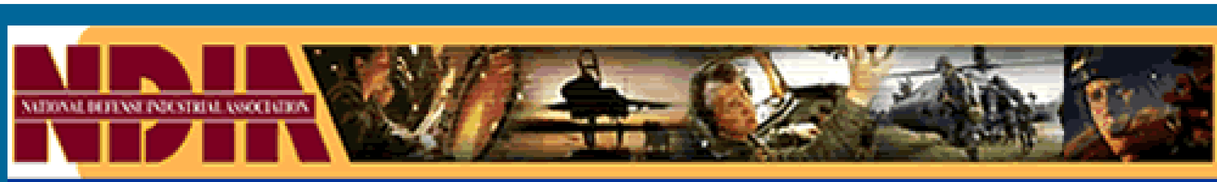

8th Annual Systems Engineering Conference
"Focusing on Mission Areas, Net-Centric Operations and Supportability of Defense Systems"

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

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

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

Tuesday, October 25, 2005

1:30 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**
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**
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**
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**
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**
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**
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**
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**

3:00 PM

Break in Display Area

3:30 PM

Regency A	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 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 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 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 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 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 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 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**

5:30 - 7:00 PM

Reception in Display Area

Wednesday, October 26, 2005

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

9:45 AM — Break in Display Area

Room	Track	8:15 AM		10:15 AM	
Regency A	TRACK 1 Systems Engineering Effectiveness Session 3A1 / Session 3B1	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***	System 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)***
Regency B	TRACK 2 Systems Engineering Effectiveness Session 3A2 / Session 3B2	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.***	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 / Session 3B3	Effective SE Metrics Tailored to the Acquisition Life Cycle ***Ms. Laura Troiola, US Army - ARDEC***	Innovative Procurement Strategies ***Mr. David Eiband, Defense Acquisition University***	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 / Session 3B4	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***	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 / Session 3B5	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***	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 / Session 3B6	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.***	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 / Session 3B7	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***	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 (8:15) / Legacy Systems Sustainment (10:15) Session 3A8 / Session 3B8	Sustaining Software-Intensive Systems – A Conundrum ***Ms. Mary Ann Lapham, SEI***	Algorithm Description Documentation and Validation Process ***Mr. Michael K. Bailey, Raytheon***	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.***

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

Wednesday, October 26, 2005

1:30 PM

Regency A	TRACK 1 Systems Engineering Effectiveness — Session 3C1	Architecture Based Systems Engineering And Integration — ***Dr. Rick Habayeb, Virginia Tech***	A Complementary Approach to Enterprise Systems Engineering — ***Dr. Brian White, The MITRE Corp.***
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***
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***
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***
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***
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***
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***
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***

3:00 PM

Break in Display Area

3:30 PM

Regency A	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 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 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 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 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 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 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/ 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.***	

5:30 PM — Conference Adjourns for the Day

Thursday, October 27, 2005

7:15 AM — Registration & Continental Breakfast

8:15 AM · 9:45 AM Break in Display Area · **10:15 AM**

Room	Track	8:15 AM	8:15 AM	10:15 AM	10:15 AM
Regency A	TRACK 1 Systems Engineering Effectiveness — Session 4A1 / Session 4B1	A Systems Affordability Approach Using Raytheon Six Sigma Design — ***Ms. Yvette Thornton, Raytheon***	Requirements Engineering Tips and Tricks — ***Mr. Frank Salvatore, HPTI***	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***
Regency B	TRACK 2 Systems Engineering Effectiveness — Session 4A2 / Session 4B2	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***	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***
Regency C	TRACK 3 Systems Engineering Effectiveness — Session 4A3 / Session 4B3	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***	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.***
Mission A	TRACK 4 Net Centric Operations — Session 4A4 / Session 4B4	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***	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***
Mission B	TRACK 5 Best Practices & Standardization — Session 4A5 / Session 4B5	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.***	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.***
Mission C	TRACK 6 Modeling & Simulation — Session 4A6 / Session 4B6	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***	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***
Garden A	TRACK 7 Education & Training in SE — Session 4A7 / Session 4B7	Educating Future Systems Engineers: US Military Academy Reception-Day Simulation and Optimization — ***LTC Simon Goerger, Department of Systems Engineering***		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.***
Garden F	TRACK 8 Net Centric Operations — Session 4A8 / Session 4B8	The Role of the Operator and System Engineer in the Force Modernization Environment — ***Mr. Thomas Nelson, Jacobs Sverdrup***	*TBA*	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

Room	Track	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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Enabling Plug & Fight Capability
through
Secured Integrated Networks of Modular, Service Oriented and Open Architectures
(Plug & Fight Architectures)

Cyrus Azani
OSJTF/NGC

SE Conference October 26, 2005

Agenda

- *Assumptions*
- *What is an Open System?*
- *The Modular Open Systems Approach Principles*
- *What is Plug and Fight Capability*
- *The Proposed Strategy*
- *Guiding Principles for Achieving Net Centric P&F capability*

Assumptions Underlying Net-Centric P&F Capability

- **Effective Implementation of Existing and Planned DoD-wide initiatives such as**:
  - GIG Architecture
  - Information Assurance and Security Infrastructure
  - JBMC2 Roadmap
  - Enterprise Business and Management Architecture
  - DODAF
  - DISR
  - Etc.
- **Transparent, Reconfigurable, and Adaptable Architectures and Organizational Structures**
- **Joint Configuration and Management of Key External Interfaces**
- **DoD-wide Application of Standardized SE Processes**
- **Availability of SoS Architecture Modeling Schemes and Standards**

Definitions

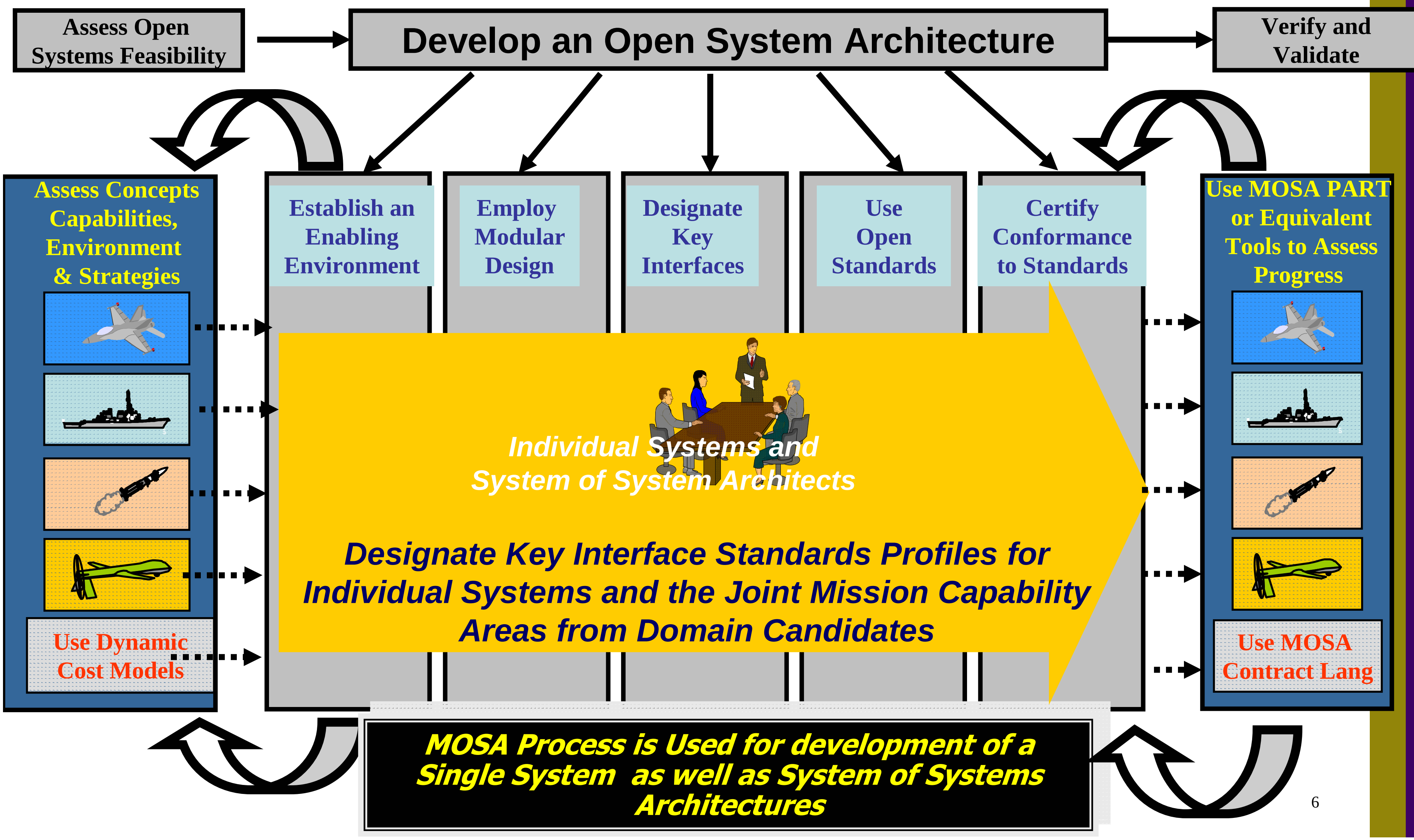
Open System: A system that employs modular design, uses widely supported and consensus based standards for its key interfaces, and has been subjected to successful validation and verification tests to ensure the openness of its key interfaces.

MOSA: An integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industry standards organization.

Why Open Systems?

1. *Reduce development cycle* and total life-cycle cost
2. *Enable evolutionary acquisition and spiral development*
3. *Accommodate changing technology and requirements*
4. *Enable access to commercial products from multiple sources both in the initial design and in future enhancements*
5. *Enable affordable interoperability*
6. *Facilitate integration within and among systems*
7. *Enable technology insertion*
8. *Enhance commonality and reuse of components among systems*
9. *Capitalize on modular design tenets*

The MOSA Process



What is Plug & Fight Capability?

OPEN SYSTEMS JOINT TASK FORCE

- The ability to automatically assemble capabilities/systems/resources and reconfigure them as necessary in response to existing or emerging threats.
- Effectively plug in the needed capabilities/systems and fight without worrying about compatibility, connectivity, and other configuration issues.

MOSA is the Principal Foundation for Achieving Plug & Fight

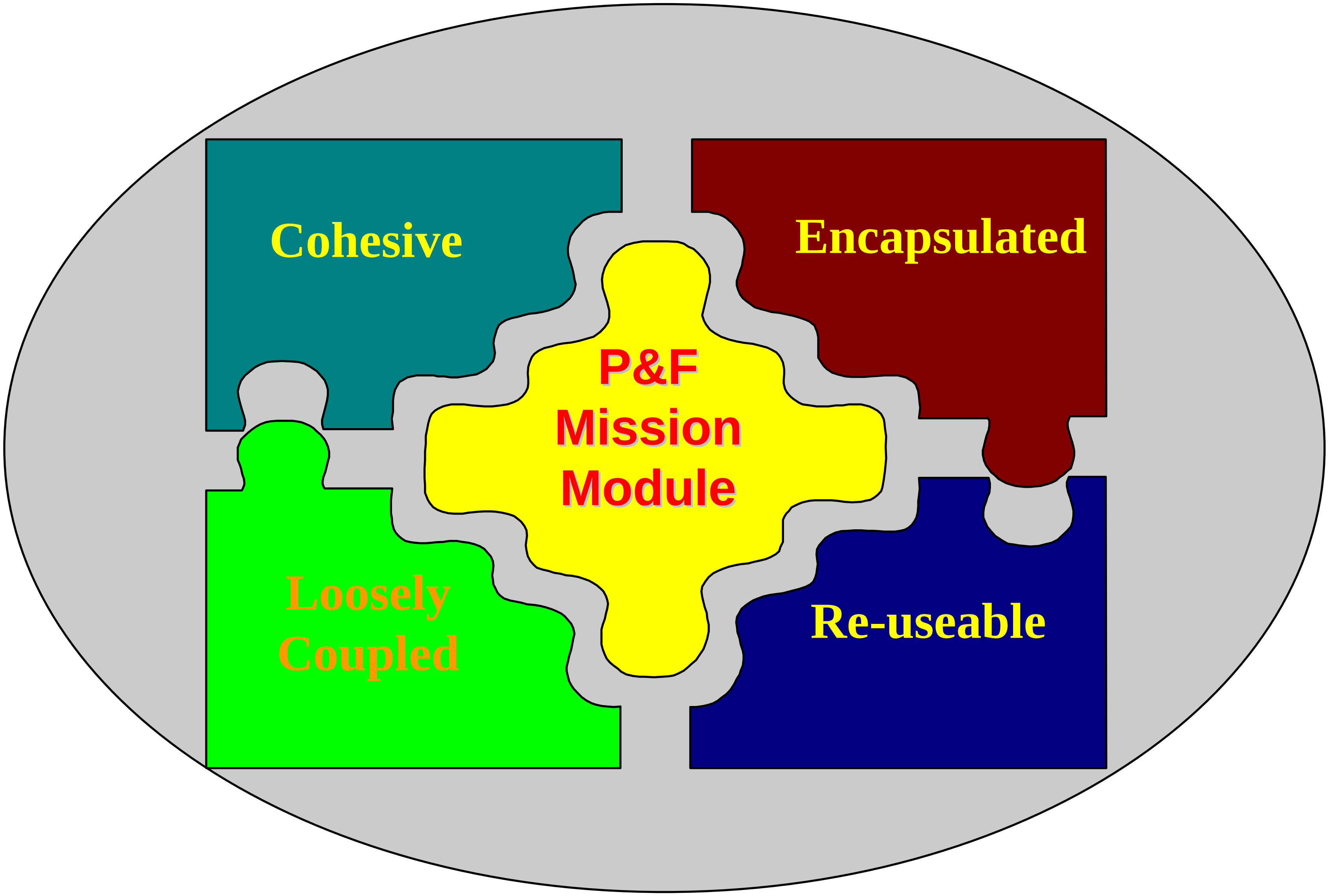
P&F Capability Enablers

- Ability to Quickly Assemble and Reconfigure Forces and Capabilities
  - Adherence to Modular Design Tenets
  - Secured Service Oriented and Open Architectures
- Effective Interface Management
  - Well-defined and Agreed-upon Key Interfaces
  - Continuing Openness Verification and Validation
  - Joint Configuration and Management
- Net Centricity

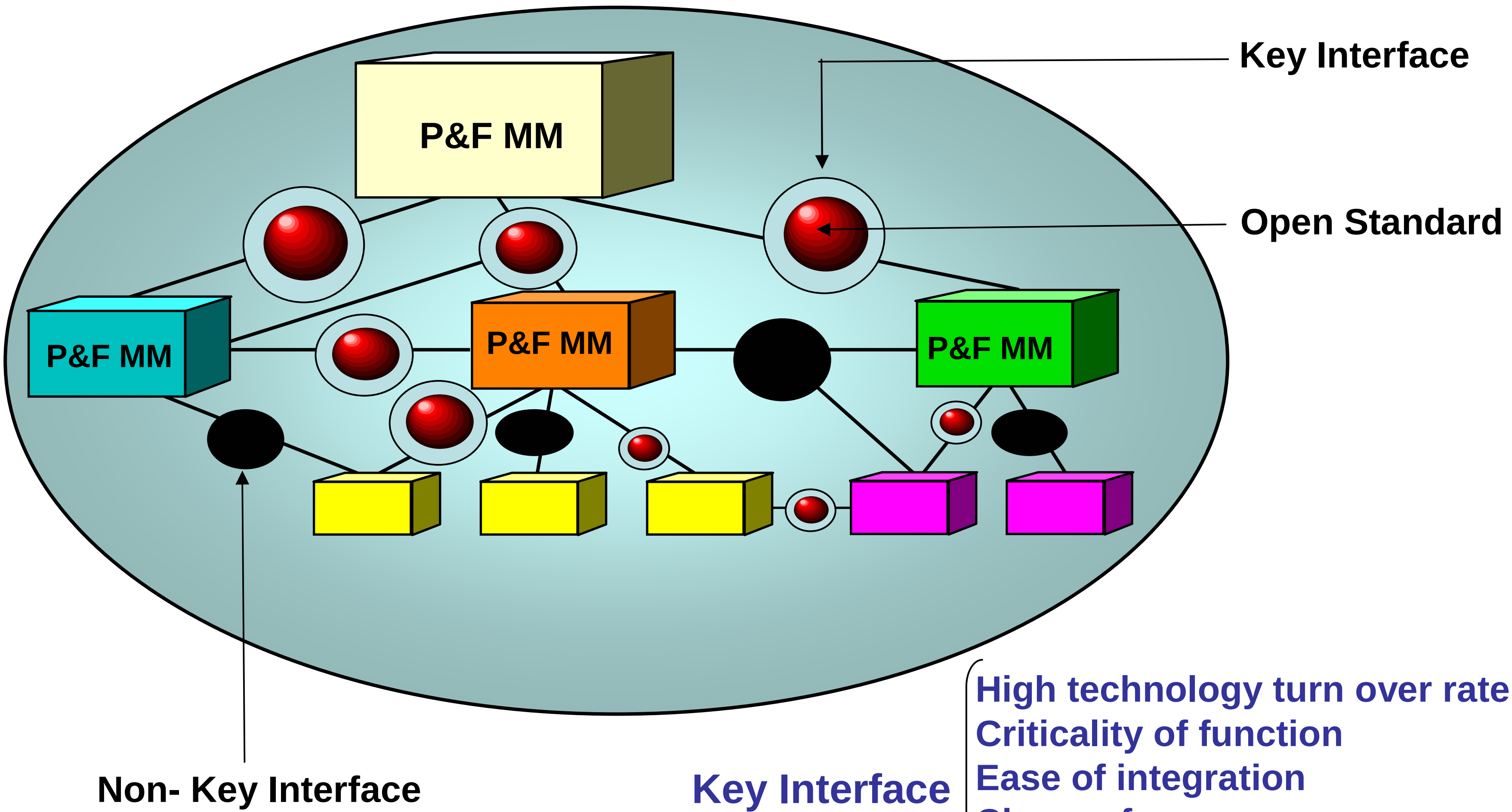
Achieving the P&F Capability
(A P&F Development Methodology)

1. Employ Modular Design Tenets to Create P& F Mission Modules
2. Designate Key Interfaces for the P&F Mission Modules
3. Develop Key Interface Profiles Using Open Standards and Common Data Strategies
4. Test the Conformance/Compliance (NR-KPP & Open Standards)
5. Configure/Reconfigure P&F Mission Modules Into Networks of Modular, Secured, Service Oriented, and Open Architectures
6. Manage Key Interfaces via Joint Interface Control Working Groups (JICWGs)

Step1: Employ Modular Design Tenets to Create P& F Mission Modules



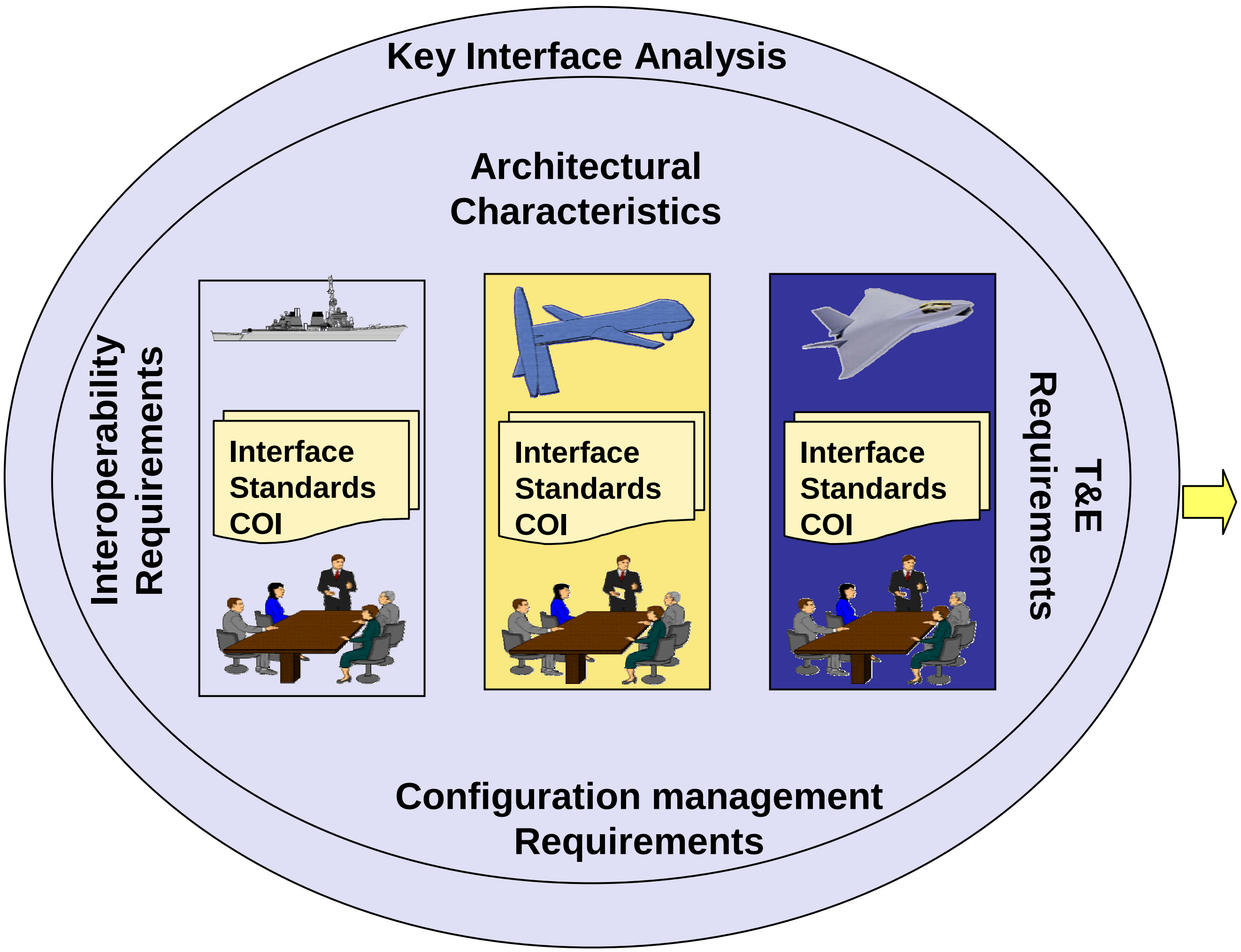
Step 2: Designate Key Interfaces for each P&F Mission Module (P&F MM)



Key Interface Designation Criteria:

- High technology turn over rate
- Criticality of function
- Ease of integration
- Change frequency
- Interoperability
- Commonality/reuse
- High cost

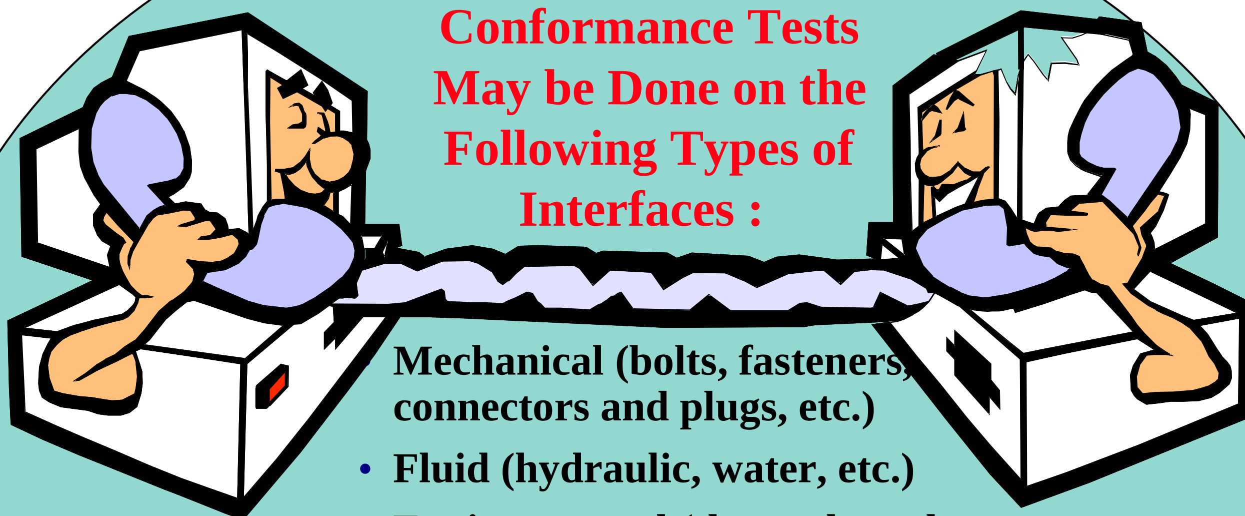
Step 3: Develop Key Interface Profiles Using Open Standards and Common Data Strategies



KIP Elements:

- OV and SV Products
- ICDs
- CCM
- Procedures for standards conformance and interoperability testing

Step 4: Test Conformance/Compliance (NR- KPP & Open Standards Conformance)

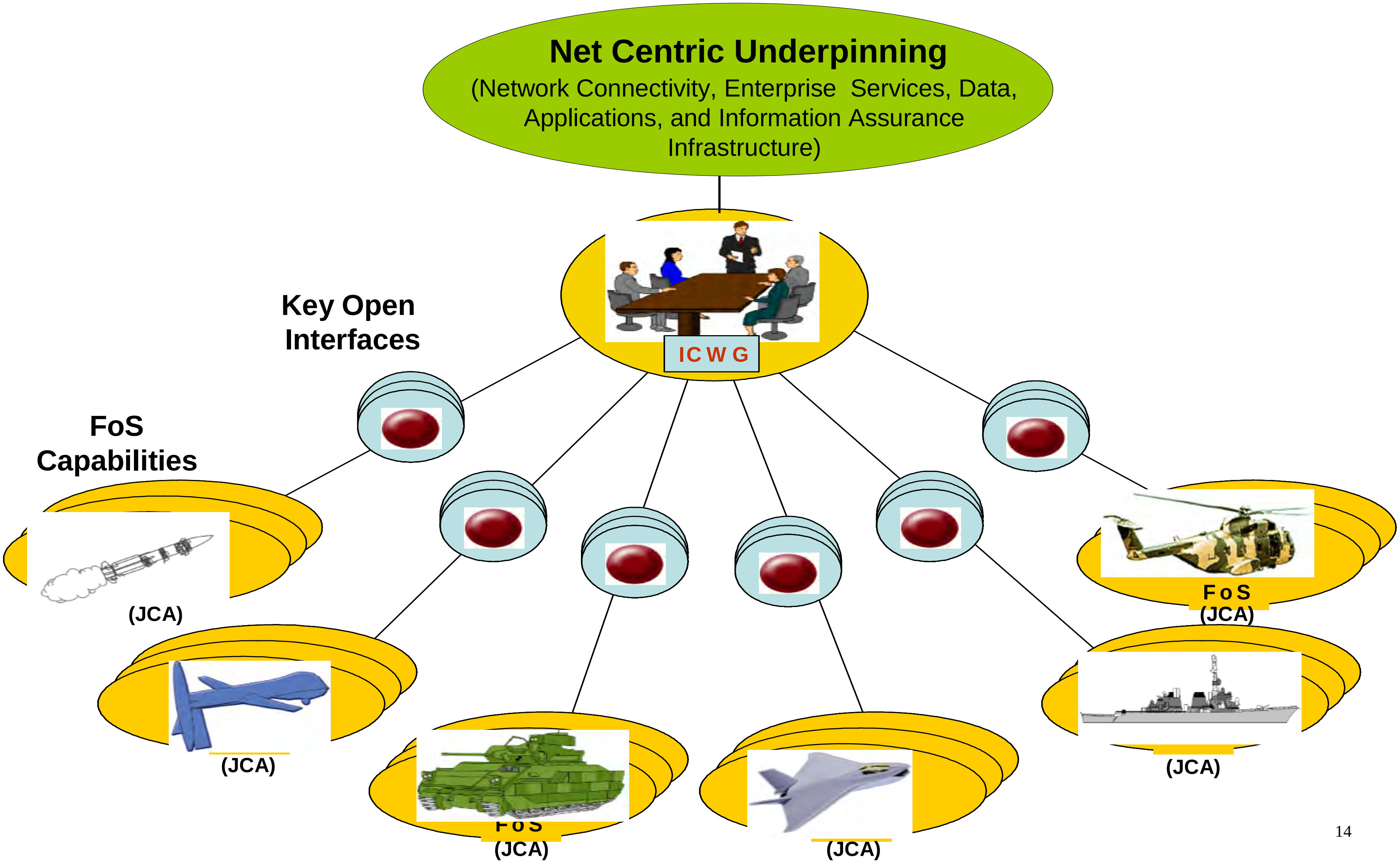


Conformance Tests May be Done on the Following Types of Interfaces :

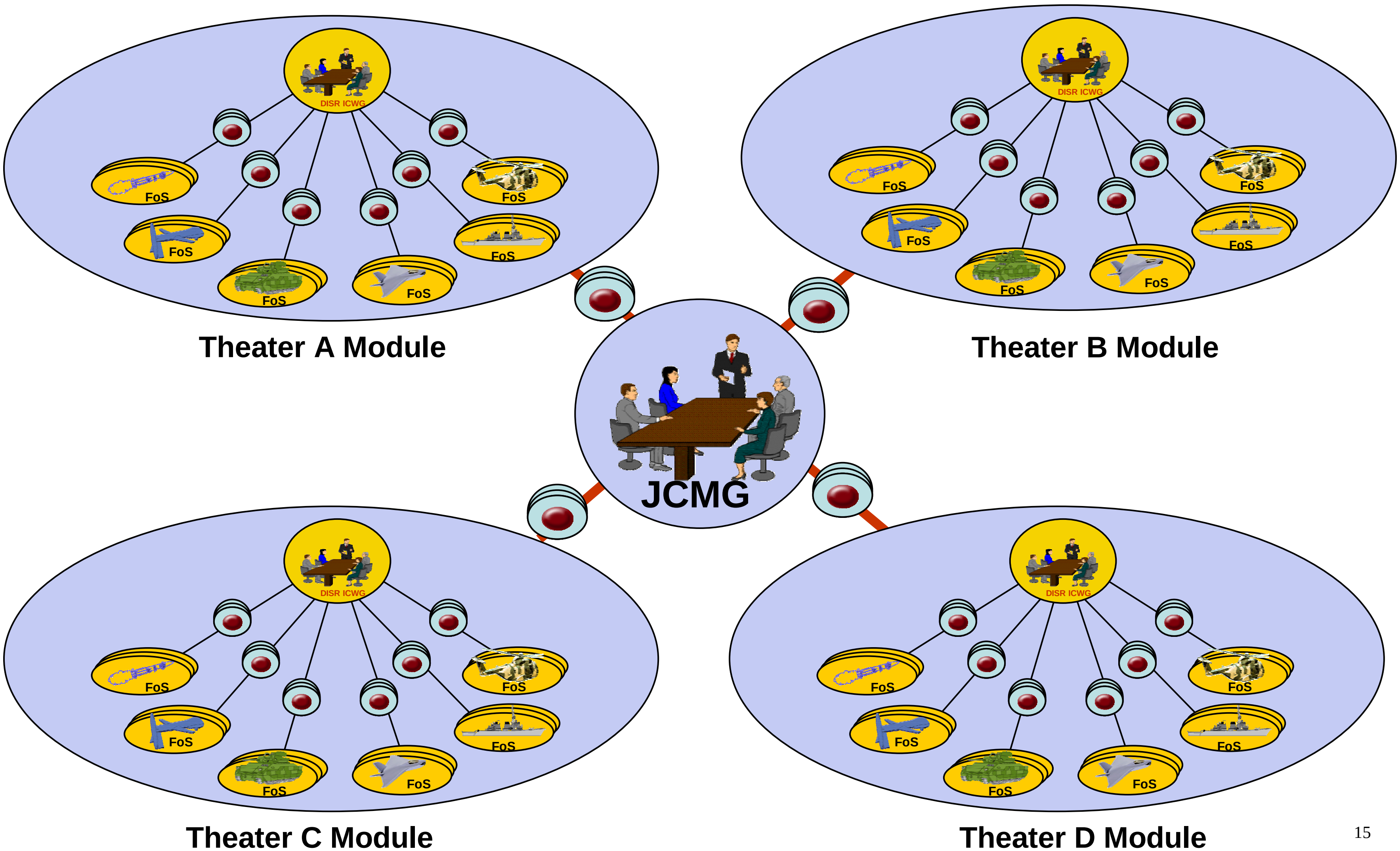
- **Mechanical (bolts, fasteners, connectors and plugs, etc.)**
- **Fluid (hydraulic, water, etc.)**
- **Environmental (thermal, nuclear (e.g., neutron, gamma, beta transmission rates and densities), etc.)**
- **Envelope (space allowances)**
- **Electrical (power, signals, etc.)**
- **Sequencing/Programming and timing**
- **Functional (data formats, etc.)**

5. Configure P&F Mission Modules into Ad-hoc Networks

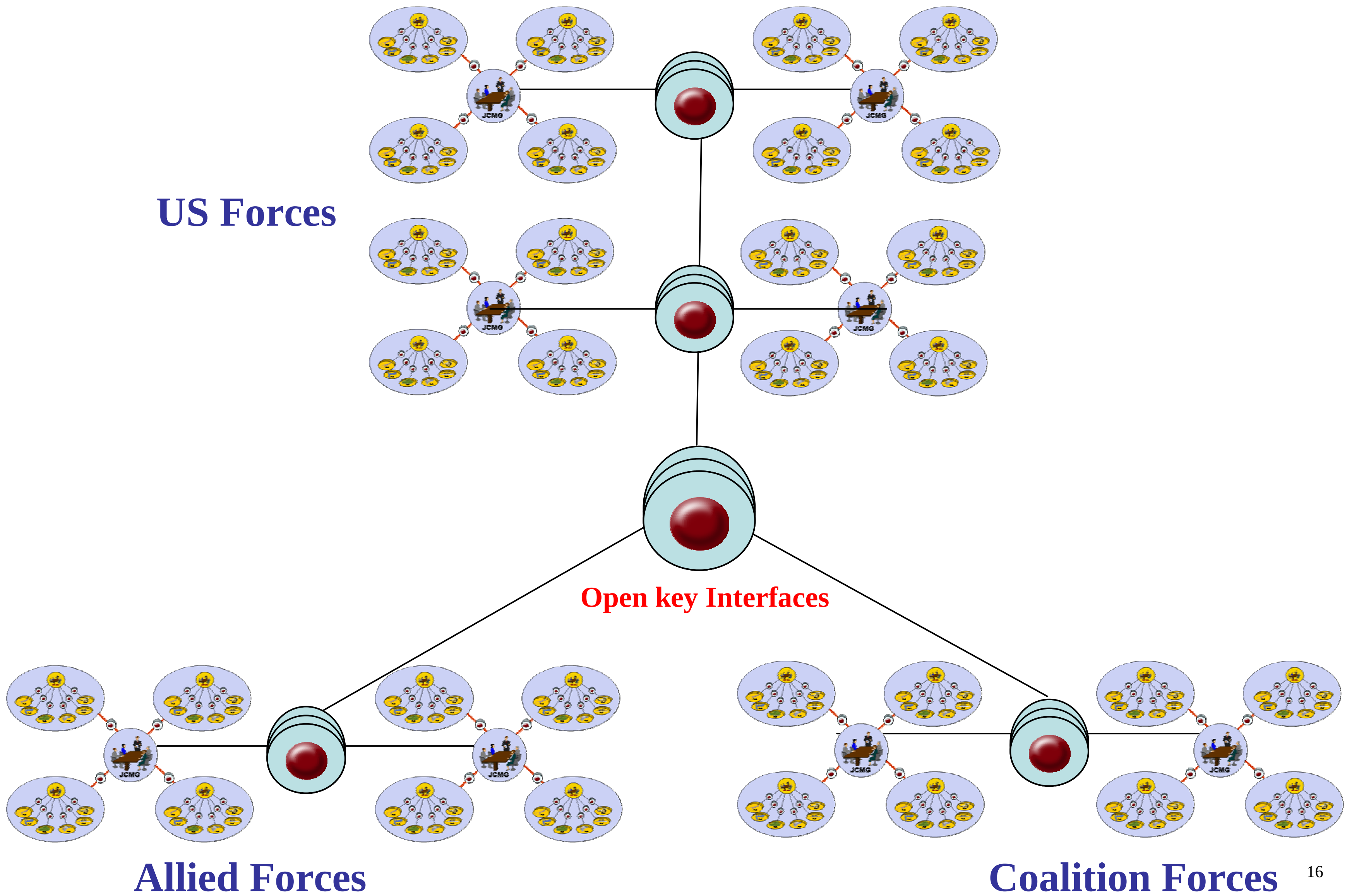
(Joint Warfghting Capability Architecting)



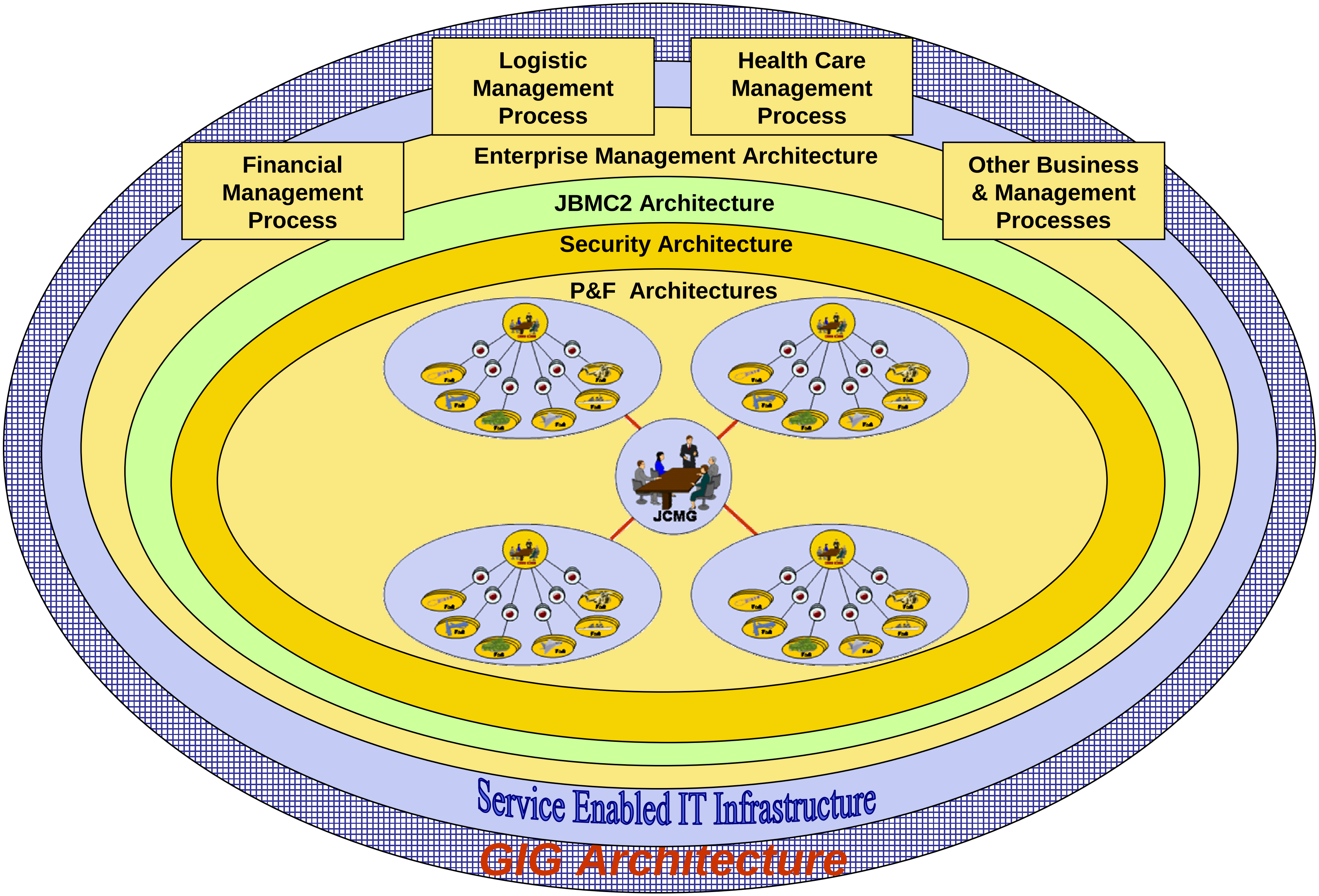
Step 5 Continued…. Networks of P&F Architectures



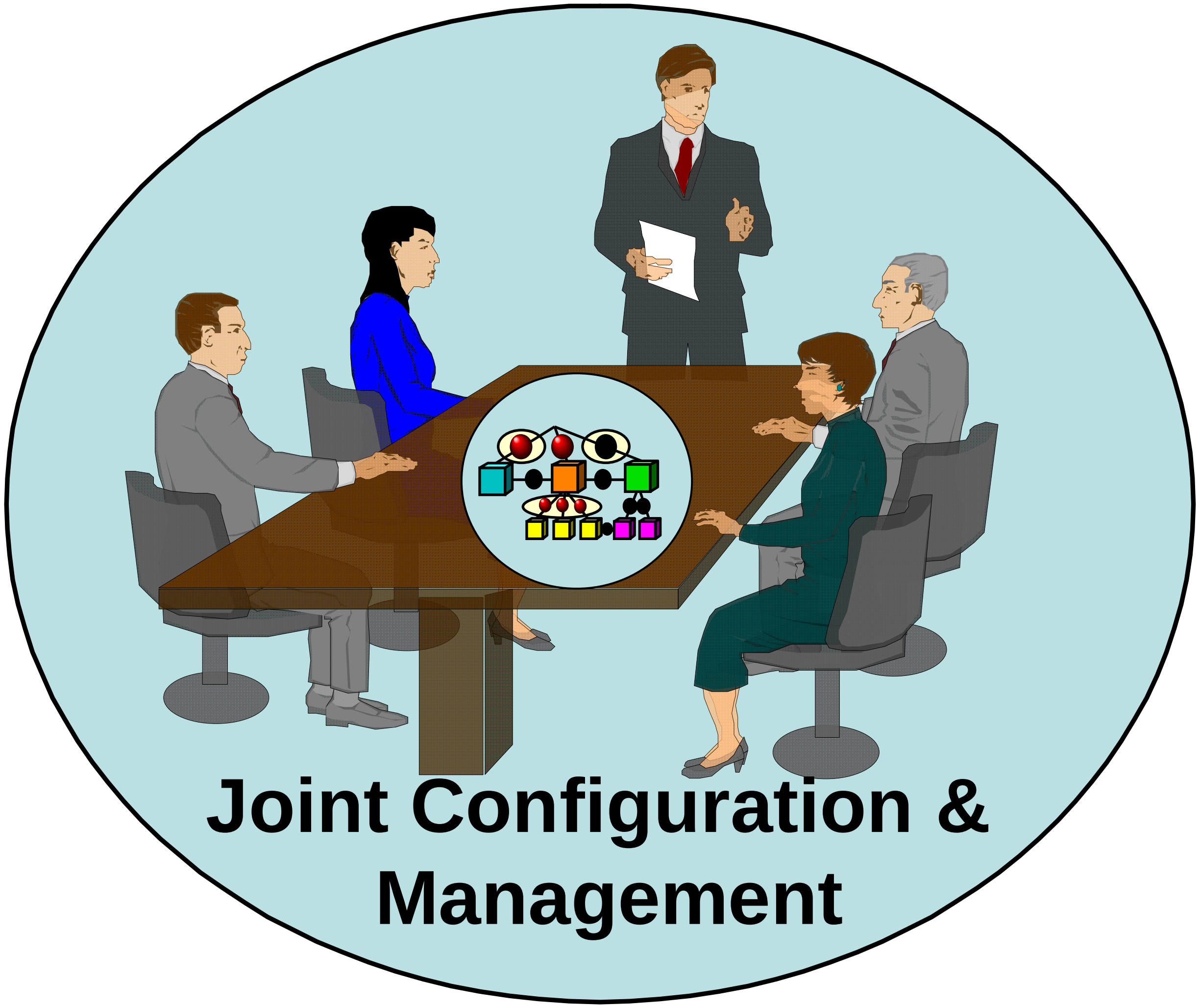
Constellation of P&F Architectures

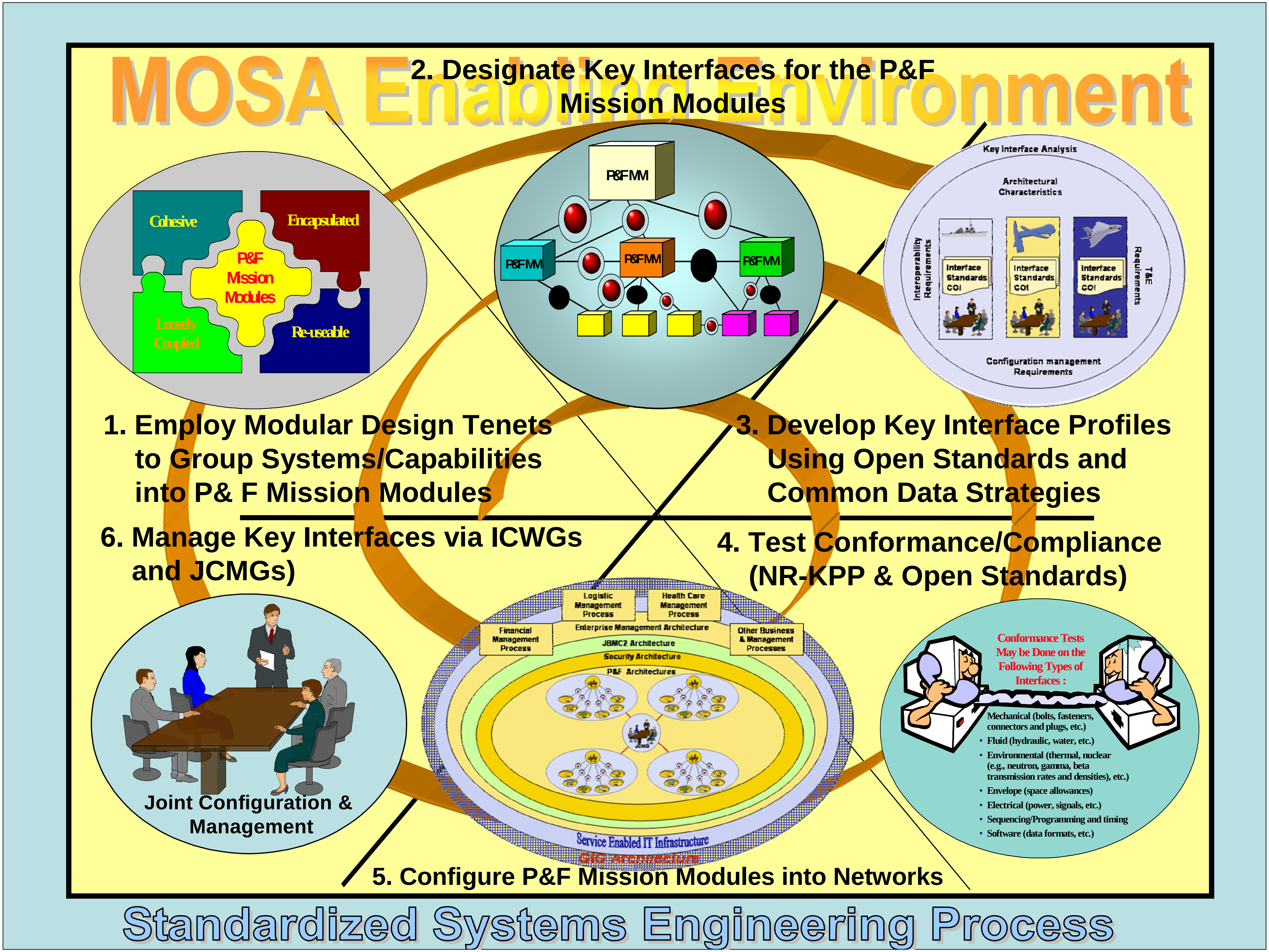


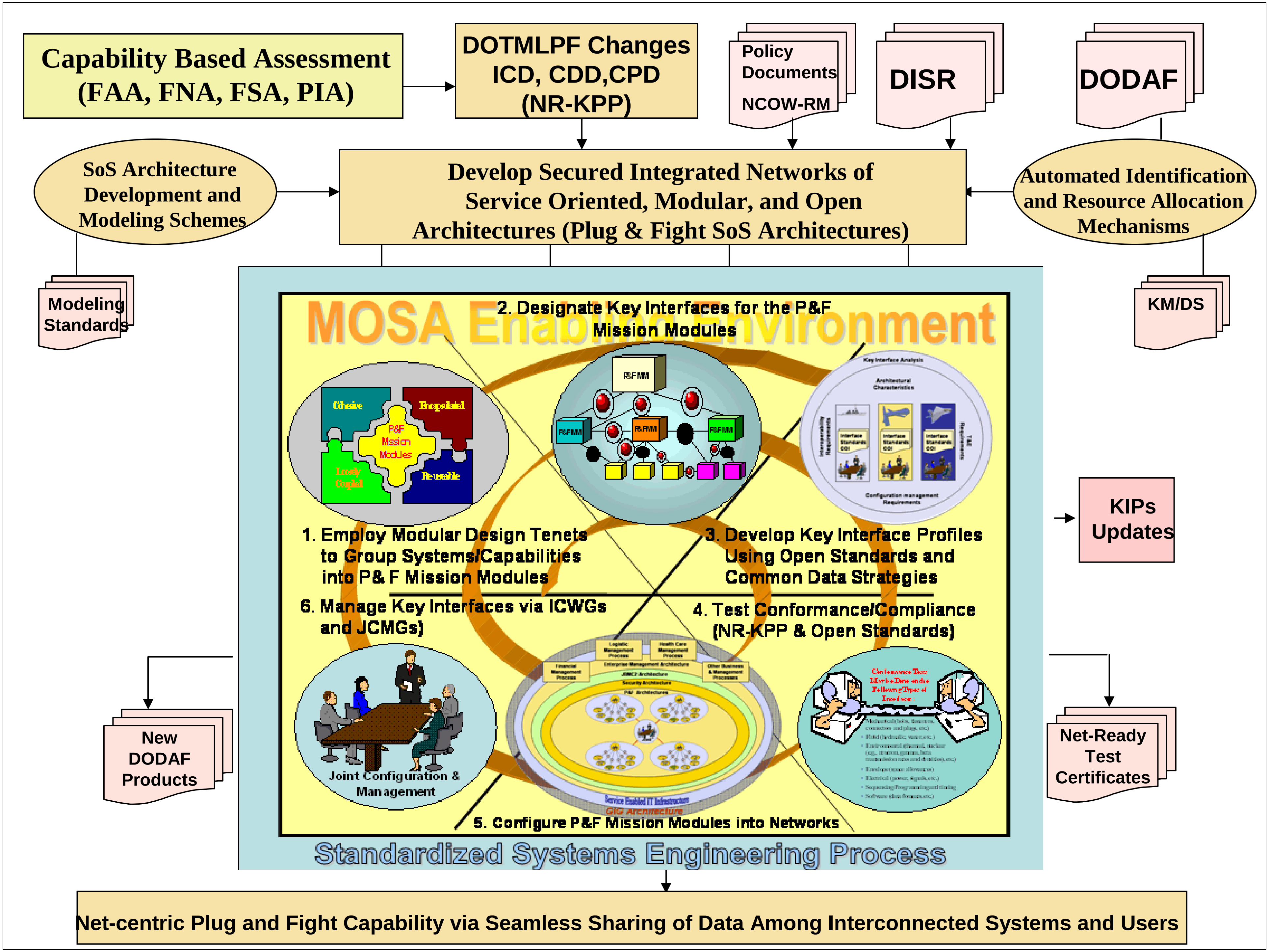
Step 5 Continued…Integration with Other Architectures



6. Manage Key Interfaces via Joint Configuration Management Councils or Joint Interface Control Working Groups (JICWGs)

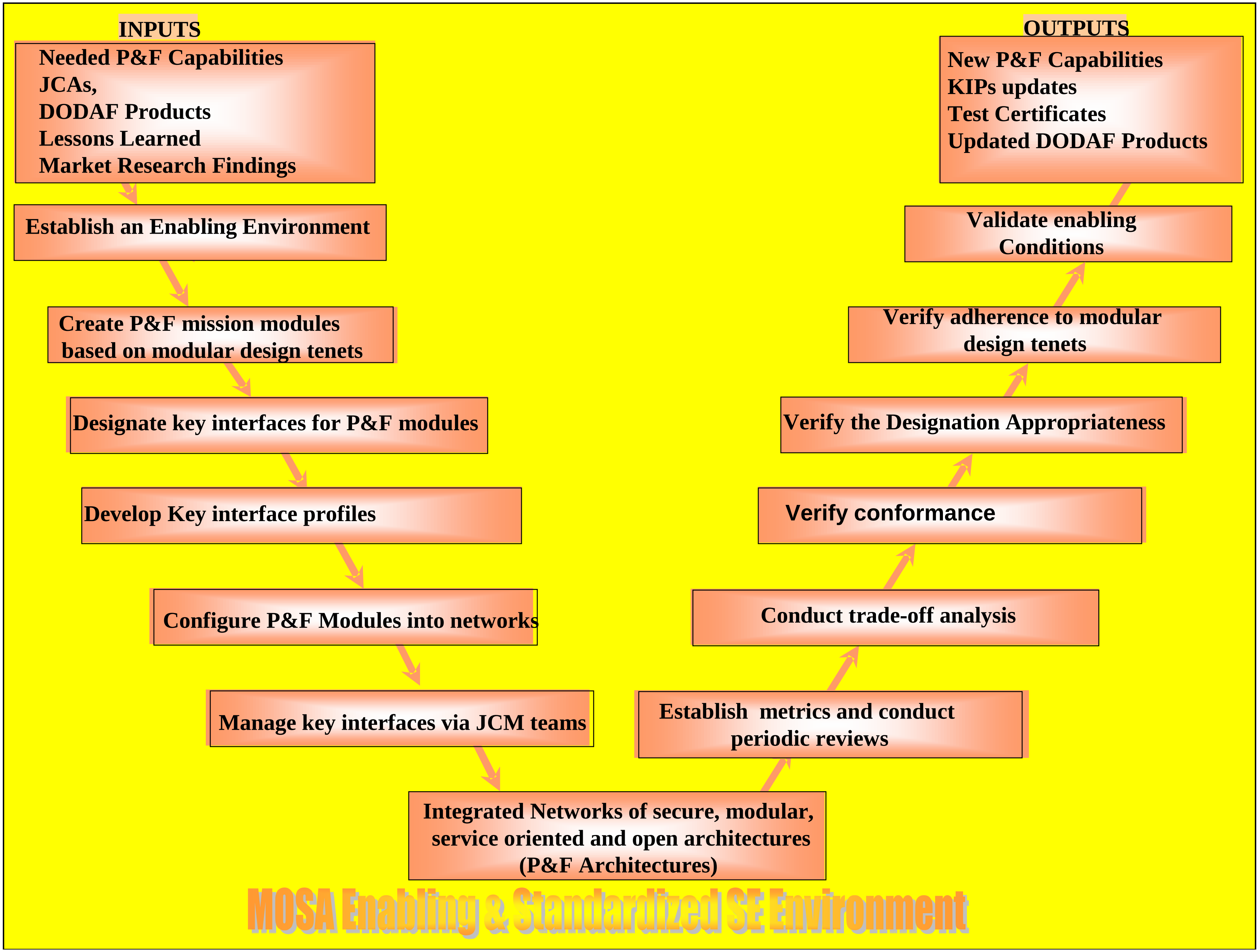



MOSA Enabling Environment
2. Designate Key Interfaces for the P&F Mission Modules
P&FMM
Cohesive
Encapsulated
P&F Mission Modules
Loosely Coupled
Re-useable
Key Interface Analysis
Architectural Characteristics
Interoperability Requirements
T&E Requirements
Interface Standards COI
Configuration management Requirements
1. Employ Modular Design Tenets to Group Systems/Capabilities into P& F Mission Modules
3. Develop Key Interface Profiles Using Open Standards and Common Data Strategies
6. Manage Key Interfaces via ICWGs and JCMGs)
4. Test Conformance/Compliance (NR-KPP & Open Standards)
Joint Configuration & Management
Logistic Management Process
Health Care Management Process
Financial Management Process
Other Business & Management Processes
Enterprise Management Architecture
JBMC2 Architecture
Security Architecture
P&F Architectures
Service Enabled IT Infrastructure
GIG Architecture
Conformance Tests May be Done on the Following Types of Interfaces :
Mechanical (bolts, fasteners, connectors and plugs, etc.)
• Fluid (hydraulic, water, etc.)
• Environmental (thermal, nuclear (e.g., neutron, gamma, beta transmission rates and densities), etc.)
• Envelope (space allowances)
• Electrical (power, signals, etc.)
• Sequencing/Programming and timing
• Software (data formats, etc.)
5. Configure P&F Mission Modules into Networks
Standardized Systems Engineering Process

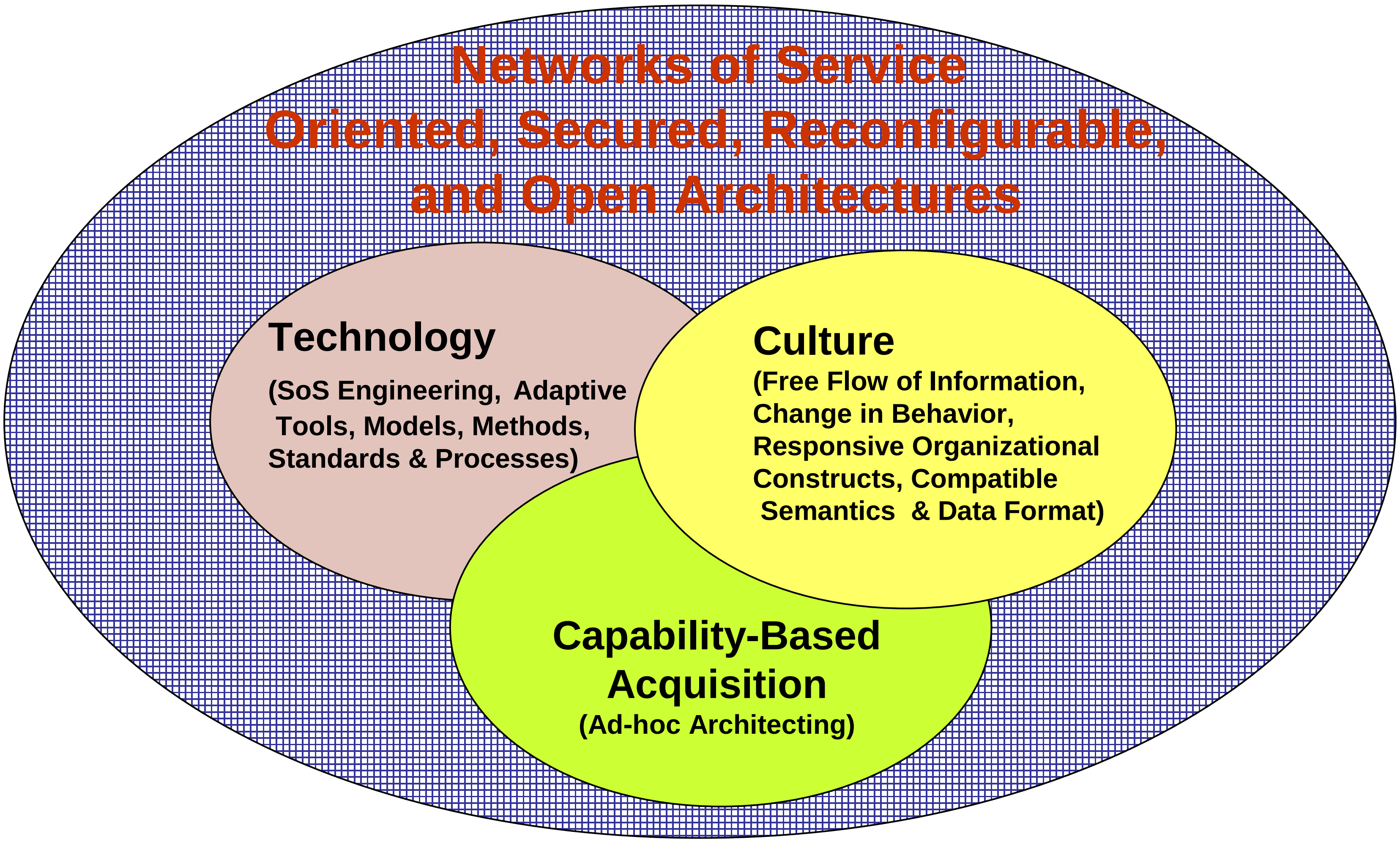


Capability Based Assessment (FAA, FNA, FSA, PIA)
DOTMLPF Changes ICD, CDD,CPD (NR-KPP)
Policy Documents
NCOW-RM
DISR
DODAF
SoS Architecture Development and Modeling Schemes
Develop Secured Integrated Networks of Service Oriented, Modular, and Open Architectures (Plug & Fight SoS Architectures)
Automated Identification and Resource Allocation Mechanisms
Modeling Standards
KM/DS
MOSA Enabling Environment
2. Designate Key Interfaces for the P&F Mission Modules
P&F Mission Modules
1. Employ Modular Design Tenets to Group Systems/Capabilities into P& F Mission Modules
3. Develop Key Interface Profiles Using Open Standards and Common Data Strategies
6. Manage Key Interfaces via ICWGs and JCMGs)
4. Test Conformance/Compliance (NR-KPP & Open Standards)
Joint Configuration & Management
GIG Architecture
5. Configure P&F Mission Modules into Networks
KIPs Updates
New DODAF Products
Net-Ready Test Certificates
Standardized Systems Engineering Process
Net-centric Plug and Fight Capability via Seamless Sharing of Data Among Interconnected Systems and Users

A "V" Model for Enabling Net-Centric P&F Capability



Achieving P&F Capability



Net Centricity Must be Designed into the Systems Rather than be Tested after Development

Guiding Principles for Achieving Net Centric P&F Capability

OPEN SYSTEMS
JOINT TASK FORCE

Empower Program Managers and other Acquisition Personnel to Effectively:

- Provide "plug and fight" capability at all levels in all domains by using transparent systems that can be reconfigured and integrated rapidly
- Address P&F Capability as major required capability and system attributes (AOA, ICD, CDD, CPD, Acquisition Strategy)
- Leverage commercial technology and practices
- Use SoS Engineering to integrate capabilities rather than develop stove-piped systems
- Balance battlefield performance and interoperability with ease of integration and total life cycle affordability
- Provide full logistics supportability via access to multiple sources of supply throughout the systems life cycle
- Modernize systems through incremental upgrades ("modernization through spares" concept)
- Build a fully synergistic partnership among the Services, AT&L, Joint Staff and with the industry.

An integrated network of open and modular architectures is the principal foundation for configuring forces and systems rapidly and affordably

Questions?

Open Systems

OS

Joint Task Force

Please send your comments to Cyrus Azani at cyrus.azani.ctr@osd.mil

Examples of Standards Needed

- Technical Standards (operational domain independent)
  - Execution environment standards (POSIX, COM, J2EE, C++, ...)
  - Interaction-based standards (Telephony, TCP/IP, http, ODBC, ...)
- Information Representation Standards (ebXML, UPC, uucode, …)
  - Increasingly operational domain specific; communities of interest
- Service Standards (SOAP, WSDL, SAML, ….)
  - Driven by the IT industry and common requirements
- Standard Services (DNS, UDDI, NCES, Blue Force Tracking, ….)
  - Driven by "the enterprise"; operational effectiveness
- Product Standards (FIPS, compliance with other standards)
- Standard (Common) Products – primarily "enterprise" cost driven
- Specifications – acquisition community oriented
- Modeling Standards (Open Model Interface (IEEE 1499), AP33, Etc.)

Systems Engineering to Enable Capabilities Based Planning

Ms. Kristen Baldwin
Office of the Under Secretary of Defense
Acquisition, Technology and Logistics
Systems Engineering

Capabilities Based Planning (CBP) Objectives

CBP should be a top-down, competitive approach to weigh options vs. resource constraints across a spectrum of challenges

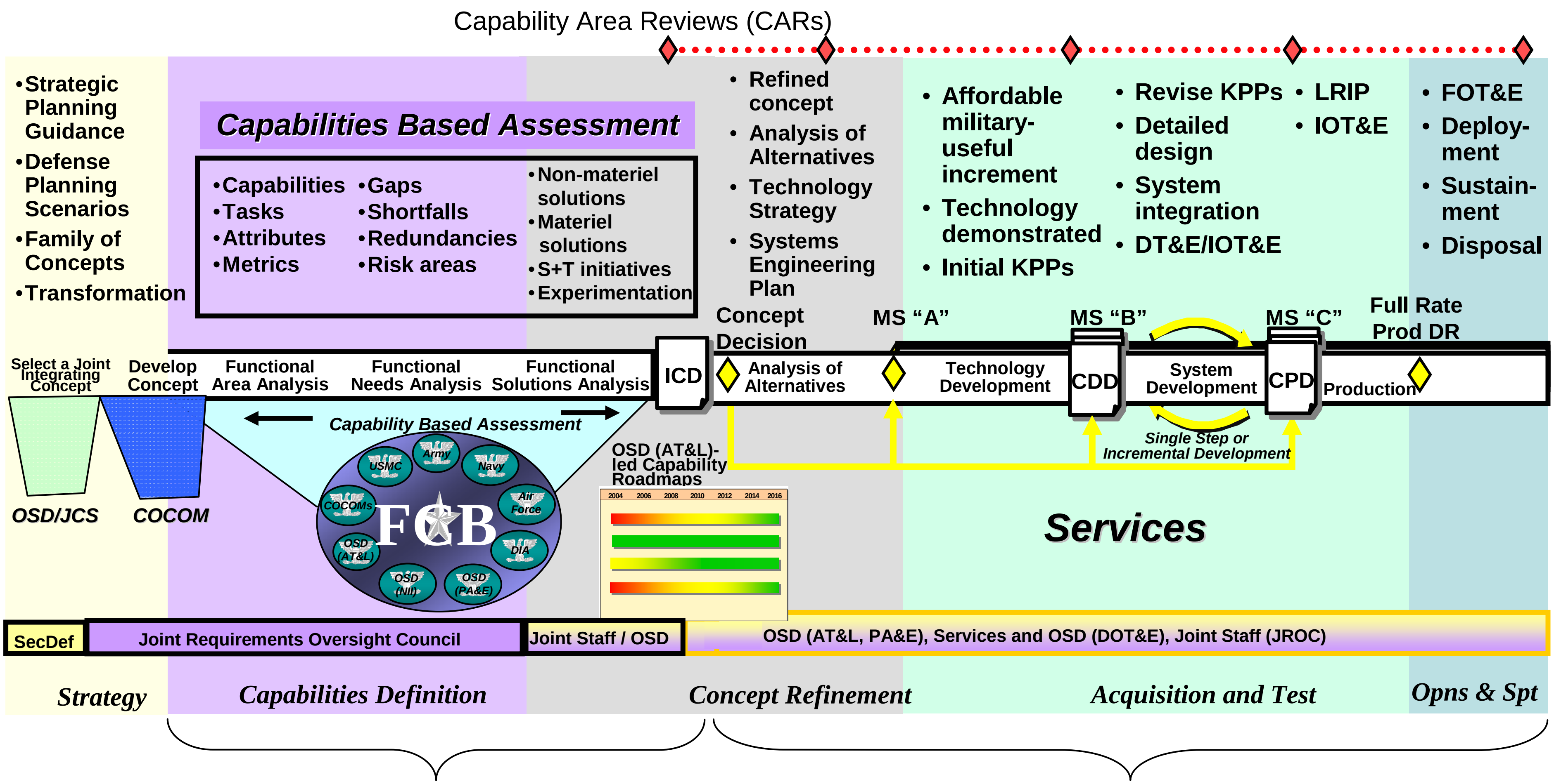
CBP should:

- ❑ Link DoD decision-making to the Defense Strategy
  - ➢ *Encompass the full set of DoD challenges*
- ❑ Inform risk tradespace -- identify joint capability gaps, redundancies and opportunities
  - ➢ *Generate common framework for capability trades*
  - ➢ *Couple programmatic capability development to operational needs*
- ❑ Facilitate the development of affordable capability portfolios

A Perspective for Acquisition

- Defense acquisition has traditionally focused at the program level
- Under CBP, acquisition will widen its perspective
  - Shape, engineer, and validate solutions to capability needs
  - Make decisions on systems within a capabilities context (systems perspective)
  - Engineer the relationships across the set of systems that together satisfy the need (systems of systems)
  - Synchronize the interaction among programs to satisfy multiple capabilities (capability roadmaps)
  - Incorporate an integrated sustainment approach (total lifecycle systems management)

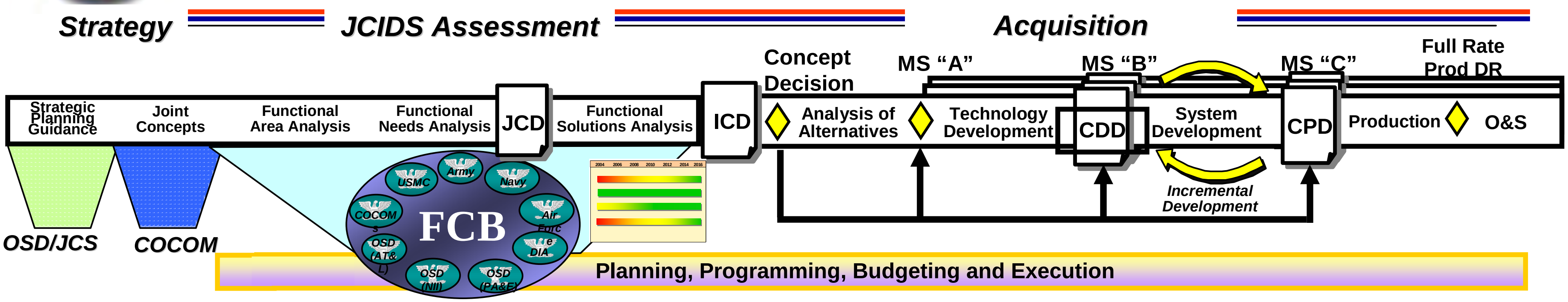
DoD End-to-End Capabilities Based Planning Process

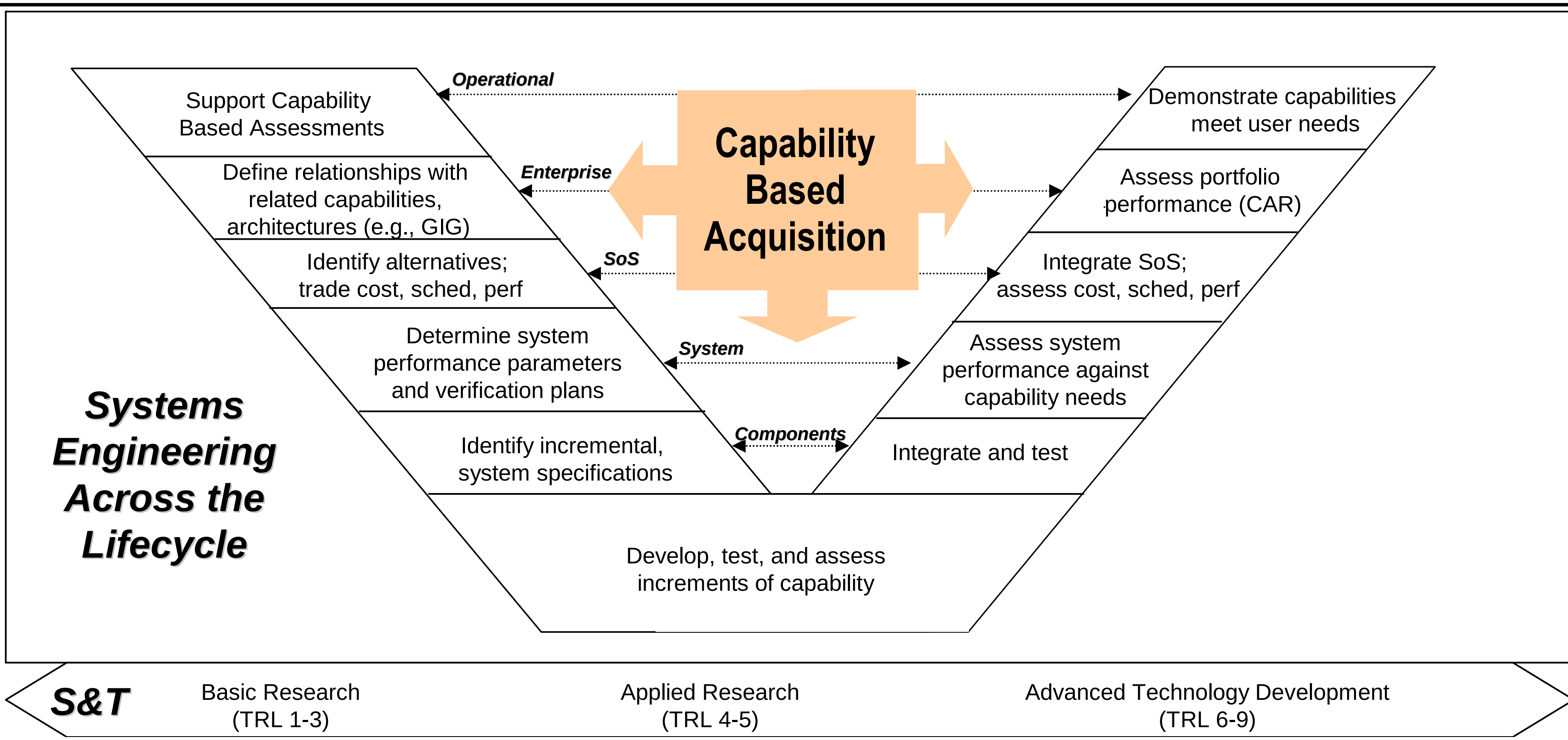


Joint Capabilities Integration and Development System (JCIDS)

DoD 5000 Acquisition Policy

Acquisition Engagement Across Strategy, JCIDS and Acquisition Processes





What have we learned?

