8th Annual Systems Engineering Conference
"Focusing on Mission Areas, Net-Centric Operations and Supportability of Defense Systems"

San Diego, CA

24-27 October 2005

Agenda

Tuesday, 25 October 2005

Open Remarks: by Mr. Bob Rassa, Director, Systems Supportability, Raytheon; Chair, Systems Engineering Division, NDIA
Keynote Address: by Mr. John Landon, Deputy Assistant Secretary of Defense (NII), C3ISR & IT Acquisition

Plenary Session - Revitalization of Systems Engineering Within DoD:

- State of Systems Engineering within DoDs, Mr. Mark D. Schaeffer, Deputy Director, Systems Engineering, OUSD (AT&L)
- USAF Systems Engineering Initiatives, Mr. Terry Jaggers, SAF/AQR (Science & Technology & Engineering)
- System Engineering Re-vitalization within DoN Status, Mr. Carl Siel, ASN(RDA) Chief Engineer
- Army SE Overview, Mr. Douglas K. Wiltsie, Assistant Deputy, Acquisition and Systems Management, Office of the Assistant Secretary of the Army, Acquisition Logistics and Technology
- "Implementation of ESE/A", Mr. Kelly A. Miller, NSA/CSS CSE

Luncheon Keynote Speaker: by Mr. Gregory Shelton, Corporate Vice President, Engineering, Technology, Manufacturing and Quality, Raytheon Company

Tracks 1 & 2 - Systems Engineering Effectiveness:

- Technical Planning for Acquisition Programs: An OSD Perspective, Col Warren Anderson, OUSD (AT&L) Defense Systems
- Implementation of Policy Requiring Systems Engineering Plans for Air Force Programs – Results and Implications, Mr. Kevin Kemper, Air Force Materiel Command
- Systems Engineering Revitalization at SPAWAR Systems Center Charleston, Mr. Michael T. Kutch, Jr., SPAWAR Systems Center
- Systems Engineering for Software Assurance, Ms. Kristen Baldwin, OUSD (AT&L) Defense Systems
- Revitalization of Systems Engineering: Past, Present and Future, Ms. Karen B. Bausman, Air Force Center for Systems Engineering
- Enabling Technology Readiness Assessments (TRAs) with Systems Engineering, Dr. Jay Mandelbaum, Institute for Defense Analyses
- A Taxonomy of Operational Risks, Mr. Brian Gallagher, Software Engineering Institute
- A Method for Reasoning About an Acquisition Strategy, Mr. Joseph Elm, Software Engineerin Institute
- WBS-Based Approach to Understanding and Predicting Program Risk, Bruce M. Heim, DCMA, Boeing Long Beach
- Program Support: Perspectives on Technical Planning and Execution, Mr. Dave Castellano, OUSD (AT&L) Systems Engineering

Track 3 - Test & Evaluation in Systems Engineering:

- Interweaving Test and Evaluation Throughout the Systems Engineering Process - Presentation and Paper, Mr. Josh Tribble, AVW Technologies

Track 4 - Net Centric Operations:

- Net-Centricity & Net-Ready - Beyond Technical Interoperability & C4ISR, Mr. Jack Zavin, ASD(NII), DoD CIO/A&I Directorate
- A Strategy for Managing Development and Certification of Net-Centric Services within the Global Information Grid, Mr. Bernal Allen, DISA, GE 4
- Next Generation Enterprise Information Management Appliances, Mr. Michael Lindow, The MITRE Corp.

Track 5 - Logistics:

- Logistics Transforming: Achieving Knowledge-Enabled Logistics, Mr. Jerry Beck, OSD Office of ADUSD(LPP)
- Condition Based Logistics, Mr. Ron Wagner, CoBaLt Technology
- System Supportability and Life Cycle Product Support: A Systems Perspective, Dinesh Verma, Stevens Institute of Technolog
- The Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance, Mr. Eugene A. Beardslee, SAIC

Track 7 - Systems Safety:

- System Safety in Systems Engineering DAU Continuous Learning Module, Ms. Amanda Zarecky, Booz Allen Hamilton
- Enabling System Safety Through Technical Excellence, Col Warren Anderson, OUSD (AT&L) Defense Systems
- Applying CMMI to System Safety, Mr. Tom Pfitzer, APT Research, Inc.
- System Safety Engineering: An Overview for Engineers and Managers, Mr. Pat L. Clemens, APT Research, Inc.
- Using MIL-STD-882D to Integrate ESOH into SE, Mr. Sherman G. Forbes, USAF - SAF/AQRE

Track 8 **-** Software Supportability:

- The Proper Specification of Requirements, Mr. Al Florence, The MITRE Corporation
- C-17 Software Development Process, John R. Allen, The Boeing Company 4
- Successful Verification and Validation Based on the CMMI Model, Mr. Tim Olson, Quality Improvement Consultants, Inc.
- "Automated Software Testing Increases Test Quality and Coverage Resulting in Improved Software Reliability.", Mr. Frank Salvatore, High Performance Technologies, Inc.
- Software Supportability: A Software Engineering Perspective, Ms. Stephany Bellomo, SAIC

Wednesday, 26 October 2005

Tracks 1, 2 & 3 **-** Systems Engineering Effectiveness:

- Decision Analysis and Resolution, Mr Robert Trifiletti, Jr., US Army ARDEC
- Defining System Development Lifecycles to Plan and Manage Projects Effectively, Mr. Bruce A. Boyd, The Boeing Company
- Systems Engineering, Program Management conjoined Disciplines over the Project Life Cycle, Mr. William Lyders, ASSETT, Inc.
- Tailoring USAF Systems Engineering for the Life Cycle: One Shape, Multiple Dimensions, Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)
- Architecture-Based Systems Engineering and Integration, Dr. Rick Habayeb, Virginia Polytechnic Institute & State University
- A Complementary Approach to Enterprise Systems Engineering, Dr. Brian White, The MITRE Corporation
- Implementing Systems Engineering Processes to Balance Cost and Technical Performance, Dr. Mary Anne Herndon, Transdyne Corporation
- Program Support: Perspectives on Technical Planning and Execution, Mr. Dave Castellano, OUSD (AT&L) Systems Engineering
- Application of Risk Management in a Net-Centric Environment, Ms. Rebecca M. Cowen-Hirsch, DISA
- "Requirements Management Tips and Tricks", Mr. Frank Salvatore, High Performance Technologies, Inc.
- Engineering and Implementing Raytheon Missile Systems Engineering Design to Cost Metric - Presentation and Paper, Mr. Edward Casey, Raytheon Missile Systems
- System Engineering Metrics, Mr. James Miller, Air Foce Materiel Command
- Technical Performance Measures, Mr. Jim Oakes, BAE Systems
- TurboTax® for Systems EngineerinTurboTax® for Systems Engineering, Michael T. Kutch, Jr., SPAWAR
- A Practical Application of A Practical Application of the Non-Advocate Review, Mr. Bruce Nishime, The Boeing Company
- Systems Engineering and the Software Laws of Thermodynamics, Dr. Thomas F. Christian Jr., 402 SMXG
- Unmanned Aerial Vehicle Survivability Influence on System Life Cycle Cost, Mr. Chuck Pedriani, SURVICE Engineering
- Effective SE Metrics Tailored to the Acquisition Life Cycle, Ms. Laura Trioilia, US Army ARDEC
- Innovative Procurement Strategies, Mr. David Eiband, Defense Acquisition University
- Next Generation Combat Systems - An Overview of Key Development Concepts, Mr. Matthew Montoya, The JHU Applied Physics Laboratory Mr. Edward Casey, Raytheon Missile Systems
- Converting High-Level Systems Engineering Policy to a Workable Program, Mr. James Miller, Air Force Materiel Command
- AFRL Systems Engineering Initiative - Risk Managment for Science and Technology, Mr. William Nolte, USAF-AFRL
- System Engineered Research and Development Magement, Dr. Steven Ligon, SAIC
- The Return of Discipline, Ms. Jacqueline Townsend, Air Force Materiel Command

Track 4 **-** Net Centric Operations:

- Testing Net-Centric Systems of Systems: Applying Lessons Learned from Distributed Simulation, Mr. Doug Flournoy, The MITRE Corp.
- A Multi-Mission Network Centric Warfare Platform, Peder Jungck, CloudSheild Technologies
- Challenges Challenges in Development of System of Systems (SoS) Architectures in a Net Centric Environment, Dr. Abraham Meilich, Lockheed Martin
- Matrix Mapping Tool (MMT), Dr. Judith Dahmann, AT&L/DS MITRE

Track 5 **-** Logistics:

- Defense Logistics as Chaos Theory, Mr. John Sells, Tobyhanna Army Depot
- Process for Evaluating LogisticProcess for Evaluating Logistics Readiness Levels (LRLs) for Acquisition Systems, Ms. Elizabeth Broadus, Booz Allen Hamilton, Inc.
- The Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance, Mr. Eugene A. Beardslee, SAIC
- System of Systems Analysis of Future Combat Systems Sustainment Requirements, Mr. Ivan W. Wolnek, The Boeing Company
- Readiness & Supportability Program Readiness & Supportability Programs, Mr. Robert M. Cranwell, Sandia National Laboratories (SNL)
- Data Management in a Performance Based Logistics Environment, Denise Duncan, LMI

Track 5 **-** Best Practices & Standardization:

- CMMI for Services, Mr. Juan Ceva, Raytheon Company
- Out of the Ordinary: Finding Hidden Threats by Analyzing Unusual Behavior, Mr. John Hollywood, RAND

Track 6 **-** Modeling & Simulation:

- Improving M&S Support to Acquisition: A Progress Report on Development of the Acquisition M&S Master Plan, Mr. Jim Hollenbach, Simulation Strategies, Inc.

- Next Generation Manufacturing Technology Initiative and the Model - Based Enterprise, Mr. Richard Neal - IMTI
- Problem Space Modeling: A Dynamic Future for Requirements Analysis, Mr. Jeffrey O. Grady, JOG System Engineering, Inc.
- Systems Modeling Language Systems Modeling Language (SysML) Overview & Update, Rick Steiner, Raytheon Company
- Data Management Support for Modeling and Simulation, Mr. Denise Duncan, LMI
- Digital Data Management an Update, Ms. Cynthia C. Hauer, Millennium Data Management, Inc.
- The Use of Simulation in the Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance, Mr. Eugene A. Beardslee, SAIC

Track 7 - System Safety:

- Mission Sustainment Through Environment, Safety, and Occupational Health (ESOH) Risk Management, Ms. Trish Huheey, ODUSD (I&E)
- Lessons Learned with the Application of MIL-STD-882D at the Weapon System Explosives Safety Review Board, Ms. Mary Ellen Caro, Ordnance Safety & Security Activity
- Industry Perspectives and Identified Barriers to the Use of MIL-STD-882D for Integrating ESOH Considerations into Systems, Mr. Jon Derickson, BAE Systems
- System Safety in Systems Engineering Process, Dr. Ray C. Terry, SURVICE Engineering Company
- Enabling Army Level Risk Mitigation, Mr. Bill Edmonds, US Army Combat Readiness Center
- Evolution of MIL-STD-882E, Mr. Robert McAllister, US Air Force Materiel Command
- Integrating MIL-STD-882 System Safety Products into the Concurrent Engineering Approach to System Design, Build, Test, and Delivery of Submarine Systems At Electric Boat, Mr. Ricky Milnarik, General Dynamics

Track 8 - Legacy Systems Sustainment:

- Sustaining Software-Intensive Systems - A Conundrum, Ms. Mary Ann Lapham, Carnegie Mellon Software Engineering Institute
- Algorithm Description Documentation and Validation Process, Mr. Mike Bailey, Raytheon Company
- ATSRAC: Background, Results and Future Impact on the Aviation Industry, Mr. Kent V. Hollinger, The MITRE Corp.
- Jammer Integration Roadmap, Mr. Adam McCorkle, GTRI
- Open Systems Architecture (OSA) and Standard Interfaces as Mission Capability Enablers, William H. Mish, Jr., AMSEC
- Naval Air Systems Command Integrated In-Service Reliability Program (IISRP), Mr. Les Wetherington, Integrated In-Service Reliability Program (IISRP)

8th Annual Systems Engineering Conference

"Focusing on Mission Areas, Net-Centric Operations and Supportability of Defense Systems"

Event # 6870

October 24-27, 2005

San Diego, CA

Onsite Program

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

IEEE

INCOSE
INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

Sponsored by the National Defense Industrial Association, with Technical Co-Sponsorship by IEEE AES, IEEE Systems Council and INCOSE

Supported by Office of Under Secretary of Defense, Acquisition Technology & Logistics, Defense Systems, Director, Systems Engineering

Sunday, October 23, 2005

5:00 PM-7:00 PM	Registration for Tutorials and General Conference (Tutorials are an additional $200 registration fee)

Monday, October 24, 2005

7:00 AM - 5 PM	Registration
7 AM	Continental Breakfast for Tutorial Attendees ONLY (Tutorials are an additional $200 registration fee)
8:00 AM - 5 PM	Tutorial Tracks (Please refer to following pages for Tutorials Schedule)
12 Noon - 1 PM	Buffett Lunch
1:00 PM - 5 PM	Tutorial Tracks (Please refer to following pages for Tutorials Schedule)
5:00 PM - 6 PM	Reception in Display Area (Open to All Participants)

Tuesday, October 25, 2005

7:00 AM	Registration & Continental Breakfast
8:15 AM	Introductions *Mr. Sam Campagna,* Director, Operations, NDIA
8:30 AM	Opening Remarks *Mr. Bob Rassa,* Director, Systems Supportability, Raytheon; Chair, Systems Engineering Division, NDIA
8:40 AM - 9:30 AM	Keynote Address *Mr. John Landon,* Deputy Assistant Secretary of Defense (NII) (C3ISR & IT Acquisition)
9:30 AM - 10 AM	Break in Display Area
10:00 AM - 12 Noon	Plenary Session: Revitalization of Systems Engineering Within DoD Moderator: *Mr. Mark Schaeffer,* Deputy Director, Defense Systems, and Director, Systems Engineering, OUSD (AT&L) Panelists: *Mr. Terry Jaggers,* Director, SAF/AQR (Science, Technology & Engineering) *Mr. Carl Siel,* ASN (RDA)CHENG *Mr. Doug Wiltsie,* US Army (Invited) *Mr. Kelly Miller,* NSA (Invited)
12 Noon - 1:30 PM	Luncheon Speaker *Mr. Greg Shelton,* Vice President, Engineering Manufacturing Technology & Quality, Raytheon
1:30 PM - 5 PM	Concurrent Sessions (Please refer to following pages for session schedule)
5:00 PM - 6:30 PM	Reception in Display Area

Monday, October 24, 2005

7:15 AM — Registration & Continental Breakfast

	8:00 AM	9:45 AM	10:15 AM	12 Noon	1:00 PM	2:45 PM	3:15 PM	5 PM-6 PM
Regency A	TRACK 1 Tutorial — How to Define System Engineering Processes That are Short and Usable — Session 1A1 — **Mr. Tim Olson, Quality Improvement Consultants, Inc.**	Break	TRACK 1 Tutorial — How to Define System Engineering Processes That are Short and Usable (Continued) — Session 1B1 — **Mr. Tim Olson, Quality Improvement Consultants, Inc.**	Buffet Lunch	TRACK 1 Tutorial — Systems Engineering Planning - A Tutorial — Session 1C1 — **Col Warren Anderson, OUSD (AT&L) Defense Systems**	Break	TRACK 1 Tutorial — Systems Engineering Planning - A Tutorial (Continued) — Session 1D1 — **Col Warren Anderson, OUSD (AT&L) Defense Systems**	Reception in Display Area
Regency B	TRACK 2 Tutorial — Integrating Systems Engineering with Earned Value Management — Session 1A2 — **Mr. Paul Solomon, Northrop Grumman Corp.**		TRACK 2 Tutorial — Integrating Systems Engineering with Earned Value Management (Continued) — Session 1B2 — **Mr. Paul Solomon, Northrop Grumman Corp.**		TRACK 2 Tutorial — Using a Measurement Framework to Successfully Achieve Measur- able Results — Session 1C2 — **Mr. Tim Olson, Quality Improvement Consultants**		TRACK 2 Tutorial — Using a Measurement Framework to Successfully Achieve Measurable Results (Continued) — Session 1D2 — **Mr. Tim Olson, Quality Improvement Consultants**	
Regency C	TRACK 3 Tutorial — Up-To-Date Systems Requirements Tutorial — Session 1A3 — **Mr. Jeffrey Grady , JOG Systems Engineering, Inc.**		TRACK 3 Tutorial — Up-To-Date Systems Requirements Tutorial (Continued) — Session 1B3 — **Mr. Jeffrey Grady, JOG Systems Engineering, Inc.**		TRACK 3 Tutorial — Requirements Development and Management — Session 1C3 — **Mr. Al Florence, The MITRE Corp.**		TRACK 3 Tutorial — Requirements Development and Management (Continued) — Session 1D3 — **Mr. Al Florence, The MITRE Corp.**	
Mission A	TRACK 4 Tutorial — Exploring the System Solution Space using Behavior Analysis and Simulation: Applying M&S to System Engineering — Session 1A4 — **Mr. James Long, Vitech Corp.**		TRACK 4 Tutorial — Exploring the System Solution Space using Behavior Analysis and Simulation: Applying M&S to System Engineering (Continued) — Session 1B4 — **Mr. James Long, Vitech Corp.**		TRACK 4 Tutorial — Air Force Integrated Collabora- tive Environment (AF-ICE) - An Air Force and Industry Partner overview and update — Session 1C4 — **Mr. Rick Peters, Air Force Material Command**		TRACK 4 Tutorial — Air Force Integrated Collabora- tive Environment (AF-ICE) - An Air Force and Industry Partner overview and update (Continued) — Session 1D4 — **Mr. Rick Peters, Air Force Material Command**	
Mission B	TRACK 5 Tutorial — Systems/Software/Hardware Quality Assurance — Session 1A5 — **Mr. Al Florence, The MITRE Corp.**		TRACK 5 Tutorial — Systems/Software/Hardware Qual- ity Assurance (Continued) — Session 1B5 — **Mr. Al Florence , The MITRE Corp.**		TRACK 5 Tutorial — The Return on Investment from Software Engineering Best Practices: An Introduction — Session 1C5 — **Mr. Thomas McGibbon, ITT Industries**		TRACK 5 Tutorial — The Return on Investment from Software Engineering Best Prac- tices: An Introduction — Session 1D5 — **Mr. Thomas McGibbon, ITT Industries**	
Mission C	TRACK 6 Tutorial — Innovative Design for Six Sigma (DFSS) Approaches to Test and Evaluation: A Hands-On Experience — Session 1A6 — **Dr. Mark Kiemele, Air Academy Associates**	Break	TRACK 6 Tutorial — Innovative Design for Six Sigma (DFSS) Approaches to Test and Evaluation: A Hands-On Experi- ence (Continued) — Session 1B6 — **Dr. Mark Kiemele , Air Academy Associates**		TRACK 6 Tutorial — What Makes A Simulation Credible? Cost-Effective VV&A in the Systems Engineering Process — Session 1C6 — **Mr. David Hall, SURVICE Engineering Company**	Break	TRACK 6 Tutorial — What Makes A Simulation Cred- ible? Cost-Effective VV&A in the Systems Engineering Process (Continued) — Session 1D6 — **Mr. David Hall, SURVICE Engineering Company**	
Garden A	TRACK 7 Tutorial — Object Oriented Systems Engineering Methodology (OOSEM) — Session 1A7 — **Dr. Abraham Meilich, Lockheed Martin**		TRACK 7 Tutorial — Object Oriented Systems Engineering Methodology (OOSEM)(Continued) — Session 1B7 — **Dr. Abraham Meilich, Lockheed Martin**		TRACK 7 Tutorial — Object Oriented Systems Engineering Methodology (OOSEM)(Continued) — Session 1C7 — **Dr. Abraham Meilich, Lockheed Martin**		TRACK 7 Tutorial — Object Oriented Systems Engineering Methodology (OOSEM)(Continued) — Session 1D7 — **Dr. Abraham Meilich, Lockheed Martin**	
Garden F	TRACK 8 Tutorial — TBA — Session 1A8		TRACK 8 Tutorial — TBA — Session 1B8		TRACK 8 Tutorial — Performability (Performance and Reliability) Modeling — Session 1C8 — **Dr. Meng-Lai Yin, Raytheon**		TRACK 8 Tutorial — Performability (Performance and Reliability) Modeling — Session 1D8 — **Dr. Meng-Lai Yin, Raytheon**	

Tuesday, October 25, 2005

	1:30 PM		3:00 PM	3:30 PM		
Regency A	TRACK 1 Systems Engineering Effectiveness Session 2C1	The Return of Discipline **Dr. Yvette Weber, HQ AFMC, USAF**	Technical Planning for Acquisition Programs: An OSD Perspective **Col Warren Anderson, OUSD (AT&L) Defense Systems**	TRACK 1 Systems Engineering Effectiveness Session 2D1	Implementation of Policy Requiring Systems Engineering Plans for Air Force Programs – Results and Implications **Mr. Kevin Kemper, US Air Force**	Systems Engineering Revitalization at SPAWAR Systems Center Charleston **Mr. Michael Kutch, Jr., SPAWAR Systems Center**	Engineering for Software Assurance **Ms. Kristen Baldwin, OUSD(AT&L)**
Regency B	TRACK 2 Systems Engineering Effectiveness Session 2C2	Technology Readiness Assessments: A Key Aspect of the Systems Engineering Process **Dr. Jay Mandelbaum, Institute for Defense Analyses**	Taxonomy of Operational Risks **Mr. Brian Gallagher, Software Engineering Institute**	TRACK 2 Systems Engineering Effectiveness Session 2D2	A Method for Reasoning About an Acquisition Strategy **Mr. Joseph Elm, Software Engineering Institute**	WBS Based Risk Assessment **Mr. Bruce Heim, (DCMA) Boeing Long Beach**	
Regency C	TRACK 3 Test & Evaluation in Systems Engineering Session 2C3	Applying the Systems Engineering Approach to the Test and Evaluation Process **Mr. Raymond Beach, NAVAIR**	Intelligent Data Analysis Options to Support Aircraft/Ship Systems Testing **Mr. Dean Carico, Naval Air Warfare Center**	TRACK 3 Test & Evaluation in Systems Engineering Session 2D3	Interweaving Test and Evaluation throughout the Systems Engineering Process **Mr. Joseph Tribble, AVW Technologies**	Recent Innovations in Design for Six Sigma (DFSS) Testing Approaches to Speed Technology to the Marketplace **Dr. Mark Kiemele, Air Academy Associates**	Flight Testing Airborne Radar Systems to Improve System Performance **Mr. Mark London, NAVAIR**
Mission A	TRACK 4 Net Centric Operations Session 2C4	Guiding DoD's move into the Information Age **Mr. Jack Zavin, ASD(NII)/DoD CIO**	Challenges in Development of System of Systems (SoS) Architectures in a Net Centric Environment **Dr. Abraham Meilich, Lockheed Martin**	TRACK 4 Net Centric Operations Session 2D4	Real-Time Tactical Services for the GIG **Mr. John Noble, JHU Applied Physics Laboratory**	Next Generation Enterprise Information Management Appliances **Mr. Michael Lindow, The MITRE Corp.**	
Mission B	TRACK 5 Logistics Session 2C5	Intro to Logistics & Supportability **Mr. Jerry Beck, OSD Office of ADUSD(L&MR)**	Condition Based Logistics **Mr. Ron Wagner, CoBaLt Technology**	TRACK 5 Logistics Session 2D5	FRACAS Implementation using ITLog **Mr. William Jacobs, Raytheon**	Creating a Logistics Health Management System **Mr. Gary O'Neill, Georgia Tech Research Inst.**	
Mission C	TRACK 6 Integrated Diagnostics Session 2C6	Intro to Integrated Diagnostics **Mr. Dennis Hecht, The Boeing Company**	Diagnostic Software - What your average developer doesn't know **Mr. Theodore Marz, Carnegie Mellon University - Software Engineering**	TRACK 6 Integrated Diagnostics Session 2D6	Designing for Health; A Methodology for Integrated Diagnostics/Prognostics **Mr. Larry Butler, Raytheon**	COTS-Based Solution for Integrated Test and Diagnostics **Dr. Ion Neag, TYX Corp.**	
Garden A	TRACK 7 Systems Safety Session 2C7	System Safety in Systems Engineering DAU Continuous Learning Module Overview **Ms. Amanda Zarecky, Booz Allen Hamilton**	System Safety in the Systems Engineering Process **Dr. Ray Terry, SURVICE Engineering Company**	TRACK 7 System Safety Session 2D7	Revitalizing System Safety as One of the Key Elements to Revitalizing Systems Engineering in Department of Defense Acquisition Programs **Col Warren Anderson, OUSD (AT&L) Defense Systems**	Linking System Safety to Systems Engineering **Ms. Paige Ripani, Booz Allen Hamilton**	Integrating MIL-STD-882 **Mr. Rick Milnarik,**
Garden F	TRACK 8 Software Supportability Session 2C8	Proper Specification of Software Requirements **Mr. Al Florence, The MITRE Corporation**	C-17 Software Development Process **Mr. Hafez Lorseyedi, The Boeing Company**	TRACK 8 Software Supportability Session 2D8	Successful Verification and Validation Based on the CMMI Model **Mr. Tim Olson, Quality Improvement Consultants, Inc.**	Automated Software Testing Increases Test Quality and Coverage Resulting in Improved Software Reliability **Mr. Frank Salvatore, High Performance Technologies, Inc.**	Software Supportability: A Software Engineering Perspective **Mrs. Stephany Bellomo, SAIC**

Break in Display Area

5 :30 - 7:00 PM — Reception in Display Area

Wednesday, October 26, 2005

7:15 AM — Registration & Continental Breakfast

	8:15 AM		10:15 AM	
Regency A	TRACK 1 Systems Engineering Effectiveness Session 3A1	Tailorable Decision Analysis and Resolution process and tools for enterprise wide application ***Mr. Robert Trifiletti, Jr., US Army ARDEC***	Defining System Development Lifecycles to Plan and Manage Projects Effectively ***Mr. Bruce Boyd, The Boeing Company***	TRACK 1 Systems Engineering Effectiveness Session 3B1	System Engineering, Program Management conjoined Disciplines over the Project Life Cycle ***Mr. William Lyders, ASETT, Inc.***	Tailoring USAF Systems Engineering for the Life Cycle: One Shape, Multiple Dimensions ***Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)***
Regency B	TRACK 2 Systems Engineering Effectiveness Session 3A2	Application of Risk Management across Engineering and Acquisition ***Ms. Rebecca Cowen-Hirsch, Defense Systems Agency***	Requirements Engineering Tips and Tricks ***Mr. Frank Salvatore, High Performance Technologies, Inc.***	TRACK 2 Systems Engineering Effectiveness Session 3B2	Engineering and Implementing RMS Engineering DTC Metrics ***Mr. Edward Casey, Raytheon Missile Systems***	System Engineering Metrics ***Mr. James Miller, United States Air Force***
Regency C	TRACK 3 Systems Engineering Effectiveness Session 3A3	Effective SE Metrics Tailored to the Acquisition Life Cycle ***Ms. Laura Troiola, US Army - ARDEC***	Innovative Procurement Strategies ***Mr. David Eiband, Defense Acquisition University***	TRACK 3 Systems Engineering Effectiveness Session 3B3	Using Systems Engineering Principles to Transform R & D Into a Military System Solution ***Dr. James Dill, Foster-Miller***	Next Generation Combat Systems - An Overview of Key Development Concepts ***Mr. Matthew Montoya, The JHU Applied Physics Laboratory***
Mission A	TRACK 4 Net Centric Operations Session 3A4	Joint Battle Management Command & Control RoadMap - Panel ***Moderators: Dr. Vitalij Garber, Ms. Robin Quinlan, DUSD (AT&L) DS/SI*** ***Panelists: Maj Gen Charles Simpson, USAF; MG Michael Vane, USA***	Joint Battle Management Command & Control RoadMap - Panel ***Moderators: Dr. Vitalij Garber, Ms. Robin Quinlan, DUSD (AT&L) DS/SI*** ***Panelists: Maj Gen Charles Simpson, USAF; MG Michael Vane, USA***	TRACK 4 Net Centric Operations Session 3B4	Network-Centric Capabilities Development for Ground Mobile Forces ***Ms. Diane Hanf, The MITRE Corp.***	Testing Net-Centric Systems of Systems: Applying Lessons Learned from Distributed Simulation ***Mr. R. Douglas Flournoy,***
Mission B	TRACK 5 Logistics Session 3A5	Improving Supportability on Currently Deployed Weapon Systems ***Mr. John Sells, Tobyhanna Army Depot***	Process for Evaluating Logistics Readiness Levels (LRLs) for Acquisition Systems ***Mr. Robert Ernst, NAVAIR***	TRACK 5 Logistics Session 3B5	The Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance ***Mr. Eugene Beardslee, SAIC***	System of Systems Analysis of Future Combat System Sustainment Requirements ***Mr. Ivan Wolnek, The Boeing Company***
Mission C	TRACK 6 Modeling & Simulation Session 3A6	Improving M&S Support to Acquisition ***Mr. James Hollenbach, Simulation Strategies, Inc.***	Improving M&S Support to Acquisition (Continued) ***Mr. James Hollenbach, Simulation Strategies, Inc.***	TRACK 6 Modeling & Simulation Session 3B6	Next Generation Manufacturing Technology Initiative and the Model-Based Enterprise ***Mr. Richard Neal, IMTI***	Problem Space Modeling ***Mr. Jeffrey O. Grady, JOG Systems Engineering, Inc.***
Garden A	TRACK 7 System Safety Session 3A7	A Model Linking Safety, Threat and Other Critical Causal Factors to Their Mitigators" Relative to (Software, Hardware, and Human System Integration ***Ms. Janet Gill, NAVAIR***	Mission Sustainment Through Acquisition Environment, Safety, and Occupational Health (ESOH) Risk Management ***Ms. Karen Gill, Booz Allen Hamilton***	TRACK 7 System Safety Session 3B7	Army Acquisition Programs' Installations, Environmental, Safety, and Occupational Health Considerations ***Mr. Donald Artis, Jr., Office of the DASA(ESOH)***	Current DoD Acquisition Policies and Guidance on the use of MIL-STD-882D to Integrate Environment, Safety, and Occupational Health (ESOH) Considerations into the Systems Engineering Process ***Mr. Sherman Forbes, USAF - SAF/AQRE***
Garden F	TRACK 8 Software Supportability Session 3A8	Sustaining Software-Intensive Systems – A Conundrum ***Ms. Mary Ann Lapham, SEI***	Algorithm Description Documentation and Validation Process ***Mr. Michael K. Bailey, Raytheon***	TRACK 8 Legacy Systems Sustainment Session 3B8	The Integration of Systems Engineering and Enterprise Architecture with respect to the Modernization of Legacy Systems - Panel ***Mr. Owen Williams, Science Applications International Corp.***	The Integration of Systems Engineering and Enterprise Architecture with respect to the Modernization of Legacy Systems - Panel (Continued) ***Mr. Owen Williams, Science Applications International Corp.***

9:45 AM — Break in Display Area

12 Noon — Lunch Speaker: Dr. Dale Uhler, Acquisition Executive, US SOCOM

Wednesday, October 26, 2005

	1:30 PM		3:00 PM	3:30 PM		
Regency A	TRACK 1 Systems Engineering Effectiveness Session 3C1	Architecture Based Systems Engineering And Integration **Dr. Rick Habayeb, Virginia Tech**		TRACK 1 Systems Engineering Effectiveness Session 3D1	Implementing SE Processes to Balance Cost and Technical Performance **Dr. Mary Anne Herndon, SAIC**	A Revolutionary Model to Support Early CAIV Trades and Cost Predictions **Mr. Bryan Piggott, InfoEdge**
Regency B	TRACK 2 Systems Engineering Effectiveness Session 3C2	Technical Performance Measures **Mr. Jim Oakes, BAE Systems**	Turbo Tax for Systems Engineering **Mr. Michael Kutch, Jr., SPAWAR**	TRACK 2 Systems Engineering Effectiveness Session 3D2	A Practical Application of the Non-Advocate Review **Mr. Bruce Nishime, The Boeing Company**	Systems Engineering and the Software Laws of Thermodynamics **Dr. Thomas Christian, Jr., 402 SMXG**	Unmanned Aerial Vehicle Survivability Influence on System Life Cycle Cost **Mr. Charles Pedriani, SURVICE Engineering**
Regency C	TRACK 3 Systems Engineering Effectiveness Session 3C3	Converting High-Level Systems Engineering Policy to a Workable Program **Mr. James Miller, US Air Force**	Revitalization of Systems Engineering; Past, Present and Future **Ms. Karen Bausman, USAF Center for Systems Engineering**	TRACK 3 Systems Engineering Effectiveness Session 3D3	AFRL Systems Engineering Initiative – Risk Management for Science and Technology **Mr. William Nolte, USAF-AFRL**	System Engineered Research and Development Management **Dr. Steven Ligon, SAIC**	
Mission A	TRACK 4 Net Centric Operations Session 3C4	What is the difference between Multi-Level Security (MLS) and Multiple Secure Levels (MSL) Architectures and why do you care? **Mr. Paul Vazquez, Jr., Raytheon NCS**	A Network Centric Warfare Platform With Multiple Missions in Mind **Mr. Peder Jungck, CloudShield Technologies**	TRACK 4 Net Centric Operations Session 3D4	Systems Engineering Analysis and Control Methods to Assure Electromagnetic Spectrum Access **Mrs. Renae Carter, DISA Defense Spectrum Office**	A Strategy for Managing the Development and Certification of Net-Centric Services within the Global Information Grid **Mr. Bernal Allen, Defense Systems Agency**	
Mission B	TRACK 5 Logistics Session 3C5	Reaping the benefits of PBL/CSL **Ms. Denise Duncan, LMI**	Priming & Tuning the ERP/MRO Engine: Integrated Through-life Supportability Data Management **Mr. Patrick Read, Pennant Canada, Ltd**	TRACK 5 Best Practices & Standardization Session 3D5	On the Shoulders of CMM: CMMI + COTS + OA + nNIH = less (cost) + more (capability) **Mr. Luke Campbell, NAVAIR**	CMMI for Services **Mr. Juan Ceva, Raytheon RIS**	
Mission C	TRACK 6 Modeling & Simulation Session 3C6	Update on SysML **Mr. Rick Steiner, Raytheon**	Data Management to support M&S **Ms. Denise Duncan, LMI**	TRACK 6 Modeling & Simulation Session 3D6	Enterprise Digital Data Management **Ms. Cynthia Hauer, Millennium Data Management, Inc.**	The Use of Simulation in the Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance **Mr. Eugene Beardslee, SAIC**	Ensuring Accomplishment of Performance Based Logistics Objectives Using Model-Based Systems Engineering **Mr. Timothy Tritsch, Vitech Corp.**
Garden A	TRACK 7 System Safety Session 3C7	Lessons Learned with the Application of MIL-STD-882D Within the Navy's Weapon System Explosives Safety Review Board **Ms. Mary Caro, Naval Ordnance Safety & Security Activity**	Industry perspectives and identified barriers to the use of MIL-STD-882D for integrating ESOH considerations into Systems **Mr. Jon Derickson, United Defense**	TRACK 7 System Safety Session 3D7	Comparisons and Contrasts Between ISO 14001, OHSAS 18001, and MIL-STD-882D and their Suitability for the Systems Engineering Process **Mr. Kenneth Dormer, USAF Contractor (SAF/AQRE)**	Evolution of Military Standard 882E **Mr. Jimmy Turner, Raytheon**	USMC Expeditionary Fighting Vehicle (EFV): A Vehicle Designed with Environmental, System Safety, and Occupational Health (ESOH) in Mind **Ms. Sandra Fenwick, USMC DRPM AAA**
Garden F	TRACK 8 Legacy Systems Sustainment Session 3C8	The Aging Transport Systems Rulemaking Advisory Committee: Background, Results and Future Impact on the Aviation Industry **Mr. Kent Hollinger, The MITRE Corp.**	Jammer Integration Roadmap **Mr. Adam McCorkle, Georgia Tech Research Institute**	TRACK 8 Legacy Systems/ Open Systems Session 3D8	NAVAIR Integrated In-Service Reliability Program - Aging Aircraft/Keeping Legacy Systems Viable **Ms. Debbie Vergos, Naval Air Systems Command**	Delivering Effective Solutions in the Age of Open Source Technology **Mr. Edward Beck, Computer Sciences Corp.**	

Break in Display Area

5:30 PM — Conference Adjounrs for the Day

Thursday, October 27, 2005

7:15 AM — **Registration & Continental Breakfast**

8:15 AM

Regency A	TRACK 1 Systems Engineering Effectiveness Session 4A1	A Systems Affordability Approach Using Raytheon Six Sigma Design **Ms. Yvette Thornton, Raytheon**	Requirements Engineering Tips and Tricks **Mr. Frank Salvatore, HPTI**
Regency B	TRACK 2 Systems Engineering Effectiveness Session 4A2	Surveying SE Effectiveness **Mr. Joseph Elm, Software Engineering Institute**	Integrated Survivability Assessment (ISA) in the Systems Engineering Process **Mr. David H. Hall, SURVICE Engineering Company**
Regency C	TRACK 3 Systems Engineering Effectiveness Session 4A3	10 Golden Questions for Concept Exploration and Development **Dr. Dan Surber, Raytheon Technical Services Co.**	The C-17 Systems Engineering Experience **Mr. Kenneth Sanger, The Boeing Company**
Mission A	TRACK 4 Net Centric Operations Session 4A4	Net Centric Test & Evaluation **Mr. Ric Harrison, DISA**	Profiling and Testing Procedures for a Net-Centric Data Provider **Mr. Derik Pack, Space & Naval Warfare Systems Center - Charleston**
Mission B	TRACK 5 Best Practices & Standardization Session 4A5	Process Architecture and Criteria for Lessons Learned **Mr. Thomas Cowles, Raytheon Space & Airborne Systems**	Successful Strategies To Improve Your Requirements **Mr. Tim Olson, Quality Improvement Consultants, Inc.**
Mission C	TRACK 6 Modeling & Simulation Session 4A6	Application of a State-Machine Model for the Analysis & Optimization of Task-Post-Process-Use [TPPU] and Task, Process, Exploitation and Disseminate [TPED] Processes **Mr. Richard Sorensen, Vitech Corp.**	A Heuristics Systems Engineering Approach to Modeling and Analysis of the U.S. Strategic Highway Network (STRAHNET) **Mr. Gerard Ibarra, Southern Methodist University**
Garden A	TRACK 7 Education & Training in SE Session 4A7	Educating Future Systems Engineers: US Military Academy Reception-Day Simulation and Optimization **LTC Simon Goerger, Department of Systems Engineering**	
Garden F	TRACK 8 Net Centric Operations Session 4A8	The Role of the Operator and System Engineer in the Force Modernization Environment **Mr. Thomas Nelson, Jacobs Sverdrup**	*TBA*

9:45 AM — **Break in Display Area**

10:15 AM

TRACK 1 Systems Engineering Effectiveness Session 4B1	How the Pro-Active Program (Project) Manager uses a Systems Engineer's Trade Study as a Management Tool, and not just a Decision-Making Process **Mr. Art Felix, US Navy**	Experience in Supporting Systems Engineering Project Management Using CORE **Mr. George Blaine, United Dfense, LP**
TRACK 2 Systems Engineering Effectiveness Session 4B2	A systems approach to Accelerating Testing, a case study **Mr. Douglas Chojecki, Stewart & Stevenson, TVSLP**	Applying the Systems Engineering Method to the Joint Capabilities Integration and Development System (JCIDS) **Mr. Christopher Ryder, JHU Applied Physics Laboratory**
TRACK 3 Systems Engineering Effectiveness Session 4B3	Performance-Based System Architecture Design in Global Hawk UAV **Mr. Deepak Shankar, Mirabilis Design, Inc.**	X-47, Joint Unmanned Air Systems (J-UCAS) Program Update **Mr. Rick Ludwig, Northrop Grumman Corp.**
TRACK 4 Net Centric Operations Session 4B4	Joint Integrated BMC4I Systems Research for Upgrading Current and Legacy BMC4I Systems **Mr. Billy Bradley, Jr., Raytheon Integrated Defense Systems**	Model Driven Architecture - Lessons Learned in Model Assessments for Large Scale Joint Implementation **Ms. Denise Bagnall, Naval Surface Warfare Center**
TRACK 5 Best Practices & Standardization Session 4B5	Mature and Secure: Creating a CMMI and ISO/IEC 21827 Compliant Process Improvement Program **Mr. Michele Moss, Booz Allen Hamilton**	Performance-Based Earned Value **Mr. Paul Solomon, Northrop Grumman Corp.**
TRACK 6 Modeling & Simulation Session 4B6	Systems Engineering Approach to Research, Analyze, Model and Simulate the Interdependencies of Container Shipping and the United States Critical Infrastructure System-of-Systems **Ms. Susan Vandiver, Southern Methodist University**	Using Commercial Simulation Software to Model Linear and Non-Linear Processes: US Military Academy Reception-Day Simulation and Optimization **LTC Simon Goerger, Department of Systems Engineering**
TRACK 7 Education & Training in SE Session 4B7	Systems Engineering Professional Development and Certification **Mr. Gerard Fisher, The Aerospace Corp.**	Education and Training in Systems Engineering Support Processes **Ms. Cynthia Hauer, Millennium Data Management, Inc.**
TRACK 8 Net Centric Operations Session 4B8	JCIP: The JBMC2 Roadmap's SoSE-Based Process for Identifying and Developing Capabilities Improvements **Dr. John Hollywood, RAND Corp.**	Matrix Mapping Tool (MMT) **Dr. Judith Dahmann, The MITRE Corp.**

12 Noon — **Lunch at the Islandia Restaurant**

Thursday, October 27, 2005

	1:00 PM		3:00 PM
Regency A	TRACK 1 Systems Engineering Effectiveness Session 4C1	Standard Approach to Trade Studies for the Systems Engineer ***Mr. Art Felix, US Navy***	Effective Implementation of Systems Engineering at the Aeronautical Systems Center: A Systems Engineering Tool Set ***Mr. Edward Kunay, US Air Force***	Conference Adjourns
Regency B	TRACK 2 Systems Engineering Effectiveness Session 4C2	Systems Engineering to Enable Capabilities-based Acquisition ***Ms. Kristen Baldwin, OUSD/(AT&L) DS/Systems Engineering***	Are New Acquisition Programs Taking Longer to Develop/Field and If so Why? ***Dr. Dennis Strouble, Air Force Institute of Technology***	
Regency C	TRACK 3 Systems Engineering Effectiveness Session 4C3	A Systems Architectural Model for Man-Packable Intelligence, Surveillance, and Reconnaissance Micro Aerial Vehicles ***Maj Joerg Walter, AFIT/SYE***	EW Integration Roadmap ***Mr. Byron Coker, Jr., Georgia Tech/GTRI***	
Mission A	TRACK 4 Net Centric Operations Session 4C4	Enabling Net Centric Capability through Secured Integrated Networks of Modular and Open Architectures ***Dr. Cyrus Azani, OSJTF/NGC***	Open Systems Architecture & Standard Interfaces as Mission Capability Enablers ***Mr. William Mish, Jr., AMSEC***	
Mission B	TRACK 5 Best Practices & Standardization Session 4C5	TBA	What CMMI Can Learn From the PMBOK ***Mr. Wayne Sherer, US Army ARDEC***	
Mission C	TRACK 6 Modeling & Simulation Session 4C6	MS2 Moorestown Modeling and Simulation (M&S) Support Approach ***Mr. David Henry, Lockheed Martin MS2***	Science-Based Modeling and Simulation on DoD High Performance Computers ***Dr. Larry Davis, High Performance Computing Modernization Program***	
Garden A	TRACK 7 Education & Training in SE Session 4C7	Training Your Systems Engineering Workforce ***Mr. Michael Kutch, Jr., SPAWAR***	Filling the Expertise "Gap" ***Mr. John White, US Air Force***	
Garden F	TRACK 8 Net Centric Operations Session 4C8	TBA	TBA	

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Raytheon

Customer Success Is Our Mission

Algorithm Description Documentation and Validation Process

8th Annual Systems Engineering Conference, National Defense Industrial Association,

San Diego, CA

Mike Bailey

Raytheon Company

714.446.4195

mkbailey@raytheon.com

10/26/05

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Abstract

- Complicated algorithms difficult to translate to SRS
  - Highlights the division between algorithm validation and software verification
  - Results in a disjoint agreement between Systems and Software engineering
- Algorithm Description Document
  - Documents the life-cycle of algorithms
  - Includes trade study analyses and validation results to illustrate details design intent
  - Allows for a mutual engineering understanding
  - Describes the most recent design
- ADD Process is presented

ADD defines the difference between Verification and Validation

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Navigation and Landing Systems Developments

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- Raytheon's NLS group developed ADDs and simulation tools to test algorithms
  - Process successfully implemented during initial operating phase of an SBAS approved for use in commercial aviation
  - Customer and Raytheon currently planning upgrades to improve service and availability
  - A combination of algorithm enhancements required to achieve future operational goals
    - To be rolled out sequentially over the next few years
- Process expanded to include all safety algorithms in NLS program subsystems
  - Continues to be used by all SBAS programs within Raytheon's NLS group as the primary algorithm development tool

ADD allows Software Enhancements

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Software Development Challenges

- Typical programs include safety-of-life systems centered on math-intensive algorithms
  - New insights in antenna design, ionospheric behavior and error mitigation lead to algorithm redesigns
- The safety-of-life requirement suggests the use of an RTC/DO-178B Level B process
- NLS programs consist of software developed to DO-178B Level B and Level D standards
  - Level B software passes through rigorous set of design and testing requirements
  - Level B coding involves creating a formal SRS, ensuring that all requirements in the SRS are addressed in the code, and formally testing all branches of the code for conformity

Ensure software meets safety requirements

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Software Requirements Document Considerations

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- SRS is relatively expensive
  - Each idea broken down into modules used to generate pseudo code
  - Common for SRS updates to lag
- SRS focuses on how code is supposed to operate
  - Does not capture discussions and trades that justify the algorithms
  - Various filters and algorithms in the system all require analysis
- Scientists operate in a results-based paradigm
  - More effort is concentrated on the results of the algorithms to be correct than that pseudo code to be clear
  - As a consequence, system prototypes were correct implementations of the SRS but not correct implementations of the algorithms envisioned
  - Software may have been appropriately verified, but was not a guaranteed implementation of validated algorithm

Methodology concentrates on Algorithm Validation

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System Engineering Methodology

- Design, prototype, tune and validate

- Process has 3 goals
  - Allow flexibility to rework algorithms and code
  - Capture information that describes how decisions were made
  - Focus on ideas and results, not implementation details

Algorithms are proposed and described in ADD

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Algorithm Generation

- Offline studies
  - Trading one approach against another or examining historical data
  - Included in the ADD to give an understanding for the motivation of the algorithm

- Design is prototyped into a simulation of deliverable system
  - If the design has not been fully decided, the prototype engineer will use best judgment to get a version working
  - If there are multiple competing designs, they are coded under compile flags and comparison simulations are executed

ADD includes off-line studies

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Algorithm Validation

- To validate that code operates as expected the simulation is executed
  - Code has extensive debugging capabilities to generate reports of algorithm functions
  - Compared to the algorithm description in the ADD to determine if it has the correct behavior
- Tuning effort where the algorithm is optimized
  - Algorithm is modified in the simulation until it meets expectation results
  - Summarized in ADD
- Once tuned, algorithm design described in ADD is updated
- ADD reviewed to ensure that the results are correct and that all anomalies are explained
- ADD given to Software Engineering for implementation

All validation efforts summarized in ADD

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Software Engineering Methodology

- Generate software requirements, code and verify

- Process has 3 goals
  - Ensure one-to-one correspondence between specification and code
    - No unimplemented requirements and
    - No code that is not described in the requirements
  - Ensure that the software has been coded to meet the prescribed RTC/DO-178B safety level
    - All branches tested for correctness and robustness

Methodology concentrates on algorithm validation

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Algorithm Implementation

- Software Engineering updates the SRS with requirements generated from ADD
- Design review held to ensure the algorithm described in the ADD can be implemented in a manner consistent with Level B design
  - It must be possible to prove that the code will operate consistently in a manner as described in the SRS
  - System operational software is coded from the requirements

    If the deliverable code is being generated by perfecting simulation code, the Software Engineer must ensure that the SRS, and not the prototype, is used as the source of requirements.
  - The operational code is to be free of dead or unused code, debugging code and any version of the algorithm other than the final version described in the SRS

SRS updated from ADD

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RTC/DO-178B Level B Coding

- Level B software is coded in a style that prohibits unsafe programming constructions
- Software Engineers specially trained in Level B programming techniques
- Once complete, the simulation code is available as a resource for comparison testing
- Discrepancy between deliverable and prototype code is comparatively great
  - Prototype coders are engineers and mathematicians focused on validation and benefit exclusively from executing the simulation
  - Prototype not developed to meet any specific coding standards

Operational code required to pass though rigorous design and testing requirements

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Limitations

- There is risk in overestimating the code correctness of the validated algorithms in the simulation
  - The simulation is validated by checking that its algorithms function as expected
  - It is possible to have simulation code that gives correct or nearly correct results while still containing coding errors

- If integration-level testing of the operational software is less rigorous because of confidence in the algorithm validation of simulation code, some corner robust cases may be under tested

Robust cases may be under tested

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Algorithm Changes

- ADD under control of Algorithm Design Team
- SRS under control of Software Engineers
  - ADD and SRS kept synchronized to facilitate communication between the two groups
  - In this way a Software Engineer is unable to originate a change to an algorithm that is not reviewed by the algorithm designer
  - Similarly, the analyst is unable to introduce a subtle change in the algorithm that is not captured in the code
- Once the algorithms themselves are defined, the algorithms and related information are documented in the

ADD is approved by System Engineering

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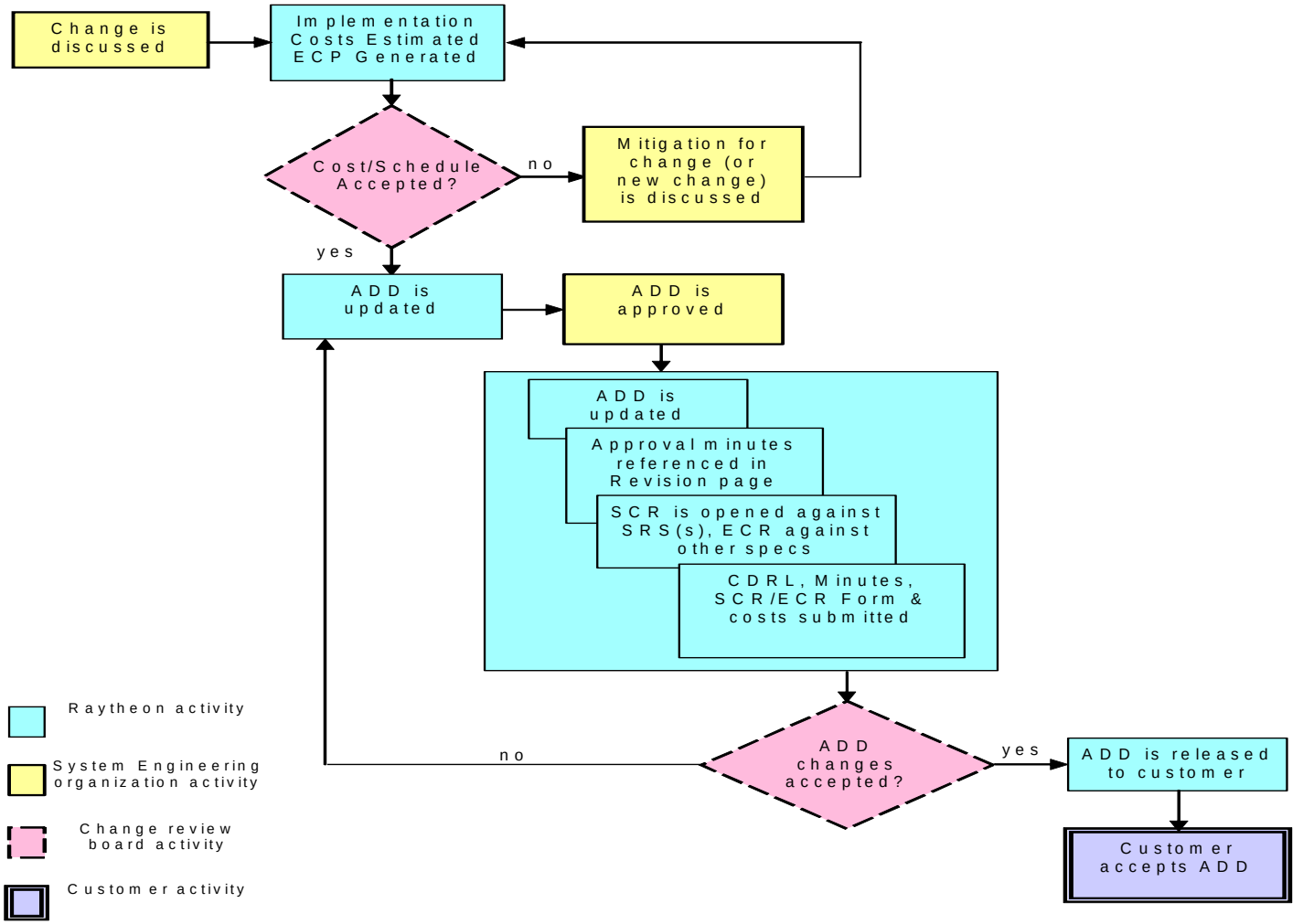
Change Process



Changes are made and approved by a change review board

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Conclusion

- ADDs and a validation process has helped programs to be more agile in the face of rapid algorithm redesign
- By centralizing information on algorithm tuning and validation, it is easier to understand the history and justification of decisions made
- By formatting the information to be more accessible to the engineers and scientists, it has kept them more engaged in the process of document review

ADDs have led to a safer and more correct product

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The Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance

Eugene A. Beardslee, SAIC
and
Dr. Hank Grant
Department of Industrial Engineering,
University of Oklahoma

Briefing Overview

- Problem Definition and Scope
- Background
- Challenges
- Solving the problem

Problem Definition

- Classic inventory problems
  - How much to stock?
  - When to order?
  - How much to order?
- Difficult problem without demand data
  - When will the stock location run out of inventory?
- Multiple Consumers, Multiple interrelated maintenance tasks
- No access to planning and production data
- Multiple-criteria optimization problem

Minimize Inventory Management Cost

- Holding Cost
  - Parts
  - Physical Space
  - Stocking Labor
- Penalty Cost
  - Idle workers
  - Delayed tasks
- Order Cost
  - Inventory Review
  - Shipping
  - Receiving
  - Forward Locating

Maximize Performance

- Inventory Bin Fill Rate
- Service Rate
- Inverse Waiting time

Background

- Bench stock inventory
- More than 400,000 stock locations
- More than 100,000 inventory items
- Over 1.8 million transactions over three years
- Multiple weapon systems:F-15, F-16, C-130, C-141, C-5, KC-135, B-1B, B-52, B-2, E-3, E-6A, FA-18, P-3, H-60, AV-8, and others.
- Multiple Sites: OCALC, OOALC, WRALC, JXNADEP, NINADEP, CPNADEP

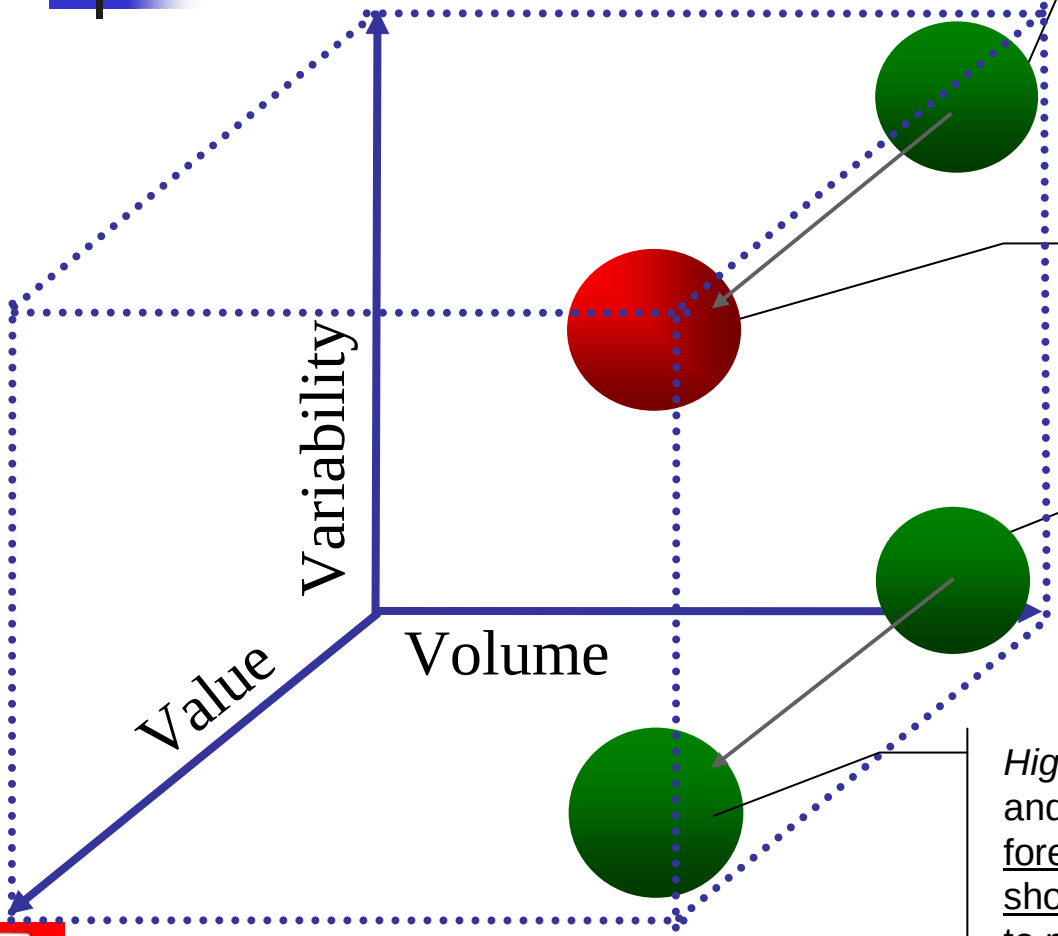
Challenges

- Detecting stock-out conditions
- Forecasting demand
- Identifying inventory policy errors
- Compensating for variability of the maintenance environment
- No access to planning and production data

More Challenges

- Exact item count in inventory location is unknown
- Accurate inventory review is not economically feasible
- Reorder level is an estimate
- Reorder quantity is fixed
- Items removed from the stock locations for direct use

Insights: Inventory Segmentation



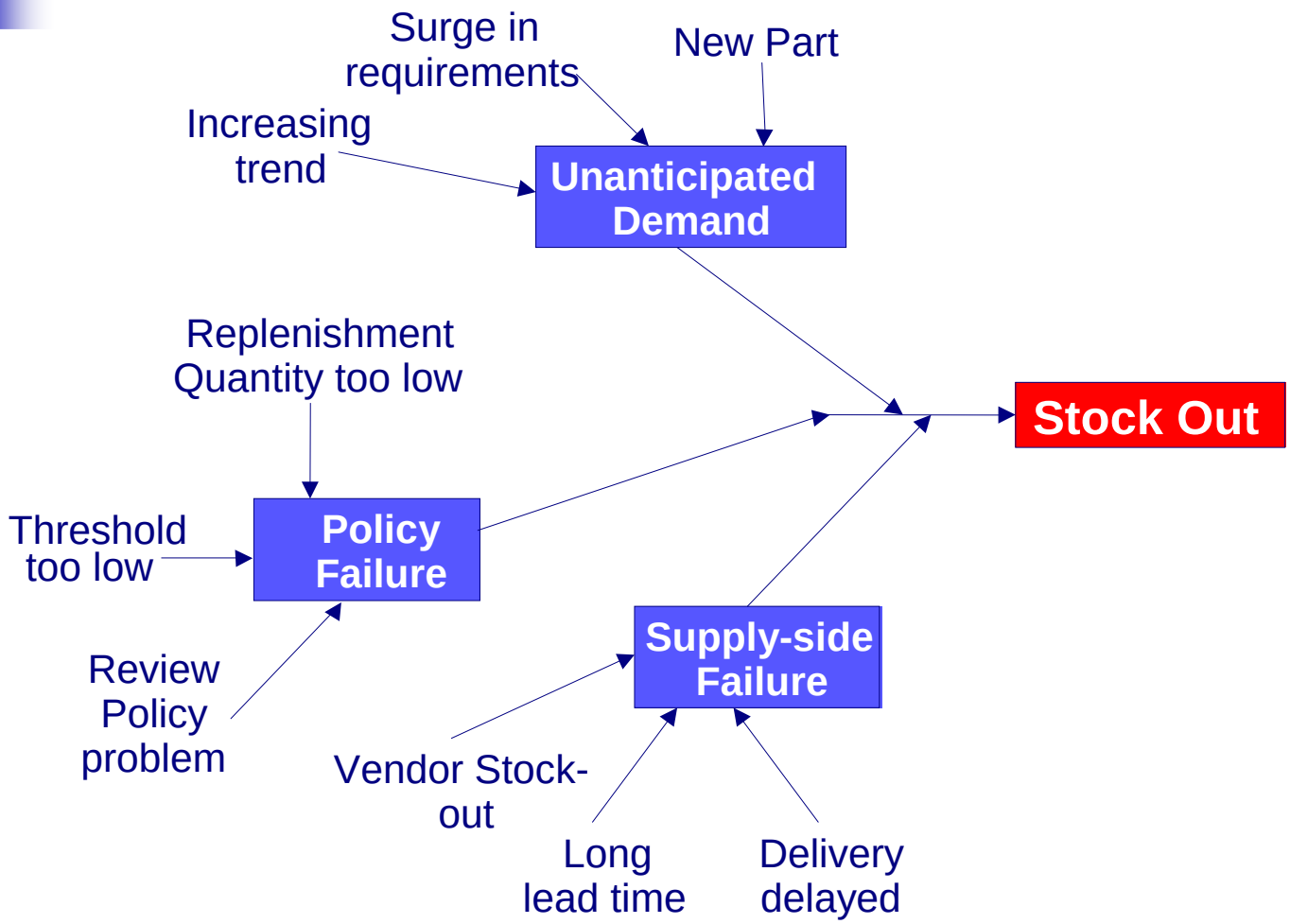
Low value parts with *highly variable* and *high volume* demand can have high reorder thresholds (safety stock) to avoid stockouts without incurring excessive inventory costs.

High value parts with *highly variable* and *high volume* demand would benefit from demand forecasts based on anticipated needs to minimize the value of stock on hand.

Low value parts with *low variability* and *high volume* demand could be "auto-replenished" based on historical demand patterns – lowering inventory review costs.

High value parts with *low variability* and *high volume* demand could be forecasted to assist suppliers, but should be reviewed more frequently to minimize overstock conditions.

Stock Out Triggers

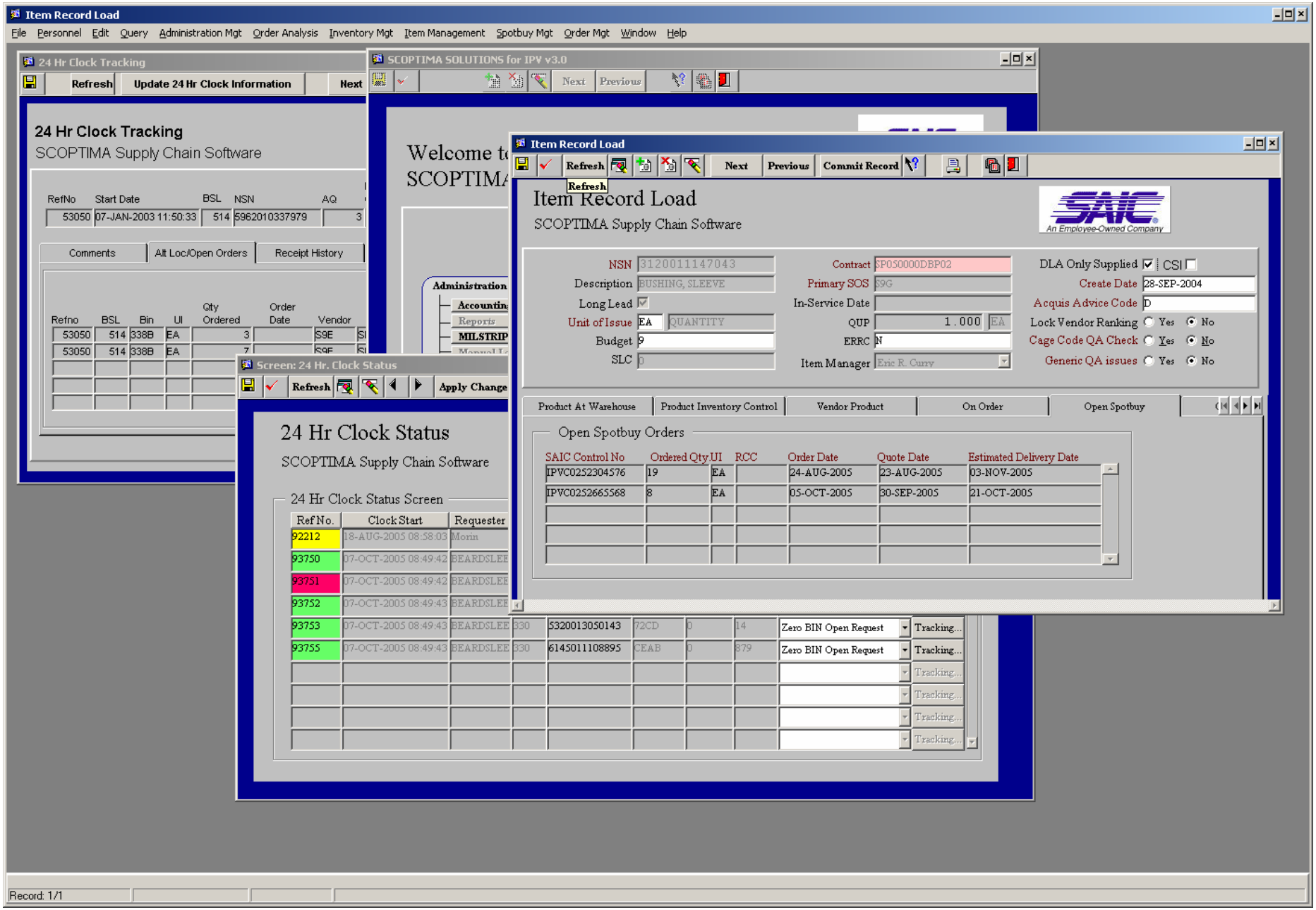


Solving the problem: Daily

- Unmanned Bench Stock Location
  - Material is placed in a bin and mechanic takes what he needs
  - If a bin is empty, inventory manager is notified and generates an emergency PR to Vendor
  - Conduct physical review of each bench stock location twice per week to create routine replenishment
- Emergency Requirements Management
  - Each emergency requirement is tracked from birth to death
- Stock outage Management
  - Intensive management to ensure parts are in the bin
  - Focuses manager on potential problems
- Web based asset visibility
- EDI Ordering and Invoicing

Enterprise Supply Chain System: SCOPTIMA™

- Oracle DBMS with custom user and system interfaces
- User-friendly interface for management queries
- Maintains record of supply chain events
  - Bin scan to generate potential order (hand-held device)
  - Order generation based on rule set (automated)
  - EDI order placement to vendor(s)
  - Order receipt and replenishment (physical inspection and confirmation)
  - EDI invoicing
- Supports analysis to identify historical demand patterns and relationships through simulation and data mining


Item Record Load
File Personnel Edit Query Administration Mgt Order Analysis Inventory Mgt Item Management Spotbuy Mgt Order Mgt Window Help
24 Hr Clock Tracking
Refresh
Update 24 Hr Clock Information
Next
24 Hr Clock Tracking
SCOPTIMA Supply Chain Software
RefNo Start Date BSL NSN AQ
53050 07-JAN-2003 11:50:33 514 5962010337979 3
Comments
Alt Loc/Open Orders
Receipt History
Refno BSL Bin UI Qty Ordered Order Date Vendor
53050 514 338B EA 3 S9E
53050 514 338B EA 7 S9E
SCOPTIMA SOLUTIONS for IPV v3.0
Next
Previous
Welcome t
SCOPTIMA
Administration
Accountin
Reports
MILSTRIP
Screen: 24 Hr. Clock Status
Refresh
Apply Change
24 Hr Clock Status
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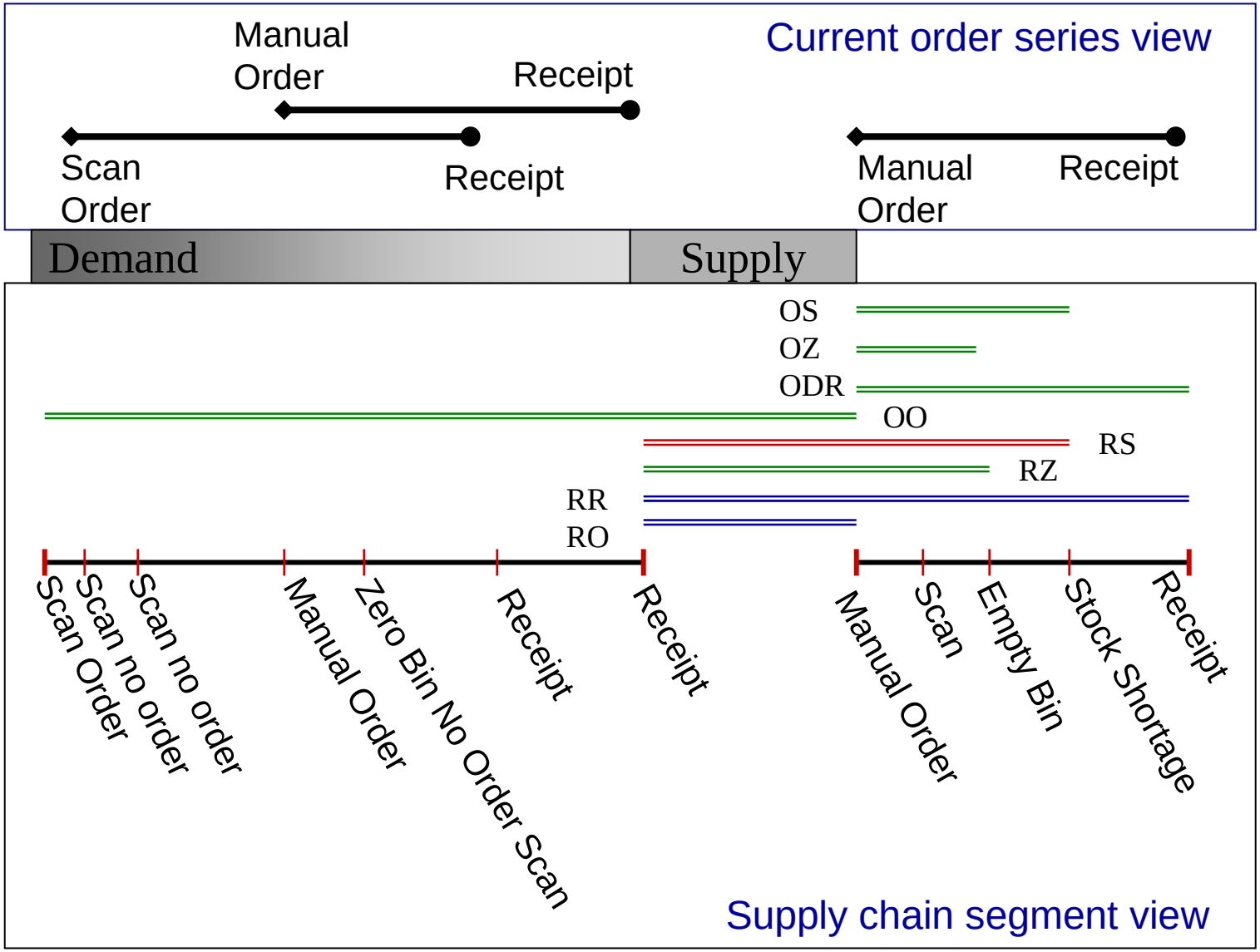
Item Record Load
Refresh
Next
Previous
Commit Record
Item Record Load
SCOPTIMA Supply Chain Software
SAIC
An Employee-Owned Company
NSN 3120011147043
Description BUSHING, SLEEVE
Long Lead
Unit of Issue EA QUANTITY
Budget 9
SLC 0
Contract SP050000DBP02
Primary SOS S9G
In-Service Date
QUP 1.000 EA
ERRC N
Item Manager Eric R. Curry
DLA Only Supplied CSI
Create Date 28-SEP-2004
Acquis Advice Code D
Lock Vendor Ranking Yes No
Cage Code QA Check Yes No
Generic QA issues Yes No
Product At Warehouse
Product Inventory Control
Vendor Product
On Order
Open Spotbuy
Open Spotbuy Orders
SAIC Control No Ordered Qty UI RCC Order Date Quote Date Estimated Delivery Date
IPVC0252304576 19 EA 24-AUG-2005 23-AUG-2005 03-NOV-2005
IPVC0252665568 8 EA 05-OCT-2005 30-SEP-2005 21-OCT-2005
Record: 1/1

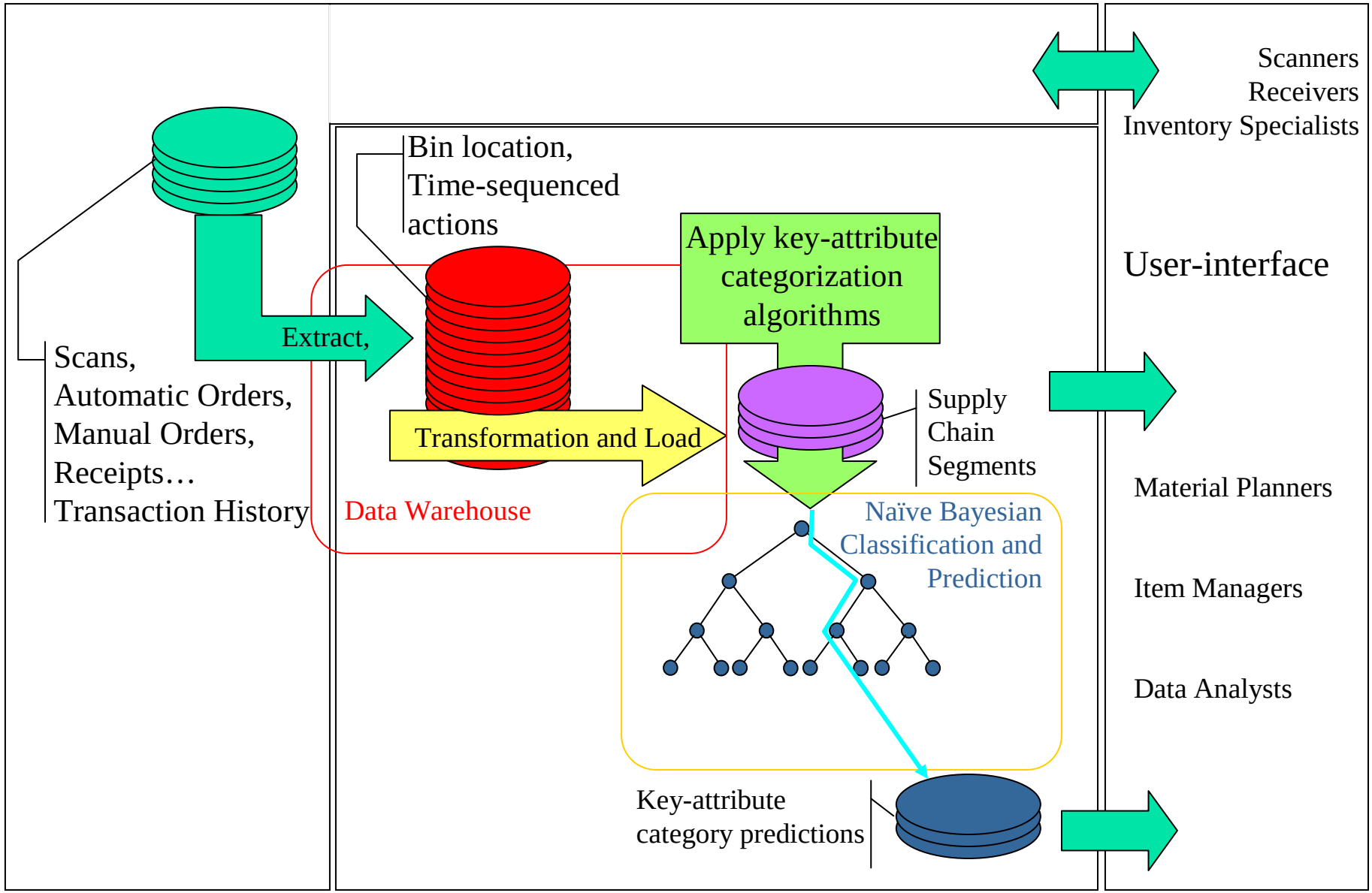
Applying Technology

- Data Warehousing
- Data Mining
- Simulation
- Time-series Forecast modeling
- Dynamic data display

Key Transaction Events



SCOPTIMA™ Data Mining



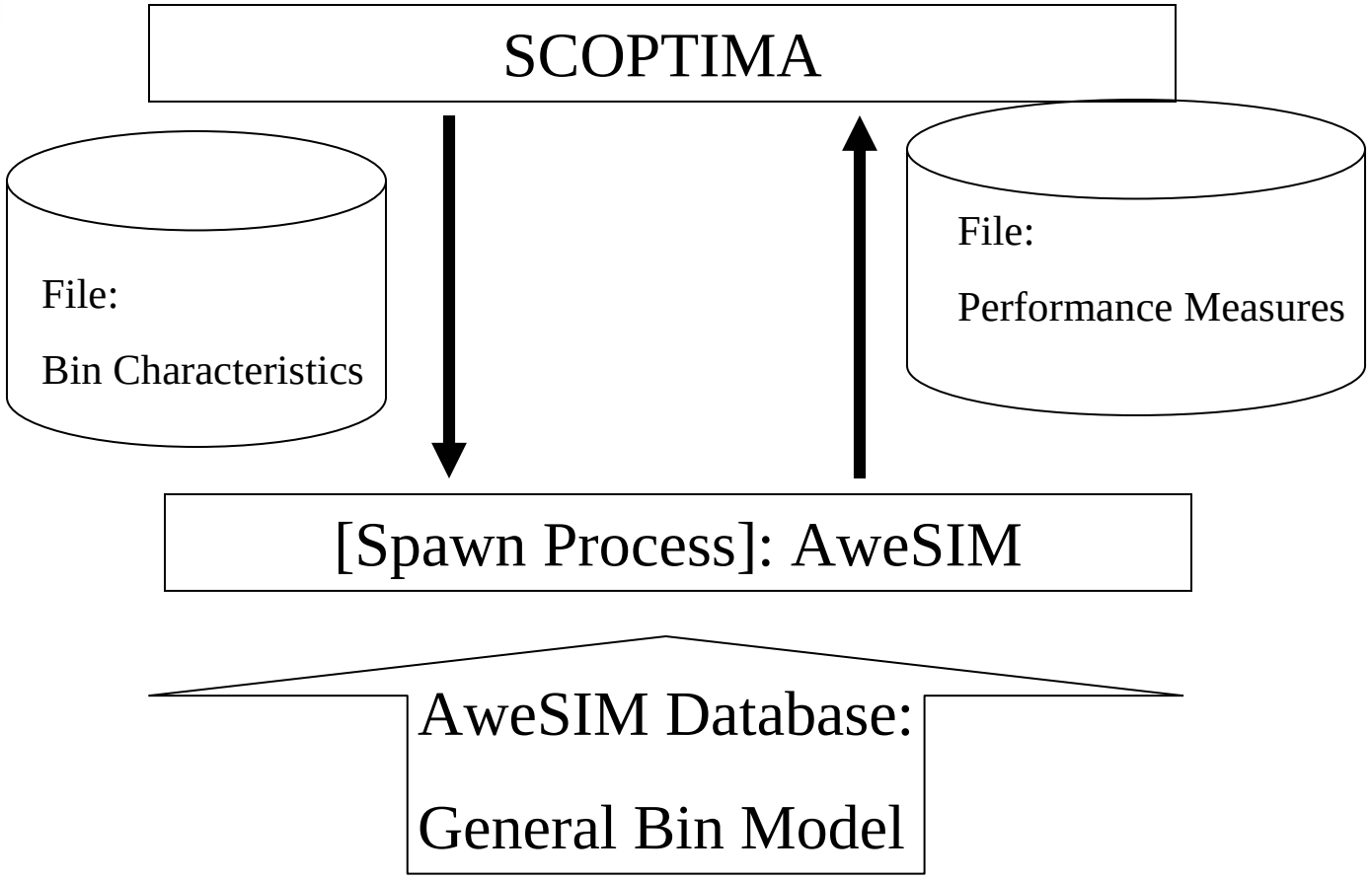
Integration of SLAM and SCOPTIMA™

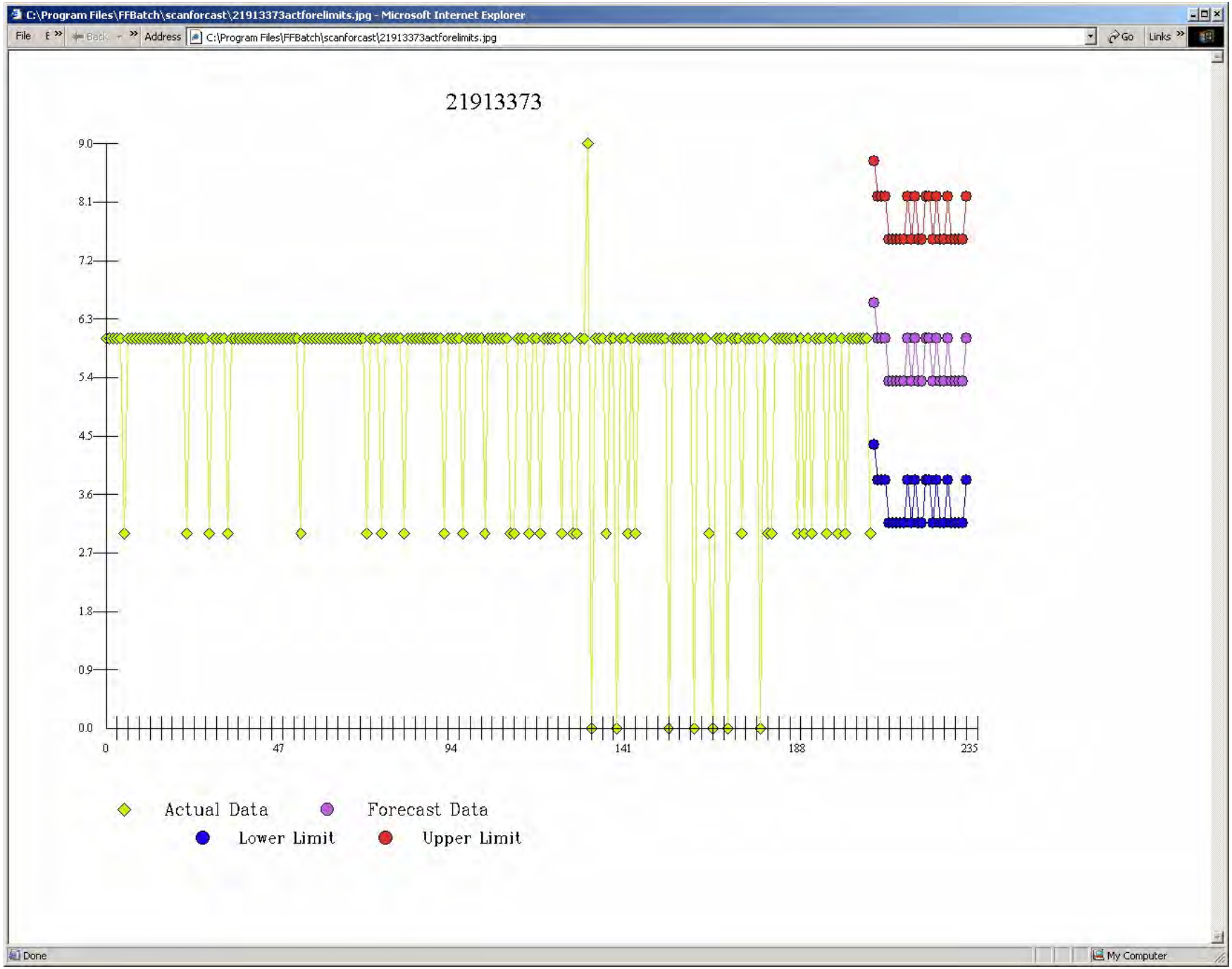
- Automatically run simulation of Bin Q,r strategy to verify results
- Support SCOPTIMA decision making using simulation
  - Verification of Q,r changes when bin agent determines need for change
- “Agent” based approach
- Automated

Integration

- Spawn process from SCOPTIMA to invoke AweSIM model
- Interface via Data Files or Database
- Results returned to SCOPTIMA via Data Files or Database

Architecture




C:\Program Files\FFBatch\scanforcast\21913373actforelimits.jpg - Microsoft Internet Explorer
File
Back
Address
C:\Program Files\FFBatch\scanforcast\21913373actforelimits.jpg
Go
Links
21913373
9.0
8.1
7.2
6.3
5.4
4.5
3.6
2.7
1.8
0.9
0.0
0
47
94
141
188
235
Actual Data
Forecast Data
Lower Limit
Upper Limit
Done
My Computer

C:\IMTOOLS\Revised Dashboard\BSLStatus_V4.swf
File Edit View Favorites Tools Help
Address C:\IMTOOLS\Revised Dashboard\BSLStatus_V4.swf
SCOPTIMA Real-Time Dashboard
LOGIN
Refresh DATA
BSL's
310
311
312
313
314
315
316
317
318
319
320
NSN's
Display Selector
BSL
BSL+NSN
October 2005
Sun Mon Tue Wed Thu Fri Sat
Service Rate
60.7
Zero Bins
Clocks
Bins
45
1
0
NSN DETAIL DATA
WAIT TIME METRICS - (Days)
CWT
1
BWT
1
Bin Performance
Daily Usage
Received
AQ
Forecast
FCST
MIN
MAX
View Forecast
SCOPTIMA Supply Chain Software
SAIC
From Science to Solutions
Done
My Computer

Conclusion

- Challenging Supply Chain Problems
- Complex inventory model
- Integrated Enterprise System
- Advanced technology solutions

Dr. Hank Grant

Dr. Grant joined the faculty at the University of Oklahoma in December of 1993 as Director of the School of Industrial Engineering and Southwestern Bell Professor. He is currently Director of the Center for the Study of Wireless Electromagnetic Compatibility and Dugan Professor of Industrial Engineering. Prior to joining the University of Oklahoma, he was with the National Science Foundation in Washington, DC, where he directed programs in Production Systems, Engineering Design, and Operations Research. Dr. Grant was instrumental in the startup and development of two Industrial Engineering software companies: Pritsker Corporation and FACTROL. Dr. Grant is a Fellow of the Institute of Industrial Engineers and is a member of the following societies: INFORMS, Tau Beta Pi and The Institute of American Entrepreneurs. Dr. Grant received his Ph.D. from Purdue University in Industrial Engineering in 1980.

Eugene Beardslee

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The Use of Simulation in the Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance

Gene Beardslee, SAIC

and

Hank Grant, U of Oklahoma

Summary

- 400,000 bins of material
- Multiple Sites
- Varying part size
  - Rivets to wings
- Difficult to monitor and forecast
  - No “production” plan
  - Demand forecast based on approximation of inventory level
    - Empty – partial - full

Summary

- General autonomous bin simulation
- Agent based approach
- Data (File) Driven
- Interface with external software
- Bins simulated over 50 years of operation

Summary

- Underlying Simulation Technology
  - V1: GPSS model
  - V2: SLAM/AWESIM
- Simulation technology is transparent to the user

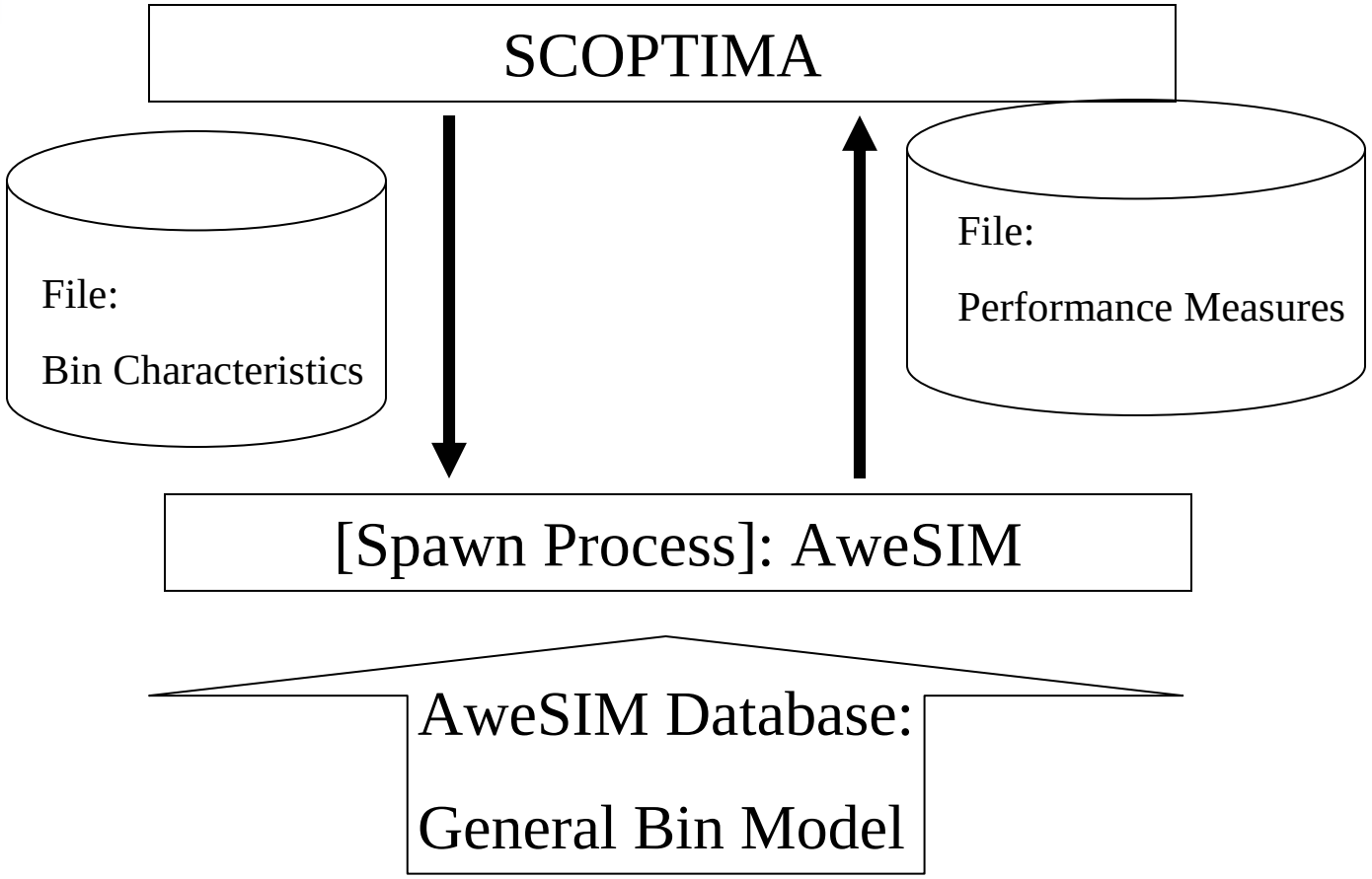
Integration of SLAM and SCOPTIMA™

- Automatically run simulation of Bin Q,r strategy to verify results
- Support SCOPTIMA decision making using simulation
  - Verification of Q,r changes when bin agent determines need for change
- “Agent” based approach
- Automated

Integration

- Spawn process from SCOPTIMA to invoke AweSIM model
- Interface via Data Files or Database
- Results returned to SCOPTIMA via Data Files or Database

Architecture



Summary of Simulator Capabilities

- Individual Bins
- Multiple Bins
- Sensitivity Analysis
  - Demand Rate
  - Reorder Quantity and Reorder Point
  - Automatically runs multiple analyses

Summary of Simulator Capabilities

- Bin Transfer Evaluation
  - Evaluate best bin to use for transfer
- Demand Rate Profile
  - Demand Rate varies over time
  - Surge modeling

Inputs

- Text file
- Simulates any number of bins with any varying, or the same, attributes
- Uses Q,r values from optimization

Inputs

- Example data file

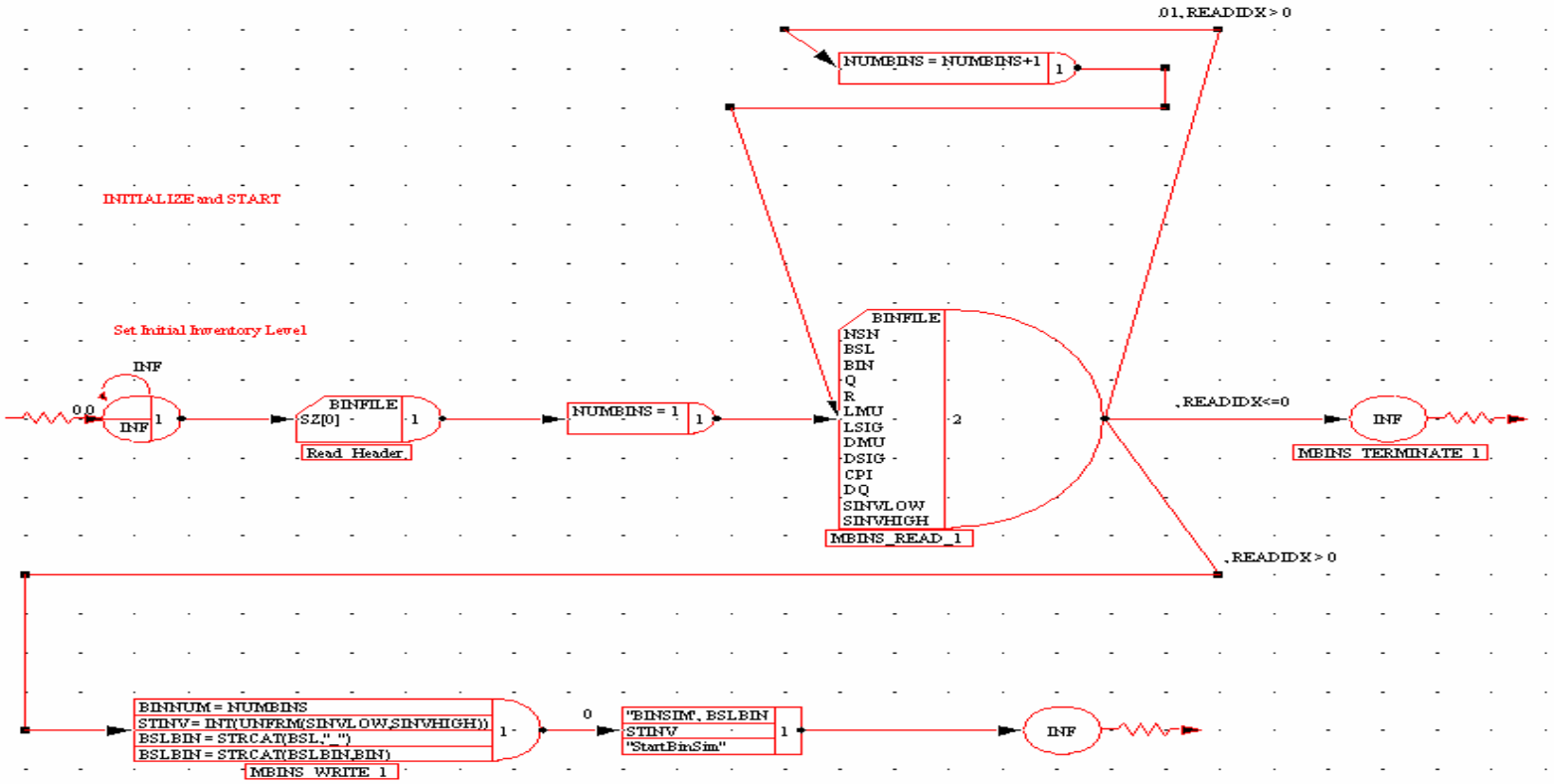
NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	210	C069	88.00	95.00	7.60	22.80	0.55	3.28	3.12	1.00	50.00	150.00
5305003383288	150	A071	159.00	222.00	7.60	22.80	0.15	0.88	3.12	1.00	100.00	300.00

- This will automatically simulate two bins

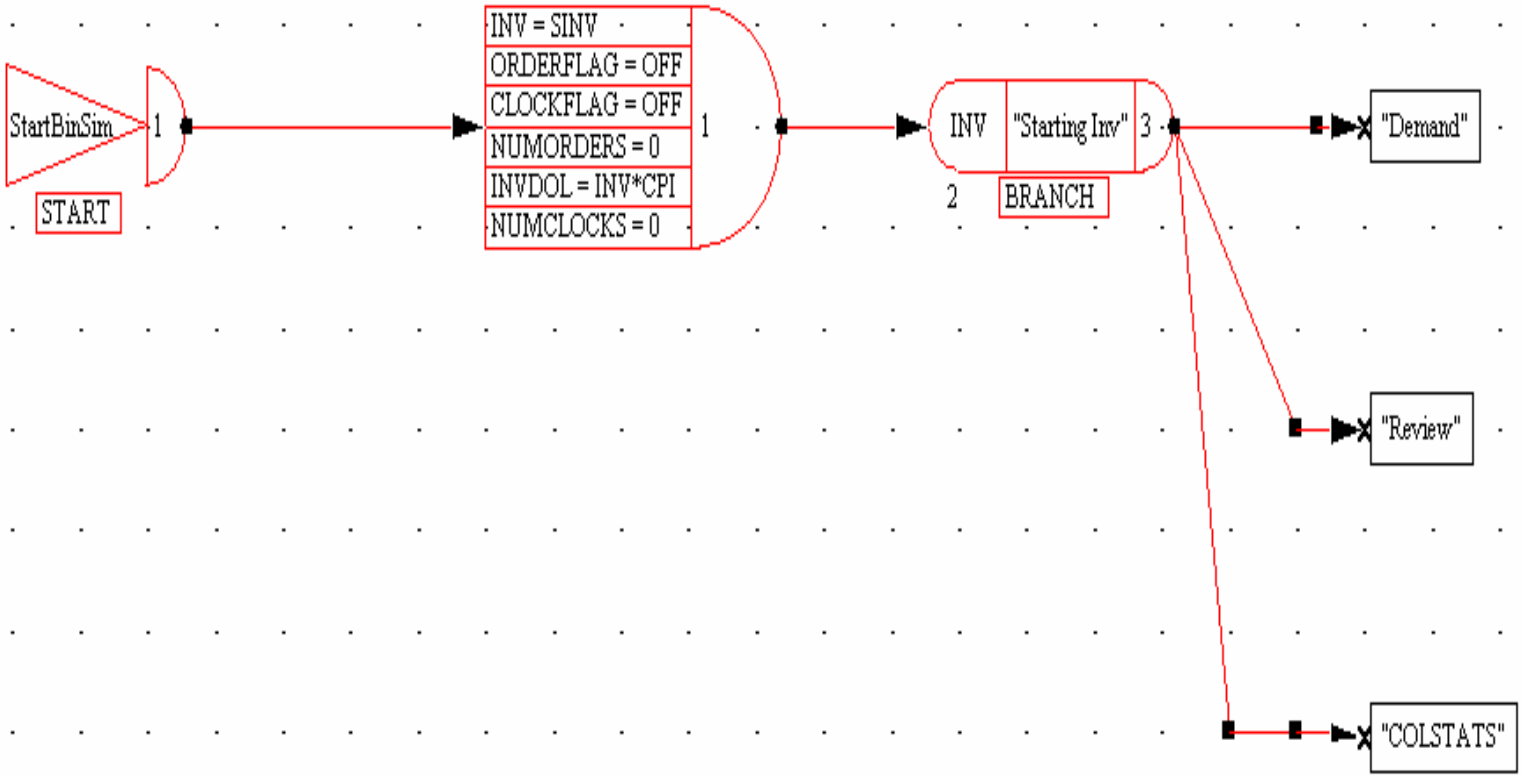
Models

- Stage I
  - Read input and invoke bin agent to simulate operation
- Stage II
  - Simulate bin operation for each bin defined
  - Stage II replicated automatically for each bin

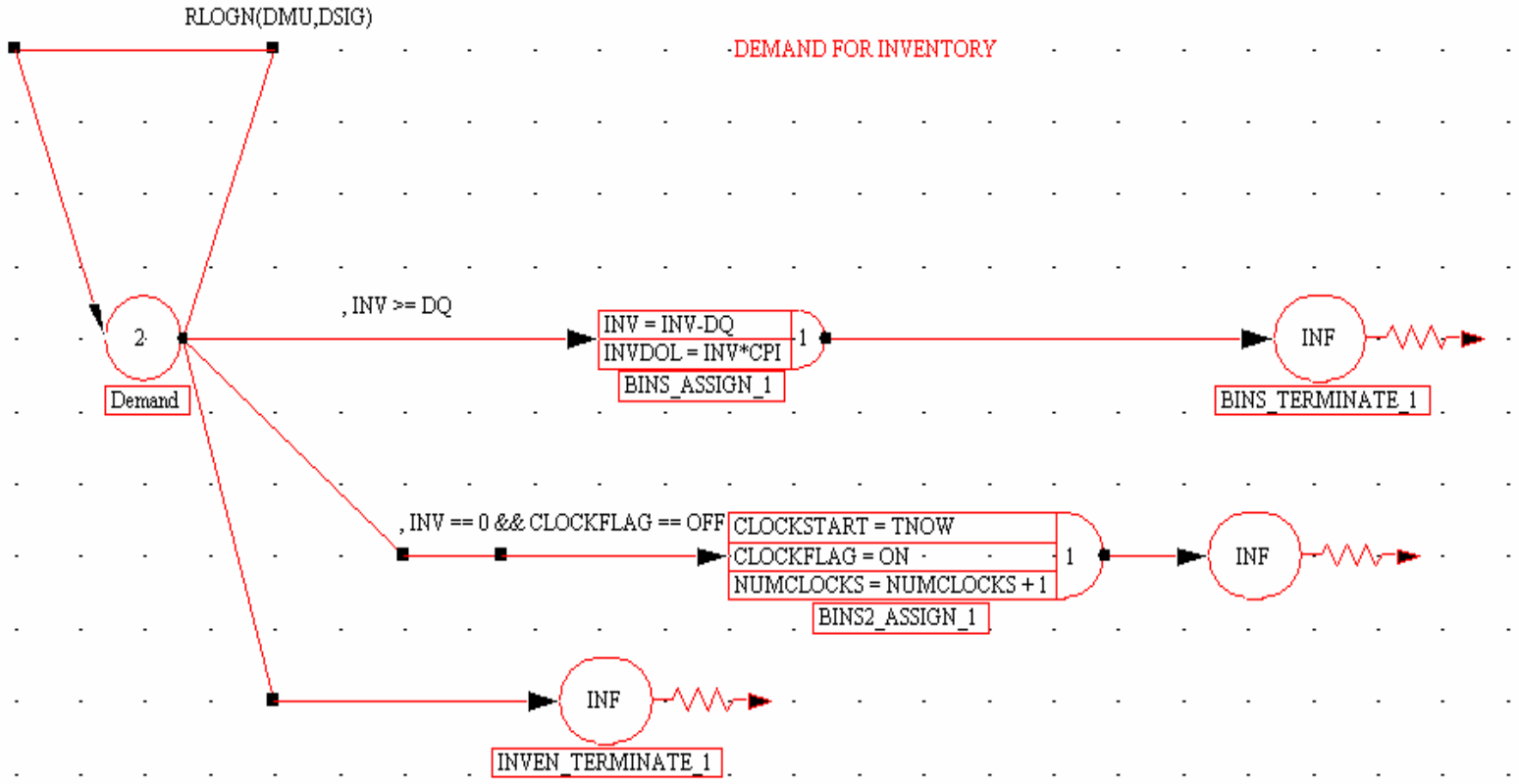
Models - Read Data and invoke bin agent/simulation (Stage I)



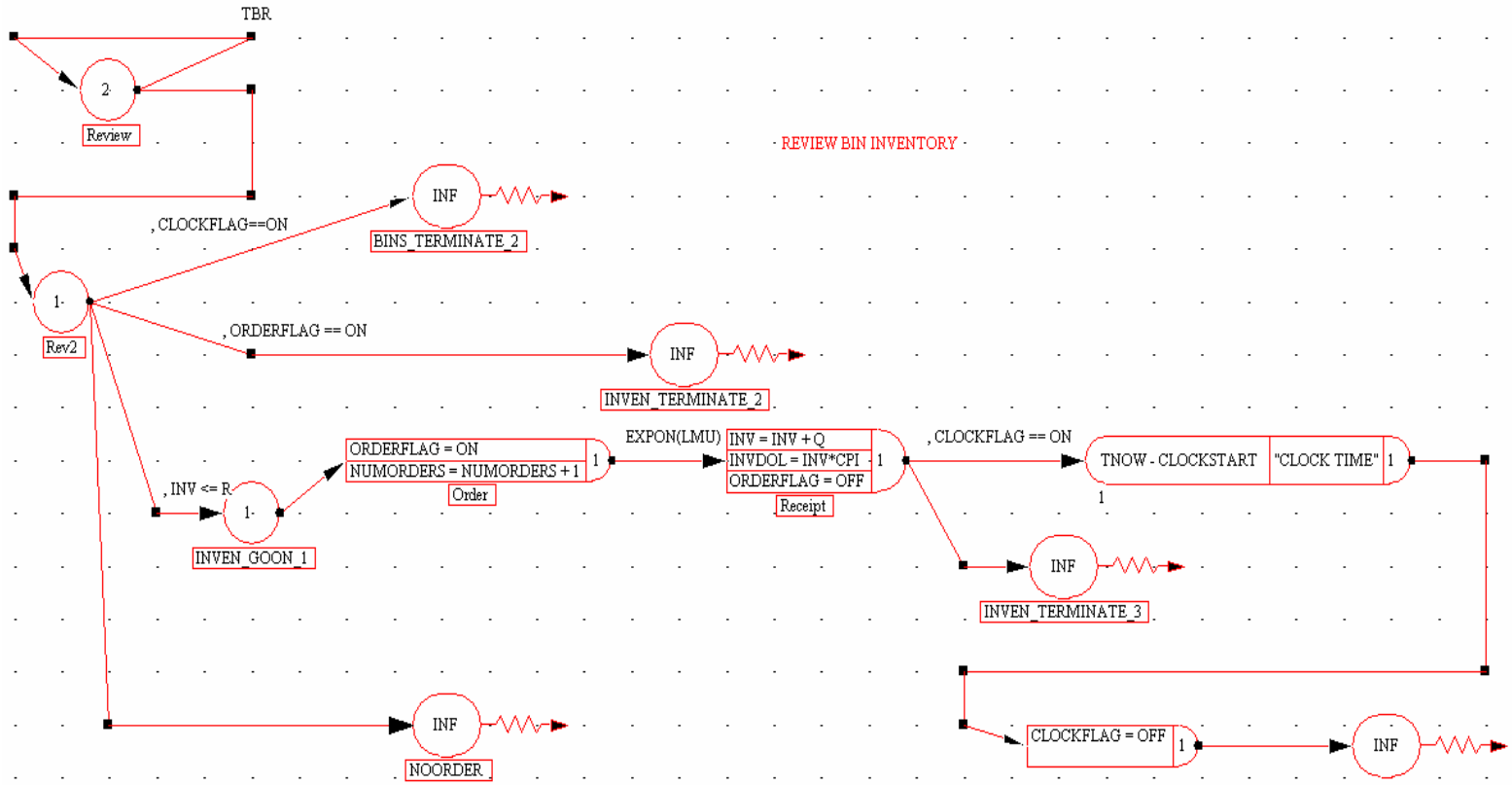
Models – Initialize Bin Agent(Stage II)



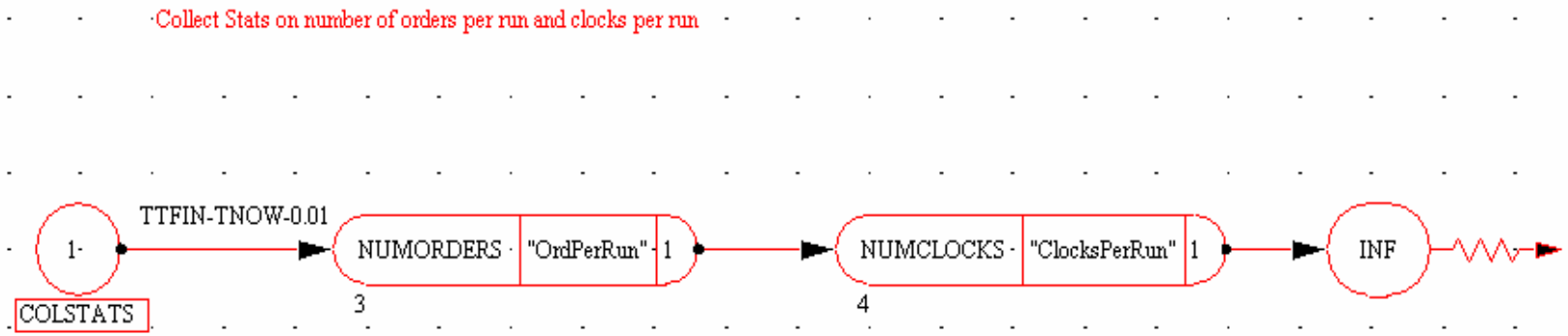
Models – Demand Agent(Stage II)



Models – Review Bin Agent(Stage II)



Models – Stat Collection Agent (Stage II)



Outputs

- Statistical collection for all Bin based performance measures
- Includes:
  - Clock Time
  - Orders per Run
  - Clocks per Run
  - Inventory
  - Inventory Cost
  - Service Level

SAIC
From Science to Solutions™

Outputs – Example Report

(Produced for each Bin)

```
** AweSim! MULTIPLE RUN SUMMARY REPORT **
   Subnetwork : BINSIM
   Instance : 175_Y676

** OBSERVED STATISTICS for BINSIM 175_Y676 **
```

Label	Mean Value	Standard Deviation	Standard Error	Minimum Average Value	Maximum Average Value
CLOCK TIME	3.380	5.844	0.826	0.000	21.402
Starting Inv	386.020	240.490	34.010	3.000	691.000
OrdPerRun	15.200	0.670	0.095	14.000	17.000
ClocksPerRun	0.400	0.571	0.081	0.000	2.000

```
** TIME-PERSISTENT STATISTICS for BINSIM 175_Y676 **
```

Label	Mean Value	Standard Deviation	Standard Error	Minimum Value	Maximum Value
Bin Inventory	735.897	39.500	5.586	622.568	805.929
Service Rate	0.990	0.017	0.002	0.941	1.000
Inventory Value	1103.846	59.250	8.379	933.852	1208.894

Virtual Bin Consolidation

- Combine demand for groups of bins with the same NSN and calculate Q,r for group using optimization spreadsheet.
- Combines and reduces variance of multiple bin processes
- Calculate new demand parameters based on number of bins and bin details
- Simulated over 50 years of operation

Bin Consolidation – Case I

- Two Bins - Identical
- Separate:
  - Q = 281
  - R = 303
- Combined
  - Q = 490
  - R = 557

Bin Consolidation – Case I Data Files

- Separate

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	176	Y677	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00

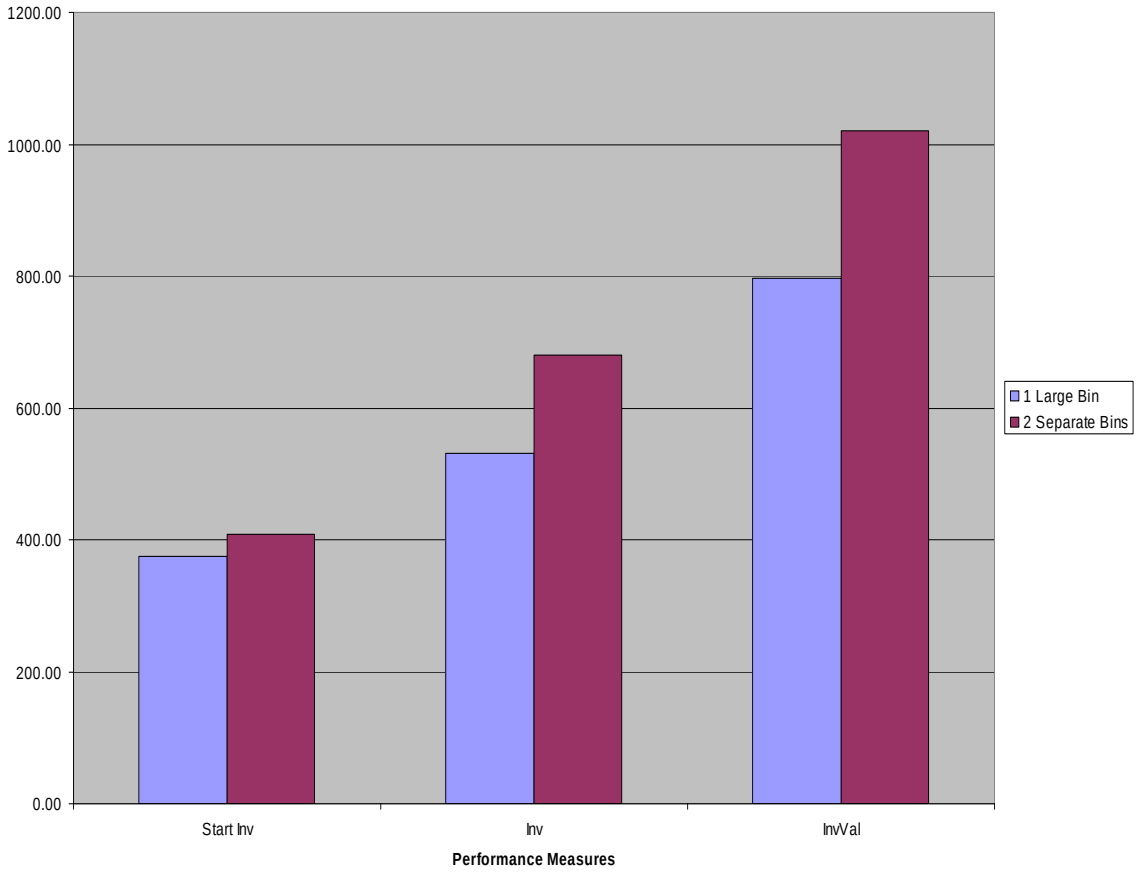
- Combined

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	490.00	557.00	7.67	10.58	0.05	0.14	1.50	1.00	0.00	700.00

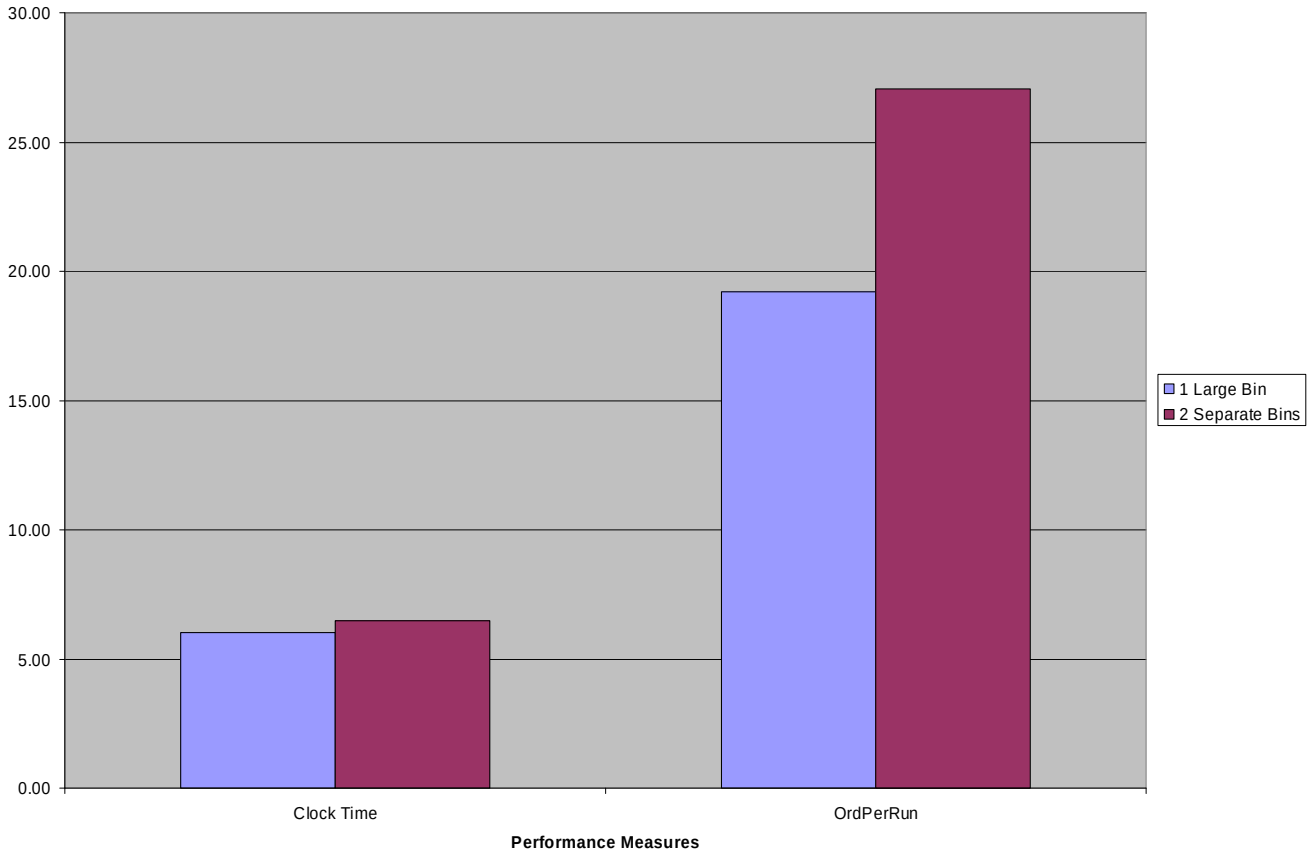
Results – Case I

	1 Large Bin	2BINA	2BINB	2 Separate Bins
Start Inv	374.78	214.00	193.80	407.80
Inv	530.90	343.46	337.40	680.86
InvVal	796.35	515.19	506.11	1021.30
Clock Time	6.03	3.20	3.29	6.49
OrdPerRun	19.22	13.54	13.52	27.06
CLocksPerRun	0.96	0.54	0.46	1.00
Service Rate	0.98	0.99	0.97	0.98

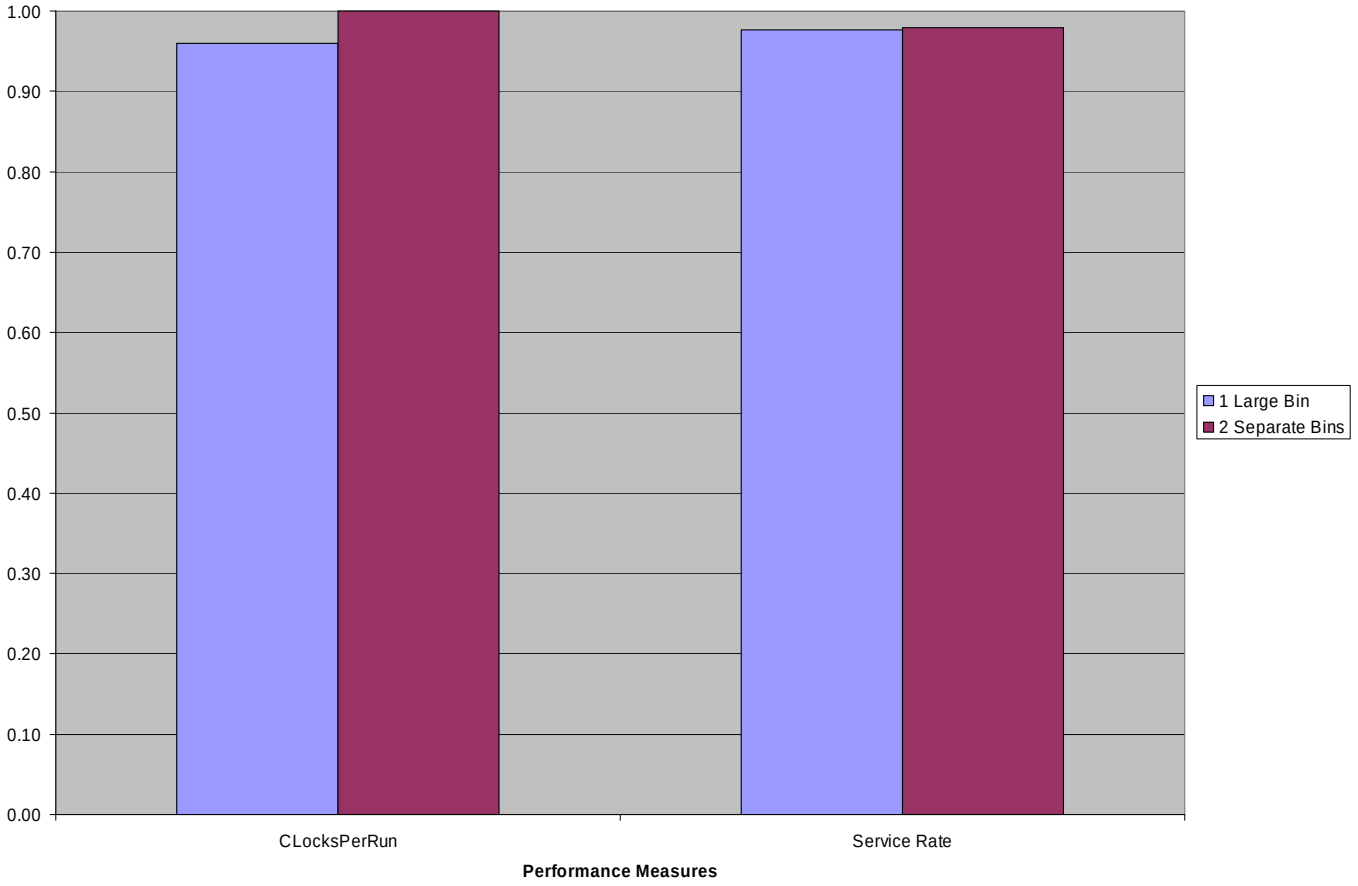
Results – Case I



Results – Case I



Results – Case I



Results – Case I

- Ordering over two bins reduces number of orders, inventory and costs, while increasing performance
- Even simple procedure is effective (managing group of bins as single bin)

Bin Consolidation – Case II

- Four Bins - Identical
- Separate:
  - Q = 281
  - R = 303
- Combined
  - Q = 543
  - R = 1086

Bin Consolidation – Case II Data Files

- Separate:

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	176	Y677	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	177	Y678	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	178	Y679	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00

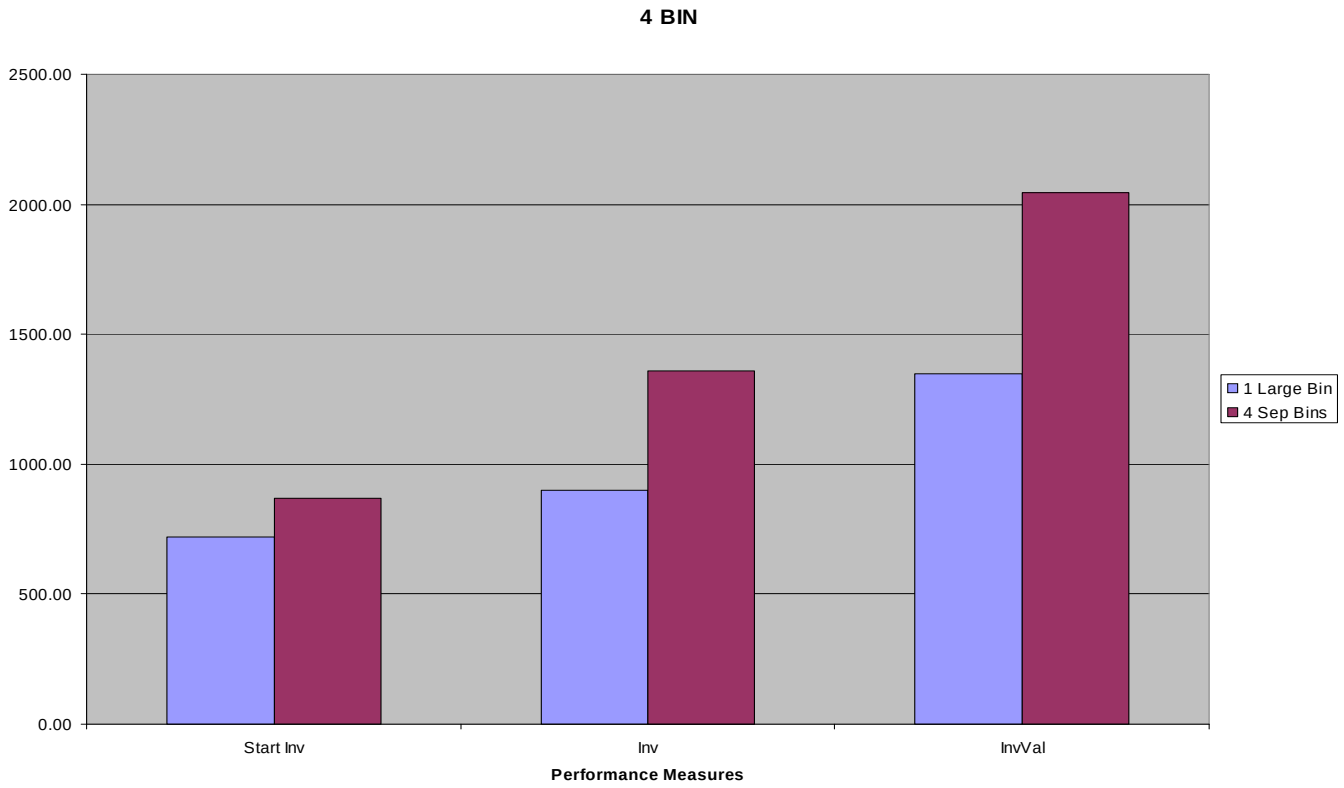
- Combined

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	543.00	1086.00	7.67	10.58	0.03	0.04	1.50	1.00	0.00	1500.00

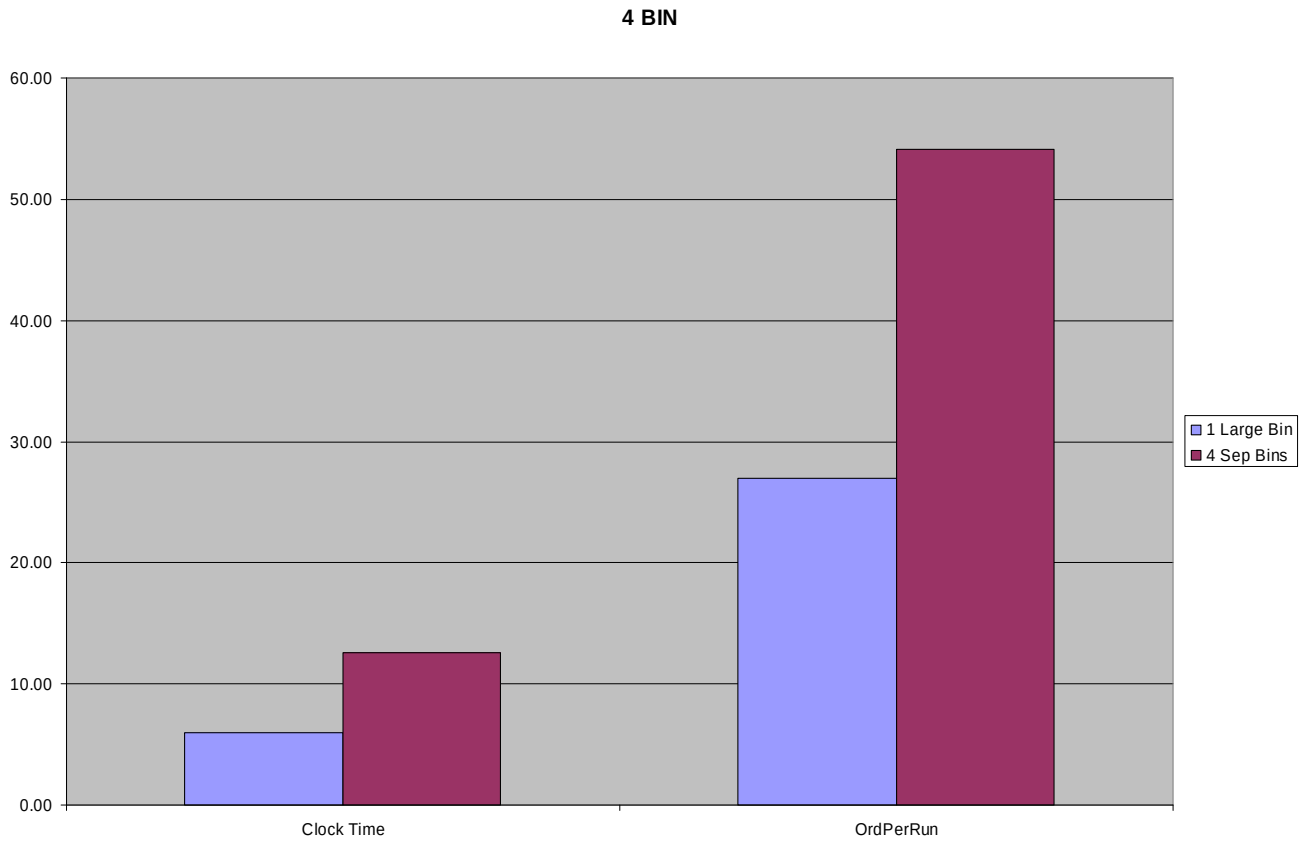
Results – Case II

	1 Large Bin	4BINA	4BINB	4BINC	4BIND	4 Sep Bins
Start Inv	719.00	200.000	231.000	221.000	217.000	869.000
Inv	898.00	340.000	344.000	336.000	341.000	1361.000
InvVal	1348.00	511.000	516.000	504.000	512.000	2043.000
Clock Time	6.00	4.600	2.600	2.700	2.700	12.600
OrdPerRun	27.00	13.500	13.600	13.400	13.600	54.100
CLocksPerRun	1.40	0.560	0.058	0.520	0.660	1.798
Service Rate	0.968	0.986	0.991	0.971	0.989	0.984

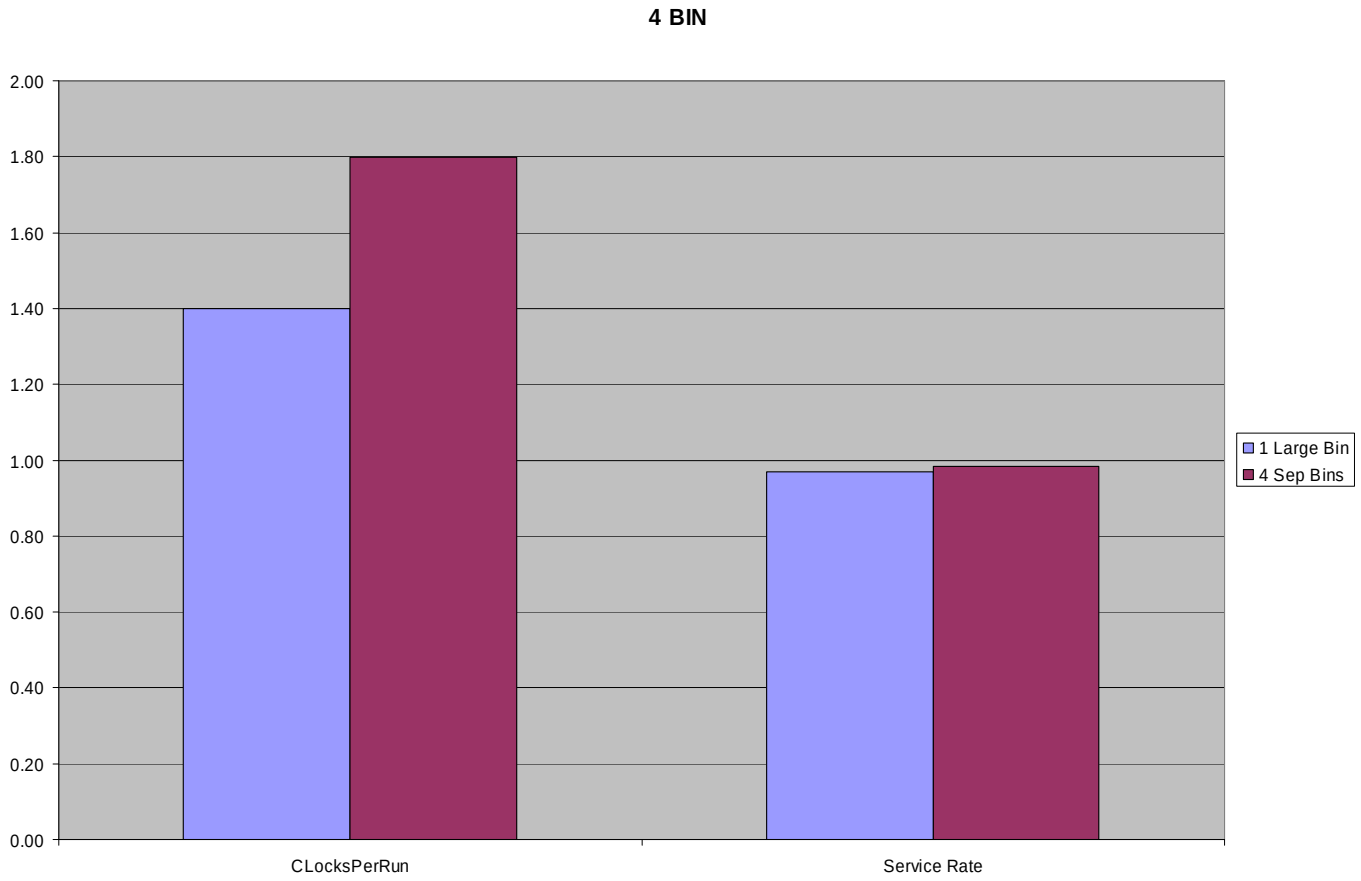
Results – Case II



Results – Case II



Results – Case II



Bin Consolidation – Case I I- Results

- Ordering over 4 bins is even more effective in reducing variance of bin management process and reducing inventory/increasing service rate

Conclusions

- Simulation has proved to be an effective tool in managing large scale inventory systems
  - Good Forecasting tool
  - Good analysis tool
  - Can be made transparent to non-technical users

Dr. Hank Grant

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Defining System Development Lifecycles to Plan and Manage Projects Effectively

Bruce A. Boyd

Associate Technical Fellow

The Boeing Company

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Problem Statement

Many plans for system development projects do not reflect an understanding of the development life-cycle strategies for the system elements being defined, developed and integrated.

