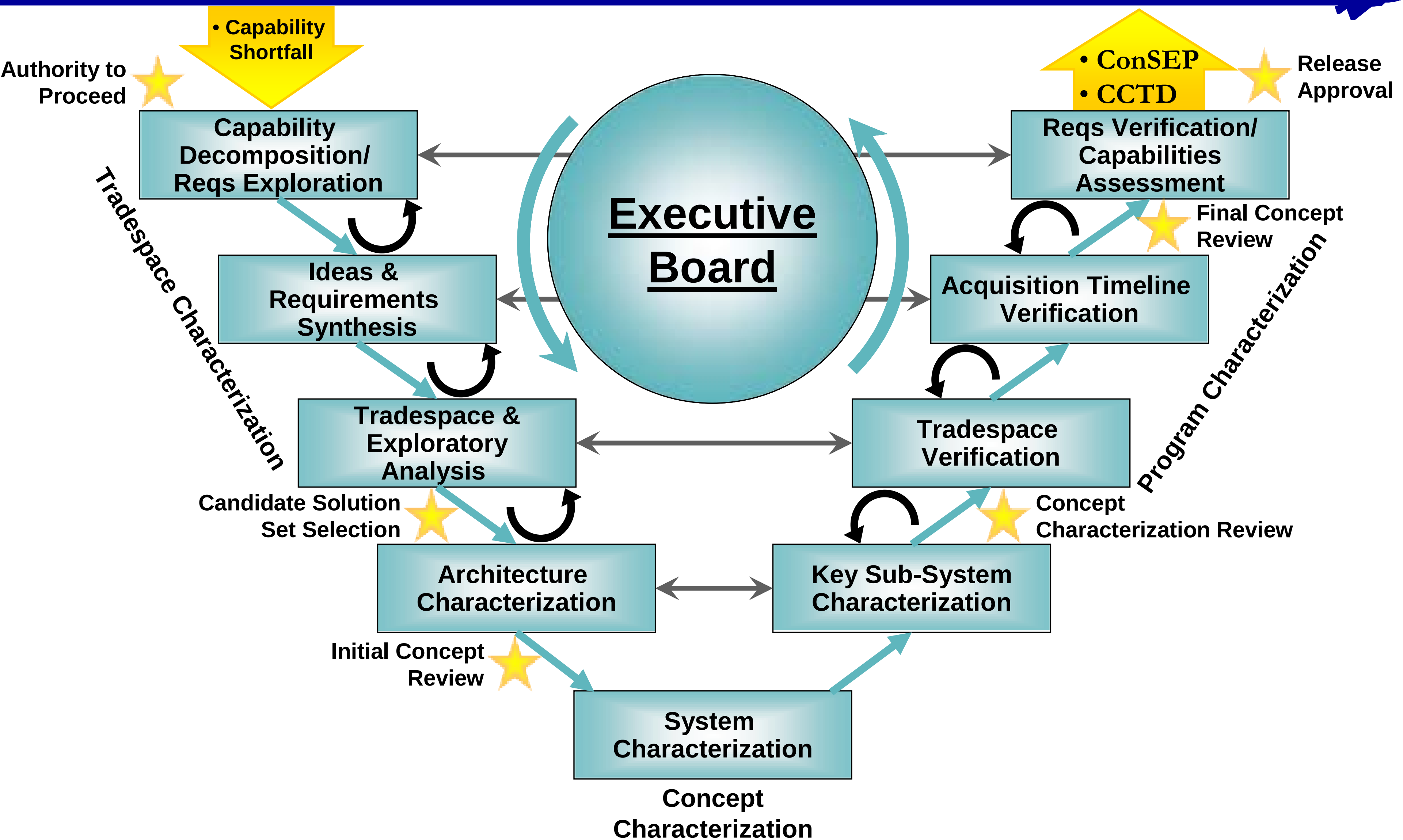
Pre-Acquisition Systems Engineering Process (PASEP)

- **Study commissioned by SAF/AQR in July 2006**
- **Objectives:**
  - **Develop & document a systems engineering process for developing pre-AoA materiel solutions**
  - **Validate the process using a case study with a stated capability shortfall & document the results**
- **Deliverables:**
  - **Systems Engineering Plan specifically tailored for pre-AoA material concepts**
  - **Characterization & technical data of the materiel solutions developed for the stated capability shortfall**

Important PASEP Results

- Concept Development Process Diagram
- Control Function Identification
- Concept Systems Engineering Plan
  - Organizational
  - Concept specific
- Concept Characterization & Technical Description (CCTD)

Pre-Acquisition Systems Engineering Process (PASEP) V-Chart



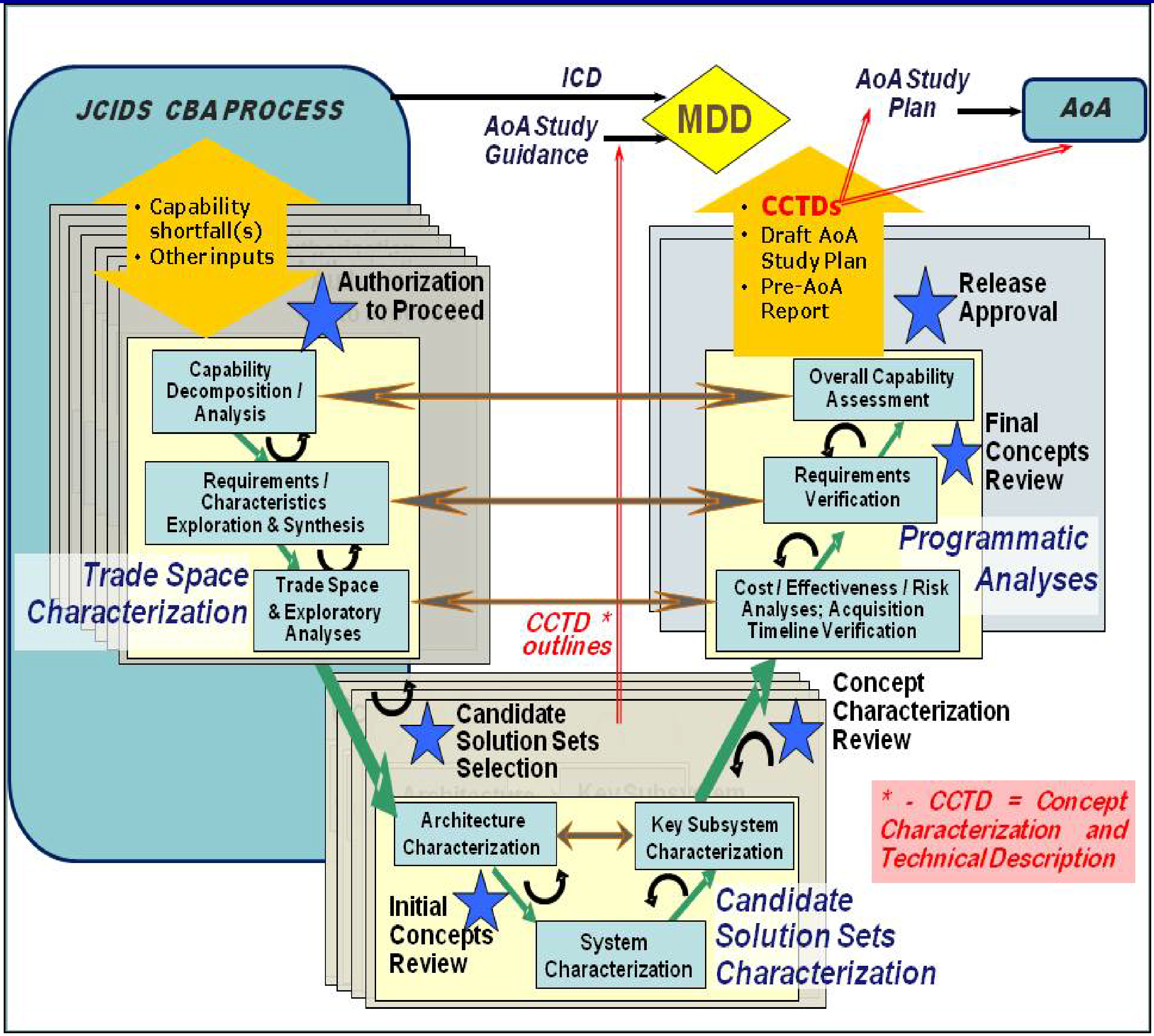
Early Systems Engineering Guidebook

- **Based On PASEP Results**
- **SAF/AQRE & HQ AFMC/ENS Authored**
  - **Expanded scope to entire Air Force**
  - **Published 31 March 2009**

Guidebook Changes From PASEP

- Modified Process Diagram
- Removed Control Function Guidance
- Eliminated Concept Specific ConSEP
- Revised CCTD Format

Early Systems Engineering Guidebook Process Diagram



Current Status

- **AFMC & SAF Guidance Memoranda**
  - **SAF/AQR released 19 December 2008**
  - **AFMC/EN released 18 February 2009**
  - **Concept Development (CD) Operating Instruction**
    - Equivalent to PASEP Organizational ConSEP
    - Standardized concept development processes

- **Draft AFMCI 63-1201**
  - **Document standard concept processes**
  - **CCTD required**
  - **Processes based on Early Systems Eng Guidebook**

AFMC Product Center CD Operating Instructions Published

Shortfalls

- **PASEP Process Relatively Immature**

- **Early Systems Engineering Guidebook**
  - **Based on PASEP**
  - **Includes non-systems engineering elements**

- **Some Key Study Findings Not Addressed**

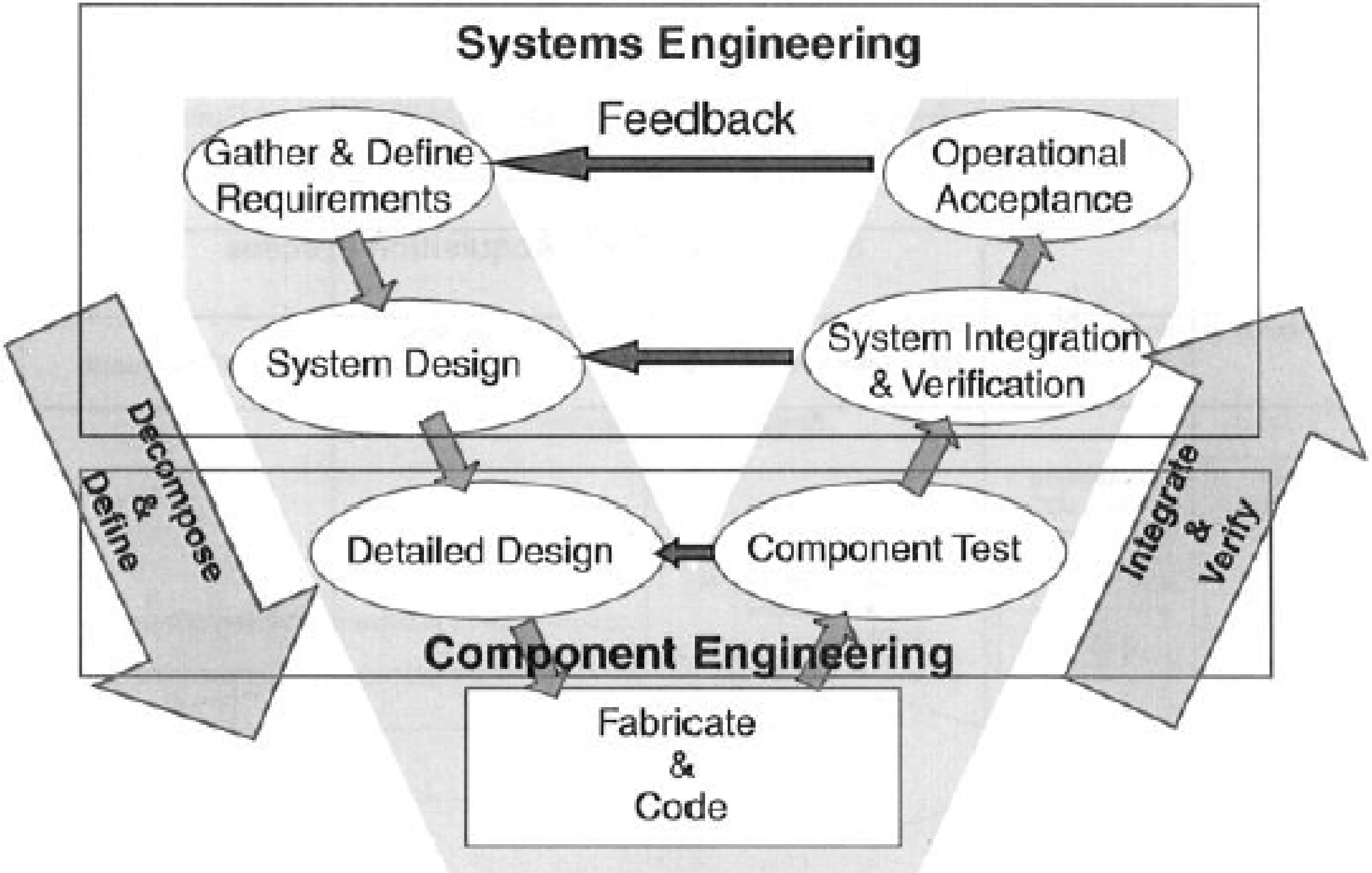
PASEP Systems Engineering Process

- Started July 2006 … completed February 2008
- Objective to develop and document a systems engineering process for developing pre-AoA materiel solutions
- Limited CCTD experience

Current Policy Based Largely On PASEP

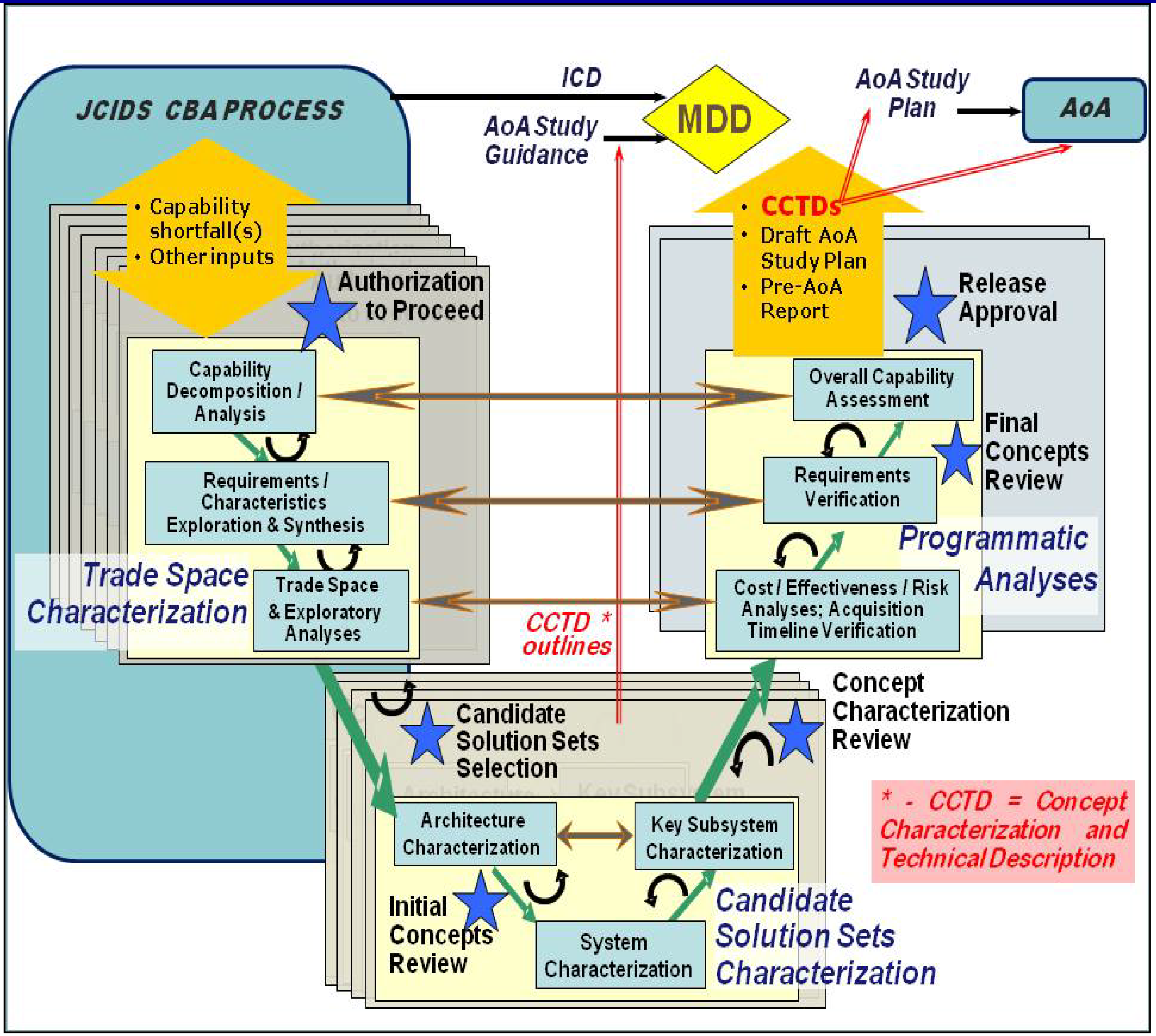
Early Systems Engineering Guidebook Weak Areas

Classic Systems Engineering Vee Diagram



Each step on the left of the "V" has a corresponding step on the right

Early Systems Engineering Guidebook "V" Diagram



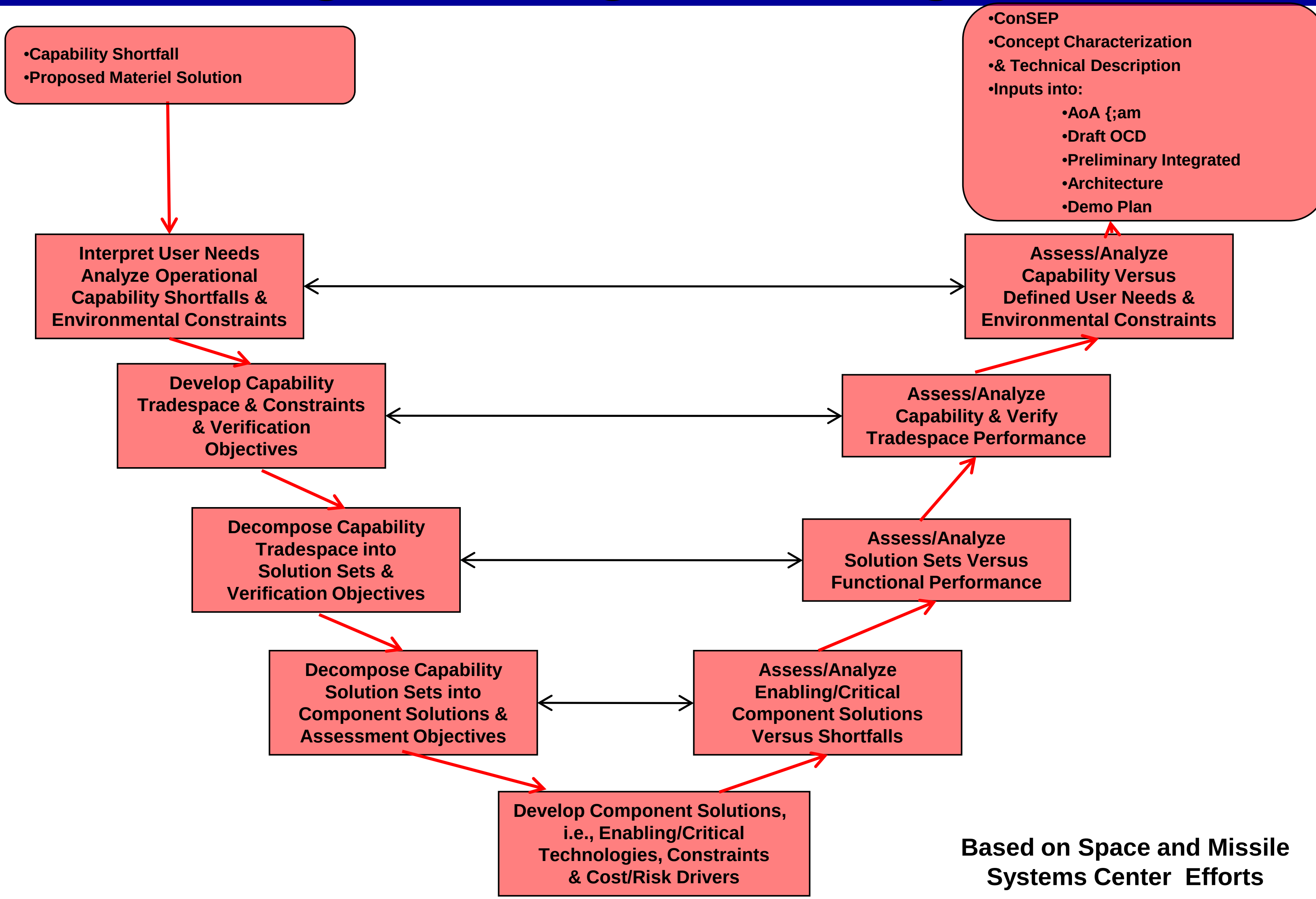
“Vee” Diagram Comparison

- Several ESE Guidebook “V” Elements Atypical
  - Cost analysis
  - Effectiveness analysis
- Not Clear How Sides Of “V” Relate
- Other Early Acquisition Processes
  - Cost est, schedule prediction, concept elim, etc.
  - Systems engineering combined with others on“Vee” diagram?

Early SE Guidebook “V” includes important steps …

Not all are systems engineering

Possible Pre-MDD Systems Engineering “V” Diagram



Based on Space and Missile Systems Center Efforts

Some Study Findings Not Addressed*

- **Inexperienced Leadership**
- **External Interface Complexity**
- **System Complexity**
- **Incomplete Requirements**
- **Immature Technology**
- **High Reliance On New Software**

*** The above is a partial list based only on the *National Research Council Pre-Milestone A and Early-Phase Systems Engineering Report.***

Recommendations

- **Build Upon Existing PASEP Process**
- **Address All Study Findings**
- **Concentrate On Systems Engineering**
- **Ensure Future Changes Cover Study Findings**
- **Adopt Greater Customer Focus**
  - **Engage early systems engineering customers**
    - Office of Aerospace Studies
    - Milestone Decision Authorities/PEOs
  - **Identify specific data needs (AoAs, MDDs, etc.)**
  - **<u>Document requirements</u>**
- **Apply Systems Engineering Process To Documented Requirements**

LEADING EDGE TECHNOLOGY • WORLD CLASS SUSTAINMENT • WAR-WINNING SYSTEMS

Study Recommendations

- **National Research Council, 2008**

  … better systems engineering could help shorten the time required for development making it more like what it was 30 years ago.

- **Defense Acquisition Performance Assessment, 2006**

  … a successful response to the instabilities caused by the current process or proper program initiation as envisioned requires early and detailed SE practices. (*DAPA Study committee member)*

- **Government Accountability Office, 2005**

  … employ the techniques of SE to close gaps between available technologies and customer needs before committing to new product development.

Methodology

- **Focus on early (pre-MDD) acquisition**
  - **High ability to influence LCC cost**
  - **No formal systems engineering process**
- **Address key study findings**
  - **Requirements definition**
  - **Technology immaturity**
- **Improve early <u>concept</u> definition**
  - **Enhanced Materiel Development Decision (MDD)**
  - **Faster and better AoAs**

Process Control Function

- Control Milestones
  - Strategically placed reviews w/ well defined entrance
    & exit criteria
  - Evaluates potential solutions for continuation and/or satisfactory progress
- Executive Board
  - Acts as gatekeeper for the process
  - Approving all Control Milestones and related materials, templates, etc.
  - Authority level corresponds to level of tasking

Concept Characterization & Technical Description (CCTD)

- Concept or Family of Concepts History
- Required For All
- Retained For Future Capability Needs
- Initiated Early During Pre-MDD Phase
- Includes:
  - Mission Statement & Requirements Synthesis
  - Research Summary
  - Trade Space Definition & Parametric Studies
  - Concept & Program Characterization
  - Final Conclusions & Recommendations

Concept Systems Engineering Plan (ConSEP)

- **Organizational ConSEP**
  - **Used as a general guide & systems engineering plan for developing concepts**
  - **Details:**
    - Organization & Responsibilities
    - Documentation
    - Tools
    - Step-by-Step Process Execution
- **Concept specific ConSEP**
  - **Any amendments to the Organizational ConSEP based on authority level or any planned deviations**
  - **Required to start the process**

Acquisition Process Studies

- National Research Council, 2008
  - Incomplete MS B requirements
  - Technology immaturity
  - Insufficient consideration of alternative concepts
  - http://books.nap.edu/catalog.php?record_id=12065
- Defense Acquisition Performance Assessment, 2006
  - Requirements instability
  - Technology immaturity
  - Funding instability
- Government Accountability Office, 2005
  - Requirements not adequately defined early or changed
  - Technologies typically not mature enough
  - Acquisition workforce deficiencies

Tailoring the SE Process to Effectively Complement the SW Agile Development Process

National Defense Industrial Association (NDIA)
12th Annual Systems Engineering Conference
October 26-29,2009

System Engineering Effectiveness Track,
Wednesday October 28, 2009

William Lyders, ASSETT Inc.

Outline

- Majority of Programs today use variations of the Traditional Waterfall Model

- An Iterative/Agile Model approach provides some important benefits not easily possible with a single Waterfall Model
  - End User Assessment
  - Accommodate Requirement Changes
  - Early delivery of production features

- System Engineering process was tailored to complement a Software Agile Development process

- Each of the Phases in the Agile Cycle is shown to incorporate traditional activities while providing the desired benefits in the Agile process for both SE and SW processes.

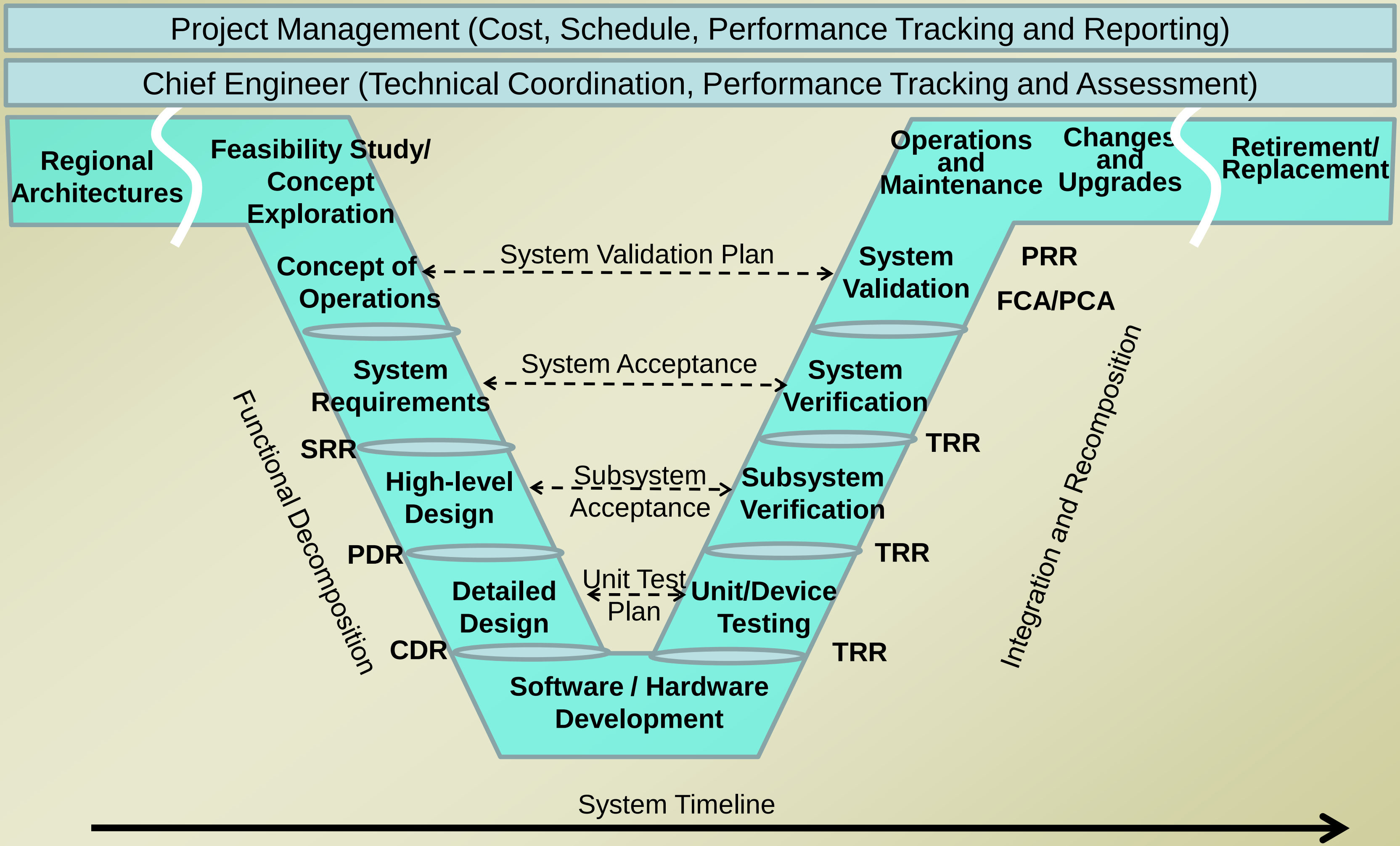
What is Systems Engineering?

- **Systems Engineering is:**
 A <u>rigorous discipline</u> for successful <u>system development and integration</u>. It <u>elaborates business needs</u> into traceable and testable requirements, <u>establishes system baselines</u> and <u>integrates and delivers</u> the full system solution.

- **Systems Engineering strengthens the development process by adding:**
  - A more <u>rigorous approach</u> to requirements definition, management, baseline management, and traceability through delivery,
  - A series of <u>formal reviews</u> linked to key lifecycle events,
  - Formal linkage to the QA process throughout the project lifecycle; accelerating the detection and resolution of defects earlier where it costs less to resolve,
  - <u>Verification</u> that the Technical Solution meets the <u>requirements</u> and <u>Validation</u> that it meets the customer needs.

- **It is also:**
  - A key enabler to achieving higher CMMI maturity levels
  - Industry-recognized as a core capability required for <u>complex systems integration</u> programs.

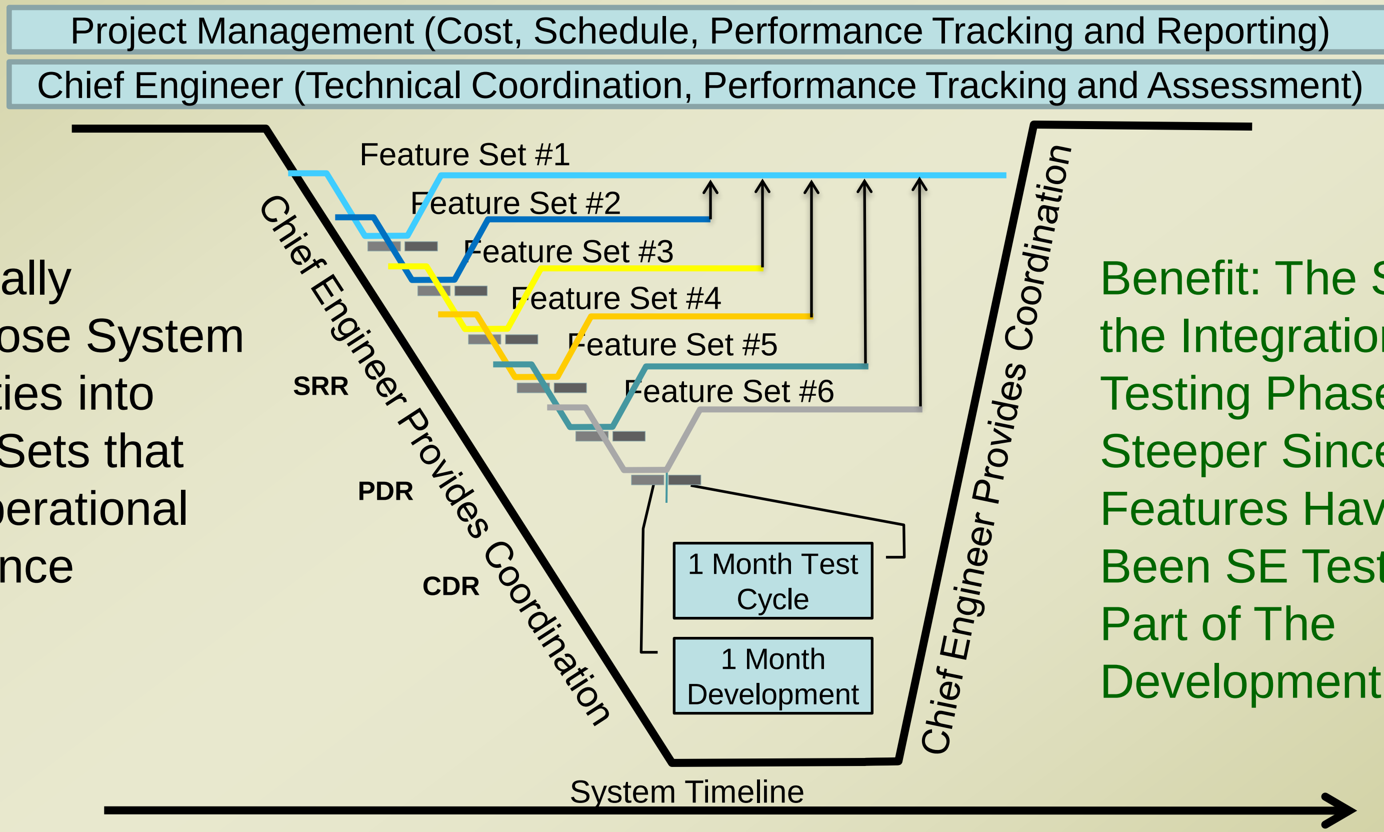
Traditional Systems Engineering “Vee” Model



Agile Model - Areas of Innovation

Innovation: Agile Development Process

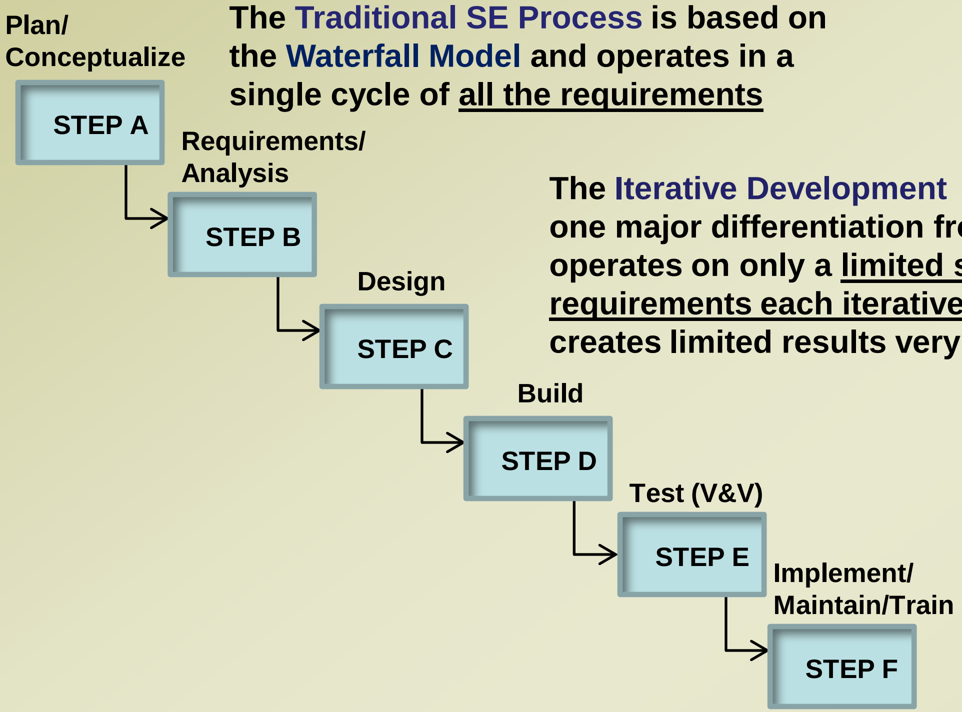
Functionally Decompose System Capabilities into Feature Sets that Have Operational Significance



Benefit: The Slope for the Integration & Testing Phase Is Much Steeper Since Features Have Already Been SE Tested as a Part of The Development Process

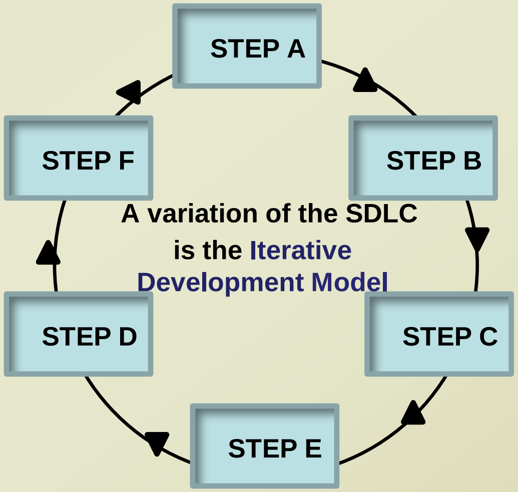
Feature Sets Provide an Operational Capability that Can Be Tested and Validated Early By the Client

Transitioning from Waterfall Model to an Agile Model



The **Traditional SE Process** is based on the **Waterfall Model** and operates in a single cycle of <u>all the requirements</u>

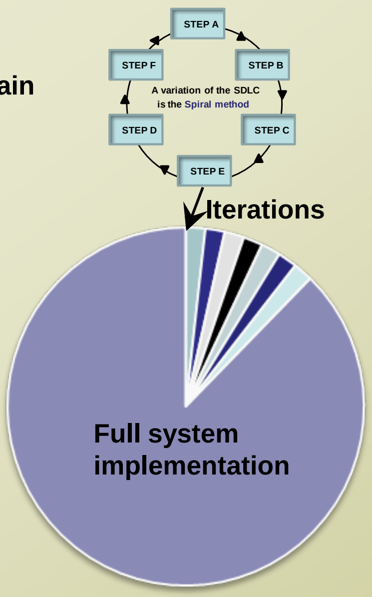
The **Iterative Development Model** has one major differentiation from SDLC: operates on only a <u>limited set of requirements each iterative cycle</u> and creates limited results very quickly.



There are many versions of the Systems Development Life Cycle (SDLC) process.

A successful and widely used method over the years is the **Waterfall Model**.

- A logical & sequential set of process steps,
- Criticisms:
  - ➢ Considered a “rigid” & “inflexible” procedure
  - ➢ Requirements usually uncertain at the beginning
  - ➢ Long process with no working version until late in the process

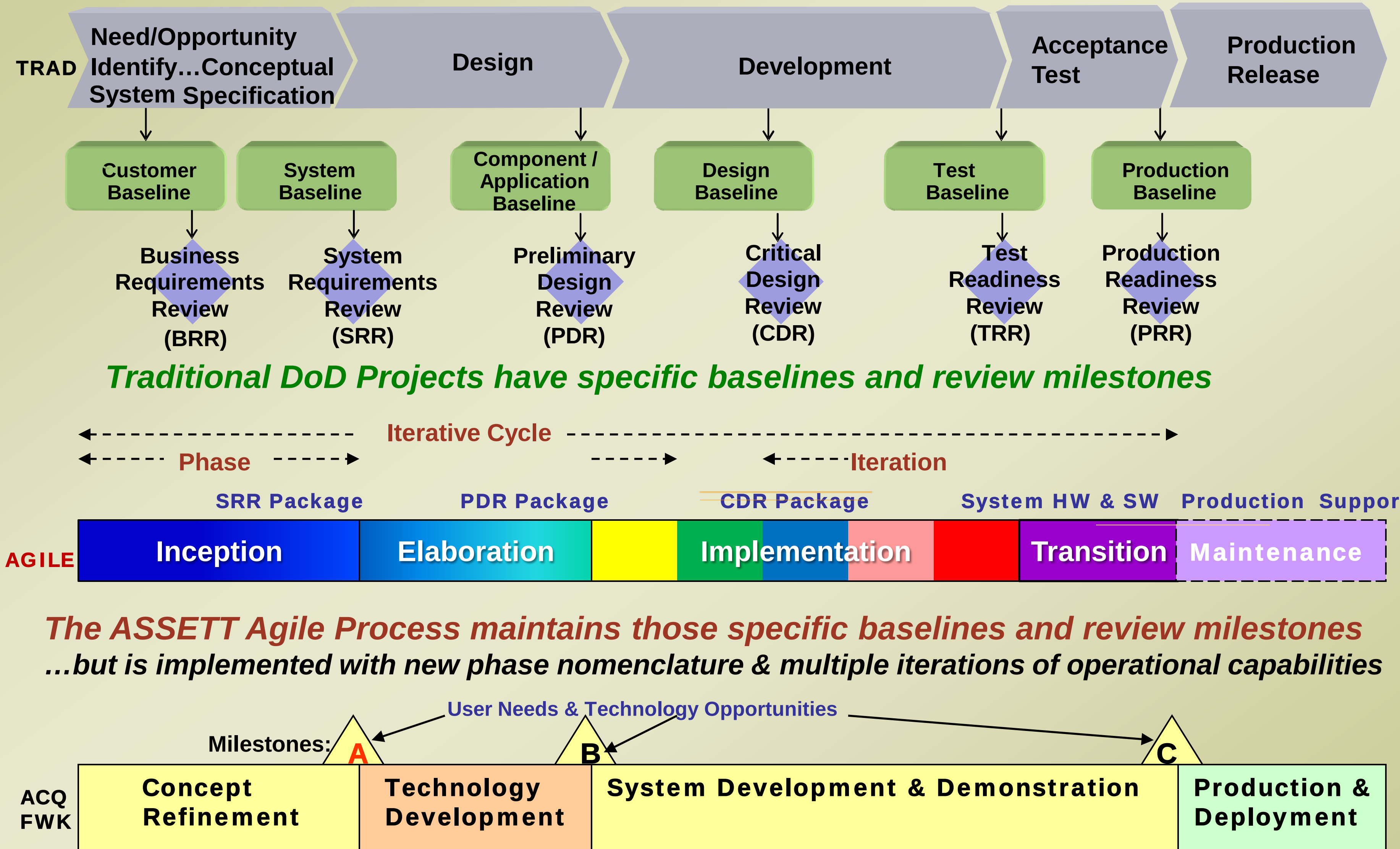


Multiple iterations of the Iterative Development Model are required to complete a full system implementation.

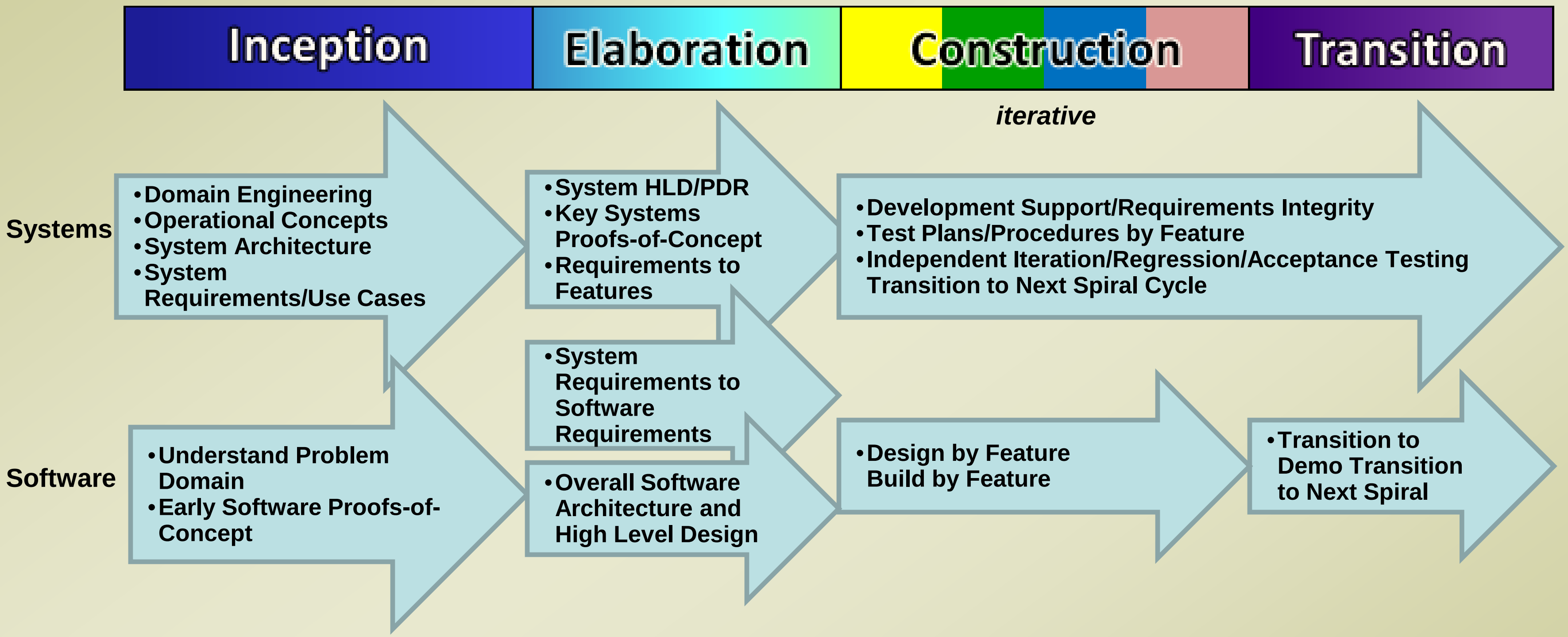
One variant of the Iterative Development Model is the Spiral Model typically used for large systems

Another variant, sometimes used for smaller projects, is the Agile Model for software development

System Agile/Traditional Engineering Process Overview



Unified System Development Process



Based on the Unified Software Development Process

A good overview of UP can be found at http://en.wikipedia.org/wiki/Unified_Process

Agile Development Cycle Definitions (Sheet 1 of 4)

- Inception Phase
  - Planning – important risks identified and project roughly estimated
  - Requirements Definition – capturing/understanding customer requirements and generating simplified use cases for operational architecture
  - Concepts - good ideas developed into product vision, tentative architecture,
  - Prototypes – obtaining and trying new infrastructure and development techniques for implementation later
- Perform Inception Phase for each Agile Cycle
  - 1st cycle may have a long Phase
  - Later cycles may be very short
- Define initial requirements with some level of knowledge of complexity
  - In Agile if the complexity of a requirement/feature exceeds the Implementation plans later, then Agile allows flexibility to defer a feature to a later iteration or even a later cycle [Spiral Model does not allow this flexibility]
  - Requirement/Feature baselines under CM control…but iteration planning allows for changes to requirements and implemented features

Agile Development Cycle Definitions (Sheet 2 of 4)

- **Elaboration Phase**
  - **Implementation Planning** – (Business architecture) Plan development by feature
    - Can defer features at customer request or move future features forward
    - Can establish full implementation iterations and "buffer" iterations
  - **Requirements Analysis/Feature Definition** – Create architecture model items
    - (Functional architecture) build feature lists for functional model based on analysis of requirements including detailed feature/iteration mapping
    - (Operational Architecture) creating detailed use case model
  - **Concepts and Prototypes** – (Physical architecture) refine concepts and infrastructure prototypes and hardware designs
    - Technology and operational realism tradeoffs
    - For SOA, map features into Services
  - **Architecture Definition** – Document above items in full System architecture

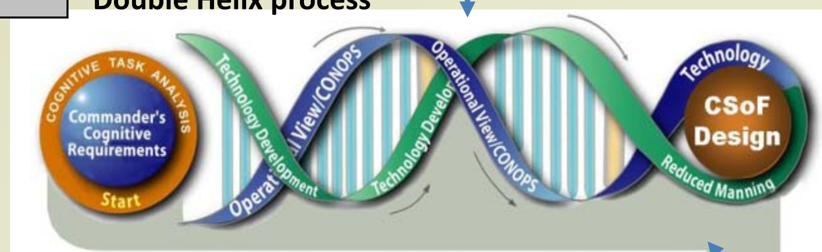
Addressing Operational Realism/Technology Features early in Inception/Elaboration [CSoF Process]

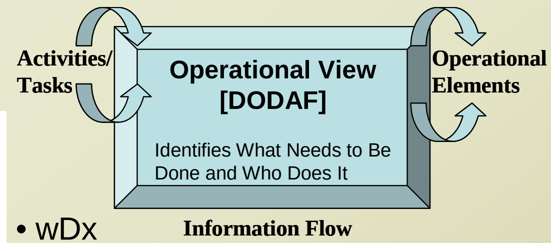
Missions: (Representative mission phases from the CSoF Operational Scenarios: Port Egress, Submerged Transit, and Intelligence Surveillance and Reconnaissance (ISR))

Decisions:
To support Missions

Objective: *Formulate data to define operational decisions & capture technology for TDS & ICD inputs*

Double Helix process





- wDx
- SME Interviews

Multiple Iterations

Step 1

Decision Information Required/Task Timeline

CONOPS (Re-thought NWP for every activity for each mission)
Decision Hierarchies, Timelines

Step 2

Technology

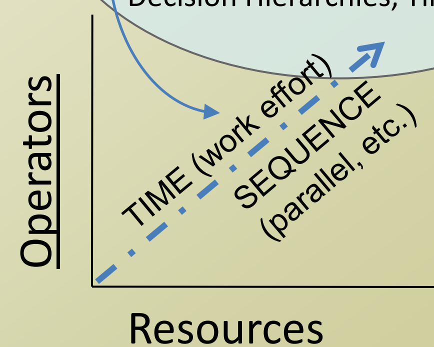
Technology Advancement

Step 3

Systems
(Data, Technology)

Person
(User Role)

Proceeding Ahead: *Refocus Data Gathering to narrow search and expand data attributes for modeling*



Agile Development Cycle Definitions (Sheet 3 of 4)

- **Implementation Phase (Multiple Development Iterations within)**
  - During each implementation iteration period, perform each of the following activities below
    - **Plan** – Revisit implementation status and re-plan feature development as necessary
    - **Requirement/Feature** – Revisit requirements/features for that iteration and revise plans as necessary
    - **Build** – develop all planned features for that iteration…Production code
    - **Test** – Conduct independent SE testing of software delivered from the last implementation iteration period. Conduct early customer demonstrations of new features – confirm requirements/features
  - Implementation iterations are typically color coded or numbered so referencing functionality in planning and documentation is simplified.
  - The ability to adapt implementation to complexity and changes in requirements a key benefit in this Phase – customer feedback and development team productivity driven.

Agile Development Cycle Definitions (Sheet 4 of 4)

- **Transition Phase**
  - **Conduct each of the following activities as necessary**
    - **Test (SE) – Conduct <u>independent testing</u> of software delivered from the last implementation iteration period. Verify functional requirements/ uses cases for the developed software.**
    - **System Integration/Regression Test – Conduct the planned set of regression tests to verify that the new capabilities being implemented did <u>not affect any previously released capabilities</u>.**
    - **Acceptance Test – Conduct testing of the new capabilities with the customer witnessing the testing as an acceptance approach. Sometimes only a <u>demonstration</u> of the new capabilities needs to be done.**
    - **Information Assurance (IA) Regression Test – If the system requires IA certification, determine if and IA certification <u>re-certification testing</u> is required and perform any that is necessary.**
  - **Formally release the new versions of the system, conduct training, and provide product assistance as necessary**

Summary

- **An Agile Model allows some special benefits over the traditional single cycle Waterfall Model**
  - **Requirements change flexibility**
  - **Observable features developed and requirements verified early**
  - **Early and often customer assessment of developed production features**
- **System Engineering process can be tailored to complement a Software Engineering Agile Development Process**
- **The SE-DE Agile process includes the traditional baselines, milestones, and provides early working products that is demonstrated to the customer for each cycle**

Q&A

Abstract

Tailoring the SE Process to Effectively Complement the SW Agile Development Process

Track: SE Effectiveness

At the 2008 NDIA SE Conference, the change to include Software Engineering topics was mentioned early in the conference. A key Software Engineering Process is the Agile (Iterative) Development Process, a version of the Spiral Process used by many companies. This presentation will identify how ASSETT Inc. has successfully tailored the traditional Systems Engineering waterfall process to complement its Agile Software Engineering Process. It will also show how we tailored the Test and Evaluation Process accordingly and incorporated operational concept designs, COOPEX events, and technology/ operational demonstrations early and throughout the tailored SE Process.

<u>The Traditional SE Process is a popular version of the systems development life cycle model (SDLC) with a single Iteration:</u> The waterfall [a.k.a Traditional or "Vee"] SE Process includes a single pass of the SE Process steps from requirements specification through design, build, and test & evaluations prior to delivery to the customer. Many customers are comfortable with this traditional acquisition process of work products but it does have its limitations.

<u>The SW Agile Process Complements the Traditional SE Process Using Multiple Iterative Steps:</u> A brief overview of the SW Agile [Spiral] Development Process will show that even though the comparable traditional SW Process steps were renamed and are performed multiple times during the system development life cycle, they are really the same types of activities and can be mapped within the traditional SE Process. The Agile Process results in demonstrable system building blocks at each iterative step. Also as each iterative step completes, key SE and SW Process decisions must be made, usually with customer input, and completed system features become available. This allows us to have multiple opportunities for customer interaction to jointly decide and prioritize upcoming iterations and operational/technology demonstrations that are important to the customer.

<u>Tailoring the Traditional SE Process blends the best of both Processes:</u> A tailored SE Process and a T&E Process have been aligned with the SW Agile Process and DoD Acquisition Process resulting in a very effective system development process. A description of the tailored SE, SW Engineering, and T&E Processes as they are performed in an iterative fashion are shown, including the work products and process step decisions. Another benefit of this tailored process is to allow for early operational realism, by conducting technical and operational demonstrations and CONOPS Exercises (COOPEX) at critical iteration completions derived from our Double Helix Methodology, Mission Driven Design (MDD), and Decision Centered (DCD) Design methodologies.

Author Biography

Tailoring the SE Process to Effectively Complement the SW Agile Development Process

Author Biography – Mr. Lyders is currently a Systems Engineering Manager and Lead Systems Engineer/ and Test Director for multiple projects at ASSETT, Inc. He has over 40 years of both systems engineering & project management experience in both federal software and commercial Information Technology (IT) development projects.

He has significant complex system specification, system information display design, system test and integration expertise, dockside, and at-sea testing experience developed through his federal work with multiple Sonar, Command and Control, and Submarine Combat Systems and multiple SBIR projects for the Navy. He is currently leading SE efforts for a new submarine Combat System of the Future (CSoF) at ASSETT for the Navy.

ASSETT is located at 11220 ASSETT Loop, Manassas, VA. Founded in January 2001, the company is focused on working with our customers to apply the systems engineering process to achieve quality deliverables that are affordable, and supportable, while meeting the demands for reduced time-to-market. ASSETT has 67 full-time and/or part-time employees ranging from recent Masters Degree graduates to experienced personnel with over 35 years of experience in the design, development, production, and support of large complex military systems.

Integrated Testing: We Can Do It

Beth Wilson
Industry Co-Chair
NDIA System Engineering Division
DT&E Committee

Principal Engineering Fellow, Raytheon Company

NDIA 2008/2009 DT&E Committee Focus

- **National Defense Industrial Association (NDIA) Effort**
  - Systems Engineering Division planning for 2008/2009
  - Developmental Test and Evaluation (DT&E) Committee priority

- **White Paper Recommendation as Follow-on Focus:**

  "DT and OT need to be integrated whenever possible to improve overall T&E efficiency. The utility and applicability of DT results are reduced due to lack of operational relevance."

- **SE Point Paper Recommendation for 2008:**

  "Starting with the recommendation from the 2007-08 white paper, develop more detail on methods and practices for Integrated Test."

- **Integrated Testing Definition (April 2008 Memo):**

  "Integrated testing is the collaborative planning and collaborative execution of test phases and events to provide shared data in support of independent analysis, evaluation and reporting by all stakeholders particularly the developmental (both contractor and government) and operational test and evaluation communities."

Integrated CT/DT/OT Focus: Methods and Practices

Committee Approach

- **Identify Existing Methods and Practices:**
  - Existing policies and instantiations in Service policies
  - Existing charters, roles and positions, collaborative planning efforts
  - Examples of successful integrated CT/DT/OT activities
- **Investigate Barriers to Integrated CT/DT/OT**
  - Data, resources, planning
  - Cultural constraints
- **Identify Approaches Within Current Policies**
  - Additional methods and practices in view of April 2008 integrated test definition
  - Interactions that can be improved between stakeholders
  - Integrated test strategy as part of overall test planning

Barrier to Integrated Testing are Cultural

Why Integrated Testing?

5000.02

a. The fundamental purpose of T&E is to provide knowledge to assist in managing the risks involved in developing, producing, operating, and sustaining systems and capabilities. T&E measures progress in both system and capability development. T&E provides knowledge of system capabilities and limitations to the acquisition community for use in improving the system performance, and the user community for optimizing system use in operations. T&E expertise must be brought to bear at the beginning of the system life cycle to provide earlier learning about the strengths and weaknesses of the system under development. The goal is early identification of technical, operational, and system deficiencies, so that appropriate and timely corrective actions can be developed prior to fielding the system.

I strongly believe that OT&E should be a process of confirmation and not one of discovery. Unfortunately, OT&E is too often the place where performance shortcomings and new failure modes are discovered. When problems are discovered late in the acquisition process, the cost to fix these problems is much higher than if they were discovered earlier. In addition, the time lost when problems are found at this stage can be substantial—and when our forces need a new capability, the latter penalty may be even more substantial than increased cost.

Dr. Charles E. McQueary
Director of Operational Test and Evaluation
Defense AT&L: January-February 2008

Navy OT&E Framework Integrated Test Methodology

Robust testing minimizes "surprises" when the product is sent to the war fighter and ensures the specified capabilities are evaluated in the operational environment. Risk is reduced by bringing all testing agents together early in the process to ensure capabilities are tied to mission, mission oriented testing is conducted, system anomalies/deficiencies are identified early in the process, and

Need early identification of problems

Why Integrated Testing?

5000.02

a. The fundamental purpose of T&E is to provide knowledge to assist in managing the risks
involve ... ems and capabilities. T&E
measur ... &E provides knowledge of
system ... for use in improving the system
perform ... n operations. T&E expertise
must b ... o provide earlier learning about
the stren ... The goal is early identification
of technical, operational, and system deficiencies, so that appropriate and timely corrective
actions can be developed prior to fielding the system.

The goal is early identification of technical, operational, and system deficiencies

OT&E should be a process of confirmation and not one of discovery

Dr. Charles E. McQueary
Director of Operational Test and Evaluation
Defense AT&L: January-February 2008

and new failure modes are discovered. When problems are discovered late in the acquisition process, the cost to fix these problems is much higher than if they were discovered earlier. In addition, the time lost when problems are found at this stage can be substantial—and when our forces need a new capability, the latter penalty may be even more substantial than increased cost.

Navy OT&E Framework Integrated Test Methodology

Robust testing minimizes "surprises" when the product is sent to the war fighter and ensures the
specified capabilities are evaluated in the o ...
testing agents together early in the process ...
oriented testing is conducted, system anom ...

Robust testing minimizes "surprises" when the product is sent to the war fighter

Need early identification of problems

Why Integrated Testing?

DSB Task Force on DT&E May 2008 Report

FINDINGS

The changes in the last 15 years, when aggregated, have had a significant negative impact on DoD's ability to successfully execute increasingly complex acquisition programs. Major contributors include massive workforce reductions in acquisition and test personnel, a lack of up-to-date process guidance in some acquisition organizations, acquisition process changes, as well as the high retirement rate of the most experienced technical and managerial personnel in government and industry without an adequate replacement pipeline.

- Major personnel reductions have strained the pool of experienced government test personnel

The attacks of September 11, 2001, ushered in a new era of warfighting with the Global War on Terrorism. Significant priority was given to finding more efficient ways to deliver new capabilities to the Combatant Commanders for use against quickly adapting threats. Rigorous T&E before deployment was sometimes sacrificed to meet schedule demands.

Navy OT&E Framework Integrated Test Methodology

all data are shared. Cost is reduced by the sharing of resources, elimination of duplicative testing, and the early identification and correction of deficiencies. Schedule compression is achieved by combined vs. sequential testing and the sharing of high-demand testing assets. None of these objectives can be achieved without the cooperation of all parties and commitment to a "team" approach between the program office, OT, DT, and contractor personnel involved.

Need integrated testing to meet cost/schedule demands

Why Integrated Testing?

DSB Task Force on DT&E May 2008 Report

FINDINGS

The changes in the last 15 years, when aggregated
DoD's ability to successfully execute increasin
contributors include massive workforce reductions i
to-date process guidance in some acquisition organ
as the high retirement rate of the most experien
government and industry without an adequate replacement pipeline.

- Major personnel reductions have strained the pool of experienced government test personnel

***Negative impact on ability to successfully execute complex programs*:**
Massive workforce reductions in acquisition and test personnel

The attacks of September 11, 2001, ushered in a new era of warfighting with the
Terrorism. Significant priority was given to finding more efficient ways
capabilities to the Combatant Commanders for use against quickly adapting threats. Rigorous

Rigorous T&E … sacrificed to meet schedule demands

Cost is reduced by sharing of resources, elimination of duplicative testing

…on of duplicative testing,
and the early identification and correction of deficiencies. Schedule compression is achieved by
combined vs. sequential testing and the sh
objectives can be achieved without the co
approach between the program office, O

Schedule compression is achieved by combined vs. sequential testing and the sharing of high-demand testing assets

Need integrated testing to meet cost/schedule demands

Paper at NDIA Test & Evaluation Conference

NDIA Test and Evaluation Conference
Paper #7847

Walking the Line with Title 10: Implementation Strategies for Integrated Testing

Beth Wilson
Industry Co-Chair NDIA System Engineering Division, DT&E Committee
Test Architect, Raytheon Company

Darlene Mosser-Kerner
Government Chair NDIA System Engineering Division, DT&E Committee
Developmental Test & Evaluation
OUSD(AT&L)/Systems & Software Engineering

Implementation Framework

Attributes of Integrated Testing

- **If you find the contractor data augmenting the OT&E data**, *you might be doing integrated testing*
- **If the DT&E and OT&E personnel recognize each other in the airport**, *you might be doing integrated testing*
- **If the OT&E personnel influences DT&E scenarios**, *you might be doing integrated testing*
- **If the DT&E system is operated by end users**, *you might be doing integrated testing*
- **If the CT, DT, and OT teams are sharing data in a common format**, *you might be doing integrated testing*
- **If the OT&E confirms DT&E results**, *you might be doing integrated testing*

Positive Impact on Discussion

- Integrated Testing is not a new concept
- Title 10 is not a real barrier
- Polices now sufficient
- Need to institutionalize best practices

Integrated Test Definitions: DoD

OSD McQueary/Young Memo 22 Dec 2007

- Developmental and operational test activities shall be integrated and seamless throughout the system life cycle. As technology, software, and threats change, follow-on T&E should be used to assess current mission performance and inform operational users' during the development of new capability requirements.

DAG Chapter 9

9.3.3. Combined DT&E and OT&E

Whenever feasible, DT&E and OT&E events should be combined, if that supports technical and operational test objectives to gain the optimum amount of testing benefit for reasonable cost and time. The user community should be involved early in test planning to ensure the statement of desired capabilities is interpreted correctly and tested realistically. Certain events can be organized to provide information useful to developmental and operational evaluators and lend themselves to the combined DT and OT approach. The concept is to conduct a single, combined test program that produces credible qualitative and quantitative information that can be used to address developmental and operational issues. Examples of this approach include combined DT and OT events, or piggybacking an operational assessment onto a developmental test. Likewise, developmental testing data requirements can be accommodated by an operational test. This approach can reduce the time and expense of conducting dedicated OT events that replicate DT events, or vice versa, yet still provide adequate technical risk reduction. The developmental and operational testers can develop a test management structure to share control of the combined events. Combined DT and OT events and test data requirements must be identified early to prevent unnecessary duplication of effort and to control costs. It is important that neither the DT&E nor OT&E objectives are compromised in designing combined events. For further explanation of this combined strategy, refer to the DAU Test and Evaluation Management Guide.

OSD McQueary/Finley Memo 25 Apr 2008

Integrated testing is the collaborative planning and collaborative execution of test phases and events to provide shared data in support of independent analysis, evaluation and reporting by all stakeholders particularly the developmental (both contractor and government) and operational test and evaluation communities.

Integrated Test Definitions: DoD

ec 2007

tivities shall be integrated and seamless
echnology, software, and threats change,
ss current mission performance and inform
operational users during the development of new capability requirements.

Developmental and operational test activities shall be integrated and seamless

DAG Chapte

9.3.3. Combined DT&E and OT&E

Whenever feasible, DT&E and OT&E events should be combined, if that supports technical and operational test objectives to gain the optimum amount of testing benefit for reasonable cost and time. The user community should be involved early in test planning to ensure the statement of desired capabilities is interpreted correctly and organized to provide information useful to develop themselves to the combined DT and OT approac combined test program that produces credible qu be used to address developmental and operation combined DT and OT events, or piggybacking an test. Likewise, developmental testing data requir operational test. This approach can reduce the ti events that replicate DT events, or vice versa, yet The developmental and operational testers can develop a test management structure to share control of the combined events. Combined DT and OT events and test data requirements must be identified early to prevent unnecessary duplication of effort and to control costs. It is important that neither the DT&E nor OT&E objectives are compromised in designing combined events. For further explanation of this combined strategy, refer to the DAU Test and Evaluation Manag

Conduct a single combined test program that produces credible qualitative and quantitative information that can be used to address developmental and operational issues

lemo 25 Apr 2008

collaborative planning and collaborative execution s to provide shared data in support of independent d reporting by all stakeholders particularly the developmental (both contractor and government) and operational test and evaluation communities.

Collaborative planning and collaborative execution

Integrated Test Definitions: Services

Army DA PAM 73–1 • 30 May 2003

Integrated testing and evaluation

A T&E strategy that reduces the multiple and redundant products and processes, and encompasses the development of a single integrated system evaluation plan and a single integrated test/simulation strategy, leading to a single system evaluation report for the customer. The process also increases the use of contractor data for evaluation and expands the use of M&S with the goal of reducing T&E costs. Integrated T&E strategies may include combined DT/OT events where appropriate.

Integrated DT/OT

Integrated DT/OT, a special case of a Combined DT/OT, is a single phased event that generates data to address developmental and operational issues simultaneously under operational conditions. The execution strategy for this event is based on the requirements of the program.

Navy OT&E Framework Integrated Test Methodology

IT is a cooperative approach to T&E where CT, DT, and OT entities work to blend or integrate the T&E requirements throughout the defense acquisition process. Integration of CT, DT, and OT does not involve the analysis and reporting aspects of T&E, which remain solely under the purview of the respective CT, DT, or OT organization.

Air Force **AFI99-103 26 FEBRUARY 2008**

Integrated Testing—The harmonization of all types of tests and evaluations that are planned and integrated as early as possible into an efficient continuum, efficiently phased and resourced over time, and reported collaboratively in order to achieve greater test efficiency, reduced cost, and schedule savings without compromising the objectives and needs of the participating test organizations.

Integrated Test Team (ITT)—A cross-functional team of empowered representatives from multiple disciplines and organizations and co-chaired by operational testers and the program manager. The ITT is responsible for developing the T&E strategy and TEMP, assisting the acquisition community with T&E matters, and guiding the development of test plans that are integrated. Note: The ITT is the Air Force equivalent to the T&E Working Integrated Product Team (T&E WIPT) described in the Defense Acquisition Guidebook.

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Integrated Test Definitions: Services

Army DA PAM 73–1 • 30 May 2003

Integrated te

A T&E strate

Single integrated test strategy

, and encompasses the development of a single integrated system evaluation plan and a single integrated test/simulation strategy, leading to a single system evaluation report for the customer. The process also increases the use of contractor data for evaluation and expands the use of M&S with the goal of reducing T&E

where appropriate.

Integrated DT/OT

Integrated DT/OT, a special case of a Con

developmental and operational issues simultar

is based on the requirements of the program.

Generates data to address developmental and operational issues simultaneously under operational conditions

Navy OT&E Framework Integrated Test Methodology

IT is a cooperative approach to T&E where CT, DT, and OT en

or integrate the T&E requirements throughout the defense acqu

Integration of CT, DT, and OT does not involve the analysis an

of T&E, which remain solely under the purview of the respecti

organization.

CT, DT, and OT entities work to blend or integrate the T&E requirements

Air Force AFI99-103 26 FEBRUARY 2008

Integrated Testing—The harr

integrated as early as possible i

reported collaboratively in order to achieve greater test efficiency, reduced cost, and schedule savings

without comprom

Harmonization of all types of tests

Integrated as early as possible into an efficient continuum

Integrated Test T

disciplines and organizations and co-chaired by operational testers and the program manager. The ITT is

responsible for developing the T&E

matters, and guiding the developm

equivalent to the T&E Working Integrated Product Team (T&E WIPT) described in the Defense Acquisition Guidebook.

Development of test plans that are integrated

What Does Title 10 Say?

(d) Impartiality of Contractor Testing Personnel.— In the case of a major defense acquisition program (as defined in subsection (a)(2)), no person employed by the contractor for the system being tested may be involved in the conduct of the operational test and evaluation required under subsection (a). The limitation in the preceding sentence does not apply to the extent that the Secretary of Defense plans for persons employed by that contractor to be involved in the operation, maintenance, and support of the system being tested when the system is deployed in combat.

(e) Impartial Contracted Advisory and Assistance Services.—

(1) The Director may not contract with any person for advisory and assistance services with regard to the test and evaluation of a system if that person participated in (or is participating in) the development, production, or testing of such system for a military department or Defense Agency (or for another contractor of the Department of Defense).

(2) The Director may waive the limitation under paragraph (1) in any case if the Director determines in writing that sufficient steps have been taken to ensure the impartiality of the contractor in providing the services. The Inspector General of the Department of Defense shall review each such waiver and shall include in the Inspector General's semi-annual report an assessment of those waivers made since the last such report.

(3) **(A)** A contractor that has participated in (or is participating in) the development, production, or testing of a system for a military department or Defense Agency (or for another contractor of the Department of Defense) may not be involved (in any way) in the establishment of criteria for data collection, performance assessment, or evaluation activities for the operational test and evaluation.

(B) The limitation in subparagraph (A) does not apply to a
such development, production, or testing solely in testing f

10 USC 23

NB: This unofficial compilation of the U.S. Code is current as of Jan. 3

conduct of OT&E

establishing criteria for OT&E

OT&E evaluation

Contractor cannot be involved in:
- **OT&E conduct**
- **Establishing OT&E criteria**
- **OT&E evaluation**

Title 10 Allows Support to OT&E

DAG Chapter 9

Integrating T&E consists of many aspects, all designed to optimize test scope and minimize cost. For example, separate contractor developmental testing might be combined with governmental developmental test and evaluation, with control being exercised by a combined test organization. Live testing might be integrated with verified, validated, and accredited

Army DA PAM 73–1 • 30 May 2003

c. Discussions with system contractor personnel may be necessary to ensure full technical understanding of test incidents observed during the IOT&E or related activities. All discussions will be held separately from any scoring or assessment activities. The MATDEV should maintain written record of the nature of these contractor and Government discussions.

Navy OT&E Framework Integrated Test Methodology

"Integrated testing" blends or combines contractor, developmental, and OT to form a cohesive testing continuum. This integration cannot occur unless the participants (CT, DT, and OT) have determined their entering requirements for adequate testing of the system under evaluation. IT does not remove or combine any of OPTEVFOR's current or future requirements for reporting based on a separate (OPTEVFOR) analysis of the shared test information produced by the IT effort.

Air Force **AFI99-103 26 FEBRUARY 2008**

5.6.2. System Contractor Support to Operational Testing. System contractors may be beneficial in providing logistic support and training, test failure analyses, test data, and unique software and instrumentation support that could increase the value of operational test data. Explanations of how this con-

Contractor **CAN** provide:
- **Technical understanding of test incidents**
- **Logistic support and training**
- **Support to test failure analysis**
- **Unique software and instrumentation support**

Title 10:
Contractor cannot be involved in:
- **OT&E conduct**
- **Establishing OT&E criteria**
- **OT&E evaluation**

Title 10 Allows Sharing of Data

Army DA PAM 73–1 • 30 May 2003

a. The T&E WIPT goals are to develop a mutually agreeable T&E program that will provide the necessary data for evaluations. T&E WIPTs provide support for the development, staffing, coordination, and approval of all required T&E

(6) Support the CE process by accomplishing early, more detailed, and continuing T&E documentation, planning, integration, and promote the sharing of data.

T&E Management Guide

4.8 CONTRACTOR TESTING

The Deputy for T&E is responsible for ensuring that contractor-conducted tests are monitored by the government. The Deputy for T&E must also be given access to all contractor internal data, test results, and test reports related to the acquisition program. Usually, the contract requires that government representatives be informed ahead of time of any (significant or otherwise) testing the contractor conducts so the government can arrange to witness certain testing or receive results of the tests. Further, the contractor's internal data should be available as a contract provision. The Deputy for T&E must ensure that government test personnel (DT&E/OT&E) have access to contractor test results. It would be desirable to have all testers observe some contractor tests to help develop confidence in the results and identify areas of risk.

Navy OT&E Framework Integrated Test Methodology

- Fourth, OT uses the shared data from the IT period to "answer" or achieve resolution on as many measures of effectiveness (MOE) and measures of suitability (MOS) as possible. The goal being to have sufficient data/test information at the end of the IT phase to resolve most COIs, pending successful completion of the final independent OT phase.

The product of the IT integration effort should be an IT database, similar in structure and content to the OT&E Framework database (step **nine**), but merged with DT and CT requirements.

Air Force **AFI99-103 26 FEBRUARY 2008**

Operational testers may use data from sources such as DT&E, integrated testing, and OAs to augment or reduce the scope of dedicated operational testing if the data can be verified as accurate and applicable.

5.5.2. Contractor T&E Data. Test teams and TIPTs should use as much contractor T&E data as possible if its accuracy can be verified. Contractor T&E data should be visible in the common T&E database.

AFMAN63-119 20 JUNE 2008

A12.1.2. DT&E and OT&E plans and concepts are structured so that OT&E can capture and use DT&E data to reduce OT&E requirements. (ITT) (See A14, A15, A23, A27)

OSD McQueary/Young Memo 22 Dec 2007

- To maximize the efficiency of the T&E process and more effectively integrate developmental and operational T&E, evaluations shall take into account all available and relevant data and information from contractor and government sources.

T&E Strategies

5000.02

b. The PM, in concert with the user and the T&E community, shall coordinate DT&E, OT&E, LFT&E, family-of-systems interoperability testing, information assurance testing, and modeling and simulation (M&S) activities, into an efficient continuum, closely integrated with requirements definition and systems design and development. The T&E strategy shall provide information about risk and risk mitigation, provide empirical data to validate models and simulations, evaluate technical performance and system maturity, and determine whether systems are operationally effective, suitable, and survivable against the threat detailed in the STAR or STA. The T&E strategy shall also address development and assessment of the weapons support equipment during the EMD Phase, and into production, to ensure satisfactory test system measurement performance, calibration traceability and support, required diagnostics, and safety. Adequate time and resources shall be planned to support pre-test predictions and post-test reconciliation of models and test results, for all major test events. The PM, in concert with the user and the T&E community, shall provide safety releases (to include formal Environment, Safety, and Occupational Health (ESOH) risk acceptance in accordance with Section 6 of Enclosure 12) to the developmental and operational testers prior to any test using personnel.

Test and Evaluation Strategy:

- Knowledge to manage risks
- Empirical data to validate models and simulations
- Evaluate technical performance
- Evaluate system maturity
- Determine operational
    - Effectiveness
    - Suitability
    - Survivability

ITEA Journal Article
September 2009

ITEA Journal 2009; 30: 375–380

Integrated Testing: A Necessity, Not Just an Option

Beth Wilson	Raytheon	X	X	X	X	X	X	X	X
Darlene Mosser-Kerner	OSD ATL	X	X	X		X	X	X	
Tom Wissink	Lockheed Martin				X				
John Lohse	Raytheon	X			X	X	X		
Joe Terlizzese	SESO	X	X	X	X	X	X		
Woody Eischens	OSD/DT&E	X	X	X		X	X	X	X
Gordon Tillery	OSD/DOT&E							X	
Martha O'Connor	OSD ATL	X	X						
Joe Angsten	SESO					X			
Steve Henry	Northrop Grumman		X	X	X		X		
Dave Bell	Mitre		X			X	X	X	
Levi Garrett	OSD/DT&E								
Dianne Luna	ATEC								
Steve Scukanec	Northrup Grumman								
Sandy Stanford	DTRMC								
Thomas McGowan	OSD/DT&E								
Chuck Triska	AF/TEP								
Jim Eck	AFOTEC								
Bill Espinosa	OPNAV N091								
Brendan Rhatigan	Lockheed Martin								
Dave Schreiner	JITC/DCGS								
John Claxton	DAU								
Larry Leiby	HQDA,DUSA-TEO								
Melody Johnson	AF/TEP								
Bruce Moler	DHS								
Olaf Elton	Mitre								
Frank Apicella	ATEC								
Russ Hallauer	AMI/LMSI								
Ben Mancuso	P&W								
Jerry Manthei	OPNAV N091								
Robert Bowen	Army Research Lab								
Clyde Webster	ATEC								
Henry Gruner	Raytheon								
Jeff Beatty	Raytheon								
Jim Moseley	SESO								

Article Outline
- Definitions of Integrated Testing
- Barriers to Integrated Testing
- Implementation Framework for Effective Integrated Testing:
    - Collaborative Planning
    - Collaborative Execution
    - Shared Data
- Summary

Implementation Framework

- **Integrate the Planning**
  - Early and collaborative planning for efficient use of test assets
  - Improve test efficiency and streamline test schedule
  - Reduce duplication and voids
- **Integrate the People**
  - Integrated Test Teams
  - Coordination and cooperation for integrated strategy
  - Early OT&E influence on test design and scenarios
- **Integrate the Data**
  - Maximize data available and usability for OT&E
  - Common data formats to facilitate sharing
  - Incorporate operational realism in DT&E

Path Forward
Continuing Effort Output Products

- **Continuing Effort Theme**
  - Policy is okay as is (no additional changes recommended)
  - Some teams are already doing this well
  - Continue to work cultural barriers with information
- **Integrated Testing Tutorial**
  - Presented at NDIA Systems Engineering Conference
  - Basis for potential Defense Acquisition University online learning module
- **Potential Topic for ICOTE (Industry Consortium on OT&E)**
- **Promote Framework on Integrated Testing**
  - Paper presented at NDIA Test & Evaluation Conference (Mar 2009)
    "Walking the Line with Title 10"
  - Abstract planned for NDIA Test & Evaluation Conference (2010)

Attributes of Integrated Testing

- **If you find the contractor data augmenting the OT&E data**,
  you might be doing integrated testing
- **If the DT&E and OT&E personnel recognize each other in the airport**,
  you might be doing integrated testing
- **If the OT&E personnel influences DT&E scenarios**,
  you might be doing integrated testing
- **If the DT&E system is operated by end users**,
  you might be doing integrated testing
- **If the CT, DT, and OT teams are sharing data in a common format,**
  you might be doing integrated testing
- **If the OT&E confirms DT&E results**,
  you might be doing integrated testing

Summary

- **Integrated Testing is Needed**
  - Facilitate early identification and correction of system deficiencies
  - Make OT&E a process of confirmation instead of discovery
  - Minimize “surprises” when the product is sent to the war fighter
  - Reduce cost and schedule with shared resources and reduced duplication
- **Title 10**
  - Prohibits contractor involvement in OT&E conduct, criteria establishment, or evaluation
  - Allows contractor to provide technical understanding and support
  - Allows for collaborative planning and execution of an integrated test program to provide shared data to support independent analysis
- **Integrated Test Implementation Framework Involves Integrating**
  - **People**: Integrated test teams to introduce operational realism earlier
  - **Planning**: Early and collaborative efforts to streamline test program
  - **Data**: Sharing of data to address developmental and operational issues

Author

- **Dr. Beth Wilson** is a Principal Engineering Fellow who earned her PhD in Electrical Engineering from the University of Rhode Island. Since joining Raytheon in 1983, she has worked as a design engineer, program manager, research scientist, functional manager, and test director on sonar, satellite, and radar programs. She is currently the staff lead for the Systems Validation Test and Analysis Directorate. Previous assignments have included Test Architect for Dual Band Radar, a character-building deployment to Shemya, Alaska as the Test Director for the Cobra Dane Upgrade, a 2-year integration effort for the Relocatable Over the Horizon Radar (ROTHR) in Virginia, and being an exchange scientist to Australia. She is the Industry Co-Chair for the NDIA Systems Engineering Division Developmental Test and Evaluation Committee and the Industry Lead for the Integrated DT/OT focus area.

NAVSEA WARFARE CENTERS CRANE

SPECIAL MISSIONS

Rapid Development and Integration of Remote Weapon Systems to Meet Operational Requirements – Abstract 8851

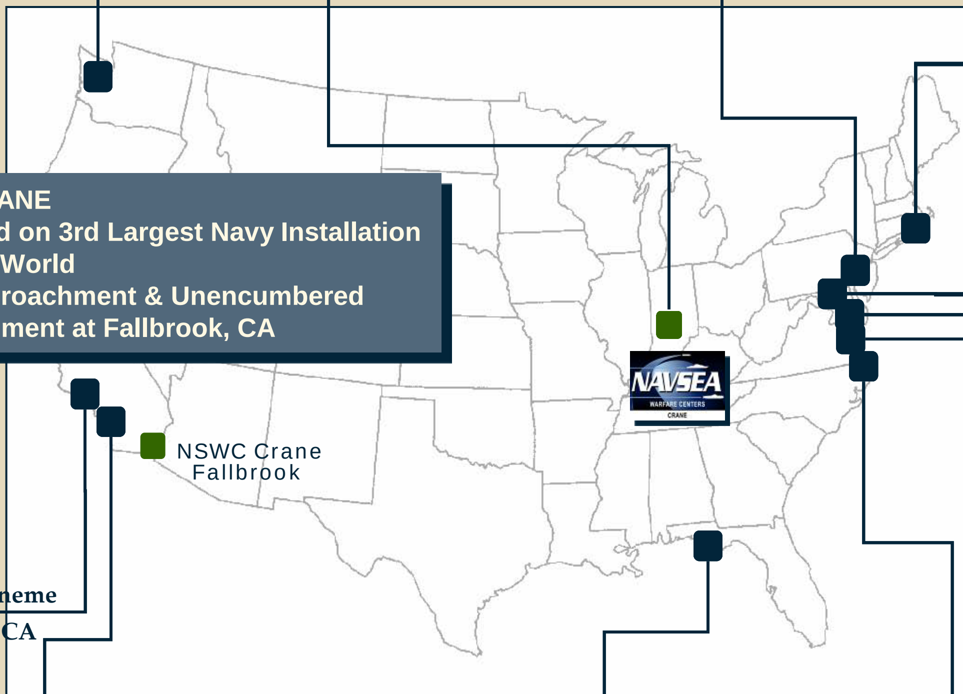
28-October 2009

Joseph Burkart

Crane Division, Naval Surface Warfare Center (NSWC Crane)

Com (812) 854-1654
DSN 482-1654
joseph.burkart@navy.mil

NSWC Crane Division



NSWC CRANE
- Located on 3rd Largest Navy Installation in the World
- No Encroachment & Unencumbered
- Detachment at Fallbrook, CA

NSWC Crane Key Attributes

- Critical concentration of 2,000 scientists, engineers and technicians
- $1.64B of work executed in FY 08
- 2720 workyears of effort
- 52 Patents Issued, 52 filed, 37 disclosed - “the metric of innovation”
- Business-based enterprise operating under the Navy Working Capital Fund

Stewards of

14 NAVSEA Technical Capabilities

NSWC Crane Mission Focus Areas:
Special Missions
Strategic Missions
Electronic Warfare / Information Operations

Four Outputs:
- *Knowledge*
- *Contracts*
- *Hardware*
- *Software*

NSWC Crane Division

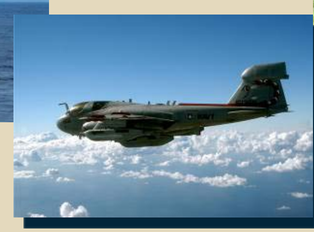
Our Mission . . .

Provide acquisition engineering, in-service engineering and technical support for SENSORS, ELECTRONICS, ELECTRONIC WARFARE and SPECIAL WARFARE WEAPONS. Apply component and system level product and industrial engineering to surface sensors, strategic systems, special warfare devices and electronic warfare/information operations systems. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Strategic Missions

Electronic Warfare / Information Operations

Special Missions



Providing innovative technical solutions for the rapidly changing combat environment

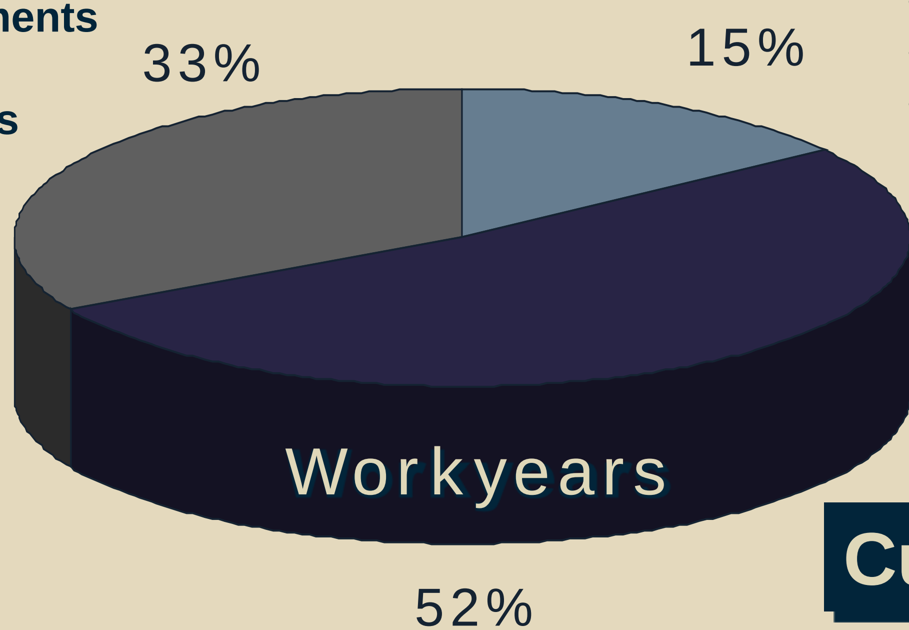
Total Life Cycle Leadership

Next Warfighter

Development
- System Engineering
- Hardware Acquisition
- Hardware Enhancements
- Rapid Design
- Acquisition Logistics
- Test & Evaluation

Warfighter After Next

Innovation
- System Engineering
- Basic Research
- Inserting Technology
- Modeling & Simulation
- Test & Evaluation



Current Warfighter

Sustainment
- In-Service Engineering
- Obsolescence Recovery
- Software Support
- Life-Cycle Logistics

Technical Expertise for the Future Navy

Approved for Public Release; Distribution is unlimited.

Small Arms Air Platform Integration

- Who are we?
  - We are a team of engineers, logisticians, and technicians with vast crew served weapons integration experience.
  - We have the capability to support the full life cycle of the systems we deploy.
  - We support multiple platform offices and team with industry partners.
  - We take great pride in providing high quality support to our customers in a timely manner.

- What do we do?
  - Design and integrate weapon systems for various aircraft.
  - Fabricate prototype parts for fit checks and testing.
  - Support flight certification process through the NAVAIR Performance Monitors.
  - Provide Finite Element Analysis (FEA) modeling for fatigue and crash loads.
  - Procure production hardware through GOV contracts.
  - Receive, inspect, kit, and deploy high quality systems.
  - Provide interim supply support.

Various Air Platforms Supported

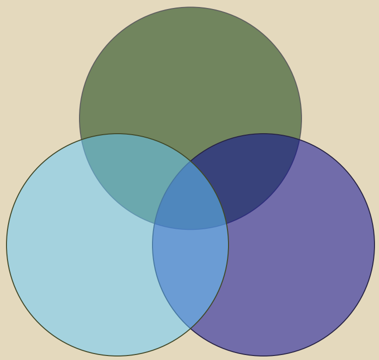
Approved for Public Release; Distribution is unlimited.

Crew-Served vs. Remote Weapons

- Multiple Department of Defense Agencies have conducted Remote vs. Crew-Served weapon effectiveness analyses.
- These tests have concluded that Remote Weapon Systems can provide increased force protection.
- Why are Remote Weapon Systems not integrated into a greater number of platforms?

Systems Engineering

Performance



Cost

Schedule

- How can we rapidly field Remote Weapon Systems on multiple platforms at a reduced cost that will provide enhanced capability for the fleet?
- How are we using Systems Engineering to solve this question?

Systems Engineering Process

- **We use applicable Systems Engineering Guides to derive a tailored Systems Engineering Plan**

May 2003

Naval Air Systems Command

NAVAIR

Systems Engineering Guide

NAVAIR NAVSEA SPAWAR Marines NAVSUP

Naval Systems Engineering Guide

October 2004

Systems Engineering Guide for Systems of Systems

Version 1.0
August 2008

SYSTEMS ENGINEERING FUNDAMENTALS

January 2001

SUPPLEMENTARY TEXT
PREPARED BY THE
DEFENSE ACQUISITION UNIVERSITY PRESS
FORT BELVOIR, VIRGINIA 22060-5565

Systems Engineering Plan Preparation Guide

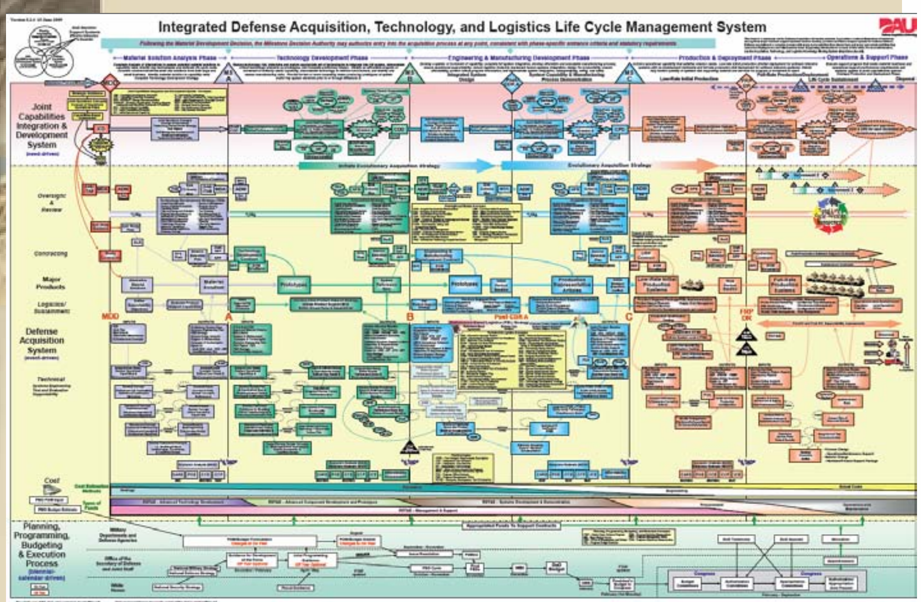
"Technical Planning for Mission Success"

Version 2.01
April 2008

Department of Defense

Office of the Deputy Under Secretary of Defense for Acquisition and Technology

Systems and Software Engineering
Enterprise Development



Approved for Public Release; Distribution is unlimited.

Tailor vs. Cut

- **The use of ‘Tailor’ instead of ‘Cut’ is key to our systems engineering process**
  - **Tailor: to fit to a particular circumstance**
  - **Cut: reduction; break off**
- **The Systems Engineering Process is often over simplified due to perceived ‘plug and play’ instead of integration**
- **Key Questions:**
  - **How can we apply guides and instructions written for an ACAT I program to a small rapid development effort?**
  - **What is the purpose of the process/document?**
  - **Does the purpose add value to the program?**
  - **How can we benefit from the purpose within cost and schedule?**

Installation vs. Integration

- **The next key concept is the difference between ‘Installation’ and ‘Integration’**
  - **Installation: putting a machine in position for operation**
  - **Integration: link to form a whole**
- **Complex Integrations are over simplified into simple installations.**
- **Square Peg in a Round Hole**

The Line of Integration

- **At what point do we draw the line for integration**
  - **COTS System onto Platform**
  - **COTS Subsystems into System onto Platform**
  - **COTS Components into Subsystems into Systems onto Platforms**
  - **The higher the better, within Performance, Schedule and Cost**
- **Use of Analysis of Alternatives and Trade Studies to identifying level of integration**
  - **Risk vs. Benefit Chart**
    - **This places the priority on the performance of the end item**
  - **Cost and Lead Time**
    - **Often COTS lead times are longer than entire project schedule**

Keeping a Fleet Perspective

- It's all about "Supporting the Warfighter"
- NSWC Crane has a close working relationship with the end user.
  - This allows us to continually receive feedback and make adjustments.
- How does the task I'm performing support the warfighter?

NSWC Crane as the System Integrator

- **RAPID RESPONSE**
  - As a DoD Activity funding can be provided immediately avoiding contract lead times
  - This allows us to be fully engaged from the start of the program, working with the sponsor and end user to solidify requirements
  - No contract mods when requirements change
  - Flexibility to adjust to SE process changes
    - Drop non-value added tasks
    - Add emerging tasks to meet goals

Tools

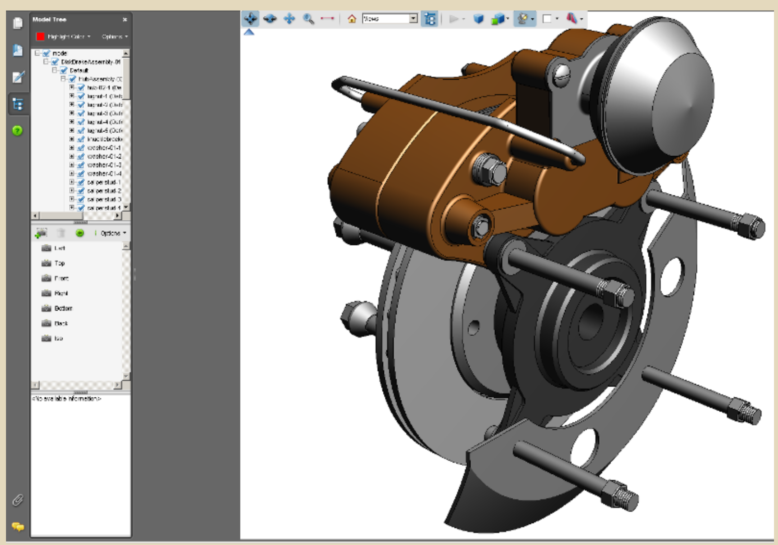
- **MS Project**
  - **Integrated Master Schedule**
  - **Setup by WBS allows for clearer tasking and reporting**
- **Guides**
  - **Start with guides and tailor, not process that reference guides**
  - **MIL-HDBK's / MIL-STD's**
  - **DoD/Navy/Industry Guides**
  - **DoD/Navy Instructions**
  - **GAO Reports**

Hardware-In-the-Loop Development

- **Establishing a DoD Hardware-In-the-Loop Working Group**
  - **Navy Warfare Centers, AFRL, TARDEC**
- **Model-Base Software development allows for rapid software development**
- **Software can be broken up into ‘Subsystems’, simulated, tested with actual hardware, and then integrated into full system.**

3D PDF

- **The use of 3D pdf's has allowed us to have integrated design reviews.**
- **The design can work right up to the meeting**
- **Meeting location not dependant on CAD capable computer**
- **Helps with non co-located quick look design reviews**



Summary

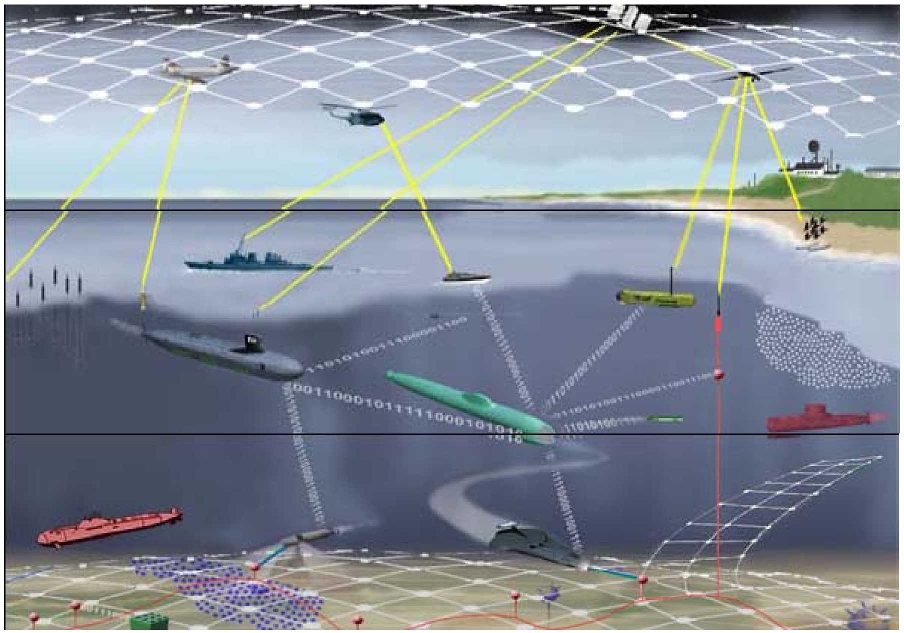
- Increase in Remote Weapon System would provide enhanced capability to the warfighter
- ‘Tailored’ System Engineering Process provide the foundation for a complex effort
- Remote Weapon Systems must be integrated, not just installed
- The point of integration must be adjusted to meet desired performance
- Rapidly adapt SE processes to stay focused on how that task benefits the warfighter
- Use new tools to perform SE activities

Thank you for your time and attention!

For more information on NSWC Crane, please visit www.crane.navy.mil

Images were downloaded via publically accessible websites

Naval Postgraduate School



C4I Architecture Supporting Conduct of Defensive and Offensive Joint ASW

Presented By:
Gregory Miller
Bill Traganza
Matthew Letourneau
Baasit Saijid

28 Oct 2009
(based on report # NPS-00-001)

Team Members

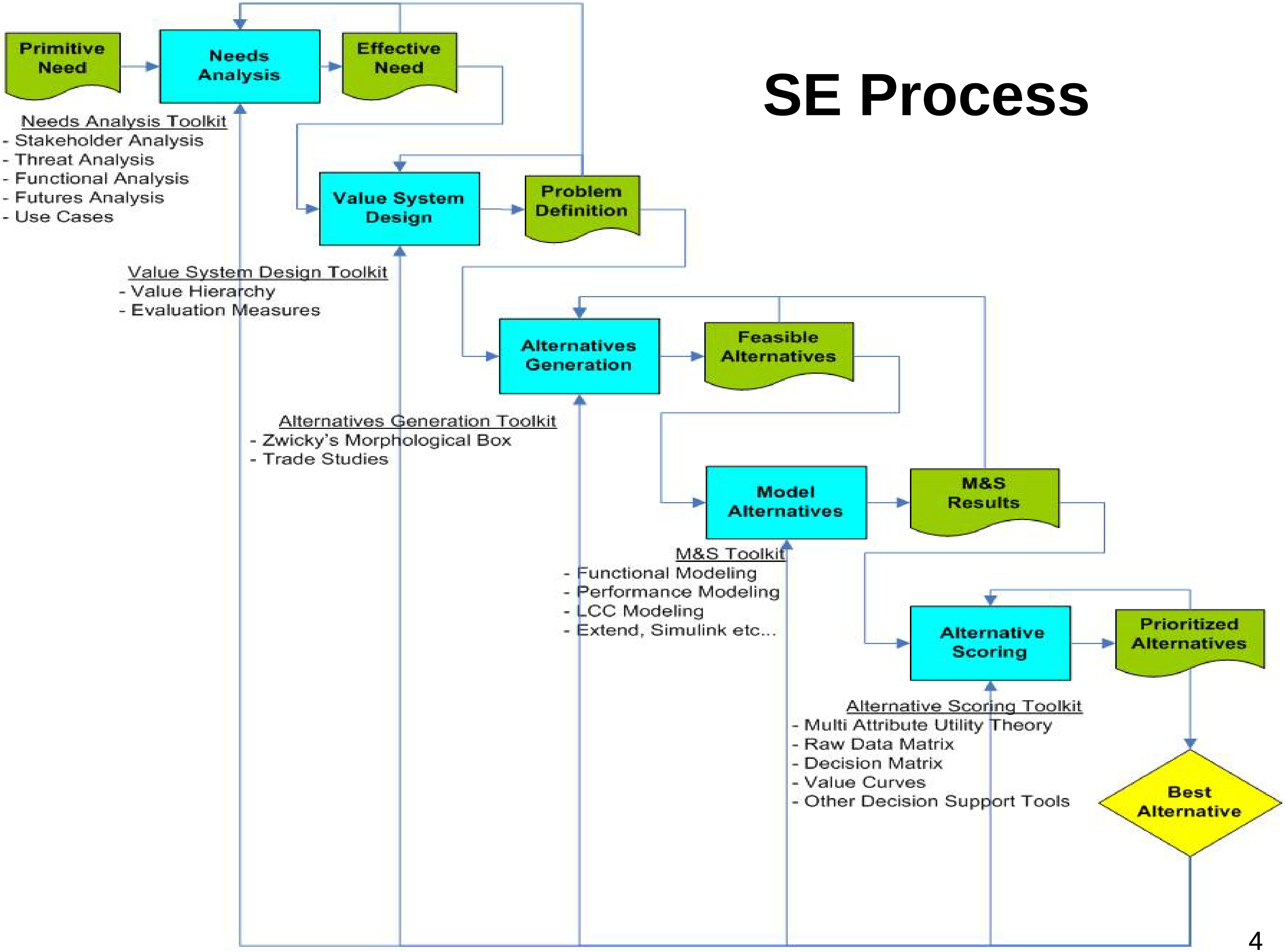
Michael Clendening	Alejandro Cuevas	Amritpal Dhindsa
Dennis Hopkins	<u>Matthew Letourneau</u>	Justin Loy
James New	Van Ngo	Amrish Patel
<u>Baasit Saijid</u>	<u>Bill Traganza</u>	

- Commands represented by team
  - Space and Naval Warfare Systems Command -- Systems Center San Diego and Charleston
  - Naval Surface Warfare Center – Corona Division
  - Program Executive Office Littoral and Mine Warfare – Maritime Surveillance Systems Program Office
  - Program Executive Office C4I
  - Joint Tactical Radio System – Joint Program Executive Office
  - East Coast Electronic Warfare Systems
  - Communications-Electronics Research Development and Engineering Center
- Project advisors: <u>Gregory A. Miller</u> & John M. Green

Project Purpose

- Create a new standardized joint ASW-specific C4I architecture
  - To enhance the commander's ability to execute the joint ASW mission in support of a combatant commander's campaign objectives [NCOE JIC, 2005].
  - To meet key ASW stakeholder requirements, addressing current capability gaps and responding to changing threats
  - To guide development, force composition, and acquisition decisions
- Constrained to:
  - Target time frame: 2020
  - Needs to use
    - Open standards
    - Common waveforms
    - Common data schema
  - Interoperable with existing & evolving systems
  - Vertically integrated with other DoD C4I systems

SE Process

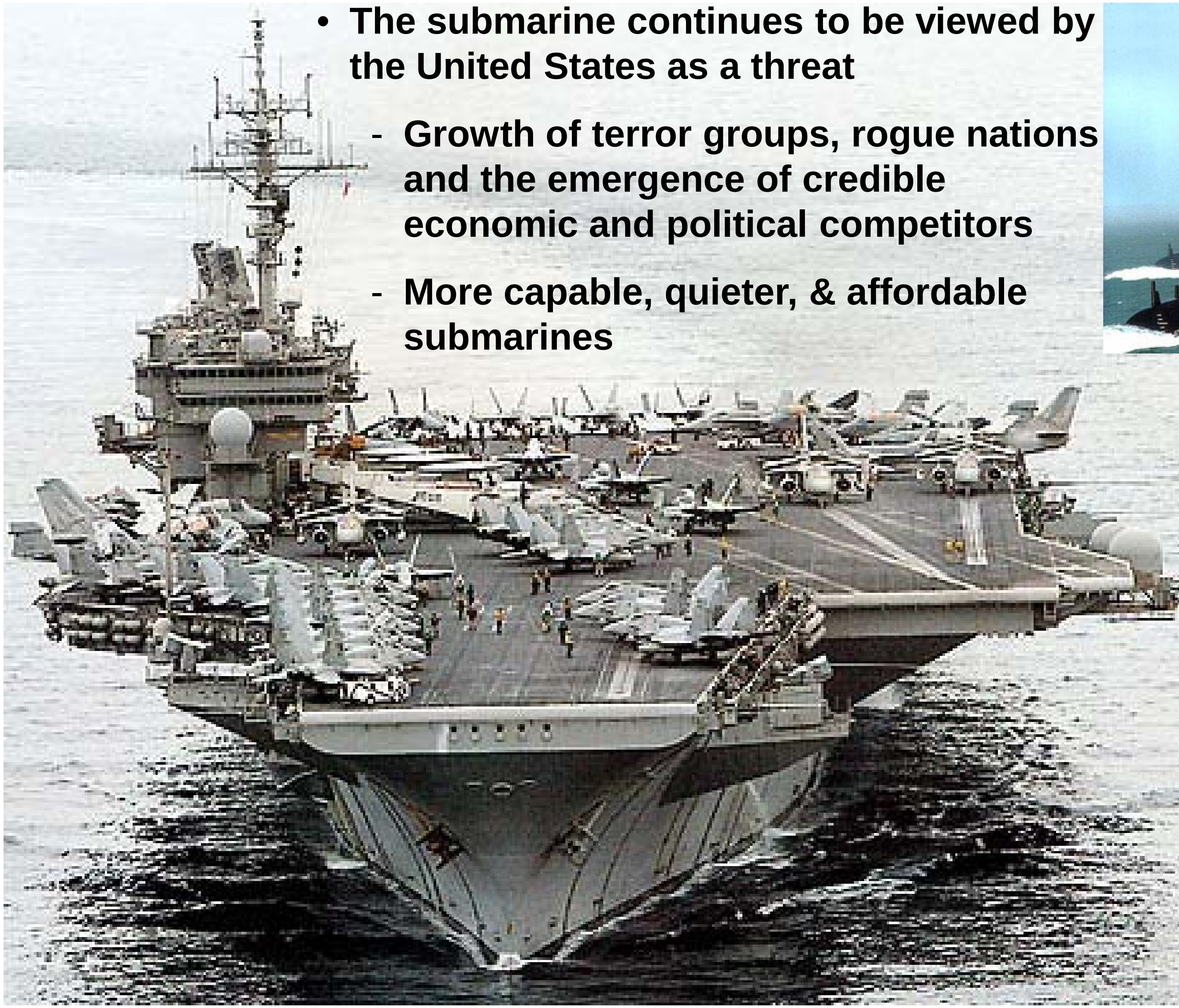


Primitive Need
Needs Analysis
Effective Need
Needs Analysis Toolkit
- Stakeholder Analysis
- Threat Analysis
- Functional Analysis
- Futures Analysis
- Use Cases
Value System Design
Problem Definition
Value System Design Toolkit
- Value Hierarchy
- Evaluation Measures
Alternatives Generation
Feasible Alternatives
Alternatives Generation Toolkit
- Zwicky's Morphological Box
- Trade Studies
Model Alternatives
M&S Results
M&S Toolkit
- Functional Modeling
- Performance Modeling
- LCC Modeling
- Extend, Simulink etc...
Alternative Scoring
Prioritized Alternatives
Alternative Scoring Toolkit
- Multi Attribute Utility Theory
- Raw Data Matrix
- Decision Matrix
- Value Curves
- Other Decision Support Tools
Best Alternative

Needs Analysis

- Capability Gaps Analysis (Situation Today)
- Stakeholders Analysis
- Future Analysis
- Functional Analysis

Situation Today



- The submarine continues to be viewed by the United States as a threat
  - Growth of terror groups, rogue nations and the emergence of credible economic and political competitors
  - More capable, quieter, & affordable submarines

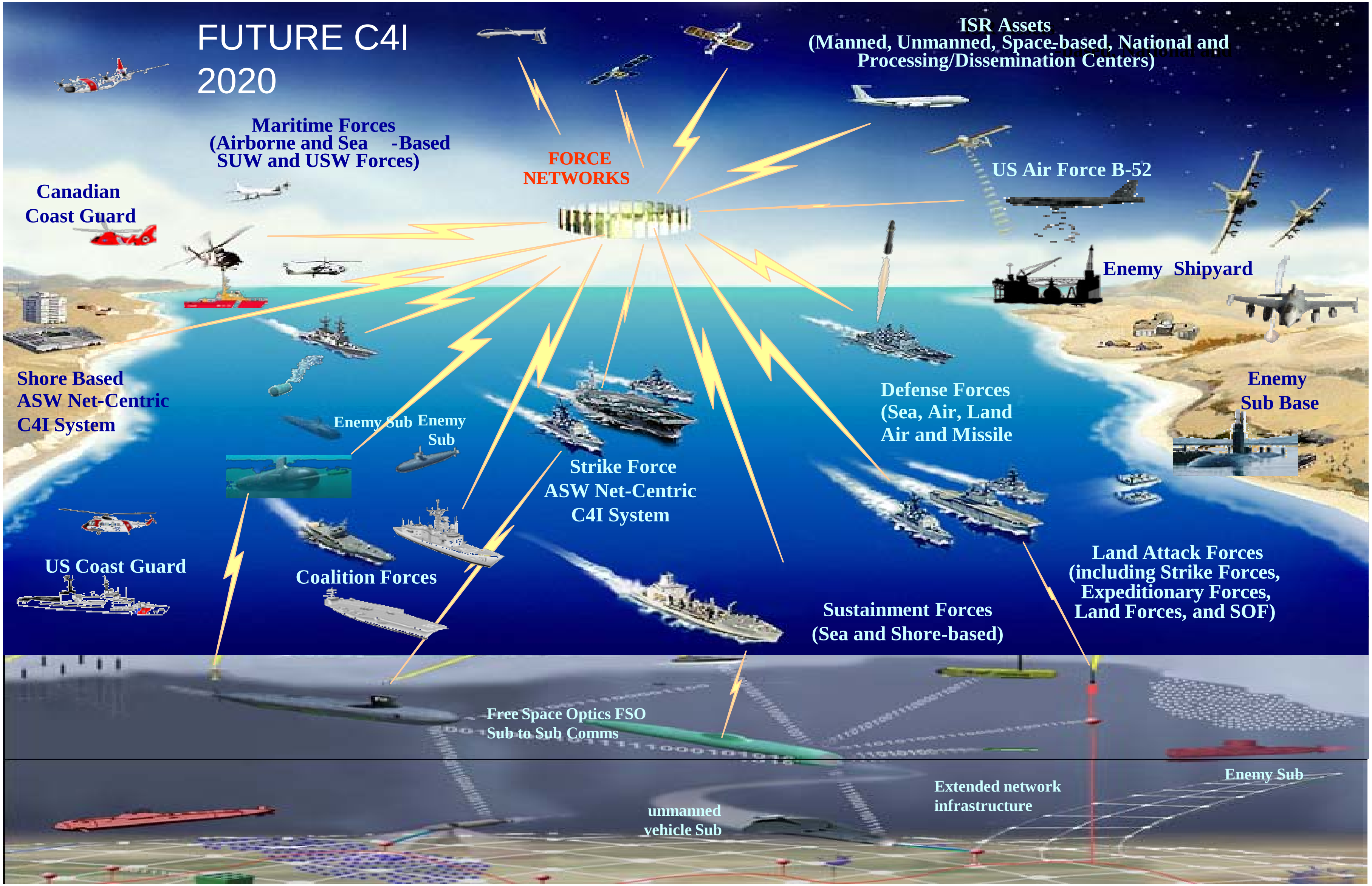
- Platform-centric ASW C4I systems are not used in a networked fashion to share data
  - Limited situational awareness
  - Limited mission effectiveness

Summary of Stakeholder Input

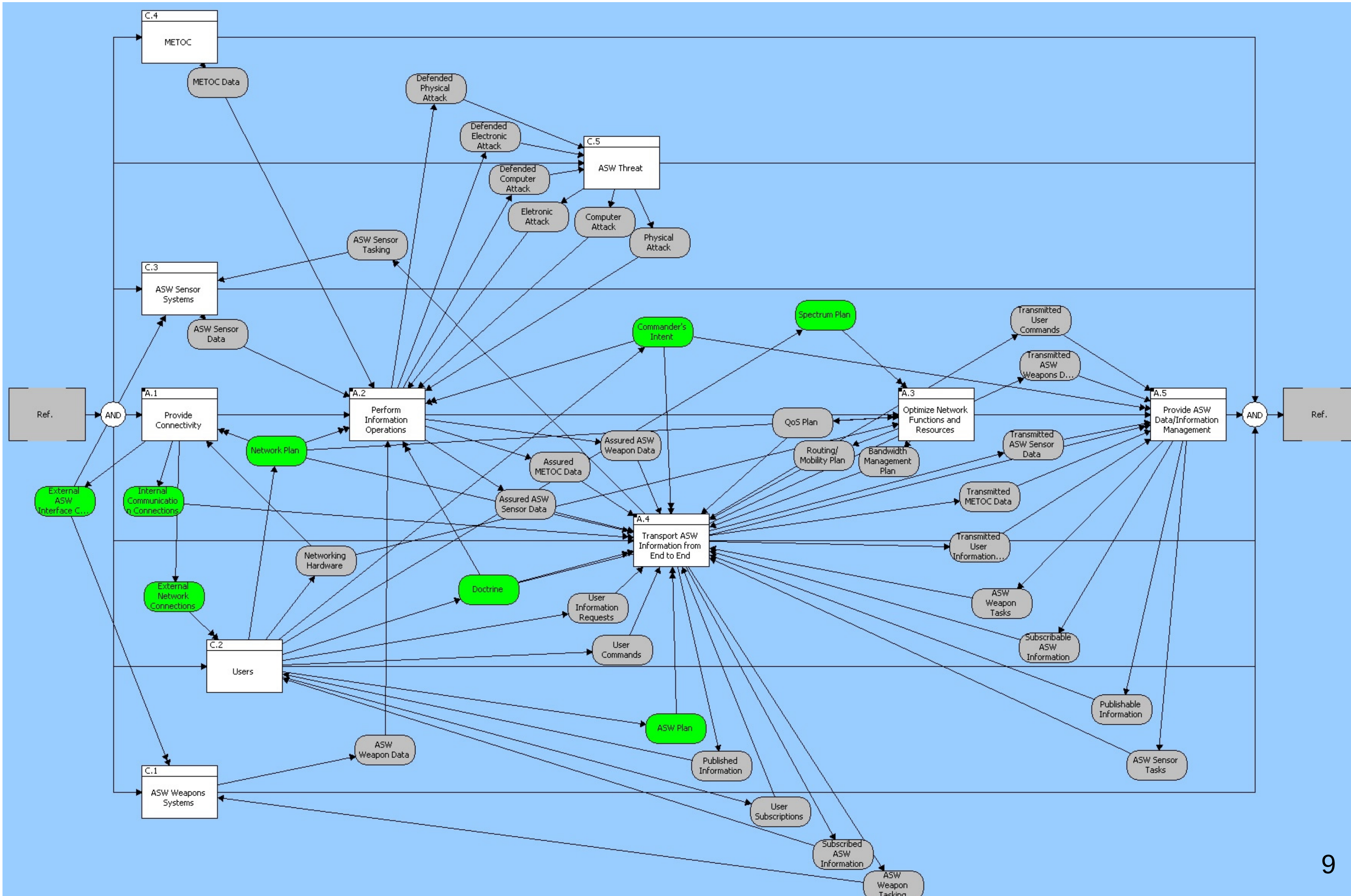
- Legacy & Evolved Systems
  – Platform-centric C4I systems
  – Platform-centric sensors
  – Platform-centric weapons
  – Limited interoperability

- Future Systems
  – Networking to connect sensors & platforms
  – Information sharing
  – Improved information quality
  – Viewing through a COTP – fused, appropriate data
  – Conducting ASW as a Team

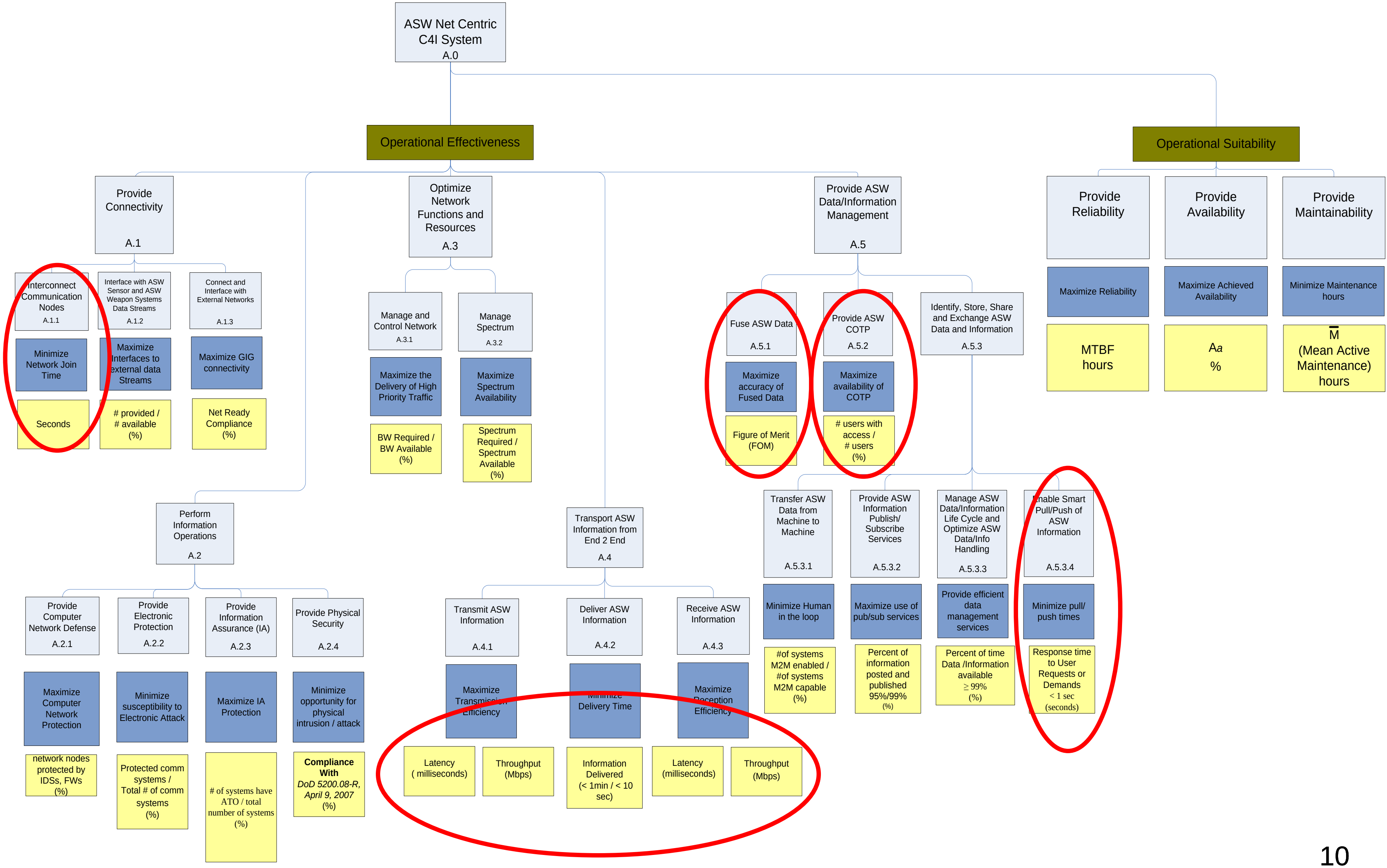
Draft Futures OV-1



C2 System Functional Analysis



Value System



Top Six Evaluation Measures

- # Users w/ access to COTP
- Time Required to Push/Pull
- Time Required to Fuse Data
- Time to Interconnect Nodes
- Transmit Latency
- Transmit Throughput

Alternatives Generation

- **Baseline Architecture**
- **Feasible Alternatives**

Programs of Record & C4I Functionality

DoD Teleport

SINGLE INTEGRATION POINT FOR DISN
(TERRESTRIAL & TACSAT COMMS);
TELECOM COLLECTION & DISTRIBUTION POINT;
MULTI-BAND, MULTIMEDIA, & WORLDWIDE REACH-BACK;
STANDARDIZED TACTICAL ENTRY POINT EXTENTION;
MULTIPLE MILCOMM & COMMSAT SYSTEMS;
SEAMLESS DISN INTERFACE;
INTER & INTRA-THEATER COMMUNICATIONS;
INCREASED DISN ACCESS

Transformational Satellite System

GLOBAL NET-CENTRIC OPERATIONS;
ORBIT-TO-GROUND LASER & RF COMMS;
HI DATA RATE MILSAT COMMS &
INTERNET-LIKE SVCS;
IMPROVED CONNECTIVITY/DATA TRANSFER;
IMPROVED SATCOMMS

Net-Centric Enterprise Services

UBIQUITOUS ACCESS; RELIABILITY;
DECISION QUALITY INFORMATION;
EMPOWER “EDGE” USER;
TASK, POST, PROCESS, USE, & STORE, MANAGE
& PROTECT INFORMATION RESOURCES
ON DEMAND

Next Generation Enterprise Network

OPEN ARCHITECTURE
SERVICE-ORIENTED ARCHITECTURE

Global Information Grid

COLLECTING, PROCESSING, STORING,
DISSEMINATING, & MANAGING INFO ON
DEMAND;
OWNED & LEASED COMMS

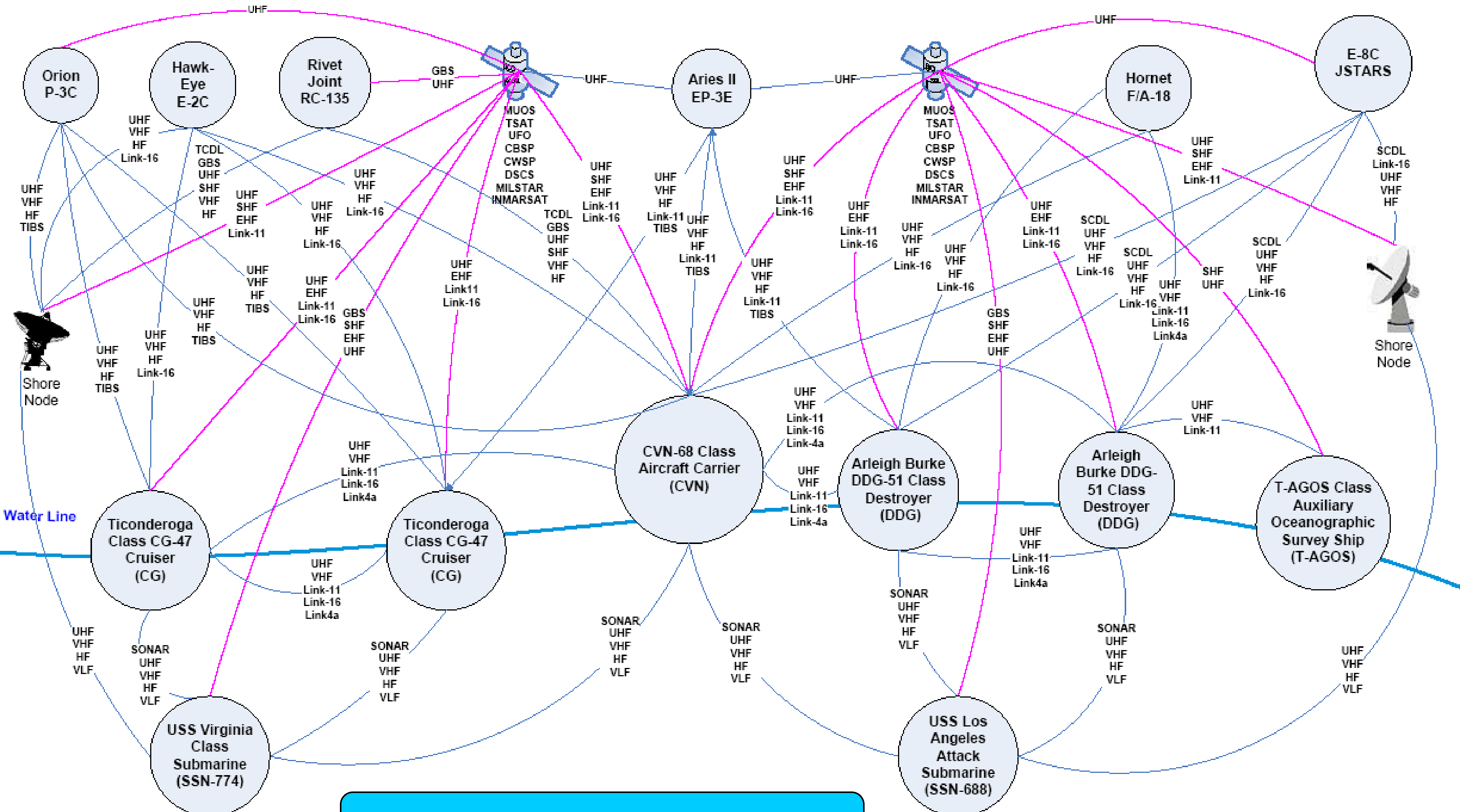
Joint Tactical Radio System

LOS / BLOS; MULTI-BAND, MULTI-MODE,
MULTI-CHANNEL; NARROWBAND &
WIDEBAND WAVEFORMS; VOICE, VIDEO AND
HIGH-SPEED DATA

Net-enabled Command Capability

JOINT COMMAND AND CONTROL

FY2020 Baseline ASW C4I Architecture



Alternative 0

Alternative Solutions

Alternative 0 – FY2020 ASW C4I Baseline Architecture

- **Joint Surveillance and Target Attack Radar System (JSTARS)**
  - **Satellite communications link (SATCOM)**
  - **Surveillance and control datalink (SCDL)**
  - **Joint Tactical Radio System (JTRS)**
- **RC-135: The Tactical Common Data Link (TCDL)**
- **Interface to the Tactical Control System (TCS)**
- **Link-16**

Alternative 1

FY2020 ASW C4I Baseline Architecture **plus:**

- **JTRS improvements**
- **NECC improvements**
- **CANES improvements**

Alternative 2

FY2020 ASW C4I Baseline Architecture **plus:**

- **JTRS improvements +**
- **CANES improvements**
- **Joint Track Manager**

Alternative 3

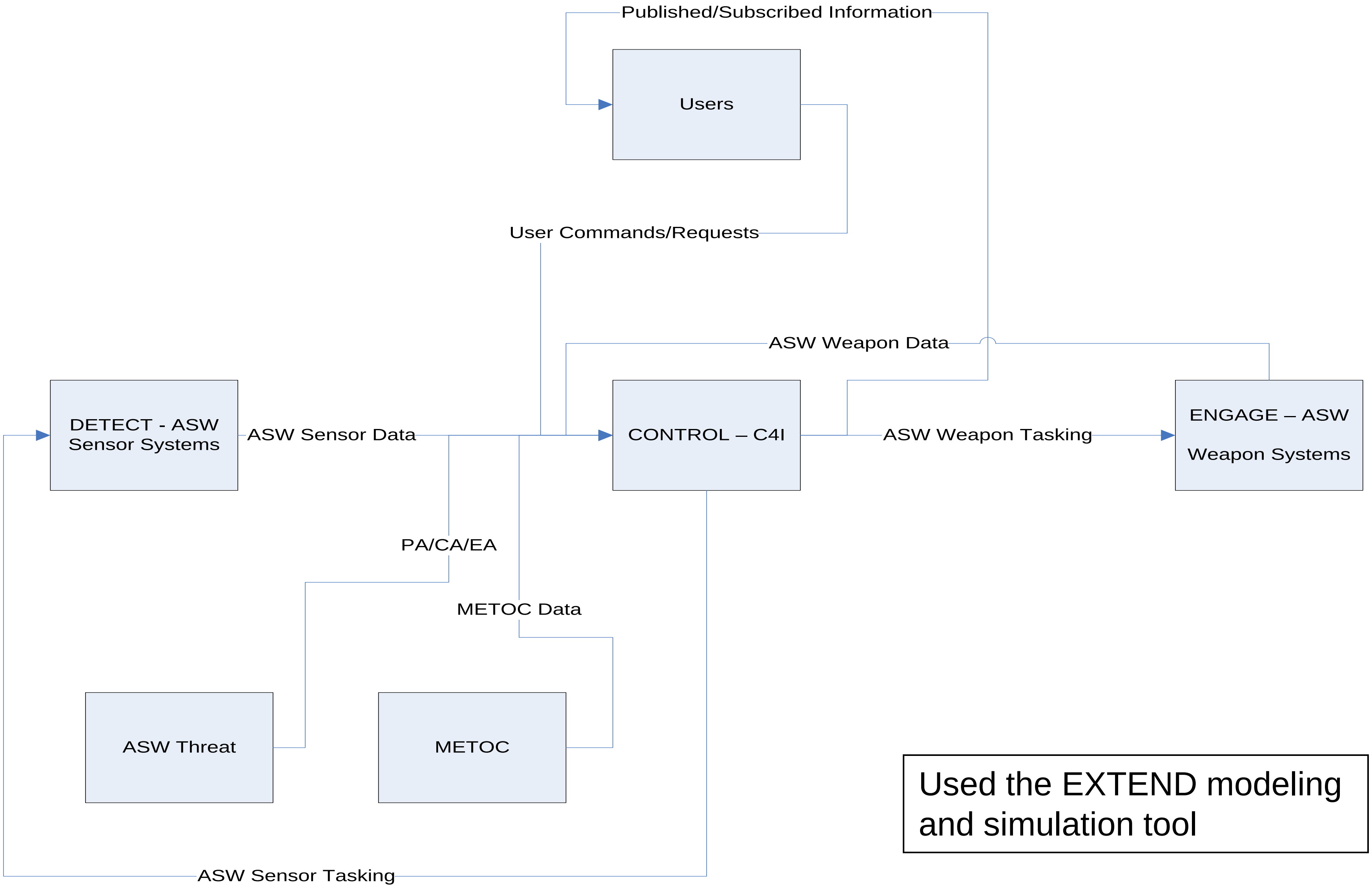
FY2020 ASW C4I Baseline Architecture **plus:**

- **Modulated X-ray source communications system**
- **Autonomous C4ISR UUVs**
- **Military High Altitude Airship (HAA)**
- **Tropospheric or space-based distribution & COTP fusion**
- **Wireless info push/pull directly to satellite or HAA based network.**

Modeling and Simulation Results

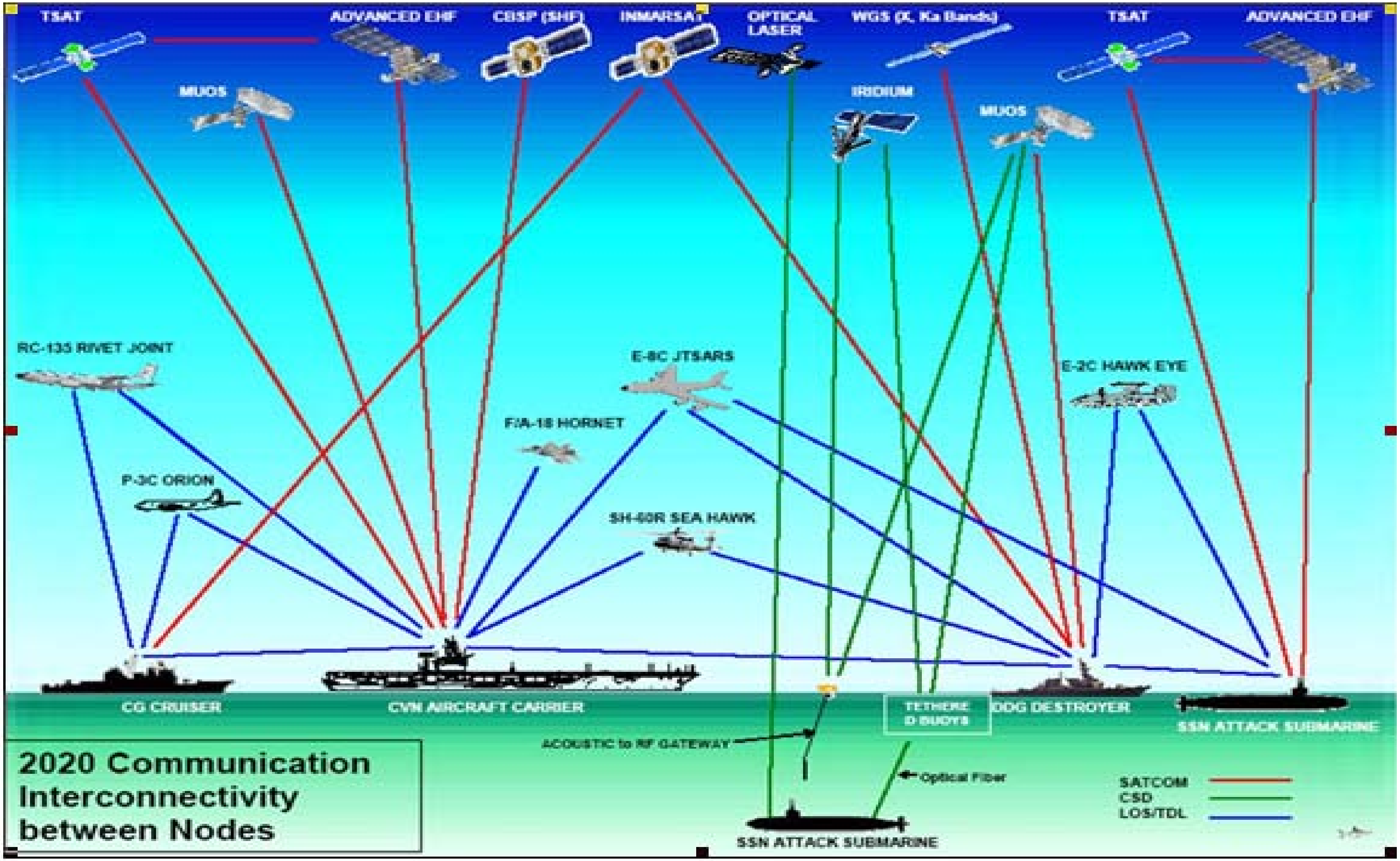
- Model Overview
- Data Inputs
- Comparison of Alternatives

Model Overview



Used the EXTEND modeling and simulation tool

Communication Between Platforms



Graphical Representation of the Systems Expected to Perform the Interconnect Communication Nodes Function for Alternatives 0, 1, and 2

Comparison of Alternatives

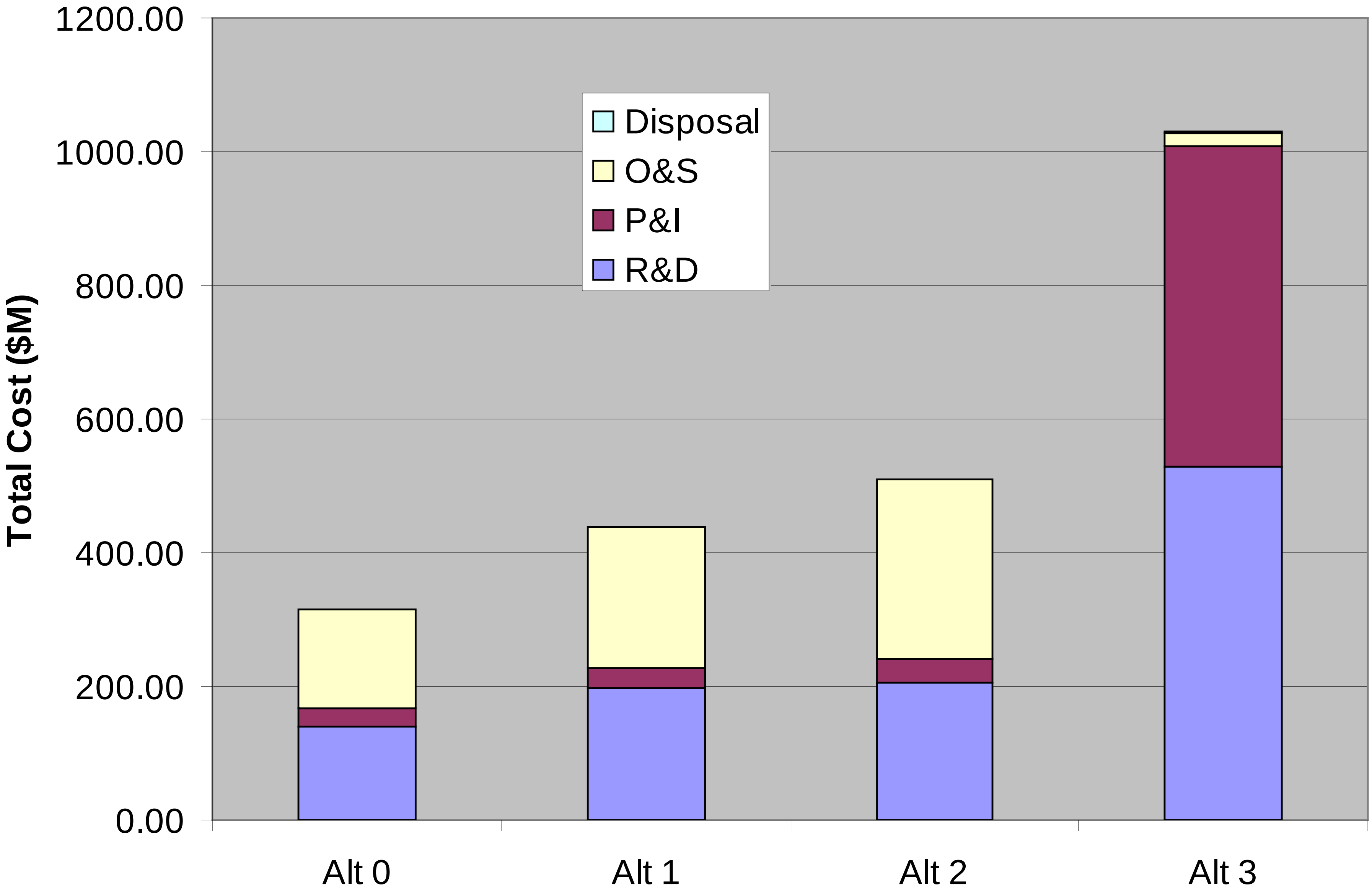
Measurement	Alt 0	Alt 1	Alt 2	Alt 3
Data Fusion Processing Time (ms)	702.39	540.13	299.82	299.72
Interconnect Communication Nodes (s)	5	4.5	2.5	2.5
Latency (ms)	1334.1	1205.0	685.56	680.16
Throughput (kbps)	51.29	53.93	58.85	58.15

Life Cycle Cost Estimate (LCCE)

LCCE

- Purpose: Basis for an informed decision when selecting an alternative
  - Assess affordability
  - Analyze alternatives
  - Cost verses performance tradeoffs
  - Establish program cost goals
- Scope: Simplified Cost Break Down Structure (CBS)
  - Research and Development (R&D)
  - Procurement and Installation (P&I)
  - Operation and Maintenance (O&M)
  - Disposal
- Assumption: A “Notional” U.S. Navy Ship
  - Common Computing, Network, Communication Infrastructure
  - C4I centric
  - Program office provided data
  - Three increments

Total Cost for Each Alternative

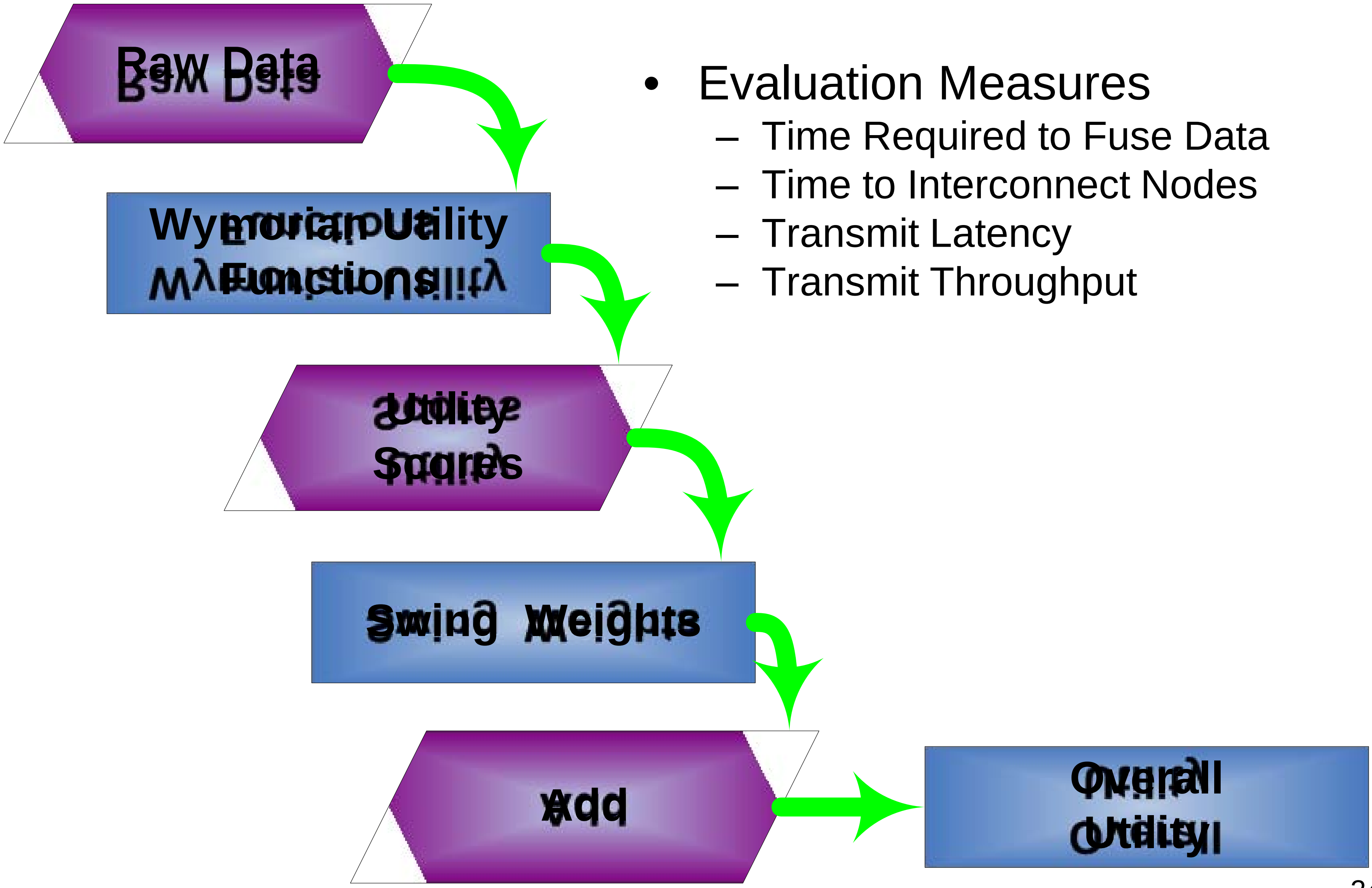


Analysis of Alternatives

- **Multi Attribute Utility Theory (MAUT)**
- **Raw Data Values**
- **Utility Scores**
- **Swing Weights**
- **Decision Matrix**
- **Utility Score vs. LCCE**

Multi Attribute Utility Theory (MAUT)

- Evaluation Measures
  - Time Required to Fuse Data
  - Time to Interconnect Nodes
  - Transmit Latency
  - Transmit Throughput



Raw Data Values

Function (Evaluation Measure)	Alternatives			
	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Fuse ASW Data (Time Required to Fuse Data)	702.395 ms	540.139 ms	299.823 ms	299.720 ms
Interconnect Communication Nodes (Time to Interconnect)	5 s	4.5 s	2.5 s	2.5 s
Transmit ASW Information (Transmit Latency)	1334.161 ms	1205.027 ms	685.560 ms	680.160 ms
Transmit ASW Information (Transmit Throughput)	51.292 Kbps	53.930 Kbps	58.855 Kbps	58.155 Kbps

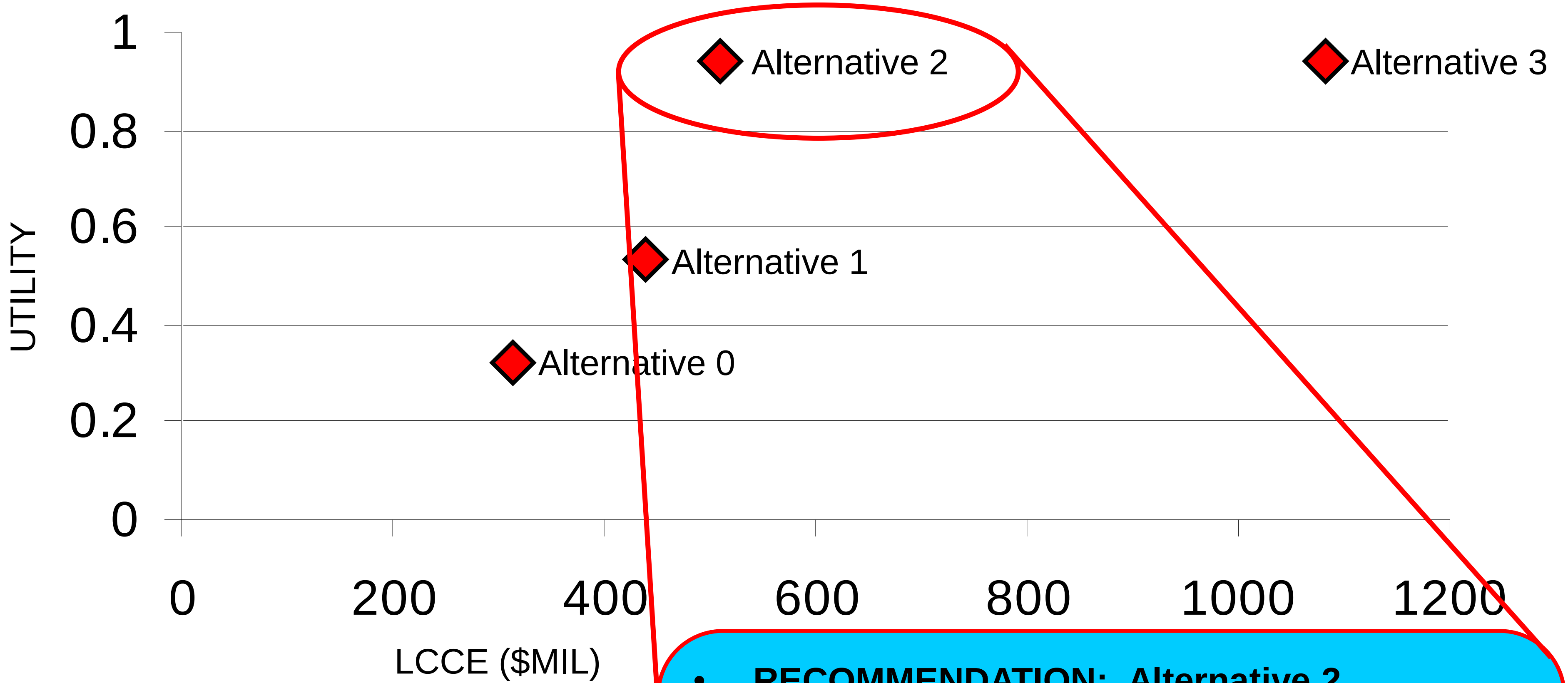
From the Extend model and scenarios

“Number of users with COTP access” and “Time required to push/pull” were identical for the four alternatives, so were not considered discriminators for decision-making.

Decision Matrix

Function (Evaluation Measure)	Weight	Alternatives			
		Alternative 0	Alternative 1	Alternative 2	Alternative 3
Fuse ASW Data (Time Required to Fuse Data)	**0.370**	0.06	0.36	0.93	0.93
Interconnect Communication Nodes (Time to Interconnect)	**0.185**	0.5	0.65	0.96	0.96
Transmit ASW Information (Transmit Latency)	**0.278**	0.37	0.49	0.9	0.9
Transmit ASW Information (Transmit Throughput)	**0.167**	0.63	0.83	0.99	0.98
Total Score (0-1)		**0.32**	**0.53**	**0.94**	**0.94**
LCCE ($Mil)		**313.90**	**439.60**	**508.65**	**1080.46**

Utility Score vs. LCCE



- **<u>RECOMMENDATION: Alternative 2</u>**
  - JSTARS
  - SATCOM
  - SCDL
  - Link-16
  - Joint Track Manager
  - RC-135: TCDL
  - Interface to the TCS
  - JTRS with latency & throughput improvements
  - CANES improvements

Conclusions

- There are initiatives to solve most ASW stakeholder concerns
- A system of systems (SoS) architect is needed
  - Conduct SoS M&S
  - Address projects at a SoS level
  - Enable cross-program manager collaboration
- Revise the modeling
  - Reflect current planned attributes for 2020 (changes since mid-2008)
  - M&S with all 24 functional evaluation measures
  - Include classified data sets
- Functional C4I characteristics *not* unique to ASW community
- Future C4I capabilities dependent upon cross-leveling of future DoD funding levels
- ASW operational C4I standards are needed in FY2020

Areas For Further Consideration

<u>Operational Users and Acquisition Community</u>

- Consider accuracy improvements provoked by data fusion and data sharing techniques during development of sensors and weapons
- ASW is a team sport [Morgan, 2008]. Need to improve ASW operational integration. Who's on the team?
  - Interagency (e.g., Coast Guard) and Joint?
  - Coalition and Allied?
    - If yes, security restraints and policies preventing IP base communications need to be addressed
- …..and many more in the report

Questions





Human Interoperability and Net-Centric Operations

Dr. Alenka Brown
Sr. Research Fellow, National Defense University
Center for Technologies and National Security Policy

Human Interoperability Enterprise

Understanding and identifying the "what" and "how" of the inter-relationships of social-systems and human-systems integration independent of and within networks.

Why is this significant?: Allows US Government to rapidly build synergism amongst mission and non-mission partners in establishing cross-cultural social networks and human-system integration. Establish reliable, effective, and trusted human net-centric environments.

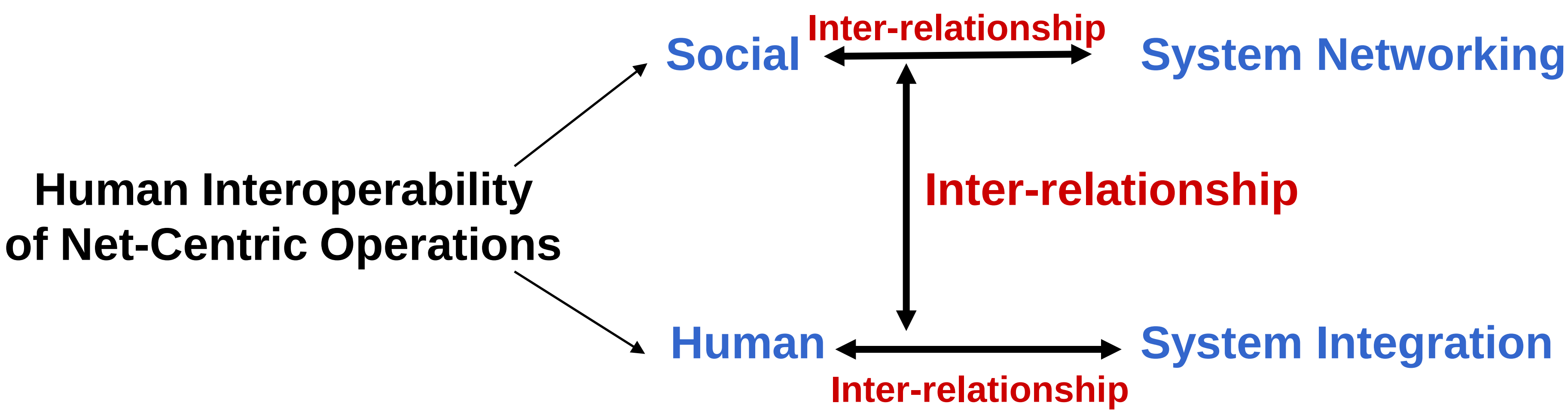
Where? – In dissimilar, stressed, and/or self-motivated environments.

How? – By exploring the processes that US Government and its mission partners incorporate in its training, education, and applications for collaboration in building partnerships and partnership capacity.

End State? – Produce effective processes that sustain trusted human networks for sharing of information, knowledge, techniques, technologies, and behaviors (beliefs and values) across Net-Centric Environments of Operations.

Human Interoperability Enterprise

Human Interoperability focuses on the processes of the inter-relations between diverse cultures within and between SSN and HSI.



Understand the Inter-relationships

Identify processes of the inter-relationships that are “compatible” for reliable, effective, and trusted social/human-system networks in net-centric environments of operations.

Thus,

- **Assess the human factor indicators/attributes that contribute to trust or mistrust factors of social/human-system networks in net-centric environments of operations.**

- **Assess the enablers/inhibitors for sharing of information and behaviors across diverse cultural domains of net-centric environments of operations.**

Understand the Inter-relationships

- **(Continued)**

  - **Assess the cognitive-matching in messaging exchange (the same message received, is the same message sent)**

  - **Assess ego-ergonomics**
  - **Assess the social-cultural interfaces**

  - **Assess the policy, doctrine, standards and technical procedures as pertaining to social and human-system networks for *alignment, adaptability, and agility.***

Understand the Inter-relationships

Understand - the issues, barriers, gaps, and processes that cause inadequate or incompatible social/human-system integration within networks.

Achieve the Understanding - through studies, experimentations, and venues of operations involving disparate groups of people, organizations, social infrastructures, and enabling technologies. For example:

The rapid organization of reliable disparate social networks from hastily formed physical networks. Or, the rapid reestablishment of a degraded human-system social network.

Understand the Inter-relationships

End State for Understanding - **enhance or refine the social/human-system integration of networks per policy, standards, practices, training and education that is required for the US Government to (though not limited to):**

- **rapidly put in place reliable and efficient social-system networks for information sharing**
- **build partnership capacities that go beyond technological architectures**
- **understand how to sustain - "smart power" capability in Irregular Warfare, Humanitarian Assistance, and Disaster Relief Events.**

Understand the Inter-relationships

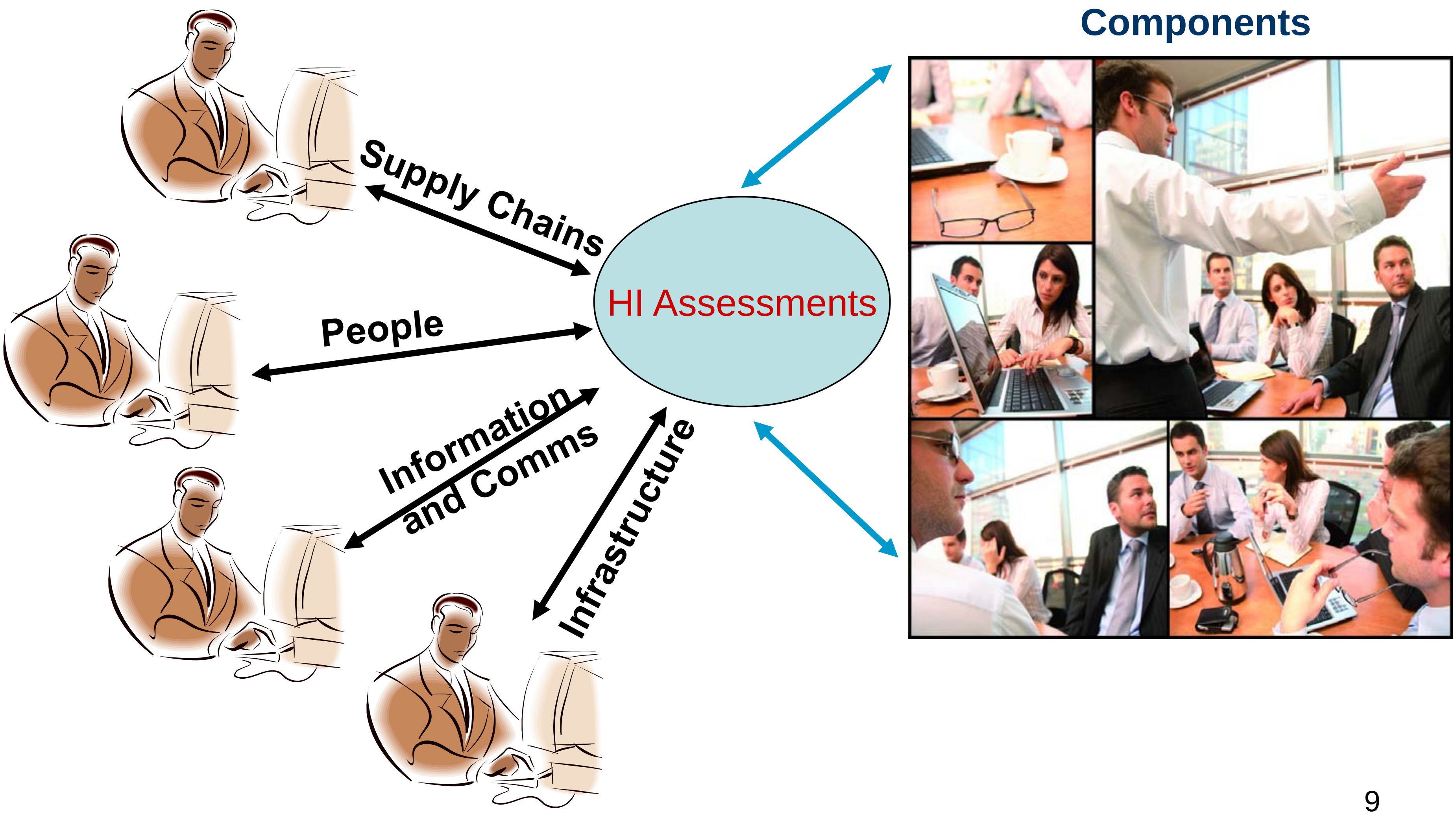
- **Test**

  - **Policy, Standards, and Operational Procedures for,**
    - **forming human networks**
    - **human to human communications**
    - **organization to organization communications**
    - **human system integration**
    - **information sharing across disparate domains:**
      - **DoD-Coalition-Interagency-intercommunity**

  - **Operational procedures that result in sharing of cultural and cognitive behaviors.**

  - **The socio-cultural boundaries for convergence of governing policies and standards.**

HI Example: Disaster Scenario

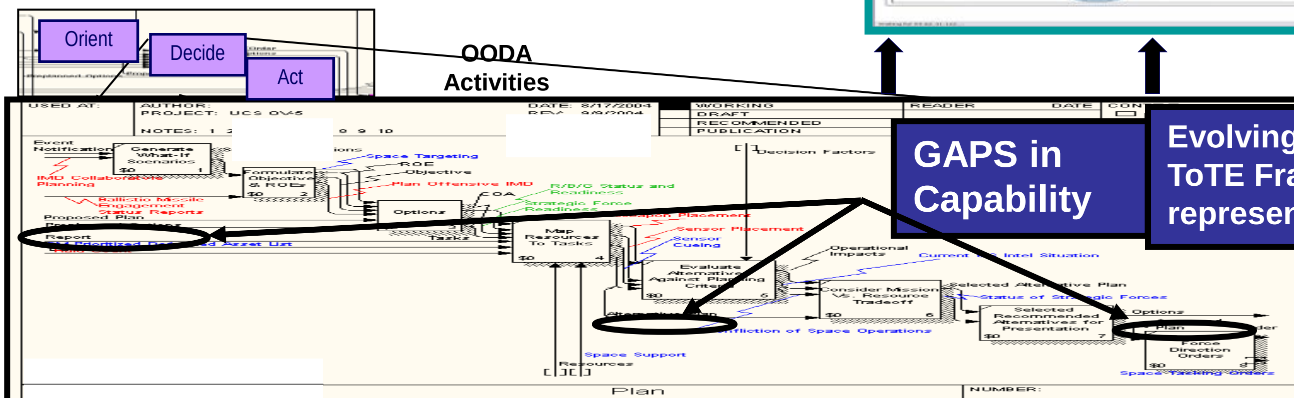


Human Interoperability

Geo-Ergonomic of Information Flow Across Multiple Languages and Cultures

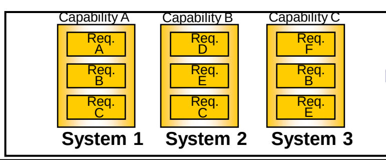
Underlying activities to get to

Operational CONOPS

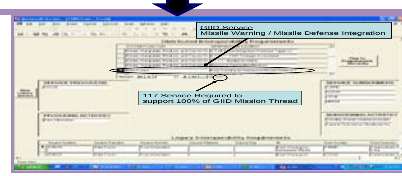


GAPS in Capability

Evolving Capability within the OODA / ToTE Framework provides a visual representation of required activities.



System Contribution, Supporting Systems Infrastructure



Common Language Discovery

De-confliction of language Inhibitors

Policy & Governance

NGO

DoD

OGA

Outputs

Performance Requirements Integration Requirements Functional Requirements Associated Architectural Products

SUMMARY

- US Government spends a great amt of $ and resources on information technology to improve government efficiency and effectiveness.

- Technology though is simply a tool to enhance our ability to share information, beliefs and values.

- To use these tools, there must be a shared understanding between those sharing the information and the human interoperability that establishes this shared understanding effectively with a sustainment of trust and compatibility.

POC Information

Dr. Alenka Brown, SES
Sr. Research Fellow
Lead for Human Interoperability Enterprise Program
National Defense University
Center for Technologies and National Security Policy

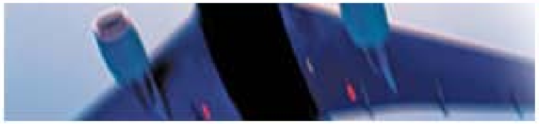
202-685-6344 (w)
202-231-7548 (w)
865-207-9054 (cell)

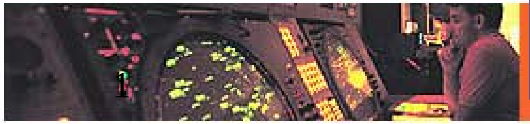
brownvanhoozers@ndu.edu
brownvanhosa@ornl.gov (blackberry)

Certify and Fly Right: Preparing for DO-297 Certification

Keith Custer

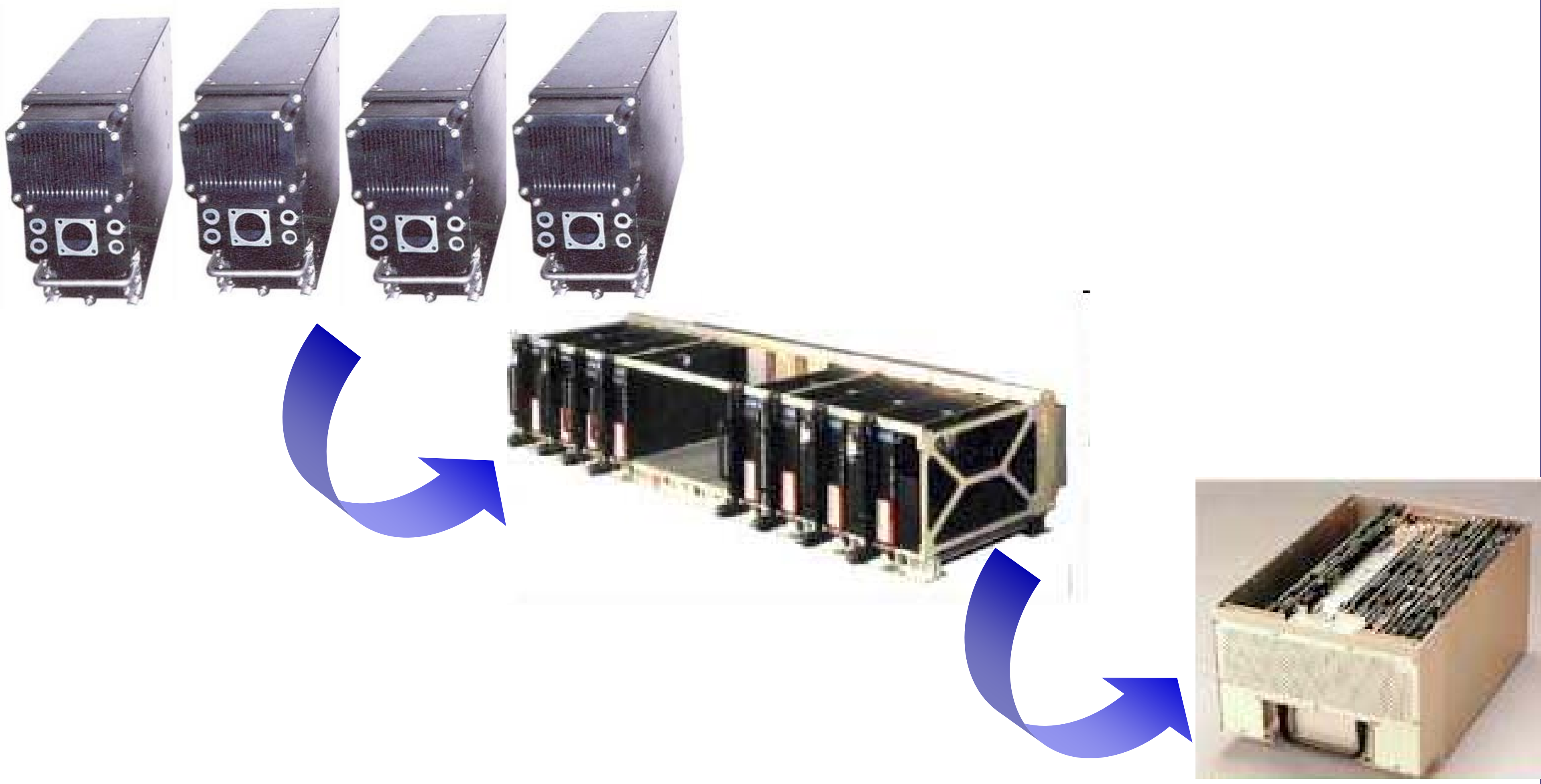
Esterline Control Systems - AVISTA





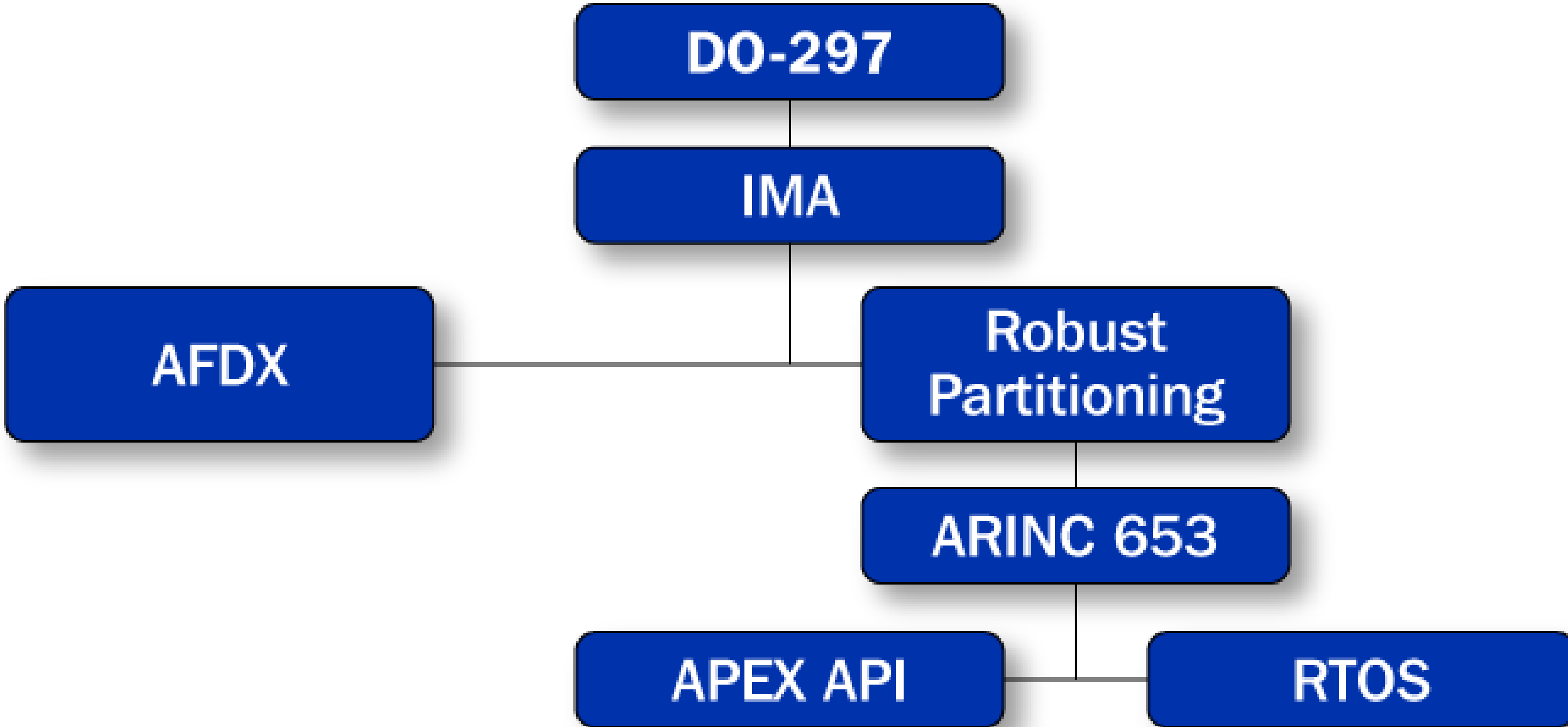
Boeing 777

Integrated Modular Avionics (IMA)



Images courtesy of avionicszone.com and Trade India

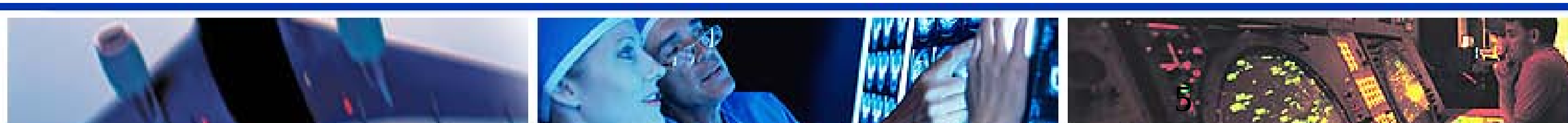
DO-297 Overview & Terminology



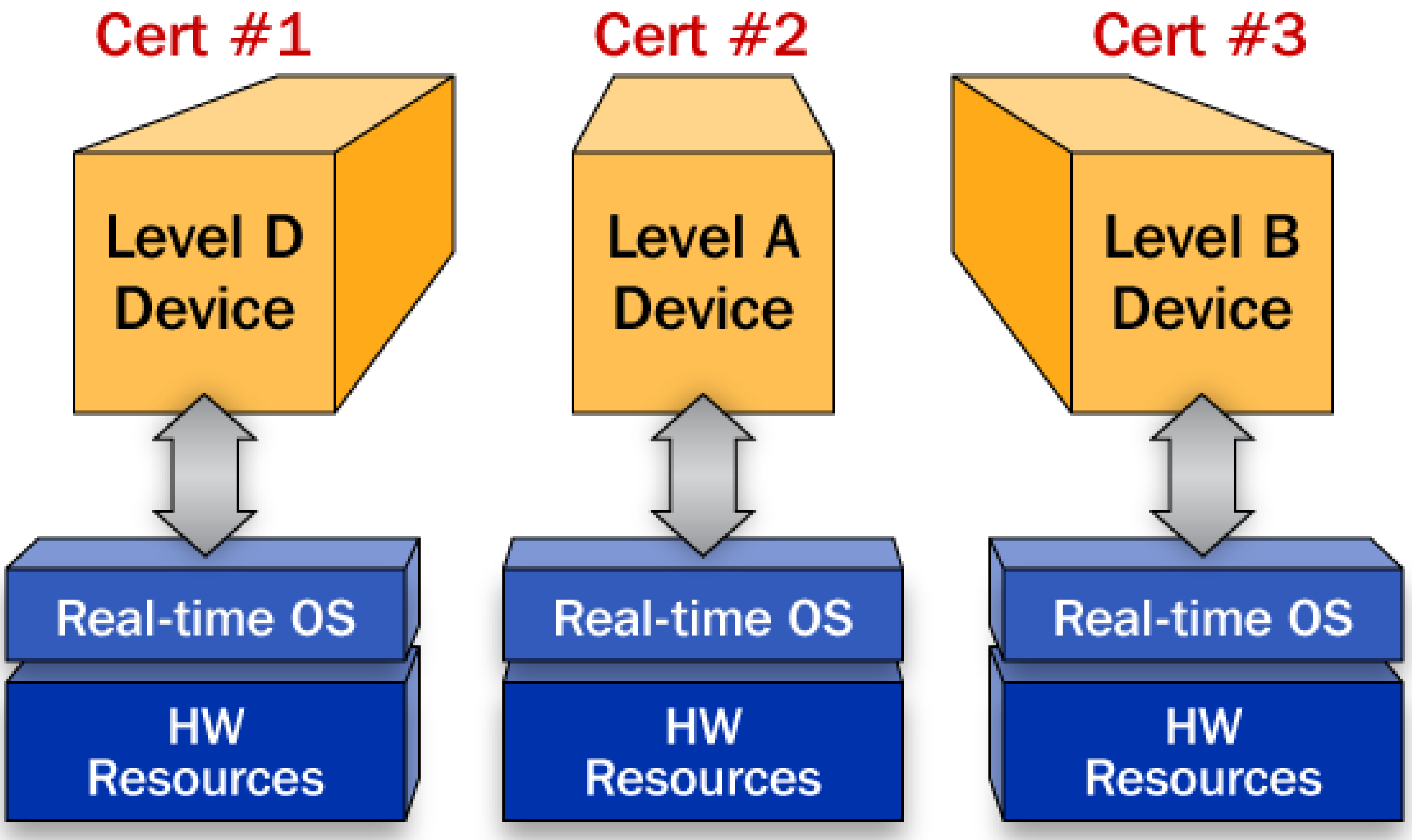
IMA Time Partition

```
/* Single Application */
switch(timeSlice)
{   case 0:
        ReadLabels();
    case 1,3,5,7:
        MainProcess();
    case 2,4:
        SaveLog();
}
```

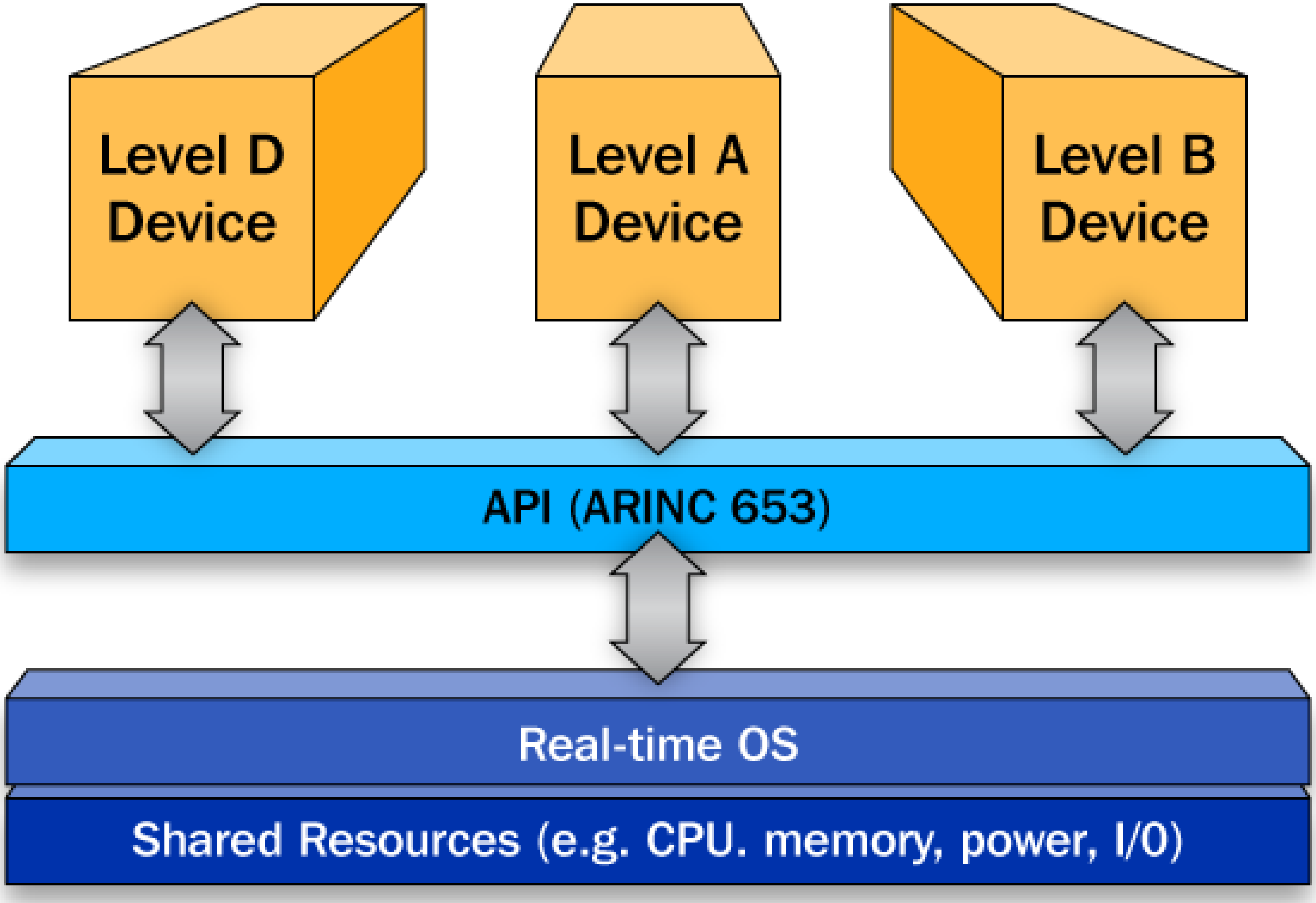
```
/* IMA System of Systems */
switch(timeSlice)
{   case 0:
        Maintenance_Sys();
    case 1,3,5,7:
        Autopilot_Sys();
    case 2,4:
        CDU_Sys();
}
```



Application Certification Today



IMA Certification



IMA Advantages

» More complex systems

» Consolidation of low-level development

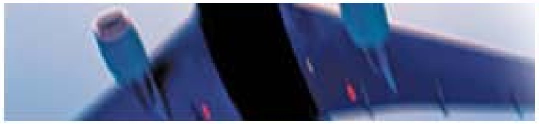
» Lower cost & weight

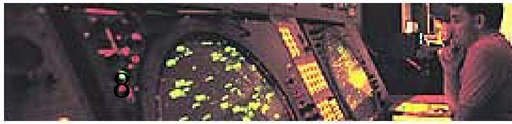
» Flexibility & modularity

» Reuse

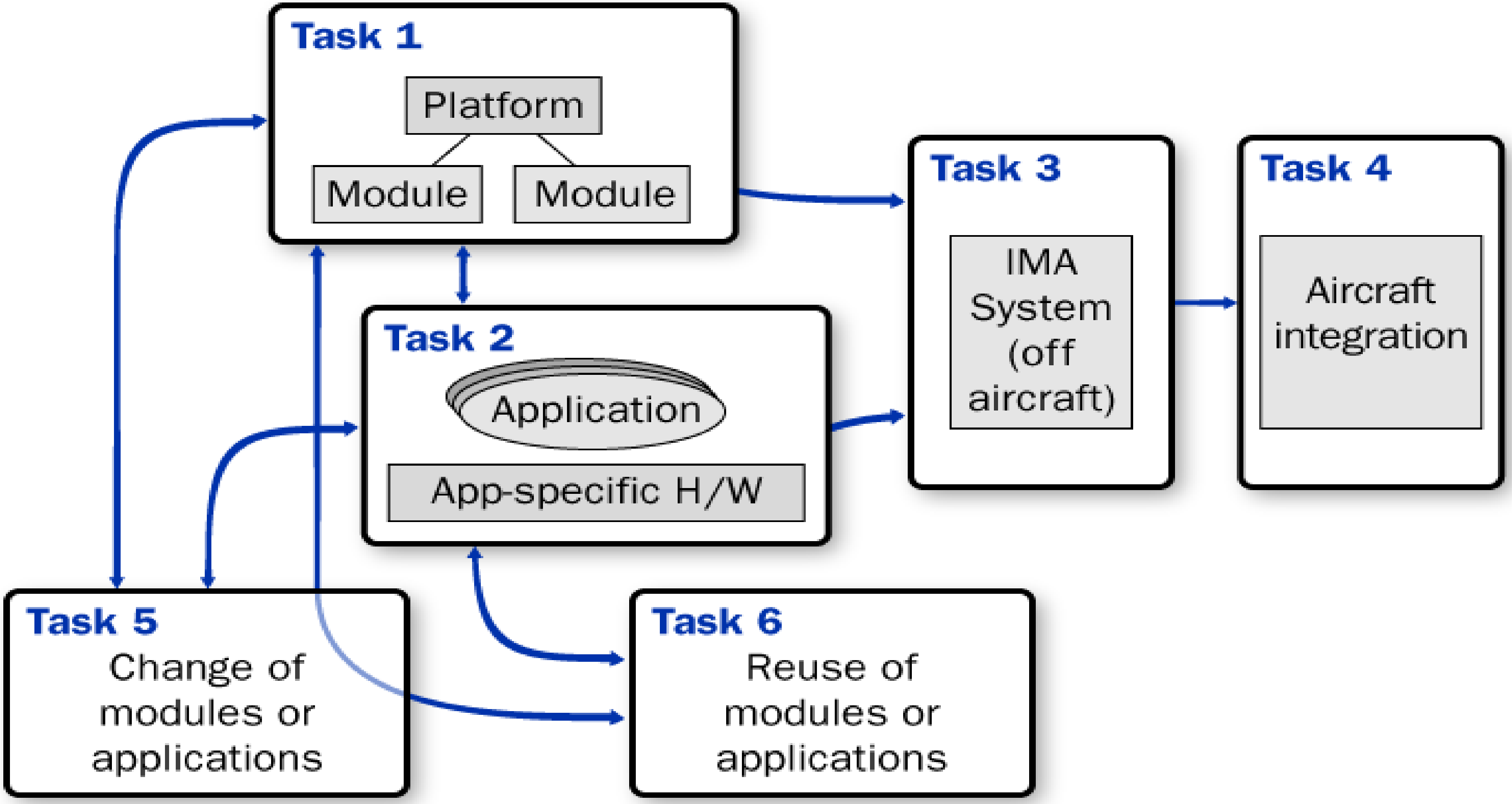
» Maintenance

» Growth





DO-297 Certification Steps



Challenges

…look for opportunities for DO-297

Keith Custer
Esterline Control Systems – AVISTA
+1-608-348-8815
Keith.Custer@avistainc.com

NDIA 12th Annual Systems Engineering Conference

"Using Requirements Compliance Metrics to Identify Gaps Between the Technical Solution and Requirements"

October 2009

David Minchala
US Army ARDEC,
Bldg 12, RFAD
Picatinny Arsenal NJ, 07806-5000
(973) 724-
Edward.Dooley@us.army.mil

Frank Salvatore
High Performance Technologies, inc.
3159 Schrader Road
Dover NJ, 07801
(973) 442-6436 ext 249
fsalvatore@hpti.com

Outline

- Background
- State of Practice
- Improving the State of Practice
- Benefits
- Compliance Method and Tool
- Report on Progress and show data
- Summary

Background

Engineering projects that are completed on time and within budget most likely implement established “frozen” designs, e.g. roads, bridges, where there is limited opportunity to change requirements

When building new and complex systems:

- Requirement changes are expected
- Requirement changes are common activities early in the lifecycle
- Material developers and stakeholders often “refine” the intended end-use of the system

Background

Metrics on cost, schedule, and performance do not account for discontinuities between the defined requirements (the intent) and the delivered technical solution.

The US Army Armament Research Development Engineering Center (ARDEC) has devised a measurement and reporting method based on Requirements Engineering best practices to identify these discontinuities and facilitate fact-based management decisions.

State of Practice Metrics

Program / Project Managers (PMs) rely on various sets of metrics to:

- Get an objective assessment of the project / program (Cost, Schedule, Performance)
- Formulate corrective actions
- Adjust budgets, schedules, and resources

Program / Project sponsors, however, often measure program / project success or failure by met or missed:

- Schedule
- Budget, and
- Requirements

State of Practice
Requirements Management

- Best-practice Requirements Management (RM) requires measurement and collection of requirements metrics
  - Process Metrics (i.e. Change Frequency)
  - Requirements Metrics (i.e. # of Requirements allocated, approved, etc…)
- Requirements Management Reports
  - Traceability
  - Priority
  - Verification
  - Compliance

State of Practice Requirements Management

SYSTEM XYZ Requirements Compliance Matrix

Section	Requirement #	Requirement Text	Compliance				Rationale, comments of how the requirement was met
			Y	N	D	W	
3.2.4 Mobility	3.2.4.6. Braking	The propulsion subsystem shall enable the system to decelerate from maximum speed to full stop at a rate of 5 m/s2 with side drift not to exceed 2 m in 15 m on a dry, level, hard surface road.					
	3.2.4.7.						
	3.2.4.8.						
	3.2.4.14.						
	3.2.4.19.						

Compliance			Comments (Missing, unallocated)
Full	Partial	None	

Legend

Y - Yes, meets requirement

N - No, does not meet requirement

D - Deviation required

W - Waiver required

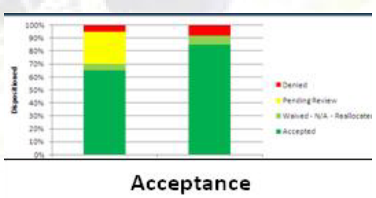
These matrices generally report the gaps between *intent* and *end-state*

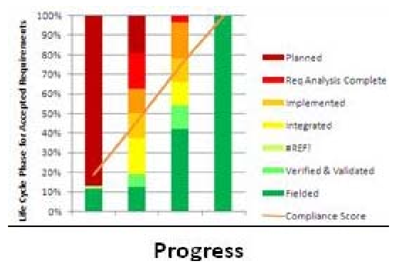
- Additionally there is no standard terminology or meaning

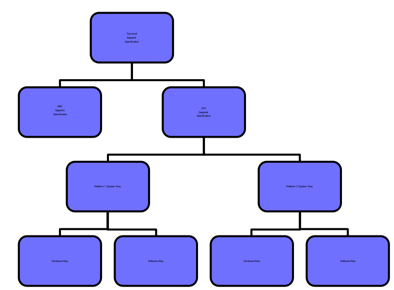
Improving the State of Practice

In our approach we take Requirements Compliance a step further by tracking progress in meeting the intent.

- **This approach provides a common language between management and developers.**







Disposition Progress → Life Cycle Progress → Requirements Compliance

Benefits

PM visibility into implementation status

- A matrix will be maintained for each (sub)system, which will allow for metrics and reports to be generated against the system requirements. This will serve as a tool the PM can use to assess the current compliance of each (sub)system.

Facilitate communication between stakeholders

- The use of this approach will improve visibility into progress toward meeting program goals.
- Discrepancies can be discussed, clarified, resolved, documented and archived.

Help with Requirements Prioritization

- Can track incremental development with improved accuracy and identify issues with development progress sooner.

Implementation

Requirements Compliance Model defined

- The model is based on the DoD’s Systems Engineering “V” approach to Systems / material development .
- The model will serve as the language that converts engineering phases to a compliance percentage.

Requirements Compliance Tool developed

- A matrix has been constructed within DOORS which allows the following:
  - ✓ Direct linking to system/component specifications.
  - ✓ Ability to run reports to collect metrics on compliance.
  - ✓ Can export to Excel or other formats with ease.

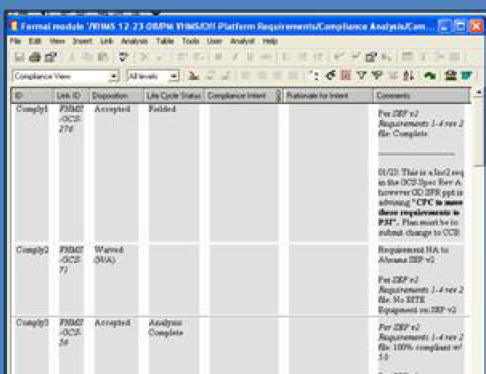
Scripts constructed to run against DOORS Module

- This helps automate the process of measuring compliance.

Requirements Compliance Tool

Requirements

Assess Compliance



Compliance

Assess Compliance

Run Script to Generate Metrics

Script Automatically Generates Metrics

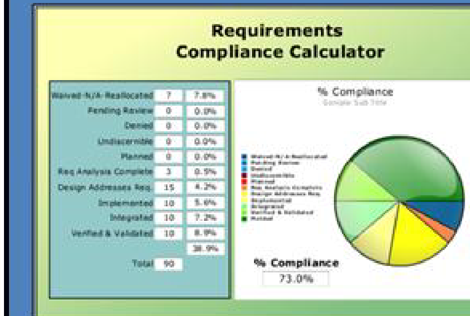
Criteria	Value	Score	Weight
Waived-N/A-Reallocated	7	7.8%	100%
Pending Review	0	0.0%	0%
Denied	0	0.0%	0%
Undiscernible	0	0.0%	0%
Planned	0	0.0%	5%
Req Analysis Complete	3	0.5%	15%
Design Addresses Req.	15	4.2%	25%
Implemented	10	5.6%	50%
Integrated	10	7.2%	65%
Verified & Validated	10	8.9%	80%
Fielded	35	38.9%	100%
Total	90		
% Compliance		73.0%	73.00%

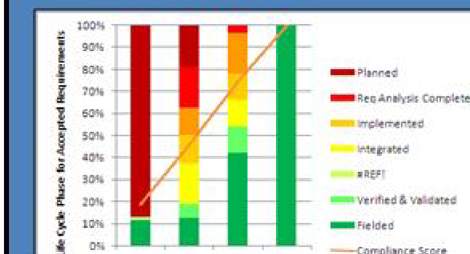
	Date 1	Date 2
Fielded	10	10
Verified & Validated	0	5
Integrated	0	15
Implemented	0	10
Design Addresses Req.	0	10
Req Analysis Complete	0	15
Waived-N/A-Reallocate	5	7
Waiver Denied	5	8
Pending Review	5	0
Planned	75	15
Compliance Score	0.1875	0.4575

	Date 1	Date 2
Accepted	65	85
Waived - N/A - Real	5	7
Pending Review	25	0
Denied	5	8

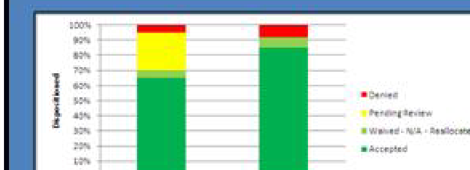
Capture Metrics

Automatic Reporting





Progress



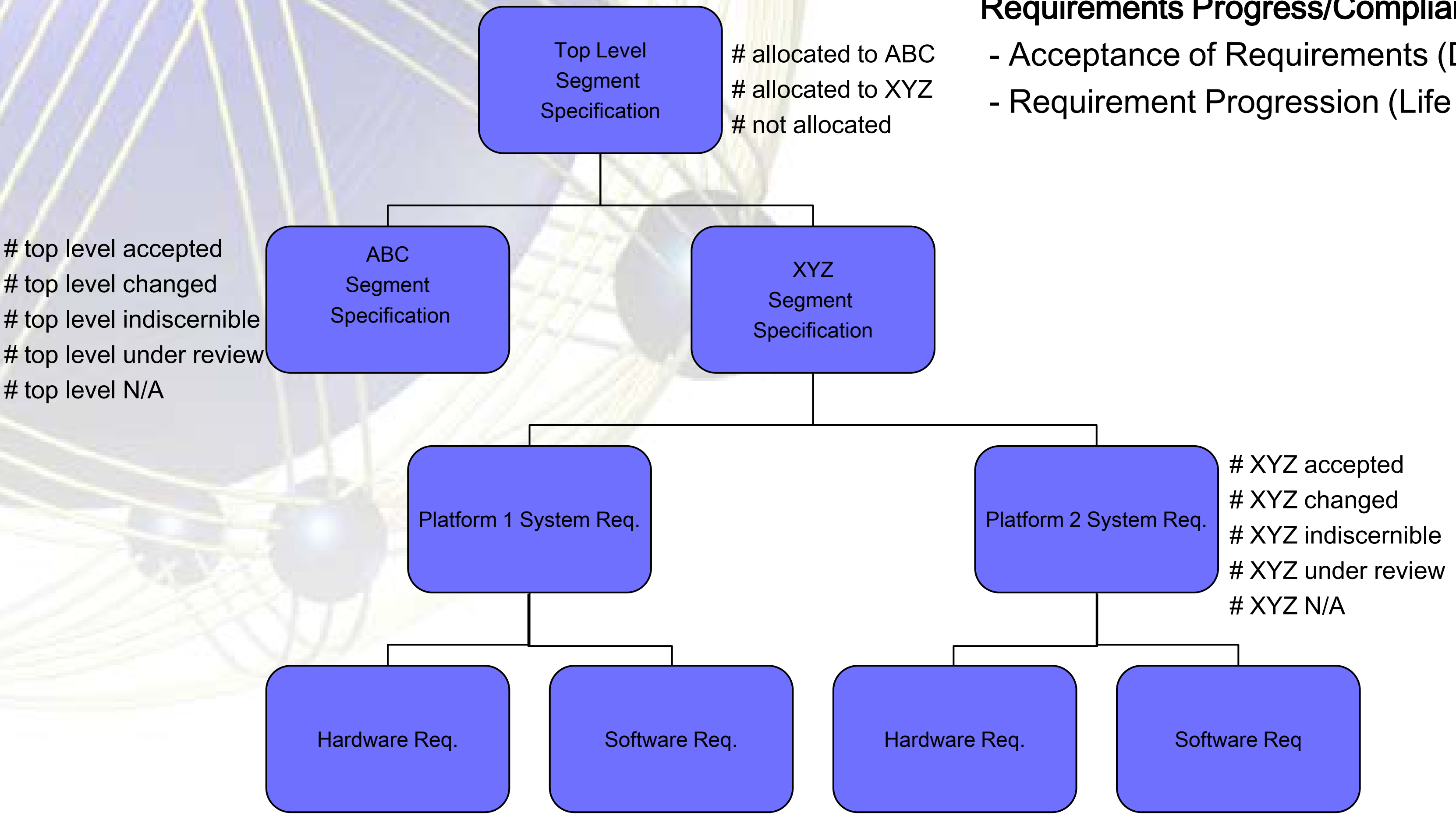
Acceptance

Report Results

Compliance Concept

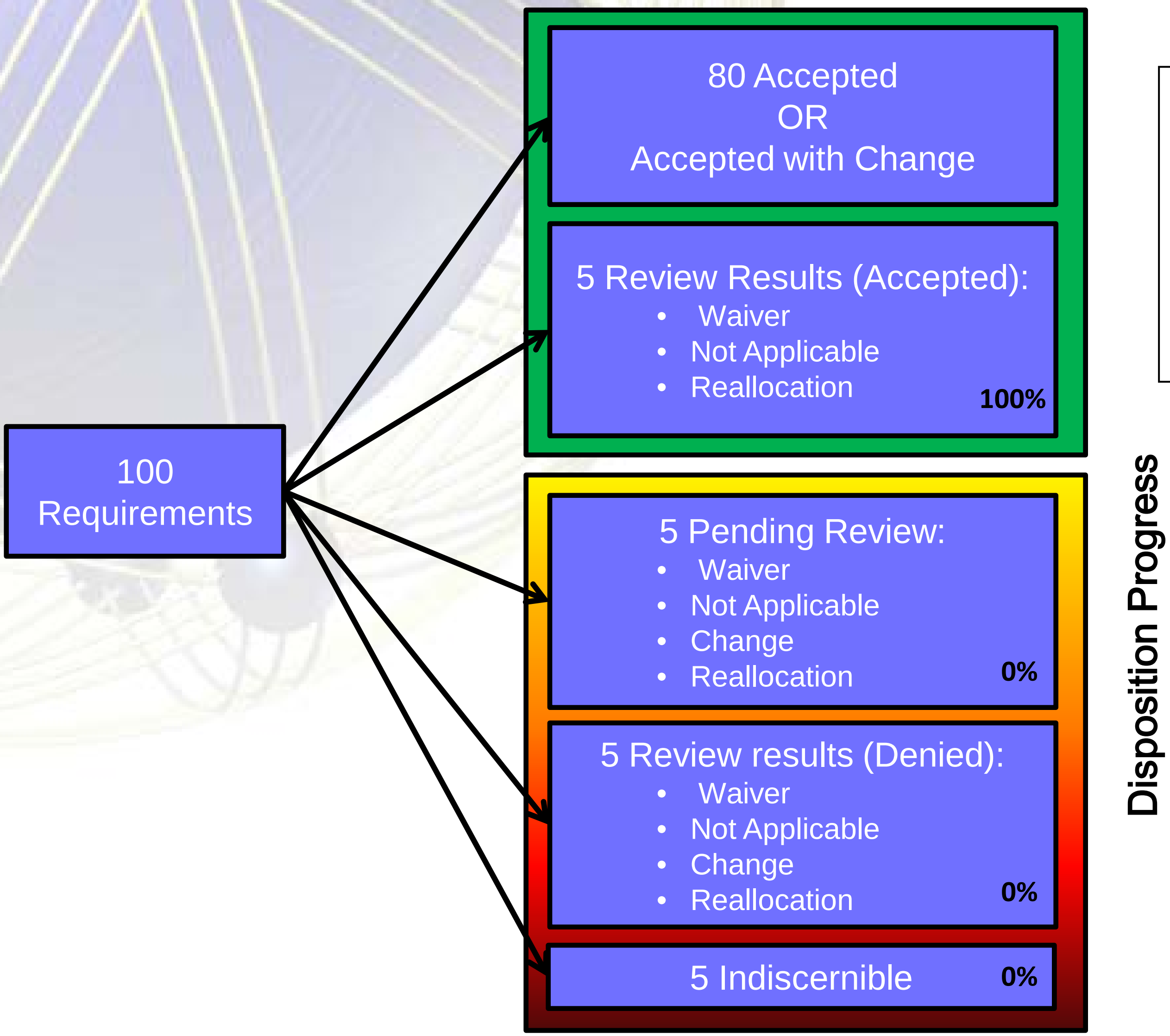
Requirements Progress/Compliance

- Acceptance of Requirements (Dispositioned)
- Requirement Progression (Life Cycle)



Metrics can be used to compare progress & compliance to planned activities and can be sorted by increment, build, priority, capability etc.

Disposition Progress

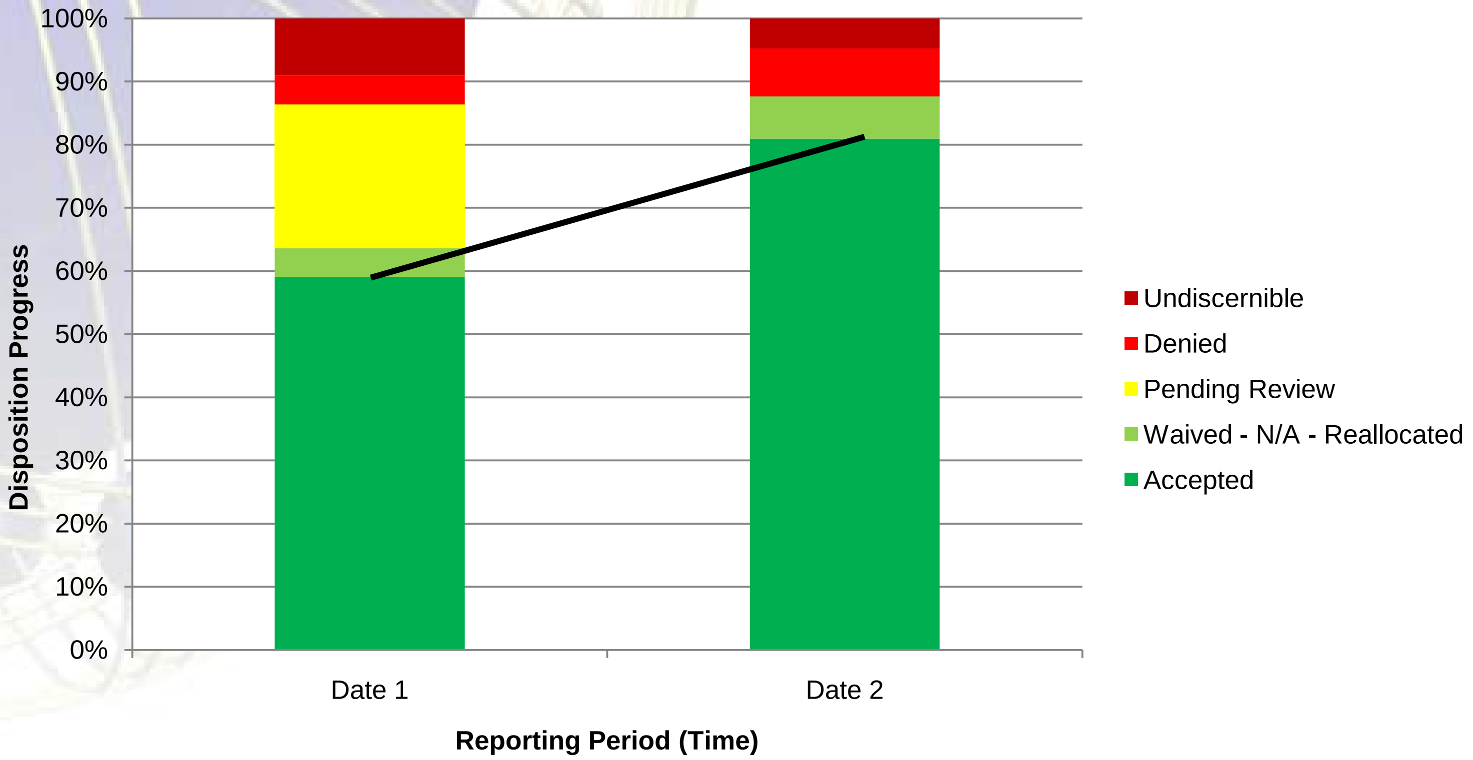


Percentage not Assigned to Accepted Requirements

This is deferred to life cycle compliance scoring.

Establishes basis for measuring the progress made towards accepting the requirements.

Disposition Progress
(Example Over Time)



Shows the project moving towards full acceptance/allocation of the requirements.

Life Cycle Progress

Once Requirements have been accepted we track their progress thru the development life cycle.

Requirement Progression (Life Cycle)

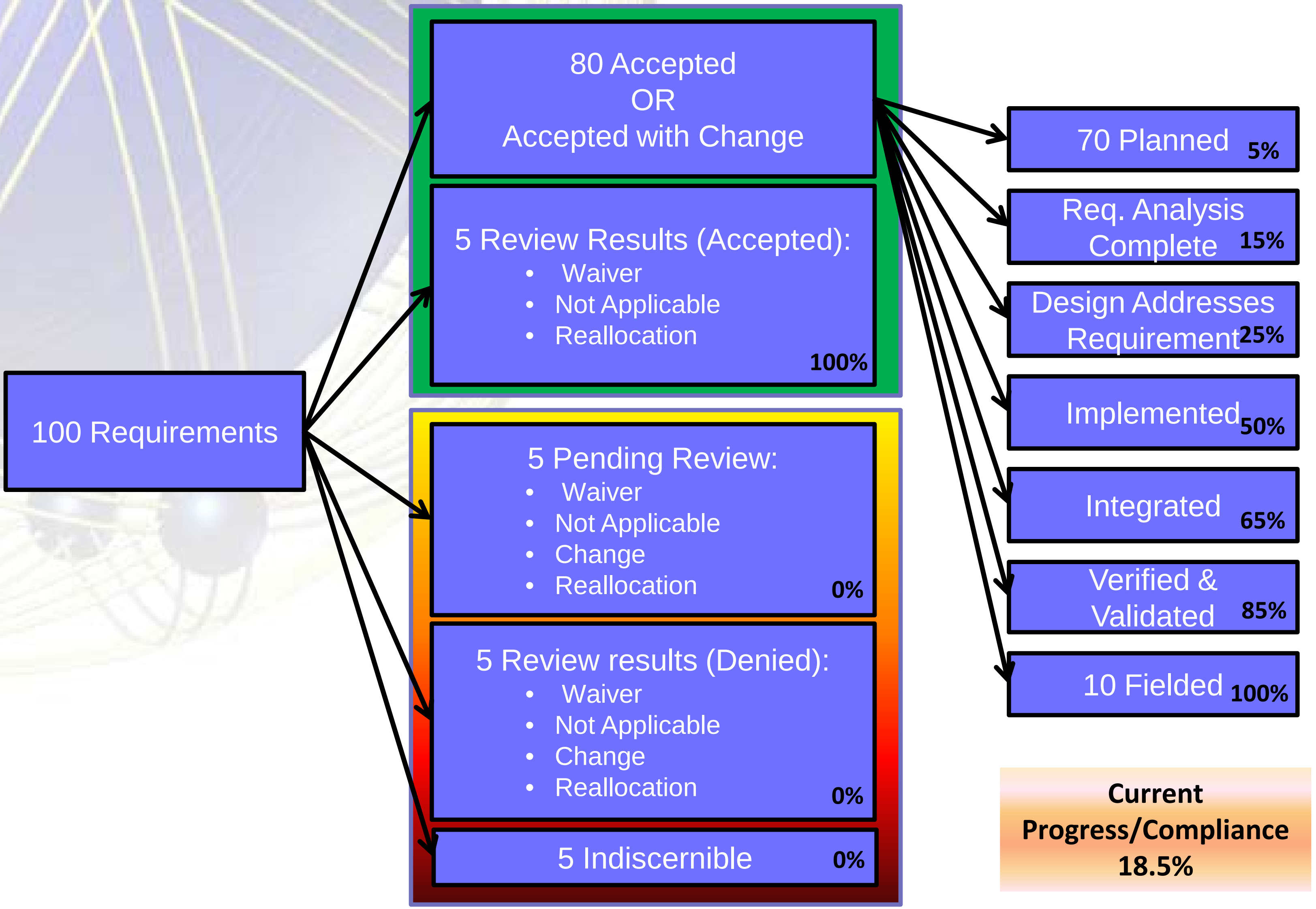
100 Requirements → 80 Accepted OR Accepted with Change

80 Accepted OR Accepted with Change →
- 70 Planned 5%
- Req. Analysis Complete 15%
- Design Addresses Requirement 25%
- Implemented 50%
- Integrated 65%
- Verified & Validated 85%
- 10 Fielded 100%

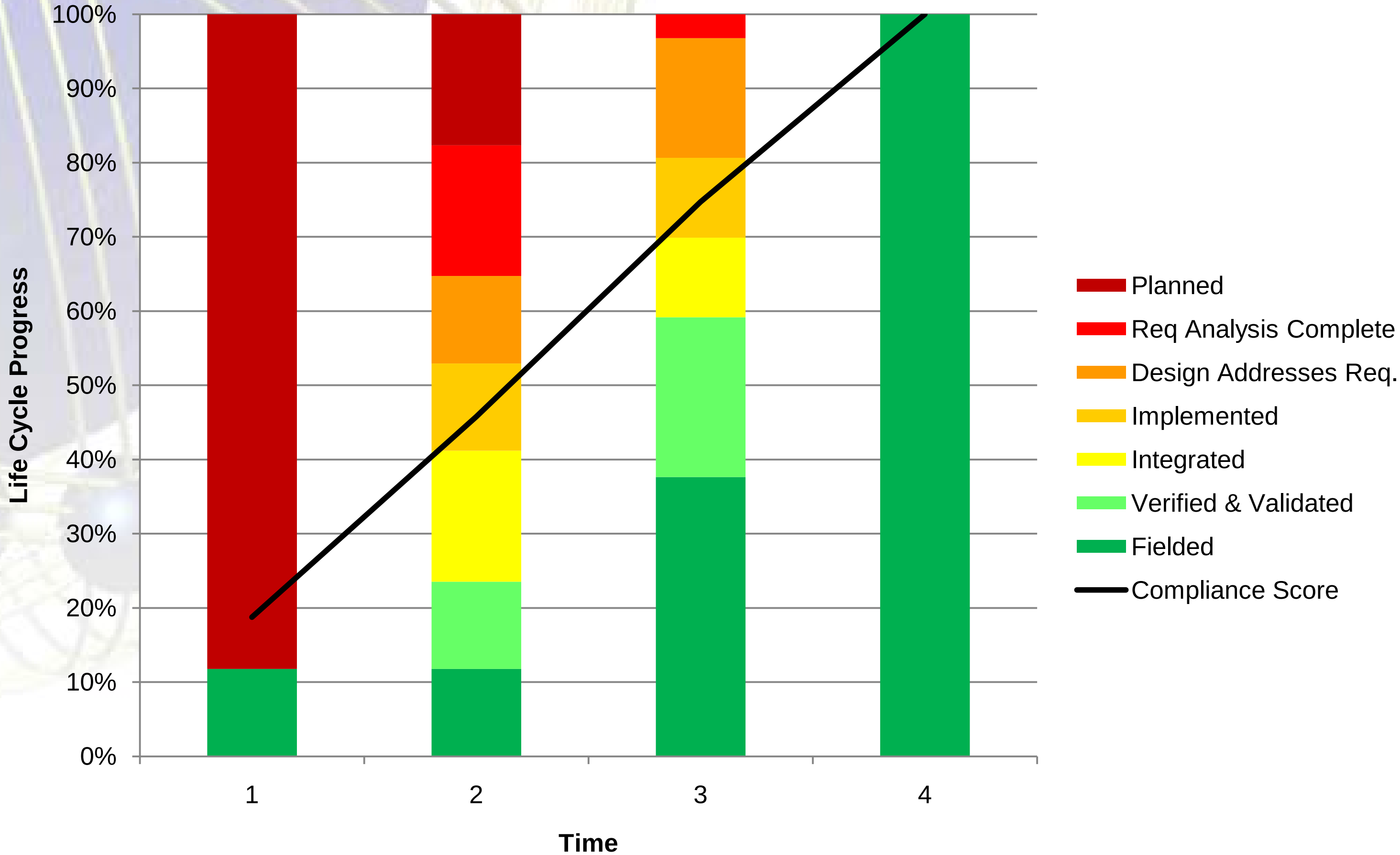
Life Cycle Progress

Credit is given when a requirement has finished each phase of the Life Cycle

Requirements Compliance Score



Life Cycle Progress
(Example Over Time)



Shows the project moving towards full fielding of the accepted requirements.

Compliance Calculator

Acceptance of Requirements

(Sample output)

Accepted	140
Accepted with Change	128
Pending N/A Review	1
Pending Change Review	31
Not Applicable	6
Not Allocated	7
Total Requirements (inc 1-3)	313

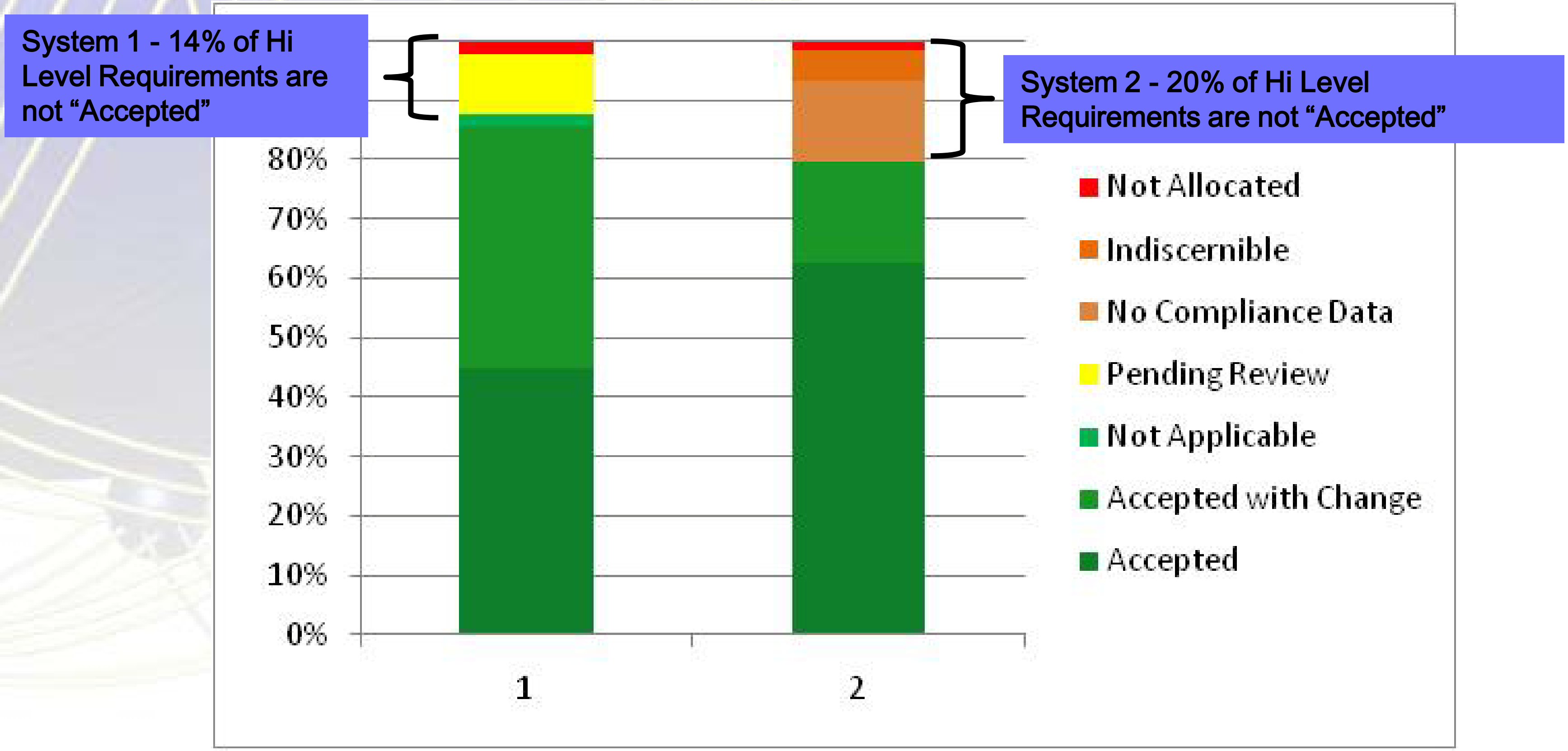
- Discovered a program that claimed almost full acceptance, but was actually changing over 50% of the requirements
- Discovered 32 requirements whose disposition had not yet been fully reviewed
- Discovered 7 High Level Requirements that were not allocated

Accepted	196
Accepted with Change	53
No Compliance Data	43
Indiscernible	16
Not Allocated	5
Total Requirements (inc1-3)	313

- Documented 43 requirements that still had not been dispositioned although they were allocated
- Discovered 16 problem requirements that developers were having trouble understanding
- Discovered 5 High Level Requirements that were not allocated

High Level Requirement Results Based on Actual Data

Acceptance of Requirements



Summary

Benefits observed are positive proof that there needs to be a well understood approach to reporting requirements

Gaps already found and reported to Customer

Just starting to roll out Life Cycle progression.

Extending FMECA to System ofSystems (SoS) Interfaces: iFMECA

PI's: Leo Mayoral, Clay Smith

28 October 2009

Agenda

- Background & Problem Description
- Proposed Concept
- Possible Model for the SoS Interface
- Technical Foundation
- Extending FMECA Process to SoS Interface Analysis
- Potential Applications
- Summary

Background

- APL interest in understanding how to objectively assess failure modes for large system of systems:
  - Especially when introducing a new system into a complex and existing architecture,
  - Identifying problem interfaces during the design phase,
  - Prioritizing SE resources,
- Question: How can the Systems Engineer characterize ***SoS interface faults*** in order to prioritize resources?

System Box-Level Problem Description

- **Failure mechanisms and failure modes are typically known for individual component systems**
  - Usually these analyses are dictated by contract
  - Full reliability and risk analyses performed within context of the system only
- **Interfaces among components systems can be uncertain**
  - Defined to the level of an internal specification or requirement
  - Not completely enveloped
  - Ambiguous
  - Cause and effects not always deterministic or known a priori
- **Interface issues exist even though all component systems are operating within system specifications**
- **Identify these interactions and prioritize their impact**

System of System Problem

- **A significant number of issues for System of Systems reside in the interfaces among the systems**
- **This iFMECA methodology extends the current FMEA techniques to provide SoS engineers with a risk based prioritization of interfaces**
  - FMECA is one of the most widely used reliability tools (see MIL-STD-1629A)
  - Bottoms up approach
    - Functional or physical breakdown
    - For each interface failure modes are identified
    - For each failure mode identified (known or potential), determine
      - Consequence (narrative description of local, system, and SoS effects)
      - Probability of occurrence
      - Method for detection
    - Determine risk criticality
  - Rank order interfaces using risk criticality number for resource allocation (i.e., which interface to worry about first)

System of System (SoS) Problem

- **A significant number of issues for System of Systems reside in the interfaces among the systems**
- **Interfaces are Often Complex**
  - Multiplexed outputs
  - Protocol Oriented
  - Timing
  - Signal Quality
  - External Coordination
  - Network Delays
- **Challenge is to find a system engineering tool that can help the PM and SE identify problem interfaces efficiently and cheaply.**

FMECA Methodology: Background

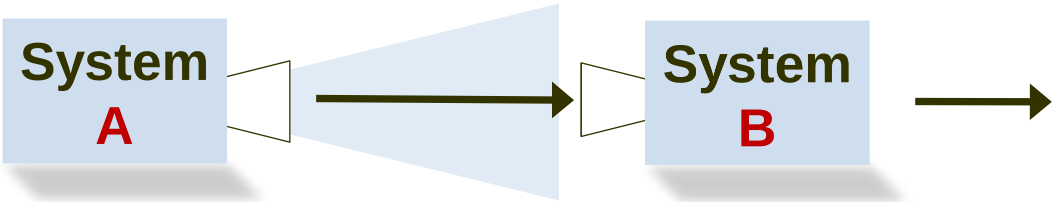
- **FMECAs are used in systems to:**
  - Identify Single Point Failures,
  - Prepare diagnostic routines such as flowcharts or fault-finding tables,
  - Prepare preventive maintenance requirements,
  - Design built-in test, failure indications, and redundancy,
  - Analyze testability to ensure that hardware can be economically tested and failures diagnosed,
  - Show as formal record of safety/reliability analysis.
- **Limitations**
  - Combined effects of coexisting failures are not considered
  - Extents upward through system hierarchy, no peer-to-peer interactions
  - Process is extraordinarily tedious and time consuming for complex systems

Proposed Concept: iFMECA Methodology

- **Analyze the interface**
  - Decompose each interface to determine failure modes
    - Level of detail may vary
    - Interface dependent, several models exist to accomplish this task
  - Determine the probability of loss
    - Qualitative (ordinal scale) or quantitative (such as loss of margin)
- **Analyze the impact of interface to the function (or system)**
  - Assign a prior probability distribution based on test data, engineering judgment, or rules-of-thumb
  - Later update with Bayesian statistical methods with operational data
- **Analyze the impact of the function to the mission (or SoS)**
  - Assign a prior probability distribution based on test data, engineering judgment, or rules-of-thumb
  - Later update with Bayesian statistical methods with operational data

SoS Interface FMECA (iFMECA)

- **Specific area of focus is the off-nominal performance at the interface among component systems**
  - Limiting scope to these failure modes
  - Assuming that system failure is treated already



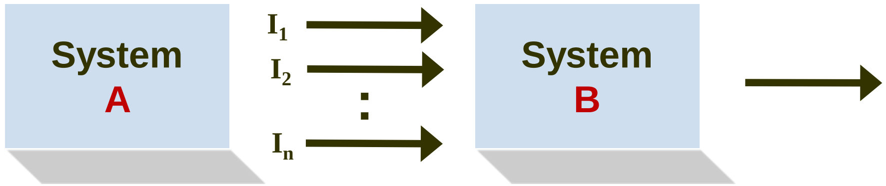
- **For this case, neither System A or B has failed by its own definition, but a portion of A output is not processed by B**
  - Uncertainty exists in the variability of System A output and the variability of System B threshold limit
  - Output spec of A and the input expected range of B may differ

SoS Interface iFMECA

- **Probability of loss of function (LOF) for Subsystem B is a function of its inherent failure rate plus the loss of input (LOI) from Subsystem A**

$$\Pr(LOF_B) = \lambda_p t \times \Pr(LOI)$$

- **For a more generalized case with multiple inputs:**



$$\Pr(LOF_B) = \lambda_p t \times \sum \Pr(LOI)_i + \text{combinatorial effects}^*$$

- **Assumptions:**
  - **Inherent failures are covered elsewhere**
  - ***Combinatorial effects from the interactions of multiple degraded inputs not yet addressed**

iFMECA Methodology Criticality Number

- **Mil-Std-1629 Defines a Criticality Number**
- **Propose an Analog for SoS Criticality Number (C_{SoS}):**

$$C_{SoS} = \gamma \cdot \beta \cdot \Pr(LOI)$$

Where,

- γ Conditional probability of LOM given LOF
- β Conditional probability of LOF given LOI
- $\Pr(LOI)$ Probability of output-input mis-match

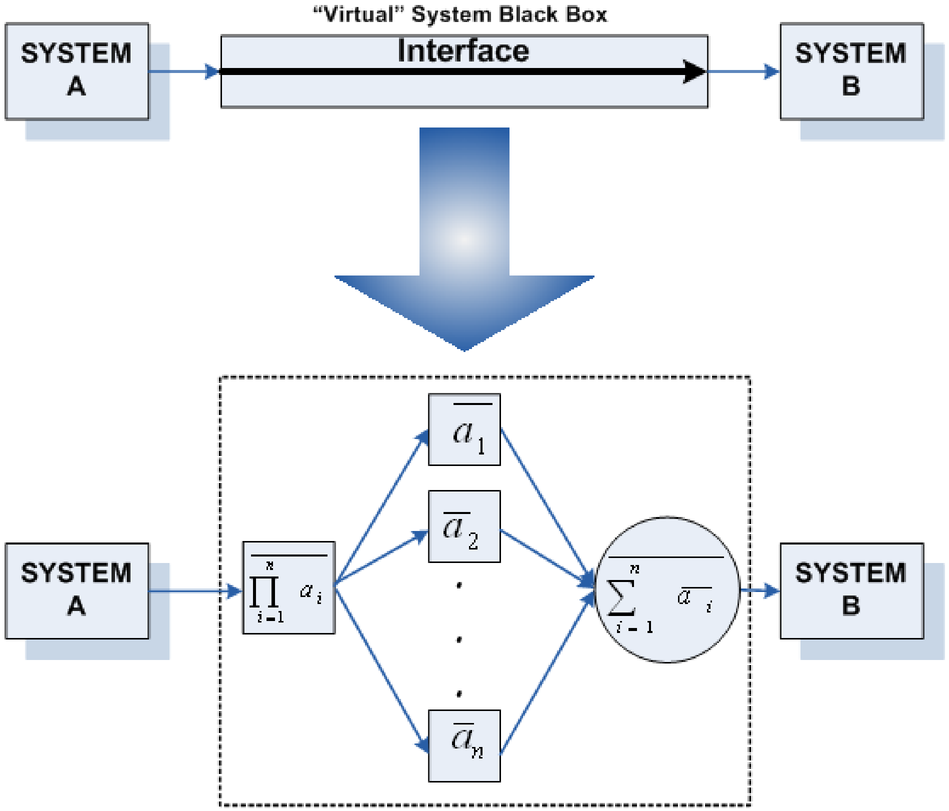
- **Parameters γ and β based on**
  - Operational data
  - System test data
  - Can be subjectively assigned and updated with Bayesian techniques as more operational experience is gathered

iFMECA Methodology … *New SE Tool*

- **Analyze the interface**
  - Decompose each interface to determine the attribute (a_i) failure modes
    - Level of detail may vary
    - Interface dependent, several models exist to accomplish this task
  - Determine the probability of loss
    - Qualitative (ordinal scale) or quantitative (such as loss of margin)
- **Analyze the impact of the interface to the function (or system)**
  - Assign a prior probability distribution based on test data, engineering judgment, or rules-of-thumb
  - Update with Bayesian statistical methods using operational data
- **Analyze the impact of the function to the mission (or SoS)**
  - Assign a prior probability distribution based on test data, engineering judgment, or rules-of-thumb
  - Update with Bayesian statistical methods using operational data

APL

One Possible Concept for Modeling an Interface

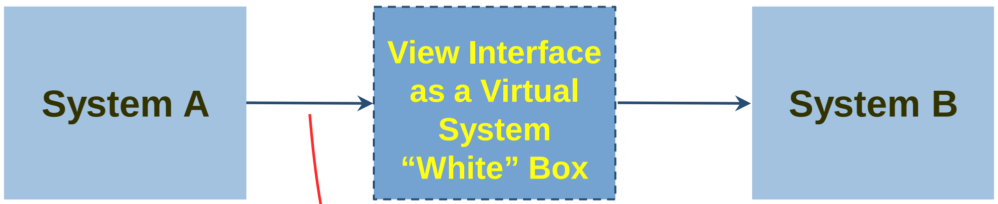


Notional Failure Model of a Typical Interface

- **A Typical Interface is Comprised of Several Interface Attributes (a_i), e.g OSI Stack**
- **All a_i Must <u>not</u> Experience a Failure for the Interface to Work**
- **Viewed as a Logical "And" at the Input**
- **Viewed as a Logical "Or" at the Output**
- **All Events (a_i) are Mutually Exclusive (Assumption)**
- **The Occurrence of Any Event, ($\overline{a_i}$), Causes a Degradation of the Interface**

APL

How Would the Data Be Analyzed?



Copper or Optical Connection

- Port or Interface Status is Disable or Shutdown
- Port or Interface Status is errDisable
- Port or Interface Status is Inactive
- Uplink Port or Interface Status is Inactive
- Trunking between a Switch and a Router
- Trunking Mode Mismatch
- Connectivity Issues due to Oversubscription
- Common Port and Interface Problems
- Data Signal Voltage Mismatch
- Data Signal Voltage out of tolerance
- Data Incompatibility
- Noise Coupling
- Crosstalk

Examples of Potential I/F Faults

Wireless

- Frequency Error
- Bandwidth Error
- Modulation Mismatch
- Link Closure
- Doppler Signal Errors
- Signal Dead Spots(R^2 Losses)
- Signal Integrity
- Multipath Errors

1. Focus on Copper/Fiber and Wireless Connectivity
2. Ignore OSI Layers 5-7 (Session, Presentation, Application Information Layers) for Now
3. Catalogue Top Level Category Interface Faults
   - Look for Statistical Data
   - Interview for Experiential Data
4. Select a Small Subset and Analyze Failure Modes for Each
5. Correlate to Methodology
   - Validate Criticality Number
   - Validate probabilistic margin analysis
6. Document Results Formally

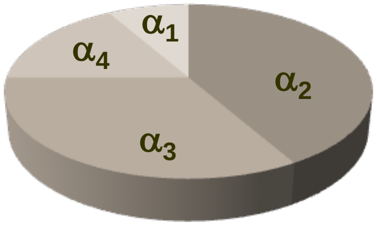
SoS Criticality Number Extends Definition

- **Mil-Std-1629 Analysis Focuses at the Box Level**
- **Standard Criticality Analysis considers part/board failure rate and the system impact**
- **Failure mode *<u>Criticality Number</u>* is used to convey the severity of the fault:**
- **Criticality Number is computed as:**

$$C_m = \beta \cdot \alpha \cdot \lambda_p t$$

  - $\lambda_p t$ Part failure rate x time (Poisson Distribution)
  - α failure mode ratio
  - β conditional probability of loss of mission (LOM) Pr(LOM | Failure Mode)

Failure Modes



Failure Effect	β Value
Actual loss	1.0
Probable loss	> 0.1 to < 1.0
Possible loss	> 0 to 0.1
No effect	0.0

iFMECA Methodology

- **Extends the FMECA to SoS**
  - Perform a systematic analysis of each SoS interaction
  - Pair-wise comparison for all output-input pairs
- **Propose an Analog for Criticality Number (C_{SoS}):**

$$C_{SoS} = \gamma \cdot \beta \cdot \Pr(LOI)$$

Our methodology extends the Criticality Number to a SoS by adding the conditional nature of the failures between systems.

Where,

- γ Conditional probability of LOM given LOF
- β Conditional probability of LOF given LOI
- Pr(*LOI*) Probability of output-input mis-match

Definitions:

LOI – Loss of Input
LOF – Loss of Function
LOM – Loss of Mission

APL

Another method to Analyze in Interface Output-Input Examples

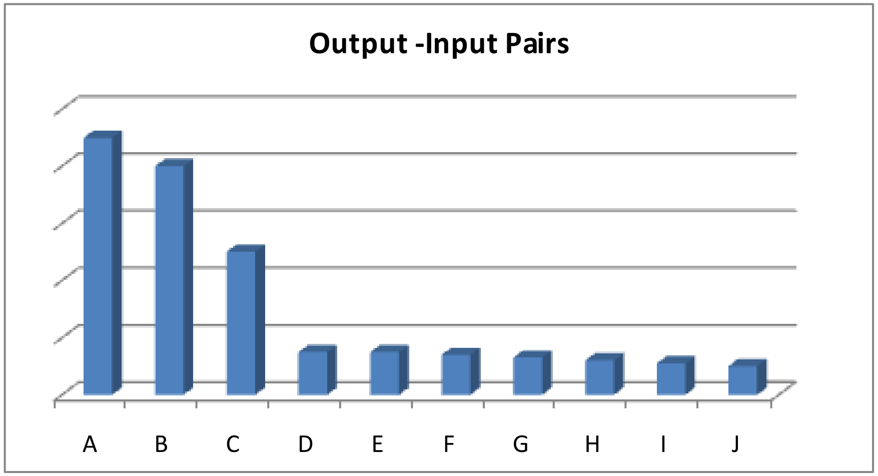
- **Parameters γ and β based on**
  - Operational data
  - System test data
  - Can be subjectively assigned and updated with Bayesian techniques as more operational experience is gathered

- **Probability of occurrence**
  - Probabilistic measure of the interference between the input variability and the variability of the input threshold limit
  - Probability density functions obtained from system designs, testing, operations

APL

iFMECA Methodology Advantages

- **Risk-based prioritization based on calculated C_{SoS}**
  - Input-Output pairs
  - System contribution pairs
    - Input-Output pairs sum within the receiving system
  - Significant Output-Input combinations



- **Provides a *Systems Engineering Tool* for analyzing the trade space for Interfaces when introducing a new system into a SoS**
  - How much should an output signal change?
- **A *New Tool* to help Identify the information needed to communicate potentially mismatched information across SoS interfaces**
  - Included into SoS ICD equivalents

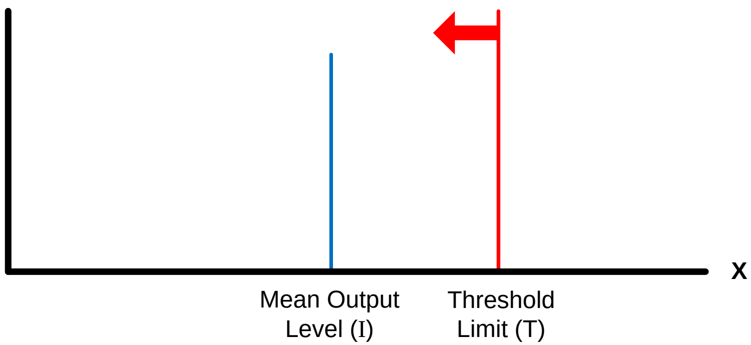
iFMECA Methodology Execution

- **Interfaces will be analyzed not for hardware on either side of the interface**
  - Assumed to be part of the normal FMEA process already in place
- **Interfaces analyzed for**
  - Content communicated
  - Medium of communication
  - Protocol interoperability
  - Stress vs strength
  - Load vs endurance

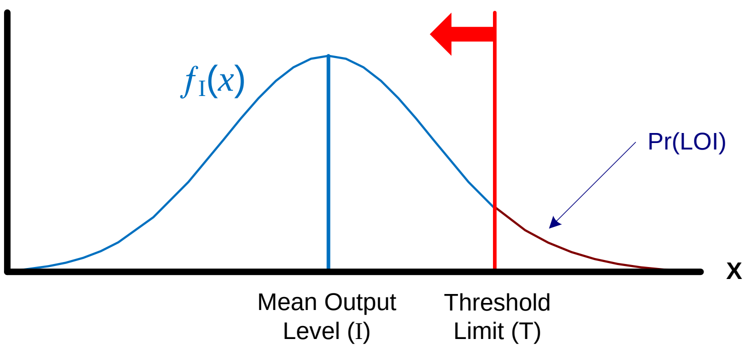
APL

Another method to Analyze in Interface Output-Input Examples

- **Case I**
  - Discrete output with discrete upper bound threshold
  - No variability is shown, therefore output will always be less than threshold
  - Pr(LOI) = Pr(**I** > **T**) = 0

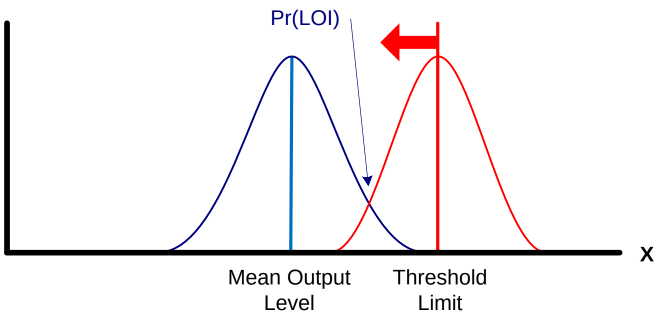


- **Case II**
  - Variation in output with discrete upper bound threshold
  - Some Pr exists that the input level will exceed the threshold
  - Pr(LOI) = Pr(**I** > **T**) = $\int_{T}^{\infty} f_I(x)\, dx$



Another method to Analyze in Interface Output-Input Examples

- **Case III**
  - Variation in output with variation in upper bound threshold
  - Some Pr exists that the input level will exceed the threshold
  - Pr(LOI) = Pr(**I** > **T**) = $\int_{-\infty}^{0} \int_{-y}^{\infty} f_T(y+x) \cdot f_I(x)\, dx\, dy$



- **Many type of interactions exist**
  - Various combinations
  - Various distributions

IRaD Summary

- **Shown that a New SoS Design Tool that Quantifies the Criticality of its Interfaces is Possible**
  - Concept is Based on Modeling the Interface as a Combination of Boolean Variables and Employing Conditional Probability Theory to Propagate the Probability of their Failure
  - Concept is Applicable to Complex Interfaces (e.g. OSI Stack, or multi-attribute)
  - Allows for the Propagation of a Poorly Performing Attribute of an Interface to be Propagated to the Next Hierarchical Level and Address Impacts to Mission
  - Though Not Investigated, Suggests that Marginally Performing Interfaces which can Affect Overall SoS Performance May be Isolated
  - Allows the PM to Adjust Program Resources to Mitigate Poorly Designed Interfaces Early in the Design Phase by Analyzing the I/F Criticality Numbers
  - Tool is Not Radically Different – It is a Simple Extension to the Well-Understood FMECA Tool (Mil-Std-1629)
  - SoS Design Challenge: Developing and Validating the Failure Rates of the Attributes of Interface Data

APL

Potential Follow-On Work

- **Need to Typify the Types and Classes of Failures Similar to How Studies Are being Performed on the Failure of Box-Level Component Parts**
- **Need to Characterize the Statistical Distributions for These Interface Types and Classes of Failures**
  - As a First Approximation, a Typical Normal, Poisson or Exponential Distributions could be Assumed
  - Distributions Need to be Validated on Real World Systems
- **Need to Develop the Data Collection Methodology at the Design Level (Extend the Procedural Language in the Mil-Std-1629 to Address SoS Interfaces)**
- **Publish the Results**

APL

Questions?

S&T Portfolio Maturity & Performance Analysis: The Concept of Critical Research Elements (CREs)

NDIA:

National Defense Industrial Association

12th Annual Systems Engineering Conference

OCT 26-29, 2009
San Diego, CA

Presented by:

Has Patel

Infologic, Inc.

has.patel@infologic.com

(888) 325 0500 Ext. 100

Motivation:
US Innovation Agenda

A Critical Need identified by the highest office in the USA

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL ECONOMIC COUNCIL
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

A STRATEGY FOR AMERICAN INNOVATION:
DRIVING TOWARDS SUSTAINABLE GROWTH AND QUALITY JOBS

History should be our guide. The United States led the world's economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that is why innovation is more important than ever. It is the key to good, new jobs for the 21st century. That's how we will ensure a high quality of life for this generation and future generations. With these investments, we're planting the seeds of progress for our country, and good-paying, private-sector jobs for the American people."

-President Barack Obama, August 5, 2009

A Strategy for American Innovation:

"History should be our guide. The United States led the world's economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that is why innovation is more important than ever. It is the key to good, new jobs for the 21st century. That's how we will ensure a high quality of life for this generation and future generations. With these investments, we're planting the seeds of progress for our country, and good-paying , private-sector jobs for the American people."

- President Barack Obama, August 5, 2009.

US Innovation Agenda: Salient Points

Innovation Funding at an Unprecedented Scale !!

A Strategy for American Innovation:
Driving toward Sustainable Growth and Quality Jobs

- Double R&D budget for key R&D agencies (inc. NSF)
- Invest 3 % of GDP in R&D (Public and Private sectors)
- Use innovation to improve government programs at all levels of government
- Harness science and technology to address the "Grand Challenges" of the 21st century.
- A number of other directions (increase in Graduate Research Fellowships, Academic funding, etc ...)

Strategic Issues: Meeting the Challenges

Innovation Management Needs Recognized

- **Office of the President** : A Strategy for American Innovation: Driving toward Sustainable Growth and Quality Jobs

- **Private Organizations:** Recent Gartner Group, Deloitte and IBM studies have said Innovation is the "top of the mind" for corporate and public CEOs. Recent IBM study, titled: "Expanding the Innovation Horizon" concluded that:

  - Business Model Innovation Matters: Business process innovation
  - External Collaboration is Indispensable: Collaboration beyond the walls
  - Innovation requires Orchestration from the top: Strategic commitments, teams, rewards and technology/process integration

- **Department of Defense:** DoD Force Transformation:

  - Support the Joint Warfighting Capability of the DoD
  - Enable Rapid Access to Information for Strategic Decisions
  - Reduce the Cost of Defense Business Operations
  - Improve Financial Stewardship to the American People

Strategic Issues: Innovation Management is Art

Call to Action: An Innovation Management model which incorporates rigor, metrics and discipline

The McGraw-Hill Companies BusinessWeek

THE BOSTON CONSULTING GROUP

Innovation Survey - 2007

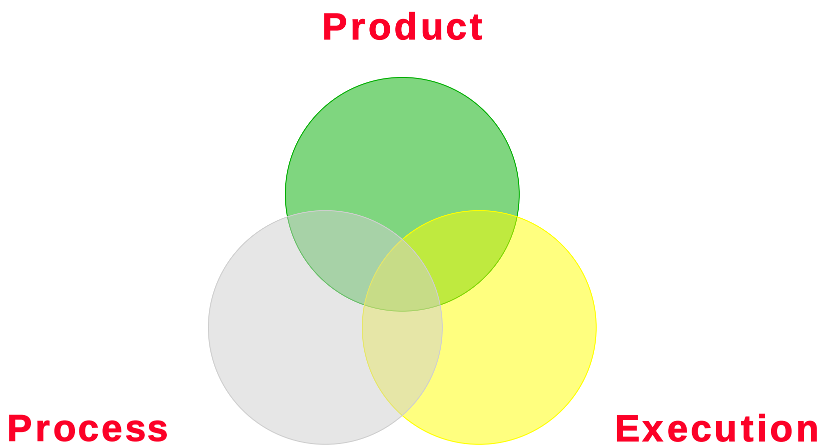
- Innovation should be held as same measurement rigor as other core functions.
- Innovation Opportunity Is About How the Process is Managed – Not Just Ideas and Creativity
- Improving Innovation is not Beyond Leaders' Control – It must be measured and controlled
- Key Innovation Mistakes: Not Emphasizing Speed, and Not Managing with Discipline and Aggressiveness

GAO
Accountability * Integrity * Reliability

- DoD Report to the Congress on Technology Transition, July 2007. Conclusion – Disconnect between S&T and Acquisition Programs
- Best Practices: Stronger Practices Needed to Improve DOD Technology Transition Processes GAO-06-883 Concussion – Immature Technology insertion causes cost and time escalation

Innovation Management Model

Innovation = f (Product, Process, Execution)



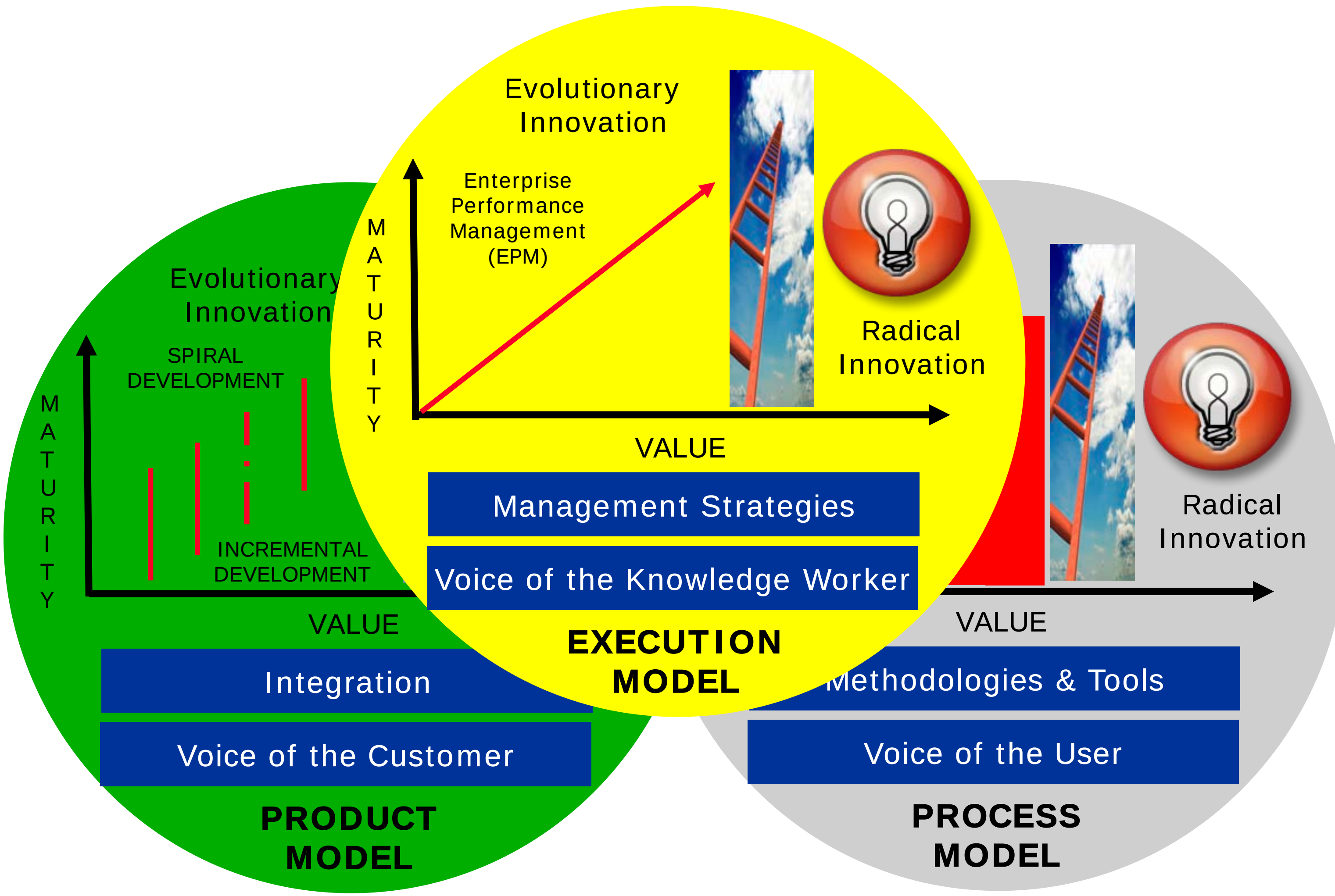
- **Product:** Technology-heavy (e.g: Airplane, iPod) OR Service-heavy (e.g: Starbucks System, eBay)
- **Process:** Any critical business process to ensure the success of product (e.g: iTune for iPod, Marketing and Supply Chain Management)
- **Execution:** Management strategies to ensure that Innovation works! (WILL to ACT !!)

To measure the success of Innovation in an organization, maturity analyses should be conducted for all THREE components:

Product, Process and Execution

Innovation Management Model: Components

Innovation Management Components



Innovation Management Model: Maturity

Innovation Management is a Process and should be matured using the CMMI methodology

Full Innovation Management model is implemented; Innovation Management is part of organization strategies; Creating and managing IP is key component of all key initiatives.

LEVEL 5: Optimizing
Focus on Process Improvement

Innovation Management model supported by consistent processes across the organization; Executive Management support; Matrices used.

LEVEL 4: Quantitatively Managed
Measured & Controlled

A form of Innovation management model implemented; Product, Process and Execution efforts are coordinated

LEVEL 3: Defined
Proactive; Organization wide

Approaches to Innovation recognized; Applied to Key projects; Usage consistency and collaboration among projects.

LEVEL 2: Managed
Characterized as a Project & Reactive

Innovation opportunities recognized; Localized inconsistent Innovation experience

LEVEL 1: Initial
Poorly performed; Reactive

Innovation not on the radar screen; No strong awareness of Innovation opportunities

LEVEL 0: Incomplete
Not performed; Partially performed

Innovation Model: Implementation

An Innovation Model can be applied to varied functions of an Organization

- **Private Organizations**
  - Organization wide Innovation maturity – measure and control the whole organization's current level of maturity in adopting Innovation
  - Product specific – measure and control Innovation in a given product (e.g: Idea to market for a given widget.)
  - Process specific - measure and control Innovation in a given Process (e.g: Human Resource Management)
- **Public Organizations (DoD)**
  - Program Specific – measure the maturity of technologies and processes for a given Program through its life cycle (e.g: FCS)
  - **Sector Specific – measure the Innovation maturity of an organization (e.g: R&D and Technology Management)**
  - Initiative specific – measure the Innovation maturity for an Initiative (e.g: eGov)

Challenges & Issues:
DoD R&D and Technology Management

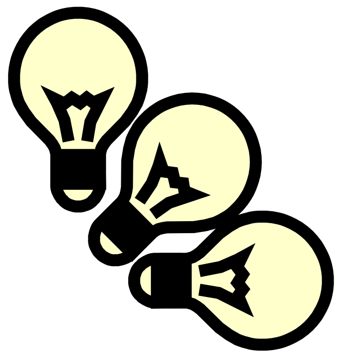
Valley of Death Phenomena !!

- **DoD Report to the Congress on Technology Transition, July 2007**
  - **Author** - John J. Kubricky, Deputy Under Secretary of Defense, Advanced Systems & Concepts and Kathleen L. Harger, Assistant Deputy Under Secretary of Defense, Innovation & Technology Transition.
  - **Conclusion** – Disconnect between S&T and Acquisition Programs
  - **Recommendations** – (1) Improve Technology Push, (2) Improve Technology Pull, (3) Remove technical, cultural and business barriers to integrate new suppliers and technologies into defense system architectures, and (4) Focused governance and oversight at the Enterprise level
- **GAO Report on Assessments of Select Weapon Programs, March 2008**
  - **Author -** Gene L. Dodaro, Acting Comptroller General of the United States
  - **Conclusion** – Immature technology causes cost and time escalation (other – software development difficulties, contractor usage, staff turnover)
  - **Recommendations** – Employ Knowledge-based approach (Technology Maturity, Design Maturity and Production Maturity)

Valley of Death ?

Disconnect between S&T and Acquisition Programs

S&T Portfolio



Technology Needs:
Programs of Record

Wasted R&D Efforts
Immature technologies
Unmet Program technology needs
Disconnect between S&T and Acquisition Programs

Valley of Death: Why?

The Issues to be resolved and Best Practices to be implemented

S&T Portfolio

Technology Needs:
Programs of Record

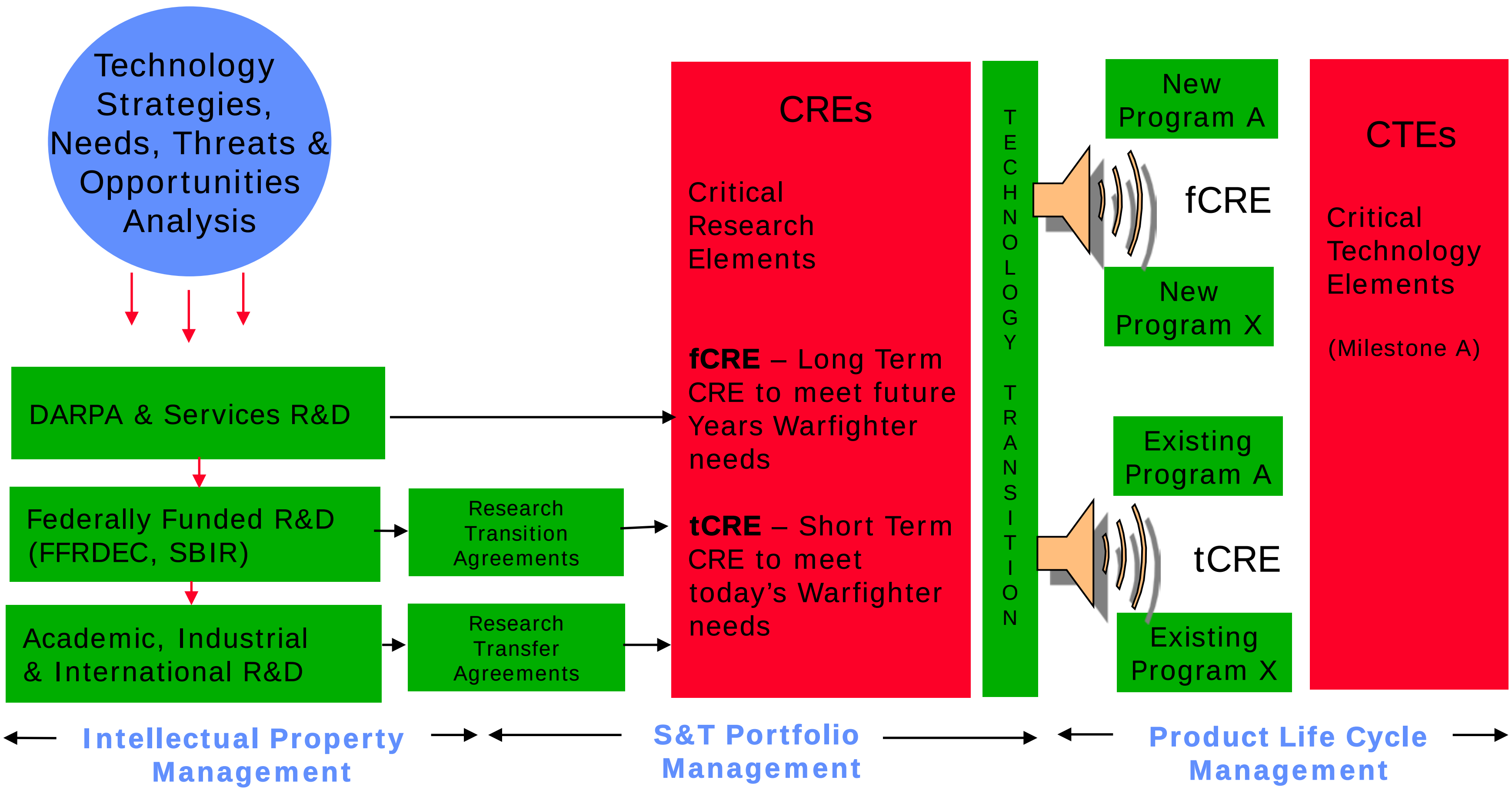
S&T and Program Management Issues

Enterprise Guidelines and Issues

Lack of Industry Best Practices

Critical Research Elements (CREs)

Linking IP, S&T Portfolio and Product Lifecycle Management



Multi-Dimension Maturity Analysis: CREs (to be developed) and CTEs (TRLs & MRLs)

What are CREs?

Linking CREs to International Standards and CTEs

Critical Research Elements (CREs)	Critical Technology Elements (CTEs)
Proposition: A CRE is a *manageable* and/or *patentable* component of a S&T Program. A Program may be composed of one or more CRE. The following definitions apply: *(a) Manageable*: The Project Manager has determined that this research element represents one of the major areas of the S&T Program, and the program can not succeed without tracking its progress through the life cycle of the program. (b) *Patentable:* World Intellectual Property Organization (WIPO), an agency of the United Nations Definition:. *"… A patent is an exclusive right granted for an **invention**, which is a **product** or a **process** that provides, in general, a new way of doing something, or offers a new technical solution to a problem. In order to be patentable, the invention must fulfill certain conditions. An invention must, in general, fulfill the following conditions to be protected by a patent - **practical use**; **novelty**, **new characteristic, inventive step)… "***	**DOD TRA Desk book Definition:** "A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (with acceptable development, cost, and schedule and with acceptable production and operation costs) *and* if the technology element or its application is either new or novel. Said another way, an element that is new or novel or is being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition, or its operational utility."

Relationship between CREs and CTEs

Comparing CREs to CTEs

Critical Research Elements (CREs)	Critical Technology Elements (CTEs)
CRE has one-to-one or one-to-many relationship with a CTE	A CTE is derived from one or more CRE
Frontend of Innovation	Backend of Innovation
Measurement Indices: “Performance & Maturity” (to be developed)	Measurement Indices: TRA/TRLs (evolving to SMA)
Independent from the Acquisition Programs and managed by the S&T Community	Related to Acquisition Programs and managed by the Acquisition Community

CREs:
What are the real questions?

Exploring CREs

- How to identify and define the CRE?

- Which criteria should be used to measure the performance and maturity of CRE?

- How is CRE related to the innovation metrics used by Industry?

- As SMA is conducted on CTEs, how does SMA relate to CREs

- How will the CRE link with the
  - CTE, and
  - the DOD Acquisition Management Framework?

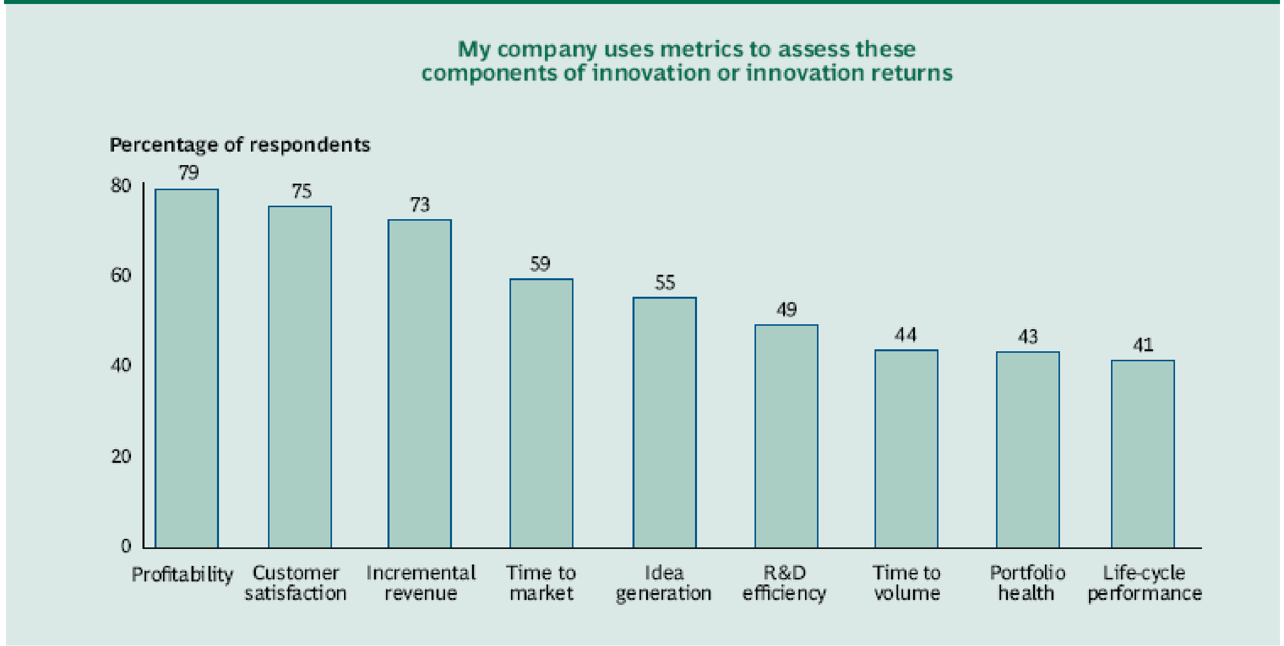
CREs:
What do we know?