- ❑ Rigorous, top-down determination of joint capabilities takes time
  - ➢ Requires sound analysis of alternatives, and
  - ➢ Cooperation from multiple communities that have not traditionally worked together
- ❑ Capabilities will be satisfied by grouping of legacy, new systems and technology insertion – Systems of Systems
  - ➢ Solutions will cross organizational and funding "stovepipes"
  - ➢ Solutions must integrate with other related capabilities and enterprise architectures (e.g., Global Information Grid)
- ❑ System designs should be extensible to support future, yet to be defined, capabilities
- ❑ Management oversight of capabilities has ripple effects on individual programs
- ❑ Early and continuous involvement of acquisition in requirements determination allows for greatest leverage to determine optimal, joint solutions

Systems Engineering is an enabler of Capabilities Based Planning

System-of-Systems (SoS)
System Engineering Considerations

- Certain capabilities only appear in a System-of-Systems context
  - How do we systems engineering these SoS capabilities?
  - How do we perform testing (V&V) of these SoS capabilities?
  - How do we sustain capabilities over time?
- Example
  - Capabilities such as Combat Identification must be implemented in numerous systems across all Services and Agencies to enable the joint warfighter to use that capability in combat

FY05 Activities to Address SoS – SE Beyond Platform Study

- Task
  - Characterize ongoing systems engineering efforts within the Services and Agencies to develop and field capabilities that <u>extend beyond individual platforms or systems</u>
    - *Include both the enterprise level SE processes and the cross systems engineering initiatives*
- Objective
  - Capture current experience base and assess implications for DOD policy, regulations and best practices
- FY05 Progress
  - Completed a first order review of pool of examples based on available data

Study Observations

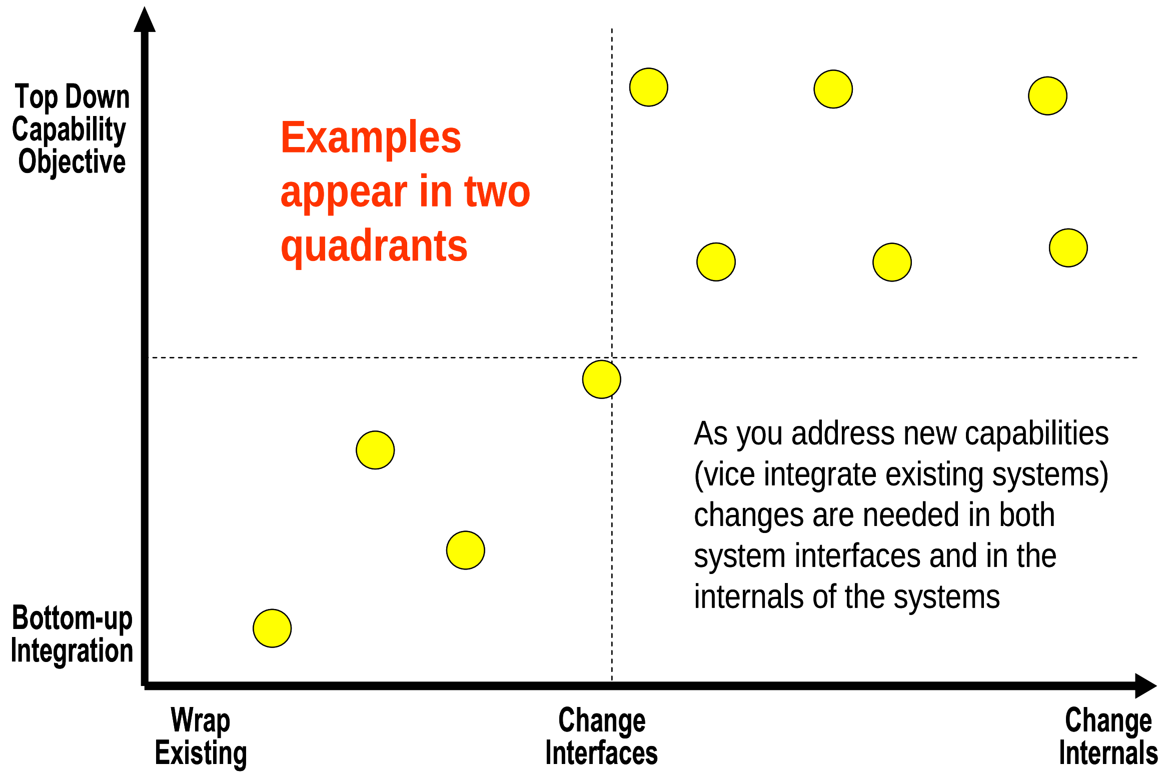
Three general classifications of SoS SE:

1. Engineering a ‘collective’ from legacy systems
   - Majority of the cases
   - Ranged from integration of new and existing systems for better interoperability to addressing new top-down requirements by integrating existing systems
2. Clean Sheet Developments
   - One case -- Future Combat Systems
3. Organizational, enterprise-wide engineering initiatives
   - New, limited experience
   - Focus on planning, developing, and integrating systems to meet broad ‘enterprise needs

Engineering a "Collective" from Legacy

Some Observations:

- ❑ Authority
  - ➢ PMs continue to own individual systems
  - ➢ No owner of the collective
  - ➢ Program success is independent of ability to integrate successfully



❑Technical approaches attempt to minimize impact on internal system functionality and limit changes to interfaces

- ➢Degree to which this can be done, and changes stay with interfaces, the smoother the process
- ➢…but this may not be the most optimal solution

Enterprise-Wide Systems Engineering

- Organizational efforts that focus on strategic objectives through
  - Investment decisions
  - Architecture principles
  - Standards and protocols
  - Engineering practices
- Measured, and/or motivated by a different set of priorities
  - Goal-oriented, organizational and stakeholder issues
- Characterized by multiple constituents with different goals and priorities
  - Requires systems engineering application to address multiple systems and SoS constraints and objectives

FY06 Activities to address SoS – SoS SE Definition and Optimization Project

- Task
  - Codify SoS SE and determine any unique SE considerations
  - Establish relevant SE process metrics
  - Experiment with models to optimize technical program resource drivers
- Objective
  - Pull together expertise from academia, industry, government to identify research, tools, training needs
- Progress
  - Conducted 1st in a series of SoS SE workshops
    - Reviewed current policy
    - Discussed perspectives and motivations
    - Identified key issues for definition, requirements processes, and other issues

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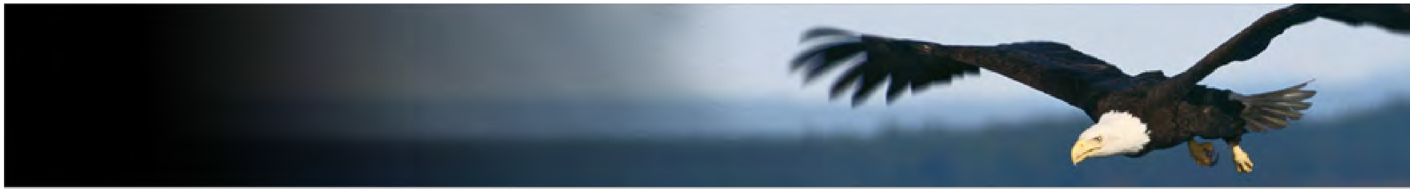
Delivering Effective Solutions in the Age of Open Source Technology

Edward Beck
Computer Sciences Corporation

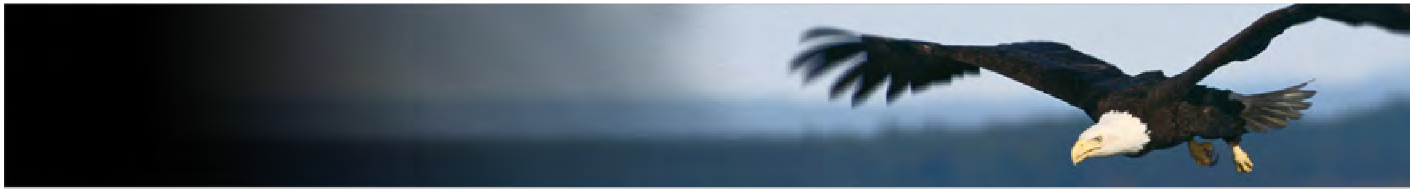
NDIA Systems Engineering Conference
October 24-27, 2005

EXPERIENCE. RESULTS.



Overview

- A Changing Landscape
  - Embracing the Open Source Movement
  - Organizational Impacts
- Navigating the Open Source Waters
  - Selection Criteria
  - Licensing
- Aegis Case Studies
  - A Migration to Open Architecture
  - ADI (Advanced Display Infrastructure)
  - Insight: Distributed Systems Management Toolset
- Conclusion



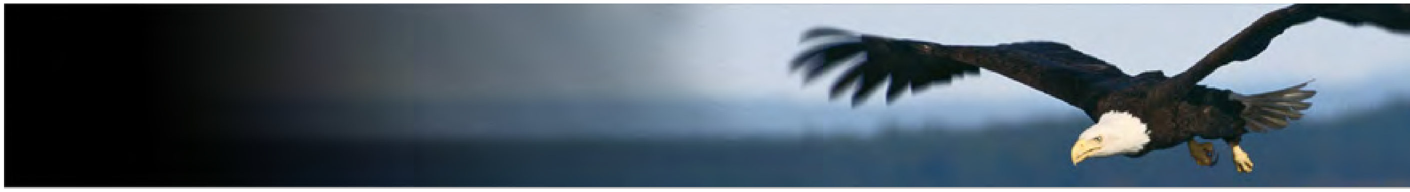
What is Open Source?

- Open Source As Defined by the Open Source Initiative

  Open Source software is software licensed such that when distributed in binary form, it comes with the source code. In addition to being available in source form, the software is also freely redistributable, modifiable, without discrimination, without ties to a specific product, without placing restrictions upon other software, and is technology neutral. (Perens)

- Open Source As Defined by Mitre and DOD

  "[Open Source] is software with its source code available that may be used, copied, and distributed with or without modifications that may be offered either with or without a fee." (Kenwood xi)



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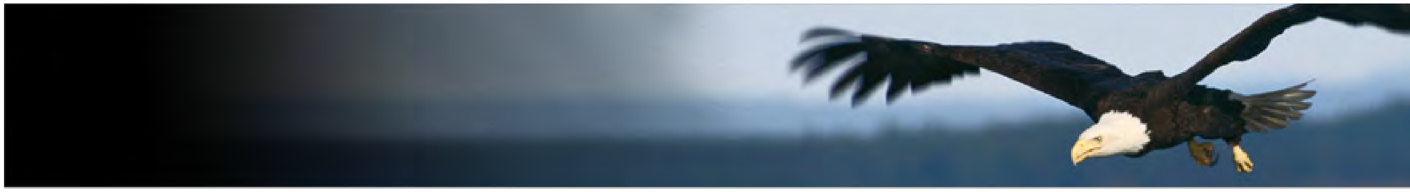
What is Open Source? (cont.)

- Practically Speaking

  Open Source is software which is freely available for use, inspection, modification, porting, and redistribution.

Open Source is a cultural phenomenon that is breaking into the commercial world and changing the rules.



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Companies:
IBM, DEC

Products:
Large-scale commercial computers

Programs:
Available in forums and magazines

1950 1960 1970 1980 1985 1990 1995 2000 2005

<u>1983-1985</u>
Free Software Foundation rolls out GNU, a UNIX-like distribution mechanism

<u>1989</u>
UC - Berkeley releases BSD UNIX.

Cygnus Corp founded to provide support for GNU and Open Source

<u>1991</u>

Linus Torvalds releases source code for Linux

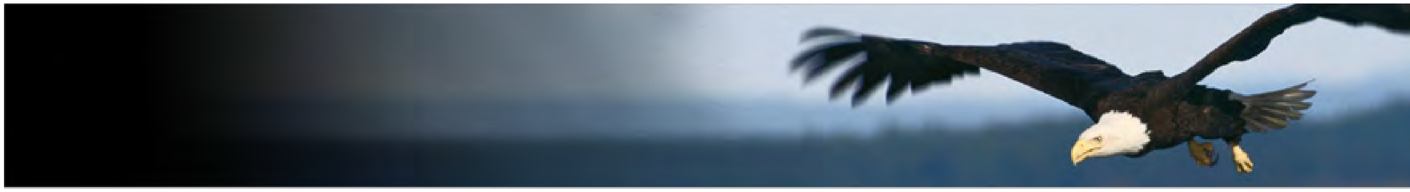
<u>1992</u>
Air Force begins work on ADA 95 Compiler. GNU is the basis

<u>1992</u>
386BSD 0.1 released as first free UNIX-like OS

<u>1993-1995</u>
SlackWare Linux is started. Becomes popular as an alternative to MS Windows

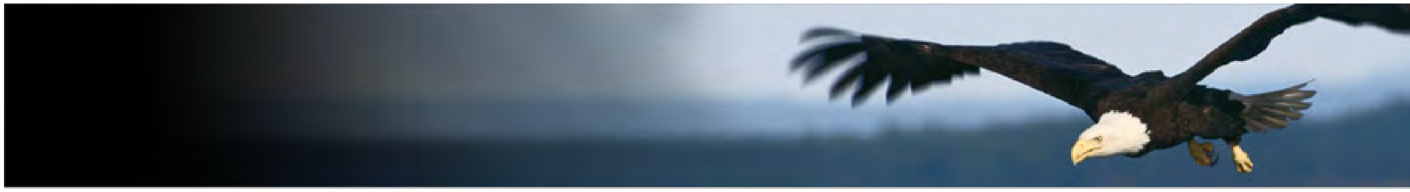
<u>1998</u>
Open Source Initiative (OSI) created as marketing agent to support free software

<u>2002</u>
Concurrent Computer Corp. releases initial version of its Real-Time Linux OS.



What Does This Mean For Us?

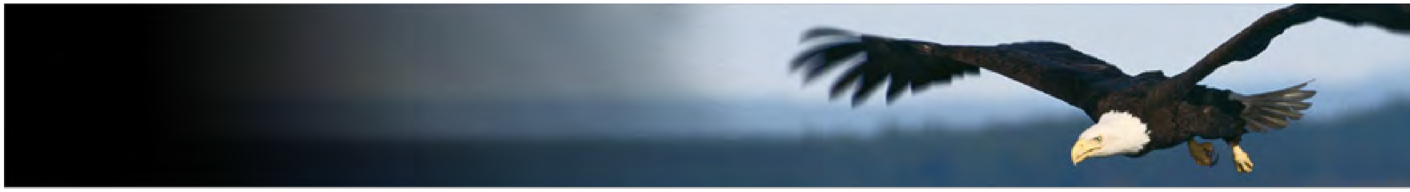
- Open Source Technology is a viable solution that must be considered in today's design models.
- Incorporating Open Source components into the System Architecture can significantly reduce the implementation effort
  - Cost benefits can be substantial
    - Aegis case studies: ADI and Insight
- Open Source components can enhance overall project quality
  - Open Source Projects have hundreds of users over multitudes of applications
  - Bugs are found quickly and incorporated back into the Open Source Repository



The New Frontier Of System Development

- Open Source product search.
  - Review available components based on current requirements
  - *It is also a continuous process*
    - ***Anticipate requirements and search for available components***
- Prototyping and Evaluation.
  - Experimental phase
  - *Core group focused on Open Source "test code"*
- Component Integration.
  - Merge the Open Source and Mainstream software
  - *Rigorous testing*

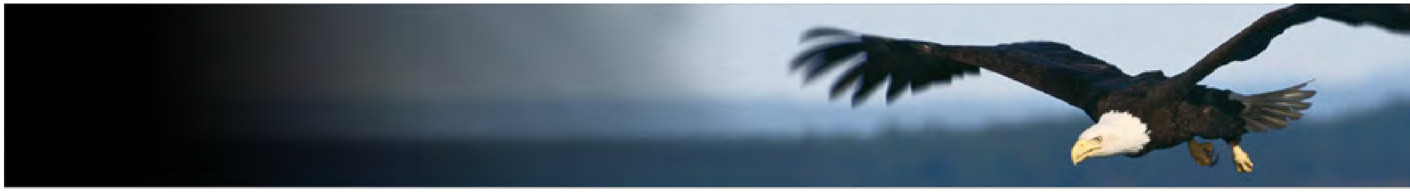
Searching for Open Source components has become a key task of the development staff.



Where Do You Begin The Search Effort?

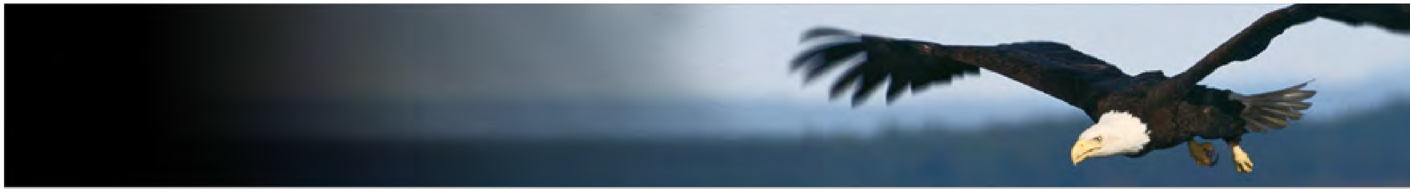
- Thousands of Open Source projects are readily available for evaluation and use
  - Websites are too numerous to count
    - freshmeat.net
    - sourceforge.net
    - slashdot.org
    - …..etc.

- Open Source is no longer just the domain of hobbyists and academics
  - Corporations beginning to contribute to Open Source efforts
    - IBM and Linux
    - Concurrent Computer Corporation and RedHawk Linux
    - Netscape and Mozilla



Selection Criteria Guideline

- Is it actively released, and how often is it released?
- Is it being actively developed?
- Is it an established project?
- Is it being used and tested by a wide community?
- Does the project have a problem tracking system?
- Is there adequate developer response?
- Does the project have an established version control methodology?
- Does the source code appear to be adequately documented and maintained?
- What type of license does it have?
- Is it portable?



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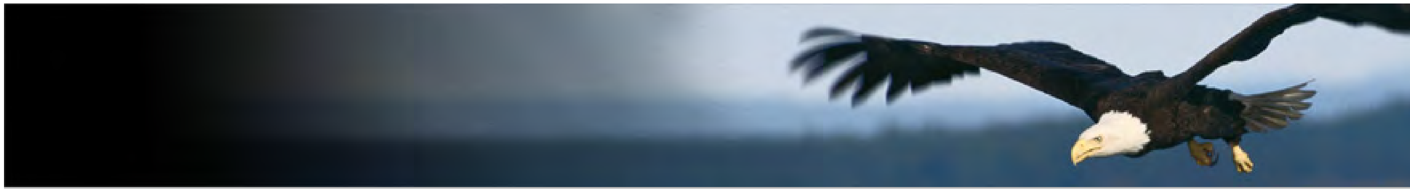
Licensing

- What is an Open Source License?

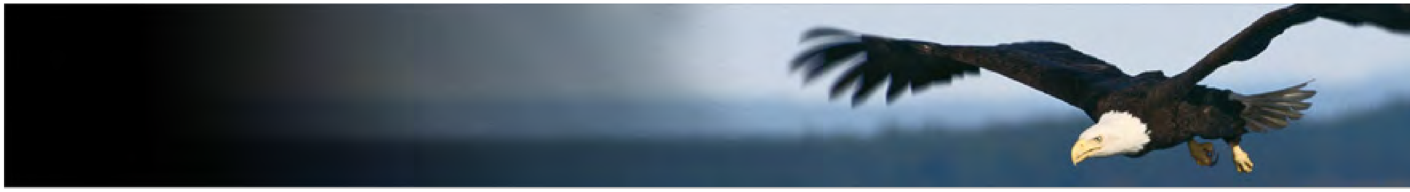
  An Open Source License is a software agreement that makes software available to the user and meets the definition of Open Source as provided by the Open Source Initiative.

- What the License means:
  - The license under which Open Source software is released determines how a company/individual can use that software.
  - License restrictions vary by component.
  - Some general license guidelines can be found at www.opensource.org



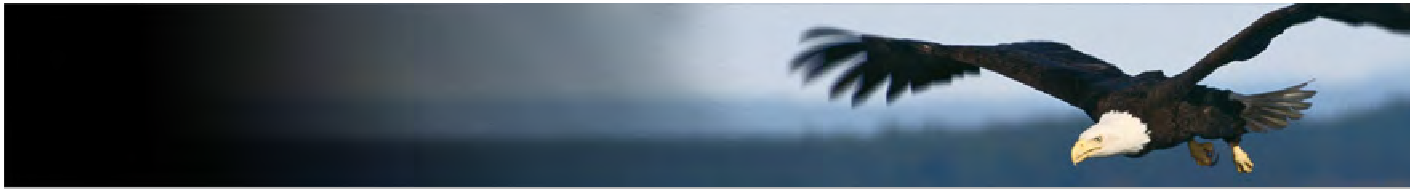
Licensing (cont.)

- GPL (General Public License)
  - Most common license in use today
  - Derivative is LGPL (GNU Lesser General Public License)
    - Less restrictive than GPL when Open Source is combined with proprietary software
- Organizations need to be disciplined about their use of Open Source software.
  - Contracts
  - Configuration Management
- Open Source legal and business issues need to be taken seriously.



A Capsule Comparison of Open Source

- Pros
  - Costs less than comparable commercial products
  - Components are often created by subject matter experts
  - Multi-Platform availability
  - Popular components with wide community interest are often very stable products
  - Lends itself to rapid prototyping
- Cons
  - Components may lack commercial polish, with inadequate user documentation
  - Some effort may be required to become proficient in using the component
  - Components, although free, may include licensing agreements that are inappropriate for application integration
  - Integrating Open Source code creates Configuration Management, Quality Assurance and Liability concerns

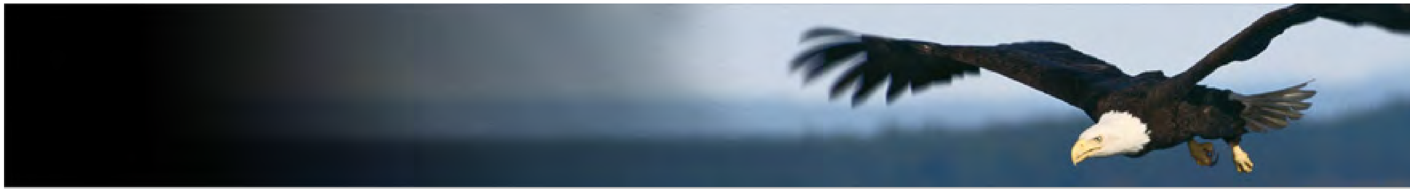


AEGIS Case Studies

- The Aegis Weapons System is the most sophisticated missile system the United States Navy has ever put to sea. It is an interconnected suite of computers interfaced to numerous sensors and devices throughout the ship.

- Recent Aegis baselines have focused on re-engineering the weapons system to take advantage of commercially available off-the-shelf (COTS) operating environments (OE).

- CSC has begun to leverage Open Source technology in the development of the “next-generation” software for AEGIS
  - Advanced Display Infrastructure (ADI)
  - Insight: Distributed Systems Management Toolset for Enterprises



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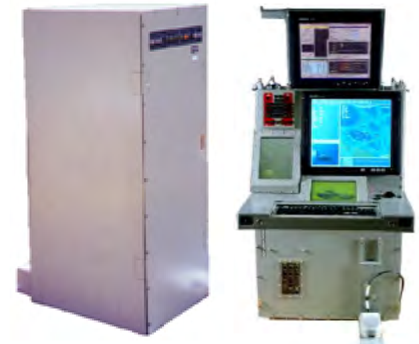
A Migration To Open Architecture

Proprietary Systems

Manufactured hardware and developed software

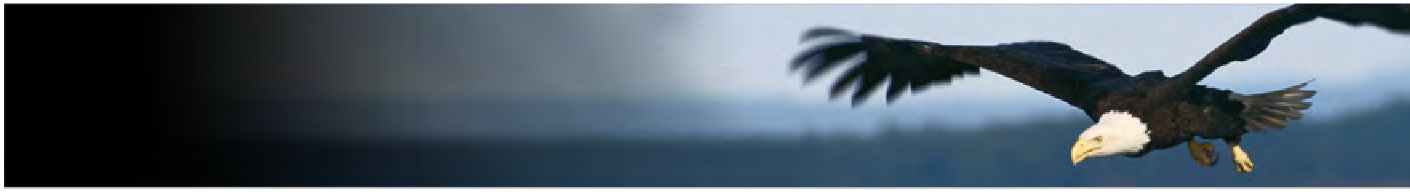
Open Systems



Emphasis on COTS hardware and software integration

Not Available — **Limited Availability** — **Readily Available**

Availability of Open Source Components

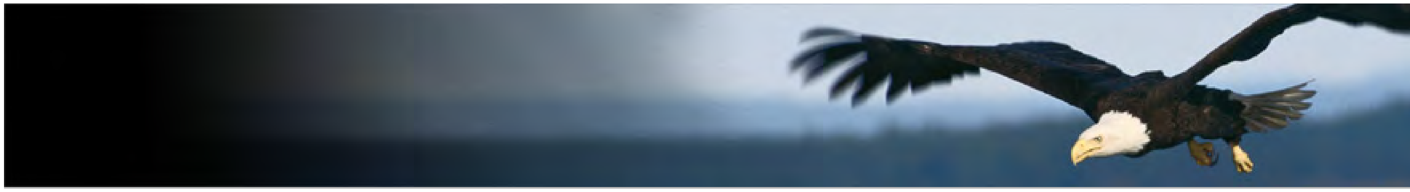


Applying Open Source Technology is an Organizational Effort

- Our Engineering Organization is tasked with the investigation and evaluation of Open Source software according to a strict set of criteria

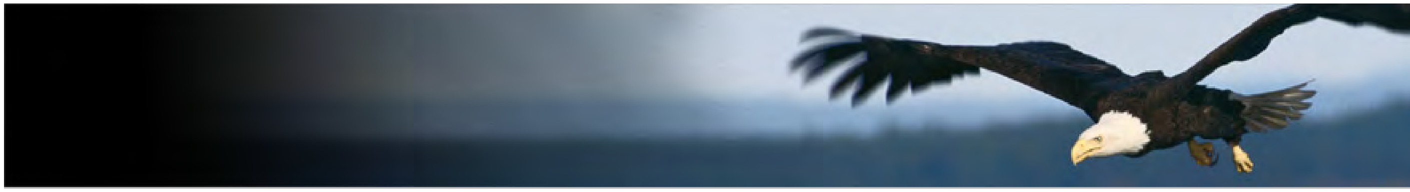
- The Contracts Organization provides authorization for the use of Open Source software based on the type of license associated with the component

- An Open Source Library is maintained by our Configuration Management Organization as a “trusted source” for officially sanctioned open source components



Adopting New Development Processes

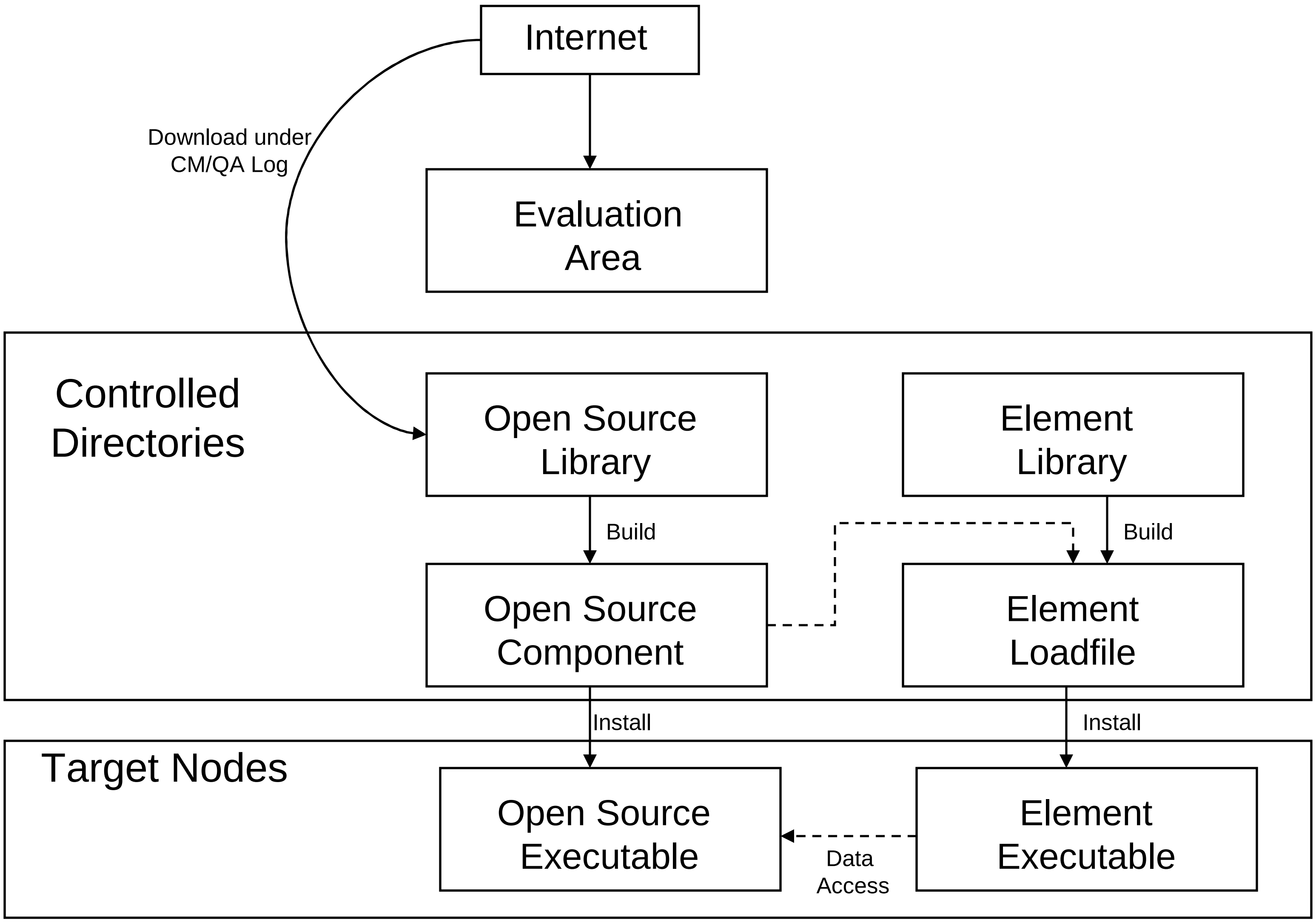
- Investigation
  - Based on system requirements, a search of available Open Source repositories is made to determine if a component exists that meets system needs
- Evaluation
  - Candidate Open Source component is subjected to internal tests and review to determine its viability as a system component
  - Licensing agreement is reviewed
- Approval
  - Candidate Open Source component is recommended for inclusion into the system architecture
- Capture
  - Official Download and CM of Open Source Product

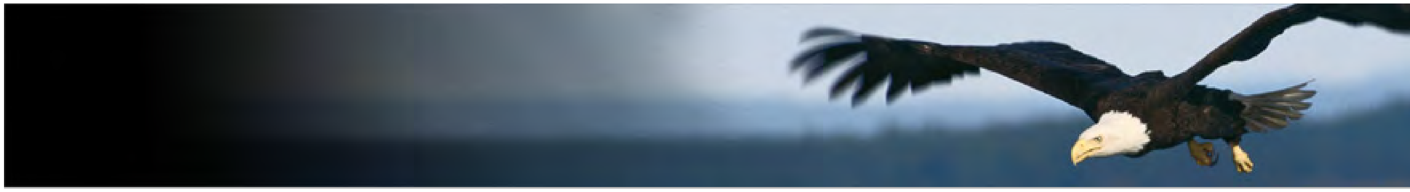


Adopting New Development Processes (cont.)

- Delivery
  - Delivery of Open Source Product for use in the project
- Upgrade
  - Capture and subsequent re-delivery of the next generation of the Open Source component
- Modification
  - Alterations to Open Source component due to locally encountered issues

Open Source Life Cycle

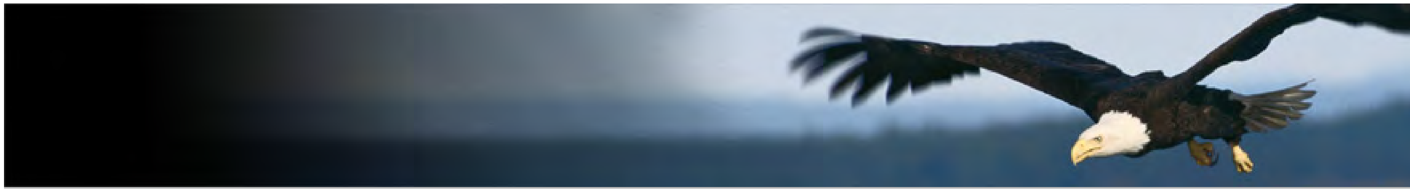




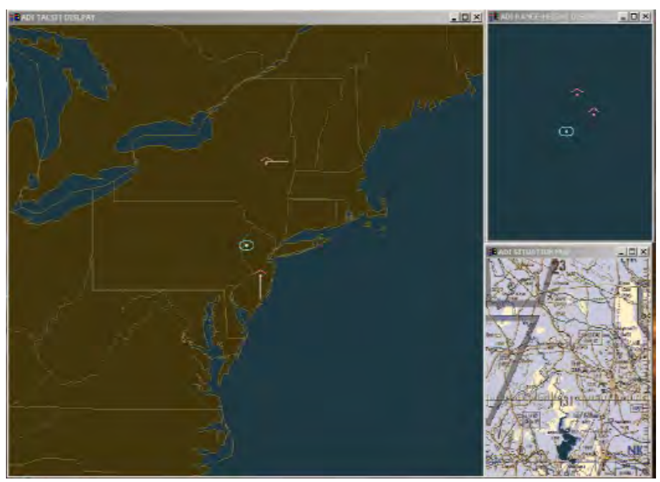
A Sampling of Open Source Components

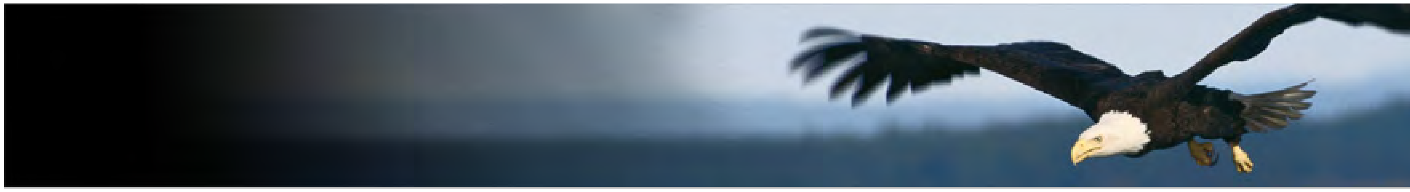
- TCL/TK – a graphical user interface toolkit
- Expect – a tool for automating interactive applications
- XPM – X Pixmap library used to store color images
- DBG – a debug library
- LSOF – used to list open file descriptors
- Flex/Bison – a language parser
- ACE/TAO – CORBA compliant network services
- Mozilla – web browser
- TCPDUMP – captures network packets
- AIDE – verifies integrity of the filesystem
- Mantis – an issues tracking database
- GKrellM – system monitor

ADI (Advanced Display Infrastructure)



- Advanced Display Infrastructure (ADI) is a prototypical display application that CSC has developed to answer the question about what a tactical display application for the future should look like.
- ADI consists of a number of COTS, Open Source, and independently developed applications integrated together to form a complete display infrastructure for tactical and non-tactical operations.

Windows	TACSIT	Video Stream
		



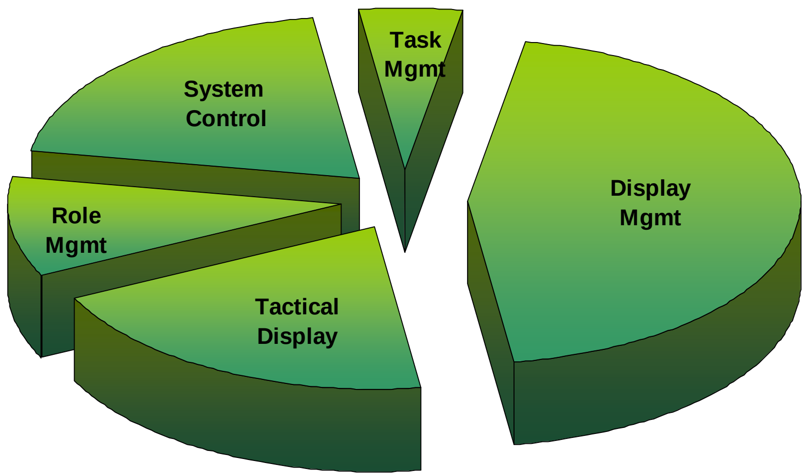
ADI – The Capabilities

- ADI Provides
  - A configurable, extensible and scalable framework for the development of display applications
  - A generic display subsystem for existing legacy applications
  - A tool for GUI/HSI prototyping that results in reusable project code
- Platform neutral
  - Based on open standards
- ADI uses
  - Open Source Software Solutions (Web Browser, OE infrastructure Abstraction)

ADI is CSC's solution to future display requirements, today. Display components are being delivered in the Aegis Open Architecture system.

ADI Component Architecture and Open Source Utilization

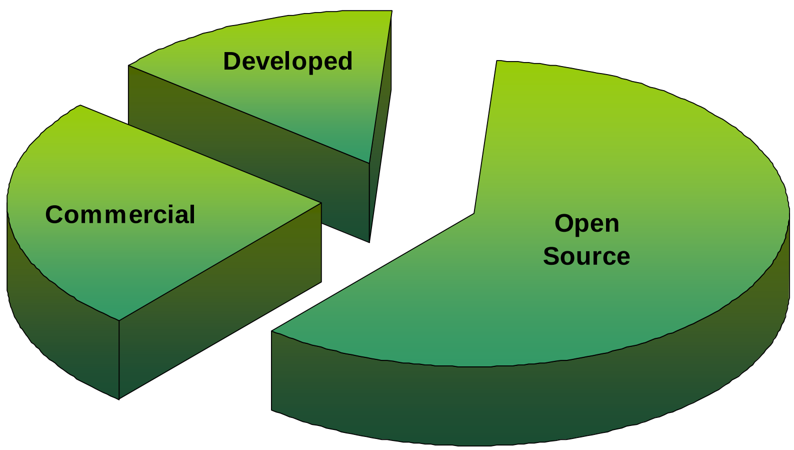
- Display Management
  - Mozilla
  - Apache
  - XMLRPC-C
- Tactical Display
  - ACE/TAO
  - Commercial Product
- Task Management
  - ACE/TAO
- Role Management
  - ACE/TAO
- System Control
  - ACE/TAO



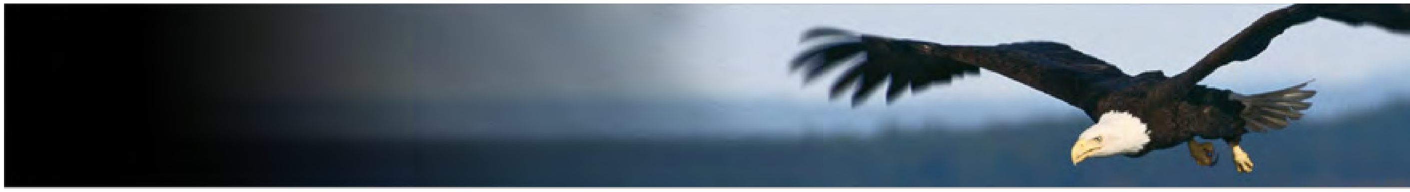
Extensive Use Of Open Source Technology

- Over 60% of ADI is comprised of Open Source software
  - Permits selection of "OA – compliant" components
  - Reduces development time
  - Leverages intellectual resources from the world wide development community

Functional Composition



Open Source is incorporated within every functional component of ADI.



The Open Source Benefits For ADI

Sample cost and schedule for **Display Management**

	Open Source Mozilla, XMLRP-C Apache, ACE	CSC Developed Display Manager
Source Lines	2,588,246	1,573
Development Cost	$103,585,139*	$62,951*
Effort	493 Staff-Years	3.6 Staff-Months

*Costing number derived from industry standard numbers as determined by the SLOCCount estimation tool. Refer to http://www.dwheeler.com/sloccount for details.

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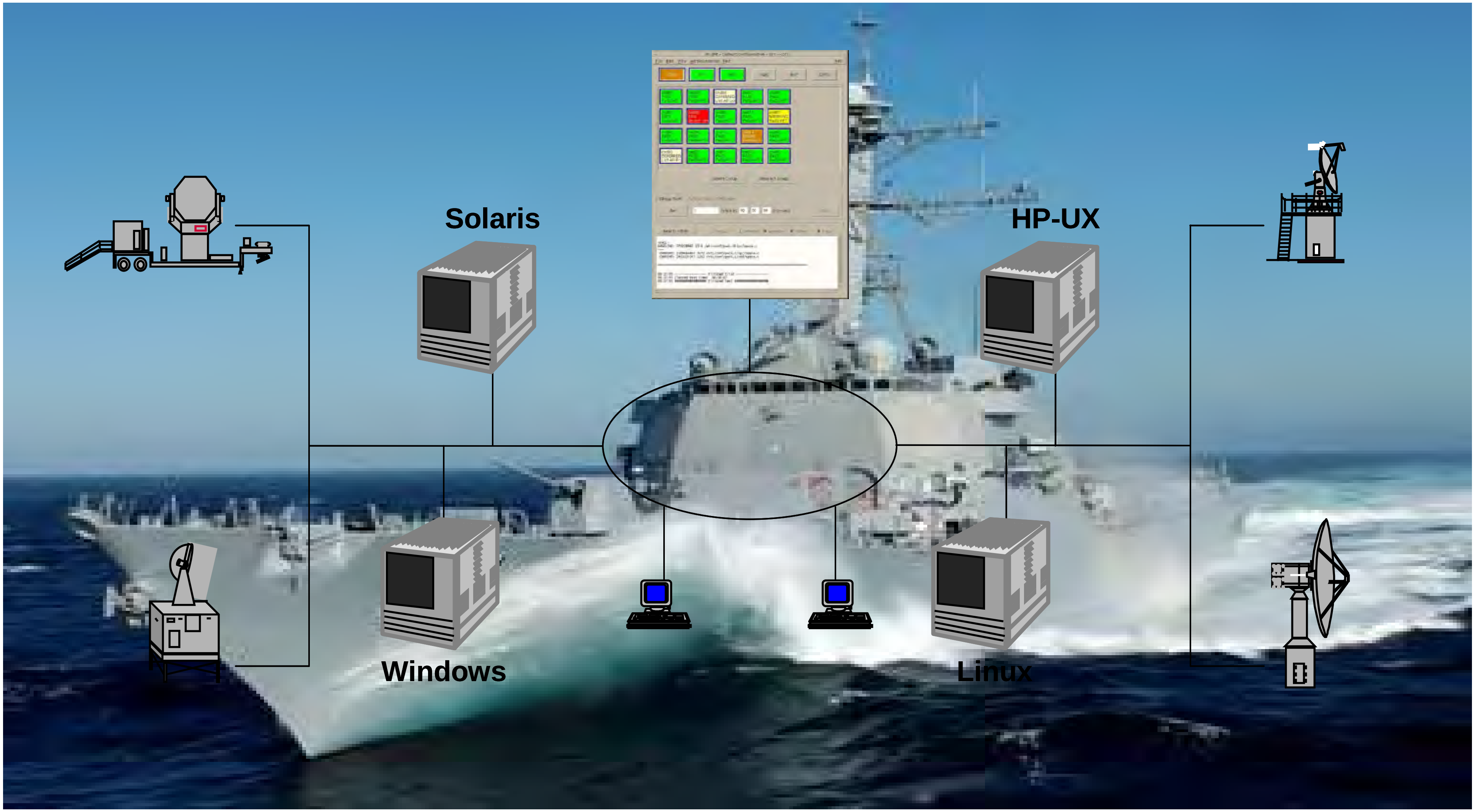
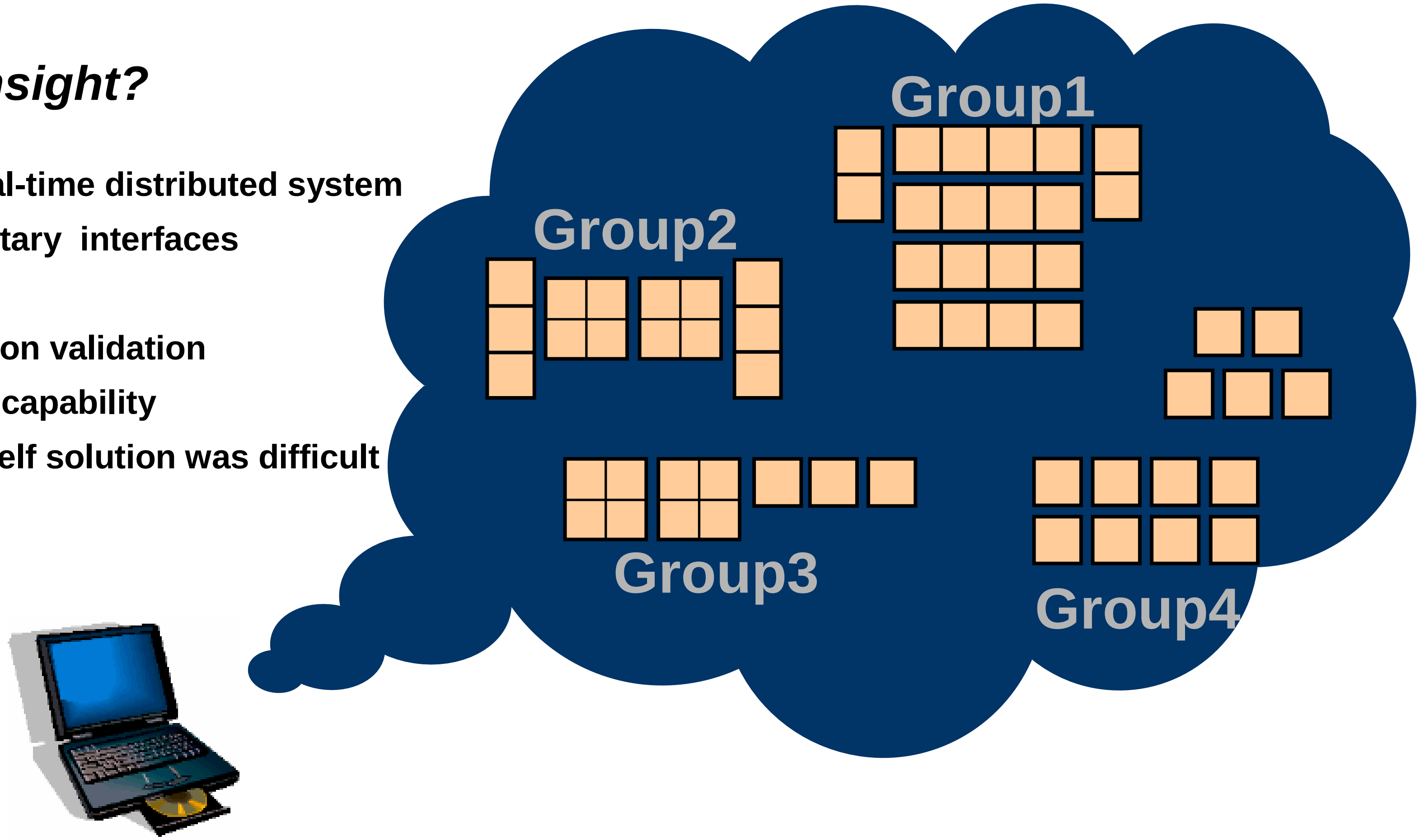
Insight: Distributed Systems Management Toolset



What is *Insight?*

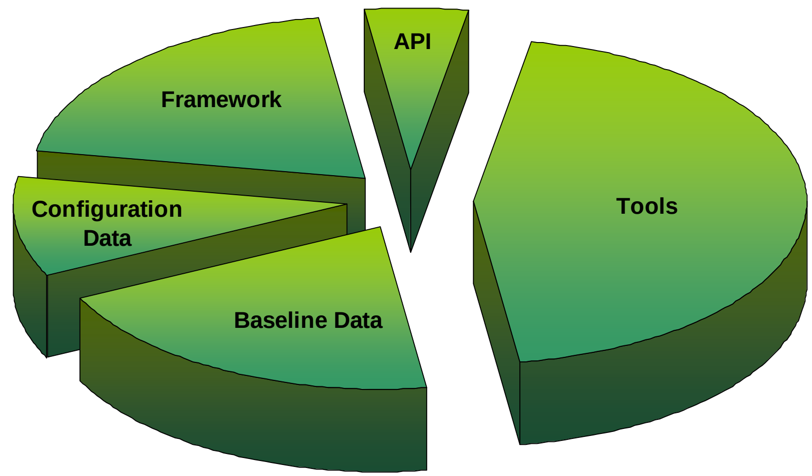
- Aegis is a real-time distributed system
- Many proprietary interfaces
- Needed:
  - Configuration validation
  - Diagnostic capability
- An off-the-shelf solution was difficult



The goal of Insight is to let an operator at a single workstation assess the operational state of the heterogeneous equipment suite in real-time.

Insight Component Architecture and Open Source Utilization

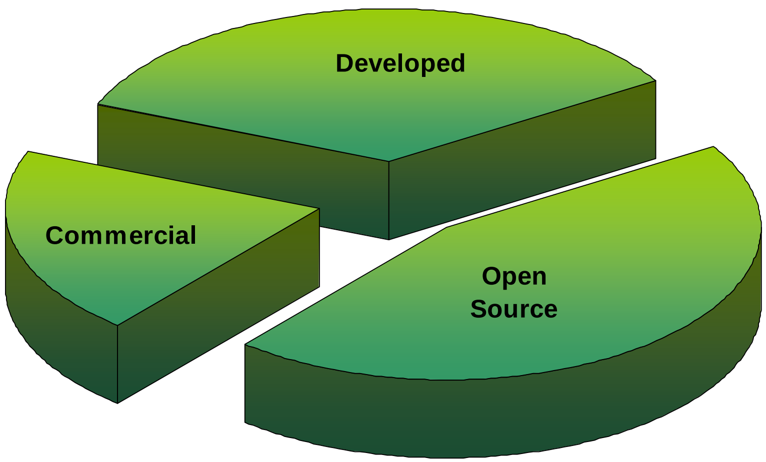
- Framework
  - TCL/TK
  - Expect
  - XPM
  - DBG
- Tools
  - TCPDUMP
  - LSOF
  - AIDE
  - GKrellM
- Configuration Data
  - Flex/Bison
- API
  - DBG



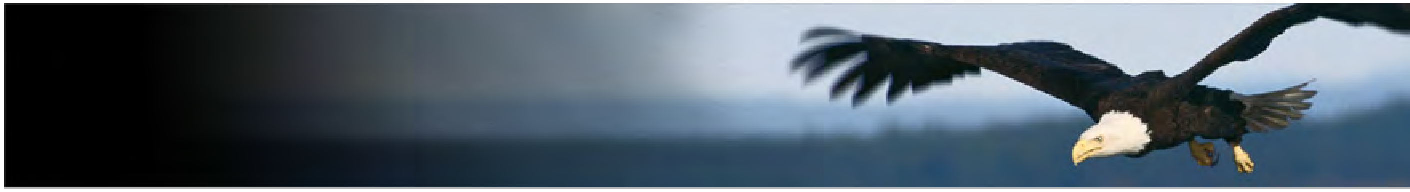
Extensive Use Of Open Source Technology

- Over 40% of Insight is comprised of Open Source software
  - Permits selection of cost effective, best-of-breed solutions
  - Reduces development time
  - Leverages intellectual resources from the world wide development community

Functional Composition

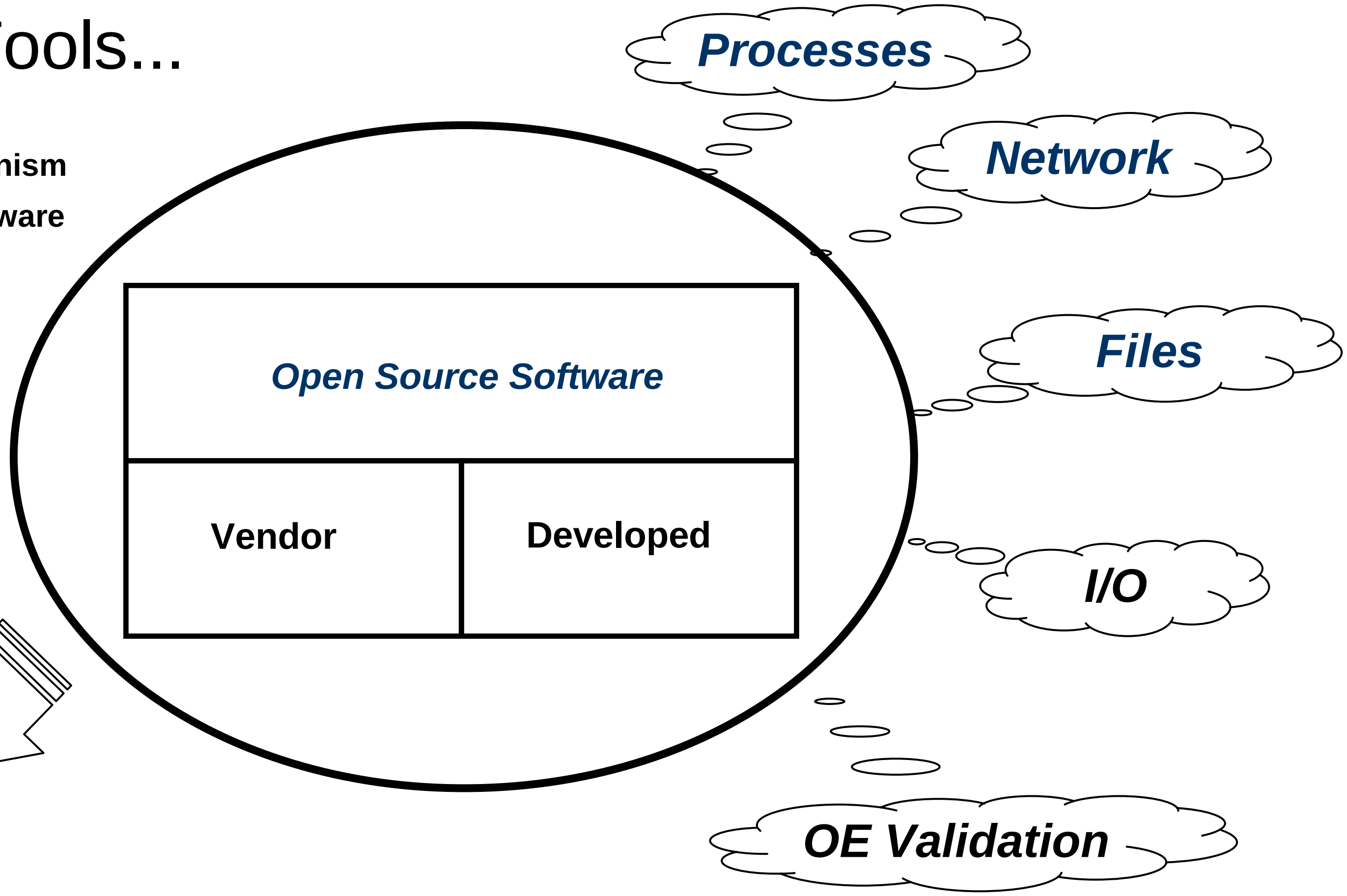


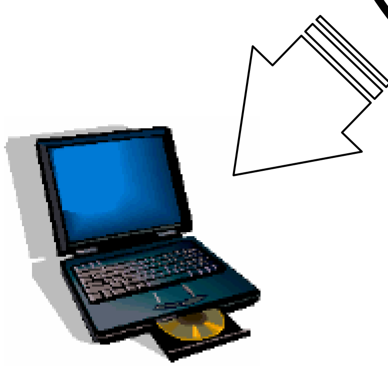
The Open Source community is our first choice for enhancing the functional capabilities of Insight.



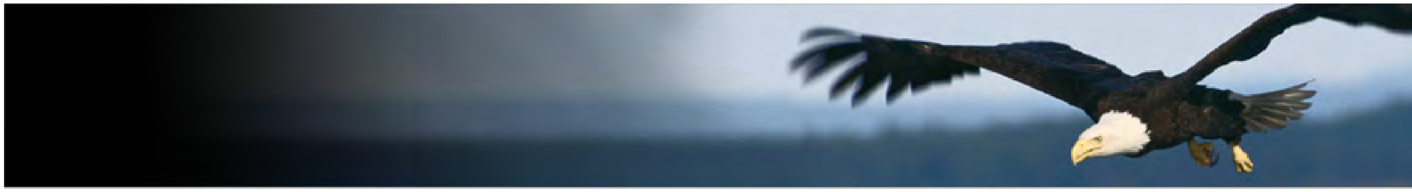
Tools, Tools, Tools...

- **Platform for disparate tools**
- **Consistent launching mechanism**
- **Leveraged Open Source software**
  - **LSOF - Processes**
  - **TCPDUMP - Network**
  - **AIDE – File System**
  - **GKrellM – Monitor**





Insight tools are a configurable collection of "best-of-breed" products and utilities to perform system management functions.



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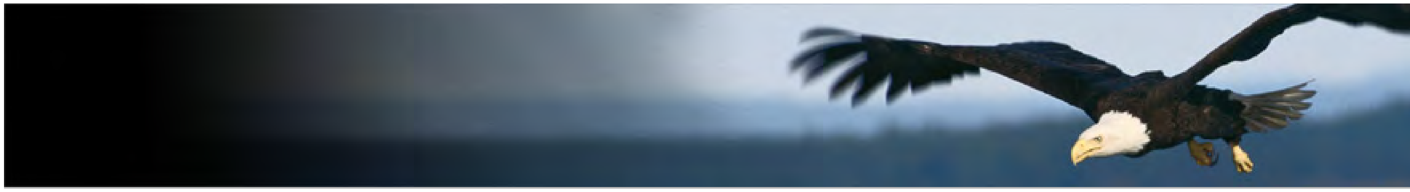
The Open Source Benefits For Insight

Sample cost and schedule

	Open Source		CSC Developed	
	Expect/TCL, XPM, DBG	LSOF, AIDE, TCPDUMP	Framework	Tools
Source Lines	102,266	38,417	10,238	8,812
Development Cost	$2,676,404*	$1,005,372*	$267,938*	$230,610*
Effort - Staff Months	227	85	23	19

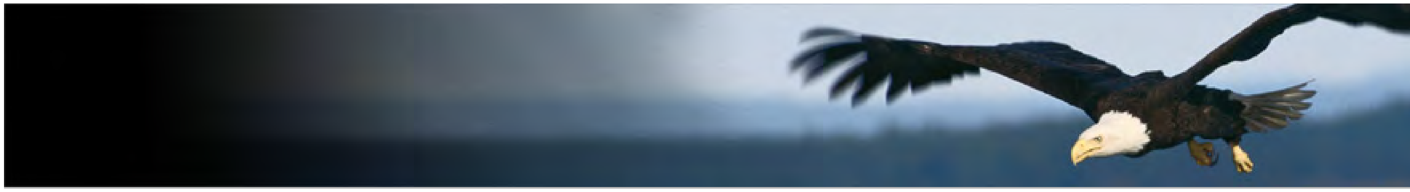
*Costing number derived from industry standard numbers as determined by the SLOCCount estimation tool. Refer to http://www.dwheeler.com/sloccount for details.



CSC’s Roadmap to Open Source Technologies

- LEF (Leading Edge Forum) activities
  - “Open Source: Open for Business”
    - Research report on open source trends

- Knowledge Community
  - Central repository of Open Source information
  - FAQ
  - Available corporate-wide, through the CSC web portal



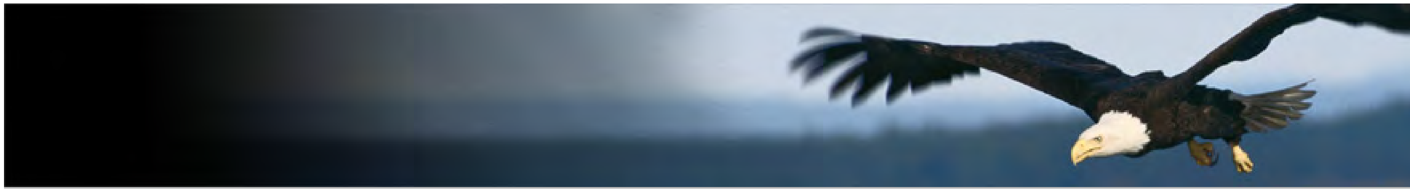
Conclusion

- We successfully leveraged the use of Open Source components to deliver effective solutions for several projects.
  - Integration of approximately 2,600,000 lines of Open Source
  - Development cost savings in the millions of dollars

- Increased knowledge base from examining Open Source components generated by subject matter experts.

- Design and development activities are now focused on software evaluation and prototyping.

- Enhanced the process for Configuration Management and Quality Assurance.



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Raytheon

Joint Integrated BMC4I
The Intermediate Control Station Concept

Billy W. Bradley Jr
Raytheon Integrated Defense Systems

Raytheon

Background Information

- All information in this presentation is unclassified.

- The purpose of this presentation is to discuss a new method of battlefield communications that would encompass the joint battlefield.

- The information presented here is meant to bring discussion to the methods and mentality of how tactical and operation communications are handled. It is also designed to show a fundamental change in how communications could be streamlined and simplified in a battle.

Raytheon

The Intermediate Control Station Concept

Modern tactical and operational communications systems do not suffer from a lack of information. Due to information exchange, the problem is actually one of too much information for the commander to have to deal with.

What is needed is a Joint BMC4I System that would allow various levels of the chain of command to weed out what they do not deem necessary for their portion of the battle. This is not just a system of “turning off” track types. It is a fundamental shift in information processing and reporting.

The Intermediate Control Station Concept

The Intermediate Control Station (ICS) Concept creates “nodes” of sensors with battle management logic and communications control through the system. Each node is capable of acting independently in case of battle damage or loss of communication with a higher ICS. It can be thought of as an object oriented approach to systems engineering.

Objects in the form of nodes create the system whereby the individual sensors, shooters and assets can be moved. Individual assets can be moved from one node to another as the commander sees fit. This system will provide the commander with the information that is required while keeping the remaining information at the lowest level.

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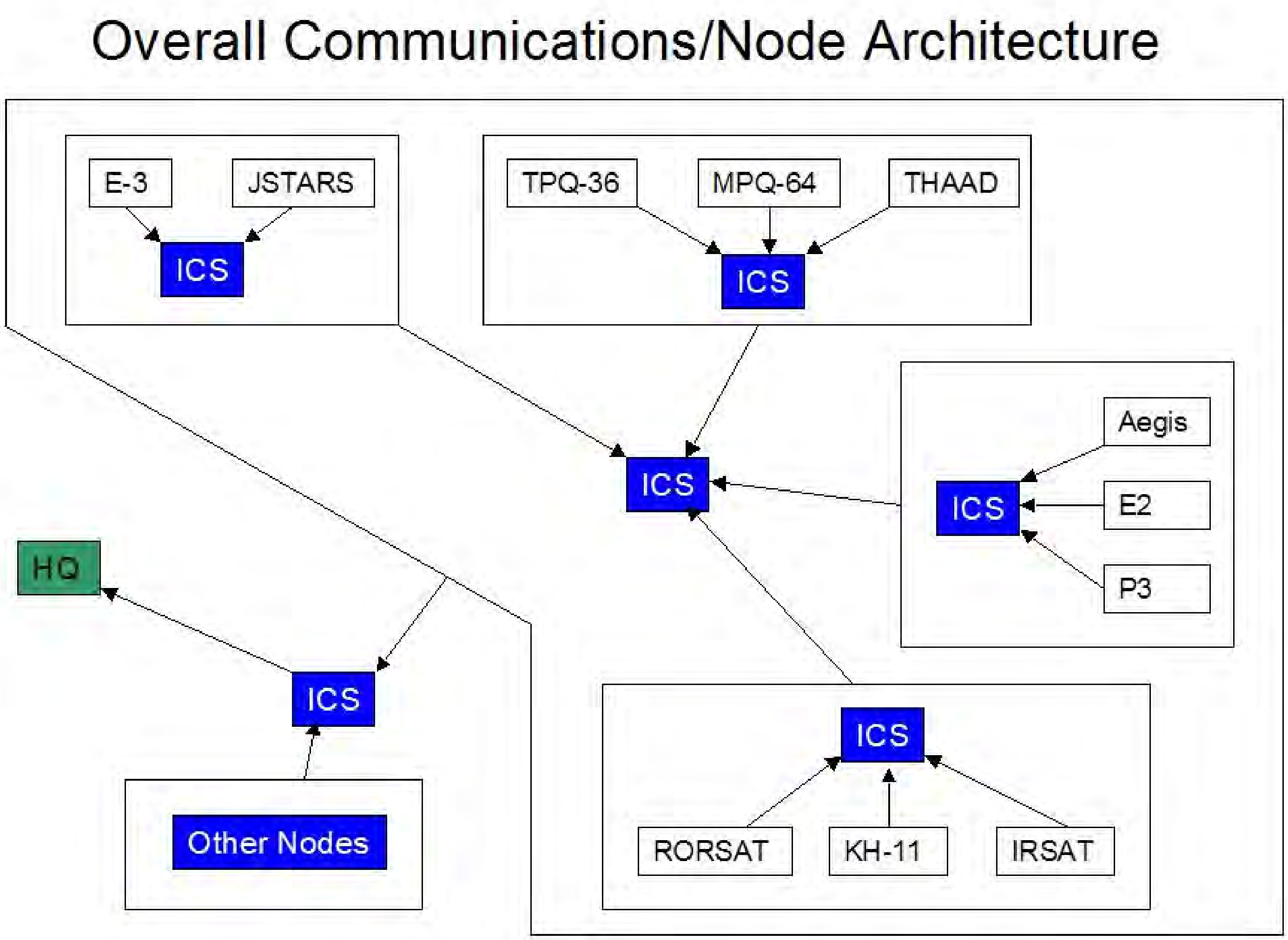
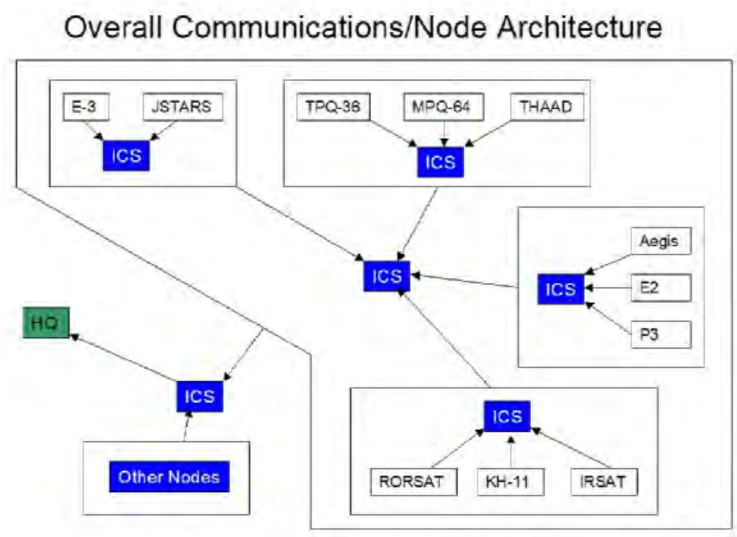
The Intermediate Control Station Concept



How does the ICS work?

Each lower level node contains all of the sensor information (radar, IR, any other source, HUMINT) for that particular node. The node can be set up by geographic area or by command structure.

Each higher level node requests the information from the lower level node. Only the information requested is passed. The commander may deem certain information necessary and does not want to cloud the picture with unnecessary data.



Fusion of the data is accomplished at the appropriate level.

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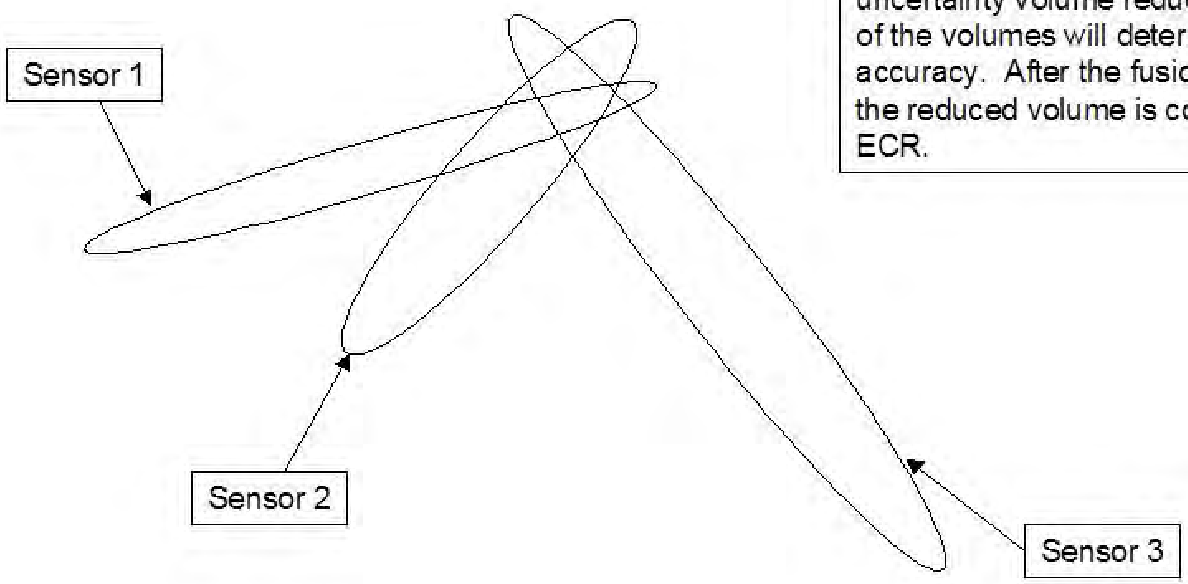
Functions of the ICS

1. Coordinate track information from sensors in the ICS node.
2. Pass requested information to a higher ICS.
3. Fuse overlapping sensor data in its node or group of nodes, accomplished using measurement, rather than track data.
4. Break off a “node” should the system reach track saturation.
5. Act as an intermediary commander if necessary.
6. Assign shooters to nodes and pass shooters between nodes.
7. Contain the battle management algorithms necessary to move fire control and sensor data when ordered.
8. Continue the OPPLAN until directed by higher ICS/HQ.

Sensor Fusion for the ICS

Sensor Fusion/Overlap



Overlapping sensors will have their volumes crossed and have the overall uncertainty volume reduced. The shapes of the volumes will determine the accuracy. After the fusion is completed, the reduced volume is converted to ECI or ECR.

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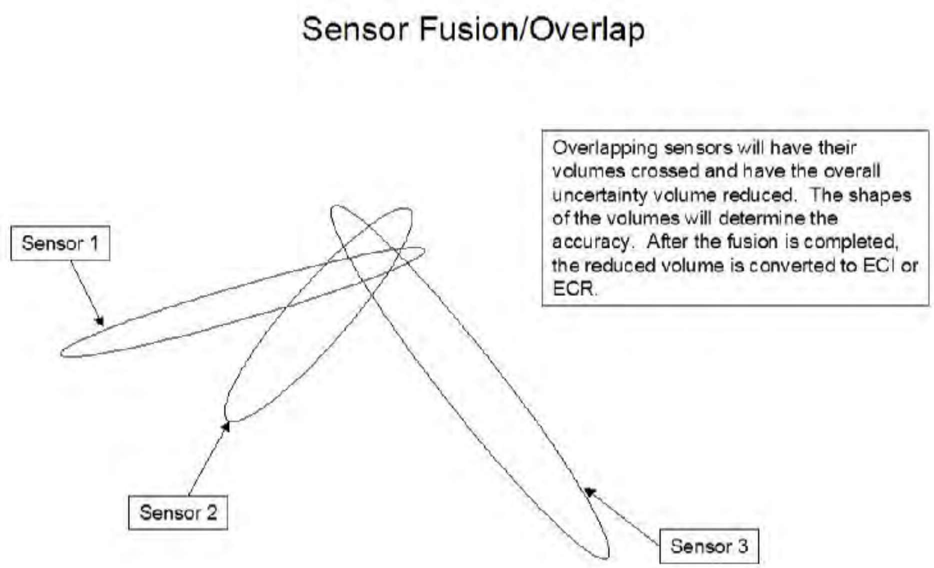
Sensor Fusion for ICS

Sensor fusion has been a primary concern at Raytheon for some time. Ongoing research and development of various methods of overlapping sensor fusion is still continuing.

At this time, the concept of using the disk shaped objects in ECR than the egg shaped objects of ECI. The ability of the system to fuse multiple sources such as ESM, elevation and azimuth from various active sensors and passive data will allow a more accurate location to be provided.

Concurrently, it is envisioned that the overlapping disks will be used. Measurement, rather than track data will be used to move targets up and down the chain. Overlapping volumes are kept and the rest of the uncertainty values are thrown out.



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Communications for the ICS

Variations of the Huffman Algorithm will be used to compress the data and provide another sub-encryption to the method.

A detailed background providing for a 4 bit alphabet and are described in the research paper.

Continuing advances in data compression and satellite communications provides the necessary impetus for the ICS to work. However, the concept of only transmitting the data that is required by the higher ICS lowers the overall volume of message traffic and makes the system run faster.

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Other Uses for the ICS

- Civilian Air Traffic Control
- Call for Close Air Support
- Call for Indirect Fire Support
- Geospatial Intelligence
- Analysis of Friendly Deployment Patterns

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Continuing Evolution of the Concept

The following steps are continuing to ensure maturation of the concept:

- Complete Sensor Fusion Algorithms at the individual and multi-ICS levels
- Completion of Data Compression Algorithm based on information required by the commander
- Conduct experiments with bistatic communications possibilities
- Create a computer simulation of individual nodes to test the Battle Management Algorithm Development
- Ensure robustness in multiple combat situations

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Questions

Questions?

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Cover Statement

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A Systems Approach to Accelerating Testing, a Case Study

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

A Systems Approach to Accelerating Testing, a Case Study

The Low Signature Armored Cab (LSAC),

Stewart & Stevenson Tactical Vehicle Systems (TVS)

Co-Presenters: Douglas Chojecki, Chief Engineer R&D

Nathan Byman. Manager ILS

Regis Luther, VP Engineering

A Systems Approach to Accelerating Testing, a Case Study

Introduction

- U.S. Army pre-OIF strategy for Tactical Wheeled Vehicles (TWV) did not require armoring

- Battlefield experience in OIF quickly showed TWV required protection; ambush – small arms, IED, RPG

A Systems Approach to Accelerating Testing, a Case Study

Introduction, continued

- Demand for Armor on TWV resulted in need for accelerated development, including system-level testing
- Normal U.S. Army development test for cab would require 6 -12 months of effort, production to follow
- LSAC tested within 3 months
- Qualification testing run in parallel with first production

A Systems Approach to Accelerating Testing, a Case Study

The "Real" world

- The customer knows what they want
- Requirements are derived considering all affected by the system; users, logistics, manufacturing, finances...
- Requirements are stable, or with the rare exception: revised in a controlled change environment
- Schedules are well planned, fixed and met
- Designs successfully anticipate all failure modes and complete documentation is available for procurement, manufacturing and field support
- The end product is verified to meet all requirements

A Systems Approach to Accelerating Testing, a Case Study

The Original Requirements

- TVS IRAD effort used existing vehicle requirements
- C130 transportability was maintained
- Coupon testing of ballistic solutions validated LSAC could be built to withstand objective threat levels
- Meeting other standard FMTV requirements with LSAC allowed maximum commonality

A Systems Approach to Accelerating Testing, a Case Study

The original project milestones

Oct. 2002	Project approval/requirements analysis
Jan. 2003	Design start
Apr. 2003	Ballistic solution chosen
Jul. 2003	1st prototype cab complete
Aug. 2003	TVS test of prototype

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August 2003, Project is on schedule! – Success!