This frequently leads to:

- **Simple, success-oriented (i.e., fantasy) plans**
- **Frequent project rebaselining and replanning**
- **Delivering less than desired capability**
- **Adding additional development cycles**
- **Work-arounds for late subsystems and components**
- **Re-architecting the system**

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Proposed Solution

- **Identify development life-cycle strategies for the overall system and for each major subsystem and component being developed.**

- **Integrate these life-cycle strategies into the plans for developing each subsystem and component comprising the system.**

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A Life-Cycle-Based Planning Process

1. Define the overall system architecture
2. Identify the applicable life-cycle strategies
3. Define the appropriate life-cycle phases
4. Define the iterations for each development
5. Identify the allocation and integration events
6. Identify the processes and work products
7. Define the overall project plan and schedule (e.g., IMP and IMS)
8. Define tasks, estimates, staffing, etc.

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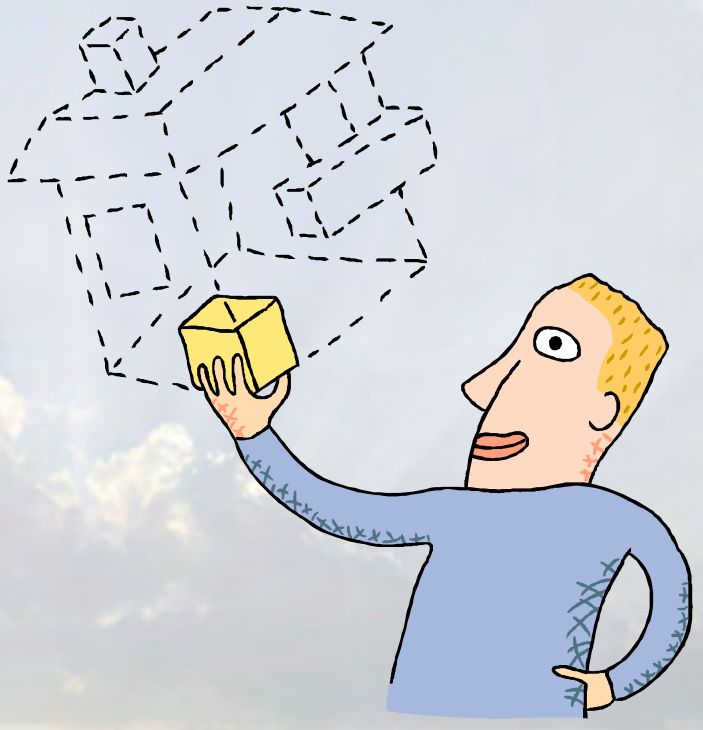
1. Define the System Architecture

Based upon an initial review and analysis of the customer's desired capabilities, define an overall system architecture (design concept).

This architecture should define the levels of system elements to be developed…

- **System of Systems**
- **Systems**
- **Segments**
- **Subsystems**
- **Software Items**
- **Assemblies**
- **Components**
- **Parts**



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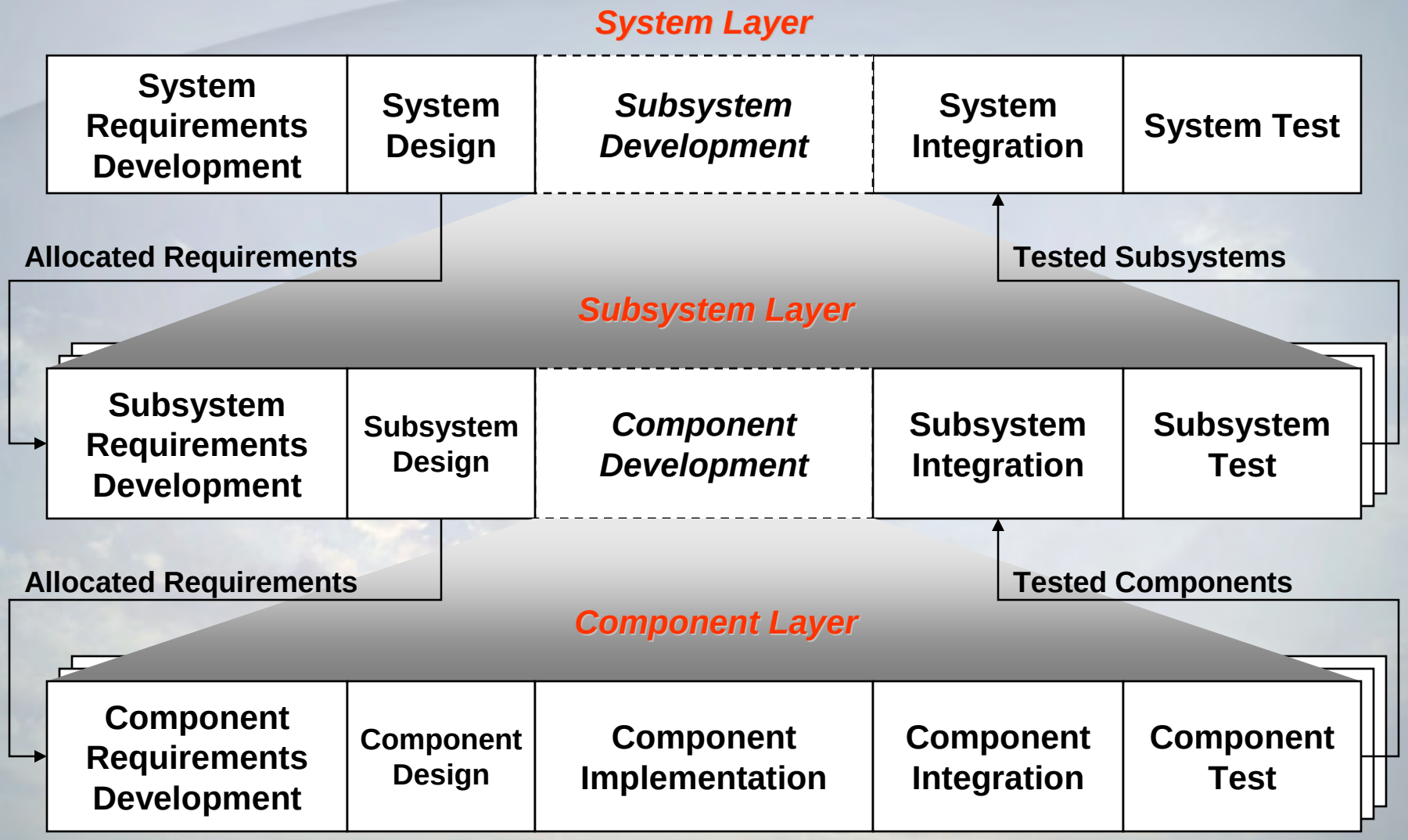
System Development Layers

The following examples will use this simple 3-layer architecture:



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Work Breakdown Structure

The project's work breakdown structure (WBS) should be developed in conjunction with the life-cycle planning activities.

- **It is assumed that the customer has provided a high-level WBS (e.g., Contract WBS or CWBS) that defines the high-level deliverables tied to contract line items (CLINs).**
- **It is the project's responsibility to add needed detail to this WBS to fully develop the Program or Project WBS (PWBS) that will be the basis for detailed project planning and tracking.**

Life-cycle-based planning provides a mechanism for evolving the WBS to the appropriate level of detail in a systematic manner.

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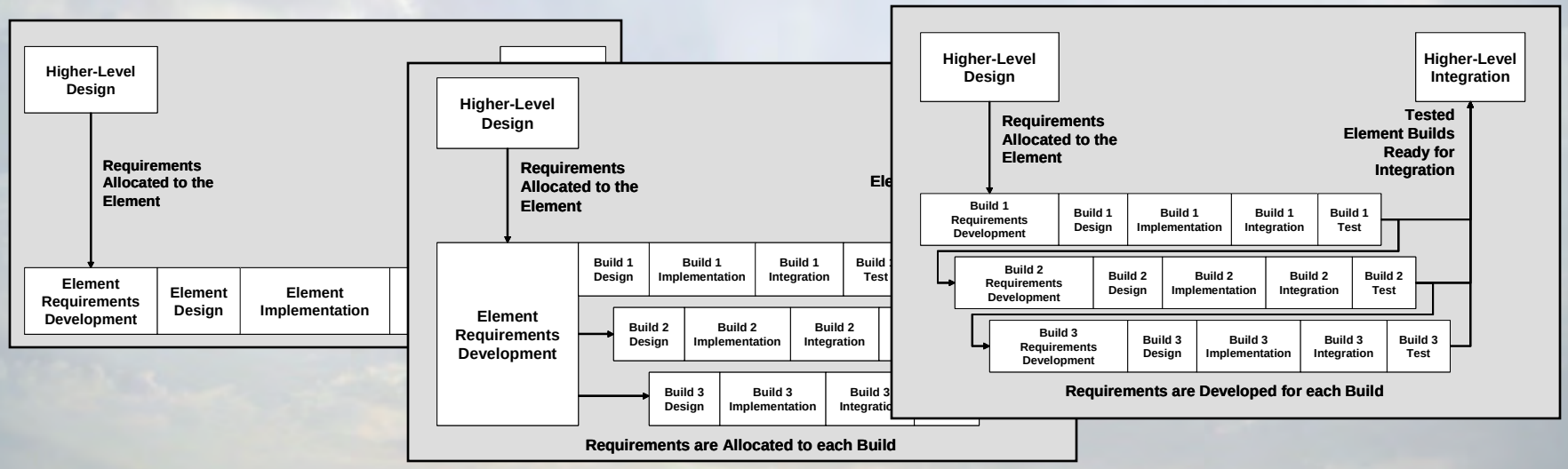
2. Identify Life-Cycle Strategy

At each level of system development identify the life-cycle strategy to be followed:

- **Once-through (Waterfall)**
- **Incremental**
- **Evolutionary (Spiral)**

The project may employ multiple strategies for different system developments, depending upon the complexities, risks, and delivery requirements for each system element.



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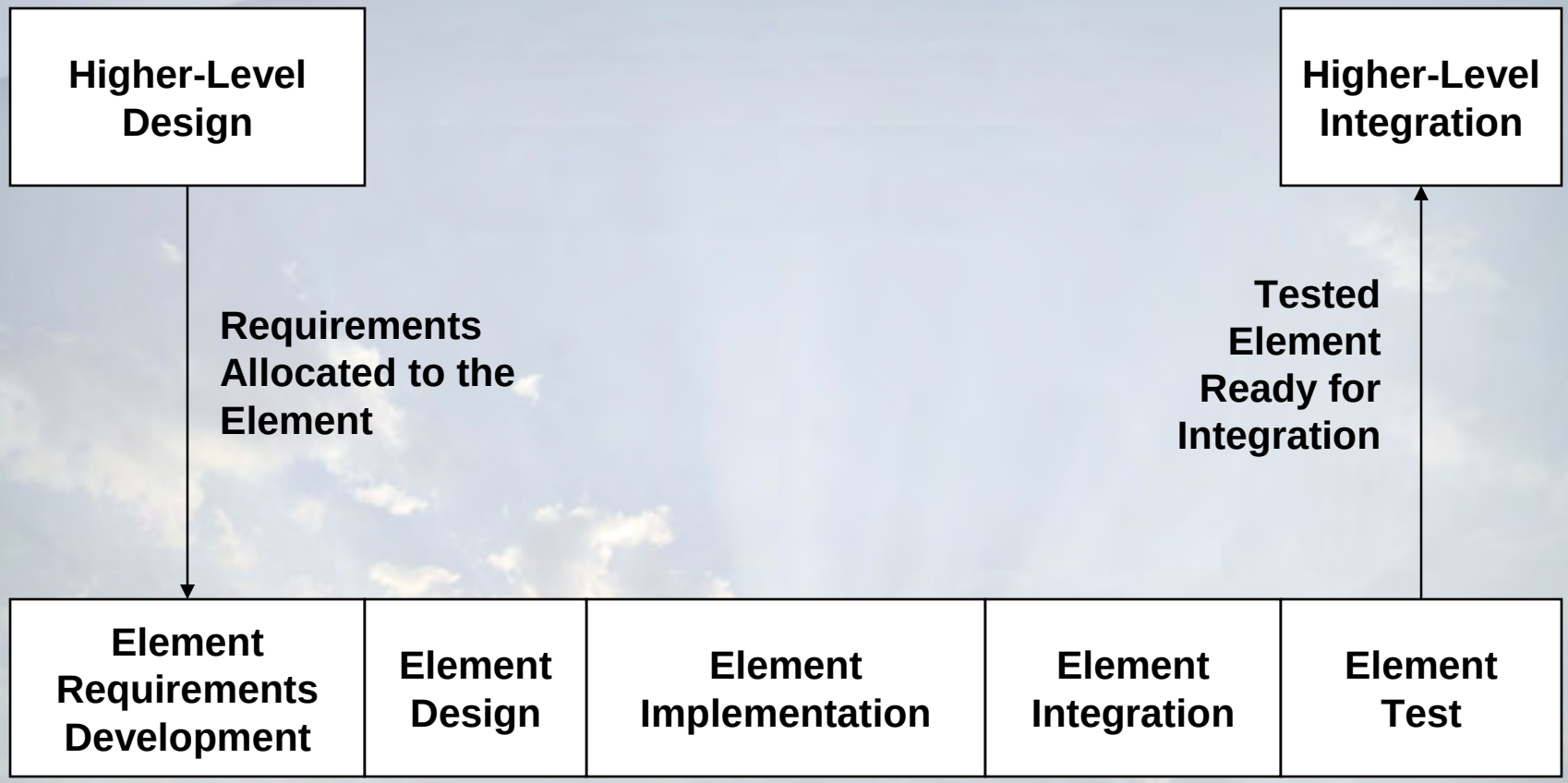
Once-Through Life-Cycle Strategy



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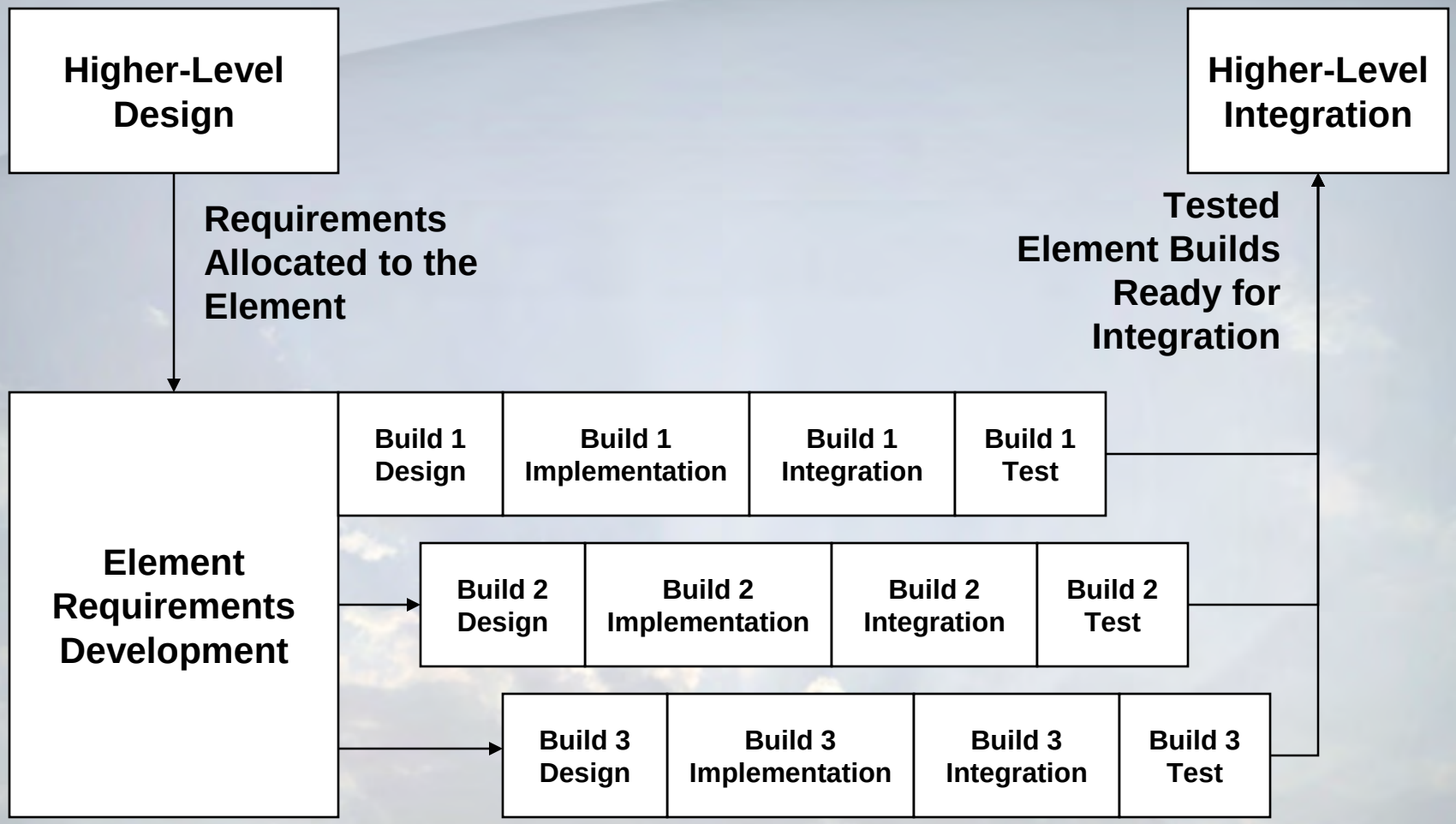
Incremental Life-Cycle Strategy



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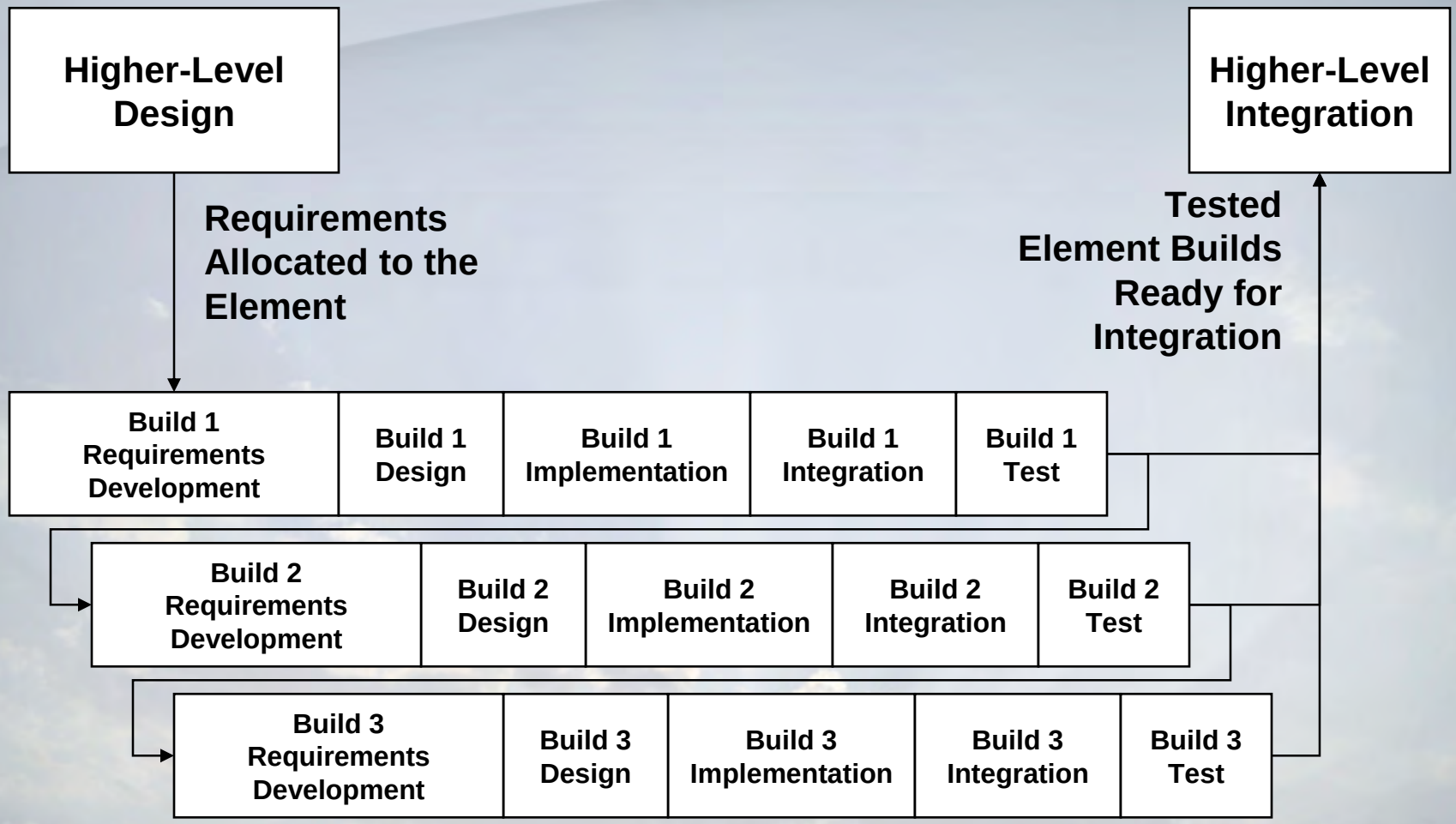
Evolutionary Life-Cycle Strategy



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Example - Overall System Strategy

- For the overall system, the customer wants Initial Operational Capability (IOC) in two years, and Final Operational Capability (FOC) in five years.
- IOC has some minimum requirements, but they would like as much capability as can be achieved with medium risk.
- FOC also has some minimum requirements, but the customer would like us to attempt to include some innovative capabilities.

These needs dictate an Evolutionary strategy at the system level with at least two iterations.

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Example – Subsystem Strategies

- One of the major subsystems is an upgrade to an existing legacy subsystem.
- The requirements are well defined and it is needed at full capability for IOC. It will not change for FOC.

The Once-Through (Waterfall) strategy is appropriate for this subsystem.

- Another major subsystem will employ an innovative networking technology that will require prototyping.
- The performance limits of this technology are not yet known.
- IOC requires this subsystem to be functional, but FOC requires a high performance level.

This subsystem will follow an Evolutionary strategy.

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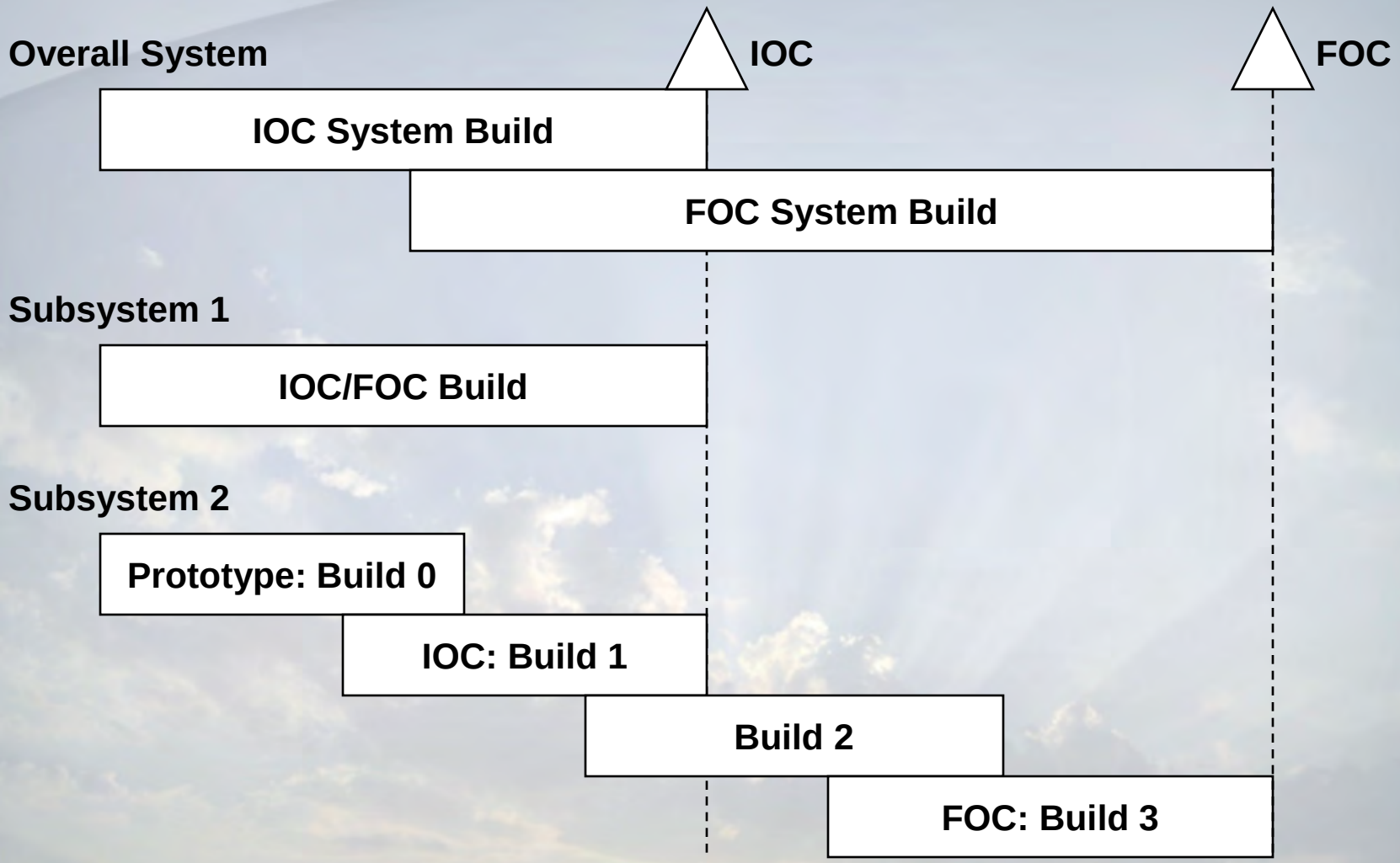
Example Build Plan



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3. Define the Life-Cycle Phases

- For each development, identify the life-cycle phases to be performed in each iteration.
- If an element includes hardware and software development, identify the phases and iterations needed for each.
- Identify procurement and supplier management phases, as appropriate.

- Typical development life-cycle phases include:
  - Requirements Development
  - Preliminary Design
  - Detailed Design
  - Implementation
  - Integration
  - Testing (V&V)

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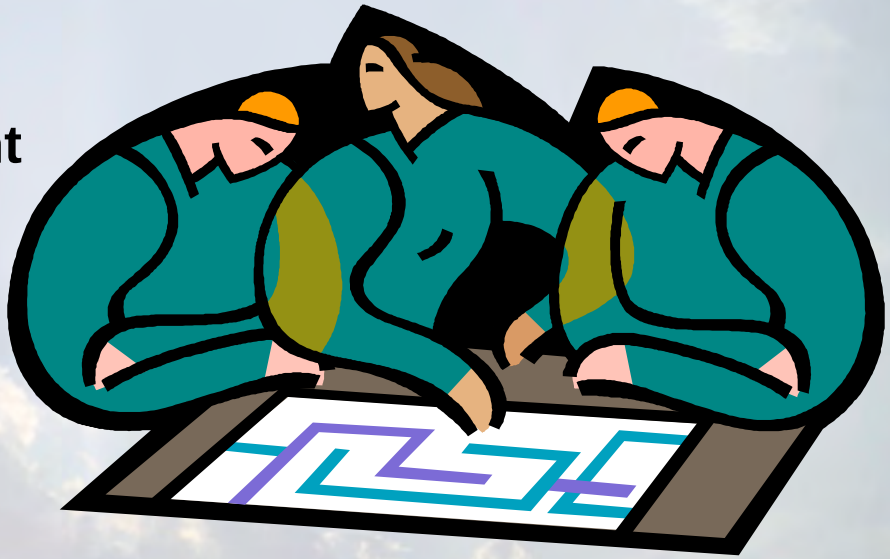
About Life-Cycle Phases

Phases may be defined at any or all system levels:

- **System of Systems, System, Subsystem, etc.**

The following are activities to be performed within phases, but are probably not themselves phases:

- **Requirements Analysis**
- **Requirements Validation**
- **Requirements Management**
- **Verification**
- **Validation**
- **Qualification Testing**
- **Rework**
- **Product Release**
- **Project Planning (?)**



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Example System Level Phases

At the overall system level, the following phases may be defined for the IOC Build:

- **System Requirements Development**
- **Preliminary System Design**
- **System Integration**
- **System Test**

Subphases may be defined within phases to provide more definition; e.g.,

- **System Test may be divided into…**
  - **Qualification Test**
  - **Flight Test**
  - **Operational Test (OT&E)**

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Example Subsystem Phases

At the subsystem level, Subsystem 2 may define the following phases for the IOC Build 1 iteration:

- **Subsystem Requirements Development**
  - **Software Requirements Development**
  - **Software Design**
  - **Software Implementation**
  - **Software Integration**
  - **Software Test**
  - **Hardware Requirements Development**
  - **Hardware Design**
  - **Hardware Implementation**
  - **Hardware Assembly and Checkout**
- **Hardware-Software Integration**
- **Subsystem Test**

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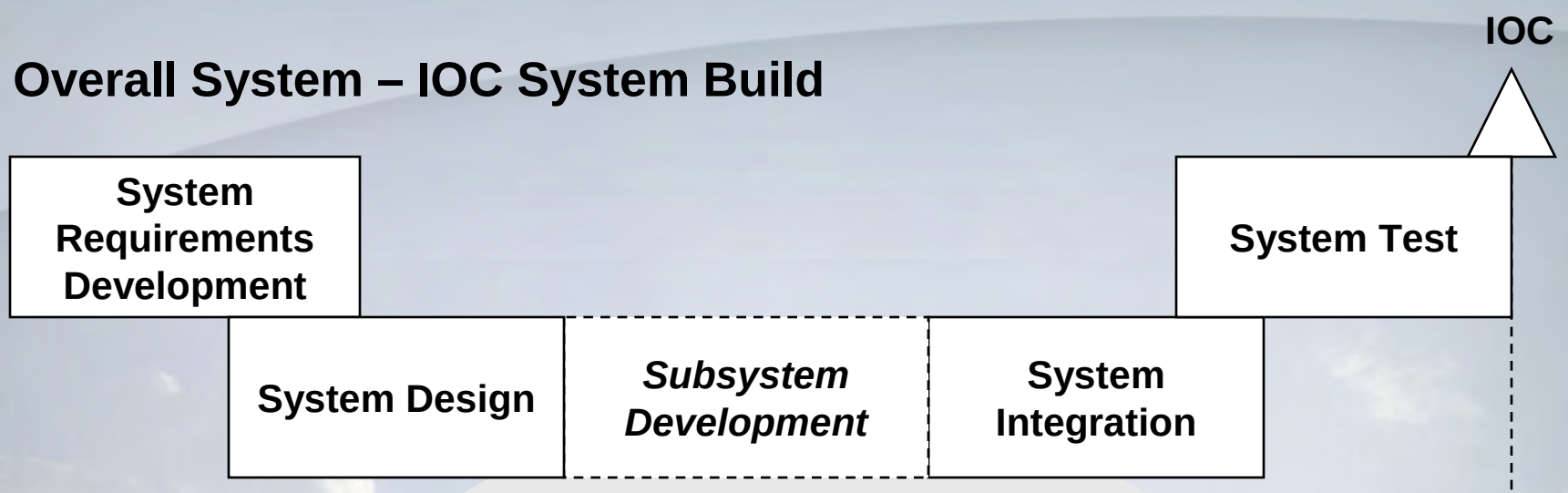
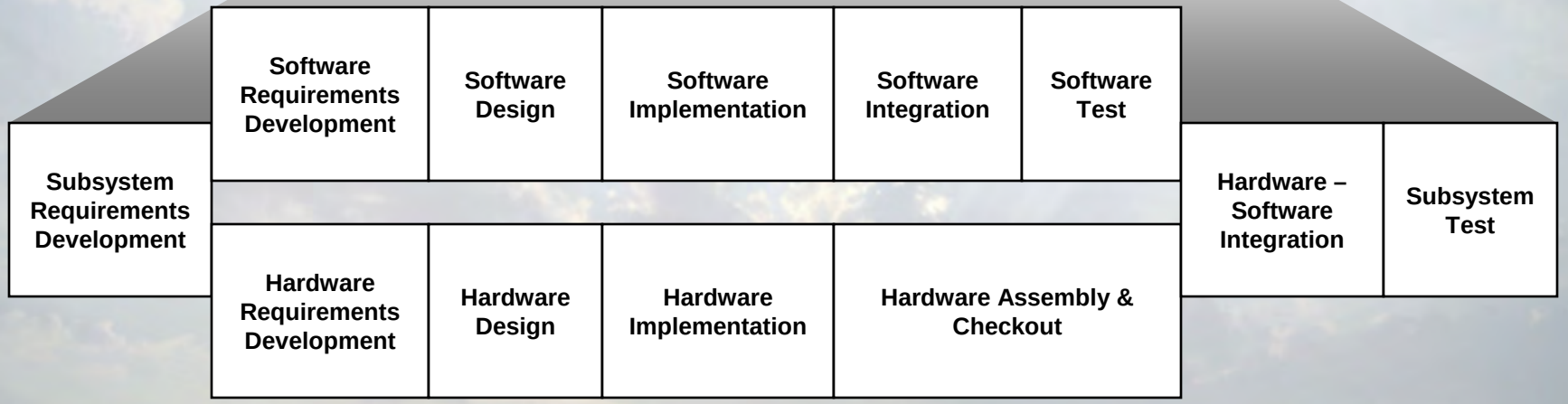
Example Phase Relationships

Overall System – IOC System Build



Subsystem 2 – IOC Build 1



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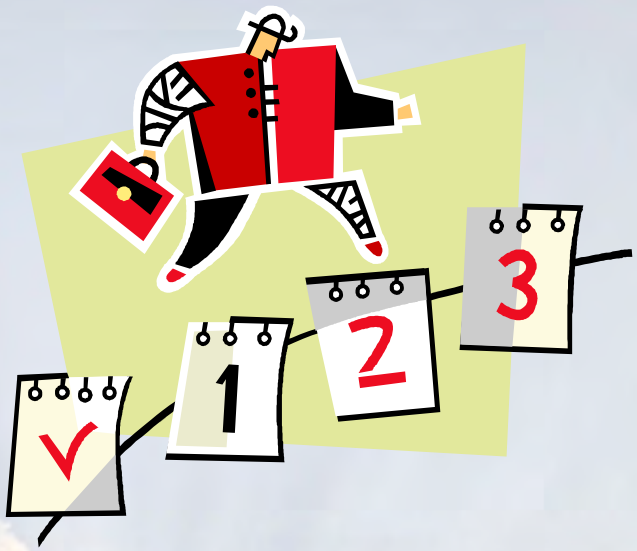
4. Identify Iterations

If not done already, define the iterations required for each incremental and evolutionary strategy.

Considerations:

- **Complexity**
- **Risk**
- **Maturity**
- **Delivery Needs**
- **Dependencies**
- **Constraints**



Each iteration should have a well-defined goal.

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Example Iteration Goal

- Subsystem 2 FOC hardware will not be ready until 1 year before the FOC milestone.
- To reduce risk, the customer would like to validate some communication functions in an operational environment using IOC hardware.
- Subsystem 2 Build 2 will accommodate this validation by providing a software-only build 1 year into FOC development.

Iteration Goal:

Validate the FOC Communication Software using the IOC Hardware Configuration

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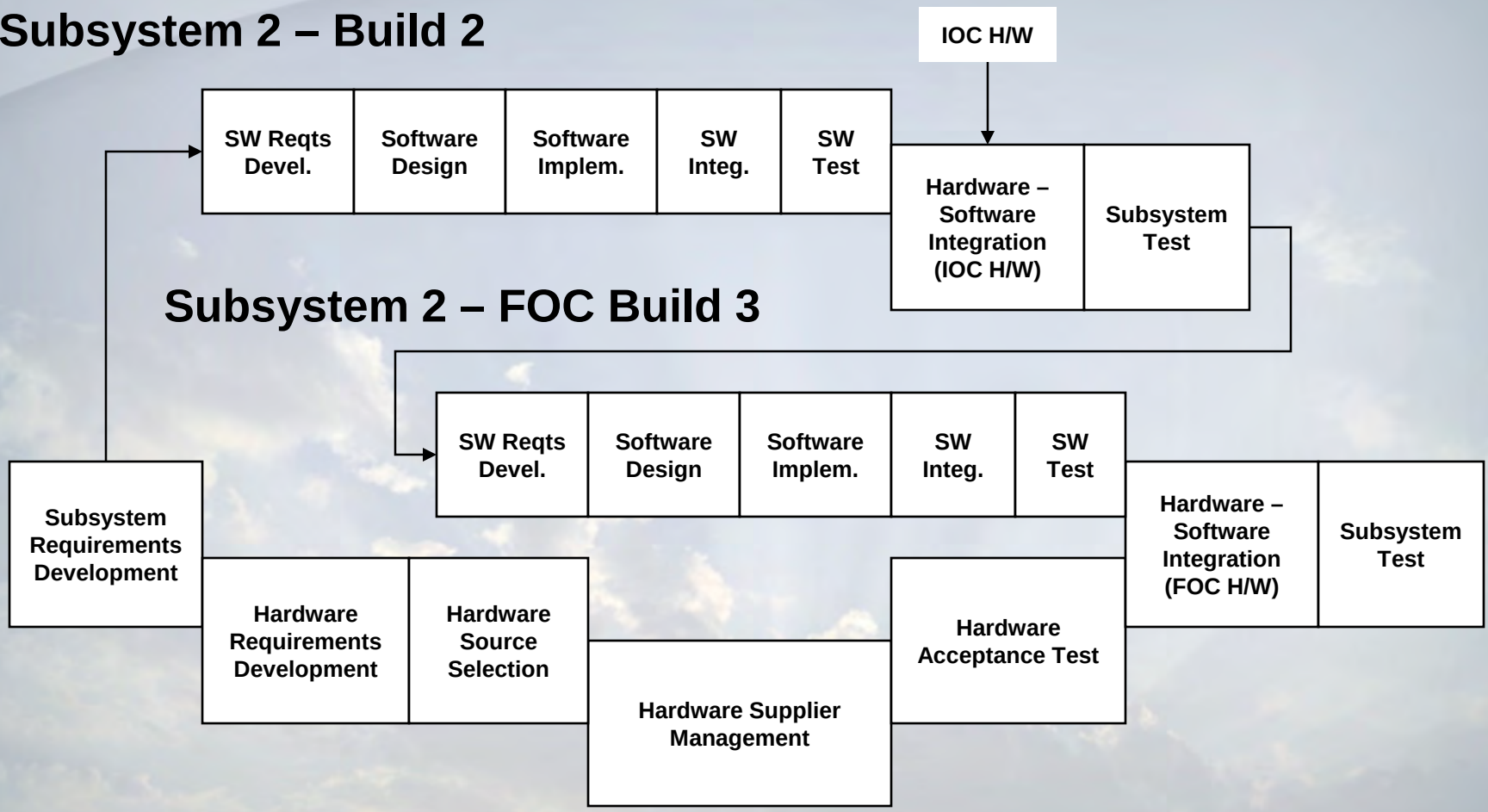
Example Subsystem Iterations



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5. Identify Allocation and Integration Events

Define the key points within each level of system decomposition when requirements will be allocated to lower tier elements and when lower-tier elements will be integrated into subsystems and systems.

These are good points at which to schedule milestone reviews such as: Subsystem Requirements Reviews (SRRs) and Test Readiness Reviews (TRRs).

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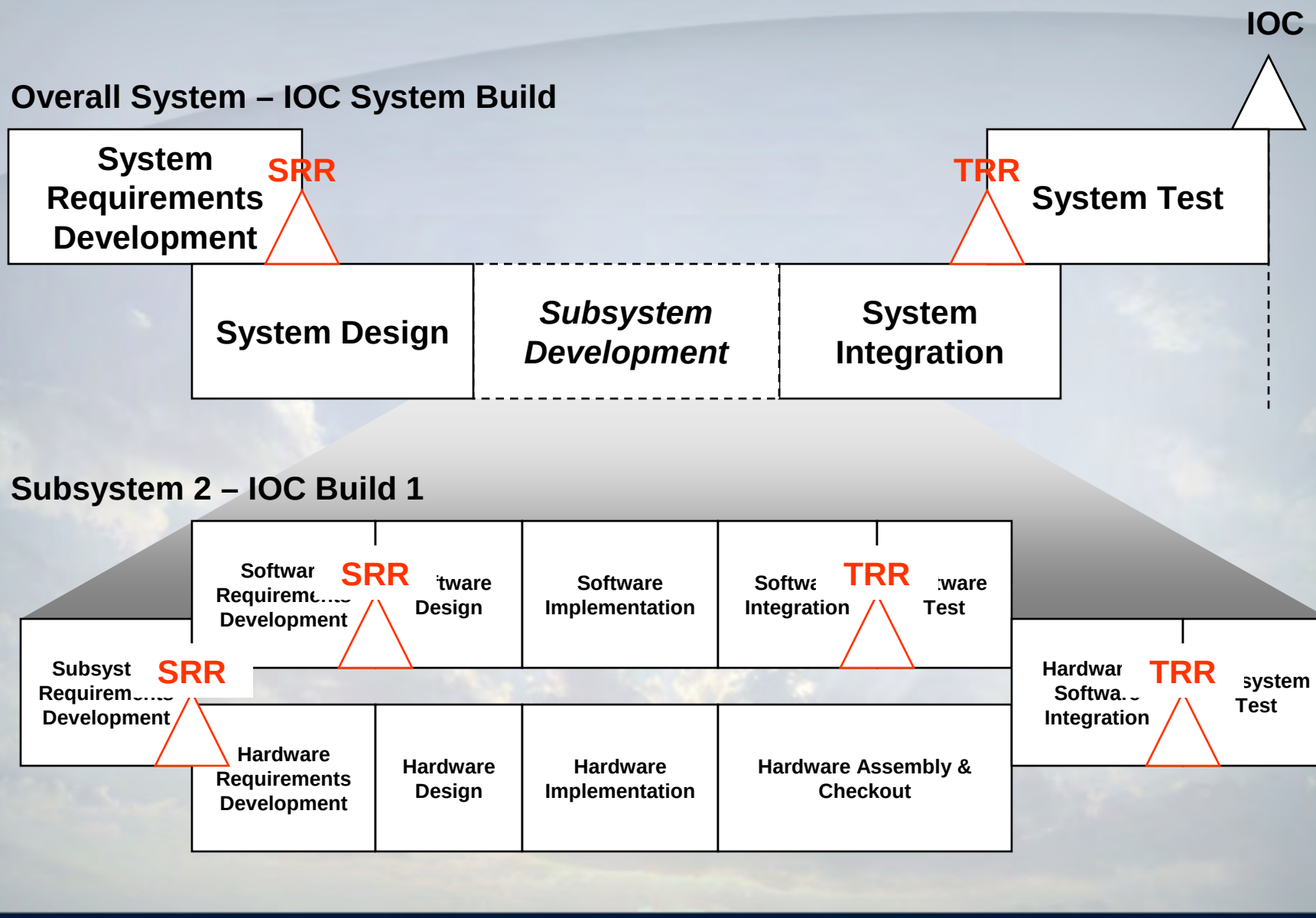
Example Milestone Events



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Allocation and Integration Events

When scheduling the project, these events are the key points for defining dependencies.

- **Subsystem development depends upon allocation of system-level requirements**
- **System-level testing depends upon completing the integration of subsystems**

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6. Identify Processes and Work Products

For each phase identified within each system element's life cycle:

- **Identify the processes that will be used to perform the activities in that phase**
- **Identify the major work products to be produced or updated during that phase.**

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Example Phase Processes and Work Products

For Subsystem 2:

Phase	Processes	Work Products
Subsystem Requirements Development	• Standard Project Planning Process • Standard Requirements Development Process • Standard Requirements Management Process	• Project Plan • Requirements Specification • Technical Performance Measures • Functional Architecture • Operational Concepts and Scenarios • Requirements Traceability

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7. Define the Project Plans and Schedule

Once the project's life-cycle phases have been defined in terms of processes and work products, define the overall project plans and schedules.

- A typical way to represent the overall planning with dependencies is with an Integrated Master Plan (IMP) and Integrated Master Schedule (IMS).
- However the overall plan is documented, it should be consistent with and/or traceable to the project's WBS.

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8. Develop Tasks, Estimates, Staffing

Using the overall project plans and schedules, define tasks that can be used as the basis for detailed estimating and staffing.

- **The tasks can be defined in terms of work packages which will be the basis for earned-value management.**
- **Again, the tasks and work packages should be consistent with the project's WBS.**

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Integration Considerations

- The steps described here may be performed iteratively or recursively, until the entire project scope has been defined.
- Life-cycle planning should be tightly integrated with project planning, requirements development, and process set definition.
- Multiple levels of life-cycle descriptions may be developed all at once or each level may be developed as its corresponding system element is defined.

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Conclusions

- Development life-cycles should be defined at all levels of the system architecture
- Life-cycle strategies, phases, and iterations should be defined as part of project planning
- Engineering processes should be mapped to all phases of system development
- Allocation and integration events define milestones and dependencies in the project's plans

The Bottom Line:
Use of a life-cycle planning process should result in project plans that are more accurate, comprehensive, and lower risk!

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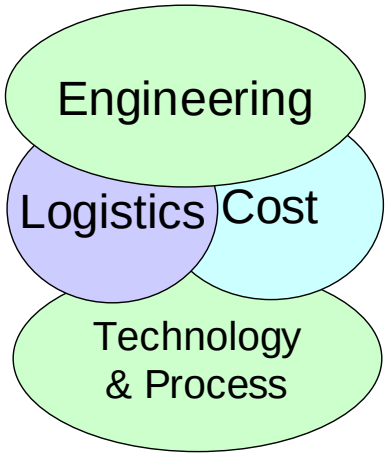
Process for Evaluating Logistics Readiness Levels (LRLs) for Acquisition Systems

October 26, 2005



Aging Aircraft Integrated Product Team (AAIPT)
Elizabeth Broadus
Booz Allen Hamilton, Inc.

Agenda

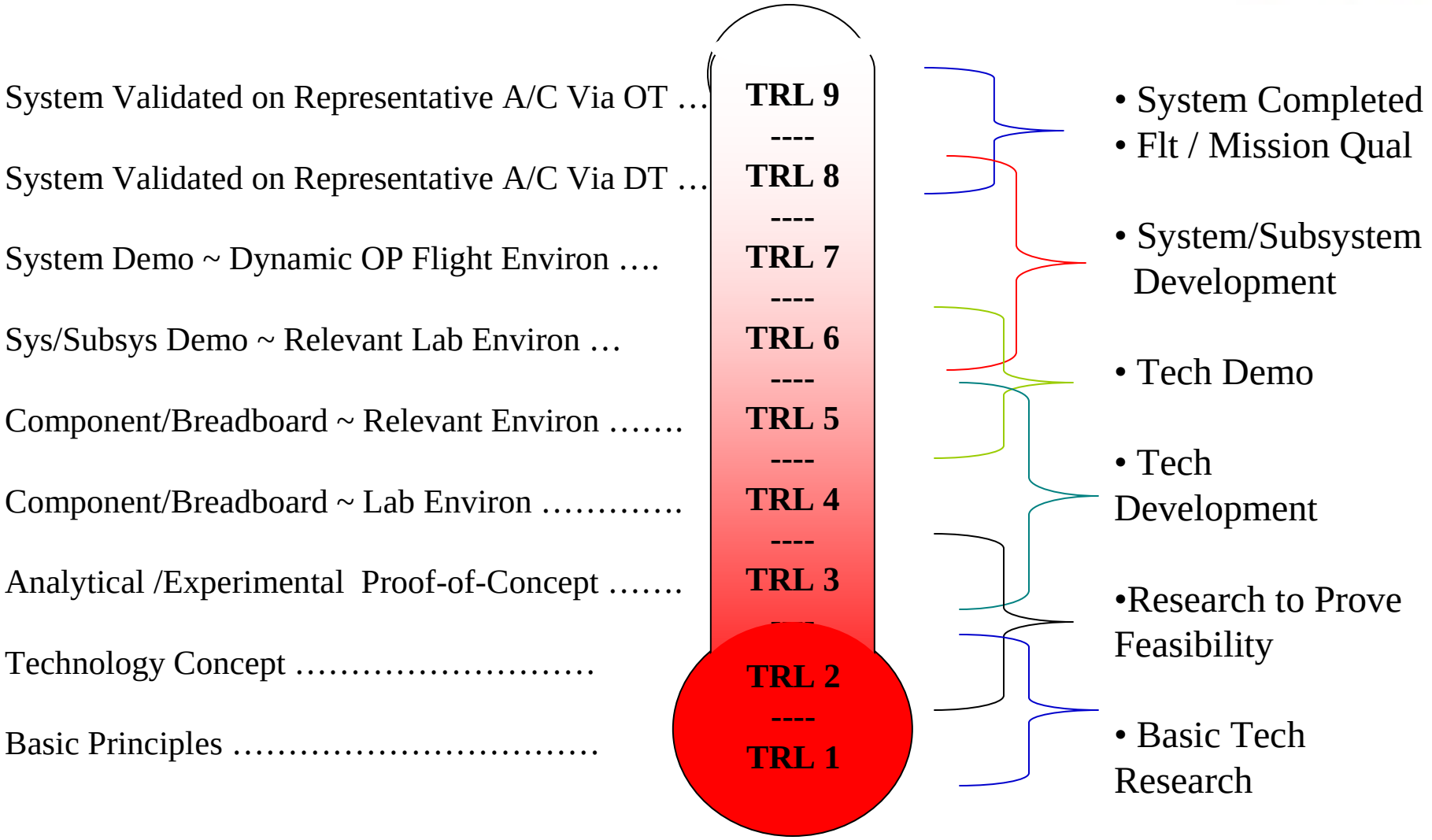
- Background of Logistics Readiness Level (LRL) concept
- LRL Defined
- LRL Excerpts
- Benefits
- Next Steps
- Questions
- NAVAIR Aging Aircraft Points of Contact

Background

- LRL concept initially based on the DOD 5000.2 mandated Technology Readiness Levels (TRL) assessment process

- TRLs provide:
  - Evaluation of critical technology maturity
  - Maturation plan (as needed)
  - Best practices/guidelines for each Milestone
    - MS B target is TRL = 6
    - MS C target is TRL = 7
    - MS C preferred is TRL = 8

Background: TRL Definitions



Background

- TRLs provide an understanding of the technical maturity without consideration of the sustainment of those technologies
  - TRLs were never intended to consider logistics
  - LRLs is a new concept with the intent to consider sustainment issues

- Logistics benchmark system was desirable
  - ~10 logistics elements that are often interdependent and parallel are required to successfully acquire, field, and support new technology
  - Aid in understanding what sustainment is required at different time phases

LRL Definition

- LRL intent:
  - Provide a methodology for assessing Logistic Element Readiness for technology
  - Establish benchmarks for programs at different phases in time
  - Provide a management tool to forecast logistics workload, manpower requirements, identify gaps, etc.
- NAVAIR Aging Aircraft convened a working group of engineers, logisticians, and program managers to draft an LRL concept
  - LRL concept is work in progress!!!
  - Initial phase was to focus on technology insertion for in-service (post MS C) aircraft platforms
  - LRL evaluated for project (vice platform)

Draft LRL

- LRL's considered at the project level (i.e. technology insertion) for an in service aircraft
- LRL's evaluated for 6 project phases:
  - Lab Test/R&D
  - Project Definition (Fleet Need/metrics/BCA/Decision to proceed)
  - Project Development /Implementation (Finalized analysis, change recommended, ECP development, Class II change development, RAMEC, LECP, other)
  - Engineering Validation
  - Fleet Verification
  - Fleet Use
- Answers question of what has to be done at each project phase for logistics

LRL Excerpt – Design Interface

Phase	Lab Test/R&D phase	Project Definition)	Project Development /Implementation	Engineering Validation	Fleet Verification	Fleet Use
Design Interface	Review and identify significant **design interface** impacts of project to existing system or platform (ex. available power, weight constraints, etc.) Create POAM to resolve any design interface issues.	Existing **Reliability and Maintainability** (RAM) metrics reviewed. Initial improvement predictions determined. **Design interface** issue resolution in work.	For new designs, **Reliability Centered Maintenance (RCM)** and **Failure Modes and Effects Analysis (FMECA)** completed to identify failure modes, failure frequency, effect on performance, and criticality. For modifications to existing design, RCM and FMECA reviewed for impacts. **Design interface** issues resolved.	Results of **RCM** and **FMECA** used to develop or modify existing condition based and schedule based maintenance tasks. Results of RCM and FMECA also used to update the Critical Items list as applicable. Technical data updates drafted and validated.	**Technical updates** (such as Maintenance Requirement Card changes) verified.	**Technical** updates completed and available.

LRL Excerpt – Training and Facilities

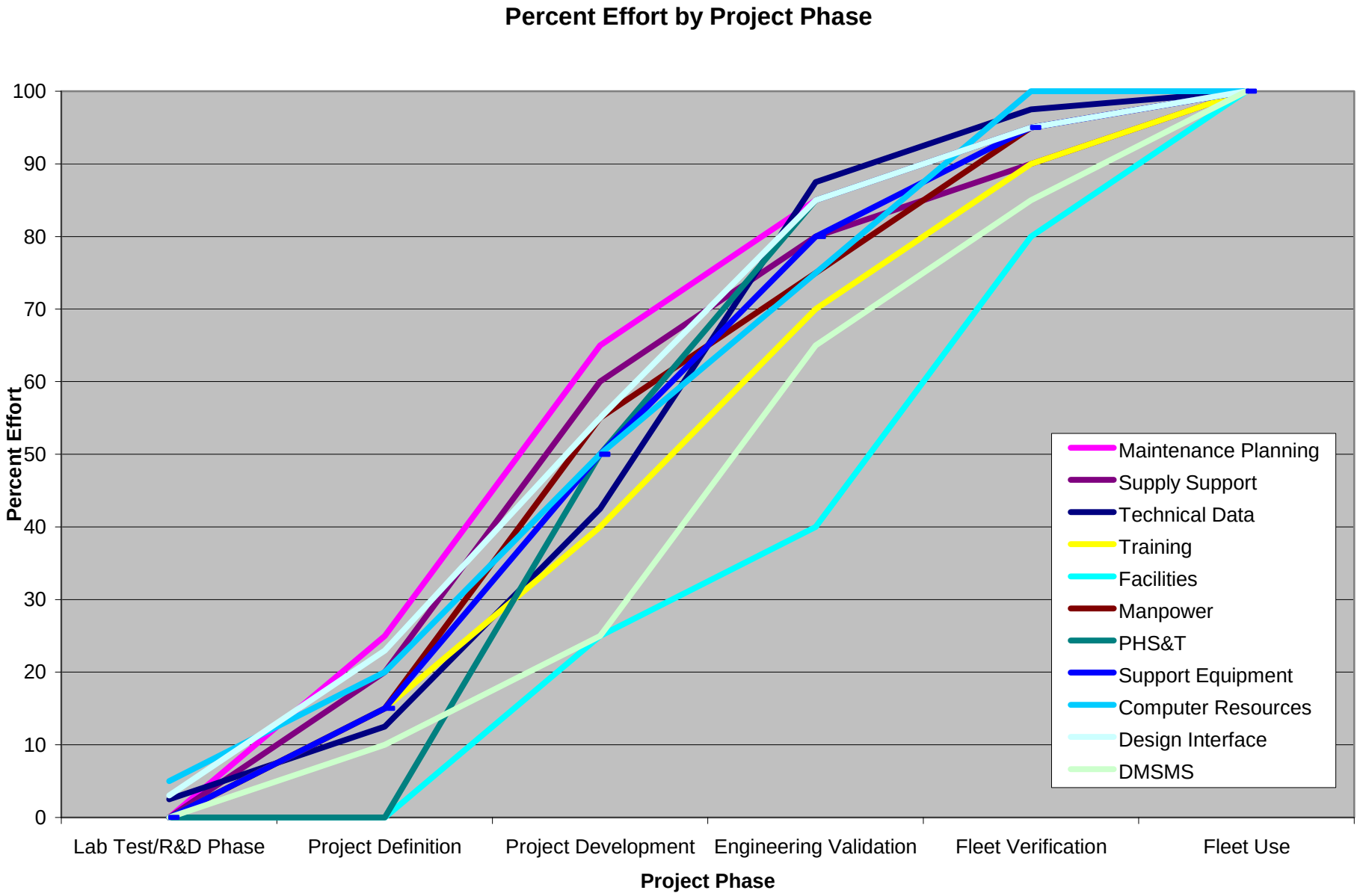
Phase	Lab Test R&D phase	Project Definition	Project Development /Implementation	Engineering Validation	Fleet Verification	Fleet Use
Training		Existing training procedures/curricula and training plan identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated post validation/verification with changes as necessary. NTSP changes finalized. Changes submitted for approval.	**Trainining** curricula updated. **NTSP** updated.
Facilities			Current **Facilities** reviewed and impacts identified. When applicable, facilities modifications or new requirements are documented and analysis completed for (in) adequacy of existing facilities, trade studies for optimal new facility, funding requested.	As needed with funding available, **Facilities** modifications or new facilities projects in work.	**Facilities** project completed and approved.	New or modified **Facilities** completed .

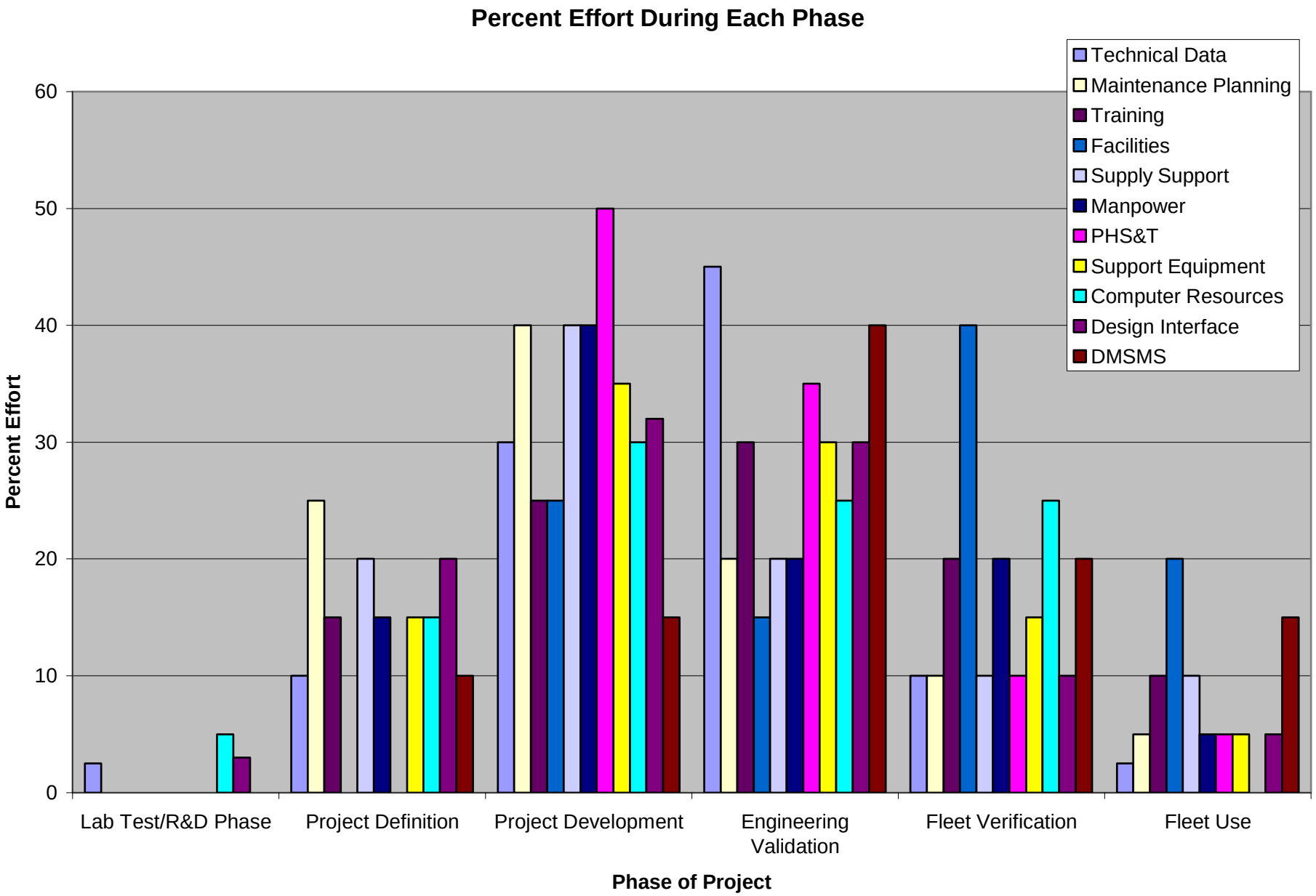
LRL Excerpt – DMSMS

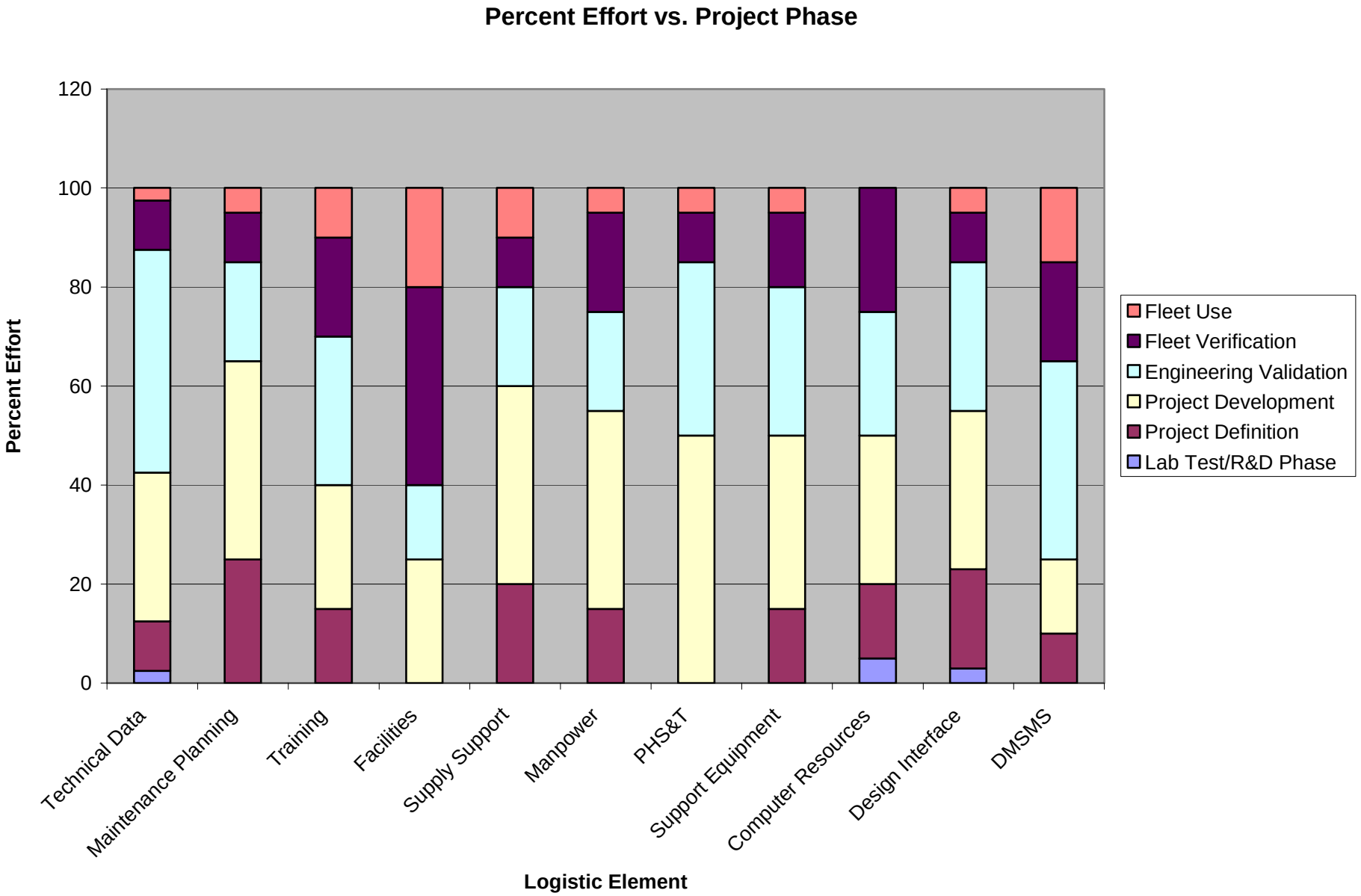
Phase	Lab Test R&D phase	Project Definition	Project Development /Implementation	Engineering Validation	Fleet Verification	Fleet Use
DMSMS		Existing **DMSMS program management plan** reviewed. Determine the **technical refresh strategy** (2 yr, 4 yr, spiral, etc.)	New technology evaluated to determine criticality as it relates to DMSMS. Assess components against the tech refresh strategy. **Impacts to DMSMS plan or metrics identified.**	**DMSMS forecasting** completed for new technology. Updates to DMSMS management plan drafted. Technical data package requirements drafted.	**DMSMS management plan** updated. Technical data package that supports DMSMS mitigation strategy available.	**Metrics** and usage monitored as required.

Draft LRL

- Evaluated percentage of total effort required at each phase
- Graphed percentage effort as a function of phase of the project
- Percent effort is subjective number based on efforts outlined in the LRL for each element at each phase
- Many other ways to depict data
  - 3 examples follow


Percent Effort by Project Phase
100
90
80
70
60
50
40
30
20
10
0
Percent Effort
Lab Test/R&D Phase
Project Definition
Project Development
Engineering Validation
Fleet Verification
Fleet Use
Project Phase
Maintenance Planning
Supply Support
Technical Data
Training
Facilities
Manpower
PHS&T
Support Equipment
Computer Resources
Design Interface
DMSMS


Percent Effort During Each Phase
Technical Data
Maintenance Planning
Training
Facilities
Supply Support
Manpower
PHS&T
Support Equipment
Computer Resources
Design Interface
DMSMS
60
50
40
30
20
10
0
Percent Effort
Lab Test/R&D Phase
Project Definition
Project Development
Engineering Validation
Fleet Verification
Fleet Use
Phase of Project


Percent Effort vs. Project Phase
Percent Effort
120
100
80
60
40
20
0
Technical Data
Maintenance Planning
Training
Facilities
Supply Support
Manpower
PHS&T
Support Equipment
Computer Resources
Design Interface
DMSMS
Logistic Element
Fleet Use
Fleet Verification
Engineering Validation
Project Development
Project Definition
Lab Test/R&D Phase

LRL Benefits

- Benefits include:
  - LRLs will be a template/benchmark to measure readiness by logistic element on a project level basis
  - Template can be utilized to train/mentor new logistics personnel (and engineering personnel) in sustainment requirements for tech insertion projects
  - LRLs will aid in planning manpower/funding/schedule requirements for projects as they mature from project concept to implementation
  - LRLs will dovetail with logistics risk assessments for another perspective

Next Steps

- Continue to collect input on Draft LRL concept
- Brief Draft LRL concept to solicit further input
- Update/change draft as needed
- Establish a working group to expand the scope to encompass aircraft in the entire lifecycle vice limiting to in-service aircraft
- Apply and test the process at NAVAIR AAIPT

Questions?

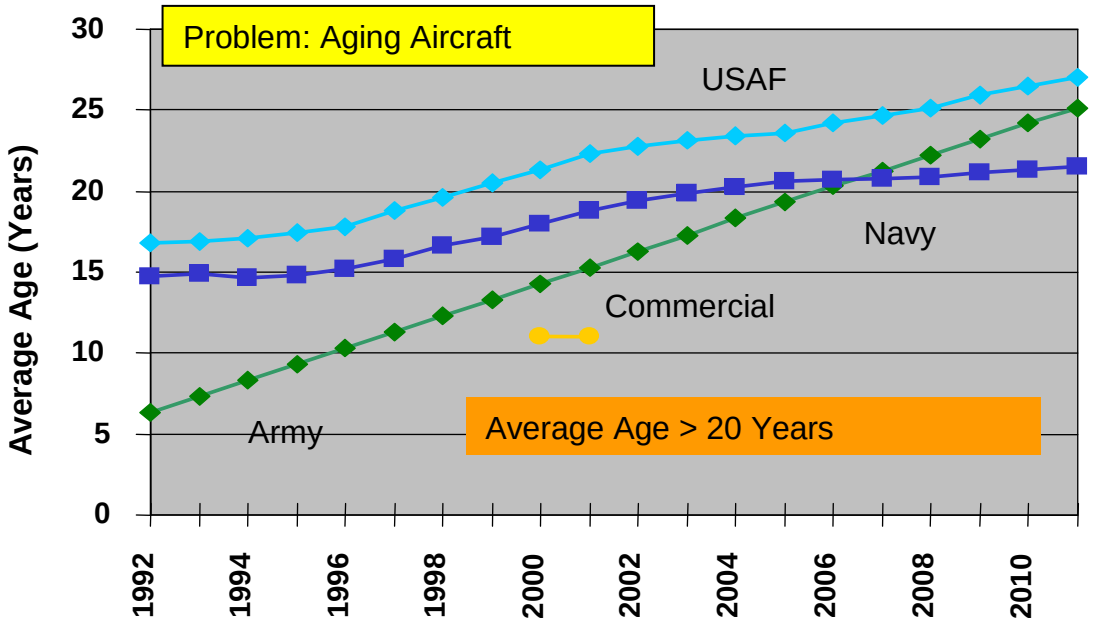
AAIPT Points of Contact

- AAIPT Lead, Bob Ernst, 301-342-2203, robert.ernst@navy.mil
- AAIPT Assistant Program Manager for Logistics, Harry Proffitt, 301-757-0868, melvin.proffitt@navy.mil
- AAIPT Air Vehicle IPT lead, Don Sheehan, 301-342-0131, donald.sheehan@navy.mil
- AAIPT Consultant, Elizabeth Broadus, 301-862-7049, broadus_elizabeth@bah.com

Backup Slides

AAIPT Organization

Why is an AAIPT needed?



AAIPT Vision:

- Identify Problems - Quantify Risk
- Provide **Information** to Program teams
- Advocate for **Enabling Technologies**
- Provide Standard **Risk & Cost Evaluation** Tools
- Focus Attention to Aging Aircraft problems
- Leveraged Funding to reduce cost

AAIPT Organization

AIR 1.0

AIR 3.0 / 6.0

AIR 4.0 / 5.0

AAIPT LEAD

STAFF FUNCTIONS

- Command Support Throughout NAVAIR
- Technical Expertise
- Adequately staffed to meet emergent needs (Triage)

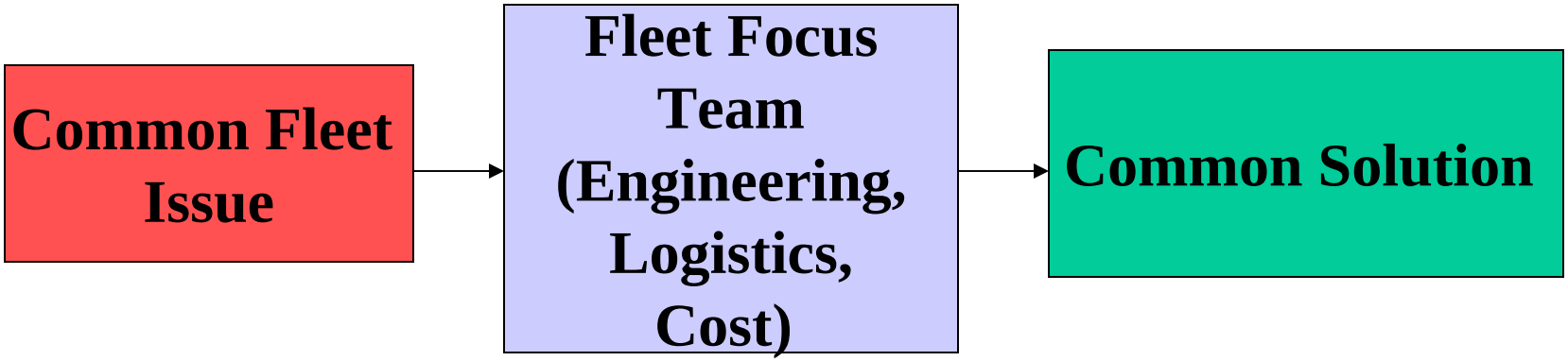
WIRING & POWER	AIR VEHICLE	AVIONICS	OBSOLESCENCE	FASTRACK SUSTAINMENT (S.E.T.)	ENVIRONMENT
On Board Diagonstics	Corrosion	S & T	Policy	Policy	LOGISTICS
Off Board Diagonstics	Hydraulics	Legacy	Process / Tools	Process	COST
Circuit Protection	Transparencies	Process	"Hot Line"	Products (H53, H-1, AV-8, H-46)	FINANCES
Batteries	Aeromachanics		PMA Support		CONTRACTS
Process Improvement	NDI / NDE				JCAA
	Bearings				
	Repair / Bonding				
	Fire Extinguisher				
	Structure Analysis				

Fleet Focus Teams

Fleet Focus Team

- Fleet Focus Teams (FFTs) identify, communicate, and leverage engineering solutions across Type Model Series and/or Service Boundaries

Simply Stated:



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Ordnance Safety & Security Activity

Lessons Learned with the Application of MIL-STD-882D at the Weapon System Explosives Safety Review Board

Mary Ellen Caro
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Systems Safety/Joint Programs
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Presented to:
8th Systems Engineering Conference
26 October 2005

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Agenda

- WSESRB Background
- MIL-STD-882D Evolution
- MIL-STD-882D Implications for
  - System Acquisition
  - System Safety Program Planning
  - Safety Program Execution
  - Safety Risk Management
- Conclusion

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WSESRB Background

- The WSESRB was established in 1967 as a result of several mishaps aboard aircraft carriers

USS Oriskany (1966)

- The purpose of the WSESRB is to provide an independent and technical review of the adequacy of the Program's system safety program and artifacts

USS Forrestal (1967)

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WSESRB Authority

DODI 5000.2 Para E7.7

- *PM shall identify, evaluate and manage safety and health hazards*
- *Explains the process for accepting risk*

SECNAVINST 5000.2C

- *CNO may establish system safety advisory boards (7.3.3)*
- *WSESRB is primary explosives safety review prior to DT/OT and Milestones (5.2.1.4.2)*

SECNAVINST 5100.10H

- *Directs CNO/CMC to establish safety programs*

OPNAVINST 8020.14/MCO P8020.11

- *Explosives Safety Policy*
- *Tasks COMNAVSEASYSCOM to establish WSESRB*

NAVSEAINST 8020.6D

- *Defines WSESRB process and procedures*

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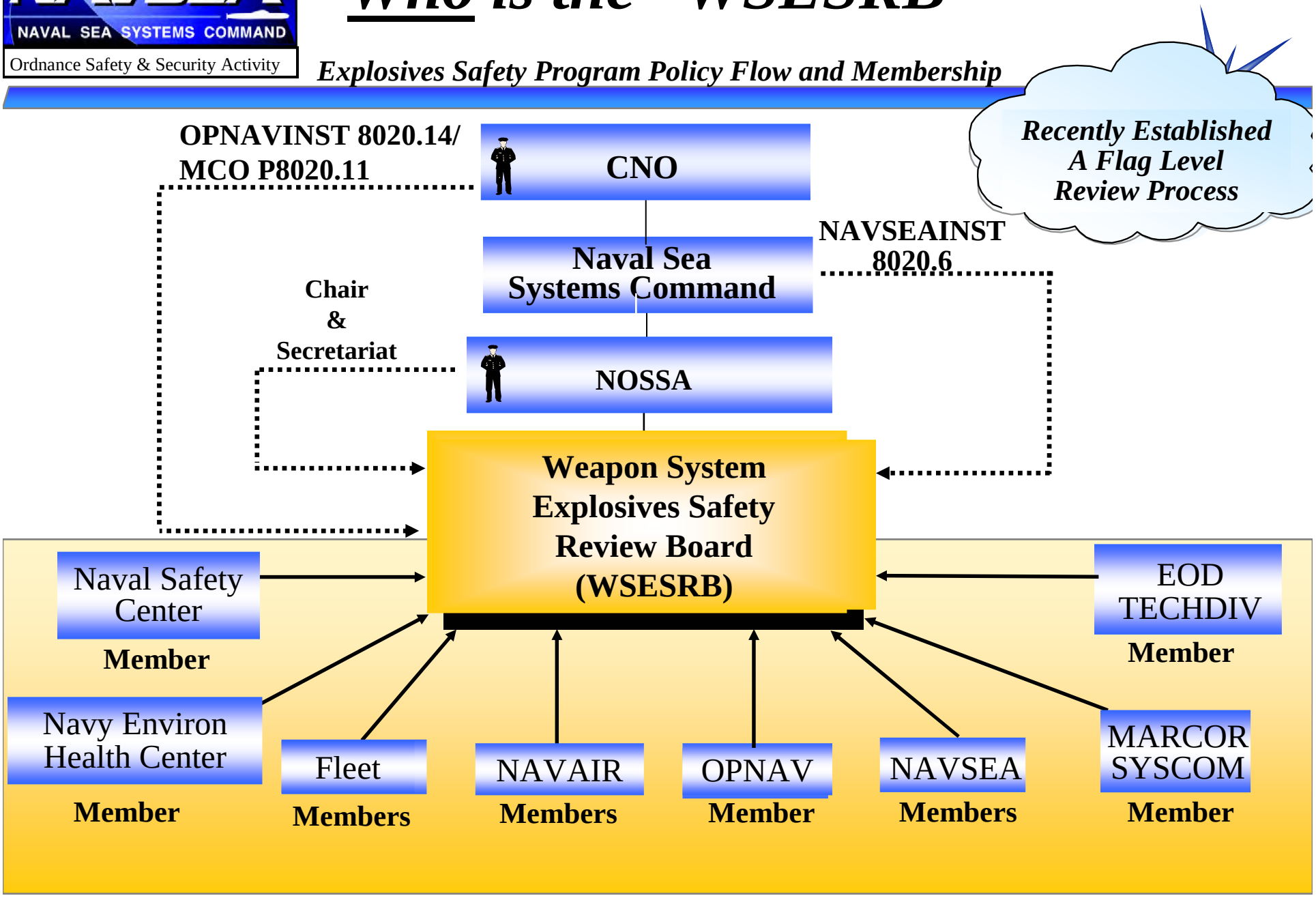
Who is the "WSESRB"

Explosives Safety Program Policy Flow and Membership



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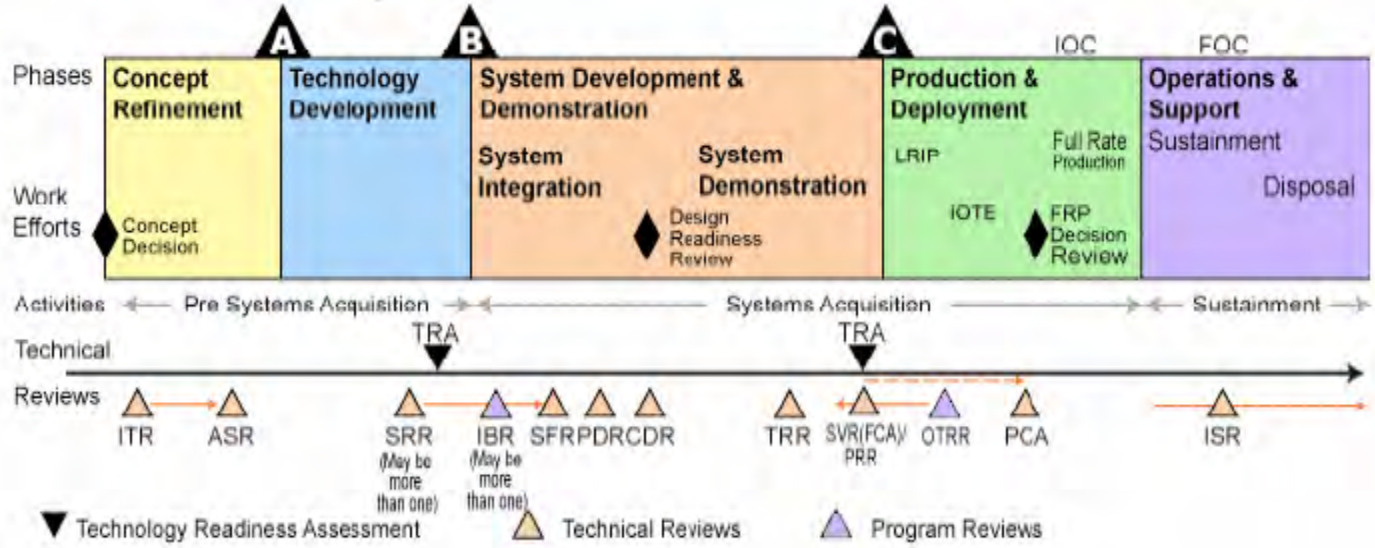
Acquisition Life-Cycle

WSESRB reviews occur throughout that life-cycle



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Transition to MIL-STD-882D

- Developed as result of acquisition reform
  - Converted to Standard Practice document
- Eliminated system safety tasks
  - "What to do" not "How to do it"
- Example Mishap Risk Index and defined High, Serious, Medium and Low risks
  - Agreement with DoDI 5000.2
  - Ability to tailor to specific programs
- Requirement for Closed Loop Hazard Tracking

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MIL-STD-882D Process

- Eight basic steps to the MIL-STD-882D Standard Practice
  - Documentation of the System Safety approach
  - Identification of hazards
  - Assessment of mishap risk
  - Identification of mitigation measures
  - Reduction of mishap risk to acceptable level
  - Verification of mishap risk reduction
  - Acceptance of residual risk
  - Hazard tracking

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System Acquisitions

- MIL-STD-882D calls for System Safety Program, but eliminated tasks
  - No tasks to identify in solicitation
    - "The bidder shall execute a system safety program in accordance with MIL-STD-882D"
    - "System Safety Hazard Analysis shall be provided xx days prior to DRR"
  - Bidders propose safety programs for best competitive advantage
  - Proposals may vary widely in planned system safety program
  - Potential ambiguities between buyer and seller in program execution

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System Acquisitions

- Lessons Learned
  - Solicitation needs to be as specific as possible and identify types of system safety efforts required of the developer (e.g., system safety program plan/POA&M, hazard analyses, hazard testing, certification requirements)
  - For Navy ordnance and weapon programs, there are many required tests and analyses that need to be identified in solicitation documents
  - Safety should to be part of Source Selection Criteria and participate in proposal evaluations

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System Safety Program Planning

- DoDI 5000.2 only requires a PESHE
- MIL-STD-882D requires system safety program planning, but no longer identifies a task for the System Safety Program Plan (SSPP)
- Solicitation may or may not require an SSPP to be submitted with the proposal

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System Safety Program Planning

- Lessons Learned
  - A specific system safety plan needs to be developed for the program including identification of responsibilities, schedules, safety analyses, safety testing. Typically SSPPs are still being prepared.
  - For large complex programs, the Government should develop a System Safety Management Plan to identify how project safety efforts are aligned and integrated.

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Safety Program Execution

- Integrated Product Process Development structure applied almost universally
- Concurrent engineering requires real time safety participation
  - Hazard identification
  - Hazard characterization
  - Prioritization of hazards
  - Identification of hazard mitigation
  - Implementation and verification of hazard risk mitigation
- Collaborative effort with Design IPTs

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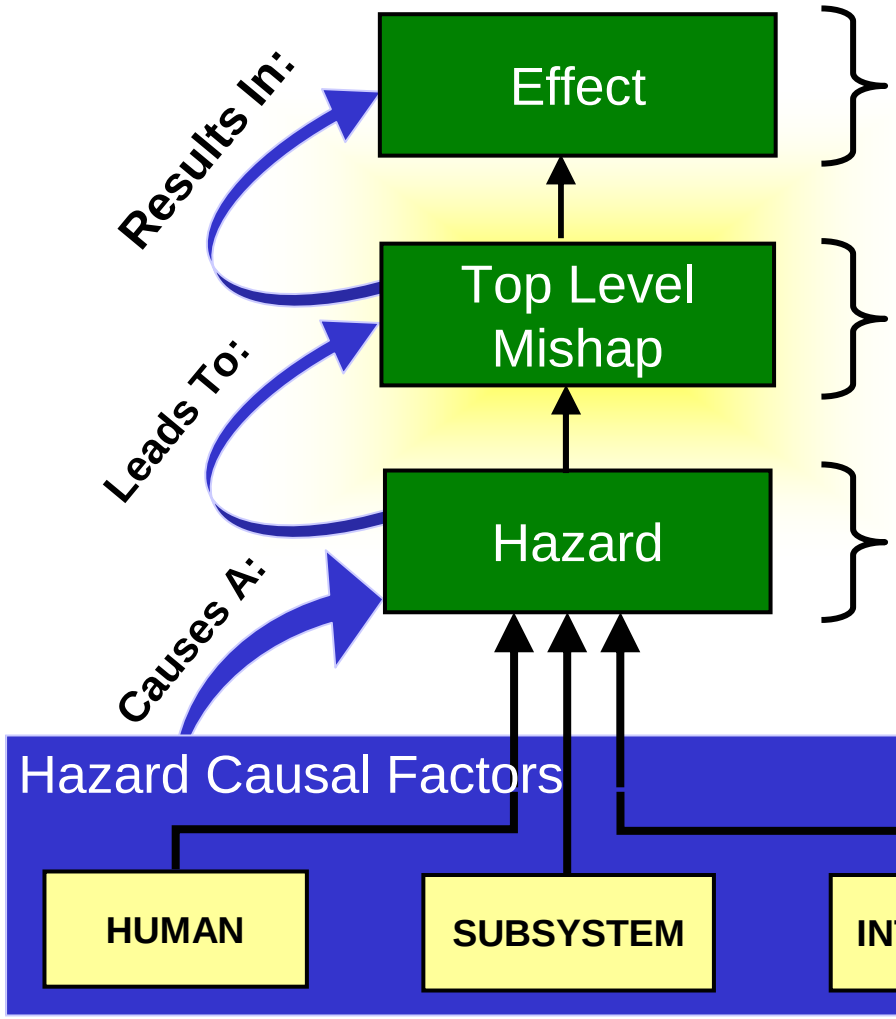
Mishap Relationships



Death, Injury, Illness, Equipment Loss, Equipment Damage, Environmental Damage

The point at which the Inadvertent Release of Energy Occurred

A Condition that exists within the system that could lead to a TLMs

Element within the system design, implementation, or operation that leads to a hazard

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Safety Program Execution

- Hazard Analysis tasks of MIL-STD-882C have been eliminated in MIL-STD-882D. However, these tasks lead the safety practitioner through a logical sequence of hazard identification/mitigation:
  - Preliminary Hazard List/Analysis (PHL/PHA) identifies top level hazards for further development
  - Safety Requirements/Criteria Analysis (SR/CA) identifies safety requirements that can be mapped to their allocated subsystems
  - Subsystem Hazard Analysis (SSHA) further evaluates hazards associated with identified subsystems
  - System Hazard Analysis (SHA) identifies hazards of interfacing subsystems/outside systems
  - Operating and Support Hazard Analysis (O&SHA) identifies those hazards associated with operations and maintenance

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Safety Program Execution

- Lessons Learned
  - Safety practitioner needs to step back from day-to-day IPT activities to ensure that correct aspects of safety analyses are being conducted
  - Safety practitioner needs to ensure the scope of all the hazard analysis types has been covered within the program execution

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Safety Program Execution

- Lessons Learned
  - Doing the system safety work doesn't necessarily mean producing the specific hazard analysis documents
  - Not having to produce the specific hazard analysis documents doesn't mean not having to do the system safety work

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Safety Program Execution

- Lessons Learned
  - Hazard tracking systems are becoming more important
    - Many are web based so everyone has access
    - Repository for all identified hazards
    - Real time tool that can capture work on-going within IPTs
    - Data base formats allow manipulation of data to produce information
    - Tool for development of System Safety Hazard Analysis deliverable documents

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Safety Program Execution

- Software safety process heavily dependent on identification of safety-related requirements and assessment of criticality

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Software Criticality Matrix

SOFTWARE CONTROL CATEGORY	MISHAP SEVERITY POTENTIAL			
	Catastrophic	Critical	Marginal	Negligible
Autonomous	SHRI 1	SHRI 1	SHRI 2	SHRI 4
Semi-Autonomous	SHRI 1	SHRI 2	SHRI 3	SHRI 4
Semi-Autonomous with Redundant Back-Up	SHRI 2	SHRI 3	SHRI 4	SHRI 4
Influential	SHRI 3	SHRI 3	SHRI 4	SHRI 4
No Safety Involvement	No Safety Analysis Required.			

High Risk – Safety verification requires requirements analysis, design analysis, code analysis and safety specific testing

Serious Risk – Requires requirements analysis, design analysis and in-depth safety specific testing

Medium Risk – Requires requirements analysis and safety specific testing

Low Risk – Requires requirements analysis and standard testing process

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Software Integrity Matrix

Phase / SRI	DESIGN	CODE	UNIT TEST	INTEGRATING UNIT TEST	SYSTEM INTEGRATION
SRI 1 **High Risk**	• Design Team Review • Safety Review • SCF Linked To SW Rqmts • SCF Linked to Design Architecture • Fault Tolerant Design.	• Design Code Walkthrough • Independent Code Review • Safety Code Analysis • SCF Code Review • Safety Fault Detection, Fault Tolerance	• Test Case Review • Independent Test Review • Failure Mode Effect Testing • 100% Thread Testing • Safety Test Result Review	• Test Case Review • Independent Test Review • Failure Mode Effect Testing • 100% Regression Testing • Safety Test Result Review	• Test Case Review • Independent Test Review • Failure Mode Effect Testing • 100% Regression Testing • Safety Test Result Review
SRI 2 **Serious Risk**	• Design Team Review • Prioritized Safety Review • SCF Linked To SW Rqmts • SCF Linked to Design Architecture.	• Design Code Walkthrough • Safety Code Analysis for Prioritized Modules • SCF Code Review • Safety Fault Detection, Fault Tolerance	• Test Case Review • Independent Test Review • Failure Mode Effect Testing • 100% Thread Testing • Safety Test Result Review		
SRI 3 **Medium Risk**	• Design Team Review • Limited Safety Review • Safety-Related Functions Linked to Design	• Design Code Walkthrough • Safety Code Analysis for Prioritized Modules • SCF Code Review • Safety Fault Detection, Fault Tolerance			
SRI 4 **Low Risk**	• Design Team Review • Minimal Safety Review • Normal Software Design Process IAW SDP				
SRI 5 **No Safety Risk**	• Normal Software Design Activity IAW the Software Development Plan	• Normal Software Code Activity IAW the Software Development Plan	• Normal Software Unit Test Activity IAW the Software Development Plan	• Normal Software Unit Integration Test Activity IAW the Software Development Plan	• Normal Software System Integration Test Activity IAW the Software Development Plan

EXAMPLE

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Safety Program Execution

- Proposed revision to MIL-STD-882D introduces concept of relating safety criticality of software to safety integrity levels similar to DO 178B
- Different levels of rigor in the design, review, analysis and test efforts for varying levels of safety criticality

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System Safety Risk Management

- MIL-STD-882D addresses Mishap Risk vice MIL-STD-882C Hazard Risk
- Higher level of abstraction associated with residual risk
  - Many hazards that can result in the same mishap

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Mishap Risk Index

FREQUENCY OF OCCURRENCE	HAZARD CATEGORIES			
	I CATASTROPIC	II CRITICAL	III MARGINAL	IV NEGLIGIBLE
(A) Frequent	1 (1A)	3 (2A)	7 (3A)	13 (4A)
(B) Probable	2 (IB)	5 (2B)	9 (3B)	16 (4B)
(C) Occasional	4 (1C)	6 (2C)	11 (3C)	18 (4C)
(D) Remote	8 (ID)	10 (2D)	14 (3D)	19 (4D)
(E) Improbable	12 (IE)	15 (2E)	17 (3E)	20 (4E)

HIGH (CAE (ASN-RDA))

SERIOUS (PEO)

MEDIUM (PM)

LOW (PM)

System Safety Risk Management

- Lessons Learned
  - Mishap Risk Index needs to be tailored for different applications, but most programs default to the identified MRI in MIL-STD-882D.
  - With Residual Risk being captured at the Mishap vice Hazard level, strategy for dealing with cumulative risk associated with many hazards should be identified.

Conclusions

- Acquisition reform and MIL-STD-882D have changed the way System Safety is performed
- Requires more understanding and thought up front to ensure the system safety program is properly structured
- Requires vigilance to ensure full scope of system safety effort is accomplished vice only those issues identified in IPT meetings
- Has fostered collaborative efforts between system safety, systems engineering, software engineering and design engineering on many programs

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Providing Ordnance Safety for our War Fighters.

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Engineering and Implementing Raytheon Missile Systems Engineering Design to Cost Metric

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Areas to be Covered

1. Background
2. Design to Cost and Cost As an Independent Variable
3. The DTC Process
4. The DTC Metric
5. Lessons Learned
6. Going Forward

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Background

- The Engineering Effectiveness Metrics initiative grew out of RMS's desire to reduce the costs and cycle times necessary to design, develop and build products that work right the first time.
- To support these goals, an Engineering Effectiveness Metrics Team developed three primary metrics:
  - On-Time Delivery Performance
  - First-Presentation Yield
  - Design To Cost (DTC)
- Today's focus is on the creation of the DTC Metric, its purpose and use at RMS.
- The DTC metric is designed to allow business unit management to quickly review program(s) progress and status towards meeting their affordability commitments.

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Background:
DTC & CAIV at Raytheon Missile Systems

- DTC and CAIV are blended into Business Development under the heading of Affordability.
- Within the process at RMS:
  - Defined cost targets are assigned to each IPT
  - Focus is on identified cost drivers
  - Cost vs performance tradeoffs are conducted that lead to best value solutions
  - Metrics are determined and reported accordingly
- Each design choice is evaluated simultaneously for both cost and benefit
- CAIV begins before Concept Exploration and remains, with DTC, vigorous throughout product development

CAIV – Cost As an Independent Variable

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DTC as a Management Control System

DTC - A Management Control System

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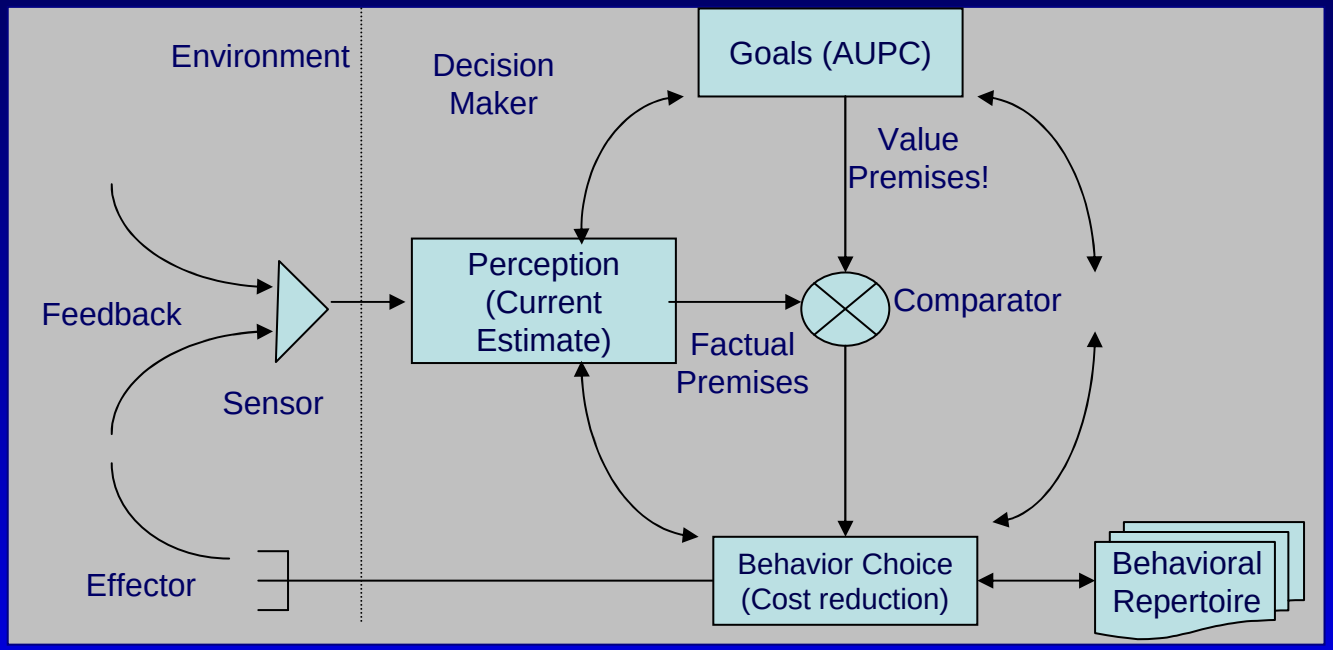

Management Control Systems are put in place to direct targeted activity toward achievement of the desired results.

Management Control Process	DTC Process
Set goals and performance measures	Sets AUPC Goal as part of DTC Plan
Measures achievement	Prepares current cost estimate
Compares achievement with goals	Current estimate vs. DTC goal
Computes the variances as the result of the preceding comparison	Estimates system and subsystem variances
Reports variances	Reports $ Data
Determines the cause(s) of the variances	Cost Drivers, spec. risk, etc.
Takes action to eliminate variances	Action plan: changes
Follow-up to ensure that goals are met	Repeats at interval per plan

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Our DTC Process

Requirements Flowchart

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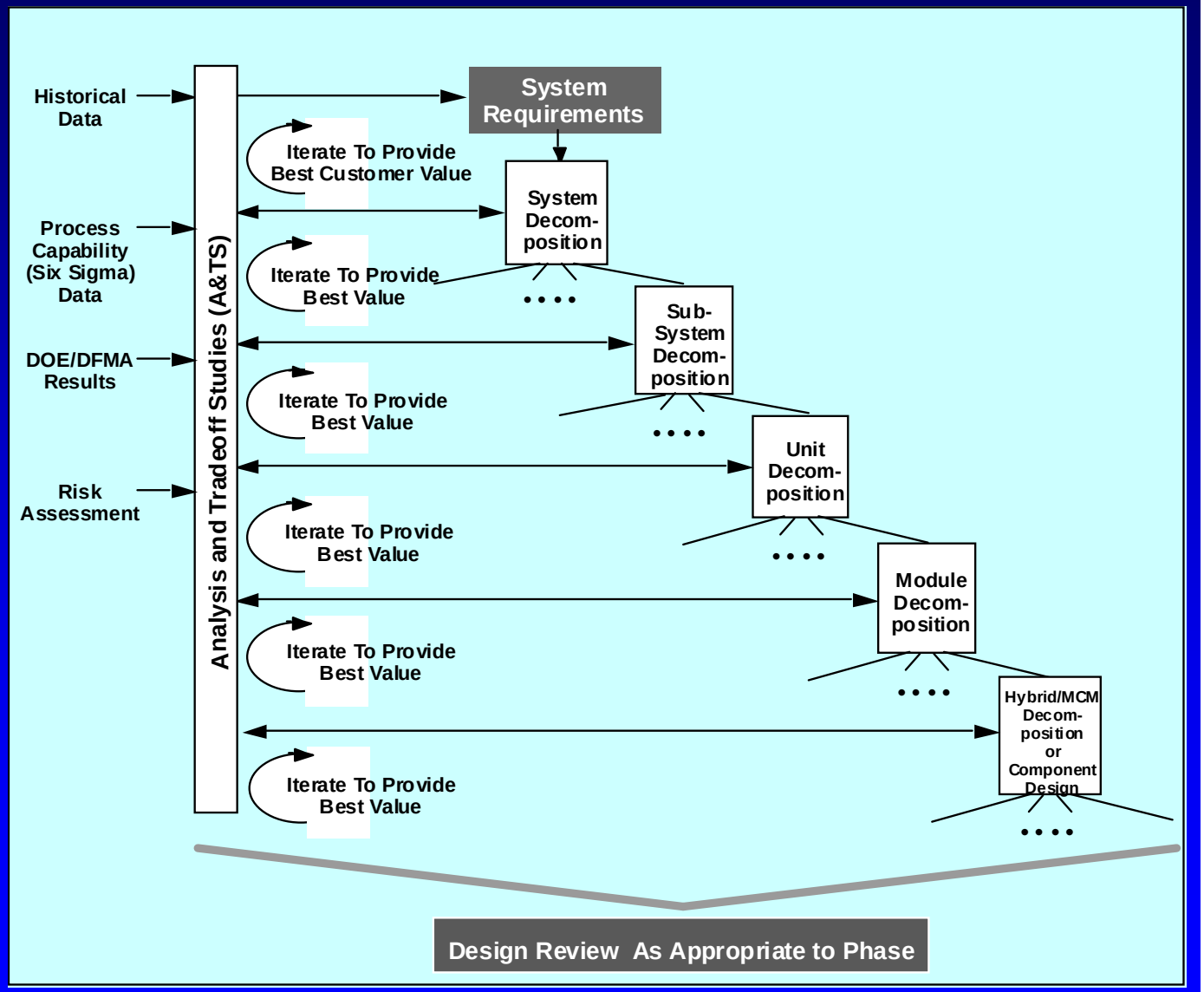
Design to Cost

is a continuous iterative process that begins at the top level with a product requirement that includes cost as a major priority and then seeks to optimize the entire product while allocating requirements down to all levels



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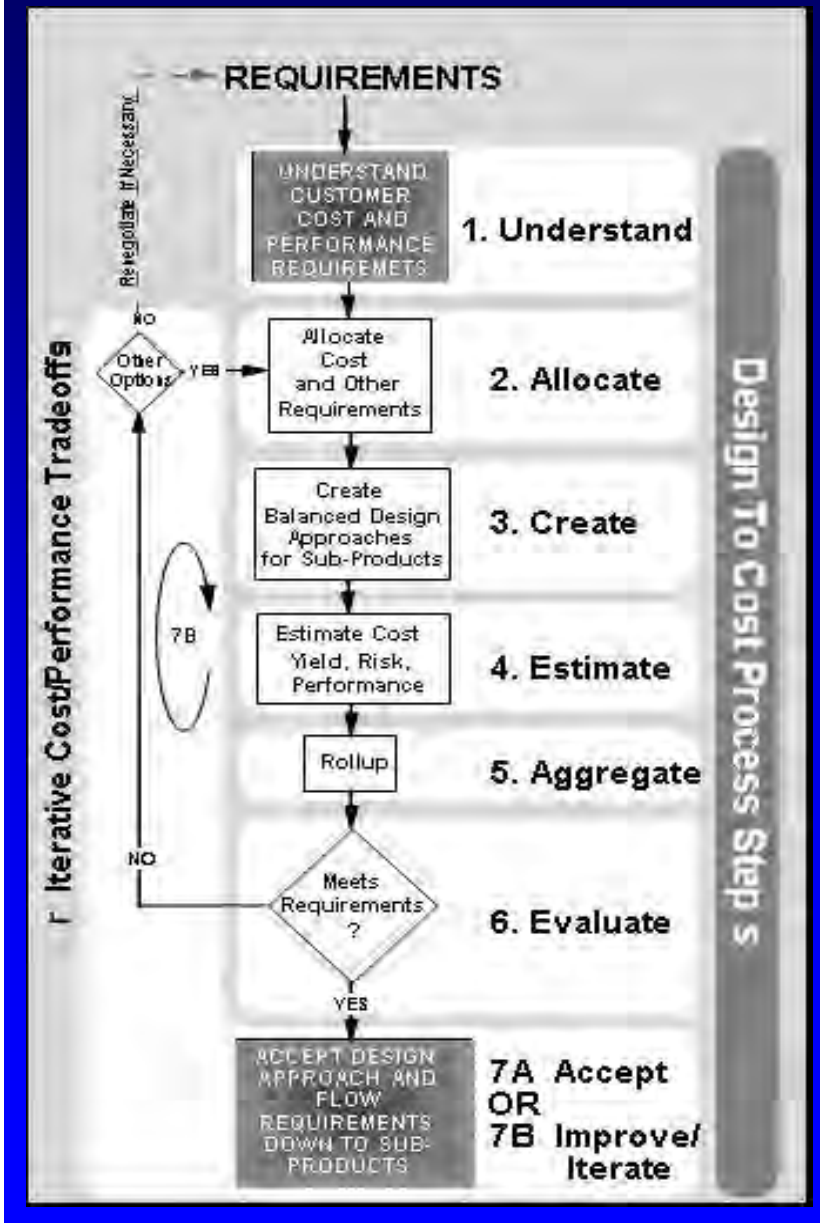
Seven Steps to an Affordable Design



The engineer must use the following 7 steps to execute DTC:

1. **Understand requirements**
2. **Analyze functions**
3. **Identify physical alternatives / allocate requirements / plan task**
4. **Design synthesis**
5. **Cost Modeling – Estimation & Rollup**
6. **Evaluate – Meet or changes requirements?**
7. **Select/Formalize Design**

Plus, an often overlooked 8th step to:

8. **Document and report progress towards meeting the cost goal.**

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The Design is Complete IF

The design is complete when the customer/contractor team has accomplished the following:

- **Performed detailed cost, performance, supportability, and risk assessments that indicate that all final requirements will be met with levels of cost, schedule and technical risk acceptable to both the customer and the company.**
- **Allocated all requirements to non NDI items or specific custom designed components.**
- **Completed the detailed design of all custom components.**
- **Successfully modeled/prototyped custom components and assemblies that can drive cost, performance, or schedule.**
- **Completed a thorough manufacturing plan defining the approach to the fabrication or procurement of all components and the assembly, integration, and test of the product and each significant sub-product.**
- **Complied with all customer and company requirements for ILS, support, review, documentation, verification, scheduling, warranty, and the like.**

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The DTC Metric

Metrics and System Engineering

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An often asked question deals within what role do metrics have within the System Engineering Community.

INCOSE
INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

Systems Engineering Measurement Primer

A Basic Introduction to Systems Engineering Measurement Concepts and Use

Version 1.0

March 1998

This document was prepared by the Measurement Working Group (MWG) of the International Council on Systems Engineering (INCOSE). It was approved as an INCOSE Technical Paper by the INCOSE Technical Board.

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Metrics

The purpose of any metric is to drive proper behavior.

- Proper behavior is achieved by setting, striving for, and ultimately reaching goals. A DTC metric is therefore one that keeps cost and cost reduction in the forefront.
- The proper metric for DTC is one that establishes a system cost goal for the design and that requires attainment of estimated production costs at specified points along a program timeline starting pre-SDD and going through production.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.
- The DTC metric is measured as cost variance to the required time-phased goals. Any variance to a cost goal should precipitate IPT action to eliminate the discrepancy.
- Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.

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Establishing a DTC Metric at RMS

- RMS Announced the formation of the Engineering Effectiveness Metrics Council in early 2003.
- The Engineering Effectiveness Metrics (EEM) team supports its goals with three primary metrics:
  - On-Time Delivery Performance
  - First-Presentation Yield
  - Design To Cost
- The DTC Metric is designed to allow business unit management to quickly review the progress and ability of their programs.
- DTC Metric implementation has a phased approach
  - SDD Programs
  - SDD and Production Programs
  - CAIV Metrics

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Implementation

- Potential programs taken from the EEM "Deployment Matrix," which are programs that are reporting other EEM metrics (First Time Presentation Yield and On-time Delivery Performance).
- Initial meetings with PLCE to identify candidate programs.
- E-mails or phone calls to program manager.
- "Getting Started" packets mailed to candidates:
  - Product Cost Control Survey
  - DTC Start-Up Instructions
  - DTC Points of Contact
  - DTC Guidelines
  - DTC Process
  - Sample DTC Plan Table of Contents
  - CAIV/DTC Training Schedules plus "Program-Specific" CAIV/DTC offered

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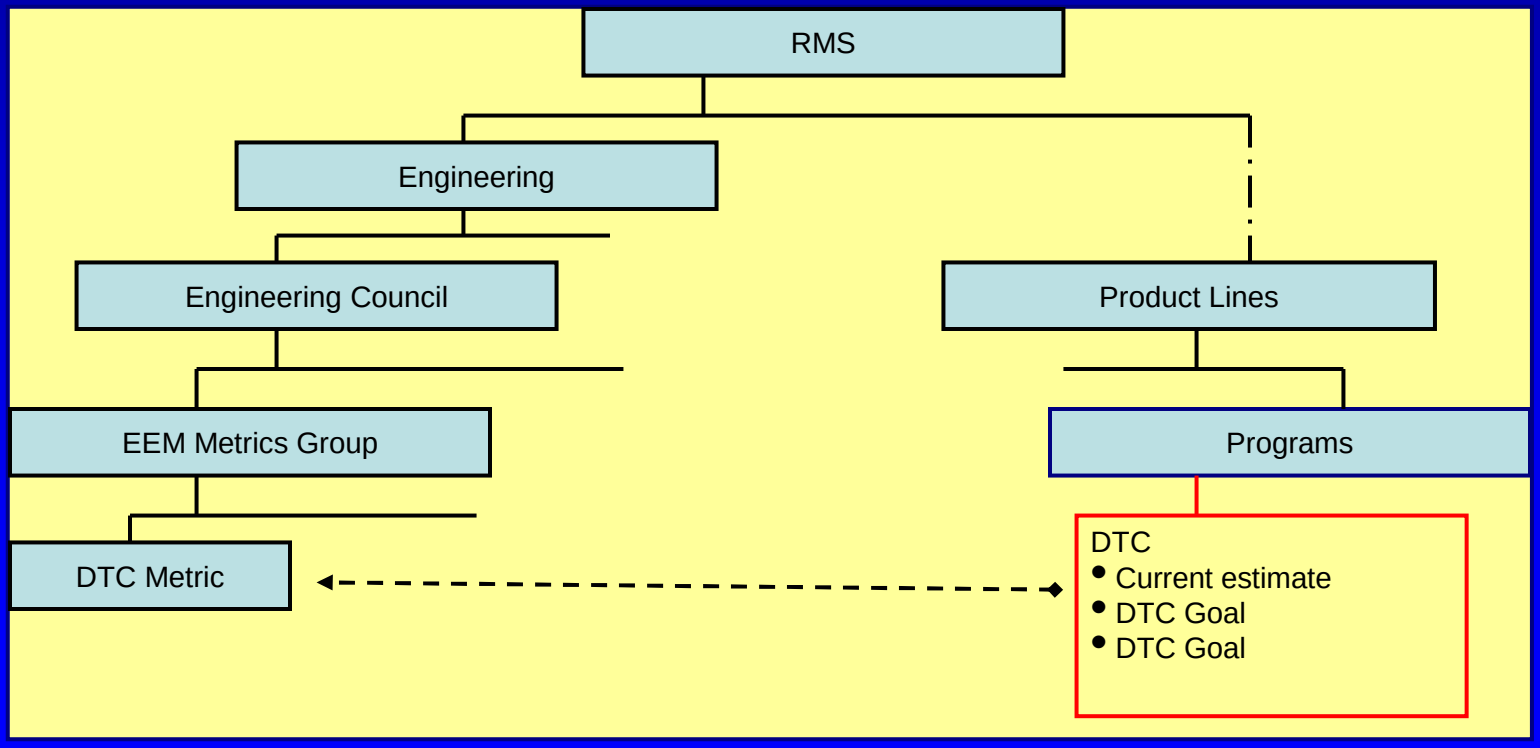
Report Structure for the DTC Metric at RMS

- The EEM reporting organizational structure below is used to facilitate executive level portfolio management of RMS programs.
- RMS' Engineering council reports its metrics monthly at the Engineering level process reviews.



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Process

- Programs provide their initial cost goal and current estimate.
- Programs provide an initial basis of estimate.
- Programs are contacted monthly for their prior month's current estimate (trailing indicator)
- Current estimate is divided by the cost goal for a DTC metric. This is reported in a percentage format; i.e., Program A's DTC metric is 1.04, which is 4% over their cost goal.

	DTC Goal <100% to no >4.99% over goal	
	Over DTC Goal >4.99% to 9.99%	
	Over DTC Goal >10%	

- Latency or how often the cost information is reviewed and updated is also reported.

	Latency - 1-2 months	
	Latency - 2-3 months	
	Latency - 5 months +	

- For programs in "yellow" and "red" categories, "Root Causes and Corrective Actions reports are required.

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DTC Metric Definition and Reporting Levels

Program	Phase	Gate	Metric	Latency	Accuracy	Comment
One A	SDD	6	1.12	1	+15 -10	High Subcontractor cost for motor assembly
Two B	SDD	7	1.50	7	+25 -15	Program undergoing major corrections and rebaselining
Three C	SDD	5	1.04	4	+10 -5	Lower FPA Cost

- **Phase/Gate:** The program's current position in its life-cycle
- **DTC Metric:** Current Cost Estimate / DTC Target
  - Green: < 1.05; Yellow: between 1.05 & 1.1; Red: > 1.1
- **Latency:** Months since completion of last Current Cost Estimate.
  - Green: < 3 months; Yellow: between 3 & 5 months; Red: > 5 months
- **Accuracy:** Represents the relative possible cost risk associated with current cost estimate expressed as a plus and minus percent. Accuracy is not currently being reported.

DTC Metric Reporting Frequency and Initial Results

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RMS's Engineering Council reports its metrics monthly at the Engineering Process Review Meeting. All engineering metrics are distilled into a series of color-coded stoplight charts that show current status in relation to goals for the year.

Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.

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Action

- "Five Why's" reports required for programs that remain in the red category without signs of improvement.
- Areas of concern are identified for "yellow" and "red" programs, and Engineering Centers assist in resolving the challenges.
- The Engineering Accountability Review Group reviews monthly the programs that should be reporting DTC Metrics.
- "Programs That Should Be Reporting 'DTC' Metrics" are now being reported to Louise Francesconi at the monthly product line reviews.

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Lessons Learned

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Lessons Learned

- Affordability is the primary driver in all architecture design and development activities.
- DTC requires mandatory cost requirements be assigned to all programs down to the lowest levels.
- Programs must track and measure their current design to cost status against their goals at periodic intervals. (Cost Management)
- Cost must be a design requirement with importance equal to or greater than performance.
- DTC focus must begin as early as possible in a program (pre-RFQ) for early cost driver identification.
- Cost estimation can be approximate in early program phases, progressively better during later phases.
- Proper DTC behavior is achieved by setting, striving for, and ultimately reaching goals. A DTC metric is therefore one that keeps cost and cost reduction in the forefront of IPT activity.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.

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Going Forward

To quote Sun Tsu, The Art of War, “the wise general in his deliberations must consider both favourable and unfavourable factors. By taking into account the favourable factors, he makes his plan feasible; by taking into account the unfavourable, he may resolve the difficulties.”

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Going Forward: Plans for the Future

A DTC Metric, by itself, is not enough!

It is time to consider expanding DTC Metrics into CAIV Metrics:

- **CAIV Metrics encompass not only cost, but performance, schedule and risk as well. The primary metric to measure specific CAIV project effectiveness is cost. The utilization of this metric requires an established cost baseline in sufficient detail to compare prior and resultant impacts of a CAIV project.**

The proper metric for CAIV:

- **Establishes a system cost goal for the design**
- **Requires specific points of estimated development production and operation/support costs**
- **Reflects on program costs and system performance**

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Going Forward: CAIV Metrics Sample Chart

DTC Metrics can be enlarged with Cost, Performance, Schedule and a Risk Assessment to form a set of CAIV Metrics.

CAIV Metric	Threshold	Goal	Current	Current/Goal	Risk Assess	Cost Driver	Latency	Plan of Action
Cost - System	$ 32,775.00	$ 31,500.00	$ 37,790.00	1.20				
Sub-System	$ 5,000.00	$ 4,500.00	$ 6,200.00	1.38			2	no
Sub-System	$ 1,500.00	$ 1,500.00	$ 1,400.00	0.93			4	no
Sub-System	$ 12,275.00	$ 12,000.00	$ 17,890.00	1.49			1	yes
Sub-System	$ 8,000.00	$ 7,500.00	$ 6,000.00	0.80			3	yes
Sub-System	$ 2,500.00	$ 2,500.00	$ 2,700.00	1.08			3	yes
Sub-System	3500	3500	3600	1.03			2	yes
Sub-System								
Sub-System								

Performance	Requirement	Goal	Current	Req/Current	Risk Assess	Cost Driver	Latency	Plan of Action
speed mph	200	220	180	1.11			1	no
range nm	500	550	525	0.95			1	yes
load lbs	750	750	800	0.94			1	yes
KPP-4								

Schedule	Contract	Goal	Expected	Exp/Con	Risk Assess	Cost Driver	Latency	Plan of Action
Dates								
Months to Go	18	15	15	0.83			2	no

Red Yellow Green Blue Violet	Red Yellow Green	What is/are the major cost driver(s)	Red Yellow Green	Is there a plan of action - yes/no Comment

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Going Forward: CAIV Metrics Sample Chart

CAIV Metrics chart at a glance:

- Discloses a program's status in the areas of cost, performance and schedule. From the above sample chart one can quickly see:
  - The program is projected to over-run costs by 20%.
    - Two of the sub-systems are in the red; one with a high risk of failing.
    - The PM has no plan of action to fix one of the red areas
    - One sub-system is in the "violet" with low risk of failure so perhaps cost goals ought to be re-allocated.
    - The others are close to goals on one-side or the other
  - Two of the performance areas have superseded requirements while one area, without a plan of action and at high risk of failure is in the red.
  - And, the program is planning on an early delivery.
- The color coding helps management key in on specific areas of concern and make necessary changes.

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Any Questions?

- Now is a good time to ask.

USNA - 75

Engineering and Implementing RMS Engineering's DTC Metric

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Abstract

Architecting a product requires a defined set of requirements for the finished product; e.g. size, weight, volume, range, power, color, cost, payload, etc. One very necessary requirement is the anticipated product production cost. Failure to set the production cost requirements at design kick-off allows for unexpected and unacceptable production costs. Previously, all too often, programs were allowing establishment of the production cost goal to slip, or they would wait for their customer to establish it for them. Raytheon Missile Systems' (RMS) Engineering Directorate has specified that all development programs will now establish a production cost goal using the Design-To-Cost (DTC) metric described within this paper and will monitor their design progress towards meeting this goal. Each program's DTC metric is now collected monthly and reviewed by senior management.

This paper will focus on the creation of the Design-To-Cost Metric (DTC), its purpose and use at RMS. The DTC metric is designed to allow business unit management to quickly review the status of their programs as to how well the various program designs are progressing as to their ability to be produced at the specified value.

Background

The Engineering Effectiveness Metrics initiative grew out of RMS's desire to reduce the costs and cycle times necessary to design, develop and build products that work right the first time. As such, we were challenged to measure factors that lead to our products costing too much, taking too long to reach the user, and, admittedly, sometimes not initially working right. To support these goals, an Engineering Effectiveness Metrics Team developed three primary metrics:

- On-Time Delivery Performance, which involves deliveries of Engineering data, documentation, requirements, hardware and software
- First-Presentation Yield, which covers technical data package change rates and identifies out-of-phase defects on all design, development and production programs
- Design To Cost, which uses affordability principles to drive all architecture, design and development activities.

Design to Cost

The traditional definition of Design to Cost (DTC) emphasizes meeting specific cost targets at various stages in a product's life cycle. To meet customer affordability objectives, we must go beyond the traditional definition and create a culture that guides every development and manufacturing decision to eliminate non-value added activity.

DTC is not a stand-alone process, and early attempts to apply it as such produced marginal results. DTC must be an over-arching philosophy that permeates the entire development environment and dominates all major design decisions. DTC must treat cost as a firm program requirement, applying the principals of Cost As an Independent Variable, or as the Department of Defense (DoD) calls it, CAIV.

Design to Cost drives engineering, manufacturing, materiel, finance, and others to find and eradicate extra cost. The DTC approach leverages lean practices and processes and uses rigorous cost target allocation together with successive cost/performance tradeoffs at all levels in the product hierarchy to achieve affordable designs offering best customer value.

The goal of the Design-to-Cost approach is to meet production and Life Cycle Cost targets for products that meet well-established cost targets and provide best customer value. By integrating Design-to-Cost with Six Sigma quality techniques the Product Development Process (PDP) offers the combined benefits of reduced production cost and improved quality/yield.

DTC embraces and leverages the concept of CAIV. As such, cost is treated as a primary requirement that may only be traded for performance or other technical attributes if the customer determines that doing so will provide overall best value and establishes a new cost target that reflects that determination.

DoD customers are focusing on affordability through Acquisition Reform and the best-value concepts of Cost As an Independent Variable (CAIV). In response to these and related initiatives, industry must simplify designs, focus on best customer value, and eliminate non-value-added activity to drive costs down. This objective is possible if we, industry, focus on a best-value balance among cost, performance, and supportability with the same intensity that we once devoted to performance alone.

To provide our customers with superior products at affordable cost, we must embed intensive cost and quality focuses into the product development process (PDP). Cost focus needs to be formalized and institutionalized as an integral part of the PDP. Cost assessment and management begin long before the product takes on a specific form and continue iteration with supportability, performance, and risk until a best-value balanced design is achieved. (HAC DTC Handbook 1996)

DTC and CAIV

In MIL-STD-337, DOD once defined DTC as follows:

> "Design to Cost is an acquisition management technique to achieve defense system designs that meet stated cost requirements. Cost is addressed on a continuing basis as part of a systems development and production process. The technique embodies early establishment of realistic but rigorous cost targets and a determined effort to achieve them."

In more recent documentation such as DOD Instruction 5000.2, DTC can not be found, but is inferred to be under CAIV. Over the years, this has caused some confusion and a blending of terms. To clarify somewhat and to try to keep CAIV and DTC clear:

- CAIV is architectural in nature and asks the question: "Given a fixed budget, how much performance can I get when I need it with maximum acceptable risk?"
- While DTC is engineering oriented and attempts to solve the mystery: "Given the budget and performance requirements, what do I design and build?"