- Industry Innovation Management Metrics (source: Boston Consulting Group Survey – Measuring Innovation , 2009)

- Industry metrics are part of Stage/Gate Process to manage product lifecycle

- Industry Metrics should be used as a guideline ONLY to develop DoD S&T Program management metrics

Exhibit 6. Profitability, Customer Satisfaction, and Incremental Revenue Are the Most Closely Tracked Components of Innovation



CREs:
What do we need to know?

Linking IP, S&T Portfolio and Product Lifecycle Management

- Industry Metrics are based on the commercial management criteria, such as profit, patents generated and new products introduced (discussed in previous slide).

- For the DOD community, the management criteria are warfare superiority, and delivering capabilities to the war fighters within the planned cost, schedule, risk/vulnerability, intelligence collection/dissemination accuracy, detection, assessment of preparedness, maintenance of situation awareness, and performance outcomes. Questions:

  - Are there any other management criteria (in addition to the above referenced criteria that should be used to develop CREs?
  - What are the desired or optimized research management practices?
  - What are the gaps between the current practices and the optimized practices?
  - What are the main challenges encountered in measuring the S&T program performance?
  - Which tools should be used?
  - How are the project selected for S&T portfolio?

CREs:
What could we do to learn that?

Linking IP, S&T Portfolio and Product Lifecycle Management

- Develop a list of research management criteria after analyzing DoD and commercial best practices for S&T and Acquisition program management.
- Prepare and conduct a market survey
- Develop a list of research performance measurement and maturity criteria and qualifications
- Research and analyze the differences between the CRE and CTE
- Develop and analyze the parameters which are essential to develop an effective communication link between the S&T and Acquisition Programs.
- Develop a link between the CRE, CTE and the Acquisition Management Framework, based on a Knowledge-based Gate Process.
- Develop a link between the OMB's Program Assessment Rating Tool (PART) and the CRE concept.
- Analyze and verify the components of the proposed multi-dimension maturity model.
- Develop a prototype software tool, using Government-off-the-shelves (GOTS) or Commercial off-the Shelves (COTS) products which will help the Defense community to link CRE to CTE.
- Develop a prototype management dash board, based on a COTS product, which will show performance and maturity health of a S&T Program using the CRE methodology and Multi-Dimension Maturity model

Conclusions

CREs – A part of the solution

- Innovation is a top National priority; However, Innovation Management is an ART and should be converted to a SCIENCE by developing concepts, methodologies and tools

- Department of Defense Innovation Management : Valley of Death is caused by disconnect between S&T and Acquisition Programs.

- Current DOD Community discussions on the Valley of Death mainly address the funding mechanism…. however, there is a need to develop a comprehensive solution (new or improved methodologies, processes and tools) by analyzing:

  - S&T and Program Management Issues
  - Enterprise Guidelines and Issues
  - Industry Best Practices

- CREs – One of the proposed methodologies

  - Proposed a CRE definition
  - Suggested links to CTEs

S&T Portfolio Maturity & Performance Analysis: The Concept of Critical Research Elements (CREs)

NDIA

12th Annual Systems Engineering Conference

OCT 26-29, 2009
San Diego, CA

Any Questions ?

Has Patel

Infologic, Inc.

has.patel@infologic.com

(888) 325 0500 Ext. 100

Item Unique Identification (IUID) Enables Streamlined Acquisition And System Engineering

NDIA System Engineering Conference
26-29 October 2009
San Diego, CA

Rob Leibrandt
Deputy, UID Policy

Office of the Secretary of Defense
Defense Procurement
OUSD(AT&L)/DP/PDI

robert.leibrandt@osd.mil

Historical Methods of Identification

- Logistics and Engineering – NSN, Manufacturer and Part Number
- Property Management – Tail Number, Hull Number, Asset Tag (usually for local tracking)
- Manufacturing – Part Number, Serial Number
- Maintenance – Manufacturer, Part Number
- Tracking (regulatory and security) – Mixed
- Acquisition – Contract and Line Item Numbers and Quantity
- Finance – Fund Cite and Requisition Documents

UID Hierarchy

- Unique Identification (**UID**) is a system of identifying entities to distinguish them from each other.

- Item Unique Identification (**IUID**) is a system of marking items with Unique Item Identifiers (UIIs) that distinguish them from all other like and unlike items.

- Other efforts include:
  - Real Property Unique Identification (RPUID)
  - Acquisition Program Unique Identification (APUID)
  - System Unique Identification (SYSUID)
  - Organization Unique Identification (OUID)
    - Internal DoD (FMID)
    - External to DoD (CAGE, DUNS, etc.)

What Does IUID Provide?

Uniquely identifying tangible items will provide the "**data key**" to item life cycle traceability in DoD business processes and information systems and provide reliable data and accurate data, via Automatic Identification Technology (2D Data Matrix), for engineering, logistics, management, financial, accountability and asset management purposes.

Required on all new Solicitations since 1 January 2004

AND

Legacy item compliance mandatory between 2008 and 2015

Automatic Identification Technology -Back to the Future

"I think the industry has sold itself on a program that offers so little return that it simply won't be worth the trouble and expense"

discussing the potential of the barcode in **1975***

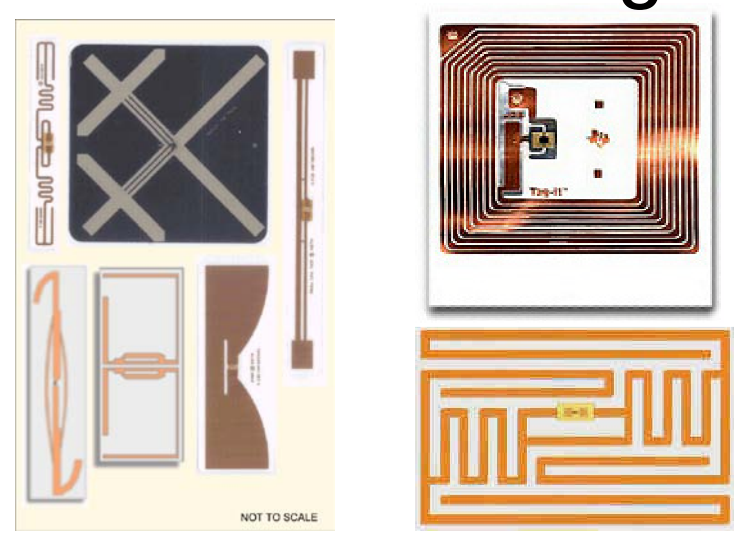
*"Scanning Hits a Snag," Progressive Grocer, December 1975, p. 47

Automatic Identification Technology

1D Barcode

Contact Memory Buttons

Passive RFID Tags

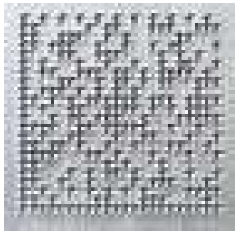
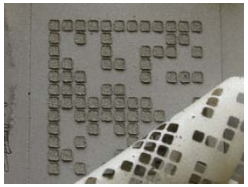


2-D Barcodes

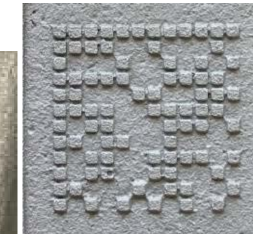
Data Matrix **QR Code** **MaxiCode**

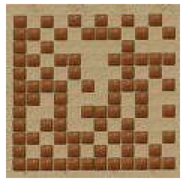
PDF417 **Bullseye** **Aztec**

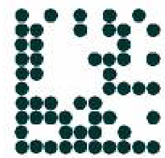
Active RFID Tags

Marking Techniques






- Labels (Stickers)
- Data Plates
- Dot Peen
- Laser Etch
- Chemical Etch
- Silk Screening
- Thermal Spray

- Ink Jet Printing
- Laser Ablation
- Laser “Annealing”
- Cast/Forged
- Laser Bonding
- Embroidery
- Photo Etch

Compliant UII marks are optically read…so almost any marking method will work!

Key Direction from IUID Policy Updates

- **Apply IUID to legacy items in inventory and operational use**

- **All program and item managers plan for and implement IUID**
  - ACAT 1D programs submitted plans by June 2005
  - All others to MDAs by January 2006
  - All new programs must submit a plan as part of their System Engineering Plan

- **Government Furnished Property (GFP) must meet IUID policy requirement effective 1 Jan 2006**
  - DD 1662 for annual inventory of GFP eliminated

- **Plans must address:**
  - All existing serialized assets will be entered in IUID Registry
  - UII marking capabilities established such that marking can commence when equipment is returned for maintenance

Key Direction from IUID Policy Updates

- <u>DUSD (Logistics and Material Readiness)</u> **develop IUID implementation plan for organic depot maintenance operations**

- <u>Jan 2007</u>: **OUSD Materiel Readiness & Maintenance Policy released "Implementing Item-Unique Identification in DoD Maintenance" (dated 31 Jan 07)**
  - **The Concept of Operations for IUID-Enabled Maintenance in Support of DoD Materiel Readiness**

- <u>14 March 2008</u>: **Memo Under Secretary (AT&L)**
  - **Policy for IUID of Tangible Personal Property – Oversight of IUID Implementation Planning and Execution**

- <u>16 June 2008</u>: **DoDI 8320.04 Item Unique Identification (IUID) Standards for Tangible Personal Property**
  - http://www.dtic.mil/whs/directives/corres/pdf/832004p.pdf

- <u>24 October 2008</u>: **Memo Under Secretary (AT&L)**
  - **Nuclear Weapons-Related Materiel (NWRM)**

- <u>3 Aug 2009</u>: **Under Secretary AT&L Ashton Carter, "Preservation and Storage of Tooling for Major Defense Acquisition Programs (MDAPs)"**
  - **Requires IUID and the planning for Preservation and Storage of Tooling for prior to Milestone C (SEP) and at Milestone C (LCSP)**

IUID Policy Overview

- Policy memorandum released on July 29, 2003 (with subsequent updates) established IUID as a mandatory DoD requirement on all solicitations issued on or after January 1, 2004.
- IUID is required for all property items delivered to the Government if:
  - *Acquisition cost is greater than or equal to $5,000*
  - *Items with an acquisition cost below $5,000, when identified by the requiring activity as DoD serially managed, mission essential, or controlled inventory*
  - *Items with an acquisition cost below $5,000 as determined by the requiring activity*
  - *Regardless of value, any DoD serially managed subassembly, component or part embedded within an item and the "parent" item in which it is embedded*
- Wide Area Workflow (WAWF) is the preferred method for capturing IUID data and is the mandatory DoD invoicing system

Create and Generate the UII

The components that make up the UII are identified in the table below. Each enterprise has two options for creating the UII.

	UII Construct #1	UII Construct #2
Based on current enterprise configurations	If items are serialized within the Enterprise	If items are serialized within Part Number
UII is derived by concatenating the data elements IN ORDER:	Issuing Agency Code* Enterprise ID Serial Number	Issuing Agency Code* Enterprise ID Original Part Number / Lot or Batch Number Serial Number
Data Identified on Assets Not Part of the UII (Separate Identifier)	Current Part Number** Other Traceability Number***	Current Part Number ** Other Traceability Number***

*The Issuing Agency Code (IAC) represents the registration authority that issued the enterprise identifier (e.g., Dun and Bradstreet, EAN.UCC). The IAC can be derived from the data qualifier for the enterprise identifier and does not need to be marked on the item.

** In instances where the original part number changes with new configurations (also known as part number roll), the current part number may be included on the item as a separate data element for traceability purposes.

*** The data identifier 30T has been designated for use as a traceability number that is not part of the UII. For example, applications may specify 30T for encoding lot or batch number when the lot or batch number is not required or desired in the UII.

Create and Generate the UII

BUSINESS RULES

The UII shall be derived from its discrete component data elements.

The UII is not required to be marked on the item as a separate data element.*

UII Construct #1[1]

EID	**MFR 0CVA5**
Serial No.	**SER 786950**

UII Construct #1

D1 0CVA5786950

IAC CAGE Serial No.

UII Construct #2[2]

EID	**(12V)194532636**
Orig. Part No.	**(1P)1234**
Serial No.	**(S)786950**

UII Construct #2

UN1945326361234786950

IAC DUNS Orig. Part No. Serial No.

[1] **This example uses Text Element Identifiers**

[2] **This example uses MH10.8.2 Data Identifiers.**

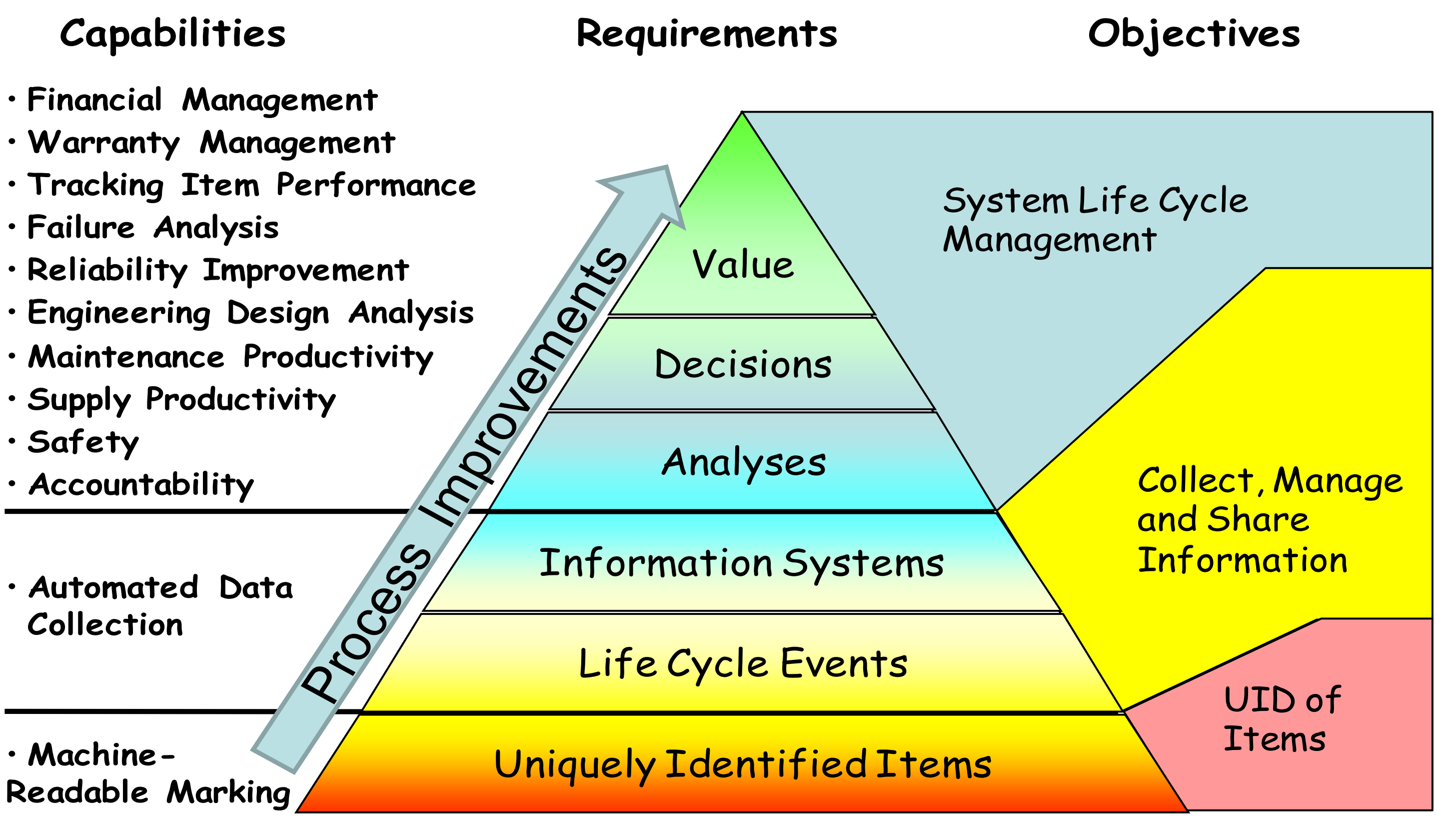
*If the enterprise chooses to mark the UII as a discrete data element on the item, the component data elements must also be marked on the item as discrete data elements, in addition to the UII.

System Engineering Requirement

- **AT&L Memo-Implementation Planning & Execution 14 March 2008**
  - System Engineering Plan
    - Describe overall IUID Implementation Strategy to include
      - Requirements Generation
      - Marking
      - Data Submission
      - Describe role of IUID in program sustainment strategy
    - List Metrics
    - Implementation Timeline
  - Life Cycle Supportability
    - Property accountability & management and financial accounting enabled by IUID
    - Incorporate capability to use IUID in all new Automated Information Systems (AIS) used for management of property

- **DODI 5000.02 “Operation of the Defense Acquisition System, 2 December 2008**
  - IUID Implementation Plan required per DoD Instruction 8320.04
    - Milestone A (summarized in SEP)
    - Milestone B (annex to SEP)
    - Milestone C (annex to SEP)

UID of Items Enabled Intensive System Life Cycle Management



Source: Study Draft 0.7 NATO Allied Publication AUIDP-1

Systems Life Cycle Management View

- UII is one of the “common data keys” needed for System Life Cycle Management to link item level data and information across multiple systems and owners
- Comprehensive UII visibility from “as–built” configuration through distribution and deployment process to item configuration at disposal
- Existing mandated tracking uses UII as a common approach across all in scope platforms
  - Tracking via serial numbers is not new (e.g. Flight Critical Safety Items, controlled items, serially managed)
  - Individual systems or reporting requirements generate “point” solutions that do not encourage common usage
- Supply Chain Management decision making using UIIs.
- Complete lifecycle traceability
- Common data exchange formats virtually eliminate translation requirements

Just Imagine the Systems Benefits Possible with:

- Fully defined Product WBS at all points during the lifecycle to which :
  - Operational, maintenance and reliability data can be associated
  - Failure data can be assigned at the item level
  - Operational planning can reduce logistics tail and target skills
- The change in culture with data that:
  - Reliable and Accurate
  - Used to pull authoritative data from databases to pre-populate work orders, requisitions, PQDR, SDR
  - Labor savings associated with automatic data capture

Online Resources

Official DoD UID Policy Office Website

www.uniqueid.org

Comprehensive resource of UID and IUID policies, standards, directives, videos and success stories.

Be sure to sign up for the *IUID in Action* eNewsletter!

IUID Helpdesk

defensepolicysupport@ebpsc.org or 1.877.376.5787

Defense Acquisition University

www.dau.mil

DAU offers **2** distinct online courses to increase your IUID knowledge

CLE040 “Item Unique Identification Marking” and CLM200 “Item Unique Identification”

Back-Up Slides

DoD IUID Registry

- Purpose:
  - Collect IUID and pedigree information of tangible items owned by DoD
  - Distribute IUID and pedigree information to DoD users
  - Provide single point of reference for DoD tangible items that have assigned Unique Item Identifiers

- Operational Environment:
  - IUID Registry – database located in Battle Creek, MI
  - Operated by Defense Logistics Information Service (DLIS)
  - Resides on Business Process Network backbone

- Submit Data
  - By WAWF
  - XML or flat file through GEX
  - Manually via IUID Web Entry Site at http://www.bpm.gov/iuid

Rapidly Growing!

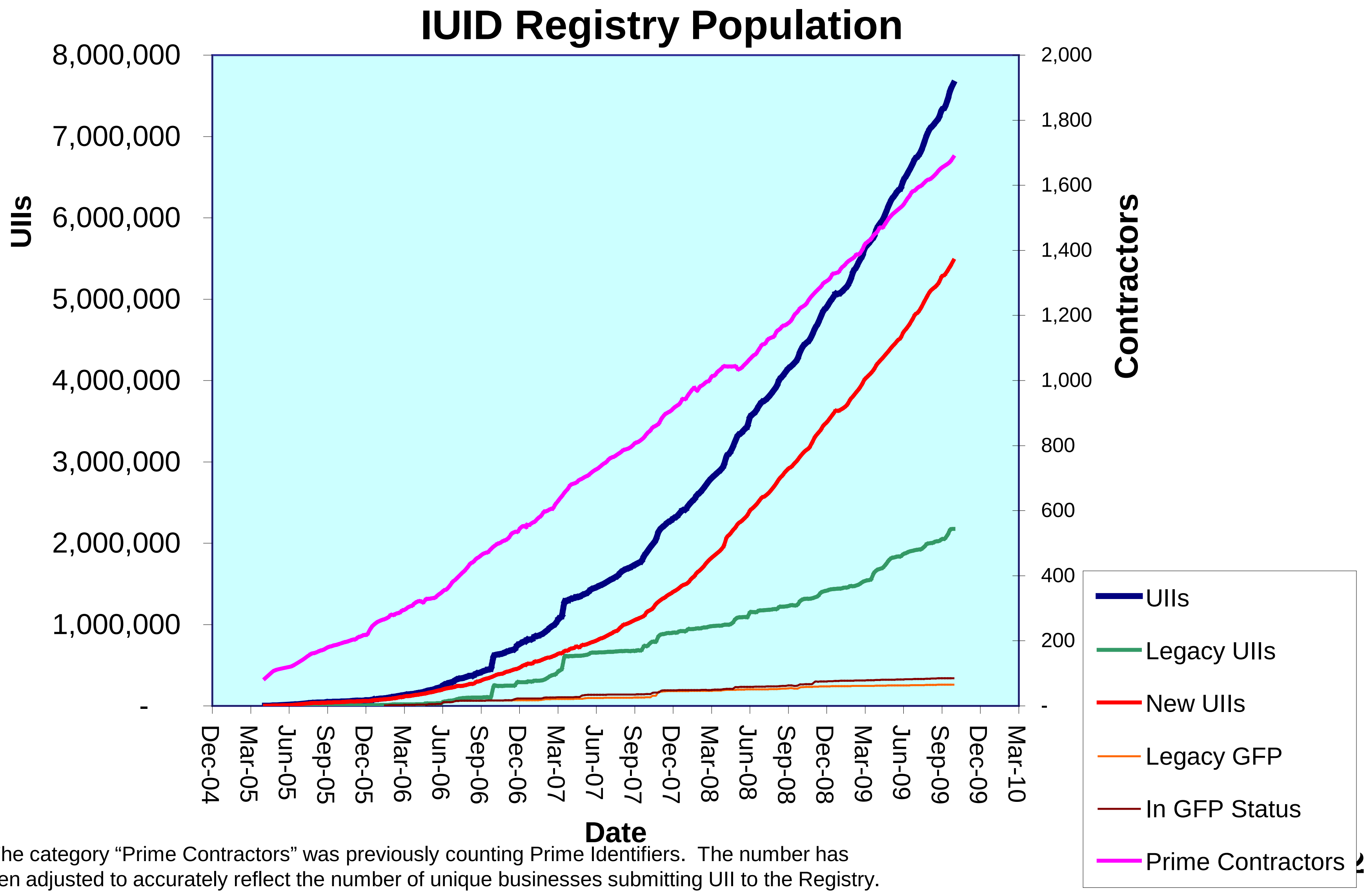
DoD IUID Registry Statistics
as of 30 September 09

- 7,650,056 Items registered
- 5,474,069 New items
- 2,175,987 Legacy
- 1,687 Contractors have delivered new UIIs
- 990 of the contractors (59%) are small businesses*
- 1,520,434 of the new items (28%) are from small businesses*
- Growth rate of over 49,000 new UIIs/week**
- 340,849 Items are in GFP status

* Based on current size status in CCR
** Legacy and GFP UIIs often come in large batches and weekly rates for those are not meaningful

Registry Population

as of 30 September 09



***** The category "Prime Contractors" was previously counting Prime Identifiers. The number has been adjusted to accurately reflect the number of unique businesses submitting UII to the Registry.

The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems

Marion L. Butterfield, Alaka Shivananda, and Dennis Schwarz (The Boeing Company)

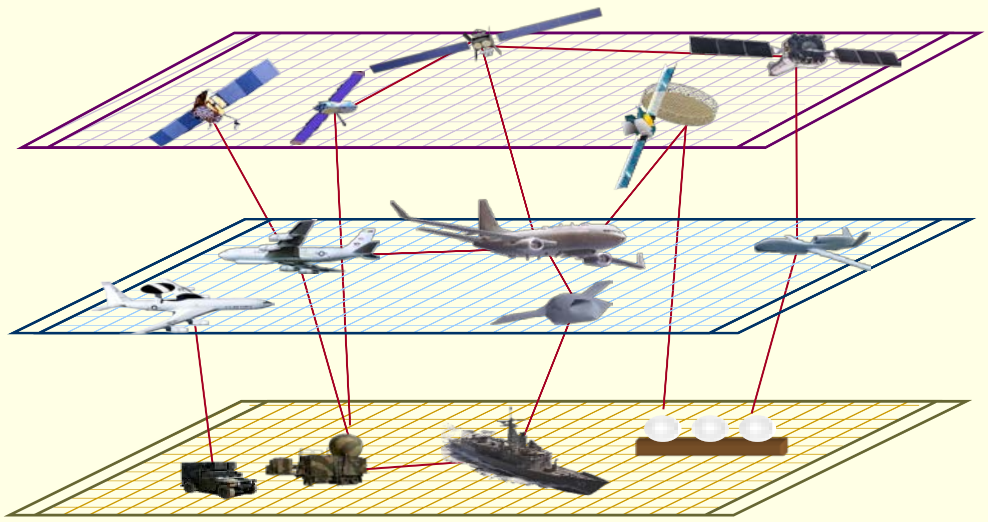
National Defense Industrial Association (NDIA) 12th Annual Systems Engineering Conference, October 26-29, 2009
Conference Session: Net-Centric Operations

Systems to Systems of Systems: The Evolving Challenge of Complexity

Complex Single System

Boeing's role as a developer of commercial and military net-centric enterprise systems of systems (SoS) has resulted in the requirement to perform Systems of Systems Engineering (SoSE) over a wide range of mission and system domains.

For example, many future military SoS's will be comprised of legacy systems from the Air Force, Army, Marines, and Navy. Effective approaches are required to transform these legacy systems into net-enabled systems capable of performing effectively as a part of these net-centric SoS's.



Net-Enabled System of Systems

System of Systems Engineering (SoSE) Process
What it is and What it does

An Enterprise (SoS) Engineering Process for development of both commercial and military complex systems and systems of systems

An architecture-centric, model-based approach that results in a single SoS/Systems Architecture Model when used in a collaborative environment

A methodology that provides detailed guidance on the net-enablement of legacy systems and their use in net-centric systems of systems

- **Provides a disciplined and more detailed SE process**
- **Follows industry standards**
- **Applicable to *all* system development programs**

- **Horizontally integrates program engineering disciplines**
- **Results in a single truth-model**
- **Incorporates a common modeling language for architecture dev.**

- **Supports industry NCO standards and strategies**
- **Improves implementation of acquisition strategies**
- **Supports system evolution**

What is a System?

A collection of components organized to accomplish a specific function or set of functions.

Reference: IEEE Recommended Practice for Architectural Description of Software-Intensive Systems, IEEE Std 1471-2000

Reference: IEEE Recommended Practice for Architectural Description of Software-Intensive Systems, IEEE Std 1471-2000

What is a “System of Systems?”

- ***Definition:***

  A System-of-Systems (SoS) is a “super-system” comprised of elements that are themselves complex, independent systems which interact to achieve a common goal.

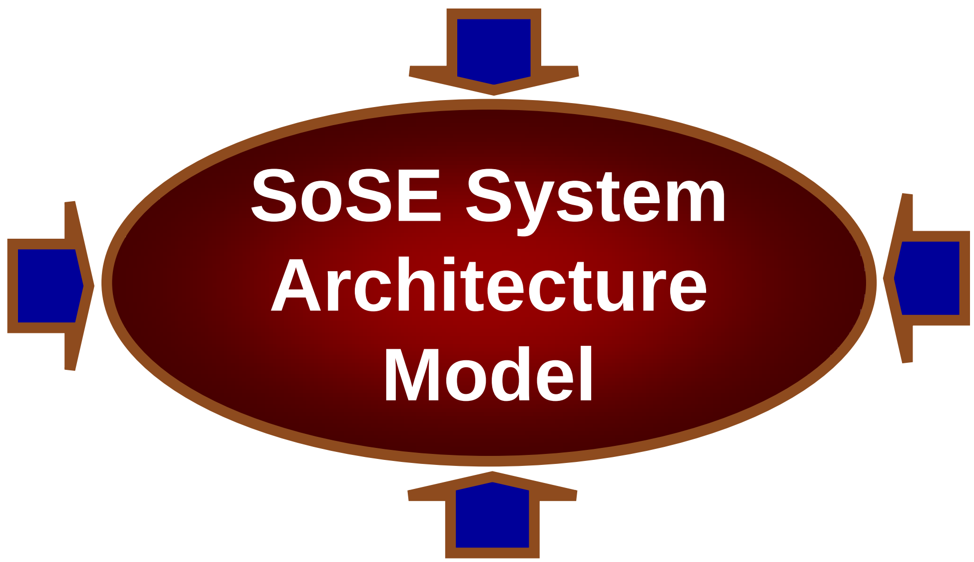
- ***Common Characteristics*:**
  - **The component systems achieve well-substantiated purposes in their own right even if detached from the overall system**
  - **The component systems are managed in large part for their own purposes rather than the purposes of the whole**
  - **It exhibits behavior, including emergent behavior, not achievable by the component systems acting independently**
  - **Constituent systems and functions may be added or removed during its use**

***After Maier, Sega, Levis**

SoSE Process is the Boeing Model-Based Best-Practices Approach to Developing a SoS/System Architecture Model

SoSE is Architecture-Centric: The system's architecture model is used as the <u>primary artifact</u> for conceptualizing, constructing, managing, and evolving the system

Provides a continuous model stream from the Stakeholder-Goal level to the architecture base level

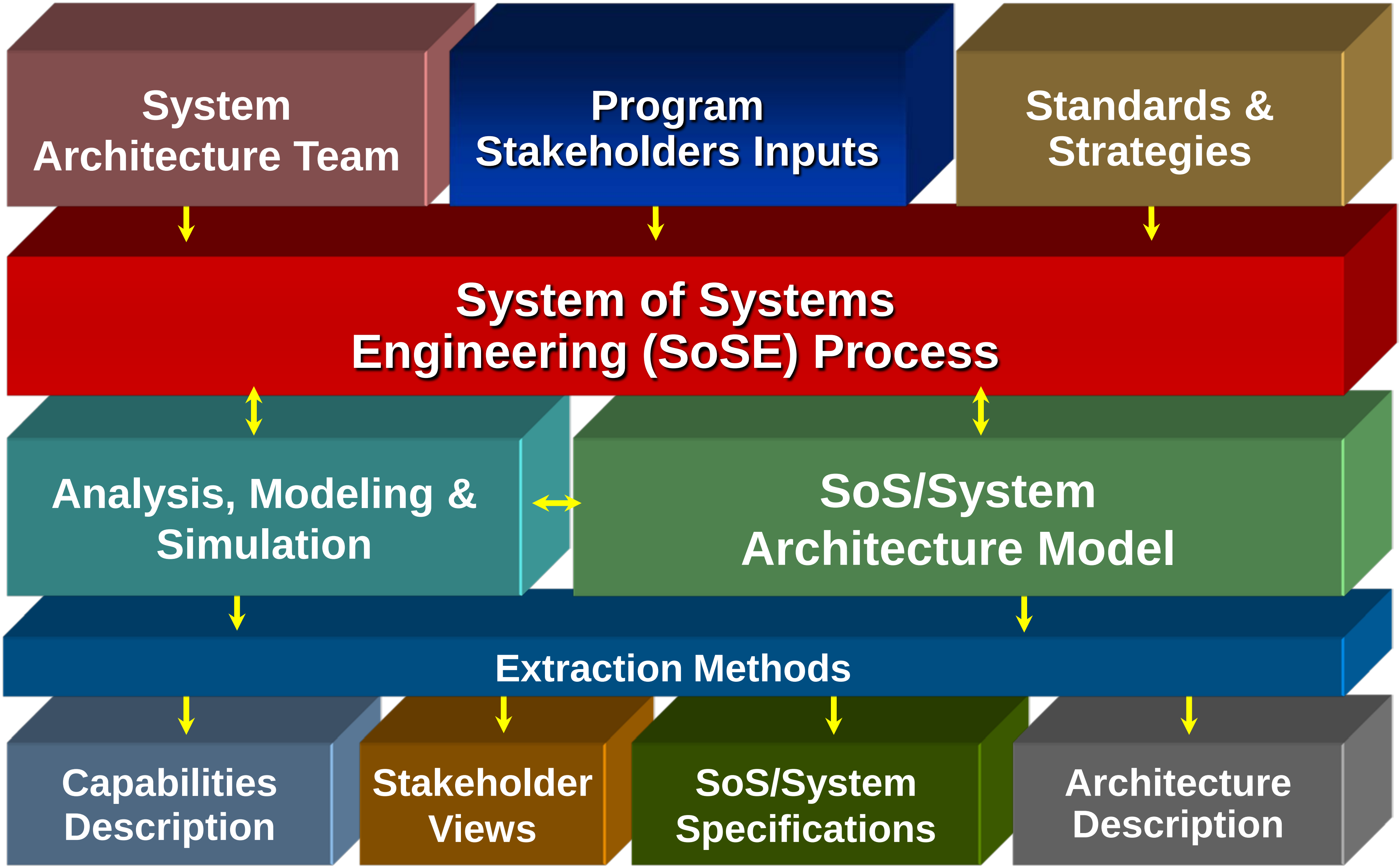


Improves traceability by defining functional requirements and system objects at each system development level

Identifies requirements, system elements, and interfaces at each level to support early design activities for all of a program's engineering disciplines

SoS/System Architecture Model: A description of the structure of a system's components, the relationships between those components, and capabilities assigned to those components.

SoSE Process Transforms the Stakeholders' Goals into a Balanced SoS/System Architecture Model



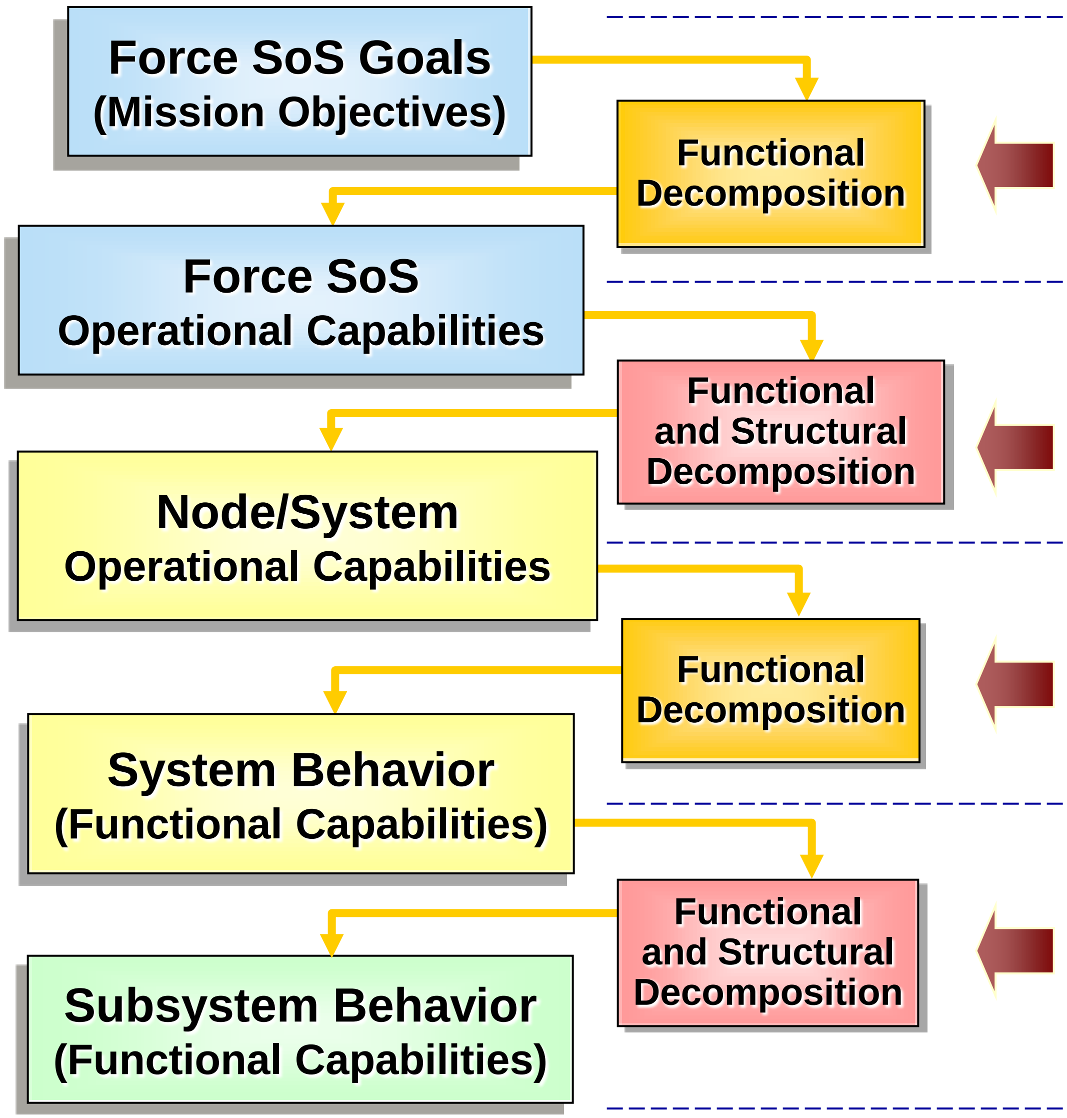
SoSE Architecture Model Includes Required Architectural Levels of Commercial and/or Government NCO SoS/Systems

Example – Force SoS Capability Levels	SoS/System Level Definitions
Force (SoS-Level) Capability Goals	Force SoS Goals (policy objectives) that drive the SoS level mission. Measurable results that have value to mission stakeholders of the SoS.
Force Operational Capabilities	Force SoS operational capabilities required to achieve the SoS goals. Measurable results that have value to the operational level authorities of the SoS.
Node (System-Level) Operational Capabilities	Force Node/System operational capabilities required to achieve SoS Capabilities. Measurable results that have value to the operational level authorities of the Node/System/Organization.
System Functional Capabilities	System/Organization functional capabilities (behavior) required to achieve the Node operational capabilities. Measurable results that have value to the functional authorities of the System/Organization.
Sub-System Functional Capabilities	Sub-System/Organization functional capabilities (behavior) required to achieve the System/Organization capabilities. Measurable results that have value to the functional authorities of the sub-System/Organization.

SoSE Operational Approach Supports all Commercial and/or Government Missions

Legacy Constraints Can Drive the SoS Architecture Model at all SoS and/or System Capability Levels

DoD NCO SoS Capability Levels | **NCO SoS Development Analyses** | **Example Architectural Decisions Affected by Legacy Constraints**



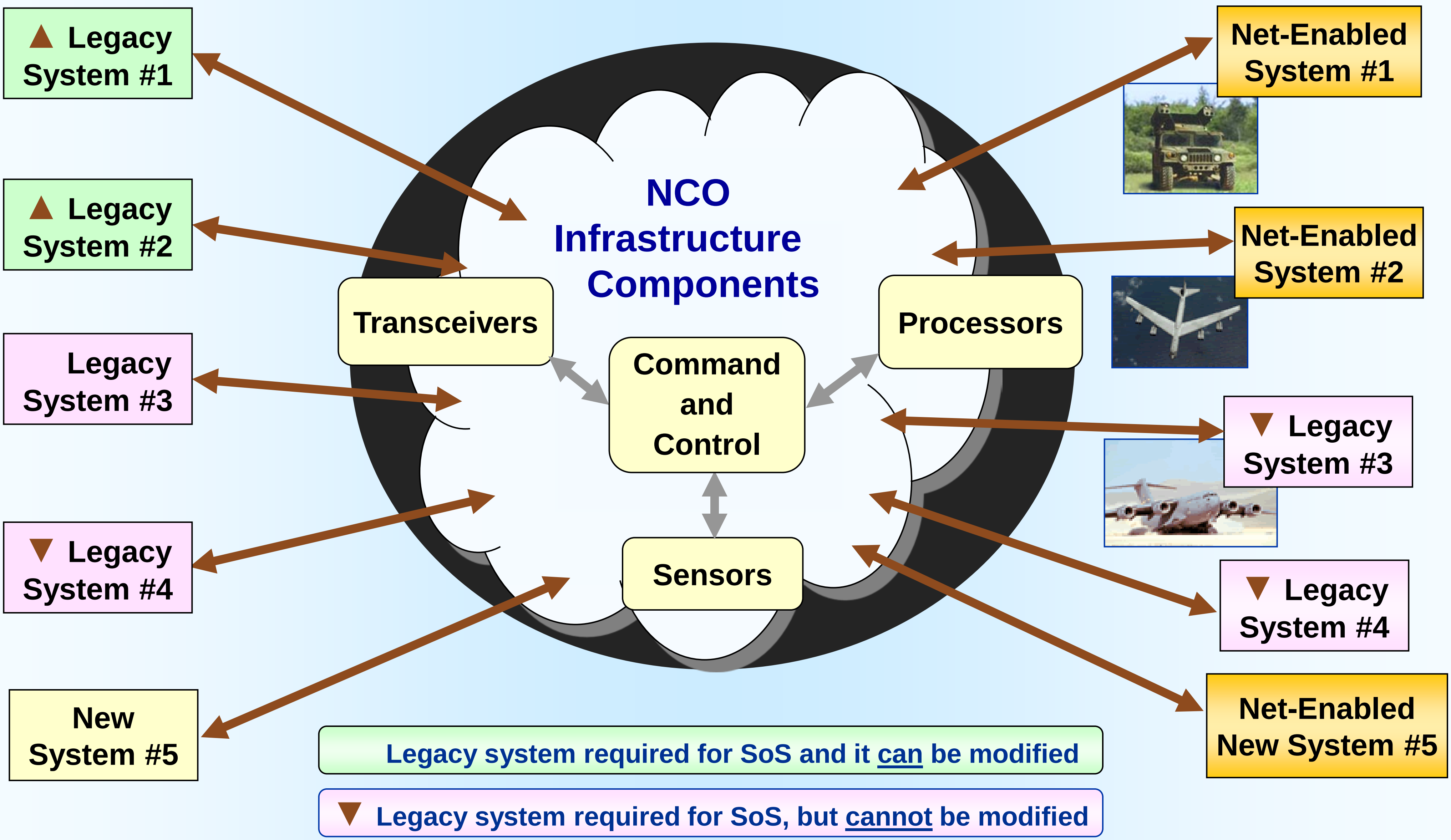
Legacy doctrines can constrain the selected Objective Capabilities and the constituent operational capabilities

Legacy force structure, operational doctrine, and systems can constrain the operational nodes selected and their allocated operational requirements

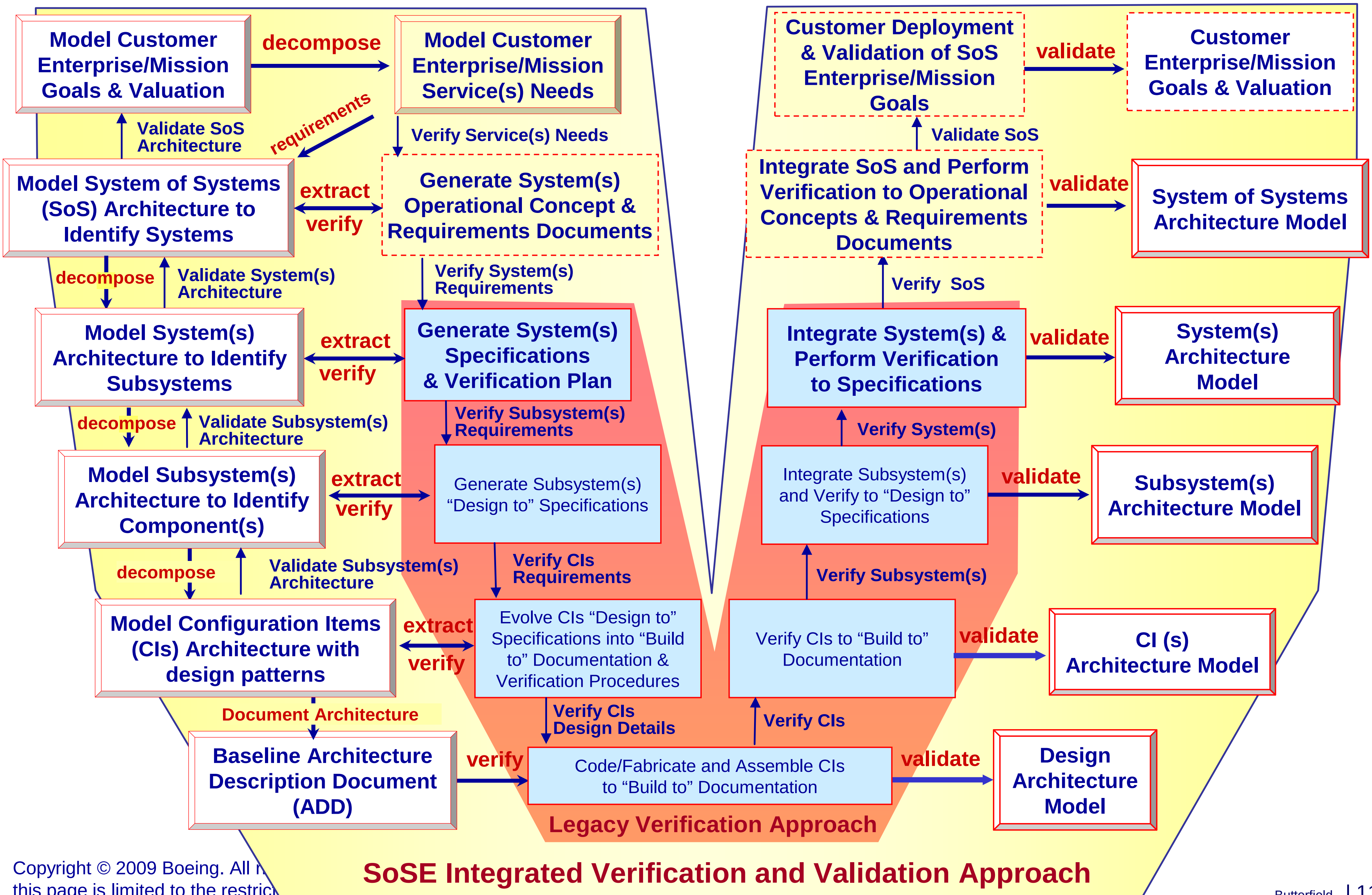
Legacy systems technology, standards, and support systems constrain the identified functional requirements and services provided and/or consumed

Legacy design features, software, and subsystems constrain the subsystems selected and their allocated functional requirements and services provided and /or consumed

Both New and Legacy Systems are Expected to be used to Develop Net-Centric Systems of Systems



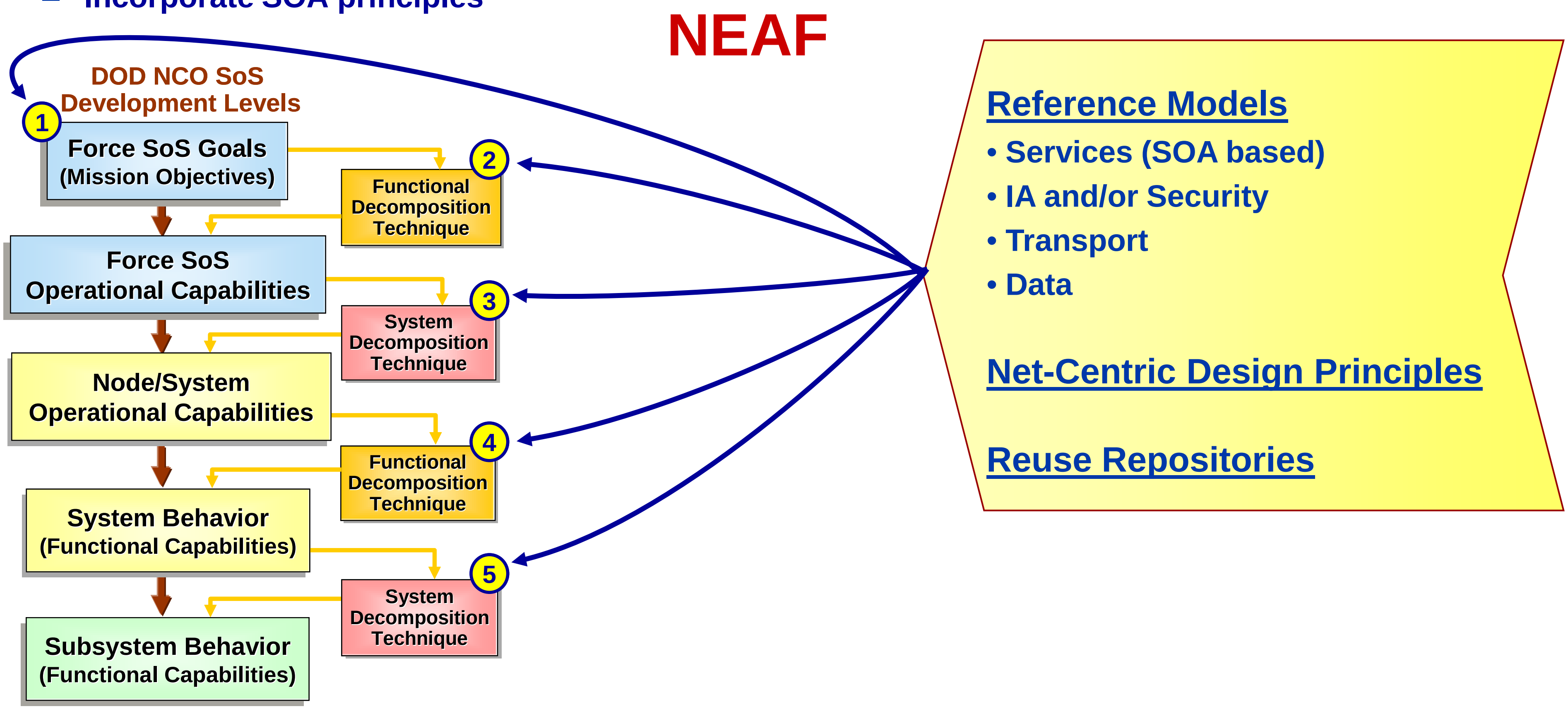
SoSE Architecture-Centric Approach Extends Legacy Methods for Verification & Validation



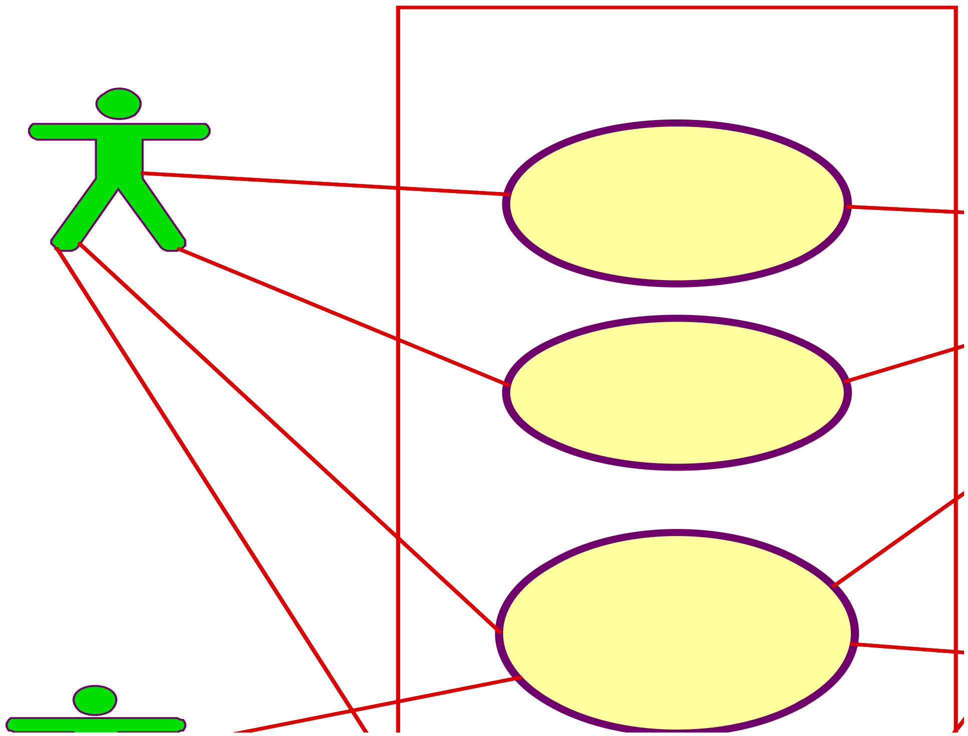
A Net-Enabling Architecture Framework (NEAF) was created to Augment the SoSE Process to Assist Net-Enabling Product Teams

NEAF Provides Product Teams Best-Practices Guidance on how to

- Develop System Architecture models using the Boeing SoSE Process
- Implement Net-Centricity and net-enable systems
- Organize and present the net-enabling aspects of the system architecture
- Develop and use a Net-Enabling Reference Architecture (NERA)
- Incorporate SOA principles

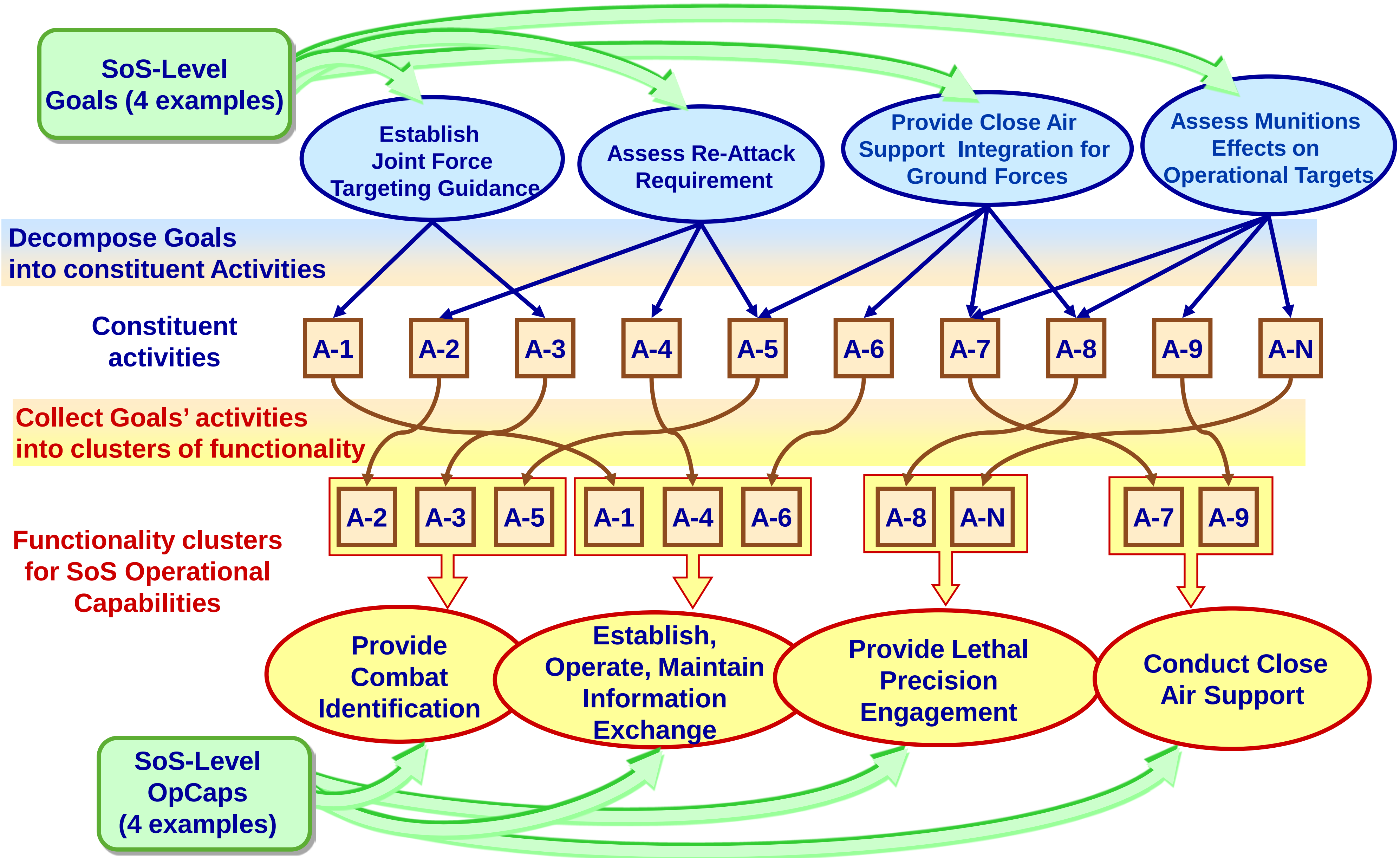


Close Air Support (CAS) Example Use Case Diagram – Enterprise Operational Capability



Example, Notional Scenario

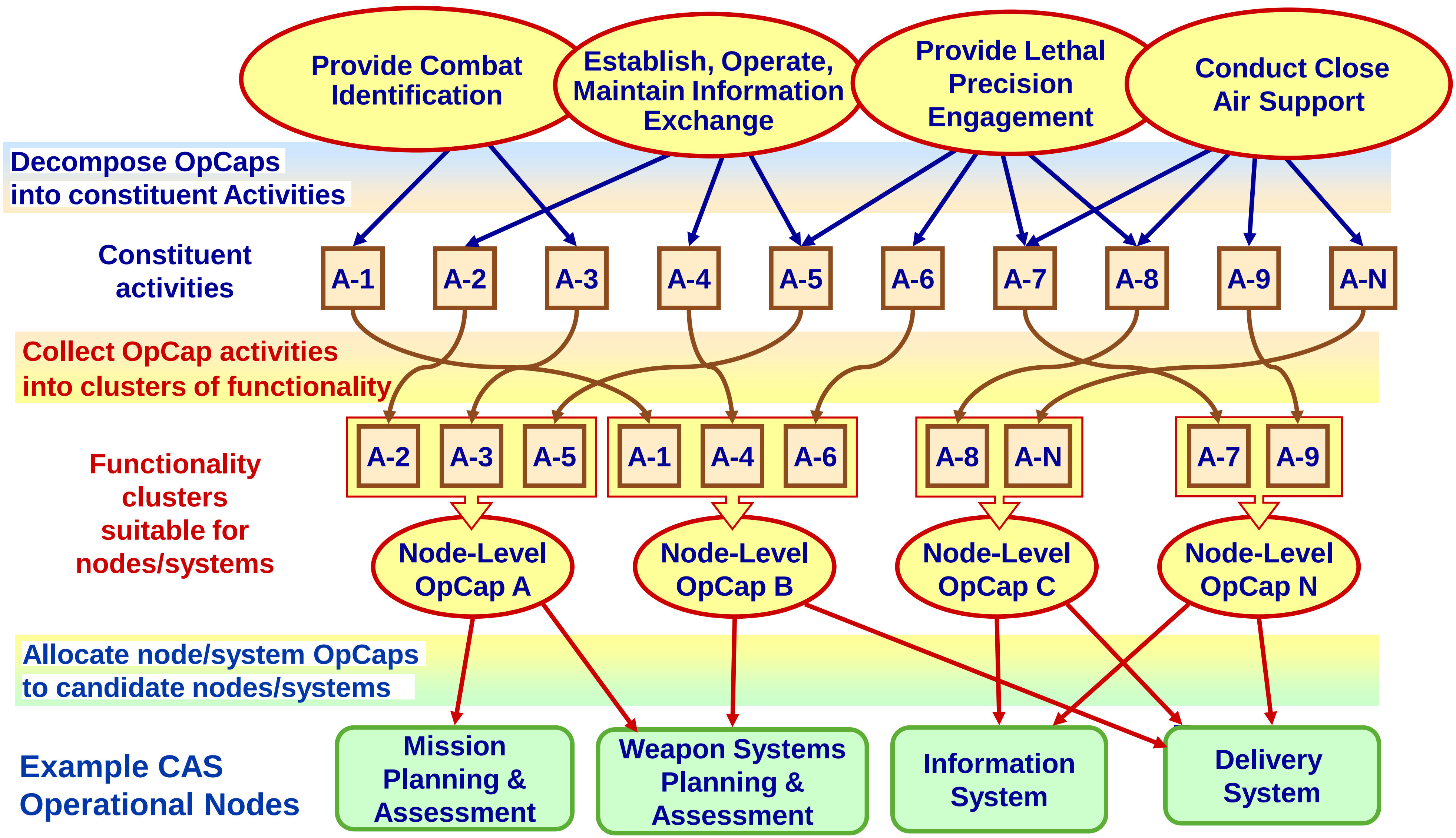
Decompose SoS-Level Goals into SoS Operational Capabilities (OpCap) – CAS Example 2



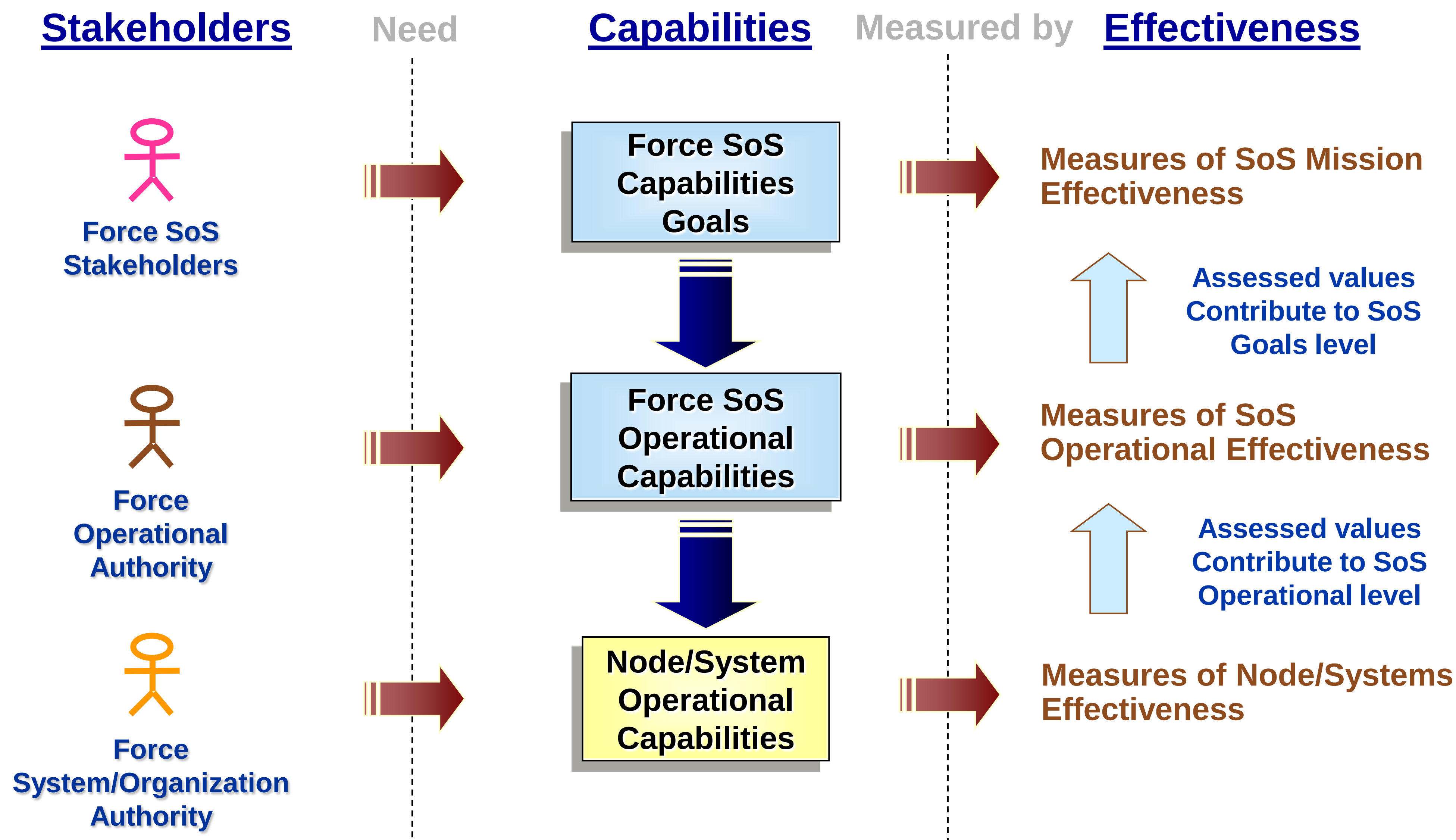
Decompose SoS-Level OpCaps into Node/ System OpCaps – CAS Example Capabilities and Nodes

3

Example CAS SoS-Level Operational Capabilities



Relationship of Force SoS Structure (the “who”) to the Force Operational Capabilities (the “need”) to Measures of Effectiveness



MOEs Drive the Architectural Design at all SoS Architecture Levels

Program Shared Situational Awareness is Achieved through Interlocking System Architecture Teams (SAT)

(★) Technical Participants:

- Domain Specialists (Analysts, HW, SW, Algorithm, Specialty, T&E)
- Scientists & Technologists
- Operations Analysts
- SE Product Management

SoS SAT

Other Participants:

- Project Management
- Marketing
- Customer Representative
- Process Specialists

Systems (a, b, and c) SAT Leaders are Member of SoS SAT

Leader

Leader

(★)

System (a) SAT

(★)

System (b) SAT

(★)

System (c) SAT

Sub-system (a,1) Leader is member System (a) SAT

Leader

Leader

(★)

Sub-system (a,1) IPT SAT

(★)

Sub-system (a,2) SAT

(★)

Sub-system (a,3) SAT

Detailed Design Team (a,1,1) Lead is member of Sub-System (a,1) SAT

Leader

Leader

Detailed Design Team (a,1,1)

(✦)

Detailed Design Team (a,1,2)

(✦)

Detailed Design Team (a,1,3)

(✦)

(✦) Participants:

- HW, SW Design Engineers
- Specialty Engineers
- IV&V Engineers
- Algorithm Developers

Summary

SoSE **is a systematic and disciplined system engineering process for defining SoS and System capabilities and net-ready compliant architectures; allocating such capabilities to a set of elements: systems and subsystems; and coordinating strategy of design, production, sustainment throughout the life cycle of a system.**

Develops the system architecture model to serve as a single common “Truth” model with the ability to incorporate the design view points of all engineering disciplines and provide architecture “situation awareness” for technical and program leadership

Establishes a “Top-Down” analytical framework for determination of the mission effectiveness for a system of systems

Incorporates open architecture development strategies and techniques and incorporates commercial and/or legacy systems

The system architecture model is the single most important development product of the System Architecture Team

References

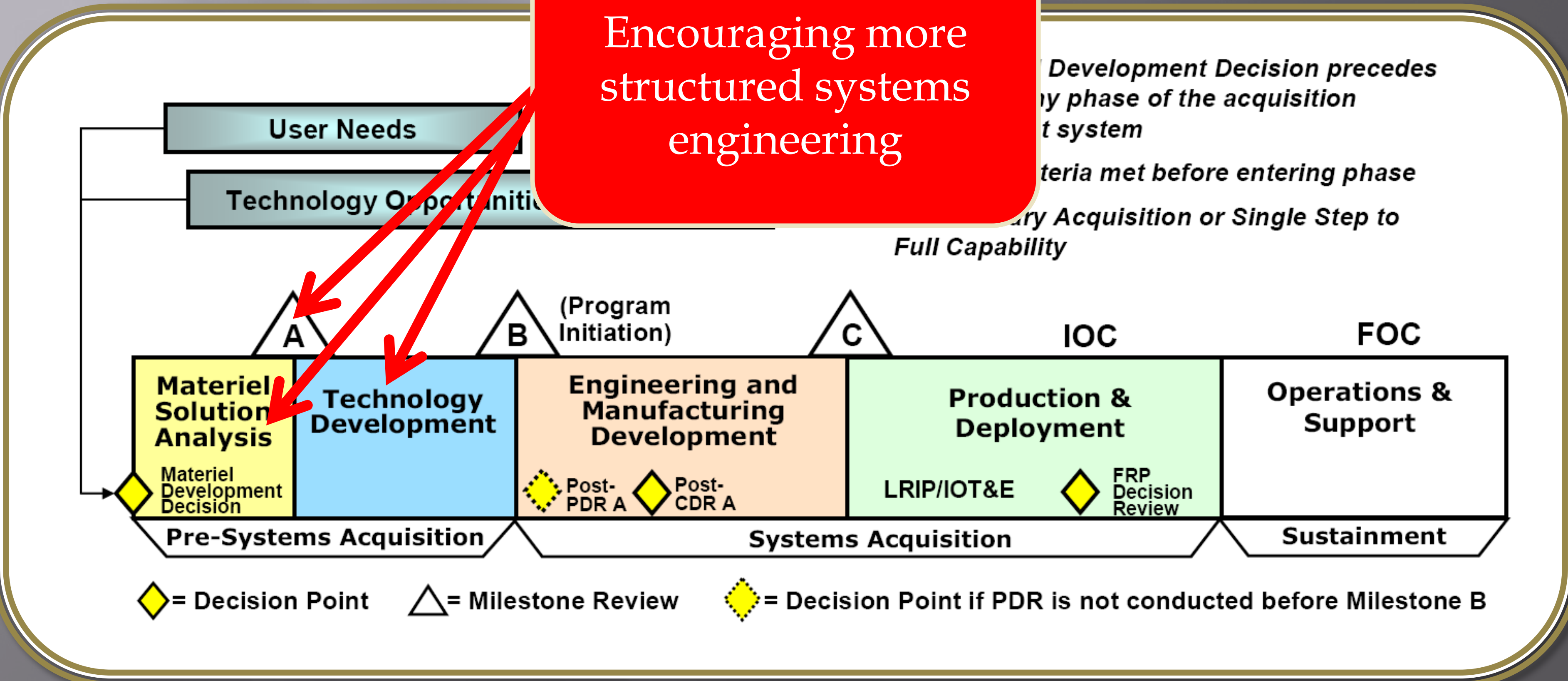
- *Net-Centric Checklist, OASD for Networks and Information Integration*, Ver. 2.1.3. 12 May 2004.
- *Net-centric Service Framework*, NIF Ver. 2. NCOIC NIF Working Group. 20 August 2008.
- *Recommended Practice for Architectural Description of Software-Intensive Systems*. ANSI/IEEE-std-1471-2000. date.
- *Reference Architecture for Service Oriented Architecture,* Ver. 1.0. OASIS. 23 April 2008.
- *Network Centric Operations Conceptual Framework*, Ver. 1.0. Prepared for John Garstka, Office of Force Transformation, Evidence Based Research, Inc., November 2003.
- *Overarching Architecture for FMLS 2010 Technical System*. Sweden FMV. LT1K P05-0074. 29 February 2006.

TRL VECTORS IN IPPD-BASED PORTFOLIO MANAGEMENT

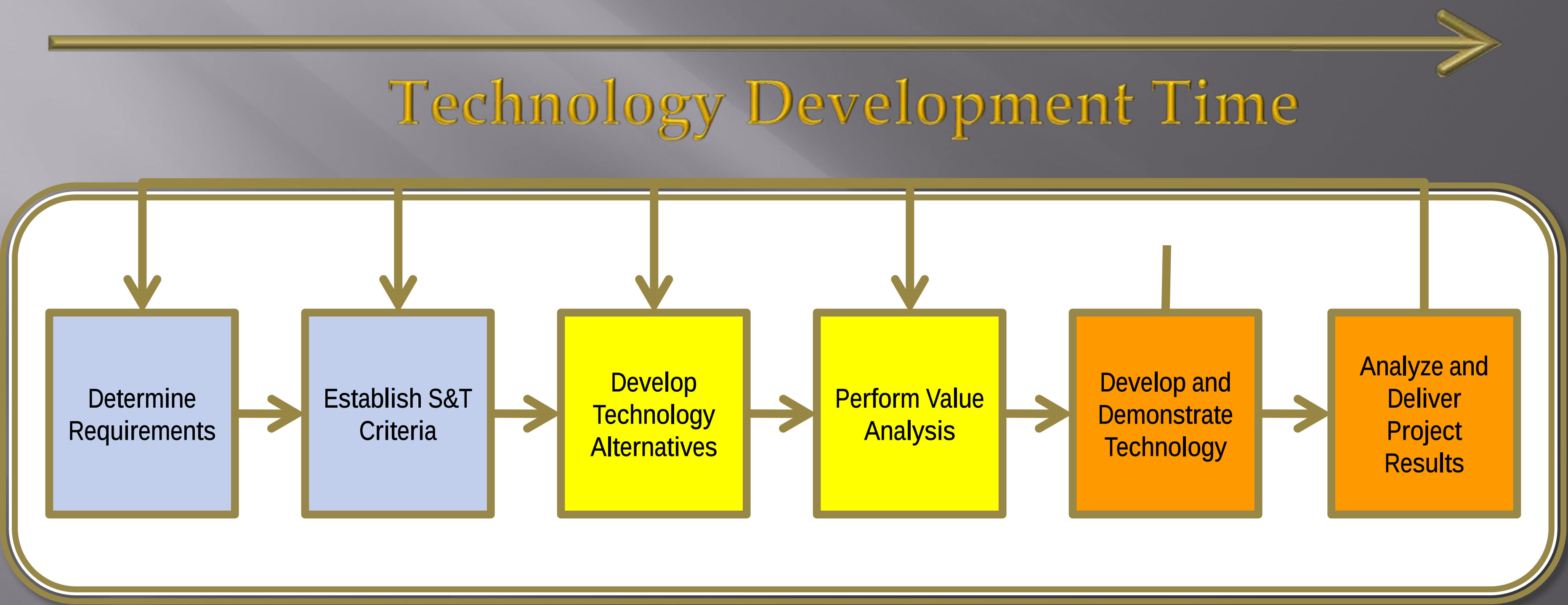
GENERAL DYNAMICS
Advanced Information Systems

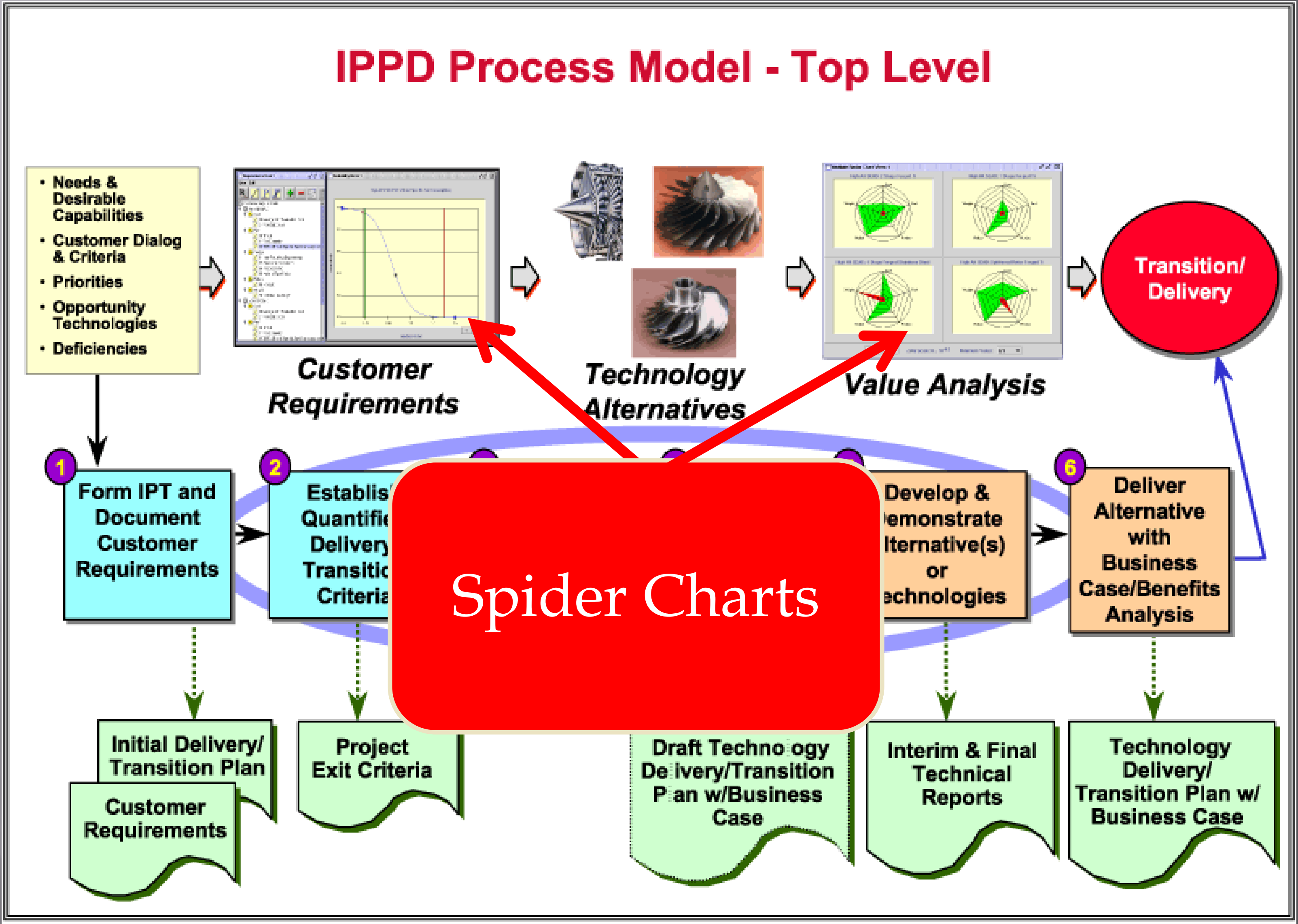
Emphasis on S&T Research Increasing in Milestone Contribution

Encouraging more structured systems engineering



IPPD-based Technology Research





Integrated Product and Process Development (IPPD) Process Model

Map TRL to Desirability and Risk

Cross technology issue measurement and performance characteristic validations completed

Quality and reliability levels established

Collection of actual maintainability, reliability, and supportability data has been started

Quality and reliability levels established

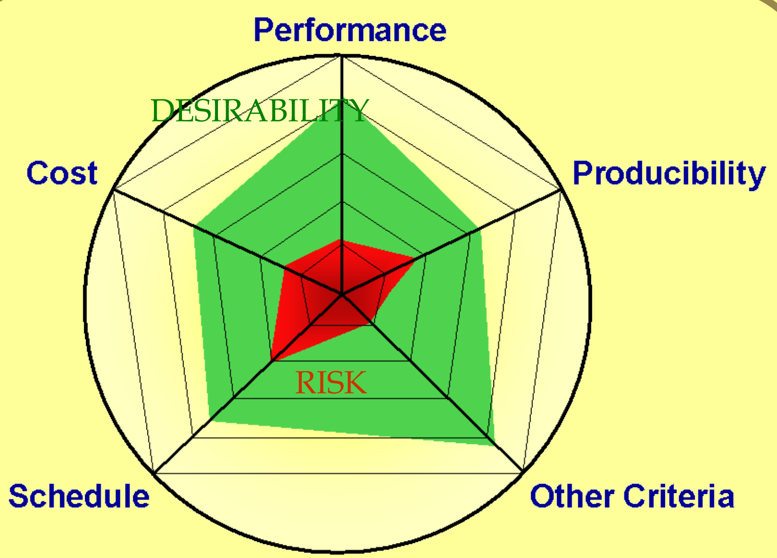
Investment needs for process and tooling determined

Design to cost goals identified

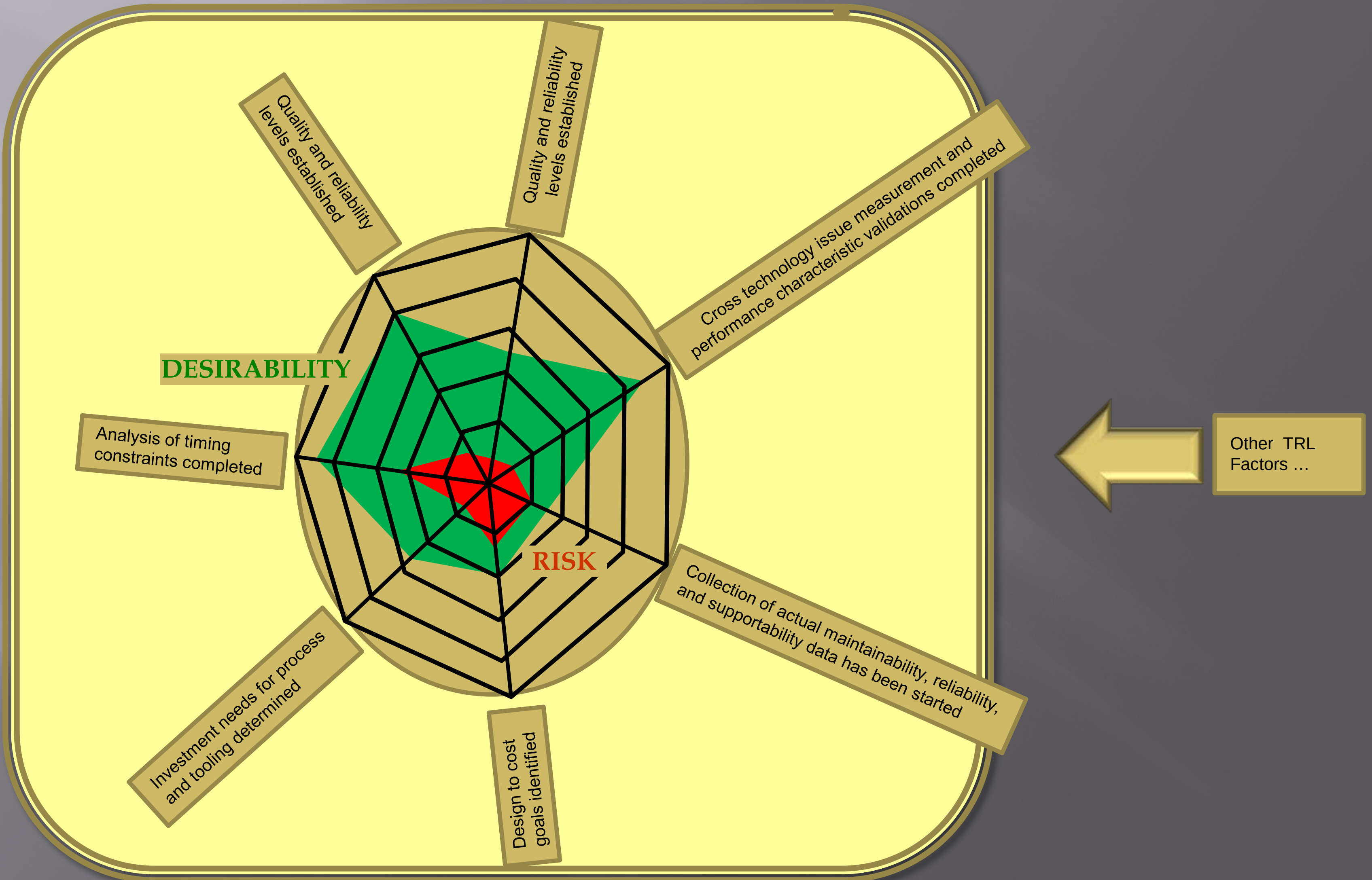
Analysis of timing constraints completed

Other …

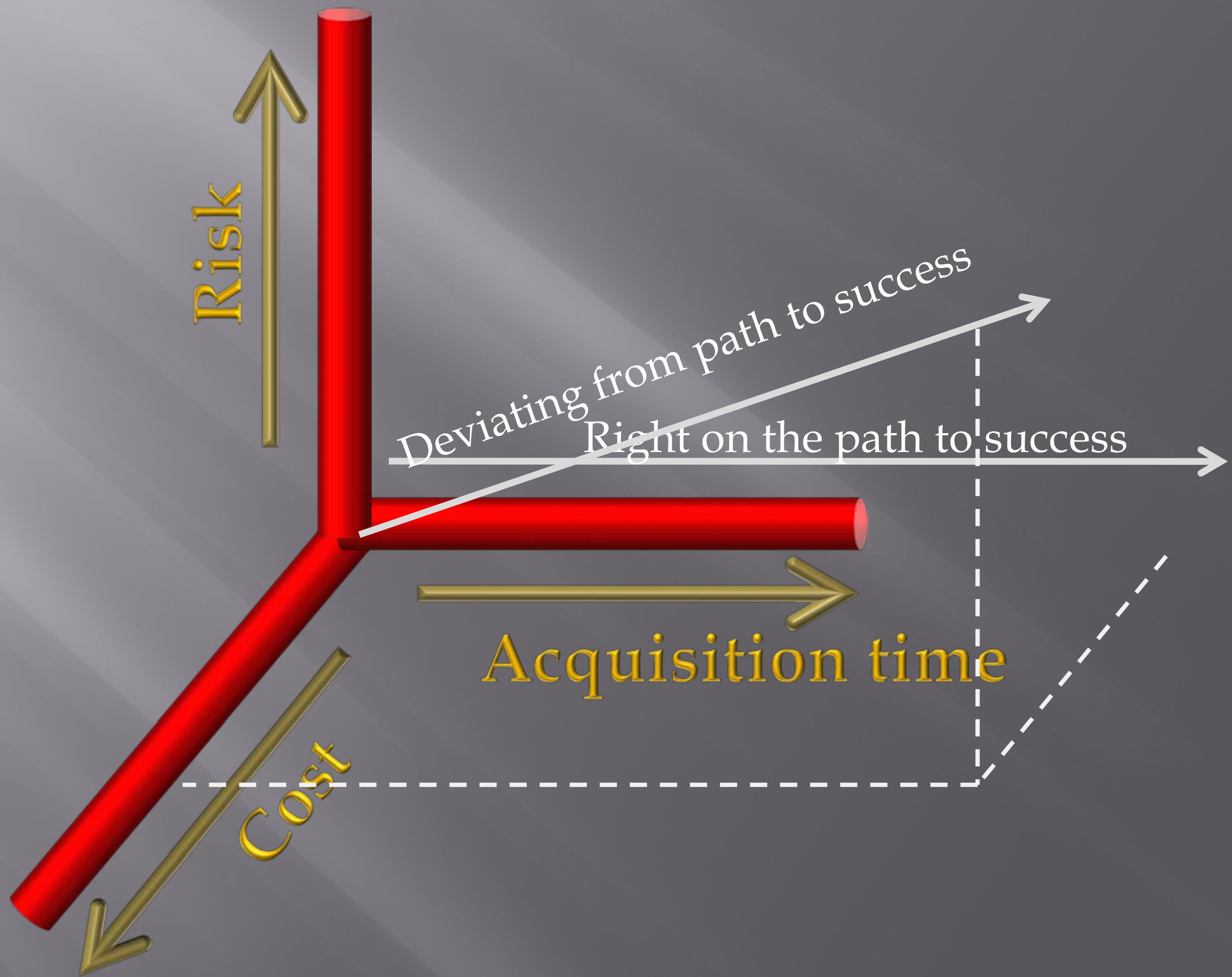
TRL Calculator Metrics



Map TRL to Desirability and Risk

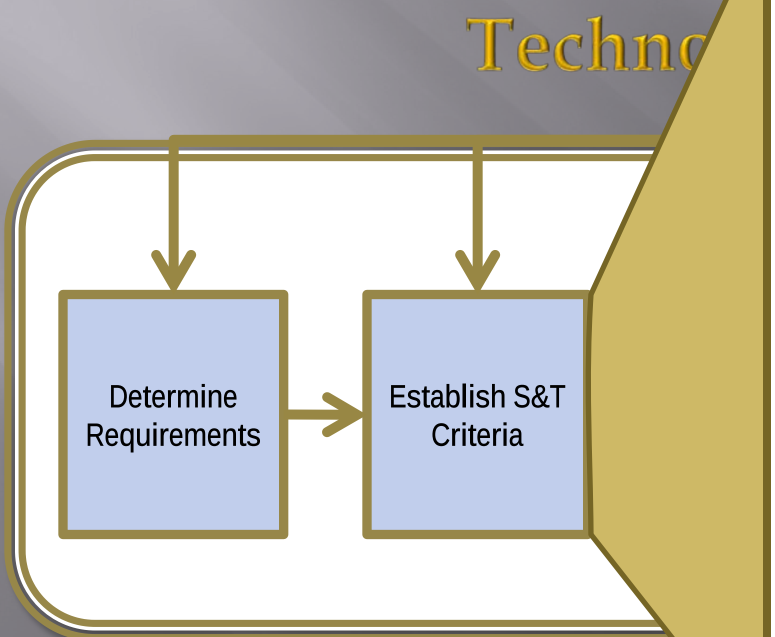


Defining a TRL Vector



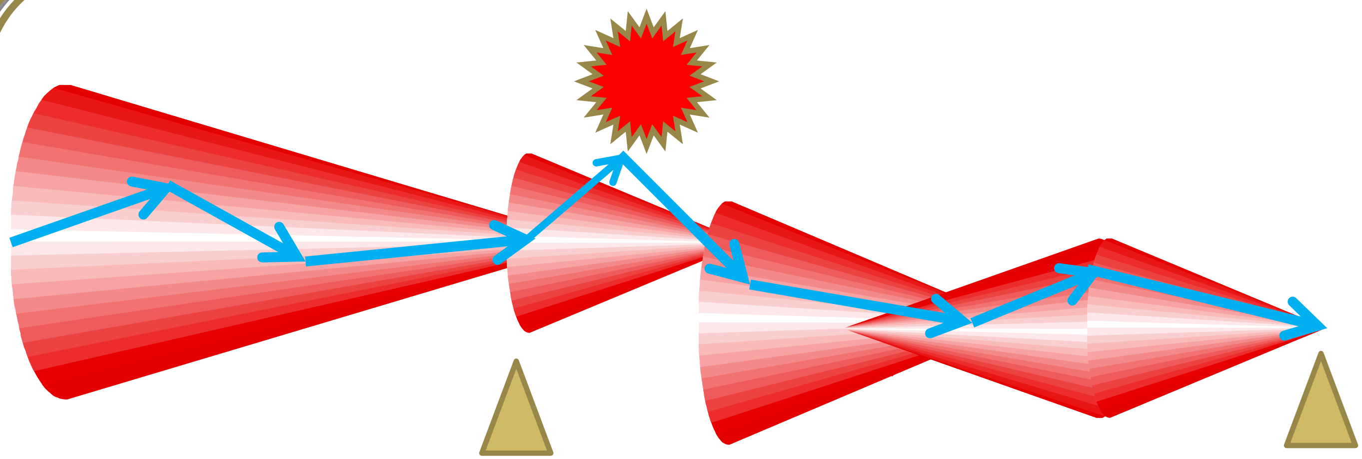
IPPD – Focused On Metric Evaluation

- A basic premise is criteria can be defined for each step and sub-step of the lifecycle process



- S&T Exit Criteria are defined to be the thresholds on the key requirements.
- They must be met if the technology is to advance to the next stage of development or transition.
- Exit Criteria for one phase of development are often synonymous with Entrance Criteria for the next phase.

Exit / Entrance Criteria Define Bounds for TRL Vector



Test & Evaluation Strategy for Technology Development Phase

Ms. Darlene Mosser-Kerner

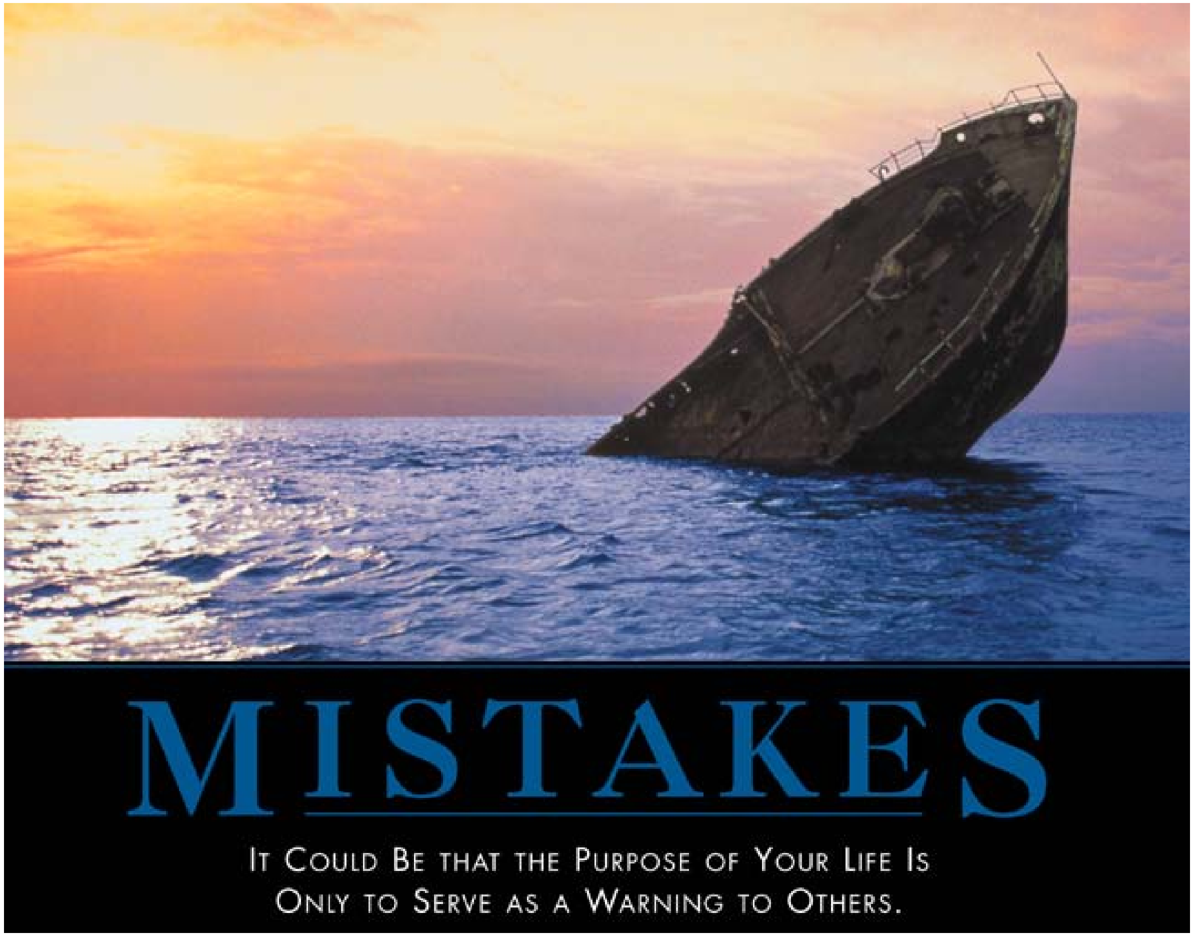
Office of the Director, Developmental Test & Evaluation

October 28, 2009

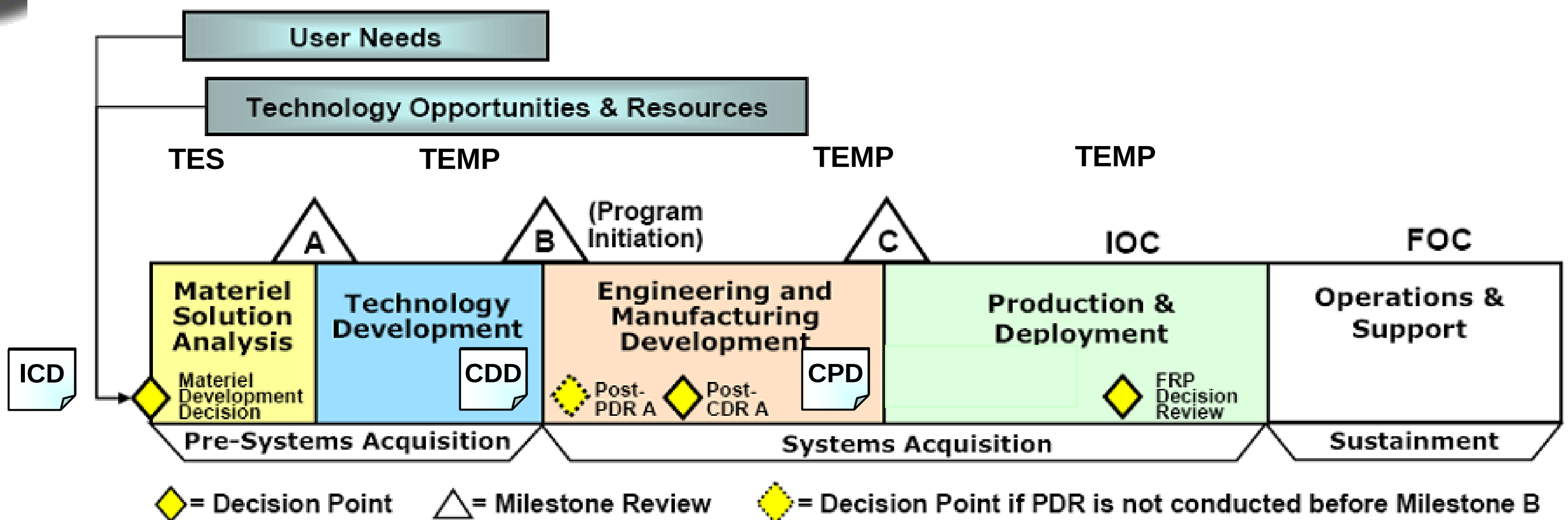
Why T&E?

PURPOSE OF T&E:
- Manage and Reduce Risk

PRODUCT OF T&E:
- Knowledge to Decision Makers



T&E in DoD: What and When



▪ Technology Development Strategy (TDS) ▪ Test Evaluation Strategy (TES) ▪ ID emerging T&E capability requirements ▪ ID T&E resources ▪ Develop T&E requirements in RFP ▪ Reporting	▪ Test and Evaluation Master Plan (TEMP) ▪ Execute T&E Program ▪ Provide T&E results for OIPT/DAB ▪ CDD requirements for evaluatability ▪ TRL Evaluation ▪ T&E requirements in RFP ▪ Reporting	▪ TEMP ▪ Execute T&E Program ▪ T&E results to OIPT/DAB ▪ Support PDR/CDR ▪ CPD requirements for testability and evaluation ▪ TRL Evaluation ▪ T&E requirements in RFP ▪ Discovery and deficiencies ▪ Reporting	▪ TEMP ▪ Execute T&E Program ▪ Characterize system capabilities and limitations ▪ T&E results for OIPT/DAB ▪ AOTR / OTRR ▪ Support training for IOT&E ▪ Reporting	▪ Follow-on DT and OT ▪ Verification of corrections for deficiencies ▪ Develop T&E programs to support upgrades, modifications, increments

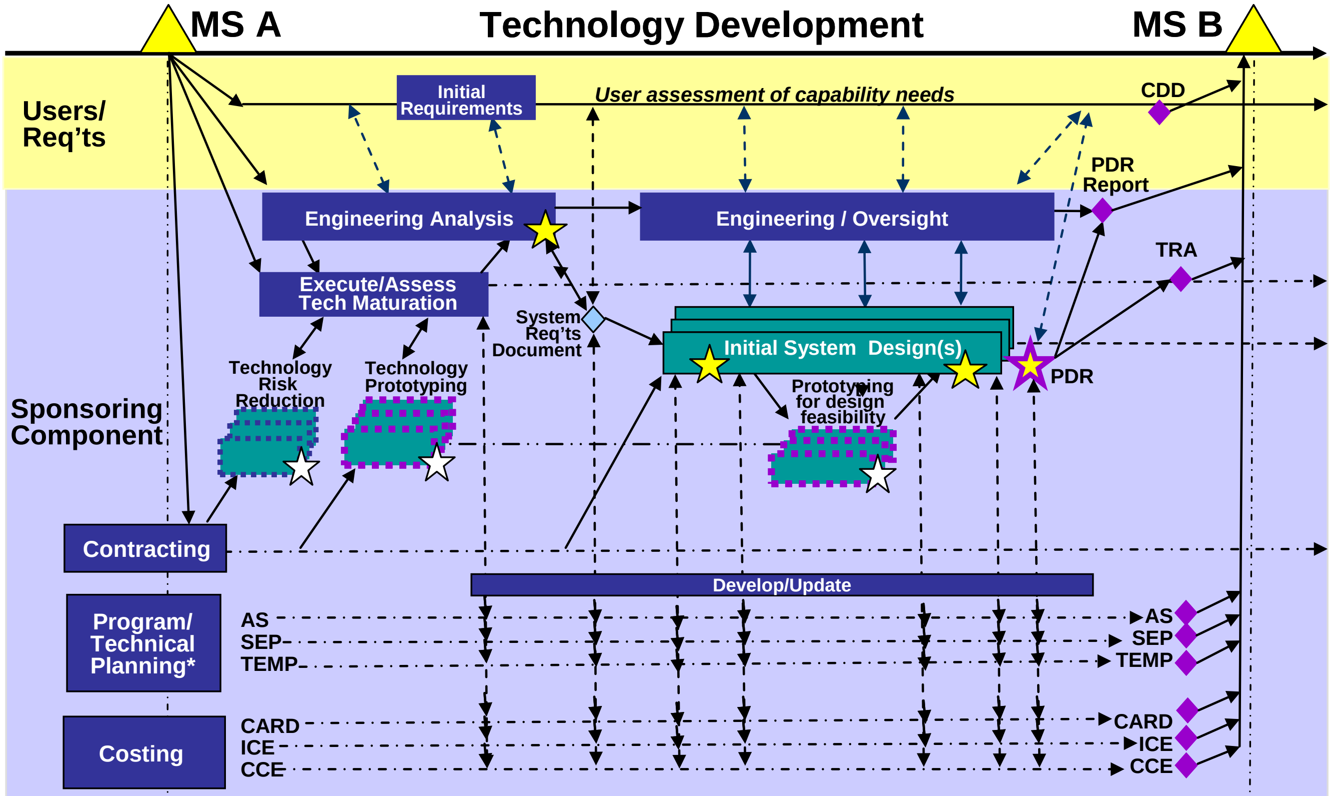
Service/Component/Agency report on accomplishing DT&E role, include earlier phases.

T&E in DoDI 5000.02

December 2008

- Integrated Testing - IOT&E still separate
- Capability Comparison
  - Additional perspective for programmatic decisions
- Data Sharing
  - Common data set (contractor, government) for evaluations
- Programs required to execute a RAM strategy that includes a reliability growth program
  - Documented in SEP and Life Cycle Sustainment Plan
  - Assessed during technical reviews and T&E
- MS-A T&E Strategy (TES) for Technology Development (TD) Phase
  - Tailor content for competitive prototyping and prep for PDR
  - Focus on TD Strategy (TDS) and ICD
  - Support maturation of technology
  - Fulfill statutory test planning

Technology Development



* Includes all Regulatory and Statutory information

Activities Products

RFP	Request for Proposals
AS	Acquisition Strategy
SEP	Systems Engineering Plan
TEMP	T&E Master Plan
CCE	Component Cost Estimate
CARD	Cost Analysis Requirements Description
ICE	Independent Cost Estimate
PDR	Preliminary Design Review

Early Evaluation of Technology Maturity

Technology Readiness Assessment (TRA) Deskbook July 2009

- AoA, early Systems Engineering, and Early Evaluation of Technology Maturity form basis for evaluating technology options in the materiel solution to the capability need identified in the approved Initial Capabilities Document (ICD).
- Best practice is to use results as follows:
  - To provide basis for modifying requirements if technological risks are too high
  - To support development of Technology Maturation Plans (TMP) that show how Critical Technology Elements (CTE) will be demonstrated in a relevant environment before preliminary design begins at the full system level
  - To refine the Technology Development Strategy (TDS)
  - **To inform T&E community about technology maturity needs**
  - To ensure potential CTEs are included in program's risk management
  - To establish Technology Transition Agreements (TTAs) to articulate external dependencies on technology base projects and to define the specific technologies, technology demonstration events, and exit criteria for the technology to transition into the acquisition program.

Pre-MS B Test and Evaluation

- T&E results (contractor & government) reported at technical (SRR, SFR, PDR) and MS B reviews
  - T&E knowledge (from prototypes, system concepts) used to address key technologies and risks
  - Ensure requirements are "evaluatable" and trace back to AoA/ICD/draft CDD
- Test and Evaluation Strategy (TES) at MS A
  - Start with evaluation objectives – What do you need to know
  - Includes statutory "test plan" for TD phase (previously in TDS) to show maturity of CTEs and mitigation of risks
    - Technology maturation demonstrations (TRL 6 by MS B)
  - Provides initial view of strategy for T&E in TD phase and beyond
    - Integrated testing approach
    - Use of M&S
    - Identifies significant and long-lead T&E resources

T&E Considerations for Pre-MS B

- **Planning Issues**
  - Technology development / maturation
  - System development
  - T&E program strategy
- **Requirements**
  - Operational requirement evaluatability
  - Contract / RFP issues
  - Competitive Prototyping
- **Technology / System maturation**
  - TRL 6 at Milestone B so that the Milestone Decision Authority can make the certification required by Title 10 United States Code (U.S.C.) 2366b.
  - TES should be consistent with TMP

TRL 6: System/subsystem model or prototype demonstration in a relevant environment.

T&E Planning Considerations

- Technology Development and Maturation
- System Development
  - System of Systems
  - Software development – T&E "hooks"
- Contracting Issues
- Modeling & Simulation – capabilities, development, VV&A
- Integrated testing – include the contractor(s)
- Data sharing – include the subs
- Test and Evaluation assets / Range resources
- Establishing the T&E WIPT
- Live Fire waiver

T&E Requirements Considerations

- Operational requirements evaluatability
  - AoA measure development – discrimination
  - CDD / KPP / CONOPS development
- System of Systems interface / interoperability reqts
- Contracting – RFPs
  - Competitive prototyping
  - Data sharing – include the subs
  - Software development – T&E “hooks”
  - Integrated testing – include the contractor(s)
- Establishing CTPs – use CTE, TMP and SE!

T&E Considerations for Technology Maturation

- TDS "Test Plan" included in TES
  - Informed by Early Evaluation of Technology Maturity
  - Critical Technology Elements
    - Test objectives
    - Relevant environment
    - M&S
    - Exit Criteria
    - Constraints and limitations
- Software development
- System risks – identification and investigation
- Reliability growth – finding the subsystem failure modes
- Susceptibility / vulnerability / lethality
  - Coupon tests and M&S

Test & Evaluation Strategy

- Basis for T&E budgetary estimates
- Addresses SE verification and validation
- Enables integration of developmental and operational test objectives
- Addresses technological capabilities and limitations of alternative concepts and design options
- Addresses technological & design risks
- Assessment of technical progress and maturity
- Stresses the system to ID failure modes
- Supports Technology Development Strategy

Recommended TES Content

Part I Introduction	Part II Mgmt & Sched	Part III Integrated T&E Strategy	Part IV Resources
Brief mission description paragraph System description Brief Threat Assessment Program Background Key Capabilities	Describe T&E management Common Data Overarching integrated schedule that includes sequencing of T&E activities (CT, DT, OT, LFT, M&S)	The philosophy recognizes a T&E continuum & emphasizes evaluations Evaluation Framework ties T&E knowledge to decisions, requirements, etc Developmental Eval - Technology Development - CTEs - Test objectives - Relevant environment - M&S - Exit criteria Operational Eval Future Testing	Include in para form or table: •Test articles needed/event •Special equip/ instr costs •Target / expendable costs •Threat representation costs •Manpower needs •M&S costs

Linkage of decisions to evaluations, requirements, test phases, and resources

What ***Who, When*** ***Why, How*** **Resources required**

Include Joint requirements throughout

Example Evaluation Framework

Key Requirements and T&E Measures				Test Methodologies/Key Resources (M&S, SIL, MF, ISTF, HITL, OAR)	Decisions Supported
Key Reqs	**COIs**	**Key MOEs/ MOSs**	**CTE/CTPs & Threshold**		
Combat Radius	**COI #1.** Can the UAV locate and engage the XXX enemy threat at a range and time that will ensure survivability of friendly troops?	**MOE 1.1.** Range	Alternate Fuel Consumption	Aero + Propulsion M&S Engine stand Performance profiles – OAR	TR PDR MS-B
		MOE 1.2. Speed	Airspeed	Performance M&S Wind Tunnel Performance Flt Test – OAR	TR PDR MS-B
	COI #2. Is the XXX suitable for…	**MOE 1.3.**			TR PDR MS-B
Weight	COI #2. Can the Is the XXX sustain hypersonic flight for XXX?	**MOS 2.4.**	Composite Material	Thermal Material Lab Tests Fatigue Test stand	PDR MS-B

Critical Technical Parameters

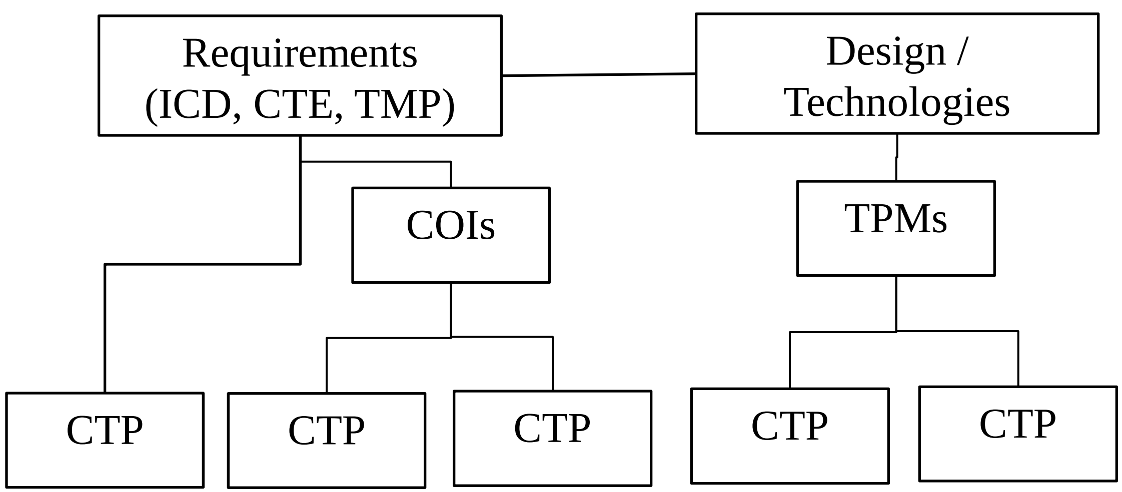
- **New to TES**
- **CTPs are not well defined or productively implemented in TEMP**
- **A short review**
  - **What are they?**
  - **How should they be determined?**
  - **How should they be used?**

- **Definition:** A CTP is a measurable critical system characteristic that, if not achieved, preclude the fulfillment of desired operational performance capabilities.
- CTPs are technical measures derived from desired user capabilities.

Critical Technical Parameters

How Derived?

- **CTP development process is the responsibility of the program T&E manager**
- **Lead Systems Engineer plays a key role in determining CTPs**



Critical Technical Parameters

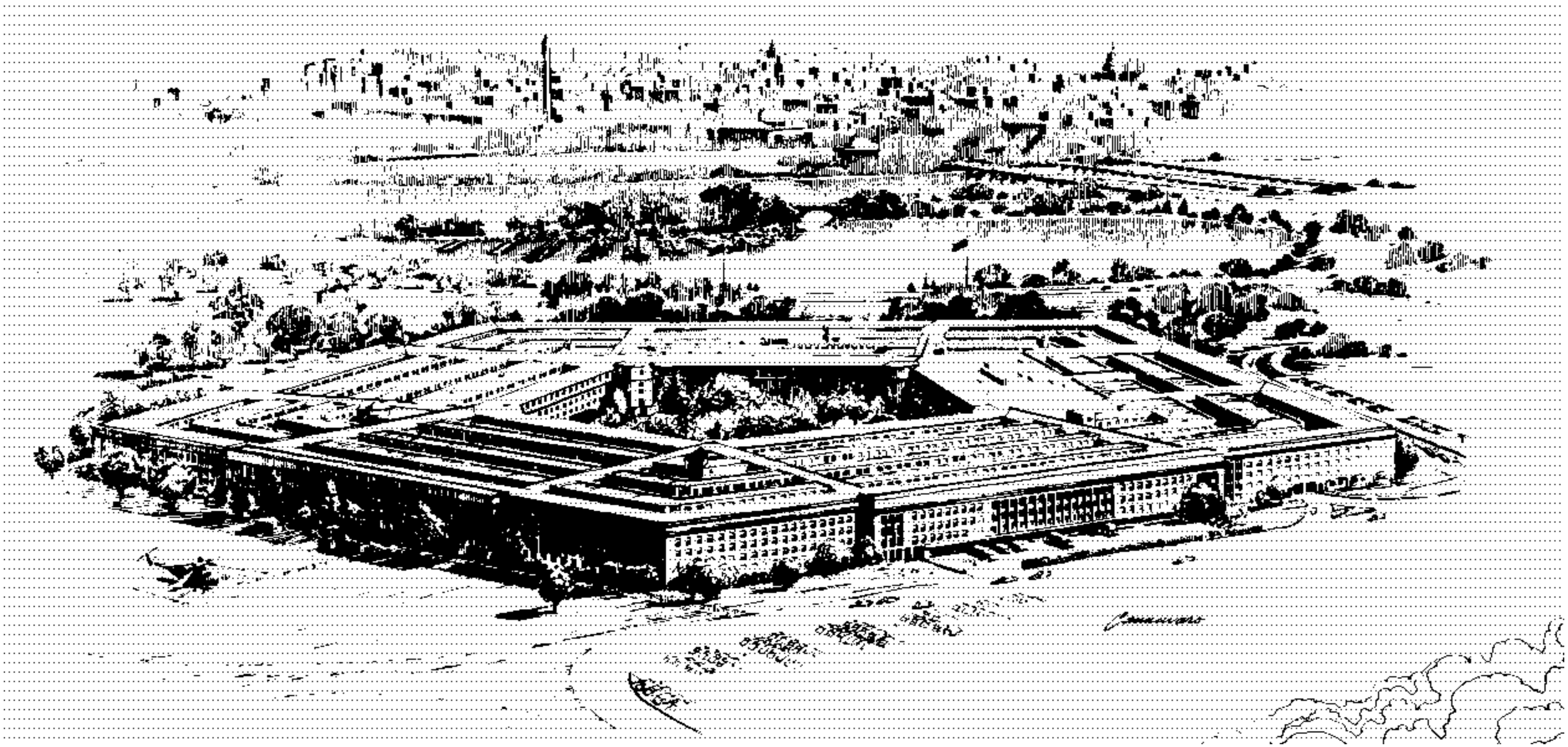
How Used?

- While not user requirements, CTPs are technical measures derived from Early Evaluation of Technology Maturity and desired user capabilities.
- T&E use CTPs as reliable indicators that the system is on (or behind) planned technology development schedule or likely (or not likely) achieve an operational capability.
- CTPs should be significant from a T&E program perspective – should drive scope / magnitude of the T&E program.

Summary

- T&E involvement pre-MS B is necessary for success
- DT&E should focus on creation of knowledge of technology maturation, capabilities and limitations
- T&E developed knowledge should be used at the technology, component, subsystem, and system level
- Early Evaluation of Technology Maturity and TMP inform TES
- New TES Content
  - Brings evaluation focus into TES
  - Assumes a continuum of T&E
  - Life cycle view versus scoping to next milestone
  - Integrated Testing and Mission-oriented context
  - TDS test plan shifted to TES
- DAG – Chapter 9

Closing Remarks



“TESTING IS THE CONSCIENCE OF ACQUISITION”

THE HONORABLE WILLIAM PERRY
FORMER SECRETARY OF DEFENSE

Contact Info

Darlene Mosser-Kerner

darlene.mosser-kerner @ osd.mil

TEMP@OSD.MIL

Contact us to provide feedback and share your experience

Test & Evaluation Products for Systems Engineering Reviews

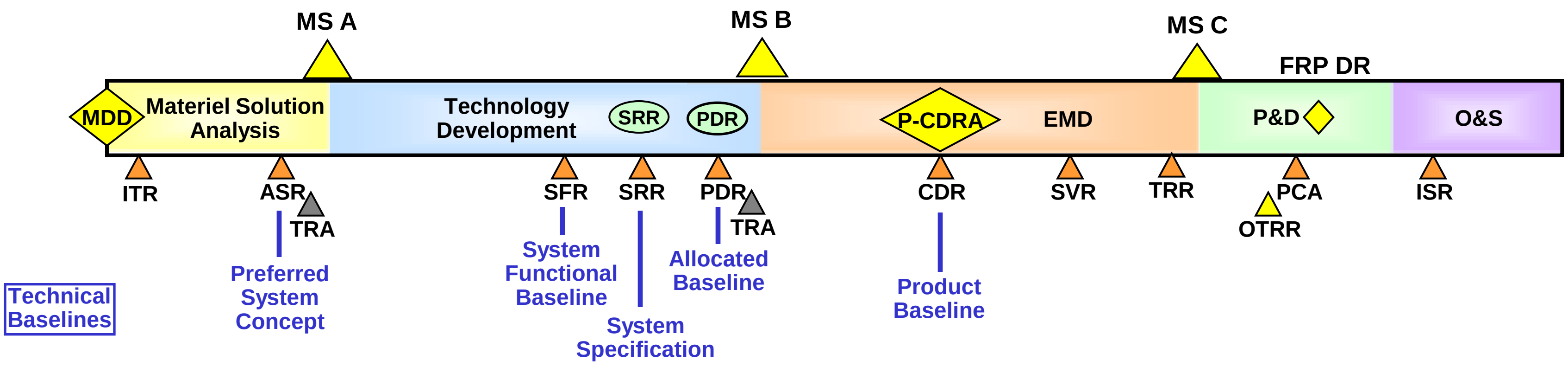
Woody Eischens

28 October 2009

Purpose of T&E

- **The purpose of T&E is to develop and deliver actionable information (knowledge)**
  - Better knowledge enables better decisions
- **T&E developed knowledge informs decisions to reduce risk in requiring, acquiring, and employing systems / capabilities**
- **T&E knowledge is used to:**
  - Assess component performance
  - Assess system capabilities / limitations
  - Assess program progress
  - Assess technical progress
  - Improve the product and processes

T&E Related SE Review Artifacts



T&E Artifacts

T&E Strategy

T&E Plans

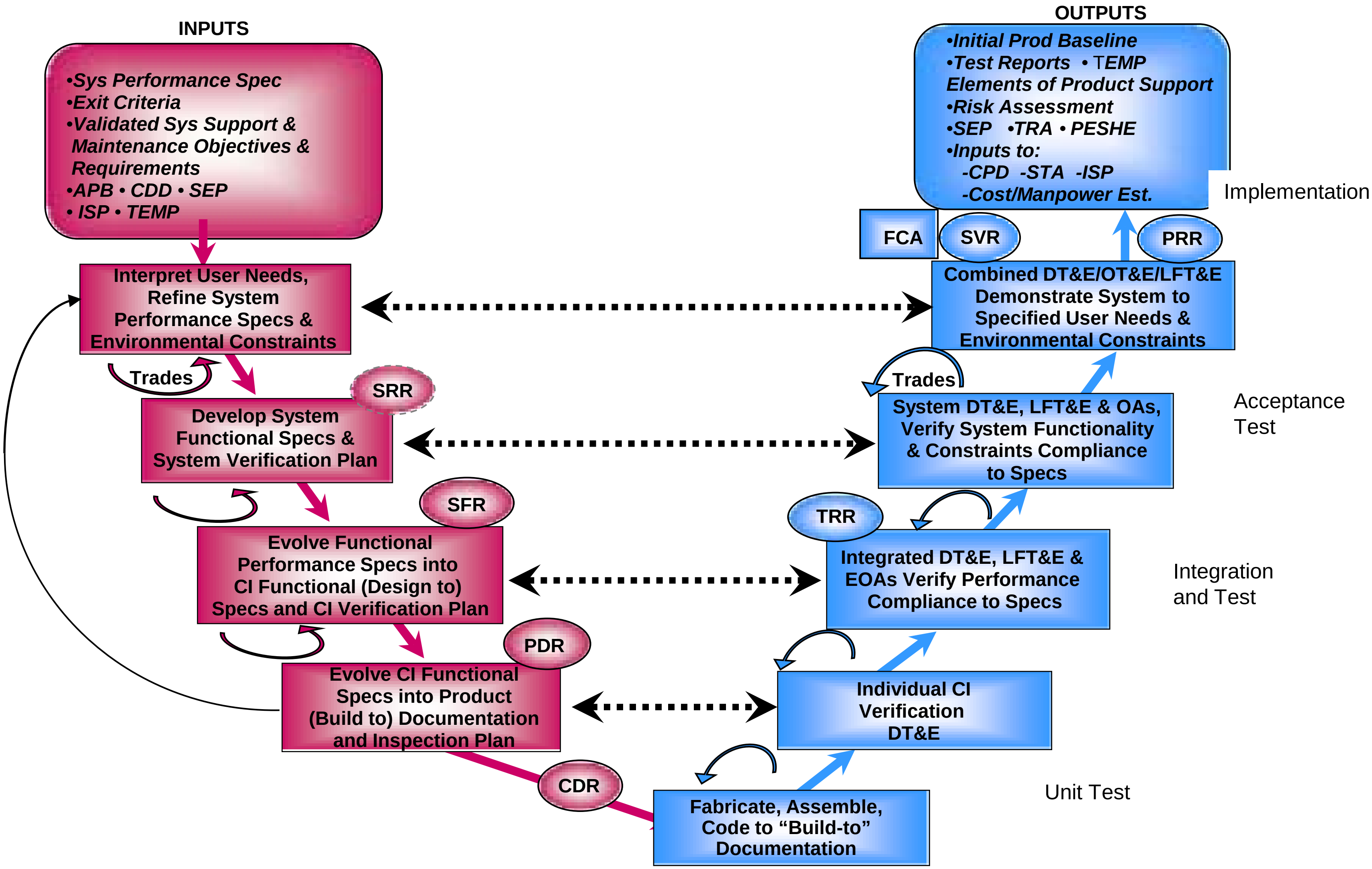
- TEMP
- T&E plans
- T&E reports

- TEMP
- T&E plans
- T&E reports

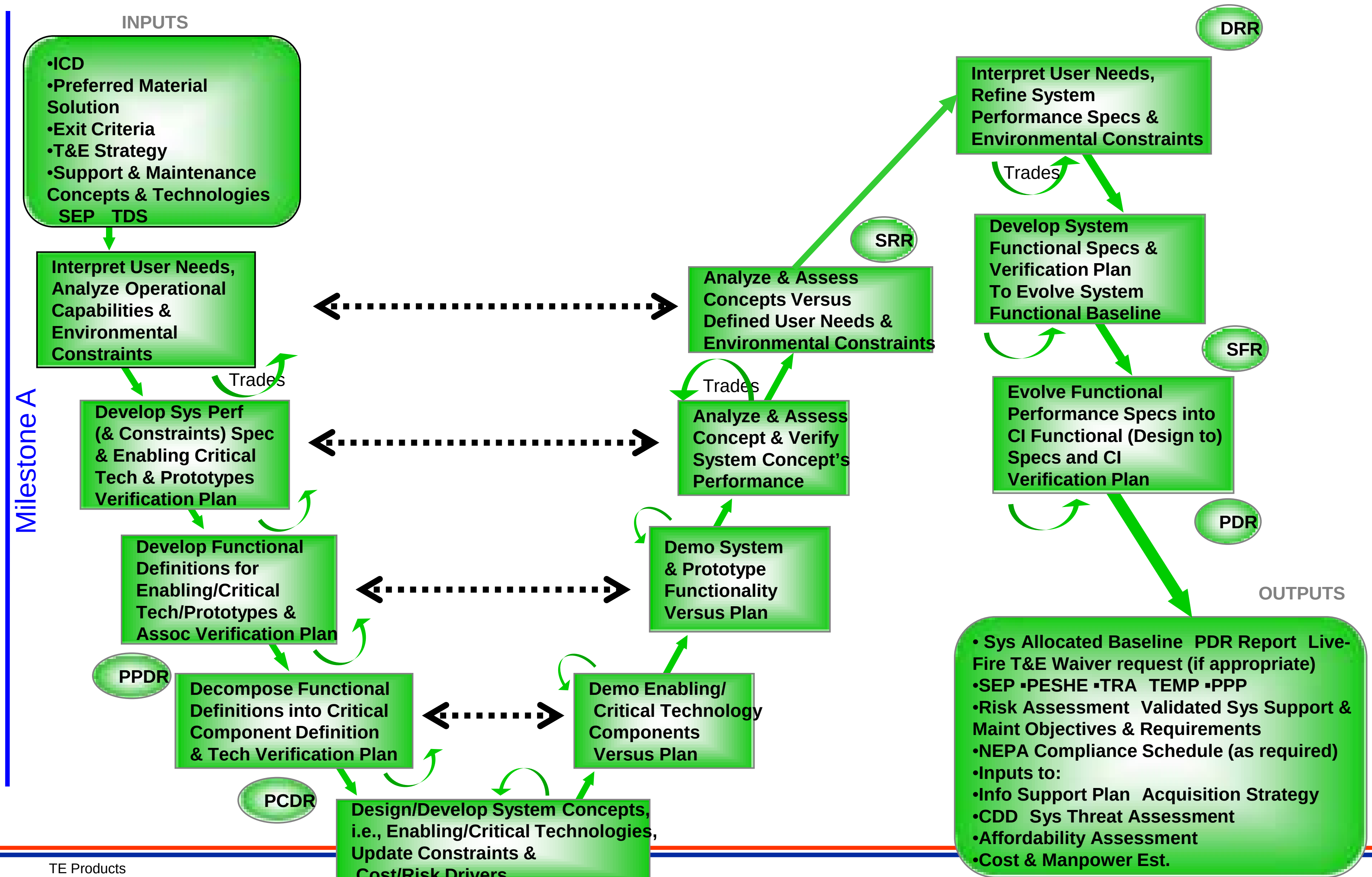
- TEMP
- Updated T&E plans
- T&E reports

- **T&E Artifacts: T&E strategy, plans, & reports**

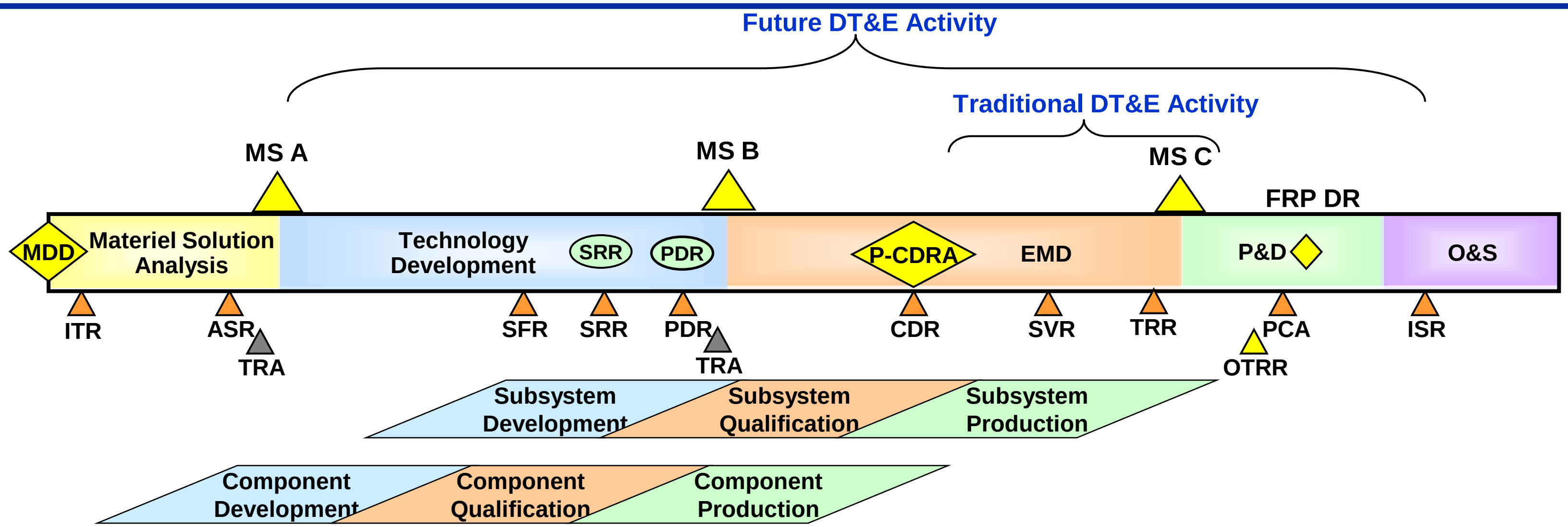
Engineering and Manufacturing Development



Technology Development Phase

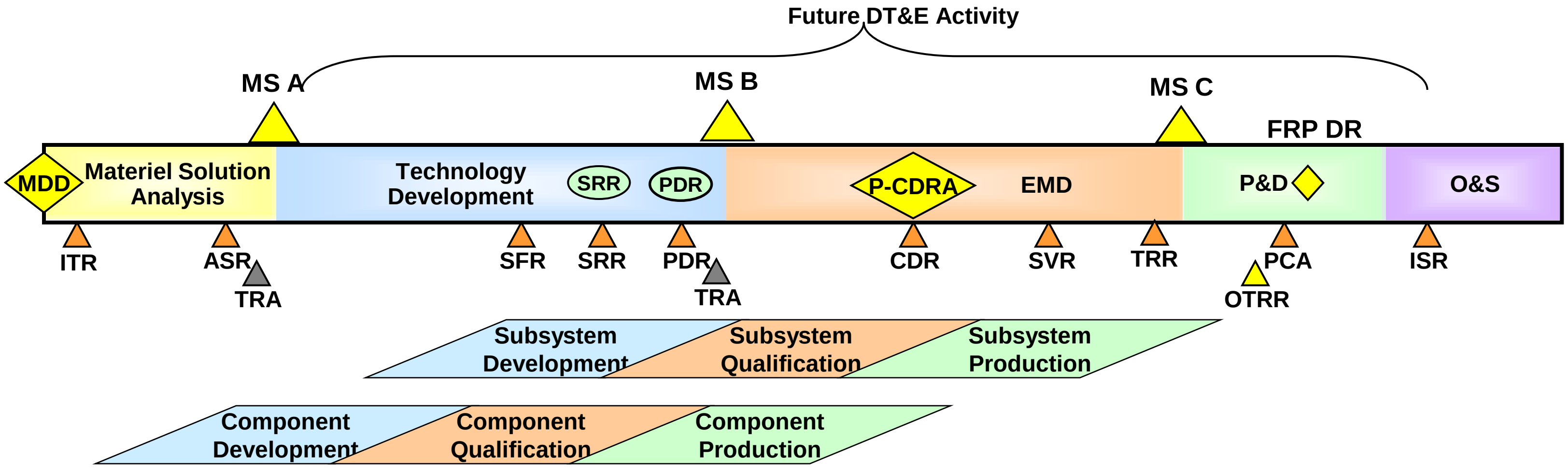


T&E Related Knowledge Needed Earlier



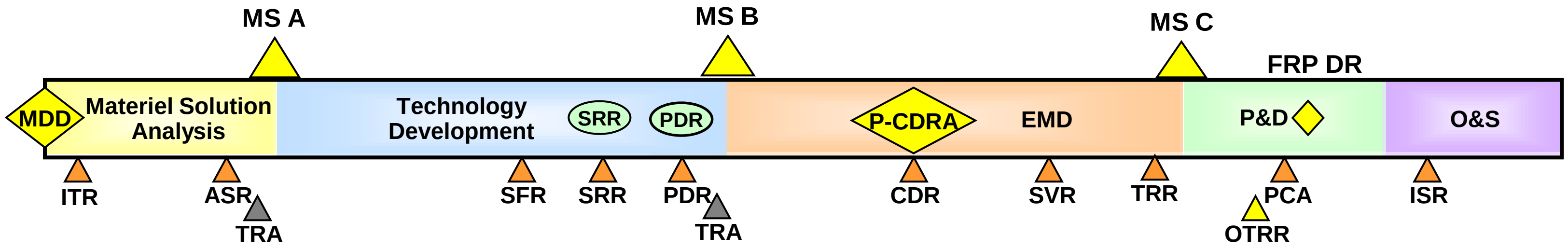
- System-level reviews are a subset of overall technical reviews
- Component and subsystem development efforts are well-underway or complete before system-level design is finalized
- Traditional DT&E programs occur at the system-level, too late to fit into component and subsystem development/qualification cycles
- Better information sooner can benefit subsystem and system-level design decisions

T&E Products at SE Reviews



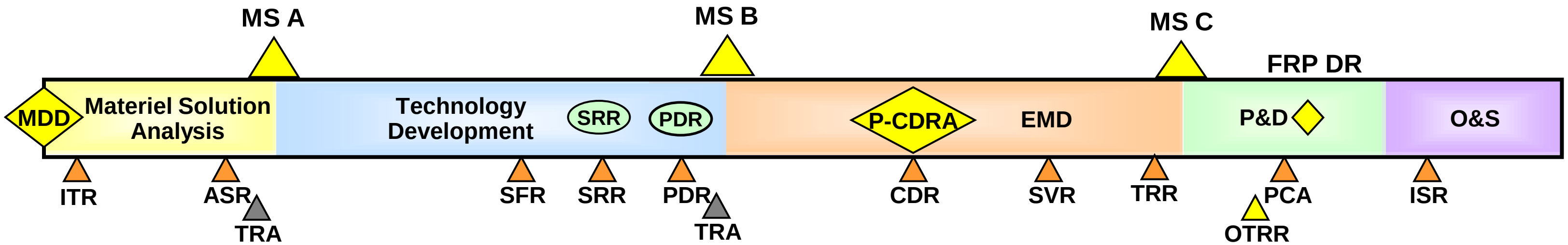
- **T&E products are more than the artifacts – value is in the contents, communications, and process to develop artifacts**
- **T&E information must answer the SE-related questions**
  - Must also represent effective / efficient T&E program
- **Focus on "verification" doesn't use DT&E to full advantage**
- **DT&E should focus on acquiring knowledge of system / subsystem / component (CI) capabilities / limitations**

System Functional Review



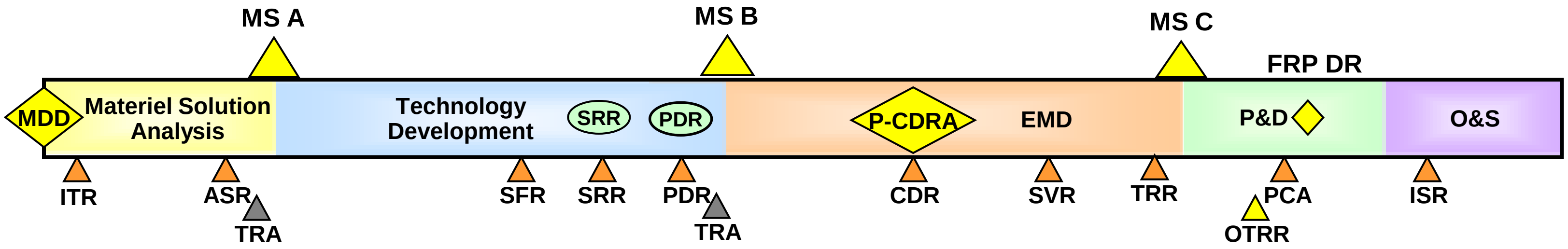
- **Focus: System performance specification – Functional Baseline**
  – Are the technologies mature (enough)? Are the system performance requirements complete?
- **T&E Activity:**
  – System / configuration item (CI) T&E planning
  – Evaluate component / subsystem technology maturity
  – M&S to evaluate alternatives
- **T&E Products: T&E strategy; Technology Development T&E plan**
  – Technology measures / discriminators (TPMs / CTPs)
  – Component / subsystem performance to validate M&S
  – Technology maturity plans & assessments
  – Component maturity plans / capabilities / limitations

Preliminary Design Review



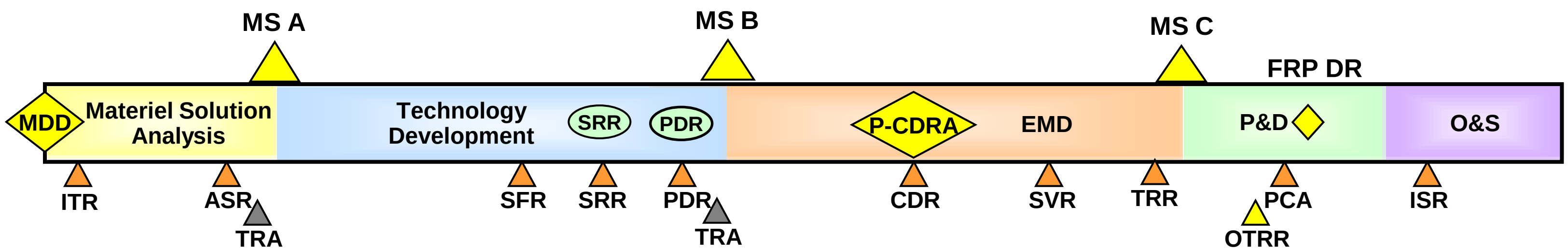
- **Focus: Subsystem/Configuration Item-level design – Allocated Baseline**
  - Functions, performance, interface requirements
  - Is the design ready to go final?
- **T&E Activity:**
  - M&S to evaluate alternatives
  - Technology demonstrations; component T&E
- **T&E Products: T&E Master Plan, system T&E plan, CI T&E plans**
  - TPM assessments
  - M&S validation
  - Technology maturity
  - CI maturity / capabilities / limitations

Critical Design Review



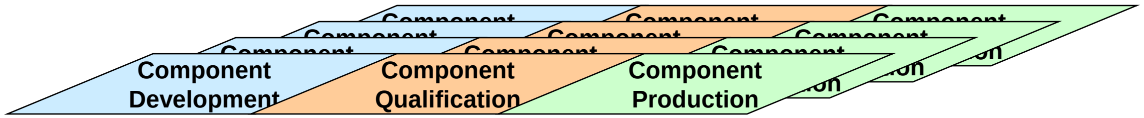
- **Focus: System design review – Product Baseline**
  - Is the design ready to start building / coding?
- **T&E Activity:**
  - CI / subsystem T&E – SIL, HITL, “open air” range
  - M&S to evaluate alternatives
- **T&E Products: TEMP, system T&E plan, detailed T&E plans, CI reports**
  - Integration issues
  - M&S validation
  - Technology maturity assessments
  - Subsystem / CI maturity / capabilities / limitations

Physical Configuration Audit



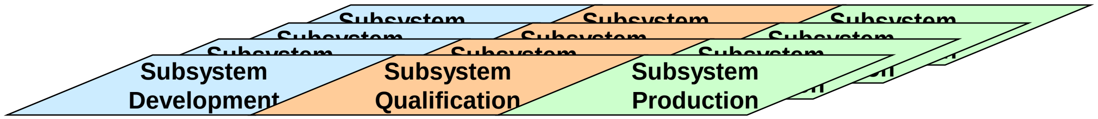
- **Focus: As-Built verification review – Product baselines completed**
  - Is the system (as built) consistent with the product baseline documentation?
- **T&E Activity:**
  - Regression T&E (deficiency corrections)
  - Mission-level T&E
  - Logistics T&E
- **T&E Products:**
  - Deficiency status
  - Support documentation V&V
  - System capabilities / limitations
  - Production process maturity

System Maturity Level 1



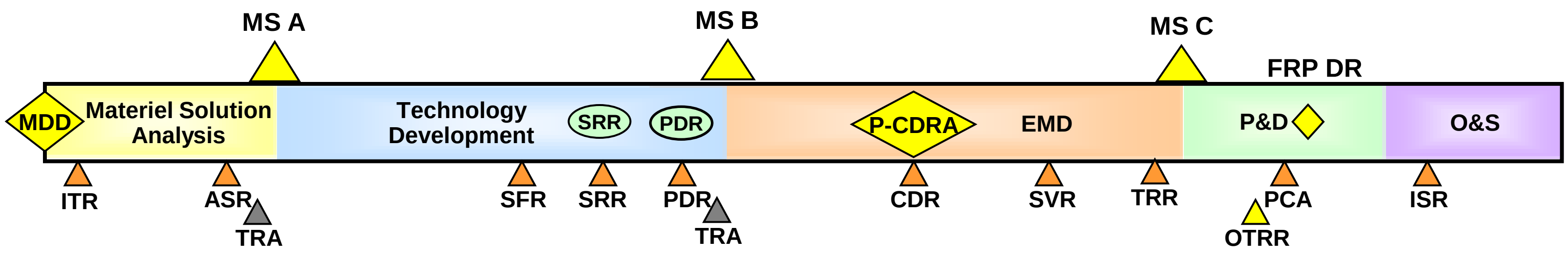
- **Focus: System maturity level 1 – Components work individually**
- **SE Reviews: Component level – all; System level – SFR, PDR, CDR**
- **T&E Activity:**
  - Component SIL, HITL testing
  - M&S to provide missing subsystem & system elements
  - Competitive prototyping
- **T&E Products:**
  - Integration risks
  - Technology maturity
  - Component/CI maturity / capabilities / limitations

System Maturity Level 2



- **Focus: System maturity level 2 – Components work as a system - integration**
- **SE Reviews: Subsystem level – all; System level – PDR, CDR, TRR**
- **T&E Activity:**
  - Component SIL, HITL testing
  - M&S to provide missing subsystem & system elements
- **T&E Products: T&E strategy, system T&E plan**
  - Subsystem maturity / capabilities / limitations
  - Validated M&S
  - Technology maturity assessments

System Maturity Level 3



- **Focus: System maturity level 3 – System works in real-world**
- **SE Reviews: SFR, TRA, SRR, PDR, CDR, SVR, TRR, PCA, ISR**
- **T&E Activity:**
  - System / subsystem / CI DT&E; OT&E
- **T&E Products: T&E strategy, system T&E plan, OT&E**
  - System maturity / capabilities / limitations
  - System supportability and sustainability
  - Operational effectiveness, Operational suitability

Summary

- T&E product is credible knowledge for better decisions
- DT&E provides verification + validation + risk mitigation
- DT&E should focus on efficient & effective knowledge of capabilities / limitations
- T&E developed knowledge should be used at the component, subsystem, and system level

The right information,
to the right decision maker,
at the right time,
for better decisions.

Summary

Questions?

Headquarters U.S. Air Force

Integrity - Service - Excellence

Human Systems Integration (HSI) in Acquisition – Integrating Human Concerns into Life Cycle Systems Engineering

U.S. AIR FORCE

NDIA Systems Engineering Conference
San Diego CA
28 October 2009

Colonel Larry Kimm
and Ms Cynthia Shewell

Overview

- Air Force HSI Office (AFHSIO)
- Project Objective
- Description
- Approach
- Results
- Possible Future Uses

AFHSIO Background

- Established in 2007 as a result of a 2004 AF Scientific Advisory Board Report
- In the past two years since the AF HSI Office (AFHSIO) established:
  - Identified top issues and instituted policy changes
  - Formalized and initiated Air Staff-level IPT
  - Moved forward with an education and training path
  - Launched and completed a series of projects to achieve mission

AFHSIO Mission Statement

- *Ensure all AF warfighting systems are designed, built, operated, and sustained in a manner that optimizes total system performance at every warfighter level*, directly supports the Air Force mission *to fly, fight and win in air, space, and cyberspace*
- AF HSI Objectives
  - *Integrate* HSI considerations and processes into the Acquisition, Technology and Logistics Life Cycle Management Framework to equip and sustain Airmen
  - *Institutionalize* HSI as the way of doing business to increase total system performance and reduce life cycle costs
  - *Sustain* HSI planning and implementation through collaboration with partners in OSD, AF, sister services, industry, and academia
  - *Improve* HSI processes through metrics, feedback, and lessons learned

U.S. AIR FORCE

AFHSIO Roles

- 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.

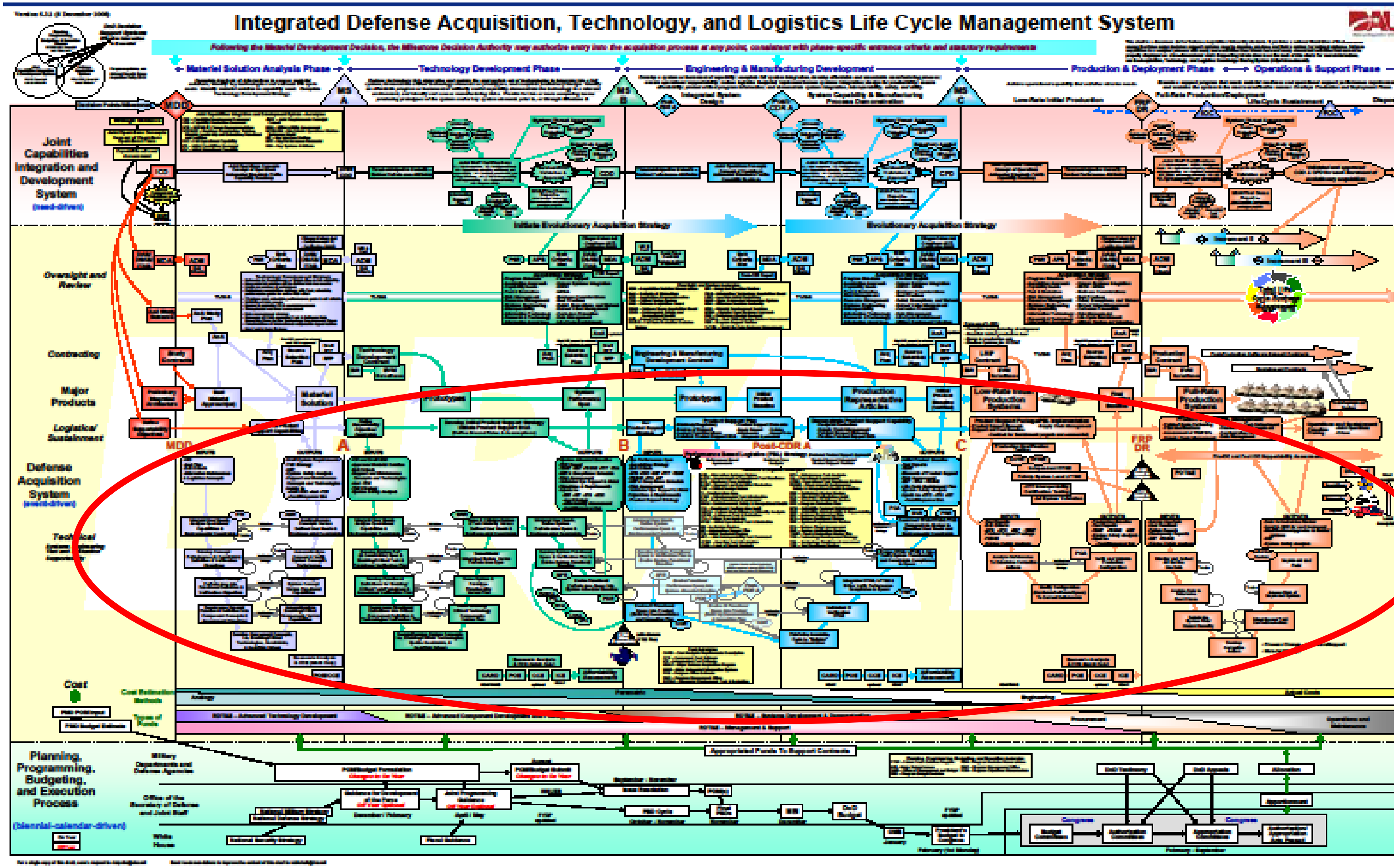
Project Objective

Objective: <u>Integrate</u> HSI considerations and processes into the Acquisition, Technology and Logistics Life Cycle Management Framework to equip and sustain Airmen

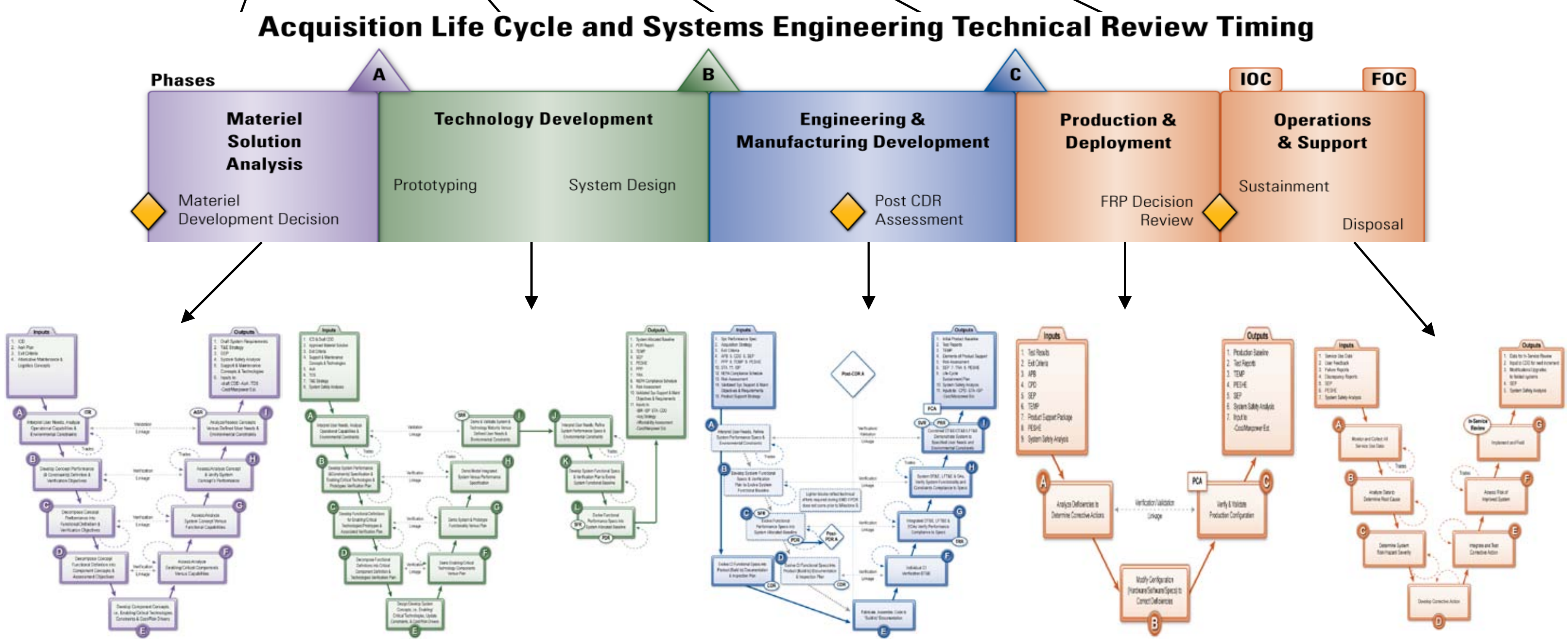
- Develop a product:
  - To facilitate systems engineers' understanding of what HSI domain experts bring to the table.
  - To help HSI domain experts understand their role in the acquisition process.
  - To assist domain and systems engineering integration on HSI issues.

Target Audience – Systems Engineers

Starting Point –
DoD Acquisition Life Cycle



Human Systems Integration (HSI) is the interdisciplinary technical and management processes for integrating human considerations within and across all system elements; an essential enabler to systems engineering practice. The HSI processes facilitate trade-offs among the human-centric domains without replacing individual domain activities, responsibilities, or reporting channels. This product maps HSI activities to the systems engineering processes and technical reviews for the acquisition life cycle.



HSI Domains

U.S. AIR FORCE

Human Factors Engineering	Manpower	Personnel	Training
*Design compatability with performance capability and expectations *Crew workload *Situational awareness *Human performance and reliability *Human performance requirements *Lighting *Usability *Maintenance interface *Costs implications of human error, inefficiency	*System manning requirements *Deployment considerations *Force structure *Manpower policy *System Manpower Estimate Reports (MERs) *A76 Considerations *BRAC Considerations *Life cycle cost implications of manpower decisions	*Personnel selection and classification *Human aptitudes *Demographics *Knowledge, skills, abilities *Accession/Attrition *Career progression & retention *Promotion flow *Personnel and training pipeline flow *Recruiting *Cognitive, physical, educational profiles	*Training concepts and strategies *Training tasks and development methods *Media, equipment, facilities *Modeling and simulation *Virtual applications *Trainer currency *Training vs. Job Aids *Timeliness of delivery *Inputs to policy implications for training flow and costs

U.S. AIR FORCE

HSI Domains

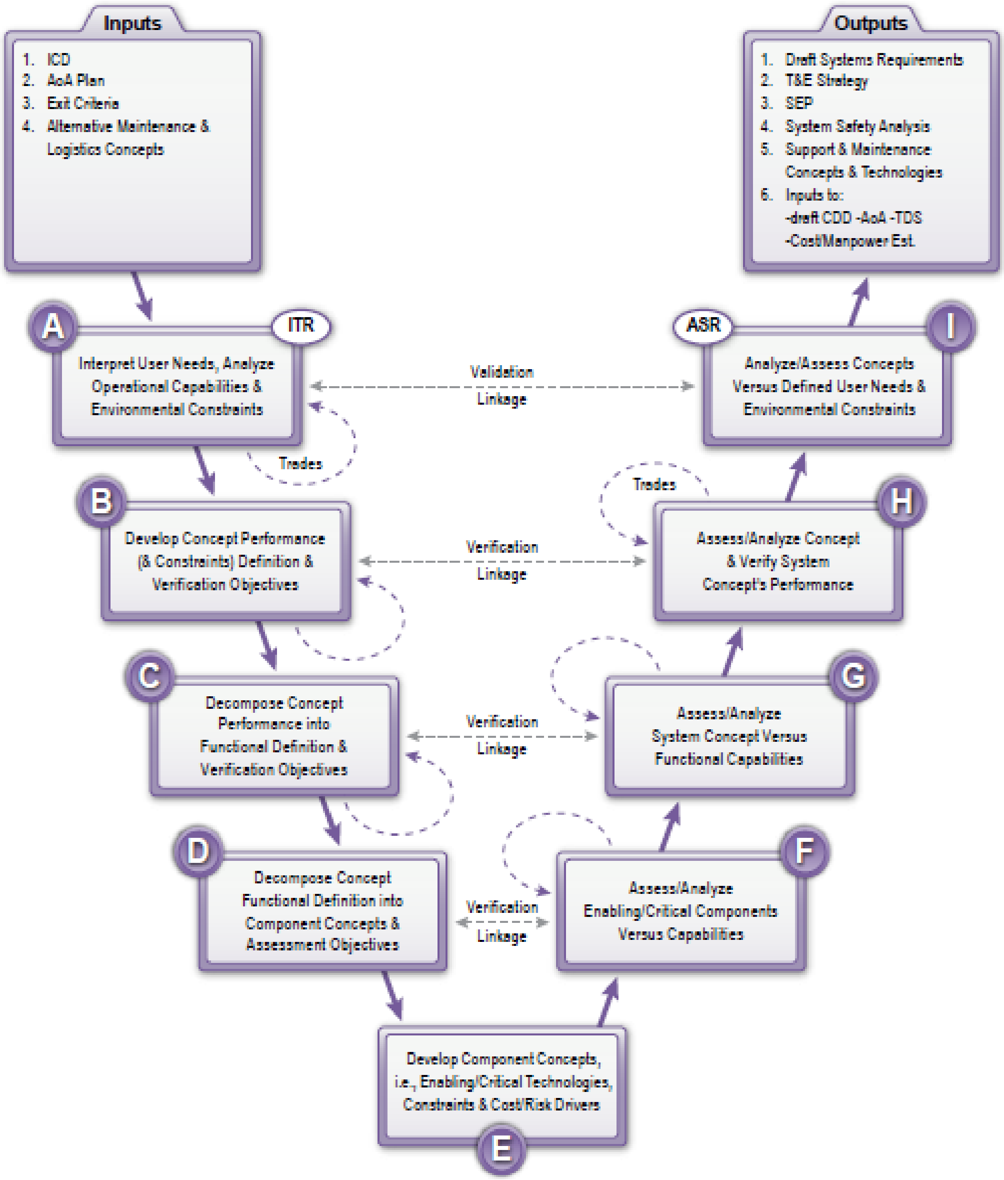
		ESOH		
Habitability	**Survivability**	**Environment**	**Safety**	**Occupational Health**
*Physical environment (*e.g.,* berth, toilet, bath) *Support services (*e.g.,* food, medical, clergy, recreation) *Impact on sustained mission effectiveness *Impact on recruiting and retention	*Threats *Fratricide Identification Friend/Foe (IFF) *Crew compartment damage *Camouflage and concealment *Protective equipment *Medical injury *Fatigue & Stress *Degraded mission	*Induced health hazards *Mechanical *Acoustics *Biological & chemical *Radiation *Oxygen deficiency and pressurization *Temperature & weather *Shock & vibration *Laser protection	*Normal & Emergency Procedures *Human error *System reliability & fault reduction *System risk reduction *Comprehensive Safety (*e.g.,* Flight, Weapon, Ground, NBC)	*Occupational health hazard reduction *Repetitive motion injuries *Heat, cold, hydration *Stress and fatigue *Exercise & Fitness *Personal protection *Disease prevention (vaccines/hygiene)

U.S. AIR FORCE

Description

- Graphically depict HSI domain activities for each acquisition phase
- Identify applicable references and potential tools for performing the domain activities
- Analyze domain activities to produce a list of integrated HSI activities for each acquisition phase

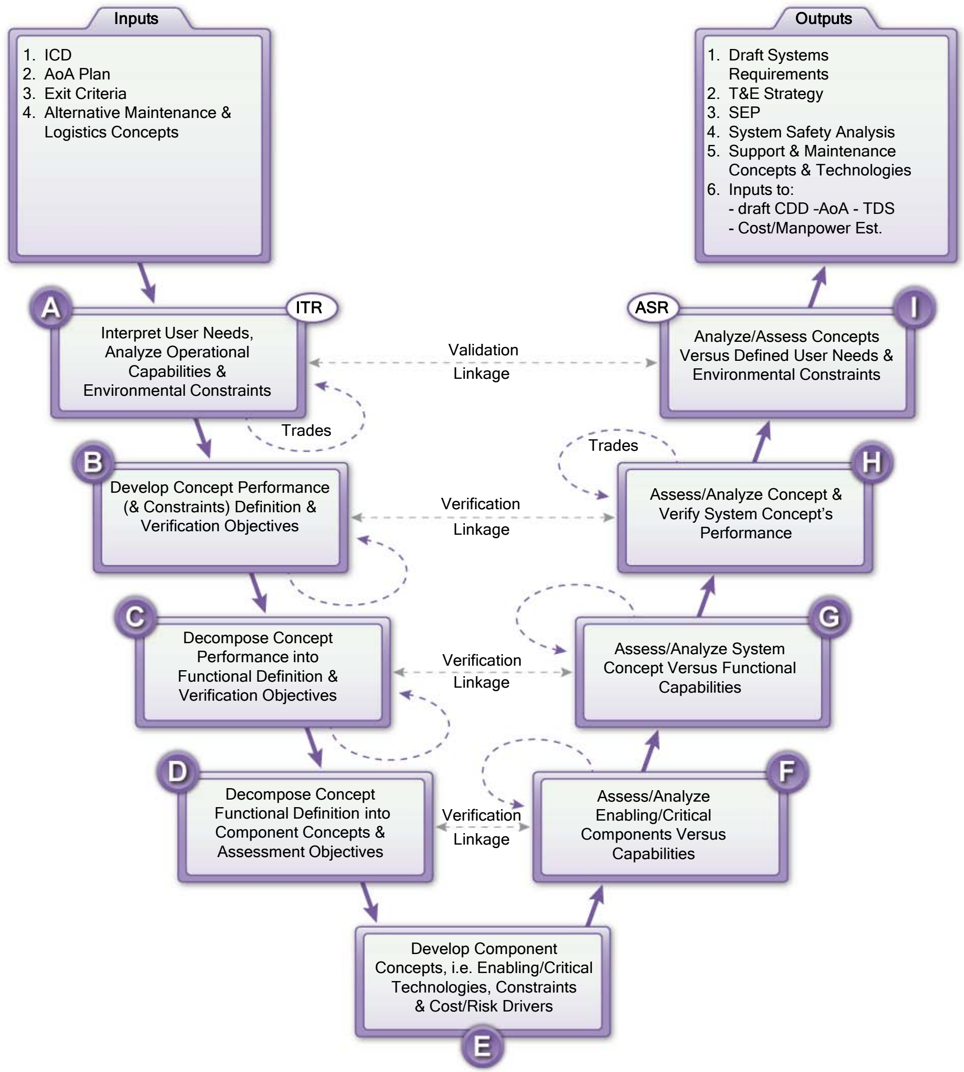
Materiel Solution Analysis Phase



Materiel Solution Analysis Phase:
Personnel

Activities for Each Input:

1.0 Review all available data (CONOPS, ICD, requirements documents, etc.)
1.1 Identify a baseline comparison system (BCS) for comparative analysis
1.2 Initiate Personnel requirements assessment
2.0 Begin developing a target audience description
2.1 Provide key skill set necessities to support system for AoA inclusion
3.0 Provide exit criteria including BCS and Integration Strategy for Personnel into the SEP
4.0 Assess personnel drivers
4.1 Look for problem areas and consider tradeoffs
4.2 Provide a list of issues/risks



The numbers in the Activities boxes correspond to the numbers in the Inputs and Outputs boxes.

Activities for Each Output:

1.1 Provide Personnel objectives, constraints, performance criteria
1.2 Identify potential new AFSCs or SEIs required to operate and support the new system
2.0 Review the initial task list based on test operations tasks
3.0 Identify responsibilities for Personnel integration into SE
4.0 Review the system safety analysis for potential personnel impacts
5.0 Assess the support and maintenance concepts and technologies
6.0 Provide Personnel inputs, as needed

References:

- AFPD 36-14, AFPD 36-21, & AFPD 36-22
- AFI 36-3802, AFI 36-2623, AFI 36-2305, AFI 36-2101, & AFI 36-2110

Tools:

- MIL/CIV PDS, CHRIS
- MPT DSS
- JASS, MVTA, TDFA
- Task Architect
- ACTA

Materiel Solution Analysis: Personnel

A
- Review aptitude constraint affects on the system functionality
- Identify potential needs for a new specialty code and/or skill set
- Recognize applicable Personnel criteria and asset requirements
- Review historical information (e.g., successes, mishaps, lessons-learned, poor human performance, etc.)

B
- Identify a baseline comparison system (BCS) and/or components for comparative analysis
- Determine personnel objectives, constraints, performance criteria, trade-offs, risks, and cost-drivers as inputs to major program documentation

C
- Begin developing a target audience description (TAD) based on the functional definition and the operations and support concept
- Compare known parameters of the BCS with functional requirements of the new system(s)

D
- Compare known parameters of the BCS with functional requirements of the new system(s)

E
- Estimate personnel necessities required for the new system (operation, maintenance, support)
- Ensure personnel requirements are adequately addressed in analyses, modeling & simulation, demonstrations, etc.

F
- Assess personnel requirements against critical component capabilities
- Document risks where Air Force personnel (military and civilian) may be unable to support system components without process and/or product modification
- Begin building task lists for the various alternatives for tasks associated with operating, maintaining, and supporting the system

G
- Associate tasks to AFSCs and assess initial training personnel requirements
- Assess personnel requirements against functional capabilities
- Document risks where Air Force personnel may be unable to support system functions without process and/or product modification
- Assess each system concept against identified Personnel criteria and requirements

H
- Evaluate the overall system's concept ability to meet performance capability requirements within identified personnel constraints
- Document risks of Air Force personnel ability to support the system without process and/or product change

I
- Evaluate the overall system's concept ability to meet performance capability requirements within identified personnel constraints
- Document risks of Air Force personnel ability to support the system without process and/or product change
- Refine the initial task lists for tasks associated with operating, maintaining, and supporting the system, including identification of all AFSCs and civilian series

ITR
- Review initial technical configuration and identify any personnel issues
- Ensure technical baseline is detailed enough to support a valid cost estimate

ASR
- Evaluate personnel costs for each alternative system and provide strategy options for reducing personnel costs if/as appropriate
- Ensure set of requirements agrees with user needs and expectations with respect to operations and maintenance concept

Trades
- Participate in trade studies to evaluate options against manpower costs throughout this phase

The letters on this page correspond with the letters on the previous page, and are associated with the respective SE step boxes.

Approach - Content

- Define HSI and domains for project
- Design a graphic template to easily display information
  - Leverage a sample format from another DOD ESOH product
  - Include information on references and tools leveraged from other projects
- Research past and existing information on HSI domain activities
- Develop straw man activity charts
- Identify subject matter experts (SMEs) and ask for chart reviews
- Consolidate over 500 SME comments
- Display and edit the information
- Revise content for new releases of the Acquisition Life Cycle chart (Dec 08), DODI 5000.02 (Feb 09) and AFI 63-101 (Apr 09)

Approach – Usability Efforts

- Leverage familiarity with the DoD chart
  - Similar look and feel
  - Color coding sections to match
- Graphical Flow Considerations
  - Letters/bubbles, Lines dividing sections, etc.
  - Splitting larger acquisition phases into multiple charts
- Font type and size for readability
- Fingertip access to large amounts of data via hyperlinks
  - Internal book marks between terms, glossary, tools, acronyms
  - External links to reference documents and tools
- Screen tips on all acronyms

Results

- Products contains on one easy-to-use CD
- Three hyperlinked guides
  - Management Version (32 slides)
    - Focus on integrated HSI activities
    - Target Audience: Program Managers
  - Acquisition Phase Version (184 slides)
    - Focus on acquisition phases
    - Target Audience: Systems Engineers
  - Domain Phase Version (194 slides)
    - Focus on domain activities
    - Target Audience: Domain SMEs

Main

Management Overview

Acquistion Phase

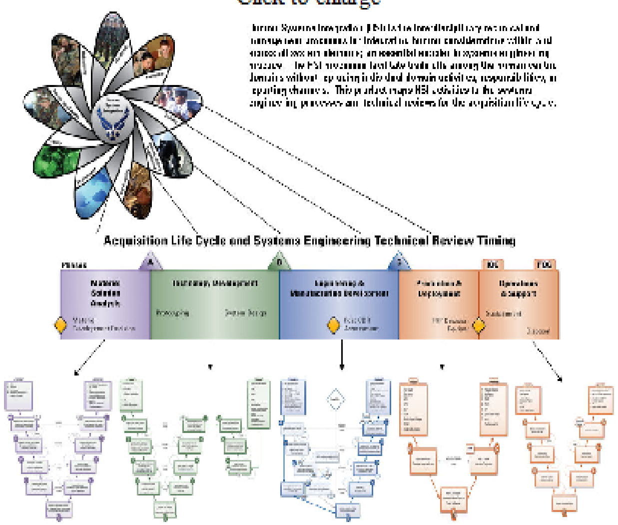
Domain Phase

Air Force Human Systems Integration Office

This CD contains three guides which map core Human Systems Integration (HSI) activities to the systems engineering activities depicted on the Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System, Version 5.3.2 (3 December 2008). Relevant tasks, tools, and references for HSI and each of the HSI domains are identified and aligned with existing Systems Engineering processes and reviews for each acquisition phase.

The first guide is a management overview focusing on HSI activities. The second guide is a more detailed collection of HSI domain activities organized by acquisition phases. The final guide contains the same level of detail as the second, but is organized by domain to make it easier to narrow in on specific functional HSI activities required to support systems engineering processes.

Click to enlarge



These guides were designed to put a lot of information into a simple to understand graphic format with supporting reference material within fingertip reach. Each of the guides contains an acronym list, glossary, and descriptions of the tools identified. Hyperlinks for the references and tools are embedded throughout and screen tips spelling out every acronym appear when moving a mouse over the acronym.

This product was produced for the Air Force Human Systems Integration Office (AFHSIO) by Booz Allen Hamilton under the auspices of the Survivability/Vulnerability Information Analysis Center (SURVIAC).

Requests for copies and any other questions should be sent to;

AFHSIO
5201 Leesburg Pike
Skyline 3 Suite 1501
Falls Church, VA 22041-3202
Email: hsi.workflow@pentagon.af.mil

At this point in the presentation switch to open CD files and briefly illustrate the look and feel of the final product along with the maneuverability features (screen tips, hyperlinks, and bookmarks)

Results

- Captured domain and integrated HSI activities in a graphic format that can be used for:
  - Ready reference
  - Training
  - Increasing HSI awareness
- Organized information for ease of use for different audiences and purposes
  - Versions organized by acquisition phase and domain
  - Overview version focusing on HSI integrated activities and performance measures
- Hyperlinked electronic files
  - Internal bookmarks to acronyms, glossary, and tools
  - External hyperlinks to references and tool web sites

Possible Future Uses

- Training – tool/illustration for acquisition and domain courses
- Reference Tool – handy reference for systems engineers and HSI practitioners
- Review Checklist – basis of future checklists to ensure HSI-related activities are performed during the acquisition life cycle
- Policy – ensure domain instructions incorporate and mandate these activities
- Strategic Communication – increase awareness of HSI concepts and activities
- Progress Measurement – basis for collecting performance data and monitoring HSI program effectiveness

Building Safer UGVs with Run-time Safety Invariants

Michael Wagner, Phil Koopman, John Bares, and Chris Ostrowski

mwagner@cmu.edu

October 28, 2009

The Message

- **To be useful, unmanned ground vehicles (UGVs) must safely operate alongside personnel, although this is not yet reliable enough with today's technology.**
- **The use of physical safety barriers and large stand-off distances is acceptable only during testing; it is infeasible for use in the real world.**
- **We are developing safeguards to reduce dependence on physical barriers and large standoff distances for UGV operating alongside personnel in real, dynamic operations.**

Presentation Synopsis

- **Our approach is based on *run-time safety invariants* enforced by a *Safety Monitor***
- **Benefits of our approach involve**
  - →**A clear definition of "safety"**
  - →**Firewalling safety-criticality to a small set of components**
  - →**Streamlined V&V of safety-critical components**
- **We are implementing our approach on the Autonomous Platform Demonstrator project**
- **We will discuss our process for developing a Safety Monitor using the Autonomous Platform Demonstrator (APD) as an example**

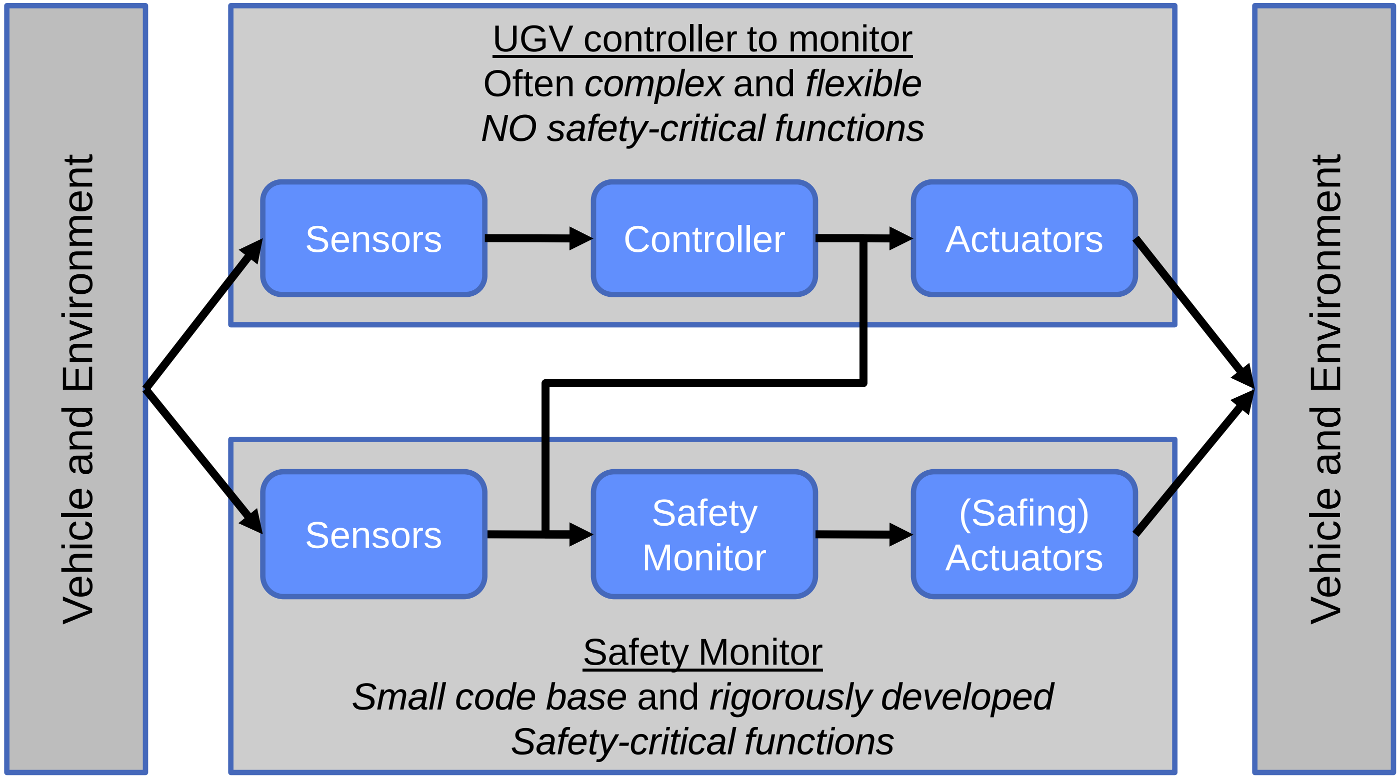
Our Approach

- ***Run-time safety invariants*** **are concise, formal expressions of critical system properties that define system safety**
  - →**E.g., "vehicle speed doesn't exceed operator-specified limit"**
  - →**We needn't enumerate detailed causes of hazards**
  - →**Rather, we create a dependable outer bound on what it means to be "safe"**
  - →**Do this based on fault-tree analysis**

Approved for Public Release. TACOM Case #20247 Date: 07 OCT 2009

Our Approach (2)

- **We then build a *Safety Monitor* that safes the UGV whenever any invariant is violated**
  - →**Has a dependable means of sensing invariant state**
  - →**Has a dependable means of safing the system**



Demonstration Vehicle: APD

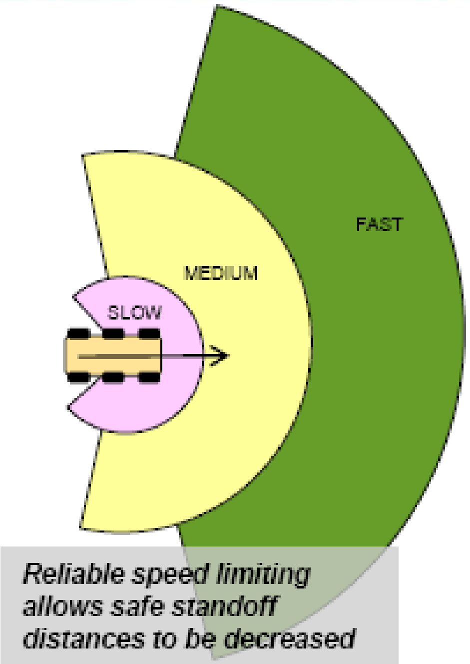
- **APD is developing, integrating, and testing next generation UGV mobility technologies such as hybrid electric drive systems, advanced suspension systems, and efficient auxiliary systems.**

TARGET GVW: 8,500 kg
TARGET SPEED: 80 km/hr

Approved for Public Release. TACOM Case #20247 Date: 07 OCT 2009

APD Safety Goals

- Initial focus is on mitigating hazards involved with driving the APD vehicle
  - →Ensure the vehicle can be stopped when commanded
  - →Ensure the vehicle maintains a commanded speed limit
- Meeting both these goals helps to decrease safe standoff distances

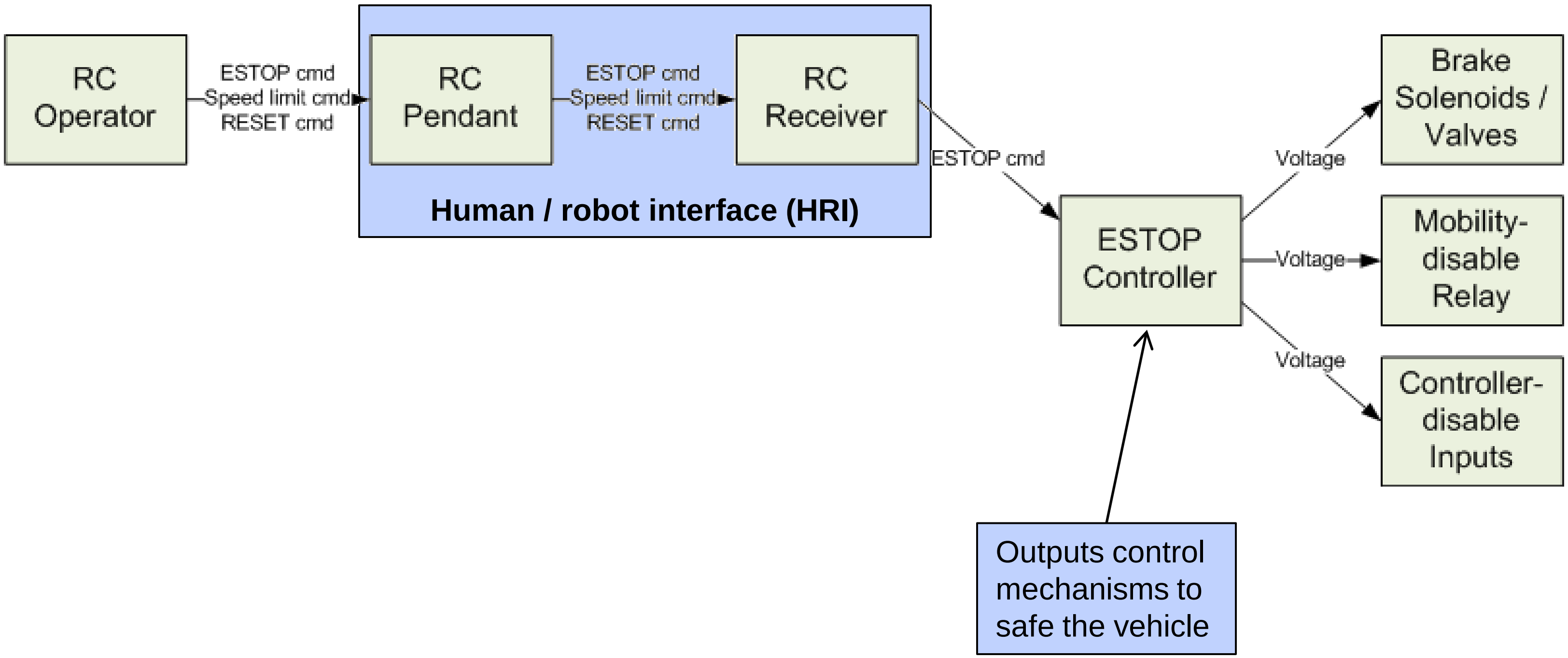


Development Process

1. Build fault model
2. Mitigate hazards with electromechanical safeguards
3. Identify remaining high-priority hazards
4. Define these hazards behaviorally to generate invariants
5. Design means of sensing invariant state
6. Design means of safing vehicle when invariant is violated
7. Build safety monitor
8. Test safety monitor to requirements

Update fault model with new detectors and safing components

APD Safety Architecture

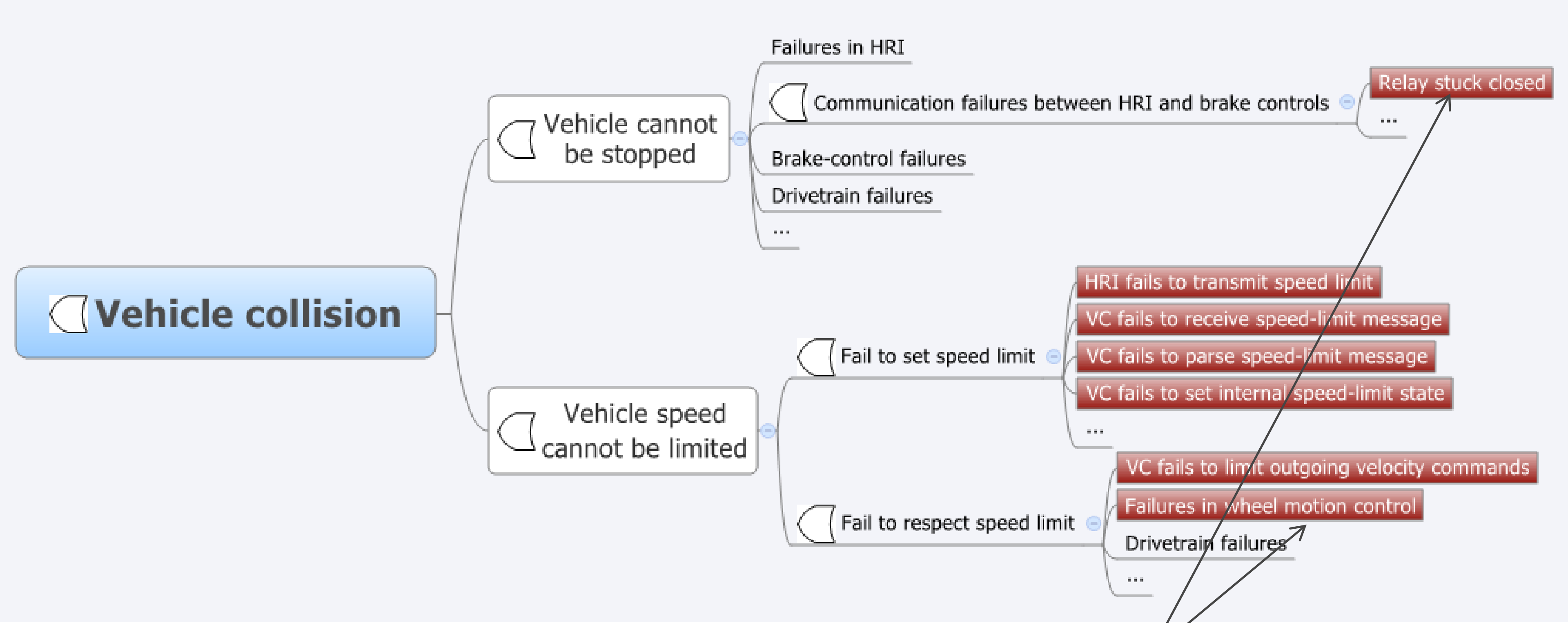


ACRONYM DECODER:

ESTOP	Emergency stop
RC	Radio controller

Approved for Public Release. TACOM Case #20247 Date: 07 OCT 2009

APD Fault Model Example



Red hazards are those not mitigated through hardware redundancy

ACRONYM DECODER:

HRI	Human/robot interface
VC	Vehicle controller software

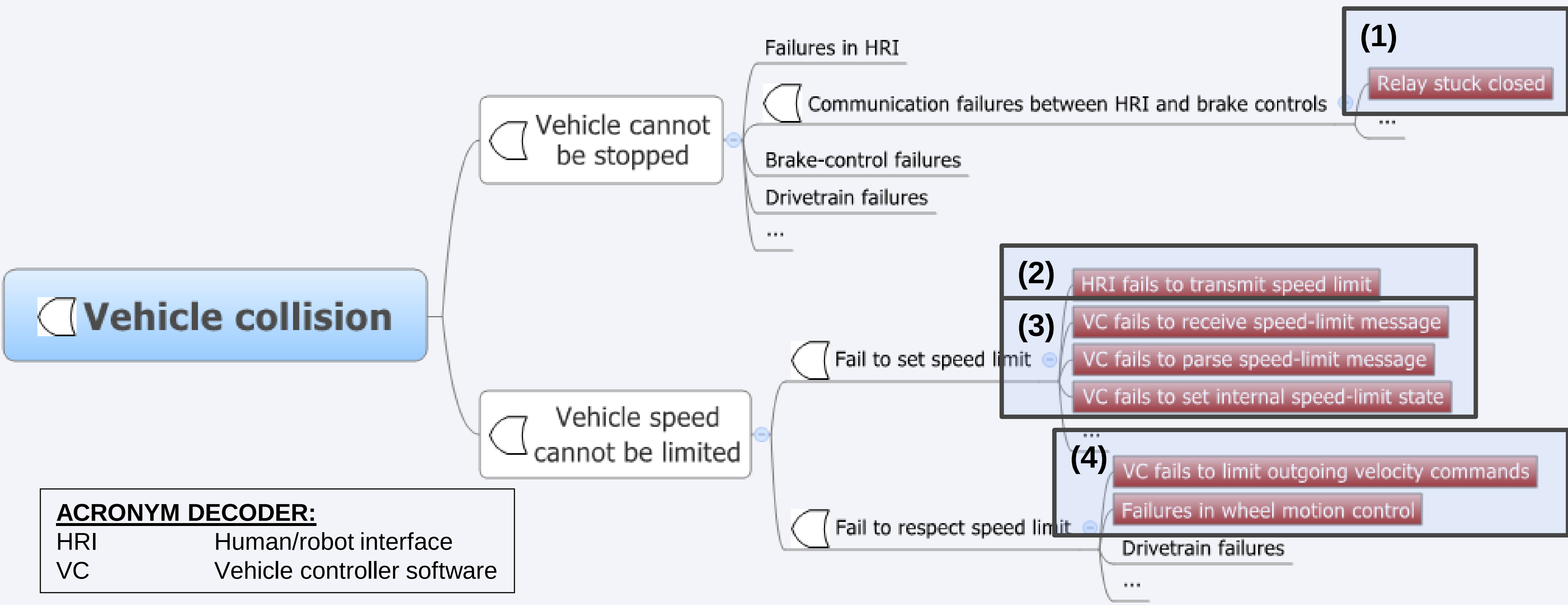
Hazard Behavioral Definition

Hazard	Behavioral Definition
(HRI) relay stuck closed	HRI reports ESTOP signal over serial line but relay is closed
Failures in HRI	No valid heartbeat from HRI
Communication failures between HRI and VC	No valid heartbeat from HRI No valid heartbeat from VC
VC fails to parse speed-limit message	Vehicle exceeds speed limit specified by HRI
VC fails to set internal speed-limit state	
VC fails to limit outgoing velocity commands	
Failures in wheel motion control	

APD Safety Invariants

Safe the vehicle if:

1. HRI ESTOP is commanded, OR
2. HRI is inactive, OR
3. VC is inactive, OR
4. Vehicle speed exceeds limit specified by HRI



ACRONYM DECODER:

HRI	Human/robot interface
VC	Vehicle controller software

Approved for Public Release. TACOM Case #20247 Date: 07 OCT 2009

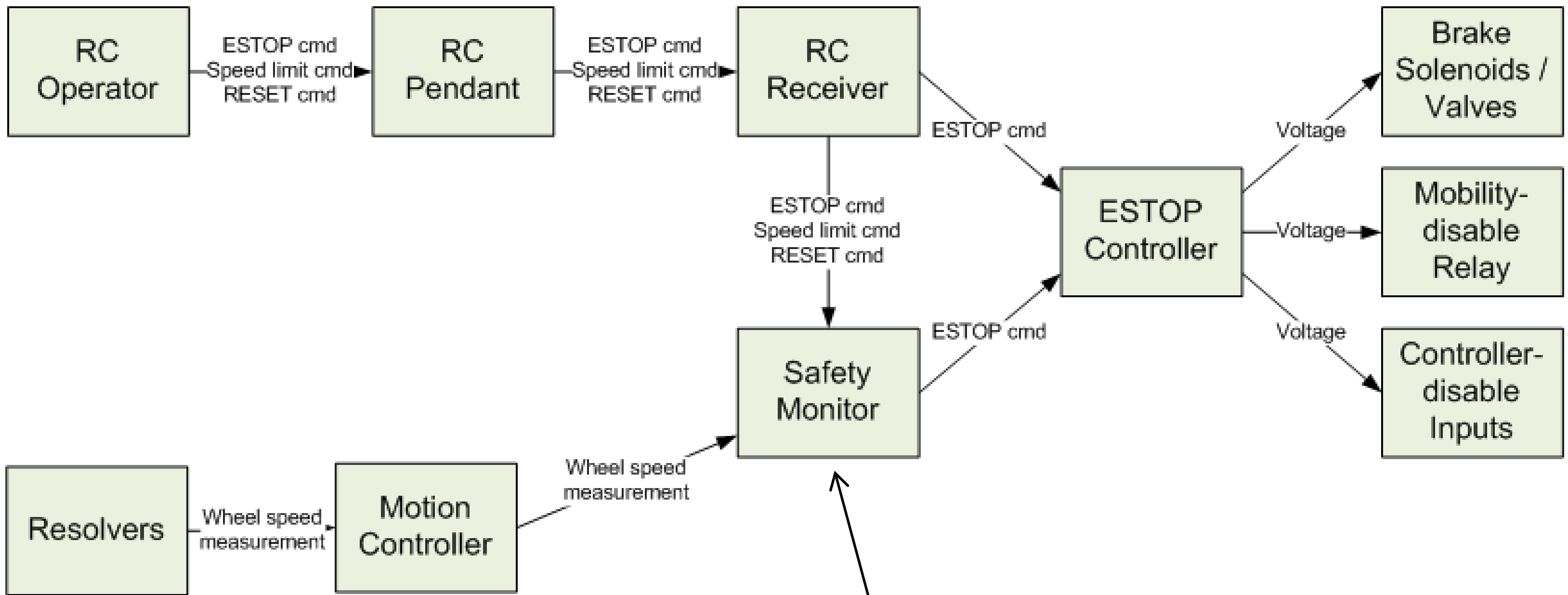
Means of Sensing Invariants

1. **HRI ESTOP command**
   - → **Data packets received from HRI**
   - → **Packets include error-detection code**
2. **HRI is inactive**
   - → **Valid packet received from HRI**
3. **VC is inactive**
   - → **Valid driving command received sent by VC and snooped by Safety Monitor**
4. **Vehicle speeds exceed limit specified by HRI**
   - → **Wheel velocities are reported through telemetry from low-level traction drive controllers**
   - → **Data packets from HRI specify setting of a speed-limit switch**

Means of Safing Vehicle

- **Must be…**
  - →**Independent of non-safety critical components**
  - →**Unable to be overridden or disabled**
  - →**Fail-safe**
- **On APD, an ESTOP-controller applies fail-safe mechanical brakes if any of a set of inputs drop low**
- **The safety monitor has control over one of these inputs**

Updated Safety Architecture

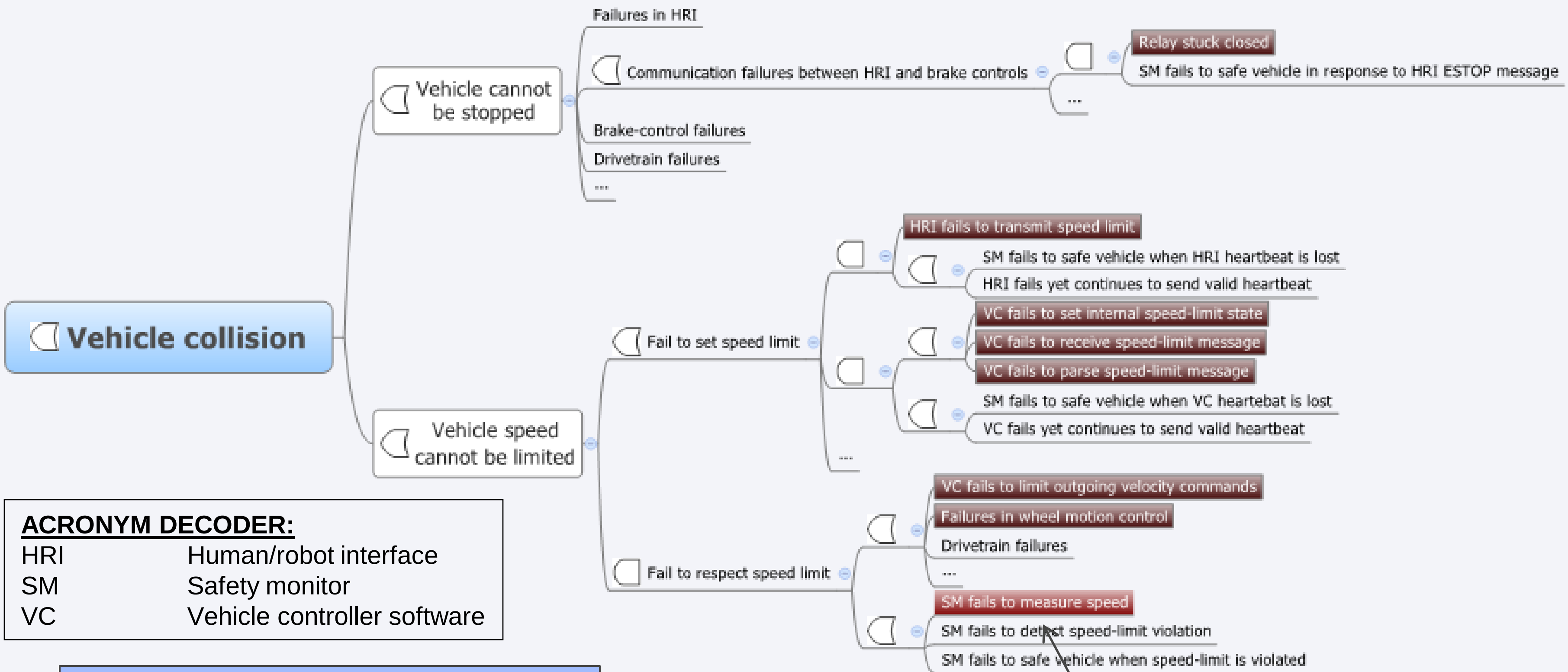


Safety Monitor senses speed and watches RC interface to enforce invariants

ACRONYM DECODER:

ESTOP	Emergency stop
RC	Radio controller

Updated Fault Model



ACRONYM DECODER:

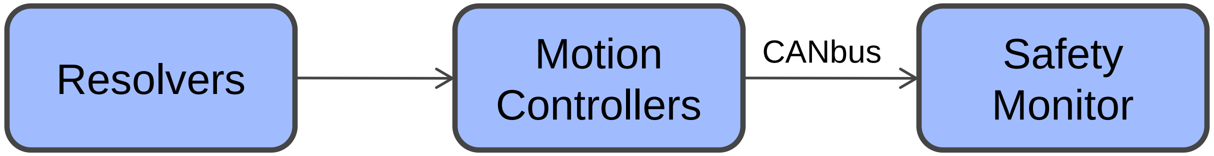
HRI	Human/robot interface
SM	Safety monitor
VC	Vehicle controller software

Redundancy has been added for previously-identified high-priority hazards

However, we now have another high-priority hazard ("SM fails to measure speed")

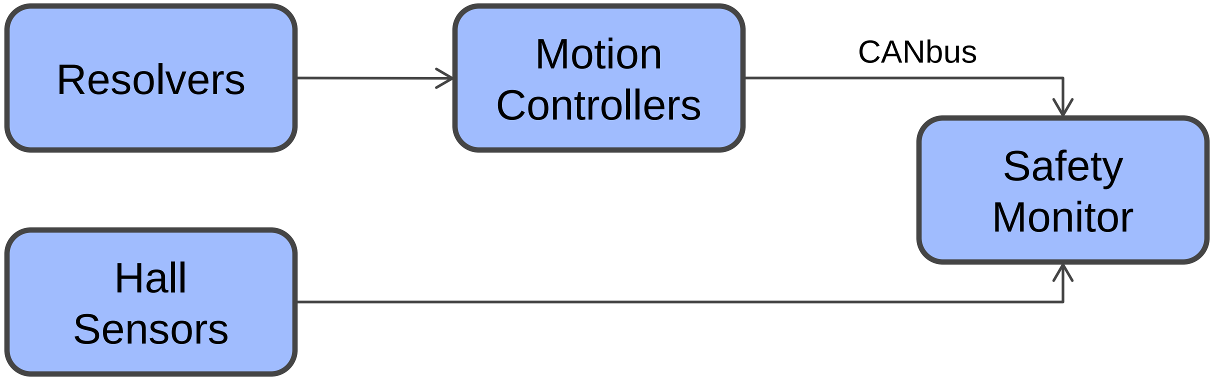
Updated Hazard Definitions

- **Speed is sensed through telemetry from motion-control hardware**
  - →**Vehicle speed is estimated as an average of wheel speeds**
- **These motion controllers are “black boxes” supplied by a vendor, so thorough V&V is infeasible**
  - →**Control hardware could report false readings**
  - →**Firmware changes could have unintended consequences**
  - →**Resolvers could fail**



Speed-sensing Safeguard

- To address these risks we added redundant wheel-speed sensing
- Hall-effect sensors are placed in hubs that are wired directly to the safety monitor
- Use these sensors to check the validity of measurements from the motion controllers



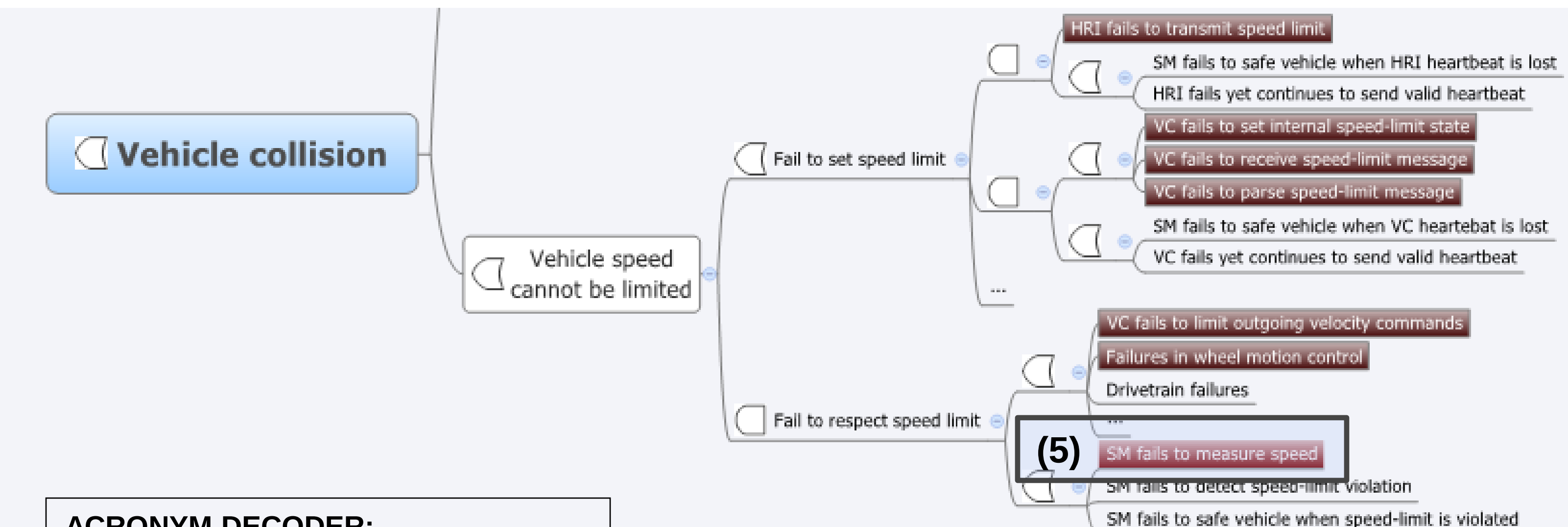
Disjoint Failure Modes

- **A failure of one sensing modality will not affect readings from the other:**
  - →**Largely separate power supplies**
  - →**Motion control firmware completely separate from hall sensors**
  - →**Motion controllers communicate via CAN bus, hall sensors use separate dedicated inputs**
  - →**Resolvers and hall sensors mounted in different locations**

Updated Safety Invariants

Safe the vehicle if:

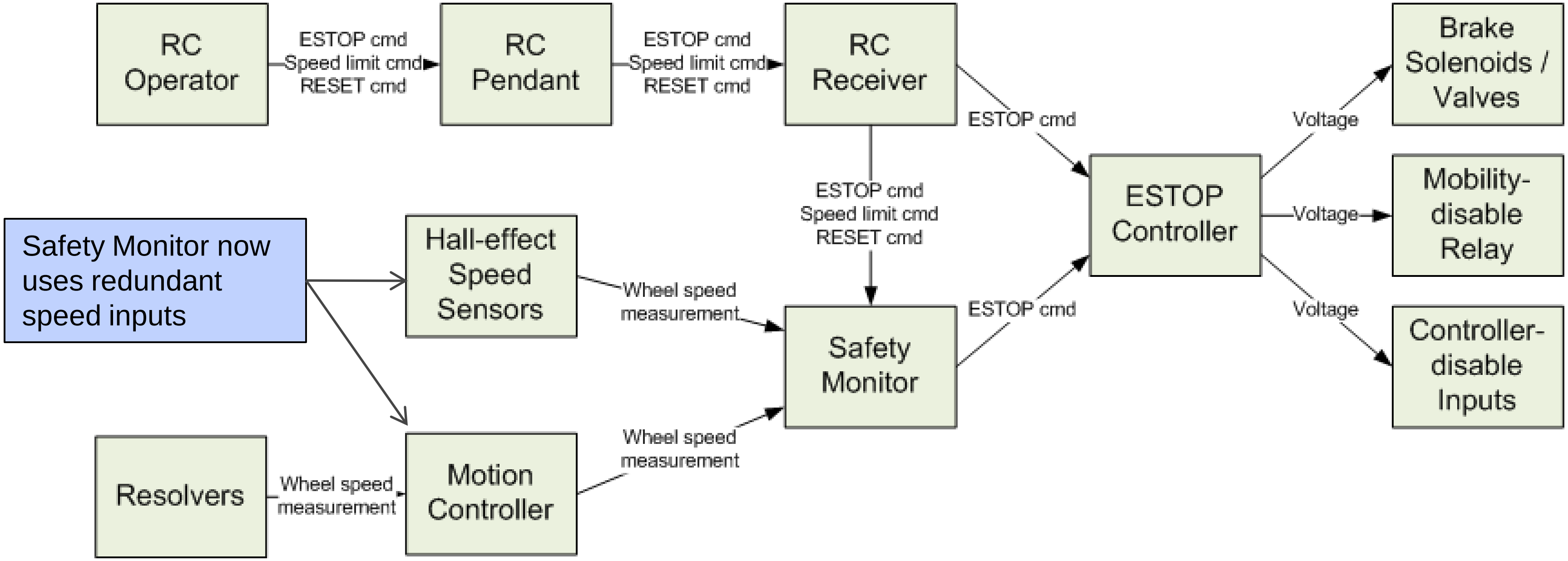
1. HRI ESTOP is commanded, OR
2. HRI is inactive, OR
3. VC is inactive, OR
4. Vehicle speed exceeds limit specified by HRI, OR
5. **Vehicle-speed measurements disagree**



ACRONYM DECODER:

HRI	Human/robot interface
SM	Safety Monitor
VC	Vehicle controller software

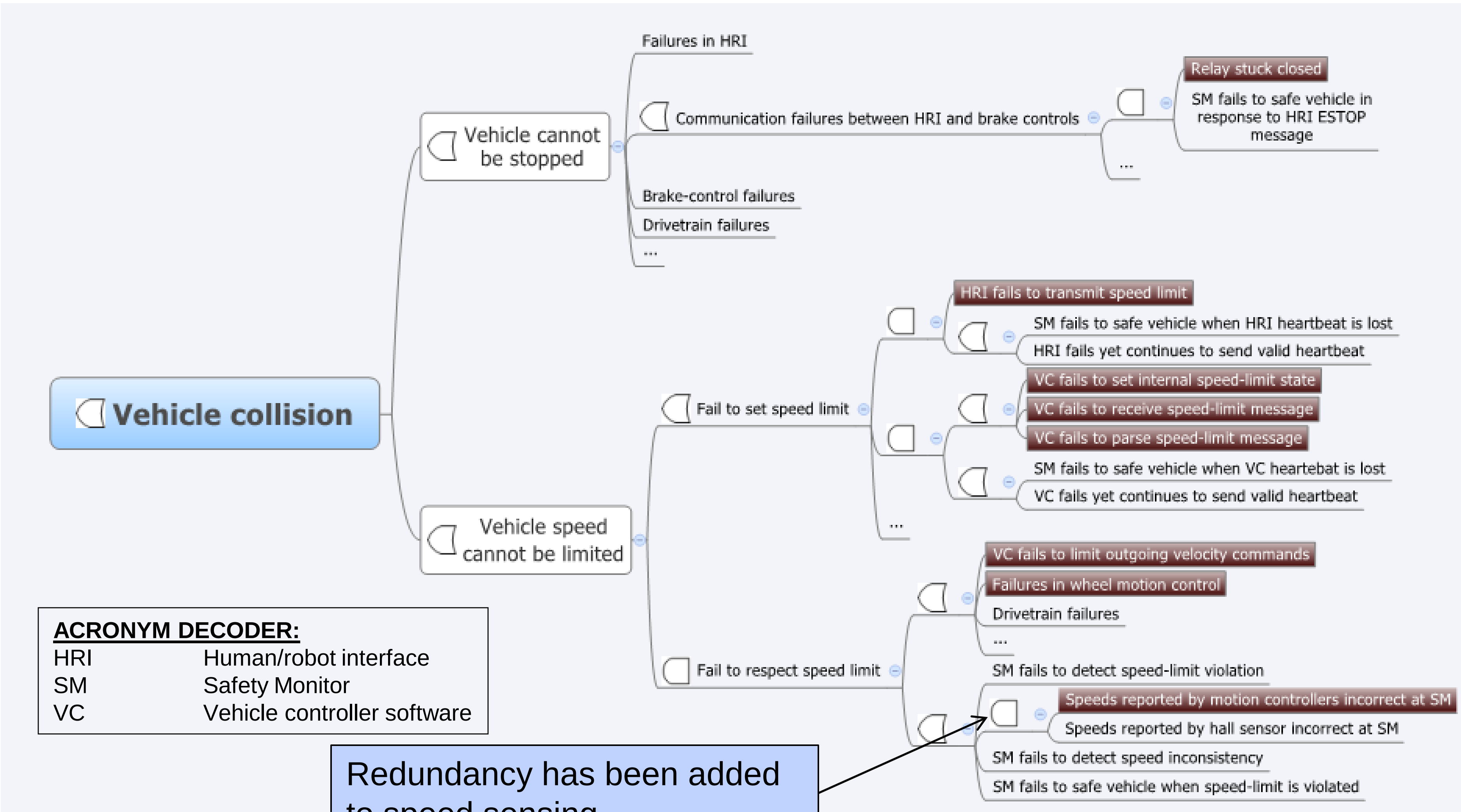
Final Architecture



ACRONYM DECODER:

ESTOP	Emergency stop
RC	Radio controller

Final Fault Model



ACRONYM DECODER:

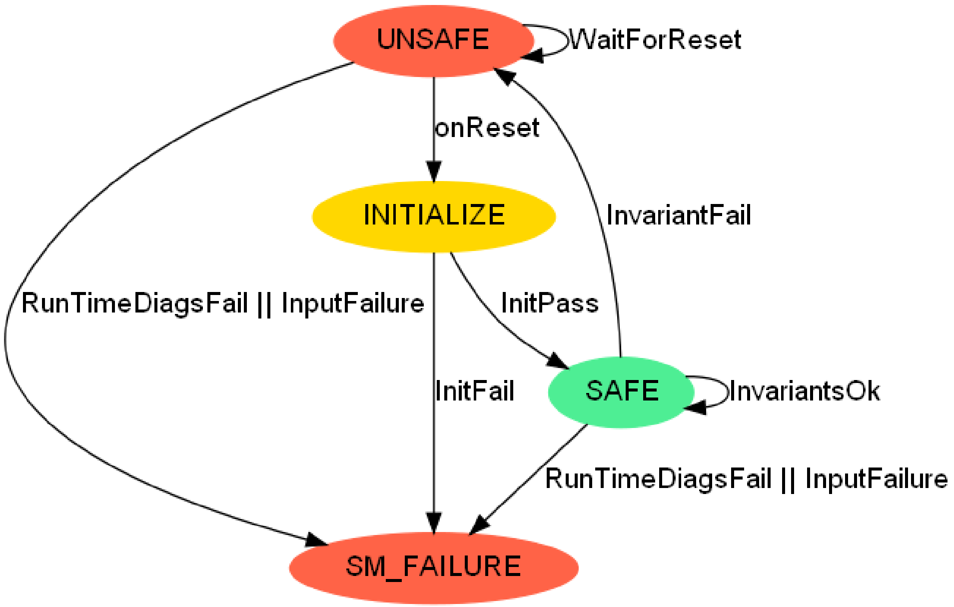
HRI	Human/robot interface
SM	Safety Monitor
VC	Vehicle controller software

Redundancy has been added to speed sensing

Safety Monitor Design

- **Simple finite state machine design**
- **If an invariant is violated, enter UNSAFE state and trigger ESTOP**
  - → **Return to SAFE state once invariants again hold and operator issues RESET**
- **If any self-checks fail, assume SM cannot evaluate invariants**
  - → **Enter SM_ASSERT state, which halts execution and triggers ESTOP with an independent hardware watchdog**

Safety Monitor Master State Chart



Safety Monitor Implementation

- **Implement as a single work loop**
  - **→Minimize use of interrupt I/O as much as possible**
- **Separate processing of input sources (e.g., conversion of hall-sensor readings to vehicle speed) from invariant evaluation**
- **Evaluate invariants based on simple boolean functions**

```
while (true)
{
   process_input_data()
   evaluate_invariants()
   update_SM_state()
   set_ESTOP_output()
   send_status_output()
}
```

Safety Monitor V&V Plan

- **The approach results in simpler test goals than we'd have if we had to verify a complex safety system**
  - → 80% of project resources are typically spent on V&V
  - → So streamlining V&V results in bigger payoffs than improving development tools
- **Safety invariants are testable safety requirements**
- **For each invariant, carry out:**
  - → <u>System test</u> that the SM issues an ESTOP if the invariant is violated
  - → <u>Bench test</u> that the SM issues an ESTOP if invalid input signals are received
  - → <u>Unit test</u> that the SM transitions to UNSAFE state upon any time-based combination of invariant-violation
  - → <u>Code review</u> that the processing of input data for the evaluation of invariants is correct
- **Prove and Document that the means of safing the system is fail-safe**

References

1) J. Black and P. Koopman, "System safety as an emergent property in composite systems," DSN 2009

2) J. Black, “System Safety as an Emergent Property in Composite Systems”, doctoral dissertation, Electrical and Computer Engineering Department, Carnegie Mellon University, April 2009.

3) P. Koopman, J. Black, and T. Maximo, “Position Paper: Deeply Embedded Survivability”, ARO Planning Workshop on Embedded Systems and Network Security, Raleigh NC, February 22-23, 2007.

4) N. G. Leveson, T. J. Shimeall, J. L.Stolzy, and J. C. Thomas, “Design for safe software,” in Proceedings of the 21st AIAA Aerospace Sciences Meeting, Reno, NV, USA, Jan. 1983.

5) D. K. Peters and D. L. Parnas, “Requirements-based monitors for real-time systems,” IEEE Transactions on Software Engineering, vol. 28, no. 2, pp. 146–158, Feb. 2002.

JB International

A comprehensive overview of techniques for measuring system readiness

JAMES W. BILBRO*

&

KYLE Y. YANG**

NDIA 12TH ANNUAL SYSTEMS ENGINEERING CONFERENCE

OCT. 26-29, 2009

*JB CONSULTING INTERNATIONAL **MIT LINCOLN LABORATORY

Technology Assessment vs. System Assessment

- Advanced, complex Missions cannot meet their goals and objectives without having to rely on advancements in technology.
- Even “heritage” systems can require technology development when they are incorporated into a new architecture with different operational environments or goals.
- Consequently, all “system” assessments must have a technology assessment as a component.

JB International

Technology Assessment vs. System Assessment

What does Technology Impact?

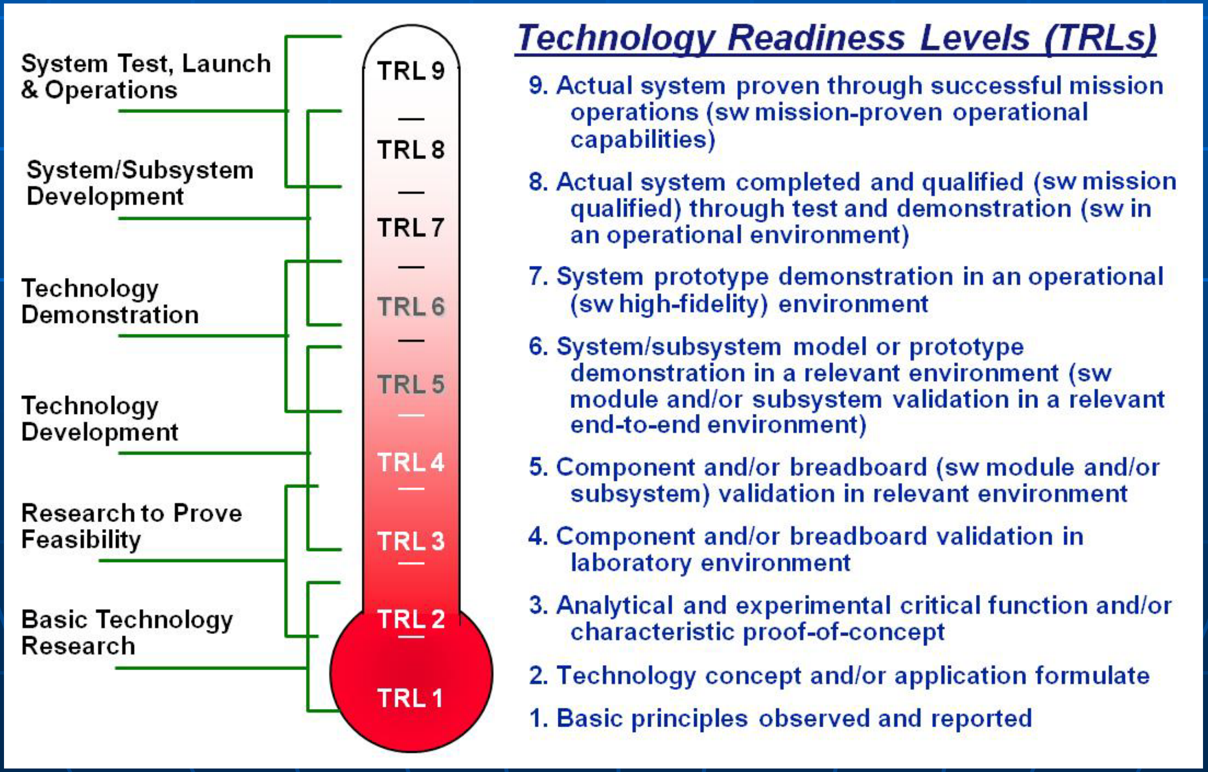
All aspects of the Systems Engineering Process!

- Stakeholder Expectation:
- Requirements Definition:
- Design Solution:
- Risk Management:
- Technical Assessment:
- Trade Studies:
- Verification/Validation:
- Lessons Learned:

Technology Readiness Level (TRL)

- A Technology Readiness Level (TRL), describes the maturity of a given technology relative to its development cycle.

- At its most basic, it is defined at a given point in time by what has been done and under what conditions.



Technology Assessment vs. System Assessment

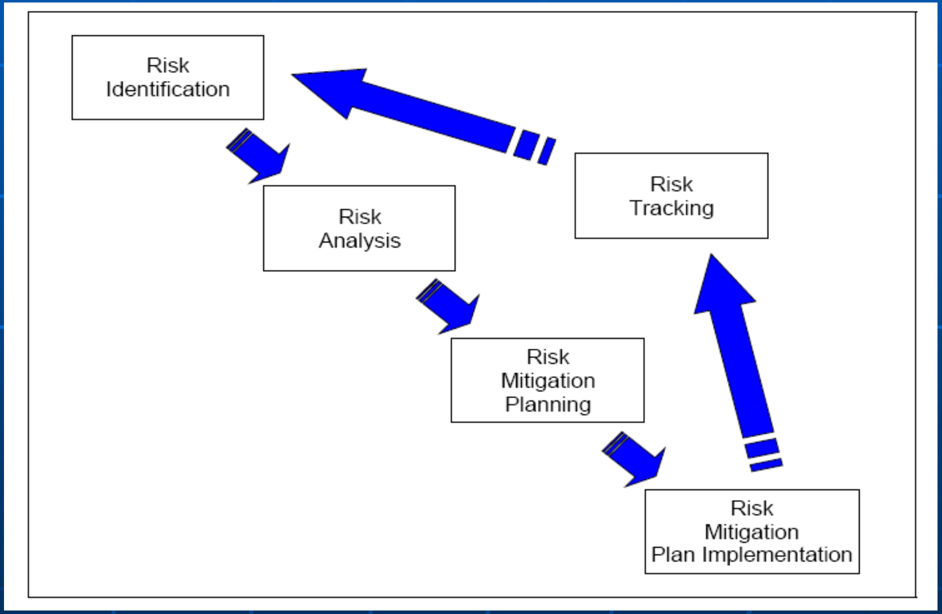
- But – Technology Assessment alone is not sufficient to determine the maturity of a system under development.

Risk Identification, *Integration & Illities (RI3)*

RI3 is a methodology for identifying technical risks due to the introduction of "new" technology, based on case studies, "lessons learned," and "best practice" from an Air Force-wide development team.

RI3 used to support, not replace, existing Risk Identification process

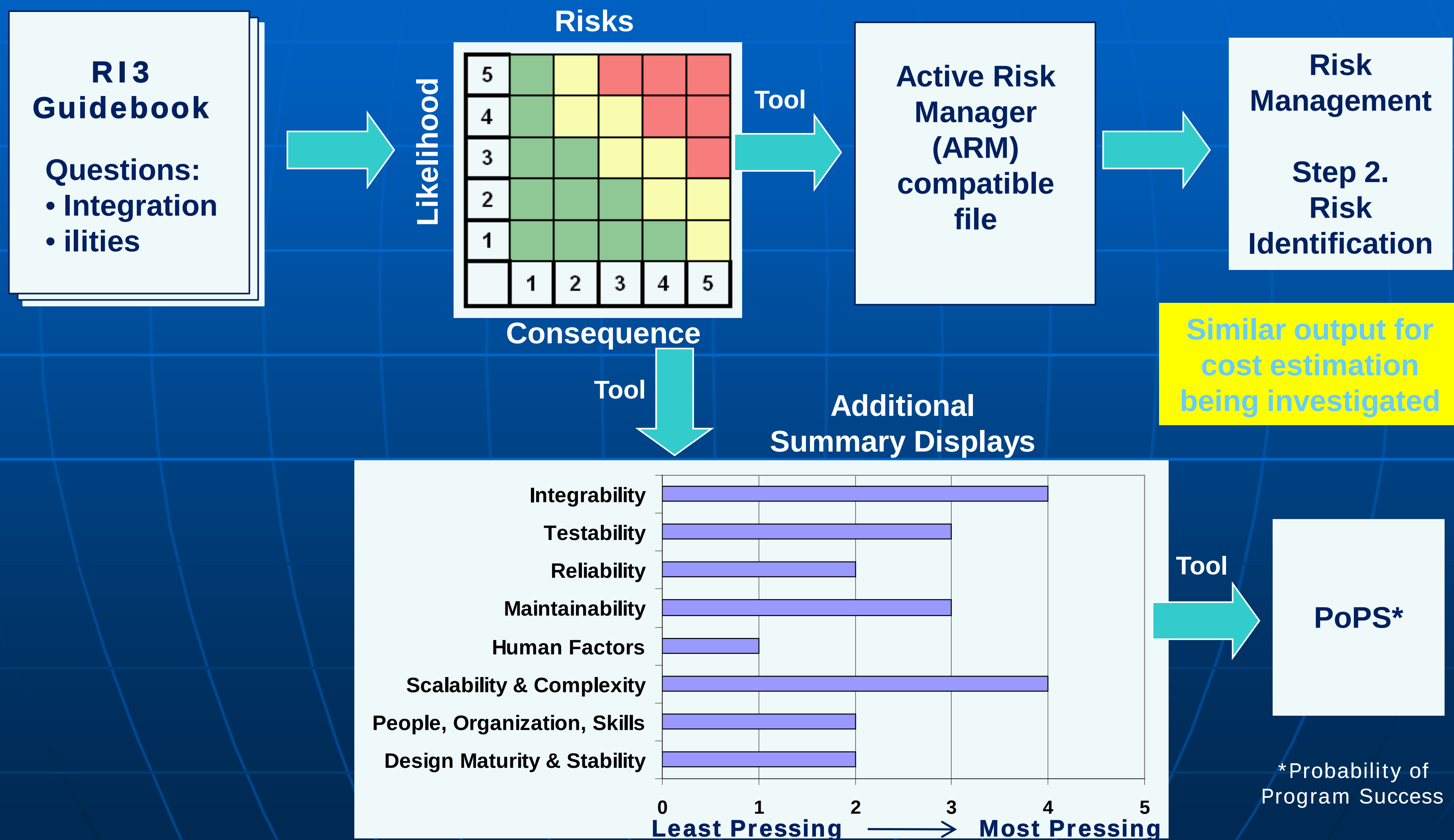
Questions in nine 'ilities areas
- Design Maturity and Stability
- Scalability & Complexity
- Integrability
- Testability
- Software
- Reliability
- Maintainability
- Human factors
- People, organization, & skills



Questions based on commonly occurring problems are contained in a compact guidebook and an Excel tool - a web based tool is under development.

JB International

Risk Identification, Integration & Illities (RI3)



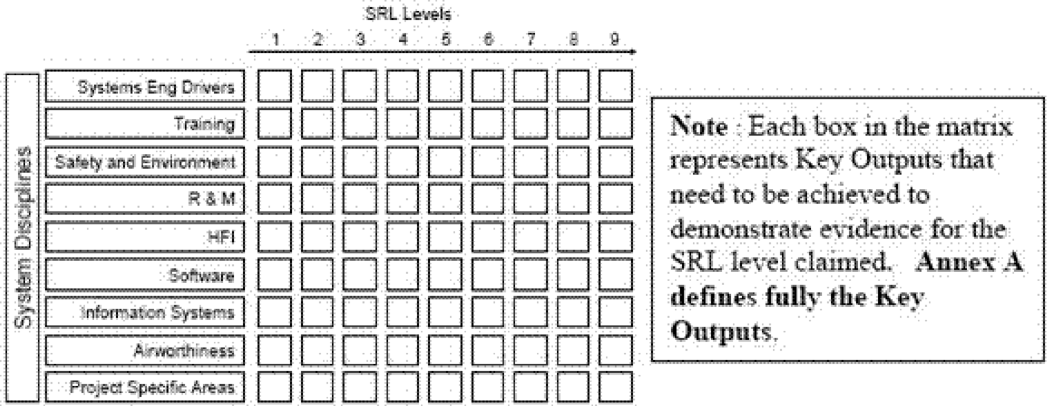
System Readiness Level (SRL) – UK Ministry of Defense

SRLs are an analysis of key outputs of an acquisition project structured in such a way as to provide an understanding of work required to mature the project.

The SRL analysis is achieved using a matrix to capture the results of a comprehensive set of questions centered around System Engineering Drivers (SEDs) and selected systems disciplines (i.e., Training, Safety and Environment, etc.) and understand how they should mature over time.

The SRL analysis employs TRL analyses to provide a means of progressively measuring project maturity at technology, component, sub system and whole system levels.

$TRL_{system} \leq TRL_{component}$



Outline SRL Matrix.

N.B. – Integration Readiness Levels (IRLs) & Design Readiness Levels (DRLs) were initially used but later rejected.

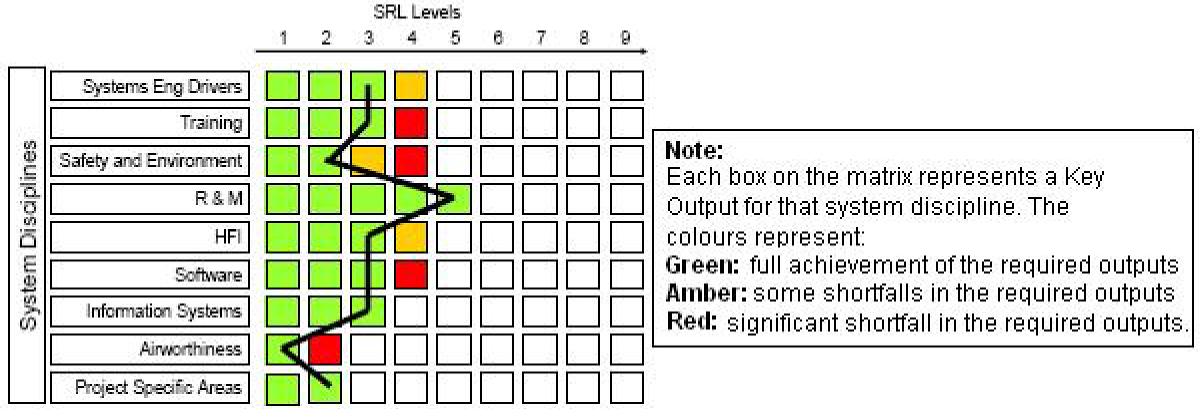
System Readiness Level (SRL) – UK Ministry of Defense

SRLs are intended to be 'descriptive' and not 'absolute' as work on each systems discipline may progress at different rates.

An SRL assessment therefore produces a 'signature' rather than an absolute single point SRL figure.

The signature records the variation of maturity that has been achieved across the systems disciplines, acknowledging that not all projects mature against the systems disciplines at a consistent rate.

The color of the boxes in the Systems Maturity Matrix is determined by analysis of the SRL signature obtained against the expectations for SRL maturity at the time of review



Example of an SRL 'Signature'

SRL Self Assessment Tool Results

Advancement Degree of Difficulty (AD^2)

JB International

Advancement Degree of Difficulty (AD2) is a method of systematically dealing with aspects beyond TRL.

It is a "predictive" description of what is required to move a system, subsystem or component from one TRL to another.

It provides information in the form of:

- Likelihood of occurrence of an adverse event. — **Risk**
- Cost to ensure that such an event does not occur.
- The time required to implement the necessary action. — **Impact**

AD^2 consists of a set of questions in 5 specific areas:

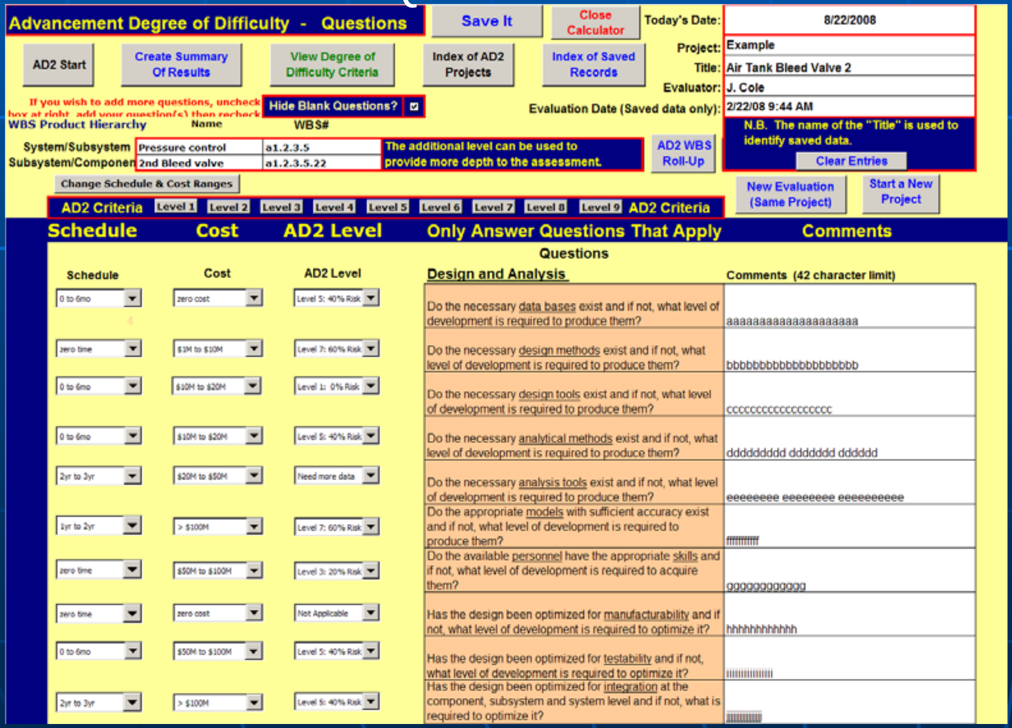
- Design and Analysis
- Manufacturing
- Software Development
- Test
- Operations

Advancement Degree of Difficulty (AD²)

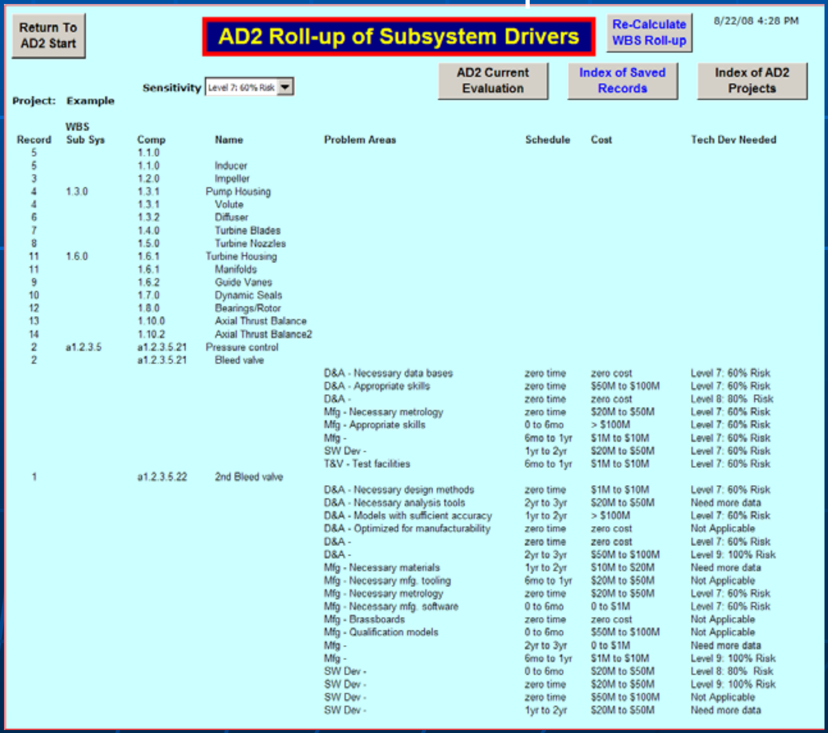
The levels of risk associated with AD² are described in terms of the experience base of the developers.

i.e., have they done this before?

AD² Tool Question Set



AD² Tool Output



System Readiness Level (SRL) – the Stevens Institute

The SRL in this case is defined through the combination of the TRL of a given technology with the Integration Readiness Level (IRL) of each of the elements with which it will be integrated.

$$SRL_i = f(TRL_j, IRL_{ij})$$

The overall SRL will be a function of the individual subsystem SRL_i

$$SRL = f(SRL_1, SRL_2, \ldots SRL_n)$$

Integration Readiness Levels

IRL	Definition	Description
9	Integration is **Mission Proven** through successful mission operations.	IRL 9 represents the integrated technologies being used in the system environment successfully. In order for a technology to move to TRL 9 it must first be integrated into the system, and then proven in the relevant environment, so attempting to move to IRL 9 also implies maturing the component technology to TRL 9.
8	Actual integration completed and **Mission Qualified** through test and demonstration, in the system environment.	IRL 8 represents not only the integration meeting requirements, but also a system-level demonstration in the relevant environment. This will reveal any unknown bugs/defect that could not be discovered until the interaction of the two integrating technologies was observed in the system environment.
7	The integration of technologies has been **Verified and Validated** with sufficient detail to be actionable.	IRL 7 represents a significant step beyond IRL 6; the integration has to work from a technical perspective, but also from a requirements perspective. IRL 7 represents the integration meeting requirements such as performance, throughput, and reliability.
6	The integrating technologies can **Accept, Translate, and Structure Information** for its intended application.	IRL 6 is the highest technical level to be achieved, it includes the ability to not only control integration, but specify what information to exchange, label units to specify what the information is, and the ability to translate from a foreign data structure to a local one.
5	There is sufficient **Control** between technologies necessary to establish, manage, and terminate the integration.	IRL 5 simply denotes the ability of one or more of the integrating technologies to control the integration itself; this includes establishing, maintaining, and terminating.
4	There is sufficient detail in the **Quality and Assurance** of the integration between technologies.	Many technology integration failures never progress past IRL 3, due to the assumption that if two technologies can exchange information successfully, then they are fully integrated. IRL 4 goes beyond simple data exchange and requires that the data sent is the data received and there exists a mechanism for checking it.
3	There is **Compatibility** (i.e. common language) between technologies to orderly and efficiently integrate and interact.	IRL 3 represents the minimum required level to provide successful integration. This means that the two technologies are able to not only influence each other, but also communicate interpretable data. IRL 3 represents the first tangible step in the maturity process.
2	There is some level of specificity to characterize the **Interaction** (i.e. ability to influence) between technologies through their interface.	Once a medium has been defined, a "signaling" method must be selected such that two integrating technologies are able to influence each other over that medium. Since IRL 2 represents the ability of two technologies to influence each other over a given medium, this represents integration proof-of-concept.
1	An **Interface** between technologies has been identified with sufficient detail to allow characterization of the relationship.	This is the lowest level of integration readiness and describes the selection of a medium for integration.

System Readiness Level (SRL) – the Stevens Institute

The computation of SRL is considered as a normalized matrix of pairwise comparisons of normalized TRL and IRL.

$$[\mathrm{SRL}] = \begin{bmatrix} \mathrm{SRL}_1 \\ \mathrm{SRL}_2 \\ \cdots \\ \mathrm{SRL}_n \end{bmatrix} = \begin{bmatrix} \mathrm{IRL}_{11}\mathrm{TRL}_1 + \mathrm{IRL}_{12}\mathrm{TRL}_2 + \cdots + \mathrm{IRL}_{1n}\mathrm{TRL}_n \\ \mathrm{IRL}_{21}\mathrm{TRL}_1 + \mathrm{IRL}_{22}\mathrm{TRL}_2 + \cdots + \mathrm{IRL}_{2n}\mathrm{TRL}_n \\ \cdots \\ \mathrm{IRL}_{n1}\mathrm{TRL}_1 + \mathrm{IRL}_{n2}\mathrm{TRL}_2 + \cdots + \mathrm{IRL}_{nn}\mathrm{TRL}_n \end{bmatrix}$$

$$\mathrm{SRL} = \frac{(\mathrm{SRL}_1/n_1 + \mathrm{SRL}_2/n_2 + \cdots + \mathrm{SRL}_n/n_n)}{n}.$$

System Maturity Optimization is underway at Stevens

Additional Areas that have been addressed with varying degrees of success

Design Readiness Level (DRL)
Manufacturing Readiness Level (MRL)
Integration Readiness Level (IRL)
Software Readiness Level (SRL)
Operational Readiness Level (ORL)
Human Readiness Levels (HRL)
Capability Readiness Level (CRL)
Organizational Readiness Level(ORL)
Programmatic Readiness Level(PRL

Summary

- Technology Assessment is a vital part of any overall system maturity assessment.
- There are many approaches to overall system assessment.
- Any successful approach for system maturity assessment must balance the need for data against the resources required to obtain that data.

Bibliography

- Sadin, Stanley T.; Povinelli, Frederick P.; Rosen, Robert, "NASA technology push towards future space mission systems," Space and Humanity Conference Bangalore, India, Selected Proceedings of the 39th International Astronautical Federation Congress, Acta Astronautica, pp 73-77, V 20, 1989
- Mankins, John C. "Technology Readiness Levels" a White Paper, April 6, 1995.
- Nolte, William, "Technology Readiness Level Calculator, "Technology Readiness and Development Seminar, *Space System Engineering and Acquisition Excellence Forum*, The Aerospace Corporation, April 28, 2005.
- Mankins, John C. , "Research & Development Degree of Difficulty (RD3)" A White Paper, March 10, 1998.

Bibliography

- Ramirez-Marquez, J.E. Sauser, B.J. "System Development Planning via System Maturity Optimization," Accepted for future publication in **IEEE Transactions on Engineering Management,** IEEExplore.
- Bilbro, James W. "Systematic Assessment of the Program/Project Impacts of Technological Advancement and Insertion Revision A," http://www.jbconsultinginternational.com

Bibliography

TOOLS

- RI3 Tool and Guidebook are available at: http://www.afit.edu/cse/page.cfm?page=164&sub=95
- AD2 Tool along with integrated TRL tool available at:
- http://www.jbconsultinginternational.com
- TRL Calculator is available at Website at: https://acc.dau.mil/communitybrowser.aspx?id=25811
- UK MOD Tool is available at: http://www.aof.mod.uk/aofcontent/tactical/techman/index.htm
- Stevens SRL Tool is under development at: http://www.systemreadinesslevel.com/
- Manufacturing Readiness Level Tool is available at: https://acc.dau.mil/CommunityBrowser.aspx?id=18231

SysML Strategies to Characterize and Analyze Systems of Systems

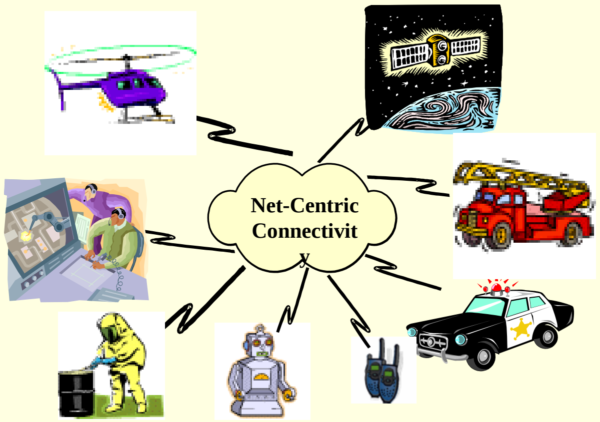
Jo Ann Lane (jolane@usc.edu)
Tim Bohn (tbohn@us.ibm.com)

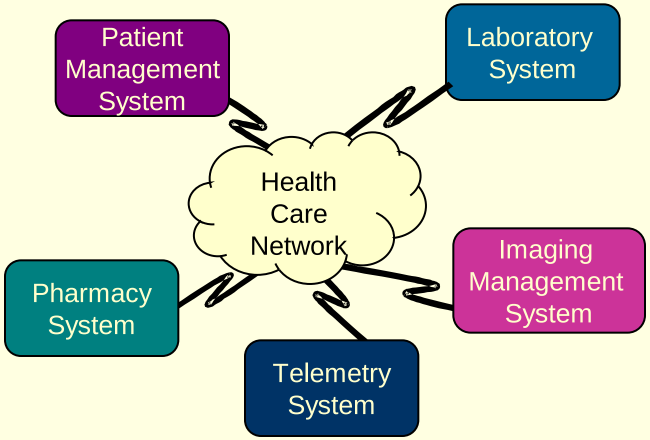
Overview

- System of systems (SoS) engineering core elements
- SysML models that support SoS engineering
- Example SoS SySML models
- Conclusions

What is a "System of Systems"?

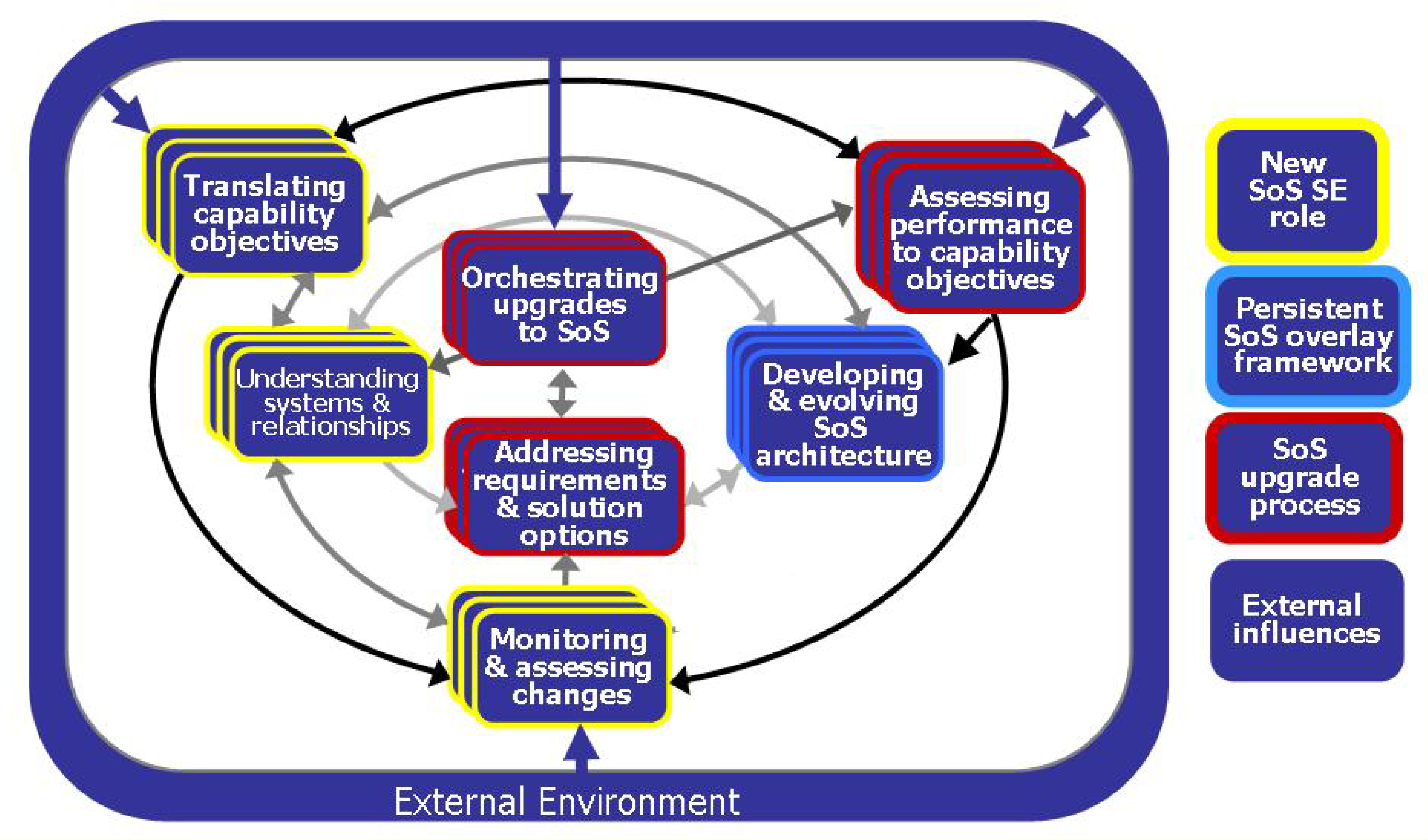
- Very large systems using a framework or architecture to integrate constituent systems
- Exhibits emergent behavior not otherwise achievable by constituent systems
- SoS constituent systems (CS)
  - Independently developed and managed
  - New or existing systems in various stages
  - May include multiple COTS products
  - Have their own purpose
  - Can dynamically come and go from SoS
- Typical domains
  - *Business:* Enterprise-wide and cross-enterprise integrations
  - *Military/Crisis Response:* Dynamic communications infrastructure





Based on Mark Maier's SoS definition [Maier, 1998]

SoS Engineering Core Elements



SoSE Core Element Description

- **Translating Capability Objectives**
  - Starts with an SoS need or new capability
  - Works to understand new capability and alternatives for providing it
- **Understanding Systems and Their Relationships**
  - Collects and maintains information about current state of the SoS and its CSs
- **Assessing Performance to Capability Objectives**
  - Evaluation of current performance and how performance meets current and future needs
- **Developing/Evolving SoS Architecture**
  - Evaluation of existing SoS architecture and identification of alternatives to mitigate limitations and improve performance
- **Monitoring and Assessing Changes**
  - Monitoring of CS non-SoS changes
- **Addressing Requirements and Solution Options**
  - Evaluation/prioritization of SoS requirements
  - Evaluation of solution options and selection of option
- **Orchestrating Upgrades**
  - Oversight activity to monitor progress of the CS SoS capability upgrades and mitigate obstacles

Desired SoS Engineering Modeling Support

- Understand CSs and their relationships
  - SoS architecture and capabilities
  - CS functional capabilities
  - Interfaces and protocols
  - Data elements, precision, and rates
- Develop and evolve an SoS architecture
  - Understand current architecture
  - Develop target architecture to guide SoS evolution

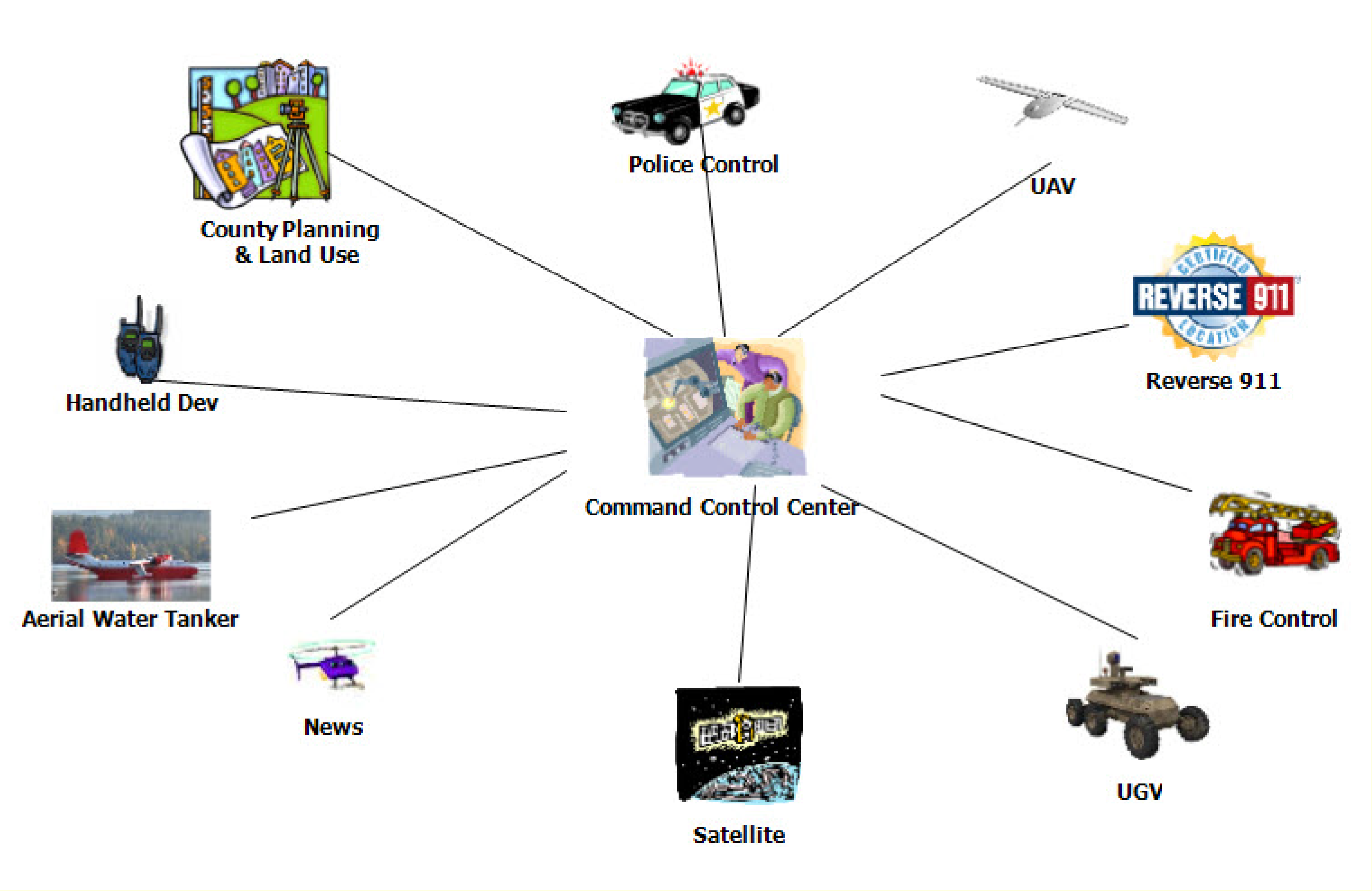
Desired SoS Engineering Modeling Support *(continued)*

- Assess CS changes
  - Impact to SoS architecture and capabilities
- Address new requirements and options
  - Implementation and transition strategies for desired capability
  - Impact to constituent systems

SysML Models that Support SoS Engineering Needs

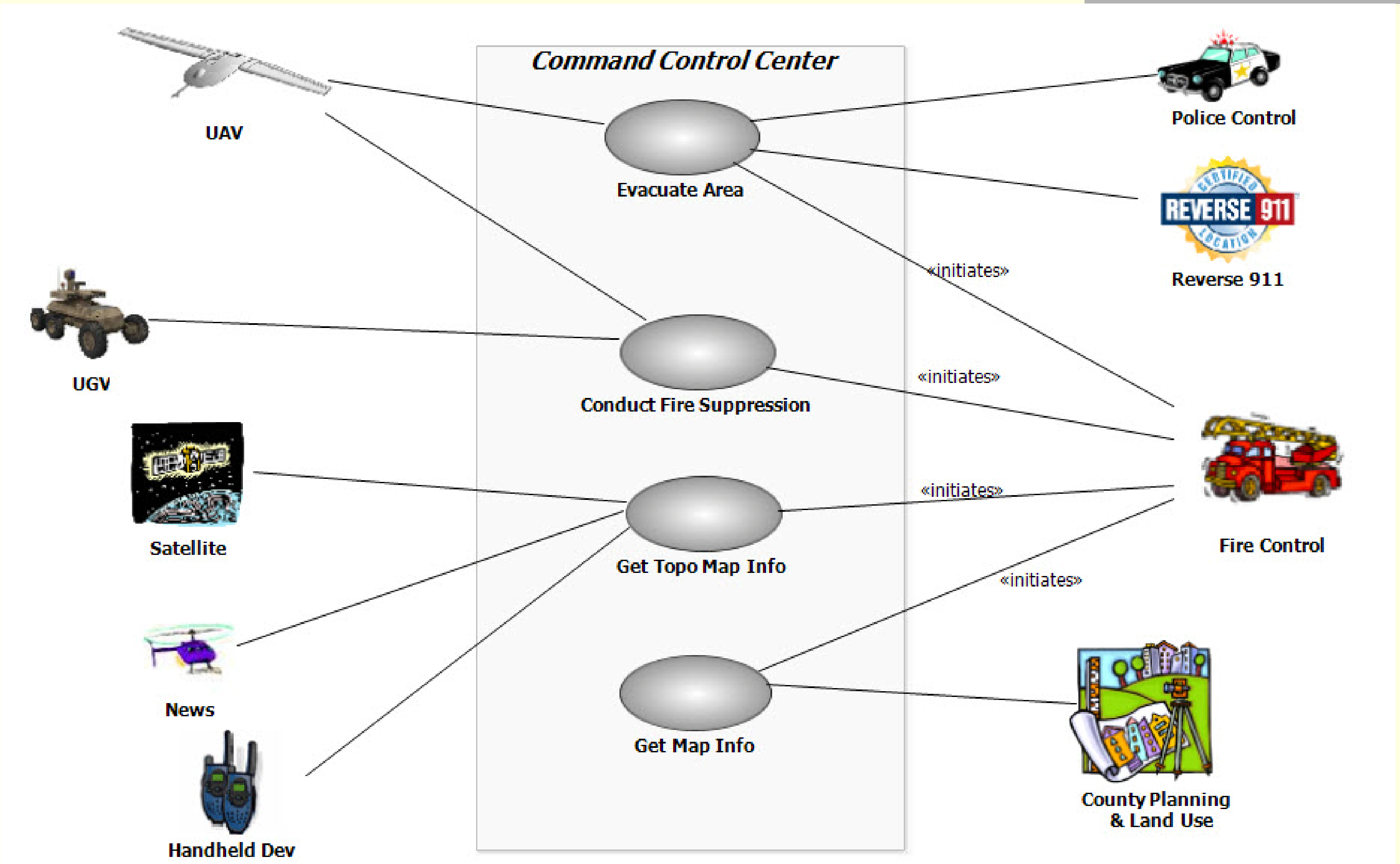
- Object classes
  - Characterize each SoS CS and its capabilities
- Interface classes
  - Describe each CS interface
- Input/output entity classes
  - Express the associated data attributes of each data item transferred over that interface
- Use cases
  - Characterize both CS and SoS capabilities from the different user perspectives
- Sequence diagrams
  - Characterize and analyze the operational flow for an SoS capability

Example SoS: Regional Area Crisis Response SoS (RACRS)

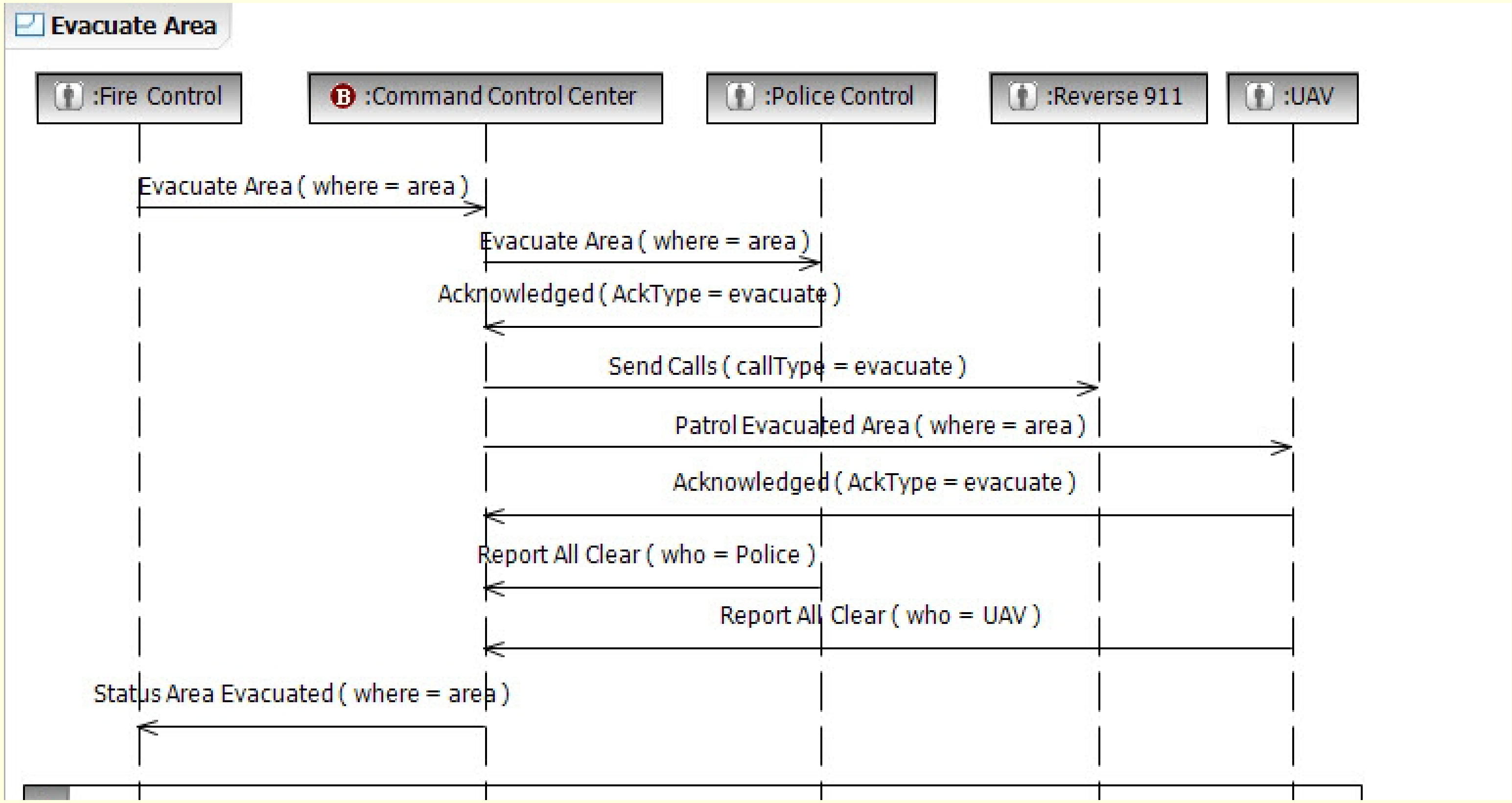


Command Control Center (CCC) Context Diagram

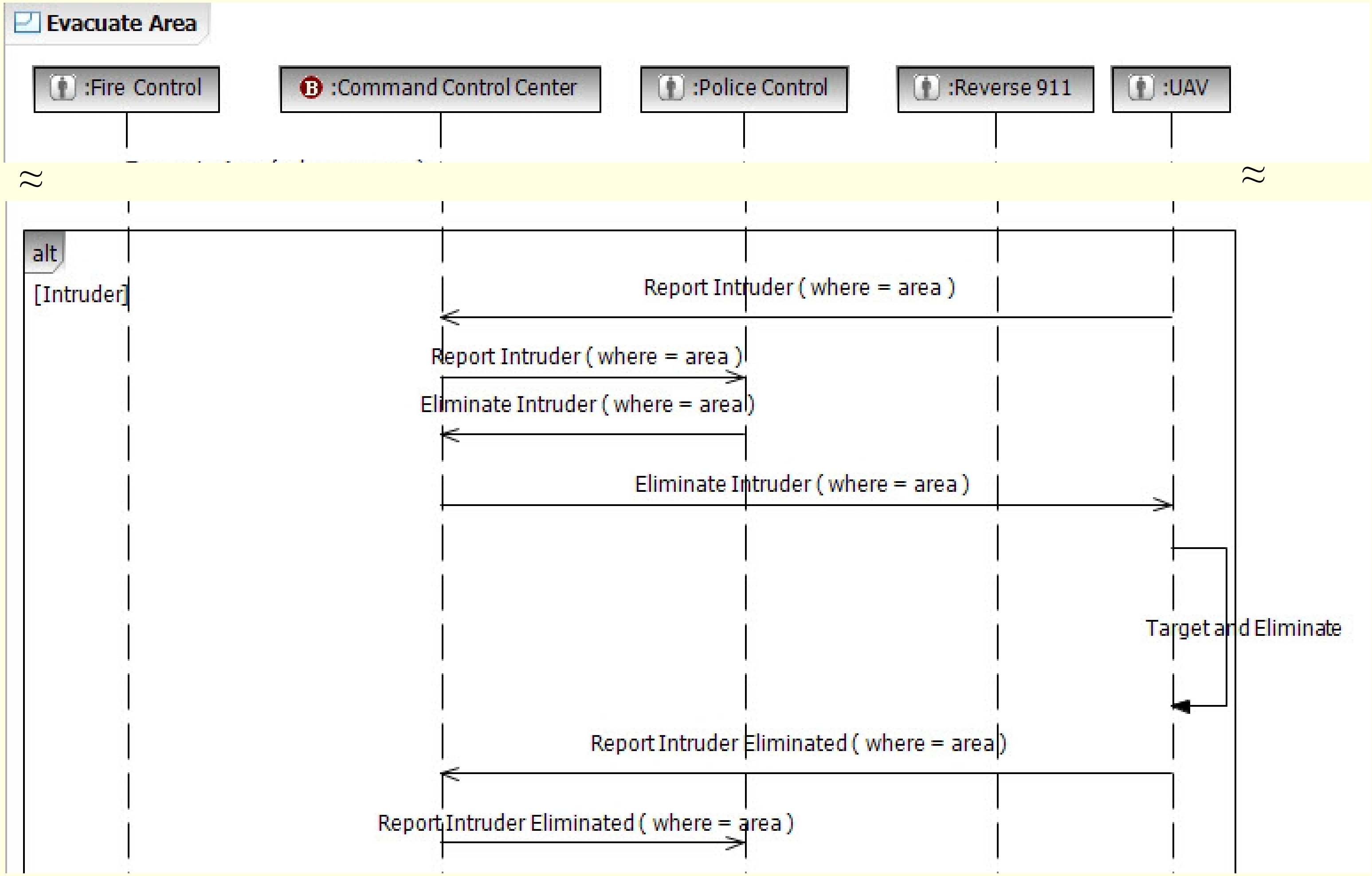
Scenarios: CCC Use Cases



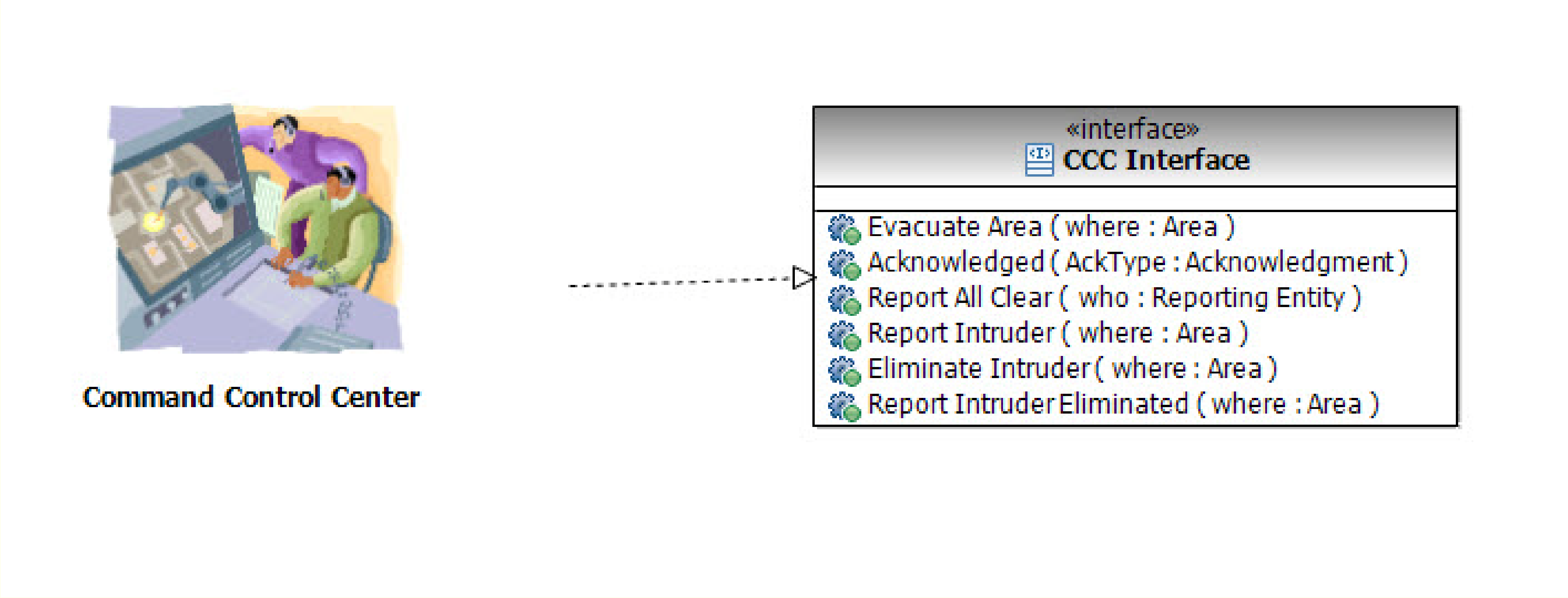
Evacuate Area Sequence Diagram



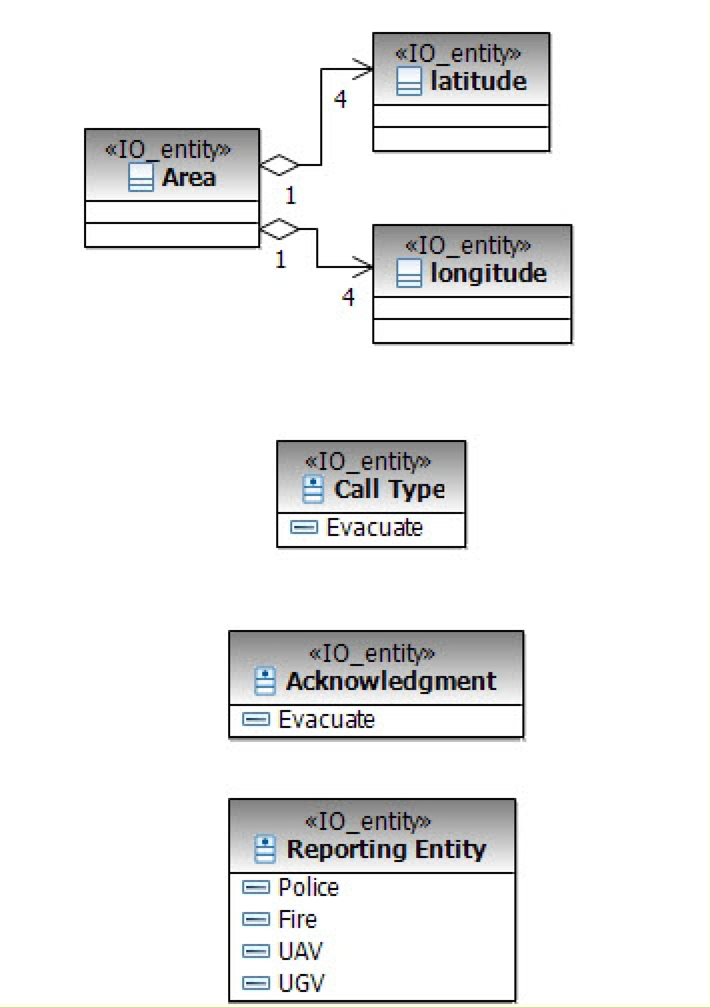
Evacuate Area Alternate Sequence for Intruder "Management"



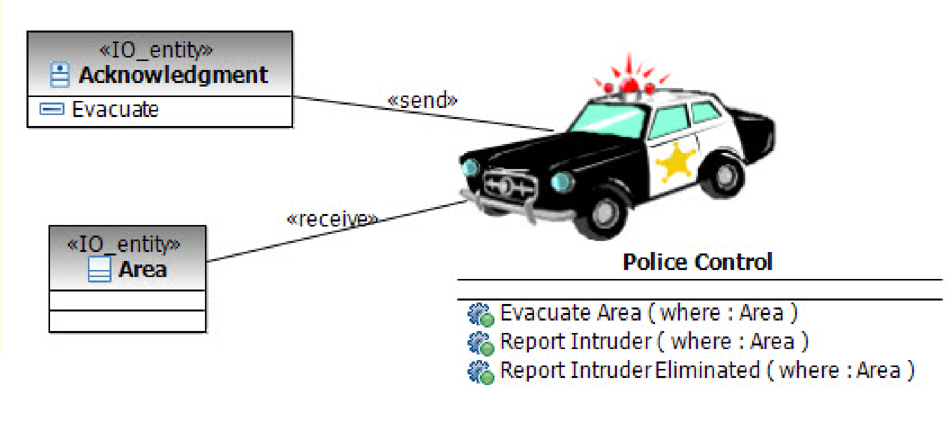
CCC Interface Class

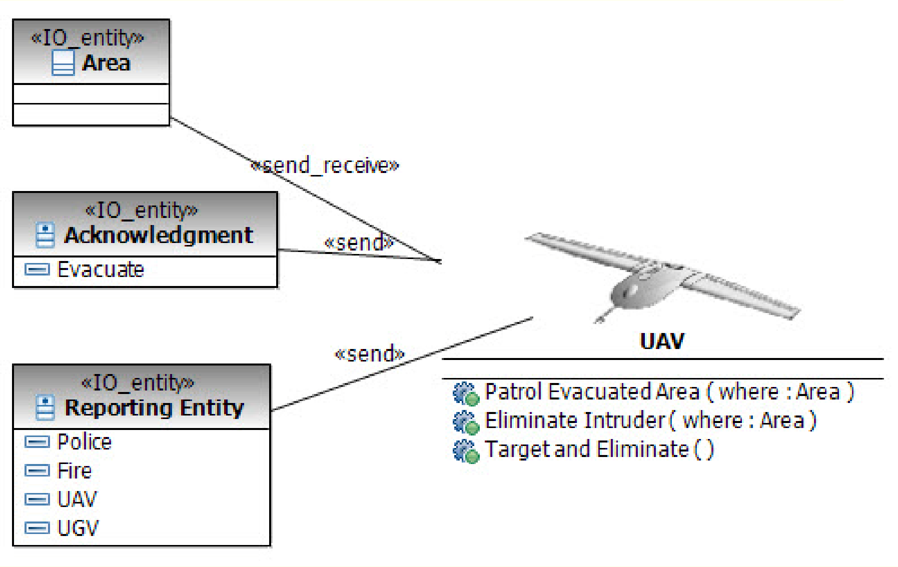


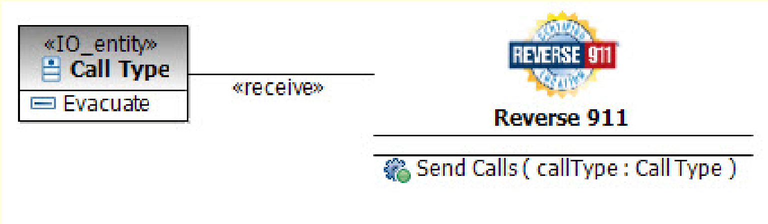
Evacuate Area I/O Entities



Evacuate Area I/O Entities by Actor







Summary and Conclusions

- Recent SoSE research identified need for useful SoSE models
- Goal of presentation to show how SysML models can be used to support some of these needs
  - Context diagrams
  - Use cases
  - Object blocks
  - Interface classes
  - I/O classes

Summary and Conclusions *(continued)*

- Captures information distilled from multiple sources and integrates to provide a “bigger” picture and support
  - End-to-end performance of SoS mission scenarios
  - Evaluate new capability alternatives
  - Evaluate proposed architecture changes
  - Evaluate impacts of proposed CS changes not related to SoS capability changes
- Key to success in modeling SoSs
  - Model only the aspects that are important for the engineering activity
  - Consider using models in new ways, for example I/O classes to capture interface data attribute information

References

- Bohn, T., Nolan, B., Brown, B., Balmelli, L, Wahli, U. (2008); Model Driven Systems Development with Rational Products, IBM Redbooks, DOI=http://www.redbooks.ibm.com/abstracts/SG247368.html?Open
- Dahmann, J., Asrat, W., Rebovich, G., Lane, J., and Lowry, R. (2009); Results of M&S Committee Survey on M&S and SoS SE. In Proceedings of the August 13, 20009 Meeting of the National Defense Industrial Association (NDIA) Modeling and Simulation (M&S) Committee. DOI= http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Modeling_and_Simulation_Committee.aspx
- Department of Defense (DoD) (2008); *Systems Engineering Guide for System of Systems,* version 1.0. DOI= http://www.acq.osd.mil/sse/docs/SE-Guide-for-SoS.pdf
- Maier, M. (1998); “Architecting Principles for Systems-of-Systems”; *Systems Engineering*, Vol. 1, No. 4 (pp 267-284)
- Object Management Group (2008); OMG System Modeling Language (SysML), version 1.1. DOI= http://www.omg.org/spec/SysML/index.htm

System Engineering for Rapid Warfighter Response

Michael Gaydar
NAVAIR-4.1 Systems Engineering, Chief Engineer

Rapid Warfighter Response

The necessary acquisition tasks to rapidly field capabilities needed by the warfighter in response to an Urgent Needs Statements (UNS)

Rapid development will be the balance of urgent needs against performance risk. Procurement, development, operations, and maintenance costs will either be characterized as a wise investment or an acceptable loss. A successful acquisition is based on warfighter satisfaction.