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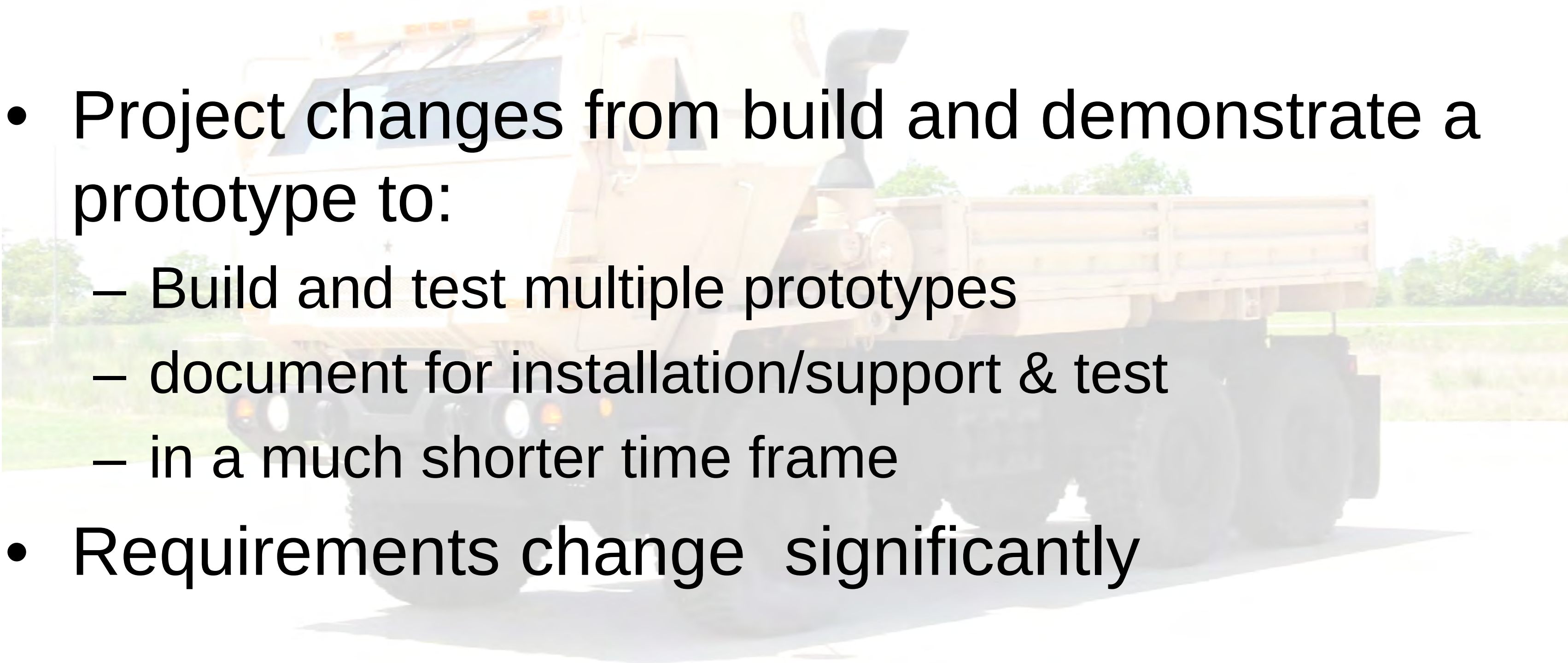
Realizing an opportunity

- Shortly after successful completion of the 2-man LSAC concept cab, U.S. Army is shown concept
- Interest quickly accelerates
- Results in requirements redefinition for the armored cab

A Systems Approach to Accelerating Testing, a Case Study

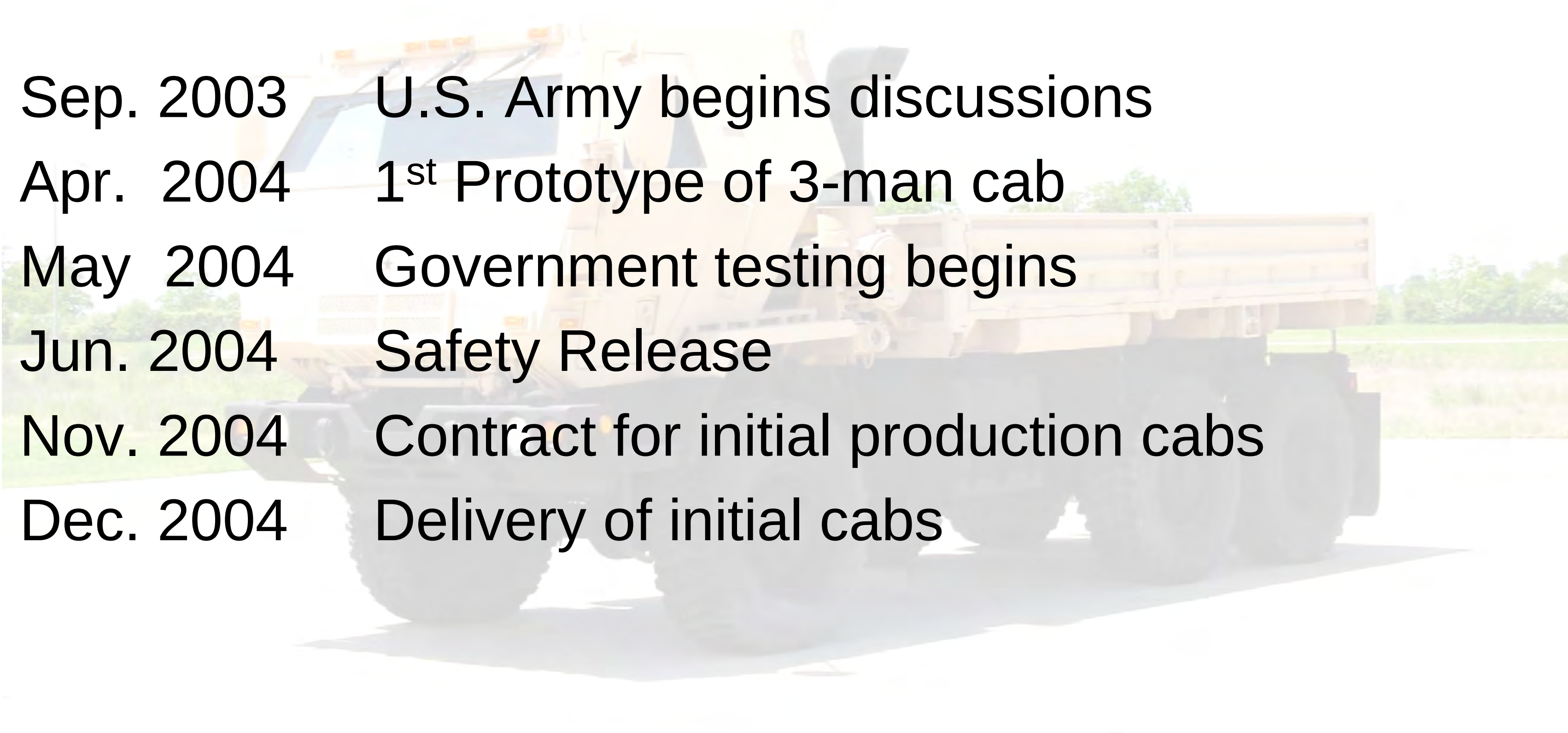
Scope and schedule change dramatically



- Project changes from build and demonstrate a prototype to:
  - Build and test multiple prototypes
  - document for installation/support & test
  - in a much shorter time frame
- Requirements change significantly

A Systems Approach to Accelerating Testing, a Case Study

The new project milestones



Sep. 2003	U.S. Army begins discussions
Apr. 2004	1st Prototype of 3-man cab
May 2004	Government testing begins
Jun. 2004	Safety Release
Nov. 2004	Contract for initial production cabs
Dec. 2004	Delivery of initial cabs

A Systems Approach to Accelerating Testing, a Case Study

Re-engineering the product

- U.S. Army ballistic requirements are specified – classified
- 3-man cab defined in place of TVS IRAD developed 2-man cab
- Man-lift changes glass configuration
- Supplemental armor requirements added

A Systems Approach to Accelerating Testing, a Case Study

Accelerated testing: durability, safety, performance

- LSAC required safety release
- 3k mile durability test scheduled at Government Test site
- Performance testing scheduled at Government Test site
- Testing scheduled to be accomplished May-June 2004

A Systems Approach to Accelerating Testing, a Case Study

Documentation; Configuration Management

- 3-D modeling developed for design
- Model revisions controlled via database
- Initial new parts built from models
- Technical data package (drawings) finalized during initial build
- Change approval streamlined
- Change approval became more limited during production to concentrate on must have, not like to's

A Systems Approach to Accelerating Testing, a Case Study

Logistics & Supportability

- Logistics/maintainability involved during design phase to ensure supportable design
- Commonality of parts, LSAC versus standard cab used to maximum advantage
- Work instructions for field retrofit developed on 1st LSAC cab(s)

A Systems Approach to Accelerating Testing, a Case Study

Production

- Ramp-up to 300 cabs/month achieved in 4 months
- Close coordination with design engineering and manufacturing during tooling and process definition
- Manufacturing changes to TDP processed with highest priority

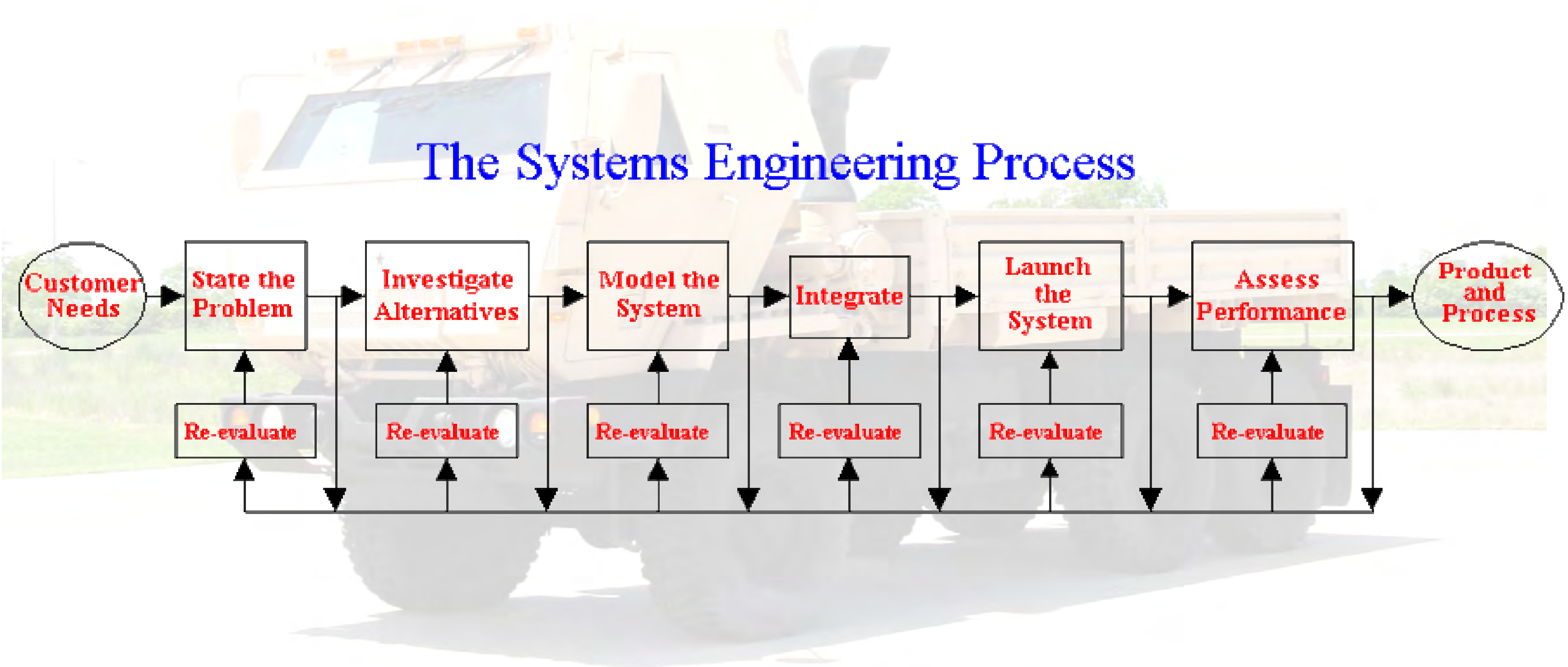
A Systems Approach to Accelerating Testing, a Case Study

Fielding

- Established installation teams and sites through existing support network,
- And additional site(s)
- Design concept of replaceable cab versus “add-on-armor” made installations quicker
- Data from initial fielding, gathered through established networks, enhanced testing and required/suggested were implemented expeditiously

A Systems Approach to Accelerating Testing, a Case Study

Evaluation of the Project - The Systems Engineering Process



This figure is from Bahill and Gissing (1998)

A Systems Approach to Accelerating Testing, a Case Study

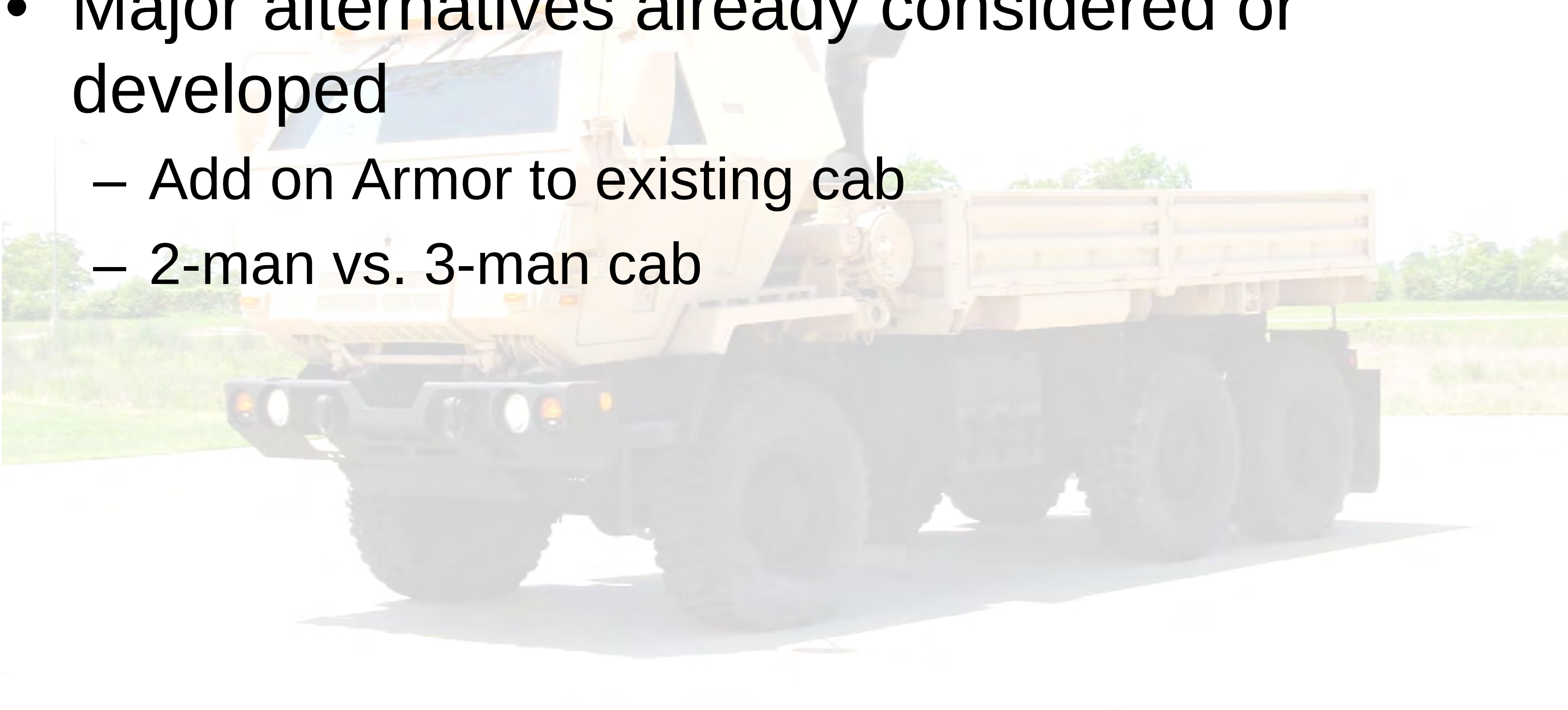
How the LSAC requirements were established and changed

- Discussions with and evaluation by U.S. Army resulted in current cab 3-man capability being retained
- Internal volume of cab was also required to be minimally changed,
- Resulting increase in axle loading during transport approved as acceptable

A Systems Approach to Accelerating Testing, a Case Study

LSAC Alternatives investigations

- Major alternatives already considered or developed
  - Add on Armor to existing cab
  - 2-man vs. 3-man cab



A Systems Approach to Accelerating Testing, a Case Study

Integration of LSAC

- Maintained standard production cab interfaces to maximum extent
- Development by OEM with full access to TDP, manufacturing and vehicles assets expedited design
- Most ILS development of technical documentation achieved during design & prototype build

A Systems Approach to Accelerating Testing, a Case Study

System Fielding

- Design concept of replaceable cab simplified installation
- Teams led by trained personnel
- Cabs shipped to theatre and installed on deployed vehicles
- Direct communication between installation teams and factory

A Systems Approach to Accelerating Testing, a Case Study

Assessing the performance

- The key to achieving success was to get the product designed and qualified ASAP
- Testing for safety release was accomplished in less than 2 months
  - Normally this would require at least 6 months
- Controlling change through production and test phases is critical. Changes must be minimized!

A Systems Approach to Accelerating Testing, a Case Study

Conclusions

- Buy-in from <u>all</u> levels required to get the project accomplished in the expedited time-frame
- Priority must be established to achieve success
- Excellent communications and working relations required

System Engineering Cost Collection Codes at Raytheon SAS

A Presentation for the
8th Annual Systems Engineering Conference
October 24-27, 2005
Hyatt Islandia, San Diego, California

Thomas R. Cowles
Raytheon Space and Airborne Systems

Table of Contents

Raytheon
Space and Airborne Systems

- Presentation Purpose
- Goals of Cost Codes
- Cost Collection Code Methodology
- Cost Estimation
- Summary

Presentation Purpose

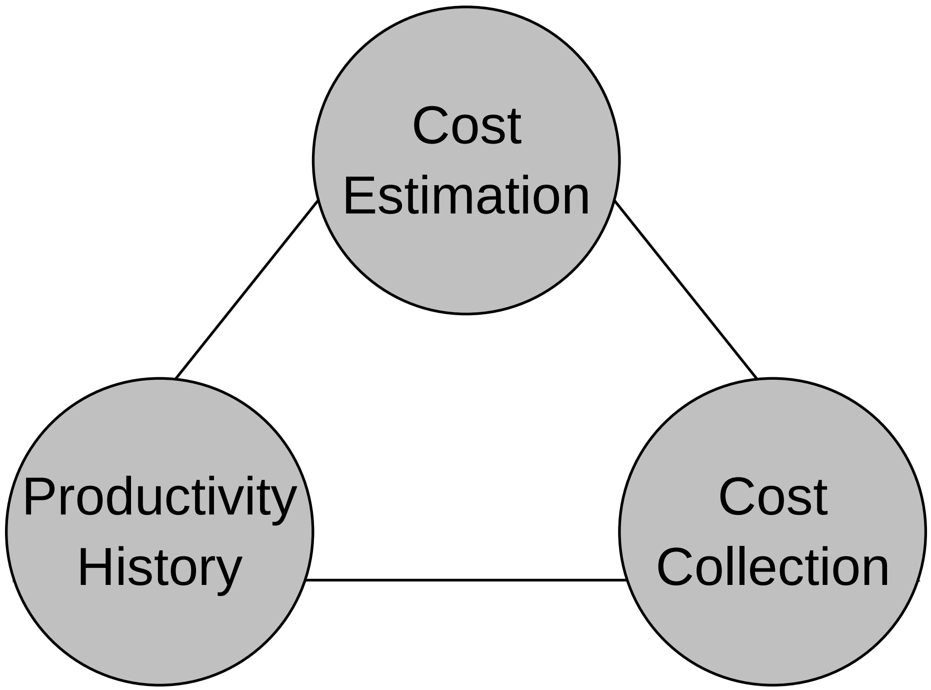
- **Show the current cost collection code methodology for Raytheon SAS**

- **Methodology for determining estimates of effort and cost**

Goals of Cost Codes

- **Multiple views and perspectives of costs in order to deliver best possible value at lowest cost**
- **Collect costs in process views as well as product views**
- **Process views allow more direct productivity comparisons**
  - ***By program***
  - ***By product***
  - ***By business or business unit***
  - ***By region***
- **Characterize our processes for productivity metrics**
- **Subdivide processes to enable process improvement opportunities**
- **Bid along process view as well as work product view**

Cost Estimation-Collection Cycle



Cost Codes are the Common Denominator

- ***Throughout program life cycle***
- ***Across all programs***
- ***Across all product lines***

Raytheon IPDP Program Phases
(Integrated Product Development Process)

Raytheon
Space and Airborne Systems

Life-Cycle Phase
PROJECT PLANNING, MANAGEMENT & CONTROL
REQUIREMENTS & ARCHITECTURE DEVELOPMENT
PRODUCT DESIGN & DEVELOPMENT
SYSTEM IV&V
PRODUCTION AND DEPLOYMENT
OPERATIONS AND SUPPORT

Raytheon IPDP Program Phases: Next Level Breakdown

Raytheon
Space and Airborne Systems

Life-Cycle Phase
PROJECT PLANNING, MANAGEMENT & CONTROL
Planning
Management and Control
REQUIREMENTS & ARCHITECTURE DEVELOPMENT
System Requirements Definition
System Preliminary Design
Product Requirements Definition
Product Preliminary Design
Component Requirements Definition
PRODUCT DESIGN & DEVELOPMENT
Technical Tracking, Simulation & Modeling
Post-Architecture IV&V Planning and Preparation
Component Preliminary Design
Detail Design
Component Implementation
Component Integration and Test
SYSTEM IV&V
Product IV&V
System Integration & Acceptance Test
System Test & Evaluation
PRODUCTION AND DEPLOYMENT
Production Material
Production Assembly & Test
Production Acceptance/Demonstration
Production Pack & Ship
OPERATIONS AND SUPPORT
Requirements Analysis
Product Support

Task Descriptors

Raytheon
Space and Airborne Systems

Life-Cycle Phase	
PROJECT PLANNING, MANAGEMENT & CONTROL	
Planning	
Management and Control	
REQUIREMENTS & ARCHITECTURE DEVELOPMENT	
System Requirements Definition	18
System Preliminary Design	39
Product Requirements Definition	12
Product Preliminary Design	43
Component Requirements Definition	11
PRODUCT DESIGN & DEVELOPMENT	
Technical Tracking, Simulation & Modeling	
Post-Architecture IV&V Planning and Preparation	
Component Preliminary Design	
Detail Design	
Component Implementation	
Component Integration and Test	
SYSTEM IV&V	
Product IV&V	
System Integration & Acceptance Test	
System Test & Evaluation	
PRODUCTION AND DEPLOYMENT	
Production Material	
Production Assembly & Test	
Production Acceptance/Demonstration	
Production Pack & Ship	
OPERATIONS AND SUPPORT	
Requirements Analysis	
Product Support	

$\left.\begin{matrix} \\ \\ \\ \\ \end{matrix}\right\}$ Number of Task Descriptors

Codes for Systems Eng. Column

Raytheon
Space and Airborne Systems

Life-Cycle Phase	SE
PROJECT PLANNING, MANAGEMENT & CONTROL	
Planning	X
Management and Control	X
REQUIREMENTS & ARCHITECTURE DEVELOPMENT	
System Requirements Definition	X
System Preliminary Design	X
Product Requirements Definition	X
Product Preliminary Design	X
Component Requirements Definition	X
PRODUCT DESIGN & DEVELOPMENT	
Technical Tracking, Simulation & Modeling	X
Post-Architecture IV&V Planning and Preparation	X
Component Preliminary Design	
Detail Design	
Component Implementation	
Component Integration and Test	
SYSTEM IV&V	
Product IV&V	X
System Integration & Acceptance Test	X
System Test & Evaluation	X
PRODUCTION AND DEPLOYMENT	
Production Material	X
Production Assembly & Test	X
Production Acceptance/Demonstration	X
Production Pack & Ship	X
OPERATIONS AND SUPPORT	
Requirements Analysis	
Product Support	

More Granularity: Separate RMSS

Raytheon
Space and Airborne Systems

Life-Cycle Phase	SE	ILS	RMA	SHF
PROJECT PLANNING, MANAGEMENT & CONTROL				
Planning	X			
Management and Control	X			
REQUIREMENTS & ARCHITECTURE DEVELOPMENT				
System Requirements Definition	X			
System Preliminary Design	X			
Product Requirements Definition	X			
Product Preliminary Design	X			
Component Requirements Definition	X			
PRODUCT DESIGN & DEVELOPMENT				
Technical Tracking, Simulation & Modeling	X			
Post-Architecture IV&V Planning and Preparation	X			
Component Preliminary Design				
Detail Design				
Component Implementation				
Component Integration and Test				
SYSTEM IV&V				
Product IV&V	X			
System Integration & Acceptance Test	X			
System Test & Evaluation	X			
PRODUCTION AND DEPLOYMENT				
Production Material	X			
Production Assembly & Test	X			
Production Acceptance/Demonstration	X			
Production Pack & Ship	X			
OPERATIONS AND SUPPORT				
Requirements Analysis				
Product Support				

SE	**Systems Engineering**
ILS	**Integrated Logistics Support (Supportability)**
RMA	**Reliability, Maintainability, Availability**
SHF	**Safety and Human Factors**

ILS Codes

Raytheon

Space and Airborne Systems

Life-Cycle Phase	SE	ILS	RMA	SHF
PROJECT PLANNING, MANAGEMENT & CONTROL				
Planning	X	X		
Management and Control	X	X		
REQUIREMENTS & ARCHITECTURE DEVELOPMENT				
System Requirements Definition	X	X		
System Preliminary Design	X			
Product Requirements Definition	X			
Product Preliminary Design	X			
Component Requirements Definition	X			
PRODUCT DESIGN & DEVELOPMENT				
Technical Tracking, Simulation & Modeling	X			
Post-Architecture IV&V Planning and Preparation	X			
Component Preliminary Design				
Detail Design		X		
Component Implementation		X		
Component Integration and Test				
SYSTEM IV&V		X		
Product IV&V	X			
System Integration & Acceptance Test	X			
System Test & Evaluation	X			
PRODUCTION AND DEPLOYMENT				
Production Material	X			
Production Assembly & Test	X			
Production Acceptance/Demonstration	X			
Production Pack & Ship	X			
OPERATIONS AND SUPPORT				
Requirements Analysis		X		
Product Support		X		

SE Systems Engineering

ILS Integrated Logistics Support (Supportability)

RMA Reliability, Maintainability, Availability

SHF Safety and Human Factors

RMA Codes

Raytheon
Space and Airborne Systems

Life-Cycle Phase	SE	ILS	RMA	SHF
PROJECT PLANNING, MANAGEMENT & CONTROL				
Planning	X	X	X	
Management and Control	X	X	X	
REQUIREMENTS & ARCHITECTURE DEVELOPMENT			X	
System Requirements Definition	X	X		
System Preliminary Design	X			
Product Requirements Definition	X			
Product Preliminary Design	X			
Component Requirements Definition	X			
PRODUCT DESIGN & DEVELOPMENT			X	
Technical Tracking, Simulation & Modeling	X			
Post-Architecture IV&V Planning and Preparation	X			
Component Preliminary Design				
Detail Design		X		
Component Implementation		X		
Component Integration and Test				
SYSTEM IV&V		X	X	
Product IV&V	X			
System Integration & Acceptance Test	X			
System Test & Evaluation	X			
PRODUCTION AND DEPLOYMENT			X	
Production Material	X			
Production Assembly & Test	X			
Production Acceptance/Demonstration	X			
Production Pack & Ship	X			
OPERATIONS AND SUPPORT			X	
Requirements Analysis		X		
Product Support		X		

SE Systems Engineering

ILS Integrated Logistics Support (Supportability)

RMA Reliability, Maintainability, Availability

SHF Safety and Human Factors

SHF Codes Complete the Picture

Raytheon
Space and Airborne Systems

Life-Cycle Phase	SE	ILS	RMA	SHF
PROJECT PLANNING, MANAGEMENT & CONTROL				
Planning	X	X	X	X
Management and Control	X	X	X	X
REQUIREMENTS & ARCHITECTURE DEVELOPMENT			X	X
System Requirements Definition	X	X		
System Preliminary Design	X			
Product Requirements Definition	X			
Product Preliminary Design	X			
Component Requirements Definition	X			
PRODUCT DESIGN & DEVELOPMENT			X	X
Technical Tracking, Simulation & Modeling	X			
Post-Architecture IV&V Planning and Preparation	X			
Component Preliminary Design				
Detail Design		X		
Component Implementation		X		
Component Integration and Test				
SYSTEM IV&V		X	X	X
Product IV&V	X			
System Integration & Acceptance Test	X			
System Test & Evaluation	X			
PRODUCTION AND DEPLOYMENT			X	
Production Material	X			
Production Assembly & Test	X			
Production Acceptance/Demonstration	X			
Production Pack & Ship	X			
OPERATIONS AND SUPPORT			X	
Requirements Analysis		X		
Product Support		X		

SE Systems Engineering

ILS Integrated Logistics Support (Supportability)

RMA Reliability, Maintainability, Availability

SHF Safety and Human Factors

Each Cost Code in the Database

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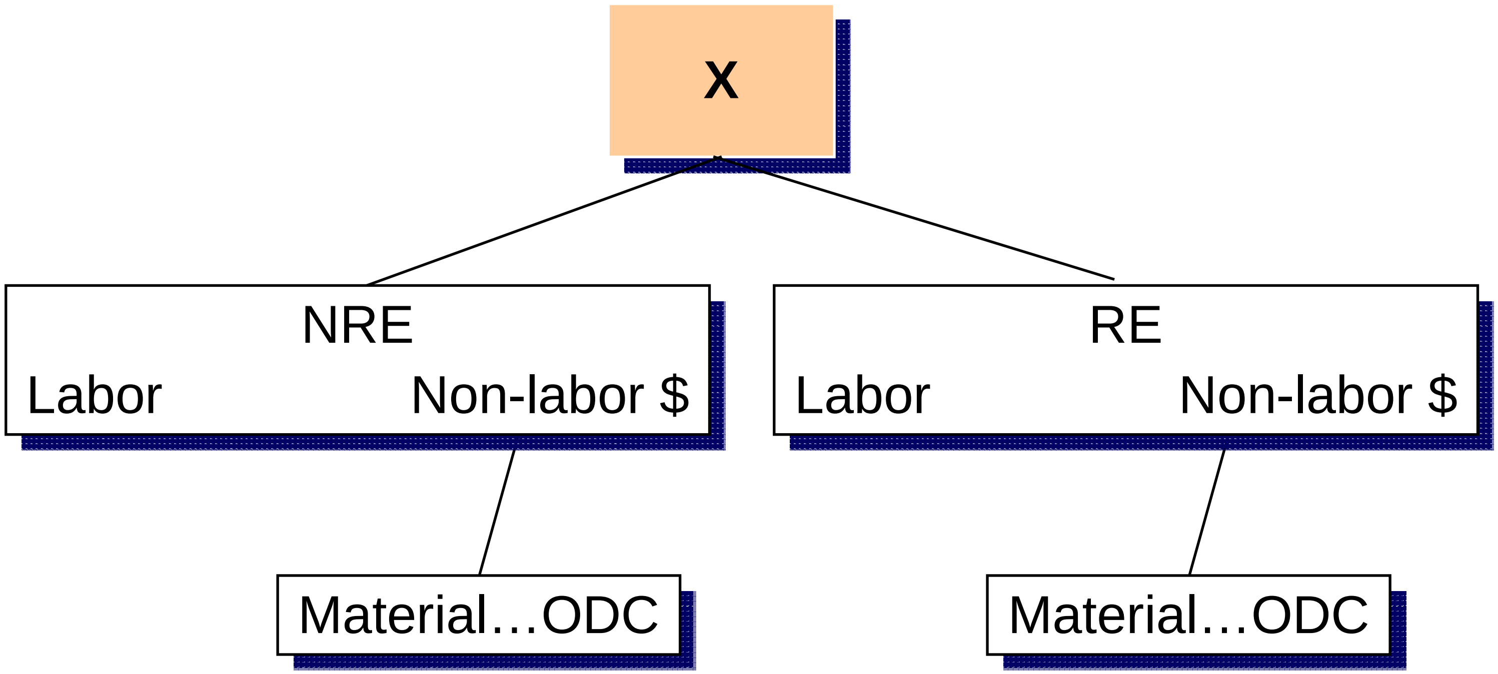
Space and Airborne Systems



A Cost Code Can Include NRE and RE; Labor Hrs and Non-labor $

Program WBS

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Space and Airborne Systems

- WBS is loaded into the database
- Elements of program WBS are mapped to the Cost Codes
- Mapping is defined within the database
- Costs can now be examined in separate views
  - *WBS view*
  - *Process view (e.g., Raytheon IPDP)*
- Mapping used for both cost estimating and cost collection

Cost Estimation

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Space and Airborne Systems

Cost Code Composition

- *Historical Actuals*
  - Actual Labor Hours
  - Actual Non-Labor $ (e.g., ODC, Material, Travel)
  - Period of Performance
  - Size Metrics (Units and Values)
  - Re-Use
  - Work Product Productivities
- *Attributes*

Actuals and attributes data are used to generate future bids

Attribute Examples

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Space and Airborne Systems

- Systems Analyst Team Capabilities
- Systems Analyst Team Experience
- Number of Requirements
- Requirements Volatility
- Defects Found
- Defects Corrected
- Rework
- Multiple Site Development
- Contract Type
- System Platform
- Effect of Schedule Slip
- Number of Configuration Items
- Number & Complexity of Interfaces
- Automated Tools Use
- Reuse
- Security Requirements

Values for attributes are collected with each cost code

Size Estimates

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Space and Airborne Systems

- **Size estimates are made for the key metric of each code**
  - ***Number of requirements***
  - ***Number of plans***
  - ***Number of tests***
- **These size estimates are multiplied by the historical work product productivity to get number of hours for a code**
  - ***Hours/requirement***
  - ***Hours/plan***
  - ***Hours/test***
- **Sum together number of hours for all codes**

Total hours are then compared to another model, such as the output from a parametric model

Summary

Raytheon
Space and Airborne Systems

- Raytheon SAS System Engineering Cost Collection Codes
  - *Methodology*
  - *Process Based*
  - *Mapped to program WBS*
  - *Provides multiple views by product and process*
  - *Cost collection elements*
  - *Work product productivities*
  - *Sizing estimates*
  - *Cost estimates for each code*
  - *Sum total for bid input*
  - *Compare total to another model for reasonableness*

Cost Code Database Is Reducing Our Bid Turnaround Time and Providing Multiple Real Time Views of Bid As Inputs Are Entered

Contact Information

Raytheon
Space and Airborne Systems

- **Questions ?**

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Raytheon
Space and Airborne Systems

Process Architecture and Criteria for Lessons Learned (LL)

A Presentation for the
8th Annual Systems Engineering Conference
October 24-27, 2005
Hyatt Islandia, San Diego, California

Thomas R. Cowles
Raytheon Space and Airborne Systems

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Raytheon
Space and Airborne Systems

Sound Familiar ?

Raytheon
Space and Airborne Systems

Users

- **"It's a pain to weed through all the irrelevant lessons to get to the few 'jewels'. There should be an easier way to find the lessons that pertain to me."**
- **"Many of the lessons just seemed to repeat a company practice or instruction. Who thought this was a 'lesson learned'?"**
- **"It takes almost two weeks to review the lessons in the database. Who's got the time for that?"**
- **"We seem to learn some lessons over and over again."**

Managers

- **"Until we can adopt a culture that admits frankly to what really worked and didn't work, I find many of these tools to be suspect."**
- **"Despite the processes and procedures in place to capture and share lessons learned, I see no evidence that lessons are being applied toward future success."**

Presentation Purpose

- **To study and examine a process architecture and criteria for lessons learned.**

- **As a strategy for implementation, we will**
  - ***Summarize a search for references of lessons learned within the CMMI model.***
  - ***Establish criteria for a lessons learned process.***
  - ***Examine a process architecture for lessons learned.***
  - ***Discuss how to turn Lessons Learned into Lessons Applied***

Lessons Learned Systems Exist to Support Organizational Goals of

- ***Promoting recurrence of successful outcomes***
- ***Precluding the recurrence of unsuccessful outcomes***

Background

- **CMMI Model used for this presentation is CMMI-SE/SW/IPPD/SS, V1.1, Staged Representation, March 2002**
- **A search on "lessons learned" returned 25 references**
- **All references were cataloged and examined**
- **The following table summarizes these references**

Background – LL References in the CMMI Model

Raytheon
Space and Airborne Systems

	Citation
1	Overview, GP 3.2, Collect Improvement Information
2	Overview, GP 3.2, Collect Improvement Information, Subpractice 3
3	Basic Process Management Process Areas (OPF Discussion)
4	Basic Process Management Process Areas (OPD Discussion)
5	PP [ML2], SP 2.3, Plan for Data Management
6	PMC [ML2], SP 2.3, Manage Corrective Action, Subpractice 3
7	PPQA [ML2], SP 1.1, Objectively Evaluate Processes, Subpractice 5
8	PPQA [ML2], SP 1.2, Objectively Evaluate Work Products and Services, Subpractice 8
9	OPF [ML3], Introductory Notes
10	OPF [ML3], SP 1.3, Identify the Organization's Process Improvements, Subpractice 1
11	OPF [ML3], SP 2.4, Incorporate Process-Related Experiences into the Org. Process Assets, Typ. Work Products 2
12	OPF [ML3], SP 2.4, Incorporate Process-Related Experiences into the Org. Process Assets, Subpractice 3
13	OPF [ML3], SP 2.4, Incorporate Process-Related Experiences into the Org. Process Assets, Subpractice 4
14	OPD [ML3], Introductory Notes
15	OPD [ML3], SP 1.3, Establish Tailoring Criteria and Guidelines
16	IPM for IPPD [ML3], Introductory Notes
17	IPM for IPPD [ML3], SP 1.4, Manage the Project Using the Integrate Plans, Subpractice 1
18	IPM for IPPD [ML3], SP 1.5, Contribute to the Organizational Process Assets, Typical Work Products 3
19	IPM for IPPD [ML3], SP 1.5, Contribute to the Organizational Process Assets, Subpractice 4
20	DAR [ML3], SP 1.3, Identify Alternative Solutions, Subpractice 1
21	OID [ML5], SP 1.3, Pilot Improvements, Typical Work Products 2
22	OID [ML5], SP 1.3, Pilot Improvements, Subpractice 6
23	OID [ML5], SP 2.2, Manage the Deployment, Subpractice 10
24	OID [ML5], GP 2.6, Manage Configurations
25	CAR [ML5], Introductory Notes

References appear in the Appendix but will not be reviewed here.

Background – Summary of LL References in the CMMI Model

- **Some requirements stated**
  - ***Process assets library (PAL)***
  - ***What LL should be included for various process areas***
- **No definition of a lesson learned**
- **No vision**
- **No criteria for a lessons learned process**

Opportunity: Tailor These to Fit Your Organization

Establish LL Criteria: Define Terms

- A lesson learned is knowledge or understanding gained by experience.
  - *Negative experience*
  - *Positive experience*

- A lesson
  - ***Must be significant***
  - ***Must be valid***
  - ***Must be applicable***
  - ***Could describe a problem or issue that the organization will investigate***

Establish LL Criteria:
Define Terms - 2

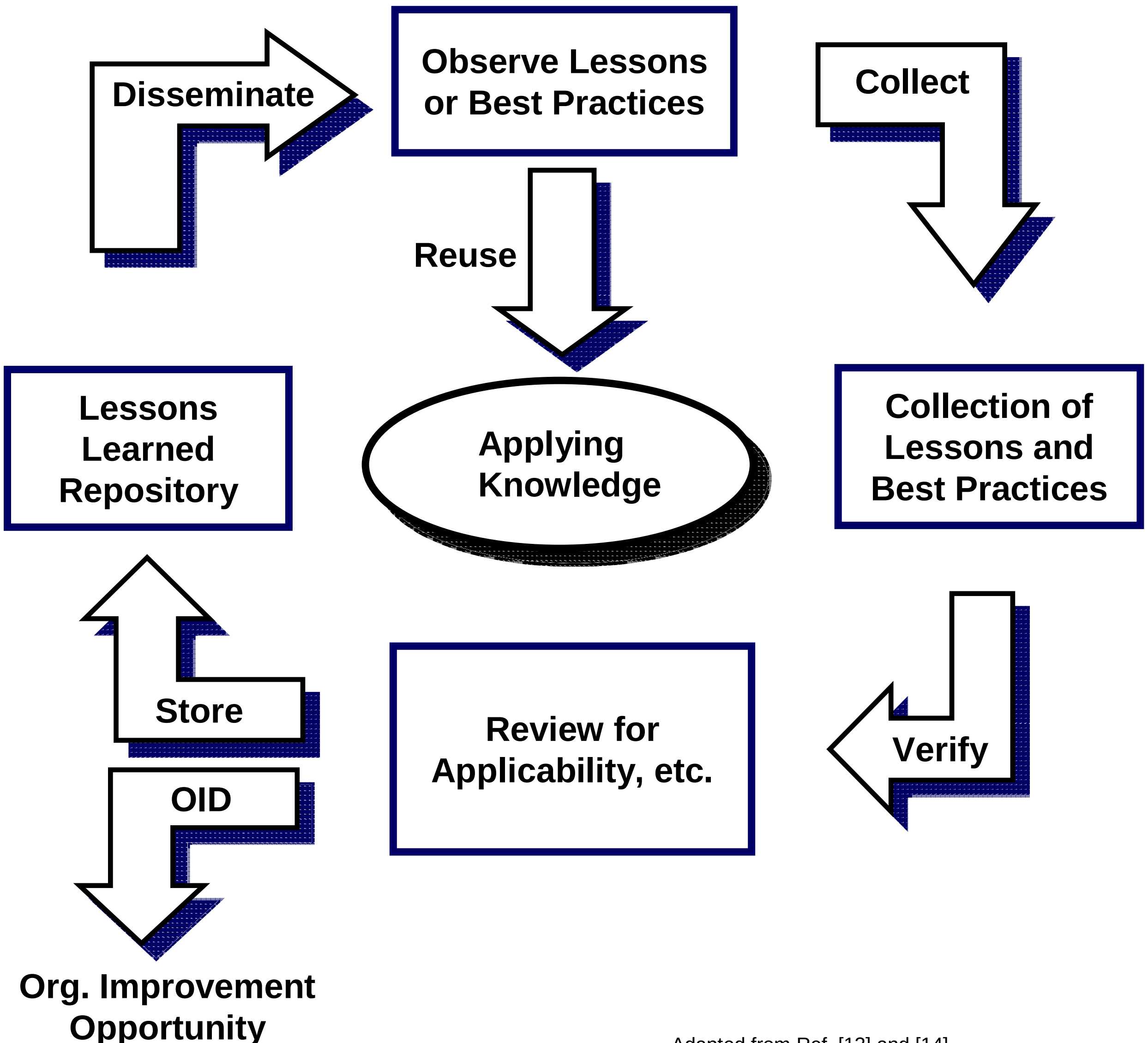
- **A lesson (continued)**
  - ***May contain or address pertinent info***
  - ***May provide information of interest***
  - ***May have a “sunset provision”***

A lesson is not simply restating or paraphrasing existing doctrine, policy, process, etc. This does not qualify as an appropriate and bona fide lessons learned.

Establish LL Criteria: Create A Strategic Plan

- **Strategic Plan**
  - ***Define how your organization will collect, validate, store, distribute, and reuse knowledge to achieve organizational objectives***
  - ***Write a purpose statement***
    - **Example purpose: U.S. Navy Lessons Learned System**
  - ***Define the stakeholders in writing***
  - ***Define roles of all involved***

Establish LL Criteria: Build A Lessons Learned Process Architecture

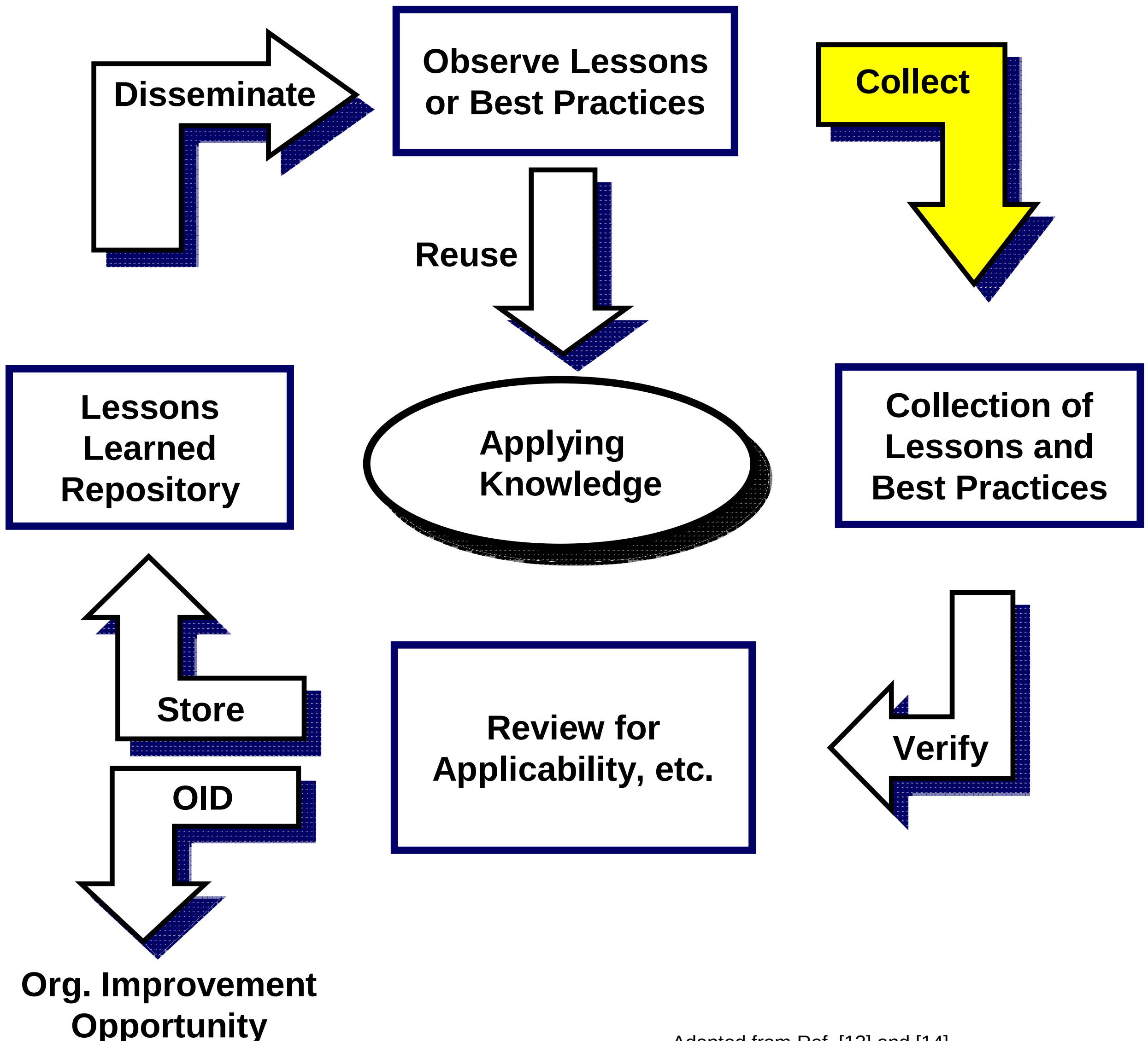


Adapted from Ref. [13] and [14]

A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Establish LL Criteria: Build A Lessons Learned Process Architecture



Adapted from Ref. [13] and [14]

A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Establish LL Criteria: Collection

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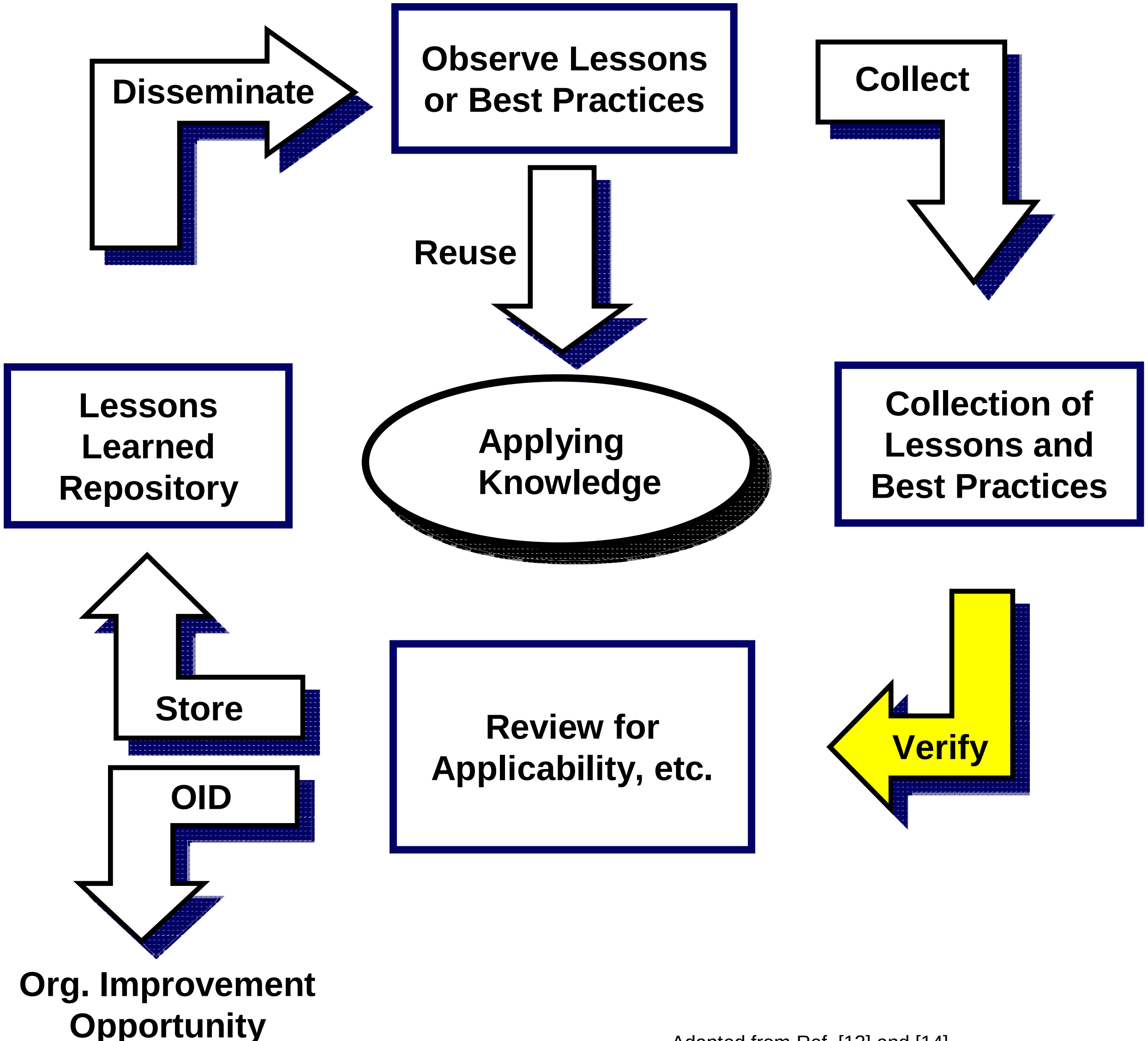
Space and Airborne Systems

- **Focuses on gathering lessons learned from many sources internal and external to the organization**
- **Collection types or sources**
  - ***Passive Collection***
  - ***Reactive Collection***
  - ***After Action Collection***
  - ***Active Collection***
  - ***Anonymous Contributions***

Focusing only on negative experiences reduces potential effectiveness and misses opportunities to improve all processes

Establish LL Criteria: Build A Lessons Learned Process Architecture

Raytheon
Space and Airborne Systems



Adapted from Ref. [13] and [14]

A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Establish LL Criteria: Verification - 1

- **Focuses on validating lessons according to established standards**
- **Examples of verification standards**
- **How do these standards serve as guidelines?**
  - ***Adding to the collection***
  - ***Removing from the collection***
  - ***Priorities***
- **Verification can also be used to**
  - ***Combine and/or adapt complementary or incomplete lessons***
  - ***Identify systemic issues or improvement opportunities***

Verification allows your organization to tailor its lessons learned repository according to the standards it selects

Establish LL Criteria: Verification - 2

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Space and Airborne Systems

- **Usually performed by some kind of Gatekeeper**
- **Gatekeepers**
  - ***One or more domain or subject matter experts (SME) or researchers***
  - ***Analyze lessons within a particular category***
  - ***Typically look for lessons that meet or exceed a set of defined criteria***
  - ***These people must be***
    - **Respected within the organization**
    - **Provided the necessary resources (time, staff, etc.)**

Gatekeepers help prevent lessons that state the obvious which discourages use of the LL collection by others

Establish LL Criteria: Verification - 3

Some Criteria for Selecting / Adding a Lesson

- Relationship
- Relevancy
- Significance
- Authoritativeness
- Currency
- Research aids
- Systemic process issues
- Information – format, cost, restrictions
- Credibility or reputation of authors/publishers

Establish LL Criteria: Verification - 4

Maintenance Issues

- **Obsolete lessons**
- **Gatekeepers periodically review**
- **Verification criteria for removing (weeding) lessons from the LL collection**
  - ***Value***
  - ***Accuracy***
  - ***Newness***
  - ***Demand***
  - ***User feedback***
  - ***Physical condition***
  - ***Multiple copies***

Establish LL Criteria: Build A Lessons Learned Process Architecture

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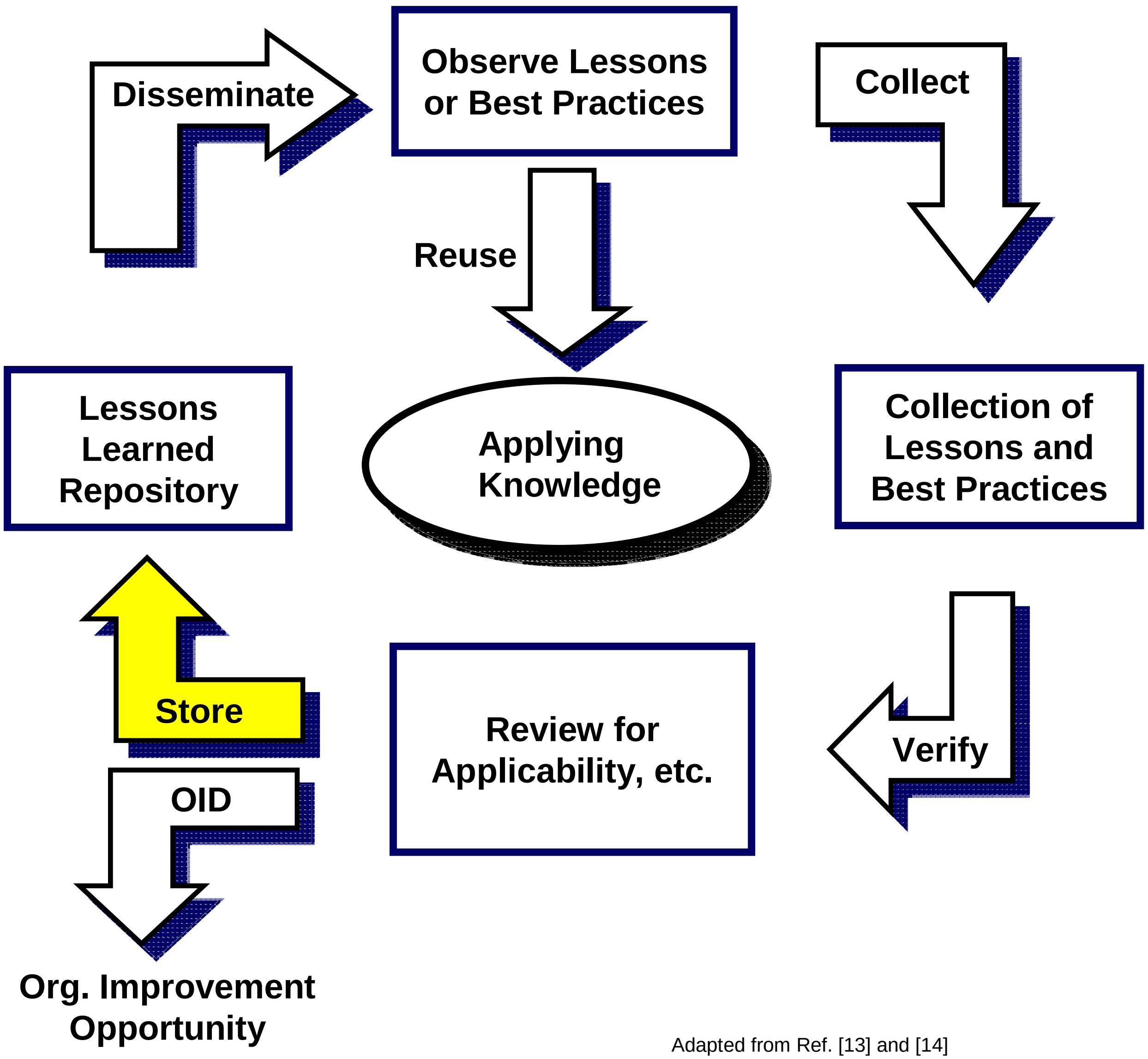


A Generic Process with 6 Elements:

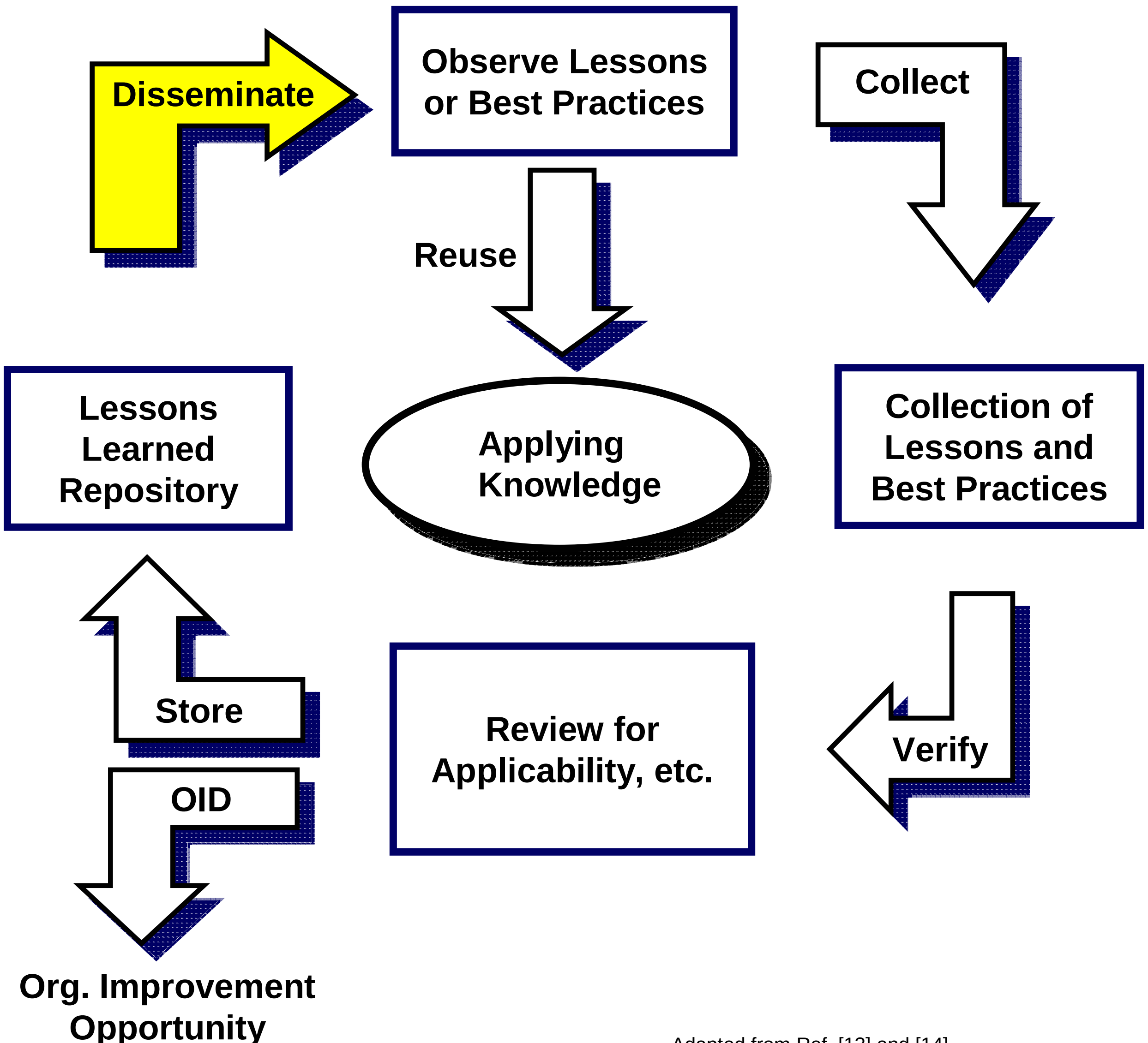
- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Adapted from Ref. [13] and [14]

Establish LL Criteria: Storage

- **Focuses on issues related to categorization, indexing, formatting, and structure**
- **Other storage issues**
  - ***Lesson representation***
  - ***Task relevant representations***
  - ***Submission templates***
  - ***Online fields***
  - ***Forwarding files or attachments***
  - ***Separate project repositories***
  - ***Repetitive errors***

Establish LL Criteria: Build A Lessons Learned Process Architecture



A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Adapted from Ref. [13] and [14]

Establish LL Criteria: Dissemination

- **Focuses on issues relating to the distribution of LL**
- **Some Issues**
  - ***Define and provide users a feedback cycle for a typical LL***
  - ***User access***
  - ***Search functions***
- **Types of Dissemination: Passive and Active**
- **Passive Dissemination Definition**
- **Passive Dissemination Examples**

Passive Dissemination: No User Action = No Dissemination

Establish LL Criteria: Dissemination - 2

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- **Active Dissemination – Definition and examples**
  - ***Use Gatekeepers***
  - ***"Push" lessons to potential users via list servers***
  - ***Continuous lessons learning***
    - **Training**
    - **Mentoring**
    - **Program reviews**
    - **After-action reviews**
    - **Project retrospectives**
    - **Periodic revisions to organizational policies and guidelines**

Try to determine when a lesson's conditions are well matched by a <u>decision context</u>. Distribute these lessons to those individuals making decisions in the same or similar context.

Establish LL Criteria: Dissemination - 3

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- **Other Active Dissemination Examples**
  - ***Host a series of forums***
  - ***Capture and share the experiences of program managers, senior engineers, design architects, analysts, testers, finance managers, etc.***
    - **In writings**
    - **Verbally**

Establish LL Criteria: Build A Lessons Learned Process Architecture

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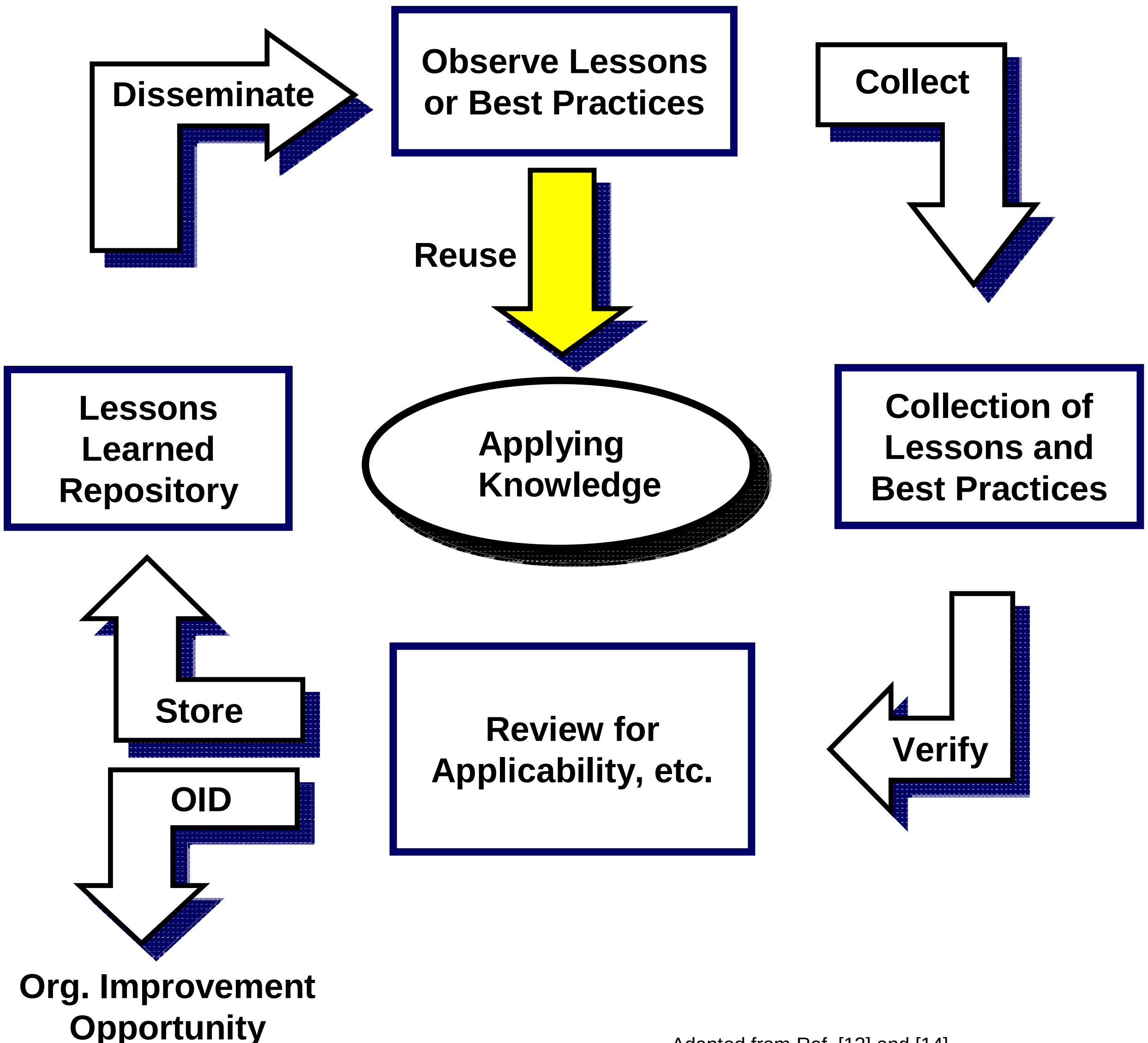

A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Adapted from Ref. [13] and [14]

Establish LL Criteria: Reuse

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- Focuses on encouraging/promoting lessons to be used by someone other than the submitter
- Browser recommendation
  - *Definition and example*
- Learning recommendation
  - *Definition and example*
  - *Amazon.com features*
    - Customers can submit reviews of items (anonymously or not)*
    - Customers can read all reviews of an item*
    - Customers can rate the item (5 Star system)*
    - Customers can rate if the item was helpful to them
    - Customers can read all reviews of the same person ("favorite reviewer")

***Raytheon SAS Feature**

Establish LL Criteria: Build A Lessons Learned Process Architecture

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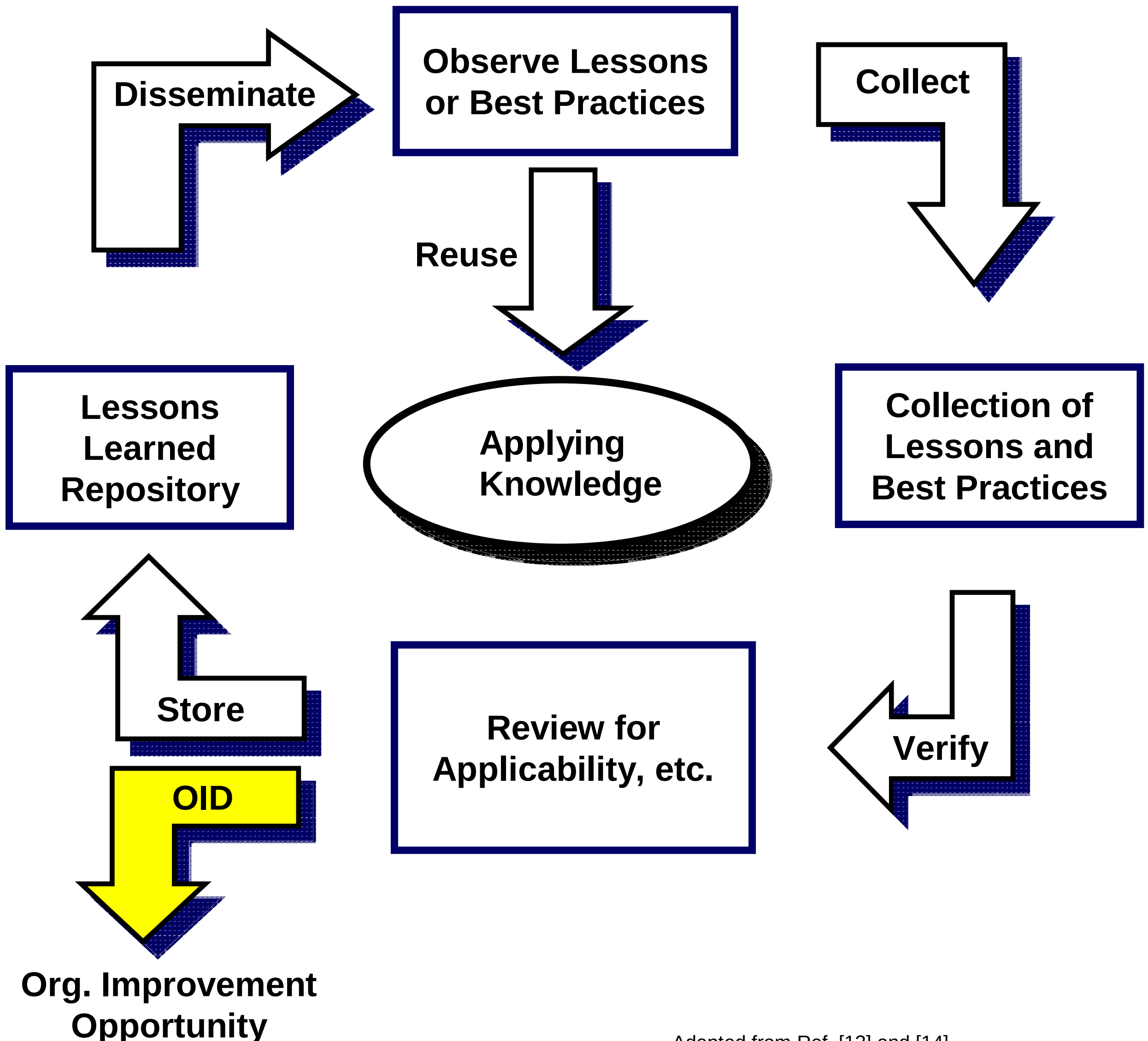

A Generic Process with 6 Elements:

- Collection
- Verification
- Storage
- Dissemination
- Reuse
- OID Identification

Adapted from Ref. [13] and [14]

Establish LL Criteria: OID Identification

- **Focuses on identifying incremental and innovative improvements that will measurably improve the**
  - ***Organization's processes***
  - ***Organization's technologies***

- **Analyze and evaluate**
  - ***The verified lessons***
  - ***The lessons learned process***

Provide periodic recommendations to the EPG (Enterprise / Engineering Process Group) of candidate improvements for selection and deployment

Establish LL Criteria: Target Performance Measurement

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- Turning Lessons Learned into Lessons Applied
- Use objective performance metrics
  - *Number of validated lessons*
    - Individual
    - Team
    - Program or project
    - Business unit
  - *Number of lessons applied*
    - Individual
    - Team
    - Program or project
    - Business unit

Raytheon SAS Lessons Learned Experience

- **Collecting Lessons Learned since the mid-1990s**
- **Multidisciplined approach**
- **SAS Programs submit applicable LL monthly**
- **LL collected, processed, and fed back to the programs**
- **Transitioning development phases**

Summary

- **Lessons Learned are a principal component of an organizational culture committed to**
  - ***Knowledge management***
  - ***Continuous improvement***
- **Establishing and tailoring a Lessons Learned process will help you reach higher process Maturity Levels (CMMI, ISO, etc.)**
  - ***Collection, Verification, Storage, Dissemination, Reuse, OID Identification***
- **Learn from successes as well as mistakes**
- **Lives may be saved by preventing recorded catastrophes from recurring!**

Performance and Reuse Metrics are the Final Keys to Turn Lessons Learned into Lessons Applied

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Contact Information

- **Questions ?**

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Appendix

Lessons Learned References in the CMMI

CMMI Background

Summary of the Lessons Learned References in CMMI

- GP 3.2 Level 3+
- Basic Process Mgmt PAs
- PP Level 2
- PMC Level 2
- PPQA Level 2
- OPF Level 3
- OPD Level 3
- IPM Level 3
- DAR Level 3
- OID Level 5
- CAR Level 5

CMMI Lessons Learned Reference: GP 3.2

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- **Overview, GP 3.2, Collect Improvement Information**

The purpose of this generic practice is to collect information and artifacts derived from planning and performing the process. This generic practice is performed so that the information and artifacts can be included in the organizational process assets and made available to those who are (or who will be) planning and performing the same or similar processes. The information and artifacts are stored in the organization's measurement repository and the organization's process asset library.

Examples of relevant information include the effort expended for the various activities, defects injected or removed in a particular activity, and lessons learned.

Sub 3: Document lessons learned from the process for inclusion in the organization's process asset library.

Requirements: Put lessons learned into the organization's PAL. Make them available to people planning/performing same/similar tasks.

CMMI LL Reference: Basic Process Management Process Areas

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- **OPF Discussion**

  ... the Organizational Process Focus process area helps the organization to plan and implement organizational process improvement based on an understanding of the current strengths and weaknesses of the organization's processes and process assets. Candidate improvements to the organization's processes are obtained through various means. These include process-improvement proposals, measurement of the processes, lessons learned in implementing the processes, and results of process appraisal and product evaluation activities.

- **OPD Discussion**

  The Organizational Process Definition process area establishes and maintains the organization's set of standard processes and other assets based on the process needs and objectives of the organization.

  ... Experiences and work products from performing these defined processes, including measurement data, process descriptions, process artifacts, and lessons learned, are incorporated as appropriate into the organization's set of standard processes and other assets.

CMMI Lessons Learned Reference: PP, Project Planning

- **PP SP 2.3, Plan for Data Management**

Data are the various forms of documentation required to support a program in all of its areas (e.g., administration, engineering, configuration management, financial, logistics, quality, safety, manufacturing, and procurement)...

Data may be deliverable (e.g., items identified by a program's contract data requirements) or data may be nondeliverable (e.g., informal data, trade studies and analyses, internal meeting minutes, internal design review documentation, lessons learned, and action items)...

CMMI Lessons Learned Reference: PMC, Project Monitoring and Control

- **PMC SP 2.3, Manage Corrective Action**

  Sub 3: Determine and document appropriate actions to correct deviations from planned results for corrective actions.

  Lessons learned as a result of taking corrective action can be inputs to planning and risk management processes.

CMMI Lessons Learned Reference: PPQA, Process and Product Quality Assurance

- **PPQA SP 1.1, Objectively Evaluate Processes**

  Sub 5: Identify lessons learned that could improve processes for future products and services.

- **PPQA SP 1.2, Objectively Evaluate Work Products and Services**

  Sub 8: Identify lessons learned that could improve processes for future products and services.

CMMI Lessons Learned Reference: OPF, Organizational Process Focus

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- **OPF, Introductory Notes**

  Candidate improvements to the organizational process assets are obtained from various sources, including measurement of the processes, lessons learned in implementing the processes, results of process appraisals, results of product evaluation activities, results of benchmarking against other organizations' processes, and recommendations from other improvement initiatives in the organization.

- **OPF SP 1.3, Identify the Organization's Process Improvements**

  Sub 1: Determine candidate process improvements.

  - ***Review the lessons learned from tailoring the organization's set of standard processes***
  - ***Review the lessons learned from implementing the processes***

CMMI Lessons Learned Reference: OPF, Organizational Process Focus - 2

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- **OPF SP 2.4, Incorporate Process-Related Experiences into the Organizational Process Assets**

  TWP 2: Process lessons learned.

  Sub 3: Derive lessons learned from defining, piloting, implementing, and deploying the organizational process assets.

  Sub 4: Make lessons learned available to the people in the organization as appropriate.

  Actions may have to be taken to ensure that lessons learned are used appropriately.

  Examples of inappropriate use of lessons learned include the following:

  - ***Evaluating the performance of people***
  - ***Judging process performance or results***

  Examples of ways to prevent inappropriate use of lessons learned include the following:

  - ***Controlling access to the lessons learned***
  - ***Educating people about the appropriate use of lessons learned***

CMMI Lessons Learned Reference: OPD, Organizational Process Definition

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- **OPD, Introductory Notes**

  The organization's process asset library is a collection of items maintained by the organization for use by the people and projects of the organization. This collection of items includes descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process-related documentation, and data. The organization's process asset library supports organizational learning and process improvement by allowing the sharing of best practices and <u>lessons learned</u> across the organization.

- **OPD SP 1.3, Establish Tailoring Criteria and Guidelines**

  Flexibility in tailoring and defining processes is balanced with ensuring appropriate consistency in the processes across the organization...

  Consistency across the organization is needed so that organizational standards, objectives, and strategies are appropriately addressed, and process data and <u>lessons learned</u> can be shared.

CMMI Lessons Learned Reference: IPM (Integrated Proj. Management) for IPPD

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- **IPM for IPPD, Introductory Notes**

  Since the defined process for each project is tailored from the organization's set of standard processes, variability among projects is typically reduced and projects can more easily share process assets, data, and lessons learned

- **IPM SP 1.4, Manage the Project Using the Integrated Plans**

  Sub 1: Implement the project's defined process using the organization's process asset library

  - ***Using lessons learned from the organization's process asset library to manage the project***

- **IPM SP 1.5, Contribute to the Organizational Process Assets**

  TWP 3: Documentation (e.g., exemplary process descriptions, plans, training modules, checklists, and lessons learned).

  Sub 4: Document lessons learned from the project for inclusion in the organization's process asset library.

CMMI Lessons Learned Reference: DAR, Decision Analysis and Resolution

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- **DAR SP 1.3, Identify Alternative Solutions**

Sub 1: Perform a literature search.

A literature search can uncover what others have done both inside and outside the organization. It may provide a deeper understanding of the problem, alternatives to consider, barriers to implementation, existing trade studies, and lessons learned from similar decisions.

CMMI Lessons Learned Reference: OID, Organizational Innovation & Deployment

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- **OID SP 1.3, Pilot Improvements**

  TWP 2: Documented lessons learned from pilots.

  Sub 6: Review and document the results of pilots.

  Reviewing and documenting the results of pilots usually involves the following:

  - ***Identifying and documenting lessons learned and problems encountered during the pilot.***

- **OID SP 2.2, Manage the Deployment**

  Sub 10: Document and review the results of process- and technology-improvement deployment.

  Documenting and reviewing the results includes the following:

  - ***Identifying and documenting lessons learned.***

- **OID GP 2.6, Manage Configurations**

  Examples of work products placed under configuration management include the following:

  - ***Documented lessons learned from pilots***

CMMI Lessons Learned Reference: CAR, Causal Analysis and Resolution

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- **CAR, Introductory Notes**

  Since defects and problems may have been previously encountered on other projects or in earlier phases or tasks of the current project, causal analysis and resolution activities are a mechanism for communicating lessons learned among projects

Department of Defense

High Performance Computing Modernization Program

Science-Based Modeling and Simulation on DoD High Performance Computers

Larry Davis

Deputy Director

http://www.hpcmo.hpc.mil

Presentation Outline

- The Program
- Allocation of Program Resources
- Examples of Science-Based Modeling and Simulation
  - Materials modeling: sonar, non-linear optical, and ceramic armor materials
  - Aircraft modeling: computational fluid dynamics of aircraft and stores; structural mechanics modeling of fatigue and corrosion of aircraft parts

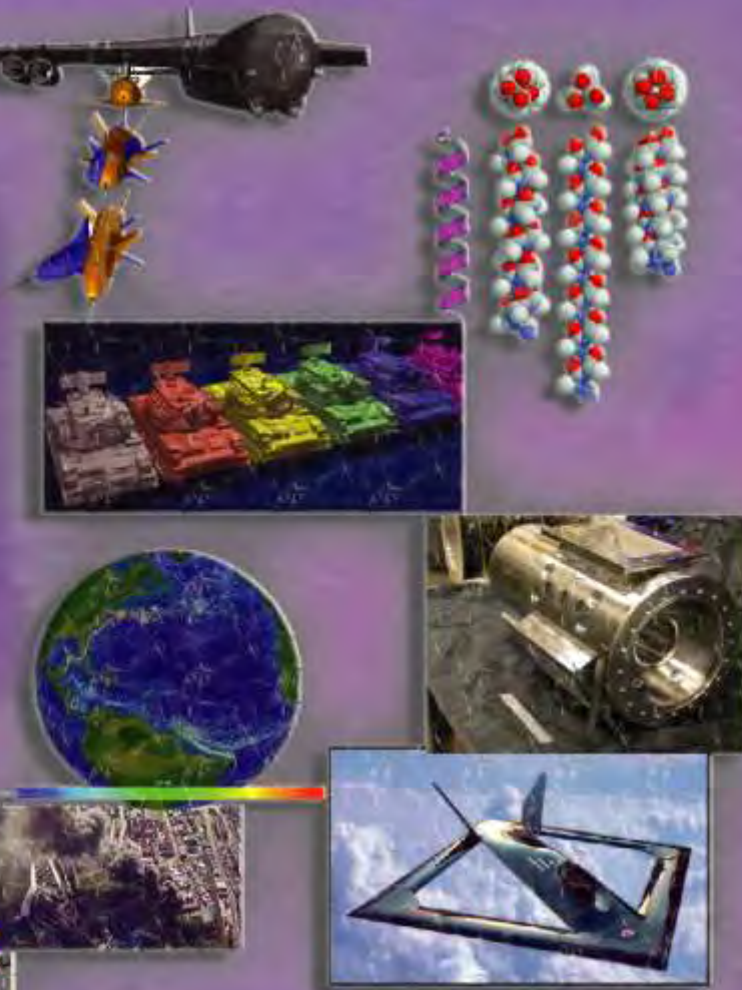
HPC Modernization Program

Mission

Deliver world-class commercial, high-end, high performance computational capability to the DoD's science and technology (S&T) and test and evaluation (T&E) communities, facilitating the rapid application of advanced technology into superior warfighting capabilities.

Vision

A pervasive culture existing among DoD's scientists and engineers where they routinely use advanced computational environments to solve the most demanding problems.