CAIV evolved from and expanded on the basic DTC concept. DTC was, and still is, concerned primarily with production costs and was focused on the lowest cost solution within a given requirements/performance set. CAIV is interested in costs from the total ownership point of view. The acquisition community, including technology and logistics, and the requirements community uses the CAIV process to develop total ownership cost (TOC), schedule, and performance thresholds and objectives. They address cost in Operational Requirements Documents (ORDs), and balance mission needs with projected out-year resources, taking into account anticipated process improvements in both DOD and defense industries. Thus, one can see how DTC became a part of CAIV.

CAIV and DTC at RMS

At RMS, CAIV and DTC are blended into both the business culture and the development process under the heading of Affordability. To work effectively, CAIV must be a part of the business culture, seeking cost reduction and best value at every turn, while DTC must be an integral part of the design and development process. Within this process at RMS, well-defined cost targets are assigned to each sub-product in a product's hierarchy; cost drivers are identified and focused on; cost/performance tradeoffs that lead to affordable, best-value solutions are conducted; and metrics are determined and reported on.

With this approach, each design choice is evaluated simultaneously for both cost and benefit. This process begins before Concept Exploration and remains vigorous throughout product development. Focus is on minimizing cost, identifying and eliminating non-value-added activity, reducing cost risk, and achieving well-defined product cost objectives by optimizing the entire product to provide best customer value. Affordability is interactive, creating a multi-tier Virtual IPT that integrates design engineering, process engineering, manufacturing, materiel, quality, and business across all IPT levels to develop

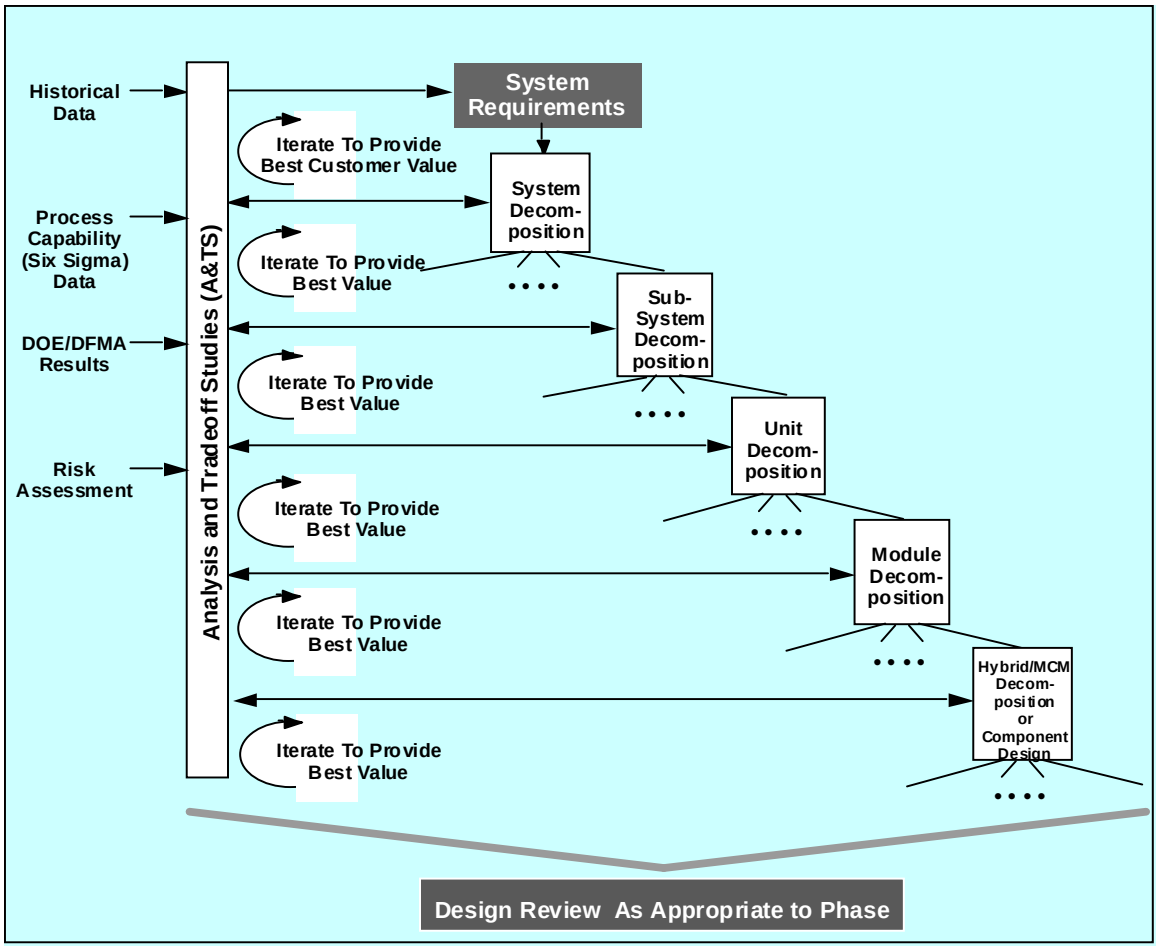
manufacturable products that meet well-defined cost targets while balancing cost, performance, supportability, and risk.

DTC Process

DTC, when taken in its most basic form, is very simple, concentrating only on meeting well-defined cost objectives. In the real world, many requirements must be satisfied simultaneously, requiring thorough analysis and tradeoff among viable alternatives through an iterative design process to achieve a balanced affordable design.

The iterative design process begins at the top level of Figure 1 (HAC DTC Handbook 1996) with a product requirement that includes cost as a major priority. The ensuing requirements flowdown and associated design process are merged into a continuous multi-tiered interactive process that seeks to optimize the entire product by allocating all requirements at all levels in the product hierarchy to produce best customer value.

Figure 1: Requirements Flowdown



The generic seven steps shown in Figure 2 (HAC DTC Handbook p. 4-6) summarize a single tier of the iterative decomposition of a product into its sub-products. This representation of the iterative development process is referred to as the "Seven Steps to an Affordable Design".

The engineer must use the following steps to execute DTC:

- Understand Requirements (Cost Goal is a key requirement)
- Analyze Functions
- ID Physical Alternatives/Allocate Requirements/Plan Task
- Design Synthesis
- Cost Modeling - Estimation & Rollup
- Evaluate – Meet or change Requirements?
- Select/Formalize Design

Plus, an added step that is rarely mentioned and often overlooked: the engineer must document and report progress towards meeting the cost goal.

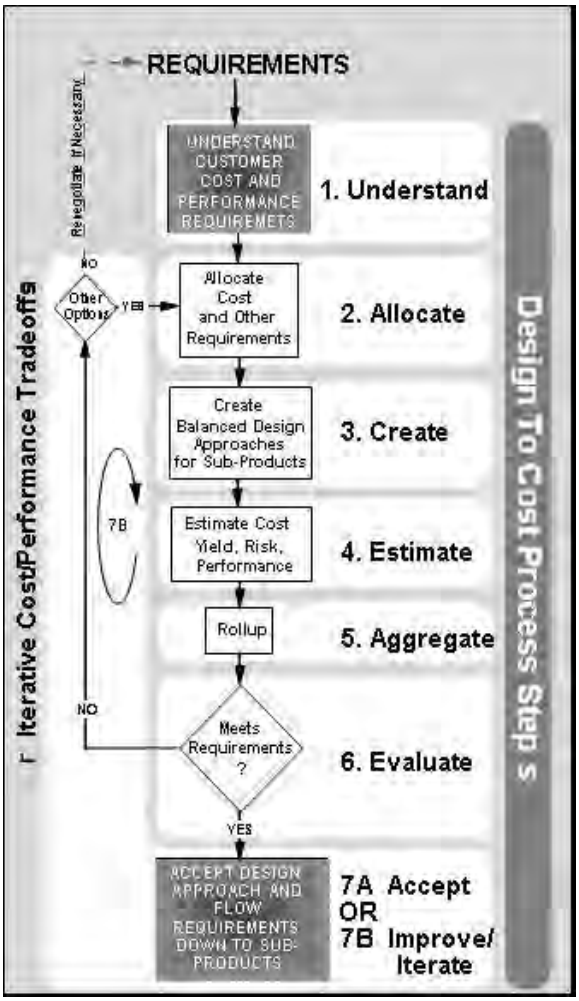


Figure 2 Seven Steps to an Affordable Design

A product-tailored derivative of these steps is applied to every sub-product at each level in the hierarchy beginning in the preconcept phase and continuing throughout detailed design. For multi-tier decompositions, the seven steps are applied at each sub-product level until no further decomposition is needed, so that initial design approaches and assessments can be used to steer each level of requirements flowdown toward a product-global optimum. Cost target allocations are a crucial part of this flowdown sequence. The iterative development process relies on open and ongoing communication among all IPT disciplines and among IPTs at all levels of the product hierarchy. This communication is a powerful benefit of IPD and is essential to the development process.

The design is complete when the customer/contractor team has accomplished the following:

- Performed detailed cost, performance, supportability, and risk assessments that indicate that all final requirements will be met with levels of cost, schedule and technical risk acceptable to both the customer and the company.
- Allocated all requirements to NDI items or specific custom components.
- Completed the detailed design of all custom components.

- Successfully modeled/prototyped custom components and assemblies that can drive cost, performance, or schedule.
- Completed a thorough manufacturing plan defining the approach to the fabrication or procurement of all components and the assembly, integration, and test of the product and each significant subproduct.
- Complied with all customer and company requirements for ILS, support, review, documentation, verification, scheduling, warranty, and the like.

Earlier, we mentioned that DTC is engineering oriented and attempts to solve the mystery: "Given the budget and performance requirements, what do I design and build?" If it were left up to only the engineers, then DTC would be simply one of many engineering processes and largely ignored, but DTC has another role within the CAIV framework as a management control system for production costs.

DTC as a Management Control System

Management control systems for human systems are equivalent to electronic control systems for electro-mechanical systems. They are put in place to direct the targeted activity toward achievement of desired results.

The Cybernetic Paradigm and the Control Process is one theory behind management control systems. Comparing the Cybernetic Paradigm and Control Process from management control system theory (Maciariello, 1984) to the DTC process, we can easy add DTC meaning to the Control Process diagram (Figure 3). Further comparison yields Table 1.

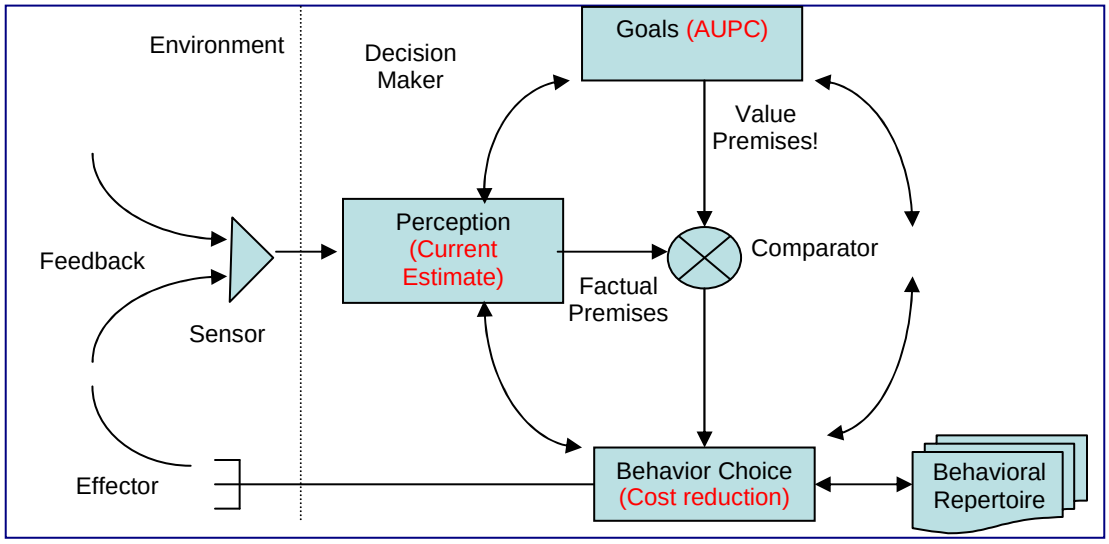


Figure 3 The Control Process with DTC comments

Cybernetic Paradigm and Control Process	DTC Process
Set Goals and performance measures	Set AUPC Goal as part of DTC Plan
Measure achievement	Prepare current cost estimate
Compare achievement with goals	Current estimate vs. DTC Goal
Compute the variances as the result of the preceding comparison	Estimate System and subsystem variances
Report the variances	Report $ Delta
Determine cause(s) of the variances	Cost Drivers, spec. risk, etc.
Take action to eliminate the variances	Action Plan: Changes
Follow-up to ensure that the goals are met	Repeat at interval per plan

Table 1. Applying the DTC Process to Management Control System Theory.

Converting the DTC Process into a management control system, we arrive at the process shown in Figure 4 which brings us to the topic of metrics. One of the main functions of proper management is to monitor and control a process; to ensure that proper decisions are made; and to act in a timely manner to mitigate risk. To do so, a manager needs reliable and accurate information. Information comes in many forms and metrics, if properly applied, are invaluable sources of information.

Both, the DTC process and management control system theory require establishment of goals, measurement of achievement of those goals, measurement of variances from the goals, feed back actions to the process to attempt to eliminate the variances, and follow up to ensure that the goals are met. We also know from theories on human behavior and organizations that when individuals or organizations are measured then those individuals tend to redirect their effort towards achieving a level of performance within the functionally being measured that will be at or above the desired measurement grading level. We built this aspect of human behavior into our metric reporting system as the organizations being measured know that they are being measured and what they are being measured against and that the results of these measurements will be reported to executive management. For this to be successfully applied as it has been at RMS, those organizations that are being measured must see the proactive loop closure that says "I'm making a positive change to do better." Beyond identifying shortcomings, measurements should be used to help engineer centers/ program IPTs replicate their successes.

> To quote Sun Tsu, The Art of War, "the wise general in his deliberations must consider both favourable and unfavourable factors. By taking into account the favourable factors, he makes his plan feasible; by taking into account the unfavourable, he may resolve the difficulties."

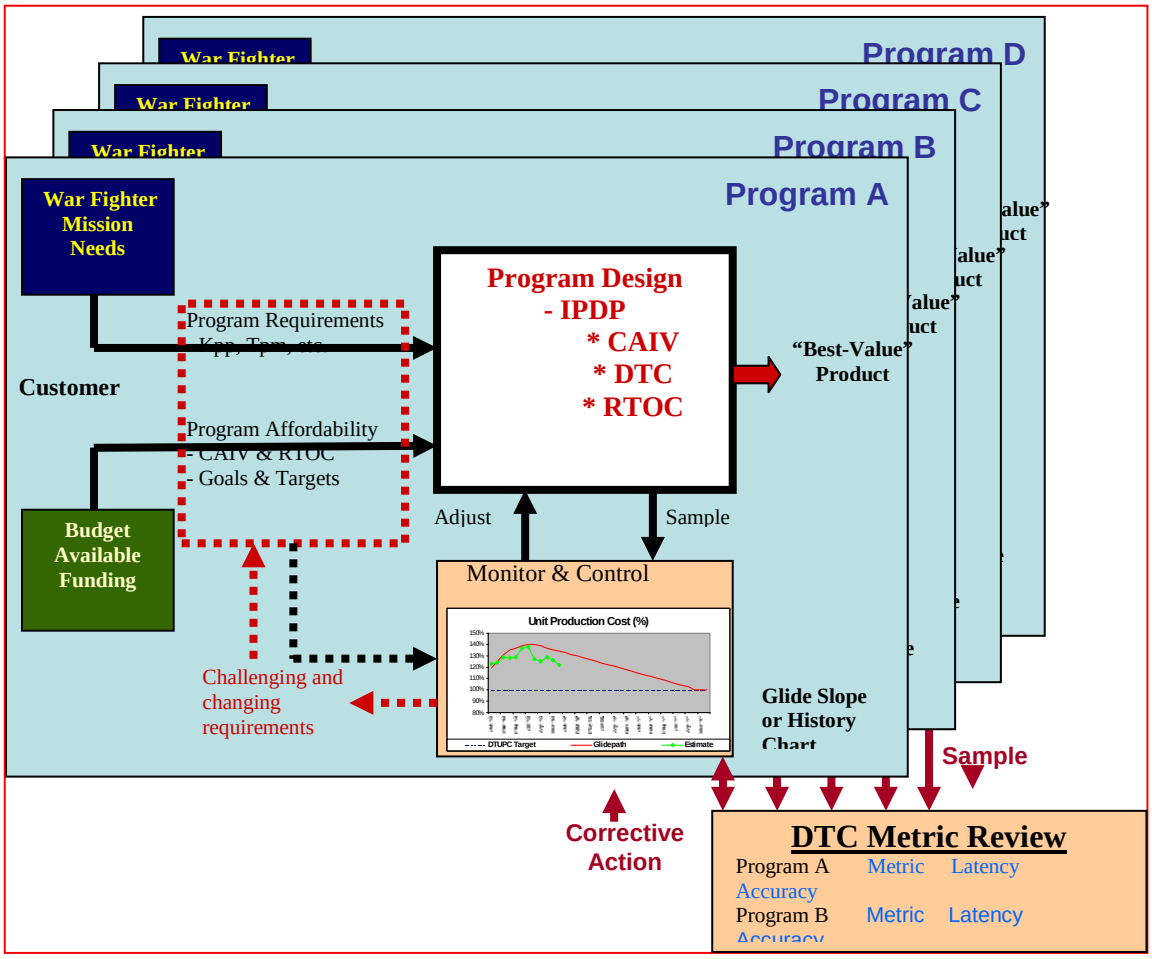


Figure 4, The DTC Process in Terms of a Management Control System

The purpose of any metric is to drive proper behavior and the purpose of the DTC Metric is no different. The DTC Metric, by providing information to both the program manager and the program manager's superiors, drives proper behavior. The program manager is aware of a program's cost status and can make decisions based on that status. The program manager's superiors can use the DTC Metric as is part of a higher level monitoring function over individual programs, across a line of similar programs, or across a business area. To be of value, it is required that this metric be reported to a level significantly above the program in order for the feed back to carry force of action to the program. It is this force of action that provides an additional monitor and control function to verify and drive the program to conduct a successful DTC program.

Establishing a DTC Metric at RMS

Raytheon Missile Systems' Engineering Directorate needed to have a few simple metrics they could use to track and report development program future design production costs, quality, and timeliness on a number of different programs. The Engineering Effectiveness Metrics (EEM) initiative grew out of RMS' desire to reduce the costs and cycle times necessary to design, develop and build products that work right the first time.

Early in 2003, RMS announced the formation of the Engineering Effectiveness Metrics Council and its development of metrics designed to help the directorate measure its performance, identify problem areas and quantify its progress in eliminating them. Selection of the appropriate measurements would help focus future efforts towards meeting and improvements in these measured areas. To support these goals, the team developed three primary metrics:

- On-Time Delivery Performance, which involves deliveries of Engineering data, documentation, requirements, hardware and software,
- First-Presentation Yield, which covers technical data package change rates and identifies out-of-phase defects on all design, development and production programs, and
- Design To Cost (DTC), which uses affordability principles to drive architecture, design and development activities

The Engineering Effectiveness Metrics reporting organizational structure (Figure 5) was set up to facilitate executive level portfolio management of RMS programs for their achievement of selected goals. RMS' Engineering Accountability Review Council, under which the EEM group functions, reports its metrics monthly at the Engineering level "Accountability" reviews.

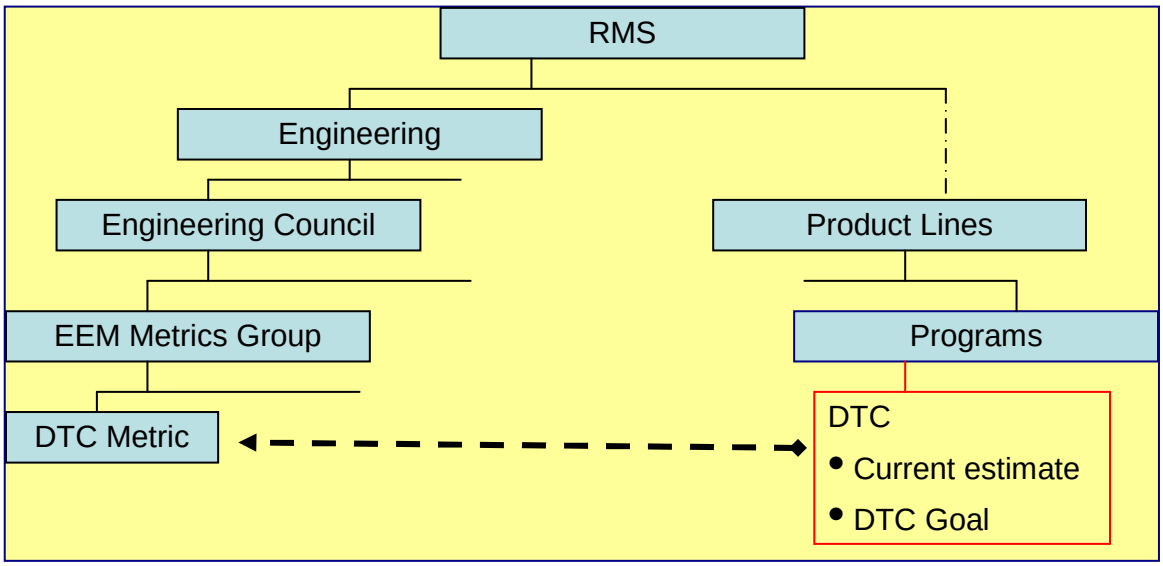


Figure 5. DTC Metric reporting Structure

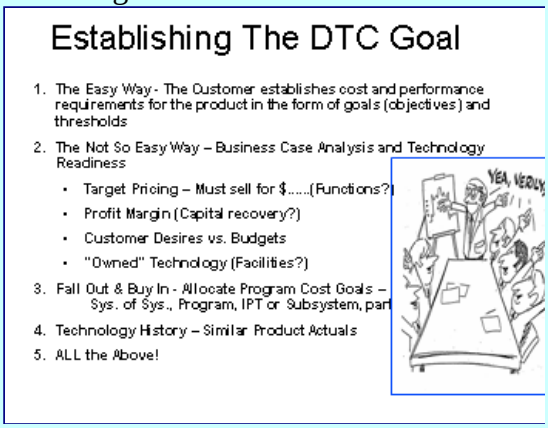
DTC Metric Definition

The DTC Metric was created to allow management to quickly access a program's progress as to how well its design, as it stands today, meets the cost target developed using the DTC process. In order to do this we must take snap shots of the design at regular intervals. For RMS' DTC Metric, the appropriate interval was determined to be monthly. For each snap shot, a cost estimate is prepared using the same set of Ground Rules and Assumptions used to create the cost target. These estimates are then compared to the target and evaluated. The formula for the DTC metric is:

DTC Metric = Current Cost Estimate / DTC Target

Of note, the current cost estimate and the DTC cost target need to be like in nature. The definition allows for targets and current estimates to be defined appropriately for the need of each individual program. However, the intent of and management's goal in establishing the DTC Metric (unless customer intentions dictate otherwise) was for the DTC Metric to measure the average unit production cost (AUPC) of the product. The production cost is defined as the total manufacturing recurring cost with appropriate overheads divided by the total production quantity. Often, the DTC Target represents a contractual cost, although it could be set lower. Again, this would be based on the ground rules and assumptions. When the DTC Metric is greater than one, the current cost is greater than the cost target and is an indication of a program starting to over run its costs.

Establishing a realistic DTC Goal (or Cost Target) is critical to the DTC Metric. There are several methods that can be used and as the program requirements evolve, the method may change causing the target to also change. All changes should be documented.



The DTC Metric is then color-coded based on severity.

- Green is when the DTC Metric is less than 1.05,
- Yellow is between 1.05 and 1.099, and
- Red is 1.10 or greater.

The color scale allows a quick glance capability to the monthly DTC metric report to ascertain the status of all reporting program across RMS quickly (Table 2). The scale was set to allow early intervention should a program tend toward cost over runs. If a program reports itself in the yellow or red, management will start to ask questions: questions that we'll leave to the reader's imagination.

Program	Jan	Feb	Mar	Apr	May	Jun	Jul
Program A	1.33	1.11	1.11	1.11	1.13	1.13	1.13
Program J	1.58	1.58	1.58	1.58	1.58	1.42	1.42
Program C				1.11	1.11	1.09	1.07
Program F	1.01	1.01	1.01	1.01	1.01	1.08	1.06
Program B							0.99
Program D	0.99	0.99	0.99	0.99	0.99	1.04	1.04
Program E	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Program G	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Program H	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Program I	0.90	0.63	0.64	0.64	0.64	0.64	0.64
Program K	0.94	0.94	0.94	0.94	0.94	0.97	0.97
Program L	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Table 2. DTC Summary Chart

Along the same line, latency is also reported. Latency equates to the number of months since completion of last the Current Cost Estimate. While it is desirable to do this monthly, there are occasions when this cannot be done. Latency is also color-coded and as before, varying levels of interest follow each color.

- Green is latency of 2 months or less,
- Yellow is latency between 2 and 4 months, and
- Red is latency greater than 4 months old.
-

Accuracy of the cost estimate is also reported and represents the relative possible cost range (cost risk) associated with the current cost estimate. This is expressed as a plus and minus percent. Phase and Gate represent where in a program's life-cycle the program current is and room for comments in the DTC report exists.

A hypothetical example is shown in Table 3.

PROGRAM	Phase	Gate	Metric	Latency	Accuracy	Comment
One A	SDD	3	1.12	1	+15 -10	High Subcontractor cost for motor assembly
Two B	SDD	3	1.55	9	+25 -15	Program undergoing major corrections and rebaselining.
Three C	SDD	2	1.04	4	+10 -5	Lower FPA Cost

Table 3: DTC Metric Report Including Accuracy

DTC METRIC Reporting Frequency and Initial Results

RMS's Engineering Effectiveness Metrics Council reports its metrics monthly at the Engineering Accountability Reviews for the previous month (trailing indicators). All engineering metrics are distilled into a series of color-coded stoplight charts that show current status in relation to goals for the year.

Data is collected during the first week of the month and areas of concern are pinpointed. Product lines, programs and functional organizations are informed when the data indicates problems exist. Process reviews are held the third week of the month, so those areas of concern should have enough time to prepare for the review and to come up with a proposed solution. If solutions are not available by review time, the issue becomes an action item, with follow-up slated for the following month or sooner depending on severity. When product lines and programs are involved, the council informs the Engineering Centers' IPTs to find a solution.

Six months after the DTC Metric was put in place, analysis shows substantial improvement. Data shows that 65 percent of the programs that the council is tracking have met their DTC goals, in contrast to only 33 percent six months earlier, with the trend toward reducing costs existing for the majority of programs that have yet to reach their DTC targets.

Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.

Implementation and Evolution – Lessons Learned

American companies have long been accused by foreign partners of wanting to close the deal in a short period of time, but taking forever to implement the decisions. "Americans are quick to sign a contract or make a decision. But try to get them to implement it---it takes forever." (Ouchi) Institutionalizing the DTC Metrics at Raytheon Missile Systems has met with some resistance. Common excuses include: "The customer does not require DTC," "We didn't fund for DTC," "We don't have time to track DTC and make reports," "We received a waiver from doing DTC," "We've never had to do this before," and "This is a very small program, so we don't need to do DTC."

Top management at Raytheon Missile Systems is now closely watching our DTC metrics and placing heavy emphasis on successfully capturing and reporting the DTC metrics. Answers to the above comments include: "While the customer may not require it, this is an internal RMS management requirement." "Tracking the current estimate is something that a well-managed program is doing already, and it is extremely easy and quick to compare the current estimate to the known cost goal." "We are doing many things that we have never had to do before to shorten our cycle times, to assure the quality of our products at initial delivery, and to stay within or under budget. These things we do to remain competitive, which in turn safeguards employment and positively impacts our bottom line." "Even though this is a very small program, it is of strategic importance, and offers lucrative

follow-on contracts." With top management emphasis, programs are now more willing to report their DTC metrics (for design and development programs) and are embracing affordability metrics (for production programs) as well.

Currently, the council is continuing to refine, systematize and institutionalize its data-gathering activities. When programs transition from "green" to "yellow" and from "yellow" to "red," they are required to provide "Root Causes/Corrective Actions" explanations at the Engineering Accountability Reviews. As mentioned previously, the various RMS Engineering centers become involved to assist in identifying solutions to programs' challenges. Should programs not exhibit improvement right away, a "Five Whys" exercise is conducted, drilling down at least five levels to assure that the true root causes have been identified so that they can be corrected. Simply put, it's about improvement. The Council is also analyzing the data to spot emerging trends, assess their significance and address problems on a case-by-case basis. Now that the basic process is up and running, we are looking more closely at long-term, systemic obstacles and solutions.

Adopting the correct metrics and using them appropriately can add tremendous value to a program, allow program managers increased ability to control their programs vice being controlled by their programs, and allow senior management an earlier opportunity to assist programs heading toward problems.

Key lessons learned are as follows:

- Affordability is the primary driver in all architecture design and development activities.
- DTC requires mandatory cost requirements be assigned to all programs down to the lowest levels.
- Programs must track and measure their current design to cost status against their goals at periodic intervals.
- Cost must be an independent design requirement with importance equal to or greater than performance (i.e., the process must address CAIV as its primary focus).
- DTC focus must begin as early as possible in a program (pre-RFQ) for early cost driver identification.
- Lean practices and processes must be effectively leveraged.
- Cost estimation can be approximate in early program phases, progressively better during Engineering and Manufacturing Development (E&MD).
- Cost estimation cycle time must be near real-time by the detailed design phase.
- Design, manufacturing and product life cycle cost data must be readily accessible.
- DTC tools must be user friendly and accessible from the IPT's desktop.
- Manufacturing process costs must be understood.
- DTC training deployment, and data collection must be given high priority.
- Proper CAIV behavior is achieved by setting, striving for, and ultimately reaching goals. A CAIV metric is therefore one that keeps cost and cost reduction in the forefront of IPT activity.
- By establishing cost and TOC goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.

A Path Forward

With the Design to Cost Metric in place and positive results being shown, it is time to consider expanding DTC into CAIV and implementing a series of metrics more in tune with CAIV principles.

CAIV seeks to find the optimum balance between Cost, Performance, Schedule and Risk, this a set of CAIV Metrics should encompass these areas. Table 3 shows how the DTC Metric can be enlarged and enriched with Performance, Schedule and a Risk Assessment.

CAIV Metric	Threshold	Goal	Current	Current/Goal	Risk Assess	Cost Driver	Latency	Plan of Action
Cost - System	$ 32,775.00	$ 31,500.00	$ 37,790.00	1.20				
Sub-System	$ 5,000.00	$ 4,500.00	$ 6,200.00	1.38			2	no
Sub-System	$ 1,500.00	$ 1,500.00	$ 1,400.00	0.93			4	no
Sub-System	$ 12,275.00	$ 12,000.00	$ 17,890.00	1.49			1	yes
Sub-System	$ 8,000.00	$ 7,500.00	$ 6,000.00	0.80			3	yes
Sub-System	$ 2,500.00	$ 2,500.00	$ 2,700.00	1.08			3	yes
Sub-System	3500	3500	3600	1.03			2	yes
Sub-System								
Sub-System								

Performance	Requirement	Goal	Current	Req/Current	Risk Assess	Cost Driver	Latency	Plan of Action
speed mph	200	220	180	1.11			1	no
range nm	500	550	525	0.95			1	yes
load lbs	750	750	800	0.94			1	yes
KPP-4								

Schedule	Contract	Goal	Expected	Exp/Con	Risk Assess	Cost Driver	Latency	Plan of Action
Dates								
Months to Go	18	15	15	0.83			2	no

Red Yellow Green Blue Violet	Red Yellow Green	What is/are the major cost driver(s)	Red Yellow Green	Is there a plan of action - yes/no Comment

Table 4: CAIV Metrics

As a management enabler, this chart, at a glance would disclose a program's status in the areas of cost, performance and schedule. From the above sample chart one can quickly see:

- The program is projected to over-run costs by 20%.
    - Two of the sub-systems are in the red; one with a high risk of failing.
    - The PM has no plan of action to fix one of the red areas
    - One sub-system is in the "violet" with low risk of failure so perhaps cost goals ought to be re-allocated.
    - The others are close to goals on one-side or the other
- Two of the performance areas have superseded requirements while one area, without a plan of action and at high risk of failure is in the red.
- And, the program is planning on an early delivery.

From the above information, management can key in on areas to get involved with. If a program, like the example, is in the "red" in cost but ahead of schedule and over-achieving in some area of performance, then perhaps adjustments can be made to lower costs while still meeting requirements. Likewise, if a program was under cost but not quite meeting a key performance parameter (KPP) then that area can be targeted appropriately. The color coding helps key in on specific areas of concern.

Of course, should a Program Manager not have a plan of action for an area lacking, then his or her management would become aware of this and can make the appropriate recommendations to ensure correction. One would hope that at the next level up, all areas lacking would have an action plan.

Going yet the next step, the proper metric for CAIV is one that establishes a system cost goal for the design and that requires attainment of estimated development, production, and operation and support costs (Total Ownership Cost) at specified points along a program timeline. It is still too early for this step, but not to early to considering how to incorporate it and when. In addition, other metrics can be included that reflect on program costs and system performance and can be used by management to enable an informed decision.

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Author's Biographies

F. Quentin Redman is a Senior Department Manager and Engineer Fellow in the Systems Engineering laboratory of Raytheon Missile Systems in Tucson Arizona. He is responsible for Total Ownership Cost, Design and Life Cycle Cost, Risk Analysis, and Cost As Independent Variable with 30 years of Economic experience. Quentin received his Bachelor of Science in Engineering Technology Electronics from California State University at Long Beach California in 1970 and his Masters of Science in Financial Economics from West Coast University Los Angeles in 1976. Quentin has been on the Board of Directors for the International Society Parametric Analyst and has also previously served as ISPA's Treasurer. Quentin has over 26 years with the company. Quentin has presented a number of papers at prior years Systems Engineering Symposia and at ISPA, SCEA, INCOSE, and NDIA conferences/symposia.

George L. Stratton is an Engineer Fellow and the assistant Department Manager in Raytheon Missile Systems' Systems Engineering Laboratory's Cost Engineering Department. He currently leads/supports many challenging assignments. He holds degrees (AS, Dixie College & BS, Utah State) in Physics, an MBA (Pepperdine), and has completed partial work toward a Ph.D. (Claremont Graduate School) in management science. He is trained on Parametric models and was selected for and completed the Hughes line managers training course. He is the past vice president of the Southern California Chapter of ISPA (International Society of Parametric Analysts) and is now serving on ISPA's international Board of Directors. George has over 23 years with the company. He helped author "The Testability Notebook" published by RADC in 1982 and has presented a number of papers at internal Raytheon Systems Engineering Symposia and at ISPA, SCEA, INCOSE, NDIA, AIAA, and ICEC conferences/symposia.

Ed Casey is a Principal Engineer in Raytheon Missile Systems' Systems Engineering Laboratory's Cost Engineering Department. He has been with Raytheon for over 11 years having worked in both the Northeast and the Southwest. Duties include Design to Cost, Cost as an Independent Variable, Affordability and parametric modeling. Ed earned his Bachelor of Science at the US Naval Academy and his Masters of Science at Salve Regina University in Newport, RI. He is currently the Membership Chair for the Southern Arizona Chapter of INCOSE. Ed is a retired Naval Officer having served on carriers, cruisers, and minesweepers and served with the SeaBees. He had a tour at the Pentagon and at the Naval War College.

Diana Patane is a Senior Systems Engineer in RMS' Systems Engineering Laboratory's Cost Engineering Department. She has been with Raytheon for four and a half years and has worked in the aerospace industry for TRW, Honeywell, and Hewlitt Packard, for 13 years. She currently serves as the Design to Cost Metrics Coordinator. Diana earned a Bachelor of Science Degree at Weber State University, Ogden, UT, and an MBA (Management (1994) and Technology Management (2003) from the University of Phoenix, Ogden/Salt Lake City, UT and Tucson, AZ campuses). She is a Certified Business Manager through the Association of Professionals in Business Management. A lifetime member of the International Society of Parametric Analysts (ISPA), she serves as their Membership Chairman.

Program Support: Perspectives on Technical Planning and Execution

Dave Castellano
Deputy Director, Systems Engineering

DEFENSE SYSTEMS
Office of the Under Secretary of Defense for Acquisition, Technology and Logistics

October 24-27, 2005

Version 1.0; CM# 05-10-002-P

Top Five Systems Engineering Issues*

- Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs
- Adequate, qualified resources are generally not available within government and industry for allocation on major programs
- Insufficient SE tools and environments to effectively execute SE on programs
- Requirements definition, development, and management is not applied consistently and effectively
- Poor initial program formulation

*** Based on an NDIA Study in January 2003**

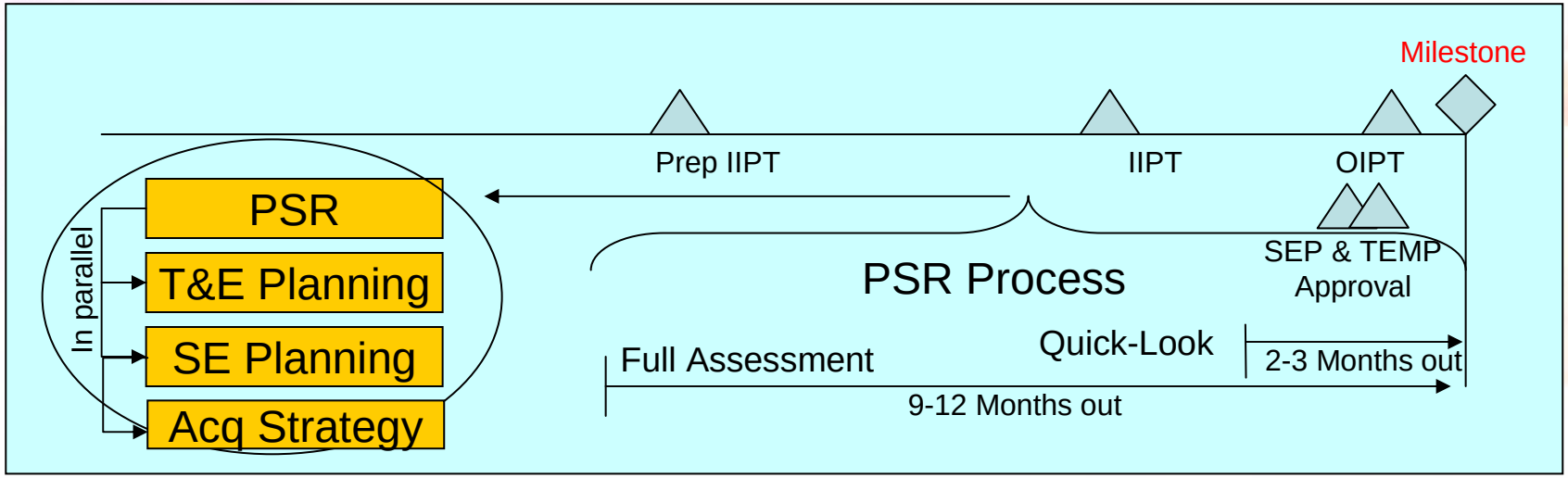
Recap: What We Have Done To Revitalize Systems Engineering

- Issued Systems Engineering (SE) policy
- Issued guidance on SE and Test & Evaluation (T&E)
- Integrating Developmental T&E with SE policy and assessment functions – focused on effective, early engagement of both
- Instituted system-level assessments in support of OSD major acquisition program oversight role
- Established SE Forum – senior-level focus within DoD
- Working with Defense Acquisition University to revise SE, T&E, and enabling career fields curricula
- Leveraging close working relationships with industry and academia

Necessary but not sufficient!

General Approach: Program Outreach Review Products

- Full reviews conducted 9-12 months before Milestone
  - Detailed findings, risks & actionable recommendations
  - Conducted in "PM support" vice "OSD oversight" mode
- "Quick-Look" reviews conducted 2-3 months before Milestone
  - Same form and formats as full assessment; conducted "for record" review
- Quarterly Defense Acquisition Executive Summary (DAES) assessments inputs
- Test & Evaluation Master Plan (TEMP) and Systems Engineering Plan (SEP) development and approval



Systems Engineering Plans

DoD Systems Engineering Shortfalls*

- Common failures on acquisition programs include:
  - Inadequate understanding of requirements
  - Lack of systems engineering discipline, authority, and resources
  - Lack of technical planning and oversight
  - Stovepipe developments with late integration
  - Lack of subject matter expertise at the integration level
  - Availability of systems integration facilities
  - Incomplete, obsolete, or inflexible architectures
  - Low visibility of software risk
  - Technology maturity overestimated

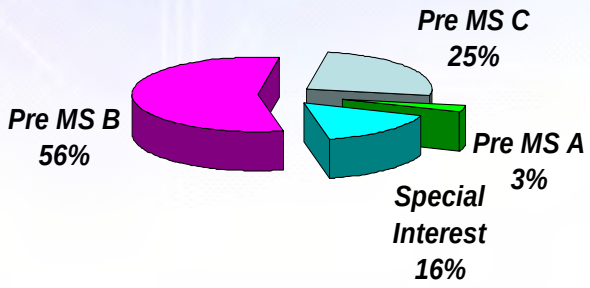
Major contributors to poor program performance

*** Findings from PSRs and DoD-directed Studies/Reviews**

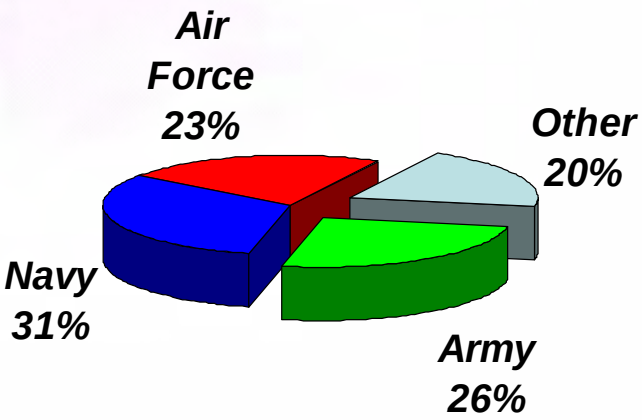
Systems Engineering Plan Activity
(since November 2004)

- Number of SEPs reviewed: 59
- Programs submitting SEPs: 36
  - Number of SEPs approved: 8
  - Number of SEPs pending: 5
- Reviews planned for rest of FY06: 103

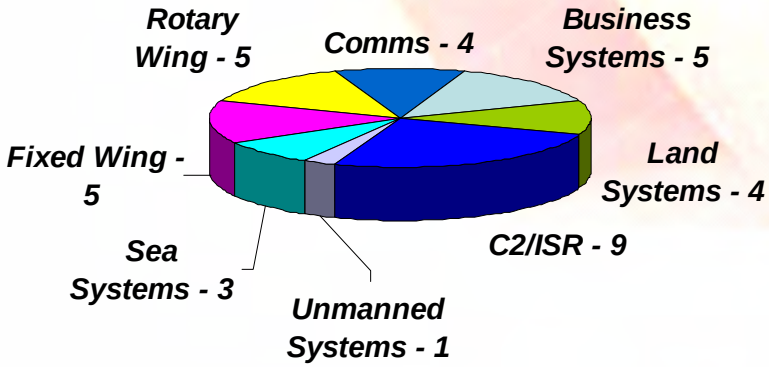
SEP Program Milestones



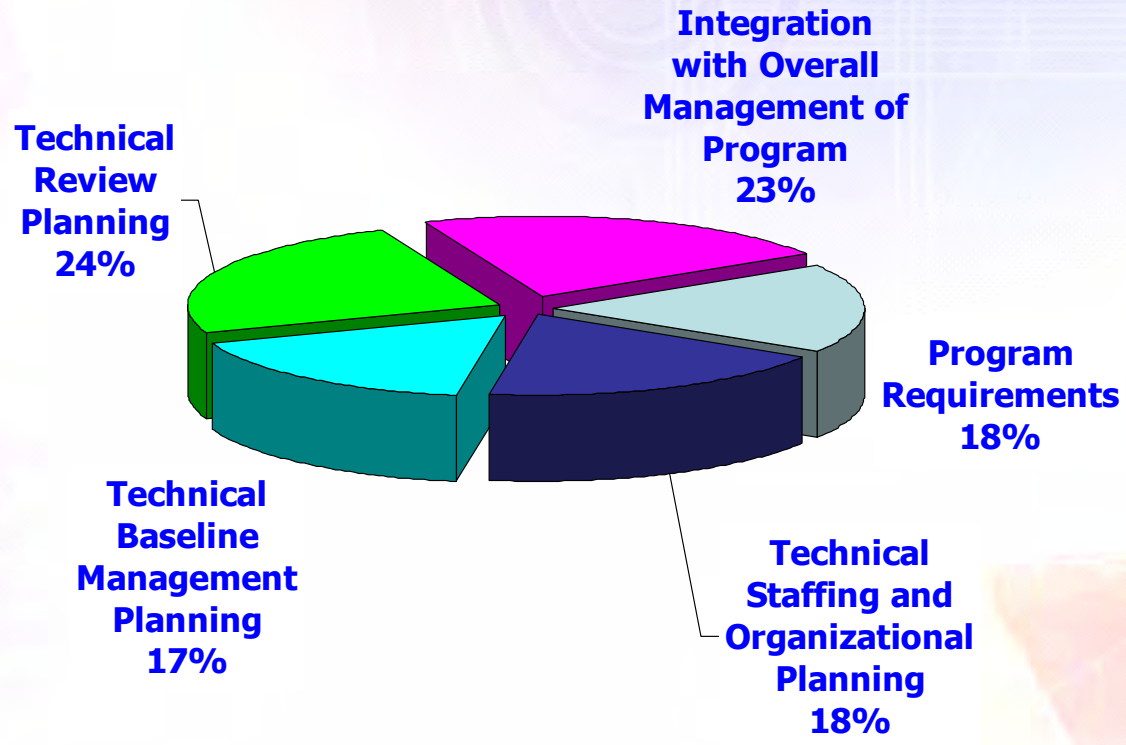
Component-Managed Acquisitions



Programs by Product Line



Emerging SEP Comments**
(not systemic across all programs)



**BASED ON ANALYSIS OF 27 OUT OF 39 PROGRAMS

Program Support

General Review Areas

ASSESSMENT METHODOLOGY FOR PRE-MILESTONE C

1.0	Mission Capabilities/Requirements Assessment Area	4
	Sub-Area 1.1 – Operational Requirements	4
2.0		
3.0		
4.0		
5.0		
6.0		

ASSESSMENT METHODOLOGY FOR PRE-MILESTONE B

1.0	Mission Capabilities/Requirements Assessment Area	4
	Sub-Area 1.1 – Operational Requirements	4
2.0		
3.0		
4.0		
5.0		
6.0		

ASSESSMENT METHODOLOGY FOR PRE-MILESTONE A

1.0	Mission Capabilities/Requirements Assessment Area	4
	Sub-Area 1.1 – Operational Requirements	4
2.0	Resources Assessment Area	9
	Sub-Area 2.1 – Program Planning and Allocation	9
	Sub-Area 2.2 – Personnel	10
	Sub-Area 2.3 – Facilities	12
	Sub-Area 2.4 – Engineering Tools	13
3.0	Management Assessment Area	16
	Sub-Area 3.1 – Acquisition Strategy/Process	16
	Sub-Area 3.2 – Project Planning	19
	Sub-Area 3.3 – Program and Project Management	21
	Sub-Area 3.4 – Contracting and Subcontracting	26
	Sub-Area 3.5 – Communication	28
4.0	Technical Process Assessment Area	30
	Sub-Area 4.1 – Technology Assessment and Transition	30
	Sub-Area 4.2 – Requirements Development	31
	Sub-Area 4.3 – Functional Analysis & Allocation	32
	Sub-Area 4.4 – Design Synthesis	33
	Sub-Area 4.5 – System Integration, Test and Verification	35
	Sub-Area 4.6 – Transition to Deployment	37
	Sub-Area 4.7 – Process Improvement	38
5.0	Technical Product Assessment Area	38
	Sub-Area 5.1 – System Description	38
	Sub-Area 5.2 – System Performance	42
	Sub-Area 5.3 – System Attributes	43
6.0	Environment Assessment Area	44
	Sub-Area 6.1 – Statutory and Regulatory Environment	45

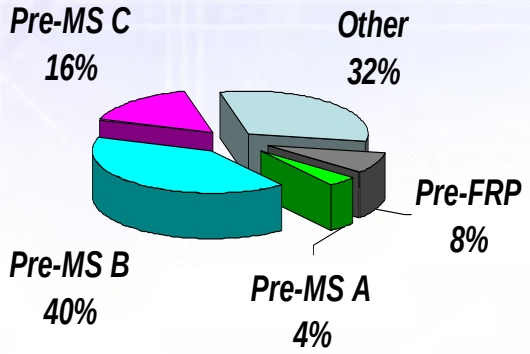
http://www.acq.osd.mil/ds/se

Program Support Review Activity
(since March 2004)

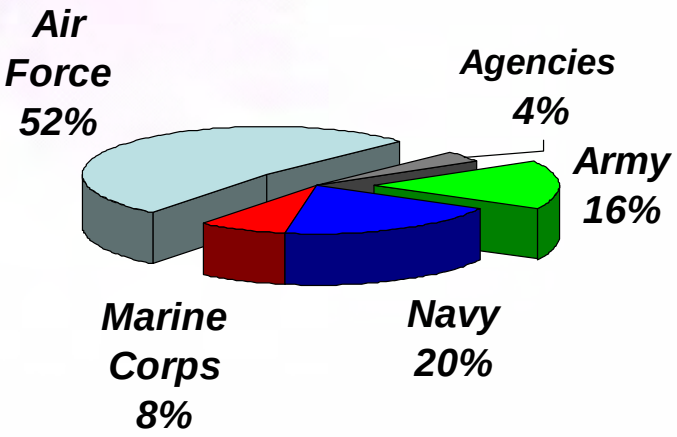
- Number of PSRs completed: 25
- Number of AOTRs completed: 4

- Reviews planned for rest of FY06
  - PSRs: at least 24
  - AOTRs: 2

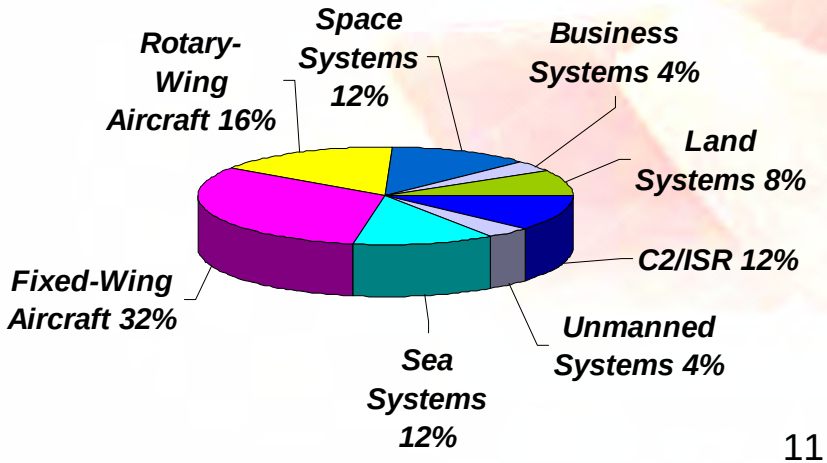
Reviews Conducted Prior to Each Milestone



Service-Managed Acquisitions



Programs by Product Line



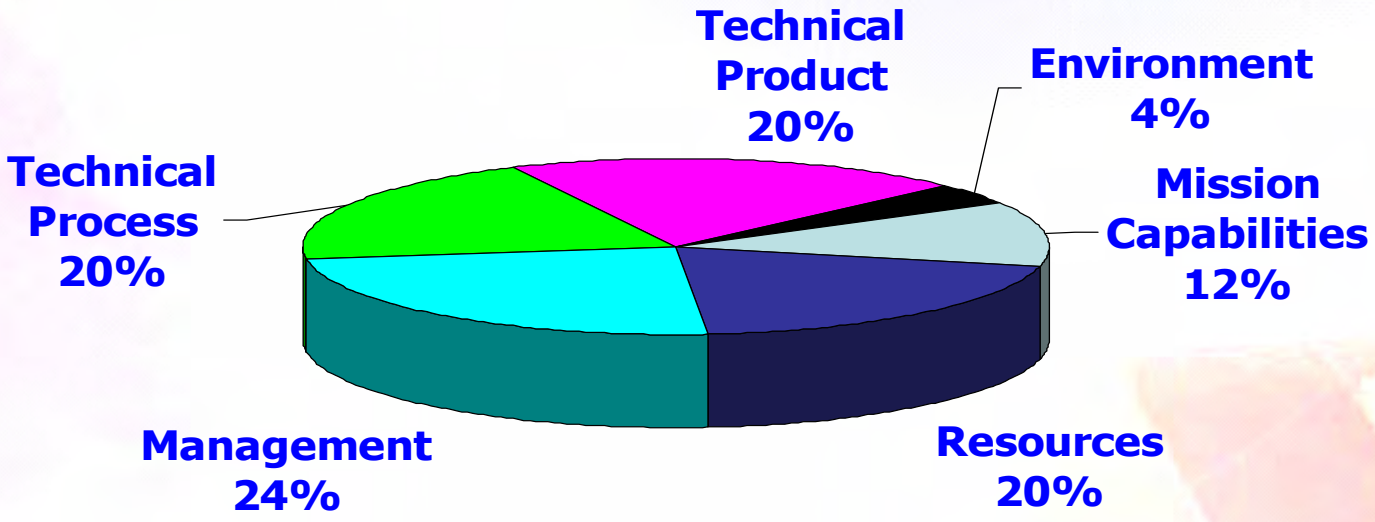
Samples of Program Support Review "Strengths"

- Experienced and dedicated program office teams
- Strong teaming between prime contractors, sub-contractors, program offices and engineering support
- Use of well defined and disciplined SE processes
- Proactive use of independent review teams
- Successful management of external interfaces
- Corporate commitment to process improvement
- Appropriate focus on performance-based logistics
- Notable manufacturing processes
- Focus on DoD initiatives
- Excellent risk management practices

But not on all Programs…

Emerging Program Support Findings**
(not systemic across all programs)

- Findings across the 6 general review areas…
  (based on assessment methodology areas)



**BASED ON ANALYSIS OF 14 OUT OF 22 REVIEWS

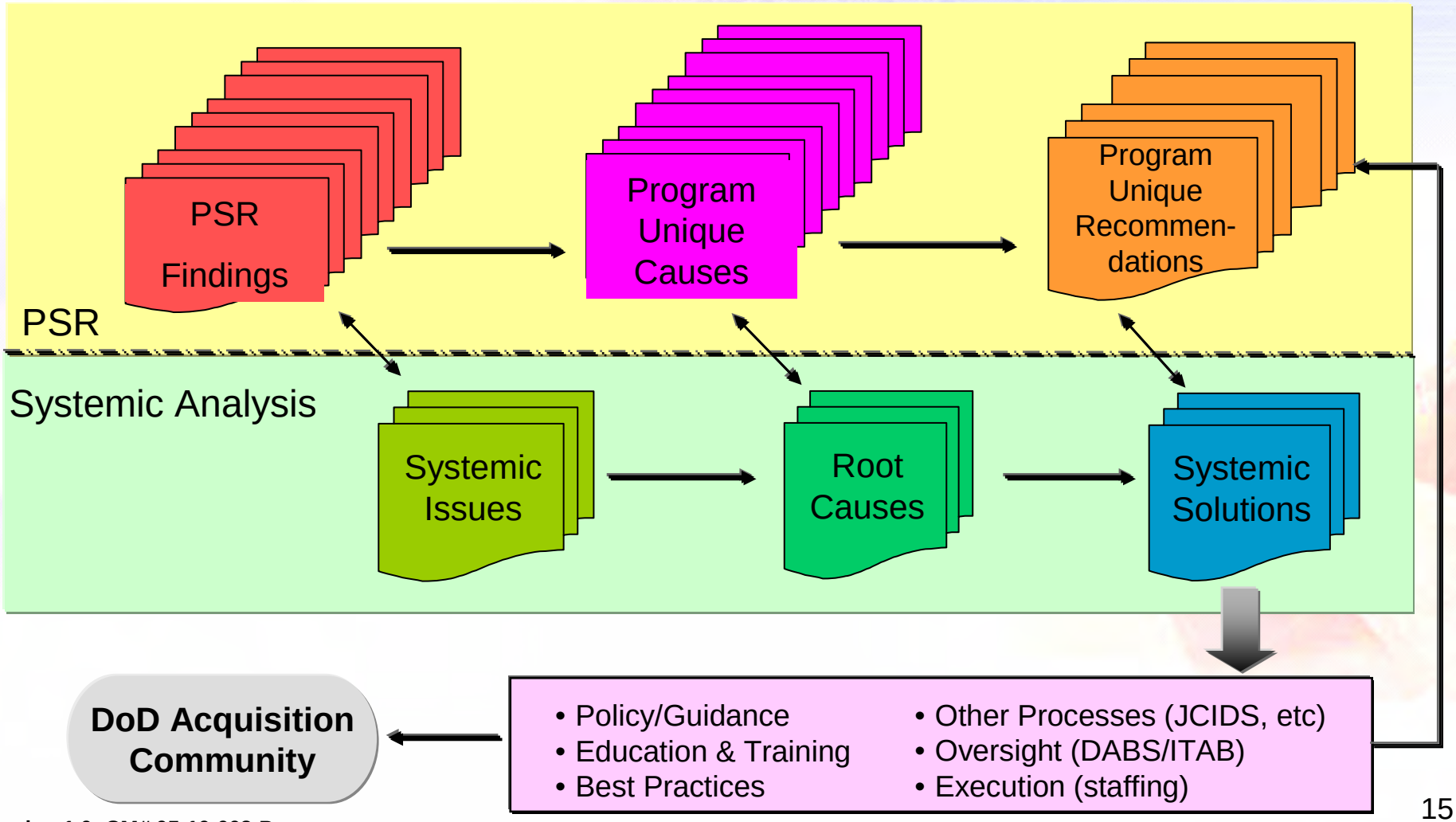
Driving Technical Rigor Back Into Programs
"How PMs are reacting to PSR recommendations?"

- Mission Capabilities - Requirements
  - – User requirements not fully defined and/or in flux
  - ☑ Established requirements management plan with all stake holders, including proactive plan for Net-Ready KPP
- Resources - Personnel
  - – Experienced, dedicated PM office staff, but stretched too thin
  - ☑ Expanded, empowered WIPT to bring in technical authority SMEs, users, and DCMA
- Management - Schedule Adequacy
  - – Technical review planning demonstrated schedule was high risk
  - ☑ Lengthen schedule to include full suite of SE technical reviews, supported by adjusted program funding
- Technical Process - Test & Evaluation
  - – Insufficient reliability growth program to meet user requirements by IOT&E
  - ☑ Increased the number of test articles and added sub-system level test events
- Technical Product - Supportability/Maintainability
  - – Logistics demonstration plan just prior to IOT&E
  - ☑ Demonstration re-scheduled prior to MS C

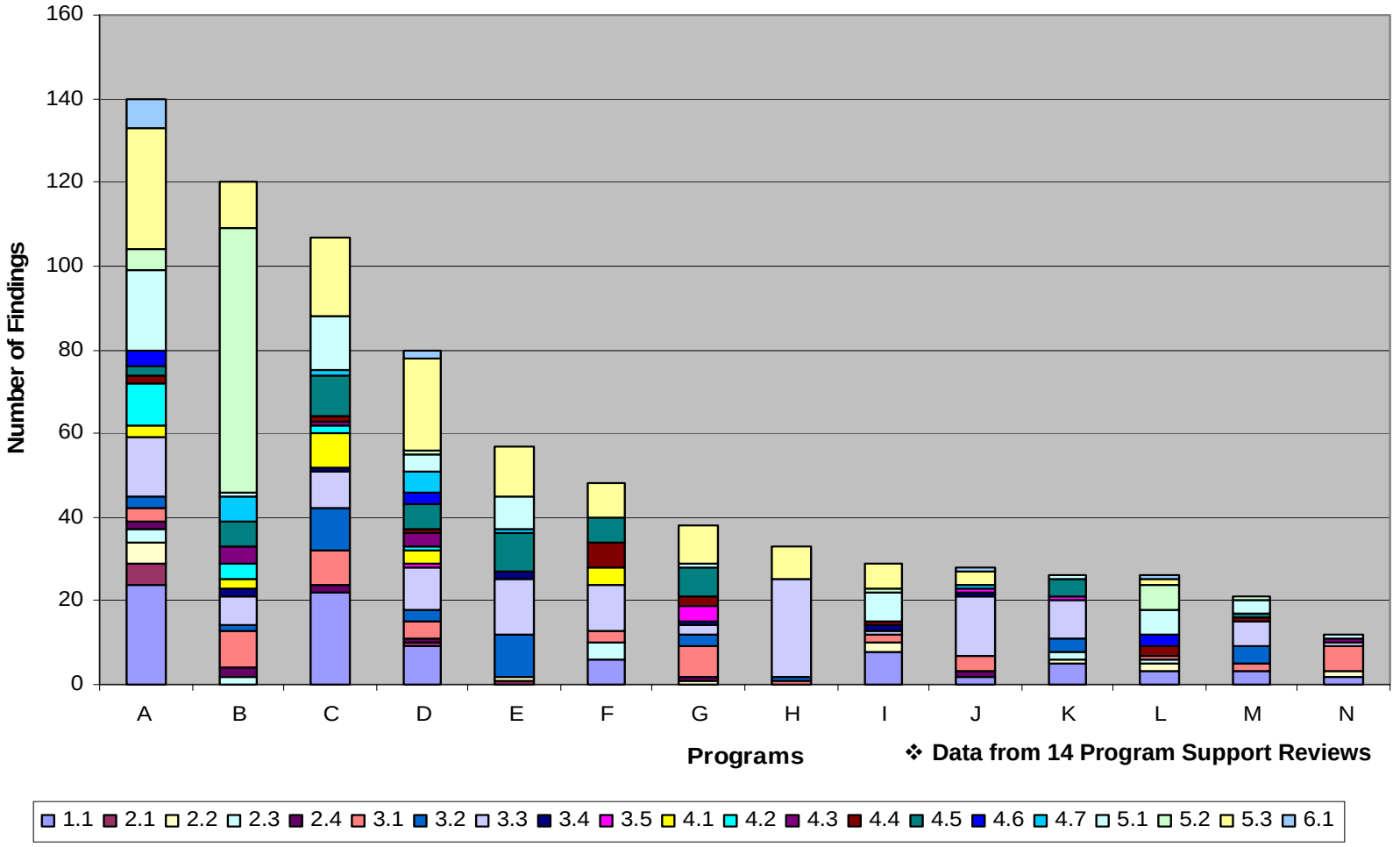
Better than 90% acceptance of recommendations

Systemic Analysis Perspective

"How do we find solutions to the systemic problems?"



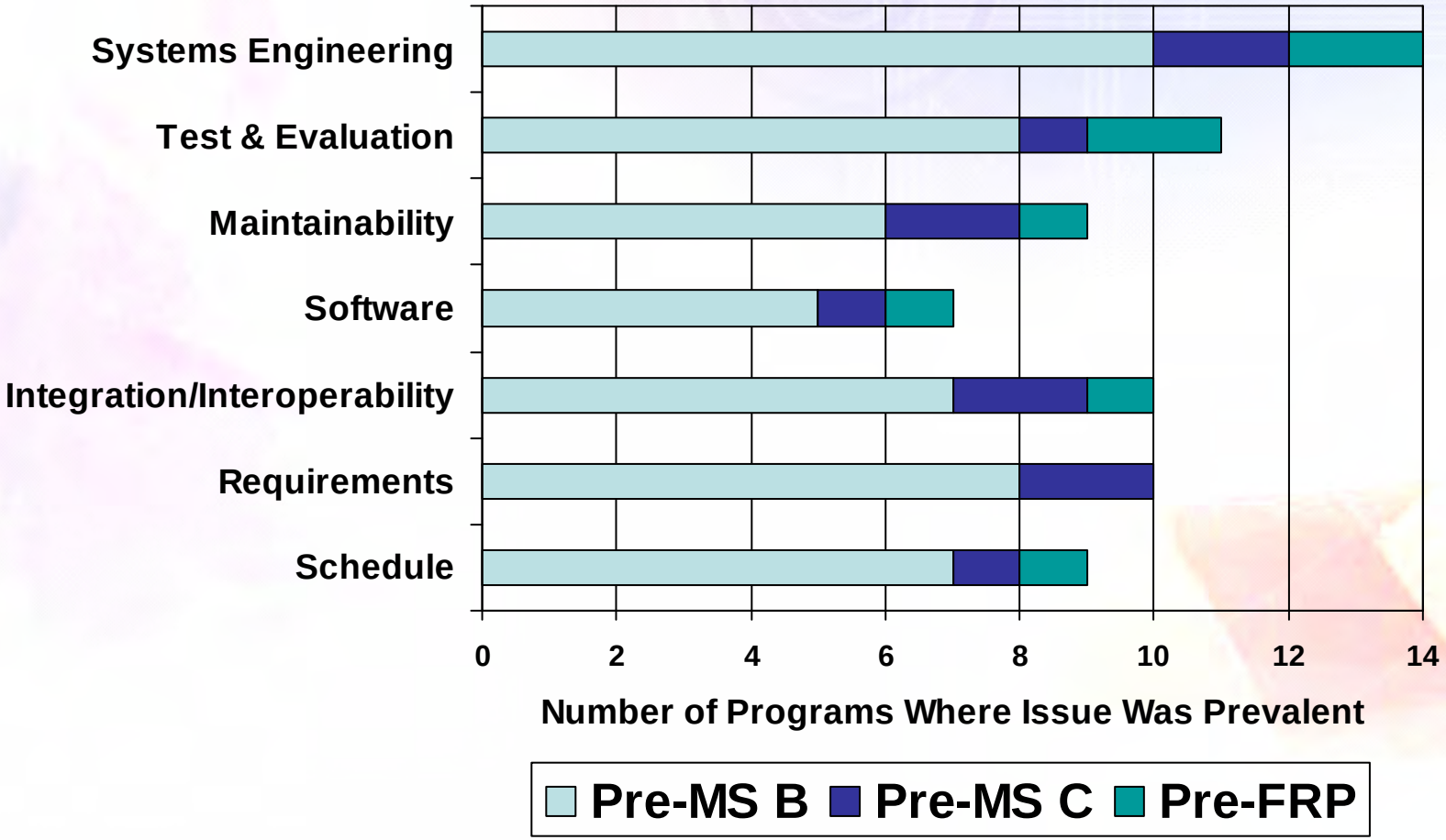
Number and Type of Findings by Program



Numbers represent sections of the PSR Metholodogy

Systemic Analysis Perspective

"What are the systemic problem areas?"



Representative Issues
(1 of 3)

- **Representative Issues for *Schedule***
  - Schedules too aggressive
  - Detailed schedules missing key components
  - Schedule concurrency (e.g. T&E activities)

- **Representative Issues for *Requirements***
  - Requirements don't support planned modifications, increasing capacity
  - Requirements changed without consideration or coordination with PM/PO and dependent programs
  - "Shortsighted" requirements, i.e. safety critical, bandwidth to support future capabilities

- **Representative Issues for *Integration/Interoperability***
  - Integration plans lacking key components
  - Multi-platform, scalable design benefits not realized due to low hw/sw commonality
  - Interoperability with Joint Forces not adequately addressed

Representative Issues
(2 of 3)

- **Representative Issues for *Software***
  - Software processes not institutionalized
  - Software development planning doesn't adequately capture lessons learned to incorporate into successive builds
  - Systems and spiral software requirements undefined
  - Software architecture immature
  - Software reuse strategies are inconsistent across programs
  - Software support plan missing

- **Representative Issues for *Maintainability***
  - Maintainability requirements incomplete or missing
  - Diagnostic effectiveness measures are either too ambiguous or missing
  - Tailoring out of criticality calculations translates to inability to monitor the maintainability status of reliability critical items

Representative Issues
(3 of 3)

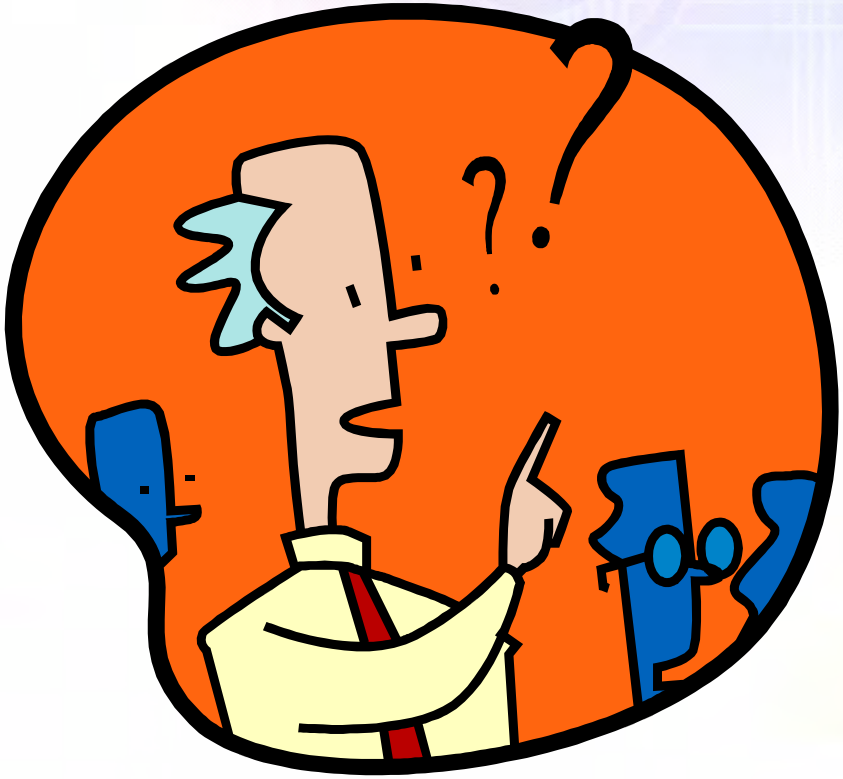
- **Representative Issues for *Test and Evaluation***
  - No reliability details (hours, profile, exit criteria, confidence level, OC curve)
  - Lack metrics
  - Basis for some threat-based requirements not fully explained or rationalized

- **Representative Issues for *Systems Engineering***
  - Lack of disciplined SE process, metrics, etc
  - PO not conducting PRR prior to LRIP
  - Missing Joint CONOPs
  - Missing System Functional Review (SFR) and PDR during SDD

Summary

- We are working to meet the Under Secretary's imperatives in support of transformation by:
  - Providing a context for decisions
  - Putting credibility into the acquisition process
  - Driving systems engineering back into programs
- Our ultimate goal in conducting PSRs is to help all programs achieve mission success through:
  - Early and persistent application of SE
  - Event-driven technical reviews and test programs

Questions…perhaps Answers



Raytheon

Customer Success Is Our Mission

CMMI for Services

Gordon Ward Director Of Quality & R6s™ Raytheon RIS
Juan Ceva, Mark Pumar, Enterprise Process Group Raytheon

Agenda

- Background
- Lessons Learned
- History
- Epiphanies
- Approach
- Conclusion

"…he who attempts it must first pass the point of this lance;" and so saying he brandished it so stoutly and dexterously that he overawed all who did not know him.

Miguel de Cervantes
Don Quixote

Background – Critical Issues

- *Need to be CMMI (L3) to stay in Business.*
- *Service Organization (that don't fit into the traditional product development model) struggle to achieve CMMI L3 in a timely and cost effective manner.*
- *How does an organization staffed with practitioners from standard (product oriented) high maturity organizations, with large range in its technical disciplines, little or no process dollars, and little or no project autonomy achieve a CMMI level 3?*
- *Welcome to the World of Technical Services!*

Background – Pasadena Operations

- Raytheon's Pasadena Operations
  - Part of Raytheon Information Solutions.
  - Establish in 1998 with the award of the SDSIO (Science Data System Implementation and Operations) contract by the California Institute of Technology and NASA's Jet Propulsion Laboratory (JPL).
  - Umbrella services contract allowing JPL Managers to contract directly with Raytheon for technical and scientific services.
  - Consists of functional departments organized along lines of businesses reporting to a Program Manager.
  - Technical disciplines range from software and systems engineering to IT, scientific analysis, and web development.

Background – Challenges to CMMI

- Service, not product-based organization.
  - No traditional end-to-end lifecycle.
  - Customer directing work – little or no autonomy.
  - Small overhead – no funding for process support & development.
- Blurring of function within projects and across departments.
  - Project activities range from software development to graphic design.
  - Departments support operations, IT, analysis, and development.
- Raytheon and Customer culture significantly different.
  - Research versus product oriented.
  - Low process maturity (relative to industry).
  - Small teams (1-2 FTE) with modest funding.

Process Improvement History

- Grass root effort
  - Started with (unfunded) special interest group in March 1999.
  - Prevailing feeling that Customer would be better served if proven process could be applied to each task.
  - Most members worked for high maturity organizations before coming to Pasadena.

- False starts and dead ends 1998 – 2003
  - Top-down approach to process improvement (unsuccessful)
  - Obstacles:
    - CMM, no CMMI yet
    - Lack of process infrastructure (QA, CM, MA, etc.)
    - Customer “owns” project areas (PP, PMC, IPM, Risk)
    - Small, diverse, short-term (< year) projects
    - Customer chooses not to perform some key practices
    - Funding

Raytheon

Process Improvement History (cont.)

- Alternatives

  - ***Approach*:** Restrict process to one or two projects where sufficient autonomy existed to apply Model.
  - **Drawbacks:** *No benefit on most projects; limited benefit to customer.*

  - ***Approach*:** Apply Model to a collective group of projects, with no single project performing all key practices of the Model.
  - **Drawbacks:** *Risky – might loose one or more key projects.*

  - ***Approach*:** Completely new (non-traditional) approach.
  - **Drawbacks:** *Not clear how to proceed; requires 'breakthroughs'.*

History (cont.)

- Breakthroughs 2003 and 2004

  - Use bottom-up approach.
    - Develop lifecycle based on how work is actually done.
    - Map Model to lifecycle.
    - "Fill" process gaps.
  - Shift focus to delivery of *service* instead of delivery of a product.
  - Use Raytheon Six-Sigma for process improvement.
  - Use a traditional engineering lifecycle (requirements, design, implementation, verification and validation) to develop the process.
  - Employ an evolutionary or staged approach to implementation.

Raytheon

Epiphanies

- Key breakthroughs that resulted in substantial progress in applying the CMMI to services.

- Epiphany 1: *Task Orders are equivalent to projects*.
  - Apply process to every task order.
  - Re-identify each Model key practice with an equivalent practices in the service environment.

- Epiphany 2: *Project requirements are services requested by the Customer*.
  - Requirements are the Customer requests for services in the form of personnel and attendant support.

Epiphanies (cont.)

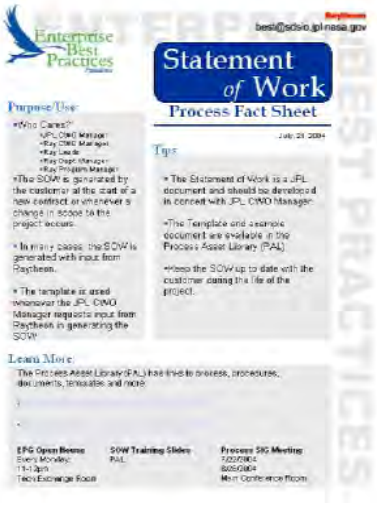
- Epiphany 3: *Every project has the same (unchanging) five requirements.*
  - Requirements are:
    - **Staffing** – e.g. supply two oceanographers.
    - **Facilities** – e.g. provide office space and equipment for assigned personnel.
    - **Finance**s – e.g. monitor and report cost associated with supplying 2 oceanographers.
    - **Management** – e.g. manage the task order (find staff and facilities, monitor cost and personnel).
    - **Infrastructure Support** – e.g. provide networks, phones, computers, etc. for 2 oceanographers.

Epiphanies (cont.)

- Epiphany 4: *The relative time spent for development versus delivery in services is reversed from that of products*.
  - Products: most of the effort is spent ***developing*** the product.
  - Services: most of the effort is spent ***delivering*** the service.

Approach

- ***Template-based solutions.***
  - Technical staff and management not burdened with process details that are not directly applicable to their work.
  - Technical staff works with solutions that are relevant to their everyday tasks without having to become versed in the CMMI.
  - A relatively small group of Model experts can concentrate on insuring that the CMMI practice areas are covered via the usage of the templates.



Approach (cont.)

Approach Used

- Multi-part SCAMPI C and B.
  - SCAMPI C divided into two events.
    - 1st event examined organization's business model.
    - 2nd event examined templates.
  - SCAMPI B divided into three events.
    - 1st event examined evidence from the project area of the Model on a single focus project.
    - 2nd event examined evidence from the support area of the Model.
    - 3rd event examined evidence from the engineering area of the Model.
  - Engaged appraisal team in improvement process
    - Team recommendations, solutions, and feedback incorporated into process before deployment.
  - SCAMPI A: Traditional

Traditional Approach

- C and B SCAMPIs are conducted as single events
  - SCAMPI C reviews policies & procedures
  - SCAMPI B reviews polices, procedures and artifacts

Lessons Learned

- ***Use Bottoms-up Approach***
  - Develop process solutions based on business model
  - Tailor solutions to the organization
- ***Run the implementation as a (serious) project.***
  - Establish a project manager, budget, schedule, and measurable goals.
  - Track and monitor progress on a regular basis using EVMS.
  - Use phased deployment
  - Develop and validate processes before deployment.
- ***Implement a 'grass roots' communications plan throughout the project***.
  - Start communication with staff and management early to establish and clarify goals.
  - Celebrate small successes publicly at all-hands meetings and other group events.
  - Setup recurring open houses and training sessions with the process developers.
  - Demonstrate the benefits to individuals.

Lessons Learned (cont.)

- ***Obtain stakeholders' support and active involvement***.
  - Gain sponsors at the highest level and understand their goals.
  - Involve Customers frequently via EPG and Steering Committee meetings.
  - Communicate the benefit of reaching goals.
- ***Make use of consultants***.
  - Leverage Model expertise from other parts of the organization.
  - Choose the lead appraiser wisely i.e. 'out-of-box' thinker.
  - Put the appraisal team to work for the organization.
  - Use their feedback to refine processes before deployment.

Conclusions

- Successfully implemented one of the first applications of the CMMI Model to Services
  - Technical Details Documented in (up-coming) SEI Technical Note
  - https://bscw.sei.cmu.edu/pub/bscw.cgi/0/79783
- Developed pragmatic and cost effective model to deploy CMMI in non-traditional applications
- True Process Improvement
  - Added processes meaningful and useful to organization
    - Day-to-day operations improved
    - Organization more efficient and effective at delivering services
  - Increased engagement with customer at all levels

SYSTEMS ENGINEERING AND THE SOFTWARE LAWS OF THERMODYNAMICS

Dr. Thomas F. Christian Jr.
Director of Engineering
ACSSW, WPAFB OH
26 Oct, 2005

SYSTEMS ENGINEERING

- Systems Engineering is the disciplined application of tools and principles to achieve a complex goal
- Software Engineering is part of Systems Engineering
- Systems Engineering must obey the Fundamental Laws of Physics

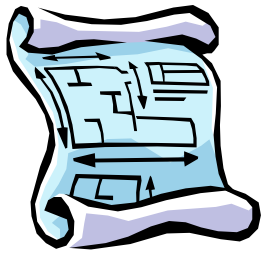
THE LAWS OF PHYSICS

- But what are the fundamental laws of physics?
- F=MA?

- Earlier seminal work at SSTC 2005 said “Yes” – Newton’s Laws of Motion govern Software Engineering

THE LAWS OF METAPHYSICS

- **“I think therefore I code”**
- **No, No!!**
- **Even EEs understand Inertia but, could there be some law even more fundamental than that?**



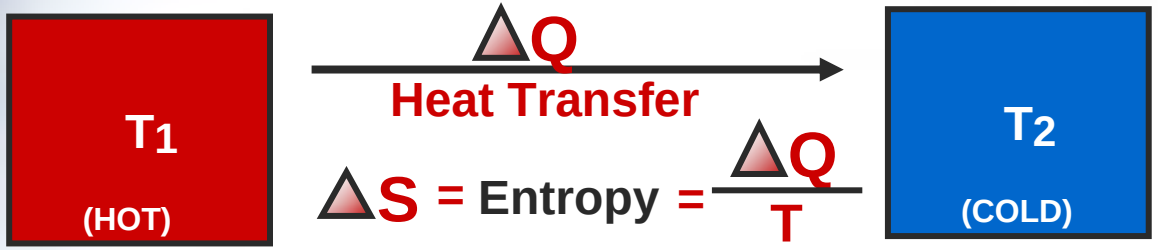
THE LAWS OF NATURAL PHILOSOPHY

-- YES --

THERMO

The unexplainable

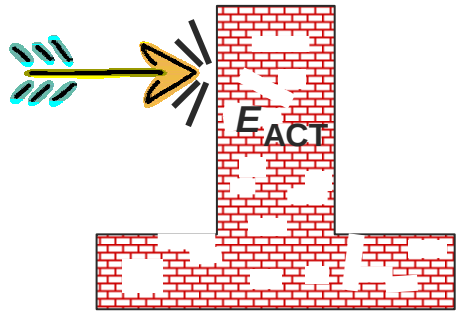
1ST LAW – CONSERVATION OF ENERGY



"If the state of a system is changed by applying work or heat or both, then the change in the energy of the system must equal the energy applied"

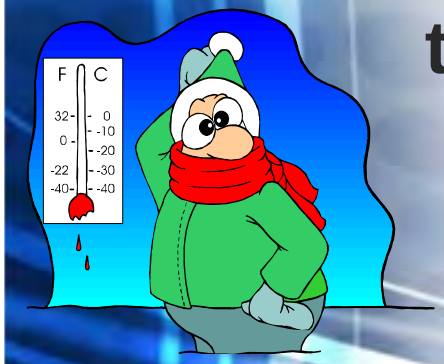
2nd LAW – TENDENCY TOWARD EQUILIBRIUM

"It is impossible to move heat, by cyclical process from something at lower temperature to something at higher temperature unless work is added to the system"



3rd LAW – ABSOLUTE ZERO

“If the entropy of each element at absolute zero can be taken as zero, then all elements above absolute zero must have a finite, positive entropy; however, because entropy cannot be reduced to zero by finite means (as per the Second Law), no system can reach absolute zero”



Since we are Systems Engineers - Not Physicists – Let's put them into System Engineering - Speak

- 1st Law: You Can't Win – Just Break Even
- 2nd Law: You Can Only Break Even at Absolute Zero
- 3rd Law: You Can't Reach Absolute Zero

THE SOFTWARE LAWS OF THERMODYNAMICS

- **Optimizing software quality, cost, schedule require proper processes, planning, and people**
- **Proper processes, planning and people requires time to do it right**
- **There is NEVER time to do it right**

"RASSA'S LAW"

- "No one can resist the temptation to edit another's work or start coding on the first day of a program"

Robert M. Cranwell, Manager

Readiness & Supportability Programs

Sandia National Laboratories (SNL)

Albuquerque, NM 87185

8th Annual NDIA Systems Engineering Conference
October 24-27, 2005
San Diego, CA

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- **8,000 employees in New Mexico, California, Nevada, and Hawaii**
- **Responsible for research, development, engineering, and maintenance of U.S. nuclear weapons**
- **Responsible for all non-nuclear subsystems; the primary systems integration and engineering lab**
- **$2B annual budget**
- **$550M from other federal agencies**
- **$50M from private industry through R&D partnerships**

Major Readiness/Supportability Initiatives

Army's FCS Supportability

JSF Autonomic Logistics

JSF

HIGHLY-RELIABLE AIRCRAFT

Prognostics & Health Management

TECHNOLOGICALLY ENABLED MAINTAINER

ROBUST LOGISTICS INFRASTRUCTURE

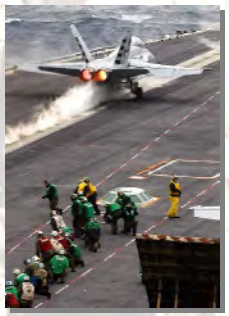
AUTONOMIC LOGISTICS INFORMATION SYSTEM

Army's Recapitalization (RECAP)

NNSA
National Nuclear Security Administration

Navy CVN 21 Manpower

Transition to the Future
PMS 378
Future Aircraft Carriers Program Office
Modernize the Past



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Sandia National Laboratories (SNL)
UA System-of-Systems (SoS)
Supportability Modeling & Simulation

FUTURE COMBAT SYSTEMS
FCS
One Team—The Army/DARPA/Industry

Distribution authorized to the Department of Defense and U.S. DoD contractors only by direction of PM UA, August 2004.
Other requests shall be referred to PM UA.

What is a System-of-Systems?

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

Key to understanding a System-of-Systems (SoS) is the notion that a SoS performs a function not possible with any of the individual parts (systems) acting alone

- **In this context, a SoS can be viewed as a collection of interdependent systems that are integrated to provide a prescribed capability**
- **The loss of individual systems within the SoS will degrade the performance or capabilities of the SoS**
- **However, individual systems within the SoS can provide a capability or function independent of the other systems within the SoS**

A SoS can be viewed as multiple systems, each capable of independent operations, but must interact in order to fulfill a global mission.

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SNL SoS M&S Framework

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

- Single model for multiple MOEs/MOPs
- Multiple states (not just functional or failed)
- Incorporates complex interdependencies
- Includes external factors (weather, terrain, threats)
- Able to incrementally add new components

State Model Objects

Uncertainty Characterization

Optimization Analyses

Simulated Campaigns

- Scalability to large numbers of platforms
- Can include multiple pulses throughout campaigns
- Includes integrated logistics support during campaign
- Tracks dynamic changes in force structure during campaign
- Includes complex communications & data networks

- **Utilizes:**
  - Unique State Modeling Concepts
  - State-of-Art SoS Simulation Framework
  - Customized Optimization Algorithms
- **Provides Capability for Analyzing:**
  - Systems as well as Systems-of-Systems
  - Warfight capabilities (pre, post, during campaigns)
  - Spiral integration of technologies
- **Flexibility to Include:**
  - Complex supply & support networks
  - Stochastic treatment of combat damage
  - Human performance (maintainers, warfighters, …)
- **Allows Analyst to Assess Impacts of:**
  - PHM
  - Asset visibility
  - Commonality & complex functional redundancies

- *Time-Dependent Warfight Capability*
- *UA/SoS MOE's/TPM's*
- *Sensitivity Trades*
- *Optimization Analyses*

Integrated methodology provides unique capabilities for SoS analysis

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State Model Concepts

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

- **State modeling attributes**
  - Multiple functions/operations
    - Mobility
    - Communications
    - Sensing
    - Lethality/Firepower
  - Multiple States (not just functional or failed)
  - Models interdependencies
  - Can include external factors (weather, terrain, combat, …)
  - Able to incrementally add new components
- **Model system behavior by defining:**
  - States for all subsystems/components/functions
  - How transitions are made between states
- **States can change through:**
  - Normal processes (failure, repair,…)
  - External conditions (weather, terrain, combat,…)
  - Changes in functional states of other systems

NLOS-C State Model Object

NLOS-C Model

Example Elements

- 105 mm Cannon
- M240 Machine Gun
- Sandstorm

Example Operations

- Operability
- Lethality
- Mobility

Intuitive Environment for Capturing System Behavior

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Soldier Performance Modeling

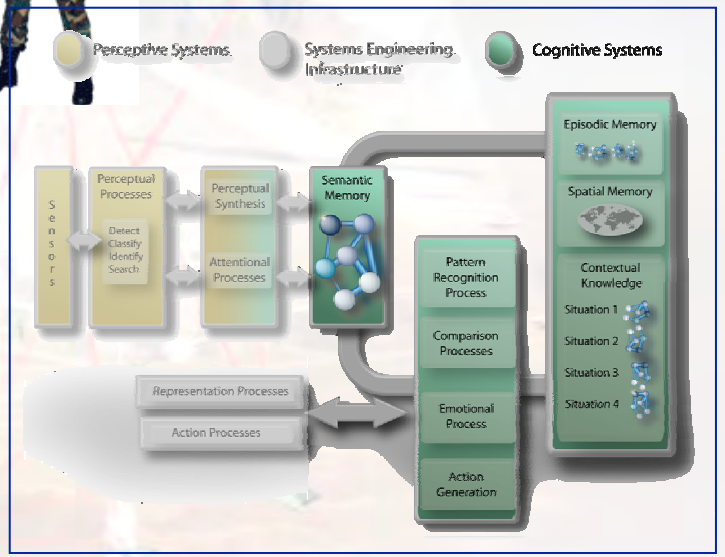
- **Multiple Functions/Operations**
  - Navigate
  - Communicate
  - Combat
  - Maintain . . .
- **Multiple States**
  - Not just functional or failed
- **Model soldier behavior by defining:**
  - All possible states
  - How transitions are made between states
- **States can change through:**
  - Fatigue
  - Stress
  - Sleep deprivation
  - Training . . .

Mobility

Lethality

Survivability

Communication



Human Performance is Key to Modeling Complex SoS's

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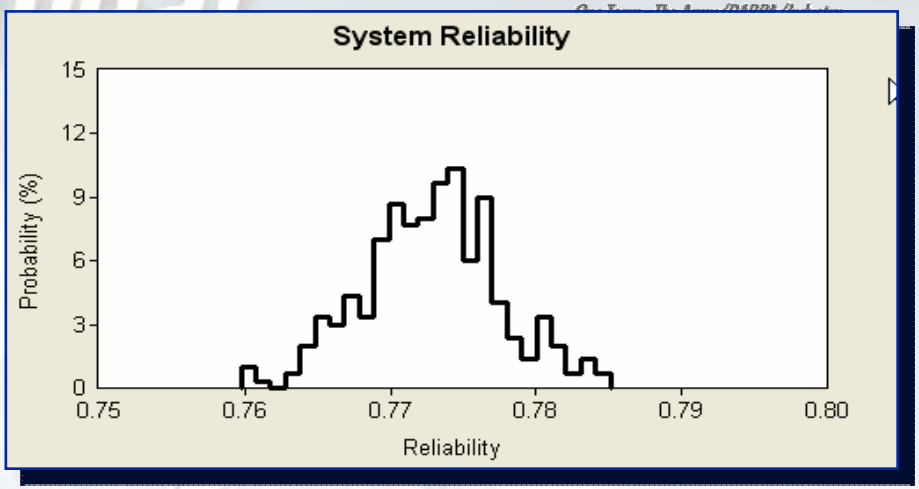
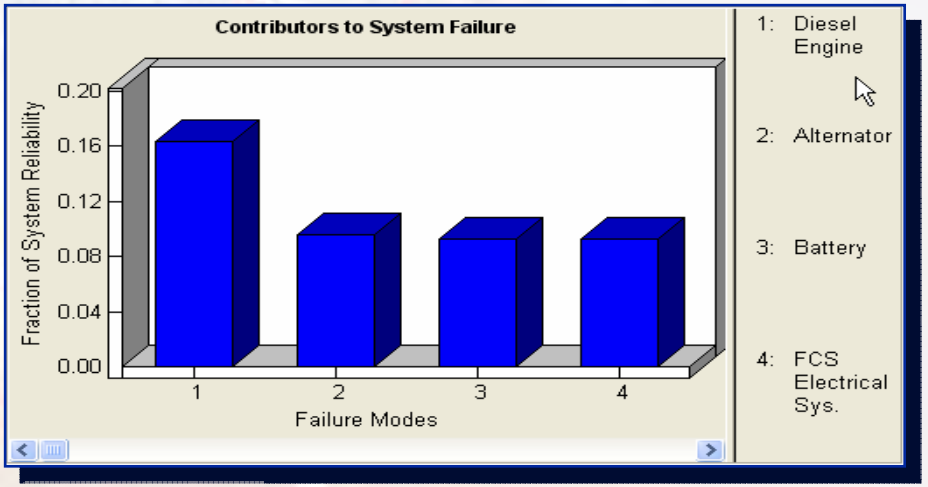
State Model Results

- System Performance Analyses
  - Reliability
  - MTBF
  - Availability …
- Sensitivity Analyses
- Optimization Analyses
  - Spares
  - Performance trades
  - Resource allocation





Rank: 1 Export...

1 Summary | 2 Details

Performance Measure	Baseline	Limit	Objective	Value
Fitness	0.00461			0.758
NLOS-C : Reliability	0.535	0.580	0.600	0.594
C2 : Reliability	0.773	0.800	0.820	0.807
Cost 1	0	2.00E+7	1.20E+7	1.23E+7

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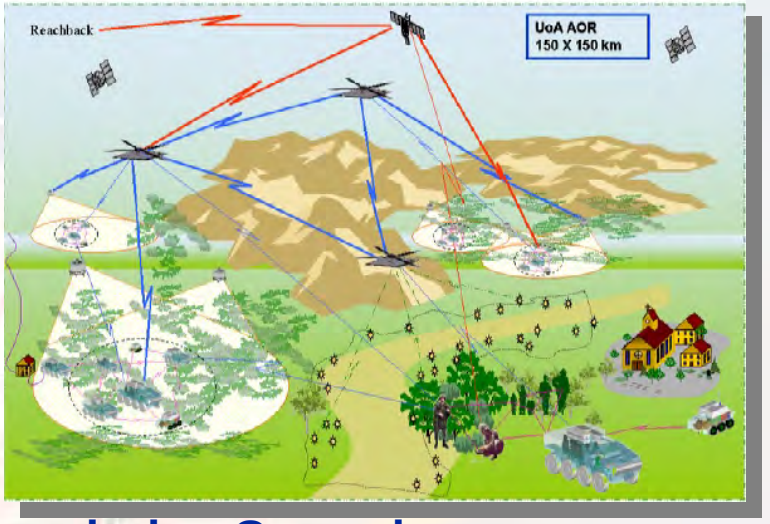
Time Simulation

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

Incorporates State Model Objects (SMOs) to dynamically represent a given scenario for a defined force structure

- Creates and duplicates platforms and platform types (Defines Force Structure)
- Describes Scenario/Campaign
- Describes Functions for Each Platform Type
- Describes System/Elements Properties
- Describes External Conditions



- Evaluates/tracks Functionality of Force Structure during Campaign
- Tracks Supplies & Services (Logistics Footprint)

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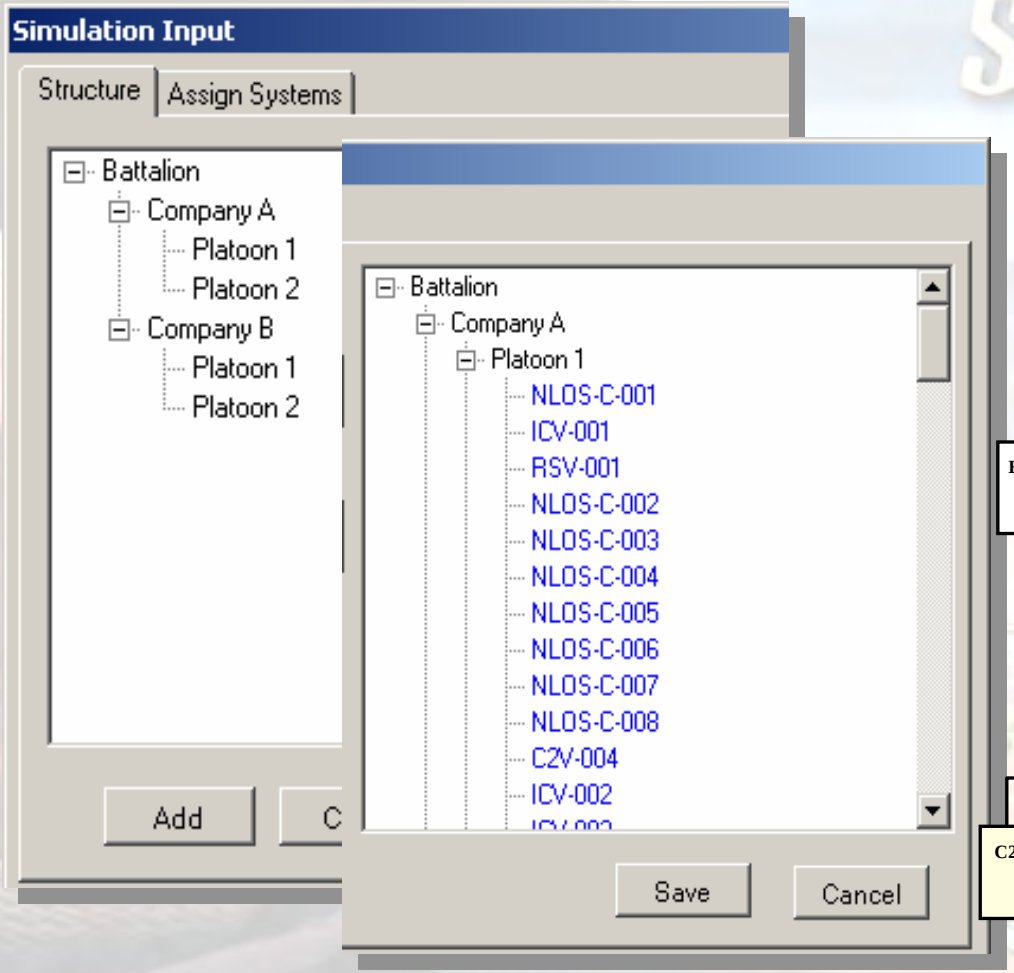
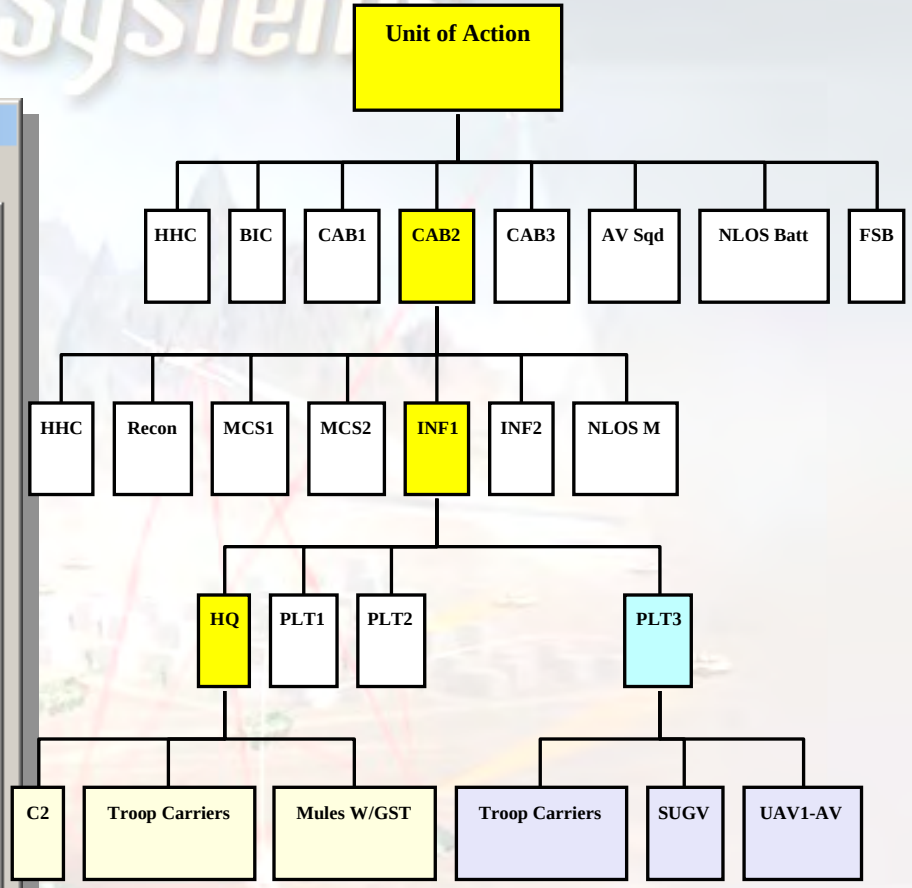
Defining Force Structure

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

Example Battalion Structure for Simulation





Force Structure is established in Simulation Software by creating and duplicating platforms and platform types

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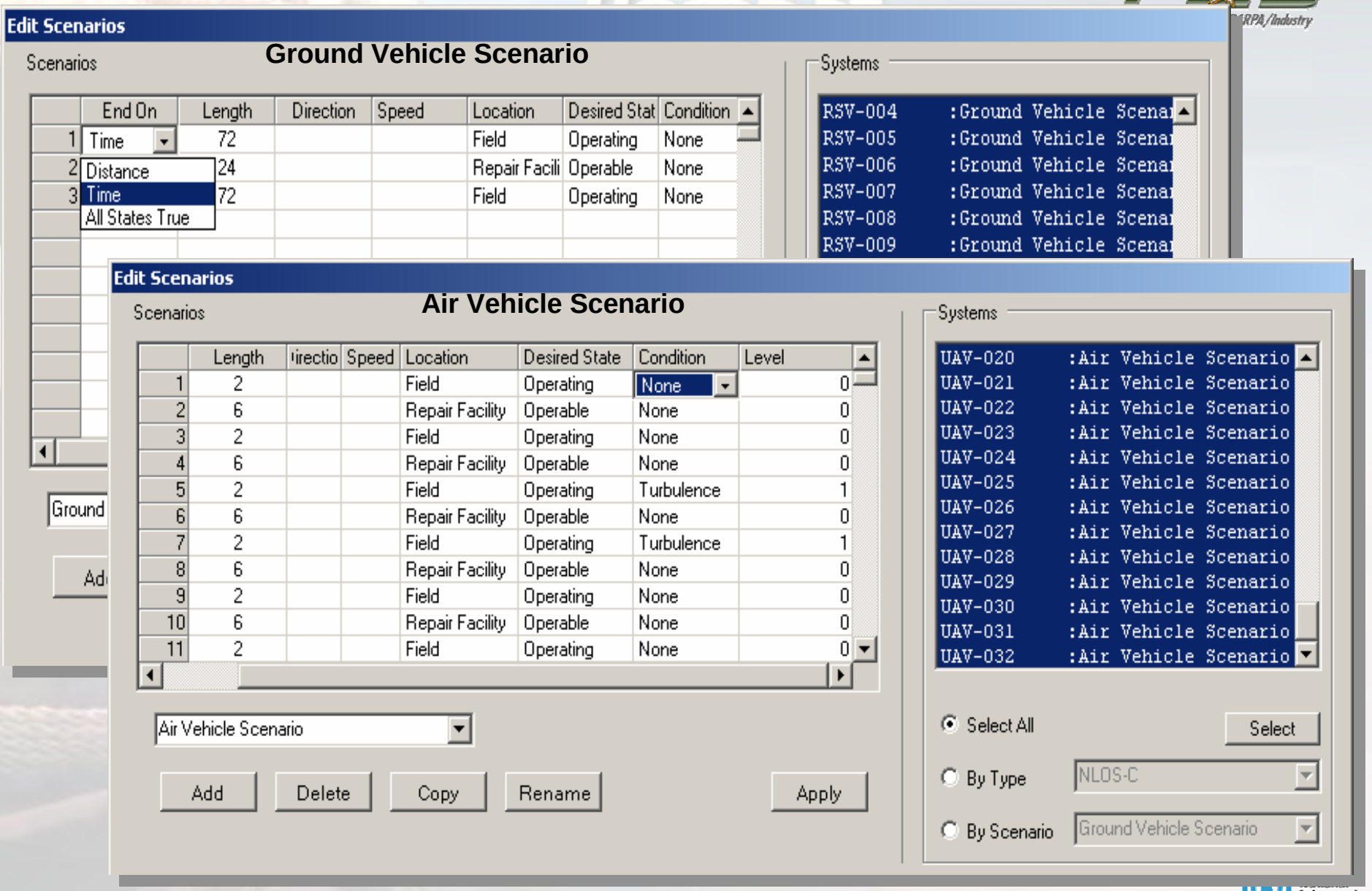
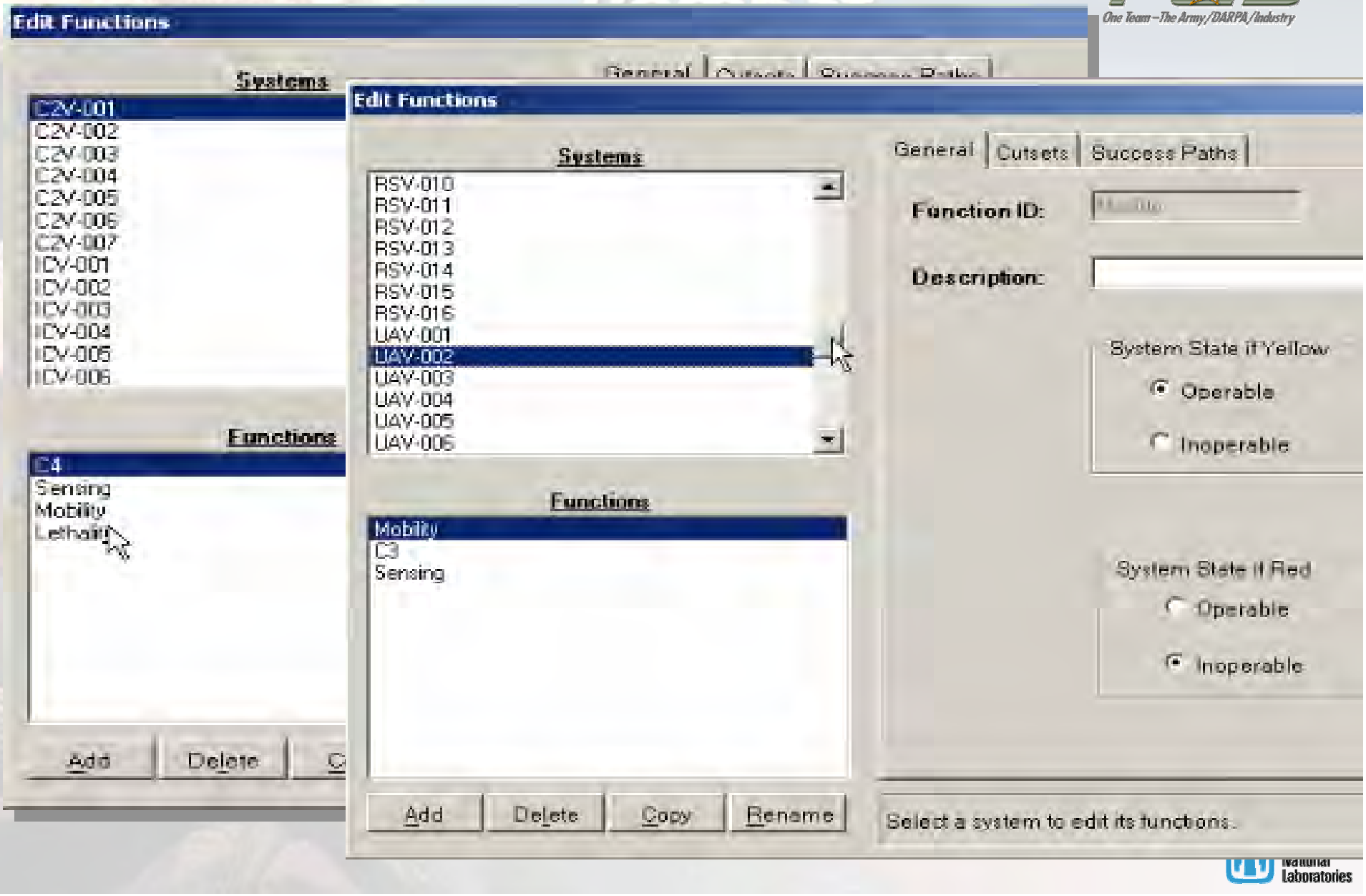
Simulation Scenario Structure



Functions for Each Platform Type



Example External Conditions

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External Conditions Can Include:

- **Terrain**
  - ✓Rough
  - ✓MOUT . . .
- **Weather**
  - ✓Sandstorm
  - ✓Turbulence . .
- **Combat . . .**

External Conditions Affect:

- **Consumables**
  - ✓Water/Fuel
  - ✓Ammo . . .
- **Random Processes**
  - ✓Time-to-failure (TTF)
  - ✓Time-to-repair (TTR) . . .
- **System/Element State(s)**
  - ✓Operable
  - ✓Inoperable . . .

Flexibility in Treatment of External Conditions

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System Functional Status

FUTURE COMBAT SYSTEMS
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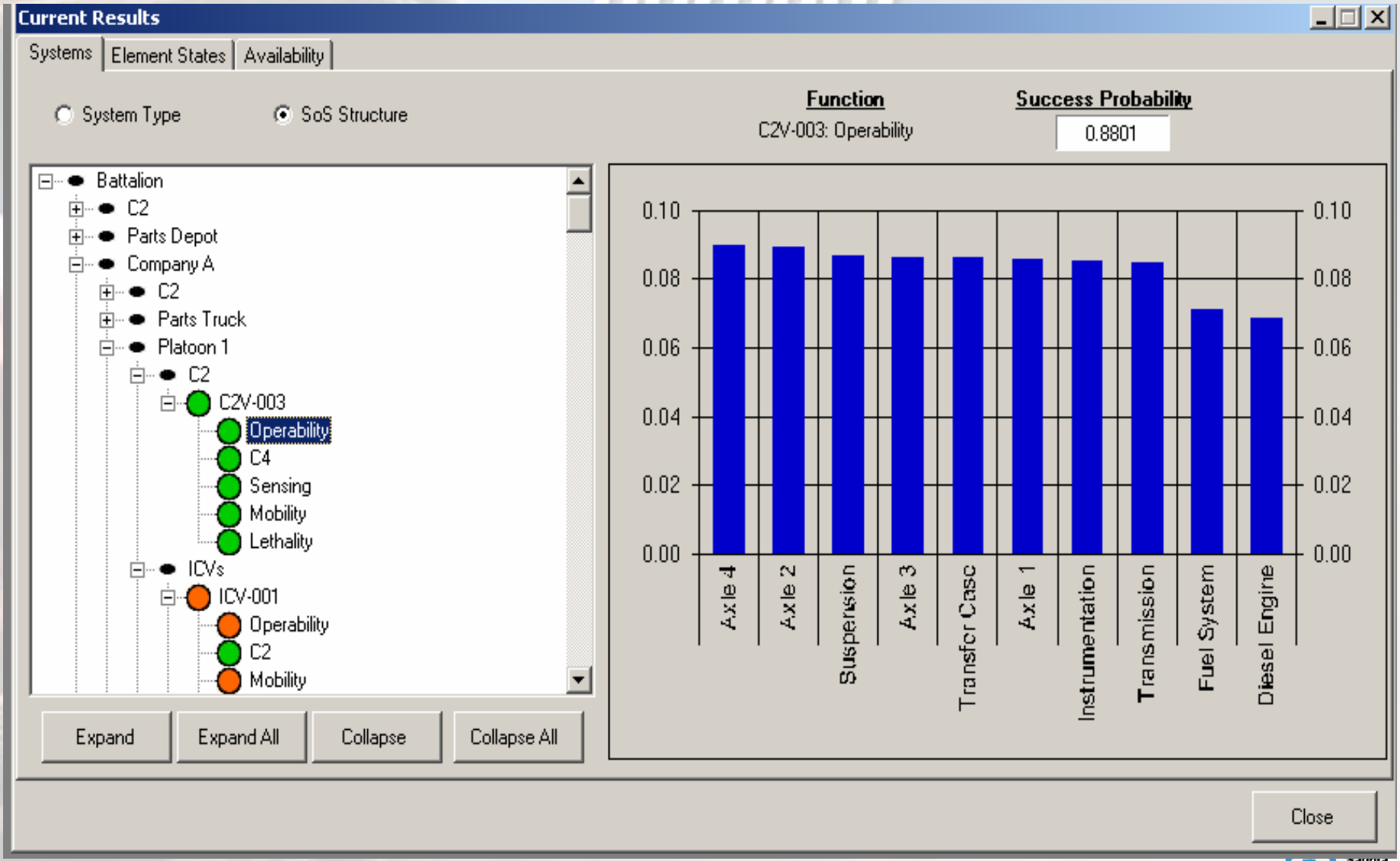

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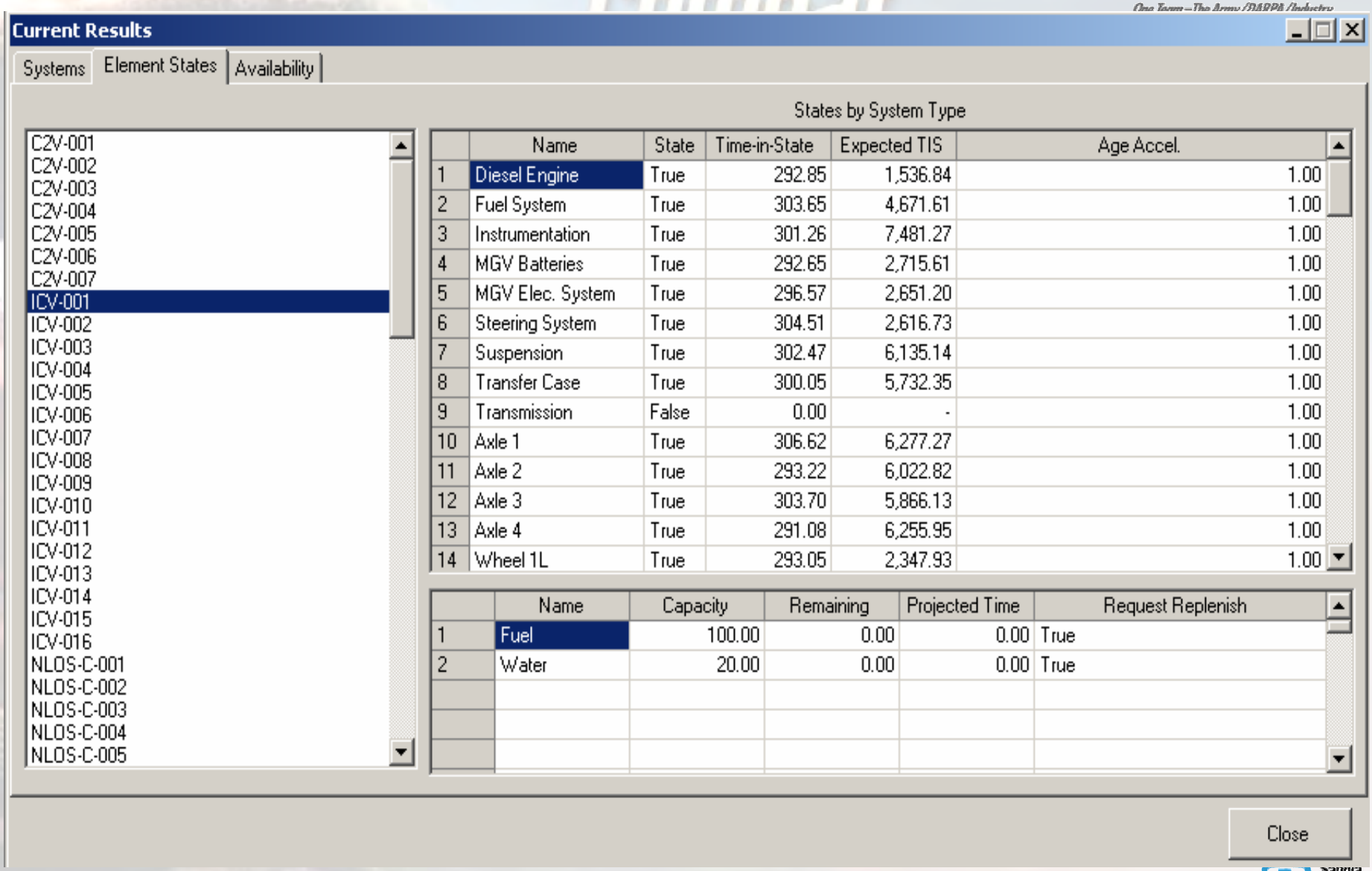
System Functional Status



	Name	State	Time-in-State	Expected TIS	Age Accel.
1	Diesel Engine	True	292.85	1,536.84	1.00
2	Fuel System	True	303.65	4,671.61	1.00
3	Instrumentation	True	301.26	7,481.27	1.00
4	MGV Batteries	True	292.65	2,715.61	1.00
5	MGV Elec. System	True	296.57	2,651.20	1.00
6	Steering System	True	304.51	2,616.73	1.00
7	Suspension	True	302.47	6,135.14	1.00
8	Transfer Case	True	300.05	5,732.35	1.00
9	Transmission	False	0.00	-	1.00
10	Axle 1	True	306.62	6,277.27	1.00
11	Axle 2	True	293.22	6,022.82	1.00
12	Axle 3	True	303.70	5,866.13	1.00
13	Axle 4	True	291.08	6,255.95	1.00
14	Wheel 1L	True	293.05	2,347.93	1.00

	Name	Capacity	Remaining	Projected Time	Request Replenish
1	Fuel	100.00	0.00	0.00	True
2	Water	20.00	0.00	0.00	True

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

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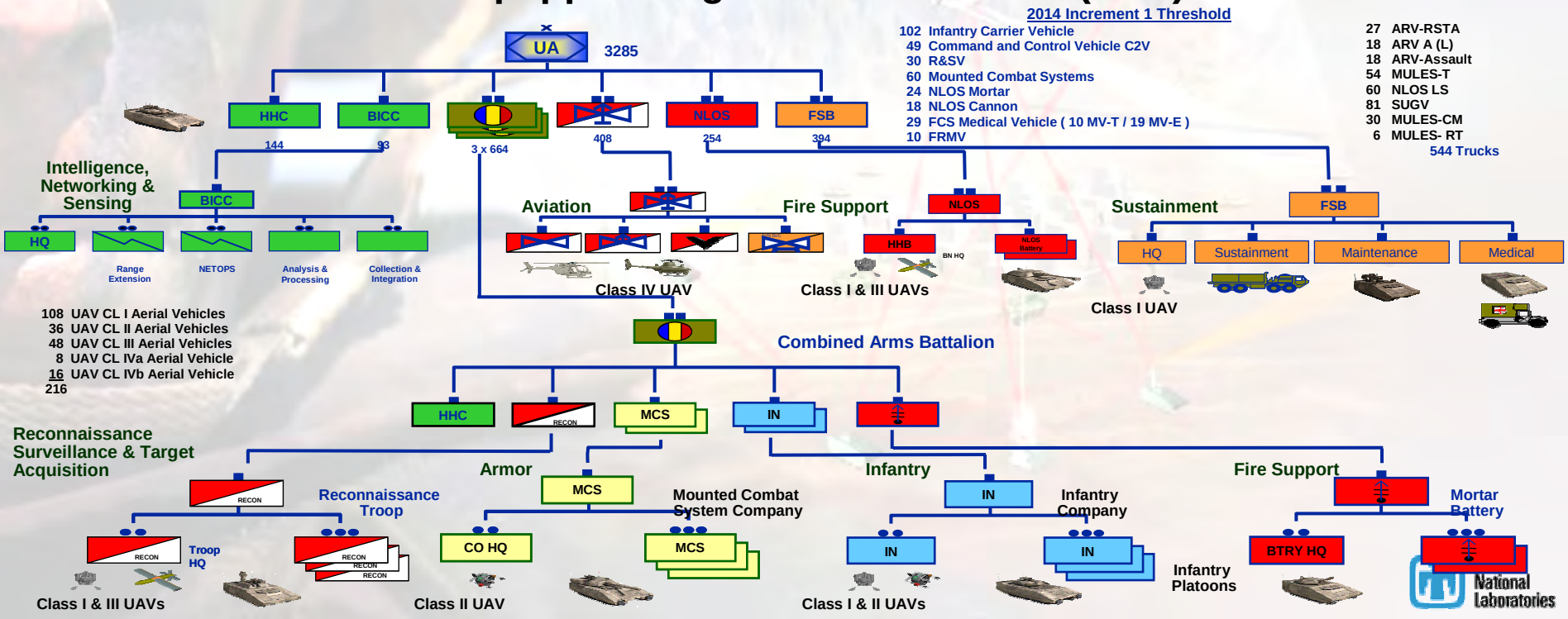
FCS UA/BCT Analyses

FUTURE COMBAT SYSTEMS
FCS
One Team – The Army/DARPA/Industry

Example FCS UA/BCT Analysis

- BCT force structure consisting of 1552 platforms
- Multiple pulses
- Level-5 subsystems – on average 265 elements
- Performed optimization and sensitivity analyses

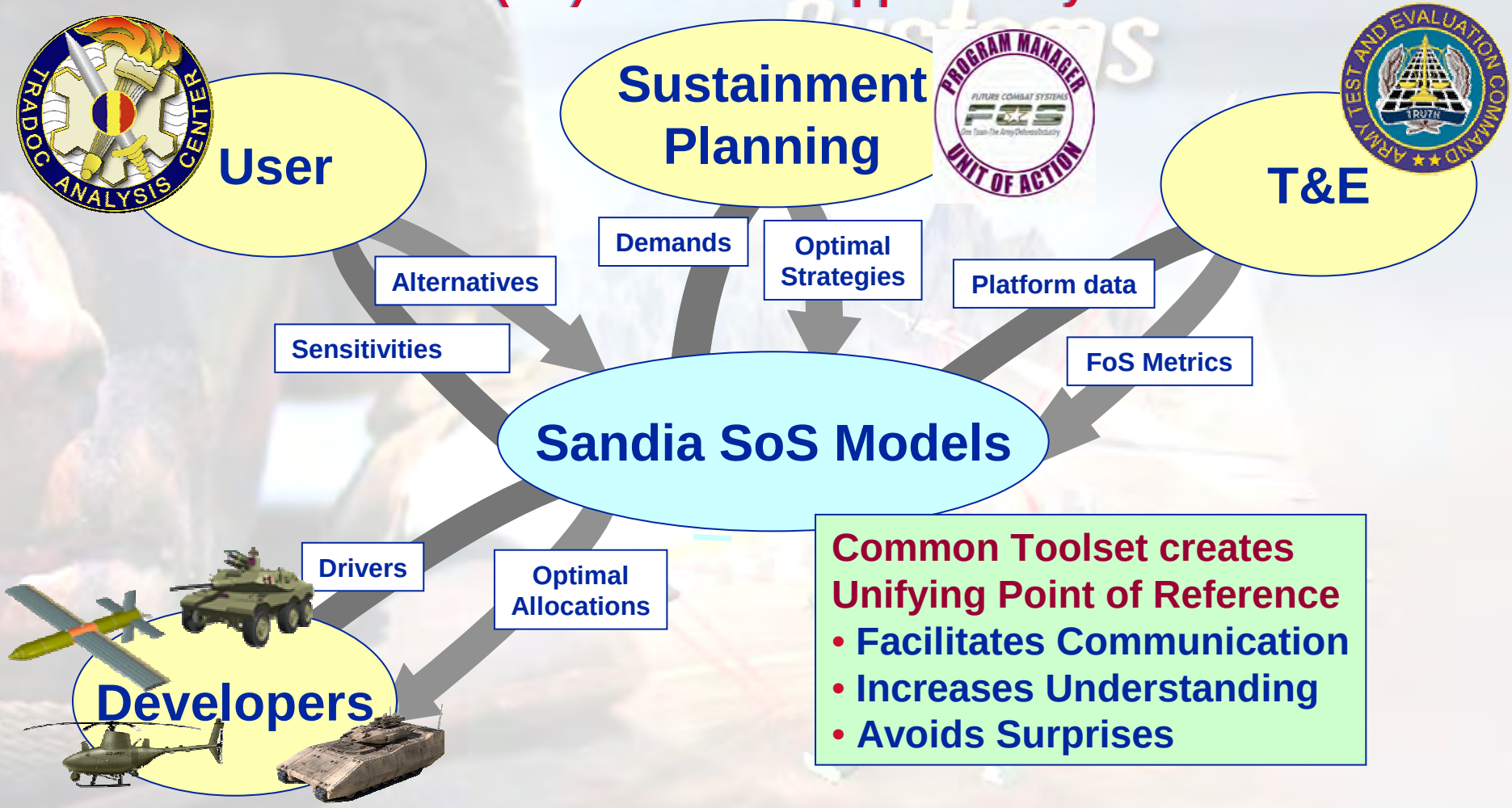
FCS Equipped Brigade Combat Team (BCT)



FCS Common Modeling Framework

FUTURE COMBAT SYSTEMS
One Team – The Army/DARPA/Industry

PM Unit of Action (UA) Common Supportability M&S Framework



Common Toolset creates Unifying Point of Reference

- Facilitates Communication
- Increases Understanding
- Avoids Surprises

SNL tools being incorporated into PM UA Common M&S Framework for use in SoS Supportability Assessment Modeling.