Rapid Development: Tactical Warfighting

Rapid Acquisition: Improvement To Traditional Acquisition

Traditional Acquisition

- Designed to Minimize Risk To Strategic Priorities Of The Services
- Recognizes Design Influence Over Operations And Maintenance Cost
  - 5% of Total Ownership Cost Influences 85%
- Future Needs-Parallel Development With Other Systems For Interoperability
- Risk Mitigation Implemented Through Predictive Analysis
  - Low to Medium Risk Guidance (Nunn-McCurdy)
  - Performance Levels Stressing
  - Predictive Analysis Takes Time & Money
  - Large Complex Project

Rapid vs. Traditional Attributes

Attributes	Rapid Development	Traditional Acquisition
Cost	Non-Optimized Life Cycle Cost Has Little Impact On Budgets	Support & Logistics Cost Minimized To Increase Total Enterprise Capabilities
Performance	Tactical Requirement- Only Impact Of Developmental Failure Is Sunk Cost & Status Quo	Strategic Capability-Failure To Deliver Has Broad Based Impact Across Enterprise
Risk	Current Operational Impact Justifies Risk Acceptance	Threshold Information Required To Accept Risk Requires Time To Develop & Assess
Safety	Current Combat Losses Justify Higher Level Of System Safety Hazards	Reluctance To Accept Inherent System Safety Hazards At Leadership Level
Security	Loss of Information Has Short Term Impact Which Can Be Contained	Loss of Information Has Broad Based Impact Causing Costly Infrastructure Changes

Rapid Development Decision

- Risk vs. Rewards Trade For Tactical Advantage
- Disciplined Process for Project Acceptance
  - Understand Risk In Key Areas
  - Accept The Possibility Of Risk Realization
- Focused or Single Purpose Performance Improvement
- Primary: Technical Risk
  - Performance Threshold Must Be Achievable
  - Performance Failure Will Prevent Fielding of System
- Secondary: Resource Risk
  - Late May Be Good Enough
  - Additional Budget May Be Found If Performance Is Achievable (High Reward vs. Risk Trade)
  - Risk To Ongoing Programs Competing For Personnel, Facilities, and Money

Types Of Rapid Development

- Time, Money, and Effort Determine Leadership Authority Required For Risk Acceptance
- Time And Money Strongly Correlated
  - Small Projects Can Be Absorb At Program Office Level
  - Subsystem Integration or Prototyping Already Managed
    - Moving New or Upgrade Project Left
    - Software Integration Facilities Established
    - Acceptance Procedures Understood
- Large Technically Complex Projects
  - Usually More Than A Year
  - Higher Technical Risk
  - Must Be Followed With Clean-Up Efforts

Rapid Development Level Of Effort

	Rapid Integration	Rapid Prototyping	Rapid Acquisition
Scope	Subsystem Integration	Subsystem Prototyping and Integration	System Architecting and Development
Time Period	30 – 90 Day	90 Day – 1 year	> 1 Year
Cost	< $3M	$3M – $20M	> $20M
Size	Small	Small/Medium	Medium/Large
Requirements	Defined	Flexible	Flexible
Risk	Need Outweighs Risk	Need Outweighs Risk	Risk Accepted
Life Cycle	Less than 3 Year	3 to 7 Year	5-10 Year
Testing	Pilot	Prototype/Pilot	Prototype/First Article
Contracting	In-House	Time & Material	Incentivized Performance
Priority	Medium/High	Medium/High	High

System Engineering & Design

Basic Tenets of Engineering Apply-Large Parallel Effort

Requirements
→ Functionality
→ Allocated Physical Baseline
→ Detailed Design
→ Test

- Resources Allocated
- COTS or NDI Systems Identified-H/W & S/W
- Initial Threshold Performance Identified
- Preliminary Design
- Prototype/First Article Build
- Test
- Delivered Performance Defined
- Supportability & Maintainability
- Risk Identification, Characterization, and Acceptance

What Makes It Rapid

- **Focus On Highest Priorities**
  - Performance, Safety, And Security
- **Minimize Design Impact Of "ilities"**
  - Work Analysis In Parallel
- **Rapid Decision Making**
  - Old Style Chief Engineer Paradigm
  - Prototyping To Support Design
  - Establish Clear Lines Of Engagement & Communication
- **Rapid Risk Acceptance**
  - Mitigation Opportunities Limited
  - User And Leadership Acceptance Of Risk
- **Rapid Contracting**
  - A Priori Contract Vehicles Available

Money Is Not Important

- Money & Accountability Slows The Process
- Commitment To Rapid Development Recognizes Failure & Wasted Dollars
  - Runs Contrary To Basic Financial Management Rules
  - Competition Slows All Procurement Actions
- Must Be Able To Exercise Sole Source Authority
- Smaller Projects-Contracts Already In Place
  - Time & Material Task Order Contracts
  - Support BOAs For Fleet Support
- Government Facilities
  - Depot Modification & Support
  - Fleet Support Teams
  - System Integration Labs-Government SSAs
  - Government Test Facilities

Summary

- Have A Rapid Warfighter Response Culture In Place Before The Need Is Identified
- Established Understanding And Triage For Filtering Request
- Smaller Projects Handled At The Program Level
- Up Front Commitment To Risk Acceptance
  - You May Fail
  - Dollars May Be Wasted
- Engineering Is Still Disciplined
- Rapid Decision Making & Risk Acceptance
- Contracting Still The Largest Hurdle

BACKUP

AFSO21 / D&SWS / Tech Development:

Air Force Initiative – High Confidence Technology Transition Planning Through the Use of Stage-Gates (TD-13)

Oct 09

Dr. Claudia Kropas-Hughes, HQ AFMC/A5S
Mr Randall Bullard, AF/A4L-FVB

Agenda

- Introduction to Air Force Initiative
- Outputs of Initiative
  - Guidebook
  - Automated Tool – *Turbo* Technology Program Management Model (*Turbo*TPMM)
  - OSD/AF Policy Changes
  - MAJCOM Policy Changes
- Next Steps
- Summary

Scope the Initiative

September 2006 GAO report: GAO recommends that DOD strengthen its technology transition processes by developing a gated process with criteria to support funding decisions; expanding the use of transition agreements, …

GAO Report to Congressional Committees, "BEST PRACTICES Stronger Practices Needed to Improve DOD Technology Transition Processes", September 2006. G**AO-06-883**

- **Initiative focuses on Technology Transition process**
  - **Ensure early and complete life-cycle transition planning**
  - **Create a common understanding of the technology transition processes to be applied at all life cycle stages**
- **Initiative goal is improved transition success**
  - **Improved planning using exit criteria enhances probability and speed of the transition, increasing confidence of acquisition programs – *REDUCE PROGRAMMING RISK!***
  - **Key aspect is ensuring the right people are involved earlier for increased collaboration between researcher, acquisition organization, and stakeholders**

Why this is important to the Enterprise

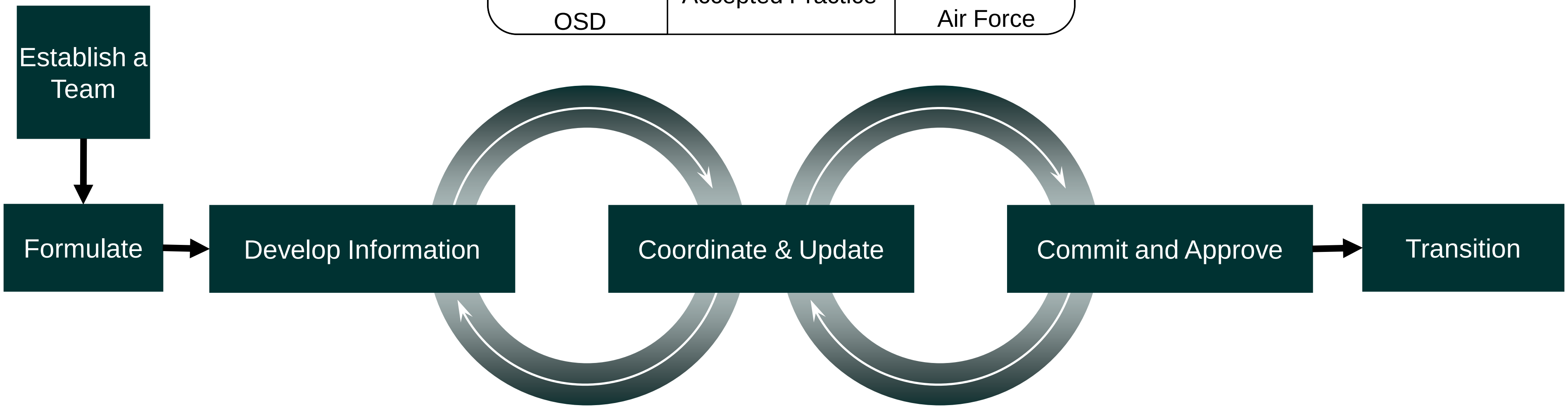
- **We know the best practices (OSD[1]/AF):**
  - **Establish a team / Formulate a strategy / Execute to the strategy (iterating over time) / Begin planning for transition *EARLY***
- **We have a Problem acting on them!**
  - **Stage gate process during technology maturation = facilitate improved planning = increased confidence of transition**
  - **Get the right people involved earlier = better communication and increased collaboration between researcher, acquisition organization, and stakeholders**

[1] OSD Transition Practical Operating Guidelines (TPOG), Version 1.0.
DUSD (AS&C) in accordance with Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)) and Director, Defense Research and Engineering (DDR&E).

Current Best Practice

- **Transition process Iterative w/in technology readiness phases:**
  - **Establish a team, formulate a strategy**
  - **→ Iterate: develop/gather information, document and coordinate agreement, and commitment / approval**

Technology Transition		
OSD	Accepted Practice	Air Force

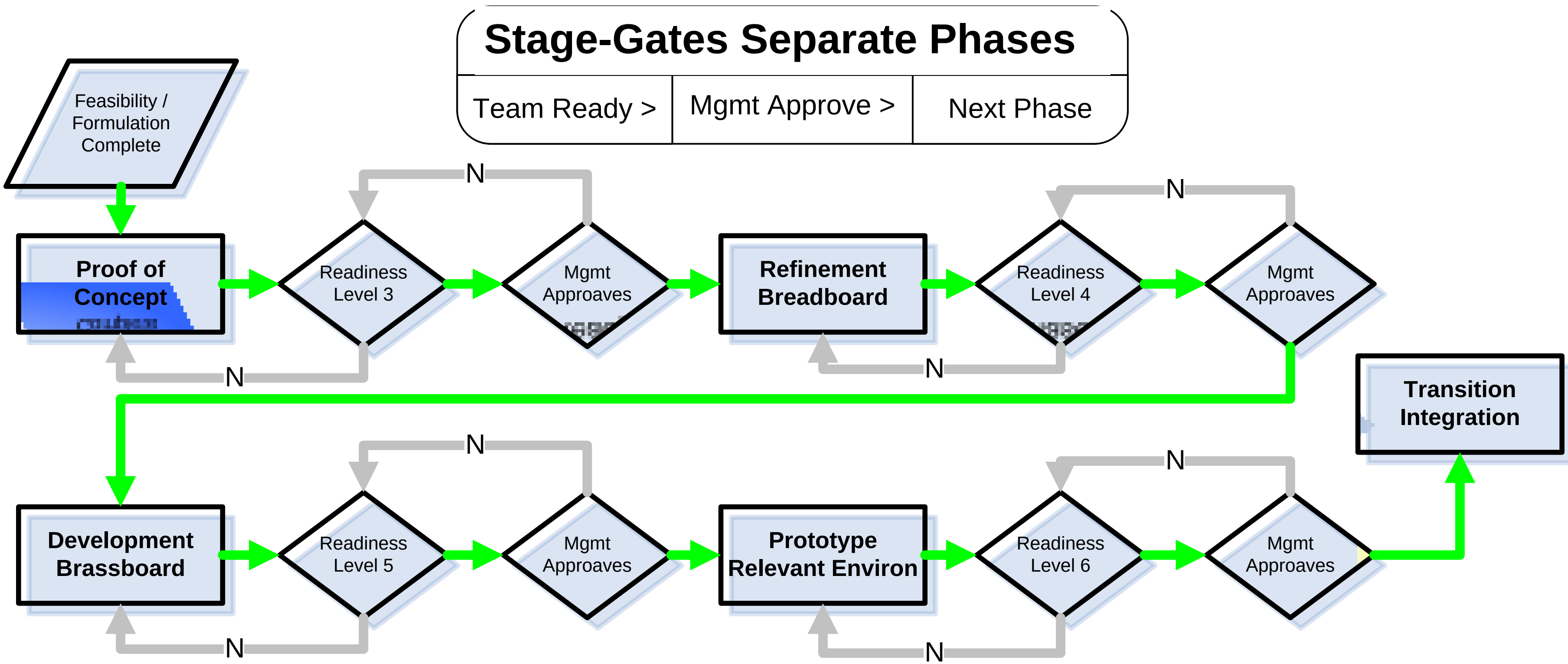


What is “New”?

- Formalized process to develop the ***strategy*** to mature and transition a new technology
- List of detailed activities needed for technology maturation
- Mechanism to ensure a robust execution of the strategy: Stage-Gate process
  - A ***Stage*** is where the activities occurs – the team completes key activities (technology and programmatic) to advance the project to the next gate and focuses on the changing roles and responsibilities
  - A ***Gate*** is a decision point – on whether a project is a go, no-go, re-directed or put on hold (TRL based / driven)
  - The decision is based on ***EXIT CRITERIA*** for each gate

What is "New"?

- **A formalized process, the mechanism (stage-gate criteria) and detailed activities and milestones necessary to transition from phase to phase**



What is "New"?

- Develop a stage-gate process (TRL based/driven)
  - A decision point on whether a project is proceeding as planned and a go, no-go or hold decision is made
  - Phases are: Feasibility, Formulation, Proof of Concept, Breadboard (Lab Env), Brassboard (Relevant Env) and Prototype (Relevant Env)   (TRL3-6)
- Entry/Exit Criteria (tech & programmatic) shall be used prior to advancing to the next stage in the transition process. Highlights change in team roles and responsibilities over time.
  - Use existing readiness levels (TRLs and MRLs), cost, schedule, performance, early "-ilities" considerations (RI3 Guidebook)

TDTS Guidebook

- Instructional document
- "How-to" guide for:
  - Assembling the proper team for each stage
  - Building the strategy to mature and transition a technology
  - Constructing the exit criteria for the gates
  - Executing the stage-gate process
  - Developing and staffing the required documentation
- TDTS documentation:
  - Replaces TTP / leverages other "early" documentation
  - TDS is subset of TDTS required at Milestone A
  - TDTS document "morphs" to LCMP at Milestone B

Today's Process

- **Stovepipe Document Generation: TTP : TDS : LCMP**

Owner:
AFRL Technology Developer, pre MS-A

Tech Transition Plan (TTP)
- Signature Page
- Development Strategy
  - Participants
  - Tech Availability
  - Program Objectives
  - Target Acq Programs
  - Approach
  - Products / Payoff
  - Risk Analysis
  - Exit Criteria / RL
- Acquisition Strategy
  - Identify Stakeholders
  - Capability / Rqmts
  - Bus/Contract/Fin
  - Logistics / Mfg
  - Intelligence
- Transition Strategy
  - Integration Plan

Owner:
Acquisition PM @ MS-A

Tech Development Strategy (TDS)
(Public Law 107-314, Sec 803)
- Acquisition Approach
  - Supporting Rationale
- R&D Strategy
  - Performance Goals
  - CSP and Spirals
- Describe Tech Demo
  - CSP and Exit Criteria
- Develop Test Plan
  - Goal / Exit Criteria
  - Ensure Maturity Level

Note: Multiple Spirals may be necessary before user & developer agree the solution is: Affordable, Military Useful and based on mature technology

Owner:
Acquisition PM @ MS-B

LCMP
- Exec Summary
- Mission/Rqmts
- Program Summary
- Program Mgmt
- Business Strategy
- Risk Mgmt
- Cost and Performance Mgmt
- Test Approach
- Product Support Concept

Note: TDS required at MS-A, but often Milestone not held

To Be Process

- **Tech Development & Transition Strategy (TDTS)**
  - **Replaces the TTP**
  - **TDS is subset of TDTS required at Milestone A**
  - **As program progresses – TDTS "Morphs" to LCMP**

Owner: Acquisition PM

Tech Development & Transition Strategy (TDTS)
- Replaces TTP, *but a gated approach defining depth required at each phase*.
- Integrated Strategy (Technology Development and Acquisition)
- Example: As team approaches:
  - MS-A (TRL-4) – Gates/checklist ensures TDS is complete
  - MS-B (TRL-6) – Gates/checklist ensures LCMP is complete

Subset

Tech Development Strategy (TDS)
(Public Law 107-314, Sec 803)
- Acquisition Approach
  - Supporting Rationale
- R&D Strategy
  - Performance Goals
  - CSP and Spirals
- Describe Tech Demo
  - CSP and Exit Criteria
- Develop Test Plan
  - Goal / Exit Criteria
  - Ensure Maturity Level

Becomes

LCMP
- Exec Summary
- Mission/Rqmts
- Program Summary
- Program Mgmt
- Business Strategy
- Risk Mgmt
- Cost and Performance Mgmt
- Test Approach
- Product Support Concept

TDTS Development Process

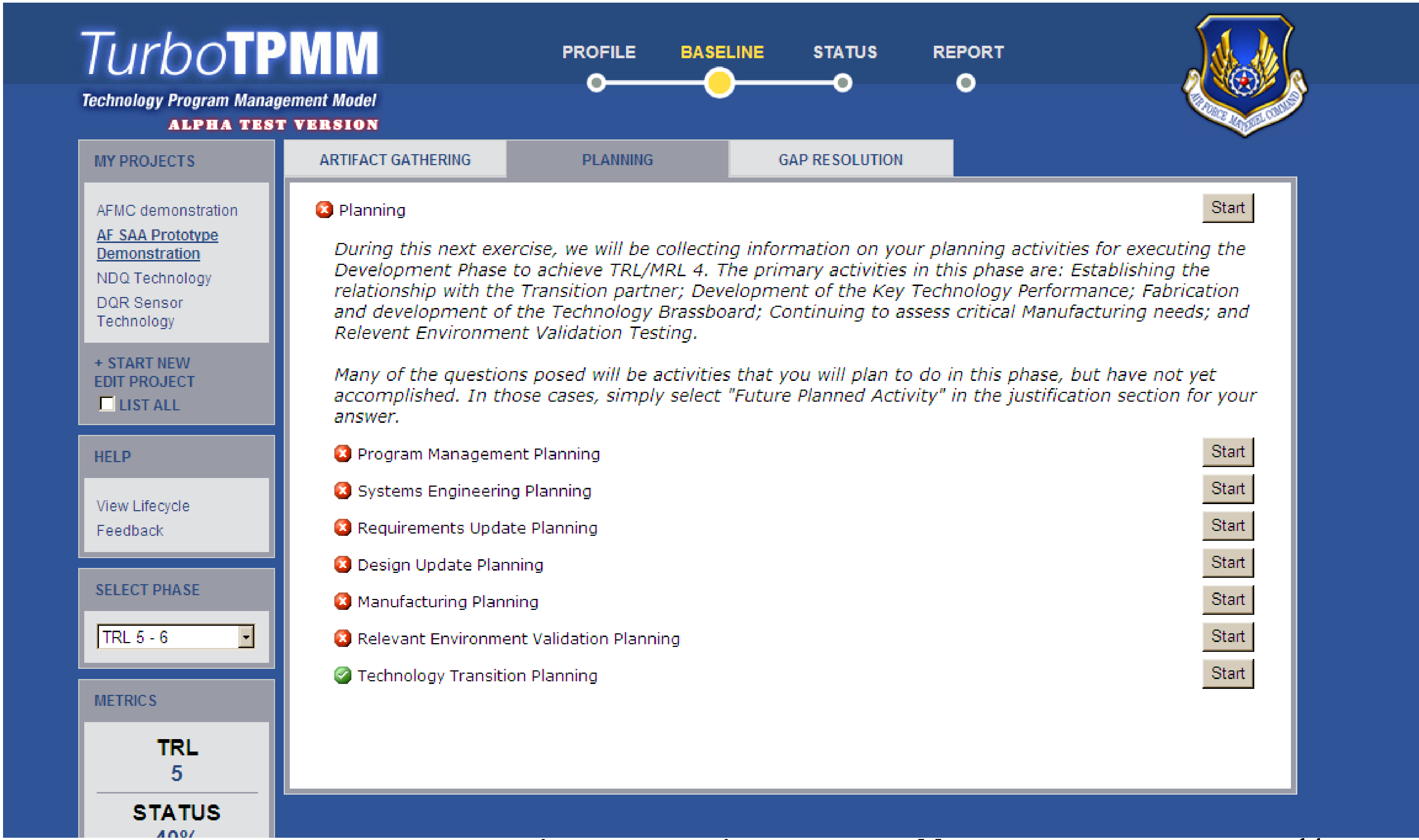
- Power of the Process is in Teamwork
  - Having the right people on the team at the right time – Chaired by Program Manger and Co-Chaired by Technology Manager
- Process will apply to all programs with technology maturation
  - Team planning for the life-cycle of the new technology
  - Stage-gate process to evaluate programs during the tech maturation
    - Provides comprehensive decision support for management!

Tool Description - *Turbo*TPMM

- Facilitates development of the "Transition Strategy" for Tech Maturation and Transition
- USAF added graphic user interface to model
- The *Turbo*TPMM S/W tool features:
  - Automates the stage-gate process
  - Easy to use, walks user through the process
  - Turbo-tax© like graphic user interface
  - Questions aligned with acquisition framework
  - Ensures application of Systems Engineering
  - Follows Project Management fundamentals
- DAU also Collaborating with TurboTPMM

Designed to Ask the "Right" Question at the "Right" Time

*Turbo*TPMM – Baseline Planning



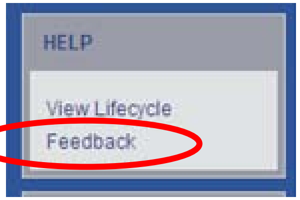
Enterprise Interface Opportunities

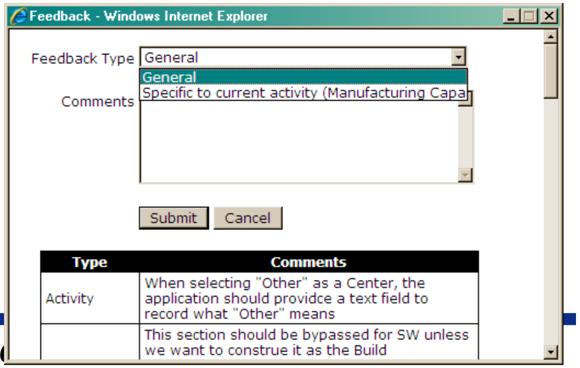
- ADDM
  - ADDM Focused on Acquisition
  - *Turbo*TPMM focused on technology maturation
  - Software efforts are good fit
  - Interface opportunities with ADDM include:
    - Providing technology maturation templates
    - Sharing reference models for key milestones
- SMART
  - Possibly include tech maturation status in MAR
  - Next step is to interface w/ PMO
- Clarity
  - AFRL program management trusted source for data

*Turbo*TPMM

- Gunter AFB is hosting “alpha” version of *Turbo*TPMM
  - URL: https://www.tdr.gunter.af.mil/GCSS-SBX031
    - UserName: TPMM.testuser
    - Password: P@$$word1234!@#$
  - IMI: model training

- *Turbo* welcomes feedback
  - Alpha version w/ no real data
  - Feedback allowed via button





Policy Changes

- DoDI 5000.02, published December 8, 2008
  - Interim Defense Acquisition Guidebook (DAG), June 2009 – includes exit criteria requirement
- SAF/AQR Guidance Memorandum, May 12, 2009
  - Tech maturation and transition strategy requirement
  - Exit criteria for each phase requirement

Policy Plans for Institutionalization

- **TDTS (described in Guidebook) = framework for standard work process**
- **Implementation of TDTS process through policy: AFIs and MAJCOM Instructions**
  - **SAF/AQR/AQX to identify AFIs for updates**
  - **AFMCIs identified for update**
    - AFMCI 61-102 *Advanced Technology Demonstrations Technology Transition Planning*
    - (New) AFMCI 61-103 *Management of Science and Technology*
    - AFMCI 63-1201 *Implementing Operational Safety Suitability And Effectiveness (OSS&E) And Life Cycle Systems Engineering*
  - **Relevant AFSPCIs**
    - **Weekly telecoms with AFSPC/A5**

Policy Changes

- If team follows stage-gate process, they will always be able to answer where they are today and how long to agreed to transition point
  - Supports MS-briefings and PDR shift to Tech Development
  - Provides information for Sufficiency Reviews
  - Make Milestone B TRA easier - less obtrusive

Next Steps

- Perform “pilots” of the TDTS development
  - To facilitate understanding the TDTS process with specific program teams
  - At completion of pilots – finalize the TDTS Guidebook
- Initiate AF/AFMC/AFSPC policy updates Feb 2010

Feedback Welcome on all Products

TDTS Guidebook:

Available on DAU Acquisition Community Connection (ACC)
https://acc.dau.mil/CommunityBrowser.aspx?id=314696&lang=en-US

*Turbo*TPMM:

Gunter AFB is hosting "alpha" version of *Turbo*TPMM
URL: https://www.tdr.gunter.af.mil/GCSS-SBX031
UserName: TPMM.testuser
Password: P@$$word1234!@#$

RI3 Guidebook:

Risk Identification: Integration & Ilities (RI3) Guidebook
Version 1.2, 15 December 2008.
Available by request from SAF/AQRE:
safaqre.workflow@pentagon.af.mil .

TDTS Guidebook

- Easy to read and understand strategy development for technology transition using stage-gates
  - Description of stage-gate process
    - Describes the phases for technology maturation (TRL/MRL based)
    - Highlights the transition process and iterative nature within each phase
    - Explains how the stage-gate criteria (for Team and Mgmt) helps to move from phase to phase using latest assessment criteria
  - Description of what people have to do to navigate the process – roles and responsibilities

The George Washington University

LOCKHEED MARTIN

A Review and Analysis of Maturity Assessment Approaches for Improved Defense Acquisition Decision Support

2009 NDIA 12th Annual
Systems Engineering Conference
San Diego, CA
October 26-29, 2009

Nazanin Azizian

Presentation Overview

1. Introduction
2. GAO Major DoD Program Assessments
3. Knowledge Gaps
   - *A. Basis*
   - *B. Consequences*
   - *C. How to Close*
4. Congressional Policy
5. Technology Maturity
   - *A. Technology Readiness Assessment (TRA)*
   - *B. Technology Readiness Level (TRL)*
   - C. TRL Limitations
6. Introduction to Other Tech Maturity Assessment Methods
7. SWOT (Strength, Weakness, Threat, Opportunity) Analysis
8. Conclusions & Recommendations

Introduction

GWU

The Department of Defense (DoD) acquisition programs have a long history of experiencing various forms of risk

DoD is experiencing consequences of risk in the form of:

- **Cost overruns**
- ***Late deliveries***
- ***Failure to meet performance requirements***
- ***Program delays***
- ***Program cancellations***
- ***Failure to deliver promised capabilities***

Underlying causes of risk:

- **Unrealistic performance expectations**
- ***Unrealistic baseline estimates for cost or schedule***
- ***Immature technologies***
- ***Evolving requirements***
- ***Changes in procurement quantities;***
- ***Funding instability;***

GAO, "Defense Acquisitions: Assessments of Selected Weapon Programs," U.S. Government Accountability Office, vol. GAO-08-467SP, GAO, Ed, 2008

GAO Assessments and Findings

GWU

GAO assessments of Acquisition Programs concluded that risk in poorly performing DoD programs result from <u>not possessing the knowledge</u> required to achieve a successful design at key points during development.

Knowledge gaps result in DoD programs moving forward without sufficiently:

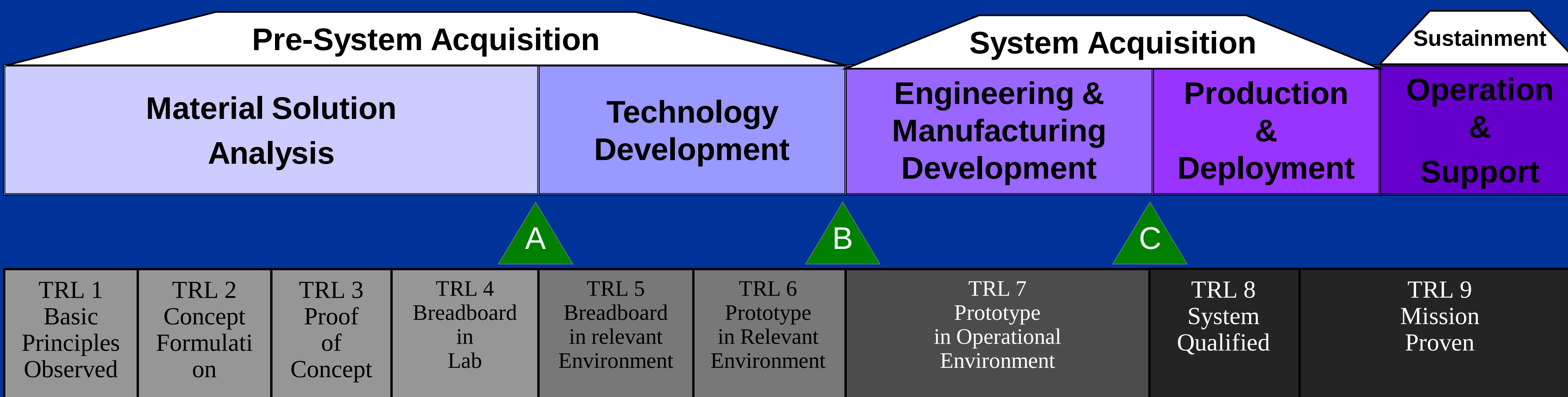
- *Maturing the new technologies,*
- *stabilizing the design, or*
- *maturing the manufacturing processes*

Multiple assessments (2000-2008) of the DoD acquisition portfolio concluded a <u>strong correlation</u> between delayed knowledge points and poor performance.

TRL Relationship to System Acquisition Milestones

DoD requires maturity assessment certification as entrance criteria for milestones B & C

Milestone B = TRL 6
Milestone C = TRL 7

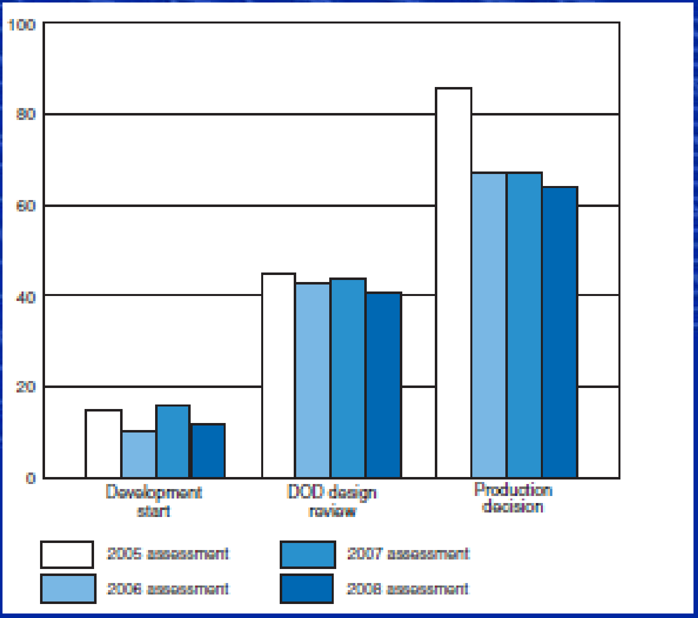


Relationship to Technology Readiness Levels

2008 GAO Assessment of 72 Weapons Programs

- **12%** began system development with fully mature critical technologies
- **4%** had demonstrated design stability before entering system demonstration phase
- **No** program had fully matured their production processes before entering production

Analysis of DOD Major Defense Acquisition Program Fiscal year 2008			
	Fiscal Year		
	2000 Portfolio	2005 Portfolio	2007 Portfolio
Number of Programs	75	91	95
Total Planned Commitments	$790 Billion	$1.5 Trillion	$1.6 Trillion
Commitments Outstanding	$380 Billion	$887 Billion	$858 Billion
	Portfolio Performance		
Change to total RDT&E costs from first estimate	27%	33%	40%
Change in total acquisition cost from first estimate	6%	18%	26%
Estimated total acquisition cost growth	$42 Billion	$202 Billion	$295 Billion
Share of programs with 25 percent or more increase in program acquisition unit cost	37%	44%	44%
Average schedule delay in delivering initial capabilities	16 Months	17 Months	21 Months



Percentage of Programs Achieving Technology Maturity at Key Junctures

Best Practices: Assessment of Selected Weapons Programs. GAO-08-467SP Washington, DC.: March 2008.

Basis of Knowledge Gaps

GWU

Why do DoD programs enter various phases of acquisition and product development with knowledge gaps?

- Organizational drive for better, faster, cheaper warfare technologies
- Program risk management strategies allow for inherent risk
- Program financial methods punish delays in program start date

Why do DoD knowledge gaps result in design, technology, and production risks?

- Risk is typically underestimated by organizational leaders
- Programs take risk to maintain production start date to avoid political risks of delay (loss of funding)

System development challenges:

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

How to Close the Knowledge Gap

GWU

1999 - GAO) stated in report that

> ***"Program managers' ability to reject immature technologies is hampered by (1) untradeable requirements that force acceptance of technologies despite their immaturity and (2) reliance on tools that fail to alert the managers of the high risks that would prompt such a rejection." GAO/NSIAD-99-162***

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**

ACQUISITION TECHNOLOGY AND LOGISTICS

'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, Unites 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 MBA 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.

Kenneth rie g

Attachment:
As stated

Technology Readiness Assessment (TRA)

GWU

A TRA is a systematic, metrics-based process and accompanying report

The TRA assesses the Maturity of Critical Technology Elements

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)

GWU

What is TRL?

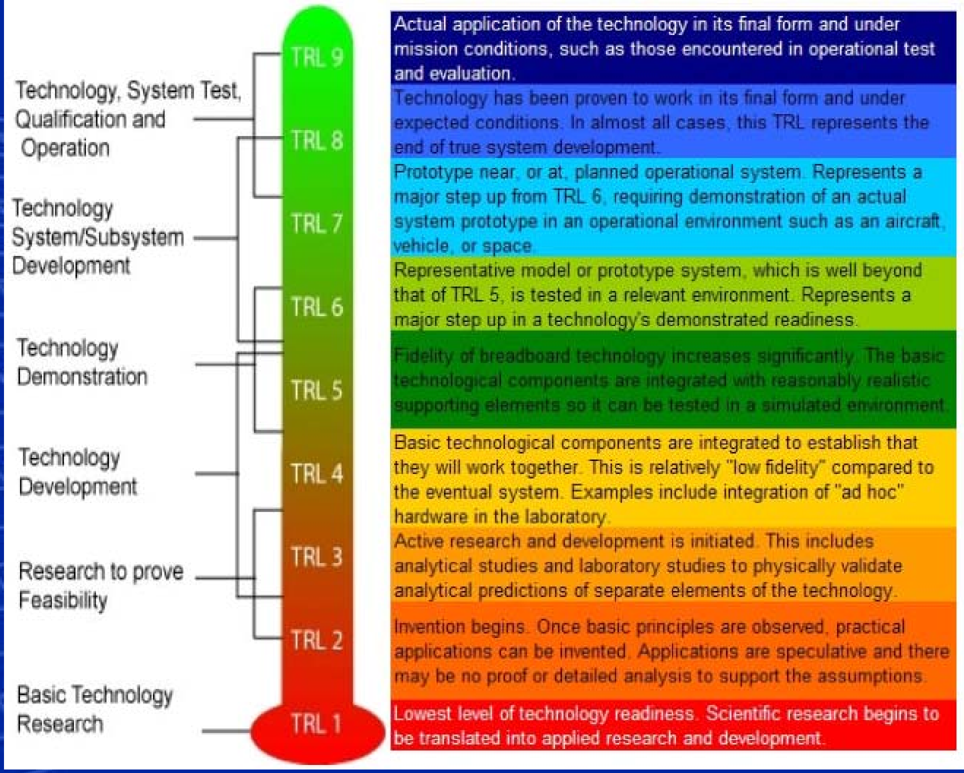
- Technology Readiness Level (TRL) is a 9 tier metric that systematically assess the maturity of a technology with respect to a particular use
- Pioneered by NASA in 1980's and adopted by the DoD in 2001

Purpose of TRL

- Provides a common language for understanding the developmental status of a technology to date
- Indicates the development maturity of a technology at a particular point in time

TRL is *not for suitability*

- Does not indicate that the technology is right for the job or that application of the technology will result in successful development of the system



Milestone B = TRL 6
Milestone C = TRL 7

TRL Limitations

GWU

- Subjective Assessment - there exist no formal guideline of implementing TRLs; the TRL value is assigned to technology by a technology developer who may be biased; the definitions of each TRL level is prone to broad interpretation
- Not focused on system-to-system integration - TRLs focus on a component of a technology and when infusing the particular component with other in a larger scale, imperative integration concerns come forth
- Lacking in definition of terminology - the definitions of each TRL level can be ambiguous and reliant on an individual's interpretation
- Combines many dimensions of technology readiness into one metric
- Lacks accuracy and precision
- Conveys the status of technology readiness on a single scale at a particular point in time – does not foretell the possibility and difficulty of further maturing technology to higher TRL levels.

Rational for Other Methods

GWU

TRLs are insufficient because they do not take into account many of DoD's system development needs

- ***large quantity manufacturing***
- ***Integration and rapid obsolescence***
- ***Increased system-of-system centricity***

To offset some of these issues, other models, tools, and methods have been developed

- ***GOAL - introduce objectivity and address the overlooked facets of technology maturity that have been omitted by the TRL***

Qualitative Techniques

GWU

Tool	Description
Manufacturing Readiness Level (MRL)	The MRL is a 10 level scale used to define current level of manufacturing maturity , identify maturity shortfalls and associated risks, and provide the basis of manufacturing maturation and risk management (Cundiff 2003).
Integration Readiness Level (IRL)	The IRL is a 9 level scale intended to systematically measure the maturity, compatibility, and readiness of interfaces between various technologies and consistently compare interface maturity between multiple integration points. Further, it provides a means to reduce the uncertainty involved in maturing and integrating a technology into a system (Gove 2007).
TRL for non-system technologies	Expansion of the TRL definitions to account for non-system technologies such as processes, methods, algorithms, and architectures (Graettinger et al 2002).
TRL for Software	Expansion of the TRL metric to incorporate other attributes specific to software development (DoD TRA Deskbook 2005).
Technology Readiness Transfer Level (TRRL)	The TRRL is a 9 level scale describing the progress of technology transfer to a new application. It expands and modifies the TRL definitions to address the transfer to space technology into non-space system (Holt 2007) .

Tool	Description
Missile Defense Agency Checklist	A tailored verstion of the TRL metric specifically in support of hardware maturity through the development life-cycle of the product (Mahafza 2005).
Moorhouses Risk Versus TRL Metric	A 9 level metric mapping risk progression analogous to technology maturity progression. The TRL descriptions are tailored specifically toward UAV (Moorehouse 2002).
Advanced Degree of Difficulty (AD2)	Leveraging the concept of RD3, the AD2 augments TRLs by assessing the difficulty of advancing a technology from its current level to a desired level on a 9 tier scale (Bilbro 2007).
Research and Development Degree of Difficulty (RD3)	The RD3 is a 5 level scale intended to supplement the TRL by conveying the degree of difficulty involved in proceeding from the current TRL state to desired level, with 5 being very difficult and 1 being least difficult to mature the technology (Mankins 1998).

Quantitative Techniques

GWU

Tool	Description
System Readiness Level (SRL)	The SRL is a normalized matrix of pair-wise comparisons of TRLs and IRL of a system. It is a quantitative method providing insight into system maturity as a product of IRL x TRL (Sauser et al. 2006, 2007, 2008) .
SRL Max	The SRL Max is a quantitative mathematical model aiming to maximize the SRL under constraint resources. The objective of the SRLmax is the achievement of the highest possible SRL based on the availability of resources such as cost and schedule (Ramirez-Marquez et al. 2009).
Technology Readiness and Risk Assessment (TRRA)	TRRA is a quantitative risk model that incorporates TRLs, the degree of difficulty (RD3) of moving a technology from one TRL to another, and Technology Need Value (TNV). The TRRA expands the concept of the risk matrix by integrating "probability of failure" on the y-axis and "consequence of failure" on the x-axis (Mankins 2007).
Integrated Technology Analysis Methodology (ITAM)	ITAM is a quantitative mathematical model that integrates various system metrics to calculate the cumulative maturity of a system based on the readiness of its constituent technologies. The system metrics include TRLs, delta TRL, R&D Degree of Difficulty (R&D3), and Technology Need Value (TND) (Mankins 2002).

Tool	Description
TRL for Non-Developmental Item (NDI) Software	A mathematical method to assess the maturity of Non-Developmental Item (NDI) software using orthogonal metrics in combination with a pair-wise comparison matrix to examine two equivalent technologies that are candidate for insertion into a system. Incorporate other attributes such as requirement satisfaction, environment fidelity, criticality, product availability, and product maturity (Smith
Technology Insertion (TI) Metric	TI involves the integration of various metrics that deal with insertion of technology and subsystems into a current system in order to develop an "enhanced system." The TI Metric is a high level metric computed from sub-metrics or dimensions intended to evaluate the risk and feasibility of technology insertion from a subsystem and a system level (Dowling and Pardo 2005).
TRL Schedule Risk Curve	This is a quantitative model that does not communicate the maturity of technology at a certain point in time but instead leverages the TRLs metric to identify the appropriate schedule margins associated with each TRL level in order to metigate schedule slipps (Dubos et al. 2007).

Automated Techniques

GWU

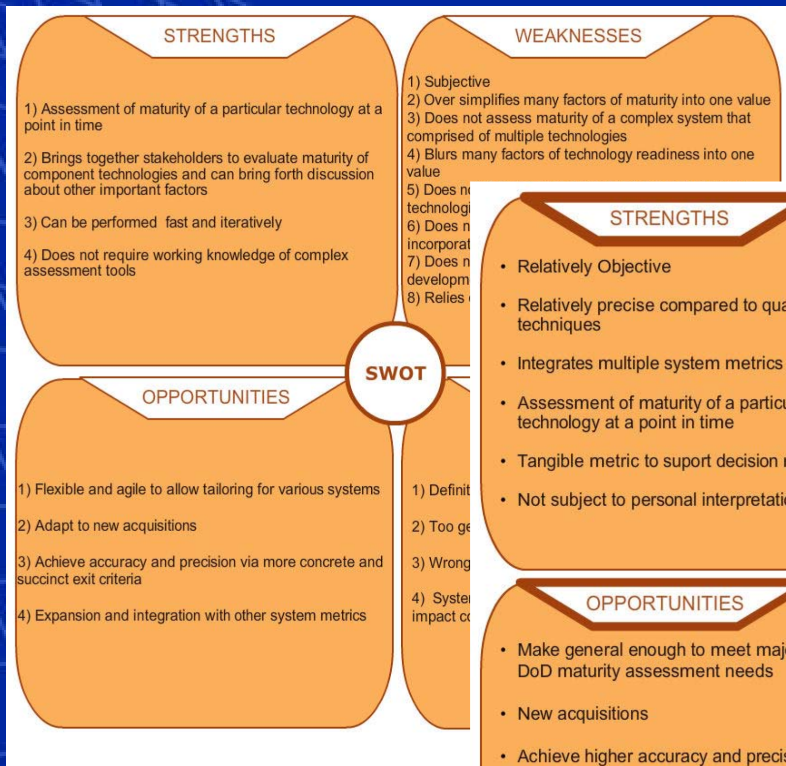
Tool	Description
Technology Readiness Level (TRL) Calculator	Microsoft excel based tool that enables the application of the TRL definitions to technology development. The calculator computes a TRL level based on the answers to a series of questions by the user and displays the output graphically (Nolte 2004).
Manufacturing Readiness Level (MRL) Calculator	Microsoft excel based tool that enables the application of the MRL definitions to technology development. Computes the MRL level based on answers to a series of questions in various threads related to manufacturing readiness.
Technology Program Management Model (TPMM)	TPMM is a technology-development activity model, partitioned into phases that are gate qualified using the TRLs. The model defines each TRL as a stage and establishes exit criteria (gate) for each stage of TRL. Each TRL stage has an associated checklist of activities that must be achieved before succeeding to the next stage. The TPMM is comprised of seven technology development phases (SMDTC 2006).
UK MoD Systrem Readiness Level	Captures key outputs from th nine levels of product development depicted by the Systems Engineering V-model in an excel-based tool. These outputs are confined and tracked in a matrix. Each output is evaluated on a 9 level SRL scale (http://www.ams.mod.uk/aofcontent/tactical/techman/content/srl_whatarethey.htm)

SWOT

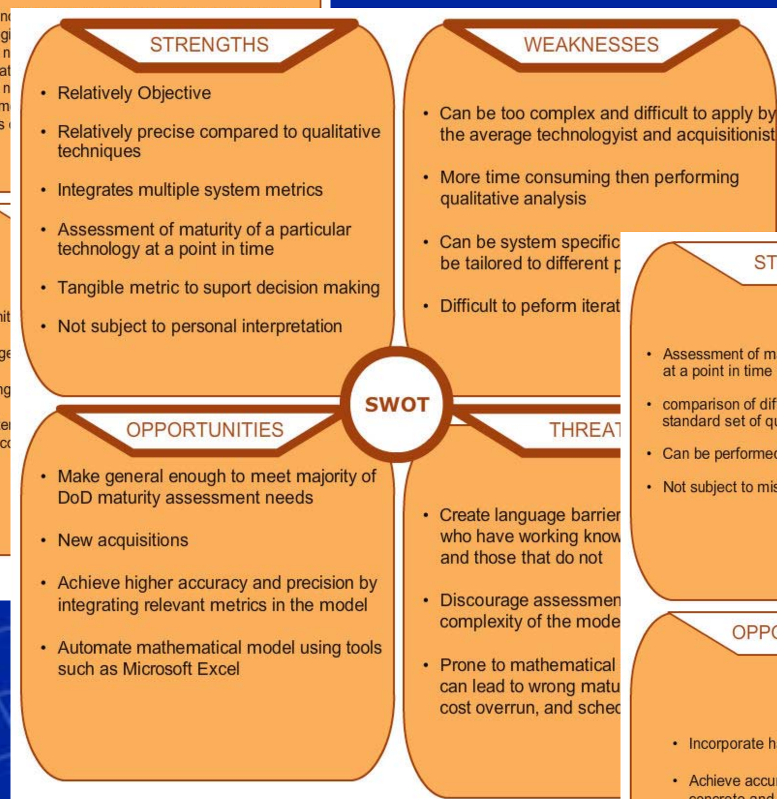
(Strength, Weakness, Opportunity, Threat)

GWU

Qualitative Tools



Quantitative Tools



Auto Tools

Conclusion & Recommendations

GWU

Evaluation of technology maturity is critical because it provides insight into technical and programmatic risk by:

- *Establishes milestones to track development progress*
- *Establishes entry and exit criteria for various milestones*
- *Provides direction for risk management and mitigation*

Objective and robust methods that can assess technology maturity accurately improve acquisition outcome

The success of programs depend on consistent and holistic evaluation of system maturity via a robust, repeatable and agile method

“Every dollar spent on inefficiencies in acquiring one weapon system is less money available for other opportunities.” (GAO 2006)

Designing Collaborative Systems of Systems in support of Multi-sided Markets

Philip Boxer,
Software Engineering Institute
Dr Nicholas J. Whittall,
Thales UK Aerospace

12th NDIA Annual Systems Engineering Conference, 28th October 2009

Working within Ultra-Large-Scale (Eco)Systems*:

Analysis needs to be done across different scales

‘Large-scale’ Analysis
‘multi-sided’ analysis of the deployed force relationship to demand

Establishing economics of alternative ways of delivering force cohesion ‘at the edge’
(e.g. through the use of Tactical UAVs)

‘Medium-scale’ Analysis
fitting together multiple stakeholders’ perspectives on how particular systems of systems support missions

Identifying the interoperability risks across multiple parts of the SoS
(e.g. AWACS modernisation)

‘Small-scale’ Analysis
establishing operational performance of software-reliant systems and sensors

Analyzing end-to-end asynchronous sensor and data fusion processes
(e.g. Multi-Sensor Integration)

The challenge is sustaining operational alignment across the different scales

* Containing large numbers of managerially and operationally independent systems

Outline

1. Engineering in support of an operational space: the need for agility

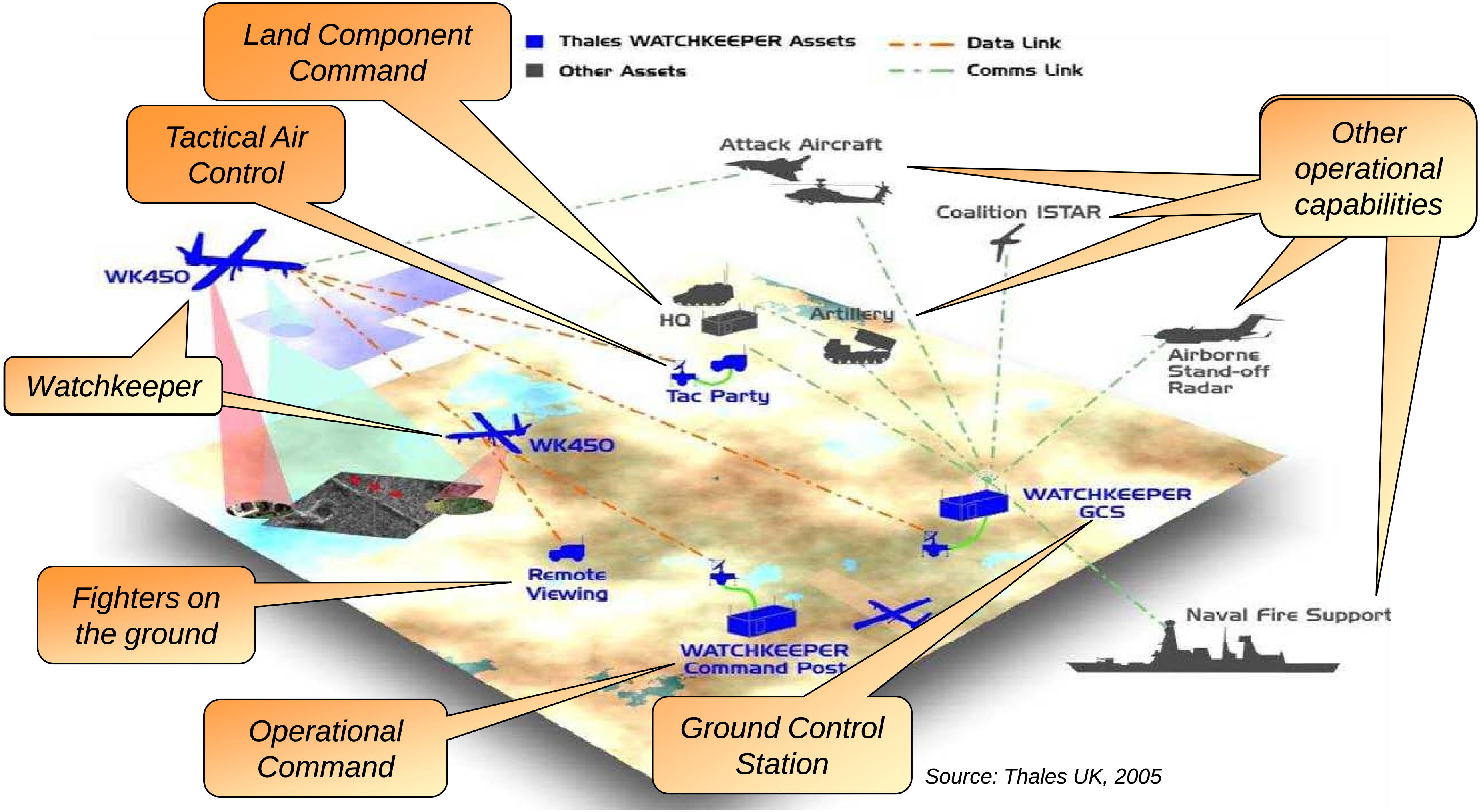
2. Engineering for a multi-sided market: the need for two kinds of value

3. Engineering two kinds of value: creating value for defense

Defining the relationship between the design space for an operational capability and the operational space within which it will be used

ENGINEERING IN SUPPORT OF AN OPERATIONAL SPACE: THE NEED FOR AGILITY

Defining the Operational Space for Tactical UAV:
The Watchkeeper CONOPS



Source: Thales UK, 2005

The evolving definition of an Operational Capability: The example of Tactical UAV

Phoenix and Watchkeeper UAVs were conceived as extensions to existing concepts of operation:

– Phoenix (TUAV 1) provided better target acquisition for Multiple Launch Rocket System (MLRS)

– Watchkeeper (TUAV II) provided better servicing of a Commander's Critical Information Requirements (CCIR)

For TUAVs I & II, the primary focus was on the required capabilities of the **system** in a ***design space***.

The evolving definition of an Operational Capability: The example of Tactical UAV

Phoenix and Watchkeeper UAVs were conceived as extensions to existing concepts of operation:

- Phoenix (TUAV 1) provided better target acquisition for Multiple Launch Rocket System (MLRS)
- Watchkeeper (TUAV II) provided better servicing of a Commander's Critical Information Requirements (CCIR)

For TUAVs I & II, the primary focus was on the required capabilities of the **system** in a ***design space***.

The Urgent Operational Requirement (UOR) in Iraq and Afghanistan was for the close coupling of UAV capability to fighters on the ground reflected an increased campaign tempo, and the need for greater tactical agility (TUAV III

For TUAV III, the focus shifted to the **variety of demands** on the way the system could be used in the ***operational space***.

The demand for greater tactical agility: the example of mission situations involving the interdiction of fleeting targets

Controlling issue

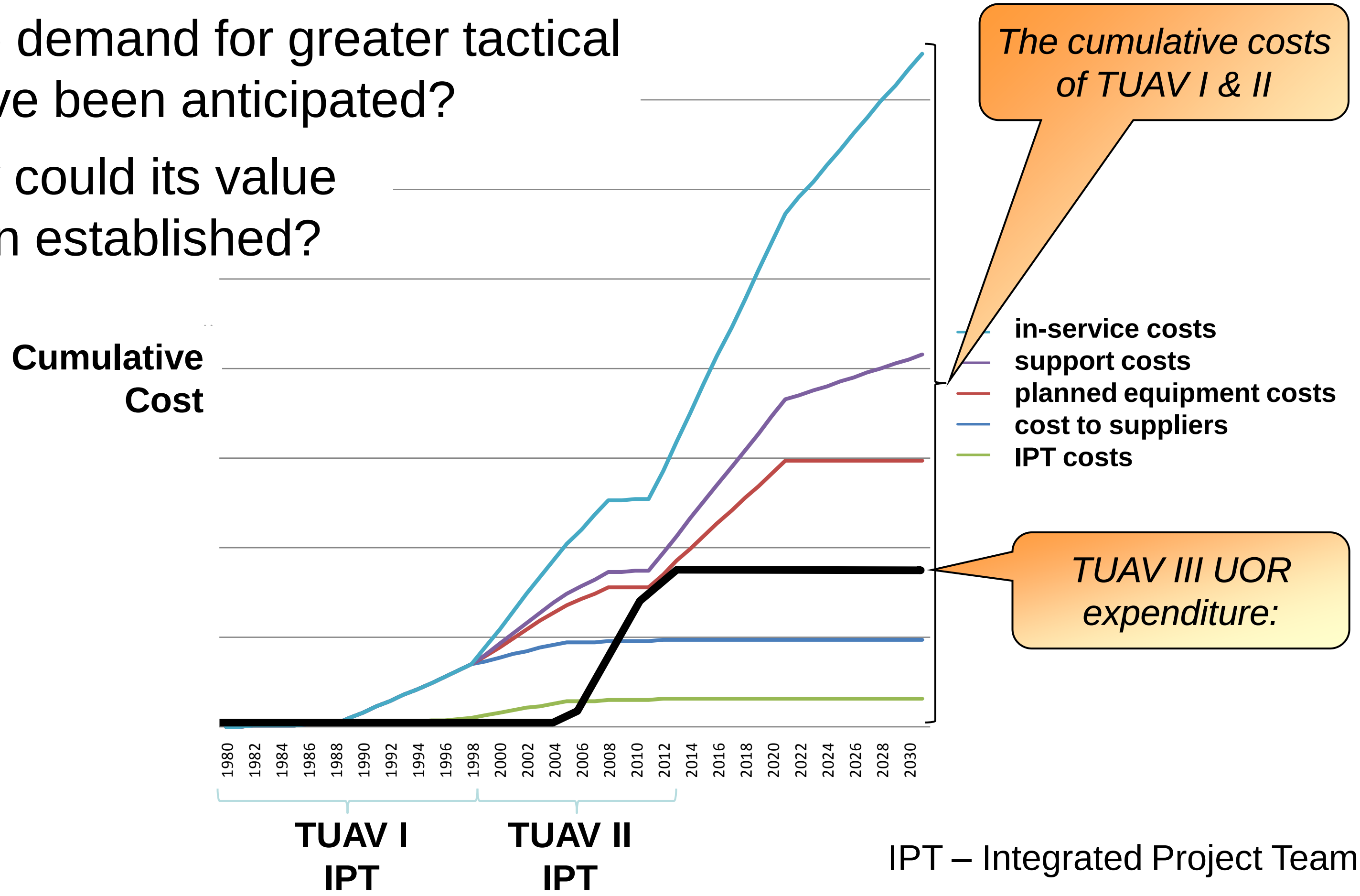
Hard to see, effects easy	*Hard to see, effects difficult*	*Easy to see, effects difficult*	**Mission Situations**
X			**Individual in Afghan-Pakistan border**
X			*Disrupts terrorist command*
	X		**Individual in Kabul Blue Zone**
	X		*Disrupts terrorist command*
	X		**Stinger Missiles in Baghdad City Centr**
	X		*Neutralization of manoeuvrist threat*
		X	**Shoot-and-Scoot in Tribal Lands**
		X	*Neutralization of manoeuvrist threat*
X			**Terrorist Escape by Sea**
X			*Disrupts terrorist command*

What the ***composite operational capability*** *had to do*

Demands/ Threats needing different kinds of ***composite operational capability***

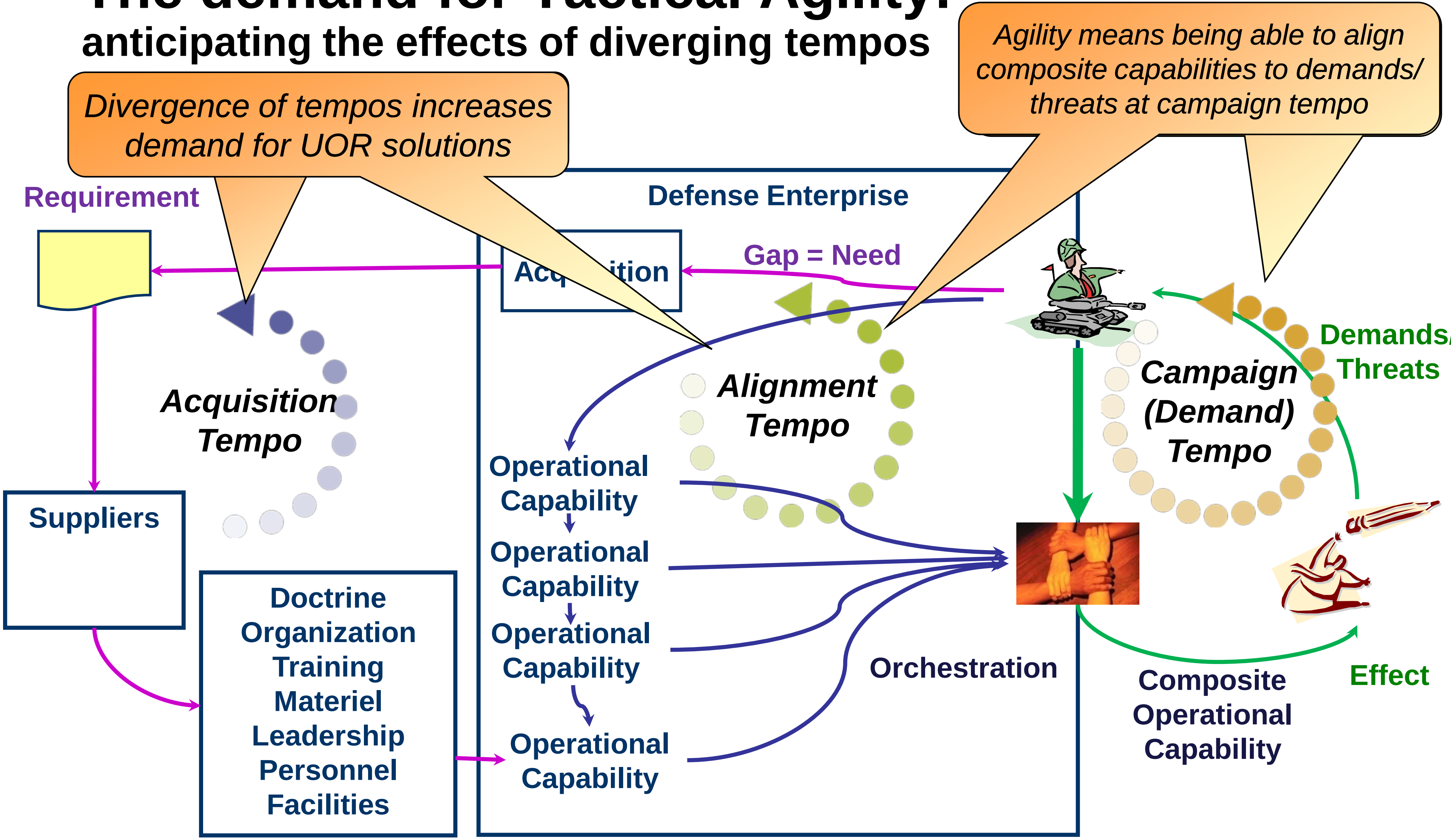
The through-life costs of operational use

- The costs of the TUAV III Urgent Operational Requirement (UOR) were of the same order as the planned equipment costs.
- Could the demand for greater tactical agility have been anticipated?
- If so, how could its value have been established?



IPT – Integrated Project Team

The demand for Tactical Agility:
anticipating the effects of diverging tempos



Adapted from: *Appropriate Collaboration and Appropriate Competition in C4ISTAR Transformation*, Dr Nicholas Whittall RUSI 2007

Engineering in support of an Operational Space:
the Composite Capability as a system-of-systems (SoS)

- The variety of mission situations needeing support in the operational space far exceeded those anticipated in the design space. Hence the need for agility
  - For Tactical UAVs, the original customer intended for the operational capability was the Land Component Commander.
  - In practice, the uses of the operational capability formed part of multiple composite capabilities, each one a System of Systems

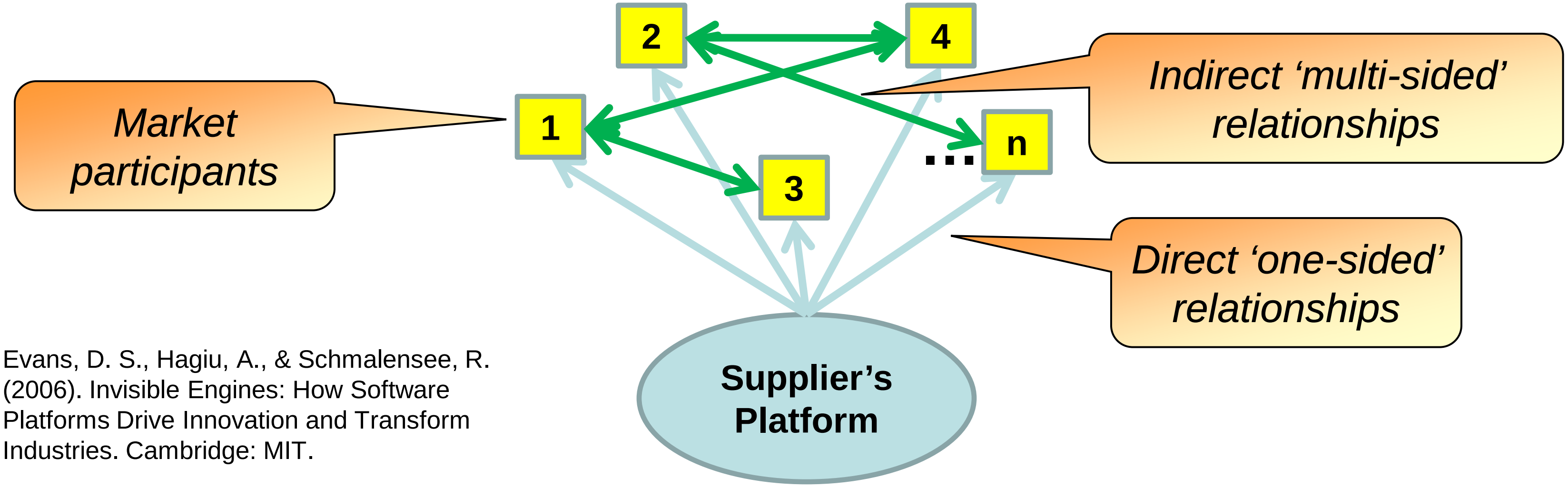
- The set of operational capabilities supporting these multiple forms of composite capability themselves formed a Collaborative SoS.
- How could the engineering of these composite capabilities be supported from within the capability design space?

Designing multi-sided platforms for an operational space defined as a multi-sided market

ENGINEERING FOR A MULTI-SIDED MARKET: THE NEED FOR TWO KINDS OF VALUE

Multi-sided markets:
counting the value of indirect market relationships

- A multi-sided market for a supplier is one in which:
  - There is value in its direct 'one-sided' relationships with each market participant
  - There is greater value in its indirect 'multi-sided' relationships with collaborating market participants
- There has to be more value for the market participant in using the supplier's platform than not

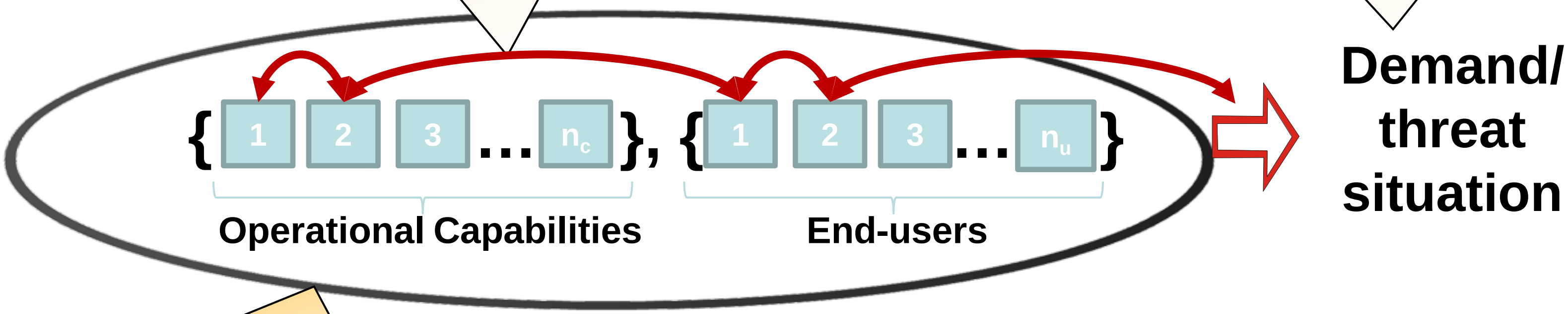


Evans, D. S., Hagiu, A., & Schmalensee, R. (2006). Invisible Engines: How Software Platforms Drive Innovation and Transform Industries. Cambridge: MIT.

Multi-sided Platforms: the iPod Touch example

The orchestration of operational capabilities and end-users needed to form the composite capability
e.g. the soldier and intelligence officer with face recognition and location-based intelligence.

The context in which the collaboration puts together a composite capability
e.g. on patrol in Baghdad



The Supplier's Platform providing the means of orchestrating end-users and operational capabilities
e.g. iPod Touch

The iPod Touch emerged as the handheld of choice to fulfill the need of each solder "to be linked electronically to other troops as well as to weapons systems and intelligence sources. Making sense of the reams of data from satellites, drones and ground sensors cries out for a handheld device that is both versatile and easy to use."

Source: Sutherland, B. (2009, April 27). Apple's New Weapon: To help soldiers make sense of data from drones, satellites and ground sensors, the U.S. military now issues the iPod Touch. Newsweek .

Defining the Composite Capabilities:
the need for tactical agility

Community of Practice

Collaborative SoS

The Demands/ Threats

Mission Situations	Composite Capabilities: End-users					Composite Capabilities: Operational Capabilities									
	Intelligence	Soldiers on the ground	Strike synchronization	Ship	Arrest synchronization	Communications	Space sensors	High Altitude UAV	Medium Altitude UAV	Tactical UAV	Fast Jet	Search Helicopter	Attack Helicopter	AWACs	Fast Patrol Boat
Individual in Afghan-Pakistan border *Disrupts terrorist command*		X	X			X	X	X	X						
Individual in Kabul Blue Zone *Disrupts terrorist command*	X	X	X			X	X		X						
Stinger Missiles in Baghdad City Centre *Neutralization of manoeuvrist threat*	X		X			X	X			X			X		
Shoot-and-Scoot in Tribal Lands *Neutralization of manoeuvrist threat*		X	X			X	X	X	X		X				
Terrorist Escape by Sea *Disrupts terrorist command*				X	X	X	X					X		X	X

A Multi-sided Market

Each of these compositions is a system of systems

Substituting a TUAV multi-sided platform:
creating indirect benefits through greater flexibility

Indirect value through its impact on the way different collaborations can be formed

Direct value through substitution

The Multi-sided platform

<u>**Mission Situations**</u>	<u>**Composite Capabilities**</u>														
	End-users					**Operational Capabilities**									
	Intelligence	**Soldiers on the ground**	**Strike synchronization**	**Ship**	**Arrest synchronization**	**Communications**	**Space sensors**	**High Altitude UAV**	**Medium Altitude UAV**	**Tactical UAV**	**Fast Jet**	**Search Helicopter**	**Attack Helicopter**	**AWACs**	**Fast Patrol Boat**
Individual in Afghan-Pakistan border		X	X			X	X	X	X						
Disrupts terrorist command		X	X			X	X	X		X					
Individual in Kabul Blue Zone	X	X	X			X	X		X						
Disrupts terrorist command	X	X	X			X	X			X					
Stinger Missiles in Baghdad City Centre	X		X			X	X			X			X		
Neutralization of manoeuvrist threat	X		X			X	X			X					
Shoot-and-Scoot in Tribal Lands		X	X			X	X	X	X		X				
Neutralization of manoeuvrist threat		X	X			X	X	X		X					
Terrorist Escape by Sea				X	X	X	X					X		X	X
Disrupts terrorist command				X	X	X	X			X				X	X

Engineering for a multi-sided market

- The multi-sidedness of the operational space (the multi-sided market) defines the need for a supporting Collaborative SoS
- Engineering a platform for a multi-sided market involves creating two kinds of benefit:
  - The direct benefit the platform provides to each of its users
  - The indirect benefit it provides by supporting collaboration between end-users and operational capabilities to form composite capabilities

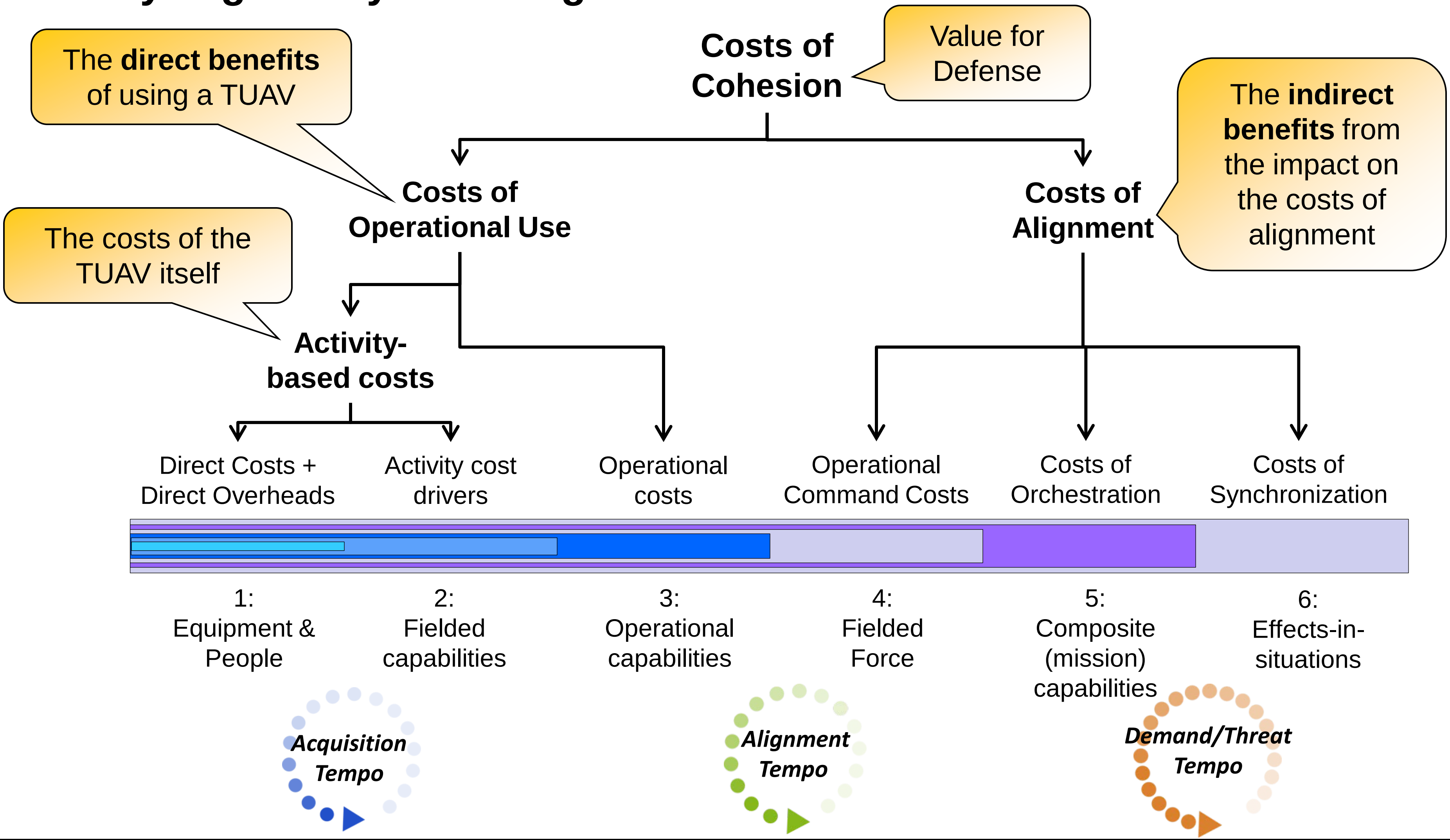
- The flexibility of a multi-sided platform in support of indirect benefits increases the agility of the force structure in which it participates

Value for Defense is maximized when agility is delivered at minimum cost

ENGINEERING TWO KINDS OF VALUE: CREATING VALUE FOR DEFENSE

Defining Value for Defense:

analyzing the layers of alignment across the different scales



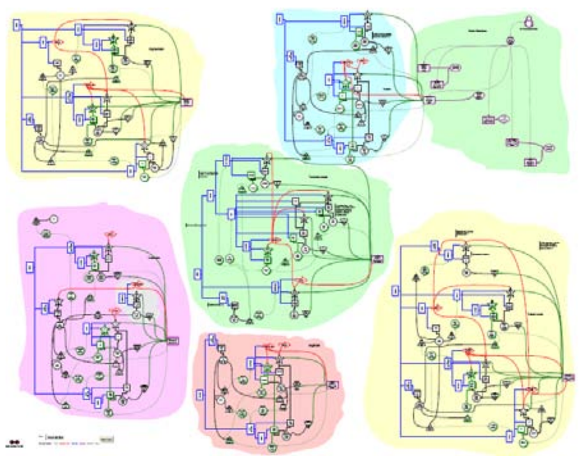
Cohesion-based Costing:
analyzing the cohesion costs of composite (mission) capabilities

Modeling the variety of composite capabilities

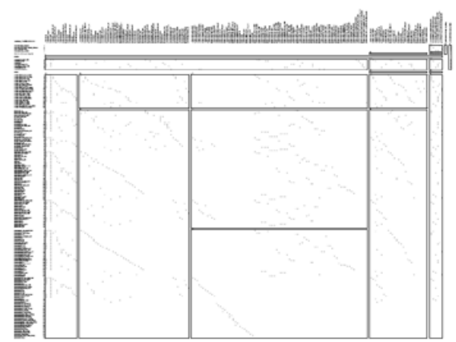
Analyzing the different layers of alignment

Analyzing cohesion costs

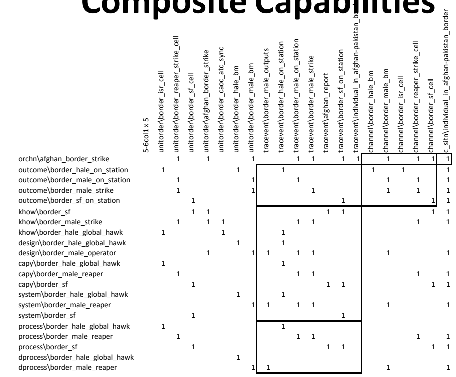
Modeling Alignment Processes



Analyzing alignment to demand



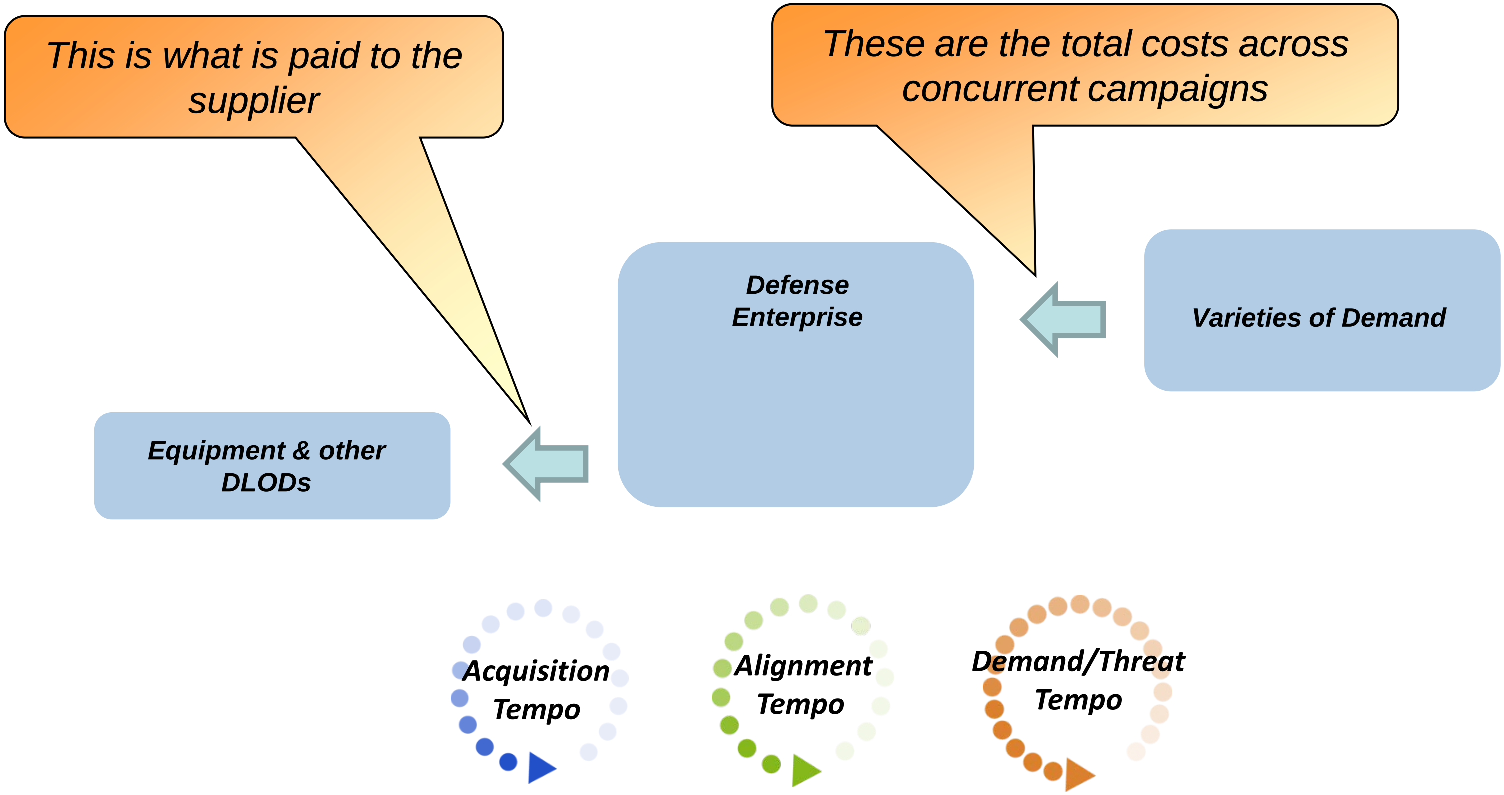
Costing Cohesion of Composite Capabilities



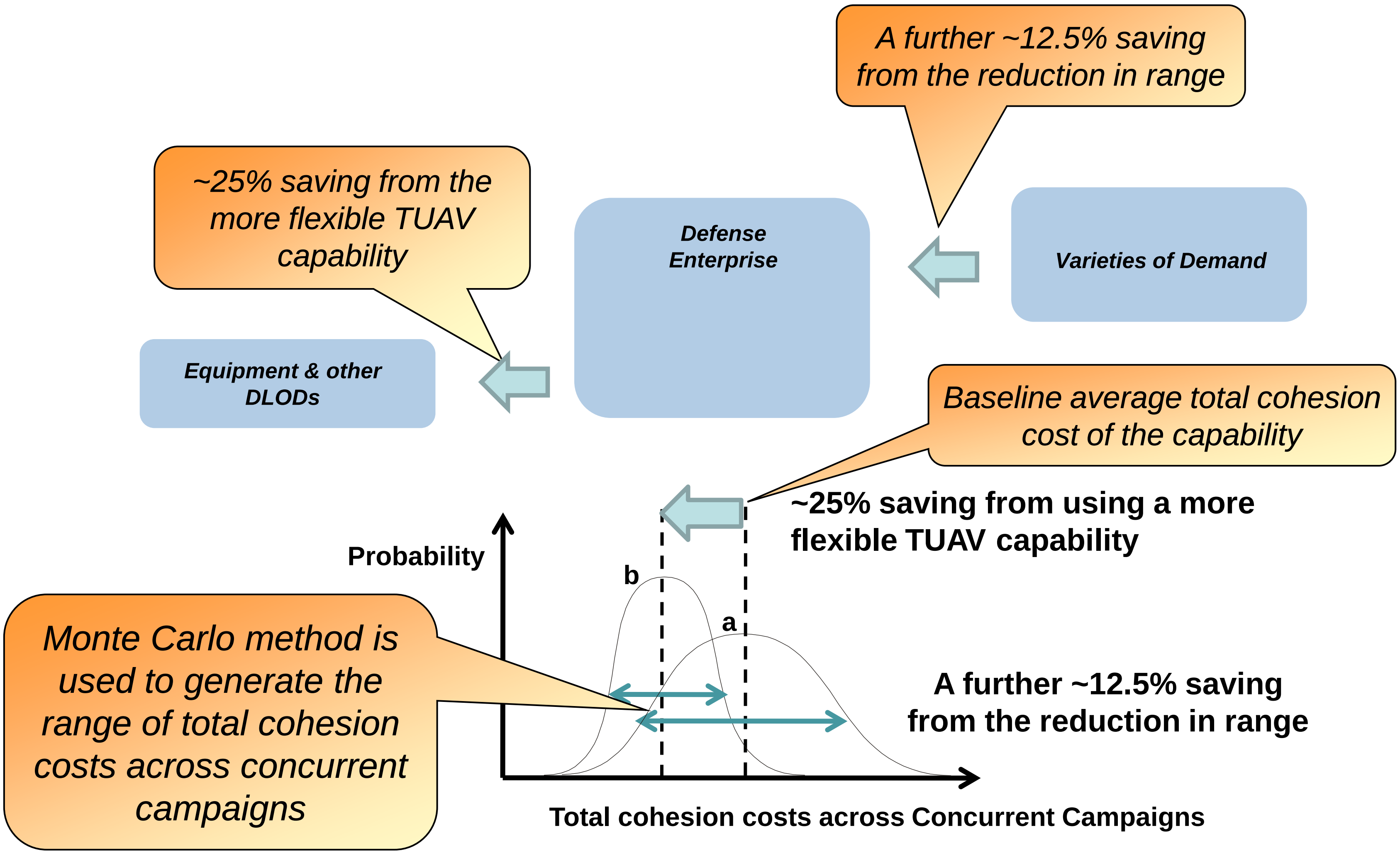
The ability to analyze cohesion costs offers:

- The cohesion costs of any particular situation in a campaign
- The range of cohesion costs across a variety of situations arising in different types of campaign

Pricing Agility: *valuing the impact of greater TUAV flexibility*



Pricing Agility: *valuing the impact of greater TUAV flexibility*



Distinguishing two kinds of value:
Determining the maximum price of Value for Defense

The analysis of total cohesion costs for Concurrent Campaigns delivers:

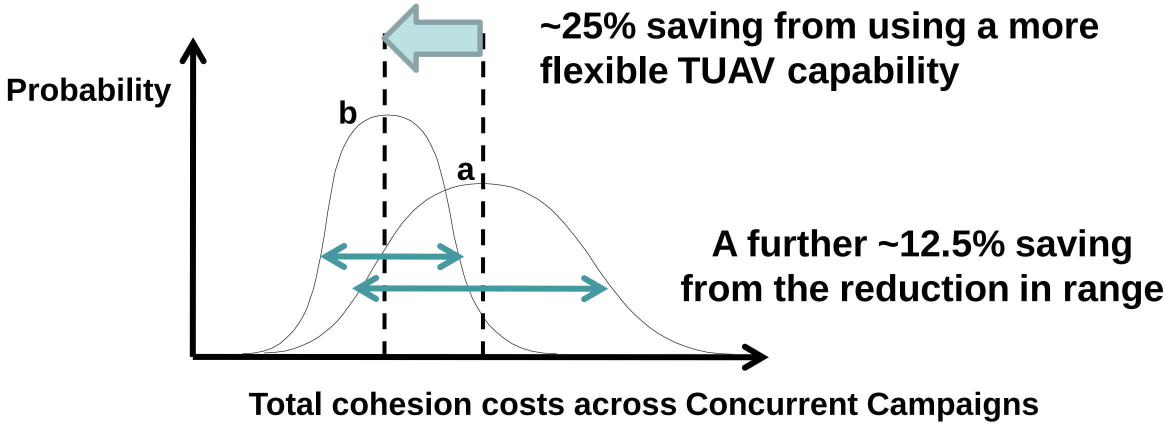
– A baseline range of costs of supporting this variety of situations

– A lower average cost and a narrower range of costs of delivering this same variety with more flexible TUAV capability

The maximum price of Value for Defense should reflect two kinds of value:

– The direct benefit of greater capability in the platform itself, and

– The indirect benefit of greater force agility arising from the flexibility of the platform



Conclusion

- The need for agility creates new challenges for engineering in support of an operational space.

  This involves understanding the impact on the design space of ***variety of use*** *in the operational capability space.*

- This variety of use can be approached in terms of the multi-sidedness of the market into which capabilities are being deployed

  This leads to designing platforms for ***multi-sided use*** *within an operational space.*

- Creating value for defense therefore involves an engineering approach that can generate indirect as well as direct benefits

  Such engineering depends on being able to define both kinds of Value for Defense.

Contact Information

Philip Boxer

Research, Technology and Systems Solutions Program,
Software Engineering Institute, Carnegie Mellon University

Email: pboxer@sei.cmu.edu

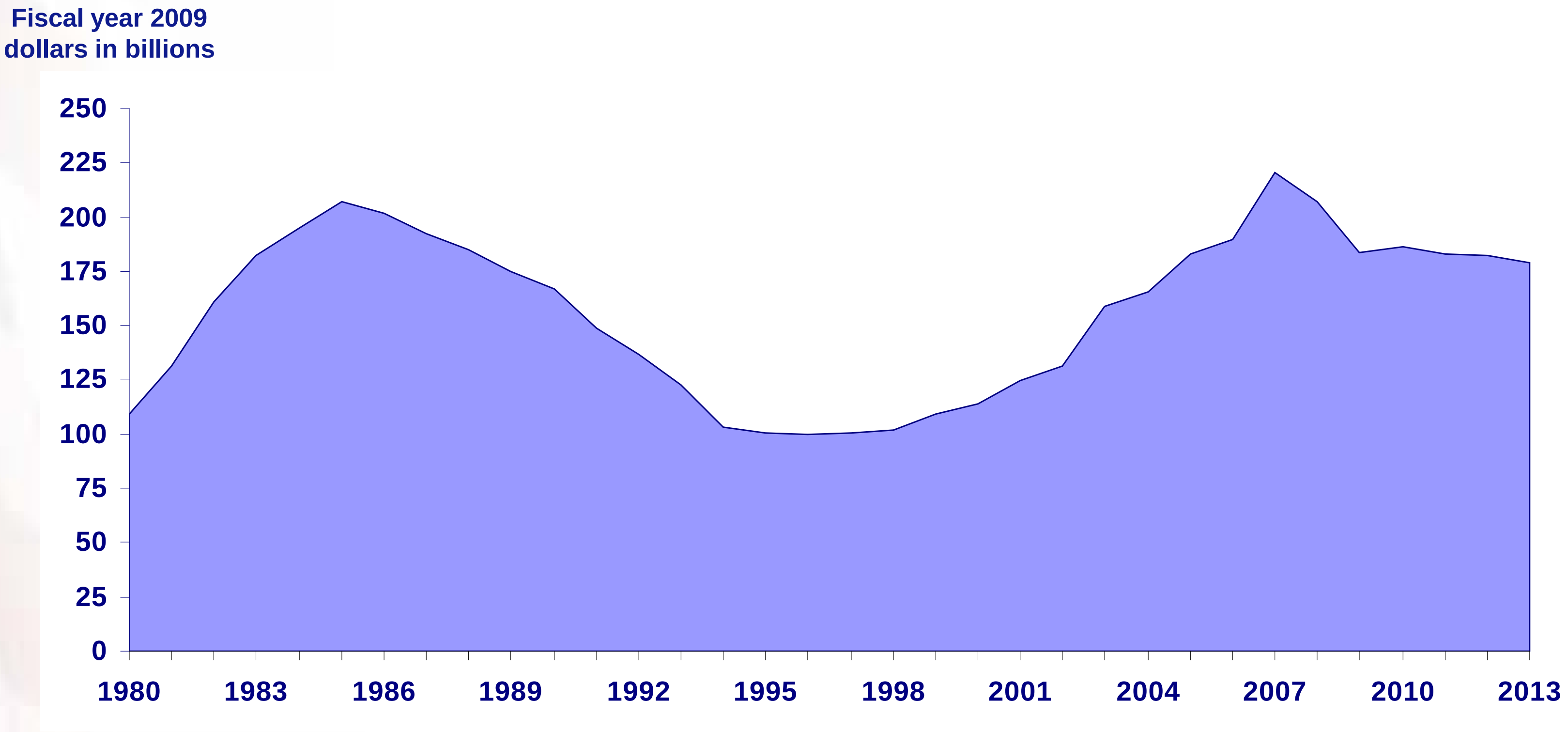
Mail:
Software Engineering Institute
4500 Fifth Avenue
Pittsburgh, PA 15213-2612
USA

DOD's Weapon System Portfolio: Are Results Getting Any Better?

Presentation by:
Mike Sullivan and Cheryl Andrew
Acquisition & Sourcing Management Team
U.S. Government Accountability Office

NDIA 12th Annual Systems Engineering Conference
October 28, 2009
San Diego, CA

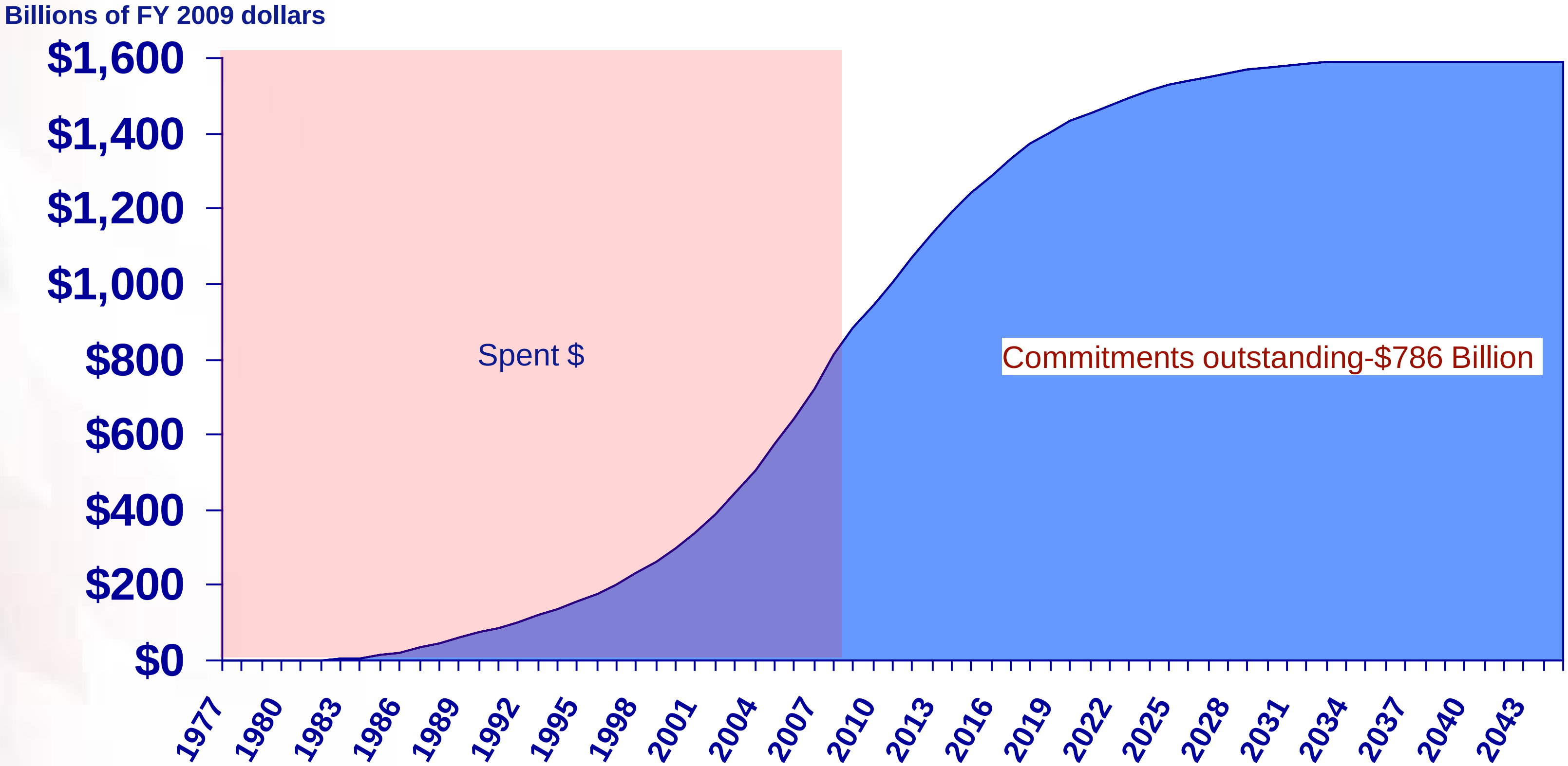
Big Picture: DOD Investment Remains High, Most Likely Unsustainable



Research, Development, Test and Evaluation and Procurement Funding

Source: GAO analysis of National Defense Budget Estimates for the Fiscal Year 2009 Budget.

Committed and Planned Spending on Current Portfolio of 96 Programs



Objectives of the Annual Assessment of Major Weapon System Programs

- **Provide a cost/schedule snapshot of DOD's 2008 portfolio** of major weapon system programs and a comparison to portfolios at two other points in time – 1 year ago and 5 years ago
- **Provide observations** about the portfolio's balance, 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 47 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 DOD acquisition policy changes

DOD Acquisition Outcomes

Outcomes Reported in GAO’s Most Recent Annual Assessment of Major Weapon System Programs

Snapshot: Cost and Schedule Growth for the 2008 Portfolio of 96 Programs

Performance of DOD's Major Defense Acquisition Program Portfolio

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

Source: GAO analysis of DOD data.

Observation: Top 10 Programs Continue to Strain DOD's Buying Power

- 10 of the department's largest programs, commanding about 50% of the acquisition dollars in the portfolio, have experienced significant cost growth and quantity reductions:
  - Development costs have grown by 32%
  - Total program costs have grown by 12%
  - Overall quantities have been reduced by 32%
  - 7 have acquisition unit costs of greater than 40%

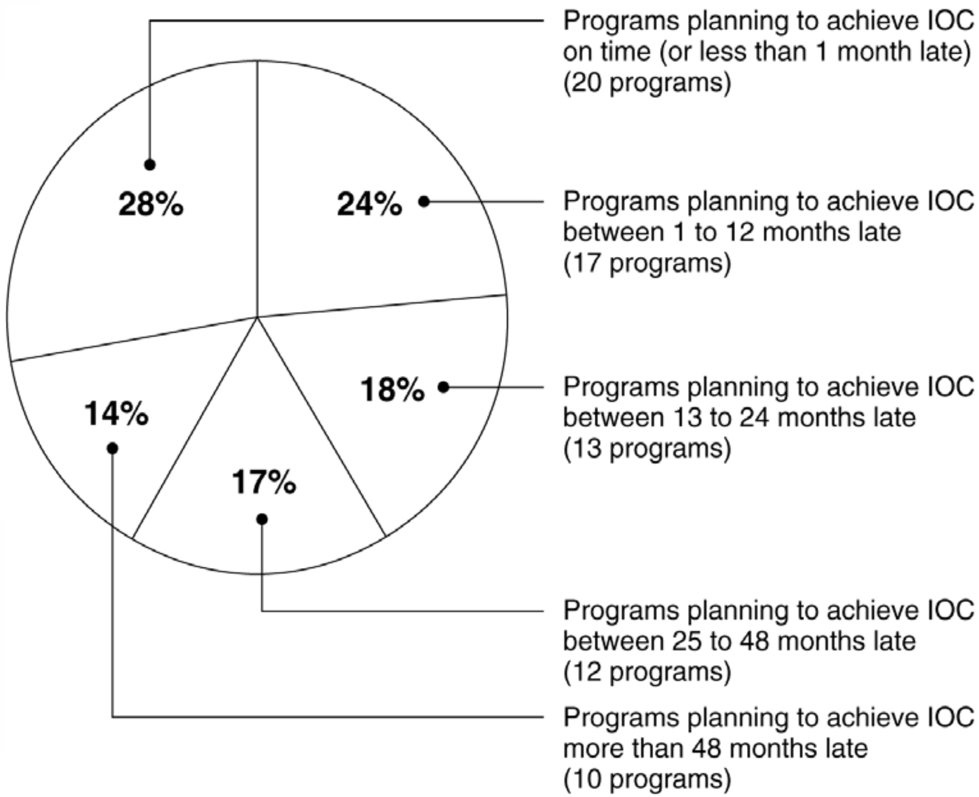
Observation: Top 10 Programs Continue to Strain DOD's Buying Power Elsewhere

	Total cost (fiscal year 2009 dollars in millions)		Total quantity		Acquisition unit cost
Program	**First full estimate**	**Current estimate**	**First full estimate**	**Current estimate**	**Percentage change**
Joint Strike Fighter	206,410	244,772	2,866	2,456	38
Future Combat System	89,776	129,731	15	15	45
Virginia Class Submarine	58,378	81,556	30	30	40
F-22A Raptor	88,134	73,723	648	184	195
C-17 Globemaster III	51,733	73,571	210	190	57
V-22	38,726	55,544	913	458	186
F/A-18E/F Super Hornet	78,925	51,787	1,000	493	33
Trident II Missile	49,939	49,614	845	561	50
CVN 21 Nuclear Aircraft Class Carrier	34,360	29,914	3	3	-13
P-8A Poseidon (MMA)	29,974	29,622	115	113	1

Source: GAO analysis of DOD data.

Observation: Promised Capabilities Continue to Be Delivered Late

Schedule Delays for DOD’s 2008 Program Portfolio



Source: GAO analysis of DOD data.

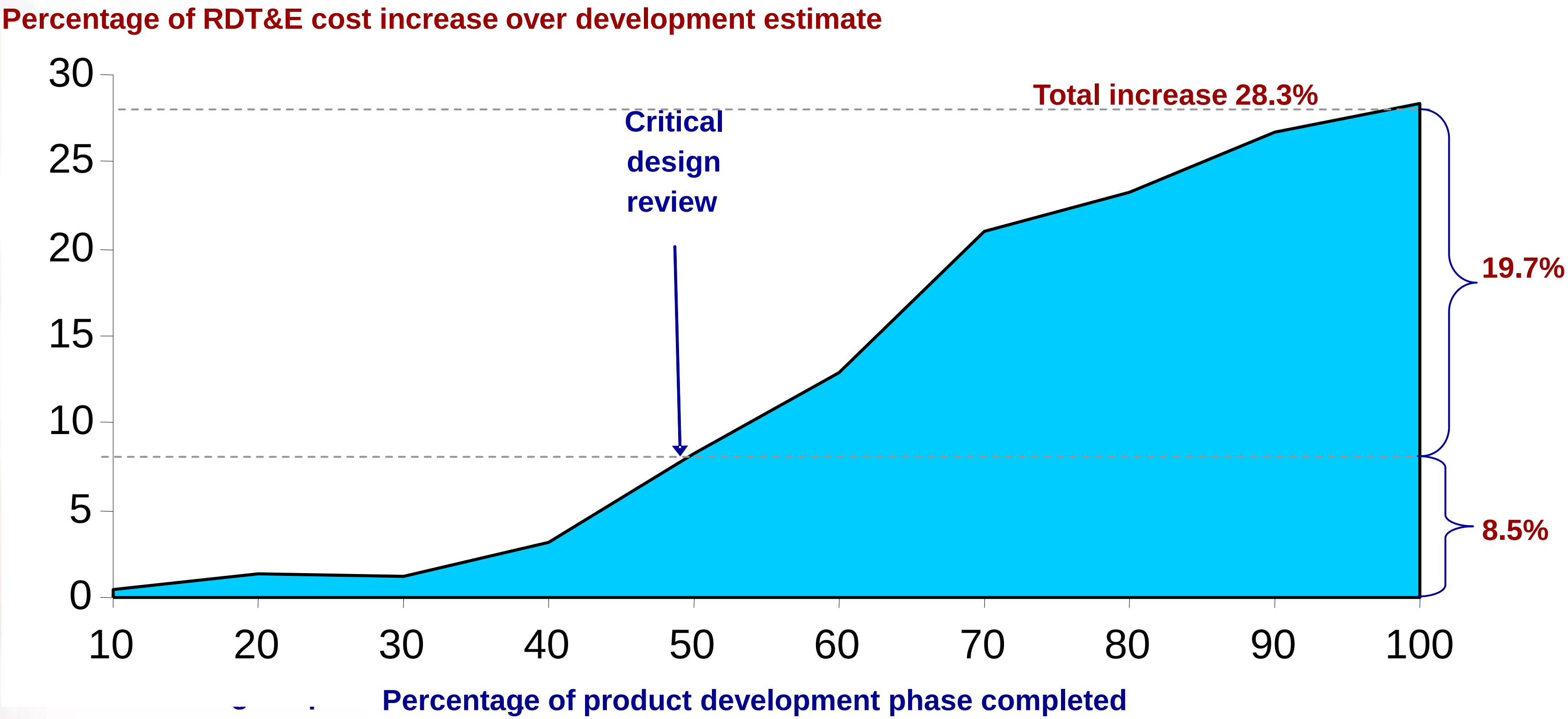
Observation: New Programs Are Performing Better at This Time

Changes in Program Cost and Schedule by Age of Program
Fiscal Year 2008 Portfolio

Age of Program	Change in total RDT&E costs from first estimate	Change in total acquisition cost from first estimate	Average change in quantities	Average number of months late	Number of programs
15 or more years since development start	47 percent	19 percent	-39 percent	37 months	10
10 to 14 years since development start	73 percent	53 percent	52 percent	26 months	17
5 to 9 years since development start	37 percent	31 percent	9 percent	22 months	25
Less than 5 years since development start	12 percent	11 percent	1 percent	5 months	28

Source: GAO analysis of DOD data.

Caveat: Historically, Largest Percentage of RDT&E Cost Growth Occurs After CDR

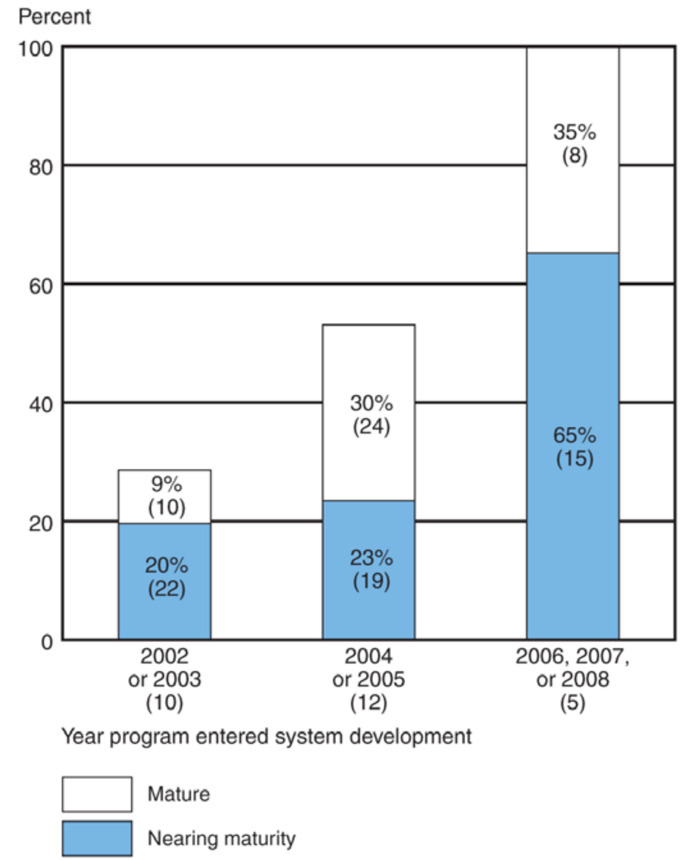


Note: Does not add due to rounding.
Source: GAO-06-391

Knowledge Analysis: Newer Programs Are Starting with Higher TRLs

- Since 2003, there has been a significant increase in the percentage of critical technologies at least nearing maturity (demonstrated in a relevant environment) prior to development start.

- In the last 3 years, all 5 programs entering system development had their critical technologies demonstrated in at least a relevant environment, in accordance with the DOD and statutory criteria.



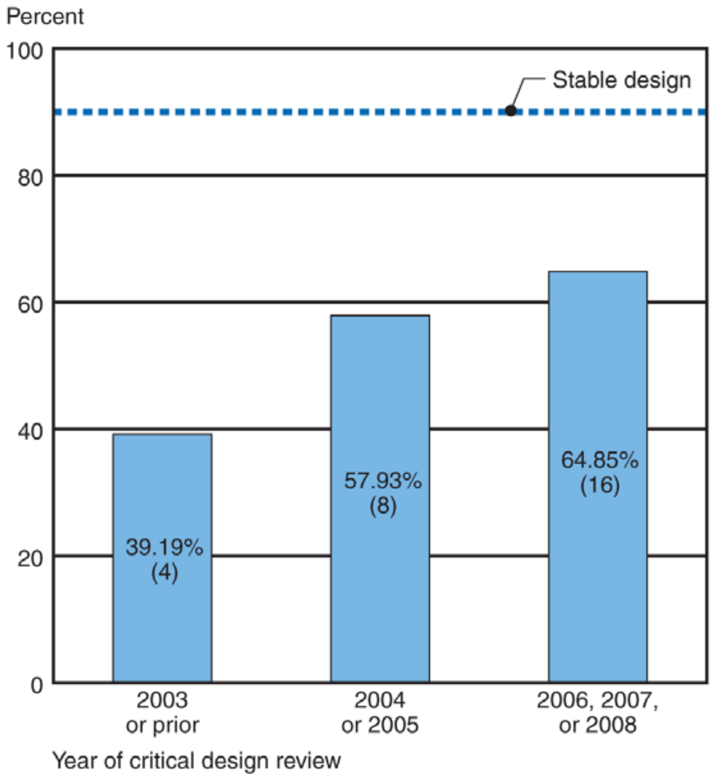
Source: GAO analysis of DOD data.

Note: Number of programs and technologies in parentheses.

Knowledge Analysis: Programs Report More Design Drawings Complete at CDR

- Since 2003, the average percentage of design drawings releasable for programs at the critical design has steadily increased.

- However, designs, on average, are still far from stable and concurrent technology development increases risk of subsequent design changes and rework.



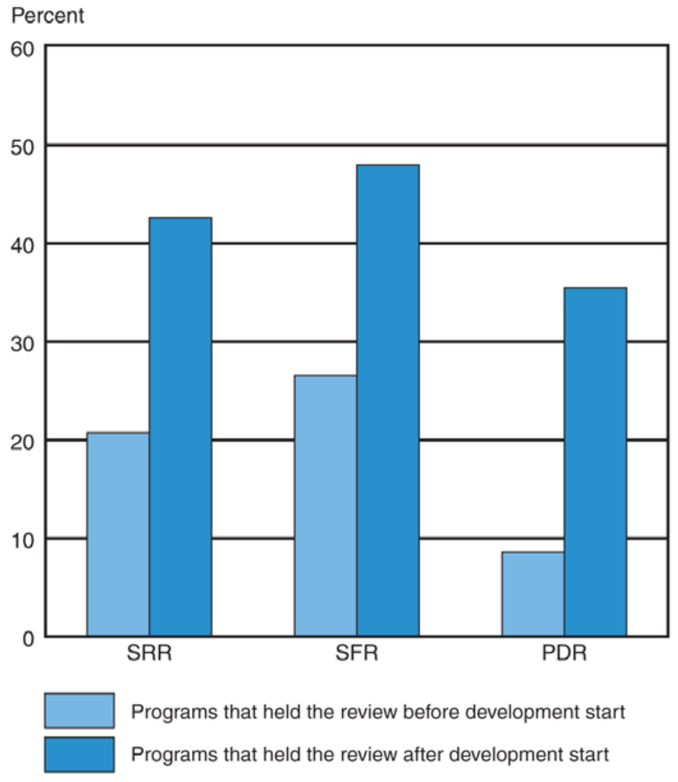
Source: GAO analysis of DOD data.

Note: Number of programs in parentheses.

Knowledge Analysis: Programs Conducting Early Systems Engineering Have Better Outcomes

- Early systems engineering, ideally before a program enters development, is critical to ensuring that requirements can be met with available resources.
- Programs that conducted key systems engineering events prior to development start have experienced lower cost growth on average and often have shorter delays in achieving initial operational capability.

Average RDT&E Cost Growth by Timing of Key Systems Engineering Reviews



Source: GAO analysis of DOD data.

Other Factors We Found That May Influence Program Outcomes

- Inadequate staffing
- Lack of independent cost estimates
- Software growth
- Changes in key system requirements

Initiatives for Change & Future Challenges

Recent Legislative and Policy Changes Have Potential to Significantly Improve Outcomes

Areas of Agreement Between DOD and GAO Concerning Problem Sources

- Acquisition problems have their roots in the requirements and funding processes
- Programs are initiated with poor foundations and inadequate knowledge for developing realistic cost estimates
- Programs move forward with artificially low cost estimates, optimistic schedules and assumptions, immature technologies and designs, and fluid requirements
- Imbalance between needs and the resources available to meet them contributes to budget and program instability
- Changing or excessive requirements cause cost growth

Recent Changes Should Result in More Knowledge (Less Risk) Upfront

- Certifications at Milestones A and B
- Director of Cost Assessment and Program Evaluation
- Materiel Development Decision required for all programs
- Configuration Steering Boards established
- Preference for incremental development
- Preference for holding PDR before start of SDD
- Competitive prototyping prior to Milestone B
- Capability Portfolio Managers

Several Areas of Continuing Concern

- Responsibility, authority, and accountability still stove-piped
- DOD policy still does not require “time certain” development
- DOD policy still allows for concurrent technology and product development and production
- Post-CDR assessment still not a milestone decision
- Controls not in place to ensure accountability and adherence to intent of new policy

Concluding Remarks

- The administration’s acquisition policy initiatives are aimed at the proper target -- the front-end of the process and the systems engineering that is required there
- There is growing consensus that the root causes of poor outcomes lie in misunderstood requirements, unreliable estimates, and unmanageable development times
- The Congress’ reform legislation also targets the appropriate troublemakers – lack of systems engineering expertise, lack of accountability and independence among key players
- What’s doable on paper is not always doable in reality – the people involved in this enterprise, all of them, must be willing to change the way we develop and deliver weapon systems

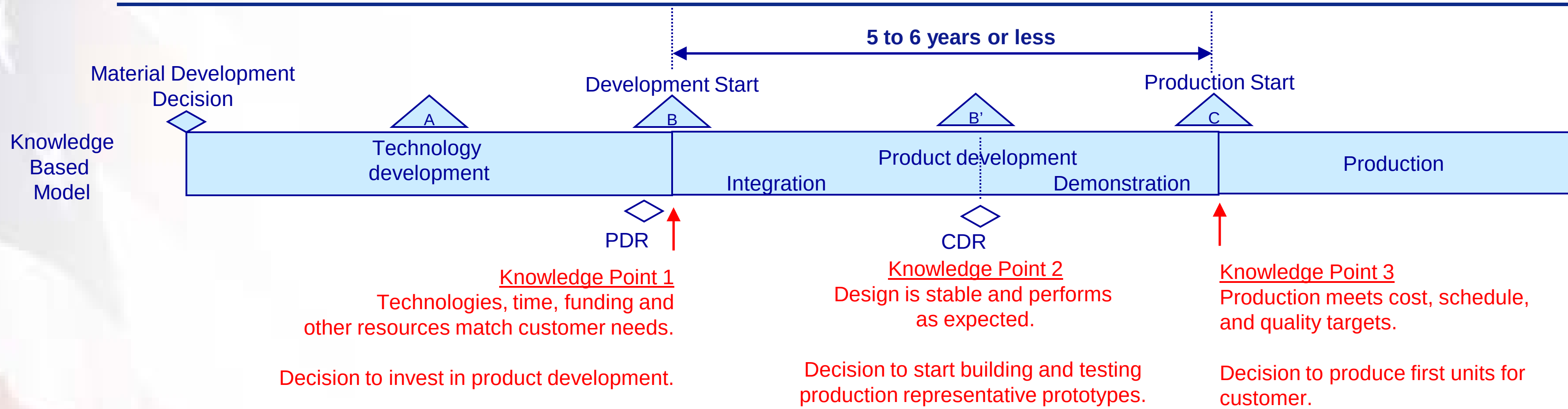
Questions?

Contact Information:

Michael Sullivan, sullivanm@gao.gov

Cheryl Andrew, andrewc@gao.gov

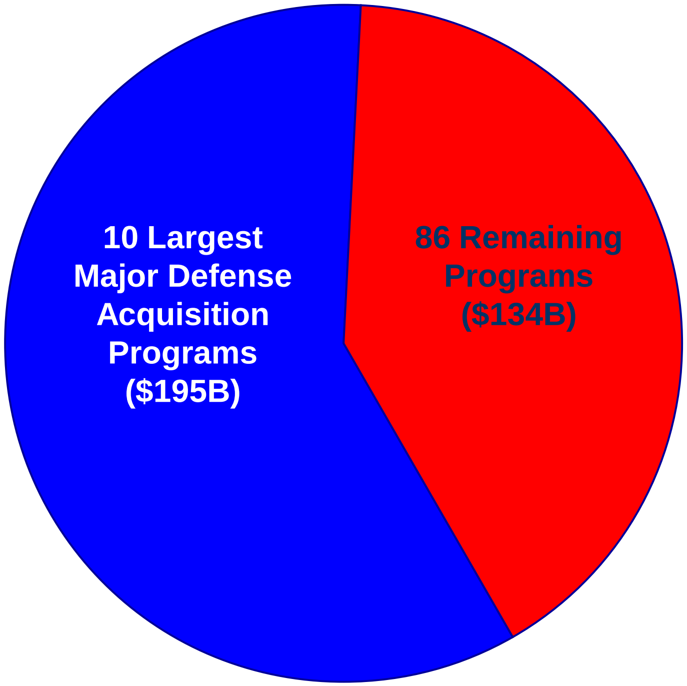
Knowledge-Based Acquisition Model Focuses on Retiring Risks by Key Decision Points



- 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.

Source: GAO.

Observation: Top 10 Programs Continue to Strain DOD's Buying Power Elsewhere



RDT&E and Procurement Funding 2009-2013 (FY09 Dollars)

Source: GAO analysis of DOD data.

Software Test & Evaluation Summit/Workshop Review

The Summit/Workshop was facilitated by the NDIA Systems Engineering Division's Software Industry Experts Panel and the Developmental Test and Evaluation Committee

Basis for SW T&E Summit/Workshop

- NDIA SE Division's SW Committee report completed in September 2006
  - Top Software Engineering Issues in the Defense Industry
- Key Theme of the Report

  Current approaches for acquiring, developing, verifying and sustaining software enabled systems are inadequate to deal with the complexities of a dynamic and changing acquisition environment.
- Requested to identify top five issues
  - Actually came up with seven

Top Seven SW Engineering Issues

1. The impact of requirements upon software is not consistently quantified and managed in development or sustainment.
2. Fundamental system engineering decisions are made without full participation of software engineering.
3. Software life-cycle planning and management by acquirers and suppliers is ineffective.
4. The quantity and quality of domain-knowledgeable software engineering expertise is insufficient to meet the demands of government and the defense industry.
5. Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.
6. There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.
7. Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

Issue 5 – Description

Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems discussion points:

- Over-reliance on testing alone rather than robust SW verification techniques.
- Manual testing techniques are labor-intensive, scale poorly, and are unproductive relative to the large investment of resources.
- Compliance-based tests do not adequately cover risks or failure conditions.
- Tests are over-documented with disproportionate effort on detailed procedures.
- Education, training, certifications are inadequate to develop effective test skills.

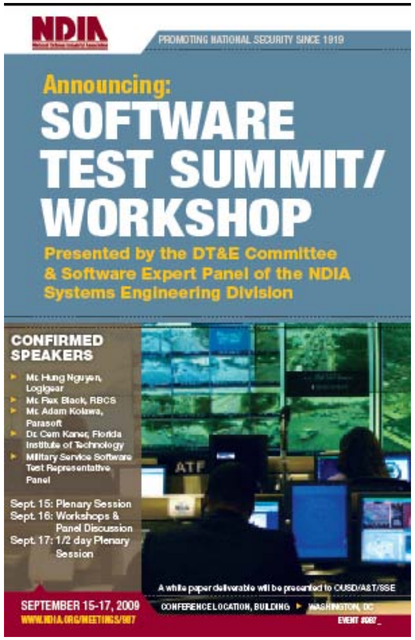
Issue 5 – Recommendation

Study current software verification practices in industry, and develop guidance and training to improve effectiveness in assuring product quality across the life cycle.

- Sponsor a study of state-of-the-practice verification and testing approaches.
- Review/update testing policies and guidance to emphasize robust, productive approaches that maximize ROI.
- Review adequacy of verification plans/approaches early in the acq. life cycle.
- Emphasize skilled investigation throughout the life cycle, based on coverage, risk mitigation, high volume automation.
- Strengthen curricula, training, certifications, career incentives for testing roles.

Summit/Workshop Objective

To recommend policy and guidance changes to the Defense enterprise to emphasize robust and productive software Testing and Evaluation (T&E) approaches in Defense acquisition.



Location & Attendance

- Hotel: Hyatt in Reston Town Center, VA
- Dates: September 15 -17, 2009
- 110 Registered Attendee
  - 9 no-shows
  - Approx. 80 stayed to the end of last day!
- Better than expected participation!

Day 1 Agenda

8:00 Introduction – Why this Summit/Workshop

8:10 Government Presentations

9:50 Break

10:15 DoD Industry Panel

11:45 Lunch & Speaker

12:45 SW Test Industry Experts

2:25 Break

2:50 SW Test Industry Experts

4:30 Adjourn

Day 2 Agenda

8:00 Re-Cap Day 1

8:10 DoD Services Panel

9:45 Introduction of Workshops

- 10:00 Break

10:30 Workshops

- 12:00 Lunch & Speaker

1:00 Workshops

- 2:30 Break

3:00 Workshops

4:30 Adjourn

Day 3 Agenda

8:00Re-Cap Day 2

8:10 Introduction of Workshop Leaders

8:15 Presentation of Issues and Recommendation by Workshop Leaders

9:45 Break

10:00 Way Forward Discussion & Final Q&A’s

– Final Summit/Workshop Product defined

11:00 Adjourn

Speakers Morning Day 1

Framing the DoD Software T&E Issues

- Dr. Ernest A. Seglie, Chief Science Advisor, DOT&E
- Mr. Chris DiPetto, Acting Director, DT&E
- Ms. Kristen Baldwin, Director for System Analysis, OD, DR&E

Speakers Morning Day 1

Panel: Framing the Industry Software T&E Issues

– Mr. Edgar Doleman, CSC

– Mr. Bruce Casias, Raytheon

– Mr. Tom Wissink, Lockheed Martin

Speakers Afternoon Day 1

- Lunch: Mr. Paco Hope, Cigital
  - Software Security in Defense T&E
- Dr. Cem Kaner, Florida Institute of Technology
  - Challenges in the Evolution of Software Testing Practices in Mission-Critical Environments
- Dr. Adam Kolawa, Parasoft
  - Software Development Management
- Mr. Rex Black, RBCS
  - Risk-Based Testing
- Mr. Hung Nguyen, Logigear
  - Software Testing & Test Automation

Speakers Morning Day 2

Panel: Framing the Services Software T&E Issues

- Dr. James Streilein, US Army Test and Evaluation Command
- Dr. Steve Hutchison, Defense Information Systems Agency (DISA)
- Mr. Mike Nicol, Aeronautical Systems Center, Wright-Patterson AFB

Lunch: Mr. Richard Kuhn, NIST

- Combinatorial Testing

Remainder of Day 2

Workshops – Three Key Challenge Areas (KCA):

1. How Much T&E is Enough
   - Risk considerations, Installed System T&E, Instrumentation, Reliability, Completion Criteria, Coverage and C&A
2. Lifecycle and End-to-End Software Testing
   - How does SW T&E get involved in early development (i.e. left-hand side of the V-model and I&T deliverables
3. Changing Paradigms
   - Open Architecture, COTS, SOA, SoS, SaaS, Legacy plus New, Security

Remainder of Day 2

Workshops – Four Focus Areas for each KCA:

1. Review, revise, improve RFP Language (Including T&E activities/deliverables in Competitive Prototyping)
2. Training, Competency Model, Human Capital
3. Policy, Guidance & Standards
4. Tools/Automation, Methodologies & Processes

Results of Workshop – Raw Data

Issues

1. Workshop #1 – 108
2. Workshop #2 – 51
3. Workshop #3 – 20

Total – 179

Recommendations

1. Workshop #1 – 44
2. Workshop #2 – 29
3. Workshop #3 – 13

Total – 86

Participants

1. Workshop #1 – 30
2. Workshop #2 – 31
3. Workshop #3 – 25

Total – 86

Results of Workshop – Raw Data

Recommendations by Focus Area

- 17 for FA #1 Revise/Improve RFPs & T&E Deliverables
- 23 for FA #2 Training, Human Capital, Competency Models
- 22 for FA #3 Policies, Guidance & Standards
- 17 for FA #4 Tools/Automation, Methodologies & Processes
- 7 for FA #5 Costs, Software, Studies, Organization

Way Forward

This is a Joint effort of the NDIA's SE Division DT&E Committee and the Software Industry Experts Panel

1. Workshop #1 Team to complete Recommendation Generation by October 9 **(Done)**
2. In parallel with the Item 1 generate draft outline for the SW T&E Summit/Workshop White Paper **(Done)**
3. Review and correlate Workshops 1, 2 and 3 issues and recommendations
   – Update White Paper outline if needed
4. Generate Initial White Paper
   – Completion goal – December 4, 2009

Q & A

SW T&E Summit/Workshop Presentations:

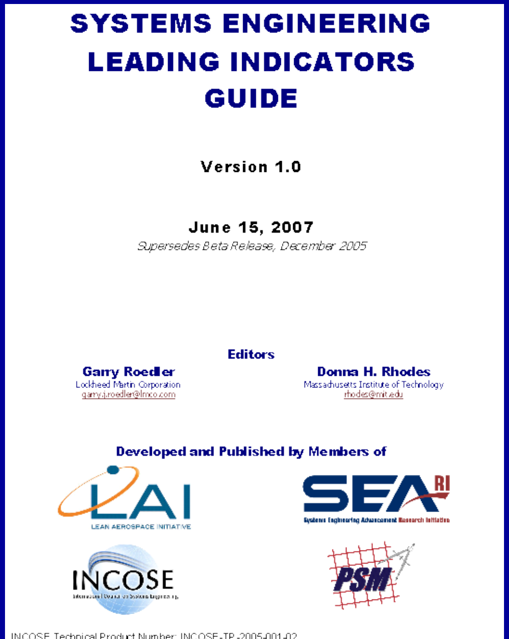
www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Test_and_Evaluation_Committee.aspx

Leading Indicators for Systems Engineering Effectiveness

Presentation for NDIA SE Conference
October 28, 2009

Garry Roedler

Lockheed Martin



SYSTEMS ENGINEERING LEADING INDICATORS GUIDE

Version 1.0

June 15, 2007

Supersedes Beta Release, December 2005

Editors

Garry Roedler
Lockheed Martin Corporation
garry.j.roedler@lmco.com

Donna H. Rhodes
Massachusetts Institute of Technology
rhodes@mit.edu

Developed and Published by Members of

LAI — LEAN AEROSPACE INITIATIVE

SEARI — Systems Engineering Advancement Research Initiative

INCOSE

PSM

INCOSE Technical Product Number: INCOSE-TP-2005-001-02

Growing Interest in SE Effectiveness

- Questions about the effectiveness of the SE processes and activities are being asked
  - DoD
  - INCOSE
  - Others
- Key activities and events have stimulated interest
  - DoD SE Revitalization
  - AF Workshop on System Robustness
    - Questions raised included:
      - ***How do we show the value of Systems Engineering?***
      - ***How do you know if a program is doing good systems engineering?***
    - Sessions included SE Effectiveness measures and Criteria for Evaluating the Goodness of Systems Engineering on a Program

Background of the Systems Engineering Leading Indicators Project

"SE Leading Indicators Action Team" formed in late 2004 under Lean Aerospace Initiative (LAI) Consortium in support of Air Force SE Revitalization

The team is comprised of engineering measurement experts from industry, government and academia, involving a collaborative partnership with INCOSE, PSM, and several others

- Co-Leads: Garry Roedler, Lockheed Martin & Donna Rhodes, MIT ESD/LAI Research Group
- Leading SE and measurement experts from collaborative partners volunteered to serve on the team

The team held periodic meetings and used the ISO/IEC 15939 and PSM Information Model to define the indicators.

PSM (Practice Software and Systems Measurement) has developed foundational work on measurements under government funding; this effort uses the formats developed by PSM for documenting the leading indicators

A Collaborative Industry Effort

LAI MIT LEAN ADVANCEMENT INITIATIVE

LOCKHEED MARTIN

Raytheon

SYSTEMS ENGINEERING Research Center

PSM

INCOSE International Council on Systems Engineering

NORTHROP GRUMMAN DEFINING THE FUTURE

BOEING

BAE SYSTEMS

SEA RI Systems Engineering Advancement Research Initiative

NDIA National Defense Industrial Association

Software Engineering Institute | Carnegie Mellon

... and several others

Objectives of the project

1. Gain common understanding of the needs and drivers of this initiative
2. Identify information needs underlying the application of SE effectiveness
   - Address SE effectiveness and key systems attributes for systems, SoS, and complex enterprises, such as robustness, flexibility, and architectural integrity
3. Identify set of leading indicators for SE effectiveness
4. Define and document measurable constructs for highest priority indicators
   - Includes base and derived measures needed to support each indicator, attributes, and interpretation guidance
5. Identify challenges for implementation of each indicator and recommendations for managing implementation
6. Establish recommendations for piloting and validating the new indicators before broad use

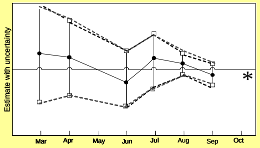
SE Leading Indicator Definition

- A measure for evaluating the effectiveness of a how a specific SE activity is applied on a program in a manner that provides information about impacts that are likely to affect the system performance objectives
  - An individual measure or collection of measures that are *predictive of future system performance*
    - Predictive information (e.g., a trend) is provided before the performance is adversely impacted
  - Measures factors that *may impact the system engineering performance*, not just measure the system performance itself
  - Aids leadership by providing insight to take actions regarding:
    - Assessment of process effectiveness and impacts
    - Necessary interventions and actions to avoid rework and wasted effort
    - Delivering value to customers and end users

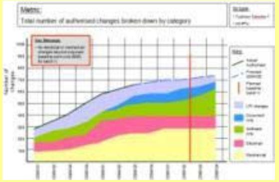
Leading Indicators

Sources of ignition | **Smoke detectors** | **Fire alarms** | **Fires**

Engineering Capability

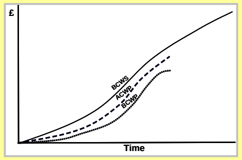


Engineering Performance



Engineering Status

Financial Indicators



Causes ← *Consequences*

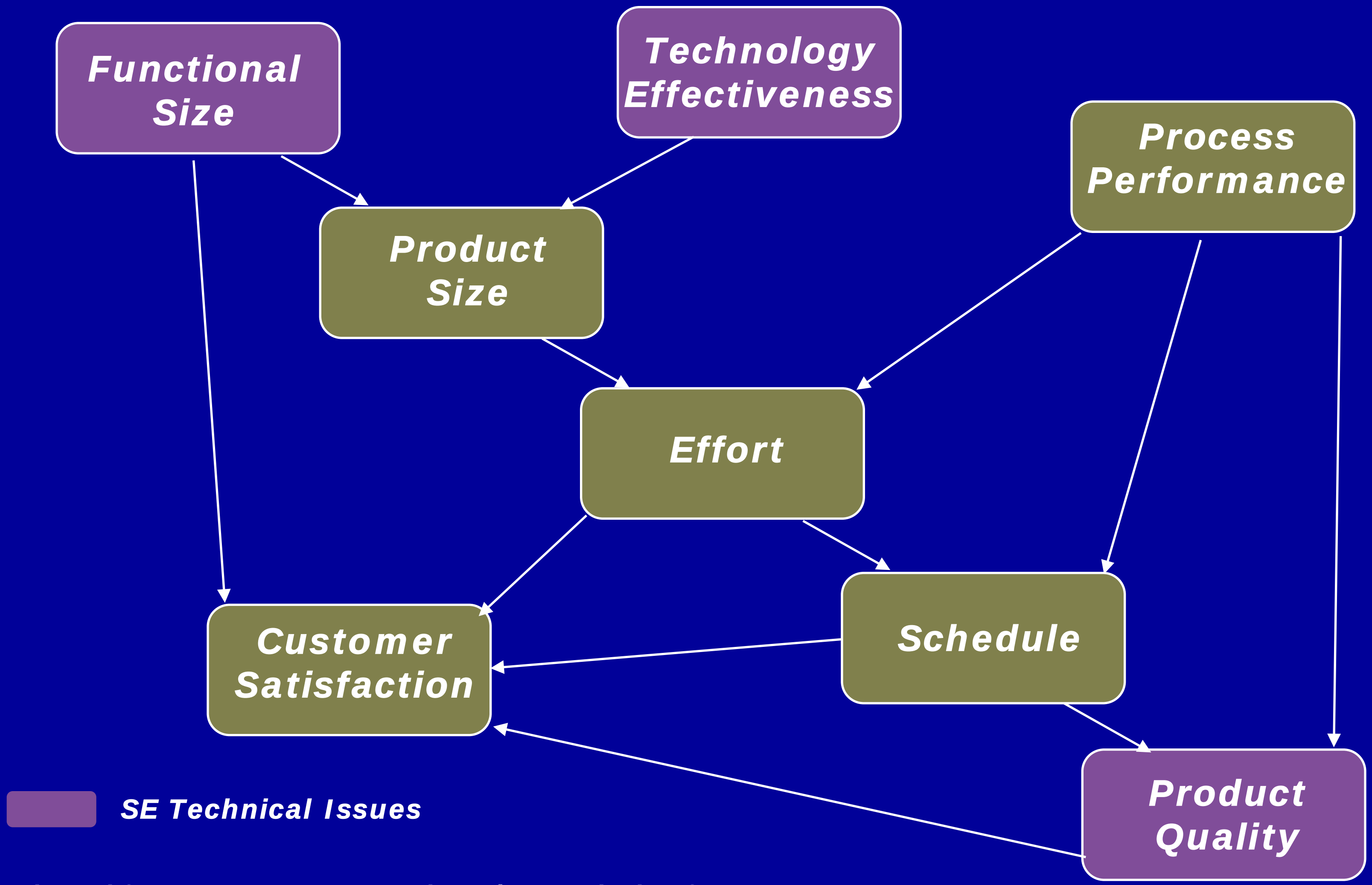
Need to monitor drivers and triggers

Performance not meeting plans

Product not maturing fast enough

Behind schedule, unpredictable

Interactions Among Factors



Adapted from J. McGarry, D.Card, et al., *Practical Software Measurement*, Addison Wesley, 2002

Criteria of Leading Indicators

- Early in activity flow
- In-process data collection
- In time to make decisions
  - Actionable
  - Key decisions
- Objective
- Insight into goals / obstacles
- Able to provide regular feedback
- Can support defined checkpoints
  - Technical reviews, etc.
- Confidence
  - Quantitative (Statistical)
  - Qualitative
- Can clearly/objectively define decision criteria for interpretation
  - Thresholds
- Tailorable or universal

Used criteria to prioritize candidates for inclusion in guide

Systems Engineering Leading Indicators

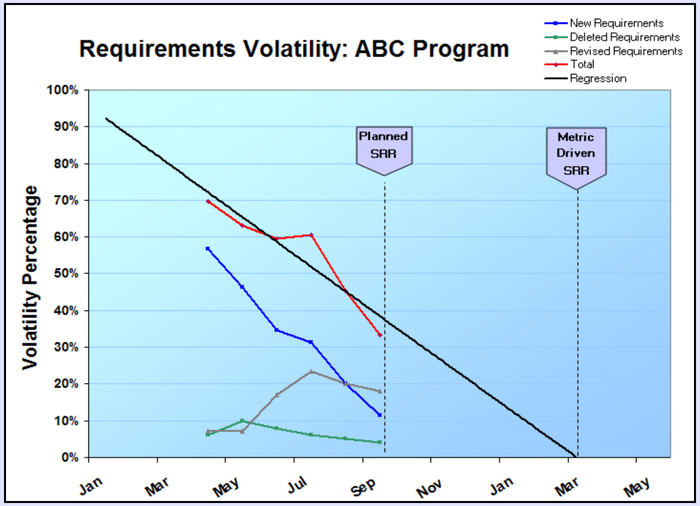
Thirteen leading indicators defined by SE measurement experts

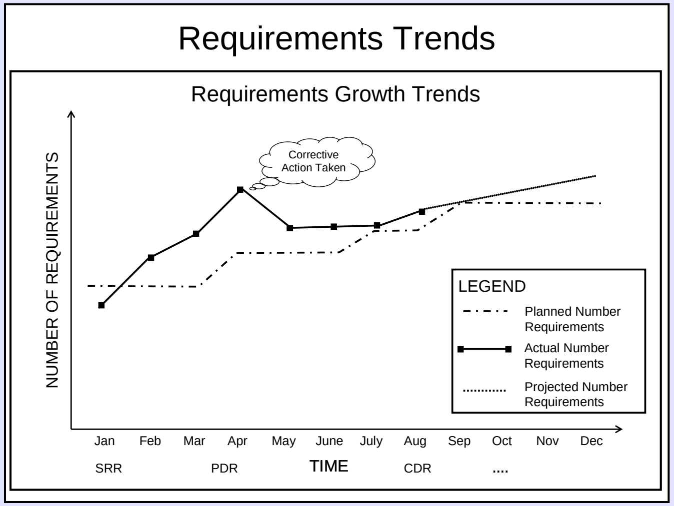
Beta guide released December 2005 for validation

- Pilot programs conducted
- Workshops conducted
- Survey conducted
  - 106 responses
  - Query of utility of each indicator
  - No obvious candidates for deletion

Version 1.0 released in June 2007

Objective: Develop a set of SE Leading Indicators to assess if program is performing SE effectively, and to enhance proactive decision making





List of Indicators

- Requirements Trends (growth; correct and complete)
- System Definition Change Backlog Trends (cycle time, growth)
- Interface Trends (growth; correct and complete)
- Requirements Validation Rate Trends (at each level of development)
- Requirements Verification Trends (at each level of development)
- Work Product Approval Trends
  - Internal Approval (approval by program review authority)
  - External Approval (approval by the customer review authority)
- Review Action Closure Trends (plan vs actual for closure of actions over time)
- Technology Maturity Trends (planned vs actual over time)
  - New Technology (applicability to programs)
  - Older Technology (obsolesence)
- Risk Exposure Trends (planned vs, actual over time)
- Risk Handling Trends (plan vs, actual for closure of actions over time)
- SE Staffing and Skills Trends: # of SE staff per staffing plan (level or skill - planned vs. actual)
- Process Compliance Trends
- Technical Measurement Trends: MOEs (or KPPs), MOPs, TPMs, and margins

Current set has 13 Leading Indicators

Fields of Information Collected for Each Indicator

- Information Need/Category
- Measurable Concept
- Leading Information Description
- Base Measures Specification
  - Base Measures Description
  - Measurement Methods
  - Units of Measure
- Entities and Attributes
  - Relevant Entities (being measured)
  - Attributes (of the entities)
- Derived Measures Specification
  - Derived Measures Description
  - Measurement Function
- Indicator Specification
  - Indicator Description and Sample
  - Thresholds and Outliers
  - Decision Criteria
  - Indicator Interpretation
- Additional Information
  - Related SE Processes
  - Assumptions
  - Additional Analysis Guidance
  - Implementation Considerations
  - User of the Information
  - Data Collection Procedure
  - Data Analysis Procedure

Derived from measurement guidance of PSM and ISO/IEC 15939, Measurement Process

Guide Contents

1. About This Document
2. Executive Summary
   - Includes Table 1 with overview of indicators and mapping to life cycle phases/stages
3. Leading Indicators Descriptions
   - Includes a brief narrative description of each indicator, description of the leading information provided and example graphics
4. Information Measurement Specifications
   - Detailed definitions of each indicators, including all fields of information

SYSTEMS ENGINEERING LEADING INDICATORS GUIDE

Version 1.0

June 15, 2007

Supersedes Beta Release, December 2005

Editors

Garry Roedler
Lockheed Martin Corporation
garry.j.roedler@lmco.com

Donna H. Rhodes
Massachusetts Institute of Technology
rhodes@mit.edu

Developed and Published by Members of

LAI LEAN AEROSPACE INITIATIVE

SEARI Systems Engineering Advancement Research Initiative

INCOSE International Council on Systems Engineering

PSM

INCOSE Technical Product Number: INCOSE-TP-2005-001-02

<http://www.incose.org/ProductsPubs/products/seleadingIndicators.aspx>

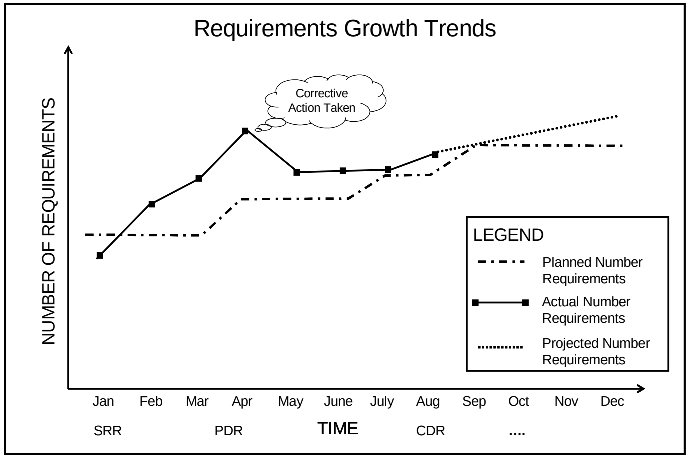
Example of Section 3 Contents

3.1. *Requirements Trends*

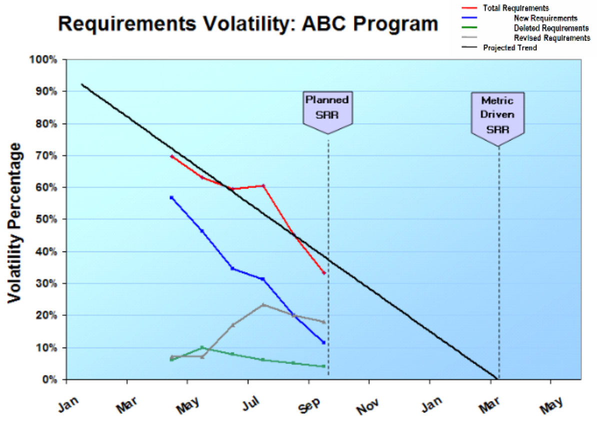
This indicator is used to evaluate the trends in the growth, change, completeness and correctness of the definition of the system requirements. This indicator provides insight into the rate of maturity of the system definition against the plan. Additionally, it characterizes the stability and completeness of the system requirements which could potentially impact design and production. The interface trends can also indicate risks of change to and quality of architecture, design, implementation, verification, and validation, as well as potential impact to cost and schedule.

An example of how such an indicator might be reported is show below. Refer to the measurement information specification in Section 4.1 for the details regarding this indicator; the specification includes the general information which would be tailored by each organization to suit its needs and organizational practices.

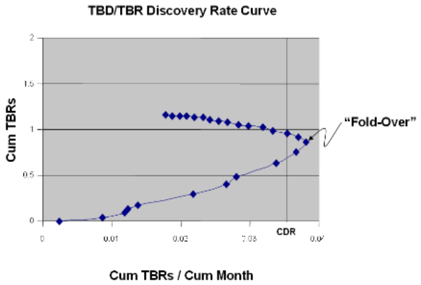
Requirements Trends

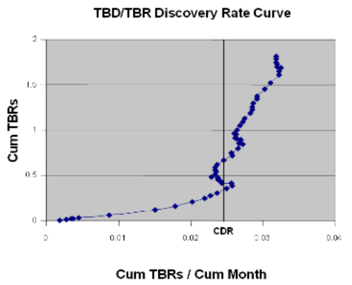


Requirements Trends. The graph illustrates growth trends in the number of requirements in respect to planned number of requirements (which is typically based on expected value based on historical information of similar projects as well as the nature of the program). Based on actual data, a projected number of requirements will also be shown on a graph. In this case, we can see around PDR that there is a significant variance in actual versus planned requirements, indicating a growing problem. An organization would then take corrective action – where we would expect to see the actual growth move back toward the planned subsequent to this point. The requirements growth is an indicator of potential impacts to cost, schedule, and complexity of the technical solution. It also indicates risks of change to and quality of architecture, design, implementation, verification, and validation.



Requirements Volatility. The graph illustrates the rate of change of requirements over time. It also provides a profile of the types of change (new, deleted, or revised) which allows root-cause analysis of the change drivers. By monitoring the requirements volatility trend, the program team is able to predict the readiness for the System Requirements Review (SRR) milestone. In this example, the program team initially selected a calendar date to conduct the SRR, but in subsequent planning made the decision to have the SRR be event driven, resulting in a new date for the review wherein there could be a successful review outcome.





TBD/TBR Discovery Rate. The graphs show the cumulative requirement TBDs/TBRs vs. the ratio of cumulative TBDs/TBRs over cumulative time. The plot provides an indication of the convergence and stability of the TBDs/TBRs over the life cycle of the project. The graph on the left shows a desirable trend of requirement TBD/TBR stability; as the ratio of decreases and the cumulative number of TBDs/TBRs approaches a constant level. This "fold-over" pattern is the desirable trend to look for, especially in the later stages of project life cycle. In contrast, the graph on the right shows an increasing number of TBDs/TBRs even as the program approaches later stages of its life cycle; this is a worrisome trend in system design stability. An advantage of this plot is that, by shape of the graph (without having to read

Graphics are for illustrative purposes only – may reflect a single aspect of the indicator.

Example of Section 4 Contents

4.1. Requirements Trends

Requirements Trends	
Information Need Description	
Information Need	• Evaluate the stability and adequacy of the requirements to understand the risks to other activities towards providing required capability, on-time and within budget. • Understand the growth, change, completeness and correctness of the definition of the system requirements.
Information Category	1. Product size and stability – Functional Size and Stability 2. Also may relate to Product Quality and Process Performance (relative to effectiveness and efficiency of validation)
Measurable Concept and Leading Insight	
Measurable Concept	Is the SE effort driving towards stability in the System definition (and size)?
Leading Insight Provided	• Indicates whether the system definition is maturing as expected. • Indicates risks of change to and quality of architecture, design, implementation, verification, and validation. • Indicates schedule and cost risks. • Greater requirements growth, changes, or impacts than planned or lower closure rate of TBDs/TBRs than planned indicate these risks. • May indicate future need for different level or type of resources/skills.
Base Measure Specification	
Base Measures	1. # Requirements 2. # Requirement TBDs/TBRs (by selected categories: interval, milestone) 3. # Requirement defects (by selected categories; e.g., type, cause, severity) 4. # Requirements changes (by selected categories; e.g., type, cause) 5. Impact of each requirement change (in estimated effort hours or range of hours) 6. Start/complete times of change
Measurement Methods	1. Count the number of requirements 2. Count the number of requirements TBDs/TBRs 3. Count the number of requirements defects per category 4. Count the number of requirements changes per category 5. Estimate the effort hours or range of effort hours expected for each change. 6. Record from actual dates & times of requirements complete in the CM system
Unit of Measurement	1. Requirements 2. TBDs/TBRs 3. Defects 4. Changes 5. Effort Hours 6. Date and Time (Hours, Minutes)
Entities and Attributes	
Relevant Entities	• Requirements
Attributes	• Requirement TBDs/TBRs • Requirement Defects • Requirement Changes • Time interval (e.g., monthly, quarterly, phase)

Derived Measure Specification	
Derived Measure	1. % Requirements approved 2. % Requirements Growth 3. % TBDs/TBRs closure variance per plan 4. % Requirements Modified 5. Estimated Impact of Requirements Changes for time interval (in Effort hours) 6. Defect profile 7. Defect density 8. Defect leakage (or escapes) 9. Cycle time for requirement changes (each and average)
Measurement Function *	1. (# requirements approved / # requirements identified and defined)*100 as a function of time 2. ((# requirements in current baseline - # requirements in previous baseline) / (# requirements in previous baseline) * 100 3. ((# TBDs/TBRs planned for closure – # TBDs/TBRs closed) / # TBDs/TBRs planned for closure) * 100 4. (# Requirements modified / Total # requirements) * 100 as a function of time 5. Sum of estimated impacts for changes during defined time interval during defined time interval 6. Number of defects for each selected defect categorization 7. # of requirements defects / # of requirements as a function of time 8. Subset of defects found in a phase subsequent to its insertion 9. Elapsed time (difference between completion time and start times) or total effort hours for each change
Indicator Specification	
Indicator Description and Sample **Also see 3.1**	Line or bar graphs that show trends of requirements growth and TBD/TBR closure per plan. Stacked bar graph that shows types, causes, and impact/severity of changes. Show thresholds of expected values based on experiential data. Show key events along the time axis of the graphs. 1. Line or bar graphs that show growth of requirements over time 2. Line or bar graphs that show % requirements approved over time 3. Line or bar graphs that show % TBDs/TBRs not closed per plan 4. Line or bar graphs that show % requirements modified, 5. Line or bar graphs that show estimated impact of changes for time interval (in effort hours) 6. Line or bar graphs that show defect profile (by types, causes, severity, etc.) 7. Line or bar graphs that show defect density 8. Stacked bar graph that shows types, causes, and impact/severity of changes on system design
Thresholds and Outliers	Organization dependent.
Decision Criteria	Investigate and, potentially, take corrective action when the requirements growth, requirements change impact, or defect density/distribution exceeds established thresholds <fill in organization specific threshold> or a trend is observed per established guidelines <fill in organizational specific>.

Example of Section 4 Contents (Cont'd)

Indicator Interpretation	• Used to understand impact on system definition and impact on production. • Analyze this indicator for process performance and other relationships that may provide more "leading perspective". • Ops Concept quality may be a significant leading indicator of the requirements stability (may be able to use number of review comments; stakeholder coverage in defining the Ops Concept). • Care should be taken that the organization does not create incentives driving perceptions that all requirements change is undesirable. Note: Requirements changes may be necessary to accommodate new functionality. • Review of this indicator can help determine the adequacy of: o Quantity and quality of Systems Engineers o Infrastructure o Process maturity (acquirer and supplier) o Interface design capability o Stakeholder collaboration across life cycle Funding by customer; financial challenge by the program management
Additional Information	
Related Processes	Stakeholder Requirements, Requirements Analysis, Architectural Design
Assumptions	Requirements Database, Change Control records, and defect records are maintained & current.
Additional Analysis Guidance	• May also be helpful to track trends based on severity/priority of changes • Defect leakage - identify the phases in which defect was inserted and found for each defect recorded.
Implementation Considerations	• Requirements that are not at least at the point of a draft baseline should not be counted. • Usage is driven by the correctness and stability of interfaces definition and design. o Lower stability means higher risk of impact to other activities and other phases, thus requiring more frequent review. o Applies throughout the life cycle, based on risk. o Track this information per baseline version to track the maturity of the baseline as the system definition evolves.
User of Information	• Program Manager (PM) • Chief Systems Engineer (CSE) • Product Managers • Designers
Data Collection Procedure	• See Appendix A
Data Analysis Procedure	• See Appendix A

Systems Engineering Leading Indicators Application to Life Cycle Phases/Stages

Table 1 - SYSTEMS ENGINEERING LEADING INDICATORS OVERVIEW											
Leading Indicator	**Insight Provided**	**Phases / Stages**									
		P 1	**P 2**	**P 3**	**P 4**	**P 5**	**S 1**	**S 2**	**S 3**	**S 4**	**S 5**
Requirements Trends	Rate of maturity of the system definition against the plan. Additionally, characterizes the stability and completeness of the system requirements which could potentially impact design and production.	●	●	●	●	●	●	●	●	●	●
System Definition Change Backlog Trend	Change request backlog which, when excessive, could have adverse impact on the technical, cost and schedule baselines.			●	●	●		●	●	●	
Interface Trends	Interface specification closure against plan. Lack of timely closure could pose adverse impact to system architecture, design, implementation and/or V&V any of which could pose technical, cost and schedule impact.	●	●	●	●	●	●	●	●	●	
Requirements Validation Trends	Progress against plan in assuring that the customer requirements are valid and properly understood. Adverse trends would pose impacts to system design activity with corresponding impacts to technical, cost & schedule baselines and customer satisfaction.	●	●	●	●	●	●	●	●	●	
Requirements Verification Trends	Progress against plan in verifying that the design meets the specified requirements. Adverse trends would indicate inadequate design and rework that could impact technical, cost and schedule baselines. Also, potential adverse operational effectiveness of the system.	●	●	●	●	●	●	●	●	●	●
Work Product Approval Trends	Adequacy of internal processes for the work being performed and also the adequacy of the document review process, both internal and external to the organization. High reject count would suggest poor quality work or a poor document review process each of which could have adverse cost, schedule and customer satisfaction impact.	●	●	●	●	●	●	●	●	●	
Review Action Closure Trends	Responsiveness of the organization in closing post-review actions. Adverse trends could forecast potential technical, cost and schedule baseline issues.	●	●	●	●	●	●	●	●	●	●

Indicator's Usefulness for Gaining Insight to the Effectiveness of Systems Engineering (1 of 3)

Indicator	Critic al	Very Useful	Somewhat Useful	Limited Usefuln ess	Not Useful	Usefulness Rating *
Requirements Trends	24%	35%	11%	3%	3%	4.1
System Definition Change Backlog Trend	7	11	7	3	1	3.9
Interface Trends	14	12	4	0	1	4.3
Requirements Validation Trends	22	16	4	0	1	4.4
Requirements Verification Trends	37	23	6	2	1	4.4
Work Product Approval Trends	7	19	21	2	0	3.9
Review Action Closure Trends	5	33	21	5	0	3.9
Risk Exposure Trends	14	37	6	1	0	4.3
Risk Handling Trends	6	25	11	1	0	4.1
Technology Maturity Trends	6	6	7	0	0	4.1
Technical Measurement Trends	21	27	6	0	0	4.4
Systems Engineering Staffing & Skills Trends	11	27	15	0	0	4.2
Process Compliance Trends	6	14	11	1	0	4.0

** Defined on the Slide . Somewhat Useful Very Useful*

Percentages shown are based on total survey responses. Not all indicator responses total to 100% due to round-off error or the fact that individual surveys did not include responses for every question.

Indicator's Usefulness for Gaining Insight to the Effectiveness of Systems Engineering (2 of 3)

- Usefulness Ratings defined via the following guidelines:
  - 4.6-5.0 = Critical: Crucial in determining the effectiveness of Systems Engineering
  - 4.0-4.5 = Very Useful: Frequent insight and/or is very useful for determining the effectiveness of Systems Engineering
  - 3.0-3.9 = Somewhat Useful: Occasional insight into the effectiveness of Systems Engineering
  - 2.0-2.9 = Limited Usefulness: Limited insight into the effectiveness of Systems Engineering
  - Less than 2.0 = Not Useful: No insight into the effectiveness of Systems Engineering

Looking Forward – What Next?

Next Steps/Action Items

- Revision to SELI Guide revision planned for release in December
- Continue to conduct SELI telecons every 3 weeks
  - Contact Howard Schimmoller, Garry Roedler, or Cheryl Jones for information

New Indicators

- New indicators
  1. Test Completeness
  2. Resource Volatility
  3. Defect and Error Trends
  4. System Affordability
  5. Architecture Trends
  6. Algorithm & Scenario Trends
  7. Complexity Change Trends
  8. Concept Development – May want to consider based on needs identified by UARC EM task
  9. 2 other indicators are being contributed for consideration

Will include those that have matured by late November

Additional Information on Specific Application and Relationships

1. Cost-effective sets of Base Measures that support greatest number of indicators
2. Indicators vs. SE Activities of ISO/IEC 15288
3. Application of the SE Leading Indicators for Human System Integration (HSI)
4. Application of the SE Leading Indicators for Understanding Complexity

SELI versus SE Activities of ISO/IEC 15288

	Requirements Trends	System Definition Change Backlog Trend	Interface Trends	Requirements Validation Trends	Requirements Verification Trends	Work Product Approval Trends	Review Action Closure Trends	Risk Exposure Trends	Risk Handling Trends	Technology Maturity Trends	Technical Measurement Trends	Systems Engineering Staffing & Skills Trends	Process Compliance Trends	Test Completeness Trends	Resource Volatility Trends	Defect/Error Trends	Algorithm/ Scenario Trends	System Affordability Trends	Architecture Trends
6.3 Project Processes																			
6.3.1 Project Planning Process																			
6.3.1.3.a Define the project																			
6.3.1.3.b Plan the project resources												x			x				
6.3.1.3.c Plan the project technical and quality management						x	x									x			
6.3.1.3.d Activate the project																			
6.3.2 Project Assessment and Control Process																			
6.3.2.3.a Assess the project						x	x					x	x		x	x			
6.3.2.3.b Control the project						x	x					x	x		x	x			
6.3.2.3.c Close the project																			
6.3.3 Decision Management Process																			
6.3.3.3.a Plan and define decisions										x								x	
6.3.3.3.b Analyze the decision information										x								x	
6.3.3.3.c Track the decision										x								x	
6.3.4 Risk Management Process																			
6.3.4.3.a Plan Risk Management																			
6.3.4.3.b Manage Risk Profile																			
6.3.4.3.c Analyze Risks								x											
6.3.4.3.d Treat Risks								x	x										
6.3.4.3.e Monitor Risks								x	x										
6.3.4.3.f Evaluate Risk Management Process								x	x										
6.3.5 Configuration Management Process																			
6.3.5.3.a Plan configuration management																			
6.3.5.3.b Perform configuration management		x																	
6.3.6 Information Management Process																			
6.3.6.3.a Plan information management																			
6.3.6.3.b Perform information management		x																	
6.4 Technical Processes																			
6.4.1 Stakeholder Requirements Definition Process																			
6.4.1.3.a Elicit Stakeholder Requirements	x																		
6.4.1.3.b Define Stakeholder Requirements	x																x	x	
6.4.1.3.c Analyze and Maintain Stakeholder Requirements	x	x		x							x						x	x	

NAVAIR Applied Leading Indicators (ALI) Methodology

- Systematically analyzes multiple data elements for a specific information need to determine mathematically valid relationships with significant correlation
  - These are then identified as Applied Leading Indicators
- Provides a structured approach for:
  - Validation of the LIs
  - Identifying most useful relationships
- Unanimous agreement to include this in the SELI guide
- NAVAIR (Greg Hein) to summarize the methodology for incorporation into the SELI Guide revision as an appendix
  - Summary will include links to any supplementary information and guidance

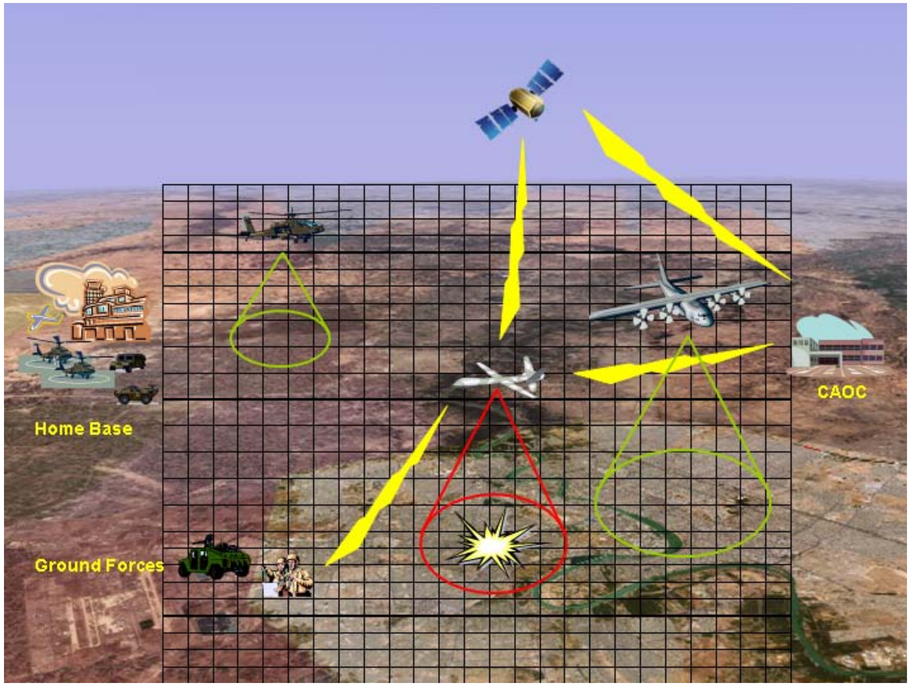
Interaction with SERC SE Effectiveness Measurement Project

- SE Leading Indicators Guide is pointed to from SERC SE Effectiveness Measurement (EM) project for quantitative measurement perspective
- SERC EM contribution:
  - Short-term:
    - Mapping of SE Effectiveness Measurement Framework to SE Leading Indicators (SELI)
      - 51 Criteria => Critical Success Factors => Questions => SELI
        - Critical Success Factors serve as Information Needs
        - Questions serve as Measurable Concepts
    - Mapping of 51 Criteria to SELI
    - Review to ensure consistency of concepts and terminology
  - Longer-term:
    - Work with OSD to get infrastructure in place to support data collection and analysis
      - Tie to SRCA DB (TBR)
      - May require government access and analysis

QUESTIONS?

Air Force Institute of Technology

LINKING INTEROPERABILITY CHARACTERS AND MEASURES OF EFFECTIVENESS: A METHODOLOGY FOR EVALUATING ARCHITECTURES



Lt Col Jan von der Felsen, DEUAF
Maj Darryl Insley, USAF
Mr. Brian McKellar, DAF

Advisors:
Dr. David Jacques
Dr. John Colombi
Sponsor:
Mr. Bruce Preiss, AFRL/RYAA

Disclaimer

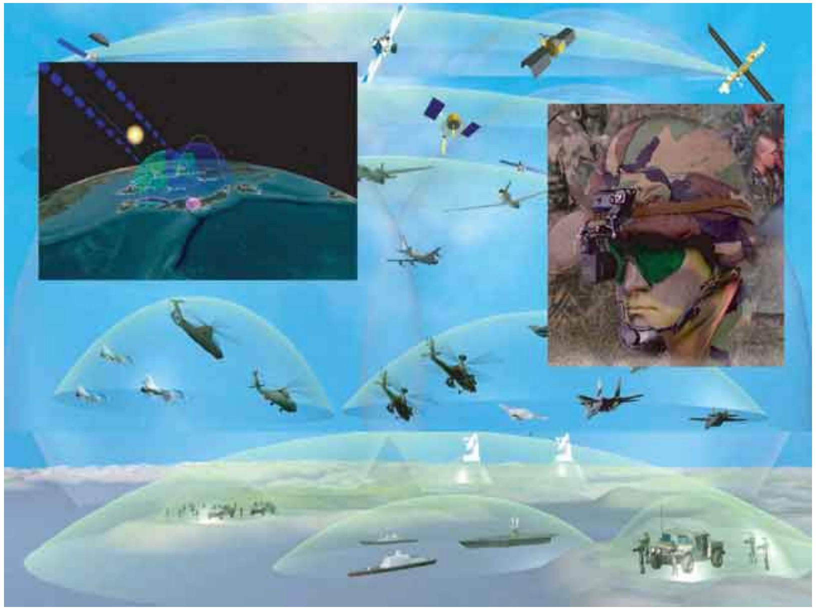
This is early on in a basic research effort ….

… but we think it has promise!

Problem Statement

Can changes in "*<u>Interoperability</u>*" of an ISR architecture be quantitatively linked to changes in mission effectiveness?

From good…..

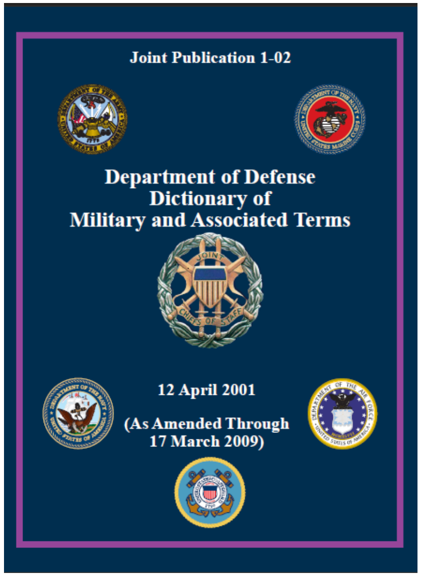


To better….?

Interoperability Defined

Joint doctrine defines interoperability as:

"The ability to operate in synergy in the execution of assigned tasks." **JP 1-02, 2008**

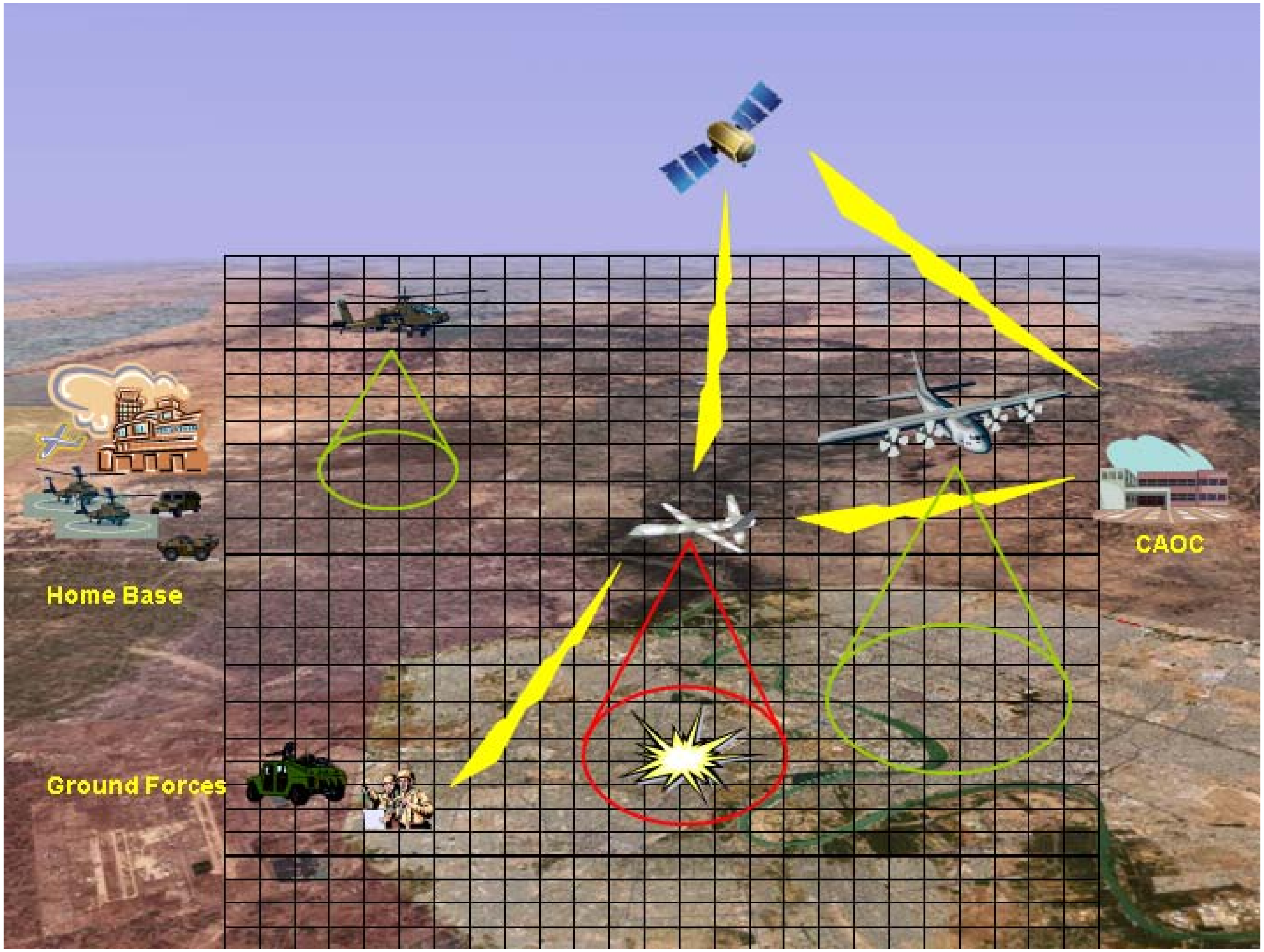


Layered Sensing Background

- Unconventional and evolving enemy tactics require better intelligence, situational awareness, tactics and technologies
- Must be robust, flexible, agile, timely, and effective
- Must be able to produce “tailored effects”

> “Layered Sensing provides military and homeland security decision makers at all levels with timely, actionable, trusted, and relevant information necessary for situational awareness to ensure their decisions achieve the desired military/humanitarian effects. Layered Sensing is characterized by the appropriate sensor or combination of sensors/platforms, infrastructure and exploitation capabilities to generate that situation awareness and directly support delivery of “tailored effects”. (AFRL White Paper, 2008)

Layered Sensing OV-1: Interoperability



Sensor Packages

Gotcha – ISR pallet on cargo aircraft

Lair/Nitestare - C-12 Huron

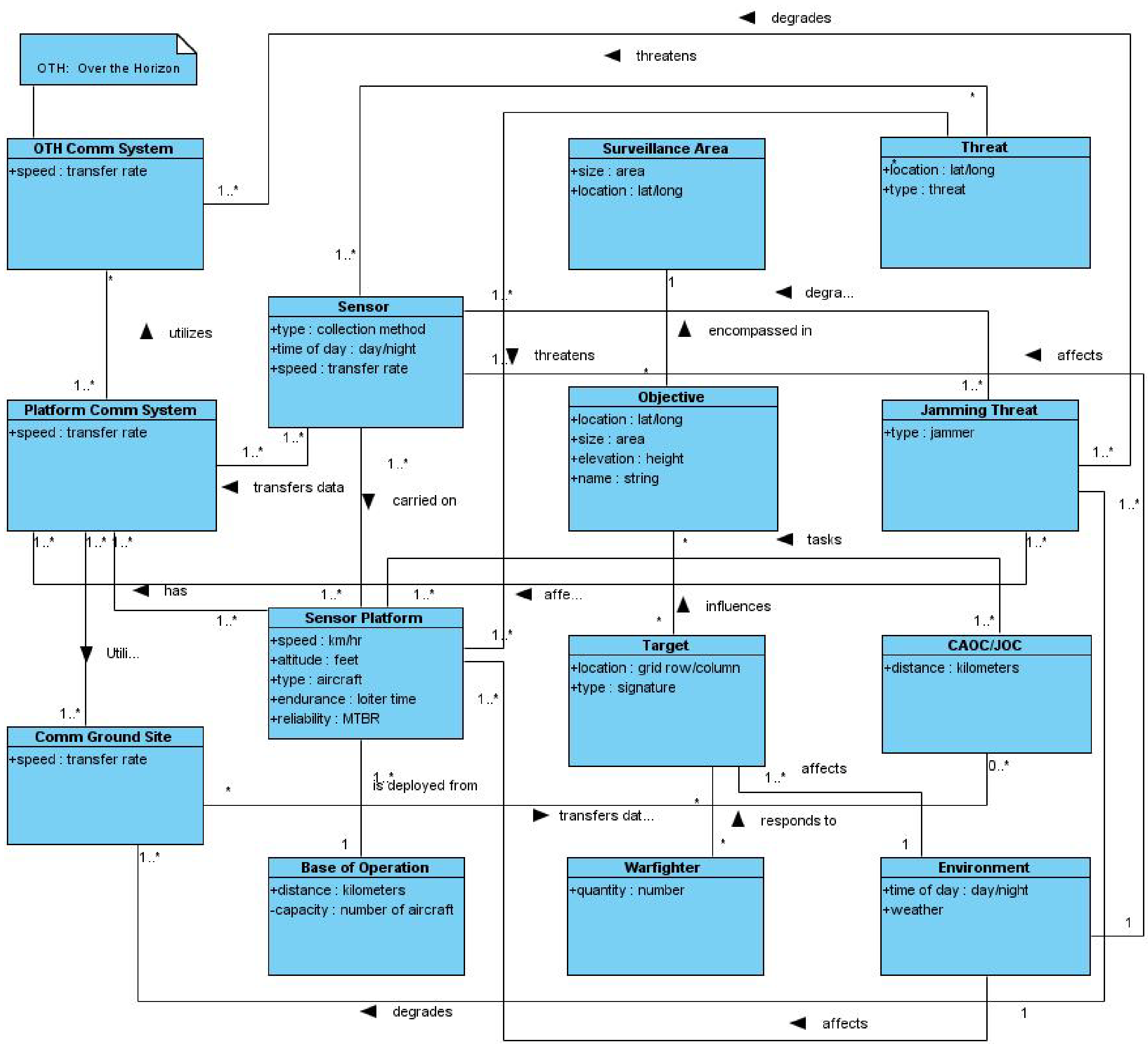
Argus-IS - A-160

“Generic” - MQ-X Pred-like

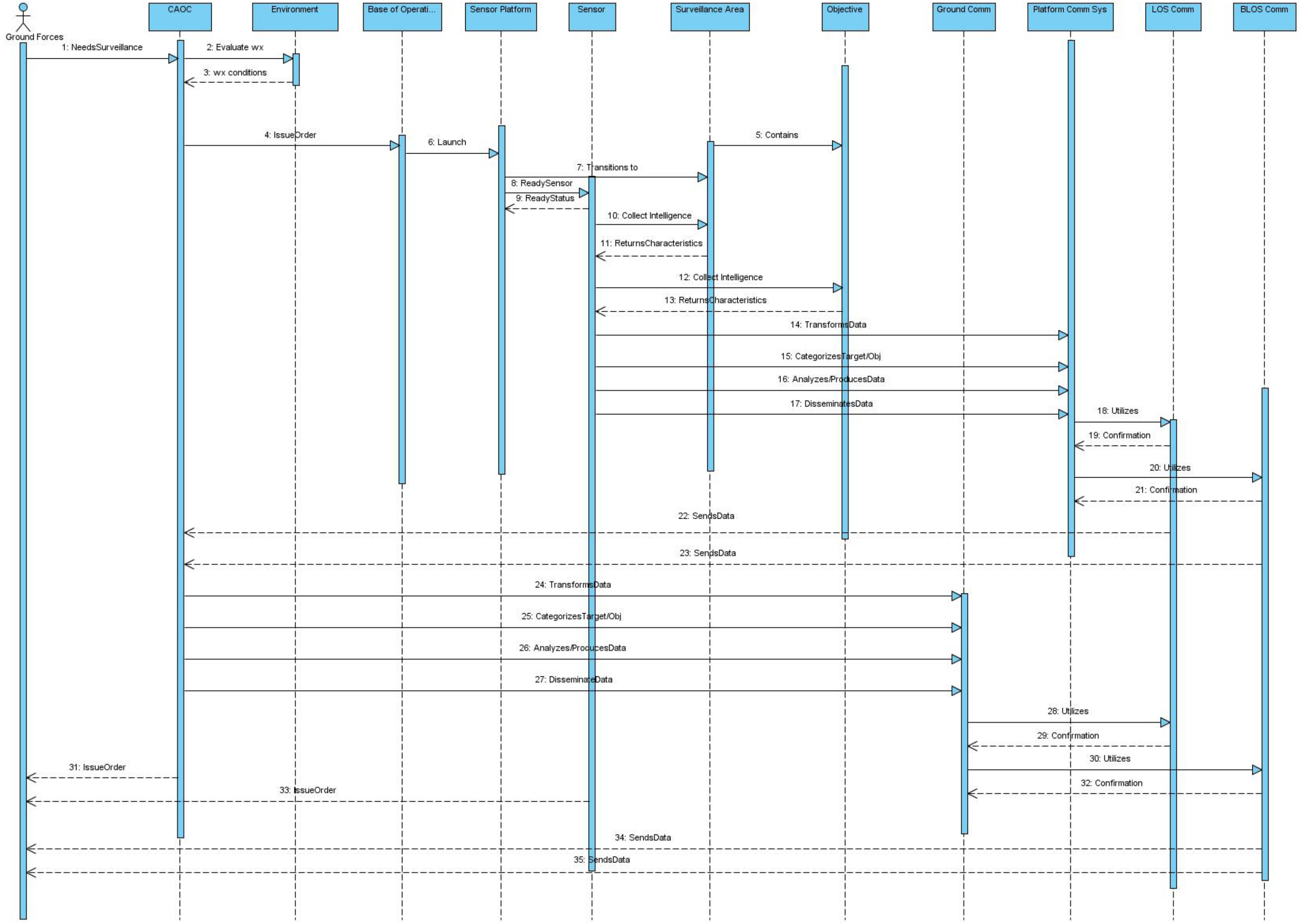
Attributes and MOEs

Attribute (LS WhitePaper)	Measure of Effectiveness (MOE)
Persistent Coverage	Percentage of time mission is covered by sensor (MOE 1)
Wide Area Coverage	Percentage of Area of Responsibility covered by sensors (MOE 2)
Timeliness	Time for information to pass from sensor to decision node (MOE 3)
Robust, Agile, Adaptable	Layered sensing mission failure rate (MOE 4)
	Average time taken to begin mission coverage (MOE 5)
Spectrum Dominance and Control	Percentage of time mission covered by at least two platforms (MOE 6)

Layered Sensing Object Diagram

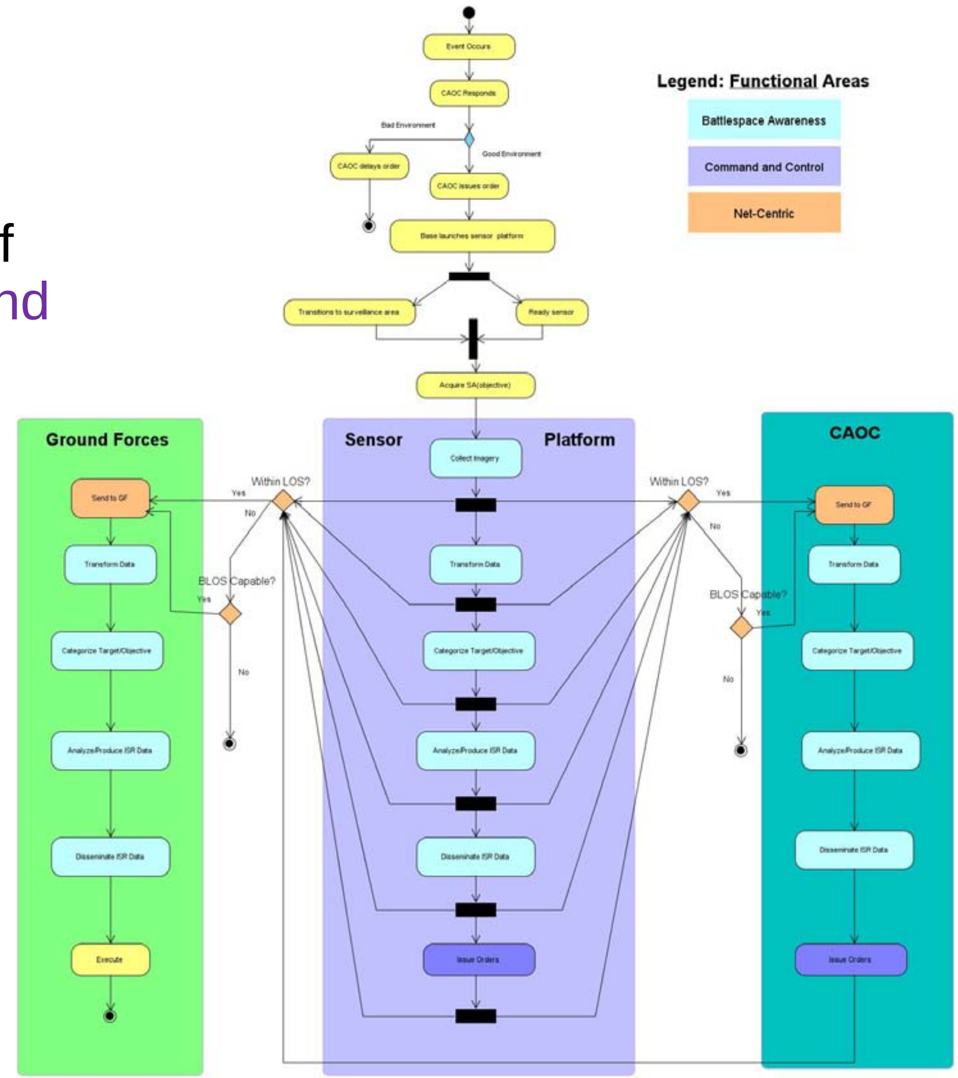


Layered Sensing System Sequence Diagram

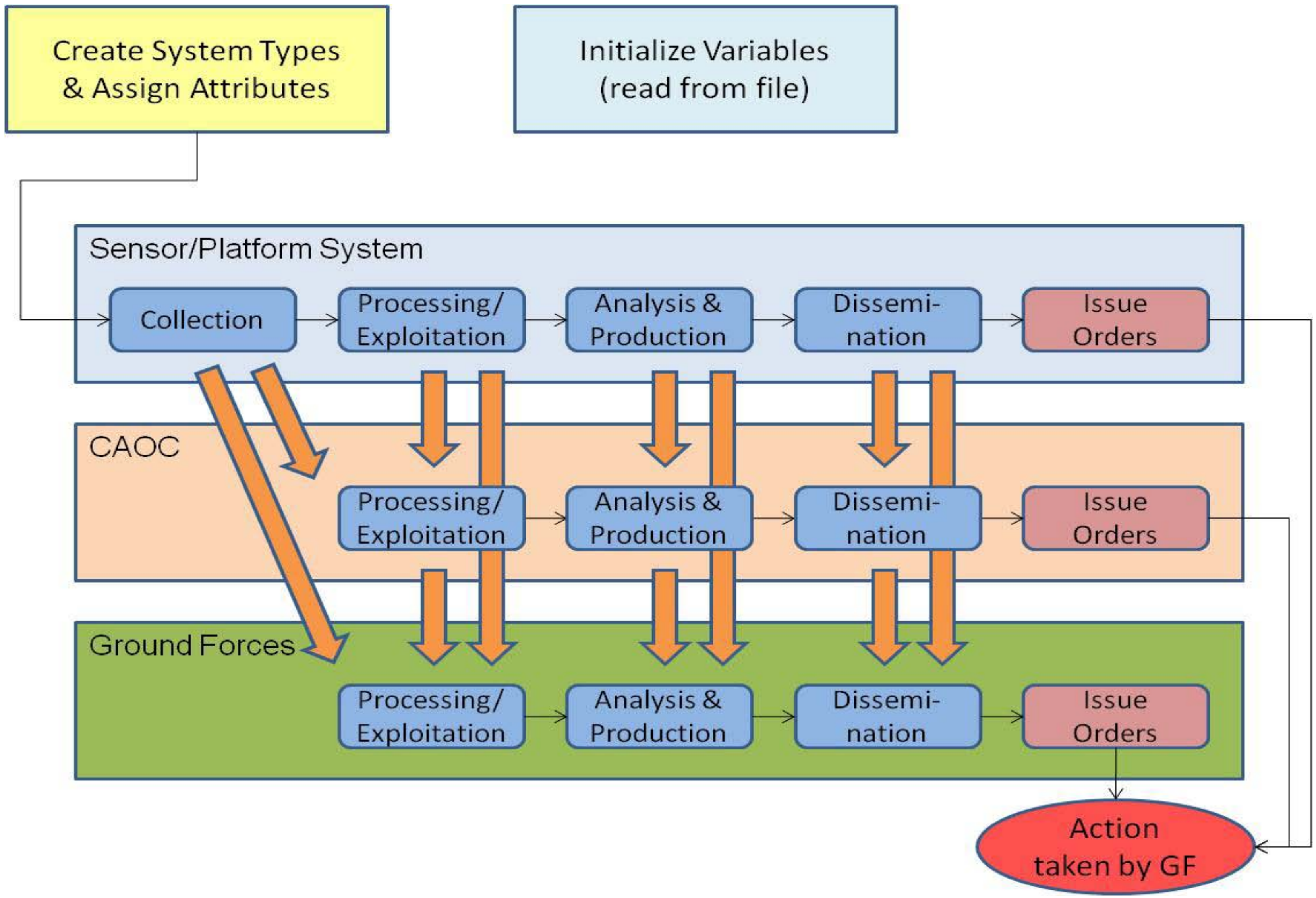


Operational Activity Model (OV-5)

- Models Use Case scenario previously described
- Organized into functional areas of Battlespace Awareness, Command and Control and Net-Centricity
- “Actions” within the activity model represent interoperability characters derived from the DoD 2009 Joint Capability Areas (JCA)



System Interoperability



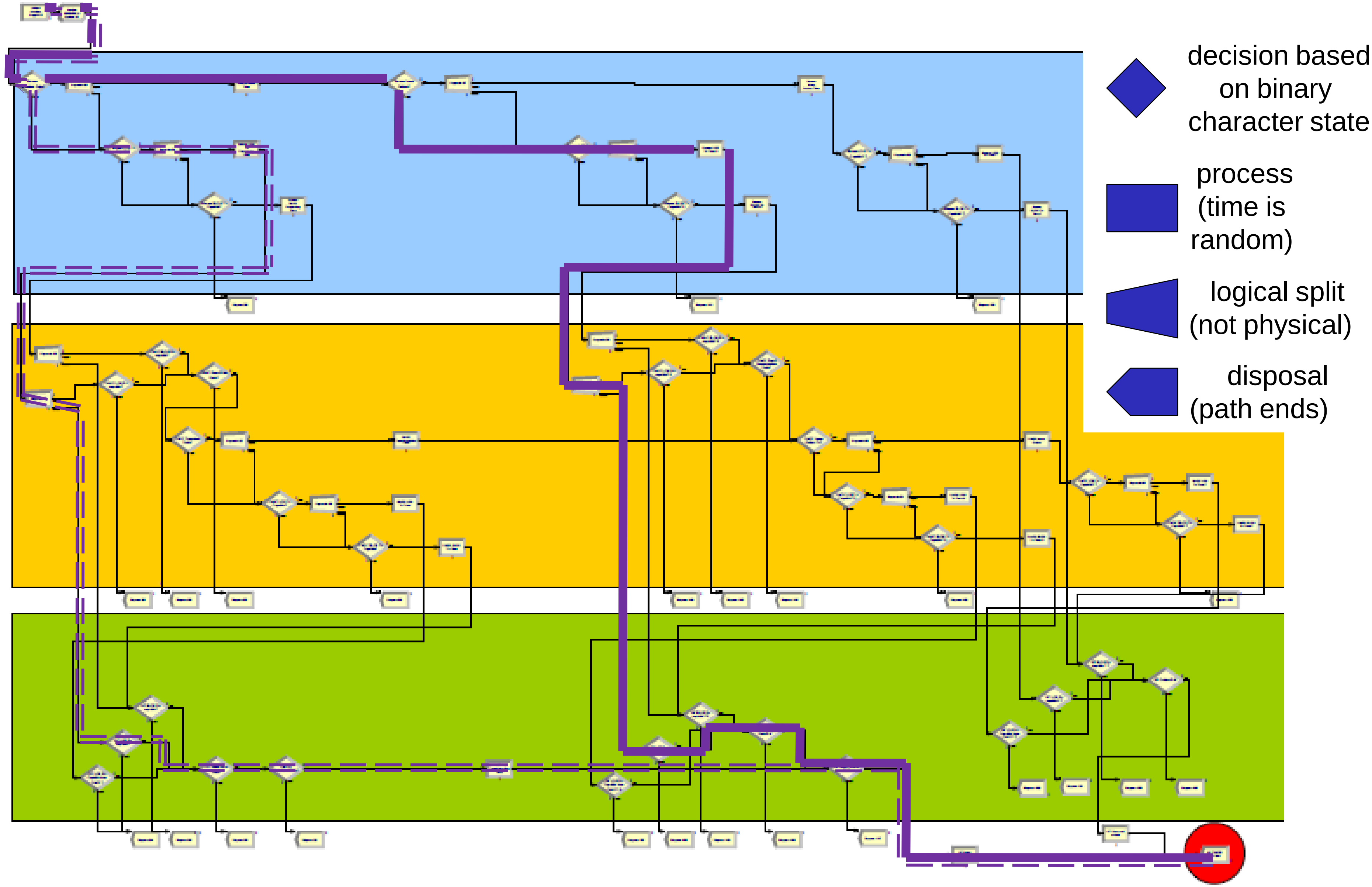
Interoperability Matrix (Transmit)

	transmit / can actively do						
	BLUE SYSTEMS					BLUE PLAYERS	
	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
Battlespace Awareness	1	1	1	1	1	1	1
Intelligence, Surveillance and Reconnaissance	1	1	1	1	1	1	1
Collection	1	1	1	1	1	0	0
Imagery Collection	1	1	1	1	1	0	0
Electro-Optical Imagery Collection	1	1	0	1	1	0	0
Panchromatic Collection	1	1	0	0	1	0	0
Infrared Collection	0	0	0	1	1	0	0
RADAR Imagery Collection	0	0	1	0	1	0	0
Processing / Exploitation	1	1	1	1	1	1	1
Data Transformation	1	1	1	1	1	1	0
Objective / Target Categorization	1	1	1	1	1	1	1
Analysis and Production	1	0	1	1	0	1	1
Intelligence, Surveillance and Reconnaissance Dissemination	1	0	1	1	0	1	1
Command and Control	1	0	1	1	0	1	1
Direct	1	0	1	1	0	1	1
Task	1	0	1	1	0	1	1
Synchronize Operations	0	0	0	0	0	0	0
Issue Plans	0	0	0	0	0	0	0
Issue Orders	1	0	1	1	0	1	1
Net-Centric	1	1	1	1	1	1	1
Information Transport (IT)	1	1	1	1	1	1	1
Wireless Transmission	1	1	1	1	1	1	1
Line of Sight	1	1	1	1	1	1	1
Beyond Line of Sight	0	0	0	0	1	1	0

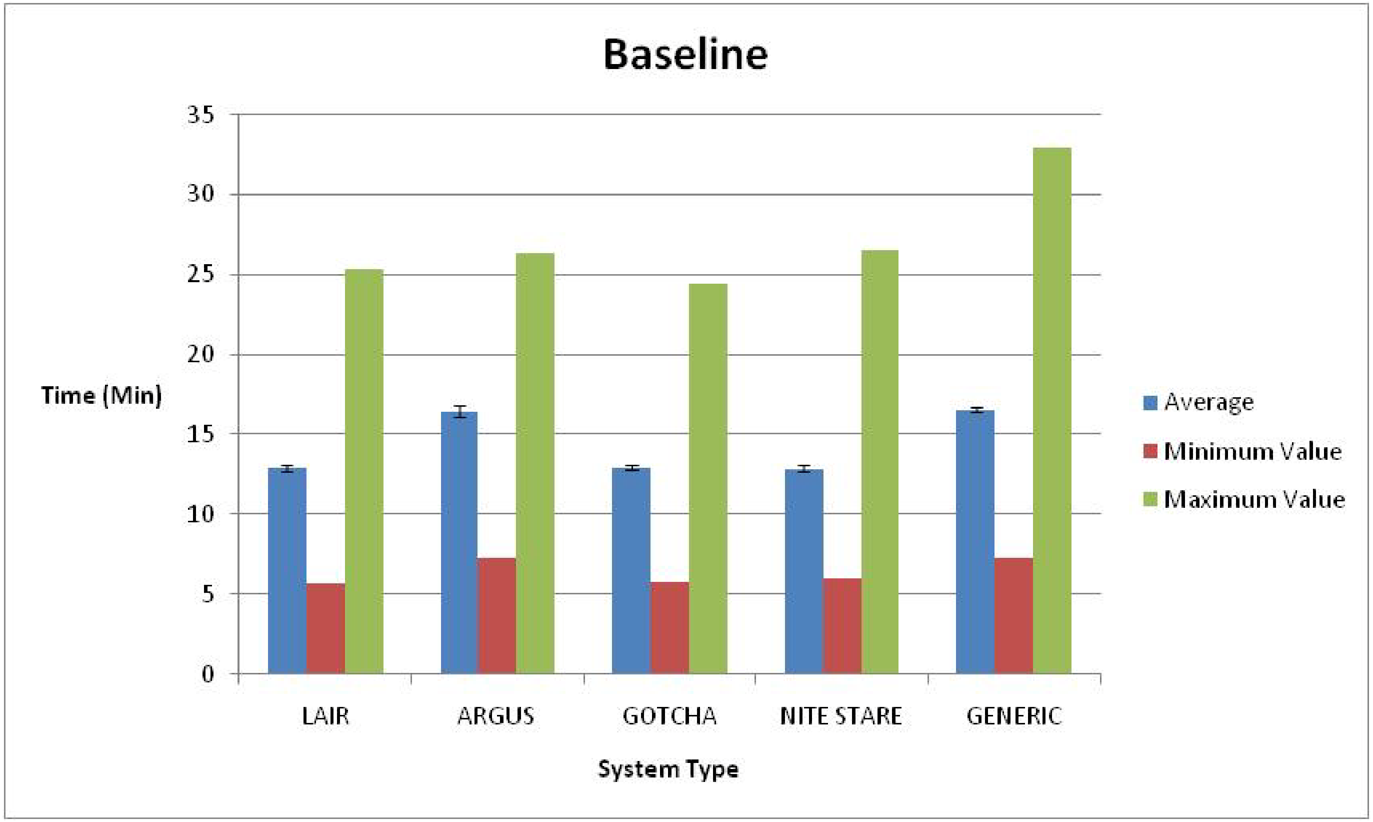
Interoperability Matrix (Receive)

	receive / can understand or work with						
	BLUE SYSTEMS					BLUE PLAYERS	
	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
Battlespace Awareness	1	1	1	1	1	1	1
Intelligence, Surveillance and Reconnaissance	1	1	1	1	1	1	1
Collection	1	1	1	1	1	1	1
Imagery Collection	1	1	1	1	1	1	1
Electro-Optical Imagery Collection	1	1	0	1	1	1	1
Panchromatic Collection	1	1	0	0	1	1	1
Infrared Collection	0	0	0	1	1	1	1
RADAR Imagery Collection	0	0	1	0	1	0	0
Processing / Exploitation	0	0	0	0	0	1	1
Data Transformation	0	0	0	0	0	1	1
Objective / Target Categorization	0	0	0	0	0	1	1
Analysis and Production	0	0	0	0	0	1	1
Intelligence, Surveillance and Reconnaissance Dissemination	0	0	0	0	0	1	1
Command and Control	1	1	1	1	1	0	1
Direct	1	1	1	1	1	0	1
Task	1	1	1	1	1	0	1
Synchronize Operations	0	0	0	0	0	0	0
Issue Plans	0	0	0	0	0	0	0
Issue Orders	1	1	1	1	1	0	1
Net-Centric	1	1	1	1	1	1	1
Information Transport (IT)	1	1	1	1	1	1	1
Wireless Transmission	1	1	1	1	1	1	1
Line of Sight	1	1	1	1	1	1	1
Beyond Line of Sight	0	0	0	0	1	1	0

System Interoperability

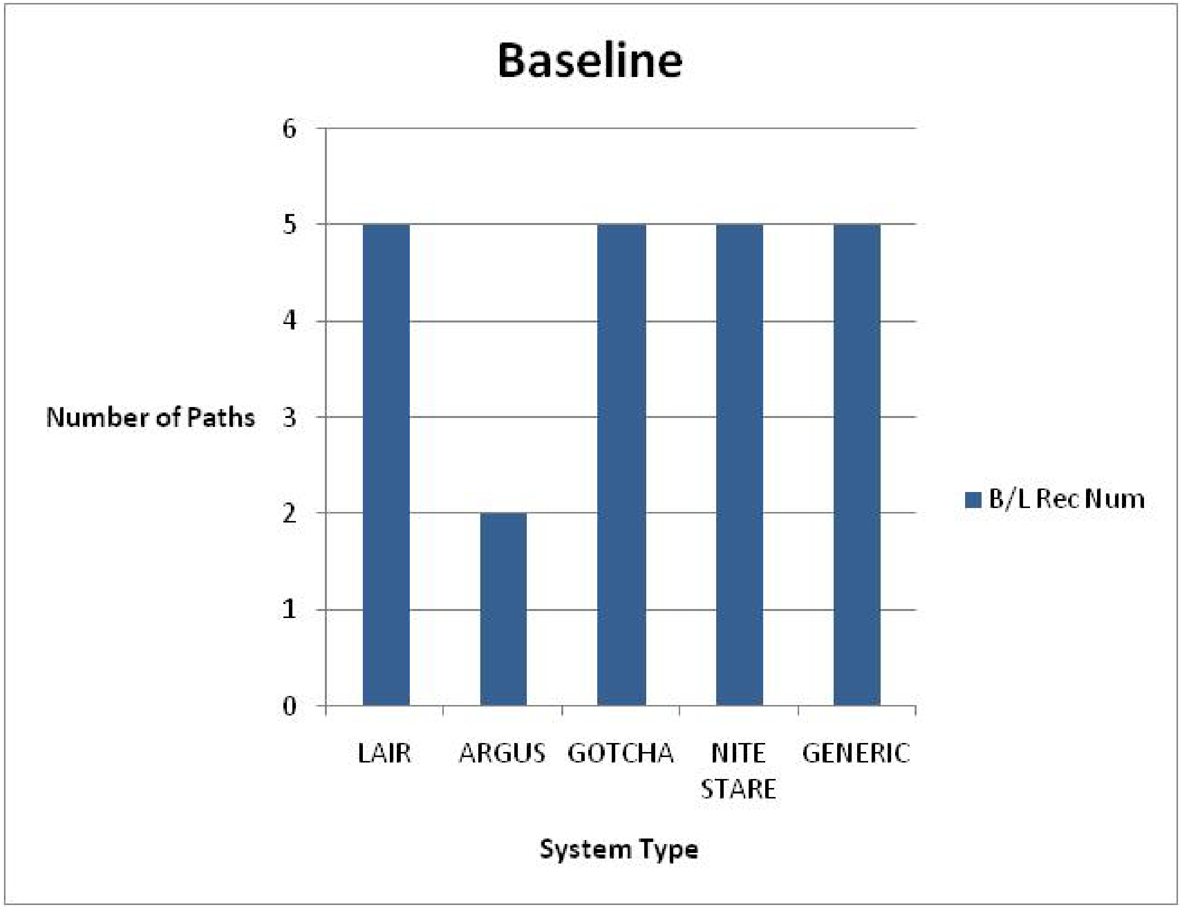


System Interoperability



Time for Data to Pass from Sensor to Ground Forces

System Interoperability



Number of Process Paths Data Can Follow from Sensor to Ground Forces

System Interoperability

Experimental setup

- IE 2: Ground forces receive BLOS comms
- Measure interoperability*
- Calculate MOE
- Compare results … look for correlation

* Used binary system similarity, T. Ford, INCOSE Systems Engineering, 2008.

System Interoperability

Interoperability Measurement

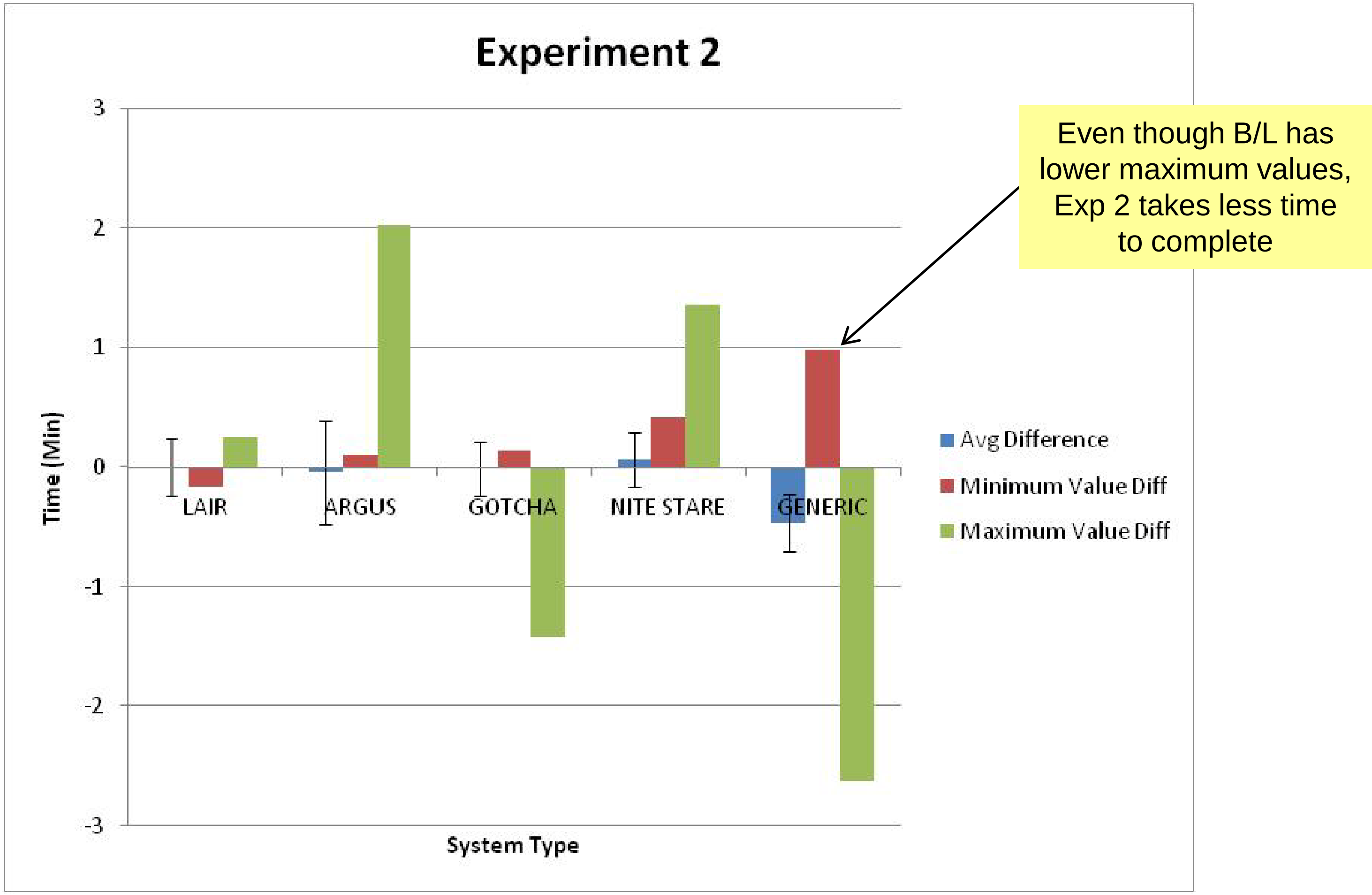
Experiment 2

	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	7/12	1/2	13/24	7/12	5/8	19/24
ARGUS-IS	5/12	0	1/3	3/8	5/12	13/24	13/24
GOTCHA	1/2	1/2	0	1/2	13/24	13/24	17/24
NITE STARE	13/24	13/24	1/2	0	7/12	5/8	19/24
generic	5/12	5/12	3/8	5/12	0	5/8	5/8
CAOC	5/12	5/12	5/12	5/12	11/24	0	2/3
GF	5/12	5/12	5/12	5/12	11/24	11/24	0
average interoperability measure:	0.5089						

Interoperability Measurement Difference

	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	0	0	0	0	0	0
ARGUS-IS	0	0	0	0	0	0	0
GOTCHA	0	0	0	0	0	0	0
NITE STARE	0	0	0	0	0	0	0
generic	0	0	0	0	0	0	1/24
CAOC	0	0	0	0	0	0	1/24
GF	0	0	0	0	1/24	1/24	0
avg interop measure difference:	0.0039						

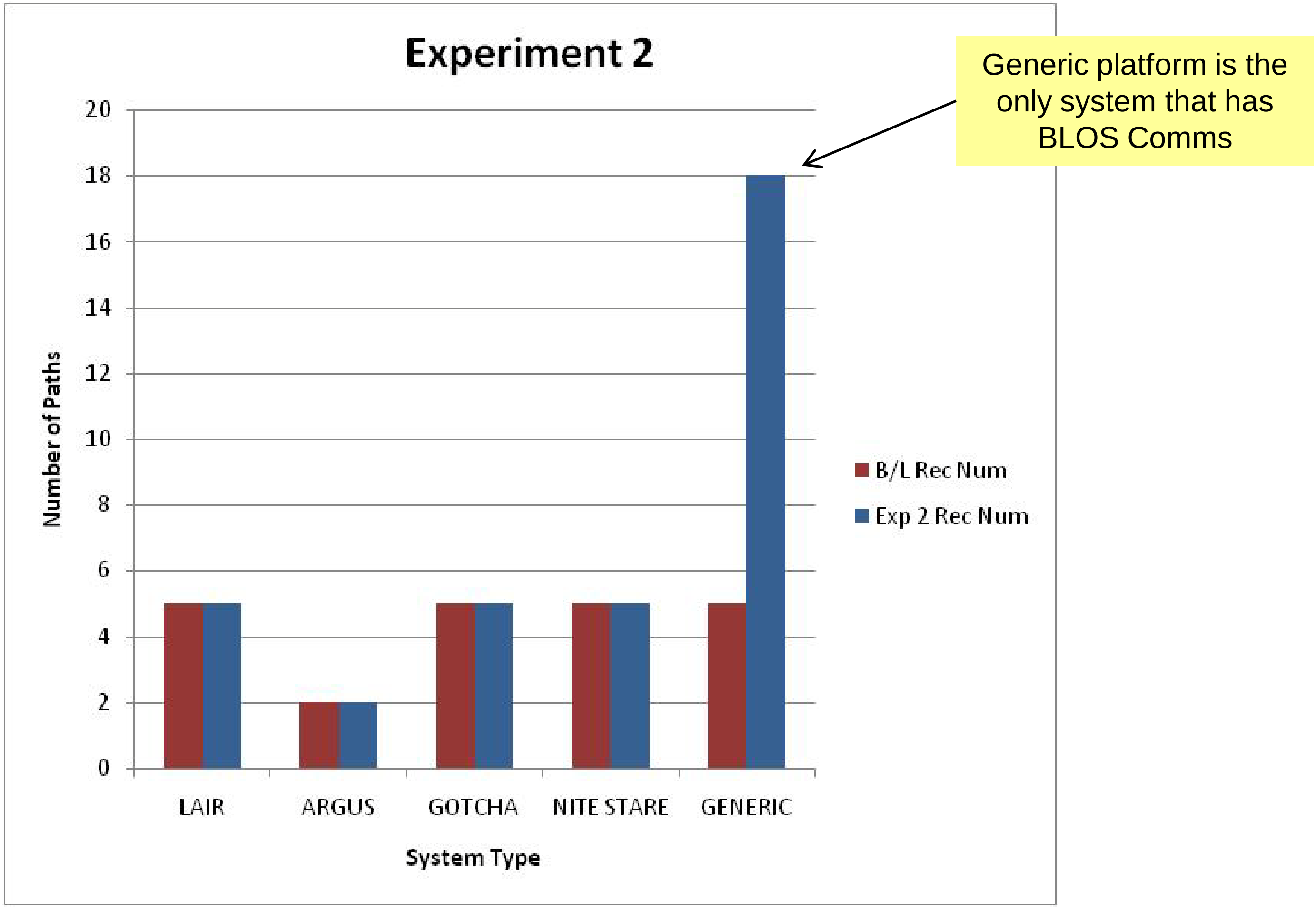
System Interoperability



Time for Data to Pass from

Sensor to Ground Forces

System Interoperability



Number of Process Paths Data Can Follow from Sensor to Ground Forces

System Interoperability

Experimental trial goals

- IE 3: Argus receives BLOS comms

System Interoperability

Experiment 3

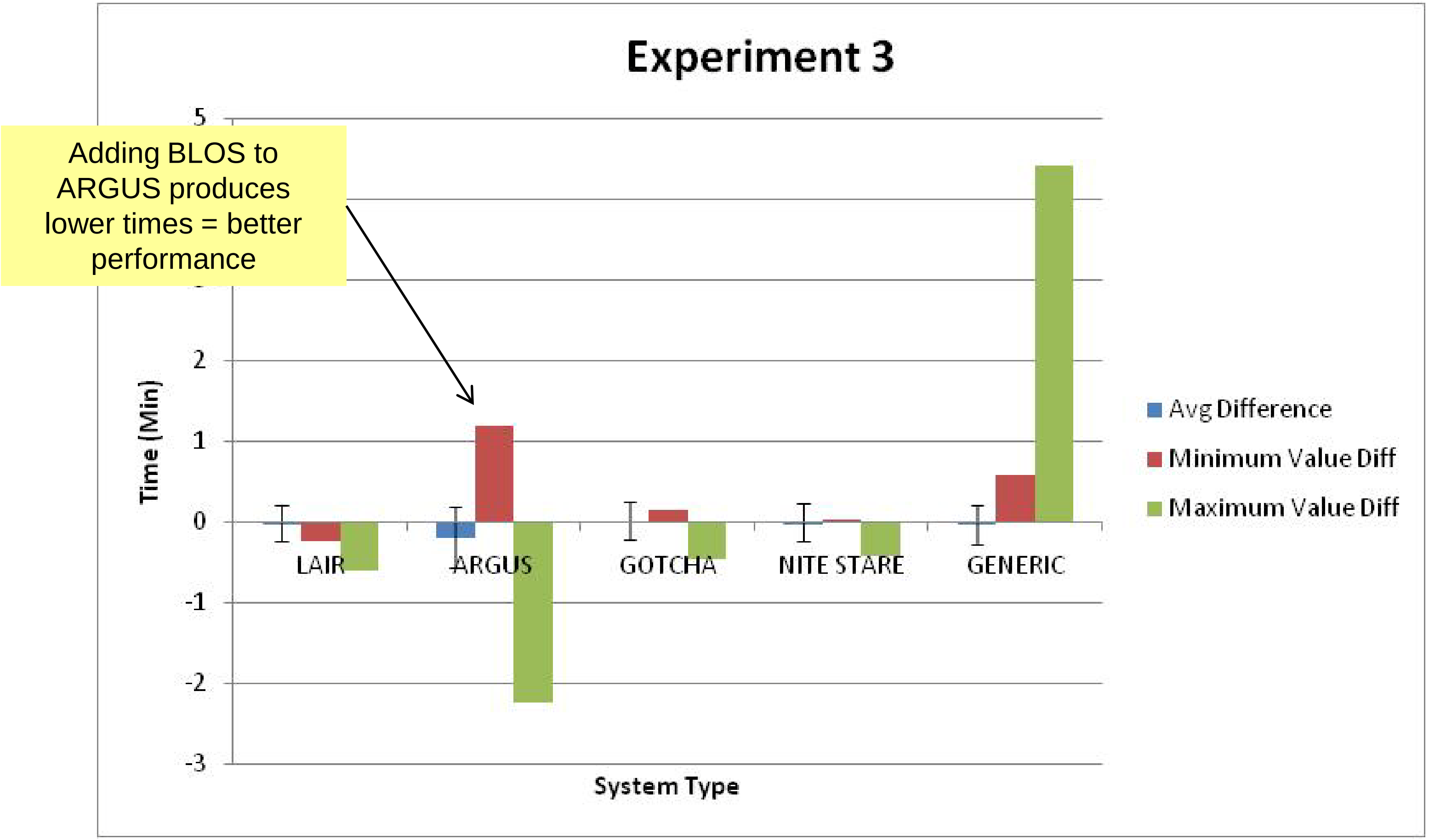
	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	7/12	1/2	13/24	7/12	5/8	19/24
ARGUS-IS	5/12	0	1/3	3/8	11/24	7/12	13/24
GOTCHA	1/2	1/2	0	1/2	13/24	13/24	17/24
NITE STARE	13/24	13/24	1/2	0	7/12	5/8	19/24
generic	5/12	11/24	3/8	5/12	0	5/8	7/12
CAOC	5/12	11/24	5/12	5/12	11/24	0	5/8
GF	5/12	5/12	5/12	5/12	5/12	5/12	0
average interoperability measure:		0.5089					

Interoperability Measurement

	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	0	0	0	0	0	0
ARGUS-IS	0	0	0	0	1/24	1/24	0
GOTCHA	0	0	0	0	0	0	0
NITE STARE	0	0	0	0	0	0	0
generic	0	1/24	0	0	0	0	0
CAOC	0	1/24	0	0	0	0	0
GF	0	0	0	0	0	0	0
avg interop measure difference:		0.0039					

Interoperability Measurement Difference

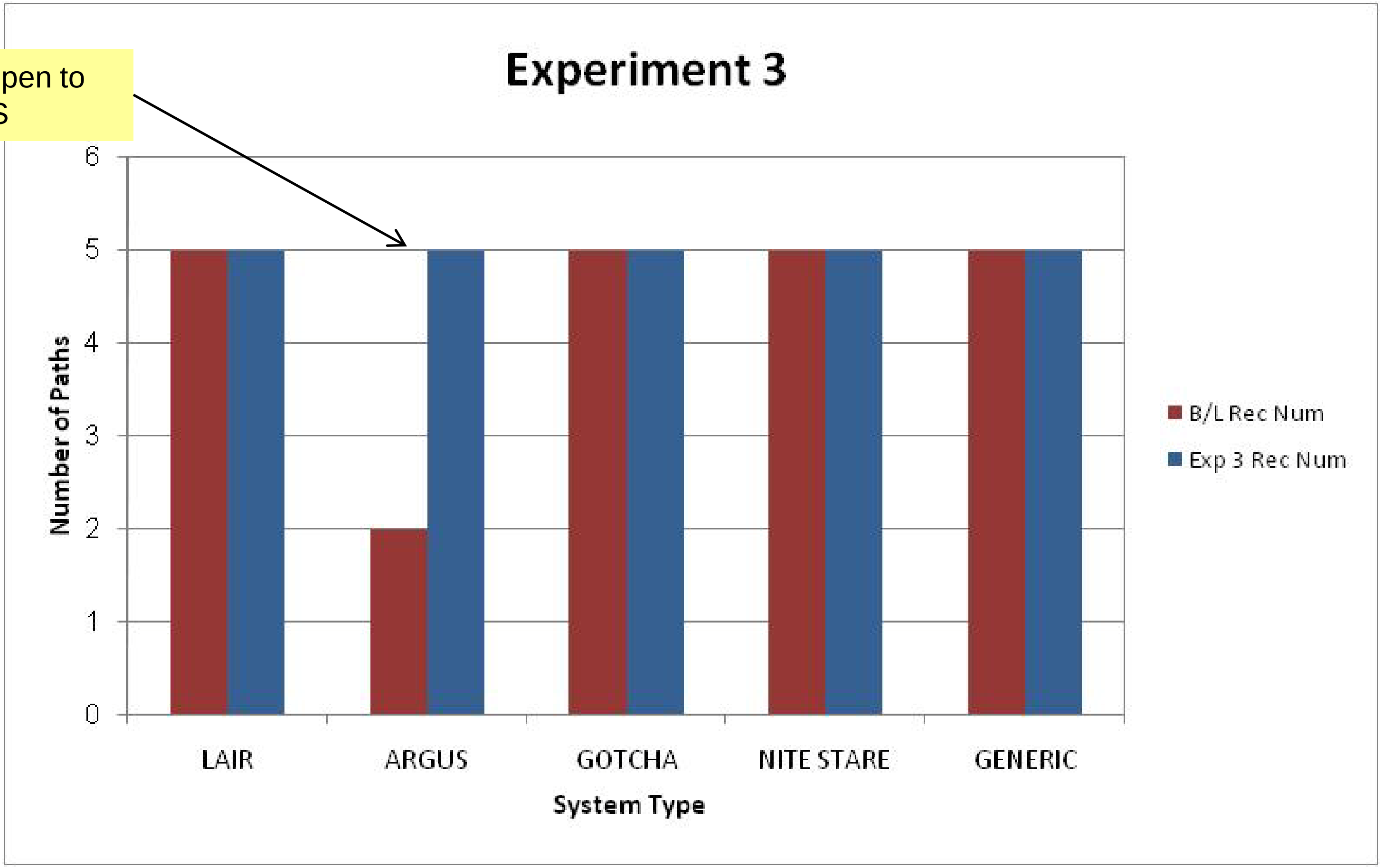
System Interoperability



Time for Data to Pass from Sensor to Ground Forces

System Interoperability

More paths open to ARGUS



Number of Process Paths Data Can Follow from Sensor to Ground Forces

System Interoperability

Experimental trial goals

- IE 4: CAOC located within LOS of the AOR

System Interoperability

Interoperability Measurement

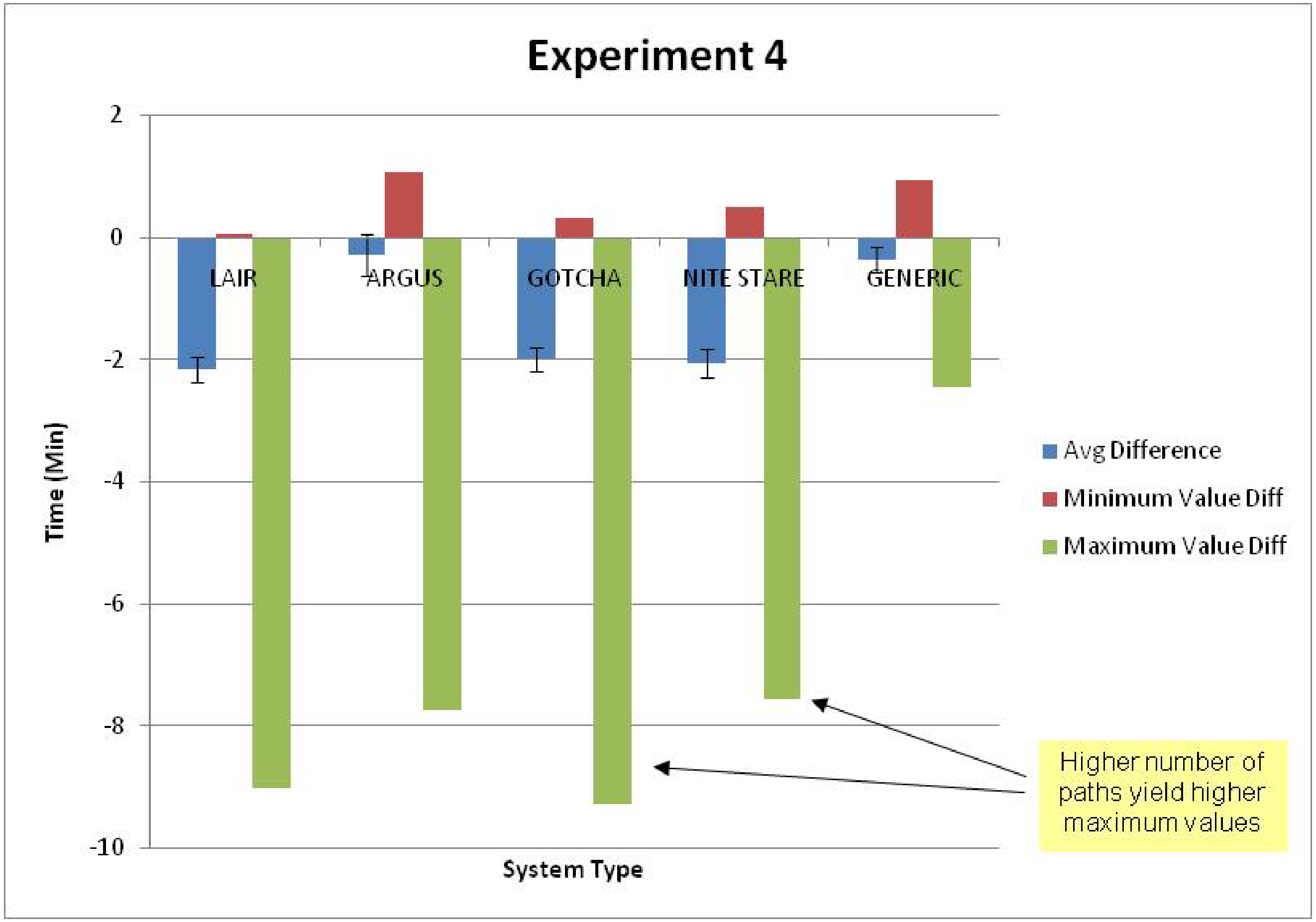
Experiment 4

	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	7/12	1/2	13/24	7/12	5/8	19/24
ARGUS-IS	5/12	0	1/3	3/8	5/12	13/24	13/24
GOTCHA	1/2	1/2	0	1/2	13/24	13/24	17/24
NITE STARE	13/24	13/24	1/2	0	7/12	5/8	19/24
generic	5/12	5/12	3/8	5/12	0	5/8	7/12
CAOC	5/12	5/12	5/12	5/12	11/24	0	5/8
GF	5/12	5/12	5/12	5/12	5/12	5/12	0
average interoperability measure:	0.5050						

Interoperability Measurement Difference

	LAIR	ARGUS-IS	GOTCHA	NITE STARE	generic	CAOC	GF
LAIR	0	0	0	0	0	0	0
ARGUS-IS	0	0	0	0	0	0	0
GOTCHA	0	0	0	0	0	0	0
NITE STARE	0	0	0	0	0	0	0
generic	0	0	0	0	0	0	0
CAOC	0	0	0	0	0	0	0
GF	0	0	0	0	0	0	0
avg interop measure difference:	0.0000						

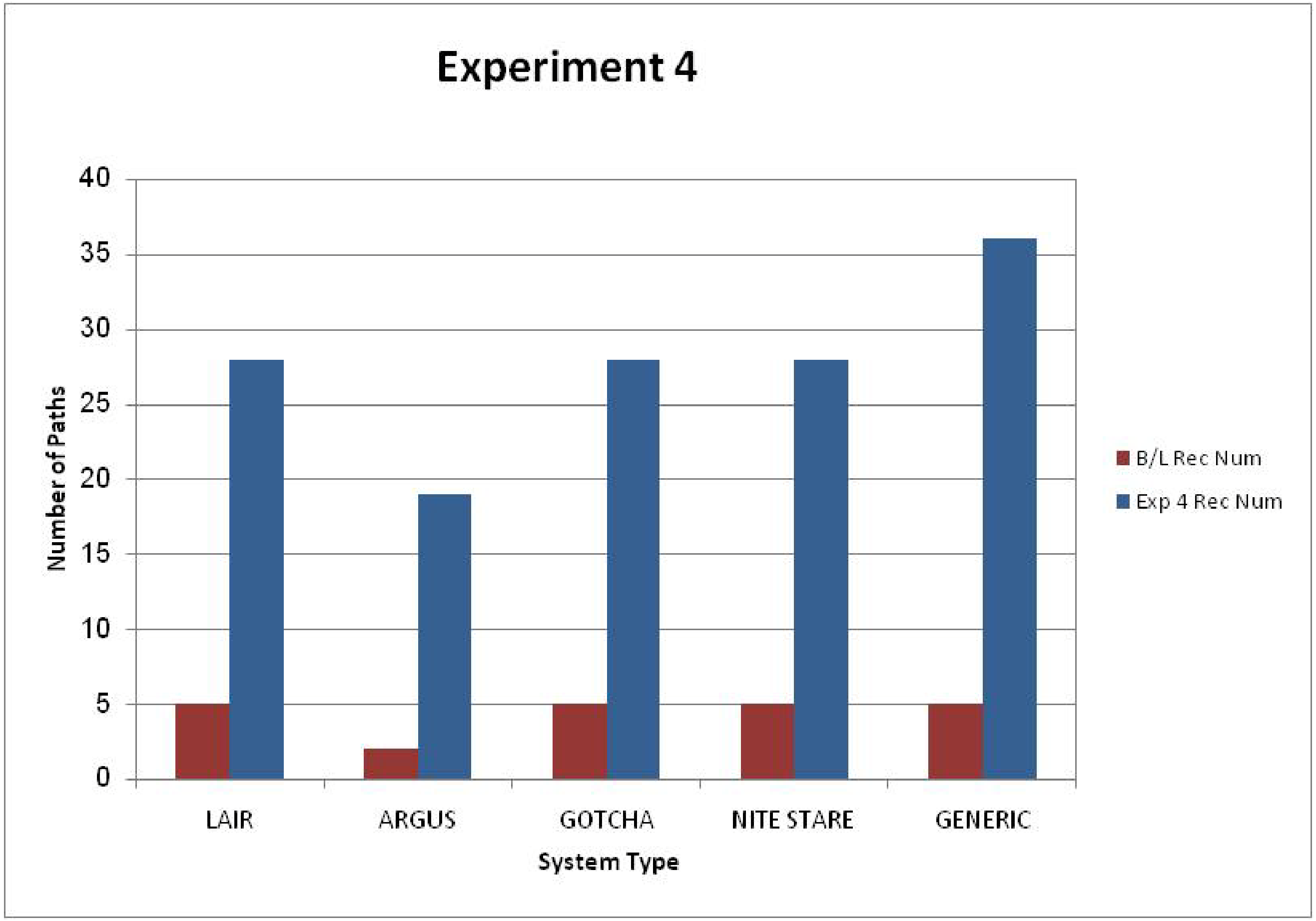
System Interoperability



Time for Data to Pass from

Sensor to Ground Forces

System Interoperability



Number of Process Paths Data Can Follow from Sensor to Ground Forces

Research Conclusions

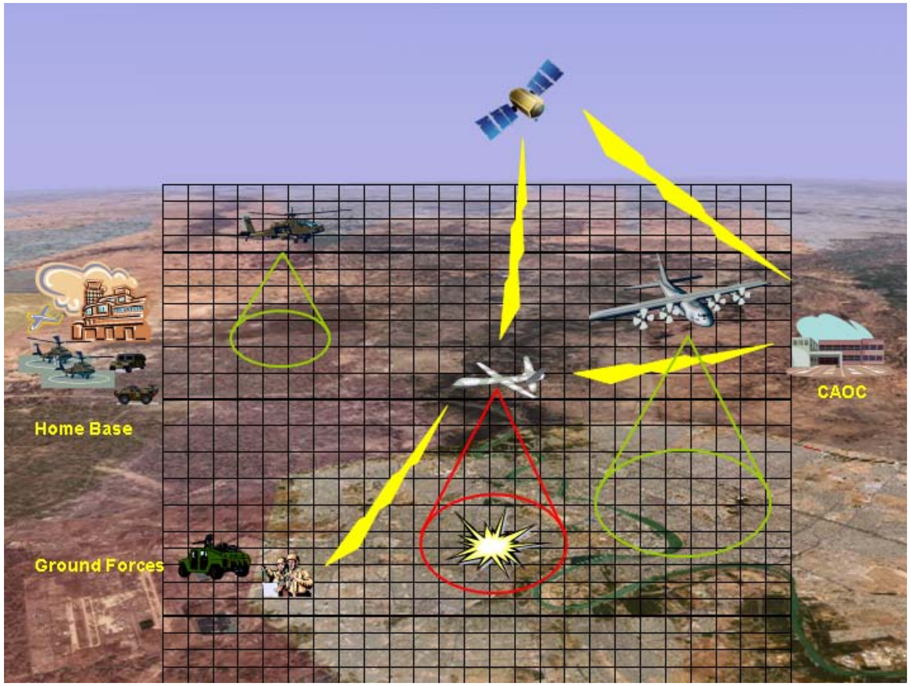
- Changes in architecture related to collaborative interoperability can be quantitatively linked to changes in mission effectiveness
  - In some cases, interoperability measurement is an insufficient indicator of effectiveness changes (e.g., process paths is probably a better indicator for this example)
- Successful linking of interoperability measurements and MOE calculations is critically dependent on character selection and MOE determination
- Not all MOEs are directly linked to interoperability
- A method to quantitatively compare architectures was demonstrated for layered sensing

Research Recommendations

- Interoperability Measurements
  - Analyze utility of additional interoperability character complexity levels
  - Explore non-Boolean character state representation
- Discrete event simulations and MOE calculations
  - Consider modeling additional scenarios (use cases)
  - Incorporate decision logic into process path selection

Air Force Institute of Technology

LINKING INTEROPERABILITY CHARACTERS AND MEASURES OF EFFECTIVENESS: A METHODOLOGY FOR EVALUATING ARCHITECTURES



Final Questions?

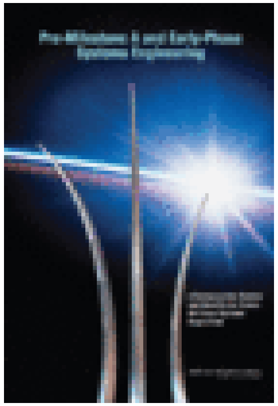
Early Systems Engineering and Development Planning

Dr. Judith Dahmann

Systems Engineering Directorate
Office of Director, Defense Research and Engineering

CLASSIFICATION – UNCLASSIFIED

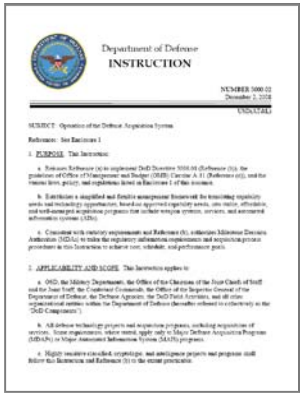
Background



National Research Council

"Pre-Milestone A and Early-Phase Systems Engineering"
Jan 2008

DoD 5000.02
December 2008


Department of Defense
INSTRUCTION

WSARA
May 2009


SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

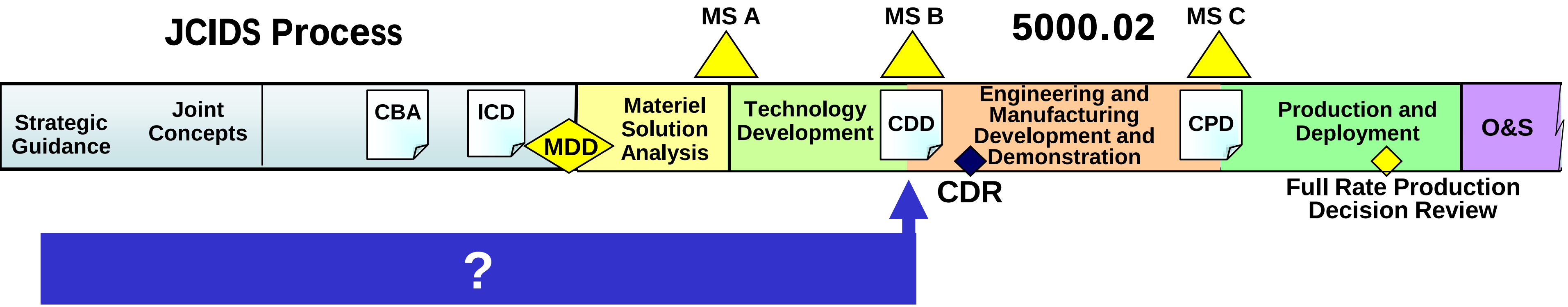
- **National Academies of Sciences Study**
  - All programs destined to fail without early [pre-MS A] systems engineering
  - Developmental planning can implement pre-MS A early systems engineering
- **DoD Acquisition Regulations (DoDI 5000.02) Update**
  - Increased focus on early pre-acquisition phases
  - Implication for added early SE
- **Weapon Systems Acquisition Reform Act of 2009 (WSARA)**
  - Direction to reinvigorate Development Planning

Increase in Emphasis on Early Systems Engineering

Topics

- Issues driving early SE
- Impact of 5000.02 on early SE
- Impact of recent legislation on early SE and development planning
- Next steps

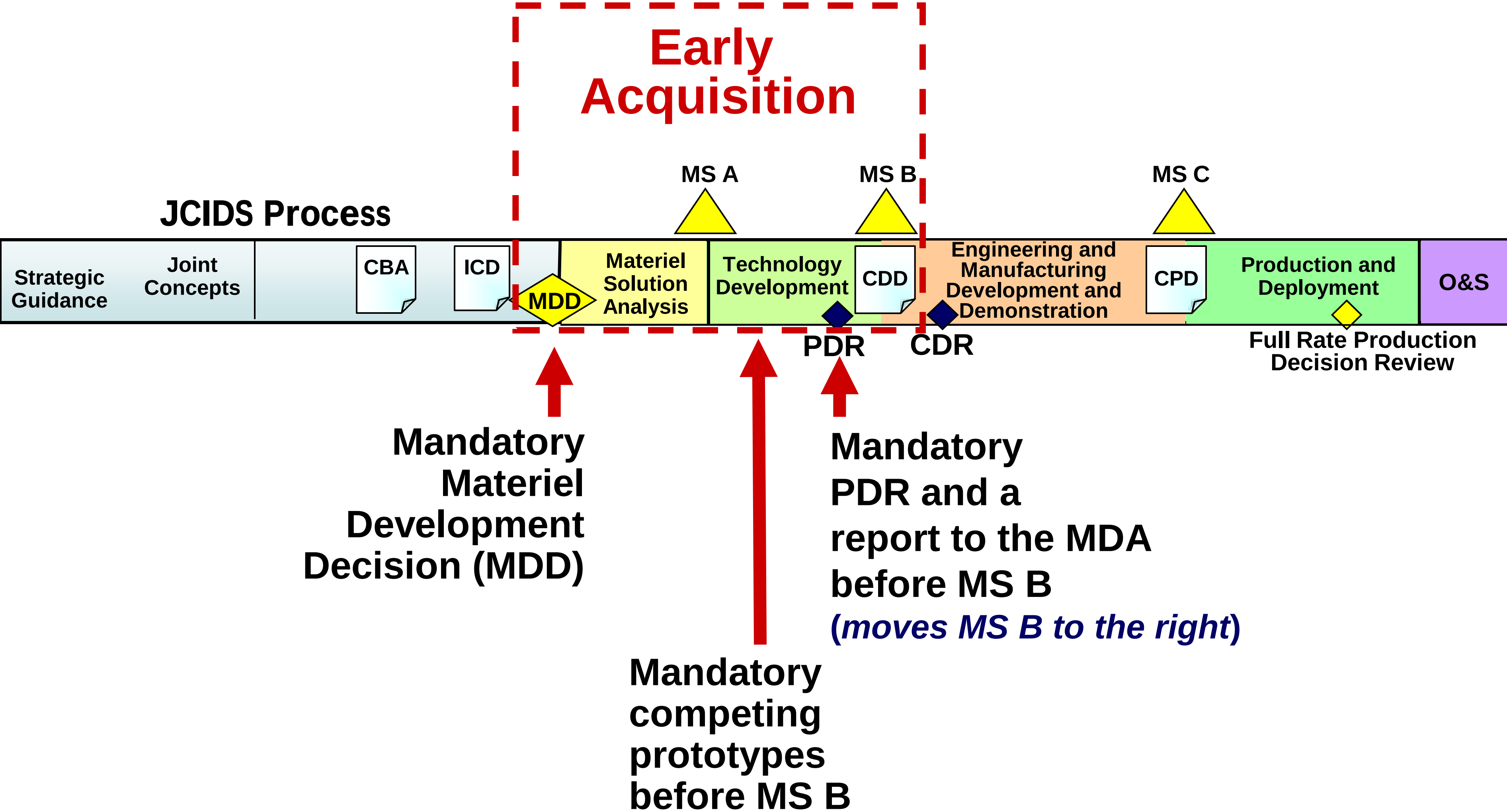
Why Early SE?



- Programs are being formally initiated at MS B without adequate understanding of the technology, feasibility and risks of the proposed solution
  - Underestimates of time and cost leading to delays and overruns against plans
  - Technology and technical integration and implementation risks have not been identified and are not effectively addressed before committing to development approaches, schedules and cost

UNCLASSIFIED

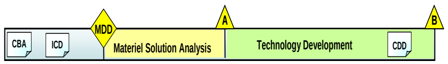
DoDI 5000.02
Early Acquisition Changes



UNCLASSIFIED

Analysis of SE Role in Early Acquisition

Acquisition Regulations and Guidance

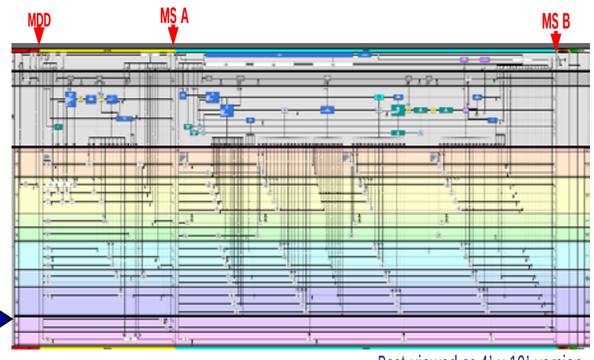


DoD 5000.02

Ch	Topics
1	Decision Support Systems
2	Acquisition Strategy
3	Affordability & Life-Cycle Estimates
4	Systems Engineering
5	Life Cycle Logistics
6	Human Systems Integration
7	IT & NSS
8	Intelligence
9	Test & Evaluation
10	Assessments and Reporting
11	Program Management

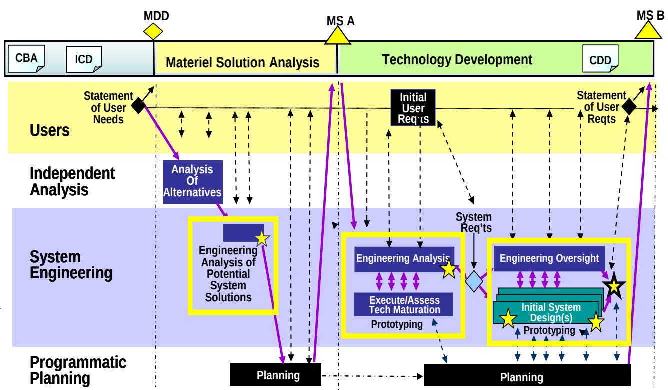
Defense Acquisition Guide

Acquisition Guidance Model



Best viewed as 4' x 10' version

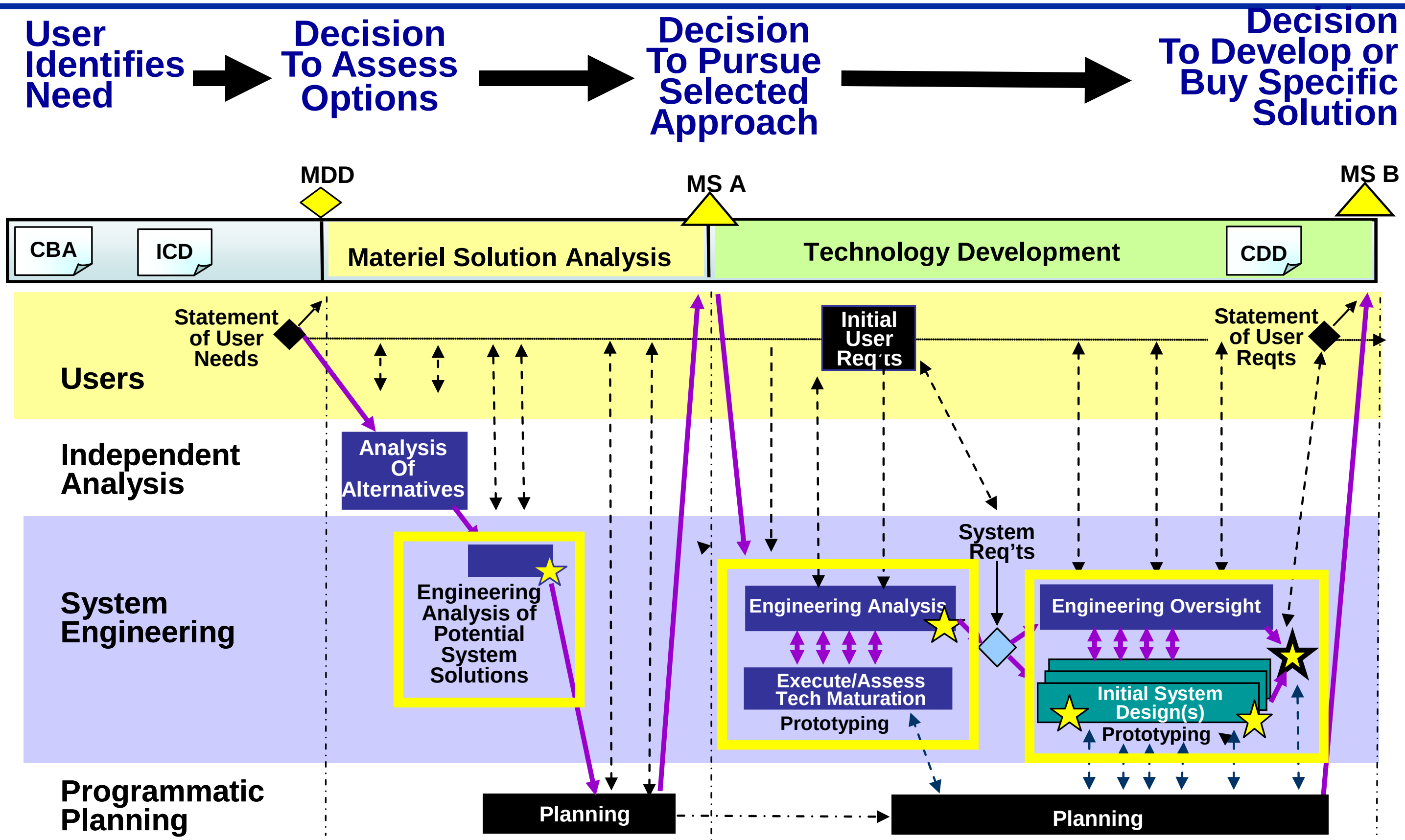
Role of SE in Program Formulation



- **Business Process Modeling used as the vehicle to**
  - Capture acquisition regulations and guidance
  - Identify critical systems engineering activities, events and products and how they impact program decisions

UNCLASSIFIED

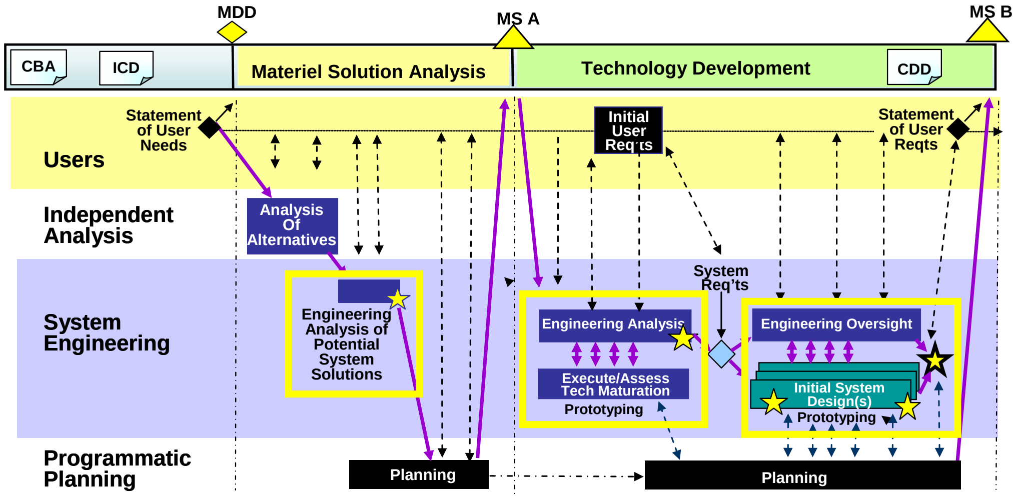
Critical SE Support to Program Formulation



During MSA and TD Systems Engineering Provides the Technical Foundation for Program Decisions

UNCLASSIFIED

Critical SE Support to Program Formulation



Materiel Solution Analysis

Engineering Analysis of Preferred System Solution

- Critical engineering and technical support for Technology Development planning
  - Technical risks and plans for prototyping
  - Plans for initial system design

Technology Development

Engineering Analysis and Oversight

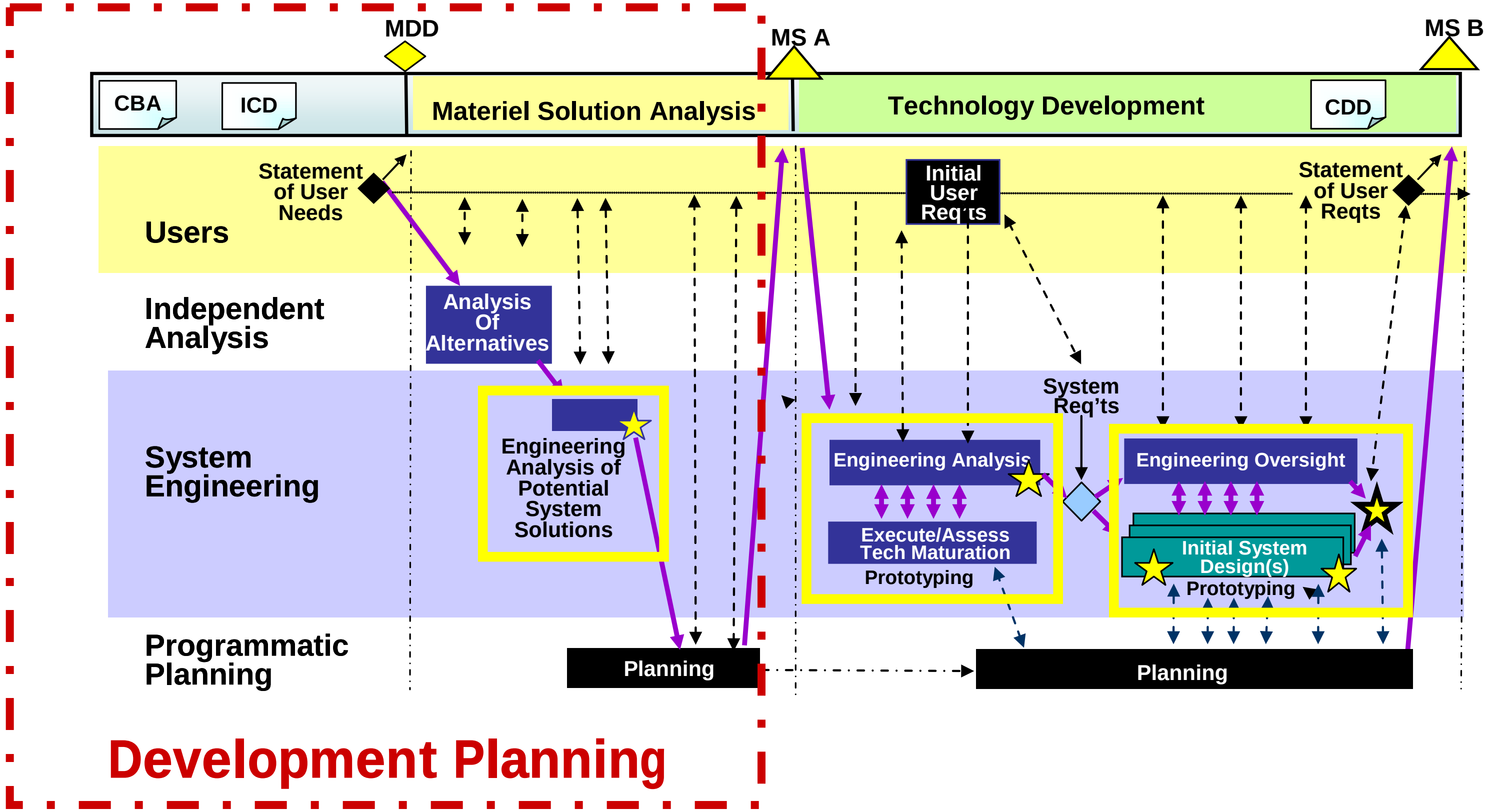
- System requirements development
- Technology maturation and prototyping
- Initial system design through Preliminary Design Review (PDR)
- Technical basis for program decision

UNCLASSIFIED

Impact of FY09 Legislation

- **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
- **Near-term plans**
  - 1st Year Annual Report Due March 2010
    - Initial Guidance based on current understanding of SE and DP
  - Parallel focus on understanding DP as the basis for guidance

Development Planning



- Begins before acquisition
- Natural application of systems engineering process
- Ensures that alternative system approaches evaluated during MSA are validated

UNCLASSIFIED

Where Does Development Planning Fit?