DoD HPC Modernization Program

Tools for Discovery

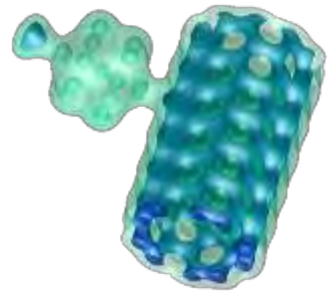
HPC Modernization Program Goals

- Provide the best commercially available high-end HPC capability
- Provide high performance computing environments and software applications that enables critical DoD research, development and test problems to be solved
- Educate and train DoD's scientists and engineers to effectively use advanced computational environments
- Link users and computers sites via high-capacity networks, facilitating user access and distributed computing environments
- Promote collaborative relationships among the DoD HPC community, the National HPC community and Minority Serving Institutions (MSIs) in network, computer, and computational science

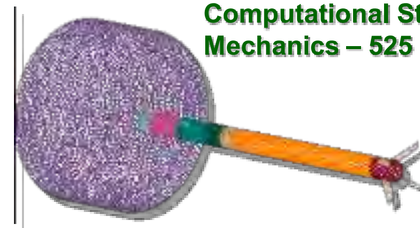
Current User Base and Requirements

- 613 projects and 4,920 users at approximately 178 sites
- Requirements categorized in 10 Computational Technology Areas (CTA)
- FY 2006 non-real-time requirements of 282 Habu-equivalents

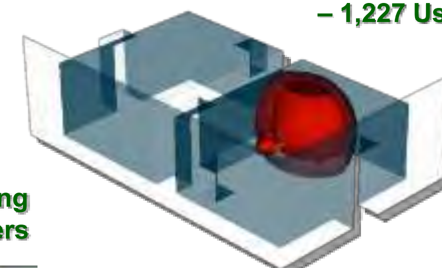
Electronics, Networking, and Systems/C4I – 34 Users



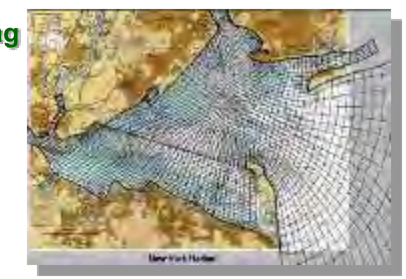
Computational Structural Mechanics – 525 Users



Computational Fluid Dynamics – 1,227 Users



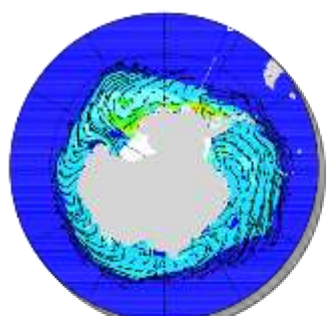
Environmental Quality Modeling & Simulation – 183 Users



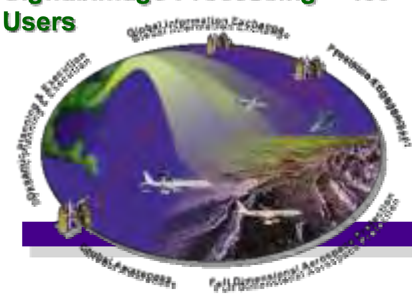
Computational Chemistry, Biology & Materials Science – 332 Users

Forces Modeling & Simulation/C4I – 916 Users

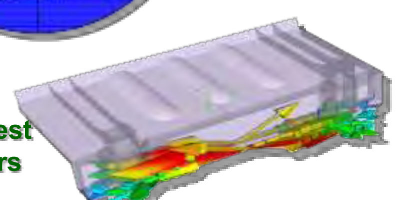
Climate/Weather/Ocean Modeling & Simulation – 233 Users



Signal/Image Processing – 439 Users



Integrated Modeling & Test Environments – 617 Users



Computational Electromagnetics & Acoustics – 347 Users

67 users are self characterized as “other”

HPC Modernization Program

Air Force HPC Centers/Projects
- ASC MSRC
- MHPCC ADC
- AEDC/AFSEO, AFRL/IF, AFWA, SIMAF, & MHPCC DHPIs
- 1,227 Users/35 Locations
- 22 DREN Sites
- 9 Challenge Projects
- 2 Institutes/1 Portfolio
- 3 CTA Leaders/1 Porfolio Leader

Army HPC Centers/Projects
- ARL & ERDC MSRCs
- AHPCRC & SMDC ADCs
- ATC, RTTC, & WSMR DHPIs
- 1,419 Users/25 Locations
- 37 DREN Sites
- 14 Challenge Projects
- 2 Institutes/3 Portfolios
- 6 CTA Leaders/3 Porfolio Leaders

Navy HPC Centers/Projects
- NAVO MSRC
- FNMOC, SSCSD, NAWCAD, NSWCCD, NUWC, & WSMR DHPIs
- 1,659 Users/24 Locations
- 23 DREN Sites
- 11 Challenge Projects
- 1 Institute/2 Portfolios
- 1 CTA Leader/2 Porfolio Leaders

Defense Agencies
- DARPA, DTRA, JNIC, JFCOM, JWARS, MDA, & OTE
- 620 Users/4 Locations
- 13 DREN Sites
- 2 Challenge Projects

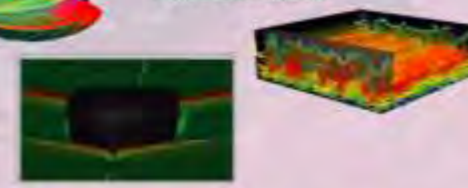
Other
- ARSC ADC

HPC Centers

Resource Mgmt

DoD Challenge Projects

Requirements & Allocations



Networking

Software Applications Support

HSAIs/Portfolios

SPI

PET

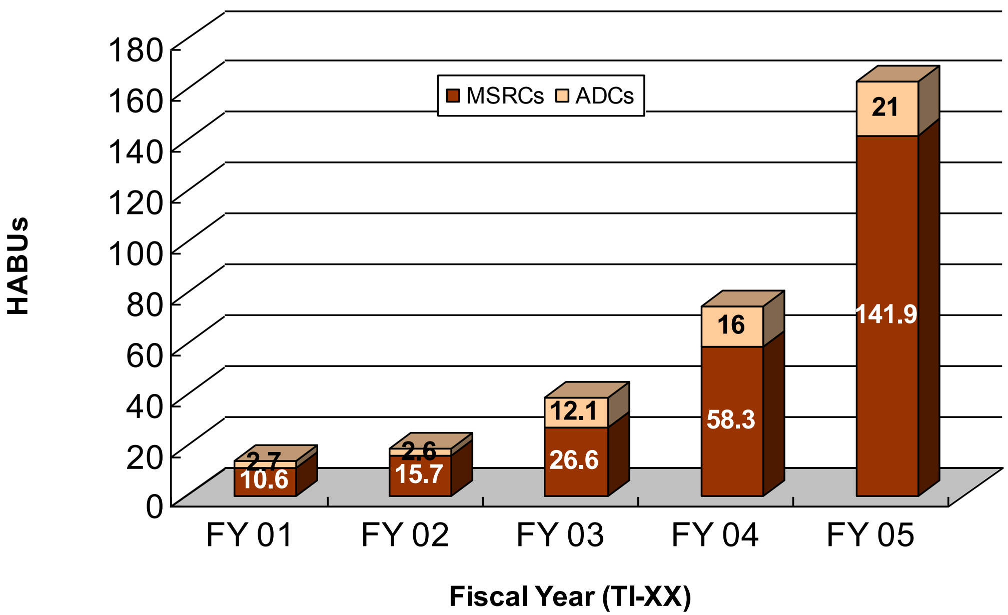
Education Outreach

HPCMP Resources

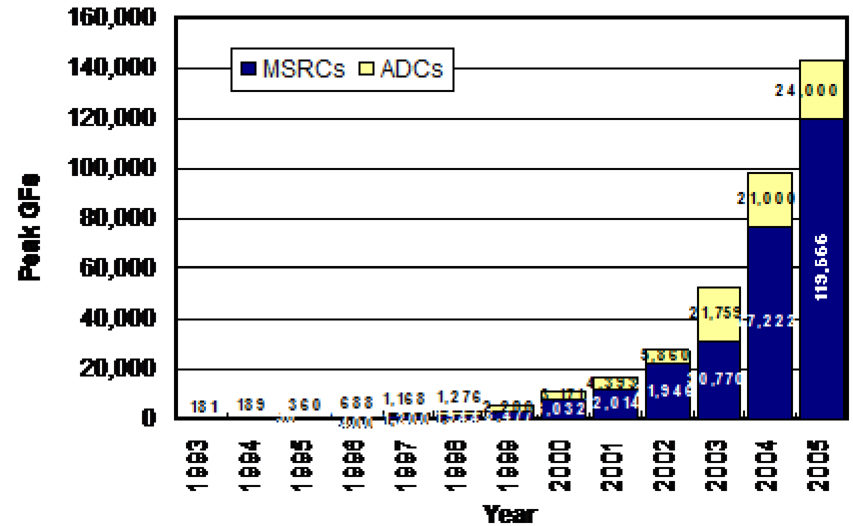
1993

2005

Legend
- ★ MSRCs
- ◆ ADCs
- ✸ DHPIs



Total HPCMP End-of-Year Computational Capabilities



Defense Research & Engineering Network (DREN)

Total number of sites
131

Updated: August 2005

Resource Management

— Integrated Requirements/Allocation/Utilization Process

Requirements Process
- Bottoms-up survey
- Includes only approved funded S&T/T&E projects
- Reviewed and validated by S&T/T&E executives

Capability Allocation Process

Capacity Allocation Process
- 75% Service/Agency, 25% DoD Challenge Projects
- Services/Agencies decide allocation resources for each project
- Reconcile capacity with requirements (first-order prioritization)

Operations Decisions
Acquisition Decisions

Utilization Tracking
- Track utilization by project
- Monitor turnaround time for timely execution

User Feedback
- Direct feedback from PI and individual users
- Summary report sent to each HPC Center
- Issue addressed and resolved
- User satisfaction impacts requirements, allocation, and utilization statistics

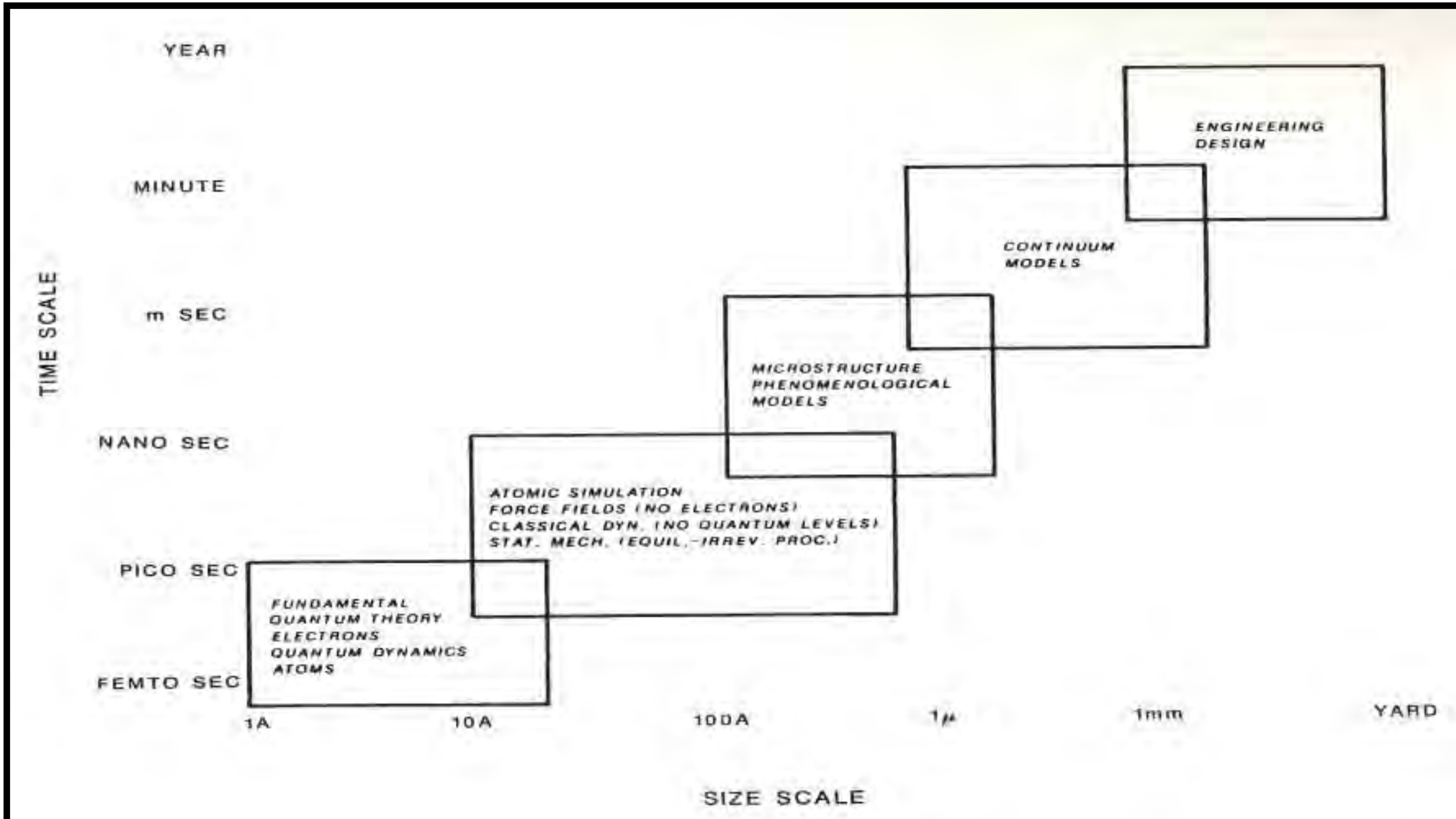
Requirements data

Initial request for allocation

Feedback to help quantify requirements

Utilization feedback for management oversight and further allocation

Towards the Design of Molecular Materials

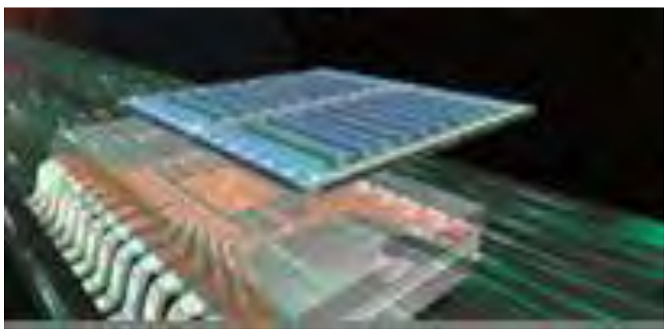


Cocke, '86

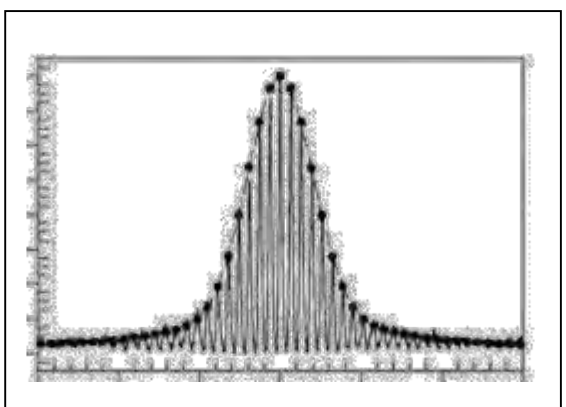
Complex Oxide Materials (Andrew Rappe, University of Pennsylvania)

Applications

- Piezoelectrics for SONAR and medical ultrasound

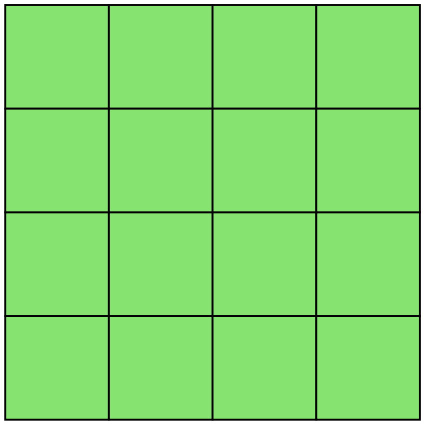


- Ferroelectric RAM for nonvolatile storage; not vulnerable to EMP

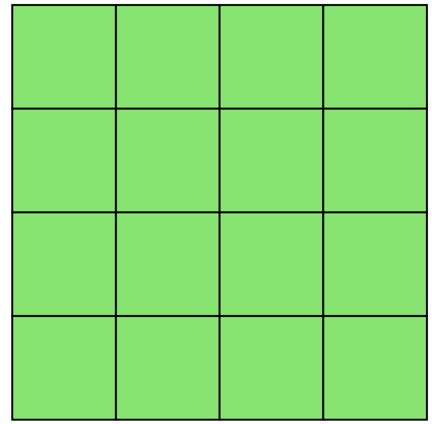


- Dielectric resonators for cell-phone communication
- Generating Terahertz frequency light (THz) for detecting improvised explosive devices (IEDs)

How does SONAR work?



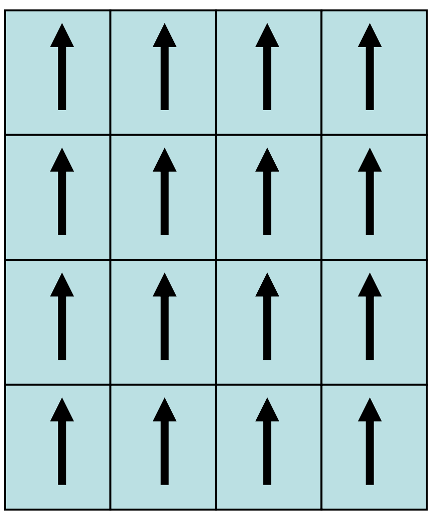
Pressure wave → undersea



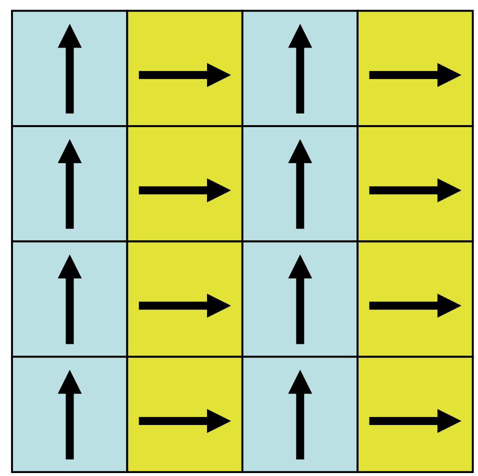
SONAR has no effect. Not useful as a detector material.

Stable structure (cubic)

No change



Pressure wave → undersea

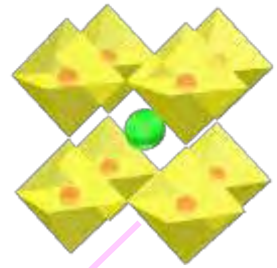


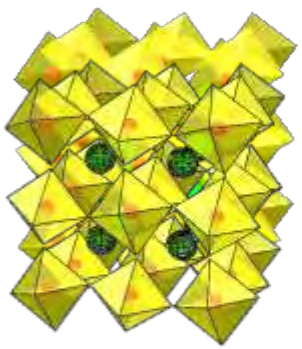
Pressure easily changes material shape. Great SONAR detector!

Single-domain (rectangles)

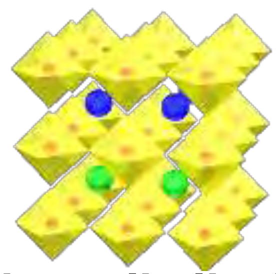
Multi-domain (cubic)

ABO_3 palette for materials discovery

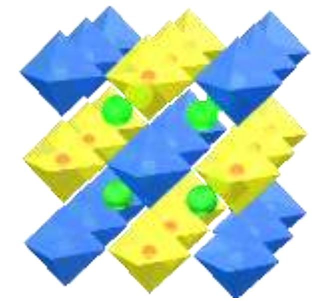




BO_6 octahedral tilting
A and B cation motion



A site: alkali, alkaline earth,
rare earth, main group

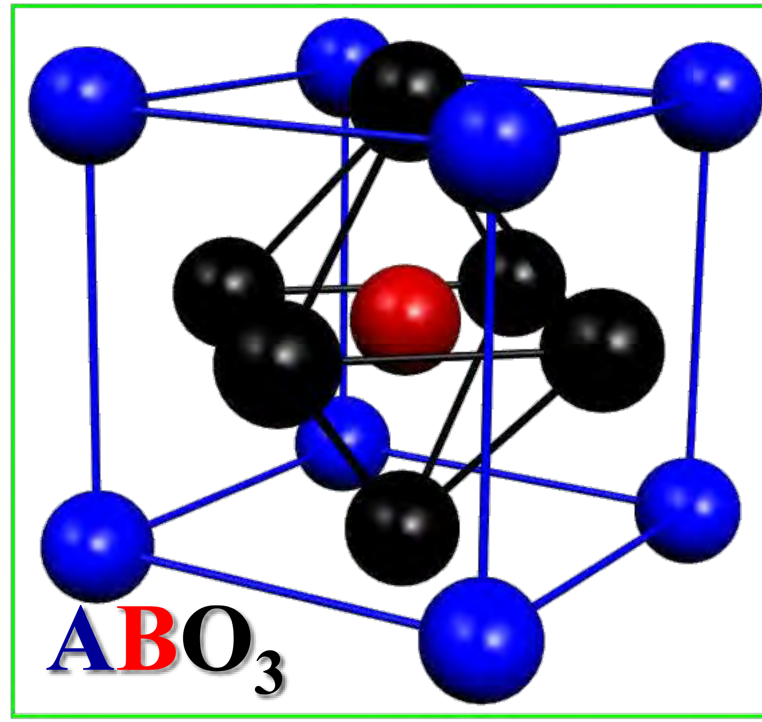


B site: transition metal,
alkaline earth

- **Variety:** Nearly any element for A and B, solid solutions
- **Frustration:** A-O and B-O bond lengths, charges, spins
- **Order/disorder:** Partial ordering, varied correlation length
- **Control:** Balance effects, frustration leads to responsive materials

Ferroelectric Perovskites (ABO_3)

- Spontaneous polarization, $\vec{P}$
  - Cation off-centering forms an electric dipole within unit cell
- Polarization can be flipped by applying an external field
- Collective phenomenon
- How does behavior change when one dimension approaches atomic scale?



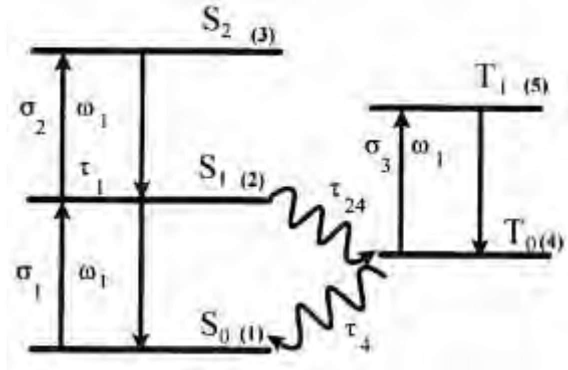
Recent Accomplishments

- Understand and enhance SONAR material response
- Discover new environmentally-friendly materials (replace Pb with Ag!)
- Computational materials design of nonvolatile RAM materials
- Ultrathin NVRAM memory devices

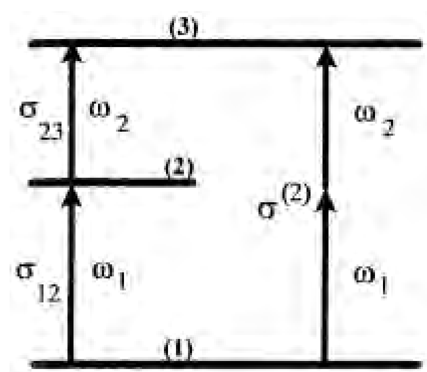
Nonlinear Optical Absorbing Materials (Ruth Pachter, Air Force Research Lab)

- **Objective:** accurate, reliable, and efficient prediction of structures and spectra for the design of RSA and TPA materials
- **RSA Materials**
  - Porphyrins, phthalocyanines
- **TPA Materials**
  - (D-p-A) stilbenes, fluorene-based molecules (AFx)

RSA (reverse saturable absorption):

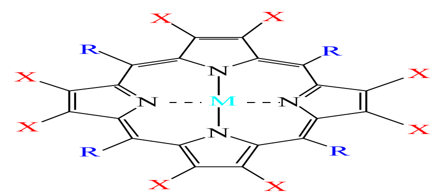


TPA (two-photon absorption):



Accurate, Reliable, and Efficient Approach

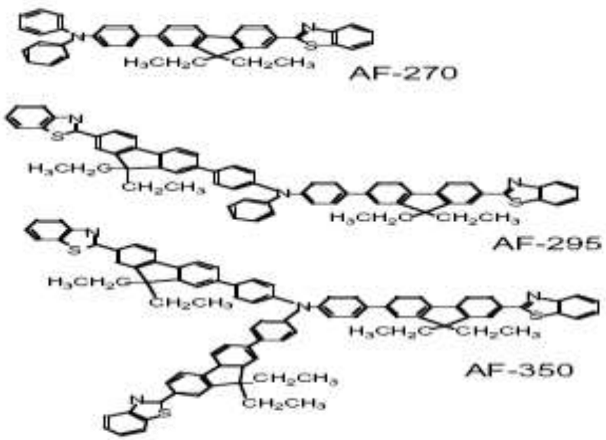
- **Density functional theory:** $O(N^3)$
  - Improvements to Hartree-Fock: MP2-4, CIS/CISD, CCSD(T)…$O(N^5\text{-}N^7)$
- **DFT validation:** structures of model compounds
  - Pyran, C_{20}
  - Meso-alkynyl porphyrins
  - Phthalocyanines
- **Linear response TDDFT:** excitation energies/cross sections
  - Improved (x-c) functionals
- **TDDFT validation:** spectra of RSA materials

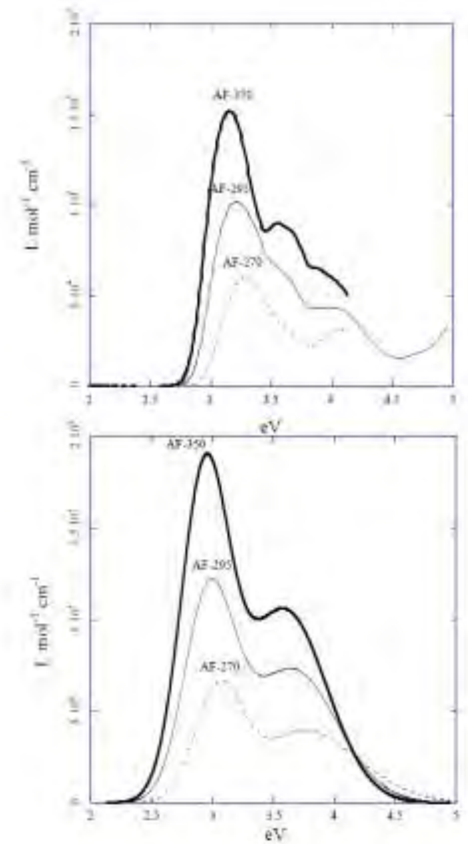


	M	X	R
PH_2	H_2	H	H
ZnP	Zn	H	H
$TPPH_2$	Zn	H	phenyl
ZnTPP	Zn	H	phenyl
$ZnTPPX_8$	Zn	F, Cl, Br	phenyl

- Good agreement with experimental trends
- Structural effects discerned
- Ionization potentials estimated

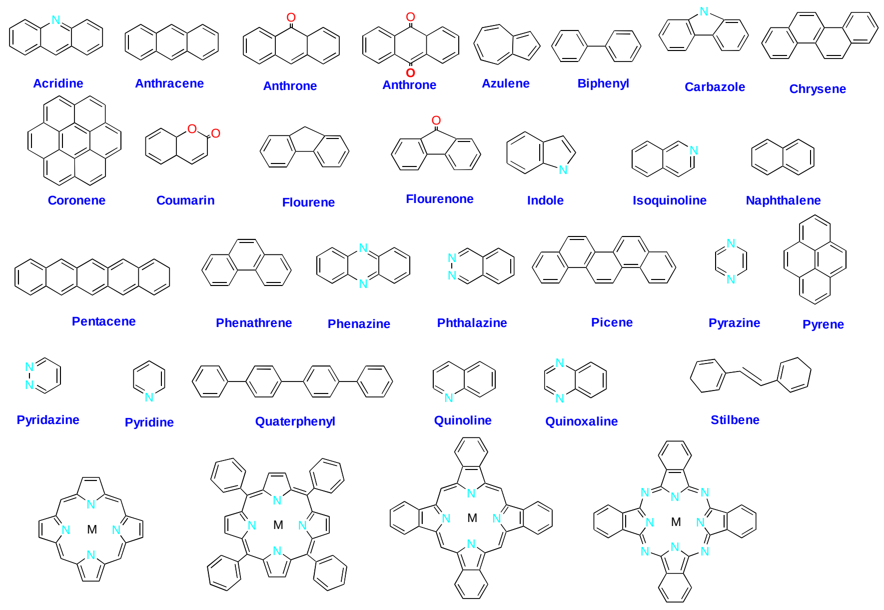
Example: Ground-state Spectra

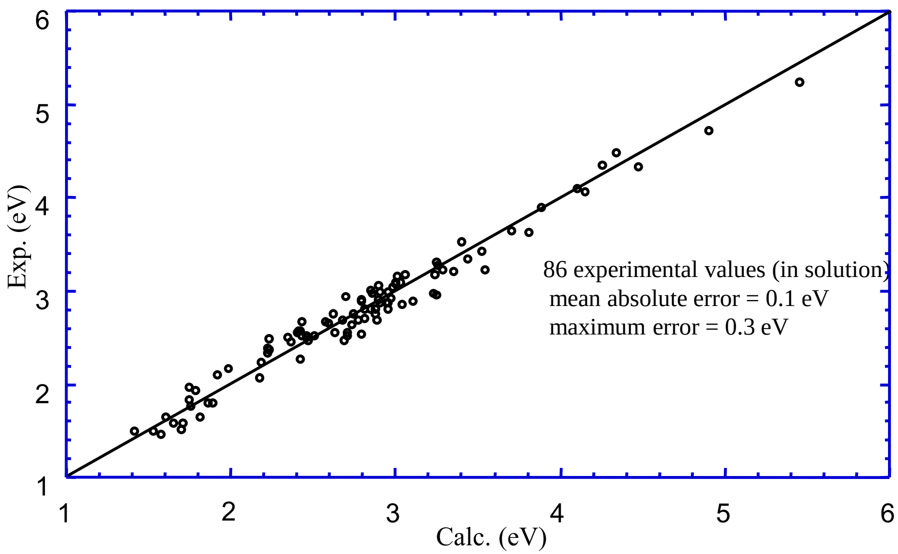




Experimental (top) and calculated (bottom) one-photon absorption spectra

Results: Excited-State Spectra





- Israel et al., JCP 2000: "..accurate triplet absorption spectra predictions remain a challenge.."; MRCISD-INDO/S calculations: average error of 0.4 eV
- Good agreement with experiment in our calculations for the T-T spectra applying TDDFT/B3LYP: average error of 0.1 eV

Why Simulate Ceramics Under Impact?

Idea

Ceramics have high hardness at low densities compared to metals

↓

Good candidates for armor applications (lightweight armor systems for vehicles)

Problem

They are very strong in compression but weak in tension and brittle

↓

Armor efficiency is reduced by fracture (need for extensive ballistic studies with different materials and geometries)

Search for Solutions

Experimental impact tests

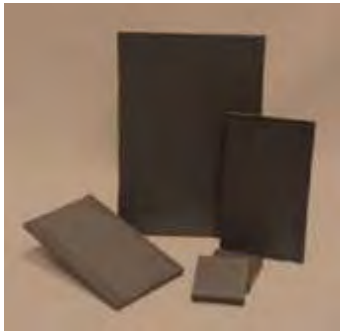
+

Computer simulations of impact (wider choice of impact parameters)

Ceramic Applications

Ceramic Fabric

Multipurpose Tiles



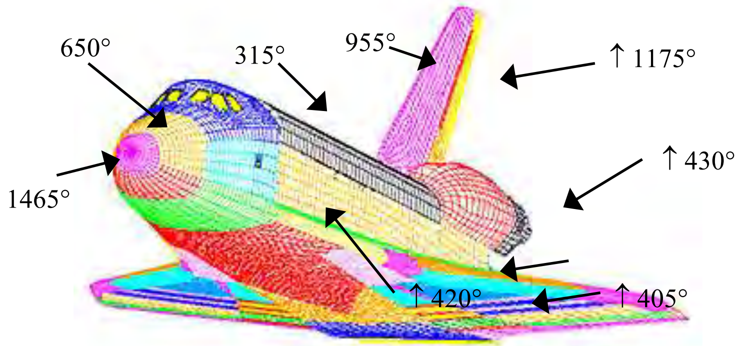
Land Vehicle Armor

Helicopter Armor

Personnel Armor

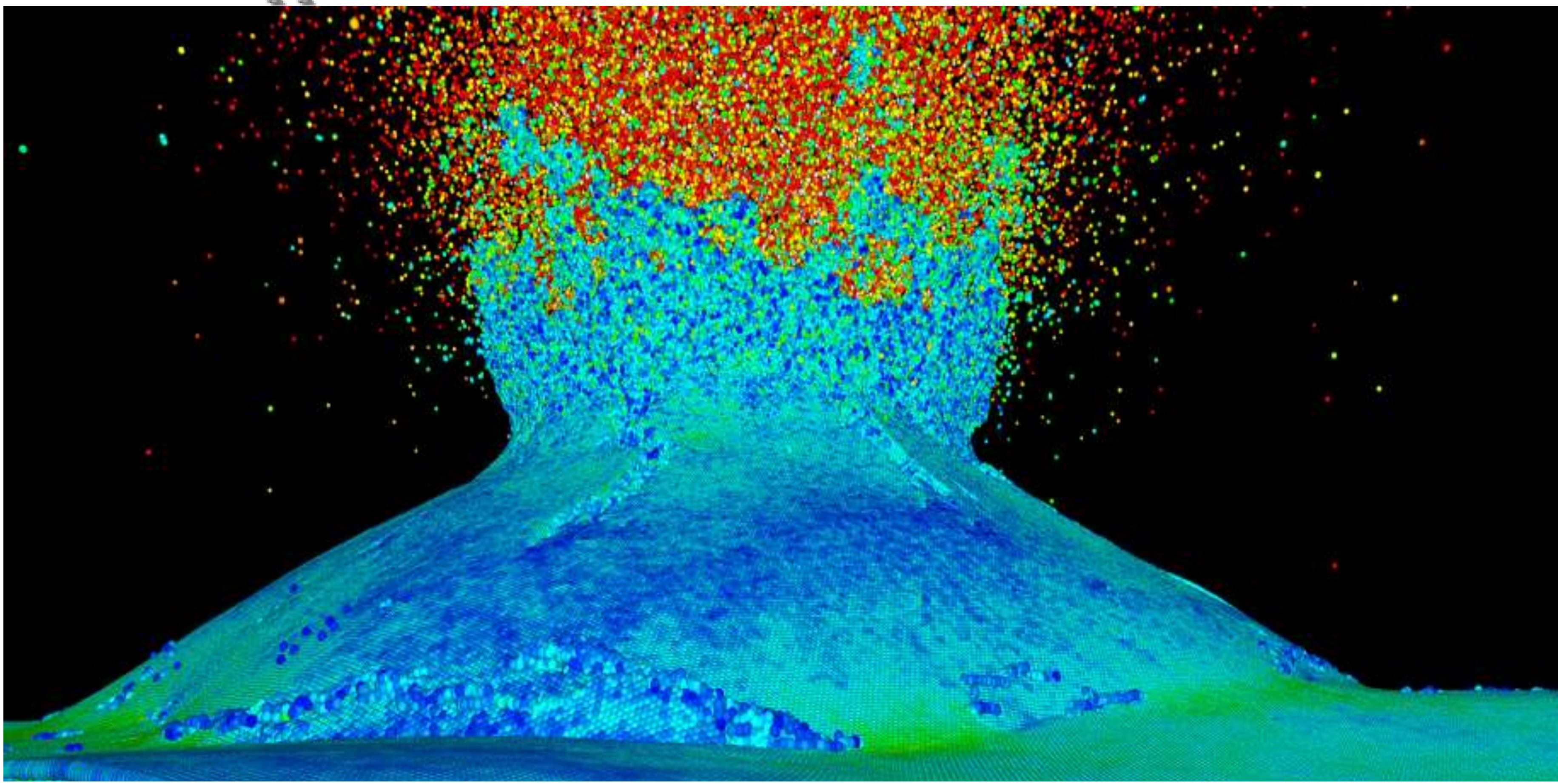
International Space Station

Space Shuttle



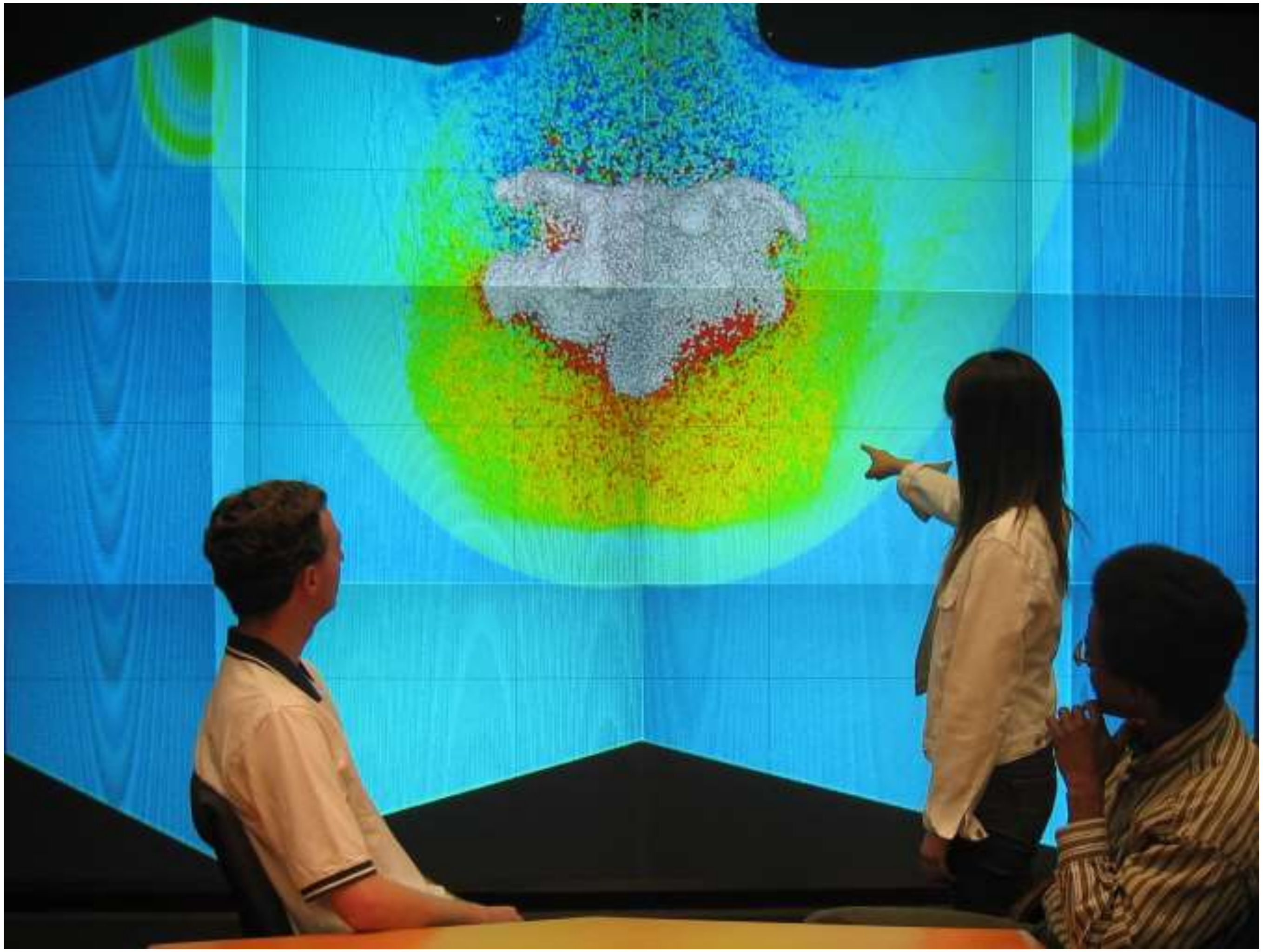
Temperatures in Celsius degrees
↑ are ascent temperatures

209 Million Atom MD Simulation of Hypervelocity Impact in Aluminum Nitride — Lightweight Ceramic for Armor Applications

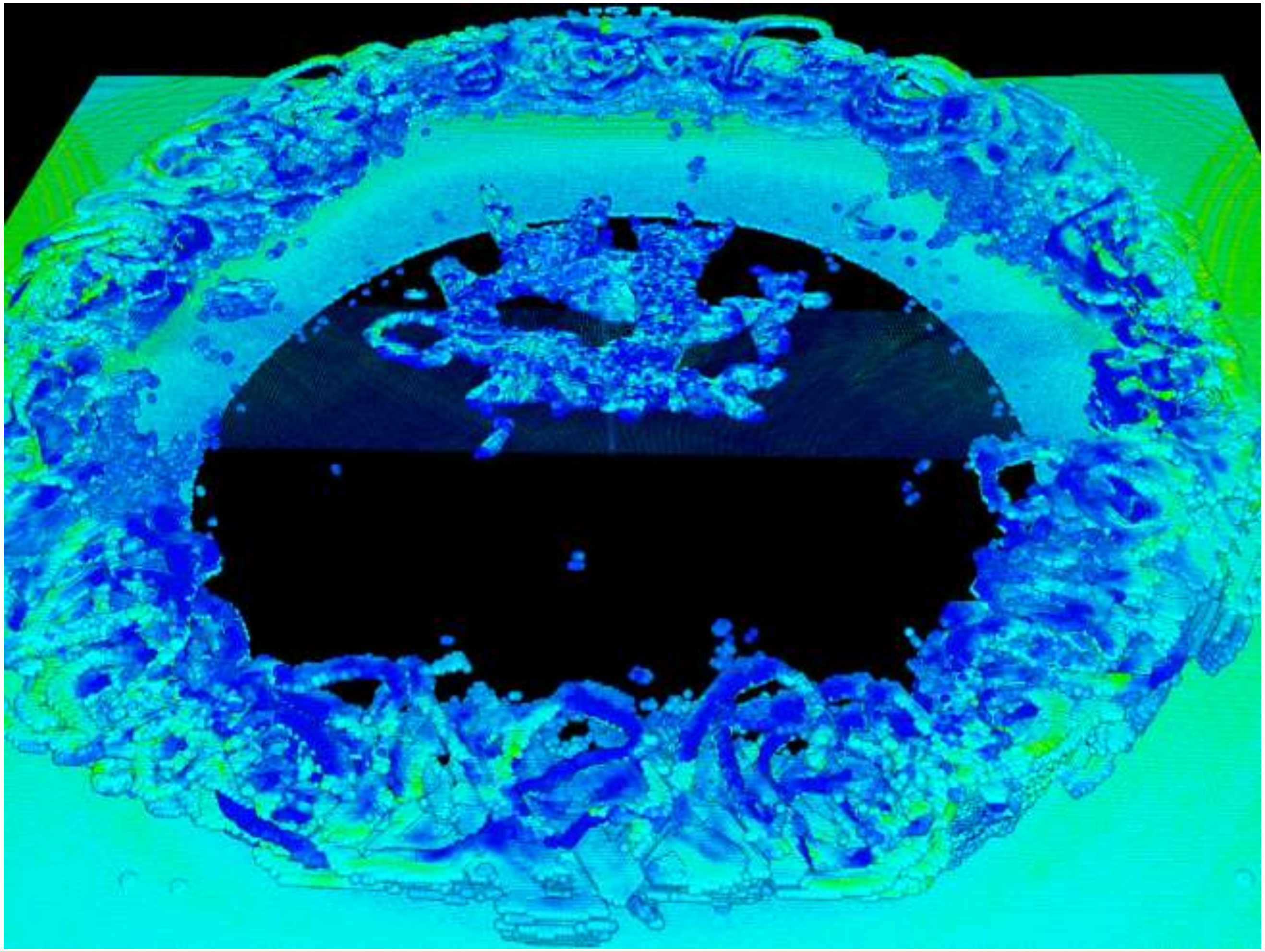


Rajiv Kalia, Aiichiro Nakano & Priya Vashishta
University of Southern California

Tiled Wall Display of 209 Million Atom MD of Shock Propagation in Aluminum Nitride



Shock-induced Damage in Aluminum Nitride



Air Force SEEK EAGLE

- USAF Aircraft-Store Certification Program
  - Store loading procedures
  - Carriage loads*
  - Store separation*
  - Flutter
  - Ballistic accuracy
  - Stability & control*
  - Safe escape
  - Electromagnetic compatibility/interference
- Stores Include
  - Munitions, fuel tanks
  - Suspension equipment
  - Pods for navigating, sensing, targeting
- CFD Supports * Items Above Plus
  - Miscellaneous aerodynamic analysis, flow visualization
  - Supplements wind tunnel (not physically constrained), test analogy assumptions, reduce flight test

CFD Project Summary

FY01

F-16/MA-31
F-16/Mk-82 fin crack
F-15/GBU-27
F-16/JASSM

Captured JASSM jettison!

FY02

F-111/SSB
F-16/CBU89/JSOW
F-16/PPB
B-52G/JASSM
F-15E/SLV
JDAM FZU Sim

FY03

F-15E/JDAM
F-15E/SATIRS
F-16/SNIPER
F-15E/SNIPER
F-15E/LITENING
F-16/BRU/CBU89
B-52H/X-37
F-15E WT Support
GBU Aero Data
F-16/ARGUS
F-16/MALD
F-15E/WCMD

Realistic fin deployment!

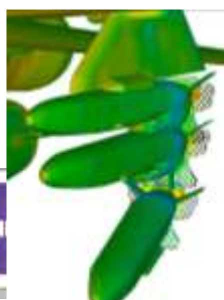
FY04

B-52H/Mailbox
Predator/GBU-12
Predator unsteady flow
SDB-FTS (GBU-39B)
A-10/multiple stores
B-52H/JASSM validation
BQM-167 rocket plume
FZU-55 on MQ-9/GBU-38
MALD design studies
B-1B/Mk-82/GBU-38
F-15E S&C w/CBU-104
F-16/600-gal tank
B-52H/MALD
F-16/MALD
F-15E/GBU-28
F-16/WCMD-ER
B-52H/X-37

Autopilot/flow interaction!

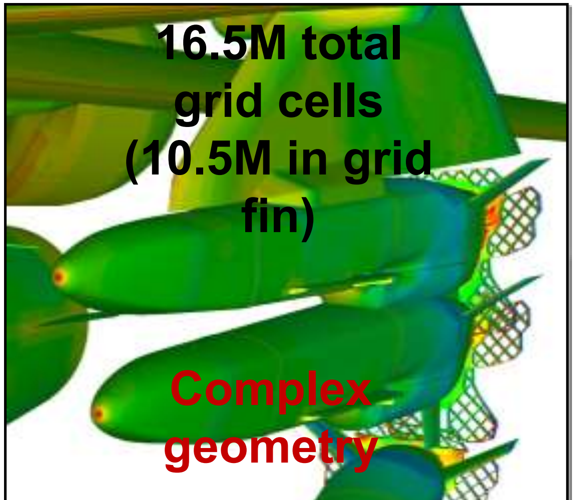
FY05

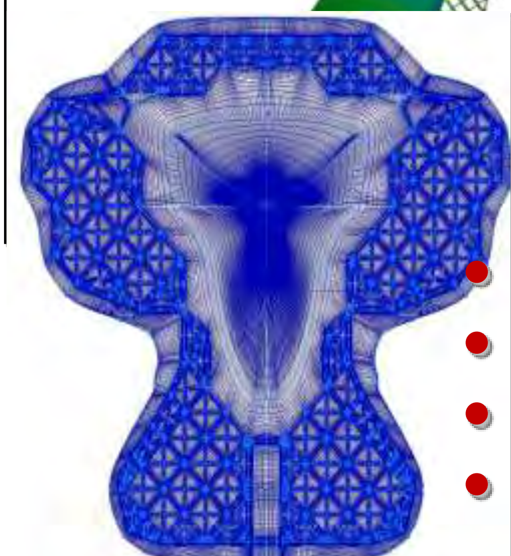
B-1B/Mk-82/GBU-38
B-1B/IHAAA - turbulence study
BQM-167 rocket plume
MALD design studies
B-52H/MALD
F-15E S&C w/CBU-104
F-15E/GBU-31
F-16 w/active control surfaces
F-16/600-gal tank
F-16/WCMD-ER
F-16/ECIPS/MA-31
F-18C/GBU-12
C-130/Store deployment
Condensation predictions
B-1B/SNIPER/GBU-38
F-15E/GBU-28
F-15E/GBU-38
F-15E/GBU-39
B-52/GBU-12 SafetyIB
B-2A/GBU-28
F-16/MALD



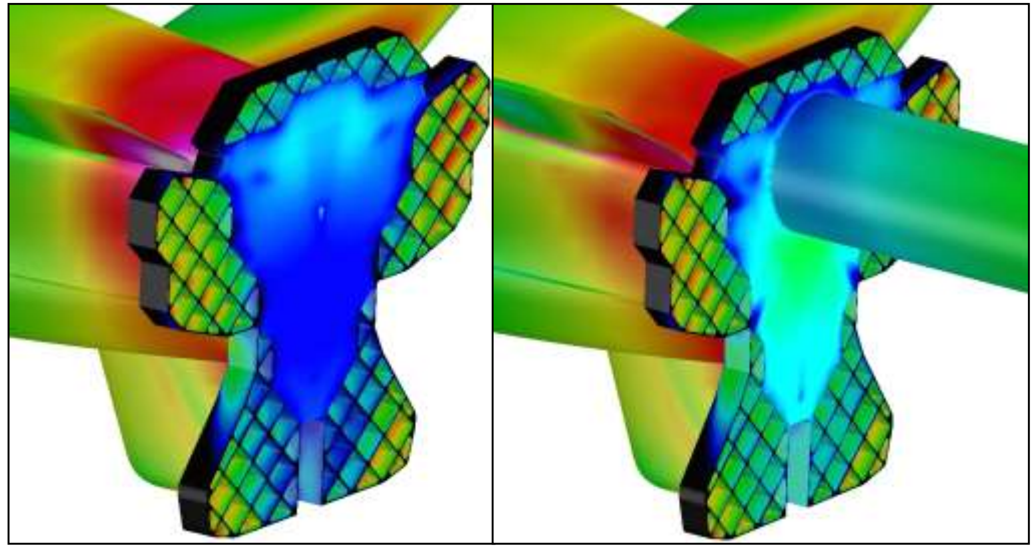
Complex grid fins!

Miniature Air-Launched Decoy (MALD)





Wind Tunnel effects – less drag with sting (Mach 0.95)

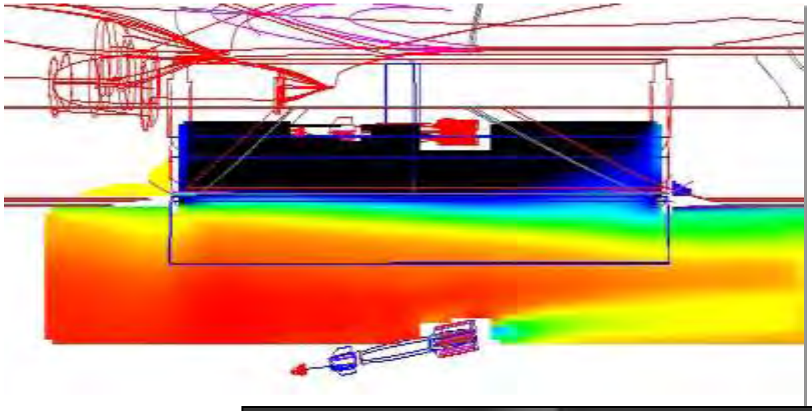


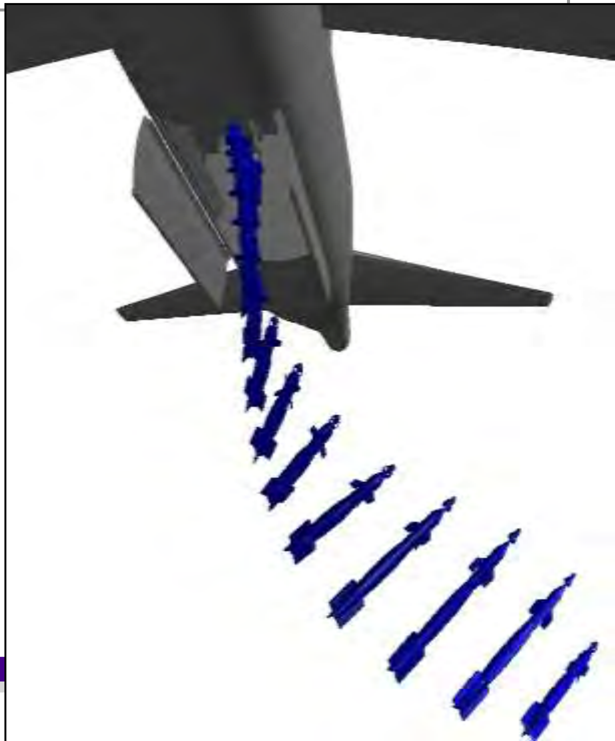
Complex flow physics

- Multiple MALD design iterations
- 32 CFD trajectories, 40 carriage, 12 freestream
- 0.6 < M < 0.95; 6k < h < 35k ft
- Good agreement w/wind tunnel & flight test (May/Jun 05)

B-52/GBU-12 Safety Investigation

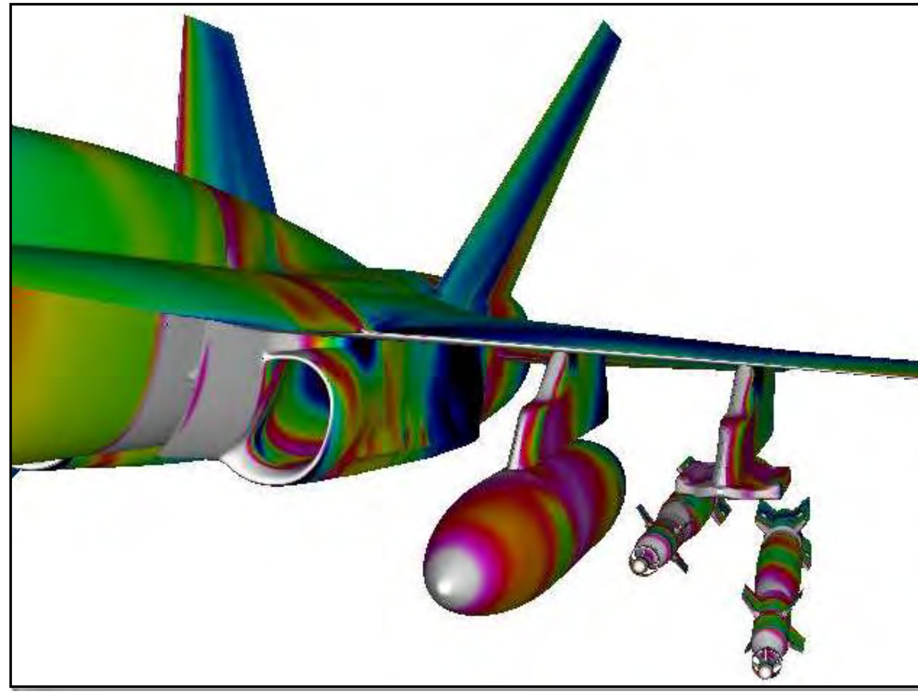
- Accident during operational training mission
- Gravity-drop GBU-12 from B-52 weapon bay; sensitivity from unsteady flow, shear layer, stowed fins
- 5 time-accurate CFD trajectories, 15 carriage/freestream in 3 weeks
- 32M computational points
- Achievable only with HPC hardware!



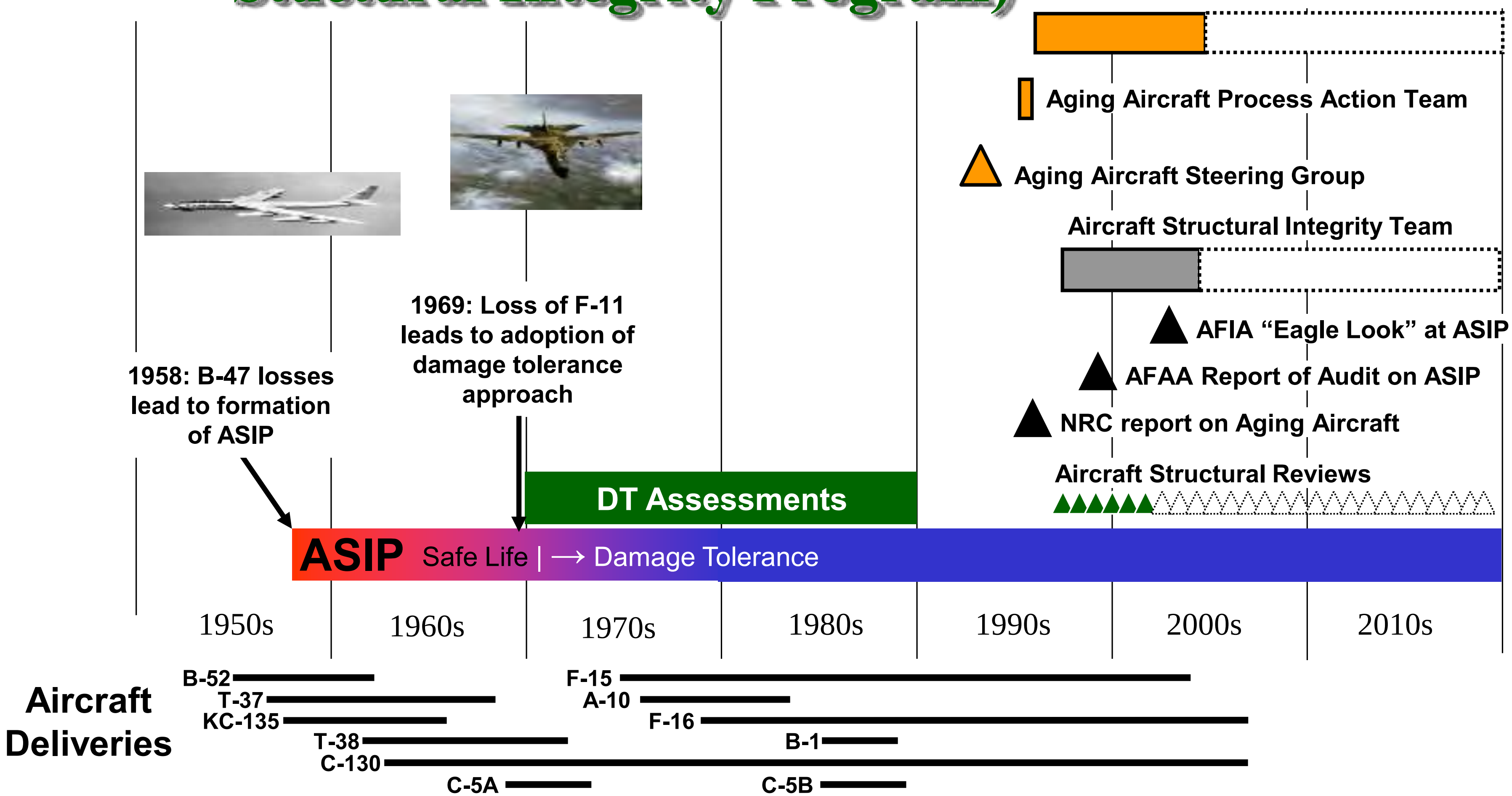


F/A-18C/GBU-12 Separation

- Quick-reaction support for Navy flight test
- 22M computational cells
- In 4 weeks – 4 CFD dynamic ripple-release GBU-12 trajectories from F/A-18C at Mach 0.88 and 1.2
- Saved USN $570K ($70K flight test, $500K Wind Tunnel Test)



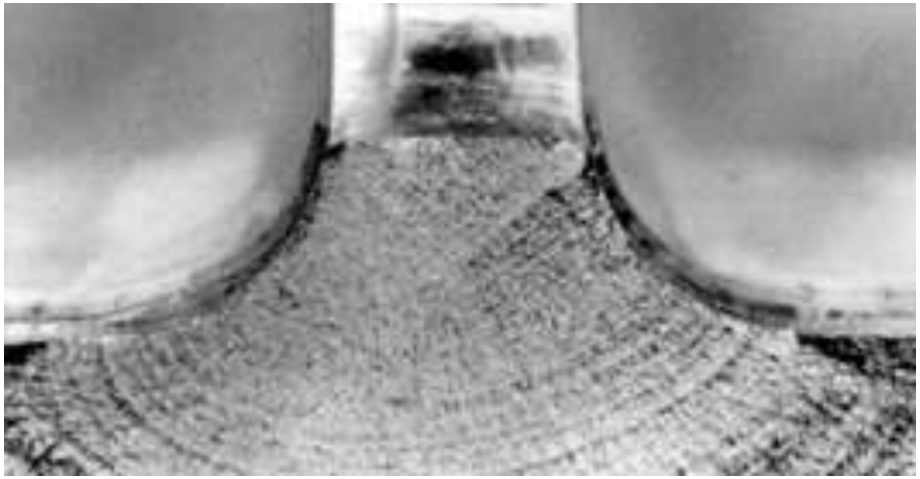
History of Structural Integrity Efforts (Aircraft Stuctural Integrity Program)

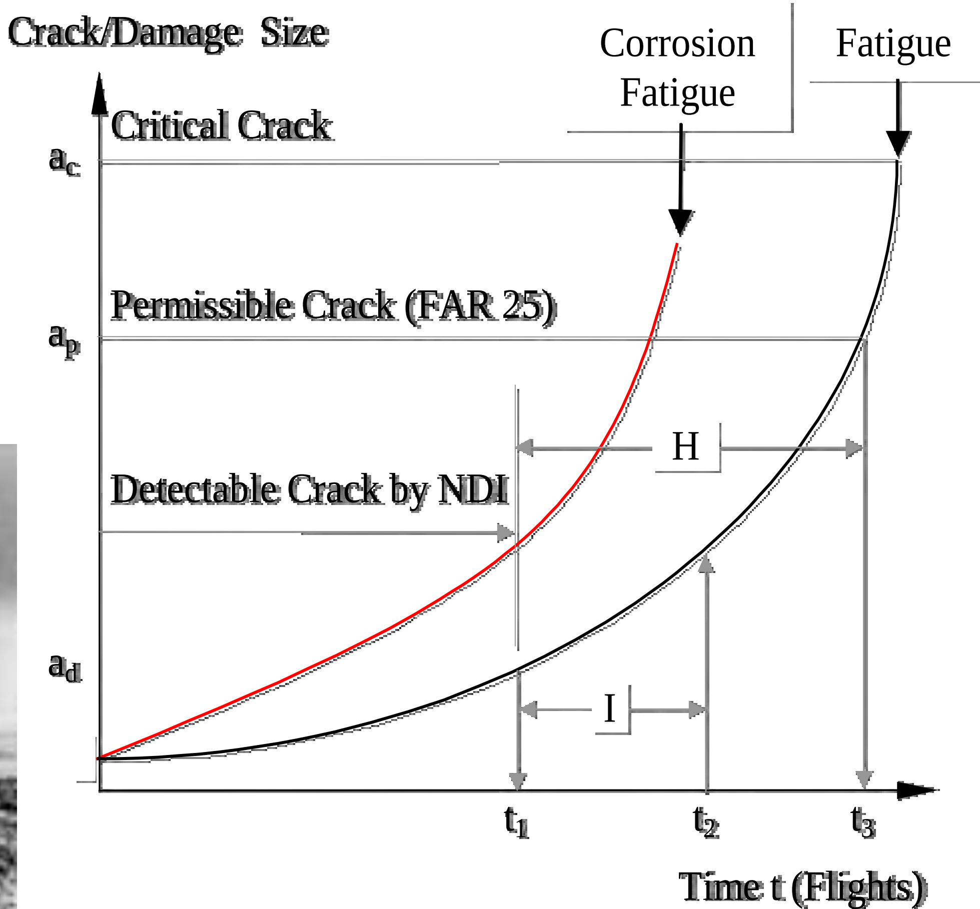


Through better designs, inspections, prevention techniques, analyses, and repairs, the AF is extending the lives of our fleets

ASIP in Practice

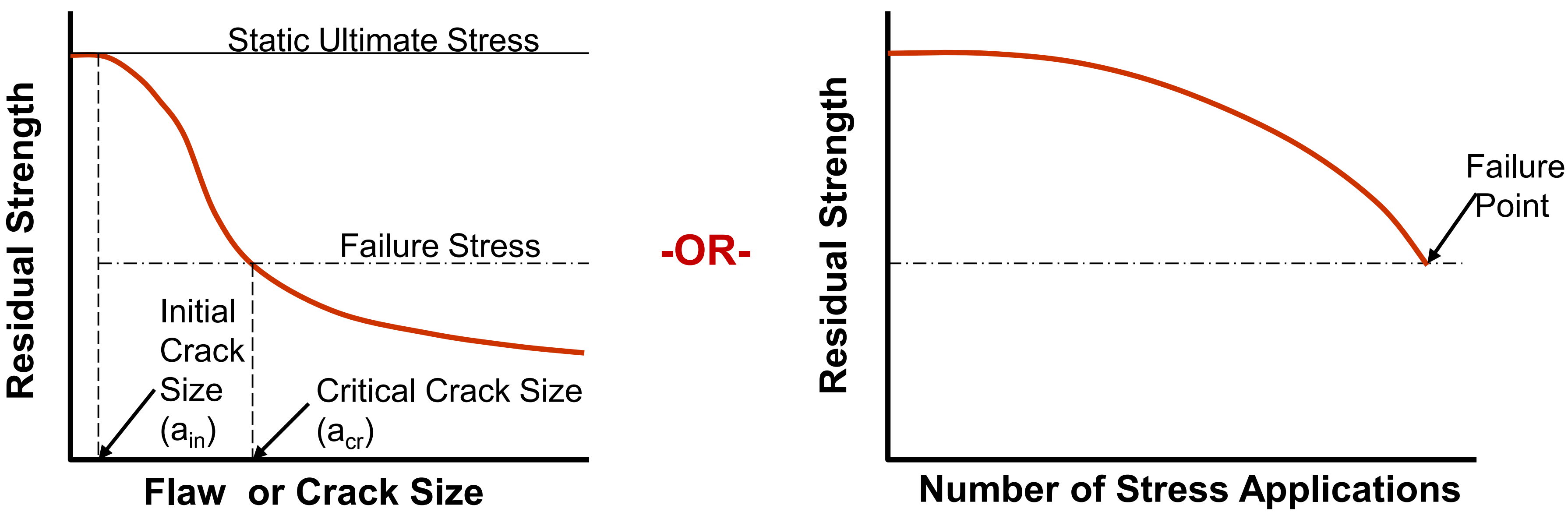
- *Fatigue* – a failure caused by cyclic loading
- Cycles often cause the growth of cracks from inherent metallurgical features or from damage induced during manufacturing or service





ASIP in Practice

- As a fatigue crack grows in a component, the component loses the ability to withstand stresses
- Thus, fatigue crack growth also causes a loss of ***Residual Strength***



Fracture Mechanics of Fatigue Crack Growth and Failure

- **Paris Law**
  - **Crack extension per cycle**

$$\frac{da}{dN} = C\Delta K^m$$

- **Failure Criterion**

$$|K_c| < |K_{Applied}|$$

  - ***C*, *m*, K_c are material dependent parameters**
- **Stress intensity factor (K)**

$$K = \sigma \underbrace{\sqrt{\pi a}\, f\left(a/c, a/t, r/t, W, B, H, e\right)}_{\text{Component and Crack Geometry}}$$

Justification/DoD Relevance

Changing Fleet Management Paradigm

Today

Find and Fix

Prevention
New or Existing Aircraft

Potential/Desired Future State

Anticipate and Manage

Aircraft Enters Maintenance

Corrosion Found

Corrosion Repaired

Aircraft Released From Maintenance

Focused Corrosion Inspection

Data feedback

Corrosion Analyzed

Corrosion Repaired

Repair Deferred

Corrosion Suppressed

Impact Assessed & Documented

Aircraft Released From Maintenance

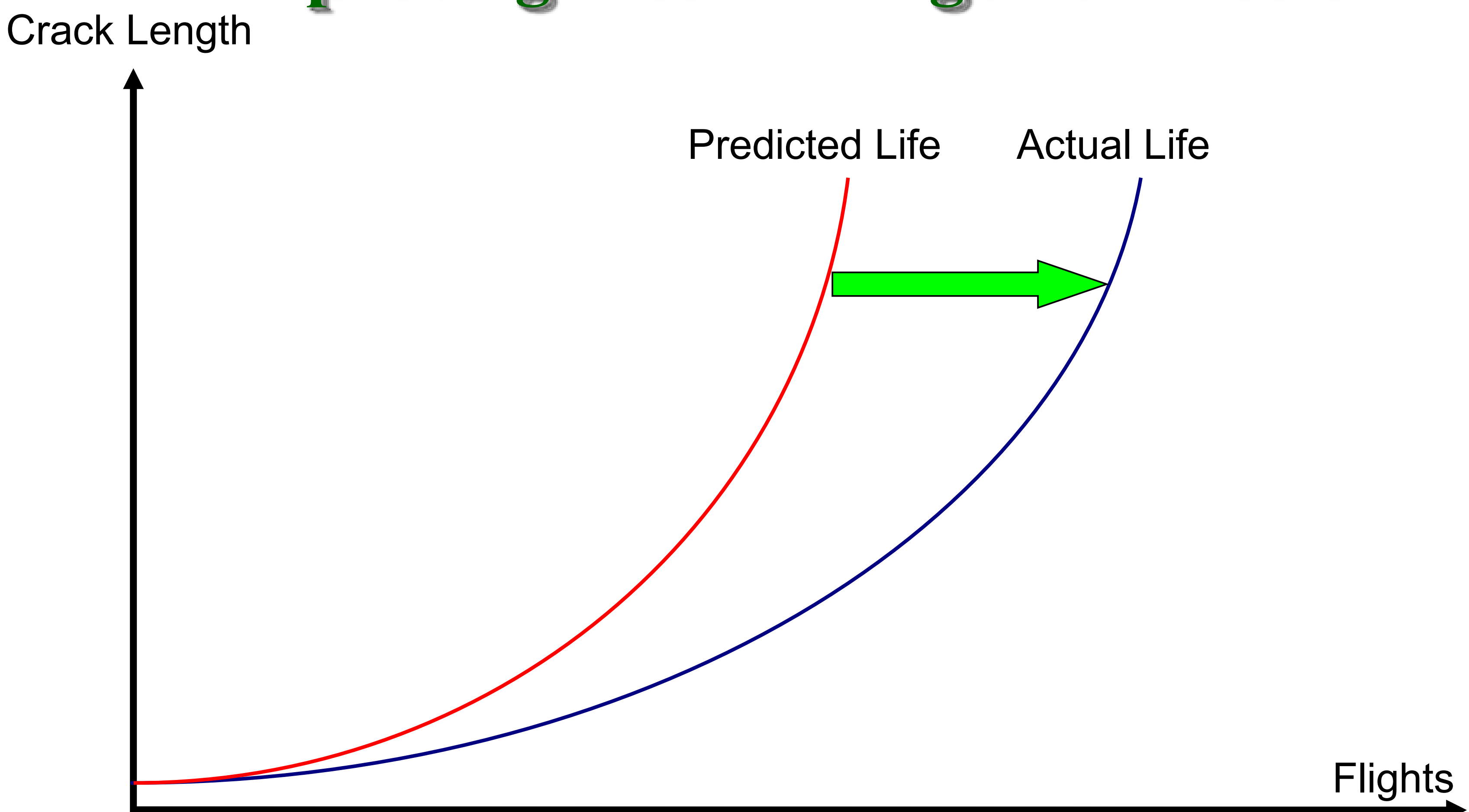
Existing

New and Existing

New Technology

Justification/DoD Relevance

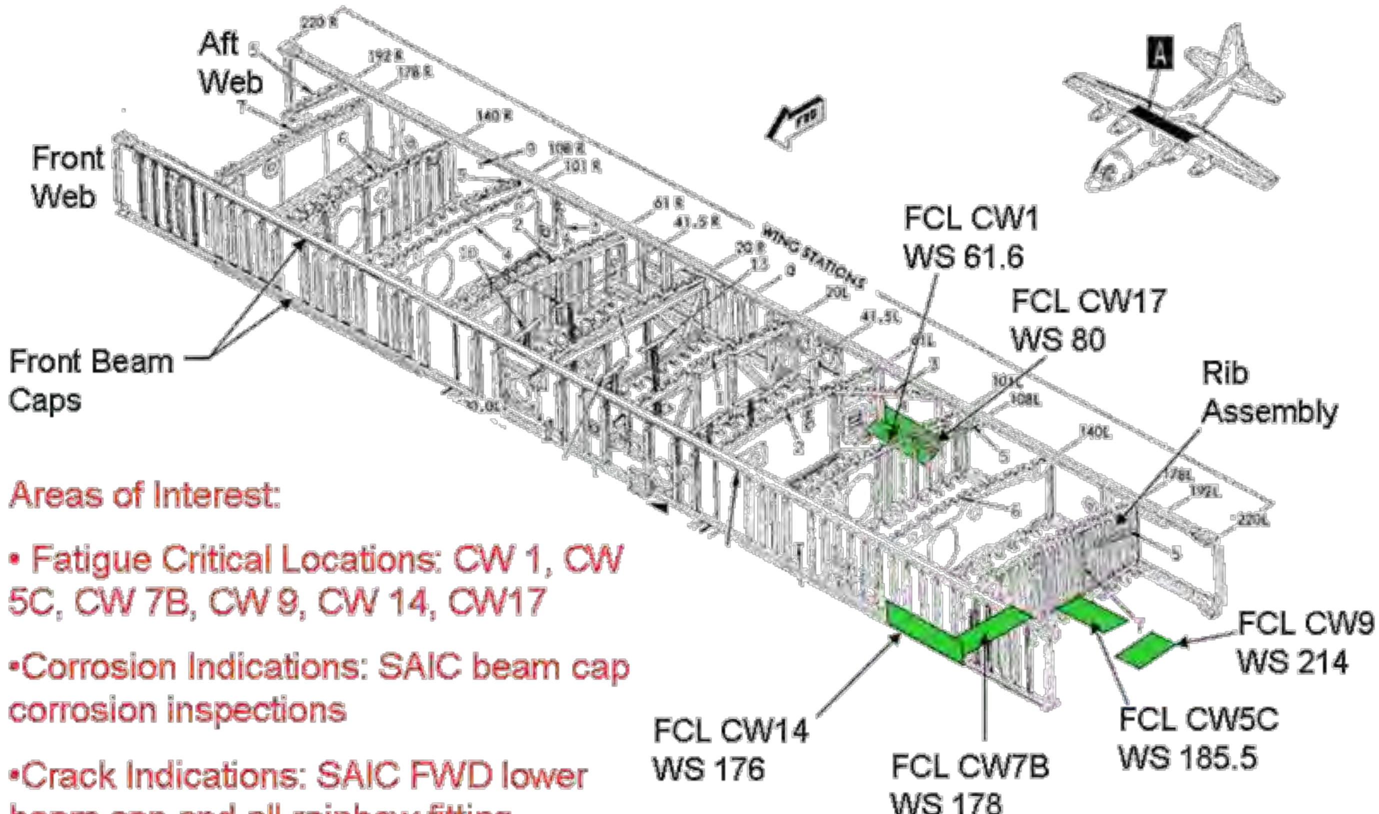
Improving Fleet Management Tools



Technical Approach

Fatigue Critical Locations in Residual Strength Analysis

Center Wing Box FCL focus from CWB Tear Down



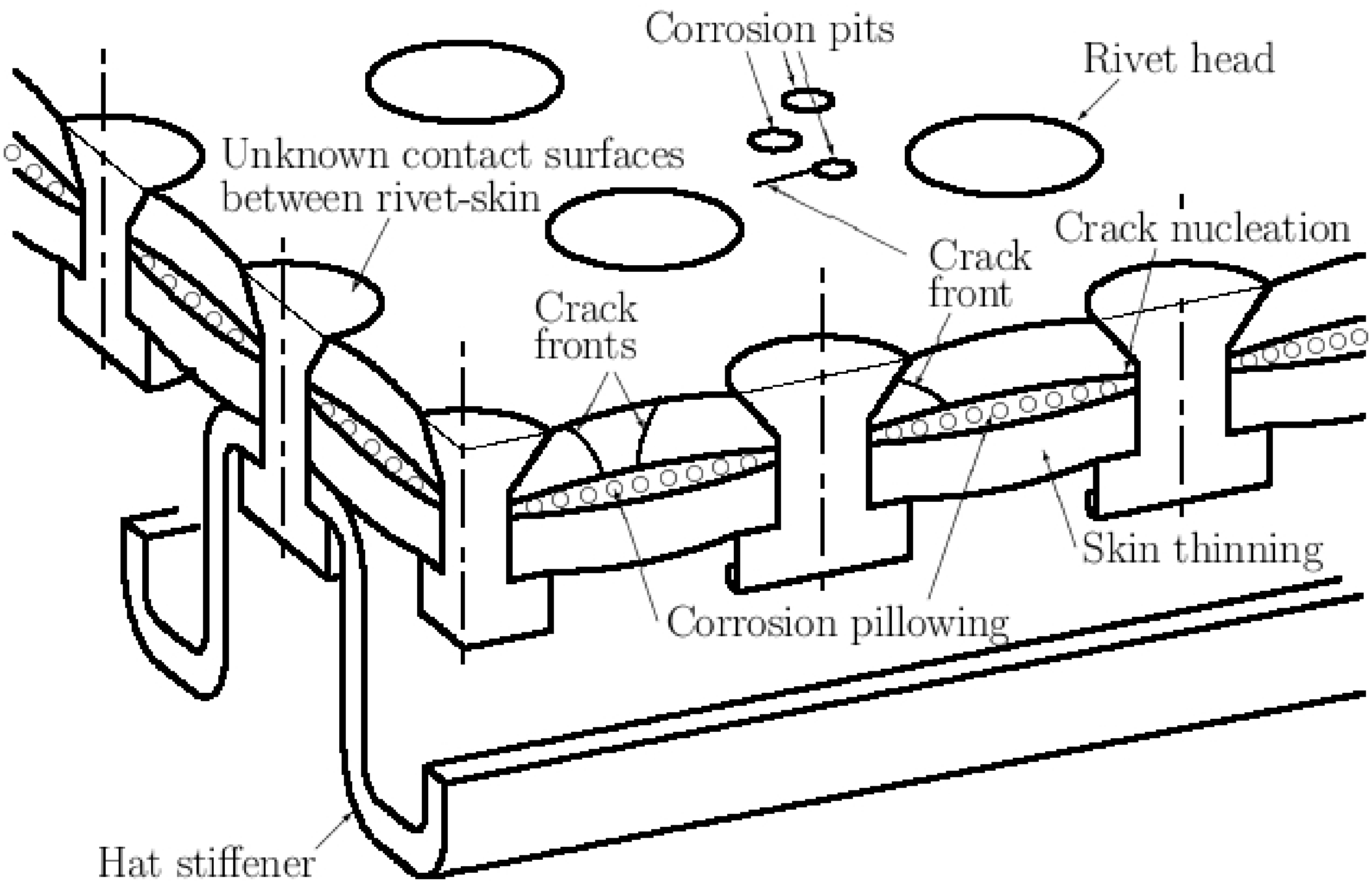
Areas of Interest:

- Fatigue Critical Locations: CW 1, CW 5C, CW 7B, CW 9, CW 14, CW17
- Corrosion Indications: SAIC beam cap corrosion inspections
- Crack Indications: SAIC FWD lower beam cap and all rainbow fitting inspections for cracks

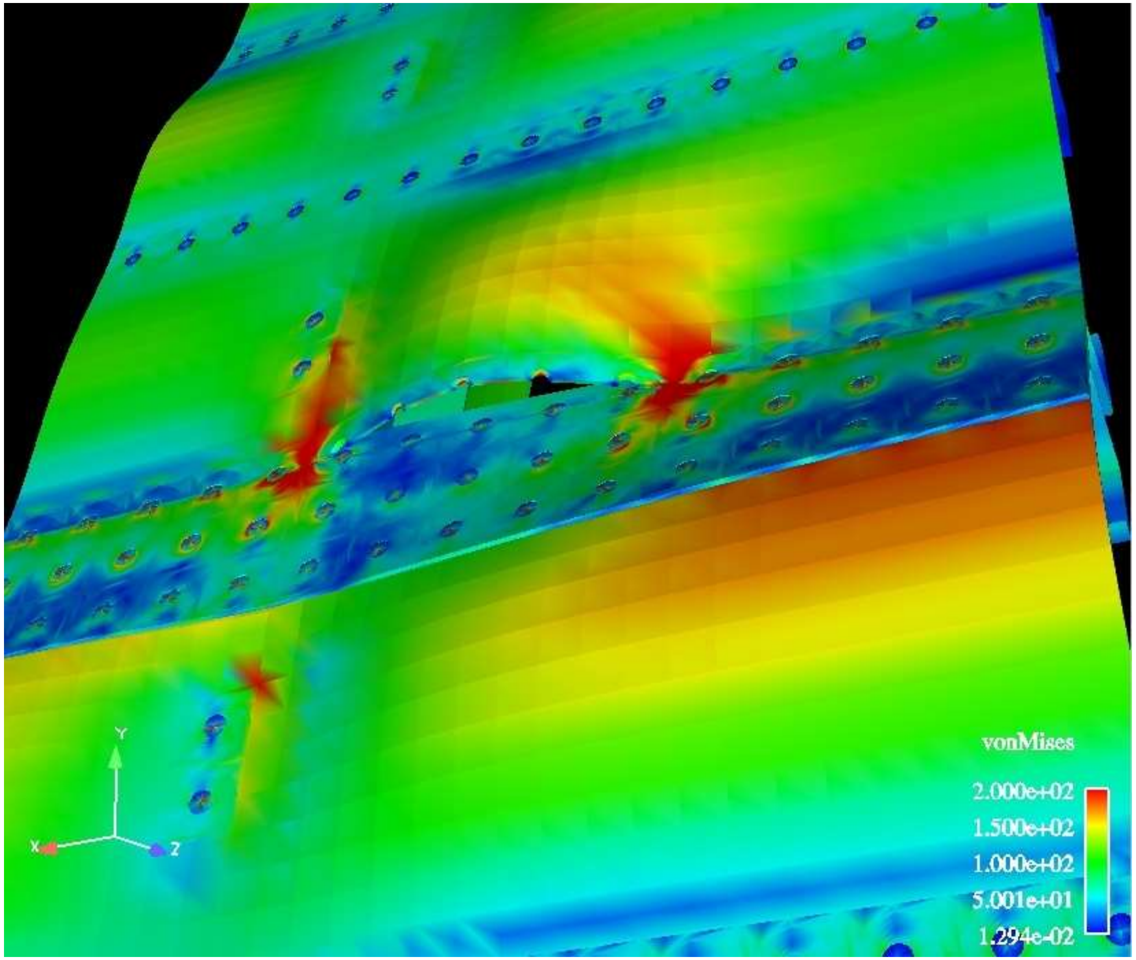
Technical Approach

Corrosion Locations in Residual Strength Analysis

Technical Approach
Modeling Corrosion



Progress to Date
Residual Strength Analysis



Summary of Stuctural Integrity Program

- USAF uses fracture mechanics in the fleet ASIP
- USAF fleet management requires robust analysis tools move from find & fix to anticipate & manage
- 108 K-solutions and residual strength calculated using mathematical splitting scheme
  - First statistical analysis of multi-site-damage in built-up structure
- 1.9 million CPU hours used to calculate 5.6M K-solutions and large shell analyses

Summary

- World-class corporate computing capability established for DoD HPC community
- High Performance Computing capabilities being employed to provide substantial contributions to DoD mission capabilities
- Successful transition to scalable, parallel computing
- Leveraging national, academic, and federal activities

ISO 14001, OHSAS 18001, and MIL-STD-882D and SE

NDIA SE Conference
San Diego, CA
27 October 2005

Mr. Ken Dormer
Office of the Deputy Assistant Secretary
(Science, Technology and Engineering)

U.S. AIR FORCE

Overview

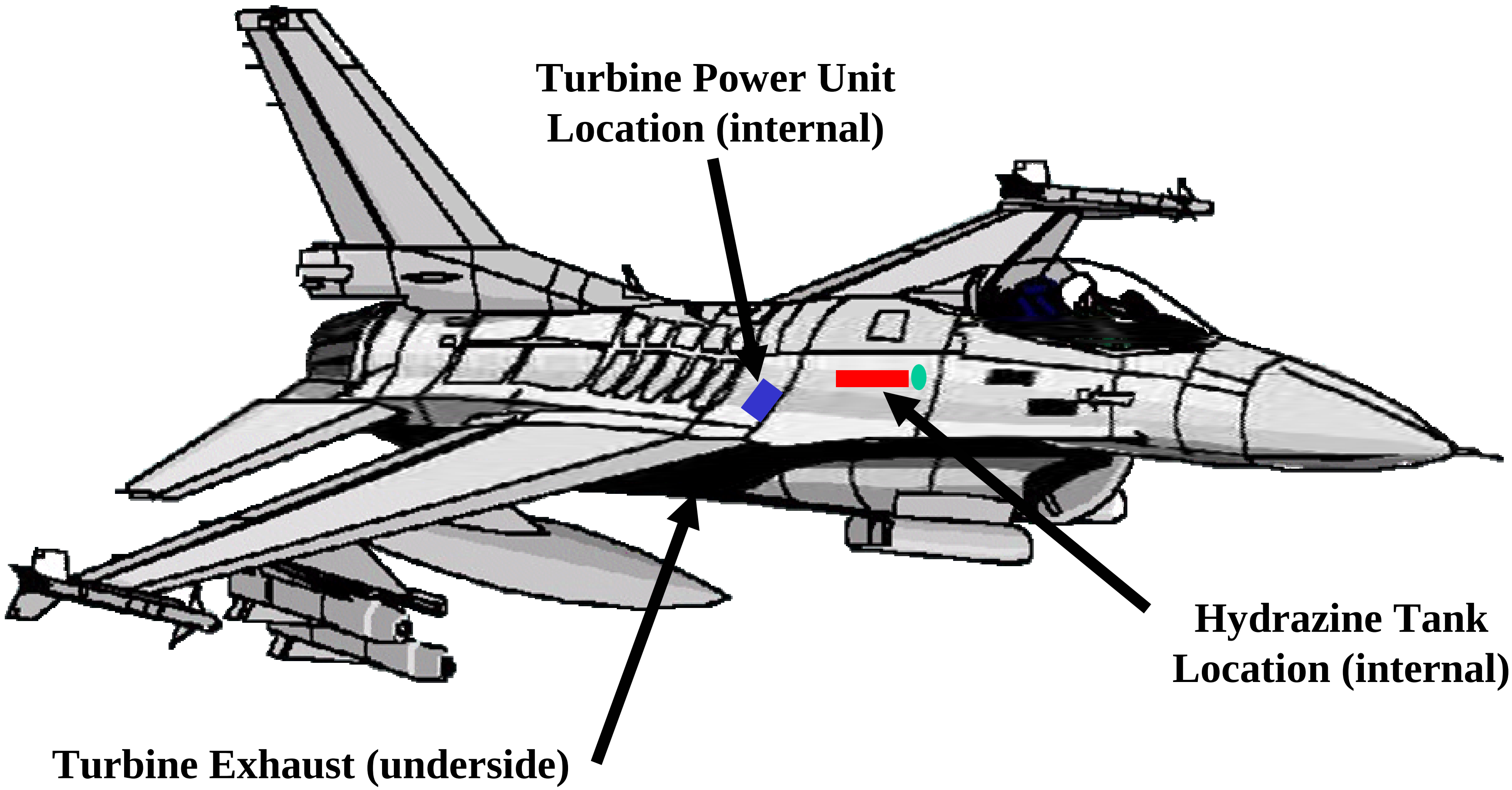
- The Need for Integrated ESOH Risk Management
- Policy, Perceptions, Reality
- Environmental Risk Management
- ESOH Risk Management
- Using MIL-STD-882D to Integrate ESOH

The Need for Integrated ESOH Risk Management

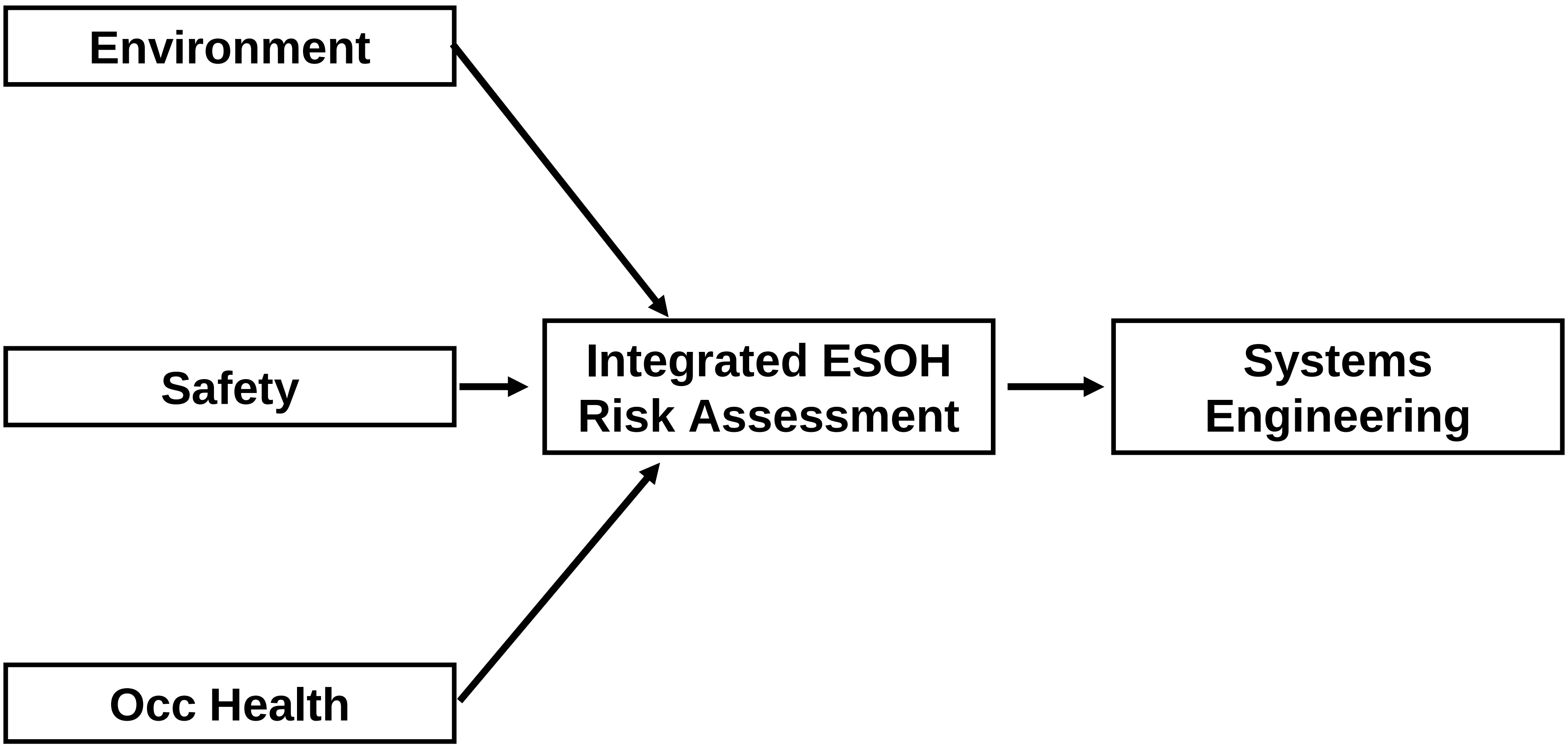
- DoD needs a way to manage ESOH risks like all other Acquisition Program risks
  - Acquisition Program Management and Systems Engineering (SE) are fundamentally Risk Management activities
  - Everything is in a program's "trade-space"
    - Capability requirements can be renegotiated if technology is insufficiently mature or too expensive
    - Funding can be increased or decreased
    - Schedule can be expanded or compressed
  - ESOH needs to be able to be evaluated with other program risks in the program's "trade-space"
- E, S, and OH risk assessments need to be integrated and de-conflicted

The Need for Integrated ESOH Risk Management

F-16 Emergency Power Unit (EPU)



The Need for Integrated ESOH Risk Management



Policy

- DoD 5000.2R (1996) integrated ESOH into Systems Engineering for the first time
  - Defined environmental compliance in risk management terms
  - Established System Safety hazard identification and risk assessment, mitigation, and acceptance requirements
- 12 May 03 DoDI 5000.2, E7 built on requirements from 1996 DoD 5000.2-R
- 23 Sep 04 USD (AT&L) Defense Acquisition System Safety memo requires ALL DoD PMs to:
  - Integrate ESOH into SE using System Safety
  - Use MIL-STD-882D as the System Safety methodology
  - Incorporate ESOH integration strategy into the new Systems Engineering Plan (SEP)
  - Address ESOH risk acceptance decisions in technical and program reviews

E - SOH Perceptions

- From its inception, Safety has been understood as a risk management activity
- Although it often has a compliance focus, Occupational Health involves risk management
- Environmental management is the “odd man out”
  - Compliance focus predominates
  - Reigning methodologies seen as incompatible with S-OH risk management methodologies

Biggest perceived gap is between E and SOH

E - SOH Perceptions

Weapon System Pollution Prevention:

JUST DO IT!

"Environment, Safety, and Occupational Health are three totally different things"

Violating environmental laws isn't a "risk" to be managed

Environmental Management: Keeping the Program Manager out of jail

ESOH Reality

Weapon System Pollution Prevention:

JUST DO IT!

"Environmen … cupational Health are th … ent things"

Violating env … tal la … a "… e managed

Environment…
Keeping the Program Manager out of jail

Environmental Risk Management

- **Environmental Management is becoming a more formalized Risk Management activity**
- **1970 NEPA Environmental Impact Analysis Process has risk management-like elements**
  - **Potential environmental impacts**
  - **Significance of the impacts**
  - **Potential mitigation measures**
  - **Approval authorities**

Environmental Risk Management

- **1980s-1990s emphasis on Pollution Prevention was based on a hierarchy of mitigation measures**
  - **Eliminate at the source**
  - **Re-use/Recycle**
  - **Treatment**
  - **Disposal**
- **1996 Environmental Management System (EMS) adopted a risk management approach (without calling it “risk management”)**

ESOH Risk Management

- **The E, S, and OH disciplines have now formally adopted risk management approaches**
  - **Since 1977 - MIL-STD-882 – *Standard Practice for System Safety***
  - **1996 - International Organization for Standardization ISO 14001 – *Environmental Management System***
  - **1999 Occupational Health and Safety Assessment Series (OHSAS) 18001 – *Occupational Health and Safety Management Systems***

ESOH Risk Management

- **Risk Management Terminology**

System Safety MIL-STD-882D	Environmental ISO 14001	Occupational Health OHSAS 18001
Hazard	Aspect	Hazard
Mishap	Impact	Accident
Risk	Significance	Risk

ESOH Risk Management

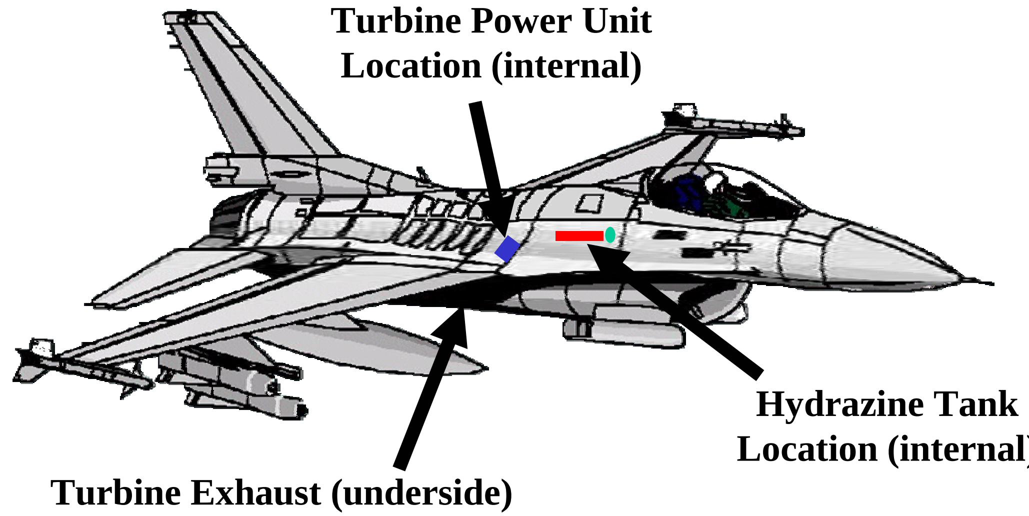
- Order of Precedence Terminology

System Safety MIL-STD-882D <u>Mitigation Measures</u>	Environmental ISO 14001 <u>Preventive Actions</u>	Occupational Health OHSAS 18001 <u>Controls</u>
Design selection	Eliminate at the source	Eliminate hazard
Safety devices	Re-use/Recycle	Engineering controls/isolation
Warning devices	Treatment	Administrative
Procedures & training	Disposal	Personal Protective Equipment

Using MIL-STD-882D to Integrate ESOH

- **Needed a vehicle to do two things:**
  - **Link environment to safety and health**
  - **Embed ESOH in the engineering process in order to influence the design process**
- **Chose 882 approach over NEPA because 882 had**
  - **Existing direct connections to the DoD Acquisition Engineering process lacking in NEPA**
  - **Risk acceptance concept that ensures senior leadership involvement mirroring NEPA approval process**
  - **Analysis process analogous to NEPA**

The Need for Integrated ESOH Risk Management



Environment

Safety

Occ Health

Integrated ESOH Risk Assessment

Systems Engineering

Using MIL-STD-882D to Integrate ESOH

MIL-STD-882D Severity Categories expanded to include Environmental Risk

Description	Category	Environmental, Safety, and Health Result Criteria
Catastrophic	I	Could result in death, permanent total disability, loss exceeding $1M, or irreversible severe environmental damage that violates law or regulation.
Critical	II	Could result in permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, loss exceeding $200K but less than $1M, or reversible environmental damage causing a violation of law or regulation.
Marginal	III	Could result in injury or occupational illness resulting in one or more lost work days(s), loss exceeding $10K but less than $200K, or mitigatible environmental damage without violation of law or regulation where restoration activities can be accomplished.
Negligible	IV	Could result in injury or illness not resulting in a lost work day, loss exceeding $2K but less than $10K, or minimal environmental damage not violating law or regulation.

Using MIL-STD-882D to Integrate ESOH

U.S. AIR FORCE

Hazard Risk Index and Acceptance
DoDI 5000.2, E7.7 & MIL-STD-882D

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

HIGH(CAE)

SERIOUS (PEO)

MEDIUM (PM)

LOW (PM)

Summary

- **Integrate across E,S, and OH to optimize and balance decision-making**
- **Integrate ESOH into the SE process in order to influence the design process**
- **System Safety is the process best positioned to accomplish this**

[redacted]

BACK UP CHARTS

ESOH Rosetta Stone

- **Aspect – An element of a facility's activities, products, or services that can interact with the environment (create an environmental impact). An aspect can be thought of as the "cause" of an environmental impact. [ISO 14001, Environmental Management Systems and Office of the Federal Environmental Executive (OFEE) - Introduction to EMS Training Materials]**

- **Hazard –Any real or potential condition that can cause injury, illness, or death to personnel; damage to or loss of a system, equipment or property; or damage to the environment. [MIL-STD-882D, DOD Standard Practice for System Safety]**

ESOH Rosetta Stone

- **Impact – any change to the environment wholly or partially resulting from an organization's activities, products or services. An impact can be thought of as an "effect" or "outcome" of an environmental aspect. [ISO 14001, Environmental Management Systems and OFEE - Introduction to EMS Training Materials]**

- **Mishap – An unplanned event or series of events resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment. [MIL-STD-882D, DOD Standard Practice for System Safety]**

ESOH Rosetta Stone

- **Significance – A significant aspect is one that has or can have a significant impact on the environment. Sites select the exact criteria for determining significance. Examples of criteria are tendency to occur, severity of impact, regulatory issues, etc. [OFEE - Introduction to EMS Training Materials]**

- **Risk – An expression of the impact and possibility of a mishap in terms of potential mishap severity and probability of occurrence. [MIL-STD-882D, DOD Standard Practice for System Safety]**

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Surveying Systems Engineering Effectiveness

Joseph P. Elm

Sponsored by the U.S. Department of Defense

Background

Case studies have shown that properly implemented systems engineering can result in commensurate benefits

Broadly applicable quantification of these costs and benefits remains elusive

- Complicated by the lack of a broadly accepted definition of Systems Engineering
- Insufficient identification and tracking of Systems Engineering costs and efforts
- Exacerbated by increasing complexity and size of systems and Systems of Systems

The Task

The Office of the Under Secretary of Defense (AT&L) has tasked the NDIA Systems Engineering Division to research and report on the costs and benefits associated with Systems Engineering practices in the acquisition and / or development of military systems.

The Systems Engineering Effectiveness Committee (SEEC) is addressing this task via a survey of program and project managers across the defense industry.

Survey Objective

Identify the degree of correlation between the use of specific systems engineering practices and activities on projects, and quantitative measures of project / program performance.

Survey Method

Use the resources of NDIA SE Division to reach a broad constituency

The initial survey will focus on industry members of NDIA that are prime contractors and subcontractors

Collect feedback from project / program managers

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Survey Development Plan

1. Define the goal
2. Choose the population
3. Define the means to assess usage of SE practices
4. Define the measured benefits to be studied
5. Develop the survey instrument
6. Execute the survey
7. Analyze the results
8. Report
9. Plan future studies

Step 1:
Define the Goal

Identify correlations between SE practices and program performance

Step 2:
Choose the population

Chosen population consists of contractors and subcontractors providing products to the DoD

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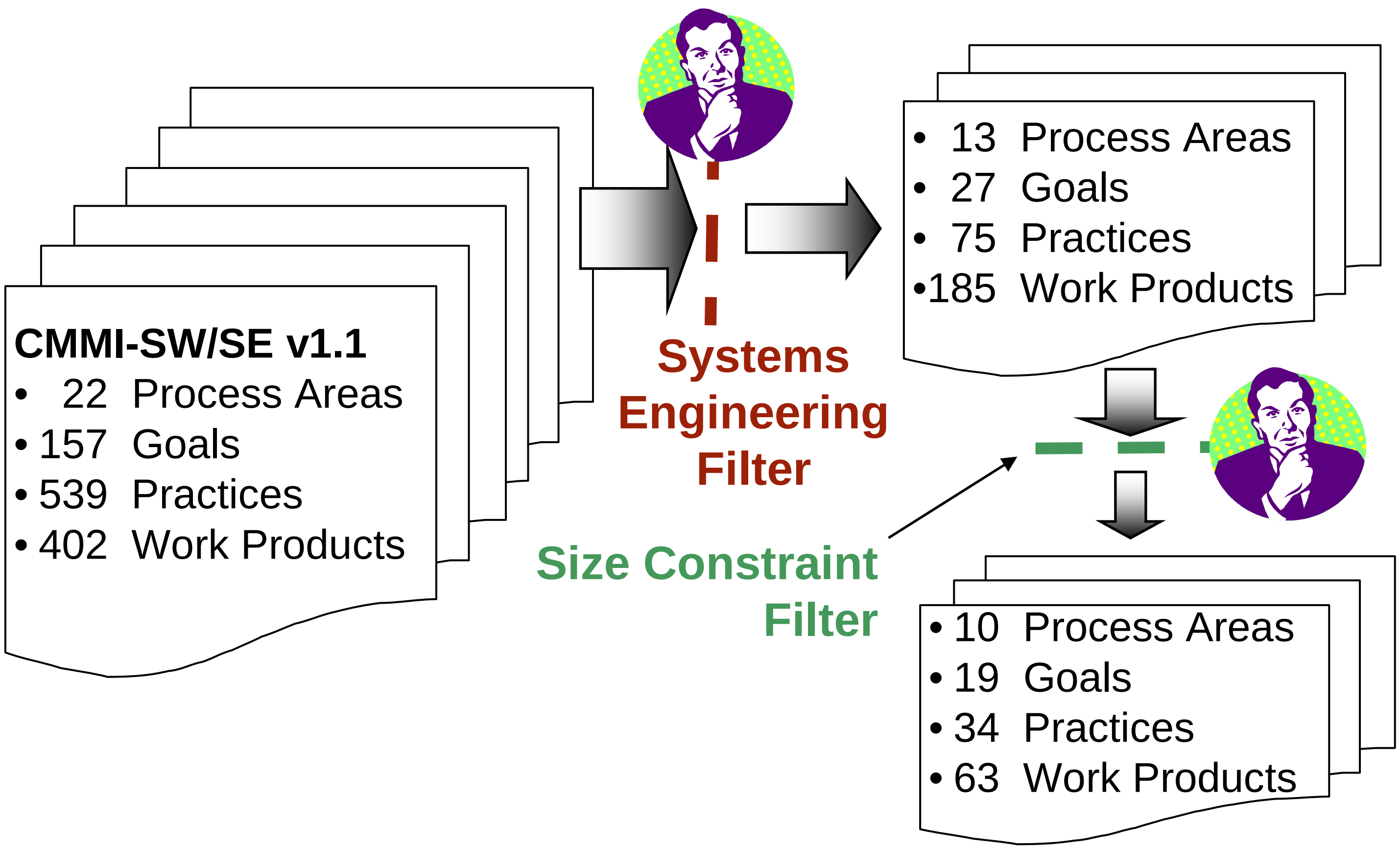
Step 3:
Define assessment of SE practices



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Step 4:
Define performance measures

Utilize measures common to many organizations

- Earned Value
- Award Fees
- Technical Requirements Satisfaction
- Milestone Satisfaction
- Problem Reports

Step 5:

Develop the survey instrument

Self-administration

- formatted for web-based deployment

Confidentiality

- No elicitation of identifying data
- Anonymous response collection
- Responses accessible only to authorized SEI staff

Integrity

- Data used only for stated purpose
- No attempt to extract identification data

Self-checking

Section 1
Project Characterization

Section 2
Systems Engineering Evidence

Section 3
Project / Program Performance Metrics

Section 1 - Characterization

Characterization of the project / program under consideration

- **Project / program**
  - Size - Stability
  - Lifecycle phase
  - Subcontracting
  - Application domain
  - Customer / User
  - etc.
- **Organization**
  - Size
  - Organizational capability
  - Related experience
  - etc.

Section 1: Characterization

The objective of this section is to gather information to characterize the project under consideration. This information will assist the survey analysts in categorizing the project, and the executing organization to better understand your responses.

1.1	**Project** – information to characterize the specific project under discussion. Size, stability, lifecycle phase, subcontracting, and application domain are among the parameters used for program characterization.	
1.1.1	What phases of the integrated product lifecycle comprise this project (check all that apply), and what phase are you presently executing (check 1)?	**Included in project (check all that apply** **Current phase (check 1)** ❐ ❐ Concept Refinement ❐ ❐ Technology Development and Demonstration ❐ ❐ Development ❐ ❐ Manufacturing ❐ ❐ Verification ❐ ❐ Training ❐ ❐ Deployment ❐ ❐ Operation ❐ ❐ Support ❐ ❐ Disposal
1.1.2	What is the current total contract value (US$) of your project?	$ ________________
1.1.3	What was the initial contract value (US$) of your project?	$ ________________
1.1.4	How many contract change orders have been received?	________________

SAMPLE

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Section 2: SE Evidence

Process definition
Project /program planning
Risk management
Requirements development
Requirements management
Trade studies
Interfaces
Product structure
Product integration
Test and verification
Project / program reviews
Validation
Configuration management

Section 2: Systems Engineering Evidence

			Strongly Disagree	Disagree	Agree	Strongly Agree
	Rate your agreement with the following statements					
2.1	**Process Definition**					
2.1.1	This project utilizes a documented set of systems engineering processes for the planning and execution of the project		❒	❒	❒	❒
2.2	**Project Planning**					
2.2.1	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that …	a. … includes task descriptions and work package descriptions	❒	❒	❒	❒
		b. … is based upon the product structure	❒	❒	❒	❒
		c. …is developed with the active participation of those who perform the systems engineering activities	❒	❒	❒	❒

Section 3: Performance Metrics

Earned Value

Award fees

Technical requirements satisfaction

Milestone satisfaction

Problem reports

Section 3: Project Performance Metrics					
3.1	Earned Value Management System (EVMS)				
	Rate your agreement with the following statements	Strongly Disagree	Disagree	Agree	Strongly Agree
3.1.1	Your customer requires that you supply EVMS data?	❒	❒	❒	❒
3.1.2	EVMS data is available to decision makers in a timely manner (i.e. current within 2 weeks)?	❒	❒	❒	❒
3.1.3	The requirement to track and report EVMS data is levied upon the project's suppliers.	❒	❒	❒	❒
3.1.4	Variance thresholds for CPI and SPI variance are defined, documented, and used to determine when	❒	❒	❒	❒

SAMPLE

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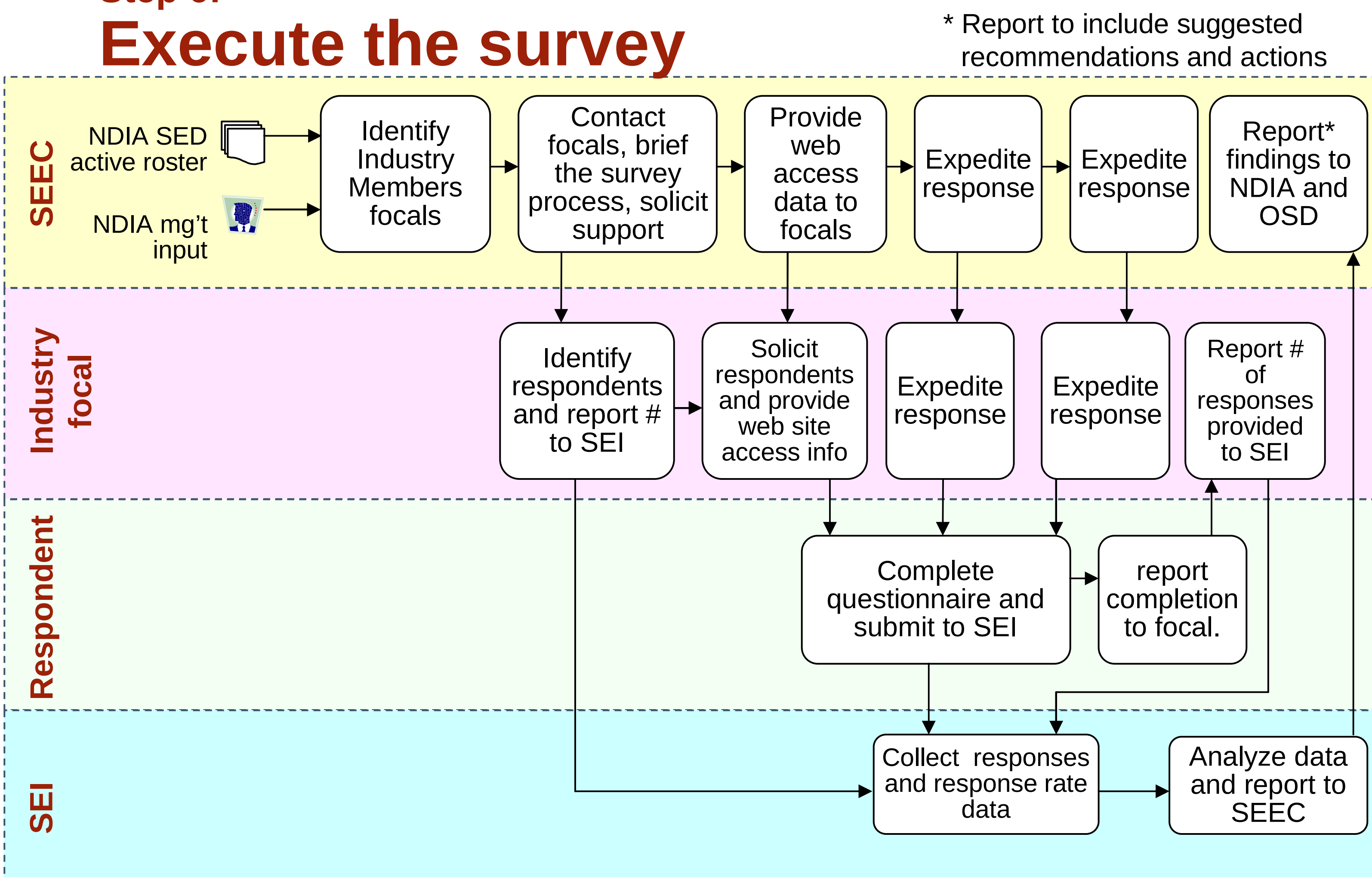
Step 6:
Execute the survey



Step 7:
Analyze the results

Partition responses based on project characterizations

Analyze survey responses to look for correlations between the SE practices and the chosen metrics.

Step 8:
Report

Summarize survey results and analysis in a report.

Step 9:
Plan future studies

Based upon the findings from the survey, the need for additional studies may be defined.

Status

Survey instrument development complete

Web deployment complete

Respondent identification in progress

Response collection through Nov.

Analysis through Dec. and Jan.

Report in Feb.

SE Effectiveness Committee

Dennis Ahearn	Marvin Anthony	Ben Badami
David P. Ball	Al Brown*	Al Bruns
Thomas Christian	Jack Crowley	John Colombi
Greg DiBennedetto	Jim Dietz	Brian Donahue
Terry Doran	Joseph Elm	John P. Gaddie
Donald J. Gantzer	Dennis Goldenson	Dennis E. Hecht
Ellis Hitte	James Holton	George Kailiwai
Ed Kunay	Jeff Loren	John Miller
Gordon F. Neary*	Brad Nelson*	Rick Neupert
Brooks Nolan	Michael Persson*	Bob Rassa
Rusty Rentsch	Paul Robitaille	Garry Roedler
Rex Sallade	Jay R. Schrand	Sarah Sheard
Jack Stockdale	Jason Stripinis	Mike Ucchino*
Ruth Wuenschel	Brenda Zettervall	

* co-chair

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Conclusion

Questions ?

Contact information

- Joseph P. Elm jelm@sei.cmu.edu

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BACK UP

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Target Audience

- AAI Corp.
- Alion Science & Technology
- Allied-Signal
- Anteon Corp
- AT&T
- BAE Systems
- BBN Technologies
- Boeing
- Computer Sciences Corp.
- Concurrent Technologies Corp.
- DCS Corp.
- DRS Technologies
- Foster-Miller Inc.
- GE
- General Dynamics
- Gestalt, LLC
- Harris Corp.
- Honeywell
- Hughes Space & Communications
- Impact Technologies LLC
- ITT Industries
- Jacobs Sverdrup
- L-3 Communications
- Lockheed Martin
- Motorola
- Northrop Grumman
- Orbital Sciences Corp.
- Raytheon
- Rockwell Collins
- SAIC
- Scientific Solutions, Inc.
- SI International
- Simulation Strategies Inc.
- Southwest Research Institute
- SRA International
- Support Systems Associates Inc.
- Systems & Electronics, Inc.
- TERADYNE, Inc.
- Titan Systems Co. (AverStar Group)
- Trident Systems, Inc.
- TRW Inc.
- United Defense LP
- United Technologies
- Virtual Technology Corp.
- Vitech Corp.

Selection criteria:
- Active in NDIA SED
- Contractors delivering products to the government

*Need Point-of-Contact (**Focal**) from each company to expedite survey deployment.*

EXPEDITIONARY FIGHTING VEHICLE

ESOH Integration into System Engineering

NDIA Conference 24-27 October 2005

PURPOSE

Highlight the Challenges of Integrating

ESOH

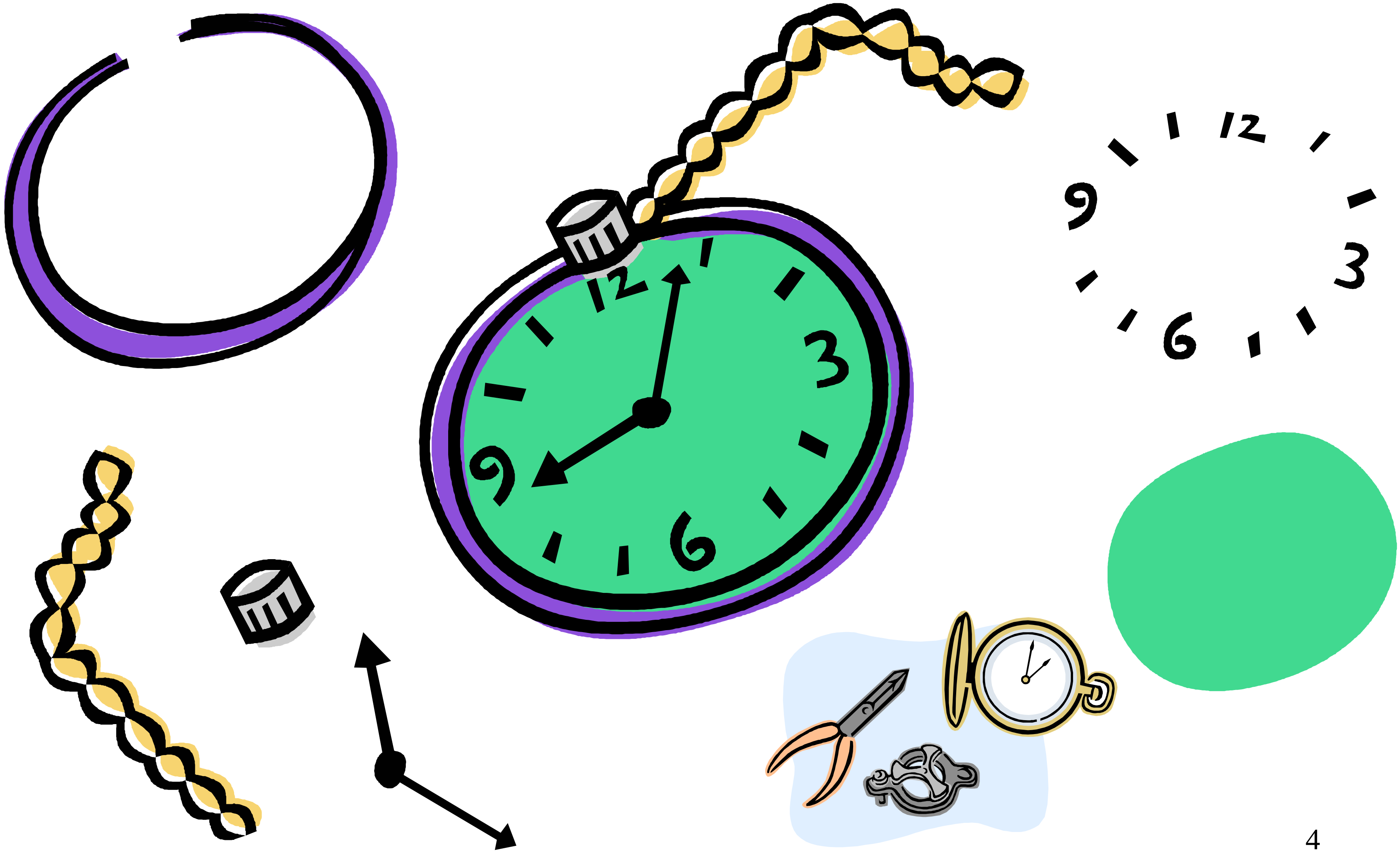
into the

Systems Engineering Acquisition process

KEY POINT

IT CAN BE DONE

BUILDING A WATCH



EXPEDITIONARY FIGHTING VEHICLE

MISSION ESSENTIAL FUNCTIONS

Move (Land)

Move (Water)

Shoot

Communicate

Carry

Protect

EFV MISSION

Provide High Speed Transport of Embarked Marine Infantry From Ships Located Beyond the Horizon to Inland Objectives

Provide Armor Protected Land Mobility and Direct Fire Support During Combat Operations

EFV DEVELOPMENT

FY95 - FY01

Program Development & Risk Reduction (PDRR)

1st Generation Prototypes

Integrated Functionality, Full Up System

Design Cycles

1st Gen Prototypes

FY01 - FY06

System Development & Demonstration (SDD)

2nd Generation Prototypes

Mature the Design, Prepare for Production

2nd Gen Prototypes

Milestone C

Sept 06
MS - C

FY07 – FY10

Production Readiness & Low Rate Initial Production (LRIP)

Low Rate Initial Production Vehicles

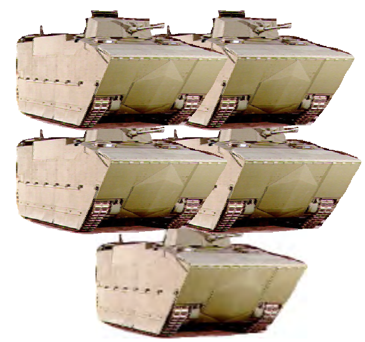
Full-Up System Live Fire, Initial Operational Test & Evaluation

LRIP

FY11 – FY20

Full Rate Production

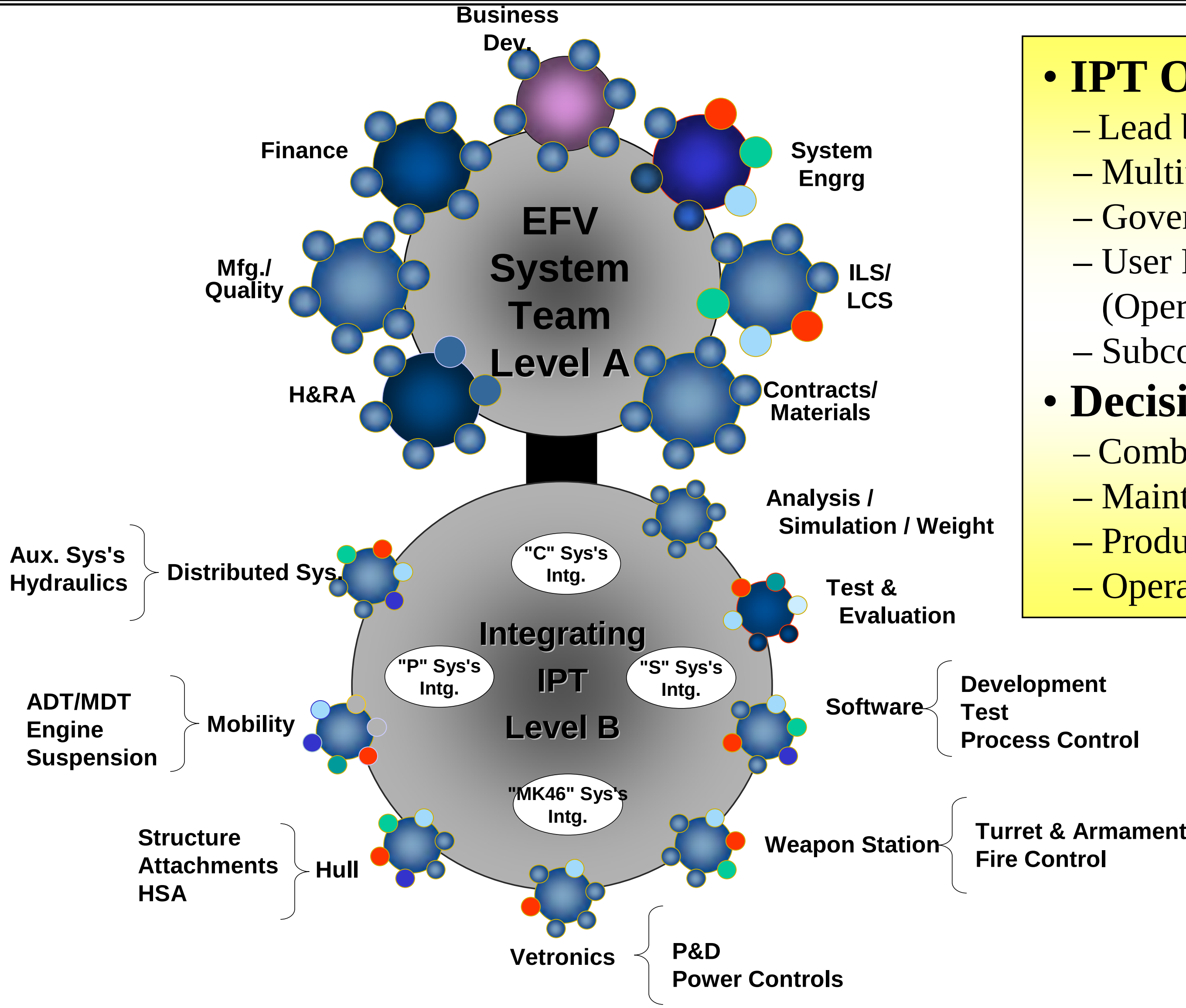
Full Rate Production Vehicles



EFV

FRP

INTEGRATED PRODUCT TEAMS



- **IPT Organization**
  - Lead by GDAMS
  - Multifunctional Representation
  - Government Representation
  - User Representation (Operator and Maintainer)
  - Subcontractor Representation
- **Decisions Made Based On**
  - Combat Effectiveness
  - Maintainability
  - Production costs
  - Operations and Support Costs

Key to Representatives

- Marine Corp
- Test & Evaluation
- Systems Engineering
- ESOH

EFV DEVELOPMENT
"Program Development and Risk Reduction Phase"

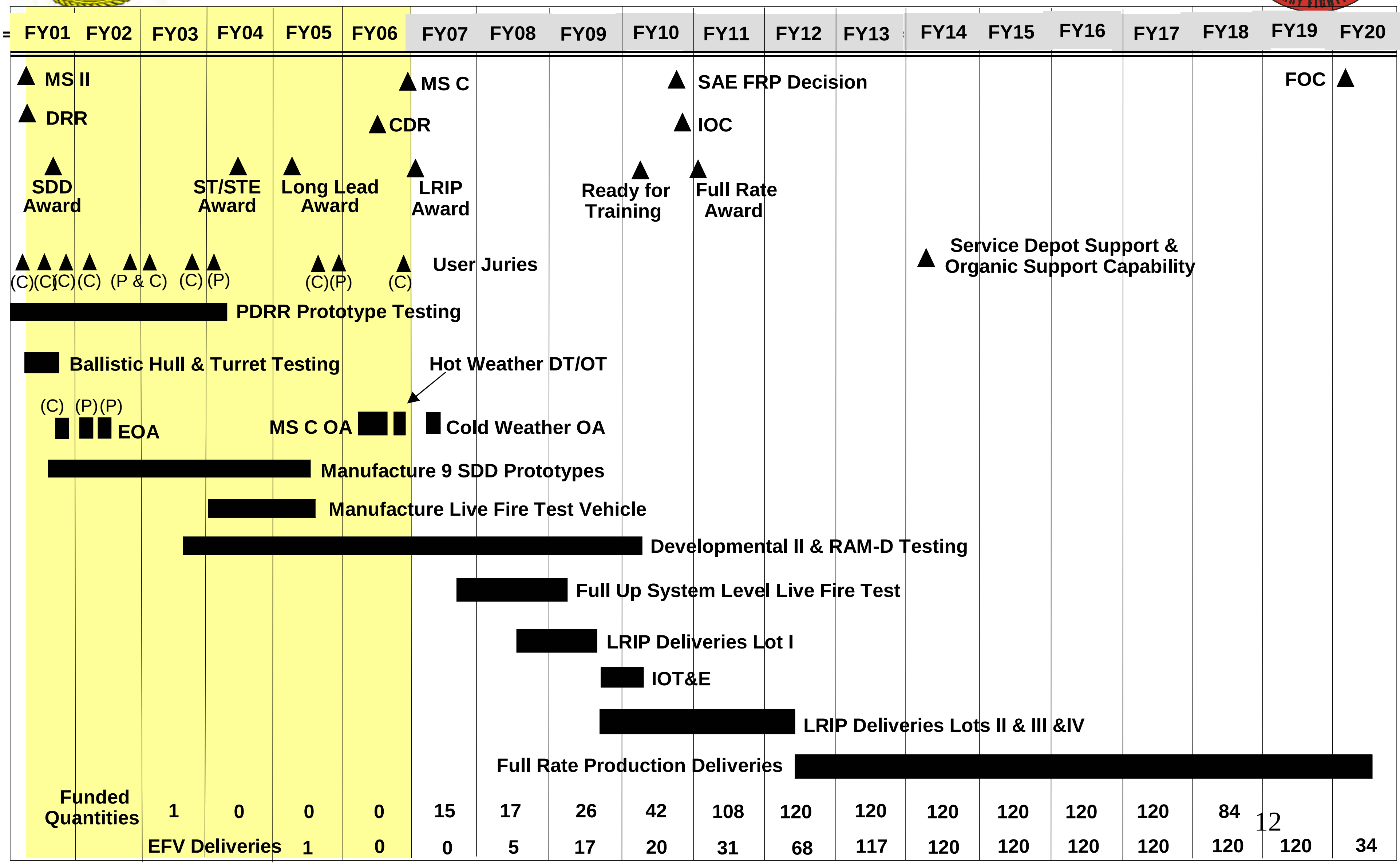
- **Utilized whole system trade process**
- **Manufactured three "objective" vehicle prototypes**
- **Conducted initial Live Fire Test**
- **Conducted Early Operational Assessment**

EFV DEVELOPMENT

"System Development and Demonstration"

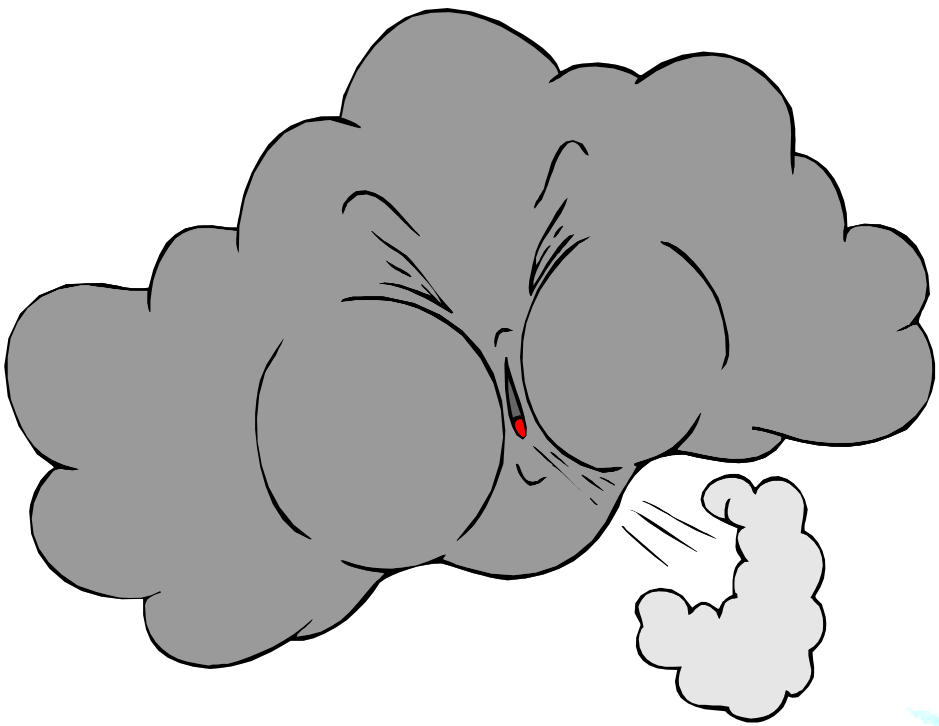
- **Build and test (DT and OT) SDD second generation prototypes**
- **Continue to mature the vehicle**
- **Develop manufacturing / production processes**
- **Build school facilities**
- **Conduct Pre-Milestone C OA**
- **Prepare for Low Rate Initial Production**

EFV PROGRAM SCHEDULE
24 March 2005



Environmental, System Safety and Occupational Health Integration

FOUNDATION



WHY SUCCESSFUL?

- Strong Foundation
  - ORD / CPD
  - SOW
  - Specification
  - Management Support
    - Policy Statement
- Strategy & Processes
- Flexibility
- Stretch The Limits

STRETCHING

- **NO carcinogens**
- **NO teflon**
- **Comply with ALL current and emerging laws**
- **No toxic fumes under normal or abnormal conditions (fire)**
- **No ODS**
- **Subcontractor's requirements same**

ESOH RISK DEFINITIONS

CATEGORY	DESCRIPTION	MISHAP DEFINITION
Category I	**Catastrophic**	**Exceeds maximum allowable use, release, or consumption** (E). **Death, system loss, or severe environmental damage** (S). **Personnel exposure levels lead directly to death or complete disability** (H)
Category II	**Critical**	**Significant impact on site/facility annual allowable use/release consumption** (E). **Severe injury, severe occupational illness, major system or environmental** (S). **Personnel exposure levels exceed maximum legal exposure or single exposure level suspected to result in severe occupational illness or severe health degradation/partial disability** (H).
Category III	**Marginal**	**Allowable release rate/consumption requiring Permit/Waiver** (E). **Minor injury, minor occupational illness, or minor system or environmental damage** (S). **Personnel exposure level exceeds allowable continuous exposure level resulting in minor occupational illness or occupational restrictions and temporary disability** (H).
Category IV	**Negligible**	**Monitored by Federal, State, Local agencies, No Permit/waiver required** (E). **Less than minor injury, occupational illness or less than minor system or environmental damage** (S). **Personnel exposure level within OSHA standards or other applicable TLVs resulting in negligible occupational illness or only minor health impacts** (H).

HEALTH – NORMAL OPERATIONS
SAFETY – MISHAP

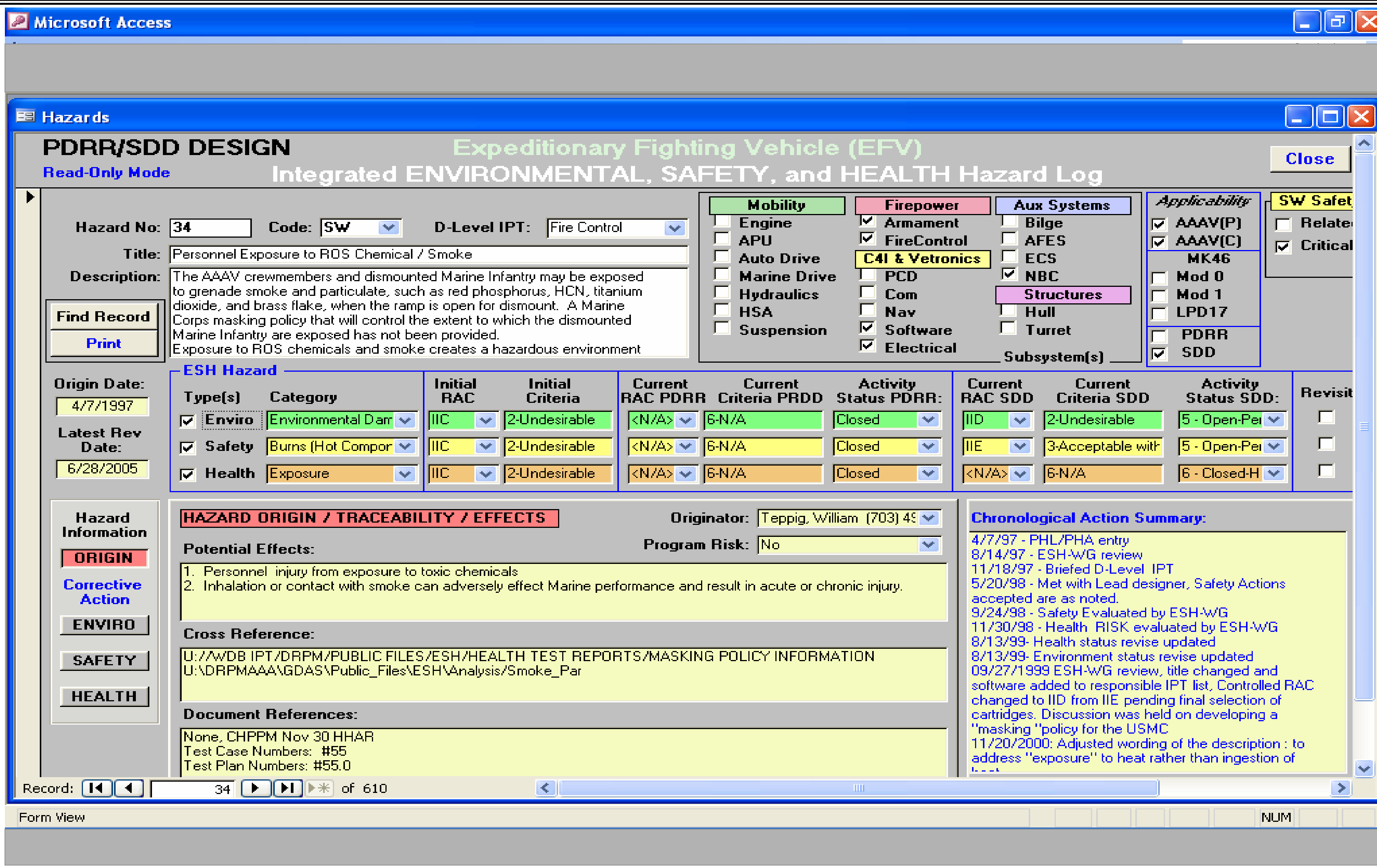
ESOH DATABASE

- **Access Database with all Environmental, System Safety and Occupational Health Hazards in a Single Database that allows Relative Ranking of Risk from the Program Manager’s perspective.**

- **The form changes as data entries occur and allows coverage of risks from design concept to disposal with a continuous chronological list of events as well as cross references to documents, drawings and other sources of data.**

- **Scope of risk includes traditional hardware and procedural risks as well as software, health, and environmental issues.**

ESOH DATABASE



CHALLENGES

- Status Quo
- Path Of Least Resistance
- Technology Shortfalls
- Balance Between Cost, Schedule, Performance
- Contractor Concern – Today's Dollar's
  Not Life Cycle Cost

SUCCESSES

- **Requirements Flow Down To Subcontractor's**
- **Trivalent Chromium**
- **Water reducible CARC**
- **Engineers /T&E/ IPT's Asking Questions**
- **QA & Logistic Engineers "Catching" & "Reporting" Non-Compliant Parts**
- **FM-200 Approval For Use**
- **Tracking Hazmats To Grams**

New Guidance Coming out – Already There

HOW

- **Proactive**
- **Involved With System Engineers Vice Versa**
- **Support IPT's**
- **Review TIR, FRACAS/DCACAS, STR**
- **Sign Off ECP's**
- **Procurement Request**
- **Education**
- **Establish Procedures – Safety Alert**

FIRM, CONFIDENT PUSH

IT CAN BE DONE

It takes Work!!!!

Be Consistent & Persistent

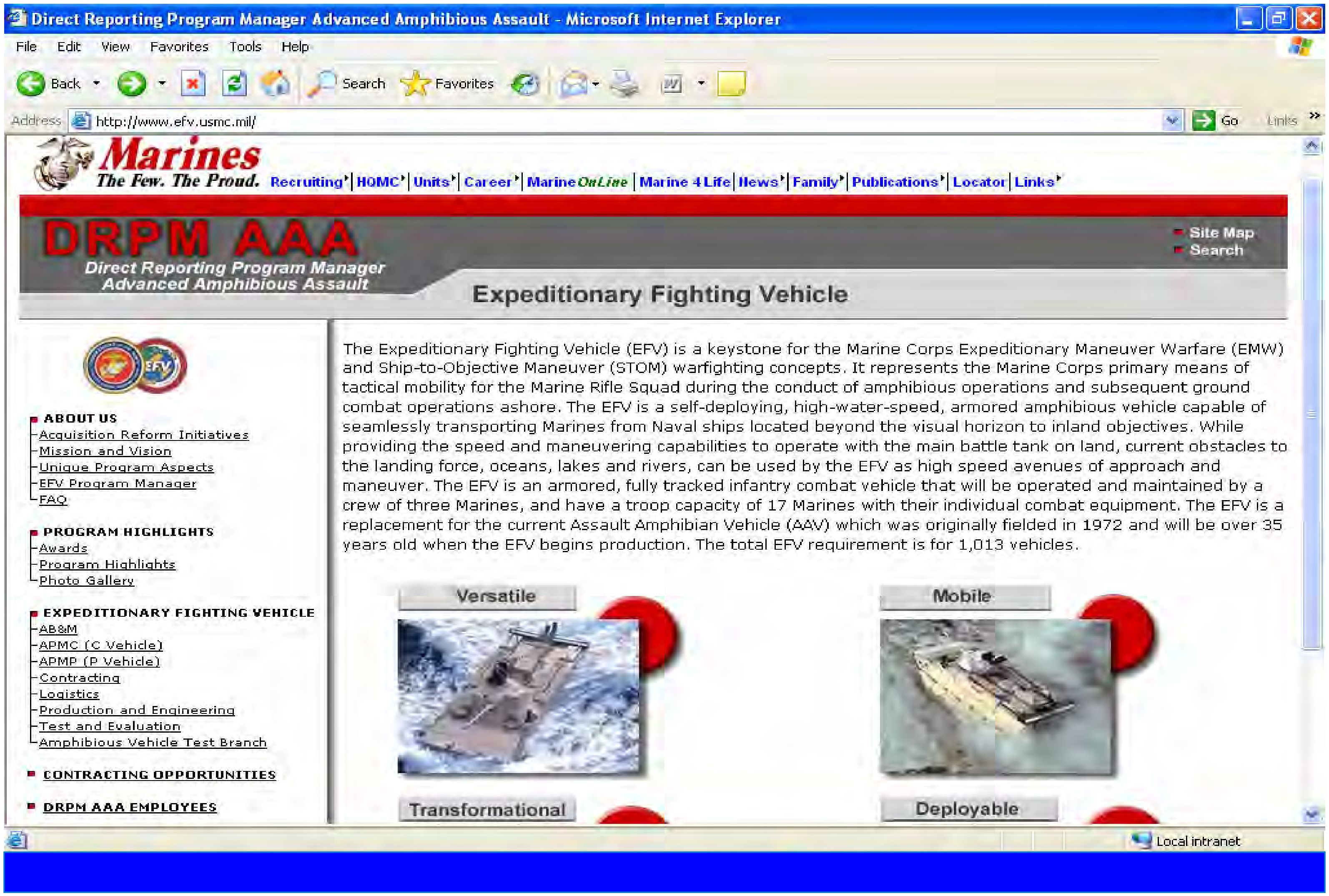
It is Challenging

The End...

QUESTIONS??

DRPM AAA
Web Site Address

http://www.efv.usmc.mil



Presenter

Ms. Sandra G. Fenwick
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EXAMPLES

ORD

Environmental Safety and Health (ESH). (Threshold)

The AAAV program will meet all environmental, safety and health Federal, State, and Local laws and regulations throughout the vehicle life cycle. Consideration must be given to the potential environmental impacts associated with developing, fielding, operating, maintaining, and disposing of the AAAV, and these considerations will be documented in accordance with the National Environmental Policy Act (NEPA). MIL-STD-882D shall be used as guidance for System Safety. The AAAV will meet all safety requirements established by applicable ESH-related review boards (e.g., the Weapons Systems Explosives Safety Review Board, Lithium Review). The AAAV shall minimize the use of materials, substances, or chemicals that cause adverse environmental impact or adversely degrade the AAAV performance and operational readiness in potential theaters of operation (threshold).

CPD

(Capability Production Document)

Environmental Safety and Health (ESH). (Threshold)

The EFV program will meet all environmental, safety and health Federal, State, and Local laws and regulations throughout the vehicle life cycle. Consideration must be given to the potential environmental impacts associated with developing, fielding, operating, maintaining, and disposing of the EFV, and these considerations will be documented in accordance with the National Environmental Policy Act (NEPA) or EO 12114, as applicable. The EFV shall minimize the use of materials, substances, or chemicals that cause adverse environmental impact or adversely degrade the EFV performance and operational readiness in potential theaters of operation. MIL-STD-882 shall be used as guidance for System Safety. ……….. The EFV Program shall follow DoD directives and instructions such as MIL-STD-1472, MIL-STD-759, MIL-STD-1474 to implement Federal guidance from DODI 6055.1 in applying OSHA and non-DoD regulatory safety and health standards to military-unique equipment, systems and operations. Minimization of OH risk shall always be a consideration/factor when addressing safety and environmental concerns with the environment. ………………..

SOW

- 3.2.5.18 Environmental, System Safety, and Health (ESH) Management Program

  The Contractor shall update and maintain the System Safety Program Plan (SSPP), Hazardous Material Management Program (HMMP) Plan, and the Hazardous Material Management Program (HMMP) Report developed in PDRR. The Contractor shall ensure that all aspects of these plans and reports are integrated into the SDD system engineering process and design. The Contractor shall update and conduct where applicable the following ESH program analysis: System Hazard Analysis (SHA), Subsystem Hazard Analysis (SSHA), Software Safety Analysis, Fault-Tree Analysis, and the Operating and Support Hazard Analysis (OHSA). The Contractor shall closeout the PDRR developed ESH Hazard Tracking Log Database. The Contractor shall then use the residual PDRR ESH Hazards to establish the SDD baseline ESH Hazard Tracking Log Database retaining the PDRR Hazard Tracking Log Database for historical record and reference. The SDD baseline Hazard Tracking Log Database shall track residual PDRR ESH Hazards and document and track ESH Hazards discovered during PDRR Integration and Assembly, PDRR testing, and SDD phase. The Contractor shall provide access via the Virtual Design Database to the Hazard Tracking Log to the DRPM, IPTs and applicable support Contractors. The Contractor will use MIL-STD-882C and NAS 411 as guidelines. The Contractor, using Government Furnished Information from PDRR, shall update and maintain a Health Hazard Assessment (HHA). The Contractor shall conduct a HHA on the final system design prior to SDD contract end. The most current results of these ESH tasks and analysis shall be documented for Design Reviews and the final results included in the Final Design Reports. The Contractor shall develop the EFV design, including Software development and the MK46 as a subsystem, to minimize hazards and ensure compliance with all Federal, state, and local ESH laws, regulations, and standards. The Contractor shall consider the impact on the environment during test site selection and test planning. The Contractor shall provide documentation to support these test-related decisions which can be added to the DRPM AAA ESH Administrative Record. The Contractor shall provide documentation to support the Government-developed National Environmental Protection Act (NEPA) analysis, including documentation relating to component, subsystem, and system testing, and fielding. The Contractor shall provide technical support to the DRPM AAA in gaining approval from all ESH related Review Boards such as: Weapon Systems Explosive Safety Review Board (WSESRB), Software System Safety Technical Review Panel (SSSTRP). Program Environmental Impact Review Board (PEIRB), Laser Safety Review Board (LSRB), United States Marine Corps Headquarters Environmental Impact Review Board (USMC HDQTRS EIRB), Test Site Safety, and Test Site Environmental. The Contractor shall establish a procedure for handling ESH related Test Incident Reports (TIRs), FRACAS reports and Engineering Change Proposals (ECPs) to completion or closeout. Any documents affecting the system and subsystems' configurations shall be reviewed and concurred in by the Contractor's ESH team. The Contractor shall define and establish an ESH checklist for verifying vehicle test readiness prior to Contractor testing and vehicle delivery. The Contractor shall develop procedures for emergency operations and influence the integration of emergency equipment to include but not limited to as appropriate; emergency egress lighting, a "Flight" Recorder type device, and emergency flotation devices. The Contractor shall certify to the Government that each EFV is safe for operation and testing prior to each EFV delivery.

- 3.2.5.18.1 System Safety Assessment Report (SAR) [CDRL L022, Safety Assessment Report]

  The SAR shall be provided to the Government for approval and review. The SAR shall be updated as needed to incorporate design changes. The SAR shall be expanded to cover environmental and health areas in as much detail as the safety.

- **3.2.5.18.2** Hazardous Material Management Program (HMMP) Report **[CDRL L048, Hazardous Material Management Program (HMMP) Report]**

  The Contractor shall provide the HMMP Report to the Government for approval as described in CDRL L048. The HMMP Report will be updated as needed to incorporate design changes.

- 3.2.5.18.3 ESH Review Board Data Packages [CDRL L049, ESH Review Board Data Packages]

  The Contractor will be notified of ESH related Reviews by DRPM AAA letter. The Contractor shall provide a draft data package for ESH related reviews. The Contractor shall provide final data packages in electronic format for each of the ESH Reviews. The Contractor shall provide technical assistance in preparation of presentation materials for ESH reviews.

System Specification

ONLY A PORTION OF ESOH REQ.

- 3.3.1.2 Environmental Protection

  All materials, parts, and processes used in the EFV shall be compatible with the performance and environmental requirements specified by this specification.

  During the manufacture, operation, service, transportation or storage of the EFV, the use of known Environmental Protection Agency (EPA) Identified Hazardous Materials, Substances, Chemicals and/or Processes as prohibited or restricted by applicable Federal, state and local statutes shall not be used or emitted. Acceptable alternative methods and materials shall be indicated. The alternatives shall be evaluated and tested in accordance with existing DoD policy prior to their implementation into the system design.

  The system shall pursue an Ozone Depleting Substance (ODS)-Free design in its system, subassemblies, components, manufacture, operation, service, transportation, storage and material selection, which is in compliance with applicable Federal, state and local statutes.

- 3.3.1.3 Toxic Products and Formulations

  Material selection shall minimize personnel exposure during normal and abnormal situations, including outgassing caused by high temperature and/or fire environments. Solvent selection shall present the least hazard, consistent with functional requirements.

- 3.3.1.3.1 Toxic Fumes

  The EFV shall have provisions to prevent the accumulation of toxic fumes within personnel areas per MIL-HDBK-759 due to EFV operations, particularly engine, heaters, or weapons operation.

- 3.3.1.4 Dangerous Materials and Components

  The EFV and its components shall not use any material which produces hazardous environments during any phase of the life cycle. For example, materials such as lead, cadmium and polytetrafluorethylene will liberate toxic gases or liquids when exposed to extremely high temperatures, and therefore shall not be used.

- 3.3.6 SAFETY

  The system shall ensure the highest degree of safety and health, consistent with mission requirements, throughout its life cycle. The system shall have a warning and monitoring sensor package which includes appropriate displays and/or audible signals to advise crew members of hazardous conditions. All components shall be designed for ease of maintenance and removal to allow maintenance personnel the ability to access necessary components without requiring extraordinary time, effort, or personnel danger.

DRPM Policy Letter

DEPARTMENT OF THE NAVY
UNITED STATES MARINE CORPS
OFFICE OF THE DIRECT REPORTING PROGRAM MANAGER
ADVANCED AMPHIBIOUS ASSAULT
14041 WORTH AVENUE
WOODBRIDGE, VA 22192-4123

IN REPLY REFER TO:
7000
DRPM AAA/sgf
Ser 04.191
23 May 04

EXPEDITIONARY FIGHTING VEHICLE (EFV) PROGRAM
ENVIRONMENTAL, SYSTEM SAFETY, AND OCCUPATIONAL HEALTH (ESOH)
POLICY STATEMENT

This ESOH policy statement updates and reinforces the EFV ESOH policy issued in August 2001. I am pleased with our progress in the area of ESOH integration. Our efforts are viewed as a model for other Department of Defense (DoD) programs as evidenced by awards from the Environmental Protection Agency, Secretary of the Navy, and the Secretary of Defense. I intend to build on that success. I want to again emphasize that everyone involved in supporting the EFV design and development is responsible for considering the life cycle ESOH impacts of their recommendations and decisions. ESOH considerations will be integrated into the Systems Engineering process, all program reviews, and Integrated Product Team (IPT) decision making.

I expect each member in an EFV IPT to be cognizant and compliant to the ESOH requirements in Appendix E section E7.1.6 of the Regulation DoD 5000.2, "Operation of the Defense Acquisition Systems" of May 2003. As noted in Appendix E, design engineers shall minimize or eliminate system characteristics that produce safety or health hazards where practicable and cost effective. The six ESOH areas that must be considered in your decision making include: Compliance, the National Environmental Policy Act (NEPA), Safety and Health, Hazardous Materials, Pollution Prevention, and Explosives Safety as detailed in the Programmatic Environmental, Safety, and Health Evaluation. If these considerations are not part of your decision making process, you have not made a fully informed recommendation or decision.

As the program proceeds through System Development and Demonstration (SDD) and enters Low-Rate Initial Production (LRIP) each person in our IPTs must be familiar and compliant with the requirements of the NEPA. As we continue to be good environmental stewards, this powerful Procedural Law shall be used in making program decisions to ensure that the EFV does not significantly affect the environment during Developmental Tests, Operational Assessments, Production, and Disposal.

Our goal has remained unchanged - our legacy will be the fielding of the world's best EFV at the lowest life cycle cost. Only through your continued active participation to integrate ESOH considerations into the systems engineering process will we accomplish this goal in an environmentally responsible and safe manner.

M. M. Brogan
M. M. BROGAN
Colonel, U.S. Marine Corps

PESOHI STRATEGY

- Integrating ESOH requirements into systems engineering processes
- ESOH Risk management and mitigation measures integrated into Life Cycle Cost and development of the EFV
- Integral part of the test – fix – test analysis to provide the user with a product they need and can safely and healthfully use
- Product and process improvement approach to the design and fabrication of EFVs that will meet the user’s needs

Environmental Strategy

- Vehicle and Program compliance with all Federal, State and local environmental laws
- Eliminate unacceptable and undesirable environmental hazards from the design and lifecycle of the EFV
- Reduce lifecycle cost by proactively influencing the EFV design.

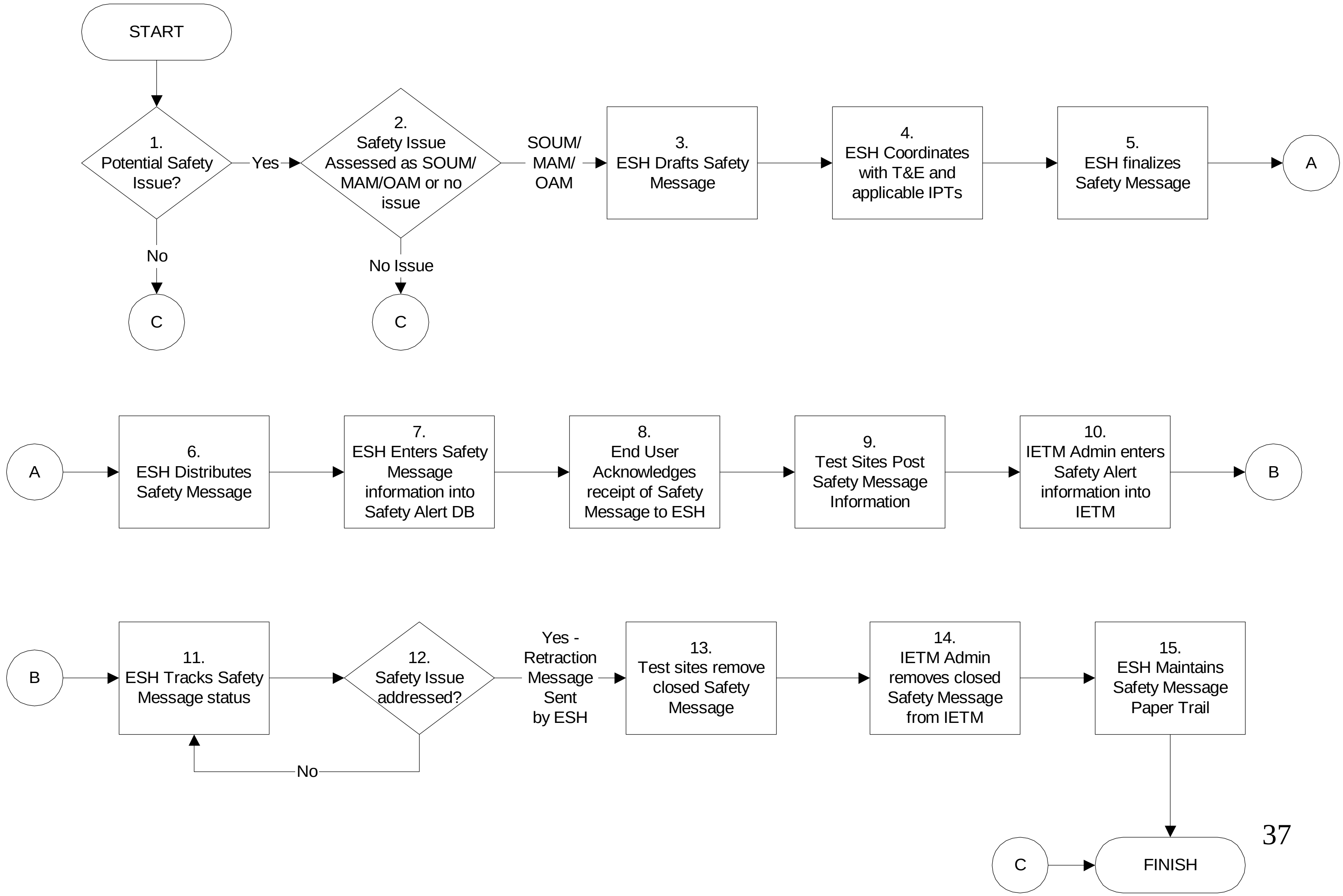
System Safety Strategy

- Eliminate unacceptable and undesirable system safety hazards from the design and the lifecycle of the EFV.
- Ensure DT and OA is conducted safely.
- Collect and analyze all necessary software system safety and system safety data prior to Milestone C.