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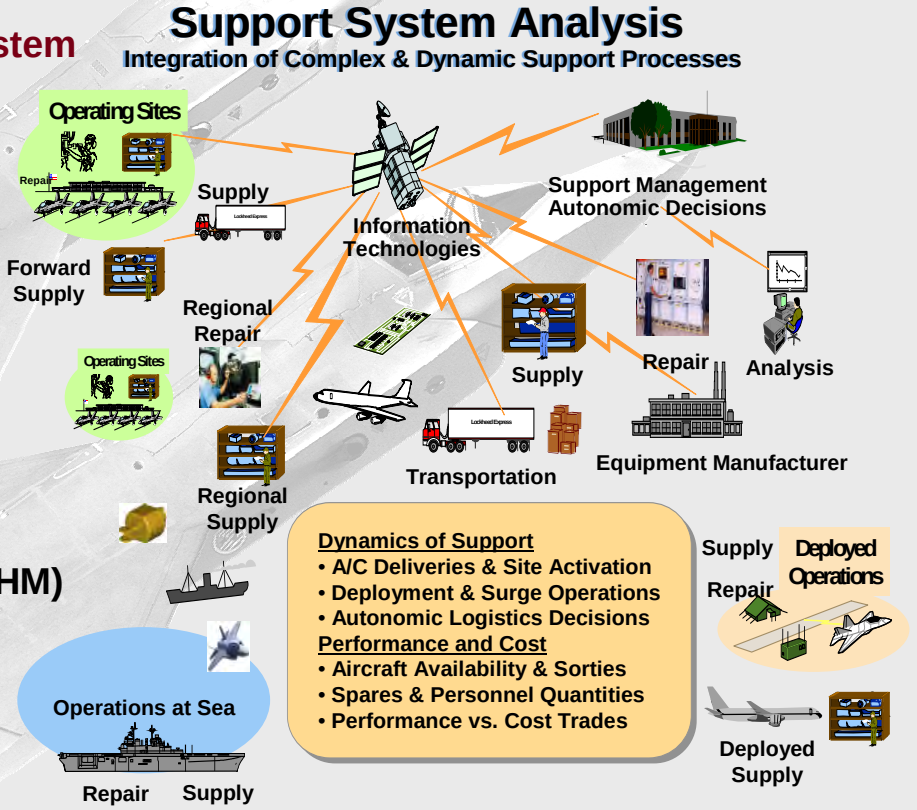
JSF Autonomic Logistics
&
Enterprise Modeling & Simulation

Support Enterprise Model (SEM)

A Unique Logistics Modeling, Analysis and Decision Support Tool

- **Features**
  - *Integrated* modeling of worldwide support system
    - Operations
    - Supply/Repair Chain
    - Transportation
  - *Dynamic* changes throughout life-cycle
    - Inventory/Fleet build up and retirement
    - Site activation/closure
    - Deployment/surge
  - *Total* support system performance & cost
    - Full on/off-system support activities
    - Prognostics and Health Management (PHM)
    - Global optimization across enterprise
- **Benefits**
  - Real-time strategic planning support
  - Dramatic risk mitigation
  - Unparalleled resource management flexibility to deal with changing conditions



SEM is a Development Design Tool and a Decision/Planning & Management Tool

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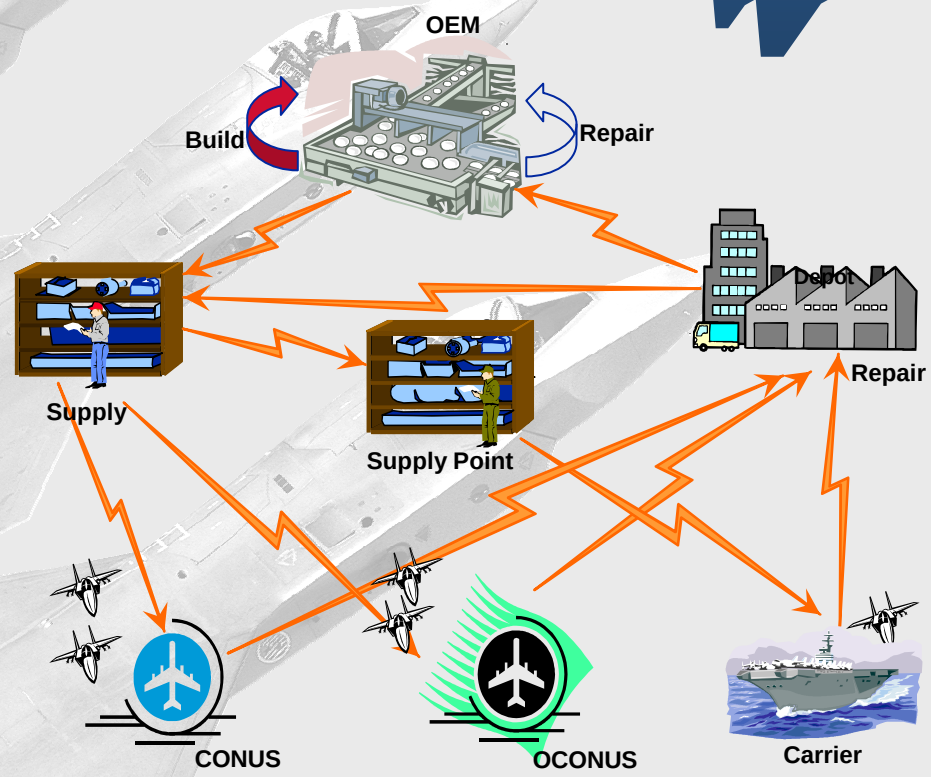
Typical Problem Scale (JSF)

- 3,000 aircraft
  - 5000+ LRC's
  - 10 configurations
- 250 sites worldwide
- 500 types of support equipment
- 50 personnel skill types
- 30 – 50 years of simulation
- ~4M data elements
- >> 1M part demands
- Arbitrary multi-echelon support structure



Unprecedented Data Integration Challenge

Sandia National Laboratories

SEM Optimization Approach

- **Unique hybrid optimization process for SEM**
  - Heuristics:
  - Analytic Mixed Integer Programming:
  - Solution Refinement
- **Problem-Oriented Factors**
  - Unprecedented problem scale
    - Roughly 1 million site/part combinations
    - Roughly 20K site/resource combinations
    - *Per year* of the simulation
    - On the order of 50 million variables in all
  - SEM simulation is stochastic
- **Algorithmic Challenges**
  - Simultaneous optimization of inventory levels, resource levels, and location of repair facilities
    - Most approaches only consider one of these facets
  - Avoiding “brittle” solutions
    - Algorithms must generate robust solutions - insensitive to minor changes in operational parameters
    - Need to characterize the trade-offs between solution robustness and cost, quantify risk

Goal: Arrange spare parts, support equipment and personnel skills across the enterprise to meet target performance at lowest cost

BAE SYSTEMS

Industry Perspectives and Identified Barriers to the Use of MIL-STD-882D for integrating ESOH Considerations into Systems

Jon Derickson, PE, CSP
Manager, FCS Environmental, Safety and Health
Ground Systems Division
BAE Systems, Land & Armaments

Outline

BAE SYSTEMS

- Systems and Safety Engineering
- MIL-STD-882D
- Potential Barriers for Integrating Safety into Systems Engineering

Systems and Safety Engineering

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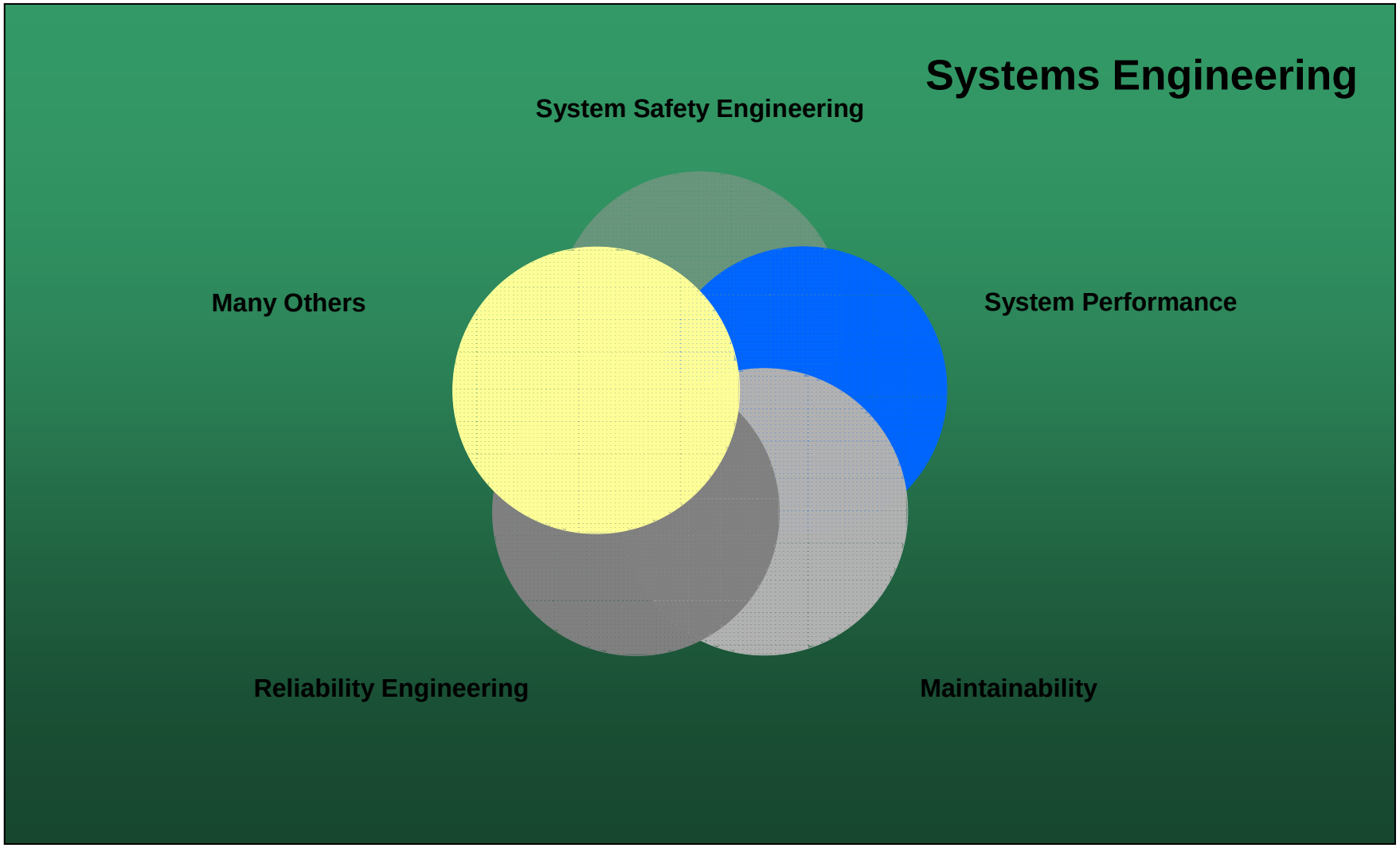
- **Systems Engineering – The design of a complex interrelation of many elements (a system) to maximize an agreed upon measure of system performance, taking into consideration all of the elements related in any way to the system, including utilization of worker power as well as the characteristics of each of the system's components**
- **System Safety – The optimum degree of safety within the constraints of operational effectiveness, time and cost, attained through specific application of system safety engineering throughout all phases of a system**
- **System Safety Engineering – An element of systems management involving the application of scientific and engineering principles for the timely identification of hazards and initiation of those actions necessary to prevent or control hazards within the system**

Reference: McGraw-Hill Dictionary of Scientific and Technical Terms

One Aspect of Systems Engineering



MIL-STD-882D Objectives

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- The DoD is committed to protecting:
  - private and public personnel from accidental death, injury, or occupational illness
  - weapon systems, equipment, material, and facilities from accidental destruction or damage
  - public property while executing its mission of national defense.
- Within mission requirements, the DoD will ensure that the quality of the environment is protected to the maximum extent practical.
- The DoD has implemented environmental, safety, and health efforts to meet these objectives. Integral to these efforts is the use of a system safety approach to manage the risk of mishaps associated with DoD operations.
- A key objective of the DoD system safety approach is to include mishap risk management consistent with mission requirements, in technology development by design for DoD systems, subsystems, equipment, facilities, and their interfaces and operation.
- The DoD goal is zero mishaps.

Major Elements of MIL-STD-882D

BAE SYSTEMS

- Document your approach
- Identify Hazards
- Assess Risk
- Identify hazard risk mitigations (requirements)
- Reduce the risks to acceptable levels
- Verify risk reduction
- Formally obtain approval of residual risk
- Conduct hazard tracking of hazards and risk

System Safety Objectives

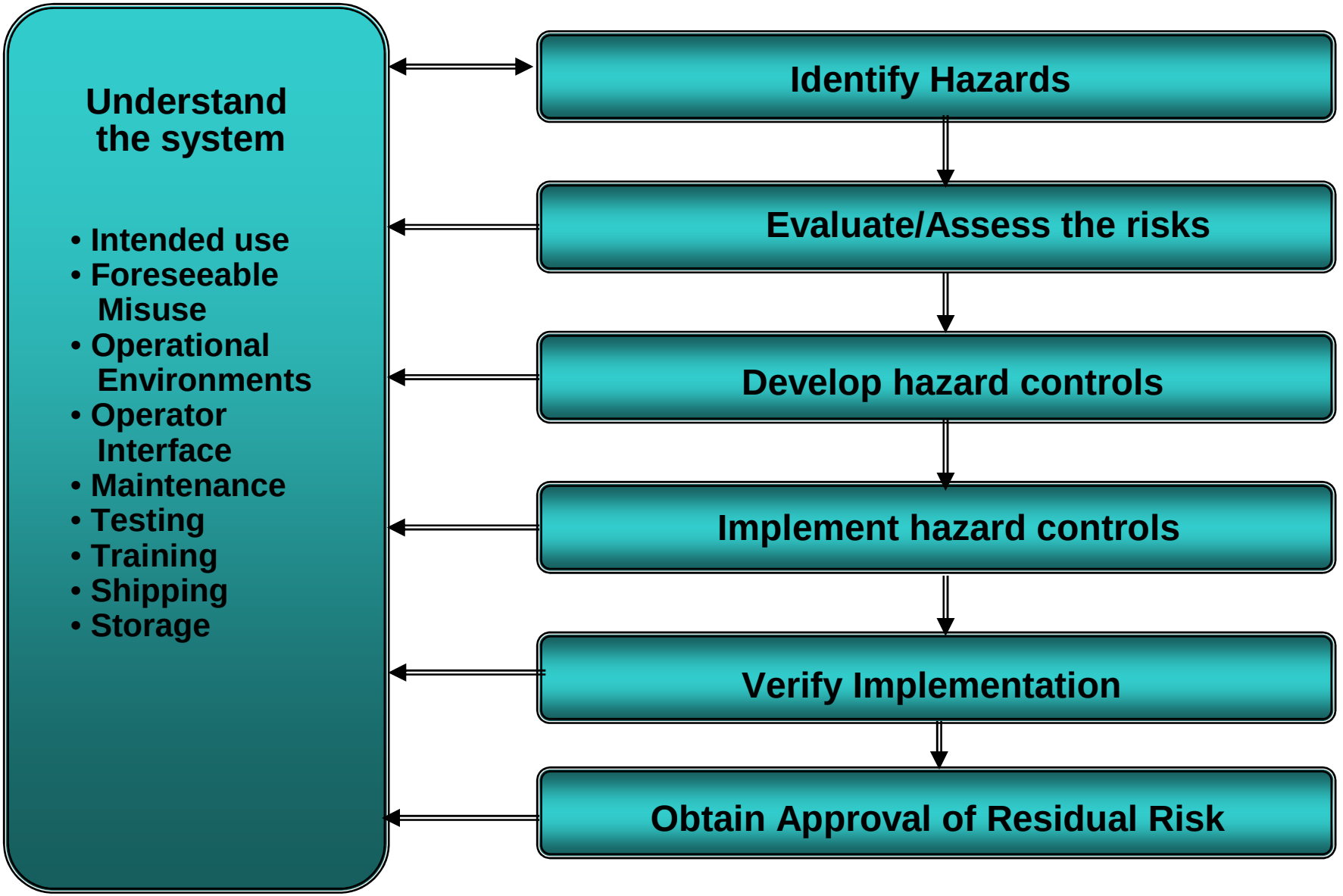
BAE SYSTEMS

"The principle objective of a system safety program within the DoD is to make sure safety, consistent with mission requirements, is included in technology development and designed into systems" (Ref MIL-STD-882C)

- **Safety, consistent with mission requirements is designed into the system**
- **Hazards are identified, tracked, evaluated, and eliminated or the risk is reduced to acceptable levels**
- **Historical safety data is considered and used in new designs**
- **Changes in design or mission requirements maintain an acceptable level of risk**
- **Significant safety data is documented as "lessons learned" for future development**

Overall System Safety Process

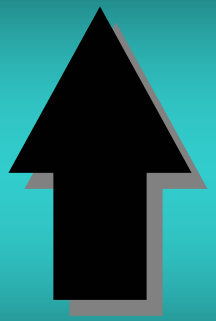
BAE SYSTEMS



Precedence for Hazard Mitigations

BAE SYSTEMS

Always do #1 first



1) Design to Eliminate Hazards
2) Incorporate Safety Devices
3) Provide Warning Indicators
4) Develop Procedures, Warnings, and Training

Work down the list only after previous items have proven not effective

Combinations of these controls are used to develop "System" of hazard controls

Potential Barriers – Speed Bumps

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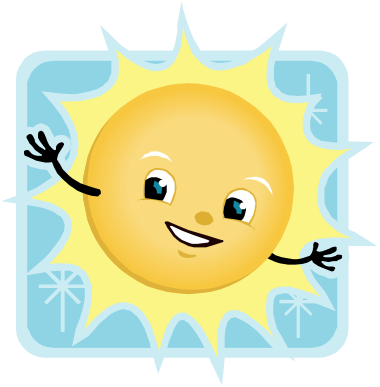
- Systems engineers are not always familiar with System Safety approaches, terms and processes
- System safety engineers are not always familiar with systems engineering approaches, terms and processes
- Timing
  - Safety often gets involved too late in the process
  - They don't always know about key systems deadlines
  - They often are asked for inputs at the end – during document release process

Potential Barriers – Jersey Barriers

BAE SYSTEMS

- Process Barriers
- Tools Barriers
- Rainy Days and Sunny Days



Process Barriers

BAE SYSTEMS

- Systems engineering processes change significantly from program to program
  - Safety engineering needs to be involved in the definition of processes in addition to definition of safety requirements and constraints
- Bait and switch
  - Everyone agrees on one process and then the process is over-taken by program schedules and other events
- Hazard discovery often continues through system development so key requirements sometimes come late
- System safety is not a Key Process area for CMMI so it often gets left out of systems engineering processes

Tools Barriers

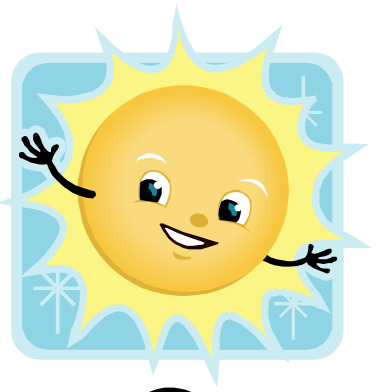
BAE SYSTEMS

- How to integrate hazard tracking into systems tools (UML, RTM, DOORS, etc)
  - Not always effective to implement tracking in the systems tool
  - This needs to be thought through early in a program to ensure effective implementation and to avoid false starts
- Different disciplines of systems engineering use different tools and/or different documents for different parts of a system
  - This often makes it difficult to fully specify hazard controls that thread through an entire system
  - We end up developing a safety view of mitigation approaches that captures hardware, software, and functional aspects of the system

Rainy Days and Sunny Days

BAE SYSTEMS

- Systems engineers are often concerned with what we WANT the system to do (Sunny Day Scenario's)
  - They strive for clear concise requirements that are verifiable



- Safety engineers are often concerned with what we DON'T want the system to do (Rainy Day Scenario's)
  - Accidents are often caused by a string of unlikely events
  - The combinations and permutations of possibilities become very complicated and is very difficult to clearly specify in neat little requirements at the beginning of a program

- Need to find Effective ways to capture what we <u>Don't Want</u> in a way that can be verified and validated

Summary

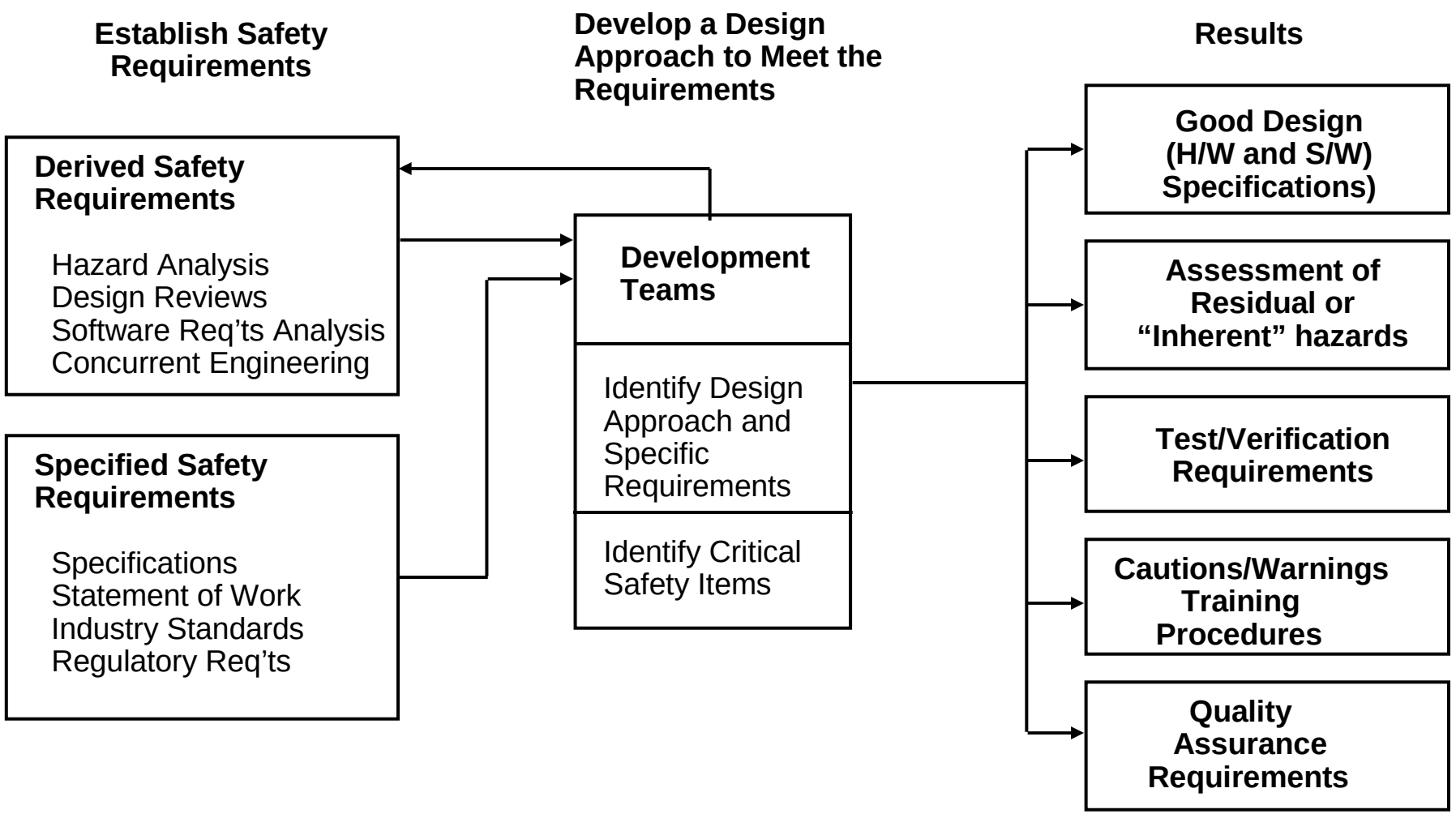
BAE SYSTEMS

- Recognize that system safety is part of systems engineering and sometimes plays a key role
  - Cultivate and nurture a cooperative environment between system safety and systems engineering
  - Make sure that system safety is integrated in the systems processes
  - Know when you need to get safety involved
- Make sure system safety is involved early in both requirements development and process development
  - Make sure they are aware of your processes and key deadlines
- Look for the win-win opportunities

BACKUP SLIDES

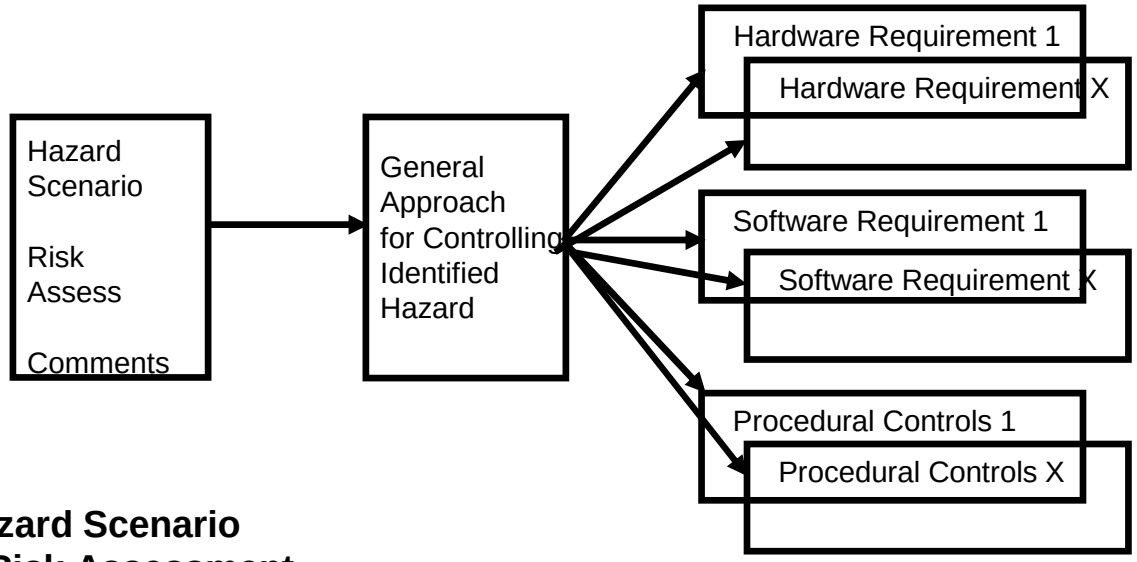
System Safety Approach

BAE SYSTEMS



Hazard Control Development

BAE SYSTEMS



Hazard Scenario & Risk Assessment

- Description of Concern
- Effects on People & Equipment
- Risk Assessment
  - Probability
  - Severity
  - Risk Assessment Code
- Background Information

Documented in Hazard Tracking System

Hazard Controls

- Design Approach
- Software Requirements
- Hardware Requirements
- Interface Requirements
- Warnings and Cautions
- Procedures

Documented in Hazard Tracking System and Software Safety Tracking System

Cost of Safety Changes

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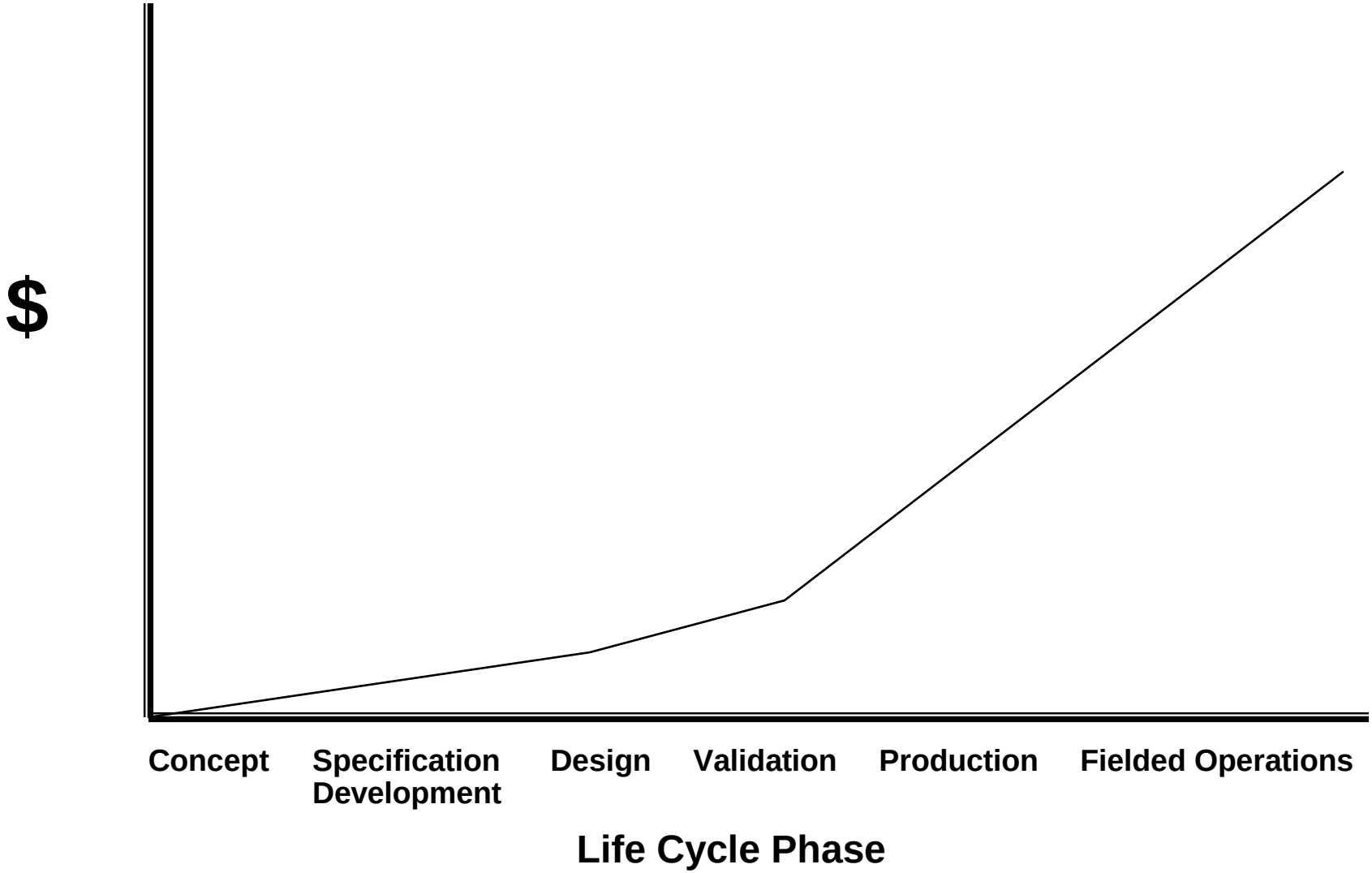


Risk Assessment Criteria

BAE SYSTEMS

SEVERITY

Category	Level	Description
Catastrophic	I	Event results in death, permanent total disability, loss of FCS assets exceeding $1M, or irreversible severe environment damage that violates law or regulation and/or FCS Program stoppage.
Critical	II	Event results in permanent partial disability, injuries or occupational illness that may result in hospitalization of > 5 days, loss of FCS assets exceeding $200K but less than $1M, or a reversible environment damage causing a violation of law/regulation, or a FCS Program delay.
Marginal	III	Event results in injury or occupational illness resulting in hospitalization of < 5 days, loss exceeding $40K but less than $200K, or mitigatible environment damage without violation of law or regulation where restoration activities can be accomplished.
Negligible	IV	Event results in injury or illness not resulting in hospitalization of < 1 day, loss exceeding $2K but less than $40K, or minimal environment damage not violating law or regulation.

PROBABILITY

Qualitative Description			
Level	**Likelihood**	**Individual Item**	**Fleet or Inventory**
A	Frequent	Likely to occur often in the life of an item, with a probability of occurrence greater than 1×10^{-1} in that life.	Continuously experienced.
B	Probable	Will occur several times in the life of an item, with a probability of occurrence less than 1×10^{-1} but greater than 1×10^{-2} in that life.	Will occur frequently.
C	Occasional	Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2} but greater than 1×10^{-3} in that life.	Will occur several times.
D	Remote	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3} but greater than 1×10^{-6} in that life.	Unlikely, but can reasonably be expected to occur.
E	Improbable	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 1×10^{-6} in that life.	Unlikely to occur, but possible.
F	Extremely Improbable	So improbable, it can be assumed occurrence is impossible probability of occurrence less than 1×10^{-7} in item life.	Extremely unlikely to occur, but not impossible.

FCS Hazard Risk Management Matrix

BAE SYSTEMS

Hazard Severity	Probability of Occurrence					
	Frequent (A)	Probable (B)	Occasional (C)	Remote (D)	Improbable (E)	Extremely Improbable (F)
Catastrophic (I)	High	High	High	Medium	Medium	Low
Critical (II)	High	High	Medium	Medium	Low	Low
Marginal (III)	Medium	Medium	Medium	Low	Low	Low
Negligible (IV)	Low	Low	Low	Low	Low	Low

Hazard Decision Authority Matrix

Residual Risk	Integrating Contractor Risk Acceptance	Government Risk Acceptance
HIGH	Program Director/Senior Leadership	Army Acquisition Executive (AAE)
MEDIUM	Program Manager and Technical Director	Program Executive Officer (PEO)
LOW	Technical Director	MGV Program Manager (MGV-PM)

Bio for Jon Derickson

BAE SYSTEMS

Jon S. Derickson, PE, CSP, Manager FCS ESOH, BAE Systems, PO Box 58123, MD C16, Santa Clara, CA 95052 USA, telephone - (408) 289-4797, e-mail – jon.derickson@baesystems.com.

Mr. Derickson is currently the Manager for Environment, Safety and Occupational Health for the Future Combat System (FCS) Programs at BAE Systems - Ground Systems Division in Santa Clara, CA. He was previously the System Safety Group Lead for Bradley Fighting Vehicle Systems.

He has a Bachelor of Science in Agricultural Engineering from California Polytechnic State University in San Luis Obispo, CA and a Masters in Computer Engineering from San Jose State University. He is a Registered Professional Safety Engineer and a Certified Safety Professional in system safety. He has over 20 years experience in system safety that includes commercial products, military combat vehicles, explosive devices, large rocket motor manufacturing, and autonomous ground vehicles.

LMI

GOVERNMENT CONSULTING

THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

NDIA SE Conference October 26, 2005

Data Management in a Performance Based Logistics Environment

Dr. Jim Forbes,
LMI
jforbes@lmi.org

Denise Duncan, LMI
GEIA Data Management Panel
dduncan@lmi.org

Agenda

- What data are we talking about?
- Background
  - Changes in environment
  - Data management yesterday, today, and tomorrow
- GEIA/ANSI STD 859 and HDBK 859
  - Results to date
  - Related support to DM community of practice
- Example HDBK content
- Summary

Types of Data

Focus of 859 projects

Type *Usage*	Examples
Product *Collaboration*	Cost, schedule and performance data. Scientific data such as written notes and observation data. Engineering drawings and models, parts catalogues, software applications and documentation, operational and maintenance instructions, and training materials.
Business *Collaboration*	Plans and schedules, financial information (budgets, bases of estimate, EVMS data…) inventory status, and human resource info.
Operational *Transactional Records Exchange*	Orders, issues, receipts, bills of lading, and invoices.

Changing Environment

Business Relationships

Vertical Integration……...Trust-Based Relationships

Design Responsibility

DoD Design Bureaus……..Industry Design Teams

Standards Development & Implementation

Military……Commercial

Acquisition Cycle

12 - 15 years……2 - 5 years

1950 *2000+→*

Computer Systems Development Cycle

NA……18 - 24 Months

Weapon System Life Cycle

20 years……..50+ years

Commercial Systems Life Cycle

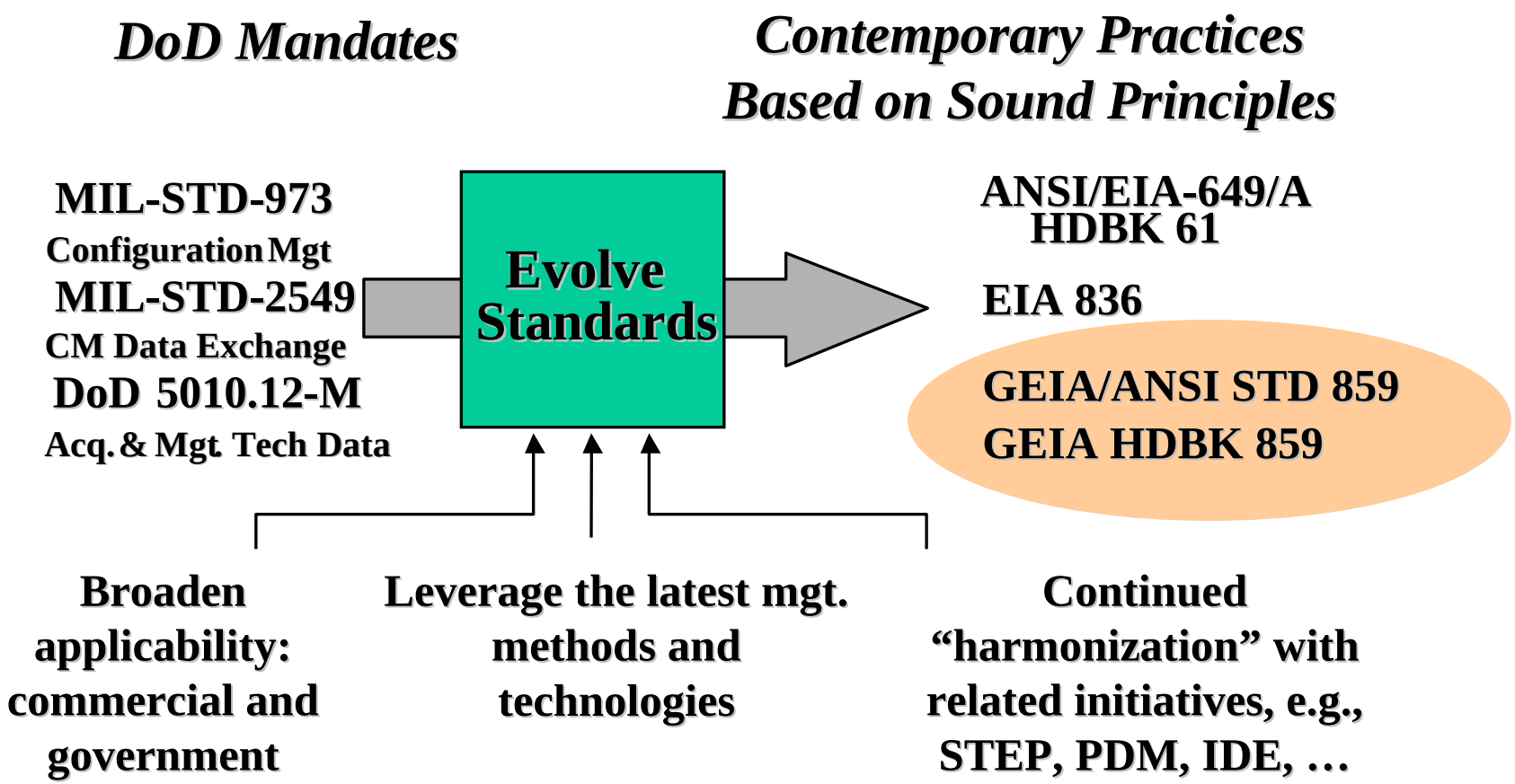
10 - 15 years……2 - 5 Years

Logistics Support

DLA, DoD Depots & IMAs……..Mix of Government and Contractor Logistics Support

Transaction-based……..Performance-based

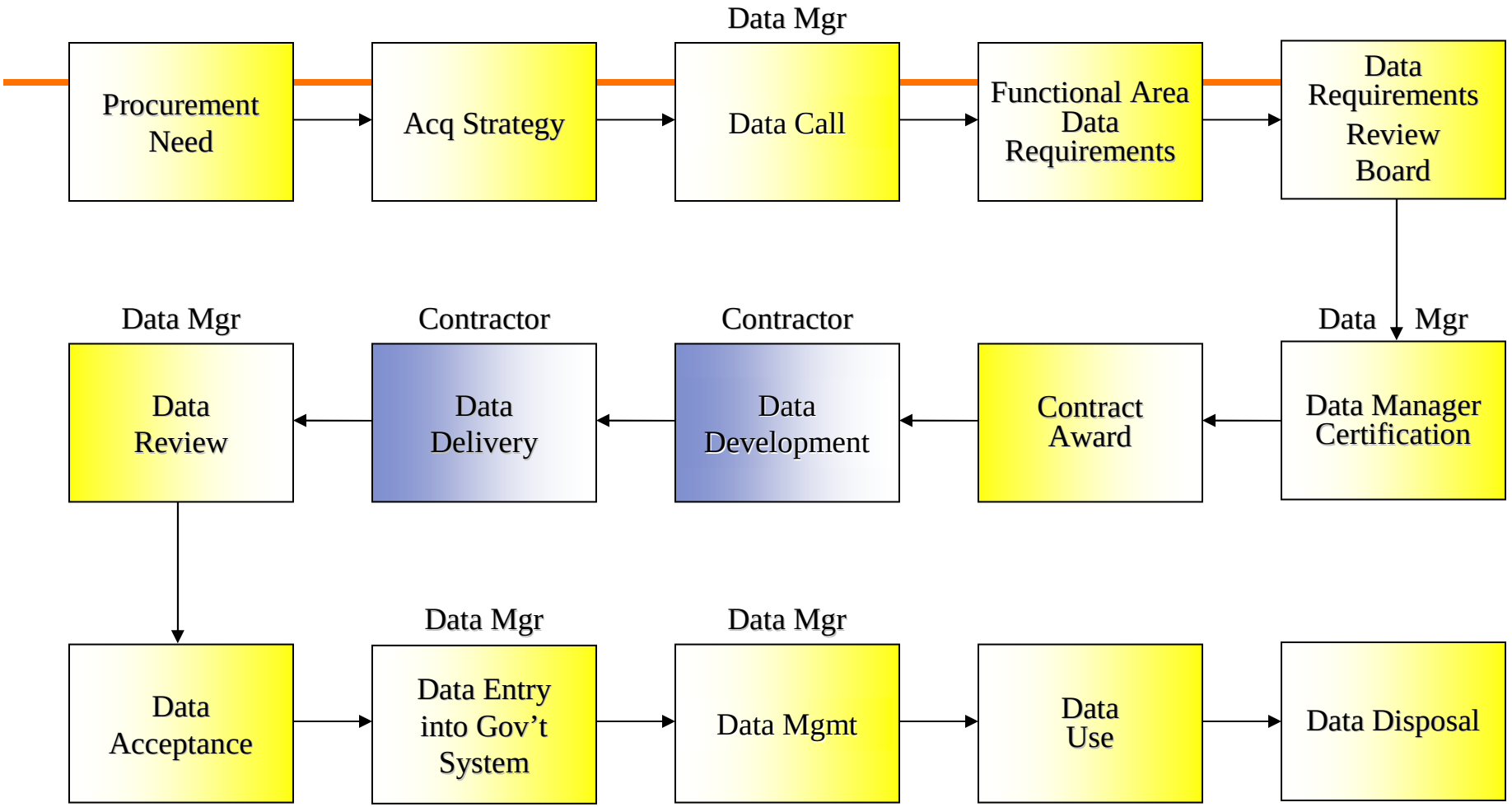
Transition to Industry Standards



Essential Changes: Data

	Was	Is
Delivery Medium	• Paper	• Electronic
What constitutes delivery	• I mail it, you open it	• I post it on web site, we access it
Standardization of deliverables	• DIDs • Use mandatory • Tailoring permitted, but made intentionally difficult	• DIDs radically tailored or ignored entirely
Data environment	• Slow • Bulky, paper storage • Fairly standard • Limited number of copies • Sometimes hard to find or obtain copy	• Rapid to instantaneous • Compact electronic storage • Non-standard • Essentially infinite number of copies • Still difficult to find
Availability in future	• Infinitely available and interoperable as long as copies not misplaced	Electronic formats subject to rapid technological obsolescence

Data Management Process (Yesterday)

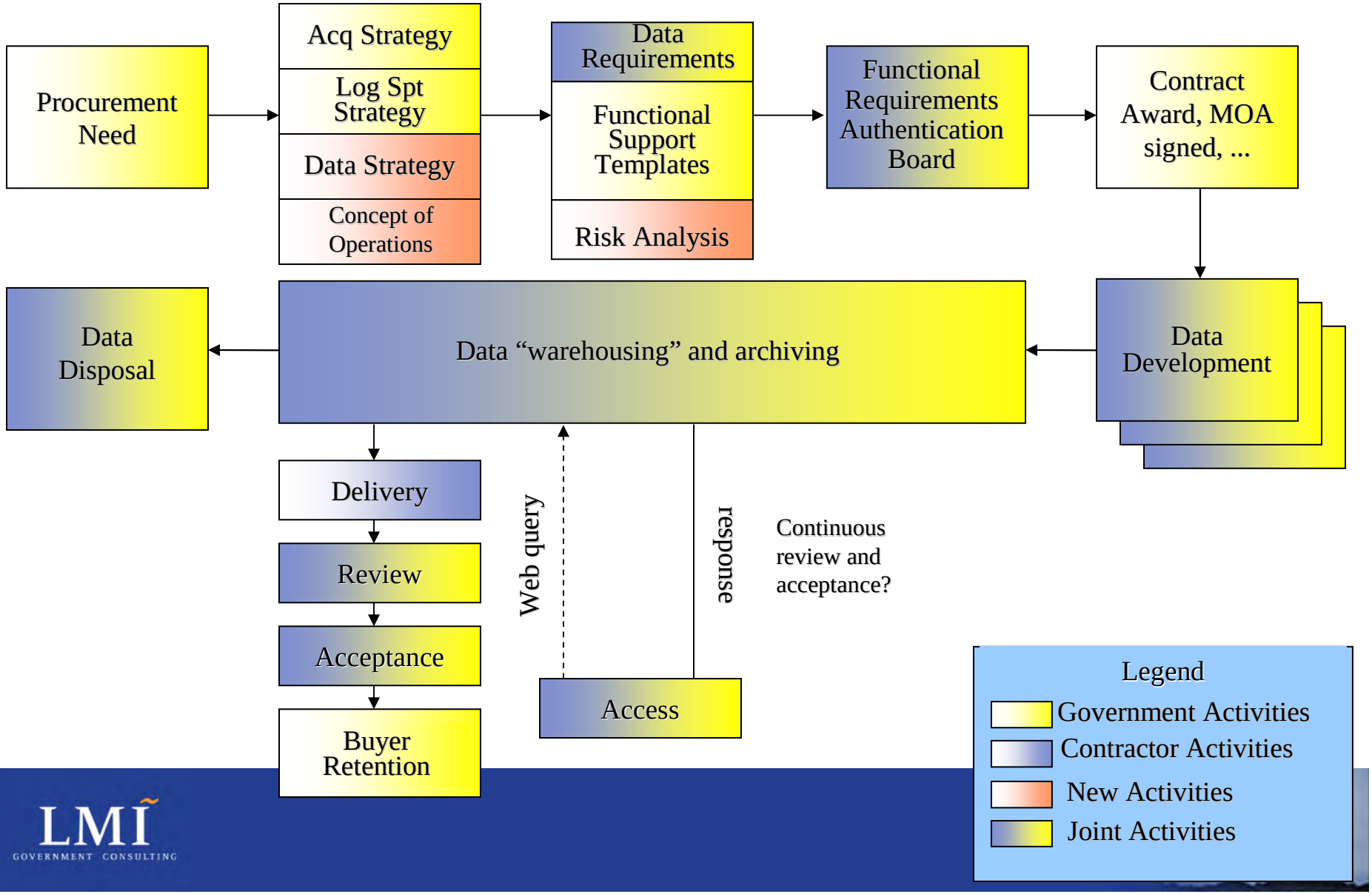


Legend:

- Government Activities
- Contractor Activities

- Sequential Process
- Had a dedicated and experienced Data Manager
- Assumed all contract required data is delivered
- Philosophy was "Buy Everything!"
- Only applied to some (contracted) data

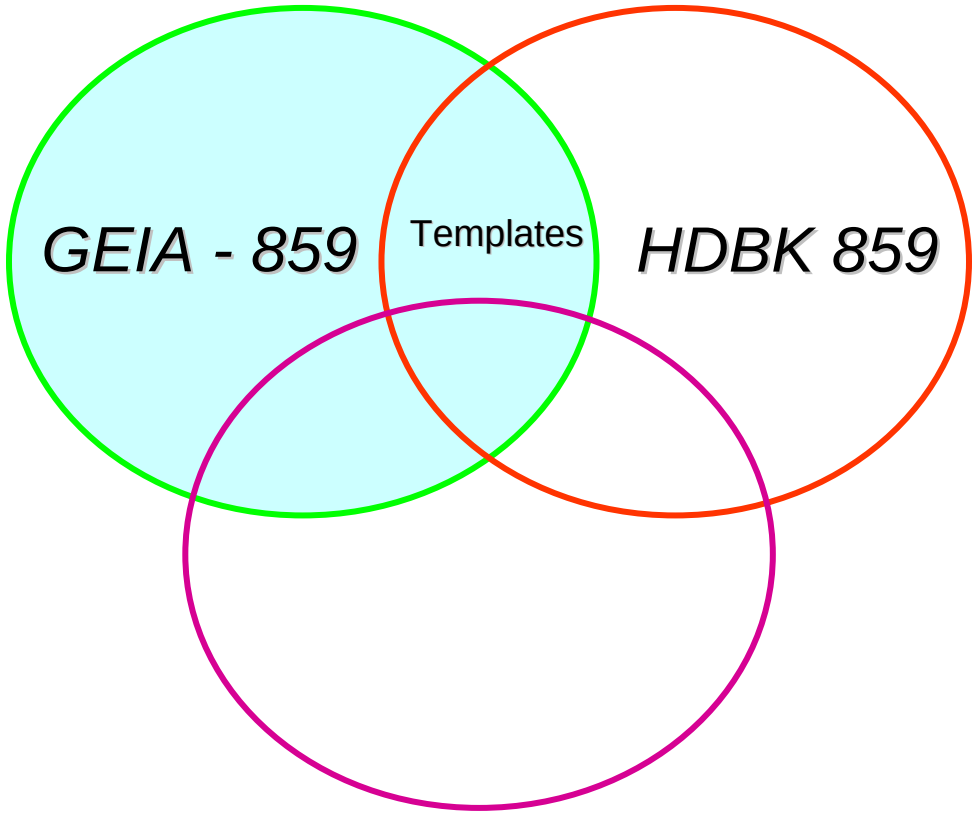
Evolving Data Management Process (Today and Tomorrow)



Components of the New Data Management

Principles

- Basic tenets and values
- General



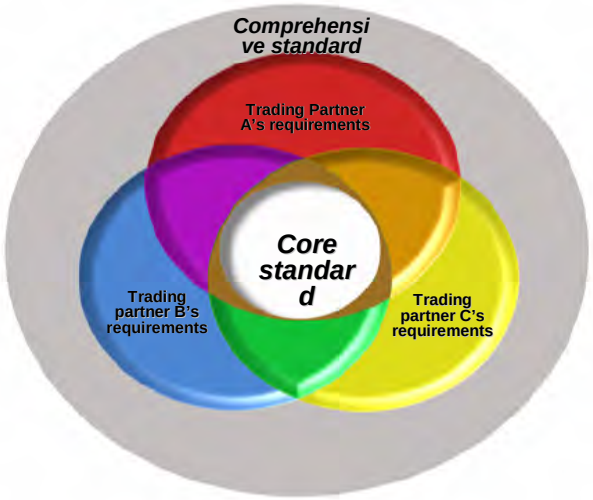
Practices

- Implementation specifics
- Some will always be organization-specific

Professionalizing the Workforce Through Training

Purpose and Scope of Std 859

- Purpose
  - Provide a contemporary, principles-level, guide to requirements for acquisition and management of data across the product life-cycle
  - Enable sharing of data among trading partners … in a performance-based environment
- Scope
  - Common principles
  - Related enablers
  - (Some) key practices



DM Principles of Standard 859

	Area	Principle
1	Focus and Scope	Define the organizationally relevant scope of data management
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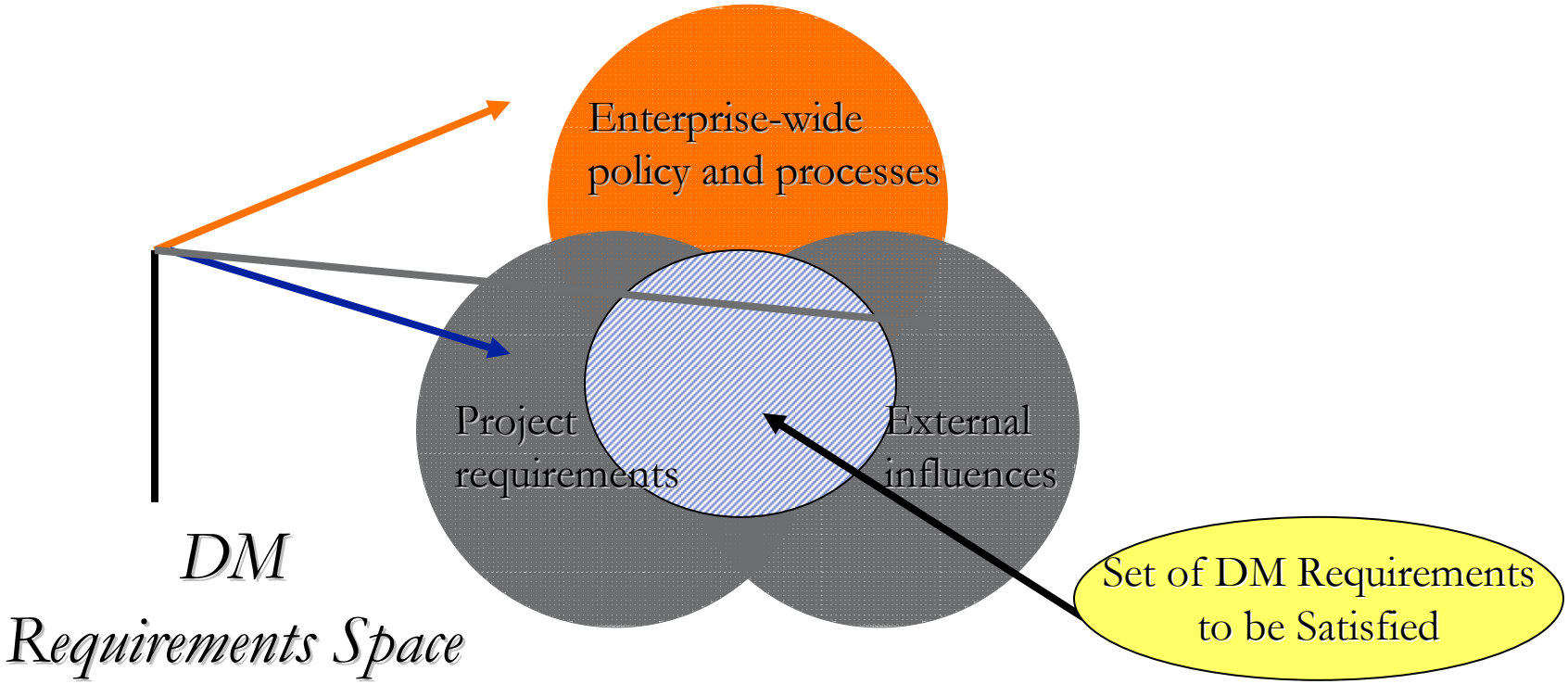
7	Data Retention	Retain data commensurate with value to the organization.
8	Process Improvement	Continuously improve data management.
9	DM/KM Connection	Effectively integrate data management with knowledge management.

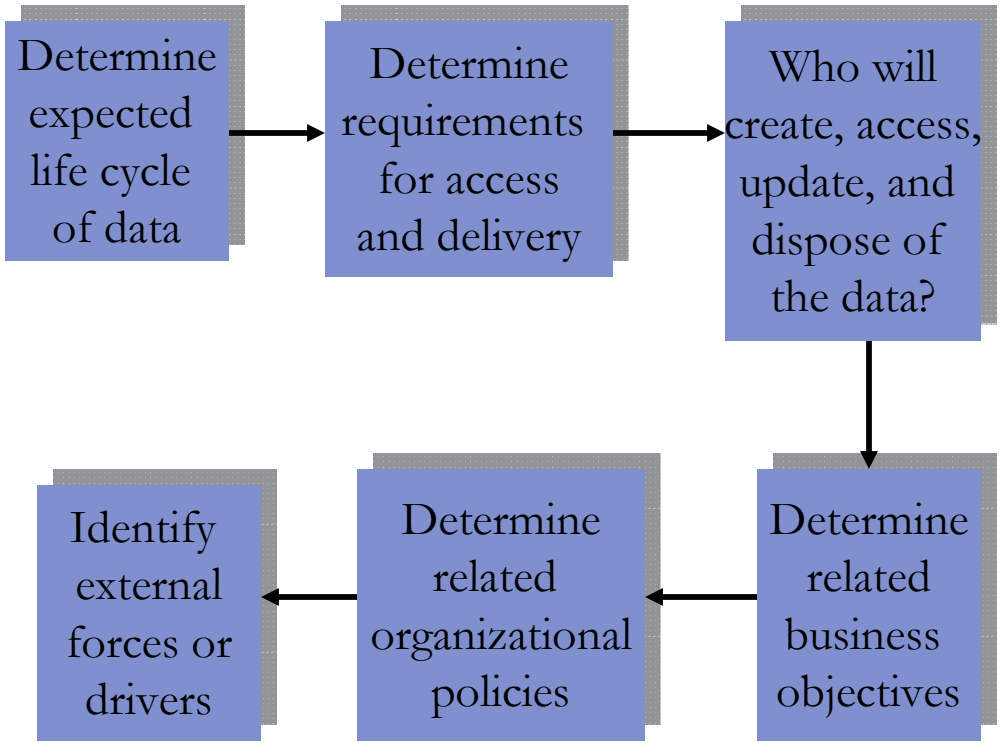
Principle 3



Develop Data Management processes to fit the context and business environment in which they will be performed.

Enabler 3.1: Determine the complete set of requirements that the DM solution must address

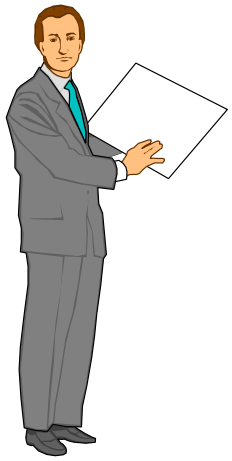
- General requirements
- Data capabilities
- Data processes
- Intended use of the data
- Related business objectives
- Technology issues
- External constraints

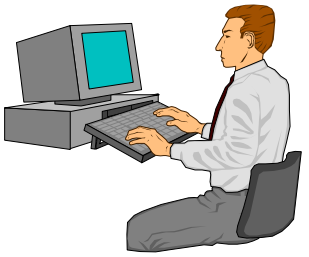


Purpose and Scope of HDBK 859

Provides the first level of 'how'

- examples and samples
- approaches
- tools
- methods
- mini-case studies
- …to illustrate how to implement DM in accordance with the principles (compliant with the standard)





Example Elements of Data Strategy

Question	Information
What is the appropriate placement model for the enterprise DM functions?	Centralized—all DM responsibilities are within one organization Decentralized—DM responsibilities are distributed throughout the organization Hybrid—one organization has most of the DM responsibilities, but leverages other enterprise assets (for example other organizations provide CM or records management resources)
What data are needed and by whom?	Evaluate program life cycle Identify the documentation that defines program requirements Review documentation and develop list of required data products Determine who (organizations, functions, or systems) will use the data, what decisions or functions are supported by the data, and how and when they will use various types of data

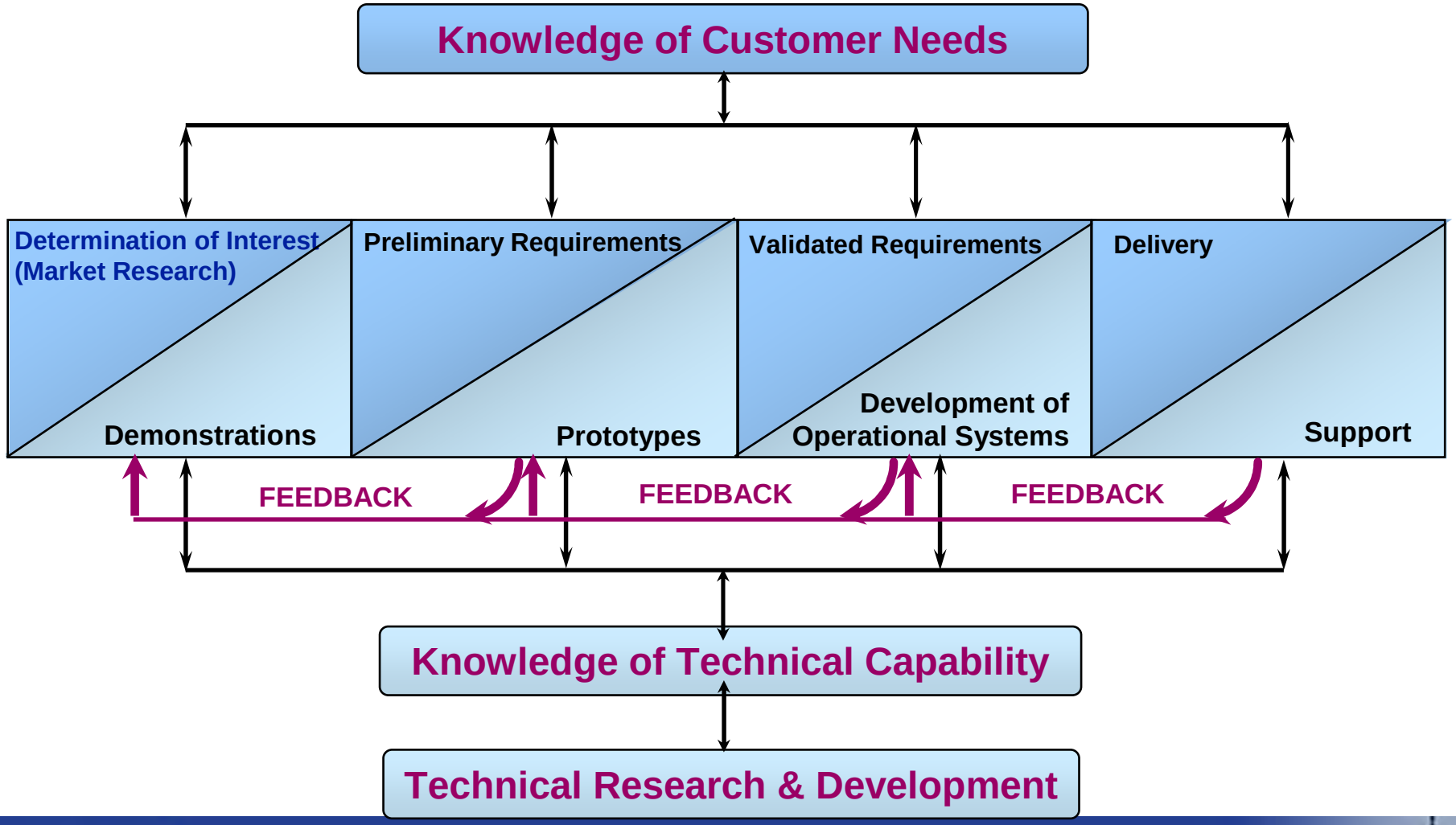
Example Elements of Data Strategy, cont.

Question	Information
Which views of data will be required?	Identify the content and format for each data product Identify duplicate data products or opportunities to combine data products Consolidate requirements for similar data products Develop complete list of data products to be created for the program
When will the data be required?	Identify the users for each data product required Establish whether multiple deliveries are required Determine delivery dates and identify updates or reversions Prepare a list of data products with users and delivery dates
What are the delivery mechanisms?	Evaluate data product requirements Identify data product sources or providers Identify external and internal data providers Verify that requirements for data identification are defined and communicated Develop a list of data products with all sources identified
What organization design and staffing changes are needed?	Determine if a change in the way DM is staffed requires specific training and certification for data management personnel.[a]

Questions to Help Ensure Completeness of Requirements

Question	Example
Who determines the quality of the data?	Customer, manufacturing, engineering
How are the data to be acquired?	In-house, contracted for, computer accessed
How are the data to be stored?	File cabinets, servers, microfilm
How will the data be protected?	Vaults, computing access control, restricted buildings, duplicate copies at different site
Who needs access to the data?	Foreign nationals, finance, release group
What view of the data do they need	Parts catalog for customer, detail drawings for manufacturing, ad hoc reports for management
How are the data to be used?	Certification, functional test, build
How are the data to be delivered?	Electronically, paper, on-demand reports, overnight updates of the systems
How are the data to be disposed of?	Shredding, burning, deletion of files, garbage can

Aligning DM with Contemporary View of Innovation—
"Chain Link" Model of Continuous Improvement



Adapted from S.J. Kline and N. Rosenberg, "An Overview of Innovation" in R. Landau and N. Rosenberg eds., *The Positive Sum Strategy*. Washington: National Academic Press, 1986.

Summary

- New environment
  - Technology
  - Business – trust-based, performance-based
- Needed a fresh way to think about DM
  - New recipes, improved methods
- Principles for the “new” DM in GEIA/ANSI STD 859, methods in GEIA/ANSI HDBK 859
- Example HDBK 859 content

LMI

GOVERNMENT CONSULTING

THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

NDIA SE Conference October 26, 2005

Data Management Support for Modeling and Simulation

Virginia Stouffer, LMI

Denise Duncan, LMI
GEIA Data Management Panel

Agenda

- Data Management
  - Changes in environment
  - New support to Data Management
    - Standard
    - Handbook
    - COP and BOK
  - Data management yesterday, today, and tomorrow
- Modeling and Simulation DM Challenge
- Example DM solutions and approaches
- Summary

Which Data Are We Talking About?

Focus of 859 projects

Type *Usage*	Examples
Product *Collaboration*	Cost, schedule and performance data. Scientific data such as written notes and observation data. Engineering drawings and models, parts catalogues, software applications and documentation, operational and maintenance instructions, and training materials.
Business *Collaboration*	Plans and schedules, financial information (budgets, bases of estimate, EVMS data…) inventory status, and human resource info.
Operational *Transactional Records Exchange*	Orders, issues, receipts, bills of lading, and invoices.

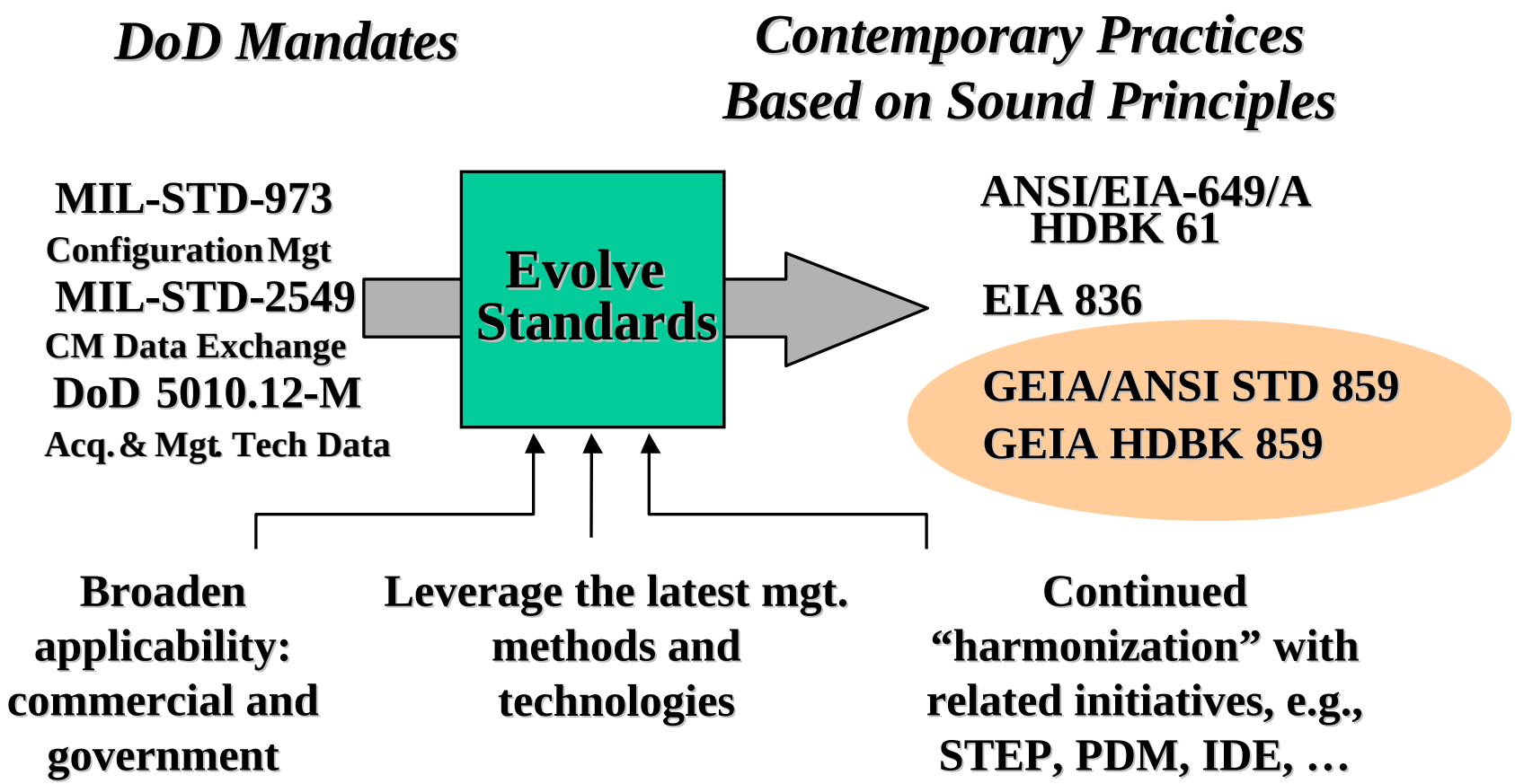
Acquisition Environment Changes

1950		2000+ →
Vertical Integration	Business Relationships	Trust-Based Relationships
DoD Design Bureaus	Design Responsibility	Industry Design Teams
Military	Standards Development & Implementation	Commercial
12 - 15 years	Acquisition Cycle	2 - 5 years
NA	Computer Systems Development Cycle	18 - 24 Months
20 years	Weapon System Life Cycle	50+ years
10 - 15 years	Commercial Systems Life Cycle	2 - 5 Years
DLA, DoD Depots & IMAs	Logistics Support	Mix of Government and Contractor Logistics Support
Transaction-based		Performance-based

Impact on DM Environment

	From	To
Medium of Delivery	Paper	Electronic
Delivery is	I mail it, you open it	I post to the Web portal, you access
Data environment	•Slow •Bulky, paper storage •Fairly standard •Limited number of copies •Sometimes hard to find or obtain copy	•Rapid →instantaneous •Compact electronic storage •Non-standard •Essentially infinite number of copies •Still difficult to find
Future availability	Infinitely available and interoperable as long as copies not misplaced	Electronic formats subject to rapid technological obsolescence

New Support to DM: Industry Standards



Components of New Data Management

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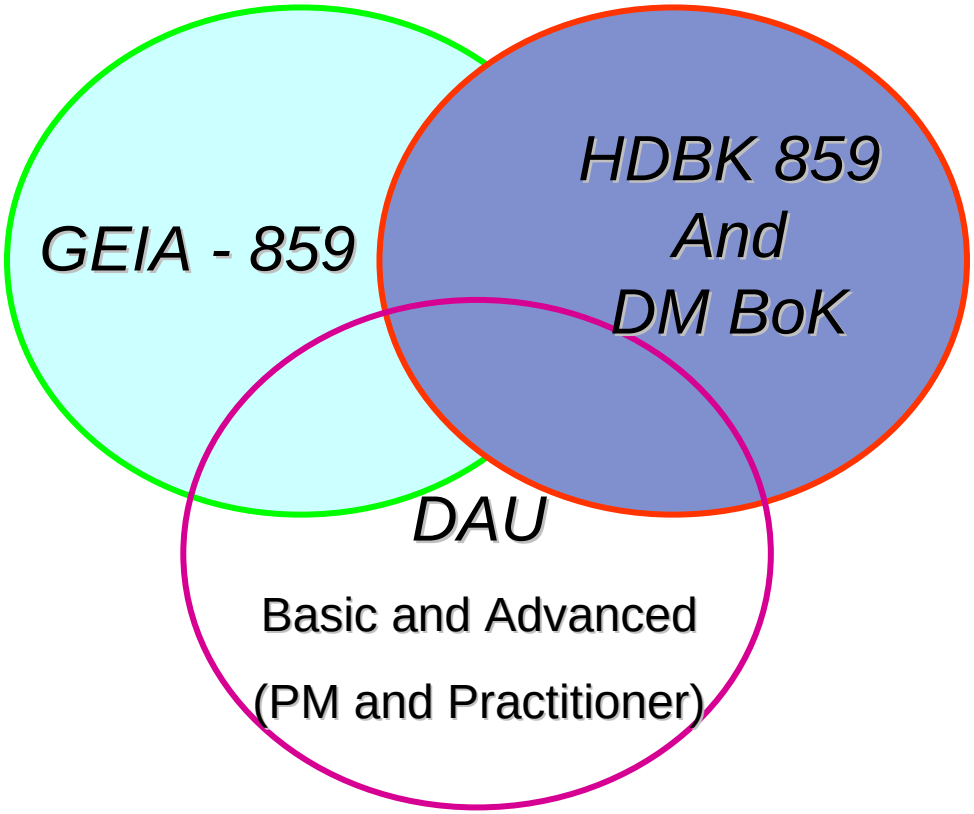

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Professionalizing the Workforce Through Training

Purpose and Scope of HDBK 859

Provides the first level of ‘how’

- examples and samples
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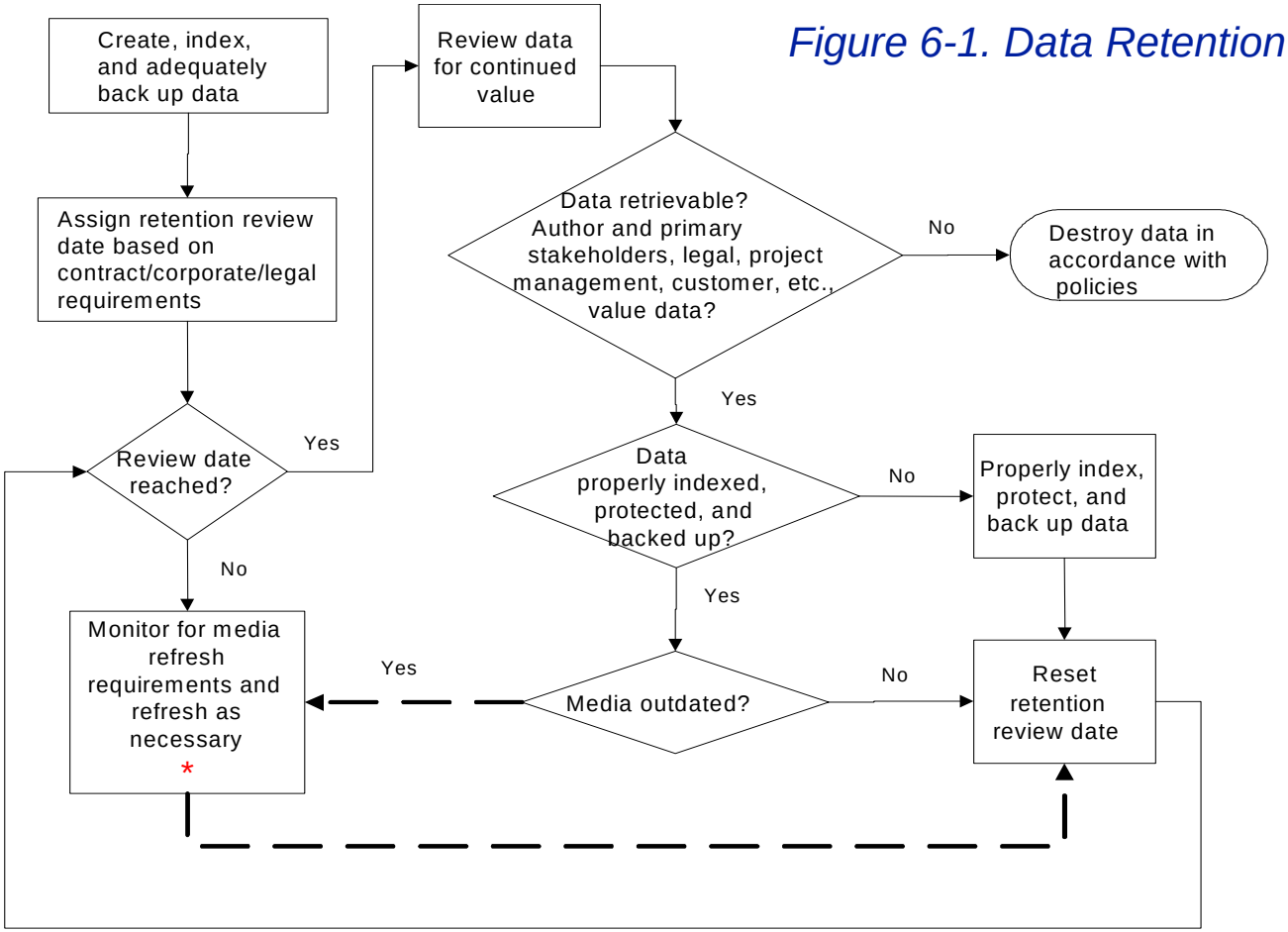
Example Content from HDBK 859

Figure 6-1. Data Retention Decision Tree



[a]Leads to notional data archive preservation process

More Recent Acquisition Changes:

- System of Systems (SoS) architectures:
  - Choice of platform
  - Choice of sensors
  - Choice of munitions
  - Choice of communications
  - . . .
- Net-Centricity
- Lifecycle Logistics

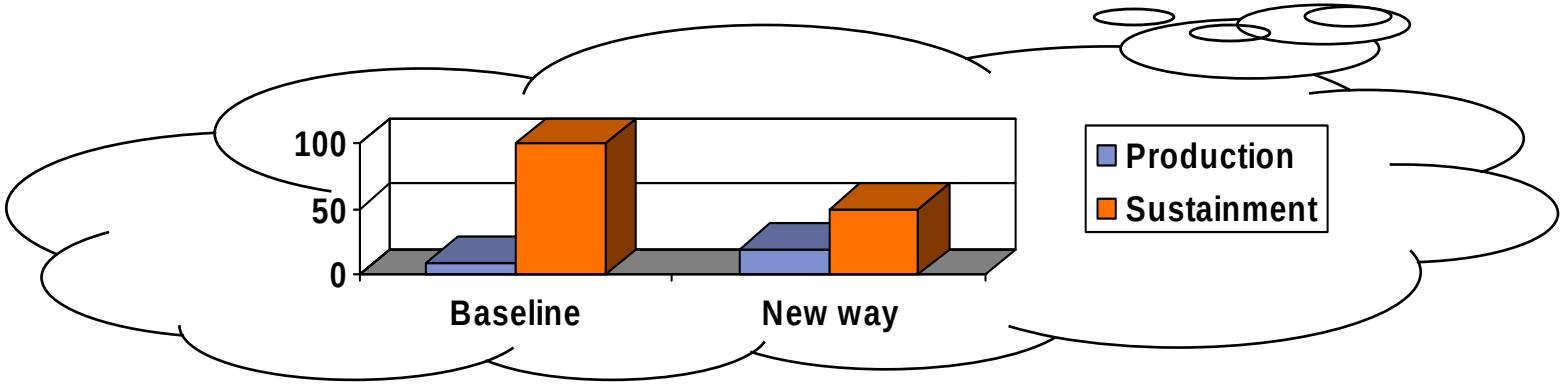
Effects of Recent Changes: Increased Use of Modeling and Simulation

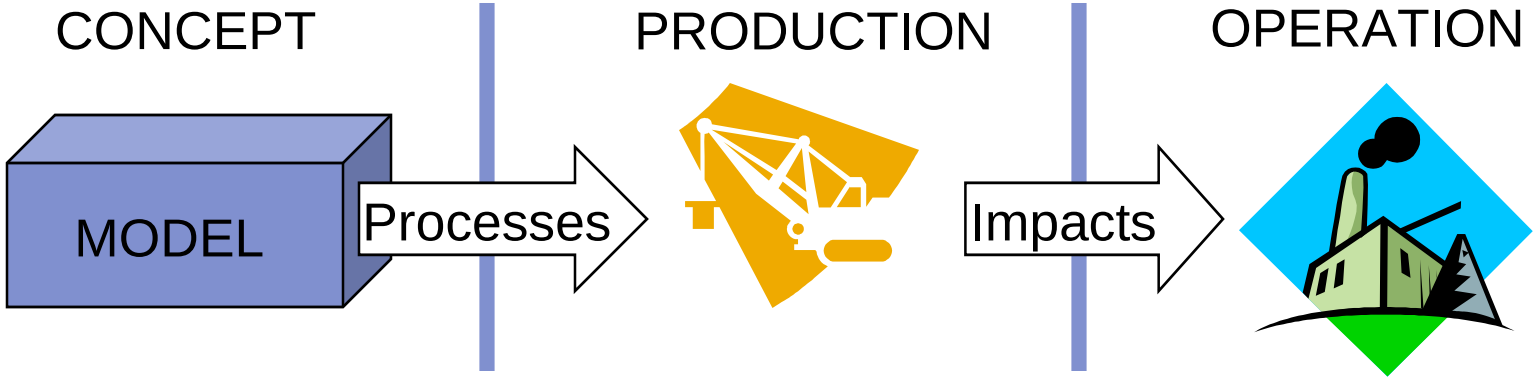
- To evaluate competing architectures before investing too much in to proofs of concept, etc.
- To evaluate full lifecycle costs of competing concepts
  - Much more modeling earlier in the lifecycle of the acquisition, and throughout the lifecycle

M&S Impacts on DM, and vice versa

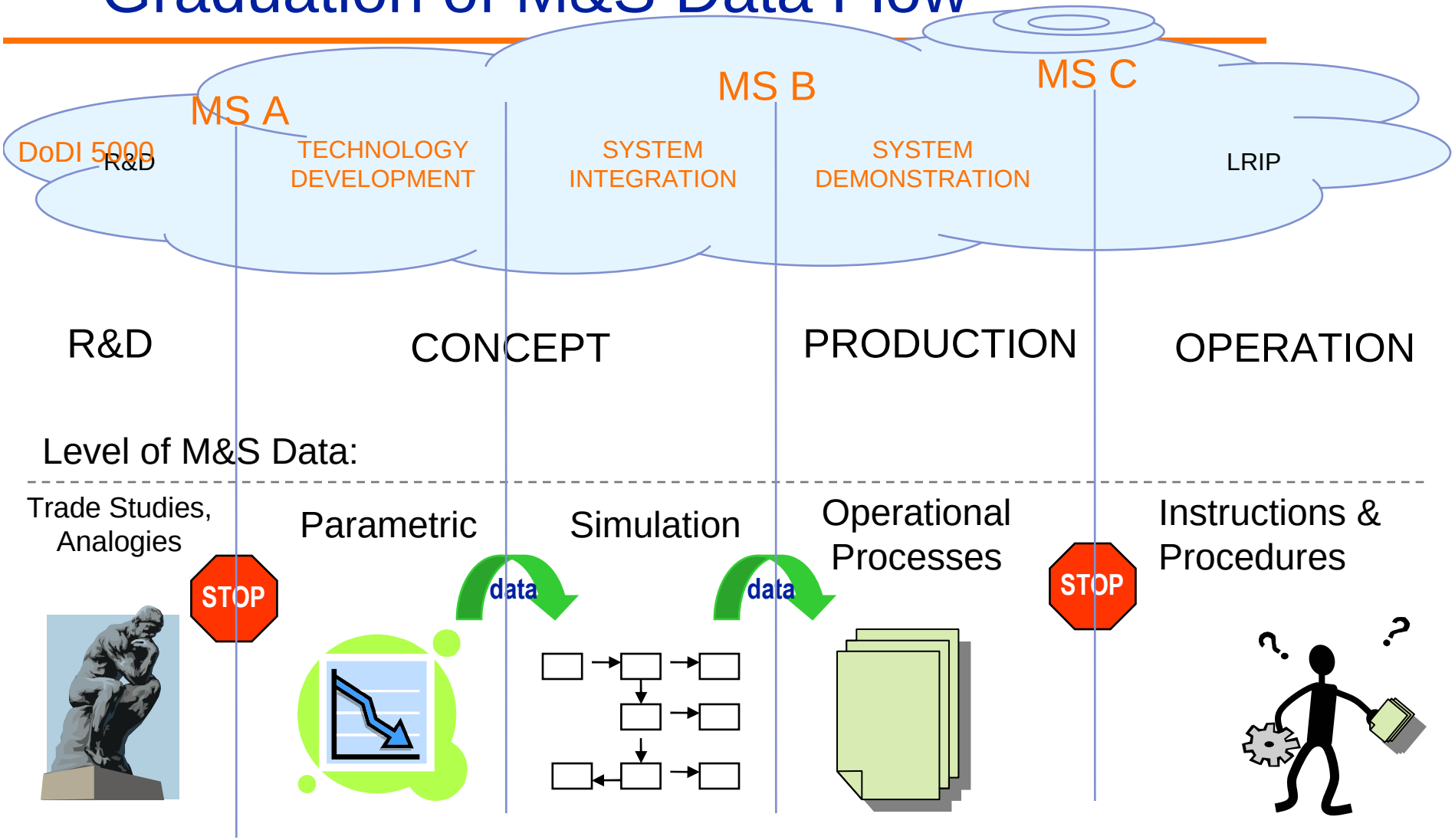
- Impact on Data Management
  - It multiplies the amount of M&S data significantly
  - Leads to M&S being applied at many more phases in the lifecycle
  - Also applied much earlier – before DM stood up in most cases
- How can Data Management help?
  - Manage M&S products
  - Manage M&S data
  - Manage ‘provenance’ of M&S results

Example: M&S Before Investing …





Graduation of M&S Data Flow



How DM Can Help

- Both DM and CM have evolved away from predictable, clerical functions to a broader perspective.
- DM especially is shifting to a corporate, strategic perspective to identify what types of data will be of importance, to various audiences, over the data's and system's entire lifecycle.
  - Can accommodate the need to capture data earlier in the 5000.2 process (from JCIDS on…?)

Purpose and Scope of Std 859

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  - Provide a contemporary, principles-level, guide to requirements for acquisition and management of data across the product life-cycle
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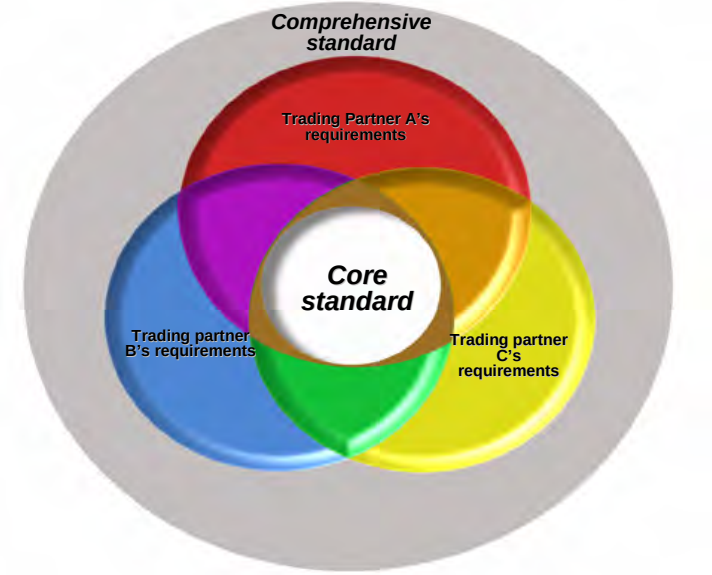

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Applying DM Principles in a M&S Scenario

1. Define the organizationally relevant scope of data management
   - Data managers now think about the strategic role of data management to the enterprise vs. a focus limited to contractual data, CDRLs and SDRLs.
2. Plan for, acquire, and provide data responsive to customer requirements.
   - A holistic, full lifecycle perspective is used by all data managers. The DM plan includes scheduled reviews of the plan itself to ensure it remains properly responsive to requirements.
3. Develop DM processes to fit the context and business environment in which they will be performed.
   - In a large, multi-tiered M&S environment, perhaps a federated data management approach is best during the most dynamic parts of the lifecycle, for example; in a smaller environment, a different DM architecture could be a better fit
4. Identify data products and views so that their requirements and attributes can be controlled.
   - Each version (in parameters, models, sets of models, scenarios…) uniquely identified so that each can be retrieved and combined correctly; each result can be reproduced

Applying DM Principles in a M&S Scenario

5. Control data, repositories, data products, data views, and metadata using approved change control processes.
   - The data manager will apply CM principles to DM items, tailored to the business context. Solutions will differ based on various factors; an example is the boundaries with CM functions in the participating organization(s).
6. Establish and maintain an identification process for intellectual property, proprietary, and competition-sensitive data.
   - In a multi-partner M&S environment, and/or one that includes proprietary commercial technology, this can both be complex and entail risk . A Bill of Information approach might be a good fit to manage this complexity.
7. Retain data commensurate with value to the organization.
   - Data must be retained for legal, contractual, and entrepreneurial value—but retention, migration, and disposal all have costs associated with them.
8. Continuously improve data management.
   - Well-designed DM processes include metrics to monitor the quality and efficiency of DM.
9. Effectively integrate data management with knowledge management.

Summary

- There's a new appreciation of M&S
  - Growth in number of M&S efforts and where applied
- It's not your father's DM
  - Big changes in perspective, tools, environment
  - Rate of change depends on
    - exposure to Standard, Handbook, BoK, CoP, Training
    - Staffing (both Library and Computer Science applicable)
- Doing both well is worth the investment

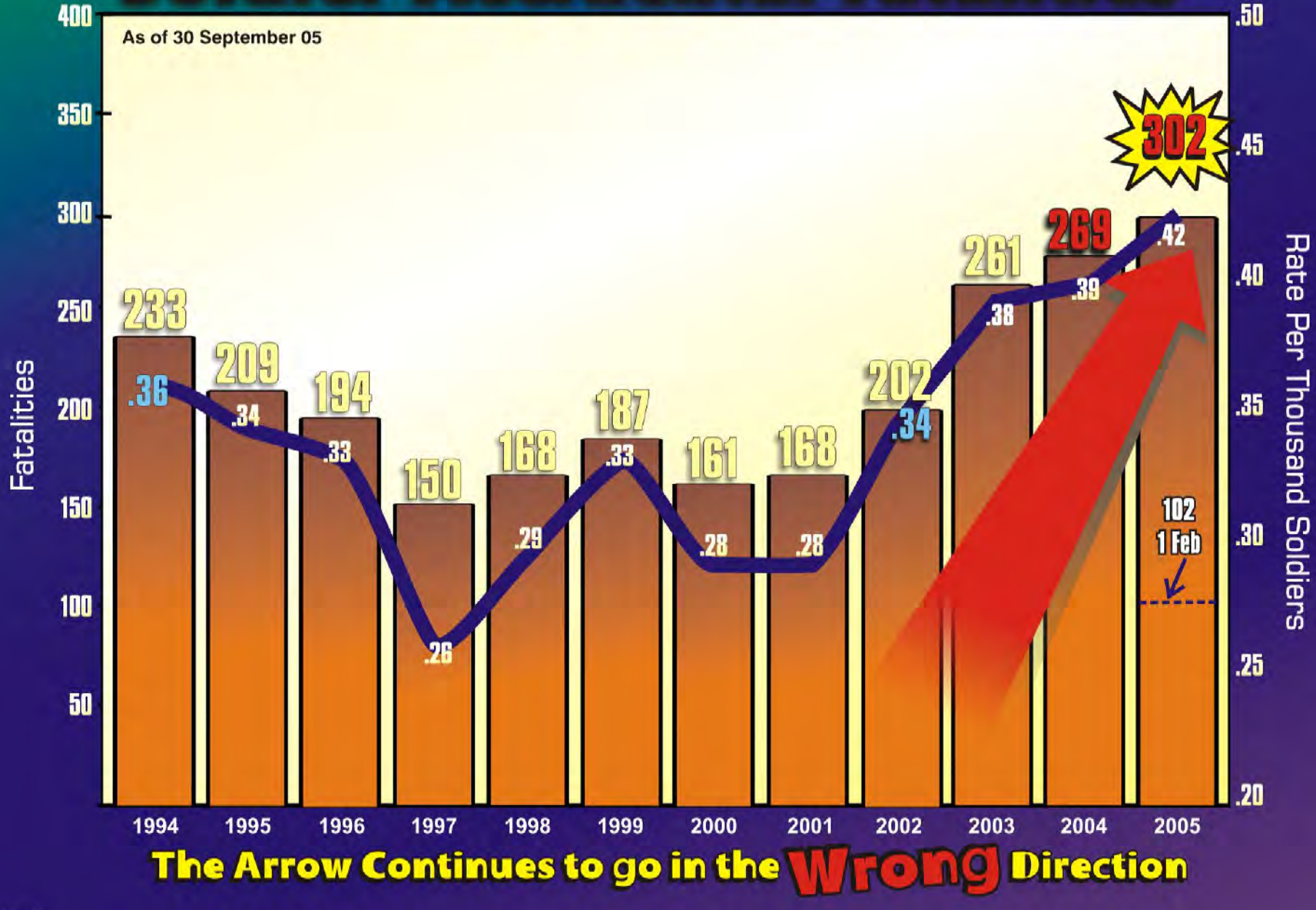
Enabling Army Level Risk Mitigation

U.S. ARMY COMBAT READINESS CENTER®

Fall 05 TEMAC

EDMONDS5-01

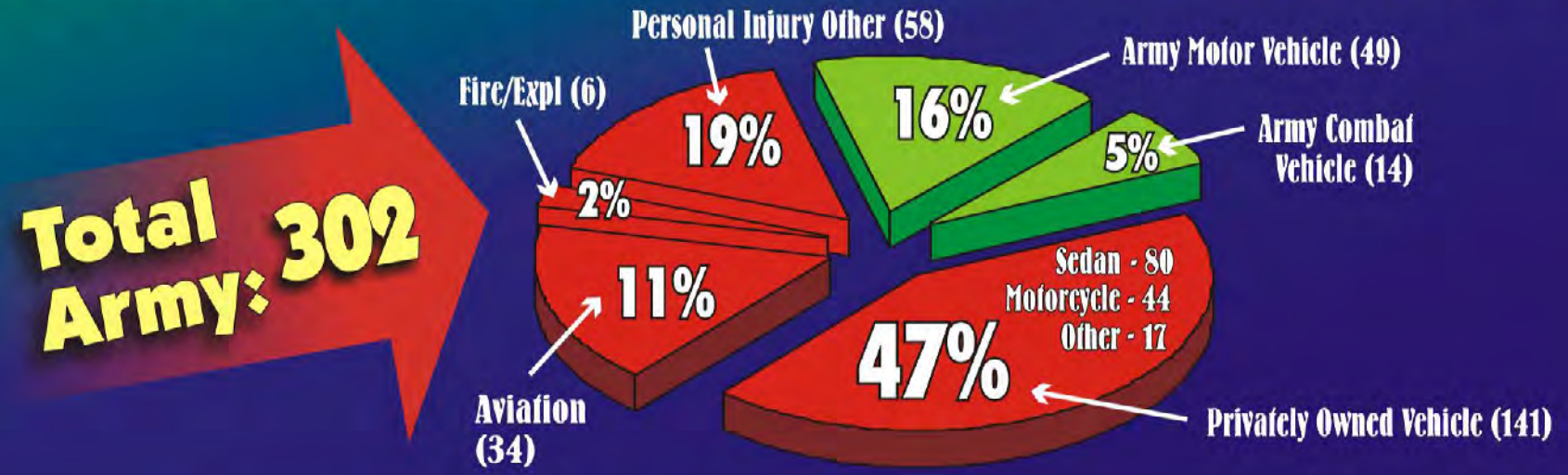
Soldier Accidental Fatalities



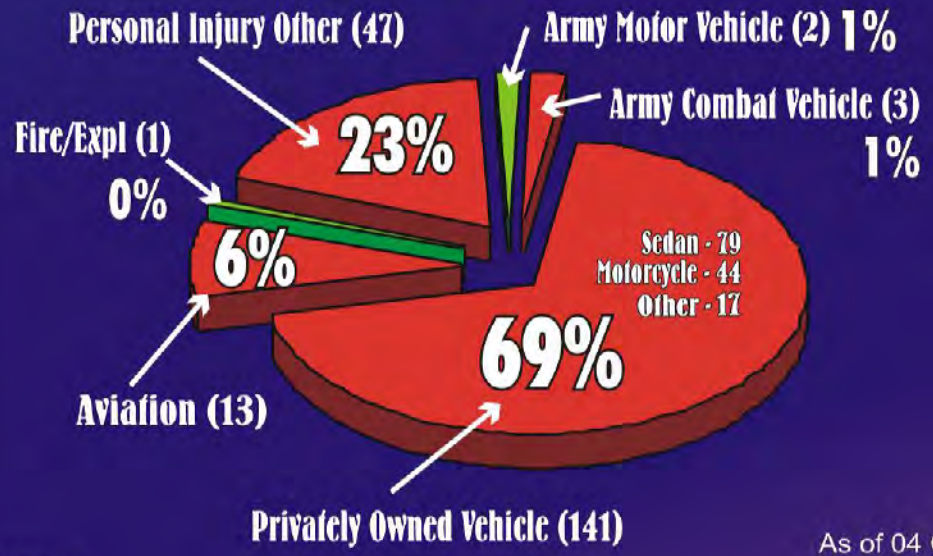
The Arrow Continues to go in the Wrong Direction

ASP5-18

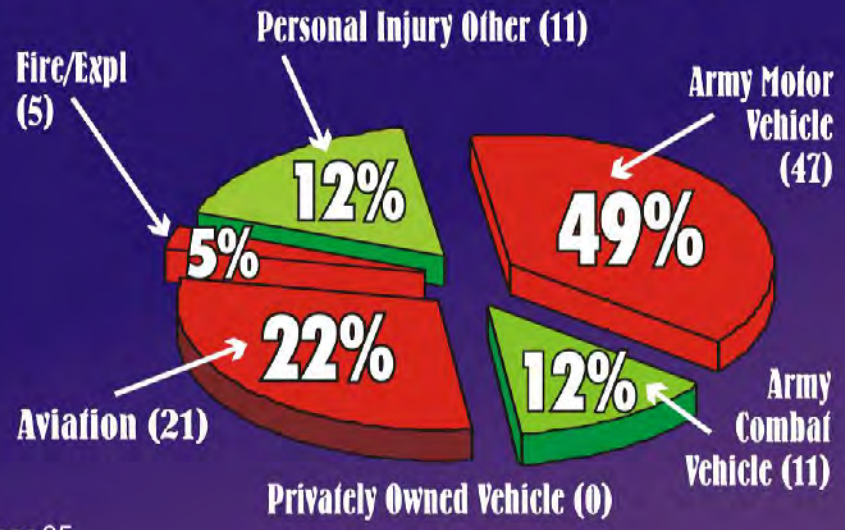
FY05 Soldier Accidental Fatalities



Everywhere Else: 207



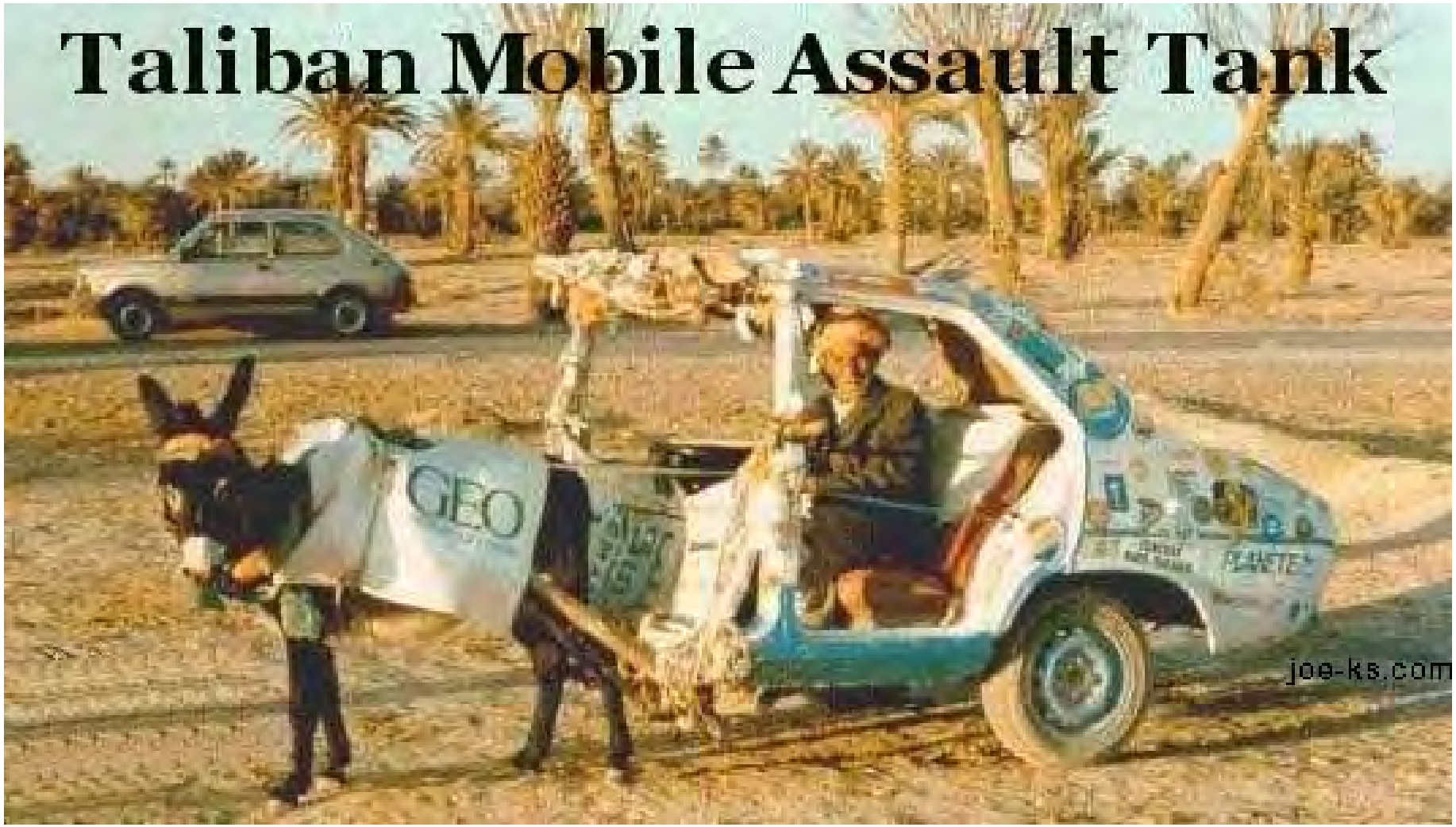
CENTCOM AOR: 95



As of 04 October 05

PCC5-12B

Is this an Enemy Threat?



Where's the Risk?

COMPOSITE RISK MANAGEMENT

Combat

Accident

RISK

MANPADS
Small Arms
RPG

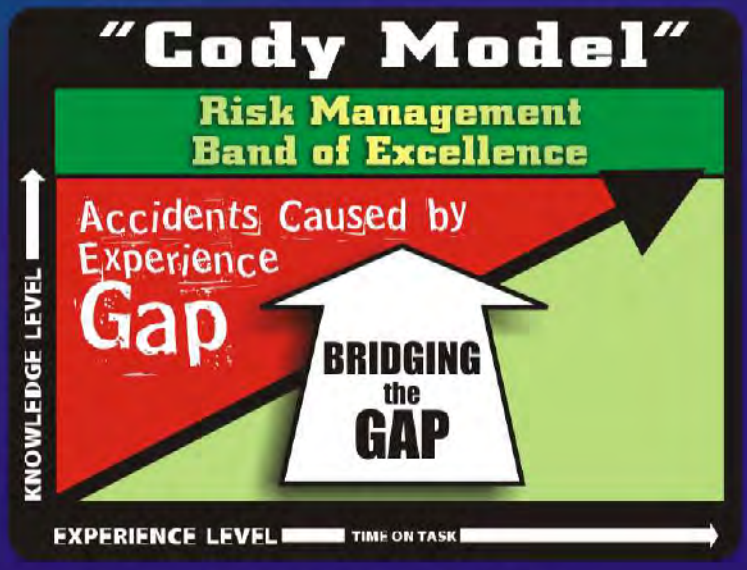
Wire
Hazards
Brownout
Fatigue
IIMC

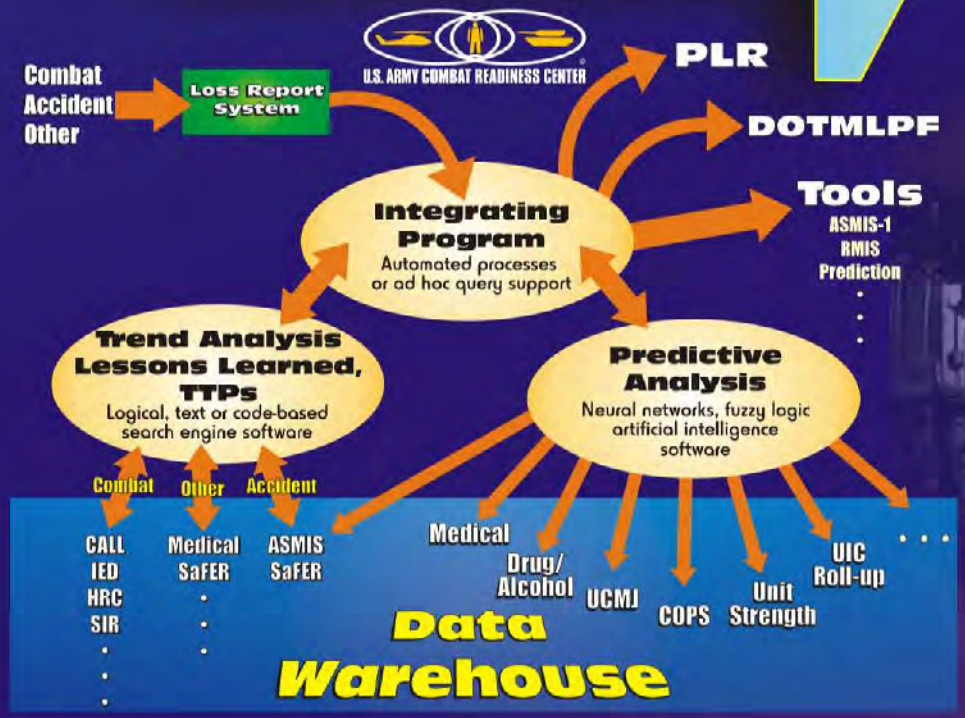
Risk Management

Risk Management

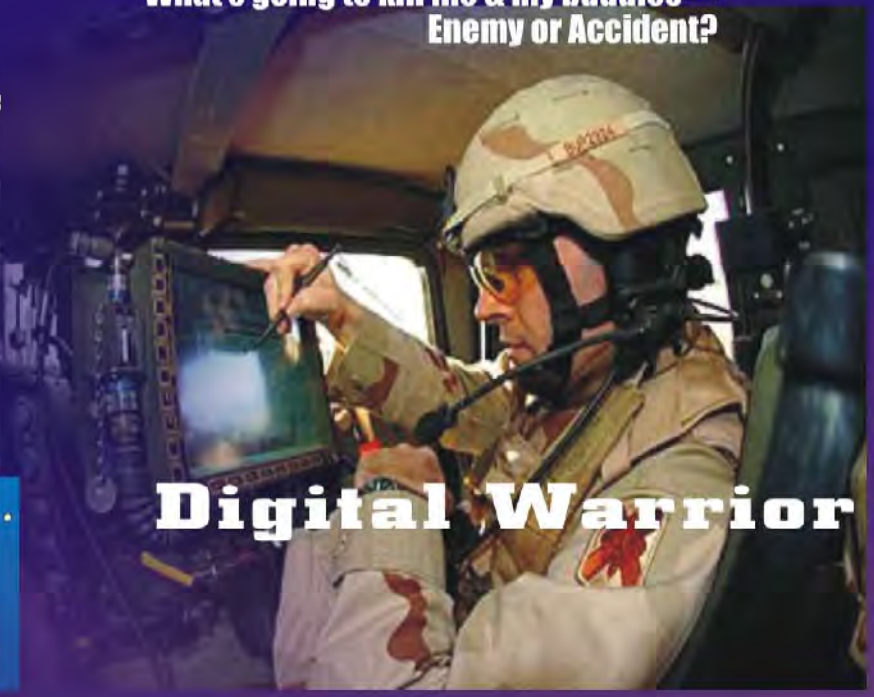
Successful Risk Management

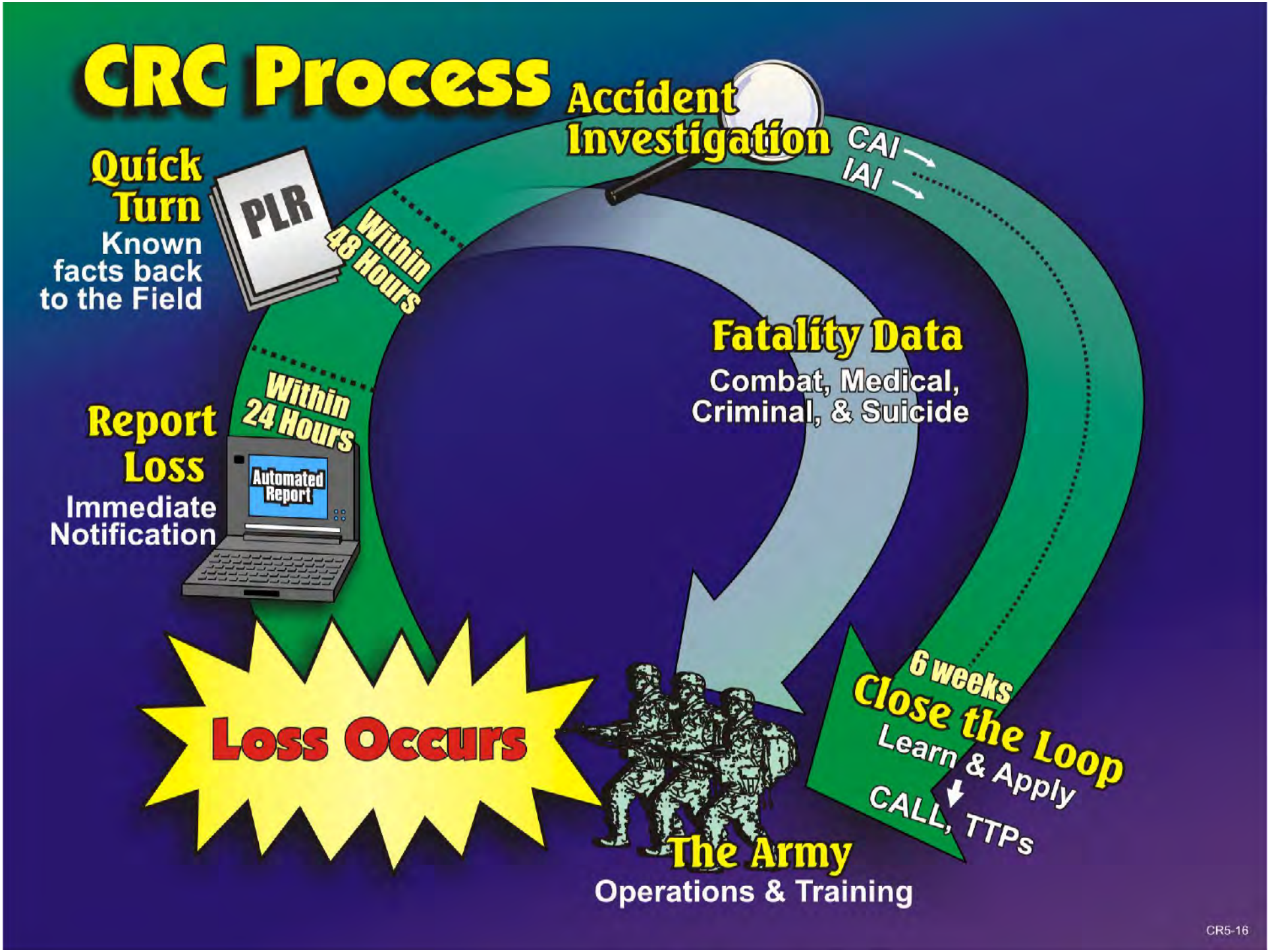
"Cody Model"

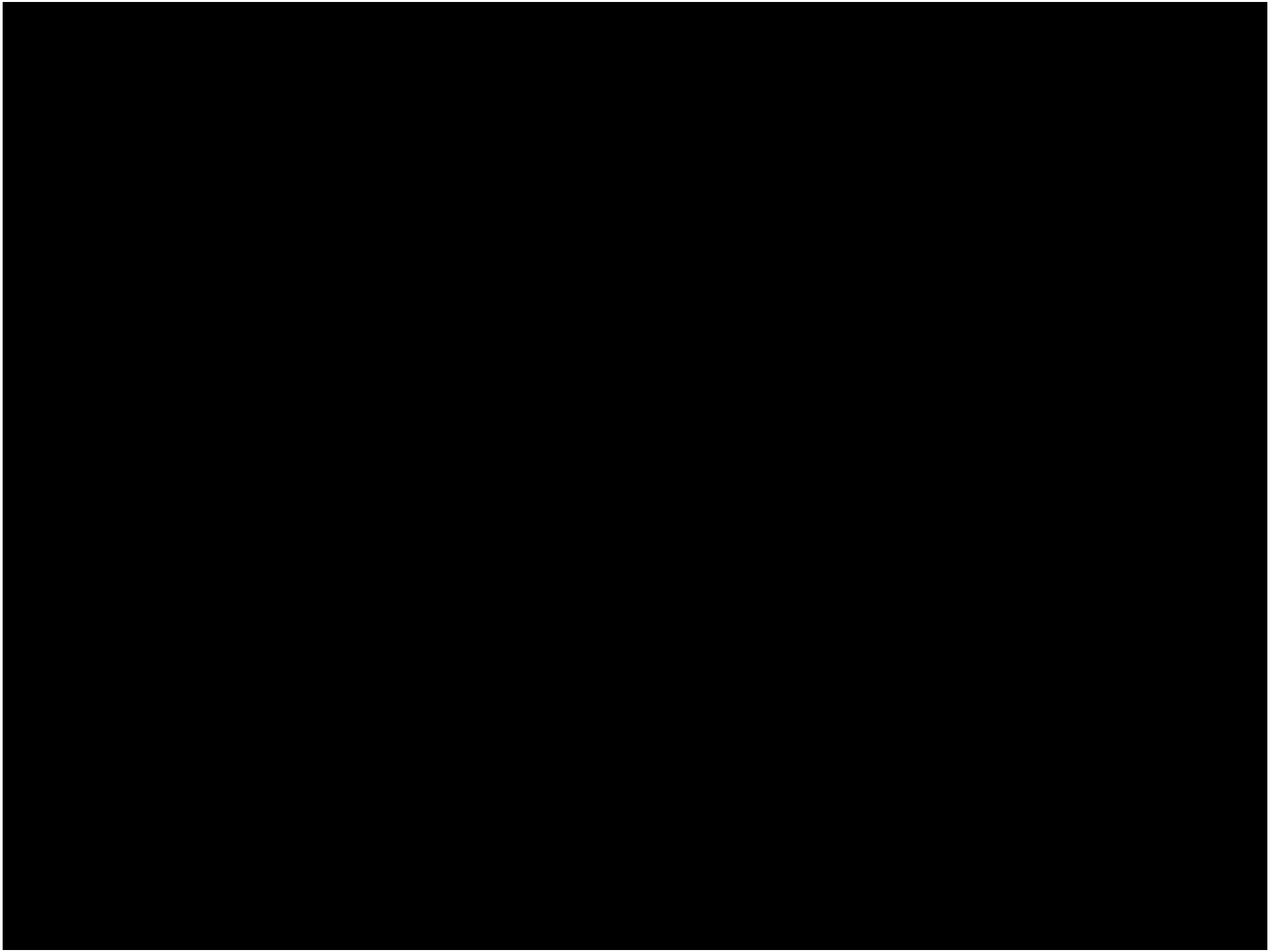




What's going to kill me & my buddies—
Enemy or Accident?




CRC Process
Accident Investigation
CAI
IAI
Quick Turn
Known facts back to the Field
PLR
Within 48 Hours
Fatality Data
Combat, Medical, Criminal, & Suicide
Report Loss
Immediate Notification
Within 24 Hours
Automated Report
Loss Occurs
6 weeks
Close the Loop
Learn & Apply
CALL, TTPs
The Army
Operations & Training
CR5-16



OVERCOMING OUR CULTURAL DILEMMA

REALITY

- Do more with less
- Reluctance to say no
- Ability to accept change
- HOOAH Factor

REQUIREMENT

Conscious Decision to Control Hazards or Accept Risks

RESULT

Decision Level

Mitigate Risk

Resources

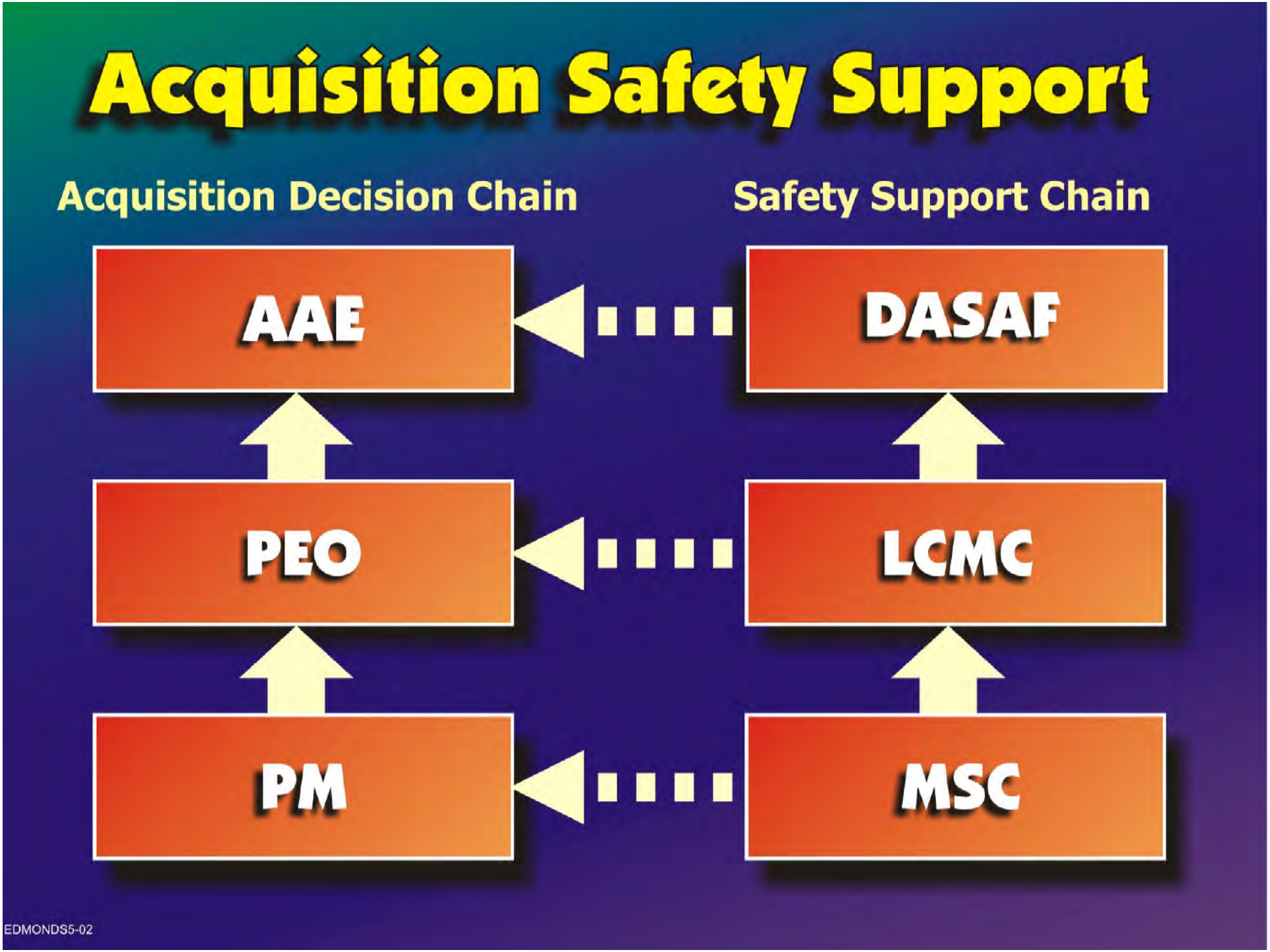
N

Y

- Assess Hazards
- Make Decisions
- Identify Hazards
- Implement Controls
- Supervise

IPR6-350

Acquisition Safety Support



EDMONDS5-02

Risk Management Roles

- **AAE**
  - Define Army safety, health, and environmental risk management policies and act as the risk decision authority for high risk residual hazards associated with Army systems.
  - Fund and evaluate safety, health, and environmental research and development programs to address resolution of generic systemic safety, health and environmental problems.
- **PEO**
  - Safety Officer for assigned systems. Act as the risk decision authority for medium risk residual safety hazards.
- **PM**
  - Responsible for identifying all hazards, eliminating or mitigating when possible, and providing an assessment of hazards that are not eliminated.
- **DASAF**
  - **Assist integrating agents, provide Risk Management information, assess Risk Management performance**

Reference AR 70-1 & AR 385-16

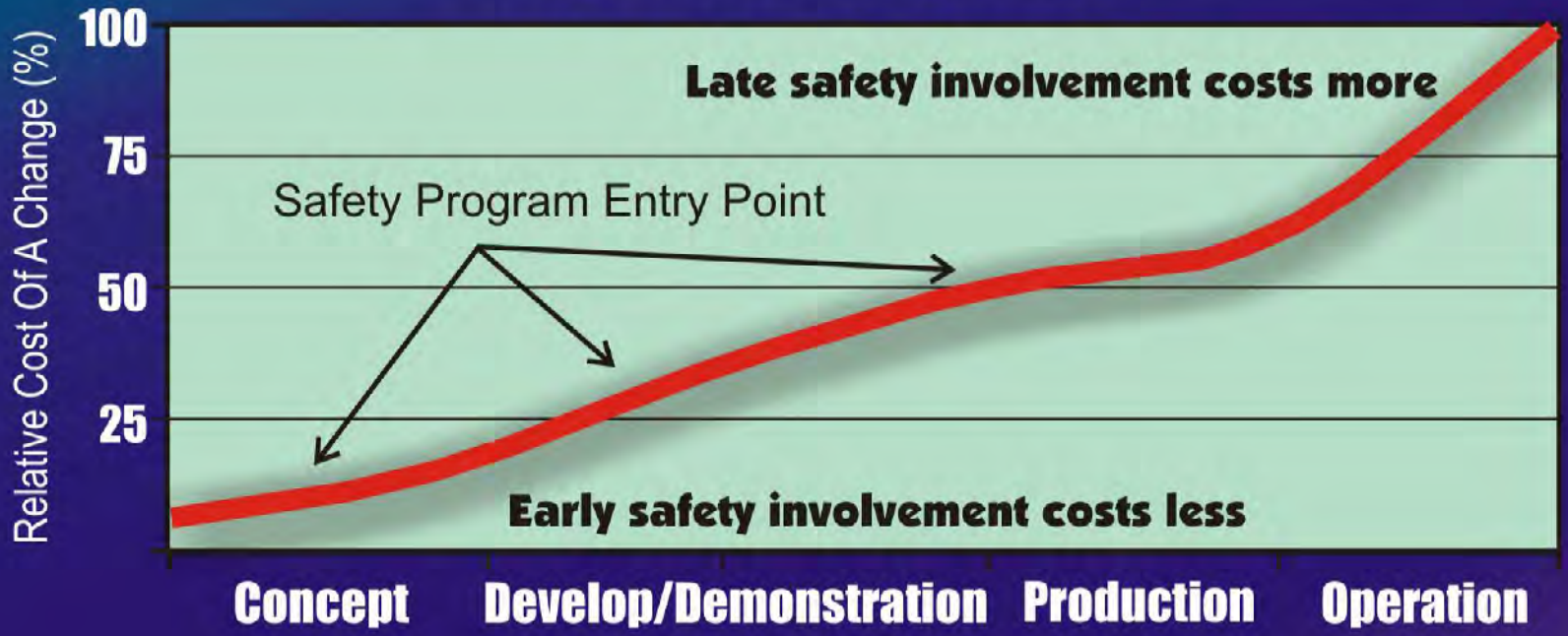
System Safety Primary Objectives

- Ensure hazard control measures are designed in up front & not trained out
- Ensure lessons learned are applied to new developments; don't reinvent the wheel (TIMING DEPENDENT- you've got to get in early to apply them)
- Ensure hazards are "risk managed"; residual risk accepted by the appropriate authority.
- Apply risk management throughout the life cycle

AR 385-16

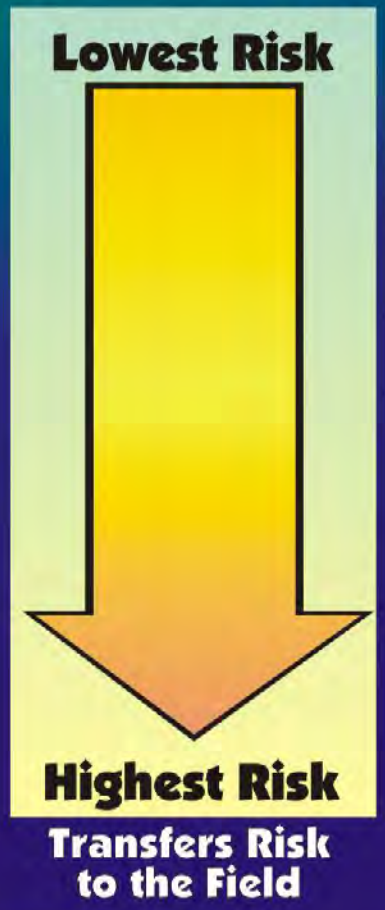
Implement System Safety Early

Over a program's lifecycle it costs less to integrate safety EARLY



Pay Me Now, or Pay Me Much More Later!!!

Order of Precedence



- **Design for Minimum Hazard**
  - Best to design risk out of System
- **Incorporate Safety Devices/Features**
  - If can't design out, design controls in (H/W Devices & S/W Features as Interlocks)
- **Provide Warning Devices**
  - Generate adequate visual or audible warning signal
- **Develop Procedures & Training**
  - Susceptible to Personnel Turnover
  - Susceptible to Human Error

The goal is to "design out" not "train out" hazards

IMPROVING COMBAT READINESS THROUGH DESIGN SELECTION

Composite Risk Management Occurs at Each Level

All Losses are at a Unit Level but all Controls are not!