Needs and Opportunities

IPL

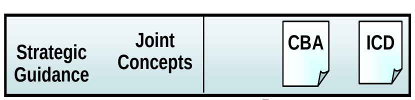
Urgent Need

New Threat

New Technology

New Strategic Direction

JCIDS



Viable Solutions

Translating User Needs <u>and Opportunities</u> Into Viable Solutions

Delivery Options

Rapid Fielding

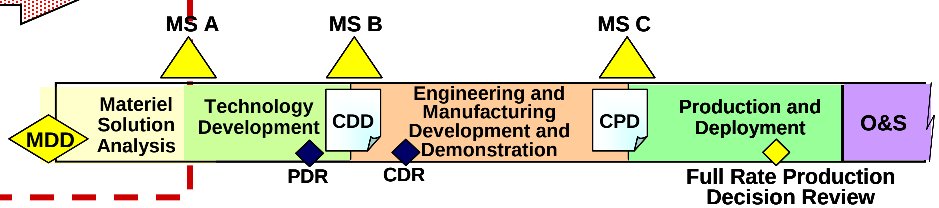
Technology Refresh

O&S Upgrade

Experimentation

JCTDs

5000.02

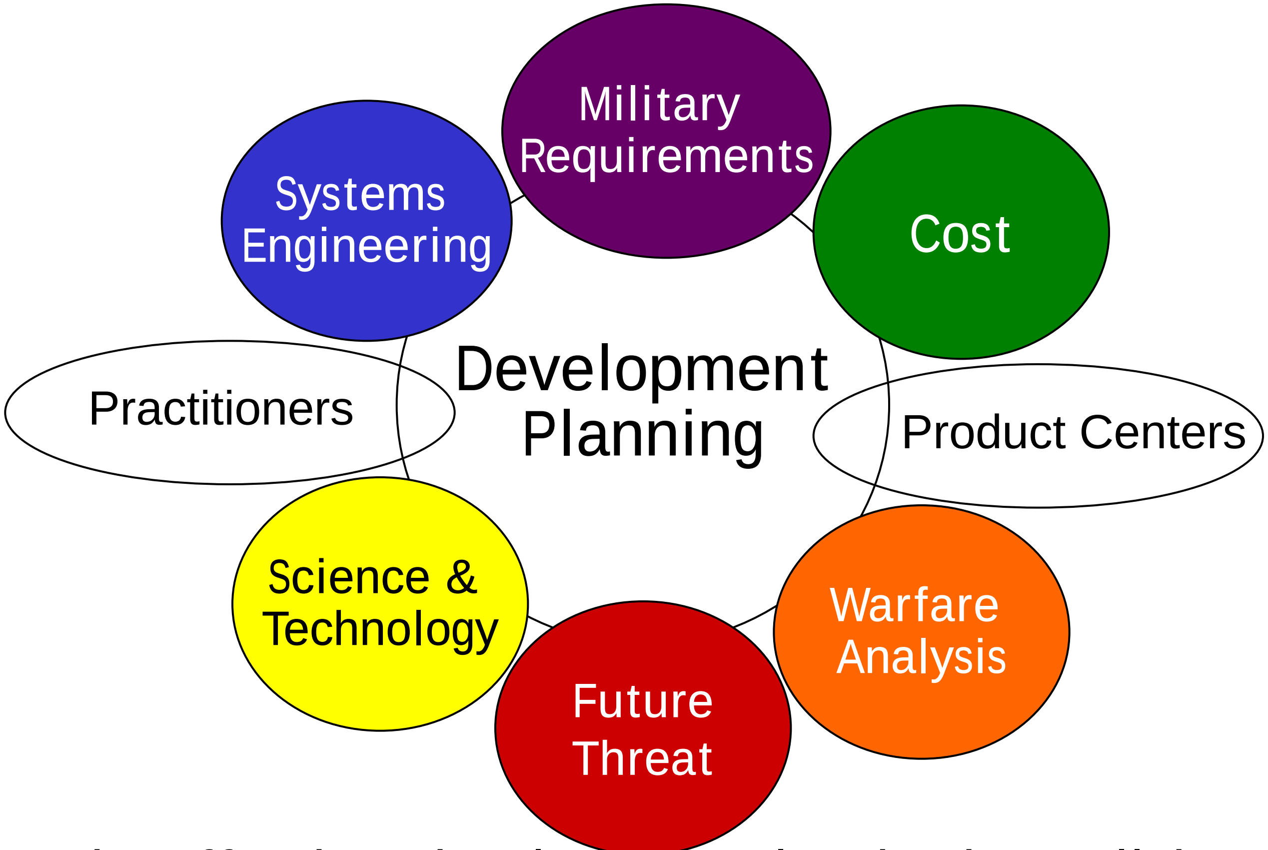


- Applies more broadly than JCIDS to 5000.02 acquisition

Development Planning Activities

- **Understand need in the context of operations and other systems**
  - Put the need into operational, threat and systems context (CONOPs, and mission threads, thread profile and current SoS architecture)
- **Identify ideas/concepts for solutions**
  - Communicate capability needs and gaps to concept generating organizations (i.e., industry, academia, S&T community, etc.)
  - Receive and catalogue ideas and concepts
- **Assess ideas/concepts to identify feasible material solution options**
  - Apply MS&A to confirm military utility (via modeling, via prototyping)
  - Identify the impact on current systems
  - Conduct initial lifecycle cost estimate
- **Technical analysis of the proposed concepts**
  - Conduct SE and refine concept technical analysis artifact on promising concepts to provide technical foundation (via prototyping)
- **Identify best mechanism to provide solution based on need and solution options**
  - Formal acquisition program, technology refresh, rapid fielding, etc.
- **Continue SA/SE support to the solution development**
  - For acquisition, technical advisor supporting the AoA study and analysis teams

Development Planning Is a Team Sport



- To be effective, development planning is a collaboration among communities
- Systems engineering provides a structured, disciplined approach as a basis for this collaboration

Extending SE Support to Development Planning

CBA ICD MDD Materiel Solution Analysis A Technology Development CDD B

Development Planning

Engage-ment in AOA	Guidance
	Plan
	Analysis Activity
	Report
SE Analysis	Consideration of SOS/Interdependency, Interoperability Context
	SEP for MSA
	Input to TDS (CTE, CPI), TES, CCE
	SE in TD contract requirements
	Tech Reviews (ASR, Early SE Requirements)

Prototyping & Risk Reduction	Prototyping (Technology and Design)
	TRL Maturation
	Trade Studies
	SE Support for Technology Risk Reduction
	Oversight of Competitive Designs
	Risk Assessment
Input to Acquisition/ Planning, CARD, Budget and Other	SE in Contract Requirements
	SE Input into the pst-PDR Report, report to MDA, Acquisition Strategy, TEMP, CARD, and the ICE
Evidence of Strong SE Activity	PDR and Post-PDR Report and Assessment
	Tech Reviews up to and including PDR
	SEP
	Strong Reliability, Availability and Maintainability (RAM)
Inputs to Requirements	Systems Requirements Definition
	RAM and Sustainability
	Requirements Traceability Matrices
	Translation of Requirements to Contract
	Inform Capability Development Document (CDD)

*Reference DAG Sections 4.3.1 and 4.3..2

Development Planning Current Initiatives

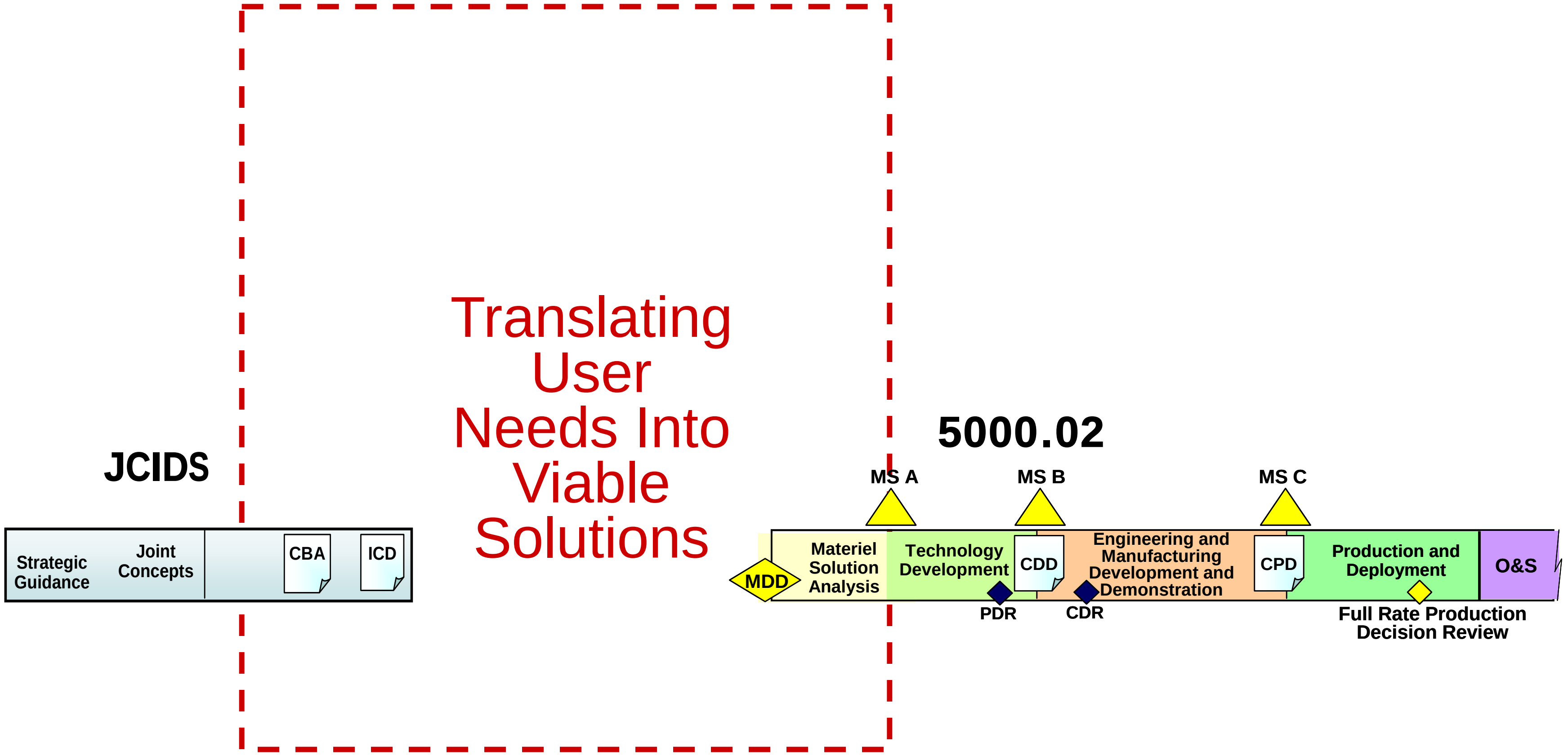
- **Determine current baseline of Development Planning practice and execution in the Components**
  - Development Planning Scope & Definition Study
  - Acquisition Guidance Model Development Planning Build
- **Identify and extend Development Planning Network**
  - Development Planning Communities of Interest Outreach
  - Development Planning Mini Workshop(s)
  - MORS Analytic Agenda Conference Planning
  - Development Planning Case Examples
- **Build Development Planning Body of Knowledge**
  - Best practices
  - Resources (e.g. Tools, Human resources)
- **Produce recommendations for Development Planning**
  - Policy & Guidance
  - Workforce Competency
  - Certification
  - Resourcing

Summary

- The need for early systems engineering has been recognized
- The recent update of the DoDI 5000.02 and supporting SE guidance provides added emphasis on the early phases of acquisition and guidance for early SE
- Weapon Systems Acquisition Reform Act of 2009 (WSARA) has further emphasized the need for more SE attention prior to acquisition as part of development planning
- Current SE efforts are underway to understand current and past DP experience, develop best practices as the basis for renewed emphasis on Development Planning

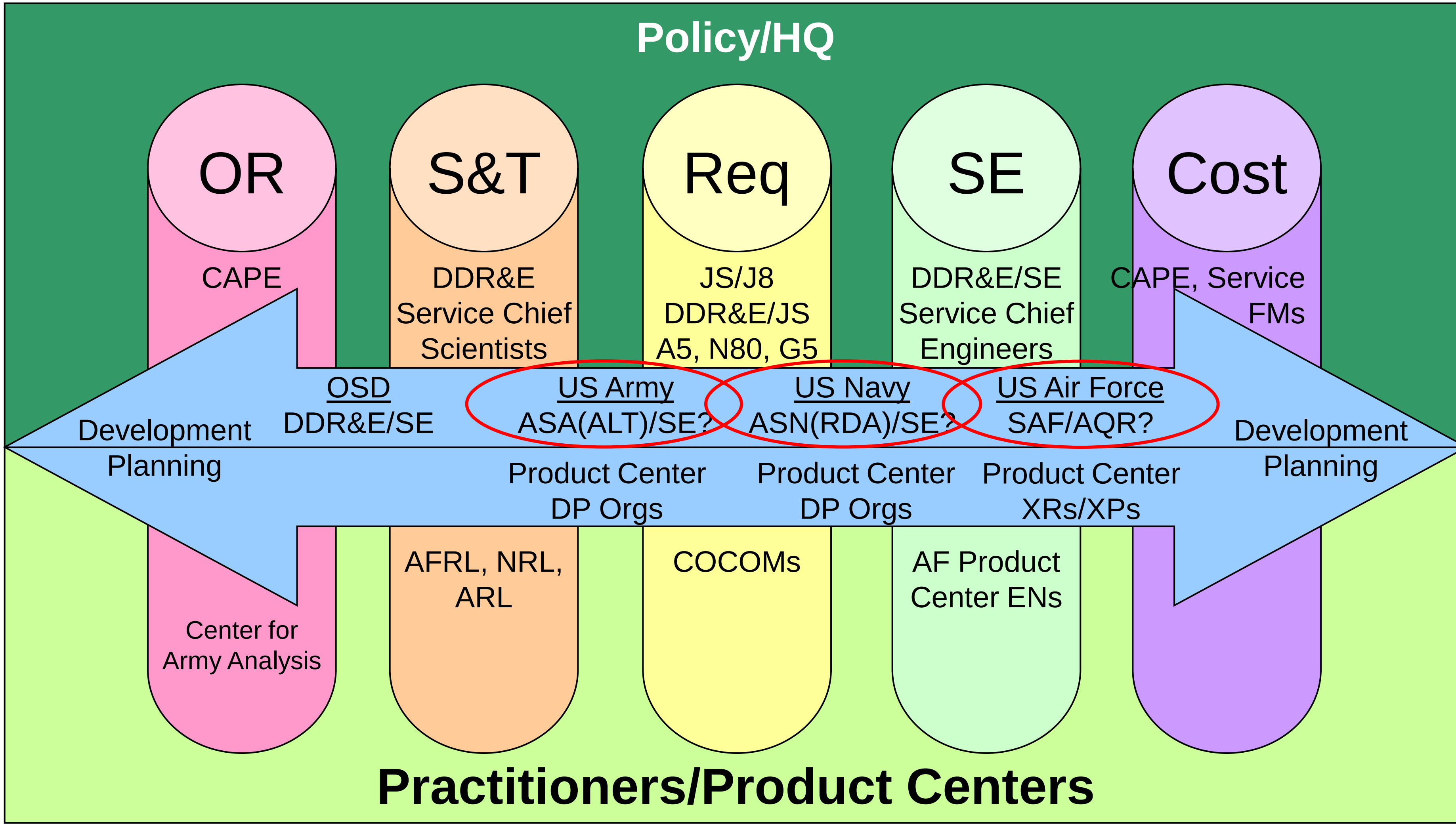
Backup

Where Does Development Planning Fit?



- Bridges the user needs identification (JCIDS) with acquisition of a solution (5000.02)

Development Planning Communities of Interest



UNCLASSIFIED

DoDI 5000.02 and WSARA* Impacts on Early Systems Engineering

Sharon Vannucci

Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

12th Annual NDIA Systems Engineering Conference
October 28, 2009

*** Weapon Systems Acquisition Reform Act**

The Bottom Line Up Front – Impact of New Statute and Policy …

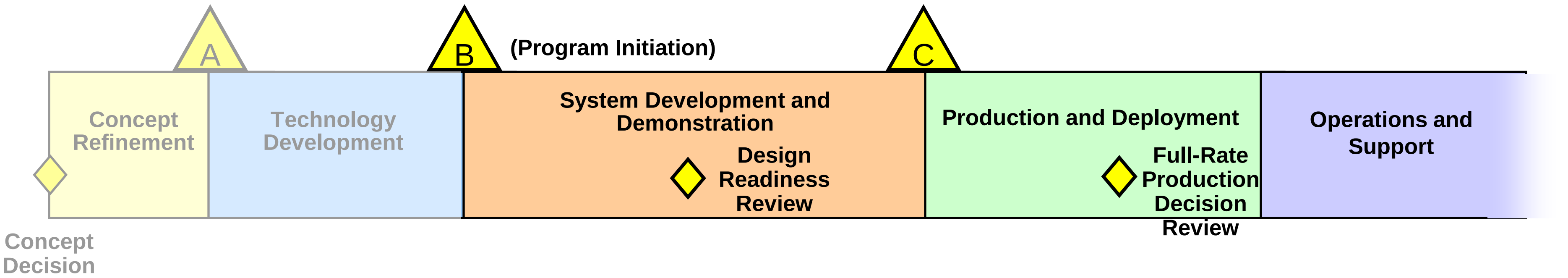
- **DoDI 5000.02 changes emphasize early stages of pre-systems acquisition - prior to Milestone B (MS B)**
  - Reduce risk before making business commitment
  - Improve likelihood of being able to meet these commitments
- **The Weapon Systems Acquisition Reform Act of 2009 furthers this emphasis with additional certification requirements at MS A and B, mandatory competitive prototyping, and system-level Preliminary Design Review before MS B for all Major Defense Acquisition Programs (MDAPs)**

Knowledge-based Acquisition – Starting Programs Right!

UNCLASSIFIED

A Little Acquisition Lifecycle History – the Phantom Phases

DoDI 5000.2, the Defense Acquisition Management System
May 12, 2003 – December 8, 2008



In the 5+ years, 2003-2008:*

- Only 1 non-ship pre-MDAP has gone through a MS A
- 20 MDAPs have gone through a MS B
- 14 MDAPs had had Nunn-McCurdy breaches

Breaches COULD be indicative of insufficient technical knowledge to establish Milestone B cost and schedule baselines.

*Data from Program Support Reviews

DoD Instruction 5000.02

- **Mandatory Materiel Development Decision**
- **Mandatory Milestone A for all "major weapon systems" requiring technology development**
- **Mandatory system-level PDR and CDR with reports to and assessments by the MDA**
- **Strengthened MDA certifications at Milestones A and B**

Department of Defense
INSTRUCTION

NUMBER 5000.02
December 8, 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 guidelines 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 issuance.

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 automated information systems (AISs).

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, where stated, apply only to Major Defense Acquisition Programs (MDAPs) or Major Automated Information System (MAIS) programs.

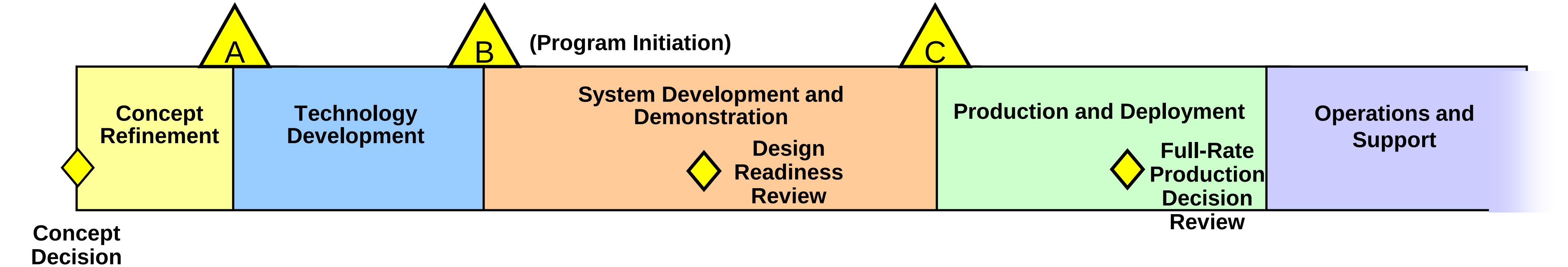
c. Highly sensitive classified, cryptologic, and intelligence projects and programs shall follow this Instruction and Reference (b) to the extent practicable.

Acquisition Reform

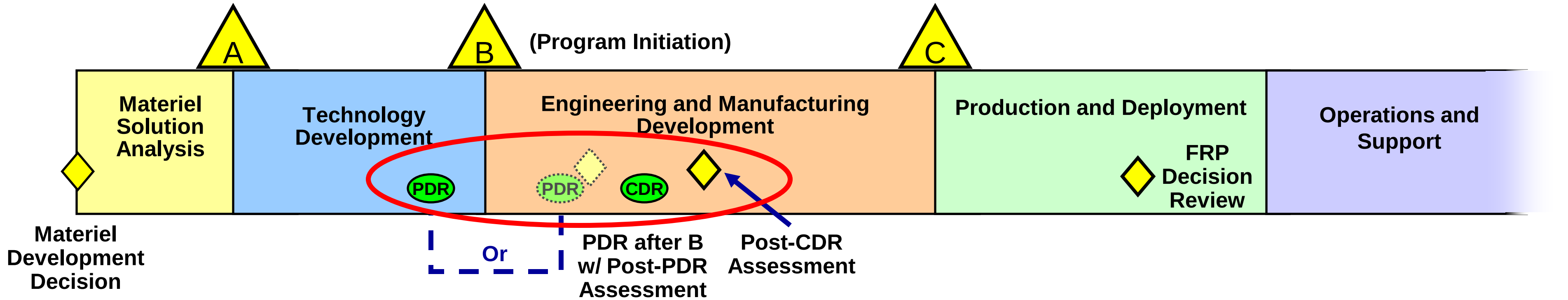
- **New legislation, Public Law 111-23 (WSARA) recognizes the importance of SE to weapon systems acquisition**
- **Heavy focus on starting MDAPs right:**
  - **Development and tracking of measurable performance criteria as part of SEPs and TESs / TEMPs**
  - **Requiring completion of competitive prototypes for all Major Defense Acquisition Programs (MDAPs)**
  - **Requiring completion and MDA assessment of a system-level Preliminary Design Review (PDR) before MS B**
  - **Codifying a role for SE in development planning, lifecycle management and sustainability**
- **Yearly OSD assessment to Congress of Component capabilities for SE, development planning, and DT&E**

Acquisition Lifecycle Comparisons

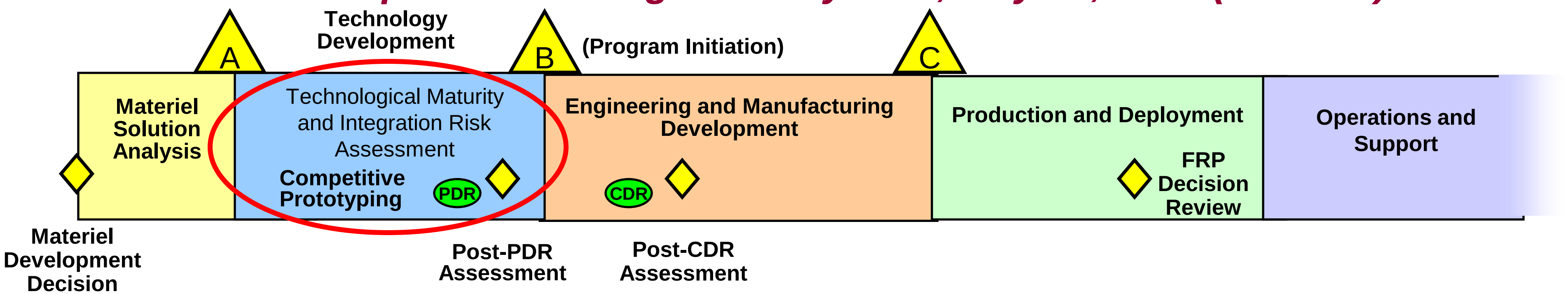
Defense Acquisition Management System, May 12, 2003 (DoDI 5000.2)



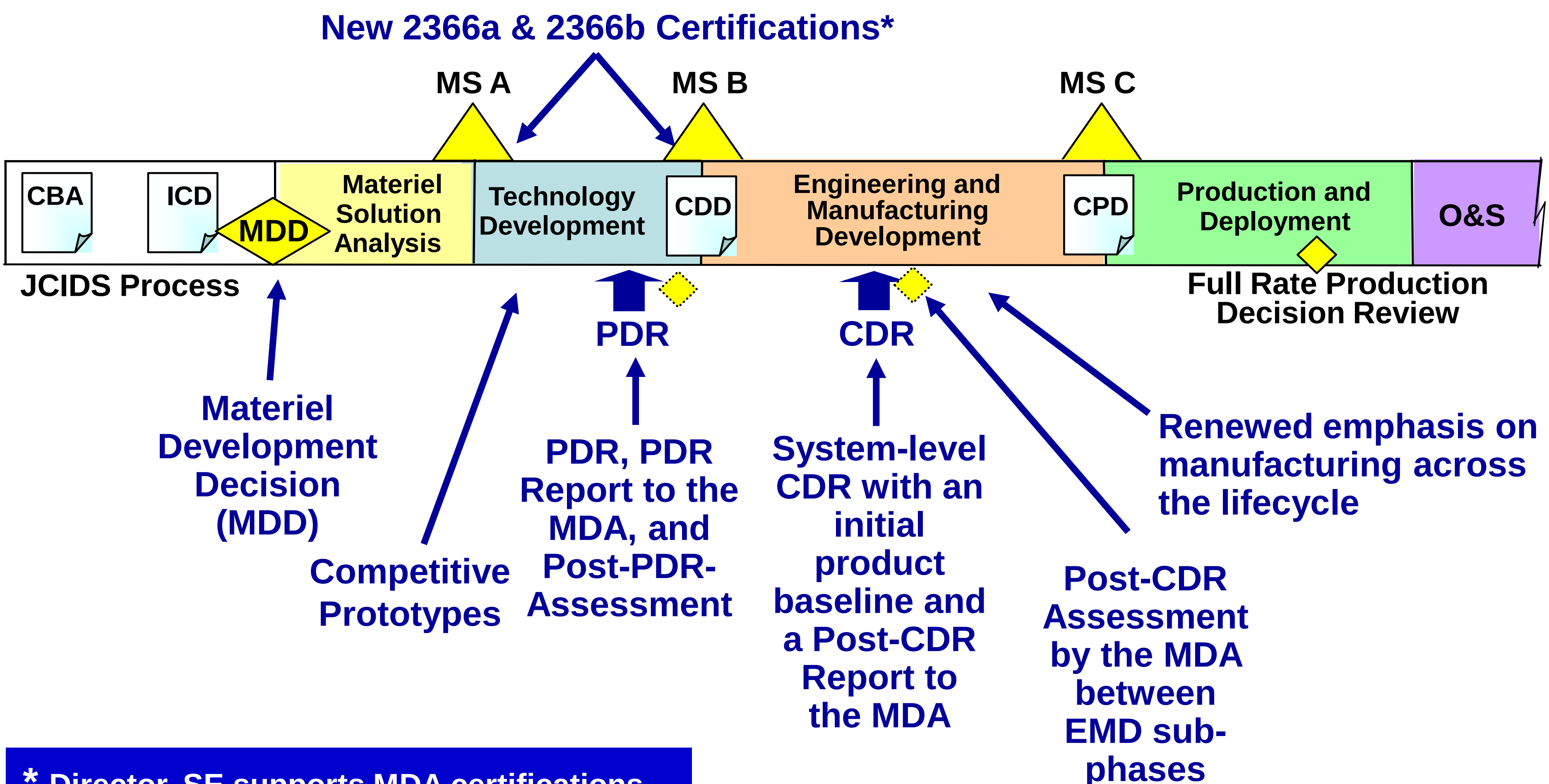
Defense Acquisition Management System, December 8, 2008 (new DoDI 5000.02)



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



DoD 5000.02 and PL 111-23 – the Changed Acquisition Landscape

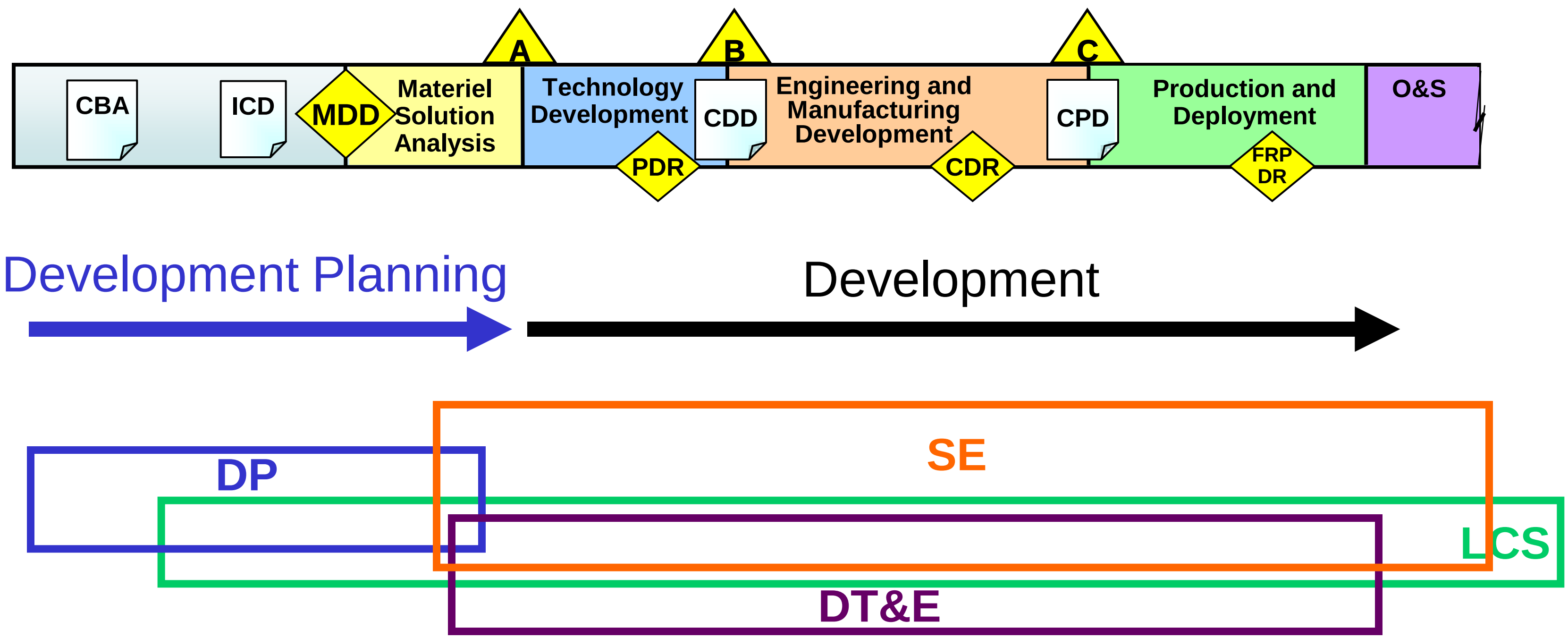


* Director, SE supports MDA certifications including PDR Report assessment at MS B

Impact of Acquisition Reform Legislation on Early Acquisition Policy

- **Establishes Director, Systems Engineering (D, SE) and Director, Developmental Test and Evaluation (D, DT&E) as principal advisors to the Secretary of Defense and the USD(AT&L) on systems engineering and development planning and on developmental T&E, respectively**
- **Mandates documented assessment of technological maturity and integration risk of critical technologies for MDAPs during the Technology Development (TD) phase**
- **Establishes D, DT&E and D, SE joint tracking and Congressional reporting on MDAP achievement of measurable performance criteria**
- **Mandates competitive prototyping and MDA completion of a formal Post-Preliminary Design Review Assessment for all MDAPs before MS B; additional MDA certification to both at MS B**
- **Strengthens technical analysis of cost and schedule breaches during the Technology Development (pre-MS B) and the Engineering and Manufacturing Development (post-MS B) phases**

New Emphasis on Development Planning and Early SE



DP: Development Planning
DT&E: Developmental Test and Evaluation
LCS: Life Cycle Sustainment
SE: System Engineering
CBA: Capabilities Based Assessment
CDD: Capability Development Document
CPD: Capability Production Document
ICD: Initial Capabilities Document
MDD: Materiel Development Decision

Development Planning and Early SE Critical Activities

CBA	ICD	MDD	Materiel Solution Analysis	A	Technology Development	CDD	B

SE Input to MDD	CONOPS	
	Awareness of Strategic Context	
	Engagement with S&T Engagement with JCIDS	
Engagement in AoA	Guidance	
	Plan	
	Analysis Activity	
	Report	
Engineering Analysis	Consideration of SOS/Interdependency, Interoperability Context	
	SEP for Milestone A	
	Input to TDS (CTE, CPI), TES, CCE	
	SE in TD Contract Requirements	
	Tech Reviews (ASR, Early SE Requirements)	

Prototyping & Risk Reduction	Prototyping (Technology and Design)
	CTE TRL Maturation
	Trade Studies
	SE Support for Technology Risk Reduction
	Oversight of Competitive Designs
	Risk Assessment
Input to Acquisition/ Planning, CARD, Budget & Other	SE in Contract Requirements
	SE into the PDR Report to MDA, Acquisition Strategy, TEMP, CARD, and ICE
Evidence of Strong SE Activity	PDR and PDR Report and Assessment
	Technical Reviews up to and including PDR
	Systems Engineering Plan
	Strong Reliability, Availability and Maintainability (RAM)
Inputs to Requirements	System Requirements Definition
	RAM and Sustainability
	Requirements Traceability Matrices
	Translation of Requirements to Contract
	Capability Development Document (CDD)

*Reference DAG Sections 4.3.1 and 4.3..2

New Challenges for Program Managers

- Need for Program Office formation and PM skill-sets after MDD and prior to MS A
- Increased importance of the Technology Development Strategy (TDS) (as a surrogate Acquisition Strategy) at MS A
- Schedule and funding shifts left – from EMD to TD
- Earlier engagement with industry and different contracting strategies for technology maturation, competitive prototyping, data rights, PDR before MS B, etc.
- Explicit need for earlier, formal SE process application (e.g., data, configuration, and risk management)
- New MS A cost and schedule baselines with breach penalties and MDA certifications for MDAPs
- Additional MS B MDA MDAP certifications including formal post-PDR assessment that the program demonstrates a high likelihood of accomplishing its intended mission

The Milestone A Planning Challenge

Documents / activities / data requiring technical input from the Systems Engineer *before* Milestone A:

- **Analysis of Alternatives**
- **Technology Development Strategy**
  - Critical Program Information
  - Technology maturation plans
  - Competitive Prototyping plans
  - Net-Centric Data Strategy
  - Market Research
  - Data Management Strategy
- **Component Cost Estimate**
- **Systems Engineering Plan**
- **Test and Evaluation Strategy**

The PM's Dilemma: Where to find the data!?

New Certifications for MDAPs

- **At Milestone A (2366a):**
  - Technology Development Report must be submitted with 2366a certification to serve as schedule and cost baseline for the program during Technology Development phase
  - If cost or schedule is breached by 25%, the MDA must report to Congress
- **At Milestone B (2366b):**
  - Appropriate tradeoffs among cost, schedule, and performance objectives have been made to insure that the program is affordable
  - The MDA has received a PDR Review Report and conducted a formal post-PDR assessment that the program "demonstrates a high likelihood of accomplishing its intended mission"
  - Technology in the program has been demonstrated in a relevant environment as determined by the MDA on the basis of an independent review and assessment by the Director of Defense Research and Engineering

Increased technical rigor before Milestone decisions

New Competitive Prototyping Challenge

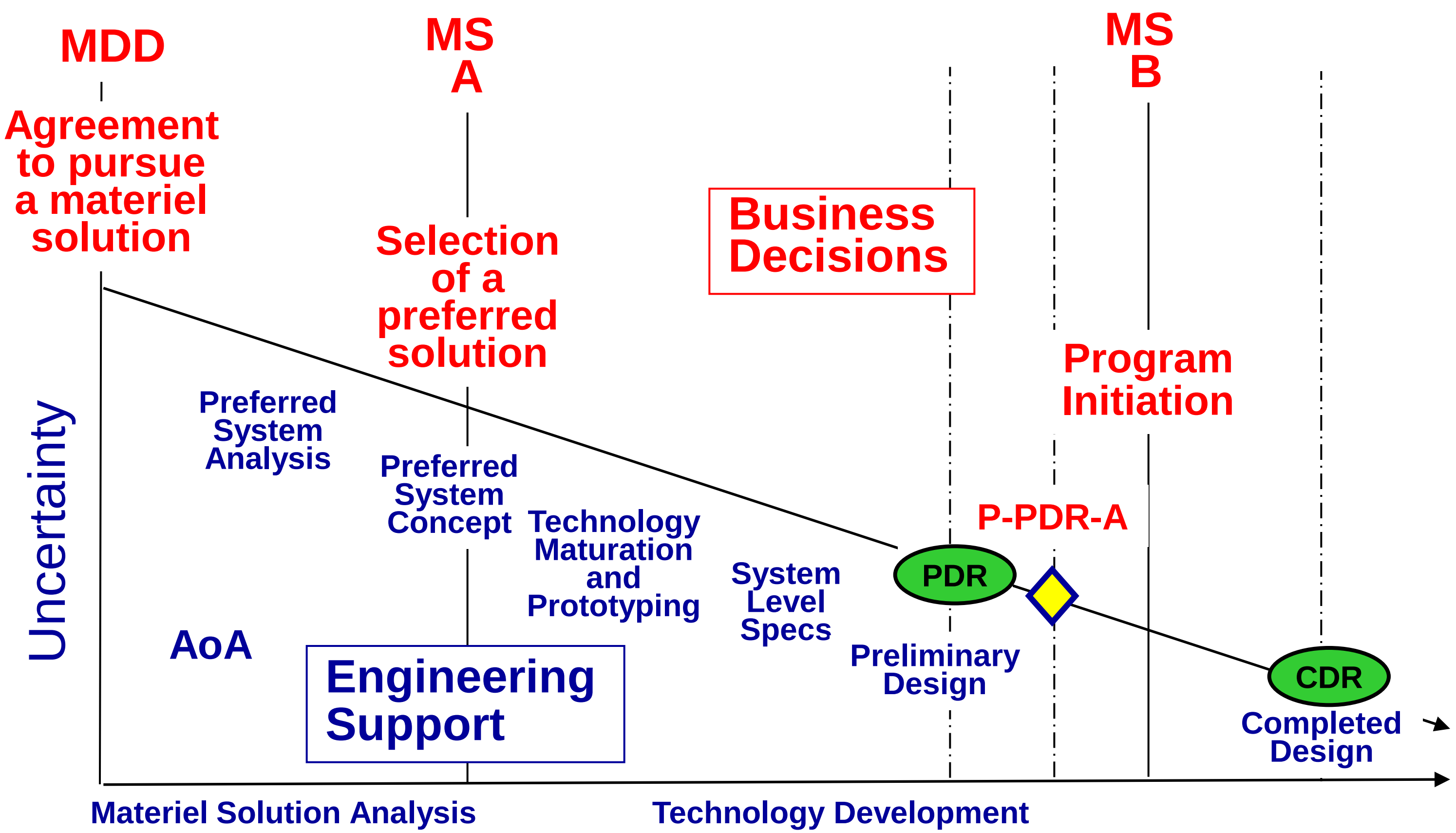
PL 111-23 ("Acquisition Reform"), Section 203:

- Requires the Secretary of Defense to modify acquisition policy to require each MDAP's acquisition strategy provides for competitive prototypes prior to a MS B decision
- Allows prototyping to occur at the system or subsystem level
- Includes provision for Milestone Decision Authority (MDA) waiver only on the basis that the cost of producing the competitive prototypes exceeds the expected life-cycle benefits (in constant dollars) of producing the prototypes or for critical national security objectives
- Programs receiving a waiver must
  - still produce <u>a</u> prototype before MS B
  - be reported in writing by the MDA to the congressional defense committees and the Comptroller General of the US

Why is this hard?

- Program offices (both government and contractor) have very little experience with pre-MS B acquisition activities, particularly competitive prototyping and PDR before MS B
- The DAG guidance is voluminous – online resource with over 750 printed pages with relevant phase-related guidance sprinkled throughout
- Program offices have limited understanding about these interdependencies within the DAG guidance
- New implementing policy and DAG guidance in response to PL 111-23 will not be available immediately

Driving Risk out of MS B Decisions . . .



"Knowledge-based" Decision Making . . .

making acquisition decisions when you have solid evidence and acceptable risk

Backup

SE Policy and Guidance

DoD 5000.02

Defense Acq Guidebook

Chapter 4 SE	**Chapter 8 Security**

Data Flow:
Acquisition Policy
Policy-specific guidance linked to . . .
. . . all other relevant guidance

- M&S Guidance
- DoD M&S Mgt DoDD 5000.59
- DoD M&S VV&A DoDI 5000.61
- RAM Guide
- RAM-C Rationale Report Manual
- CM Mil Hbk 61A
- WBS Mil Hbk 881
- Other Standards & Mil Handbooks

- Risk Mgmt Guide
- SE Slide Rule
- Safety/ESOH Guides
- Safety MIL-STD-882D
- Contracting for SE Guide
- SOS SE Guide
- IMP/IMS Guide
- MOSA Guide
- Other Design Consideration Guides

- "Wall Chart"
- SEP Prep Guide
- DM Guide
- Functional Architecture Development Guide
- Tech Review Guide

- PPP DoDI 5200.39
- Systems Assurance Guide
- DTM 08-048 Supply Chain Risk Management
- PPP Prep Guide
- CPI Security Classification Guide
- CPI Identification Tool
- PP Contract Language Compendium

- EW and C2W Countermeasures DoDD 3222.3
- DoD IA DoDD 8500.01E
- Interoperability & Supportability of IT & NSS DoDD 4630.05
- Acq Security-Related Policies & Issuances Tool

Planned
Extent

http://www.acq.osd.mil/sse/pg/guidance.html

UNCLASSIFIED

Extending Net-Centric Quality of Service to Systems of Systems

12th Annual NDIA Systems Engineering Conference
San Diego, CA 26-29 October 2009

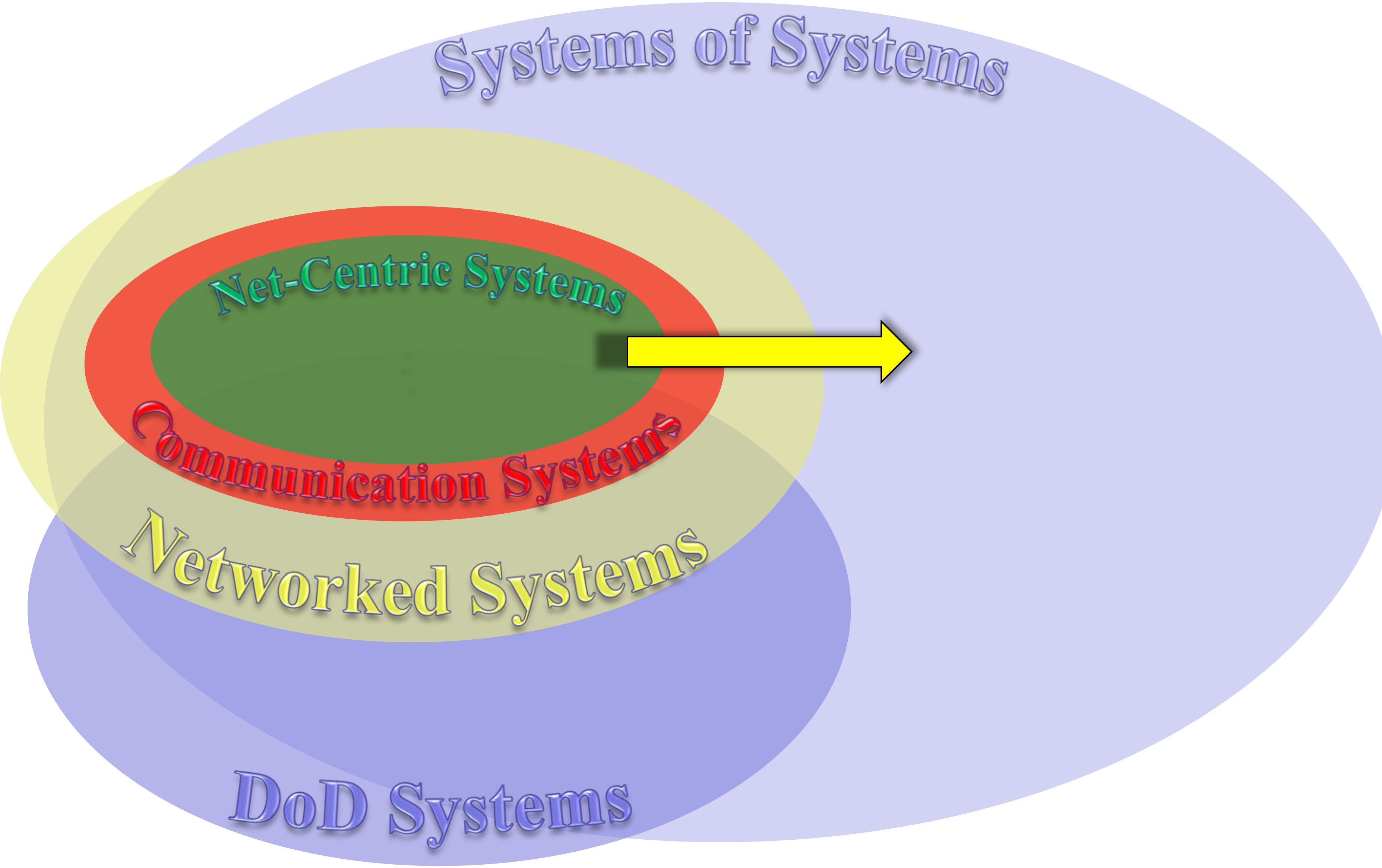
Major Vinod Naga, USAF
Systems Engineering PhD Student
Air Force Institute of Technology
Wright Patterson AFB, OH

Outline

Offer an alternative perspective to viewing interactions within systems of systems based upon a net-centric quality of service framework.

- Quality of Service (QoS)
- Systems of Systems (SoS) Abstract
- QoS in Net-Centric Systems
- Key QoS Features
- QoS in Generalized SoS
- Improving the SoS
- SoS Necessities
- Systems Engineer Perspective
- QoS Construct for the SoS

QoS for SoS


Systems of Systems
Net-Centric Systems
Communication Systems
Networked Systems
DoD Systems

Quality of Service

- Resource reservations
- Priority for apps, users, data flows
- Specific performance
- vs. best-effort and over-provisioning
- Service Level Agreement (SLA)
- Monitored, maintained, managed
  - QoS may refer to <u>the measure</u>
  - Intserv – per flow (RSVP)
  - Diffserv – per class (DSCP)
  - Traffic Shaping and Scheduling techniques
- Device capability
- Service-Oriented Architecture (SOA) view

Quality of Service Key Parameters

- Resource Reservation
- How Signaling Transferred
- Coupling with Routing/Forwarding Method
- State of Resource Management
- Required Participation

QoS Key Parameters Example (1 of 2)

RSVP: - reservation-based QoS protocol
- based on integrated services (INTSERV) model

Key Feature	Implementation
Resource Reservation	Class • best-effort • rate-sensitive • delay sensitive Assignment • distinct (per flow) • shared (group)
How Signaling Transferred	Messages • reservation-request • path • error/confirm • teardown Communicants • host-to-router • router-to-router Maintenance • refreshed • times out

http://www.cisco.com/en/US/docs/internetworking/technology/handbook/RSVP.html

QoS Key Parameters Example (2 of 2)

RSVP: - reservation-based QoS protocol
- based on integrated services (INTSERV) model

Key Feature	Implementation
Routing Coupling	Routing Independent
Resource Management State	Soft in all nodes
Required Participation	Clusters – tunneling possible

http://www.cisco.com/en/US/docs/internetworking/technology/handbook/RSVP.html

Origins and Directions

- SERVQUAL: - developed by Zeithaml, Parasuraman, Berry
  - measure how service organizations meet customer needs
- QoS: maintaining circuit-switched telephony – transitioned to IP QoS.
- QoE: user perception of product quality and utility.

Service Quality SERVQUAL	**Quality of Service QoS**	**Quality of Experience QoE**
▪ Tangibles ▪ Reliability ▪ Responsiveness ▪ Competence ▪ Courtesy ▪ Credibility ▪ Feel Secure ▪ Access ▪ Communication ▪ Understanding the Customer	▪ Delay ▪ Jitter ▪ Dropped Packet Rate ▪ Packet Error Rate ▪ Throughput	▪ Usefulness ▪ Happiness ▪ Satisfaction ▪ Worthwhile ▪ Expected

System of Systems

a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities [Defense Acquisition Guidebook Ch. 4 “System of Systems Engineering"]

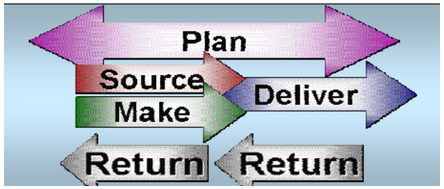
- Characteristics
  - Operational Independence SOA QoS
  - Managerial independence SOA QoS
  - Evolutionary development SOA QoS
  - Emergent behavior SOA QoS
  - Geographic distribution SOA QoS
- Control [Maier 1998]
  - Directed
  - Collaborative
  - Virtual
  - Acknowledged
- Examples
  - Aerospace Operations Center (AOC)
  - Air Traffic Control Systems
  - Public Utilities
  - Supply Chains

System of Systems

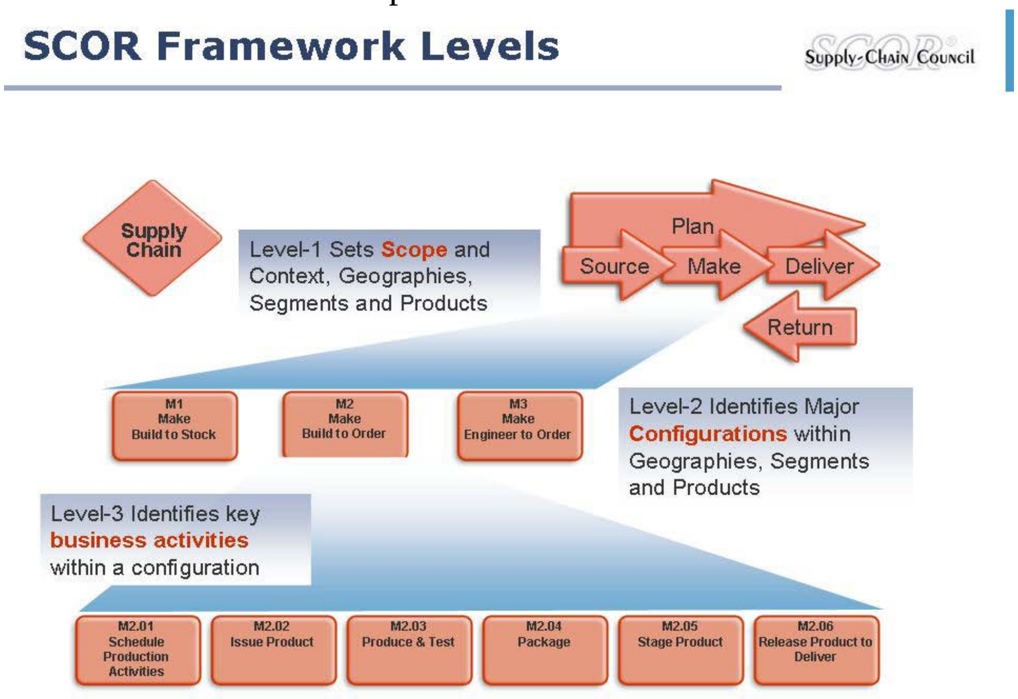
- Architecture
- Evolution and complexity
- Evolutionary architectures require: [Selberg & Austin, INCOSE 2008]
  - Standard interfaces
  - Interface layers
  - Continual system verification and validation
- Self-organized SoS [Bak Tang Wiesenfeld 1987]
- SoS may grow scale-free [Albert Jeong Barabasi 2000]
  - Hierarchical
  - Non-exclusive interdependencies
  - Fault tolerant

Supply Chain as a SoS

- DoD Supply Chain as a System of Systems [LTG Christianson (J-4) 26Jul06]
  - Objective: Timely & Precise Response
    - Speed - Reliability
    - Visibility - Efficiency
    - Performance Tracking - Process Diagnosis



  - Independent Players: Same Team, Dispersed, Complex, Resource Pressures
- Supply Chain Reference Model (SCOR) – Supply Chain Council
  - sequencing
  - elements of functional decomposition



Value of QoS for Net-Centric Systems

- Timely Data
- Design Service Levels
  - Specific Applications
  - Specific Users
  - Classes
- Designate and Maintain
  - Command and Control
  - Communications
- Preserve Scarce Resources
- Enable Cloud-Computing and SOA-Type Processes
  - Reduced forward footprint and resources
  - Centralized storage/processing
  - Minimize secondary methods
- Requirements
  - Efficient Routing
  - Control Signaling
  - Message Marking
  - Admission Policy
  - Admission Control

Key Features Delivered by QoS

Reliability

Accessibility

Timeliness

Scalability

Customizability

Durability

Availability

Portability

Evolvability

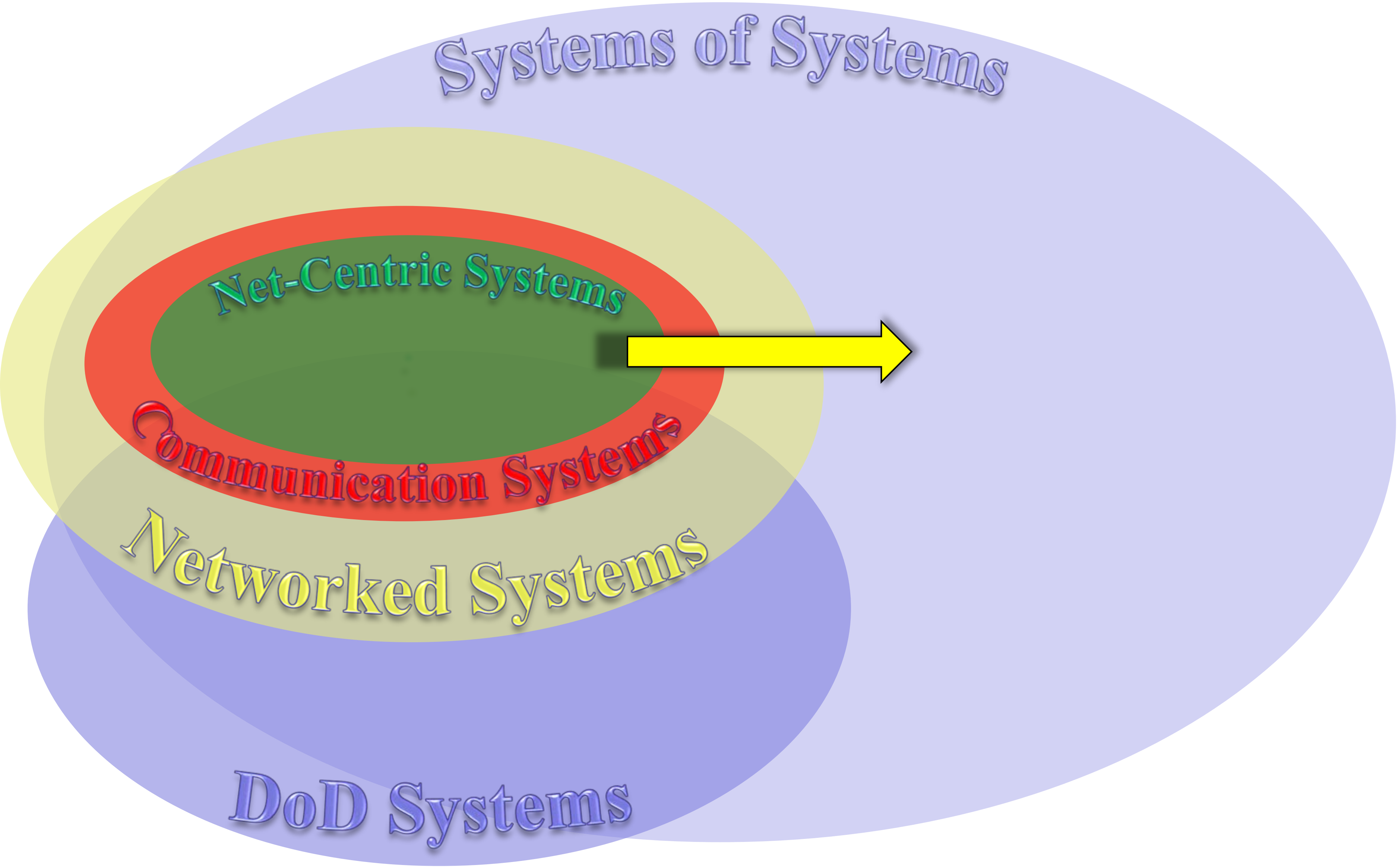
Extensibility

Interoperability

Survivability

Distributability

QoS for SoS


Systems of Systems
Net-Centric Systems
Communication Systems
Networked Systems
DoD Systems

QoS in a Generalized SoS

Key Feature	Implementation	Discussion
Resource Reservation	Priority, responsiveness, quality, detail, precision… distinct or shared	Heavily Application Dependent
How Signaling Transferred	• request-for-bids, RFP, proposal, contract, kickoff, reviews, wrapup • non-disclosure-agreement • advertisement, menu, subscription, publish, instructions, terminate	contract, PO, warranty, maintenance SLA, contract, PO, warranty, maintenance
Routing Coupling	Closely or loosely coupled	CBD, sub-contract, invitation to bid
Resource Management State	Soft or Hard one, some or none	IDIQ or FFP/pre-paid
Required Participation	Clusters – tunneling possible	Agreements form communities

Improvements to the SoS

- Managing with greater fidelity
  - Own resources
  - Promises
- Systems leverage other systems
  - Reliability
  - Confidence
  - Risk
- Layered management of complexity
  - Framework
  - Emergence
  - Guarantees
- Outsourcing and core expertise
  - High cohesion
  - Purpose
  - Modularity (low coupling)

Requirements for QoS in SoS

Requirements for QoS in Net-Centric SoS

- Efficient Routing
- Control Signaling
- Message Marking
- Admission Policy
- Admission Control

Similarly…

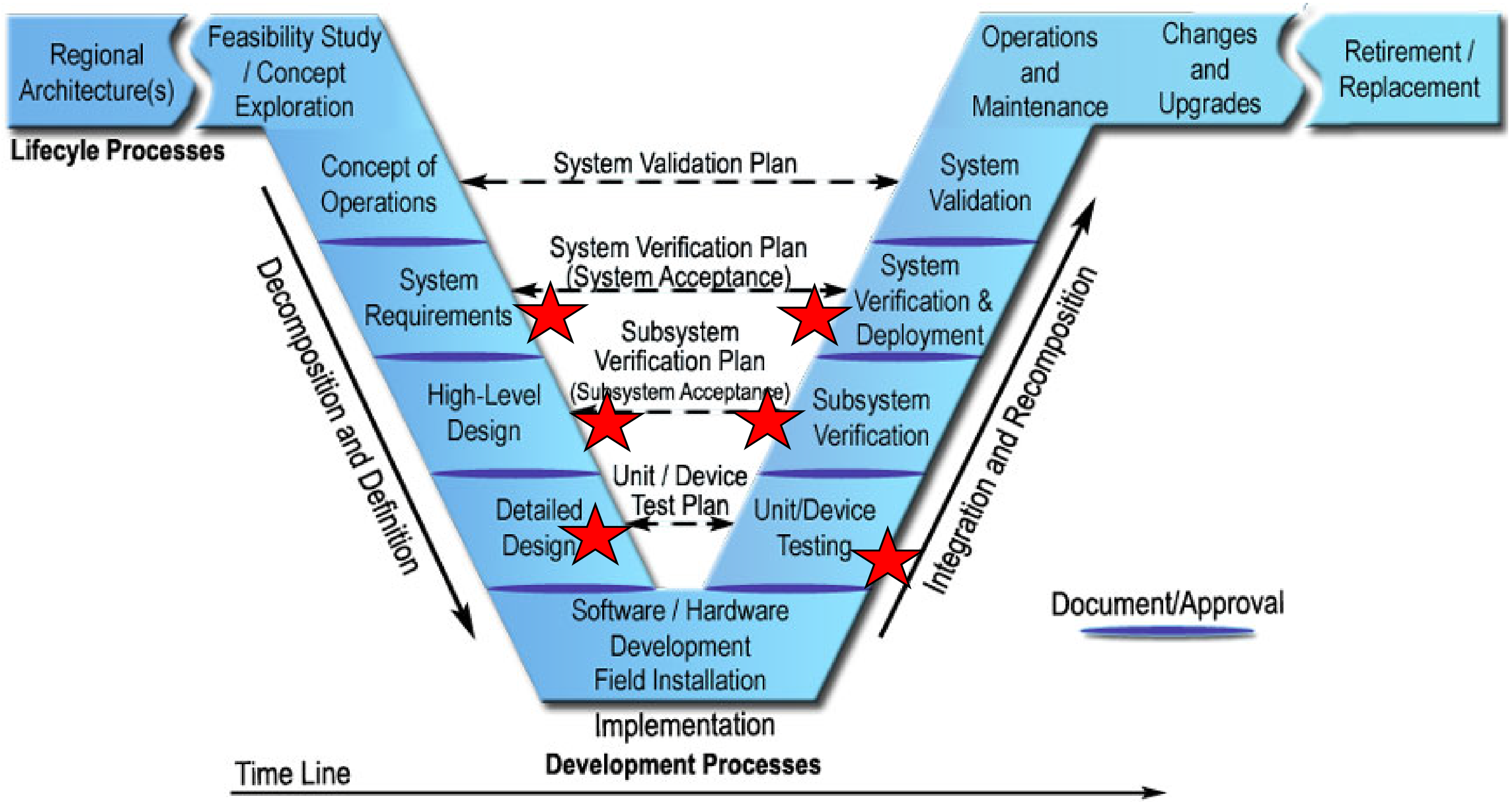
- Efficient product delivery
- Vehicles
  - initiate
  - terminate
  - adjust
  - modify
- Labeling (ID and Priority)
- Admission criteria
- Triage at each node

QoS for SoS vs SERVQUAL

- SERVQUAL measured organization performance relative to customer needs
- QoS
  - Establish contract
  - Maintain commensurate flows
  - Means to adjust flows
- Automation in SoS
  - More common today
  - Measurement and control common
  - Feedback possible
- QoS for SoS requires
  - Documenting requirements
  - Monitor requirements fulfillment
  - Intermediates: divide and apply resources

Systems Engineering Motivation

- SoS Design and Build difficult undertaking
- QoS: critical and responsive
- QoS for SoS in "V" highlighted★



Systems Engineering Motivation

System Engineering for System of Systems: Core Elements

- Translating Capability Objectives
- Understanding Systems and Relationships
- Assessing Performance to Capability Objectives
- Developing and Evolving an SoS Architecture
- Monitoring and Assessing Changes
- Addressing Requirements and Solution Options
- Orchestrating Upgrades to SoS

- Systems Engineering Guide for Systems of Systems 2008

Summary

- The Quality of Service (QoS) framework has promise to aid in design and operation of a System of System (SoS) which must allocate scarce resources.
- The SoS must include certain basic elements to gain from a QoS framework.
- SoS using a Service Oriented Architecture (SOA) are most compatible--any SoS may adopt the framework.

Contact

Major Vinod D. Naga, USAF

PhD Student

Air Force Institute of Technology

Department of Systems and Engineering Management

vinod.naga@us.af.mil

937-255-3636 x7126

Early Systems Engineering Planning: Milestone A Systems Engineering Plans (SEPs)

Ms. Lisa M. Reuss

Systems Engineering Directorate

Office of the Director, Defense Research and Engineering

12th Annual NDIA Systems Engineering Conference

October 28, 2009

UNCLASSIFIED

Outline

- What is a SEP?
- What is a Milestone (MS) A SEP?
- Why do one for MS A?
- How should it be written?
- Who should write it?
- When should it be written?

  and then . . .
- What do you do with it?

What is a SEP?

A SEP

- Articulates and communicates technical planning and management approach to program team, stakeholders, and contractor teams (including bidders if provided with Request for Proposal (RFP))

- Captures integration of both government and contractor systems engineering (SE) activities, roles, and responsibilities over the acquisition and sustainment life cycle

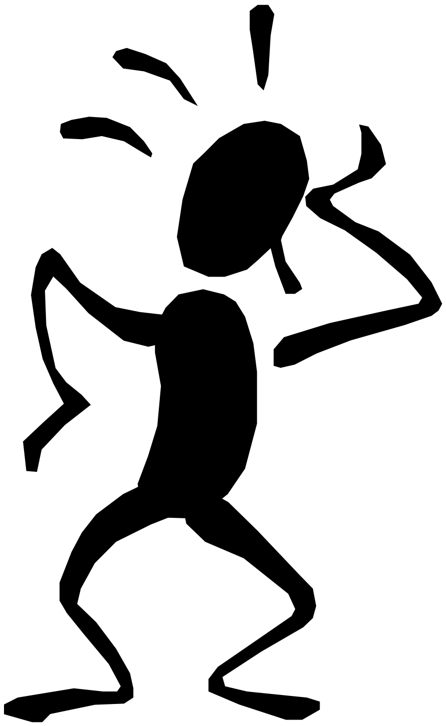
- Provides expected management interactions and impacts of their respective processes not only by addressing program-tailored processes, but also the "who, when, and to what result(s)"

What is a MS A SEP?

	MS A SEP for TD Phase Planning	MS B SEP for EMD Phase Planning	MS C SEP for P&D and O&S Phases
Focus	•Technology maturation •Trade studies •Competitive prototyping •Requirements definition •SRR, SFR (SDR) & PDR	•Engineering •Manufacturing maturity •DT&E results integrated w/ SE •Requirements refinement •CDR, TRR, PRR & FCA	•Production planning & sustainment engineering •Technology refresh mechanisms and plans •OTRR & ISRs
All SEPs	Risk management and reduction Requirements management PMO & IPT staffing Tech baseline management Tech review management Integration of SE with program management IUID implementation planning		

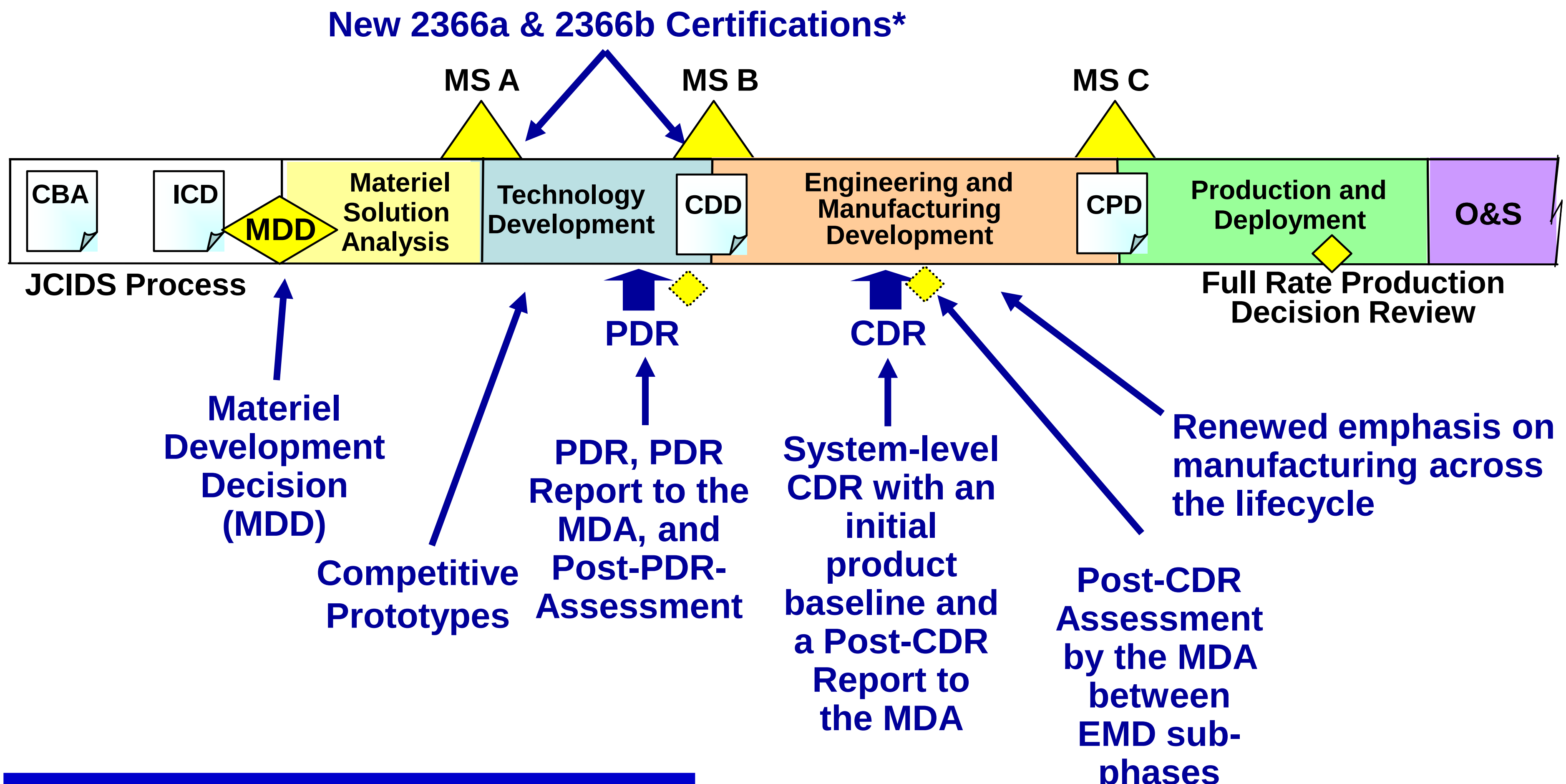
PMO-Program Management Office
SFR-System Functional Review
TRR-Test Readiness Review
IPT-Integrated Product Team
SDR-System Design Review
PRR-Production Readiness Review
IUID-Item Unique Identification
PDR-Preliminary Design
FCA-Functional Configuration Audit
DT&E-Developmental Test & Evaluation
SRR-System Requirements Review
CDR-Critical Design Review
ISR-In-Service Review

SEP Blooper



"Fifteen (15) trade studies are planned during the EMD phase. These trade studies are undefined at this time."

DoDI 5000.02 and PL 111-23 – the Changed Acquisition Landscape



* Director, SE supports MDA certifications including PDR Report assessment at MS B

Systemic Program Planning Issues

	Planning
Requirements	•Lack of reasonable/measurable/testable requirements
Resources	•Schedule driven programs •Marginal Program Office staffing •Optimistic plans to leverage M&S
Management	•Lack of incremental acquisition strategy •Poor communications prior to contract award •Lack of IMP/IMS •Unclear roles, responsibilities, lines of authority •Lack of mature risk management program
Tech Process	•Lack of rigorous SE planning; no SE tech reviews •Lack of growth margins/trade-space •Underestimation of integration efforts & COTS mods •Insufficient efforts to design-in reliability •Inadequate testing and verification approach

Early SE Planning should prevent these findings!

Top Five SE Issues*

As identified in the NDIA Systems Engineering Division's Task Group Report on the *Top Five Systems Engineering Issues within Department of Defense and Defense Industry*, July 2006, not necessarily in priority order:

- Key SE practices known to be effective are not consistently applied across all phases of the program life cycle.
- Insufficient SE is applied early in program life cycle, compromising foundation for initial requirements and architecture development.
- Requirements are not always well-managed, including effective translation from capabilities statements into executable requirements to achieve successful acquisition programs.
- Quantity and quality of SE expertise is insufficient to meet demands of government and defense industry.
- Collaborative environments, including SE tools, are inadequate to effectively execute SE at joint capability, system of systems (SoS), and system levels.

*Past Projects at http://www.ndia.org/Divisions/Divisions/SystemsEngineering/

SEP Blooper

"The … Program Manager and Systems Engineer monitor integration activities to ensure that the KPPs and the KSAs are *not* achieved."

SEP Preparation Guide v2.01
(April 2008)

Describes expected SEP content

- **Requirements: KPPs, Statutory/Regulatory, and Certification**
- **Technical Staffing: Program Office and IPT**
- **Technical Baselines: Traceability and related processes**
- **Technical Reviews: Tailored details**
- **Integration: SE activities with program management**

***Prep Guide v3.0* to accommodate the PL 111-23 (Spring 2010)**

Addendum to SEP Prep Guide v2.01
(July 2009)

Identifies impacts of DoDI 5000.02 to all SEPs by phase; Specifically for MS A:

- **Describe the design impact of and assessment at technical reviews of**
  - Reliability, Availability, and Maintainability
  - Manufacturing
  - Human Systems Integration
  - Critical Program Information
- **Mandatory PDR details**
- **Use of Configuration Steering Boards**
- **Inclusion of IUID Implementation Plan Summary**

More planning earlier!

SEP Blooper

"Task analyses conducted by *human and engineers* provide qualitative data to support …."

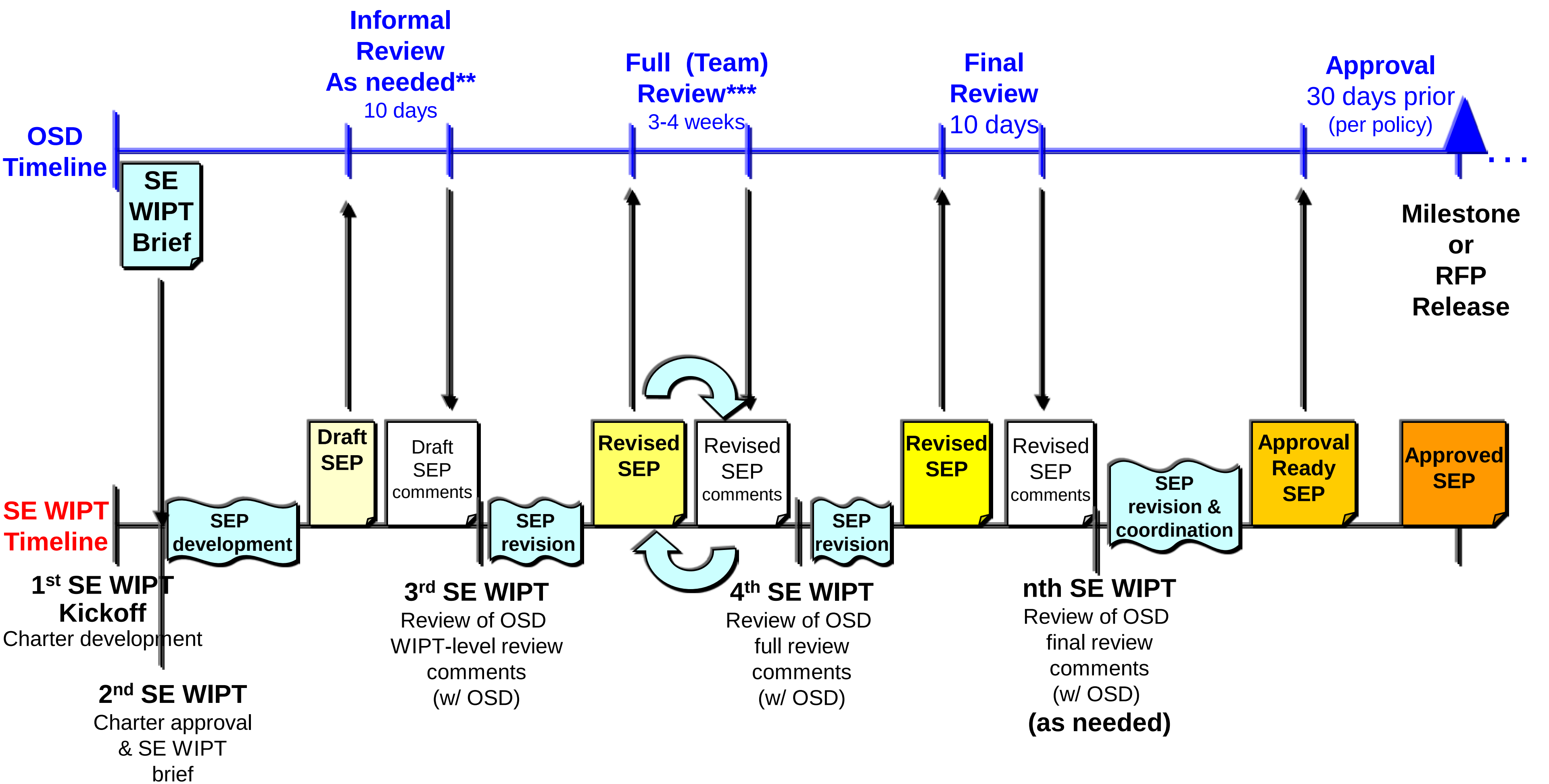
Systems Engineering Working Integrated Product Team (SE WIPT)

- **To be effective, an SE WIPT (like all WIPTs) requires:**
  - Full support of Program Manager, Chief Engineer, and Lead Systems Engineer (LSE)
  - Charter defining goals, products, membership, and reporting requirements
- **Recommended participants, as applicable:**
  - Program Manager
  - LSE (Program and Contractor)
  - IPT Leads (Program and Contractor)
  - LSEs from PEO and applicable System of Systems
  - Service Systems Engineering organization representatives (e.g., AF: SAF/AQRE, NAVSEA: SEA05, NAVAIR: AIR 4.0, etc.)
  - OSD SE representative (s)

Even with a limited program office staff, involve the right people!

SEP Development Timeline*

Note: Planning should be thought-through and take place long before it is documented in a SEP



*Not to scale

**Informal Review: Showstopper only review

***Full (Team) Review: Detailed review

How to use your SEP

- Starting a new program? Use SEP Prep Guide to help ensure much is considered before SE plans are finalized
- New to the program? Read the SEP to understand the program's system-level technical planning
- Going to a technical review? Check the SEP's documented entry and exit criteria prior to conduct and participation
- Working in a program office? Refer to the SEP for SE process descriptions, roles, responsibilities, and expected products
- Going to an IPT meeting? Check the SEP for which positions and functions who should be invited/present
- Have an approved SEP? Execute to it!

Execute to the Plan!

MS A SEP Summary

Your MS A SEP should

- Reflect well-thought-through, actual technology development and risk reduction planning for the Government program office
- Abide by law and comply with policy
- Be written by the right people on the right timeline
- Follow guidance and use charts, figures, tables, graphics, and hotlinks as much as possible
- Guide conduct of IPTs/WIPT meetings, technical reviews, and process usage

Session Summary

Revised policy, the new statute, and SEP guidance enable you to

- Improve early planning
- Improve product design and integration
- Improve program execution
- ***Succeed!***

Improved Capability for the Warfighter!

For More Information

- **Contact me:**
  - Lisa M. Reuss, 703-602-0851x128 Lisa.Reuss.ctr@osd.mil

- **Refer to: http://www.acq.osd.mil/sse/pg/guidance.html**

Systems of Systems and Test & Evaluation

Dr. Judith Dahmann, MITRE
John Palmer, Boeing
Dr. JoAnn Lane, USC
George Rebovich, MITRE

Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

UNCLASSIFIED

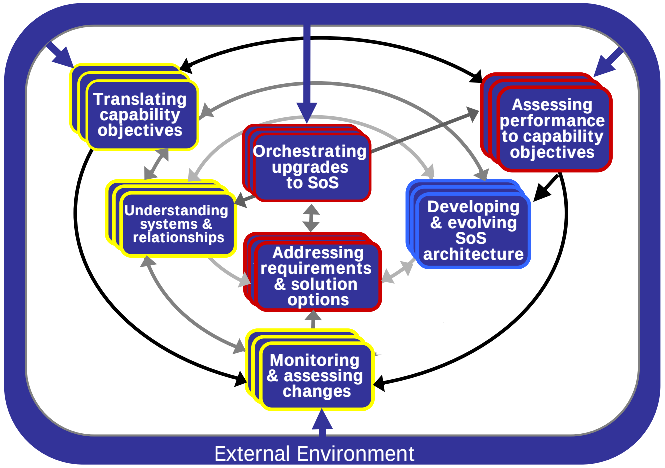
Overview

- SoS and T&E was identified as a topic of interest for the NDIA SoS SE Committee
- White paper on SoS and T&E used as basis for discussion
  - **http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/SystemsofSystemsCommittee.aspx**
- This presentation provides a summary of the key elements of the paper and the discussions
- Identified as a potential 2010 focus area for NDIA SoS SE Committee

Starting Point
System of Systems (SoS) SE Guide

❖ DoD SoS SE Guide

- Focus on technical aspects of SE applicable to SoS
- Characterize SoS in DoD Today
- Describe Core Elements of SoS SE
- Translate application of basic SE processes for SoS SE



❖ SoS types and examples

- Directed - DoD Information System Network (DISN), National System for Geospatial Analysis
- Acknowledged – Ballistic Missile Defense System, Air Operations Center
- Collaborative – Communities of interest
- Virtual - Internet

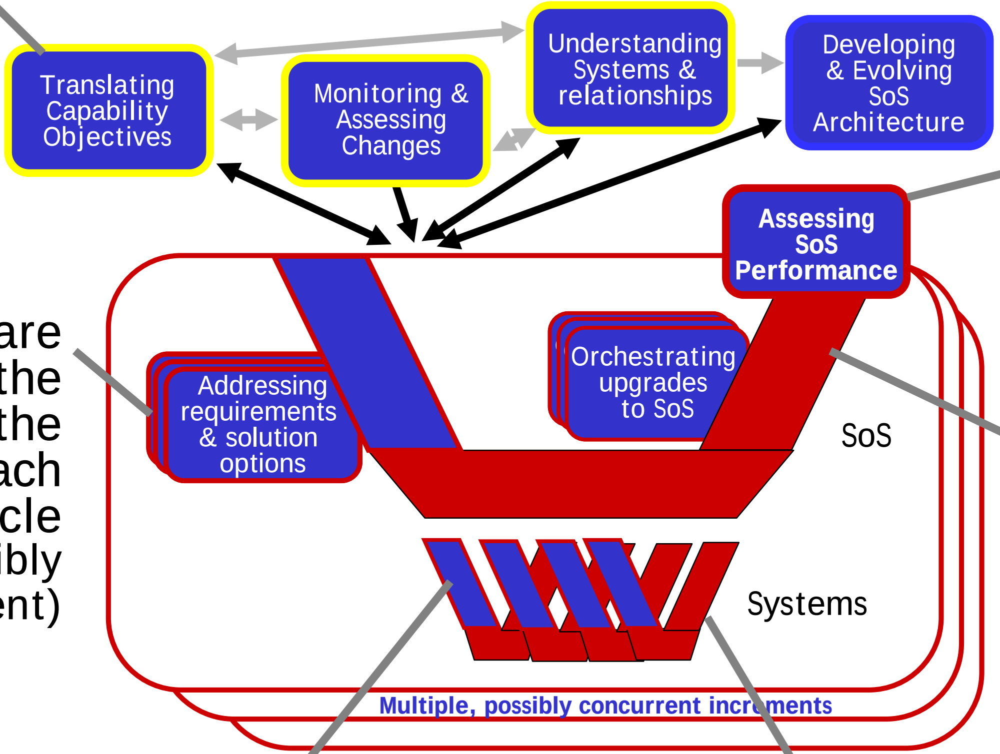
System of Systems: (ref: Defense Acquisition Guide)
A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities.

View of T&E In a SoS

Capability objectives are often stated at a higher level

SoS performance is assessed in various settings (exercise, operations, other)

Requirements are specified at the level of the system for each upgrade cycle (multiple, possibly concurrent)



To varying degrees sets of systems may be integrated and tested

Systems implement changes as part of their own development processes

These system development processes are typically asynchronous

Systems level T&E validates implementation according to system requirements

UNCLASSIFIED

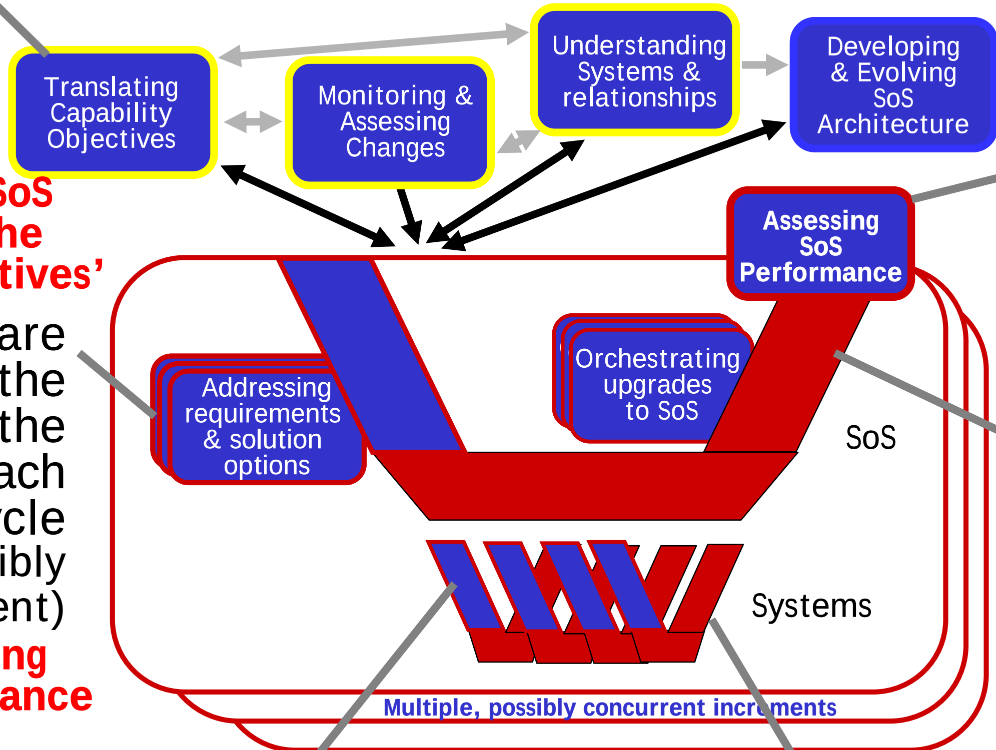
View of T&E In a SoS

Capability objectives are often stated at a higher level

Basis for assessing SoS performance, not the same as 'test objectives'

Requirements are specified at the level of the system for each upgrade cycle (multiple, possibly concurrent)

Basis for assessing system performance



SoS performance is assessed in various settings (exercise, operations, other)

SoS performance assessment may not be possible before fielding

To varying degrees sets of systems may be integrated and tested

Systems may not be available; may need surrogates

Systems implement changes as part of their own development processes

These system development processes are typically asynchronous

Systems level T&E validates implementation according to system requirements

SoS may have little impact on when systems are tested and deployed

UNCLASSIFIED

Implications and Recommendations

- Approach SoS T&E as an evidence based approach to addressing risk
- Encourage use of analytic methods to support planning and assessment
- Develop approach to evaluation of networks which can apply across SoS
- Employ a range of venues to assess SoS performance over time
- Establish a robust process for feedback once fielded

SoS T&E as evidence-based approach (1 of 2)

- Respond to SoS T&E constraints
  - Full conventional T&E before fielding may be impractical for incremental changes in SoS based on systems with asynchronous development paths
  - Live testing at the SoS level can be infeasible due to difficulty in bringing all constituent systems together and set up meaningful test conditions
- Focus on areas of risk
  - Identify areas critical to success and places where changes could have adverse impacts on the user missions
  - Focus pre-deployment T&E on these risks areas
  - Assess the risk using evidence from a range of sources including live test

UNCLASSIFIED

SoS T&E as evidence-based approach
(2 of 2)

- Evidence can be based on
  - Activity at the SoS level, as well roll-ups of activity at the level of the constituent systems
  - Activity can be explicit verification testing, results of models and simulations, use of linked integration facilities, and results of system level operational test and evaluation
- Results
  - Feedback to end users in the form of 'capabilities and limitations' rather than as test criteria for SoS 'deployment'
    - This is done by the Navy Battle Group assessment process

Analytic methods to support SoS planning and assessment

- Analytical models of the SoS behavior can serve as effective tools to
  - Assess system level performance values against SoS operational scenarios
  - Validate the allocations to systems
  - Provide the analytical framework for SoS level verification
- Develop reasonable analytically based expectations for SoS performance
  - Relevant operational conditions should be developed with end user input
  - Guided by design of experiments discipline, so as to expose a broad a range of conditions

Develop approach to evaluation of networks which can apply across SoS

- The network is a unique constituent of almost all SoS
  - Often a major determinate of SoS effectiveness
    - Needs to be assessed as part of the SoS planning, integration, testing and evaluation
  - Realistic assessment of SoS performance demands evaluation of the network performance and it's degradation under the vagaries of operational conditions
    - Typically network is shared and performance is not predictable
- Consider an approach to network assessment which is independent of particular SoS applications, as an input to SoS planning and T&E
  - DoD is developing a set of network capabilities which are applied in a wide range of applications
  - Common way to address network performance could support multiple SoS

Employ a range of venues to assess SoS performance over time

- Evaluation criteria are conventionally established based on quantified performance requirements
  - SoS end-user metrics used to assess the results of SoS capabilities
- Recommend using a range of available opportunities to collect data on SoS performance
  - Assessment opportunities will be both planned and opportunistic
  - These may not be expressly timed to the development and fielding of system changes to address SoS capability objectives
- Performance data can serve a range of needs
  - Support periodic assessments of evolving capability
  - Provide valuable insight to developers and users including the opportunity to identify unexpected behavior

Establish a robust process for feedback once fielded

- Once deployed, continuing "T&E" of the SoS capability of the fielded operations can be used to identify operational problems and make improvements
  - **Continual evaluation can be facilitated through system instrumentation and data collection to provide feed-back on**
    - Constraints
    - Incipient failures warnings
    - Unique operational conditions
- Can provide a vital link to the ongoing operational needs for the SoS
- Includes technical and organizational dimensions
  - An example of the former is instrumenting systems for feedback post-fielding
  - An example of the latter is posting a member of the SoS SE and management team with the SoS operational organization
- Continually exercised feedback mechanisms between operational and acquisition/development communities

In Sum

- Characteristics of SoS pose challenges for conduct of T&E
  - Independence, synchronous development cycles, limited availability of fielded systems
- **Recommended approaches for providing assurance of SoS in light of these constraints**
  - Approach SoS T&E as an evidence based approach to addressing risk
  - Encourage use of analytic methods to support planning and assessment
  - Develop approach to evaluation of networks which can apply across SoS
  - Employ a range of venues to assess SoS performance over time
  - Establish a robust process for feedback once fielded
- Continued attention is needed in this area as DoD has increased dependence on SoS to support user capabilities

Systems Engineering for Systems of Systems: Update

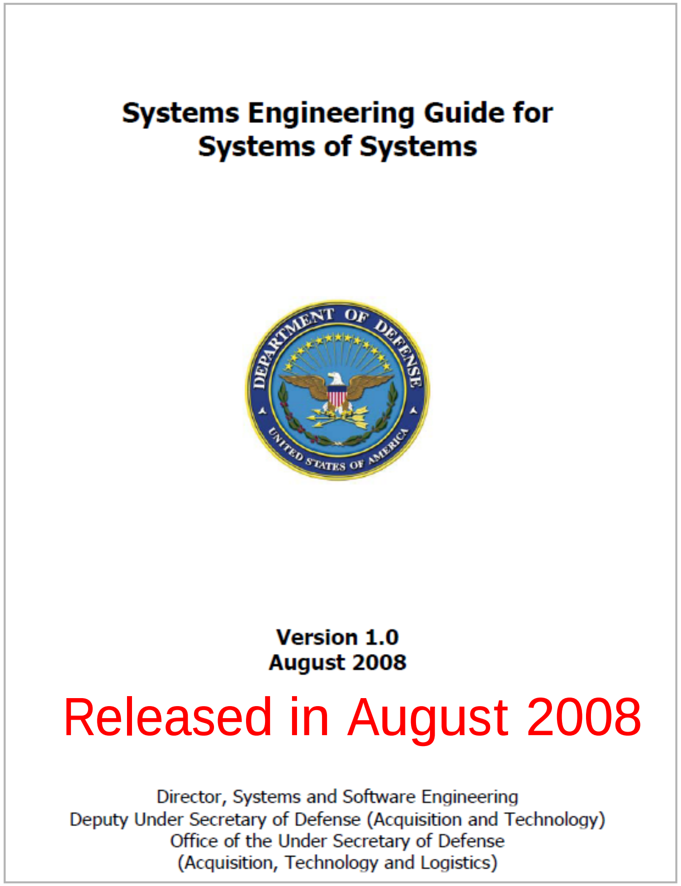
Dr. Judith Dahmann, MITRE

Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

Purpose and Topics

- Purpose
  - Provide an update on current SoS SE initiatives
- Topics
  - Applying current guidance
  - Current Initiatives
  - Relationships

DoD System of Systems SE Guide


Systems Engineering Guide for
Systems of Systems

Version 1.0
August 2008

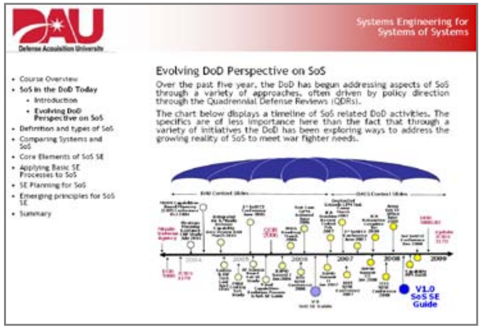
Released in August 2008

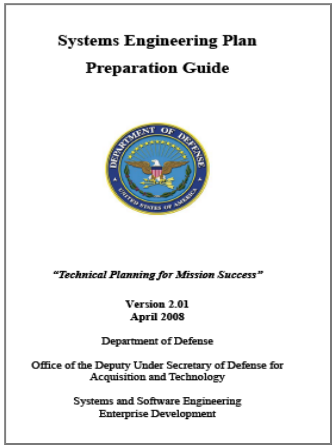
Director, Systems and Software Engineering
Deputy Under Secretary of Defense (Acquisition and Technology)
Office of the Under Secretary of Defense
(Acquisition, Technology and Logistics)

- Initiative of the Office of the Secretary of Defense
- Collaborative approach with DoD, Industry, Academia
- Purpose:
  - Focus on technical aspects of SE applicable to SoS
  - Characterize SoS in DoD Today
  - Describe Core Elements of SoS SE
  - Translate application of basic SE processes for SoS SE
- Audience: PMs and Lead/Chief Systems Engineers

Guidance is based on structured reviews of ongoing SoS SE efforts to identify successful patterns of practice across recent practitioner experience

Applying and Sharing Current Guidance

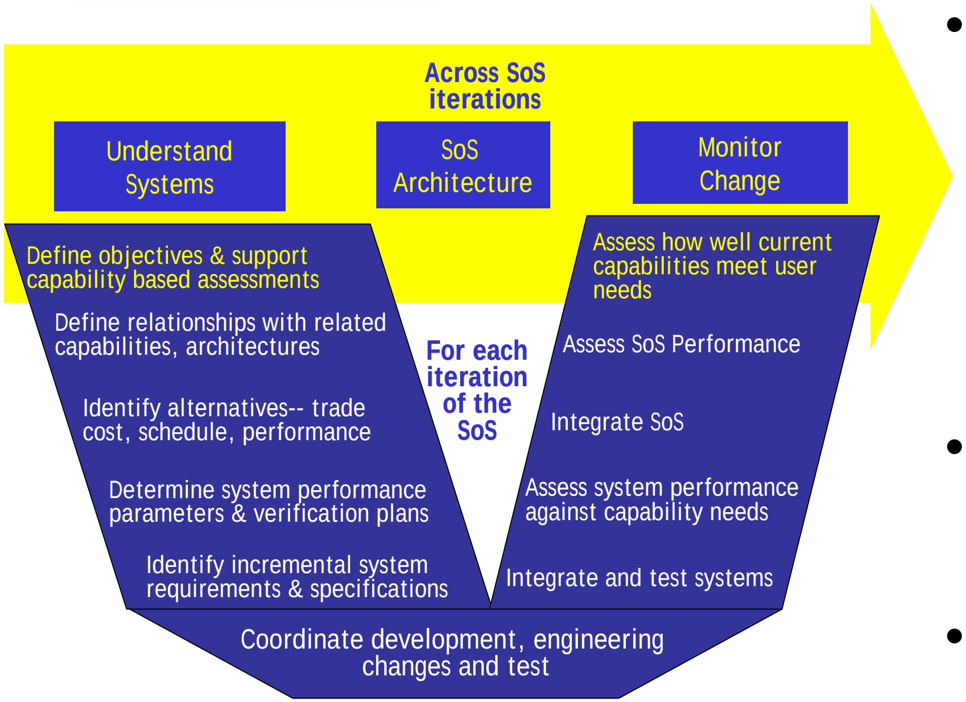




- Defense Acquisition Guide (DAG) Update
  - DAG was updated with the changes in 5000.02; interim DAG is now on line (URL)
  - Section 4.1.4 on SoS SE was updated and links to SoS SEG
- Education and Training
  - DAU Continuous Learning Module (CLM) is in development
  - Online offering, 3 hour course
  - Course objectives and outline are complete, materials being assembled
- SEP and Program Assessment and Support
  - SoS team is participating in SE reviews of SEPs and program support reviews of systems and SoS
  - Currently examining possible options for guidance for SoS SEPs

UNCLASSIFIED

SoS Artifacts



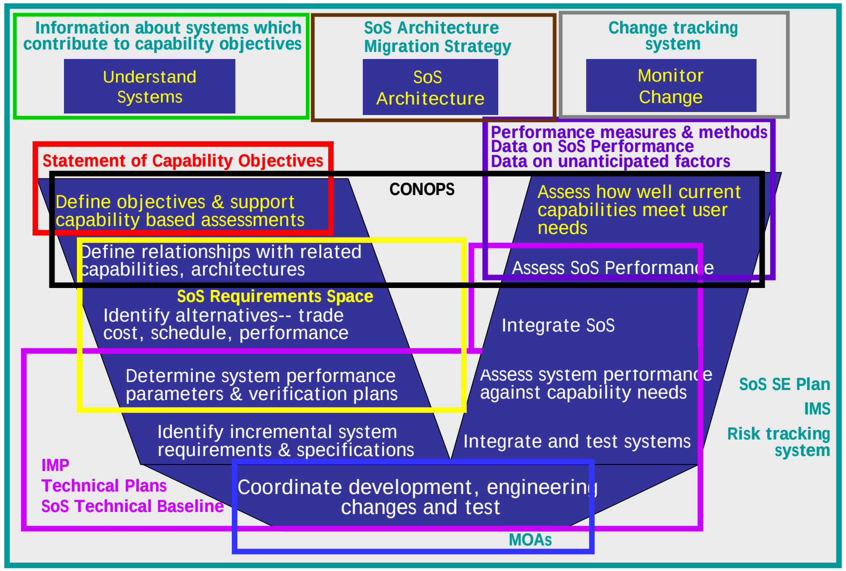
Initiated as a cooperative effort with Australia

- Why focus on "SoS SE Artifacts"?
  - Tangible
  - Evident ROI in terms of a useful product
- Anticipated results
  - Examples based on actual experience
  - Compare to SE artifacts
  - Understanding of the role of the artifacts in the SoS SE process (e.g. impact analysis)
  - Basis for SoS management commitment (governance, resourcing, etc)
- Initial set of artifacts have been developed
  - Shared with TTCP TP4 workshop
- TTCP-TP4 Follow-on
  - Continued development and application but the different nations

UNCLASSIFIED

Candidate Artifacts

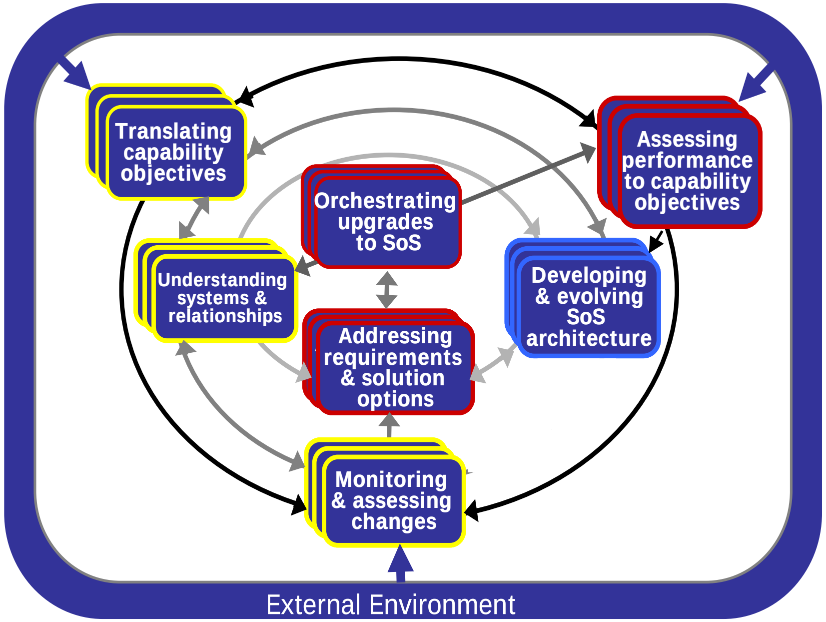
- **Currently working with selected pilots**
  - **Collect examples**
  - **Develop templates**
- **Ongoing exchange with UK, CAN and AUS**
  - **Share experiences as each nation applies these in their own context**



Overlay of Artifacts on Process

1	**SoS SE Plan (SEP)**
2	**SoS Capability Objectives**
3	**Requirements space for the SoS**
4	**Concept of Operations (CONOPS)**
5	**Information about systems which contribute to capability objectives**
6	**Performance measures and methods**
7	**Data on performance of the SoS**
8	**Data on unanticipated factors**
9	**SoS Architecture**
10	**Migration Strategy**
11	**Change management artifacts**
12	**SoS technical baseline**
13	**Technical Plans**
14	**Integrated Master Schedule (IMS)**
15	**Integrated Master Plan (IMP)**
16	**Memoranda of Agreement (MOAs)**
17	**Risk tracking system**

SoS SE and M&S

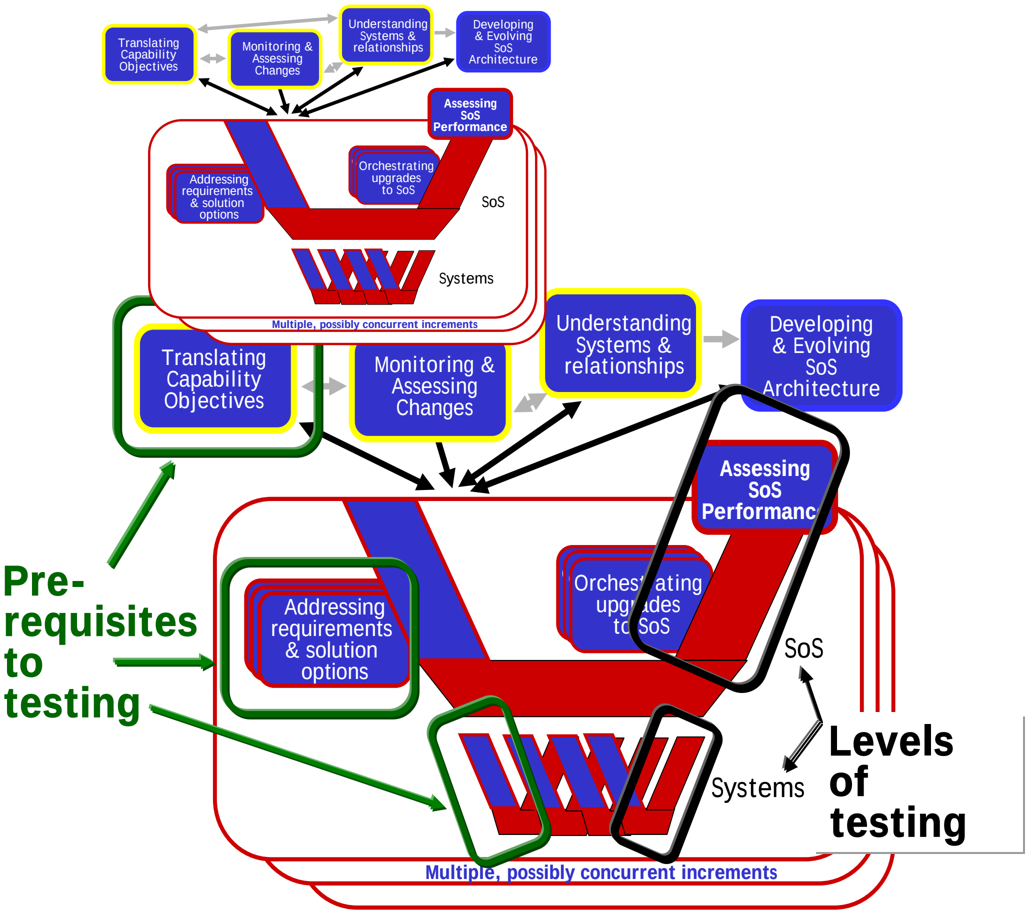


Identify Enablers & Inhibitors to the Effective Use of M&S for each core element of SoS SE

- SoS SEG v1 Practitioner inputs recognized potential of M&S but reported limited application
- Input provided by NDIA M&S Committee on M&S support for SoS Core Elements
  - See NDIA Presentation #9060 "Modeling and Simulation and Systems Engineering"
- New DSB on Modeling and Simulation for Defense may offer added insights

UNCLASSIFIED

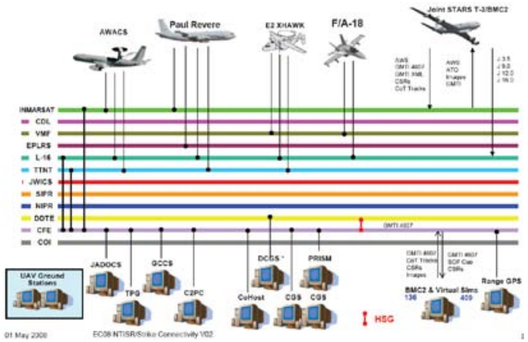
SoS SE and T&E

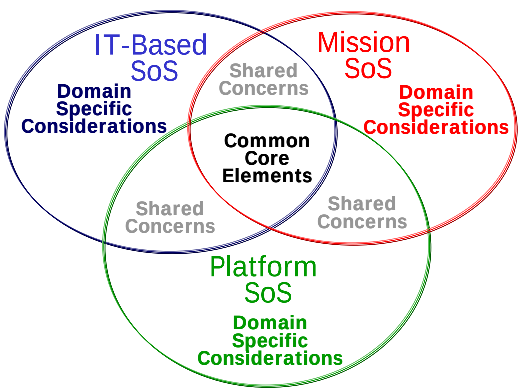


- SoS SE Guide addresses T&E in a limited way
- Area of strong interest for the NDIA SoS SE Committee
- White paper outlined key issues and made recommendations
- See NDIA Presentation #8935: “SoS and T&E”
- Under consideration with NDIA SoS SE Committee as a 2010 focus area with T&E Committee

UNCLASSIFIED

New Initiatives



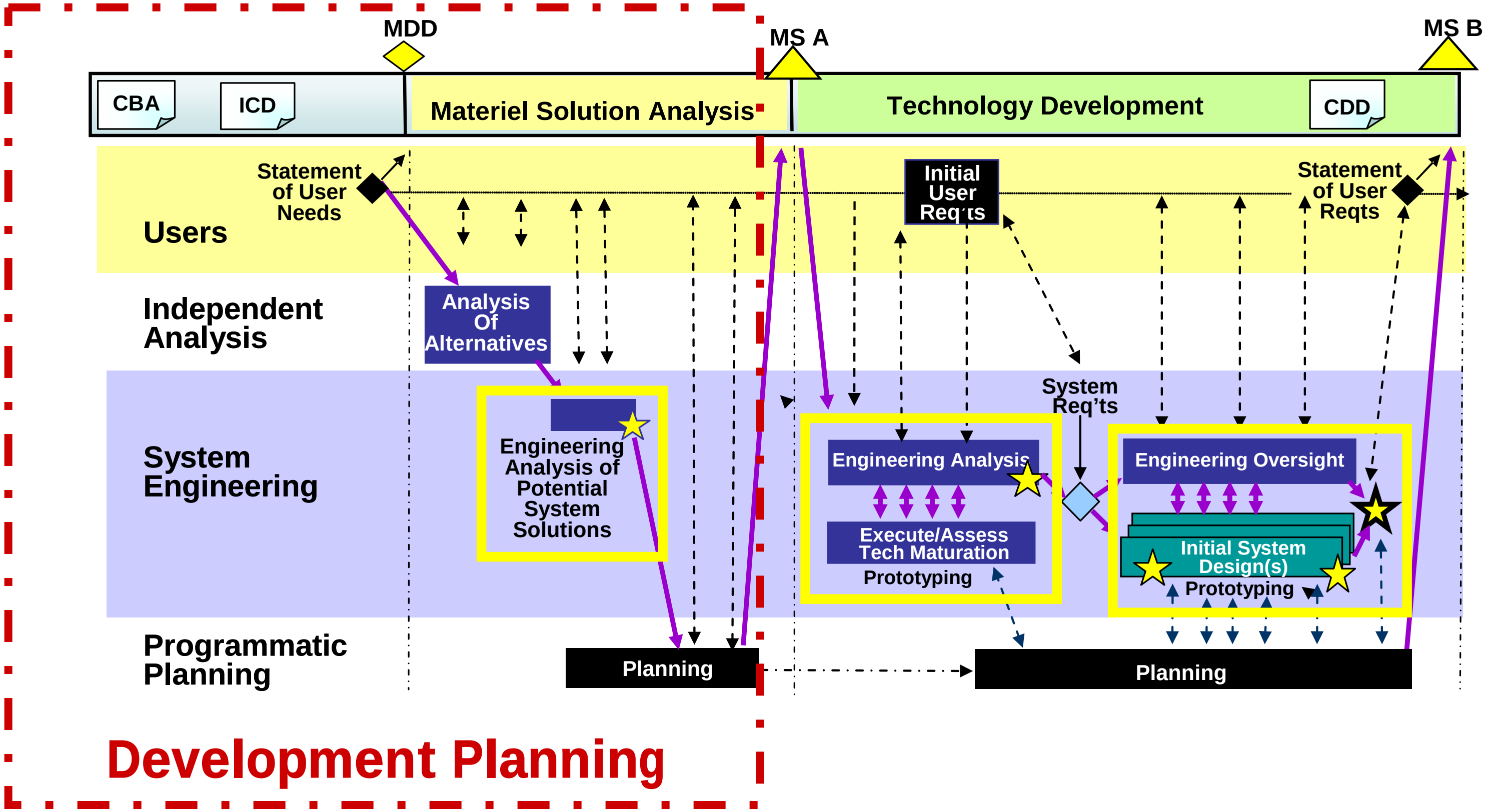


- Collaborative SoS
  - Beginning to look at cases of collaborative and better understand issues related to this type of SoS; Beginning with Ground Moving Target Indicator COI
- Managing Complex SoS
  - New study co-sponsored with ASD-NII on managing complexity in SoS
- SoS Domain Application Areas
  - Mission SoS – Platforms, weapons, sensors and C2 to meet operational mission objectives (e.g. BMDS, NIFC-CA)
  - Platform SoS– Configuration of SoS aboard a platform; Traditionally a Navy (e.g. submarines) consideration but with migration to open systems this will be come more widespread
  - IT-based SoS – Suites of C2, Battlespace Awareness systems or services (e.g DCGS, AOC); Net-centric or SOA based systems

SoS in Acquisition Process

- Most SoS efforts are not 'acquisition programs' per se
  - May be outside of acquisition altogether
    - Influence acquisition of new systems or changes/upgrades in current systems
  - When SoS are implemented as acquisition programs, specific acquisition increments are new SoS components (i.e. systems) or system upgrades/changes to address SoS needs
    - Examples include AIAMD, CANES, DCGS-AF
  - Most systems acquisitions do not explicitly consider the larger SoS context except for interfaces or interdependencies
- Recent legislation requires D/SE to address 'development planning' or early SE
  - Addressing SoS and its impact on systems will be a central part of the SE development planning initiative

Development Planning



- Begins before acquisition
- Natural application of systems engineering process
- Ensures that alternative system approaches evaluated during MSA are validated

UNCLASSIFIED

Where Does Development Planning Fit?

Needs and Opportunities

IPL

Urgent Need

New Threat

New Technology

New Strategic Direction

JCIDS

Viable Solutions

Translating User Needs <u>and</u> <u>Opportunities</u> Into Viable Solutions

Delivery Options

Rapid Fielding

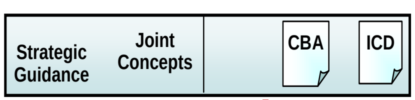
Technology Refresh

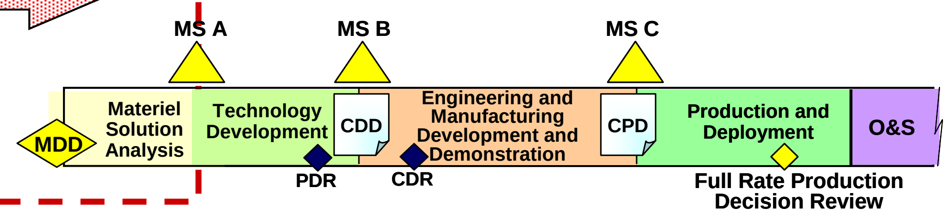
O&S Upgrade

Experimentation

JCTDs

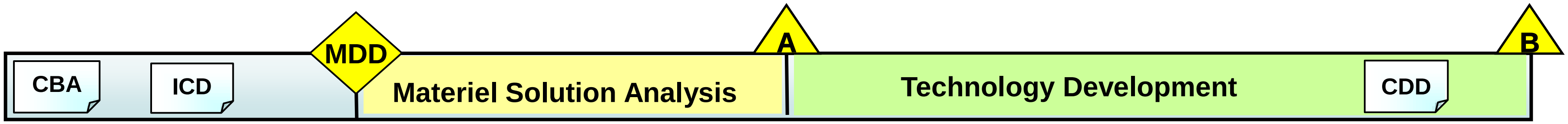
5000.02

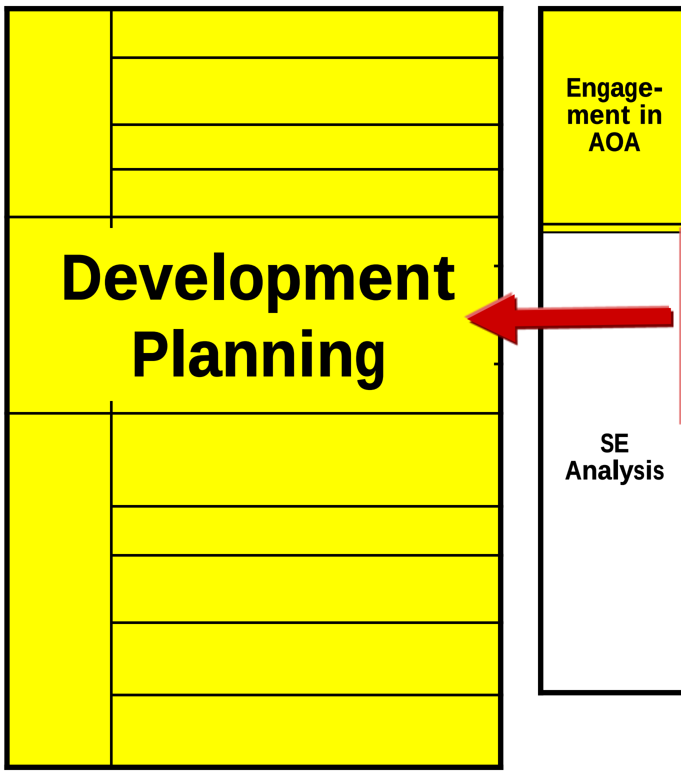




- **Applies more broadly than JCIDS to 5000.02 acquisition**

Role of SoS in Development Planning





Engage-ment in AOA	Guidance
	Plan
	Analysis Activity
	Report
SE Analysis	Consideration of SOS/Interdependency, Interoperability Context
	SEP for MSA
	Input to TDS (CTE, CPI), TES, CCE
	SE in TD contract requirements
	Tech Reviews (ASR, Early SE Requirements)

Prototyping & Risk Reduction	Prototyping (Technology and Design)
	TRL Maturation
	Trade Studies
	SE Support for Technology Risk Reduction
	Oversight of Competitive Designs
	Risk Assessment
Input to Acquisition/ Planning, CARD, Budget and Other	SE in Contract Requirements
	SE Input into the pst-PDR Report, report to MDA, Acquisition Strategy, TEMP, CARD, and the ICE
Evidence of Strong SE Activity	PDR and Post-PDR Report and Assessment
	Tech Reviews up to and including PDR
	SEP
	Strong Reliability, Availability and Maintainability (RAM)
Inputs to Requirements	Systems Requirements Definition
	RAM and Sustainability
	Requirements Traceability Matrices
	Translation of Requirements to Contract
	Inform Capability Development Document (CDD)

*Reference DAG Sections 4.3.1 and 4.3..2

UNCLASSIFIED

Relationships

- **Practitioners**
  - Practitioner experience provides foundation for developing guidance
- **Cooperation with Services (Navy, Army)**
  - Navy and Army have created SoS organizations and focused initiatives
- **Industry**
  - **SoS SE Committee NDIA SE Division**
- **International**
  - Australia: Under Software Intensive Systems SW Improvement Group (SISAIG) initiated SoS Artifacts project
  - TTCP TP4 – Systems Engineering For Modernization: May 2009 Workshop on SoS SE and ongoing development SoS Artifacts
  - UK: British liaison officer to AT&L, part of the UK Systems Engineering Integration Group, joining SoS SE effort
- **Research**
  - Conference participation and publications (IEEE, CSER)

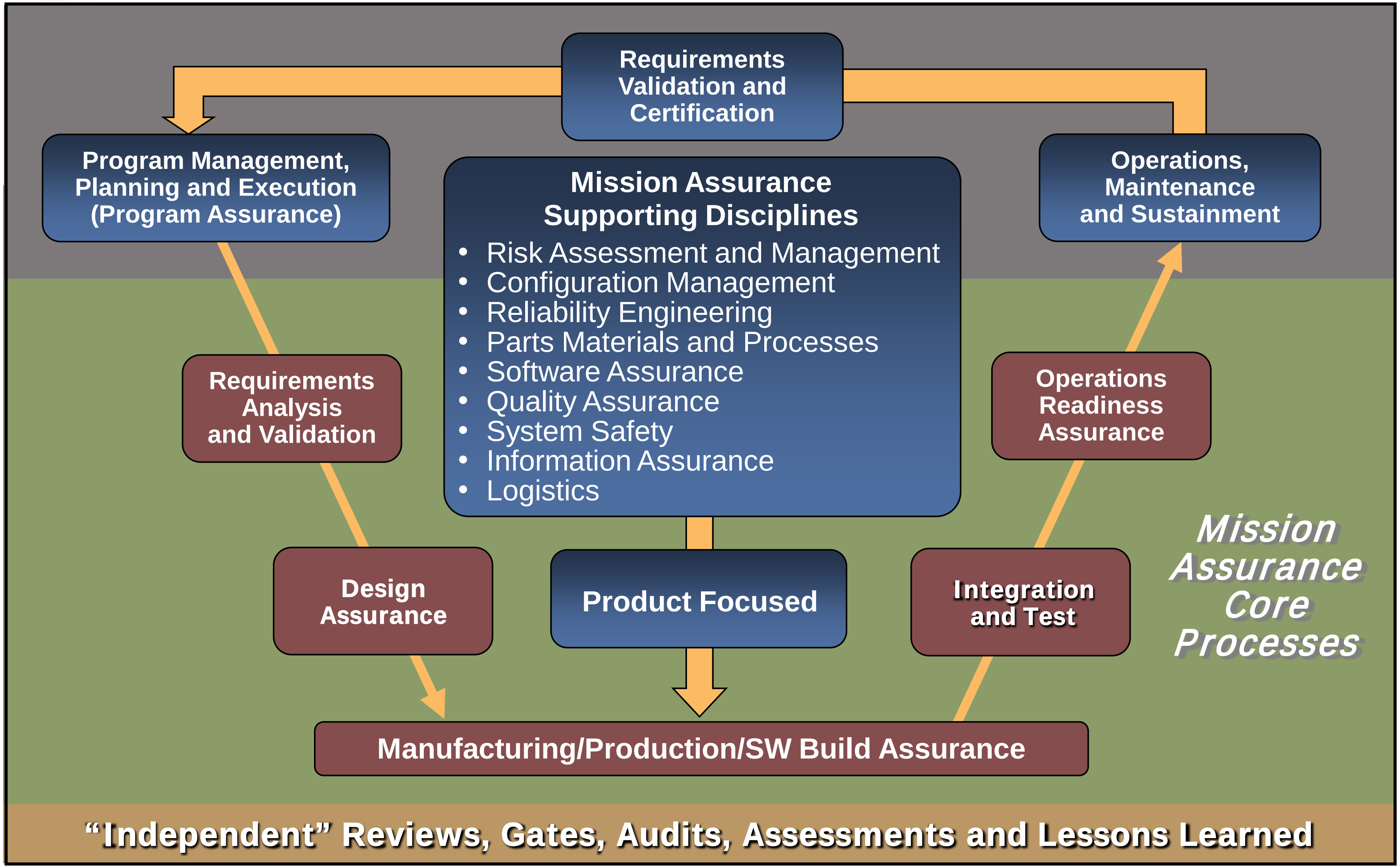
In Sum

- **SoS SE Guide**
  - **Version 1 provides the foundation for ongoing development of an understanding of SoS SE as the basis for evolving guidance**
- **Current efforts focus on**
  - **Applying and sharing current understanding and guidance**
  - **Extending our understanding through a set of investigations of key open issues**
- **Importance of relationships**
  - **Large issue which is gaining in interest**
  - **Participate in existing for to share our work and capitalize on work of others**
  - **Important to be part of this larger community as together we develop a better appreciation and understanding of SE for SoS**

DoD's Refocus on Specialty Engineering in Support of Mission Assurance

Chet Bracuto
OSD Systems Engineering/Mission Assurance
28 October 2009

Specialty Engineering, Systems Engineering and Mission Assurance



Specialty Engineering Common Initiatives

- Have a clear entry point into OSD Systems Engineering
- Identify policy and guidance gaps in the community and fill those gaps: Defense Acquisition Guide Chapter 4 and SEMP DID
- Work with Industry and DoD to identify and address issues negatively impacting the community
- Work with Academia, Industry and DoD to improve the ‘state of the art’ of the community
- Inject the specialty engineering areas early in the acquisition process
- Progress a ‘purple’ DoD in all specialty areas
- Improve training and education for the workforce in each specialty area through Lessons Learned, Best Practices, and Program feedback
- ‘Get the word out’ through Outreach
- Lower program costs

Production, Quality and Manufacturing

- Finalizing the Manufacturing Readiness Levels (MRL) Matrix and MRL Deskbook
- Developing a policy letter for the Services to conduct an MRL-based assessment of manufacturing readiness prior to the acquisition milestones and to incorporate the results of those assessments into all technical reviews throughout the life cycle phases.
- Developing a policy letter for the Services on lead free electronics.
- Holding Quality Advisory Group (QUAG) meetings to address ongoing common quality issues in the Service.
- Working with DLA, the Services and the OSD Comptroller to resolve quality and funding issues related to DLA procurements.
- Holding PQM FIPT team meetings to improve the PQM workforce.
- Progressing on a PQM Competency Assessment.

Reliability, Availability, and Maintainability

- Implementing recommendations from Reliability Improvement Working Group
  - Updated 5000.02, DAG and DAPS methodology
- Initiated DoD Working Group to identify common areas to be worked in the Reliability community to working RAM issues
  - MIL-HDBK-217
  - Develop roadmap for RAM Tech Support Capability
  - Develop gap analysis to identify tools and policy
  - Software reliability
- Released RAM-C to assist in implementing Material Availability KPP
- Participated on GEIA-STD-0009
- Presenting at numerous conferences/submitting papers

Supportability

- Participating in key LM&R Working Group/Teams
  - Product Assessment Support Team
  - Legacy Parts Identification Working Group
  - IUID Working Group
- Working with the Parts Management and DMSMS organizations to meet their needs in all areas
- Working with AIA and NDIA Product Support Teams
- Engaged with the Prognostics Health Management community
- Worked closely to align Chapters 4 and 5 of the DAG
- Working with LM&R on increasing R-TOC opportunities and reducing out-year costs of programs.
- Working with LM&R to get increased visibility in the early stages of acquisition

Reduction in Total Ownership Cost

- Executed the $25M budget line in FY09
- Continue assessment of R-TOC SIP progress toward their cost reduction goals for FY 2010
- Prepared quarterly R-TOC meetings to review and assess Special Interest Programs (SIPs) progress toward meeting the AT&L FY 2010 cost reduction goal for R-TOC
- Developed and assessed Service R-TOC projects for FY 2011 Initiated planning for the future direction and format of R-TOC post FY 2010
- Issued a call for R-TOC projects for FY 2012
- Held a R-TOC/VE track for the 2009 DMSMS Conference and the NDIA Systems Engineering Conference
- Prepared an issue paper for an additional $35M funding for R-TOC projects

Value Engineering

- Led the Value Engineering (VE) Management Advisory Group (MAG) to assess and approve VE awards for FY 2008
- Collected and approved VE savings results for FY 2008
- Planned, conducted and hosted the annual VE awards ceremony
- Published 3 VE papers in ‘Defense AT&L’ and the ‘Defense Standardization’
- Continue VE activities to complete and document VE for FY09 and continuing activities for FY10
- Stood up VE JAT and continued actions to complete the VE JAT recommendations
- Working with OMB on changes to OMB Circular A-131.
- Visited with numerous defense contractors to help facilitate an increase in Value Engineering Change Proposals
- Initiated effort to increase VE usage in service contracts

Human Systems Interface

Objective: Plan for HSI early in the acquisition process to optimize total system performance and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain and support the system.

- Significant cost avoidance/savings has been realized in applying HSI, but hasn't been effectively institutionalized on acquisition programs. We need to do better.
- Key Highlights:
  - NDAA 2008 and 2009 requires stronger OSD HSI leadership in acquisition programs.
  - AT&L assigns senior OSD officials co-lead by (DDRE SE and S&T) responsible for the management of HSI S&T and acquisition activities.
  - DoDI 5000.02 Enclosure (8) requires HSI to be part of the Systems Engineering Plan.
  - Developed comprehensive DoD HSI Management Plan to strengthen HSI within the acquisition process.
  - OSD and the Services are working closely to strengthen HSI in acquisition programs by: addressing better process integration, resources, research and technology.
-

Summary

- Specialty Engineering is Critical to Mission Assurance
- Additional Critical Areas in Mission Assurance
  – Safety
  – Software
  – Information
  – Data Management/Configuration Management
  – Policy/Guidance/Standards
  – Workforce Planning
- Chet Bracuto/OSD Systems Engineering/Mission Assurance

  (703) 695-7793 chet.bracuto@osd.mil

Value Engineering Applications in Service Contracts

12th Annual NDIA Systems Engineering Conference
October 28, 2009

Dr. Jay Mandelbaum
Institute for Defense Analyses
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

Outline

- Introduction to VE and the VE methodology
- Using VE for systems engineering trades in hardware contracts
- Opportunities in service contracts
- Overcoming difficulties

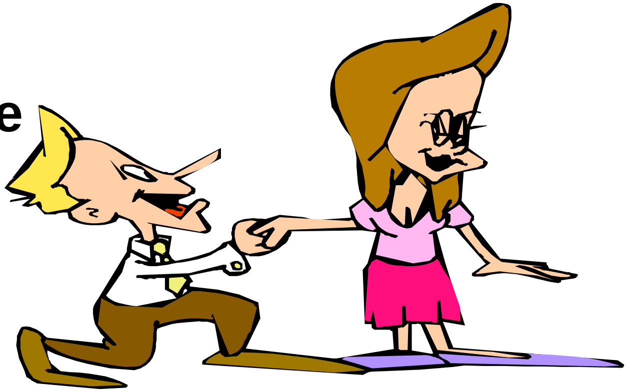
What is VE?

According to Public Law 104-106 value engineering means an analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor personnel, directed at improving performance, reliability, quality, safety, and life cycle costs.

- Characteristics
  - Systems engineering tool
  - Employs a simple, flexible and structured methodology
  - Promotes innovation and creativity
  - When contractually authorized, it incentivizes contractor to help government’s value proposition

VE Implementation Mechanisms

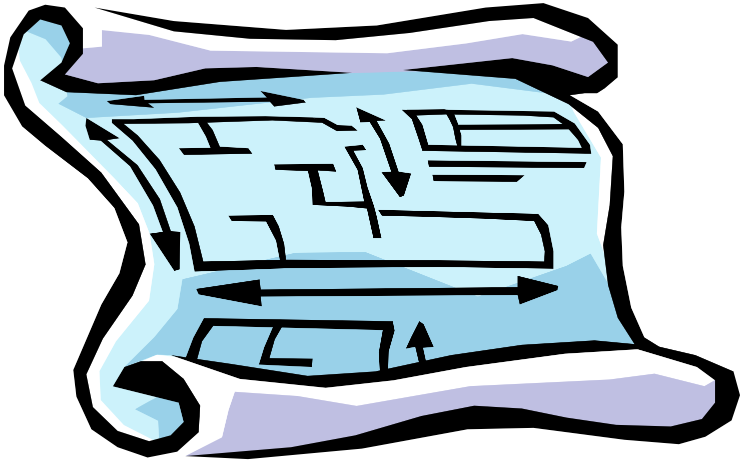
- **A Value Engineering Proposal (VEP) is a specific proposal developed internally by DoD personnel for total value improvement from the use of VE techniques. Since VEPs are developed and implemented by Government personnel, all resulting savings accrue to the Government.**



- **A Value Engineering Change Proposal (VECP) is a proposal submitted to the Government by the contractor in accordance with the VE clause in the contract. A VECP proposes a change that, if accepted and implemented, provides an eventual, overall cost savings to the Government. The contractor receives a substantial share in the savings accrued as a result of implementation. It therefore provides a vehicle through which acquisition and operating costs can be reduced while the contractor's rate of return is increased.**

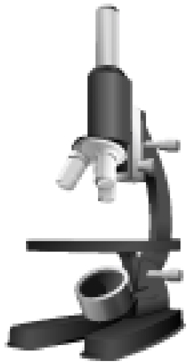
Phases of the VE Methodology (Job Plan)

- Orientation Phase
- Information Phase
- Function Analysis Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase
- Implementation Phase



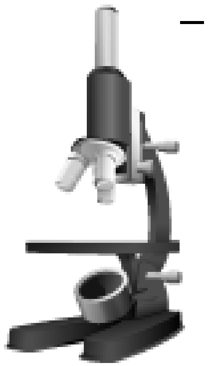
Often carried out in a Workshop format

Function Analysis System Technique (FAST) Basics



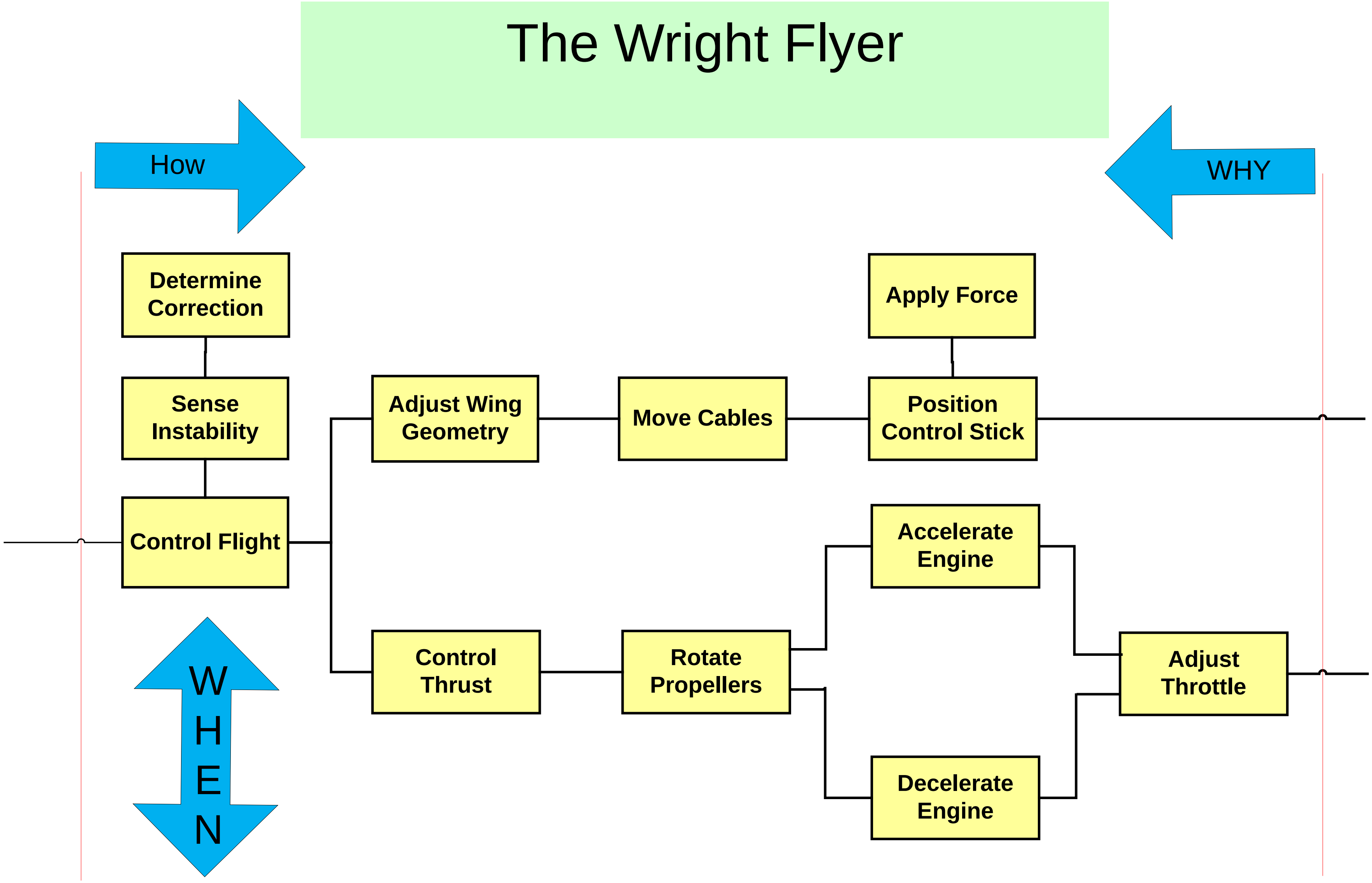
- FAST (developed by Charles Bytheway in 1964) structures the subject matter by breaking it down into functions that enable the subsequent application of problem solving techniques
- Functions are expressed as an action verb and a measurable noun, e.g., control thrust
  - Verb answers the question "what does it do"
  - Noun tells what is acted upon
- FAST diagrams display functional relationships
  - Highest order functions represent the output of the subject under study
  - The basic function is essential to the performance of the higher order functions, they form the critical path
    - Moving from "left" to "right," successively answer the question how in a dependent relationship accomplished (the method selected)
    - Moving from "right" to "left" answers the question "why" (the goal)
    - E.g., control flight ⟷ control thrust ⟷ rotate propellers ⟷ accelerate engine

FAST Basics (cont'd)



- **FAST diagrams display functional relationships (cont'd)**
  - **Independent or supporting functions above the critical path explain "when"**
    - **For example**
      - **When you control flight, you have to sense instability**
      - **When you sense instability, you have to determine correction**
    - **A minor critical path may be built horizontally from these independent functions**
    - **Functions may be taken off (put above) the critical path if the answer to the "how" question is not important to the issue being examined**
  - **Activities are shown below the critical path**
    - **They represent the result of the function**
  - **Objectives and specifications for each function may be shown in matrix form at the bottom of the FAST diagram**

Simple FAST Example



Outline

- Introduction to VE and the VE methodology
- Using VE for systems engineering trades in hardware contracts
- Opportunities in service contracts
- Overcoming difficulties

VE in Systems Engineering

- **VE methodology is an effective tool for making systems engineering decisions**
  - **Reduce cost**
  - **Increase productivity**
  - **Improve quality related features**
  - **Improve processes/procedures**

  While**…meeting or exceeding functional performance capabilities**
- **VE is applicable at any point in the life cycle**

  How**…making SE trades**

Factors Leading to VE Changes

- Advances in technology
- Excessive cost
- Questioning specifications
- Additional design effort
- Changes in user's needs
- Feedback from test/use
- Opportunities for design improvements
- Need to improve reliability

Changes based on systems engineering trades

Hardware VE Example

ORIGINAL CONTRACT		CONTRACT AFTER VECP ACCEPTANCE	
Original Unit Cost	$10,000	Revised Unit Cost	$6,000
Original Unit Profit	$1,000	Original Unit Profit	$1,000
Original Total Cost	$11,000	Revised Total Cost	$7,000
		Non-Recurring Engineering $1 million 500	$2,000
		New Unit Price	$9,000
Original Qty	X500	Affected Qty	X500
Original Total	$5,500,000	Revised Total	$4,500,000
		Savings ($1,000,000)	
		Contractor share	$500,000
		New contract total	$5,000,000

Outline

- Introduction to VE and the VE methodology
- Using VE for systems engineering trades in hardware contracts
- Opportunities in service contracts
- Overcoming difficulties

New VE Opportunities

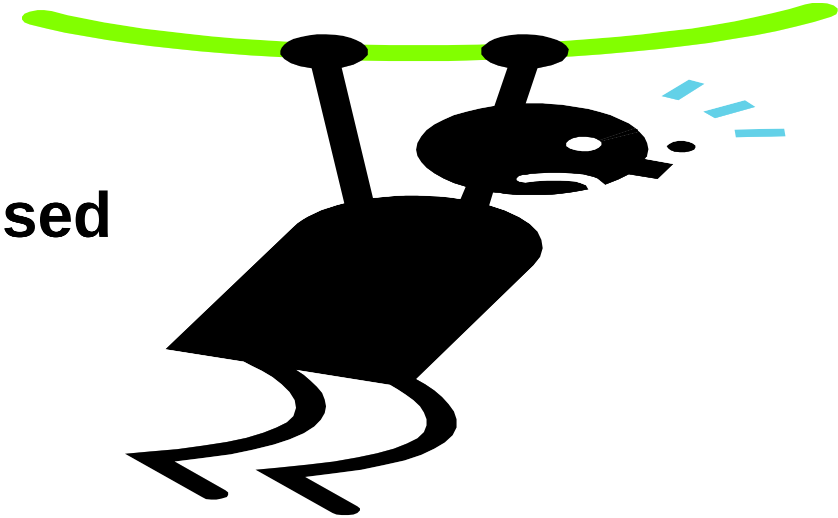
- **In the past, the government mainly purchased hardware where VE works well**
  - **Relatively straight forward**
  - **Based on the unit cost of production**
  - **Number of units to be bought is known**

- **The acquisition of services has increased substantially**
- **Services acquisition represents a large untapped source for VE**

but . . .

There are Difficulties in Pursuing these new Opportunities

- **Current FAR language not conducive for VE in services contracts**
  - **Difficult to administer**
  - **Difficult to calculate**
- **Opportunities are being missed**
- **Workarounds are possible**



VE Applicable to Services

- Savings on a unit price basis operates like hardware as long as the unit price can be changed to reflect the VECP
- Business case for the contractor and the government is as attractive as the hardware case
- Provides a distinct incentive for the contractor to propose contract changes

Performance-Based Service Contracts

- Performance-based acquisition (PBA) structures all aspects of a contract around the results to be achieved
  - Not the manner by which the work is to be performed

- Performance based logistics (PBL) is a contractor based support strategy
  - Specifies the outcome performance
  - Contractor provides services to achieve that outcome
  - Includes incentives for achieving outcome performance levels above a baseline
- First PBL contract on a system often is cost-type to collect sufficient data to understand the risks
  - During contract execution, the government collects cost data for negotiating future contracts/options
- Follow-on contract should be firm-fixed price with incentives to provide optimal support

Example of How VE May Affect the PBL Business Case (1 of 2)

- **Assume**
  - **PBL contract to incentivize the availability of an item**
  - **It is first PBL contract to collect data, so it is cost type**
  - **One type of failure is from misuse in the field**
- **Contractor has a choice of two basic approaches to achieve/exceed the performance objective**
  - **Increase manning to repair items**
  - **Reengineer the item to reduce failures**

- **The business case underlying the choice is complex**
  - **How do the choices affect the rate of profit wrt PBL incentives?**
  - **How do the choices affect revenue and total profit?**
  - **How will the above answers change in future contracts?**
- **VE adds other considerations to the business case**
  - **Sharing savings in future contracts**
  - **Reimbursement for NRE**
- **VE adds similar considerations to fixed-price PBL contracts**

Example of How VE May Affect the PBL Business Case (2 of 2)

- **Assume there is a cost objective as well as a performance objective being incentivized in the PBL contract**
  - **E.g., cost per unit**
- **VE authorities add additional incentives that affect the business case in a way that may benefit all stakeholders**
  - **Reimbursement of NRE from the savings**
  - **Sharing savings in future contracts**

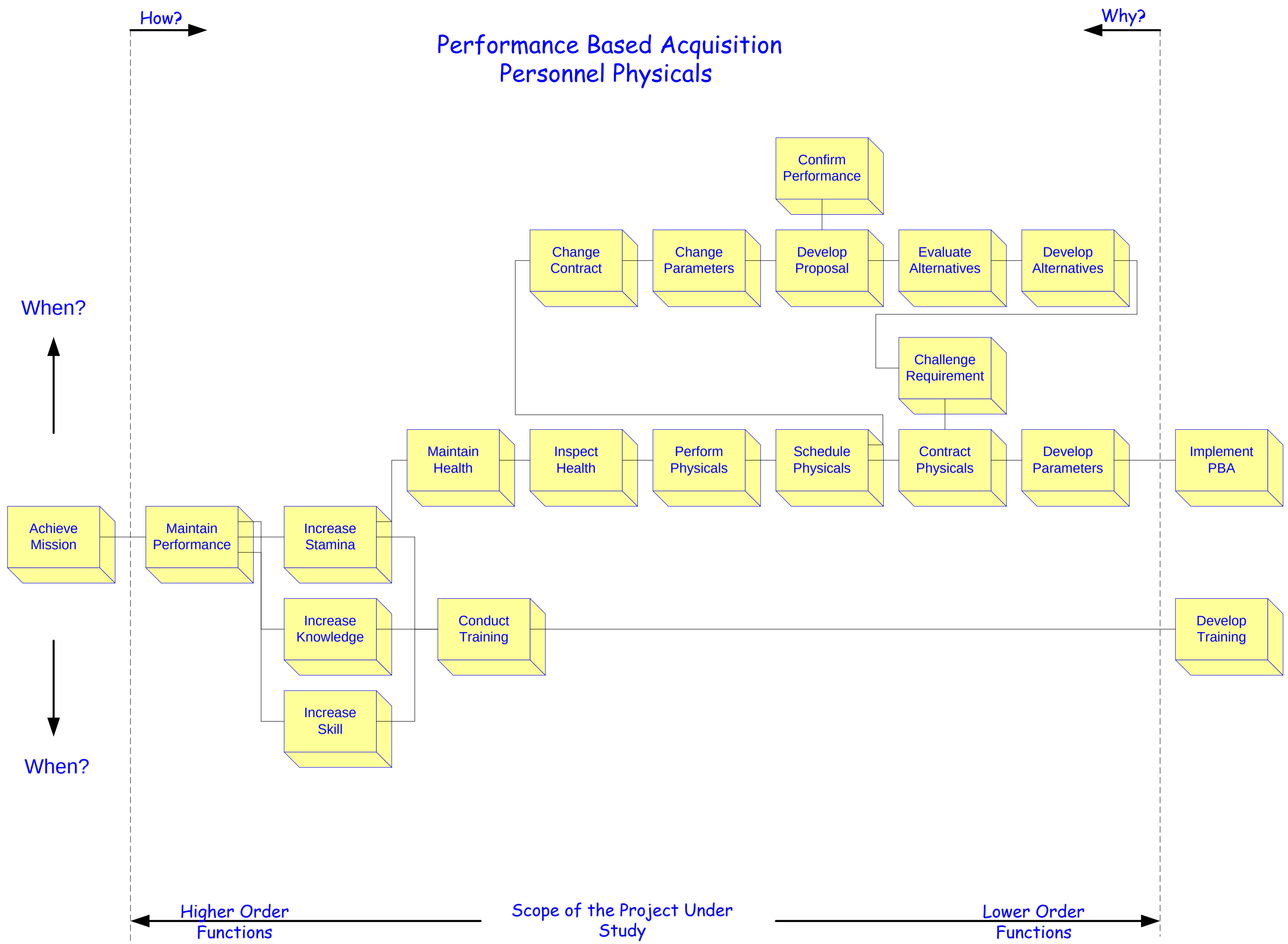
VE complements PBL contracts by adding cost-related incentives to the performance incentives thus enabling performance improvements to be made at lower cost

The Job Plan Applies to Service Contracts

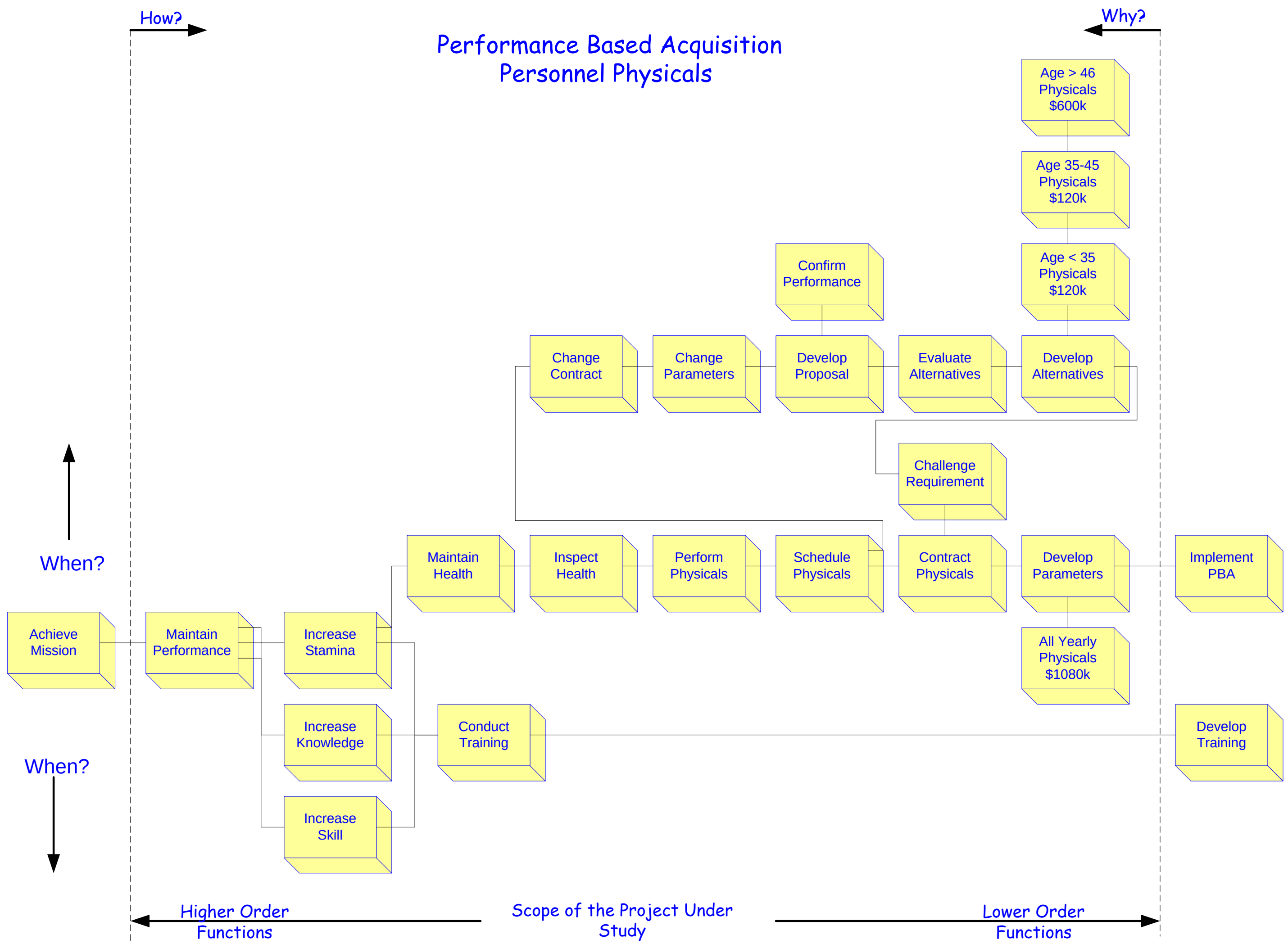
- Processes can be vastly improved
- Repair procedures can be optimized
- Logistics applications can be streamlined
- Requirements can be challenged

The very act of analyzing the proposed method in a structured process leads to real innovation resulting in improved performance, cost, and/or quality

Using the Job Plan on a Services Contract to Provide Physicals (1 of 3)



Using the Job Plan on a Services Contract to Provide Physicals (2 of 3)



ve@valuebaseddesign.com

Using the Job Plan on a Services Contract to Provide Physicals (3 of 3)

ORIGINAL CONTRACT		CONTRACT AFTER VECP ACCEPTANCE	
Provide a complete annual physical to military personnel	$100	Provide a **complete** annual physical to military personnel	$100
Original Qty	X10,800	Revised Qty	X6,000
		Revised Subtotal	$600,000
		Provide a **modified** physical to military personnel	$50
		Revised Qty	X4,800
		Revised Subtotal	$240,000
Original Total	$1,080,000	Revised Total	$840,000
		Savings ($240,000)	
		Contractor share	$120,000
		New contract total	$960,000

FAST Provides a Vehicle for Finding Opportunities to Improve System Value

- **FAST is a particularly powerful tool when used in conjunction with service contracts**
- **FAST enables**
  - **Questioning of the existing system**
  - **Critical thinking**
  - **Innovative solutions**
- **FAST assures areas of major expenditure receive attention in the early stages of a service contract**
  - **Not typically done for a service contract**

You can't improve the value if you don't look

Outline

- Introduction to VE and the VE methodology
- Using VE for systems engineering trades in hardware contracts
- Opportunities in service contracts
- Overcoming difficulties

Medical Data Entry Example Showing Difficulties in Using Unit Price to Share Savings

ORIGINAL CONTRACT		REVISED CONTRACT	
		Purchase software	$1,000,000
Provide data entry services for medical records:		Provide data entry services for medical records:	
Unit Cost	$10,000	Unit Cost	$10,000
Profit	$1,000	Profit	$1,000
		Per unit share of NRE	$3,333
Original Unit Price	$11,000	Revised Unit Price	$14,333
Quantity	X500	Quantity	X300
Total	$5,500,000	Subtotal	$4,300,000
		Savings ($1,200,000 50%)	$600,000
		New Contract Total ($16,333 x 300 units)	$4,900,000

Hard to Identify Savings Mechanisms

- Unit price may actually increase
- Savings based on reduced hours – increased productivity

Hard to Calculate Savings

- **Indefinite Quantity Contracts**
  - **Uncertainty in amount of effort to be purchased**
  - **Risk to contractor for recouping investment**
  - **Risk to government to obtain benefit**

- **Collateral savings**
  - **Generally smaller in hardware contracts and may be waived**
  - **Could be significant in services**
- **Workload and efficiency issues**
  - **If workload is less and payment is "per unit," contractor may not be fairly compensated**
  - **If workload is less and "lump sum" payment is used, government may pay too much**
  - **If efficiency is less, contractor wins and government loses**
  - **If workload and efficiency are greater, it's less of a problem**

Initial Actions

- **Be innovative within current rules**
- **Utilize mandatory VE to build experience**
- **Establish specific mandatory VE criteria for services:**
  - **Clearly specify expected outcomes**
  - **Define incentives**
  - **Establish performance measures**
  - **Secure top management commitment**
  - **Determine source of the money**

Future Actions

- Improve training and guidance
  - Case and test studies
  - Primer in mandatory VE
- Explore changing FAR to clarify how VE may be used in service contracts
  - New Clause?
  - Revisit the deal
  - Sharing non-recurring engineering costs
  - Changing the sharing period or percentage
  - Better address collateral savings issues

Updated DoD 5000 and CJCS 3170 Policies: A Requirements to Acquisition Gap Analysis

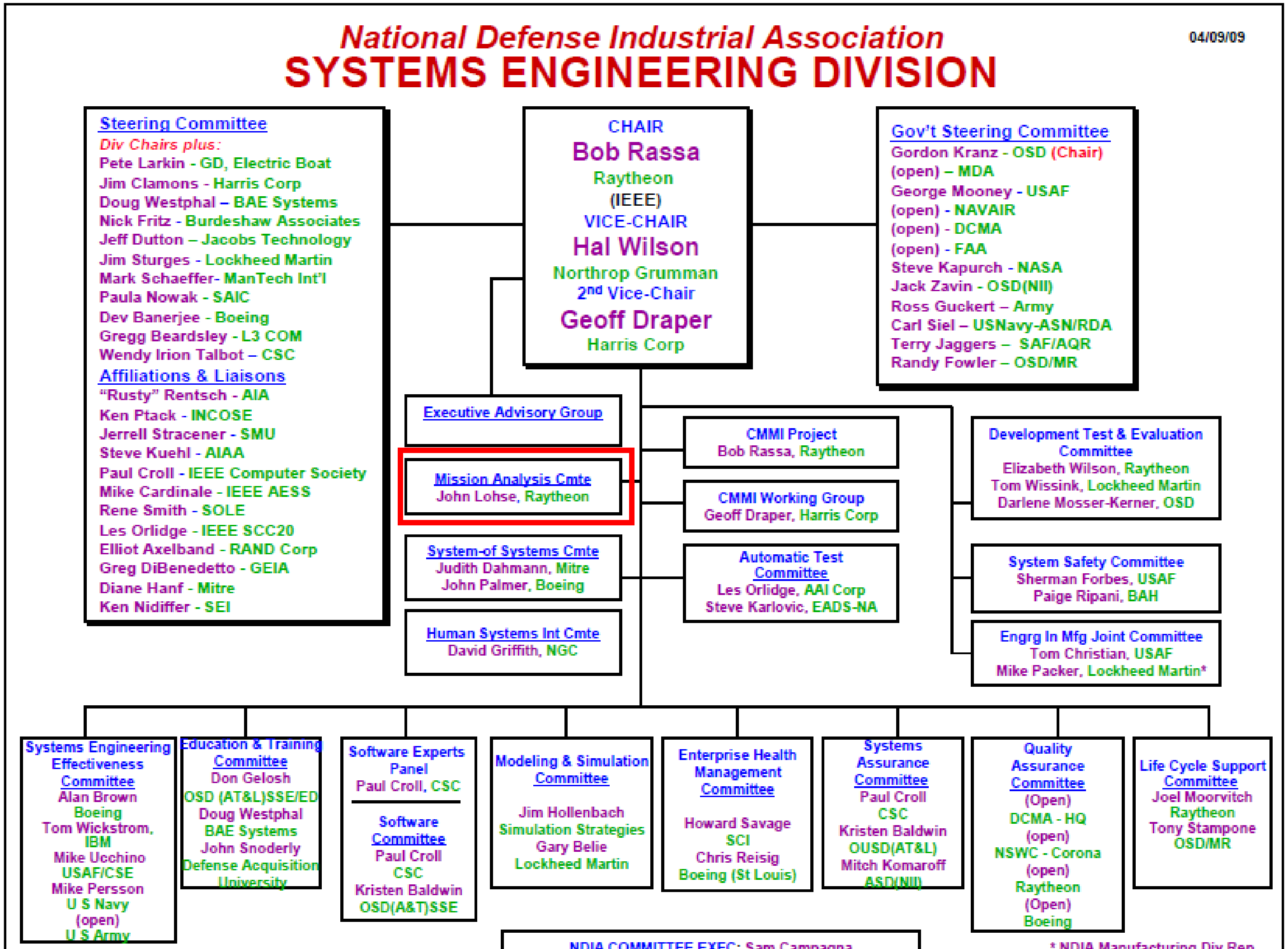
John Lohse, Raytheon
Co-Chair: NDIA SE Division Mission Analysis (MA) Committee

28 October 2009

Agenda

- Mission Analysis Committee
- Requirements to Acquisition Study
- Transition From ICD to the AoA
- Early SE Development Planning
- Summary

Mission Analysis Committee



- http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Mission.aspx

Mission Analysis Committee

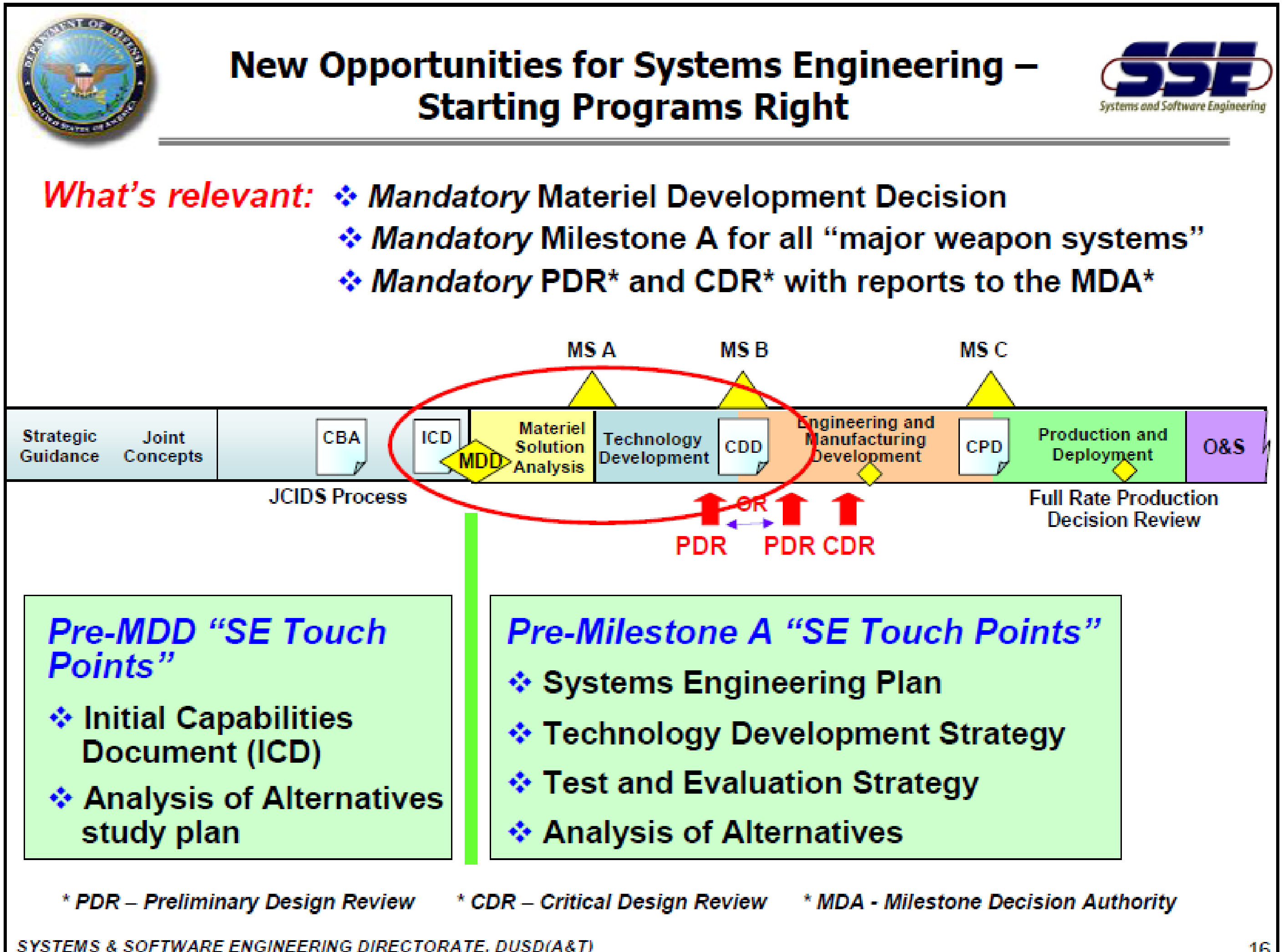
Charter

To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate the role of Pre-Milestone A Mission Analysis in the Systems Engineering process. The primary purpose is determining successful strategies for incorporating mission analysis principles and their relationships to CONOPS, Mission Architecture, M&S, etc. to provide better Warfighter solutions.

Mission Analysis Committee

- **Committee Objectives**
  - Understand the impact of the new DoD 5000.02, DAG, and CJCS 3170 on Pre-Milestone A Systems Engineering
  - Determine a common lexicon for Mission Analysis terminology
  - Strengthen the Systems Engineering methodology for dealing with high level of abstraction Mission Analyses
  - Understand the relationship of CONOPS, Mission Architecture, M&S, etc. to the Mission Analysis Process
  - Define the way Industry can better support JCIDS Capability Based Assessments through Mission Analysis
  - Evaluate and provide recommendations on policy and guidelines as to their impact on Pre-Milestone A Systems Engineering activities
  - Provide best practices for Pre-Milestone A Mission Analysis and other Pre-Milestone A Systems Engineering activities.
  - Etc.

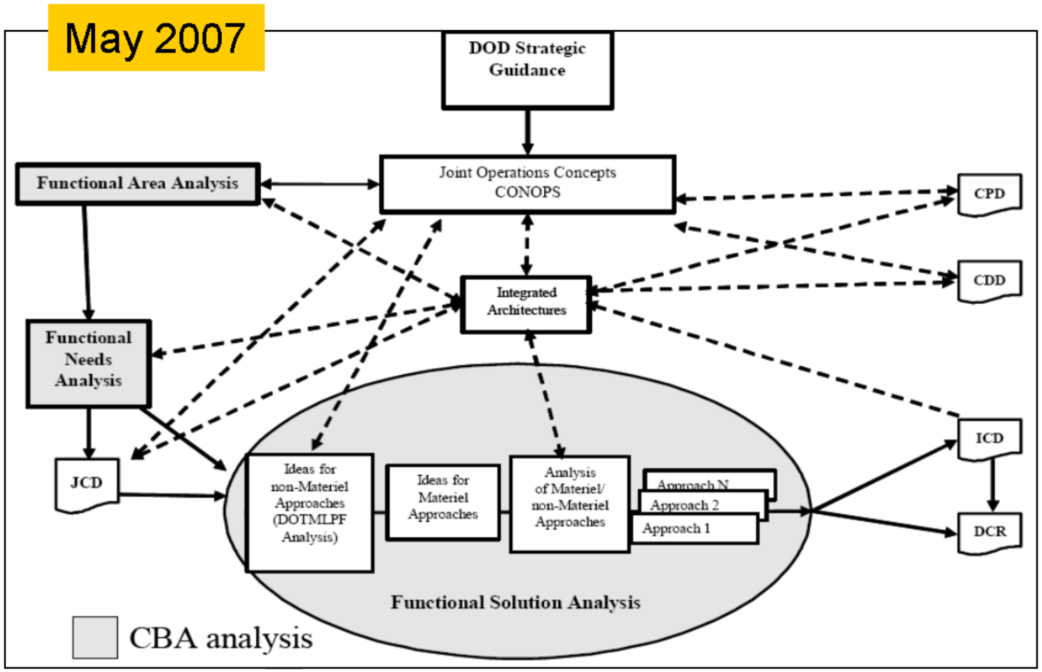
Requirements to Acquisition Study



Source: Mr. Gordon M. Kranz, ODUSD(A&T) Systems and Software Engineering
NDIA Systems Engineering Division Meeting
February 26, 2009

Requirements to Acquisition Study

Recent JCIDS Evolution



- Feb 2009 JCIDS eliminates references to FAA, FNA, FSA
- Is FSA-like work truly eliminated and, if so, to what extent?

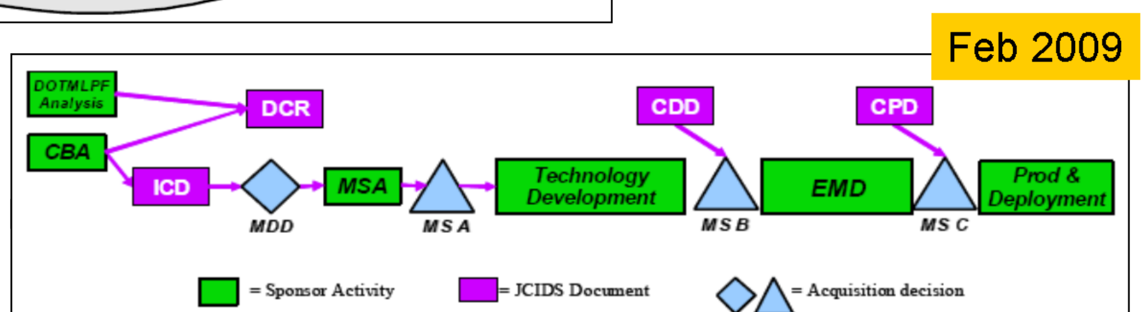


Figure A-1. JCIDS Process and Acquisition Decisions

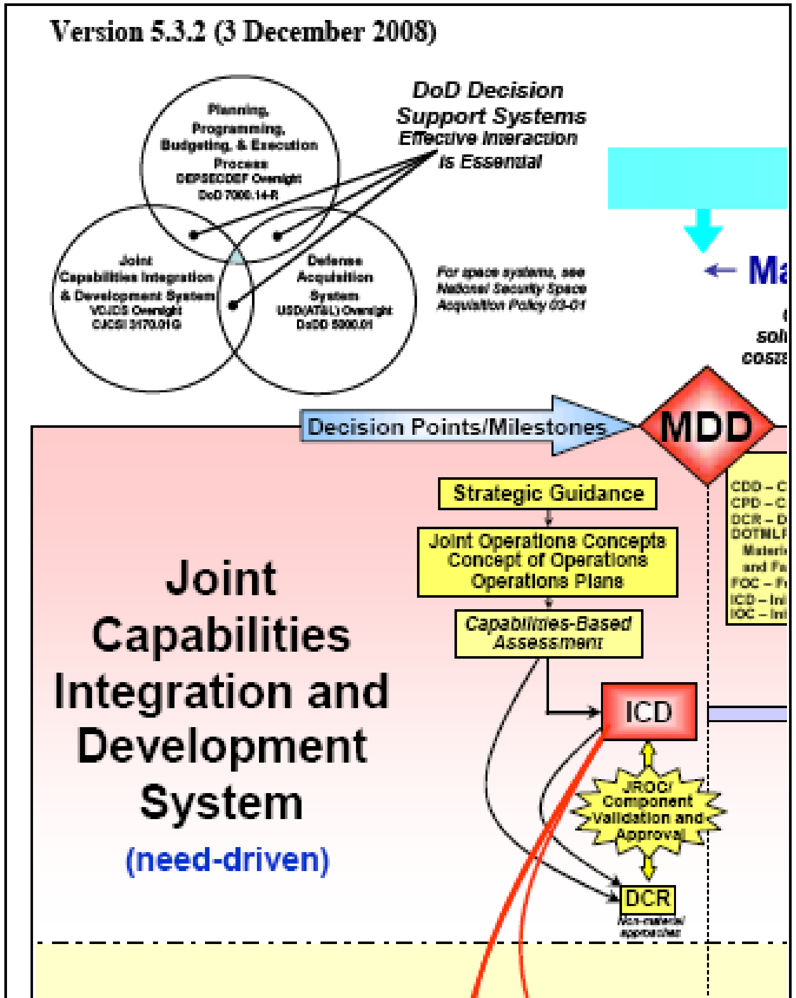
CJCSI 3170.01G

Requirements to Acquisition Study

- Top Level Goals
  - Understand the Transition from the Requirements process to the Acquisition process
  - Determine the attributes required for successful transition
  - Work with OT&E and DT&E to pull a thread for T&E in determining T&E specific attributes
    - Collaborative effort with the DT&E Committee

Transition From ICD to the AoA

Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System



Initial Capabilities Document (ICD).• A document that describes the need for a materiel approach to a specific capability gap derived from an initial analysis of materiel approaches. The ICD defines the capability gap in terms of the functional area, the relevant range of military operations, desired effects, and time. It summarizes the results of the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) analysis and describes why non-materiel changes alone are not adequate to fully provide the capability. The ICD supports the Materiel Development Decision and Milestone A.

Transition From ICD to the AoA

APPENDIX A TO ENCLOSURE F

INITIAL CAPABILITIES DOCUMENT FORMAT

CLASSIFICATION OR UNCLASSIFIED
INITIAL CAPABILITIES DOCUMENT
FOR
TITLE

Validation Authority: ________

Approval Authority: _______

Milestone Decision Authority: ________

Designation: JROC Interest/JCB Interest/Joint Integration/Joint Information/Independent

Prepared for Materiel Development Decision
(or specify other acquisition decision point)

Date

- **ICD format and detailed content identified in the JCIDS Manual (Appendix A to Enclosure F)**
  - **No mention of MOEs, MOPs, COIs, etc.**

The ICD format and detailed content instructions:

1. Concept of Operations Summary.

2. Joint Capability Area.

3. Required Capability.

4. Capability Gaps and Overlaps or Redundancies

a. Describe, in operational terms, the missions, tasks, and functions that cannot be performed ....

b. Describe the attributes of the desired capabilities in terms of desired outcomes....

f. Definitions of the identified capabilities should satisfy two rules:

(1) Rule 1. Capability definitions must contain the required operational attributes with appropriate qualitative parameters and metrics, e.g., outcomes, time, distance, effect (including scale), obstacles to be overcome, and supportability....

5. Threat and Operational Environment

6. Ideas for Non-Materiel Approaches (DOTMLPF Analysis). 7. Final Recommendations

Mandatory Appendices

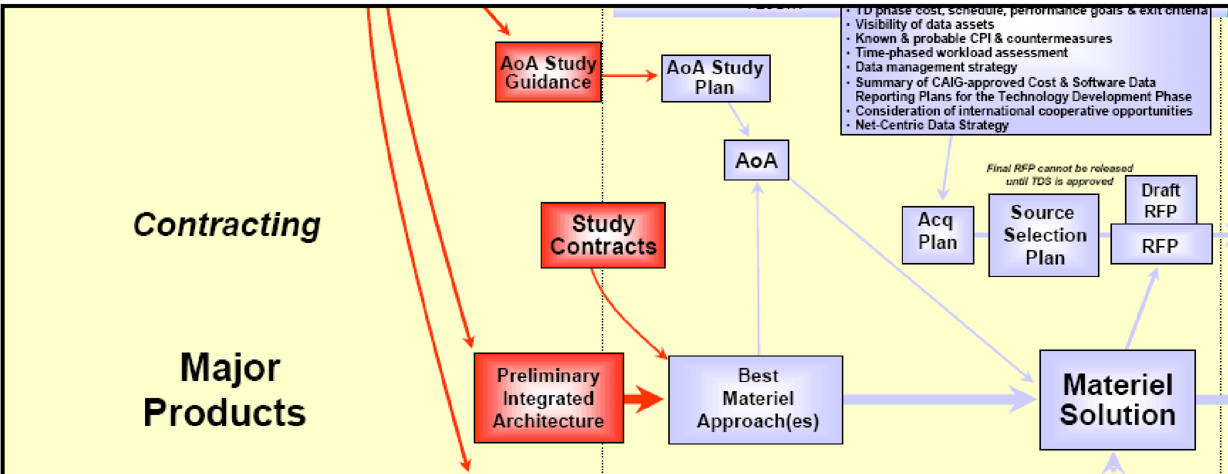
Appendix A. Integrated Architecture Products.

Appendix B. References

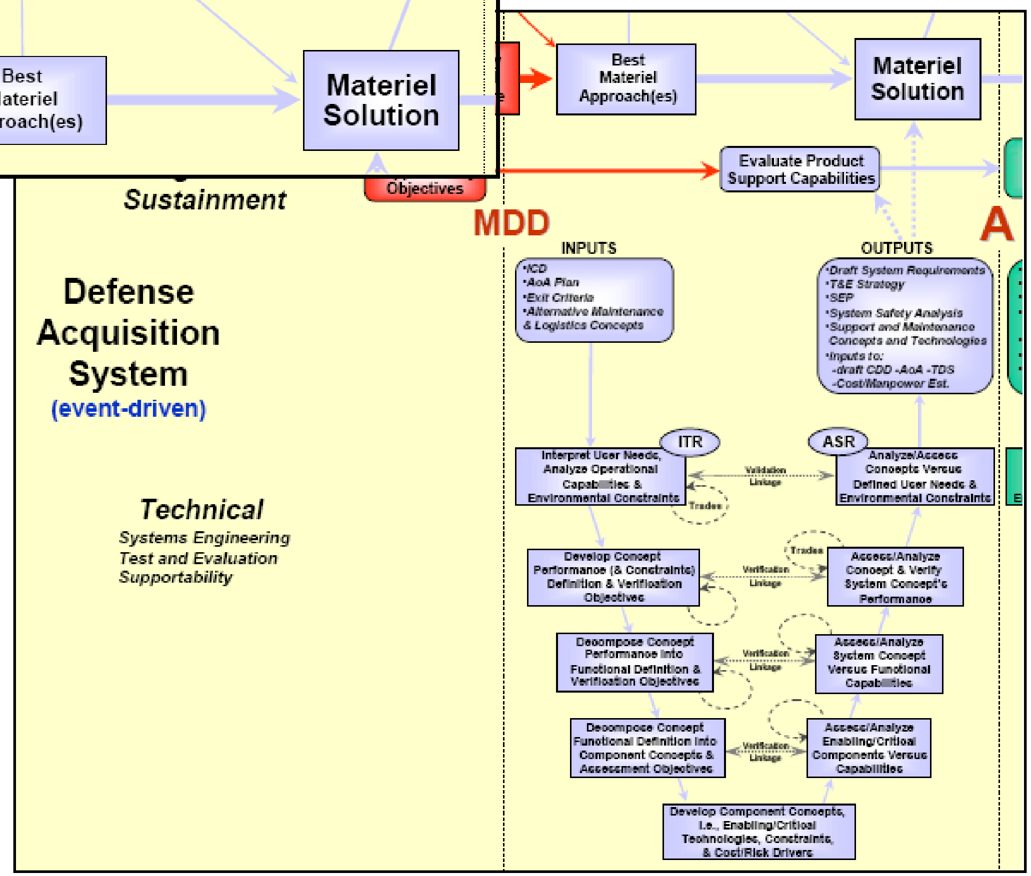
Appendix C. Acronym List

Other Appendices or Annexes.

Transition From ICD to the AoA



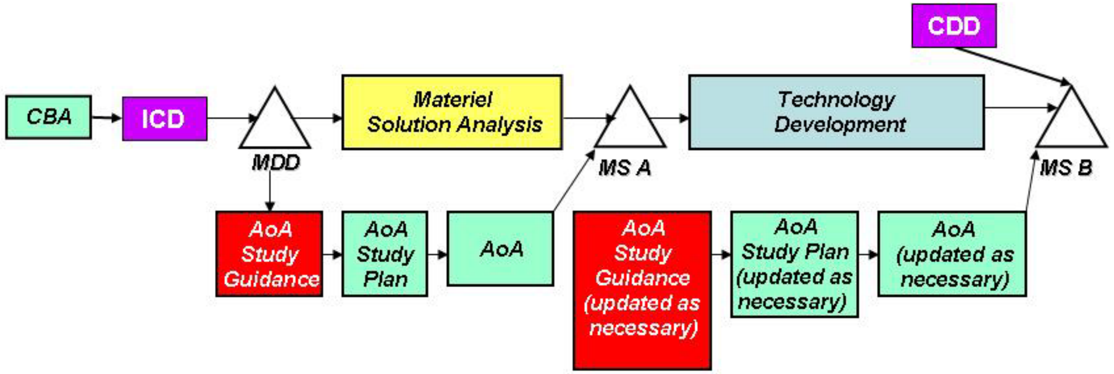
Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System



Materiel Solution Analysis Phase
AoA SE "V"

Transition From ICD to the AoA

Analytic Support to the Defense Acquisition Management System



CBA	Capabilities-Based Assessment
ICD	Initial Capabilities Document
MDD	Materiel Development Decision
AoA	Analysis of Alternatives
CDD	Capability Development Document

Interim DAG 3.3.2
….At the Materiel Development Decision review, the Director, Program Analysis & Evaluation (DPA&E), or DoD Component equivalent, proposes study guidance for the AoA. The AoA study guidance is approved by the Milestone Decision Authority (MDA), and is provided to the lead DoD Component. Following approval of the AoA study guidance, the lead DoD Component prepares an AoA study plan that describes the technical approach and management of the AoA. A suggested template for the AoA study plan is provided in section 3.3.3. The study plan is coordinated with the MDA, and approved by the DPA&E, prior to the start of the AoA.…

Interim DAG AoA Guidance

Transition From ICD to the AoA

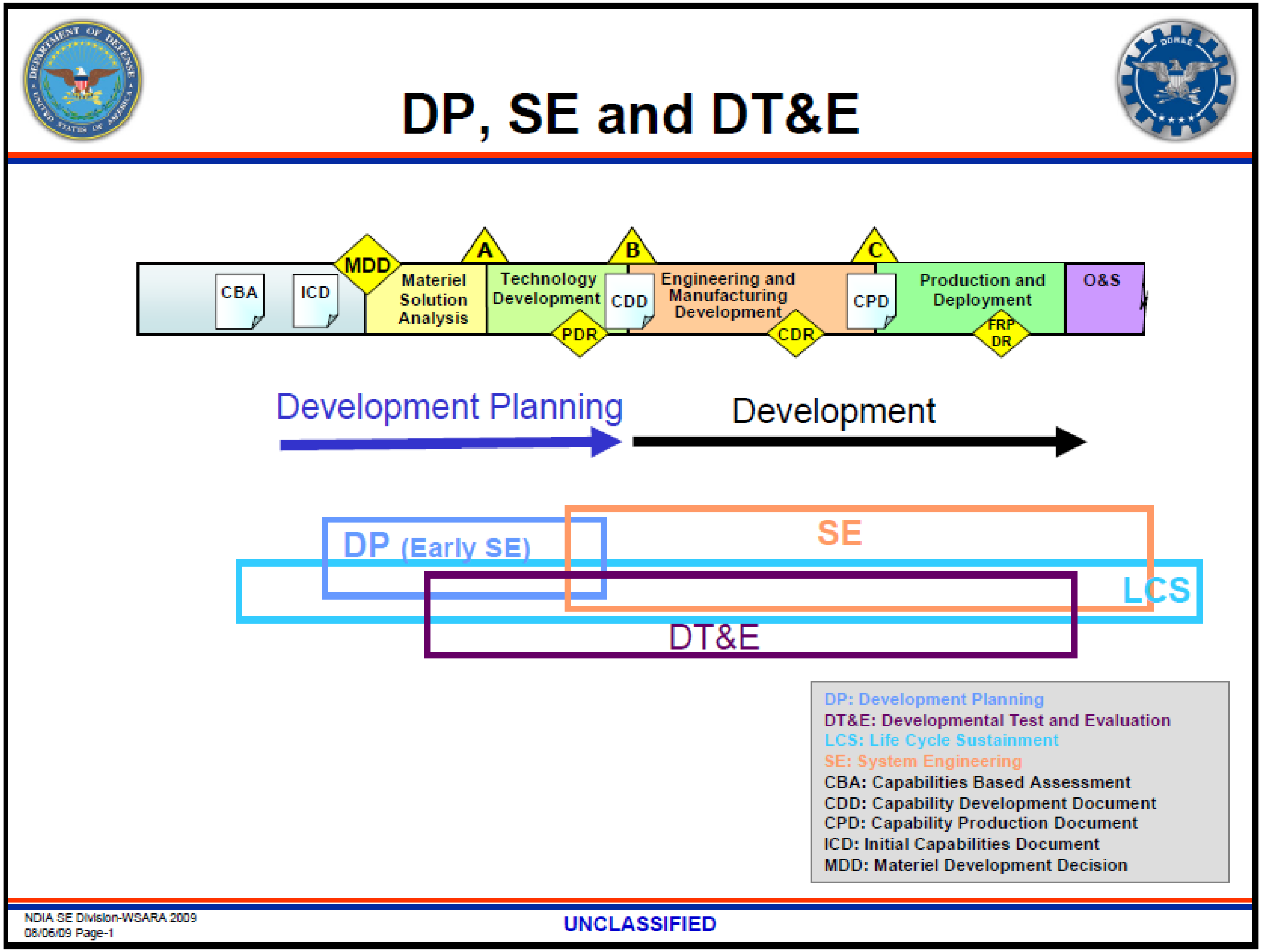
Interim Defense Acquisition Guidebook, 3.3.3

….A recommended outline for the AoA plan would resemble the following:

- Introduction <GB section 3.3.3.1>
  - ☐Background
  - ☐Purpose
  - ☐Scope
- Ground Rules <GB section 3.3.3.2>
  - ☐Scenarios
  - ☐Threats
  - ☐Environment
  - ☐Constraints and Assumptions
  - ☐Timeframe
  - ☐Excursions
- Alternatives <GB section 3.3.3.3>
  - ☐Description of Alternatives
  - ☐Nonviable Alternatives
  - ☐Operations Concepts
  - ☐Sustainment Concepts
- Determination of Effectiveness Measures <GB section 3.3.3.4>
  - ☐Mission Tasks
  - ☐Measures of Effectiveness
  - ☐Measures of Performance
- Effectiveness Analysis <GB section 3.3.3.5>
  - ☐Effectiveness Methodology
  - ☐Models, Simulations, and Data
  - ☐Effectiveness Sensitivity Analysis
- Cost Analysis <GB section 3.3.3.6>
  - ☐Life-Cycle Cost Methodology
  - ☐Additional Total Ownership Cost Considerations (if applicable)
  - ☐Fully Burdened Cost of Delivered Energy (if applicable)
  - ☐Models and Data
  - ☐Cost Sensitivity and/or Risk Analysis
- Cost-Effectiveness Comparisons <GB section 3.3.3.7>
  - ☐Cost-Effectiveness Methodology
  - ☐Displays or Presentation Formats
  - ☐Criteria for Screening Alternatives
- Organization and Management <GB section 3.3.3.8>
  - ☐Study Team/Organization
  - ☐AoA Review Process
  - ☐Schedule

Need to map the ICD content to the AoA Plan content.
(Capability Requirements to MOEs/MOPs)

Early SE Development Planning

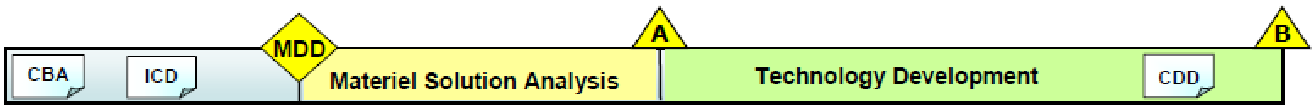


Source: Mr. Nicholas Torelli, Deputy Director,
Office of the Director, Defense Research and Engineering/Systems Engineering
NDIA SE Division Meeting
August 6, 2009

Early SE Development Planning

DP (Early SE) Activities

What are the critical SE activities that occur between ICD and MS-B?



SE Input to MDD	CONOPS
	Awareness of Strategic Context
	Engagement with S&T
	Engagement with JCIDS
Engagement in AOA	Guidance
	Plan
	Analysis Activity
	Report
Engineering Analysis	Consideration of SOS/Interdependency, Interoperability Context
	SEP for MSA
	Input to TDS (CTE, CPI), TES, CCE
	SE in TD contract requirements
	Tech Reviews (ASR, Early SE Requirements)

Prototyping & Risk Reduction	Prototyping (Technology and Design)
	TRL Maturation
	Trade Studies
	SE Support for Technology Risk Reduction
	Oversight of Competitive Designs
	Risk Assessment
Input to Acquisition/ Planning, CARD, Budget and Other	SE in Contract Requirements
	SE Input into the pst-PDR Report, report to MDA, Acquisition Strategy, TEMP, CARD, and the ICE
Evidence of Strong SE Activity	PDR and Post-PDR Report and Assessment
	Tech Reviews up to and including PDR
	SEP
	Strong Reliability, Availability and Maintainability (RAM)
Inputs to Requirements	Systems Requirements Definition
	RAM and Sustainability
	Requirements Traceability Matrices
	Translation of Requirements to Contract
	Inform Capability Development Document (CDD)

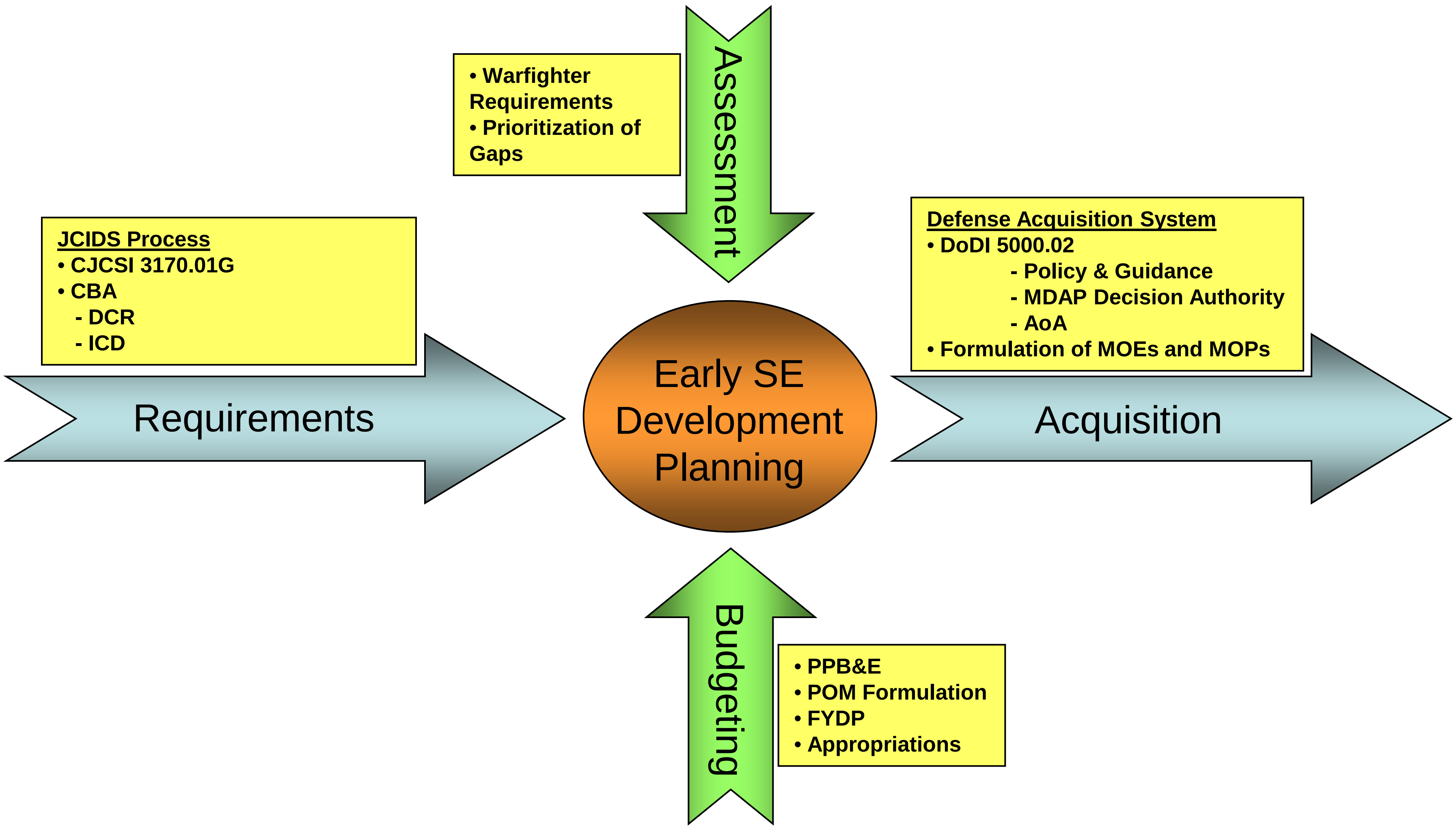
*Reference DAG Sections 4.3.1 and 4.3..2

NDIA SE Division-WSARA 2009
08/06/09 Page-2

UNCLASSIFIED

Source: Mr. Nicholas Torelli, Deputy Director,
Office of the Director, Defense Research and Engineering/Systems Engineering
NDIA SE Division Meeting
August 6, 2009

Early SE Development Planning



Summary

- NDIA SED Mission Analysis Committee established to focus on Pre-Milestone A Systems Engineering enhancement
  – All are welcome to join!

- Recent updates to the JCIDS and DoDI 5000.02 processes have left concern of new gaps in the transition from requirements to acquisition

- Early SE Development Planning must correlate between the mission context, ICD capability requirements, and the AoA MOEs/MOPs

Headquarters U.S. Air Force

Integrity - Service - Excellence

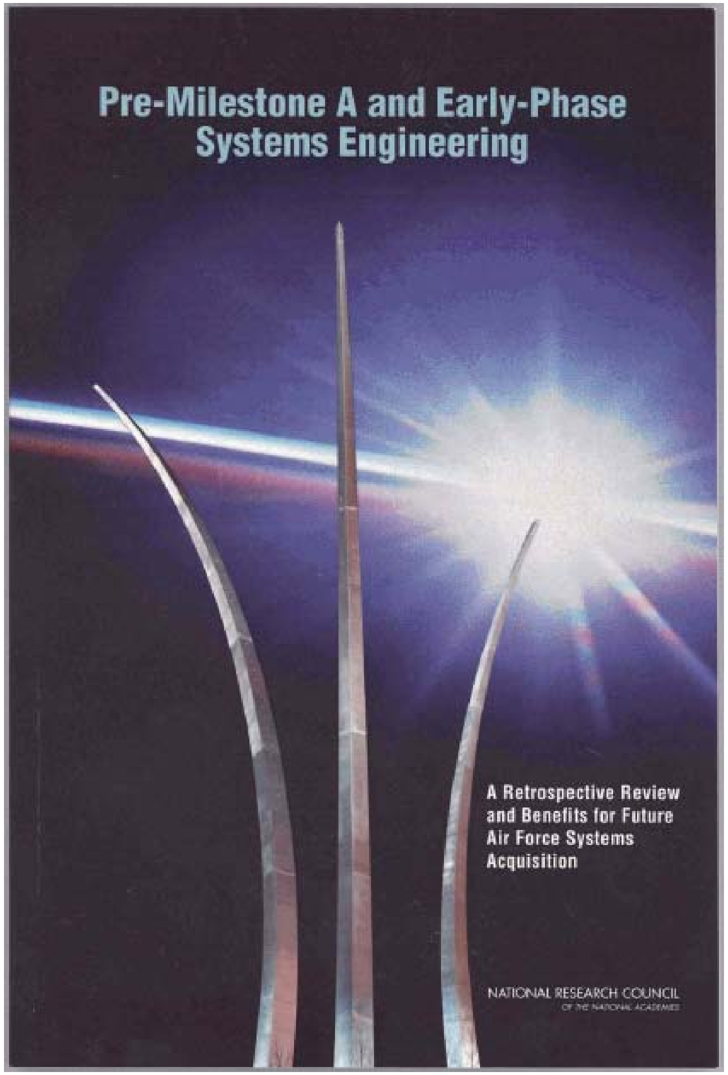
USAF View of National Research Council "Pre-Milestone A and Early-Phase Systems Engineering" Study Committee Recommendations as Addressed By Weapon System Acquisition Reform Act of 2009 (PL 111-23)

NDIA Systems Engineering Division
Annual Conference
San Diego, CA
28 October 2009

Jeff Loren
Engineering Policy Branch
SAF/AQRE (Alion Science & Technology)
571.256.0306
jeff.loren@pentagon.af.mil

U.S. AIR FORCE

NRC Study Committee Report



"Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Systems Acquisition"

December 2007

http://books.nap.edu/catalog.php?record_id=12065

Recommendations

- **Recommendation #1**

  Air Force leadership should require that Milestones A and B be treated as critical milestones in every acquisition program and that … the "Pre-Milestone A/B Checklist" … be used to judge successful completion.

Sec.102 (a)(1)(b)(5)(A)

… policies and guidance for … the use of systems engineering principles and best practices, generally …

Sec.102 (a)(1)(b)(5)(E)

… inclusion of systems engineering requirements in the process for consideration of joint military requirements by the (JROC) including specific input relating to each (CDD) …

U.S. AIR FORCE

Checklist (1 of 4)

Concept Development

Have at least two alternative concepts been evaluated?
Can an initial capability be achieved within ~5 years from MS/KDP B? If not, can critical subsystems (or a key subset) be demonstrated within that timeframe?
Will high-risk new technologies have been matured prior to MS/KDP B? If not, is the risk mitigation plan adequate?
Have external interface complexities (incl. dependencies on other programs) been identified and minimized? Is there a plan to mitigate risks?

KPPs and CONOPS

At MS/KDP A, have KPPs been identified in clear, comprehensive, concise, understandable terms?
At MS/KDP B, are major system-level requirements (including all KPPs) sufficiently well defined to provide a stable basis for system development?
Has a CONOPS been developed showing that system operation can handle expected throughput and meet response time requirements?

Checklist (2 of 4)

Cost and Schedule

Are major cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?
Have principal stakeholders accepted the confidence level (risk assessment) associated with cost estimates?

Performance Assessment

Are models and simulations adequate and appropriate to validate the selected concept and CONOPS against the KPPs?
At MS/KDP B, do the requirements consider likely future mission growth over the life cycle?

U.S. AIR FORCE

Checklist (3 of 4)

Architecture, Risk

Has the system been partitioned to define segments that can be independently developed and tested?
By MS/KDP A, is there a plan to have information exchange protocols in place by MS/KDP B?
At MS/KDP B, is the program plan structured to ensure that the contractor addresses rqmts decomposition / allocation to hardware, software, and human elements sufficiently early in development?
Are all key risk drivers (including but not limited to critical technologies) identified?

Checklist (4 of 4)

Program Implementation

Does the program implementation plan account for necessary and sufficient numbers and skill levels of organic (military and civilian), FFRDC, and support contractor personnel to manage the program?
At MS/KDP A, is there a plan in place that identifies all necessary activities and resources to reach MS/KDP B?
Is there a top-level system integration and test plan?
At MS/KDP B, are the necessary and sufficient program management and systems engineering management personnel in place? Have they been empowered to tailor processes and enforce requirements stability through IOC?
Has the government attempted to align the duration of the program manager's assignment with key milestones and deliverables?

Recommendations

- **Recommendation #2**

  Assess career field needs and develop a program to address

Sec.102 (b)(2)(B))

… resources are needed to attract, develop, retain, and reward developmental test and evaluation personnel and systems engineers with appropriate levels of hands-on experience and technical expertise

U.S. AIR FORCE

Recommendations

- **Recommendation #3**

  Pre-A decisions should be supported by rigorous SE processes and analyses involving teams of acquirers, users, and industry

Sec.102 (a)(1)(b)(5)(E)

… inclusion of systems engineering requirements in the process for consideration of joint military requirements by the (JROC) including specific input relating to each (CDD) …

Sec.102 (b)(1)(B)(iii)

… identify systems engineering requirements … during the Joint Capabilities Integration Development System process, and incorporate such systems engineering requirements into contract requirements …

Findings and Recommendations

- **Recommendation #4**

  A development planning function should be established in the military departments to coordinate the concept development and refinement phase of all acquisition programs to ensure that the capabilities … as a whole are considered and that unifying strategies such as … interoperability are addressed.

Sec.102 (b)(1)

(SAE) … develop & implement plans to ensure … 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 … during the Joint Capabilities Integration Development System process, and incorporate such systems engineering requirements into contract requirements …

U.S. AIR FORCE

AIP and WSARA

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 …

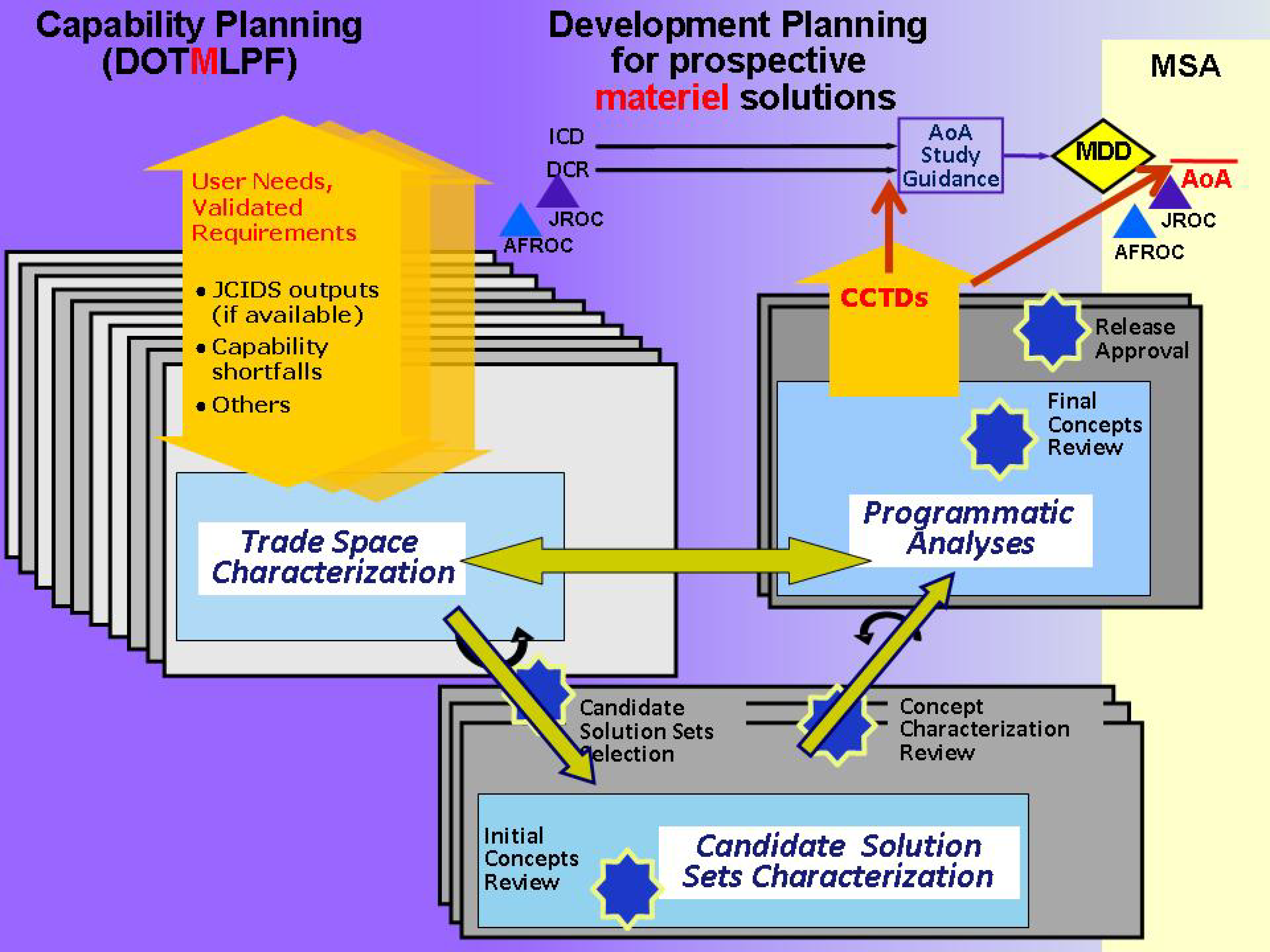
(b) Developmental Test and Evaluation and Systems Engineering in the Military Departments

(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 …*



Capability Planning
(DOTMLPF)
Development Planning
for prospective
materiel solutions
MSA
ICD
DCR
JROC
AFROC
AoA
Study
Guidance
MDD
AoA
JROC
AFROC
User Needs,
Validated
Requirements
• JCIDS outputs
(if available)
• Capability
shortfalls
• Others
CCTDs
Release
Approval
Final
Concepts
Review
Programmatic
Analyses
Trade Space
Characterization
Candidate
Solution Sets
Selection
Concept
Characterization
Review
Initial
Concepts
Review
Candidate Solution
Sets Characterization

System Security Engineering
A Critical Discipline of SE

Ms. Kristen Baldwin
Director, Systems Analysis
DDR&E/Systems Engineering

12th Annual NDIA Systems Engineering Conference
28 October 2009

Defense Research & Engineering

Director, Defense Research and Engineering (DDR&E)

Honorable Zachary J. Lemnios

Defense Advanced Research Projects Agency (DARPA)
Dr. Regina Dugan

Defense Technical Information Center (DTIC)
Mr. Paul Ryan

Director, Research
Dr. David Honey

Director, Systems Engineering
Mr. Stephen Welby

Director, Developmental Test & Evaluation (DT&E)
Mr. Chris DiPetto (A)

Director, Rapid Fielding
Mr. Earl Wyatt

Increased Priority for Program Protection

- ***Threats*: Nation-state, terrorist, criminal, rogue developer who:**
  - Gain control of systems through supply chain opportunities
  - Exploit vulnerabilities remotely
- ***Vulnerabilities*: All systems, networks, applications**
  - Intentionally implanted logic (e.g., back doors, logic bombs, spyware)
  - Unintentional vulnerabilities maliciously exploited (e.g., poor quality or fragile code)
- ***Consequences*: Stolen critical data & technology; corruption, denial of critical warfighting functionality**

Today's acquisition environment drives the increased emphasis:

Then		Now
Standalone systems	>>>	Networked systems
Some software functions	>>>	Software-intensive
Known supply base	>>>	Prime Integrator, hundreds of suppliers

Vulnerability Assessments

122 STAT. 4402 PUBLIC LAW 110–417—OCT. 14, 2008

(F) Recommendations regarding the appropriate management structure, fiscal controls, and stakeholder engagement required to ensure that a unified technology transition program will cost-effectively and efficiently enable technology transition.

(b) REPORTING REQUIREMENT REPEALED.—Section 2359a of title 10, United States Code, is amended—

(1) by striking subsection (h); and

(2) by redesignating subsection (i) as subsection (h).

10 USC 2302 note.

SEC. 254. TRUSTED DEFENSE SYSTEMS.

(a) VULNERABILITY ASSESSMENT REQUIRED.—The Secretary of Defense shall conduct an assessment of selected covered acquisition programs to identify vulnerabilities in the supply chain of each program's electronics and information processing systems that potentially compromise the level of trust in the systems. Such assessment shall—

(1) identify vulnerabilities at multiple levels of the electronics and information processing systems of the selected programs, including microcircuits, software, and firmware;

(2) prioritize the potential vulnerabilities and effects of the various elements and stages of the system supply chain to identify the most effective balance of investments to minimize the effects of compromise;

(3) provide recommendations regarding ways of managing supply chain risk for covered acquisition programs; and

(4) identify the appropriate lead person, and supporting elements, within the Department of Defense for the development of an integrated strategy for managing risk in the supply chain for covered acquisition programs.

(b) ASSESSMENT OF METHODS FOR VERIFYING THE TRUST OF SEMICONDUCTORS PROCURED FROM COMMERCIAL SOURCES.—The Under Secretary of Defense for Acquisition, Technology, and Logistics, in consultation with appropriate elements of the Department of Defense, the intelligence community, private industry, and academia, shall conduct an assessment of various methods of verifying the trust of semiconductors procured by the Department of Defense from commercial sources for use in mission-critical components of potentially vulnerable defense systems. The assessment shall

DEPUTY SECRETARY OF DEFENSE
1010 DEFENSE PENTAGON
WASHINGTON, DC 20301-1010

FEB 19 2009

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARIES OF DEFENSE
DEPUTY CHIEF MANAGEMENT OFFICER
ASSISTANT SECRETARIES OF DEFENSE
GENERAL COUNSEL OF THE DEPARTMENT OF DEFENSE
DIRECTOR, OPERATIONAL TEST AND EVALUATION
INSPECTOR GENERAL OF THE DEPARTMENT OF DEFENSE
ASSISTANTS TO THE SECRETARY OF DEFENSE
DIRECTOR, ADMINISTRATION AND MANAGEMENT
DIRECTOR, PROGRAM ANALYSIS AND EVALUATION
DIRECTOR, NET ASSESSMENT
DIRECTORS OF THE DEFENSE AGENCIES
DIRECTORS OF THE DoD FIELD ACTIVITIES

SUBJECT: Directive-Type Memorandum (DTM) 08-048, "Supply Chain Risk Management (SCRM) to Improve the Integrity of Components Used in DoD Systems"

References: See Attachment 1

Purpose. This DTM establishes policy and a defense-in-breadth strategy for managing supply chain risk to information and communications technology (ICT) within DoD critical information systems and weapons systems in accordance with National Security Presidential Directive-54/Homeland Security Presidential Directive-23 (Reference (a)). The DTM also assigns responsibilities to meet the assessment and reporting requirements of section 254 of Public Law 110-417 (the Fiscal Year 2009 National Defense Authorization Act) (Reference (b)). Furthermore, the DTM directs actions in accordance with DoD Instruction 5200.39 (Reference (c)). The Department of Defense increasingly relies on ICT for components and

- **National Defense Authorization Act Section 254 – Directed DoD:**
  - **Perform vulnerability assessments of major systems**
- **Vulnerability Assessments**
  - **Supply chain review**
  - **Program protection planning review**
  - **System Engineering/In-depth design review**

- **Deputy Secretary of Defense Directive**
  - **Assigned "responsibilities to meet the assessment and reporting requirements of Section 254" of NDAA to ASD(NII)/DoD CIO and USD (AT&L)**

UNCLASSIFIED

Vulnerability Assessment Highlights

- **Assessed 3 Major Defense Acquisition Programs**

- **Assessed 42 methods for verifying trust in commercial microelectronics**

- **Report to Congress in October 2009**
  - Summarizes assessment results, current DoD strategy, and way ahead
  - Demonstrates understanding of wider supply chain risk – not just microelectronics

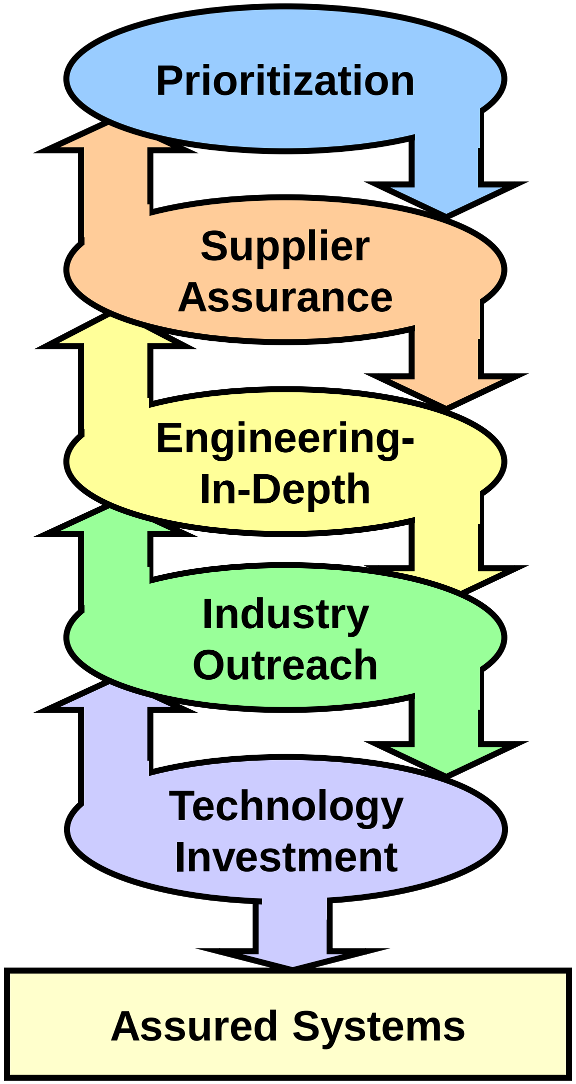
- **Recommended Actions**
  - Continue joint leadership by USD(AT&L) and ASD(NII)/DoD CIO
  - Address counterfeits during Logistics and Sustainment
  - Continue piloting mitigations with acquisition programs, implement findings in policy
  - Evaluate additional verification methods, including supplier management, inspections, and testing

Current Program Protection Challenges

- Policy and guidance for security is not streamlined
- There is a lack of useful methods, processes and tools for acquirers and developers
- Criticality is usually identified too late to budget and implement protection
- Horizontal protection process is insufficiently defined
- Lack of consistent method for measuring success of "protection"
- Security not typically identified as an operational requirement, and is therefore lower priority

Data Source: GAO report, white papers, military service feedback

Vision of Success



- The requirement for assurance is allocated among the right systems and their critical components
- Awareness of supply chain risks
- Systems are designed and sustained at a known level of assurance
- Commercial sector shares ownership and builds assured products
- Technology investment transforms the ability to detect and mitigate system vulnerabilities

7

DoDI 5200.39 Program Protection Policy

- **Perform comprehensive protection of Critical Program Information**
- **CPI includes elements or components of an RDA program that, if compromised, could:**
  - Cause significant degradation in mission effectiveness;
  - Shorten the expected combat-effective life of the system;
  - Reduce technological advantage;
  - Significantly alter program direction; or
  - Enable an adversary to defeat, counter, copy, or reverse engineer the technology or capability
- **Includes information about applications, capabilities, processes, and end-items**
- **Includes technology that would reduce the US technological advantage if it came under foreign control**
- **Includes elements or components critical to a military system or network mission effectiveness**

-DoDI 5200.39

Protection Disciplines: Some Definitions

- **<u>Information Assurance</u>: Measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation** *(DoD 8500.01E: Information Assurance)*
- **<u>Cyber Security</u>: Measures taken to protect a computer, networks, or information or computer system (as on the internet) and electronic information storage facilities belonging to, or operated by or for, the DoD or US Government, against unauthorized access, or attack, or attempts to access** *(DoDI 5205.ff: Defense Industrial Base Cyber Security/Information Assurance Activities)*
- **<u>System Assurance</u>: 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** *(NDIA Engineering for System Assurance Guidebook)*
- **<u>System Security Engineering</u>: An element of system engineering that applies scientific and engineering principles to identify security vulnerabilities and minimize or contain risks associated with these vulnerabilities** *(MIL-HDBK-1785: System Security Engineering Program Management Requirements)*

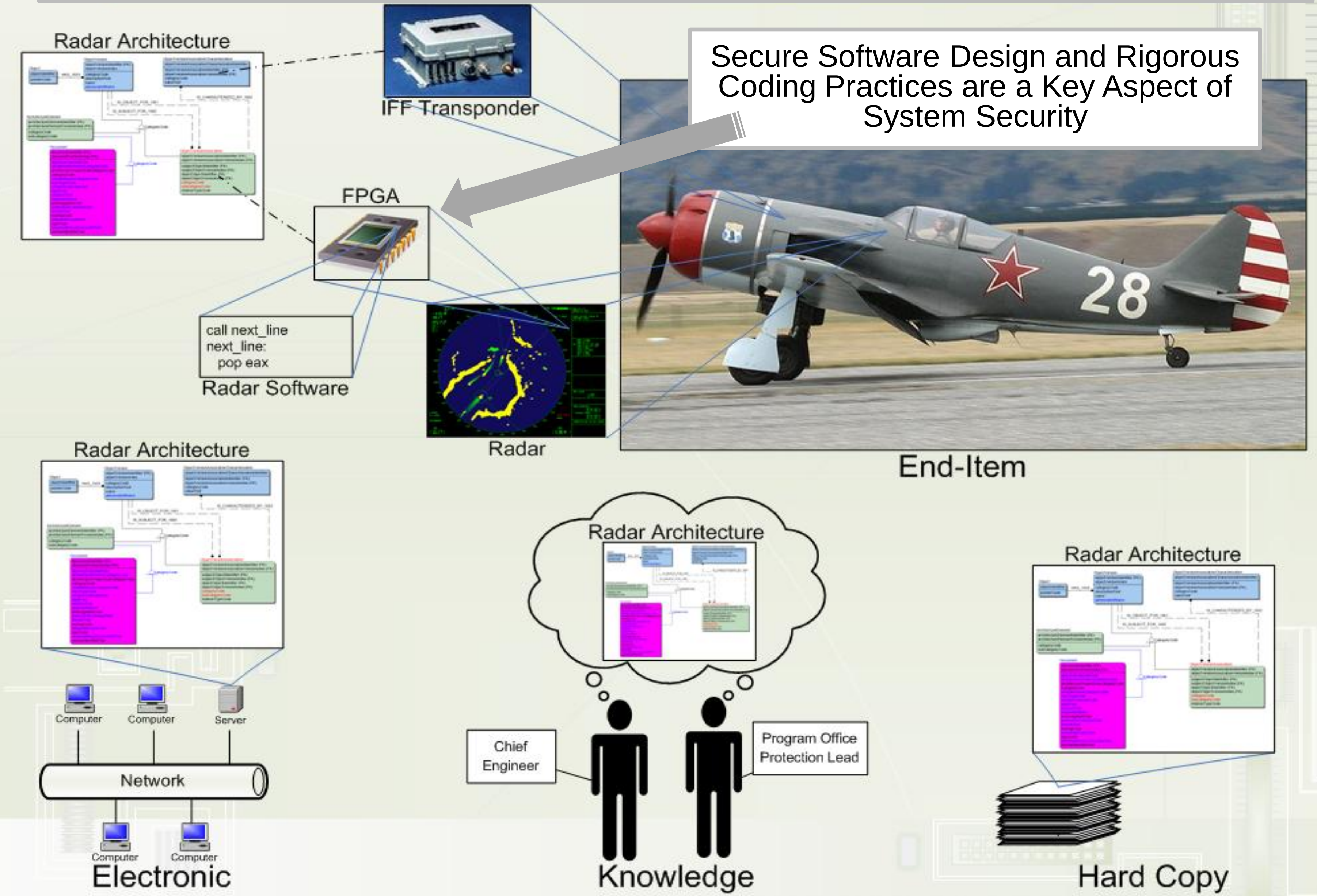
A Comparison

System Assurance	Information Assurance/Cyber Security
• **Protects**: Critical Program Information	• **Protects**: Protects any information/ functionality, ***not specific to CPI***
• **Format**: End-items, critical components, integrated circuits, field programmable gate arrays, embedded software, etc.	• **Format**: Applications, networks, IT processes, platform IT interconnections (includes weapon systems)
• **Purpose**: Through design, builds in safeguards, resistance, redundancy, and intrinsic strength	• **Purpose**: Standardizing strong network security and system administration practices
• **Verification:** Systems engineering and test procedures; system security engineering	• **Verification**: DIACAP

CPI Protection Example: **Aircraft Radar Architecture and Waveform**

- **What are the formats/locations of the information?**
  - **End-items (hardware and software), Information Systems (networks, applications), Human Knowledge, Hard Copy Documents**
- **How is the information protected in those formats?**
  - **Countermeasures and verifications vary by format**

System Security Engineering is Required to Cost Effectively Design-In CPI Protection



Notional Diagram – Does not illustrate actual locations of CPI or components of any aircraft

CPI Formats and Example Protections

- **Information Systems**
  - Information Assurance (controls for applications, networks, IT processes and platform IT interconnections)
  - Communications Security (Encryption, decryption)

- **Hard Copy Documents**
  - Information Security (Document markings, handling instructions)
  - Foreign Disclosure (restrict/regulate foreign access)
  - Physical Security (gates, guards, guns)

- **End Items**
  - Anti-Tamper (deter, prevent, detect, respond)
  - Information Assurance
  - Supply Chain Risk Management (assessing supplier risk)
  - Software Assurance (tools, processes to ensure SW function)
  - System Security Engineering
  - Trusted Foundry (integrated circuit providers)

- **Ideas/Knowledge**
  - Personnel Security (trustworthy, reliable people)
  - Access Controls

System Security Engineering

- **Security Specialties have evolved overtime in response to threats:**
  - Information Security
  - Computer/Network Security
  - Physical Security
  - Information Systems Security
- **The above specialties do not adequately address end-item threats**
- **Much work is needed to fully expand this discipline**
  - Foundational science and engineering, competencies (as compared to other SE Specialties: reliability, safety, etc)
  - Methods and tools: V&V, architecting for security
  - Community and design team recognition of SSE as a key design consideration
- **INCOSE has chartered a System Security Engineering Working Group that can take on many of these challenges**
- **The SE Research Center (SERC) is defining a SSE Research Initiative**

Our Challenge: Protection Hard Problem List

- **CPI identification, and duration (years) of protection required**
- **Identification of attack vectors (vulnerabilities)**
- **Quantifying the amount of Protection needed to reduce program risk**
  - Cost of protection countermeasures vs security risk to CPI
  - Effectiveness of protection throughout life cycle
- **Measuring effects/false alarm rates as part of system design**
- **New Protection Mechanisms, Tools**
  - Technologies to improve protection available to programs (Anti-Tamper, Software Assurance, Integrated Circuit pedigree, etc.)
  - Tools to test and assess system assurance
  - Methodologies for assessing assurance level

Questions?

DODD 8500.01E: Information Assurance

- **Information assurance requirements shall be identified and included in the design, acquisition, installation, operation, upgrade, or replacement of all DoD information systems**
- **For IA purposes all DoD information systems shall be organized and managed in four categories:**
  - Automated information system (AIS) applications,
  - Enclaves (includes networks),
  - Outsourced IT-based processes, and
  - Platform IT interconnections (includes weapon systems)

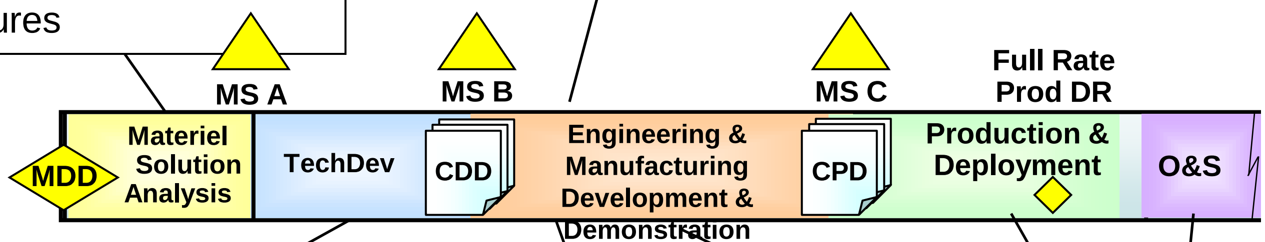
Early, Designed-In Program Protection

- Acquisition Strategy, **TDS**, RFP, SEP, and TEMP must be revised to include PPP relevant information
- **Milestone Decision Authority approves PPP in addition to PM**

Streamlined Program Protection Plan

- **One-stop shopping for documentation of acquisition program security (ISP, IAS, AT appendices)**
- **Living document, easy to update, maintain**
- **Improve over time based on feedback**

- Identify draft CPI, estimated protection duration and S&T Lab countermeasures



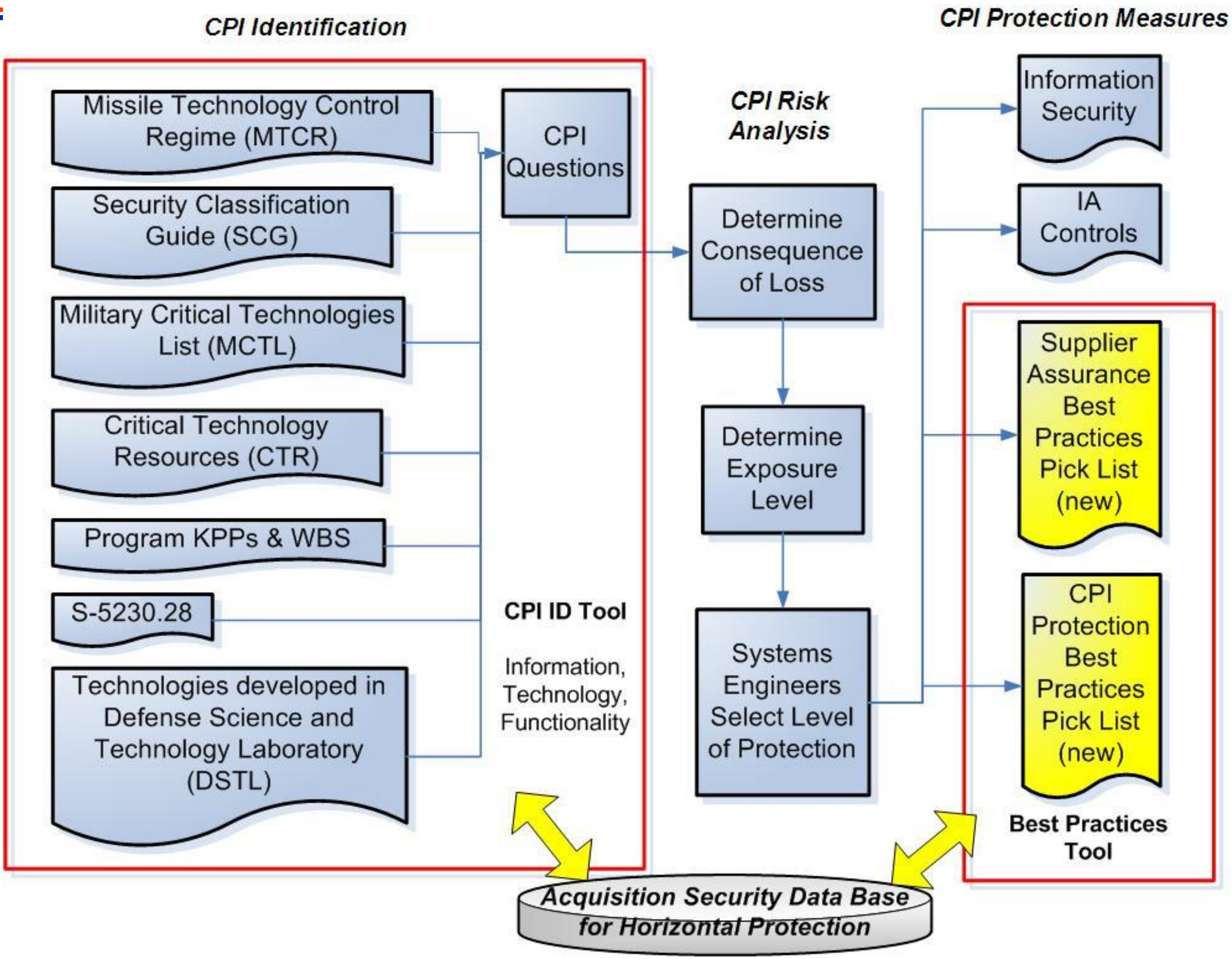
- Obtain threat assessments from Intel/CI, assess supplier risks
- Develop design strategy for CPI protection
- **Submit PPP to Acquisition Security Database (ASDB)**

- Contractor adds detail to Program Protection Plan
- Preliminary **verification and validation** that design meets assurance plans

- Enhance countermeasure information in Program Protection Plan (PPP)
- **Evaluate** that CPI Protection RFP requirements have been met

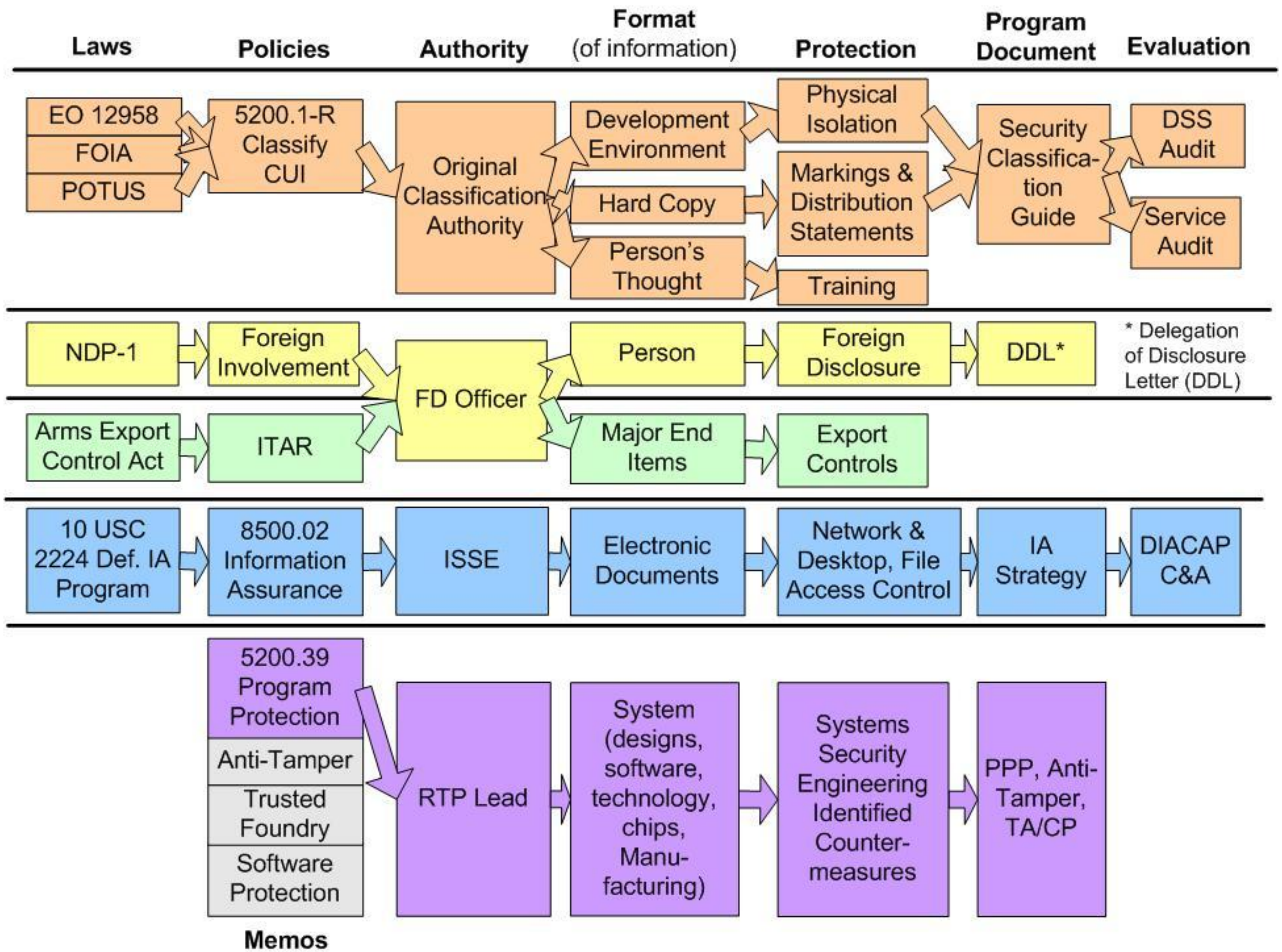
17

Program Protection Tools



18

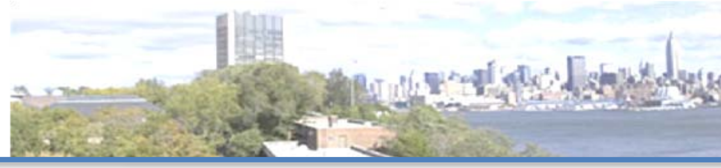
OLD: Stovepipe Security (5 of 120 policies shown)



Path Forward

- **Create a policy 'framework' to link multiple security disciplines**
- **Leverage and implement Program Protection Planning policy**
  - Link with acquisition oversight and program management processes
  - Provide training and support
  - Establish horizontal protection procedures
- **Augment system engineering guidance and practice to implement protection throughout lifecycle**
  - "Engineering for System Assurance" v1.0 Guidebook http://www.acq.osd.mil/sse/ssa/guidance.html

Raise the bar:	
Awareness	- Knowledge of the supply chain - Who has access to our critical assets
Protection	- Protect critical assets through security - Engineer our systems for assurance



A Distillation of Lessons Learned from Complex System of Systems Acquisitions

Richard Turner, Dinesh Verma Stevens Institute of Technology

Mark R. Weitekamp, ANSER

Ann Tedford, Federal Aviation Administration

Presented at the NDIA Systems Engineering Conference

Mission Bay, San Diego, CA

October 28, 2009

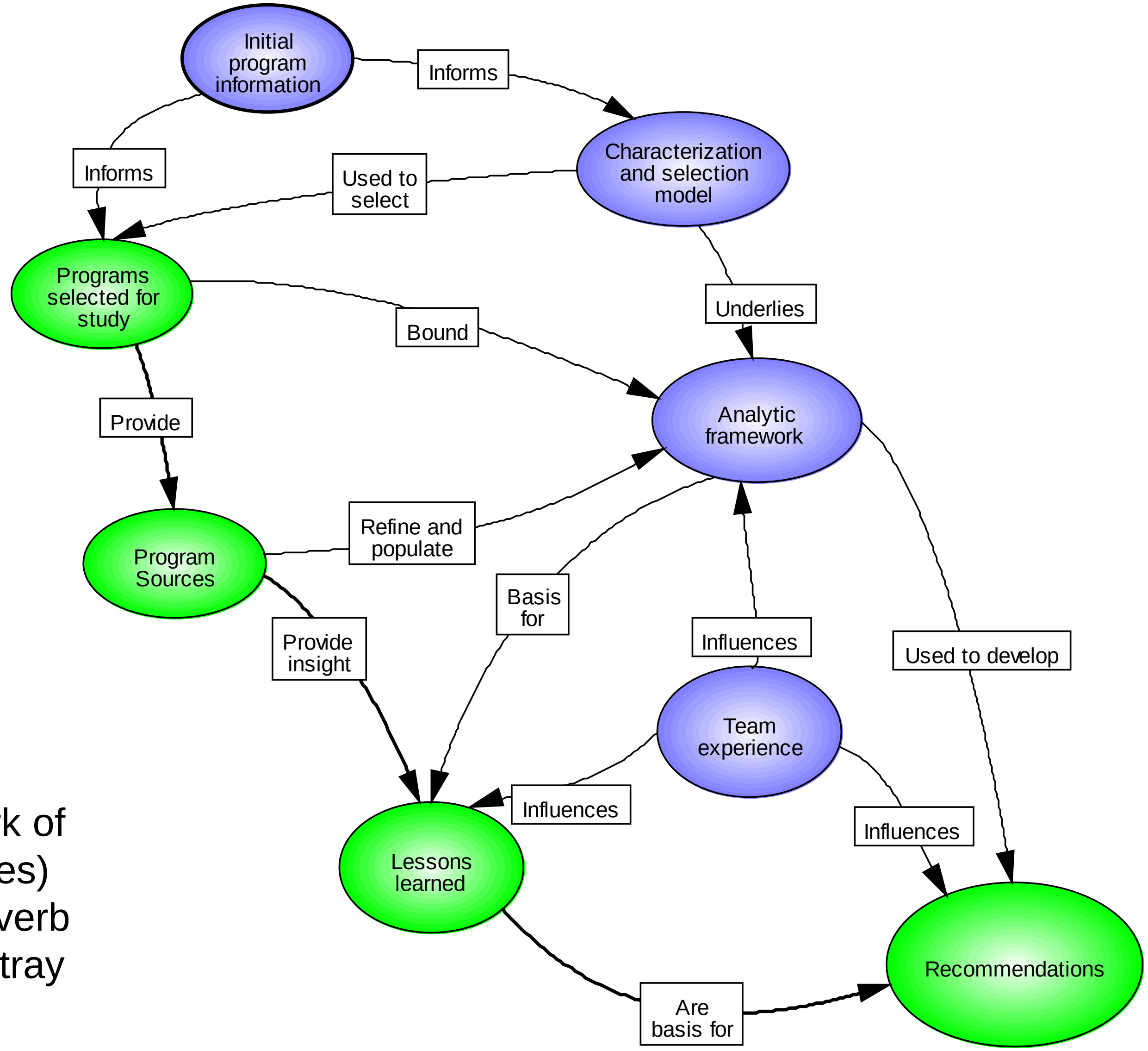
The Project

- To support FAA NextGen, Stevens tasked to
  - Study lessons learned from comparable large-scale, complex systems-integration projects
  - Make specific recommendations to FAA
- Study goals
  - Consider programs largely similar to NextGen.
  - Interview key decision-makers and leaders (e.g., program managers, chief engineers).
  - Identify lessons learned that are specifically applicable, rather than generic, to NextGen.
  - Place specific emphasis on governance approaches.
  - Provide clear, relevant, and implementable recommendations.

NextGen

- Broad in scope and significant in functionality
- Will change air traffic control by exploiting new technologies to enable
  - satellite-based navigation and surveillance
  - digitally communicated routine information
  - improved data accessibility
  - more effective air traffic “management”
  - weather forecasts embedded into air-traffic-control decisions
  - continued operation in lower visibility conditions
  - intelligent, prognostic safety functions.
- Multi-phase acquisition program spread over an extended time period.
- Unprecedented number, influence and diversity of critical stakeholders

Research Activities Systemigram



A systemigram™ is a network of nodes (nouns or noun phrases) and directed arcs, (verbs or verb phrases) that graphically portray the meaning of the prose.

http://www.boardmansauser.com/thoughts/systemigrams.html

Key Comparative Programs

- International Space Station (NASA)
- Future Combat Systems (United States Army)
- Deepwater (USCG)
- Ballistic Missile Defense System (MDA)
- Internet/World Wide Web (Commercial)

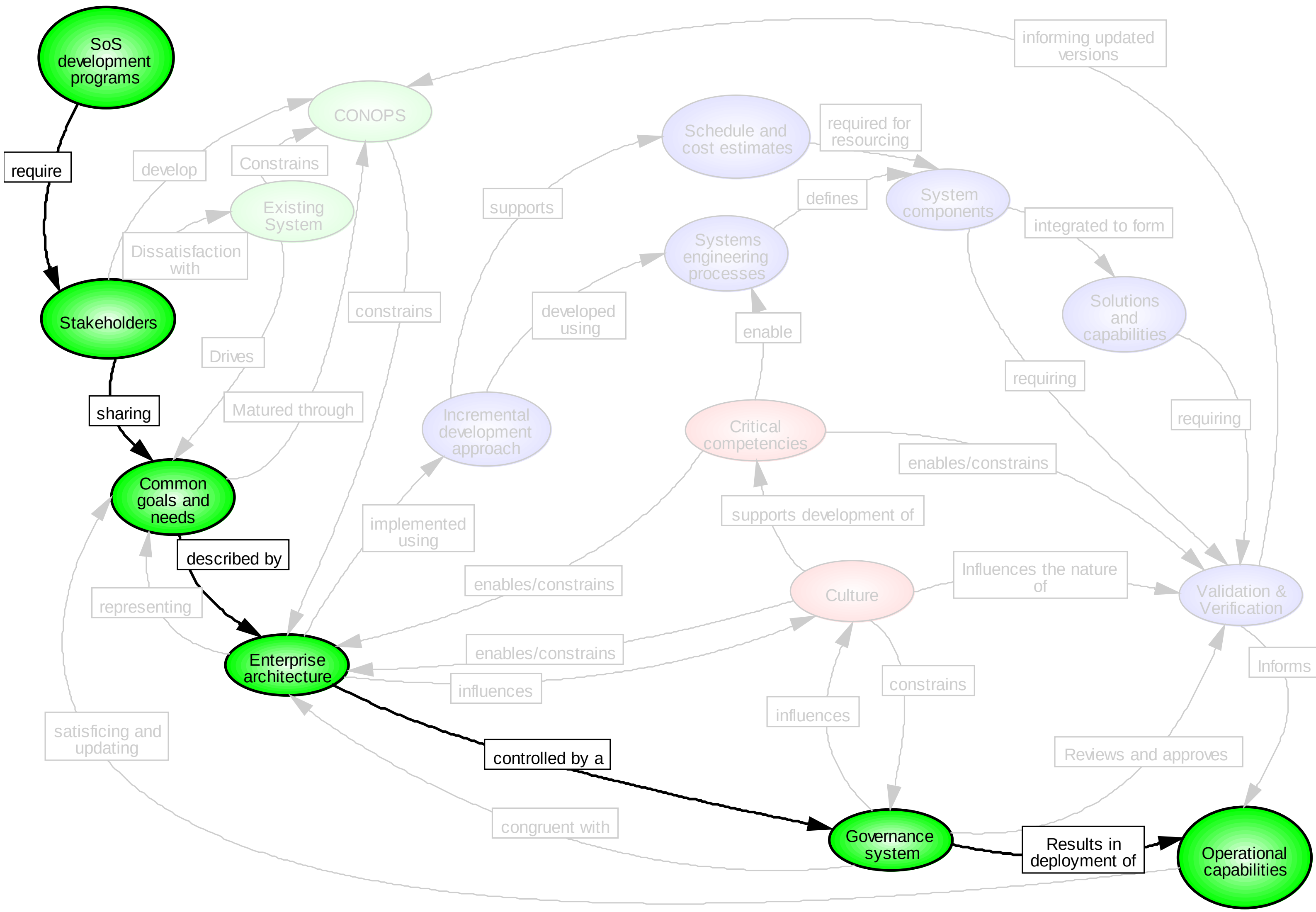
Key Observations

- CONOPS
- Enterprise Architecture
- Governance System
- Acquisition and Implementation Approach
- Critical Competencies
- Validation and Verification
- Cost and Schedule Estimates
- Organizational Culture

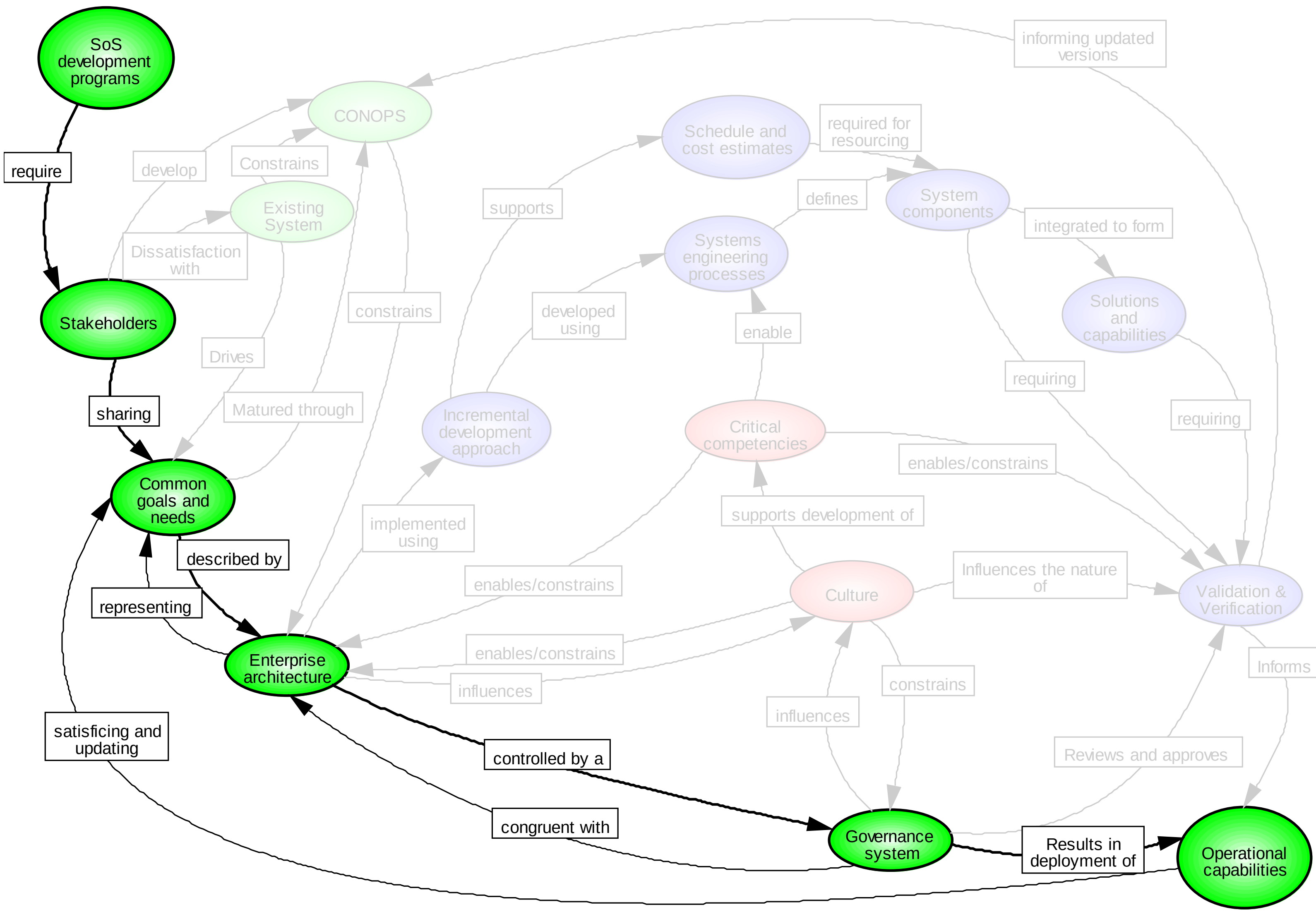
Analysis Framework

Development Environment	Knowledge Concerning System Developers
	System Stakeholder Diversity and Complexity
	Structural Complexity
	Program Uncertainty at Program Start
	Deadline Driven
	Significant Changes to Doctrine or Operational Policy Required for System Success
	Product Precedence
	Mission Predictability
	Technology Novelty
	Replace Existing System
	Number of Evolving and Interdependent System Developments within a SoS
	Type of SoS (Department of Defense definitions))
Development Approach	Approach to Requirements Development
	Concept of Operations (CONOPS) from inception
	Interface Maturity
	Validation and Verification (V&V)
	Governance system
Out-come	Success/Failure

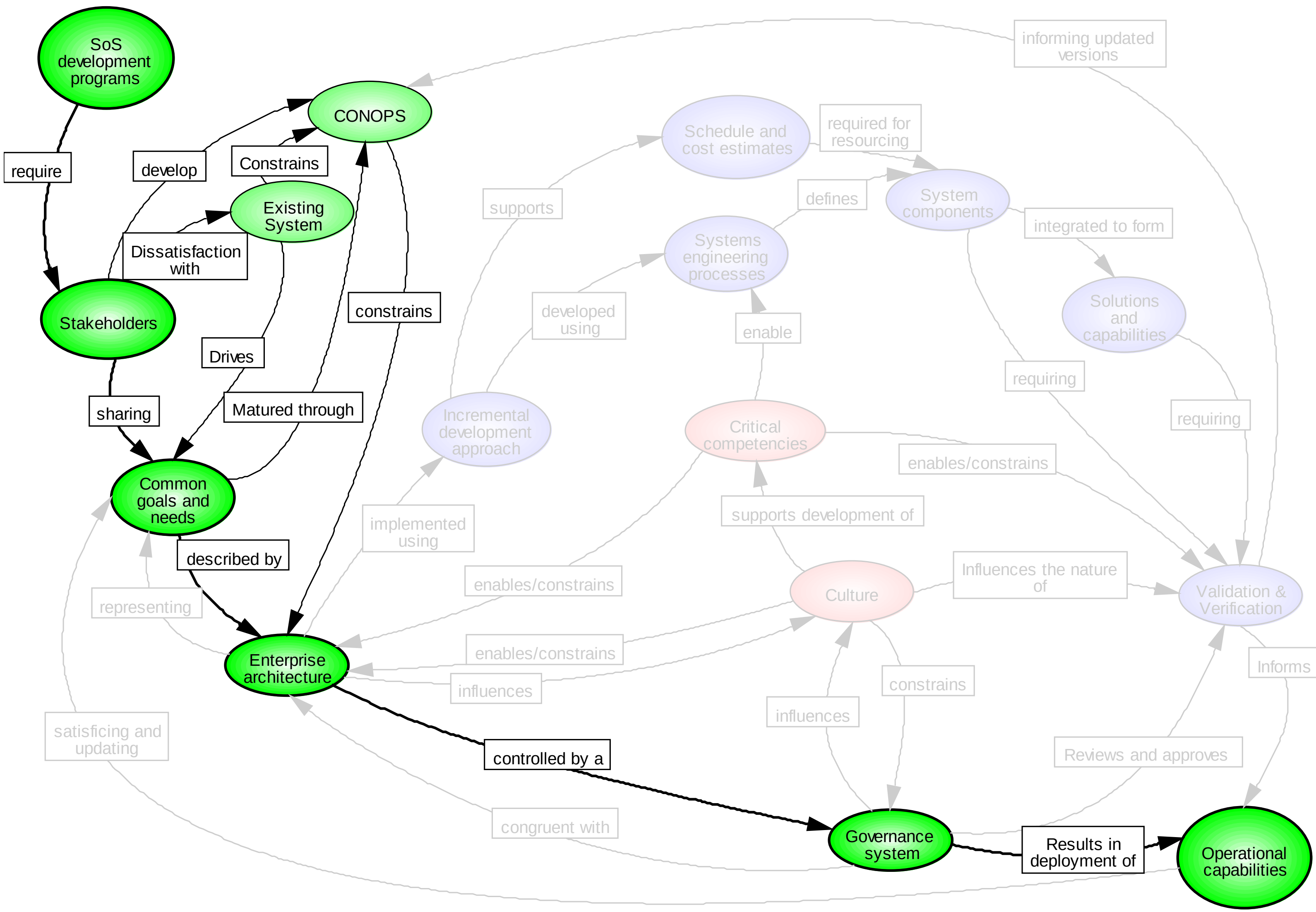
Foundation


SoS development programs
require
Stakeholders
sharing
Common goals and needs
described by
Enterprise architecture
controlled by a
Governance system
Results in deployment of
Operational capabilities
CONOPS
develop
Constrains
Existing System
Dissatisfaction with
Drives
Matured through
constrains
informing updated versions
Schedule and cost estimates
required for resourcing
supports
defines
System components
integrated to form
Systems engineering processes
developed using
enable
Solutions and capabilities
Incremental development approach
requiring
requiring
Critical competencies
enables/constrains
implemented using
supports development of
enables/constrains
Culture
Influences the nature of
Validation & Verification
enables/constrains
influences
representing
influences
constrains
Informs
satisficing and updating
Reviews and approves
congruent with

Alignment

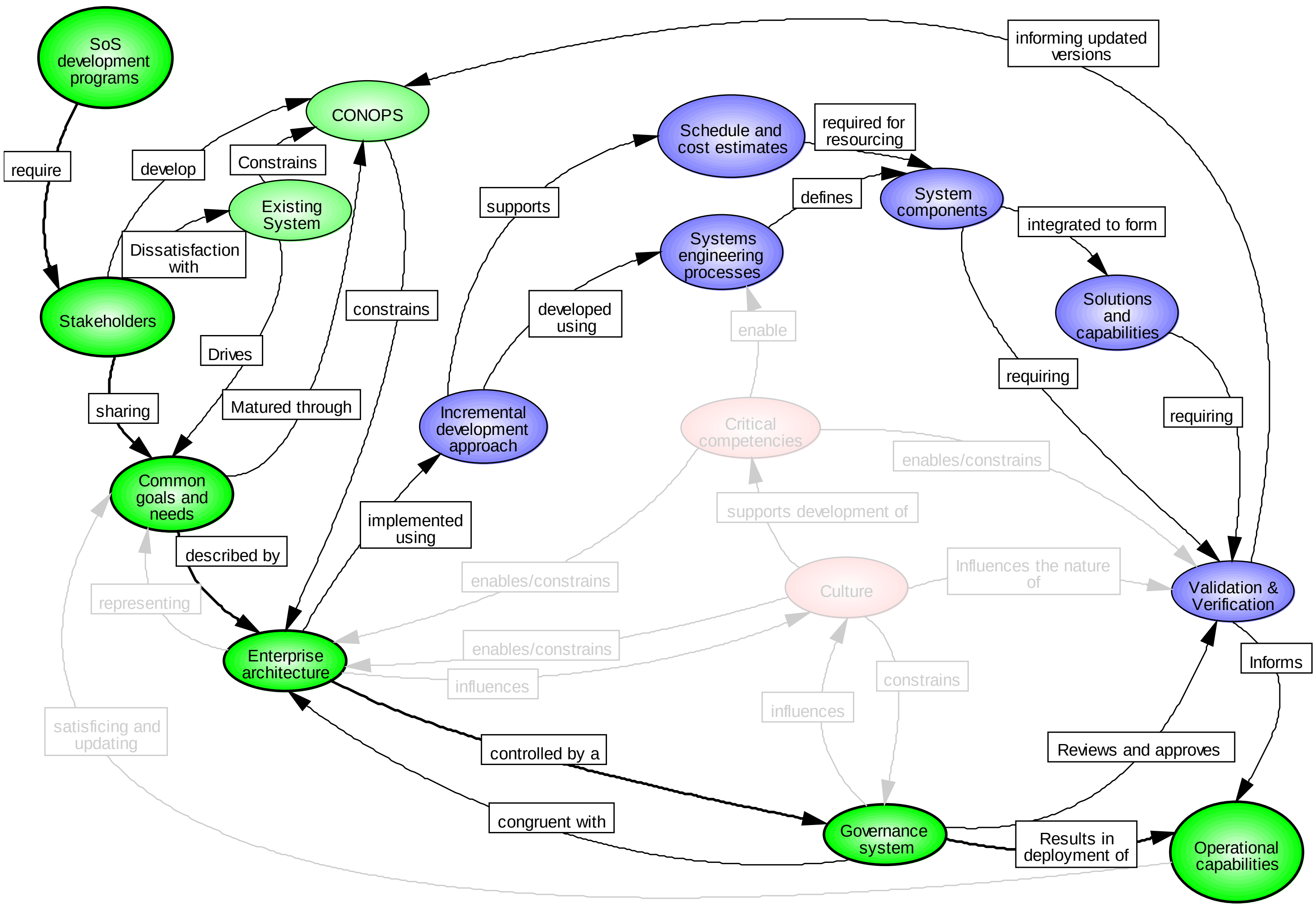

SoS development programs
require
Stakeholders
sharing
Common goals and needs
described by
representing
Enterprise architecture
controlled by a
congruent with
Governance system
Results in deployment of
Operational capabilities
satisficing and updating
CONOPS
develop
Constrains
Existing System
Dissatisfaction with
Drives
Matured through
constrains
informing updated versions
Schedule and cost estimates
required for resourcing
supports
System components
defines
Systems engineering processes
integrated to form
Solutions and capabilities
developed using
enable
Incremental development approach
Critical competencies
requiring
requiring
enables/constrains
implemented using
supports development of
enables/constrains
Culture
Influences the nature of
Validation & Verification
enables/constrains
influences
constrains
influences
Informs
Reviews and approves

CONOPS

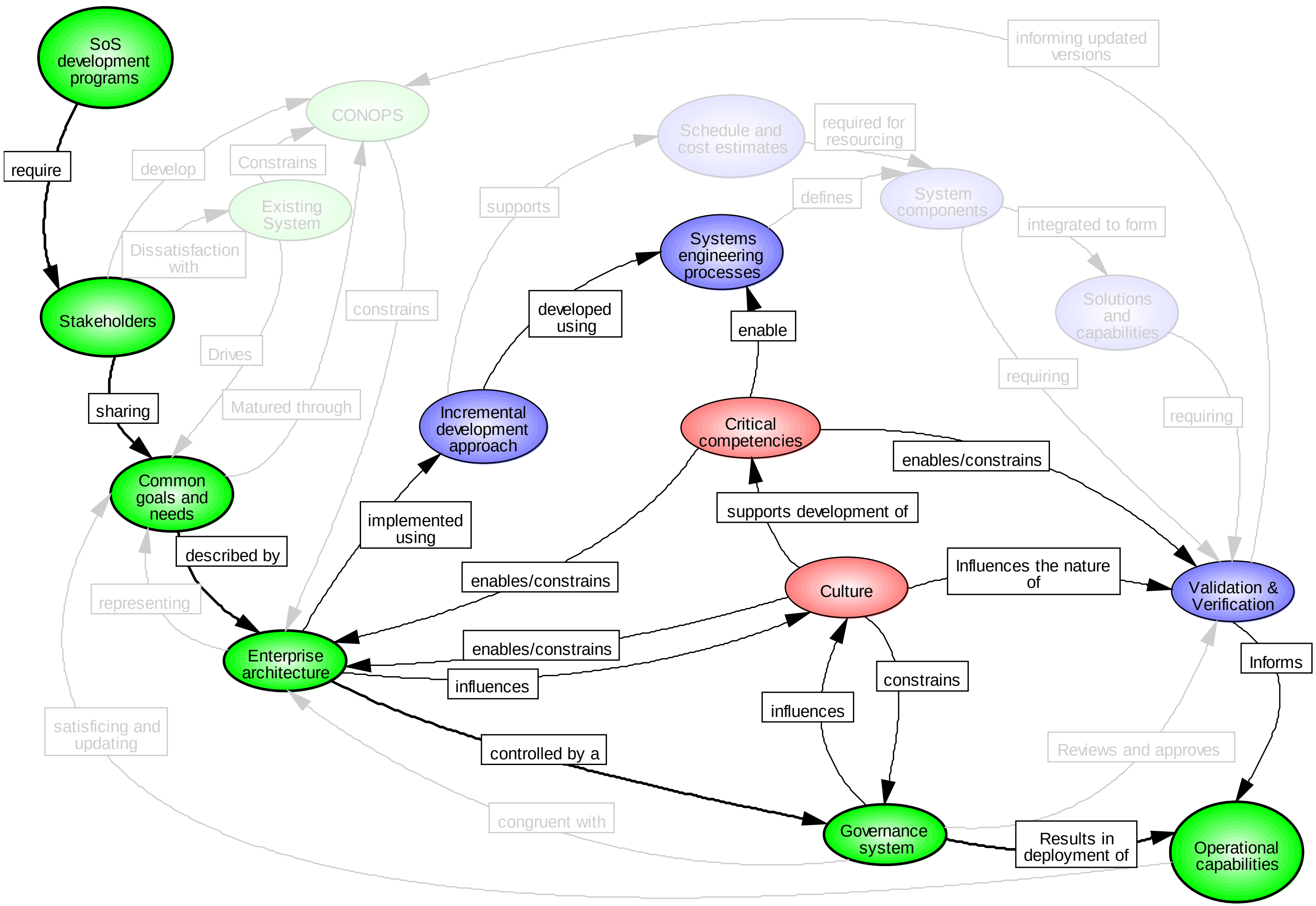


SoS development programs
require
Stakeholders
develop
CONOPS
Constrains
Existing System
Dissatisfaction with
Drives
sharing
Common goals and needs
Matured through
constrains
described by
Enterprise architecture
controlled by a
Governance system
Results in deployment of
Operational capabilities
informing updated versions
Schedule and cost estimates
required for resourcing
supports
defines
System components
integrated to form
Systems engineering processes
Solutions and capabilities
developed using
enable
requiring
requiring
Incremental development approach
Critical competencies
enables/constrains
supports development of
implemented using
enables/constrains
Culture
Influences the nature of
Validation & Verification
representing
enables/constrains
influences
constrains
influences
Informs
Reviews and approves
satisficing and updating
congruent with

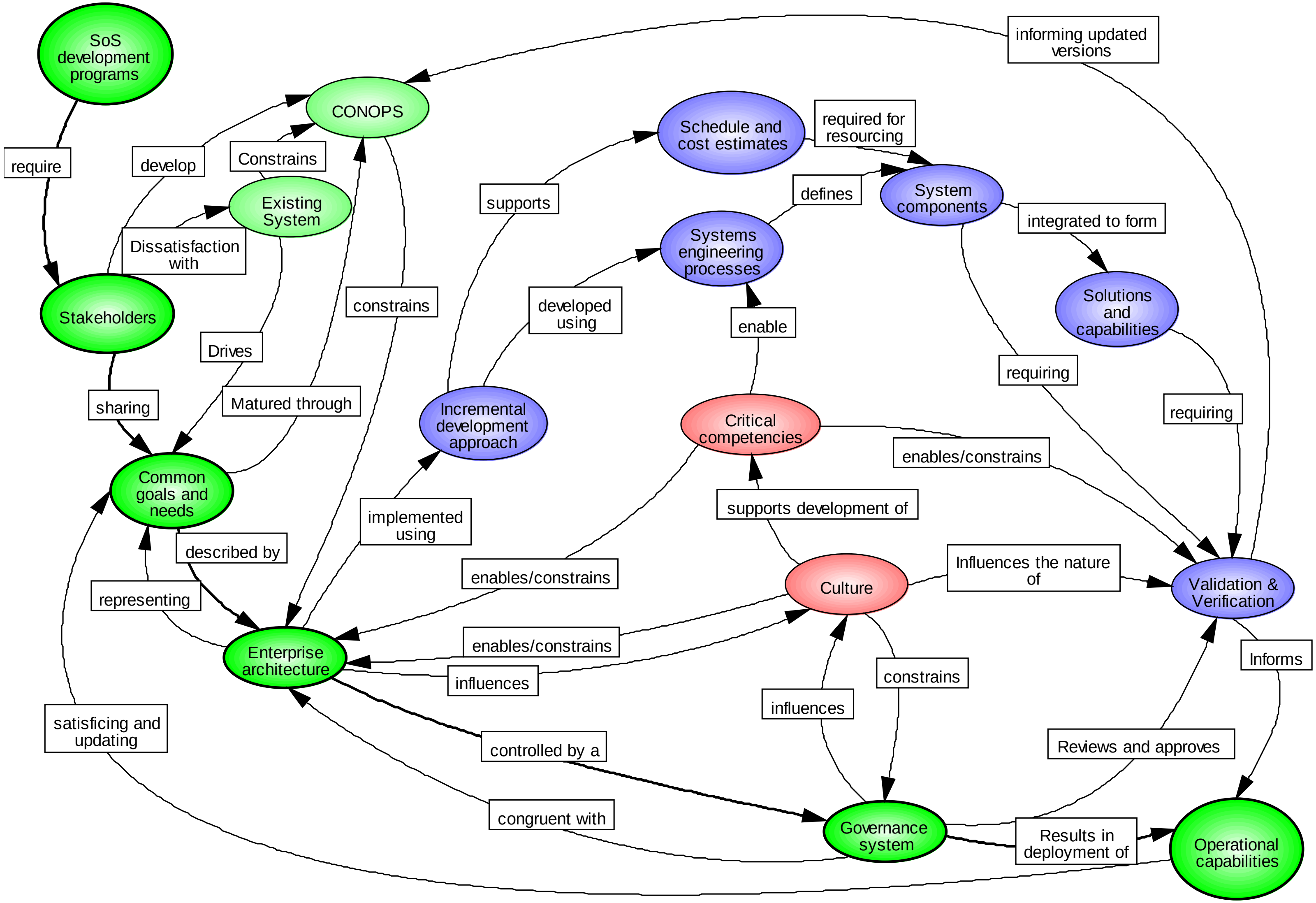
Second-Order Concerns



People


SoS development programs
require
Stakeholders
sharing
Common goals and needs
described by
Enterprise architecture
CONOPS
develop
Constrains
Existing System
Dissatisfaction with
Drives
Matured through
constrains
representing
satisficing and updating
congruent with
supports
Schedule and cost estimates
required for resourcing
defines
System components
integrated to form
Solutions and capabilities
requiring
requiring
informing updated versions
Systems engineering processes
developed using
enable
Incremental development approach
implemented using
Critical competencies
enables/constrains
supports development of
enables/constrains
Culture
Influences the nature of
Validation & Verification
enables/constrains
influences
influences
constrains
controlled by a
Governance system
Informs
Reviews and approves
Results in deployment of
Operational capabilities

The Entirety



Recommendation 1

- The FAA should ensure that metrics are in place to assess the "goodness" and improve the value of the NextGen CONOPS. At a minimum, the metrics should measure:
  - degree to which NextGen stakeholders are identified and participate in the development of the CONOPS
  - degree to which the stakeholders share a common understanding of the problem, constraints, solution trade space, and potential solution concepts
  - determination of the most reasonable increment length(s)
  - ability of the CONOPS to be achieved through the existing EA structure

Recommendation 2

- The FAA should ensure that are in place to assess the capability of the EA to support the development and implementation of the solution system described in the CONOPS. Furthermore, the EA should be assessed from the following perspectives:
  - **Resiliency**
  - **Latency and Responsiveness**
  - **Scalability**
  - **Security**

Recommendations 3, 4 and 5

- The FAA should ensure that an explicit governance system is defined. This governance system should have the following characteristics:
  - be reflected in specific artifacts
  - be congruent with the EA
  - be congruent with the organizational culture
- The FAA should ensure that metrics are in place to assess the effectiveness of the governance system. The metrics should also provide insight into the alignment between the governance system, the EA, and the organizational culture.
- The FAA should ensure alignment between the evolving CONOPS, the EA, and the governance system in support of NextGen. This will also support the evolving V&V strategy and approach for NextGen. The alignment between the CONOPS, the EA, and the governance system should be periodically assessed, both qualitatively and quantitatively.