Occupational Health Strategy

- Assure that the vehicle accommodates a safe, healthy work environmental for personnel.
- Ensure compliance with all local/federal/DoD laws and regulations; maintain knowledge of current guidelines and regulations.
- Proactively participate in the design to ensure hazards are controlled or eliminated from the start.
- Enhance Marine performance and ensure mission performance by eliminating/controlling hazards that may cause adverse health effects.
- Maintain a medical surveillance program to monitor potential exposures resulting from identified health hazards.
- Provide timely assessment response as part of the test-fix process to assist the development team in making informed decisions regarding the impact on health and personnel performance.

SAFETY ALERT PROCESS



8th Annual
Systems Engineering
Conference

Thursday, 27 October 2005

Using Commercial Simulation Software to Model Linear and Non-Liner Processes: US Military Academy Reception-Day Simulation and Optimization

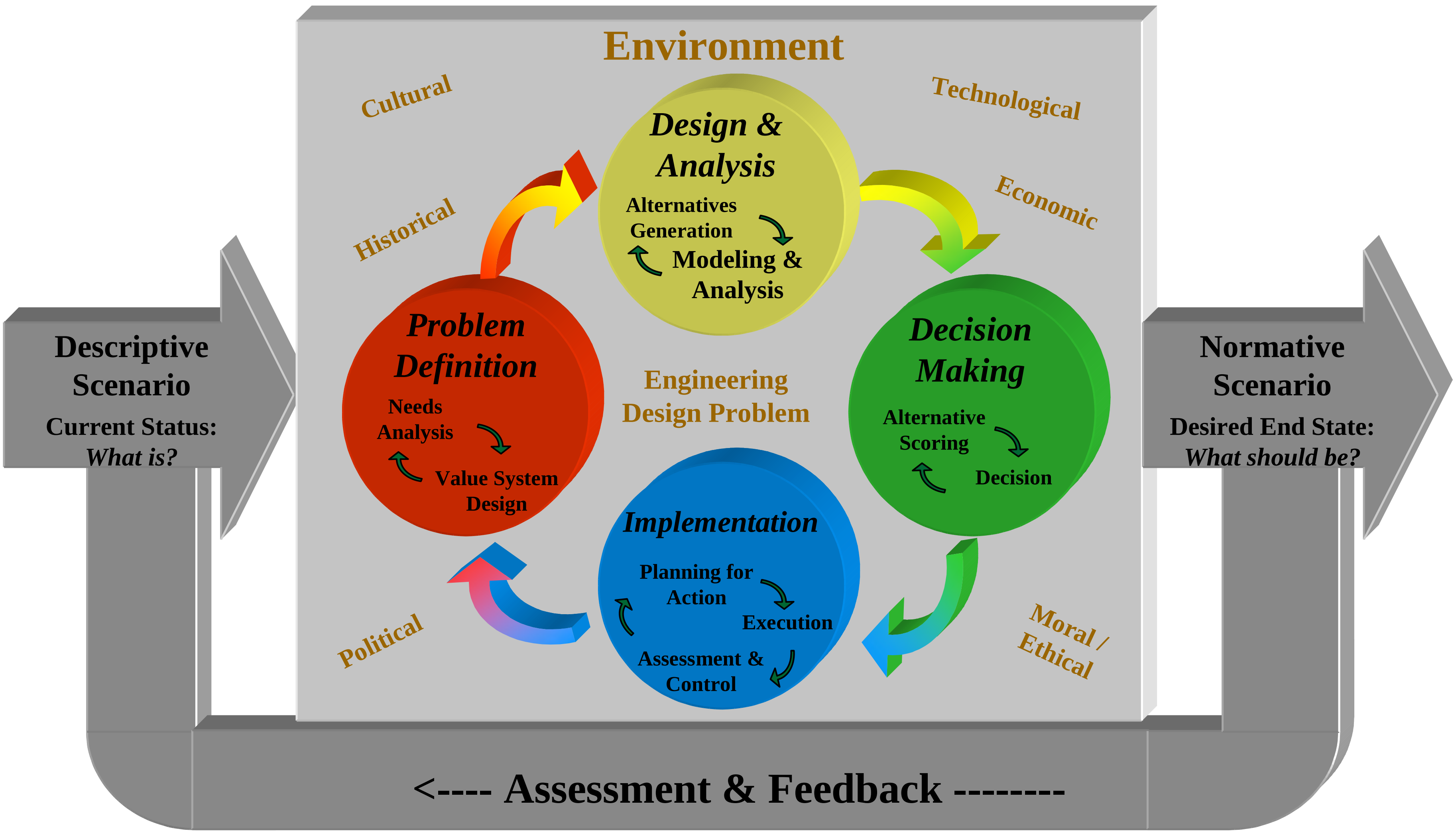
LTC Simon R. Goerger, PhD
2LT Stephen P. Fuller
2LT Jeffrey D. Glick
2LT Thomas P. Kavanaugh
Mr. Arlan C. Sheets

Operations Research Center of Excellence
Researching the Army's Future
Developing Tomorrow's Leaders

Agenda

- Systems Engineering Management Process
- Reception-Day Background
- Problem Statement
- Assumptions
- Overview of R-Day simulation in *ProModel*
- Initial analysis
- Alternatives
- *SimRunner* Optimization
- Study Conclusions
- Summary

Systems Engineering and Management Process



Reception-Day Background

- Process conducted annually in some form for over 200 years
- All tasks must be completed in one day between 0630 and 1730
- Over 1200 cadets in-processed annual for over 20 years
- Critical Reception-Day (R-Day) tasks
  - Thayer Hall (Linear)
  - United States Corps of Cadets (USCC) (Non-Linear)

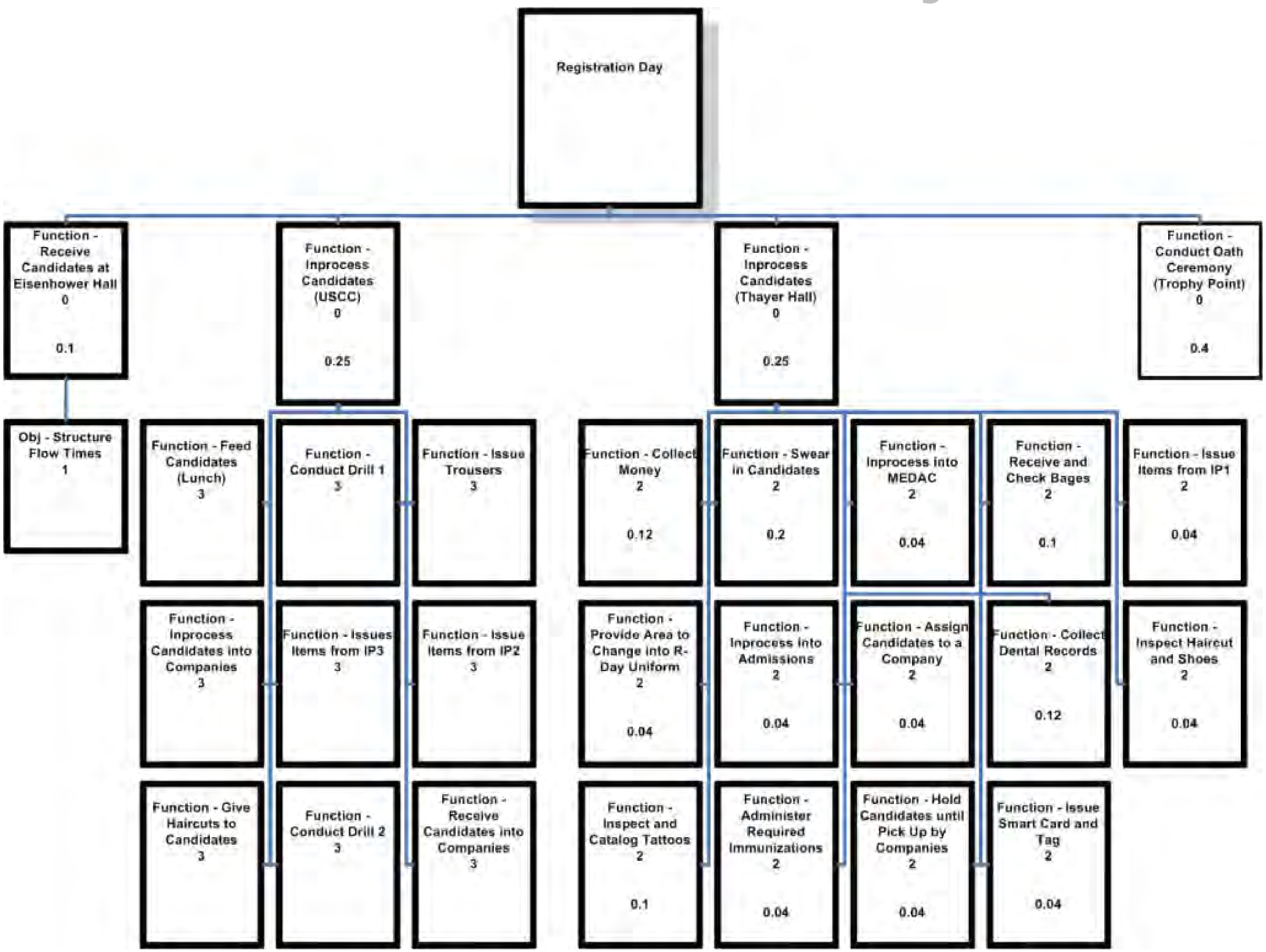
Problem Statement

- Stream line Reception-Day activities for in-processing new cadets into the Corps of Cadets from the initial arrival of candidates at Thayer Hall until the start of the Oath Ceremony to ensure all critical tasks and training are completed prior to the Oath Ceremony at 1745.

Information Resources

- Information Resources:
  - Admissions
  - “Beast” Company Commanders
  - Directorate of Logistics
  - Medical Department Activity
  - R-Day Director
  - Thayer Hall Non-Commissioned Officers
  - Treasurer
- Literature:
  - Operations Order (OPORDs) R-Day 2004
  - Data sets/maps from R-Day 2004
    - Data analysis implemented into model to greatest extent possible
  - Thayer Hall models form Academic Year 2004

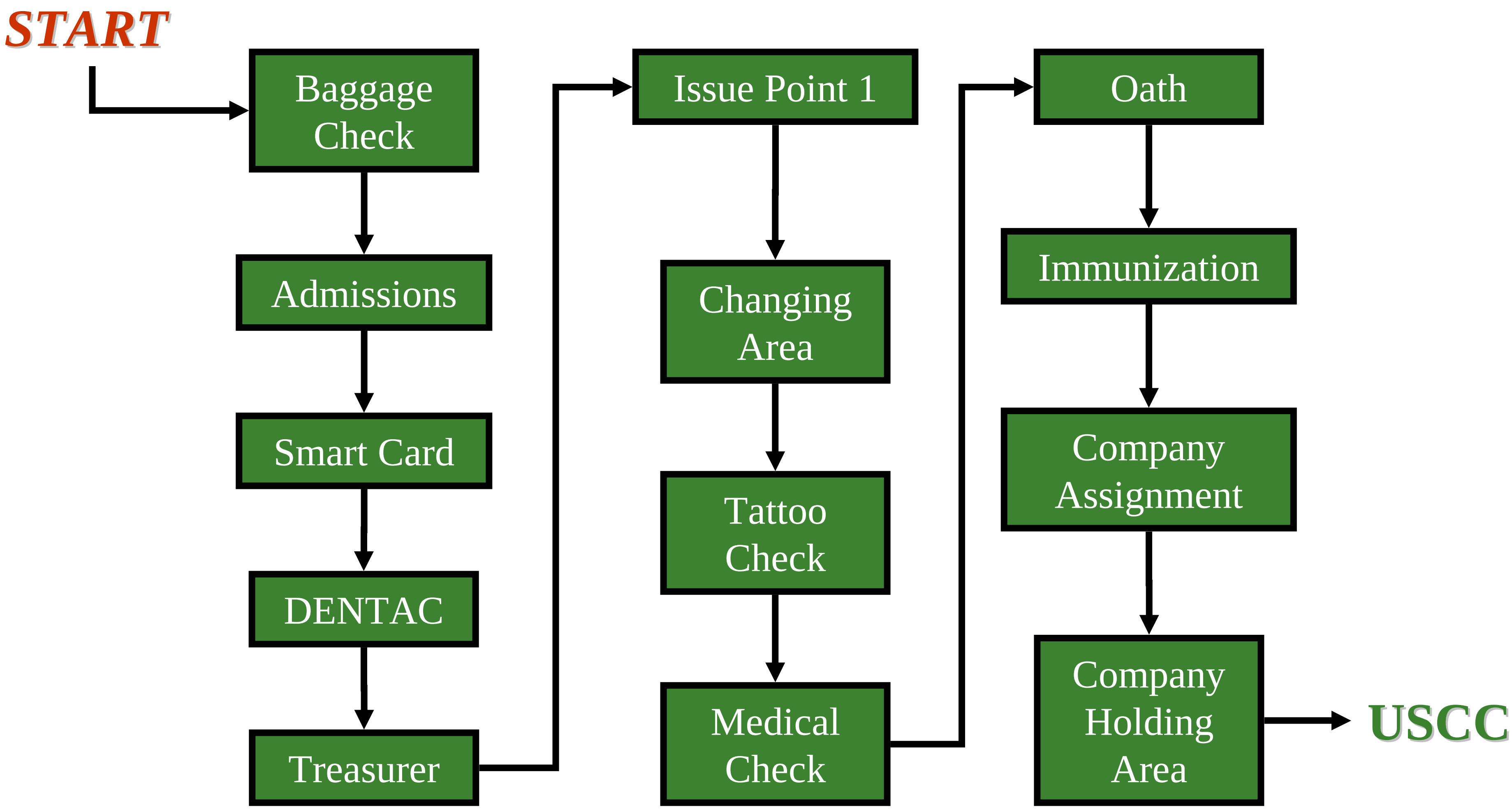
Value Hierarchy



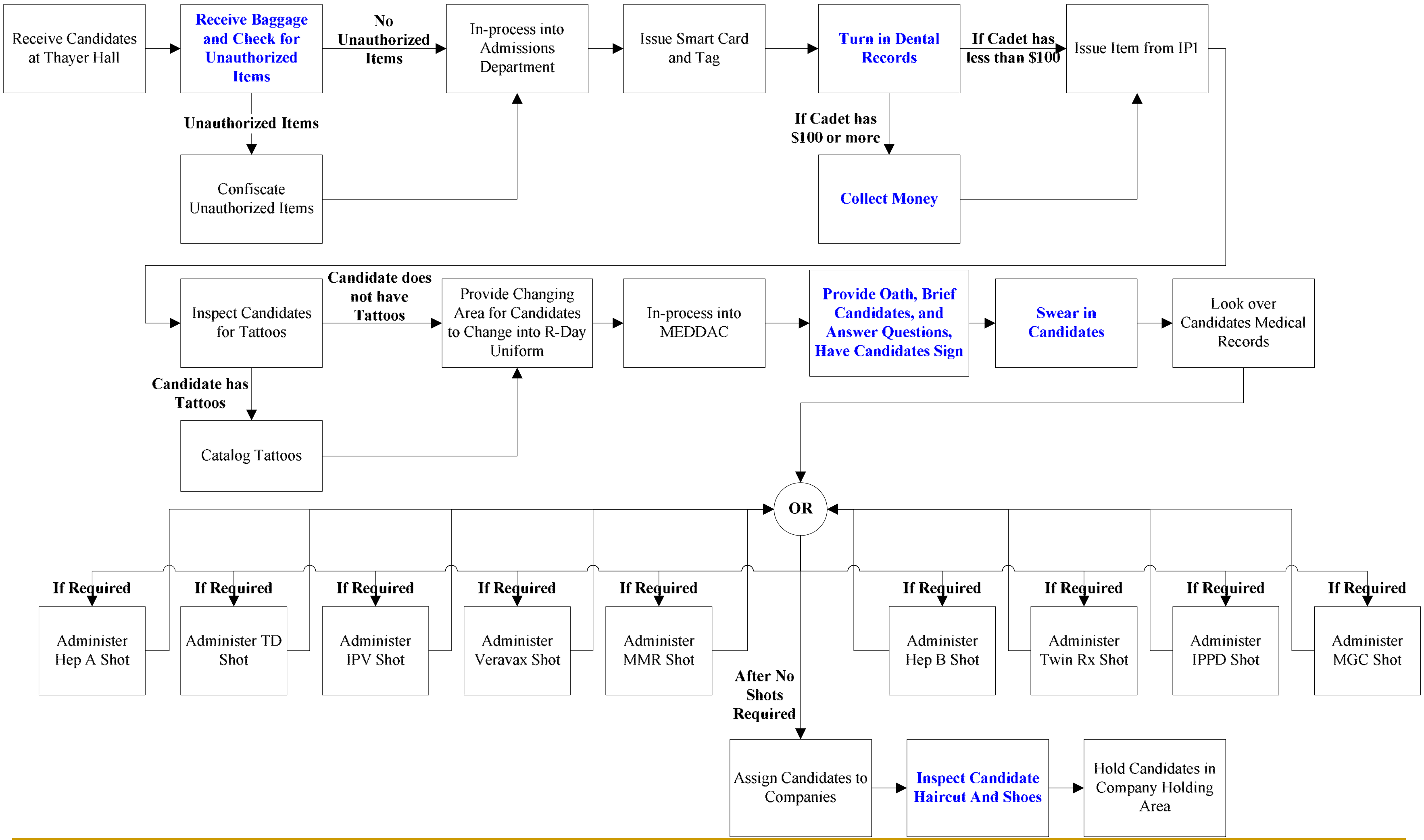
Assumptions

- Assumptions due to:
  - Modeling constraints
  - The need to account for imperfect data
- Examples:
  - Candidates return to Company Holding Area after each station
  - Candidates stay together as a single squad throughout the USCC portion of R-Day
  - All Candidates have trousers in hand when they leave Issue Point #2 (IP2)
  - Drill 1 and Drill 2 are combined
  - Every Candidate goes to the Barber Shop
  - IP3 and Company In-Processing grouped together

Process Flow: Thayer Hall

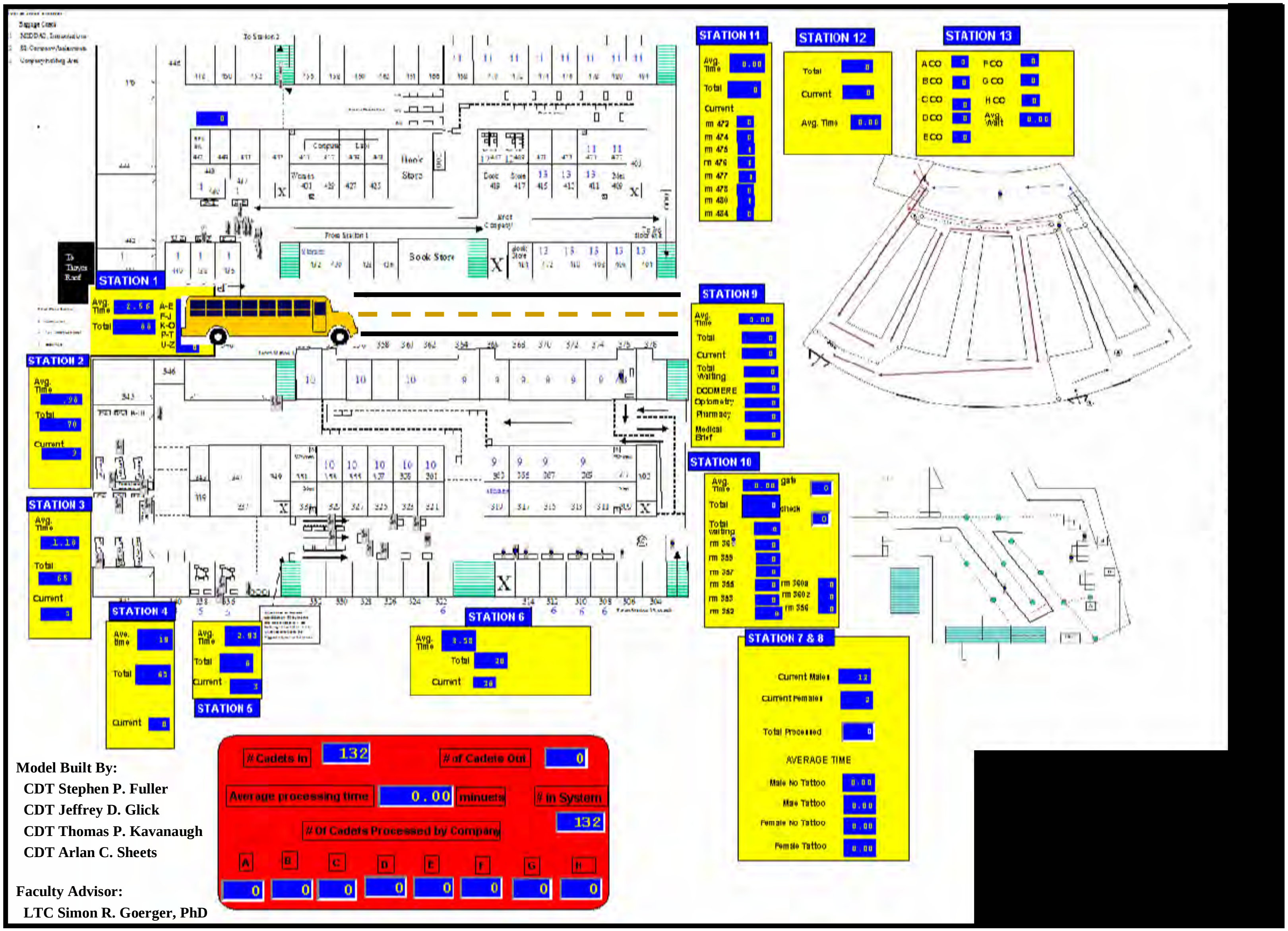


Functional Flow: Thayer Hall



Researching the Army's Future
Developing Tomorrow's Leaders

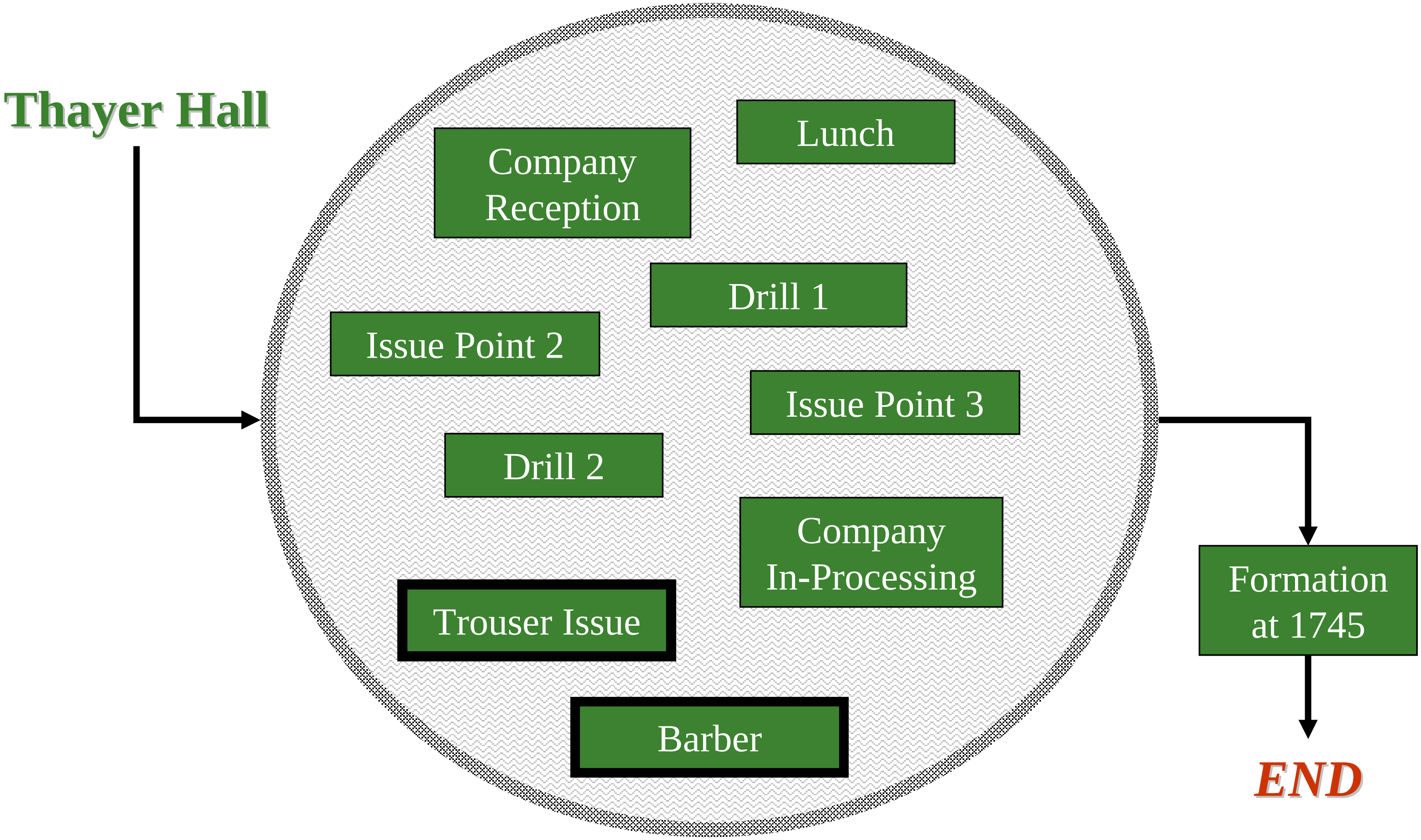
ProModel: Thayer Hall



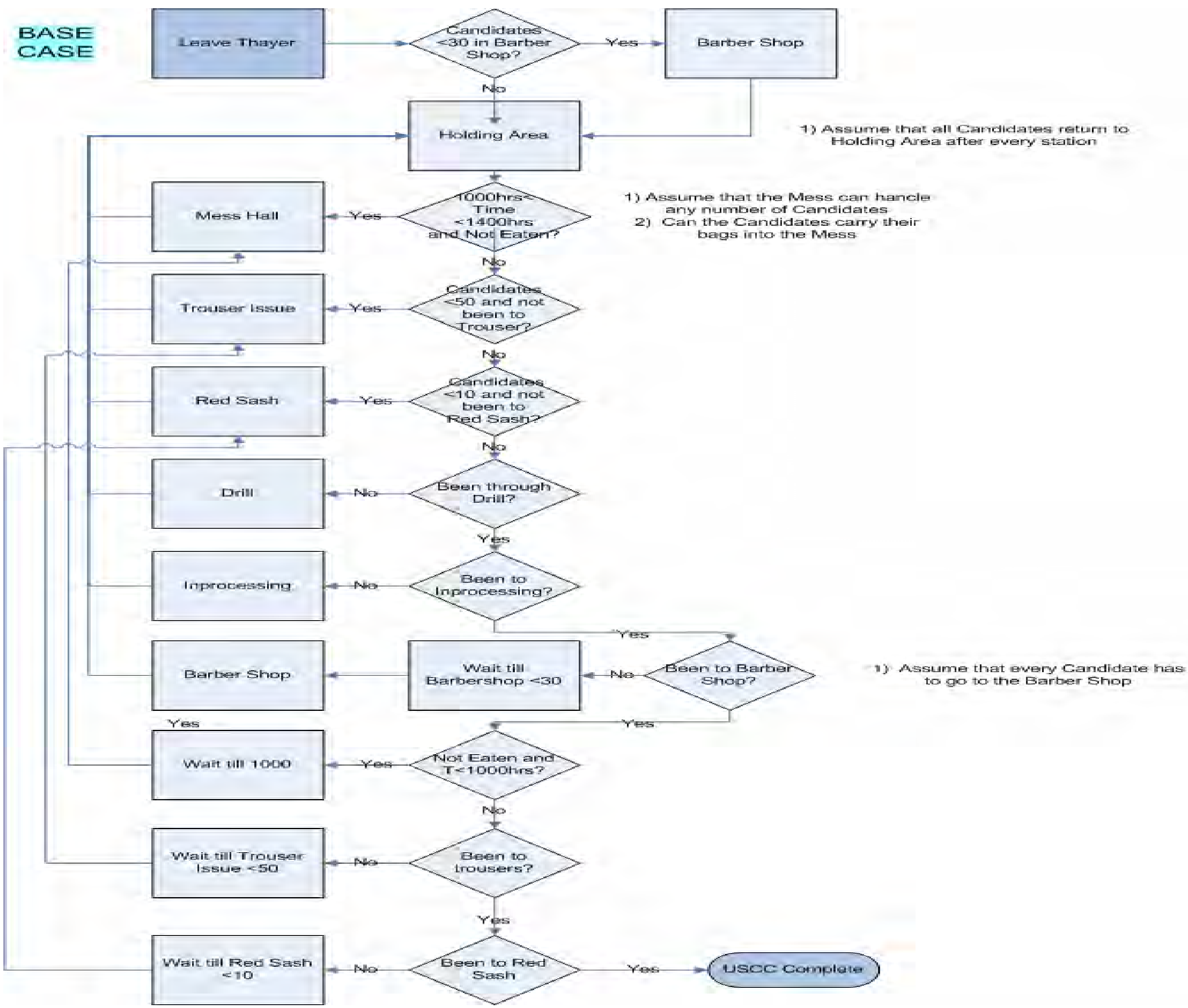
Model Built By:
CDT Stephen P. Fuller
CDT Jeffrey D. Glick
CDT Thomas P. Kavanaugh
CDT Arlan C. Sheets

Faculty Advisor:
LTC Simon R. Goerger, PhD

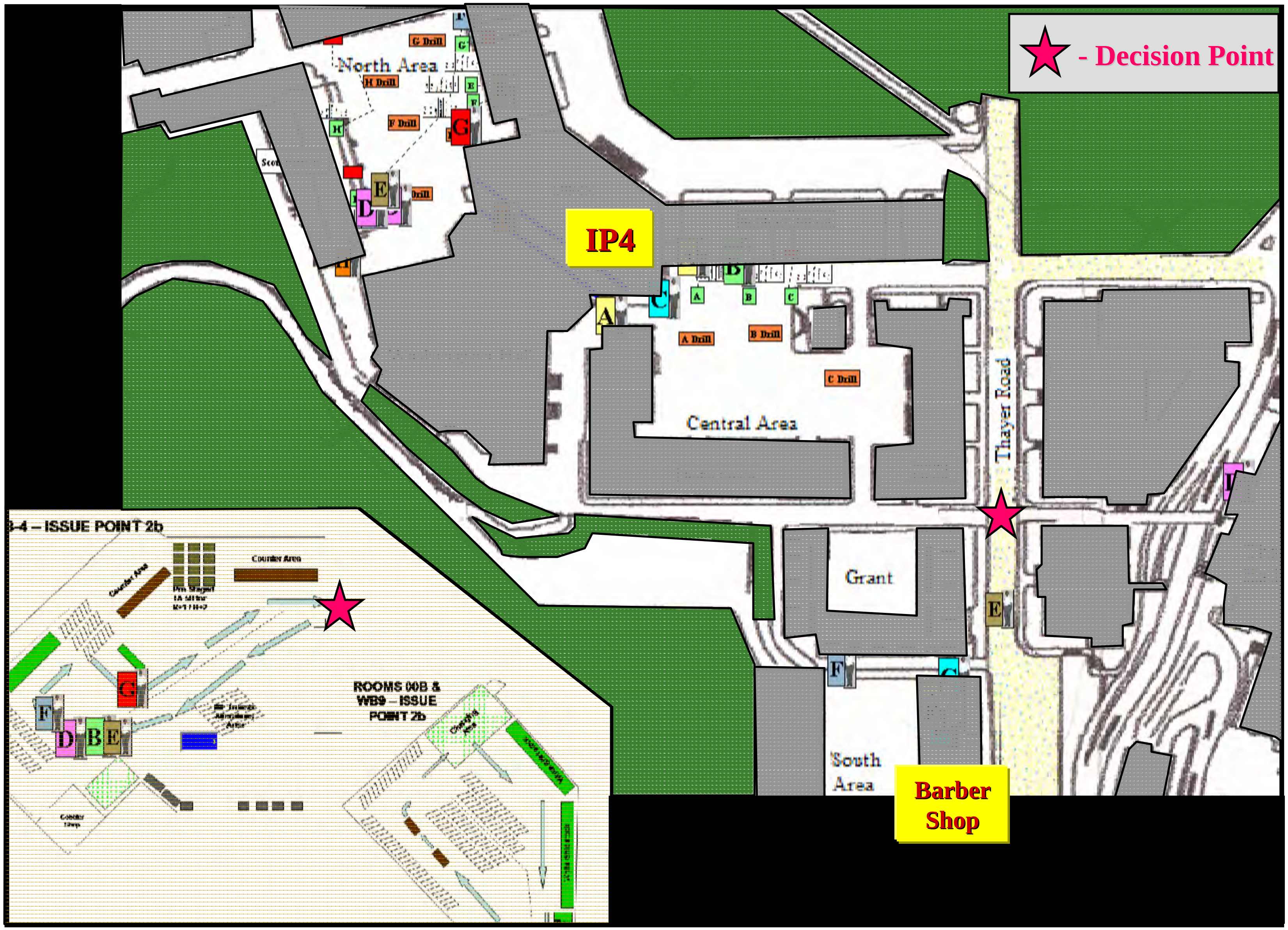
Process Flow: USCC



Functional Flow: USCC



ProModel: USCC



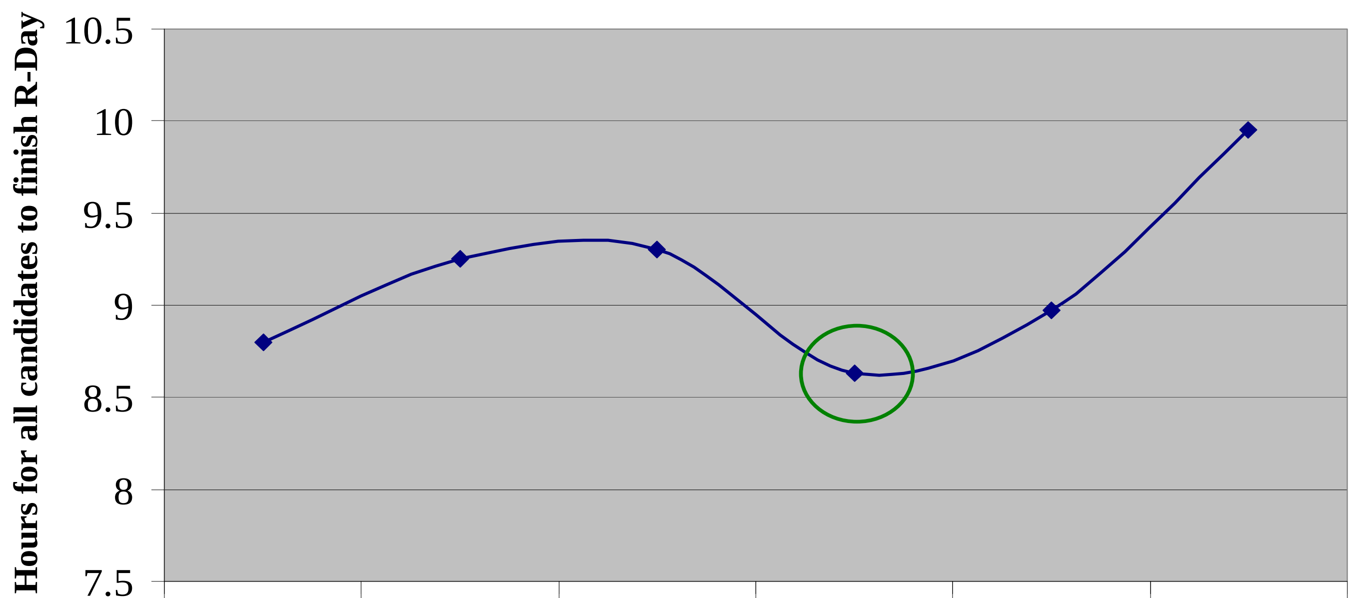
Alternatives/Issues

- Arrival rates of busses to Thayer Hall
- *Pick-up rates of the candidates from Thayer Hall*
- Routing of candidates in order to reduce average wait times at the barbershop and delaying trouser issue
- Number of Squad Leaders available
- Number of barbers available

Alternatives

- Arrival rates of busses to Thayer Hall
- ***Bottom Line: Buses should arrive to Thayer Hall approximately every 8:30***

Arrival Times to Thayer

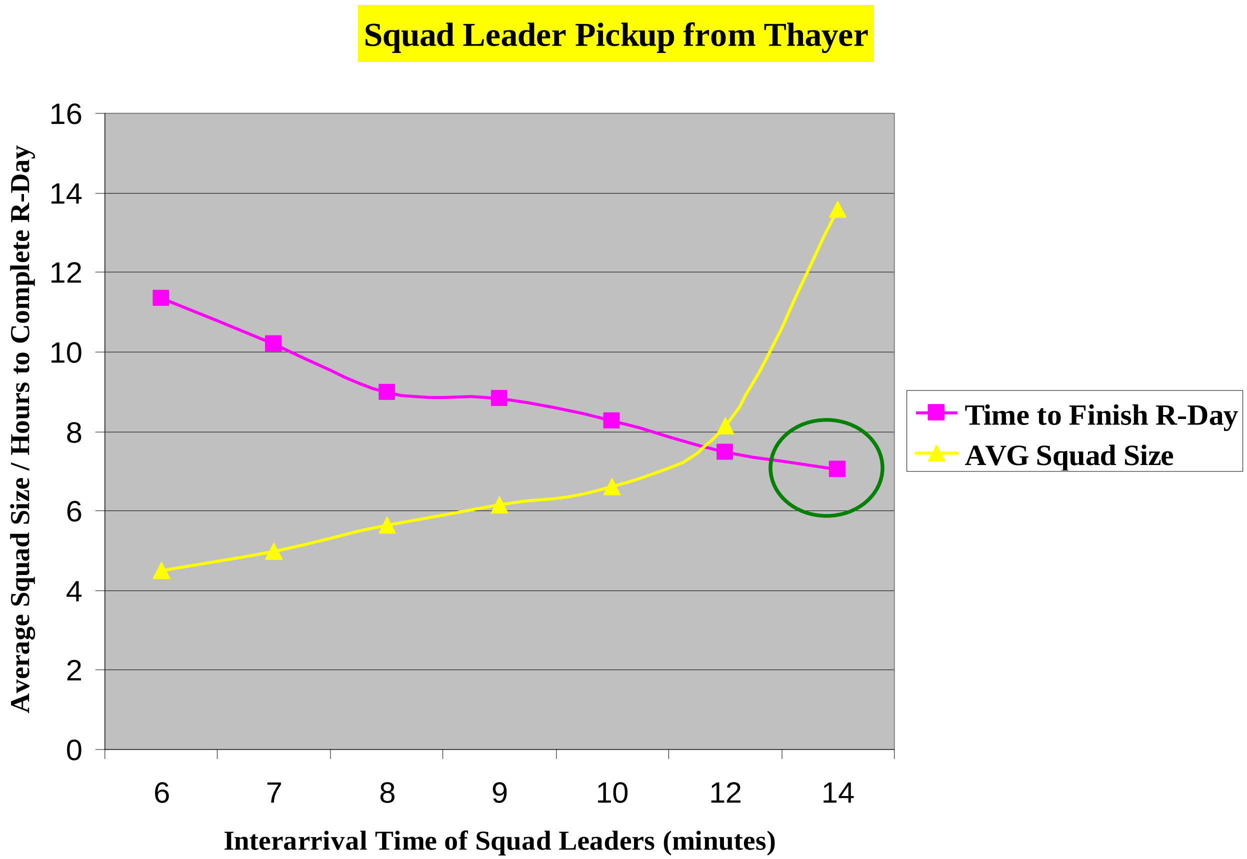


Time to Complete R-Day	8:48	9:15	9:18	8:38	8:58	9:57
Inter-Arrival Time	5	6	7	8	9	10

Interarrival Time (minutes)

Alternatives

- Pick-up rates of the candidates from Thayer Hall
- ***Bottom Line: Longer inter-arrival time = larger squads = shorter R-day***



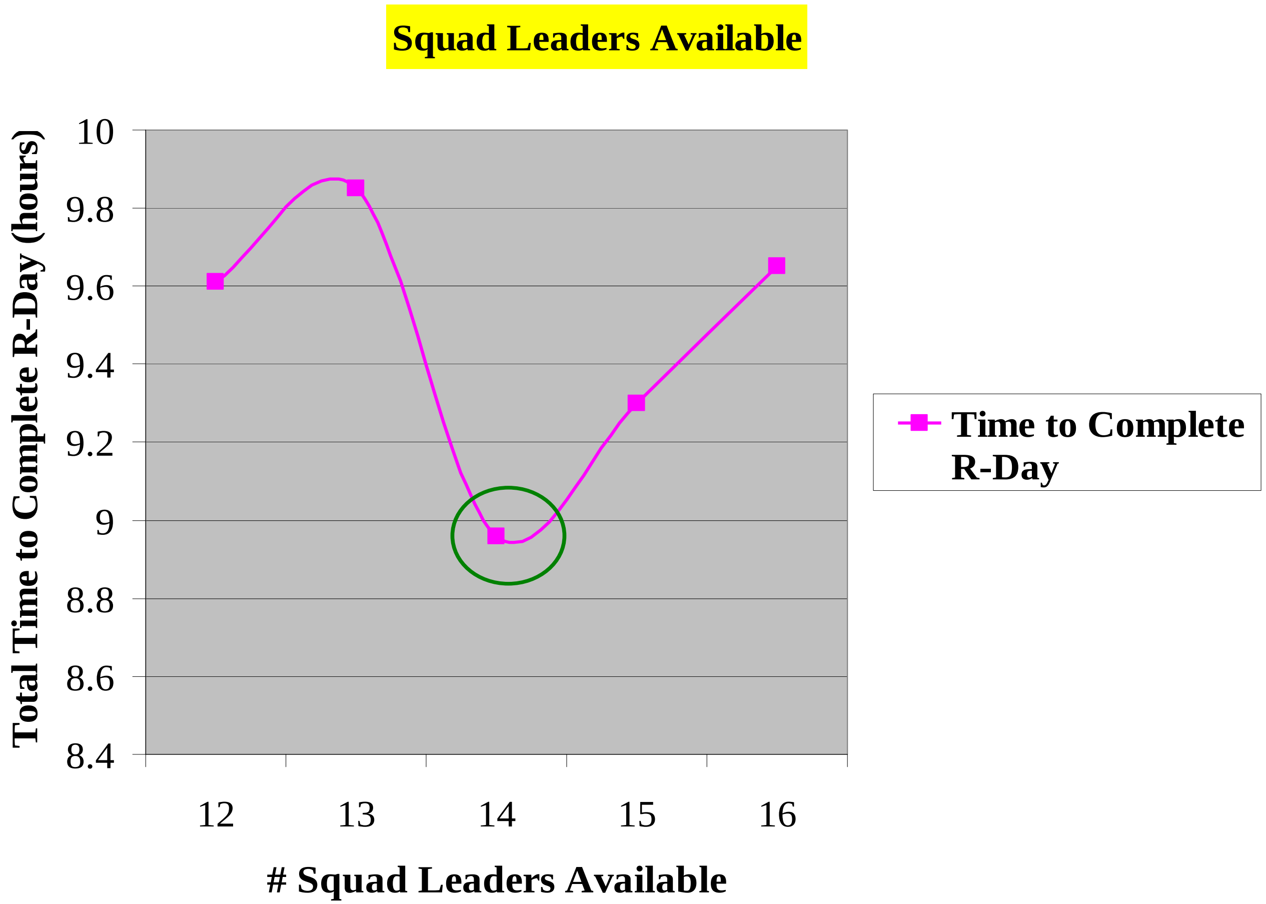
Alternatives

- Routing of candidates in order to reduce average wait times at the barbershop and delaying trouser issue
- ***Bottom Line: Limit the flow of cadets into the barber shop when trouser issue still incomplete***

Rule	Time to Complete R-Day
Haircut First	9:02
Trousers First	8:58

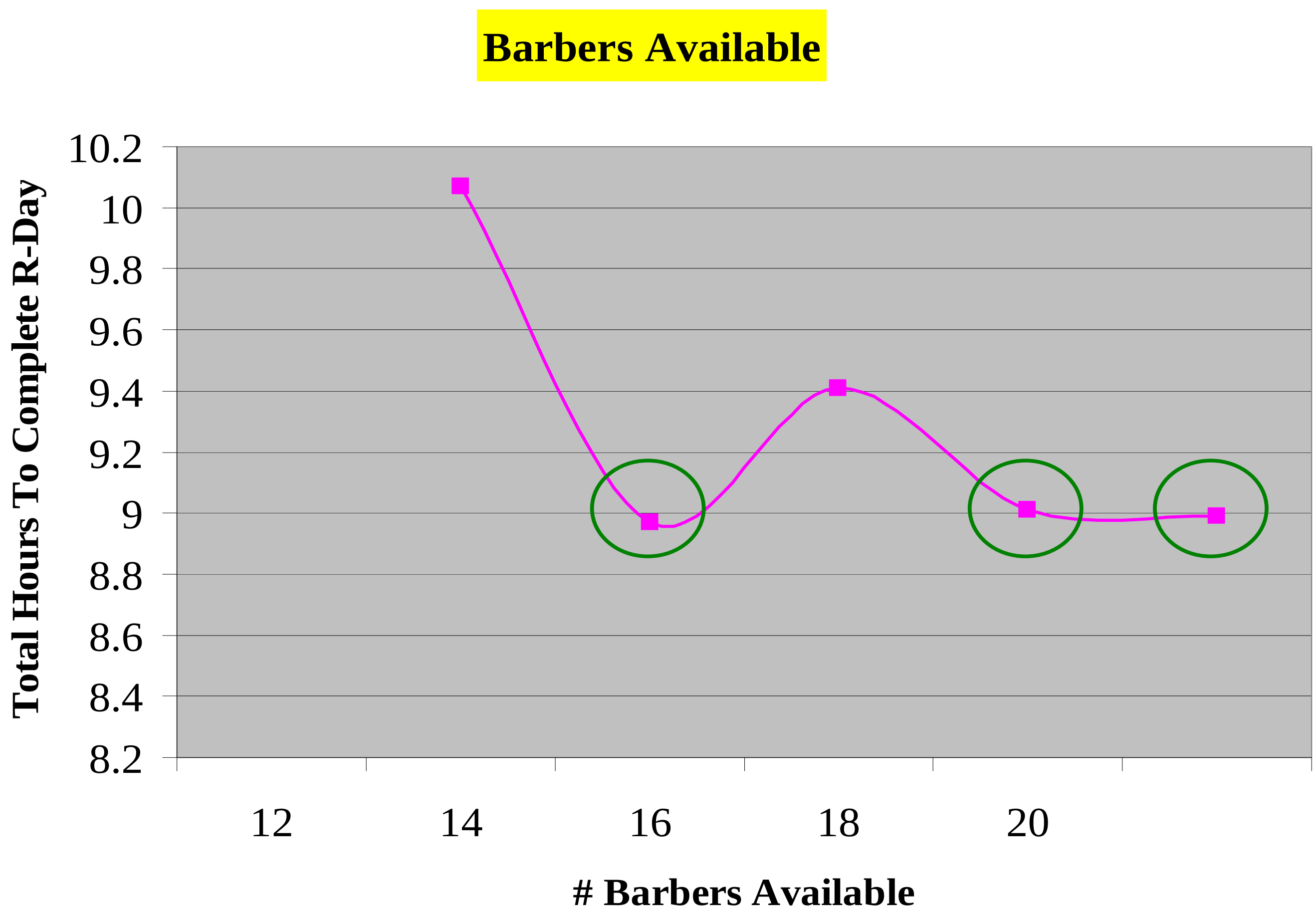
Alternatives

- Number of Squad Leaders available
- ***Bottom Line: Recommend 14 squad leaders; too many squad leaders creates too many (and smaller) squads moving in system***



Alternatives

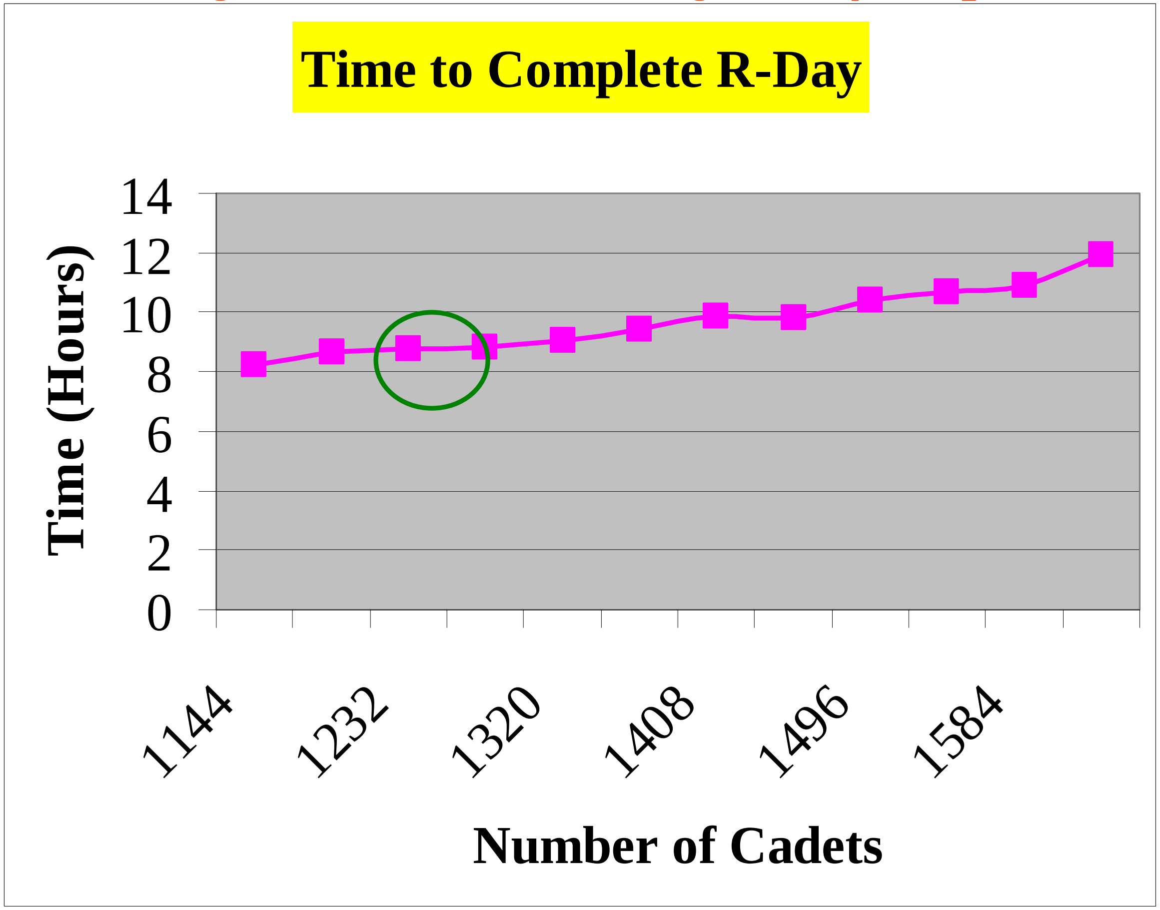
- Vary the number of carbers available
- ***Bottom Line: 16 Barbers cost effective***



Increase the Size of the Corps

Bus Trips	Cadets	Time to Complete R-Day
26	1144	8.25
27	1188	8.68
28	1232	8.78
29	1276	8.8
30	1320	9.05
31	1364	9.45
32	1408	9.85
33	1452	9.83
34	1496	10.42
35	1540	10.65
36	1584	10.9
37	1628	11.95

- ***Bottom Line: Time to complete R-day shows linear growth with increasing size of Corps***



Effect of Decreased Control Flow Measures

- When you decrease control flow measures, the amount of time needed to complete R-Day increases.

  - **SCENARIO**: Allow Squad Leaders to randomly decide where to take his/her squad until complete:

    RESULT: 25:16 hours (*Actual time = 7:46 AM, R-Day + 1*)

  - **SCENARIO**: Ignore the counters at the various stations:

    RESULT: Approximately 16:30 hours (*Actual time = 10:30 PM*)

SimRunner Optimization

- Picked four critical parameters
- Understand the interaction of:
  - Bus Arrival Rates
  - Squad Leader Pick-Up Arrival Rates
  - Squad Leaders Available
  - Barbers Available

SimRunner Optimization Function

x_i = average time at stations 1, 2,…i (a_i is the associated weight for each station)

x_j = number of minutes to complete R-Day (b_j is the associated weight for each station)

x_k = cost per bus driver, barber, and squad leader (c_k is the associated weight for each station)

x_l = % complete at stations 1, 2,…l (d_l is the associated weight for each station)

x_m = total throughput of the simulation (e_m is the associated weight for each station)

SimRunner Optimization Function

- Objective Function:

$$\text{Min } z_1 = \sum a_i x_i + \sum b_j x_j + \sum c_k x_k$$

$$\text{Max } z_2 = \sum d_l x_l + \sum e_m x_m$$

$$z_0 = z_2 - z_1$$

SimRunner Optimization Results

Bus Arrival Rates (Min)	Squad Leader Pick-Up Arrival Rates (Min)	Number of Squad Leaders Available (per Company)	Number of Available Barbers	Objective Function
7	14	13	12	27248.613
7	14	15	12	27248.613
7	14	14	12	27248.613
6	14	15	12	27245.455
6	14	14	12	27245.455
6	14	13	12	27222.004
6	14	12	12	27168.011
9	14	12	12	27116.028
8	14	12	12	27077.671
8	14	13	12	27077.671

SimRunner Optimization Results

Method	Bus Arrival Rates (Min)	Squad Leader Pick-Up Arrival Rates (Min)	Number of Squad Leaders Available (per Company)	Number of Available Barbers
Four Factor Optimization	7	14	13	12
One Factor Optimization	8	14	14	16
Actual for 2004	~9	~10	Average 13	Average 14
Actual for 2005	~8	~15	Average 13	Average 14

Study Conclusions

- Limited resources requiring non-linear utilization can be optimized by establishing flexible process thresholds which allow freedom of execution.
- Process thresholds need to be subjectively altered by a central command (operations center) throughout the day to maximize throughput.
- Real-time information of status of key areas is required to allow system administrators (squad leaders) and central command (operations center) to execute tasks in a timely manner.
- Impact to USMA and the Army:
  - Efficiency (*2005 process shaved nearly 30 minutes from 2004 time*)
  - Cost-savings

Summary

- Commercial simulation software such as ProModel can be utilized to model linear and non-linear processes to provide insight into system enhancements.

Questions

LTC Simon R. Goerger
Assistant Professor and ORCEN Director
Simon.Goerger@usma.edu

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Educating Future Systems Engineers: US Military Academy Reception-Day Simulation and Optimization

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Operations Research Center of Excellence
Researching the Army's Future
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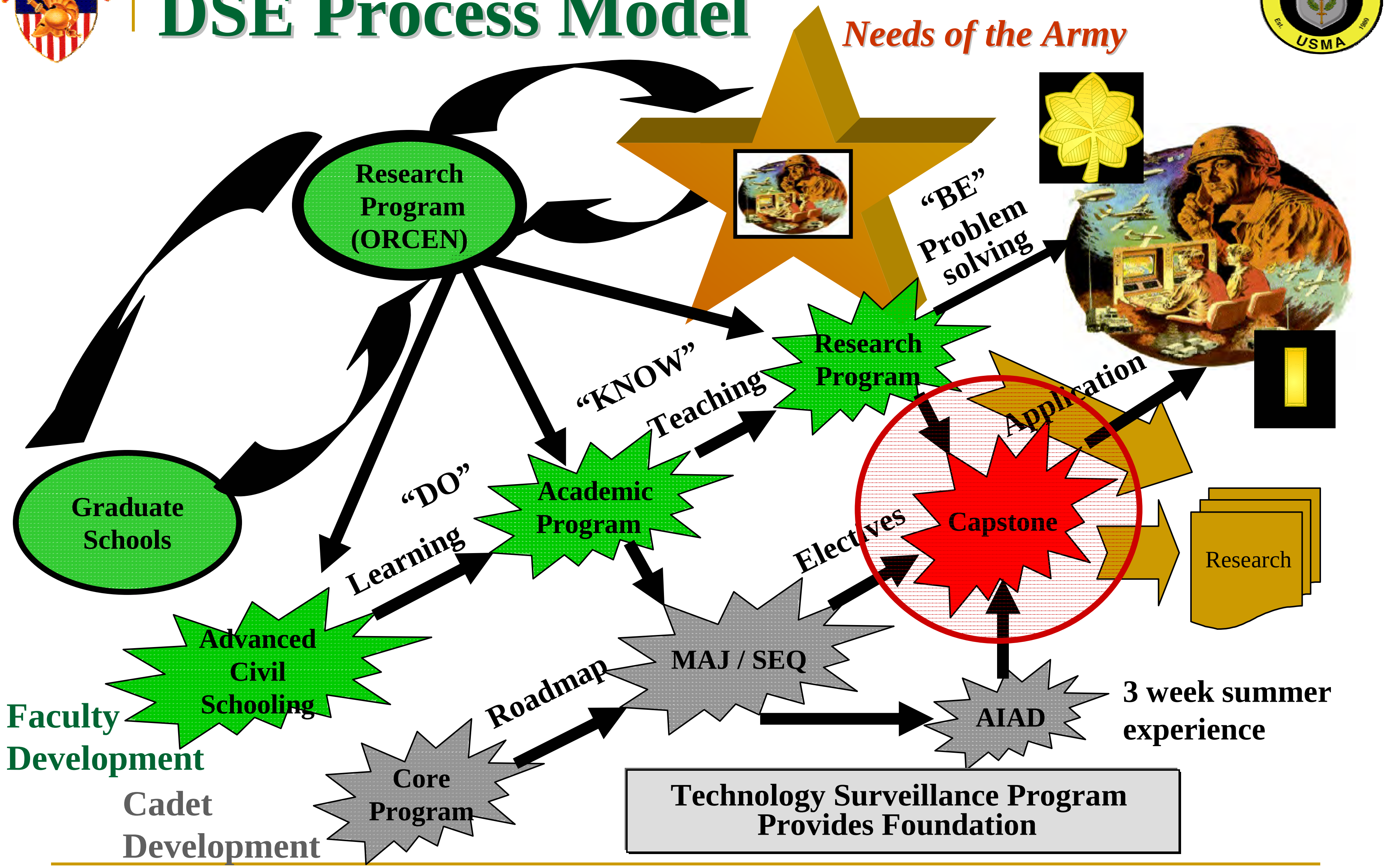
Agenda

- Department of Systems Engineering (DSE) Process Model
- Systems Engineering Management Process
- Research & Educational Environment
- Capstones
- Reception-Day Capstone
- Study Conclusions
- Summary

DSE Process Model

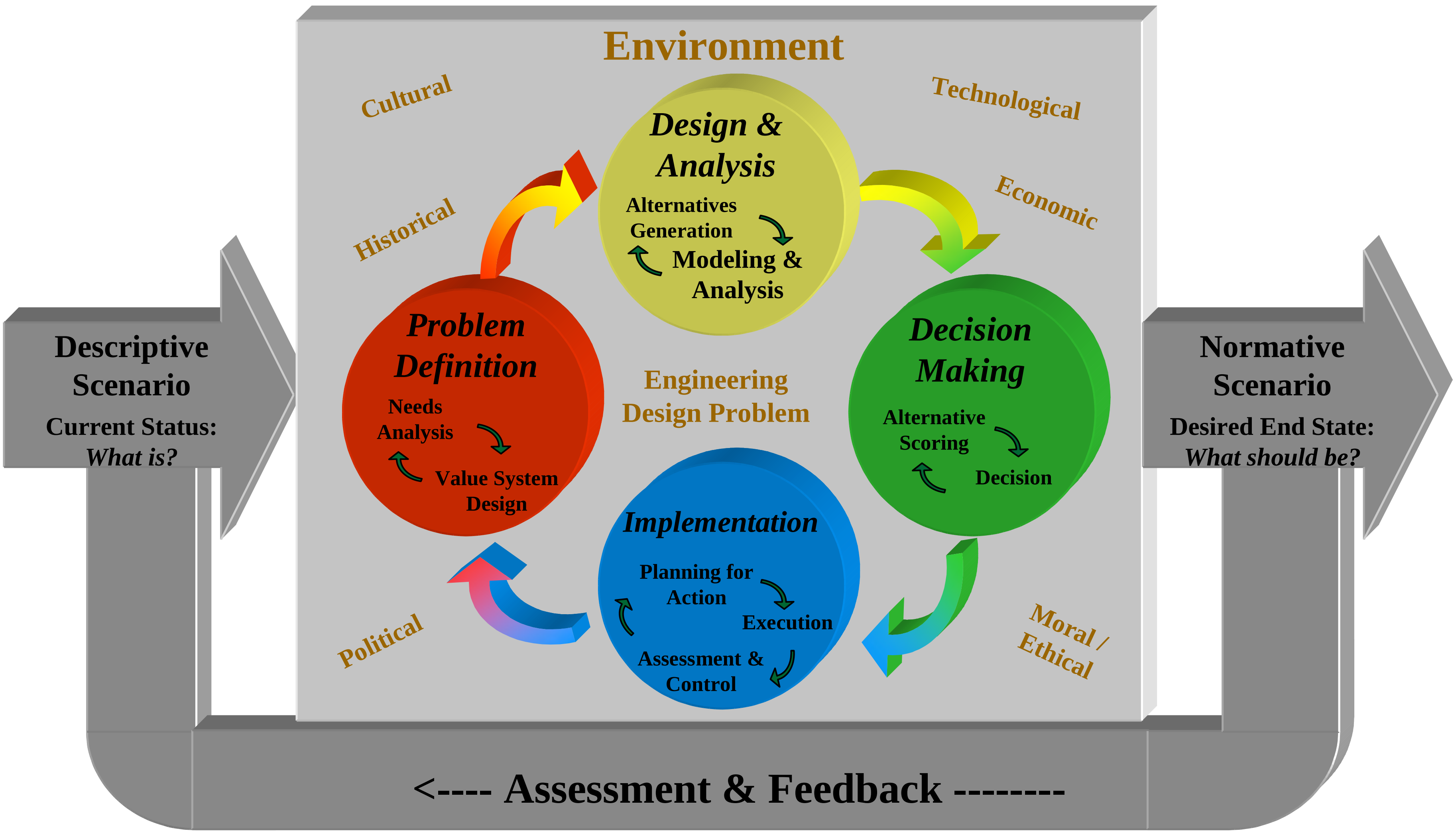


DSE Majors: Class of 2008

Major	Core Courses	Major Courses	Total Courses	Cadets (% of Class)
Systems Engineering *	26	18	44	19 (1.8)
Operations Research	27	15	42	9 (0.8)
Engineering Management *	26	18	44	64 (5.9)
Information Systems Engineering	27	17	44	6 (0.6)
Systems Management	27	13	40	12 (1.1)
Total/Ave	26.2	16.2	42.8	110 (10.2)

*** ABET Accredited**

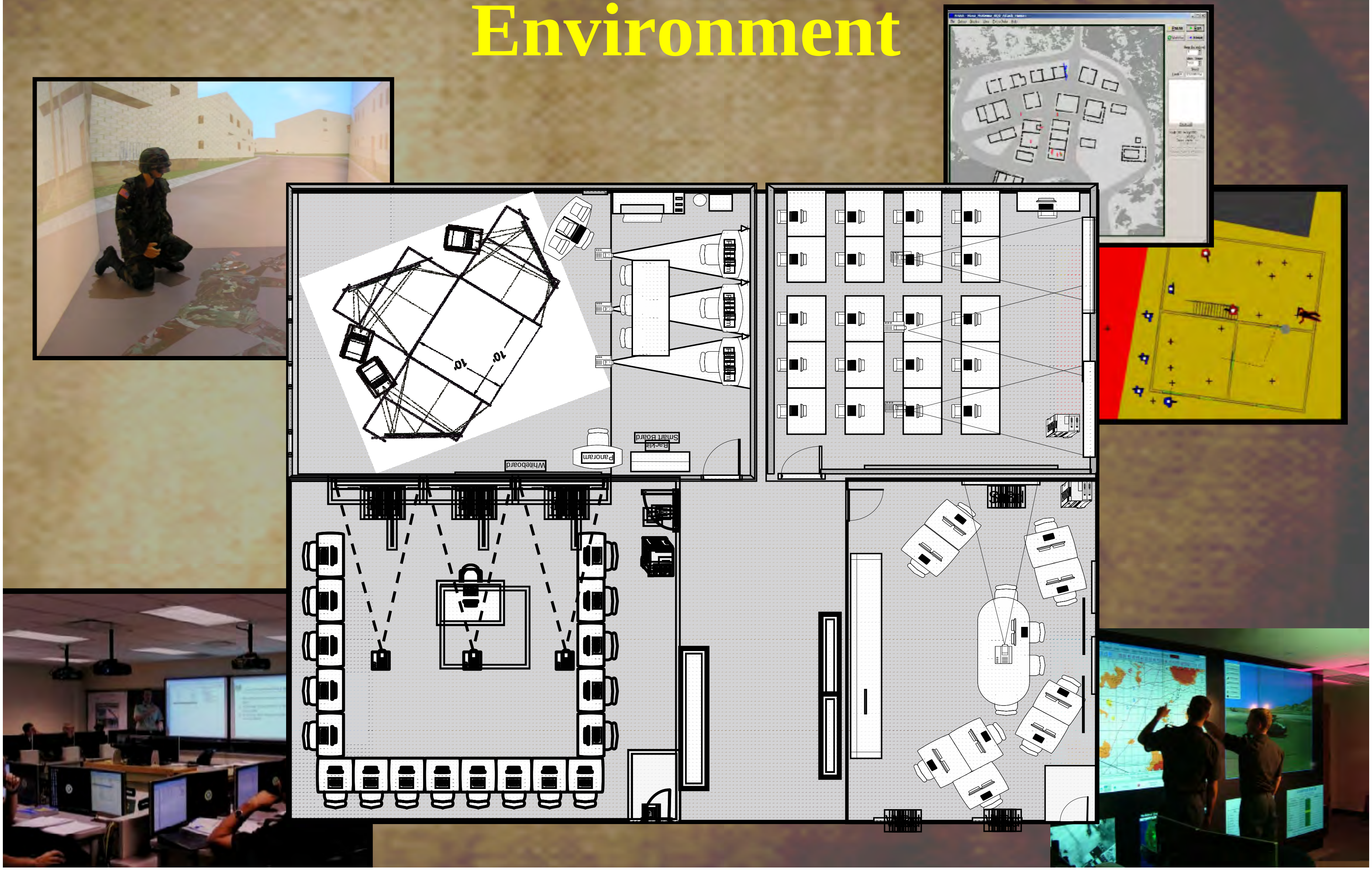
Systems Engineering and Management Process



Advanced Individual Academic Development (AIAD)

- Provide Cadets with Systems Engineering, Engineering Management, Information Systems Engineering, Systems Management and Operations Research experience outside a classroom environment
- Two types of experiences
  - Broaden academic experience
  - Conduct capstone background research
- Support academic program objectives
- Summer 2005:
  - 84 cadets
  - 5 countries (17 states including D.C.)
  - 45 sponsors

Research & Educational Environment



Capstones

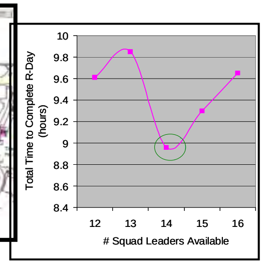
- All capstones are lead by Ph.D.s
- Where possible, AIAD opportunities precede capstones
- Generally 3-5 cadets per capstone team
- Work significant problem with real client for two semesters

USMA R-Day Design Simulation

- <u>Issue</u>:
  - In the past, some R-Day operations have not functioning at optimal rates
    - Inefficiencies in R-Day operations cause back-ups that leave some new cadets lacking proper training and/or attire for the Oath Ceremony
  - Previous analyses of R-Day operations focused on thirteen Thayer Hall stations, the USCC stations (non-linear processes) were not included
    - Incomplete analysis has lead to local instead of global optimizations

- <u>Approach</u>:
  - Use SEMP to review past R-Day activities, datasets, maps, and projects to identify critical points and areas of potential improvement
  - Develop a simulation to determine optimal parameters for:
    - Station order
    - Staff levels for squad leaders & barbers
    - Optimal bus & squad leader arrival rates

- <u>Objective</u>:
  - Build on previous R-Day studies to provide a global optimization
  - Create a model/simulation to be used as a possible test bed for future adjustments to R-Day activities



- <u>Outcomes</u>:
  - Modeled USCC areas (non-linear process) incorporating the model with an improved Thayer Hall model (linear process) to yield a more complete simulation for analysis of the system
  - Identified optimal staff numbers, execution order for USCC stations, and processing guidelines to complete in-processing as efficiently/quickly as possible

AY 06 Capstone Research

- American Insurance Group (AIG) Assessment of Catastrophic Models
- Black Dart
- Border Security
- BRAC
- Casualty Assistance Officer Wizard
- Developing New Readiness Metric
- First Term Dental Readiness (FDTR): Fort Benning, GA
- First Term Dental Readiness (FDTR): Fort Jackson, SC
- Flying the Warrior UAV within the National Airspace System
- Future Force Warrior Simulation

AY 06 Capstone Research

- Future Forecasting
- GIS Integration Into Virtual West Point
- Hypersonic High-Intensity Anti-Ballistic Missile Systems
- In/Out Processing
- Integrated Base Defense
- Logistical Support for a Lunar Base
- Leaders Tactical Medical Monitoring Collective (LTM2C)
- MAGIC *
- Mini-Baja *
- OneSAF Behavioral Specifications

**** With Dept C/ME***

AY 06 Capstone Research

- Product Manager-Individual Combat Equipment (PM-ICE) Study
- Reception-Day (Plus Day 1 and Day 2) Simulation Study
- Scramjet Topic
- Sustainability of the Brigade Combat Team
- Homeland Security Resilience Metric(s)
- Unmanned/Robotic Vehicles

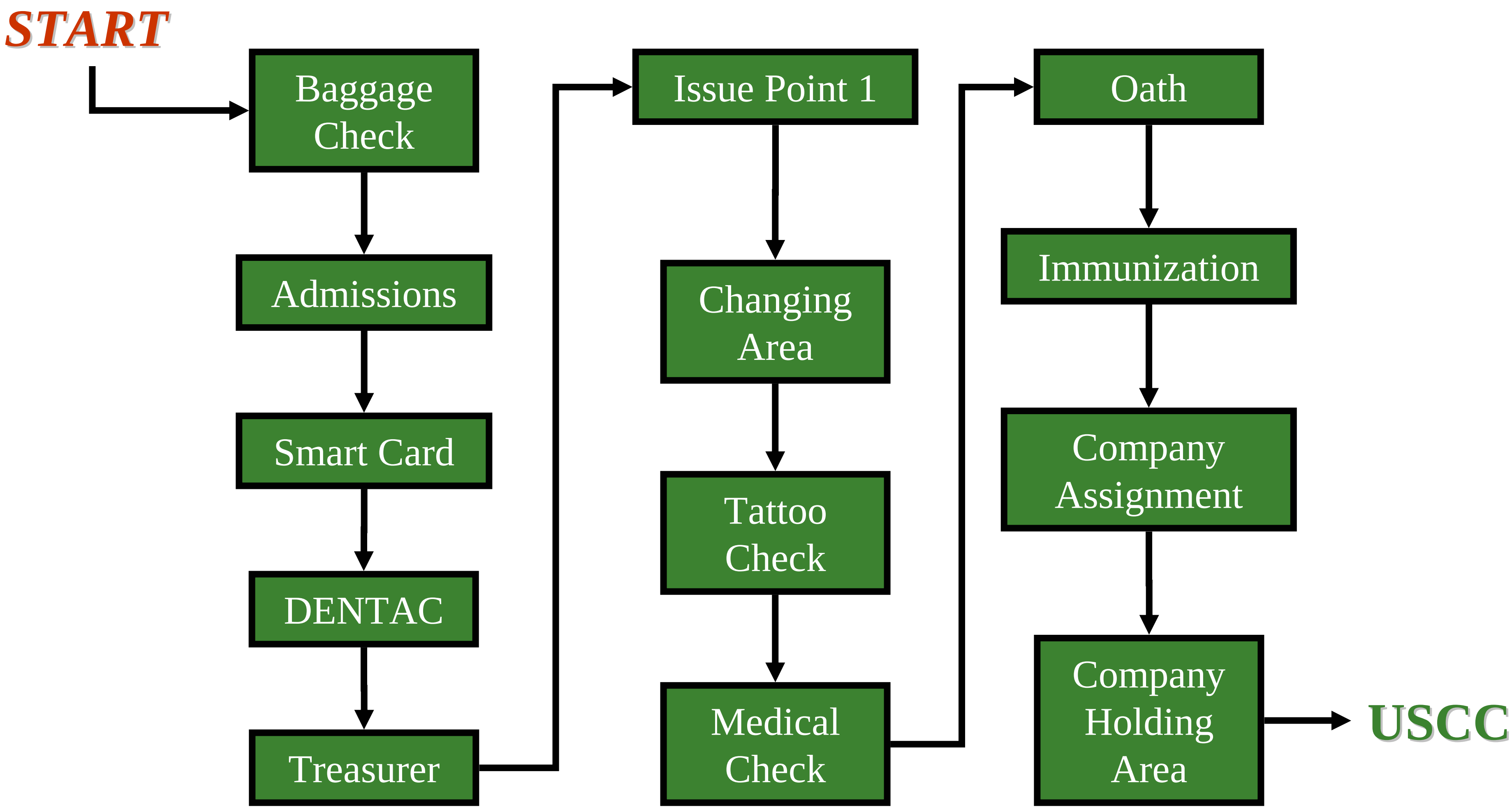
Problem Statement

- Stream line Reception-Day activities for in-processing new cadets into the Corps of Cadets from the initial arrival of candidates at Thayer Hall until the start of the Oath Ceremony to ensure all critical tasks and training are completed prior to the Oath Ceremony at 1745.