Unit Level
Higher Level
Army Level

Risk Management occurring at the system level and throughout the lifecycle prevents unnecessary safety challenges for Soldiers

Unit Level: At this level, the Soldier can never get rid of the hazard—IT WILL ALWAYS BE WITH HIM

Both the Risk and the Controls transferred to the Soldier through procedures and training

- **TTP**
  - Rollover Drills
  - Water Egress Drills
- **Increases task load**
  - Subject to human error
- **Limited risk reduction**
  - -Does not reduce severity; reduces probability by only one level

Higher Level: Additional procedural/training controls tax available manpower and mission effectiveness with no reduction in the severity of the risk

- Risk transferred to the Soldier reduces mission effectiveness
  - Develop/modify TTP
  - Provide training range
  - Provide additional manning to support increased operational tasks
    - Mission resources diverted to training
    - Increases exposure to hazard

Army Level: Best position for risk mitigation—SOLDIERS CAN'T AFFORD TO PAY FOR ARMY LEVEL HAZARDS

- Hazard identified, assessed and controlled to an acceptable level of risk (using Order of Precedence)
  - Possible control alternatives:
    - Design: alternate egress access when inverted (reduces severity and probability)
    - Safety Devices: combat door latch wrenches (reduces probability only)
    - Residual risk reduced to level acceptable at the PM Level
- Residual risk mitigated; not transferred to the Soldier
  - Lower order of precedence controls (i.e. TTP) would have required risk acceptance at the AAE level
    - Procedural/training: Rollover Drill

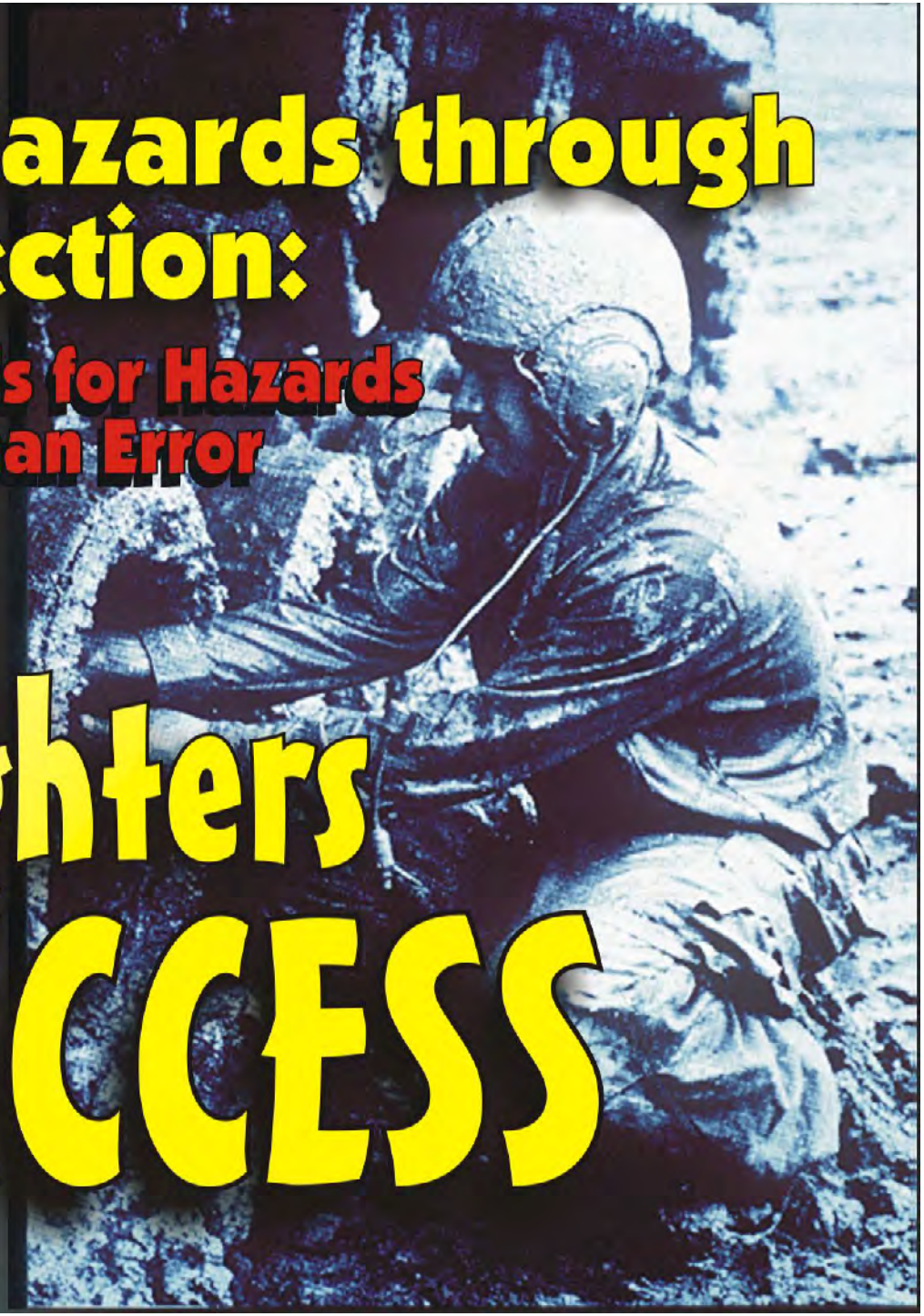
Summary

- **USACRC supports the ASP by—**
  - Reviewing total Army operations from platoon-level to HQDA-level daily to identify RMI opportunities for keeping soldiers safe
  - Providing information & tools that commanders can use to make informed risk decisions
  - Assessing risk management performance

Supporting commanders' safety programs worldwide

Eliminate Hazards through Design Selection:

Procedural Controls for Hazards are Subject to Human Error

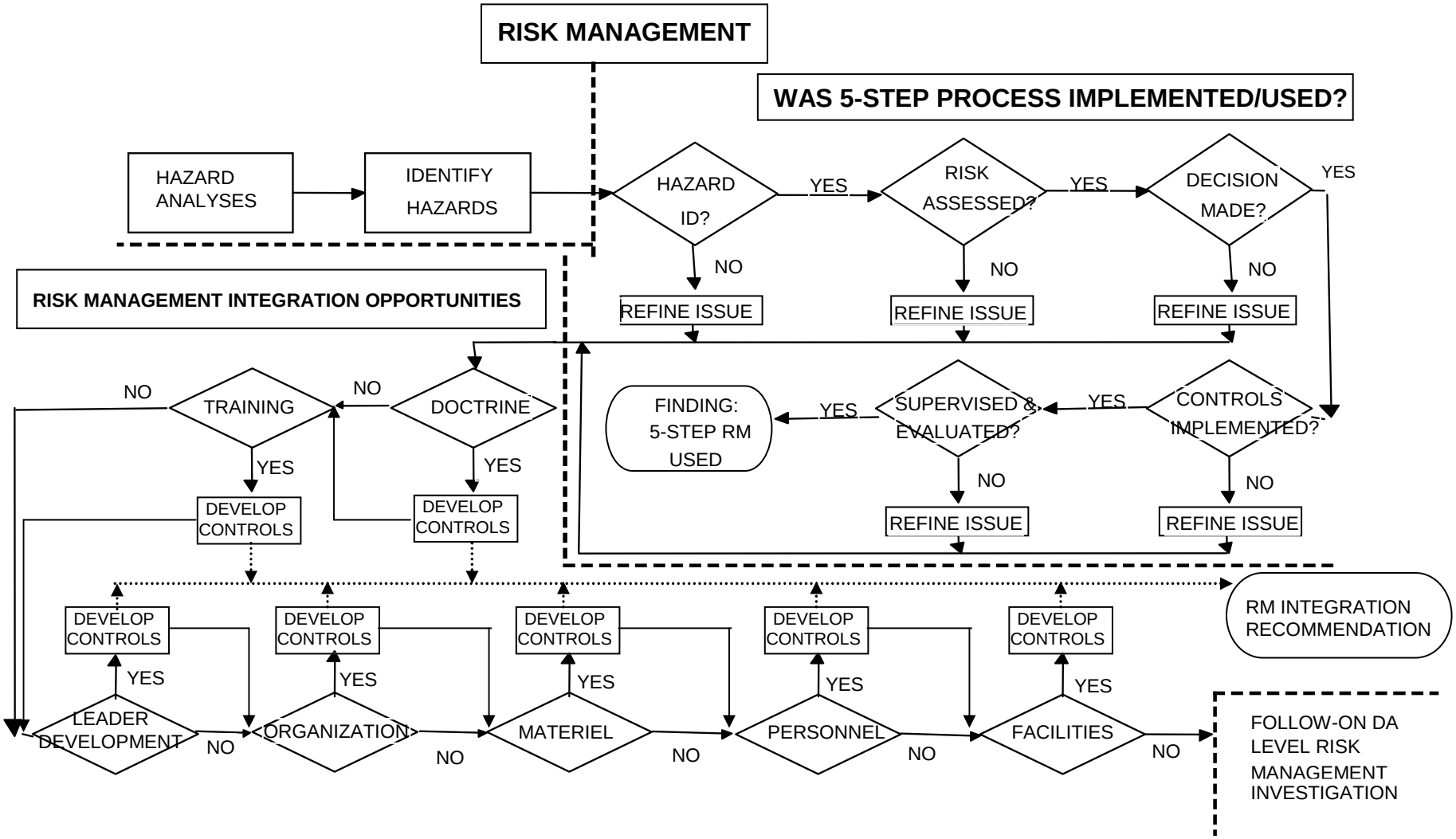


Set Warfighters Up for SUCCESS

EDMONDS4-14

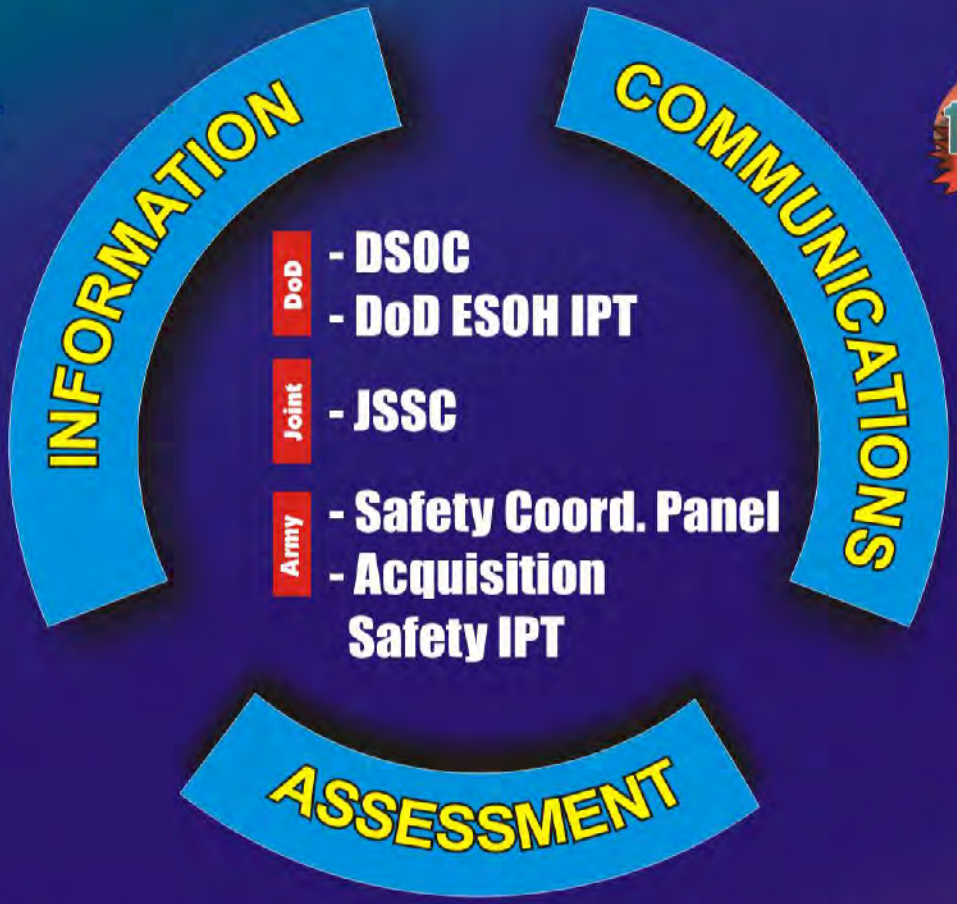
BACKUP SLIDES

RISK MANAGEMENT PROCESS FLOW



Where we're engaged in supporting acquisition safety.

- Developing hazards/ controls information for disseminating historical safety lessons learned for new systems (ASMIS-1)
- Synchronizing acquisition & safety policies
- Reviewing DAU coursework safety content

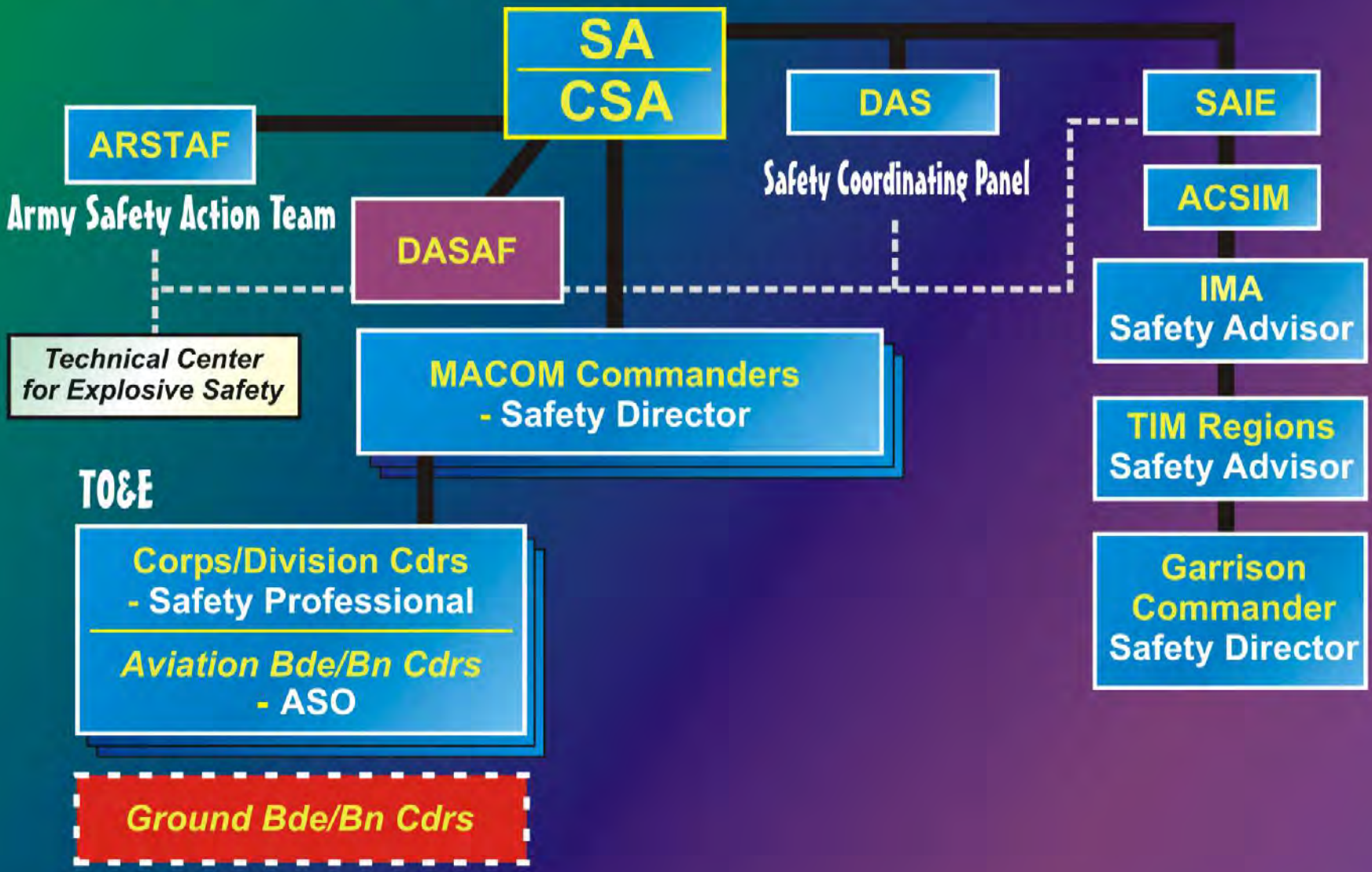


- Safety Campaign Plan
- JSSC MOA "System Safety in Materiel Acquisitions"
- DASAF Memo "Eliminating Hazards through Design Selection"
- ASA(ALT) Bulletin

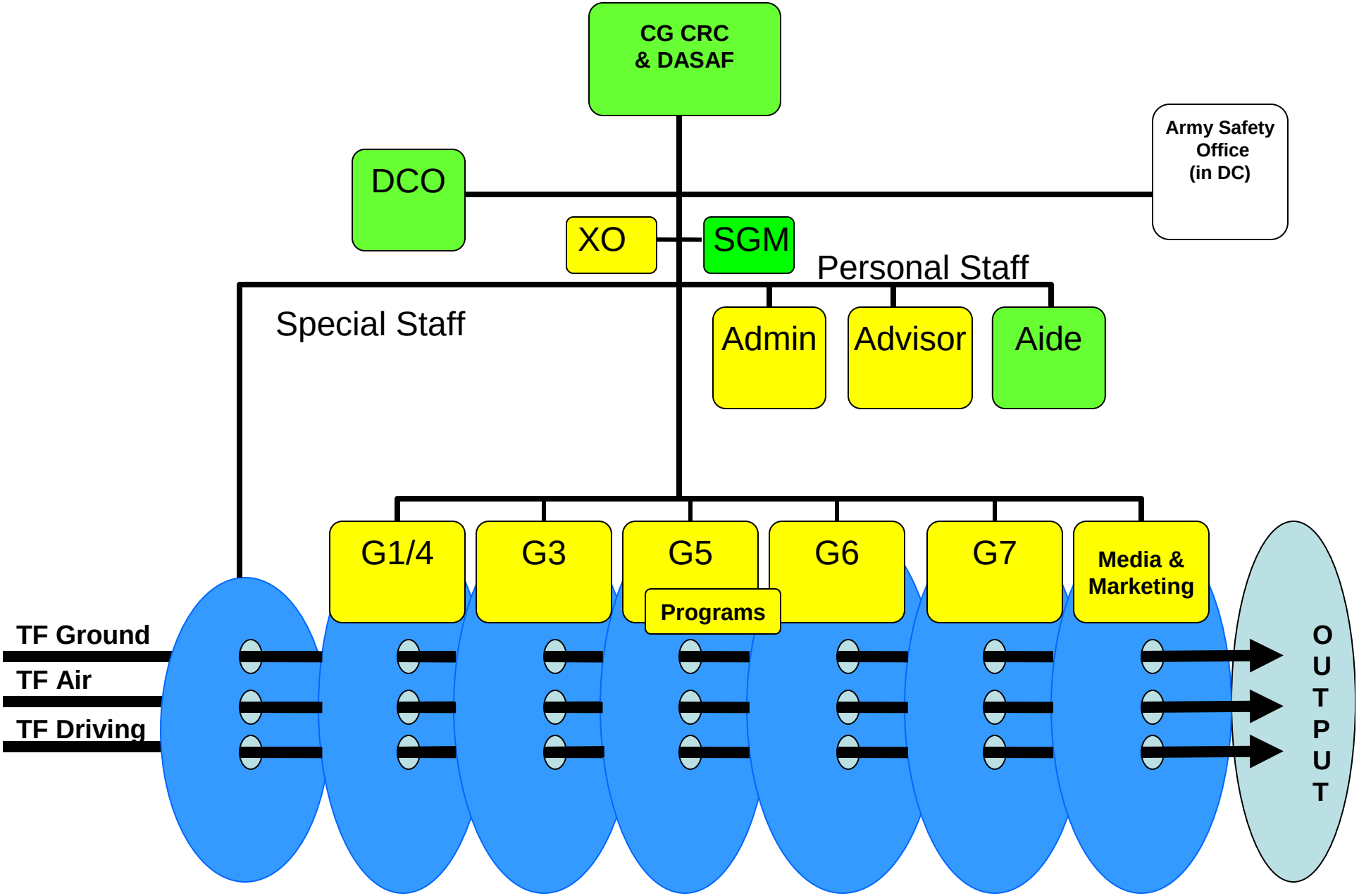
- Providing Independent Safety Assessments at MDRs/IPRs for ACAT I & II
- Participating in program IPTs & SSWGs to provide proactive guidance
- Conducting Accident Investigations of selected accidents
- Review of System Safety Risk Assessments & Safety Notification Messages

EDMONDS5-02

Army Safety Program Key Players & Interfaces

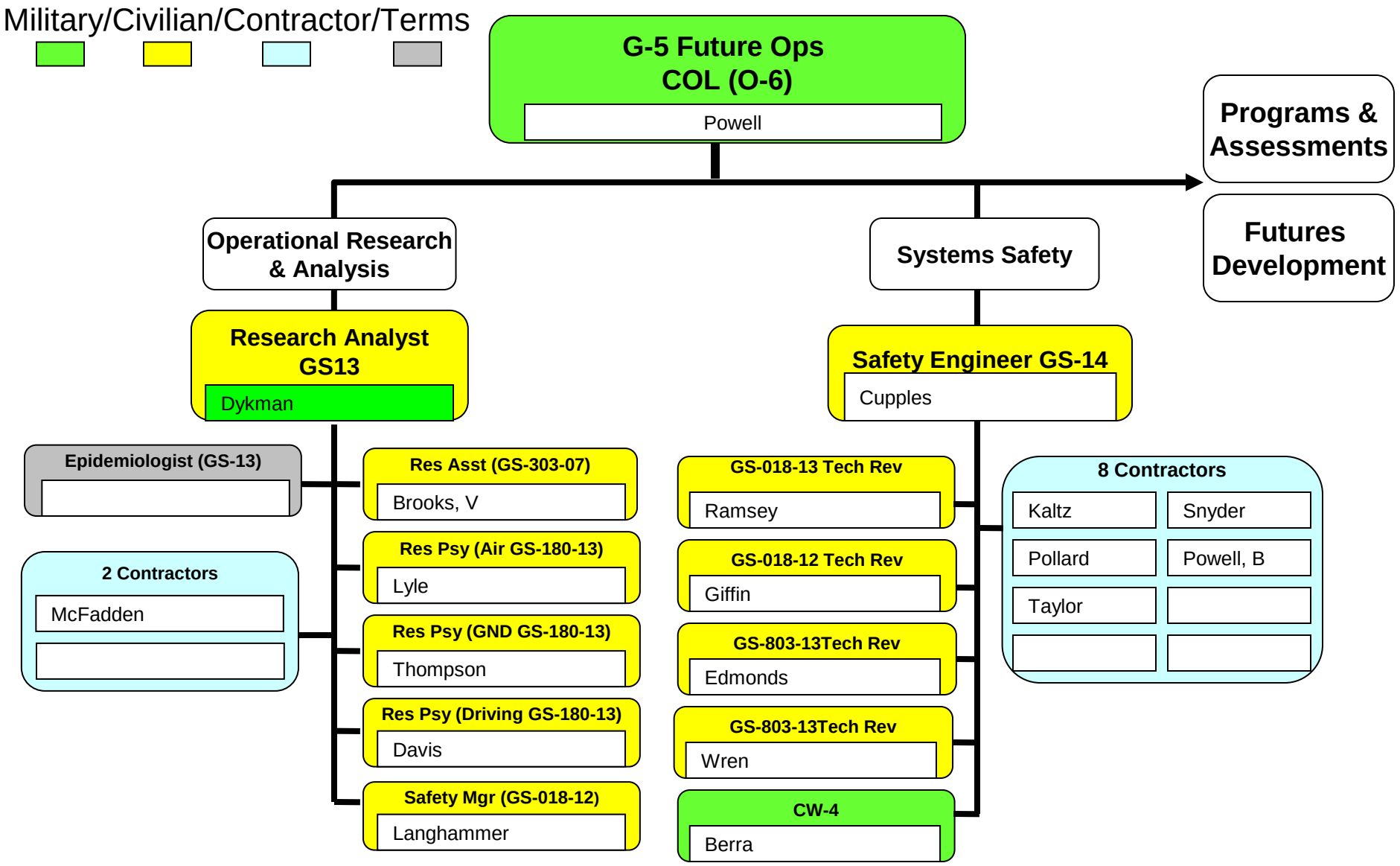


U.S. Army Combat Readiness Center (CRC)



Composite Risk Management Is The Key To Success

Assessing risk from multiple hazards cumulatively!


Military/Civilian/Contractor/Terms
G-5 Future Ops
COL (O-6)
Powell
Programs & Assessments
Futures Development
Operational Research & Analysis
Systems Safety
Research Analyst GS13
Dykman
Safety Engineer GS-14
Cupples
Epidemiologist (GS-13)
2 Contractors
McFadden
Res Asst (GS-303-07)
Brooks, V
Res Psy (Air GS-180-13)
Lyle
Res Psy (GND GS-180-13)
Thompson
Res Psy (Driving GS-180-13)
Davis
Safety Mgr (GS-018-12)
Langhammer
GS-018-13 Tech Rev
Ramsey
GS-018-12 Tech Rev
Giffin
GS-803-13Tech Rev
Edmonds
GS-803-13Tech Rev
Wren
CW-4
Berra
8 Contractors
Kaltz
Snyder
Pollard
Powell, B
Taylor

SUPERVISE & EVALUATE "FEEDBACK"

- USACRC provides the independent "honest broker" feedback
- How?
  - System Safety Advocacy
  - ISA's

- If we don't perform this step of the cycle, the risk management process is incomplete.

Integrating Agents:

OPPORTUNITY FOR WORLD CLASS SAFETY PERFORMANCE

PROJECT THE FORCE

Integrating Agent: CG FORSCOM

Power Projection
- Planning
- Training
- Warfighting

Force Projection Platforms
- Deployment
- Mobilization
- Redeployment
- Demobilization

DEVELOP THE FORCE

Integrating Agent: CG TRADOC

DOCTRINE
- RM connected to Strategic Plan
  - Embed emerging but mature doctrine & TTP
  - FM 101-5

TRAINING
- RM standardization
- RM in tng development
- RM integration in lesson plans and MTPs

COMBAT DEVELOPMENT
- Human performance synergy
- Accident investigation & followup
  - Materiel issues
  - SSRA in Battle Labs

LEADER DEVELOPMENT
- Embed RM in BCTP
- Embed RM in Prairie Warrior

SUSTAIN THE FORCE

Integrating Agent: CG AMC

- Materiel acquisition policy changes
- Strengthened acquisition process by codifying system safety risk assessment procedures
- World class performance by PEOs and PMs
- Handoff info about hazards to soldiers

FAAVALUE

EDMONDS5-10

A Major Subjective Analysis Shortfall…

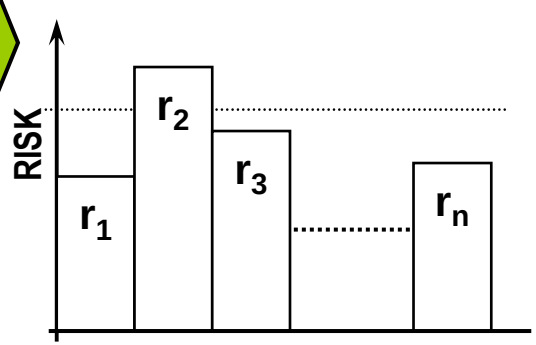
All **"Line-Item Inventory" Hazard Analysis / Risk Assessment methods * suffer this shortfall:**

THE ANALYTICAL CONSTRUCT

HAZ-ARDS	SEV-ERITY	PROB-ABILITY	RISK
h_1	s_1	p_1	r_1
h_2	s_2	p_2	r_2
h_3	s_3	p_3	r_3
⋮	⋮	⋮	⋮
h_n	s_n	p_n	r_n

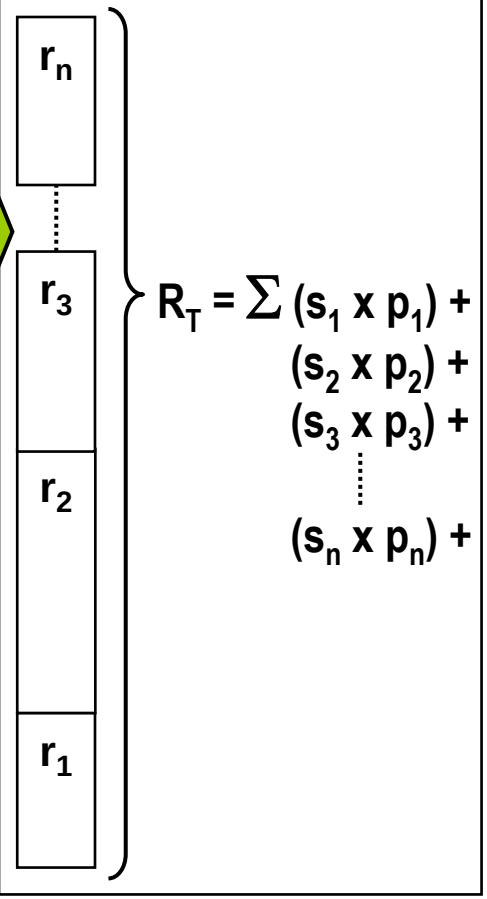
- **Examples:**
  Preliminary Hazard Analysis
  Failure Modes and Effects Analysis
  Functional Hazard Analysis

THE ANALYST'S VIEW of SYSTEM RISK



RISK SUMMATION METHODS ARE NEEDED!

REAL WORLD SYSTEM RISK



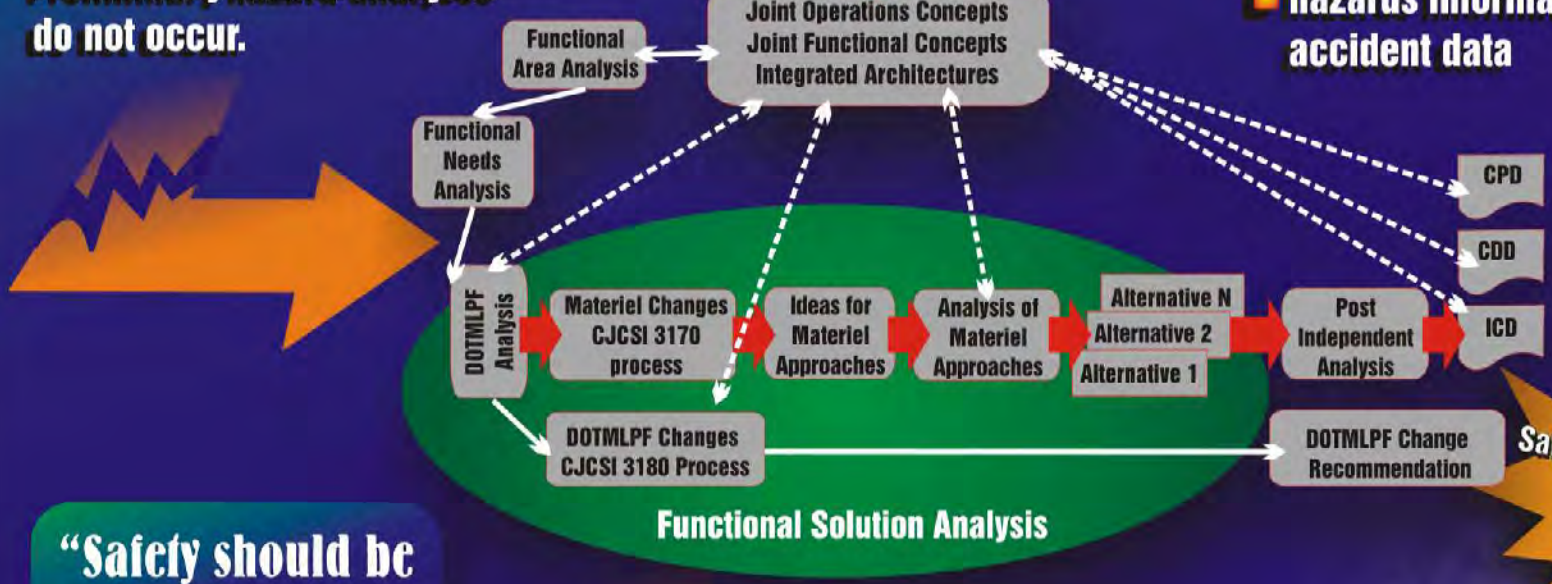
$$R_T = \sum (s_1 \times p_1) + (s_2 \times p_2) + (s_3 \times p_3) + \vdots + (s_n \times p_n) +$$

Establishing Safety Performance in the Capability Identification Process

PROBLEM: Historical safety lessons learned, accident data, known hazards, etc. are not leveraged in the selection process. Preliminary hazard analyses do not occur.

Strategic Policy Guidance

Joint Operations Concepts



SUPPORT: System safety resources needed:

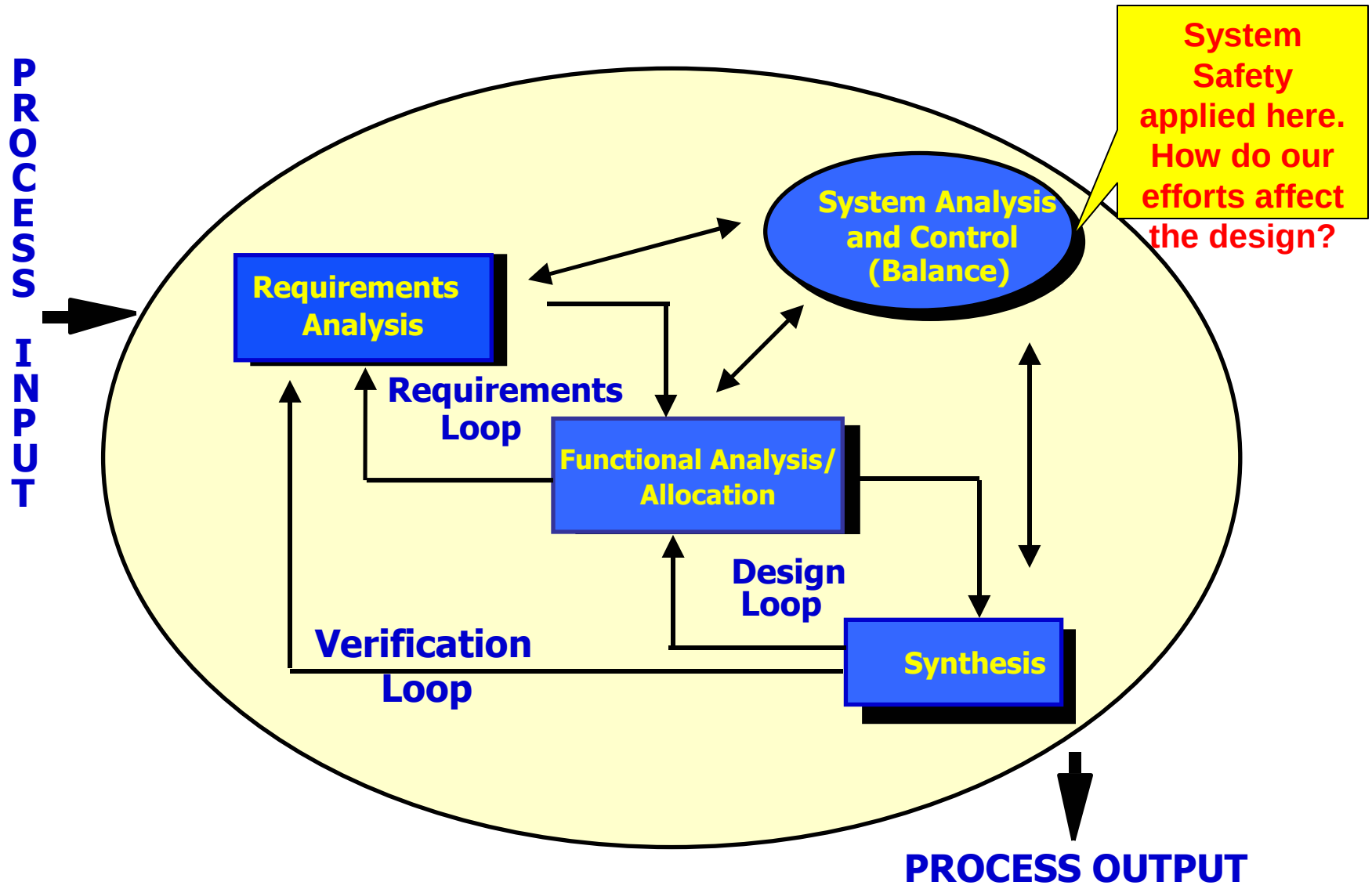
- system safety engineers in all combat developments
- hazards information from accident data

Safety results in improved mission capability and reduced risk

"Safety should be a requirement up front and across the DOTML-PF"
– Hon. Claude Bolton, AAE

RESULTS: Safety performance criteria established in requirements documentation.

Systems Engineering Process



Where we can help you...

- **Supporting risk management decisions**
  - System Safety Risk Assessments (SSRA)
  - Army Safety Action Team (ASAT)
- **Providing hazards information from Army accidents to influence design selection**
- **Coordinating safety investment strategies to fund safety improvements**
  - Safety Coordinating Panel (SCP)
- **Analyzing and communicating safety information**
  - *Countermeasure, Flightfax, Impax,* PLRs

Where we need your help...

- Ensuring an effective SSMP is developed & executed as part of the acquisition strategy
- Providing design solutions for recurrent hazards that produce accidents
- Enabling acquisition leaders to routinely assess safety performance
- Integrating system safety within the overall systems engineering process
- Establishing safety performance capabilities for the user

Where's the Risk?

COMPOSITE RISK MANAGEMENT

Combat

IED
Small Arms
RPG

Risk Management

Accident

Air
Ground
Driving

Risk Management

Successful Risk Management

MISSION ACCOMPLISHED

What's going to kill me & my buddies, Enemy or Accident?

CR5-05

INNOVATIVE PROCUREMENT STRATEGIES

BY
DAVID M. EIBAND

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6767 OLD MADISON PIKE, BUILDING 7
HUNTSVILLE, AL 35806

OVERVIEW

- FIRST PROCUREMENT FOR PRINTED WIRING BOARDS (PWB)
  - $2 MILLION CEILING
  - 2 YEAR TERM

- SECOND PROCUREMENT FOR ENTIRE CLASSES OF ITEMS FROM COMPONENTS TO COMPLEX ASSEMBLIES
  - $45 MILLION CEILING
  - 5 YEAR TERM

FIRST PROCUREMENT APPROACH

- PWBs HISTORICALLY PROCURRED VIA CREDIT CARD AS MICRO-PURCHASES
  - MULTIPLE BUYS ≤ $2,500
  - PERCEIVED AS “SPLITTING”
    - PENALTIES ARE $10,000 FINE AND/OR 5 YEAR IMPRISONMENT

FIRST APPROACH (CONT)

- SOLUTION
  - USE FEDERAL ACQUISTION REGULATION (FAR) TEST PROGRAM AUTHORITY
    - RAISED SIMPLIFIED ACQUISITION PROCEDURES (SAP) LIMIT FROM $100,000 TO $5 MILLION
  - PROCURE PWBs AS A SUPPLY RATHER THAN A SERVICE
    - REQUIRED TO MEET SAP DICTATES

FIRST APPROACH (CONT)

- USE TWO YEAR CONTRACT
  - LOCK-IN PRICES
  - DECREASE ADMINISTRATIVE COSTS AND PROCESSING TIME DELAYS

- WARRANT ORDERING OFFICER IN TECHNICAL OFFICE
  - AVOIDED USING CONTRACTING SHOP FOR EACH BUY

FIRST APPROACH (CONT)

- USE PURCHASE CARD FOR PAYMENT
  - CONTRACTOR PAID IN TWO DAYS WITHOUT DFAS INVOLVEMENT
  - NEGOTIATED BETTER OVERALL PRICES

FIRST APPROACH (CONT)

- RESULTS
  - AWARDED A $1.2 MILLION PROCUREMENT IN 70 DAYS RATHER THAN 260 DAYS USING NORMAL CONTRACTING BY NEGOTIATION PROCEDURES
  - NEGOTIATED LOWER PRICES
  - SIGNIFICANTLY IMPROVED PROCUREMENT TURN AROUND TIME
  - BROUGHT ORDERING CAPABILITY INTO TECHNICAL OFFICE

SECOND PROCUREMENT APPROACH

- PURCHASED MYRIAD ITEMS RANGING FROM ELECTRONIC COMPONENTS TO COMPLEX SYSTEMS
  - $5 MILLION PER YEAR
  - TIME CONSUMING
  - PROCUREMENTS OFTEN COMPLICATED
  - OFTEN LESS THAN TIMELY

SECOND APPROACH (CONT)

- PROCUREMENT STRATEGY
  - BUY EVERYTHING, EXCEPT COMPUTERS, FROM A SINGLE VENDOR
  - STRUCTURE A FIVE YEAR CONTRACT
  - RETAIN BASIC FEATURES OF THE FIRST PROCUREMENT APPROACH

SECOND APPROACH (CONT)

- PROBLEMS
  - APPEARANCE OF “BUNDLING” AND RESTRICTING SMALL BUSINESS
  - FORCED TO INCLUDE ANOTHER ORGANIZATION RAISING CONTRACT TO $45 MILLION
    - UNABLE TO USE SAP
    - FAR REQUIRED CONTRACTING BY NEGOTIATION PROCEDURES

SECOND APPROACH (CONT)

- SOLUTION
  - USED FAR SOURCES SOUGHT REQUEST TO ADDRESS BUNDLING
    - AVAILABLE ONLY TO R&D PROGRAMS
    - EVALUATED 113 SUBMITTALS--ONLY TWO VENDORS WERE “QUALIFIED”
    - NEITHER MET THE REQUIREMENT TO PROVIDE 100% SMALL BUSINESS MATERIALS

SECOND APPROACH (CONT)

- NEGOTIATED APPROACH WITH SMALL BUSINESS ADMINISTRATION (SBA)
  - 5% PRICE ADVANTAGE TO SMALL BUSINESS SUPPLIER
  - TWO VENDORS, ONE PURELY SMALL BUSINESS AND ONE UNRESTRICTED BUSINESS
  - COMPETE OFFERS USING SBA AGREEMENT TO SELECT BUYS

SECOND APPROACH (CONT)

- WARRANTED ORDERING OFFICER IN TECHNICAL OFFICE FOR PROCUREMENTS

- UTILIZED PURCHASE CARD FOR PAYMENT

SECOND APPROACH (CONT)

- RESULTS
  - 90 DAYS TO ACCOMPLISH SOURCES SOUGHT AND SBA NEGOTIATIONS
  - APPROACH HIGHLY POLITICAL
    - PROCUREMENT EXPENDED 17 MONTHS FROM START TO SOURCE SELECTION COMPLETION

CONCLUSIONS

- FAR CAN BE USED TO MAXIMIZE PROGRAM SUCCESS
- COMPETENT, OPEN-MINDED TEAMS OPTIMIZE RESULTS
  - TECHNICAL OFFICE
  - PROCUREMENT AND SMALL BUSINESS OFFICE

Innovative Procurement Strategies

By

David M. Eiband

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Abstract

Given downsizing and shrinking budgets in the Department of Defense (DoD), most organizations are searching for means to affect savings, operate more efficiently, and produce a higher quality product. At times those admirable goals can go astray, leading to potentially improper procurements while striving to meet mission requirements. We executed two innovative procurement experiments that accomplished those goals specifically in the research, development, test and evaluation (RDT&E) environment. R&D, by its nature, does not deal in commonly available systems, and our first experiment pushed the procurement envelope by repetitively procuring unique developmental hardware through use of the Simplified Acquisition Procedures defined in the Federal Acquisition Regulation (FAR) combined with aggressive use of the Government purchase card as a payment vehicle. This approach eliminated the very common risk of "splitting" procurements to meet purchase card dollar limits and utilized Ordering Officer capability resident in a group outside of the procurement organization to minimize administrative overhead time and organizational conflicts. The follow-on experiment expanded upon the simplified acquisition approach while additionally aggregating large numbers of different developmental hardware purchases into a single, multi-year contract. The expanded approach developed a methodology that avoided "bundling" procurements and required extensive negotiation with the Small Business Administration to complete the procurement. This paper will discuss the evolution of both strategies, their regulatory basis, and the net effect of the total experiment.

The Setting

Our group designed, validated, fabricated, tested, and collected data from telemetry systems, in particular weapons applications. Comprised of a mixed group of engineers, technicians, and support specialists, the group had designed and built telemetry systems for weapons ranging from 2. 75 inch rockets, to 10 inch diameter hypersonic anti-radar missiles, to five inch diameter air-to-air missiles, to one inch bomb fuzes, to foreign military system evaluation. In all applications, our designs required significant procurement effort to fabricate and test systems, and when appropriate, our designs were also carried internally into prototype production. Professional technical image aside, our work could not be completed without continuing forays into the world of Government procurement.

Procurement Background

Within the Government and certainly within the DoD RDT &E environment, procurements follow a common preferred evolution. When possible, procurements are first made using micro-purchase procedures, which are less than or equal to $2,500; then small purchase procedures which are greater than $2,500 and no more than $100,000; and finally contract procedures for all procurements greater than $100,000. Procurement complexity, lead time, and administrative costs all increase as one ascends the hierarchy from group to group, and within the small purchase and contract ranges, complexity, lead

time, and administrative costs increase at prescribed cost threshold levels. Clearly, there are advantages to keeping individual procurement costs as low as possible to avoid the noted procurement overhead, but as discussed later, there are disadvantages as well.

The First Experiment

Organizations do not change their operating philosophy without reason, and our group procurement strategy fits that mold. For years, our group had used multiple $2,500 per purchase micro-purchases to procure printed wiring boards (PWB) as well as a myriad of other classes of items. The PWBs, while very complex in this application, are essentially the easily recognized nonconducting fiberglass boards overlaid with conducting traces found in most electronic devices. Various electronic components, connectors, and wiring harnesses are attached to the traces to implement a particular design. From a technical standpoint, each PWB is unique to a peculiar system with multiple PWBs used in each system; however, the procurement system does not treat PWBs with such fidelity. From a procurement standpoint, a PWB is a PWB just like every other PWB. That perceived similarity was the genesis of our procurement change.

Using that logic, the procurement community believed that the micro- purchase agent was breaking down, more commonly "splitting," similar PWB procurements to keep the individual procurements under the $2,500 threshold. By FAR Part 13.003(c)(1)(2)definition, splitting breaks a procurement into "several purchases that are less than the applicable threshold merely to (1) permit use of simplified acquisition

procedures or (2) to avoid any requirement that applies to purchases exceeding the micro-purchase threshold." Our perceived splitting was, therefore, potentially a violation of the FAR. Even more critically, splitting can also have significant legal penalties under 18 U.S.C. 287 of a $10,000 fine and/or 5 year imprisonment. In other words, our multiple buys via credit card were likely prohibited and corrective action was required to eliminate any potential violation.

With that newly found impetus, we embarked to change our PWB procurement strategy and began investigating alternatives to the commonly utilized micro-purchase approach. Because of their intentionally structured abbreviated requirements, FAR Part 13 Simplified Acquisition Procedures for commercial items apparently offered the best option. This conclusion seemed obvious as the simplified acquisition procedures were designed to "(a) reduce administrative costs; (b) improve opportunities for small, small disadvantaged, and women-owned small…. (c) promote efficiency and economy in contracting, and (d) avoid unnecessary burdens for agencies and contractors." Of course in the R&D arena, many items were not traditionally considered commercial, and the $100,000 limit on simplified acquisition procedure use loomed as a significant drawback as our annual procurements easily exceeded that limit by an order of magnitude.

Fortunately, several factors improved our situation. FAR 13.500(a) authorizes test programs greater than $100,000 but not exceeding $5,000,000 for simplified acquisitions, if the proper approval could be secured. Additionally from an administrative overhead perspective, simplified acquisition offered no-cost local

procurement department processing, an obviously attractive characteristic not necessarily available at all procurement organizations.

The major inhibitor to that approach was the FAR 13.500(c) test program requirement to purchase commercial items, or supplies in laymen terms, rather than services. Historically, the local procurement office considered PWBs a service rather than a supply because labor was required to manufacture each PWB. A closer reading of FAR 2.101 indicated that a commercial item is, by definition, "(a) any item, other than real property, that is of a type customarily used for nongovernmental purposes and that (1) has been sold, leased, or licensed to the general public; or, (2) has been offered for sale, lease, or license to the general public." Needless to say, PWBs are ubiquitous in modern society and clearly met the FAR definition of a commercial item. The contracting officer conceded that point, and with that agreement, the fundamental procurement approach was established.

The opportunities garnered by this strategy greatly benefited the PWB procurement. By using a two-year contract, the administrative costs and lead-time were significantly decreased in comparison to annual reprocurements. The commercial item or catalog pricing aspects of simplified acquisition allowed the contract to be limited to one page of text for the Statement of Work (SOW) by using the entire matrix of PWB combinations from the catalog instead of individual specifications. Because the contract allowed the development of Government-contractor relationships over a two-year period

of performance, the strategy significantly enhanced the potential for improvement and efficiency over the normal, mandatorily-competed individual procurement.

Commercial item or catalog pricing also facilitated ordering via electronic media and more importantly allowed ordering using the Government purchase card and a warranted Ordering Officer within our own group. Use of the Government-wide commercial purchase card and Ordering Officer was critical because orders may be placed without resorting to a procurement contracting officer or, after delivery, to utilize the Defense Finance and Accounting System (DFAS) in compliance with FAR 13.301(a). This advantage resulted in faster turnaround times and greatly improved contractor payment, two notably inefficient aspects of Government procurement, and even recommended in FAR 13.500.

In the end, this contract experiment produced several startling results. A $1.2 million procurement was awarded in 70 days rather than the nominal 260 days using normal FAR Part 15 Contracting by Negotiation contracting procedures. The two-year contract featured fixed, published prices over the duration of the contract, and from a technical standpoint, the single order limit was raised from the $2,500 micro-purchase limit to $50,000 of PWBs per month. The contractor benefited from more efficient production runs that are not constrained by the micro-purchase size limit, and from a business aspect, the contractor receives payment within two days of acceptance rather than months or later after submittal to DFAS. For these reasons, the simplified acquisition procedure approach was clearly a boon for both the Government and industry.

The Second Experiment

Given the preceding discussion, the first experiment was obviously limited in scope to a single item type, and while the simplified acquisition approach and Government purchase card payment method offered savings, the administrative overhead savings applied only to a single item type procurement. The second experiment was therefore designed to significantly expand the coverage of the contract while retaining all the positive aspects identified and proven by the first experiment.

Ninety percent of all procurements within our organization consisted of electronic components and devices, clearly making that area our new target. Our procurement requirement for the second experiment was structured to include classes of items ranging from simple components such as resistors, diodes, and capacitors to complete complex assemblies such as transmitters, global positioning systems (GPS), inertia navigation systems (INS), and electronic test equipment. Our historical procurement of these items was over $5,000,000 annually and rose to $9,000,000 annually when a sister organization was added.

The magnitude of this effort had two immediate impacts. First, since the technical requirements would likely exceed the capability of any small or disadvantaged business to meet the requirement, the procurement strategy directly conflicted with the Government's policy in FAR 19.201 to provide maximum practicable opportunities in its acquisitions to those same groups. In addition, our intention to maximize the benefits of multi-year contracting and therefore structure a five-year, maximum-length contract

further complicated this strategy, and the resulting $45,000,000 contract could not escape the intense scrutiny of the small business community or their champions in the Small Business Administration (SBA).

Because simplified acquisition procedures apply to commercial item contracts worth no more than $5,000,000 using the FAR-authorized test program, our planned five year, $45,000,000 approach created the second problem, a reliance on the more traditional combination of FAR Part 12 Acquisition of Commercial Items and Part 15 Contracting by Negotiation procedures. Due to the nature of the procurement, this latter problem did not adversely effect the overall experiment and could not be avoided in any event; the first problem with the small business community, however, was significant and required serious attention.

The shear magnitude of the procurement guaranteed small business scrutiny and the consequent potential for protest; in addition, the nature of the required items themselves could be grounds for protest. Because the procurement covered a broad spectrum of items from electronic components to complete electronic assemblies, "bundling" became an issue. By FAR 2.101 definition, bundling is the "consolidation of two or more requirements for supplies or services, previously provided or performed under separate smaller contracts, into a solicitation for a single contract that is likely to be unsuitable for award to a small business concern due to: (i) the diversity, size, or specialized nature of the elements of the performance specified; (ii) the aggregate dollar value of the anticipated award; (iii) the geographic dispersion of the contract performance

sites; or (iv) any combination of the factors described in (l)(i), (ii), and (iii)." Without doubt, our intended procurement had the look and feel of bundling and thus was highly suspect as a viable procurement strategy. However given our intent to truly explore the extremes of the procurement envelope, we elected to pursue a mitigating tactic that would hopefully preserve our intended strategy while satisfying the dictates of the small business regulations.

In order to address these small business issues, we coordinated with our base Small Business Office to release a "sources sought" request to industry. The sources sought request stated our requirement and directed interested contractors to provide key data describing their capability to meet the published requirement in accordance with FAR 5.205(a). Available only to R&D programs, the sources sought option perfectly fit our needs. One hundred thirteen contractors responded with data, and the packages were evaluated against the known requirement. Only two contractors were rated "qualified" as meeting the technical requirement, but none of the 113 small business concerns met the FAR 19.502.2(c) requirement that small business suppliers must furnish products from 100% small business concerns.

Armed with that information, we negotiated an acceptable small business set aside agreement with the SBA. The agreement would allow the selected small business to bid, within the noted FAR constraints, for the maximum number of items for which they qualified, and the remainder of the procurement would be awarded unrestrictedly to any qualified vendor, which could include either small and large businesses. In essence, the

original procurement would consist of two separate awards, and as negotiated, the small business contractor would be allowed a 5% cost advantage over the large business contractor. However because the requirement was identical whether met by a small business or unrestricted vendor, the contract awards would vary only by the scope of materials provided and the peculiar small business clauses unique to a small business contract.

In the end, the second experiment performed very much as the original had. The final contract allowed product ordering without using the procurement department or a procurement contracting officer; the Government purchase card system paid the contractor after the acceptance of each order; and, most importantly, the contract covered the universe of electronic requirements over a five year contract period. When one considers that our group averaged over 750 procurement actions annually, this single contract was a manifold improvement in acquisition overhead costs and time delays.

Processing the contract did not, however, proceed as quickly as had the original procurement. First, the sources sought and SBA approval effort required 90 days to accomplish, but that delay can be fully avoided on future procurements as the answer is generically appropriate to any other like procurement. Second, no $45 million program will quickly advance through either the procurement or management approval process, and it did not. In fact, the entire process required over 17 months from initiation to source selection.

Conclusions

This paper reports the results of two experiments in Government procurement. The experiments were evolutionary in nature with the second procurement growing upon the successful results of the first. As was noted, the procurements tested the ability of the Federal acquisition regulations to optimally meet the requirements of the RDT &E environment, the patience of the procurement system in addressing and eventually accepting innovative concepts, and the professionalism of the disparate technical and procurement communities in accomplishing a very different but mutually beneficial goal.

Biographical Sketch

David Eiband is Professor of Systems Engineering with DAU and has worked with manned and unmanned aircraft, rocket, and missile programs during his career. He earned his BS at the USAF Academy and his MA at the University of Texas at Austin. Mr. Eiband holds three U.S. Patents and is a former USAF pilot.

Testing Net-Centric Systems of Systems: Applying Lessons Learned from Distributed Simulation

Presentation to the NDIA Systems Engineering Conference

October 26, 2005

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MITRE

Outline

- Motivation
- Net-Centric Computing & Testing Challenges
- Distributed Simulation Computing & Similarities to Net-Centric Computing
- Distributed Simulation Test Experiences and Tools
- Applicability to Net-Centric Services Testing
- Findings & Recommendations

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Motivation

- **Over the next several years, DoD will begin fielding components of the Net-Centric Enterprise Services (NCES) and Global Information Grid (GIG)**
  - **Testing these Service Oriented Architecture (SOA)-based capabilities will require new techniques and tools beyond those used for traditional platform-based systems**

- **Hypothesis: *an approach to testing net-centric systems can be formed based on successful experiences testing service oriented distributed simulation systems.***
  - **This briefing presents the findings of a MITRE IR&D study that examined the potential for simulation test methods and tools to address net-centric test challenges**

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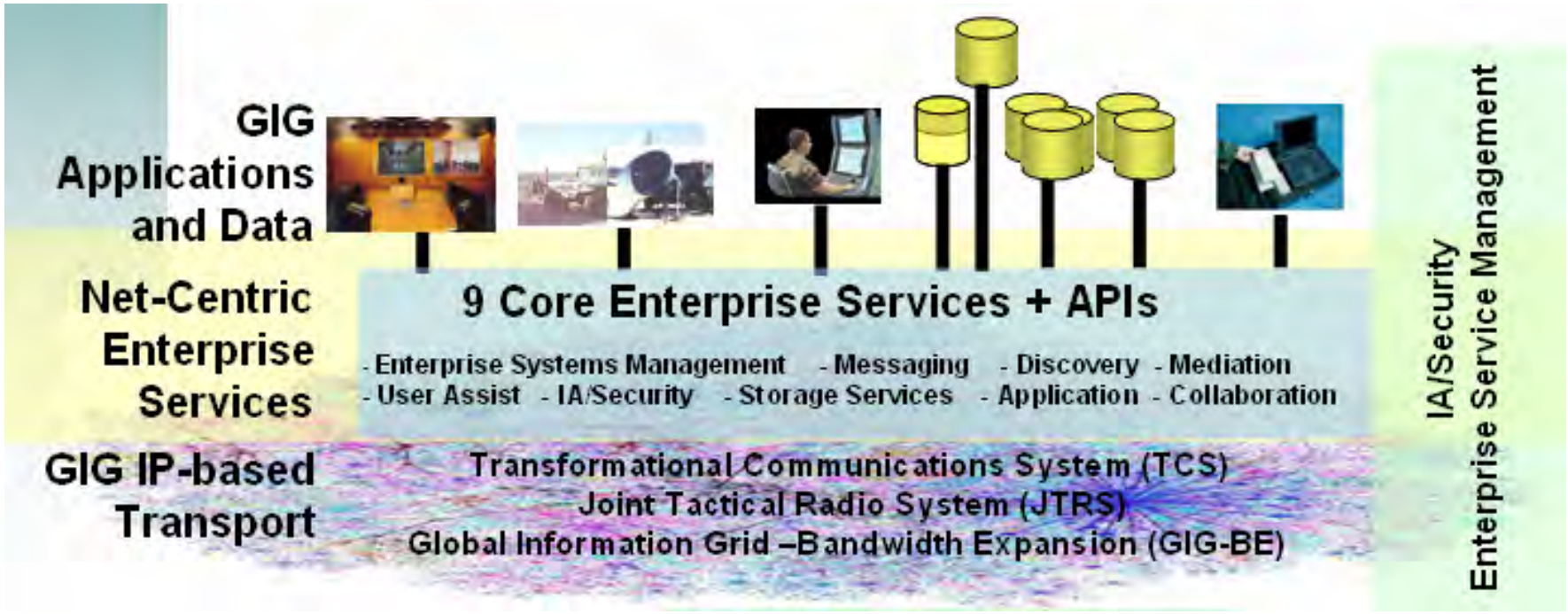
Trends in Net-Centric Computing: The GIG and NCES



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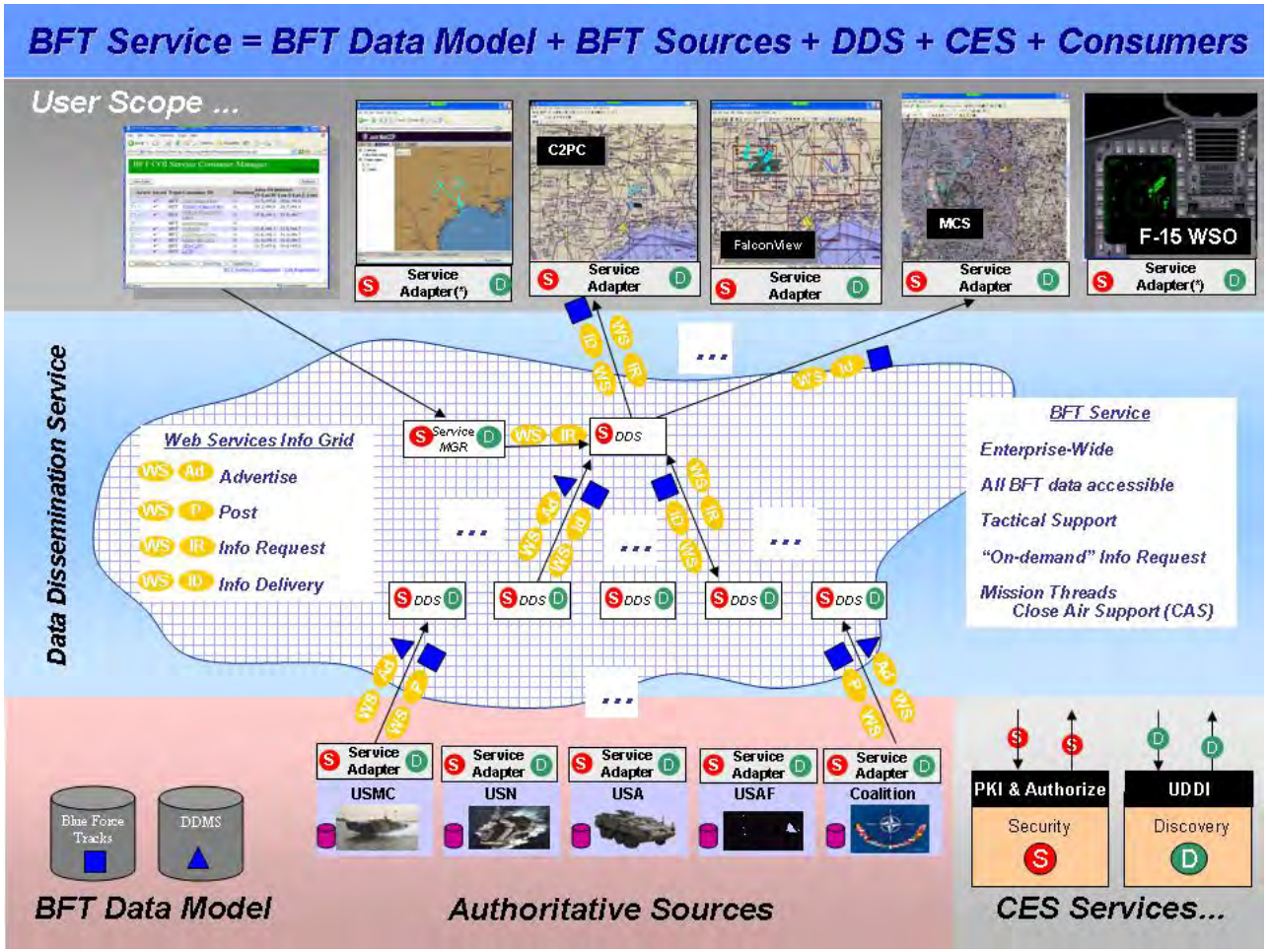
Trends in Net-Centric Computing: Communities of Interest (COIs) and the Blue Force Tracking (BFT) COI



BFT COI Architecture (from *Blue Force Tracking (BFT) Community of Interest (COI) Service (v1.0);* F. Wildes, K. Kelley, and P. Kim; MITRE Working Note: WN 05W0000001, Dec. 2004.)

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Challenges Associated with Testing SOAs: Why is it hard?

- Rapidly Evolving Standards
  - limits potential choreography between services
- Rapidly Evolving Core Services
  - many still in early prototyping phase
- Organization of Registries
  - the right service is out there somewhere, can you find it?
- Service Pedigree
  - once you find a service, can you trust it?

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Multiple Levels of Testing will be Required for NCES and the GIG

- Testing of each component
  - Does this node (database, consumer console, service provider) perform its function properly (as expected and according to specifications)?
- Testing services and transport components working together as different subnets
  - Do this/these services work in an integrated fashion on the network as expected?
- Testing each system's use of the network
  - Does this network architecture have bottlenecks and what is the maximum volume it can handle?
  - What is the network performance?
- Testing the end-to-end suite of systems over the network

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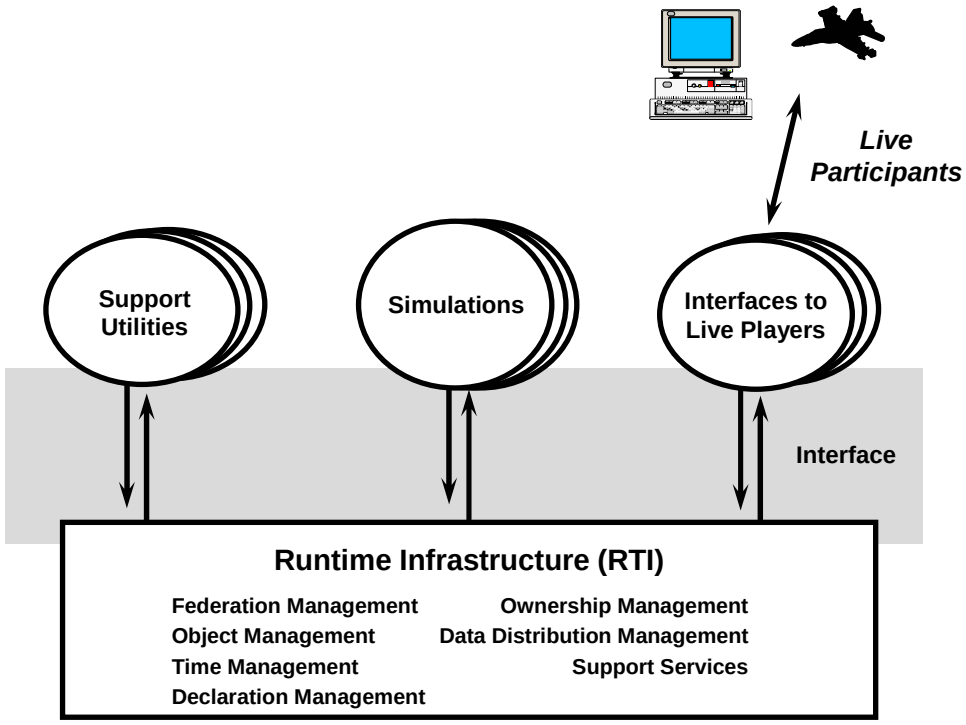
Services Used in Distributed Simulation: The High Level Architecture

- Service Oriented Architecture for exchanging data among federated applications
  - Simulations, real-world systems and/oror system emulators, support utilities…
- Calls for an RTI which brokers data exchange via 7 service families
  - Includes publication & subscription services
  - Offers simulation time clock services



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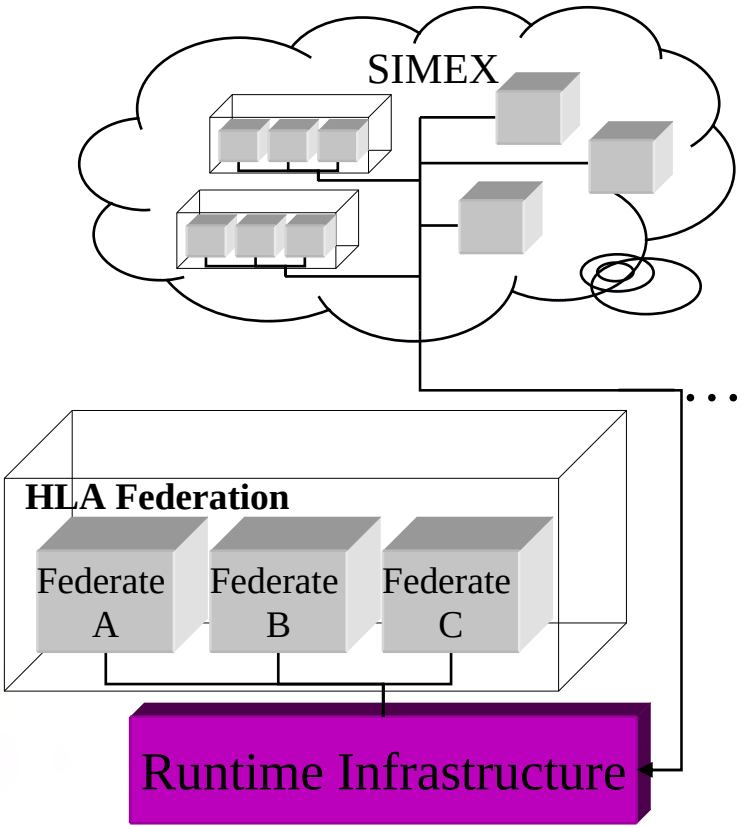
Parallels Between the Two Computing Worlds

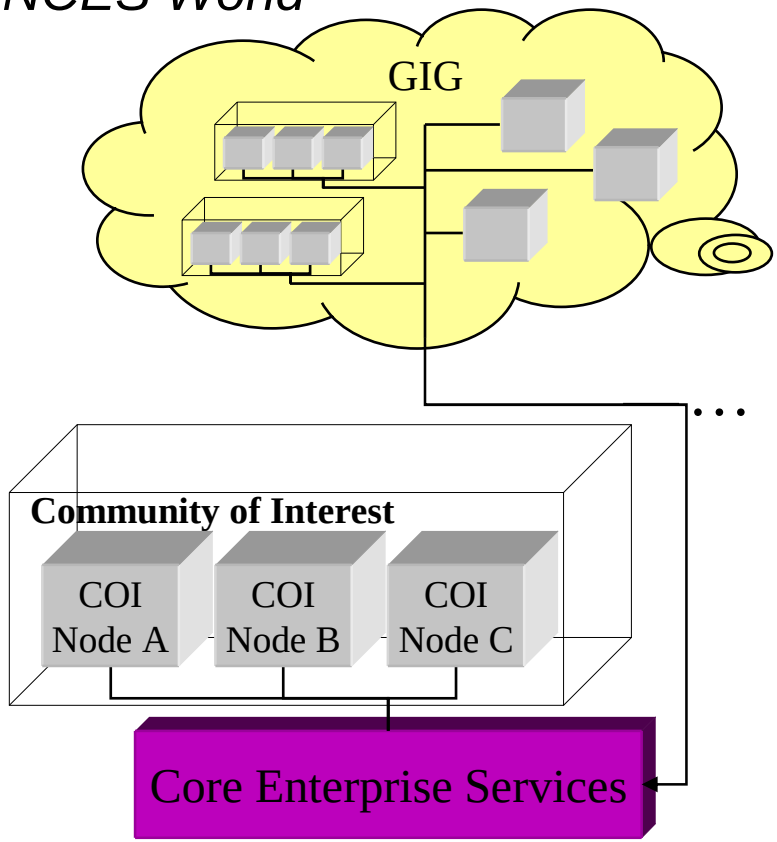
Distributed Simulation World



Test Tools:

- SITH, RTI Verifier, …

NCES World



Test Tools:

- *SOA Test™, TestMaker™*

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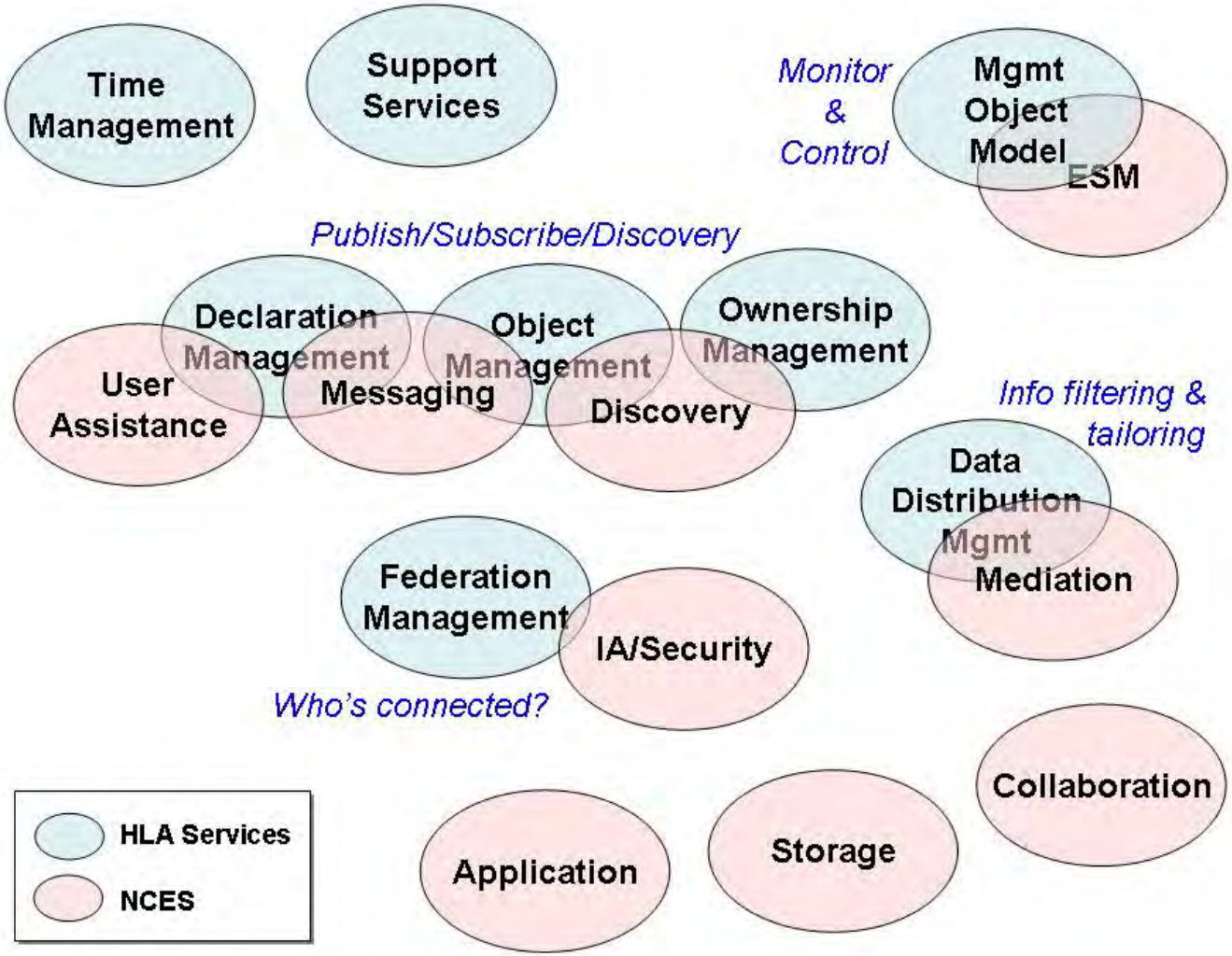
Parallels Between the Two Computing Worlds

- Lessons learned from testing distributed simulation systems, including High Level Architecture (HLA) systems, have the potential to be leveraged to test net-centric systems
  - Both HLA and NCES are based on service oriented principles that have, at their core, a set of common infrastructure services that provide the basic connection mechanisms necessary for interoperability
  - Both worlds also embrace the concept that some subsets of the systems need to be tightly coupled together because their missions are strongly related or they share certain data exchange requirements
  - Both worlds also embrace a larger enterprise view whereby multiple nodes and multiple system subsets can interoperate as needed on a loosely coupled basis.

There are striking similarities between HLA Services and Core Enterprise Services



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Operational Differences between HLA and GIG Computing

- Routing of information exchanges
  - HLA: all data must pass through middleware (runtime infrastructure)
  - GIG: data routed "directly" between services
    - Most appropriate route between any two services likely to change over time
- Persistence of participants
  - HLA: static set of federates and data exchanges
    - Addition or deletion of services during execution is not the norm
  - GIG: can be open-ended
    - Dynamic addition or deletion of services is expected during normal operations

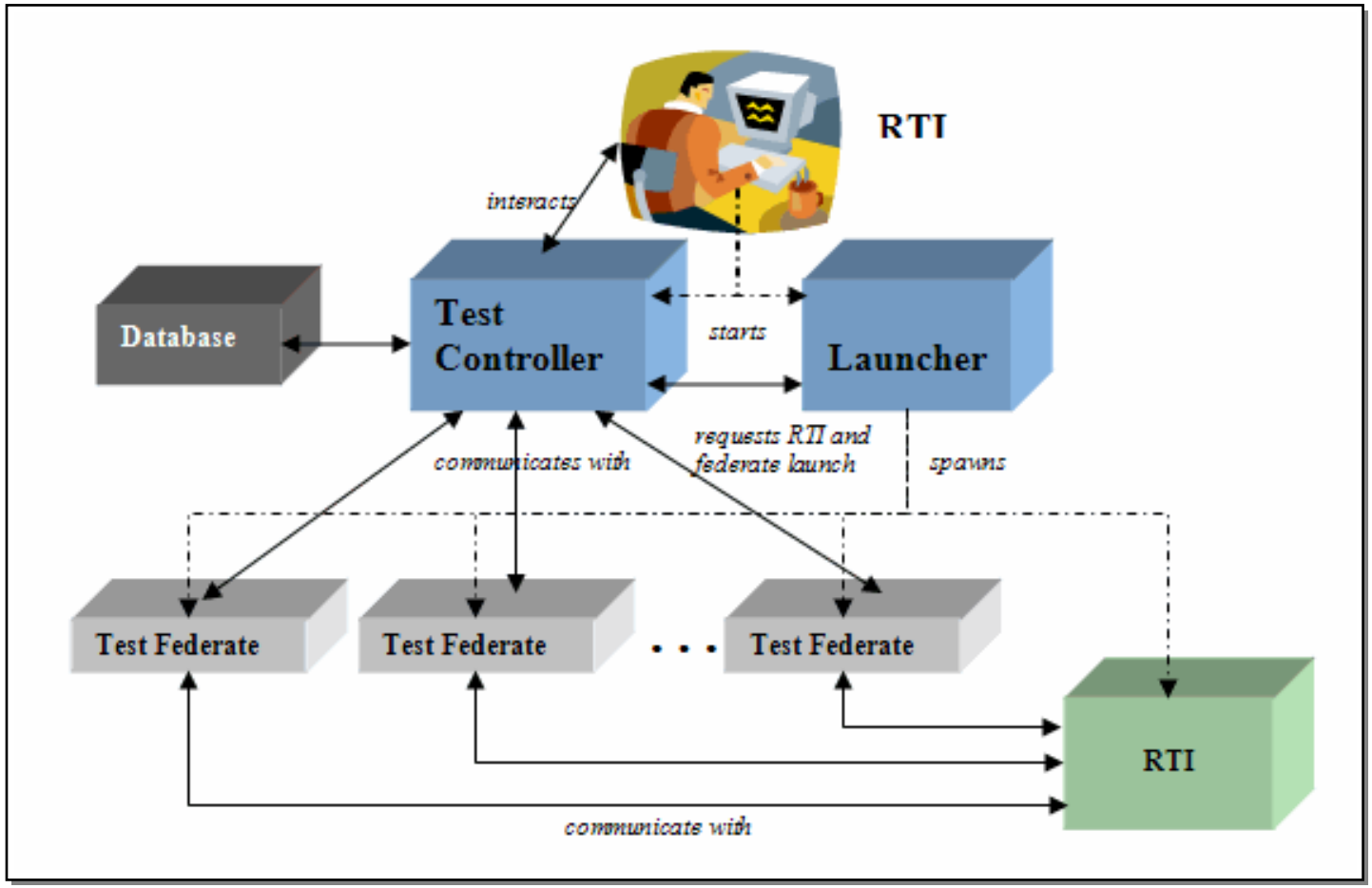
Testing Expertise in the Distributed Simulation Community

- The simulation community has years of successful experience testing complex distributed simulation systems, including High Level Architecture (HLA) systems:
  - Testing individual system functionality and performance.
  - Testing runtime infrastructure services for correct functionality and for performance.
  - Testing the simulations for their ability to use the runtime infrastructure services and to publish and subscribe to data as specified.
  - Testing subsets of the simulations working together over the RTI services.
  - Testing the end to end federation for functionality and performance.

Distributed Simulation Test Tools: RTI Verifier

- Created to certify compliance of RTIs with HLA Interface Spec
- RTI Verifier consists of:
  - Database of required tests
  - Launcher that starts federates and RTI
  - Test Controller that stimulates interplay between federates and RTI
- Key component: Script Definition Language
  - For specifying tests

Distributed Simulation Test Tools: RTI Verifier (cont'd)



RTI Verifier Architecture (Ref. *Verifier3 User's Manual*, HLA RTI Verifier Team, MITRE Corporation, February 2005.)

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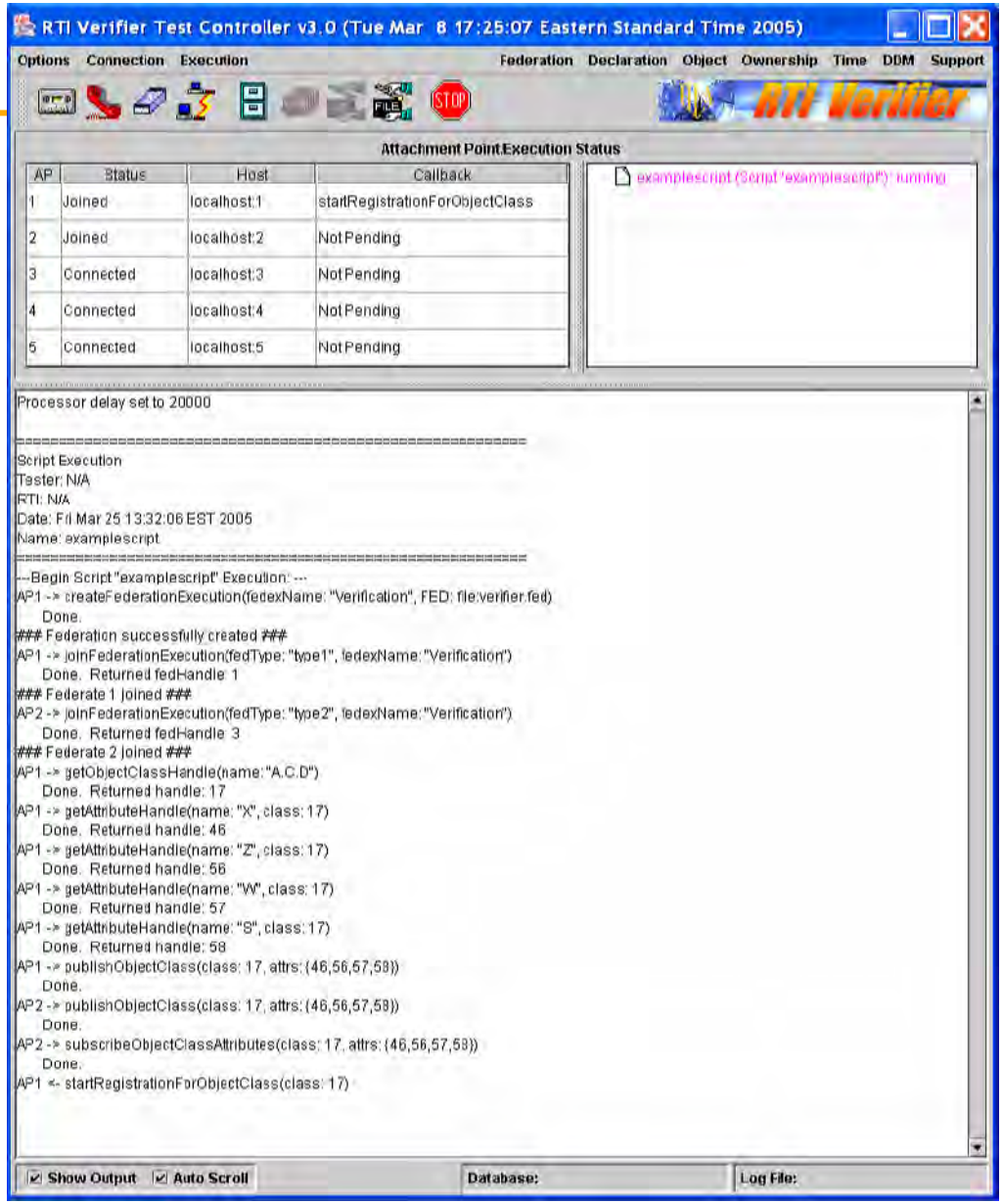
Distributed Simulation Test Tools: RTI Verifier

- **RTI Verifier Test Controller GUI**

Status of federates

Test Controller activities



Distributed Simulation Test Tools: Simulation Interoperability Test Harness (SITH)

- Supports development and integration testing of HLA federations
  - general purpose tool that allows federate emulation for runtime data validation, functional testing, and performance testing
- Built around RTI Verifier core. Key add'l features:
  - Ability to create unlimited stand-in federates
  - Object Script Creator (OSC) for graphically creating/modifying SDL test scripts
- The SITH uses a sophisticated scripting capability to produce complex data exchanges, along with a data logging capability, to run tests that lead to quick diagnosis of problems
  - The SITH has been instrumental to the successful development and testing of several HLA federations

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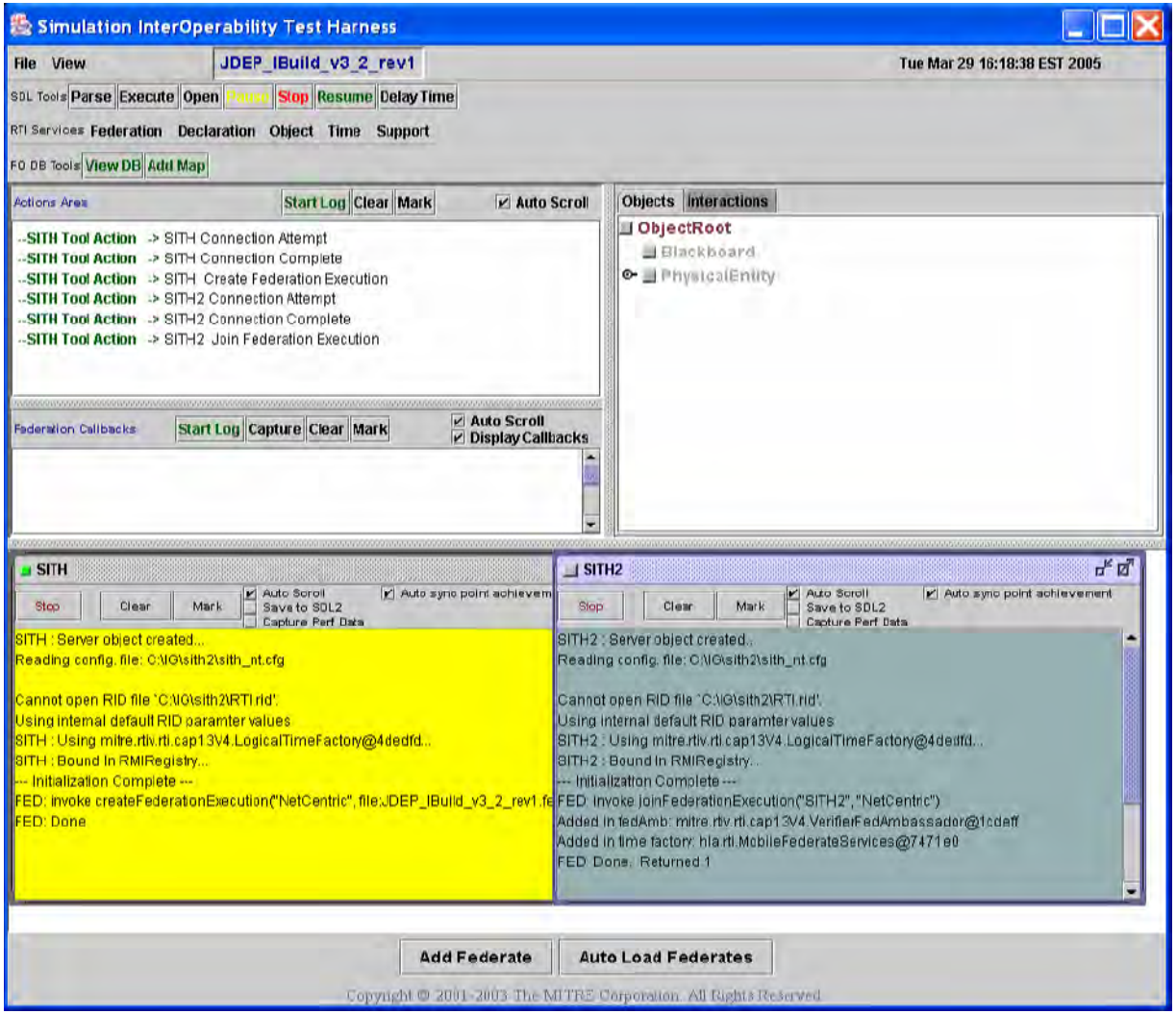
Distributed Simulation Test Tools: SITH (cont'd)

- **SITH GUI**



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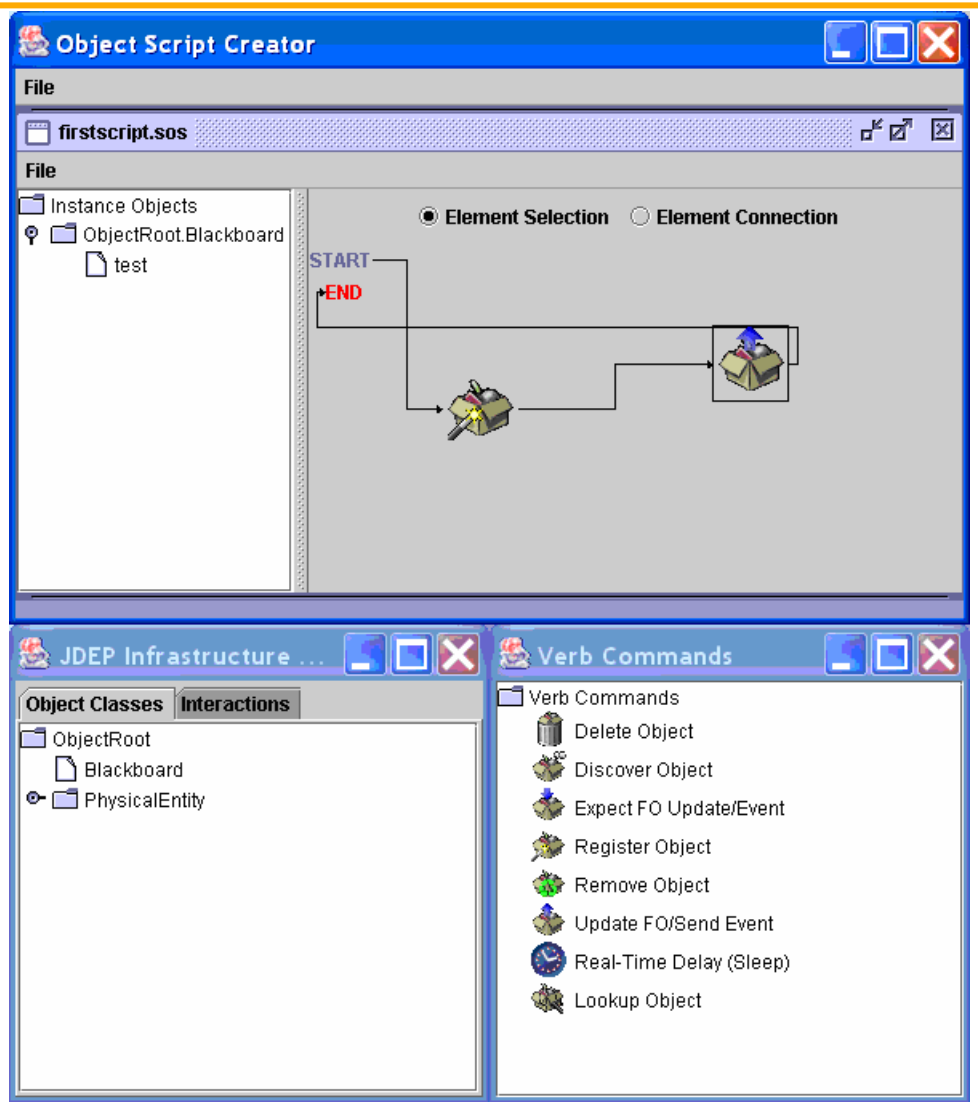
Distributed Simulation Test Tools: SITH (cont'd)

- **Object Script Creator GUI**



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Applicability of Simulation Test Tools to Net-Centric Services Testing

- The following characteristics of the SITH and Verifier can be useful applied to testing net-centric SOAs:
  - GUI- this will be necessary to control the test environment which the tool will emulate
  - Test scripting capability (SDL)- this will be useful for setting up and repeating parts of the scenario relating to the network response and service behavior
  - Ability to see the entity states in the GUI
  - Record entity state changes for analysis
  - Run-time data validation capability
  - Service or system emulation
  - Network flooding capabilities
- However, fundamental differences in underlying core services will require reworking the SDL to control net-centric services

SOA Test: An Emerging Automated Tool for Testing SOAs

- **WSDL Verification**
  - **XML Validation**
  - **Tests interoperability against WS-I Standards**
- **Unit Testing**
  - **Verifies web service responses against valid and invalid data sets**
    - **Data sets can be composed of a range of values in legacy data stores**
      - **E.g. Microsoft Excel or Database queries**
- **Functional Testing**
  - **Scenario based testing using a chain of services**
  - **XML Databank used to map the output of a given web service to the input of another**

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SOA Test: An Emerging Automated Tool for Testing SOAs

- Scripting
  - JavaScript, Jython (Java-enabled Python)
- Security
  - Message layer security
    - Username or SAML Tokens
  - Penetration testing
    - SQL Injections
      - Passing SQL Query Strings as parameters to the Web Service
    - Parameter fuzzing
      - Unbounded parameters leading to buffer overflow or explicit error messages
  - XML Encryption and Signature

SOA Test: An Emerging Automated Tool for Testing SOAs

- **Regression testing**
  - **Automated testing in continuous integration environments**
  - **Evaluate trends over time**
- **Load testing**
  - **How do multiple users affect timeliness, content**

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Challenges

- Number and volatility of associated standards
  - E.g. Web services with attachments must account for:
    - Soap with Attachments, MIME, DIME, MTOM Recommendations
- Automated failover
- Federated registries
- Evaluation of service pedigree
- Semantic interoperability

Findings and Recommendations

- Significant overlap between HLA and GIG operations warrants closer look at simulation test tools and approaches
  - Examined SITH due to documented successes and extensible software design
- Recommend an exploratory prototype that reuses much of SITH for net-centric testing purposes
  - Replace SITH SDL with a new scripting language that leverages web services standards (WSDL, BPEL4WS)
- Apply the new SITH-like application first to interoperability testing of small groups of services
  - Then expand use for performance and behavior testing of larger groups of services in more complex internet-like environments

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PROBLEM SPACE MODELING
A Dynamic Future For Requirements Analysis

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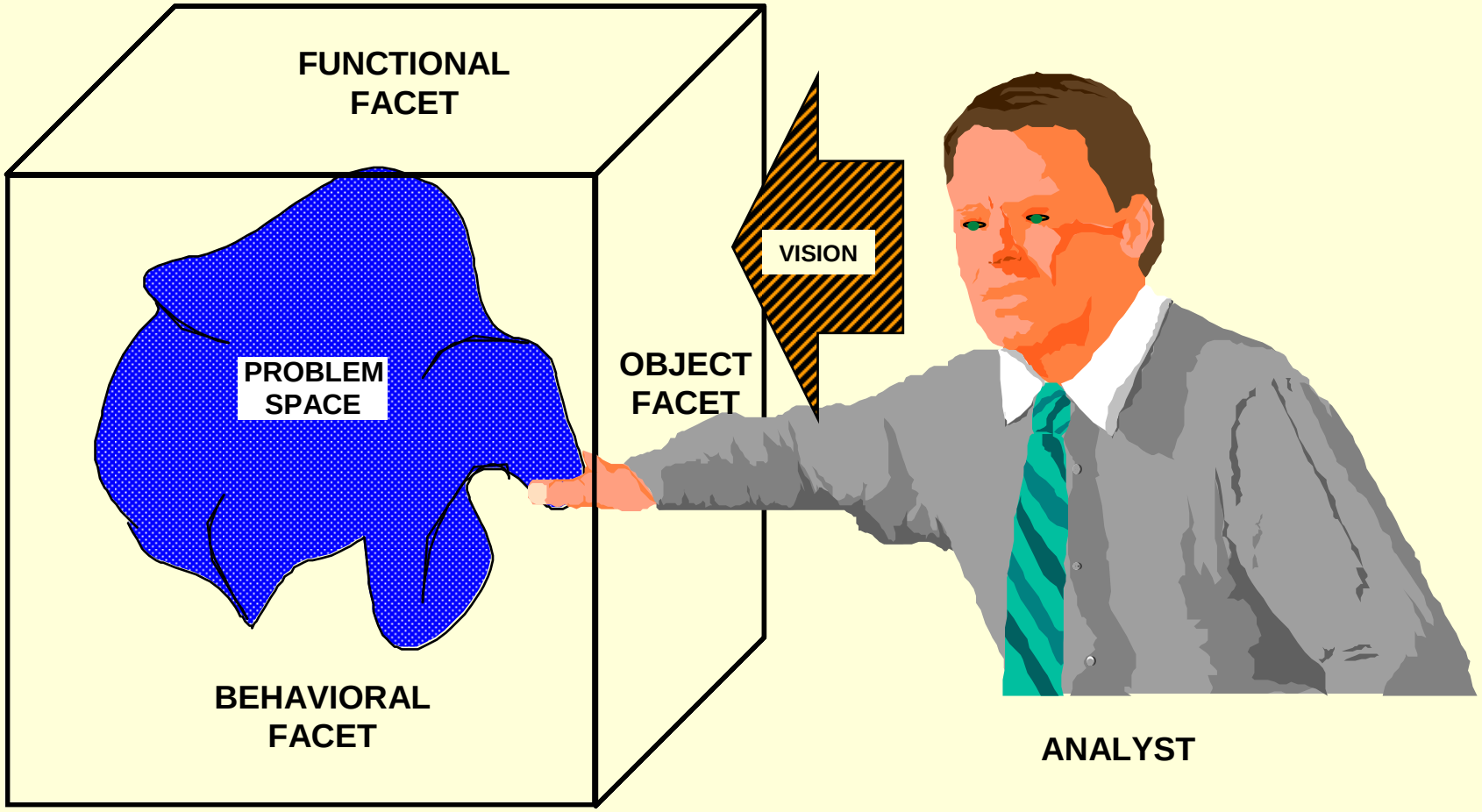
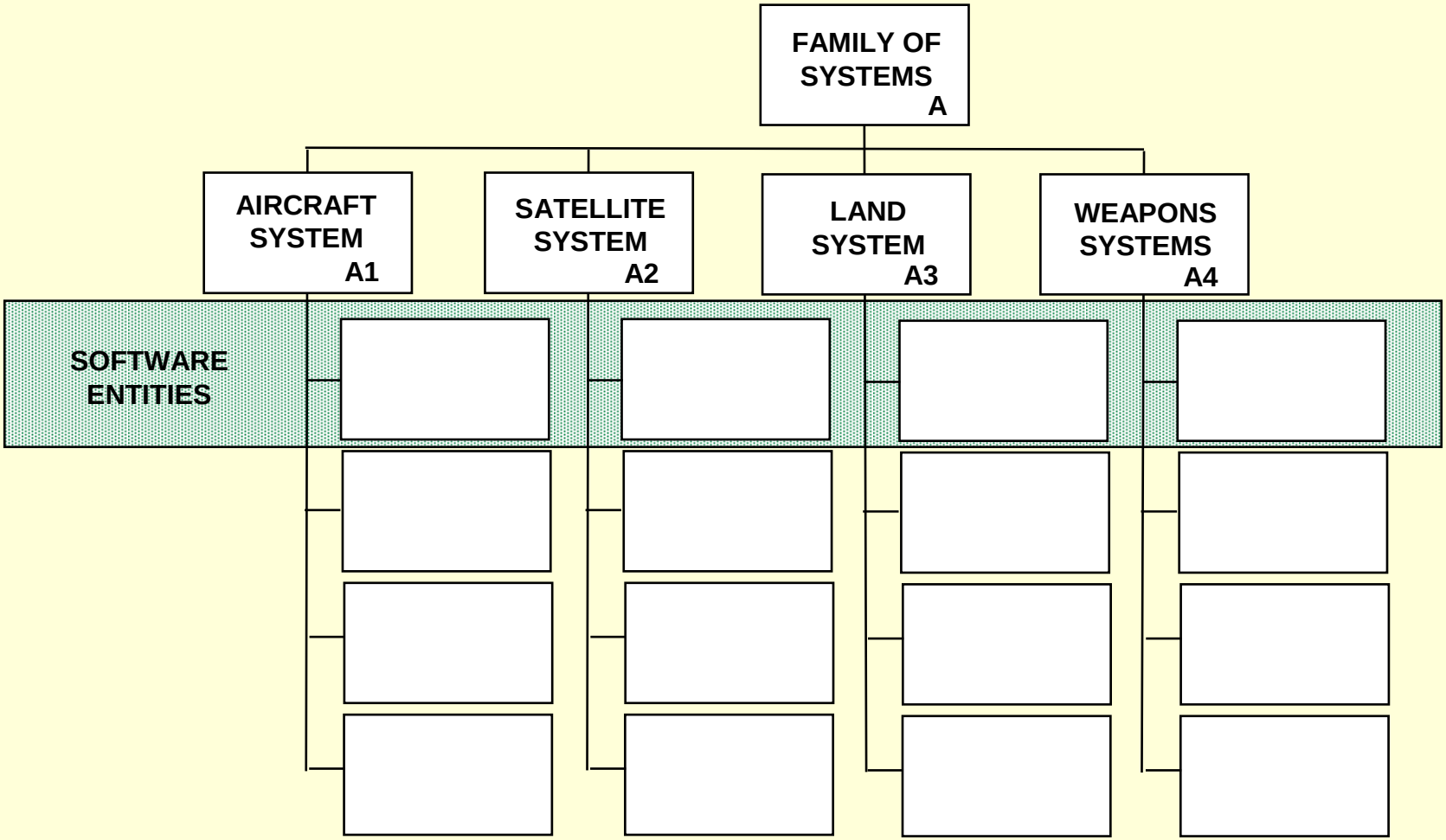
Agenda

- A current reality
- Program preparation
- Traditional structured analysis
- UML
- The future

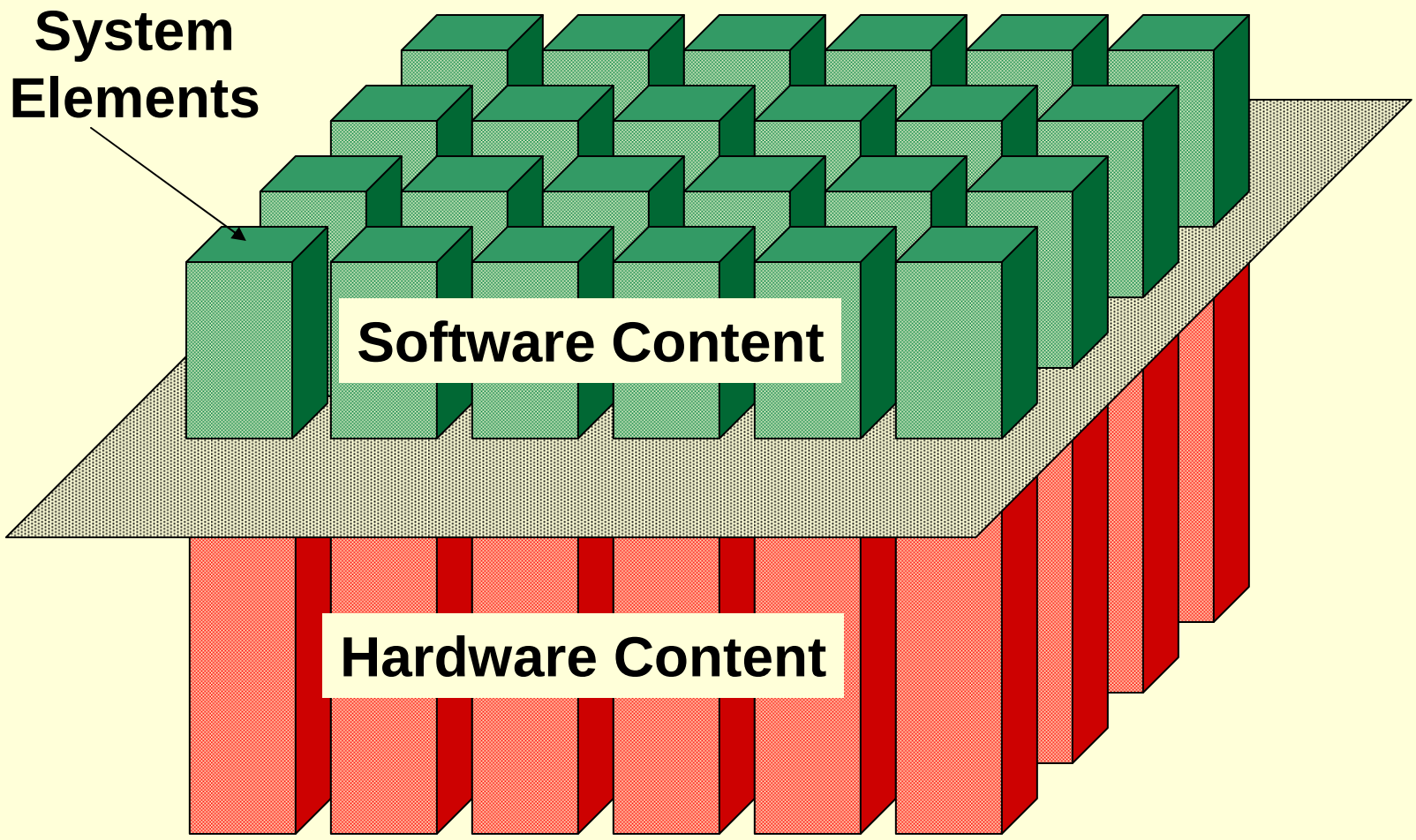
How Should the Engineer Approach Unprecedented Problem Space?



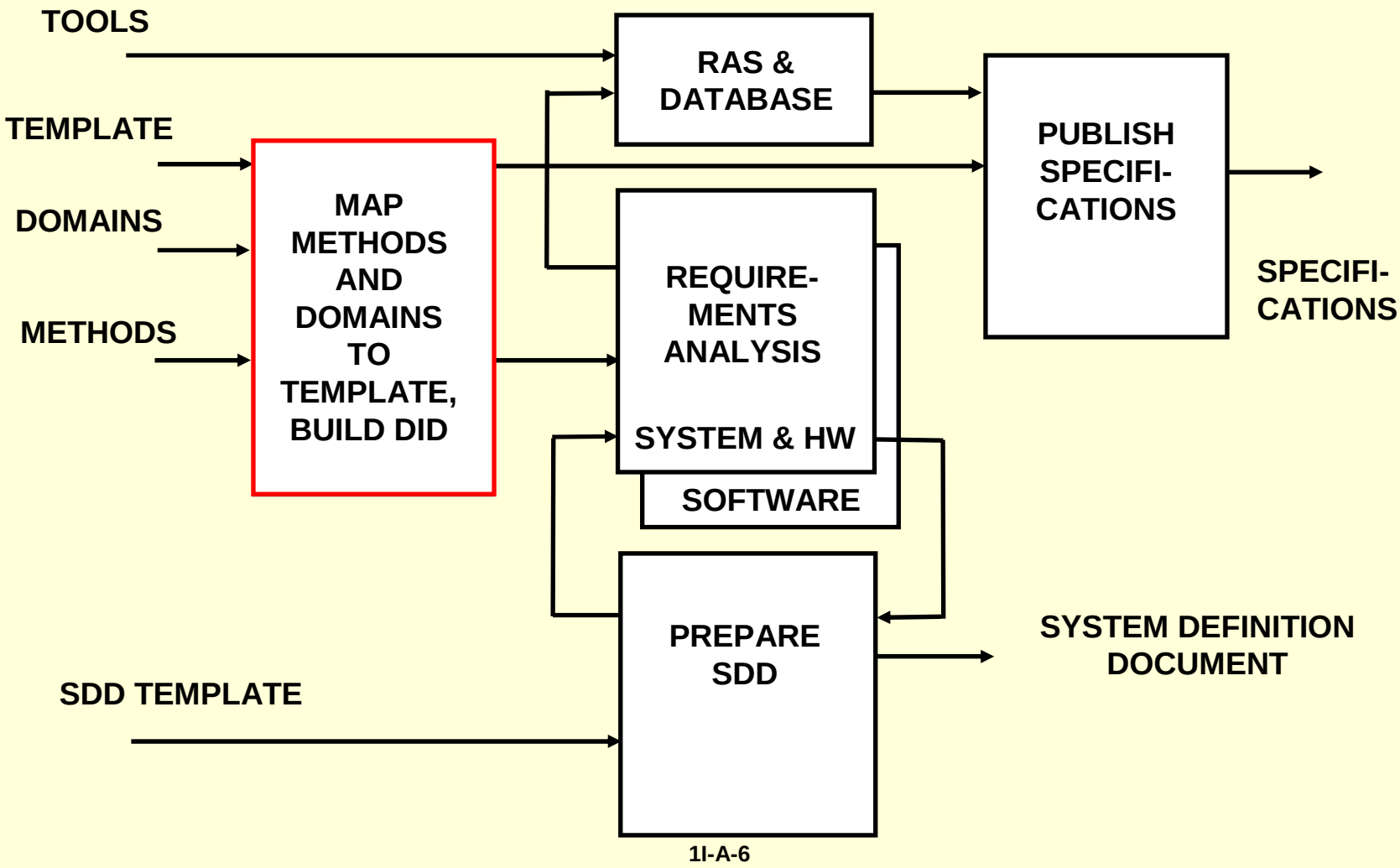
System Entities



A Single Model Will Not Work



Prepare the Enterprise



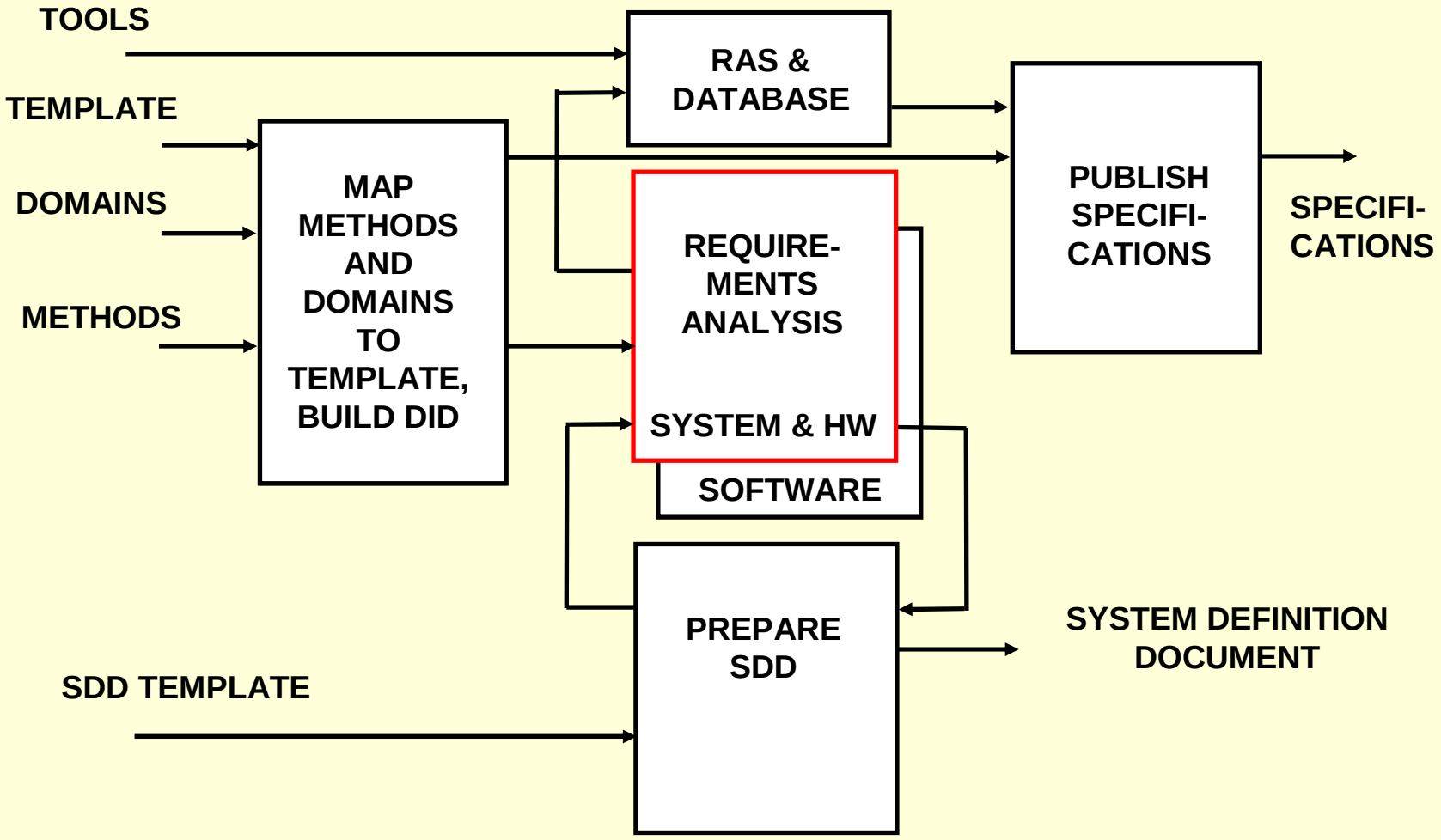
Prepare the Enterprise

- Select standards and corresponding templates
- Select preferred structured analysis models
- Tailor templates for alignment with models you choose to use to explore problem space
- Build data item description (DID) for each specification type/model application
  - System specification/TSA
  - Hardware performance specification/TSA
  - Software performance specification/UML
  - Software performance specification/DoDAF
  - Hardware ICD/TSA and software IRS/UML and DoDAF
- Map organization and models to template
- Apply SDD as a means to capture models products

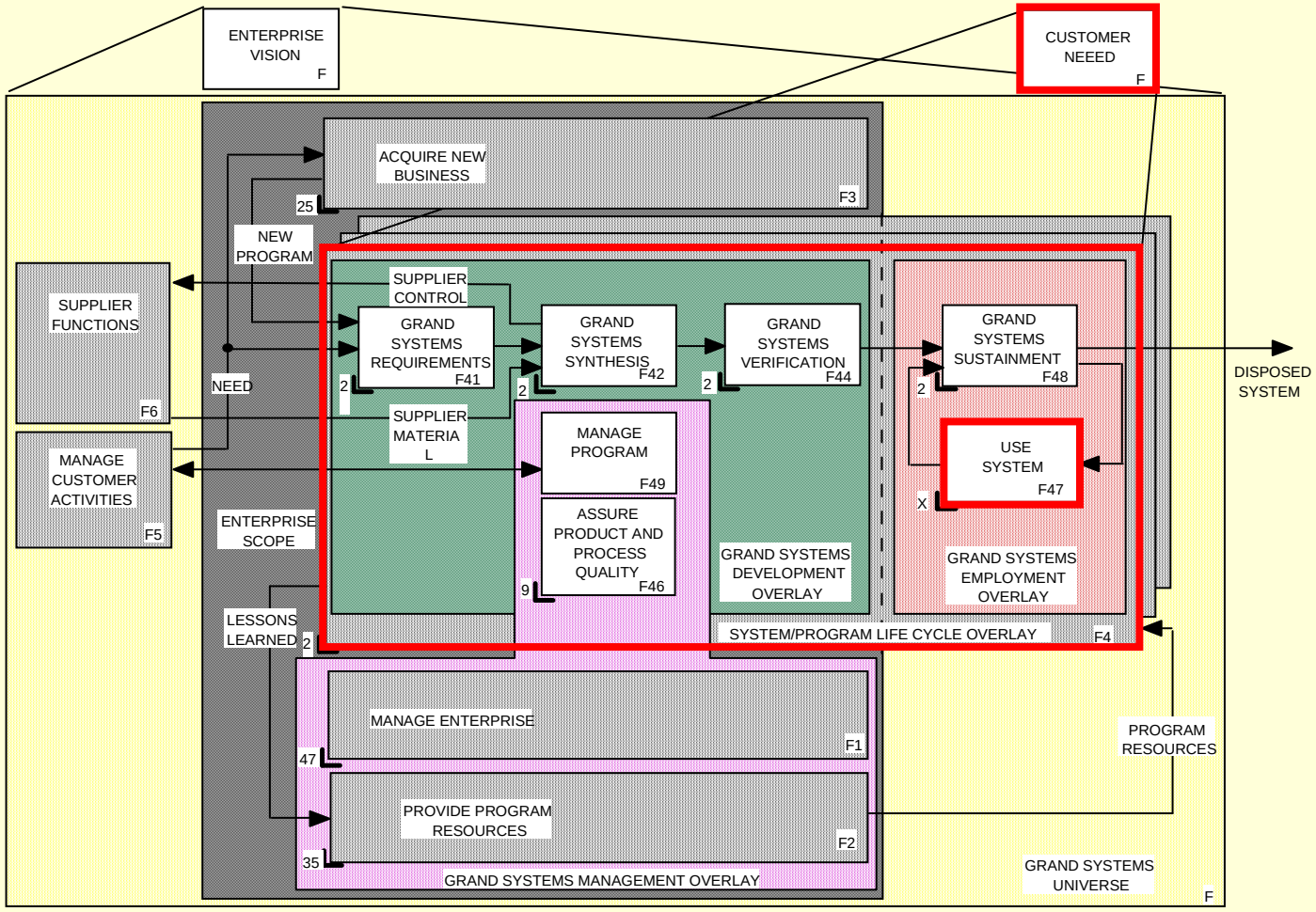
Generic Template

3.1	States and modes
3.2	Entity capabilities
3.2.m	Entity capability m
3.2.m.n	Entity capability m, requirements n
3.3	Interface requirements
3.3.1	External interfaces
3.3.1.m	External interface m
3.3.1.m.n	External interface m, requirement n
3.3.2	Internal interfaces
3.3.2.m	Internal interface m
3.3.2.m.n	Internal interface m, requirement n
3.4	Specialty engineering requirements
3.4.m	Specialty discipline m
3.4.m.n	Specialty discipline m, requirement n
3.5	Environmental requirements
3.6	Precedence and criticality considerations

Do the Analysis Work Using Preferred Models

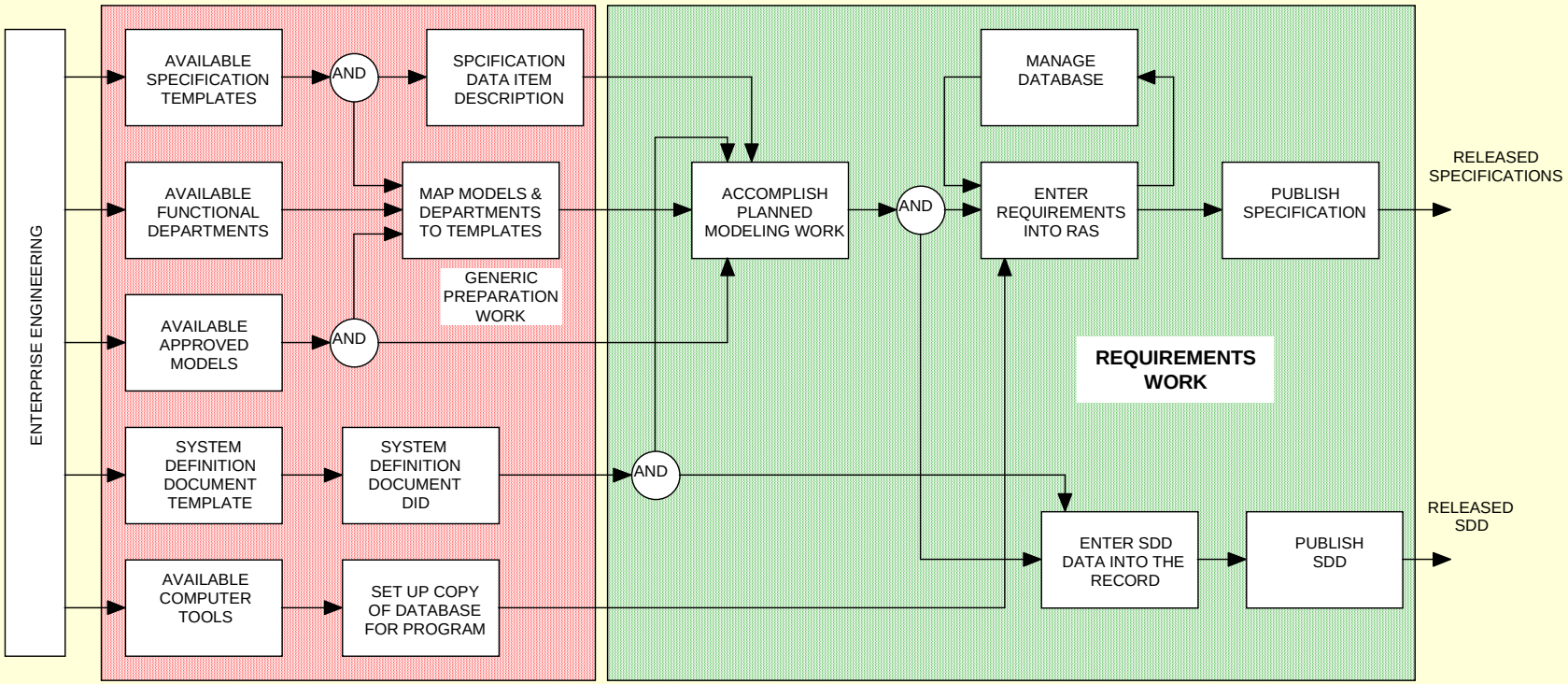


Ultimate Process Diagram

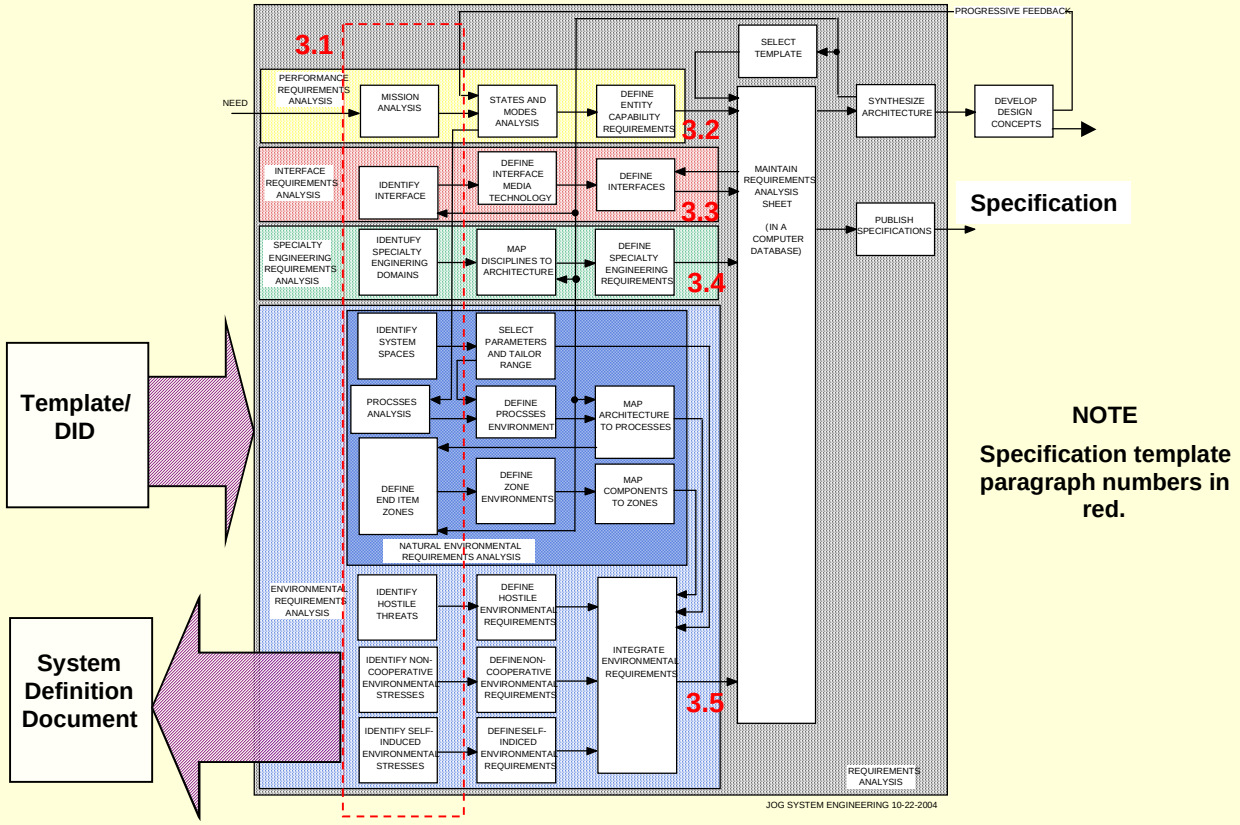


X: REFER TO PROGRAM SYSTEM DEFINITION DOCUMENT FOR EXPANSION

The Process


ENTERPRISE ENGINEERING
AVAILABLE SPECIFICATION TEMPLATES
AND
SPCIFICATION DATA ITEM DESCRIPTION
AVAILABLE FUNCTIONAL DEPARTMENTS
MAP MODELS & DEPARTMENTS TO TEMPLATES
GENERIC PREPARATION WORK
AVAILABLE APPROVED MODELS
AND
SYSTEM DEFINITION DOCUMENT TEMPLATE
SYSTEM DEFINITION DOCUMENT DID
AVAILABLE COMPUTER TOOLS
SET UP COPY OF DATABASE FOR PROGRAM
AND
MANAGE DATABASE
ACCOMPLISH PLANNED MODELING WORK
AND
ENTER REQUIREMENTS INTO RAS
PUBLISH SPECIFICATION
RELEASED SPECIFICATIONS
REQUIREMENTS WORK
ENTER SDD DATA INTO THE RECORD
PUBLISH SDD
RELEASED SDD

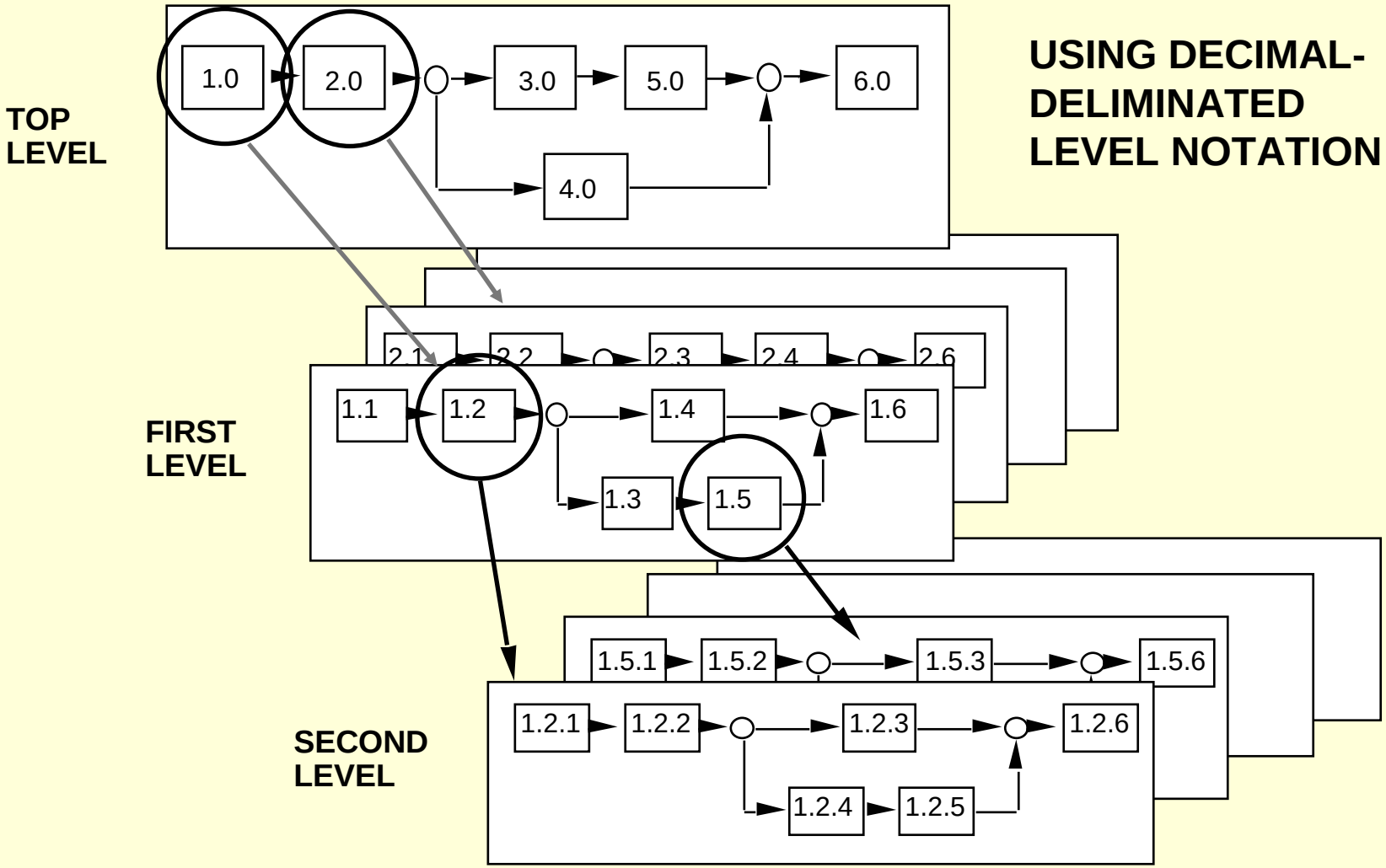
Traditional Structured Analysis



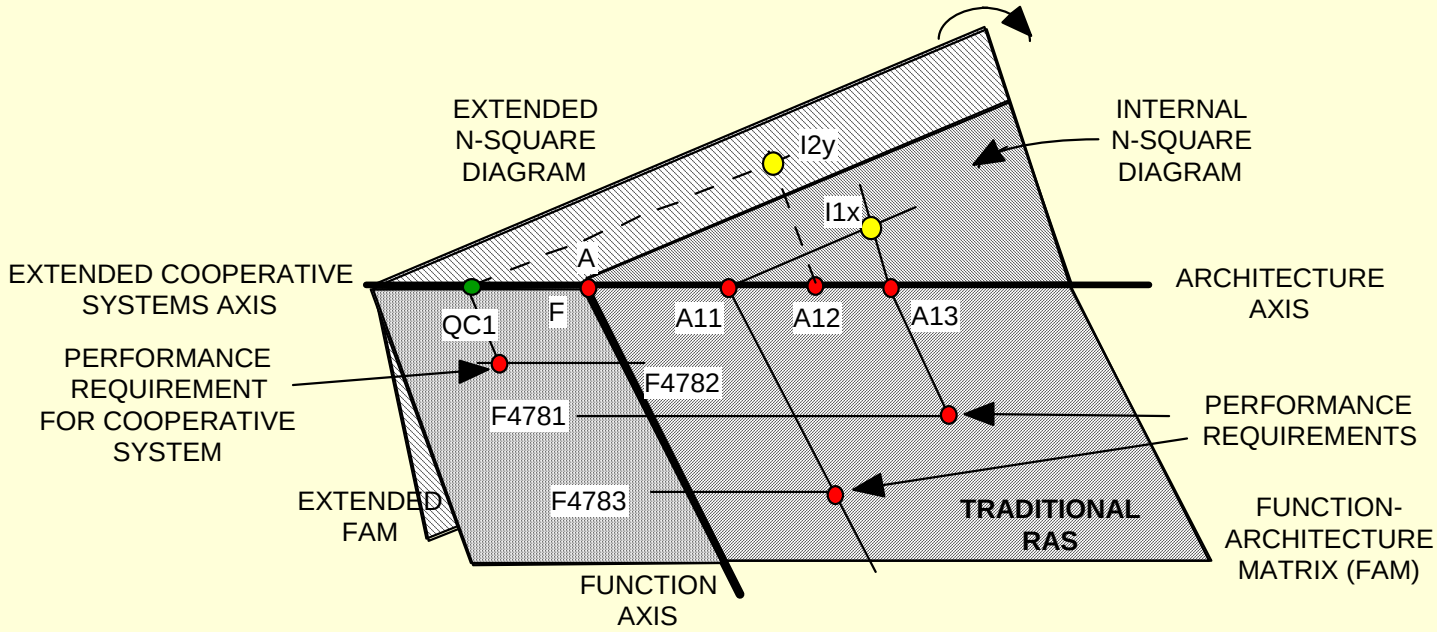
NOTE

Specification template paragraph numbers in red.