Recommendation 6

- The FAA should utilize an acquisition, development, and implementation approach that focuses on explicit increments.
  - Although the DoD recommends an increment's time span not exceed five years, the specifics of the NextGen problems, resource availability, and technology maturity may require varying and shorter cycle-times. For selected aspects of the NextGen enterprise, the increments may be significantly less than five years. Care should be taken to provide sufficient time to allow technologies to reach the maturity level required for increments in which they are to be used.
- In addition to determining the optimal time span for NextGen increments, the FAA should develop and implement governance mechanisms to ensure that each increment not only considers hardware, software, and policy components, but also identifies changes required in human–system components, such as staffing, skills, and training, required to field the desired incremental capability.

Recommendations 7, 8, and 9

- The FAA should identify, monitor, and manage critical workforce competencies required for the successful development and deployment of NextGen capabilities. Critical workforce competencies should include both technical and non-technical requirements.
- The FAA should include active and continuous V&V as an explicit component of the EA and that is supported by the governance system. Metrics assessing the EA and governance system should provide insight into their ability to support the desired level, tempo, and quality of V&V.
- The FAA should obtain independent cost and schedule estimates for each program increment. These estimates should be defined as probability curves and incorporated into program funding requests and schedule development. Over the long term, statistical analysis of the independent estimates, compared to the actual cost and schedule, should be used as an additional data input for the program development process.

Engineering Systems of Systems: An Integration Perspective

NAVSEA WARFARE CENTERS
DAHLGREN

Distribution Statement A: Approved for Public Release; Distribution is Unlimited.

Emmett Maddry
emmett.maddry@navy.mil
540-653-8197

NDIA 12TH ANNUAL SYSTEMS ENGINEERING CONFERENCE

26-29 October 2009

System of Systems Engineering (SoSE) at NSWCDD

Objectives:

Discuss systems engineering practices of NSWC Dahlgren Division when carried out in the system of systems environment.

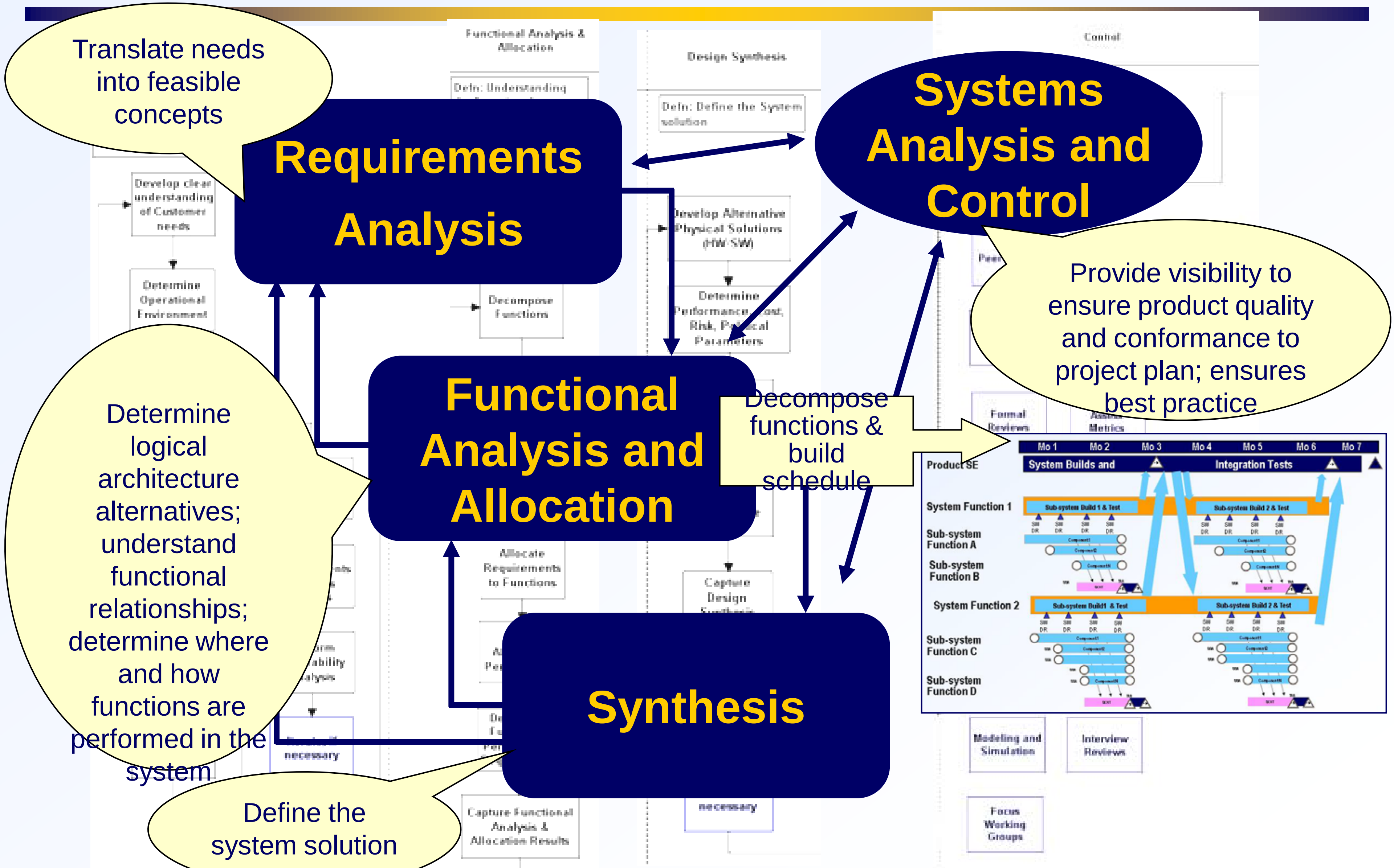
Discuss Dahlgren SoSE efforts and related system context, lessons learned, and challenges

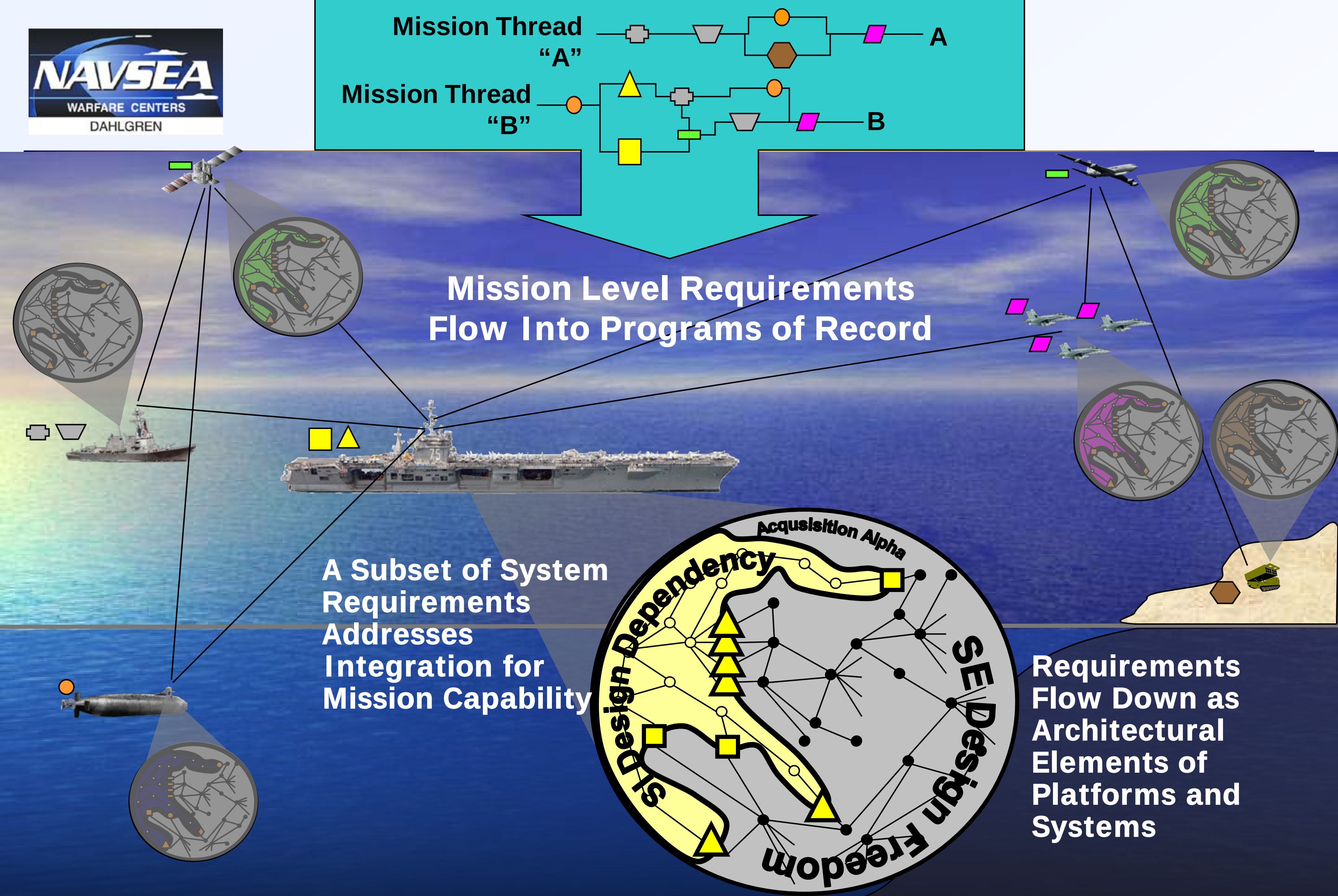
Opinions expressed are those of the principal author, and do not reflect official policy or positions of the Navy, Navy or DoD programs of record, or NSWCDD. With grateful acknowledgement to co-authors G. Goddin, J. Heil, J. McConnell, P. Pierce, G. Rivera, S. Such for valuable discussion and perspectives on best practice and lessons learned in SoSE.

Agenda

- NSWCDD's Systems Engineering Process
- NSWCDD Perspective and inputs to the OSD SoSE Guide
- Case studies, Best practice, Lessons learned
  - Chem-Bio Architecture Engineering
  - Naval Integrated Fire Control – Counter-Air
  - Combat Systems Engineering across Surface Ship Classes
  - Aegis Ballistic Missile Defense
  - Software Engineering
  - Affordable Weapons Systems

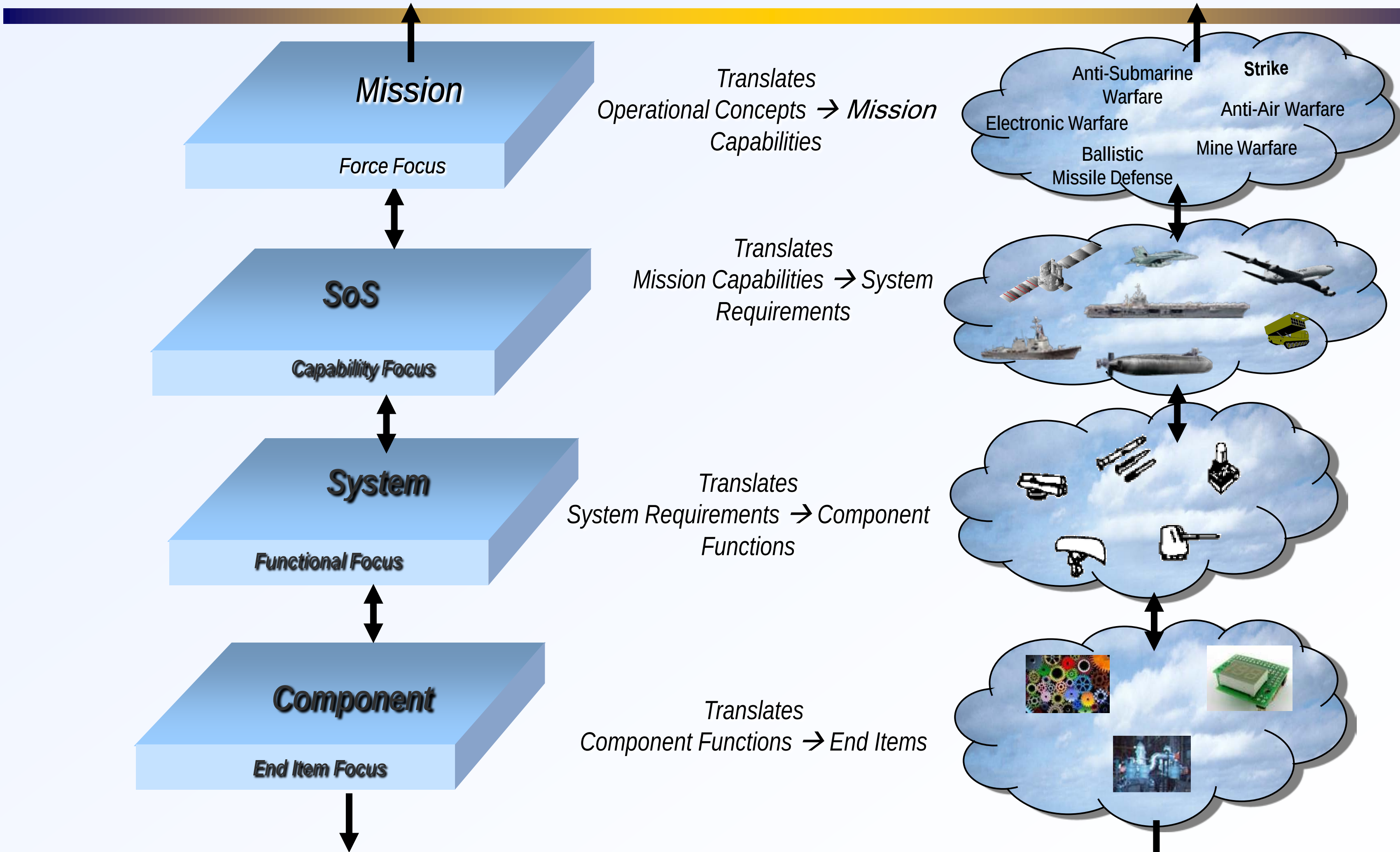
NSWCDD Systems Engineering*





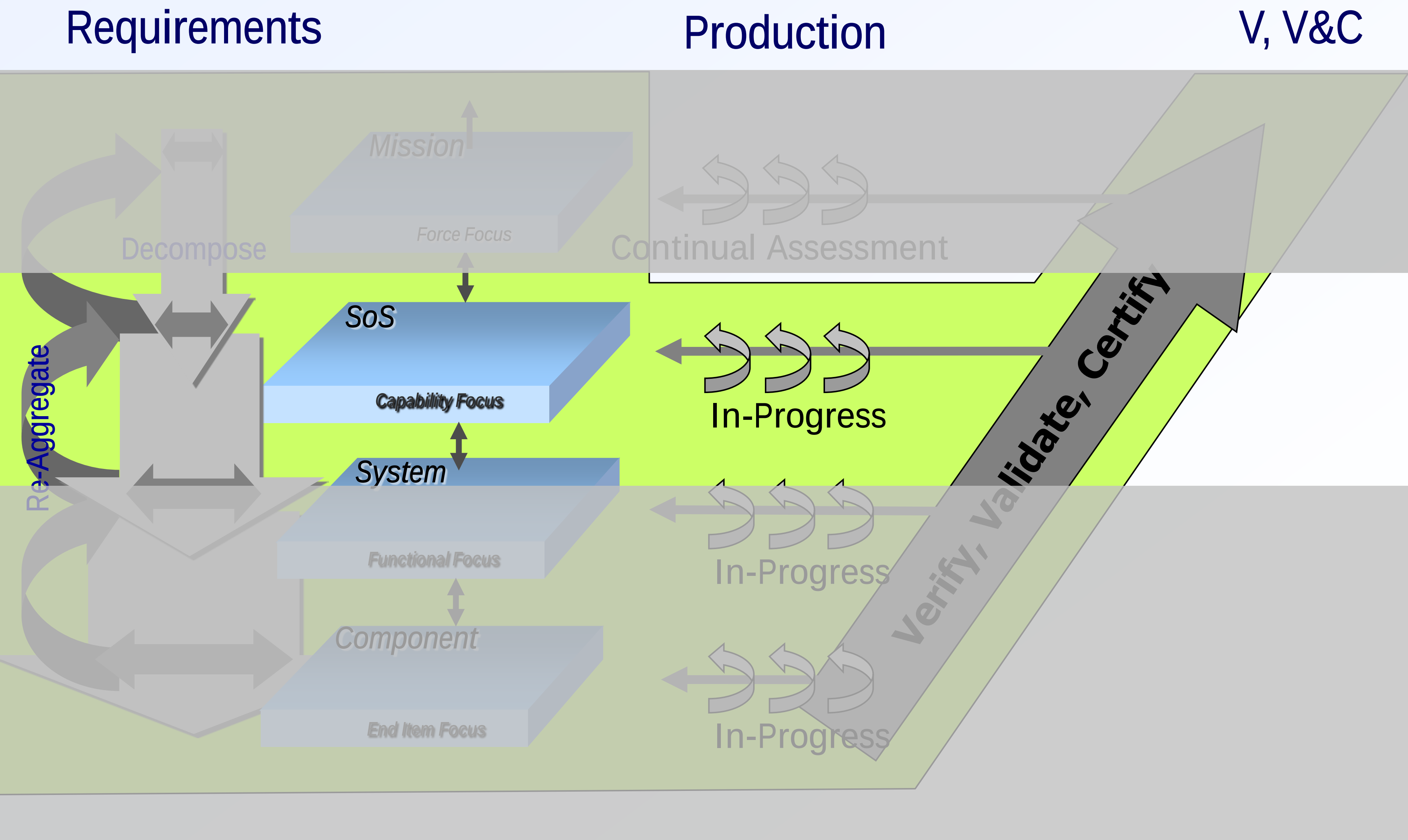
Multiple Missions, Multiple Acquisitions, Requirements Flowing to Different Levels Concurrently
A Highly Complex Engineering Endeavor Requiring Discipline, Competence and Tools

DoN Engineering of Systems
(a spectrum of Systems Engineering)



Systems Integration takes place at each level of the hierarchy and requirements are passed between levels of the hierarchy

System-of-Systems Integration



NAVSEA
WARFARE CENTERS
DAHLGREN

Chem-Bio Architecture Engineering: System of Systems Approach to Counter the Threat

Sustained Combat Power

CB Threats & Hazards

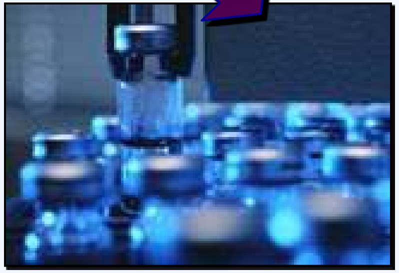
Agent Delivery

Doses on Target

Downwind Dispersal

Doses Absorbed

Symptoms



Medical Pretreatment

Individual & Collective Protection

Medical Treatment

Information Systems

Contamination Avoidance and NBC Battle Management (Detection, Identification, Reconnaissance & Warning)

Installation Force Protection

Decontamination, Restoration

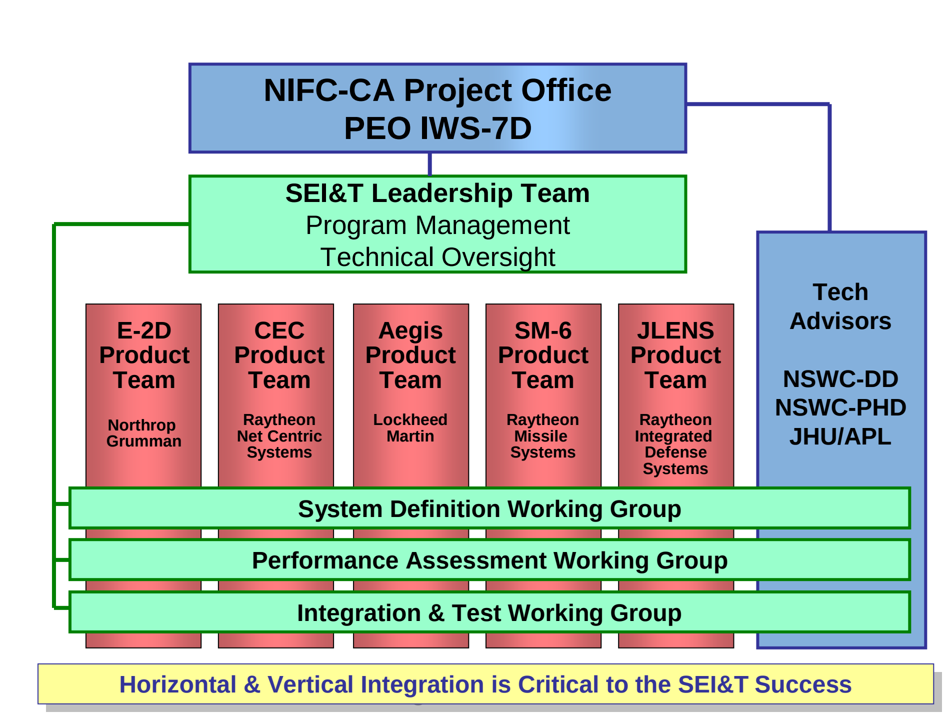
Chem-Bio Architecture Engineering Best Practices

- Architectures are useful in managing complexity
- Architecture framework (DODAF) facilitates the sharing of information and requirements among systems engineers and architects
- SE and Architecture tools are necessary to manage the complexity
- Managing CBRD requirements and gaps facilitates the identification of S&T opportunities that effect cross-Service capability
- Managing CBRD requirements for the services facilitates the identification of common elements resulting in life-cycle savings
- Open architecture concepts promote the ability to leverage needed subcomponent elements (specific algorithms from components rather than the total component)

Naval Integrated Fire Control – Counter Air (NIFC-CA)

Objective: Achieve Naval and Joint Integrated Fire Control capability against over-the-horizon and below-the-horizon AAW threats by distributing the AAW fire control loop across multiple PoR platforms.

Approach: Form a collaborative government/industry SoS systems engineering team by collecting lead engineers and managers from across all participating PoR systems. Develop IFC-unique operational concepts, systems engineering products and trade studies and allocate results to PoR programs.

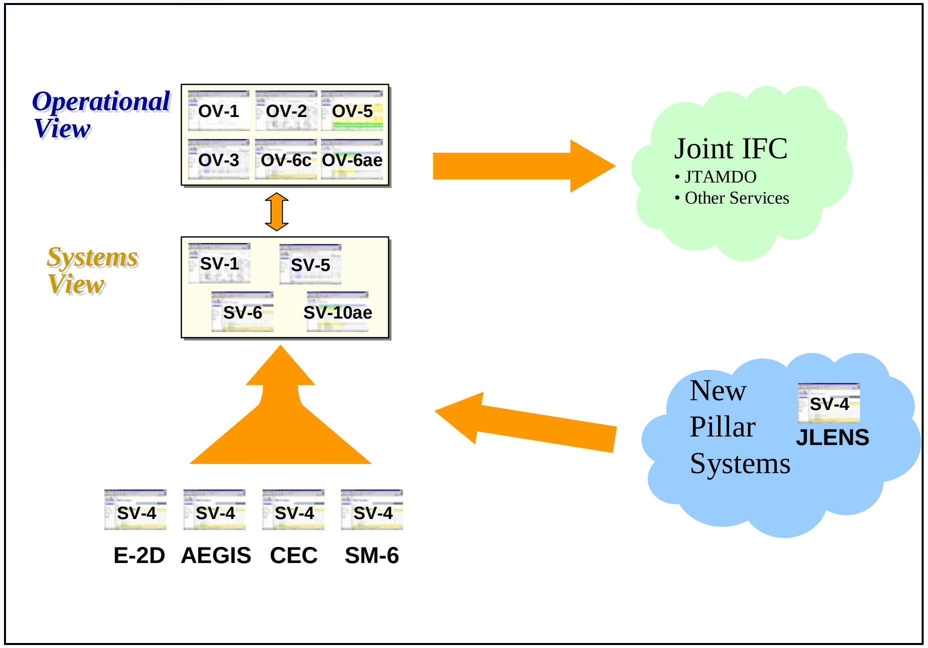


NIFC-CA Lessons Learned

Leadership, teaming and collaboration are essential to success for SoS development.

DODAF architecture is essential for definition and organization of SoS capability and the eventual allocation of unique functionality to existing and future PoR programs.

- Define capability within the OVs
- Compare OVs to similar SoS
- Expand the intermediate SVs
- Allocate functions to PoR SV-4s
- Add new PoRs via their SV-4s



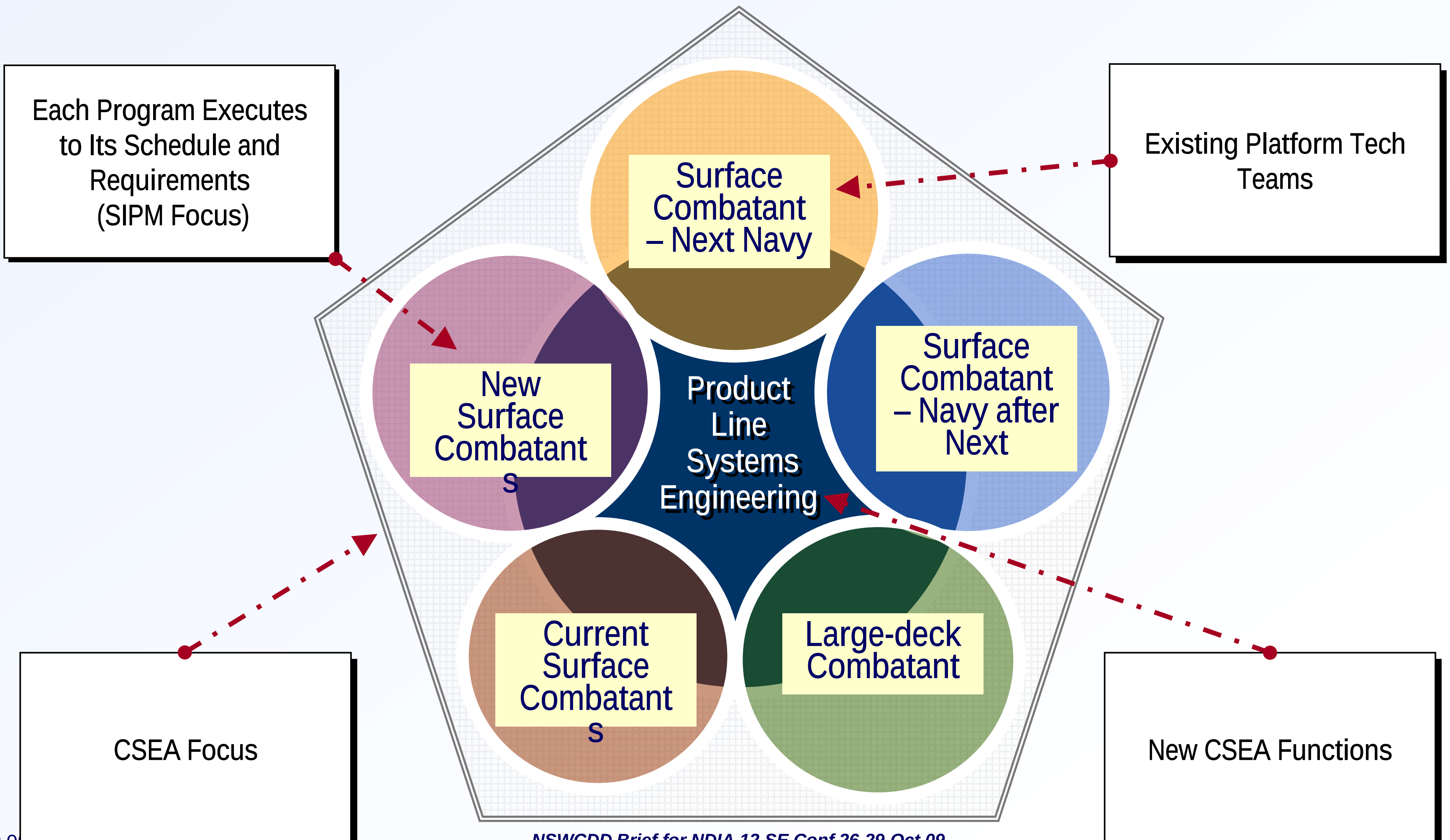
NIFC-CA Best Practice

Conduct SoS-unique systems analysis and trade studies as needed for critical functions.

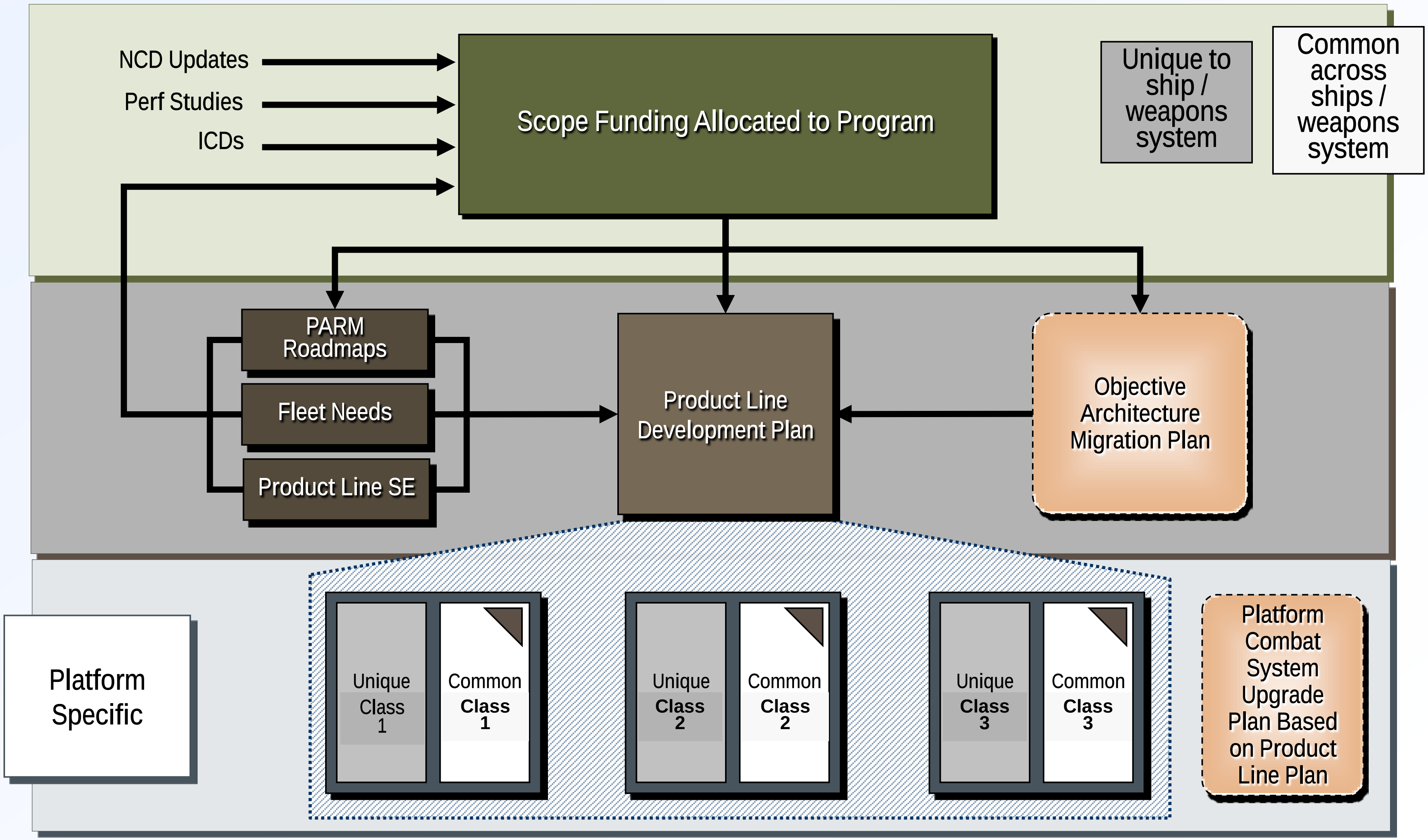
- Identify SoS MOEs (measures of effectiveness).
    - Unique goals and objectives to be achieved by the SoS in order to accomplish the SoS mission.
- Identify PoR MOPs (measures of performance).
    - Parameters and functions unique to each PoR that contribute to overall SoS MOEs.
- Analyze and trade functionality and performance across the SoS.
    - Quantify results against the MOPs and roll up to the overall MOEs
- Simulate and analyze SoS performance via low-fidelity (spreadsheets, MatLab tools) to higher-fidelity (federated PoR models) methods as feasible.

SoSE Combat Systems Engineering

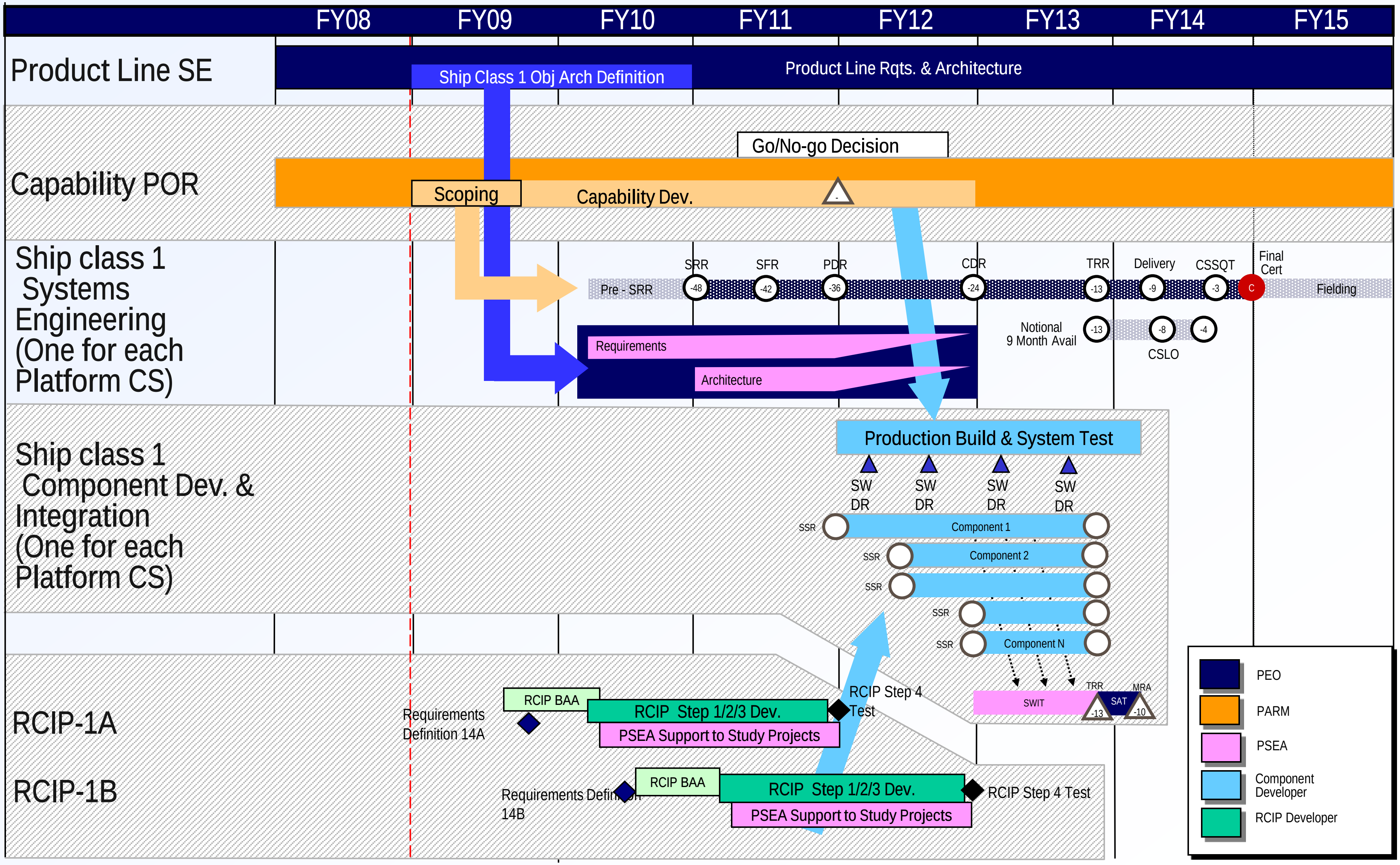
Combat Systems Engineering accomplished across platform combat systems via Product Line Approach



Desired Future State
Product Line Acquisition



Product Line SE / Upgrade Development Example – Notional Ship Class 1



Common Weapons Control System Background

- CWCS is:
  - Common system for preparing/launching various weapons across multiple warfare areas
  - Applicable to various platforms (surface and sub-surface)
  - Establishes open architecture environment for adapting/scaling new weapons/systems
  - Moves Navy (& potentially Joint) weapons control away from creating NEW & modifying closed stove-pipe systems
  - Leverages existing Naval systems (Tomahawk Weapons Control System, Navigation, C4I Systems, etc.)
- CWCS concept being evaluated by multiple NSWCDD department's systems engineers
- Systems engineering artifacts and system prototype under development

Establish Common Weapons Control System for Navy Platforms and Weapons

CWCS SoSE Approach

- Leverage current surface and submarine systems
  - Weapons Control
  - Navigation
  - C4I
  - Networks (ship and sub-based)
- Follow established systems engineering processes
- Leverage established systems engineering products
  - Architecture, weapon system requirements specs, interface requirements, employment concepts, scenarios, etc.
- Integrate existing functionality to provide benefit to warfighter and taxpayer
  - CWCS integrates two existing systems
    - Naval Fires Control System (NFCS)
    - Tactical Tomahawk Weapons Control System (TTWCS)
  - Integrates Marine & Army fires networks and capabilities to all surface combatants
  - Coordination of fires
  - Reduces overall program cost and lifecycle support

CWCS SoSE Approach

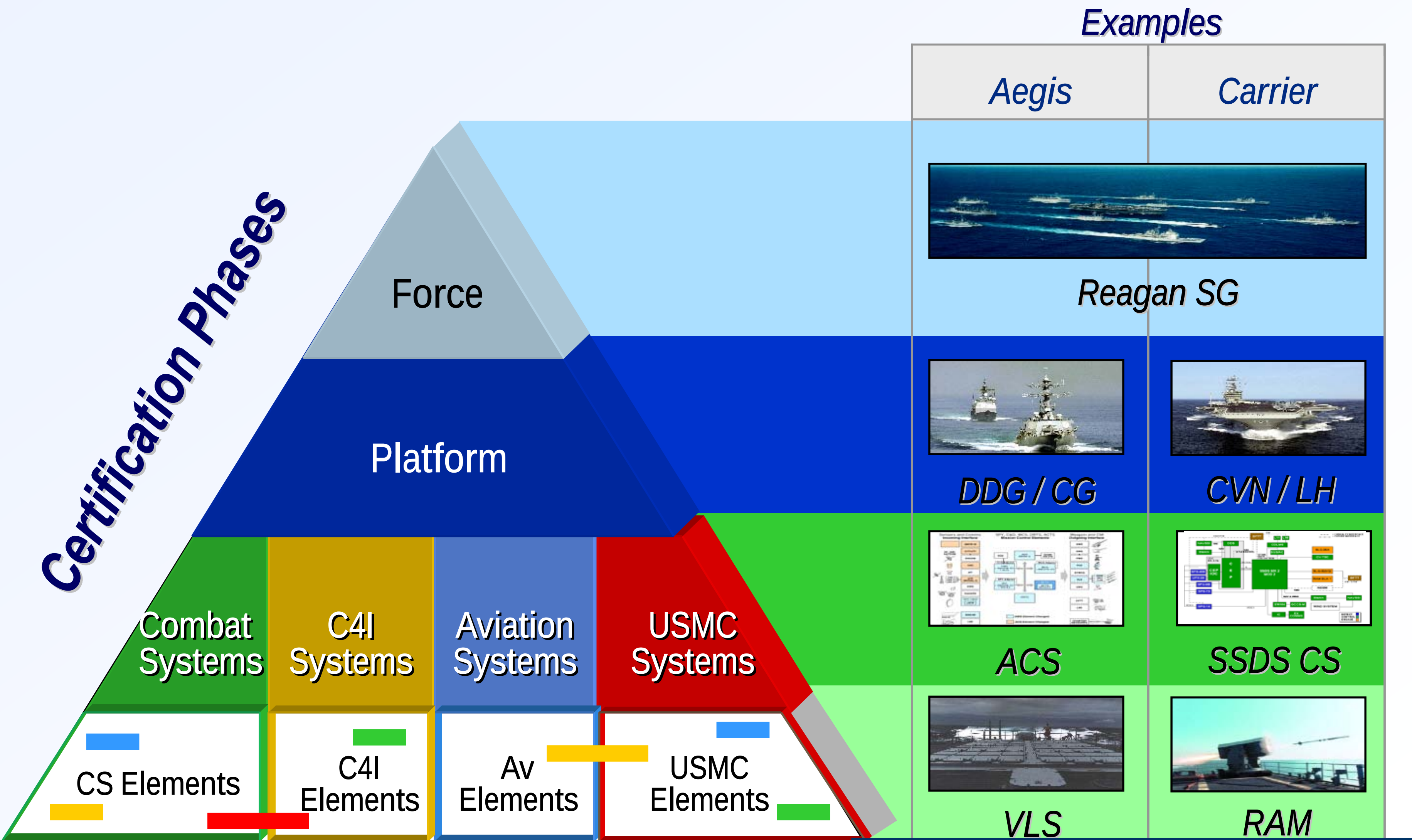
- Leverage training curricula and documentation
- Leverage established training pipelines
- Joint interoperable with various systems (end-to-end)
  - Tasking from multiple sources
  - Battle Management & Coordination Systems
  - Situational Awareness systems (e.g. GCCS-M, J,…)
  - Manages and deconflicts multiple weapon variants for simultaneous weapon prep/launch
  - Threat data, obstruction data, etc.
- Leverage existing tactical data analysis and extraction applications/tools
- Leverage combat systems training and simulation functionality

Combat Systems Certification
Situation Before 2004

- Combat System Certification Processes Varied Widely Across Systems and Programs
  - Certification did not Occur for all Combat System Elements
  - Combat System Certification for SSDS & ACDS Ships was not Conducted
    - Fielded Through Existing SEA62 Fleet Delivery Readiness Review (FDRR)
  - Platform Certification for Aegis Ships was not Conducted
    - Assumed as Part of Aegis Combat System Certification
  - Certification Criteria not well Defined or Understood
- In-Service Programs Viewed Certification Largely as a T&E Event Vice a Continuous Process Throughout System Definition And Development
  - Quality Issues Drove Test / Fix / Test Loop
    - Drove Perception That Certification is Long and Expensive
  - Various Test Efforts Were not well Coordinated
    - Developer, Cert, CSSQT, DT / OT

NAVSEA WARFARE CENTERS DAHLGREN

Combat Systems Certification
One Process – Four Phases



Pre-decisional Draft

Coordinating the Phases

- CS Cert is Focal Point for all Certification Activities
  - Coordinates and Aligns Element Certifications
  - Administers and / or Oversees Critical System Integration
  - Supports Platform Certification by Providing the Activities and Data to Fulfill the Warfare System-Related Platform Cert Criteria
    - Including Many of the WSIIT Requirements
  - Also Provides Process and Means to Address Corrective Actions Required as a Result of Platform / Interoperability Cert Assessments

Well Coordinated Phases – No Duplication

Achieving CS Cert Objectives

Certification is Both a Process and an Act of Attestment

- Continuous Assessment (Vice End-Game Only)
  - Objectively Assess the Progress of the Development Effort to Reduce the Risk that the System will be Ready to Certify on Schedule
    - Assessment of Progress Versus Plan
    - Verification of System Efficacy and Quality
    - Identification and Resolution of Potential Certification Issues
- Authorizations
  - Assess the Ability of a Specific Version of the System to Perform Specific, Well Defined Scenarios or to Perform a Limited Mission (Usually an At-Sea Test Or Trial)
  - Assess the Ability of the System to Operate Safely Within Documented Restrictions
- Certification Panels
  - Assess the Readiness of a Specific Version of the System to Perform the Broad Mission Requirements of the System (Readiness for Full, Unrestricted Fleet Use)
  - Assess the Ability of the System to Operate Safely

Process Value-Added

- Provides a Structured, Systematic Assessment Methodology
- Applies Full Rigor: Defines Certification Activities, Detailed Tasks, Work Products, and Applicable Metrics IAW Industry Standards
  - Establishes Expectations for Developer-Executed V&V / Certification Activities and Artifacts
  - Assesses Developer's V&V Work / Results
  - Defines Appropriate Degree of Independent Assessment Activity
- Fully Adapted to Evolutionary Acquisitions
- Coordinates With Other Critical Processes (e.g. Safety, CM, QA, etc.)
- Addresses: COTS / NDI, Reuse, HSI, Security, Safety, etc.
- Generates and Accumulates Technical Insight for Continuously Updated Assessments and Cert Status
- Builds in Accountability of the Cert Process Itself

Detects and Eliminates Defects and Risks Earlier

Software Engineering and Development Applied Experience

- NSWCDD has 50+ year history of providing full spectrum SW Engineering <u>and actual SW Development</u> for multiple Combat and Fire Control Systems

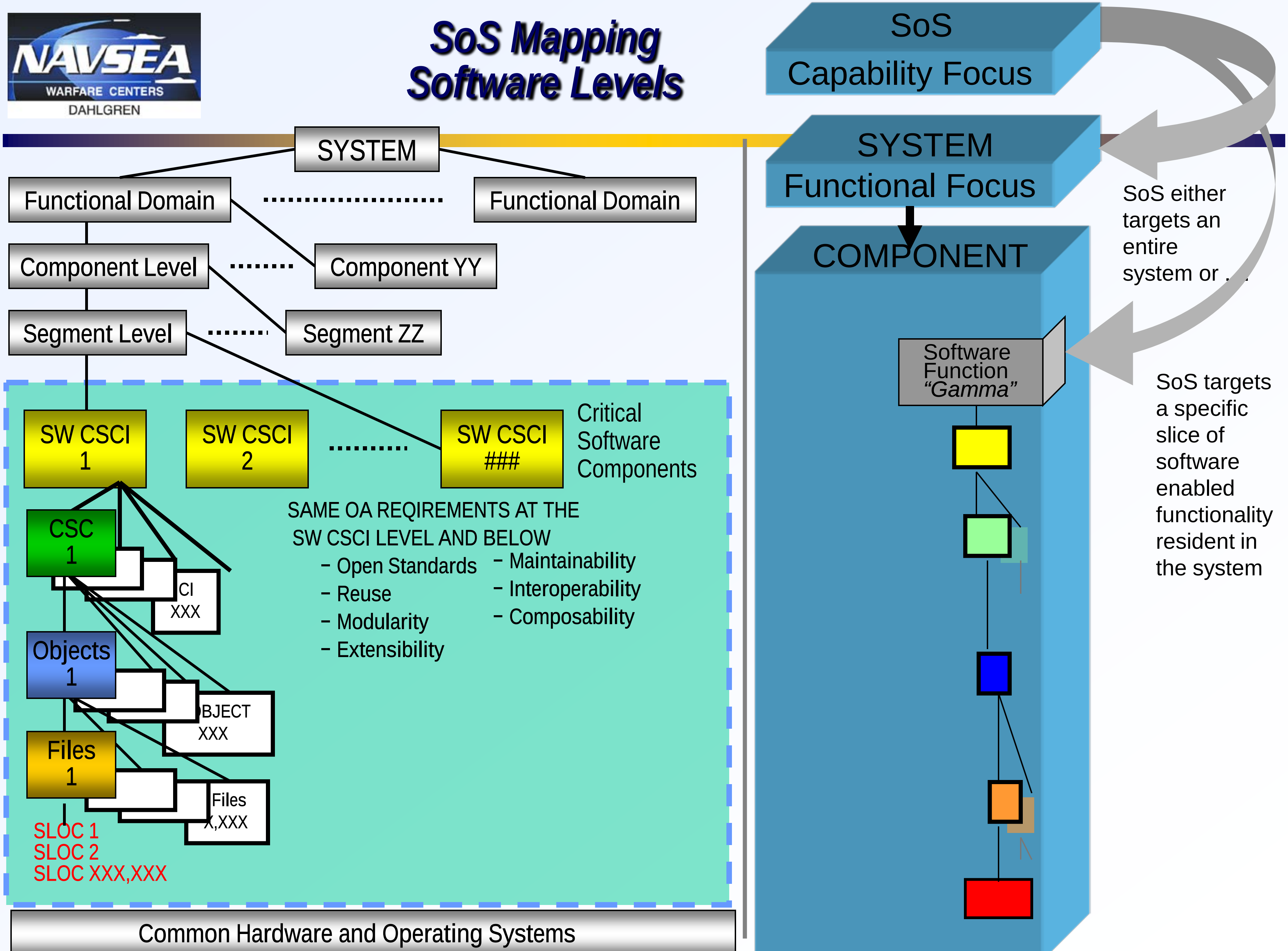
- Includes real-time, safety critical, complex algorithms, multi-process, multi-interface tactical and simulation sw design, code, and test

- Participation in cross organizational and cross discipline (SE/SW/Test) IPT and Leadership of Industry and Government Engineering SW Development IPTs
  - Pro-active SW expert participation in from Concept Development through System Requirements, System Development, Deployment, and Operational Support

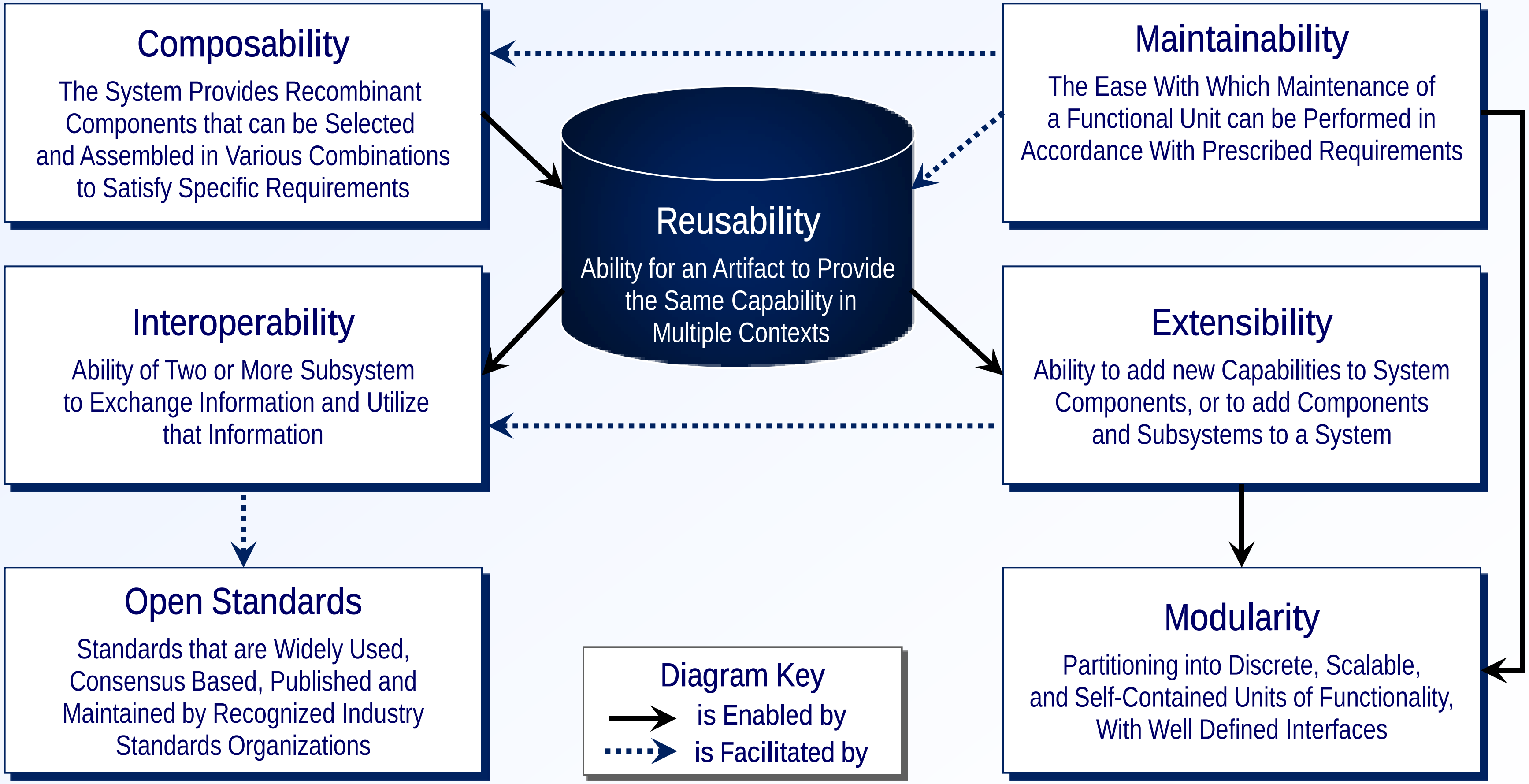
- Demonstrated success in developing Open Architecture based multi-platform capable, re-usable, scalable, and maintainable software components

Applied Software Engineering and *<u>Development</u>* Expertise

SoS Mapping Software Levels



Software Lessons Learned
Open Architecture is more than just 'Reusability"

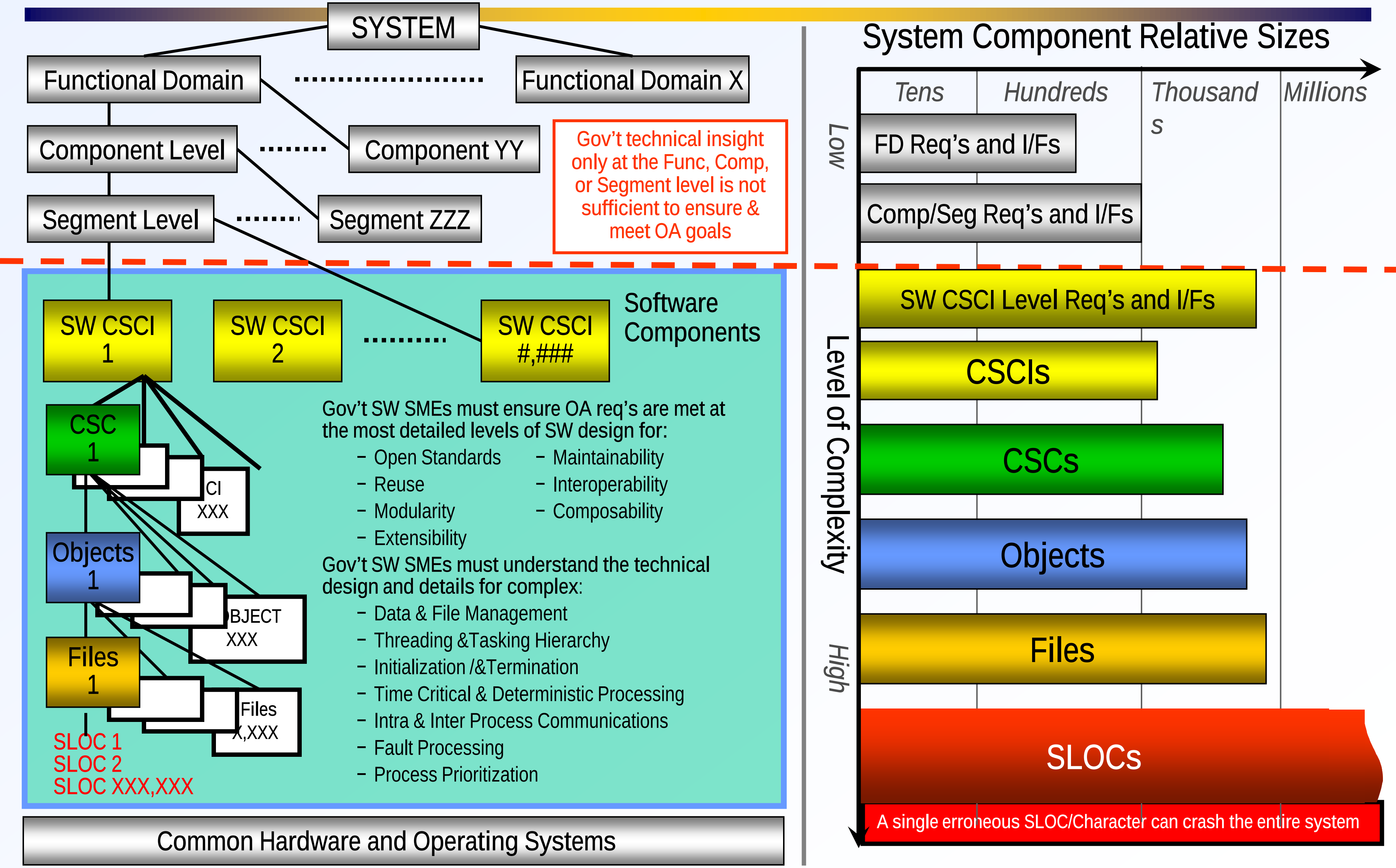


These OA "ILITIES" Cannot be Easily Verified by System Testing Alone.
Gov't SW Expertise Insight Into Design and Code is Required to Ensure Reusable Software.

Designing and Coding for These "ILITIES" is the Key to Saving Significant $$$$$$$$.

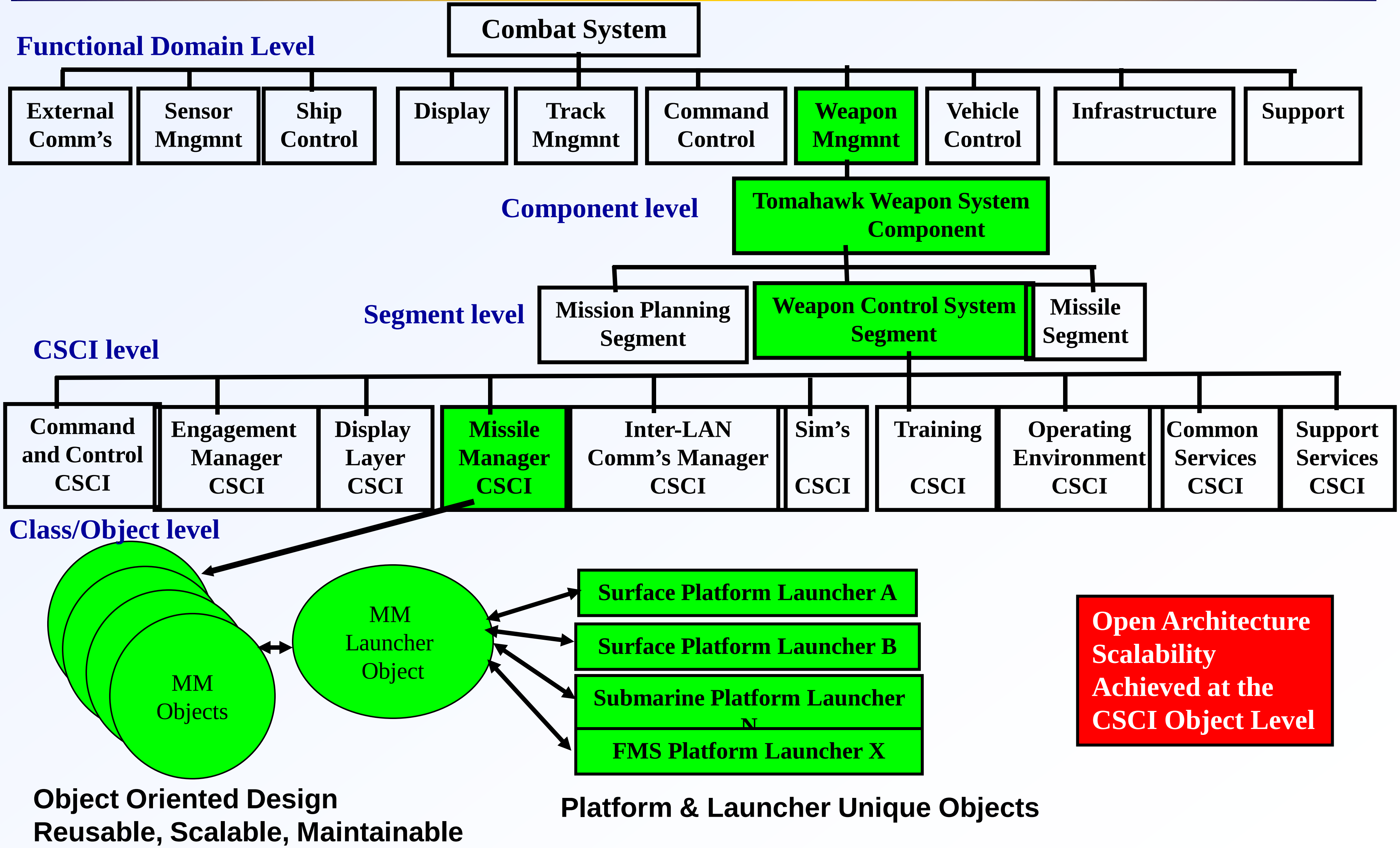
* Reference: OA Architectural Principles and Guidelines v 1.5.6, 2008, IBM, Eric M. Nelson, Acquisition Community Website (ACC) DAU Navy OA Website

SW Lessons Learned:
Levels of SW Complexity / Devil is in the Details



NAVSEA WARFARE CENTERS DAHLGREN

Open Architecture: Example Achieved at the CSCI and Class Level



Wrap-Up
SoSE Key Points

- Tailoring the Systems Engineering Process
- Technical Considerations in System- and Family-of-Systems Engineering
- Distributing Functionality across Systems
- Leveraging Commonality
- Life-cycle Affordability
- Development for System Certification

NAVSEA

WARFARE CENTERS

DAHLGREN

Air Force Concept Maturity Assessment

NDIA Systems Engineering Division
12th Annual Systems Engineering Conference
San Diego, CA
28 Oct 2009

Jeff Loren
Principal Analyst
SAF/AQRS
(Alion Science & Technology)
571.256.0306
jeff.loren@pentagon.af.mil

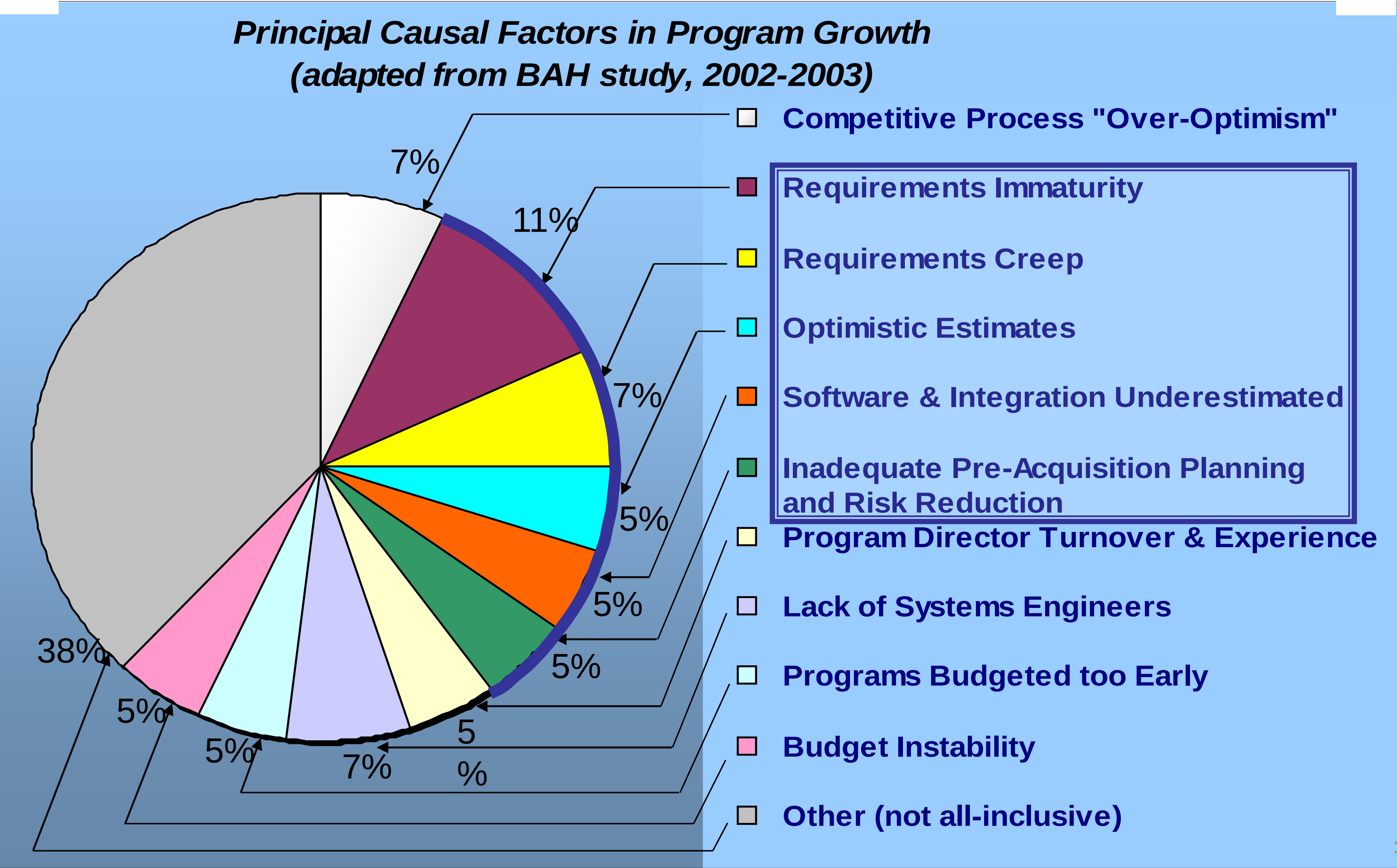
G. Richard Freeman
Technical Director
Air Force Center for
Systems Engineering
937-255-3355 ext 3419
richard.freeman@afit.edu

U.S. AIR FORCE

Agenda

- **Background**
- **The Challenge**
- **Ongoing Efforts**
- **Path Ahead**

The Problem …

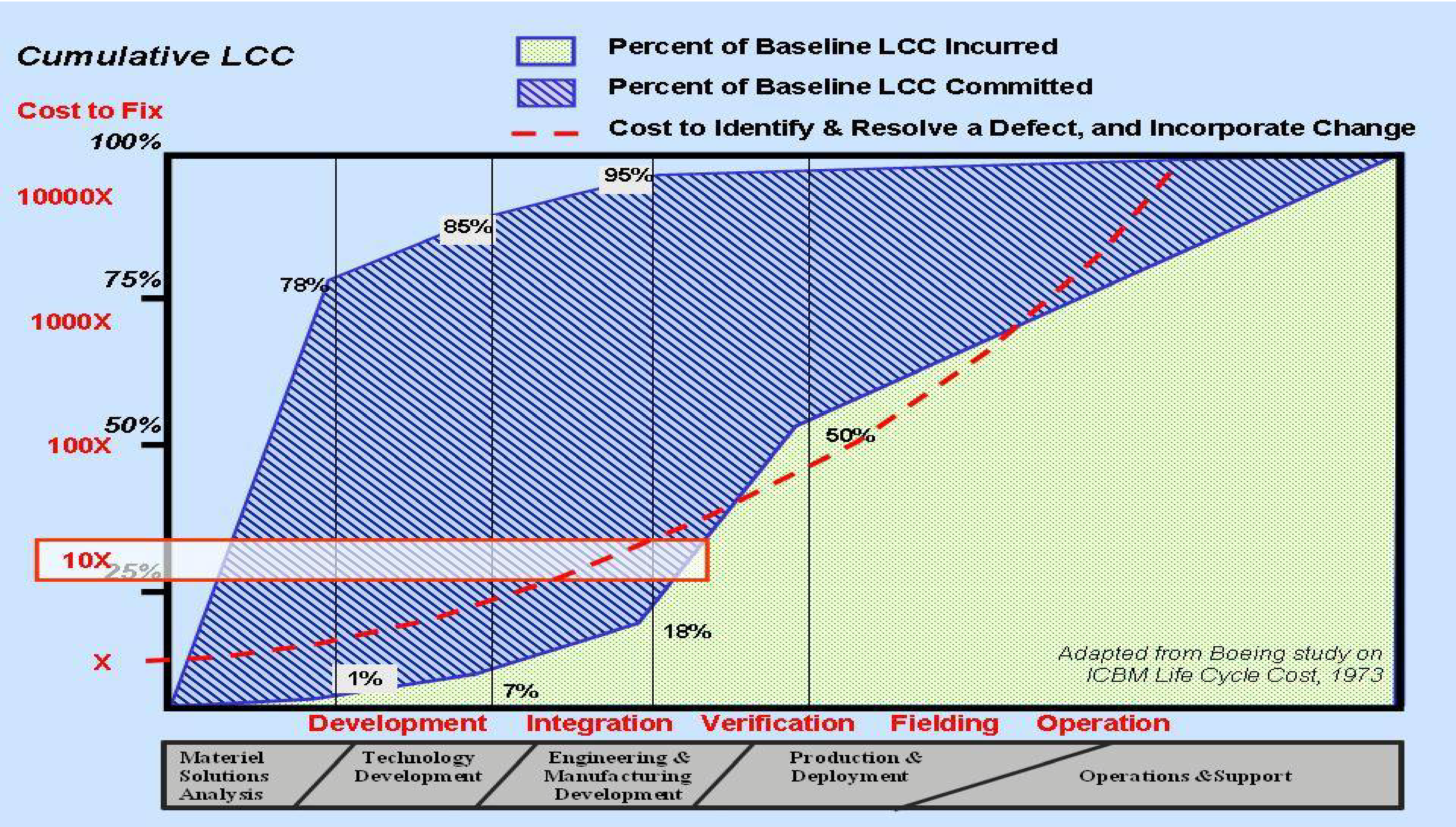


Principal Causal Factors in Program Growth
(adapted from BAH study, 2002-2003)
7%
11%
7%
5%
5%
5%
5
%
7%
5%
5%
38%
Competitive Process "Over-Optimism"
Requirements Immaturity
Requirements Creep
Optimistic Estimates
Software & Integration Underestimated
Inadequate Pre-Acquisition Planning and Risk Reduction
Program Director Turnover & Experience
Lack of Systems Engineers
Programs Budgeted too Early
Budget Instability
Other (not all-inclusive)

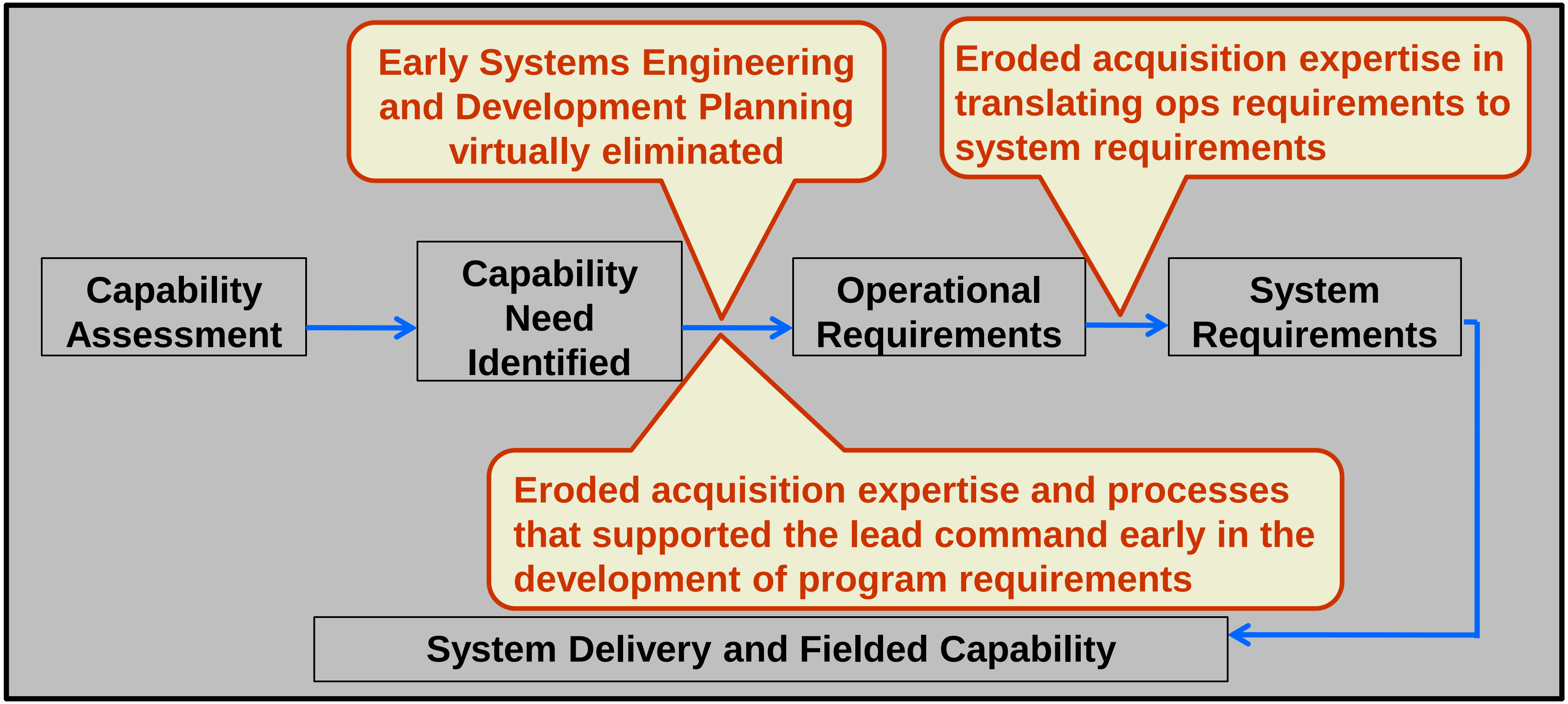
Nearly 40 Years of History

- General Accounting Office, “Acquisition of Major Weapons Systems,” (GAO Report to Congress, B-163058), March 1971; cited in DAPA Project report
- The Boeing Company, “ICBM Life Cycle Cost,” unpublished study, 1973
- General Accounting Office, “Lasting Change in Weapons Acquisition,” GAO/NSIAD-93-15, December 1992
- General Accounting Office, “Best Practices: Successful Application to Weapon Acquisition Requires Changes in DoD’s Environment,” GAO/NSIAD-98-56, February 1998
- General Accounting Office, “Best Practices: Setting Requirements Differently Could Reduce Weapon Systems’ Total Ownership Costs,” GAO-03-57, February 2003
- Government Accountability Office, “Assessments of Selected Major Weapon Programs,” GAO-05-301, March 2005
- Defense Acquisition Performance Assessment (DAPA) Project report, January 2006
- Government Accountability Office, “Best Practices: Stronger Practices Needed to Improve DoD Technology Transition Processes,” GAO-06-883, September 2006
- National Research Council of the National Academies, “Pre-Milestone A Systems Engineering: A Retrospective Review and Benefits for Future Air Force Systems Acquisition,” The National Academies Press, December 2007
- Government Accountability Office, “JOINT STRIKE FIGHTER: Recent Decisions by DoD Add to Program Risks,” GAO-08-388, March 2008
- Government Accountability Office, “DEFENSE ACQUISITIONS: Better Weapon Program Outcomes Require Discipline, Accountability, and Fundamental Changes in the Acquisition Environment,” GAO-08-782T, June 2008

Early Decisions Impact Overall System Life Cycle Cost



Problem Statement & Visual Depiction



Problem Statement

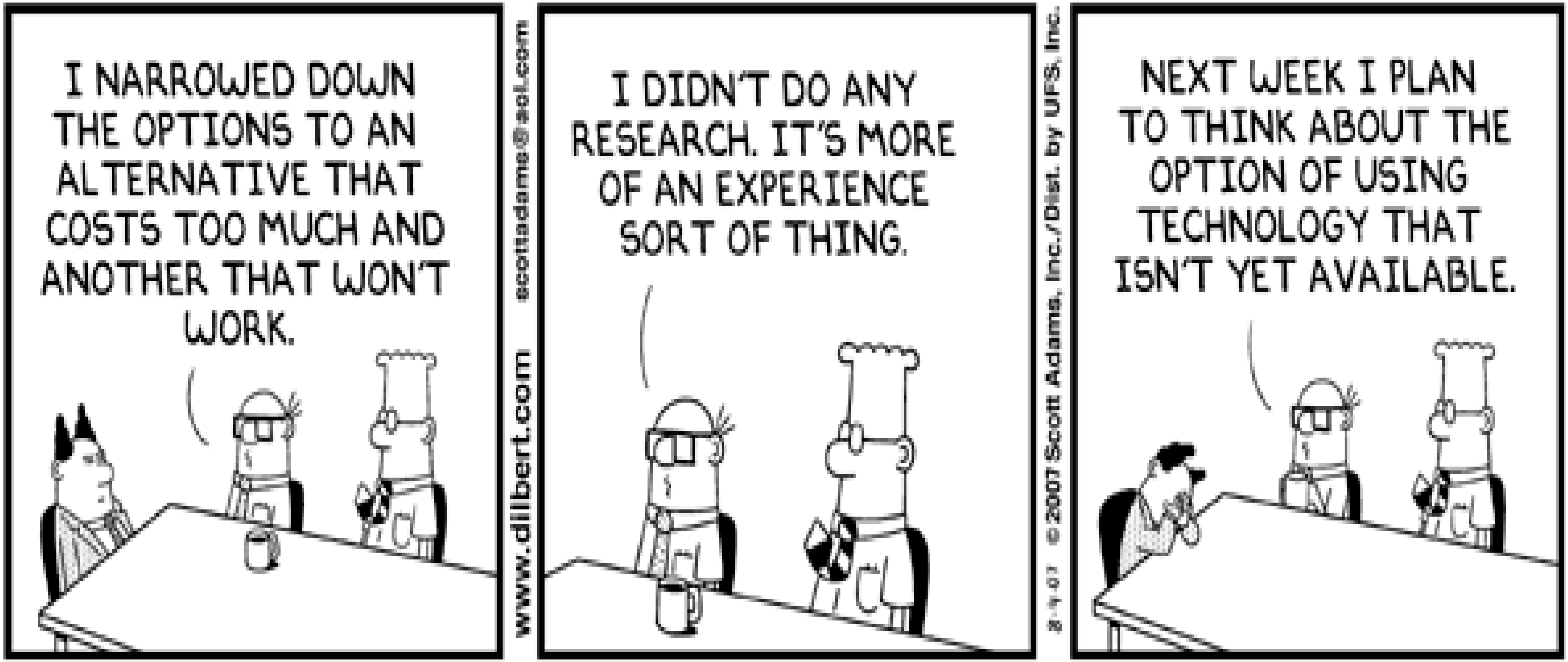
"Overstated and unstable requirements that are difficult to evaluate during source selections"

"Ensure acquisition involvement and leadership in support of the lead command early in the development of program requirements"

NRC Recommendations

1. Air Force leadership should require that Milestones A and B be treated as critical milestones in every acquisition program and that … the “Pre-Milestone A/B Checklist” … be used to judge successful completion.
2. Assess career field needs and develop a program to address
3. Pre-A decisions should be supported by rigorous SE processes and analyses involving teams of acquirers, users, and industry
4. A development planning function should be established in the military departments to coordinate the concept development and refinement phase of all acquisition programs to ensure that the capabilities … as a whole are considered and that unifying strategies such as … interoperability are addressed.

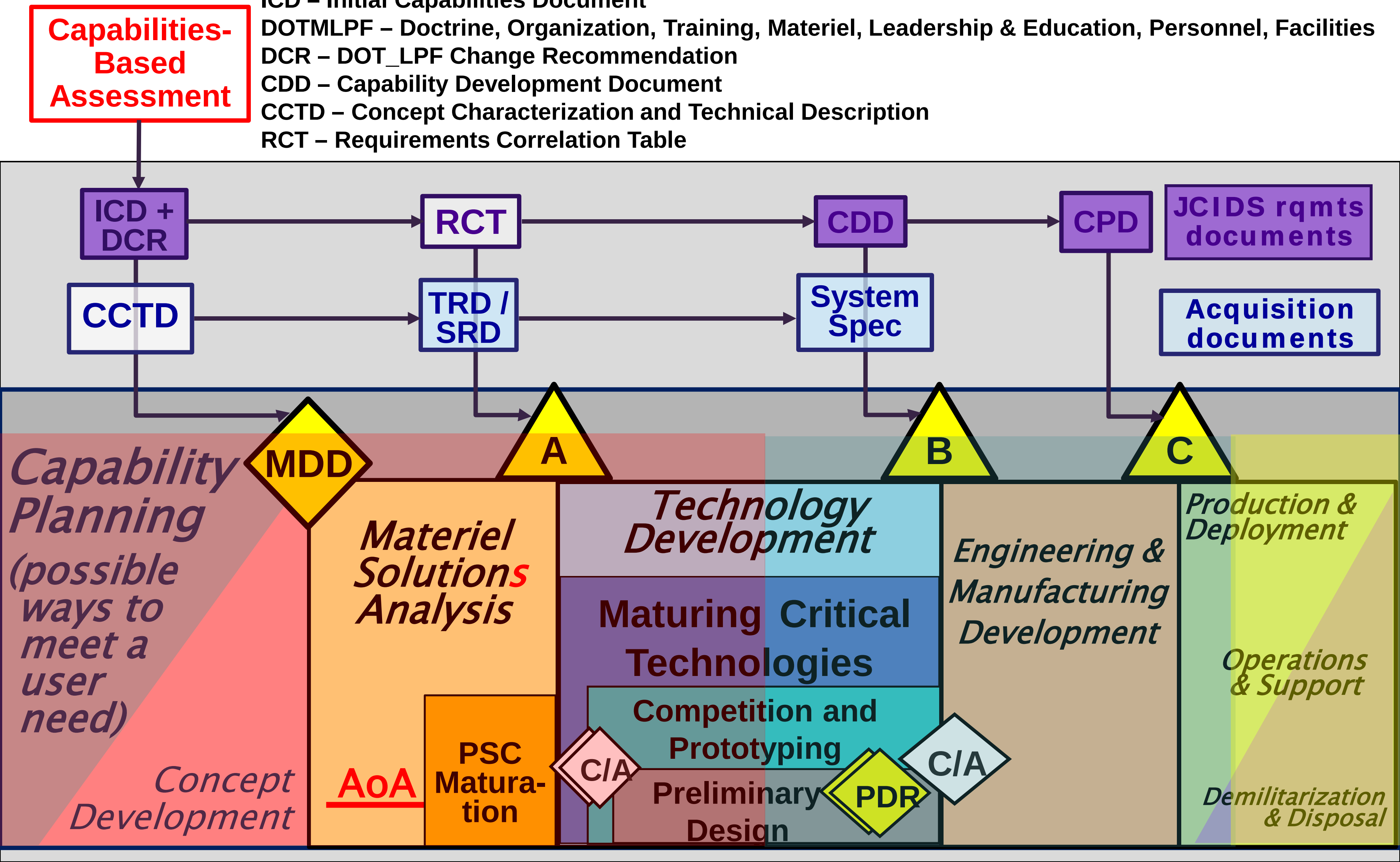
How NOT to do it …



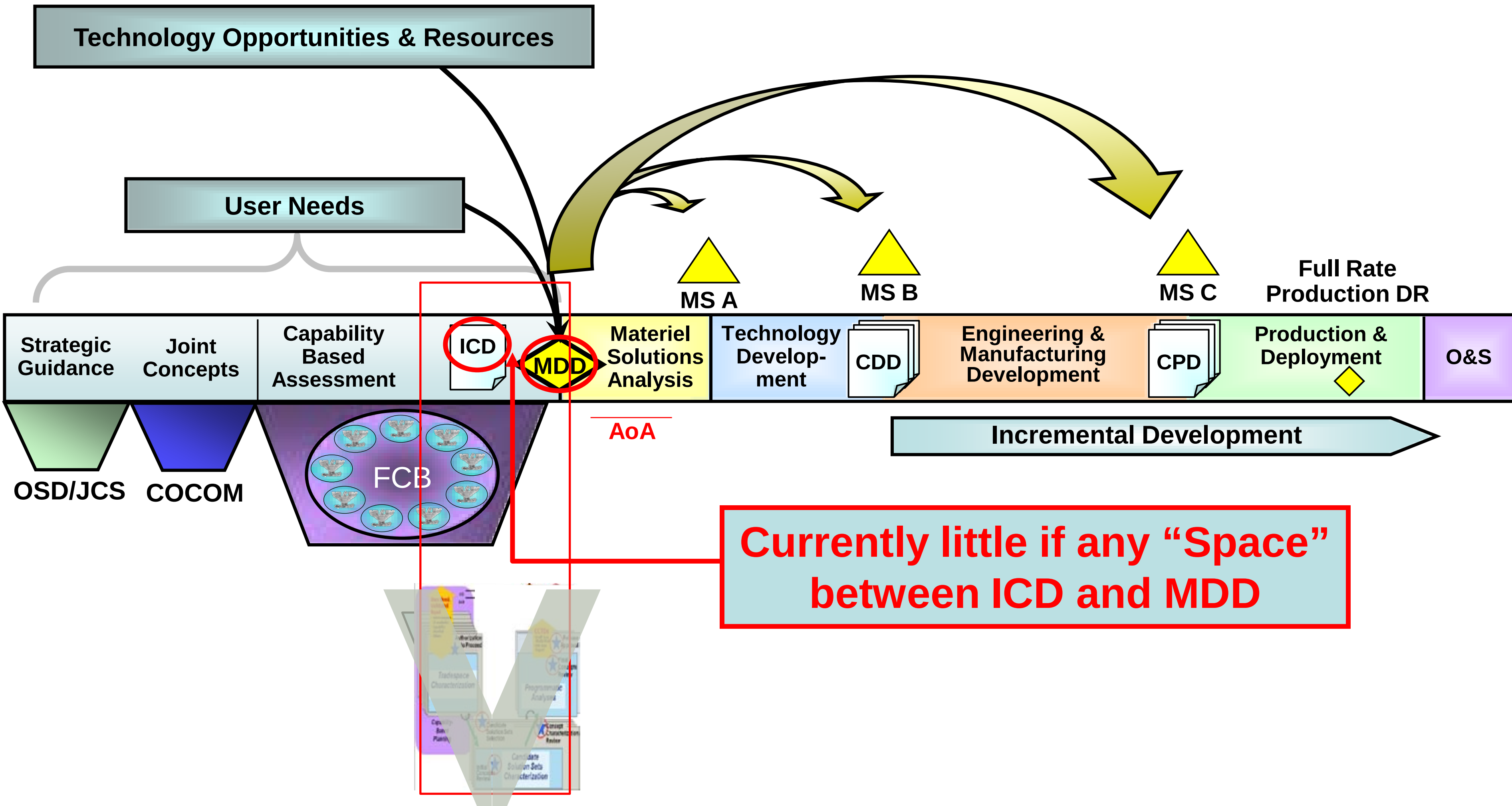
SO WHERE ARE WE NOW?

New JCIDS and DoDI 5000.02 (with additions)

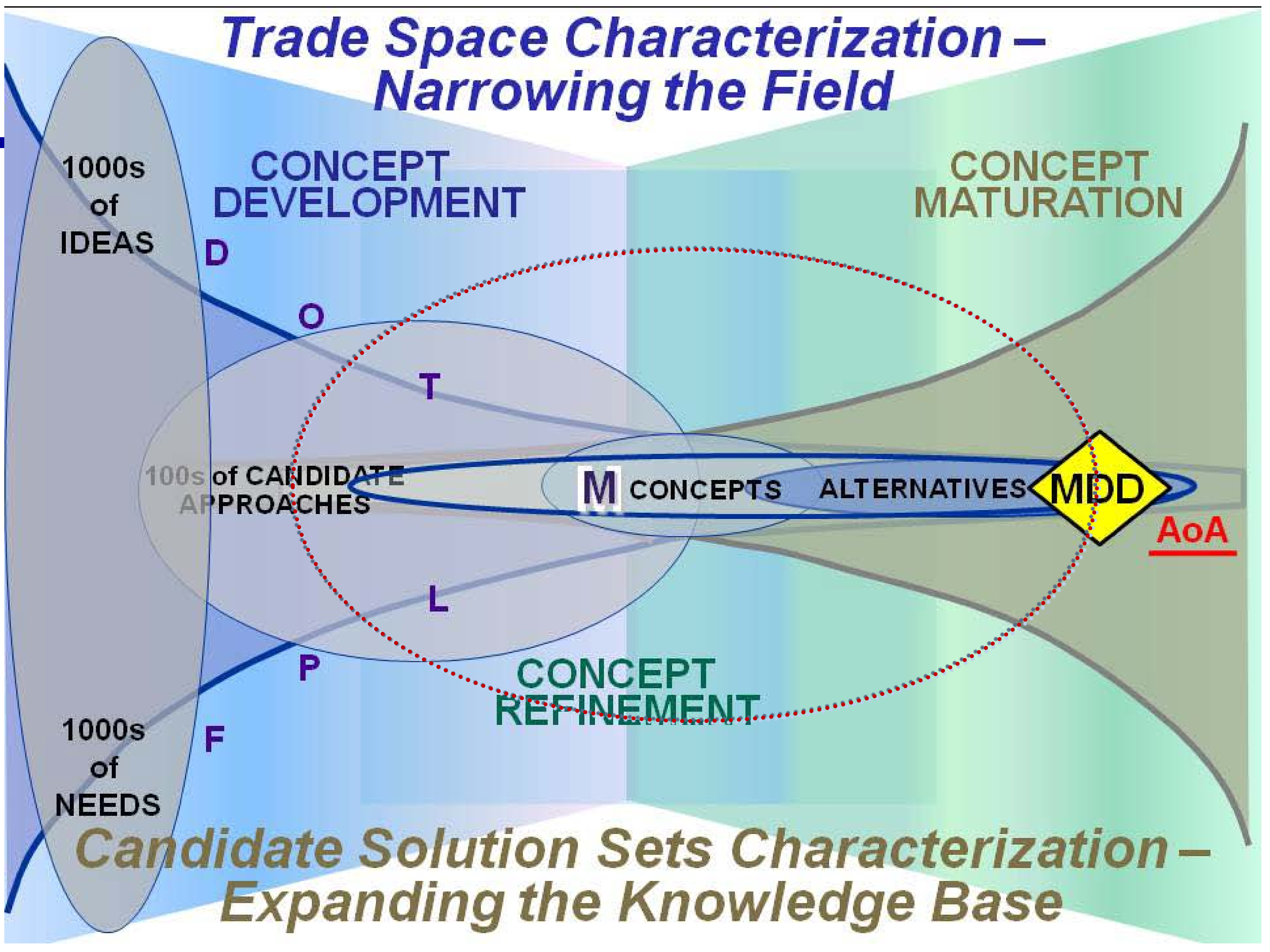
ICD – Initial Capabilities Document
DOTMLPF – Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, Facilities
DCR – DOT_LPF Change Recommendation
CDD – Capability Development Document
CCTD – Concept Characterization and Technical Description
RCT – Requirements Correlation Table



THE CHALLENGE
Filling the Space Between CBA and MDD



DEMANDS APPLICATION OF EARLY SE


Trade Space Characterization – Narrowing the Field
1000s of IDEAS
CONCEPT DEVELOPMENT
CONCEPT MATURATION
D
O
T
M
L
P
F
100s of CANDIDATE APPROACHES
CONCEPTS
ALTERNATIVES
MDD
AoA
CONCEPT REFINEMENT
1000s of NEEDS
Candidate Solution Sets Characterization – Expanding the Knowledge Base

AF Vision for Systems Engineering

- ***Disciplined, repeatable processes*** **from JCIDS CBA (pre-ICD) to AoA that result in Concept Characterization and Technical Descriptions (CCTD)**
  - **Inform decision makers on technical feasibility of prospective concepts for materiel solutions**
  - **Initial integrated risk assessment addressing both operational and programmatic issues**
- **Support realistic program formulation through application of early Systems Engineering**
  - **Robust and disciplined up-front technical planning**
  - **Solid technical foundation for the future program**
  - **Reduce the chances of poorly planned concepts emerging from AoA with relatively high rankings**

Clear, Actionable Policy & Process

Recent Early SE Guidance

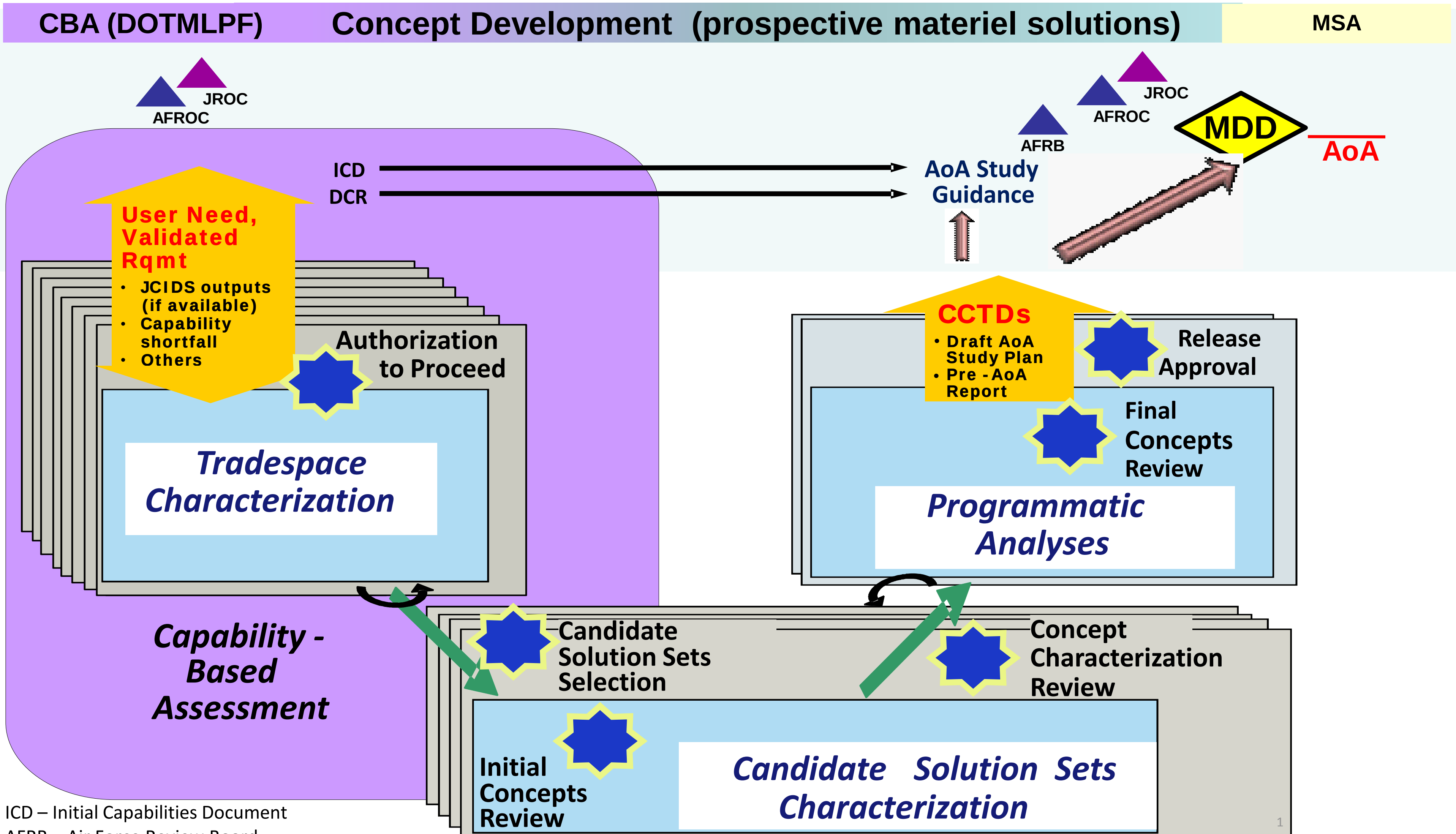
- **Guidance Memo: Early Systems Engineering Planning Documentation and Concept Characterization and Technical Description (CCTD) Implementation,** SAF/AQR, 19 Dec 08
  – Establishes requirements for pre-Milestone A technical planning and concept development
- **Guidance Memo: Organizational Systems Engineering Plan Implementation,** SAF/AQR, 19 Dec 08
  – Incorporates the CCTD memo amplifying the need to “ensure pre-program SE processes are incorporated into organizational Systems Engineering Plans”
- **Early Systems Engineering Guidebook,** SAF/AQR, Mar 09
  – Provides first definition of a CCTD

Concept Characterization and Technical Description (CCTD)

- Essentially the "concept spec" or initial technical baseline
- Evolves into the Technical Requirements Document / System Requirements Document (TRD / SRD)
- Principal Elements:
  1. Mission / Capability Need Statement / CONOPS
  2. Concept Overview
  3. Trade Space Definition / Characterization
  4. Studies, Analyses, Experiments
  5. Concept Characterization / Design
  6. Program Characterization
  7. Risk Assessment
  8. DOT_LPF Implications
  9. Conclusions (Capability Description; Traceability to Need Statement)

Annex A, Early Systems Engineering Guidebook, 31 March 09

Using CCTD elements to support "Concept Maturity"



ICD – Initial Capabilities Document
AFRB – Air Force Review Board
DOTMLPF – Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, Facilities
DCR – DOT_LPF Change Recommendation
JROC / AFROC – Joint / Air Force Requirements Oversight Council

Lessons Learned Along the Way

- Single AF leadership vision is essential
- CCTD construct will provide the basis for a formal technical analysis/assessment process to support MDD
- Development Planning efforts ongoing at Materiel Enterprise level -- CCTDs must "feed" these processes
- Engagement with MDA and D,CAPE is necessary to scope technical analysis expectations and efforts for each prospective program prior to its MDD
- We need an environment to develop collaborative solutions (user/materiel team/cost/others)

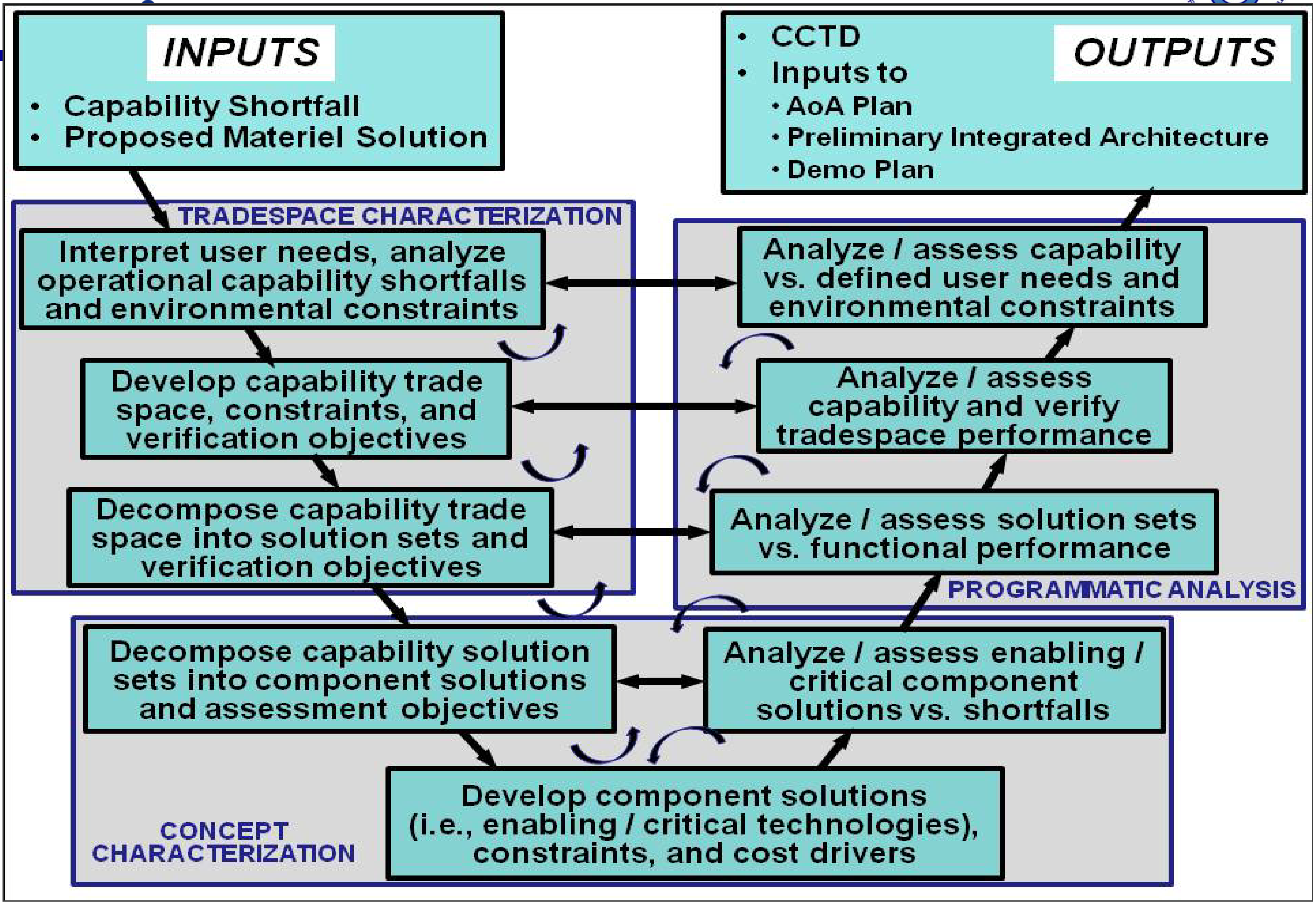
Collaborative SAF/AQR – Center for Systems Engineering Effort

AF Path Ahead

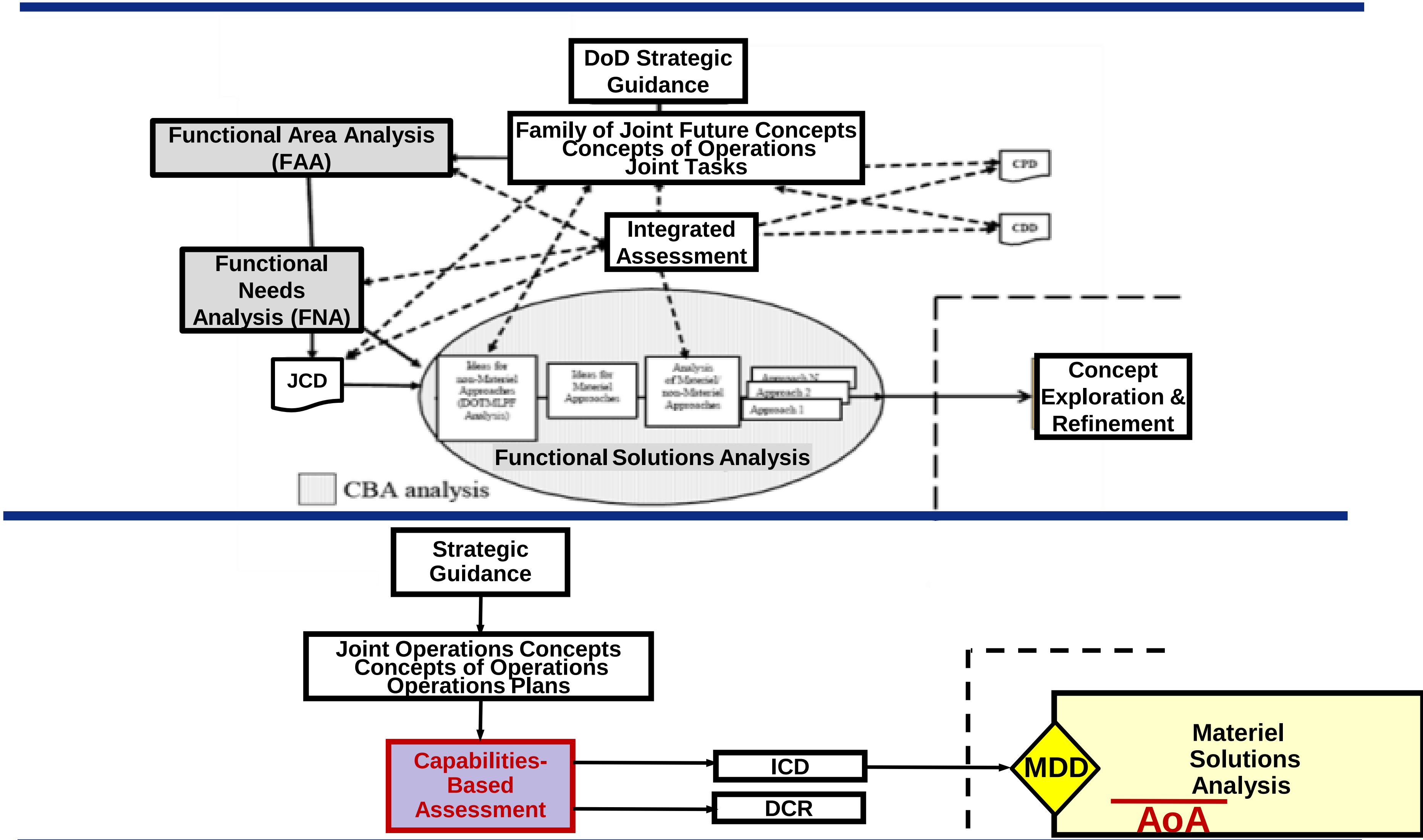
- **Institutionalize CCTD process across five Product Centers – *CURRENTLY IN WORK***
- **Clarify CCTD descriptions; develop Guidebook**
  - **Simplify implementation**
  - **Provide template for authors to follow**
- **Update Early SE Guide – set and enforce policy**
- **Flesh out "Collaborative Development Centers" concept for use across all Product Centers**
- **Address resource requirements**

QUESTIONS ?

SE “V” Diagram for Concept Development



Joint Capabilities Integration & Development System
CJCS 3170 Changes (Feb 09)



Concept Characterization and Technical Description (CCTD)

Early Systems Engineering Guidebook, Annex A, dated 31 March 2009

1.		Mission / Capability Need Statement / CONOPS
2.		Concept Overview
3.		Trade Space Definition / Characterization
	3.1	Top-Level Architecture
	3.2	Principal Interfaces
	3.3	Operating Regime
	3.4	Key System Parameters
4.		Studies, Analyses, Experiments
	4.1	Parametric Studies (*e.g.*, weight, power, cooling, throughput)
	4.2	Analyses (*e.g.*, HSI considerations, supportability concepts)
	4.3	Experiments
	4.4	Conclusions
5.		Concept Characterization / Design
	5.1	Common Analysis Assumptions
	5.2	Operating Regime
	5.3	Interfaces / Interoperability / System-of-Systems Approach
	5.4	Critical Subsystem Design and Sizing
	5.5	Supportability / Sustainment Features
	5.6	Configuration Summary
	5.7	Analysis Results
	5.8	Concept Design Conclusions (Capability Description)
6.		Program Characterization
	6.1	Critical Technologies
	6.2	Technology Maturation Approach
	6.3	Test & Evaluation / Verification & Validation Approach
	6.4	Prototyping Approach
	6.5	Manufacturing / Producibility Approach
	6.6	Sustainment / Supportability Approach
	6.7	Schedule Assumptions
	6.8	Cost Analysis Assumptions
	6.9	Cost Estimates
7.		Risk Assessment
8.		DOT_LPF Implications
9.		Conclusions (Capability Description; Traceability to Need Statement)

Updated CCTD Content (from 5-6 Aug Concept Maturity Workshop)

1.		**Mission/Capability Need Statement/CONOPS (MOEs)**
	1.1	Stakeholders
2.		**Concept Overview (OV-1)**
3.		**Trade Space Characterization**
	3.1	Scope
	3.2	Assumptions and Constraints
	3.3	Interfaces
	3.4	Operating Environment (Draft Enabling CONOPS,
	3.5	Key Parameters / Attributes / MOPs
	3.6	Compliance Issues
4.		**Evaluation (Studies, Analyses, Experiments)**
	4.1	Common Assumptions & Methodologies
	4.2	Parametric Studies
	4.3	Analyses
	4.4	Experiments
	4.5	Modeling & Simulation (and Associated Data)
	4.6	Evaluation Results
	4.7	Conclusions
5.		**Concept Characterization / Design**
	5.1	Design Description & Variants
	5.2	Concept of Employment
	5.3	Architecture Considerations (Interfaces/Interoperability/SoS Approach/Integration)
	5.4	Critical Design Constraints
	5.5	Critical Technology Elements
	5.6	Supportability / Sustainment / Logistics Features
	5.7	Cost Drivers
	5.8	Required Enabling Capabilities (Human Systems Integration [HSI], communications, intelligence, etc)
6.		**Program Characterization**
	6.1	Critical Technologies (including S&T needs / feed-forward)
	6.2	Technology Maturation Approach
	6.3	T&E/V&V Approach
	6.4	Prototyping Approach
	6.5	Manufacturing / Producibility Approach
	6.6	Sustainment / Supportability Approach
	6.7	Other Relevant Considerations (intel, HSI, security, etc.)
	6.8	Schedule Assumptions/ethodologies (IOC from ICD)
	6.9	Cost Analysis Assumptions and Methodologies
	6.10	Cost Estimates
7.		**Risk Assessment and Decision-Certain Consequences**
	7.1	Operational Risk
	7.2	Program Risk
	7.3	Technology Risk
8.		**DOT_LPF Implications and other interdependencies**
9.		**Conclusions (Capability Description; Traceability to Need Statement)**

C-17 Transition to Criteria-based Airworthiness Certification

Mr. Marty Steiger, PhD
C-17 Avionics/Flight Controls IPT
Systems Engineer
Herbert.M.Steiger@Boeing.com

Mr. Michael McKinney
C-17 Air Vehicle IPT
Lead Systems Engineer
Michael.J.McKinney@Boeing.com

Mr. Christian Stillings
516 AESG Capabilities IPT
Lead Systems Engineer
A.Stillings@US.AF.MIL

Program Airworthiness Certification History

- Jan/1995 – C-17 Initial Operational Capability (IOC)
- May/1995 – Official certification record from USAF released after FCA/PCA/FQR conducted in March
  - Letter 2108-95-2708, dated 09 May 1995
- Jul/2003 – C-17 Aircraft airworthiness certified by ASC/YC (P-70)
  - AFPD 62-6, USAF Aircraft Airworthiness Certification
  - Legacy system certification procedure in MIL-HDBK-514 (OSS&E)
- 2010 – AFPD 62-6 / AFI 62-601 updates on the horizon
  - Design-based airworthiness certification based on MIL-HDBK-516 criteria
    - » *TACC/MACC is certification basis*
  - ASC/EN as independent Technical Airworthiness Authority (TAA)
    - » *Approval authority for TACC/MACC*

TACC/MACC Scope

- Tailored Airworthiness Certification Criteria (TACC)
  - Documents airworthiness criteria, requirements, and methods of compliance (MOC) used in development of an air vehicle system
- Modification Airworthiness Certification Criteria (MACC)
  - Documents airworthiness criteria, requirements, and methods of compliance used in development of a *reportable modification*
  - MACC is a transient document folded into TACC

C-17 Block Upgrade/Reportable Modification

- C-17 has on-going Air Vehicle changes/upgrades:
  - PE/PI (Performance Enhancement/Product Improvement) projects
  - GSP (Globemaster III Sustainment Partnership) projects
  - A C-17 Block Upgrade is a configuration change to implement new or improved capabilities resulting from multiple projects (reportable modification)
- C-17 reportable modifications will be captured in a MACC for each Block Upgrade
- C-17 developed a TACC using 516B (released in 2005, superseded 516A)
  - A baseline for future MACCs
  - Risk reduction/complete learning

C-17 TACC – SG Experience

- **2005-2007 – TACC Development Challenges**
  - — Insufficient familiarity with MIL-HDBK-516B criteria, C-17 specifications, and their relationships
  - — Inconsistent traceability analysis
  - — Legacy systems documents not leveraged to support analysis
    - » Criteria not accounted for when not directly traceable to SS & AVS
  - — MOCs not adequately addressed
- **2008 – Reverse trace to ensure that all C-17 top level specs had been considered**
  - — Increased understanding of 516 scope
    - » Accounted for more criteria
  - — Identified mismatched system/subsystem mappings between 516 and C-17 specs
  - — Discovered spec appendices were omitted

C-17 TACC – Joint Initiative

- **2008 - SG & Boeing initiated joint TACC development**
  - — **Small expert team approach**
    - » **Familiarity with 516 criteria and C-17 specs/design, process, and documents**
    - » **Consistency control on traceability and MOC analysis**
    - » **Experience with legacy system airworthiness process**
  - — **Used DOORS tool to**
    - » **Establish a controlled, structured environment**
    - » **Facilitate traceability management and reporting**
    - » **Ensure data integrity**
    - » **Provide reusability for future MACCs**

C-17 TACC – Approval

- **May/2009 - SG signed C-17 TACC, establishing a baseline for future MACCs**
  - — **Critical Traceability Documented**
  - — **Environment Established**
  - — **Corporate Knowledge Enhanced**
  - — **FMS Support (Air-to-Air Refuel, Airdrop AW Reviews)**
  - — **Cultural Change**
    - » **Change in documentation method for Airworthiness**
    - » **Complying with the Intent of modern guidance**

C-17 Airworthiness Considerations

- **Reportable modification requires Airworthiness Plan, IAW AFI 62-601**
  - — **Approach to obtaining and maintaining airworthiness certification, including Risk Plan**
  - — **Certification basis development, coordination, and approval process**
  - — **First flight review activities and flight test program envelope expansion approach**
  - — **Description of airworthiness related entrance and exit criteria for major program reviews**
- **Final MACC for TAA approval required to show**
  - — **MOC verification References**
  - — **Summary of any noncompliance to the certification basis along with an estimate of the associated risk**

Potential Risk Items/Initiatives

- **Potential areas for risk analysis**
  - 4.2 Tools and databases
  - 4.6 Configuration identification
  - 4.7 Configuration status accounting
  - 14.3 Software safety program
  - 15.1 Air vehicle processing architecture
- **C-17 initiatives making incremental process improvements**
  - System level AIRVER (Airworthiness Verification)
  - Software Safety Assurance Plan
  - Ground test facility qualification for system safety requirements

Future Program Airworthiness Activities

- Develop an Airworthiness Plan
- Create an Operational Instruction for analyzing reportable modifications
- Develop MACC as airworthiness certification basis for Block Upgrade
  - Start with the C-17 TACC
    - Add/revise requirements traceability
    - Update impacted MOC's
  - Leverage on existing setup in DOORS
- Continue C-17 process improvements

Conclusion

- **C-17 TACC development is beneficial**
  - **Critical learning experience, facilitates project training**
  - **Baseline for MACC generation**
  - **Supports FMS customers**
- **C-17 system specs/design, discipline, processes, and documents demonstrate strong relationships with 516 criteria**
- **C-17 is making incremental process improvements**
- **C-17 airworthiness moving towards latest industry standards by transitioning to 516B**

Human Systems Integration What is It? Why Should We Do It?

Stuart T. Booth

Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

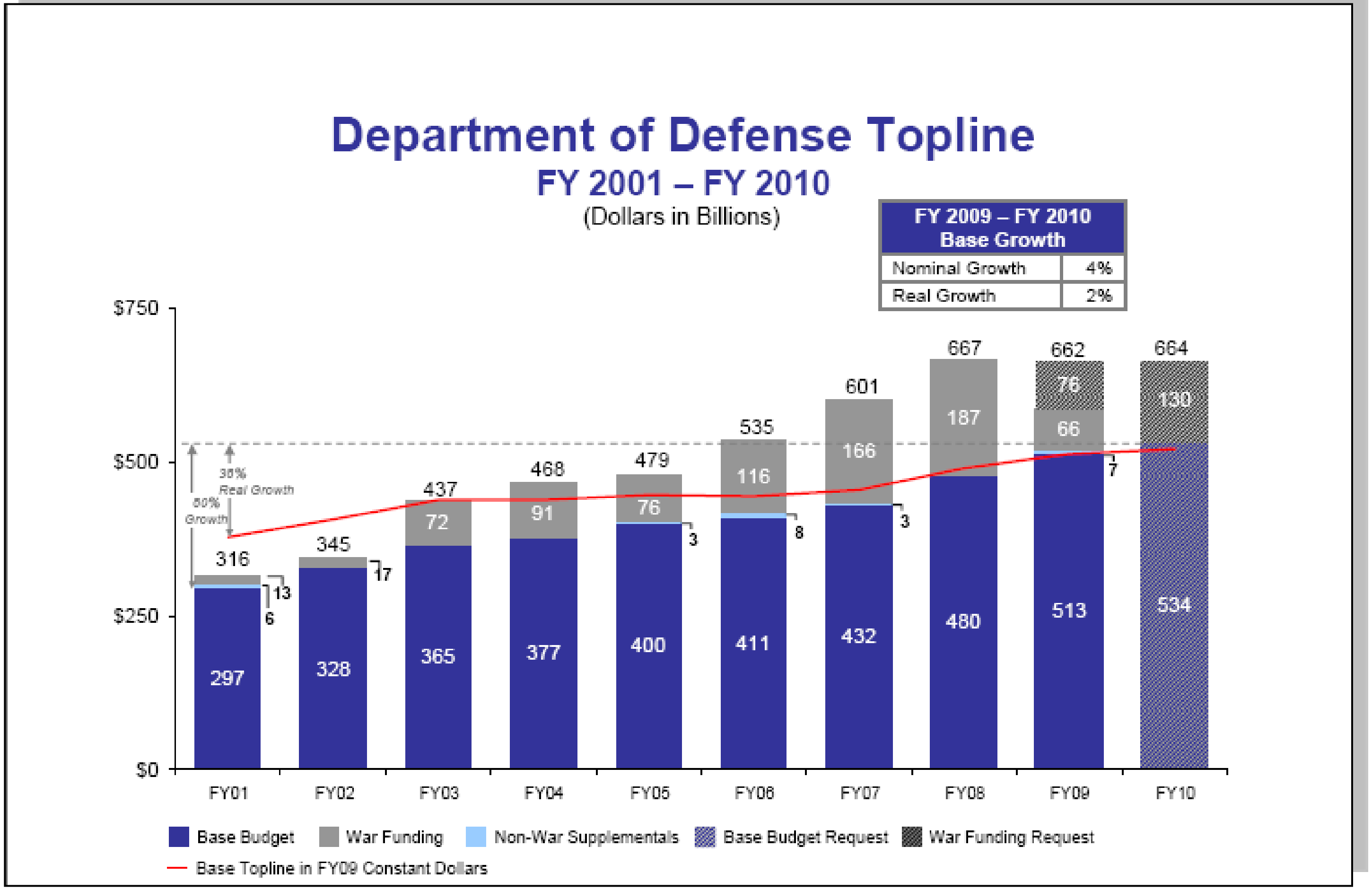
12th Annual NDIA Systems Engineering Conference
October 28, 2009

UNCLASSIFIED

Outline

- Examine Human Component of the Defense Budget
- Summarize “What Is” Human Systems Integration (HSI)
- Summarize DoD HSI Policy
- Address the Role of the Human and the “System”
- Address How Much HSI is Enough
- Discuss Several HSI Success Stories
- Discuss DoD Efforts to Better Organize and Align HSI Efforts

DoD Defense Budget



Focusing on FY09 and FY10…… Base Budget > $500B (see next slide)

Ref: http://www.defenselink.mil/news/FY10%20Budget%20Request.pdf

Human Aspect of the Defense Budget…It's Really Big!

Summary By Appropriation Title

(Dollars in Billions)

Appropriation Title	FY 2009	FY 2010	Δ FY 2009 – FY 2010
Military Personnel	124.9	136.0	+8.9%
Operation & Maintenance	179.1	185.7	+3.7%
Procurement	101.7	107.4	+5.6%
RDT&E	79.5	78.6	-1.1%
Military Construction	21.9	21.0	-4.1%
Family Housing	3.2	2.0	-38.0%
Other	3.2	3.1	-1.1%
Total	513.3	533.8	+4.0%

We need to be smart when we think about the human dimension and the DoD Enterprise.

Ref: http://www.defenselink.mil/news/FY10%20Budget%20Request.pdf

HSI Domains

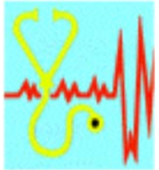
MANPOWER - number of military and civilian personnel required and potentially available to operate, maintain, sustain and provide training for systems

PERSONNEL - cognitive and physical capabilities require to train, operate, maintain and sustain material and information systems

TRAINING - instruction, education, and OJT required to provide personnel and units with their essential job skills, knowledge, values and attitudes.

SURVIVABILITY - characteristics of system that can reduce fratricide, detectability, and probability of attack, as well as minimizing system damage, personal injury, and cognitive and physical fatigue

SAFETY - design and operating characteristics of a system that minimize the human or machine errors or failures that cause accidents



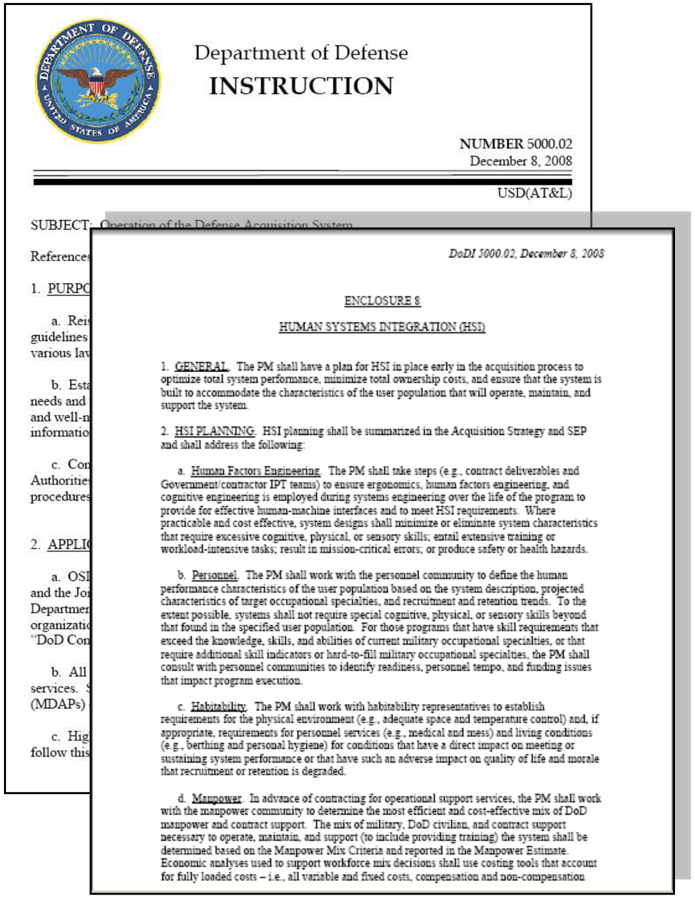
OCCUPATIONAL HEALTH - design and operating characteristics of a system that create significant risks of bodily injury or death; sources of health hazards include: loud noise, chemical and biological substances, extreme temperatures, and radiation energy.

HUMAN FACTORS ENGINEERING - integration of characteristics into system definition, design, development and evaluation to optimize human-machine performance

HABITABILITY – establish requirements for physical environment (e.g. , adequate space and temperature control) and, if appropriate, requirements for personnel services (e.g., medical and mess) living conditions that have a direct impact on meeting or sustaining system performance.

HSI Policy and Guidance

Policy: DoD Acquisition Management System



Department of Defense
INSTRUCTION

NUMBER 5000.02
December 8, 2008

USD(AT&L)

SUBJECT: Operation of the Defense Acquisition System

References

1. PURPO

a. Rei guidelines various lav

b. Esta needs and and well-n informatio

c. Con Authoritie procedures

2. APPLIC

a. OSI and the Joi Departmen organizatio "DoD Con

b. All services. S (MDAPs)

c. Hig follow this

DoDI 5000.02, December 8, 2008

ENCLOSURE 8

HUMAN SYSTEMS INTEGRATION (HSI)

1. GENERAL. 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.

2. HSI PLANNING. HSI planning shall be summarized in the Acquisition Strategy and SEP and shall address the following:

a. Human Factors Engineering. The PM shall take steps (e.g., contract deliverables and Government/contractor IPT teams) to ensure ergonomics, human factors engineering, and cognitive engineering is employed during systems engineering over the life of the program to provide for effective human-machine interfaces and to meet HSI requirements. Where practicable and cost effective, system designs shall minimize or eliminate system characteristics that require excessive cognitive, physical, or sensory skills; entail extensive training or workload-intensive tasks; result in mission-critical errors; or produce safety or health hazards.

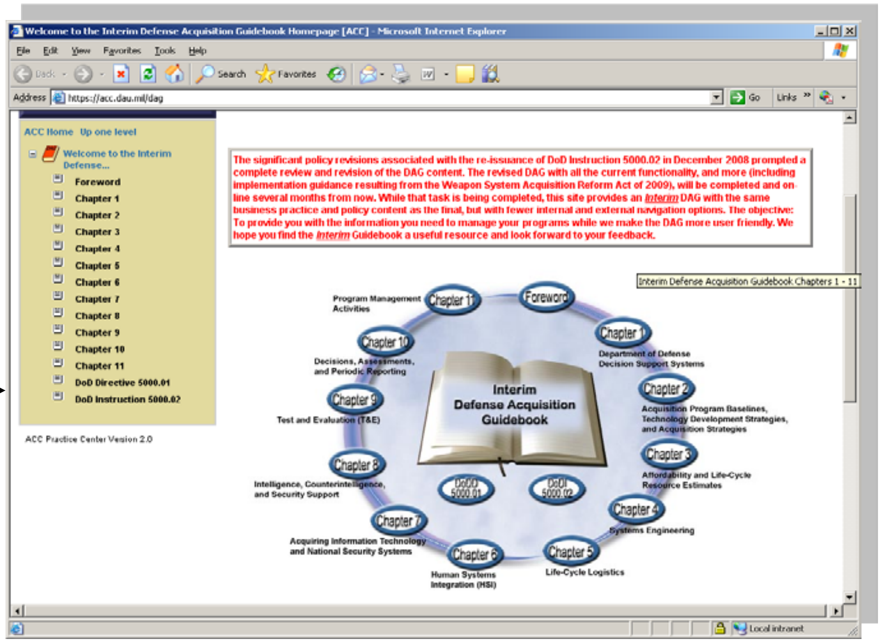
b. Personnel. The PM shall work with the personnel community to define the human performance characteristics of the user population based on the system description, projected characteristics of target occupational specialties, and recruitment and retention trends. To the extent possible, systems shall not require special cognitive, physical, or sensory skills beyond that found in the specified user population. For those programs that have skill requirements that exceed the knowledge, skills, and abilities of current military occupational specialties, or that require additional skill indicators or hard-to-fill military occupational specialties, the PM shall consult with personnel communities to identify readiness, personnel tempo, and funding issues that impact program execution.

c. Habitability. The PM shall work with habitability representatives to establish requirements for the physical environment (e.g., adequate space and temperature control) and, if appropriate, requirements for personnel services (e.g., medical and mess) and living conditions (e.g., berthing and personal hygiene) for conditions that have a direct impact on meeting or sustaining system performance or that have such an adverse impact on quality of life and morale that recruitment or retention is degraded.

d. Manpower. In advance of contracting for operational support services, the PM shall work with the manpower community to determine the most efficient and cost-effective mix of DoD manpower and contract support. The mix of military, DoD civilian, and contract support necessary to operate, maintain, and support (to include providing training) the system shall be determined based on the Manpower Mix Criteria and reported in the Manpower Estimate. Economic analyses used to support workforce mix decisions shall use costing tools that account for fully loaded costs – i.e., all variable and fixed costs, compensation and non-compensation

DoDI 5000.02 Enclosure (8)

Defense Acquisition Guidebook (DAG)



DAG Ch 6 Human Systems Integration (HSI)
https://acc.dau.mil/dagch6/

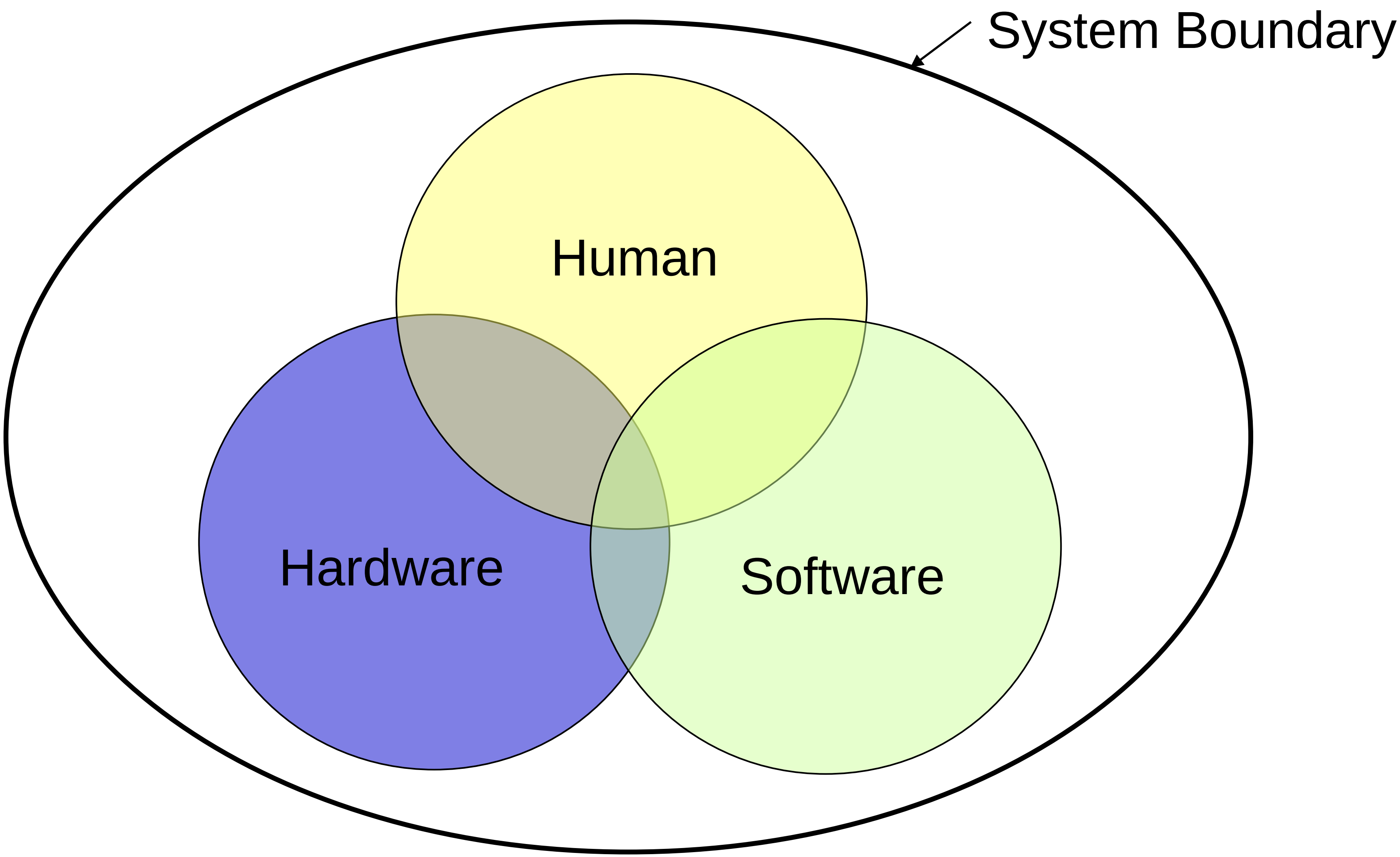
UNCLASSIFIED

DoD Acquisition Policy

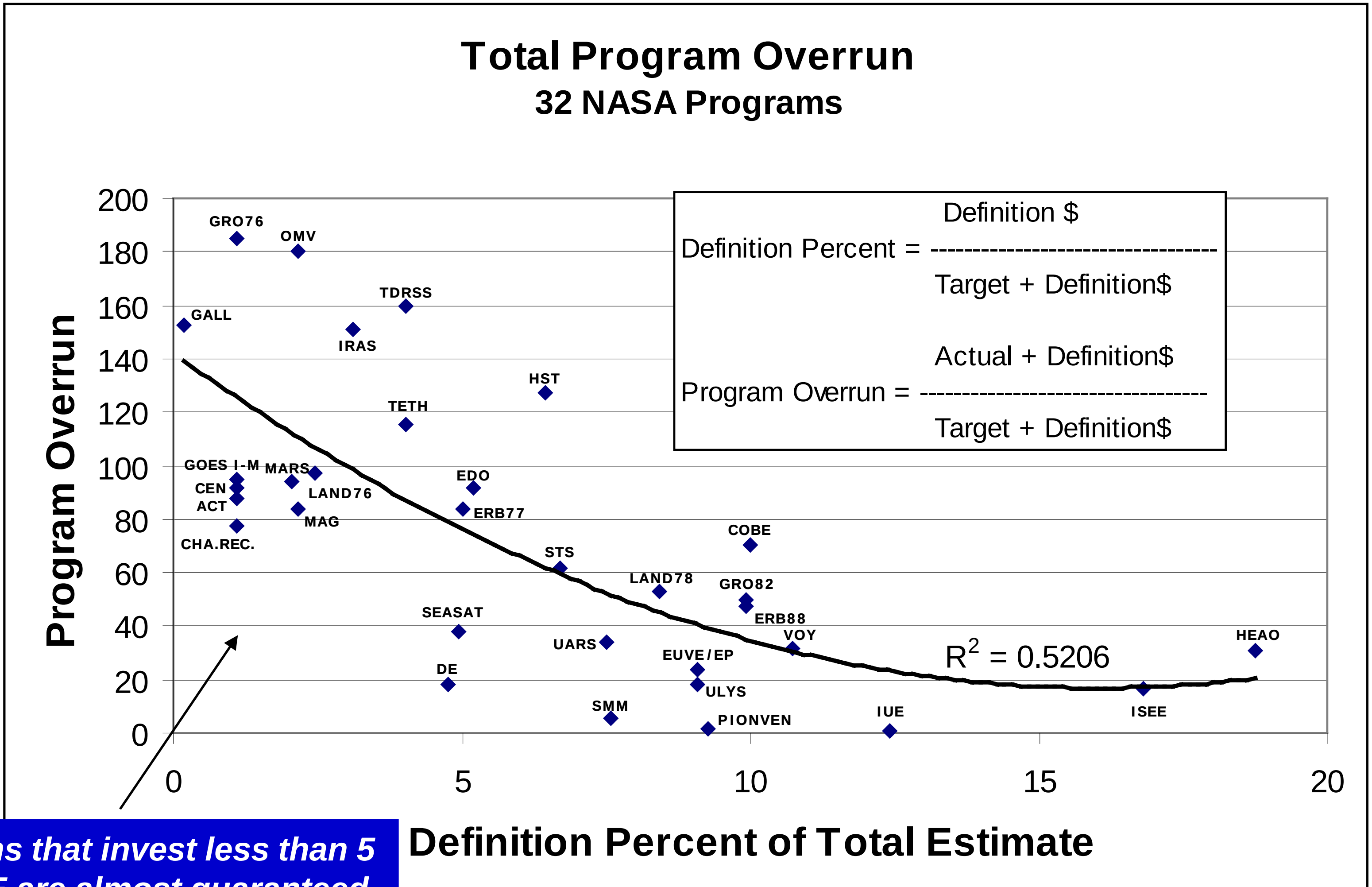
"The PM shall have a plan for HSI in place early in the acquisition process to **optimize total system performance**, **minimize total ownership costs**, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system."

DoDI 5000.02: Operation of the Defense Acquisition System, Enclosure (8)

The Human is Part of the System



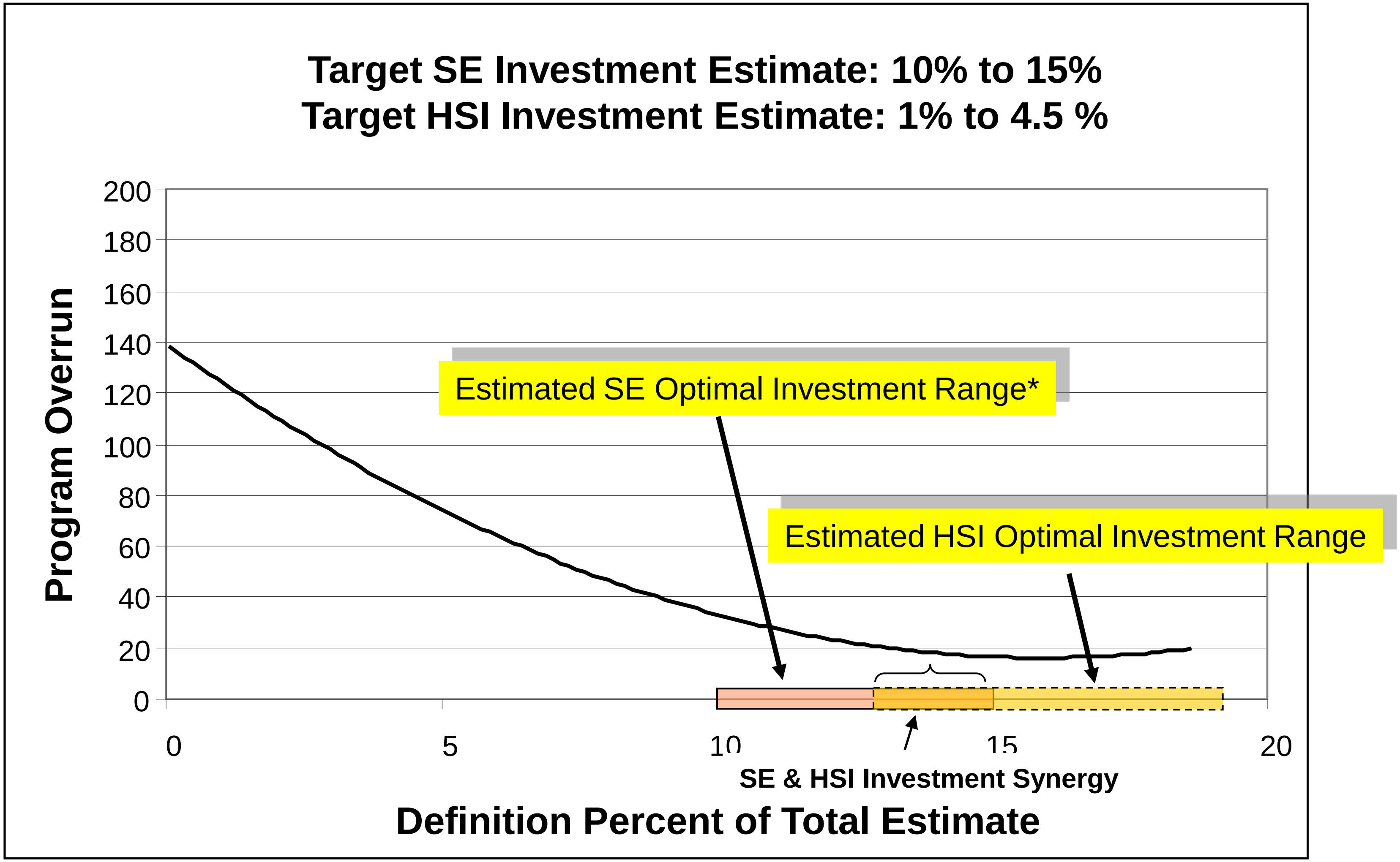
NASA SE Investment Analysis



Programs that invest less than 5 % on SE are almost guaranteed an 80% or greater overrun.

Source Werner Gruhl, 1992
NASA Comptroller's Office

Consolidated SE and Design Consideration (e.g. HSI) Investment Outlook



*Ref: Impact of SE at NASA (SECOE 02-02) http://www.incose.org/secoe/

UNCLASSIFIED

Technical and Technical Management Processes for Engineering a System

Technical Management Processes

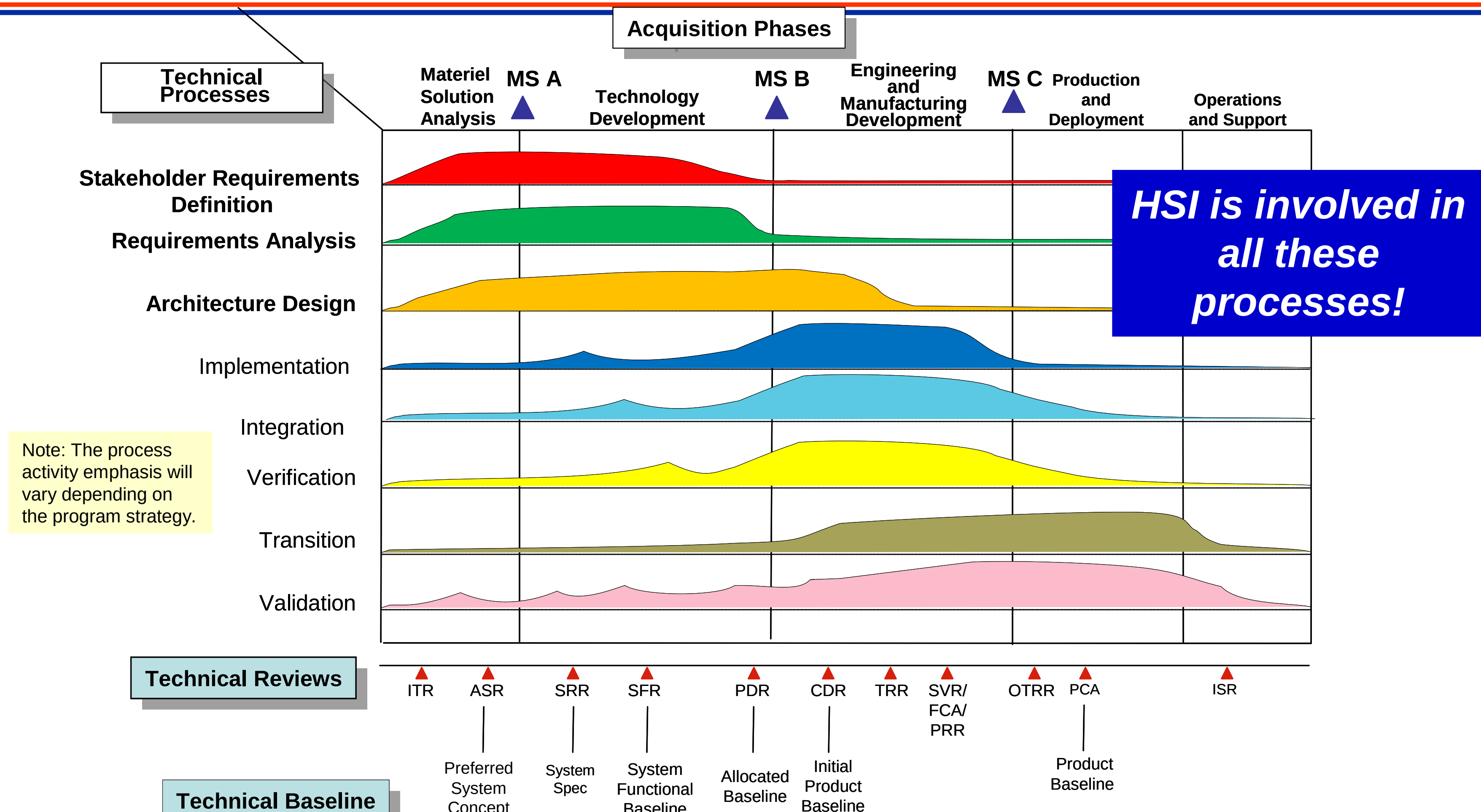
- Decision Analysis
- Technical Planning
- Technical Assessment
- Requirements Management
- Risk Management
- Configuration Management
- Technical Data Management
- Interface Management

Technical Processes

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

The respective overarching technical processes (that include HSI) are iterative, concurrent, & integrated …and the processes are applied with different emphasis over the program development life cycle.

Technical Processes
Notional Emphasis of Activity



ITR - Initial Technical Review
ASR- Alternative Systems Review
SRR - System Requirements Review
SFR – System Functional Review
PDR – Preliminary Design Review
CDR – Critical Design Review

SVR – System Verification Review
TRR- Test Readiness Review
FCA- Functional Configuration Audit
PRR – Product Readiness Review
OTRR – Operational Test Readiness Review
PCA – Physical Configuration Audit
ISR – In-Service Review

UNCLASSIFIED

HSI Success Stories

Lightweight 155mm Howitzer

HRED Contributions:

- Human Factors Evaluation
- Task Network Modeling & Validation
- Human Figure Modeling
- Concept Design, Fabrication Evaluation
- Operational Assessment

REQUIREMENTS RISK REDUCTION

FUNCTION	SHOOT-OFF	JORD	IMPRINT
EMPLACEMENT (firm soil)	284 sec	180 sec	184 - 202 sec
EMPLACEMENT (loose soil)		180 sec	138 - 152 sec
DISPLACEMENT	176 sec	120 sec	120 - 134 sec
RATE-OF-FIRE (for 2 min)	4.2rd/min	5.0 rds/min	4.1 - 4.5 rds/min (1)
BOLD SHIFT	423+ sec	180 sec	172 - 204 sec (2)
1ST RD RESPONSE LOW ANGLE	41 sec	30 sec	27- 30 sec (3)
1ST RD RESPONSE HIGH ANGLE	56 sec	45 sec	45 - 49 sec (3)

(1) assumes bang-to-bang and first round free
(2) f(soil); may need 7 crewmen in sand & mud
(3) worst case QE (800 LO, 1200 HI); lower QE will have lower times

JPM XM777 estimates $6.2M cost avoidance due to MANPRINT efforts

9

F-22 Maintenance Study

U.S. AIR FORCE

Domains affected: manpower, personnel, training

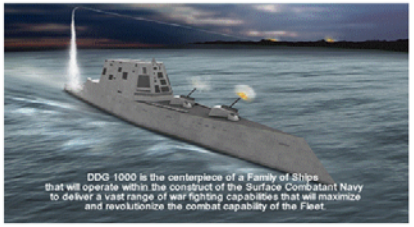
- 1995-1996 IMPACT analysis for Rivet Workforce
  - How many maintenance specialties can be "rivetted" together?
- Predecessor F-16 system had 15
- Study looked at 10, 7, and 5
- Max compression of 5 specialties reduced manpower cost but raised training cost for life of F-22
- "Sweet spot" was 10 specialties

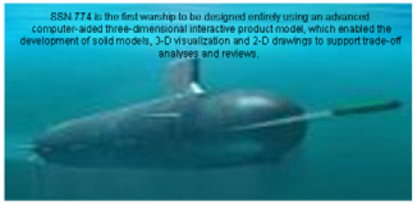
- $2M overall investment
  - Manpower, personnel, and training decision support system (MPT-DSS)
- $777M overall savings
  - $335M saved on Maintenance AFSC structure and training
  - $442M saved on ACC maintenance organization restructure
- Return on investment 388:1 in life cycle cost avoidance
- MPT-DSS recommended and used in JSF decision making

Integrity - Service - Excellence

13

HSI Success: DDG1000 & VA Class Submarine



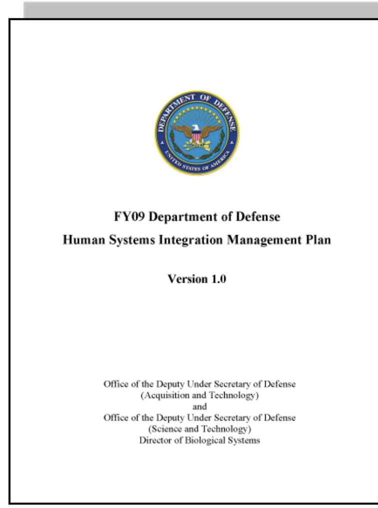


- High HSI impact for both programs:
  - Reduced manning costs
  - Manpower / Workload reductions
  - Survivability, Safety, Health Hazard Risk avoidance
  - Performance enhancement
  - Cross domain use of task and role analysis
- Fleet brought in early to identify design hazards, proposing modifications to optimize design for human performance
- DDG 1000 leveraged human performance modeling very early in system design to explore impact of manning concepts, automation technologies, and other system design concepts on crew ability perform the mission.
- VA Class Submarine identified life cycle cost avoidance, safety, human performance enhancement

14

DoD HSI Plan

Objectives:
- Foster communication
- Address common need areas
- Describe how HSI is implemented
- Report on progress against plan
- Foster consistency where it makes sense



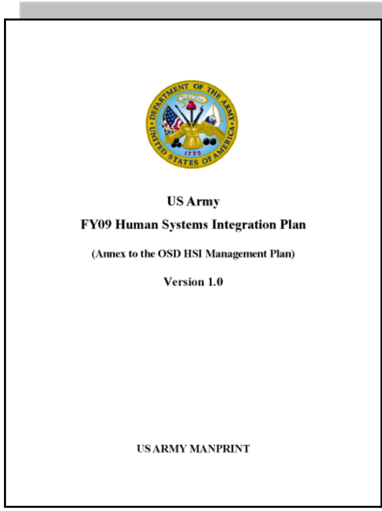
FY09 Department of Defense
Human Systems Integration Management Plan

Version 1.0

Office of the Deputy Under Secretary of Defense
(Acquisition and Technology)
and
Office of the Deputy Under Secretary of Defense
(Science and Technology)
Director of Biological Systems

Summary Outline
- HSI Organization
- Roles and Responsibilities
- Lifecycle Process
- HSI Acquisition Integration
- HSI Human Capital Development
- FY09 Key Tasks
- FY09 Schedule
- Resource Requirements
- Maturity and Effectiveness Metrics
- Assessment Process

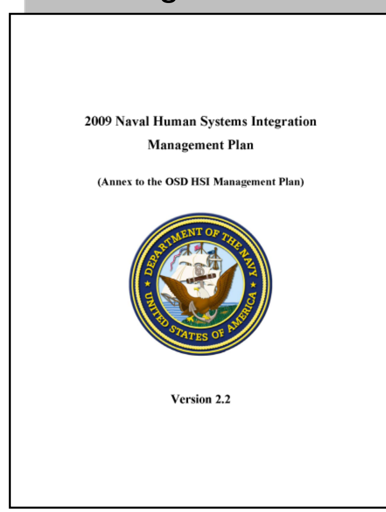
Army HSI Mgmt Plan Annex



US Army
FY09 Human Systems Integration Plan
(Annex to the OSD HSI Management Plan)
Version 1.0

US ARMY MANPRINT

Naval HSI Mgmt Plan Annex

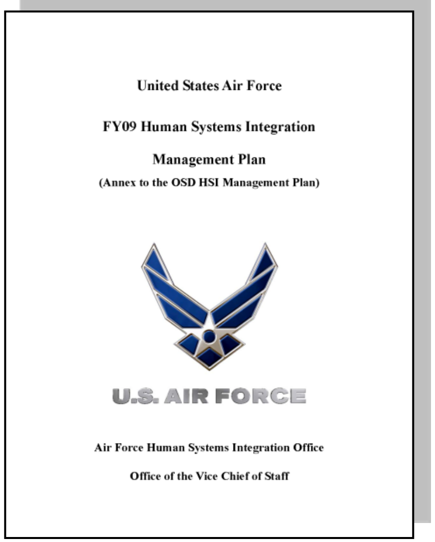


2009 Naval Human Systems Integration
Management Plan

(Annex to the OSD HSI Management Plan)

Version 2.2

Air Force HSI Mgmt Plan Annex



United States Air Force

FY09 Human Systems Integration

Management Plan
(Annex to the OSD HSI Management Plan)

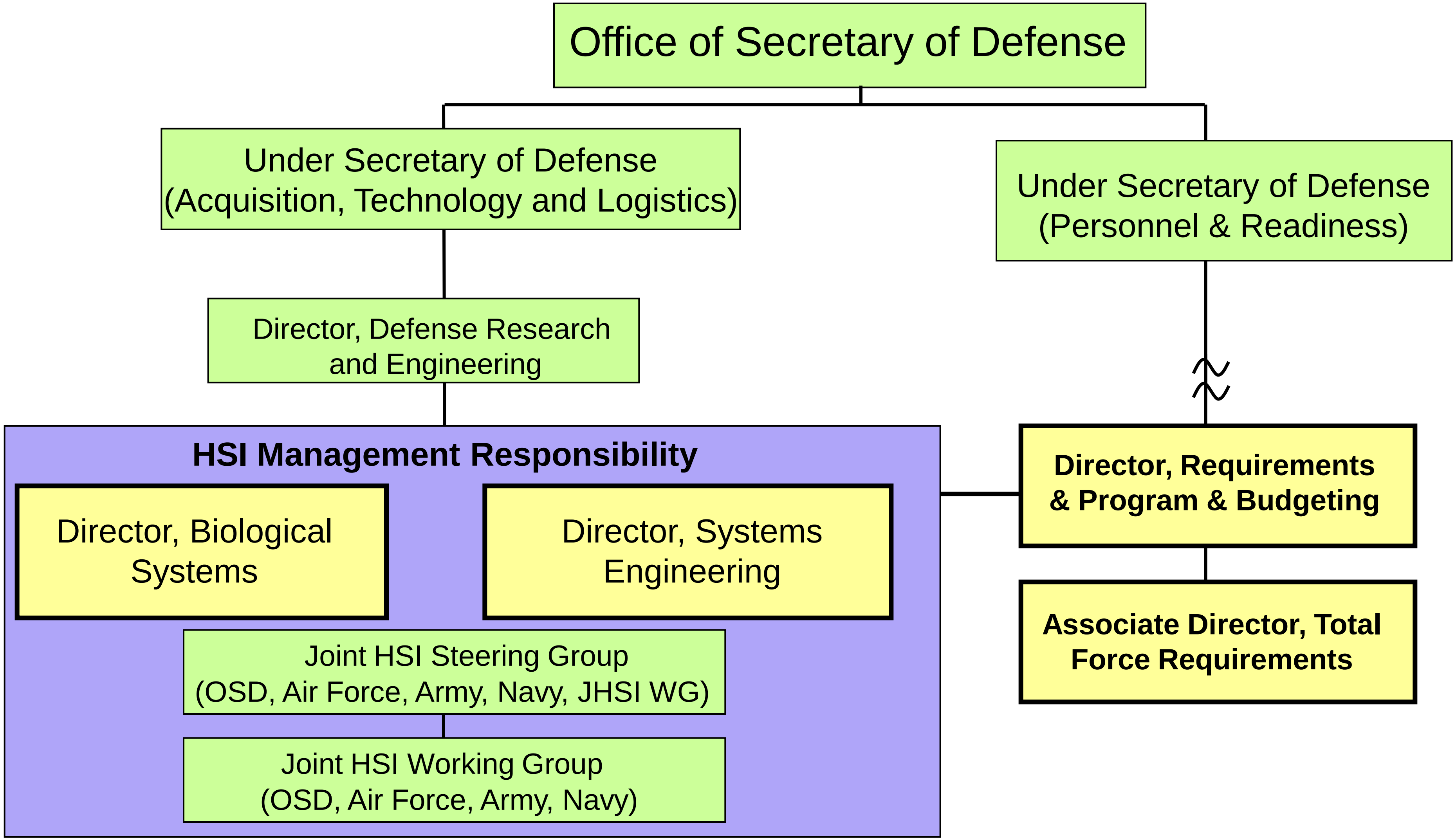
U.S. AIR FORCE

Air Force Human Systems Integration Office

Office of the Vice Chief of Staff

UNCLASSIFIED

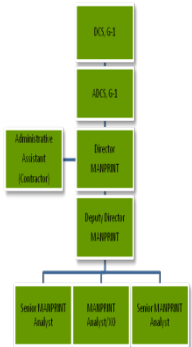
OSD HSI Organization

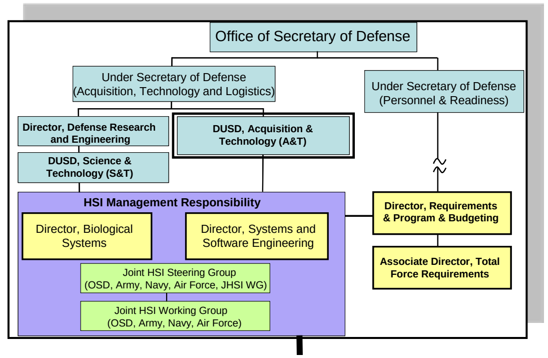


UNCLASSIFIED

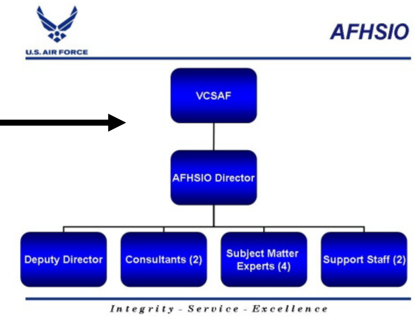
DoD HSI Acquisition Implementation

Army MANPRINT Program

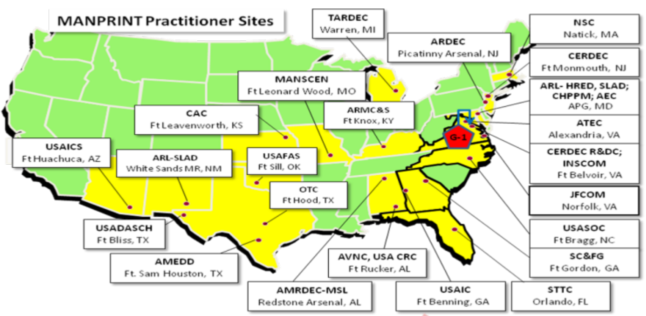


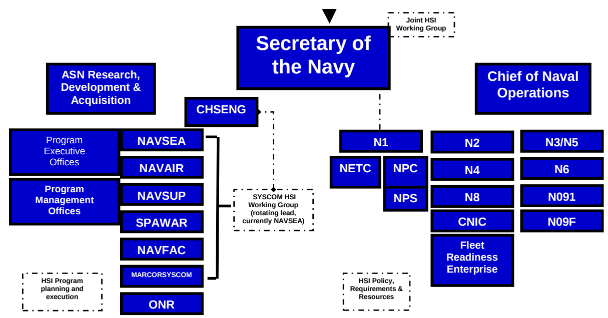


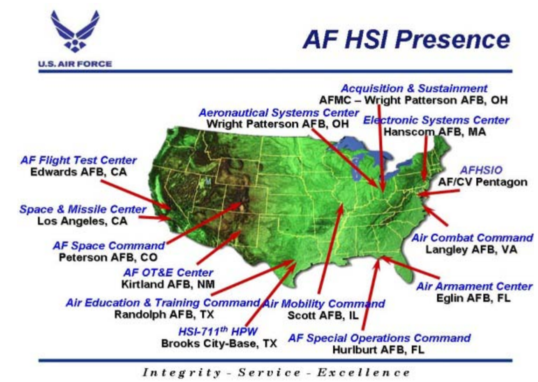
Air Force HSI Program

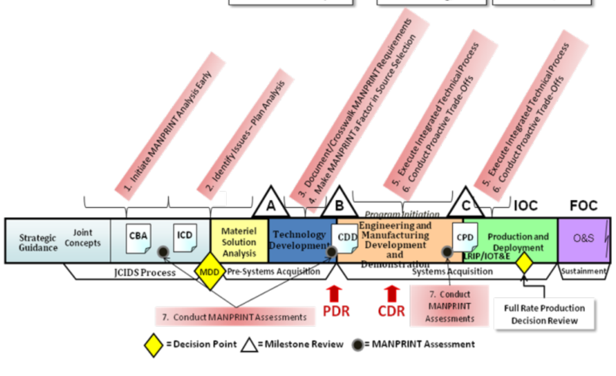


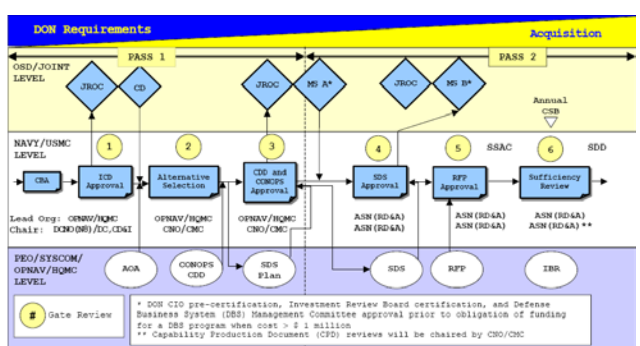
NAVPRINT Program

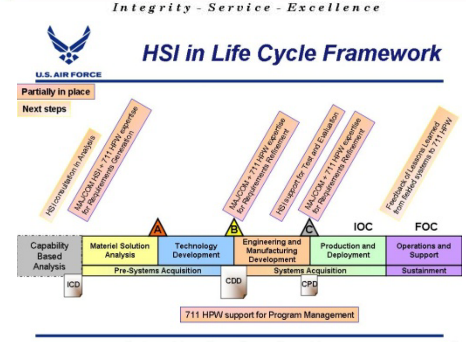












UNCLASSIFIED

Summary

- The Human Component is a significant portion of the overall defense budget.
- HSI is a strategy to optimize total system performance and minimize total ownership costs.
- HSI is part of Systems Engineering.
- The DoD HSI Management Plan is intended to better organize and align efforts within acquisition.

Thank You!

For Info:
Stuart Booth
stuart.booth.ctr@osd.mil

Tactical Planning at Program Start-Up

Guiding Projects Toward Excellence in Execution

Gerry Becker, PMP
Harris Corporation

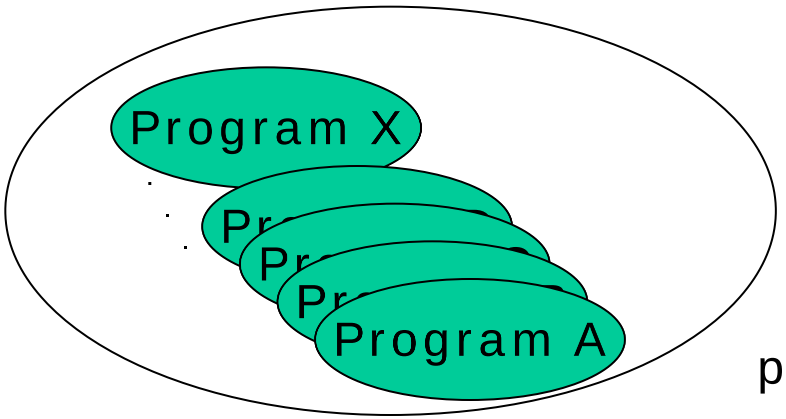
Agenda

- How did Boots Come About?
- What is Boots?
- How Boots Works
- What Boots Does Not Provide
- Assessment Tools
- Hurdles
- Summary
- Backup Information

- Acronyms
  - GCSD – Government Communications System Division
  - DPG – Division Process Group

How did Boots Come About?

Program Teams



GCSD Programs are empowered to execute within the bounds of the customer contract

Some programs performed better than others

Reactive support was given to programs that did not perform well

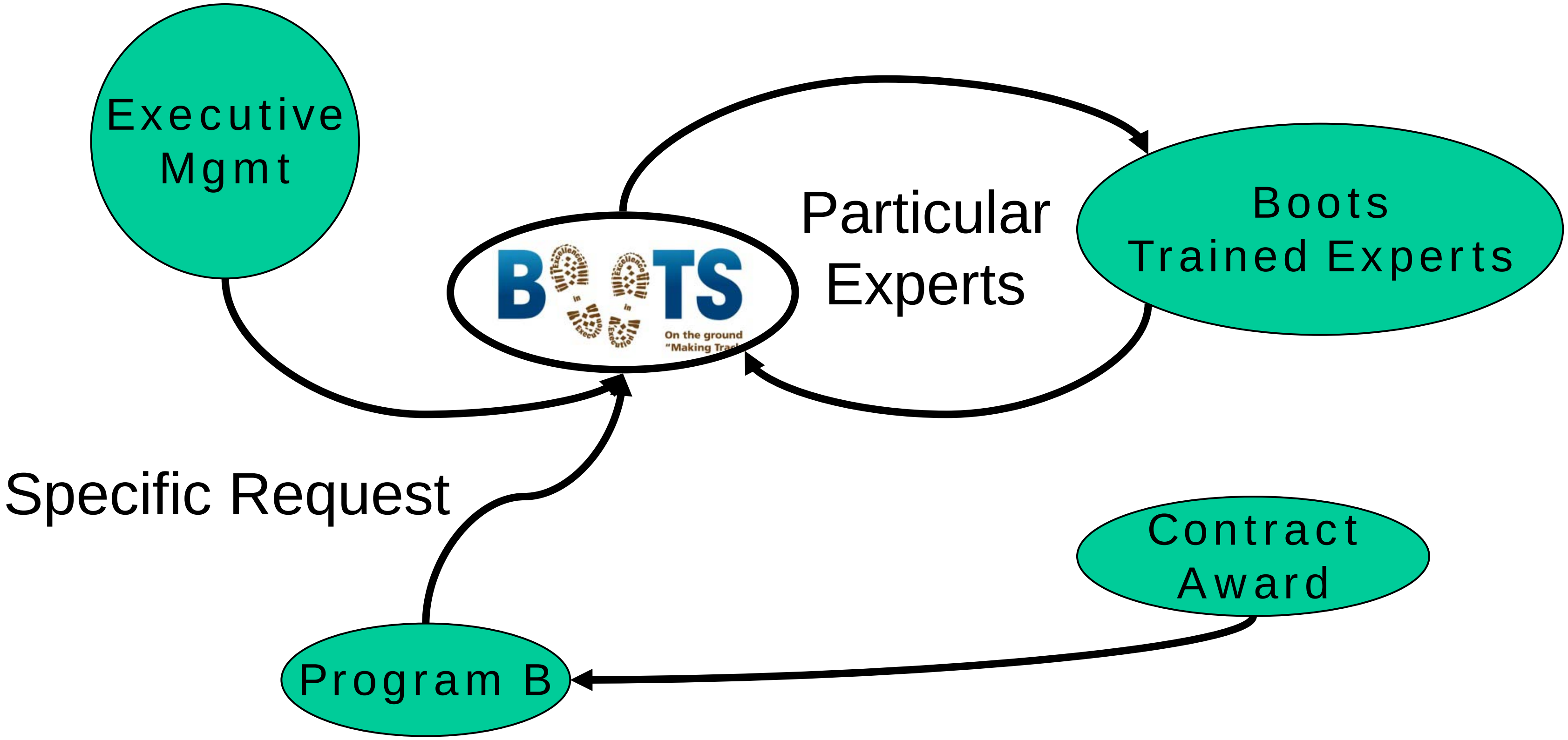
June 2007 - “When are we going to stop trying to fix red programs and start getting programs off on the right foot?”

The Concept For Boots Was Formed

What is Boots?

- “Boots on the ground” is the help on the front lines (on the program) during start-up
  - Boots is not Air Support
    - Coming in and strategically taking out the big targets
  - Boots is the ground troops helping to clear a route for your team to get to a successful Start-Up Review
- Boots is part of the refocusing the DPG from Functional Centric (Air Support) to Program Centric (Boots on the Ground)
- NDIA Program Start-up Workshop:
  - “Provide Program Start-Up Assistance to PMs”
  - “Act as a Catalyst for Rapidly Applying Lessons Learned, Best Practices, and Exemplary Program Management Approaches”

How Boots Works



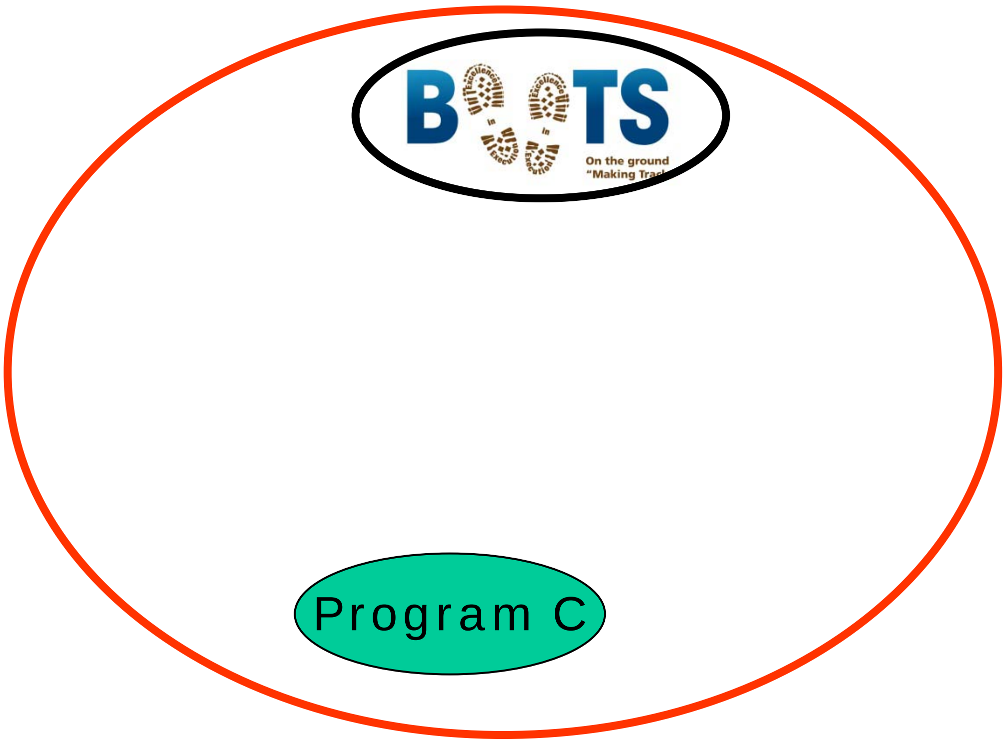
The Particular Team Is Composed Of Experts Who Understand The Customization Needed For The Specific Program Type

Boots Charter

- Boots facilitates a program team's application of processes, tools and people needed to permit the program to complete a successful program Start-Up Review (SUR).
- The Boots Team focuses on the establishment of a solid integrated technical, cost and schedule baseline including;
  - risk and opportunity tools and processes
  - and a comprehensive change management process.

Facilitating the Start-Up Review Process to Produce An Integrated Program Baseline

Working with the Program Team

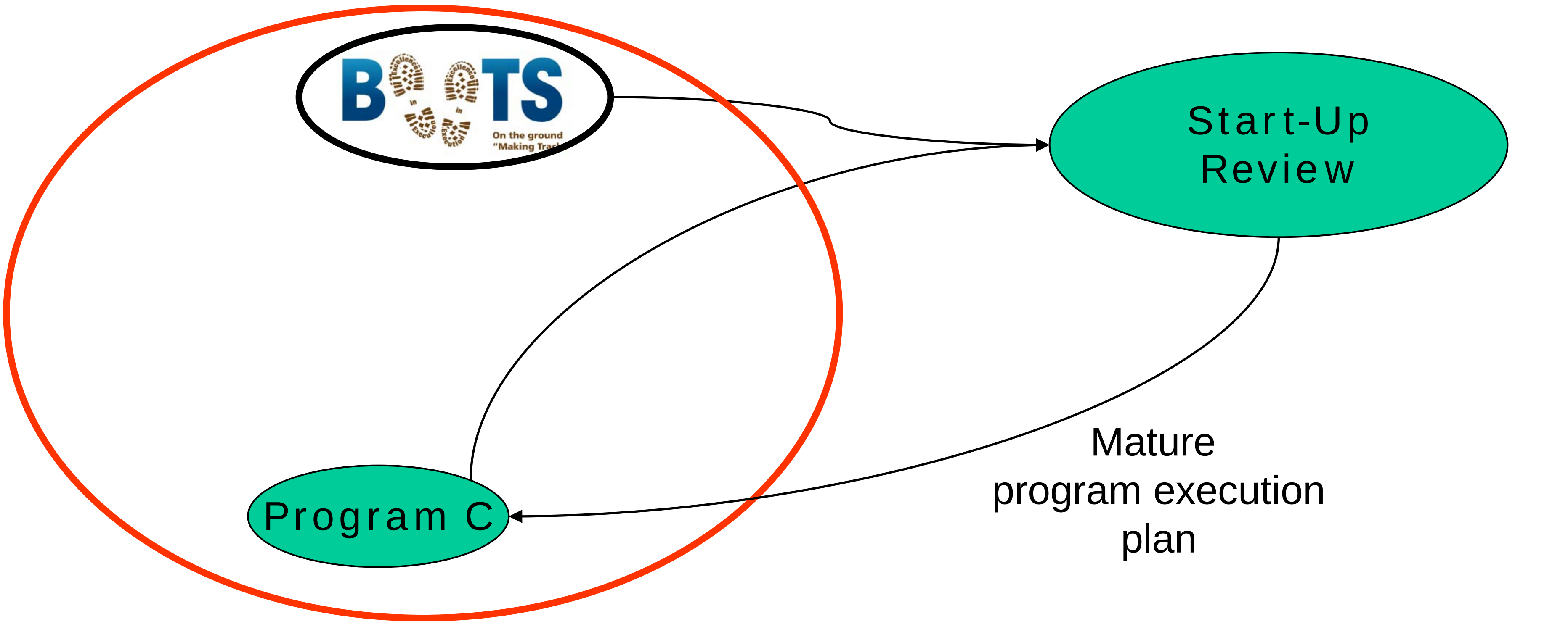


- Facilitation of the Start-Up processes and tools
- Assistance with refresher training
- Program Advocate for the Program
- Mentor
- Feedback to DPG on processes and tools
- Improve the probability of success
- Improve their ability to accurately predict
- Independent Assessment
- Improve Morale

One Size Does Not Fit All

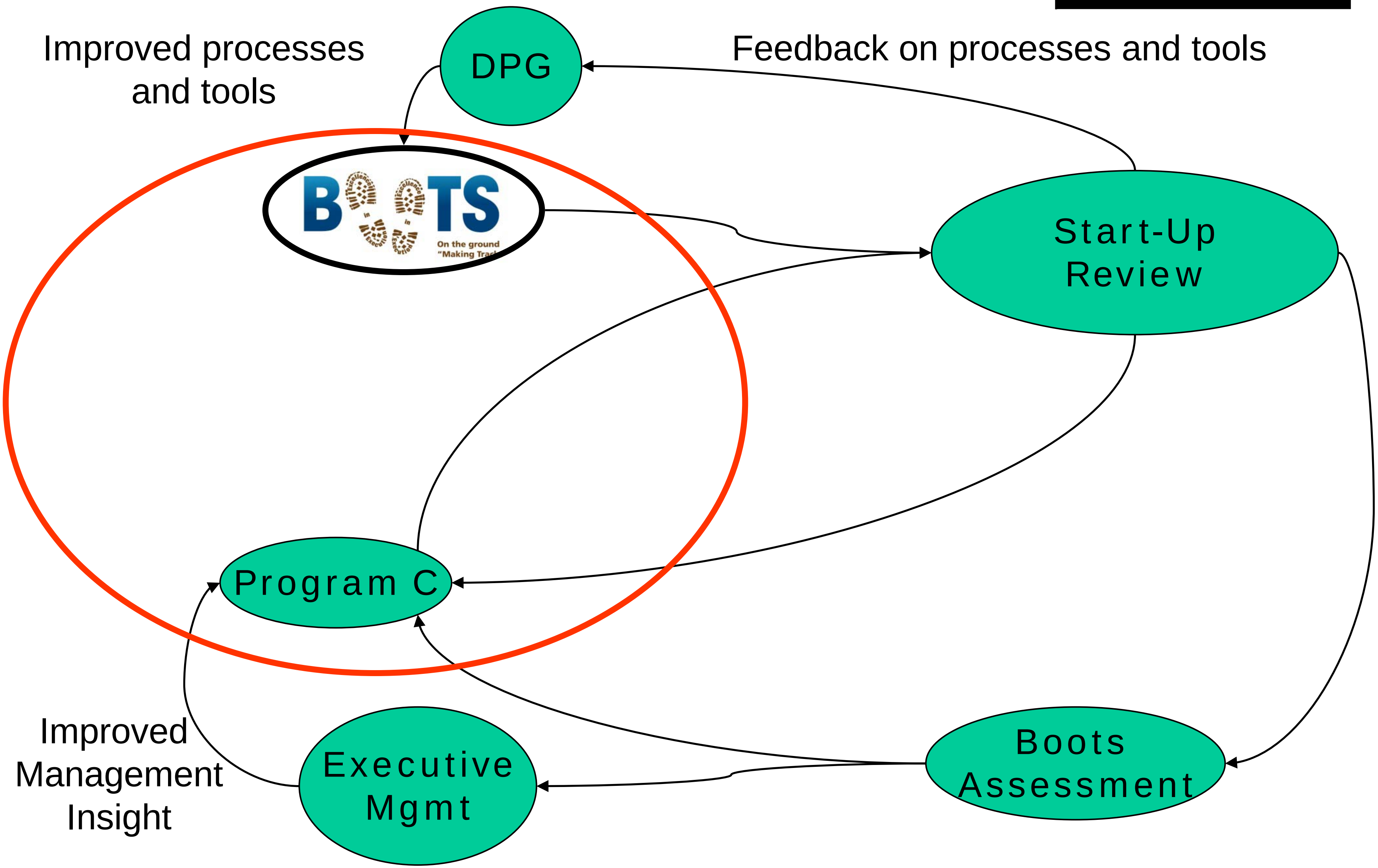
HARRIS

Customize Processes And Tools, Implement Initial Processes And Tools, Use Industry Accepted Assessments, And Program Start-up



The Boots And Program Team Members Must Address Program Specific Conditions And Satisfy Customer Requirements (Externally And Internally)

Feedback to the Division



HARRIS

What Boots Does Not Provide

- Forty different ways to do everything
  - Boots is going to suggest proven best practices, but support variation where required
- An answer to every problem in Start-Up
  - The program team knows the program best and the final decision rests with the program team
- An independent staff to do the Start-Up

**Boots assists in the building of the plan,
Keeping the tempo high to Start-Up
and guiding the team in the right direction
(avoiding missteps)**

Assessment Tools

HARRIS

Focus	Score	Sub-Focus
1.0 Program Planning		
1.0 Program Planning		1.1 - EVMS
		1.2 - Concurrent Scheduling
		1.3 - Requirements Allocations
2.0 Baseline		
2.0 Baseline &		
3.0 Risk Mgt.		
3.0		
4.0 Design		
4.0 Design		4.5 - Design-to-Cost
5.0 Material Procurement		
5.0		5 - Material Procurement
6.0 Subcontract Management		
6.0		6 - Subcontract Management
7.0 Monitoring, Statusing,Control		
7.0 Monitoring		7.1 - Program Reviews
		7.2 - Customer Relationship / Intimacy
		7.3 - Roles/Responsiblity/Accountability
		7.4 - Team Communications
8.0 Product Development		
8.0 Product		8.1 - Transition to Production / Operations
		8.2 - Product Quality Mgt.

	Sub-Focus		Objective measure	Score (0-4)	Scoring method	User Input		Score (0-4)
1.1 - EVMS								
1.1	EVMS	2.5	Baseline Macro: Current wave is 100% in sync	4	Yes/No	Yes		4
			Do you have a monthly ETC review process?	-	Yes/No	No		0
			Baseline Macro: Value of "yellow months" compared total value of each month	4	Percentage of dollars in "yellow" status for "yellow months"	$ 12,000,000	$ 300,000	4
			Is the entire program planned? (Headcount is distributed across the entire contract life)	-	Yes/No	No		0
			Percent LOE (must be the dollar value) (Is this based on the current rolling wave or on all packages including planning packages?)	2	Input percent LOE	$ 15,000,000	$ 2,500,000	2

Boots has selected objective evaluation of work products to be used in combination with subjective evaluation of the team overall

Hurdles

- Program Teams are suspicious
  - Trust must be developed and maintained
- "Support" must be clearly defined
  - Some teams see Boots only as additional (free) resources, not experts to help avoid past pitfalls
- Program team restrictions
  - Proper credentials must be in place for Boots team members or new, properly credentialed, Boots team members must be trained

The Boots Team Members Must Have Excellent Interaction Skills And Be Conscious Of These Hurdles

Summary

- Boots cannot provide everything
  - Program team knowledge is required
- The support must be open and collaborative
- The assessment must involve the program team
  - No Surprises
- Teams using Boots have successfully completed Start-Up Review on first pass

"Boots made my job easier. They were a sounding board and their involvement significantly contributed to our delivery success. They proved again;
GREAT STARTUPS = GREAT EXECUTION"
Bob Hails, Harris Program Manager

The Bottom Line

- Establish The Plan
- Measure Against The Plan
- Determine How To Get Back On Plan
- Regularly Estimate The Effort To Complete The Plan

Facilitates
The Establishment Of The Plan
And The Needed Processes
To Promote
Excellence In Execution

Backup

Boots on the Ground:
Tactical Planning at Program Start-Up

Gerry Becker, PMP

Harris Corporation

September 8, 2008 NDIA ICPM Meeting

- Provide credible Program Management and Integration Assistance
- Create Applicable Program Management Solutions and Deliver a High Value Assistance to Wings and Functional Staffs
- Build Robust Organic Acquisition Program Management and Integration Capabilities
- Provide Program Start-Up Assistance to PMs
- Provide Program Executability and Sufficiency Assistance
- Develop Reusable Life Cycle Based Integrated Risk Objects for Program Management and Integration Capability
- Act as a Catalyst for Rapidly Applying Lessons Learned, Best Practices, and Exemplary Program Management Approaches
- Lead, Manage, Train, and Equip PMAG members to Develop High Performance Integrated PM Capability to Assist Program Managers

Source: September 8, 2008 NDIA Industrial Committee for Program Management, Program Startup Workshop, Presentation by Colonel Kwon (USAF) of SMC on Program Management Assistance Group.

Other Supporting References

HARRIS

- Government Electronics And Information Technology Association. *ANSI/EIA-748-B-2007*, *Earned Value Management Systems.* Arlington, VA: Government Electronics and Information Technology Association, Standards & Technology Department, 2007
- Covey, Stephen R. *The 7 Habits of Highly Effective People.* New York: Simon and Schuster, 1989, 2004.
- Project Management Institute. *A Guide to the Project Management Body of Knowledge, PMBOK® Guide – Fourth Edition.* Newton Square, Pennsylvania: Program Management Institute, 2008.
- CMMI Product Team, *CMMI® for Development, Version 1.2.* Carnegie Mellon University, 2006.
- Feisel, Lyle D. “Lyle’s Law of Hiking" *The Bent* Fall 2009: 12-14.

Systems Engineering for Rapid Capability Development

NDIA 12th Annual Systems Engineering Conference

presented by:

Tom McDermott
Director of Research, and
Deputy Director
Georgia Tech Research Institute
tom.mcdermott@gtri.gatech.edu

Kathleen Harger
Private Consultant
kathleen.harger@verizon.net

Georgia Tech Research Institute

US Secretary of Defense Robert M. Gates:

The Department of Defense's conventional modernization programs seek a 99 percent solution over a period of years. Stability and counter-insurgency missions require 75 percent solutions over a period of months. The challenge is whether these two different paradigms can be made to coexist in the U.S. military's mindset and bureaucracy… The issue then becomes how to build this kind of innovative thinking and flexibility into the rigid procurement processes at home.

Robert M. Gates, "A Balanced Strategy, Reprogramming the Pentagon for a New Age," *Foreign Affairs*, January/February 2009

DSB Study on Fulfillment of Urgent Operational Needs:

- *All of DoD's needs cannot be met by the same acquisition processes*
- *"Rapid" is countercultural and will be undersupported in traditional organizations*
- *Any rapid response must be based on proven technology and robust manufacturing process*
- *Current approaches to implement rapid responses to urgent needs are not sustainable*
- *An integrated triage process is needed*
- *Institutional barriers – people, funding, and processes – are powerful inhibitors to successful rapid acquisition and fielding of new capabilities*

Report of the Defense Science Board Task Force on Fulfillment of Urgent Operational Needs, OSD/AT&L; July 2009

What we are Sharing Today

- Rapid Capability Development is rooted in sound Systems Engineering
- There are Best Practices Proposed, Founded in Commercial Rapid Product Development
- Specific Metrics Can (& Must) be Applied
- Application to DoD Acquisition
- Practices Applied to Selected Case Studies
- Conclusions and Recommendations

Prerequisites to Rapid

1. There is a business case
2. There is a vendor with a product portfolio
3. There is an organizational focus on rapid development
4. Product risk is manageable

10 Best Practices for Rapid Development

1. Adhere to the Rapid Capability Development Lifecycle
2. Separate Technology Development and Product Development
3. Capture New Opportunities Frequently
4. Introduce New Capabilities as part of a System Architecture
5. Align Product (Customer) and Engineering Requirements
6. Product Scheduling Reflects Rapid Development
7. Use Risk Management Effectively
8. Organize in Teams to Operate More Rapidly
9. Incrementally Develop and Test
10. Use Fundamental Decision Metrics for Management of Rapid Development

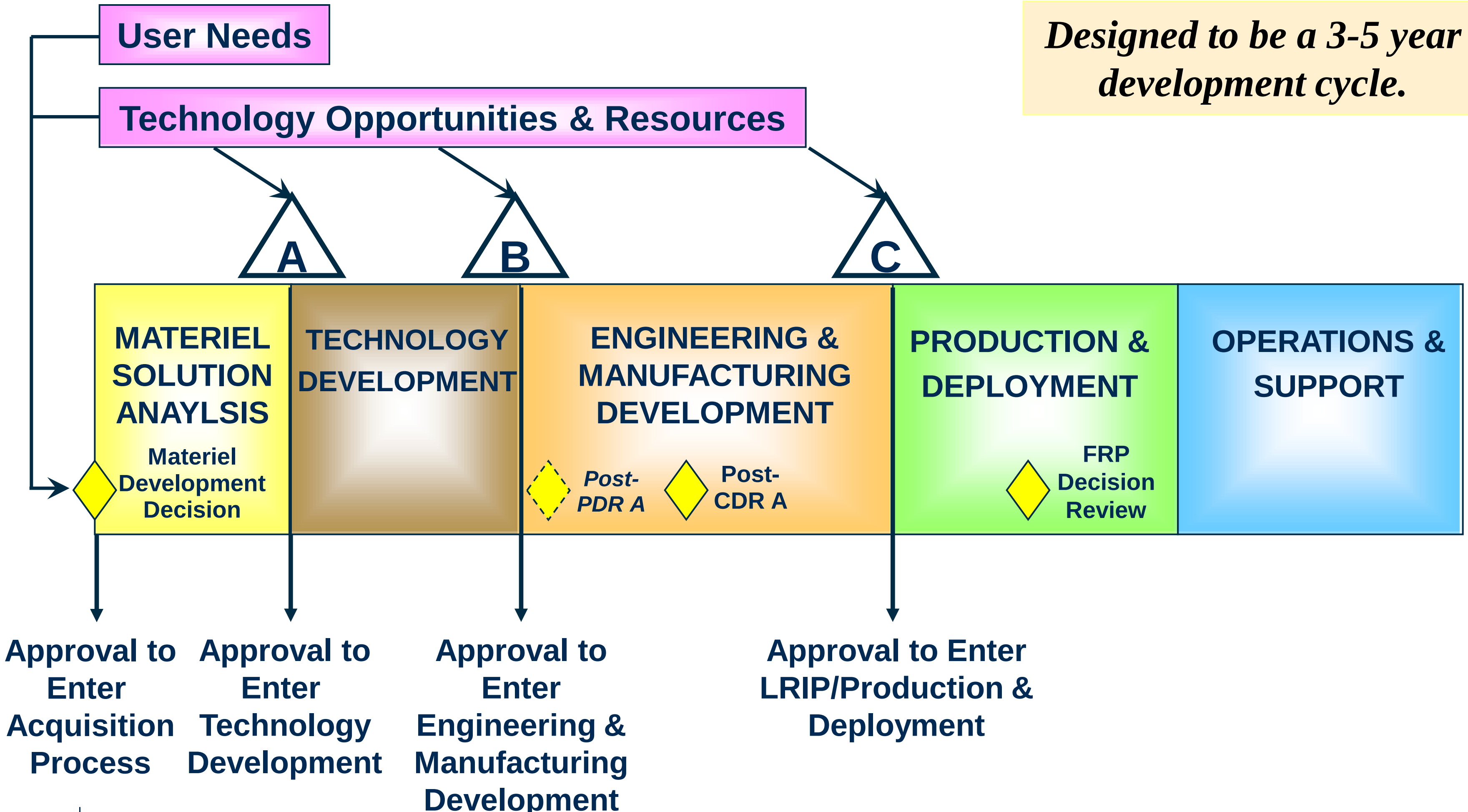
1: Adhere to the Rapid Capability Development Lifecycle

- Two fundamental rules for starting a rapid project:
  - Idea is matched to opportunity
  - Technology exists to implement the idea
- Lifecycle is driven by "time-to-market" as opposed to satisfaction of requirements
  - There is a time window to satisfy user need
  - If you cannot define a time window, there is no need to be rapid
- Rapid Capability Development begins with mature technology

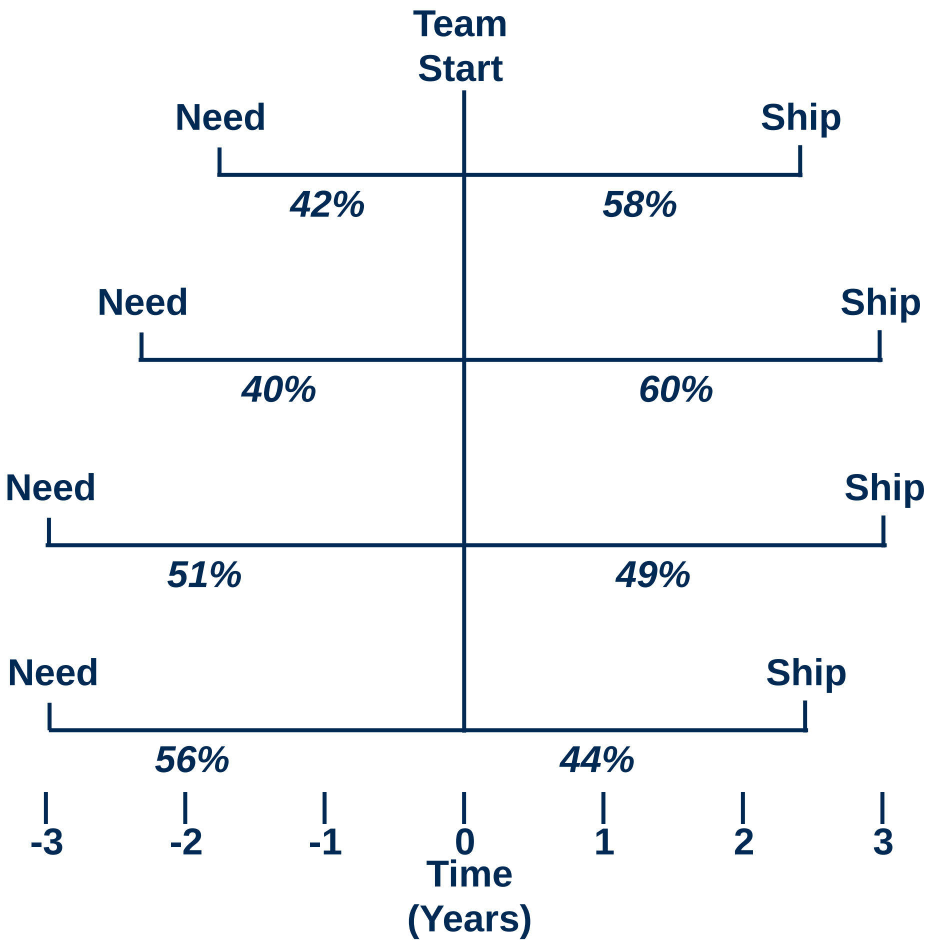
DOD Systems Life Cycle Today

per the DoD 5000 Acquisition Model

Designed to be a 3-5 year development cycle.



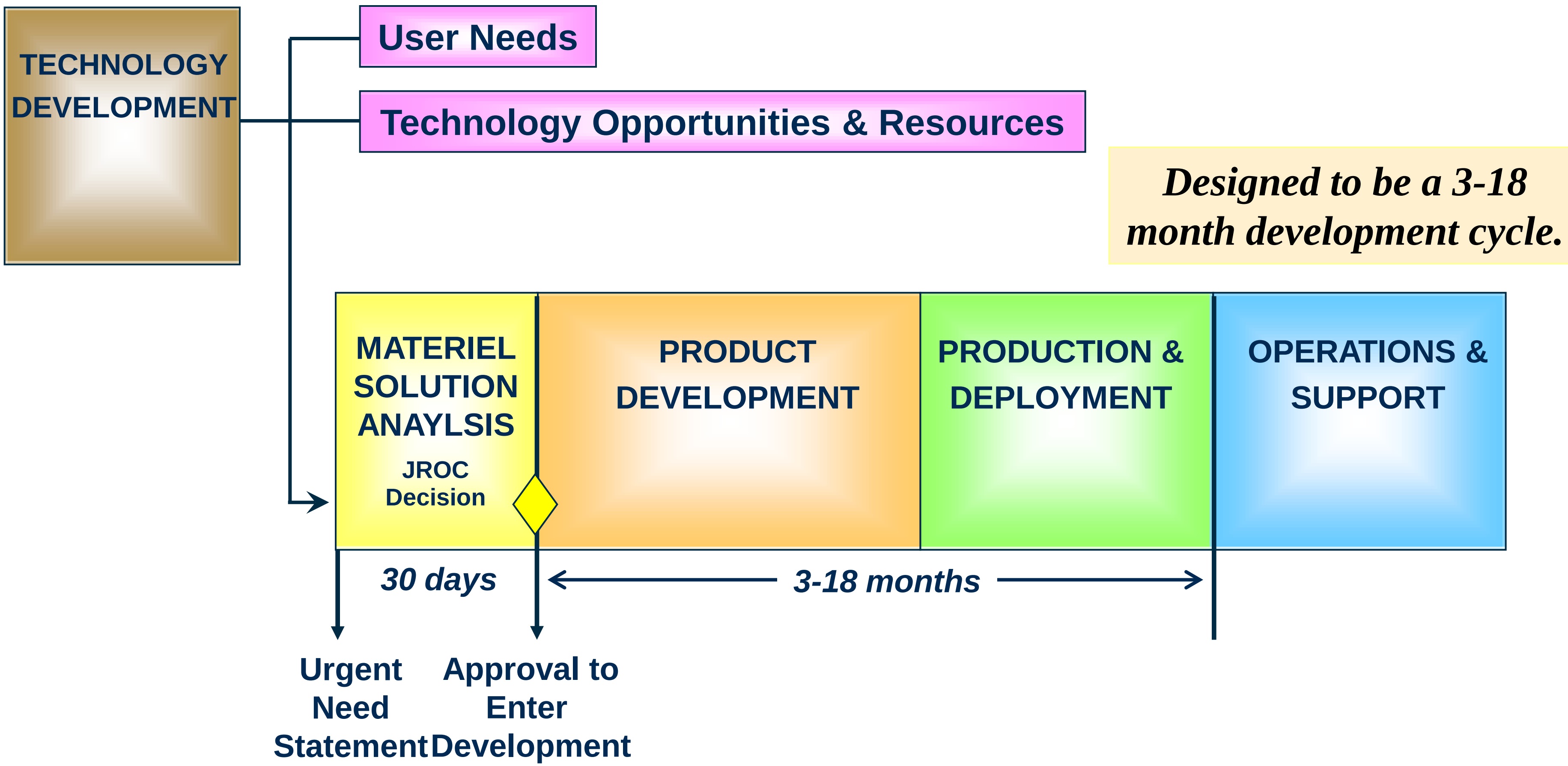
Saving Time in the "Fuzzy Front End"



- **Understand and address project "cycle time"**
- **Best opportunity to save time is at the front end**
- **1 week delay in starting has the same cost in market need as 1 week at the end**
- **Typically urgency increases as "burn rate" goes up**
- **As a result, urgency ends up highest when the market need is decreasing**

page 51, figure 3-1; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

Rapid Capability Development Life Cycle
tied to Joint Urgent Operational Needs

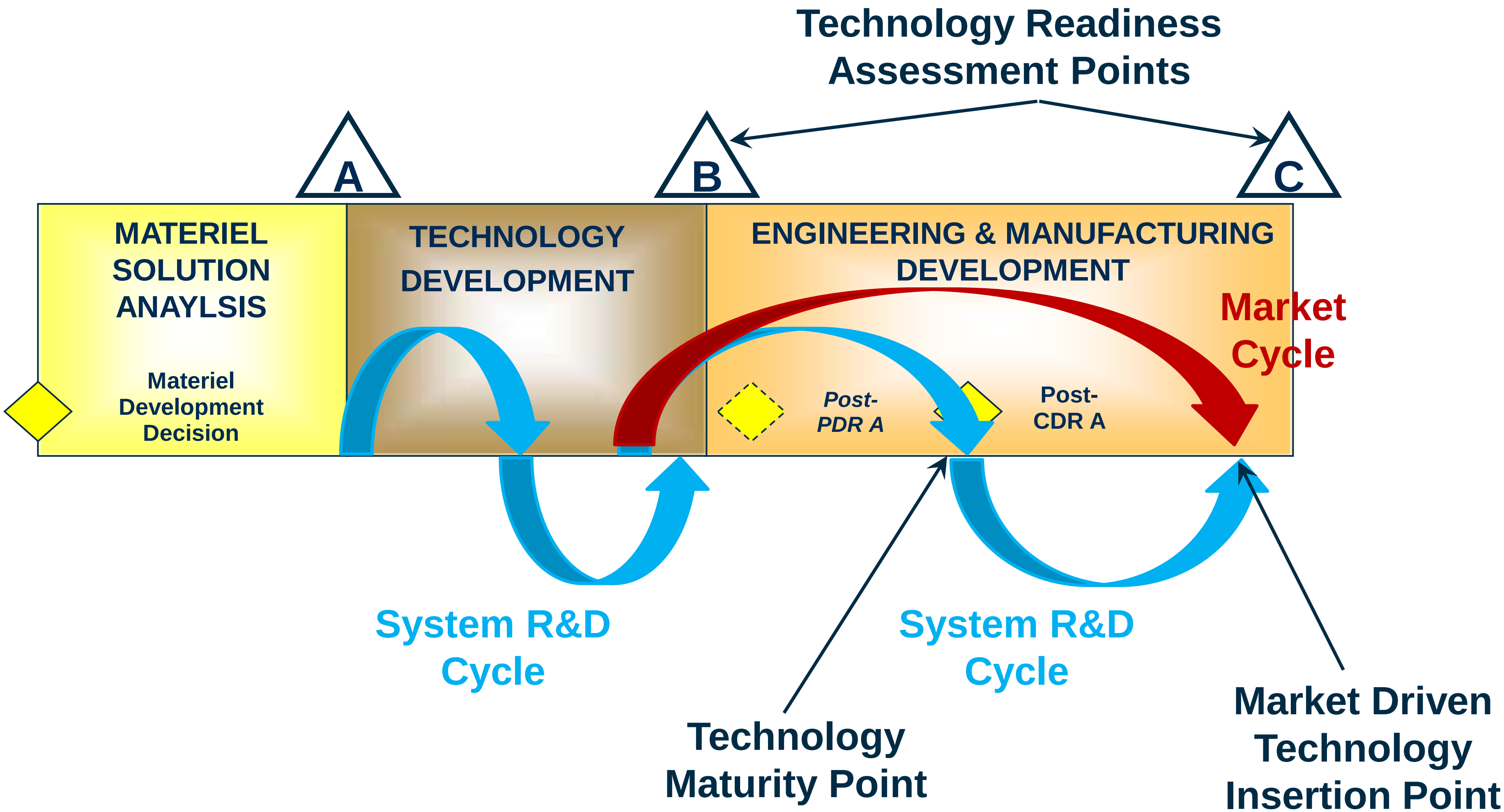


Chairman of the Joint Chiefs of Staff instruction CJCSI 3470.01, Rapid Validation and Resourcing of Joint Urgent Operational Needs (JUONS) in the Year of Execution, 15 July 2005

Technology Insertion Planning

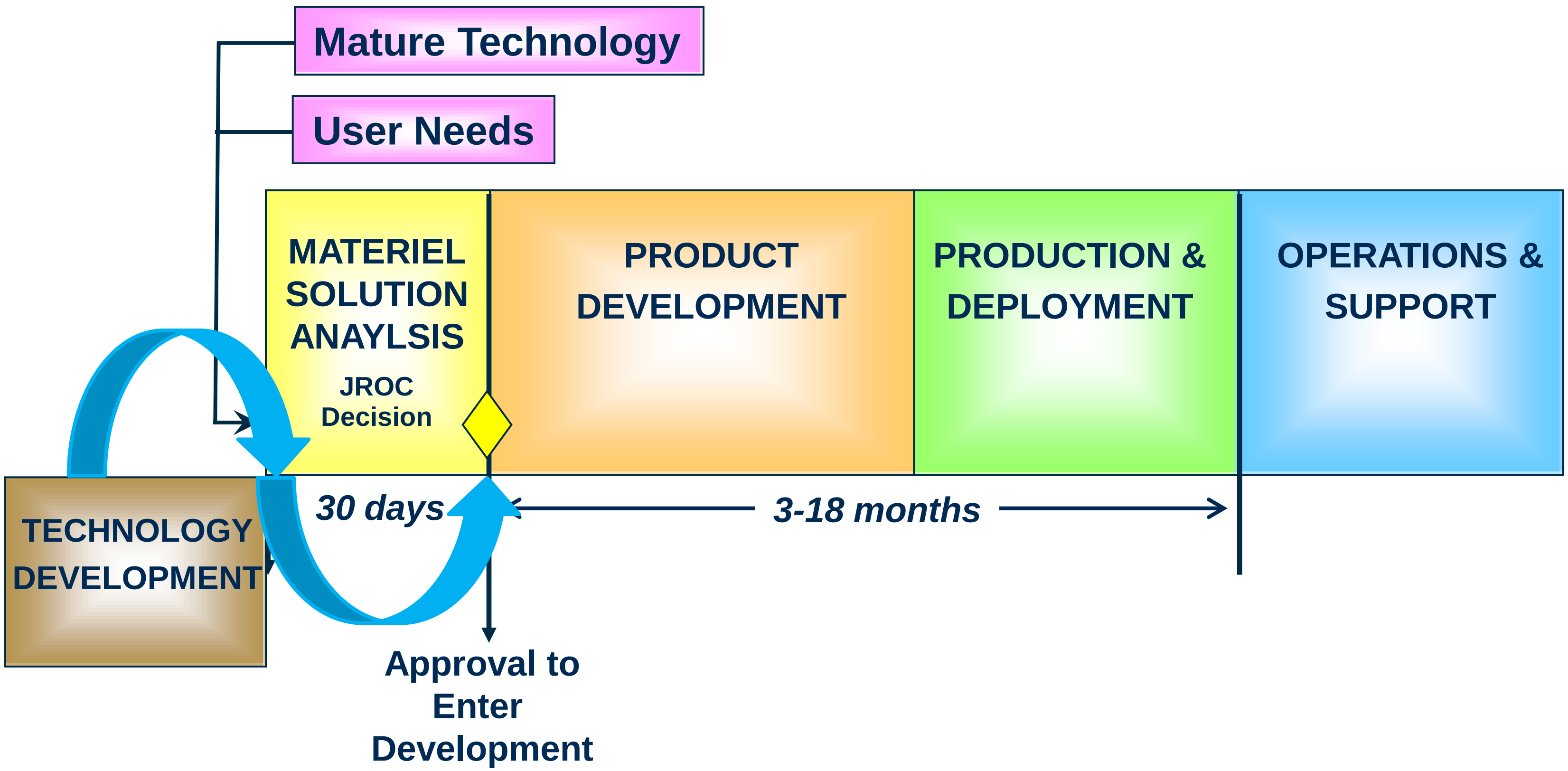
- Technology Maturity is the fundamental factor in most schedule delay
- Technology development brings uncertainty and undermines schedule accountability
- To be rapid, technology must be developed outside of the project
- Technology readiness assessment is a necessary decision process

Technology Insertion in a Typical Development



Rapid Capability Development Life Cycle

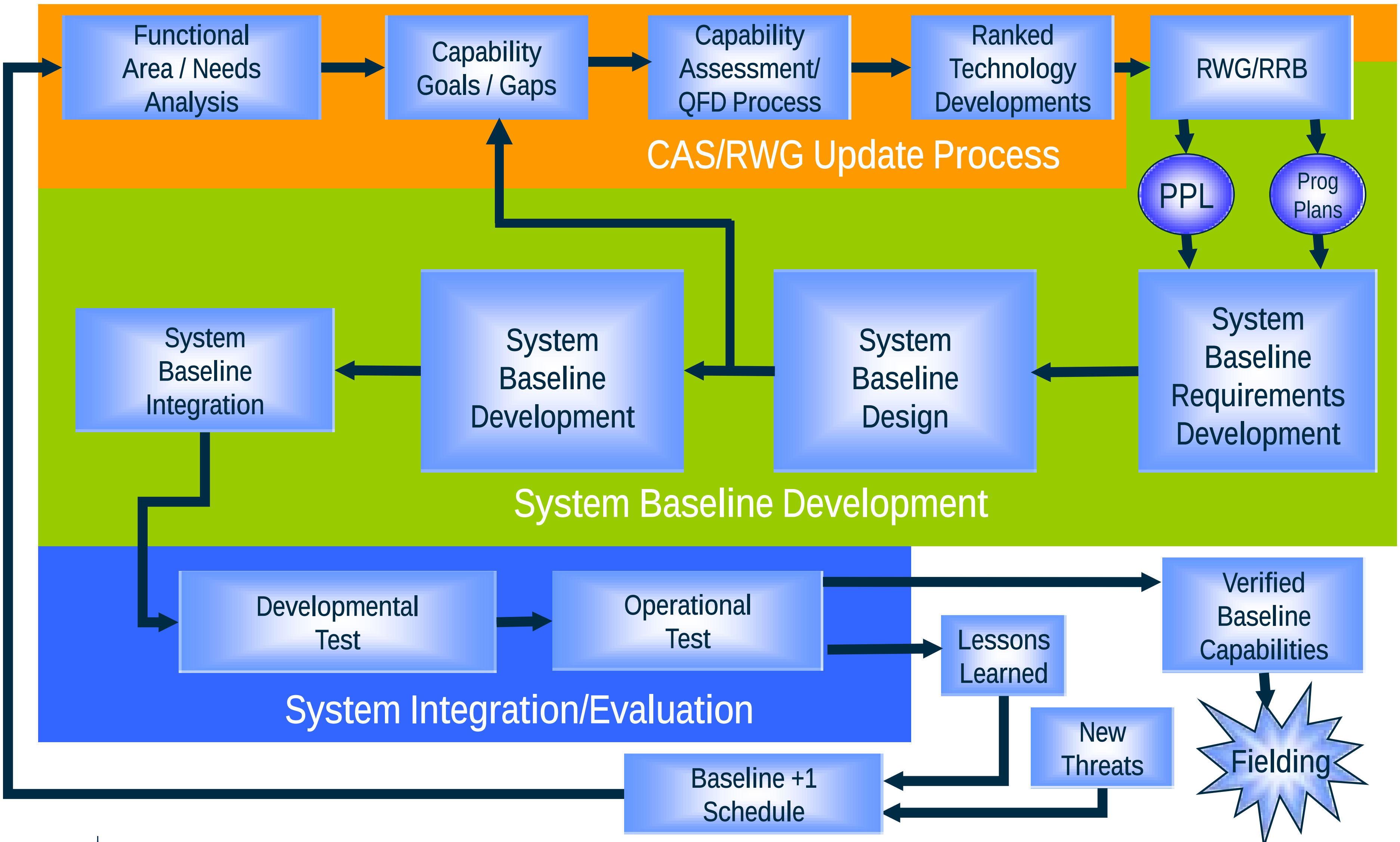
tied to Joint Urgent Operational Needs



2: Separate Technology Development and Product Development

- **Technology development is organizationally separated from product development**
- ***Technology development or acquisition is driven by needs of a product portfolio***
- ***The technology development organization is separately and consistently funded***
- **Effective technology transfer moves the technologists into the product team, then returns them**
  - **Side benefit: improves technology organization's understanding of product portfolio and customers**

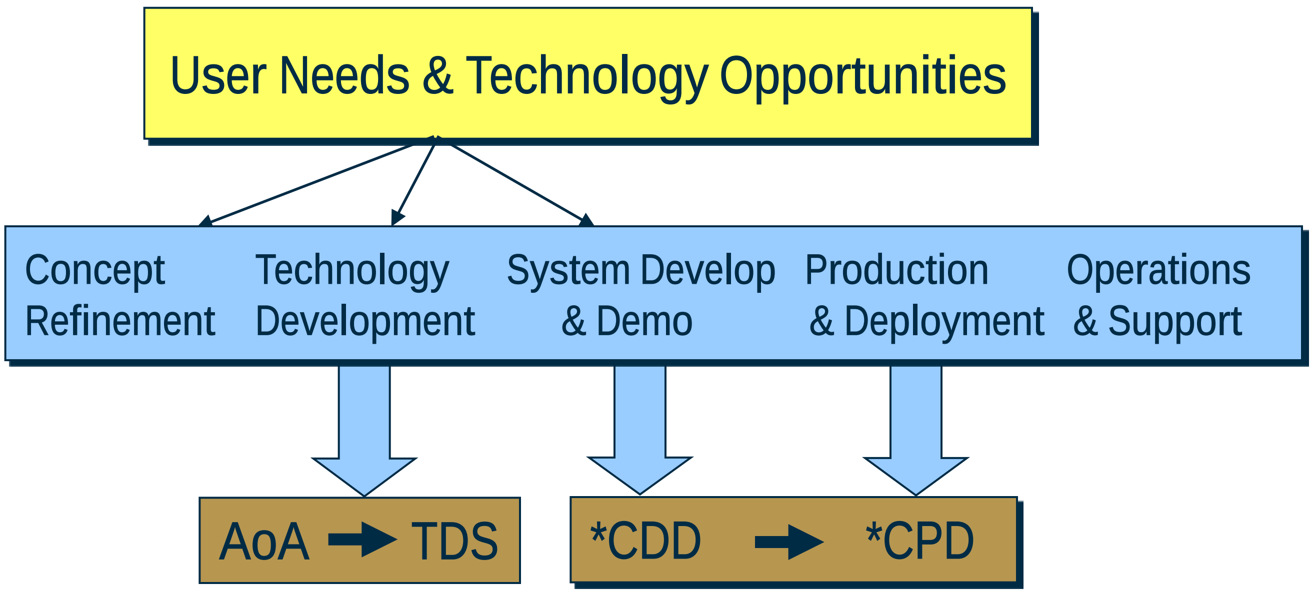
Air Force Big Safari Portfolio Baseline Process

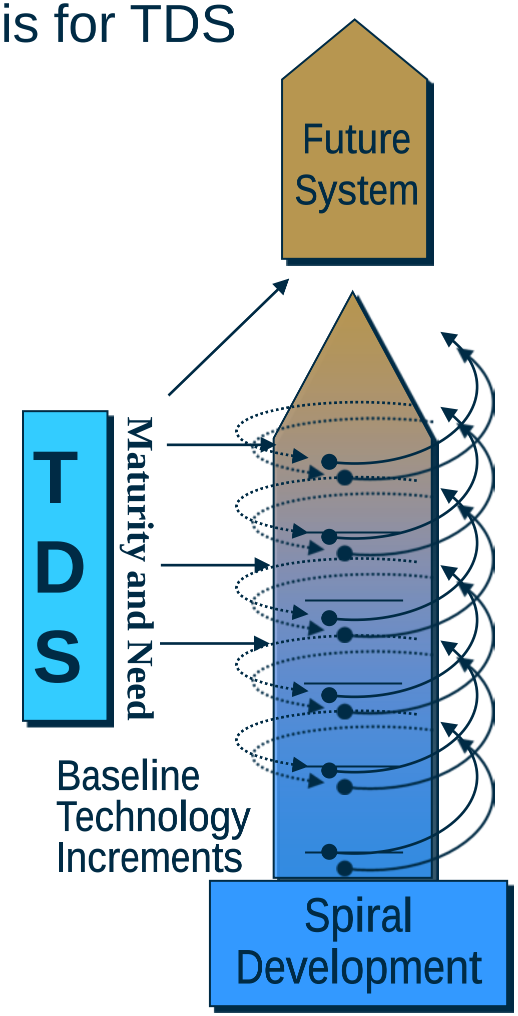


Georgia Tech Research Institute

Air Force Big Safari Technology Development Strategy (TDS)

- Analysis of Alternatives refines concept, provides basis for TDS
- TDS focuses technology efforts and feeds Baselines to optimize capability evolution

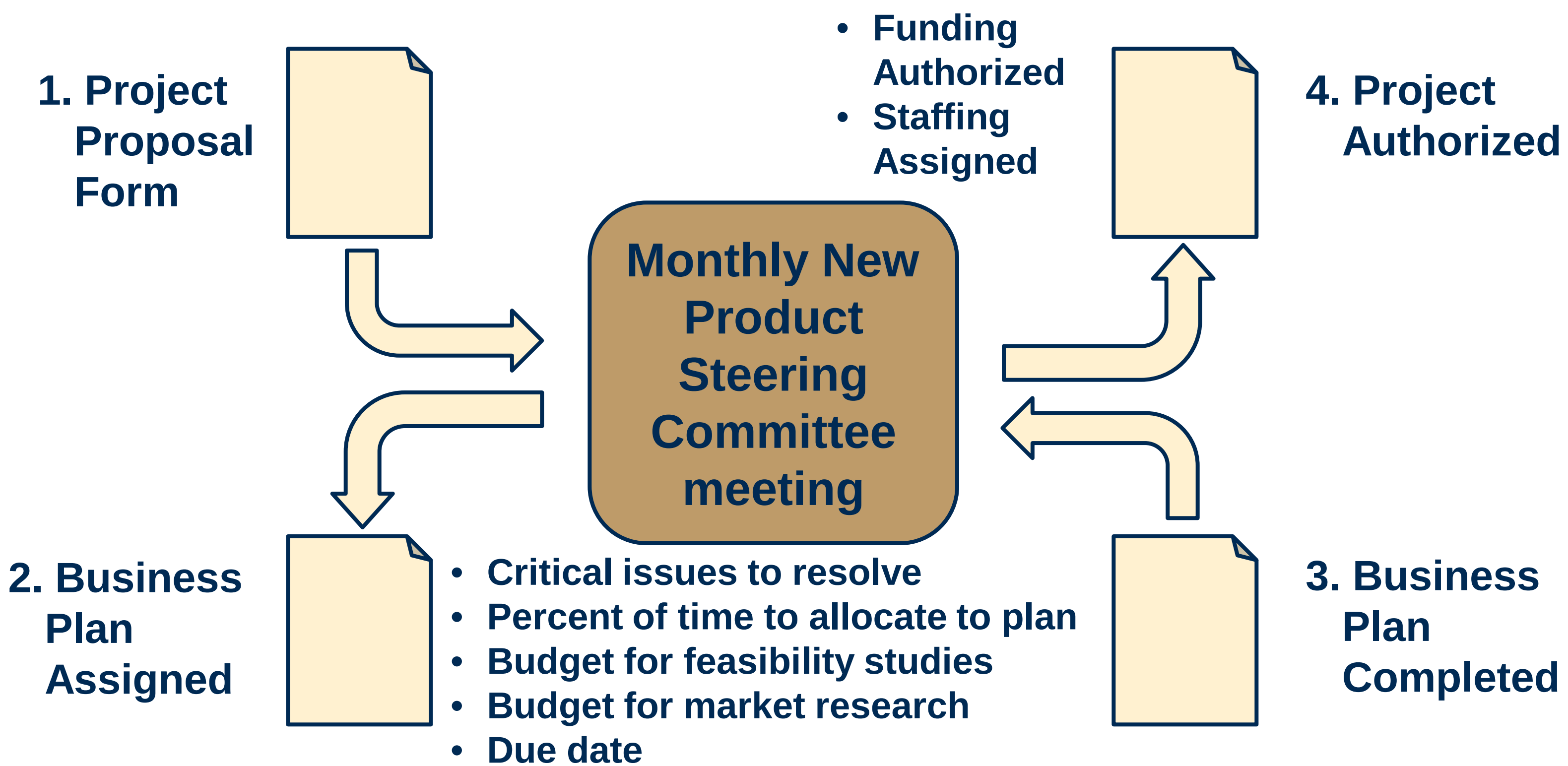




Reference:
- Defense Acquisition Management Framework (DoDI 5000.2)
- CJCSM 317 0.01A, CJCSI 3170.01d

3: Rapid Development Organizations Capture New Opportunities Frequently

- **Assign stable funding lines to product portfolios, regularly collect and review fundable opportunities.**



page 64, figure 3-5; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

DefenseSolutions.gov

DEFENSESOLUTIONS.GOV

The U.S. Department of Defense New Idea Portal

A Part of the DoDTechipedia Suite of Services

Search:

Propose an Idea

Funding decisions fast: DoD's new idea portal

Find Out More

Different ways to do business with DoD

Georgia Tech Research Institute

4. System Defined as a Product Architecture

- Solid architecture definition allows:
  - a looser coupling of designs and technologies
  - more concurrent tasks to be scheduled
  - incremental development and delivery
- Designate a system architect and recognize architecture as a primary management tool, not an engineering design

5. Align Engineering and Product Requirements

- ***One spec for product forces agreement up front by user, acquirer, and developer***
- **Gain clear alignment of user need and available technology**
  - **Use QFD to assess alternatives of need versus technology**

6. Project Scheduling Reflects Rapid Development

- **Keep a critical path mindset, let schedule be the primary goal**
- **Develop measures and triggers to allow next stage activities to proceed. Overlap activities and start on design triggers not completion of previous activity**
- ***Do not delay development on formal stage gates, consider periodic reviews instead or milestone reviews***
- **Use incremental prototyping wherever possible (spiral development for SW)**
- **Detailed planning is essential, but keep schedule status at a higher level. Adapt EVMS to key completion points or activities and not a rollup of detailed work packages. Shift focus of schedule control to lower levels**
- ***Adapt metrics focused on speed of progress (i.e. time to release eng'g, not #eng'g releases)***

7. Exercise Risk Management

- **Assume risk only where it provides an advantage toward customer need**
- ***Projects that concentrate risk in one area generally achieve faster development times that those that distribute risk broadly***
- **Tie risk to the project decision rules**
- **Balance technical and market risk, or technical and operational risk in the DoD case**
- **In areas with significant unknowns, model and test**

8. Teams Operate More Rapidly

- Do real integrated product development – organize around physical or logical subsystems, create cross-functional design teams
- Organize teams for <u>rapid communication</u>, push decisions down where possible
- Co-location is important, particularly in early phases

9: Incrementally Develop and Test

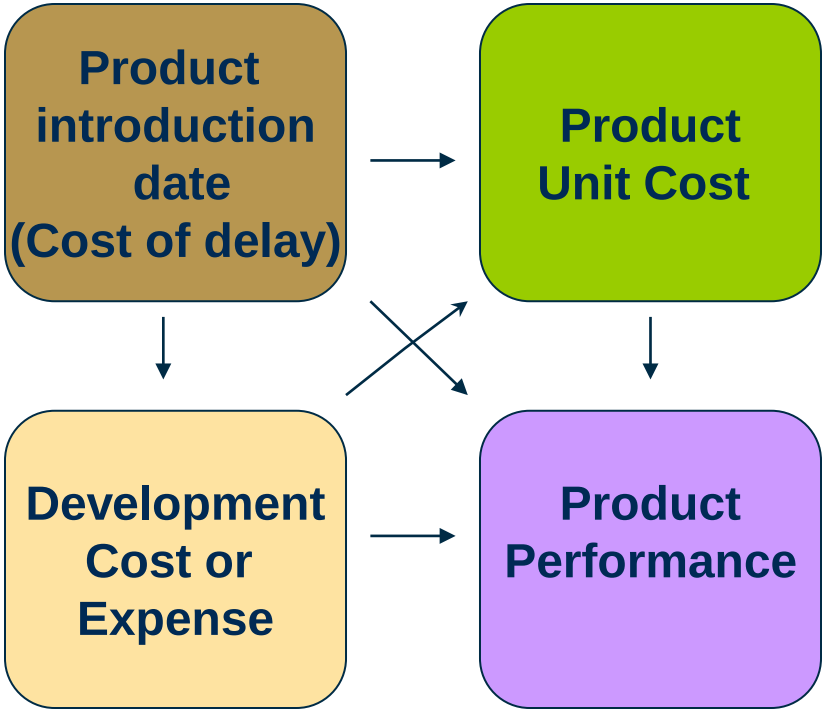
- **Concentrate risk within the system**
- **Strong system architecture**
- **Contract with a small set of target customers to pilot and mature the design**
- **Integrated product development: consider DOTMLPF throughout the process**

MRAP Lessons Learned:
1. ***Develop a long-term sustainment plan***
2. ***Integrate with existing vehicle programs***
3. ***Ensuring Best Value***
4. ***Competition***

Lewis, Ryan, A Case Study of the Mine Resistant Ambush Protected Vehicles (MRAPs), University of Maryland School of Public Policy, PUAF 699N: PPPE in National Defense, April 27, 2009

10: Decision Metrics for Management of Rapid Development

- Business models will have sensitivities based on the following 4 objectives:
  (Smith and Reinertsen, Developing Products in Half the Time)
  - Market introduction date (project delivery date)
  - Product Performance
    - Includes Quality requirement
  - Product Unit Cost
  - Development Expense



Four possible sensitivities yields six different tradeoffs

page 23, figure 2-1; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

Establish a Decision Metric for Rapid Development

- Success of a rapid product development can be tied to an essential decision metric which can be used to develop decision rules for project trades
- “Time to market” can be defined by the decision metric as follows:
  - There is a knowable cost of delay that can be quantified by the decision metric.
  - The cost of delay can be used to trade schedule versus other objectives using decision rules.
  - Program management must consistently apply these decision rules.

Establish a Decision Metric for Rapid Development

- **For commercial product development, decision metric is normally tied to profit**
- **For DoD acquisition, the JUONS Decision Process states:**
  - **"Could result in loss of life,"**
"could endanger completion of a near term mission"
  - **Also recommend "innovate idea that could be a game changer and should be tried as soon as practical"**
- **Possible "Time to market" decision metrics:**
  - **Casualties per month (MRAP example).**
  - ***Targeted mission success goals (deployment times, etc.).***

Summary

1. Adhere to the Rapid Capability Development Lifecycle
2. Separate Technology Development and Product Development
3. Capture New Opportunities Frequently
4. Introduce New Capabilities as part of a System Architecture
5. Align Product (Customer) and Engineering Requirements
6. Product Scheduling Reflects Rapid Development
7. Use Risk Management Effectively
8. Organize in Teams to Operate More Rapidly
9. Incrementally Develop and Test
10. Use Fundamental Decision Metrics for Management of Rapid Development

References

1. Chairman of the Joint Chiefs of Staff instruction CJCSI 3470.01, Rapid Validation and Resourcing of Joint Urgent Operational Needs (JUONS) in the Year of Execution, 15 July 2005
2. Defense Science Board, Report of the Defense Science Board Task Force on Fulfillment of Urgent Operational Needs, July 2009
3. Lewis, Ryan, A Case Study of the Mine Resistant Ambush Protected Vehicles (MRAPs), University of Maryland School of Public Policy, PUAF 699N: PPPE in National Defense, April 27, 2009
4. Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

UNCLASSIFIED: DIST. A. Approved for public release.

Systems Engineering for the Science & Technology Community

12th Annual NDIA Systems Engineering Conference
28 October 2009

Russell Menko
US Army – TARDEC Systems Engineering

Introduction

This presentation provides insight into changes in the Tank Automotive Research Development and Engineering Center (TARDEC) Army Technology Objectives (ATO) culture and examines lessons learned from the application of formal Systems Engineering principles and practices.

Systems Engineering

- Department of Defense Instruction 5000.2 Requires Systems Engineering Be Performed On All Programs.
- RDECOM SE Policy, Dated 24 April 2007, Requires SE Be Performed On All New ATO-D Programs.
  - Must Have A Systems Engineering Plan (SEP) Formally Defining The SE Process
    - SE Group Developed SEP Instructions To Standardize SEPs. The Instructions Provide a Detailed Explanation, Examples For Each Paragraph
  - SE Group Then Works With ATOs To Implement The SEP Contents Within The Program

The SEP Process

- Conduct Initial Meetings With ATO Personnel and SE Subject Matter Experts (SME)
  - Begin SEP Process With Planning Before Writing
  - Discuss Objectives; Status Of Requirements; Schedules; Potential Risks; Partners; etc.
  - Include Additional (Non-ATO) Issues, Such As Disposability, Security, Manufacturing
- Using The SEP Instructions And Results Of Initial Meetings, SE and ATO Personnel Develop Draft SEP
- After Formal Approval, The SEP Is Published in an Army Database
  - Available For Reference By Other Interested Parties

Subject Matter Experts

- SE Has Specialists (SMEs) In Support Of the Enterprise Community
  - Risk Management, Requirements Management, SEP Generation, Etc.
  - The Use Of SE SMEs Reduces Risks, Costs & Schedule Impacts
- Central Pool of SMEs Eliminates Technology Teams' Need To Hire / Maintain SE Experts
  - Technology Teams Must Still Have A Fundamental Knowledge Of Systems Engineering

Requirements Management

- Right From The Start –
  - Define, Decompose, And Manage Project Requirements
  - Must Be Data-driven, Clear, And Unique
- Government Should Control Requirements, Not Contractors
  - Ensure Correct Work Is Performed
  - Impacts Required Validation & Verification
  - Reduces Risks, Cost, Schedule Impacts

Government Owns & Manages Requirements

Risk Management

- Identify Risks, From The Very Beginning
- Continuously Identify Additional Risks Throughout The Program
  - Designate A Risk Manager For The Project
  - Allow Anyone To Submit A Risk
- Track And Manage Risks In A Database
  - Identify Mitigation Techniques
  - Perform Frequent Reviews Of Risks
  - When No Longer Valid, Close Risks Out Of The Database.

Control Risks At The Project Level

Enhance Communications

- Participate in ATO Approval Process
  - Ensure Proposals Address Documented Warfighter / PEO Needs
  - Ensure Proposals Include Systems Engineering
- Technology Transfer Agreements
  - Ensure The Customer Knows Our Intent; We Know the Customer's Needs
- IPTs And SEITs
  - PM/TRADOC/Contractor/Industry Partners Involvement
  - Resolve Concerns Early
- Increased Levels Of Communications Reduces Risks, Costs, Schedule Delays And Replans

Technical Reviews

- Use A Rigorous Approach To Technical Reviews
  - Clearly Define Inputs, Artifacts, Exit Criteria, And Roles And Responsibilities
  - Designate The Technical Review Decision Authority
    - Approves Transition To Next Phase
      - Full Approval
      - Conditional Approval (Minor Issues To Close Out)
      - Disapproval (Major Issues To Resolve; Present At Another Review!)
  - Involve SMEs From Related Programs
- Have Customer/Contractor/Industry Partner Participation

PROGRAMS Go Through Design Reviews, Not CONTRACTS!

Key to Success!

- Most Unsung Hero: Communication / Interaction Between Projects, Their Program Managers, And The TRADOC User Community
  - No Surprises
  - Reduce Risks
  - Manage Requirements
  - Eliminate Confusion
- Strong Participation In Technical Reviews
- Involve Everyone In IPTs/SEITs

Consistent Systems Engineering Sets Expectations For The Customer, The Developer, & The Warfighter

Some Lessons Learned

ATO Managers Conducted A Review Several Months After The First Set Of SEPs Were Completed.

Comments Received Included:

- SEPs Improved Communications Between Stakeholders
  - PM, Contractors/Government Partners, And ATO Personnel
  - Ensured Consensus, Commitments
  - Use Of SEIT, IPT, Technical Reviews
- Helped Align Projects With Program Manager's Strategic Plans, Goals, And Priorities

Lessons Learned

- SE Practices Added Value
  - Risk Mgmt, Schedules, SEIT/IPT, Event-Driven Technical Reviews, Modeling & Simulation
- Increased Uses For WBS: Planning, Developing the Statement of Work and Integrated Master Schedule
- Aligned Technical Process with Communication and Management Processes

Systems Engineering Must Be Planned Before The Project Starts!

Lessons Learned

In General:

- Need To Tailor Efforts
- Research Projects Have Different Needs Than Production Programs
- Needs Vary One Research Project To Another
- Use CM From The Very Beginning
  - Documents Are Stored In A Common Facility; Enables Access By Contractors/Government Partners

Systems Engineering, Up Front and Early

Quotes

- “SEIT makes the tough decisions and is a good sounding board”
- “Identifying risks early aided in developing mitigation plans to manage the risks when manifested”
- “Development of the SEP for the ATO helped communicate the ATO execution strategy to TARDEC’s PM partners, developing ties to their modernization plan and ensuring the program is aligned with PM goals.”

Developmental Test & Evaluation
OUSD(AT&L)/DDR&E

Chris DiPetto

12th Annual NDIA Systems Engineering Conference

Agenda

- DT&E Title 10 USC overview
- Organization
- DDR&E imperatives
- What Title 10 means for DT&E within DoD
- Initial Vectors
- Challenges
- Initiatives
- Summary

Our Guidance

- **Defense Budget Recommendation Statement**
  Secretary of Defense Robert M. Gates, April 06, 2009
  - ***reaffirm our commitment to take care of the all-volunteer force***
  - ***rebalance this Department's programs***
  - ***institutionalize and enhance our capabilities to fight the wars we are in today and the scenarios we are most likely to face in the years ahead,***
  - ***provide a hedge against other risks and contingencies***
  - ***fundamental overhaul of our approach to procurement, acquisition, and contracting***
- **Economic Club of Chicago**
  Secretary of Defense Robert M. Gates, July 16, 2009
  - ***What is needed is a portfolio of military capabilities with maximum versatility across the widest possible spectrum of conflict***

DT&E in Title 10, USC

No

- **DT&E Primary Responsibilities**
  w
  - Policy and guidance for the conduct of DT&E in the DoD
  - Defining Performance Criteria
  - DT&E approval of the TEMP for each MDAP
  - Assessing the DT&E activities of each MDAP
  - Advocacy, oversight, and guidance to acquisition DT&E workforce
  - Assessing the DT&E organizations and capabilities of the military departments

- **Annual Report to Congress (with Director, SE)**
  - The extent to which MDAPs are meeting test objectives
  - The organizations and capabilities of the DoD for DT&E

The DDT&E is the principal advisor to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology, and Logistics on developmental test and evaluation in the Department of Defense

Acquisition Concerns

THE USUAL SUSPECTS:

Cost, Schedule, Performance

- **Over budget**
  - GAO: 96 active MDAPs are $300B over initial estimates
- **Late to need**
  - Getting capability to the user to meet urgent needs
- **Programs failing Operational Test**
  - Suitability issues
  - Late discovery

Weapon Sys Acq Reform Act

"…. 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

DDR&E Organization

Director, Defense Research and Engineering (DDR&E)
Honorable Zachary J. Lemnios

Principal Deputy
Mr. Alan R. Shaffer

Defense Advanced Research Projects Agency (DARPA)
Dr. Regina Dugan

Defense Technical Information Center (DTIC)
Mr. Paul Ryan

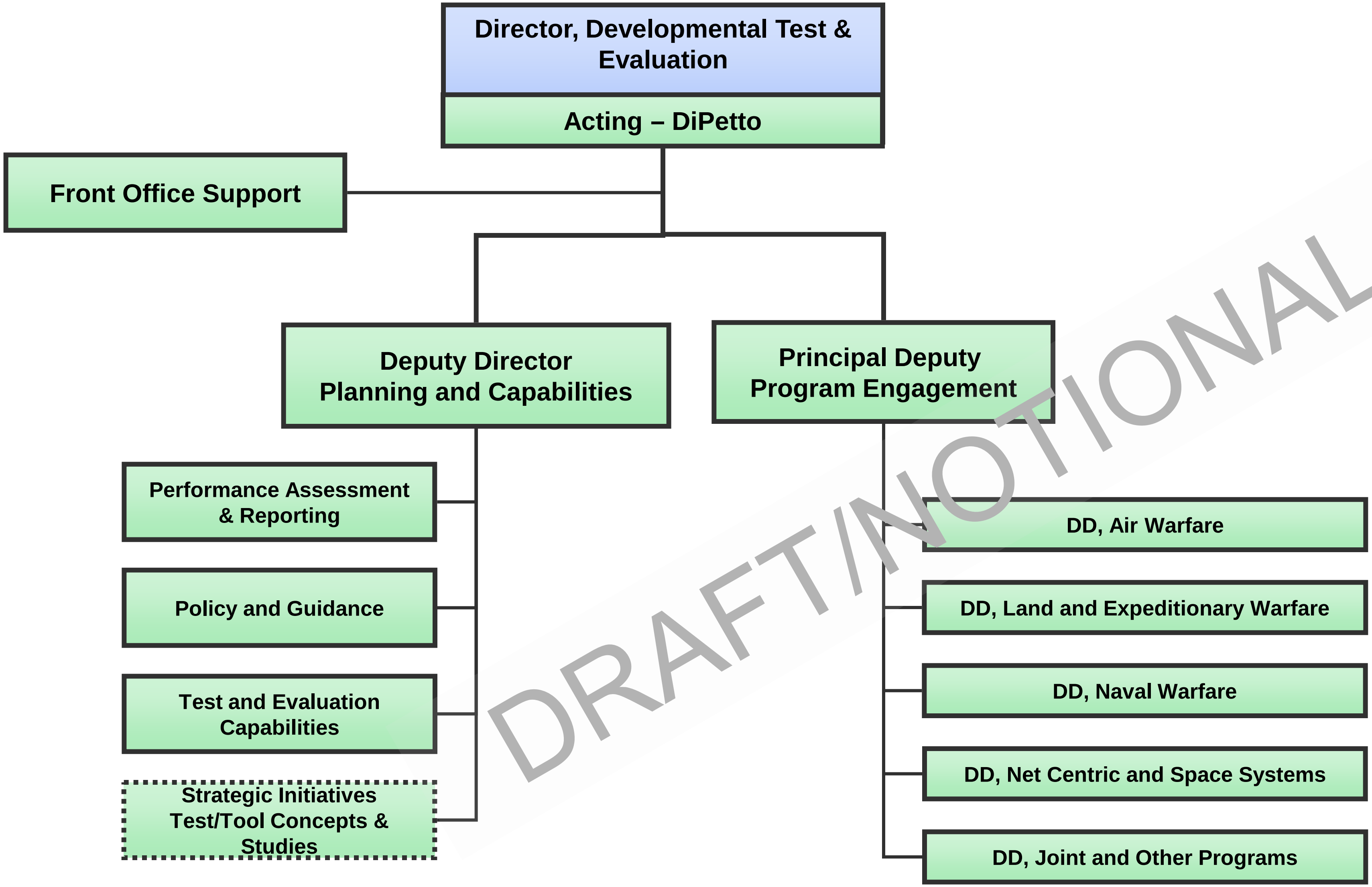
Director, Research
Dr. David Honey
Principal Deputy
Dr. André van Tilborg

Director, Systems Engineering
Mr. Stephen Welby
Principal Deputy
Mr. Terry Jaggers

Director, Rapid Fielding
Mr. Earl Wyatt
Principal Deputy
Mr. Ben Riley

Director, Developmental Test & Evaluation (DT&E)
Mr. Chris DiPetto
(Acting)
Principal Deputy
Mr. Chris DiPetto

D,DT&E Draft Org Chart



DDR&E Imperatives

- Accelerate delivery of technical capabilities to win the current fight: Rapid Fielding
- Prepare for an uncertain future.
- Reduce the cost, acquisition time and risk of our major defense acquisition programs.
- Develop world class science, technology, engineering, and mathematics capabilities for the DoD and the Nation.

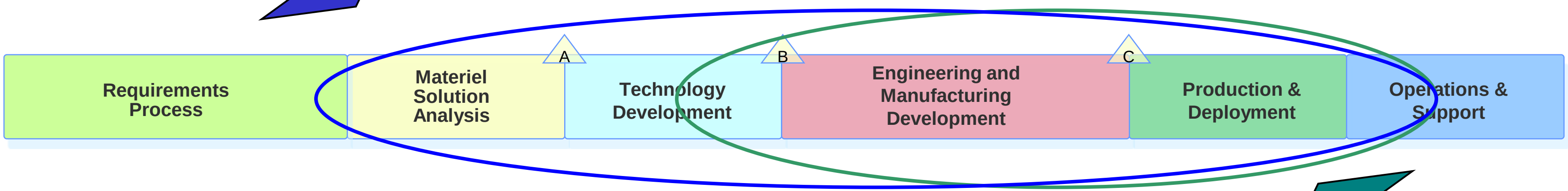
"One dollar of waste in our defense budget is a dollar we can't spend to support our troops or prepare for future threats or protect the American people."

Robert M. Gates
Secretary of Defense

What this Means for DT&E in DoD

2009 and Beyond: Establish D,DT&E and focus on Programs

- T&E consideration during program formulation
- TEMP focus: risk (scope of DT&E etc), assessment criteria
- Integrated Test
- Technology Maturity and Integration risk
- Oversight of program performance relative to TEMP and SEP criteria
- DT&E-driven Assessment of Operational Test Readiness
- Independent DT assessment to MDA (read voice at the DAB)



2003 – 2008:
Systems Engineering focus on Program Execution

- Integrated SE and DT&E
- TEMP focus on evaluation framework
- Published AT&L policy letters instantiated in DoDI 5000.02
- Overhauled and enriched DAWIA curriculum
- OSD Systems Engineering T&E assessments

Initial Vectors

Reconstitute the DT&E Organization

Principal advisor to the SecDef and USD(AT&L) on DT&E

- **Build foundations for program engagement**
  Reinstitute meaningful and effective T&E oversight of MDAPs
  - Establish measurable performance criteria (TES & TEMP)
- **Capability assessments**
  Evaluate Component plans
  - How are the components positioned (resource-wise) for DT&E?
    - For contracting, planning, and execution of DT&E
- **Annual report on MDAPs**
  - Analogous to D,OT&E annual report

Right test, right information, right decision.

Challenges

- **Interaction with DT&E organizations within the program management framework**
  - No DT&E analog to OTA
  - NAVAIR-like APEO/APM relationships
  - Role of government in DT&E

- **Early DT&E involvement in program formulation to reduce acquisition cost, risk, and cycle time**
  - DDR&E assessment of technology readiness
  - Accurate cost and resource estimates
  - Correct staffing, experience, and training
  - Correct T&E capabilities (with TRMC)

"I reject the notion that we have to waste billions of taxpayer dollars to keep this nation secure."
- President Obama

Initiatives

- **Collaborative DT&E reviews tailored to program lifecycle phase**
  - What information should the DT&E community provide the MDA?
- **Integrated Testing**
  - Now DoD policy
- **Reliability**
  - Policy changes in 5000 and 3170 series
  - Contract language, assessment scorecards
- **Workforce**
  - DDR&E STEM imperative, in-sourcing, 852
- **T&E integration in DDR&E technology imperatives & rapid fielding**
  - DDR&E rapid capability development study
  - What's the goal:
    - Capabilities & limitations
    - Safety

Summary

- **The importance of effective DT&E planning, execution, and reporting is recognized, valued and now prescribed in public law**
- **The OSD/DT&E has a voice in the acquisition process**
  - TEMP review and approval
  - Independent, T&E - based risk assessments to the MDA for each MDAP
  - Annual report

OFFICE OF THE SECRETARY OF DEFENSE
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING

DEVELOPMENTAL TEST & EVALUATION

3090 Defense Pentagon
Room 5A1076
Washington, DC 20310

TEMP at OSD dot MIL

Questions

Backup

What this Means for DT&E in DoD

D,DT&E provides independent risk assessments to the Milestone Decision Authority based on assessments of DT&E planning, resourcing, and execution for each MDAP

- **Policy & Guidance**
  - Collaborative development of integrated T&E and Joint T&E policy and guidance
  - Emphasis on development, tracking, and reporting of performance criteria

- **Capability Assessment**
  - Functional leader for T&E career field
  - DT&E planning, execution, and reporting
  - Collaboration with TRMC on DT&E capabilities

- **Program Oversight**
  - T&E consideration during program formulation
  - Technological maturity and integration risk of critical technologies
  - Scope of DT&E and integrated T&E planning
  - T&E schedule and resource adequacy
  - Program performance relative to TEMP and SEP criteria
  - Assessment of Operational Test Readiness

Acquisition Concerns

THE USUAL SUSPECTS:

Cost, Schedule, Performance

- **Programs failing Operational Test**
  - Suitability
  - Late discovery
- **Requirements – are they testable, well written?**
  - Early involvement
- **Risk**
  - Is the T&E planning/resourcing adequate to <u>assess</u> performance?
  - How does the T&E community <u>inform</u> acquisition decisions?
- **Resources**
- **Expertise -**

Human Systems Integration – Ensuring the Human is Considered "Left of A"

Colonel Larry Kimm, Director
Air Force Human Systems Integration Office (AFHSIO)
NDIA Systems Engineering Conference
28 October 2009

U.S. AIR FORCE

U.S. AIR FORCE

Overview

- Scope of HSI
- HSI: Optimizing Total System Performance
- Lessons Learned
- Inserting HSI into JCIDS “Left of A”
- Translation between JCIDS and Acquisition
- HSI Requirements Pocket Guide

Scope of HSI

Human Systems Integration is the integration of the human into the engineering of the system

- **AFPD 63/20-1 definition of HSI: *The integrated, comprehensive analysis, design and assessment of requirements, concepts and resources for system Manpower, Personnel, Training, Environment, Safety, Occupational Health, Habitability, Survivability and Human Factors Engineering***
- **"We'll continue to push the UAS envelope…unmanned systems are unmanned in name only. While there may be no Airmen onboard the actual vehicle, there indeed are airmen involved in every step of the process, including the pilots who operate the vehicles' remote controls and sensors and maintenance personnel." (General Fraser, VCSAF, 23 Jul 09, Pentagon News Conference)**

Human Systems Integration: Vision and Mission

U.S. AIR FORCE

The mission of the United States Air Force is to fly, fight and win ... in air, space and cyberspace.

Vision

Integrate Air Force people and technology for total systems performance

Mission

Ensure all AF warfighting systems are designed, built, tested, operated, and sustained in a manner that optimizes total system performance at every warfighter level

The purpose: permanent Air Force cultural & organizational change – optimize & sustain human performance at every warfighter level

Human Systems Integration "Domains"

U.S. AIR FORCE

MANPOWER
- Wartime/Peacetime manning requirements
- Deployment considerations
- Force structure

PERSONNEL
- Selection & Classification
- Demographics
- Knowledge, Skills & Abilities

TRAINING
- Training strategy
- Training methods & development
- Simulation/Embedded/ Emulation

HUMAN FACTORS
- Human-centered design
- Human-system interface
- Design impact on skill, aptitudes, performance

HABITABILITY
- Living environment
- Support services
- Working conditions (Ergonomics, bed, toilet, bath, food, medical, lighting)

SURVIVABILITY
- Threats
- Operational arenas
- Fratricide & Identification Friend/Foe
- Force protection

ENVIRONMENT
- Hazards that affect/impact human or earth
  - Air, water, earth
  - Noise
  - Natural Resources
  - Local Communities
  - Disposal

SAFETY
- Safety of design
- Normal Ops & Emergency Procedures
- Human error prevention and recovery

OCC HEALTH
- Operational Health
  - Hazards
  - Acoustics
  - Chem - Bio
  - Radiation - Laser Protection
  - Oxygen Deficiency
  - Air Pressure
  - Temperature
  - Weather
  - Shock/ vibration

HSI: Optimizing Total System Performance

- "The (Air Force's) aircraft inventory dropped by 10 percent while operational costs grew by 19 percent compared to 2000.": Air Force Times 09/15/2009
- HSI reduces long term costs:
  - A small investment up front to consider the human can result in substantial future O&S savings
  - Prevents costly re-designs

Hardware

Tools / Aircraft /
Equipment / Workspace

Software

Computer Software / Procedures /
Policies / Manuals

Liveware (Human)

Knowledge, Skills and Abilities / Stress / Attitudes / Cultures
Physical Capabilities, Needs and Limitations

U.S. AIR FORCE

AF HSI: Role and Cost in the Procurement Process

NEED OR OPPORTUNITY

Requirements Generation

- HSI role: Review, Consult, Refine, Plan
- HSI cost: May add cost in design

CONCEPT

Program Management

- HSI role: Support, Consult, Evaluate
- HSI role: Participate in tradespace
- HSI cost: Zero sum

OPERATIONAL ITEM

Test & Evaluation

- HSI role: Set goals and standards
- HSI cost: May add cost in test

FIELDED SYSTEM

Operations and Sustainment

- HSI role: Lessons learned
- **HSI PAYOFF = Mission + $$$**

$$$
HSI PAYOFFS
are realized
for the lifetime
of the system:

IMPROVE

PERFORMANCE

and SAFETY

DECREASE

OPERATIONS and

SUSTAINMENT

COST

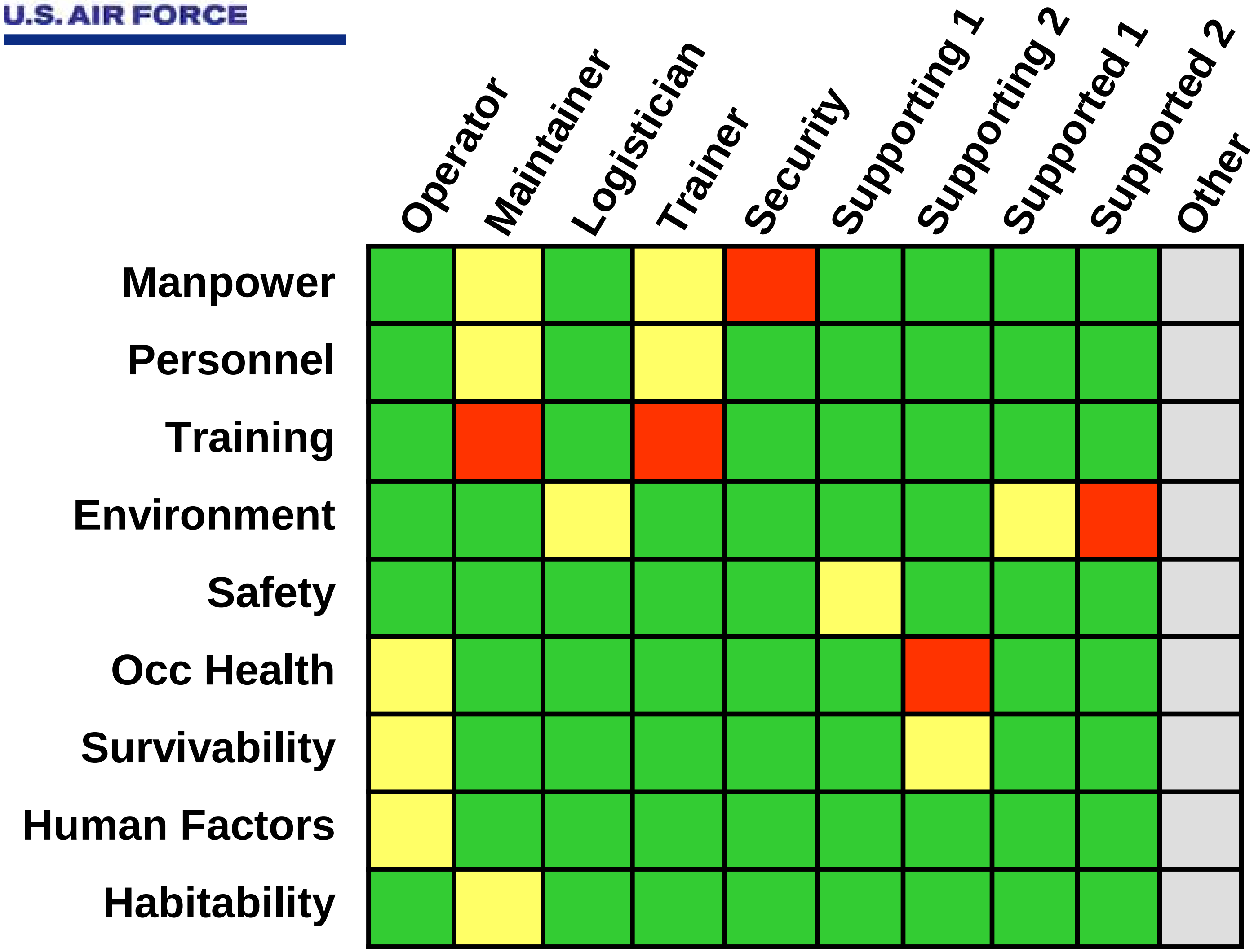
U.S. AIR FORCE

Matrix: Roles and Domains

	Operator	Maintainer	Logistician	Trainer	Security	Supporting 1	Supporting 2	Supported 1	Supported 2	Other
Manpower										
Personnel										
Training										
Environment										
Safety										
Occ Health										
Survivability										
Human Factors										
Habitability										

Include in the analysis all the humans who touch the system

Matrix: Roles and Domains

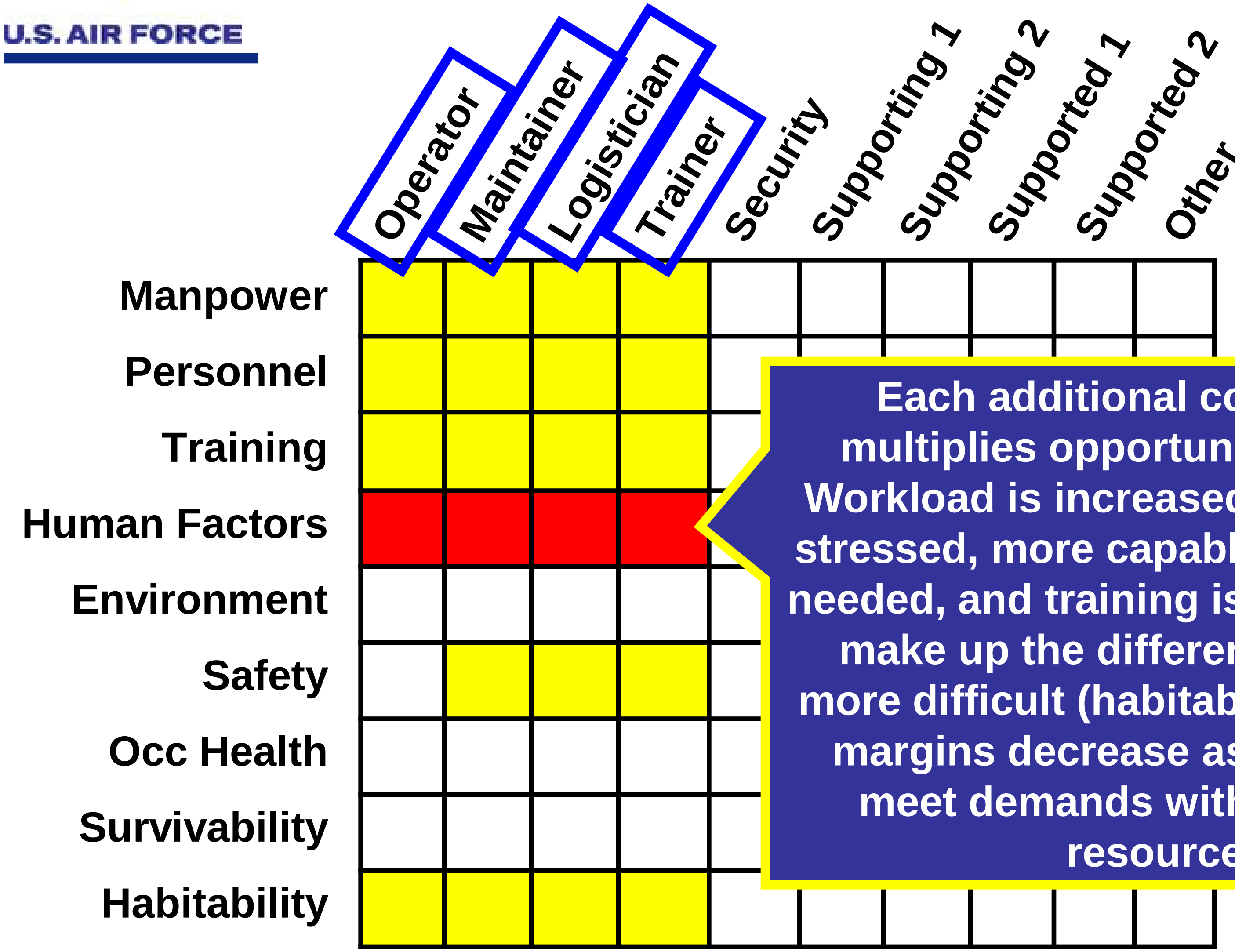


Include in the analysis all the humans who touch the system

Example: Predator Configurations

- How many configurations on one flightline?
- Imagine the cost of:
  - Parts stocked
  - Training required
  - Different weapons loading
  - Technical orders maintained
  - Maintenance tools required
  - Opportunities for human errors

Predator Configurations



Each additional configuration multiplies opportunities for error. Workload is increased. Manpower is stressed, more capable personnel are needed, and training is often tasked to make up the difference. Jobs are more difficult (habitability) and safety margins decrease as people try to meet demands with insufficient resources.