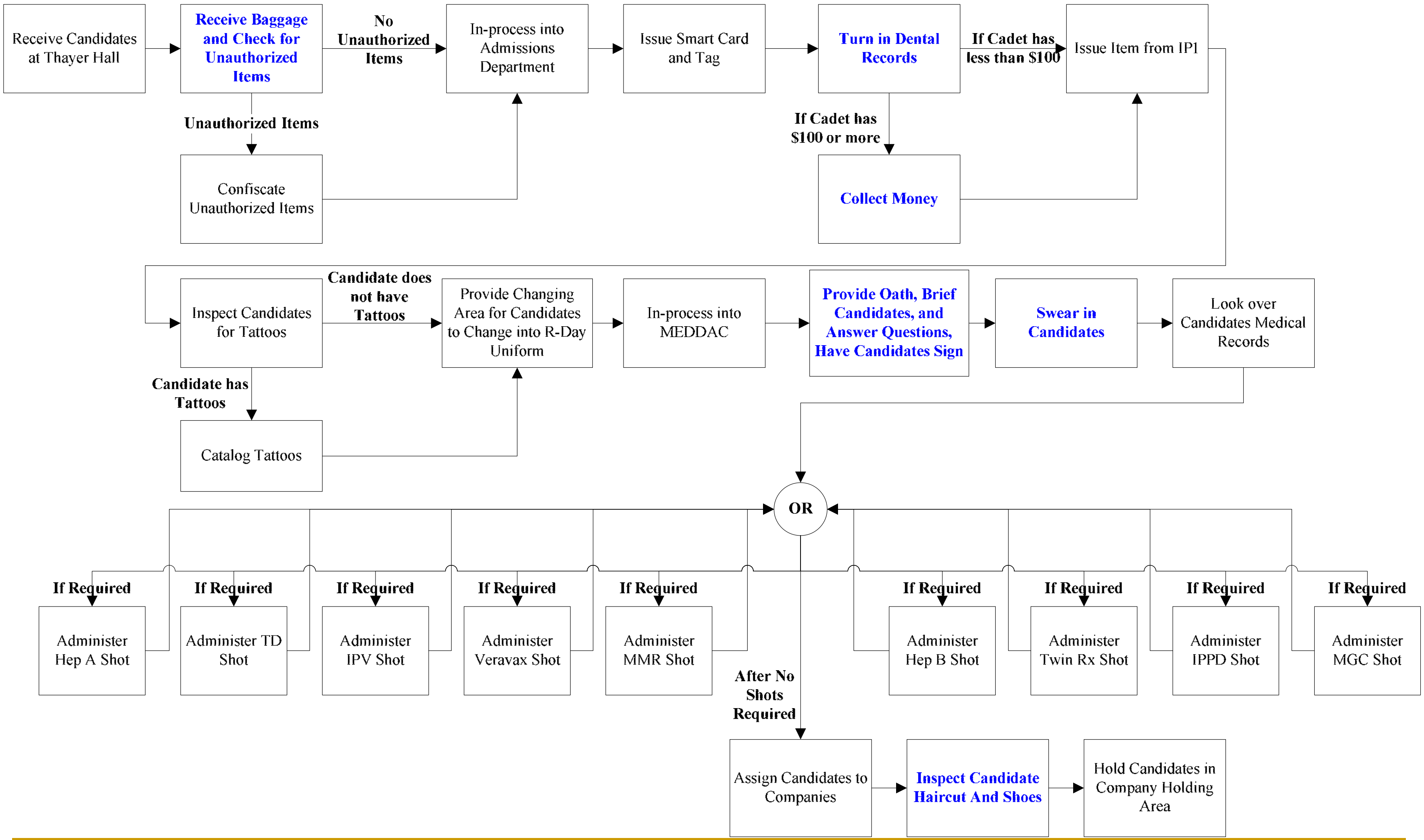
Assumptions

- Assumptions due to:
  - Modeling constraints
  - The need to account for imperfect data
- Examples:
  - Candidates return to Company Holding Area after each station
  - Candidates stay together as a single squad throughout the USCC portion of R-Day
  - All Candidates have trousers in hand when they leave Issue Point #2 (IP2)
  - Drill 1 and Drill 2 are combined
  - Every Candidate goes to the Barber Shop
  - IP3 and Company In-Processing grouped together

Process Flow: Thayer Hall



Functional Flow: Thayer Hall



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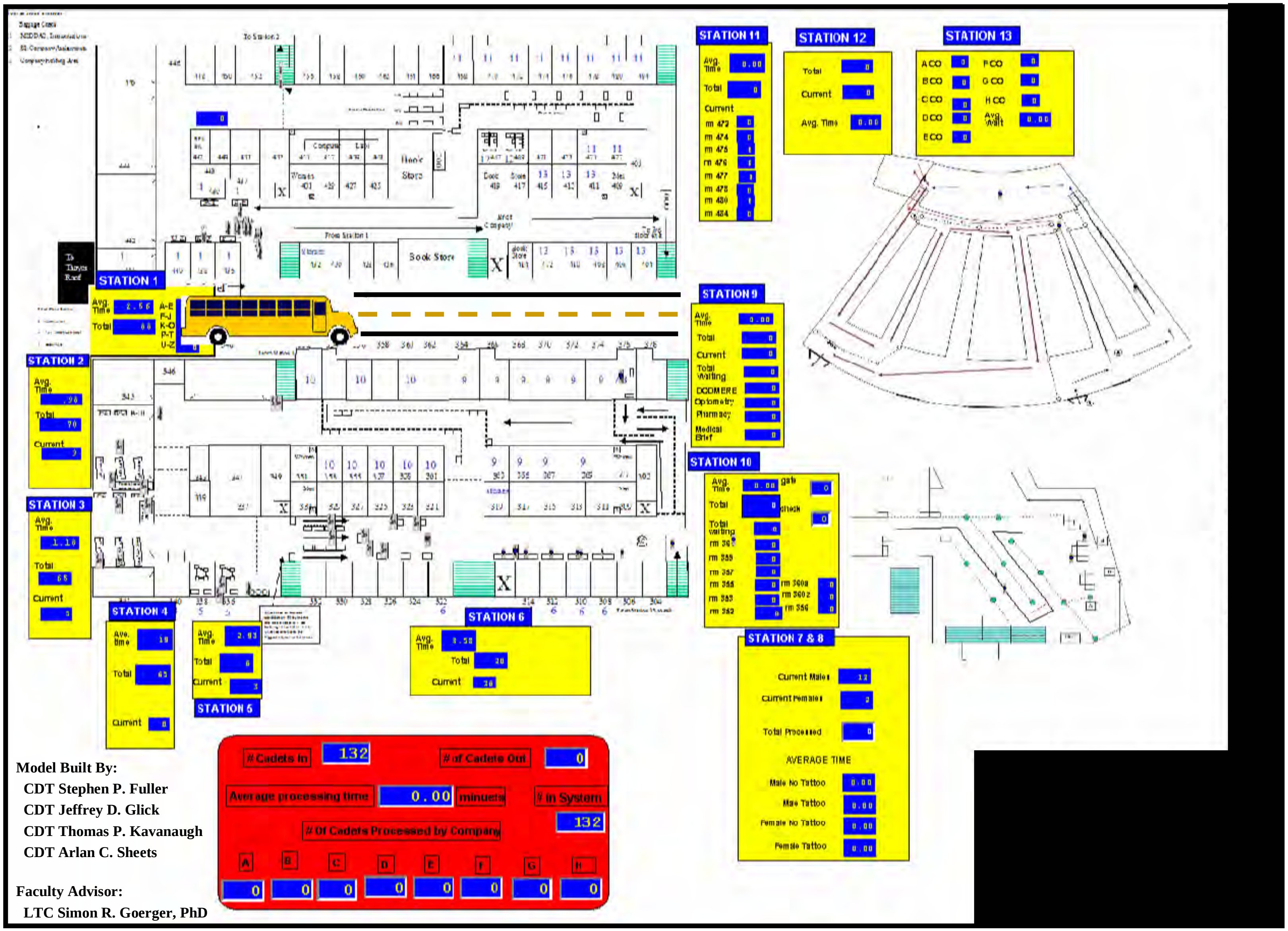
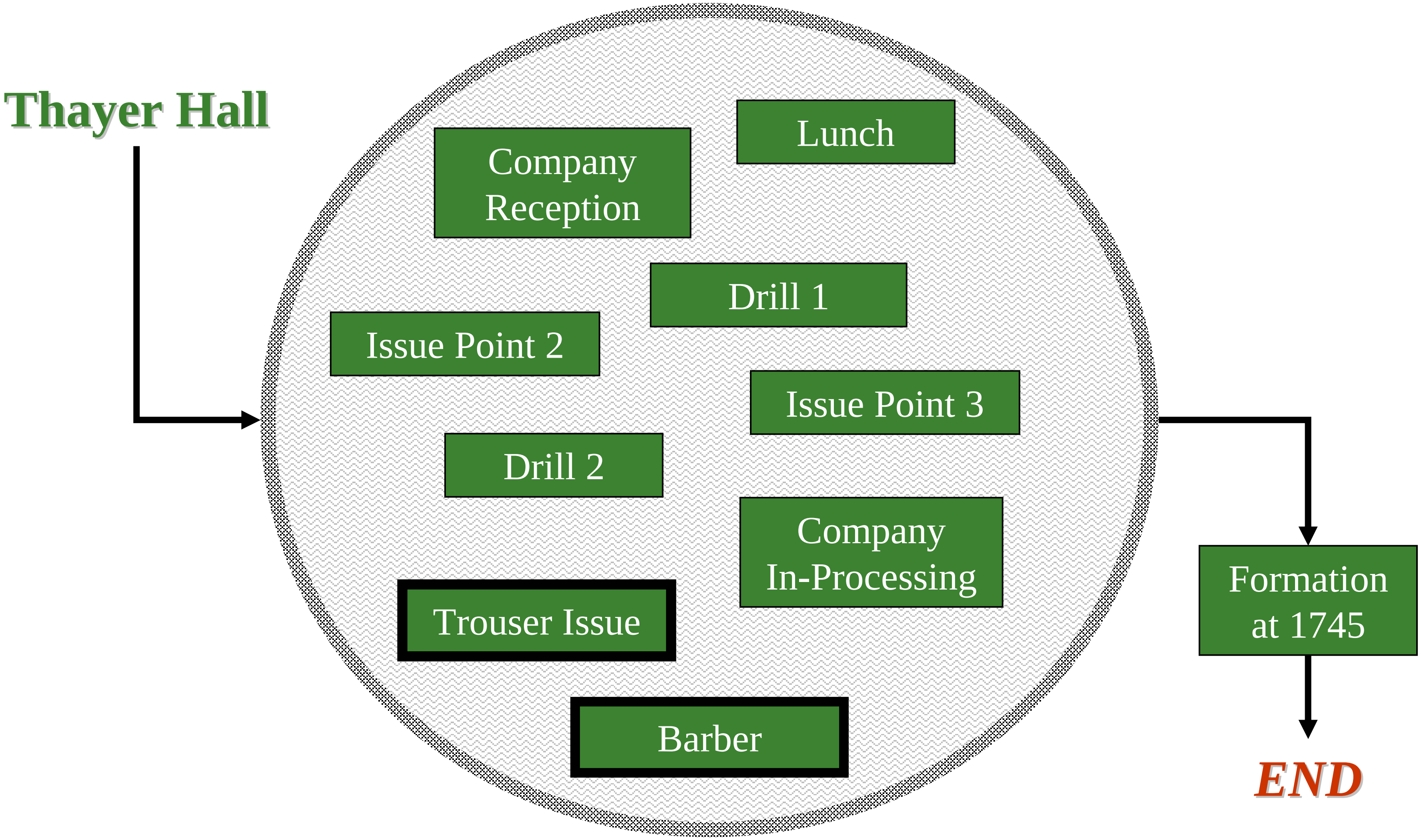
ProModel: Thayer Hall



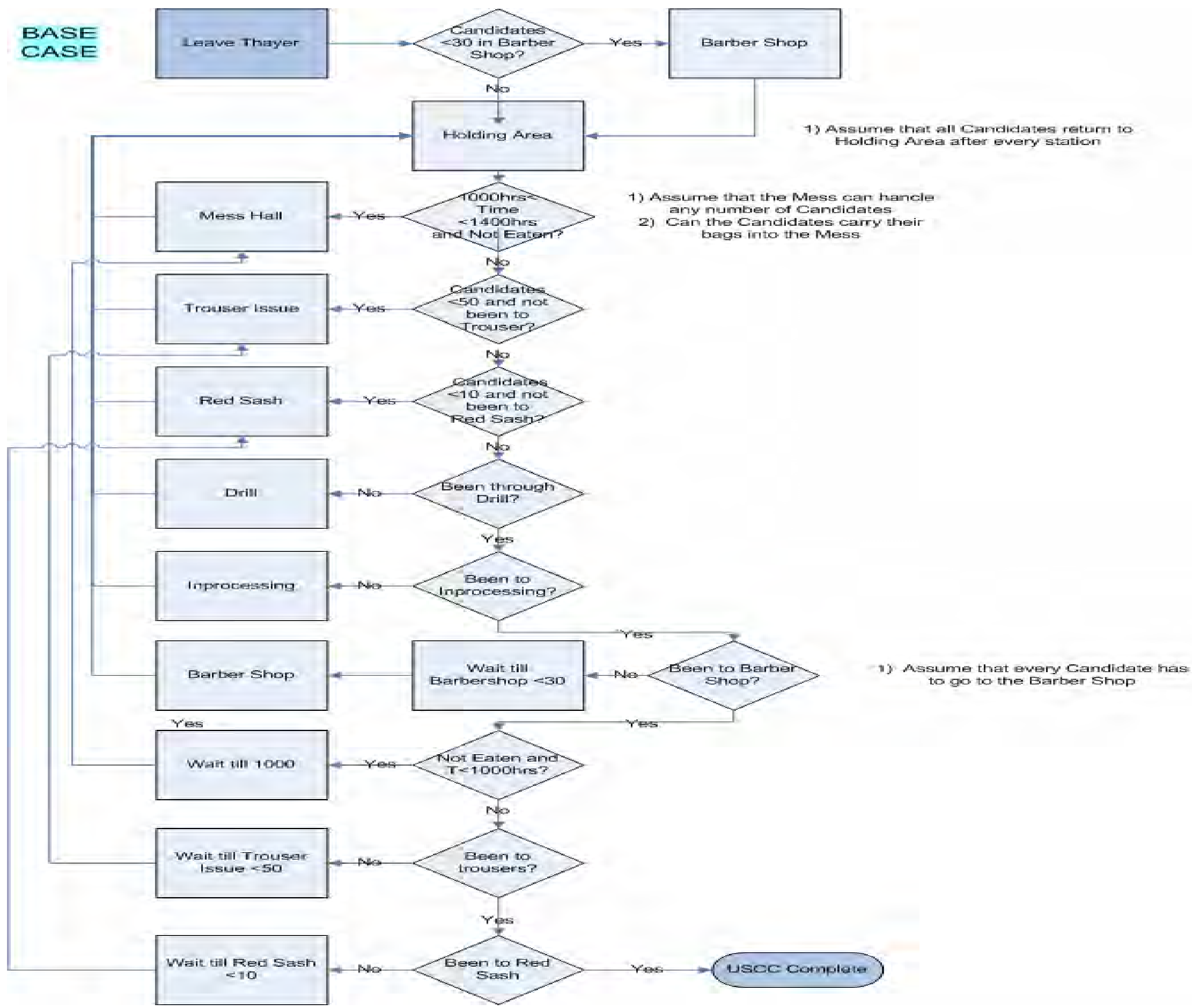
Model Built By:
CDT Stephen P. Fuller
CDT Jeffrey D. Glick
CDT Thomas P. Kavanaugh
CDT Arlan C. Sheets

Faculty Advisor:
LTC Simon R. Goerger, PhD

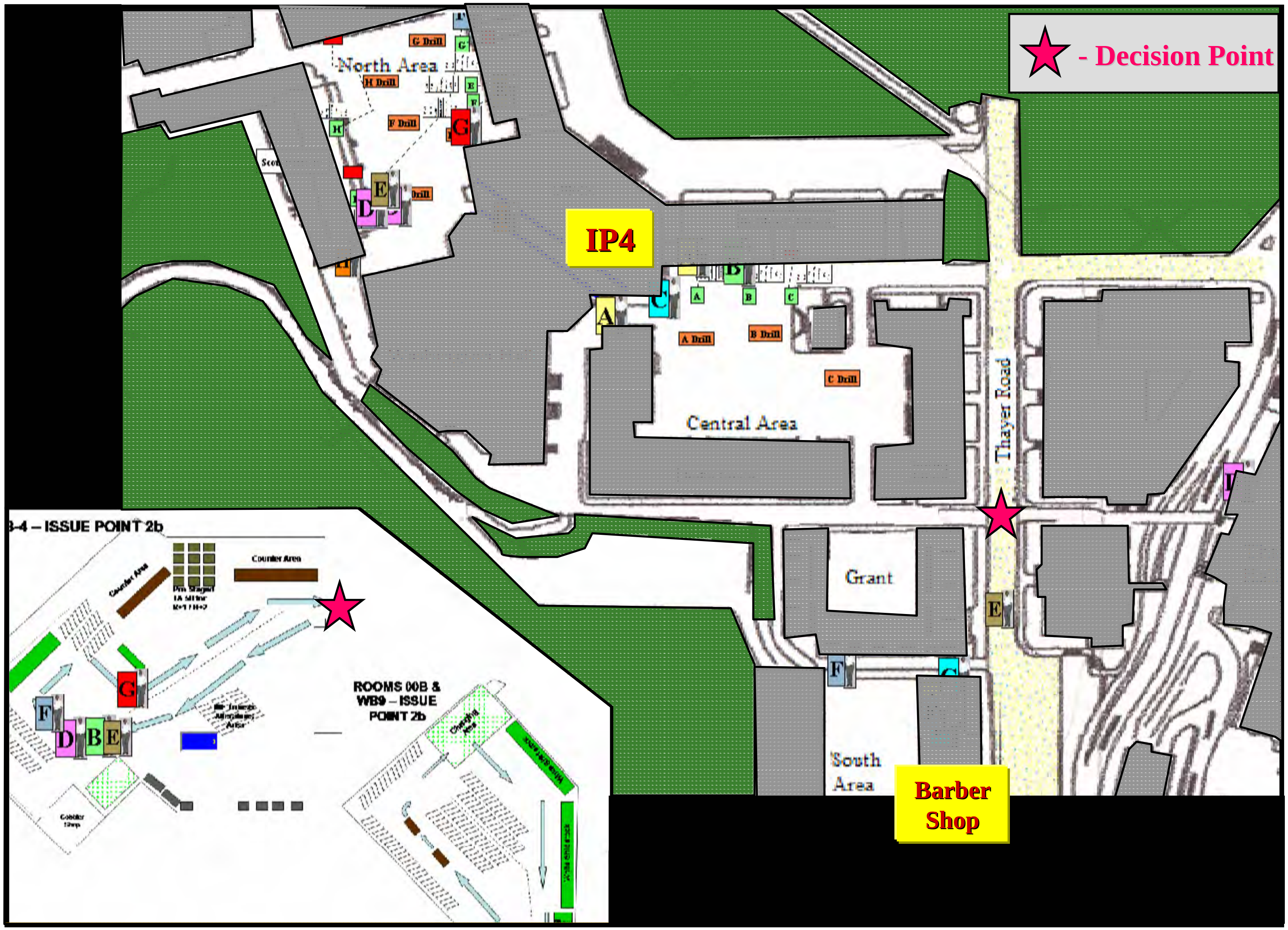
Process Flow: USCC



Functional Flow: USCC



ProModel: USCC



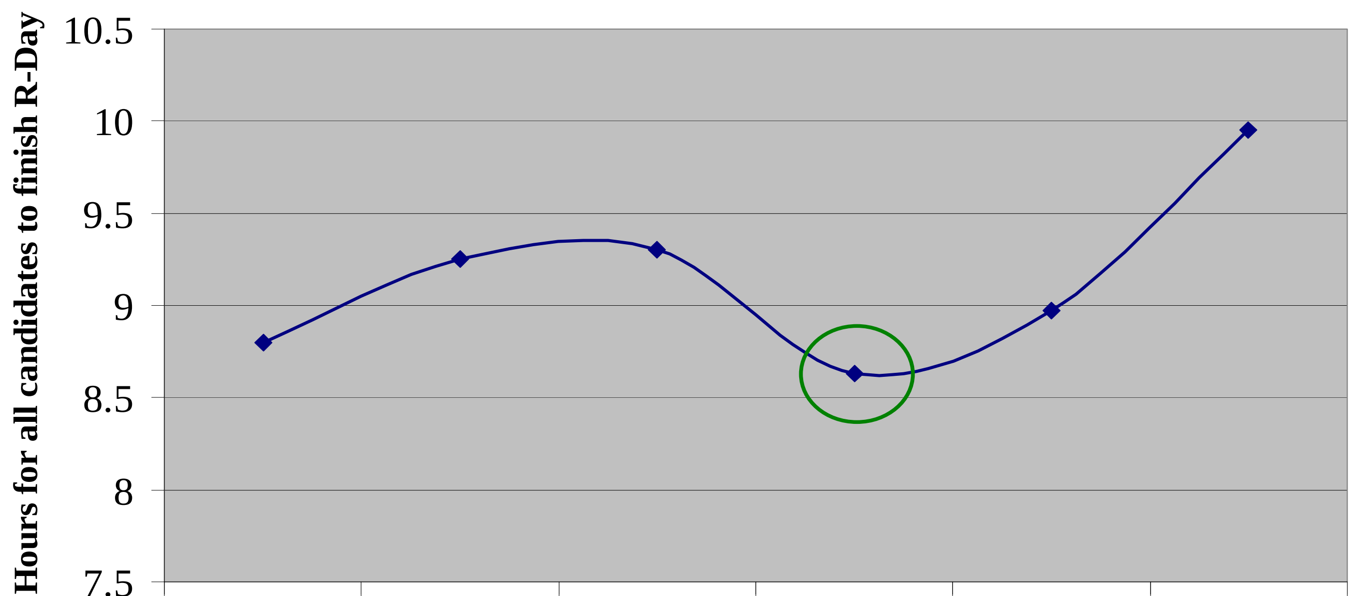
Alternatives/Issues

- Arrival rates of busses to Thayer Hall
- *Pick-up rates of the candidates from Thayer Hall*
- Routing of candidates in order to reduce average wait times at the barbershop and delaying trouser issue
- Number of Squad Leaders available
- Number of barbers available

Alternatives

- Arrival rates of busses to Thayer Hall
- ***Bottom Line: Buses should arrive to Thayer Hall approximately every 8:30***

Arrival Times to Thayer

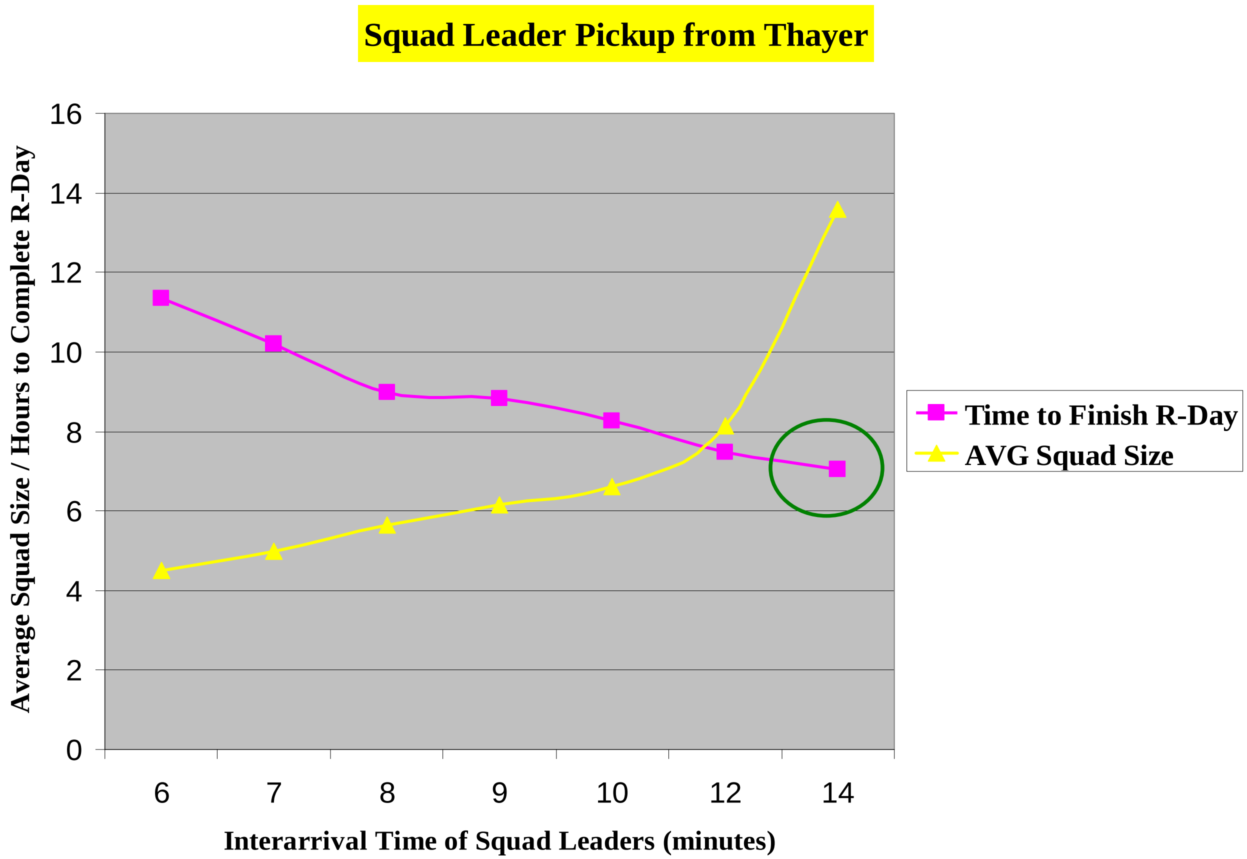


Time to Complete R-Day	8:48	9:15	9:18	8:38	8:58	9:57
Inter-Arrival Time	5	6	7	8	9	10

Interarrival Time (minutes)

Alternatives

- Pick-up rates of the candidates from Thayer Hall
- ***Bottom Line: Longer inter-arrival time = larger squads = shorter R-day***



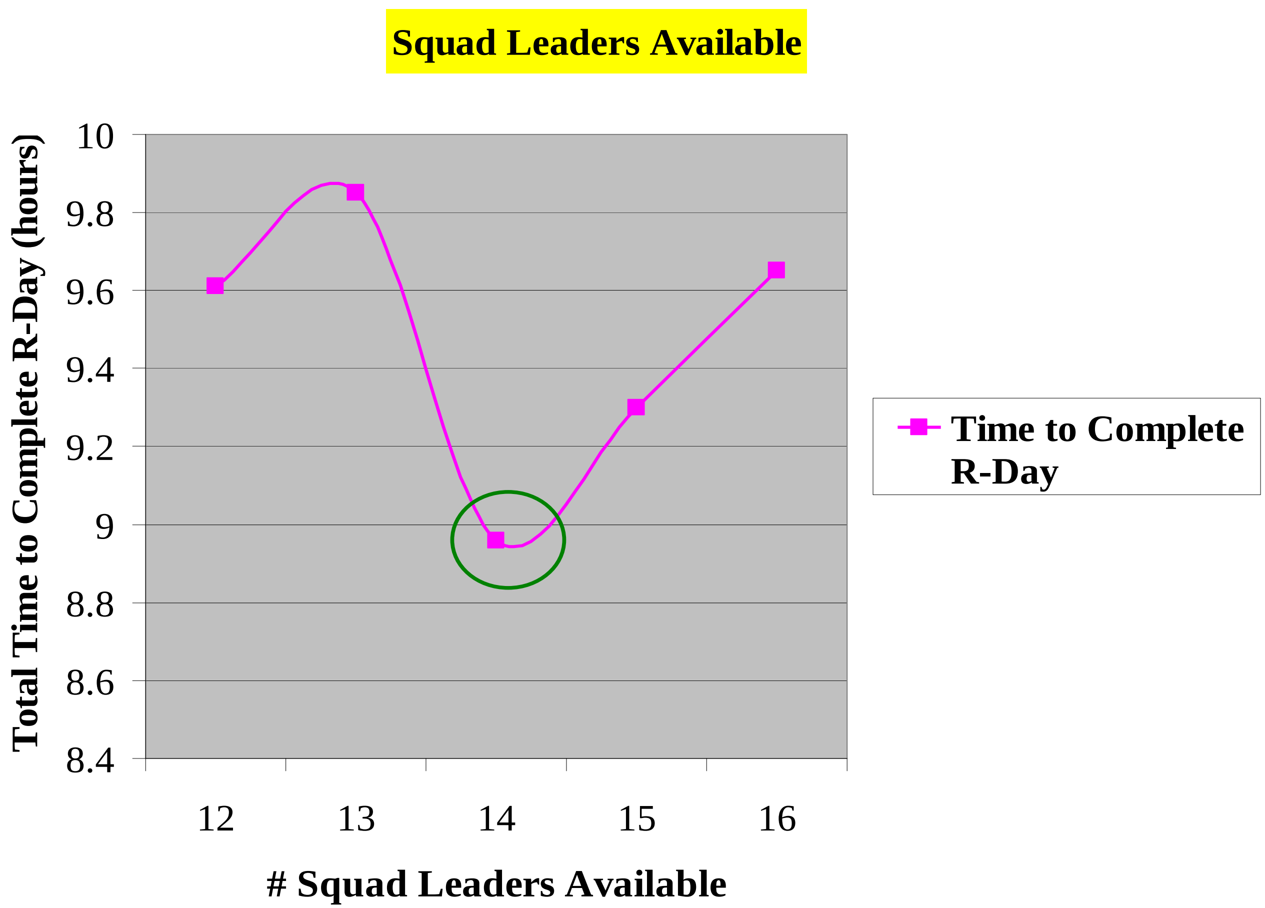
Alternatives

- Routing of candidates in order to reduce average wait times at the barbershop and delaying trouser issue
- ***Bottom Line: Limit the flow of cadets into the barber shop when trouser issue still incomplete***

Rule	Time to Complete R-Day
Haircut First	9:02
Trousers First	8:58

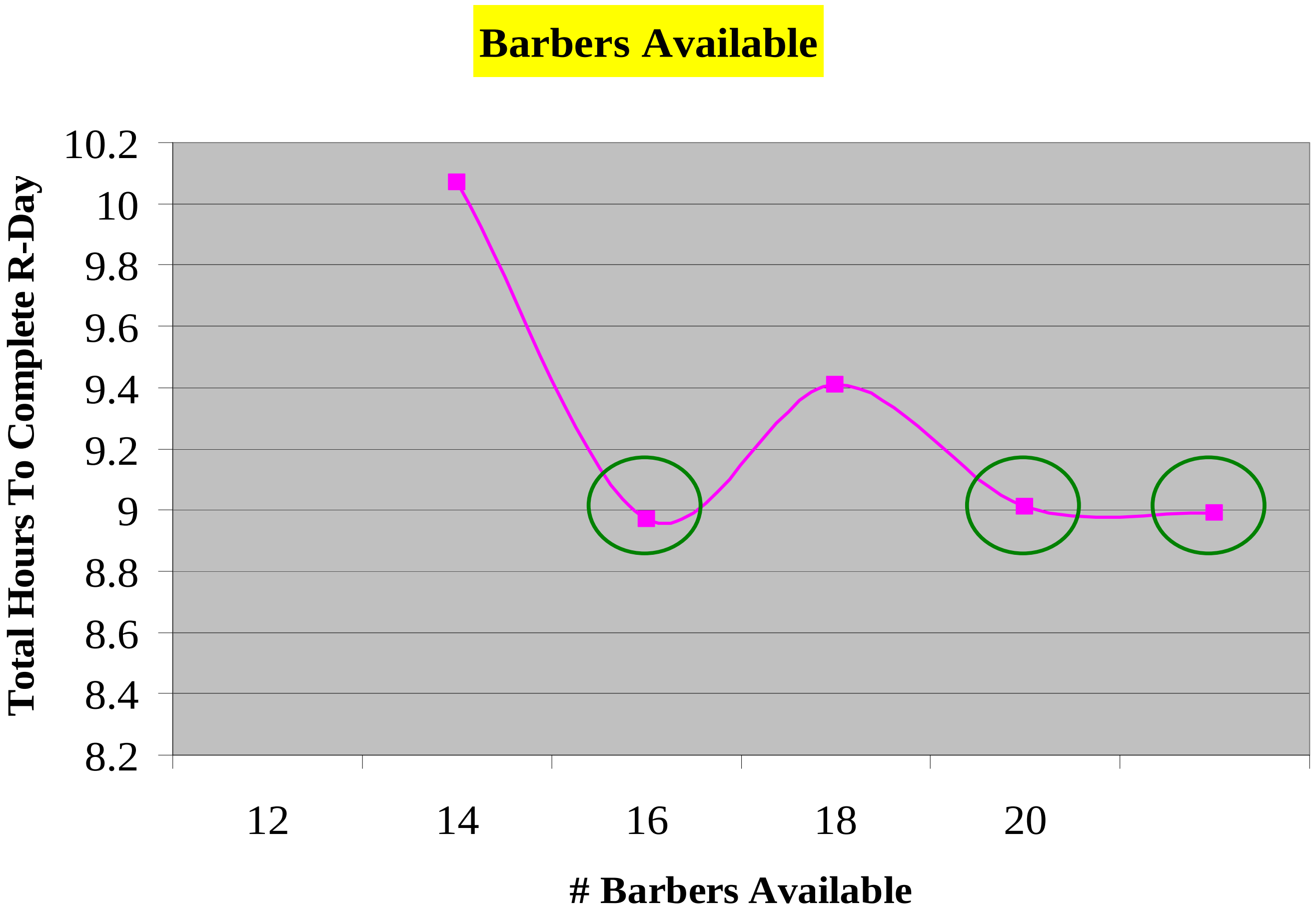
Alternatives

- Number of Squad Leaders available
- *Bottom Line: Recommend 14 squad leaders; too many squad leaders creates too many (and smaller) squads moving in system*



Alternatives

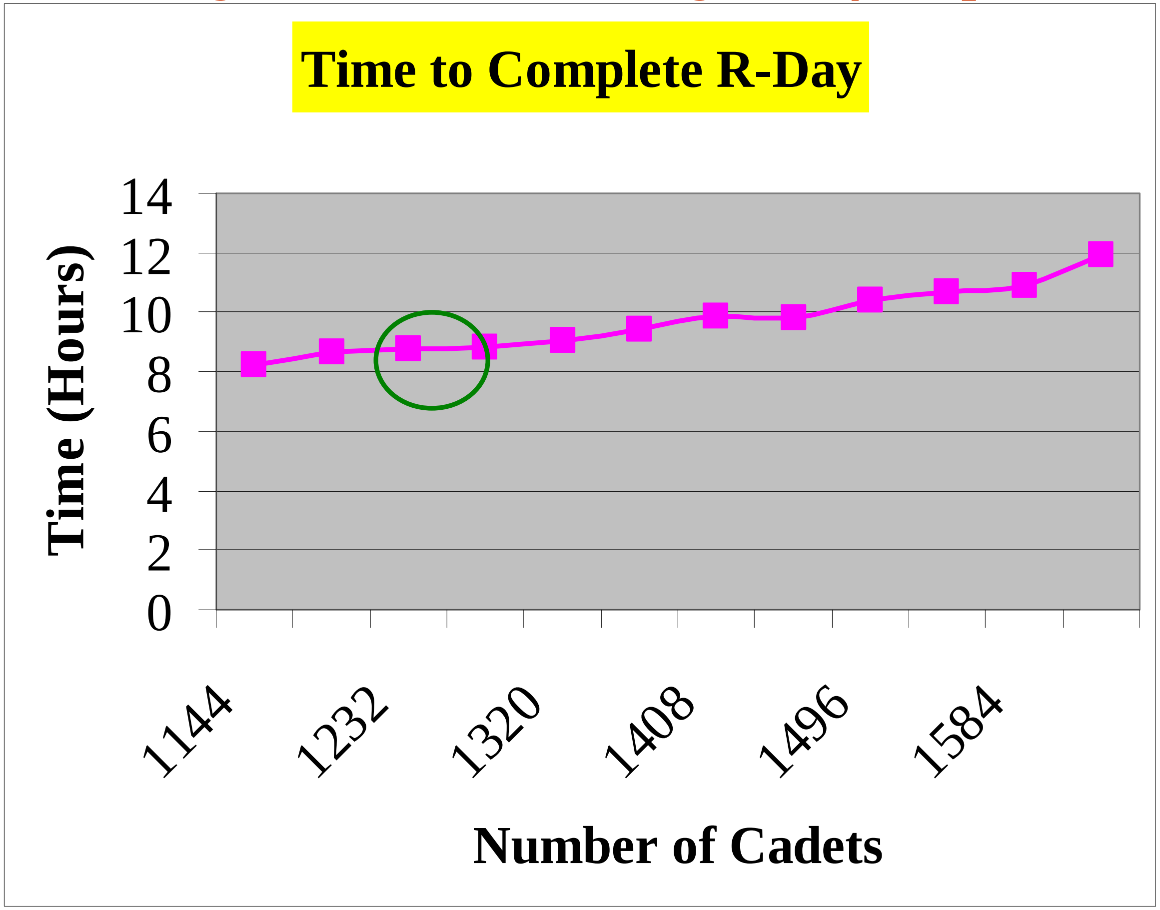
- Vary the number of carbers available
- *Bottom Line: 16 Barbers cost effective*



Increase the Size of the Corps

Bus Trips	Cadets	Time to Complete R-Day
26	1144	8.25
27	1188	8.68
28	1232	8.78
29	1276	8.8
30	1320	9.05
31	1364	9.45
32	1408	9.85
33	1452	9.83
34	1496	10.42
35	1540	10.65
36	1584	10.9
37	1628	11.95

- ***Bottom Line: Time to complete R-day shows linear growth with increasing size of Corps***



Effect of Decreased Control Flow Measures

- When you decrease control flow measures, the amount of time needed to complete R-Day increases.

  - **SCENARIO**: Allow Squad Leaders to randomly decide where to take his/her squad until complete:

    RESULT: 25:16 hours (*Actual time = 7:46 AM, R-Day + 1*)

  - **SCENARIO**: Ignore the counters at the various stations:

    RESULT: Approximately 16:30 hours (*Actual time = 10:30 PM*)

SimRunner Optimization

- Picked four critical parameters
- Understand the interaction of:
  - Bus Arrival Rates
  - Squad Leader Pick-Up Arrival Rates
  - Squad Leaders Available
  - Barbers Available

SimRunner Optimization Function

x_i = average time at stations 1, 2,…i (a_i is the associated weight for each station)

x_j = number of minutes to complete R-Day (b_j is the associated weight for each station)

x_k = cost per bus driver, barber, and squad leader (c_k is the associated weight for each station)

x_l = % complete at stations 1, 2,…l (d_l is the associated weight for each station)

x_m = total throughput of the simulation (e_m is the associated weight for each station)

SimRunner Optimization Function

- Objective Function:

$$\text{Min } z_1 = \sum a_i x_i + \sum b_j x_j + \sum c_k x_k$$

$$\text{Max } z_2 = \sum d_l x_l + \sum e_m x_m$$

$$z_0 = z_2 - z_1$$

SimRunner Optimization Results

Bus Arrival Rates (Min)	Squad Leader Pick-Up Arrival Rates (Min)	Number of Squad Leaders Available (per Company)	Number of Available Barbers	Objective Function
7	14	13	12	27248.613
7	14	15	12	27248.613
7	14	14	12	27248.613
6	14	15	12	27245.455
6	14	14	12	27245.455
6	14	13	12	27222.004
6	14	12	12	27168.011
9	14	12	12	27116.028
8	14	12	12	27077.671
8	14	13	12	27077.671

SimRunner Optimization Results

Method	Bus Arrival Rates (Min)	Squad Leader Pick-Up Arrival Rates (Min)	Number of Squad Leaders Available (per Company)	Number of Available Barbers
Four Factor Optimization	7	14	13	12
One Factor Optimization	8	14	14	16
Actual for 2004	~9	~10	Average 13	Average 14
Actual for 2005	~8	~15	Average 13	Average 14

Study Conclusions

- Limited resources requiring non-linear utilization can be optimized by establishing flexible process thresholds which allow freedom of execution.
- Process thresholds need to be subjectively altered by a central command (operations center) throughout the day to maximize throughput.
- Real-time information of status of key areas is required to allow system administrators (squad leaders) and central command (operations center) to execute tasks in a timely manner.
- Impact to USMA and the Army:
  - Efficiency (*2005 process shaved nearly 30 minutes from 2004 time*)
  - Cost-savings

Summary

- The USMA systems engineering undergraduate program combines a sound mathematical foundation with a comprehensive methodology, viable techniques, and appropriate computer technology. It culminates with an ***open-ended, real world capstone project*** to solidify the academic experience. The 2005 Reception-Day Project is an example of the level of effort and type of product produced by a students completing the DSE Program.

Questions

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Operations Research Center of Excellence
Researching the Army's Future
Developing Tomorrow's Leaders

8th Annual
Systems Engineering
Conference

Thursday, 27 October 2005

Educating Future Systems Engineers: US Military Academy Reception-Day Simulation and Optimization

LTC Simon R. Goerger, PhD
2LT Stephen P. Fuller
2LT Jeffrey D. Glick
2LT Thomas P. Kavanaugh
Mr. Arlan C. Sheets

Operations Research Center of Excellence
Researching the Army's Future
Developing Tomorrow's Leaders

Integrated Survivability Assessment (ISA) in the Systems Engineering Process

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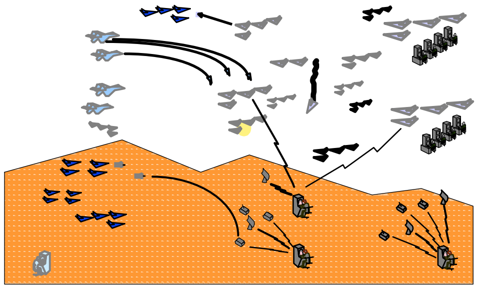
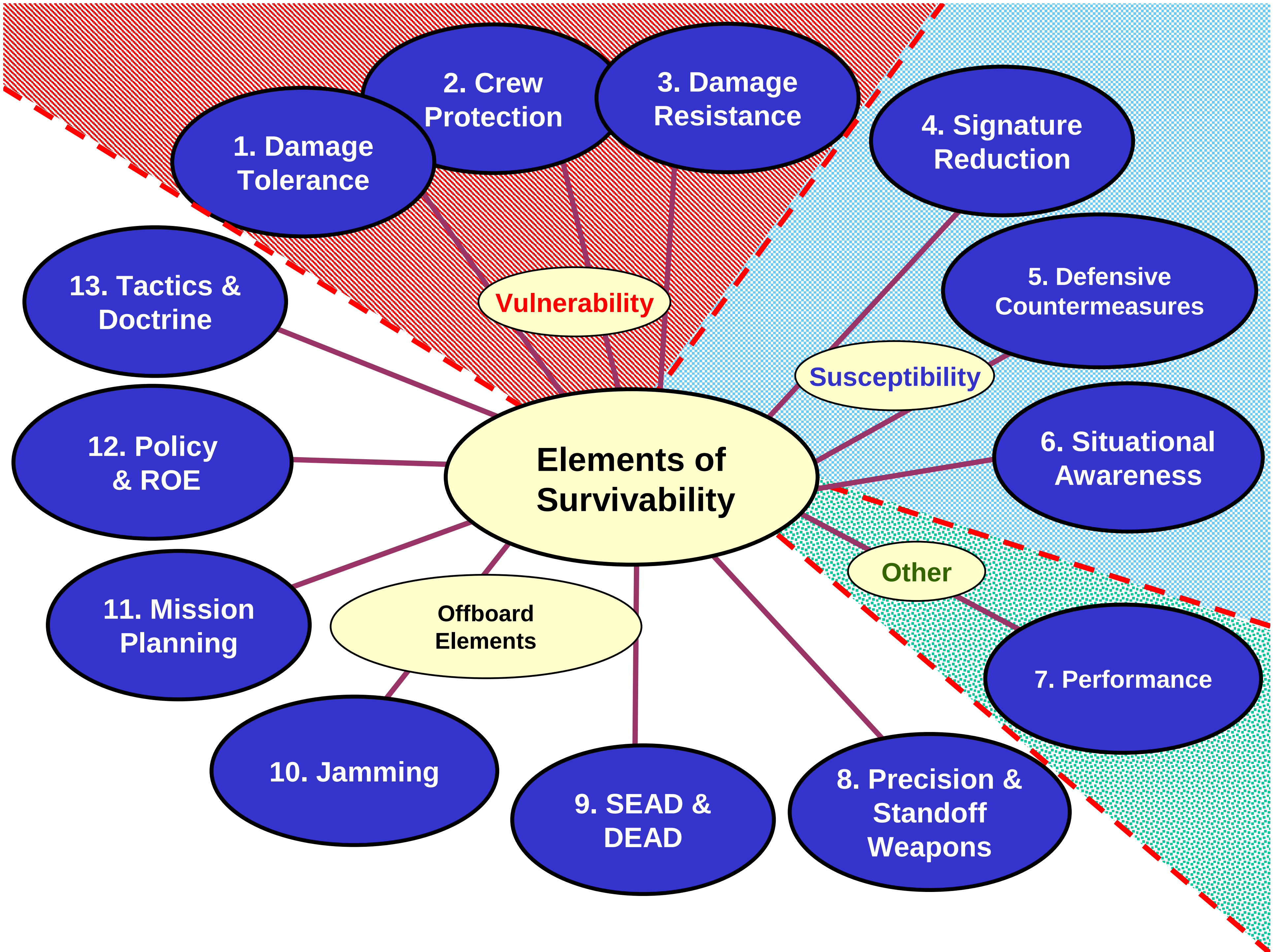
What is Integrated Survivability Assessment?

- ISA is a process for evaluating all aspects of system survivability in a coordinated fashion
  - Using both M&S and T&E resources where appropriate
- Developed by SURVICE Engineering Company
  - For the Joint Aircraft Survivability Program (JASP) with funding from DOT&E
- SURVICE's Experience in many related areas led to its selection for this work
  - Survivability, Effectiveness and Mission Modeling and Analysis
  - Test and Evaluation Planning, Execution, and Analysis
  - Model and Simulation Verification, Validation and Accreditation
  - Systems Safety Engineering and Analysis

What does the Integrated Survivability Assessment Process Do?

- **Measures system survivability in the context of missions and scenarios**
  - **Ensures that mission and scenario vignettes “cover the waterfront” to avoid a point design**
- **Ensures consistent treatment of survivability if applied throughout the system acquisition lifecycle**
  - **Requirements development, AOA, spec compliance, LFT&E, OT&E, retrofits, SLEP, system mods, training applications…**
- **Enables trades of Survivability, Effectiveness, and Mission Metrics in a Consistent and Documented Process**



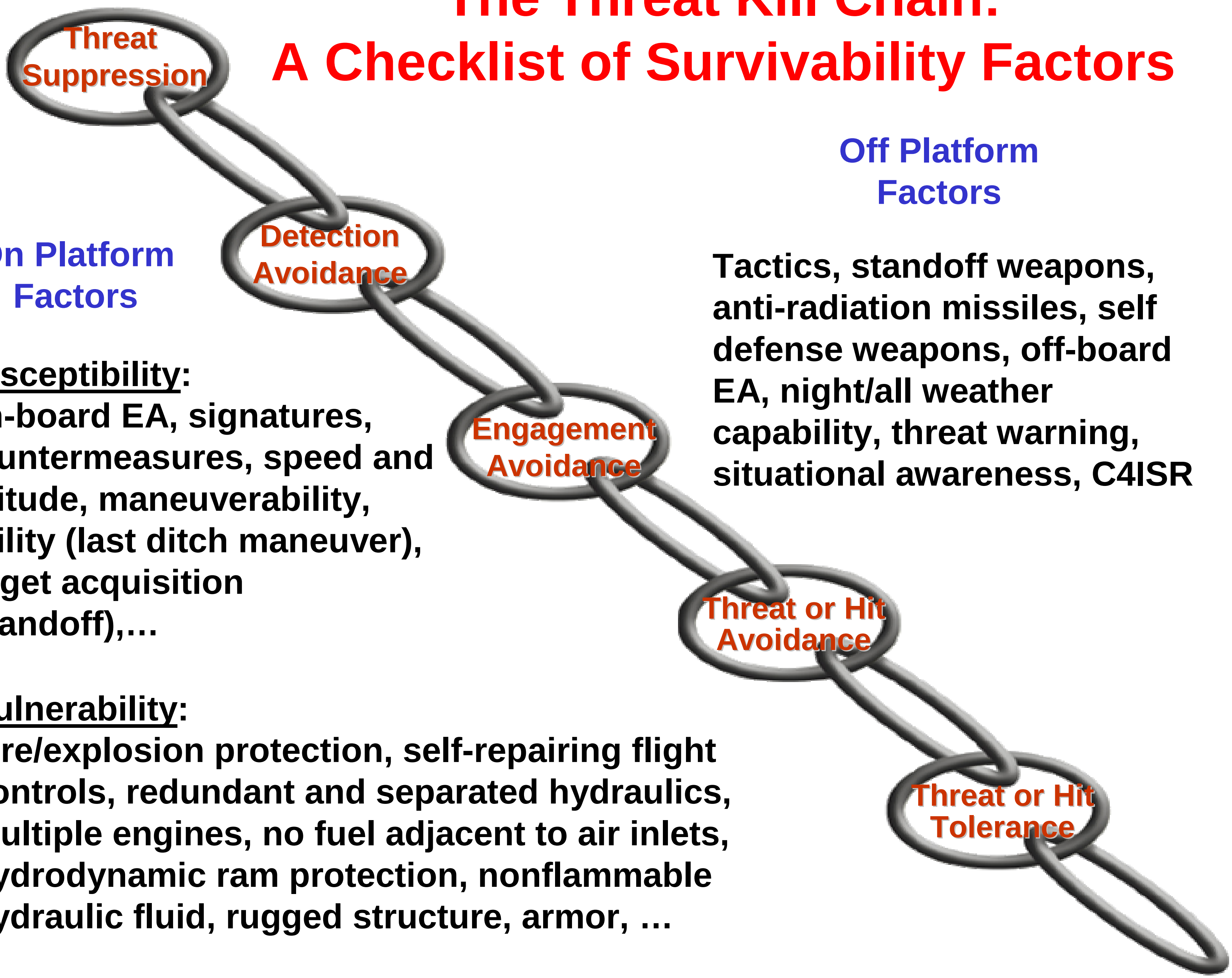


1. Damage Tolerance
2. Crew Protection
3. Damage Resistance
4. Signature Reduction
5. Defensive Countermeasures
6. Situational Awareness
7. Performance
8. Precision & Standoff Weapons
9. SEAD & DEAD
10. Jamming
11. Mission Planning
12. Policy & ROE
13. Tactics & Doctrine
Vulnerability
Susceptibility
Other
Offboard Elements
Elements of Survivability

Developing an Integrated Survivability Assessment Process

- Develop a checklist of important survivability factors
- Define the operational context and environment
- Select and evaluate the metrics identified as important to integrated survivability assessment
  - Provide a modeling path to measure and quantify those metrics
  - Identify test range assets and processes to measure those metrics
- Identify assumptions, limitations, and deficiencies in both M&S and Test resources
  - And mitigation actions for deficiencies
- Provide for a path to validation of the modeling processes with available test range data
  - Model - test - model

The Threat Kill Chain:
A Checklist of Survivability Factors



On Platform Factors

Susceptibility:
On-board EA, signatures, countermeasures, speed and altitude, maneuverability, agility (last ditch maneuver), target acquisition (standoff),…

Vulnerability:
Fire/explosion protection, self-repairing flight controls, redundant and separated hydraulics, multiple engines, no fuel adjacent to air inlets, hydrodynamic ram protection, nonflammable hydraulic fluid, rugged structure, armor, …

Off Platform Factors

Tactics, standoff weapons, anti-radiation missiles, self defense weapons, off-board EA, night/all weather capability, threat warning, situational awareness, C4ISR

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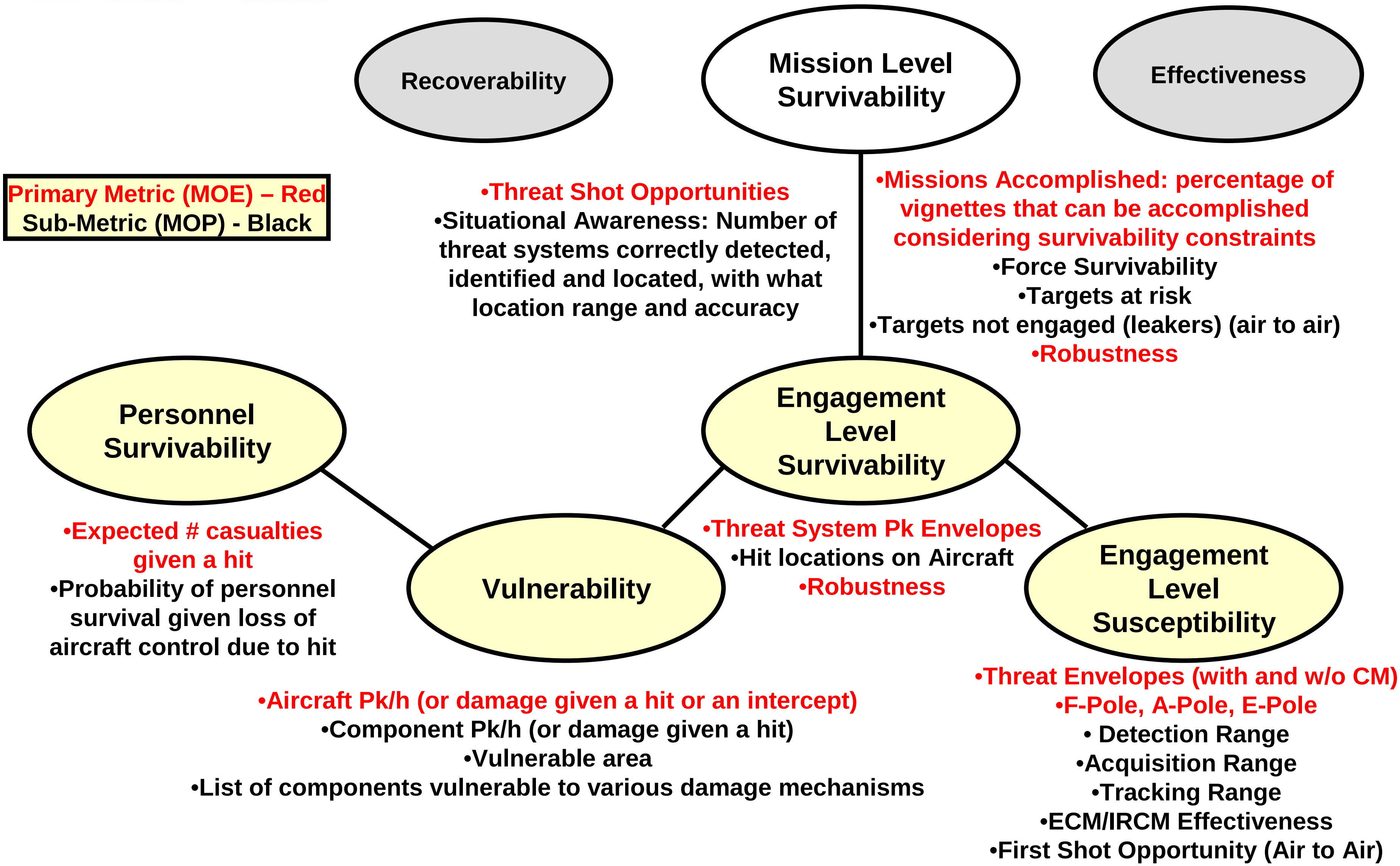
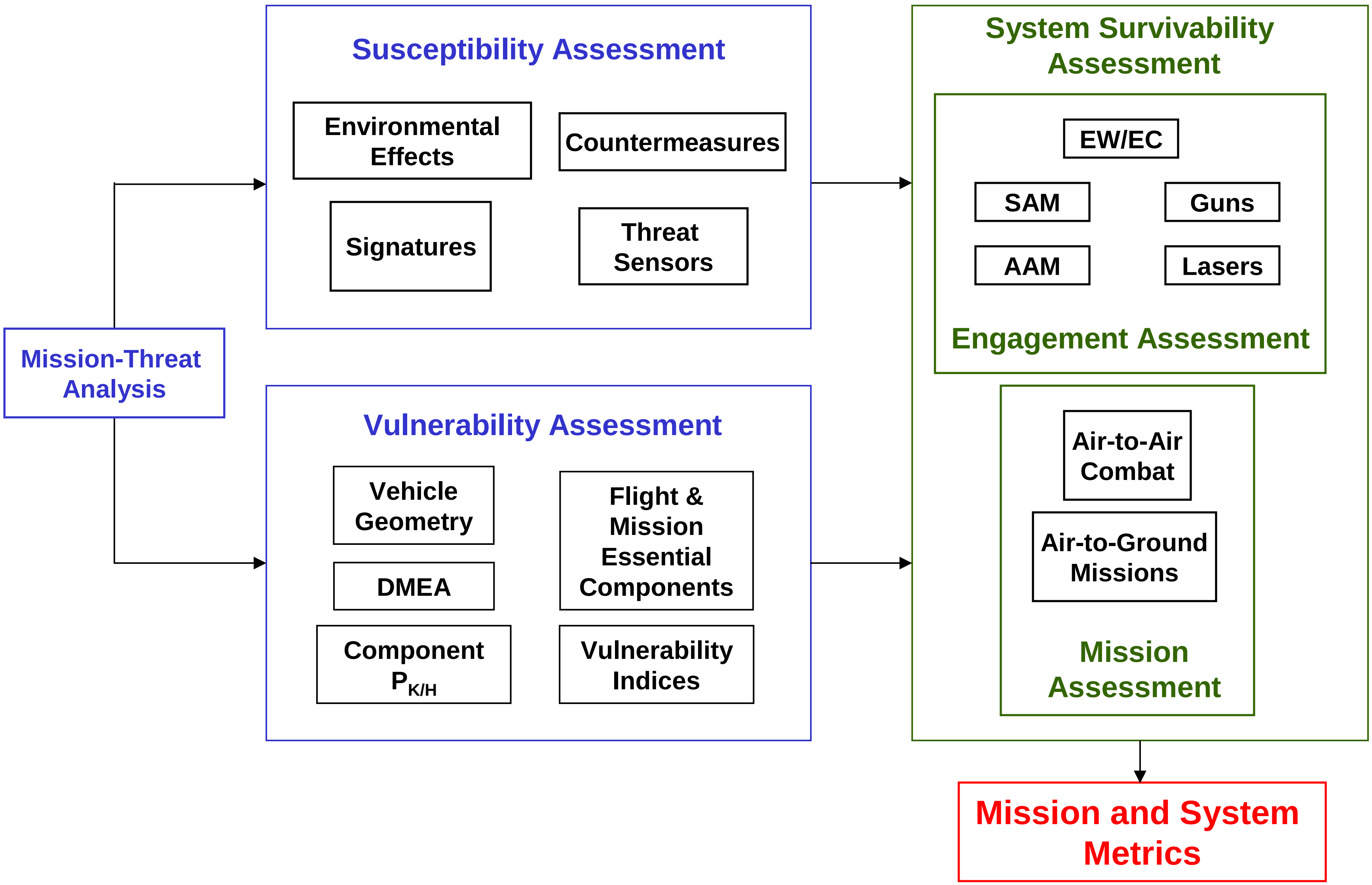
Survivability Metrics



Metrics and the Checklist

Links in the Threat Kill Chain	ISA Metrics	Potential Survivability Enhancement Features Along the Kill Chain
Mission Survivability	Missions Accomplished; robustness	All features combine to support mission level survivability
Threat Suppression	Threat Shot opportunities; situational awareness (number, timeliness and accuracy of threats detected)	Tactics, Precision Guided Munitions, mission planning, low signatures, fighter escort, ARM, self defense weapons
Detection Avoidance	Threat Detection & Acquisition Envelopes	SOWs, Night Capability, on-board Electronic Attack (EA), stand-off EA, low signatures, good target acquisition, Terrain Following, Situational Awareness (SA), chaff, threat warning, tactics, mission planning
Engagement Avoidance	Threat Tracking envelopes; F-Pole, A-Pole, E-Pole; ECM effectiveness	SOWs, Onboard EA, Off-board EA, low signatures, good target acquisition, SA, chaff and flares, threat warning, speed and altitude, mission planning
Threat or Hit avoidance	Threat Intercept Envelopes; ECM/IRCM effectiveness	On-board EA, low signatures, chaff and flares, threat warning, speed and altitude, maneuverability, agility
Threat or hit tolerance	Threat system Pk envelopes; Aircraft Pk/h; Component Pk/h; VA; Vulnerable Components; Casualties given a hit; hit locations on aircraft	Fire/explosion protection, self-repairing flight controls, redundant and separated hydraulics, multiple engines, no fuel adjacent to air inlets, hydrodynamic ram protection, nonflammable hydraulic fluid, rugged structure, armor

The Survivability Assessment Process



Data Sources for a Typical Survivability Assessment

$$P_{K/E} = P_{A/E} * P_{T/A} * P_{L/T} * P_{I/L} * P_{F/I} * P_{H/F} * P_{K/H}$$

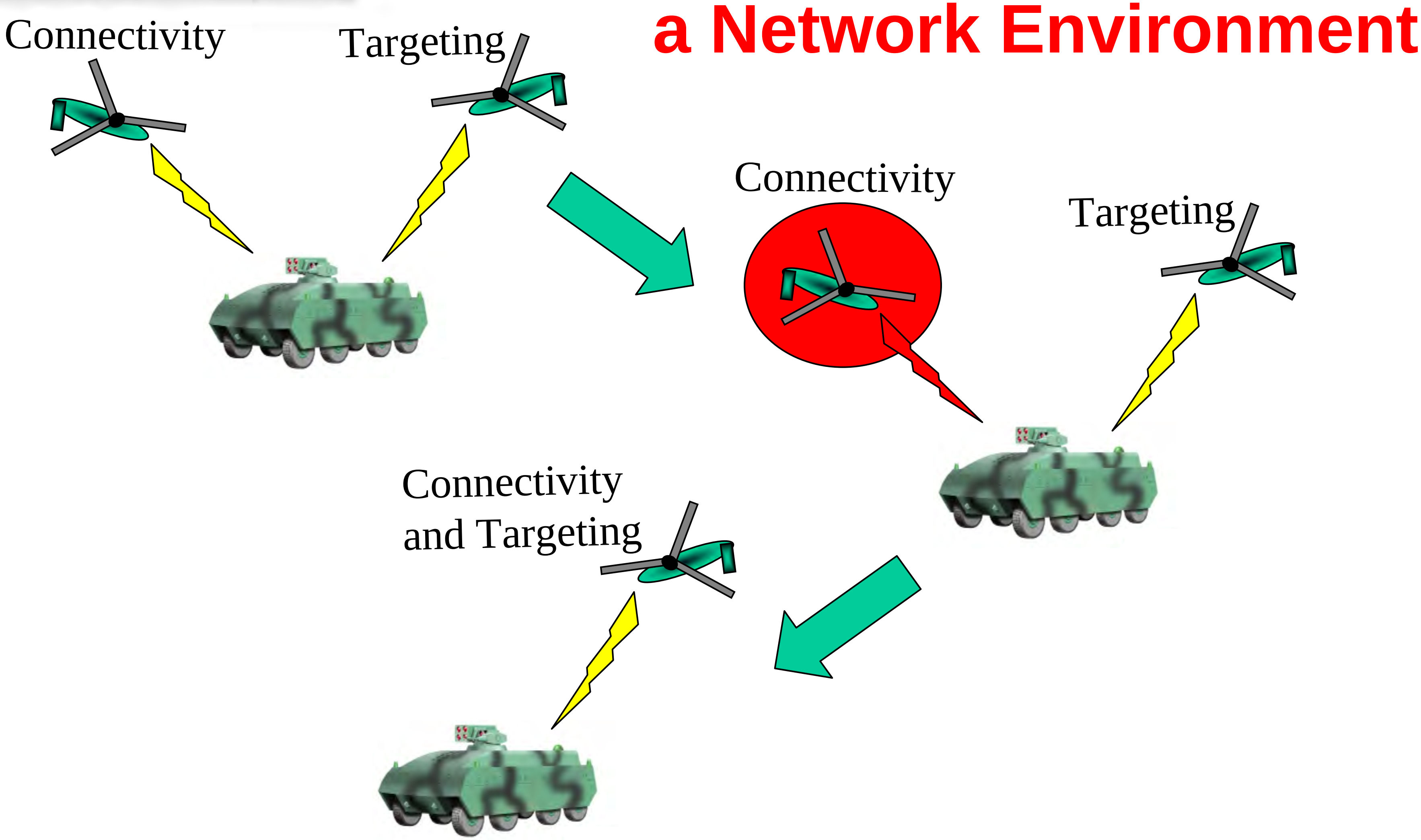
DT/OT&E **M&S** **LFT&E**

E = Engagement
A = Acquisition
T = Track
L = Launch

I = Intercept
F = Fuzing
H = Hit

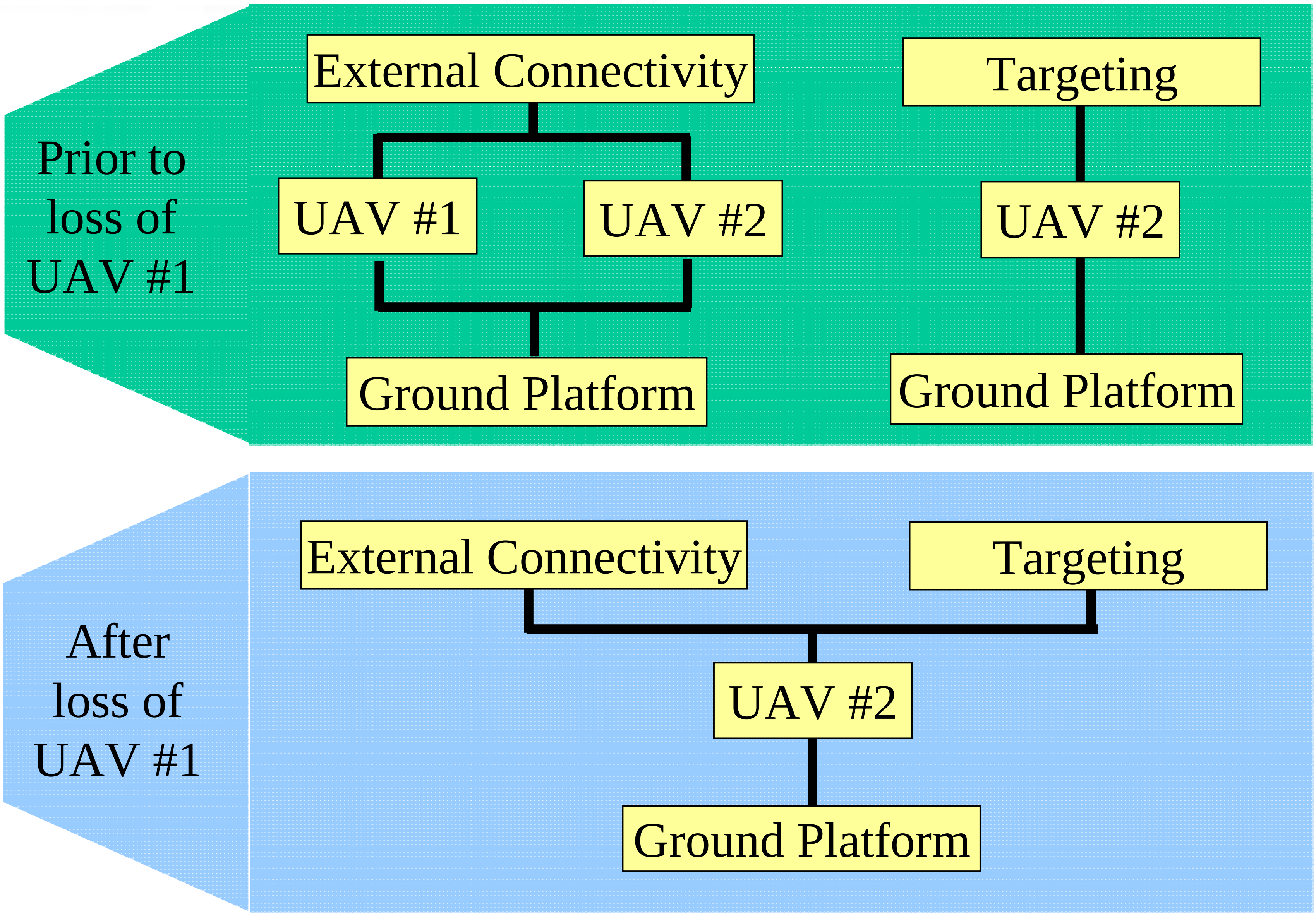
K = Kill

System Survivability in a Network Environment

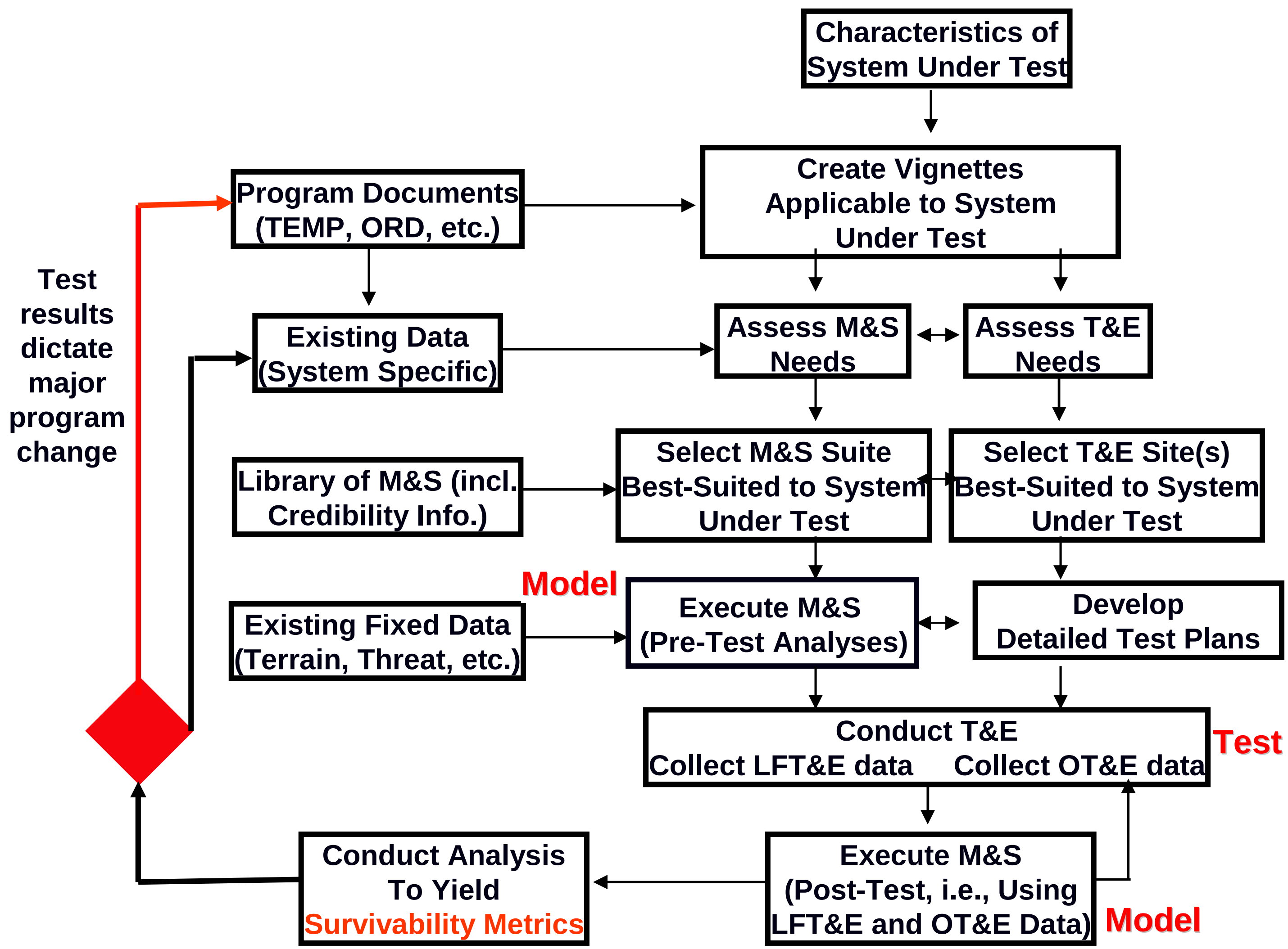


How does loss of a UAS element affect the network?

Network Fault Tree Approach



Integrated Survivability Assessment Process: Model-Test-Model Concept



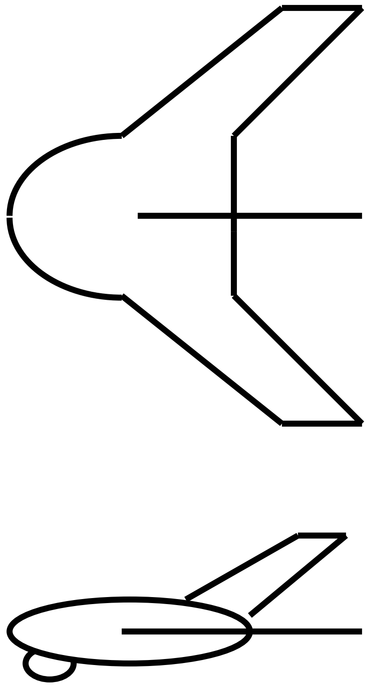
"Case Study" Example

- **Unmanned Combat Aircraft System (UCAS) with the following characteristics:**

  Role: CAS, battlefield interdiction, SEAD/DEAD, etc.
  Dimensions:
  Weight:
  Speed:
  Range:

- **To be determined:**

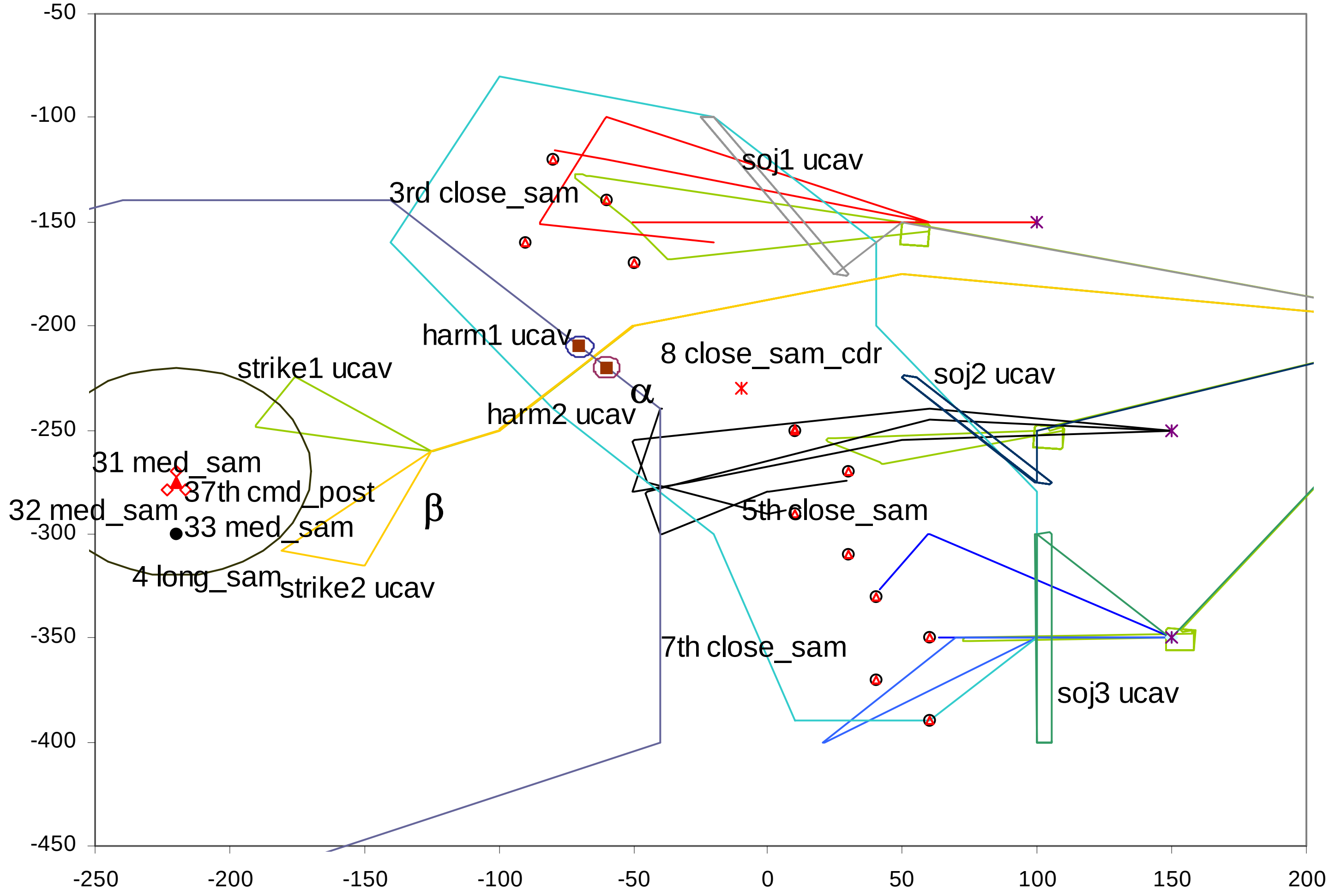
  RCS:
  IR signature:
  DECM/IRCM:
  Vulnerability:
  etc.