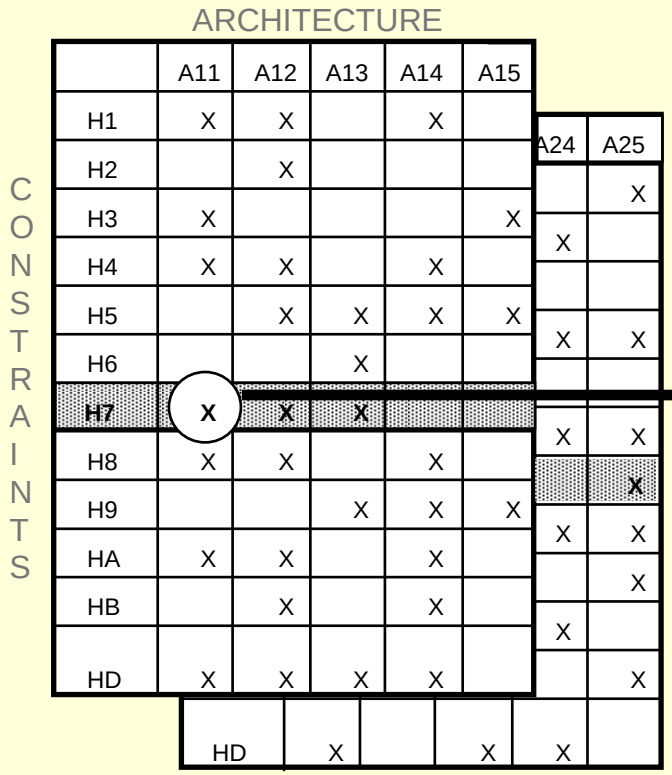
Functional Decomposition



Integrated RAS and N-Square Diagram For Internal and External Interface



Identification of Specialty Engineering Constraints



ARCHITECTURE-SPECIALTY ENGINEERING MATRIX
(DESIGN CONSTRAINTS SCOPING MATRIX)

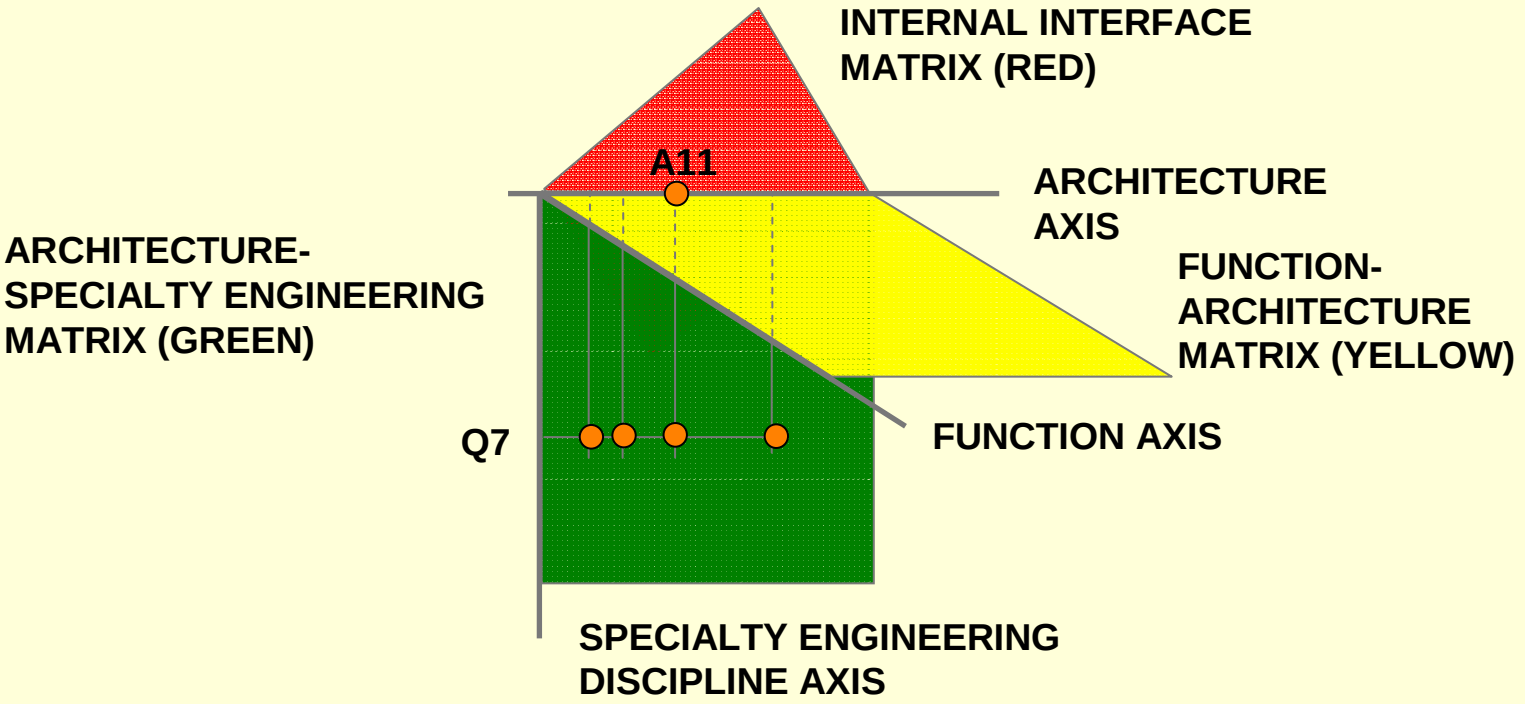
SDD APPENDIX E

CONSTRAINT	ARCH
H7	A11
H7	A12
H7	A13
H7	A25

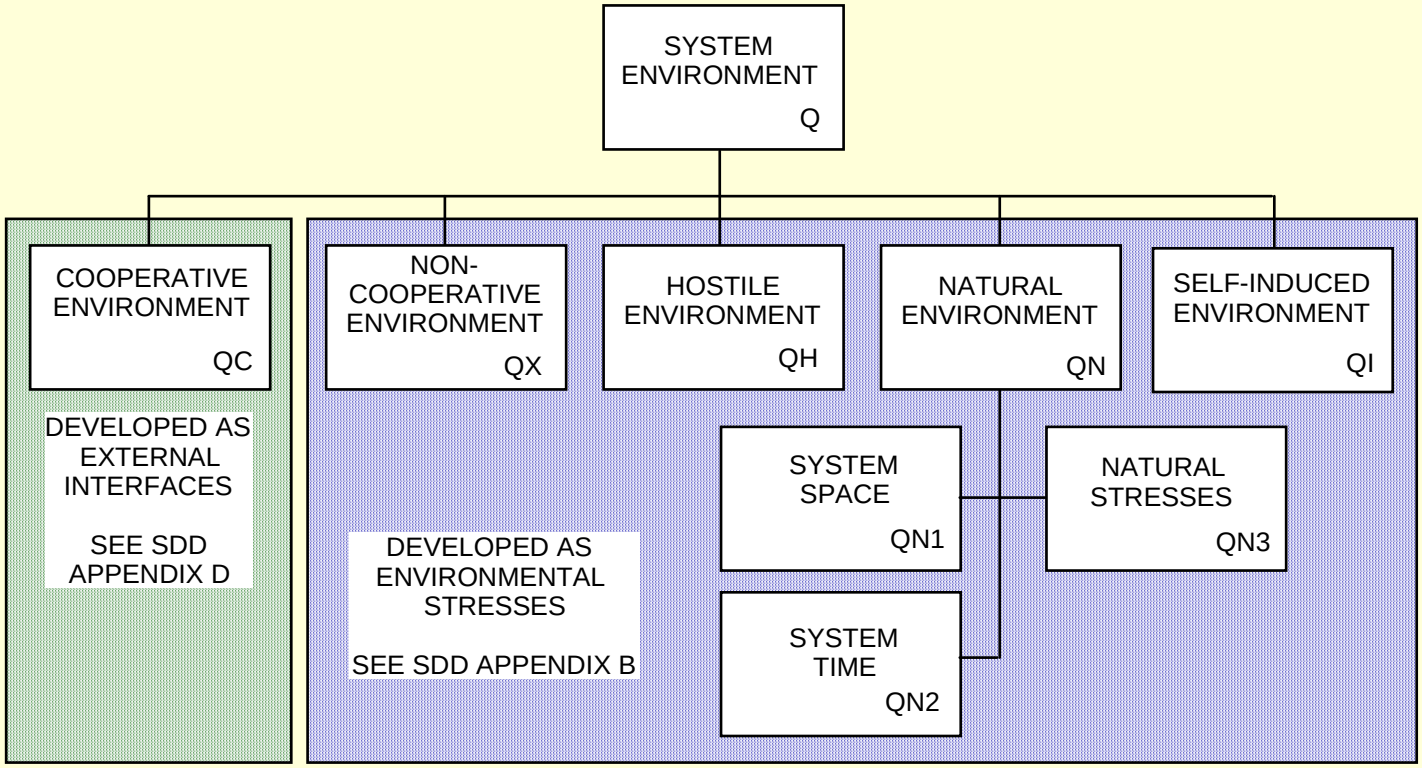
SPECIALTY ENGINEERING REQUIREMENTS FLOW INTO THE INDICATED SPECIFICATIONS THROUGH THE RAS

Specialty Engineering Allocation

Specialty Discipline Q7 Allocated to Architecture A11



Four System Environmental Classes



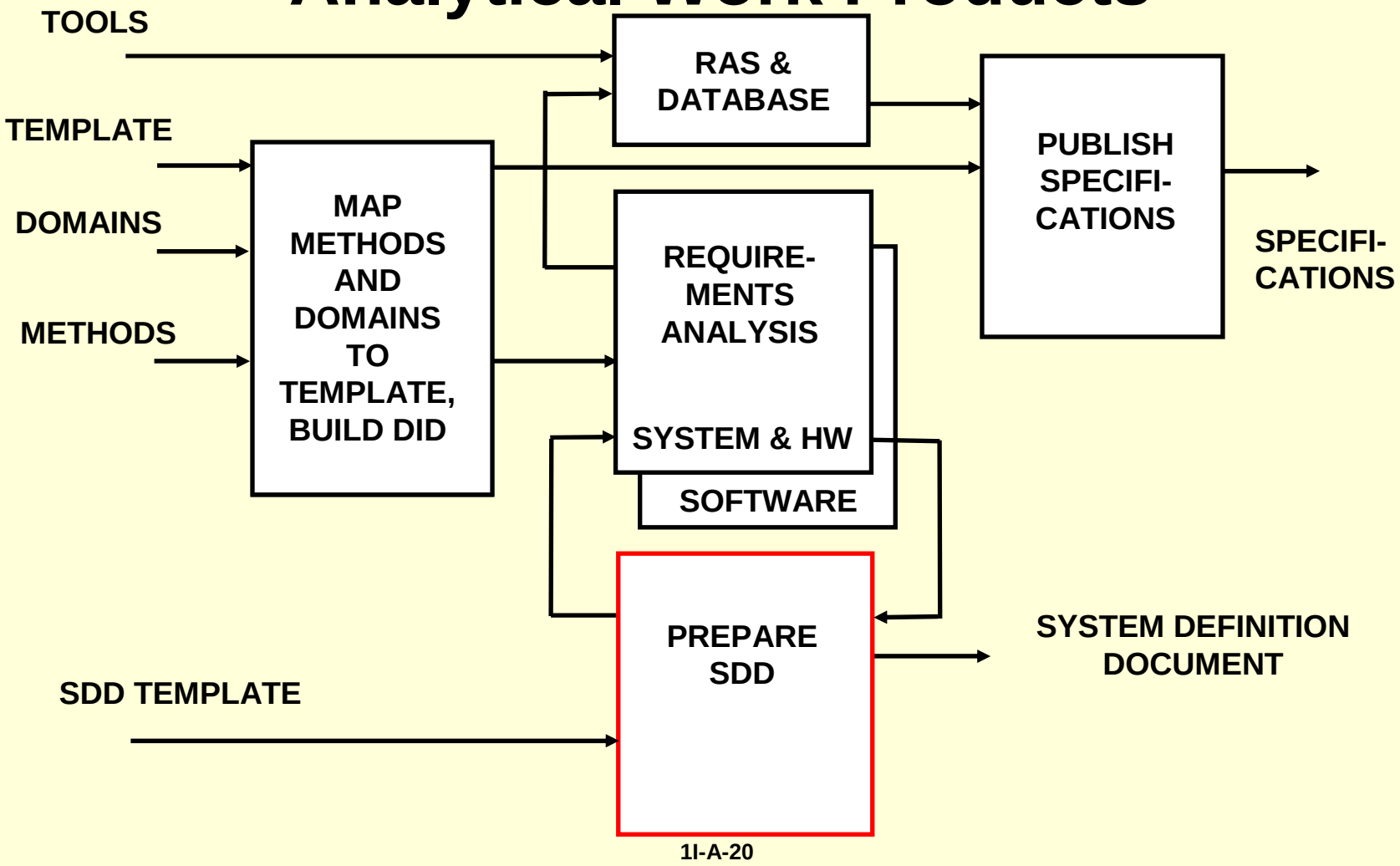
Three Environmental Requirements Layers

- System
  - Identify spaces within which the system will have to function
  - Select standards covering those spaces
  - For each standard, select parameters that apply
  - Tailor the range of selected parameters
- End item
  - Build three dimensional model of end items, physical processes, and process environments
  - Extract item environments
- Component
  - Zone end item into spaces of common environmental characteristics
  - Map components to zones
  - Components inherit zone environmental requirements

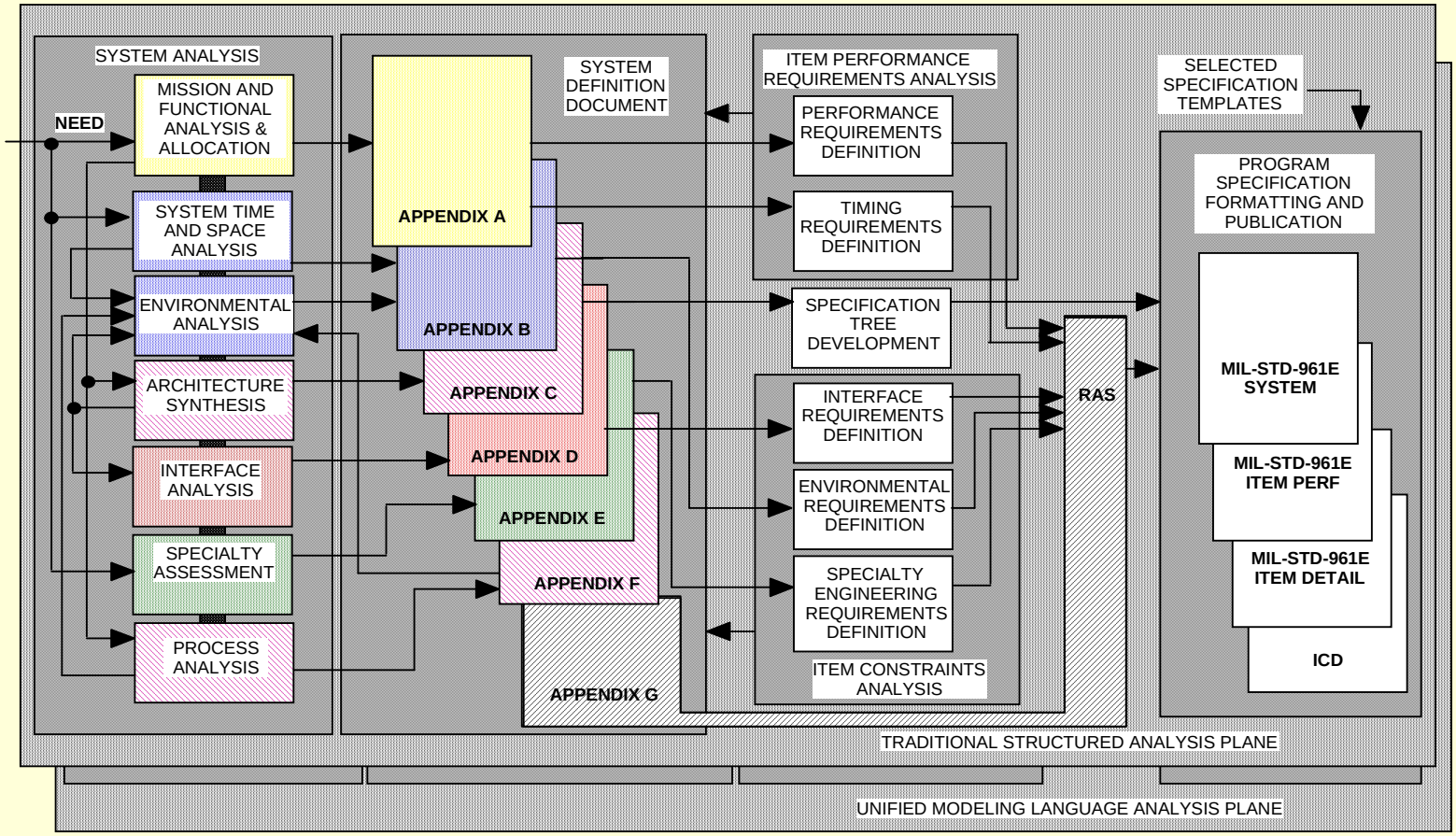
RAS-Complete In Table Form

MODEL ENTITY		REQUIREMENT ENTITY		PRODUCT ENTITY		DOCUMENT ENTITY	
MID	MODEL ENTITY NAME	RID	REQUIREMENT	PID	ITEM NAME	PARA	TITLE
F47	Use System			A	Product System		
F471	Deployment Ship Operations			A	Product System		
F4711	Store Array Operationally	XR67	Storage Volume < 10 ISO Vans	A1	Sensor Subsystem		
H	Specialty Engineering Disciplines			A	Product System		
H11	Reliability	EW34	Failure Rate < 10 x 10-6	A1	Sensor Subsystem	3.1.5	Reliability
H11	Reliability	RG31	Failure Rate < 3 x 10-6	A11	Cable	3.1.5	Reliability
H11	Reliability	FYH4	Failure Rate < 5 x 10-6	A12	Sensor Element	3.1.5	Reliability
H11	Reliability	G8R4	Failure Rate < 2 x 10-6	A13	Pressure Vessel	3.1.5	Reliability
H12	Maintainability	6GHU	Mean Time to Repair < 0.2 Hours	A1	Sensor Subsystem	3.1.6	Maintainability
H12	Maintainability	U9R4	Mean Time to Repair < 0.4 Hours	A11	Cable	3.1.6	Maintainability
H12	Maintainability	J897	Mean Time to Repair < 0.2 Hours	A12	Sensor Element	3.1.6	Maintainability
H12	Maintainability	9D7H	Mean Time to Repair < 0.1 Hours	A13	Pressure Vessel	3.1.6	Maintainability
I	System Interface			A	Product System		
I1	Internal Interface			A	Product System		
I11	Sensor Subsystem Innerface			A1			
I181	Aggregate Signal Feed Source Impedance	E37H	Aggregate Signal Feed Source Impedance= 52 ohms $\pm$ 2 ohms	A1	Sensor Subsystem		
I181	Aggregate Signal Feed Load Impedance	E37I	Aggregate Signal Feed Load Impedance= 52 ohms $\pm$ 2 ohms	A4	Analysis and Reporting Subsystem		
I2	System External Interface			A	Product System		
Q	System Environment			A	Product System		
QH	Hostile Environment			A	Product System		
QI	Self-Induced Environmental Stresses			A	Product System		
QN	Natural Environment			A	Product System		
QN1	Temperature	6D74	-40 degrees F< Temperature < +140 degrees F	A	Product System		
QX	Non-Cooperative Environmental Stresses			A	Product System		

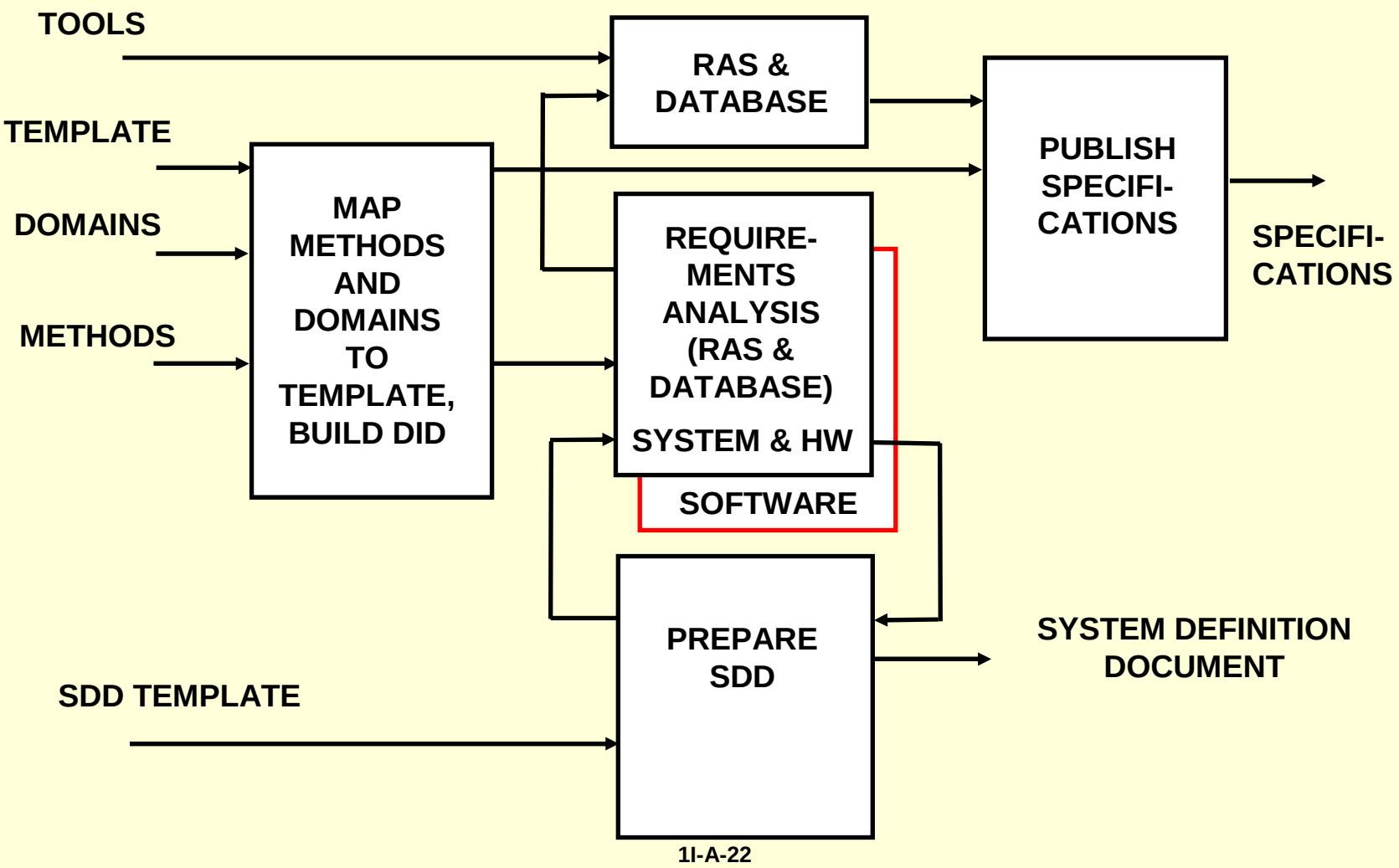
Prepare the SDD Capturing the Analytical Work Products



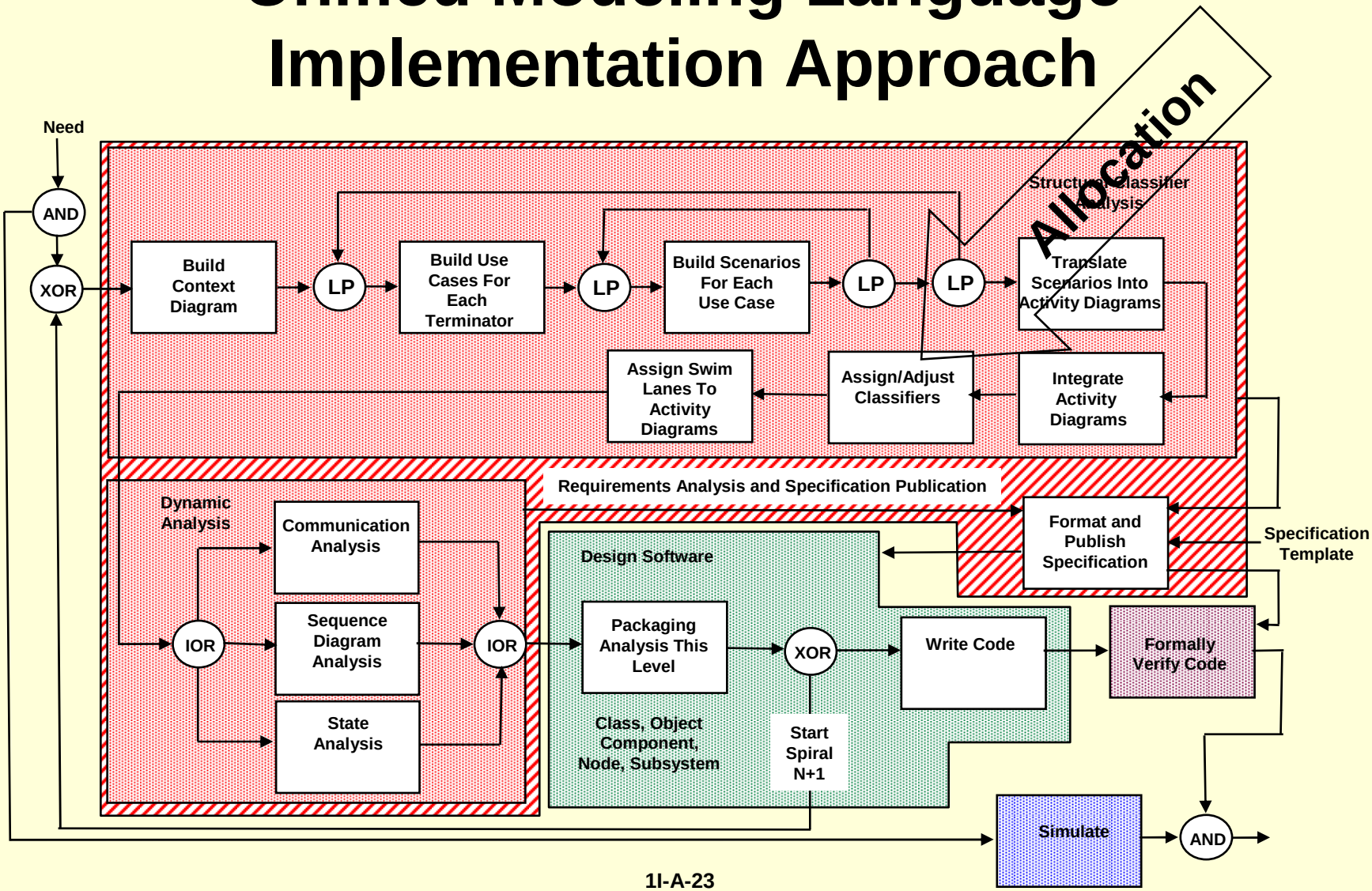
Structured Analysis Work Product Capture and Configuration Management



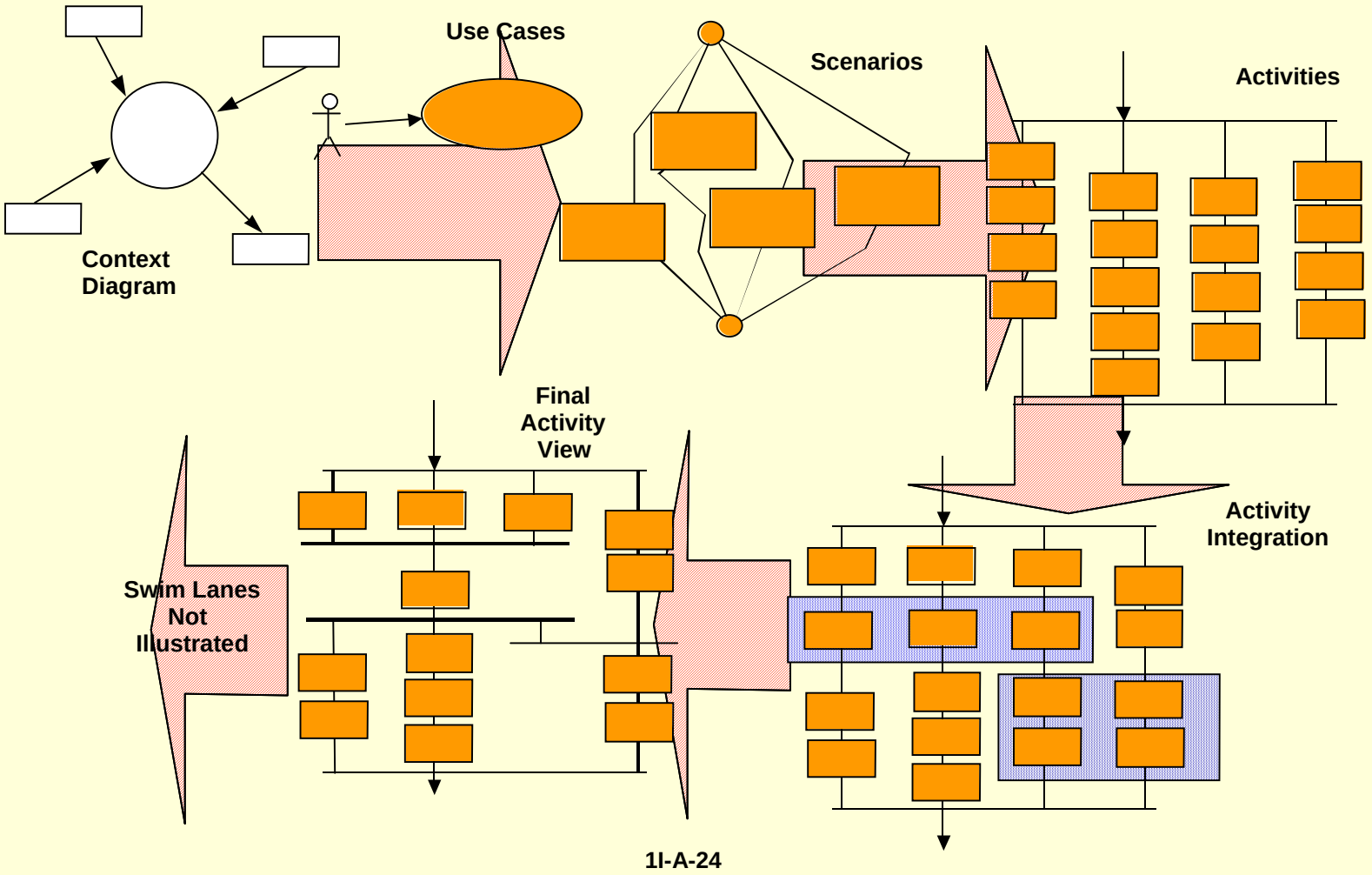
Accomplish the SW Analysis



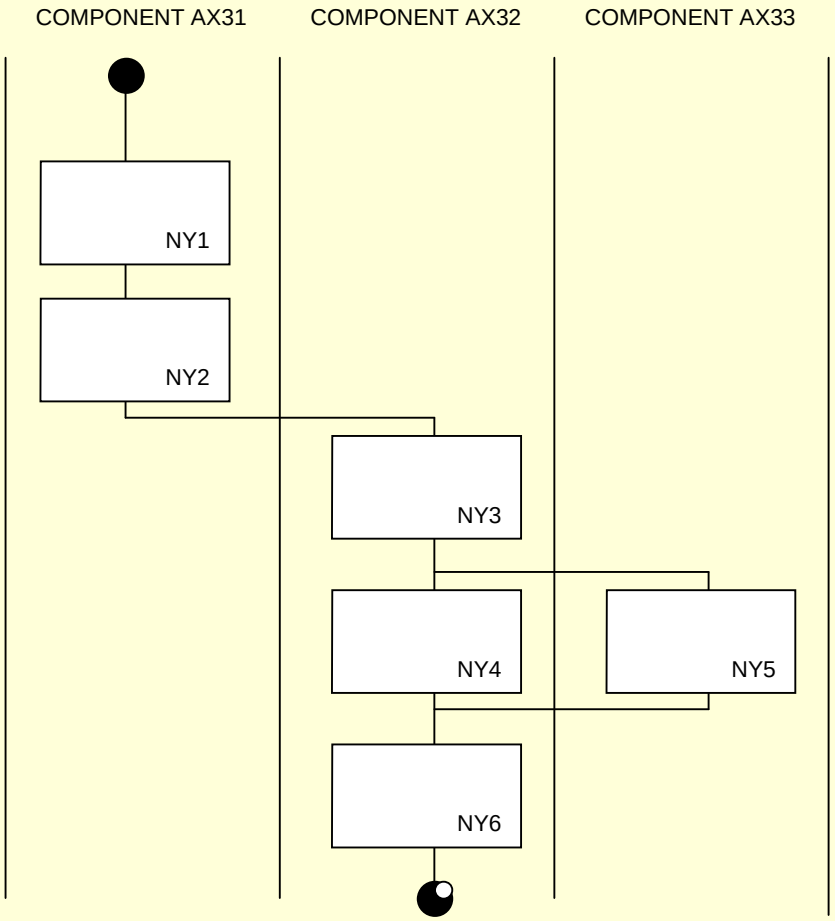
Unified Modeling Language Implementation Approach



Structural Classifier Analysis

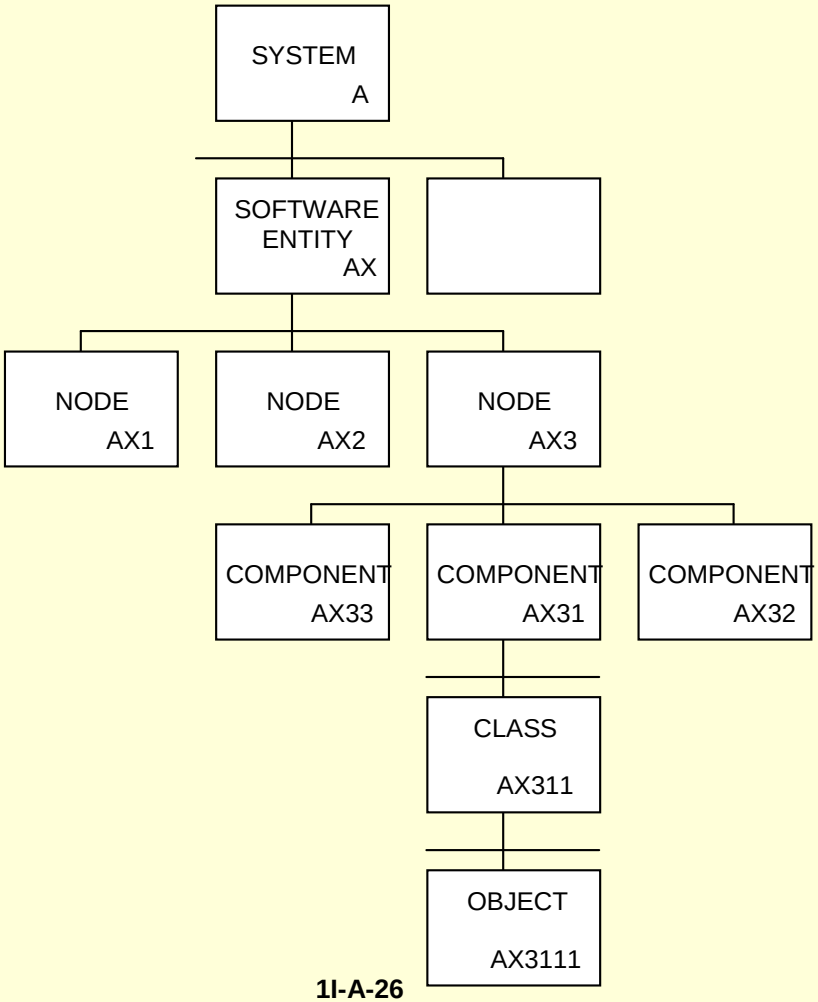


Swim Lanes for Allocation

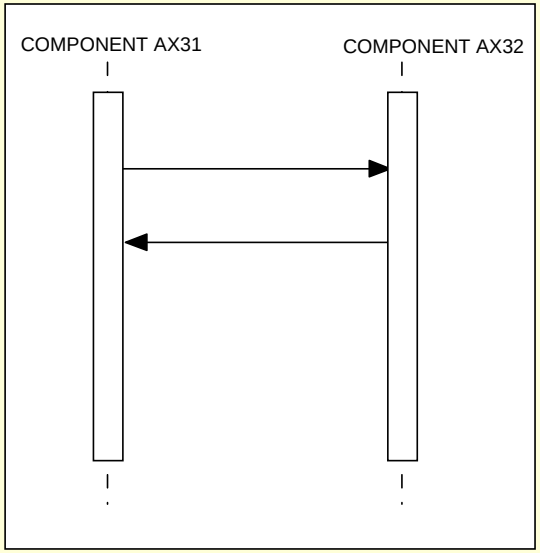


ACTIVITY DIAGRAM FOR NODE AX3

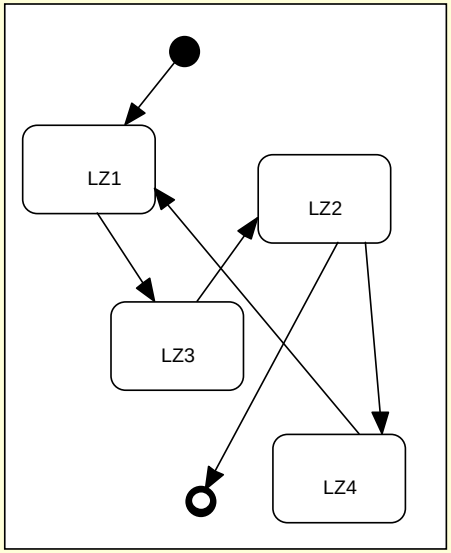
Progressive Identification of Product Entities



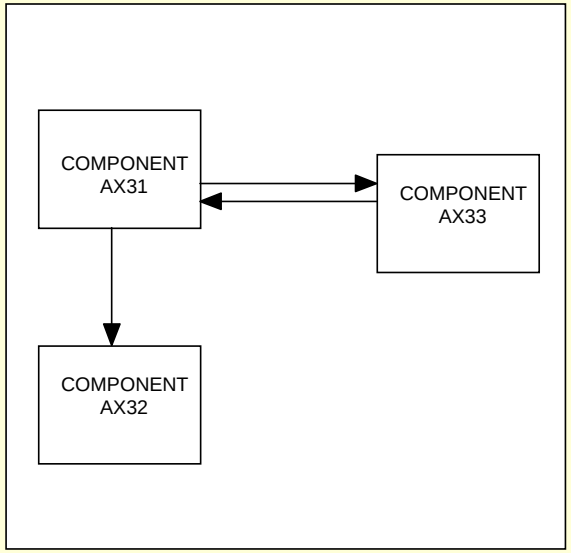
Dynamic Diagrams to Explore Product Entity Capabilities



Sequence Diagram



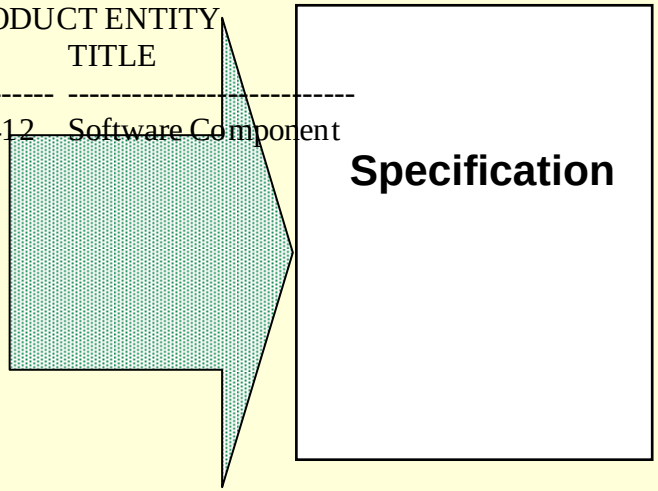
State Diagram



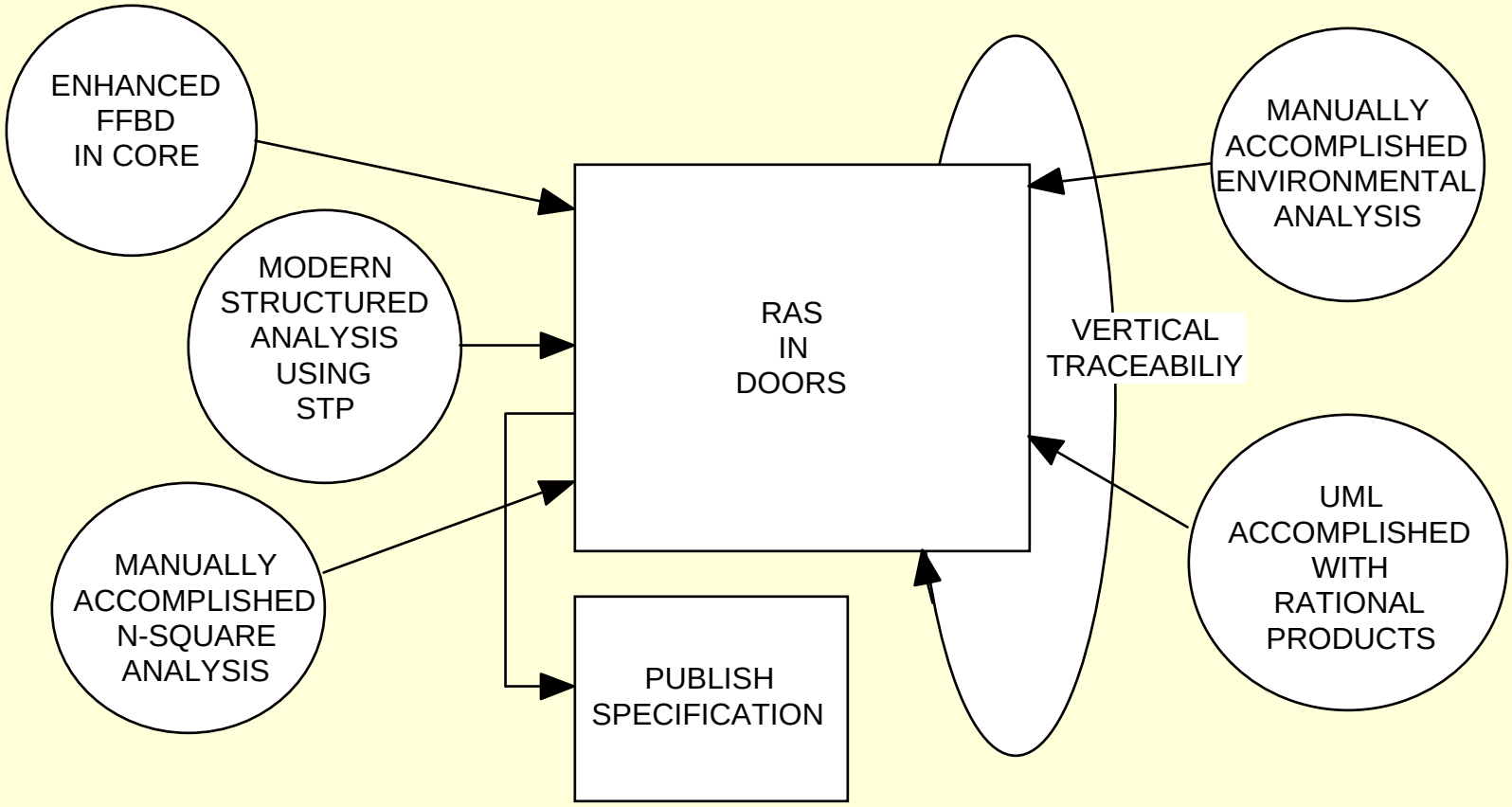
Communication Diagram

The Entity Capabilities Flow Into the Specification Through the RAS

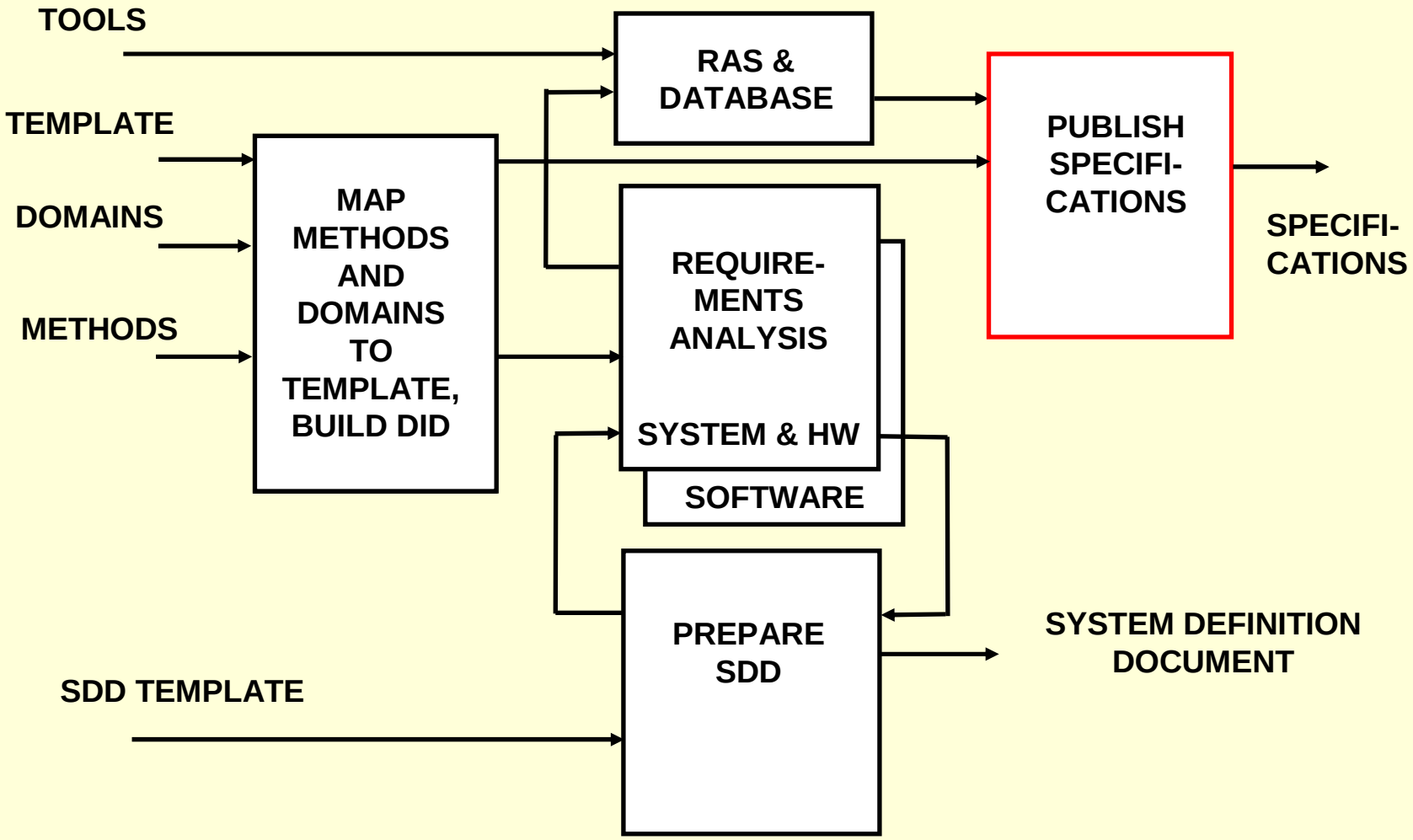
MODELING ENTITY		REQUIREMENT ENTITY		PRODUCT ENTITY	
MID	TITLE	RID	TITLE	PID	TITLE
U452	Use Case	D4XT		A5412	Software Component
BU7Y	Activity Diagram				
L456	State Diagram				
R4367	Sequence Diagram				
C5RT	Communication Diag.				
O44324	Object/Class Diagram				
C4432	Component Diagram				
Z443	Deployment Diagram				



A Particular Implementation Today

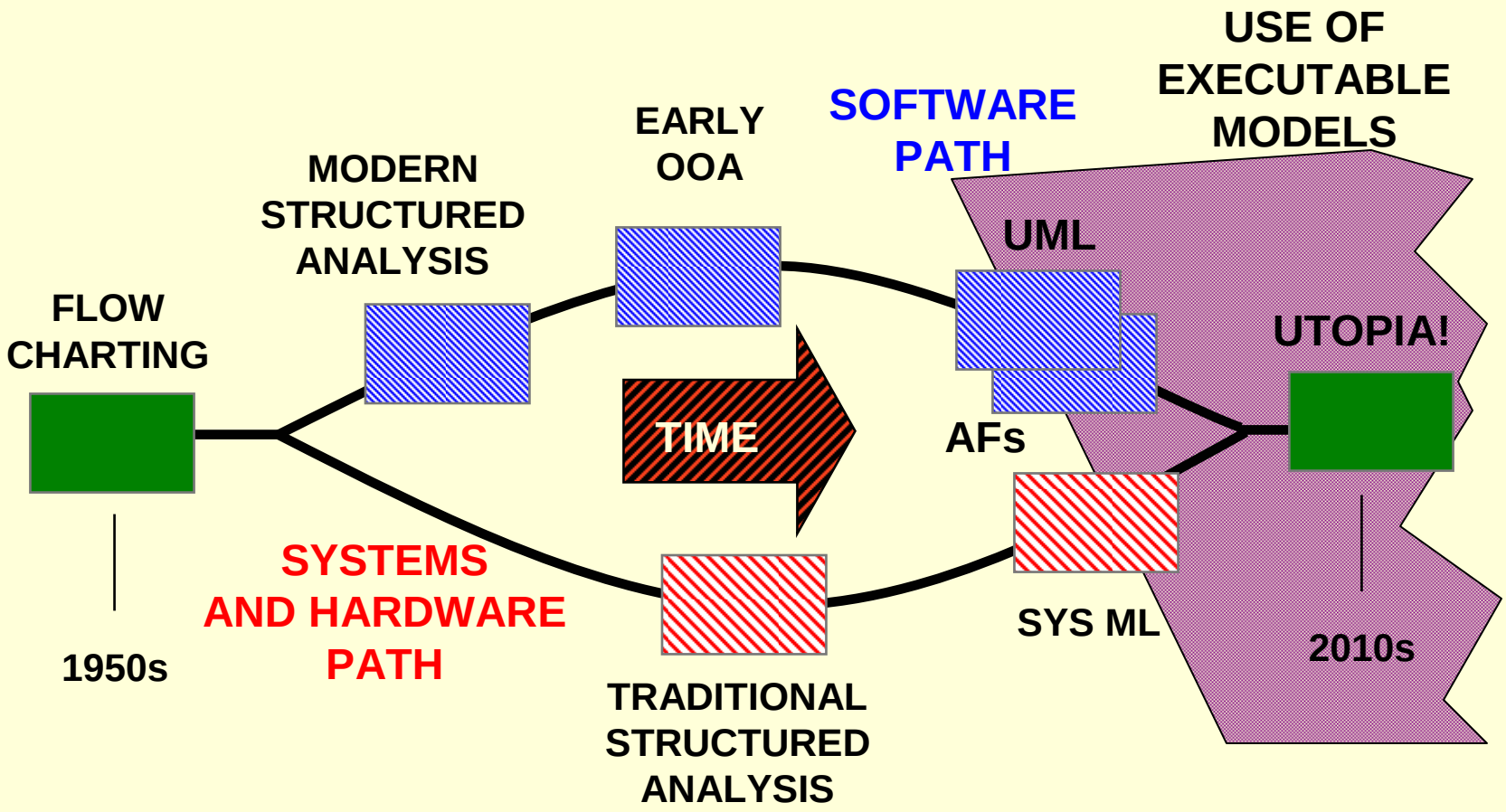


Publish the Results



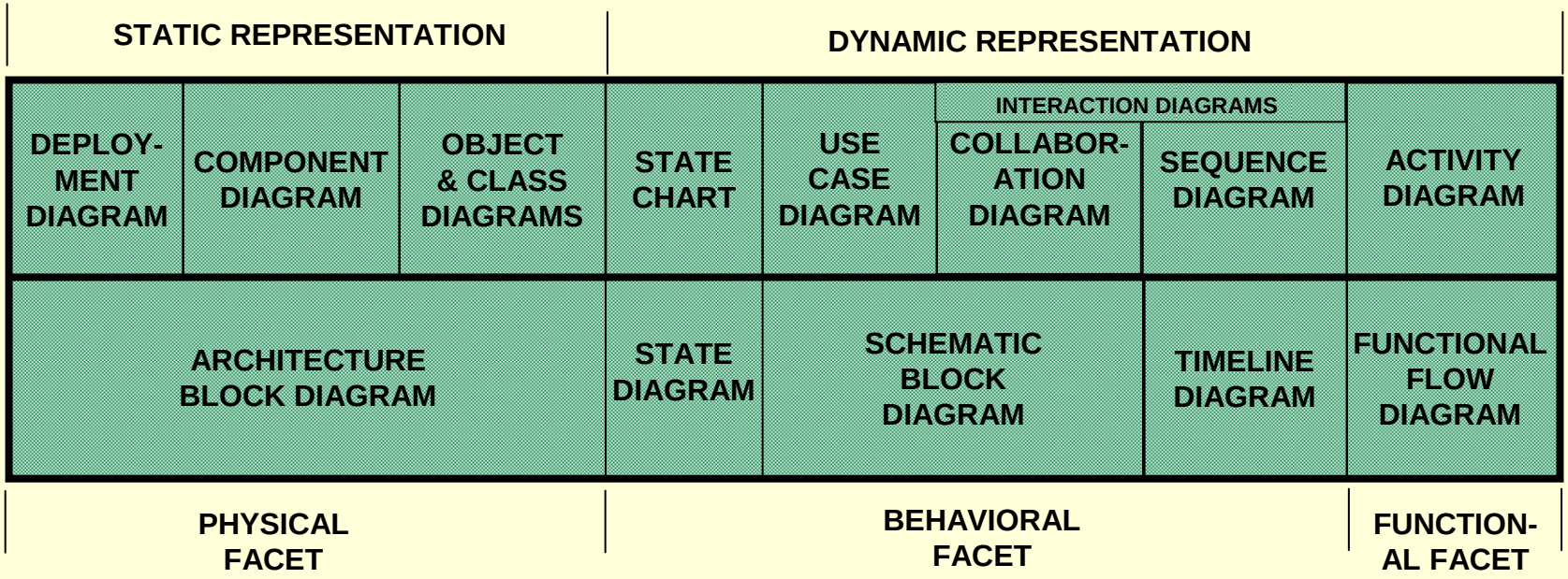
Specification Review and Approval Process

Toward Process Simplicity



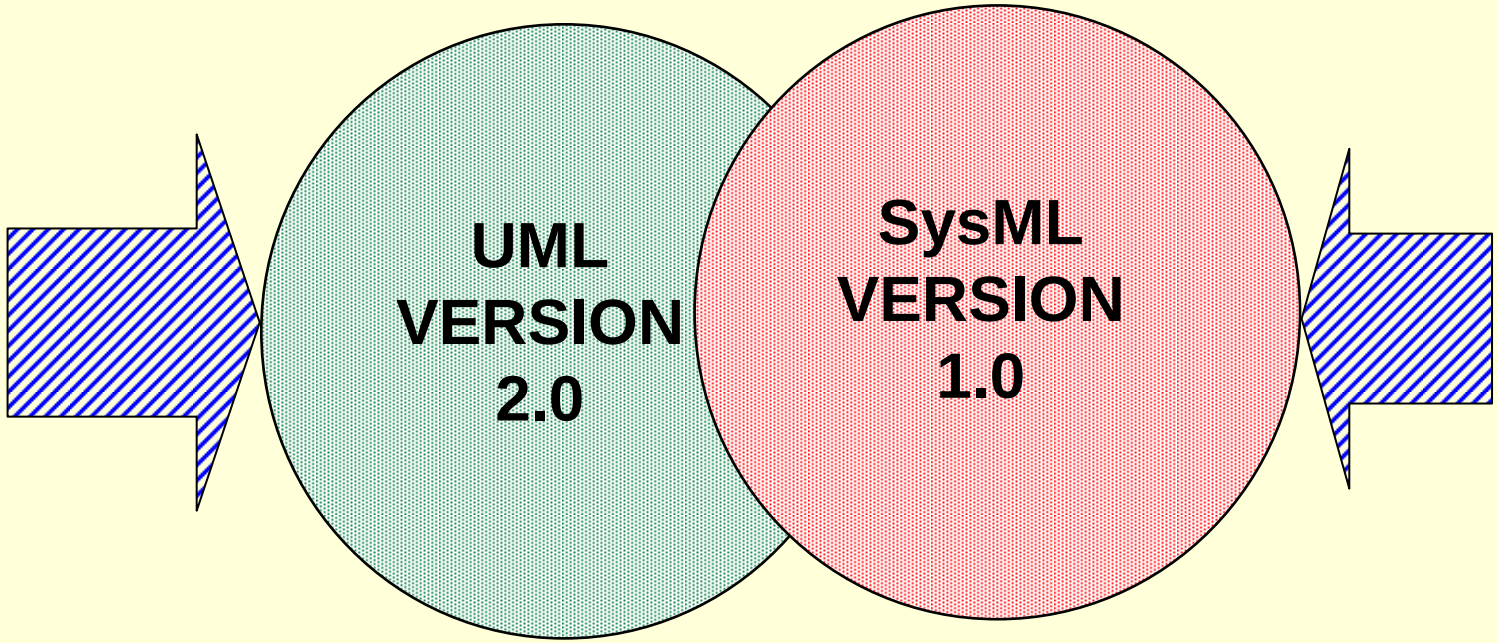
Evidence of an Approach Path
UML and TSA

UNIFIED MODELING LANGUAGE (UML)

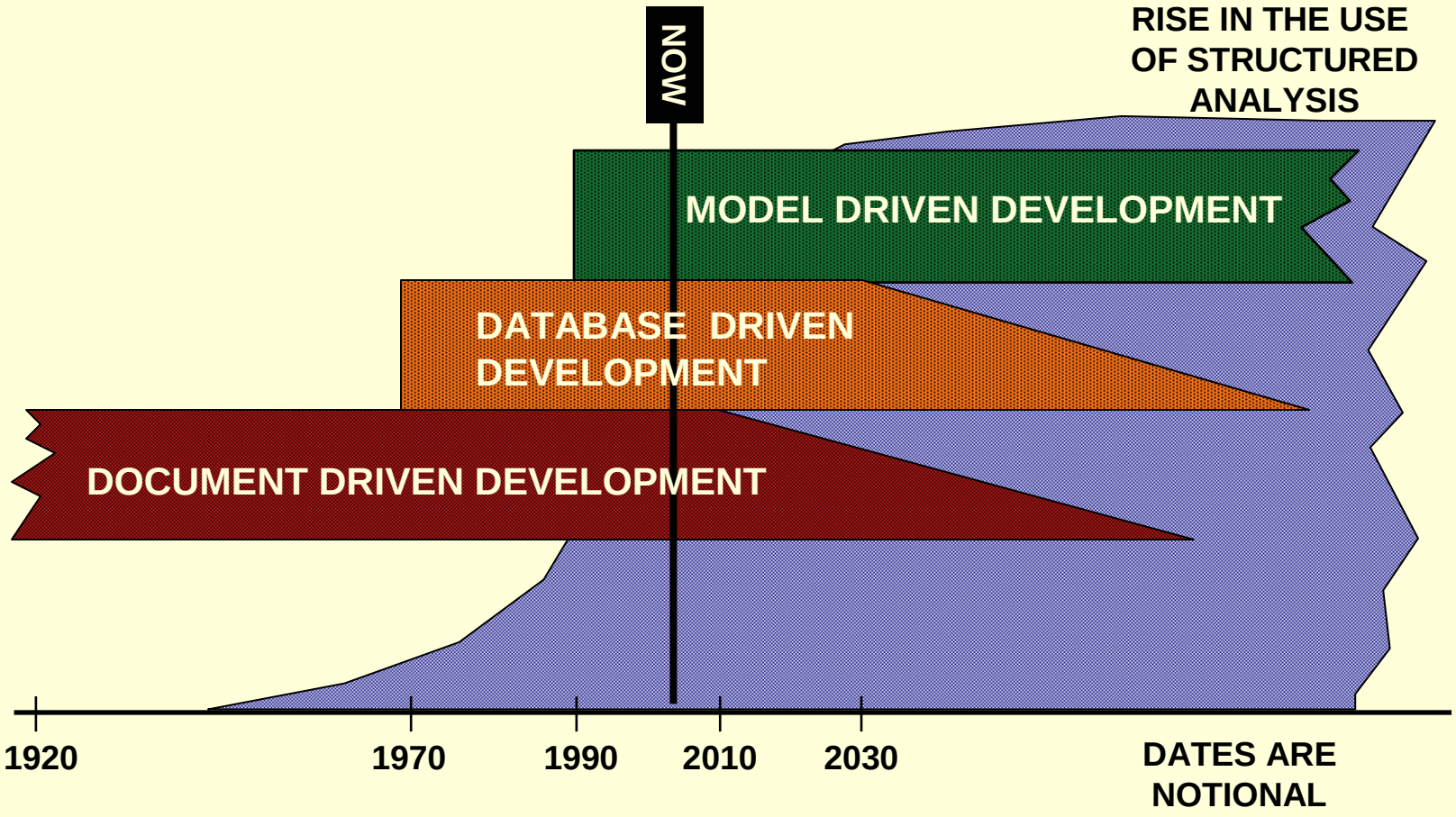


TRADITIONAL STRUCTURED ANALYSIS (TSA)

We Still Have to Push These Together Some More



Movement to Model-Driven Development



Architecture-Based Systems Engineering and Integration

By

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8th Annual Systems Engineering Conference Oct. 24-27, 2005

San Diego, CA

Outline

1.0 Why Architecture-Based Systems Engineering?
What does Architecting bring to the Systems Engineering Process?
2.0 DODAF views and Products
3.0 Four Aspects of Systems Engineering.
Five Phases of Systems Engineering Process.
4.0 Five System Architectures;
The 4+1 Software Architectures.
5.0 Merging Activities: Architecting, Engineering Integration, and Evaluation.
6.0 System Integration and Interfaces.
7.0 Conclusion

Why Architecture-Based Systems Engineering?

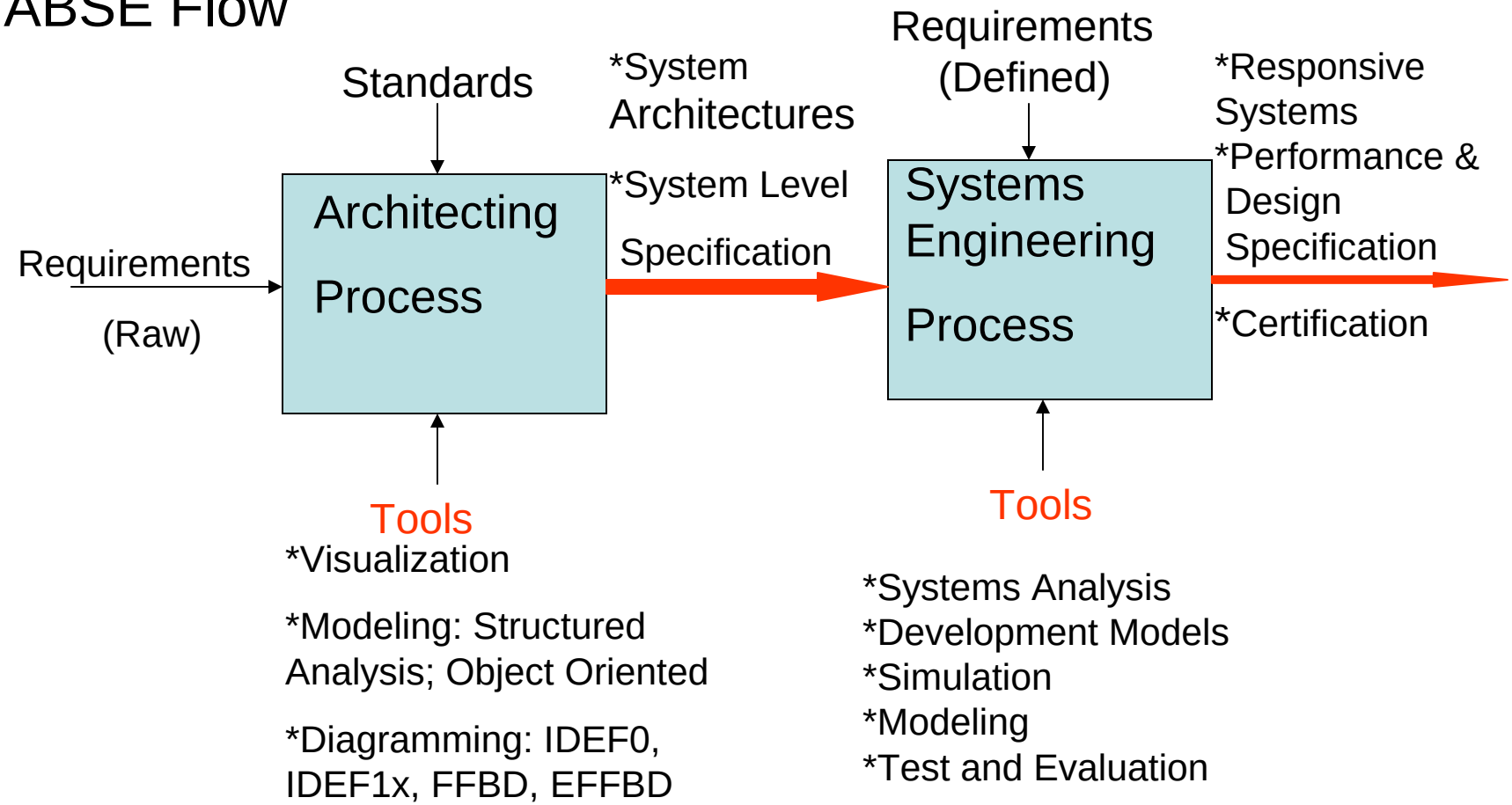
- DOD Systems Acquisition paradigm is moving away from acquiring products to acquiring Capabilities.
- Emphasis on using existing systems with new systems.
- Network Centric Operations demands flexibility and Interoperability between System-of-Systems.
- Coping with Complexity, uncertainty and cost of Engineering Effective Systems and Enterprises.
- Utilizing Information Technology to improve Productivity, integration, and build unprecedented Complex Systems.

Architecture-Based Systems Engineering

- Responding to these changes and challenges: We must systematically merge: Architecting activities, Engineering, Integration, and Evaluation of systems.
- The response is using the Systems Engineering approach of iterative top-down design and bottom-up integration of software and hardware.
- DOD has directed that DODAF be used to describe several Aspects of system architecture. DODAF consists of 26 views products.
- DODAF 1.0 does not provide guidance for detailed design, integration, or evaluation of systems.
- DODAF products can be used to create the System Architecture.

Architecture-Based Systems Engineering

ABSE Flow



Concept of Architecture

- The concept of architecture entered the domains of Software and Systems Engineering in recent decades
- Some people argue that the Software and System architecture are similar to that of civil architecture
- A building architecture is a detailed endeavor driven by the user that is meant to stay for many years. The drawings are very detailed to support the builder.
- Enterprise /System architecture must be more responsive to change & extensible: flexible, adaptable, and scalable than building architecture. It must be interchangeable / modular, & reusable.

Types of Architectures

There are two types of architectures:

(1) System Architecture of building real systems: Civil, Hardware, and Embedded systems architecture,

(2) Domain Specific Architectures: Software, supply chain, finance, insurance, business processes, security, C4ISR, avionics, weapon system.

** Architectures are preambles and part of the systems engineering process.

Architecture Framework

- Framework is the structural frame of reference,
- Architecture Framework e.g. DODAF or Zachman give the structure of the architecture.
- Framework does not give detailed guidance on how to design or implement architectures.
- Architecture (Framework +Design) = System Architecture

DODAF Linkages Among Views

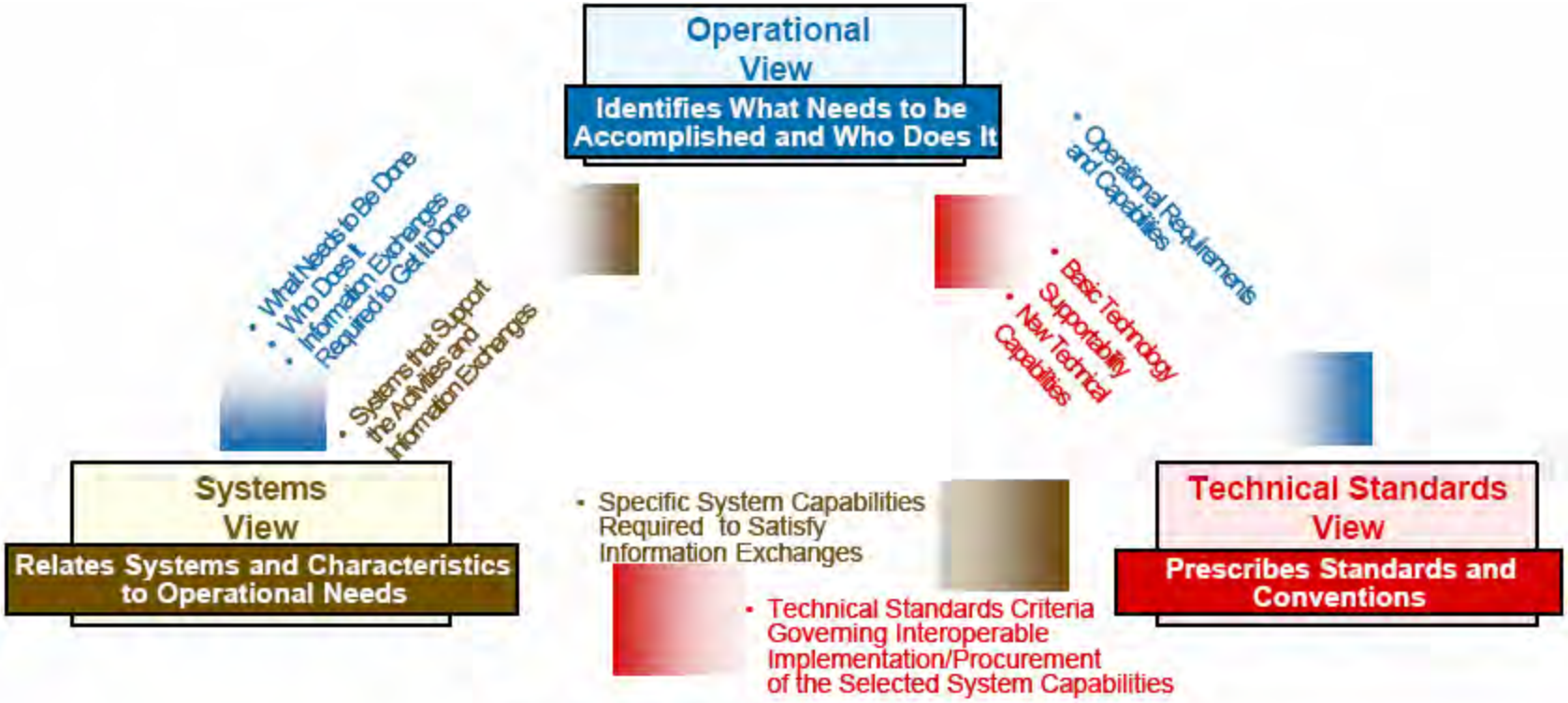


Figure ES-1. Linkages Among Views

System Architecture Must Have:

- Every system/enterprise must have an architecture
- An architecture must have:
  * Structure (Topology)/Organization,
  * Functionalities: Function Blocks, Modules
  * Connectivity: Linkages and interfaces- Function Blocks Diagram for a given set of events

Architecture-Based System Design Process

- Two approaches:

  (1) Structured Analysis (SA):

  using IDEF0, IDEF1x, DFD, FFBD, EFFBD

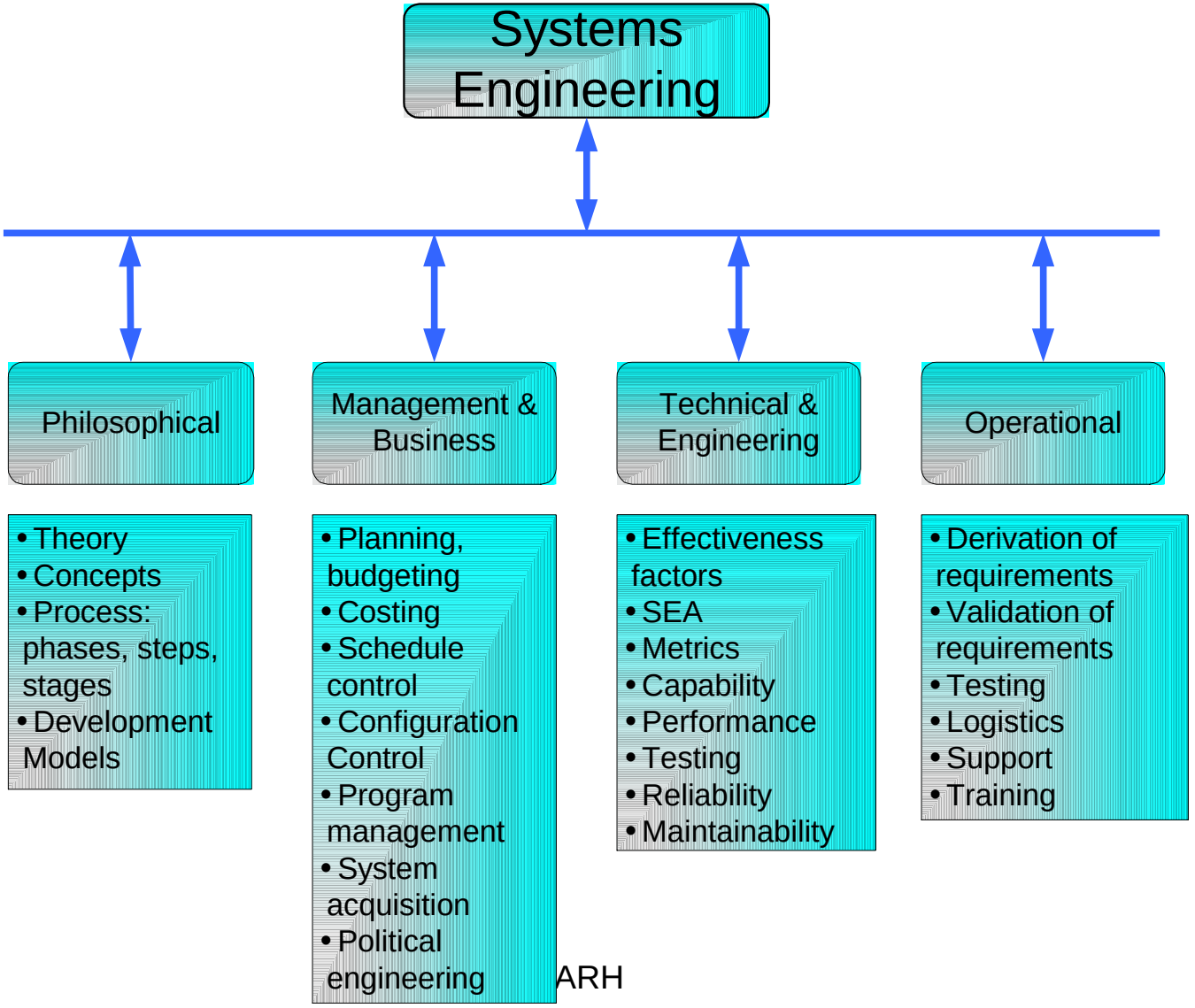
  (2) Object Oriented (OO):

  using UML or equivalent

Systems Engineering

Systems engineering is a multidisciplinary subject dealing with the integration of all parts of a system (hardware, software, and operator) into the real world environment. It provides rationalization for tradeoffs in meeting the requirements and building the system.

Systems Engineering Framework



Systems Engineering Process

Systems Engineering Process deals with all aspects of system design, development, integration, evaluation, disposal, and management.

(1) Determination of requirements,

(2) Definition of system architectures,

(3) Establishing performance, reliability, and availability goals

(4) Tradeoff analysis: performance versus cost, reliability, support,

(5) Decomposition and partitioning of system, and system design,

(6) Integration of building blocks, interfaces, testing, and safety,

(7) Metrics to evaluate all these activities, evaluate the effectiveness of alternatives and options,

(8) System engineering management: system acquisition, project management, and risk analysis.

Partitioning Levels of System Architecture

There are five levels of architectures:

(1) **System/Enterprise** level ⇢ Conceptual Architecture
Expressing stakeholders needs, concerns, capability requirements, and strategy

(2) **Subsystem** level ⇢ Functional/Logical Architecture
Performance, functional connectivity, and interfaces

(3) **Module** level ⇢ Physical Architecture
Physical connectivity and interfaces

(4) **Function** Block level ⇢ Operational/Implementation Architecture

(5) **Subfunction** level ⇢ Bottom-up Integration and Interfaces Architecture

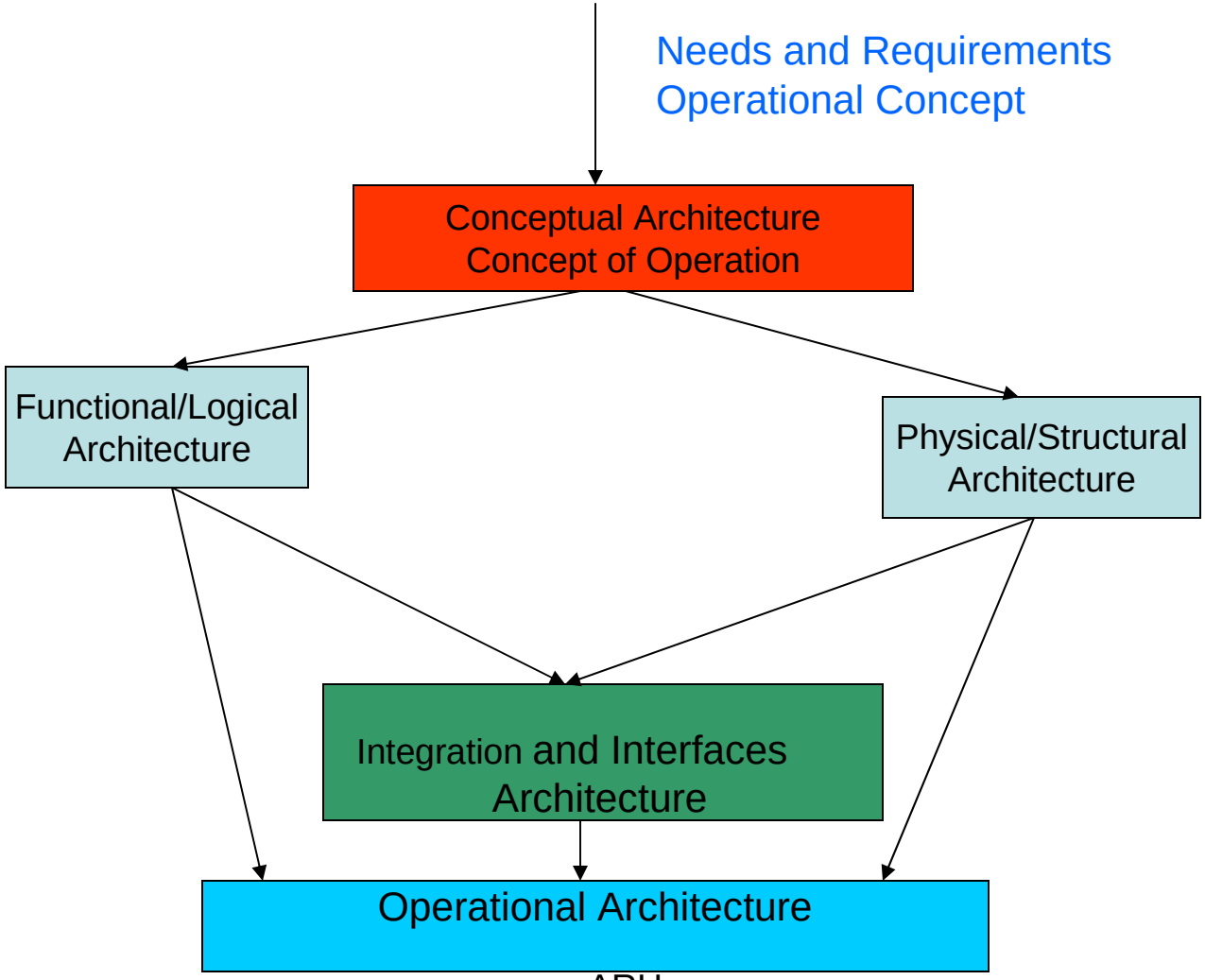
* Physical and functional connectivity are interfaces driven

** Functional and Physical architectures are performed concurrently

** The final architecture is achieved by iteration between these levels

** These architectures evolved into architecture Views: System, Operational, Technical and All

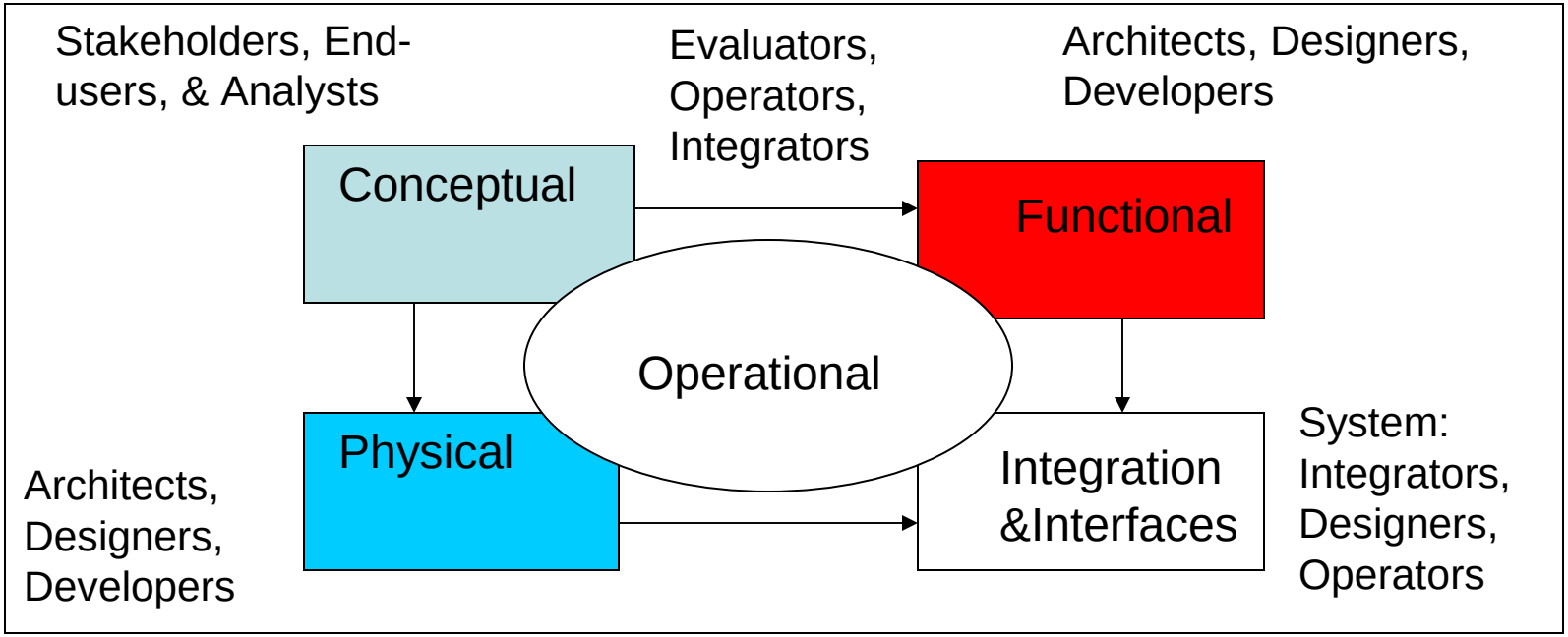
System Architectures Flow and Relationship



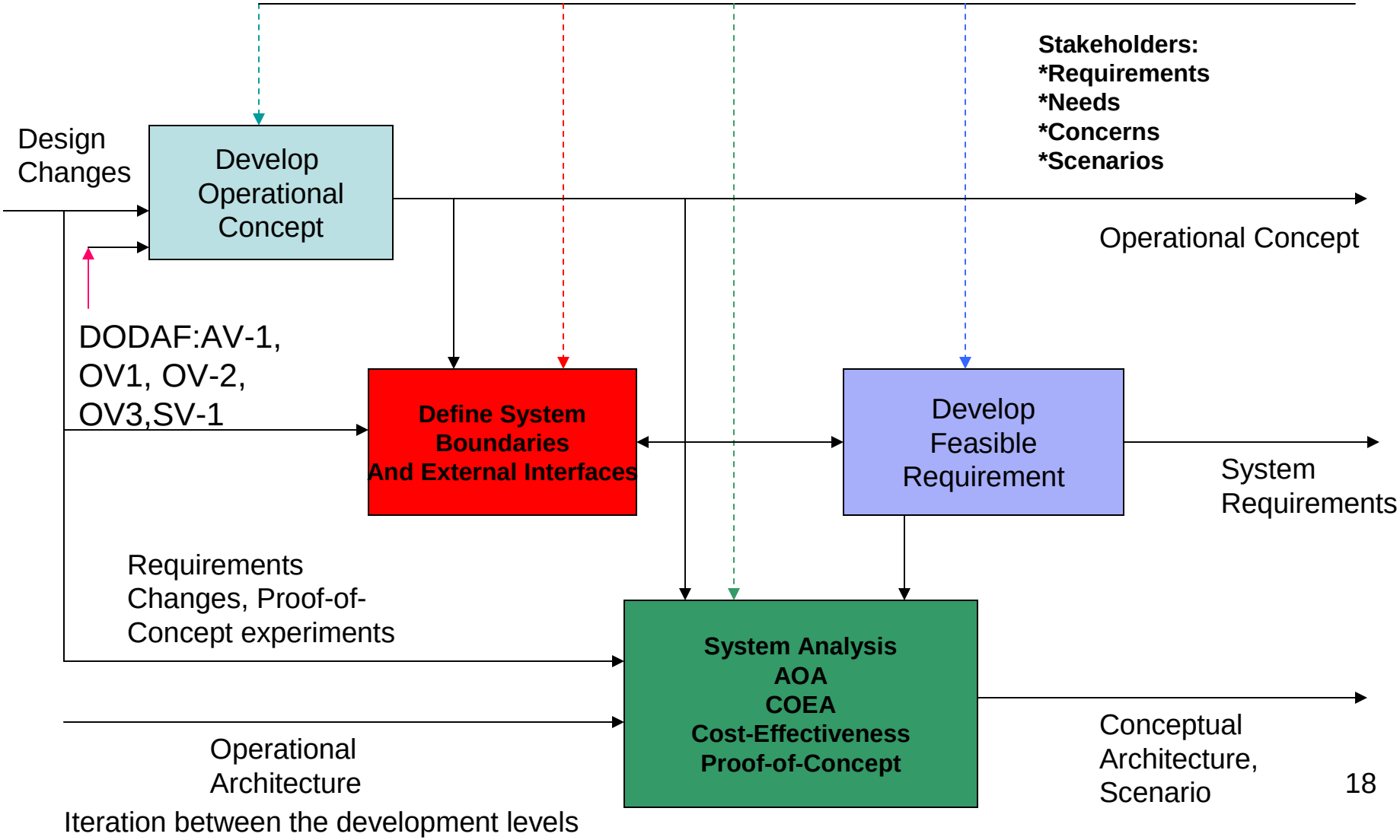
Architecture flow development in the engineering of a system

System Architecture Model

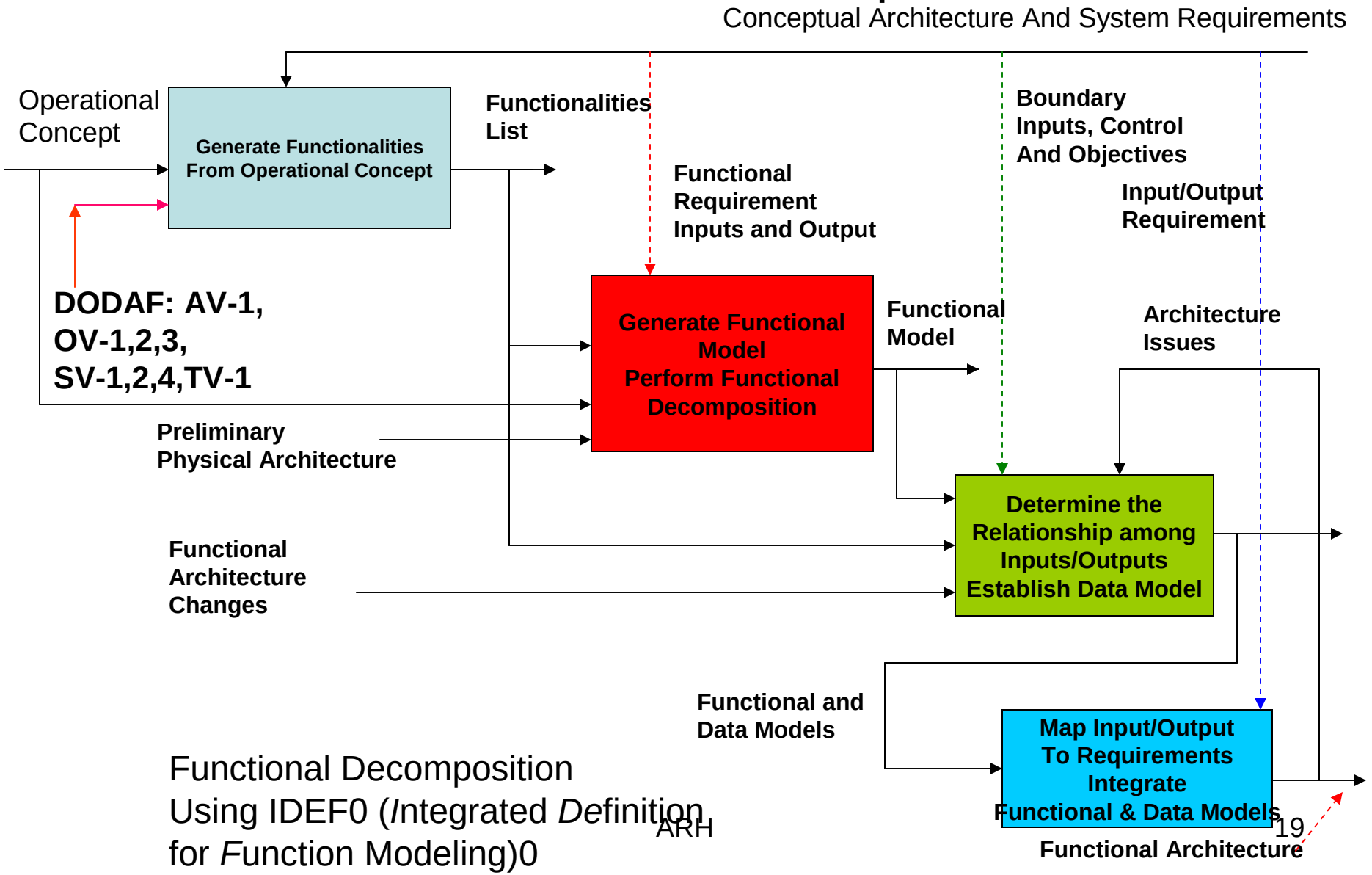
The relationship of the five kinds of system architecture:



Conceptual Architecture Development Process



Functional Architecture Development Process

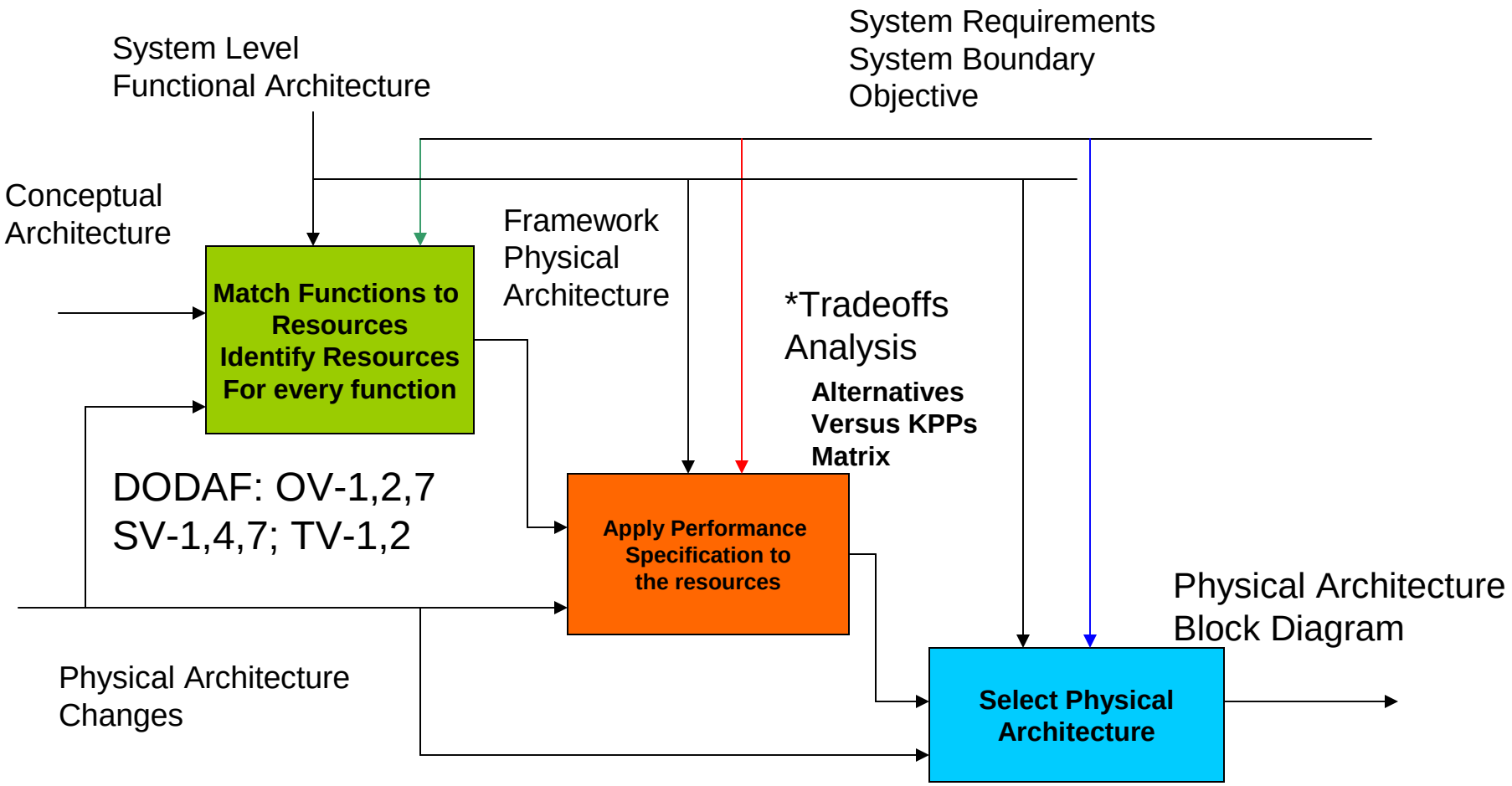


Functional Decomposition Using IDEF0 (*I*ntegrated *De*finition for *F*unction Modeling)0

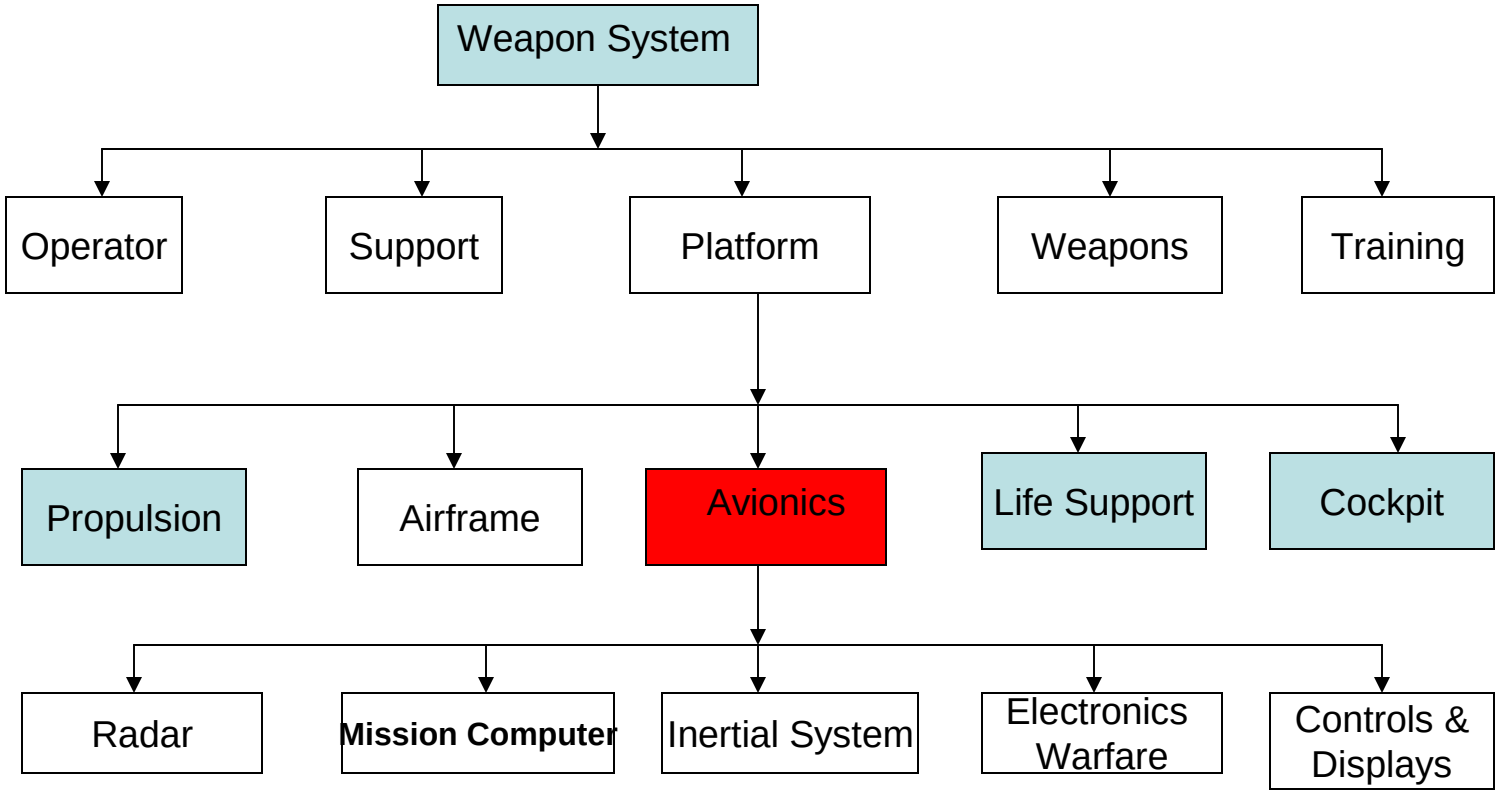
Physical/Structural Architecture

- The physical architecture gives the physical resources to perform the system functions. It is developed concurrently with the Functional Architecture.
- It identifies resources to form the structural architecture. Physics-Based simulations provide insights into the physical architecture
- Physical architecture is a description of the partitioned elements of the system without their performance specifications.
- It accounts for all the nonfunctional attributes: Reliability, availability, security, scalability, reusability.

Physical Architecture Development Process



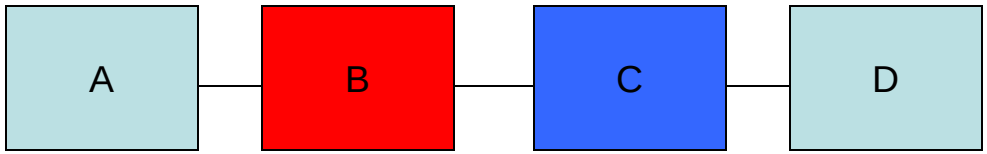
Physical Architecture of a Weapon System



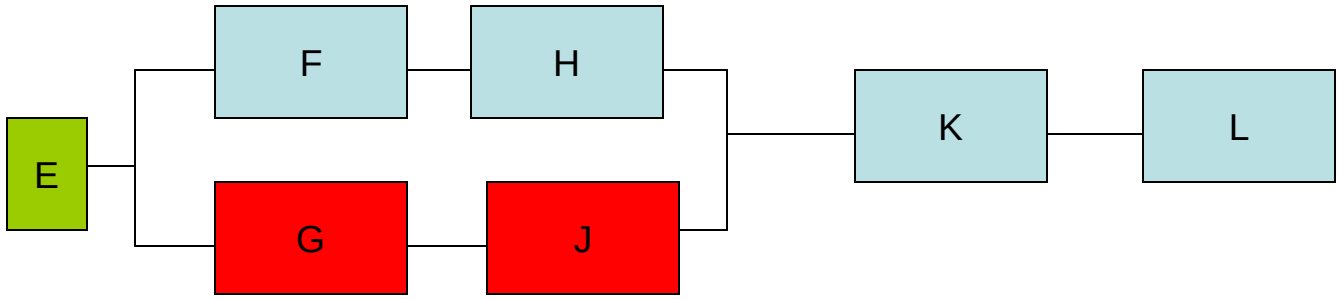
Work Breakdown Structure is similar to the physical architecture (WBS)

Reliability/Availability Block Diagram

Example of a Physical/Structural architecture

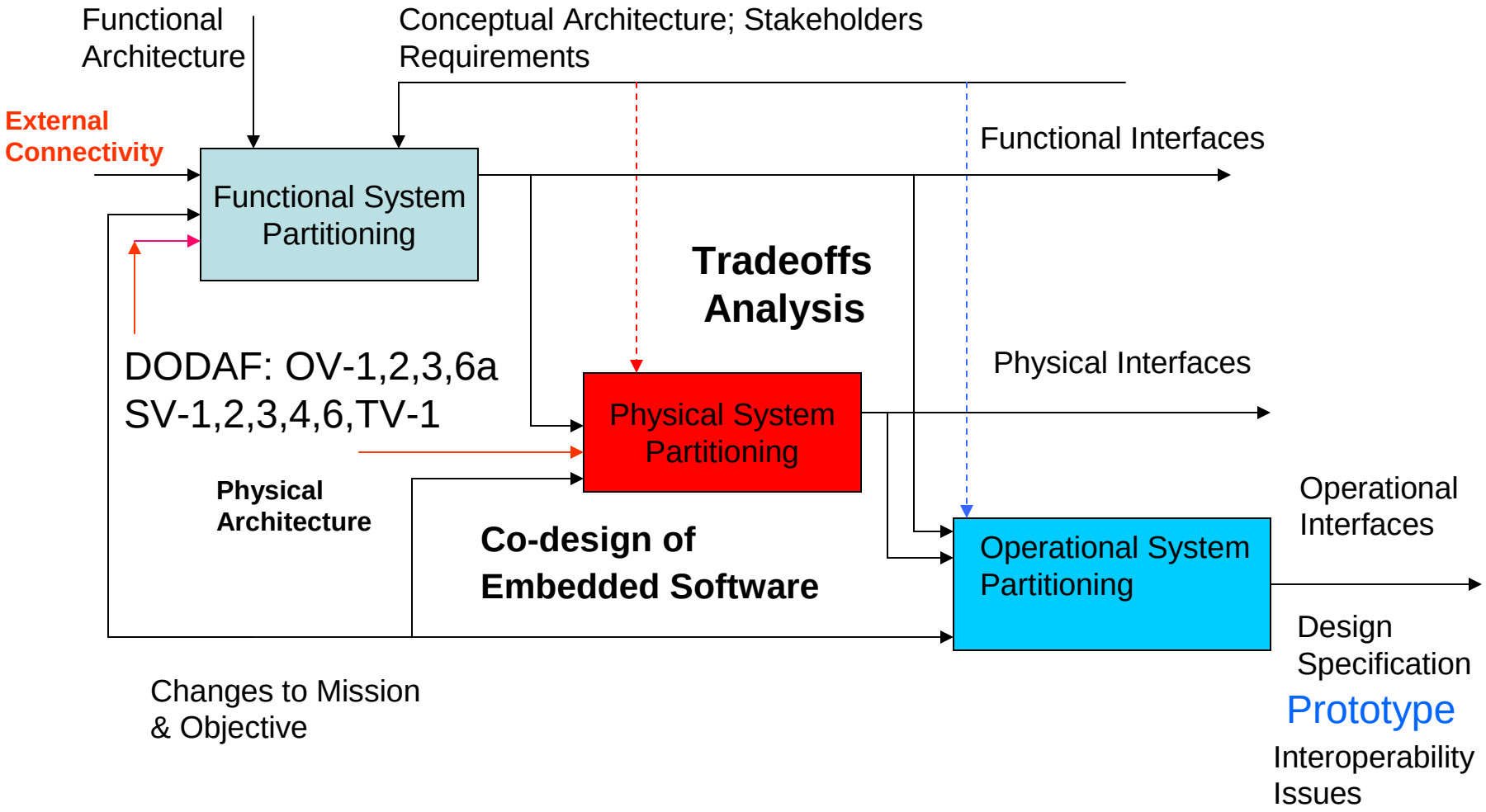


Series Architecture

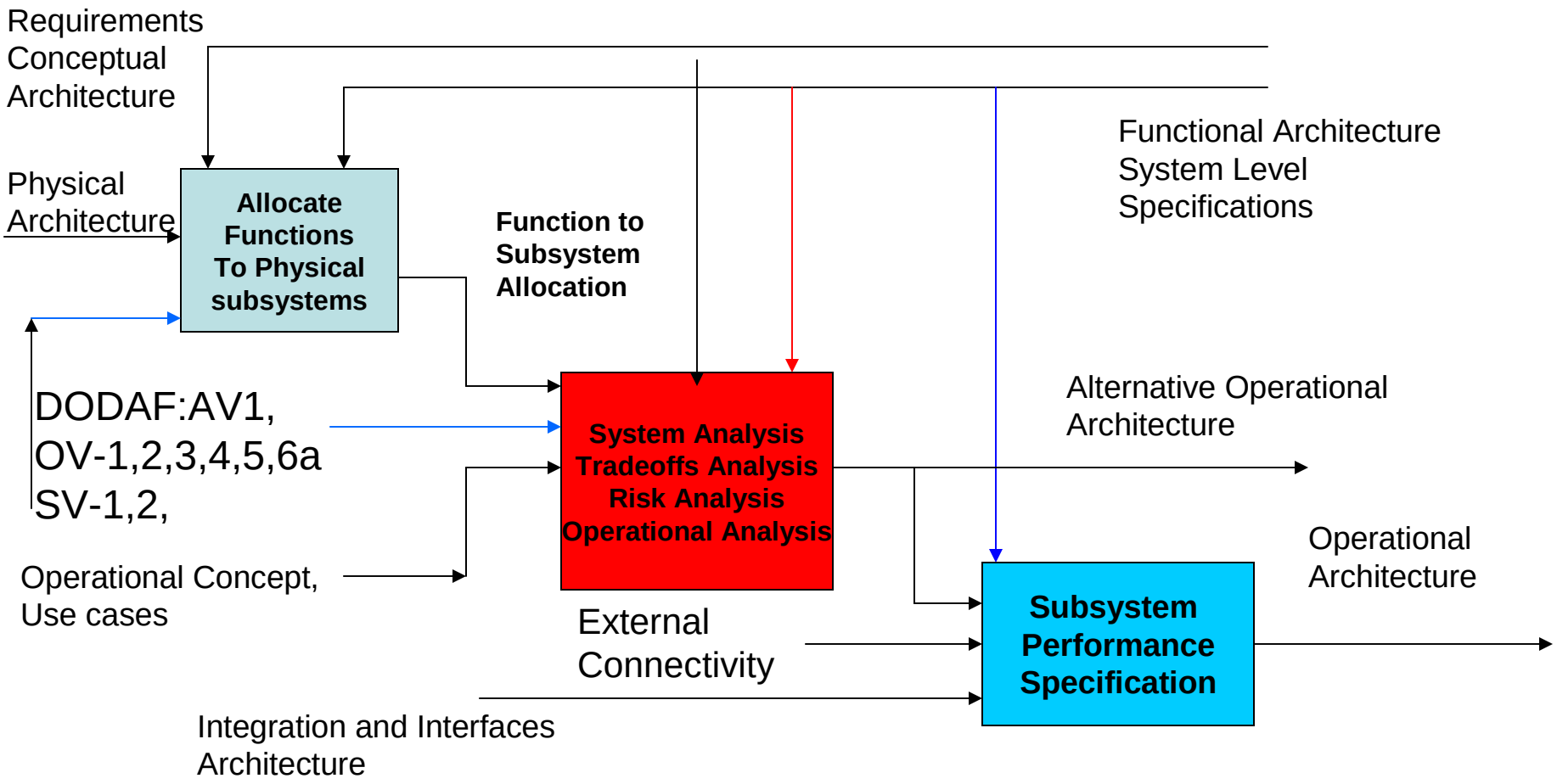


Series parallel Architecture

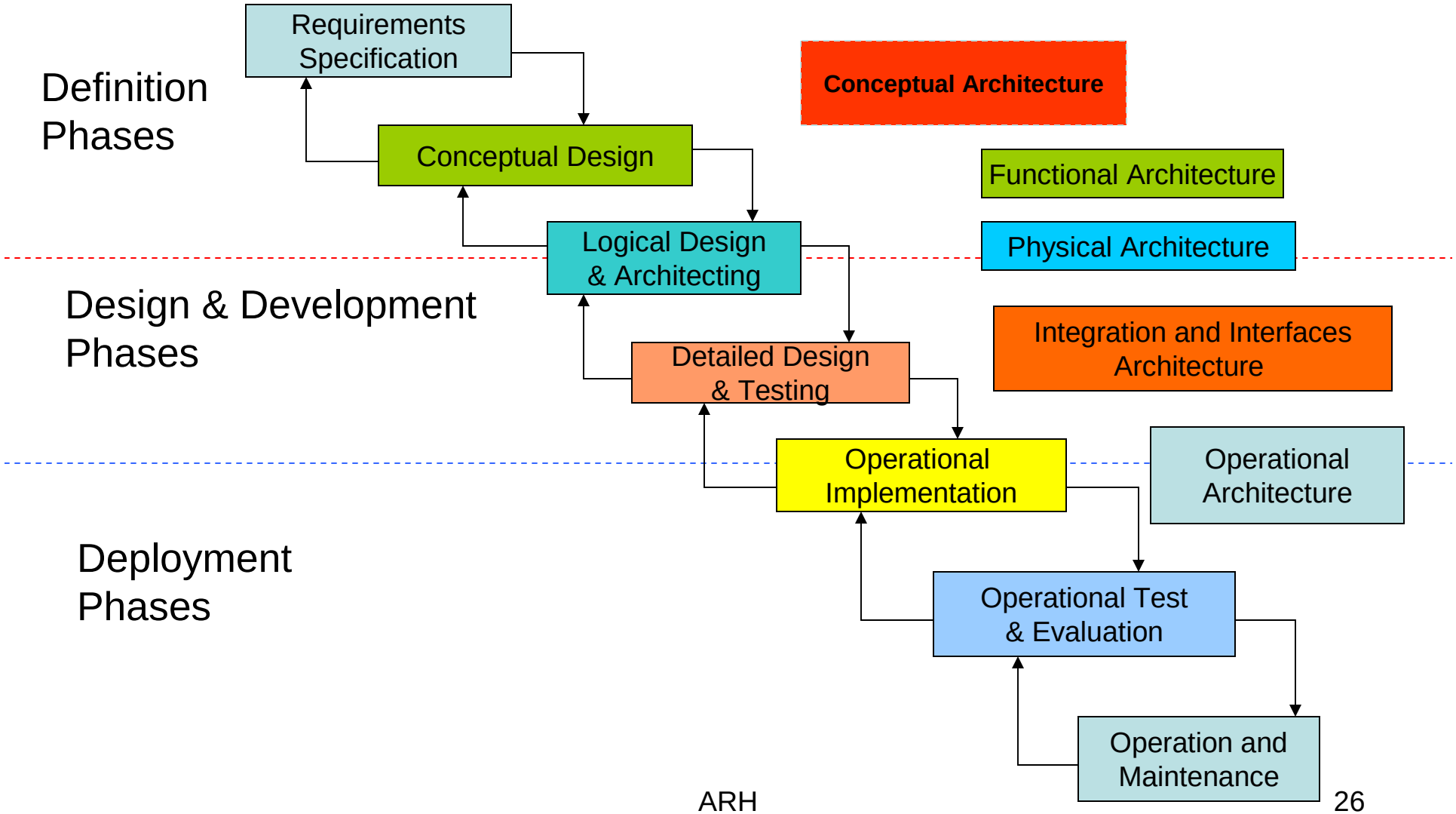
Development Process of Integration and Interfaces Architecture



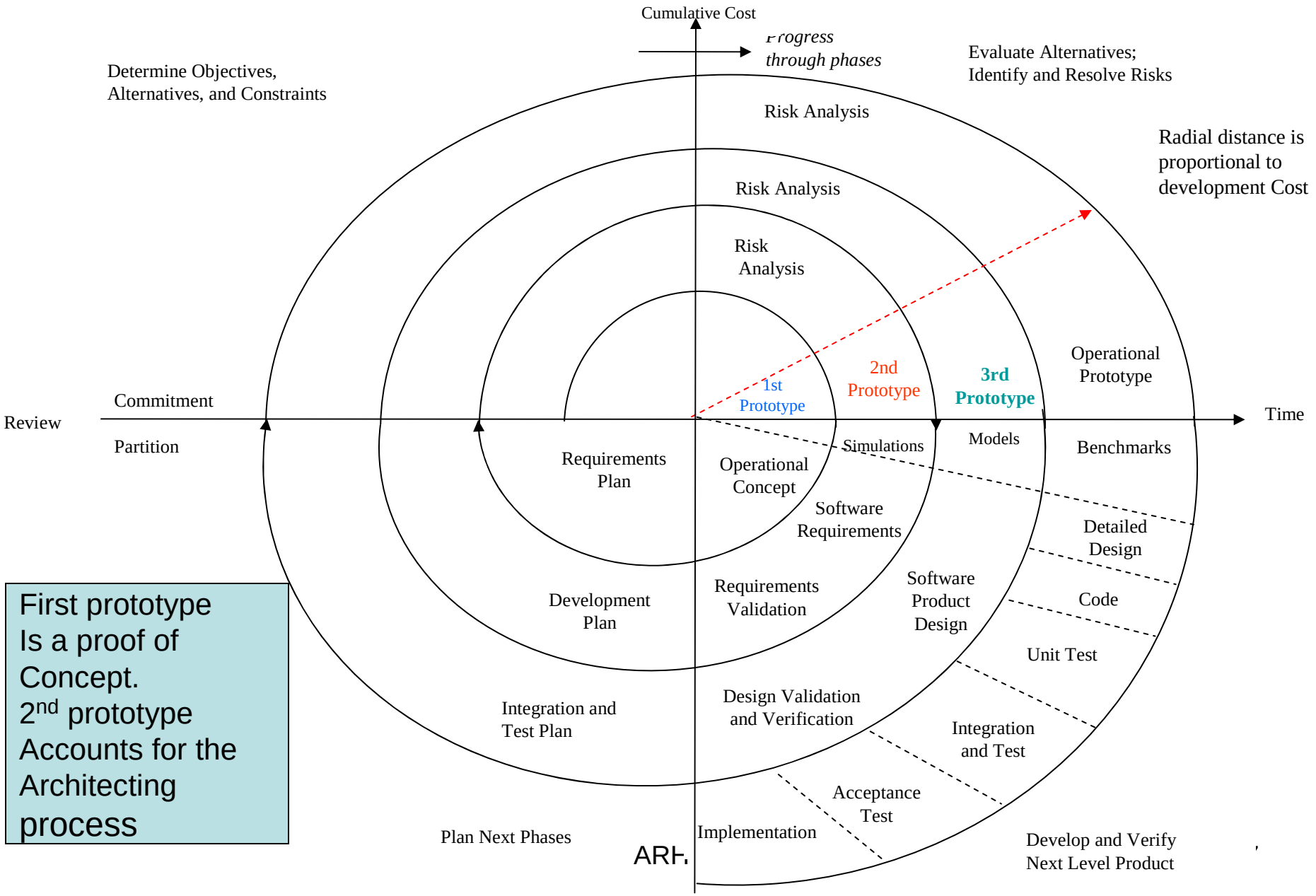
Development of Operational Architecture



Systems Engineering Process
Seven Phases for Acquisition/Production

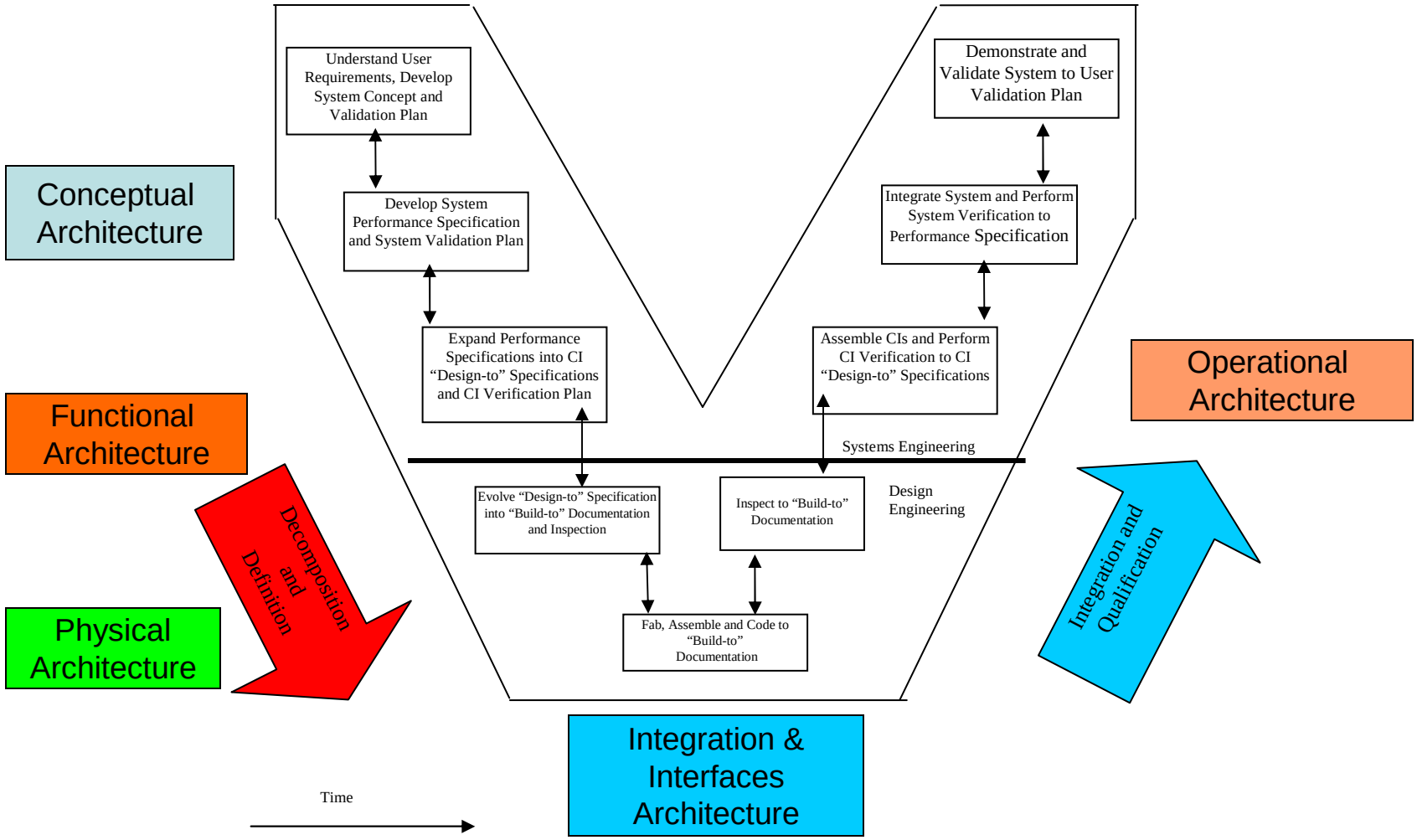


Spiral Model

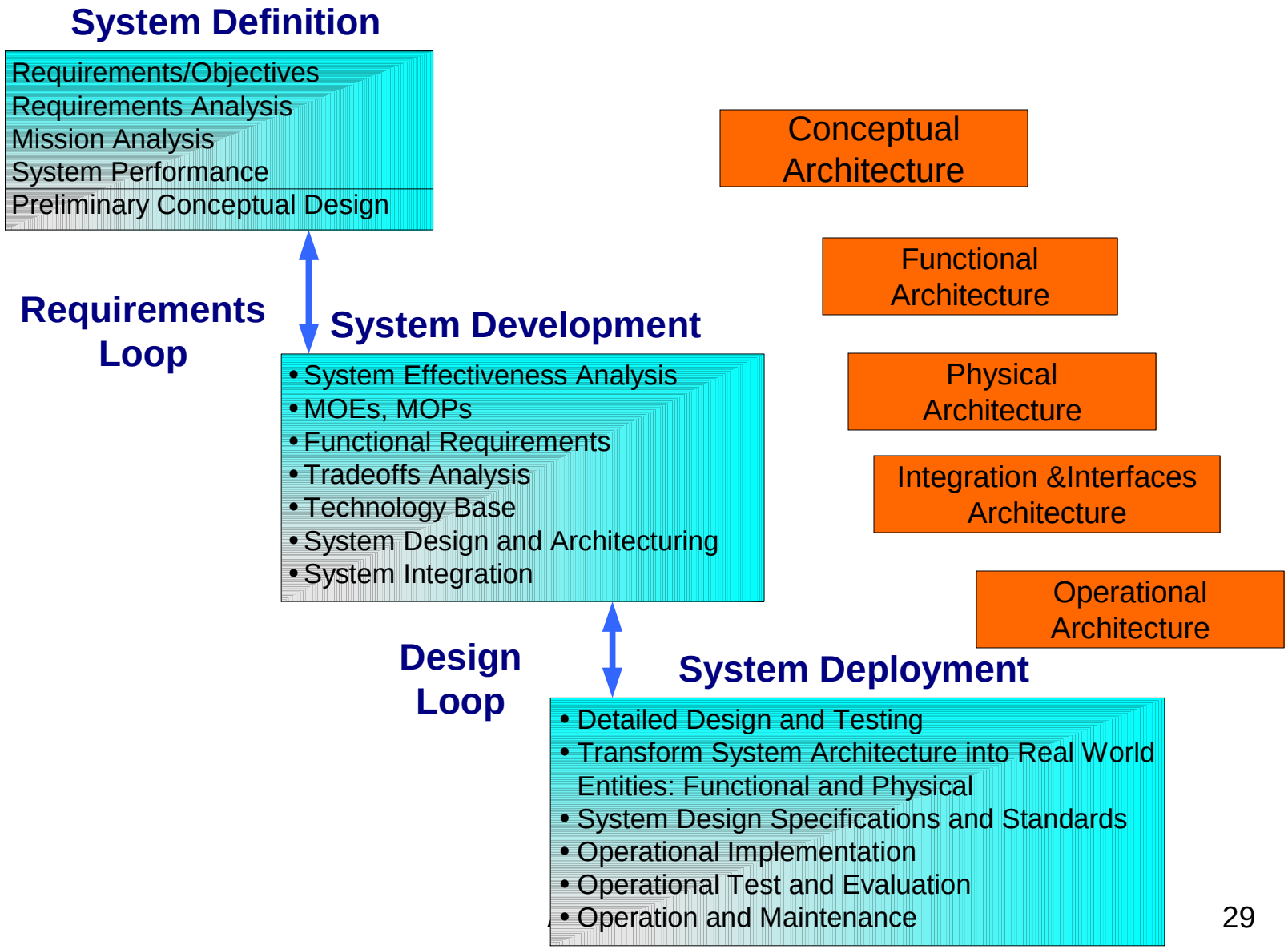


First prototype
Is a proof of Concept.
2nd prototype
Accounts for the Architecting process

Vee Model


Conceptual Architecture
Functional Architecture
Physical Architecture
Understand User Requirements, Develop System Concept and Validation Plan
Develop System Performance Specification and System Validation Plan
Expand Performance Specifications into CI "Design-to" Specifications and CI Verification Plan
Evolve "Design-to" Specification into "Build-to" Documentation and Inspection
Fab, Assemble and Code to "Build-to" Documentation
Inspect to "Build-to" Documentation
Assemble CIs and Perform CI Verification to CI "Design-to" Specifications
Integrate System and Perform System Verification to Performance Specification
Demonstrate and Validate System to User Validation Plan
Systems Engineering
Design Engineering
Decomposition and Definition
Integration and Qualification
Operational Architecture
Integration & Interfaces Architecture
Time
CI-Configuration Item

Systems Engineering Interactive Model



Software Architecture

- Software architecture deals with the design and implementation of the high-level structure of software.
- A model of five views called (4+1) is used to describe the software architecture:

  (1) Logical View,

  (2) Process View,

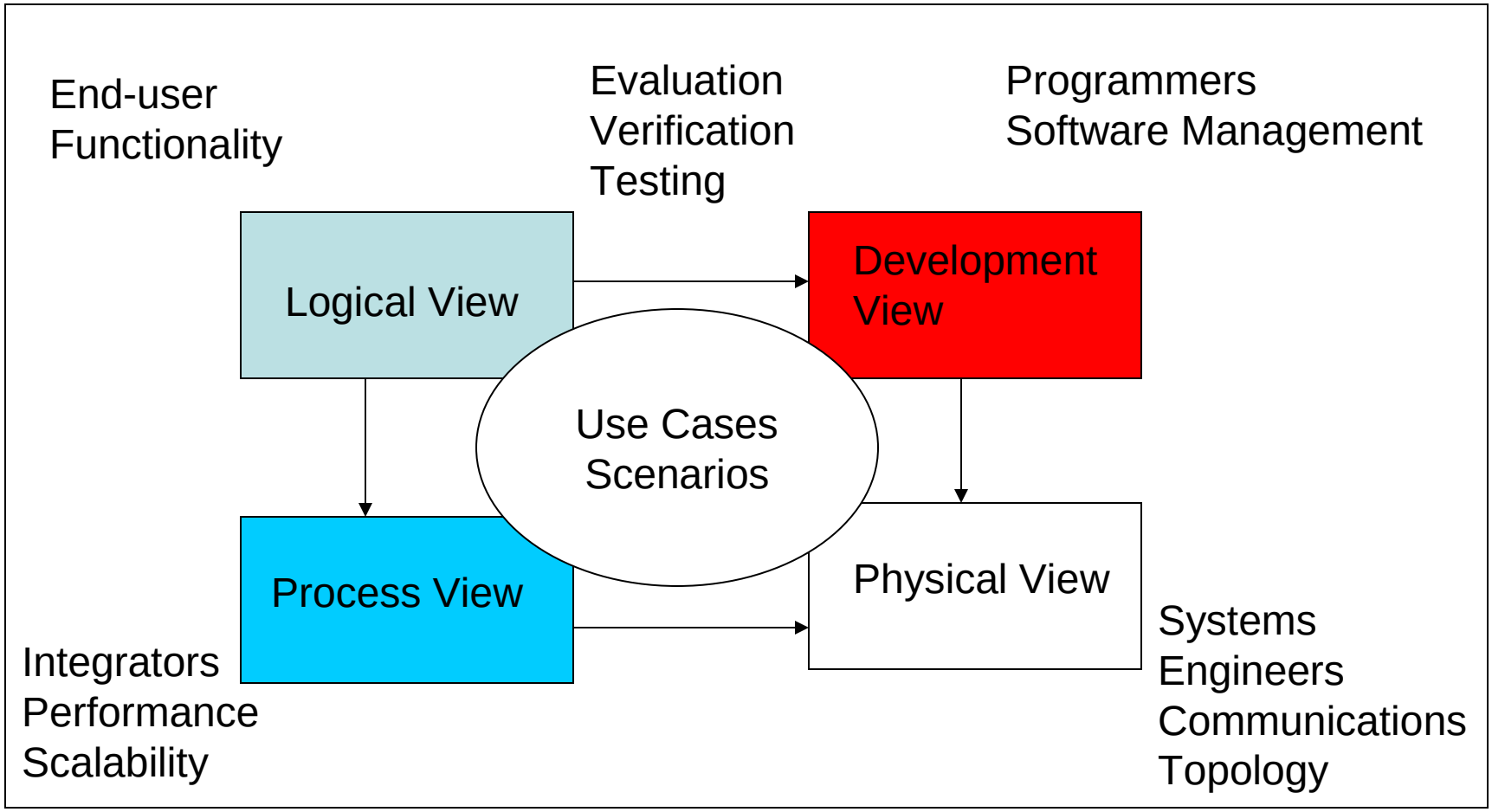
  (3) Development View,

  (4) Physical View

  (5) Use Case view

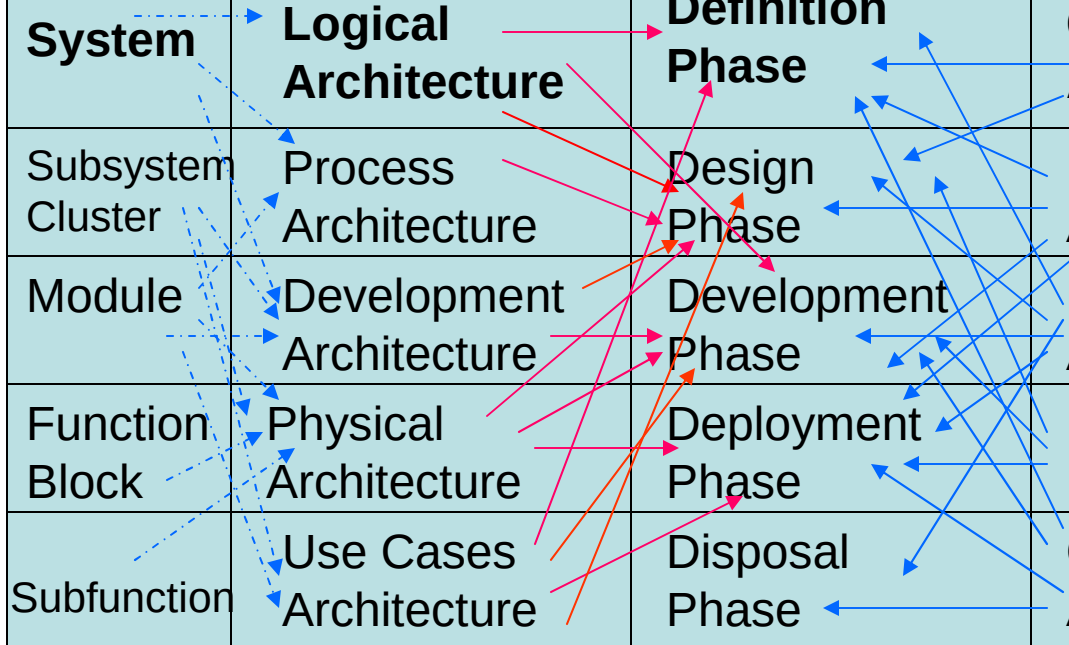
Software Architecture Model

Four + One View Model

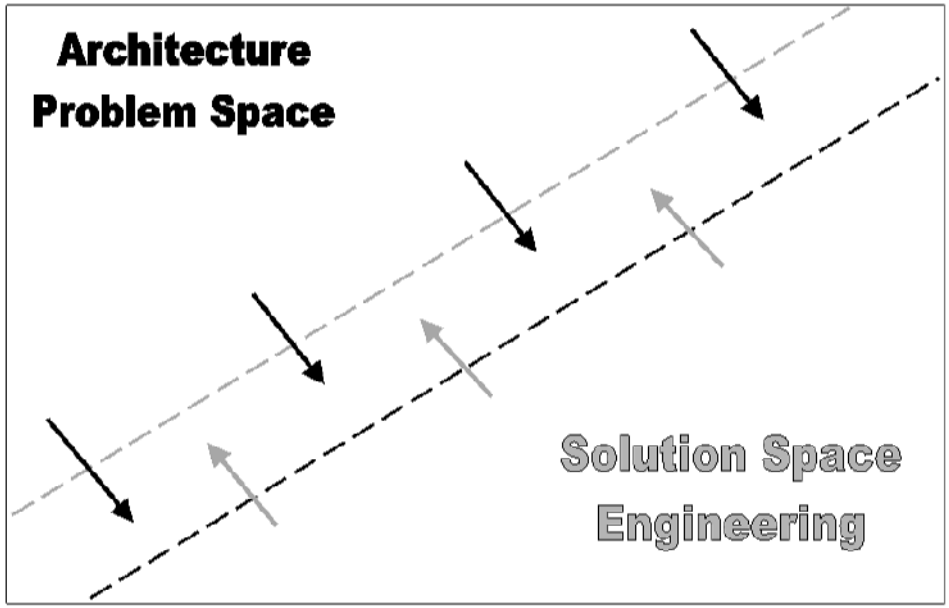


Merging Architecting Into the Systems Engineering Process

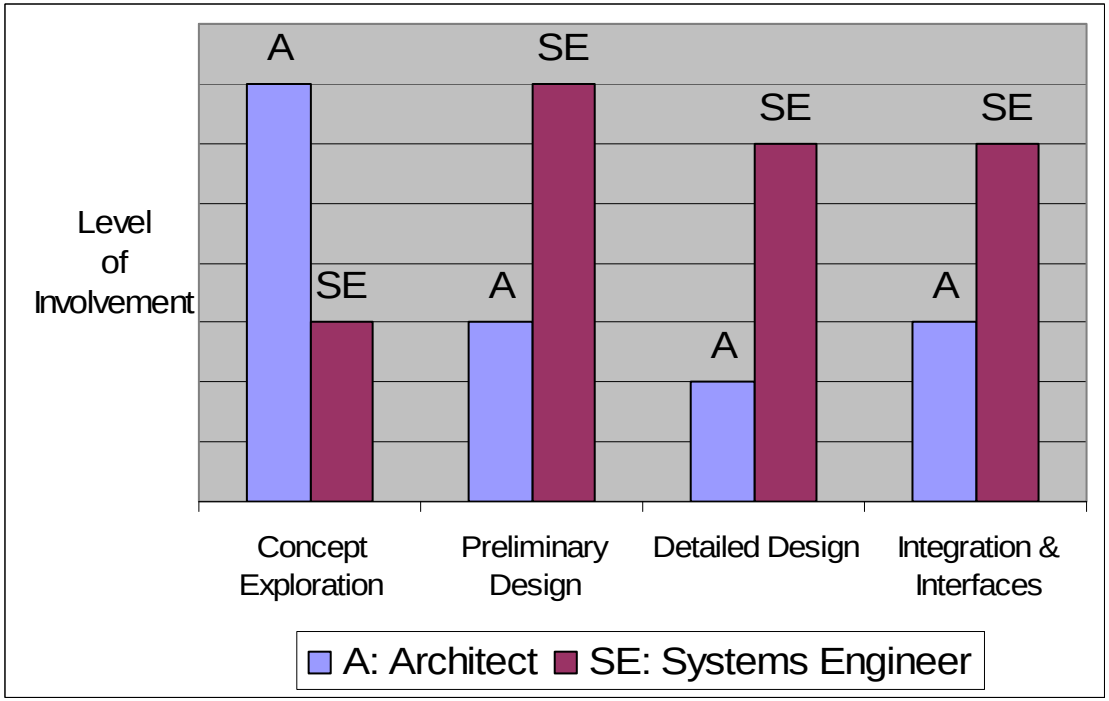
Partitioning Level	Software Architecture Views	Systems Engineering Process: 5Ds	System Architecture Views	DoDAF: C4ISR Views
System	**Logical Architecture**	**Definition Phase**	**Conceptual Architecture**	**ALL View**
Subsystem Cluster	Process Architecture	Design Phase	Functional Architecture	Operational View
Module	Development Architecture	Development Phase	Physical Architecture	Systems View
Function Block	Physical Architecture	Deployment Phase	Integration & Interfaces Arch.	Technical View
Subfunction	Use Cases Architecture	Disposal Phase	Operational Architecture	
Component Element				



Architect and Systems Engineer Spaces



Level of Architecting Involvement in the Systems Engineering Process



System Integration and Interfaces: Why is it important?