Lessons Learned

- Army and Navy Lessons Learned
  - Army HSI (MANPRINT)
  - Naval HSI in multiple SYSCOMs
  - Air Force is studying their programs to build ours
- Challenges:
  - “Requirements creep”
  - Technology readiness –readiness of (or for) the human
  - Budget constraints (especially sustainment)
  - Costs: Acquisition vs. Lifecycle vs. Total Ownership
  - Systematic application of lessons learned from legacy
- Results:
  - Insert HSI “left of A”
  - Work collaboratively with all stakeholders

Inserting HSI into JCIDS "Left of A"

- **Ensure that human concerns are addressed in capability based analyses (CBA), Analysis of Alternatives (AoA) and JCIDS requirements documents**
- **Write testable human requirements for all users, not just the operators, to help ensure more effective and sustainable systems in the future**
- **Work collaboratively to support Early Systems Engineering, Continuous Capability Planning and Developmental Planning**

U.S. AIR FORCE

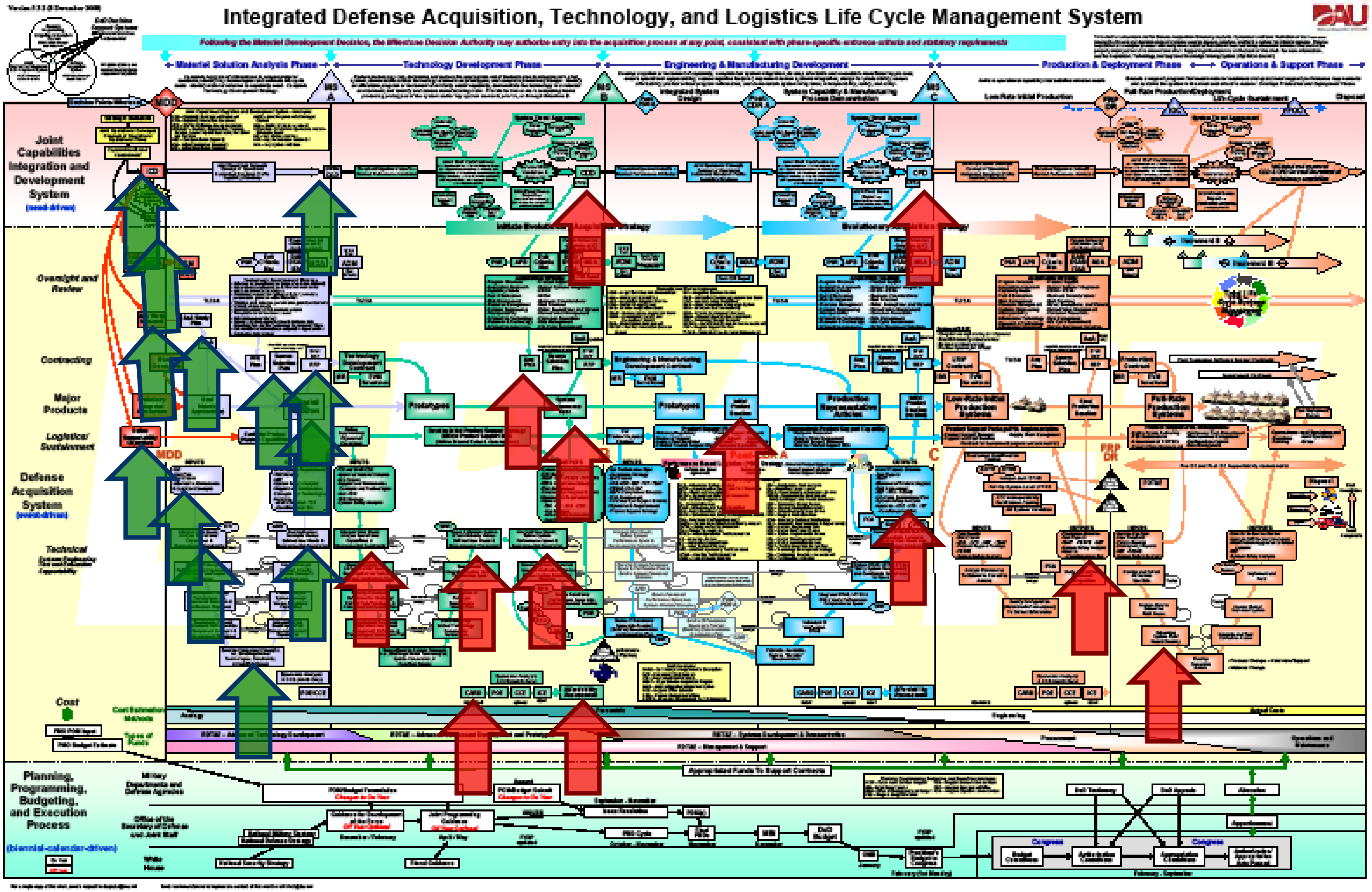
Where Does HSI Fit in These Processes?

- **Analysis:**
  - Analyze operator surveys and provide lessons learned to document Total System capability gaps
  - Provide realistic cost data on human factors engineering, integration, manpower, personnel, and training
- **Requirements:**
  - Address "human issues" within mandatory KPP/KSAs, and attributes related to maintenance, integration, safety
  - Insert correct safety, manpower, personnel, training, logistics and maintenance information in CDD/CPD sections 14 and 15
  - Provide the appropriate hook so system engineers can further clarify design needs in follow-on documents
- **Acquisition:**
  - Translate the CDD/CPD hooks into acquisition requirements
  - Assist in technology development/engineering and design
  - Participate in IPTs writing technical documents, test plans and cost/manpower assessments

HSI in AoA/Post-CBA Analysis

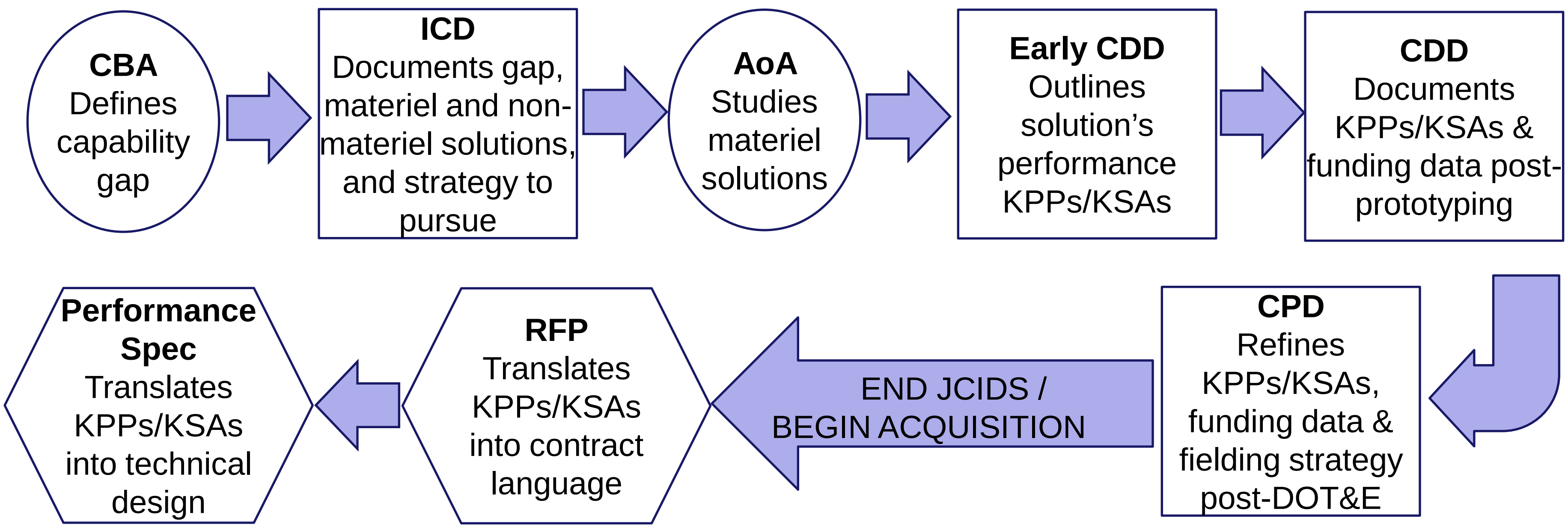
- **AoAs are now done for <u>all</u> ACAT programs – challenge yet an opportunity for HSI to be inserted/considered**
- **Post-CBA Analyses are intended to take it to next level of granularity**
- **HQ Air Force Material Command's Office of Aerospace Studies (OAS) guides all AoAs**
  - **AFHSIO and 711th Human Performance Wing are working with OAS to begin more active participation in AoAs and other analyses**
  - **OAS facilitators are enthusiastic about Human Systems Integration's ability to positively affect outcomes of analysis and development of systems**

HSI Opportunities in the Process



Translation between JCIDS and Acquisition

- **Humans must be considered at each step in the process in order to be adequately represented in the acquisition. Waiting until acquisition documents to introduce HSI invites problems:**
  - **Cost overruns: Unfunded “requirements creep”**
  - **Schedule delays: Re-design or integration problems**
  - **Performance lag: System performance relies on humans**



HSI Requirements Pocket Guide

- **Air Force HSI Tiger Team, held January 2009**
- **Pocket Guide can be used by HSI practitioners to assist requirements writers**
- **Can also be used by requirements writers to help them consider human centered requirements**
- **Contents include: What is HSI?, Critical Nodes, Writing Requirements, DOs and DON'Ts, Key Word Reference, Personnel Resources**
- **AFIT course SYS 161 will utilize the Pocket Guide and address how to use it in writing requirements**

Decision Authority Issues Addressed by CBAs and AoAs

- Is the functional/mission need understood well enough?
- What capabilities are needed? When must they be introduced to the field or fleet?
- What is the best approach to develop these capabilities?
- Has a capability baseline been identified?
- How much will the options cost?
- Is the option affordable?
- Have alternative solutions been reviewed?
- Why was this solution selected?
- Has risk been assessed?
- Is the solution operationally effective and suitable?
- Can it be supported?

- Source: AFIT, REQ 111

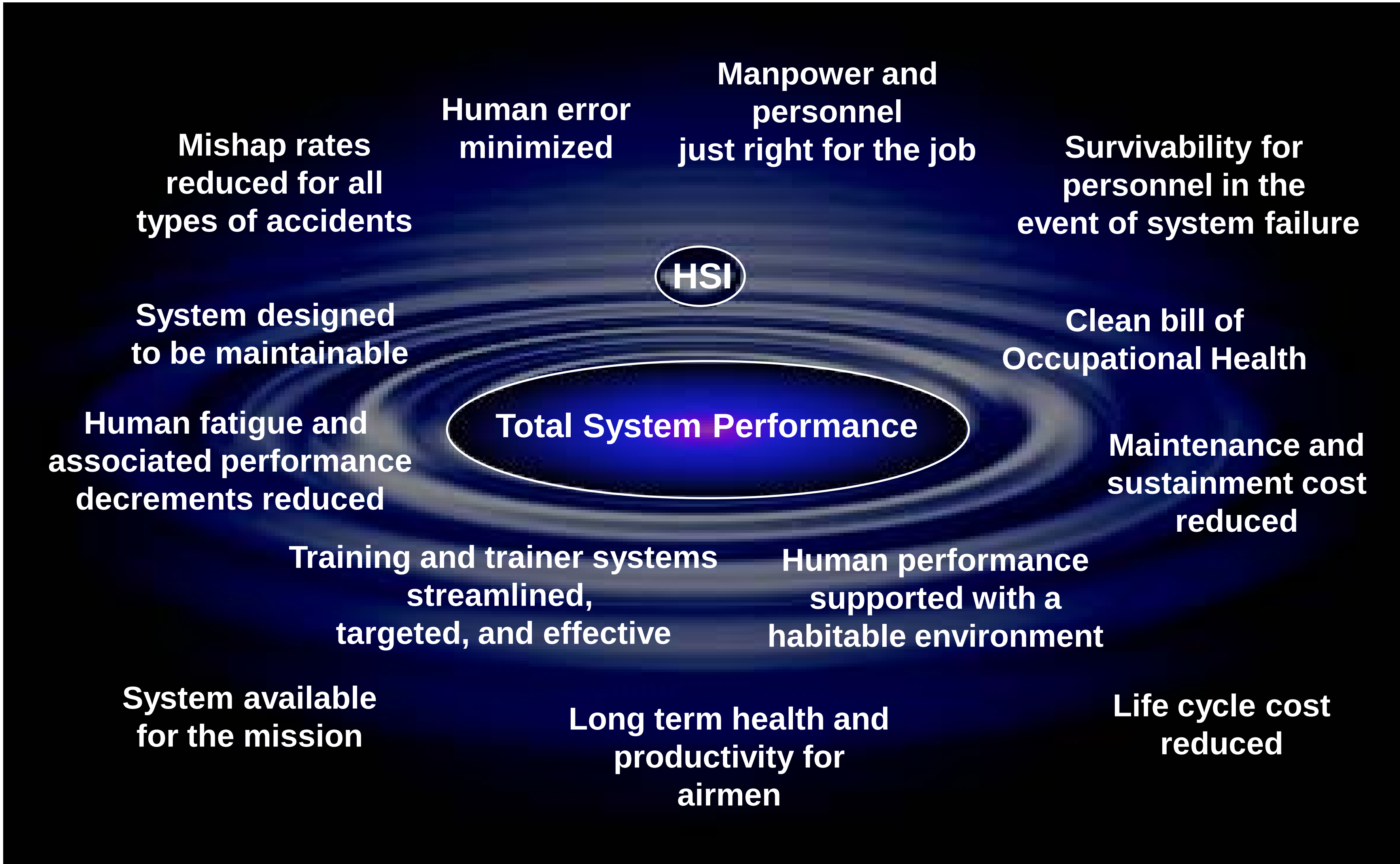
Summary

- HSI integrates people and technology
- Consider the human equally with other aspects of the system:
  - Hardware
  - Software
  - Liveware (human)
- HSI takes a holistic view to consider ***all*** users of a system: operator, maintainer, logistician, trainer, support, customer, coalition partner, etc.

Human Systems Integration is a key process by which affordable, more capable systems are acquired

U.S. AIR FORCE

Ripple Effect of Early HSI



QUESTIONS?

Acquisition Program Technical Measurement

James Thompson

Director, Major Program Support

Systems Engineering Directorate

Office of the Director, Defense Research and Engineering

12th Annual NDIA Systems Engineering Conference
October 29, 2009

Outline

- **Background**
  - Weapon Systems Acquisition Reform Act of 2009 (WSARA)
  - Acquisition Program Technical Measurement
- **Program Assessment & Monitoring**
  - Individual Program Support Review (PSR) Stop light
  - Signs of Good Programs
  - Integration of Existing Metrics to Uncover Trends and Relationships
  - Program Insight
- **Preferred End State**
  - Notional Scorecard
  - Integration of DoD Data Repositories
  - Leveraging Industry Best Practices
- **Summary**

Weapon Systems Acquisition Reform Act of 2009

- Establishes Director, Systems Engineering (D, SE) and Director, Developmental Test and Evaluation (D, DT&E) as principal advisors to the SECDEF and the USD(AT&L)
- Mandates documented assessment of technological maturity and integration risk of critical technologies for MDAPs during the Technology Development (TD) phase
- **Establishes D, DT&E and D, SE joint tracking and Congressional reporting on MDAP achievement of measurable performance criteria**
- Mandates competitive prototyping and MDA completion of a formal Post-Preliminary Design Review Assessment for all MDAPs before MS B; additional MDA certification to both at MS B
- Strengthens technical analysis of cost and schedule breaches during the Technology Development (pre-MS B) and the Engineering and Manufacturing Development (post-MS B)


President Barack Obama hands a pen to U.S. Rep. Robert Andrews (D-NJ) as he signs the Weapons Systems Acquisition Reform Act in the Rose Garden at the White House Friday, May 22, 2009. Standing from left are: Andrews, Rep. John McHugh (R-NY), Sen. Carl Levin (D-MI), Rep. Ike Skelton (D-MO) and Rep. Mike Conaway (R-TX). Official White House Photo by Samantha Appleton

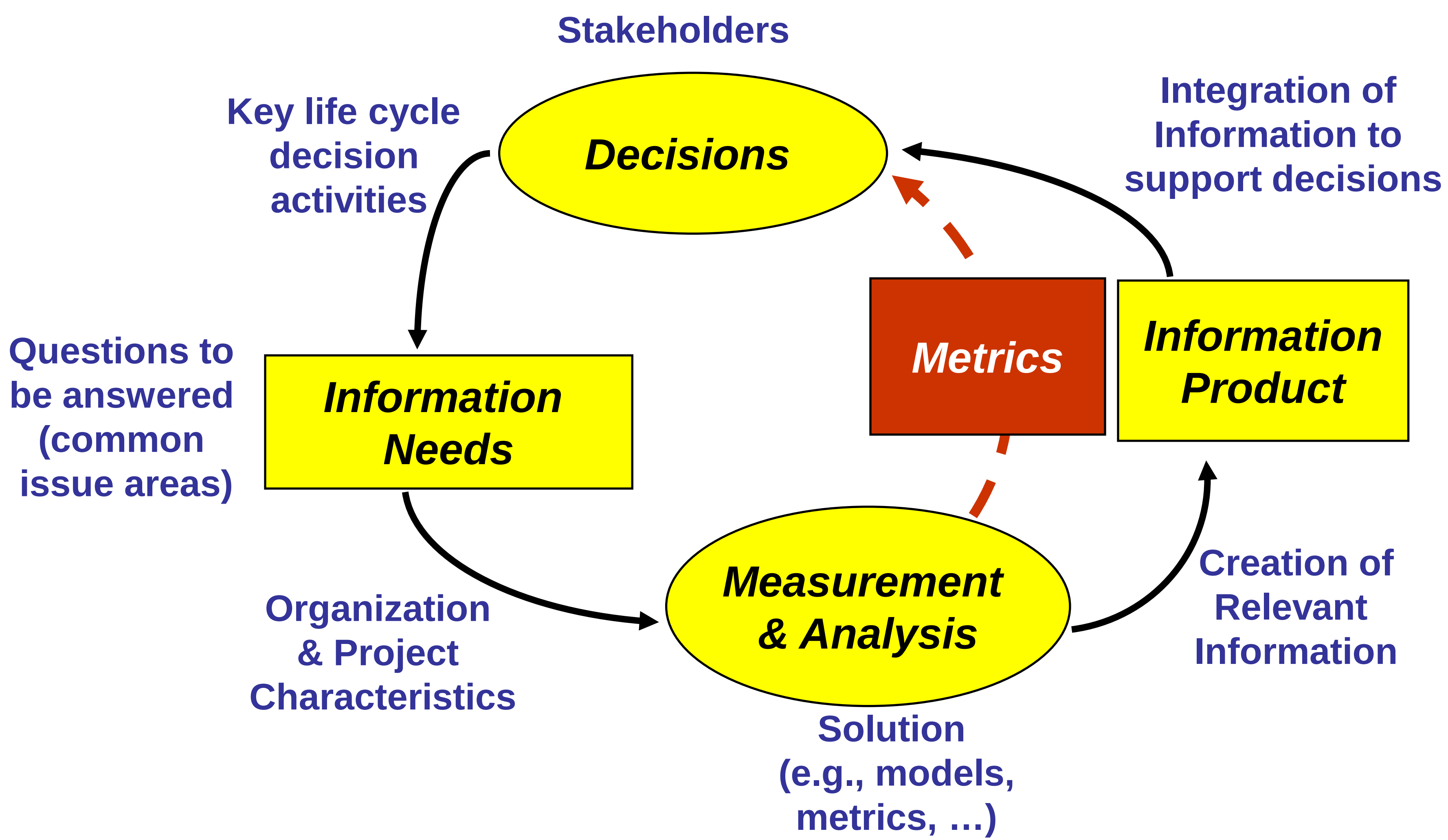
MDAP- Major Defense Acquisition Program (USC 2430)
MDA – Milestone Decision Authority

Acquisition Program Technical Measurement

- **Program performance reporting inadequate to support effective Acquisition decision making**
  - Program-level metrics change as through out the life cycle to address changing information needs (prevents Acquisition organization from obtaining complete data covering the program's full life cycle)
  - Programs develop unique metrics which help them effectively manage their program (prevents Acquisition benchmarking due to dissimilar program data)
- **Our objective is to establish an objective trustworthy Acquisition Program Measurement capability**
  - Fulfilling Statutory requirements of the Weapons Systems Acquisition Reform Act of 2009
  - Maximizing use of existing program reporting requirements and processes
  - Linking Services' and OSD databases to enable DoD Program benchmarking

Enable Objective Information Based Decision Making

Conceptual Information Flow:
(Creating Meaningful Metrics)



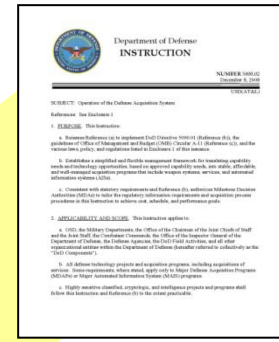
(Adapted from: SSCI 2007)

UNCLASSIFIED

Program Assessment and Monitoring

- **Fall 2002: OSD establishes SE organization to:**
  - Drive SE back into programs
  - Instill credibility in the acquisition process

- **Program Assessments: Element of DoD SE revitalization effort**
  - Help Program Managers identify & mitigate risks
  - Shape technical planning and management
  - Provide insight to OSD stakeholders
  - Identify systemic issues requiring resolution above program


Department of Defense
INSTRUCTION

3.9.6. Program Support Review (PSR). PSRs are a means to inform the MDA, OIPT, and Program Office of the status of technical planning and management processes by identifying cost, schedule, and performance risk and recommendations to mitigate those risks. PSRs shall be conducted by cross-functional and cross-organizational teams appropriate to the program and situation. PSRs for ACAT ID and IAMs shall be planned by the Director, Systems and Software Engineering to support pending OIPT program reviews, at other times as directed by the USD(AT&L), and in response to requests from PMs.

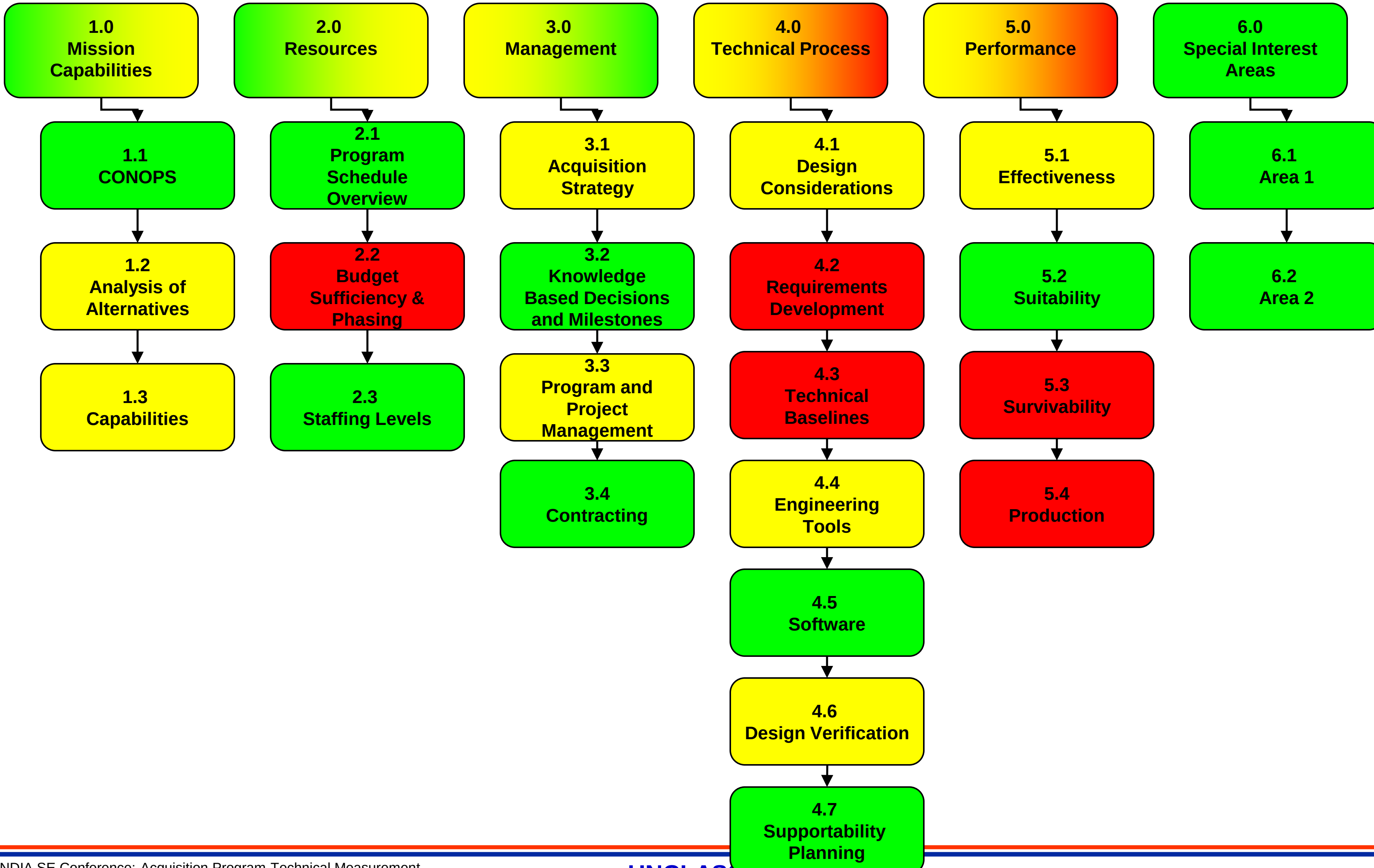
Program Assessments
- Support acquisition decisions & requests
- Address technical issues
- DAPS Methodology provides framework

Program Monitoring
- SE technical reviews, WIPTs, test events
- Program Signature
- Metrics to assess program performance
- Systemic Root Cause Analysis

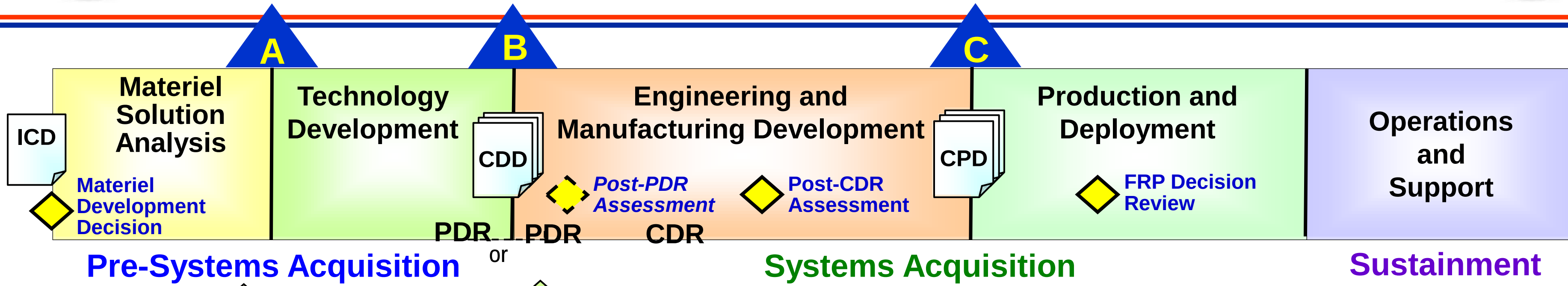
Continuous Program Engagement Enhances Program Execution

UNCLASSIFIED

Notional PSR Stop Light



Use Signs and Artifacts of Good Programs to Identify Meaningful Metrics



Technical Excellence Milestone A

- ✓SEP
  - Risk management planning
- ✓TES
- ✓TDS
- ✓ADM, Phase exit criteria
- ✓Draft RFP

Technical Excellence Milestone B

- ✓SEP
  - Risk management planning
- ✓TEMP
- ✓Acquisition Strategy
  - Contract Scope
- ✓ADM, Phase exit criteria
- ✓PDR report

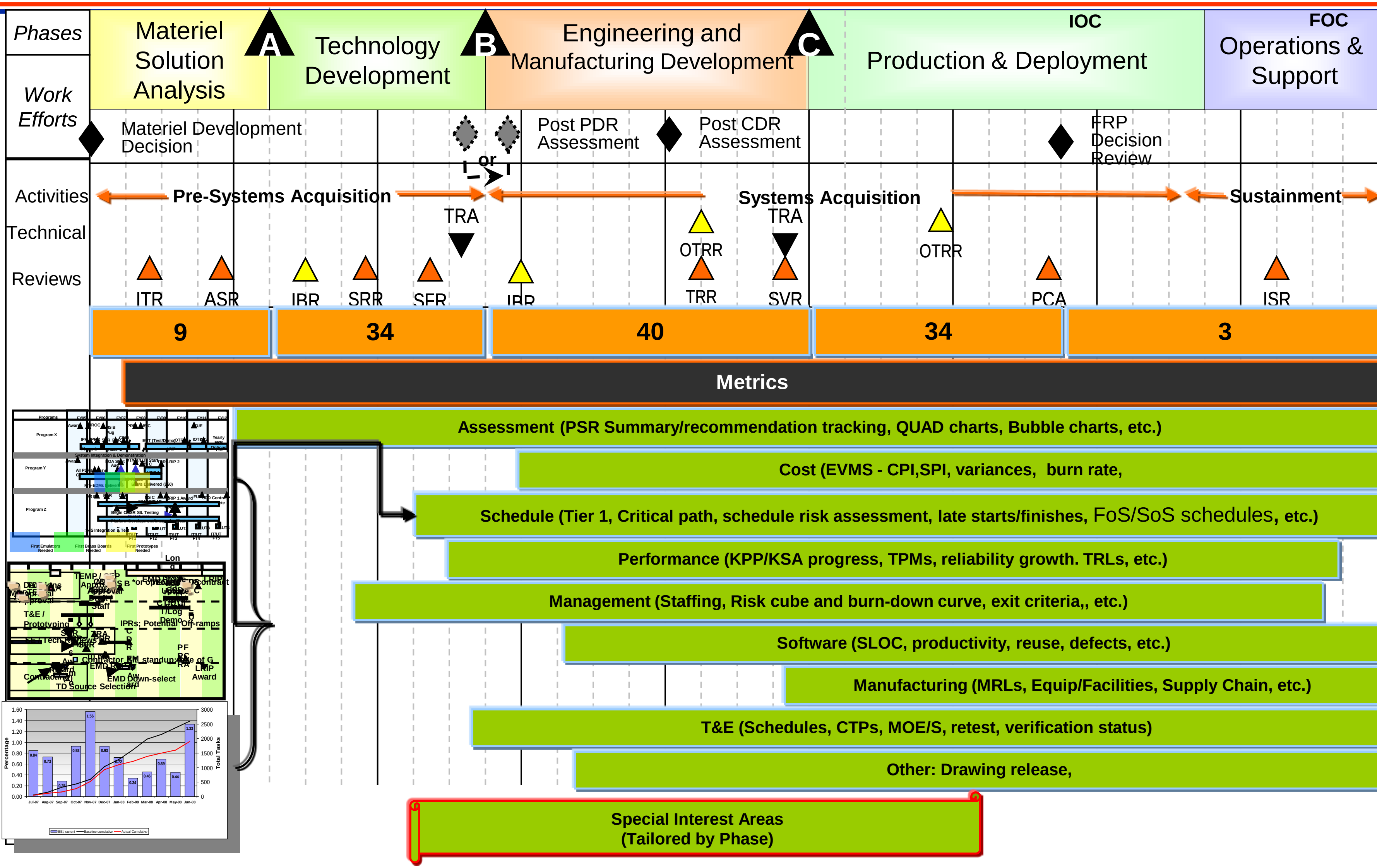
Technical Product
- Mature technologies and modular open architecture
- Reliability and maintainability designed-in
- Early focus on production planning
- Realistic software size, productivity, and reuse estimates
- Assessments of manufacturing planning and maturity

Technical Process
- Established SE processes in use
- SEP approved prior to RFP release
- Adequate requirements flow-down/ traceability/ decomposition
- Emphasis on test and verification approach
- Comprehensive contractual verification (section 4 of spec) of meeting requirements (section 3 of spec)

Mission Capabilities/Requirements
- Establish reasonable, measurable and testable CDD/CPD requirements
- Conducts SRR in TD phase with competing contractors
- Uses competitive prototyping
- Establishes PM/User/Contractor advisory group to assess cost/performance trades
- Maintains stable requirements

Resources and Management
- Funding properly phased and adequate to support planned SE activities
- Adequately staffed with qualified personnel
- Adequate management reserve consistent with program risks
- Good communication between user, acquirer, supplier; IPTs
- Manages external interfaces with complementary programs
- Maintains event driven schedules
- Robust risk management process and mitigation activities; Integration with IMS and EVM

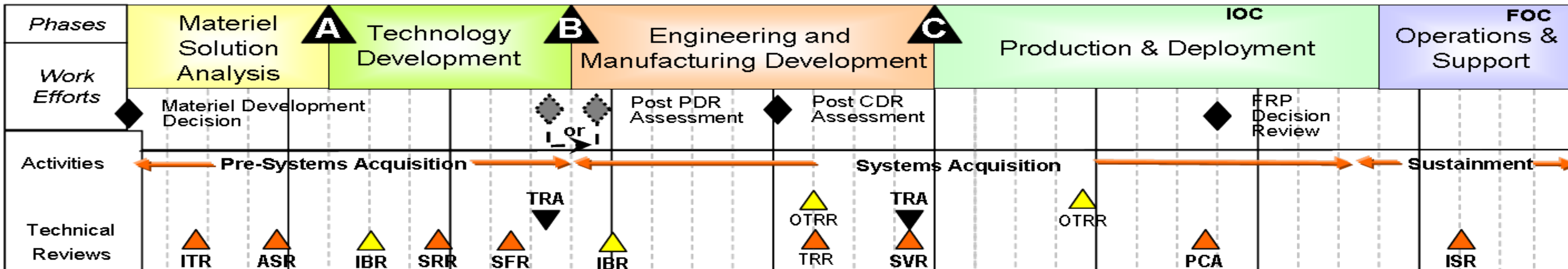
Integration of Indicators to Uncover Relationships and Trends



UNCLASSIFIED

Leverage Existing Data & Metrics

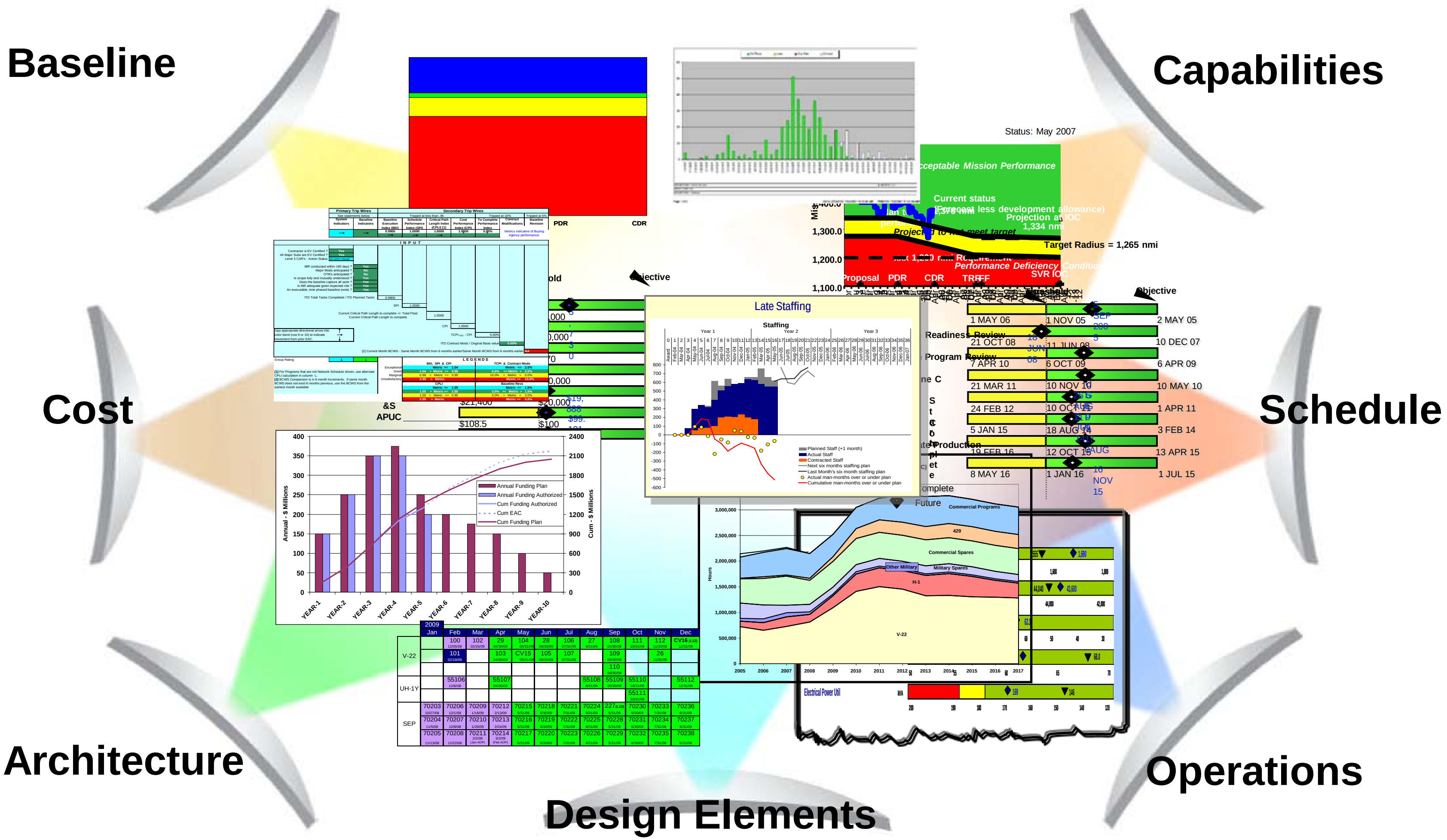
- **Portfolio of MDAP Programs**
- **PSRs provide primary Major Program Support (MPS) touch points to collect data and assess Program Performance**



# of Programs on 2009 DT Oversight	28	34	44	31	37
Service					
Air Force	9	14	10	13	13
Army	5	7	8	7	6
Navy	13	7	20	8	16
DoD	1	6	6	3	2
Domain					
C2	6	9	5	8	2
Comms	3	3	10	4	2
Fixed	7	1	6	6	9
Helo	3	2	4	0	5
UAS	0	0	5	2	0
Land	0	4	2	1	2
Munitions	1	2	0	2	4
Ships	6	3	6	2	4
Missile	2	3	5	1	6
Space	0	6	1	5	2
Other	0	1	0	0	1

UNCLASSIFIED

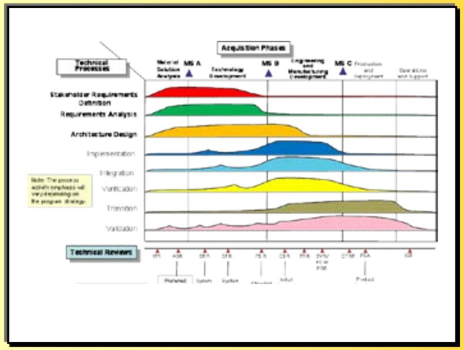
Program Insight



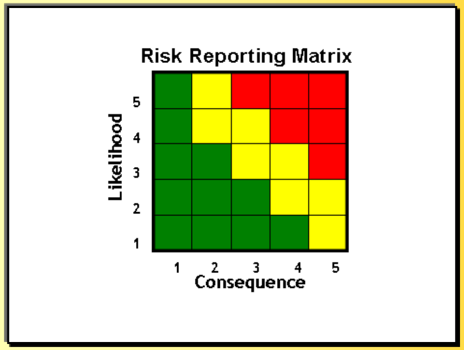
UNCLASSIFIED

Notional Dashboard

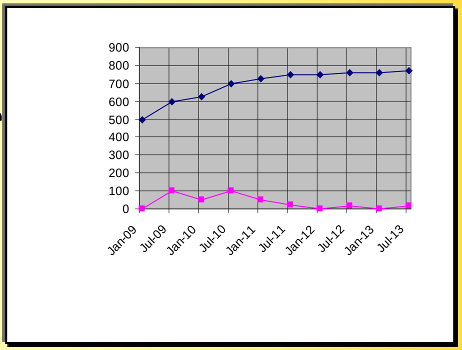
Staffing Plan



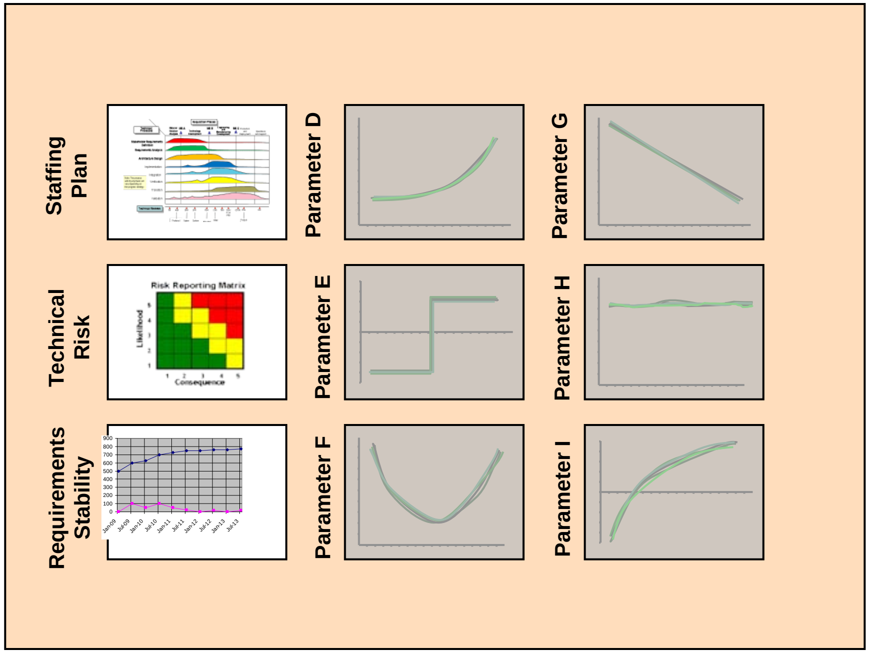
Technical Risk



Requirements Stability



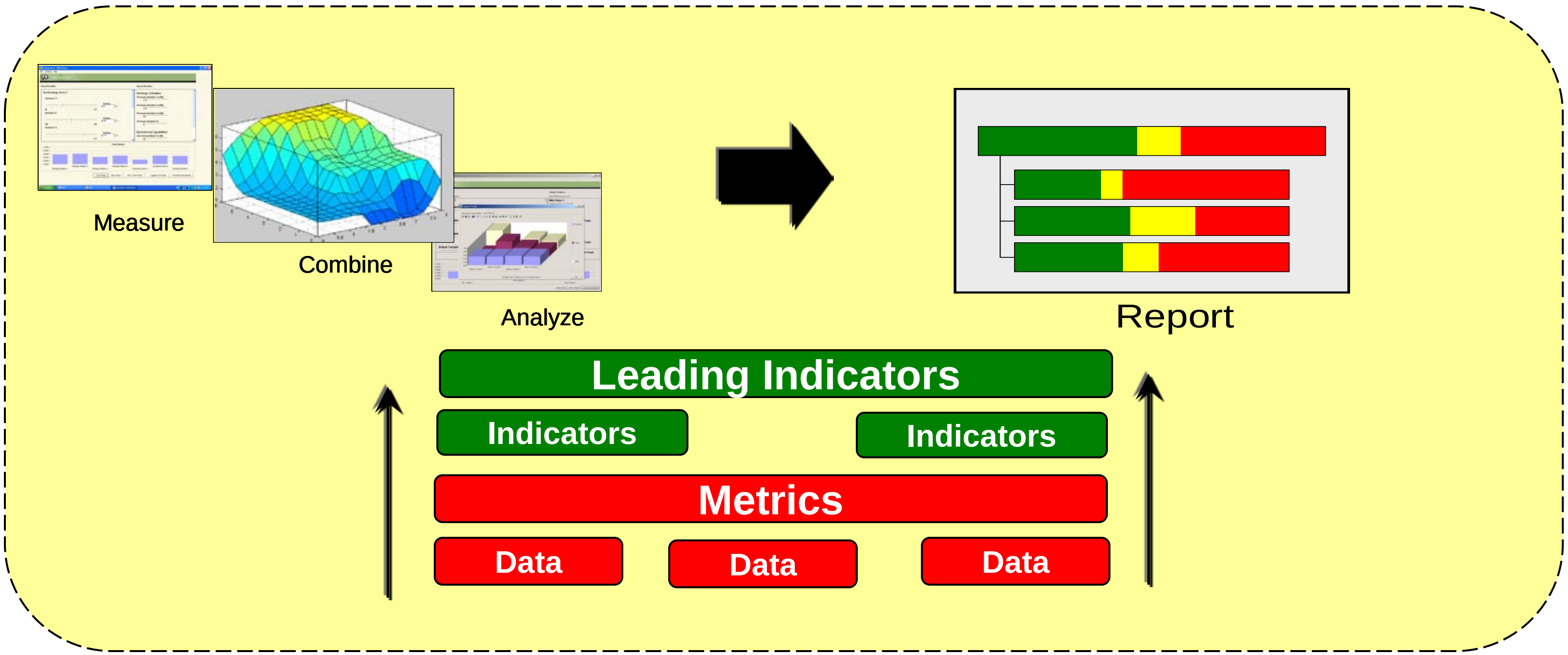
Decision Support Matrix

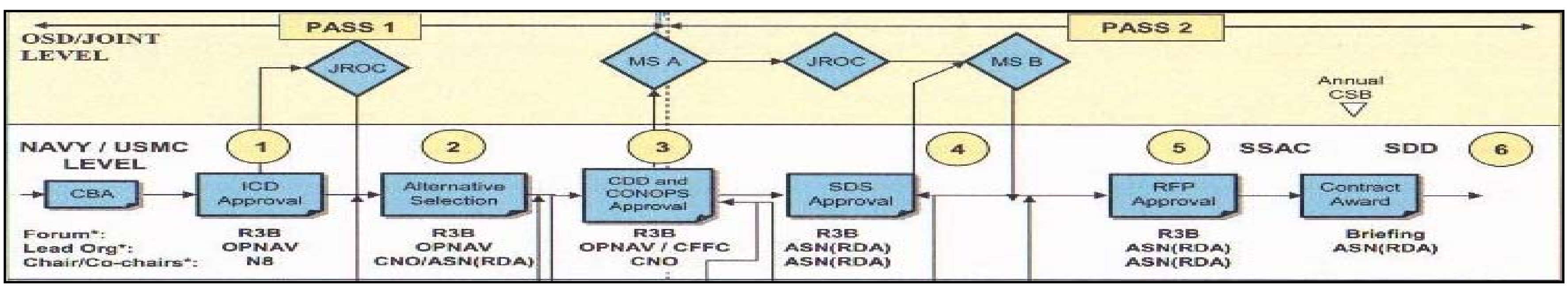


Inform Milestone decisions by providing assessment against key program factors as well as comparison against past program trends

UNCLASSIFIED

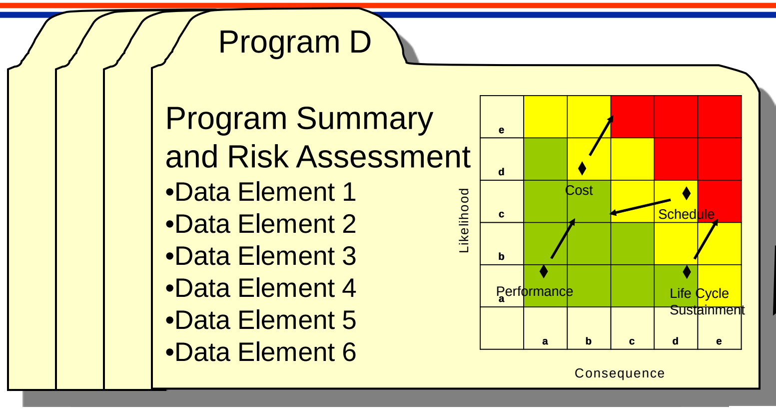
Dashboard Contents based on Existing Indicators



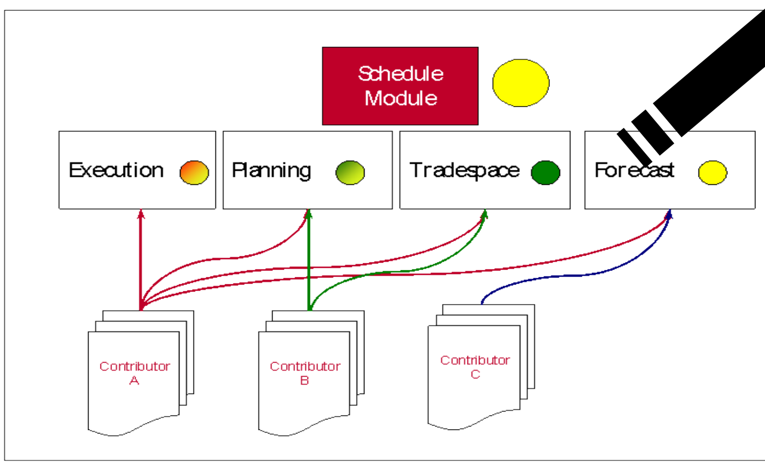


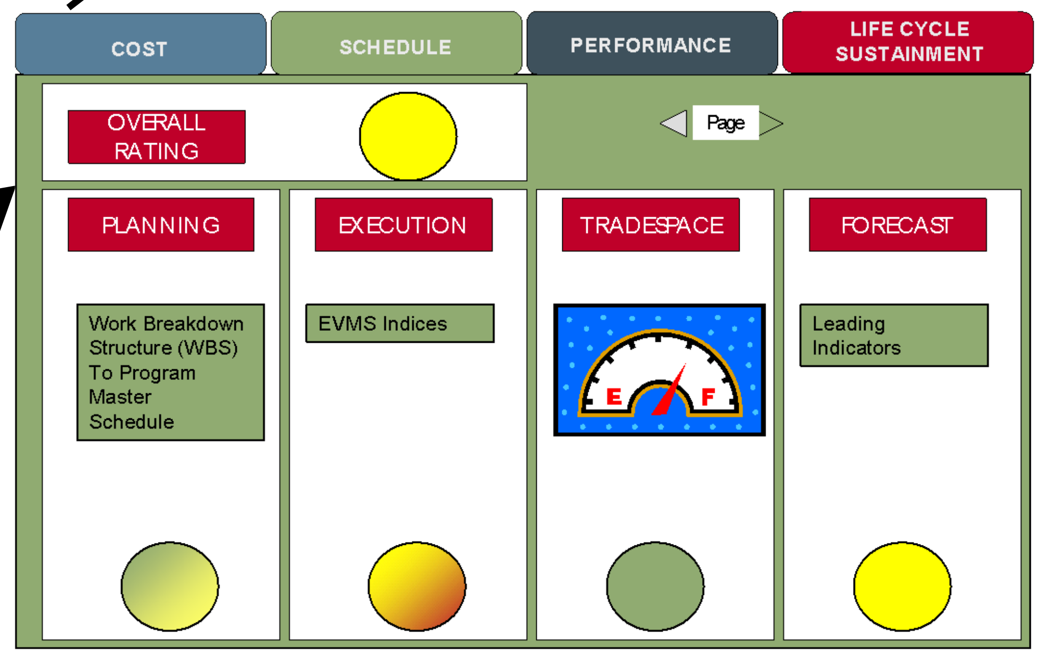
UNCLASSIFIED

Preferred End State



Program Assessment and Display Level

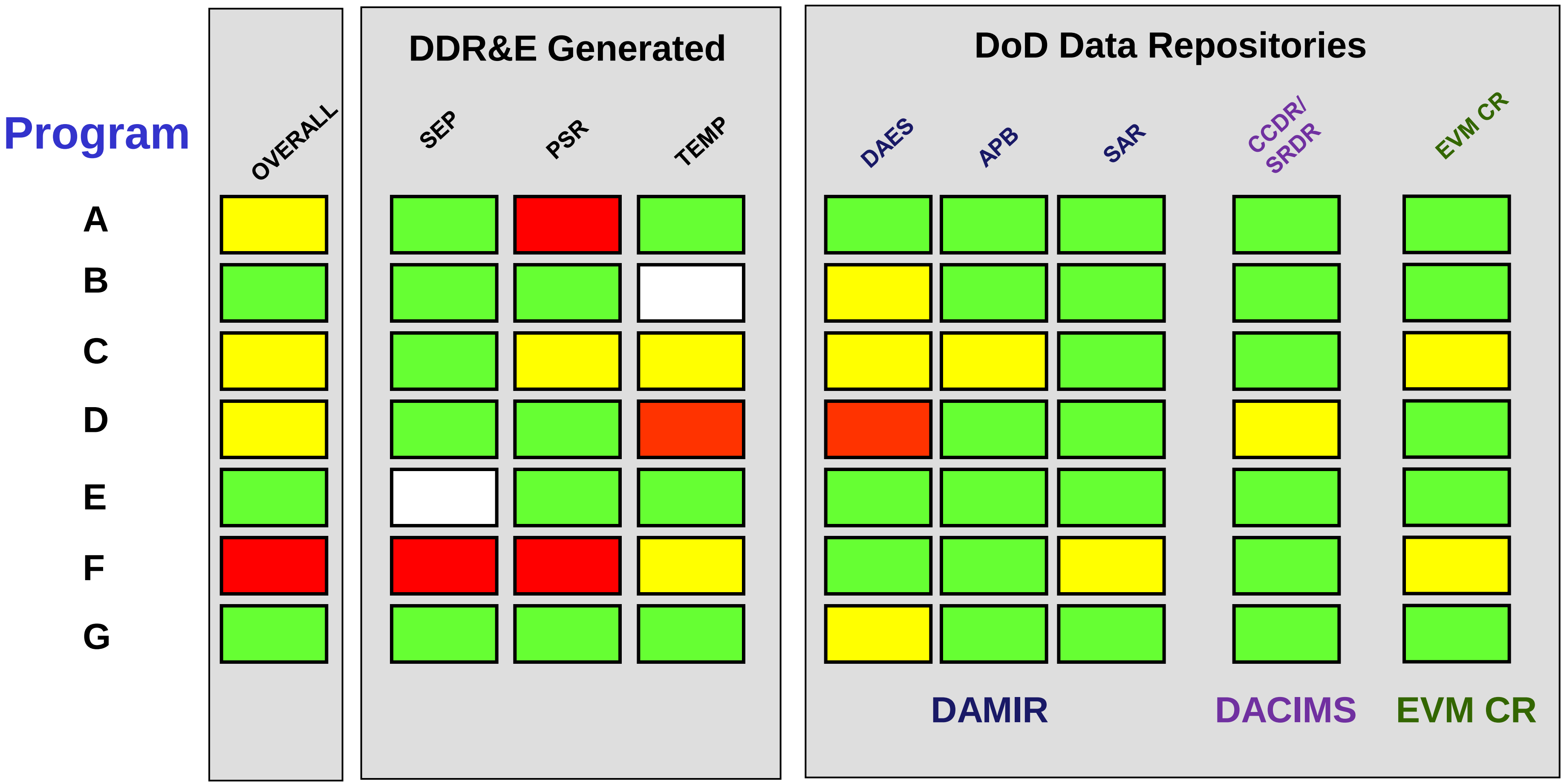




Aggregation and Integration Level

UNCLASSIFIED

Notional Example for Director of Major Program Support



Position DDR&E to Leverage Related Industry Best Practices

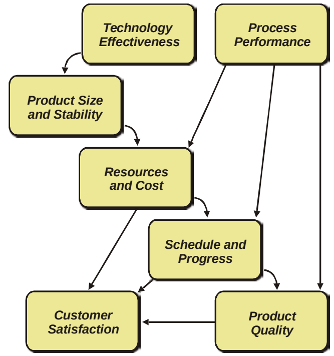
LAI

LEAN AEROSPACE INITIATIVE

INCOSE

International Council on Systems Engineering

PSM



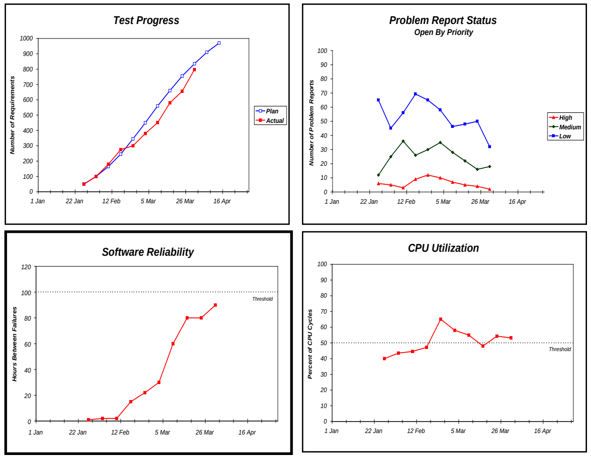
SYSTEMS ENGINEERING LEADING INDICATORS GUIDE

TABLE 1. SYSTEMS ENGINEERING LEADING INDICATORS OVERVIEW

Leading Indicator	Insight Provided	P1	P2	P3	P4	P5
Requirements Trends	Rate of maturity of the system definition against the plan. Additionally, characterizes the stability and completeness of the system requirements which could potentially impact design and production.	•	•	•	•	•
System Definition Change Backlog Trend	Change request backlog which, when excessive, could have adverse impact on the technical, cost and schedule baselines.			•	•	•
Interface Trends	Interface specification closure against plan. Lack of timely closure could pose adverse impact to system architecture, design, implementation and/or V&V any of which could pose technical, cost and schedule impact.	•	•	•	•	•
Requirements Validation Trends	Progress against plan in assuring that the customer requirements are valid and properly understood. Adverse trends would pose impacts to system design activity with corresponding impacts to technical, cost & schedule baselines and customer satisfaction.	•	•	•	•	•
Requirements Verification Trends	Progress against plan in verifying that the design meets the specified requirements. Adverse trends would indicate inadequate design and rework that could impact technical, cost and schedule baselines. Also, potential adverse operational effectiveness of the system.	•	•	•	•	•
Work Product Approval Trends	Adequacy of internal processes for the work being performed and also the adequacy of the document review process, both internal and external to the organization. High reject count would suggest poor quality work or a poor document review process each of which could have adverse cost, schedule and customer satisfaction impact.	•	•	•	•	•
Review Action Closure Trends	Responsiveness of the organization in closing post-review actions. Adverse trends could forecast potential technical, cost and schedule baseline issues.	•	•	•	•	•
Risk Exposure Trends	Effectiveness of risk management process in managing / mitigating technical, cost & schedule risks. An effective risk handing process will lower risk exposure trends.	•	•	•	•	•
Risk Handling Trends	Effectiveness of the SE organization in implementing risk mitigation activities. If the SE organization is not retiring risk in a timely manner, additional resources can be allocated before additional problems are created.	•	•	•	•	•
Technology Maturity Trends	Risk associated with incorporation of new technology or failure to refresh dated technology. Adoption of immature technology could introduce significant risk during development while failure to refresh dates technology could have operational effectiveness/customer satisfaction impact.		•	•	•	•
Technical Measurement Trends	Progress towards meeting the Measures of Effectiveness (MOEs) / Performance (MOPs) / Key Performance Parameters (KPPs) and Technical Performance Measures (TPMs). Lack of timely closure is an indicator of performance deficiencies in the product design and/or project team's performance.			•		
Systems Engineering Staffing & Skills Trends	Ability of SE organization to execute total SE program as defined in the program SEP or SEMP. Includes quantity of SE personnel assigned, the skill and seniority mix and the time phasing of their application throughout the program lifecycle.	•	•	•	•	•
Process Compliance Trends	The quality and consistency of the project defined SE process as documented in the program's SEP / SEMP. Poor/inconsistent SE processes and/or failure to adhere to SEP / SEMP, increase program risk.	•	•	•	•	•

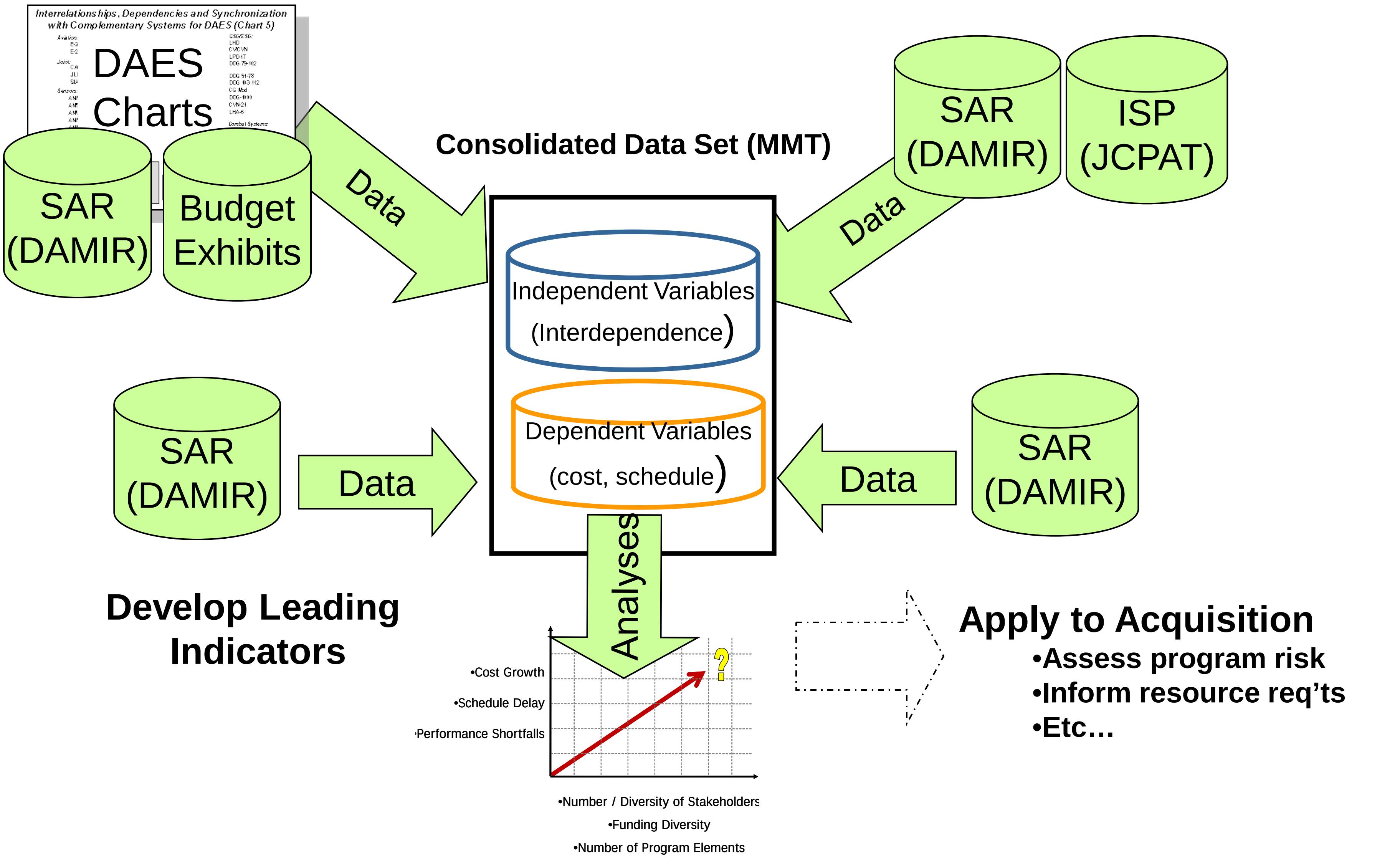
Integrated Analysis Example

Readiness for Delivery



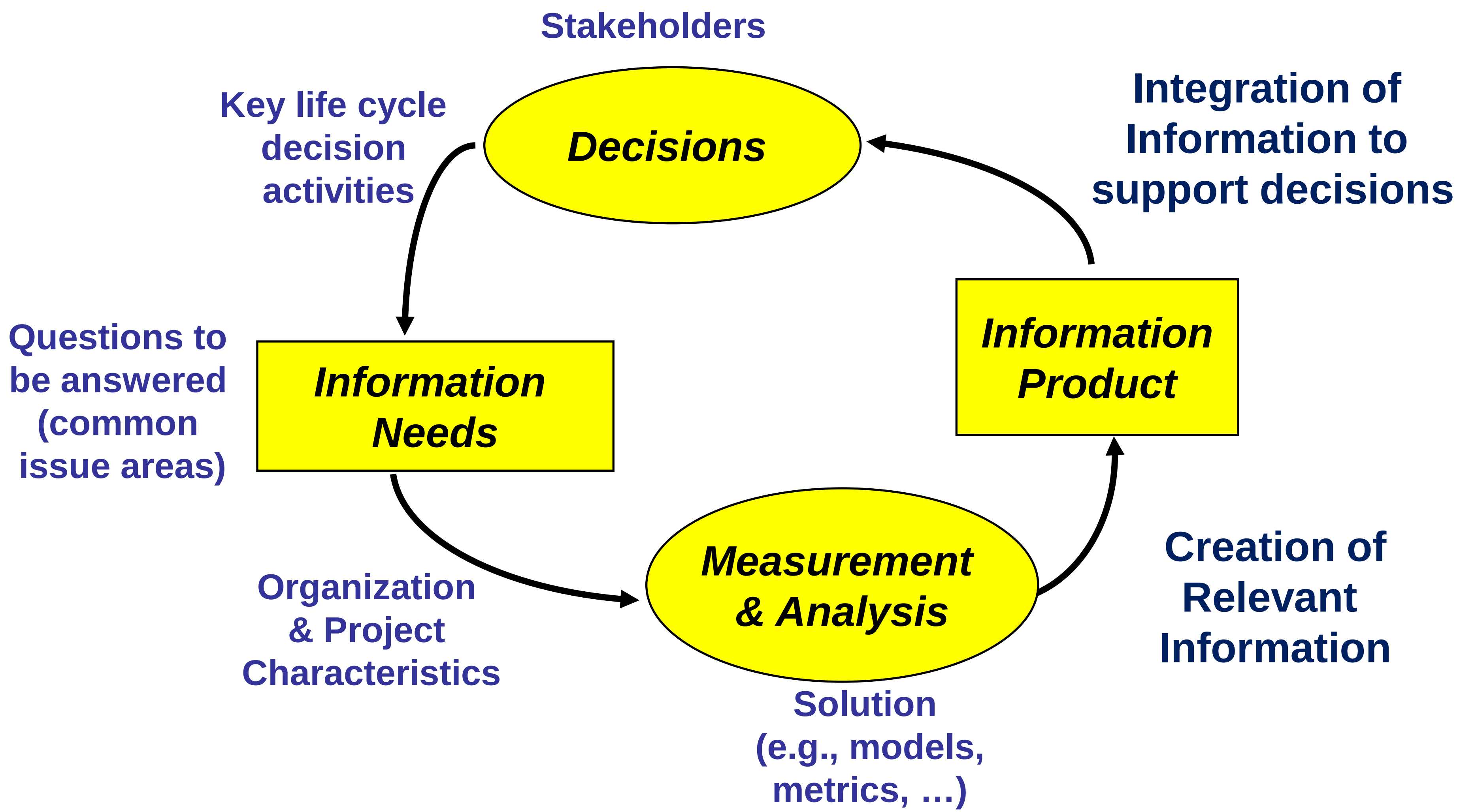
UNCLASSIFIED

Supporting Future Alignment of Existing DoD Data Sources



UNCLASSIFIED

Conceptual Information Flow:
(Creating Meaningful Metrics)



(Adapted from: SSCI 2007)

Summary

- **Objective is to better insight to Acquisition decision makers**
  - Statutory reporting requirements of the Weapons Systems Acquisition Reform Act of 2009
  - Effective decision making supported by existing program performance reporting as well as increasing the integration of DoD Data repositories
- **Development of useful Acquisition metrics and leading indicators requires integration of existing engineering and management performance data**
  - Minimizing effort associated with data collection and analysis, yet increasing the degree of objective program performance data
- **Focus on creating a set of useful Information products for Acquisition stakeholders, which requires:**
  - Knowledge of data quality (reproducible, unbiased, …)
  - Baselining key decisions and information needs
  - Creating meaningful ways to aggregate and integrate data throughout the Acquisition hierarchy

Questions/Discussion

Contact Information:

Mr. James Thompson
Director, Major Program Support
Systems Engineering Directorate
Office of the Director, Defense Research and Engineering
James.thompson@osd.mil

CMMI® for Executives

NDIA Systems Engineering Division

in partnership with:
Software Engineering Institute
Carnegie Mellon University

October 2009

Topics

Do You Need CMMI?

What Is CMMI?

How Can CMMI Benefit You?

Who Is Using CMMI?

How Can You Get Best Value from CMMI?

Do You Need CMMI?

Recognize these symptoms?

- **Missed commitments**
  - Late delivery
  - Last minute crunches
  - Spiraling costs
- **Inadequate management visibility**
  - Too many surprises
- **Quality problems**
  - Too much rework
  - Functions not working correctly
  - Customer complaints
- **Poor morale**
  - Crisis atmosphere
  - High turnover
  - Low productivity

Does the following occur?

- **Poor planning**
  - Plans not realistic or followed
  - Work is not tracked against the plan; plans are not adjusted.
- **Baselines not controlled**
  - Inconsistent requirements
  - Changes not managed
- **Ineffective organizational structure**
  - Functions not well integrated
  - Designs not producible
- **Unable to repeat successes**
  - Staff skills and knowledge not available when needed
  - Dependent on heroic individuals

CMMI Features Help Address Common Issues

CMMI Feature	Description and Examples
Results Oriented	• Industry best practices for project planning and execution • Performance-driven measures for consistent outcomes
Priorities Based on Business Value	• Investments and maturity prioritized to align with business goals • Appraisals relative to model to set direction (“map and compass”)
Customer Focus	• Validation of customer needs across the project life cycle • Manage product/service quality (verification, validation, reviews)
Proactive Management	• Forward-looking measurement, monitoring, risks, corrective action • Management decisions based on plans, data, alternatives
Flexibility	• Adaptable to a variety of businesses (domain, size, products) • Non-prescriptive (required, expected, informative components)
Business Process Integration	• Cross-functional stakeholder involvement • Coordinate various improvement strategies and methods (Lean, Six Sigma, ISO, Agile, etc.)
Continuous Learning	• Standardized assets tailored for project characteristics • Leverage experience and history across projects

Why Focus on Process?

The quality of a system is highly influenced by the quality of the process used to acquire, develop, and maintain it.

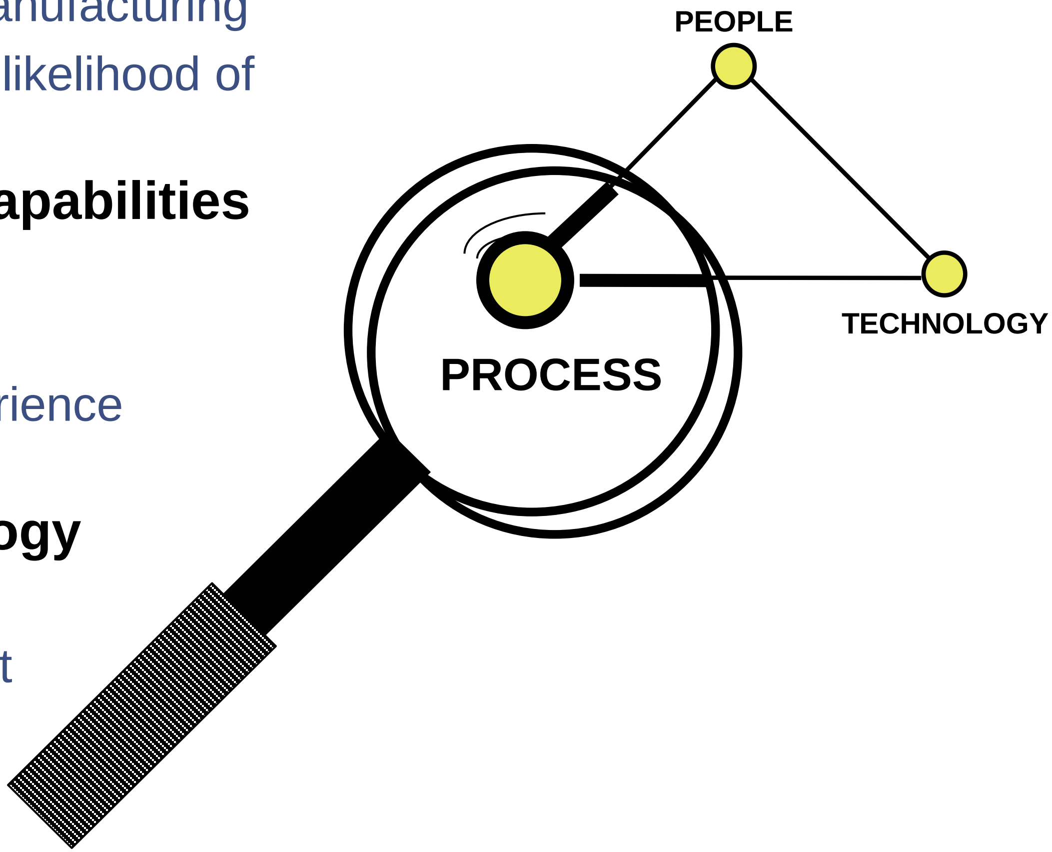
- A long-standing premise in manufacturing
- Good processes increase the likelihood of successful projects

Process can enhance the capabilities of your workforce

- Work smarter, not just harder
- Leverage organizational experience and best practices

Process integrates technology with resources

- Technology, by itself, will most likely not be used effectively



Topics

Do You Need CMMI?

What Is CMMI?

How Can CMMI Benefit You?

Who Is Using CMMI?

How Can You Get Best Value from CMMI?

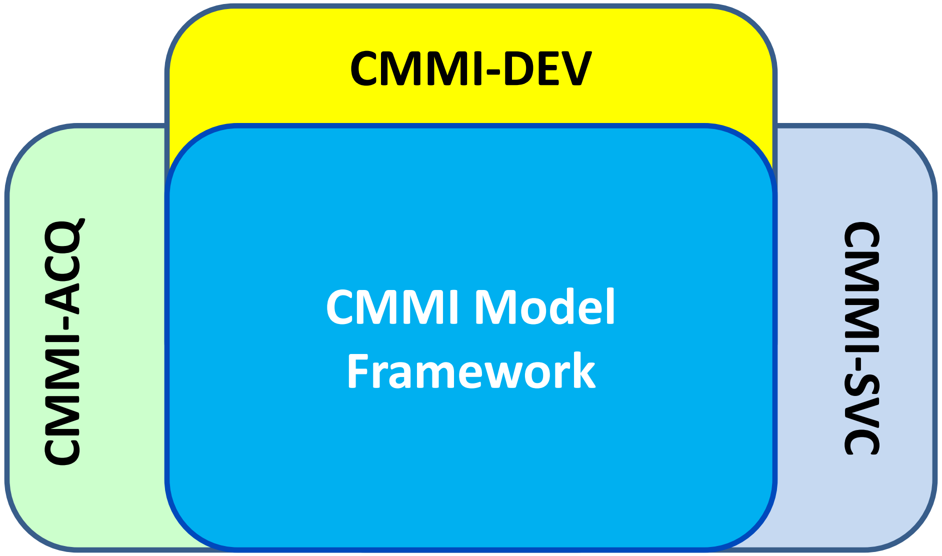
What Is CMMI?

CMMI is a model representing a collection of best practices proven effective in industry

- A framework for developing, improving, and sustaining business performance
- Provides a process focus on work activities
- Developed by industry (commercial and defense), government, academia

CMMI targets three primary environments:

- Development -
  Engineering a product or service
- Services –
  Providing services
- Acquisition –
  Acquiring products and services



The CMMI product suite consists of:

- Models and primers
- Appraisal methods
- Training courses

Capability Maturity Model Integration (CMMI®)

What CMMI Can Add to Your Organization

- Integration of business processes across functions based on industry best practices
- Visible project and organizational measures aligned with achievement of business objectives
- Commonly accepted process framework for inter-company coordination and competitor benchmarking
- Repeat project successes through standardization, tailoring, and capture of organizational process assets
- Avoid project performance issues through process discipline, proactive management, and early stakeholder engagement
- Predictable project performance, with fewer surprises

CMMI Model Overview

Process Areas	**Clusters of related practices, in several categories** •**Project Management** – planning, monitoring, suppliers, risk, … •**Support** – CM, QA, measurement, decision analysis, … •**Process Management** – organizational processes, training, … •**Engineering** – requirements, development, integration, … •**Services –** development, delivery, transition, … •**Acquisition** – requirements, solicitation, agreements, …
Generic Practices	**Enable process management, deployment and improvement** •Plans, monitoring, CM, stakeholders, objective evaluation, …
Goals	**Describes characteristics for implemented processes**
Capability Levels	**Achievement of process improvement within an individual process area**
Maturity Levels	**Achievement of process improvement across a predefined set of process areas (stages)**

CMMI Appraisals

Appraisals compare organization and project processes against CMMI models to determine improvement priorities

Senior management’s role in appraisals:

- Provide sponsorship and resources
- Set appraisal scope and objectives
- Ensure follow-through on appraisal findings and prioritized improvement actions

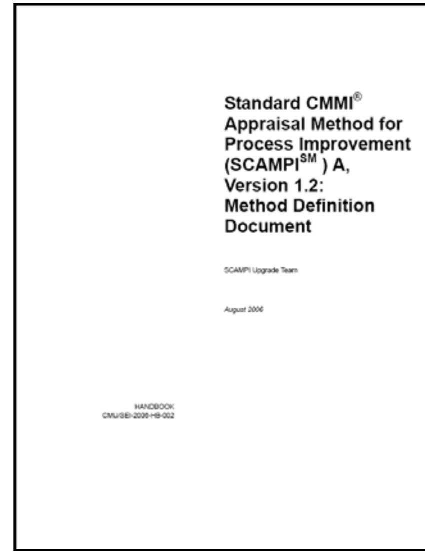
CMMI provides a family of appraisal methods, with varying intent, confidence levels, data collection, resources needed

- Flexible focus: approach, deployment, institutionalization
- Rigorous benchmark rating method (for maturity levels)
- “Quick look” diagnosis of process weaknesses

Licensed SEI partners deliver SCAMPI^{SM} appraisal services

- http://www.sei.cmu.edu/collaborating/partners/cmmiv1.2/

Note that for internal process improvement, company-developed and other methods can be effective


Standard CMMI® Appraisal Method for Process Improvement (SCAMPI^{SM}) A, Version 1.2: Method Definition Document

SCAMPI Upgrade Team

August 2006

HANDBOOK
CMU/SEI-2006-HB-002

Topics

Do You Need CMMI?

What Is CMMI?

How Can CMMI Benefit You?

Who Is Using CMMI?

How Can You Get Best Value from CMMI?

Reasons You Should Adopt CMMI

1. **Increase customer satisfaction**
   - Deliver products and services that satisfy user needs
   - Deliver products and services on time and within budget
2. **Increase probability of capturing new and repeat business**
   - Improved ability to meet commitments
   - Reduces customer-perceived risk of award to your organization
   - Can be a discriminator relative to your competition
3. **Increase profit through improved quality and less rework**
   - Better predict actual costs through repeatable processes
   - Better visibility into projects due to established measures and analysis techniques
   - Significantly reduce the probability of problem programs
   - Reduce costs by capitalizing on organizational infrastructure, processes, training, tools and early/often stakeholder involvement
4. **Increase productivity**
   - More efficiency through implementation of common processes, tools and training
   - Improved productivity by implementing process improvement that are directly aligned key organizational goals and objectives.
   - Higher employee morale and less turnover

Benefits of CMMI-Based Process Improvement

Many companies cite performance benefits from CMMI

- Published in conferences, articles, papers, studies, surveys, reports

SEI collects quantitative measures of CMMI performance improvement

- Technical reports, including:
  - "Performance Results of CMMI-Based Process Improvement" (http://www.sei.cmu.edu/pub/documents/06.reports/pdf/06tr004.pdf)

Performance Category	Median Improvement
Cost	34%
Schedule	50%
Productivity	61%
Quality	48%
Customer Satisfaction	14%
ROI	4.0 : 1
CMU/SEI-2006-TR-004. Data from 35 organizations.	

Topics

Do You Need CMMI?

What Is CMMI?

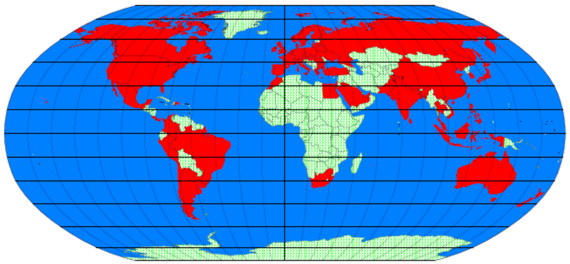
How Can CMMI Benefit You?

Who Is Using CMMI?

How Can You Get Best Value from CMMI?

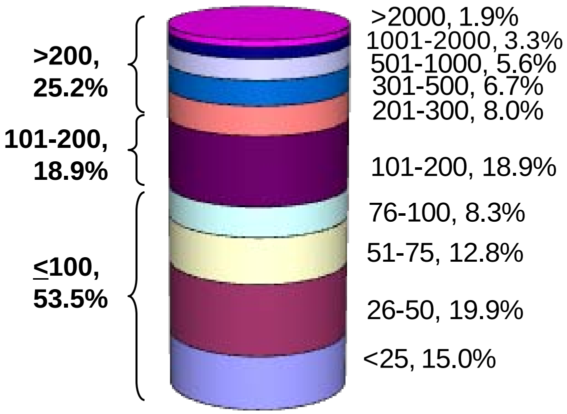
CMMI Adoption

CMMI appraisals are conducted worldwide…



	USA		Non-USA	
	Qty	%	Qty	%
Commercial In-House	354	33.6%	2566	91.3%
Contractor for Military/Government	586	55.7%	183	6.5%
Military/Government Agency	113	10.7%	63	2.2%
	1053	100.0%	2812	100.0%

…in small and large organizations and projects



Organization Size (Employees)
(3863 organizations reporting)

…in a wide range of businesses

Services (70.1%)
- Business Services
- Engineering and Management Services
- Health Services
- Other Services

Manufacturing (16.8%)
- Electronic and Electric Equipt
- Transportation Equipment
- Instruments & Related Products
- Industrial Machinery
- Other Mfg Industries

Other (13.1%)
- Finance, Insurance, Real Estate
- Public Administration/Defense
- Transportation, Communication, Utilities

Based on primary Standard Industrial Classification (SIC) codes reported in CMMI-based appraisals.

…at all levels of process maturity

	Commercial In-House	Contractor for Military/ Government	Military/ Government Agency
No Rating Given	5.7%	8.5%	22.7%
Initial (ML1)	0.8%	1.6%	1.7%
Managed (ML2)	28.0%	31.7%	44.3%
Defined (ML3)	53.6%	46.7%	26.7%
Quantitatively Managed (ML4)	3.1%	1.4%	1.1%
Optimizing (ML5)	8.7%	10.1%	3.4%
	(2920 orgs)	(769 orgs)	(176 orgs)

Source: SEI Process Maturity Profile, Sept 2009.
http://www.sei.cmu.edu/appraisal-program/profile/

Topics

Do You Need CMMI?

What Is CMMI?

How Can CMMI Benefit You?

Who Is Using CMMI?

How Can You Get Best Value from CMMI?

Getting Value from CMMI
Your Role as an Executive

Set the vision and direction for CMMI-based improvement

- Establish measurable objectives
- Be a visible sponsor – set expectations for involvement
- Manage process improvement like a project

Provide resources and support

- Funding, staffing, tools
- Choose the best people to lead - respected opinion leaders

Keep it real

- Maintain relentless focus on business value and program performance
- Involve projects and practitioners for the best ideas
- Hold people accountable
- Track and communicate progress
- Recognize and reward achievement

The Effective Use of CMMI®

Summary of NDIA industry position statements for obtaining best value from CMMI investments*:

1. **Good processes** increase the likelihood of achieving successful project performance
2. **CMMI is a model, not a standard** – adapt CMMI to your business environment, resources, and objectives
3. **Focus on business improvement objectives** – a primary emphasis on achieving levels may not achieve significant benefits and may increase rather than decrease costs
4. **High maturity is a business case** – justify the investment; many organizations find business value in improving processes even at lower CMMI maturity levels
5. **Maturity level ratings are not alone a predictor of project performance** – many other factors can be significant contributors
6. **Don't specify maturity levels in acquisitions** – use CMMI to probe supplier capability and process execution risks
7. **Greatest benefits of appraisals are from improvements, not evidence or ratings -** disproportionate effort on appraisal preparation risk can diminish business returns

"The Effective Use of CMMI®", NDIA Systems Engineering Division, June 2009.
http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/CMMI_Working_Group.aspx

Want to Learn More about CMMI?

SEI CMMI web pages:

- What is CMMI?
- Models
- Adoption
- Conferences
- Performance Results
- Appraisals
- FAQs
- Background Information
- Contacts

CMMI focus topics, guidance, technical reports:

- CMMI and Agile
- CMMI and Six Sigma
- Product Line Practices
- CMMI in Small Settings
- CMMI in Acquisition
- Interpretive Guidance
- Earned Value Management
- SW-Only Organizations
- Operations Organizations

Training:

- Process Improvement
- Introduction to CMMI
- Intermediate Concepts of CMMI
- CMMI Level 2-3 for Practitioners
- Understanding High Maturity
- SCAMPI Appraiser training

User Networks

- SEI Partner Network
- Newsgroups, Blogs, Wikis
- Books, Periodicals, Articles
- Consultants
- Conferences
- Asset Repositories

Questions? Comments?

Web: http://www.sei.cmu.edu/cmmi

Email: cmmi-comments@sei.cmu.edu

SEI Customer Relations: (412) 268-5800, customer-relations@sei.cmu.edu

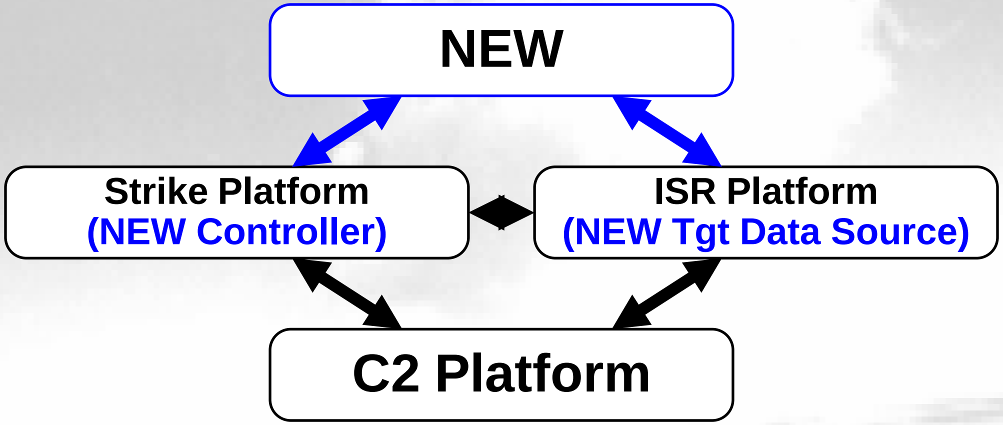
NEW as a Forcing Function to Rethink System Engineering Process

Andrew Lieux
Head, System of Systems Synthesis Branch
Systems Engineering Department

28 Oct. 2009

Net Enabled Weapons (NEW)

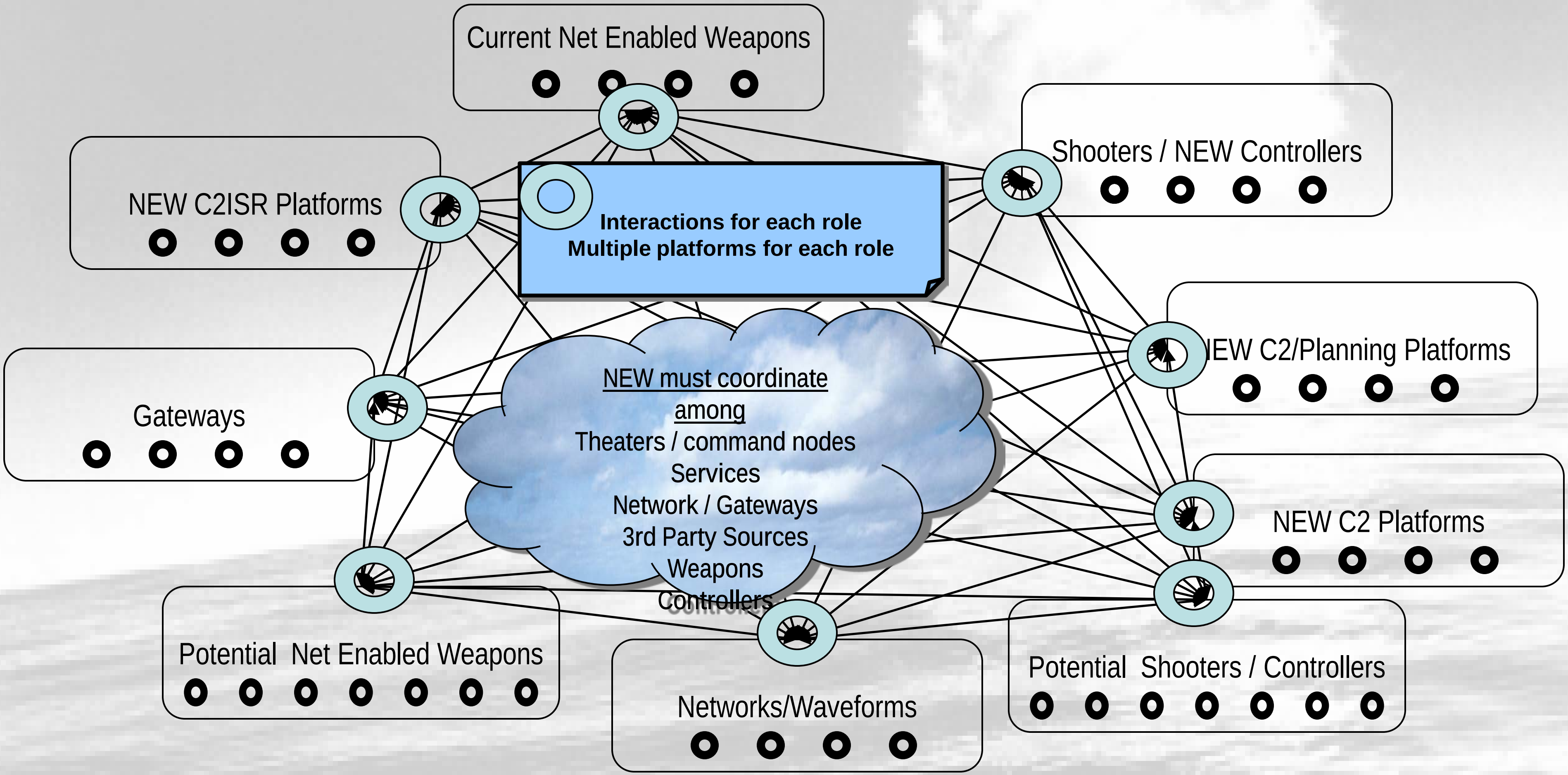
- Weapons with a data link integrated and interoperable with shooters, sensors, and C2 throughout the kill chain to enhance weapon effectiveness and target selectivity



- Key players
  - Weapon
  - Shooter / Controller
  - 3rd Party Source
- Key challenges
  - NEW digital communication <u>must</u> be complete and deterministic
  - First data link node without a human or voice backup
- Key digital messages
  - In Flight Target Update (IFTU)
  - Re-target
  - Abort
  - Weapon in Flight Track (WIFT)
  - Bomb Hit Indicator (BHI)

NEW Roles and Complexity

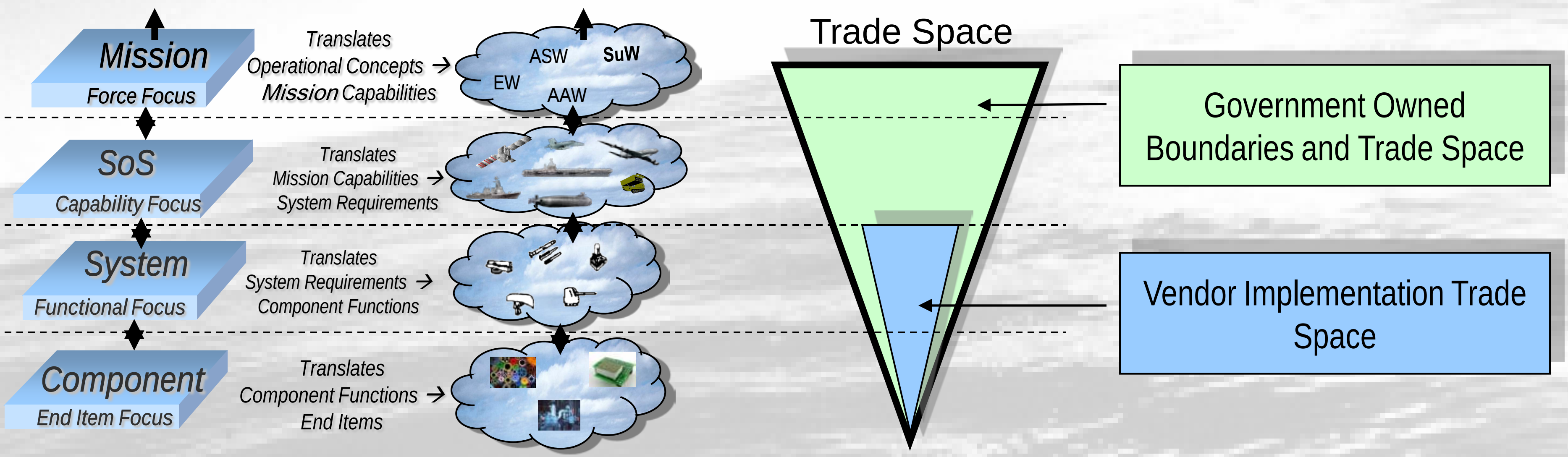
Combination of currently funding programs, existing platform capabilities, and upgrade requirements



Government Must define system information transaction requirements for each role.
Too Complex with Too Many Players for stove piped solutions

Early Systems Engineering

- Systems Engineering early in the acquisition phase
  - Well defined system trade space that accurately takes into account the mission and SoS trade space prior to system development
- Government defined / declared information transactions
  - Any Platform-to-Platform interaction

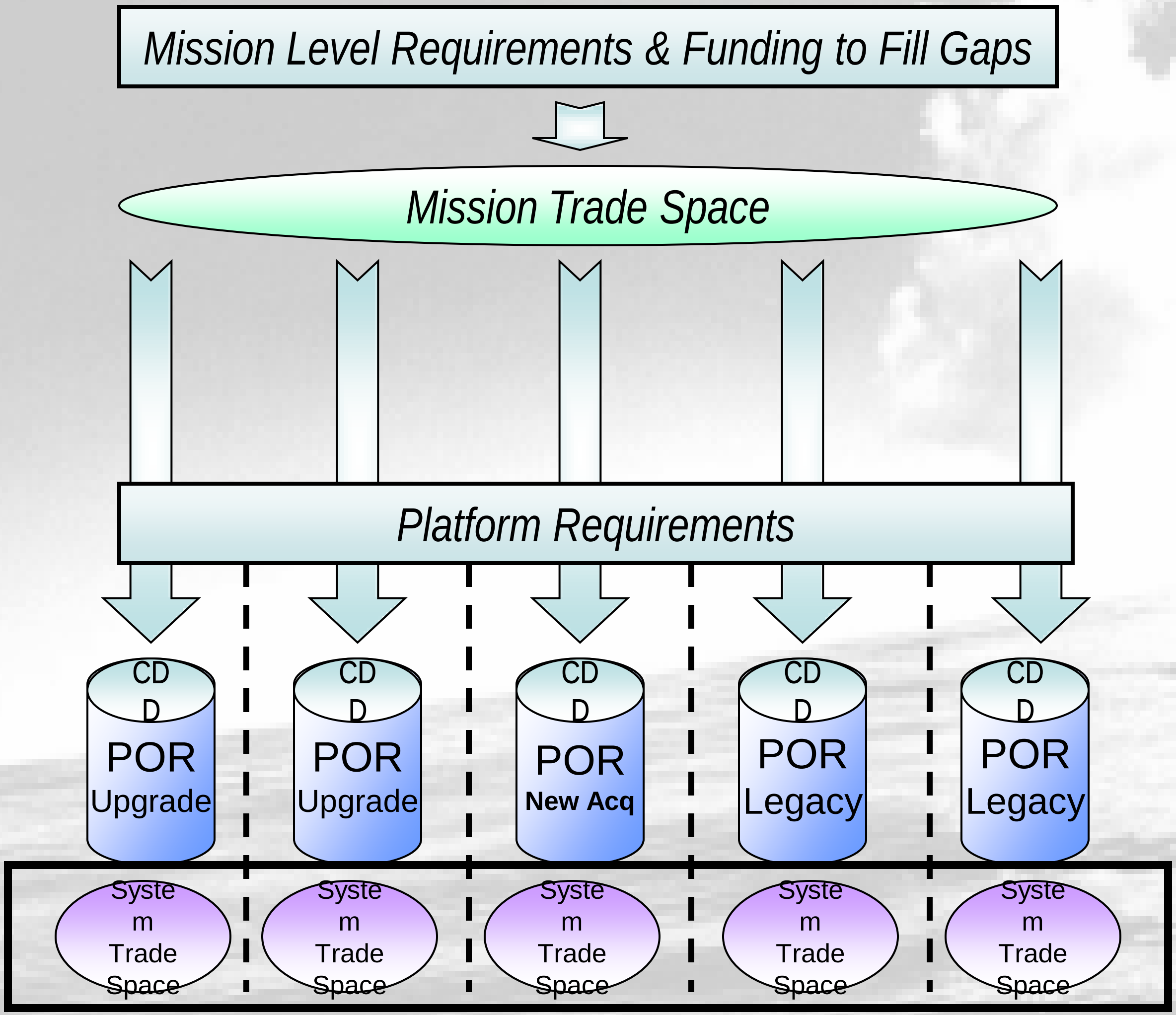


Government Declared / Designed Information Transactions

- NOT just a standards document
- Technical design effort to provide engineering solutions
- Products
  - Validation of interface control document (ICD) prior to POR software development
  - Minimum implementation requirements for programs across mission areas and SoS
  - Provide a software implementation of information transactions / standards
    - Removes ambiguity
    - Reduce software development time by ability to continually test during software development

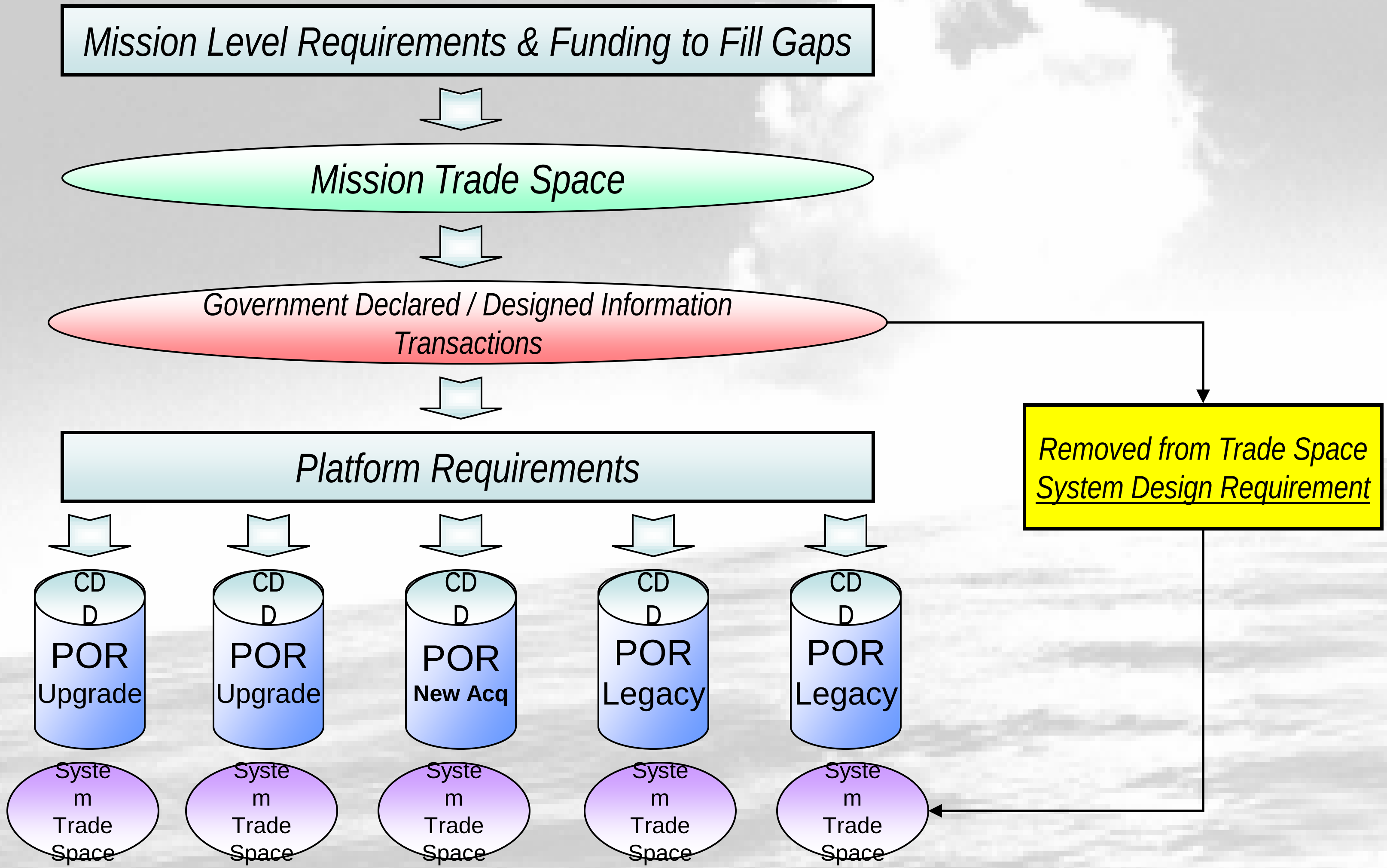
Process has been developed, implemented, and demonstrated for NEW

Current Requirements Flows



System Trade Space Includes Information Transactions → Creating Unique, "Stove Piped" Solutions

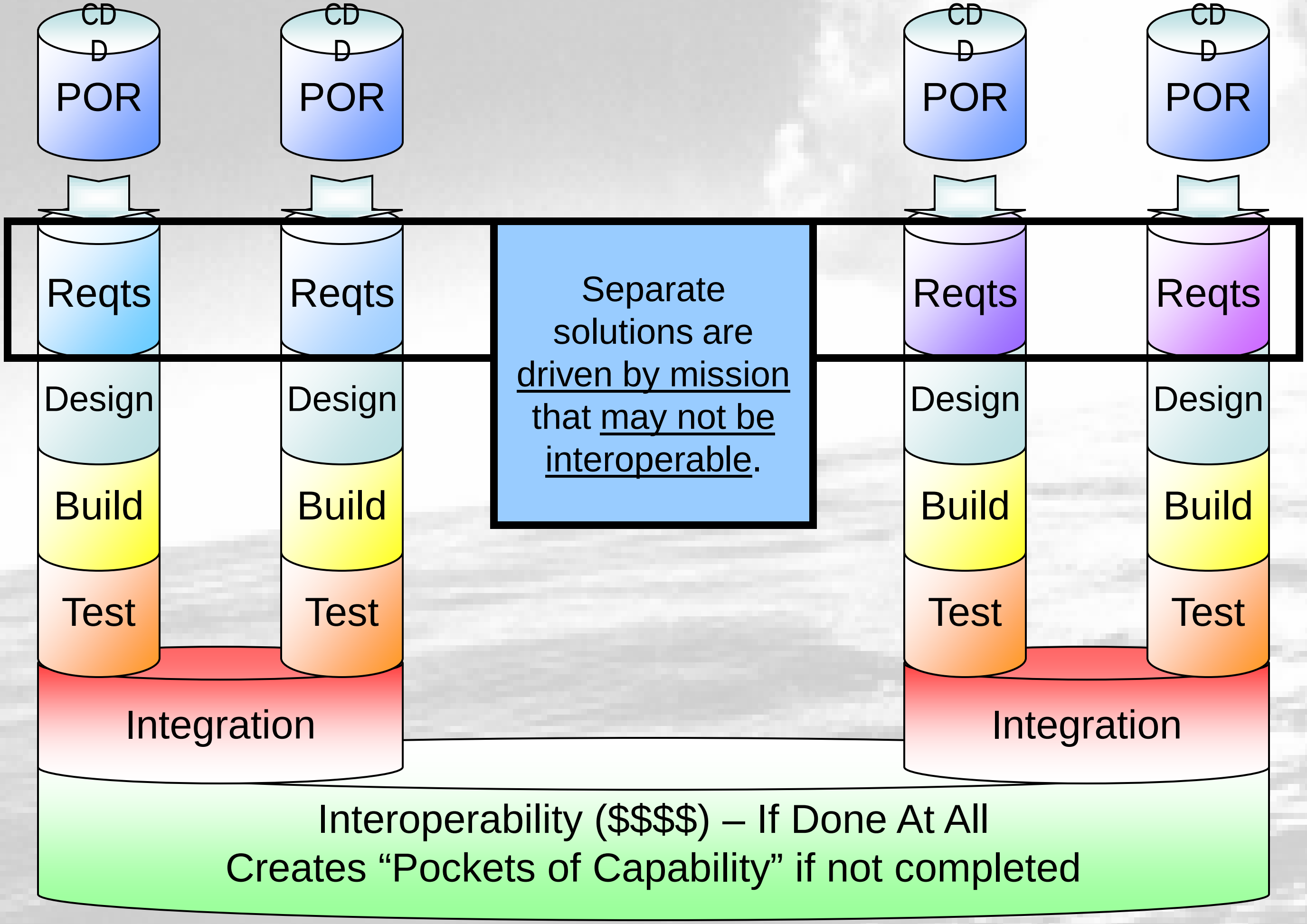
SI Pre Milestone A



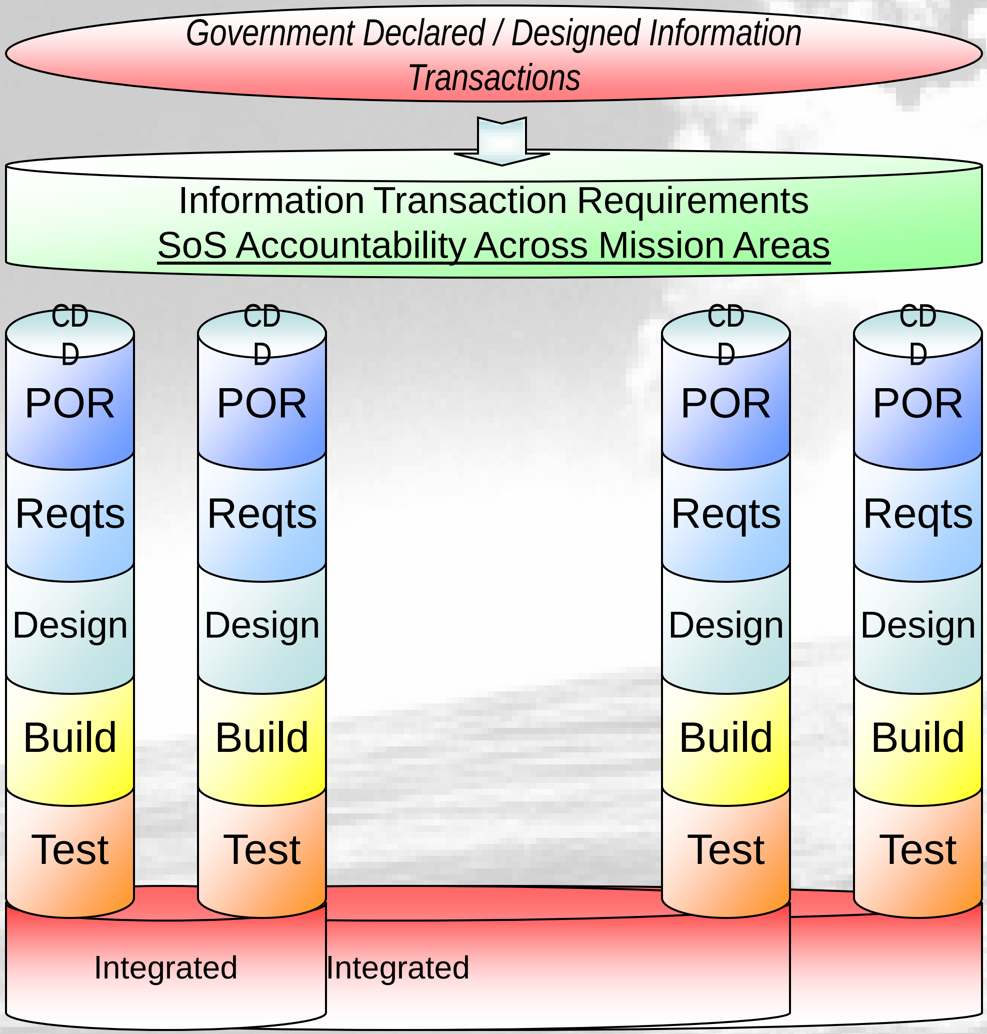
Government Driving Engineering Solutions to System Requirements for ALL Applicable Programs.
Driving Interoperable Systems

Traditional Systems Integration

- PORs have requirement to integrate for Mission A
  - Potentially Similar starting requirements
- PORs have requirement to integrate for Mission B
  - Potentially Similar starting requirements



Horizontal Development

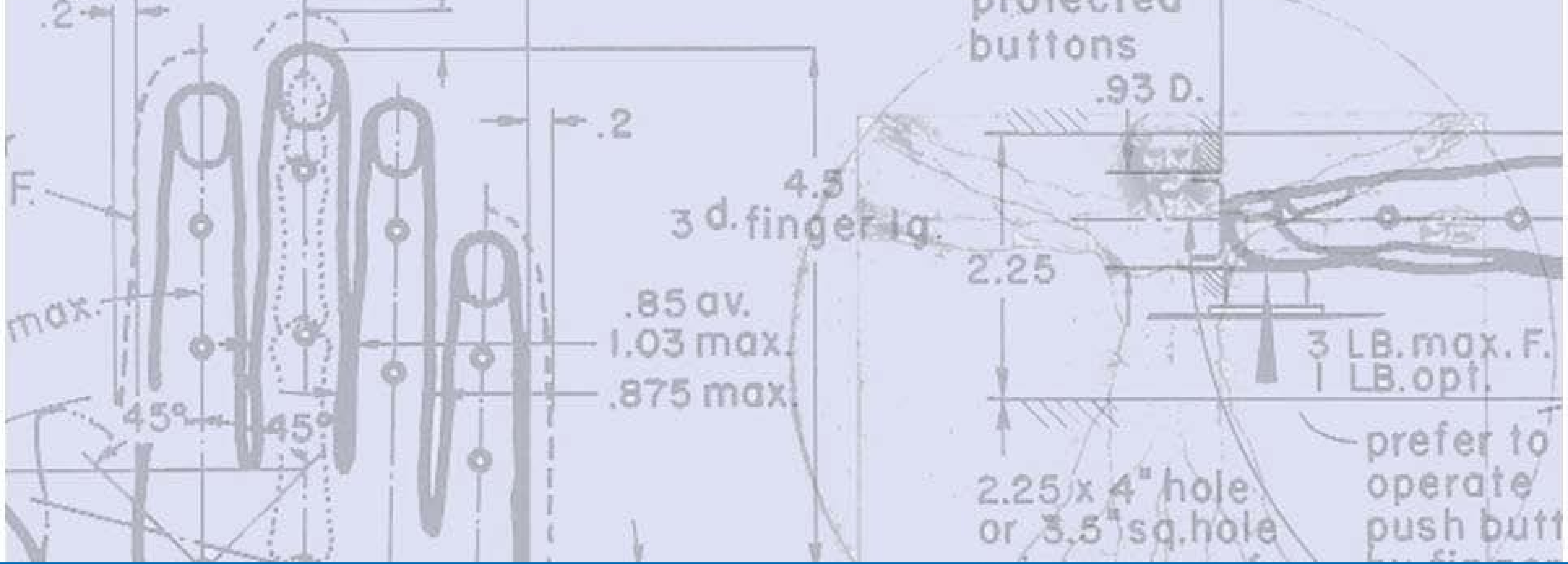


Upfront Government Declared / Defined Information Transaction Requirements Will Create Interoperable PORs with more predictable cost and schedule

Summary

- Can not afford to drive unique solutions
  - Increasing need due to financial constraints to the defense budget requires the need for programs to function across multiple mission areas
  - Increased need for interoperable capability and SoS requirements across missions
- Need to “Fund like we fight”

NAVAIR



HUMAN SYSTEMS INTEGRATION:

DEFINING AND VALIDATING A FRAMEWORK FOR ENHANCED SYSTEMS DEVELOPMENT

Matthew Risser, Ph.D.

Alisha Belk, M.S.

Pacific Science & Engineering Group

Major Andrew E. Gepp, USMC, Retired

PEO C4I, Battlespace Awareness and Information Operations (PMW 120)

Robert J. Smillie, Ph.D.

SPAWAR Systems Command

Human Systems Integration (5.1.4)

NDIA 12th Annual System Engineering Conference, October 26-29, 2009

Understanding the HSI Process

- What: Human Systems Integration is a management and technical process that ensures human capabilities and limitations are considered an essential part of total system performance in each phase of system development.
- Why: HSI Mandate: DoD Instruction 5000.02, Enclosure 8 (HSI)
- How: HSI practitioners employ proven scientific processes, tools, products, and standards to:
  - support concept development, user-centered design, and testing
  - work collaboratively with program managers, engineers, and end-users
- When: HSI technical work is coordinated with the overall needs of the system engineering process to support timely product development in each phase.
- Benefits: Enhances usability, reduces human error, optimizes workload, mitigates safety risks, improves decision-making, operational workflow, and ROI.

Rationale: HSI Process Challenges

- However, both internal and external challenges exist when executing HSI processes.
  - External - Challenges outside of the HSI domain involving stakeholders who directly impact our work process
  - Internal – Challenges within the HSI domain involving coordination of HSI practitioners with varied expertise
- Externally, HSI and system engineering disciplines each have their established set of processes; however, one of the challenges is the effective assimilation of the two.
- Internally, HSI guidance to-date has some limitations:
  - May be written at a level that is ambiguous and difficult to interpret
  - Activities are not always synchronized with acquisition events
  - Limited guidance on collaboration (trade-off) opportunities among HSI practitioners (e.g., Human Factors Engineering and Training)

Mitigation and Purpose

- An HSI Integrated Framework (HSIIF) was developed to provide specific guidance on how to integrate HSI processes, products, and tools into the Defense Acquisition Lifecycle.
  - Referenced DoD policy, guidance, and standards - defined and mapped activities for all HSI domains to each acquisition phase.
  - Scoped activities in the middle at an "action" level vice a higher “policy”, or lower "how-to" level
  - Sequenced activities with system engineering and acquisition events
- The intent of the Framework is to provide a coordinating mechanism, aligned with the Defense Acquisition Lifecycle, to support:
  - Program Managers
  - Technical Authority/Warrant Holders and Program Reviews
  - System Engineering
  - HSI Domain Practitioners

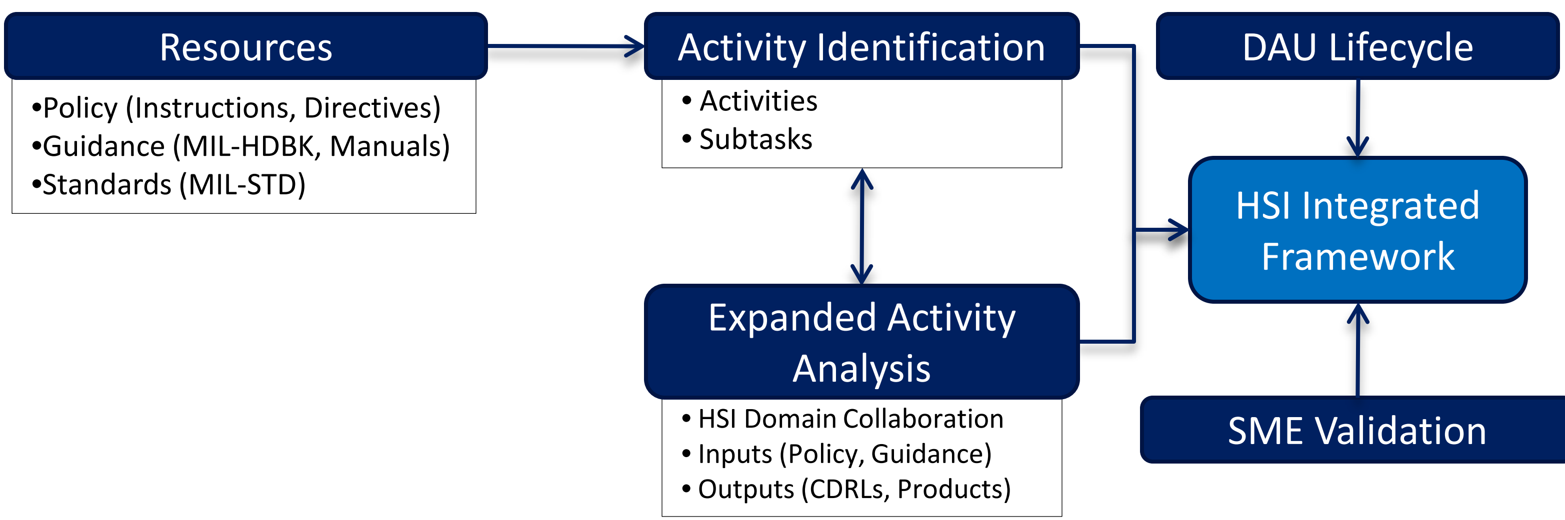
Framework Development Methods

Five primary methods were used to develop the HSI Integrated Framework:

1. *Documentation Review* – DoD policy, guidance, and standards were reviewed for HSI domain relevance
2. *Activity Identification* – Multiple resources (e.g. guidance documents, HSI architecture, manuals, etc) were combined to define HSI activities
3. *Sequence and Timing Analysis* - Key HSI activities were aligned with acquisition events and information from the Defense Acquisition University (DAU) Life Cycle Management System.
4. *SME Validation* – MPT activities were independently reviewed, edited, and validated by a Government MPT SME
5. *Expanded Activity Analysis* – identified and traced inputs (policy documents) and outputs (products) through each activity

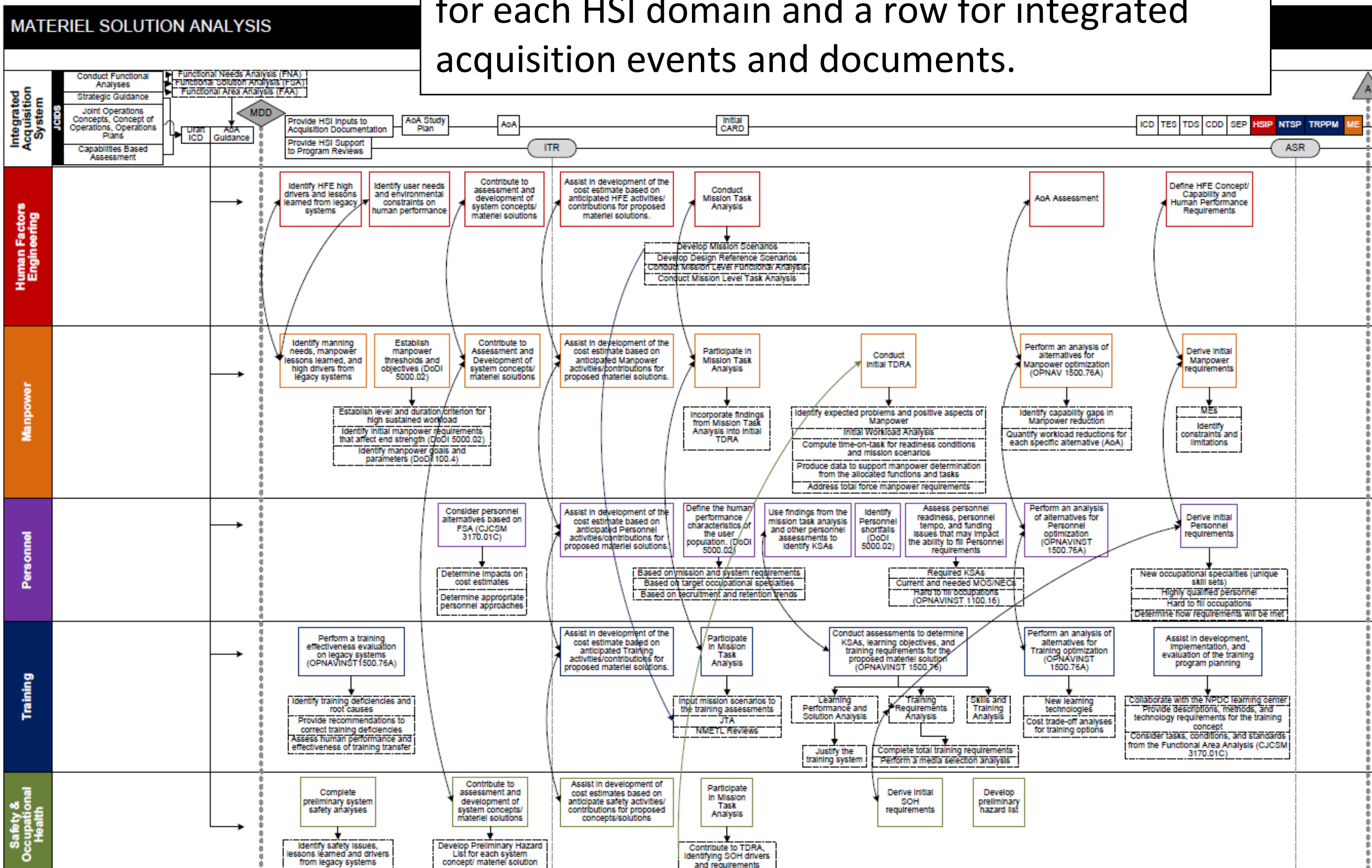
Framework Development Process

- Complete sets of HSI activities across the Defense Acquisition Lifecycle were derived from the analysis of source documentation.
- Timing of HSI activities were analyzed and aligned:
  - With the DAU Lifecycle diagram and relevant acquisition events
  - Between and within the various HSI domains
- An expanded activity analysis derived the inputs and outputs for each of the activities.



Example: HSI Integrated Framework Diagram

Materiel Solution Analysis phase includes rows for each HSI domain and a row for integrated acquisition events and documents.



HSI Integrated Framework Version 1.3 DRAFT (9/30/09) - Contact: Pacific Science and Engineering Group/SPAWAR 5.1.4

Example: HSI Integrated Framework Documentation

Policy, Standards, and Guidance for each HSI domain.

DOCUMENTATION

	POLICY	STANDARDS	GUIDANCE
Human Systems Integration	DoDD 5000.01 DoDI 5000.02 SECNAVINST 5000.2D OPNAVINST 5310.23 (draft)		SECNAV M-5000.2 JCIDS Manual [G-A-7] SPAWARINST 5400.3 (Policy within SPAWAR Enterprise) NAVSEAINST 3900.8A (Policy within NAVSEA Enterprise) DAU Guidebook [Ch 6]
Human Factors Engineering	DoDI 5000.02 [Pg. 29 Section 8.c.(1)(c)2.a. & Pg.60 Section 2.a.] SECNAVINST 5000.2D [Encl 7 Pg. 12-13 Section 7.2.3; Pg. 26; Pg. 9] OPNAVINST 5310.23 (draft) [Pg. 2-7 Section 4.f.(5)(a); Pg. 2-9 Section 4.g.(3); Pg. 2-3: Section 2.c.(2)(a); Pg. 3; Pg. 5 (HFE risk)]	MIL-STD-1472F	MIL-HDBK-46855A MIL-HDBK-759C SECNAV M-5000.2 [Encl 7 Pg. 25 Section 7.2.3]
Manpower	DoDI 5000.02 [Pg. 60] DoDD 1100.4 SECNAVINST 5000.2D [Encl 7 Pg. 12-13 Section 7.2.2] OPNAVINST 1000.16K OPNAVINST 1500.76A OPNAVINST 5310.23 (draft) CJCSI 3500.1D CJCSM 3170.1C DoDD 1104.4 DoDD 4630.5 DoDD 5000.1 DoDI 1100.22 DoDI 4630.8 DoDI 8510.1 DoDM 5000.4M	Interim Policy and Procedures for Strategic Manpower Planning and Development of Manpower Estimates OPNAV P-751-1-9-97 OPNAV P-751-2-9-97 OPNAV P-751-3-9-97	NAVPERS 18068F Vol II
Personnel	DoDI 5000.02 [Pg. 60] DoDD 1100.4 SECNAVINST 5000.2D [Encl 7 Pg. 12-13 Section 7.2.2] OPNAVINST 1000.16K OPNAVINST 1500.76A OPNAVINST 5310.23 (draft) CJCSI 3500.1D CJCSM 3170.1C DoDD 4630.5 DoDD 5000.1 DoDI 1100.22 DoDI 4630.8 DoDI 8510.1 DoDM 5000.4M	OPNAV P-751-1-9-97 OPNAV P-751-2-9-97 OPNAV P-751-3-9-97	
Training	DoDI 5000.02 [pg. 61] CJCSI 3500.01E DoDD 1322.18 DoDI 1322.20 DoDI 1322.26 SECNAVINST 5000.2D [Encl 7 Pg. 12-13 Section 7.2.2] OPNAVINST 11102.2 OPNAVINST 1500.76A OPNAVINST 5310.23 (draft) CJCSI 3500.1D CJCSM 3170.1C DoDD 4151.18 DoDD 4630.5 DoDD 5000.1 DoDI 4151.22 DoDI 4630.8 DoDI 8510.1 DoDM 5000.4M NAVSO P-1000 OPNAVINST 3500.34F NNWCINST 12271.1 SPAWARINST 4160.3B	OPNAV P-751-1-9-97 OPNAV P-751-2-9-97 OPNAV P-751-3-9-97 DI-MGMT-81650 DI-SESS-81519B DI-SESS-81520B DI-SESS-81523B DI-SESS-81524B DI-SESS-81526B MPT&ECIOSWIT-ILE-GUID-1B MPT&ECIOSWIT-ILE-GUID-2B MPT&ECIOSWIT-ILE-GUID-3B MPT&ECIOSWIT-ILE-GUID-4A MPT&ECIOSWIT-ILE-GUID-5A MPT&ECIOSWIT-ILE-HDBK-1B MPT&ECIOSWIT-ILE-INTR-1B MPT&ECIOSWIT-ILE-SPEC-1B MPT&ECIOSWIT-ILE-SPEC-2B MPT&ECIOSWIT-ILE-SPEC-3B MPT&ECIOSWIT-ILE-SPEC-4D MPT&ECIOSWIT-ILE-STD-1B	DI-ILSS-81070 DI-SESS-81517B DI-SESS-81518B DI-SESS-81521B DI-SESS-81522B DI-SESS-81525B DI-SESS-81527B MIL-HDBK-29612-1A MIL-HDBK-29612-2A MIL-HDBK-29612-3A MIL-HDBK-29612-4A MIL-HDBK-29612-5 MIL-PRF-29612
ESOH	DoDD 4715.1E DoDD 4151.18 [Pg. 3 Section 3.1.9] DoDI 5000.02 Pg. 61 DoDI 4715.15 OPNAVINST 5310.23 (draft)	MIL-STD-882D MIL-STD-1474D	SECNAV M-5000.2 [Encl 7 Pg. 27 Section 7.3] JCIDS Manual [G-A-7]
Survivability	DoDI 5000.02 Pg.61		JCIDS Manual
Habitability	DoDI 5000.02 Pg.60		

HSI Integrated Framework Version 1.3 DRAFT (9/30/09) - Contact: Pacific Science and Engineering Group/SPAWAR 5.1.4

Summary

The HSI Integrated Framework augments previous HSI guidance efforts by introducing additional capabilities and specificity with respect to:

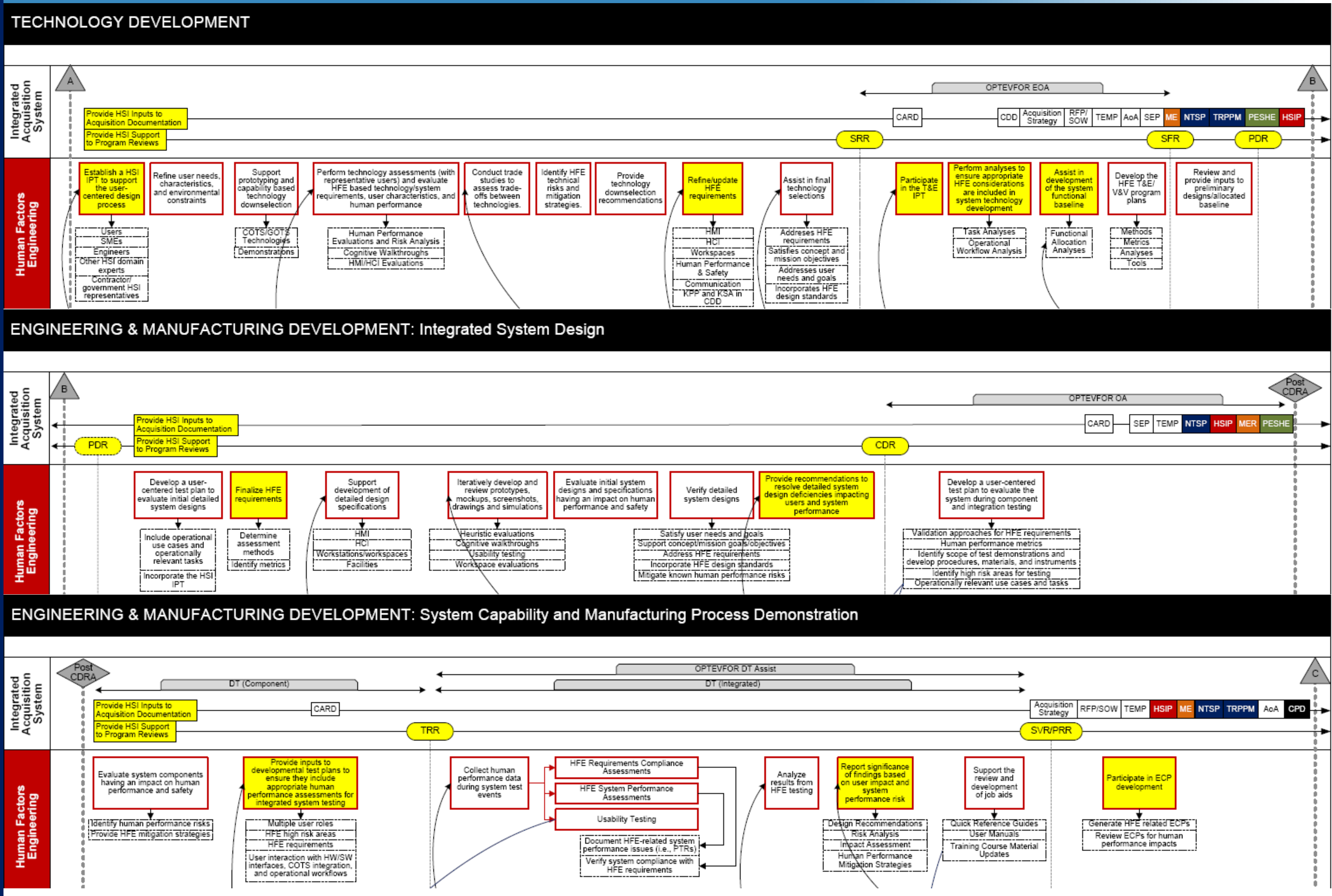
- Individual HSI domains (horizontal)
- Interactions among HSI domains (vertical)
- Sequence and timing of activities with acquisition milestones, documentation, technical reviews, and testing events
- Support for multiple users - Program managers, System Engineering, Technical Authority/Warrant Holder, and HSI practitioners
- Identification of inputs and outputs for each activity
- Tasks and products from HSI best practices and past acquisition program support experience (lessons learned)

A FRAMEWORK VALIDATION: METMF(R) NEXGEN

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 in support of the Marine Air Ground Task Force (MAGTF).
  - 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.
- Sub-systems must be stored within a limited space and used safely and efficiently by operators and technicians within tight time constraints under various environmental conditions.

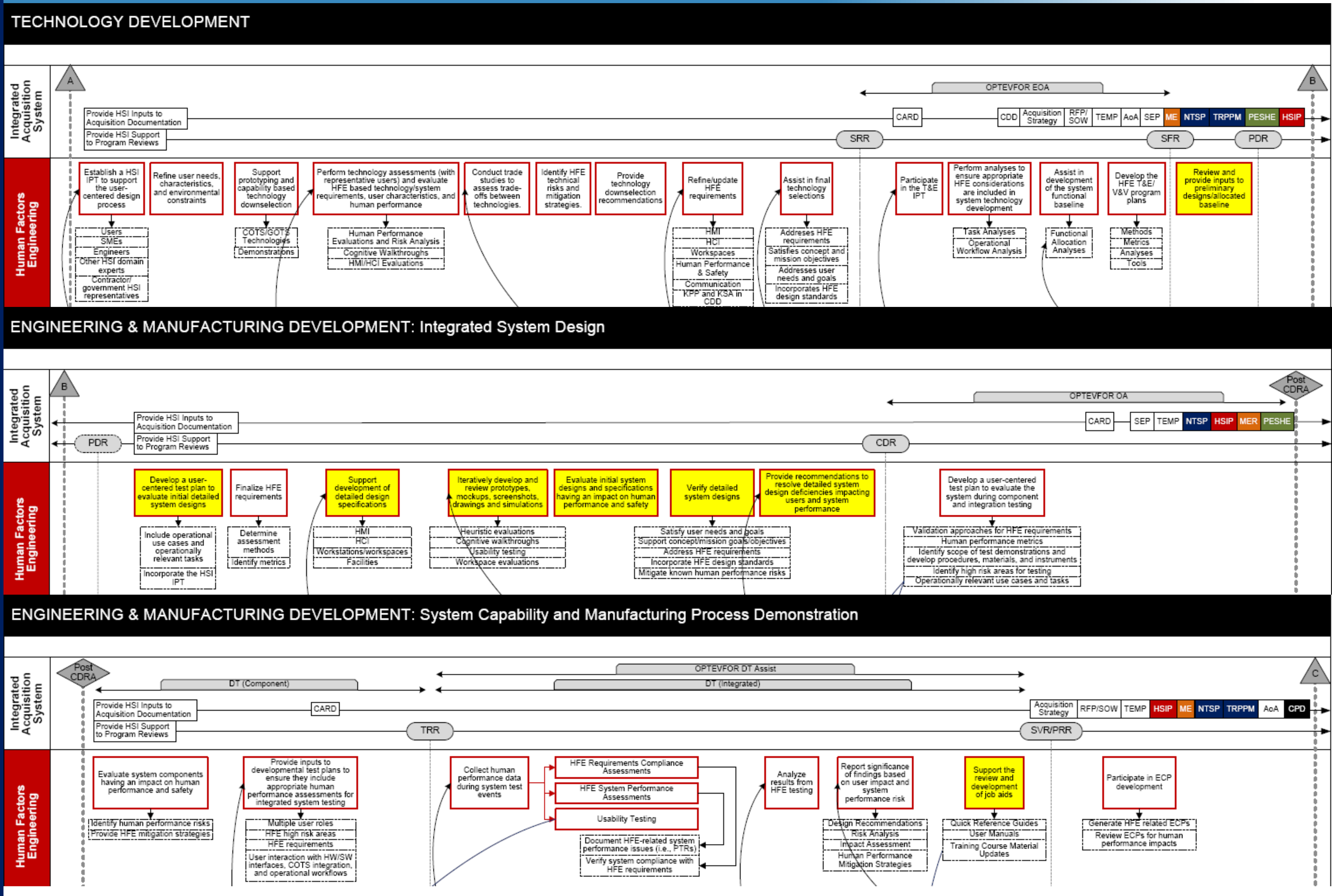
HSIIF in METMF(R) NEXGEN HSI Program Office Support



METMF(R) NEXGEN: HSI Program Office Support

- Provided continuous HSI analyses and products to support requirements definition, through design and integration, and into test and evaluation
- Performed user advocacy role with engineering team
- Participated in System Engineering Technical Reviews as HSI representative
  - SRR, SFR, PDR, CDR, IPRs, TRR, SVR
- Participated in Government design and testing meetings
- Reviewed and provided inputs to HSI-related CDRLs
  - e.g., user manuals, training materials
- Provided inputs to Government acquisition documents
  - e.g., CDD, TEMP, CPD

HSIIF in METMF(R) NEXGEN Design Support

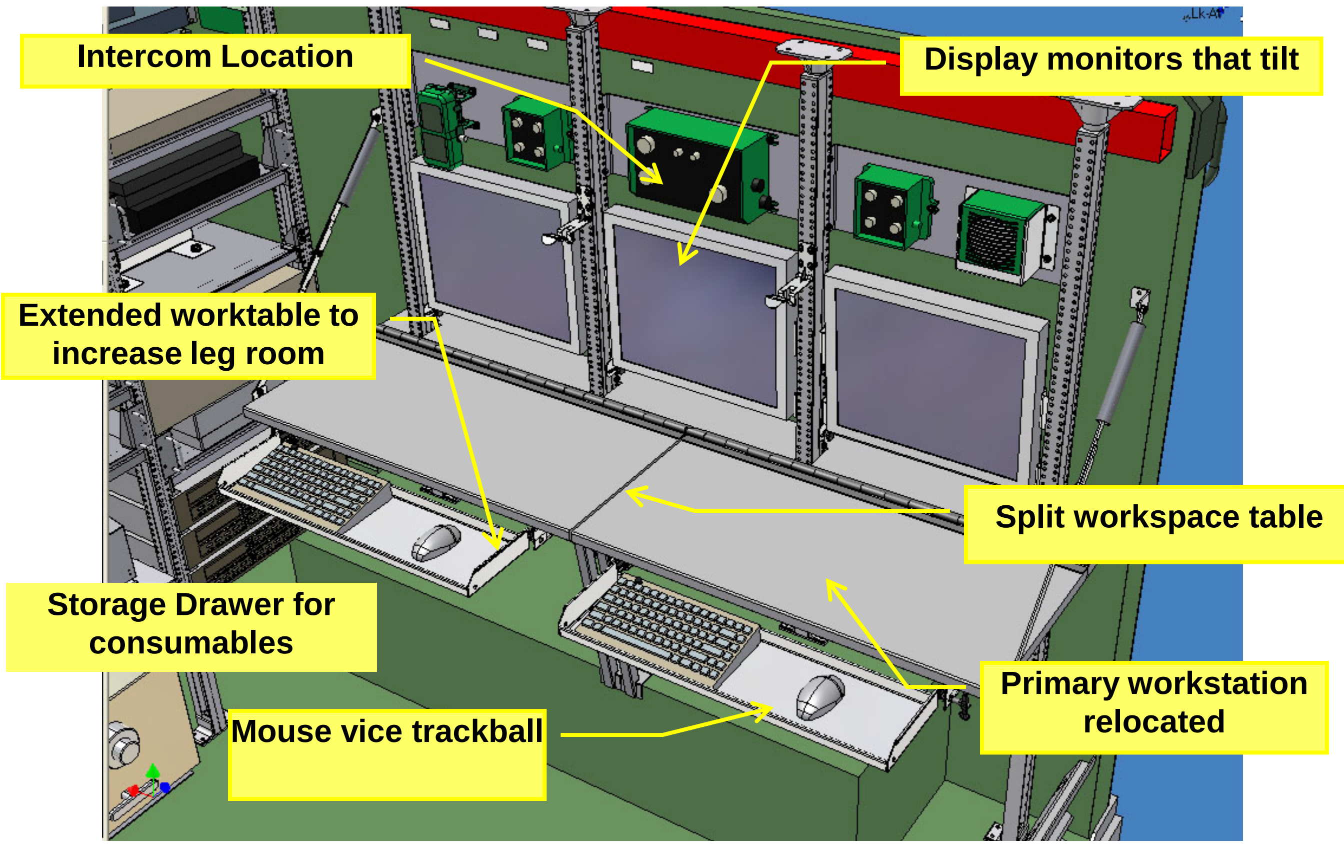


METMF(R) NEXGEN: Design Support

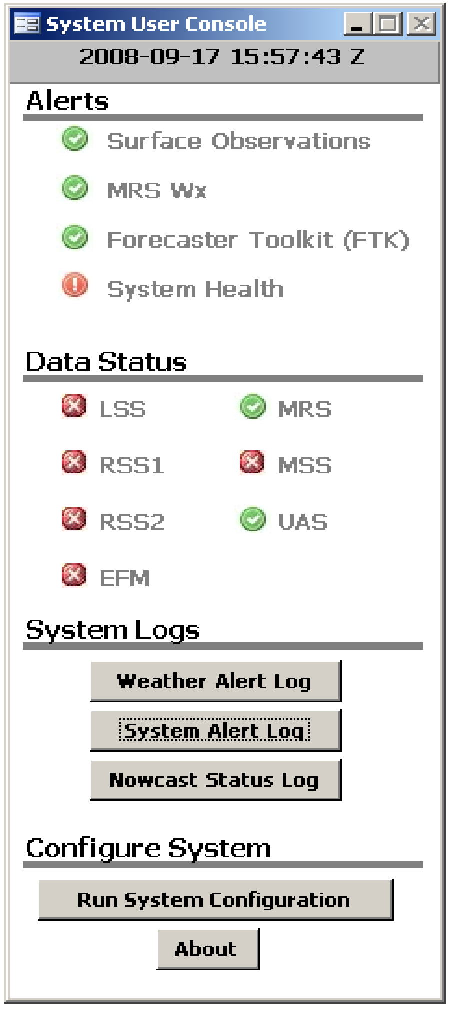
- Leveraged capabilities and requirements documents, user workflows, and user needs assessment to scope design efforts
- Facilitated multiple HSI Working Groups with users and engineers to work through operational task flows.
  - Derived 82 detailed system design requirements and generated 7 new design concepts across 10 sub-systems to optimize system performance and safety during meteorological operations
- Provided human factors design inputs and recommendations to:
  1. Organization and placement of controls and displays in the shelter
  2. Ergonomic design of physical workstations
  3. Design and usability of software user interfaces
  4. Alerting and system status displays
  5. Mitigation of safety risks
  6. Coding and labeling of 25 sub-system cases, cables, and controls
  7. Shelter and trailer pack-out configurations
  8. Inclusion of human engineering standards

METMF(R) NEXGEN: Example Design Concepts

- Provided workspace design inputs
- Designed system user console (GUI)



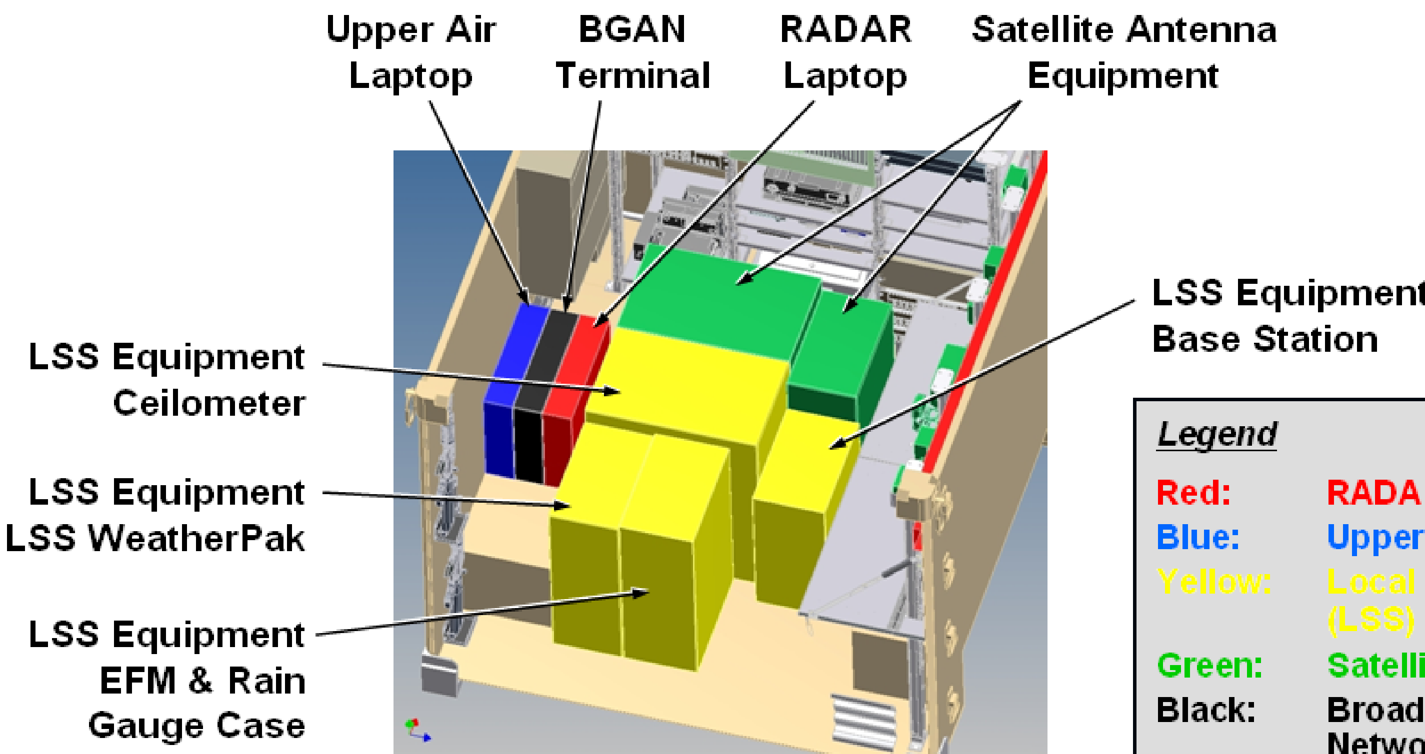
View of Passenger Side Wall




BARCO
BARCO
BARCO

METMF(R) NEXGEN: Shelter Storage

Smart storage of local sensor suite and satellite receiver facilitates rapid deployment requirement to reach initial capability with 2 Marines in 1 hour.

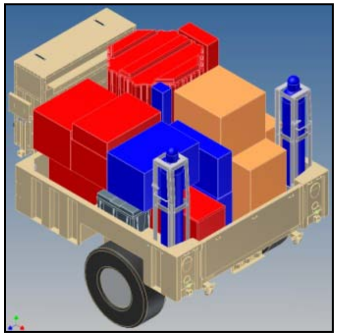


Legend

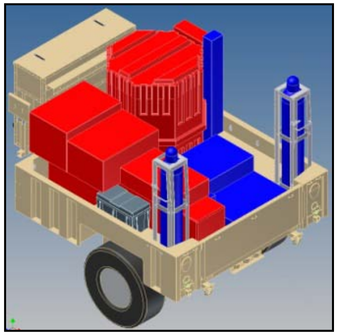
Red:	RADAR
Blue:	Upper Air System (UAS)
Yellow:	Local Surface Sensor (LSS)
Green:	Satellite
Black:	Broadband Global Area Network (BGAN)

METMF(R) NEXGEN: Trailer Storage

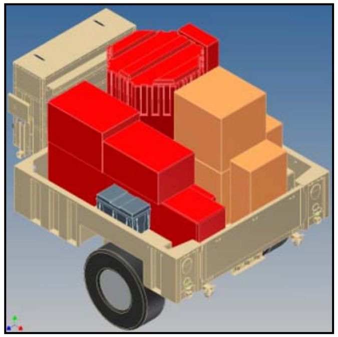
- Flexible configuration for additional hatches, side or roof mounted equipment, and cable pass-thru openings.
- Trailer can be packed differently to accommodate various operational scenarios.
- Equipment is grouped by sub-system.
- Modifications: tie-down configurations, cable reel storage, helium transport, & radar mast mount.



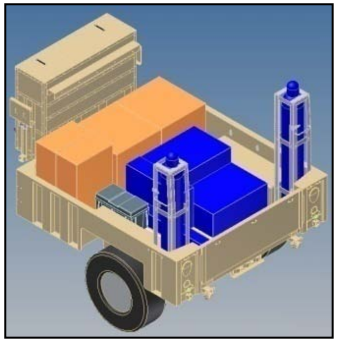
Fully Loaded



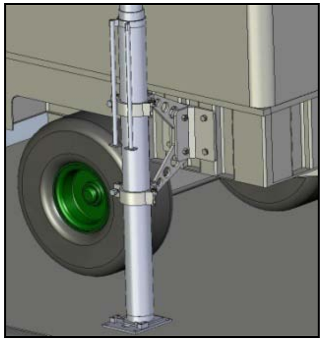
No RSS



No Upper Air

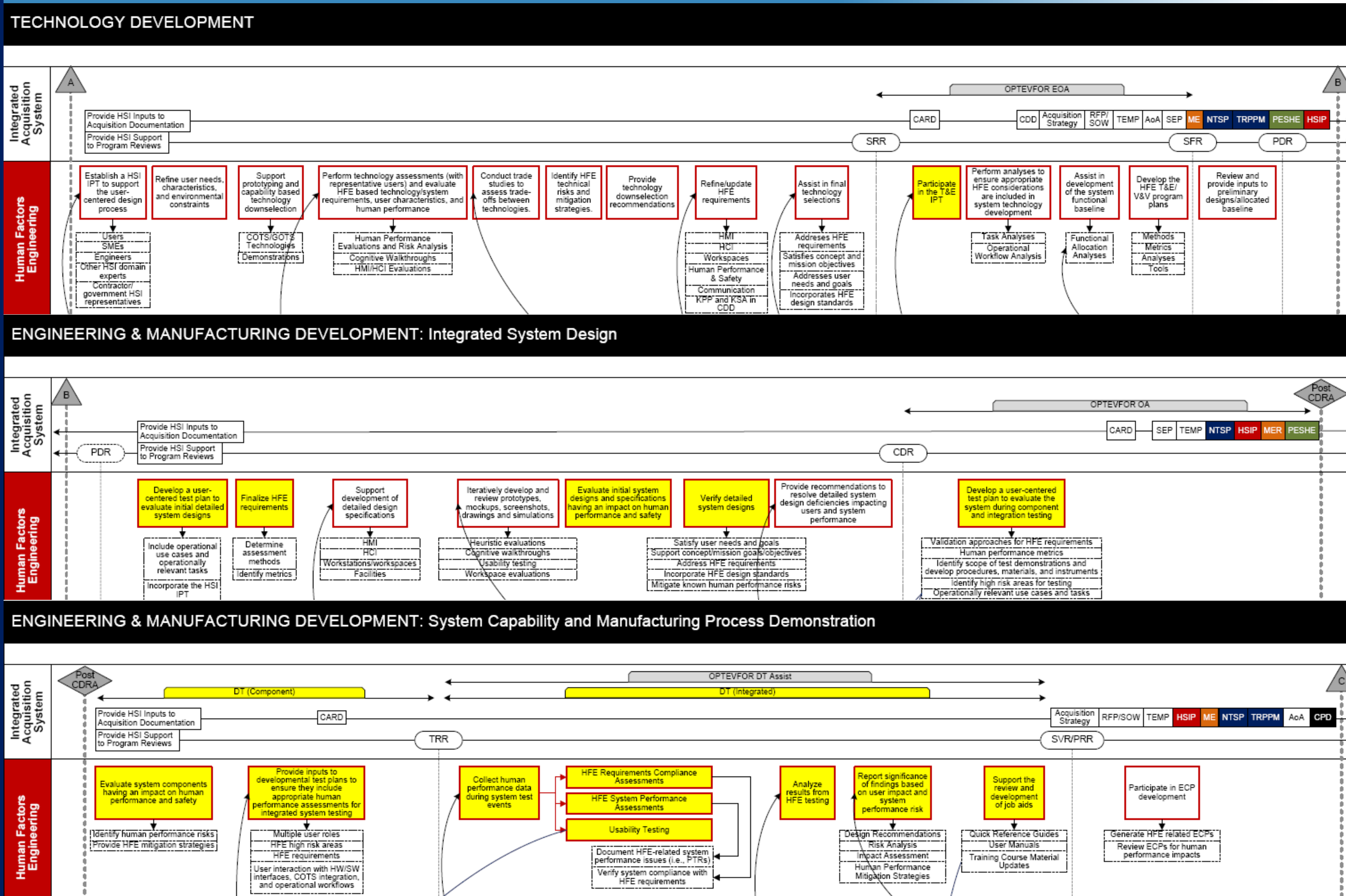


No RADAR



RADAR Mast Mount

HSIIF in METMF(R) Testing Support

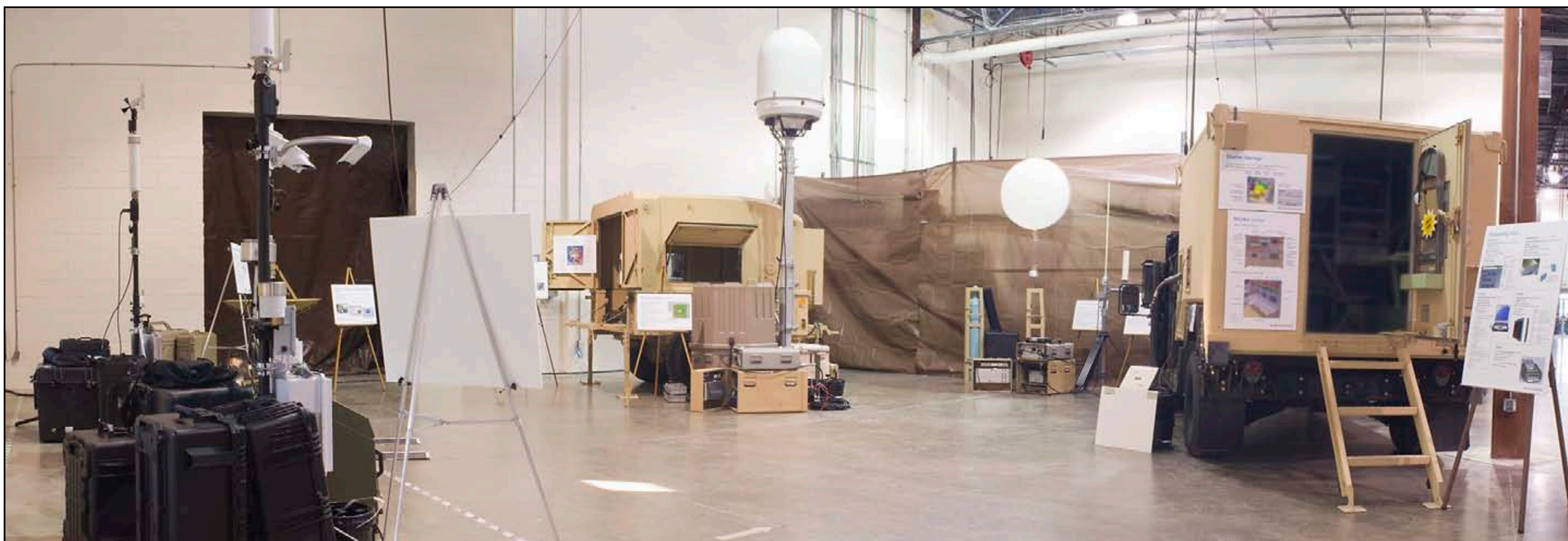


METMF(R): HSI Testing Support

- Ensured DT/OT test plans included procedures consistent with operational task flows to support human performance assessments.
- Supported data collection and performed direct observations and assessments with users during contractor and government test events.
- HSI DT/OT evaluations included:
  - Verification and validation of HSI *system* and HFE *design* requirements
  - Ergonomic and usability assessments
  - Occupational safety hazard assessments
  - Assessments of human performance risk (workload, safety, error)
- HSI findings and recommendations from DT/OT evaluations:
  - Solutions/mitigation strategies for high-risk human performance areas
  - Shelter and trailer hardware pack-out guidance
  - Various user Quick Reference Guides (QRGs)
  - Inputs to user manuals and training material
  - Task-based analysis and redesign of the system configuration user interface
  - Feedback on system usability, user impact, and any existing or future operational HSI issues

METMF(R) NEXGEN:
Work Environment Assessment

- Optimized Embark/Debark procedures
- Identified safety hazards and mitigation strategies (e.g., power-on, cable trip hazards, lift and carry, visible labeling)
- Determined sensor placement for different operational configurations
- Optimized spatial workflow during sensor setup and initialization to meet 1-hour (with 2 Marines) and 3-hour (with 8 Marines) observation and dissemination requirements



METMF(R) NEXGEN: Summary

HSI Successes

- HSI improved the usability and design of the METMF(R) NEXGEN by reducing operator workload, human error, and safety hazards. This helped maximize the throughput of the system, its capabilities, and operational utility.
- HSI enabled the program office to make key decisions as a result of the HSI analyses that identified system- and operational-level human performance risks
- Integrated HSI processes, analyses, and products with:
  - System engineering and program management – addressed external challenge
  - Other HSI domains (i.e., HFE, Training, and Safety) – addressed internal challenge

Conclusions

The HSI Integrated Framework:

- makes HSI activities explicit and facilitates the alignment of tasks and products among all stakeholders.
- can help identify HSI activity gaps relative to other acquisition activities which can be used to support future HSI policy and requirements.
- supports the consistent application of HSI processes, tools, and products within the acquisition community to mitigate human performance shortfalls and maximize system effectiveness.

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

Aerospace Vehicle Systems Institute

SAVI: Aerospace Platform Development and Certification Using Modeling & Simulation to "Integrate, then Build"

NDIA Systems Engineering Conference

October 2009

Outline

- Who and What is AVSI SAVI?
- Why SAVI?
- How does SAVI approach modeling?
- When is SAVI used?
- Where is SAVI going?

Who and What is AVSI SAVI?

Aerospace Vehicle Systems Institute

AVSI is a global cooperative of aerospace companies, government organizations, and academic institutions

Aerospace systems and research

- Reliability
- Certification
- Virtual Integration

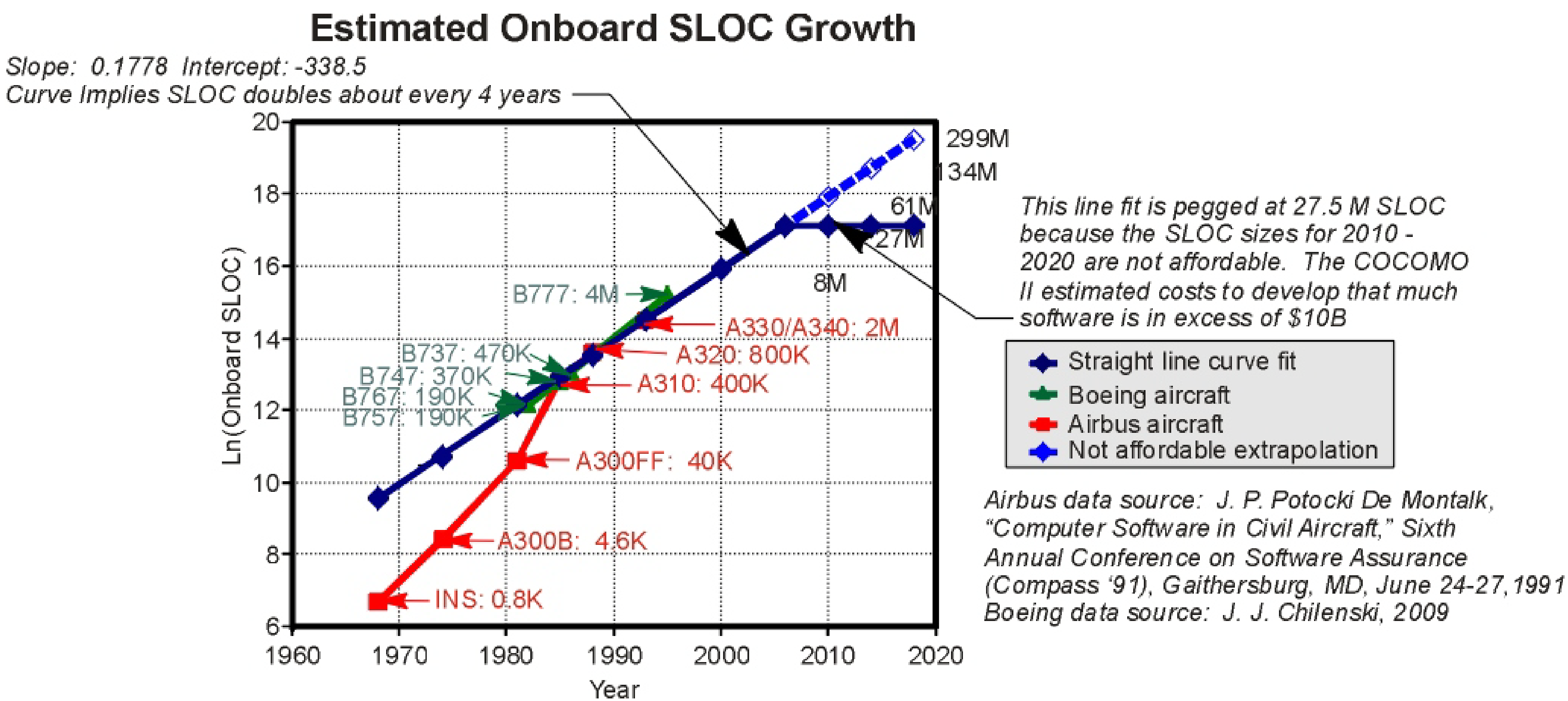
System Architecture Virtual Integration

SAVI: a program addressing <u>virtual systems integration</u>

Why SAVI？

The Need for Predictable Systems Integration

System Complexity



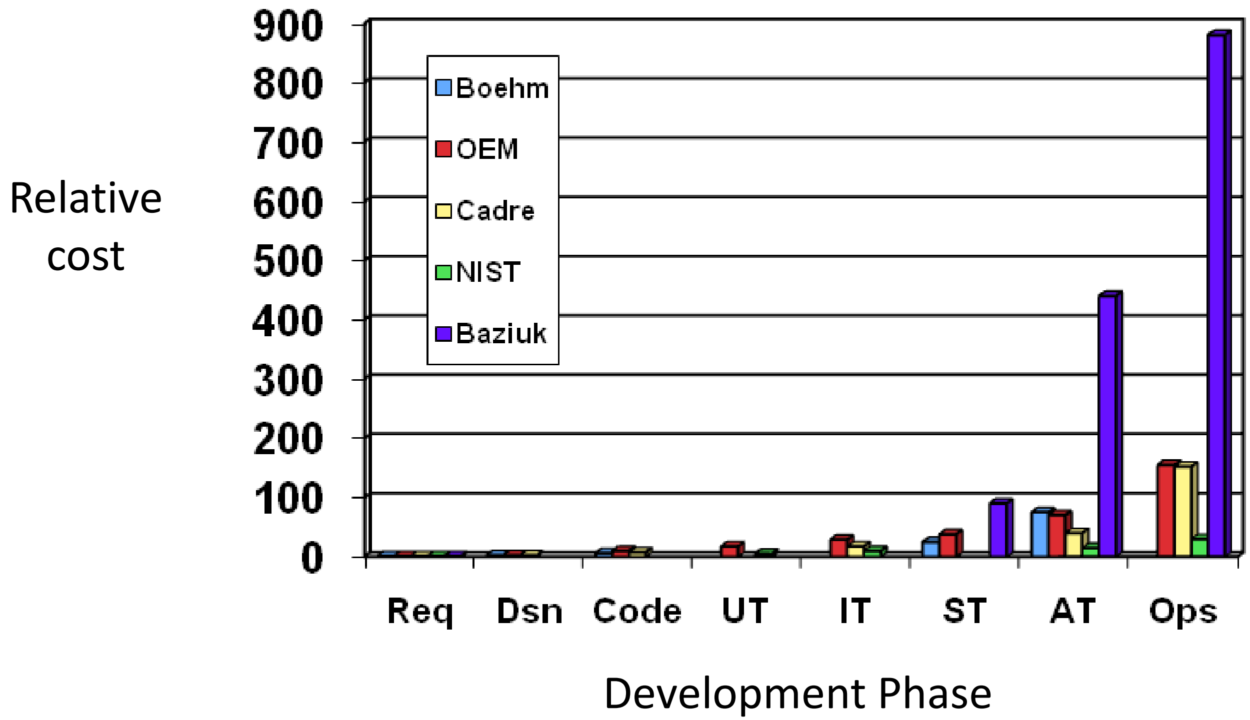
Acronyms:

SLOC: source lines of code
COCOMO II: COnstructive COst MOdel *II*

Development Cost Growth

Errors discovered late in the product lifecycle

Relative cost to fix an error by development phase



Reaching Limits of Traditional Methods

- Integration complexity will continue to increase
- Individual companies cannot solve it alone
- Industry cannot afford to solve it multiple times
- We can't afford not to solve it

A coordinated, industry-wide effort is needed to solve this issue.

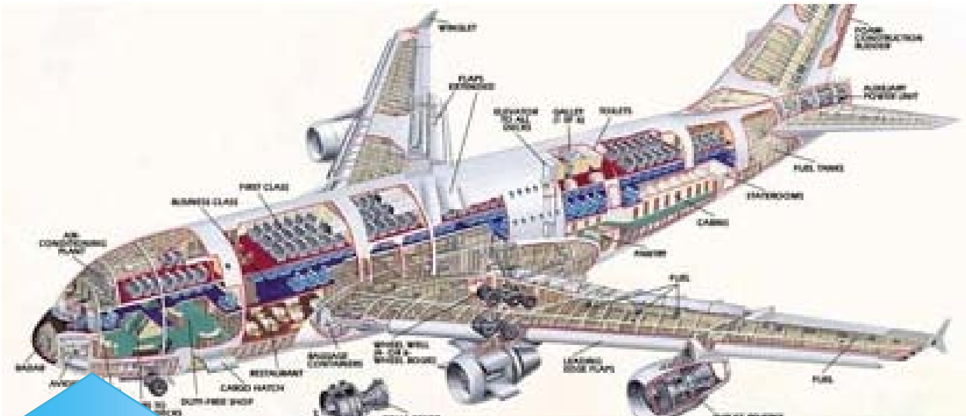
How Do We to Address This Issue?

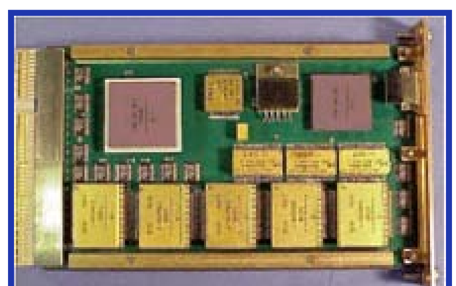
Modeling

(But what exactly does that mean?)

How Does SAVI Approach Modeling？

The Systems and the Supply Chain Are Both Hierarchical





We should expect similar structure in the tools and in the processes employed in their development.

OEM

Tier 1 Supplier

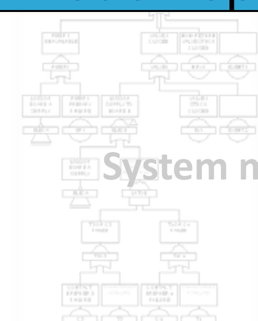
Tier 2 Supplier

Potential Model-Based Engineering Pitfalls

The Issues

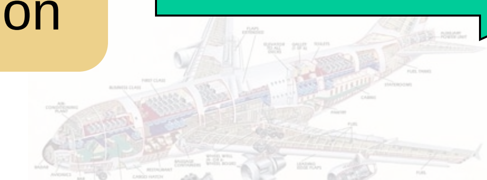
Potential Solution

Inconsistency between independently developed analytical models → Architecture-centric model repository



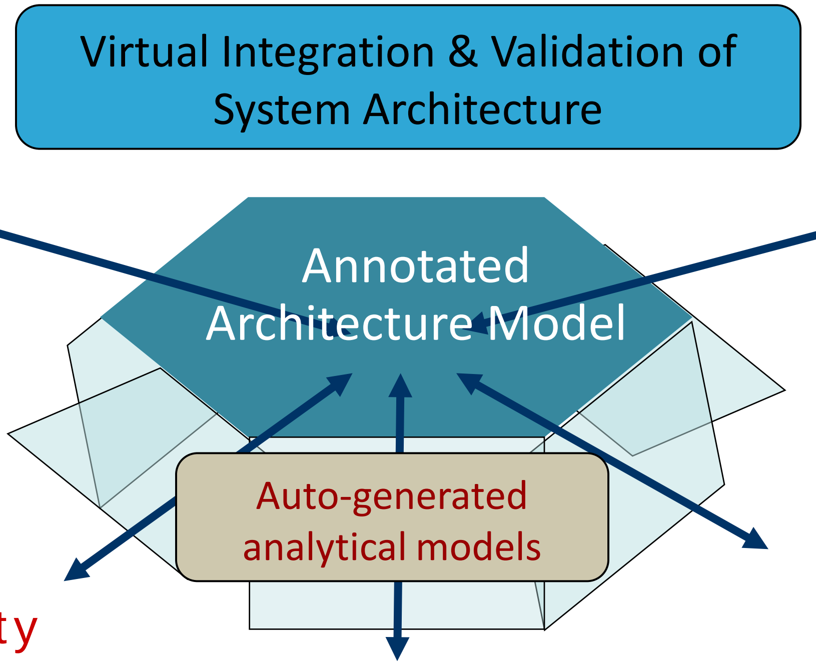
System models

Confidence that model reflects implementation → Generation from validated models



System implementation

Architecture-Centric (but Data-Friendly) Engineering Approach



Availability and Reliability
- MTBF
- FMEA
- Hazard analysis

Cyber Security
- Availability
- Authentication
- Integrity
- Confidentiality
- No repudiation

Data Quality
- Data precision/ accuracy
- Temporal correctness
- Confidence

Real-time Performance
- Execution time/Deadline
- Deadlock/starvation
- Latency

Resource Consumption
- Bandwidth
- CPU time
- Power consumption

How Will SAVI Work?

Requirements

Verification/Validation

Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation

Define the data structure needed for information storage & analysis (Model Repository)

Model Repository

Design & Build

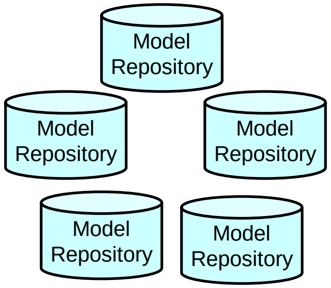
Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation

Define the data structure needed for information storage & analysis (Model Repository)



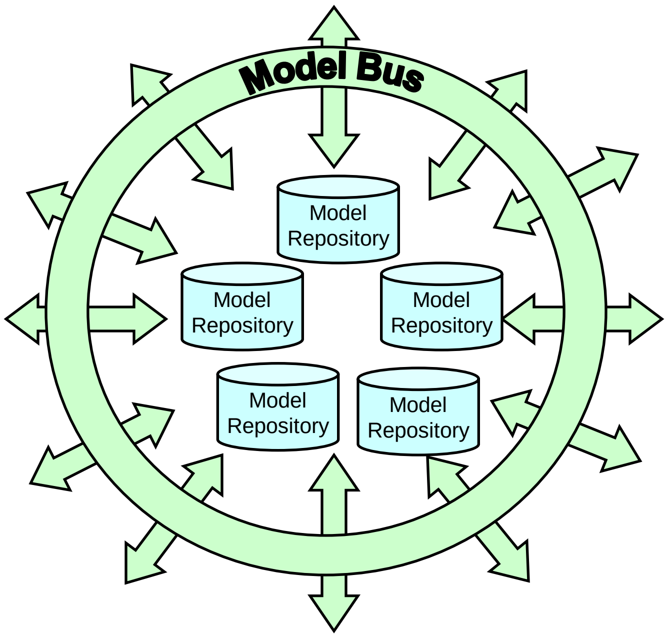
Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation



Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

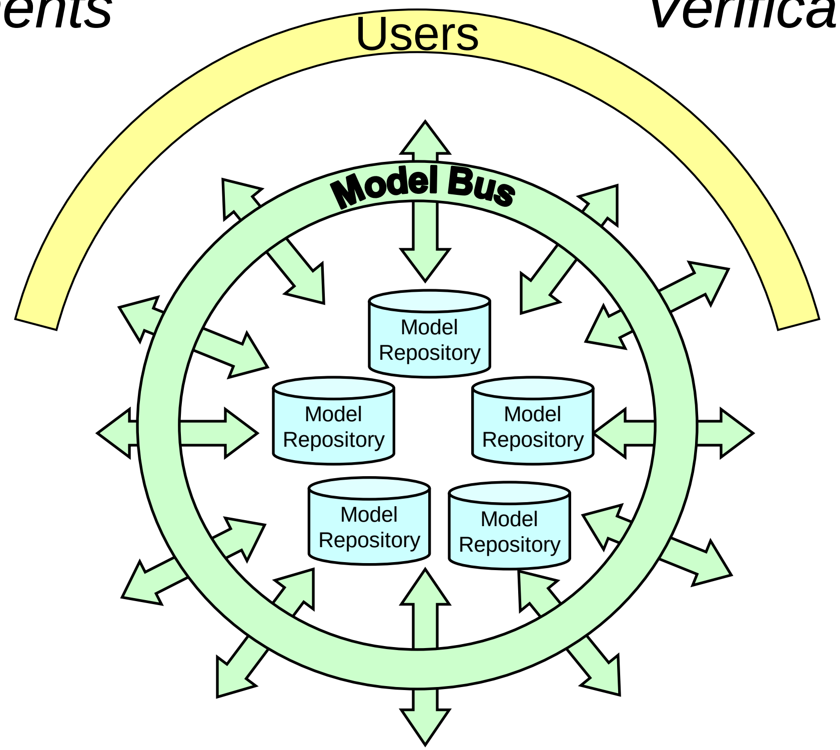
Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation



Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

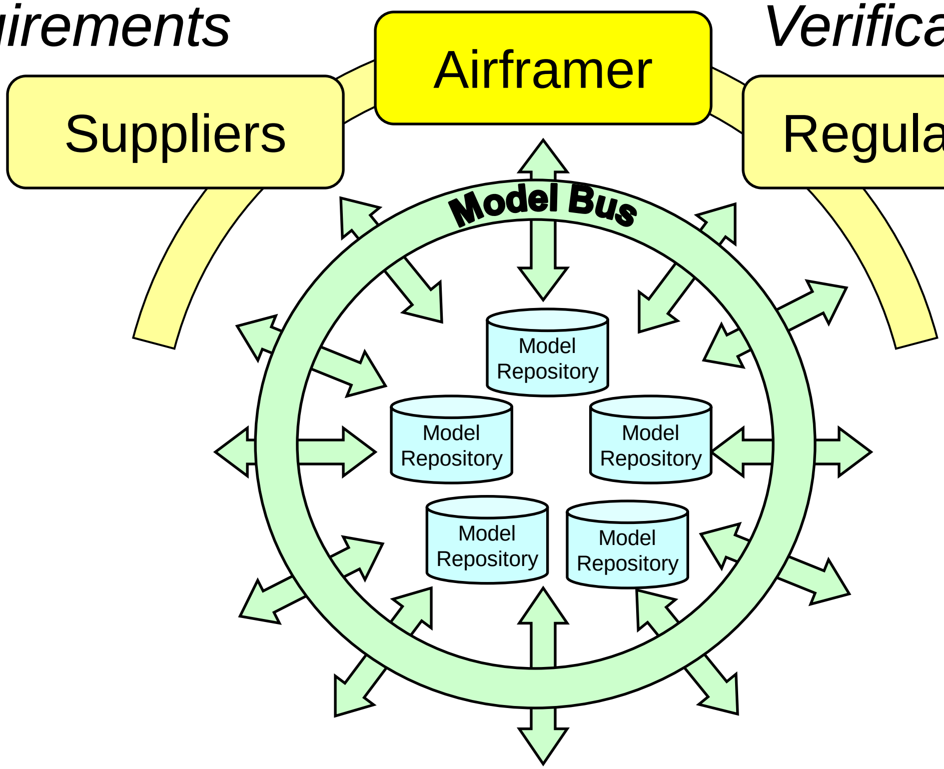
Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation



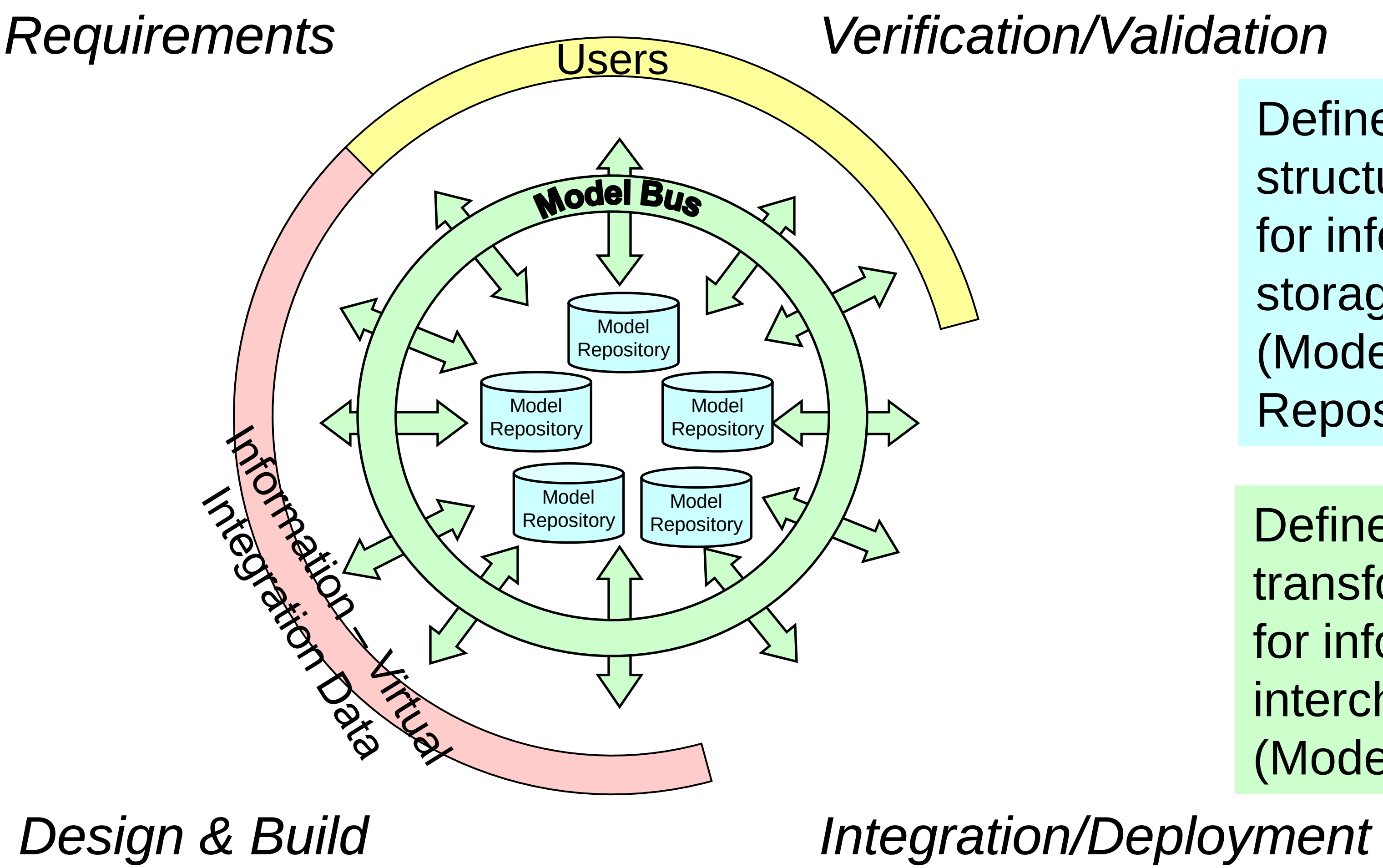
Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

Design & Build

Integration/Deployment

How Will SAVI Work?



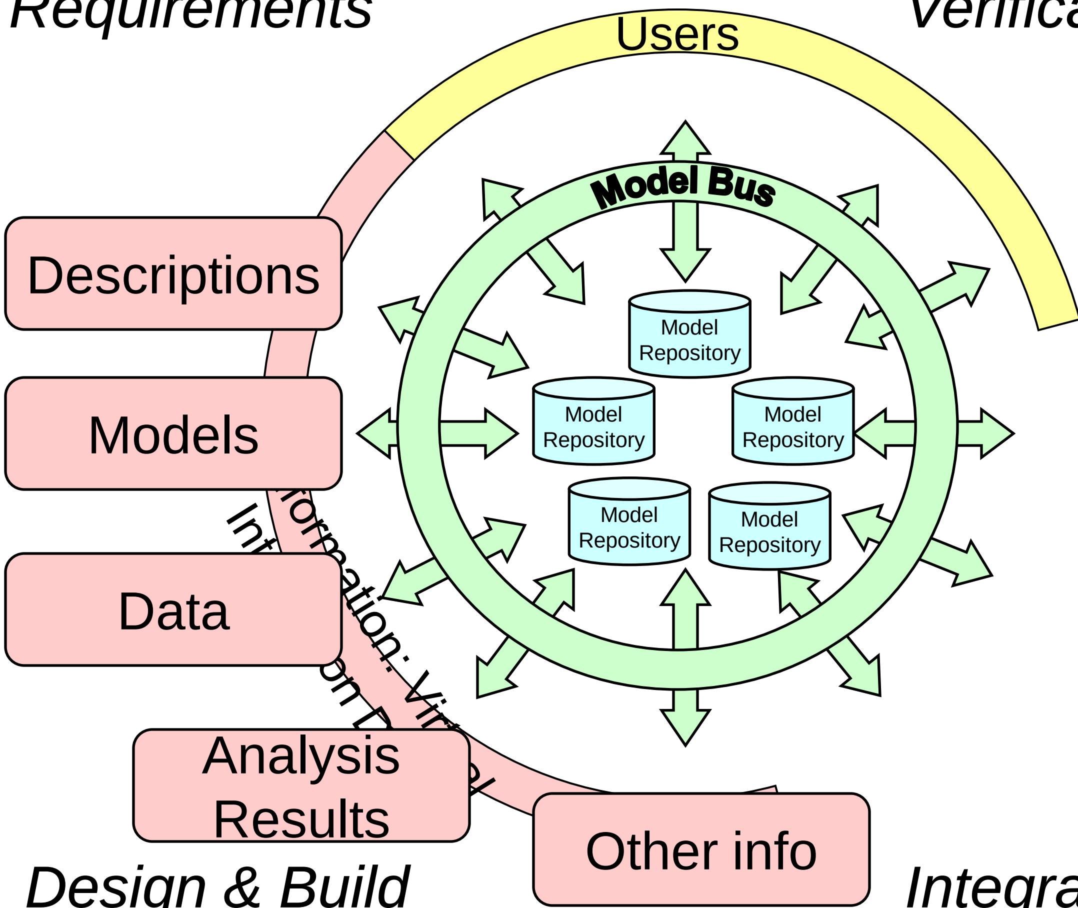
Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

How Will SAVI Work?

Requirements

Verification/Validation



Design & Build

Integration/Deployment

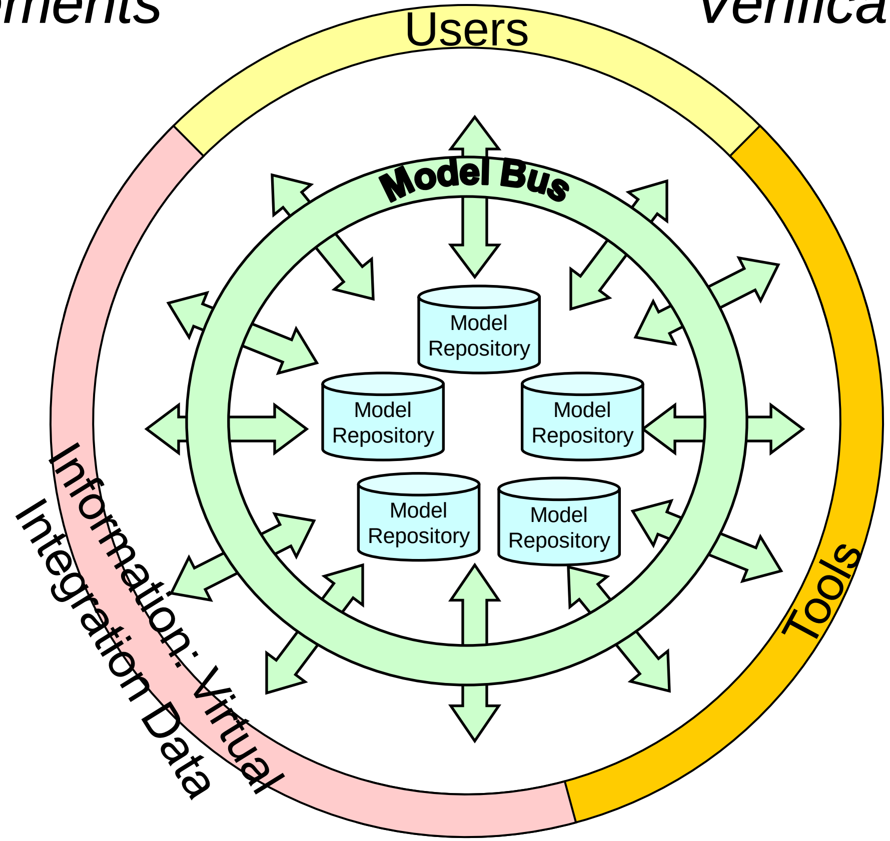
Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

How Will SAVI Work?

Requirements

Verification/Validation



Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

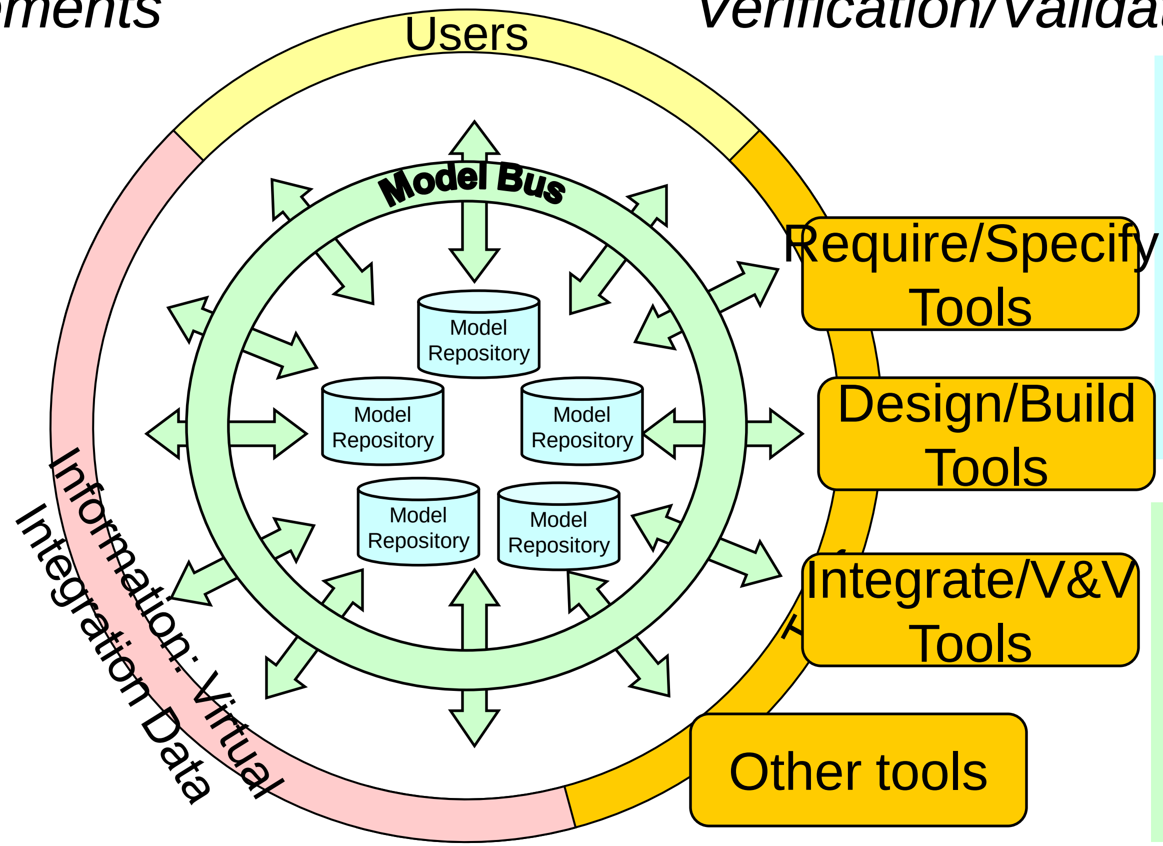
Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation



Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

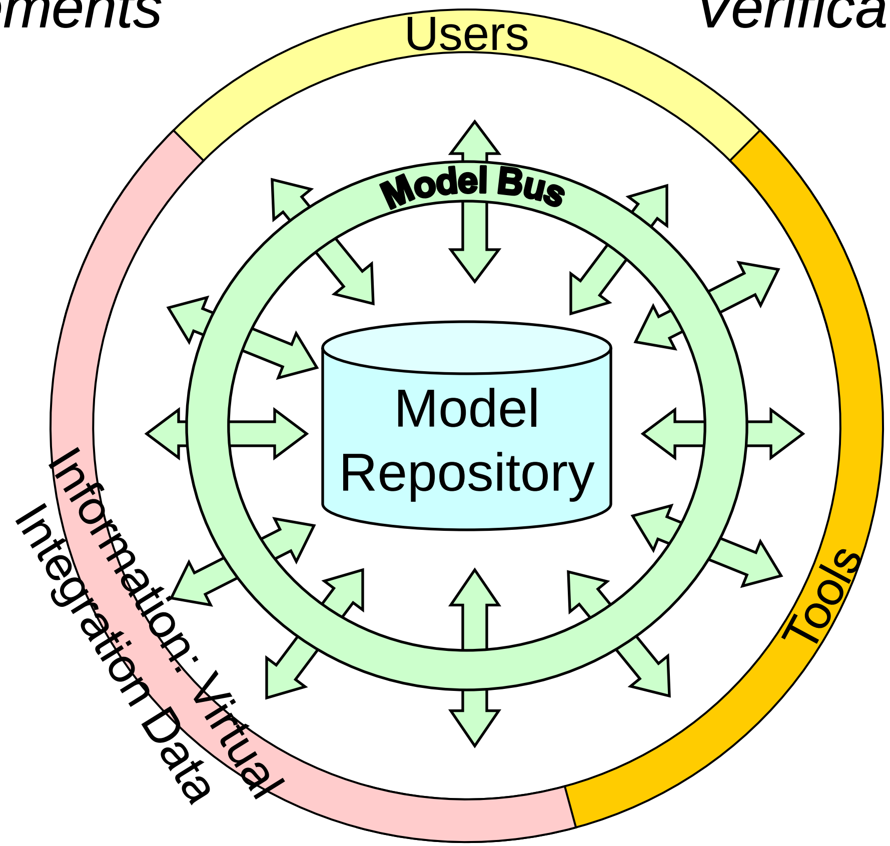
Design & Build

Integration/Deployment

How Will SAVI Work?

Requirements

Verification/Validation



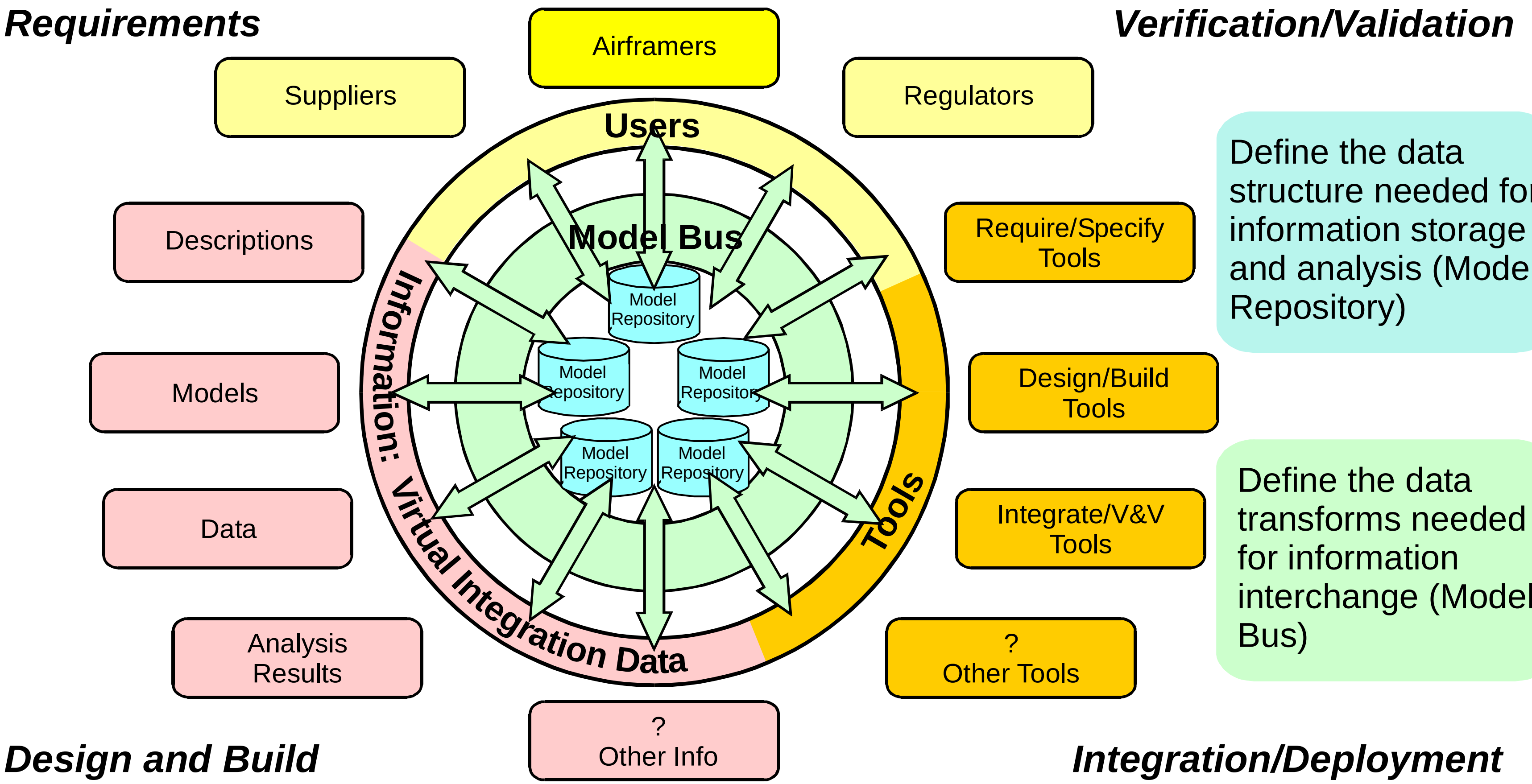
Define the data structure needed for information storage & analysis (Model Repository)

Define the data transforms needed for information interchange (Model Bus)

Design & Build

Integration/Deployment

How Will SAVI Work?

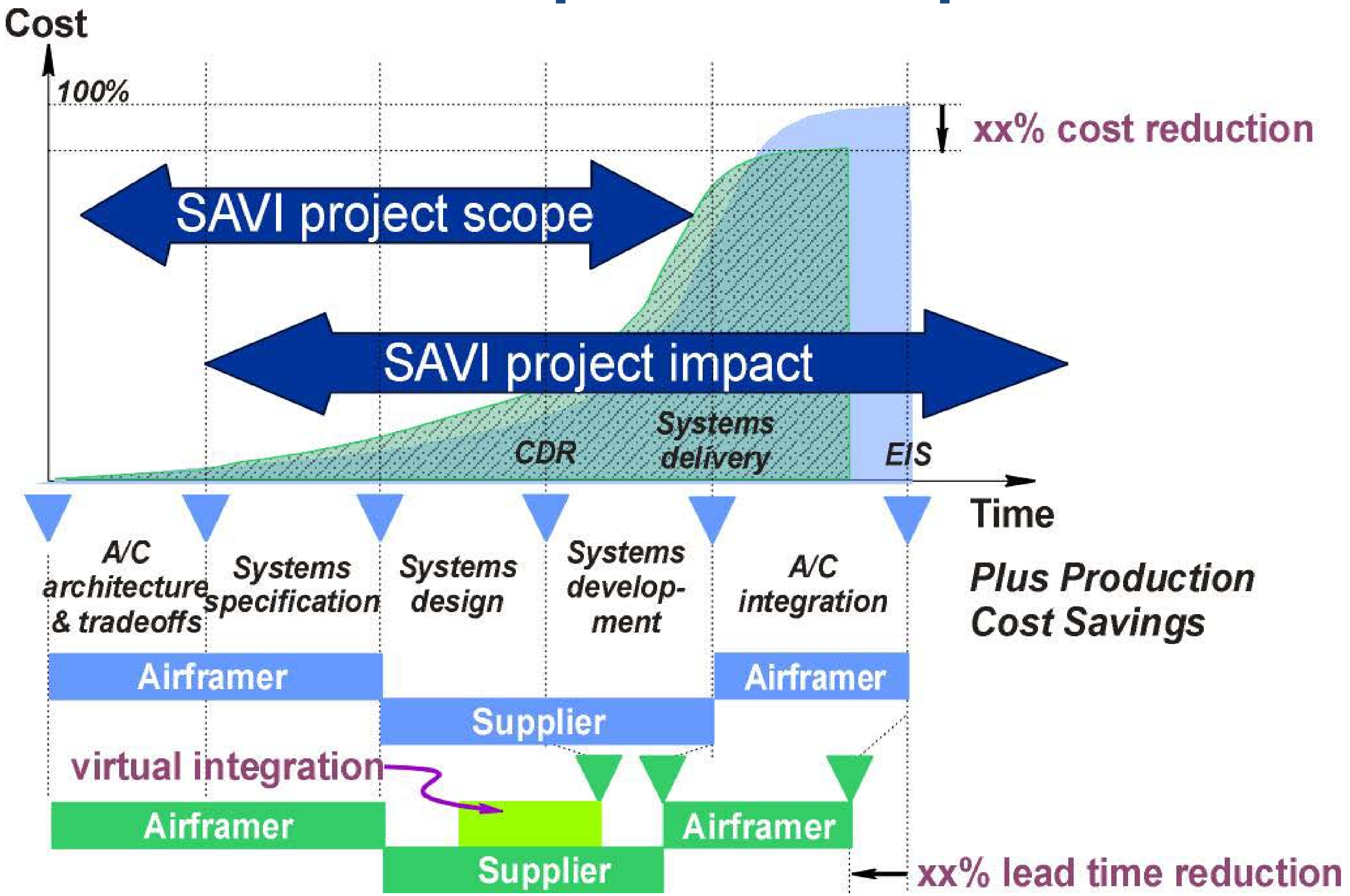


Define the data structure needed for information storage and analysis (Model Repository)

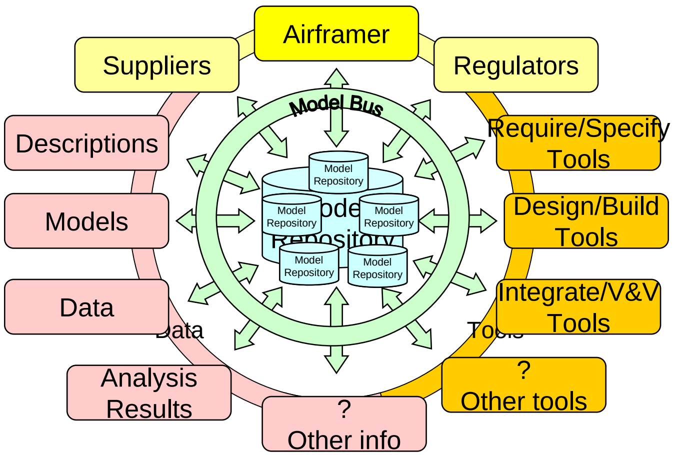
Define the data transforms needed for information interchange (Model Bus)

When is SAVI used?

SAVI Scope, SAVI Impact



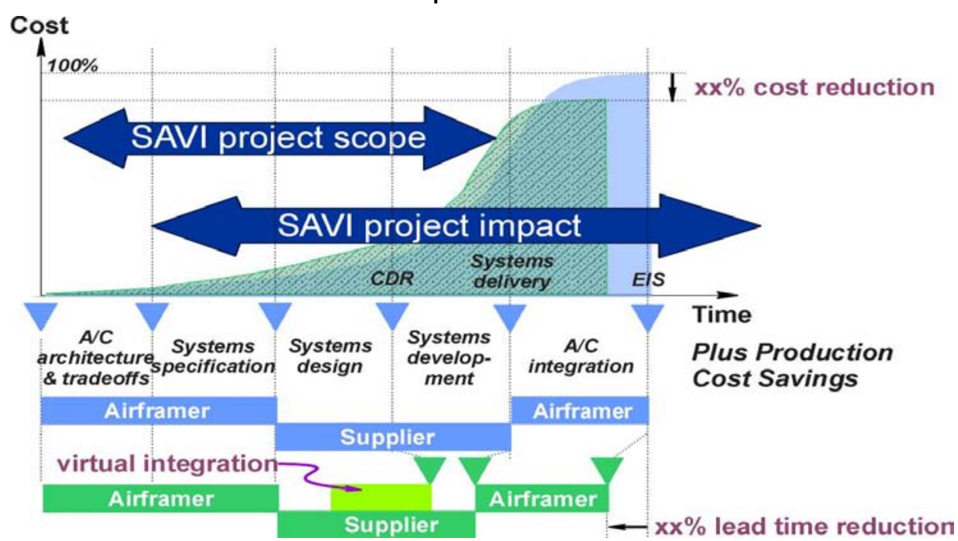
Virtual Systems Integration Uncovers Errors Earlier in Development



The Model Bus and Model Repository are SAVI constructs that enable…

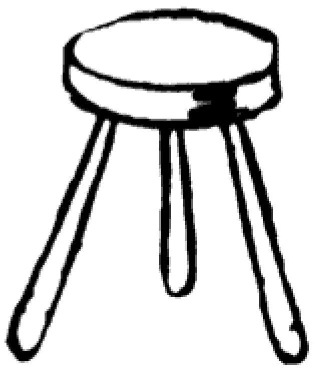
… early validation of system behavior to reduce integration errors.

Model Based Acquisition Environment



SAVI Approach: Integrate, Then Build

- **SAVI is**
  - A changed acquisition paradigm to facilitate systems integration
  - A research effort to define the standards and technologies needed to effect virtual integration
  - Built on the three-legged stool of
    - ✓ *Model-Based*
    - ✓ *Proof-Based*
    - ✓ *Component-Based*
  - Structured/transformable data interfaces
  - A global collaboration

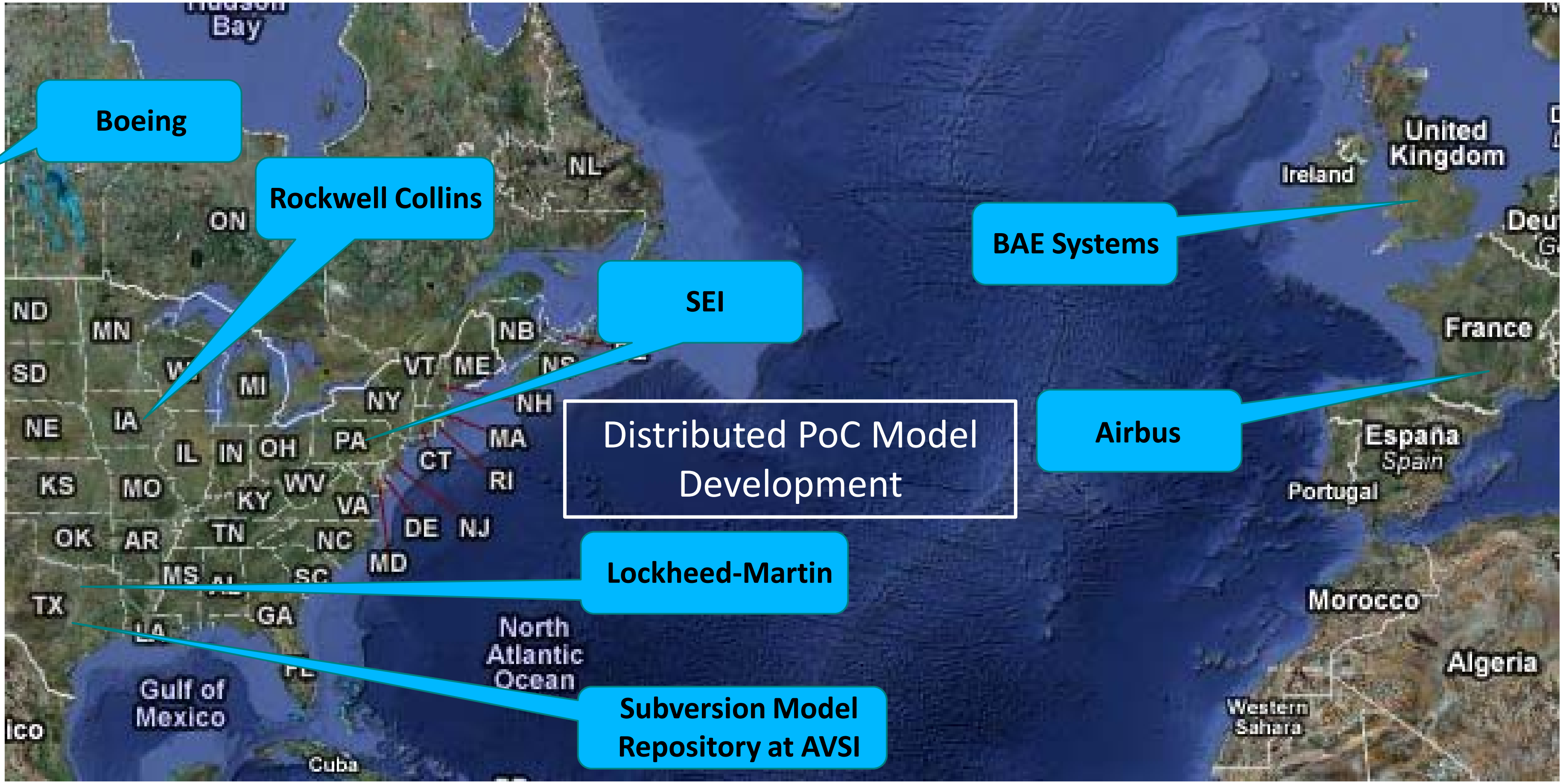


- **SAVI is not**
  - A software tool or a design tool
  - A continuation of current system development practices

Proof-of-Concept (PoC) Objectives

- Produce a credible ROI estimate
- Define a roadmap for development of SAVI
- Develop a Proof-of-Concept Modeling environment:
  - Establish a prototype Model Bus
  - Establish a prototype Model Repository
  - Define a sample model that captures targeted systems properties
  - Perform system analyses across multiple levels of abstraction

Proof-of-Concept Demonstration - (1/3)



Global Team

Proof-of-Concept Demonstration - (2/3)

- Three Models （Tiers 1, 2, and 3） Analyzed
  - Tier 1 (Aircraft level)
  - Tier 2 (Aircraft system level)
  - Tier 3 (Sub-system/LRU level)
- Analysis and Demonstration
  - Propagated requirements and constraints from higher-level model down to suppliers' lower-level models
  - Verified lower-level models satisfy higher-level requirements and constraints
- Evaluation Based on Quality Factors
  - Started with 19 (Criticality, Frequency, Difficulty, Cost,...)
  - Video demonstrations available

Proof-of-Concept Demonstration - (3/3)

- Did this PoC Demonstration show that SAVI methodology is technically feasible?

UNANIMOUS -- YES!

- Core concepts were demonstrated on three different models, BUT…
  - **Scalability was not fully explored**
  - **Open issues with Architecture Description Language (ADL) that was used for the PoC (AADL in this case)**
    - ***Meets needs of all Use Cases?***
    - ***Full compatibility with DoDAF version 2?***

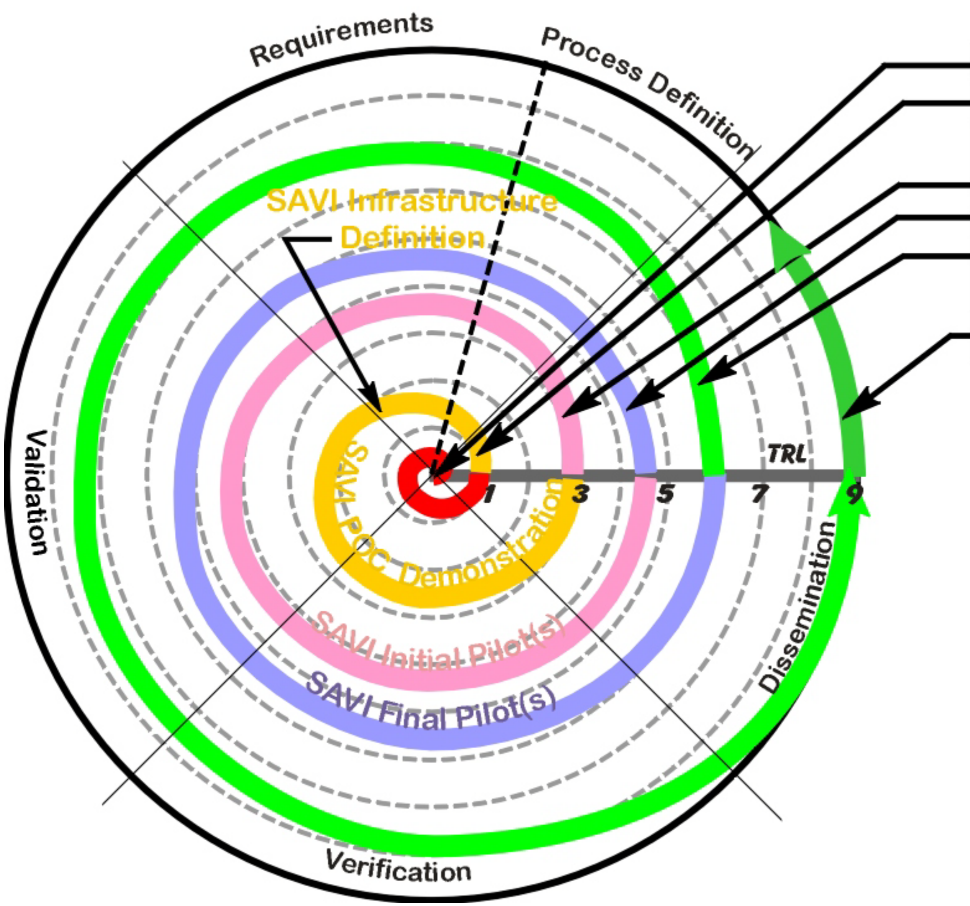
Accomplishments

First Feasibility Demonstration Completed

- Documented As-Is, To-Be Acquisition Models
- Proof-of-concept demonstrates SAVI technical feasibility
- Created Road Map for this new paradigm
- Analysis shows favorable Return on Investment (ROI)

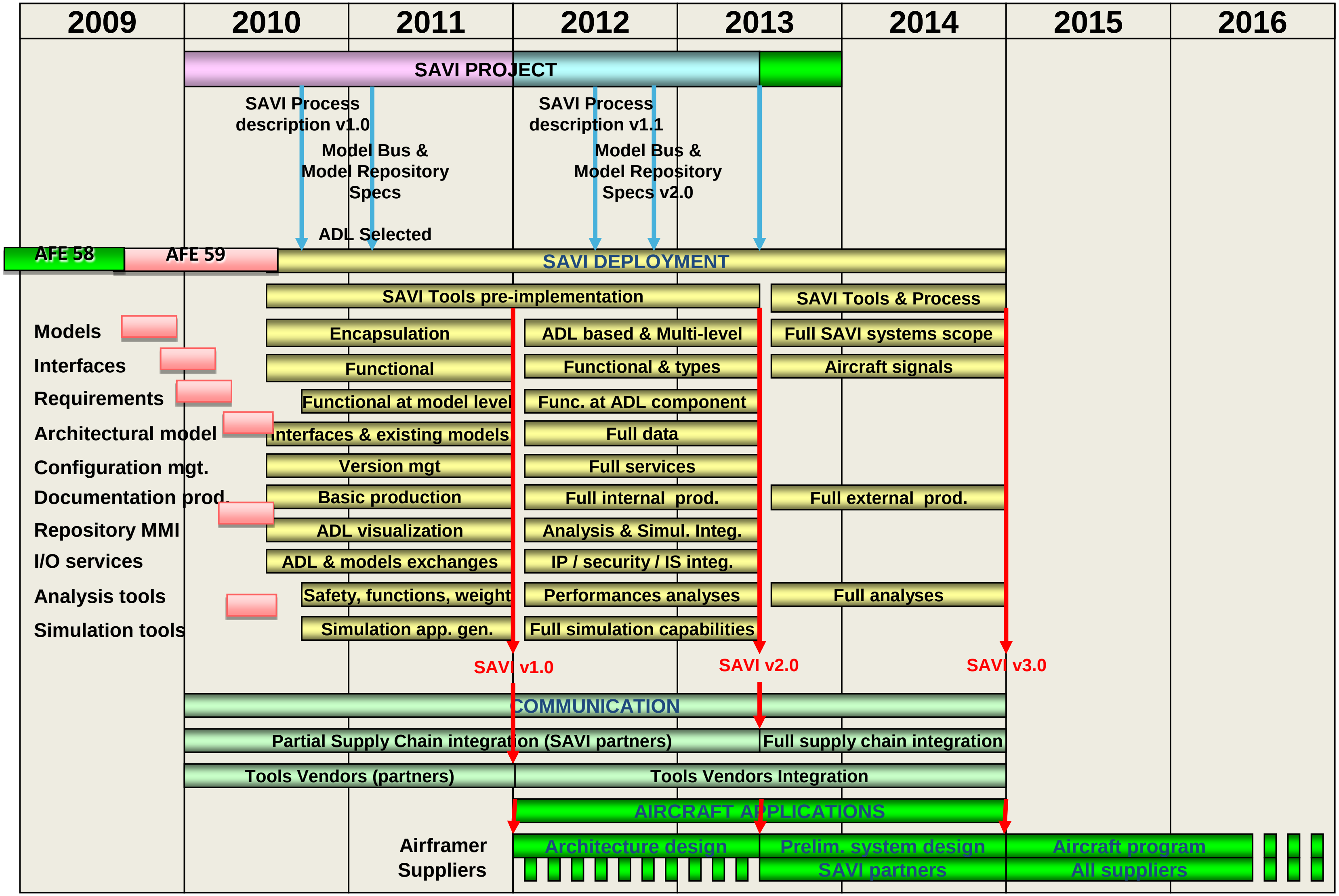
Spiral Development Planned

- Technical Readiness Level （TRL） 9



	SAVI Program
Concept Loop	
Proof of Concept Loop	AFE#58
Technology Demonstration Loops SAVI v1.0 SAVI v2.0	AFEs#60-67
Development "Productionization" Loop SAVI v3.0	
Sustainment Loop(s)	

SAVI Development Roadmap



Questions?

Contacts:

Greg Pollari (319) 295-1629
gmpollar@rockwellcollins.com

Dr. Don Ward (254) 842-5021, (903) 818-3381
SAVIPM@dishmail.net

A Framework for Enhancing Forward-looking Capability Delivery Metrics

Leonard Sadauskas

Presented at
12th NDIA SE Conference
Early Systems Engineering Track
28 October 2009

Disclaimer

The views and opinions expressed in this presentation are those of the author and do not reflect the policy of the Department of Defense

Motivation for this Presentation

- DoD has been in transition since 2003 from

  REQUIREMENTS to ***CAPABILITIES-BASED*** planning

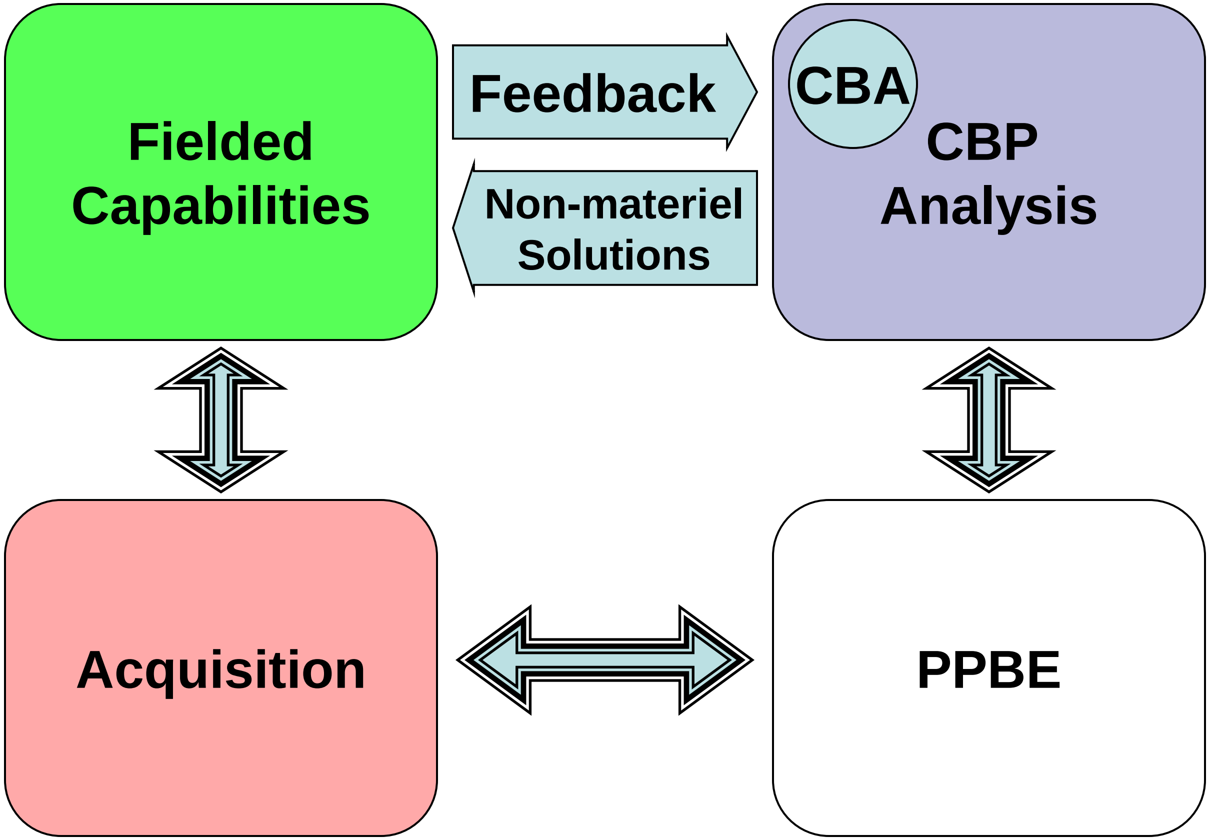
- The state of the transition includes
  - JCIDS and a revised 5000
  - Testing in a Joint Environment Roadmap in 2004
  - Revitalized Joint Test and Evaluation (JT&E) Program in 2005
  - Development of Joint Capability Areas
  - Capability Portfolio Managers Directive in 2008
  - Several recent articles on Capability Test & Evaluation
- **Yet the ability to predict a timely delivery of capability to the warfighter is the subject of the Weapons Systems Acquisition Reform Act of 2009**
- One conclusion is that our risk management process has neither embraced capabilities nor developed risk metrics for delivery of capabilities

Definitions Related to Capability

- Capability
  - The ability to achieve a desired effect under specified standards and conditions through a combination of means and ways across the DOMLPF to perform a set of tasks to execute a specific course of action
- Joint Capability Area (JCA)
  - Collection of like DoD capabilities functionally grouped to support capability analysis, capability portfolio management and …….
- Capabilities-Based Assessment (CBA)
  - Study that identifies the capabilities (and operational performance criteria) required to successfully execute missions
- Capability-based planning (CBP)
  - An overarching framework for planning under uncertainty that provides capabilities suitable for a wide range of modern-day challenges and circumstances while working within an economic framework that necessitates choice

Capabilities-based Planning Framework

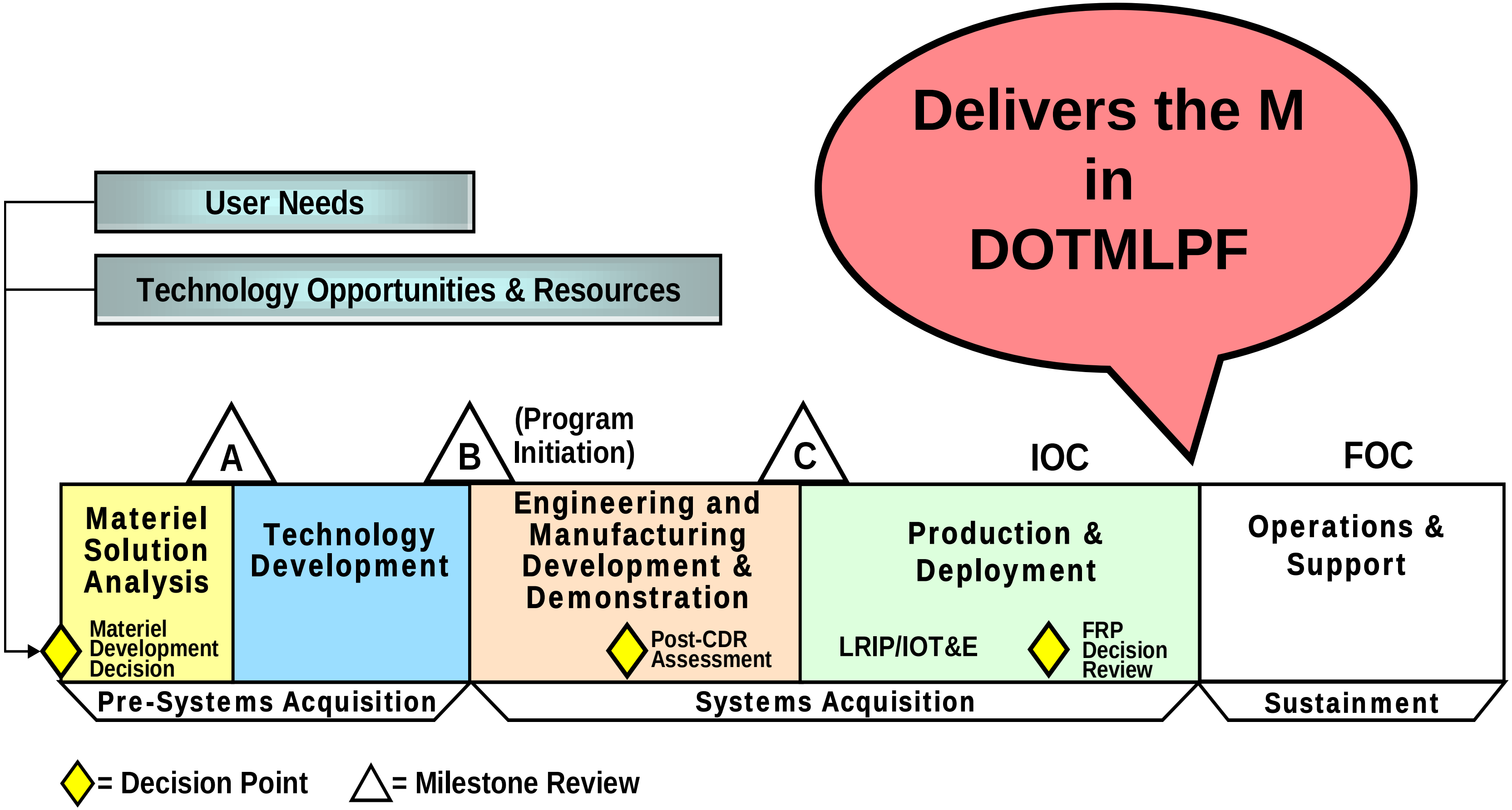
Adapted from DAU Course Material



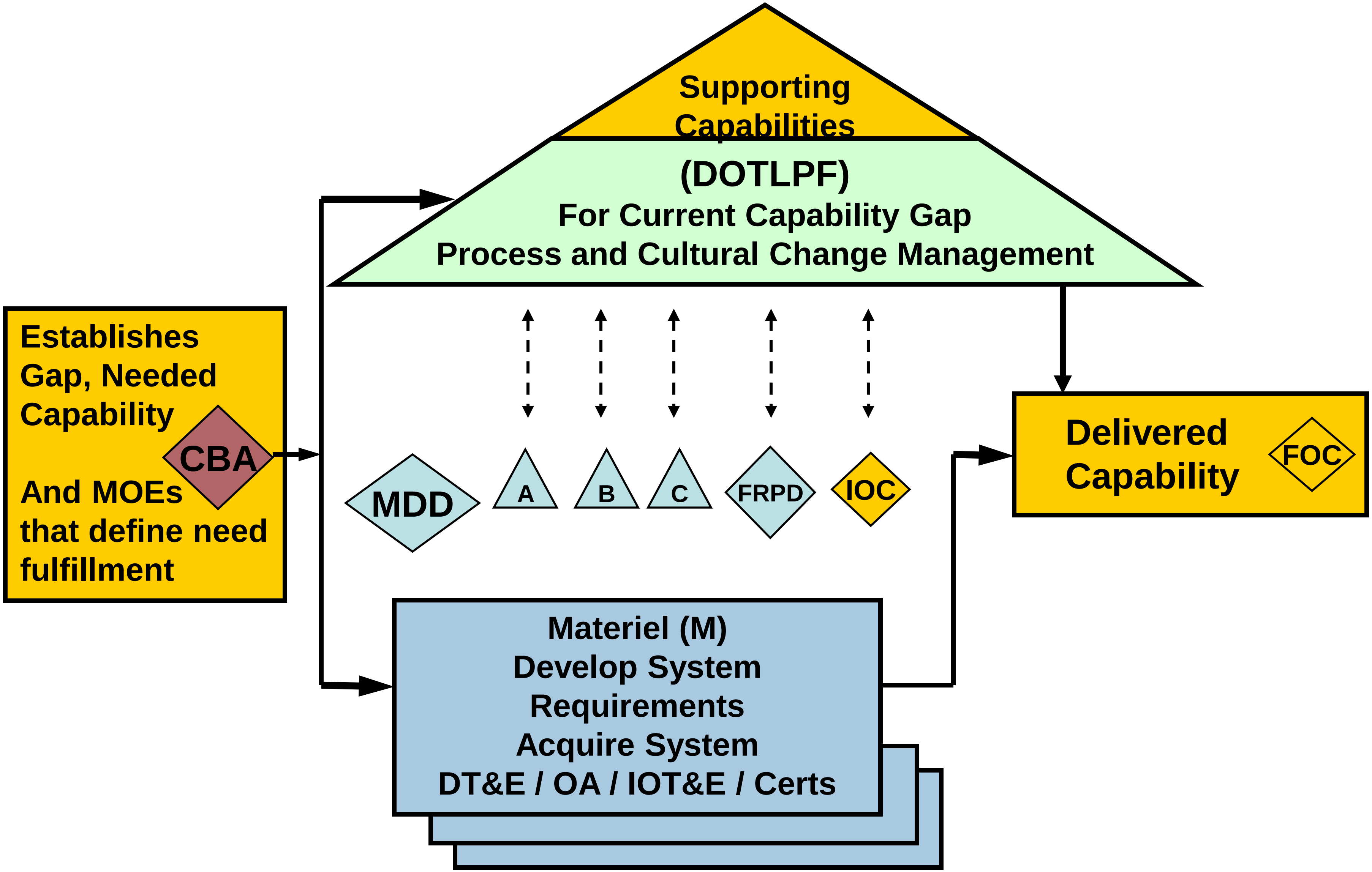
Implications of Delivering Capability

The ability to achieve a **desired effect** under **specified standards** and **conditions** through a combination of means and ways across the **DOTMLPF** to perform a set of tasks to execute a specific course of action

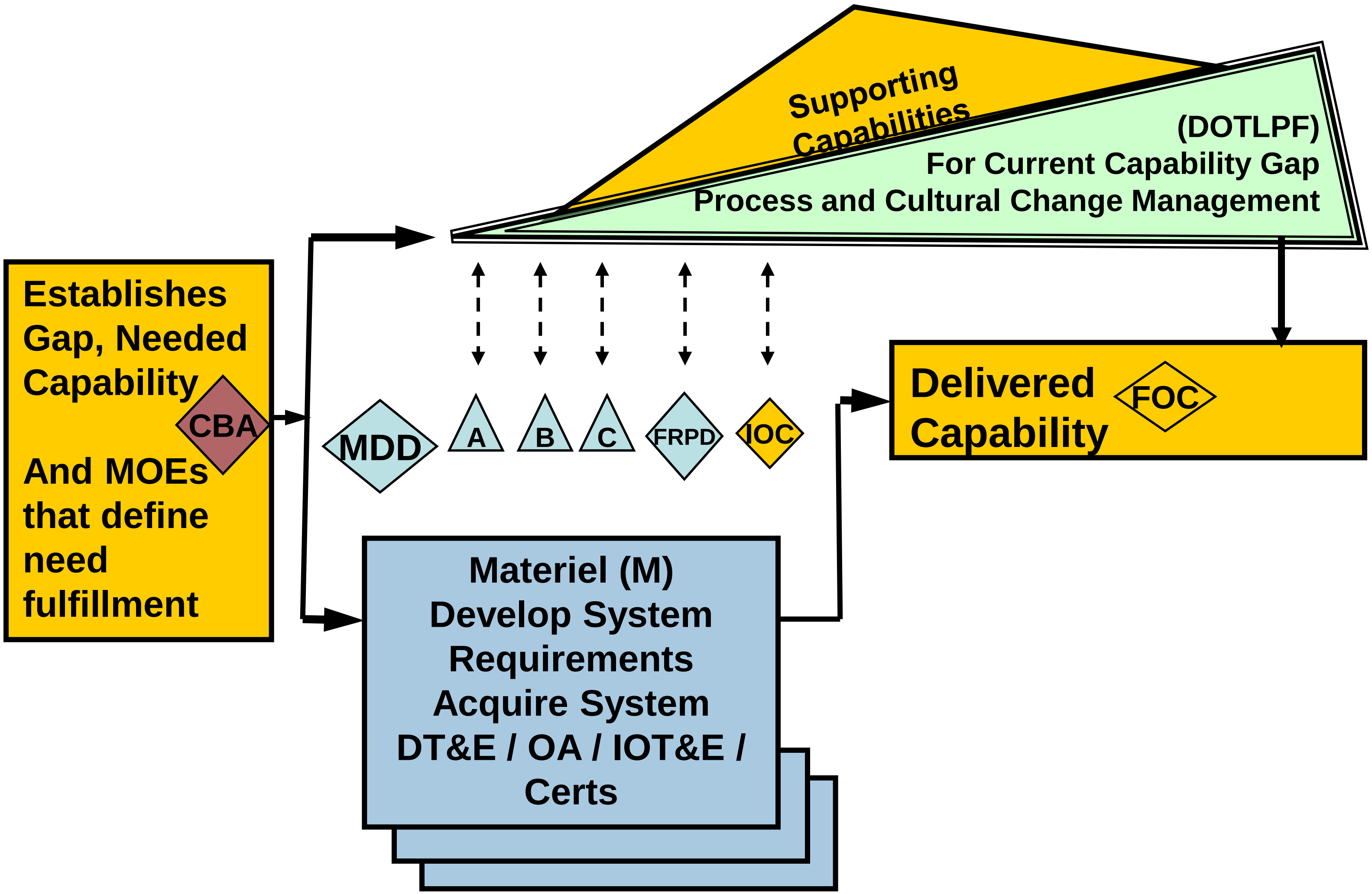
The 5000 Model for Delivering Capability



A Notional Model for Delivering Capability



Often Seen Model for Joint Capability Delivery



The Capability Development and Delivery Metric of Interest

WSARA 2009 sec. 103.c: Performance Assessments

The extent to which the predicted cost**, schedule and performance is likely to result in the timely delivery of a level of capability to the warfighter** that is consistent with the level of resources to be expended and provides superior value to alternative approaches that may be available to meet the same military requirement

Analytical Approach

Defining success as the timely delivery of a level of capability (such as an increment) to the warfighter, then

$P\,(\text{success}) = F\,(P_{\text{that each DOTMLPF element meets Schedule and Performance}})$

Simplifying with assumptions that each DOTMLPF element is:

- independent
- accomplished in series
- equal in importance
- has a known schedule, performance probability distribution

$P\,(\text{success}) = P_D * P_O * P_T * P_M * P_L * P_P * P_F$

Of course this is a gross oversimplification and removing these assumptions will produce a significantly more complex, albeit more robust model.

Current DAS Predictive Approach

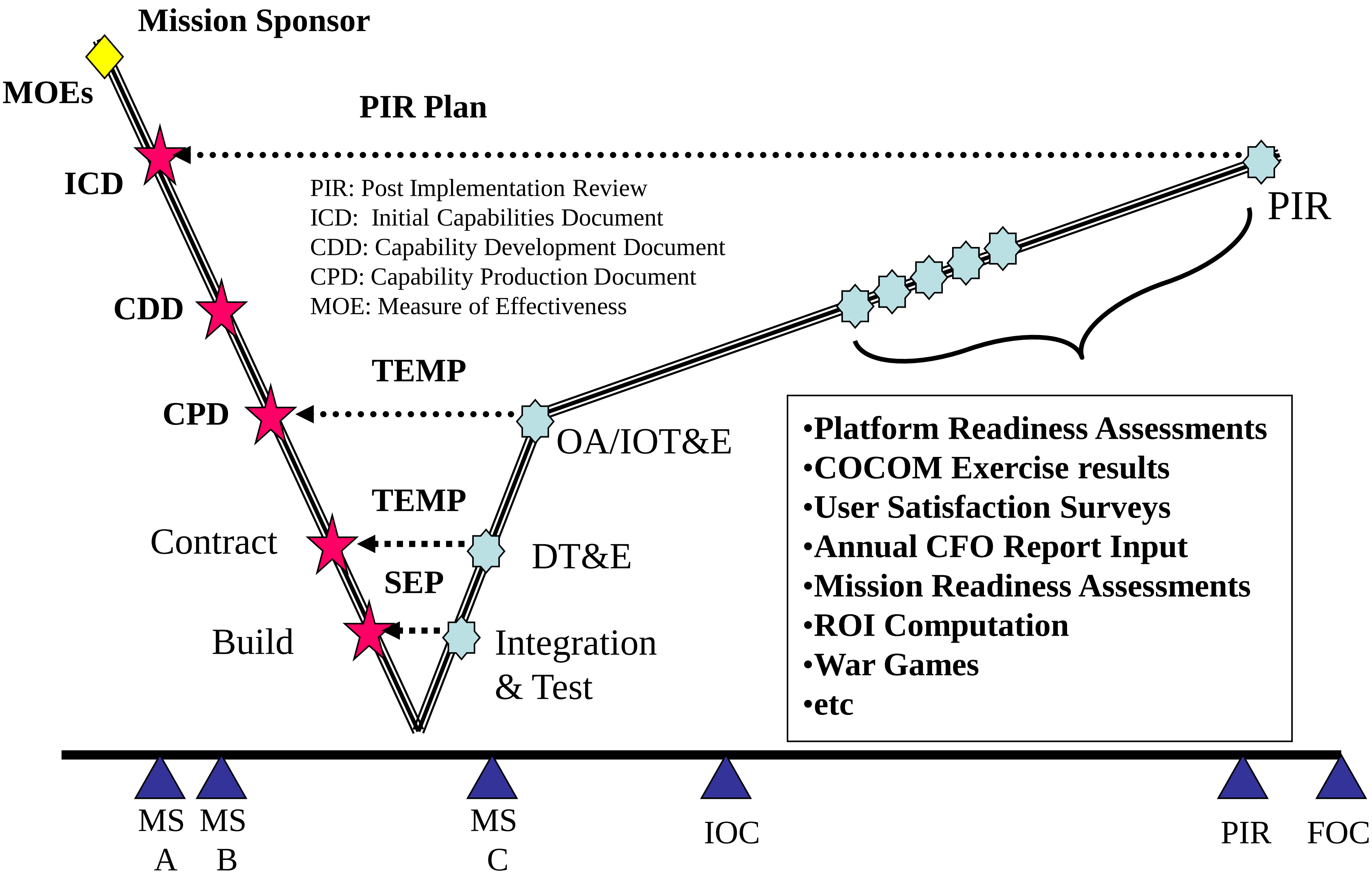
- For programs operating within their APBs, the key predictors for successful delivery of capability are T&E, certifications and post implementation review (PIR)
  - DT&E estimates the system's military utility when introduced
  - IOT&E translates measures of effectiveness (MOEs) into critical operational issues and predicts suitability and effectiveness when introduced
  - PIR verifies the ICD MOEs and collects customer satisfaction prior to FOC

Post Implementation Review (PIR) Defined

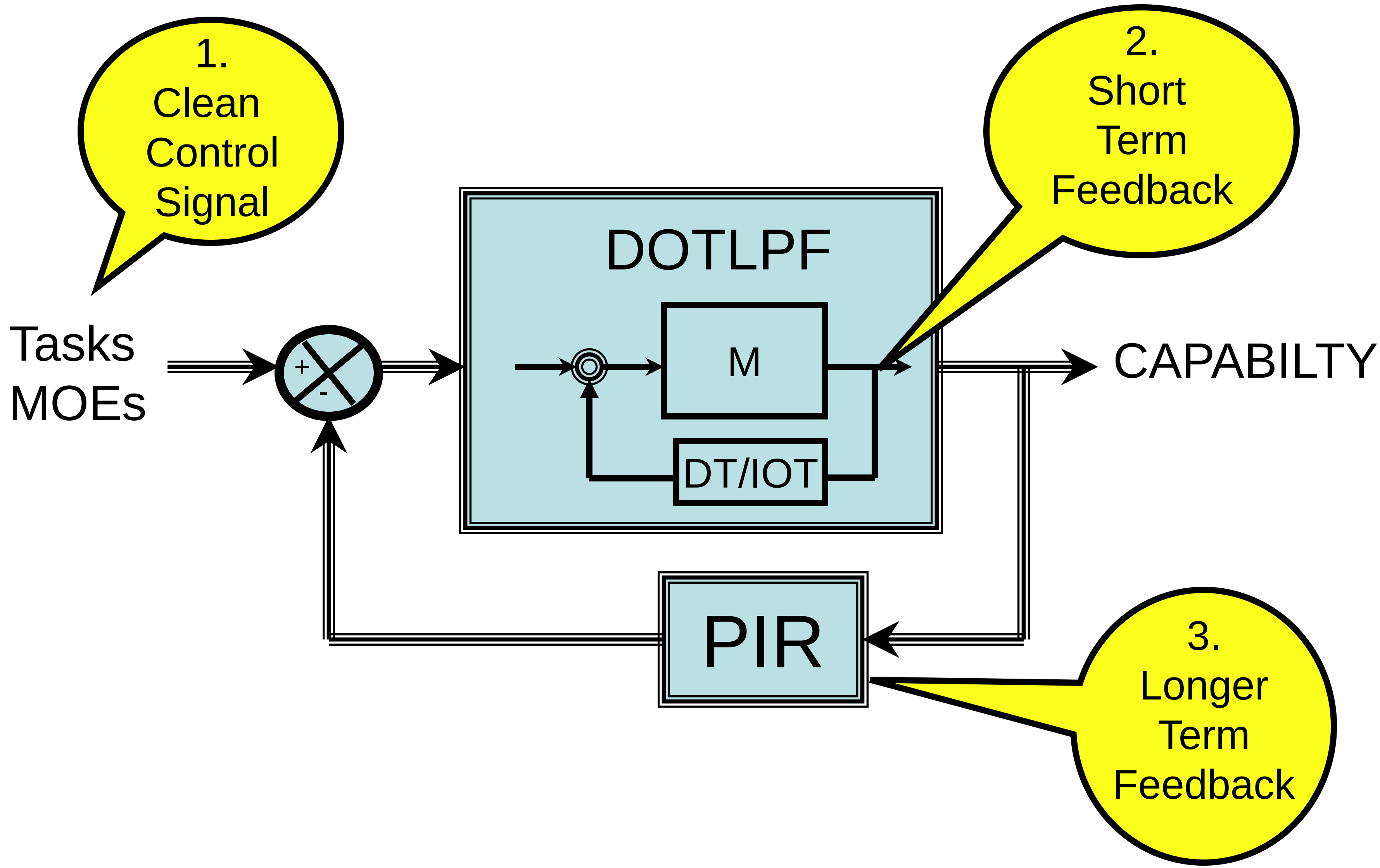
An analysis of an investment or acquired system that is part of a capability portfolio, operating in its intended environment, using data collected from various sources to answer the question:

Did we get what we needed, and if not what to do about it?

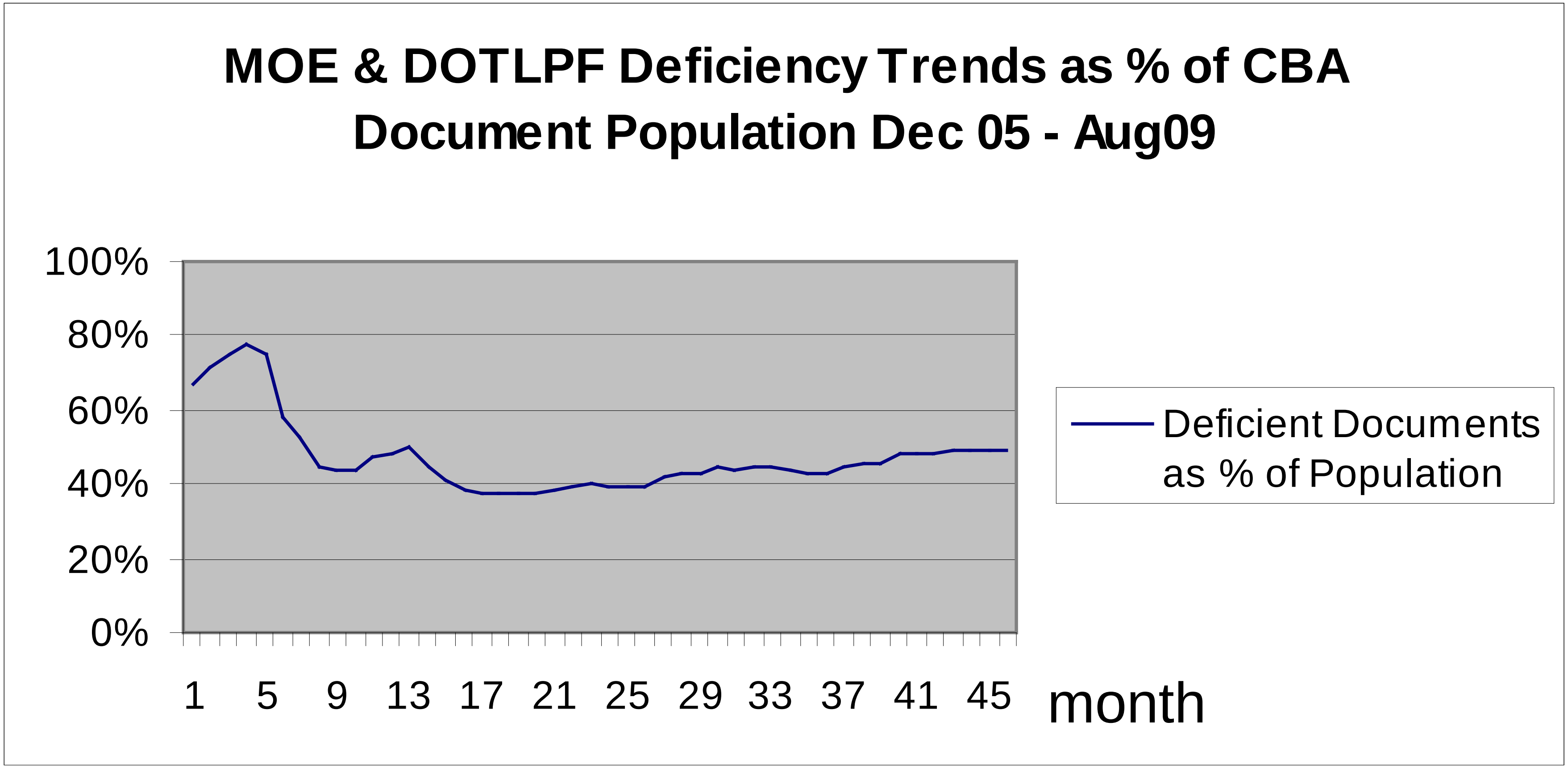
System and Capability Verification



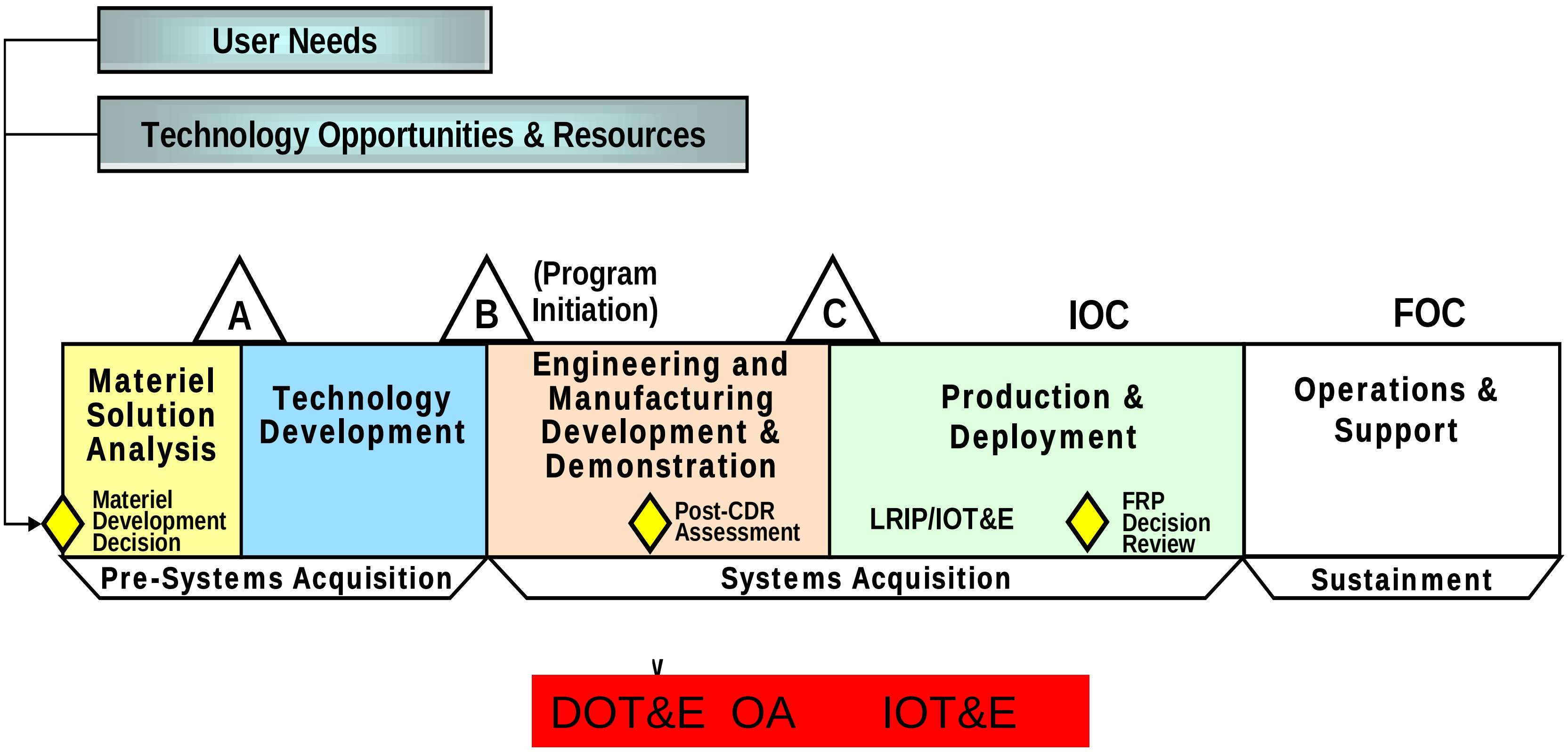
Notional Model for Enhancing Forward-looking Schedule and Performance Predictors



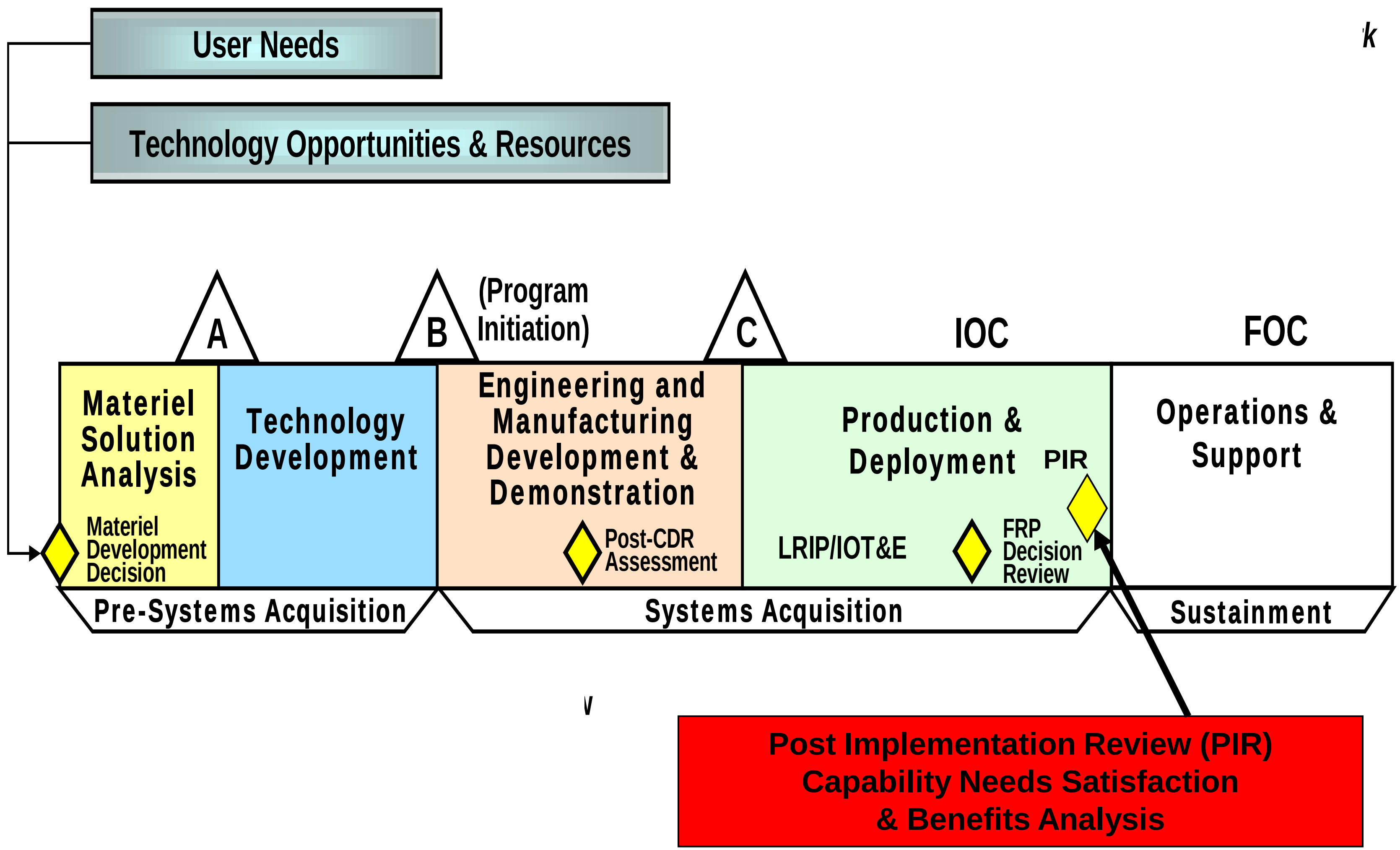
1. Clean Control Signal (Problematic but doable)



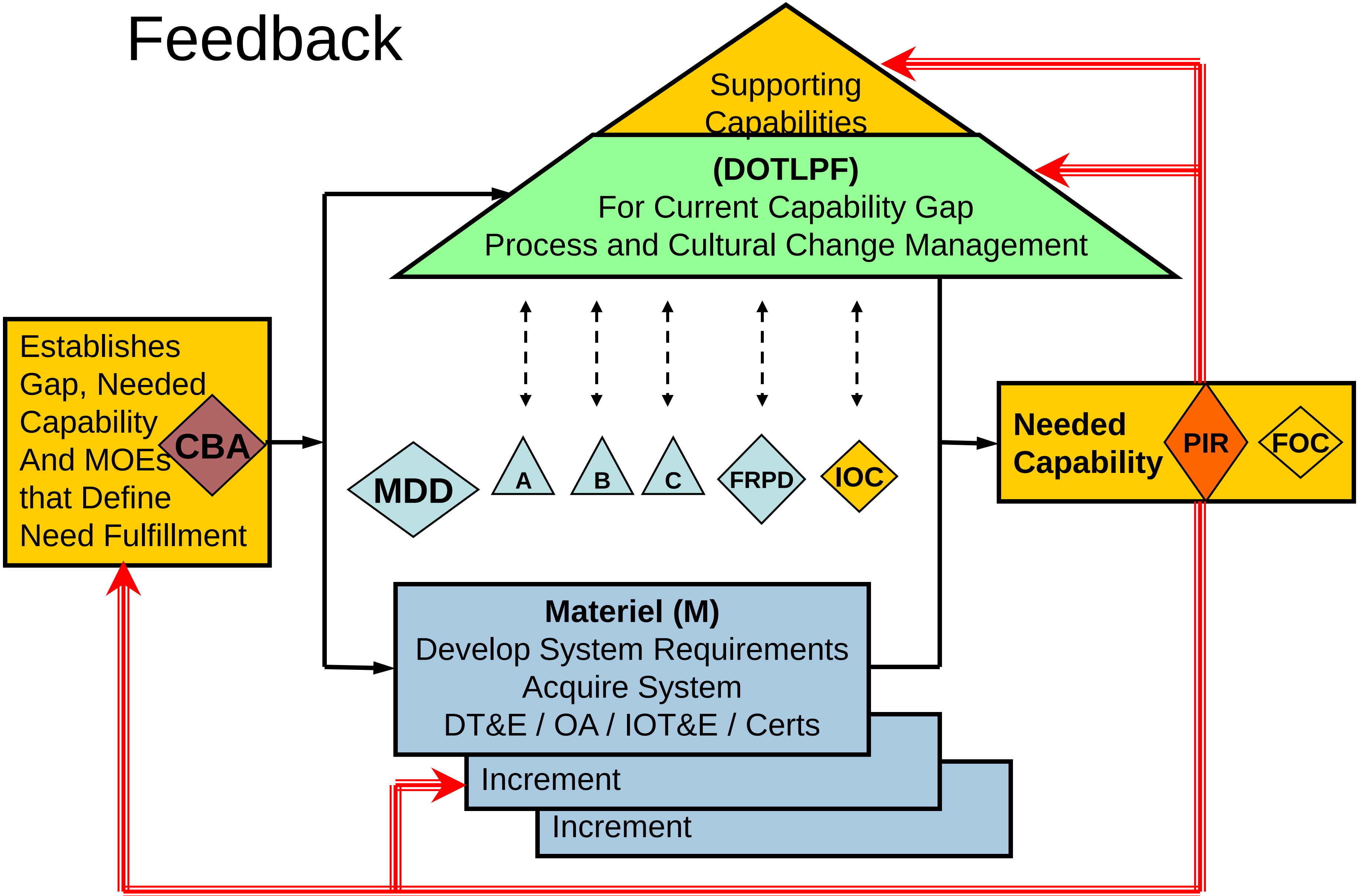
2. Short Term Feedback



3. Longer Term Feedback in 5000 (DAG Ch 7.9)



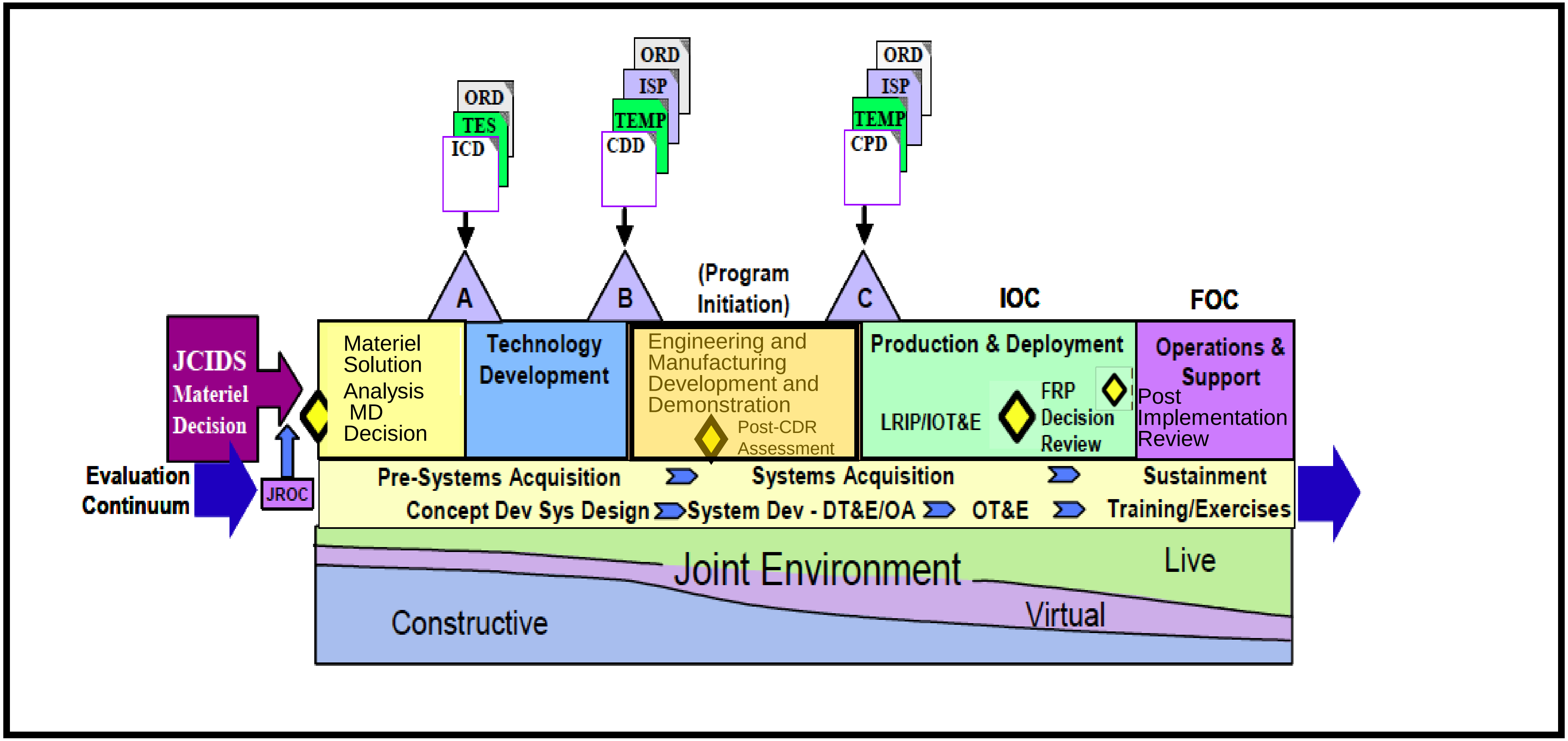
3. Longer Term Capability Delivery Feedback



First Steps for Predictor Enhancement

- **DAG Chapter 9.9.10**
- DoD Instruction 5000.02 requires that PIRs be conducted for MAIS and MDAP programs in order to collect and report outcome-based performance information. **The T&E community will participate in the planning, execution, analysis, and reporting of PIRs, whose results will be used to confirm the performance of the deployed systems and possibly to improve the test planning and execution for follow-on increments or similar systems.**

Vision for Continuous Predictor Enhancement



Adapted from Testing in a Joint Environment Roadmap

?