- System Integration is a critical part of the Systems Engineering Process, it brings the decompositions together.
- Interfaces are the keys to a successful Integration.
- The recognition and identification of Interfaces are very important in building responsive, robust, and Effective systems.
- Interfaces occur at the boundaries of the building Blocks of the system: functionally, physically, and operationally.
- The capability of recognizing and counting the interfaces will ensure the success of the architecting and engineering process.

The Binary Interfaces Model

- We build systems to give outcomes. System behavior is described by its outcomes.
- We will use a binary building blocks model to determine and count interfaces.
- Given a system whose functionality is achieved by integrating (merging) **n** = three building blocks: A, B, C.
- The number of possible outcomes is "$\mathbf{2^n}$"=$\mathbf{2^3}$= **8**.
- The outcomes are represented by:

  (1) Events (Euler, or logical) Diagrams,

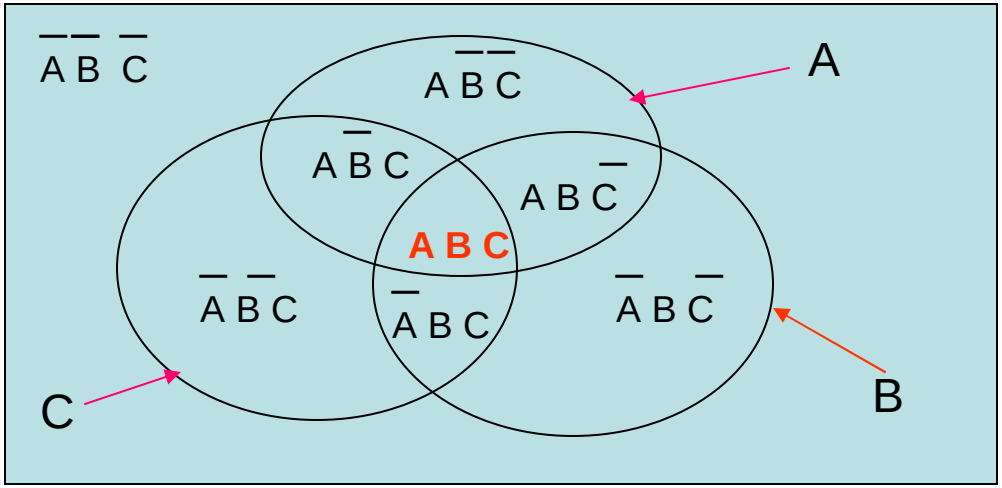
  (2) Network (Decision tree),

  (3) Truth table,

  (4) Combinatorial mathematics.

Binary Model of Interfaces

- When the functionalities of A,B, and C merge new functions are created and are represented by the events (logic) diagram



Interfaces occur when two or more functionalities are merged, we call them mathematical intersections of order two or more. For this example:
There are three second order interfaces: $A\,B\,\overline{C}$, $A\,\overline{B}\,C$, $\overline{A}\,B\,C$

and a third order interface: A B C

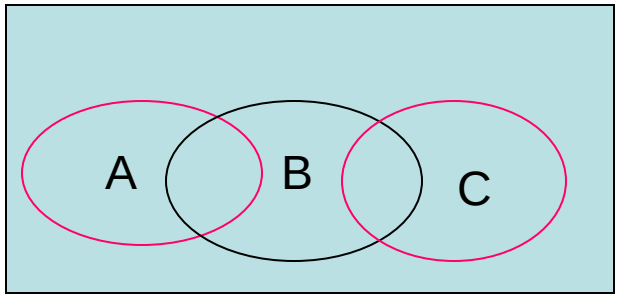
Subsumed Interfaces

- As we integrate systems not all interfaces are recognized and accounted for.
- The question is what happens when interfaces are subsumed?
- Subsumed interfaces are either absorbed by other interfaces, or they are neglected. This can happen when functionalities are not merged properly, poor coupling, low amplification, or by **organizational design**.
- The impact of subsumed interfaces is serious degradation in system effectiveness.

Logically Integrated System versus System with Subsumed Interfaces

The area of the function is proportional to its: **Design Limitation=1-Design Adequacy**

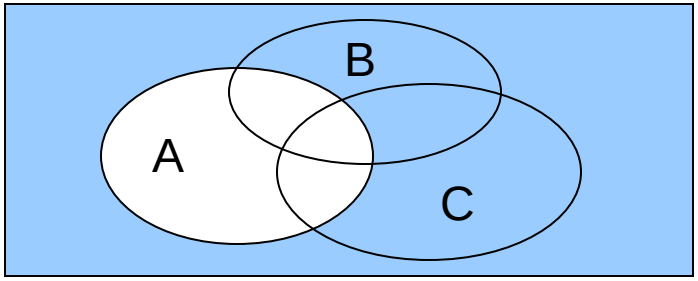
System S1: 2 Subsumed Interfaces



Design Limitation= A+B+C-AB-AC
Design Adequacy=1-A-B-C+AB+AC

A=B=C	Adequacy
0	1.0
.1	.72
.2	.48
.3	.28
.4	.12
.5	0
.7	0
1.0	0

System S2: Logically Integrated



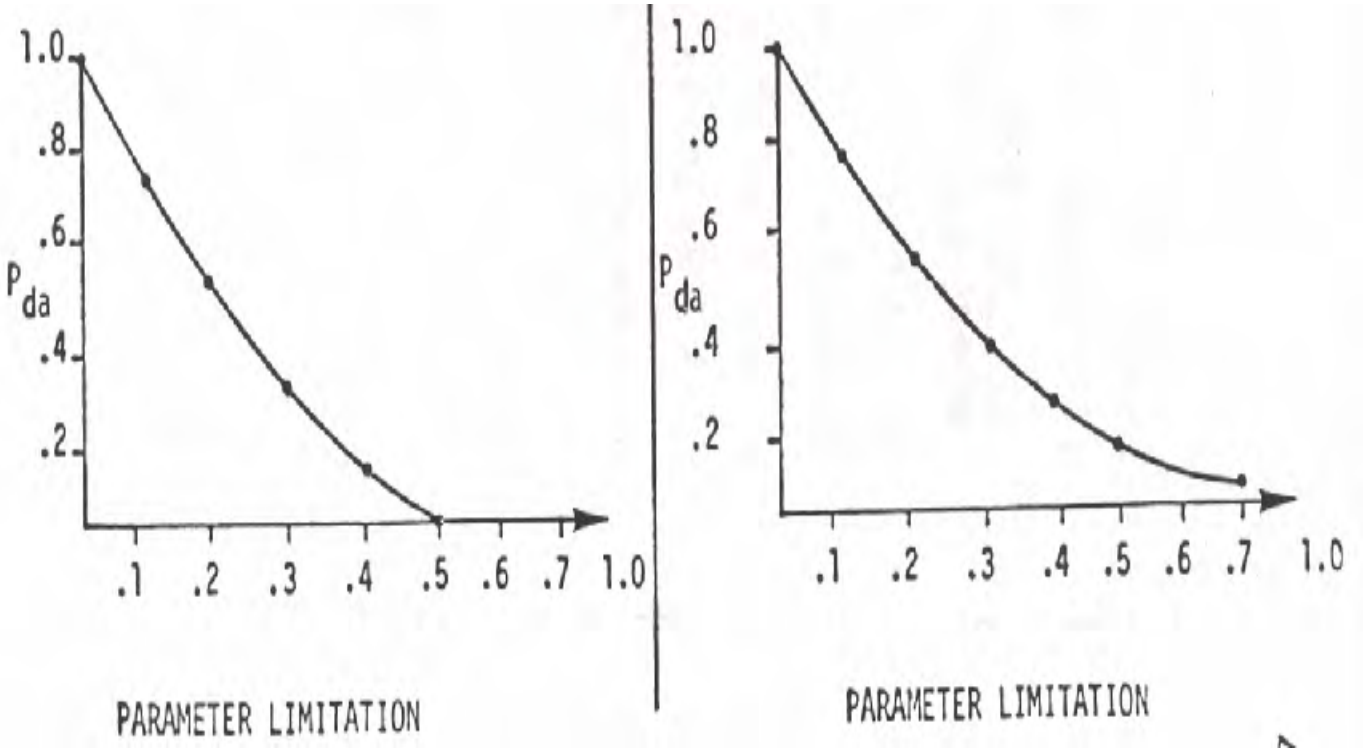
Design Limitation=A+B+C-AB-AC-BC+ABC
Design Adequacy=1-A-B-C+AB+AC+BC-ABC

A=B=C	Adequacy
0	1.0
.1	.729
.2	.512
.3	.343
.4	.216
.5	.125
.7	.027
1.0	0

Comparing Two Systems

System S_1 with subsumed Interfaces

System S_2 Logically Integrated



Conclusion

• Architecting is a major contributor to the engineering of responsive systems. It strengthens the systems engineering process and provides critical insights into the stakeholder and user requirements.

• System architecture and software architecture should be congruent.

* Interfaces are the keystones of system integration.

* Merging the architecting, engineering, integration, and evaluation into the Systems Engineering process will provide a comprehensive and a balanced approach to deal with the complexity of building effective systems.

Architecture-Based Systems Engineering and Integration

Backup

Next Generation Systems

- Traditional Systems Engineering and Systems Acquisition are focused on Vertical (Stovepipe) System design.
- System acquisition have moved away from the traditional model to acquiring **Capabilities**.
- Next generation systems must be flexible, scalable, interoperable, and adaptable/agile. Therefore, the design of Future Systems should be based on "**Capability Building Blocks**"
- Current and Future Network Centric Operations requirements mandate Interoperability.
- Current and future systems are software intensive. Software is embedded into systems and intermingled within System-of-Systems.

** We need a comprehensive approach to build systems, whose architectures are compatible with the systems engineering process.

System Architecture Model

The system architecture model is the model of function and form that defines the physical structure, functional flow, interfaces, and the connectivity of the system

Architecture Implementation

- **Architecture Implementation Principles**
- Architecture framework
  - DoDAF
  - Zachman
- Implementation methodology of software
  - SOA
  - Data driven
  - Client/Server
  - Model driven architecture (MDA) using UML
  - Event driven architecture (EDA)
  - Component-based architecture
  - Aspect Driven Architecture
  - Domain Driven Architecture

Input/Output of System Design Activities During Architecting and Engineering

Design Activity	Input	Output
(1) Conceptual System Design	Stakeholders Needs & Concerns Operational Concept	Requirements Conceptual Architecture Concept of Operation
(2) Functional System Design	Requirements Conceptual Architecture	Functional Architecture System Level Specification
(3) Physical System Design	Requirements Conceptual/Functional Architecture	Physical Architecture System Level Specification Performance Specification
(4) Integration & Interfaces Subsystem, Module, Function Block	Functional & Physical Architecture Performance Specification	Integration & Interfaces Architecture Design Specification KPPs
(5) Operational System Design And Risk analysis	Requirements Functional Architecture Physical Architecture Interfaces	Operational Architecture Performance Specification Risk management
(6) Evaluation and Testing of system design	Integration &Interfaces & Operational Architecture;	Design Parameters Tradeoff &Feedback

Conceptual Architecture

- The conceptual architecture is a high level abstraction of the requirements.

  Virtual Simulation provides insights into the conceptual architecture.
- It is obtained by partitioning the requirements based on the stakeholders needs, concerns, and requirements.
- The conceptual architecture establishes the system/enterprise design requirements based on: Input/Output, Performance and cost tradeoffs, and mission analysis.
- Proof-of-concept experiments are used to support the Conceptual Architecture.

* In software engineering conceptual architecture can be derived from "use cases", scenarios, and activity diagrams.

Functional/Logical Architecture

- The **functional architecture** contains the system functions, configuration units, building blocks and components. It is represented by a directed network.

- It is a logical representation of what the system must do ?, it provides a decomposition of the system objective. Physics-based simulations give insights into the functional architecture

- A logical model of transforming inputs into outputs using control information-flow throughout the functional decomposition. It defines the functions and the data flows.

- It is derived using an IDEF0 model, FFBD, DFD, or "OO" UML methodology.

** Functions express activities, actions

*** Form follows function, Physical follows functional

*** Fit follows form which follows function: **Function, Form, Fit**

Functional Decomposition

- Several system features are used to partition a system into building blocks

(1) At the top level systems operate in modes. Modes lead to partition the system into subsystems.

(2) Each subsystem is partitioned into modules based on grouping of functions.

(3) Modules that have multiple inputs and outputs are partitioned by tracing the input to the output to establish the function.

(4) Partition each function block into subfunctions: Circuits/Applications.

(5) The lowest level of the functional architecture identifies devices and activities such as, transmit output, receive input, store output, format input, amplify input.

Relationship Among DODAF Views

The operational view provides the information exchanges, interoperability levels, and performance parameters required to support a mission or task

The systems view defines system attributes, and provides the basis for comparing system performance against operational requirements.

The technical view defines the standards to the implementation criteria for fielding an interoperable system.

The three views and their interrelationships are designed for deriving measures such as interoperability, performance and measuring the impact of these metrics on operational mission and task effectiveness

Many data elements of the products are used in more than one product and there are several mapping relationships between products.

Integration and Interfaces Architecture

- **Integration is a** bottom-up process of assembling the system from its components. Engineering-Based simulations and mockups provide **insights** into the integration and interfaces architecture.
- Integration is a hierarchical process. At the top level, it is the merging of subsystems functionally and physically. At the subsystem level it is the merging of modules functionally and structurally.
- Integration and Interfaces Architecture merges the functional, physical, and conceptual architectures.
- Interfaces are critical parts of the systems.
- Interoperability is based on system-to system interfaces; it is a major driver in architecting SoS& FoS.

Operational Architecture

- The operational architecture brings together through scenarios the requirements decomposition (conceptual architecture) with the **functional**, physical, and **integration and interfaces** architectures.
- Scenarios are used to develop the operational architecture. It identifies the system's internal and external interfaces, connectivity, and nodes.
- It provides sufficient details to evaluate system performance, performance tradeoff analysis, and risk analysis.
- Operational architecture describes the **mission, tasks, operational elements**, and information flows required to accomplish or support system functions
- It is concerned with interoperability and human interfaces. It defines and analyzes functional activation and control structure. Engineering-Based Simulation provides insights into the operational architecture.

Integration and Interfaces Architecture Continue

- Interfaces are connections for tying the system parts to each other, and creating new functions and nodes.
- There are internal interfaces of merging one system part to another. External interface is the connection of the system to another system- Interoperability.
- Integration and interfaces are united activities in building systems.
- Interfaces are the basic building blocks of the system integration process.
- There are several types of interfaces: Electrical, logical, physical, environmental, communications, thermal, social (human interfaces).
- Interfaces are the mathematical intersections of the interacting functions that create new functions, or activities. .

Products of Architecture Views

- Each view is described by a set of products, e.g., graphics, diagrams, tables, scripts.
- Each product contains “data” that describes some aspect of the architecture, e.g., functionality, structure, connectivity.

Issues:

(1) Are the products consistent?

(2) What are the relationships among the products?

(3) Does the group of products contain all the information that define an architecture?

Products of Architecting

- Architecting is a key upfront activity and is strongly tied to the customer and user (stakeholder).
- Architecting is a major part of the definition and design phase of the Systems Engineering Process
- **Architecting Products To Systems Engineering**

(1)Provide visualization of needed capability based on requirements
(2)System Conceptualization and Innovation
(3)Interfacing with stakeholders
(4)Provide Architecture Framework: DODAF
(5)Generate and balance operational views and systems views
(6)Identify Standards
(7)Provide capabilities road-map
(8)System partitioning: functional, Physical, Logical, and Operational
(9)Define System boundaries
(10)Identify tradeoffs space: Cost, Capability, Support, Reliability, availability, and Risk
(11)Identification of interfaces (external and internal)
(12)Modeling/operation analysis

Products of Systems Engineering

System Definition, Design, Development/Production, Deployment, and Disposal.

(1)Visualization of what a system should look like: Engineering the System

(2)Tradeoff studies – AOA - CE, CB, Risk

(3)Requirements decomposition/Functional Decomposition, traceability

(4)System and design specification, and Configuration Management

(5)Detailed system analysis and identification of capability drivers

(6)Detailed system partitioning

(7)Detailed System integration and interfaces; codesign issues

(8)System Acquisition

(9)Resource allocation (scope)

(10)Integrated Logistics Support (ILS)

(11)Select metrics: MOEs, MOPs

(12)Data exchange and collaboration

(13)Test and Evaluation Plan

(14) Management of the Systems Engineering Process

Systems Engineering Attributes

- Systems Engineering is the integrating mechanism across the technical efforts related to the design, development, acquisition, integration, manufacturing, verification, deployment, operations, support, disposal, and user training of systems and their life cycle processes.
- Systems Engineering develops technical information to support the program management decision-making process in meeting: Cost, Schedule, Performance and Risk.

“ALL Views”
Two Views

Framework View	Product Name	General Description
AV-1	Overview and Summary Information	Purpose, scope, stakeholders, user, environment description, analytical assessment
AV-2	Integrated Dictionary	Data repository with definitions of terms used in all products

Operational View
Nine Views

Framework Product	Product Name	General Description
OV-1	Graphic high Level Operational Concept	**High-level graphical & textual description of operational concept**
OV-2	Operational node Connectivity Description	Operational nodes, operational activities at each node, connectivity and information exchange need-lines between nodes
OV-3	Operational Information Exchange Matrix	Information exchanged between nodes, and the relevant attributes of that exchange
OV-4	Organizational Relationship Chart	Operational role, or other relationships among organizations
OV-5	Operational Activity Model	Capabilities, operational activities, relationships among activities, inputs, and outputs. May show cost.
OV-6a	Operational Rules Model	Describes sequence and timing of operational activities - identifies business rules that constrain operation
OV-6b	Operational State Transition Description	Describes sequence and timing of operational activities identifies business process response to events
OV-6c	Operational Event Trace Description	Describes sequence and timing of operational activities traces actions in a scenario or sequence of events
OV-7	Logical Data Model	Data requirements documentation and structural business process rules of the Operational View

Systems View
Seven Views

Framework Product	Product Name	General Description
SV-1	Systems Interface Description	Identification of systems nodes, systems, items, and their interconnections within and between nodes
SV-2	Description of Systems Communications	Systems nodes, systems, and system items and their related communications lay-downs
SV-3	Systems-Systems Matrix	Relationships among systems, system-type interfaces Planned vs. existing interfaces
SV-4	Systems Functionality Description	Systems Functions and data flow among them
SV-5	Operational Activity to Systems Function Traceability Matrix	Mapping systems to capabilities, functions and Operational activities
SV-6	Systems Data Exchange Matrix	Systems data elements exchanged between systems and the attributes of that exchange
SV-7	Systems Performance Parameters Matrix	Performance characteristics of elements for a given timeframes)

Systems View
Six Views

Framework Product	View Name	General Description
SV-8	Systems Evolution Description	Planned migration of systems to more efficient suite, or Evolving a current system to future implementation
SV-9	Systems Technology Forecast	Time table of emerging software & hardware products Technologies and that will impact future architecture
SV-10a	Systems Rules Model	Describes systems functionality constraints due to some aspect of systems design or implementation
SV-10b	Systems State Transition Description	Describes systems functionality: identifies responses of a system to events
SV-10c	Systems Events Trace Description	Describes systems functionality: identifies system changes due to critical sequences of events of the Operational View
SV-11	Physical Schema	Physical implementation of the Logical Data Model entities: message formats, file structure, physical schema

Technical Standards View Products Two Products

Framework Product	Product Name	General Description
TV-1	Technical Standards Profile	Listing of standards that apply to System View elements in a given architecture
TV-2	Technical Standards Forecast	Description of emerging standards and potential impact on current System View Elements within a set of timeframes

Tailoring the Views

- Not all software architectures need all five views. Not relevant views can be omitted from the architecture description. For example, the physical view can be omitted if there is only one processor, also, the process view can be omitted if there is only one program. For very small system it is possible to merge the logical with the development view.
- Similarly, in the DODAF not all views are essential. In general, AV-1,AV-2, Ov-1,OV-2,OV-3, SV-1, and SV-4 are essential. The remaining products are supporting views.

Logical Software Architecture & Process Software Architecture

- The Logical Architecture supports the functional requirements; it describes the “Object Oriented” system decomposition using: Class, Collaboration diagrams and the sequence diagram.

- The Process Architecture gives Process partitioning into Tasks; it describes how processes communicate and interact. It accounts for the nonfunctional attributes: performance, availability, reliability, security, and scalability. Activity diagrams are used to describe this view

Development Software Architecture

- The Development Architecture describes the actual software modules of the system and its interaction with the environment. Packages, subsystems, and class libraries are considered modules.
- The Development view gives the layers of the system:

  (1) User Interface layer,

  (2) Presentation layer,

  (3) Application Logic,

  (4) Business Logic.

* The Development Architecture is given by module and subsystem diagrams.

Physical Software Architecture

- The Physical Architecture is a mapping of Software onto the Hardware. It describes how the applications are installed into the hardware, and how it executes in a network environment. It takes into account the non-functional requirements of the system: reliability, performance, availability, reuse, scalability. Deployment diagrams are used to represent the Physical Architecture.

The “Plus One” View
Use Case Architecture

- The Use Case View is putting it all together. The elements in the four views are shown to work together by using a set of scenarios. The scenarios are abstractions of the most important functionalities (requirements). Scenarios are expressed by using Objects and Interaction diagrams

General formula of Interfaces

The total number of interfaces: (2^n – n – 1)

The number of second order interfaces: $C_2^n = \frac{n!}{(n-2)!\ 2!}$

The number of third order interfaces : $C_3^n = \frac{n!}{n(-3)!\ 3!}$

The total number of possible outcomes:

$$2^n = \sum_{m=0}^{n} C_m^n$$

** A System that contains all intersections is called Logically Integrated

Digital Data Management
An Update

NDIA Systems Engineering Conference
San Diego, California – October 2005

Cynthia C. Hauer
Millennium Data Management, Incorporated
Huntsville, Alabama

AGENDA

- Looking back
- Framing the issues
- Elements of the solution
- Cause and effect
- Panacea versus process
- The way forward

Challenges, Questions, and Solutions

DM Definition

Data management is the structured processes and systems that plan for, acquire, and maintain data, consistent with requirements, throughout the data life cycle.

ANSI-859

Data Management Functions

- Identification/Definition
  - Data Requirements, Life cycle Needs
- Preparation
  - Internal and External Data
- Control
  - Document control processes
  - Import/Export of data
  - IP, proprietary, limited access
  - User authorizations, use requests
  - Master Lists
  - Data Marking
- Dispositioning
  - DMP
  - Delivery (digital or physical)
- Archival
  - Project files, decision data, data retention

Changes were required in the approach range, and the methods for the DM functions

Looking back

- DM was mandated in the 1960's by Congress and the DoD
- Original intent
  - Eliminate redundancy of data production and storage
  - Centralize systems use
  - Acquire only specific data for deliberate, planned, and specified use

Background

- DM evolved out of DoD and Congressional concerns (circa 1960)
  - $$$ being spent on technical data and no one knew how much
  - Available $ was not being spent effectively
  - Much of what was being acquired was unnecessary, redundant, and obsolete
  - DM was an expensive resource that was not being managed wisely
  - Finally – no one knew what was being purchased, ordered, or used, anyway
- Industry complaints increased re: the number and variety of management systems being imposed on them in development and production contracts
  - Data was pushing up the cost of contracts
- Perception was that DoD was attempting to increase and maintain control of contracts by requiring even more information
  - And no one knew what the originally acquired data really was, what it supported, and what anyone was doing with it
- Perception: the necessity for some of the management systems and the supporting data was questionable and unclear
  - Some elements required and acquired the same things in different ways
  - Some DoD systems required generation of data that was already available in the contractor's own internal data systems

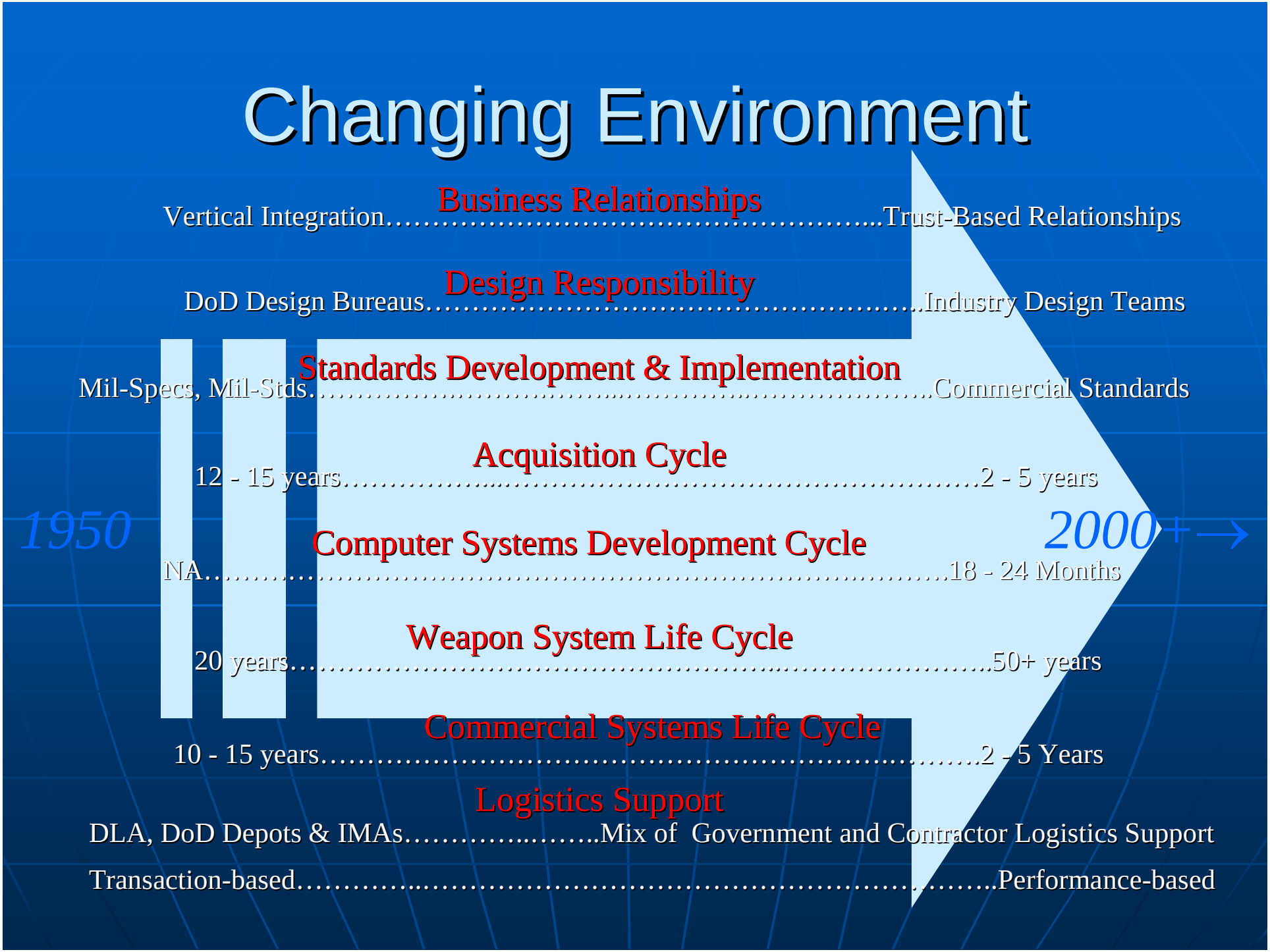
So What Has Changed?

The problem is more pressing

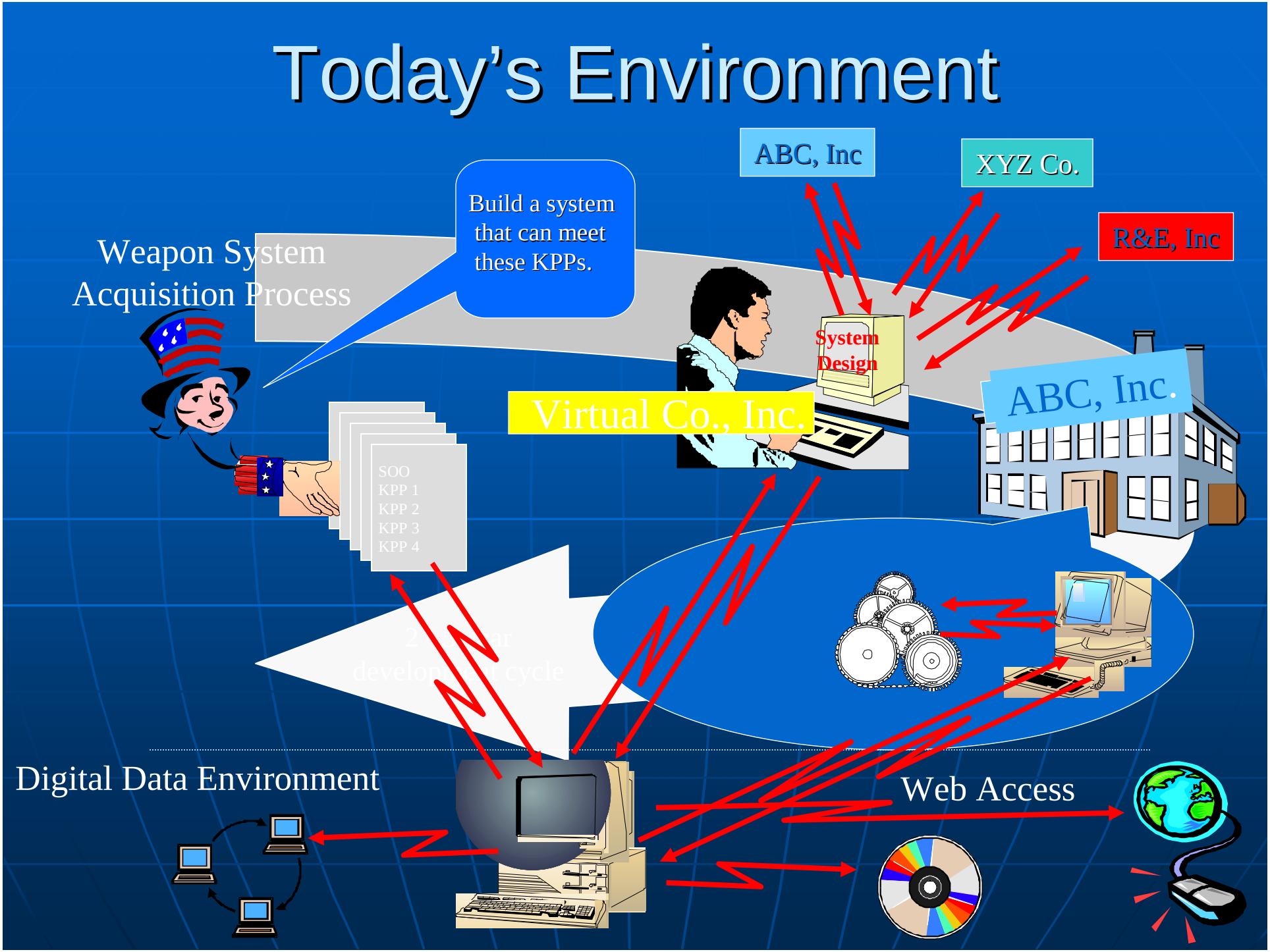
- More data than ever
- Less money than before
- Business model revolution
- Best practices rule
- Transaction and decision time is compressed
- Network centric strategies

And “technology” is not the solution

Changing Environment



Today's Environment

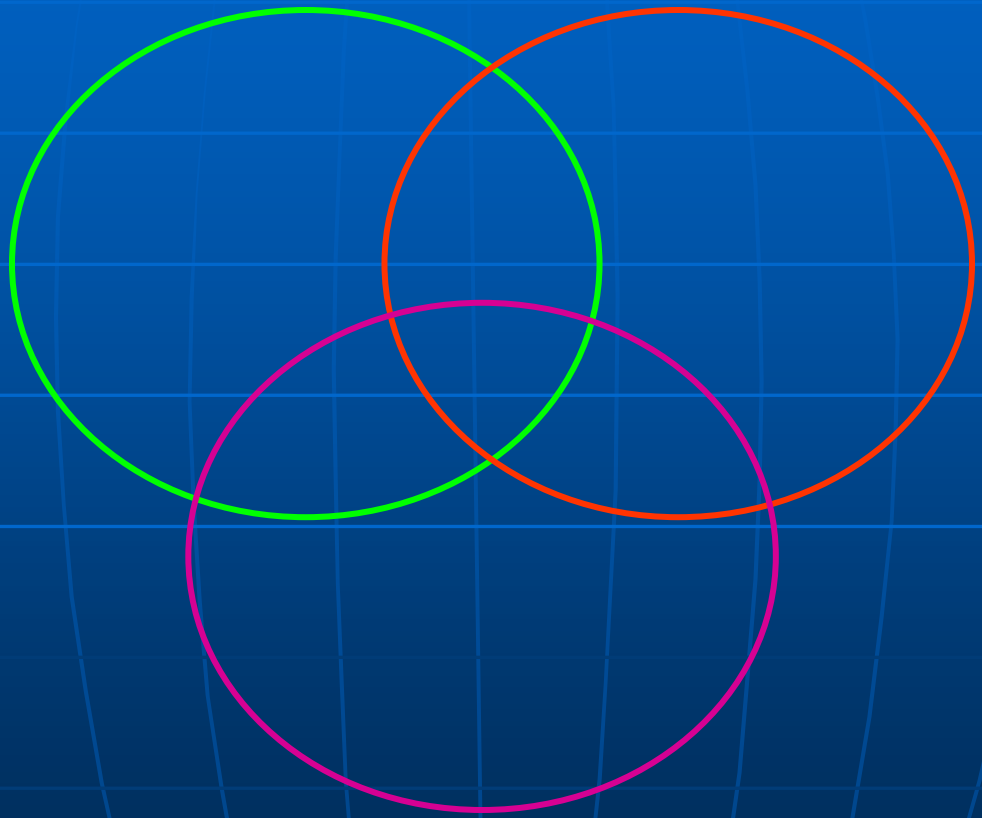


Data Management "Solution":

Three Primary Areas - Principles, Practices, and Training

Principles

- Basic tenets and values
- General



Practices

- Implementation specifics
- Organization-specific

Training

Basic and Advanced
(PM and Practitioner)

Data Management "Solution:" continued

Three Primary Areas - Principles, Practices, and Training

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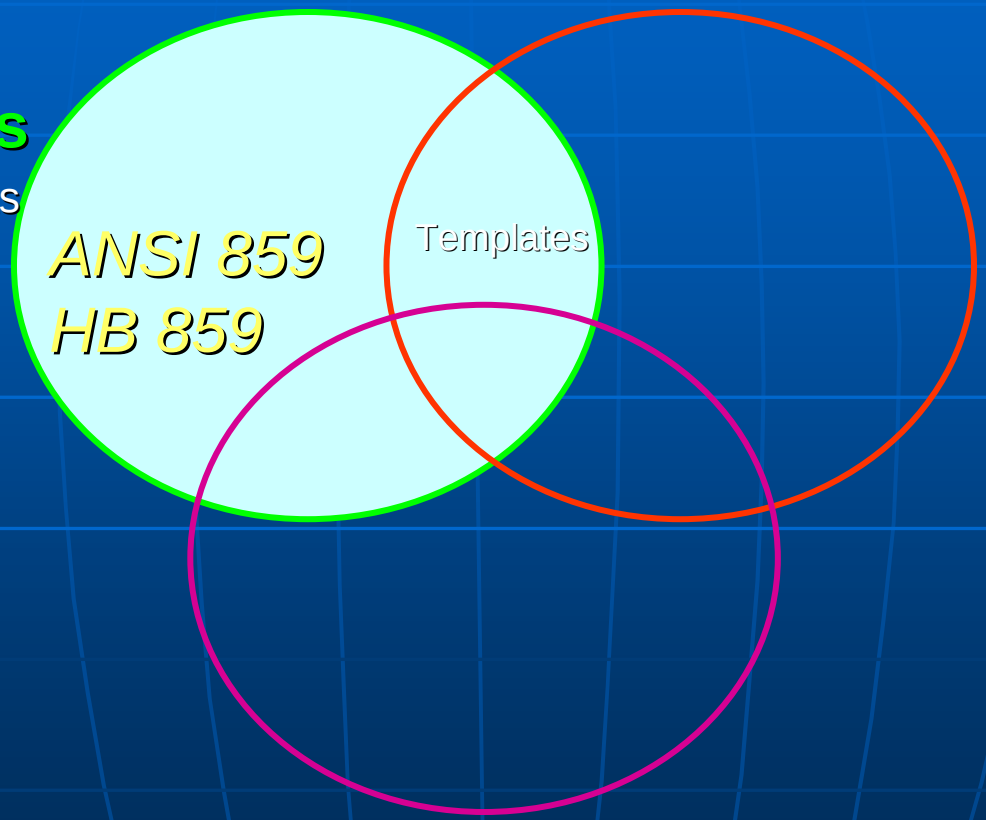
- Basic tenets and values
- General



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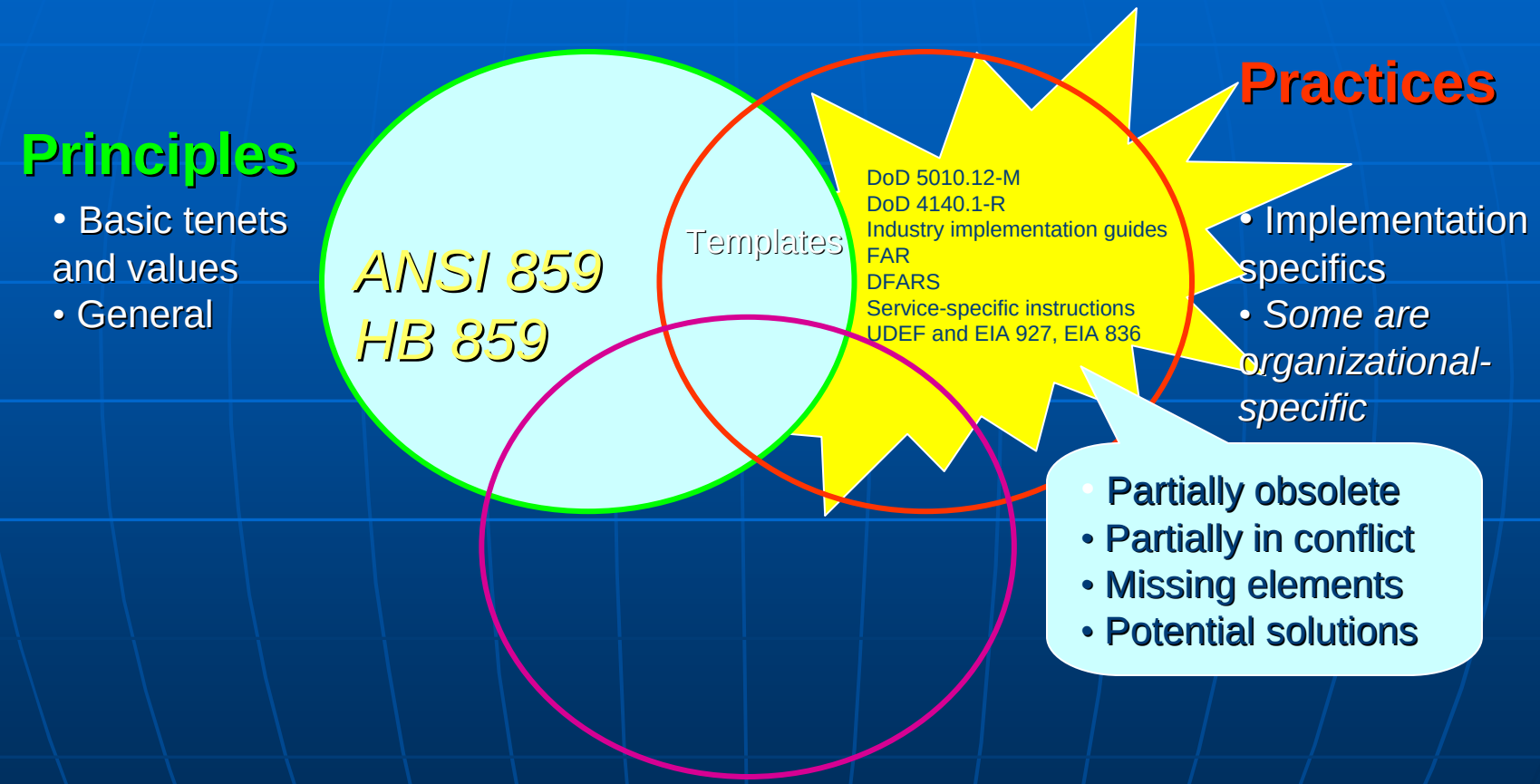
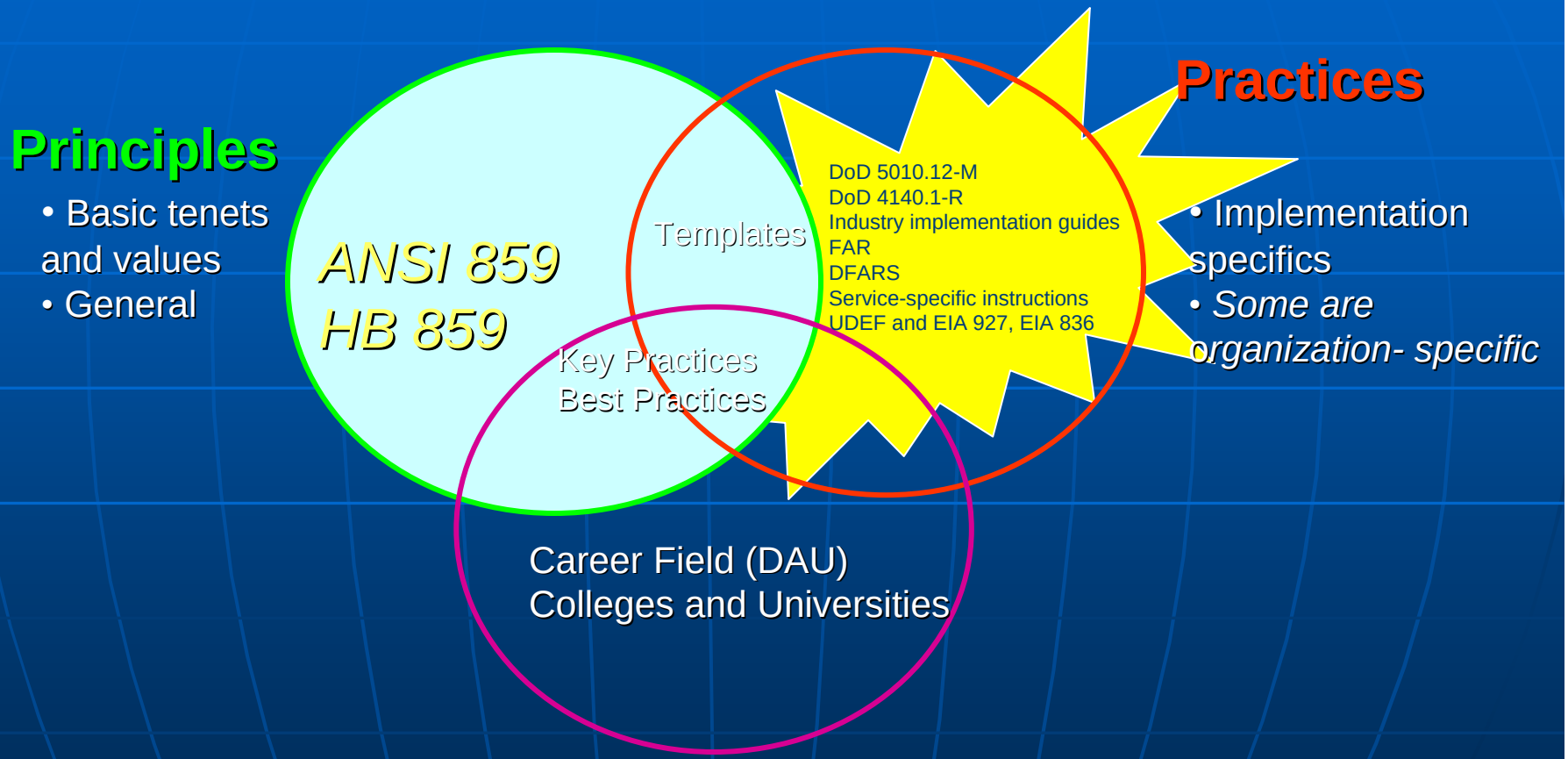
Data Management "Solution," continued

Three Primary Areas - Principles, Practices, and Training



Data Management "Solution," continued

Three Primary Areas - Principles, Practices, and Training



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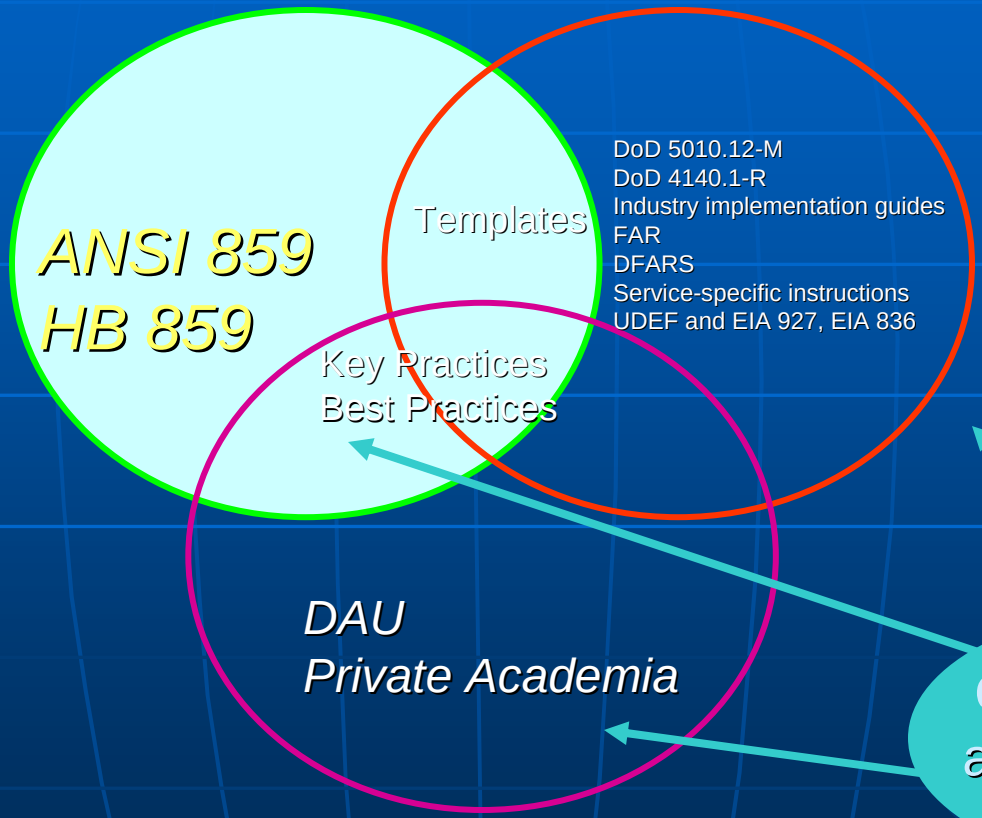


DoD 5010.12-M
DoD 4140.1-R
Industry implementation guides
FAR
DFARS
Service-specific instructions
UDEF and EIA 927, EIA 836

Practices

- Implementation specifics
- Some are organization-specific

Complete solution addresses all three areas

Training

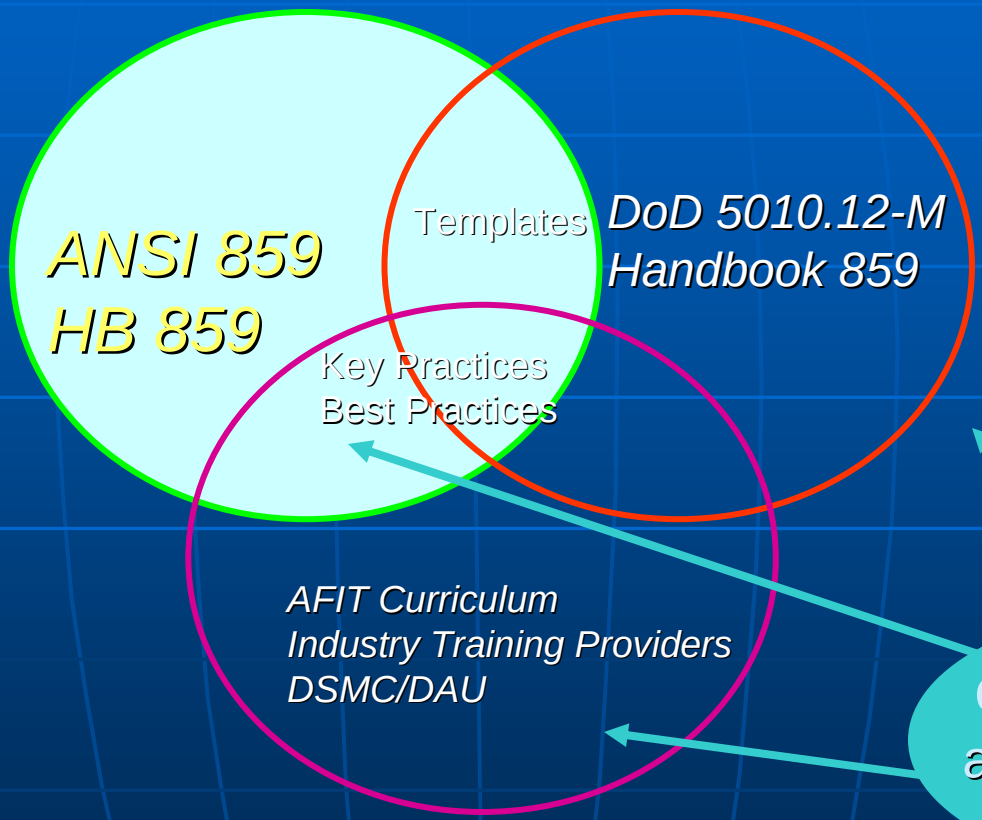
Basic and Advanced
(PM and Practitioner)

Data Management "Solution," continued

Three Primary Areas - Principles, Practices, and Training

Principles

- Basic tenets and values
- General



Practices

Training

Basic and Advanced
(PM and Practitioner)

Complete solution addresses all three areas

Panacea versus Process

- Adjusting the approach, not
  - Allowing it to stalemate unresolved
- Clarifying the objectives/role for DM, not
  - Wasting more money, on more data that is not required, and driving up costs, as well
- Allowed DM to make a contribution, not
  - Continuing to ignore the obvious problems for all parties
- Enabled paradigmatic changes in “acquisition”, and extended them to “logistics” not
  - Ignoring the obvious cause and effect between data and end-item costs in contracting
  - Discouraging commercial suppliers from contributing high-end, niche end items
  - Allowing contractors to do business as usual

Structuring outcomes

- Addressed challenges
- Identified disconnects
- Created solutions
- Established relationships
- Crafted an accepted and value-added role
- Built credibility and acceptance

Strategic Data Management

The way forward

- Process first! then automation
- Sequencing the “push/pull” correctly
- Creating intentional, understood outcomes
- Strategic thinking
  - Enterprise focus

Challenges for the DM Practice

- Consistency
  - Expectations and practice
- Communication
  - Internal and external
- Training
  - Practitioners and other disciplines
- Synchronizing USG and industry effectively
- Finding our way towards reintegrating with associated domains

Summary

- DM goals, need, and requirements are the same as they were in 1960
- Urgency to transition DM to the digital environment increased
  - And we met the challenge
- Recognized pathway and importance for resolution identified and found
- ANSI-859 is the beginning
- Handbook 859 is complete
- DAU courseware development is underway

Implementing Systems Engineering Processes to Balance Cost and Technical Performance

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October 26, 2005

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Continuous and Effective Program Performance Sustainment in Multi-Year System Engineering Programs

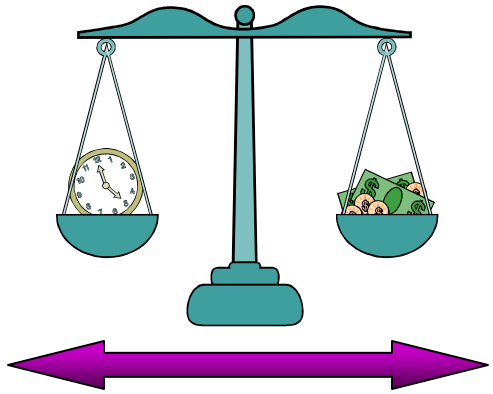
Critical Program Performance Challenges….

- Large scope technical services and products programs are intended to provide wide range of service levels and product maintenance support over 5 – 10 years.
- Sustaining multi-year technical service and product support levels is impacted by increases in costs, staff transitions and changing customer requirements.

Candidate Engineering Solution…..

- Sustaining service levels and technical performance at planned costs is facilitated by applying SE Vee life cycle model to engineer a support framework across the program.
- This support framework is used to balance the costs of maintaining program infrastructure functions and technical resources with the costs of achieving program performance goals.
- Application of the practices in the CMMI® Process Areas (PAs) are used across the program and projects to implement the relevant phases in the SE Vee model.

Challenges in Balancing Cost and Technical Performance



Time Factors

Realistic understanding of continually evolving customer environments

Developing and implementing validated techniques to balance cost and performance

Availability of global rapidly emerging technologies

Impact of operational changes

Life cycle planning

Cost Factors

Exponential increase in costs downstream

Mismatch in technical performance requirements versus program budget

Inflexible, non-scalable designs

System requirements obsolete before deployment

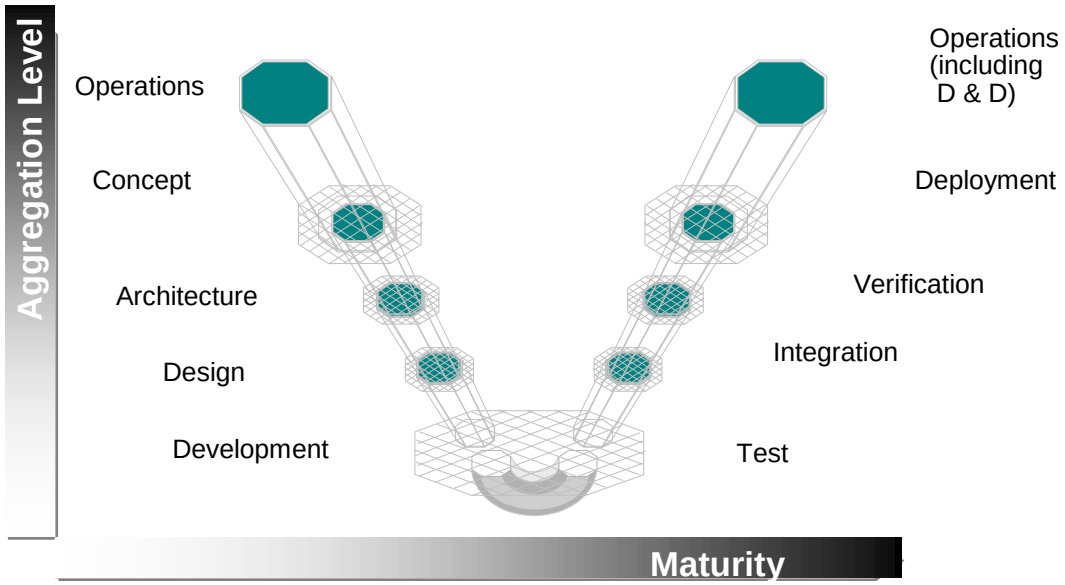
O&M infrastructure costs vs. service levels

Constructing the Program Performance Framework Using the SE Vee and CMMI Practices

Guidance….

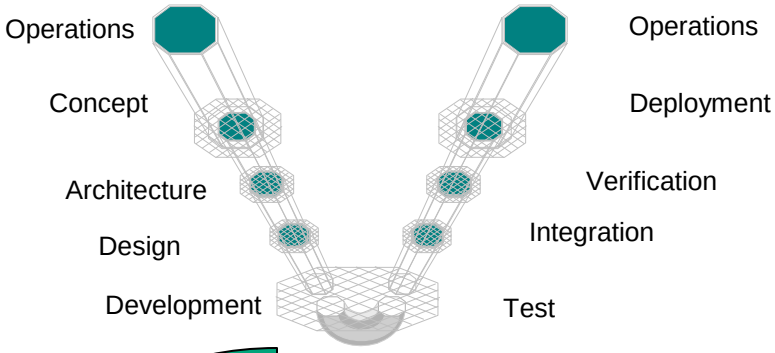
- Focus on defining business goals and related measurements for the **entire** period of program performance.
- Plan and implement SE Vee model in projects across the organization sooner rather than later as retrofitting is difficult.
- Focus on measurement processes on forecasting yearly costs, required technical performance levels and program support levels.
- Engineer a process performance framework using the set of SE activities represented in the SE Vee.
- Apply SE tools and techniques, such as alternative evaluations, performance simulations, requirements definition and risk analysis across the infrastructure functions as well as technical services using practices in the CMMI.

About the SE Vee Model



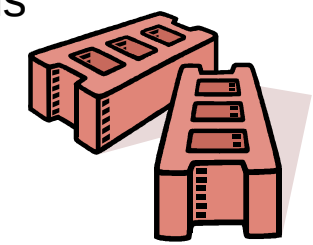
- The SE Vee Life Cycle Model presented to the Texas Board of Professional Engineers, 1999, by Arunski, Martin, Brown and Buede.
- The phases in the Vee are traditionally applied to engineering products and services such as weapons systems, communications networks and technical support.
- In any program, phases in the Vee may not be performed or applicable or may exist in numerous projects at different times.
- Key infrastructure functions, such as finance, contracts, and HR benefit from implementing the same engineering discipline and activities as technical projects.

Engineering of Process Performance Models



"Vee" Activity	Example Critical Support Functions
Operation	Resources (space, accounting, BP systems)
Concept	Business goals performance intervals
Architecture	Structure of business performance interfaces (receivables, quality measures inventory, growth)
Design	Performance constraints for cash flow, service level performance
Development	Increments to support planned site expansion

Engineering of Program Process Performance Models



SE Vee Phases

Operations

Concept

Architecture

Design

Development

Test

Integration

Verification

Deployment

Operations

CMMI Process Area Categories

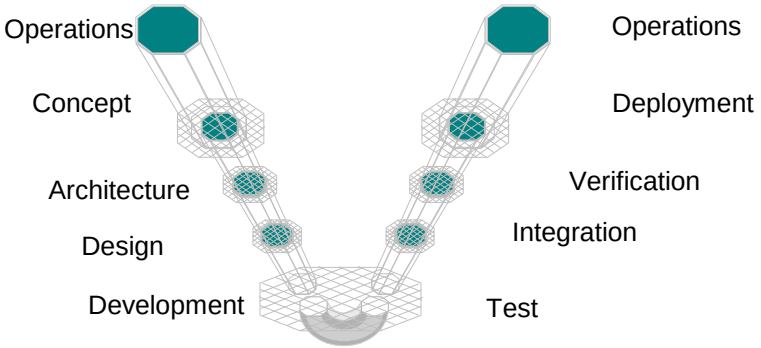
Project Management
(Project Planning, Project Monitoring & Control, Risk Management, Integrated Project Management, Integrated Teaming, Integrated Supplier Management, Quantitative Project Management)

Process Management
(Organizational Process Focus, Organizational Process Definition, Organizational Training, Organizational Process Performance, Organizational Innovation and Deployment)

Engineering
(Requirements Management, Requirements Development, Technical Solution, Product Integration, Verification, Validation)

Support
(Configuration Management, Process & Product Quality Assurance, Measurement & Analysis, Causal Analysis & Resolution, Decision Analysis & Resolution, Organizational Environment for Integration)

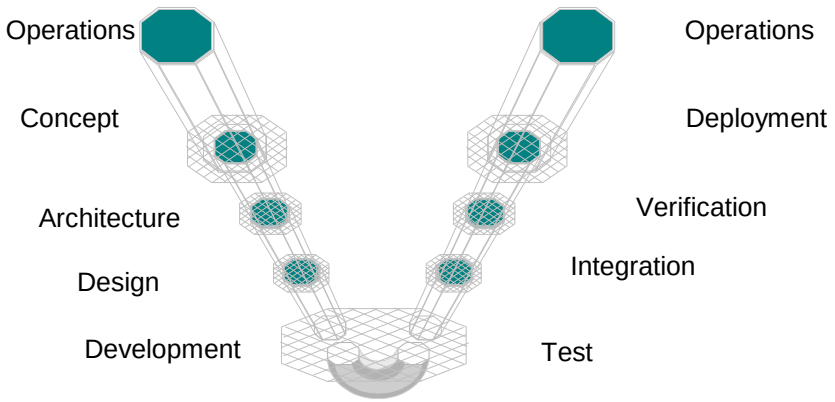
Engineering of Support Function Framework

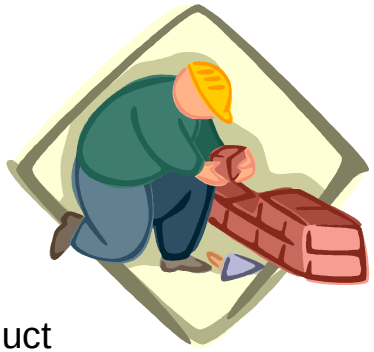


CMMI Product Suite

“Vee” Phase	**Example Key Support Functions**	**Key CMMI PAs**
Operations	Resources (space, BP systems, staffing levels)	M&A, PP, RSKM
Concept	Business goals performance intervals	M&A, RD
Architecture	Structure of business performance interfaces (cash flow, quality measures, inventory, growth, .etc.)	M&A, TS, PI
Design	Performance constraints for cash flow, service performance, staffing	M&A, RD, RM, TS
Development	Builds to support planned market and program expansion	M&A, RD, PP, RSKM

Engineering of Support Function Framework (Continued)



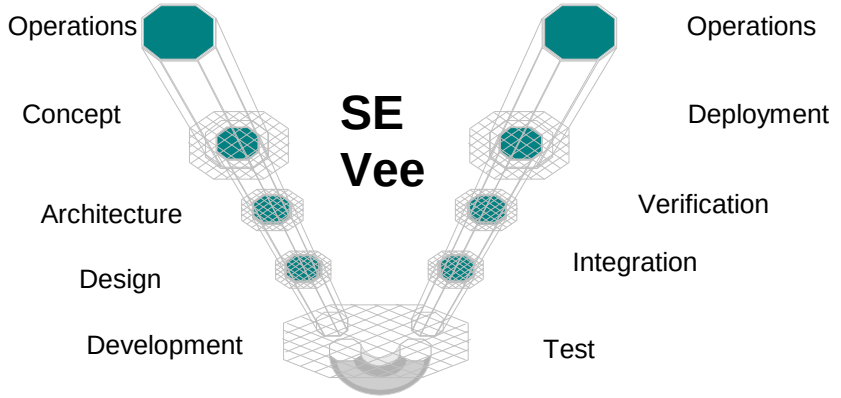


CMMI Product Suite

“Vee” Phase	Examples Key Support Functions	Key CMMI PAs
Test	Finance test scenarios and databases	M&A, VER, VAL
Integration	New interfaces of components (acquisitions) for growth goals, finance and HR functions	TS, PI
Verification	Invoicing and staffing processes	M&A, VER, VAL
Deployment	Perfective and adaptive maintenance of support functions	PP, PMC, TS
Operations	Forecasting of staffing and facilities costs	PP, PMC, QPM, OPP, OID

Overview of the SE Vee, CMMI Process Areas and Business Goals

CMMI
Product Suite



Key Process Areas
Measurement & Analysis, Project Planning, Project Monitoring & Control,
Risk Management, Quantitative Project Management, Organizational Innovation & Deployment,
Causal Analysis & Resolution, Decision Analysis & Resolution…

Practices

Program Business Goals

Support → **Technical** → **Customer Satisfaction**

Invoicing	Latent Defects	Customer
Procurement		Satisfaction
Contracts		
Staffing		

Case Study Example of Balancing Cost and Technical Performance in a Small Setting

Key CMMI Process Areas
Measurement & Analysis, Project Planning, Project Monitoring & Control,
Risk Management, Quantitative Project Management, Organizational Innovation & Deployment
Causal Analysis & Resolution, Decision Analysis & Resolution…

Practices

Program Business Goals

Support → **Technical** → **Customer Satisfaction**

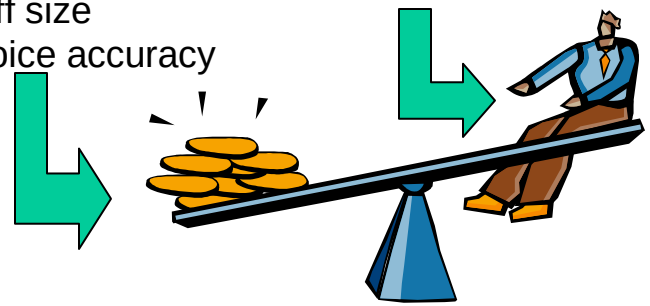
Key Measurements

Support	Technical	Customer Satisfaction
Invoicing Procurement Contracts Staffing	Latent Defects	Customer Satisfaction

Process Performance Intervals

Staff size
Invoice accuracy

Catches/Escapes



Customer Satisfaction

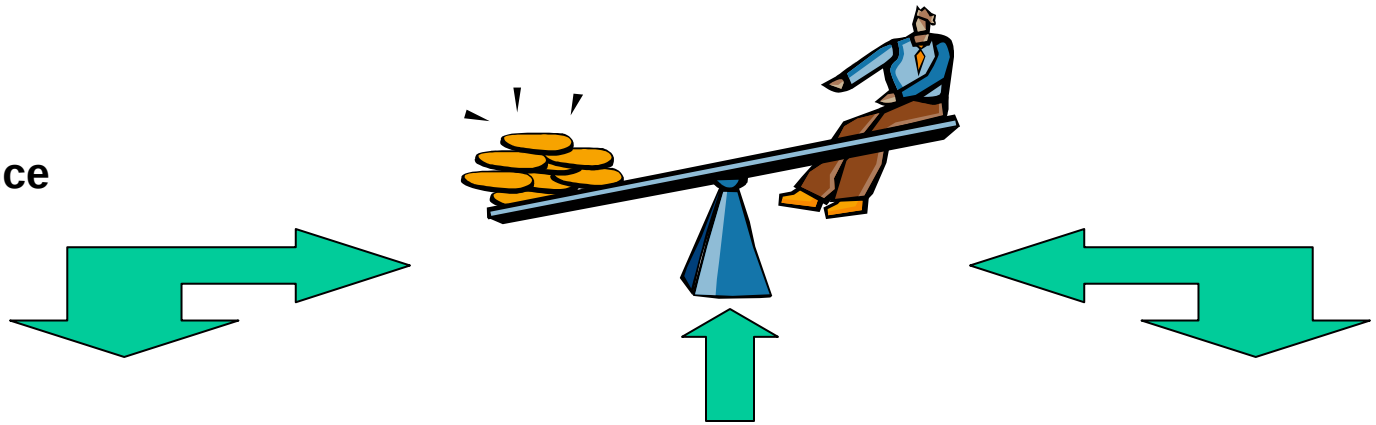
Case Study Example of Balancing Cost and Technical Performance in a Small Setting (Continued)

Program Business Goals

Support → **Technical** → **Customer Satisfaction**

	Support	Technical	Customer Satisfaction
Key Measurements	Invoicing Procurement Contracts Staffing	Latent Defects	Customer Satisfaction

Process Performance Intervals



-6.0% ≤ Staff Size Accuracy ≥ 9.0%
-8.1% ≤ Invoice Accuracy ≥ 6.5%

0 ≤ Latent Defects ≥ 3

4.5 ≤ Customer Satisfaction ≥ 5.0

Summary

Lessons Learned……

- ✓ The phases in the SE Vee provide a useful and applicable life cycle model for engineering of a framework to integrate management and technical practices across a program.
- ✓ The SE Vee is very adaptable to small settings and applies to support services, such as finance, contracts and HR.
- ✓ The practices in the current version of CMMI Process Areas cover a large percentage of the phases in the Vee.
- ✓ For best results, focus on first defining business goals and relevant measurements to implement continuous process improvement to achieve a balance of cost and technical performance via the CMMI.

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Application of Risk Management in a Net-Centric Environment

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Defense Information Systems Agency
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Traditional Risk Management

- **RISK is a measure of potential inability to achieve overall program objectives within defined cost, schedule and technical constraints**

- **RISK MANAGEMENT is the act of of dealing with RISK**

SOURCE: Risk Management Guide for DOD Acquisition, V2.0, June 2003

The Times … They are Changing

Stovepipe systems seek risk avoidance …

Controlled Environment

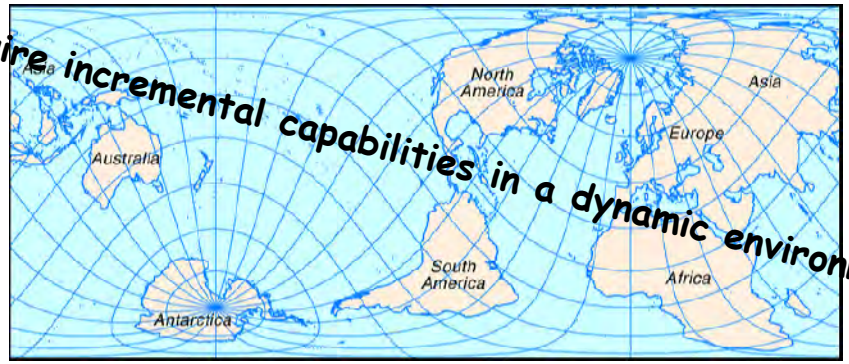
Build turn-key systems in a static environment

Risk Avoidance

Net-Centric Transformation

… An impossibility in era of Net Centricity – risk must be an accepted fact of life

Net Centric World Wide Web



Acquire incremental capabilities in a dynamic environment

Risk Management

Old risks have not disappeared and new risks abound

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Net-Centric Transformation

- **Old Information Systems World**
  - Systems oriented
  - Specific design requirements process (dream and develop)
  - R&D from scratch
  - Years spent developing entire system
  - Tightly integrated functionality
  - Test against perfection
  - System-Level Security
  - Obsolescence and disposal
  - Prescriptive Governance
- **New Net-centric World**
  - Services oriented
  - Functionality-based, “close enough” (see and use)
  - Greater use of COTS, especially for enterprise services
  - More focused on sustainability and scalable deployment
  - Dynamic functionality through composability
  - Security built in, with balanced risks
  - Living and adaptable
  - Collaborative governance

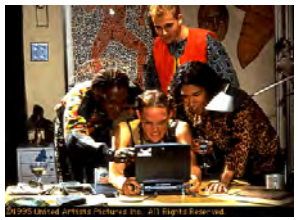
Net-Centric Environment raises different risk management challenges

How Is Risk Management Conditioned by Net-Centric Transformation?

- Emphasis on the use of COTS

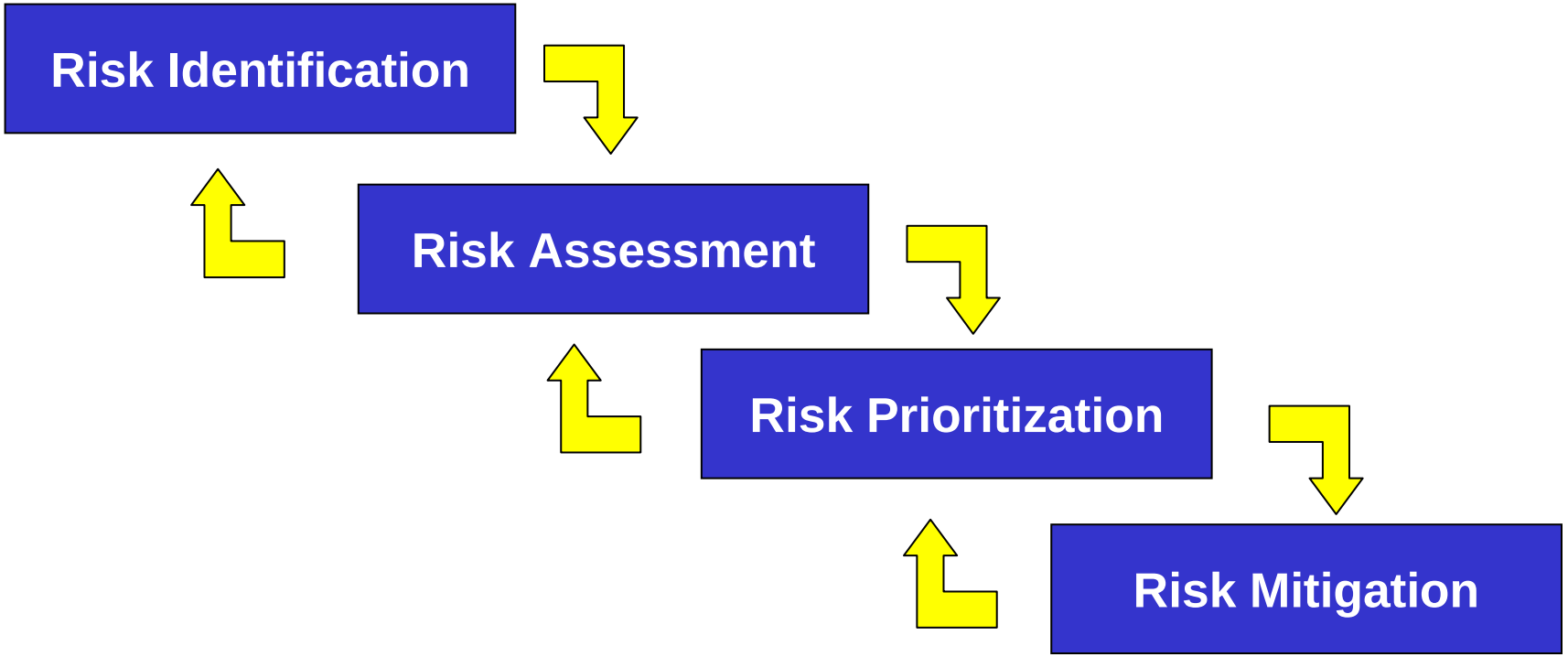
- Use of spiral, incremental capabilities development strategies
- Dynamic test environments

- Warfighter need for “early-to-market” product delivery
- Abbreviated Milestone development process
- Immediacy to vulnerability exploitation via web



All the above and more increase pressure on risk management mitigation strategies and tactics

Risk Management Process



How will Risk Management differ in the Net-Centric Environment?

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Notional Risk Framework for Net-Centric Environment

- **Technological Risk**
  - Standards maturity
  - Vendor products stability and interoperability
  - Scalability
  - Security challenges
- **Deployment/Provisioning Risk**
  - Predicting results of service composition
  - Testing and certification of services
  - Service Release management
  - Blend of managed services from others and own-provided services
- **Business Risk**
  - New contracting models and incentives (not LSI)
  - Cost projection not focused on development/fielding cost
  - Cost-recovery models for services
  - Market effect and agility to mature services based on usage
  - Do we understand the marketplace? Who is offering competing services? How much usage is "our" capability module getting?
- **Organizational Risk**
  - System engineering process – adapted to services model
  - Risk management process – aligned with outcomes
  - Governance process
  - Life cycle management
  - Staffing / skills / experience matches
  - Right partnerships? With industry? With other government organizations?

Capability-Based Acquisition

- Focus on outcomes linked to operational use
- Less constraining requirements place more decision options with program

Systems Engineering for Net-Centricity

- Concurrent engineering of multiple material solutions/delivery models
- Rapid fielding, agility, and service refresh must be enabled (not constrained)

Challenge: Not Just Cost, Schedule, Performance …

Risk Assessment for Net-Centric Environment

- **Traditional approaches still apply**
  - **Probability of occurrence**
  - **Severity of impact of occurrence**
- **But, …**
  - **Complexity or displacement may mask effective valuation**
  - **"Contract, buy, build" decreases emphasis on development control factors (schedule and cost) and increases emphasis on performance and utility**
  - **We must learn to quantify risk in the face of more degrees of uncertainty**
    - **Looking for sources of lessons learned**
    - **Early adopters, pilots, commercial lessons learned, academic study?**

Challenge: Credible valuation must be the foundation - We don't know what we don't know

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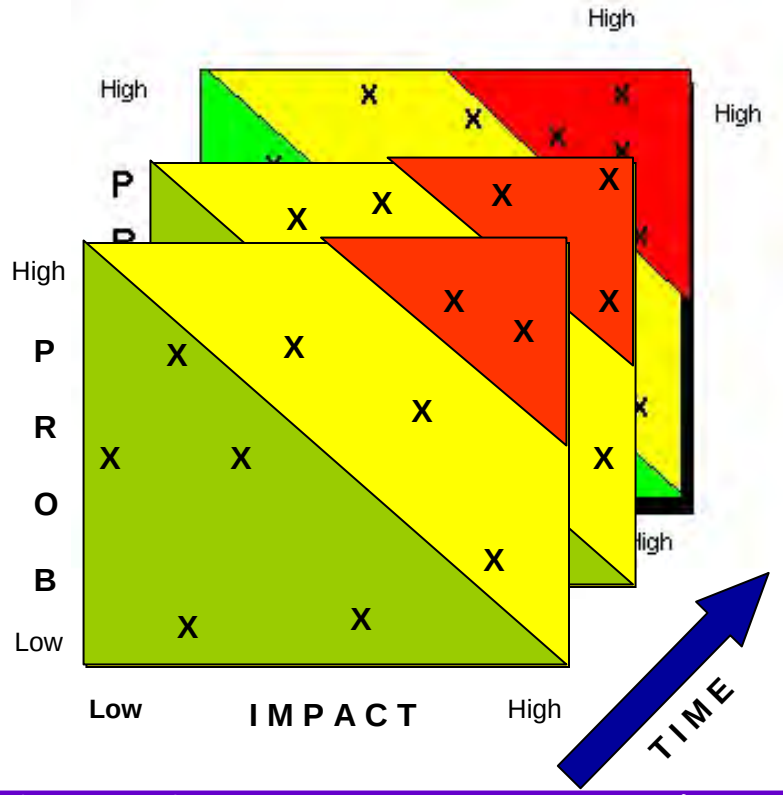
Risk Prioritization for Net-Centric Environment

- **Prioritization: Use of a decision framework that identifies and prioritizes risks, such that**
  - **Risks with greatest impact and the greatest probability of occurring are handled first**
- **But …**
  - **Expand risk model elements**
  - **View multi-dimensionally**
  - **Devise new metrics for prioritizing risk**
  - **Results may revise material solutions and Acquisition Strategy**



Challenges: Optimize ROI / Link Risks to Strategy / View risks in aggregate

Risk Mitigation for Net-Centric Environment

- **Prioritization identifies highest-impact targets for risk mitigation**
- **Decision-makers must then lay out options for risk mitigation and consider resource investment, before choosing a course of action**
  - **Traditional Risk Mitigation options**
    - **Risk avoidance (traditionally, our first option)**
    - **Risk transfer/distribution to another party, e.g. contractor**
    - **Reducing negative effect of risk**
    - **Accepting consequence of risk**
  - **New business models may offer new options, or change our perception about acceptable mix of options**

Challenge: Finding new balance between risk mitigation and risk assumption

Summary

- Dynamics of net-centric environment put different pressures on risk management
- Old risks have not disappeared and new risks abound
- Emphasis shift from risk avoidance to risk management
- New dimensions to consider beyond cost, schedule & performance
- Need to continually revisit key decisions to assure they still apply
- Unknowns still to be investigated, studied and discussed
- Challenges remain in understanding complexities and implications of net-centric and service oriented architectures …

Net-Centric Risk Management process …
Challenges to address

Challenges

- **Risk Identification: Expanding the framework beyond Cost, Schedule, Performance …**
- **Risk Assessment: Credible valuation is the foundation - We don't know what we don't know (but we need to learn quickly!)**
- **Risk Prioritization: Still need to optimize ROI – CBA demands that we also link risks to materiel solutions strategy**
- **Risk Mitigation: Risk-averse culture must balance risk mitigation and risk assumption**

DEFENSE INFORMATION SYSTEMS AGENCY

Improving M&S Support to Acquisition:

A Progress Report on Development of the

Acquisition M&S Master Plan

Fred Myers, OUSD (AT&L) DS/SE
Jim Hollenbach, Simulation Strategies, Inc.,

NDIA Systems Engineering Conference
26 October 2005

Introduction

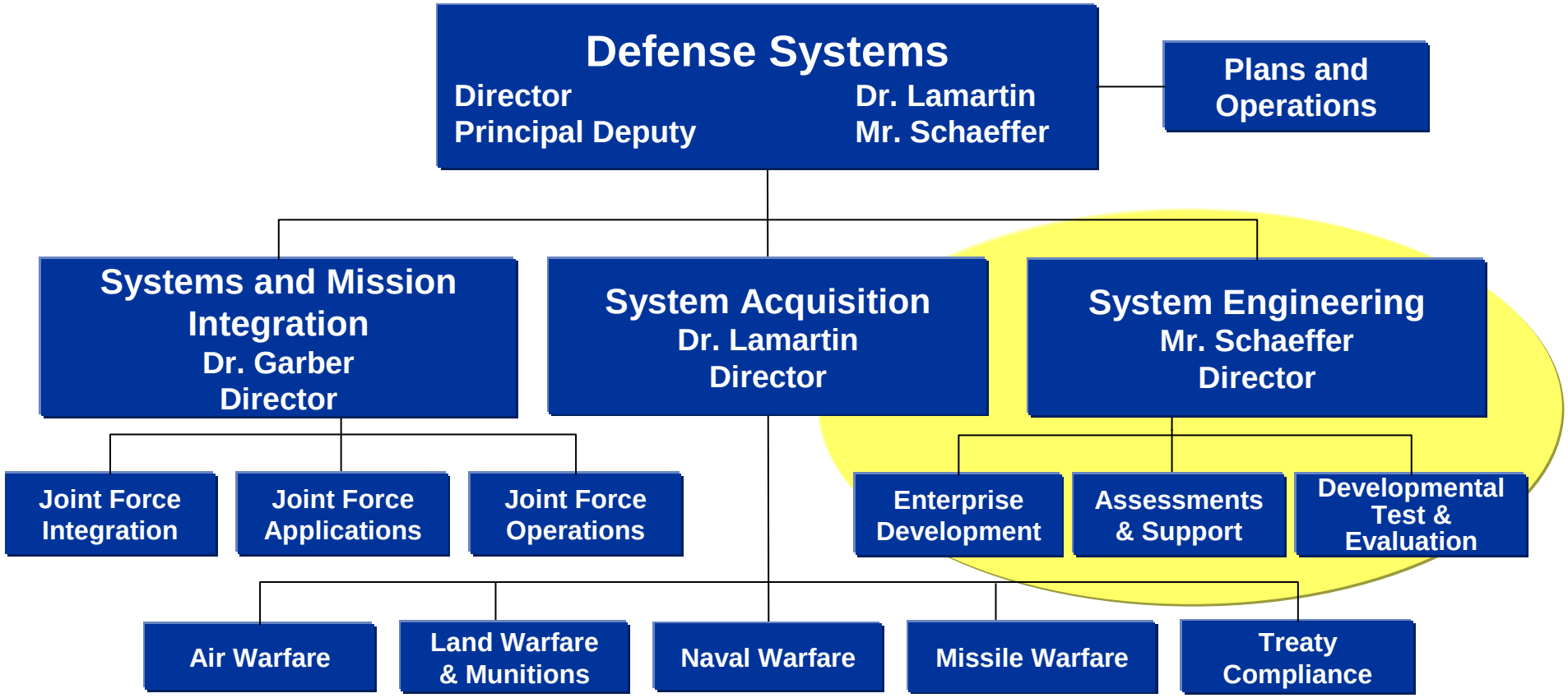
- This presentation key aspects of the emergent DoD Acquisition M&S Master Plan
  - Background
  - Process
  - Draft action set
- Questions and comments are invited here as time permits
- NDIA M&S Committee meeting 1445-1730 Thursday to answer remaining questions and discuss your change recommendations
  - All are welcome to attend

Senior Leadership Imperatives

Under Secretary of Defense for Acquisition, Technology and Logistics:

- "Provide a context within which I can make decisions about individual programs."
- "Achieve credibility and effectiveness in the acquisition and logistics support processes."
- "Help drive good systems engineering practices back into the way we do business."

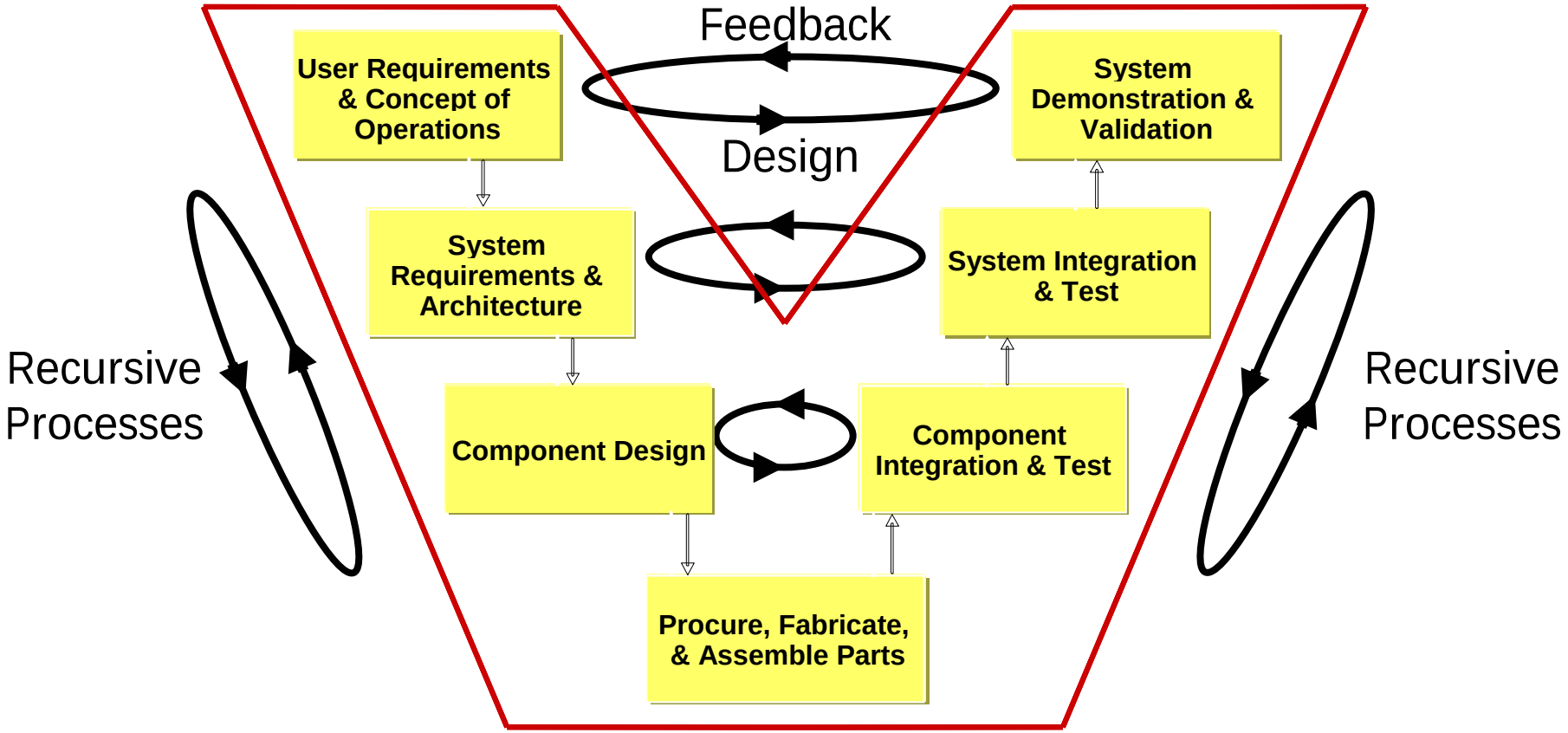
Response: Establish an SE Office
Defense Systems Directorate, OUSD(AT&L)



An integrated structure to develop capability

M&S is a Necessary Part of Acquisition

M&S is broadly useful to enable systems engineering throughout a system or S-o-S life cycle

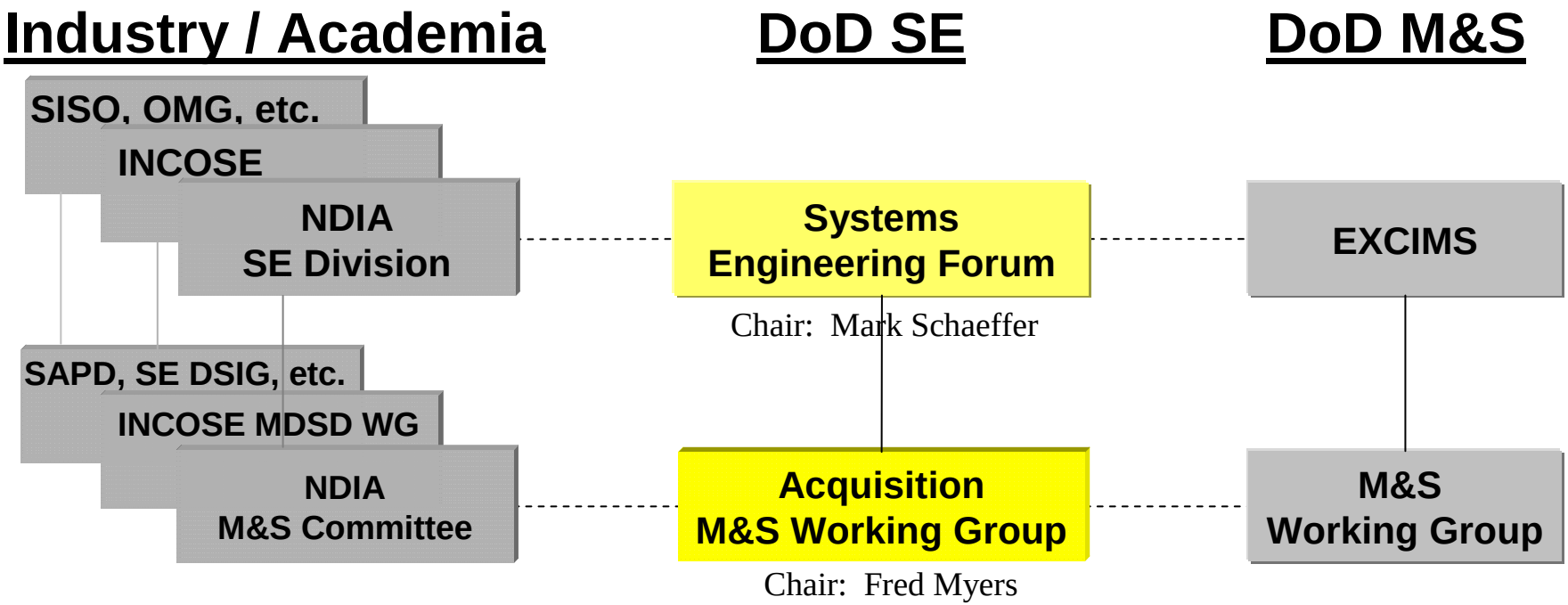


Iterative "V" process across acquisition phases

Acquisition M&S Working Group

Per AMSWG Charter, approved by SE Forum Feb 2005

…anchored in acquisition community, linked to industry and M&S



Products

Reports (e.g., "M&S Support to the New DoD Acq. Process"), standards, papers, etc.

Product

Acquisition M&S Master Plan

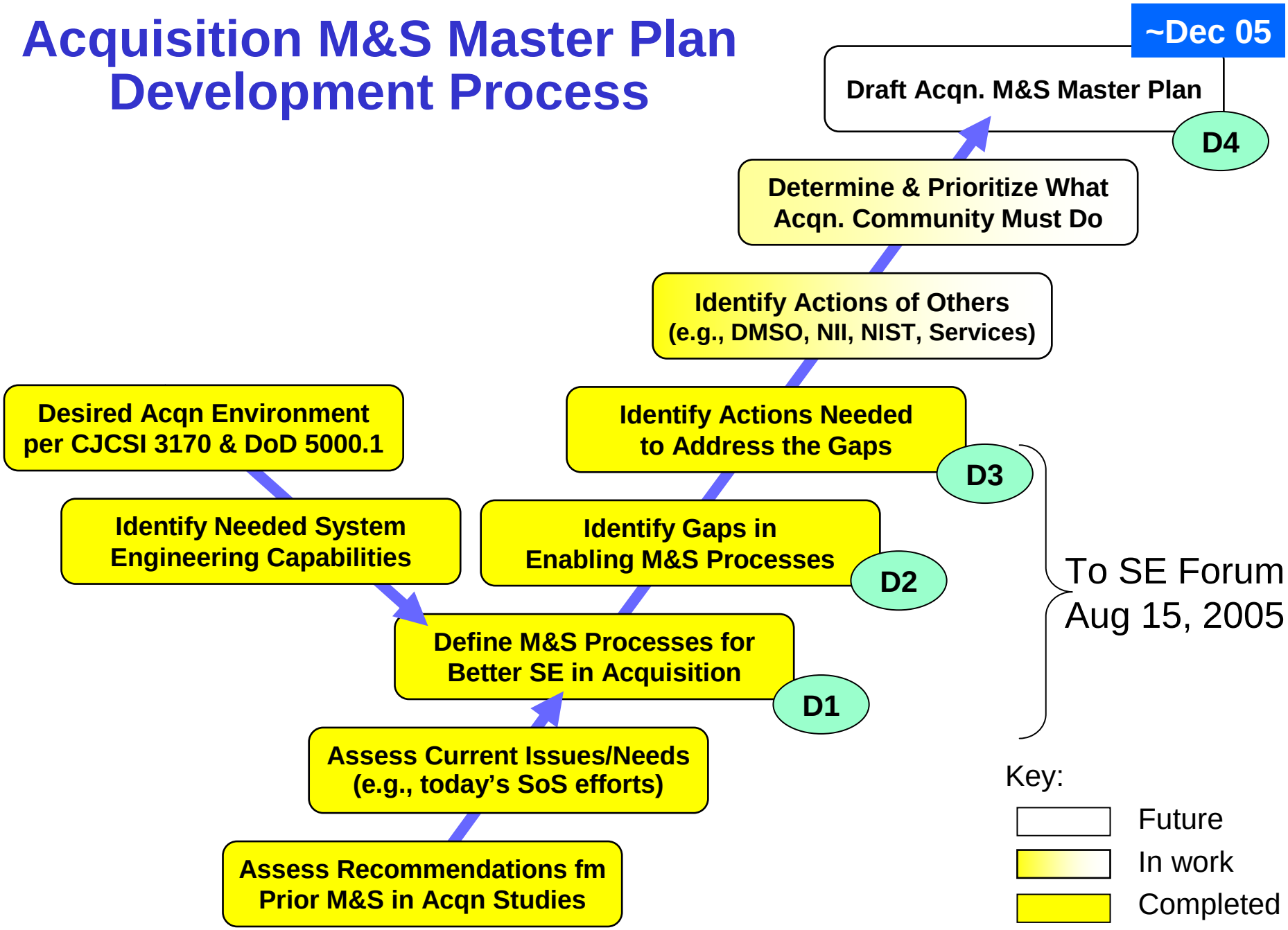
Product

DoD M&S Master Plan

Approach

- Foster widely-needed M&S capabilities that are beyond the reach of individual programs
- Address M&S issues and actions necessary to enable acquisition of effective joint capabilities (systems of systems)
- Not seek to do the job of program/capability managers; rather seek to empower them
  - By removing systemic obstacles in their path
  - By identifying new options for approaching their tasks
  - By helping meet widely-shared needs

Acquisition M&S Master Plan Development Process



A Decade of Studies on M&S Support to Acquisition

1. *Final Report of the Acquisition Task Force on M&S*, 1994
   Sponsor: DDR&E (Dr. Anita Jones); Chair: VADM T. Parker, USN (Ret.)
2. *Naval Research Advisory Committee Report on M&S*, 1994
   Sponsor: ASN(RDA); Chair: Dr. Delores Etter
3. *Collaborative Virtual Prototyping Assessment for Common Support Aircraft*, 1995
   Sponsor: Naval Air Systems Command; conducted by JHU APL and NSMC
4. *Collaborative Virtual Prototyping Sector Study*, 1996
   North American Technology & Industrial Base Organization; sponsor: NAVAIR
5. *Application of M&S to Acquisition of Major Weapon Systems*, 1996
   American Defense Preparedness Association; sponsor: Navy Acqn. Reform Exec.
6. *Effectiveness of M&S in Weapon System Acquisition*, 1996
   Sponsor: DTSE&E (Dr. Pat Sanders); conducted by SAIC (A. Patenaude)
7. *Technology for USN and USMC, Vol. 9: M&S*, 1997
   Naval Studies Board, National Research Council; sponsor: CNO
8. *A Road Map for Simulation Based Acquisition*, 1998
   Joint SBA Task Force (JHU APL lead); sponsor: Acquisition Council of EXCIMS

A Decade of Studies on M&S Support to Acquisition

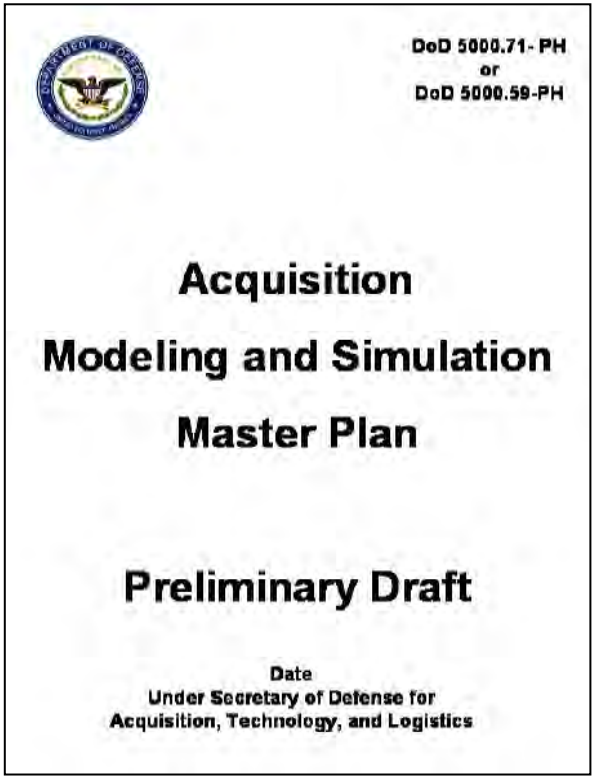
9. *M&S for Analyzing Advanced Combat Concepts*, 1999
   Defense Science Board Task Force (Co-chairs: L. Welch, T. Gold)
10. *Advanced Engineering Environments*, 1999
    National Research Council; sponsor: NASA
11. *Survey of M&S in Acquisition*, 1999 and 2002
    Sponsor: DOT&E/LFT&E; conducted by Hicks & Associates (A. Hillegas)
12. *Test and Evaluation*, 1999
    Defense Science Board Task Force (Chair: C. Fields)
13. *"SIMTECH 2007" Workshop Report*, 2000
    Military Operations Research Society (Chair: S. Starr)
14. *M&S in Manufacturing and Defense Systems Acquisition*, 2002
    National Research Council; sponsor: DMSO
15. *M&S Support to the New DoD Acquisition Process*, 2004
    NDIA Systems Engineering Div. M&S Committee; sponsor: PD, USD(AT&L)DS
16. *Missile Defense Phase III M&S*, 2004
    Defense Science Board Task Force (Chair: W. Schneider)

Assessment of Current Issues/Needs

- Cooperative effort between AMSWG & NDIA M&S Committee
- AMSWG venue:
  - Air Force – Roe (Jan 05)
  - Army – Gillis, Wallace (Jan 05)
  - Navy – Vaughn (Feb 05)
  - Visits to NAWC/AD (ACETEF); Army RDECOM; AFMC (SIMAF, ICE)
- NDIA M&S Committee venue:
  - Joint SIAP Systems Engineering Organization (Aug 04)
  - Future Combat Systems (Sep 04)
  - Missile Defense Agency (Feb 05)
  - Lockheed Martin (Feb 05)
  - Raytheon (Apr 05)
  - Boeing (Apr 05)
  - Northrop Grumman (Jun 05)
  - BAE Systems (Aug 05)
- Affirmed many findings and recommendations from studies and provided new inputs as well

Content of Acquisition M&S Master Plan

- **Forward**
- **Purpose**
- **Background**
- **Vision**
- **Objectives (5)**
- **Actions (28)**
  - Action
  - Rationale
  - Discussion
  - Lead & supporting organizations
  - Products
  - Completion goal (year)
- **Execution Management**


DoD 5000.71- PH
or
DoD 5000.59-PH

Acquisition

Modeling and Simulation

Master Plan

Preliminary Draft

Date
Under Secretary of Defense for
Acquisition, Technology, and Logistics

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Five Objectives

(buckets for 28 actions)

Objective 1

Provide necessary policy and guidance

Actions

1. **M&S management**
2. **Model-based systems engineering & collaborative environments**
3. **M&S in testing**
4. **M&S planning documentation**
5. **RFP & contract language**
6. **Security certification**

Objective 2

Enhance the technical framework for M&S

Actions

7. **Data standards framework**
8. **Product development metamodel**
9. **Commercial SE standards**
10. **Distributed simulation standards**
11. **DoDAF utility**
    - **DoDAF 2.0 Acqn Overlay**
    - **Standards for depiction & interchange**
12. **Metadata template for reusable resources**

Objective 3

Improve model and simulation capabilities

Actions

13. **Acquisition inputs to DoD M&S priorities**
14. **Best practices for model/sim development**
15. **Distributed LVC environments**
    - **Standards**
    - **Sim/lab/range compliance**
    - **Event services**
16. **Central funding of high-priority, broadly-needed models & sims**
    - **Prioritized needs**
    - **Pilot projects**
    - **Expansion as warranted**

Objective 4

Improve model and simulation use

Actions

17. **Help defining M&S strategy**
18. **M&S planning & employment best practices**
19. **Foster reuse**
    - **Business model**
    - **Responsibilities**
    - **Resource discovery**
20. **Info availability**
    - **Scenarios**
    - **Systems**
    - **Threats**
    - **Environment**
21. **VV&A**
    - **Documentation**
    - **Risk-based**
    - **Examination**
22. **COTS SE tools**
23. **M&S metrics**

Objective 5

Shape the workforce

Actions

24. **Definition of required M&S competencies**
25. **Harvesting of commercial M&S lessons**
26. **Assemble Body of Knowledge for Acqn M&S**
27. **M&S education & training**
    - **DAU, DAG & on-line CLMs**
    - **Conferences, workshops & assist visits**
28. **MSIAC utility**

Objective 1: Provide Necessary Policy & Guidance

(Preamble) Need to assign responsibility for management of the joint capability areas, to include systems engineering and its M&S component

1. Provide effective, persistent DoD-wide M&S management to address cross-cutting M&S issues, coordinate actions
   Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
   Products: Revised DoDD 5000.59 (M&S Management) with clearer responsibilities, revised EXCIMS membership, SOP for EXCIMS processes, a refocused DMSO
   Completion goal: 2006

2. Promote model-based systems engineering (MBSE) and M&S-enabled collaborative environments, at both the program and joint capability level
   Lead: OUSD(AT&L)/DS; **Support:** Components
   Products: Revised guidance in DAG
   Completion goal: 2007

3. Establish policy on appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities
   Co-leads: OUSD(AT&L)/DS, ODOT&E; **Support:** Components
   Products: Revised policy and guidance in DoDI 5000.2 and DAG
   Completion goal: 2006

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Obj. 1: Provide Necessary Policy & Guidance (cont.)

4. Establish policy to require documented M&S planning at the joint capability & program levels as part of the Systems Engineering Plan, T&E Strategy and T&E Master Plan
   - **Co-leads:** OUSD(AT&L)/DS, ODOT&E; **Support:** Components
   - **Products:** Revised policy and guidance in DoDI 5000.2, DAG, and DOT&E TEMP Planning Guidance
   - **Completion goal:** 2006
5. Establish guidelines for M&S-related RFP language & contract provisions
   - **Lead:** OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DPAP, Components
   - **Products:** Sample language in DoD publications (e.g., DAG, SEP Preparation Guide, Contracting for Systems Engineering Guidebook) regarding M&S requirements, data rights, and the responsibilities and liabilities of parties regarding sharing and reuse
   - **Completion goal:** 2006
6. Publish practical guidelines for security certification of M&S activities falling under multiple Information Assurance Defense Accreditation Authorities
   - **Lead:** OASD(NII); **Support:** OUSD(AT&L)/DS, NSA
   - **Products:** Guidelines published in DoD 8500.2-H, per DoDI 8500.2 "Information Assurance Implementation," Feb 6, 2003
   - **Completion goal:** 2007

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Objective 2: Enhance the Technical Framework for M&S

7. Establish a framework for data interchange-related standards
   Lead: OASD(NII); **Support:** OUSD(AT&L)/DS
   Products: Revised guidance in NII policy documents
   Completion goal: 2008

8. Develop a product development information metamodel & associated metadata extensions to the DoD Discovery Metadata Specification
   Lead: OUSD(AT&L)/DS; **Support:** OASD(NII), Components
   Products: Revised DDMS; revised guidance in DAG.
   Completion goal: 2008

9. Support development of open commercial systems engineering-related standards, such as OMG's Systems Modeling Language (SysML) and ISO Standard 10303 AP-233
   Lead: OUSD(AT&L)/DS; **Support:** DLA, OUSD(AT&L)/DDRE, OASD(NII)
   Products: Published standards suitable for adoption by DoD
   Completion goal: 2007

10. Establish a forum to clarify the characteristics and application of various distributed simulation standards (HLA, TENA, DIS, ALSP, SI3, etc.) and examine opportunities for convergence
    Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/TRMC & DS, ODOT&E, Components
    Products: (1) Information on strengths & weaknesses of the various standards; (2) agreement on policy and/or guidance on the use of distributed simulation standards; (3) a way ahead regarding distributed simulation standards
    Completion goal: 2007

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Obj. 2: Enhance the Technical Framework for M&S (cont.)

11. Improve the utility of the DoD Architecture Framework (DoDAF) for acquisition

    11-1. Develop the Acquisition Overlay (profile) for DoDAF v2.0

    Lead: OUSD(AT&L)/DS; **Support:** OASD(NII), Components
    Products: Acquisition Overlay for DoDAF v2.0
    Completion goal: 2006

    11-2. Support development of open commercial standards for the depiction and interchange of DoDAF-compliant architectures

    Lead: OASD(NII) **Support:** OUSD(AT&L)/DS
    Products: Published standards suitable for adoption by DoD in DoDAF 2.0; revised guidance in DAG
    Completion goal: 2007

12. Establish a standard template of key characteristics (metadata) to describe reusable M&S resources

    Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/DS & TRMC, DOT&E; Components
    Products: Published standard template; usage guidance in DAG
    Completion goal: 2007

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Objective 3: Improve Model & Simulation Capabilities

13. Establish a process to ensure acquisition needs are reflected in DoD M&S priorities, including S&T
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS
    Products: Incorporate in M&S requirements process (ref: DoD M&S Master Plan) a method to capture and prioritize those acquisition needs.
    Completion goal: 2007

14. Define and foster best practices for efficient development and evolution of credible M&S tools, incorporating user-defined requirements, a systems engineering approach, and appropriate verification & validation
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Best practices DMSO publication, available via MSIAC, DTIC, etc.; DAG guidance to use
    Completion goal: 2008

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Obj 3: Improve Model & Simulation Capabilities (cont.)

15. Enable readily-available distributed live-virtual-constructive environments, leveraging related initiatives

15-1. Establish DoD-wide standards for distributed environments

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/TRMC & DS; ODOT&E; Components
Products: Published standard; DODI (# TBD) policy to use
Completion goal: 2008

15-2. Make candidate simulations, labs and ranges compliant with these standards

Lead: Components; **Support:** OUSD(AT&L)/DS & TRMC
Products: Toolkit of live, virtual and constructive representations ready to be employed in distributed events
Completion goal: 2009

15-3. Provide services to help plan and conduct distributed events

Lead: Components; **Support:** OUSD(AT&L)/TRMC & DDRE, DISA
Products: Fee-based technical services to help users (e.g., PMs, Capability Managers, OTAs) plan and conduct distributed events
Completion goal: 2009

DRAFT

Obj 3: Improve Model & Simulation Capabilities (cont.)

16. Centrally fund and manage the development and maintenance of high-priority, broadly-needed M&S tools

    16-1. Identify and prioritize broadly-needed M&S tools

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS; Components
    Products: Prioritized list of common M&S tool needs
    Completion goal: 2007

    16-2. Conduct one or more pilot projects to develop new M&S tools or update existing ones to meet these needs

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Proof of concept for managing the development/evolution of M&S tools to meet broadly-shared needs
    Completion goal: 2009

    16-3. Expand the scope of central M&S tool management as warranted by pilot project results and the list of common M&S needs

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Optimal means to meet common needs for M&S tools
    Completion goal: 2011

DRAFT

Objective 4: Improve Model & Simulation Use

17. Provide potential acquisition M&S users the knowledge needed to formulate an effective M&S strategy via ready access to M&S expertise and information about M&S capabilities and gaps, reusable resources, lessons-learned, etc.

    Lead: OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DDRE

    Products: Revised guidance in DAG; improved knowledge base in MSIAC; assist visits (e.g., by OUSD(AT&L)/DS)

    Completion goal: 2007

18. Define best practices for disciplined M&S planning & employment
    - Rigorous analysis of M&S requirements and alternative solutions, selection of best course
    - Efficient configuration management, initialization, execution and post-run analysis
    - Cautions against inappropriate use; approaches to maximize cost-effective reuse across lifecycle

    Lead: OUSD(AT&L)/DS, **Support:** OUSD(AT&L)/DDRE, Components

    Product: Revised best practices guidance in DAG and MSIAC

    Completion goal: 2007

DRAFT

Obj. 4: Improve Model & Simulation Use (cont.)

19. Facilitate the sharing of reusable resources

19-1. Establish a DoD-wide business model for compensating providers of reusable M&S resources (e.g., information, software, services)

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Documented business model; revised policy and/or guidance in DoD 5000 series and DAG

Completion goal: 2007

19-2. Establish DoD policy and/or guidance regarding responsibilities to share, protect and properly use information and M&S tools

Co-Leads: OASD(NII) and OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS & DPAP, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Revised policy and/or guidance in various issuances (e.g., DoD 5000 series, DAG, contracting guidance)

Completion goal: 2007

19-3. Enhance the means (e.g., directory service, registries, bulletin boards) to discover existence of reusable M&S resources and contact information

Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Functional means, with appropriate resources and incentives, and a continuous improvement process

Completion goal: 2007

DRAFT

Obj. 4: Improve Model & Simulation Use (cont.)

20. Define the types of information DoD organizations shall make available to others with a valid need to know and the processes to obtain them (per reuse business model)

    20-1. Scenario data
    Lead: OUSD(AT&L)/DDRE **Support:** OCJCS(J8), OUSD(C)/PA&E, DIA, Components
    Product: Approved scenarios and process to obtain
    Completion goal: 2007

    20-2. System-related data
    Lead: OUSD(AT&L)/DS; **Support:** Components
    Product: Authoritative system data (characteristics and performance, interactions, interfaces, logistic support, etc.) and process to obtain
    Completion goal: 2007

    20-3. Threat data
    Lead: DOD MSEA for Threat Data; **Support:** OUSD(AT&L)/DDRE & DS, Components
    Product: Authoritative threat data and process to obtain
    Completion goal: 2007

    20-4. Natural environment data
    Lead: DoD Natural Environment MSEAs; **Support:** OUSD(AT&L)/DDRE & DS, Components
    Product: Authoritative natural environment data and process to obtain
    Completion goal: 2007

DRAFT

Obj. 4: Improve Model & Simulation Use (cont.)

21. Foster cost-effective VV&A

21-1. Require DoD-wide standardized documentation of VV&A

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
Products: Revised policy in DODI 5000.2 and 5000.61; revised guidance in DAG
Completion goal: 2007

21-2. Develop risk-based methodology and associated guidelines for VV&A expenditures

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
Products: Updated DMSO VV&A Best Practices documents/web site; guidance in DAG
Completion goal: 2006

21-3. Examine a program's VV&A when M&S informs major acquisition decisions and unambiguously state the purpose, key assumptions and significant limitations of each model/simulation when results are presented.

Lead: OUSD(AT&L)/DS **Support:** DoD Components
Products: Guidance & training for oversight personnel; updates to DAG Chaps 4 & 9
Completion goal: 2006

DRAFT

Obj. 4: Improve Model & Simulation Use (cont.)

22. Assess the use of COTS systems engineering tools (modeling environments) for collaborative architecture development
    Lead: OUSD(AT&L)/DS**; Support:** OASD(NII), Components
    Products: Revised guidance in DAG; enhanced M&S body of knowledge for dissemination
    Completion goal: 2006
23. Define and capture meaningful metrics for M&S utility in acquisition
    Lead: Navy; **Support:** OUSD(AT&L)/DS, Components
    Products: Metric definitions in DAG; methods to capture and submit data in DAG; data from individual projects in MSIAC, Body of Knowledge, etc.
    Completion goal: 2007

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Objective 5: Shape the Workforce

24. Define required M&S competencies for the acquisition workforce
    Co-Leads: DAU and OUSD(AT&L)/DS; **Support:** OUSD(P&R), OUSD(AT&L)/DDRE, OUSD(C)/PA&E, Components
    Product: Identified lead FIPT; workforce qualification requirements; management process & structure
    Completion goal: 2008
25. Harvest lessons from commercial sector activities in the use of M&S to support product development
    Lead: OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DDRE, Components
    Products: Lessons collected at a defined site (TBD); annual update to best practices in DAG of lessons from industry that should be considered by PMs in planning for M&S
    Completion goal: Recurring; initial in 2007
26. Assemble and evolve the M&S Body of Knowledge (information set) relevant to acquisition
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Product: Information base available to potential M&S users (e.g., PMs, CMs, OTAs); source material for education and training
    Completion goal: Recurring; initial in 2007

DRAFT

Obj. 5: Shape the Workforce (cont.)

27. Drawing on the M&S Body of Knowledge, educate and train the workforce to achieve required M&S competencies

    27-1. Provide M&S knowledge via an expanded set of DAU courses, the Defense Acquisition Guide, and on-line CLMs

    Lead: DAU; **Support:** OUSD(AT&L)/DS & DDRE, Components

    Product: Expanded set of DAU courses, improved M&S guidance in the Defense Acquisition Guide, on line Continuous Learning Modules; a better educated workforce

    Completion goal: 2009

    27-2. Provide M&S knowledge via conferences, workshops, and assist visits

    Lead: OUSD(AT&L)/DS; **Support:** DAU, OUSD(AT&L)/DDRE, Components

    Product: Annual outreach program; a better educated and trained workforce

    Completion goal: Recurring; initial in 2006

28. Improve the knowledge and expertise available through the MSIAC to make it of greater utility to the acquisition community

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

    Product: Plan of action with coordinated MSIAC CONOPS & staffing requirement; list of knowledge shortfalls that MSIAC will take on; success criteria & process to bring MSIAC up to criteria

    Completion goal: 2008

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Next Steps

- Broadly vet actions (DoD, Industry)
  - Fine-tune actions, lead & support, products, etc.
- Finalize Acquisition M&S Master Plan
  - Acqn M&S Working Group consensus
  - SE Forum approval (Dec 2005)
  - Informal DoD coordination
  - Formal coordination as a DoD issuance?
  - USD(AT&L) approve plan
- Implement plan, monitor action completion
- Assess impact (metrics)

Discussion

- Questions and comments are invited here as time permits
- NDIA M&S Committee meeting 1445-1730 Thursday to answer remaining questions and discuss your change recommendations
  - All are welcome to attend

BACKUP

AMSWG Participants

Allen, John	DOT&E
Amick, Karl *	OSD(AT&L) LP&P
Anderson, William	SEI
Anthony, Marvin	NAVSEA 06P
Atkinson, Kenn	DMSO
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Bailey, Bruce (ctr)	DMSO
Ball, David P.	Army G37/BCSE
Barnabe, Dennis	NSA
Bilmanis, John (ctr)	Army G3/BC
Bounker, Paul	RDECOM TARDEC
Burris, William	TRMC
Butterworth, Robert *	DOTE
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Duesterhaus, Dave	DOT&E
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Elliott, Steve	OUSD(AT&L) DS/MW
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Falkey, Mark *	JNIC/SY COLEMAN
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Friedenthal, Sanford	LMC
Furness, Zach (ctr)	MITRE
Gill, Jim *	DDFP/JTAMDO/CSC
Gillis, John (ctr)*	ASA(ALT) RDA M&S
Glasow, Jerry	DMSO
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Goode, Francine *	NSA
Halayko, Bob Hardy, Dwayne *	OUSD(P&R) OUSD(AT&L)DS
Hollenbach, Jim (ctr)	OUSD(AT&L) DS/SE
Hutchings, Charles	NAVSEA
Johnston, Jerald	JHU/APL
Keener, Jim	IWS 1B% (NSWCDD)
Kelly, Doug	DIA
Kline, Tom	PEO IWS
Lackner, Bob	PEO IWS IC/ ANTEON
Long, James	Vitech Corp
Long, Vicki	HQAFMC/XRA
Mackoy, Rebecca	TRADOC
Manthei, Jerry	CNO N091/N912
Mathis, Thomas	RDECOM/SOSI Camber
Matzner, John	Army G-3/5/7/Alion
McDonnell, Joe (ctr)	RDECOM
Merrill, Bruce	NSA
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Montoya, Matt	JHU/APL
Myers, Fred *	OUSD(ATL)DS
Nunez, Patrick	RDECOM TARDEC
Parmele, Truman	OASD/NII
Pikul, Ronald	ASN RDA
Pittenger, Bill *	DISA/MITRE
Placanica, John *	NGA
Preissman, Dan	NAVAIR
Prill, Mark *	NASA/ESMD
Prosnik, George *	DAU
Roe, James W	AF AFMC/XRA
Sas, Robert	NCEE
Schmidt, Karl	NGA/LMC
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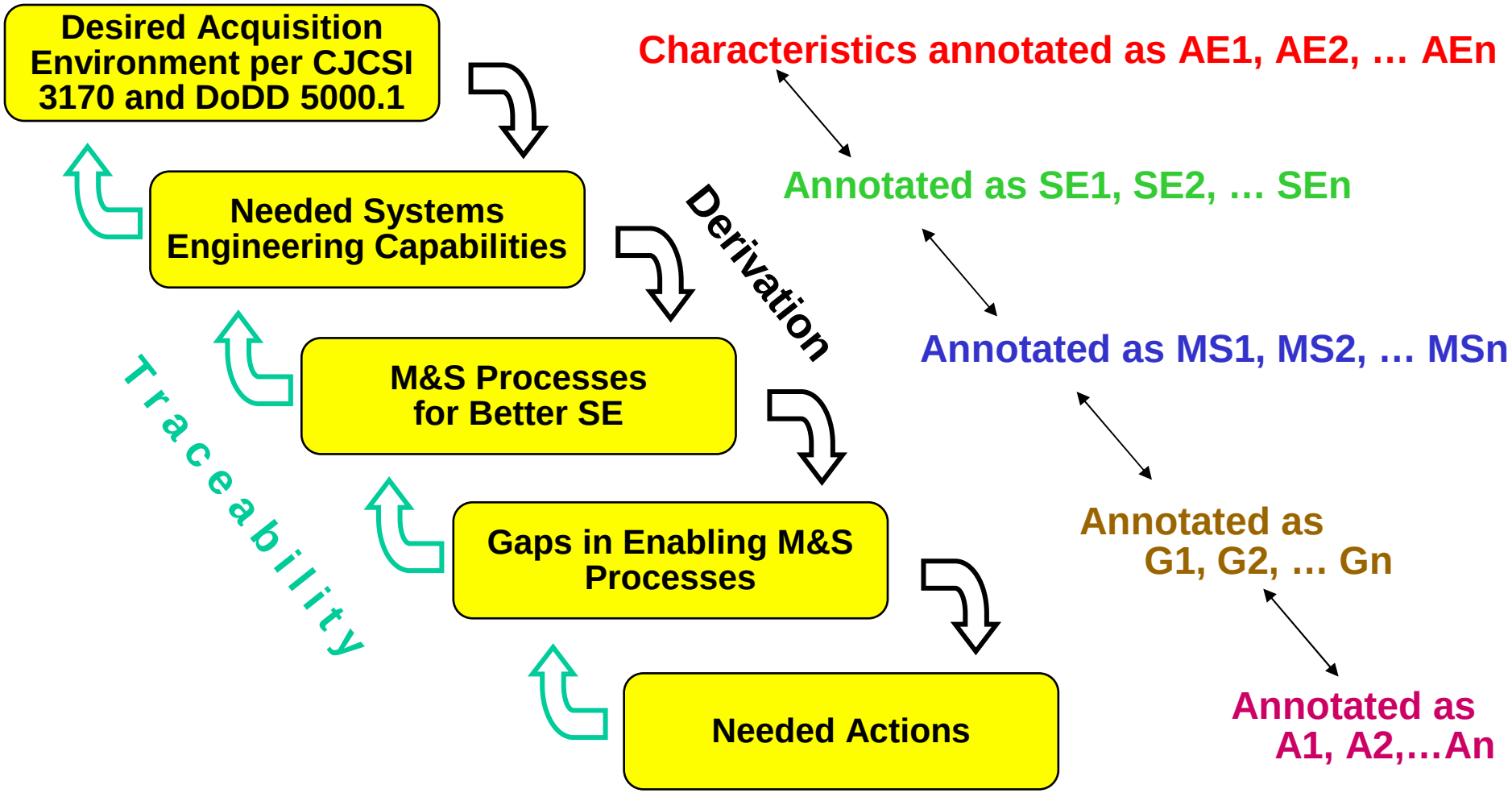
Suter, Richard	OUSD (AT&L) (T&E)
Swift, Lloyd ctr	ASN(RDA) CHENG
Tillery, Gordon (ctr)	OUSD(AT&L) DS/SE
Tirres, Carlos *	DTRMC
Truelove, Michael(ctr)	OUSD (AT&L) DS/SE
Vaughn, Barbara	ASN RDA CHENG
Walker, Oral	PMUA MSMO
Wallace Jim Walsh, John *	Army G37/BCSE OUSD(P&R)
Wright, Susan	OSD DOT&E
Znachko, Carrall	SAF/AQIZ

* Indicates SE Forum Representatives that are AMSWG Voting Members

Top-Down Derivation/Cross-Check



Desired Acquisition Environment:

Key CJSCI 3170.01E Policies

- AE1 *Joint concepts-centric capabilities identification process to allow joint forces to meet the full range of military operations and challenges…*
- AE2 *Assess existing and proposed capabilities in light of their contribution to future joint allied and coalition operations. … Produce capability proposals that* AE3 *consider the full range of DOTMLPF solutions in order to advance joint warfighting in a unilateral and multinational context.*
- *New solution sets…crafted to deliver technologically sound, testable,* AE4 *sustainable and affordable increments of militarily useful capability.*
- *The* AE5 *FoS and SoS solutions may also require systems delivered by multiple sponsors/materiel developers.* AE6
- *The process to identify capability gaps and potential solutions must be supported by a robust analytical process* AE7
- *JCIDS implements a capabilities-based approach that…requires a* AE8 *collaborative process that utilizes joint concepts and integrated* AE9 *architectures to* AE10 *identify prioritized capability gaps and integrated DOTMLPF and policy approaches to resolve those gaps* AE11

Desired Acquisition Environment:

DoDD 5000.1 Acquisition Policies

"The primary objective of Defense acquisition is to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price."

Governing policies:

- *Flexibility, Responsiveness (time-phased capabilities, evolutionary acquisition), Innovation, Discipline, Streamlined Effective Management*
- *Armaments Cooperation; Collaboration; Competition; Cost and Affordability; Cost Realism; Cost Sharing; Financial Management; Independent OTAs; Information Assurance; Information Superiority; Integrated T&E; Intelligence Support; Interoperability; Knowledge-Based Acquisition; Legal Compliance; Performance-Based Acquisition; Performance-Based Logistics; Products Services and Technologies [seek most cost-effective solution over the system's life cycle], Professional Workforce, Program Information [complete, current, tailored]; Program Stability; R&D Protection; Safety; Small Business Participation; Software Intensive Systems; Streamlined Organizations; Systems Engineering; Technology Development and Transition; Total Systems Approach*
- *Oct 04 policy memo: Technical reviews … shall be event-driven*

Necessary Systems Engineering Capabilities

(which M&S can affect; derived from Desired Acquisition Environment)

SE1. Early, continuing systems engineering from an SoS/FoS capabilities perspective; seamless transition from JCIDS to acquisition **(AE1-3,5,9-11,16,20,21,25,27)**

SE2. Lifecycle-wide exploration of the maximum available trade space, including time-phased requirements and technology insertion **(AE1-5,7,10,11,13,16,19,23-27)**

SE3. Collaboration among all stake holders (multiple gov't and contractor organizations) for key enterprise-level SE decisions **(AE6-8,10,18,22,25,27)**

SE4. Rapid assessment of concept/design alternatives **(AE2,4,7,10,14,16,19,25,28)**

SE5. Comprehensive, accurate, event-based assessment of technical baselines; avoidance of costly fixes for problems discovered late **(AE2-4,7,9,10,12-17,19,20,22,24-26,28)**

SE6. Focused, effective & efficient testing; including at the capability level **(AE1,2,4,5,9-11,13,15,19-22,25)**

SE7. Appropriate reuse of all resources – information, software tools, expertise, facilities, ranges, etc. – across programs & organizations **(AE4,14,15,19,24,25)**

D1

M&S Processes for Better Systems Engineering

(derived from Needed Systems Engineering Capabilities)

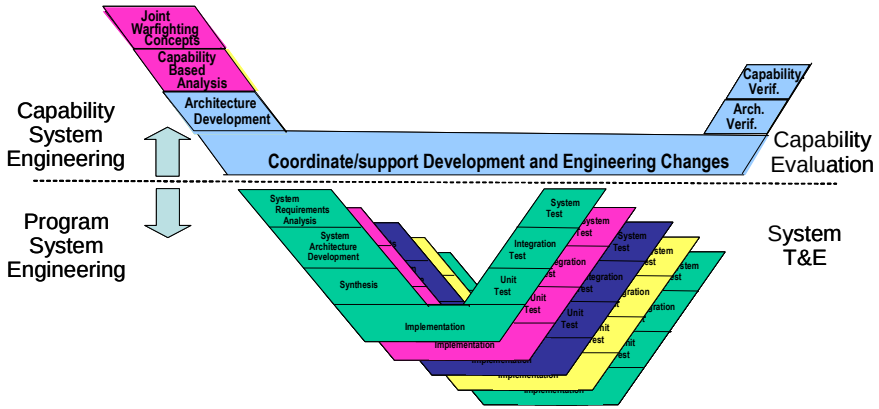
MS1. Use of a model-based systems engineering approach **(SE1,2,4,5)**

(Emerging concept under INCOSE, OMG, etc.; growing suite of COTS SE tools)

- SE tool modeling environments to analyze requirements, develop architecture, and specify constraints; views linked to, and generated from, an underlying database
- Embedded simulation to verify the architecture and assess its merits
- Automated generation of documents/reports

MS2. Establishing M&S-enabled collaborative engineering environments **(SE1,2,3,4,5,6)**

- Shared, authoritative information
- Interoperable modeling environments for architecting/design
  - Models as communication means
- Models & simulations to assess
  - Option to immerse warfighters, etc.
- Distributed live-virtual-constructive environments for integration, verification, and test



MS3. Model-Test-Fix-Model process across the life-cycle **(SE4,5,6)**

- Better test planning, more effective tests
- Increased M&S validity; credible surrogates; reuse savings

D1 M&S Processes for Better Systems Engineering

MS4. Harnessing M&S knowledge to formulate an effective M&S strategy **(SE2,3,4,5,7)**

- Ready access to M&S expertise and information about capabilities and gaps (M&S holes), reusable resources, lessons-learned, etc.

MS5. Disciplined M&S planning & employment **(SE2,4,5,7)**

- Rigorous analysis of M&S requirements, alternatives, best course
- Efficient configuration/initialization, execution and post-run analysis
- Avoid inappropriate use; maximize cost-effective reuse across lifecycle

MS6. Efficient development/evolution of credible M&S tools **(SE2,3,5,7)**

- A systems engineering approach with appropriate V&V

MS7. Access/sharing of authoritative, understandable data needed for M&S representations **(SE2,3,4,5,7)**

- Reducing a major time and cost burden that inhibits M&S use

MS8. Inspection of M&S used to inform acquisition decisions **(SE2,5,7)**

- Examine capabilities and limitations (VV&A) of M&S
- During lead-up to program/technical reviews, OTRRs, DABs, etc.

D2

Gaps

1. Management

G1. Robust but confused landscape of M&S activities; no clearly designated leadership or effective coordinating mechanism **(MS1-8)**

- Current EXCIMS ineffective; little coordination for capabilities/SoS/FoS

G2. Inadequate constancy of purpose because time to fix problems >> tour length; "DoD has an attention deficit disorder" **(MS2-7)**

G3. Gov't acquisition guidelines don't promote M&S use or reuse **(MS1-6)**

G4. No DoD requirement for formal M&S planning to support acquisition (other than T&E) **(MS1-5)**

G5. No contractual guidelines regarding M&S and the data it needs **(MS1-8)**

G6. Gov't typically doesn't give contractors meaningful M&S guidance **(MS1,2,6,8)**

G7. Most DoD M&S takes a project, vice an enterprise, approach **(MS2,3,6,7)**

G8. No consensus on value of integrated architectures, nor responsibility for **(MS1,2)**

G9. Managing distributed collaboration is very hard **(MS1-8)**

G10. Public law precludes OT based solely on M&S, but no clear guidance on use for SoS/FoS T&E **(MS2,3,5,6,8)**

D2

Gaps

2. Architecture/standards/technical framework

G11. No standard modeling notation (like UML v2.0) for capturing full range of information critical to system engineering (e.g., structure, behavior, requirements hierarchy/traceability, test cases, verification results) **(MS1,2,6,7)**

G12. No standard for interchanging systems engineering information (same examples as above) **(MS1,2,6,7)**

G13. No conceptual framework (like Open System Interconnect protocol stack) for data interchange **(MS1,2,3,6,7)**

G14. Lack of agreement on a common distributed simulation standard increases complexity and cost, limits simulation interoperability **(MS2,5,6)**

G15. DoDAF v1.0 is difficult to use for architecting due to lack of data-centricity and executability; some products of marginal value **(MS1,2,6,7)**

G16. Use of DoD-unique standards limits their user base, quality, COTS tool support, and opportunities for reuse **(MS1,2,5,6)**

D2

Gaps

3. Model/simulation capabilities & use

G17. Many M&S tool gaps and deficiencies **(MS1,2,3,5,7)**

- What's modeled (e.g., urban warfare, comm networks, threats, system sustainment)
- Fidelity, granularity, interoperability
- Only limited consensus on common models to be used across a domain

G18. No good way to develop and maintain widely-needed M&S tools that cut across programs **(MS5,6)**

- Not incorporating mods by other organizations into "street version," etc.

G19. M&S developers, not M&S users, tend to drive M&S development **(MS6)**

G20. In general, architecture development (modeling) is lagging, not collaborative, and not exploiting COTS SE tools (modeling environments) **(MS1,2)**

G21. No readily-available distributed M&S infrastructure (e.g., JDEP) **(MS2,5)**

G22. Hard to get security certification for multi-organization (company/ Service) distributed simulation **(MS2,3,5,6)**

G23. Hard to get approval and security certification for M&S involving multiple compartmented programs (SAPs) **(MS2,3,5,6,7)**

D2

Gaps

4. Trustworthiness/VV&A

G24. Post-development model validation expensive and slow **(MS2,3,5,8)**

G25. VV&A often weak or non-existent; documentation inconsistent **(MS2,3,5,8)**

- Plans to use M&S to avoid testing costs often rejected due to poor/no validation

G26. VV&A usually not enforced and also not examined during program reviews **(MS2,3,5,6,8)**

G27. Models and sims often not updated to reflect empirical evidence (e.g., test results) **(MS2,3,5,8)**

D2

Gaps

5. Sharing/reuse and protection of tools & information

G28. Little reuse; only 7% of models & sims used on >1 program **(MS2,5,6)**

G29. Concurrent engineering requires an integrated process, data sharing and a coherent tool set, but <20% of programs have such a collaborative environment **(MS2,7)**

G30. Hard to discover reusable resources (software, info, services) **(MS2,4,5,7)**

- M&S repositories are not integrated, lack an effective search capability, and are mostly empty
- MSIAC knowledge/expertise is lacking

G31. Insufficient info (metadata) to evaluate data/reuse candidates **(MS2,4,5,7)**

G32. Hard to obtain reusable resources **(MS2,4,5,7)**

- Industry to gov't: To protect proprietary info & competitive advantage
- Gov't to industry: Contractual liabilities associated with GFE/GFI
- Gov't to gov't: Concerns about misuse; cost to deliver and guide

G33. No incentives to encourage reuse **(MS2,3,5,6)**

- Negative incentives include cost to make reusable, workload assisting users, vulnerability to criticism

[plus approval and security certification gaps 22 & 23 listed under M&S use]

D2

Gaps

6. Research/S&T/tech base

G34. Conceptual foundation of M&S weak **(MS5,6)**

- E.g., theoretical understanding of modern warfare, human behavior, relating M&S at different granularities, dealing with uncertainty, agent-based modeling and generative analysis

G35. Little acquisition community input to DoD S&T management regarding needed M&S-related research **(MS2,5,6)**

7. Business model, metrics & ROI, funding and incentives

G36. No business model for how M&S capabilities should be developed, used and maintained **(MS1-8)**

G37. Metrics are critical to keep interest and funding up, but metrics regarding M&S use and cost-effectiveness are inadequate **(MS1-8)**

- M&S funding difficult to identify; most embedded within other PEs

G38. Too little funding **(MS2-7)**

D2

Gaps

8. Workforce Shaping

G39. Body of knowledge for M&S support to acquisition is deficient, not managed **(MS1,2,4-6,8)**

G40. Acqn community managers and staffs mostly uninformed about M&S capabilities and limitations **(MS1-8)**

- Weak acquisition personnel understanding of commercial M&S activities ("We don't get out enough")
- Not enough M&S experts (no career path [except Army], no formal education or training)

G41. M&S developers lack understanding of modeling best practices, abstraction techniques, context dependencies, etc. **(MS3,6)**

G42. M&S users often not adequately trained **(MS1,2,4,5,8)**

G43. Insufficient M&S education options **(MS2,4,5,6,8)**

Improving M&S Support to Acquisition:

A Progress Report on Development of the

Acquisition M&S Master Plan

Fred Myers, OUSD (AT&L) DS/SE
Jim Hollenbach, Simulation Strategies, Inc.,

NDIA Systems Engineering Conference
26 October 2005

Introduction

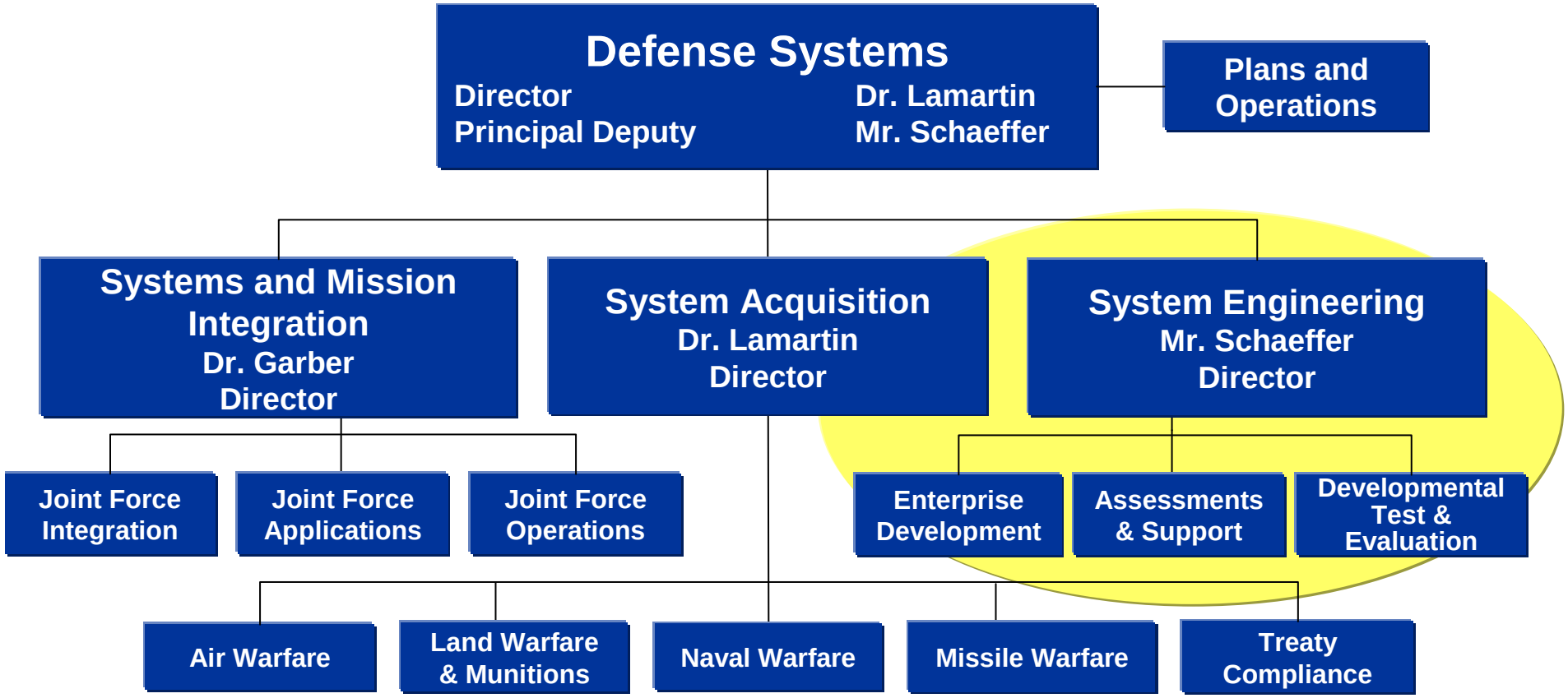
- This presentation key aspects of the emergent DoD Acquisition M&S Master Plan
  - Background
  - Process
  - Draft action set
- Questions and comments are invited here as time permits
- NDIA M&S Committee meeting 1445-1730 Thursday to answer remaining questions and discuss your change recommendations
  - All are welcome to attend

Senior Leadership Imperatives

Under Secretary of Defense for Acquisition, Technology and Logistics:

- "Provide a context within which I can make decisions about individual programs."
- "Achieve credibility and effectiveness in the acquisition and logistics support processes."
- "Help drive good systems engineering practices back into the way we do business."

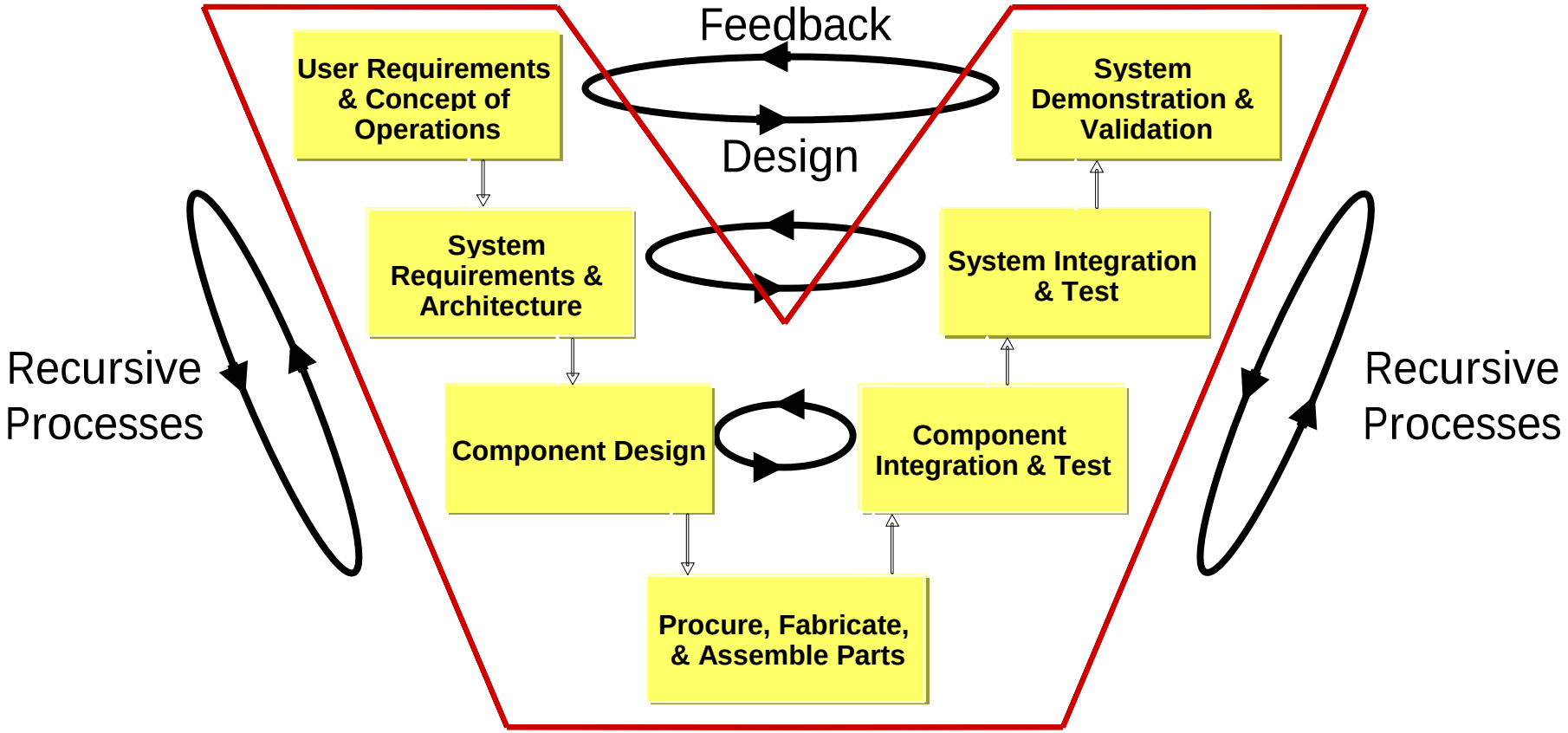
Response: Establish an SE Office
Defense Systems Directorate, OUSD(AT&L)



An integrated structure to develop capability

M&S is a Necessary Part of Acquisition

M&S is broadly useful to enable systems engineering throughout a system or S-o-S life cycle

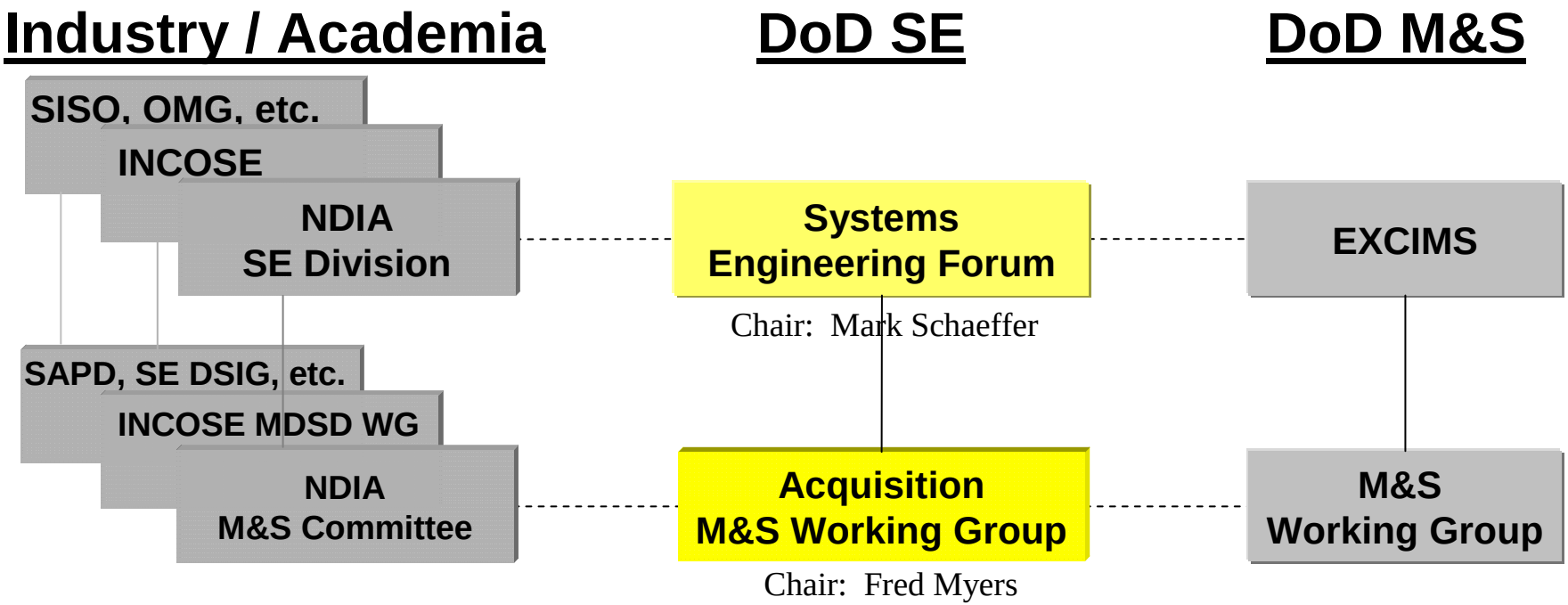


Iterative "V" process across acquisition phases

Acquisition M&S Working Group

Per AMSWG Charter, approved by SE Forum Feb 2005

…anchored in acquisition community, linked to industry and M&S



Products

Reports (e.g., "M&S Support to the New DoD Acq. Process"), standards, papers, etc.

Product

Acquisition M&S Master Plan

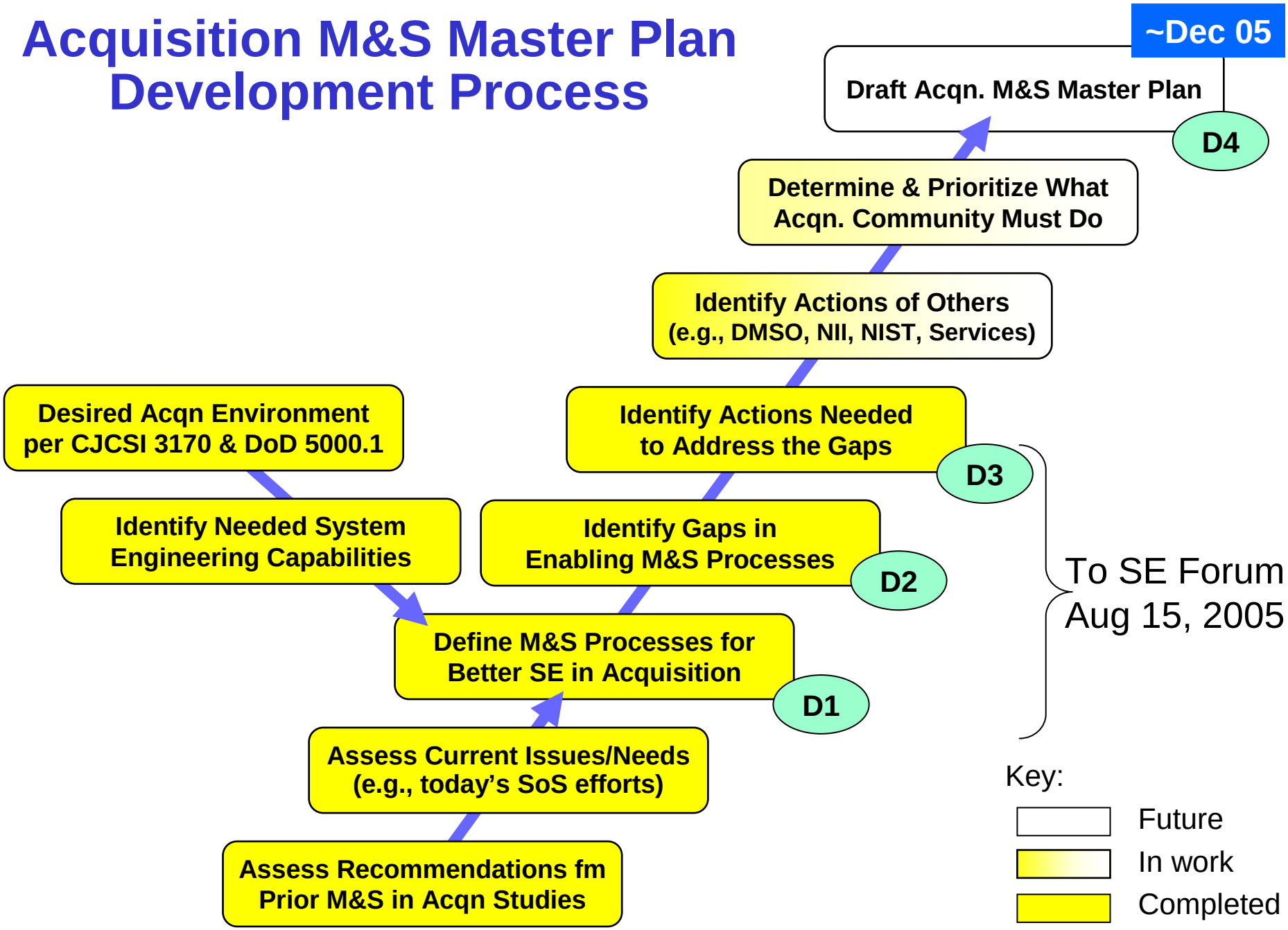
Product

DoD M&S Master Plan

Approach

- Foster widely-needed M&S capabilities that are beyond the reach of individual programs
- Address M&S issues and actions necessary to enable acquisition of effective joint capabilities (systems of systems)
- Not seek to do the job of program/capability managers; rather seek to empower them
  - By removing systemic obstacles in their path
  - By identifying new options for approaching their tasks
  - By helping meet widely-shared needs

Acquisition M&S Master Plan Development Process



A Decade of Studies on M&S Support to Acquisition

1. *Final Report of the Acquisition Task Force on M&S*, 1994
   Sponsor: DDR&E (Dr. Anita Jones); Chair: VADM T. Parker, USN (Ret.)
2. *Naval Research Advisory Committee Report on M&S*, 1994
   Sponsor: ASN(RDA); Chair: Dr. Delores Etter
3. *Collaborative Virtual Prototyping Assessment for Common Support Aircraft*, 1995
   Sponsor: Naval Air Systems Command; conducted by JHU APL and NSMC
4. *Collaborative Virtual Prototyping Sector Study*, 1996
   North American Technology & Industrial Base Organization; sponsor: NAVAIR
5. *Application of M&S to Acquisition of Major Weapon Systems*, 1996
   American Defense Preparedness Association; sponsor: Navy Acqn. Reform Exec.
6. *Effectiveness of M&S in Weapon System Acquisition*, 1996
   Sponsor: DTSE&E (Dr. Pat Sanders); conducted by SAIC (A. Patenaude)
7. *Technology for USN and USMC, Vol. 9: M&S*, 1997
   Naval Studies Board, National Research Council; sponsor: CNO
8. *A Road Map for Simulation Based Acquisition*, 1998
   Joint SBA Task Force (JHU APL lead); sponsor: Acquisition Council of EXCIMS

A Decade of Studies on M&S Support to Acquisition

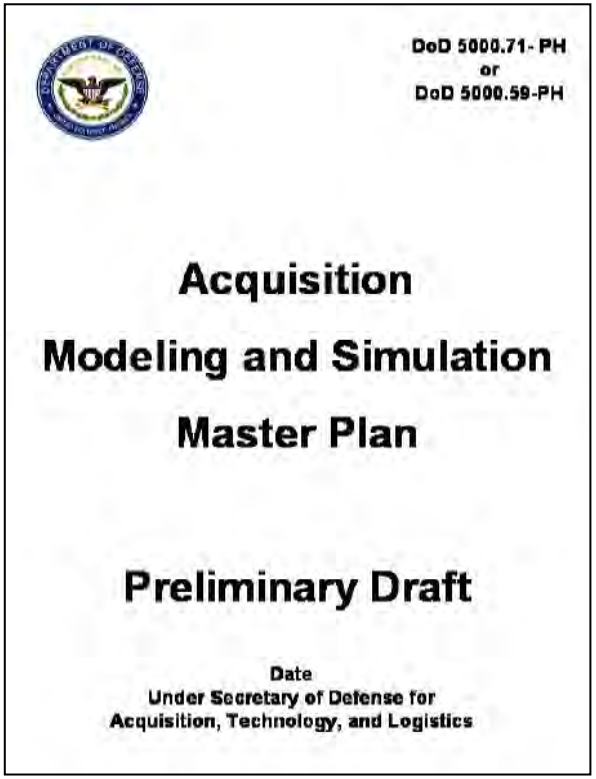
9. *M&S for Analyzing Advanced Combat Concepts*, 1999
   Defense Science Board Task Force (Co-chairs: L. Welch, T. Gold)
10. *Advanced Engineering Environments*, 1999
    National Research Council; sponsor: NASA
11. *Survey of M&S in Acquisition*, 1999 and 2002
    Sponsor: DOT&E/LFT&E; conducted by Hicks & Associates (A. Hillegas)
12. *Test and Evaluation*, 1999
    Defense Science Board Task Force (Chair: C. Fields)
13. *"SIMTECH 2007" Workshop Report*, 2000
    Military Operations Research Society (Chair: S. Starr)
14. *M&S in Manufacturing and Defense Systems Acquisition*, 2002
    National Research Council; sponsor: DMSO
15. *M&S Support to the New DoD Acquisition Process*, 2004
    NDIA Systems Engineering Div. M&S Committee; sponsor: PD, USD(AT&L)DS
16. *Missile Defense Phase III M&S*, 2004
    Defense Science Board Task Force (Chair: W. Schneider)

Assessment of Current Issues/Needs

- Cooperative effort between AMSWG & NDIA M&S Committee
- AMSWG venue:
  - Air Force – Roe (Jan 05)
  - Army – Gillis, Wallace (Jan 05)
  - Navy – Vaughn (Feb 05)
  - Visits to NAWC/AD (ACETEF); Army RDECOM; AFMC (SIMAF, ICE)
- NDIA M&S Committee venue:
  - Joint SIAP Systems Engineering Organization (Aug 04)
  - Future Combat Systems (Sep 04)
  - Missile Defense Agency (Feb 05)
  - Lockheed Martin (Feb 05)
  - Raytheon (Apr 05)
  - Boeing (Apr 05)
  - Northrop Grumman (Jun 05)
  - BAE Systems (Aug 05)
- Affirmed many findings and recommendations from studies and provided new inputs as well

Content of Acquisition M&S Master Plan

- **Forward**
- **Purpose**
- **Background**
- **Vision**
- **Objectives (5)**
- **Actions (28)**
  - Action
  - Rationale
  - Discussion
  - Lead & supporting organizations
  - Products
  - Completion goal (year)
- **Execution Management**


DoD 5000.71- PH
or
DoD 5000.59-PH

Acquisition

Modeling and Simulation

Master Plan

Preliminary Draft

Date
Under Secretary of Defense for
Acquisition, Technology, and Logistics

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Five Objectives

(buckets for 28 actions)

Objective 1

Provide necessary policy and guidance

Actions

1. **M&S management**
2. **Model-based systems engineering & collaborative environments**
3. **M&S in testing**
4. **M&S planning documentation**
5. **RFP & contract language**
6. **Security certification**

Objective 2

Enhance the technical framework for M&S

Actions

7. **Data standards framework**
8. **Product development metamodel**
9. **Commercial SE standards**
10. **Distributed simulation standards**
11. **DoDAF utility**
    - **DoDAF 2.0 Acqn Overlay**
    - **Standards for depiction & interchange**
12. **Metadata template for reusable resources**

Objective 3

Improve model and simulation capabilities

Actions

13. **Acquisition inputs to DoD M&S priorities**
14. **Best practices for model/sim development**
15. **Distributed LVC environments**
    - **Standards**
    - **Sim/lab/range compliance**
    - **Event services**
16. **Central funding of high-priority, broadly-needed models & sims**
    - **Prioritized needs**
    - **Pilot projects**
    - **Expansion as warranted**

Objective 4

Improve model and simulation use

Actions

17. **Help defining M&S strategy**
18. **M&S planning & employment best practices**
19. **Foster reuse**
    - **Business model**
    - **Responsibilities**
    - **Resource discovery**
20. **Info availability**
    - **Scenarios**
    - **Systems**
    - **Threats**
    - **Environment**
21. **VV&A**
    - **Documentation**
    - **Risk-based**
    - **Examination**
22. **COTS SE tools**
23. **M&S metrics**

Objective 5

Shape the workforce

Actions

24. **Definition of required M&S competencies**
25. **Harvesting of commercial M&S lessons**
26. **Assemble Body of Knowledge for Acqn M&S**
27. **M&S education & training**
    - **DAU, DAG & on-line CLMs**
    - **Conferences, workshops & assist visits**
28. **MSIAC utility**

Objective 1: Provide Necessary Policy & Guidance

(Preamble) Need to assign responsibility for management of the joint capability areas, to include systems engineering and its M&S component

1. Provide effective, persistent DoD-wide M&S management to address cross-cutting M&S issues, coordinate actions
   Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
   Products: Revised DoDD 5000.59 (M&S Management) with clearer responsibilities, revised EXCIMS membership, SOP for EXCIMS processes, a refocused DMSO
   Completion goal: 2006

2. Promote model-based systems engineering (MBSE) and M&S-enabled collaborative environments, at both the program and joint capability level
   Lead: OUSD(AT&L)/DS; **Support:** Components
   Products: Revised guidance in DAG
   Completion goal: 2007

3. Establish policy on appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities
   Co-leads: OUSD(AT&L)/DS, ODOT&E; **Support:** Components
   Products: Revised policy and guidance in DoDI 5000.2 and DAG
   Completion goal: 2006

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Obj. 1: Provide Necessary Policy & Guidance (cont.)

4. Establish policy to require documented M&S planning at the joint capability & program levels as part of the Systems Engineering Plan, T&E Strategy and T&E Master Plan
   - **Co-leads:** OUSD(AT&L)/DS, ODOT&E; **Support:** Components
   - **Products:** Revised policy and guidance in DoDI 5000.2, DAG, and DOT&E TEMP Planning Guidance
   - **Completion goal:** 2006
5. Establish guidelines for M&S-related RFP language & contract provisions
   - **Lead:** OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DPAP, Components
   - **Products:** Sample language in DoD publications (e.g., DAG, SEP Preparation Guide, Contracting for Systems Engineering Guidebook) regarding M&S requirements, data rights, and the responsibilities and liabilities of parties regarding sharing and reuse
   - **Completion goal:** 2006
6. Publish practical guidelines for security certification of M&S activities falling under multiple Information Assurance Defense Accreditation Authorities
   - **Lead:** OASD(NII); **Support:** OUSD(AT&L)/DS, NSA
   - **Products:** Guidelines published in DoD 8500.2-H, per DoDI 8500.2 "Information Assurance Implementation," Feb 6, 2003
   - **Completion goal:** 2007

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Objective 2: Enhance the Technical Framework for M&S

7. Establish a framework for data interchange-related standards
   Lead: OASD(NII); **Support:** OUSD(AT&L)/DS
   Products: Revised guidance in NII policy documents
   Completion goal: 2008

8. Develop a product development information metamodel & associated metadata extensions to the DoD Discovery Metadata Specification
   Lead: OUSD(AT&L)/DS; **Support:** OASD(NII), Components
   Products: Revised DDMS; revised guidance in DAG.
   Completion goal: 2008

9. Support development of open commercial systems engineering-related standards, such as OMG's Systems Modeling Language (SysML) and ISO Standard 10303 AP-233
   Lead: OUSD(AT&L)/DS; **Support:** DLA, OUSD(AT&L)/DDRE, OASD(NII)
   Products: Published standards suitable for adoption by DoD
   Completion goal: 2007

10. Establish a forum to clarify the characteristics and application of various distributed simulation standards (HLA, TENA, DIS, ALSP, SI3, etc.) and examine opportunities for convergence
    Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/TRMC & DS, ODOT&E, Components
    Products: (1) Information on strengths & weaknesses of the various standards; (2) agreement on policy and/or guidance on the use of distributed simulation standards; (3) a way ahead regarding distributed simulation standards
    Completion goal: 2007

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Obj. 2: Enhance the Technical Framework for M&S (cont.)

11. Improve the utility of the DoD Architecture Framework (DoDAF) for acquisition

    11-1. Develop the Acquisition Overlay (profile) for DoDAF v2.0

    Lead: OUSD(AT&L)/DS; **Support:** OASD(NII), Components
    Products: Acquisition Overlay for DoDAF v2.0
    Completion goal: 2006

    11-2. Support development of open commercial standards for the depiction and interchange of DoDAF-compliant architectures

    Lead: OASD(NII) **Support:** OUSD(AT&L)/DS
    Products: Published standards suitable for adoption by DoD in DoDAF 2.0; revised guidance in DAG
    Completion goal: 2007

12. Establish a standard template of key characteristics (metadata) to describe reusable M&S resources

    Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/DS & TRMC, DOT&E; Components
    Products: Published standard template; usage guidance in DAG
    Completion goal: 2007

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Objective 3: Improve Model & Simulation Capabilities

13. Establish a process to ensure acquisition needs are reflected in DoD M&S priorities, including S&T
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS
    Products: Incorporate in M&S requirements process (ref: DoD M&S Master Plan) a method to capture and prioritize those acquisition needs.
    Completion goal: 2007

14. Define and foster best practices for efficient development and evolution of credible M&S tools, incorporating user-defined requirements, a systems engineering approach, and appropriate verification & validation
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Best practices DMSO publication, available via MSIAC, DTIC, etc.; DAG guidance to use
    Completion goal: 2008

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Obj 3: Improve Model & Simulation Capabilities (cont.)

15. Enable readily-available distributed live-virtual-constructive environments, leveraging related initiatives

15-1. Establish DoD-wide standards for distributed environments

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/TRMC & DS; ODOT&E; Components
Products: Published standard; DODI (# TBD) policy to use
Completion goal: 2008

15-2. Make candidate simulations, labs and ranges compliant with these standards

Lead: Components; **Support:** OUSD(AT&L)/DS & TRMC
Products: Toolkit of live, virtual and constructive representations ready to be employed in distributed events
Completion goal: 2009

15-3. Provide services to help plan and conduct distributed events

Lead: Components; **Support:** OUSD(AT&L)/TRMC & DDRE, DISA
Products: Fee-based technical services to help users (e.g., PMs, Capability Managers, OTAs) plan and conduct distributed events
Completion goal: 2009

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Obj 3: Improve Model & Simulation Capabilities (cont.)

16. Centrally fund and manage the development and maintenance of high-priority, broadly-needed M&S tools

    16-1. Identify and prioritize broadly-needed M&S tools

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS; Components
    Products: Prioritized list of common M&S tool needs
    Completion goal: 2007

    16-2. Conduct one or more pilot projects to develop new M&S tools or update existing ones to meet these needs

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Proof of concept for managing the development/evolution of M&S tools to meet broadly-shared needs
    Completion goal: 2009

    16-3. Expand the scope of central M&S tool management as warranted by pilot project results and the list of common M&S needs

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Products: Optimal means to meet common needs for M&S tools
    Completion goal: 2011

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Objective 4: Improve Model & Simulation Use

17. Provide potential acquisition M&S users the knowledge needed to formulate an effective M&S strategy via ready access to M&S expertise and information about M&S capabilities and gaps, reusable resources, lessons-learned, etc.

    Lead: OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DDRE

    Products: Revised guidance in DAG; improved knowledge base in MSIAC; assist visits (e.g., by OUSD(AT&L)/DS)

    Completion goal: 2007

18. Define best practices for disciplined M&S planning & employment
    - Rigorous analysis of M&S requirements and alternative solutions, selection of best course
    - Efficient configuration management, initialization, execution and post-run analysis
    - Cautions against inappropriate use; approaches to maximize cost-effective reuse across lifecycle

    Lead: OUSD(AT&L)/DS, **Support:** OUSD(AT&L)/DDRE, Components

    Product: Revised best practices guidance in DAG and MSIAC

    Completion goal: 2007

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Obj. 4: Improve Model & Simulation Use (cont.)

19. Facilitate the sharing of reusable resources

19-1. Establish a DoD-wide business model for compensating providers of reusable M&S resources (e.g., information, software, services)

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Documented business model; revised policy and/or guidance in DoD 5000 series and DAG

Completion goal: 2007

19-2. Establish DoD policy and/or guidance regarding responsibilities to share, protect and properly use information and M&S tools

Co-Leads: OASD(NII) and OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS & DPAP, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Revised policy and/or guidance in various issuances (e.g., DoD 5000 series, DAG, contracting guidance)

Completion goal: 2007

19-3. Enhance the means (e.g., directory service, registries, bulletin boards) to discover existence of reusable M&S resources and contact information

Lead: OUSD(AT&L)/DDRE **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Functional means, with appropriate resources and incentives, and a continuous improvement process

Completion goal: 2007

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Obj. 4: Improve Model & Simulation Use (cont.)

20. Define the types of information DoD organizations shall make available to others with a valid need to know and the processes to obtain them (per reuse business model)

    20-1. Scenario data
    Lead: OUSD(AT&L)/DDRE **Support:** OCJCS(J8), OUSD(C)/PA&E, DIA, Components
    Product: Approved scenarios and process to obtain
    Completion goal: 2007

    20-2. System-related data
    Lead: OUSD(AT&L)/DS; **Support:** Components
    Product: Authoritative system data (characteristics and performance, interactions, interfaces, logistic support, etc.) and process to obtain
    Completion goal: 2007

    20-3. Threat data
    Lead: DOD MSEA for Threat Data; **Support:** OUSD(AT&L)/DDRE & DS, Components
    Product: Authoritative threat data and process to obtain
    Completion goal: 2007

    20-4. Natural environment data
    Lead: DoD Natural Environment MSEAs; **Support:** OUSD(AT&L)/DDRE & DS, Components
    Product: Authoritative natural environment data and process to obtain
    Completion goal: 2007

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Obj. 4: Improve Model & Simulation Use (cont.)

21. Foster cost-effective VV&A

21-1. Require DoD-wide standardized documentation of VV&A

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
Products: Revised policy in DODI 5000.2 and 5000.61; revised guidance in DAG
Completion goal: 2007

21-2. Develop risk-based methodology and associated guidelines for VV&A expenditures

Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
Products: Updated DMSO VV&A Best Practices documents/web site; guidance in DAG
Completion goal: 2006

21-3. Examine a program's VV&A when M&S informs major acquisition decisions and unambiguously state the purpose, key assumptions and significant limitations of each model/simulation when results are presented.

Lead: OUSD(AT&L)/DS **Support:** DoD Components
Products: Guidance & training for oversight personnel; updates to DAG Chaps 4 & 9
Completion goal: 2006

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Obj. 4: Improve Model & Simulation Use (cont.)

22. Assess the use of COTS systems engineering tools (modeling environments) for collaborative architecture development
    Lead: OUSD(AT&L)/DS**; Support:** OASD(NII), Components
    Products: Revised guidance in DAG; enhanced M&S body of knowledge for dissemination
    Completion goal: 2006
23. Define and capture meaningful metrics for M&S utility in acquisition
    Lead: Navy; **Support:** OUSD(AT&L)/DS, Components
    Products: Metric definitions in DAG; methods to capture and submit data in DAG; data from individual projects in MSIAC, Body of Knowledge, etc.
    Completion goal: 2007

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Objective 5: Shape the Workforce

24. Define required M&S competencies for the acquisition workforce
    Co-Leads: DAU and OUSD(AT&L)/DS; **Support:** OUSD(P&R), OUSD(AT&L)/DDRE, OUSD(C)/PA&E, Components
    Product: Identified lead FIPT; workforce qualification requirements; management process & structure
    Completion goal: 2008
25. Harvest lessons from commercial sector activities in the use of M&S to support product development
    Lead: OUSD(AT&L)/DS; **Support:** OUSD(AT&L)/DDRE, Components
    Products: Lessons collected at a defined site (TBD); annual update to best practices in DAG of lessons from industry that should be considered by PMs in planning for M&S
    Completion goal: Recurring; initial in 2007
26. Assemble and evolve the M&S Body of Knowledge (information set) relevant to acquisition
    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, Components
    Product: Information base available to potential M&S users (e.g., PMs, CMs, OTAs); source material for education and training
    Completion goal: Recurring; initial in 2007

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Obj. 5: Shape the Workforce (cont.)

27. Drawing on the M&S Body of Knowledge, educate and train the workforce to achieve required M&S competencies

    27-1. Provide M&S knowledge via an expanded set of DAU courses, the Defense Acquisition Guide, and on-line CLMs

    Lead: DAU; **Support:** OUSD(AT&L)/DS & DDRE, Components

    Product: Expanded set of DAU courses, improved M&S guidance in the Defense Acquisition Guide, on line Continuous Learning Modules; a better educated workforce

    Completion goal: 2009

    27-2. Provide M&S knowledge via conferences, workshops, and assist visits

    Lead: OUSD(AT&L)/DS; **Support:** DAU, OUSD(AT&L)/DDRE, Components

    Product: Annual outreach program; a better educated and trained workforce

    Completion goal: Recurring; initial in 2006

28. Improve the knowledge and expertise available through the MSIAC to make it of greater utility to the acquisition community

    Lead: OUSD(AT&L)/DDRE; **Support:** OUSD(AT&L)/DS, OUSD(P&R), OUSD(C)/PA&E, Components

    Product: Plan of action with coordinated MSIAC CONOPS & staffing requirement; list of knowledge shortfalls that MSIAC will take on; success criteria & process to bring MSIAC up to criteria

    Completion goal: 2008

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Next Steps

- Broadly vet actions (DoD, Industry)
  - Fine-tune actions, lead & support, products, etc.
- Finalize Acquisition M&S Master Plan
  - Acqn M&S Working Group consensus
  - SE Forum approval (Dec 2005)
  - Informal DoD coordination
  - Formal coordination as a DoD issuance?
  - USD(AT&L) approve plan
- Implement plan, monitor action completion
- Assess impact (metrics)

Discussion

- Questions and comments are invited here as time permits
- NDIA M&S Committee meeting 1445-1730 Thursday to answer remaining questions and discuss your change recommendations
  - All are welcome to attend

BACKUP

AMSWG Participants

Allen, John	DOT&E
Amick, Karl *	OSD(AT&L) LP&P
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Barnabe, Dennis	NSA
Bilmanis, John (ctr)	Army G3/BC
Bounker, Paul	RDECOM TARDEC
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Butterworth, Robert *	DOTE
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Elliott, Steve	OUSD(AT&L) DS/MW
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Friedenthal, Sanford	LMC
Furness, Zach (ctr)	MITRE
Gill, Jim *	DDFP/JTAMDO/CSC
Gillis, John (ctr)*	ASA(ALT) RDA M&S
Glasow, Jerry	DMSO
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Hollenbach, Jim (ctr)	OUSD(AT&L) DS/SE
Hutchings, Charles	NAVSEA
Johnston, Jerald	JHU/APL
Keener, Jim	IWS 1B% (NSWCDD)
Kelly, Doug	DIA
Kline, Tom	PEO IWS
Lackner, Bob	PEO IWS IC/ ANTEON
Long, James	Vitech Corp
Long, Vicki	HQAFMC/XRA
Mackoy, Rebecca	TRADOC
Manthei, Jerry	CNO N091/N912
Mathis, Thomas	RDECOM/SOSI Camber
Matzner, John	Army G-3/5/7/Alion
McDonnell, Joe (ctr)	RDECOM
Merrill, Bruce	NSA
Mitchell, Jeff	JHU/APL
Montoya, Matt	JHU/APL
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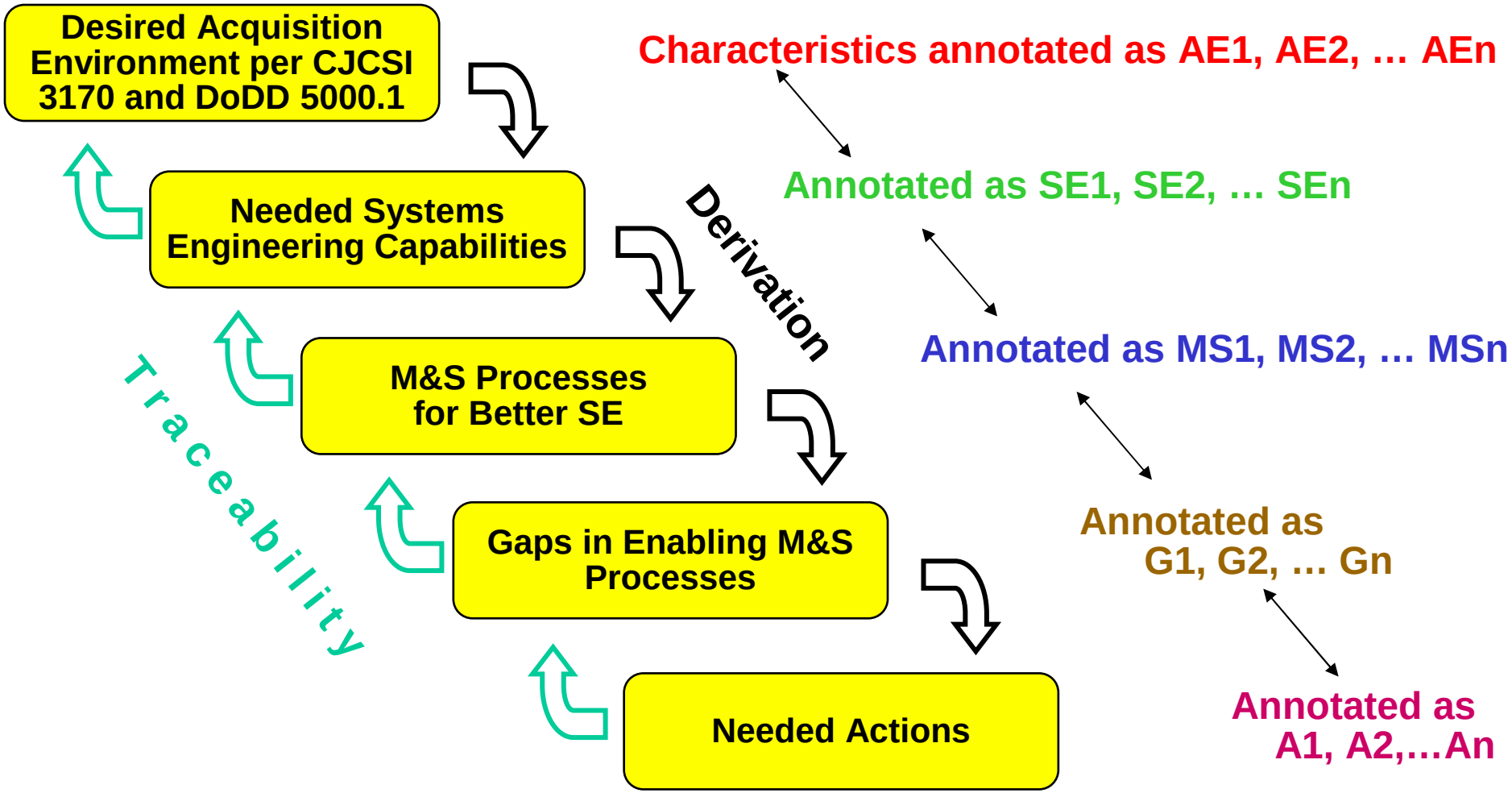
Nunez, Patrick	RDECOM TARDEC
Parmele, Truman	OASD/NII
Pikul, Ronald	ASN RDA
Pittenger, Bill *	DISA/MITRE
Placanica, John *	NGA
Preissman, Dan	NAVAIR
Prill, Mark *	NASA/ESMD
Prosnik, George *	DAU
Roe, James W	AF AFMC/XRA
Sas, Robert	NCEE
Schmidt, Karl	NGA/LMC
Shah, Nehal *	ASN(RDA) CHENG
Solosky, Tom *	DCMA
Suter, Richard	OUSD (AT&L) (T&E)
Swift, Lloyd ctr	ASN(RDA) CHENG
Tillery, Gordon (ctr)	OUSD(AT&L) DS/SE
Tirres, Carlos *	DTRMC
Truelove, Michael(ctr)	OUSD (AT&L) DS/SE
Vaughn, Barbara	ASN RDA CHENG
Walker, Oral	PMUA MSMO
Wallace Jim Walsh, John *	Army G37/BCSE OUSD(P&R)
Wright, Susan	OSD DOT&E
Znachko, Carrall	SAF/AQIZ

* Indicates SE Forum Representatives that are AMSWG Voting Members

Top-Down Derivation/Cross-Check



Desired Acquisition Environment:

Key CJSCI 3170.01E Policies

- AE1 *Joint concepts-centric capabilities identification process to allow joint forces to meet the full range of military operations and challenges…*
- AE2 *Assess existing and proposed capabilities in light of their contribution to future joint allied and coalition operations. … Produce capability proposals that* AE3 *consider the full range of DOTMLPF solutions in order to advance joint warfighting in a unilateral and multinational context.*
- *New solution sets…crafted to deliver technologically sound, testable,* AE4 *sustainable and affordable increments of militarily useful capability.*
- *The* AE5 *FoS and SoS solutions may also require systems delivered by multiple sponsors/materiel developers.* AE6
- *The process to identify capability gaps and potential solutions must be supported by a robust analytical process* AE7
- *JCIDS implements a capabilities-based approach that…requires a* AE8 *collaborative process that utilizes joint concepts and integrated* AE9 *architectures to* AE10 *identify prioritized capability gaps and integrated DOTMLPF and policy approaches to resolve those gaps* AE11

Desired Acquisition Environment:

DoDD 5000.1 Acquisition Policies

"The primary objective of Defense acquisition is to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price."

Governing policies:

- *Flexibility, Responsiveness (time-phased capabilities, evolutionary acquisition), Innovation, Discipline, Streamlined Effective Management*
- *Armaments Cooperation; Collaboration; Competition; Cost and Affordability; Cost Realism; Cost Sharing; Financial Management; Independent OTAs; Information Assurance; Information Superiority; Integrated T&E; Intelligence Support; Interoperability; Knowledge-Based Acquisition; Legal Compliance; Performance-Based Acquisition; Performance-Based Logistics; Products Services and Technologies [seek most cost-effective solution over the system's life cycle], Professional Workforce, Program Information [complete, current, tailored]; Program Stability; R&D Protection; Safety; Small Business Participation; Software Intensive Systems; Streamlined Organizations; Systems Engineering; Technology Development and Transition; Total Systems Approach*
- *Oct 04 policy memo: Technical reviews … shall be event-driven*

Necessary Systems Engineering Capabilities

(which M&S can affect; derived from Desired Acquisition Environment)

SE1. Early, continuing systems engineering from an SoS/FoS capabilities perspective; seamless transition from JCIDS to acquisition **(AE1-3,5,9-11,16,20,21,25,27)**

SE2. Lifecycle-wide exploration of the maximum available trade space, including time-phased requirements and technology insertion **(AE1-5,7,10,11,13,16,19,23-27)**

SE3. Collaboration among all stake holders (multiple gov't and contractor organizations) for key enterprise-level SE decisions **(AE6-8,10,18,22,25,27)**

SE4. Rapid assessment of concept/design alternatives **(AE2,4,7,10,14,16,19,25,28)**

SE5. Comprehensive, accurate, event-based assessment of technical baselines; avoidance of costly fixes for problems discovered late **(AE2-4,7,9,10,12-17,19,20,22,24-26,28)**

SE6. Focused, effective & efficient testing; including at the capability level **(AE1,2,4,5,9-11,13,15,19-22,25)**

SE7. Appropriate reuse of all resources – information, software tools, expertise, facilities, ranges, etc. – across programs & organizations **(AE4,14,15,19,24,25)**

D1

M&S Processes for Better Systems Engineering

(derived from Needed Systems Engineering Capabilities)

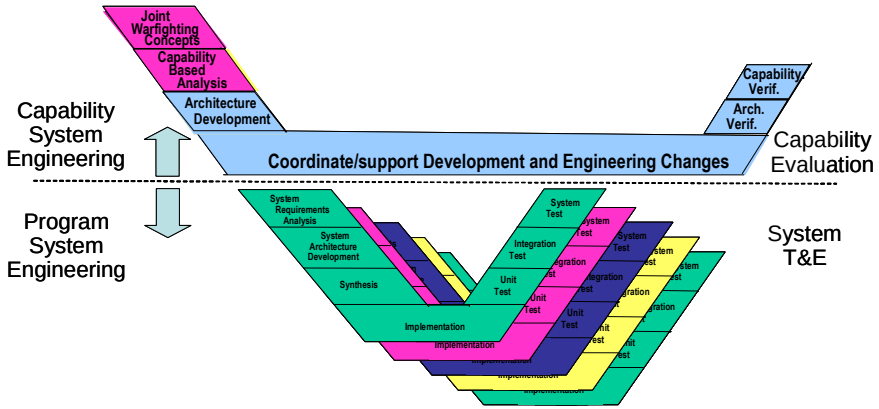
MS1. Use of a model-based systems engineering approach **(SE1,2,4,5)**

(Emerging concept under INCOSE, OMG, etc.; growing suite of COTS SE tools)

- SE tool modeling environments to analyze requirements, develop architecture, and specify constraints; views linked to, and generated from, an underlying database
- Embedded simulation to verify the architecture and assess its merits
- Automated generation of documents/reports

MS2. Establishing M&S-enabled collaborative engineering environments **(SE1,2,3,4,5,6)**

- Shared, authoritative information
- Interoperable modeling environments for architecting/design
  - Models as communication means
- Models & simulations to assess
  - Option to immerse warfighters, etc.
- Distributed live-virtual-constructive environments for integration, verification, and test



MS3. Model-Test-Fix-Model process across the life-cycle **(SE4,5,6)**

- Better test planning, more effective tests
- Increased M&S validity; credible surrogates; reuse savings

D1 M&S Processes for Better Systems Engineering

MS4. Harnessing M&S knowledge to formulate an effective M&S strategy **(SE2,3,4,5,7)**

- Ready access to M&S expertise and information about capabilities and gaps (M&S holes), reusable resources, lessons-learned, etc.

MS5. Disciplined M&S planning & employment **(SE2,4,5,7)**

- Rigorous analysis of M&S requirements, alternatives, best course
- Efficient configuration/initialization, execution and post-run analysis
- Avoid inappropriate use; maximize cost-effective reuse across lifecycle

MS6. Efficient development/evolution of credible M&S tools **(SE2,3,5,7)**

- A systems engineering approach with appropriate V&V

MS7. Access/sharing of authoritative, understandable data needed for M&S representations **(SE2,3,4,5,7)**

- Reducing a major time and cost burden that inhibits M&S use

MS8. Inspection of M&S used to inform acquisition decisions **(SE2,5,7)**

- Examine capabilities and limitations (VV&A) of M&S
- During lead-up to program/technical reviews, OTRRs, DABs, etc.

D2

Gaps

1. Management

G1. Robust but confused landscape of M&S activities; no clearly designated leadership or effective coordinating mechanism **(MS1-8)**

- Current EXCIMS ineffective; little coordination for capabilities/SoS/FoS

G2. Inadequate constancy of purpose because time to fix problems >> tour length; "DoD has an attention deficit disorder" **(MS2-7)**

G3. Gov't acquisition guidelines don't promote M&S use or reuse **(MS1-6)**

G4. No DoD requirement for formal M&S planning to support acquisition (other than T&E) **(MS1-5)**

G5. No contractual guidelines regarding M&S and the data it needs **(MS1-8)**

G6. Gov't typically doesn't give contractors meaningful M&S guidance **(MS1,2,6,8)**

G7. Most DoD M&S takes a project, vice an enterprise, approach **(MS2,3,6,7)**

G8. No consensus on value of integrated architectures, nor responsibility for **(MS1,2)**

G9. Managing distributed collaboration is very hard **(MS1-8)**

G10. Public law precludes OT based solely on M&S, but no clear guidance on use for SoS/FoS T&E **(MS2,3,5,6,8)**

D2

Gaps

2. Architecture/standards/technical framework

G11. No standard modeling notation (like UML v2.0) for capturing full range of information critical to system engineering (e.g., structure, behavior, requirements hierarchy/traceability, test cases, verification results) **(MS1,2,6,7)**

G12. No standard for interchanging systems engineering information (same examples as above) **(MS1,2,6,7)**

G13. No conceptual framework (like Open System Interconnect protocol stack) for data interchange **(MS1,2,3,6,7)**

G14. Lack of agreement on a common distributed simulation standard increases complexity and cost, limits simulation interoperability **(MS2,5,6)**

G15. DoDAF v1.0 is difficult to use for architecting due to lack of data-centricity and executability; some products of marginal value **(MS1,2,6,7)**

G16. Use of DoD-unique standards limits their user base, quality, COTS tool support, and opportunities for reuse **(MS1,2,5,6)**

D2

Gaps

3. Model/simulation capabilities & use

G17. Many M&S tool gaps and deficiencies **(MS1,2,3,5,7)**

- What's modeled (e.g., urban warfare, comm networks, threats, system sustainment)
- Fidelity, granularity, interoperability
- Only limited consensus on common models to be used across a domain

G18. No good way to develop and maintain widely-needed M&S tools that cut across programs **(MS5,6)**

- Not incorporating mods by other organizations into "street version," etc.

G19. M&S developers, not M&S users, tend to drive M&S development **(MS6)**

G20. In general, architecture development (modeling) is lagging, not collaborative, and not exploiting COTS SE tools (modeling environments) **(MS1,2)**

G21. No readily-available distributed M&S infrastructure (e.g., JDEP) **(MS2,5)**

G22. Hard to get security certification for multi-organization (company/ Service) distributed simulation **(MS2,3,5,6)**

G23. Hard to get approval and security certification for M&S involving multiple compartmented programs (SAPs) **(MS2,3,5,6,7)**

D2

Gaps

4. Trustworthiness/VV&A

G24. Post-development model validation expensive and slow **(MS2,3,5,8)**

G25. VV&A often weak or non-existent; documentation inconsistent **(MS2,3,5,8)**

- Plans to use M&S to avoid testing costs often rejected due to poor/no validation

G26. VV&A usually not enforced and also not examined during program reviews **(MS2,3,5,6,8)**

G27. Models and sims often not updated to reflect empirical evidence (e.g., test results) **(MS2,3,5,8)**

D2

Gaps

5. Sharing/reuse and protection of tools & information

G28. Little reuse; only 7% of models & sims used on >1 program **(MS2,5,6)**

G29. Concurrent engineering requires an integrated process, data sharing and a coherent tool set, but <20% of programs have such a collaborative environment **(MS2,7)**

G30. Hard to discover reusable resources (software, info, services) **(MS2,4,5,7)**

- M&S repositories are not integrated, lack an effective search capability, and are mostly empty
- MSIAC knowledge/expertise is lacking

G31. Insufficient info (metadata) to evaluate data/reuse candidates **(MS2,4,5,7)**

G32. Hard to obtain reusable resources **(MS2,4,5,7)**

- Industry to gov't: To protect proprietary info & competitive advantage
- Gov't to industry: Contractual liabilities associated with GFE/GFI
- Gov't to gov't: Concerns about misuse; cost to deliver and guide

G33. No incentives to encourage reuse **(MS2,3,5,6)**

- Negative incentives include cost to make reusable, workload assisting users, vulnerability to criticism

[plus approval and security certification gaps 22 & 23 listed under M&S use]

D2

Gaps

6. Research/S&T/tech base

G34. Conceptual foundation of M&S weak **(MS5,6)**

- E.g., theoretical understanding of modern warfare, human behavior, relating M&S at different granularities, dealing with uncertainty, agent-based modeling and generative analysis

G35. Little acquisition community input to DoD S&T management regarding needed M&S-related research **(MS2,5,6)**

7. Business model, metrics & ROI, funding and incentives

G36. No business model for how M&S capabilities should be developed, used and maintained **(MS1-8)**

G37. Metrics are critical to keep interest and funding up, but metrics regarding M&S use and cost-effectiveness are inadequate **(MS1-8)**

- M&S funding difficult to identify; most embedded within other PEs

G38. Too little funding **(MS2-7)**

D2

Gaps

8. Workforce Shaping

G39. Body of knowledge for M&S support to acquisition is deficient, not managed **(MS1,2,4-6,8)**

G40. Acqn community managers and staffs mostly uninformed about M&S capabilities and limitations **(MS1-8)**

- Weak acquisition personnel understanding of commercial M&S activities ("We don't get out enough")
- Not enough M&S experts (no career path [except Army], no formal education or training)

G41. M&S developers lack understanding of modeling best practices, abstraction techniques, context dependencies, etc. **(MS3,6)**

G42. M&S users often not adequately trained **(MS1,2,4,5,8)**

G43. Insufficient M&S education options **(MS2,4,5,6,8)**

ATSRAC:
Background, Results and Future Impact on the Aviation Industry

presented to

NDIA 8th Annual Systems Engineering Conference

Kent V. Hollinger

26 October 2005

Who is ATSRAC?

- Aging Transport Systems Rulemaking Advisory Committee
  - Initially chartered 19 January 1999
  - Re-chartered:
    - 25 January 2001
    - 28 January 2003
    - 21 January 2005
  - See www.mitrecaasd.org/atsrac/index.html

Background

- Two major 1996 accidents caused national USA attention to aviation safety
- Growing number of flights will create more accidents, even with a lower rate
- White House Commission on Aviation Safety and Security - 22 August 1996

Gore Commission Report

- Final Report published 12 February 1997
- 1.9 In cooperation with airlines and manufacturers, the FAA's Aging Aircraft Program should be expanded to cover non-structural systems

Initial ATSRAC Members

Chairman: Kent Hollinger

- FAA
- DoD
- ALPA
- ATA
- AIA
- NASA
- GAMA
- Flight Safety Foundation
- JAA
- Transport Canada
- AECMA
- General John Loh
- Boeing
- Airbus
- NEMA
- SAE (DuPont)

Added ATSRAC Members

- AirTran Airways
- Dassault
- IATA
- IAM
- International Federation of Airworthiness
- NADA/F
- NBAA
- Northwest Airlines
- Garrett Aviation Services

Initial Five Tasks

- Sampling inspection of the fleet
- Review of fleet service history
- Improvement of maintenance criteria
- Review and update standard practices for wiring
- Review air carrier and repair station inspection and repair training programs and recommend actions to address aging systems

Status of Initial Tasks

- All tasks are complete
- ATSRAC approval of Final Reports during January 2001 meeting
- Final Reports with recommendations forwarded to FAA

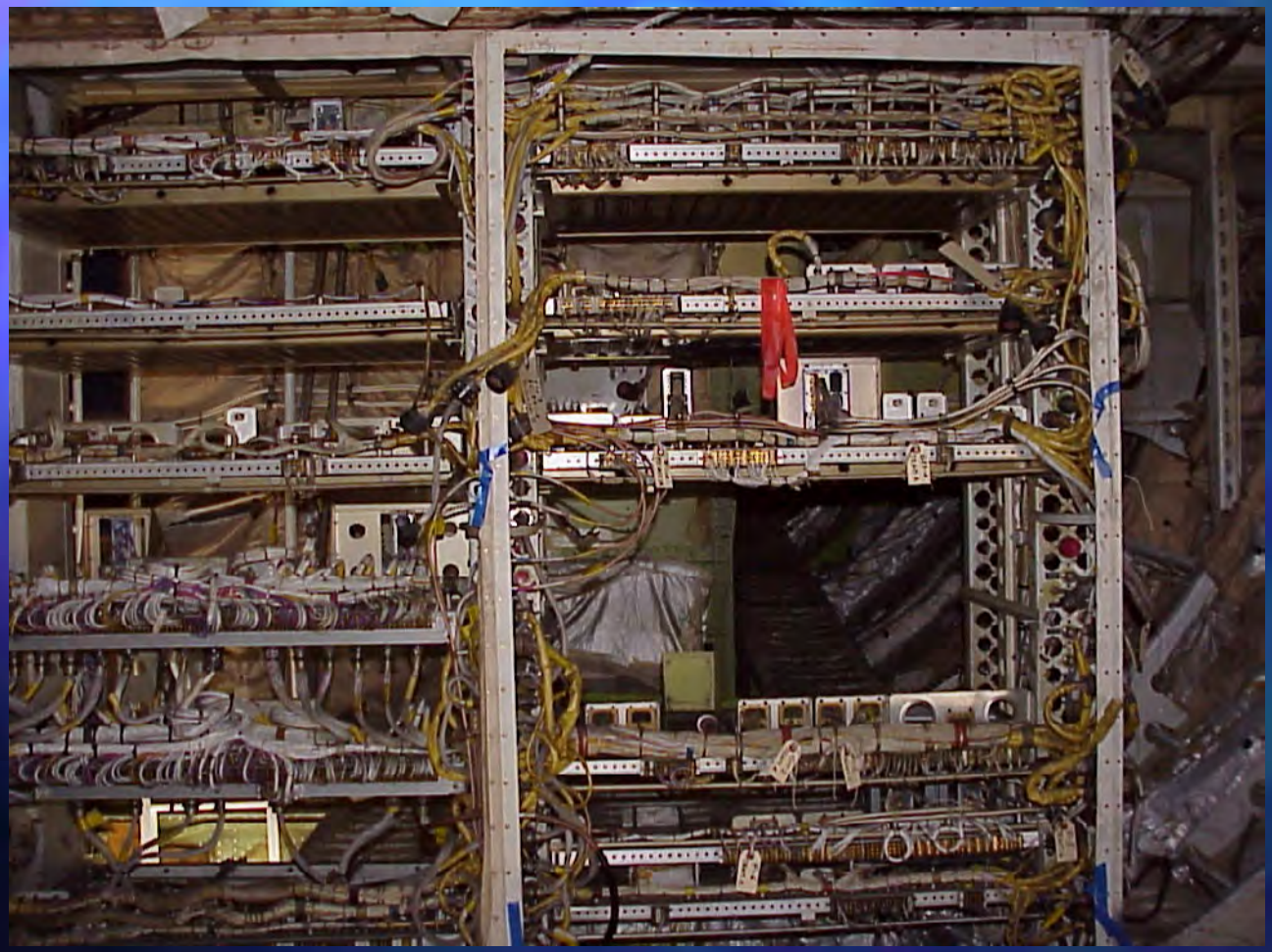
Task 1 Results

- Non-intrusive Inspections of 81 aircraft
  - Aged up to 82,000 hours and 92,000 cycles
  - 3,372 individual discrepancies (sorted by risk)
    - Immediate Fleet-wide Safety of Flight Concern – **0**
    - Potential Hazard or Frequently Occurring Item - 182
      - SB's required for 3 and enhanced inspection guidelines for 2
    - Defects noted - 3,190

Task 1 Results (continued)

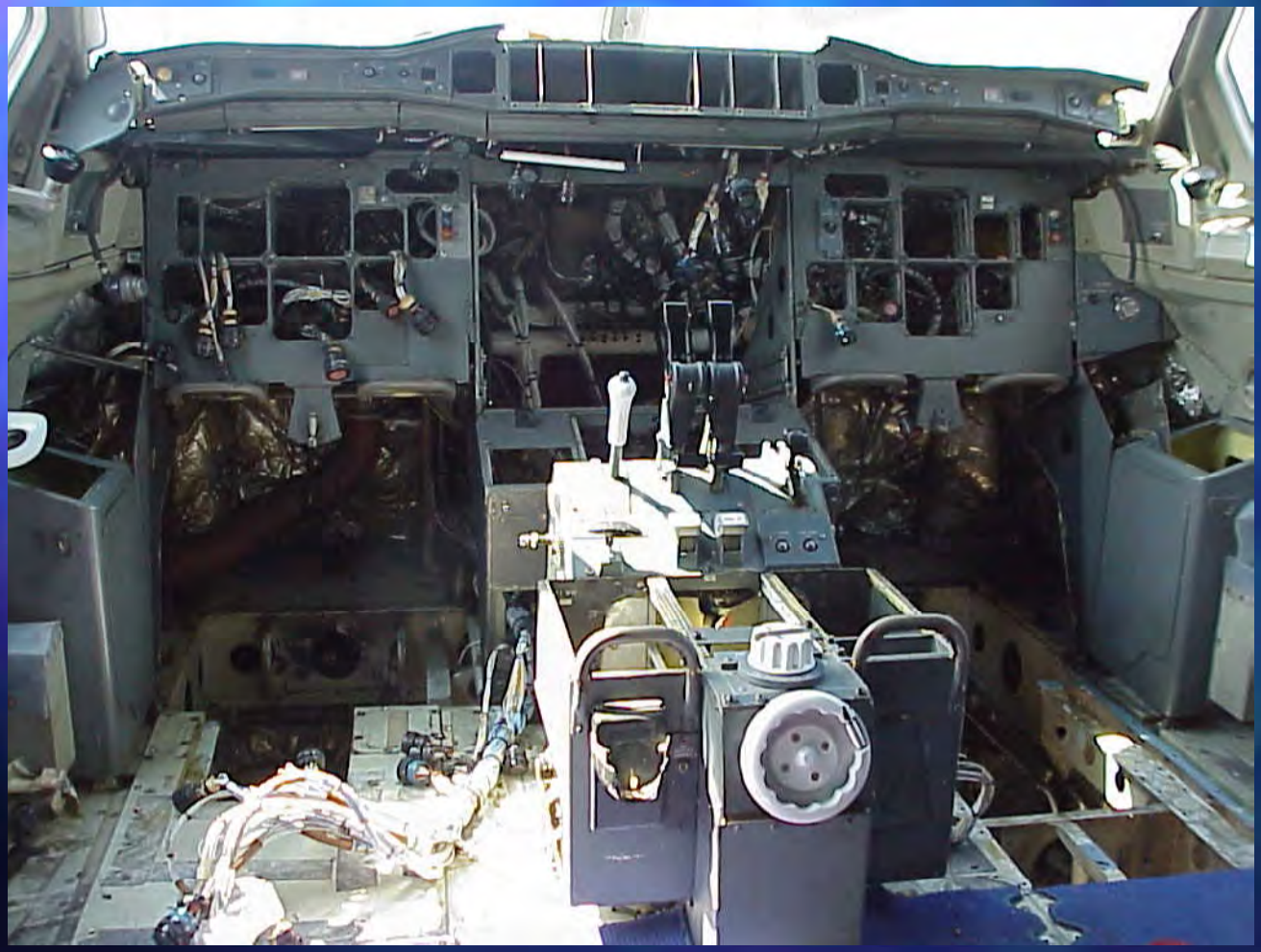
- Intrusive Inspections of 6 retired aircraft
  - Aged up to 100,241 hours and 100,017 cycles
  - Targeted specific wire types and aircraft zones
  - On-board visual inspection and NDT
  - Wires removed and 25 laboratory tests applied
  - Recommendations:
    - 1 general - education of inspection & maintenance personnel
    - 9 research - degradation, chaffing, contamination, NDT, AFCB
    - 90 specific - splices, heat shields, clamping

Typical Aircraft Zones (1 of 4)



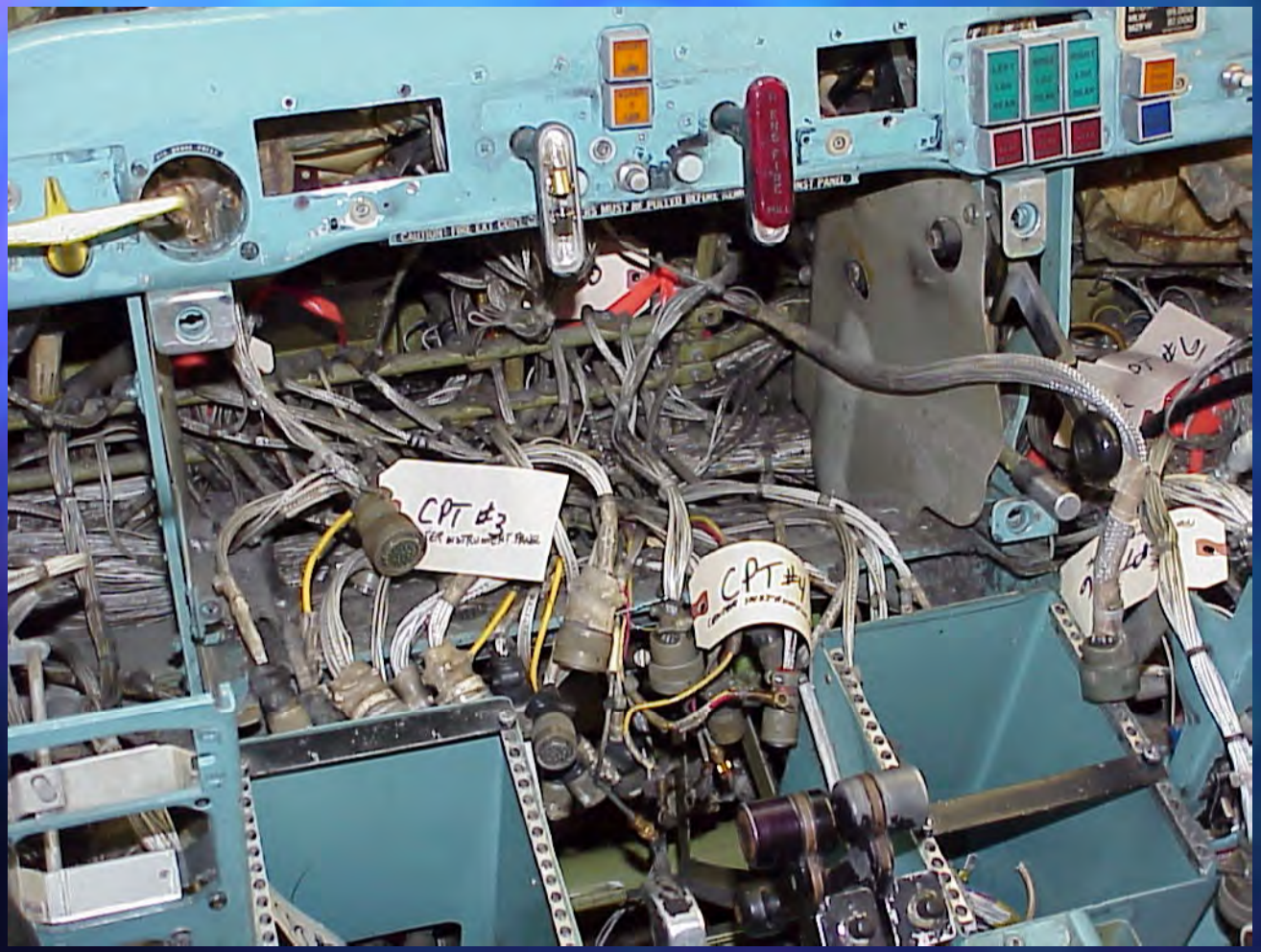
B747 Electronics Rack, E&E Bay

Typical Aircraft Zones (2 of 4)



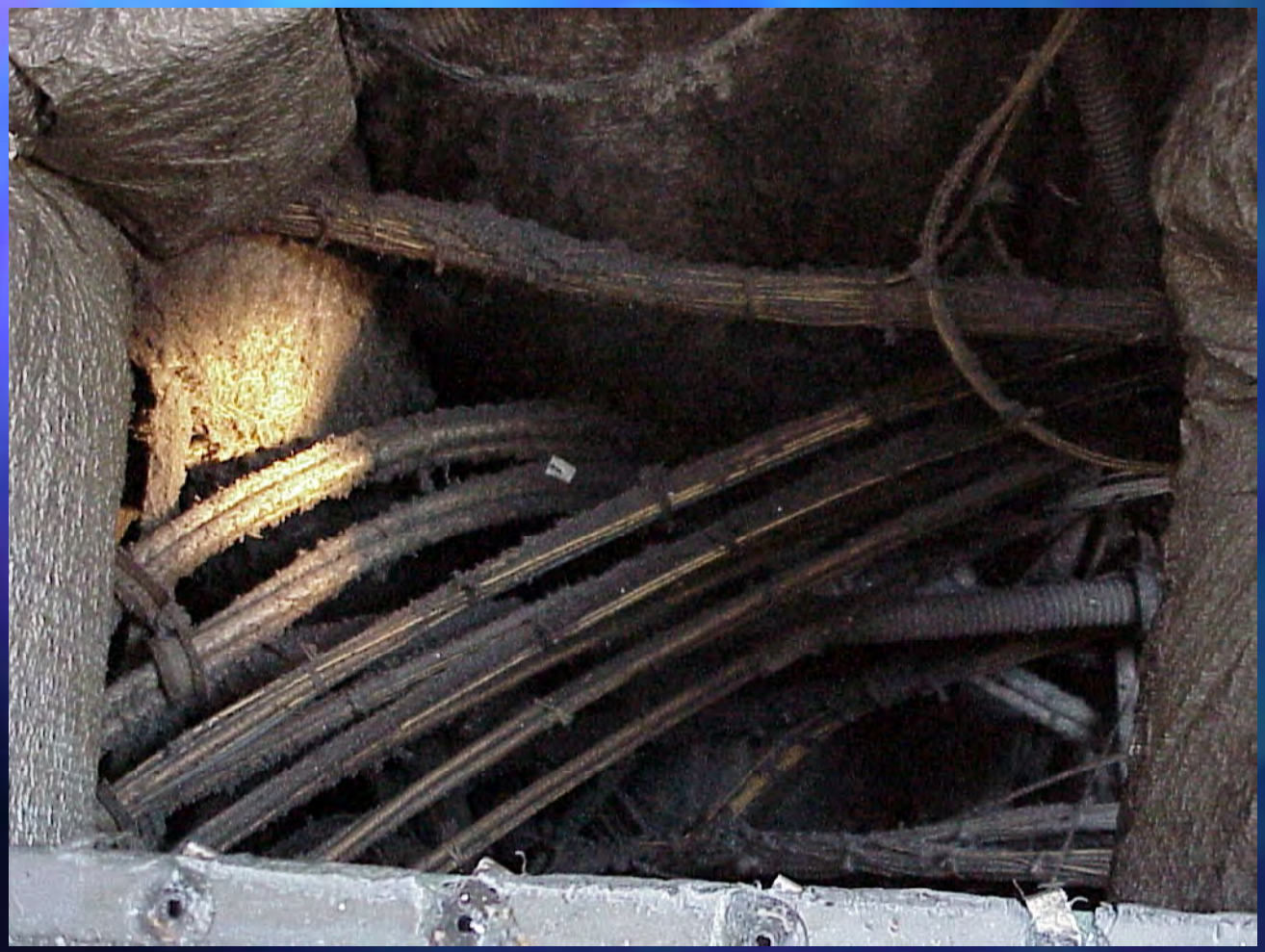
A300 Cockpit

Typical Aircraft Zones (3 of 4)



DC-9 Cockpit

Typical Aircraft Zones (4 of 4)



L1011
Under
Floor Panels

Defects Found by NDI

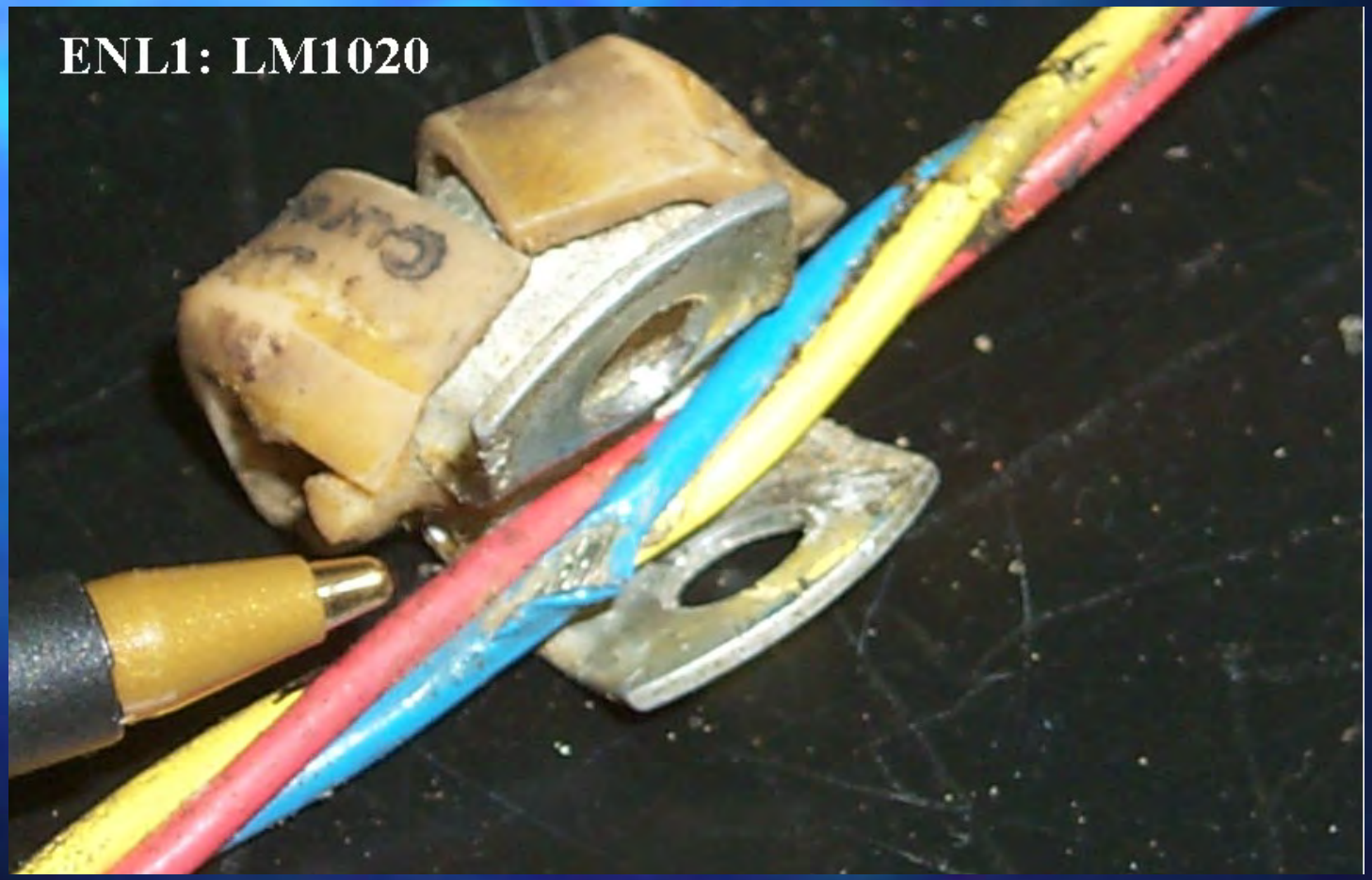
Hot Stamp Damage

Installation Problems

Contact with hot duct

Power feeder chafing

Clamping Problem



Further Information

- Intrusive Inspection Report available at:

http://www.mitrecaasd.org/atsrac/intrusive_inspection.html

Task 2 Results

- Reviewed 714 Service Documents
  - Boeing - 27 upgraded to Alert status
  - Airbus - 3 upgraded to Alert status
  - Lockheed - no further action required
- Reviewed 79 ADs with repetitive inspections
  - Recommended 8 for terminating action

Next Four Tasks (Phase II)

- Federal Register 29 May 2001 p. 29203
  - Wire system certification requirements
  - Standard format and content of SWPM
  - Enhanced training program for wire systems
  - Enhanced maintenance criteria for systems

Status of Phase II Tasks

- All tasks are complete
- Final Reports with recommendations forwarded to FAA in 2002
- Small airplane recommendations forwarded to FAA in January 2003

Task 6 Results

- Created new FAR 25 Subpart H for Electrical Wiring Interconnection Systems
  - Consolidated current wiring regulations
  - Wire system separation
  - Wire system identification
  - Wire system safety assessments
- Revised current FAR 25 sections and created Advisory Circulars

Task 7 Results

- Defined minimum content for Electrical Standard Wire Practices Manual (ESWPM)
- Defined standard format for new ESWPM
- Created a Master Breakdown Index (MBI) for use with existing ESWPM

Task 8 Results

- Created an Advisory Circular titled "*Aircraft Electrical Wiring Interconnection Systems Training Program*"
- Applicable to air carriers, maintenance providers, OEMs and STC holders
- Voluntary incorporation is encouraged

Task 9 Results

- SFAR to require OEMs to implement and communicate an Enhanced Zonal Analysis Program (EZAP) to airlines
- Created Special Maintenance Program Requirements for >30 seat airplanes
- Created new FARs to require training on electrical systems (see AC from Task 8)

Current HWG#12

- Numerous recommendations to FAA:
  - Industry standard for EWIS routing
  - Aging circuit breakers (cycling by industry)
  - Arc Fault Circuit Breakers (AFCB)
  - Effects of additives on wiring qualification
  - Maintenance training requirements
  - Improved shield terminators

Current Schedule

- Notice of Proposed Rule Making (NPRM) scheduled for 6 October 2005
- Final Rules and Advisory Circulars are expected by year end 2006
- Inclusion of airplanes with <30 seats is required for new designs but is still under consideration retroactively (ATSRAC split)

Future Public Meetings

- 10 – 12 January 2006 @ ATA
- 4 – 6 April 2006 @ Airbus North America
- **Sunset** of ATSRAC

Are There Any

Questions?

Out of the Ordinary: Finding Hidden Threats by Analyzing Unusual Behavior

A New Approach to "Connecting the Dots" in Intelligence

John Hollywood
RAND

Presentation to the NDIA Systems Engineering Conference
October 26, 2005

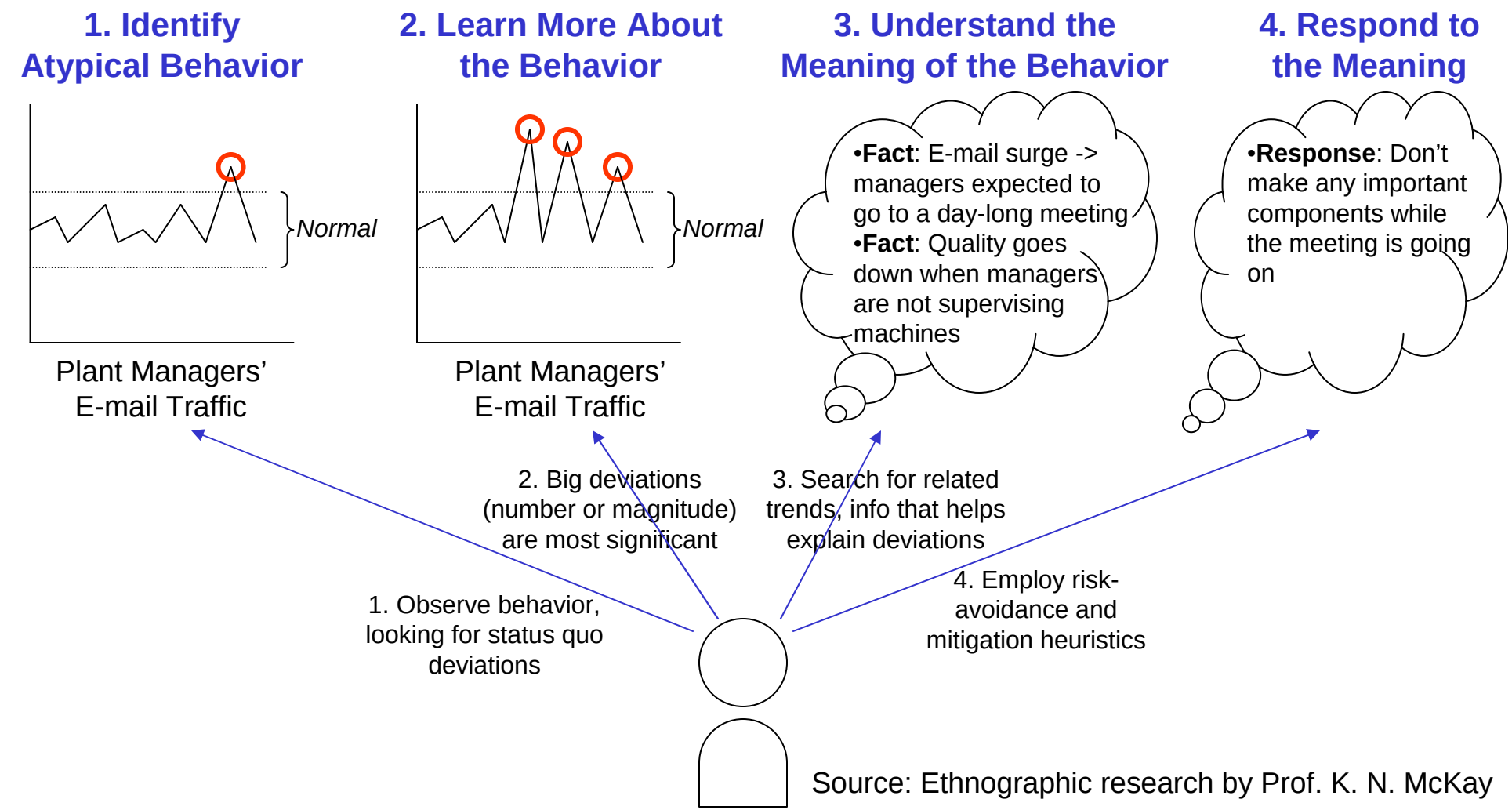
Introduction

- Today's presentation is on the "Atypical Signal Analysis and Processing" (ASAP) Schema, an architecture for—
  - Identifying "unusual" observations worth further attention
    - E.g, violations of the status quo
  - Relating these observations to other data
  - Generating and testing hypotheses about these observations
- Purpose of research was to identify and characterize terrorist threats, but basic approach may have a number of other applications
  - Previously asked about applications for "tracking and identifying problem acquisition personnel early in the process"
  - Might also have applications for PM and SE
- From a RAND IR&D project – results documented *Out of the Ordinary: Finding Hidden Threats by Analyzing Unusual Behavior* (RAND MG-126-RC)
  - Focuses primarily on top-level architecture, with some discussion of data management and analysis algorithms

Motivation for "Out of the Ordinary" Research

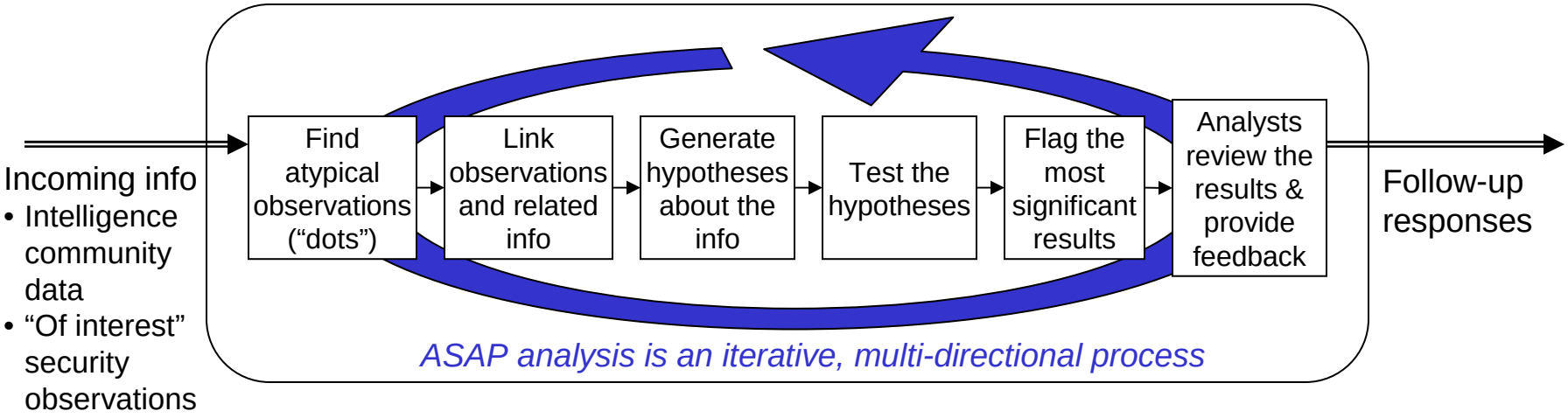
- Immediate motivation was to improve ability to "connect the dots" – pieces of information that could be combined to produce understanding of a threat
- Focus on intelligence and homeland security data, especially on reports
  - Others were working on large-scale data mining; taking advantage of intelligence / HLS reports was unique opportunity
  - Also wanted to avoid privacy / legal issues
  - For acquisition, equivalent would be steady stream of reports and products coming out of PM and acquisition offices, plus any reported complaints
- Additional focus – look for "anti-patterns"
  - Knew we wanted to avoid "fighting the last war problem" (I.e. just looking for patterns matching previous attacks)
  - Also inspired by how proactive, successful problem solvers have "connected the dots" in the past…

Proactive, Successful Problem Solvers Study the Atypical to "Connect the Dots"



Source: Ethnographic research by Prof. K. N. McKay

The ASAP Schema Is Modeled After Problem Solvers' Analysis of the "Out of the Ordinary"

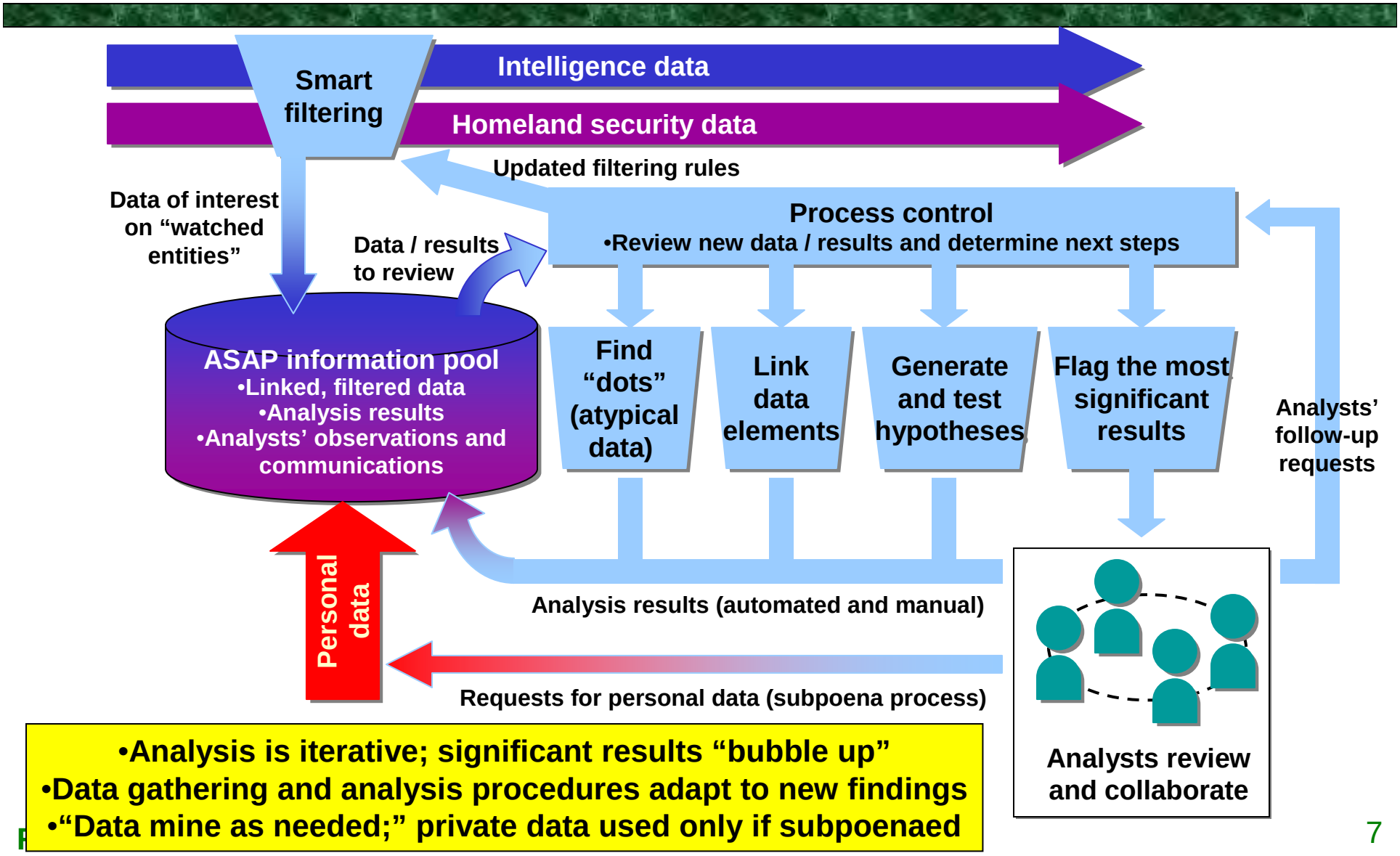


Improve awareness and collaboration for networks of intelligence collectors and analysts at all levels— national, strategic, operational and tactical

Observations on Research and Development Needs

- Initial research focus was going to be on algorithms development, but numerous tools carrying out specific tasks to "connect the dots" already exist
  - Text to structured data tools
  - Network analysis tools / link analysis tools
  - Data mining tools
  - Collaboration / groupware suites
- What was missing was putting them together into a single architecture
  - Led to focus on developing ASAP *architecture*, rather than specific algorithms or tools
- What is also needed is a basic suite of analysis and collaboration tools that can be deployed quickly and cheaply, and can be customized and tailored to the situation at hand
- "Artificial intelligence" research on developing models of the status quo, and developing algorithms to find outliers, also needed

The ASAP Architecture for Automated Support to Counter-Terrorism Analysis

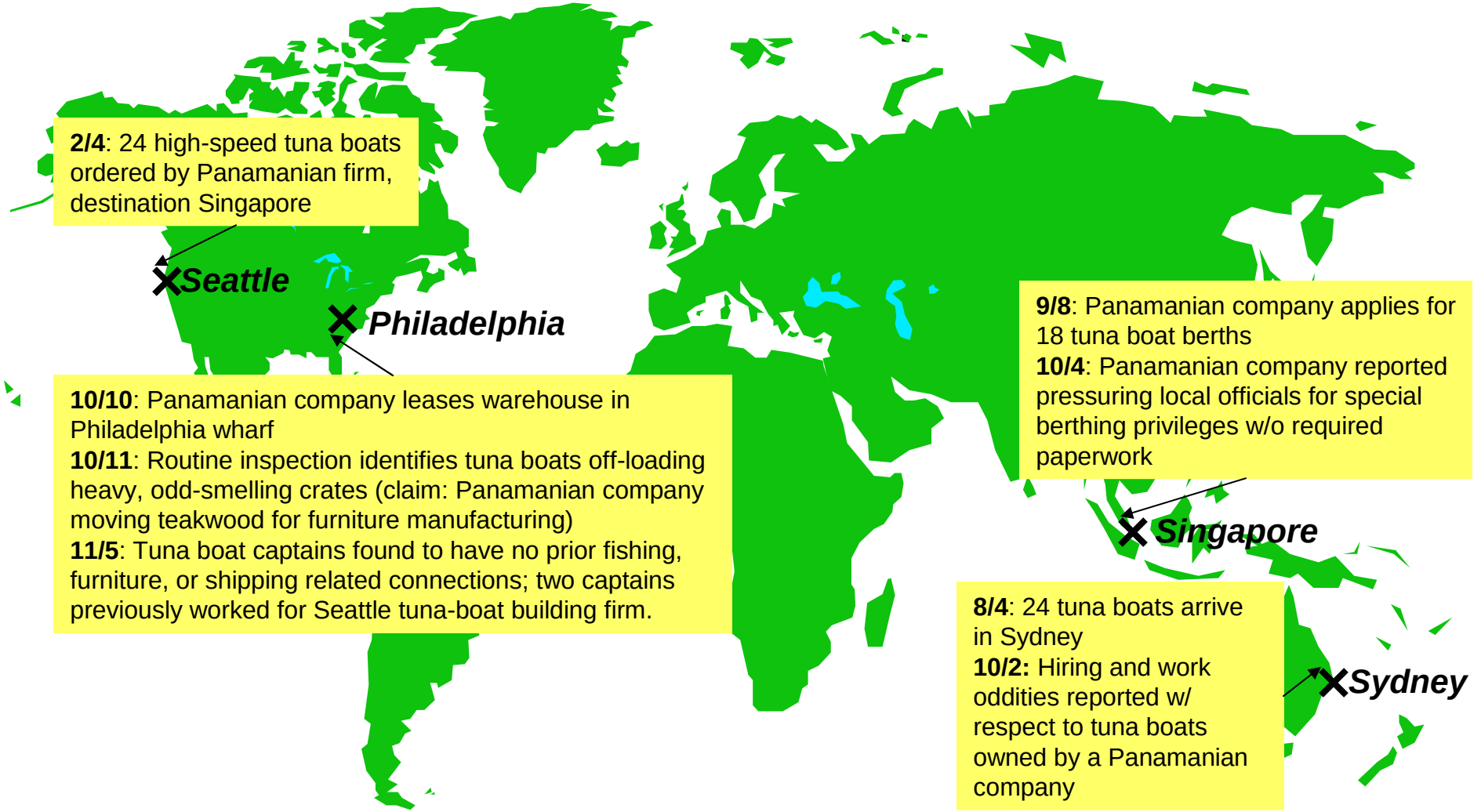


- Analysis is iterative; significant results "bubble up"
- Data gathering and analysis procedures adapt to new findings
- "Data mine as needed;" private data used only if subpoenaed

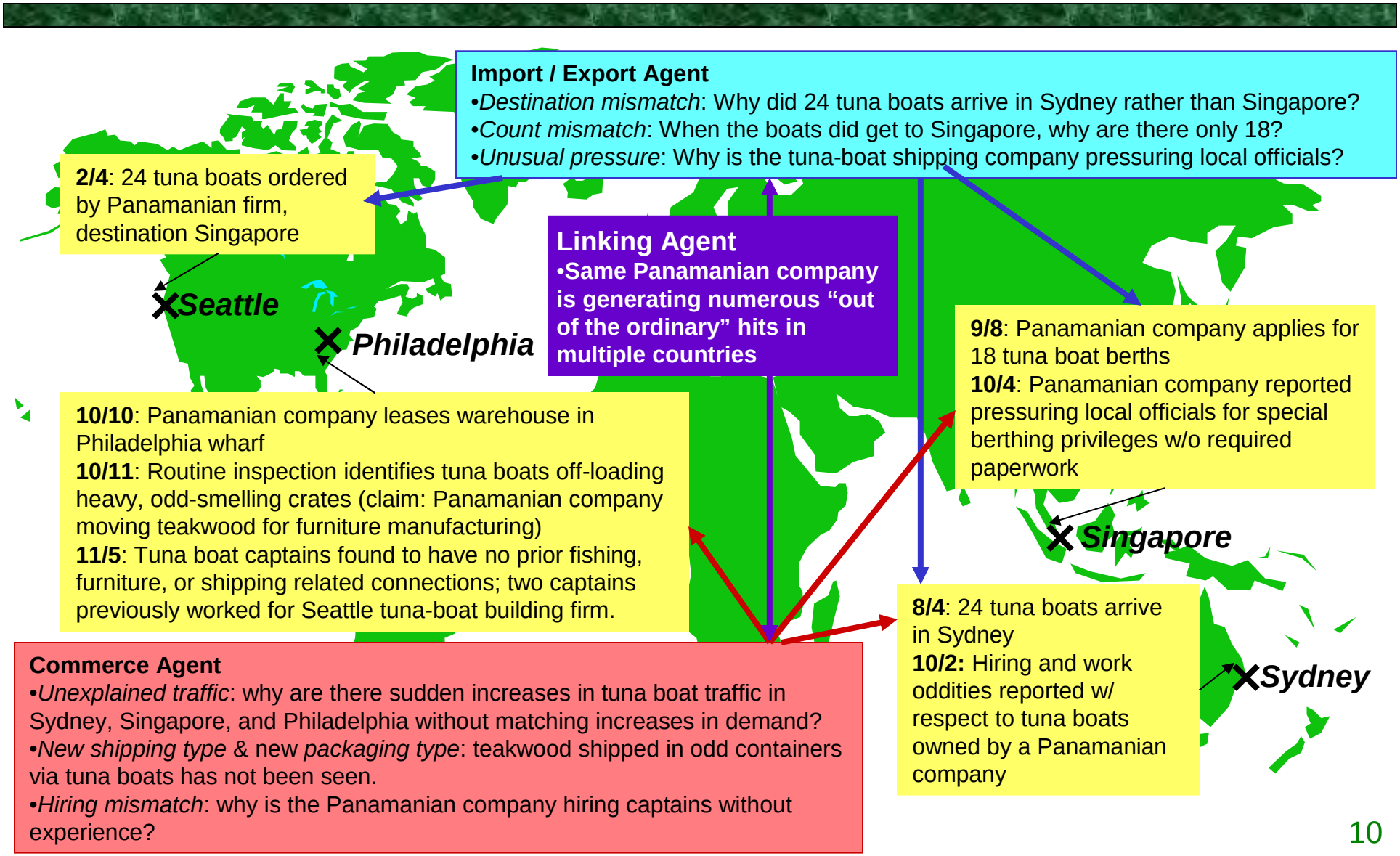
Major Features of the ASAP Architecture

- Identifies phenomena that are “out of the ordinary,” even if they do not match previous patterns for suspicious behavior
- Focuses on information already collected from intelligence and other government monitoring systems
  - In the acquisition / SE context, this would be acquisition and SE-related products, and any incoming complaints
- Employs rules allowing data to be analyzed in the context of existing knowledge
- Employs rules that are dynamic – significant developments automatically increase the priority of related information
- Explicitly deals with uncertainty by formulating and testing competing hypotheses
- Initiates collaboration of personnel needed to “connect the dots”
  - Analysts’ reviews are considered data just as much as source information

An Example Scenario: "Something Bad Happened on November 9th"



Applying the ASAP Schema to the 11/9 Scenario



What Can Be Done in the Near Term To Bring About ASAP Schema Benefits? (1)

Basic Collaboration Support:

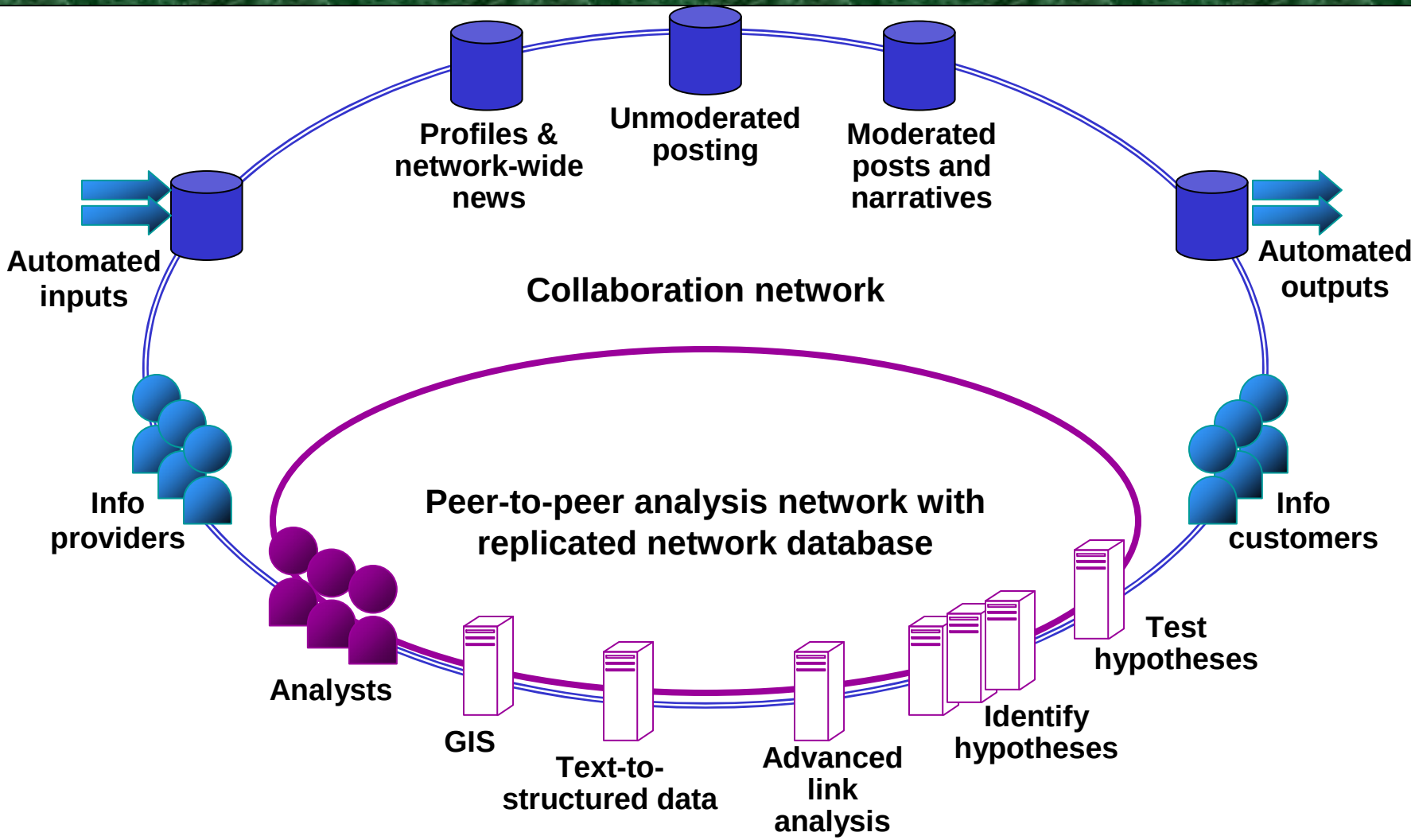
- Core functionality – improve collaboration
  - Create and distribute 2-4 page profiles of ordinary behavior, and examples of "significant" violations
    - Tight initial focus on training
    - Update regularly – "be on the look out for…"
  - Create a family of posting boards for the Community
    - Have unmoderated boards for posting "curious" or "unusual" information
    - Have moderated board for posting of "key" information on various potential problems
    - Have weblogs / wikis for presenting narratives
- Extended functionality – support analysis of posting boards
  - Allow Google-like search engines for posts
  - Use simple heuristics on posts, looking for connections and patterns across the posted messages

What Can Be Done in the Near Term To Bring About ASAP Schema Benefits? (2)

Analysis Support:

- Focus on evolutionary build-out of analysis tools, starting with existing products
- Core functionality – create and manage "the dots":
  - Network database / analysis tool that stores data in a replication-friendly and update-friendly format
  - Peer-to-peer system for performing the distribution and updating
    - Ideally, includes project management / workflow tools as well
- Extended functionality – automatically populate and analyze "the dots":
  - Free text / data to structured data tool
  - Advanced link analysis tool
  - Hypothesis generation tools (pattern-matching and pattern-violation agents)
  - Hypothesis tracking and testing tools

What Might a Near-Term ASAP Network Look Like?

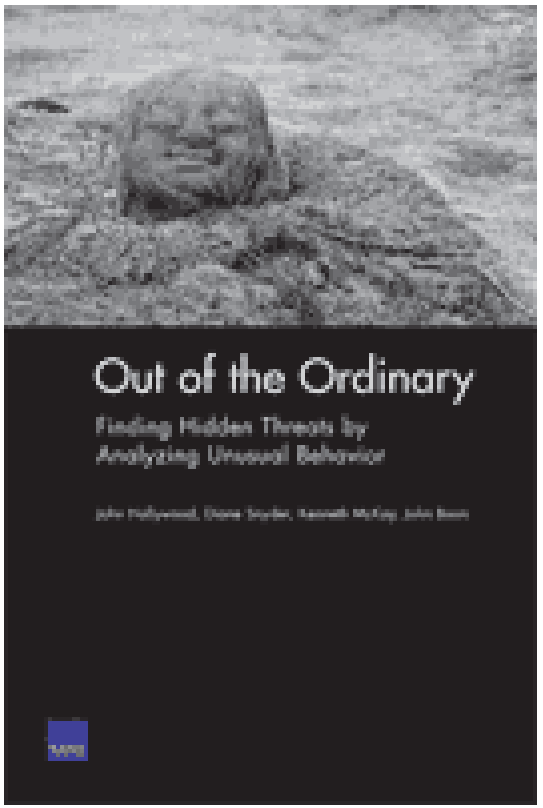


How Might The ASAP Schema Be Applied to Defense Acquisition?

- Generate simple models of the “status quo” for acquisition programs and acquisition jobs
  - Describe major steps that the program or person performing the job should go through, and what each step should look like
    - Acquisition Culture, Successful Program Implementations discussions may be useful here
    - Exercise: “this quarter, the program does nothing problematic. What kind of things occur?”
- ID and prioritize diagnostic measures and metrics that can determine whether a program or acquisition job is “likely staying on track”
- Set up near-term implementation described on previous slides
  - Start by distributing models and diagnostic metrics, identifying key personnel who should be involved in the “ASAP for Acquisition” network, and identifying key sources of acquisition data
- Begin building a library of decision rules on how to flag information for further review, and what sorts of hypotheses to generate

For More Information…

- *Out of the Ordinary: Finding Hidden Threats by Analyzing Unusual Behavior* available at:
  - http://www.rand.org/publications/MG/MG126/
- POC: John_Hollywood@rand.org



Mission Sustainment Through Environment, Safety, and Occupational Health (ESOH) Risk Management

Systems Engineering Conference
San Diego, CA
October 24 – 27, 2005

Trish Huheey
Office of the Deputy Under Secretary of Defense
(Installations & Environment)

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- **Why Integrate ESOH in Systems Acquisition**
- **Key Initiatives to Enhance ESOH Integration**
- **ESOH Risk Management with System Safety**
- **ESOH Risk Management is not Optional**
- **Other DoD Sustainment Related Policies With Acquisition ESOH Considerations**
- **Conclusions**

Increased DoD Emphasis on ESOH

- Total Life-Cycle Systems Management (TLCSM)
  - PM is the designated life-cycle manager
  - Conduct trade analyses early to achieve savings and ensure ESOH compliance throughout the life-cycle, especially regarding impacts to mission sustainment and installations
- Systems Engineering (SE) and Performance Based Logistics (PBL) strategies
  - Increased reliability and reduced logistics footprint
  - ESOH risk reduction and effective integration into systems engineering process
- AT&L Memorandum on *Policy for Systems Engineering in DoD*, 20 February 2004 – Systems Engineering Plan
  - Mandates robust SE approach that balances total system performance and total ownership costs

Why Integrate ESOH in Systems Acquisition?

- ESOH regulations potentially impact sustainability of operations, maintenance, and natural infrastructure
- ESOH compliance issues can impact capability to achieve system missions and exacerbate encroachment problems
- DoDD and DoDI 5000.2 policies
  - Program Mangers required to identify, eliminate when possible, and minimize ESOH hazards and associated risks
  - ESOH considerations are integral part of defense system's operational effectiveness and sustainability
  - SE is one of the primary processes for addressing ESOH with regard to system design, test, deployment, operation, training, maintenance, and disposal, as well as to help maximize resources and reduce total life-cycle costs.

ESOH Risk Management Is Not Optional

- ESOH risk management includes:
  - Hazardous materials and waste
  - Environmental and occupational noise
  - Personnel safety and occupational health
  - Natural environmental assets and infrastructure
  - Compliance with numerous regulations
  - System safety and explosive safety
- ESOH risk management must be ingrained in the program's entire risk identification and acceptance process
  - Using a risk management approach for ESOH compliance does not allow programs to accept risks of non-compliance with ESOH regulations; it does highlight the impacts and allow for informed decision-making

ESOH Risk Management Is Not Optional (Cont.)

- Lack of attention or failure to address ESOH requirements and risks early in the system acquisition process could impact program cost, schedule, performance, and result in
  - Loss of life and/or serious injury to personnel
  - Serious damage to facilities and/or equipment
  - Serious adverse impact on mission capabilities and operability from failures
  - Negative public opinion
  - Potential lawsuits or injunctions from citizens and public interest groups
  - Detrimental harm to the environment and surrounding community

Key Initiatives to Enhance ESOH Integration

- Revise DAU curricula to improve ESOH content
  - DAU System Safety in Systems Engineering Continuous Learning Module (April 2005)
  - Acquisition Core, System Engineering, Logistics, Test and Evaluation, and Program Management functional areas
- Establishment of ESOH risk management criteria in the acquisition process
- Incorporation of ESOH considerations in the Systems Engineering Plan (SEP)

ESOH Risk Management With System Safety

- System safety is the SE approach for eliminating or minimizing ESOH hazards and risks across the system's life- cycle
- AT&L Memorandum on *Defense Acquisition System Safety*, 23 September 2004
  - Integration of system safety into SE mandated
  - MIL-STD-882D, *DoD Standard Practice for System Safety*, used for ESOH risk identification and management
- Defense Safety Oversight Council (DSOC), July 2003
  - Acquisition and Technology Programs Task Force, April 2004
  - Investigate and recommend investments to ensure safety is addressed throughout an acquisition program's life-cycle

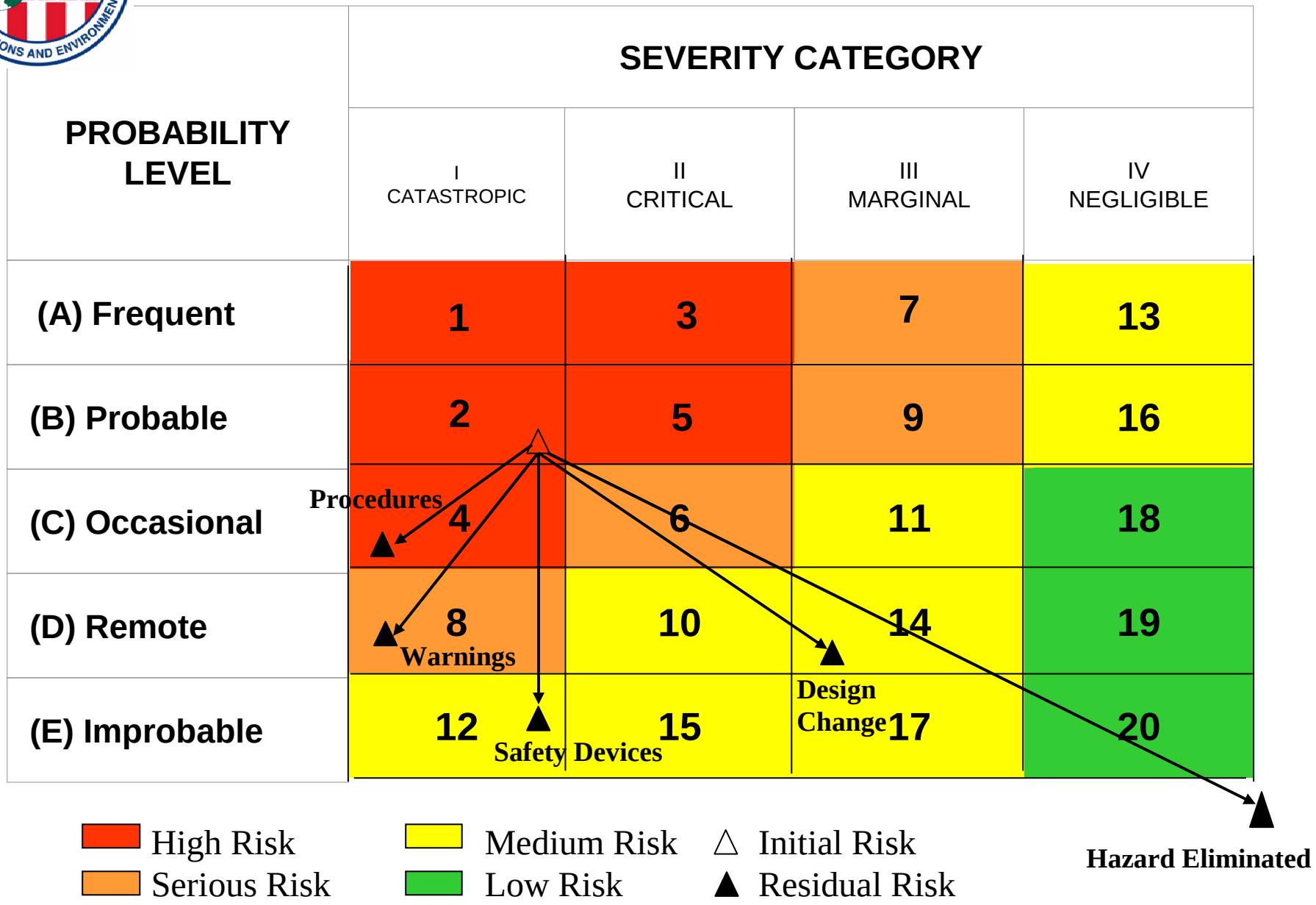
System Safety Order of Precedence

Listed in order from most to least preferred

1. Eliminate hazards through design selection
2. Incorporate safety devices
3. Provide warning devices
4. Develop procedures and training

1. If unable to eliminate an identified hazard, reduce the associated risk to an acceptable level through design selection.
2. If unable to eliminate an identified hazard through design selection, reduce the risk to an acceptable level using protective safety features or devices.
3. If safety devices do not adequately lower the risk of the hazard, include a detection and warning system to alert personnel to a particular hazard.
4. Where it is impractical to eliminate hazards through design selection or to reduce the associated risk to an acceptable level with safety and warning devices, incorporate special procedures and training. Procedures may include to use of protective equipment.

Risk Mitigation Measures (RMM) Example



Conclusions

- Effective ESOH integration into the acquisition SE process is essential to sustainability and operational effectiveness
  - Regulatory and public interest concerns can impede ability to develop, test, operate, maintain, train, and dispose of systems
  - Effective life-cycle ESOH risk management during system design and development maximizes potential for cost and liability reduction
- The PM must look forward over the entire life-cycle of the system and make the case to Resource Sponsors for early investments for future cost avoidance
- Resource sponsors must recognize that investing in designs and materials that reduce the burden on the natural infrastructure result in lower life-cycle costs and unencumbered, sustainable operations
  - Further supports the mandatory use of TLCSM

Questions and Answers

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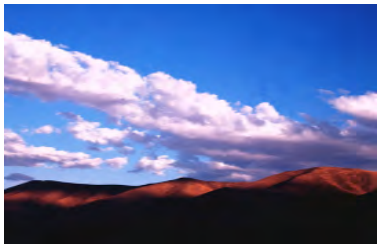

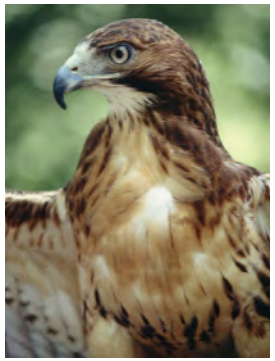

Acquisition ESOH Guidance References

Acquisition Community Connection, ESOH Special Interest Area (http://acc.dau.mil)

AT&L Knowledge Sharing System (AKSS) (http://deskbook.dau.mil)