Backup

Abstract

- The Weapon Systems Acquisition Reform Act of 2009 includes a Performance Assessment requirement to evaluate the extent to which current metrics are likely to predict a timely delivery of a level of capability to the warfighter that is consistent with the level of resources to be expended and provides superior value to alternative approaches that may be available to meet the same military requirement.

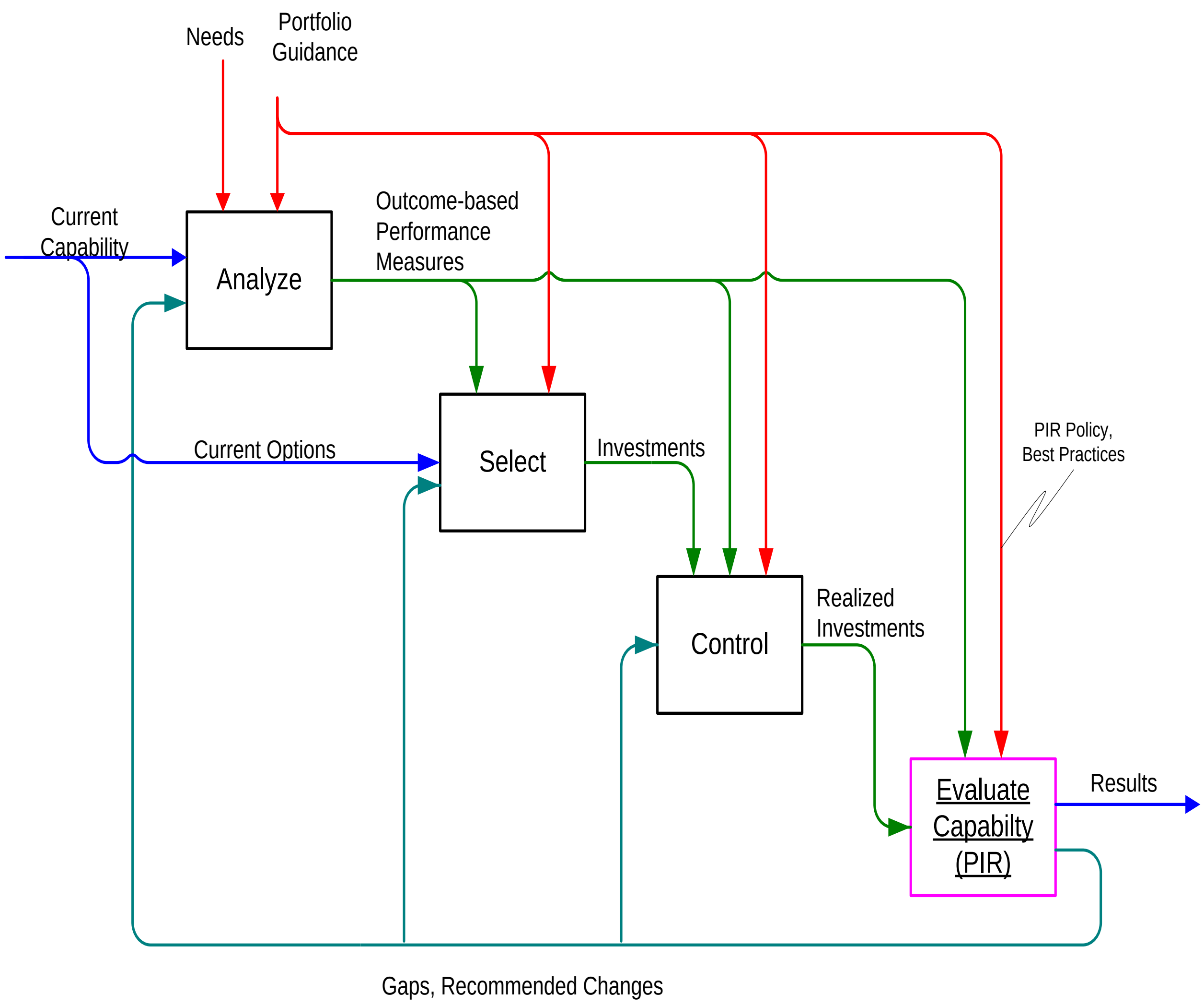
- Development of forward-looking metrics is a long standing quest within the Department and remains in the forefront of Congressional interest. The author discusses the implication of predicting capability performance vice system performance and offers a control system framework for enhancing the quality of such forward looking metrics. The key elements of the framework are a clean input signal, a short term predictive feedback loop and a long term feedback loop to continually improve the predictive metric.

DODD 8115.01 IT Portfolio Management

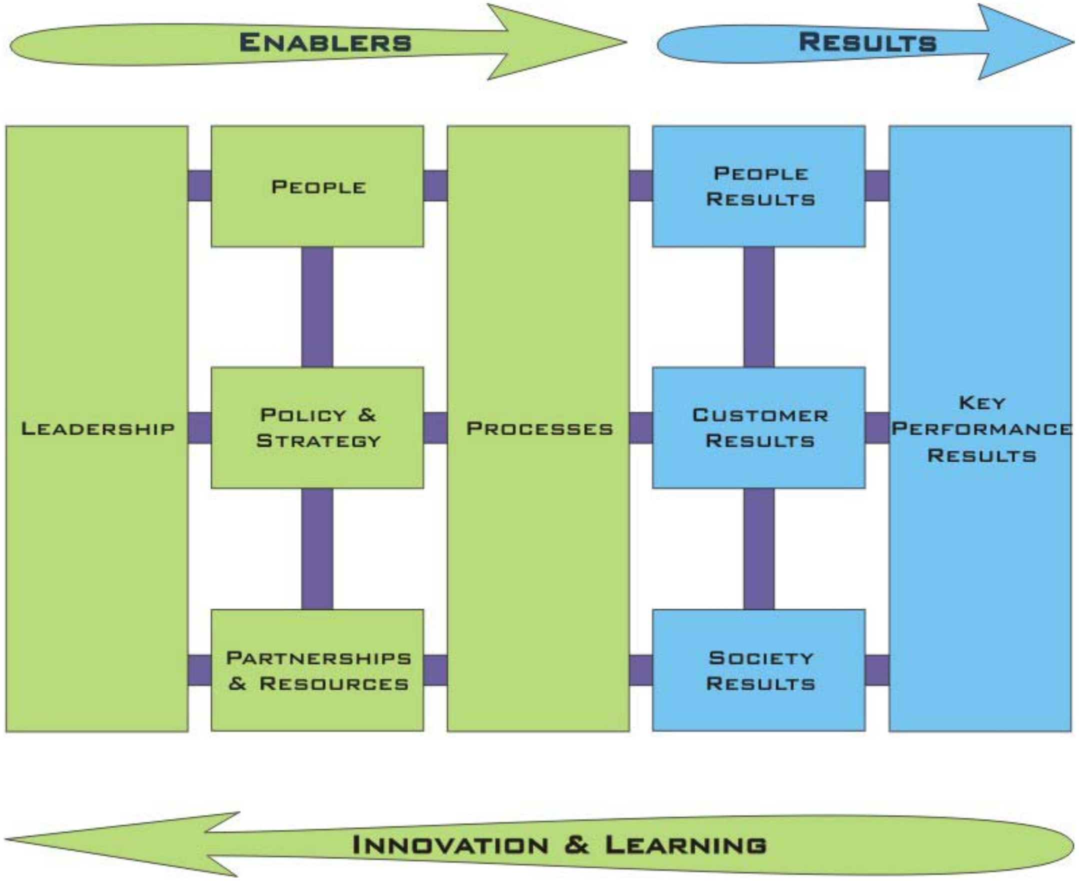
- **4.4. All authorities addressed in Section 5 of this Directive shall manage DoD portfolios by performing the following core functions:**

- 4.4.1. Analysis. Links portfolio objectives to Enterprise vision, mission, goals, objectives, and priorities; develops quantifiable outcome-based performance measures; identifies capability gaps, opportunities, and redundancies; identifies risks; and provides for continuous process improvement.
- 4.4.2. Selection. Identifies and selects the best mix of IT investments to strengthen and achieve capability goals and objectives for the portfolio and demonstrates the impact of alternative IT investment strategies and funding levels.
- 4.4.3. Control. Ensures a portfolio is managed and monitored using established quantifiable outcome-based performance measures. Portfolios are monitored and evaluated against portfolio performance measures to determine whether to recommend continuation, modification, or termination of individual investments within the portfolio.
- 4.4.4. Evaluation. Measures actual contributions of the portfolio against established outcome-based performance measures to determine improved capability as well as to support adjustments to the mix of portfolio investments, as necessary.

DODD 8115.01 IT Portfolio Management



European EFQM Model



ARTICLES AND REPORTS

- Steven Hutchison, A Capability Focused T&E Framework, Defense AT&L: Jan-Feb 2009
- Chris DiPotto, Paving the Way for Testing in a Joint Environment, Defense A&L: Sep-Oct 2009
- Hutchison-Lorenzo-Bryan, Capability Test Methodology and Joint Battlespace Dynamic Deconfliction, Defense AT&L: Jan-Feb 2009
- DOT&E, Testing in a Joint Environment Roadmap, Strategic Planning Guidance FY 2006-2011, Final Report: Nov 12, 2004

Paper Reference Number: 9017
Session: Technology Maturity

Linking Systems Engineering Artifacts with Complex System Maturity Assessments

2009 NDIA Systems Engineering Conference
28 October 2008

Brian Sauser, Ph.D.
Stevens Institute of Technology

Richard Volkert
SSC-Pacific

Eric Forbes
Northrop Grumman Corporation

Lance Harper
Northrop Grumman Corporation

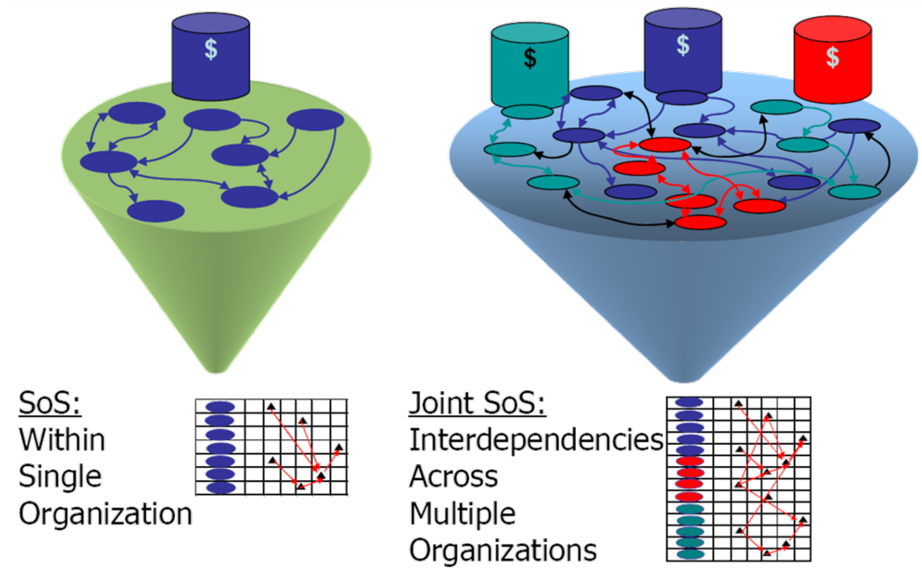
Overview

- Motivation
- System Acquisition Management Approach
- System Readiness Level Concept Overview
- System Maturity Assessment Process
- System Performance Level Monitoring
- System Availability
- System Capability Satisficing
- Future Work and Applications

Motivation

- Development and acquisition activities continue to be challenged by the formulation of larger and more complex systems

- This is compounded by the emergence of *Acknowledged Systems of Systems* which are characterized as having multiple stakeholders with competing interests and priorities



Source: DoD Systems Engineering Guide for Systems of Systems, Version 1.0, August 2008

- Traditional management tools continue to be applied, but do not provide a holistic view of development

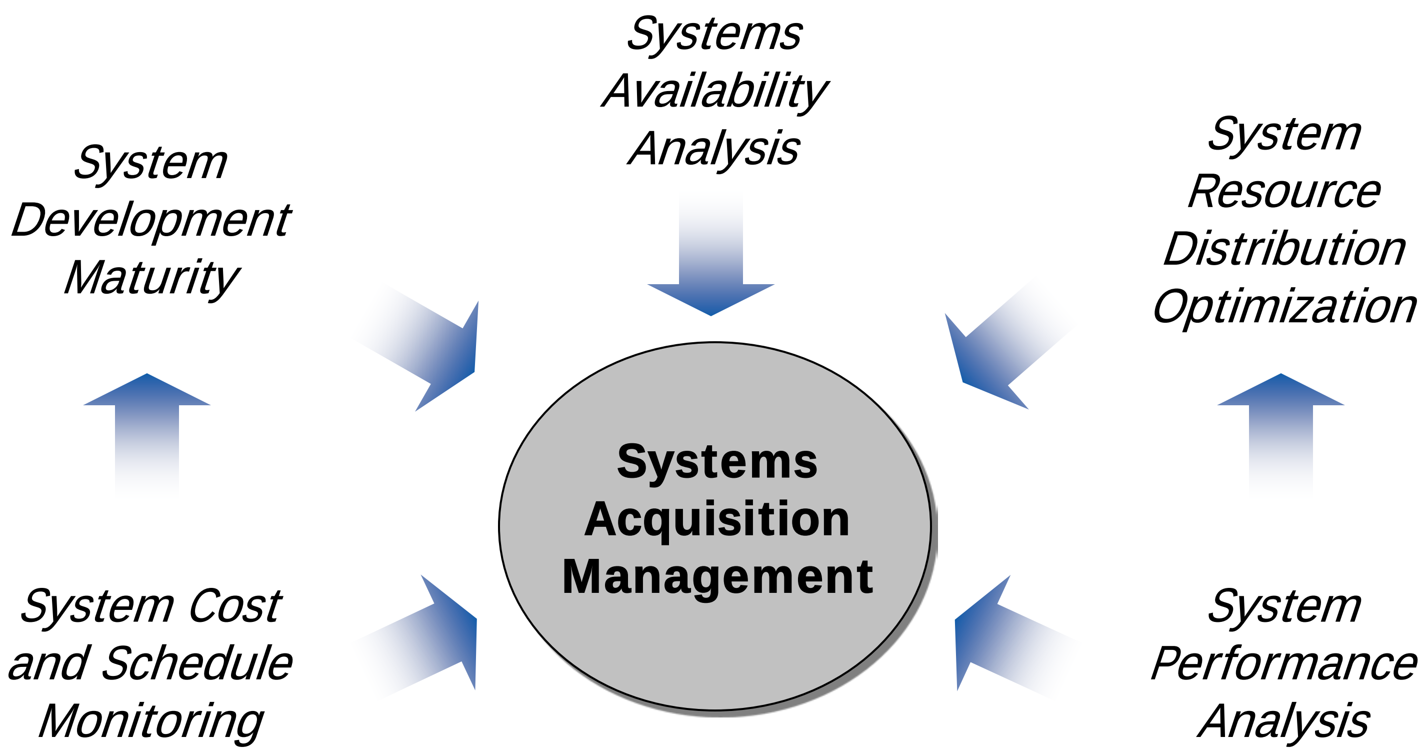
- Failure to adequately consider all systems integration challenges has led an environment of cost overruns, schedule slips, and degraded performance

System Level Program Management Tools

- New methods, processes, and tools are needed in order to effectively manage and optimize complex system development
- Significant management tools exist at the individual technology level, but are limited in application for systems development
  - Technology Readiness Levels:
    Do not consider integration of components into a system
  - Technical Performance Measures:
    Individual component performance does not translate to system level
  - Availability Analysis:
    Multiple system sub-capabilities present different availability options
  - Risk Management:
    Additional unanticipated risk areas are introduced through the linkage of formerly independent systems
- Emerging systems management resources have been few and far between
- DoD's Systems Engineering Guide for Systems of Systems *"acknowledges these issues, but does not make any recommendations for changes to existing management and control structures to resolve inter-system issues".*

System Acquisition Management Approach

The US Navy's Littoral Combat Ship Mission Modules Program (PEO LMS) in collaboration with the Northrop Grumman Corporation and Stevens Institute of Technology is developing a holistic System Maturity Model for systems development management



System Maturity Monitoring - TRL Shortcomings

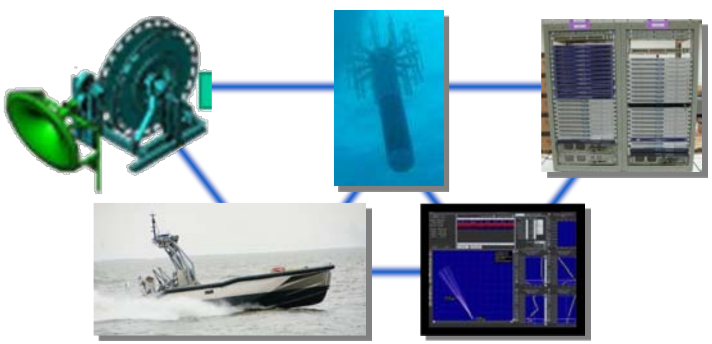
- Application of TRL to systems of technologies is not sufficient to give a holistic picture of complex system of systems readiness
  - TRL is only a measure of an individual technology
- Assessments of several technologies rapidly becomes very complex without a systematic method of comparison
- Multiple TRLs do not provide insight into integrations between technologies nor the maturity of the resulting system
  - Yet most complex systems fail at the integration points

Individual Technology

Can TRL be applied?

Yes

System of Technologies



Can TRL be applied?

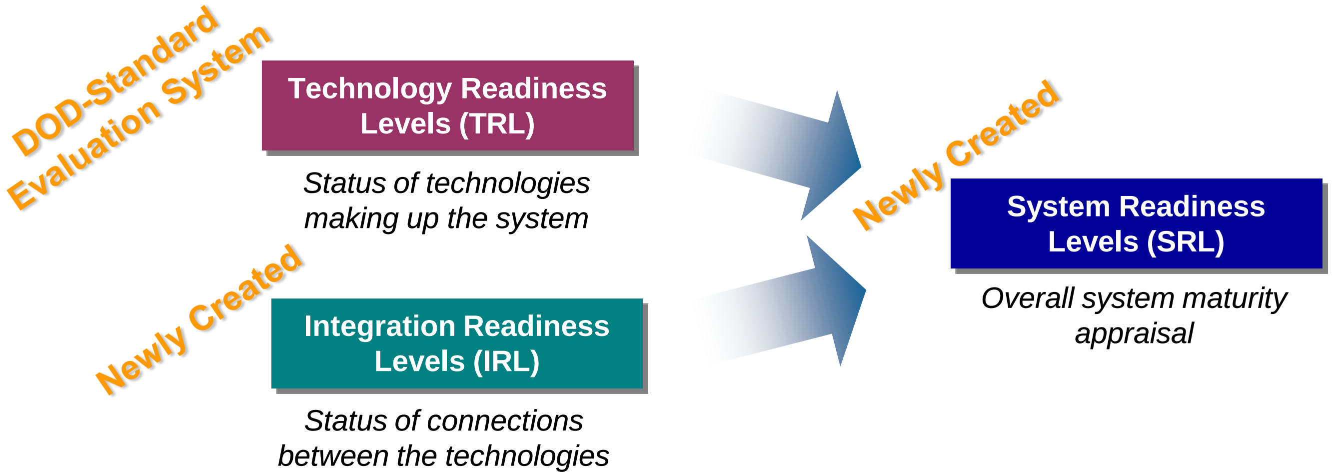
NO

System Readiness Level Concept Overview

Goal: Institute a robust, repeatable, and agile method to monitor / report system development and integration status

APPROACH

Create a System Readiness Level (SRL) that utilizes SME / developer input on technology and integration maturity to provide an objective indication of complex system development maturity



- Provides a **system-level** view of development maturity with opportunities to drill down to element-level contributions
- Allows managers to evaluate system development in real-time and take **proactive** measures
- Highly **adaptive** to use on a wide array of system engineering development efforts
- Can be applied as a **predictive** tool for technology insertion trade studies and analysis

What is an IRL?

A systematic measurement reflecting the status of an integration connecting two particular technologies

	IRL	Definition
Pragmatic	9	Integration is Mission Proven through successful mission operations.
	8	Actual integration completed and Mission Qualified through test and demonstration, in the system environment.
Syntactic	7	The integration of technologies has been Verified and Validated with sufficient detail to be actionable.
	6	The integrating technologies can Accept, Translate, and Structure Information for its intended application.
	5	There is sufficient Control between technologies necessary to establish, manage, and terminate the integration.
	4	There is sufficient detail in the Quality and Assurance of the integration between technologies.
Semantic	3	There is Compatibility (i.e. common language) between technologies to orderly and efficiently integrate and interact.
	2	There is some level of specificity to characterize the Interaction (i.e. ability to influence) between technologies through their interface.
	1	An Interface between technologies has been identified with sufficient detail to allow characterization of the relationship.

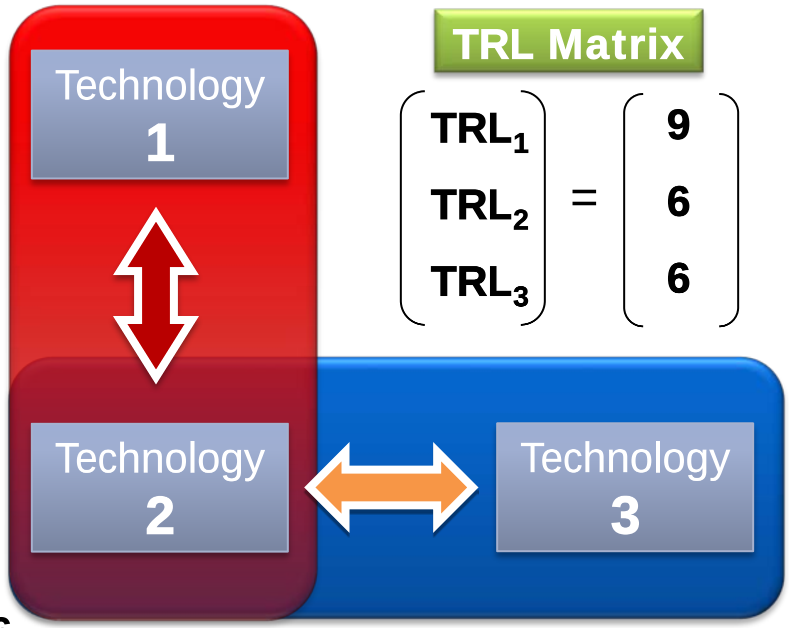
Source: Sauser, B., E. Forbes, M. Long, and S. McGrory. (2009). Verification of an Integration Readiness Level Assessment. *International Symposium of the International Council of Systems Engineering*, July 20-23, Singapore

SRL Calculation Example

$TRL_1 = 9$

$IRL_{1,2} = 1$

$TRL_2 = 6$



$IRL_{2,3} = 7$ $TRL_3 = 6$

TRL Matrix

$$\begin{pmatrix} TRL_1 \\ TRL_2 \\ TRL_3 \end{pmatrix} = \begin{pmatrix} 9 \\ 6 \\ 6 \end{pmatrix}$$

IRL Matrix

$$\begin{pmatrix} IRL_1 & IRL_{12} & IRL_{13} \\ IRL_{12} & IRL_2 & IRL_{23} \\ IRL_{13} & IRL_{23} & IRL_3 \end{pmatrix} = \begin{pmatrix} 9 & 1 & 0 \\ 1 & 9 & 7 \\ 0 & 7 & 9 \end{pmatrix}$$

SRL = IRL x TRL
(Normalized)

$$\text{Component SRL} = \begin{bmatrix} SRL_1 & SRL_2 & SRL_3 \end{bmatrix} = \begin{bmatrix} 0.54 & 0.43 & 0.59 \end{bmatrix}$$

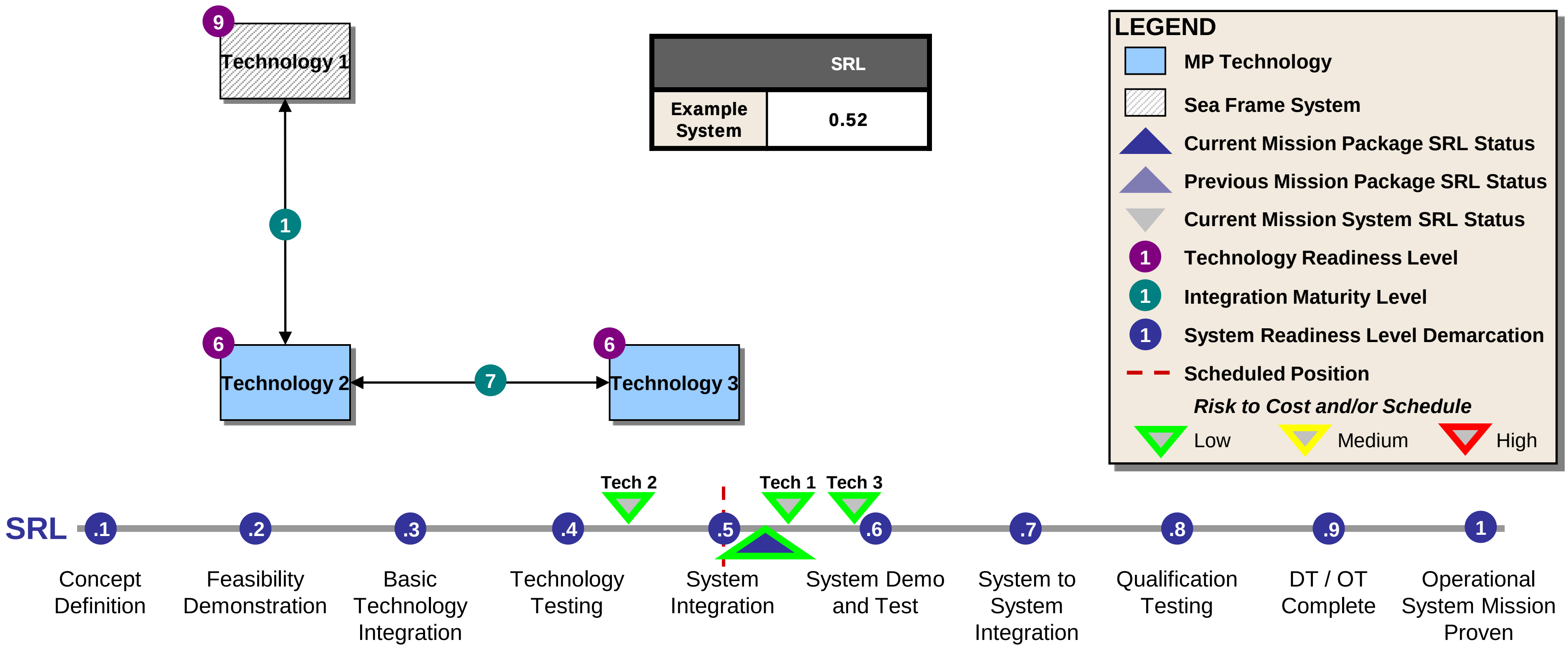
Component SRL_x represents Technology "X" and its IRLs considered

$$\text{Composite SRL} = 1/3\ (0.54 + 0.43 + 0.59) = 0.52$$

The Composite SRL provides an overall assessment of the system readiness

Source: Sauser, B., J. Ramirez-Marquez, D. Henry and D. DiMarzio. (2007). "A System Maturity Index for the Systems Engineering Life Cycle." *International Journal of Industrial and Systems Engineering*. 3(6).

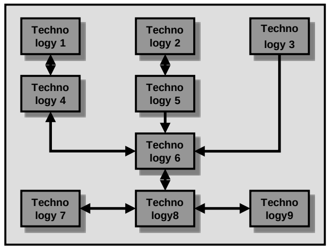
SRL Reporting Method



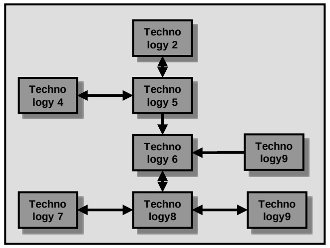
- For complex systems, the amount of information obtained from the SRL evaluation can be overwhelming
- To maximize applicability SRL outputs are tied to key, program- specific development milestones
- Progress against these milestones provide key insight to the user regarding current program status, risk and progress

System Maturity Assessment Process

1. Develop System Architectures



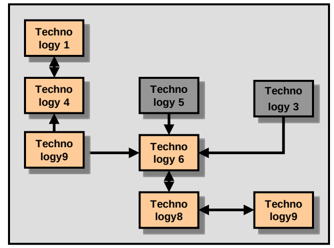
Functional
Capability



Physical
Software/ Hardware

System architecture provides the foundation for system maturity assessments

2. Determine Criticality



Critical Elements

Identification of critical elements and interfaces to be evaluated

3. Build Assessment Process

Systems Engineer

- Customize applicable TRL / IRL criteria
- Build SRL advancement schedule
- Tie criteria to program test events / milestones

Systems Engineering IPT

- Review proposed criteria, schedule, and milestones

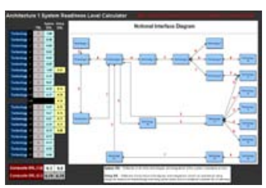
PM

- Approve assessment framework

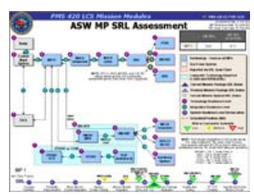
Architectures and framework are locked after approval and will remain so unless the program is re-baselined

4. Conduct System Maturity Analysis w/ SRL

Evaluate and Justify TRLs / IRLs



Calculate SRL



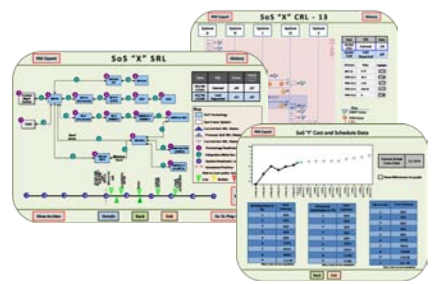
Build Maturity Reports

Iterate

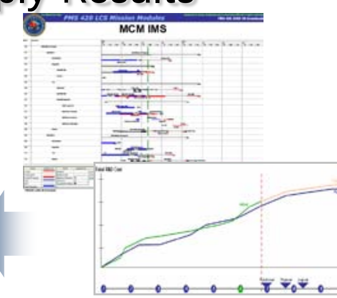
Identify Risks Against Schedule

- 🟢 SRL assessment and test events / milestone gates are at or in advance of schedule
- 🟡 SRL assessment is at or in advance of schedule, but test events / milestone gates remain to be closed
- 🔴 SRL assessment and test events / milestone gates are behind schedule

5. Interpret and Apply Results



Maturity Analysis Outputs



EVMS and Schedule Data Inserted

Outputs of the analysis are analyzed against projected cost and schedule data to determine current development status

Future planning can also be conducted through trade-off analyses and risk management activities

Iterate

System Performance Level Monitoring (PLM)

Goal: Predict the ability of a complex systems to achieve required performance

1. Map the Systems to their impacts on key performance parameters

2. Map the maturity development of the Systems to the SoS development schedule

Notional System of Systems				
	KPP Impacted			
Capability/MS	**Search**	**Detect**	**Classify**	**Engage**
Tech 1	X	x	X	
Tech 2		x	X	
Tech 3	X	x	X	X
Tech 4				X
Tech 5	X	x		

	Notional Maturity				
	MP Impacted				
Capability/MS	MP1	MP2	MP3	MPn	MPn+1
Tech 1	EDM	PROD	PROD	PROD	PROD
Tech 2	ADM	EMD	EDM	PROD	PROD
Tech 3	EDM	PROD	PROD	PROD	PROD
Tech 4	PROD	PROD	PROD	PROD	
Tech 5	PROD	PROD	PROD	PROD	PROD

Detect	Tech 1	Tech 2	Tech 3
T_{1n}		x	
$Tm_{(1,2)n}$	x	x	
$Tm_{(2,3)n}$		x	x
T_{1n}			x

$T_{1n} = \omega_n * \alpha$

$Tm_{(1,2)n} = \omega_n * \alpha$

$Tm_{(2,3)n} = \omega_n * \alpha$

$T_{4n} = \omega_n * \alpha$

3. Develop a relationship between system usage satisfying a KPP in a SoS and its maturity (in terms of a weighted value) against anticipated performance

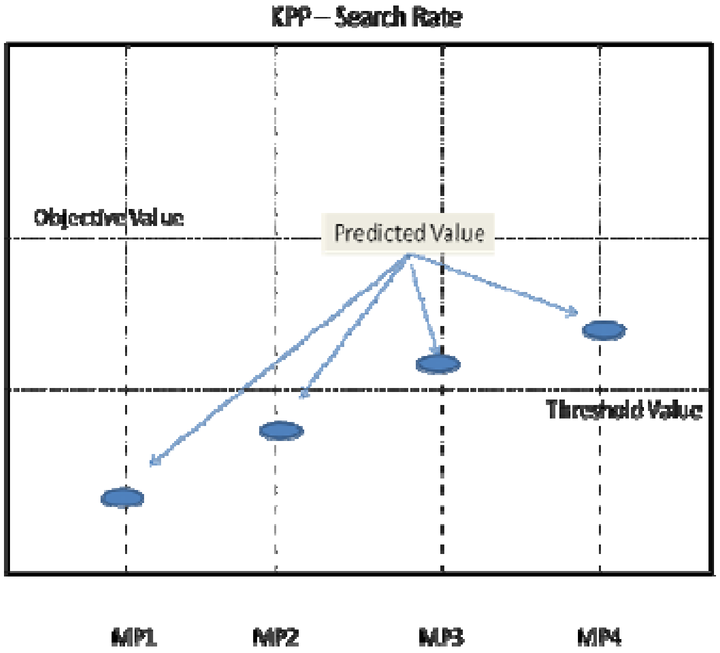
Performance Level Monitoring (PLM)

4. Adjust for usage impact under various employment options

$$CONOPS_{An} = \beta T_{1n} + \gamma T_{5n}$$
$$CONOPS_{Bn} = \delta T_{1n} + \varepsilon T_{3n} + \gamma T_{5n}$$
$$CONOPS_{Cn} = \theta T_{3n} + \eta T_{5n}$$

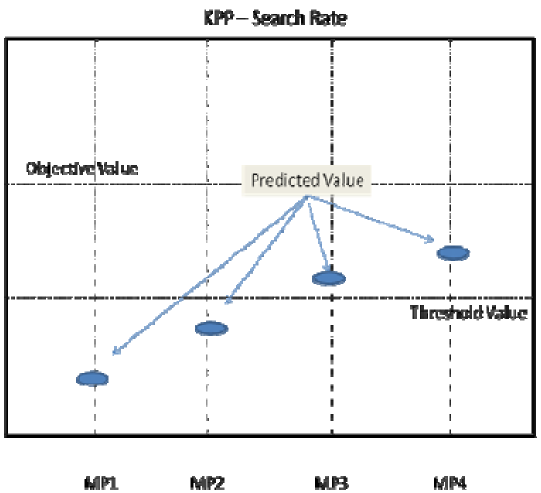
5. Average the results from individual employment options to obtain insight into ability to achieve obtainment of the desired performance parameter

6. Use predictions of improved maturity (SRL) over time to derive a predicted growth path of performance for SoS

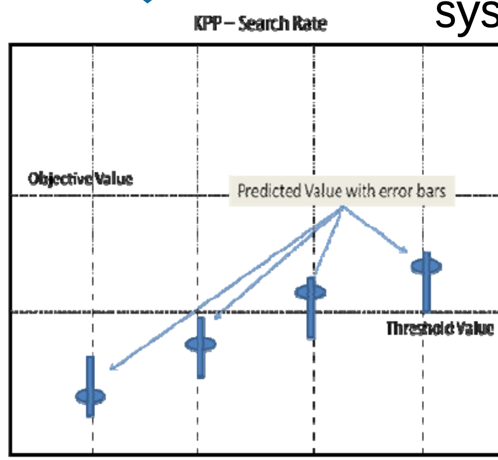


$$KPP_{SEARCH} = [CONOP_A, CONOP_B, CONOP_C] = AVG(CONOP_A + CONOP_B + CONOP_C)$$

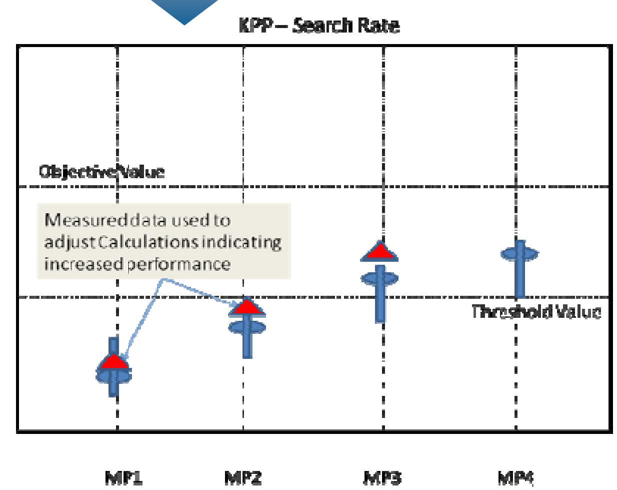
Performance Level Monitoring (PLM)



7. Use estimates of performance and maturity to define predictions of performance



8. Use variances of the usage rates to establish bands of performance based on varying usage options of the individual systems/modules

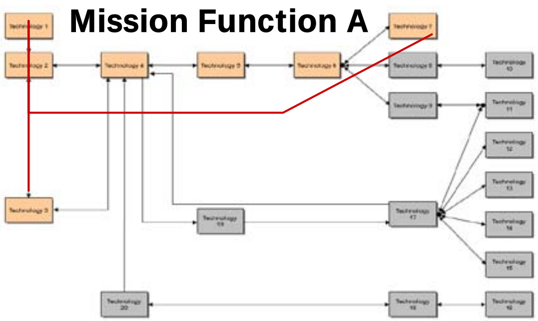


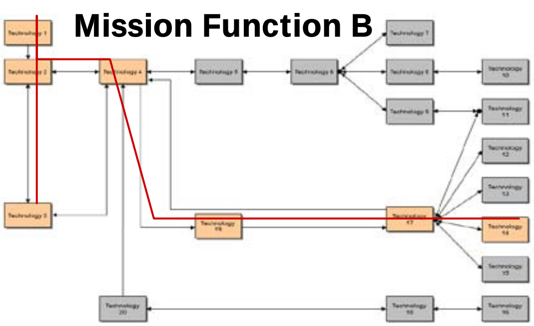
9. As data is gathered, updated predictions/ calculations to verify if development is proceeding as desired

System Availability

Goal: Adapt availability analysis to systems with multiple capabilities

- Defining a subset of system components that contribute to the mission will vary the Availability
  - Increased number of system components weighs heavily on mission function availability
  - Statistical combination of CONOPS and a blending of the contributions will identify the critical components and provide insight into which provide better availability
- Through mission string analysis we gain insight into system functional performance and availability insight linked to CONOPS

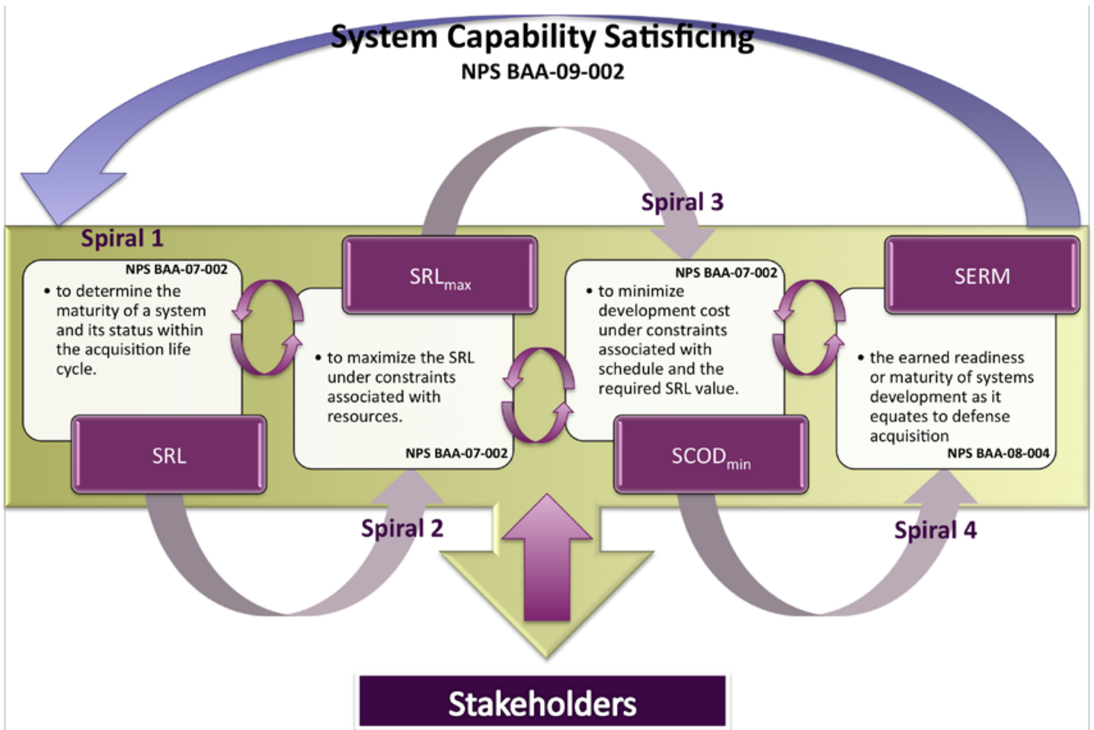




- Alternative System/Mission components or CONOPS can help achieve System availability
  - Plan Availability Evolution (Improved Technology Insertion or Obsolescence Removal)
  - Trade improvement options with Program Cost and Schedule, so that in the system roadmap availability increases over the program life cycle
- Modular concept components enable functional expansion across system
- Using Reliability Block Diagram's as a method for picking component insertion/replacement by looking at the available and functional impact across a mission

System Capability Satisficing

Goal: Optimize system resource allocation across multiple variables



Builds upon the foundational approaches previously defined to maximize system capability for every dollar spent

"What technologies and integrations are important or critical to each architectural view to achieve a functionality or capability?"… "How will the systems maturity vary depending on the architectural variants?"

"What functionalities or capabilities are sufficient, critical, or important to achieving a level of system maturity that can satisfy a warfighter's needs?"

"What impact does this have on system maturity and ultimately the acquisition of a deployable system?"

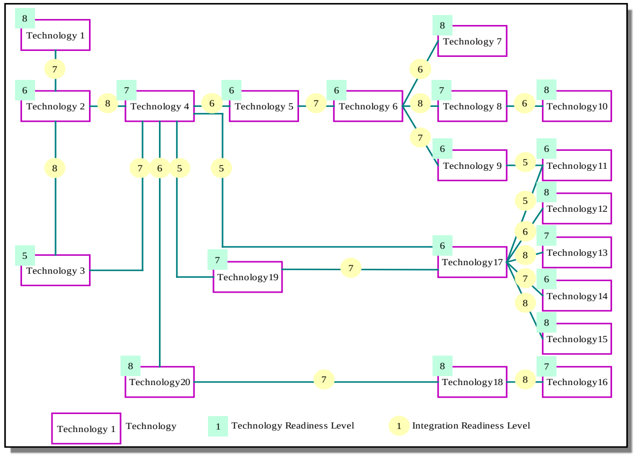
"Can we use multi-attribute decision making/techniques in systems maturity assessment; parametric sensitivity analysis on how various TRL/IRL combinations drive SRL; and sensitivity analysis to determine what the most critical technologies are?"

Analyzing Component Importance

- Analytical approach provides insight into which components and integrations provides greatest contribution to maturity

- This can then be used to ensure some level of functionality can be attained while full system continues to develop

- Factors can include performance, schedule, cost, etc...



Increasing by One Level	Function	Capability	Top Three Most Important Components					
			1st		2nd		3rd	
			Component	I^P	Component	I^P	Component	I^P
	F_1	C_{11}	2	1.0298	4	1.0246	6	1.0239
		C_{12}	2	1.0255	8	1.0212	4	1.0210
		C_{13}	2	1.0276	4	1.0227	9	1.0208
	F_2	C_{21}	2	1.0305	4	1.0275	17	1.0246
		C_{22}	2	1.0290	4	1.0262	17	1.0249
		C_{23}	2	1.0287	17	1.0275	4	1.0260
		C_{24}	2	1.0297	17	1.0269	4	1.0268
		C_{25}	2	1.0282	17	1.0270	4	1.0255
	F_3	C_{31}	2	1.0270	18	1.0242	4	1.0222

Future Work and Applications

SRL methodology can be used not only to assess current system maturity status, but also to roadmap and assess future development options along with cost and performance

Future work will focus on the creation and integration of applications which continue to leverage the SRL foundation to provide a holistic management dashboard and decision environment

Key Aspects:

- Development of a cost discretization across maturity increments using historical data
- Validation of an approach to monitor planned versus actual system maturity, cost, and schedule
- Linking of requirements and testing to performance and maturity

Applications:

- Future technology insertion, obsolescence, and evolution planning

QUESTIONS?

Back-up

Abstract

In a collaborative research effort that has involved Stevens Institute of Technology's Systems Development & Maturity Laboratory, the Northrop Grumman Corporation, and the U.S. Navy (PMS 420 / SSC-P), a measure of complex system development maturity entitled System Readiness Level (SRL) has been created. This measurement methodology builds upon the pre-existing Technology Readiness Level (TRL) and incorporates an Integration Readiness Level (IRL) in its formulation and practice. Unfortunately, the use of TRL, and subsequently IRL, in the formulation of SRL means that all of the drawbacks associated with the inherent subjectivity of their evaluation and assessment are carried forward. To address this issue, work was previously done to grow the readiness level definitions from a somewhat ambiguous, single line per level to a series of program tailored guides delineating tasks to be completed to achieve each maturity increment. Though the guides have been a significant step forward, additional work remains to be done in linking these TRL and IRL attributes and SRL increments with system architectures, technical performance measures, and development milestones (i.e. systems engineering artifacts). This is a critical step for two reasons: 1) it enables the tracking of development performance via the number and degree to which the artifacts have been satisfied; 2) it provides the decision maker with insight into the current level of system performance achieved and an understanding of what employment of the system (or a subsystem) at its current level of maturity will provide in terms of overall performance against requirements. Furthermore, a more accurate linkage to program costs can be established by tracking projected versus actual expenditures required to meet each successive level of development maturity. This presentation will review the development, implementation, and verification and validation of this concept as it is being executed with the U.S. Navy's PMS 420 Program Office.

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

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

SRL Calculation

- The SRL is not user defined, but is instead based on the outcomes of the documented TRL and IRL evaluations

- Through mathematically combining these two separate readiness levels, a better picture of overall complex system readiness is obtained by examining all technologies in concert with all of their required integrations

SRL = IRL x TRL

$$\begin{bmatrix} SRL_1 & SRL_2 & SRL_3 \end{bmatrix} = \begin{pmatrix} IRL_{11} & IRL_{12} & IRL_{13} \\ IRL_{12} & IRL_{22} & IRL_{23} \\ IRL_{13} & IRL_{23} & IRL_{33} \end{pmatrix} \times \begin{pmatrix} TRL_1 \\ TRL_2 \\ TRL_3 \end{pmatrix}$$

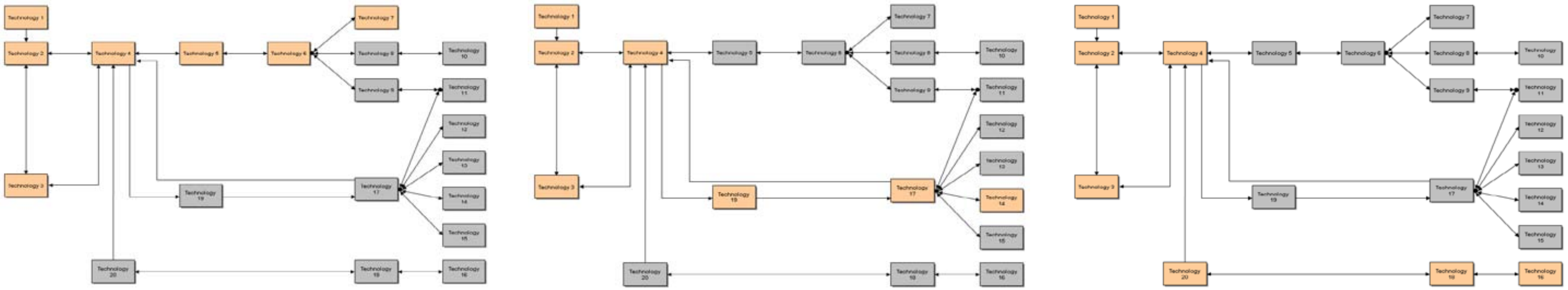
$$\text{Composite SRL} = 1/n \left(SRL_1/n + SRL_2/n + SRL_3/n \right)$$

$$= 1/n^2 \left(SRL_1 + SRL_2 + SRL_3 \right)$$

- These values serve as a decision-making tool as they provide a prioritization guide of the system's technologies and integrations and point out deficiencies in the maturation process

“String” Analysis Incorporated

Complex systems often offer numerous options for conducting operations



- Operational strings were created that identified the components required to utilize a single function of the system
- Assessment of the SRL for each of these options allows for a better understanding of the maturity of each operating configuration
- Understanding the true status of the system on an operational string level allows for the opportunity to field initial capability earlier and then add to it as other strings mature

Verification and Validation Activities

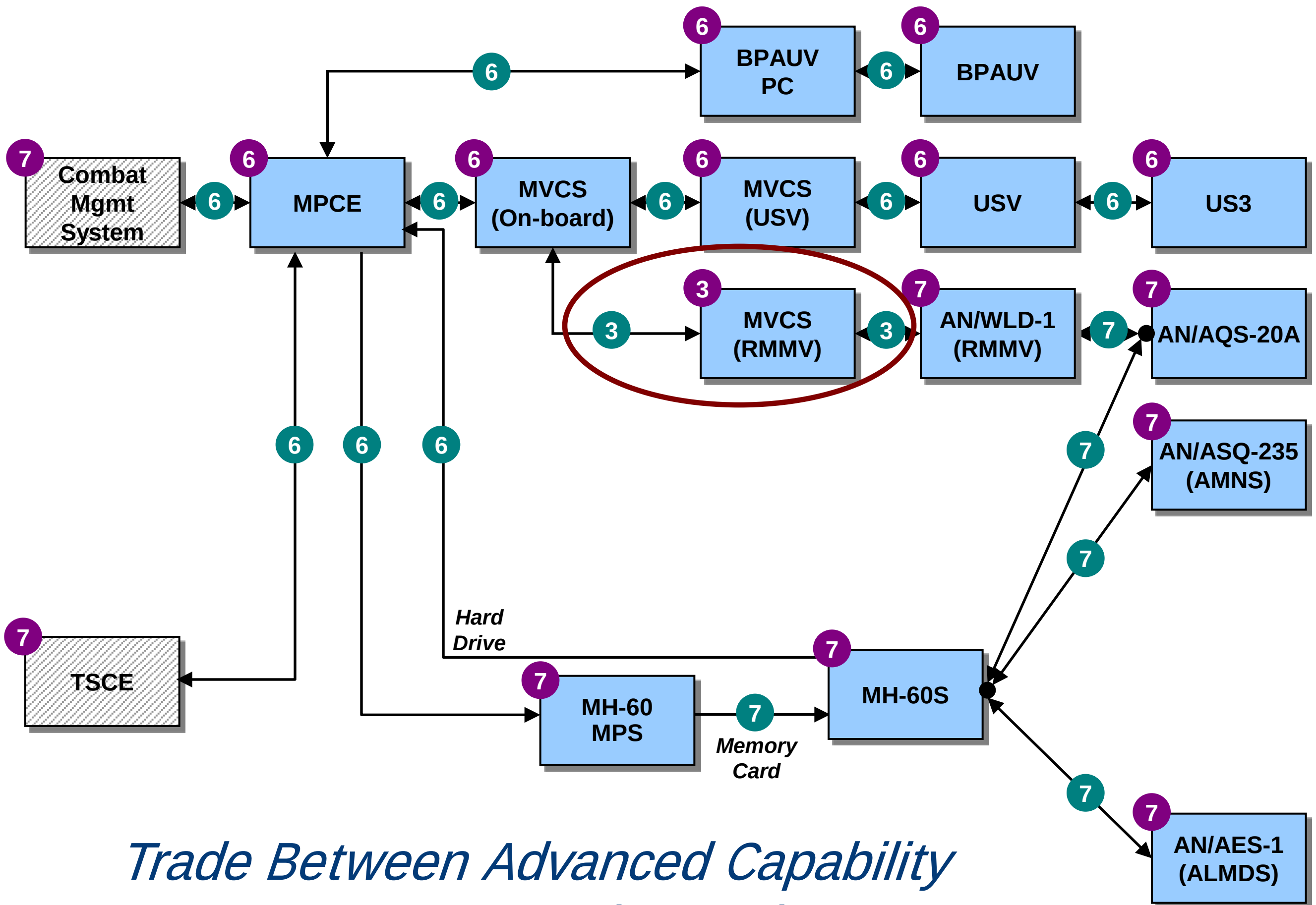
IRL Criteria

- Created expanded list of IRL criteria for each readiness level
- Goal was to capture the key elements of the integration maturation process
- Presented to 30 integration SMEs from across government, academia, and industry
- Asked to assess importance of each criterion
- Results show solid buy-in among SMEs that identified criteria are key factors in successful integration

SRL Evaluation Process

- Conducted a “blind trial” of SRL methodology and evaluation process
- User’s Guide and evaluation criteria were sent to key system SMEs
- From just these resources SMEs were asked to conduct the evaluation and report on the results
- Compiled results and iterated on lessons learned to improve the process

Trading Off Technology Options



	MP SRL	MP SRL w/o Sea Frame
MP 1	0.60	0.57

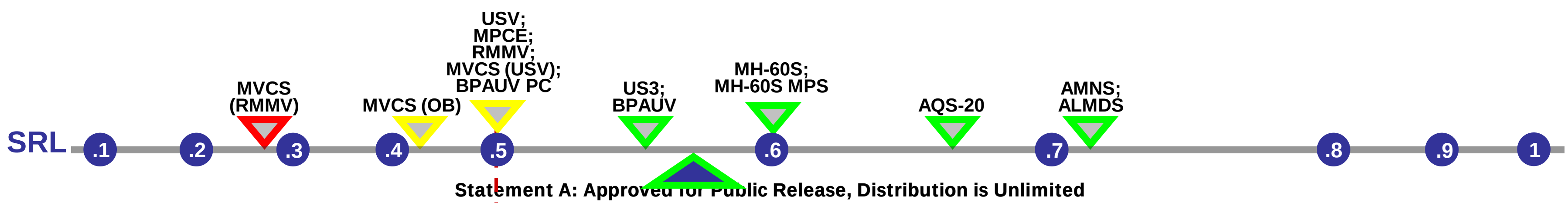
LEGEND

- MP Technology
- Sea Frame System
- Current Mission Package SRL Status
- Previous Mission Package SRL Status
- Current Mission System SRL Status
- Technology Readiness Level
- Integration Maturity Level
- System Readiness Level Demarcation
- Scheduled Position

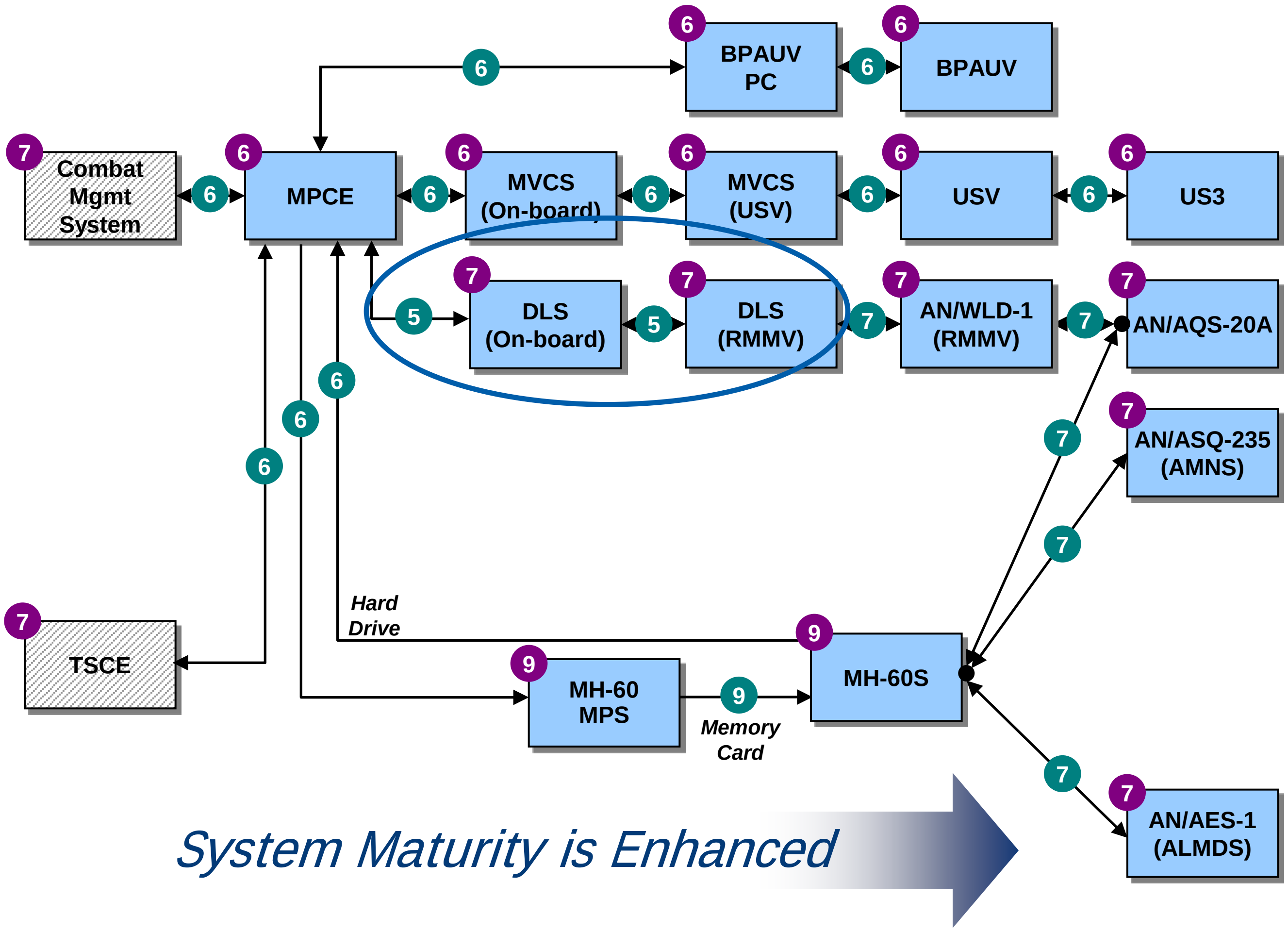
Risk to Cost and/or Schedule

Low Medium High

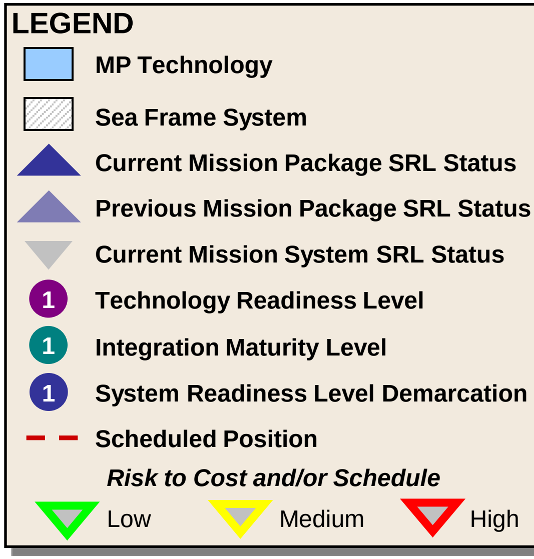
Trade Between Advanced Capability or Increased Maturity

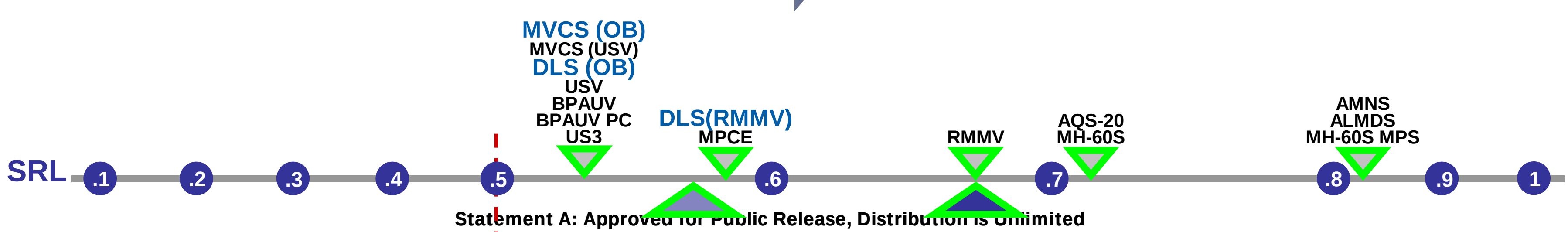


Taking Action to Mitigate Risk

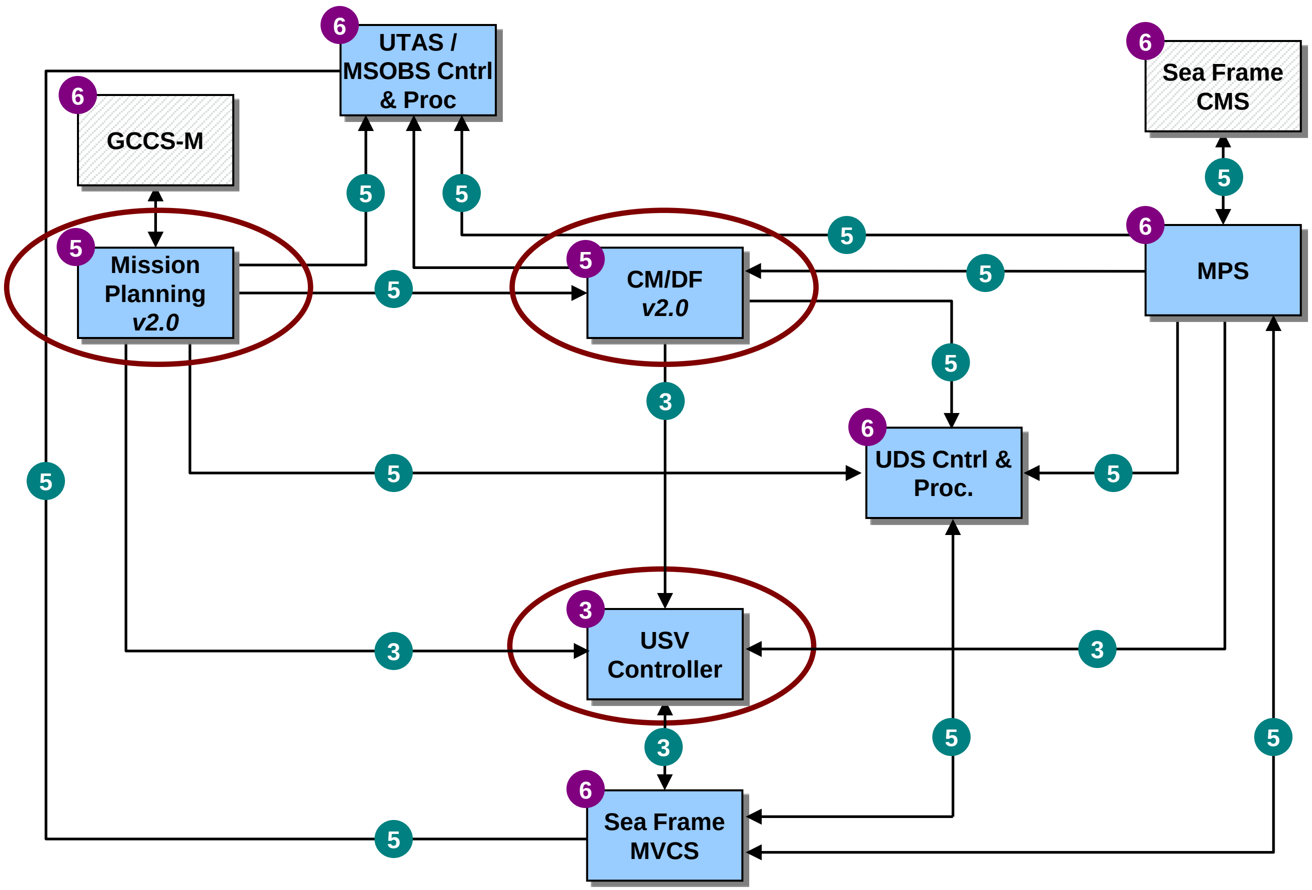


	MP SRL	MP SRL w/o Sea Frame
MP 1	0.64	0.67

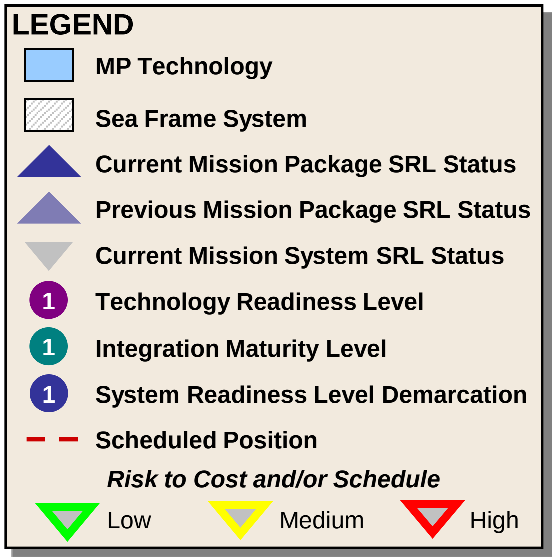




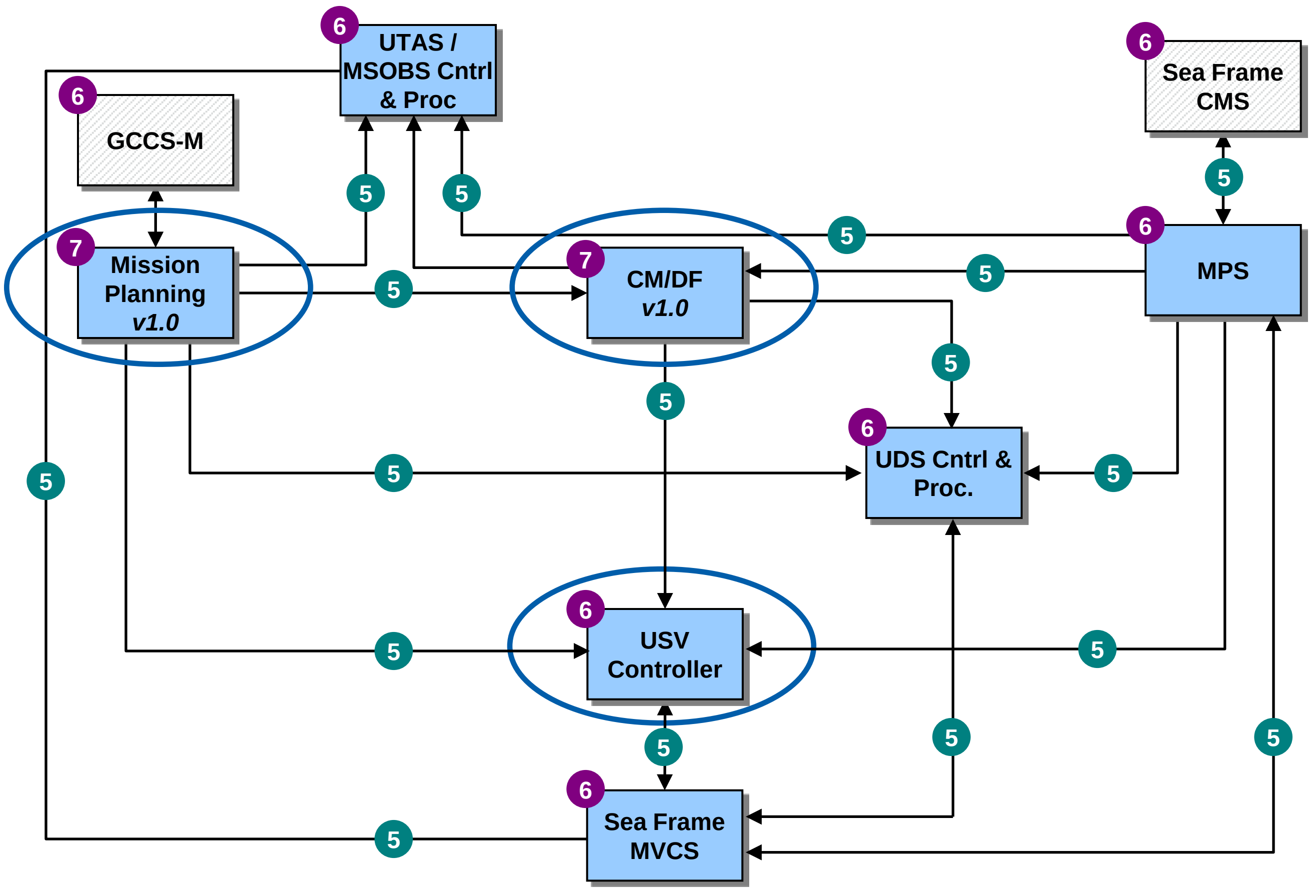
Planning for the Unexpected



	MP SRL	MP SRL w/o Sea Frame
MP SW	0.39	0.35



Effectively Channeling Resources



	MP SRL	MP SRL w/o Sea Frame
MP SW	0.46	0.45

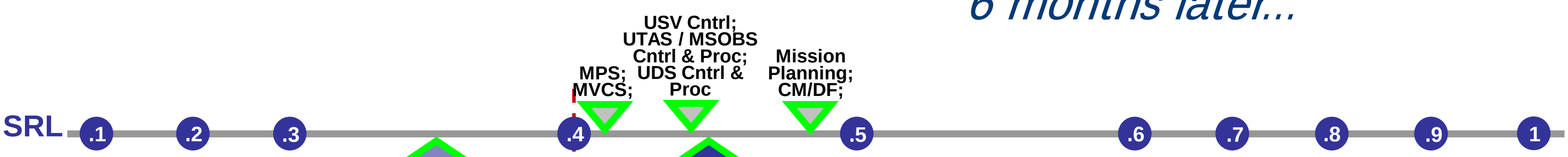
LEGEND

- MP Technology
- Sea Frame System
- Current Mission Package SRL Status
- Previous Mission Package SRL Status
- Current Mission System SRL Status
- Technology Readiness Level
- Integration Maturity Level
- System Readiness Level Demarcation
- Scheduled Position

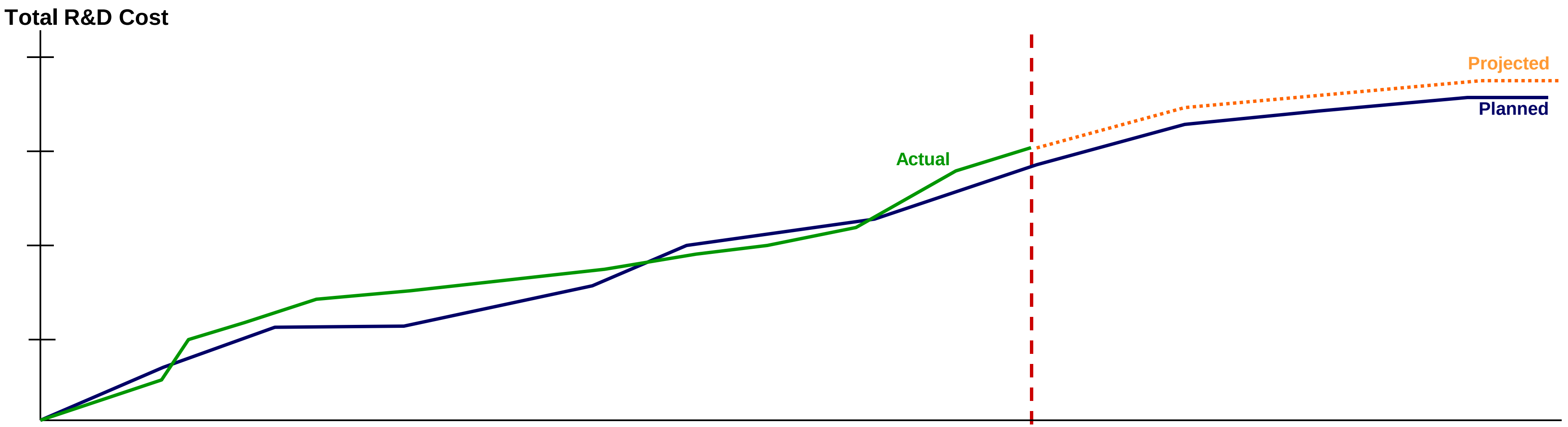
Risk to Cost and/or Schedule

Low | Medium | High

6 months later...



Linking Cost to Maturity via Milestones



.1	.2	.3	.4	.5	.6	.7	.8	.9	1
Jun 2006	*Jan 2007*	*Jul 2007*	*Nov 2007*	*May 2008*	*Sep 2008*	*Aug 2009*	*Apr 2010*	*Jan 2011*	*Apr 2012*
Materiel Development Decision	**MILESTONE A**	Systems Requirements Review	System Functional Review	**MILESTONE B**	Critical Design Review	Test Readiness Review	**MILESTONE C**	**Initial Operational Capability**	**Full Operational Capability**
Initial Technical Review	Alternative Systems Review	Mission Systems Testing	Technology Readiness Assessment 1	Preliminary Design Review	Mission Module Testing	MP End-to-End Testing	System Verification Review	Physical Configuration Audit	In-Service Review
						DT / OT	Functional Configuration Audit	Full Rate Production Decision Review	
							Production Readiness Review		
							Technology Readiness Assessment 2		

Current Mission Package SRL Status by View (Functional, Physical, Logical)

System Readiness Level Demarcation

Scheduled Position (IMS)

SRL assessment and test events / milestone gates are at or in advance of schedule

SRL assessment is at or in advance of schedule, but test events / milestone gates remain to be closed

SRL assessment and test events / milestone gates are behind schedule

Lessons Learned

- Methodology is highly adaptable and can be quickly applied to a wide variety of development efforts
- Programs tend to minimize the importance of system and subsystem integration and thus overestimate the maturity of their development
- Widespread familiarity with TRL makes acceptance and utilization of TRL and IRL easier
- Formulating the system architecture early in development is a key step and leads to an enhancement of the overall systems engineering effort
- System architecture formulation also provides the opportunity to bring together SMEs from both the physical and logical realms and necessitates insightful discussions across the team
- The decision maker is afforded the ability to asses program status from a system of systems perspective

The SRL methodology delivers a holistic evaluation of complex system readiness that is robust, repeatable, and agile

Critical Success Factors for Milestone Review Risk Identification

Barry Boehm, JoAnn Lane USC CSSE

NDIA Systems Engineering Conference

October 28, 2009

Summary

- Schedule-based and event-based reviews are risk-prone
- Evidence-based reviews enable early risk resolution
  - They require more up-front systems engineering effort
  - They have a high ROI for high-risk projects
  - They synchronize and stabilize concurrent engineering
  - The evidence becomes a first-class deliverable
    - It requires planning and earned value management
- They can be added to traditional review processes

Types of Milestone Reviews

- Schedule-based reviews (contract-driven)
  - We'll hold the PDR on April 1 whether we have a design or not
  - High probability of proceeding into a Death March
- Event-based reviews (artifact-driven)
  - The design will be done by June 1, so we'll have the review then
  - Large "Death by PowerPoint and UML" event
    - Hard to avoid proceeding with many unresolved risks and interfaces
- Evidence-based commitment reviews (risk-driven)
  - Evidence provided in Feasibility Evidence Description (FED)
    - A first-class deliverable
  - Shortfalls in evidence are uncertainties and risks
  - Should be covered by risk mitigation plans
  - Stakeholders decide to commit based on risks of going forward

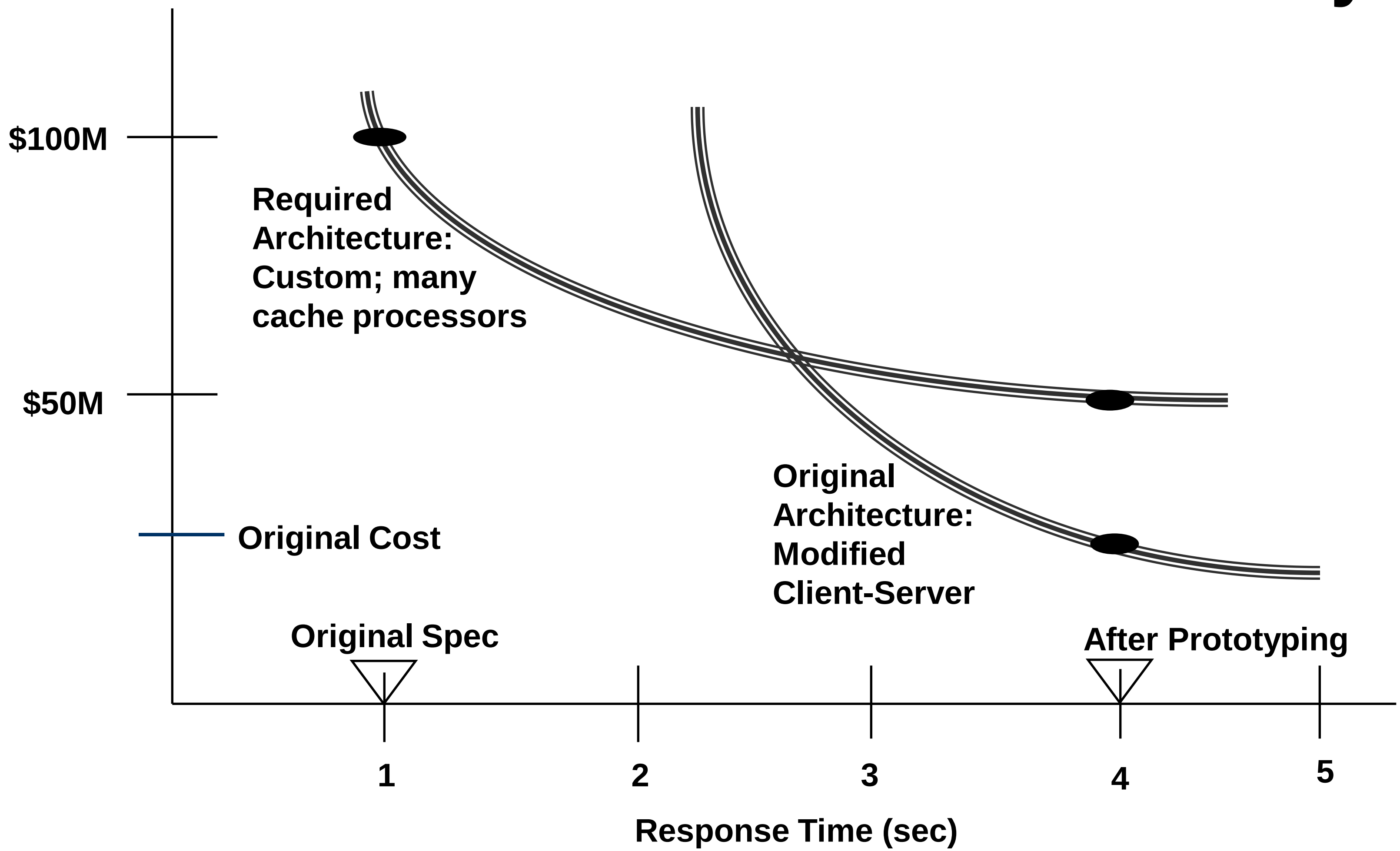
Nature of FEDs and Anchor Point Milestones

- ***Evidence*** **provided by developer and validated by independent experts that:**

  If the system is built to the specified architecture, it will
  - **Satisfy the specified operational concept and requirements**
    - **Capability, interfaces, level of service, and evolution**
  - **Be buildable within the budgets and schedules in the plan**
  - **Generate a viable return on investment**
  - **Generate satisfactory outcomes for all of the success-critical stakeholders**
- **Shortfalls in evidence are uncertainties and risks**
  - **Should be resolved or covered by risk management plans**
- **Assessed in increasing detail at major anchor point milestones**
  - **Serves as basis for stakeholders' commitment to proceed**
  - **Serves to synchronize and stabilize concurrently engineered elements**

Can be used to strengthen current schedule- or event-based reviews

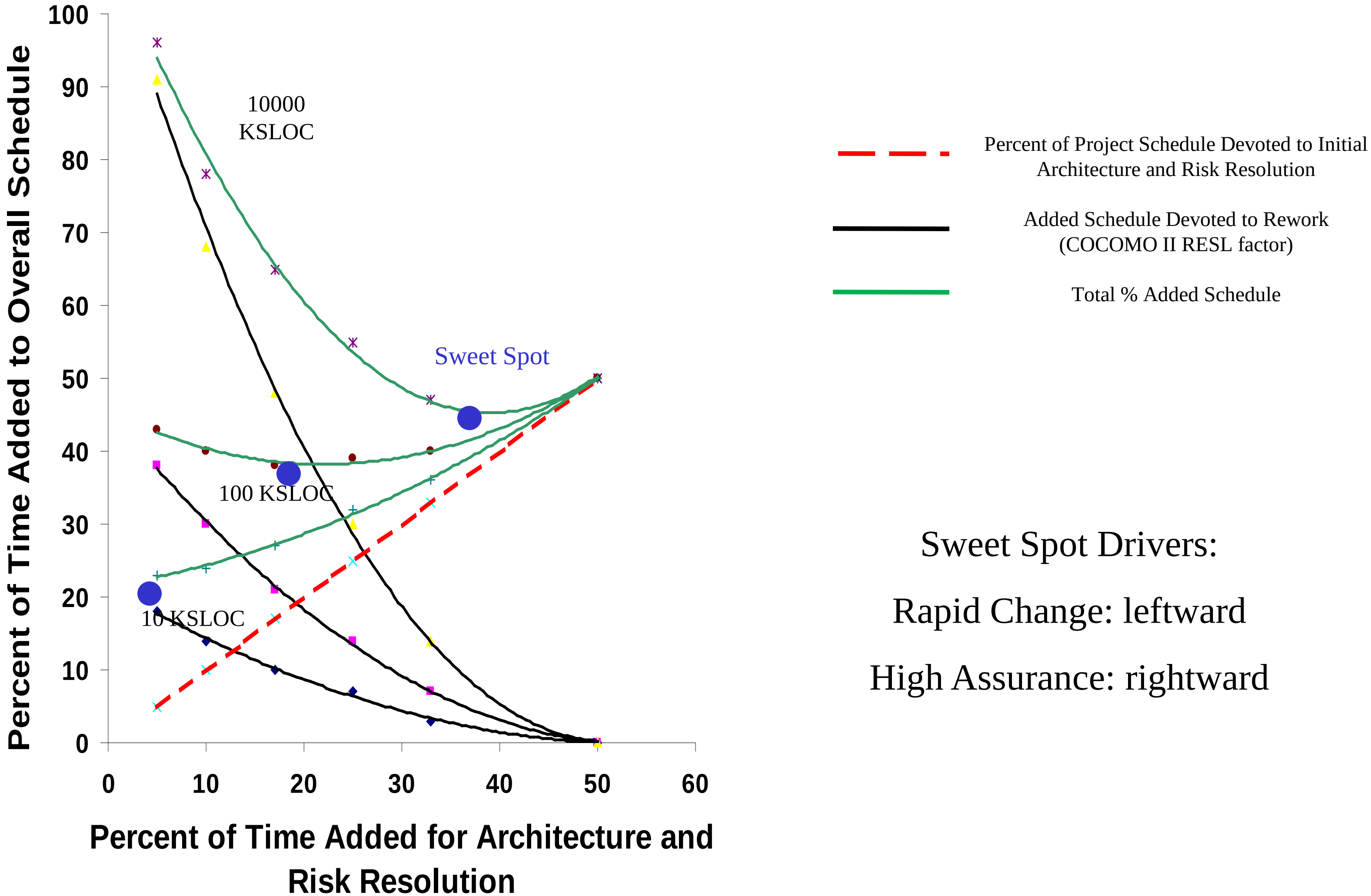
Problems Encountered without FED: 15-Month Architecture Rework Delay



Problems Avoidable with FED

- Attempt to validate 1-second response time
  - Commercial system benchmarking and architecture analysis: needs expensive custom solution
  - Prototype: 4-second response time OK 90% of the time
- Negotiate response time ranges
  - 2 seconds desirable
  - 4 seconds acceptable with some 2-second special cases
- Benchmark commercial system add-ons to validate their feasibility
- Present solution and feasibility evidence at anchor point milestone review
  - Result: Acceptable solution with minimal delay

Need for FED in Large Systems of Systems



Sweet Spot Drivers:

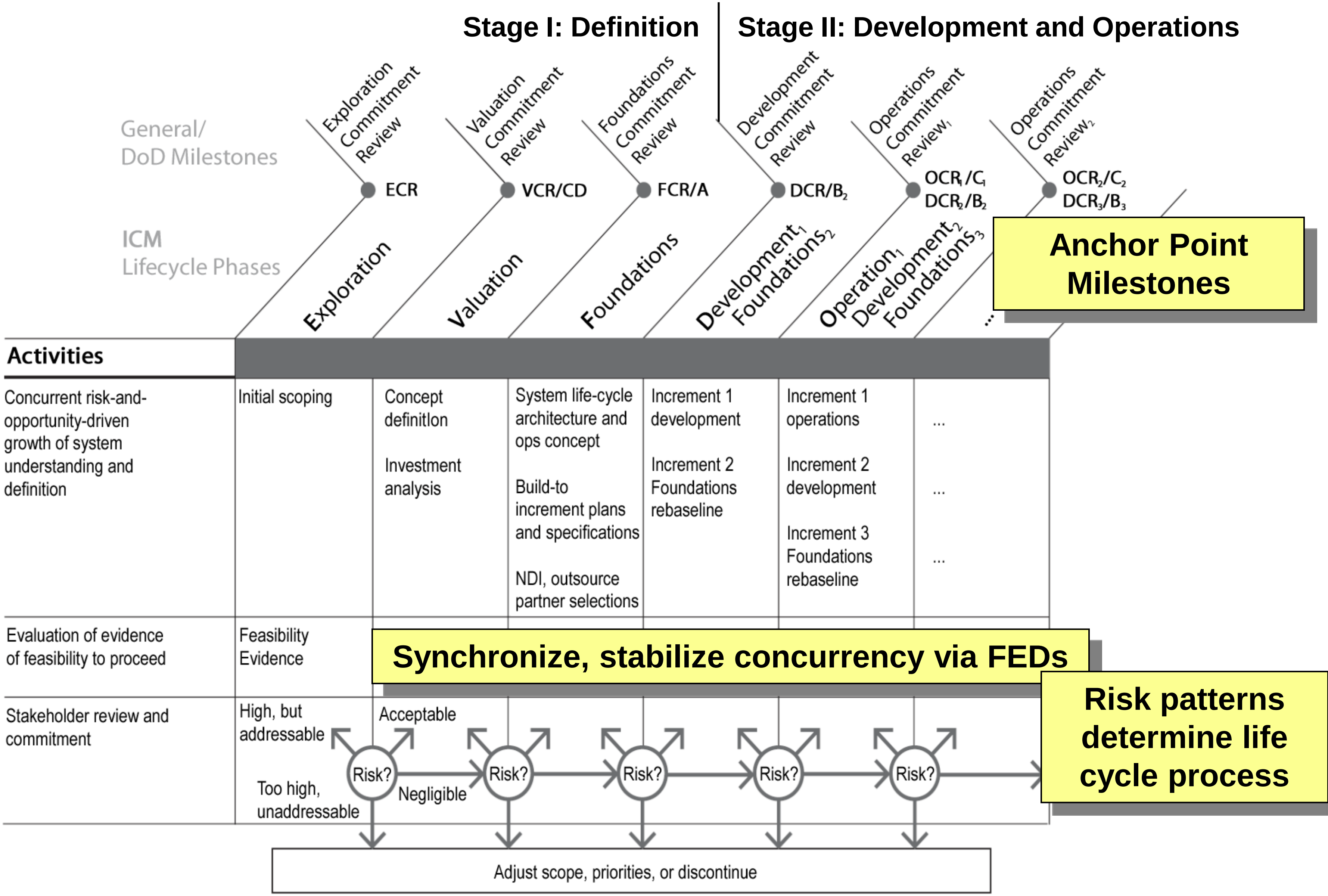
Rapid Change: leftward

High Assurance: rightward

Summary

- Schedule-based and event-based reviews are risk-prone
- Evidence-based reviews enable early risk resolution
  - They require more up-front systems engineering effort
  - They have a high ROI for high-risk projects
  - They synchronize and stabilize concurrent engineering
  - The evidence becomes a first-class deliverable
    - It requires planning and earned value management
- They can be added to traditional review processes

The Incremental Commitment Life Cycle Process: Overview



Nature of Feasibility Evidence

- Not just traceability matrices and PowerPoint charts
- Evidence can include results of
  - Prototypes: of networks, robots, user interfaces, COTS interoperability
  - Benchmarks: for performance, scalability, accuracy
  - Exercises: for mission performance, interoperability, security
  - Models: for cost, schedule, performance, reliability; tradeoffs
  - Simulations: for mission scalability, performance, reliability
  - Early working versions: of infrastructure, data fusion, legacy compatibility
  - Previous experience
  - Combinations of the above
- Validated by independent experts
  - Realism of assumptions
  - Representativeness of scenarios
  - Thoroughness of analysis
  - Coverage of key off-nominal conditions

Common Examples of Inadequate Evidence

1. Our engineers are tremendously creative. They will find a solution for this.
2. We have three algorithms that met the KPPs on small-scale nominal cases. At least one will scale up and handle the off-nominal cases.
3. We'll build it and then tune it to satisfy the KPPs
4. The COTS vendor assures us that they will have a security-certified version by the time we need to deliver.
5. We have demonstrated solutions for each piece from our NASA, Navy, and Air Force programs. It's a simple matter of integration to put them together.

Examples of Making the Evidence Adequate

1. Have the creative engineers prototype and evaluate a solution on some key nominal and off-nominal scenarios.
2. Prototype and evaluate the three examples on some key nominal and off-nominal scenarios
3. Develop prototypes and/or simulations and exercise them to show that the architecture will not break while scaling up or handling off-nominal cases.
4. Conduct a scaled-down security evaluation of the current COTS product. Determine this and other vendors’ track records for getting certified in the available time. Investigate alternative solutions.
5. Have a tiger team prototype and evaluate the results of the simple matter of integration.

Summary

- Schedule-based and event-based reviews are risk-prone
- Evidence-based reviews enable early risk resolution
  - They require more up-front systems engineering effort
  - They have a high ROI for high-risk projects
  - They synchronize and stabilize concurrent engineering
  - The evidence becomes a first-class deliverable
    - It requires planning and earned value management
- They can be added to traditional review processes

FED Development Process Framework

- As with other ICM artifacts, FED process and content are risk-driven
- Generic set of steps provided, but need to be tailored to situation
  - Can apply at increasing levels of detail in Exploration, Validation, and Foundations phases
  - Can be satisfied by pointers to existing evidence
  - Also applies to Stage II Foundations rebaselining process
- Examples provided for large simulation and testbed evaluation process and evaluation criteria

Steps for Developing Feasibility Evidence

A. Develop phase work-products/artifacts
   - For examples, see ICM Anchor Point Milestone Content charts

B. Determine most critical feasibility assurance issues
   - Issues for which lack of feasibility evidence is program-critical

C. Evaluate feasibility assessment options
   - Cost-effectiveness, risk reduction leverage/ROI, rework avoidance
   - Tool, data, scenario availability

D. Select options, develop feasibility assessment plans

E. Prepare FED assessment plans and earned value milestones
   - Try to relate earned value to risk-exposure avoided rather than budgeted cost

"Steps" denoted by letters rather than numbers to indicate that many are done concurrently

Steps for Developing Feasibility Evidence
(continued)

F. Begin monitoring progress with respect to plans
   - Also monitor project/technology/objectives changes and adapt plans

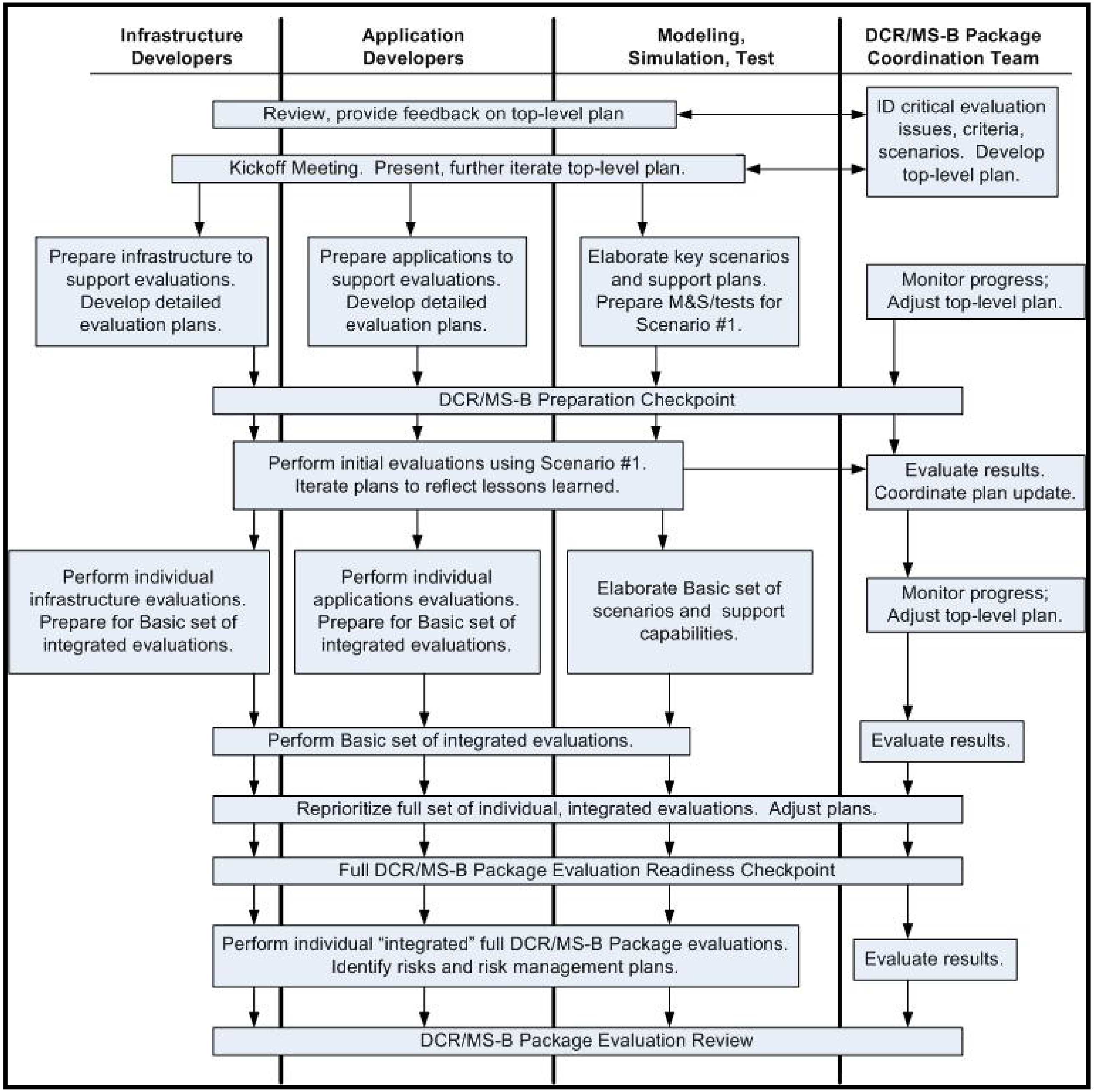
G. Prepare evidence-generation enablers
   - Assessment criteria
   - Parametric models, parameter values, bases of estimate
   - COTS assessment criteria and plans
   - Benchmarking candidates, test cases
   - Prototypes/simulations, evaluation plans, subjects, and scenarios
   - Instrumentation, data analysis capabilities

H. Perform pilot assessments; evaluate and iterate plans and enablers

I. Assess readiness for Commitment Review
   - Shortfalls identified as risks and covered by risk mitigation plans
   - Proceed to Commitment Review if ready

J. Hold Commitment Review when ready; adjust plans based on review outcomes

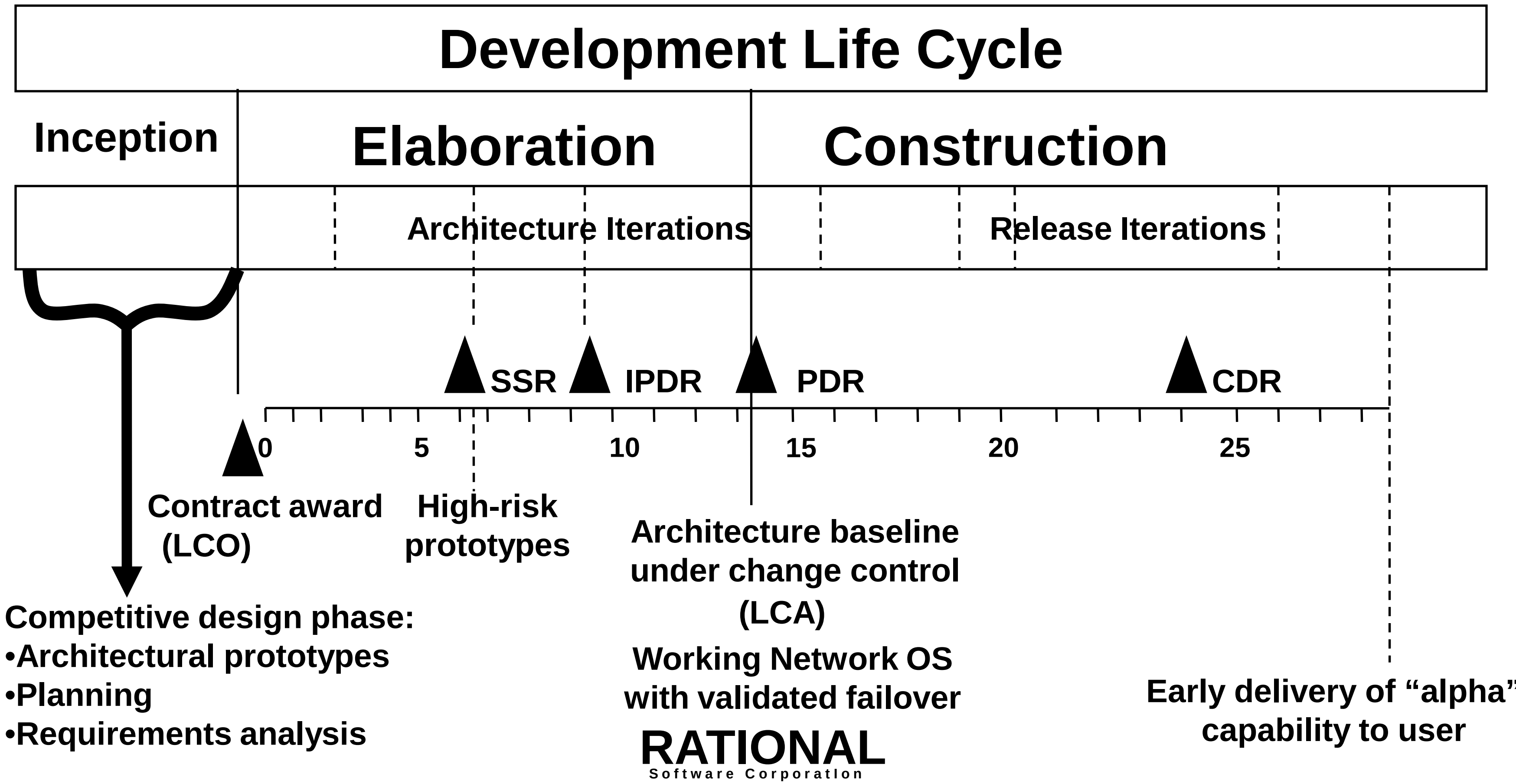
Large-Scale Simulation and Testbed FED Preparation Example



Summary

- Schedule-based and event-based reviews are risk-prone
- Evidence-based reviews enable early risk resolution
  - They require more up-front systems engineering effort
  - They have a high ROI for high-risk projects
  - They synchronize and stabilize concurrent engineering
  - The evidence becomes a first-class deliverable
    - It requires planning and earned value management
- They can be added to traditional review processes

CCPDS-R Reinterpretation of SSR, PDR



References

B. Boehm and J. Lane, "Guide for Using the Incremental Commitment Model (ICM) for Systems Engineering of DoD Projects, v.0.5," USC-CSSE-TR-2009-500, http://csse.usc.edu/csse/TECHRPTS/by_author.html#Boehm

B. Boehm, "Anchoring the Software Process," IEEE Software, July 1996

B. Boehm, A.W. Brown, V. Basili, and R. Turner, "Spiral Acquisition of Software-Intensive Systems of Systems," Cross Talk, May 2004, pp. 4-9.

B. Boehm and J. Lane, "Using the ICM to Integrate System Acquisition, Systems Engineering, and Software Engineering," CrossTalk, October 2007, pp. 4-9.

J. Maranzano et. al., "Architecture Reviews: Practice and Experience," IEEE Software, March/April 2005.

R. Pew and A. Mavor, *Human-System Integration in the System Development Process: A New Look*, National Academy Press, 2007.

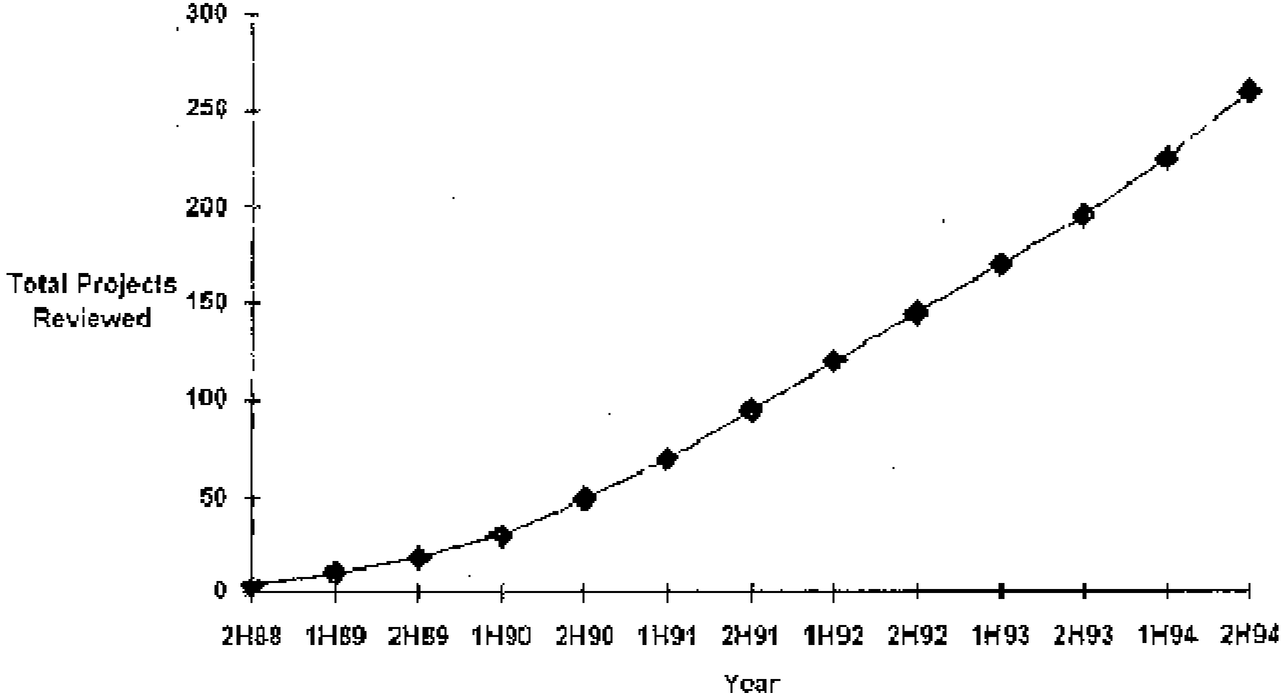
W. Royce, Software Project Management, Addison Wesley, 1998.

R. Valerdi, "The Constructive Systems Engineering Cost Model," Ph.D. dissertation, USC, August 2005.

CrossTalk articles: www.stsc.hill.af.mil/crosstalk

Backup Charts

AT&T Experience with AP Reviews



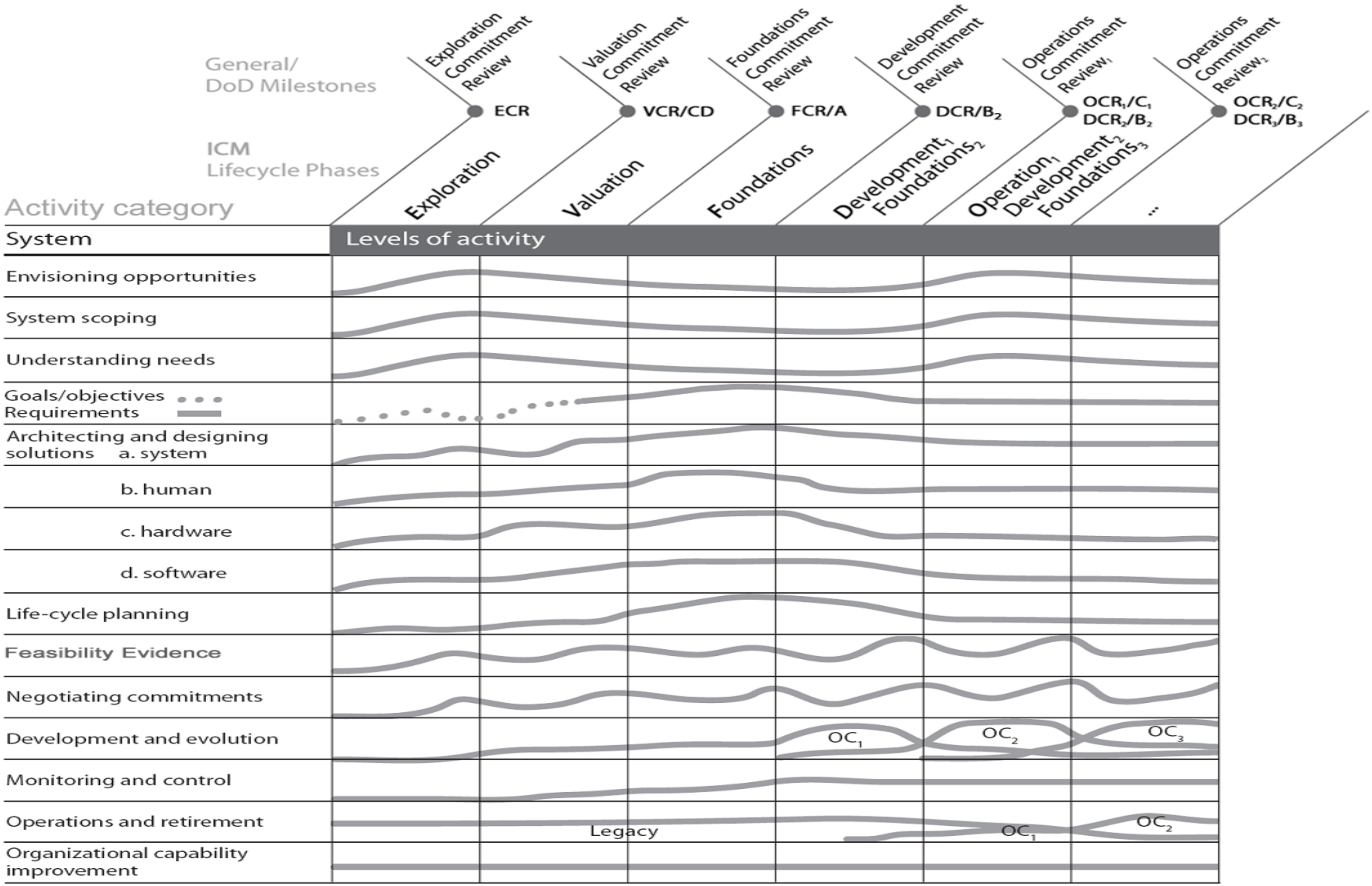
Benefits:

- Average 10% savings per reviewed project
- Substantially larger savings on a few reviewed projects

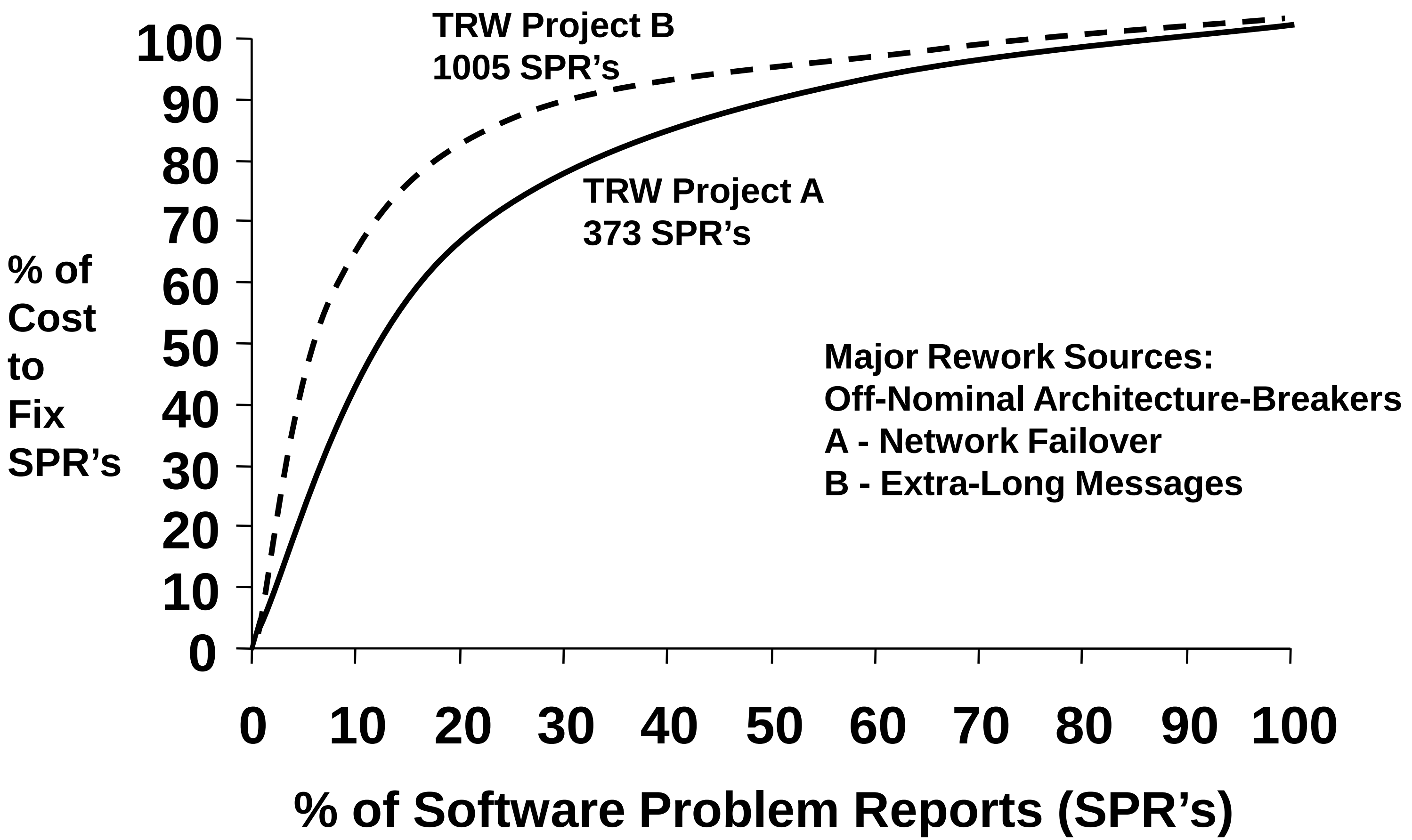
AT&T
Software Technology Center

ICSE-17
April 1995 Page 5

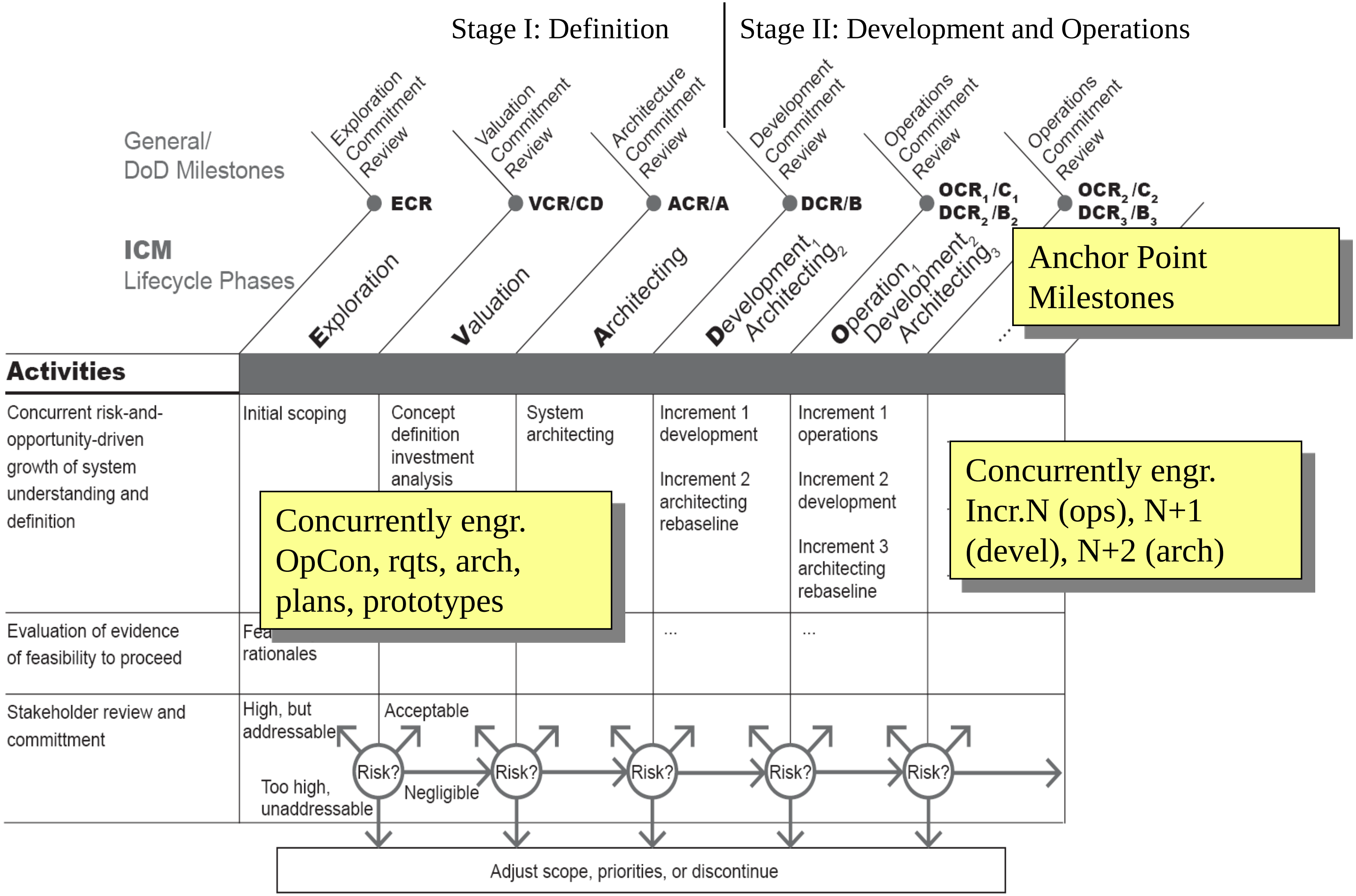
ICM Levels of Activity for Complex Systems

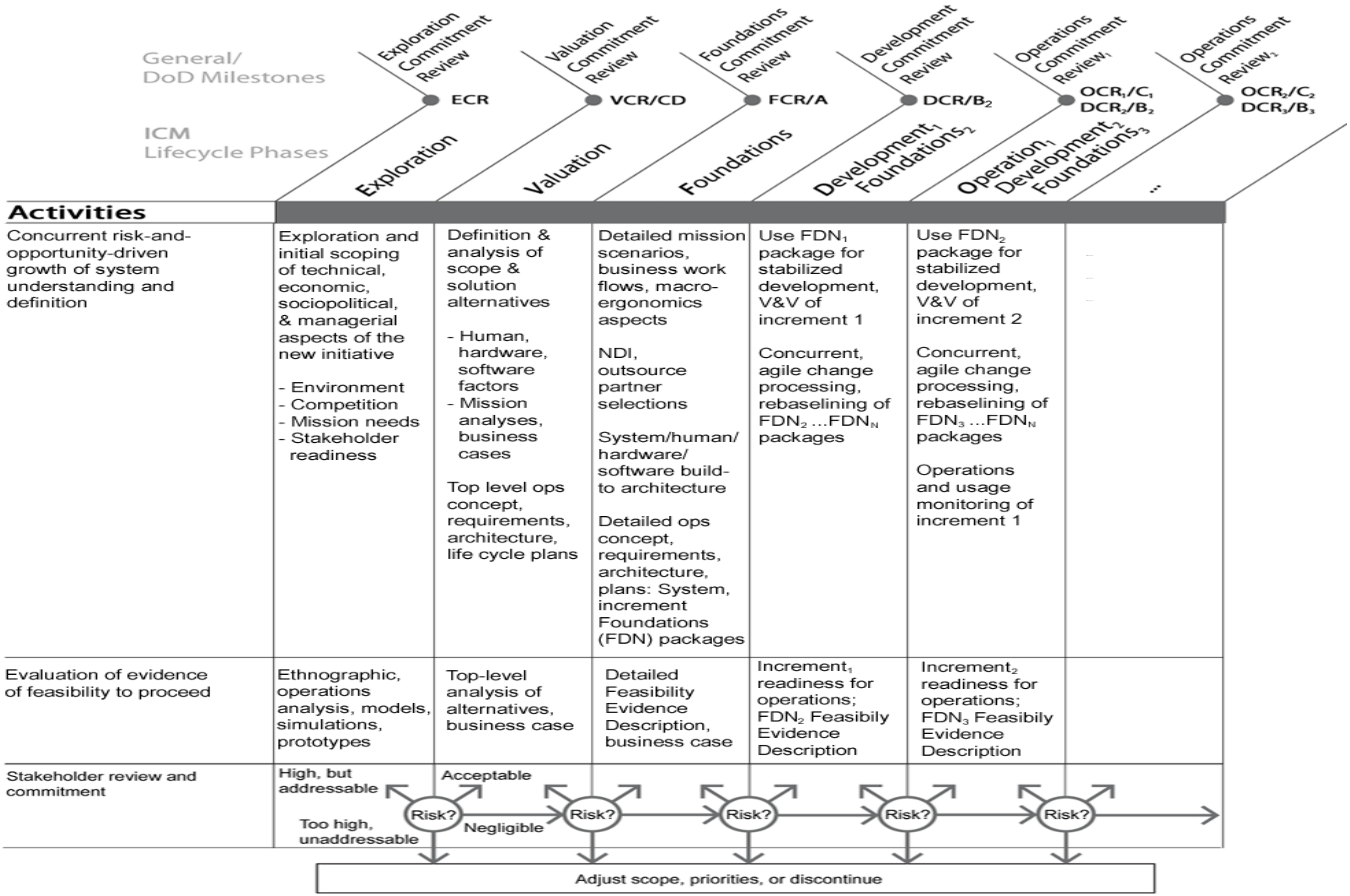


Off-Nominal Architecture-Breakers



The Incremental Commitment Life Cycle Process: Overview




General/ DoD Milestones
Exploration Commitment Review
ECR
Valuation Commitment Review
VCR/CD
Foundations Commitment Review
FCR/A
Development Commitment Review
DCR/B2
Operations Commitment Review1
OCR1/C1 DCR2/B2
Operations Commitment Review2
OCR2/C2 DCR3/B3
ICM Lifecycle Phases
Exploration
Valuation
Foundations
Development1 Foundations2
Operation1 Development2 Foundations3
...
Activities
Concurrent risk-and-opportunity-driven growth of system understanding and definition
Exploration and initial scoping of technical, economic, sociopolitical, & managerial aspects of the new initiative
- Environment
- Competition
- Mission needs
- Stakeholder readiness
Definition & analysis of scope & solution alternatives
- Human, hardware, software factors
- Mission analyses, business cases
Top level ops concept, requirements, architecture, life cycle plans
Detailed mission scenarios, business work flows, macro-ergonomics aspects
NDI, outsource partner selections
System/human/hardware/software build-to architecture
Detailed ops concept, requirements, architecture, plans: System, increment Foundations (FDN) packages
Use FDN1 package for stabilized development, V&V of increment 1
Concurrent, agile change processing, rebaselining of FDN2 …FDNN packages
Use FDN2 package for stabilized development, V&V of increment 2
Concurrent, agile change processing, rebaselining of FDN3 …FDNN packages
Operations and usage monitoring of increment 1
Evaluation of evidence of feasibility to proceed
Ethnographic, operations analysis, models, simulations, prototypes
Top-level analysis of alternatives, business case
Detailed Feasibility Evidence Description, business case
Increment1 readiness for operations; FDN2 Feasibily Evidence Description
Increment2 readiness for operations; FDN3 Feasibily Evidence Description
Stakeholder review and commitment
High, but addressable
Acceptable
Risk?
Too high, unaddressable
Negligible
Adjust scope, priorities, or discontinue

Focus of Each Commitment Review

- Each commitment review evaluates the review package created during the current phase
  - Work products
  - Feasibility evidence
    - Prototypes
    - Studies
    - Estimates
    - Basis of estimates

Enter-Next-Phase Commitment Review	Source of Package Information
Valuation (VCR/CD)	Exploration phase
Foundations (FCR/MS-A)	Valuation phase
Development (DCR/MS-B)	Foundations phase
Operations (OCR)	Development phase

- Goal is to determine if
  - Efforts should proceed into the next phase
    - Commit to next phase – risk acceptable or negligible
  - More work should be done in current phase
    - Do more work before deciding to commit to next phase – risk high, but probably addressable
  - Efforts should be discontinued
    - Risk too high or unaddressable

Exploration Phase Activities

- Protagonist identifies need or opportunity worth exploring
  - Service, agency, joint entity
- Protagonist identifies additional success-critical stakeholders (SCSs)
  - Technical, Managerial, Financial, DOTMLPF
- SCS working groups explore needs, opportunities, scope, solution options
  - Materiel and Non-Materiel options
  - Compatibility with Strategic Guidance
  - SCS benefits realization
  - Analysis of alternatives
  - Define evaluation criteria
    - Filter out unacceptable alternatives
    - Identify most promising alternative(s)
    - Identify common-special-case process if possible
  - Develop top-level VCR/CD Package
- Approval bodies review VCR/CD Package

Major starting points in sequence, but activities concurrent

Top-Level VCR/CD Package

- Operations/ life cycle concept
  - Top-level system boundary and environment elements
  - Benefits chain or equivalent
    - Links initiatives to desired benefits and identifies associated SCSs
    - Including production and life cycle support SCSs
  - Representative operational and support scenarios
  - Prototypes (focused on top development and operational risks), objectives, constraints, and priorities
  - Initial Capabilities Document
- Leading solution alternatives
  - Top-level physical, logical, capability and behavioral views Life Cycle Plan
- Key elements
  - Top-level phases, capability increments, roles, responsibilities, required resources
- Feasibility Evidence Description
  - Evidence of ability to meet objectives within budget and schedule constraints
  - Evidence of ability to provide desired benefits to stakeholders
    - Mission effectiveness evidence

ICM Anchor Point Milestone Content (1)

(Risk-driven level of detail for each element)

Milestone Element	Foundations Commitment Review (FCR/MS-A) Package	Development Commitment Review (DCR/MS-B) Package
Definition of Operational Concept	• System shared vision update • Top-level system objectives and scope – System boundary; environment parameters and assumptions • Top-level operational concepts – Production, deployment, operations and sustainment scenarios and parameters – Organizational life-cycle responsibilities (stakeholders)	• Elaboration of system objectives and scope by increment • Elaboration of operational concept by increment – Including all mission-critical operational scenarios – Generally decreasing detail in later increments
System Prototype(s)	• Exercise key usage scenarios • Resolve critical risks – E.g., quality attribute levels, technology maturity levels	• Exercise range of usage scenarios • Resolve major outstanding risks
Definition of System Requirements	• Top-level functions, interfaces, quality attribute levels, including – Growth vectors and priorities • Project and product constraints • Stakeholders' concurrence on essentials	• Elaboration of functions, interfaces, quality attributes, and constraints by increment – Including all mission-critical off-nominal requirements – Generally decreasing detail in later increments • Stakeholders' concurrence on their priority concerns

ICM Anchor Point Milestone Content (2)

(Risk-driven level of detail for each element)

Milestone Element	Foundations Commitment Review (FCR/MS-A) Package	Development Commitment Review (DCR/MS-B) Package
Definition of System Architecture	• Top-level definition of at least one feasible architecture – Physical and logical elements and relationships – Choices of Non-Developmental Items (NDI) • Identification of infeasible architecture options	• Choice of architecture and elaboration by increment and component – Physical and logical components, connectors, configurations, constraints – NDI choices – Domain-architecture and architectural style choices • Architecture evolution parameters
Definition of Life-Cycle Plan	• Identification of life-cycle stakeholders – Users, customers, developers, testers, sustainers, interoperators, general public, others • Identification of life-cycle process model – Top-level phases, increments • Top-level WWWWWHH* by phase, function – Production, deployment, operations, sustainment	• Elaboration of WWWWWHH* for Initial Operational Capability (IOC) by phase, function – Partial elaboration, identification of key TBD's for later increments

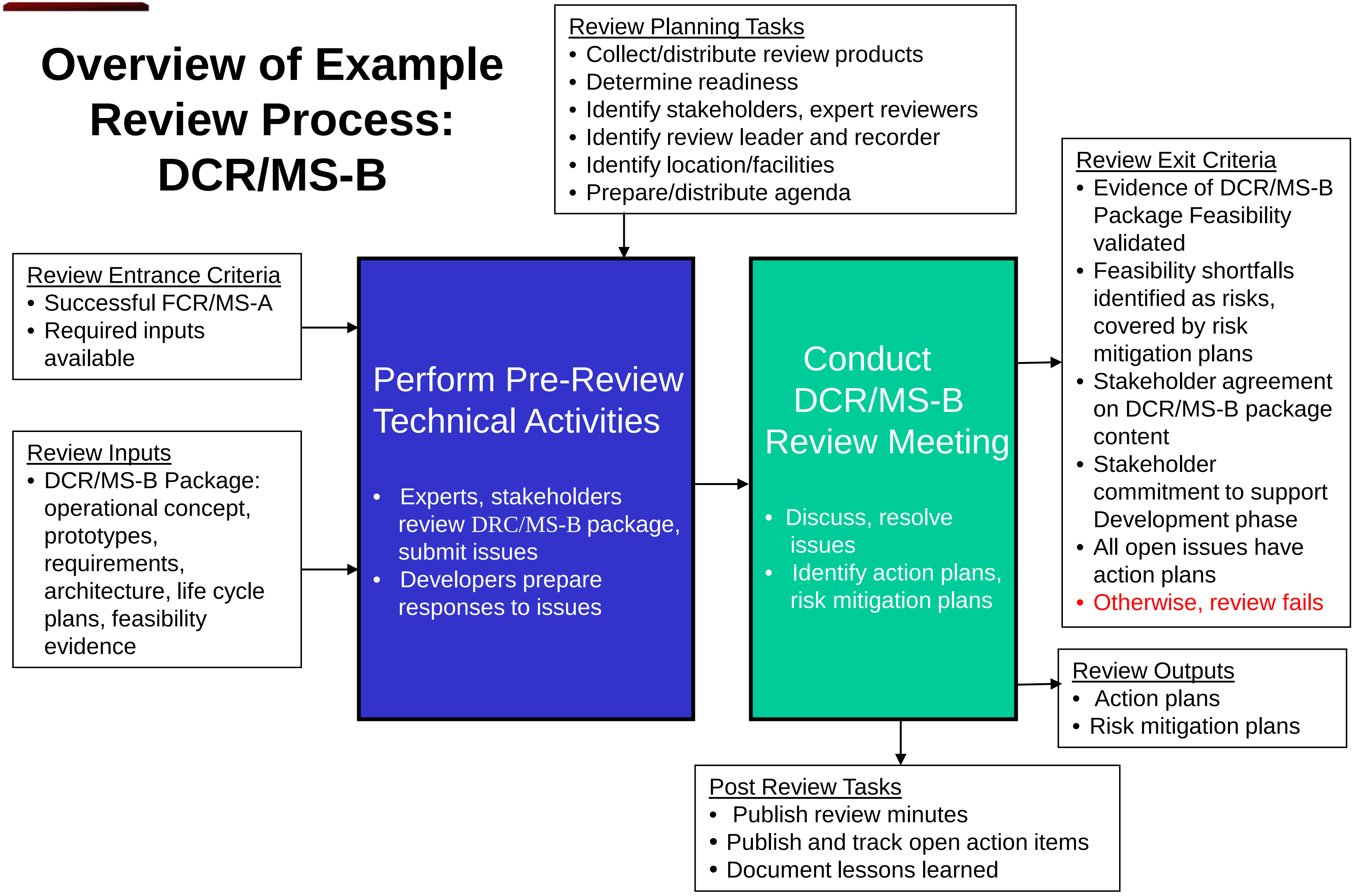
*WWWWWHH: Why, What, When, Who, Where, How, How Much

ICM Anchor Point Milestone Content (3)

(Risk-driven level of detail for each element)

Milestone Element	Foundations Commitment Review (FCR/MS-A) Package	Development Commitment Review (DCR/MS-B) Package
Feasibility Evidence Description (FED)	• Evidence of consistency, feasibility among elements above – Via physical and logical modeling, testbeds, prototyping, simulation, instrumentation, analysis, etc. – Mission cost-effectiveness analysis for requirements, feasible architectures • Identification of evidence shortfalls; risks • Stakeholders' concurrence on essentials	• Evidence of consistency, feasibility among elements above – Identification of evidence shortfalls; risks • All major risks resolved or covered by risk management plan • Stakeholders' concurrence on their priority concerns, commitment to development

Overview of Example Review Process: DCR/MS-B



Lean Risk Management Plan:
Fault Tolerance Prototyping

1. Objectives (The "Why")
   - Determine, reduce level of risk of the fault tolerance features causing unacceptable performance (e.g., throughput, response time, power consumption)
   - Create a description of and a development plan for a set of low-risk fault tolerance features
2. Deliverables and Milestones (The "What" and "When")
   - By week 3
     1. Evaluation of fault tolerance option
     2. Assessment of reusable components
     3. Draft workload characterization
     4. Evaluation plan for prototype exercise
     5. Description of prototype
   - By week 7
     6. Operational prototype with key fault tolerance features
     7. Workload simulation
     8. Instrumentation and data reduction capabilities
     9. Draft Description, plan for fault tolerance features
   - By week 10
     10. Evaluation and iteration of prototype
     11. Revised description, plan for fault tolerance features

Lean Risk Management Plan: Fault Tolerance Prototyping *(continued)*

- **Responsibilities (The "Who" and "Where")**
  - System Engineer: G. Smith
    - Tasks 1, 3, 4, 9, 11, support of tasks 5, 10
  - Lead Programmer: C. Lee
    - Tasks 5, 6, 7, 10 support of tasks 1, 3
  - Programmer: J. Wilson
    - Tasks 2, 8, support of tasks 5, 6, 7, 10
- **Approach (The "How")**
  - Design-to-Schedule prototyping effort
  - Driven by hypotheses about fault tolerance-performance effects
  - Use multicore processor, real-time OS, add prototype fault tolerance features
  - Evaluate performance with respect to representative workload
  - Refine Prototype based on results observed
- **Resources (The "How Much")**

$60K - Full-time system engineer, lead programmer, programmer (10 weeks)*(3 staff)*($2K/staff-week)

$0K - 3 Dedicated workstations (from project pool)

$0K - 2 Target processors (from project pool)

$0K - 1 Test co-processor (from project pool)

<u>$10K</u> - Contingencies

$70K - Total

Example of FED Risk Evaluation Criteria

- Negligible
  - Anticipated 0-5% budget and/or schedule overrun
  - Identified only minor shortfalls and imperfections expected to affect the delivered system
- Low
  - Anticipated 5-10% budget and/or schedule overrun
  - Identified 1-3 moderate shortfalls and imperfections expected to affect the delivered system
- Moderate
  - Anticipated 10-25% budget and/or schedule overrun
  - Identified >3 moderate shortfalls and imperfections expected to affect the delivered system
- Major
  - Anticipated 25-50% budget and/or schedule overrun
  - Identified 1-3 mission-critical shortfalls and imperfections expected to affect the delivered system
- Severe
  - Anticipated >50% budget and/or schedule overrun
  - Identified >3 mission-critical shortfalls and imperfections expected to affect the delivered system

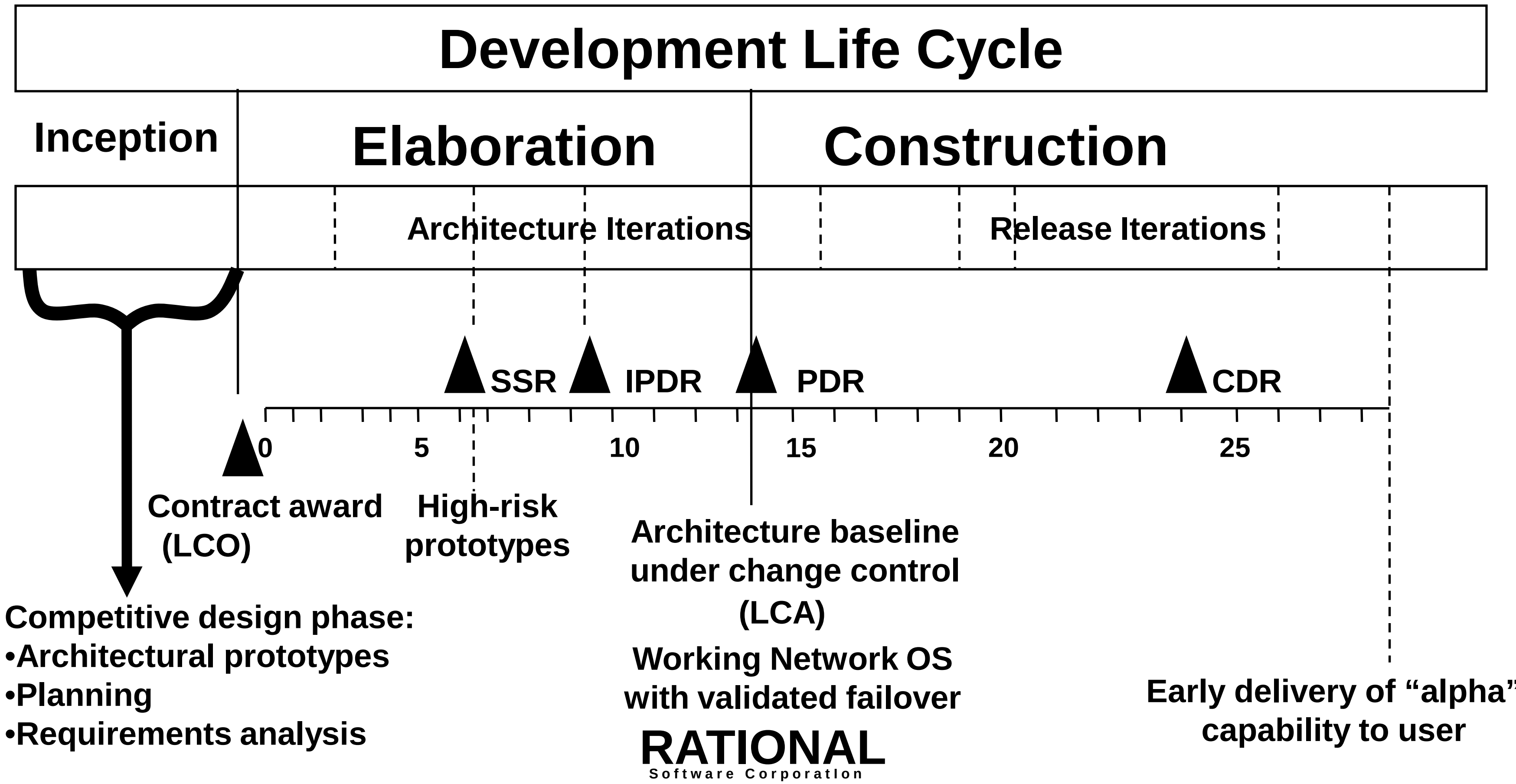
Case Study: CCPDS-R Project Overview

Characteristic	CCPDS-R
Domain	Ground based C3 development
Size/language	1.15M SLOC Ada
Average number of people	75
Schedule	75 months; 48-month IOC
Process/standards	DOD-STD-2167A Iterative development
Environment	Rational host DEC host DEC VMS targets
Contractor	TRW
Customer	USAF
Current status	Delivered On-budget, On-schedule

Reference: [Royce, 1998], Appendix D

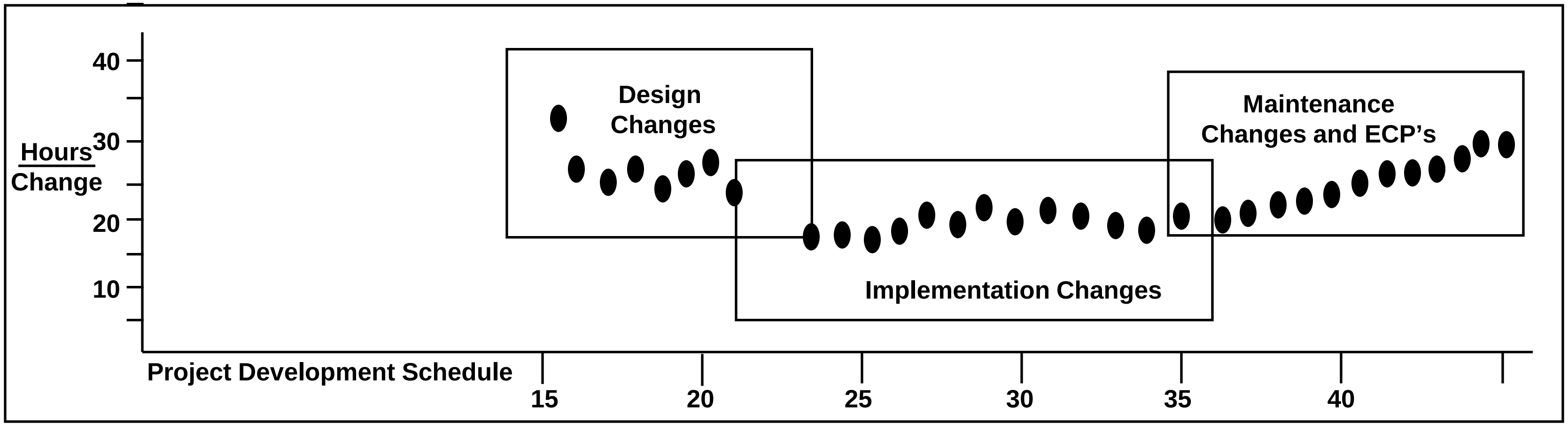
RATIONAL
Software CorporatIon

CCPDS-R Reinterpretation of SSR, PDR



CCPDS-R Results: No Late 80-20 Rework

- Architecture first
  - -Integration during the design phase
  - -Demonstration-based evaluation
- Risk Management
- Configuration baseline change metrics:



Conclusions

- Anchor Point milestones enable synchronization and stabilization of concurrent engineering
  - Have been successfully applied on small to large projects
  - CCPDS-R large project example provided in backup charts
- They also provide incremental stakeholder resource commitment points
- The FED enables evidence of program feasibility to be evaluated
  - Produced by developer
  - Evaluated by stakeholders, independent experts
- Shortfalls in evidence are sources of uncertainty and risk, and should be covered by risk management plans
- Can get most of benefit by adding FED to traditional milestone content and reviews

List of Acronyms

CD	Concept Development
CP	Competitive Prototyping
DCR	Development Commitment Review
DoD	Department of Defense
ECR	Exploration Commitment Review
EV	Expected Value
FCR	Foundations Commitment Review
FED	Feasibility Evidence Description
GAO	Government Accounting Office
ICM	Incremental Commitment Model
KPP	Key Performance Parameter
MBASE	Model-Based Architecting and Software Engineering
OCR	Operations Commitment Review
RE	Risk Exposure
RUP	Rational Unified Process
V&V	Verification and Validation
VB	Value of Bold approach
VCR	Valuation Commitment Review

Early SE Determination of Best-Fit System Life Cycle Processes

Barry Boehm, Jo Ann Lane
University of Southern California

NDIA SE Conference
October 2009

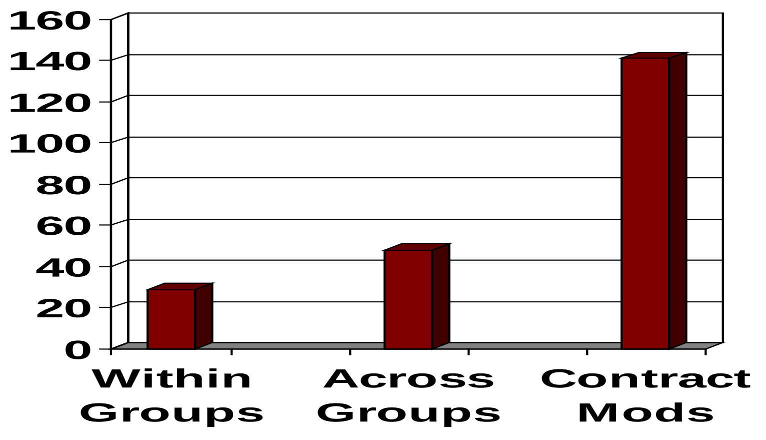
Outline

- Life cycle process goals and challenges
  - Too much versus too little process
- Balancing process goals and challenges via the Incremental Commitment Model
  - ICM nature and risk-driven framework
  - Decision table for common special cases
    - Including pure agile, pure rigorous, hybrids
    - Example: Architected Agile
- Conclusions and references

Need for SE Agility and Rigor

- Future need for agility
  - Rapid change; turning within adversaries' OODA loop
- Future need for rigor
  - Secure, safe, always-on systems
- Risky to overemphasize agility
  - Easiest-first, unscalable, unsecurable systems
- Risky to overemphasize rigor

Average workdays to process changes, 2 large systems of systems



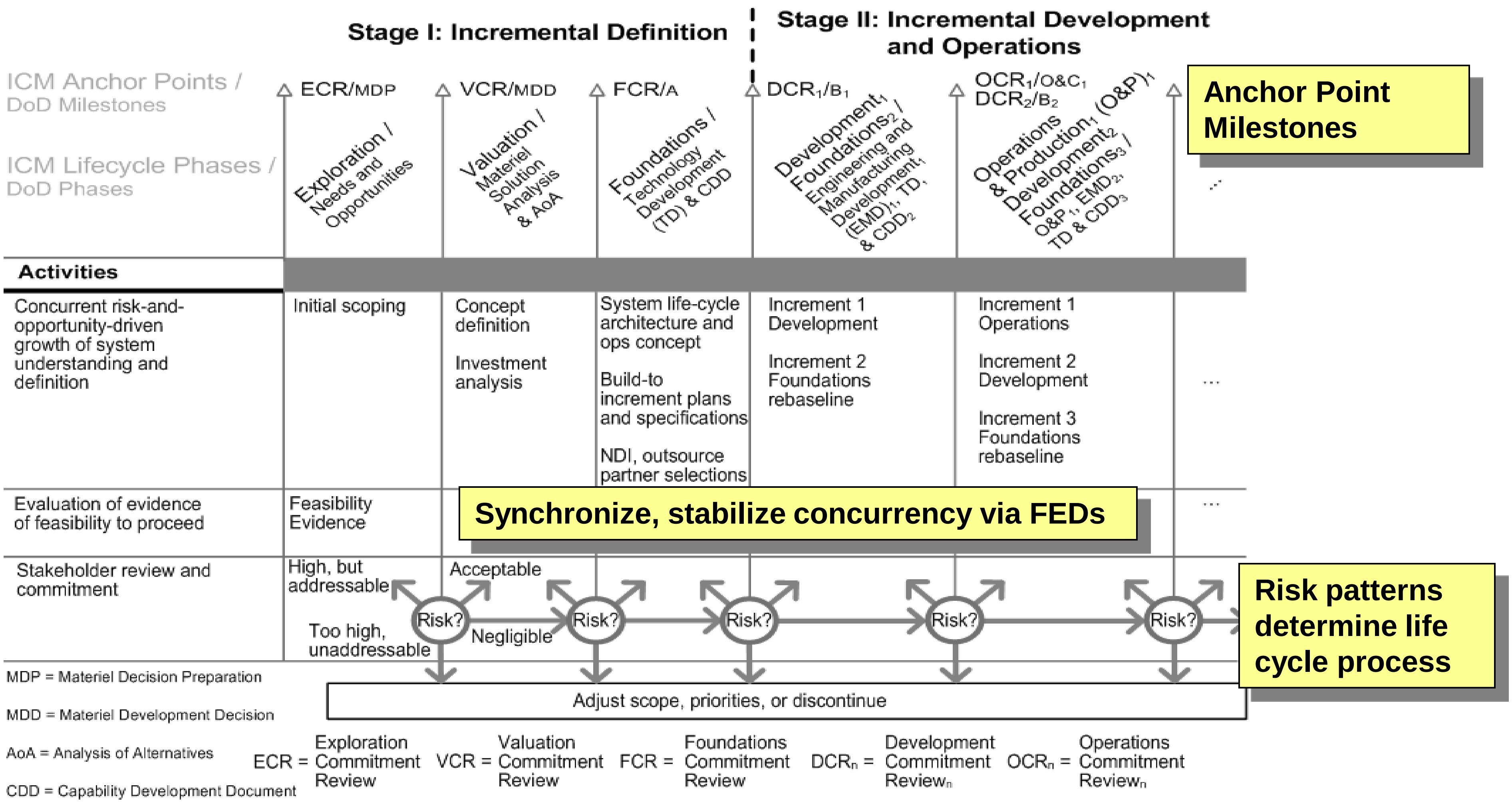
What is the ICM?

- **Risk-driven framework for determining and evolving best-fit system life-cycle process**
- **Integrates the strengths of phased and risk-driven spiral process models**
- **Synthesizes together principles critical to successful system development**
  - **Commitment and accountability of system sponsors**
  - **Success-critical stakeholder satisficing**
  - **Incremental growth of system definition and stakeholder commitment**
  - **Concurrent engineering**
  - **Iterative development cycles**
  - **Risk-based activity levels and anchor point milestones**

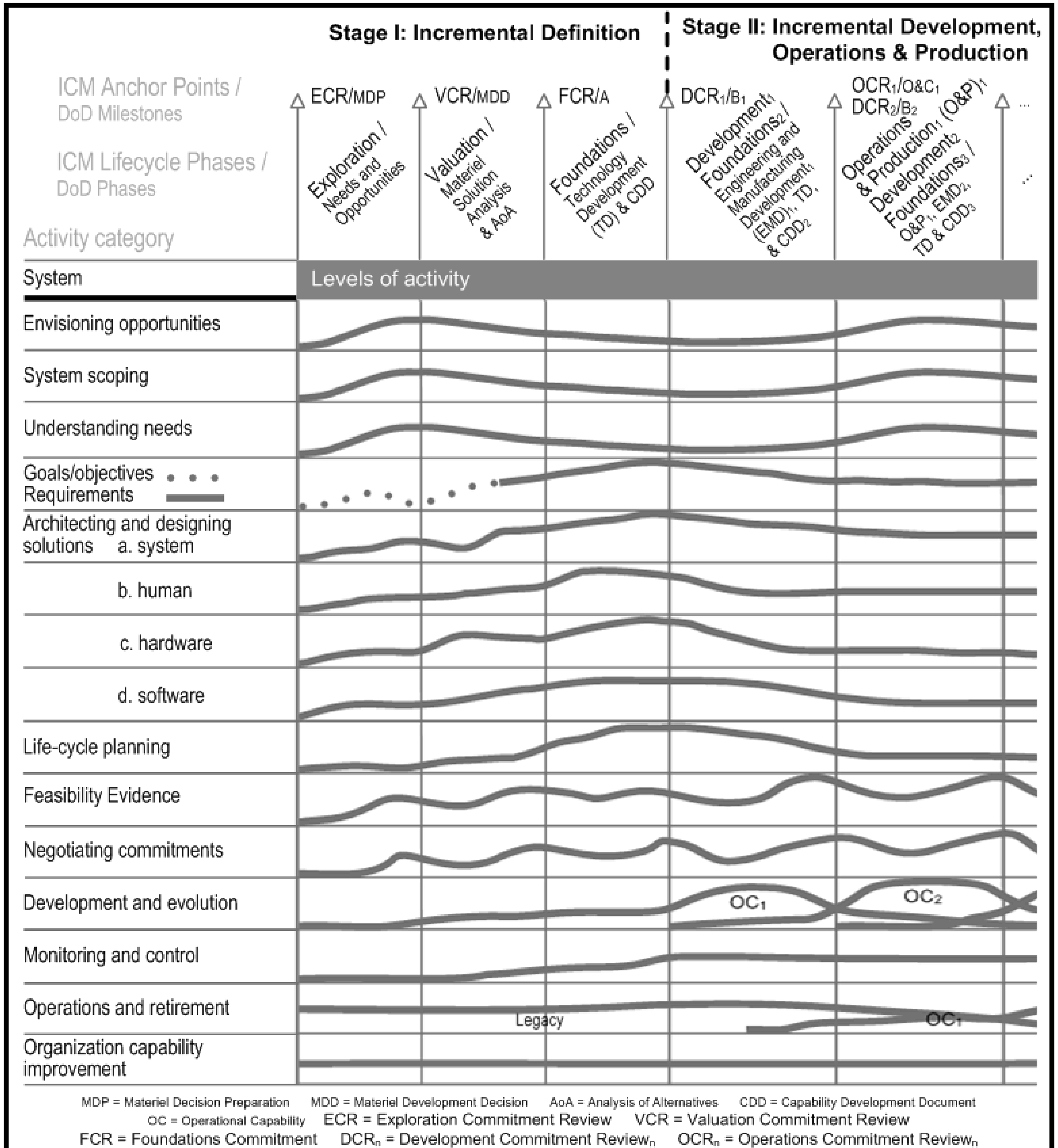
Principles trump diagrams…

Principles used by 60-80% of <u>CrossTalk</u> Top-5 projects, 2002-2005

The Incremental Commitment Life Cycle Process: Overview



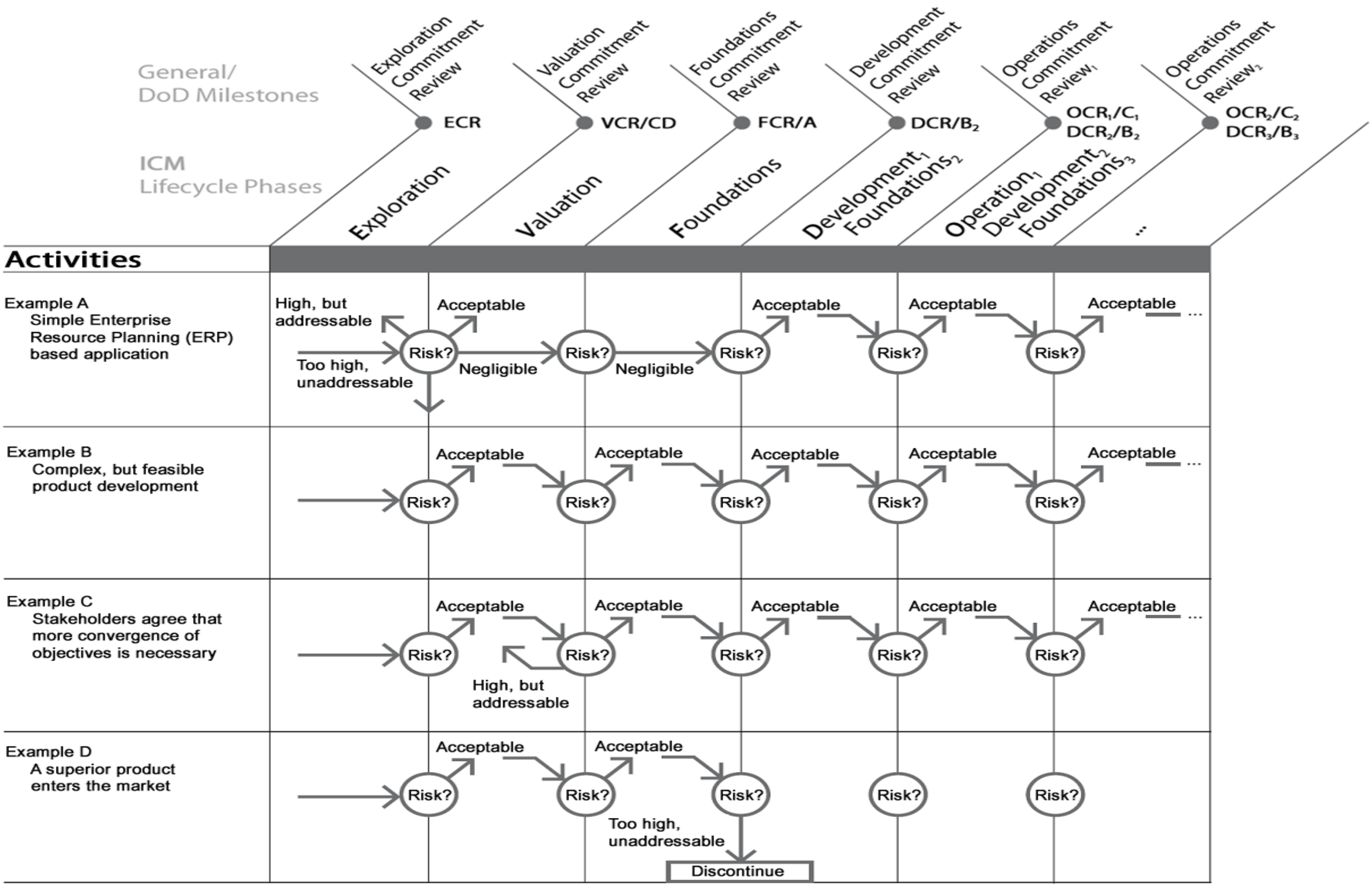
ICM Activity Levels for Complex Systems



The ICM as Risk-Driven Process Generator

- Stage I of the ICM has 3 decision nodes with 4 options per node
  - Culminating with incremental development in Stage II
  - Some options involve go-backs
  - Results in many possible process paths
- Can use ICM risk patterns to generate frequently-used processes
  - With confidence that they fit the situation
- Can generally determine this in the Exploration phase
  - Develop as proposed plan with risk-based evidence at VCR milestone
  - Adjustable in later phases

Different Risk Patterns Yield Different Processes



The ICM Process Decision Table

- **Key Decision Inputs**
  - Product and project size and complexity
  - Requirements volatility
  - Mission criticality
  - Nature of any Non-Developmental Item (NDI) support
    - Commercial, open-source, reused components
  - Organizational and Personnel Capability

In most cases, can characterize these in the early very early in the system Exploration and Valuation phases (early SE)...

- **Key Decision Outputs**
  - Key Stage I activities: incremental definition
  - Key Stage II activities: incremental development and operations
  - Suggested calendar time per build, per deliverable increment

Common Risk-Driven Special Cases of the ICM (Cases 1-4)

Case 1: Use NDI	Case 2: Agile
Example: Small accounting system **Size, Complexity:** Size variable, complexity low **Typical Change Rate/Month:** Negligible **Criticality:** n/a **NDI Support:** Complete **Organizational Personnel Capability:** NDI-experienced (medium) **Key Stage I Activities (Incremental Definition):** Acquire NDI **Key Stage II Activities (Incremental Development/Operations):** Use NDI **Time/Build:** n/a **Time/Increment:** Vendor-driven	**Example:** E-services **Size, Complexity:** Low **Typical Change Rate/Month:** 1-30% **Criticality:** Low to medium **NDI Support:** Good, in place **Organizational Personnel Capability:** Agile-ready, medium-high experience **Key Stage I Activities (Incremental Definition):** Skip Valuation and Architecting phases **Key Stage II Activities (Incremental Development/Operations):** Scrum plus agile methods of choice **Time/Build:** <= 1 day **Time/Increment:** 2-6 weeks
Case 3: Architected Agile	**Case 4: Formal Methods**
Example: Business data processing **Size, Complexity:** Medium **Typical Change Rate/Month:** 1-10 % **Criticality:** Medium to high **NDI Support:** Good, most in place **Organizational Personnel Capability:** Agile-ready, medium to high experience **Key Stage I Activities (Incremental Definition):** Combine Valuation, Architecting phases. Complete NDI preparation. **Key Stage II Activities (Incremental Development/Operations):** Architecture-based Scrum of Scrums **Time/Build:** 2-4 weeks **Time/Increment:** 2-6 months	**Example:** Security kernel; Safety-critical LSI chip **Size, Complexity:** Low **Typical Change Rate/Month:** 0.3% **Criticality:** Extra high **NDI Support:** None **Organizational Personnel Capability:** Strong formal methods experience **Key Stage I Activities (Incremental Definition):** Precise formal specification **Key Stage II Activities (Incremental Development/Operations):** Formally-based programming language; formal verification **Time/Build:** 1-5 days **Time/Increment:** 1-4 weeks

Common Risk-Driven Special Cases of the ICM (Cases 5-8)

Case 5: Hardware with Embedded Software Component

Example: Multi-sensor control device
Size, Complexity: Low
Typical Change Rate/Month: 0.3 - 1 %
Criticality: Medium to very high
NDI Support: Good, in place
Organizational Personnel Capability: Experienced, medium-high
Key Stage I Activities (Incremental Definition): Concurrent hardware/software engineering. CDR-level ICM DCR
Key Stage II Activities (Incremental Development/Operations): IOC development, LRIP, FRP. Concurrent version N+1 engineering
Time/Build: Software 1-5 days
Time/Increment: Market-driven

Case 6: Indivisible IOC

Example: Complete vehicle platform
Size, Complexity: Medium to high
Typical Change Rate/Month: 0.3 – 1%
Criticality: High to very high
NDI Support: Some in place
Organizational Personnel Capability: Experienced, medium to high
Key Stage I Activities (Incremental Definition): Determine minimum-IOC likely, conservative cost. Add deferrable software features as risk reserve
Key Stage II Activities (Incremental Development/Operations): Drop deferrable features to meet conservative cost. Strong award free for features not dropped.
Time/Build: Software: 2-6 weeks
Time/Increment: Platform: 6-18 months

Case 7: NDI-Intensive

Example: Supply chain management
Size, Complexity: Medium to high
Typical Change Rate/Month: 0.3 – 3%
Criticality: Medium to very high
NDI Support: NDI-driven architecture
Organizational Personnel Capability: NDI-experienced, medium to high
Key Stage I Activities (Incremental Definition): Thorough NDI-suite life cycle cost-benefit analysis, selection, concurrent requirements/architecture definition
Key Stage II Activities (Incremental Development/Operations): Pro-active NDI evolution influencing, NDI upgrade synchronization
Time/Build: Software: 1-4 weeks
Time/Increment: Systems: 6-18 months

Case 8: Hybrid Agile/Plan-Driven System

Example: C4ISR system
Size, Complexity: Medium to very high
Typical Change Rate/Month: Mixed parts; 1-10%
Criticality: Mixed parts; Medium to very high
NDI Support: Mixed parts
Organizational Personnel Capability: Mixed parts
Key Stage I Activities (Incremental Definition): Full ICM, encapsulated agile in high change, low-medium criticality parts (Often HMI, external interfaces)
Key Stage II Activities (Incremental Development/Operations): Full ICM, three-team incremental development, concurrent V&V, next-increment rebaselining
Time/Build: 1-2 months
Time/Increment: 9-18 months

Common Risk-Driven Special Cases of the ICM (Cases 9-11)

Case 9: Multi-Owner Directed System of Systems

Example: Net-centric military operations
Size, Complexity: Very high
Typical Change Rate/Month: Mixed parts; 1-10 %
Criticality: Very high
NDI Support: Many NDIs, some in place
Organizational Personnel Capability: Related experience, medium to high
Key Stage I Activities (Incremental Definition): Full ICM; extensive multi-owner team building, negotiation
Key Stage II Activities (Incremental Development/Operations): Full ICM; large ongoing system/software engineering effort
Time/Build: 2-4 months
Time/Increment: 18-24 months

Case 10: Family of Systems

Example: Medical device product line
Size, Complexity: Medium to very high
Typical Change Rate/Month: 1-3%
Criticality: Medium to very high
NDI Support: Some in place
Organizational Personnel Capability: Related experience, medium to high
Key Stage I Activities (Incremental Definition): Skip Valuation and Architecting phases
Key Stage II Activities (Incremental Development/Operations): Scrum plus agile methods of choice
Time/Build: 1-2 months
Time/Increment: 9-18 months

Case 11: Brownfield

Example: Incremental legacy phaseout
Size, Complexity: High to very high
Typical Change Rate/Month: 0.3-3%
Criticality: Medium-high
NDI Support: NDI as legacy replacement
Organizational Personnel Capability: Legacy re-engineering
Key Stage I Activities (Incremental Definition): Re-engineer/refactor legacy into services
Key Stage II Activities (Incremental Development/Operations): Incremental legacy phaseout
Time/Build: 2-6 weeks/refactor
Time/Increment: 2-6 months

Common Risk-Driven Special Cases of the ICM (Cases 12a/b)

Case 12a: Net-Centric Services – Community Support	Case 12b: Net-Centric Services – Quick Response Decision Support
Example: Community services or special interest group	**Example:** Response to competitor initiative
Size, Complexity: Low to medium	**Size, Complexity:** Medium to high
Typical Change Rate/Month: 0.3-3%	**Typical Change Rate/Month:** 3-30%
Criticality: Low to medium	**Criticality:** Medium to high
NDI Support: Tailorable service elements	**NDI Support:** Tailorable service elements
Organizational Personnel Capability: NDI-experienced	**Organizational Personnel Capability:** NDI-experienced
Key Stage I Activities (Incremental Definition): Filter, select, compose, tailor NDI	**Key Stage I Activities (Incremental Definition):** Filter, select, compose, tailor NDI
Key Stage II Activities (Incremental Development/Operations): Evolve tailoring to meet community needs	**Key Stage II Activities (Incremental Development/Operations):** Satisfy quick response; evolve or phase out
Time/Build: <= 1 day	**Time/Build:** <= 1 day
Time/Increment: 2-12 months	**Time/Increment:** Quick response-driven

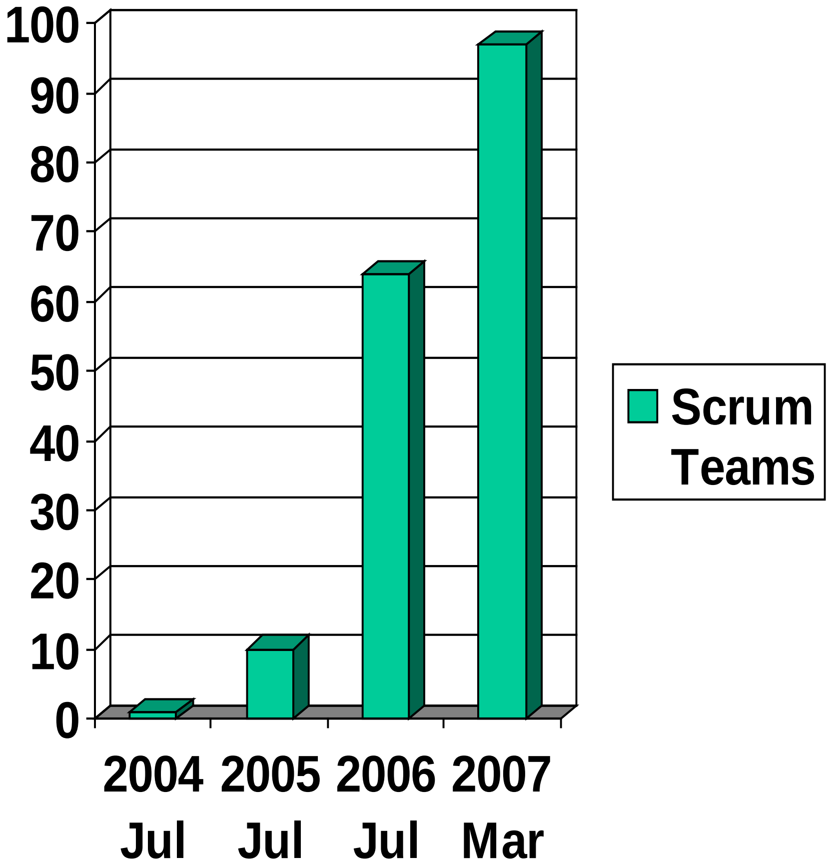
LEGEND

C4ISR: Command, Control, Computing, Communications, Intelligence, Surveillance, Reconnaissance.
CDR: Critical Design Review.
DCR: Development Commitment Review.
FRP: Full-Rate Production.
HMI: Human-Machine Interface.
HW: Hard ware.
IOC: Initial Operational Capability.
LSI: Large Scale Integration.
LRIP: Low-Rate Initial Production.
NDI: Non-Development Item.
SW: Software

USA Medical Case Study

- 1400 software people; 7M SLOC; 7 sites
  - 4 in Europe, 2 in India
- 500 medical applications; 500 financial; others
- Survivability-critical software problems
  - Reliability, productivity, performance, interoperability
  - Sarbanes-Oxley requirements
  - Management receptive to radical change
- Some limited experimental use of agile methods
  - Led by top software technologist/manager
- Committed to total change around Scrum and XP

USA Medical Process Adoption Profile



- **July 2004 - July 2005**
  - Recruit top people from all sites into core team(s)
  - Get external expert help
  - Develop architecture
  - Early Scrum successes with infrastructure
  - Revise policies and practices
  - Train, reculture everyone
  - Manage expectations
- **July 2005 – July 2006**
  - Begin full-scale development
  - Core teams as mentors

USA Medical Development Process Characteristics

- Include customers and marketers
  - New roles; do's/don'ts/opportunities; CRACK personnel; full collaboration and teamwork; expectations management
- Scrum; most XP practices; added company practices
  - 6-12 person teams with team rooms, dedicated servers
  - Hourly smoke test; nightly build and regression test
  - Just-in-time analysis; story-point estimates; fail fast; detailed short-term plans; company architecture compliance
  - Embrace change in applications and practices
  - Global teams: wikis, daily virtual meetings, act as if next-door
- Release management
  - 2-12 week architecting Sprint Zero; 3-10 1-month Sprints; Release Sprint; 1-6 month beta test
  - Next Sprint Zero concurrent with Release Sprint
- Initiative manager and team
  - Define practices; evolve infrastructure; provide training; guide implementation; evaluate compliance/usage; continuous improvement

Best Fit: Case 3—Architected Agile

- Exploration phase determines
  - Need to accommodate fairly rapid change, emergent requirements, early user capability
  - Low risk of scalability up to 100 people
  - NDI support of growth envelope
  - Nucleus of highly agile-capable personnel
  - Moderate to high loss due to increment defects
- Example: Supply chain management
- Size/complexity: Medium
- Anticipated change rate (% per month): 1-10%
- Criticality: Medium to high
- NDI support: Good, most in place
- Organizational and personnel capability: Agile-ready, med-high capability
- Key Stage I activities: Combined Valuation and Architecting phase, complete NDI preparation
- Key Stage II activities: Architecture-based scrum of scrums
- Time/build: 2-4 weeks Time/increment: 2-6 months

Why is Early Determination and Tailoring Important?

- One-size-fits-all processes can be
  - Overly heavy-weight, requiring teams to perform too many non-value adding tasks that increase costs and schedule
  - Not rigorous enough in identifying and managing risks early on, leading to failed programs
- Forces an early understanding of scope, complexity, and risks associated with proposed system development
- Through early engineering, may find opportunities to simplify and reduce risks, allowing development team to proceed with more agile processes

Conclusions

- Future systems increasingly need both agility and rigor
- Risk analysis helps determine how much of each is enough
  - Balancing risks of doing too little, too much of each
  - Can vary across subsystems
- Increasingly risky to use one-size-fits-all process models
  - Waterfall, V model, risk-insensitive spiral model
  - Associated inflexible contractual frameworks
- ICM provides tailorable risk-driven framework
  - And decision table for common special-case processes
  - Typically tailorable in early SE stages
  - Compatible with new evolutionary US DoDI 5000.02

References

Beck, K., *Extreme Programming Explained*, Addison Wesley, 1999.
Boehm, B., and Lane, J., "Guide for Using the Incremental Commitment Model (ICM) for Systems Engineering of DoD Projects, v0.5,“ USC-CSSE-TR-2009-500.
Boehm, B., “Some Future Trends and Implications for Systems and Software Engineering Processes”, *Systems Engineering* 9(1), pp. 1-19, 2006.
Boehm, B., Brown, W., Basili, V., and Turner, R., “Spiral Acquisition of Software-Intensive Systems of Systems, *CrossTalk*, Vol. 17, No. 5, pp. 4-9, 2004.
Boehm, B., and Lane, J., “Using the ICM to Integrate System Acquisition, Systems Engineering, and Software Engineering,” *CrossTalk*, October 2007, pp. 4-9.
B. Boehm and R. Turner*, Balancing Agility and Discipline: A Guide for the Perplexed,* Addison Wesley, 2004.
Checkland, P., *Systems Thinking, Systems Practice*, Wiley, 1980 (2nd ed., 1999).
Department of Defense (DoD), *Instruction 5000.02, Operation of the Defense Acquisition System,* December 2008.
Department of Defense (DoD), *Systems Engineering Guide for System of Systems*, June 2008.
Lane, J. and Dahmann, J., "Process Evolution to Support System of Systems Engineering,“ Proceedings, ICSE 2008 ULSSIS Workshop, May 2008.
Maier, M., “System and Software Architecture Reconciliation,” *Systems Engineering* 9 (2), 2006, pp. 146-159.
Northrop, L., et al., *Ultra-Large-Scale Systems: The Software Challenge of the Future*, Software Engineering Institute, 2006.
Pew, R. W., and Mavor, A. S., *Human-System Integration in the System Development Process: A New Look*, National Academy Press, 2007.
Rechtin, E. *Systems Architecting*, Prentice Hall, 1991.

Lessons learned in motivating Software Engineering Process Group to focus on achieving business goals, and not just on achieving a maturity level

12th Annual Systems Engineering Conference

October 28, 2009

Trademarks and Service Marks

- The following are service marks of Carnegie Mellon University
  - CMMI℠
  - Team Software Process℠
  - TSP℠
  - Personal Software Process℠
  - PSP℠
- The following are registered trademarks of Carnegie Mellon University
  - Capability Maturity Model®
  - CMM®
  - Capability Maturity Model® Integration
  - CMMI®
  - CERT®
- The following are registered trademarks of Advanced Information Services Inc.
  - CPIW ®
  - SOLONsys ® (Pending)

ais

Preamble

Don’t think of business as a life without greatness

Unless the distant goals of meaning, greatness, and destiny are addressed, we can’t make an intelligent decision about what to do tomorrow morning – much less set the long-term strategy of the company

First decision must be to commit to an ethical world, a civilized existence, a moral order

Nothing is more practical than for people to deepen themselves.

- Peter Koestenbaum (pkipeter@ix.netcom.com)

ais

Advanced Information Services Inc.

Winner IEEE Software Process Achievement Award

http://www.sei.cmu.edu/managing/ieee-award/ieee.award.html

SEI Partner

CMMI · TSP

CMMI Level 5

Topics

- Issues
  - Quality and Schedule
  - Rational Management and Commitment
  - Insanity and Malpractice
- Goals and Measurement – Myths, Facts
- SEPG and Top Management
- Balanced Scorecard
  - Objectives, Core Outcomes, Performance Drivers
  - Linkage, Alignment
- GQM – Six Step Process
- AIS SEPG – Role, Examples, Results
- Lessons Learned

Quality Is More Important Than Schedule

"In today's software marketplace, the principal focus is on cost, schedule, and function; quality is lost in the noise. This is unfortunate since poor quality performance is the root cause of most software cost and schedule problems."

Watts Humphrey

ais

Irrational Management

- Why do competent software professionals agree to delivery dates when they have no idea how to meet them?
- Why do rational managers accept schedule commitments when engineers offer no evidence that they can meet the commitments?

Rational Management - Developers

When pressed for early deliveries, the responsible team members say

"I understand your requirements, I will do my utmost to meet it, but until I make a plan, I can not responsibly commit to a date"

ais

Rational Management - Managers

When pressed for early deliveries, the responsible managers say

"I trust you to create an aggressive and realistic plan, I will review the plan, but I will not commit you to a date that you can not meet"

ais

Rational Management - Principles

- Set challenging goals
- Get the facts
- Use facts and data
- Anticipate and address problems

ais

Insanity or Malpractice?

Insanity

Doing the same thing over and over and expecting a different result

Malpractice

An organization which does not have a top-management-sponsored continuous improvement initiative in place

ais

Goals and Measurement Myths and Facts - 1

- Dr. Deming
  - Numerical goals accomplish nothing
  - Extrinsic motivation leads to the destruction of the individual
  - Rewards motivate people to work for the rewards
  - Various components should work together for optimization of profit and joy in work
  - System must create something of value, in other words, results
  - Life is variation

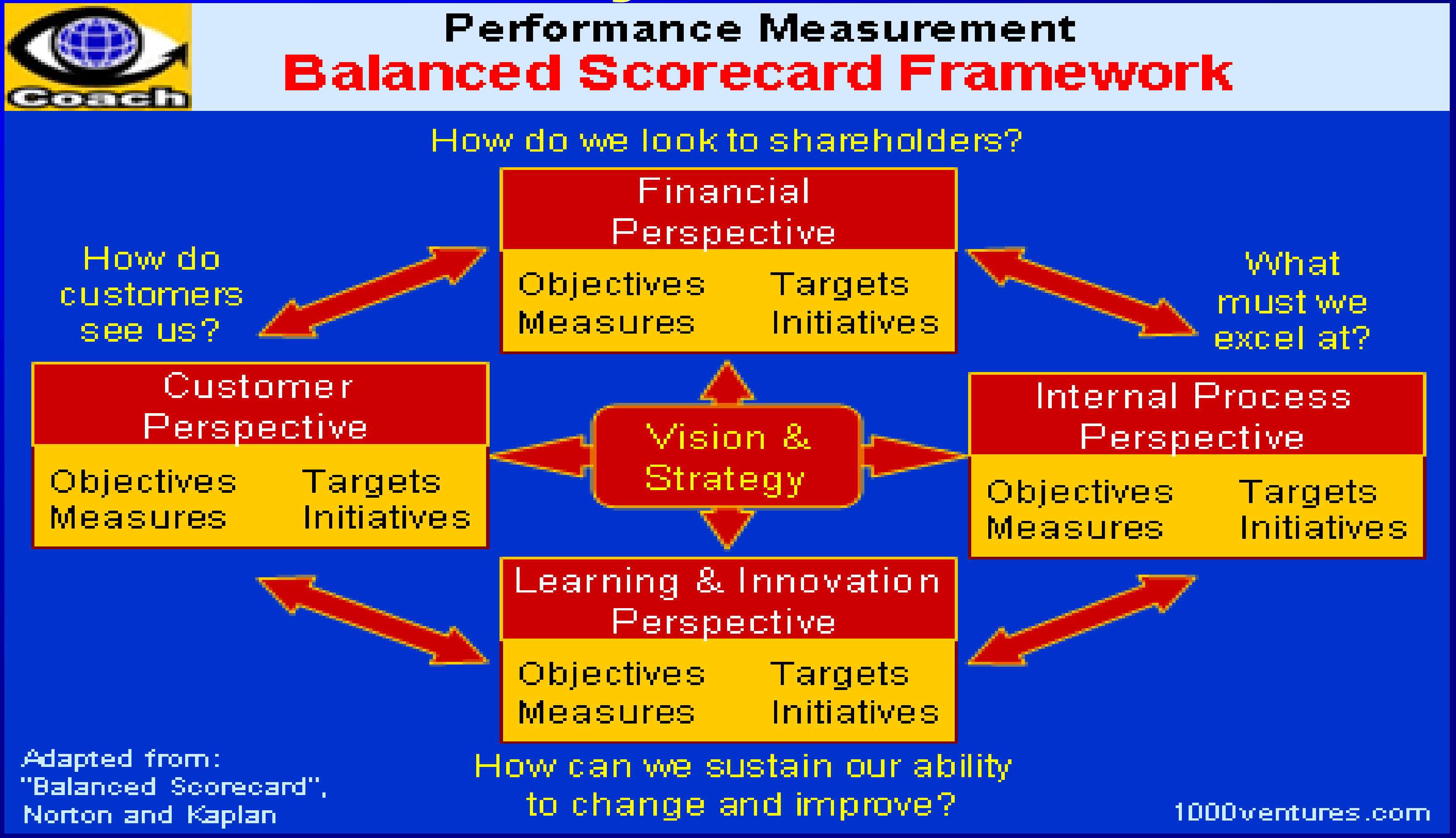
Goals and Measurement Myths and Facts - 2

- Watts Humphrey
  - Undisciplined or unmotivated people can not do timely or predictable intellectual work; quality work is not done by accident
  - Disciplined and motivated people need aggressive goals
  - Support goals with specific programs and plans
  - You can’t easily tell the quality of a program, but you can ask if it was properly developed
  - If measures can not detect one-day slip, you can not anticipate problems and prevent them
  - Defining measures is not always easy, but it is almost always possible
  - Business is prediction

SEPG and Top Management

- SEPG has highly visible responsibility for improving organization process capability and achieving high maturity level certification
- Software Process Improvement (SPI) and high maturity level achievement are long term propositions
- Management has short term expectations
- The language of top management: money, return on investment, customer satisfaction, business objectives
- No direct linkage between SPI goals and business objectives
- Only common agreed upon goal– desired maturity level by a mandated date

Linking SPI Goals and Business Objectives



Source:1000ventures.com

AIS Business Strategic Objectives

Our Purpose:
Continuously advance the boundaries of quality

OBJECTIVES

FINANCIAL	CUSTOMER	EMPLOYEE	INTERNAL BUSINESS PROCESS	LEARNING & GROWTH
Consistently meet or exceed shareholder expectations for • Revenue growth • Profitability • Valuation increase	Consistently meet or exceed customer expectations for • Defect free delivery • On-time delivery • Value for products & services	Consistently meet or exceed employee expectations for • Training • Compensation • Communication • Work environment • Performance management • Career development	• Individuals achieve the highest possible quality in their work products • Individuals and teams achieve results for effort, schedule, and defects within the known range of their process capability • Continuously optimize organizational processes	• Invest in people, process, and technology to enable achievement of customer, employee, and shareholder satisfaction goals • Innovate and offer new products and services

AIS BSC Core Outcomes, Performance Drivers

FINANCIAL	CUSTOMER	EMPLOYEE	INTERNAL BUSINESS PROCESS	LEARNING & GROWTH

CORE OUTCOMES – LAGGING INDICATORS

•Quarterly increase
•Annual va increase

•Customer feedback indicating met or exceeded customer expectations for:
- Quality
- Timeliness
- Value for Products & Services

oducts with less than or equal to rework effort
oducts with zero post development

ments with actual effort equal to or
n committed effort
ments with actual schedule equal to

g
e
sed

•Monthly percent of revenue from targeted customers
•Monthly percent of revenue from targeted services
•Monthly percent of employees meeting or exceeding their budgeted revenue target

•Defect free delivery
•On-time delivery

less
fied

•Individuals following the PSP
•Work products with targeted percent of defects removed before peer review

P
cts being
ket needs

Linkage Between Internal Business Process, Customer and Financial Perspectives - 1

When *individuals follow the PSP*, they will develop *work products with targeted percent of defects removed before peer review* which will lead to *work products with zero post development defects* as well as *work products with less than or equal to targeted rework effort* thereby achieving the strategic internal business process objective –

Individuals achieve the highest possible quality in their work products

ais

Linkage Between Internal Business Process, Customer and Financial Perspectives - 2

This in turn helps project teams *deliver nearly defect free product on time* which leads to *Customer feedback indicating met or exceeded customer expectations for Quality, Timeliness and Value for Products & Services* which leads to achieving financial objective of *profitability and revenue growth*

Goal, Questions, Metrics (GQM)

Victor Basili’s six step process

1. Develop a set of corporate, division and project business goals and associated measurement goals for productivity and quality
2. Generate questions (based on models) that define those goals as completely as possible in a quantifiable way
3. Specify the measures needed to be collected to answer those questions and track process and product conformance to the goals
4. Develop mechanisms for data collection
5. Collect, validate and analyze the data in real time to provide feedback to projects for corrective action
6. Analyze the data in a postmortem fashion to assess conformance to the goals and to make recommendations for future improvements

SEPG Role

- We motivated SEPG to
  - Focus on achieving business objectives and not just achieving a maturity level
  - Use GQM to determine what measurements are needed for leading/lagging indicators
  - Present “vital few” project and organization data along with process maturity and process improvement information
  - Speak the language of top management

What SEPG Accomplished

- Identified 23 organizational level metrics related to 9 BSC objectives
- Identified 7 project level goals, questions, and metrics
- Collected the data systematically during phase reviews and project postmortems
- Presented the data in Quarterly Status Reviews

AIS GQM Example - 1

Goal (objective)	To consistently meet or exceed customer expectations for defect-free delivery
Question	Have we met or exceeded customer expectations for defect-free delivery?
Metric (Measures)	# of Customer Feedback Forms # of Customer Feedback Forms with exceeded needs or met needs for quality # of post-delivery defects
Source of Goal	BSC - Customer
Source of Measures	Customer Feedback Form indication of exceeded needs or met needs for quality SEPG Data Collection Form
How Reported	QSR by SEPG
Current Capability	90%
Target	Goal - 100%

AIS GQM Example - 2

Goal (objective)	Individuals achieve the highest possible quality in their work products
Question	Have teams produced -work products with less than or equal to targeted rework effort? -work products with zero post development defects?
Metric (Measures)	Estimated rework effort vs. actual rework effort # of work products with 0 post-development defects # of Acceptance test defects
Source of Goal	BSC - Internal Business Process
Source of Measures	Project’s planned rework effort vs.. actual rework effort from tracking tool # defects found in peer review and beyond
How Reported	QSR - Components with 0 post unit test defects; acceptance test defects per KLOC by SEPG
Current Capability	Average AT defects = 0.311/KLOC
Target	Goal 100% at 0 AT defects

AIS GQM Example - 3

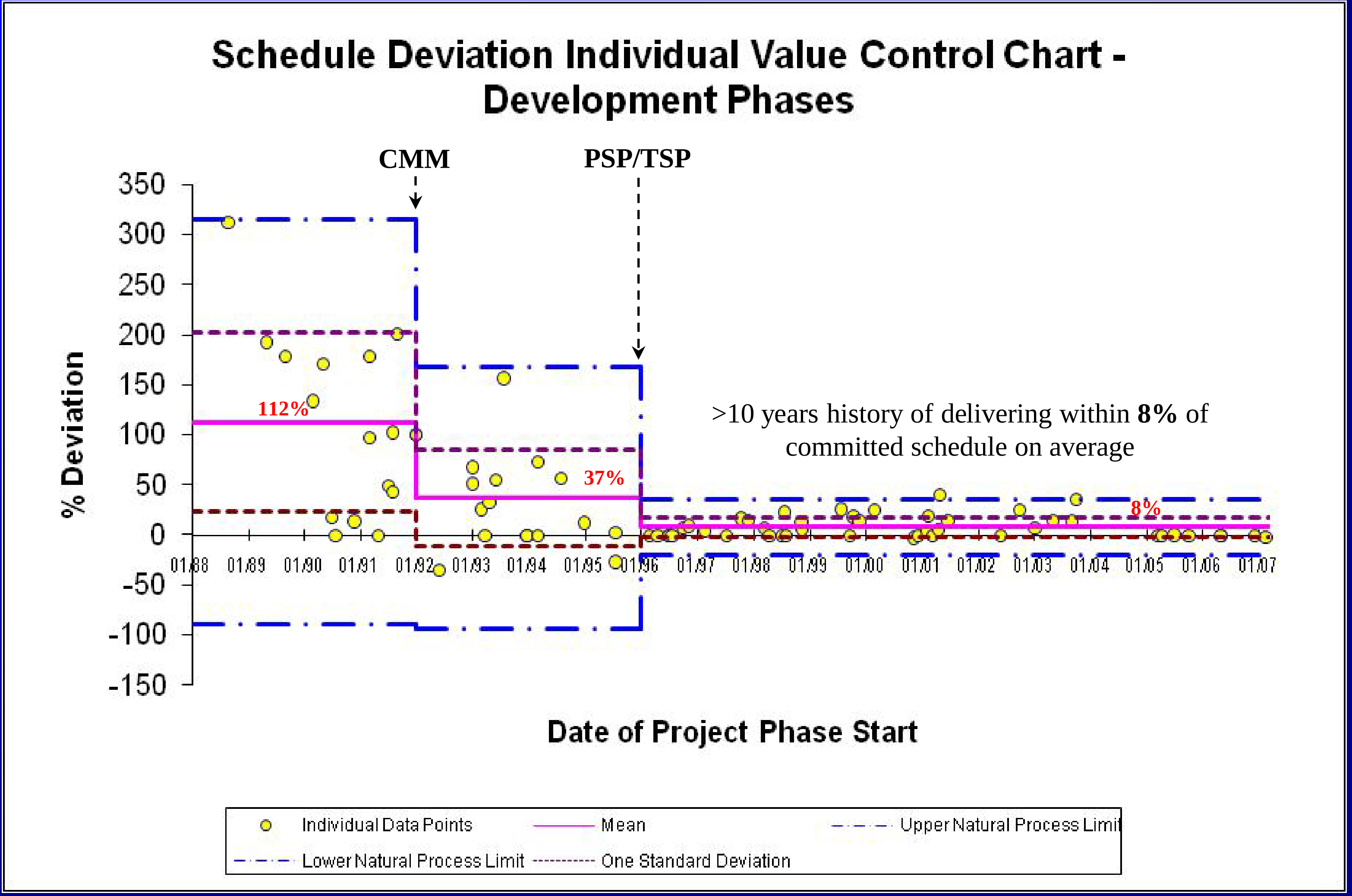
Goal (objective)	Individuals and teams achieve results for effort, schedule, and defects within the known range of their process capability
Question	What is the organization's range of process capability? Are the results in range?
Metric (Measures)	Planned vs. Actual effort, schedule; variance
Source of Goal	BSC - Internal Business Process
Source of Measures	SEPG Data Collection form
How Reported	QSR - Effort deviation; Schedule deviation; Effort Commitments; Schedule Commitments by SEPG
Current Capability	Average deviation - Effort - 9.44, Schedule - 14.06,
Target	100% within range

AIS GQM Example - 4

Goal (objective)	Deliver substantially defect free product
Question	Are we catching defects early in the lifecycle?
Metric (Measures)	Yields
Source of Goal	Project Manager/TSP
Source of Measures	SOLONsys*
How Reported	Weekly TSM
Analysis	On target?, action needed? Use PSP/TSP analysis methods.

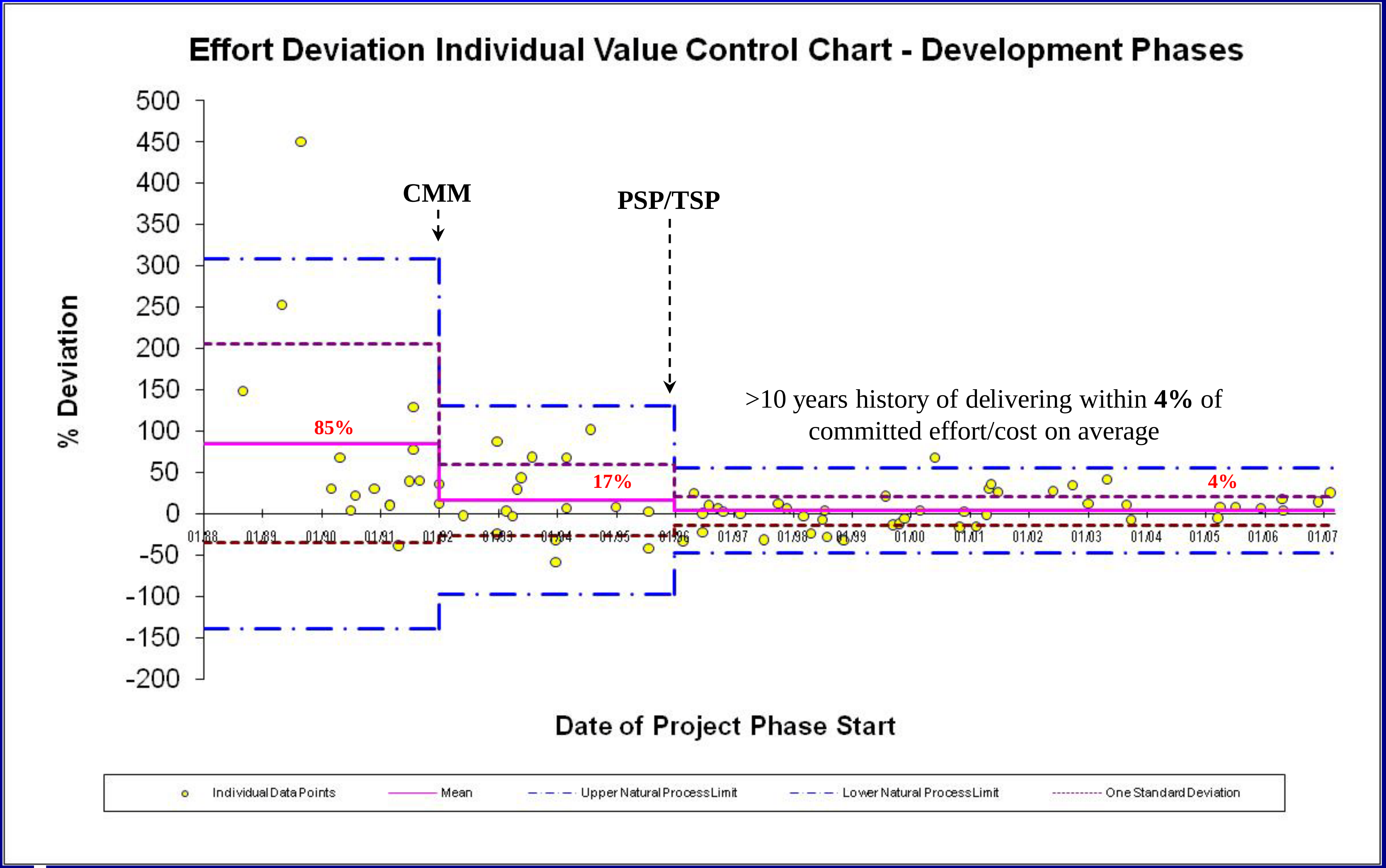
* AIS TSP Tool

AIS Value Proposition
Predictable Schedule



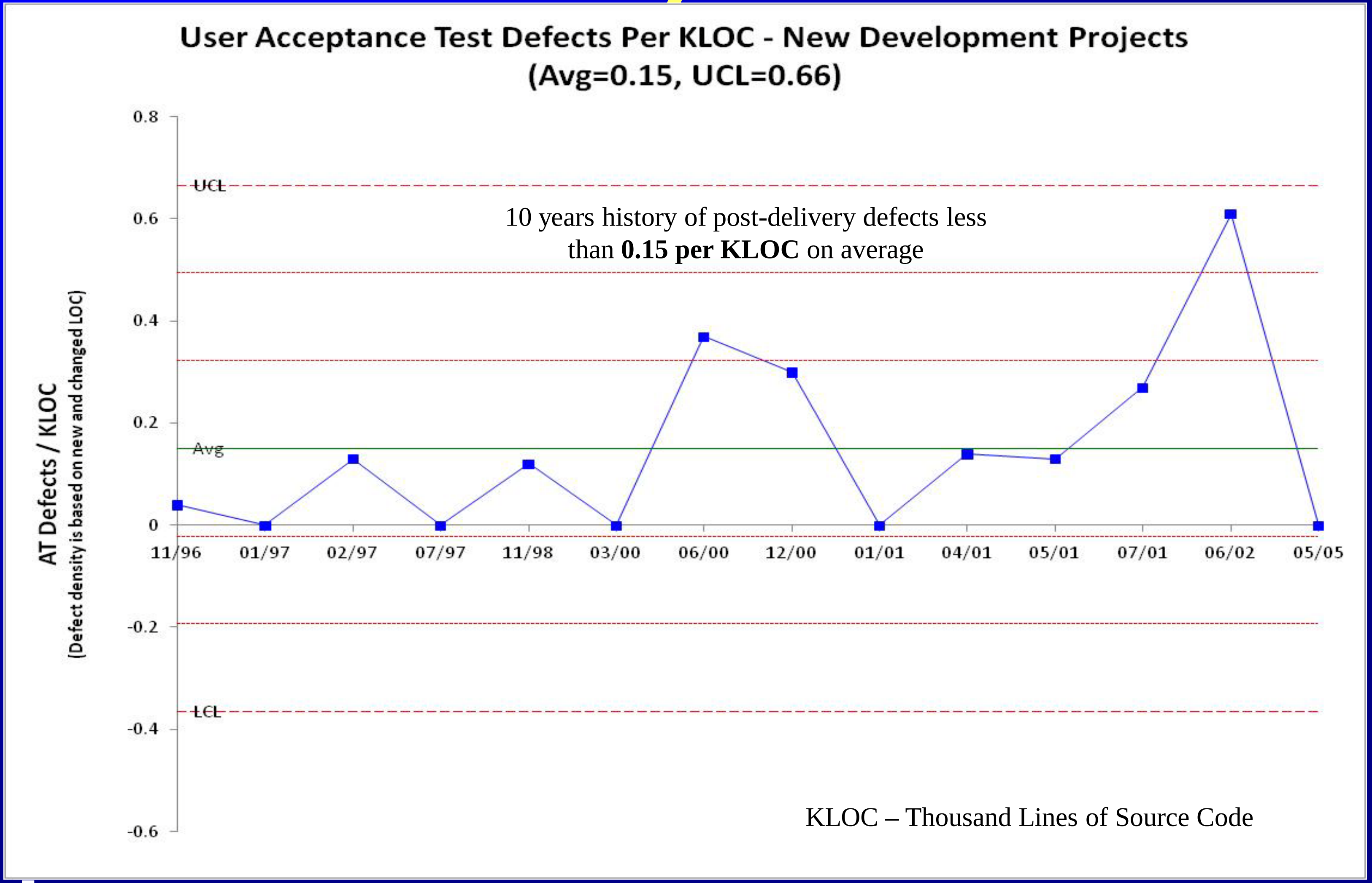
ais

AIS Value Proposition Predictable Cost



ais

AIS Value Proposition – Substantially Defect Free



ais

Lessons Learned - 1

- Keep BSC objectives simple
- Top management must articulate financial, and customer perspectives
- Brainstorm with employee participation
  - Cause and effect between internal process / learning objectives and customer / financial objectives
  - Lagging, leading indicators

ais

Lessons Learned - 2

- Motivate employee part time participation in SEPG activities as broadening assignment in career development
- PSP training is key to transitioning to culture of precision and accuracy in data collection/analysis
  - Basic data – size, time, defect
- Assign SEPG the responsibility for quarterly status reviews and presentation of “vital few” organizational and project data

ais

Lessons Learned - 3

- Include BSC objectives in new employee orientation
- Provide direct linkage by aligning employee objectives to BSC strategic objectives
- Aligning business goals such as market share, win/loss ratio of new business etc to process and employee objectives is not easy
- Keep everyone focused on business results; maturity level is not an end in itself

What does

"FUN ON THE JOB"

Mean to you?

Contact Information

Girish Seshagiri

Advanced Information Services Inc.

(703) 286 0781

Email: girish.seshagiri@advinfo.net

Website: www.advinfo.net

ais

SPAWAR Systems Center ATLANTIC

Sustainment and Continued Institutionalization of Best Practices and CMMI® at SPAWAR

Michael T. Kutch, Jr
SPAWAR Systems Center Atlantic
Head, ISR/IO/IA & Cyber

Mike Knox
Technical Software Services, Inc. (TECHSOFT)
Director, Engineering Process Services

NDIA Systems Engineering Conference - Oct 28, 2009

Presentation Outline

- ▼ Intro to SPAWAR
- ▼ SPAWAR Systems Center Atlantic CMMI® History
- ▼ Post ML3 – Now What ?
- ▼ Sustainment & Institutionalization
- ▼ Multiple Methods
- ▼ 2010 and Beyond
- ▼ Lessons Learned

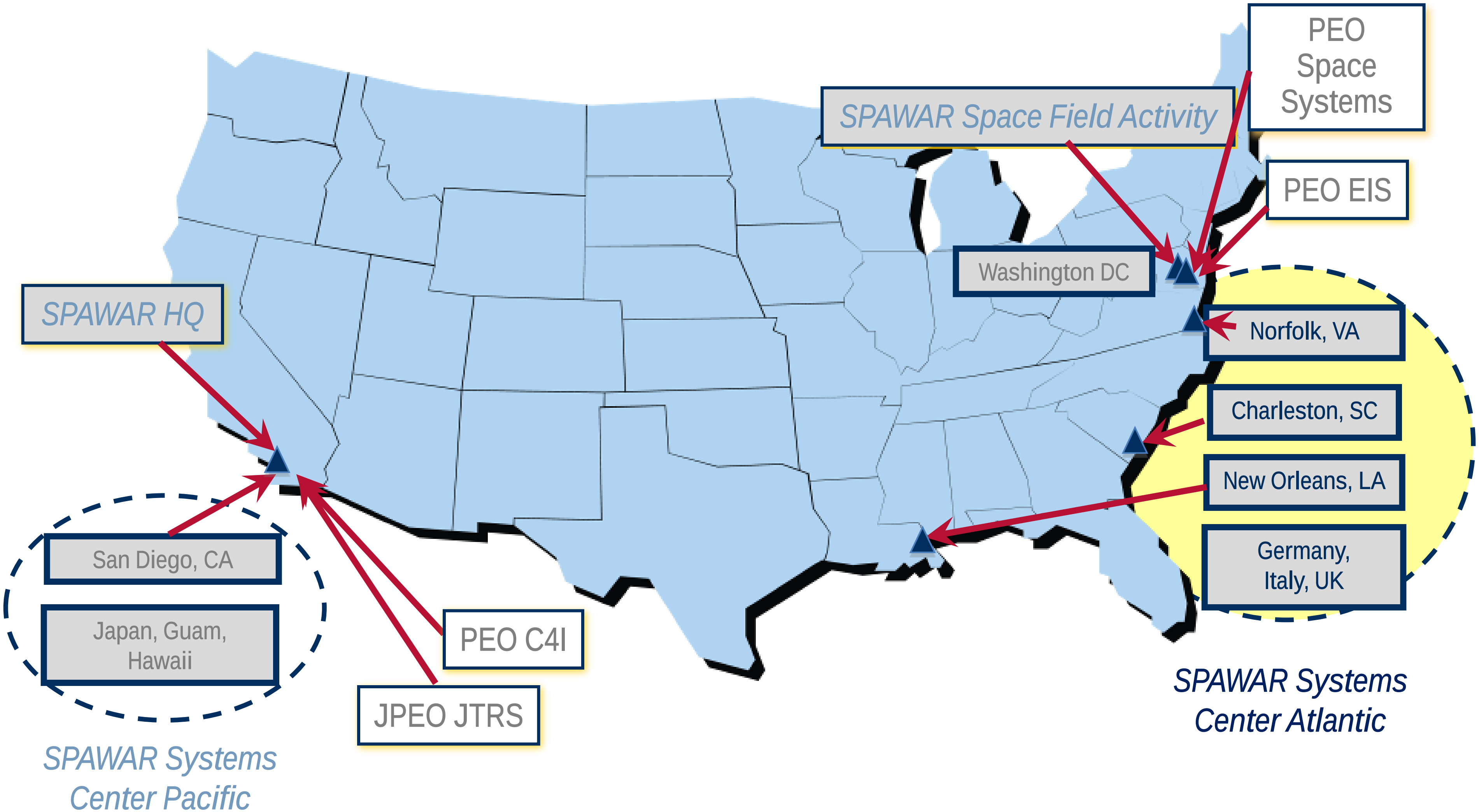
SPAWAR
Systems Center
ATLANTIC

Space and Naval Warfare Systems Command
Intro to SPAWAR – Who We Are

- Navy's Technical Authority and acquisition command for C4ISR*, business IT, and space systems
- Provide quality full-service systems engineering and acquisition to rapidly deploy capabilities to the Warfighter
- More than 12,000 employees and contractors deployed globally and near the fleet
- $9.869B Organization

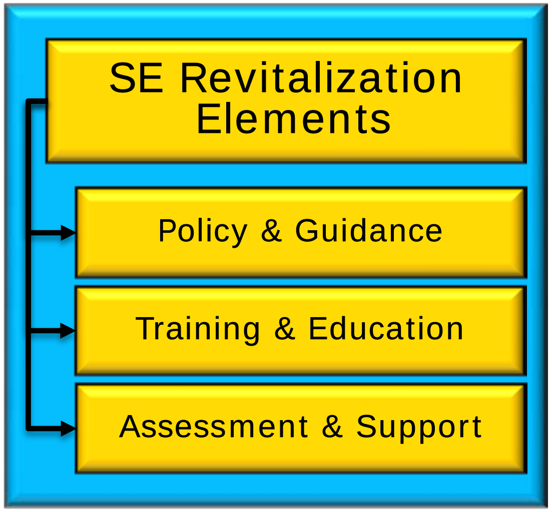
*Command, Control, Communications, Computers, Intelligence, Surveillance & Reconnaissance

Intro to SPAWAR – Where We Are



SPAWARSYSCEN Atlantic CMMI History: Process Improvement Approach

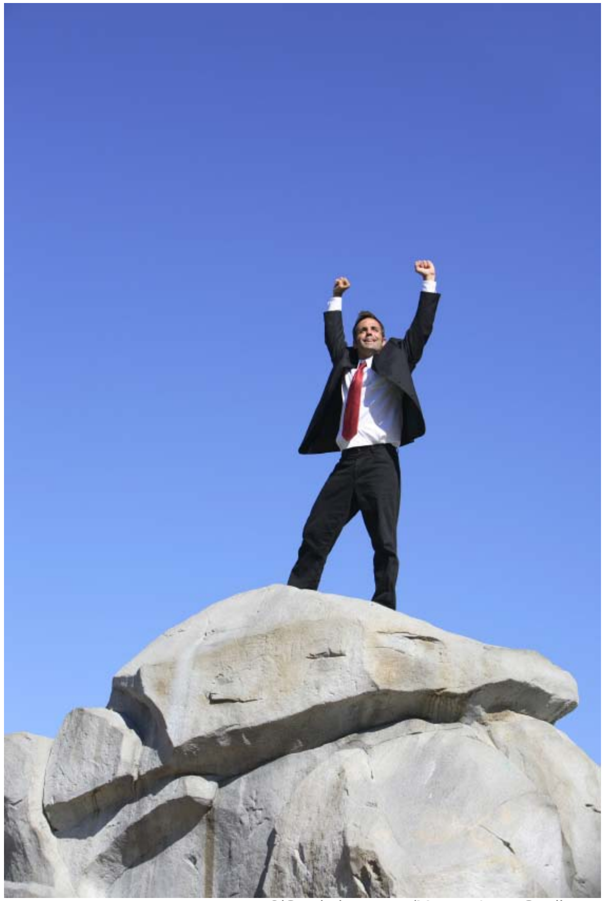
- Aligned with common issues/themes from DoD SE Issues Lists
  - Need for SE Revitalization, Engr & Proj Mgmt Guidance, & Training
- Selected CMMI as assessment model
- Selected broad variety of pilot projects
- Developed Organizational infrastructure, templates, and tools
  - Processes assigned/owned by Integrated Process Teams
- Conducted extensive Training – SE, Proj. Mgmt., CMMI, Risk Mgmt.
- Coaching & Mentoring
  - Organization and project level
- Frequent benchmarks – Class C, B, A appraisals
  - Publicized successes



SPAWARSYSCEN Atlantic CMMI® History: Timeline of Success

▼ Process Improvement Timeline

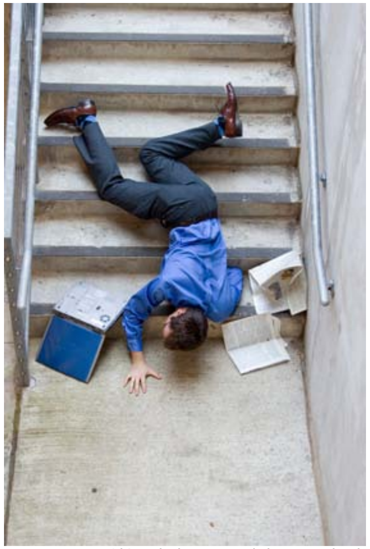
- 2001-2003 – Figuring it all out
  - Pilot projects; Initial CMMI® training
  - 20-30 projects working on Level 2 processes
  - Trained over 800 employees
- 2004/2005 – Shift to SE focus (not CMMI®)
  - Project level benchmark SCAMPI A appraisals
  - Heavy Training continued – SE, PM, CMMI®
  - Integrated Process Team (IPT) infrastructure established for process ownership and sharing
  - Successful ML2 SCAMPI A (Charleston)
- 2006/2007 – Similar 2-year approach for ML3
  - "Focus" and "non-focus" projects
  - Successful ML3 SCAMPI A (Charleston, Tidewater)
- 2008 – Command Consolidation (Charleston, Tidewater, New Orleans)
- 2009 – Successful ML3 SCAMPI A (New Orleans)



©iStockphoto.com/Morgan Lane Studios

Post ML3 – Now What ?
Continuous Process Improvement !

- What did that mean?
  - High Maturity (ML4/5)? - Logical next step
    OR
  - Institutionalization and broader exposure?
- Pushed both agendas
  - Educated on high maturity processes & measures
    - Existing data not complete, clean or detailed
    - Lack of agreement on common measure
  - Developed internal assessment for new "CMMI® projects"
- End Result
  - Splintered message; overtaxed resources; loss of focus
  - Realization - Not Ready for High Maturity
  - Danger of slipping back!



Post ML3 – Now What?
Continuous Process Improvement at ML3

Sustainment (Project Level)

- Like Diet Maintenance
  - Keep the Discipline
- Fix/Improve weaknesses
  - Peer Reviews
  - Measurement
- Regular Monitoring and Control
  - Active Quality Assurance
  - Contribute to Organization PAL
- Seamless shifts/changes
  - Project phases
  - Team members
- Internal improvements

Institutionalization (Org Level)

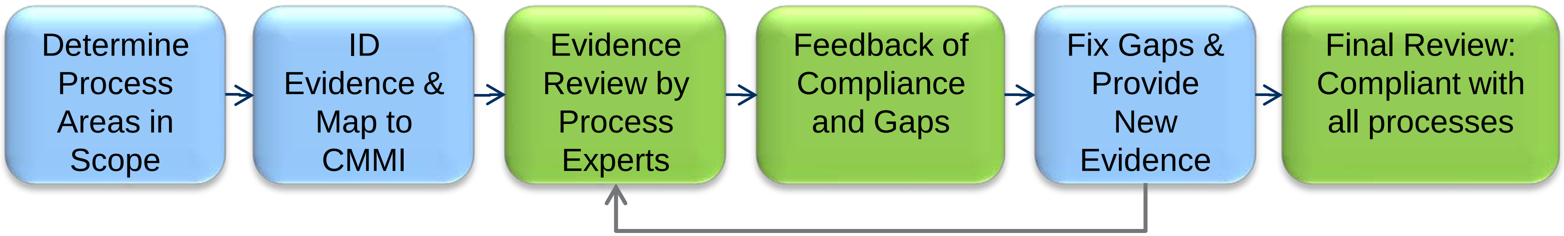
- Grow and spread usage
  - Convert the non-believers
  - Apply to more/all projects
- Refine and Improve processes
  - Address “global” issues
  - Add detail where necessary
  - Institute control points
  - Consolidate the common
  - Simplify
- Integration
  - Lean Six Sigma
- Update infrastructure

Methods for Sustainment & Institutionalization

- CMMI® Internal Assessments
  - Less costly than SCAMPI A
  - Project, Program, Area scope
- New Project Initiation and Startup process
  - Improve initial scoping/planning
- Enhanced Reviews Process
  - SOPs and Checklists
  - Management Oversight Reviews
- Integrate with other initiatives
  - Lean Six Sigma
  - Technical Authority
  - Navy ERP (SAP)
- Maintain infrastructure
  - Process Maintenance by IPTs
  - Adapt to changing organization
- Continue Training
  - CMMI
  - SE, Integrated Risk Mgmt
  - Project Initiation
  - Reviews
- Measure
  - Internally Assessed Projects
  - Reviews
  - Other Maturity Models
- Spread News of Success

Methods for Sustainment & Institutionalization- CMMI® Internal Assessment

- Typically, at Project or Program level
  - Full body of evidence and artifacts required
  - Not a single event, but an assessment over time with gap analysis and multiple feedback loops
  - By objective CMMI® -trained resources (1 or 2)
- May not assess all CMMI® ML3 process areas
  - Allows for focusing / scaling to most beneficial areas
  - Minimum core areas – Project Mgmt, Requirements, Risk, CM



Methods for Sustainment & Institutionalization- CMMI® Internal Assessment

▼ Outcome

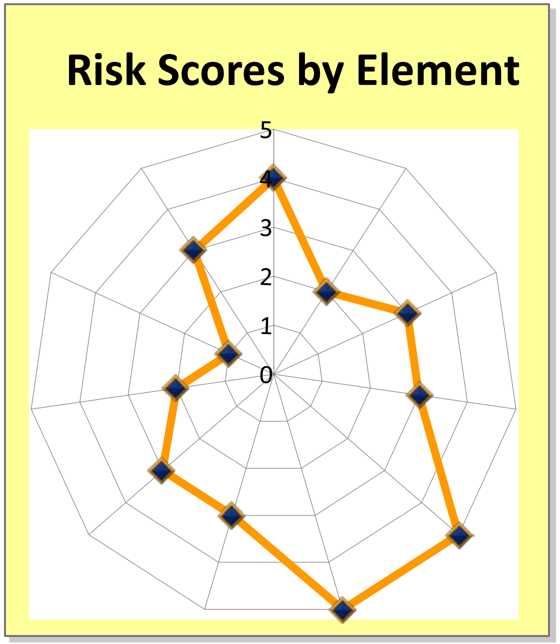
- Validates that project/program is following CMMI® best practices
- Recognition – Process Excellence certificate
  - NOT a Maturity Level (or CL) rating, but high probability that project would achieve the corresponding rating if SCAMPI A assessed

▼ Benefits

- Expansion of best practices
- Broadens participation
  - Suitable for all sizes
  - Tailorable for non-Development
- Projects experience improvement first hand
- Incremental approach

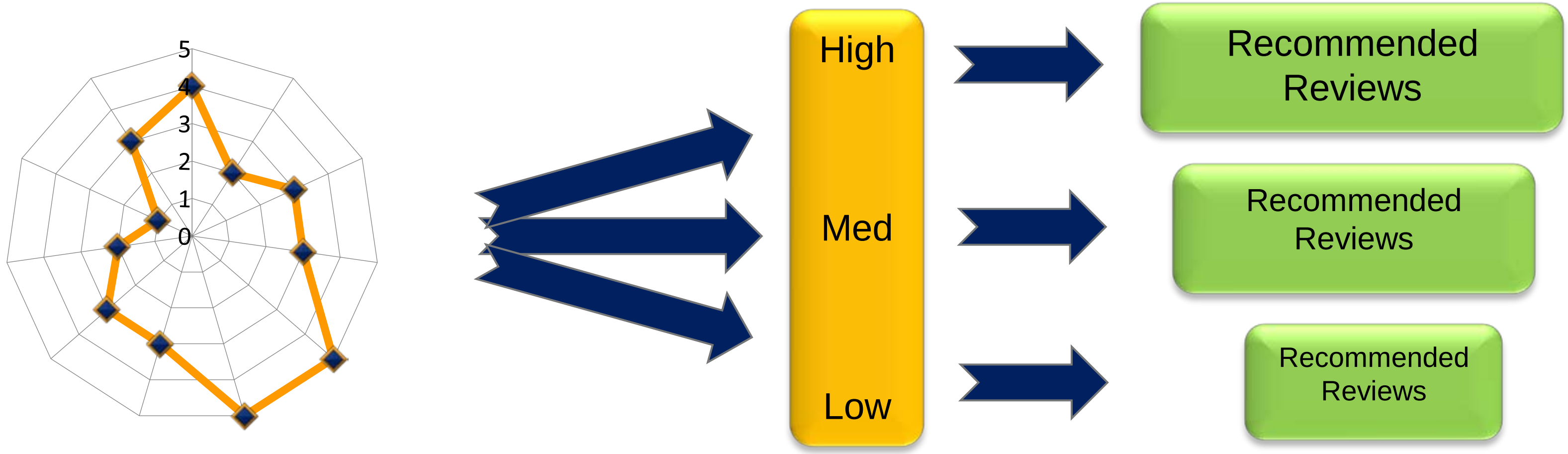
Methods for Sustainment & Institutionalization- Project Initiation Request

- How to get new projects to determine right amount of SE and Project Planning needed?
  - SPAWAR is too diverse for canned "tailoring scenarios"
- Objective method to assess potential risk was needed
  - Often, small projects with high visibility had big execution issues
- Project Initiation Request (PIR) process:
  - Profiling questions: Visibility, Teaming complexity, Impact of failure, Quality of requirements, Technology dependency, Project leader experience, Similarity to other projects, Funding issues, Schedule drivers, etc.



Methods for Sustainment & Institutionalization- Enhanced Reviews Process

Risk Profile Score … Drives Level of Rigor … and Recommended Reviews



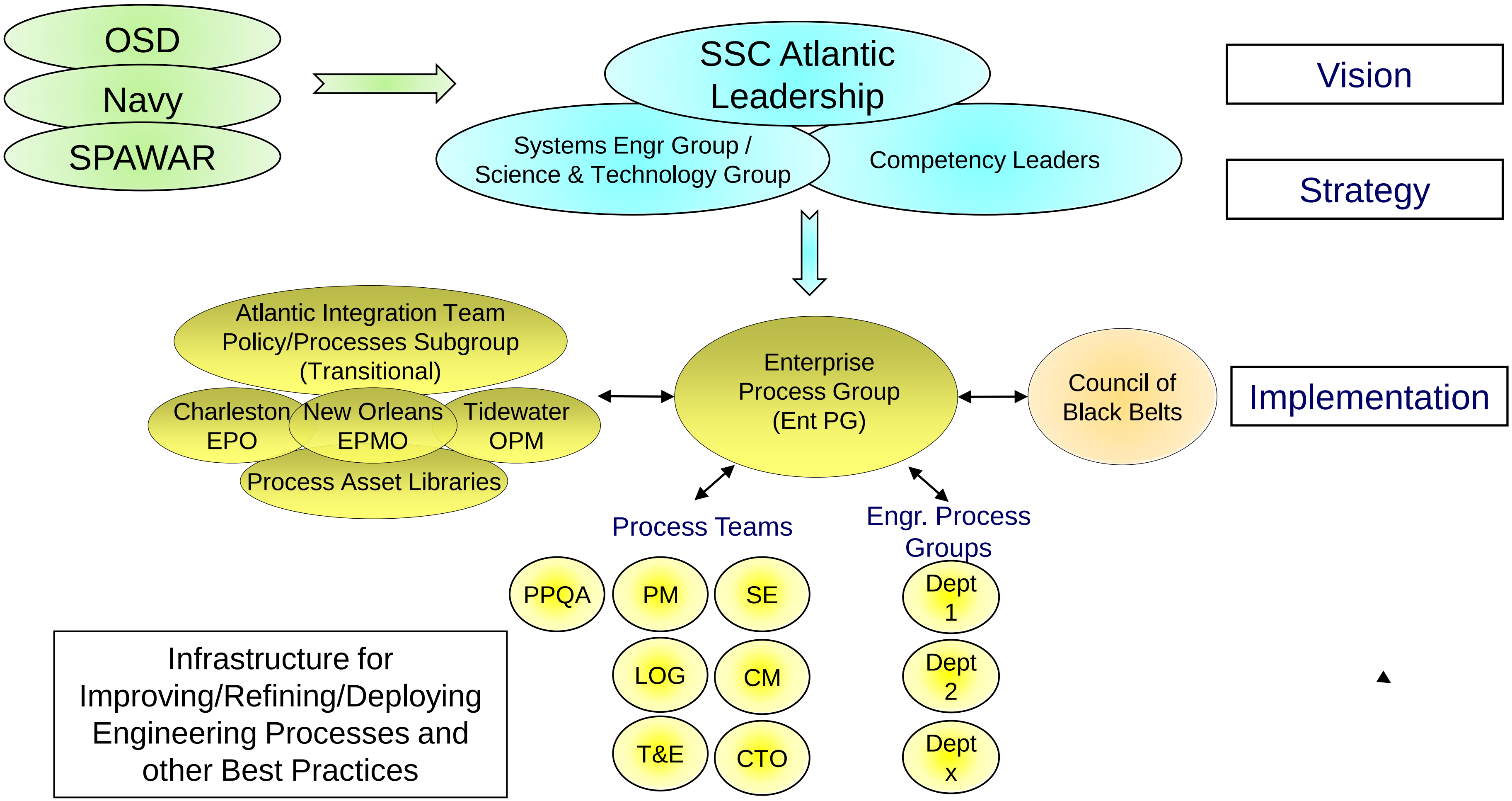
- **What we are doing:**
  - Built a flexible reviews process scalable to managerial needs and/or project size
  - Emphasizing ACAT SETR type reviews for non-ACAT programs
    - Tailored Review Checklists
  - Improved Review tracking

- **What we are gaining:**
  - Well-defined triggers to spawn higher level reviews
  - Continuity in management and SE across the command
  - Identifying opportunities to increase net readiness of product

Methods for Sustainment & Institutionalization- Integrate with Other Initiatives

- Lean Six Sigma
  - Enabler for Continuous Process Improvement
    - Tools and Structure (DMAIC)
- Technology Authority
  - Utilize "warranted" experts on technical reviews (SETRs)
  - Scaling down ACAT/POR SETR checklists for non-Program of Record projects
- Navy ERP
  - Linking completion of Project Initiation to release of funds in ERP
  - ERP to improve cost and schedule measurement/monitoring

Methods for Sustainment & Institutionalization-Maintain Infrastructure



Methods for Sustainment & Institutionalization- Command Funded Training

- Introduction to CMMI®
  - 3-day Introduction to CMMI® course with SPAWAR flavor
  - Students learn how the best practices build and relate across process areas
- Systems Engineering Fundamentals, Integrated Risk Management
  - Multi-day, on-site, classroom courses
  - Based on SMU SE Masters courses
  - Customized to incorporate SSC Atlantic SE process
- Project Initiation, Self Assessment
  - 2-day Project Initiation, Review Process & CMMI Internal Assessment workshop
- Lean Six Sigma - # of Active Belts
  - 40 Black Belts, 217 Green Belts, 260 Yellow Belts
- Web-Based Engineering Modules

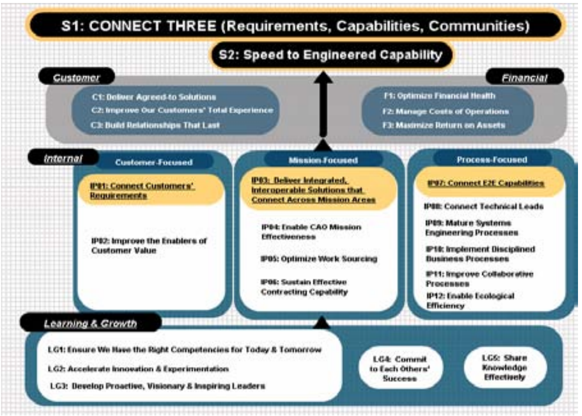
"Thought provoking, motivating, and challenging. Learning basic SE caused me to brainstorm many different applications of organized system processes. It motivated me to want to begin organizing its application. It also challenged me to apply GOOD SE practices in order to successfully be more efficient in the process.."

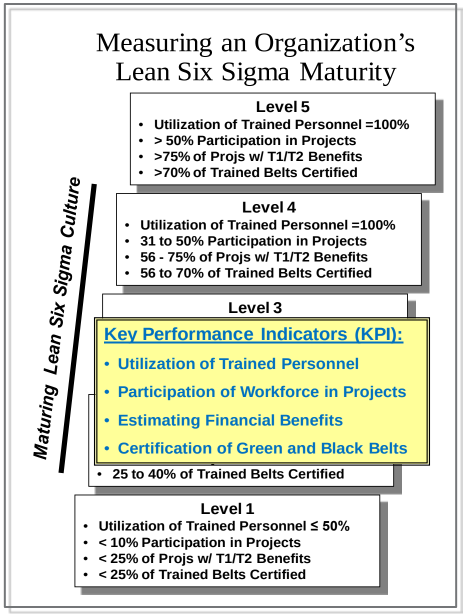
"It was extremely beneficial to have a professor with extensive knowledge of the subject matter and one who could apply it to the SPAWAR methods."

Student Feedback

Methods for Sustainment & Institutionalization- Measure

- **Balanced Scorecard – Quarterly/Annual targets**
  - Number of CMMI® Assessed Projects
  - Project Initiation Usage
  - Reviews Tracking
  - ForceNet – Fully Netted Force (FnF) and Fully Netted Resource (FnR) assessments
- **Lean Six Sigma Maturity Model**
  - Maturity Model framework is easy to understand
  - Assesses levels of training, certification, participation, and utilization
- **Documented Processes**
  - # of processes and procedures documented using Oracle Tutor tool





Methods for Sustainment & Institutionalization- Spread the Word

- Systems and Software Engineering Newsletter (S^{2}E News)
  - Informs folks of latest improvements/initiatives
  - Spreads the word on upcoming training or events
  - Recognizes projects for their achievements

2010 and Beyond

- CMMI® Maturity Level 3 Appraisal/Re-appraisal
  - 1st for new SSC Atlantic organization
  - All sites comprising Atlantic achieved ML3 previously
  - Challenge to show integration and alignment to Atlantic standard organizational processes
- CMMI® for Services
  - Begin implementation of new Services constellation
  - Appropriate for many projects/programs in SPAWAR
    - Software Help Desks, Data Centers, Network Management
- Leverage Navy ERP
- Consolidation and Integration of process assets to single process asset library

Lessons Learned

- No room for complacency
  - Must keep focus on continuous process improvement
  - Maintain high standards; don't dilute the effort

©iStockphoto.com/Lisa Gagne

- Sharing isn't "natural"
  - Successful projects are often focused on remaining successful and may ignore the "outside"
  - Need intermediaries to help push/pull, make sharing easier
- Continue to refine the "how do I …"
  - Models and high level processes say "what to do"
  - Workers want to know how to do it
    - Templates, Checklists, Examples, Options
- Even the Resistors can be converted
- Process Improvement is a marathon - Be the Tortoise

Thank You !

Michael T. Kutch, Jr
SPAWAR Systems Center Atlantic
Head, ISR/IO/IA & Cyber

Mike Knox
Technical Software Services, Inc. (TECHSOFT)
Director, Engineering Process Services

On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems

S. Balestrini-Robinson
Research Engineer
Georgia Institute of Technology
Atlanta, GA 30332
santiago.balestrini@asdl.gatech.edu

J. M. Zentner
Research Engineer
Georgia Tech Research Institute
Atlanta, GA 30332
zentner@gatech.edu

T. R. Ender
Research Engineer
Georgia Tech Research Institute
Atlanta, GA 30332
tommer@gatech.edu

12th Annual Systems Engineering Conference
National Defense Industrial Association

October 26-29, 2009
San Diego, CA

Georgia Institute of Technology

The Need for Modeling and Simulation

- System-of-Systems Engineering (SOSE) problems require a different approach than traditional Systems Engineering (SE)
- Good Modeling and Simulation is crucial to good Decision Making
  - Good decisions are based on good analysis
  - Analysis is based on models
- If models are not good → analysis will not be good → decisions won't be good either

Definitions

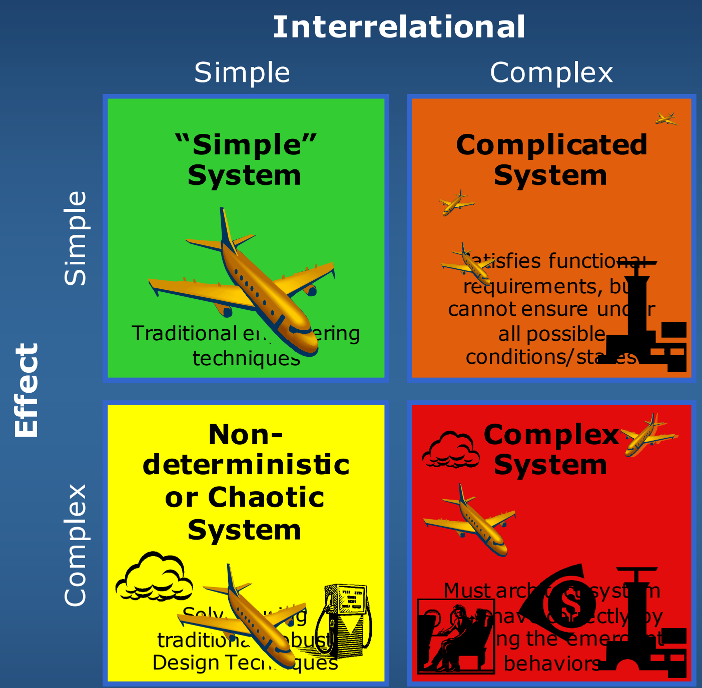
- System: a collection of components organized to accomplish a specific function or set of functions (IEEE)
- System-of-Systems: “a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities” [DoD Def. Acq. Guidebook 2004]
  - Emergent behavior, Evolutionary Development, Operational Independence of the Elements, Managerial Independence of the Elements, Geographic Distribution [Maier1996]
- Family-of-Systems: “A set or arrangement of independent systems that can be arranged or interconnected in various ways to provide different capabilities”

Definitions

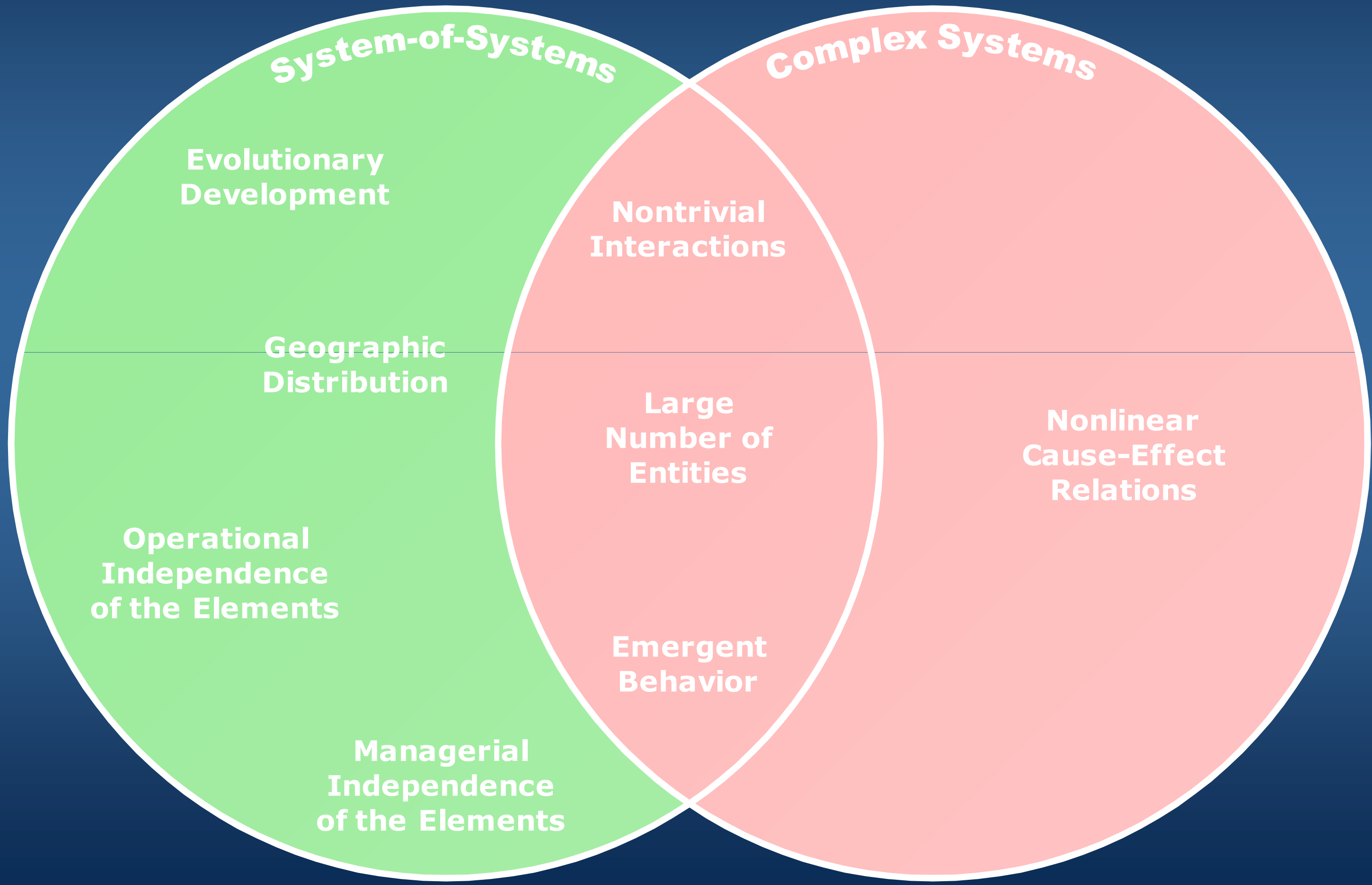
- Emergence
  - Macro level behaviors (patterns) that cannot be predicted from studying the micro level behaviors in isolation
- Modeling & Simulation
  - Modeling: A rigorous method for creating and testing models.
  - Simulation: The exercise--either statistically or over time--of a model.
  - Model: An abstract representation of a system developed to aid in the understanding and/or predicting of its behavior.
- Complex Systems
  - Systems composed of a (1) large number of entities, with (2) non-trivial interaction networks (not too simple or too complete) , whose (3) impacts on one another are non-linear, and whose overall behavior tends to display emergent characteristics

What is a Complex System?

- “A whole comprehending in its compass a number of parts, *esp.* (in later use) of interconnected parts or involved particulars; a complex or complicated whole” [Oxford English Dictionary]
- Definition (Interrelational)
  - A system composed of
    - a large number of (heterogeneous) entities
    - interacting nonlinearly
    - of the parts through non-trivial networks
    - which produce a macro-level pattern that cannot be inferred from the analysis in isolation
- Definition (Effect)
  - “A measure of uncertainty in understanding what it is we want to know or in achieving a functional requirement” [Suh2005]
- “It is exceedingly difficult to discern causality in a complex system from observation alone… Researchers must watch a very large number of [events] before the patterns become evident” [Cares2005]

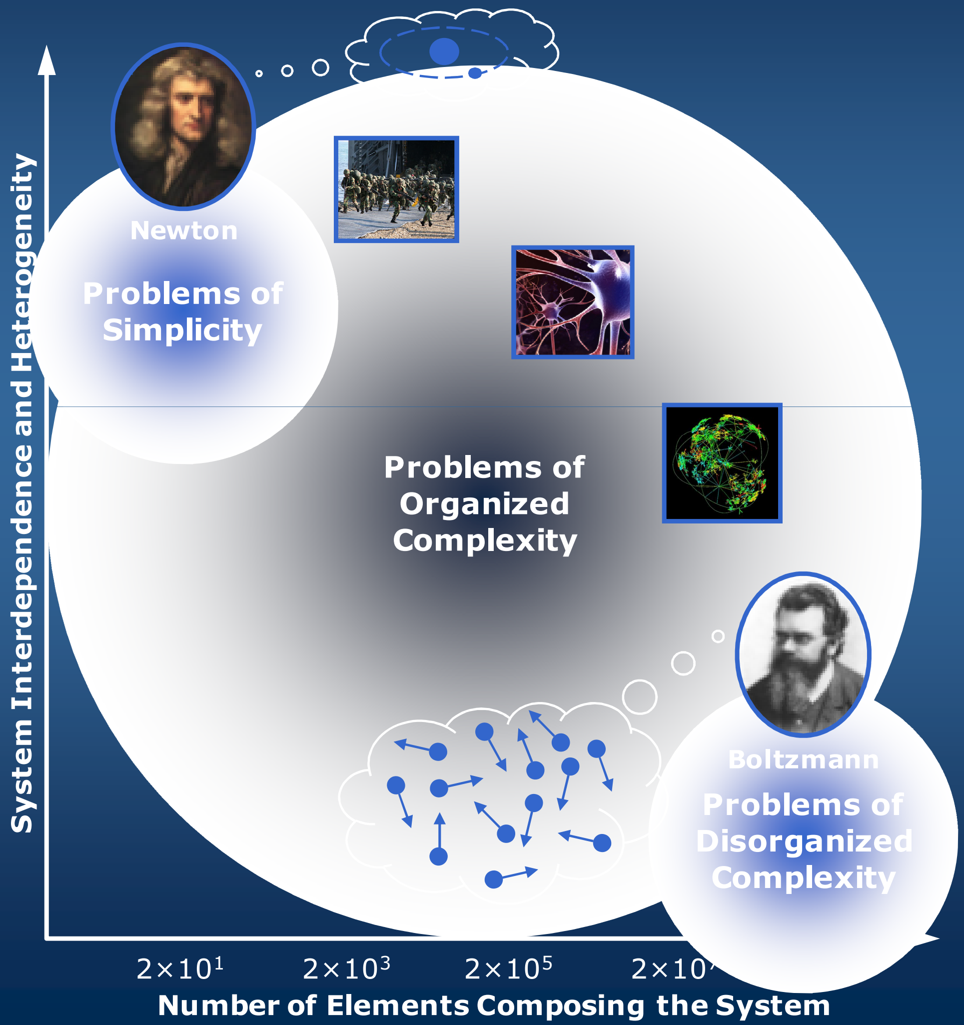


Complex System vs. System-of-Systems



The Evolution of Science towards Complexity

- In 1947, Weaver analyzed the history of science from the 17th century and noticed a pattern
- Recognizes that there were two main efforts until then
  - Between the 17th and 19th centuries science focused on problems with only a handful of variables (< 4)
  - In the 20th century statistical methods were developed to handle problems with large number of variables (> 10^9)
- This left a considerable range of the problems faced by science without solid foundations
- The advent of the computer enabled the study of the area in-between the two camps
- This in-between field has come to be known as *complexity science*



Modeling Techniques

- Experts undergoing efforts to develop an ontology of simulation techniques
  - to establish a common vocabulary and capture domain expert knowledge
  - Current efforts centered around sub simulation categories,
    - e.g., Discrete Event Simulation Taxonomies*, Agent-based Simulation Taxonomies†
  - Still no definite general simulation taxonomy
- Mental Models
  - We can only take a few factors into account when making a decision
  - Suited to linear problems
  - ([Hogarth1987], [Kahneman1982])
- Spreadsheet (a.k.a. List) Models
- Case Studies
- Computer Models
  - Optimization Models
  - Econometric Models
  - Simulation Models (not all inclusive)
    - Network Analysis
    - Markov Simulation
    - Petri Net Simulation
    - Discrete Event Simulation
    - Dynamical Systems
    - System Dynamics Simulation
    - Cellular Automata
    - Agent-based Simulation

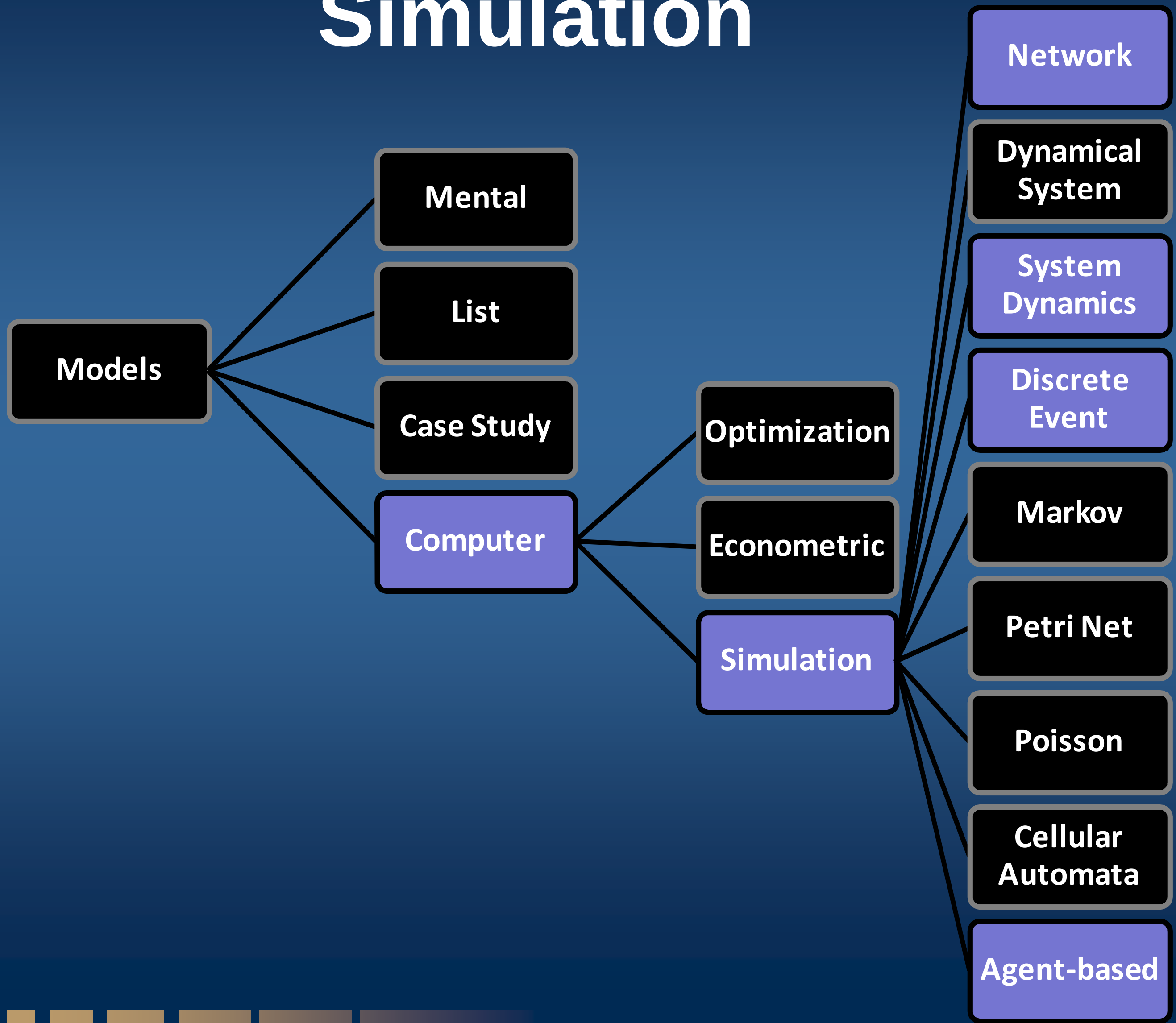
Model for insights, for explanation, not numbers

* [Sulistio2004], [Fishwick1998], [Fishwick2004], [Miller2004], [Silver2006]

† [Brenner2007]

List of techniques based on [Ferguson2006], [Gustafsson2007], [Volovoi2004]

A Taxonomy of Modeling and Simulation



Evaluation of Simulation Techniques

Modeling Technique	Common Applications	Characteristics
Network Analysis	Biology, IT, telecommunications	Enables holistic analysis Space-time implicit
Markov Simulation	Queuing theory, statistical physics	Very Limited Scalability
Petri Net Simulation	Reliability, manufacturing, fault diagnosis	Limited Scalability
Discrete Event Simulation	Queuing theory, ecology, manufacturing	Efficient for sparse events Spatially implicit
Dynamical Systems	Electrical circuits, mechanics, e.g., RLC circuit, SMD system...	Used for Hi-Fidelity Modeling of physical systems
System Dynamics Simulation	Population, ecology, economy	Macro-level Analysis Spatially implicit
Cellular Automata	Ecology, real estate, artificial biology, self-replication	Spatially fix; Elements share the same rules
Agent-based Simulation	Ecology, population, artificial biology, combat simulation	Time and spatially explicit Scalability

Modeling Techniques for Complex Systems

- No ideal method
  - ***ABM*** most suitable, but most difficult to implement and validate
  - ***NM*** are the easiest to implement but do not capture the dynamic behaviors or intelligence
- Methods are not exclusive, but complementary
- Others techniques considered but not discussed:
  - Markov Simulation, Petri Net Simulation, Dynamical Systems, Cellular Automata

Complexity \ Technique	Network Models	Discrete Event Simulations	System Dynamics Models	Agent-based Models
Nonlinearity	Very Poor	Very Good	Very Good	Excellent
Interactions	Very Good	Poor	Poor	Very Good
Intelligent Agents	Very Poor	Poor	Poor	Excellent
Represent Hierarchies	Very Good	Good	Good	Excellent
Emergent Behavior	Poor	Poor	Poor	Excellent
Adaptation	Very Poor	Poor	Poor	Excellent
Dynamic Behavior	Poor	Very Good	Very Good	Very Good
Ease of Creation	Excellent	Poor	Good	Very Poor
Ease of V&V	Very Good	Good	Good	Very Poor

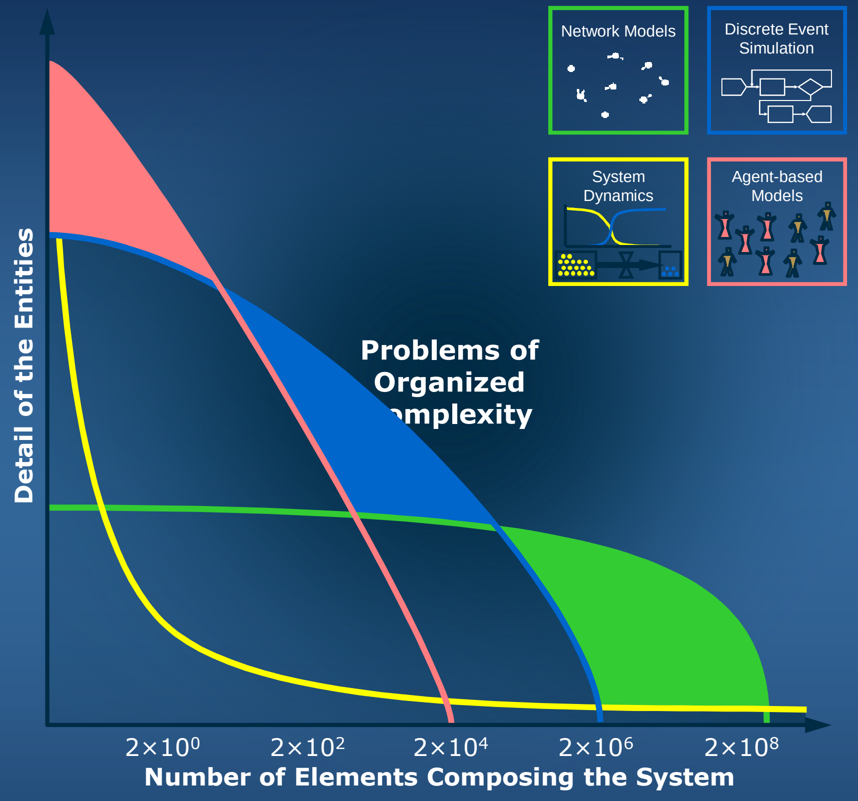
Legend: = Excellent = Very Good = Good = Poor = Very Poor

Complementary: Coarse modeling can guide detailed modeling

Modeling Techniques and the Paradigm of Complexity

- The question of how much can be modeled can be considered to be a question of
  - how many entities?
  - in how much detail?

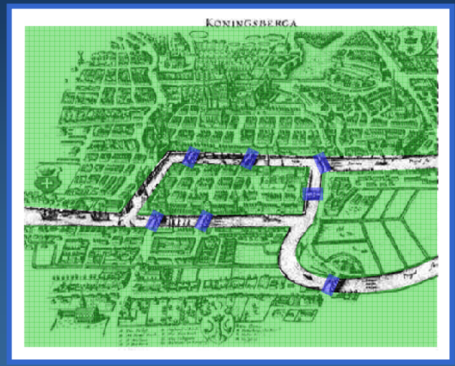
- The modeling techniques map to a distinctive Pareto-front in the continuum
  - Notional plot based on literature reviews of different applications of the modeling techniques
  - As more entities are modeled, the techniques require that the entities be simplified
    - System Dynamics is an exception, because in its pure form it assumes that there are an infinite number of entities
  - Anything in the below or to the left of the line is a dominated solution

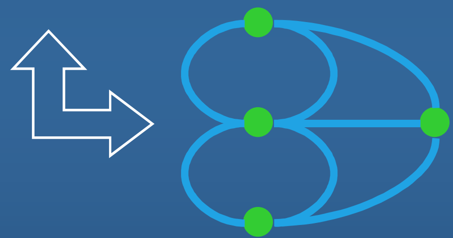


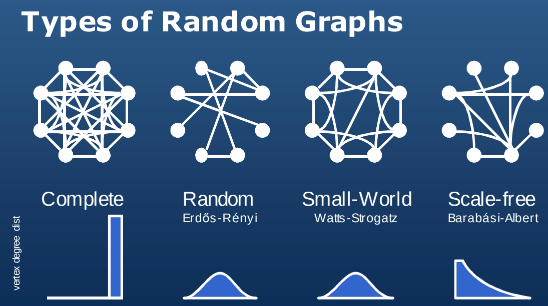
Large-Scale SoS → Network Models

Network Models

- In 1736 Leonhard Euler published *Seven Bridges of Königsberg* and gave birth to the study of graphs
- Graphs are "…mathematical structures used to model pairwise relations between objects from a certain collection"
- Depicted in diagrammatic form as a set of dots (for the points, vertices, or nodes), joined by curves (for the lines or edges)
- Different types of network models
  - e.g., Flow Graphs, Bipartite Graphs, Multi-layered Graphs, etc…
- Large number of algorithms to compute characteristics of the graph
- Suitable for capturing functional complexities, traditionally not suitable for capturing space and time dependent effects
- Recent efforts have developed algorithms for quickly generating random graphs that mimic characteristics of real networks
  - e.g., scale-free, small-world networks, etc..







Discrete Event Simulation

- Formulated by Geoffrey Gordon (1960s)
- "Modeling approach based on the concept of entities, resources and block charts describing entity flow and resource sharing" [Borshchev2003]
- "A global entity processing algorithm, typically with stochastic elements" [Borshchev2003]
- Primarily investigates the performance over time of an interconnected system subject to internal (e.g. process failure) and external (e.g. environmental conditions) random variability [Morecroft2006]
- Any model that requires free movement of entities or a very detailed movement pattern is not easily simulated with DES
  - No intrinsic capability to capture spatial effects
- Generally preferred by the logistics communities to model supply chains
  - Supply networks are not as simple

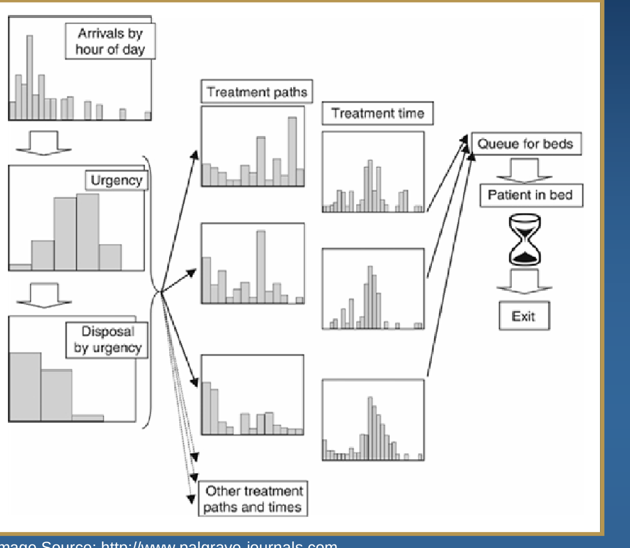
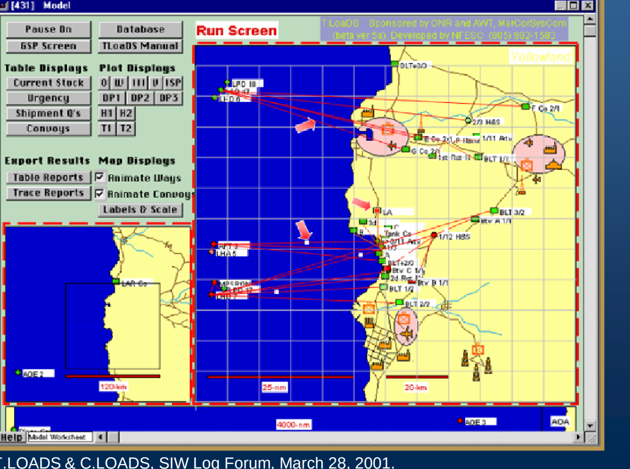


Image Source: http://www.palgrave-journals.com



T.LOADS & C.LOADS, SIW Log Forum, March 28, 2001.

System Dynamics

- Formulated by Jay W. Forrester (1950s)
- System Dynamics is a
  - Top-down modeling approach, where the aggregate behavior of the system is modeled directly
  - methodology for studying and managing complex feedback systems, such as one finds in business and other social systems
- “Mathematically, an SD model is a system of differential equations” [Andrei2003]
- If the model works only with aggregates, the items in that same stock are indistinguishable, they have no individuality
- “The modeler needs to think in terms of global structure dependencies and has to provide accurate quantitative data for them” [Andrei2003]
- Feedback is the key word here, if X affects Y but X also depends on Y, their effects cannot be studied in isolation, a holistic approach must be taken to account for their interdependency
- Shortcomings of System Dynamics
  - Difficult to determine which portions of the problem should be modeled
  - Must understand things from an aggregated level
  - Hard to obtain accurate aggregated data, especially when there is no real system to base it on

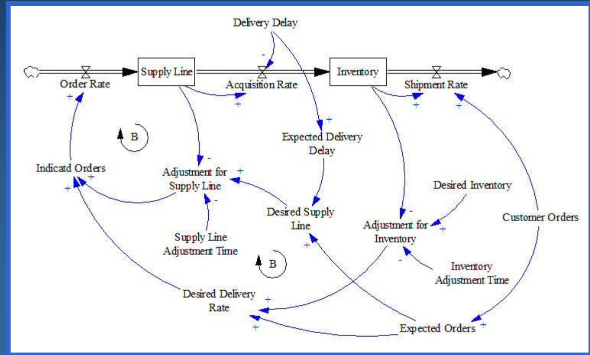


Image Source: http://www.control.hut.fi

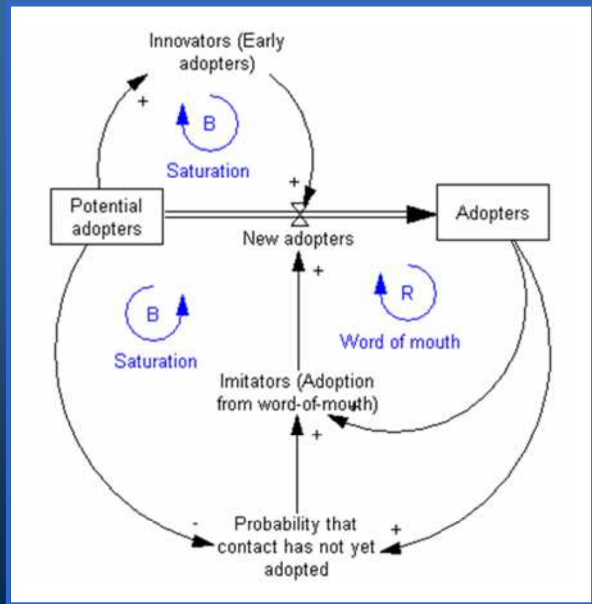


Image Source: http://www.wikimedia.org

Agent-Based Models

- Many definitions of an agent
- Behavior defined at individual level, and aggregated behavior emerges from the interaction of individual behaviors
- "Agent-based models (ABM) are examples of complex adaptive systems, which can be characterized as those systems for which no model less complex than the system itself can accurately predict in detail how the system will behave at future times" [Bankes2002]
- Shortcomings of Agent-based Modeling
  - Hard to determine which portions of reality should be modeled
  - Which portions of the model can be characterized as independent stochastic events, and which have to represent reality more accurately?
  - Complete knowledge of every interaction at the individual levels may not be available
  - Playing it safe and attempting to model as much as possible can create a model that is too complicated to execute efficiently and may convolute the results to the point that understanding is impaired
  - Need to run very large number of simulations because the interactions diminish the effectiveness of the Central Limit Theorem [Cares2007]

Simple entities that interact with each other and the environment while obeying simple rules

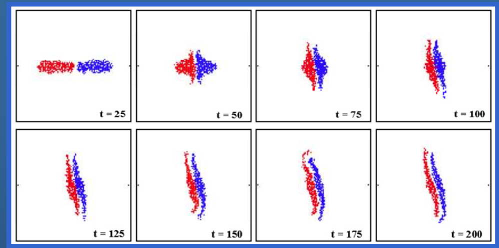
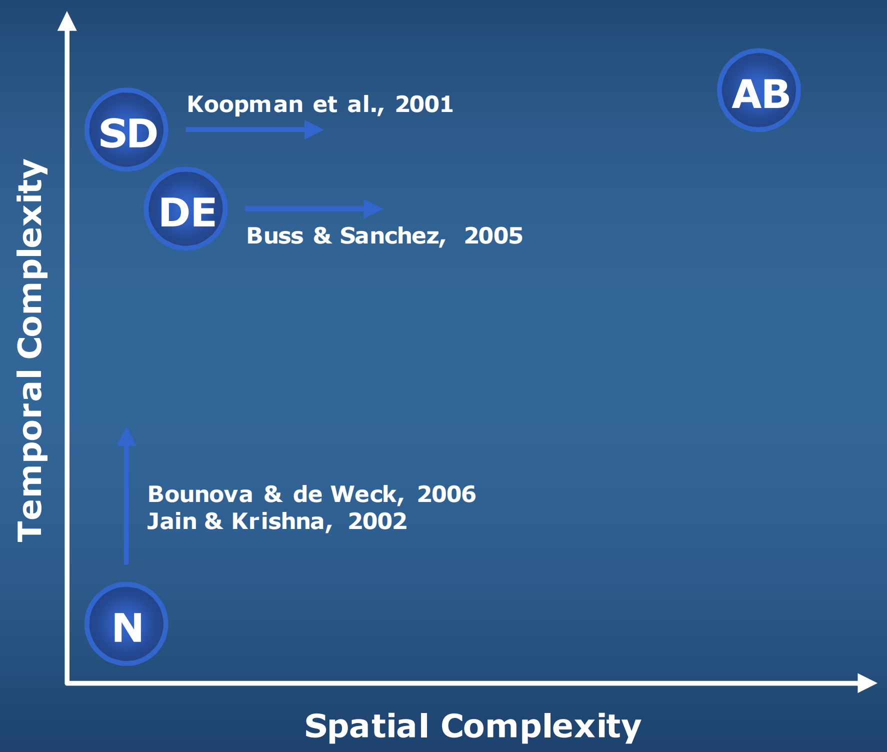


Image Source: www.cna.org

Image Source: www.spa.com

Extending Existing Techniques

- Models are an attempt to capture complexities of reality
- Some modeling approaches can capture certain complexities better than others
- Techniques have been extended, e.g.,
  - Buss & Sanchez, 2005 describes how DES can be used for spatially explicit models
  - Bounova & de Weck, 2006 describes a state-space-like augmented network model that can capture high-level dynamics



Extending techniques increases effort of model creation and V&V

Legend

N: Network
DE: Discrete-event
SD: System Dynamics
AB: Agent-based

New versus Integration

New Modeling Technique

- Develop a new technique for modeling complex systems architectures
- Advantages
  - Tailor it to the complex problems described in this body of work
- Disadvantages
  - Disregards decades of advances in modeling
  - Time consuming
    - Limited resources, limited time
  - How do we obtain buy-in from M&S community

Integrate Existing Techniques

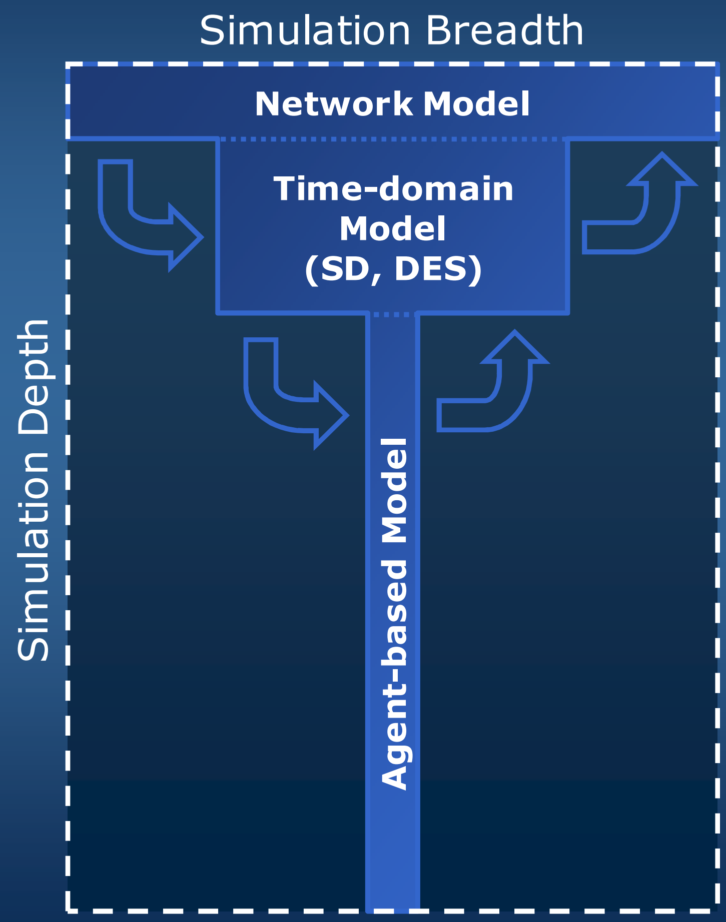
- Develop a process for using existing techniques to model complex systems
- Advantages
  - Leverages advances in the field of simulation and mathematics
- Disadvantages
  - Unproven approach
  - No standardized method for integrating modeling techniques

"If I have seen a little further it is by standing on the shoulders of Giants"

Isaac Newton

How do we Integrate the Candidate Techniques?

- Simulation Breadth
  - What systems are modeled, the extent to which an architecture is represented in the model
  - e.g., if modeling a sea base, do we include the ships traveling from CONUS to ISB, or just ISB to Sea Base?
- Simulation Depth
  - Detail with which the characteristics are modeled
  - e.g., if modeling a sea base, do we model how ships circumnavigate obstacles (decision making, spatially explicit information), or simply set a distance for their travel



Questions?

Bounding the Human Within the System

Michael W. Mueller

Air Force Center for Systems Engineering

Michael.mueller@afit.edu

HUMAN IN SYSTEMS

Hardware-Dominant Systems

Users

THE HUMAN IS AN INTEGRAL ELEMENT OF EVERY SYSTEM

Maintainers

Human-Dominant Systems

Software-Dominant Systems

BOUNDING

- ***Process of defining what is inside and what is outside of a system***

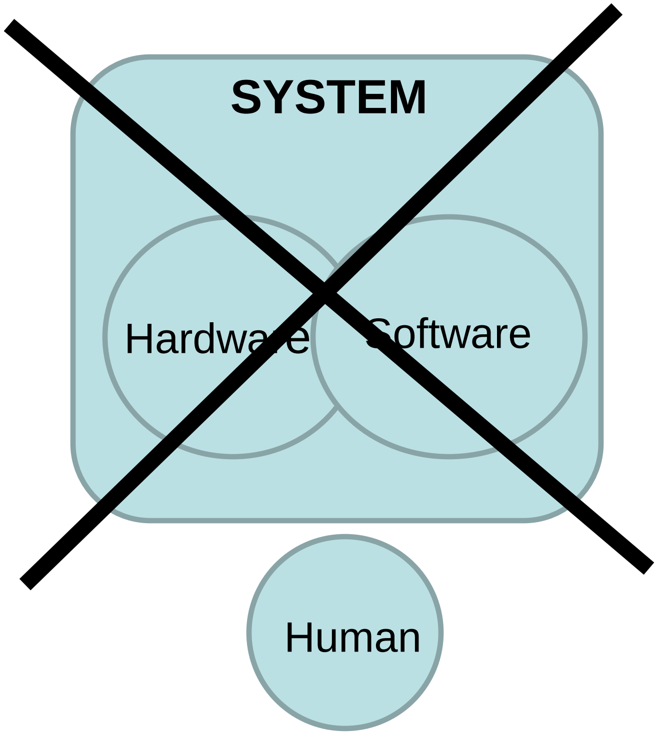
  - Identifies system internal and external components

  - Helps focus development decisions and efforts

SYSTEM

"Defining the boundaries of a system is critical but often neglected" – Dennis Buede, The Engineering Design of Systems

BOUNDING HUMAN OUTSIDE SYSTEM



- ***Enables attention to interfacing technology (hardware/software) of system with external components (e.g., the human)***
- ***However, easy to get focused on hardware and software***

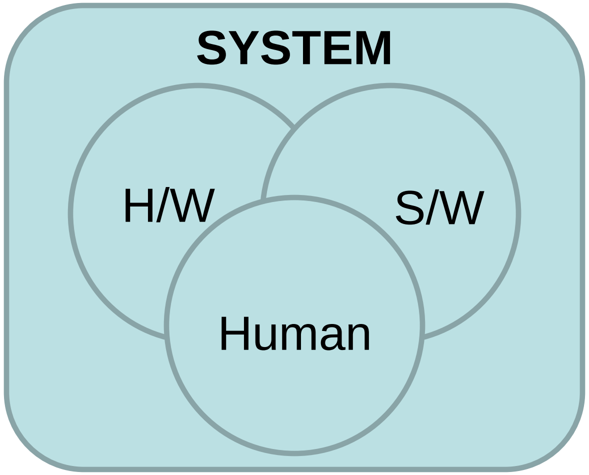
- ***Often neglect human in design and trade-off decisions, resulting in:***
    - ***Degraded system performance***
    - ***Costly modifications***

BOUNDING HUMAN WITHIN SYSTEM

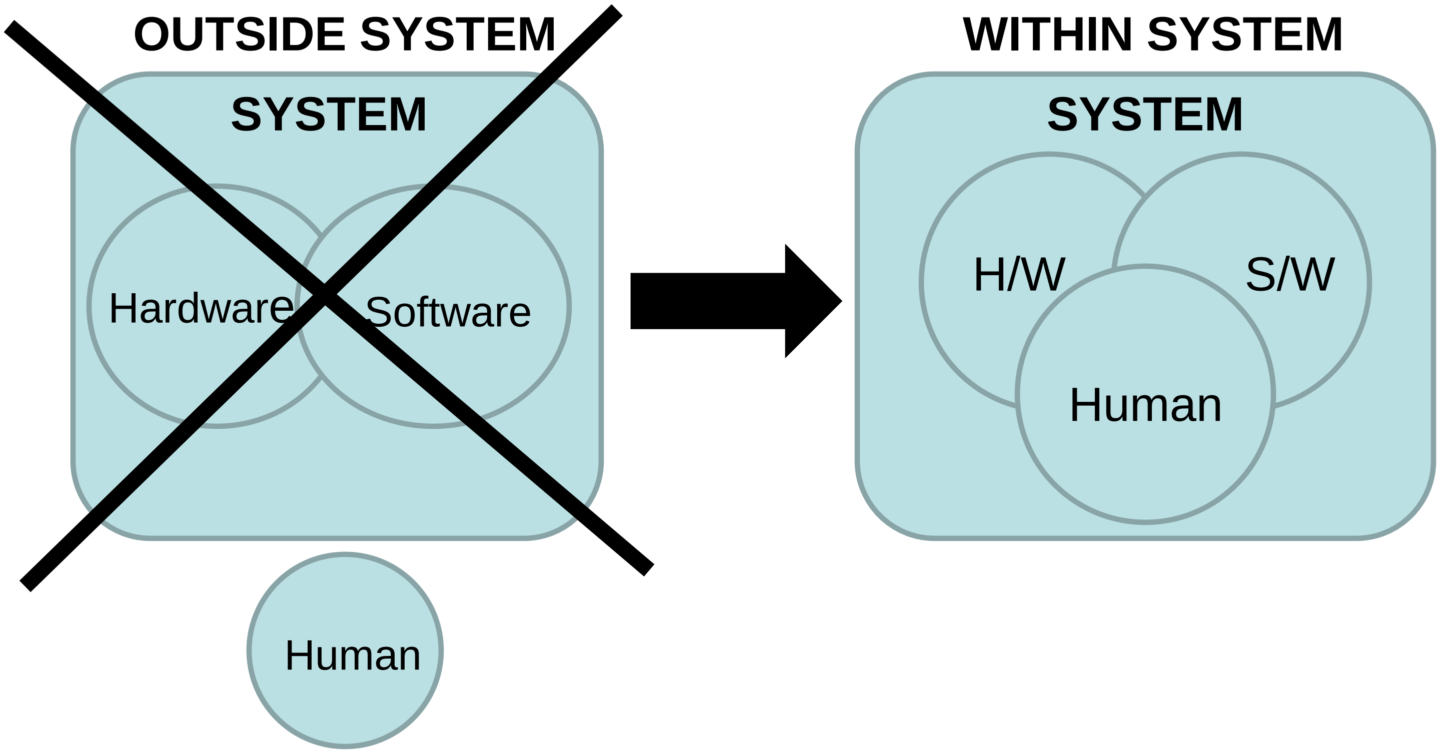
- Promotes **consideration of human in conjunction with hardware and software in requirements development** and system development and design decisions

- Requirements drive system functional, physical, operational, and interface architecture

WITHIN SYSTEM



BOUND HUMAN WITHIN SYSTEM

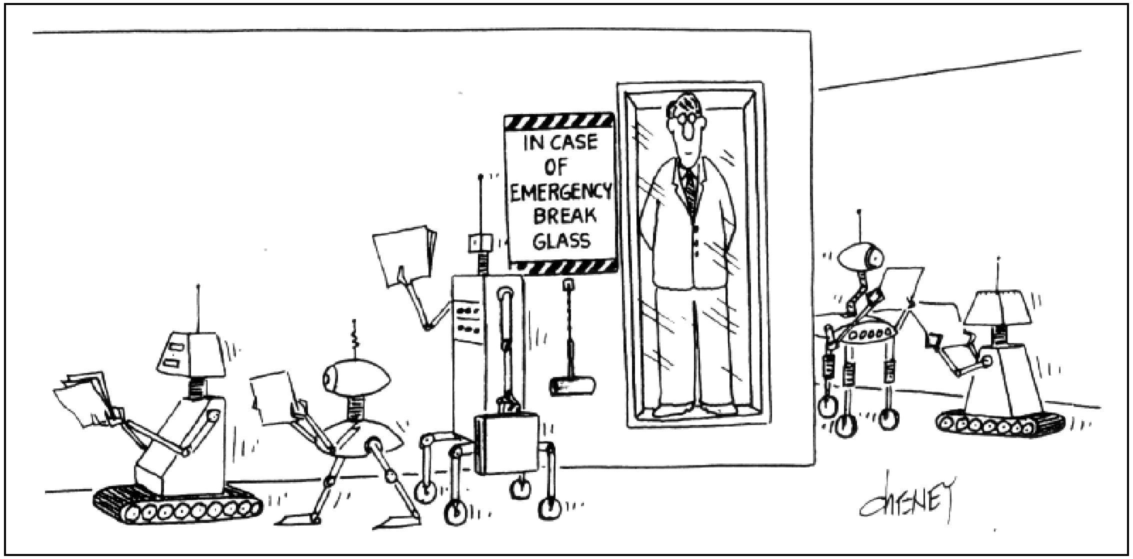


Need to BOUND HUMAN WITHIN SYSTEM to better assure addressing essential human considerations in development & design of systems

HUMAN IN SYSTEMS

AFCSE

- *There is no such thing as an unmanned system*
- *The "human" in HSI includes all people who interact with the system:*
  - ***users/customers***
  - ***system owners***
  - ***operators***
  - ***maintainers***
  - ***support personnel***
  - ***trainers***
  - ***etc.***



THE HUMAN IS AN INTEGRAL ELEMENT OF EVERY SYSTEM

DEFINITION

Human Systems Integration (HSI):

The interdisciplinary technical and management processes for integrating human considerations within and across all system elements; an essential enabler to systems engineering practice

Human Systems Integration Working Group, International Council on Systems Engineering (INCOSE), 2007

GOALS OF HSI

ENSURE THAT SYSTEMS, EQUIPMENT, FACILITIES:

- Incorporate **effective human-HW/SW interfaces**
- Achieve the required levels of **human performance**
- Make **economical demands upon personnel** resources, skills, and training
- **Minimize life-cycle costs**
- **Manage risk of loss or injury** to personnel, equipment, or environment

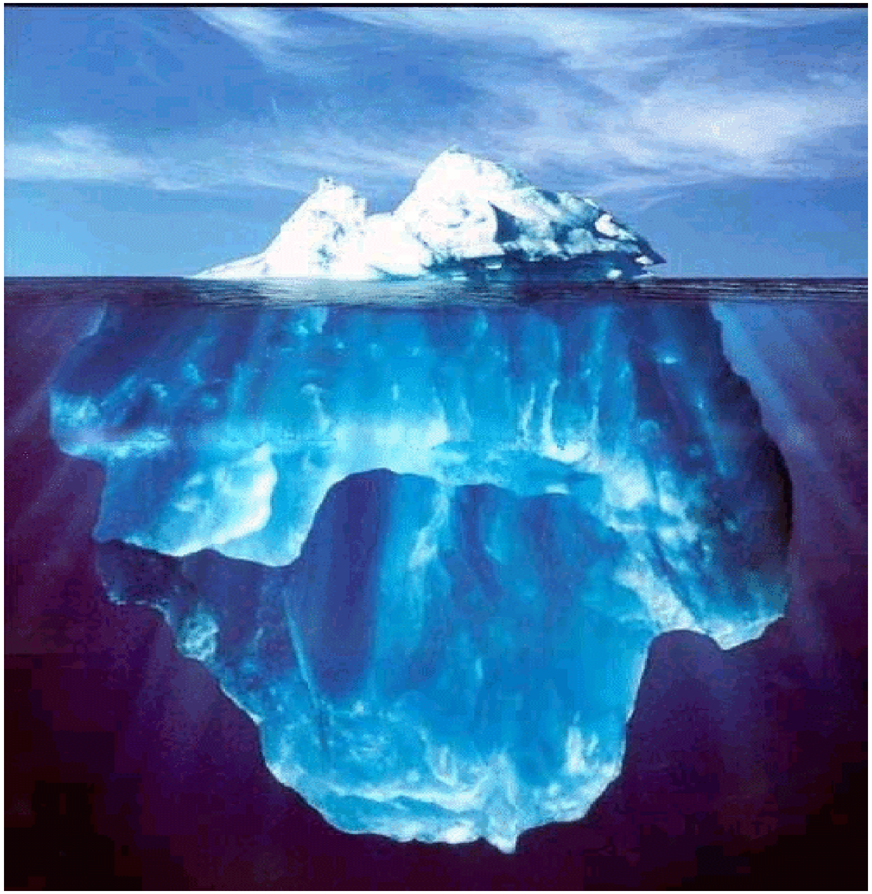
HSI brings human-centered disciplines and concerns into the SE process to improve overall system design and performance – BOUNDING THE HUMAN WITHIN SYSTEM PROMOTES A TOTAL SYSTEM APPROACH

IMPORTANCE OF HSI

AFCSE

- **DoD studies reveal**:
  - Over 90% of operating & support costs are determined early in development
  - **O&S costs are significantly HSI-related**

Source: GAO-03-57



- **Critical to INCLUDE HSI EARLY in system concept development to realize greatest LIFE CYCLE COST SAVINGS**

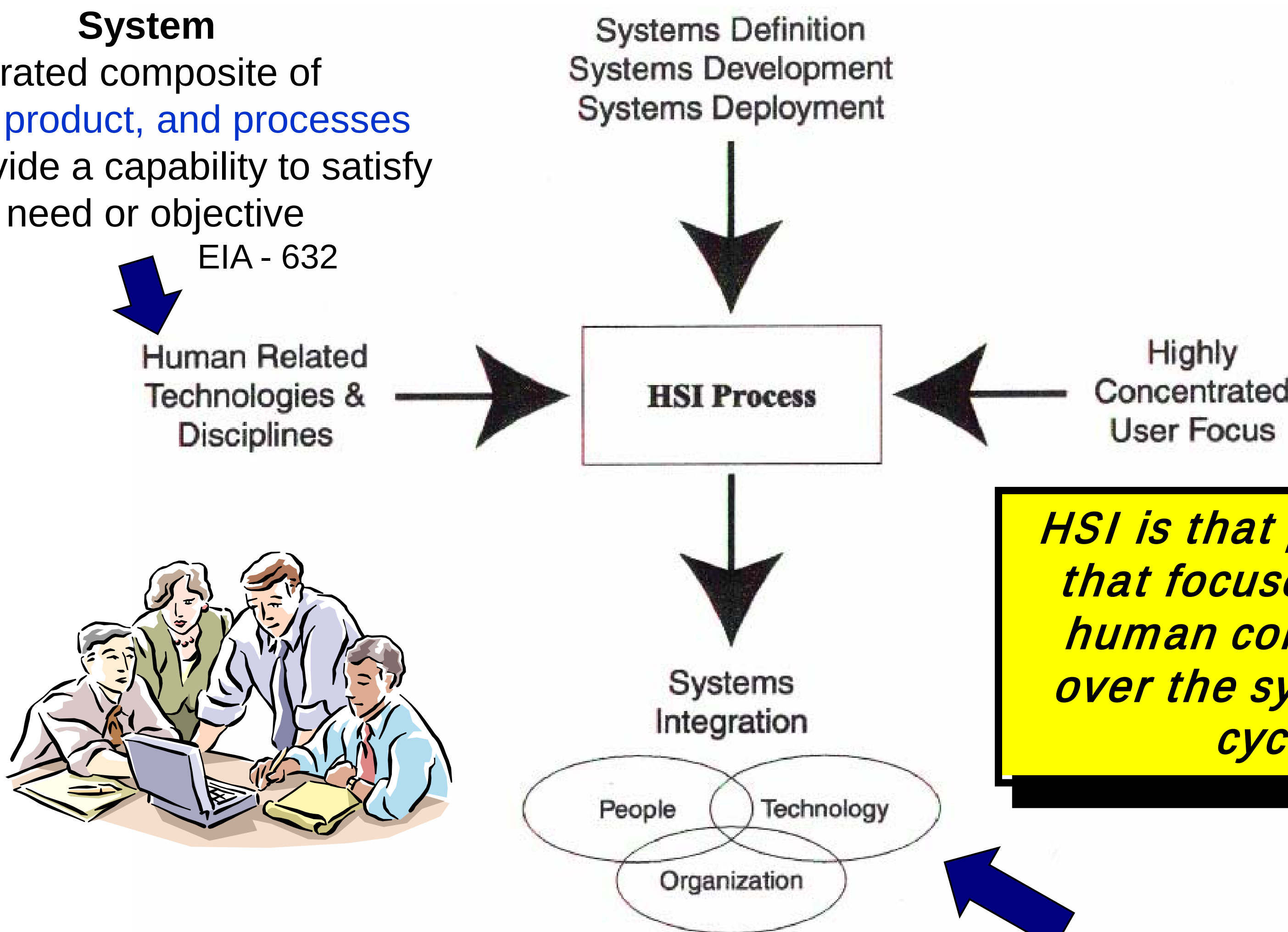
BOUNDING HUMAN WITHIN SYSTEM demands inclusion of HSI early

HSI KEY PART OF SYSTEMS ENGINEERING PROCESS

System

An integrated composite of **people**, product, and processes that provide a capability to satisfy a stated need or objective

EIA - 632



HSI is that part of SE that focuses on the human component over the system life cycle

Systems Engineering

- **Integration**
- **Balance**

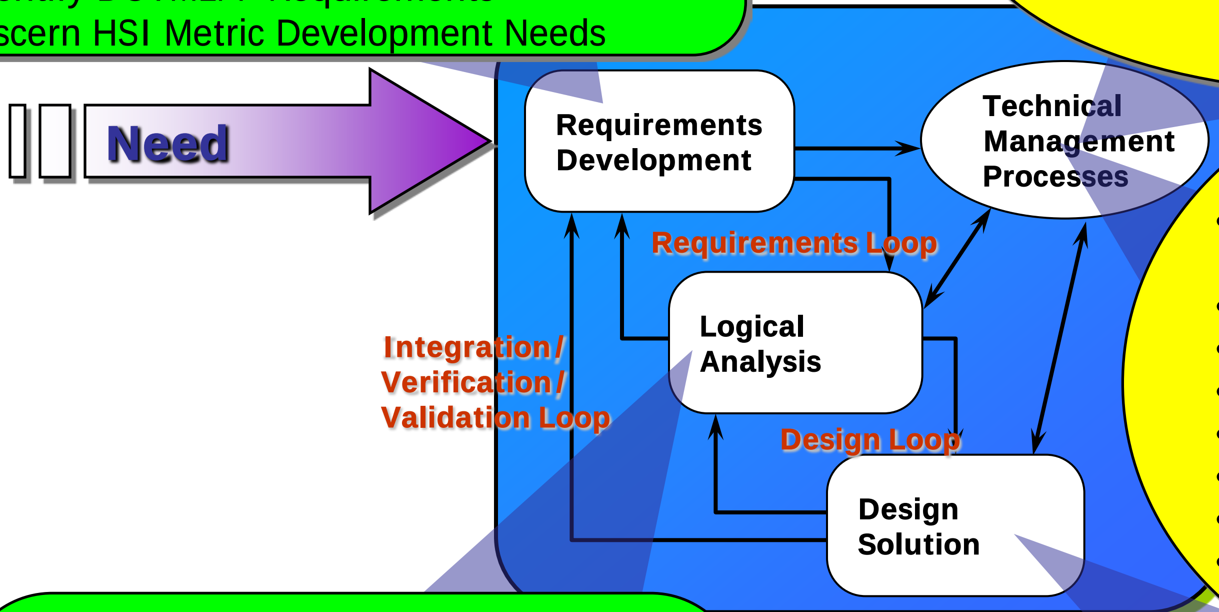
Adapted From: Booher, Principles and Applications of Human Systems Integration. SPAWAR CHARLESTON, 04 November 2003.

HSI CRITICAL PART OF SE PROCESS

AFCSE

Identify Human Performance Component of Total System Capability/Requirements
Identify Total System Environment
Identify HSI Research Needs
Capabilities Document Review for HSI Impact
Identify DOTMLPF Requirements
Discern HSI Metric Development Needs

FUNCTIONS
Manning Optimization
Human Performance Optimization
Decision Support Aid
Plan for Trainers/Simulators
HSI Metric Development
FoS / SoS Impacts
T&E Support



TRADE STUDY CRITERIA

- Human Performance
- Usability
- Maintainability
- Cost
- Quality of Life
- Redundancy
- Suitability
- Effectiveness
- Reliability
- Availability & Recovery
- User Population Characteristics
- Organization/ Career Impacts
- Trainability
- Resilience
- Supportability

System Capability

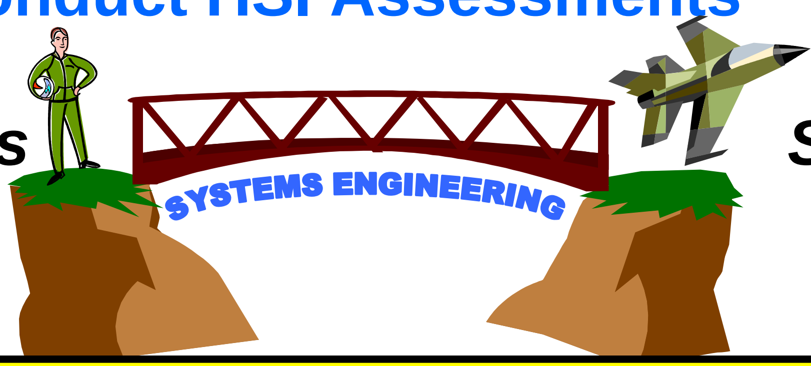
Document all Functions/Tasks
Identify Human/Automation Allocations
Evaluate Technology Integration Feasibility
Analysis of ESOH Issues
Identify Human Interface Issues
Address Workspace/Living Space Design
Design for Interoperability & Survivability

Participate in IPT's to ensure optimization of the Total System by designing to optimize the Human Element

KEY HSI TENETS

- Initiate HSI Early
- Identify Issues and Plan Analysis
- Document/Crosswalk HSI Requirements
- Make HSI a Factor in Source Selection for Contracted Development Efforts
- Execute Integrated Technical Processes
- Conduct Proactive Tradeoffs
- Conduct HSI Assessments

Needs



Solution

HSI most effective when HUMAN BOUNDED WITHIN SYSTEM from early concept development

F-117 vs. F-22 STORY

- **F-117**
  - **No access panels originally designed into aircraft**, so had to cut holes in structure to perform routine maintenance
  - Eventually some access doors added to production F-117, but routine maintenance still not easy

- **F-22**
  - HSI input from maintainers led to advanced door seal and associated technologies making aircraft much more maintainable
  - **Success in F-22 led to high level of HSI attention in F-35, balanced with rest of aircraft's stealth and operational characteristics**

Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

HSI makes good SE sense and can help to address emerging technology challenges in system development

F-22 HSI SUCCESS STORY

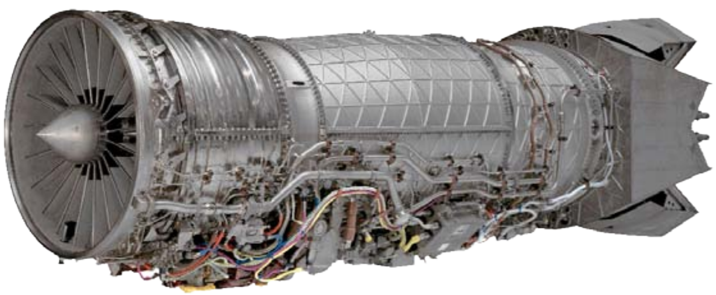
- **Senior NCOs attached to every system and subsystem team**
  - NCOs had to assess each full-scale mock-up before it was approved
- **Minimized number of AF Specialty Codes and people needed to operate and maintain F-22**
  - Reduced training requirements & life cycle costs
- **Avionics operational flight program modified to be usable in ground training simulators without major redesign**
  - Avoid “version skew”
- **Composite skin designed to resist damage from maintenance activities**
  - Reduced need for extra maintenance to fix induced damage

Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

F-22 design gave strong consideration to HSI

F119-PW-100 ENGINE DESIGN HSI SUCCESS STORY

- **F119-PW-100 Engine Design**
  - **F-22**
  - **"Blue Two" Visits – Program Office and Industry Executives worked side-by-side with airmen performing normal maintenance**
  - **F119-PW-100 Chief Engineer Mandated:**
    - **All line replaceable units (e.g., Full Authority Digital Engine Controllers, Computerized Engine Diagnostic Units, and all pumps) would be mounted along the bottom half of the engine**
    - **Would be no more than 6 standard tools, available from Sears, needed to do external engine maintenance**
  - **F119-PW-100 engine is maintainer-friendly, while still giving highest engine performance in any fighter**



Source: New Concepts in Human Systems Integration, Potomac Institute for Policy Studies Report PIPS-08-01, March 2008

F-119 engine design changes are direct result of CONDSIDERING THE HUMAN AS CRITICAL ELEMENT EARLY IN DESIGN AND DEVELOPMENT

USS ZUMWALT (DDG-1000)

US Navy Destroyer

- Designed as multi-mission ship with a focus on land attack
- **Specifically designed to require a smaller cre**w (142 vs. 330 on Spruance destroyers and 200 on Perry frigates)
- **Reduced crew represents significant reduction in life cycle costs**, since staffing is a major contributor to that cost on a warship

Source: Naval Technology

THAAD MISSILE SYSTEM TACTICAL OPERATIONS CENTER

Theater High-Altitude Area Defense (THAAD) Missile System, TOC – Mobile system to detect and eliminate enemy missiles

- **Used standard office chairs on rollers**
- **Not enough leg room for larger soldiers**
- **Inside operator had to squeeze past foreground operator to enter/exit work station**
- **No storage for MOPP gear**
- **Operators bumped switches when putting on MOPP gear**
- **Took 2-3 days to assemble the TOC, starting from an empty vehicle**

Source: "Pit Stop Engineering," presentation by Dennis Carlson, Jan 08

THAAD MISSILE SYSTEM TOC IMPROVED CONCEPT DESIGN

- **SEATING:**
  - Replaced standard office chair with seat bolted in place (several notches to allow adjustment)
  - Ample leg room for 1-99 percentile human
- **MOPP GEAR:**
  - Stored in bins
  - Seats rotated so soldiers could don gear in aisle without bumping equipment
- **ASSEMBLY:**
  - Using modular units, able to assemble equipment in empty vehicle in just minutes
  - Modules color-, number-, and shape-coded for ease of assembly

- **Greatly improved performance of system**
- **Significantly reduced set-up and maintenance time**
- **Savings estimated in billions**

CONCLUSION

• ***The HUMAN is an essential element of every system***

• ***Key to successful HSI is INTEGRATION:*** ***Integration of human considerations with hardware & software considerations***

Critical to BOUND HUMAN WITHIN SYSTEM from early concept development to enable informed decisions and optimize overall system success

Implementing the Materiel Availability KPP in DoD Acquisition Programs—Balancing Life Cycle Costs with Warfighter Needs

Grant Schmieder

Systems Engineering Directorate

Office of the Director, Defense Research and Engineering

12th Annual NDIA Systems Engineering Conference

October 28, 2009

UNCLASSIFIED

Introduction

- **Domain Expert for Reliability, Availability, and Maintainability (RAM) in OSD AT&L SSE:**
  - OUSD AT&L SSE: Office of the Under Secretary of Defense; Acquisition, Technology, and Logistics; Software and Systems Engineering
    - HCSE: Human Capital and Specialty Engineering
    - ASETS: Acquisition Systems Engineering and Test Support
- **DoD 5000.02, dated 8 December 2008, provides for:**
  - Operation of the JCIDS Process including robust Systems Engineering
    - PSRs
    - Nunn-McCurdy Certifications
    - JAT, DST, OIPT Support, etc.
- **Mandatory Sustainment KPP in CJCSM 3170.01D (March 2009)**
  - KPP: Availability
    - KSA: Reliability
    - KSA: Ownership Cost
- **Operational versus Life-Cycle Based Metrics**
  - Traditional development efforts end at full rate production decision
  - Costs of sustainment are set by system design
  - Programs have become both unreliable and expensive to sustain
- **Implementation covered in RAM-C Report Manual**

Current Situation
—and How We Got Here

Mistakes have been made!

Background: Defense Science Board Report on Developmental Testing (cont.)

- **Congressional Testimony (March 3, 2009) by Mr. Pete Adolph (Chairman of DSB Team):**
  - Loss of Core Acquisition Personnel in DoD:
    - 500,000 in 1990
    - 200,000 in 2009
  - "Concurrent with acquisition reform, the general practice of reliability growth during development was de-emphasized and, in most cases, eliminated. This departure from a widely recognized best practice may not have been a direct result of acquisition reform, but may instead be related to the loss of key personnel and experience, **as well as short-sighted attempts to save acquisition funds at the expense of increased sustainment and life cycle costs**."
- **Dr. Paul Kaminski**
  - "…further underscored the importance of early system engineering effort in that, prior to the key Milestone A and B decisions, we find that those decisions **impact somewhere between 75 percent and 85 percent of the total lifecycle costs**. So the time to address those issues is up front before those decisions are made."

Background: Defense Science Board Report on Developmental Testing (cont.)

- **Acquisition workforce reductions mandated by 1996 thru 1999 Defense Authorization Acts**
  - Loss of experienced management and technical personnel throughout government and industry
  - Service acquisition test organizations were affected:
    - Army essentially eliminated their military DT component and made government DT discretionary
    - Navy reduced DT workforce by 10%
    - Air Force transitioned DT conduct and control to the contractor while significantly reducing test personnel (~15%) and program office engineering support (up to 60%)

Background: Defense Science Board Report on Developmental Testing (cont.)

- **Programs complexity increasing significantly**
  - Software lines of code increases, off-board sensor data integration, system of systems
- **Elimination or reduction of Military Standards from contracts**
  - Use of commercial specifications and standards encouraged under Acquisition Reform
- **De-emphasis of Reliability Growth**
  - Industry recommendations in the 1970's had caused the Services to implement Reliability Growth as an integral part of development

> "Lack of failure prevention during design leading to low initial MTBF and reduced growth potential are the most significant reasons for systems failing to meet operational reliability requirements"

Background: Program Support Review Reliability Findings

- **Unrealistic Reliability requirements**
  - Requirements not measurable, quantifiable, reasonable, etc…
    - “as good as or better than current system…” – impacts translation of user needs into technical requirements
  - User R&M requirements not underpinned by sound rationale
    - Failure to document mission context or mission profile
  - Maturation timeframes or maturity at IOC not defined
  - Inconsistent use of R&M measures makes comparison of programs difficult

Background: Program Support Review Reliability Findings

- **Maturing "suitability" (e.g., RAM)… not always a priority**
  - Little effort to design-in reliability and maintainability
    - Inadequate allowance of resources (time, money, people)
    - Scope of effort to design-in RAM not aligned with schedules and resources
  - Optimistic growth rate assumptions
    - Over optimistic view of starting reliability (prior to growth)
    - Lack of understanding of statistical confidence issues
  - DT&E not always tested under realistic OT&E (e.g., OMS/MP) conditions
    - Reliability growth strategy incompatible with demonstration requirements
    - Supply chain and maintainers not operationally representative in DT&E
  - No interim measures for suitability to gauge progress/growth
  - Log Demos to evaluate IETMs and diagnostics effectiveness are not timely or comprehensive; Most are conducted too close to IOT&E

Background: Other Considerations

- **Performance based contracts allowed contractors to determine how to reach reliability requirements—often with disastrous results for the warfighter**
- **There is an inherent disincentive for contractors to spend acquisition funds on improving Reliability**
  - Partially due to the lucrative nature of contractor support and sparing
- **Acquisition program managers are not held accountable for post-FRP support costs**
  - But are held accountable for Average Per Unit Cost (APUC)—leading to restricting the expenditure of “discretionary” funds (like those required for Reliability Demonstration and Growth)

Background: Defense Science Board Report on Developmental Testing

- **May 2008 Defense Science Board Report on Developmental Tests & Evaluation**
  - Commissioned by AT&L in 2007

> "In recent years, there has been a dramatic increase in the number of systems not meeting suitability requirements during IOT&E. Reliability, Availability and Maintainability (RAM) deficiencies comprise the primary shortfall areas."

Program	Service	ACAT	IOT&E Result		Reason
FY 2004					
[redacted]	Navy	II	Effectiveness unresolved	Suitable	Testing was not adequate to determine effectiveness.
	Army	1D	Effective	Suitable	
	Navy	1D	Effective with restrictions	Not suitable	Effective for short duration missions; not effective for all missions and profiles. Not suitable due to RAM.
	Navy	1C	Effective	Suitable	
	Army	1D	Effective	Not Suitable	RAM and safety concerns.
FY 2005					
[redacted]	Army	1C	Effective	Not Suitable	RAM; communications system less suitable than did not meet Information Exchange Requirements for Block I.
	USAF	1D	Effective	Not Suitable	RAM; needed more maintenance resources and spare parts; BIT
	Navy	1C	Not Effective		Not effective against moderately hardened targets; mission planning time was excessive.
	Army	1C	Effective	Suitable	
	Army	1C	Effective	Suitable	
	Navy	1D	Effective	Suitable	
	Navy	II	Effective	Suitable	

Figure 2: DoD IOT&E Results FY 2004-2005.

Program	Service	ACAT	IOT&E Result		Reason
FY 2001					
[redacted]	USAF	II	Effective	Not Suitable	Reliability, Maintainability, Availability
	Navy	1D	Effective	Not Suitable	Reliability, Availability, Maintainability (RAM), Human Factors, BIT
	USAF	1C	Effective only with legacy fuses	Not Suitable	Integration with delivery platforms
	Army	1D	Effective	Suitable	
FY 2002					
[redacted]	USAF	1C	Effective with deficiencies	Not Suitable	RAM, Safety, Human Factors
	Navy	1D	Effective	Suitable	
	Army	1C	Effective	Suitable	
	Navy	1C	Effective	Not Suitable	RAM, excessive administrative and logistic repair time impacted RAM
FY 2003					
[redacted]	USAF	1D	Effective	Not Suitable	
	Navy	1D	Effective	Suitable	Several requirement thresholds were not met but overall system effective and suitable

Figure 1. DoD IOT&E Results FY 2001-2003.

Program	Service	ACAT	IOT&E Result		Reason
CY 2006					
[redacted]	Army	1C	Effective	Suitable	Effective and suitable in the OIF/OEF environment but needs further testing outside of the OIF/OEF environment.
	Navy	1AM	Effective	Not Suitable	Operational Test Agency, COTF, reported effective, not suitable. BLRIP not complete.
	Navy	II			Test suspended due to reliability problems.
	Navy	II	Not Effective	Not Suitable	Block 1A Upgrade does not make the operationally effective and suitable but does enhance ability
	USAF	1C	Effective single ship; Not effective in formation	Suitable with shortfalls	Effective single ship; not effective in formation air land / air drop; not effective in non permissive threat environment. Shortfalls in suitability due to maintainability issues
	USAF	1D	Effective with limitations	Suitable with limitations	Limited effectiveness and suitability due to reliability and deficiencies in software used to predict optimum fuzing solutions.

Figure 3: DoD IOT&E Results for 2006.

UNCLASSIFIED

DSB Report on DT: Suitability

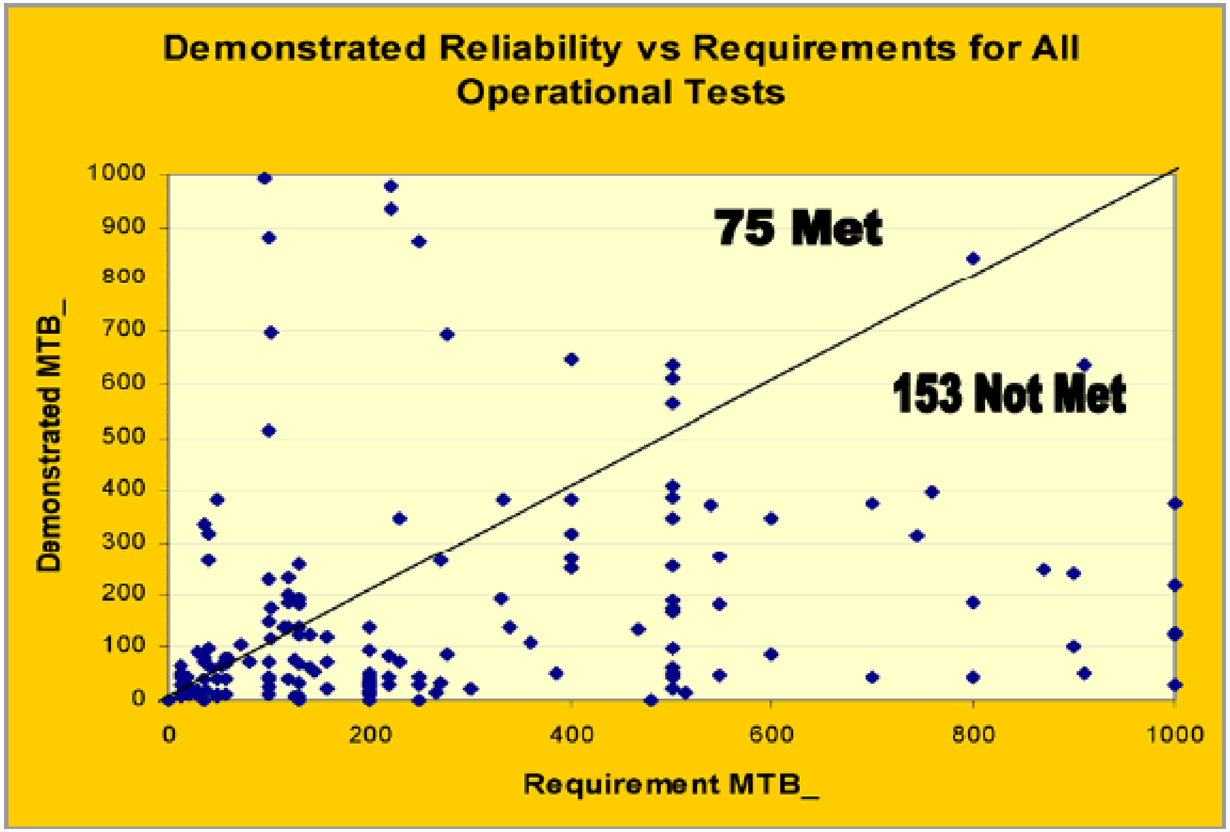


Figure 4: Army Systems Failing Reliability during Operational Testing (1997-2006).

- **Only 75 of 228 Army programs met their Reliability requirements from 1997 to 2006**

Other Considerations (One Man's Opinions)

- **Performance based contracts allowed contractors to determine how to reach reliability requirements—with disastrous results**
  - There is an inherent disincentive for contractors to spend acquisition funds on improving Reliability due to the lucrative nature of contractor support and sparing
  - Acquisition program managers are not held accountable for post-FRP support costs

"…short-sighted attempts to save acquisition funds at the expense of increased life cycle costs."—DSB Report on DT&E

Program Support Review Reliability Findings

- **Unrealistic Reliability requirements**
  - Requirements not measurable, quantifiable, reasonable, etc…
    - "as good as or better than current system…" – impacts translation of user needs into technical requirements
  - User R&M requirements not underpinned by sound rationale
    - Failure to document mission context or mission profile
  - Maturation timeframes or maturity at IOC not defined
  - Inconsistent use of R&M measures makes comparison of programs difficult
- **Maturing "suitability" (e.g., RAM)… not always a priority**
  - Little effort to design-in reliability and maintainability
    - Inadequate allowance of resources (time, money, people)
    - Scope of effort to design-in RAM not aligned with schedules and resources
  - Optimistic growth rate assumptions
    - Over optimistic view of starting reliability (prior to growth)
    - Lack of understanding of statistical confidence issues
  - DT&E not always tested under realistic OT&E (e.g., OMS/MP) conditions
    - Reliability growth strategy incompatible with demonstration requirements
    - Supply chain and maintainers not operationally representative in DT&E
  - No interim measures for suitability to gauge progress/growth
  - Log Demos to evaluate IETMs and diagnostics effectiveness are not timely or comprehensive; Most are conducted too close to IOT&E

Examples of Issues Found During AOTRs
(Not systemic across all reviews)

- **Immature technologies**
- **Lack of quantitative user requirement lead to subjective evaluation**
- **Lack of measures to assess resolution of Critical Operational Issues**
- **Inadequate Stakeholder involvement during development phase**
- **DT&E not always conducted in all IOT&E regimes and environments**
  - KPPs not always demonstrated in DT&E
- **Not meeting reliability thresholds**
- **Poor logistics support planning; Immature IETMs and training**
- **LFT&E conducted too late to impact design**
- **Budget vice not event-driven schedules**
  - Pressures to meet IOT&E and IOC dates
- **Planning and resources for FOT&E not identified**

IOT&E Results

- **57% (20 of 35) of DoD programs from FY2001 to FY2007 entered IOT&E and failed to meet Operational Effectiveness and/or Suitability requirements**
  - 12 of the 20 (60%) failed to meet effectiveness requirements
  - 17 of the 20 (85%) were either not operationally suitable or suitability was the cause of test suspension
  - 11 of the 17 (65%) cited Reliability as the cause of failure or suspension

Materiel Availability KPP Established to Relate Logistics Reliability to Ownership Cost

- **May 2007: CJCSI 3170.01F and CJCSM 3170.01C**
  - Included Materiel Availability KPP
    - Supported by Materiel Reliability and Ownership Cost KSAs
  - Mandatory for JROC Interest Programs

CJCSM 3170.01C
1 May 2007

on validation. The sponsoring component will validate the KPPs for non-JROC Interest CDDs and CPDs. A single KPP can be developed provided it complies with the congressional direction pertaining to force protection and survivability.

(1) Survivability KPP. Survivability attributes are those that contribute to the survivability of a manned system. This includes attributes such as speed, maneuverability, detectability, and countermeasures that reduce a system's likelihood of being engaged by hostile fire, as well as attributes such as armor and redundancy or critical components that reduce the system's vulnerability if it is hit by hostile fire.

(2) Force Protection KPP. Force protection attributes are those that contribute to the protection of personnel by preventing or mitigating hostile actions against friendly personnel, military and civilian. This may include the same attributes as those that contribute to survivability, but the emphasis is on protecting the system operator or other personnel rather than protecting the system itself. Attributes that are offensive in nature and primarily intended to defeat enemy forces before they can engage friendly forces are not considered force protection attributes. Attributes that protect against accidents, weather, natural environmental hazards, or disease (except when related to a biological attack) are also not part of force protection.

(3) Exemptions. Document sponsors who determine that the survivability and/or force protection KPPs do not apply will include rationale in the CDD/CPD explaining why they are not appropriate. The JROC must concur in this recommendation for JROC Interest documents.

b. Sustainment KPP. A Sustainment KPP (Materiel Availability) and two mandatory supporting KSAs (Materiel Reliability and Ownership Cost) will be developed for all JROC Interest programs involving materiel solutions. For non-JROC Interest programs, the sponsor will determine the applicability of this KPP. During the CBA, the relevant sustainment criteria and alternatives will be evaluated to provide the analytical foundation for the establishment of the sustainment KPP and KSAs.

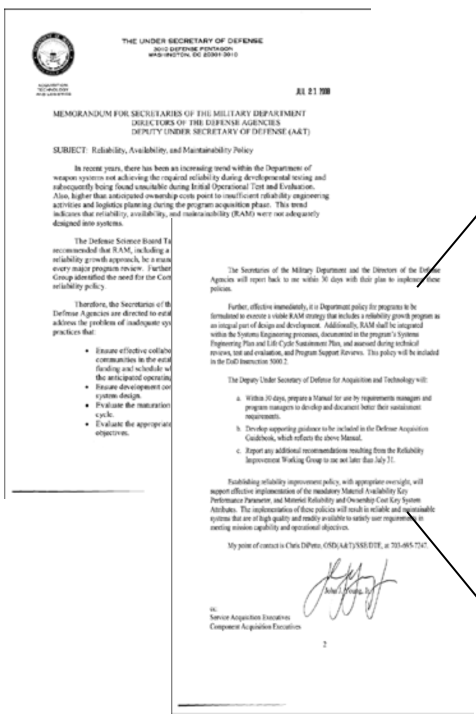
(1) Mandatory KPP. Materiel Availability is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. This can be expressed mathematically as (number of operational end items/total population). Materiel Availability also indicates the percentage of time that a system is operationally capable of performing an assigned mission and can be expressed as (uptime/(uptime + downtime)). Determining the optimum value for Materiel Availability requires a comprehensive analysis of the system and its planned use, including the planned operating environment, operating tempo, reliability alternatives, maintenance approaches, and supply chain solutions. Materiel Availability is primarily determined by system

B-3 Enclosure B

b. Sustainment KPP. A Sustainment KPP (Materiel Availability) and two mandatory supporting KSAs (Materiel Reliability and Ownership Cost) will be developed for all JROC Interest programs involving materiel solutions. For non-JROC Interest programs, the sponsor will determine the applicability of this KPP. During the CBA, the relevant sustainment criteria and alternatives will be evaluated to provide the analytical foundation for the establishment of the sustainment KPP and KSAs.

RAM Policy Memo

- **July 2008: Reliability, Availability, and Maintainability Policy Requires RAM be integrated into the Systems Engineering process**



Further, effective immediately, it is Department policy for programs to be formulated to execute a viable RAM strategy that includes a reliability growth program as an integral part of design and development. Additionally, RAM shall be integrated within the Systems Engineering processes, documented in the program's Systems Engineering Plan and Life Cycle Sustainment Plan, and assessed during technical reviews, test and evaluation, and Program Support Reviews. This policy will be included in the DoD Instruction 5000.2.

The Deputy Under Secretary of Defense for Acquisition and Technology will:

a. Within 30 days, prepare a Manual for use by requirements managers and program managers to develop and document better their sustainment requirements.

b. Develop supporting guidance to be included in the Defense Acquisition Guidebook, which reflects the above Manual.

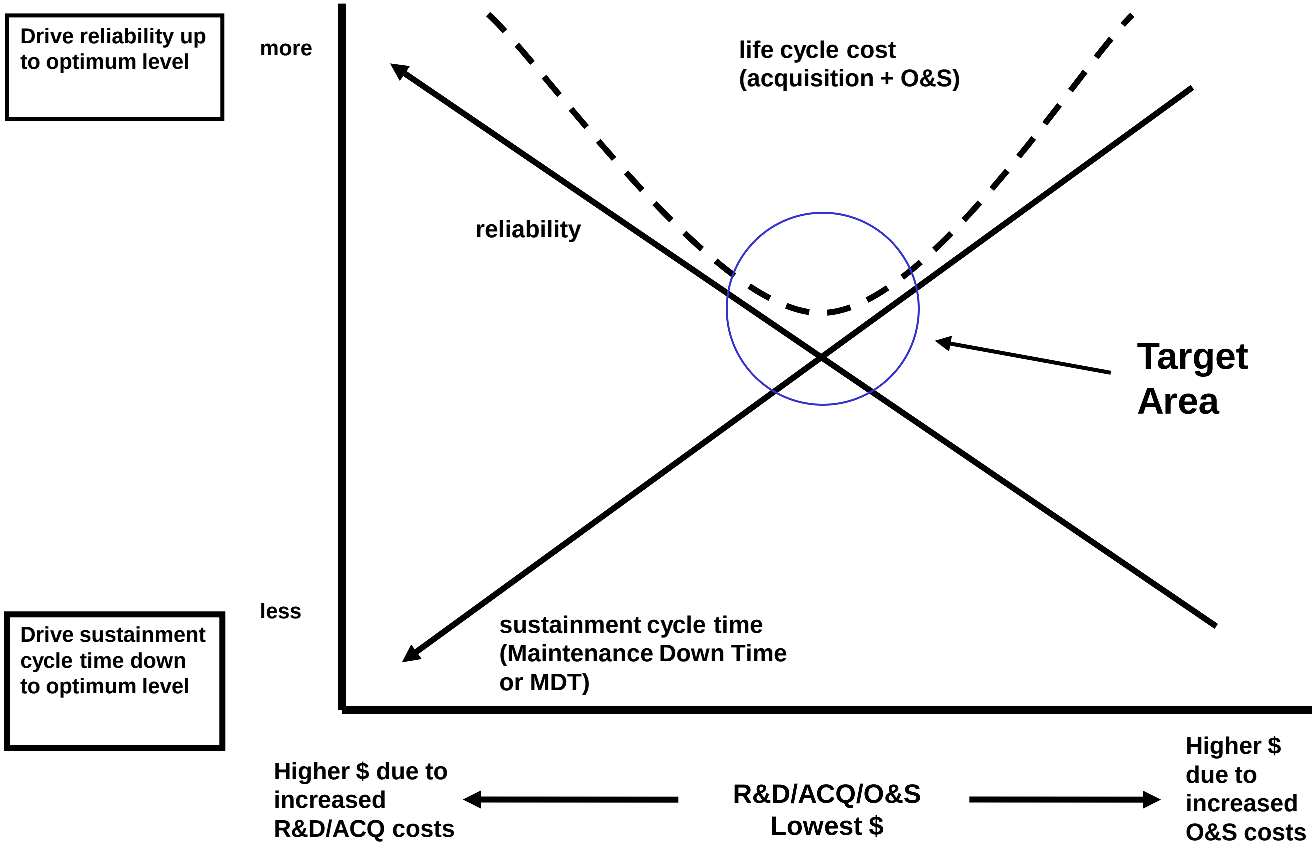
c. Report any additional recommendations resulting from the Reliability Improvement Working Group to me not later than July 31.

Establishing reliability improvement policy, with appropriate oversight, will support effective implementation of the mandatory Materiel Availability Key Performance Parameter, and Materiel Reliability and Ownership Cost Key System Attributes. The implementation of these policies will result in reliable and maintainable systems that are of high quality and readily available to satisfy user requirements in meeting mission capability and operational objectives.

Defense Acquisition Guidebook Design Considerations

Achieving the “best value” solution is an iterative task performed within the framework of Systems Engineering.

Trade Off Considerations



- **The Sustainment KPP ensures the program considers reliability and O&S costs equally during system design and development**

Sustainment KPP: Materiel Availability

- **Materiel Availability (A_M) is a system design metric**
  - Applies to all items that have been delivered at any point in time—entire inventory (Active + Inactive)
    - A_O applies only to the Active Inventory—and usually to a subset of that!
  - A_M is optimized—not maximized
    - A_O is a direct measure of operational effectiveness and, as such, it is usually best when maximized
    - A_M is a function of how the system is intended to be fielded
      - Proper implementation requires tradeoffs between operational AND non-operational factors:
        - » Operational factors include A_O, Mission Reliability, Logistics Reliability, MDT
        - » Non-Operational factors include Total Inventory, Active Inventory, Sustainment Strategy (repair levels, spares availability, delays, etc.), Ownership Cost
- **A_M includes two Key System Attributes (KSAs):**
  - Materiel Reliability
  - Ownership Cost
- **SSE AS has developed a handbook for implementation of the Sustainment KPP**
  - RAM-C Report Manual
  - Presently in coordination
    - Army non-concurral based on A_M not being immediately under the full control of the combat commander

What is RAM, really?

- **Definitions (Adapted from Reliability Statistics by Dovich):**
  - Reliability:
    1. The duration or probability of failure-free performance under stated conditions.
    2. The probability that a system can perform its intended function for a specified interval under stated conditions.
       - For non-redundant designs, the definitions are equivalent. For designs including redundancy, definition 2 reflects the "mission" reliability.
  - Availability:
    - A measure of the degree to which a system is in the operable and committable state AT THE START of the mission when the mission is called for at an unknown (random) time.

      {Emphasis Added!!!!}
  - Maintainability:
    - The measure of the ability of a system to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

Reliability, Availability, and Maintainability → RAM

Measures of RAM

- **Mean Time Between Failures (MTBF):**
  - The mean number of life units during which all parts of the item perform within their specified limits during a particular measurement interval under stated conditions
  - Applies to REPAIRABLE items only
- **Mean Time To Failure (MTTF):**
  - The mean number of life units to failure of the item under stated conditions
  - Applies to NON-REPAIRABLE items only
- **Mean Time Between Maintenance (MTBM):**
  - The mean number of life units before maintenance events (scheduled or unscheduled) *necessitating that the system be taken offline* are required
    - A measure of reliability taking into account maintenance policy
    - Note: Standard definitions of MTBM do not specifically limit analysis to actions which take the system offline. In view of the Sustainment KPP, definition of MTBM to cover only this specific subset of actions is required to support implementation of the Materiel Availability KPP.

Measures of RAM—Continued

- **Maintenance Downtime (MDT):**
  - Mean time required to perform maintenance
    - Includes supply time, logistics time, administrative delays, active maintenance time, etc.
- **Administrative Delay Time (ADT):**
  - That element of downtime during which no maintenance is being accomplished due to administrative delay
- **Logistics Delay Time (LDT):**
  - That element of downtime during which no maintenance is being accomplished due to logistics delay
- **Administrative/Logistics Delay Time (ALDT):**
  - Mean value of ADT + LDT
- **Mean Time To Repair (MTTR):**
  - Mean active maintenance time
    - Usually repair action specific due to variability of repair times (replacing an engine takes much more time than changing a tire)

Math Basics Required: Metrics

- **The symbol λ represents the failure rate**
- **MTBF (or MTTF) =** $\dfrac{1}{\lambda}$
- **Availability Measures**

$$\text{Inherent Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

$$\text{Operational Availability} = \frac{\text{MTBM}}{\text{MTBM} + \text{MDT}} \text{ or } \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

$$\text{Materiel Availability} = \frac{\text{Active Inventory}}{\text{Active Inventory} + \text{Inactive Inventory}} \text{ or } \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

Note: Operational Availability and Materiel Availability both have uptime/(uptime + downtime) definitions but the uptime and downtime definitions are different for each measure!

New RAM Policy

New RAM Policy: Origins of Sustainment Key Performance Parameter (KPP)

- **JCIDS process detailed in DoD 5000.02**
- **Incorporated into JCIDS 3170.01 series in May 2007**
- **Refined in new JCIDS 3170.01 versions in March 2009**
- **Availability KPP**
  - Materiel Availability
  - Operational Availability (Added in March 2009)
    - May require multiple values
- **Reliability Key System Attribute (KSA)**
  - Mission Reliability
    - May require multiple values!
  - Logistics (Basic) Reliability
- **Ownership Cost KSA**

New RAM Policy: July 21st RAM Policy Memo

- **DDR&E SE maintains that a viable RAM strategy requires consideration of sustainment and fielding issues during system design**
  - Mandated in new Acquisition Reform Law (WASARA)
- **Note the policy intentionally calls for a "…reliability growth program…" and not simply a growth curve**

> "Effective immediately, it is Department policy for programs to be formulated to execute a viable RAM strategy that includes a reliability growth program as an integral part of design and development."

UNCLASSIFIED

Applicable RAM Metric Relationships

- **Operational Availability:** $$A_O = \frac{MTBM}{MTBM + MDT}$$

- **Maintenance Down Time:** $$MDT = MTTR + \overline{ADT} + \overline{LDT}$$

- **Available Tradeoffs:**
  - **A_O is improved by:**
    - Decreasing MDT
    - Increasing MTBM
  - **MDT is decreased by:**
    - Reducing MTTR
    - Reducing average ADT
    - Reducing average LDT
  - **MTBM is increased by:**
    - Increasing MTBF
    - Decreasing need for scheduled maintenance requiring system to be taken offline

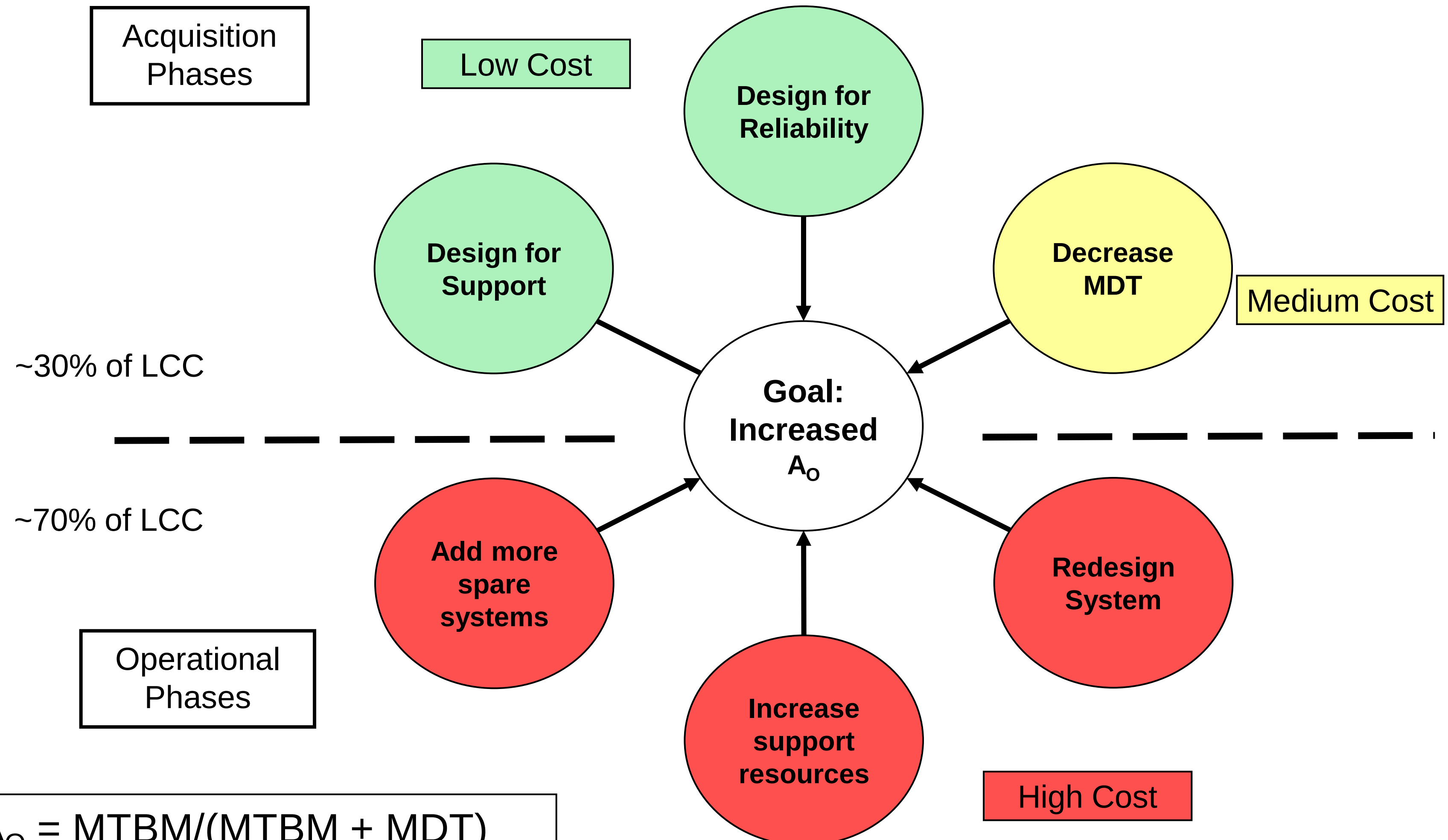
MDT is Decreased by…

- **Decreasing Mean Time To Repair**
  - Adding Maintainers (Increases Cost)
  - Designing for Maintainability (Cost Neutral to Slightly Increased)
- **Decreasing Average Administrative Delay Time**
  - Increasing efficiency of request for repair system (Cost Neutral)
- **Decreasing Average Logistics Delay Time**
  - Increasing spares availability
    - Pre-position spares to decrease shipping time (Increases Cost)
    - Acquire extra spares (Increases Cost)
    - Adding Maintenance Locations (Increases Cost)
  - Improving efficiency of spares distribution system (Cost Neutral)

MTBM is Improved by…

- **Increasing Reliability**
  - Incorporating Redundancy Into the Design
    - Increases Cost, Weight, Logistics Failures
  - Using Best Practices
    - Reliability Growth Testing (Slight Cost Increase)
    - Using High Reliability Parts (Slight Cost Increase)
    - Implementing a Failure Reporting and Corrective Action System (Cost Neutral)
    - Executing a Failure Modes, Effects, and Criticality Analysis (Cost Neutral)
    - Design for Reliability (Cost Neutral)
    - Physics of Failure Analysis (Cost Neutral)
- **Decreasing Scheduled Maintenance Requirements (Cost Neutral)**

Approaches to Improve Operational Availability (A_O)



$$A_O = MTBM/(MTBM + MDT)$$

A_O vs. A_M

A_O vs. A_M: What is Materiel Availability?

- **Materiel Availability (A_M) is a system design metric**
  - Applies to all items that have been delivered at any point in time—Active + Inactive
  - A_O applies only to the Active Inventory—and usually to a subset of that!
- **A_M is optimized—not maximized**
  - A_O is a direct measure of operational effectiveness
    - Usually best when <u>maximized</u>
  - A_M is a function of how the system is intended to be fielded
    - <u>Any value</u> is acceptable
      - A missile system where only 5% of the missiles are fielded at any one time might have a valid A_M of 0.05!

A_O vs. A_M: What is Materiel Availability? (cont.)

- **Definitions:**
  - For End Items or Assemblies procured with spares (includes one-shot devices) :

$$A_M = \frac{\text{Number Ready for Tasking}}{\text{Total Number Acquired}}$$

  - For Systems procured as part of an end item:

$$A_M = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

A_O vs. A_M: What is Materiel Availability? (cont.)

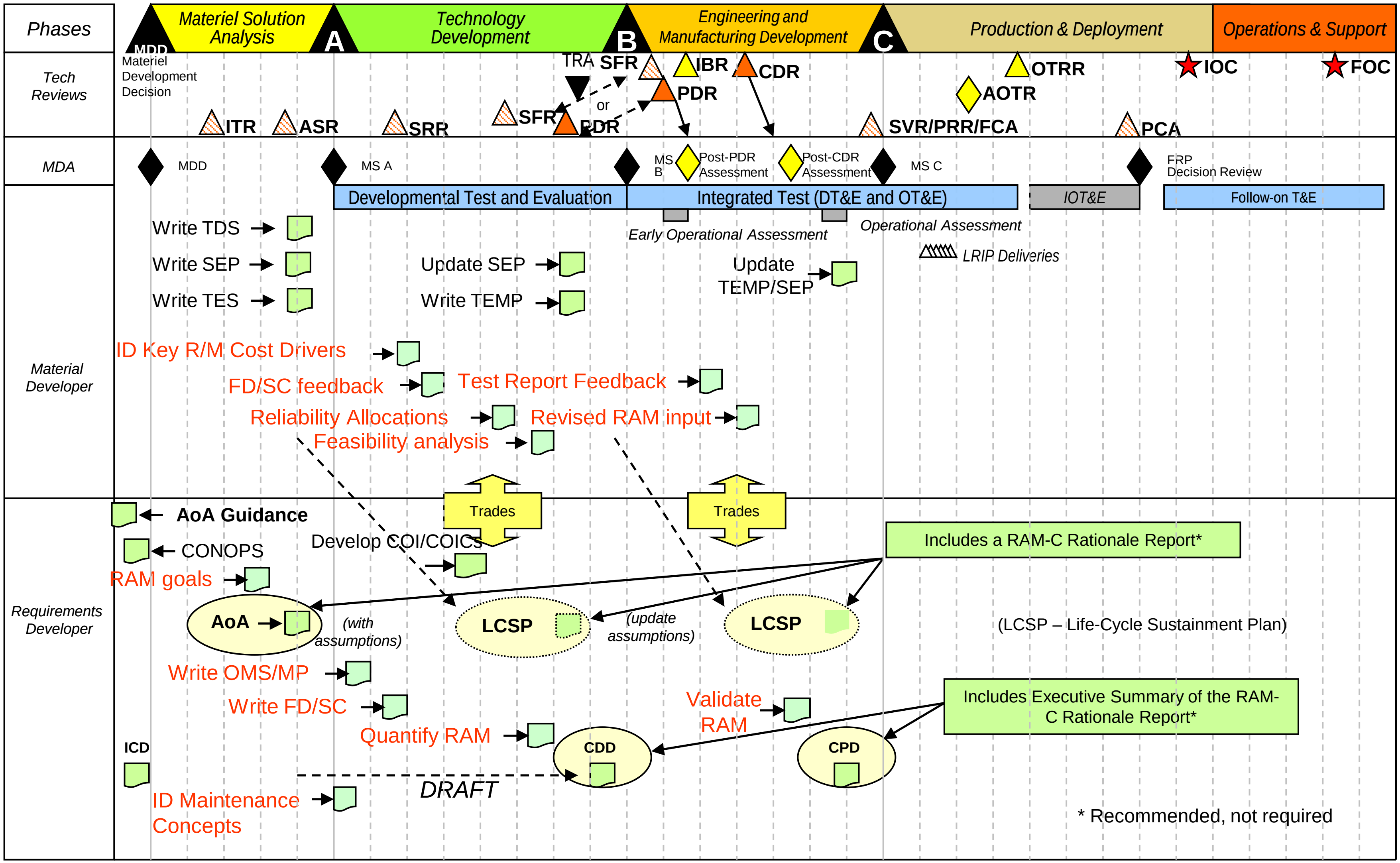
- **Proper implementation requires tradeoffs between operational AND non-operational factors:**
  - Operational factors include:
    - A_O
    - Mission Reliability
    - Logistics Reliability (aka Basic Reliability)
    - Maintenance Down Time (MDT)
  - Non-Operational factors include:
    - Total Inventory
    - Active Inventory
    - Sustainment Strategy (repair levels, spares availability, delays, etc.)
    - Ownership Cost

A_O vs. A_M: What is Materiel Availability? (cont.)

- **DDR&E SE has developed a handbook for implementation of the Sustainment KPP**
  - RAM-C Rationale Report Manual
    - Called for in the July 21st memo
  - Signed May 31, 2009
    - Army non-concurral based on A_M not being immediately under the full control of the combat commander
    - Added A_O as additional consideration in newest version of 3170.01 series manuals

Guidance in RAM-C Manual

RAM-C Manual: Report Timeline



UNCLASSIFIED

RAM-C Manual: Phased Requirements and Measurements

Metric	Milestone	How Measured	Responsible Activity	When Measured	Program Phase Metric
Availability Materiel Availability (A_M)	A	Comparative Analysis with Legacy Systems and/or Engineering Assessment	Program Manager (PM) or Program Sponsor if PM not assigned	Pre Alternative System Review (ASR) for all candidate systems Post ASR for preferred system selected	$\frac{\text{(number of operational end items)}}{\text{(total number of end items acquired)}}$ or $\frac{\text{uptime}}{\text{uptime} + \text{downtime}}$ Value is “as planned” given the expected system use and support concept
Operational Availability (A_O) KPP	B	Demonstrated through testing plus modeling and simulation where needed	Test and Evaluation Activity	During DT and Early User Tests (EUT)	Scored failure rate per FD/SC • MTBF if all failures classified as critical and MTBM otherwise MDT modeled from MTTR, LDT, and ADT • MDT estimates from early in program; Replaced by data as available
	C	Demonstrated through testing and analysis of early fielded system performance	Test and Evaluation Activity and Program Manager	During DT, DT/OT and Limited User Tests/Operational Assessment	Scored failure rate per FD/SC • MTBF if all failures classified as critical and MTBM otherwise MDT modeled from MTTR, LDT, and ADT values
	FRP and Beyond	Demonstrated through analysis of fielded system performance	OTA and Program Manager	During IOT and throughout system life cycle	$\frac{\text{(number of operational end items)}}{\text{(total number of end items acquired)}}$ or $\frac{\text{uptime}}{\text{uptime} + \text{downtime}}$

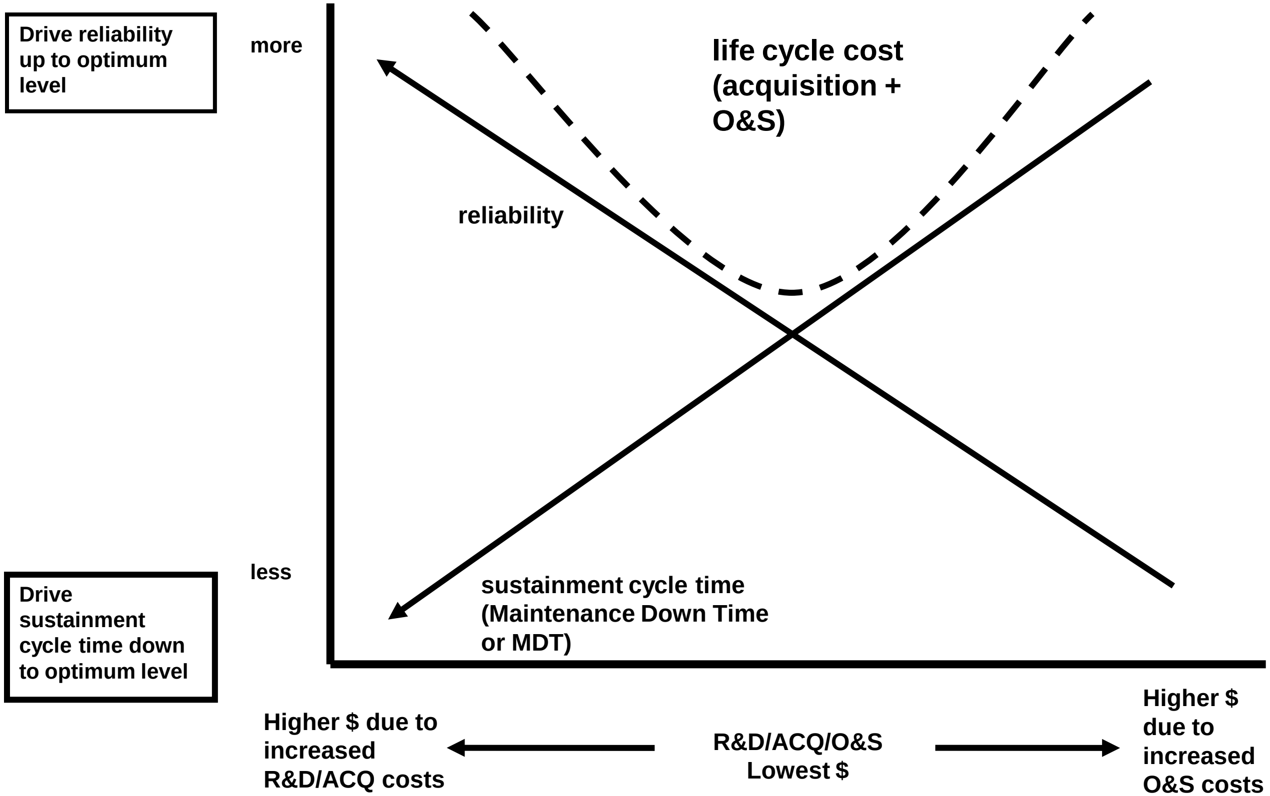
RAM-C Manual: Phased Requirements and Measurements (cont.)

Metric	Milestone	How Measured	Responsible Activity	When Measured	Program Phase Metric
Reliability (R_M) (KSA)	A	Comparative Analysis with Legacy Systems and/or Engineering Analysis	Program Manager or Program Sponsor if PM not assigned	Pre ASR for all candidate systems Post ASR for preferred system selected	MTBF/MTBM derived from warfighter's stated needs and translated into contract level testable values.
	B	Demonstrated through testing, analysis, and modeling/ simulation	Test and Evaluation Activity	During DT and EUT	Scored failure rate per FD/SC • MTBF if all failures classified as critical and MTBM otherwise
	C	Demonstrated through testing, analysis, modeling/ simulation, and analysis of early fielded system performance	Test and Evaluation Activity and Program Manager	During DT, DT/OT, and LUT)/ Operational Assessment	Scored failure rate per FD/SC • MTBF if all failures classified as critical and MTBM otherwise
	FRP and beyond	Demonstrated through analysis of fielded system performance	OTA and Program Manager	During IOT and throughout system life cycle	Scored failure rate per FD/SC • MTBF if all failures classified as critical and MTBM otherwise

RAM-C Manual: Phased Requirements and Measurements (cont.)

Metric	Milestone	How Measured	Responsible Activity	When Measured	Program Phase Metric
Ownership Cost (OC) (KSA)	A	Comparative analysis with legacy systems or documented analysis when legacy systems unavailable	Program Manager (PM) or Program Sponsor if PM not assigned	Pre Alternative System Review (ASR) for all candidate systems Post ASR for preferred system selected	Initial, rough approximation based on projected energy and maintenance costs for assumed inventory and operating tempos and "placeholders" for Sustaining Support and Continuing System Improvements.
	B	Results of prototype testing; projected requirements for Sustaining Support and Continuing System Improvements as described in the Cost Analysis Requirements Description (CARD)	Program Manager with inputs from test and evaluation activity and contractors	During DT and Early User Tests (EUT)	For energy and maintenance, refined estimate based on demonstrated results in testing. Estimates for Sustaining Support and Continuing System Improvements, as described in the CARD, are refined based on analysis of test results and similar, legacy systems
	C	Demonstrated through testing and analysis of early fielded system performance	Program Manager with inputs from test and evaluation activity and contractors	During DT, DT/OT and Limited User Tests/Operational Assessment	Further refined estimates for all four OC elements, based on SDD test results and validated requirements for Sustaining Support and Continuing System Improvements
	FRP and Beyond	Demonstrated through analysis of fielded system performance	OTA and Program Manager	During IOT and throughout system life cycle	Updates based on actual energy consumption, maintenance, Sustaining Support and Continuing System Improvements costs.

RAM-C Manual: Trade-offs Required for Sustainment KPP



- **The Sustainment KPP ensures the program considers reliability and O&S costs equally during system design and development**

RAM-C Manual: Stakeholder Tasks and Responsibilities

Stakeholder	Tasks/Responsibilities
Combat Developer	o Primary responsibility for drafting sustainment requirements and rationale articulated in the RAM-C Report. o Drafts the Operational Mode Summary/Mission Profile and Fault/Failure Definition and Scoring Criteria o Develops the maintenance and support concepts articulated in the CONOPS, CDD, and CPD o Solicit warfighter insights/inputs into sustainment requirements, fault/failure definition and scoring criteria, and maintenance/support concepts
Program Manager (Program Sponsor if PM not yet Assigned)	o Supports the combat developer in providing expert engineering and supportability analysis in developing sustainment requirements detailed in the applicable JCIDS document (CDD and CPD) o Responsible for implementing design for R&M and to demonstrate it through M&S, analysis, and event driven component, subsystem, and system level testing o Ensures development of the Product Support Elements (IETMs, provisioning, training, support equipment, etc.) required to implement the support concept o Establishes Performance-Based Agreement (PBA) with Product Support Integrators/Providers

UNCLASSIFIED

RAM-C Manual: Stakeholder Tasks and Responsibilities

Office of the Under Secretary of Defense (OUSD)	o Provides management and technical oversight as appropriate o PA&E provides Analysis of Alternative Guidance o CAIG will conduct assessment of RAM-C reports when conducting independent cost estimates in support of Milestone Reviews
Joint Staff	o Staffs and approves requirements in accordance with the JCIDS process
DoD Component (Lead Service)	o As directed, conduct the Analysis of Alternatives and include the results of sustainment analysis in the briefings and final report
Test and Evaluation Activities	o Provides appropriate input into the statement of requirements to ensure they are articulated in measurable and testable terms while also providing input into the validity and clarity of assumptions o Confirms sufficiency of test assets and schedule to support the RAM evaluation efforts including system reliability and maintenance o Verifies test program includes sufficient time for retest of any needed corrective actions o Evaluate A_M and R_M

RAM-C Manual: Failure Definition and Scoring Criteria (FD/SC)

Document	Purpose	Contents
Failure Definitions	**To establish the guidelines used to classify the cause and effect of test incidents prior to test start**	▪ Mission Essential Functions must be determined and recorded • Mission essential functions are the minimum operational tasks that the system must be capable of performing in order to accomplish the assigned mission • Descriptions of mission essential functions should be in operational terms that relate to mission requirements • The equipment operator should be able to readily identify the loss of a mission essential function
Scoring Criteria	**Test scoring results are used to determine reliability estimates for the system at the applicable point in time**	▪ Scoring criteria must be applicable to the sustainment requirements ▪ Charging of incidents must be grouped as to the reason/cause of the incident (i.e. hardware, software, operator error, accident, etc.) ▪ Includes a classification process that ensures the consistent analysis of all test events including (at the minimum): • No-Test • Correctable Maintenance • Operational Mission Failure • Essential Maintenance Action • Unscheduled Maintenance Action • Identification of the Chargeable Event • Rating of the Hazard/Severity of the failure/incident

UNCLASSIFIED

RAM-C Manual: Operational Modes Summary and Mission Profile (OMS/MP)

Document	Purpose	Contents
Operational Mode Summary	To provide a description of the anticipated mix of ways a system will be used in carrying out its operational role	▪ Documented system usages to be used as fundamental inputs to the design process and as the basis for test and evaluation efforts ▪ All primary missions listed in the mission profile must be covered ▪ Includes relative frequency of the various missions or the percentage of the systems to involved in each mission ▪ Details percentage of time the system will be exposed to each type of environmental condition during the system life
Mission Profile	Provision of a time phased description of the operational events and environments an item experiences from beginning to end of a specific mission	▪ Identification of the tasks, events, durations, operating conditions, and environments the system encounters during each phase of the mission ▪ Must include typical mission scenarios ▪ Should identify mission tasks or operational events that must be completed to successfully accomplish the mission ▪ States specific amounts of operation (e.g. hours, rounds, miles, cycles, etc.) for each mission essential functions within the mission ▪ Shall be consistent with doctrine and tactics ▪ May use a timeline or any other appropriate format

Summary

- **RAM must return to being a key design consideration during system development—and the new Acquisition Reform legislation mandates this!**
- **Sustainment costs are mostly set during system design**
- **The Sustainment KPP is intended to establish necessary trade space**

Modeling and Simulation Support for the Systems Engineering of Systems of Systems

Presented by: Dr. JoAnn Lane, USC

Dr. Judith Dahmann, MITRE
Dr. William Asrat, MTSI
George Rebovich, MITRE
Ralph Lowry, MTSI
Jim Hollenbach, Simulation Strategies

NDIA Modeling and Simulation Committee

12th Annual NDIA Systems Engineering Conference
October 28, 2009

UNCLASSIFIED

NDIA M&S Committee Contributors

Emily Andrew, Raytheon

Terry Christian, AF Research Lab

David Dubuque, Aegis Technologies

Frank Grange, Lockheed Martin

Hugh Griffis, Aeronautical Sys Ctr

Thomas Haley, NUWC Newport

Steve Hall, Lockheed Martin

Chet Harris, Lockheed Martin

George Hazelrig, NSF

Hans Polzer, Lockheed Martin

Robert Koury, Lockheed Martin

Dennis Bergin, 3CE

Favio Lopez, US Army

Stephen Lyda, NAVAIR

Lan-Thanh McGough, MC Systems Command

Dave Prochnow, MITRE

Kenneth Small, NSWC Dahlgren

Danny Thomas, Aegis Technologies

William Tucker, Boeing Company

Robert Upchurch, Aegis Technologies

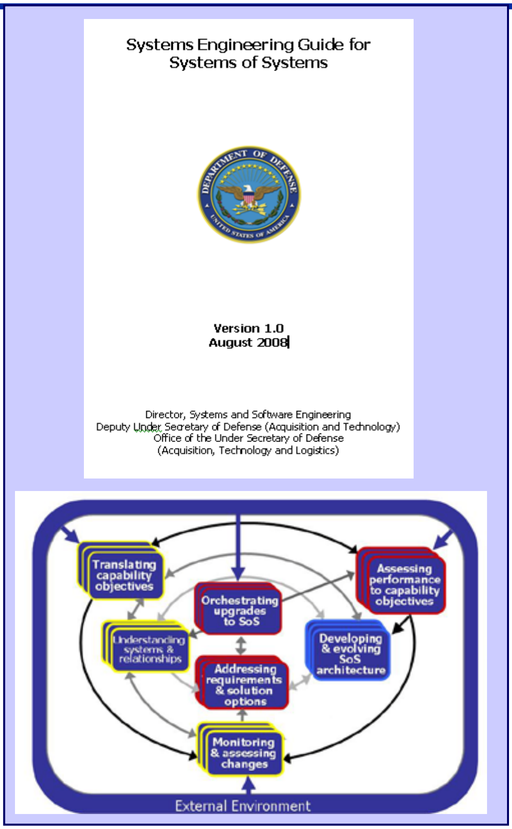
Pin Chen, Australia DoD

Eric Johnson, US Army TRAC

Brian Hobson, Booz Allen Hamilton

UNCLASSIFIED

Systems Engineering for Systems of Systems



SoS: ***A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities***

- **AT&L Released "Systems Engineering for Systems of Systems" Version 1.0 in August 2008**
- **How does the SoS SE Guide address M&S?**
  - Initial .9 Version included M&S throughout the draft
  - The practitioner reviews indicate limited use of M&S
    - Main place where M&S was cited is in the emulation of systems not otherwise available for testing
  - Consequently the 1.0 Working Draft limited M&S to this area
  - Comments on the draft identified more uses of M&S
  - The final 1.0 Version has an M&S section and added places where M&S is discussed
- **Requested M&S Committee provide input on use of M&S to support SE for SoS**

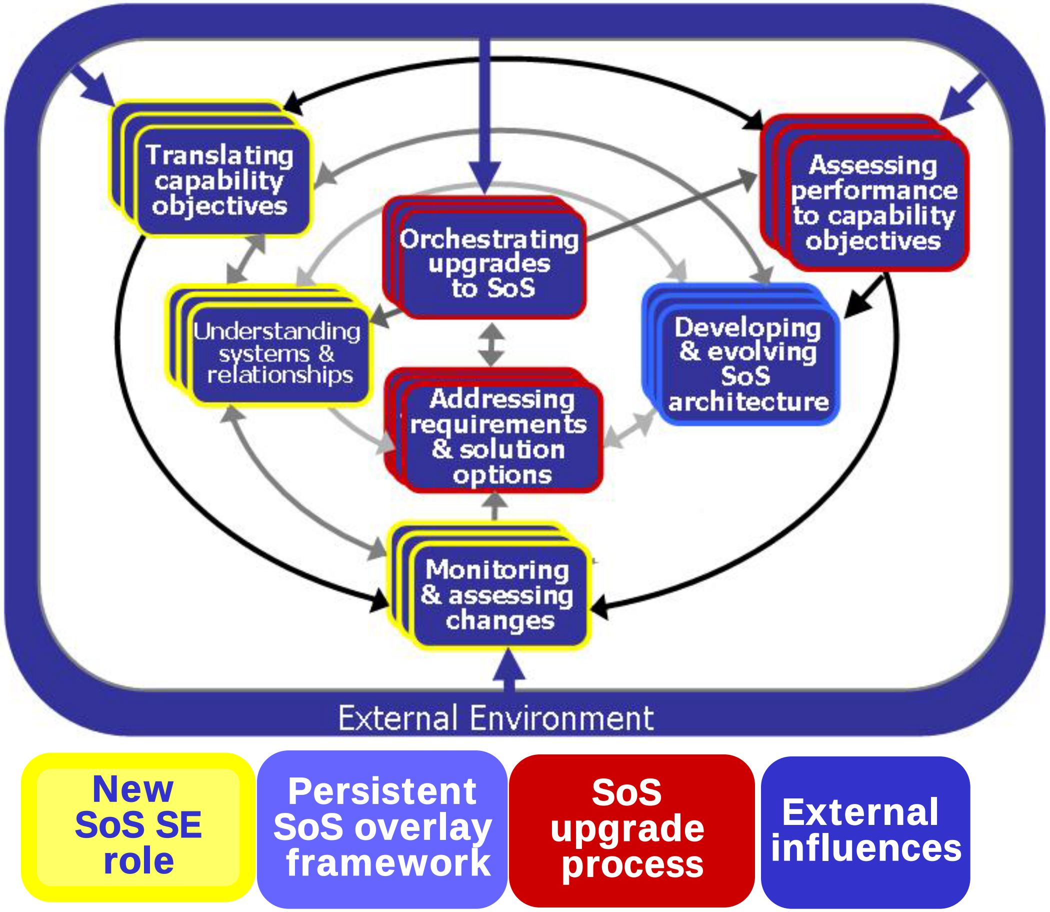
Modeling and Simulation in SoS*

- A technical toolset used regularly in systems acquisition & engineering [NDIA, 2004]
- Applied throughout system development lifecycle
  - Supports early concept analysis, through design, DT&E and OT&E
- Supports SoS SE in a number of areas
  - Understand complex & emergent behavior of systems that interact with each other
  - Provides an environment to help SoS SE team create new capability from existing systems
  - Illuminates integration issues that can have a direct effect on the operational user
  - Analysis of architecture approaches & alternatives
  - Analysis of requirements & solution options
  - Support T&E when difficult or infeasible to do in other ways, particularly end-end performance
- Challenges
  - Ensuring M&S validity
  - Include M&S considerations early in SE planning, including resources to identify, develop, evolve & validate M&S to support SE and T&E.

**** From SEG Reference Guide, section 1.7.4***

Specific Survey Request

SE Model for SoS Based on 7 Core Elements of SoS SE



For each of the seven core elements of SoS systems engineering (SE), please share your views on:

- The potential for applying modeling and simulation, including why M&S has potential value
- Your experience using M&S for this SoS SE element, including the context of the application, the ways M&S was applied, the products produced, how they were used, and the value added by M&S
- The enablers for use of M&S in this element, including what attributes made successful use of M&S possible (in cases where it was applied)
- and barriers that inhibited use of M&S (in cases where the potential is not being realized).

UNCLASSIFIED

Summary of Survey Inputs

Organization	Quick Summary	Example
Raytheon	Views and specific experiences	X
AF Research Lab (AFRL/XPT)	Organizational experience	
Aegis Technologies	Perspective on issues	
Lockheed Martin	Views and specific experiences	X
Aeronautical Sys Ctr (ASC/END)	Organizational experience	
NUWC Newport	Views based on M&S for SE	
Lockheed Martin	Views and specific experiences	
Lockheed Martin	Perspective on issues	
National Science Foundation	Views based on M&S for SE	
Lockheed Martin	Views and specific experiences	X
3CE	Views and specific experiences	X
NAVAIR	Views based on M&S for SE	
MC Systems Command	Views and specific experiences	X
MITRE	Views and specific experiences	X
NSWC Dahlgren	Perspective on issues	
Aegis Technologies	Perspective on issues	
Boeing Company	Views and specific experiences	X
Aegis Technologies	Perspective on issues	
Australia	Paper	

- **19 responses from 14 organizations**
- **10 volunteers synthesized the report on survey results**
- **Responses were of several types**
  - Views and specific experiences with M&S and SoS
  - Perspective on issues of M&S and SoS
  - Views based on M&S for SE
  - Organizational experience
  - Relevant papers on topic
- **8 specific project experiences cited in survey responses or papers**

UNCLASSIFIED

NDIA Survey Analysis: What We Did and Why We Did It

What we did …..

- Listed key SoS SE activities for each core element
- Mapped survey responses to each of these key activities by asking ourselves "how can M&S support this key SoS SE activity?"
- We retained the *potential-experience-enabler/inhibitor* organization of responses under each activity – it is a useful organizing principle for presenting information
- Added a "General" category for those responses that were relevant but not easy to categorize by SoS core element

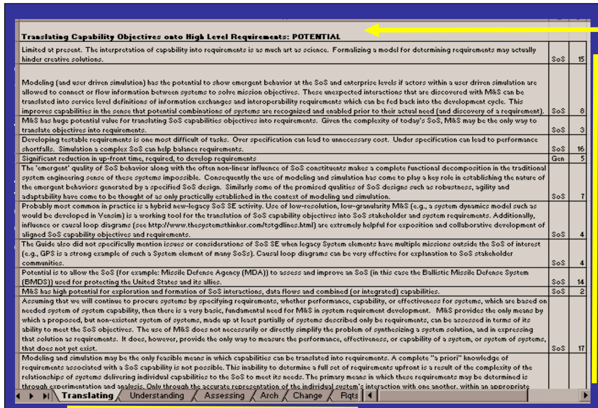
Why we did it …..

- We saw the audience for this information as SoS SEs asking 2 basic questions:
  - ***What are the critical or unique SE activities in each core element?***
  - ***What are the potential, experience, & enablers/inhibitors of M&S to support me in executing each core element activity?***

UNCLASSIFIED

Process

- Compiled inputs into master workbook
- Reviewed inputs by SoS SE core element



Sections for Potential, Experience, and Enablers

Comments are tagged by survey number and basis (SoS, Systems, of General Experience)

One worksheet for each SoS SE Core Element

- Binned inputs for each element in terms of the key activities in each element

Core Element	Element Activities	M&S Responses		
		Ptnl	Exp	En/ In
Translating Capability Objectives	SoS SE translates needed capabilities into high-level requirements at the outset of the program & as the situation changes & SoS evolves	3		
	SoS SE needs to understand nature & dynamics of SoS & anticipate areas likely to vary in implementation & over time			
	SoS SE defines functions to provide capability & variability in environment that impacts different ways they are executed			
	Evaluate operational utility & derive requirements via reference missions & use cases		1	

- Summarized the inputs across elements and activities

M&S in *Assessing Performance to Capability Objectives* (1 of 2)

- **SoS SE establishes metrics and methods for assessing performance of SoS capabilities independent of implementation alternatives**
  - **Potential:** M&S can be applied to systems as they are developed and then re-applied to systems as they are combined to prove concepts at each development phase
  - **Potential:** Measurements of envisioned performance can be determined such as the amount of time it takes for an associated function of the capability to be performed (e.g., an hour to get updated information on pilot availability from an envisioned Pilot Skills System).
  - **Experience:** M&S-based interoperability HWIL testing to assess performance of the fielded SoS configuration provides key data for the accreditation authority's decisions about caveats and limitations in accreditation of the constructive simulation of the SoS
  - **Experience:** We have used hardware in place of the ship simulation and still provided the environment to the hardware through a Force-On-force or Mission level simulation. Examples of this approach include performance analysis of a C4I network connection of a SoS, missile flyout for design verification, an Asymmetric Missile Defense architecture concept, and a proof of concept for a Wide Area Surveillance of land and sea.
  - **Enabler:** Availability of appropriately high-resolution element M&S for integration into the SoS-level M&S in performance assessment
  - **Enabler:** Define and supply the data necessary to construct a valid M&S solution.

- Presented results to the M&S committee at August meeting

Results of M&S Committee Survey on M&S in SoS SE

Judith Dahmann
William Asrat
George Rebovich
Jo Ann Lane
Ralph Lowry

http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/Modeling_and_Simulation_Committee.aspx

UNCLASSIFIED

Findings from Survey Responses (1 of 3)

- **General**
  - Many feel that M&S can be value-adding for many aspects of SoS development and evolution
  - M&S is better suited to some SoS domains/aspects than others
  - However, there seems to be limited SoS-level experience with M&S and often this experience is with low-fidelity M&S tools with limited usefulness
  - Most experience appears to be with respect to testing/assessment, with results fed back to the next evolution/development cycle

- **Types of models/simulations identified in responses**
  - Static models such as DoDAF, SysML, and parametric cost models
    - Depiction of organizational relationships among the systems
    - Use cases to identify scenarios
    - Identification of SoS configurations and evolution options
    - Identification of gaps
    - Cost vs. performance analysis

Findings from Survey Responses
(2 of 3)

- **Types of models/simulations identified in responses *(continued)***
  - Dynamic interface simulators to provide data needed to drive systems, support analysis/testing, and evaluate mission scenarios
  - Dynamic simulations to probe current and future
    - Capabilities/functions
    - Relationships and dependencies
    - Architecture/design alternatives
    - CONOPS
  - Dynamic simulations to support performance evaluations
    - Background loading for mission evaluations
    - Data to facilitate accreditation authority decisions
    - Network analysis
    - Algorithm analysis
    - System interoperability assessment
    - Proof of concept
  - Dynamic simulations to support operator-in-the-loop exercises and training

Findings from Survey Responses
(3 of 3)

- **Few enablers reported with respect to experiences**
  - Most were a “need” to realize a potential
- **Considerable inhibitors/barriers to effective M&S in the SoS environment:**
  - Inexperienced staff (developers to develop needed models/sims, analysts that can interpret/make use of the results, and people with both M&S and domain experience)
  - Low-fidelity tools (when high-fidelity tools are needed)
  - Data to drive the models/sims
  - Flexible/easily-adapted tools
  - Funding
- **Some comments suggested that M&S can replace some testing**
  - Additional insights into that would be useful

Summary and Conclusions
(1 of 2)

- **All SoS SE core elements supported to some extent by M&S as indicated by the experience responses**
- **But, continue to struggle with the application of M&S in the SoS environment**
  - Lots of potential identified
  - Considerable number of enablers/inhibitors for M&S in the SoS SE environment
  - Much less experience (8 specific project experiences) with M&S in the SoS SE environment
    - Consistent with SoS SE pilot program interviews
- **Considerable overlap between actual use in experiences and potential**
  - Implication: A few have found ways to realize some of the potential

Summary and Conclusions
(2 of 2)

- **Inhibitors key to understanding lack of actual experience**
  - Models/simulations not comprehensive and tend to focus on a specific aspect or area of interest
  - Often not applicable "as is" for other opportunities
    - Needed models/simulations not at the right fidelity
    - Considerable time/resources needed to develop/modify models/simulations
    - Not worth the ROI given the needed lead time and funding
- **If M&S is to be a valuable tool for SoSs, need to overcome barriers**
- **Potential follow-on**
  - Details of experiences
  - Additional insights into using M&S instead of testing

Safety Technology Insertion in DoD Acquisition Programs

Dr. Elizabeth Rodriguez-Johnson
Executive Secretary, Acquisition and Technology Programs Task Force (ATP TF)
Systems Engineering Directorate
Office of the Director, Defense Research and Engineering

12th Annual NDIA Systems Engineering Conference
October 28, 2009

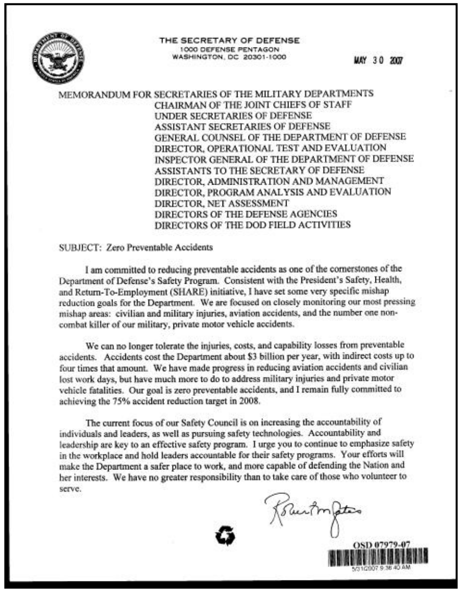
Overview

- Secretary of Defense Guidance
- DoD Response
- DSOC ATP TF Policy Initiatives
- DSOC ATP TF Tool Development Initiatives
- Implementation Gap – Technology Insertion
- ATP TF Technology Insertion Study
    - Roadblocks
    - Recommendations
- Summary
- Contact Information

Secretary of Defense Guidance

- **"We will fund as a first priority those technologies and devices that will save lives and equipment. We will retrofit existing systems, and consider these devices as a 'must fund' priority for all new systems." – Secretary Rumsfeld, June 22, 2006**
- **"We have no greater responsibility than to take care of those who volunteer to serve" – Secretary Gates, May 10, 2007**

"DoD Components will pursue the following accident reduction and prevention initiatives: emphasizing safety in the workplace and hold leaders accountable for their safety programs; … and achieving a 75 percent accident reduction target by 2012 from a 2002 baseline in military and civilian injuries, private motor vehicle fatalities, and aviation accidents." - Guidance for the Development of the Force 2010-2015, April 2008



THE SECRETARY OF DEFENSE
1000 DEFENSE PENTAGON
WASHINGTON, DC 20301-1000

MAY 30 2007

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARIES OF DEFENSE
ASSISTANT SECRETARIES OF DEFENSE
GENERAL COUNSEL OF THE DEPARTMENT OF DEFENSE
DIRECTOR, OPERATIONAL TEST AND EVALUATION
INSPECTOR GENERAL OF THE DEPARTMENT OF DEFENSE
ASSISTANTS TO THE SECRETARY OF DEFENSE
DIRECTOR, ADMINISTRATION AND MANAGEMENT
DIRECTOR, PROGRAM ANALYSIS AND EVALUATION
DIRECTOR, NET ASSESSMENT
DIRECTORS OF THE DEFENSE AGENCIES
DIRECTORS OF THE DOD FIELD ACTIVITIES

SUBJECT: Zero Preventable Accidents

I am committed to reducing preventable accidents as one of the cornerstones of the Department of Defense's Safety Program. Consistent with the President's Safety, Health, and Return-To-Employment (SHARE) initiative, I have set some very specific mishap reduction goals for the Department. We are focused on closely monitoring our most pressing mishap areas: civilian and military injuries, aviation accidents, and the number one non-combat killer of our military, private motor vehicle accidents.

We can no longer tolerate the injuries, costs, and capability losses from preventable accidents. Accidents cost the Department about $3 billion per year, with indirect costs up to four times that amount. We have made progress in reducing aviation accidents and civilian lost work days, but have much more to do to address military injuries and private motor vehicle fatalities. Our goal is zero preventable accidents, and I remain fully committed to achieving the 75% accident reduction target in 2008.

The current focus of our Safety Council is on increasing the accountability of individuals and leaders, as well as pursuing safety technologies. Accountability and leadership are key to an effective safety program. I urge you to continue to emphasize safety in the workplace and hold leaders accountable for their safety programs. Your efforts will make the Department a safer place to work, and more capable of defending the Nation and her interests. We have no greater responsibility than to take care of those who volunteer to serve.

OSD 07979-07
5/31/2007 9:36:40 AM

DoD Response led by the Defense Safety Oversight Council (DSOC)

DSOC Task Forces

- Aviation Safety
- Military Training
- Private Motor Vehicles
- Installation & Industrial Ops
- Worker's Compensation
- Enterprise Information
- Deployment & Ops
- Sports Injuries
- Acquisition & Technology Programs (ATP)*
  - Aviation Safety Working Group
  - Tactical Vehicle Safety Working Group

* With support from the ODUSD(I&E)-led DoD Acquisition Environment, Safety, and Occupational Health (ESOH) IPT

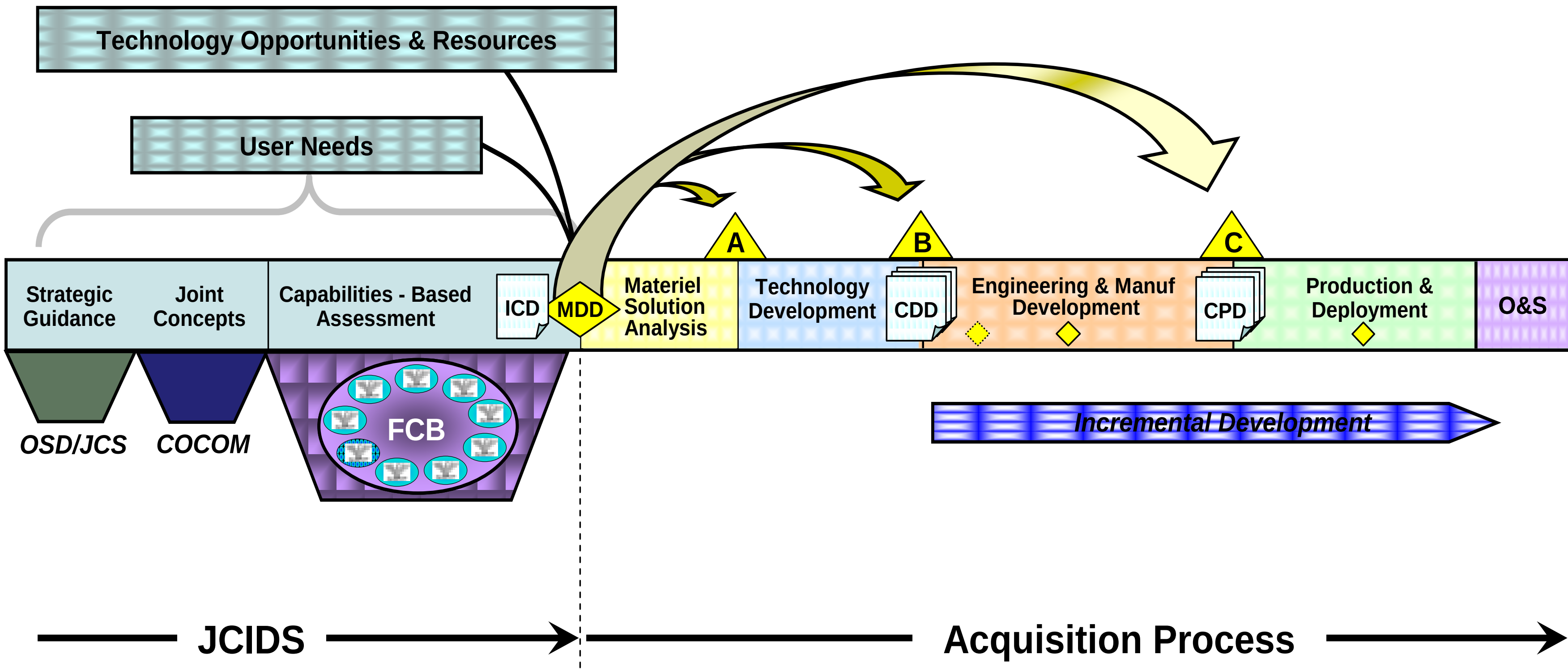
UNCLASSIFIED

ATP TF Policy Initiatives

- ✓ **Program Managers are required to use the structured ESOH risk assessment framework in the DoD Standard Practice for System Safety, MIL-STD-882D, as part of the Systems Engineering process to:**
  - Design out ESOH risks early in the acquisition process, or
  - Mitigate ESOH risks to an acceptable level
- ✓ **Prior to exposing people, equipment, or the environment to known system-related ESOH hazards, the associated risk levels must be accepted by the authorities identified in DoDI 5000.02. The User Representative must:**
  - be part of this process throughout the life cycle and
  - provide formal concurrence prior to all Serious and High risk acceptance decisions
- **Developing a process, "ESOH in Joint Capabilities Integration and Development System (JCIDS)," with recommendations that have potential to cost effectively prevent accidents.**
  - Endorsement of JCIDS documents by Senior-level ESOH leaders
  - NDIA System Safety Sub-Committee is sponsoring meetings to develop training for ESOH participants in JCIDS

ATP TF Policy Initiatives, Cont.

- Address ESOH risks early in the acquisition process as part of the "ESOH into JCIDS" & early Systems Engineering initiatives



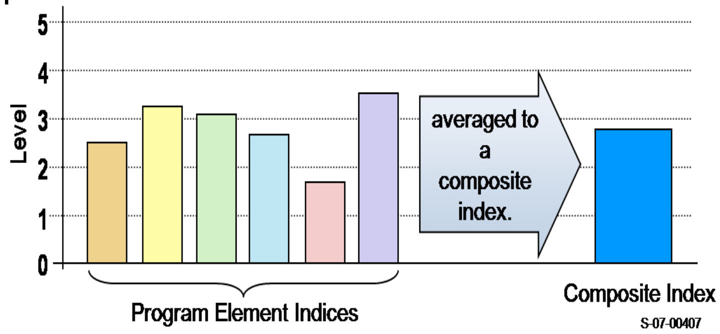
Defense Acquisition Management System

ATP TF Policy Initiatives, Cont.

- **Reporting ESOH Risk and Technology Requirements for Acquisition Program Reviews and Fielding Decisions**
  - Document the status of all ESOH hazards with a current risk category of **High or Serious**
  - ESOH Technology Requirement: Hazard mitigation technology required to eliminate or reduce the risk of systems or equipment failure and associated personnel and environmental hazards which may occur with or without failure of the system.
    - These technologies are not inherent parts of the design of the system, but rather are additions that have the primary purpose of mitigating a specific safety, personnel, or environmental hazard.
    - "Requirement" either specified in a DoD or Component Policy or JCIDS document or derived from a JCIDS requirement
  - ACAT ID, ACAT IAM, and Special Interest Programs shall report to the offices of the Director, Systems Engineering (D, SE) and the Deputy Under Secretary of Defense, Installations and Environment (DUSD(I&E)) via ***ESOH_Risk_Reporting@osd.mil*** at least ten working days prior to the OIPT
  - Reference Defense Acquisition Guidebook (DAG), Section 4.4.7.6 or **www.acc.ESOHRiskReporting**

ATP TF Tool Development Initiatives

- **System Safety Metrics Method Tool**
  - Development funded by DSOC
  - Tool to gauge the effectiveness of contractor system safety process
    - Separately identifies areas of *specific* strengths and weaknesses
    - In *any phase* of program life cycle
    - At low cost
    - With *fast turn-around* of results — *days, not weeks*
  - Similar to CMMI® model for assessing design maturity
    - Equally applicable by Government or Contractor
    - Improvement guidance available on an internal "No-Fault" basis
  - Can be used at any point in the system life cycle
    - Manager sees Program strengths / weaknesses with *"right-now"* immediacy
    - Can identify safety performance inadequacies and provide feedback to direct positive corrective action
    - Low cost, No special expertise required to administer
    - Gives tight focus of results on specific areas needing improvement
  - Built around responses to series of common-sense interview questions
    - The "System Safety Metrics Model" consists of one composite index supported by 6 element indices. Indices are evaluated by 39 indicators, each evaluated at one of 6 levels.
  - Data is analyzed and assigned metrics to identify areas of concern
    - Enables equitable program-to-program comparisons
    - Leads to improved management of risks / hazards
    - Reduced turn-around supports leading-indicator capability to reduce both number and severity of mishaps
  - US Army Aviation & Missile Command Safety Office conducted Beta test using 17 program practitioners
    - Report and Model: ***http://www.acq.osd.mil/atptf***

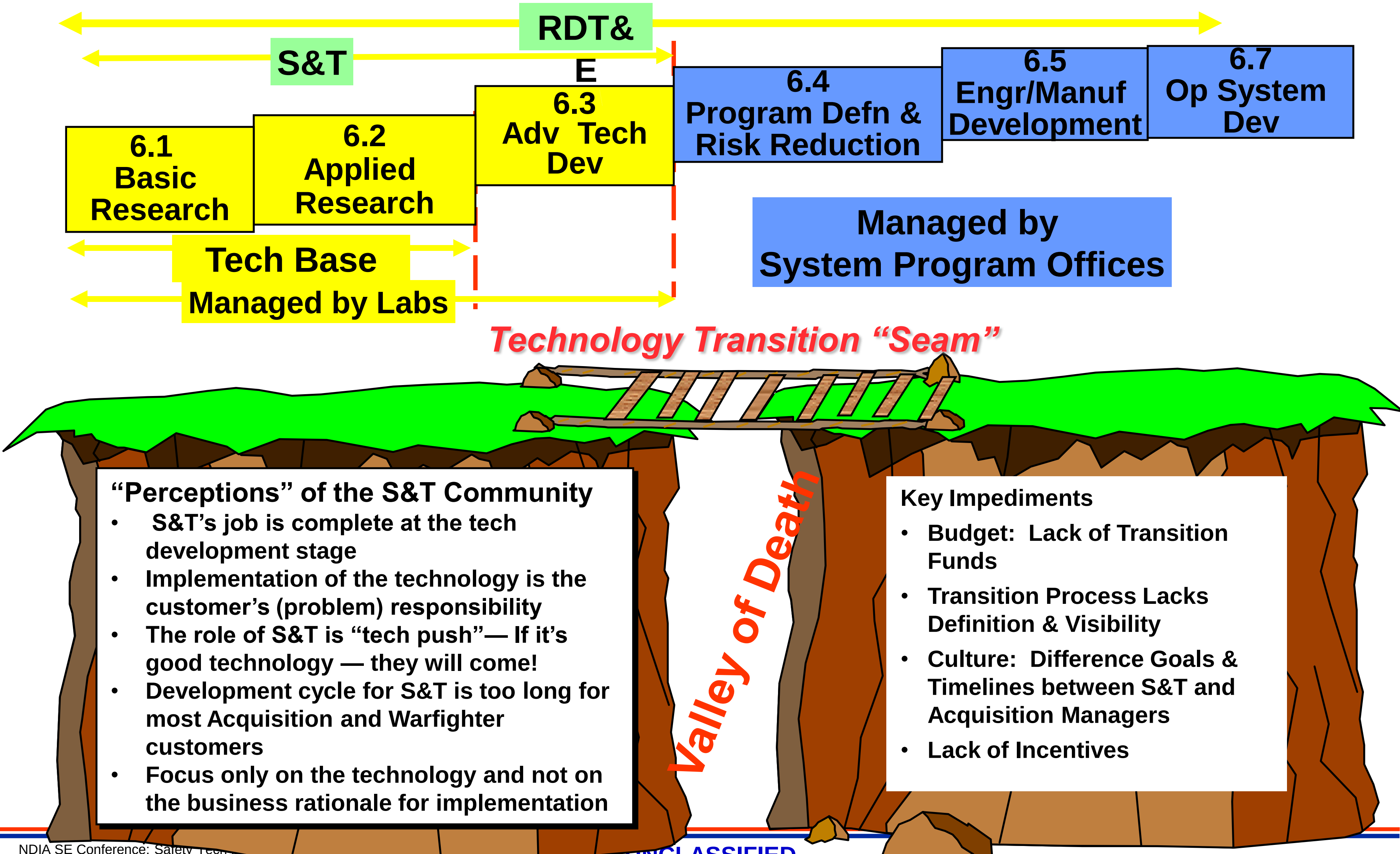


UNCLASSIFIED

ATP TF Tool Development Initiatives, Cont.

- **Noise Evaluation Acquisition Tool (NEAT)**
  - Development funded by DSOC
  - Help answer- What does noise cost the DoD?
  - Customizes existing steady-state noise exposure calculation tools resulting in a tool to meet DoD needs.
  - Applies validated research and existing processes to create a balanced incentive for system designers and their external reviewers to include noise control in the design process.
  - Includes detailed guidelines and examples to assist acquisition system managers, technical staff and external program reviewers in estimating realistic costs and risks associated with noise exposures.
  - Calculate life-cycle costs due to hearing loss caused by:
    - Dynamic steady-state noise exposure (military tactical vehicle)
    - Stationary steady-state noise exposure (mechanical room, cockpit)
  - Calculate speech interference levels for noisy environments
  - Illustrate the potential cost savings from integrating noise controls in the acquisition phase of military system procurements

One Significant Gap: Insertion of Technologies to Reduce ESOH Risks



ATP TF Technology Insertion Study

- **Goal: address impediments to incorporating high-payoff safety technologies into major defense acquisition programs.**
- **Focused on two major combinations of weapon system type and hazard as the "case studies"**
  - Tactical vehicles, rollover issue
  - Rotorcraft, brownout issue
- **Study was conducted in three phases:**
  - Conducted Stakeholder Workshop (October 2008)
  - Researched and evaluated existing business processes within the DoD military and commercial industry
    - Interviews with DoD, Military and commercial program representatives were conducted to investigate their business processes and identify how system safety and safety technologies are considered and evaluated.
  - Identified roadblocks and issues to inserting safety technologies
    - Examined the business processes from Phase 2 to determine the gaps in system safety and safety technology related actions and decisions.

ATP TF Technology Insertion Study Conclusions

- **Six categories of roadblocks to the insertion of safety technologies:**
  1. Systems Engineering (SE) and System Safety Roadblocks
  2. Capabilities (Requirements) Development Process Roadblocks
  3. Science and Technology Transition Challenges
  4. Science and Technology Investment Process Roadblocks
  5. Acquisition (Future) Program Challenges
  6. Legacy Program Challenges

NOTE: These are roadblocks to insertion of any technology, not just safety technologies

ATP TF Technology Insertion Study Identification of Roadblocks

- **Systems Engineering (SE) and System Safety Roadblocks:**
  - Safety is not an integral part of systems engineering culture or processes
  - Safety analysis lacks rigor and is not maintained across the product's life cycle
- **Capabilities (Requirements) Development Process Roadblocks:**
  - Lack of safety requirements / capabilities in the JCIDS documents
  - If included, safety requirements are too easily traded during system development activities
- **Science and Technology (S&T) Transition Challenges:**
  - Identifying & sustaining funding sources and Program sponsor throughout life cycle
  - Lack of understanding and communication between the S&T communities and the defense system PMs
- **Science and Technology Investment Process Roadblocks:**
  - S&T community lacks awareness of safety gaps and has no visibility to mishap data
  - No consolidated source that program offices or the S&T community can search to find out what technologies have been, or are being, invested in across the numerous S&T organizations, so there may be duplications across the S&T communities

UNCLASSIFIED

ATP TF Technology Insertion Study Identification of Roadblocks, Cont.

- **Future Acquisition Program Challenges:**
  - Competing performance requirements within the Program Manager's given cost and schedule constraints
  - Unwillingness to endure the additional risk (cost, schedule and/or performance) associated with inserting new technologies especially safety related technologies
  - Lack of information and cost sharing between program offices of similar product lines, which could reduce the risk and funding commitments for technology transition for an individual program
- **Legacy Program Additional Challenges:**
  - Requirements definition process is less formal and must rely on the strength of their sponsor or PM to sell the "safety requirement" to their leadership and acquire funding during the Planning Programming Budgeting and Execution (PPBE) process
  - Some legacy systems are not assigned to a program office, these systems are rarely examined for improvements or safety enhancements that would eliminate, or mitigate, existing safety design deficiencies

ATP TF Technology Insertion Study Recommendations

1. **Examine the Processes for the Collection, Analyses, and Utilization of Mishap and Epidemiological Data in the Acquisition Process**
   – Analyze the existing processes for collecting, analyzing, and utilizing mishap and epidemiological data from the Services. OSD should examine:
2. **Develop and Communicate Implementation Guidance for the DoDI 5000.02 ESOH Policy**
3. **Director, Defense Research and Engineering (DDR&E) should sponsor an ESOH Technology Focus Team (TFT) in FY2010**
4. **Establish a High Level Safety Requirement or Safety Key Performance Parameter for JCIDS Process**
5. **Establish a DoD-wide S&T Knowledge Management System**
6. **Develop a Feedback Mechanism to Determine How Acquisition Safety Policies are being Implemented**

UNCLASSIFIED

ATP TF Technology Insertion Study Recommendations Summary

Safety Technology Insertion Barriers	Recommendations: 1. Examine the Processes for the Collection, Analyses, and Utilization of Mishap Data and Epidemiological in Acquisition Process	2. Develop and Communicate Implementation of DoDI 5000.02 ESOH Policy	3. DR&E sponsor an ESOH TFT in FY10	4. Establish a High-level Safety Requirement or Safety KPP for the JCIDS Process	5. Establish a DoD-wide S&T Knowledge Management System	6. Develop a Feedback Mechanism on How Acquisition Safety Polices are Being Implemented
SE & System Safety Process	X	X		X	X	X
Capabilities (Requirements) Development Process	X			X	X	
Acquisition (Future) Program Challenges	X	X	X	X	X	X
Legacy Program Challenges	X		X	X	X	X
S&T Transition Challenges			X	X	X	
S&T Investment Process			X		X	

Summary

- Secretary of Defense Emphasis on Safety
- DoD Established DSOC with Nine Task Forces
- DSOC ATP TF Initiatives – Policies & Tools
- Implementation Challenge – Technology Insertion
- Identified Six Roadblocks to Technology Insertion (not exclusive to safety)
- Identified Six Cross-cutting Recommendations to Address the Roadblocks

Contact Information

Dr. Elizabeth Rodriguez-Johnson
Elizabeth.Rodriguez-Johnson@OSD.mil
703-697-4812

Assurance in Service-Oriented Environments

Soumya Simanta

Research, Technology, and System Solutions (RTSS) Program
Software Engineering Institute
Carnegie Mellon University
Pittsburgh 15232

28th October, 2009

Assurance in a Service-oriented World

Assurance of service-oriented systems is similar to assurance of any distributed systems

- Existing assurance approaches still apply at a component level

However, service-oriented environments bring new challenges because of their unique characteristics

- Reduced control
- Reduced observability and visibility
- Reduced trust
- Increased coordination and collaboration

Therefore, assuring SOA-based systems requires

- A new mindset
- Additional assurance methods, techniques, and tools
- Successful collaboration and coordination between participants

Dimensions of Assurance in Service-Oriented Systems

Assurance

Strategies
- Testing
- Monitoring
- Analysis
- Simulation
- Compliance

Elements
- SOA Infrastructure
- Web services
- Composites
- End-to-end Threads

Methods
- Techniques
- Tools

Aspects
- Functionality
- Quality Attributes
- Conformance

Perspectives
- Service Developer
- Service Consumer
- Service Integrator
- Infrastructure Provider
- Third Party Tester

Assurance Strategies$_1$

Testing

- Popular and effective strategy
- Not exhaustive but often provides good confidence
- Both automated and manual
- Works on the actual implementation

Monitoring

- Essential for providing runtime assurance for dynamic nature of SOA environments
- Complementary to other strategies
- Automated with manual intervention
- Works on the actual implementations

Analysis

- Limited applicability and scalability. Techniques such as model checking and static analysis are not always applicable
- When applicable can provide high assurance and confidence
- Almost always automated
- Works mostly on abstractions (models)

Assurance Strategies$_2$

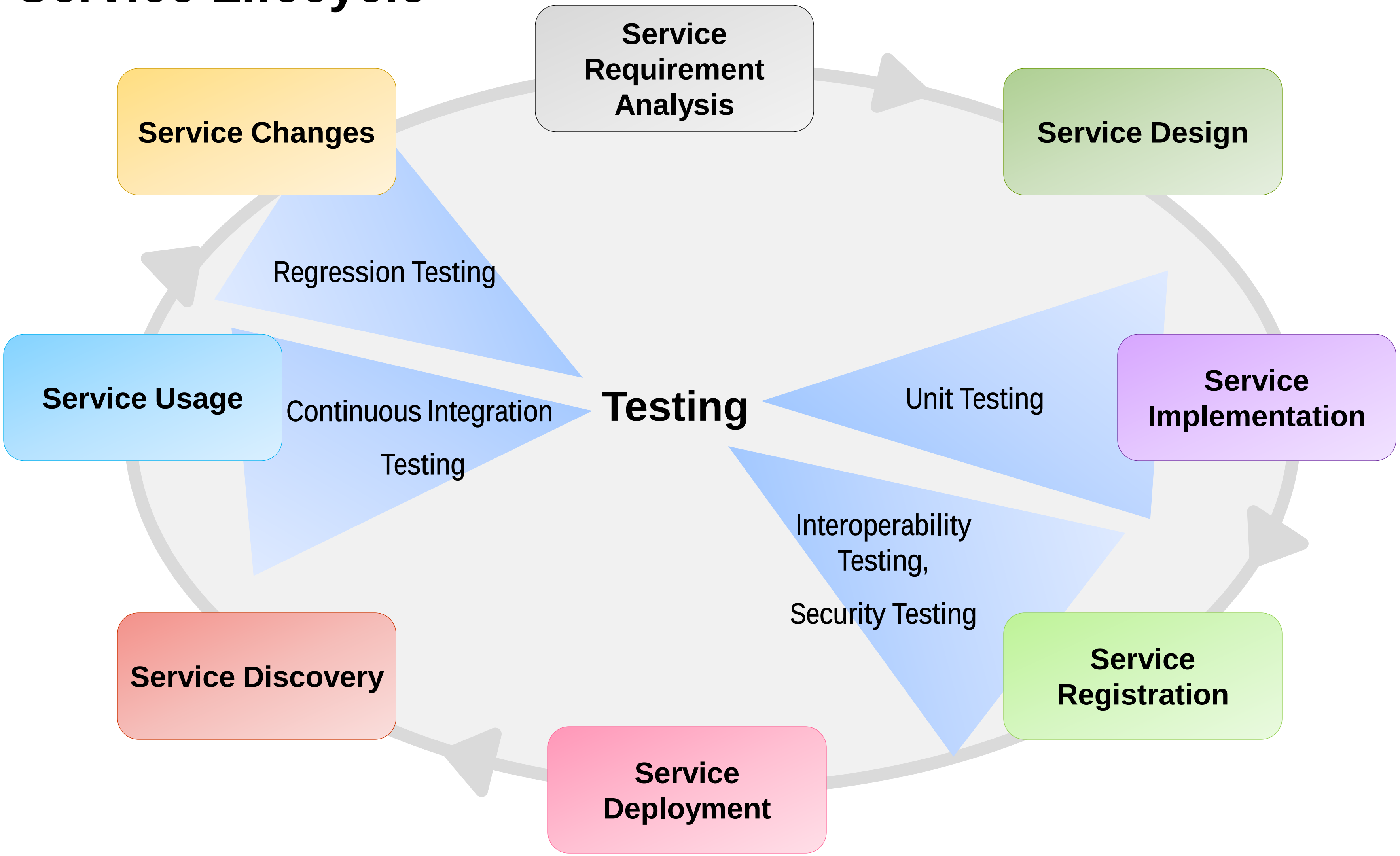
Simulation

- Limited applicability and use
- Can be useful to obtain insights when all elements are not ready
- Works when actual implementations are really complex and/or expensive to test
- Often requires substantial modeling and results are only as good as the models

Compliance

- Third party assurance
- Cannot be applied to all properties
- Difficult to achieve because of distributed, loosely coupled, and dynamic nature of SOA
- Weaker than certification

Example: Assurance Strategy (Testing) Applied to Service Lifecycle



Assurance Strategies: Summary

Strategies are not mutually exclusive

- *Conformance* often requires a combination of **testing**, **simulation** and **analysis**
- *Simulation* can be used to perform **unit testing** of web services

Strategies have strengths and weaknesses. Therefore, a combination of strategies is required to get better assurance.

Not all strategies are applicable to all contexts and perspectives.

SOA Elements that Require Assurance

SOA Infrastructure

- Consists of business independent capabilities
- Capabilities common across multiple services
- Example: service discovery, managing metadata, provide security, and message delivery

Web Services

- Provide business-level capabilities
- The elements of a web service from a testing perspective are the service interface, service implementation, message format, message payload, and service level agreement (SLA).

End-to-end Threads/ Business Processes

- End-to-end threads or business processes are composites of humans, applications, services, back-end applications, and databases that utilize the SOA and network infrastructure to perform a mission or business task.
- End-to-end threads include services along with other interacting components (human, functional, infrastructural), along with the operating environment.

SOA Infrastructure: Assurance Challenges

Limited internal and technical information

- Testers may not have access to source code and design information necessary for testing all components used in a SOA infrastructure

Complex configurations

- Infrastructure often consists of complex components that are configured for a particular infrastructure

Rapid release cycles

- Commercial components are upgraded and patched frequently, requiring a rapid assurance cycle

Cross infrastructure variation

- Different product implementations and versions across multiple SOA infrastructures may result in variations, making assurance difficult

Web Services: Assurance Challenges$_1$

Unknown contexts and environments

- From a service developer's perspective it is not easy to anticipate and unit test for all usage scenarios.
- Even when the service developer is aware of all contexts, it may be difficult and expensive to create a test environment that addresses each context.

Lack of source and binary code

- The source code and binary code of the web service are unavailable to the service integrator and service tester.
- White box testing and analysis techniques such as static analysis are impossible.
- This challenge is problematic for organizations that maintain high information assurance standards.

Web Services: Assurance Challenges$_2$

Unanticipated demand

- Specific usage of the service (e.g., load, network and infrastructure delay, data) is unknown at development time, making it difficult to test and verify QoS expectations.

Standards conformance

- Web services should conform to standards, if they are to provide syntactic interoperability. Testers have to ensure that web services comply and conform with standards, if they have to provide syntactic interoperability.

End-to-end Threads: Assurance Challenges$_1$

Decentralized ownership and lack of centralized control

- Distributed ownership that makes it difficult to set up a test environment
- Data and process contexts that are often outside the control of the end-to-end tester
- Services that participate in an end-to-end thread are loosely coupled

Complexity

- End-to-end threads that require interaction of services are black boxes and can be recursive
- Service implementations

Long-running business activities

- End-to-end threads are often long running business processes. This increases the testing time if all conditions have to be tested.
- It may not be possible to indentify all conditions that need to be tested.

End-to-end Threads: Assurance Challenges$_2$

Cascading failures

- It can be difficult to identify the cause of failure, assign blame, and mandate an appropriate patch when many nodes in the pathway are outside the control of the organization performing end-to-end testing.

Regression testing

- Changes at any service, node, or component along the pathway exercised in support of an end-to-end thread may indicate a need for regression testing of the thread. Maintaining awareness of these changes requires agreements regarding what types of changes require notification, when such changes are allowed to occur, and how affected parties are notified.

Dynamism

- End-to-end threads are not static. Changes in one node may affect many threads. In some cases these changes may be unknown and therefore difficult to test.

Perspectives$_1$

Service Developer

- Creates the interface of an individual service and its underlying implementation by using an existing component and wrapping it as a service or creating the service implementation "from scratch"

Service Provider

- Provides services. A service provider may or may not be the developer of the service; however, a service developer can also be a service provider.

Service Integrator (Service Consumer)

- Uses existing services (individual or composite) to either create composite services or to create an end-user application

Perspectives$_2$

Infrastructure Provider

- Provides the necessary SOA infrastructure middleware (e.g., enterprise service bus [ESB]) and infrastructural mechanisms such as service discovery to service providers, service consumers, and service integrators

Third-party Service Tester or Certifier (Service Consumer)

- Validates and potentially certifies whether a service (individual or composite) works as expected

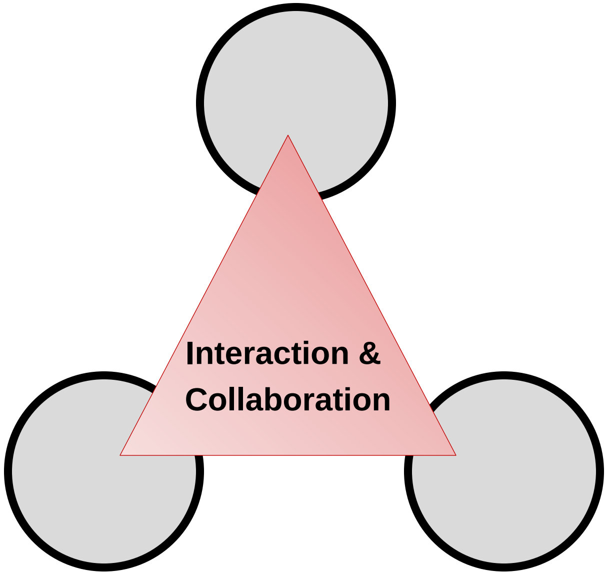
End User (Service Consumer)

- Uses applications that directly or indirectly use services
- Participates in beta-testing and report errors and faults

Collaborative Assurance

Successful assurance in an SOA-environment requires collaboration between various perspectives

- An SOA requires participation by service provider, service consumer, and infrastructure provider
- Some assurance strategies are more collaborative than others—such as group testing or collaborative verification and validation (CV&V)



What Aspects for Service-oriented Elements Require Assurance

Functionality

- The functional capability provided by the SOA element – SOA infrastructure (e.g., service registration), service (e.g., get customer data), and end-to-end threads/business process (e.g., order book)

Quality

- The quality of the functionality provided by the SOA elements. Example qualities are performance, security, reliability etc.

Standards/Policies Conformance

- The standards set the SOA elements must conform to. These standards can be open or proprietary.

Assurance Challenges - Interoperability

WS standards (e.g., WS-*) are currently limited to enabling syntactic interoperability

Assuring syntactic interoperability is difficult

- Customized vendor implementations of standards
- Large number of evolving standards
- Only some standards are meant to be interoperable

Assuring interoperability at higher levels (semantic and organizational) is more challenging

- Difficult to standardize due to large number of agreements required
- Specific needs associated with business processes and data models
- Testers have to understand the semantics and the business processes to verify interoperability at these levels

Assurance Challenges - Security

Services are autonomous and black boxes to the service consumers

- White box testing and static analysis techniques cannot be used by service consumers
- Sandboxing techniques to isolate a service implementation cannot be used

Services may be provided on a untrusting network by service providers

- An application developer must establish trust across a large number of distributed nodes having varying degrees of trust

Service composition is recursive

- A service invoked by the application may invoke other services with their own set of distributed nodes, any of which could be untrustworthy

Unknown and dynamic attack surface

- New services are added and old services are retired
- New service consumers are added
- Late binding of services

Assurance Challenges - Reliability

Service implementations are hidden from service consumers

- Difficult to debug if the implementation has crashed or just failed because of specific input(s)
- The developer often finds it difficult to design tests to stress boundary conditions of the service through fault injection or other techniques

Long-running business processes and transactions

- Testing reliability of long-running processes is difficult

Difficult to implement a central coordinator

- Hard to detect root causes of faults and recover from them when services are autonomous
- Not easy to implement transactional services

Assurance Challenges - Performance$_1$

Evaluation, verification, and monitoring of performance properties such as the latency and throughput of web services is similar to that of other distributed computing technologies

- Unavailability of source or binary code makes the empirical verification of performance even more challenging
- It becomes almost impossible to trace execution paths unless owners of all participating elements agree to collaborate

Difficult to pinpoint performance bottlenecks

- Services are black boxes to service consumers
- No single authority controls all the services in a composition
- Composite web services are more difficult to analyze for performance because the elements of a composite service are not known until runtime

Runtime monitoring of these services needs to ensure that services do not cross the acceptable limits set for them and applications can react when these are crossed

Assurance Challenges - Performance$_2$

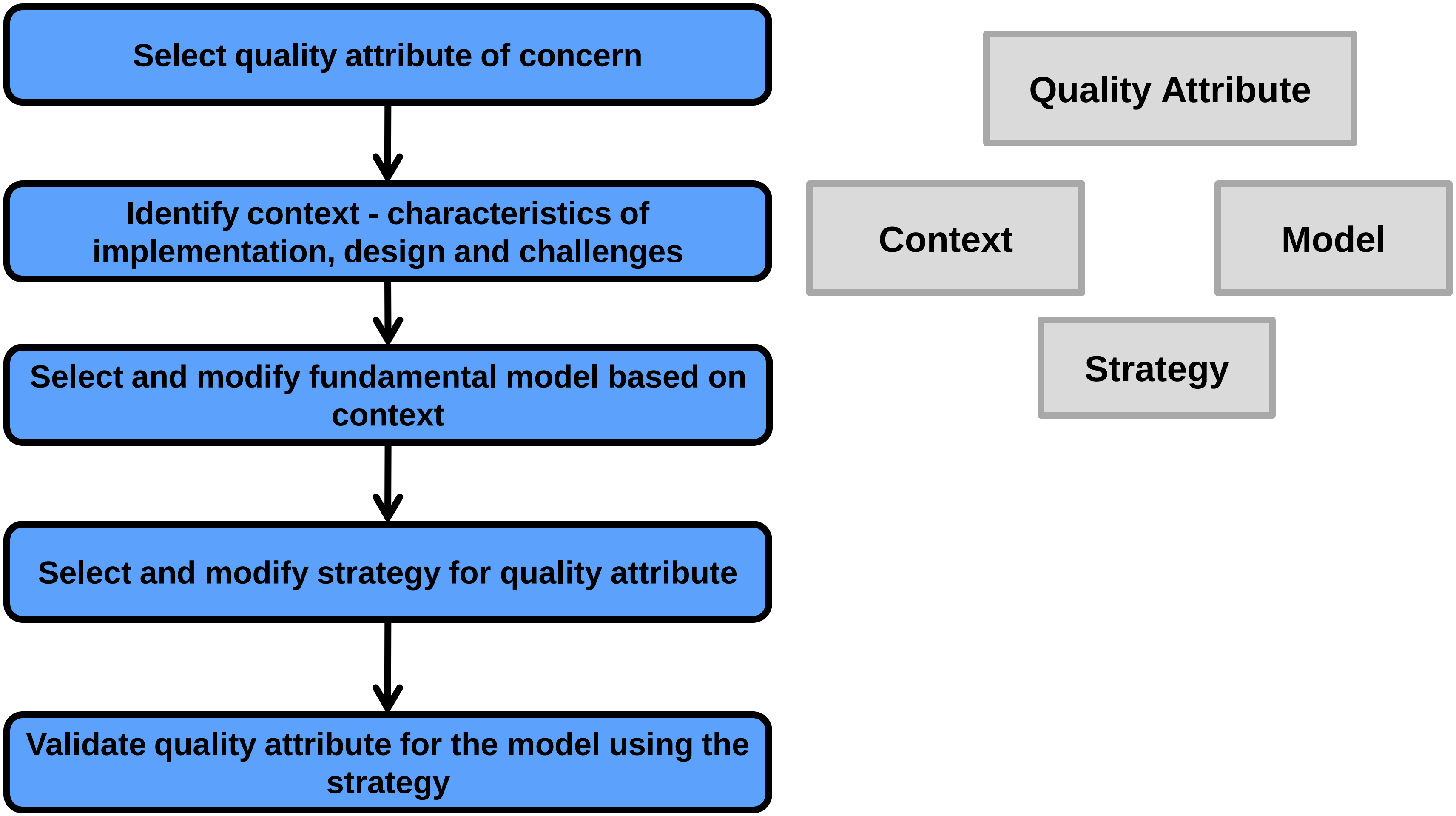
Web services are vulnerable to changing loads

- The effect of unpredictable loads can be much more drastic in the case of shared web services and composite web services
- If a web service has multiple consumers, the increase in load from one service consumer can degrade performance of all other consumers, unless the services are specifically designed for the load
- It is difficult to identify the specific source of a bottleneck, where source code is not available

In the case of composite web services, it may not be clear if they are under-performing due to

- Heavy load on the service
- Heavy load on the network
- A performance bottleneck in another service invoked by the composite service

Assuring Quality Attributes



Assuring Quality Attributes

Quality Attribute	Base Model Elements	Strategies
Interoperability	Levels of Interoperability Set of Standards	Compliance – For WS-* based web services check conformance to WS-I profiles Testing – Identify critical interactions (business processes and mission threads) and perform integration testing Compliance and Monitoring – Test services for conformance to standards at the time of time of registration and publishing
Reliability	Fault Model	Fault injection – check the response of the service to different types of faults Empirical evidence using test execution Monitoring and adaptive correction

Assuring Quality Attributes

Quality Attribute	Base Model Elements	Strategies
Security	Threat Model	Testing - Fault injection, bad input generation at unit testing level
	Attack Surface	Testing - Penetration testing
		Analysis - Static analysis
		Compliance - Conformance to security standards
		Monitoring - Monitoring for malicious code and attacks
Performance	Latency	Testing – Continuous load testing
	Throughput	Monitoring – Monitoring for increased load
		Testing – Testing for impact of other quality attributes (e.g., security) on performance

Evaluating Tool Capabilities$_1$

Usability

- Is the tool easy to use? How steep is the learning curve?
- Example: Intuitive GUI

Protocol and standard support

- What standards and protocols does the testing tool support?
- Example: Support for both REST and SOAP-based web services

Interoperability

- Is the testing tool interoperable with other tools?
- Example: Can test cases from one tool be reused with another tool?

Automation

- What level and type of automation does the tool provide?
- Example: Capture and replay; generating test cases from models

Evaluating Tool Capabilities$_2$

Monitoring

- Does the tool provide service monitoring capabilities?
- Example: Monitoring a service for increased load or denial of service attacks

Simulation

- What kind of simulation support does the tool provide?
- Example: Mocking services clients and instances

Static analysis

- Does the tool provide static analysis support for checking service code?
- Example: Taint analysis of a service for checking security

QoS Testing

- What qualities of services testing can be performed by the tool?
- Example: Load testing, security analysis

Formal models

- Does the tool support formal models for exhaustive checking?
- Example: Model checking

SOA Testing Tools

SoapUI

TestMaker

WebInject

SOAPSonar

Qengine

iTKO LISA

SOAPscope

SOAtest

SOA Test Governance

Should be part of the overall SOA governance strategy

Shared governance framework between service providers, service consumers, and infrastructure providers

- Service-orientation often hides information that may be relevant or sometimes necessary for assurance
- Shared governance mechanisms can allow sharing this information resulting in better assurance

Assurance Decisions

Decision makers should consider

- How much should be invested in quality assurance?
- When should assurance be performed? (i.e., how do assurance activities integrate with the phase of a service life cycle?)
- Who should participate in assurance activities?
- What are the risks and cost associated with not doing proper assurance?
- What polices and governance should be place for collaborative assurance?
- What tools, frameworks, and mechanisms should be used for assurance?
- What types of assurance strategies are appropriate for the context?

Takeaways and Recommendations

Characteristics of service-oriented systems (distributed, loosely coupled) pose serious challenges from an assurance perspective.

Testability should be an important concern from the start when engineering a service-oriented system. Introducing assurance later in the cycle can be expensive.

Often a combination of complementary strategies will be required to achieve acceptable assurance in service-oriented environments.

Existing assurance approaches are still valid below the service level.

As a service-oriented systems becomes more distributed and loosely coupled, it becomes harder to provide assurance because of decreasing control.

As service-oriented becomes widely accepted, more focus has been given to assurance issues. The service-oriented assurance field is evolving, with many open issues that are still under research.

Contact Information

Soumya Simanta

ssimanta@sei.cmu.edu

Research, Technology, and System Solutions (RTSS)

Software Engineering Institute

Carnegie Mellon University

4500 Fifth Avenue

Pittsburgh, PA 15213

9082 – Including ESOH Requirements in JCIDS Documents

Sherman G. Forbes
SAF/AQRE
Acquisition ESOH Risk Management
Phone: 571-256-0327
E-mail: sherman.forbes@us.af.mil

Agenda

- Background
- Process Description
- Training Development
- Way Ahead

Background
SECDEF Memo – 22 Jun 06

- **Memo Title: "Reducing Preventable Accidents"**
- **Defense Safety Oversight Council (DSOC) and the nine DSOC Task Forces responsible for action**
- **Acquisition & Technology Programs Task Force (ATP TF) focused on responding to these points:**
  - **"Accountability is essential to effective leadership"**
  - **"If we need to change our training, improve our materiel acquisition, or alter our business practices to save the precious lives of our men and women, we will do it."**
  - **"We will fund as a first priority those technologies and devices that will save lives and equipment."**
  - **"We will retrofit existing systems"**

Background
USD (AT&L) Memo – 21 Nov 06

- ATP TF prepared AT&L memo to "influence the entire life cycle of systems" in order to effectively integrate Environmen, Safety, and Occupational Health (ESOH) considerations
  - Joint Capabilities Integration and Development System (JCIDS) – define system required capabilities
  - System development process – to meet JCIDS requirements
    - Must address each High and Serious ESOH risk and applicable safety technology requirements in program reviews
  - Fielded systems – where ESOH problems manifested; where pain is felt (by the operator)
    - Class A & B mishap reports must include System Program Office hazard analysis and materiel mitigation measure recommendations to eliminate or reduce risk of reoccurrence

Background
Specific JCIDS Task Statement

"The Acquisition & Technology Programs Task Force will develop a process to provide the DoD Joint Capabilities Integration and Development System with recommendations that have the potential to cost effectively prevent accidents. These inputs should include all aspects of the MIL-STD-882D System Safety Process."

USD (AT&L) Memo – 21 Nov 06

Background
Scope of JCIDS Task

- "accident" as used by SECDEF = mishap
- "all aspects of the MIL-STD-882D System Safety Process" = MIL-STD-882D definition of mishap

  "An unplanned event or series of events resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment"

System Safety Focus: Preserving combat capability by reducing the risk of mishaps

U.S. AIR FORCE

Process Development ATP TF Response

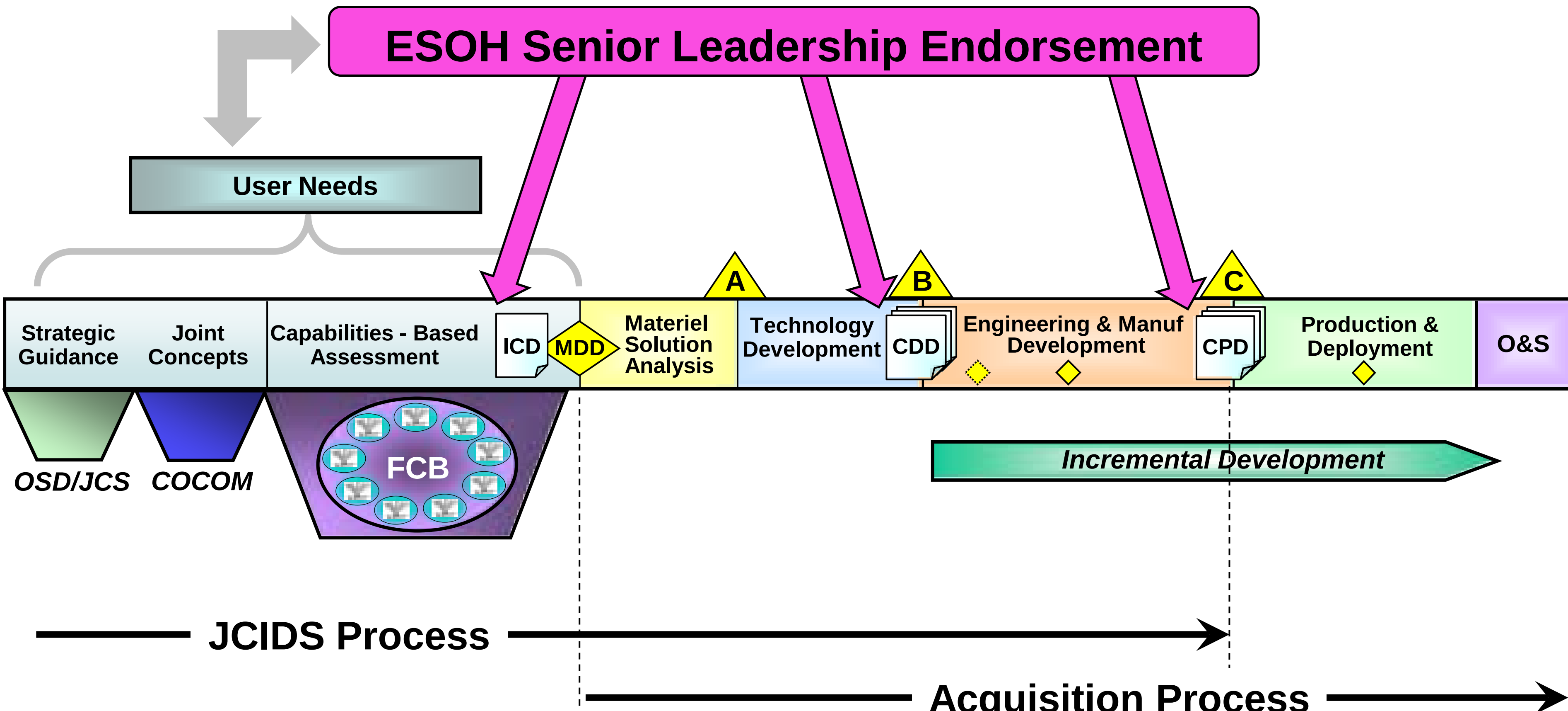
- ATP TF stood up Preventable Accident Reduction Working Group (PARWG)
  - Purpose: develop response to 21 Nov 06 USD (AT&L) memo assigning ATP TF JCIDS task
  - Co-Chairs:
    - Dr. Rodriguez-Johnson, ATP TF Vice-Chair
    - Mr. Wilmeth, Joint Staff J-8 Protection Assessment Division
  - Focus: process to provide opportunity for including ESOH recommendations into the Sponsor JCIDS document development process
  - Development: vetted process details with J-8 and DoD Secretariat Systems Engineering and ESOH principals
  - Implementation: parallel development of policy and supporting training

Process Development ESOH in JCIDS

- Applies to all JCIDS documents
- Requires ESOH senior leadership endorsement of JCIDS documents
  - Acknowledges that ESOH communities had opportunity to provide inputs (no guarantees)
  - Ensures ESOH leadership aware of future systems or system modifications for support planning purposes
  - Each DoD Component to designate ESOH senior leaders responsible for endorsing JCIDS documents
  - Each DoD Component to set up its own internal ESOH review process to support endorsements
- ATP TF developing training to support ESOH SME participation in JCIDS document development

U.S. AIR FORCE

Process Development ESOH in JCIDS



Integral Part of the Early Systems Engineering Activities

Integrity - Service - Excellence

Process Development
Draft AT&L Policy Memo

- **Draft ready to enter formal staffing following ESOH Risk and Technology Reporting policy memo**
- **Linked to development of training materials**
- **Addressed to Components and Joint Staff**
- **Directs each Component to designate to AT&L the office(s) that must provide ESOH endorsements**
- **Requests Joint Staff incorporate process into CJCSI 3170 Manual**
- **Directs the DoD Components to brief AT&L (or designee) annually on implementation status**

Training Development ESOH in JCIDS

- Effort funded by DSOC through the ATP TF
- Purpose: to prepare ESOH SMEs to be effective participants in the JCIDS document development process
- Goal: Have training in place to support policy release
- End State: a Defense Acquisition University (DAU) Continuous Learning Module (CLM), similar to CLE009 “System Safety in Systems Engineering”
  - Generic DoD training, not Service-specific
  - Potential for follow-on Service-specific training development
- NDIA Systems Engineering Division System Safety Committee sponsoring workshops to develop training materials content
  - First workshop held 16-17 Sep 09 in St. Louis, MO
  - Second workshop set for 18-19 Nov 09 in Arlington, VA

Training Development ESOH in JCIDS

- Training material topics
  - JCIDS basics
  - Developing appropriate ESOH capability statements
  - Participating in JCIDS document development
- JCIDS basics - focused on what ESOH SMEs will need
  - CJCS 3170.01 Manual
  - Terminology
  - Top-level process description
  - Sequence and appropriate content of documents: Initial Capabilities Document (ICD), Capability Development Document (CDD), Capability Production Document (CPD)

Training Development ESOH in JCIDS

- Developing appropriate ESOH capability statements
  - Identifying potential ESOH issues/concerns for a given solution/system
    - Lessons learned from similar systems' mishap data, Notices of Violation, NEPA documents, ESOH hazard logs, etc.
    - ESOH engineering evaluation of proposed system concept or design (extent of evaluations depend on maturity of system)
    - Results from testing activities
  - Tailoring for the given JCIDS document (ICD vs. CDD vs. CPD)
    - Degree of specificity
    - Thresholds and Objectives (except for Other System Attributes)

Training Development ESOH in JCIDS

- Participating in JCIDS document development
  - Goal: effective advocacy for inclusion of ESOH capability statements
    - Describe contribution to preserving mission capability
    - Demonstrate potential program and ESOH risk reduction
    - Address any potential lifecycle cost savings
  - Understanding the appropriate use of parameters and attributes
    - Key Performance Parameters (KPPs): essential and critical to program success; typically not appropriate for ESOH
    - Key System Attributes (KSAs): crucial to program success; appropriate for the most significant ESOH issues
    - System Attributes: support KPPs and KSAs; appropriate for ESOH issues
    - Other System Attributes: appropriate for detailed ESOH inputs

U.S. AIR FORCE

Way Ahead

- Formal staffing of policy memo through OSD and Components
  - Expected to begin Feb 2010
  - ECD Oct 2010
- Continue training development
  - Next workshop 18-19 Nov 09
  - Third workshop TBD
  - Compile and refine training materials
  - FY2010 DSOC funding of course development

Questions?

Integrity - Service - Excellence

Chemical and Material Risk Management Directorate

www.denix.osd.mil/MERIT

Environment, Safety, and Occupational Health (ESOH) Risk and Technology Requirements Status Reporting Procedures for all Program Reviews

NDIA Systems Engineering Conference

October 28, 2009

Ms. Lucy Rodriguez

Booz Allen Hamilton

Mr. David Asiello

Office of the Deputy Under Secretary of Defense

(Installations & Environment)

Outline

- Purpose
- Background
- The Requirement
- Advantages of Reporting
- Reporting Procedures
- Reporting Example
- Contact Information

Purpose

- **This briefing provides the recommended format for reporting High and Serious category ESOH risks and the status of compliance with ESOH technology requirements for programs, regardless of Acquisition Category (ACAT)**
    - These procedures are specified in the Defense Acquisition Guidebook Chapter 4.4.7.6
    - Guidance on ESOH risk management and the most current reporting requirements are located on the Acquisition Community Connection, ESOH Special Interest Area http://acc.dau.mil/ESOH

Background

- **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
  - failure with adverse impact on mission capability, mission operability, or public opinion
- **To accomplish this in systems acquisition we must 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

Background, Con't

- **MIL-STD-882D, *DOD Standard Practice for System Safety***
  - DoDI 5000.02 requires all programs, regardless of ACAT, to use MIL-STD-882D as the Systems Engineering methodology for managing ESOH risks
  - Programs must apply MIL-STD-882D throughout the life cycle for all developmental or sustaining engineering activities
  - When properly applied, this methodology should ensure the identification and understanding of ESOH hazards and their associated risks and options available to eliminate or mitigate the risks

- **Program Managers (PMs) are required to eliminate ESOH hazards where possible and manage ESOH risks where hazards cannot be eliminated**
  - Consistent with overall program cost, schedule, and performance requirements
  - Utilization of applicable ESOH technology requirements

Background, Con't

- **The three types of ESOH risks that a Program Manager should address are:**
  - Impacts and adverse effects from routine system development, testing, training, operation, sustainment, maintenance, and demilitarization and disposal
  - Mission readiness impacts from system failures or mishaps, including critical software failures
  - System life cycle cost, schedule, and performance impacts from ESOH compliance requirements.

The Reporting Requirement (DoDI 5000.02, E12.6)

- **For acquisition program reviews and fielding decisions, the program manager must report the status of all High and Serious ESOH risks and applicable ESOH Technology Requirements**

- **ESOH Risk assessments must be completed in accordance with MIL-STD-882D, the DoD Standard Practice for System Safety**

This reporting policy is not being effectively implemented and we may be unknowingly exposing people, equipment, or the environment to system-related ESOH hazards

Advantages of Reporting

- **Understanding the life cycle ESOH risks associated with the system and status of mitigation measures implementation over time**
  - Providing appropriate management level review and allocation of resources when problems arise

- **Conducting trend analysis to identify recurring hazards, focus resources, provide technology solutions, and reduce risks across platforms and DoD**

Ensures Senior Leadership Awareness of Risk Management Decisions Being Made in Program Development and Sustainment

Definitions

- **Hazard.** A condition that if triggered by one or more causal factor(s) can contribute to or result in a mishap.
- **Risk.** A measure of the potential loss from a given hazard. Risk is a combined expression of the severity of the mishap and the probability of the causal factor(s).
- **Initial Risk.** The first assessment of the potential risk of an identified hazard. Initial risk establishes a fixed baseline for the hazard
- **Current Risk.** A measure of the risk from an identified hazard at a snapshot in time, taking into account the implemented mitigation measures and verification and validation of mitigation measures designed to reduce the likelihood of a mishap occurring or to reduce the potential consequences of a mishap if it occurs

Definitions, Con't.

- **Target Risk.** The projected residual risk level that the program manager plans to achieve by implementing mitigation measures consistent with the design order of precedence.

- **ESOH Technology Requirement.** Hazard mitigation technology designed to eliminate or reduce the risk of systems or equipment failure and associated personnel and environmental hazards which may occur with or without failure of the system. These technologies are not inherent parts of the design of the system, but rather are additions that have the primary purpose of mitigating a specific safety, personnel, or environmental hazard. For example, aircraft landing gear would not be an ESOH technology because it is an essential part of the basic design of an aircraft.

Definitions, Con't.

❖ **Risk Assessment Code (RAC).** **A combination of one probability level and one severity category that correlates to a specific cell (and risk assessment value).**

RISK ASSESSMENT MATRIX				
FREQUENCY OF OCCURRENCE	**I. CATASTROPHIC**	**II. CRITICAL**	**III. MARGINAL**	**IV. NEGLIGIBLE**
A – FREQUENT	IA	IIA	IIIA	IVA
B – PROBABLE	IB	IIB	IIIB	IVB
C – OCCASIONAL	IC	IIC	IIIC	IVC
D – REMOTE	ID	IID	IIID	IVD
E – IMPROBABLE	IE	IIE	IIIE	IVE
HAZARD Risk Index	**Risk Level & Acceptance Authority**			
IA, IB, IC, IIA, IIB:	**HIGH**			
ID, IIC, IIIA, IIIB:	**SERIOUS**			
IE, IID, IIE, IIIC, IIID, IIIE, IVA, IVB:	**MEDIUM**			
IVC, IVD, IVE:	**LOW**			

Reporting Procedures

- **The PM will summarize ESOH risk and technology requirements, in the recommended format at program reviews**
  - Risk data will include all ESOH risks for which the current or target risk categories are High or Serious
  - ESOH Technology Requirements on the system and their implementation status
  - Supporting Information should be maintained in the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) document

ESOH Risk Reporting Requirements

- **For all hazards whose current or target risk categories are High and Serious, as derived using MIL-STD-882D methodology, include:**
  - Hazard ID and Title
  - Description of Hazard
  - Current RAC and risk category
  - Mitigation(s) and mitigation status, including implementation date(s)
  - Target RAC and risk category

ESOH Risk Reporting Format EXAMPLE

Current or Target Risk Categories are High & Serious

- 5 Current High & Serious ESOH Risks

(Two are also Target Serious ESOH Risks)

	I	II	III	IV
A				
B				
C	2			
D	3			
E				

Hazard ID	Hazard Title	Description	Current RAC & Category	Mitigation	Mitigation Status / Date	Target RAC & Category
1	Inadvertent Launch	Inadvertent launch or release of ordnance could result in personnel death or system loss.	ID Serious	1. Incorporate redundant interlocks to preclude inadvertent launch. 2. Incorporate warnings / cautions in TM 3. Validate design features via testing.	1. Complete – Aug 2005 2. Open – Oct 2008 3. Open - Jan 2009	IE Medium
2	Fire	Uncontrolled fire causes personnel death, loss of system or environmental damage.	IC High	1. Incorporate automatic fire protection. 2. Change material to be more fire resistant and environmentally friendly.	1. Open – Dec 2008 2. Open – Dec 2008	IE Medium
5	Toxic Materials Released into Environment	In the event of a fire, toxic material is released into the environmental, leading to irreversible environmental damage.	IC High	1. Incorporate automatic fire protection. 2. Change material to be more fire resistant and environmentally friendly.	1. Open – Dec 2008 2. Open – Dec 2008	IE Medium
6	Toxic Fumes During Operation	During weapon firing operations, excessive toxic fumes (CO, NO, NO2) are present and could result in personnel death.	ID Serious	1. Change explosive composition to minimize toxic fumes. 2. Improve toxic fumes evacuation system. 2a. Improve seals around system. 2b. Increase fan capacity. 3. Obtain test data to verify design changes.	1. Open – Aug 2010 2. Complete – July 2007 2a. Complete – July 2007 2b. Complete – July 2007 3. Open – Jan 2009	ID Serious
7	Software Failure Leads to Ballistic Error	Inaccurate targeting of ordnance fired leads to friendly firing.	ID Serious	1. Perform software V&V to verify safety critical software meets requirements.	1. Open – TBD (Need Funding)	ID Serious

Note: Underlined Mitigation / Mitigation Status is Open (Not Complete)

ESOH Technology Reporting Format EXAMPLE

- **Requirement Description: Voice and Flight data recorders**
  - Requirement Source: External – 9 Apr 96 DEPSECDEF memo
  - Status: Incorporated into System Specification
  - Funding Status: Incorporated into System Baseline
  - ECD for Implementation: Done
  - Issues (if any): None
- **Requirement Description: Military Flight Operations Quality Assurance (MFOQA) Capability**
  - Requirement Source: 11 Oct 05 USD(AT&L) memo
  - Status: Seeking waiver IAW USD(AT&L) memo
  - Funding Status: None
  - ECD for Implementation: None
  - Issues (if any): Memo issued after CDR; design change would require more time and funding than available within established cost and schedule requirements; User decided to not include requirement in update to CPD

ODUSD(I&E), Chemical & Material Risk Management Directorate

Mr. David Asiello
ESOH in Acquisition Lead
(703) 604-1874
David.Asiello@osd.mil

Ms. Lucy Rodriguez, (703) 412-7685, lucy.rodriguez.ctr@osd.mil
Mr. William Thacker, (703) 412-7757, thacker_william@bah.com

DoD Green Procurement Program

12th Annual Systems Engineering Conference
San Diego, California
October 28, 2009

Outline

- **Green Procurement Overview**
  - Drivers and Regulations
  - Program Components
- **DoD's Green Procurement Program (GPP)**
- **Acquisition and Green Procurement**
- **DoD Success, Reporting, Challenges, and Activities**

Green Procurement Drivers

Regulatory Drivers

- Farm Security and Rural Investment Act (2002), Section 9002
- Section 104 of the Energy Policy Act (EPAct) (2005)
- Energy Independence and Security Act (2007)
- Resources Conservation and Recovery Act, Section 6002
- Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulations Supplement (DFARS)
- E.O. 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (2007)
- E.O. 13514, *Environmental, Energy, and Economic Performance* (2009)
- Hexavalent chrome memo (2009)
- Registration, Evaluation, Authorization and Restriction of Chemicals “REACH”

Mission Capabilities/Goals

- Effective performance and product availability
- Less dependence on foreign petroleum
- Reduce life cycle cost

Executive Order (EO) 13514

- **President Obama signed EO 13514 on October 5, 2009**
  - EO sets sustainability performance goals for Federal agencies.
  - EO requires Federal agencies to:
    - » set a 2020 greenhouse gas emissions reduction target within 90 days;
    - » increase energy efficiency; reduce fleet petroleum consumption;
    - » conserve water; reduce waste; support sustainable communities;
    - » and leverage Federal purchasing power to promote environmentally-responsible products and technologies.
  - Implementation of the EO will focus on integrating achievement of sustainability goals with agency mission and strategic planning to <u>optimize performance</u> and <u>minimize cost</u> to implement.

Hexavalent Chromium Memorandum

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
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 d
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 o
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

"Requires 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."

Green Procurement Components

- Recycled content products, also known as Comprehensive Procurement Guidelines (CPG)
- Energy Star® and energy-efficient products
- Alternative fuel vehicles/alternative fuels
- Bio-based products
- Non-Ozone Depleting Substances (ODSs)
- Environmentally Preferable Products (EPP)
- Non-toxic or least hazardous chemicals
- Electronics with environmentally preferable attributes
- Water efficient products

DoD's Green Procurement Program (GPP)

- **Educate Department employees on the GPP**
  - DAU course, product success, conferences, and training
    - » **DAU Course** (https://learn.dau.mil/html/clc/Clc1.jsp?cl=) CLC 046
- **Increase purchases of green products and services**
  - DoD EMALL (ENAC's, Green Default) and GSA Advantage
    - » **EMALL** (https://emall6.prod.dodonline.net/main)
  - Environmental Reporting Logistics System (ERLS)
- **Reduce the amount of solid waste generated**
- **Reduce consumption of energy and natural resources**
- **Expand markets for green products and services**

DoD's GPP Metric = 100% Compliance with all Mandatory Federal GPP programs in all procurement transactions.

DoD’s GPP Strategy

- **Established GPP Policy and Strategy in August 2004**
  - Guidance for the acquisition of environmentally preferable products and services in accordance with federally-mandated “green” procurement preference programs
  - Each DoD Component has issued a GPP policy and plan
- **Updated DoD GPP Strategy in November 2008**
  - Reflects current legislation and guidance, incorporating bio-based, EPEAT, FEMP, and other “green” products
  - Submitted updated Strategy to Congress through NDAA 2008 Section 888

DoD's GPP Work Group

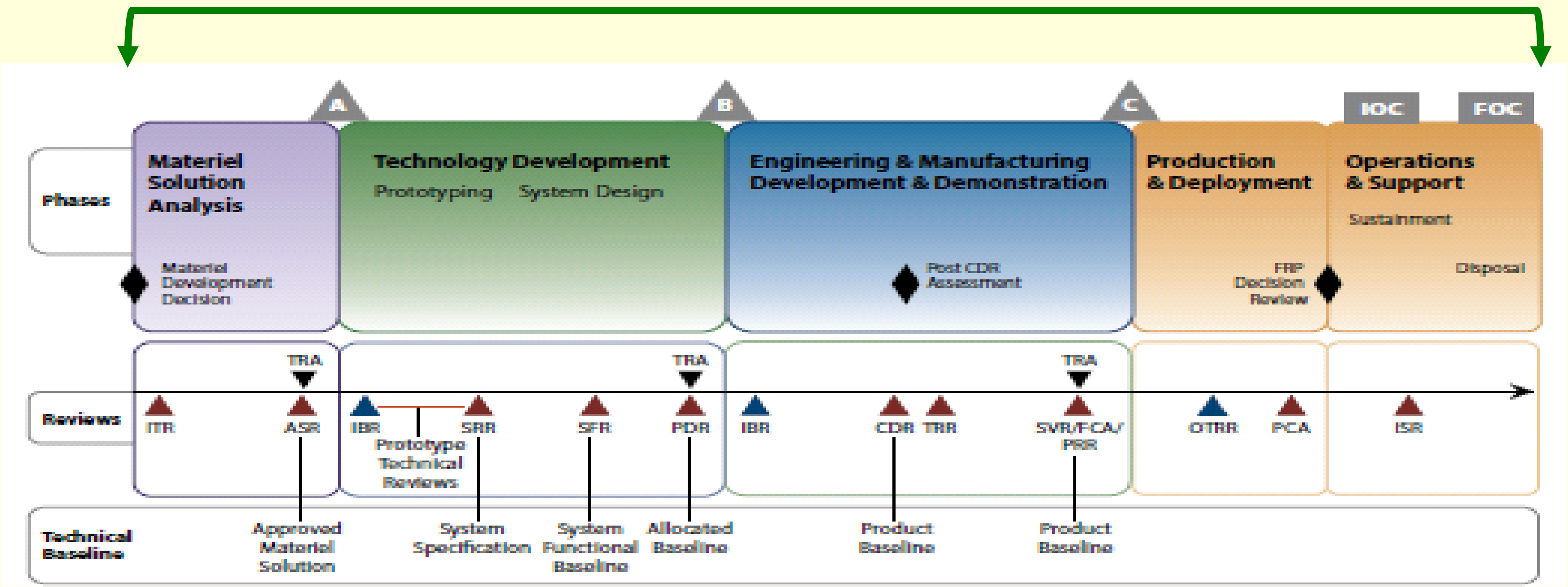
- **Co-stewards of DoD's GPP Work Group are:**
  - Deputy Under Secretary of Defense for Installations and Environment
  - Director of Defense Procurement and Acquisition Policy
- **Collaborates across the Department**
  - Federal reporting requirements
  - Training
  - Executive Order compliance
- **Promotes and integrates DoD's GPP**
  - Use of greener products across all levels of the Department

Acquisition Process and GPP

- **Green Procurement applies to all acquisitions**
  - Part of the Defense Acquisition Guidebook (DAG) for weapon systems
- **FAR Requirements Exist:**
  - FAR 7.105 – **Acquisition Planning**
  - FAR 11.002 – **Describing Agency Needs**
  - FAR 13.201 – **Actions at or Below the Micro-Purchase Threshold**
  - FAR 23.202 – **Energy Conservation**
  - FAR 23.404 – **Use of Recovered Materials**
  - FAR 23.703 – **Contracting for Environmental Preferable and Energy-Efficient Products and Services**
  - FAR 72.215 – **Bio-based Products Preference Program**
  - FAR 72.225 – **Implementation of EPAct 2005**

Acquisition Process and GPP

Green Procurement should be considered



Key for Green Procurement in Acquisition Process is to consider use of "Green" materials and technologies in the Systems Engineering Trade Space

DoD Success Highlights

Portsmouth Naval Shipyard (PNS) – Biobased Adhesive Strippers

- PNS worked with GSA to field-test and implement marine Soy Strip in submarine renovations
- Chemical strippers required over sanding due to sensitive instrumentation
- Previous counterpart contained methylene chloride (volatile hazardous air pollutant) and required ventilation and respirators to prevent worker exposure
- Soy Strip reduces health risks and enables work throughout ship

DoD Success Highlights

U.S. Army Environmental Center (USAEC) Smoke and Dye Replacement

- Sugar-chlorate formulation and less toxic dyes successfully implemented for green and yellow M18 grenades and for red, green and yellow 40mm projectiles
- Traditional grenades emits toxic and carcinogenic compounds in significant quantities, presenting health risks
- Change made transparent to end-users (soldiers) and tracked by unique NSN and DoDIC numbers with labels identifying "Reduced Sulfur Smoke Grenades"

DoD Success Highlights

Navy Launches Green Hornet

- Biofuel powered engine for new F/A-18 “Green Hornet”
- Hybrid electric power systems using biofuels will power sensors, weapons, and other electronic onboard systems
- Improvements to traditionally fueled F/A-18 engines will increase fuel efficiency of each aircraft by 3%
    - » 127,000 barrels of fuel per plane per year
    - » $15 million for Fleet at today’s fuel prices
- Holding industry contractually accountable for meeting energy targets and system efficiency requirements

Challenges and Activities

Requirements Awareness

- Training/Awareness of Green Procurement Requirements
- Getting approved FAR/DFAR clauses on green procurement requirements into all procurement contract language
  - » FAR now includes EPEAT, energy, recovered materials, and bio-based products
- Improve EMALL to identify green products first, require additional documentation if they are not chosen
- De-conflict requirements: Include “green” in mandatory source requirements
  - » Preference priorities

Product Awareness

- Availability for purchase
- Improve success stories publicity – broaden adoption

Challenges and Activities (continued)

- **Build more energy efficient military equipment**
  - To cut Operational Costs
    - » Fully-burdened cost of fuel in theater of operations is currently $40 to $400 per gallon
  - To "Save Lives"
    - » Loss of troops to enemy attack delivering fuel
  - To lower Green House Gas (GHG) emissions
- **Consider use of renewable products**
  - Can it be maintained with bio-based lubricants
  - Will it run on bio-based fuel

Challenges and Activities (continued)

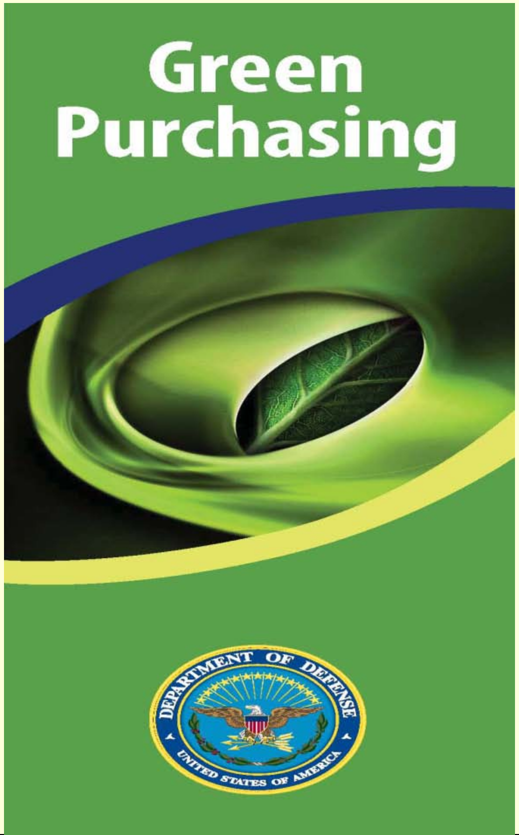
- **Material Substitution**
  - Can we prevent corrosion without using Hexavalent Chromium?
  - How will REACH and other regulations affect DoD?
- **New energy sources**
  - Will wind or solar work to recharge equipment batteries for this system?
- **New Green Technology**
  - “The Sky is the Limit”

Challenges and Activities (continued)

- **Increase Performance Confidence**
  - Demonstrate & document performance, mission benefits, and/or life cycle savings
- **Increase Accountability**
  - Enhance existing procurement reporting tools to capture green purchases (e.g., DoD EMALL and Federal Procurement Data System (FPDS))
  - Improve credit card purchase data & tracking
- **Better integrate GPP into the Acquisition process**
  - Consider in SE early and across all phases of the lifecycle
- **Shift Culture & Overcome Inertia**
  - Myth busting: green = lesser performance
  - Life cycle considerations (initial price vs. total cost)

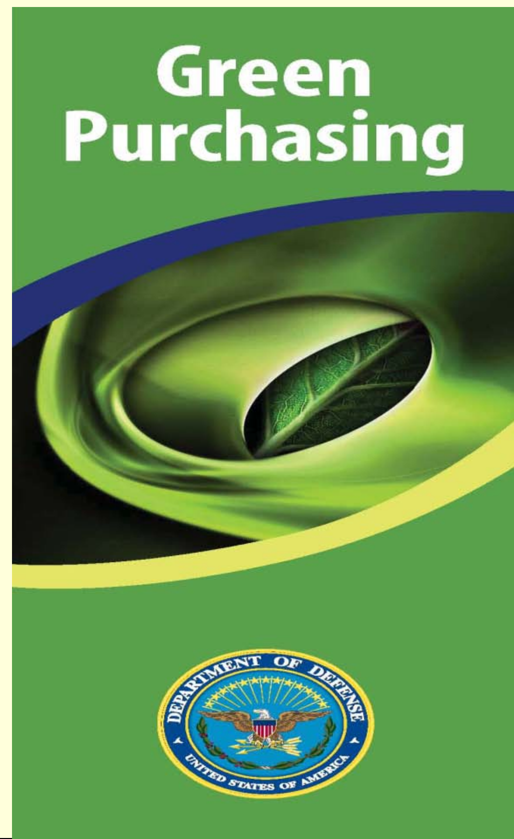
Questions & Discussion

David Asiello
ODUSD(I&E)/CMRM
(703) 604-1874
David.Asiello@osd.mil



Sandra Ross
ODUSD(AT&L)/DPAP
(703) 695-9774
Sandra.Ross@osd.mil

BACK-UP



Defense Acquisition University (DAU) GPP Training

- **DoD released Green Procurement training online course in July 2008**
  - Provides an opportunity to learn about integrating environmental sustainability into purchasing decisions and practices
  - Includes Senior leadership introductory videos
  - Utilized across all Federal Agencies
  - Available online through Defense Acquisition University (DAU) – Continuous Learning Module CLC 046 , Green Procurement (https://learn.dau.mil/html/clc/Clc1.jsp?cl=)

DoD GPP Reporting Tools

DoD EMALL

- Uses a green tree icon to identify environmentally preferable attributes
- Reporting features by Component
- https://emall6.prod.dodonline.net/main

Environmental Reporting Logistics System – Green Procurement Report (ERLS GPR)

- Tracks environmentally friendly products

National Defense Authorization Act (NDAA) 2008 Section 888

Background

- Required by the Secretary of Defense to submit a report to Congress on a plan to increase the usage of environmentally friendly products that minimize the potential impacts to human health and environment at all Department of Defense (DoD) facilities inside and outside the United States.

DoD Response

- DoD provided a report detailing the Green Procurement Strategy, current procurement and logistics tracking systems, available green purchasing training, and budgetary impacts.

DoD Success Highlights

Environmentally Acceptable Propellant Charges for Medium Caliber Guns

- Green nitrocellulose (NC) propellant with solventless formulation was developed to replace medium caliber propellants
- Traditional solvent formulations contain diphenyl amine (DPA) and/or dibutyl phathalate (DBP) – both listed as “environmental watch” ingredients
- New solventless formulation contains no toxic ingredients
- Other benefits:
  - » Reduce total overall usage of volatile solvents by ~85%
  - » Additional reductions realized through the deterrent process
  - » Insensitive Munitions (IM) benefits – improved reactionary responses in respect to impact

DoD Success Highlights

Low Observable (LO) Coating that Facilitates Rapid Application

- Environmentally compliant LO coating technology primarily used in F-35 and F-18 aircraft tuned to weapons-specific use
- Coating formulation contains <1% VOCs and contains no Hazardous Air Pollutants (HAP) or free diisocyanates
- Does not decompose into environmentally noxious materials during prolonged storage
- Benefits:
  - Eliminate major source of hazardous material waste
  - 100% reduction of VOC emissions generated during spray application (potential cost savings estimated between $9 and $30 million annually)
  - Reduce material disposal costs for aircraft maintenance
  - Increase safety for personnel involved in application and removal process

DoD Success Highlights

Green Alternative to Ammonium Perchlorate in DoD Missiles

- Used as oxidizer in solid fuel for rockets and missiles
- Estimated 24 million lbs of AP produced each year which cause contamination of groundwater and drinking water attributing to iodine deficiency in thyroid glands
- Environmentally benign alternative ball powder system made from combination of organic and inorganic fuels and oxidizers
- Benefits:
  - » Low cost
  - » AP-free helps reduce further contamination
  - » High performance and good mechanical properties

Using Proposed MIL-STD-882 Change 1 For Hazardous Materials Management

Hazardous Materials Management Plan Description of Task 107

Karen Gill

NDIA Systems Engineering Conference,
San Diego, CA
October 28, 2009

Table of contents

- Background
- New Approach for HMMP in Systems Acquisition
- Task 107 HMMP
- Examples for Managing HAZMAT
  - Prohibited: Hexavalent Chromium
  - Restricted: Advanced Composites with Boron Fibers
- Conclusion

Booz | Allen | Hamilton

Background

- International, federal, state, and local regulation of hazardous materials has become increasingly stringent over time.
- New and emerging regulatory requirements and the global economy are creating additional chemical management requirements.
- Prior to acquisition reform, DoD used military specifications and standards to dictate the design and build of systems, including materials to be used.
- This practice often resulted in industry requiring separate production lines for military and commercial products.
- 2002 Single Process Initiative (SPI) at a defense contractor established a common Hazardous Materials Management Program (HMMP) across multiple DoD contracts.
- Set a precedent that DoD and industry can adapt to provide financial incentives to contractors to reduce hazardous chemical use.

Current Status

- DoD requires each acquisition program to manage hazardous materials over the system life cycle as one component of the program's overall environment, safety, and occupational health (ESOH) risk management effort.
- The adequacy of the implementation of the DoD acquisition hazardous material policy and guidance tends to be program-dependent.
  - Larger programs are more likely to have robust hazardous materials management activities.
  - Smaller programs may not have the resources (funding and expertise) to implement effective hazardous materials management efforts.
- There are few specific DoD or industry requirements to eliminate hazardous material usage.
  - Exceptions are the DoD mandate to not use Ozone Depleting Substances and hexavalent chromium.
  - However, programs must include an HMMP effort as part of the overall ESOH risk management requirement.
- DoD requires use of MIL-STD-882D for assessing and managing ESOH risks, including those from hazardous materials, through systems engineering.

Table of contents

- Background
- New Approach for HMMP in Systems Acquisition
- Task 107 HMMP
- Examples for Managing HAZMAT
  - Prohibited: Hexavalent Chromium
  - Restricted: Advanced Composites with Boron Fibers
- Conclusion

New Approach for HMMP in Systems Acquisition

- The Proposed MIL-STD-882D Change 1* includes a HMMP Task 107 which incorporates key elements of the original SPI HMMP.
  - This standardization would provide a flexible framework to target materials that are subject to evolving regulatory restrictions.
  - The proposed HMMP Task 107 could be applied to any contract that includes requirements for developmental or sustaining engineering.
  - Task 107 would be in lieu of NAS 411 and should be more cost effective as it provides for prioritized and focused management efforts.

- The proposed standardized HMMP would enable DoD and industry to team to reduce risks and costs driven by the use of hazardous material in system production and manufacturing, operation, maintenance, demilitarization, and disposal.
  - Making the proposed HMMP a mandatory part of contract documents through Task 107 will compensate contractors for specific hazardous materials reduction activities, while providing DoD with insight into potential developmental cost increases and sustainment cost decreases.
  - Using the contractual imposition of Task 107 to implement a standardized HMMP will also facilitate the prime contractor’s ability to flow the HMMP requirements down to second and third tier suppliers.

*MIL-STD-882D Change 1 is currently in DoD technical comment adjudication

Table of contents

- Background
- New Approach for HMMP in Systems Acquisition
- Task 107 HMMP
- Examples for Managing HAZMAT
  - Prohibited: Hexavalent Chromium
  - Restricted: Advanced Composites with Boron Fibers
- Conclusion

Task 107 HMMP - *Purpose*

- Requires the DoD Program Office and the contractor to collaboratively identify and categorize the list of hazardous materials that they want to eliminate or manage during system development or sustainment.

- Finalization of the initial list would occur as part of the first actions once DoD has selected a contractor to award a contract to and would be part of the activities to finalize the contract cost by definitizing the cost of the HMMP effort based on the agreed to list of hazardous materials.

- Either the contractor or the DoD Program Office could propose chemicals for inclusion on the list of managed hazardous materials.

- The HMMP will use the categorized list to guide decisions about the materials contained within the system, required for operation or support, or generated during sustainment, disposal, or demilitarization activities. The change would not require contractors to include hazardous materials that are unique to their production and manufacturing processes.

Task 107 HMMP - *Description*

- The HMMP defines DoD PM and contractor roles, responsibilities, and procedures needed to accomplish HAZMAT management and tracking contractual requirements included in the general and special provisions of the contract.

- The HMMP will include, at a minimum, the following content:
  - the PM and contractor processes to properly identify, control, analyze, and track HAZMAT to protect human health and the environment and to support end user needs;
  - HAZMAT targeted for elimination and reduction;
  - the process for approving prohibited HAZMAT usage where it cannot be eliminated; and
  - the list of HAZMAT contained within the system and required for the operation or support of the system.

Task 107 HMMP – *Categorizing Identified HAZMAT*

- Working together, the DoD program office and the contractor will categorize the hazardous materials that they agree to manage as prohibited, restricted, or tracked.
  - ***Prohibited:*** materials for which the contractor is required to obtain DoD approval before they can be included in systems, subsystems, and support equipment, or planned for operations and support (If approved, managed as restricted-focus on elimination).
  - ***Restricted:*** materials the contractor will target for elimination or minimization.
  - ***Tracked:*** do not require specific contractor action other than inclusion in the hazard tracking system and the list of hazardous materials. (Does not require risk assessment or identification of mitigation measures, e.g,. use of JP-8.)

- The contractor will be required to track all three categories of hazardous materials, and deliver a list of hazardous materials contained within the system and which are required for operation or support or disposal.

Uses risk management decision making to focus management attention and engineering activities on materials of concern to contractor and government.

Task 107 HMMP – *Modification of HAZMAT List and Categorization*

- The program will focus its HAZMAT management efforts on ***restricted*** materials and ***prohibited*** materials that have been approved for specific use on the system or during operations and support.

- Dialogue between the DoD program office and the contractor will continue after the initial agreement on the listing of hazardous materials.

- Due to changing concerns or a shifting regulatory environment, either the DoD Program Office or the contractor may want to add materials to the list of managed HAZMAT or change the categorization of selected materials.
  - The Chemical & Materials Risk Management Directorate at OSD is a resource for identifying materials of regulatory concern.

- The HMMP will include procedures for adjusting contract documents and cost if list modifications increase the cost of executing the HMMP during the life of a given contract.

Task 107 HMMP – *HAZMAT Data Tracking*

- The HMMP will describe how the contractor will integrate data required to manage HAZMAT with the data included in the hazard tracking system. The minimum additional data elements required for HAZMAT management and tracking include —

1. The locations and quantities of HAZMAT within the system
2. Processes/activities where HAZMAT are used or generated during operations, support, and disposal of the system
3. Reasonably anticipated materials used or generated during:
   - the life cycle of the system (e.g. installation, test and evaluation, normal use, maintenance or repair, and disposal)
   - emergency situations (e.g., exhaust, fibers from composite materials released during accidents)
4. Special HAZMAT control, training, handling measures, and personal protective equipment needed, including provision of required material safety data sheets

Task 107 HMMP – *Implementation Considerations*

- DoD will have to structure contracts to support execution of the HMMP, e.g., DoD Program Offices will have to budget appropriately for the implementation of the HMMP once a contract has been awarded and the list of hazardous materials be managed is finalized.

- This places a cost risk on the DoD Program Office since DoD and the contractor will not definitize the final cost of the HMMP effort until after contract award and the Program Office and contractor agree on the list of hazardous materials included in each of the three categories identified above. This structure will place emphasis on hazardous material management from the beginning of the development of a contract requiring developmental or sustaining engineering activities. This recommendation also provides synergy with ongoing efforts within DoD to drive the inclusion of ESOH considerations earlier in the process.

- Ideally, a DoD Program Office would list and categorize hazardous materials it wants managed under the HMMP in solicitations for bids, which will help to place all contractors on a level playing field in preparing their proposals. This will also incentivize a contractor to include its proposed list of hazardous materials as part of its proposal. These two steps would have the effect of expediting the finalization of the contract once the DoD Program Office has selected the contractor.

Table of contents

- Background
- New Approach for HMMP in Systems Acquisition
- Task 107 HMMP
- Examples for Managing HAZMAT
  - Prohibited: Hexavalent Chromium
  - Restricted: Advanced Composites with Boron Fibers
- Conclusion

Prohibited: Hexavalent Chromium (Cr^{+6})

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+} pr
- 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."

Booz | Allen | Hamilton

Prohibited: Hexavalent Chromium (Cr^{+6})

- Cr^{+6} is recognized as a human carcinogen via inhalation. Workers in many different occupations are exposed to hexavalent chromium.
- Cr^{+6} is used primarily in DoD as anti-corrosion and conversion coatings as well as a variety of niche uses.
- Normally, the PM would need to approve use of a **"Prohibited"** material, but Cr^{+6} is a special case due to DoD's increased management requirement
- If PEO-level approves use (per memo), manage CR^{+6} as if it were ***"Restricted"*** with the goal to find a suitable alternative and eliminate use of CR^{+6}

SEVERITY / PROBABILITY	Catastrophic 1	Critical 2	Marginal 3	Negligible 4
Frequent (A)				
Probable (B)		Initial		
Occasional (C)		Current		
Remote (D)				
Improbable (E)				
Eliminated (F)	Target			

MIL-STD-882D Rev 1 Risk Assessment

Hazard ID	Description	Initial RAC & Category	Mitigation	Current RAC & Category	Mitigation Status / Date	Target RAC & Category
1	Inhalation of Cr6+ while stripping coating systems and re-painting the aircraft during maintenance. Exposure likely to occur frequently in a 12 month period. May cause permanent or partial disability, acute or chronic illness.	2B High	1. Perform painting activity in a space with appropriate ventilation and control technology 2. Institute procedures mandating the use of PPE during painting. 3. Qualify alternative coating with no Cr^{+6}	2C Serious	1. Complete – 10/08 2. Open – verify mitigation test by 02/09 3. Open – new paint test will be completed by 11/09	F Eliminated

Restricted: *Advanced Composites with Boron Fibers*

- Elemental boron and the borates are not considered to be toxic. However, in fibrous form they are an acute skin and eye irritant. Allergic reaction to boron fibers may cause chronic dermatitis.

- Boron fiber is a high performance synthetic fiber used for structural applications. It is found in aircraft, space, and industrial applications. In adhesive tape form it provides high compression strength and stiffness with reduced weight.

- **"Restricted"** materials - contractor must attempt to eliminate the usage or mitigate the risks.

SEVERITY / PROBABILITY	Catastrophic 1	Critical 2	Marginal 3	Negligible 4
Frequent (A)				
Probable (B)			Initial	
Occasional (C)				
Remote (D)			Current Target	
Improbable (E)				
Eliminated (F)				

MIL-STD-882D Rev 1 Assessment

Hazard ID	Description	Initial RAC & Category	Mitigation	Current RAC & Category	Mitigation Status / Date	Target RAC & Category
1	**Penetration of the skin or eyes by fibers during maintenance activities.**	3B Serious	**1) Advise careful handling and use of approved PPE when working with materials containing boron fibers. Ensure maintenance and handling and storage procedures include appropriate precautions.**	3 D Medium	1) Closed 9JUL09. All maintenance and handling and storage materials contain appropriate warnings and safety precautions. PPE is provided to all maintainers.	3 D Medium

Table of contents

- Background
- New Approach for HMMP in Systems Acquisition
- Task 107 HMMP
- Examples for Managing HAZMAT
  - Prohibited: Hexavalent Chromium
  - Restricted: Advanced Composites with Boron Fibers
- Conclusion

Conclusion

- Proposed MIL-STD-882D Change 1 Task 107, HMMP, can be used to insure HAZMAT management is an integral part of the SE ESOH hazard management effort
  - Provides a risk-based approach to targeting materials that are subject to evolving regulatory restrictions or which present ESOH hazards.
  - Used in lieu of NAS 411 for more cost effective and efficient management.

- Enables DoD and industry to reduce risks and costs driven by the use of hazardous material in system production, composition, operation, maintenance, demilitarization, and disposal.

- Requires **collaboration** between the DoD Program Office and the contractor to identify and categorize the list of hazardous materials that they want to eliminate or manage during system development or sustainment.
  - The HMMP will use a categorized list (***prohibited***, ***restricted***, or ***tracked***) to guide decisions about the materials contained within the system, required for operation or support, or generated during disposal or demilitarization activities.
  - Placing HMMP Task in contract documents will compensate contractors for specific hazardous materials reduction activities, while providing DoD with insight into potential developmental cost increases and sustainment cost decreases.

Booz | Allen | Hamilton

Questions?

Ms. Karen Gill
703.412.7436
gill_karen@bah.com

Backup Slides

HM Tracking Example

HAZMAT	Hexavalent Chromium
Location	Struts on landing gear
Quantity	10 grams
Procedures using HAZMAT	Machining struts on landing gear during mtce repairs produces chrome particulate which could be inhaled
Special controls/training	Designated area with specific ventilation rate/PPE/all mtce personnel trained on Cr6+ hazards
Waste generated by activity?	Respirator cartridges, shavings generated during mtce activities, and cleaning chemicals will be disposed of according to specific procedures.

Restricted: Acetone

- The most common hazard associated with acetone is its extreme flammability. Acetone may pose a significant risk of oxygen depletion in aquatic systems due to the microbial activity consuming it.

- Acetone is a good organic solvent that is a component of some paints and varnishes, as well as for most plastics and synthetic fibers. It is ideal for thinning fiberglass resin, cleaning fiberglass tools and dissolving two-part epoxies and superglue before hardening. A heavy-duty degreaser, it is useful in the preparation of metal prior to painting; it also thins polyester resins, vinyl and adhesives.

	IV	III	II	I
(A)				
(B)				
(C)			**Initial** ↓	
(D)			**Current Target**	
(E)				
(F)				

MIL-STD-882D Rev 1 Assessment

Hazard ID	Description	Initial RAC & Category	Mitigation	Current RAC & Category	Mitigation Status / Date	Target RAC & Category
1	Acetone spills and catches fire causing serious injury and destruction of property. Spill flows into natural water supply and causes reversible environmental damage.	IIC Serious	1. Specify the use of spill pan as containment protection when pouring acetone. 2. Require appropriate fire extinguishing agent in proximity of acetone storage and usage areas.	IID Medium	1. Complete – 04/09 2. Complete – 04/09	IID Medium

Tracked: (Jet Propellant Fuel) JP-5 Fuel

- Fire hazard, but less than auto gasoline. The main component of JP-5 is kerosene. Inhalation of JP-5 can cause headache, lightheadedness, loss of appetite, poor coordination, and difficulty concentrating

- Propellants are substances that move other objects or give thrust. JP-5 is a jet propellant used by the military as an aircraft fuel. JP-5 is one of the jet fuels used by the U.S. Navy.

	IV	III	II	I
(A)				
(B)				
(C)				
(D)	**Initial Current Target**			
(E)				
(F)				

MIL-STD-882D Rev 1 Assessment

Hazard ID	Description	Initial RAC & Category	Mitigation	Current RAC & Category	Mitigation Status / Date	Target RAC & Category
1	JP-5 fuel spills onto ground while topping off fuel tank of aircraft which could lead to a fire or inhalation of JP-5 vapors	IVD Low	No program office or contractor mitigation actions planned beyond the typical control measures for this material.	IVD Low	Complete	IVD Low

Restricted: *Beryllium (Be)*

- Beryllium is a know human carcinogen and respirable Be is associated with chronic and acute beryllium disease. Ingestion and contact with solid forms pose no occupational illness risk. Main concern with Be is inhalation.

- Beryllium is a naturally occurring element that is one third lighter than aluminum and six times stiffer than steel. Because of its many desirable qualities, Be metal and Be containing alloys are used for a wide-variety of purposes such as structural members on satellites and aircraft, aircraft brake parts, large bushings and bearings, equipment supports, fasteners.

- **"Restricted"** materials - contractor must attempt to eliminate the usage or mitigate the risks

	IV	III	II	I
(A)				
(B)				
(C)			**Initial**	
(D)			**Current Target**	
(E)				
(F)				

MIL-STD-882D Rev 1 Assessment

Hazard ID	Description	Initial RAC & Category	Mitigation	Current RAC & Category	Mitigation Status / Date	Target RAC & Category
1	**Inhalation of Be particulate while abrasive blasting of Be containing rudder during corrosion control maintenance activities.**	IIC Serious	**1) Set safe distances from work area, require approved PPE for maintenance personnel within the work are, keep work clean and collect all blast residue for proper, safe disposal. 2) Provide warnings and safety precautions in all maintenance manuals, as appropriate.**	IID Medium	1) Tests scheduled for 14JAN09 to take Be sampling during abrasive blasting operations. This information will be used to determine appropriate PPE and safe distances.	IID Medium

The Economics of CMMI®

NDIA CMMI® Working Group
NDIA Systems Engineering Division

NDIA Systems Engineering Conference

October 28, 2009

The Economics of CMMI

CMMI is an investment

- Are you obtaining the returns you should?
- Is performance improving?
- Do benefits outweigh the costs?
- Or just an added cost of doing business?

Value often stems from business choices

- Organizational objectives
- Performance goals
- Implementation strategies

These choices are under an organization's control

- Utilize effective strategies and mechanisms to achieve improved business performance and cost efficiencies

The Effective Use of CMMI®
- NDIA Position Paper

Summary of NDIA industry position statements for obtaining best value from CMMI investments:

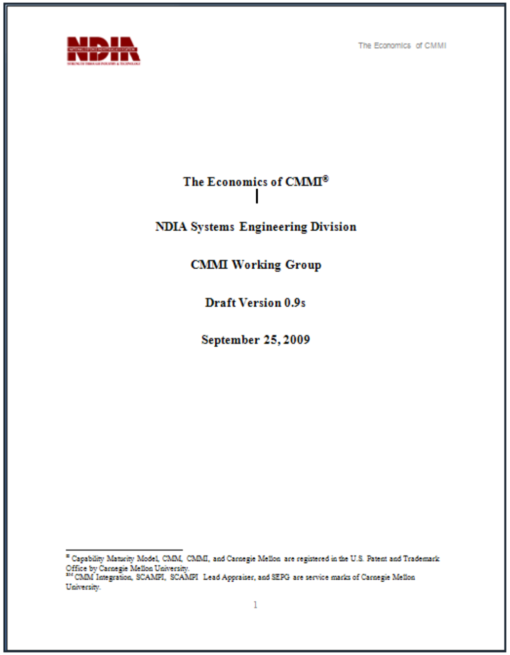
1. **Good processes increase the likelihood of achieving successful project performance**
2. **CMMI is a model, not a standard – adapt CMMI to your business environment, resources, and objectives**
3. **Focus on business improvement objectives – a primary emphasis on achieving levels may not achieve significant benefits and may increase rather than decrease costs**
4. **High maturity is a business case – justify the investment; many organizations find business value in improving processes even at lower CMMI maturity levels**
5. **Maturity level ratings are not alone a predictor of project performance – many other factors can be significant contributors**
6. **Don't specify maturity levels in acquisitions – use CMMI to probe supplier capability and process execution risks**
7. **Greatest benefits of appraisals are from improvements, not evidence or ratings - disproportionate effort on appraisal preparation risk can diminish business returns**

•"The Effective Use of CMMI®", NDIA Systems Engineering Division, June 2009.
http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Documents/CMMI%20Working%20Group/CMMI%20NDIA%20position%20statement_final_.pdf

The Economics of CMMI

Overview:

- Developed by NDIA CMMI Working Group
- Guidance by industry, and for industry, on achieving business value through CMMI
- Suggested CMMI strategies and mechanisms, intended to be tailored much like the model itself


The Economics of CMMI

The Economics of CMMI®

NDIA Systems Engineering Division

CMMI Working Group

Draft Version 0.9s

September 25, 2009

® Capability Maturity Model, CMM, CMMI, and Carnegie Mellon are registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.
SM CMM Integration, SCAMPI, SCAMPI Lead Appraiser, and SEPG are service marks of Carnegie Mellon University.

1

Content:

1. Guidance on achieving business performance improvement through economical use of CMMI
2. Guidance on effective CMMI implementations to address common business issues

Objectives:

- Provoke thoughtful dialog on the effective use of CMMI
- Influence the mindset of CMMI business value – focus on improvement
- Help raise expectations across industry for results achieved through CMMI

The Economics of CMMI –
Targeting CMMI Decision-Makers

Section	Topics
Economical Business Application of CMMI *(Executives)*	• Support of Business Goals and Strategy • Organizational Leadership • Improvement Velocity • Making Performance Improvement Intrinsic to the Job
Economical Implementation of CMMI *(Implementers)*	• Use CMMI as an Integrating Framework • Develop and Deploy Processes Effectively • Tailor CMMI Implementation Appropriately • Implement CMMI in a Practical Way • Make an Informed Decision on High Maturity • Conduct Appraisals Economically

Economical Business Application of CMMI (Part 1)

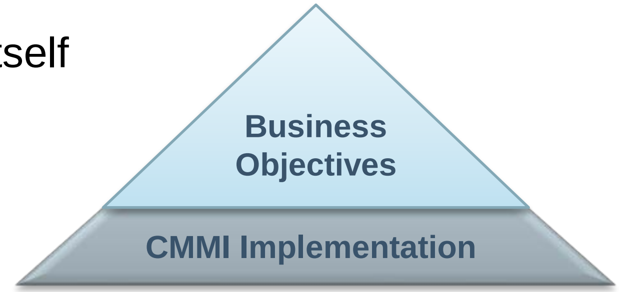
CMMI business value depends on a foundation of underlying principles:

First Principles of CMMI Adoption	Potential Impact When Not Adopted
CMMI-based improvement efforts must align with and support defined business goals.	CMMI investments do not affect business performance; process improvements which are not really improvements have detrimental effects.
Organizational leadership must be actively involved and visibly committed to the improvement effort.	Improvements are not substantial or lasting, due to lack of organizational commitment and resources. Missed opportunities to improve the business.
Manage process improvement velocity. The rate at which processes are improved must respond to the needs of the business.	Massive simultaneous change overwhelms an organization and results in loss of focus on high priority improvement targets. Improvements are not realized in a reasonable time frame, which reduces the return on investment.
Continuous performance improvement must be an intrinsic part of the job - not secondary to it.	Workforce not engaged in improvement initiatives. Waste due to inefficiencies and organizational resistance to change. Premature abandonment based upon failures leaving a worsened condition in the aftermath.

Support of Business Goals and Strategy

CMMI is for improvement with a purpose

- Fit CMMI to the business objectives, not vice versa
  - Improving cycle time, productivity, quality, cost efficiency, customer satisfaction, etc.
- CMMI is a means to an end – not the objective itself



Prioritize improvements where business performance needs are greatest

- What business issues are being faced?
- How can CMMI help address them?

Pursue business value and improved performance

- Disproportionate emphasis on maturity levels can lead to a compliance-focused approach with burdensome processes at increased cost

Economical Business Application
➢ Support Business Goals/Strategy
Organizational Leadership
Improvement Velocity
Make Improvement Intrinsic to the Job
Economical Implementation of CMMI
CMMI as an Integrating Framework
Develop/Deploy Effective Processes
Tailor CMMI Appropriately
Implement CMMI in a Practical Way
Informed Decisions on High Maturity
Conduct Appraisals Economically

Organizational Leadership

Prominent executive sponsorship of CMMI

- Management commitment is crucial
- Set and communicate the strategic vision
- Provide adequate resources (staff, funding, tools)
- Model and reinforce desired behaviors

Hold people accountable for improvement progress

- Set objectives
- Get the organization involved
- Recognize and reward achievements

Understand and communicate CMMI commitment

- Set the tone on why CMMI is important
- The workforce will follow cues from management

Economical Business Application
- Support Business Goals/Strategy
- ➢ Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

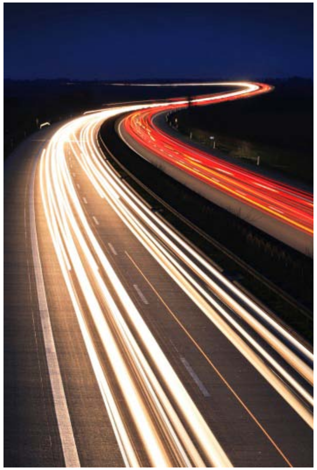
Improvement Velocity

Manage process changes at the rate needed to support the business

- What changes are needed, in what timeframe?

Plan for change at the organizational level

- Factors influencing the ability to absorb change
  - Relationships of processes with performance
  - Current state of processes and leadership
  - Project profiles (size, complexity, domain, etc.)
  - Improvement strategies and methods
- Prioritize improvements where most needed



Manage process improvement like a project

- Apply the same rigor as for any key project
- Led by a capable project manager
- Org charts, with defined roles and responsibilities
- Budget, schedule milestones, project reviews
- Engage the appropriate stakeholders

Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- ➢ Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Making Performance Improvement Intrinsic to the Job

Process improvement is everyone's responsibility

- "Quality is not an act, it is a habit" (Deming)
- Set expectations for organization-wide involvement
  - Managers at all levels
  - Process groups
  - Practitioners and support groups
- Establish mechanisms for a learning organization
  - Improvement suggestions, lessons learned, process assets

Engage practitioners

- The most useful processes are often developed by those doing the work – not "ivory tower" process groups
- Ensure connection to the real issues faced by projects

Involve respected experts and opinion leaders

- Ensure process relevance, ownership, buy-in

Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- ➢ Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Economical Implementation of CMMI (Part 2)

Section	Topics
Economical Implementation of CMMI *(Implementers)*	• Use CMMI as an Integrating Framework • Develop and Deploy Processes Effectively • Tailor CMMI Implementation Appropriately • Implement CMMI in a Practical Way • Make an Informed Decision on High Maturity • Conduct Appraisals Economically

Practical guidance for implementing CMMI economically

- Helps ensure investments yield returns in business performance
- Recommendations for effective implementations to avoid common pitfalls
- Non-exhaustive, perhaps subject to debate - intended to be interpreted, tailored and applied in business context

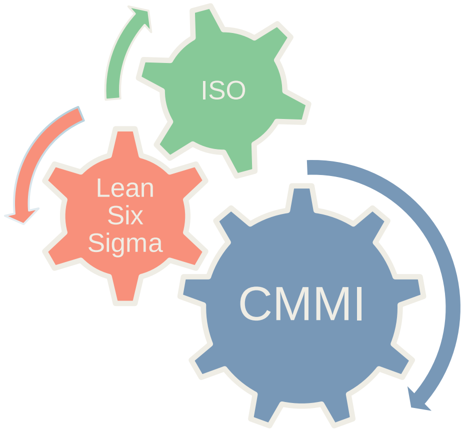
Intent is to help maintain CMMI emphasis where it belongs

- Improvement in business results and project performance, achieved economically

Use CMMI as an Integrating Framework

Common Issues	Recommendations
• Multiple parallel improvement strategies (e.g., CMMI, ISO, Lean, Six Sigma) not well coordinated at the organizational level. • Not all functions engage in integrated process improvement, resulting in sub-optimized processes or disjoint initiatives.	• Create one set of organizational process standards supporting multiple improvement strategies. Use CMMI to create a process architecture and framework supporting multiple process guidance sources. • Integrate stakeholders and cross-functional processes using CMMI to identify issues early in the product life cycle.

CMMI can be used to integrate processes, stakeholders and improvement initiatives



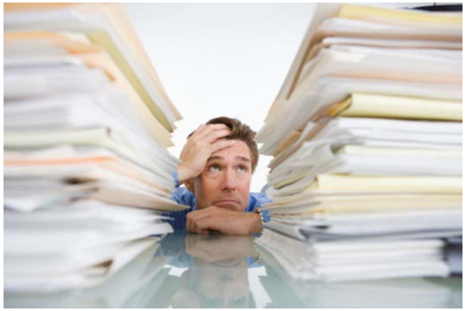
Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- ➢ CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Develop and Deploy Processes Effectively

Common Issues	Recommendations
• Processes too closely aligned with CMMI model don't fit the organization • Processes developed in isolation from projects aren't realistic or accepted • Too much change at once overwhelms the organization • Process descriptions are too verbose, disorganized, or overly dependent on manual effort to be useful to projects	• Integrate CMMI with current practices. Design processes around work actually performed. • Involve practitioners to help develop and deploy processes that are practical and useful. • Manage the improvement initiatives. Consider improvement lifecycles. Pilot for effectiveness. • Maintain perspective - remember who processes are for, and why. Keep end users in mind as the primary target for useful, concise process descriptions ready to be followed

Design processes so they are effective and most useful to those that must follow them



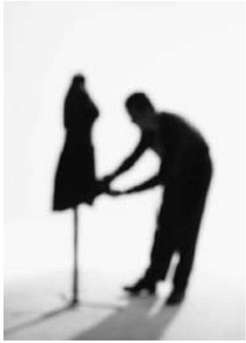
Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- ➢ Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Tailor the CMMI Implementation Appropriately

Common Issues	Recommendations
• Organizations adapting to CMMI, instead of adapting CMMI to their business • Forcing a “one size fits all” CMMI implementation on the diverse projects in the organization	• <u>Tailor CMMI model implementation to the business context</u>. Adapt CMMI implementations to meet the needs of the business. • <u>Recognize the needs of different types of projects</u>. Allow and encourage project tailoring of the organization’s process.

CMMI is a model, not a process – adapt it to fit the characteristics and constraints of the business context



Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- ➢ Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Implement the CMMI in a Practical Way

Common Issues	Recommendations
• Size of the CMMI model can be overwhelming for newcomers.	• Start simply and bite off manageable chunks. Identify areas where needs are greatest. Understand model dependencies.
• Confusion about generic practices causes process rework.	• Interpret and apply CMMI generic practices with good judgment. Find practical solutions for implementation/appraisal that support the work.
• Inability to estimate process improvement effort causes cost and schedule problems.	• Learn from experience. Collect measures for improvement cost and effort. Use training and other resources to minimize misunderstandings that can cause rework.

Use good judgment on CMMI implementation strategies to manage complexity and maximize business leverage

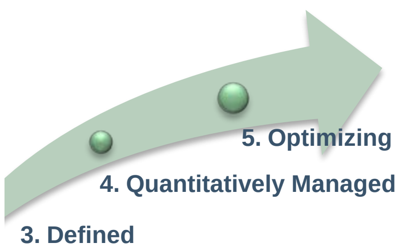
Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- ➢ Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- Conduct Appraisals Economically

Make an Informed Decision on High Maturity

Common Issues	Recommendations
• Misunderstanding high maturity leads to folklore on burdensome processes. • Focus on high maturity level ratings over actual improvement value. • Concern that high maturity requires excessive rework of processes. • Un-measurable quality and process performance objectives. • Settling for ML3, losing opportunities for greater business leverage.	• Separate fact from fiction. Take training to understand high maturity and find opportunities. • Focus on process improvement, not maturity levels. • Anticipate process evolution. Plan for natural progression of improvement, at any level. • Derive measurable quality and process performance objectives from business needs. • Make an informed decision on high maturity. Seek first to understand , then determine where it makes sense for the business.

Greatest business benefit can be obtained by implementing the appropriate level of process maturity based on business objectives



Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- ➢ Informed Decisions on High Maturity
- Conduct Appraisals Economically

Conduct Appraisals Economically

Common Issues	Recommendations
• Behaviors based on fear of failing ratings drives disproportionate effort on appraisal preparation and dry runs. • Focusing on appraisal ratings and not acting upon improvements. • Expensive appraisals, preparation and evidence collection can burden CMMI adoption. • Appraisals of supplier processes can be cost-prohibitive in acquisition.	• Utilize the entire family of appraisal methods (Class A, B, C) appropriately – right tool for the right purpose. Design an appraisal strategy. • Use appraisals as process improvement opportunities and as a measure of progress. • Conduct efficient appraisals. Minimize creation of evidence repositories and artifacts intended just for appraisals. • Use targeted appraisals to determine supplier processes risks most relevant to a planned acquisition. Look beyond ratings for suitability.

Establish cost-effective strategies for appraisals that align with business needs and measure improvement progress

Economical Business Application
- Support Business Goals/Strategy
- Organizational Leadership
- Improvement Velocity
- Make Improvement Intrinsic to the Job

Economical Implementation of CMMI
- CMMI as an Integrating Framework
- Develop/Deploy Effective Processes
- Tailor CMMI Appropriately
- Implement CMMI in a Practical Way
- Informed Decisions on High Maturity
- ➢ Conduct Appraisals Economically

Summary –
The Economics of CMMI

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Business returns on CMMI investments are dependent largely on underlying principles

- **Objectives** – *alignment with business goals*
- **Sponsorship** – *leadership, commitment, resources*
- **Action** – *improvement velocity for business needs*
- **Engagement** – *participation, project focused*
- **Value** – *performance results to justify investments*
- **Motivation** – *performance improvement vs. ratings*

These factors are under an organization's control

- The Economics of CMMI is a balance sheet for obtaining best value from CMMI
- Implementation strategies govern whether CMMI investments translate into improved business performance, or simply added costs of doing business

Focus on business value to provoke thoughtful dialog and raised expectations for the effective use of CMMI

For More Information….

NDIA CMMI Working Group

http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/CMMI_Working_Group.aspx

Jim Armstrong *Stevens Institute*	**Dan Blazer** *SAIC*	**Michael Campo** *Raytheon Company*	**Geoff Draper** *Harris Corporation*
Jeffrey L. Dutton *Jacobs Technology*	**Nancy Fleischer** *Raytheon Company*	**Ray Kile** *Lockheed Martin*	**Renee Linehan** *The Boeing Company*
Wendell Mullison *General Dynamics, Land Systems*	**Randy Walters** *Northrop Grumman*		

The 12th Annual Systems Engineering Conference

"Acquisition Excellence through Effective Systems Engineering"

Systems Engineering Deficiencies and Corrections for Air Launched Tactical Weapons

28 October 2009

Marvin Ebbert----Industry Panel Chair

Introduction

Numerous studies and reports have indicated persistent performance issues in the development of defense programs

- GAO, NRC, NDIA, …

Many issues relate to a lack of adherence to fundamental systems engineering (SE) principles

These SE issues are being considered and addressed at multiple levels of DoD and the defense industry

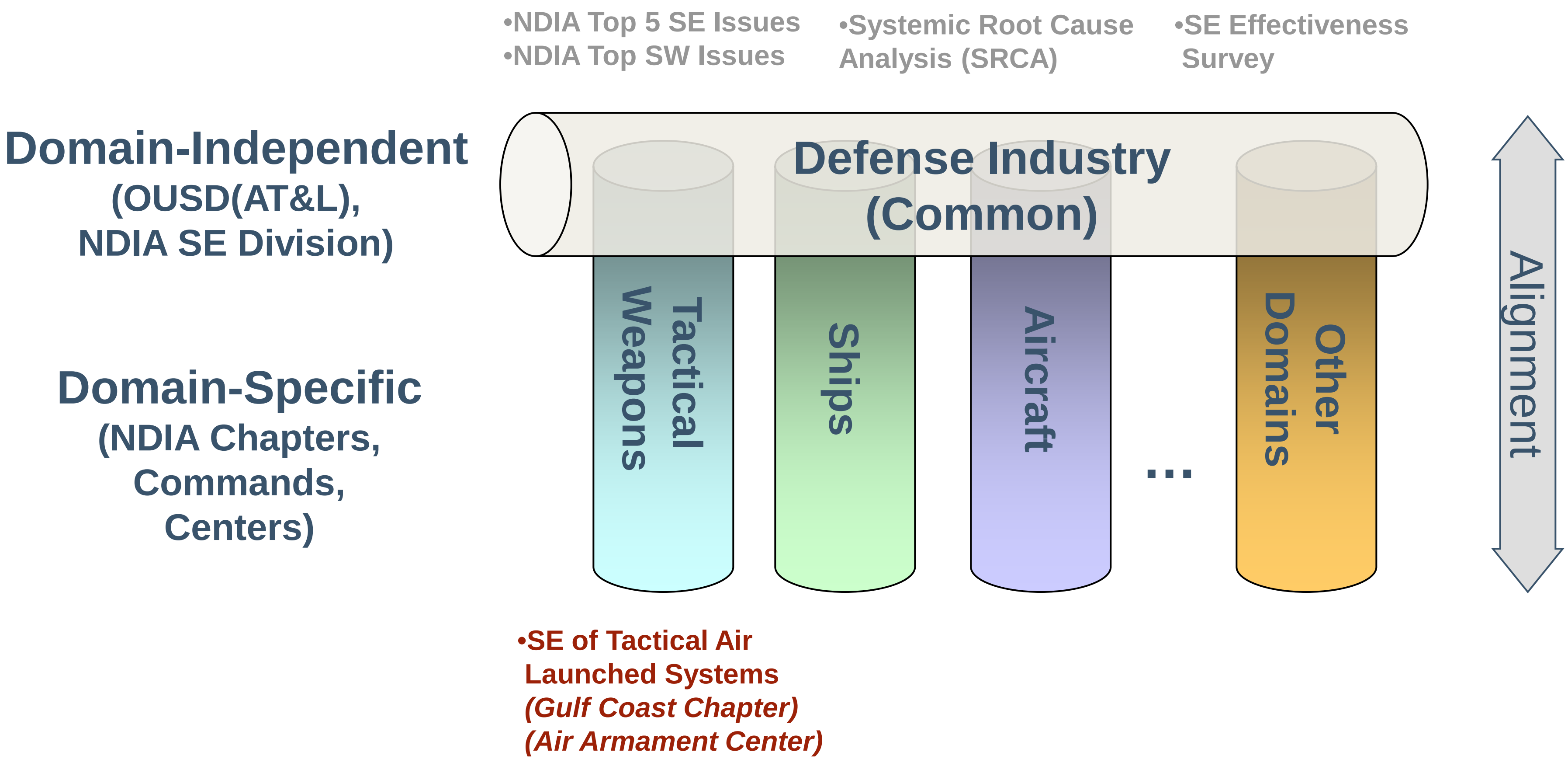
- DoD – OSD, services, commands, centers
- NDIA – divisions, chapters, committees

Issues and solutions may vary, depending on the context and situation

- Common (domain-independent)
- Unique (domain-dependent)

Integrating SE Findings and Recommendations

NDIA SE Division to serve as integrating framework for coordinating SE issues with OSD and sponsoring improvements across the enterprise



Air Armament Symposium 2008

SYSTEMS ENGINEERING OF

TACTICAL AIR-LAUNCHED WEAPONS

AN INDUSTRY EXAMINATION

And others…..

USAF Weapons
The Most Capable in the World

Challenge and Charter

AAC Challenge To Industry:

Identify Weapon Systems Engineering Best Practice Improvements That Will Provide:

- Improved Program Performance (Cost And Schedule)
- Earlier Weapon Maturity
- Reduced Weapon Acquisition and Sustainment Cost

NDIA Response:

Chartered An Industry Expert Panel To Determine If Improvements In "Systems Engineering Best Practices" When Combined With Program Structure And Control Improvements, Could Provide The Desired Results.

System Engineering Industry Panel

Program Structure and Control Sub-Panel
Lockheed Martin

Risk ID and Management Sub-Panel
Northrop Grumman Electronic Systems

Core Panel

Chair:
Marvin Ebbert (Raytheon)

Co-Chairs:
Frank Robbins (NDIA Board)
Carl Avila (Boeing)
Jim Pappafotis (Lockheed Martin)

Direction and Integration

Requirements and Verification Sub-Panel
Boeing

Supplier Management Sub-Panel
Rockwell Collins

System Design Sub-Panel
General Dynamics-Ordnance & Tactical Systems

Panel Structured to Address The "Root Causes" of Systemic Deficiencies

AAC Expectations
Recent Program Structure

- AAC Objective And Customer Expectations:
  - EMD Programs Must Be Executed On Schedule And Within Budget!
  - Systems Fully Matured At Milestone C- Ready For Production And Deployment
- The Strategy: Increase The Level Of Achievement In Risk Reduction Phase (Pre Milestone B)
  - Force EMD To Be Production-configuration Build, Integrate, And Formal Verification Tests---with Fielding Preparations
    - Significant Reduction In Time And Cost Of SDD Program Expected
  - Move The CDR Milestone To Milestone B Position As An Entry Criteria
  - Use Competition To Ensure That The Highest Levels Of Risk Reduction Are Achieved

Achieve A Level Of Maturity Of The Product Baseline At MS B Necessary To Accurately Predict Program And Product Performance And Cost.

COMMON SYMPTOMS

Concepts | (A) Risk Reduction | (B) SDD | (C) Production & Deployment | Operations & Support

PDR CDR Integration And Formal Verification

Earlier SE Deficiencies At Root Cause!

Spec Requirements Definition, Flowdown, and Control

- Inability to complete the design-to requirements
- Requirements Creep---Not Stable
- Unplanned requirements verification efforts

Design Maturity and Control

- Multiple Unplanned tests required for performance data or design
- Multiple Configuration Changes—Not Planned

Verification Test Failures

- Component Qualification Test
- Weapon Level Integration Tests
- Weapon Level Qualification Tests
- Weapon Flight Testing

Production/Field Failures

- Redesign for Producibility/Cost
- Redesign for Field Reliability and Sustainability
- Configuration variation issues

Weapon Development And Production Programs Have Common "Symptoms Of Systems Engineering Deficiencies"

Deficiencies In Systems Engineering- Root Causes

Program Structure And Control: (Deficiencies)

- Insufficient Maturity Of Design At Critical Decision Points
- Insufficient Testing And Analysis Planned To Achieve Maturity
- Late Integration Of Production Critical Processes And Controls
- Program Funding Profiles Not Structured For Improved Practices
- Configuration Management: Form, Fit, Function And Margin (F^3M)

Requirements And Verification: (Deficiencies)

- Lack Of Service Use Profile Leaves Interpretive Requirements
- Insufficient Mapping Of Requirements To Design
- Ineffective Maturation And Verification Planning

Deficiencies In Systems Engineering- Root Causes

Design Best Practices: (Deficiencies)

- Inadequate Design Analysis
  - Fault Tree Analysis On All Subsystems During Design
  - Single Point Failure Analysis During Design
  - Critical Parameter and Key Feature Identification
- Inadequate Maturation Analysis And Testing
  - COTS Integration
  - Design Margin And Sensitivity Development
  - Critical Manufacture And Assembly Process ID / Control
- Miss-Use Of "Production Representative" Configuration For Verification

Risk Identification And Management: (Deficiency)

- Inadequate Relationship To "Knowledge" Of Design

Supply Chain Practices: (Deficiency)

- Inconsistent Approaches To Design Characterization

5000.02 and Recent AAC Program Structure Changes Improve EMD Performance, But…

Concepts | A | Risk Reduction | B | B | B | EMD | C | Production & Deployment | Operations & Support

(Expanded)

PDR

CDR

Integration And Formal Verification

Draft 5000.2 Revised Program Structure

AAC Revised Program Structure

Unstated or Controlled Requirements

- Inability to complete the design-to requirements
- Multiple Unplanned Hardware and software Configuration Changes
- Unplanned requirements verification efforts

- Multiple Unplanned tests required for performance data or design
- Component Integration Test

Design Failures

- Component Qualification Test
- Weapon Level Integration Tests
- Weapon Level Qualification Tests
- Weapon Flight Testing

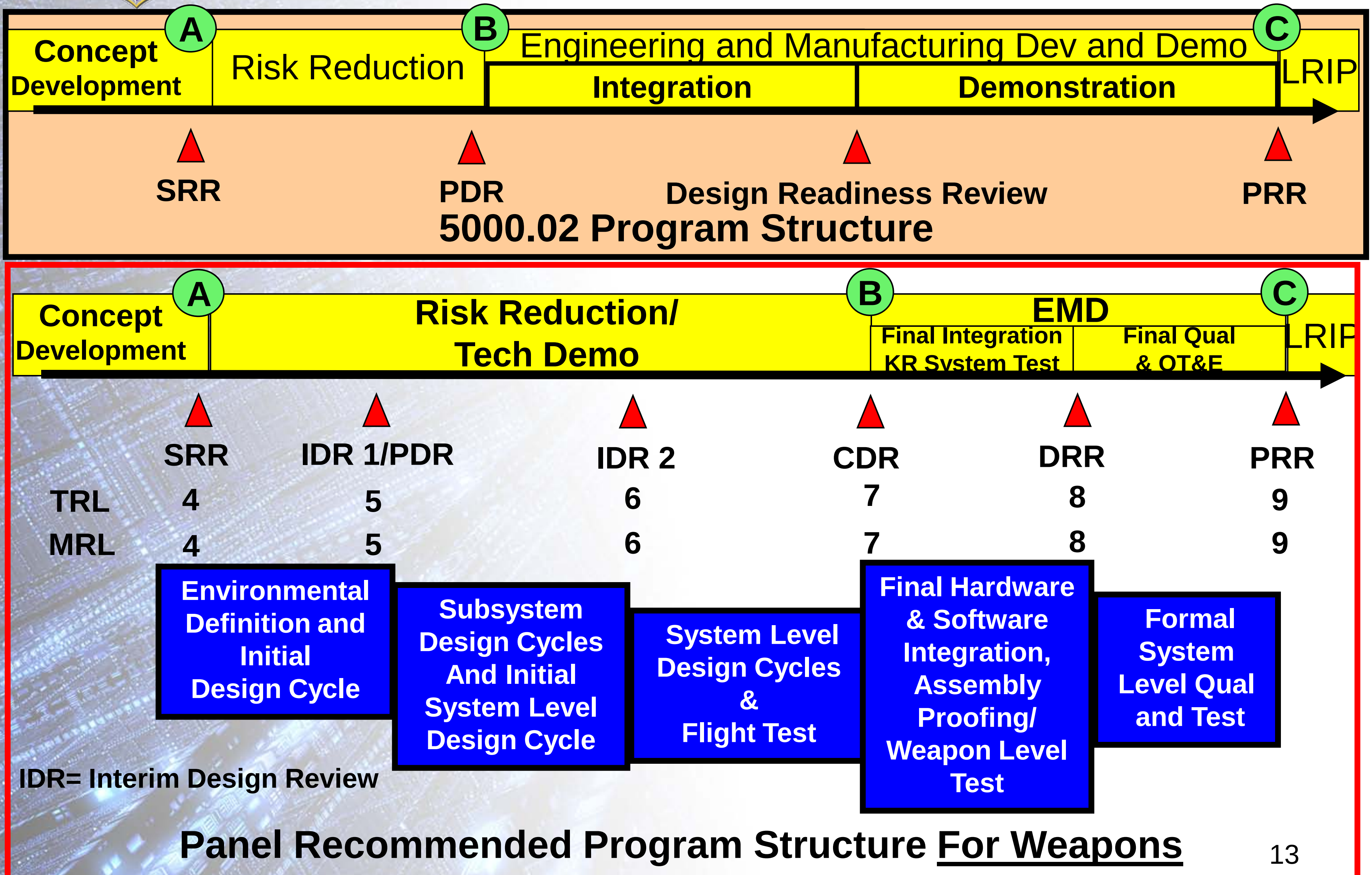
Verification Test Failures

- Redesign for Producibility/Cost
- Redesign for Field Reliability and Sustainability
- Configuration variation issues

Production/Field Failures

Greater Maturity at EMD Entry Provides Improvement
Improved Best Practices Ensure the Solution

5000.02 Tailored For Weapons



Recommendations and Benefits: Program Structure and Control

Adopt the Expanded Risk Reduction Model for Acquisitions

- Incorporate Knowledge Based Decision Milestones (A, B & C)
- Provide For Variations In Milestone Attainment Timelines
  - Based On Contractor's Unique Design Maturity
- Funding Must Be Based On Design Characterization/Maturation
- Re-Establish Program Contractor Configuration Control Boards (CCBs):
  - Form, Fit, Function and Margin (F^3M)
- Establish Culture That Accepts "Press to Failure" Approaches
- Downselect To Single Source When No Longer Cost Effective To Maintain Competition

Benefits: (When Combined with other Recommendations)

1. Shortens EMD and Total Program Timelines—Reduces Verification Test Failures
2. Earlier Maturation and Reliability
3. Reduced Weapon Costs---Less Costly Production Testing and Rework
4. Reduced Need to Create Changes in Early Production Phases

Recommendations Should Be Contained In Risk Reduction RFP (EMD Planning Must Be Included)

Recommendations and Benefits: Requirements and Verification

Recommendations

- Provide a Complete/Coordinated Service Use Profile (Pre-MS A)
- Initiate Joint Requirements Working Group
- Initiate Joint Interface Control Working Group
- Establish Overarching Test Strategy (including Acceptance) and Requirements at MS A
- Develop and Control an Asset Utilization Matrix
  - Define the Configuration and Number of Every Test Article
  - Map Testing to Assure Minimum "System Firsts" in Testing

Benefits

- Reduced Total Program Timeline
  - Reduced Level of Requirements Interpretation Issues
  - Increased Probability of Verification Test Success---"Test Mature System"
- Reduced Weapon Cost
  - Demonstrated Maturity and Reliability --- Lot Sample Acceptance Test

Recommendations and Benefits:
System Design

Incorporate Design Characterization And Document

- Bi-directional Mapping Of Requirements To Design Features
- Critical Parameter and Key Feature Identification and Control
- Fault Tree And Single Point Failure Analyses (1629A)
  - Completed As The Design Process, Not As An After-thought
- Perform Design Characterization As Part Of Design
  - Design And Manufacturing Sensitivity
  - Design And Manufacturing Process Margin Summary
  - Critical Manufacturing And Assembly Process ID And Controls
- Treat COTS As Military Equipment
  - Must Be Isolated, Or
  - Subject Of Design Characterization And Configuration Control

Benefits

- Reduction In Total Program Timeline And Cost
  - Reduced Verification Test Failures
- Earlier Weapon Maturity
- Reduced Weapon Cost
  - Reduced Production Phase Changes And Acceptance Test Costs
  - Reduced Cost of Sustainment

These Recommendations Should Be Contained In Risk Reduction RFP's

Recommendations and Benefits:
Risk Identification and Management

Recommendations

- Continue Risk Identification And Management Practices
- Implement Risk Rating Factors/Checklists To Assess:
  - Sufficiency Of Design Characterization
  - Program Resource Sufficiency To Support Design Characterization and Verification
  - Approach to Include COTS (Commercial Off the Shelf)
- Create Knowledge-Based Technology/Manufacturing Readiness Level (TRL/MRL) Definitions

Benefits

- Reduced Total Program Timeline---Fewer Failures
- Knowledge Based Sufficiency Reviews---Cost Certainty

Incorporating Knowledge-based Risk Management Technique Will Improve Program Success.

Recommendations and Benefits:
Supply Chain

Recommendations

- Weapon Development And Production Practices Should Be Vertically Consistent
  - For Design Characterization/Maturation,
  - For Development Test, And Production ATP Philosophy,
  - For Risk ID And Management, And
  - For The Use Of COTS.

Benefits

- Fact: Typically 50% To 80% Of Design And Manufacturing Detail Resides Below The Prime Contractor Level
- Full Benefit Of Enhanced System Engineering Practices Can Only Be Realized With Inclusion Of The Supplier Chain Within Engineering Reform

The Targeted Level To Which Practices Should Be Applied Will Vary From Program To Program.

Summary of Industry Panel Findings

- **Acquisition Reform, Competitive Pressures, and Industry Over-Reliance on Modeling/Analysis, parented a Loss of Critical Systems Engineering Fundamentals:**
  - Government Standards Lost to Acquisition Reform
  - Insufficiently Defined Requirements in Government RFP's to Assure Complete Design Maturation
  - Lack of Detailed Technical Planning Being Provided In Industry Proposals
    - For Government Technical Evaluation
    - For Program Funding Development and Contract Pricing
- **Consensus Opinion on SE**
  - If the Government Doesn't Require Definition of the Core Practices to Mature a Product Design………then,
  - Technical Activities (ie Fundamental Systems Engineering Practices) Are Within Industry's "Trade Space" and Can Be Eliminated Unilaterally-
    - **Very Likely to Occur With Pressures of Competition In Today's Acquisitions**

Government Need- A New Level of Insight

- **The Government Needs A New Level of Insight into Contractor Planning for Development and Production**
  - To understand how the Desired Levels of Maturity will be Reached at Program Decision Milestones
  - To Select the Highest Probability of Success Contractors
  - To Establish Revised Funding Profile "Front Loaded" Necessary to Support "Robust Systems Engineering"
  - To Understand Sufficiency of Contractor Cost Proposals
- **Will Require Changes In RFP's, Source Selection Emphasis, and Government/Contractor Education**

Recommended RFP Requirement

Volume 1 – System Performance Specification
Volume 2 – Risk Management Plan
Volume 3 – Integrated Characterization Maturation Verification Plan
Volume 4 – System Engineering Plan (Hardware and Software)
Volume 5 – Small Business Consideration Plan
Volume 6 – Supply Chain Management Plan
Volume 7 – Safety Program Plan
Volume 8 – Configuration Management Plan
Volume 9 – Manufacturing and Assembly Plan
Volume 10 – Logistics and Support Plan
Volume 11 – Reliability Growth Plan

Cost/Price/Schedule/Contract Data
Volume 1 – Integrated Master Plan (IMP)/Integrated Master Schedule (IMS)
Volume 2 – Model Contract
Volume 3 – Risk Reduction Program Cost/Price
Oral Presentation/Power Point Charts

Summary

- Thanks to USAF's AAC Challenge to Industry,
-
- Fundamental Deficiencies in Systems Engineering Practices of Industry have Been Identified.

- Correction recommended through modification of :
- 1. RFP Requirements --- Plans traceable to Bid
- 2. Source Selection Criteria --- Affordable Maturation
- 3. Revised Program Structure
- 4. Revised Milestone Requirements

- Recommendations for RFP requirements and assessment have been provided and are available.

Industry and Government Working Together Will Correct Current Deficiencies in Systems Engineering and Improve Program Performance

For Additional Information…

NDIA Systems Engineering Division

Bob Rassa (Chair)
rcrassa@raytheon.com

Hal Wilson (Vice Chair)
hal.wilson@ngc.com

Geoff Draper (2nd Vice Chair)
gdraper@harris.com

Industry Task Group - SE of Tactical Air-Launched Weapons

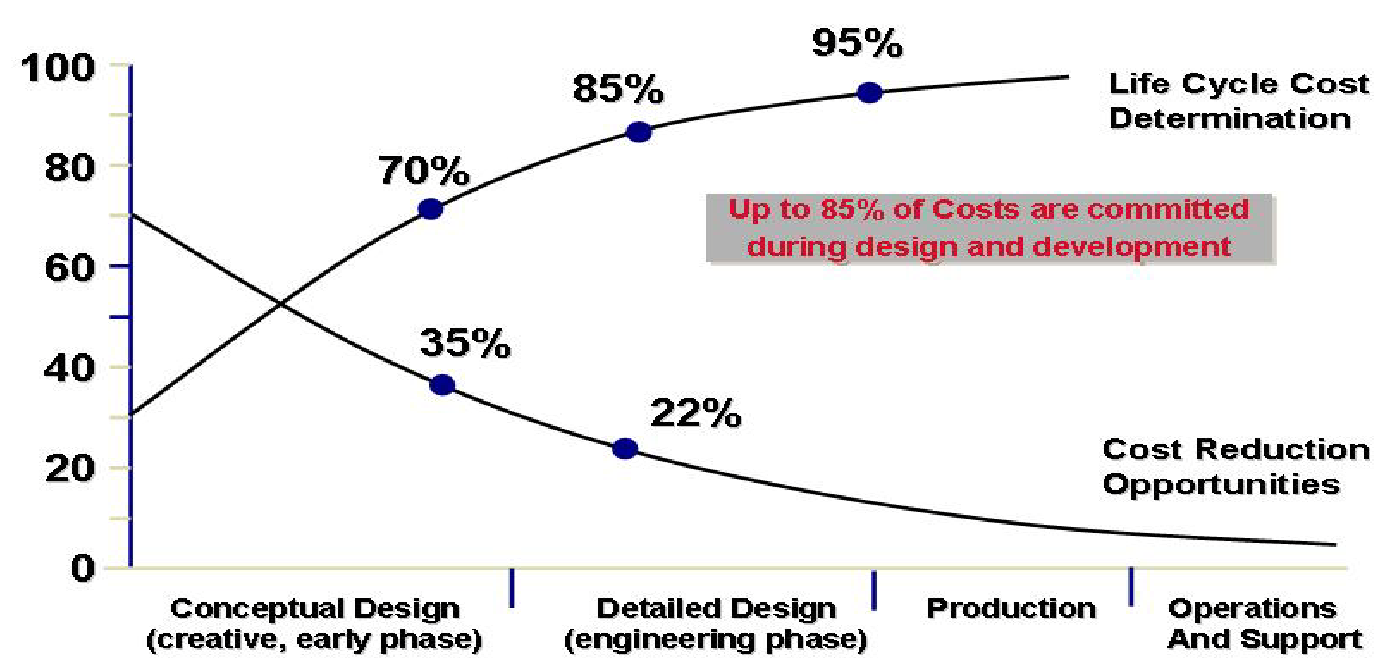
(NDIA Gulf Coast Chapter)

Marvin Ebbert (Chair)
mdebbert@raytheon.com

Frank Robbins (NDIA Advisor)
No1Hog@aol.com

Backups

Systems Engineering Addresses Costs of Decision Timeliness



Source: DARPA Rapid Design Exploration and Optimization Project

Service Use Profile Definition

- Begins with Weapon Delivery to the Government and Continues through the entire weapon life cycle
- Service Use Profile is the Description of the following with sufficient specificity to allow Weapon System Development and Qualification
  - Transportation Modes, Environments, Times, Distances, Packaging, Etc.
  - Storage, Handling, Packaging and Unpackaging, Assembly, Test, Etc.
  - Load Operations, Support Equipment Interfaces
  - Platforms, Load Outs with all Tactical and Test Configurations
  - Take Offs/Landings/Cats/Traps
  - Mission Planning Requirements
  - All Mission Profiles (to be platform specific)
    - Captive Carriage
    - Release Parameters (Range, Altitude, Air Speeds, etc.)
    - Special Considerations (Presence of Emitters, etc.)
  - Performance
    - Survivability
    - Lethality against Target Set (Including "Kill Criteria"
    - Special Timeline Requirements
    - Special Communication Requirements
  - Reliability (Transportation, Storage and Handling, Captive Carriage, Free-Flight, End Game Reliability, Testing, etc.)
  - Logistics Approach (O-Level, Depot, RETOK, etc.)
  - Decontamination, Cleaning, Recontainerization, EOD, DeMil
  - Etc.
- Must be Consistent with Over-Arching System Architecture, CONOPS and Employment Concept

Definitions

- **Design Characterization:**
  - **Determining Capability Margins Through Analysis And Test**
    - **Integrated Performance**
    - **Physical, Logical, And Electrical**
    - **Against Specified Requirements**
    - **Including Sensitivities To Environments/Conditions Outside Specified Requirements.**

- **Design Margin:**
  - **Capability Of A Product Design In Excess Of "Design-to" Requirements**
    - **Includes The Extremes Of Variation In Manufacture/Assembly Processes**

- **Design Sensitivities:**
  - **Susceptibility Of Product Design Performance When Exposed To Specified <u>And Non-specified</u> Environments.**

Definitions (cont'd)

- Configuration Management: Form, Fit, Function and Margin (F^3M)
  - Margin Maintenance
  - System Engineering/Configuration Management Best Practice
  - Requires Fully Characterized Product Design (Baseline Record)
  - No Change Allowed Without Full Understanding Of Individual And Cumulative Effects Of Product Margins And Sensitivities.
  - Requires Evaluation Of All Potential Class I And Class II Changes

- Non-Redundant Design (NRD)
  - Design In Which Redundancy Not Available Due To Physical Or Cost Constraints
  - Typical Characteristic Of Tactical Weapons
    - Stressing Performance Requirements
      - High Reliability
      - Lengthy Storage And Use Times
      - Full Range Of Military Environments.
  - Challenge to Weapons: Reliability without Redundancy

Definitions

- **Integrated Verification And Maturation Matrix**
  - **Matrix That Contains At All Levels Of The Configuration:**
    - **A Mapping Of Requirements To Verification Test(s), Engineering Analyses, And Basis Of Similarity Analyses Used To Verify Compliance Of The Design With Specification Requirements.**
    - **A Mapping Of All Testing And Analyses Required In Addition To The Requirements Verification Testing That Are Necessary To Fully Characterize And Mature The Product Design.**

- **Asset Utilization Matrix**
  - **Matrix That Contains The Configuration Definition (And Number Of) Each Of The Units-Under-Test Contained In The Integrated Characterization, Maturation, and Verification Matrix.**

- **Knowledge Of The Design**
  - **The Degree To Which The Design Is Characterized, Qualified, And Verified Against The Specified Requirements.**

Building a Defense SoS SE Community: NDIA SoS Committee

John Palmer, The Boeing Company
Judith Dahmann, The MITRE Corporation

Abstract

There is increasing interest in DoD in approaches to apply systems engineering to address systems of systems (SoS). OSD has issued an initial guide for systems engineering for SoS as a starting point for DoD consideration of the SE SoS challenges and current understanding of approaches. The Army and Navy have established SoS SE organizations. And there is an increasing number of SoS initiatives in the Service and at the Joint and DoD levels.

As a result, the NDIA SE Division has formed an SoS SE committee. This committee held its kickoff meeting in April 2009 and held meetings in June and August. This presentation will describe the purpose of the committee, committee discussions to date and interests of committee members.

The presentation will focus on plans for committee activity in 2010 including a new website to support ongoing discussion and information exchange among members of the SoS SE community.

Purpose and Topics

- Purpose
  - Introduce new SoS SE Committee to SE community
  - Share current thinking about the shape and focus of SE Committee activities and plans
  - Solicit input on Committee direction
- Topics
  - Background on Committee creation
  - Committee activities and participation to date
  - "Sleepless Nights" Topics
  - Creation of 'online community'
  - Next steps

Background

- Increasing attention focused on the challenges of engineering independently useful systems to work together to meet user capability needs
  - Includes Service Oriented Architectures, Systems of Systems, Net-centric Enterprise Systems, and more
- The systems engineering community has begun to address these challenges
  - DoD Guide for Systems Engineering for SoS
  - Army SoS SE Organization
- A new committee of the NDIA SE division was proposed to address this area

SoS SE Challenges

- Many SE models are based on the ability of the systems engineer to
  - Define boundaries and requirements clearly
  - Control the development environment so that requirements can be optimally allocated to components based on technical trade analyses
- Today's defense SoS environments challenge this approach
  - Constraints to use existing systems as SoS components result in an extant allocation of functionality & implementation which may not be optimal
  - Component systems have independent ownership, funding, and development processes requiring the consideration of factors beyond the technical when evaluating capability objective options
  - Changes during development and unanticipated changes or emergent behavior may have an overriding effect on user capabilities, further complicating the work of the systems engineer
- These factors add complexity to both the systems and the systems engineering context

Committee Mission and Objectives

- Mission
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
    - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- Objectives
  - What does it mean to do SE in these environments?
  - What are the roles of processes, policy, guidance, and governance?
  - What is the role of SE in Capability Portfolio Management?
  - What are the architecture changes that will incorporate the SoS attributes necessary for SoS integration across the enterprise?
  - What new methods, processes and tools are needed to address the breadth, complexity of today's systems of systems?

Plan to Revisit Mission and Objective Based on Initial Committee Experience

Committee Activities

- April 2009- Kickoff Meeting
  - ❖ Government sponsor SoS interests and expectations
  - ❖ Background, challenges, mission and objectives of SoS Committee
  - ❖ Candidate topics discussion – "Sleepless Nights"
- June 2009
  - ❖ SoS SE committee plans including review of input on topics of interest
  - ❖ SoS and T&E Discussion
  - ❖ Presentation by AFEI SOA Working Group on SOA and Acquisition
- August 2009
  - ❖ "SoS SE Track" at the NDIA SE Conference in October
  - ❖ Update on ongoing "SoS and M&S" activity under the NDIA M&S Committee
  - ❖ "SoS and T&E", continuation of discussion from the June meeting
  - ❖ Planning for next year's committee activities

Committee Participation

- Large interest in committee participation
  - ~ 80 people have expressed interest and have participated in one or more of the meetings
  - ~ 30-40 participants at each meeting split between onsite and remote participation
  - Participants include Government, Industry, FFRDCs and Universities
- Responding to participant preferences for structuring committee operations
  - Committee plans to meet in conjunction with bimonth SE Division meetings to leverage travel
  - Remote access will be provided for regular meetings
  - Online facility (SharePoint site) has been established to facilitate continuous asynchronous exchange
- Very <u>lively</u> discussions

‘Sleepless Nights’ Topics

23 Sleepless Nights Topics

1 Lessons learned from past and on-going SoS programs
2 Perspective of the SoS manager for SoS SE
3 Defining SoS relationship in terms of an 'SoS Signature'
4 Relationship among SE approaches for systems, SoS, FoS
5 Difference in SoS definitions
6 Developing validated SoS policy
7 Relationship between SoS and acquisition process
8 Addressing SoS from perspective of a new system acquisition
9 Role of requirements in SoS
10 SoS architecture
11 SoS Integration
12 SoS and Complexity
13 Role of optimization in SoS SE
14 Defining and measuring SoS performance
15 SoS test and evaluation
16 SoS SE competencies and training
17 SoS governance
18 Constructive approaches to addressing politics in an SoS
19 SoS business models
20 Relationship between SoS and net-centric services
21 Science based theory to support SE of systems and SoS
22 SoS modeling and simulation
23 SoS SE Analyses of CBRN

Below is a compendium of the SoS SE topics recommended by committee members. In the space below, please indicate your top 5 topics along with specific questions you would like the committee to address in the area.

	Suggested Topics	Top 5 Topics	Specific questions you would like to see addressed
1	Lessons Learned from past and on-going SoS programs		
2	Perspective of the SoS manager for SoS SE		
3	Defining SoS relationship in terms of an 'SoS Signature'		
4	Relationship among SE approaches for systems, SoS, FoS		
5	Difference in SoS definitions		
6	Developing validated SoS policy		
7	Relationship between SoS and acquisition process		
8	Addressing SoS from perspective of a new system acquisition		
9	Role of requirements in SoS		
10	SoS architecture		
11	SoS Integration		
12	SoS and Complexity		
13	Role of optimization in SoS SE		
14	Defining and measuring SoS performance		
15	SoS test and evaluation		
16	SoS SE competencies and training		
17	SoS governance		
18	Constructive approaches to addressing politics in an SoS		
19	SoS business models		
20	Relationship between SoS and net-centric services		
	SE in Net Centric SoS		
21	Science based theory to support SE of systems and SoS		
22	SoS modeling and simulation		
	Representation of an SoS in Simulation Environmentt		
	Need for a valid sythentic environment for SoS		
23	SoS SE Analyses of CBRN		
24	Other		

Participants Provided Feedback On Top 5 Topics of Interest

- At the April Kickoff meeting
  - Participants were asked to share the aspects of SoS which “keep them awake at night”
- Between April and June Meetings
  - Sleepless nights topics were synthesized and topic list was circulate to participants to provide feedback on topics of specific interest
- Initial set of topics of high interest were used to set agenda for June and August meetings

Committee Interest Areas

- Areas of highest interest (14 responses)
  - SoS Test and Evaluation (8 of 12)
  - Relationship between SoS and acquisition process (7 of 12)
  - Lessons Learned from past and on-going SoS programs (6 of 12)
  - Defining and measuring SoS performance (5 of 12)
    [related questions were posed under SoS Test and Evaluation]
  - SoS modeling and simulation (5 of 12)
    [Already a topic of NDIA M&S Committee]
  - SoS architecture (4 of 12)
- Wide range of interests and lots of energy around topics
  - Very hard to address some topics in the space of a meeting
- Seeking opportunities to augment bimonthly meetings
  - NDIA SE Conference – special committee meeting and SoS SE Track
  - Online facility – SoS SE SharePoint

NDIA SE Conference
18 Presentations in the SoS SE Track (1 of 2)

Updates on DoD SoS Activities

Smith	Establishing a Departmental-Level Systems-of-Systems Engineering Management Construct for the Department of the Navy, Progress Report
Reed	Naval Systems of Systems Engineering Guidebook Update
Dahmann	DoD Systems of Systems Update

Characterizing SoS

Turner	A Distillation of Lessons Learned from Complex System of Systems Acquisitions
McGovern	Global Earth Observation System of Systems (GEOSS)
Colombi	System of Systems Challenges and Solutions: Case Study Insights

Modeling and Simulation and M&S

DeLauerntis	Dynamic Modeling of Programmatic and Systematic Interdependence for System of Systems Acquisition
Zentner	On Modeling and Simulation Methods for Capturing Emergent Behaviors for Systems of Systems
Lane	Modeling and Simulation Support for the Systems Engineering of Systems of Systems (short title “M&S Support for SoS SE”)

NDIA SE Conference
18 Presentations in the SoS SE Track (1 of 2)

Engineering SoS

Simanta	Requirements Engineering for Systems of Systems
Maddry	Engineering Systems of Systems: An Integration Perspective
Sledge	Software Assurance in a System of Systems World: Interoperability Challenges - Reports from the Field
Mayoral	Extending FMECA to Systems of Systems
Anderson	Applying Readiness and Fit Analysis to Systems of Systems Environments

Extending Our Understanding of Sos

Boxer	Designing Collaborative Systems of Systems in support of Multi-sided Markets
Smith	An Introduction to Influence Maps: Foundations, Construction, and Use
Roney	Systems Engineering: Asynchronous System Integration Theory

Tools

Smith	An Introduction to Influence Maps: Foundations, Construction, and Use

NDIA SE Conference
T&E and Net-Centric Tracks

T&E Track

Potential focus topic for 2010 with T&E Committee

McDermott	Test and Evaluation in a System of Systems Environment
Rajczak	Joint Integration and Interoperability Lab (JSIIL)
Rebovich	Systems of Systems Systems Engineering and Test and Evaluation

Net-Centric Track

Way	Net-Centric Best Practices
Christman	Data sharing in a Stability Operations Community of Interest: Utilizing a pilot program to prove concepts and develop trust.
Miller	C4I Architecture for Joint ASW
Brown	Human Interoperability Enterprise and Net-Centric Operations
Butterfield	The Boeing System of Systems Engineering (SoSE) Process and Its Use in Developing Legacy-Based Net-Centric Systems of Systems
Jacques	Linking Interoperability and Measures of Effectiveness: A Method for Evaluating Architectures
Naga	Extending Net-Centric Quality of Service to Systems of Systems
Willhite	Network Enabled Weapons, A System Engineering Approach to Achieve Interoperabilty
Simanta	Testing in Service-oriented Environments

NDIA SoS SE SharePoint Site

Home | Documents and Lists | Create | Site Settings | Help

NDIA SoS SE

Home

Modify Shared Page

Documents
- Shared Documents

Pictures

Lists
- Resources

Discussions
- General Discussion

Surveys

Quick Launch

To support NDIA SoS Committee

Welcome to the NDIA SoS SE Committee Share Point Site

The notion of "systems of systems" (SoS) is becoming a critical perspective in thinking about systems.

The systems engineering (SE) community, including members of industry, academia, government and commercial organizations, is paying increasing attention to issues of SoS, complex systems, and enterprise systems. Community members have diverse perspectives on the nature of these types of systems and their implications for SE, and there is considerable research under way in this area.

As a consequence, the time is right to begin the process of capturing SoS SE experiences and research to inform and shape guidance for the SE community.

The purpose of this Share Point site is to support the community in meeting the challenges and achieving this goal.

Announcements

12th Annual NDIA SE Conference 9/24/2009 12:56 PM
by George Rebovich, Jr.

Conference Date
10/26/2009 to 10/29/2009
Location
Hyatt Regency Mission Bay
Contact
Ms. Suzanne Havelis at shavelis@ndia.org or (703)247-2570

Introduction
This year's theme is, "Achieving Acquisition Excellence via Effective Systems Engineering."

Links
- 12th Annual NDIA SE Conference

Add new link

Members
- George Rebovich, Jr.
- Jo Ann Lane
- John Palmer
- Judith S. Dahmann
- Karen L. Carten
- Kimberly J. Diorio
- Lysa A. Olimpo
- Ralph Lowry
- William Asrat

Add new member

NDIA SoS Community Share
Instructions for Requesting an Account

This is a 2-step process.

- Step 1: Request a new account.
  - Go to https://partners.mitre.org/accountsetup/new/default.html
  - Once there, you'll be required to enter information. After you've submitted the following information, your account will need to be verified by email using the security question and answer you will be asked to provide during the request process.
    - Enter your email address.
    - Create a password.
    - Enter a security question and answer (such as your mother's maiden name).
    - Fill in the name of our extranet community: NDIA SoS
    - Provide George Rebovich's email address for the Community owner: grebovic@mitre.org
- Step 2: Validate your email address with your security answer.
  - You will receive an email with a link to verify your email address. You will be asked to provide the answer to your security question. Once you have successfully done this, the registration process is complete. You will be notified by email when your account has been successfully created. (This can take up to three business days to complete).

Next Steps (1 of 2)

- Potential topics for the SoS SE Committee next year
  - Modeling and Simulation for SoS
    - Partner with M&S Committee
    - Followup to survey completed this past year
  - SoS and T&E
    - Partner with T&E Committee
    - Build on white paper discussions at June and August Meetings
    - Leverage NDIA SE Conference SoS and T&E Presentations
  - Modeling and Simulation in support of SoS and T&E
  - Role of SoS in acquisition
  - Sharing of ongoing experience with SoS SE
    - Example from discussion at August meeting was NSSO SoS activity

Next Steps (2 of 2)

- SoS as it is addressed by other committees
  - SoS can be viewed as a cross-cutting topic across most of the other committees (such as has been the case with M&S and T&S)
  - Contacting the other committee chairs to solicit their views on
    - How SoS affects their areas
    - What topics they see from their perspective driven by SoS considerations
- Launch online discussion groups to supplement meeting based exchanges?
- We welcome
  - New participants in the committee
  - Other topics to be considered for committee attention
  - Opportunities for partnerships with other committees