EXAMPLE: UCAS VIGNETTES

	3rd World Urban	Advanced Threat, Forested	Conventional Threat, Desert	3rd World Mountains
ISR	Ж	X	X	X
Force Protection	X	Ж	X	X
SEAD DEAD	X	Ж	X	X
C2		Ж	X	X
All Weather, Night Strike	Ж	X	X	X
CSAR	X	X	X	Ж
Driving Factors Ж = Most stressing Scenario	Target Acquisition Difficult Conventional Threat	IADS, Wx, Target Acquisition Advanced Threat	Flat Terrain, Clear Wx High Threat	High Altitude, Rough Terrain Conventional Threat

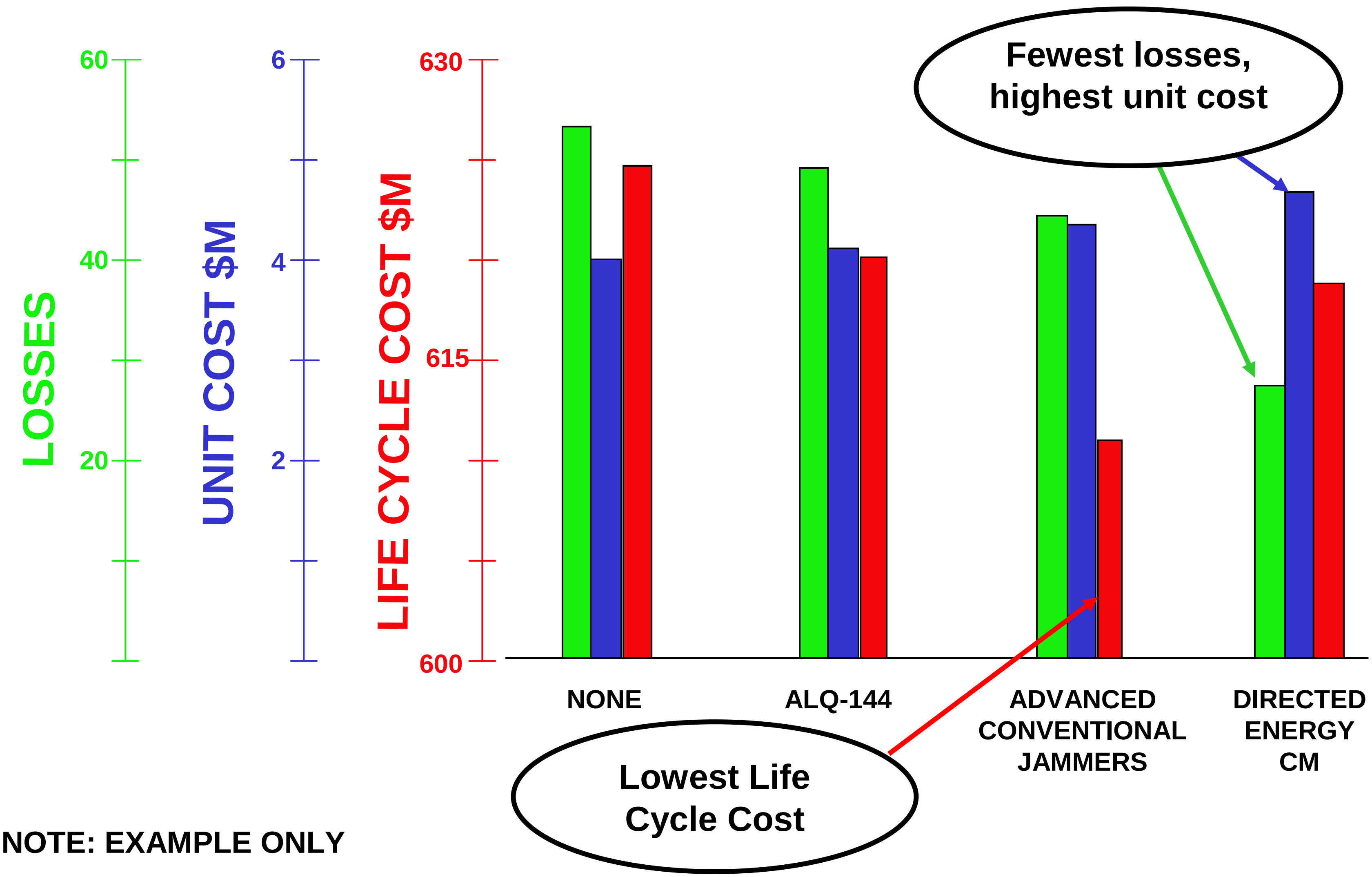
Example: SEAD/DEAD Vignette



Timeline

TOT -12	Checkpoint α
TOT -5	Decoys on @ β
TOT -4	2 x HARMs
TOT -3	2 x HARMs
TOT -2	2 x HARMs
TOT -1	Weapons away
TOT -0	Weapons impact
TOT +1	2 x HARMs

Example Integrated Survivability Results : Impact of IRCM Improvements on UAS



NOTE: EXAMPLE ONLY

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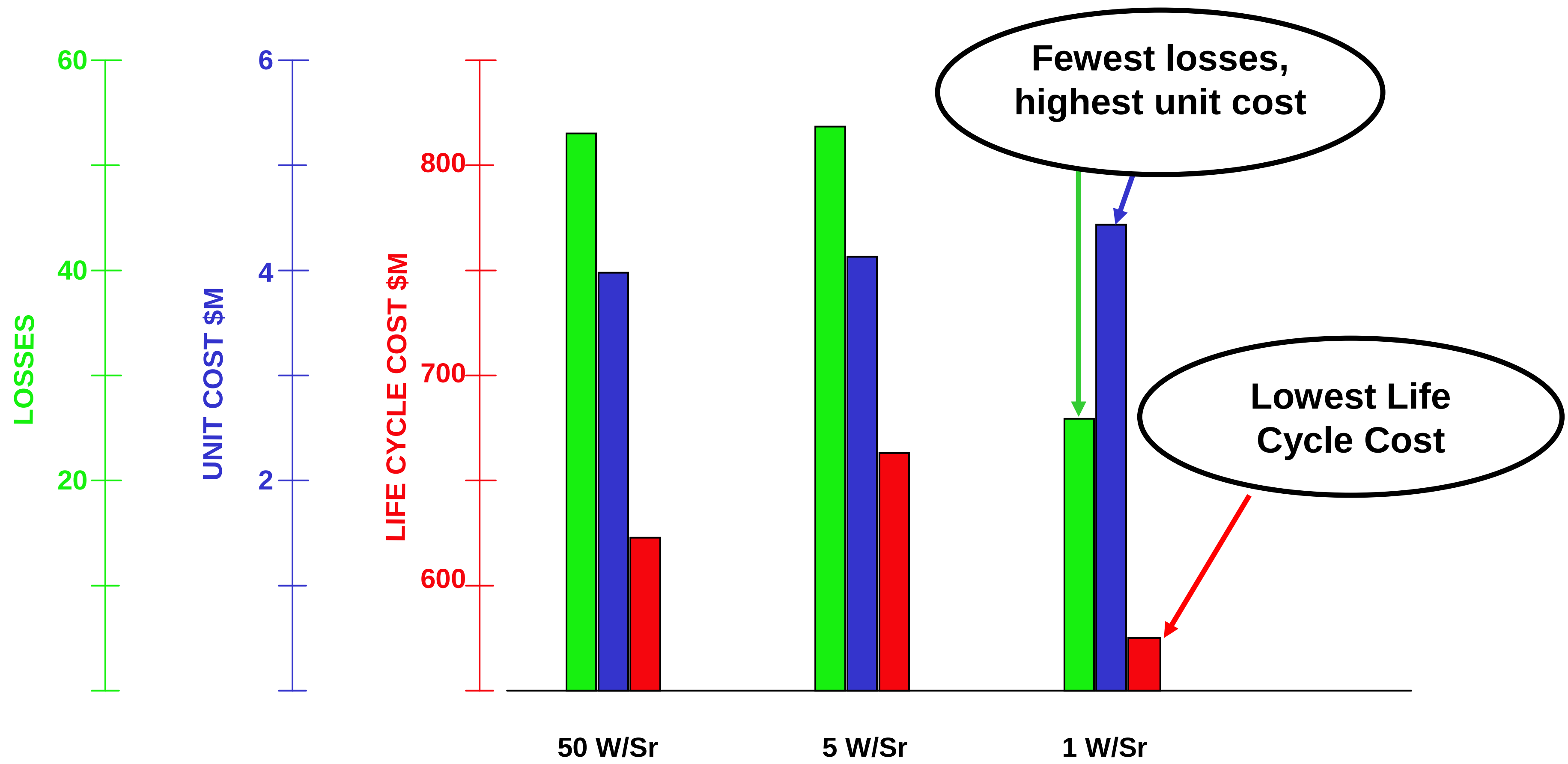
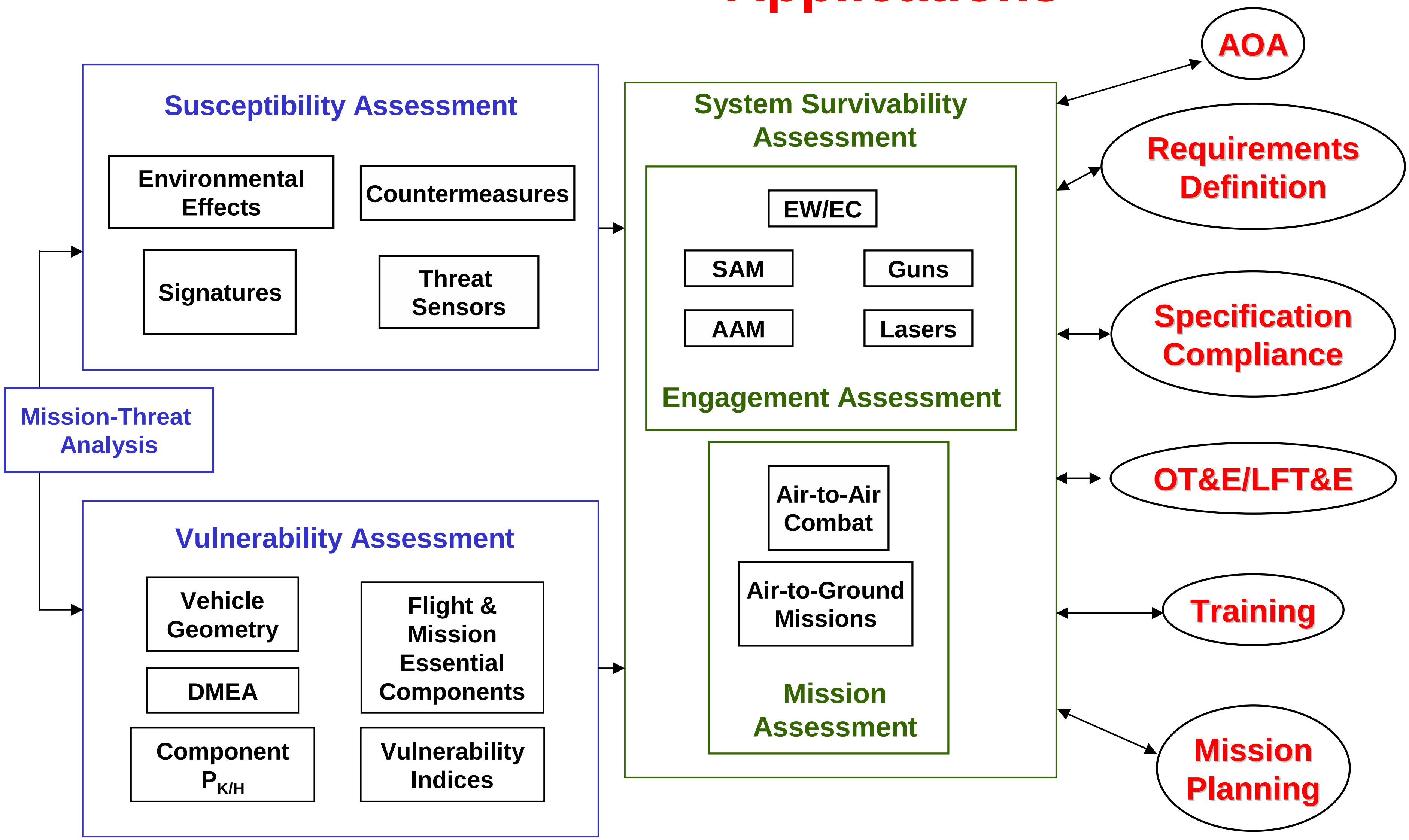
Example Integrated Survivability Result: Impact of IR Signature Reduction on UAS



NOTE: EXAMPLE ONLY

Integrated Survivability Assessment Applications



Summary

- **Integrated Survivability Assessment incorporates survivability into the systems engineering process for all phases of system development**
  - **Supports both individual platform and network system assessment**
- **JASP has funded the development of a baseline ISA capability focused on air systems**
  - **ISA process is extensible to ground, shipboard and space systems as well**

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ISA Demonstrations

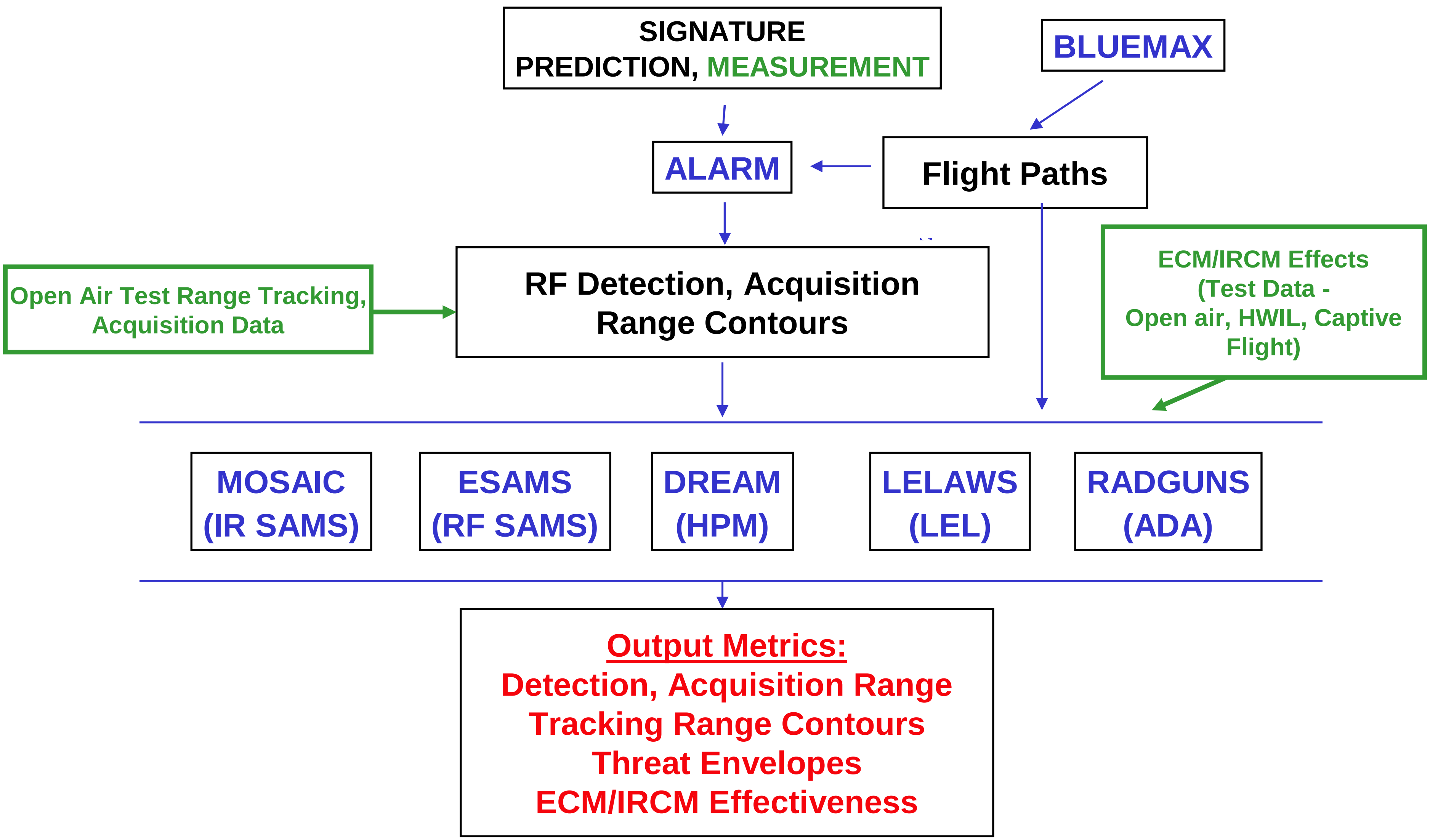
- **JASP is co-funding demonstrations of the ISA process for two acquisition programs**
- **Multi-Mission Maritime Aircraft (MMA)**
  - **Demo began in FY04**
- **Aerial Common Sensor (ACS)**
  - **To begin in FY06**

Supplemental Material

Example: SEAD/DEAD Vignette

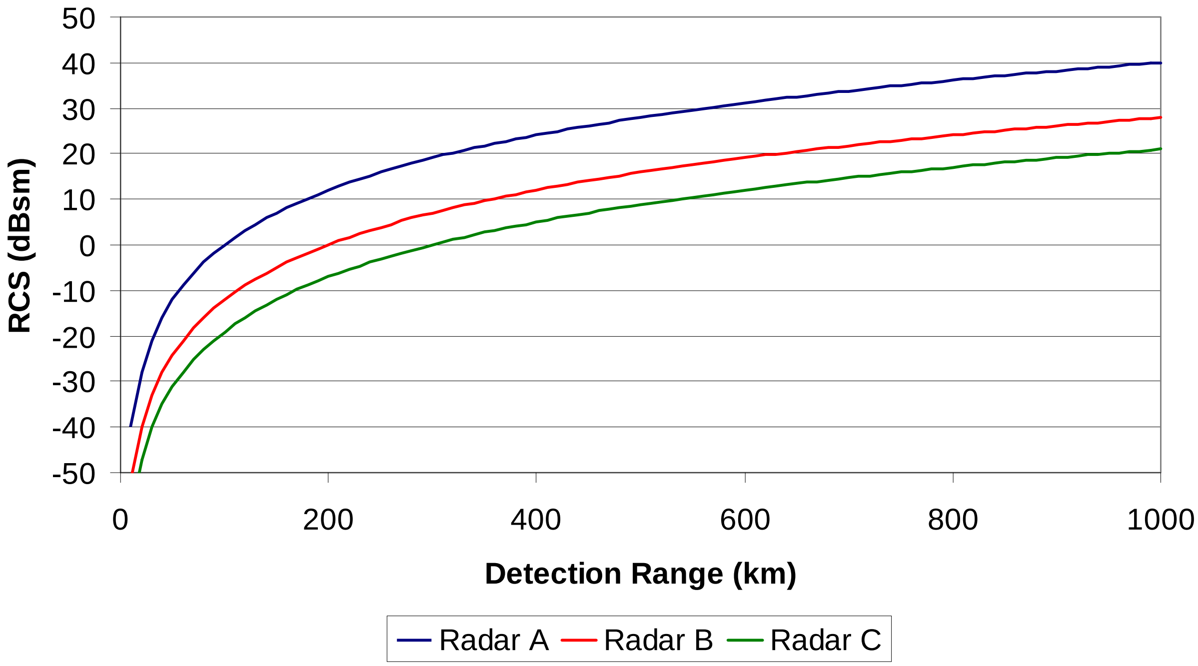
- **SEAD/DEAD mission**
  - **SOJ**
  - **HARM**
  - **Part of Battlefield Interdiction (Strike)**
    - **Command Post target**
- **Scenario:**
  - **Unclassified scenario taken from Joint Integrated Mission Model (JIMM) dataset**
- **Threats:**
  - **Surface-to-air RF and IR missiles only**

Single Threat Engagement Assessment

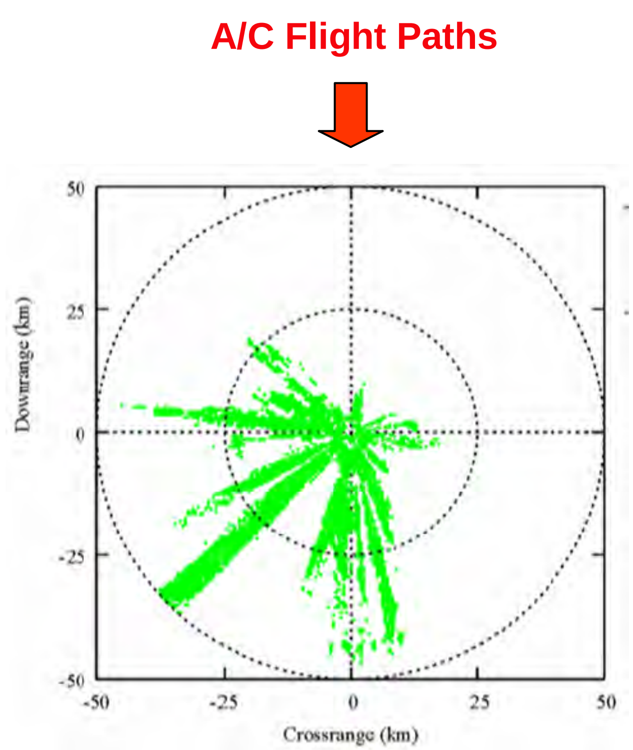


Example Susceptibility Results: Impact of RCS and Terrain on Detection

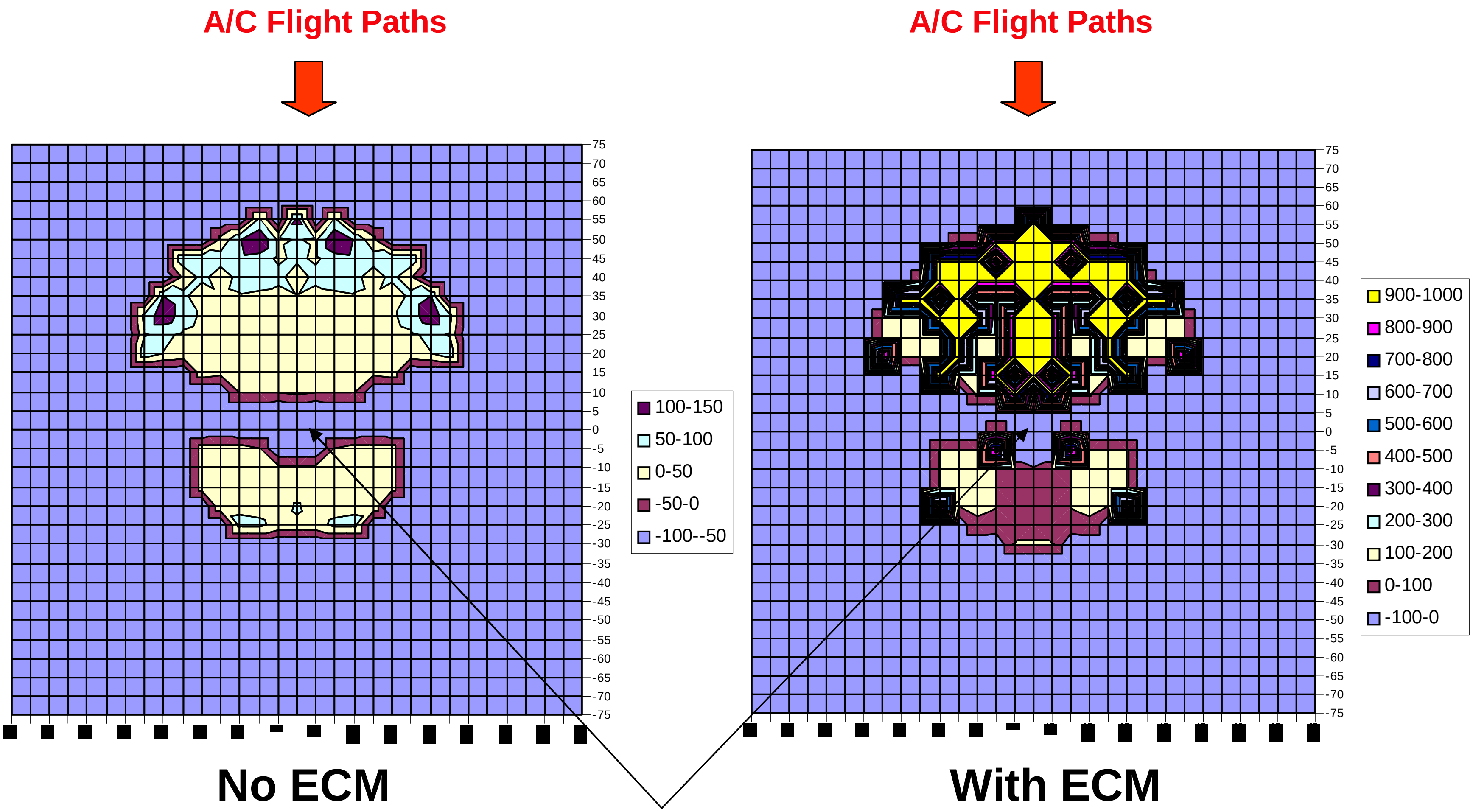
Detection range vs. RCS



Effects of Terrain Masking on Detection Contour



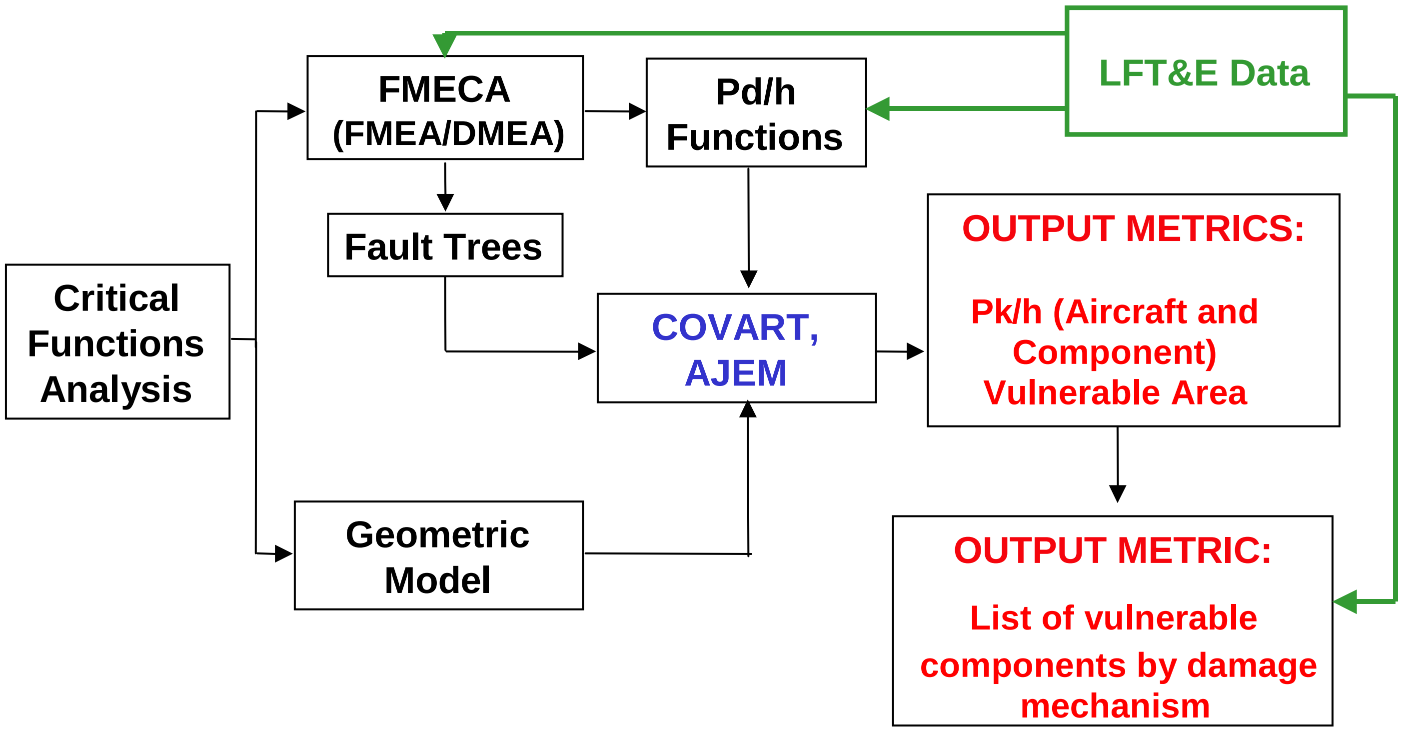
Example Results: Impact of ECM on Miss Distance



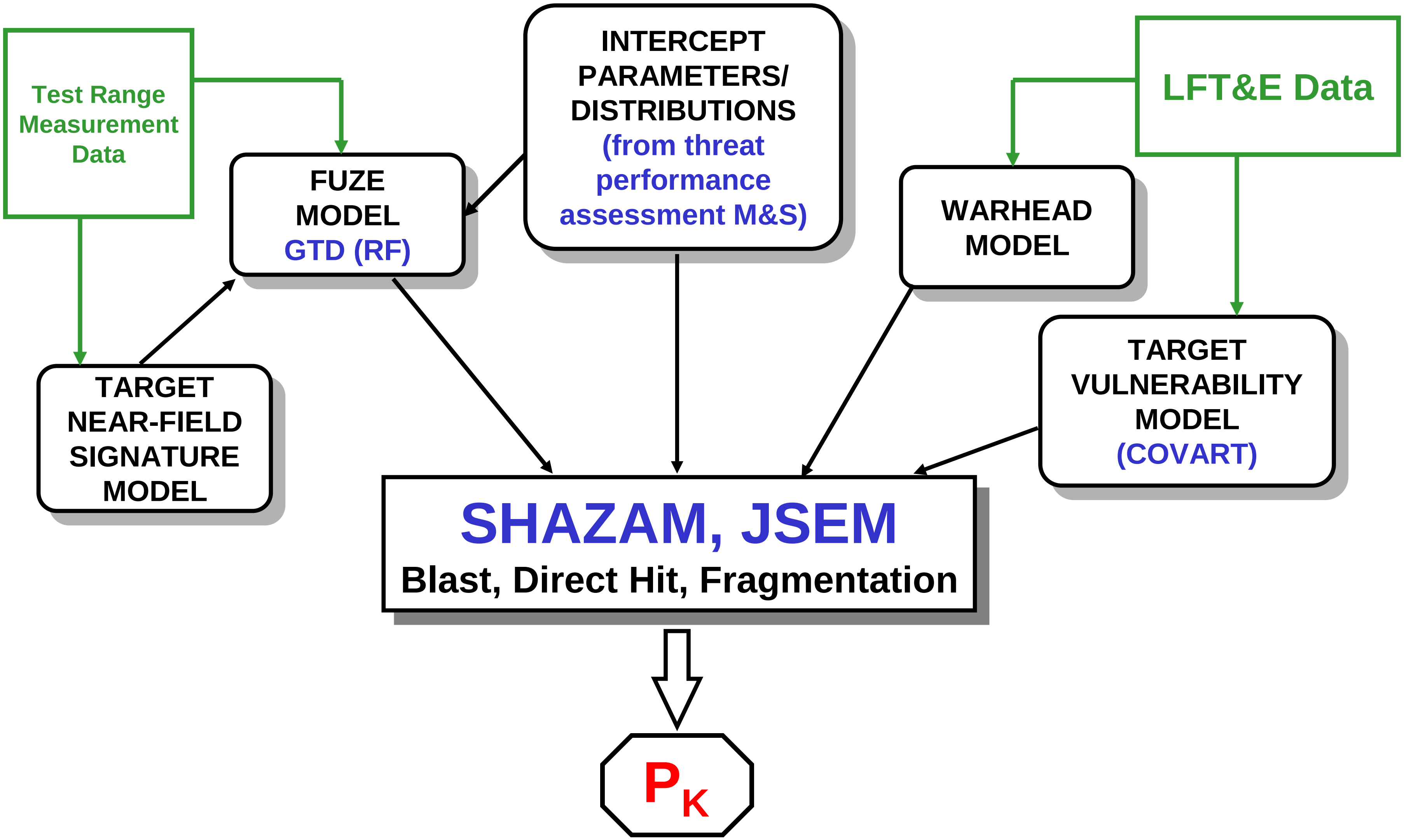
Threat System

Miss Distances in Meters
Locations in KM

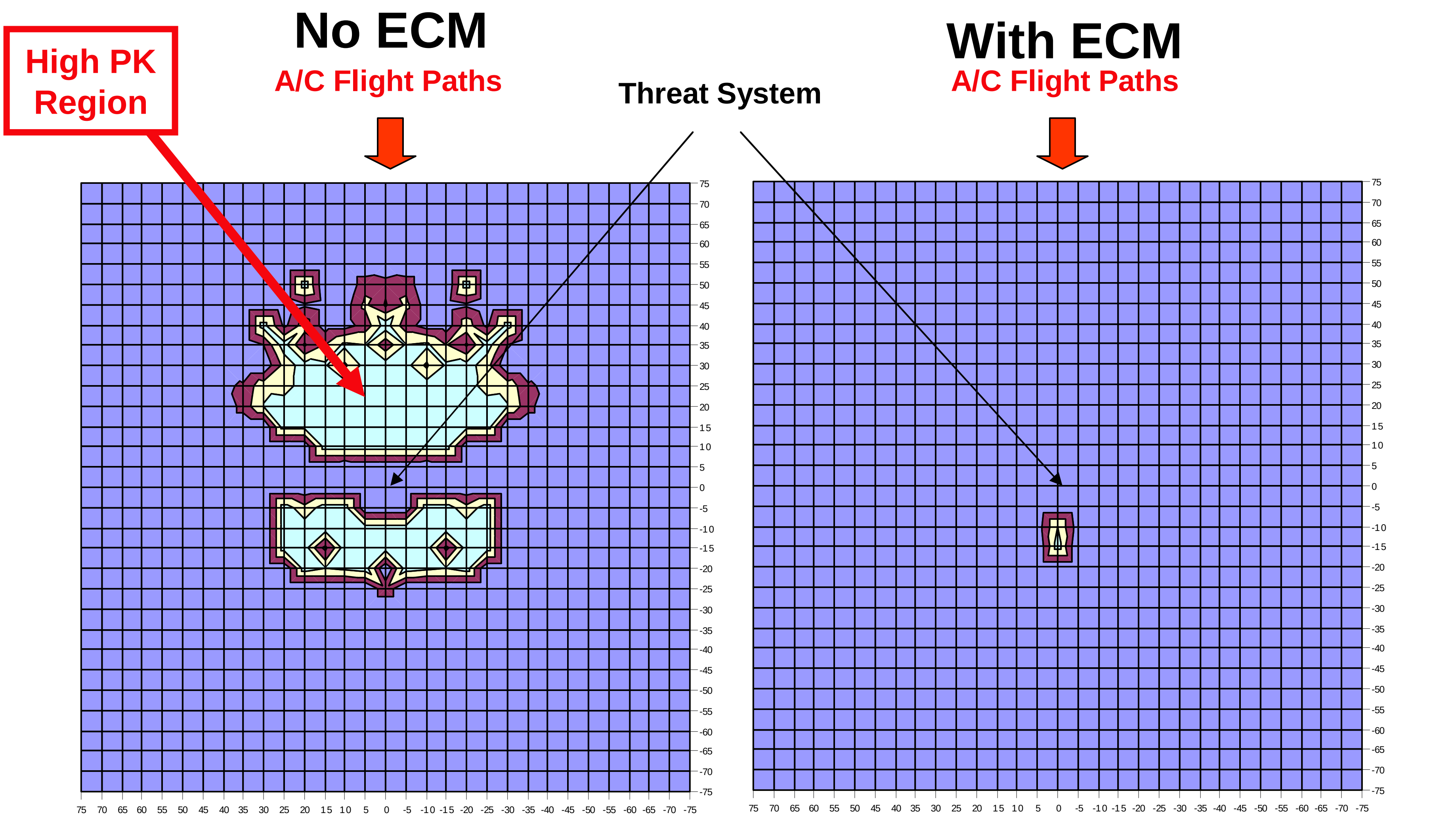
Vulnerability Assessment



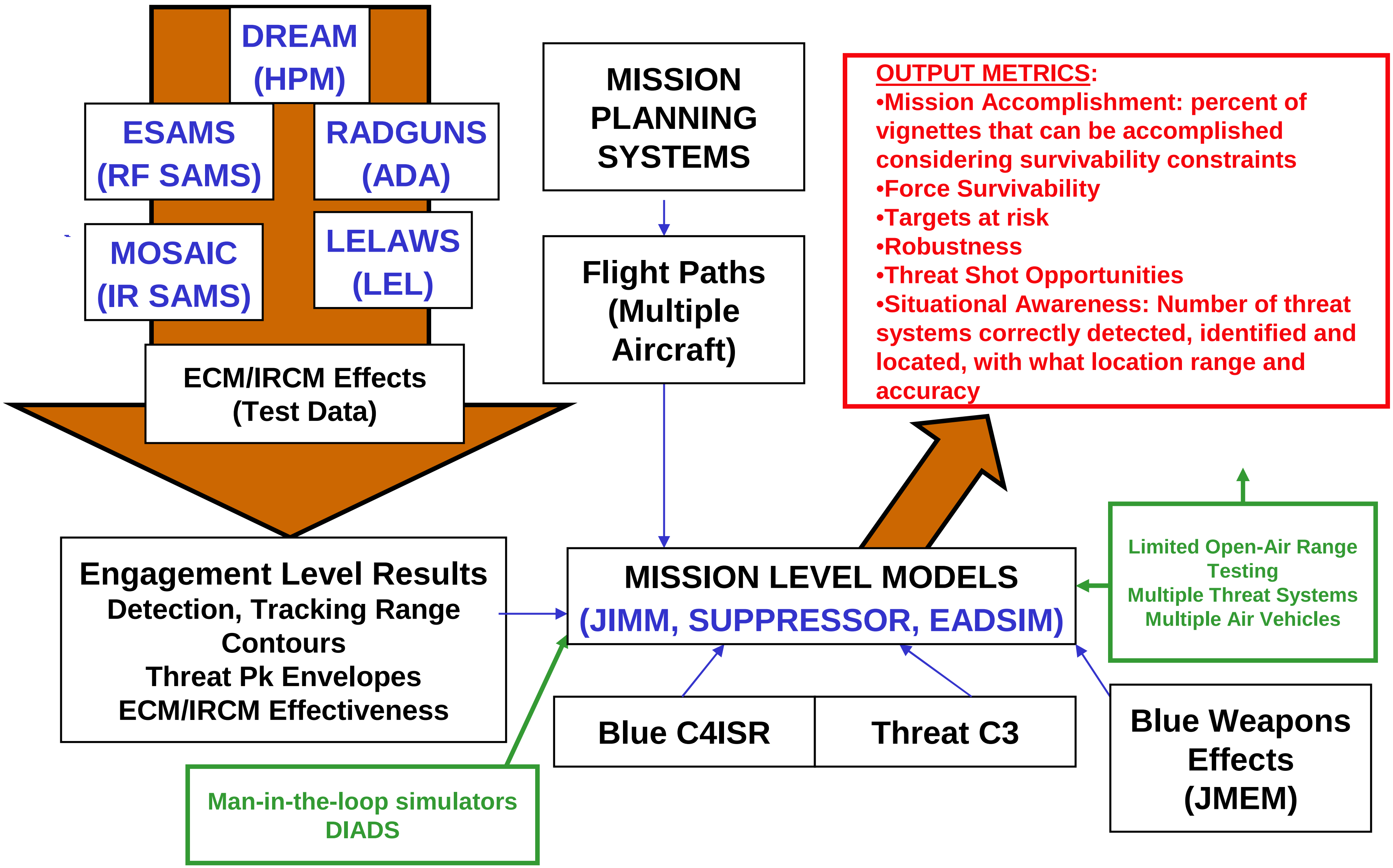
Threat Missile Endgame (Pk) Assessment



Example Engagement Survivability Results: Effect of ECM on PK



Mission Survivability Assessment



Distributed Net-Centric Interoperability Certification Testing

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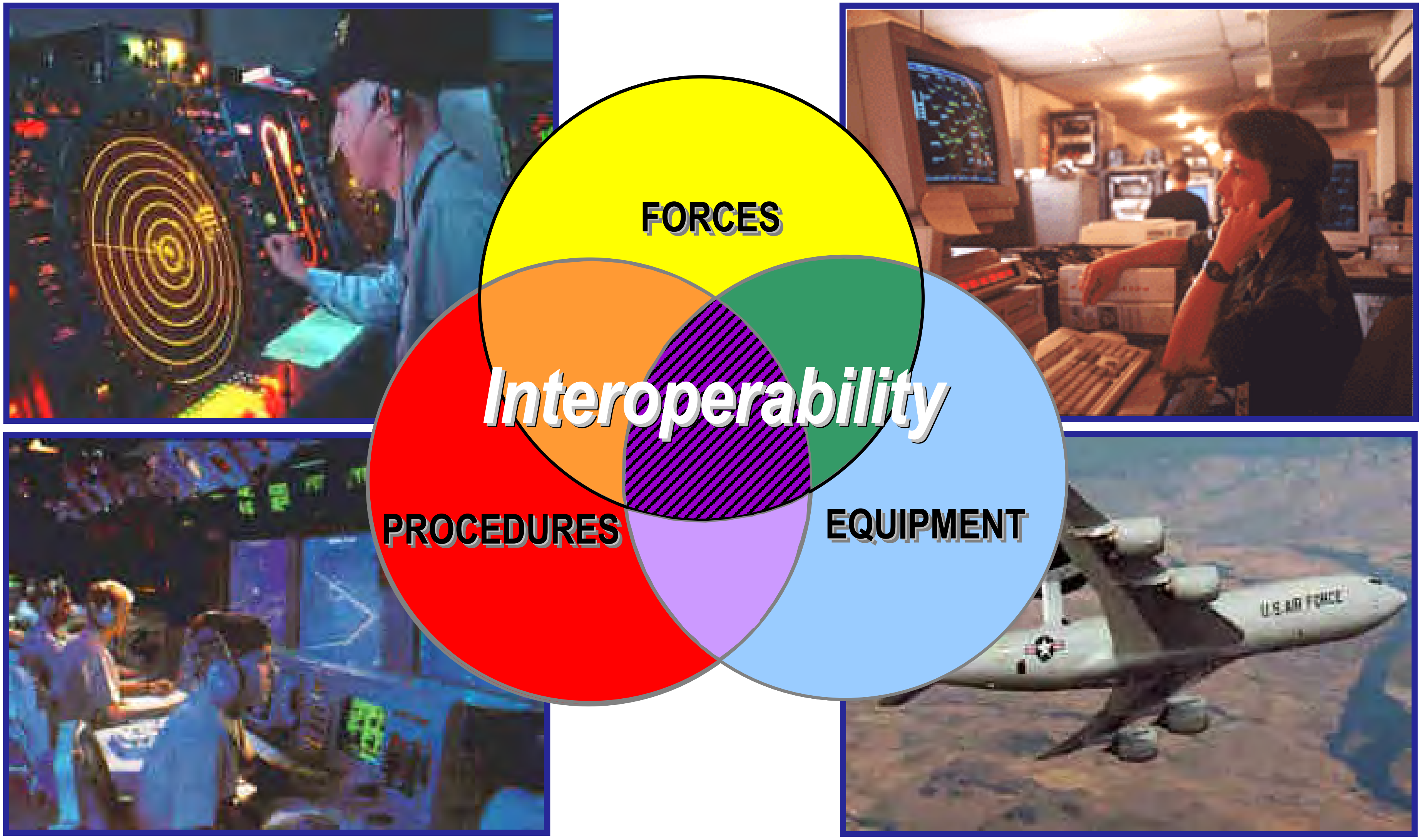
National Defense Industrial Association 8th Annual Engineering Conference
October 2005

JITC's Interoperability Perspective



DICE Mission / Focus Areas

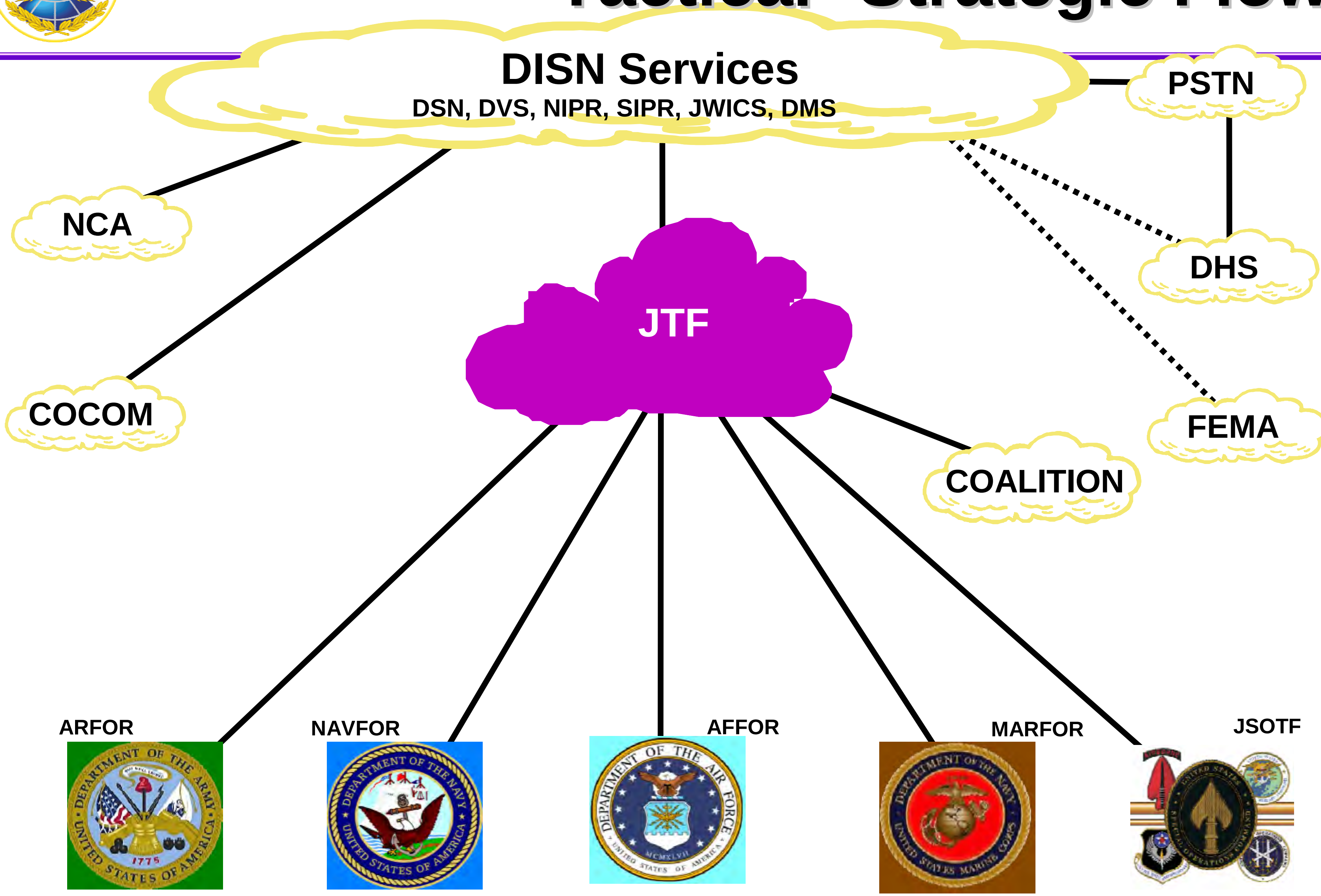
- **Mission:**
  - **Replicate, in the greatest detail possible, a "typical" Joint Task Force (JTF) communications network for the purpose of conducting joint interoperability certifications and assessments of warfighter systems.**

- **Focus Areas:**
  - **Joint interoperability certification / assessment**
  - **Emerging technology demonstrations**
  - **Warfighter training and procedures**
  - **Critical interfaces between Department of Defense (DOD) and Department of Homeland Security (DHS)**

Why participate in DICE?

- Only DOD exercise dedicated solely to interoperability testing in JTF environment
- OPTEMPO of the exercise is controlled by testing requirements
- Significantly lower testing costs due to cost / asset sharing among participants and JITC
- Opportunity to train as we fight--joint environment

Tactical--Strategic Flow



DICE 2005 Observations

- **Technology advancements continue to outpace user training and expertise**
  - **Technology insertions / upgrades are more frequent**
  - **Increase in contractor / specialist involvement with fielding**

- **Ku-band replacing X-band as preferred JTF satellite access method**
- **Definite movement towards converged IP (voice, video, data)**

DICE 2006 Focus

- Net-Ready Key Performance Parameters (NR-KPP)
  - Information Assurance
  - Information exchange (i.e., joint interoperability)
    - Service systems (legacy & emerging)
    - GIG applications
    - IPv6
    - Collaboration tools
    - Wireless technology testing

- DHS, Civilian Government, 1st Responders
  - DOD-to-DHS interfaces
  - DHS-to-state / local authorities

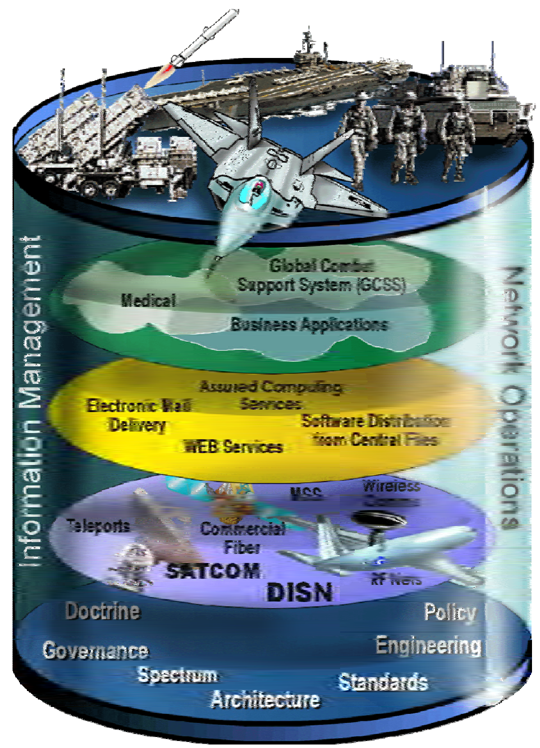
IPv6 and DOD

- **August 2005 ASD, NII Memo**
  - **Global Information Grid (GIG) assets being developed, procured, or acquired shall be IPv6 capable by 2008**
  - **Aggressive participation in pilots, demos, test beds**

- **DOD IPv6 Transition Office established Feb. 2004**
  - **Lead DOD transition to IPv6**
  - **JITC is developing the Generic IPv6 Test Plan**

JITC IPv6 Background

- Sole interoperability certification authority for DOD
  - Integrating IPv6 capability assessments into certification testing process
- Testing IPv6 since 2003
  - DICE 2003, 2004, 2005
  - Moonv6 Phase I & II
  - JUICE 2004 / Joint Rapid Architecture Experiment
  - Moonv6 / JITC Test Set 2004



Transition to IPv6 will touch everything

JITC Advanced Internet Protocol Technology Laboratory

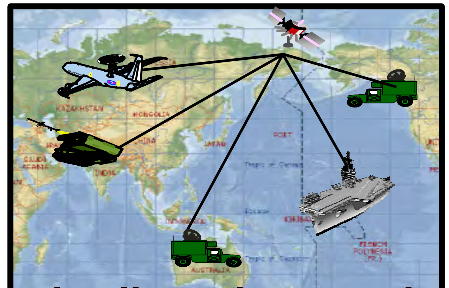
- Advanced Internet Protocol Technology (AIPT) Laboratory
  - Established January 2004
  - Built on a GIG-like core of equipment
  - Equipment from many vendors

- Supports DOD IPv6 Transition Office and ASD-NII

- Focus areas
  - IPv6 capability
  - Interoperability

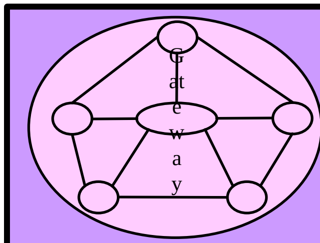
JITC AIPT Lab Capabilities

- Use Generic IPv6 Test Plan (DRAFT)
  - End-to-End—DREN, Satellite, DISN-LES
    - GIG and JTF-like architectures
    - Strategic and tactical interfaces (realistic but non-operational)
    - Connectivity to multiple DOD sites



Distributed Network

  - Lab Testing
    - Multitude of vendors represented in the lab
    - Complex strings-- ARFOR, NAVFOR, MARFOR, AFFOR
    - Custom strings-- dependent on vendor / component need
    - Intrusive / catastrophic testing can be done that is not viable on operational networks

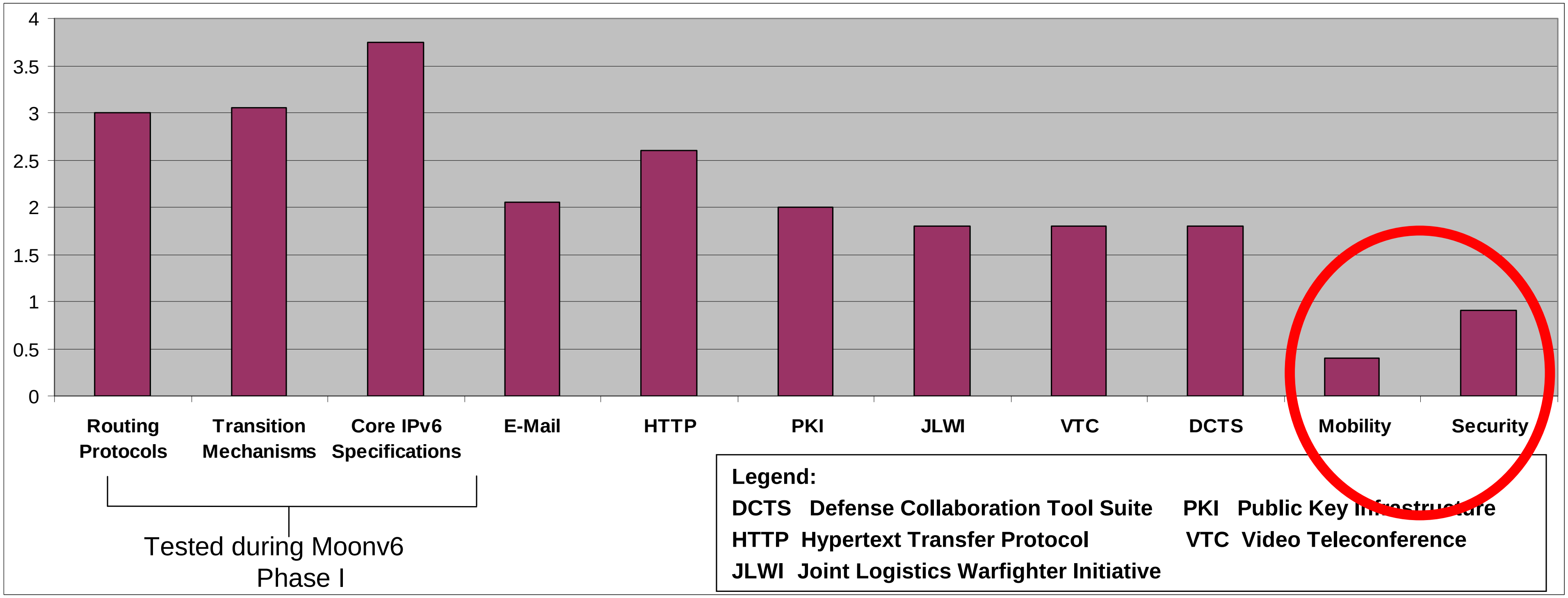


Lab Network

Moonv6 Program

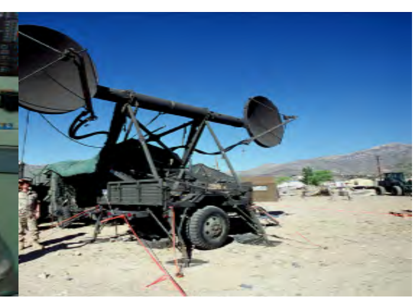
- **Cooperative effort between**
  - **North American IPv6 Task Force (NAV6TF)**
  - **University of New Hampshire-Interoperability Laboratory (UNH-IOL)**
  - **DOD**
  - **JITC**
  - **Commercial service providers**
- **Test items are determined by the DOD requirements and commercial service provider requirements**
- **Distributed test events began in 2003**

Overall Moonv6 Summary



Rankings:	2 = Majority of the RFC functionality implemented
0 = No RFC functionality implemented	3 = Full RFC functionality, some bugs exist
1 = Minimal RFC functionality implemented	4 = Full RFC functionality, minimal/no bugs remain



Conclusion

- **Distributed testing is more cost effective**
- **DICE affords opportunity to assess joint interoperability in a typical JTF environment at a reduced cost**
  - **Mitigates risk**
  - **Joint communications strategy development and training**
- **Moonv6 and DICE provide excellent venues to assess IPv6 products through a robust distributed test network**
- **Must ensure that the battleground is not the interoperability testing ground**

DEFENSE INFORMATION SYSTEMS AGENCY

Supporting Systems Engineering Through Education and Training

Presented to the NDIA Systems Engineering Conference

October, 2005

San Diego, California

Cynthia C. Hauer

Millennium Data Management, Incorporated

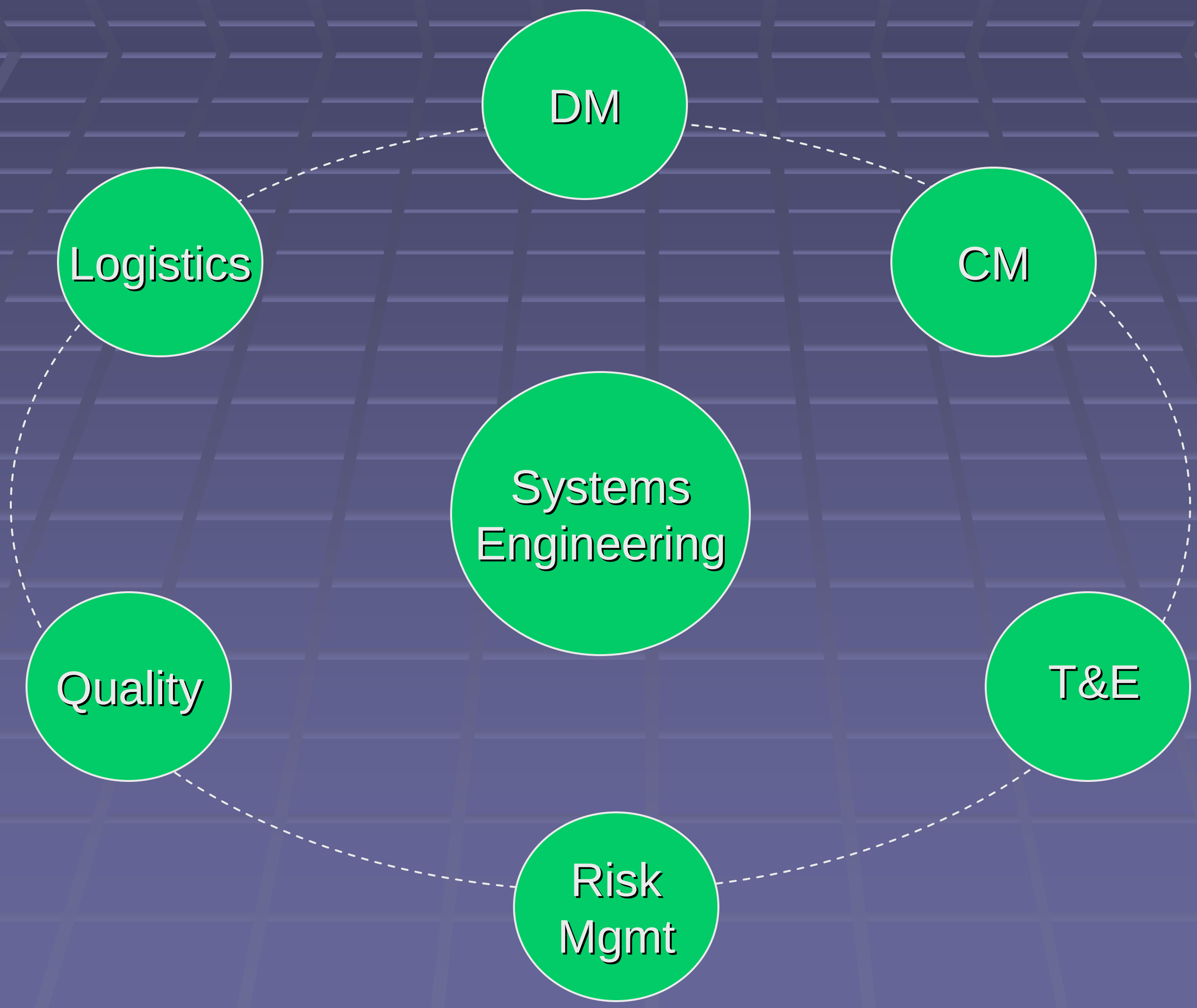
Huntsville, Alabama

AGENDA

- Problem statement
  - The challenge
- Essential challenges of training and education
  - Target environments
- How DM can help
  - A prototype case
- The benefits of standardizing practices across disciplines

SE Relationships

Integrating Specialty and Discipline Groups



Problem and Challenge Statements

- As baby boomers retire, the result is the loss of experienced and senior professionals in many fields – and systems engineering is no exception
- Capturing the domain expertise is key to providing a pathway for new or younger personnel
- Data Management is uniquely postured to provide the mechanism, support, and methods for managing training materials
- Data Management has also lead the pathway to training and outreach
- This capability supports the propagation of systems engineering expertise to standardize the SE discipline across organizations
- Training creates standardization of practices across organizations

Essential Challenges of Training

- Distance learning and onsite training
- Creating modules for associated domains
- Capturing the expertise of practitioners
- Supplementing the college curriculum
- Penetrating academia

Capturing Domain Expertise

- Knowledge engineering
  - Writing down the methods
  - Tacit experience is invaluable
- Educational opportunities
  - Curriculum development
  - Crossing relevant boundaries
- Standards development
  - Consensus agreement
  - Exponential influence

How DM Can Help

- Extending our prototype
  - DAU
  - Industry
  - Academia
- Managing training materials
  - Organizing, communicating

Elements of the DM Solution

- DAU web-based courseware
- Outreach to our discipline and others
- A new standard and associated handbook
- Community of Practice
- Practitioner training
- College-level training
  - Two year program, four year program, focus is now on a post-graduate area of focus program

We are creating a prototype in Alabama to extend to other areas

DM Education and Outreach Approach

- Continuous learning courses
- Web-based education
- Creating courses through subject matter experts
- The role of continuing education in certifying good data managers and good DM processes
- DAU – for Industry and Government

Benefits of Standardizing Processes

- Creates understanding
- Improves communication
- Strengthens practices
- Clarifies goals and objectives
- Unifies practitioners

Summary

- DM has a stake in SE’s successful future
- Reinvention and improvement of domains are vital
- Challenges are significant
- Education and outreach are key

Effective Implementation of Systems Engineering at the Aeronautical Systems Center:

A Systems Engineering Tool Set

Edward J. Kunay
Charles C. Gebhard
ASC/ENS

Outline

- Background
- ASC/EN Perspective
- Policy and Approach
- Applied SE tools (for Airplanes)
- Summary

Recent SE Guidance

Policy:

- **OSD Memo, 22 Oct 2004, *Policy Addendum for Systems Engineering***
- **OSD Memo, 20 Feb 2004, *Policy for Systems Engineering in DoD***
- **SAF/AQ Policy Memo, 7 Jan 2004, *Revitalizing Air Force and Industry Systems Engineering***
- **SAF/AQ Policy Memo, 9 April 2003, *Incentivizing Contractors for Better Systems Engineering***
- **SAF/US and SAF/AQ Policy Memo, 20 Sep 2004, *Revitalizing the Software Aspects of Systems Engineering***
- **ASC/CC Memo, 4 Oct 04, *PEO Policy for Systems Engineering***

ASC/EN Perspective

- Critical aspect of Systems Engineering effectiveness: program implementation
  - Need good practices at the working level
  - Meaningful SE content in contracts is important
- Significant challenge: Systems Engineering within a performance-based environment
- SE practitioners need tools to help them work
  - Standards & references
  - Guidance documents
  - Training
  - Shortcuts

Our challenge

What Have
YOU
Done Today That's
Relevant to Engineers in the Program Offices ?

<u>Practical solutions</u> to systems engineering issues …
…within the context of <u>performance-based acquisition</u>

Performance-based Acquisition:
Responding to Paradigm Change

Rapidly delivering war-winning capability

- 1994 Sec Def Policy changed environment
  - Performance not prescription – reduced Mil Stds (esp process)
  - Focus on flexibility/efficiency/streamlining/innovation
- Resultant action: Significant and critical SE shift
  - Emphasis on contract specification: functional and interface requirements and verification
    - Adjusted for what was embedded in Mil Stds
  - Processes: Measure results (of contractor processes) vice dictating process
    - Information focus: evidence of product maturity for planned activity

New Thinking, New Tools, New Approach

Outline

- Background
- ASC/EN Perspective
- Policy and Approach
- Applied SE tools (for Airplanes)
- Summary

New SE Application Paradigm

- Acquisition reform initiatives
  - Did not eliminate disciplined systems engineering!
  - Performance requirements at the appropriate level of detail
  - Evidence of sound, disciplined systems engineering
- Tools contain essential program content
  - Information focused; not “how to” or process control
- Provide tools to contractor
  - RFP language
- Contractor tailors content for program
  - **Embed in contract** (SOW, Spec, WBS, IMP)
  - Establishes common understanding of program content (avoid ECP’s later)
- Government assesses progress & results
  - Process outputs & information products

Contract Framework

Government Requirements

(Architecture, CDD, RFP L&M, SRD, etc)

Contractor's Processes

Facility Processes (Generic)

Contractor's Concept

Program Specific Plan

Sec Def Perry Reform 1994
"Performance Based Acquisition"
frames today's acquisition

What does the SE content include?

Actual Program

System Specification*
- Performance and verification basis

Allocated requirements

IMP* – What
- Incremental (entrance/exit criteria)
- Insight/measure product acceptance at each supplier level

IMS – When

SOW* and WBS – Work content

Selective Mil Stds*, Specs, Hdbks

Budgets, Schedules, Staffing

Process Metrics*
- Cost
- Performance
- Schedule
- Quality

* Contractual commitment with Gov't

ASC PEO Policy

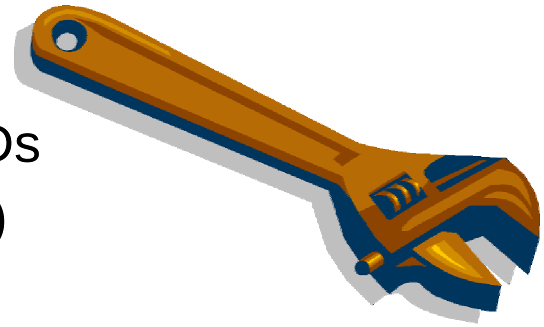
Signed by ASC/CC 4 Oct 04

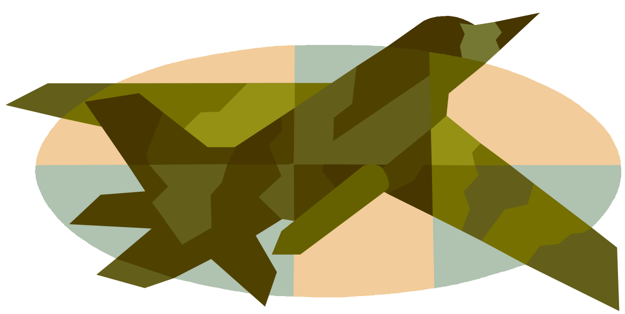
- Commanders/Directors/Senior Functionals implement SE Policies (OSD & AF)
- ASC/EN responsible for SE tools and guidance for ASC programs (work with ACE)
- New SDD/major modifications
  - Develop SEPs – SE tool foundation
  - Product integrity and AW Plan in contract (IMP, etc)
  - Independent first flight/AW assessment required
- Existing programs employ SE tools for reviews, incentives, and health assessment

Why Policy? By-product of reorganization to Wings/Groups/Squadrons and emphasis on focusing/maintaining Center's critical practices

SE Emphasis

- ASC Policy foundation: SE content in program contract/execution
  - "SE Tool Set" -- RFP language, guides, MIL STDs
  - Linkage to SOW, IMP, WBS (all levels of supply)
  - Information focused – not "how to" or process
    - Event based review structure
    - Tailorable criteria – verification emphasis
    - Health assessment/metrics
  - Improved program cost estimating
  - Drive life cycle planning
  - Applies to new and existing programs
- Basis for SE Plans



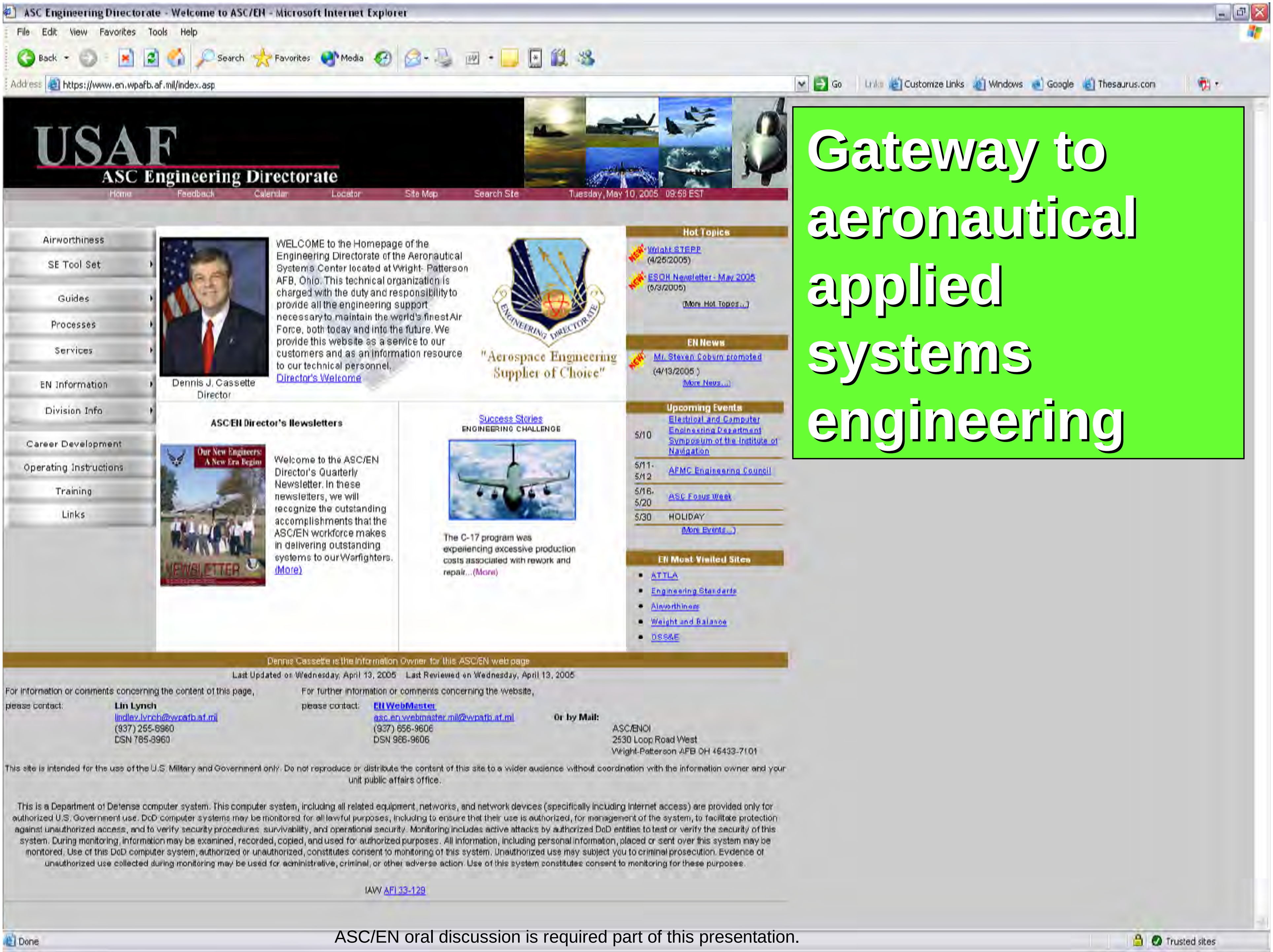


Tools accessible via ASC/EN Web site

Outline

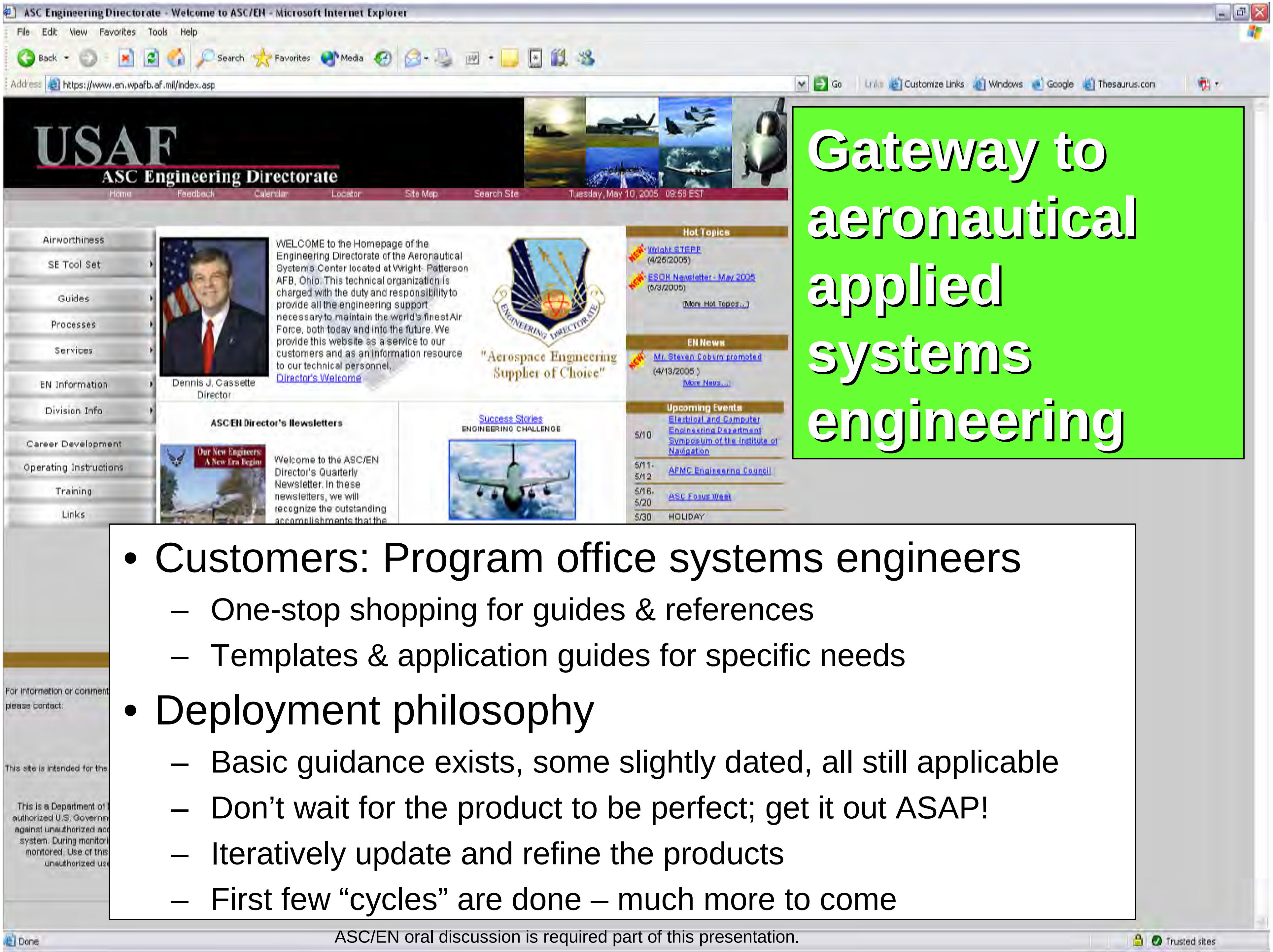
Rapidly delivering war-winning capability

- Background
- ASC/EN Perspective
- Policy and Approach
- Applied SE tools (for Airplanes)
- Summary



Gateway to aeronautical applied systems engineering

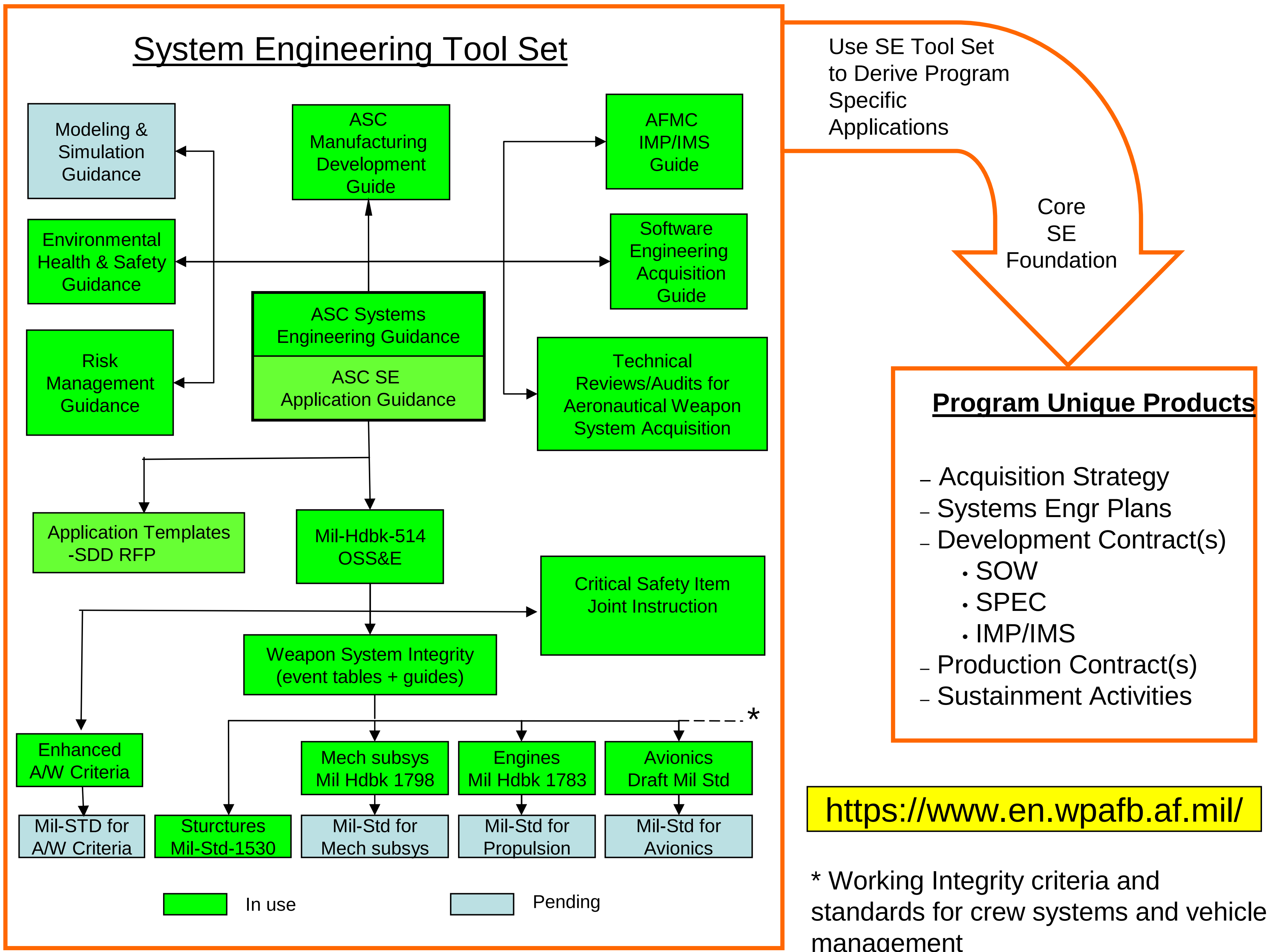
ASC/EN oral discussion is required part of this presentation.



Gateway to aeronautical applied systems engineering

- Customers: Program office systems engineers
  - One-stop shopping for guides & references
  - Templates & application guides for specific needs
- Deployment philosophy
  - Basic guidance exists, some slightly dated, all still applicable
  - Don’t wait for the product to be perfect; get it out ASAP!
  - Iteratively update and refine the products
  - First few “cycles” are done – much more to come

ASC/EN oral discussion is required part of this presentation.



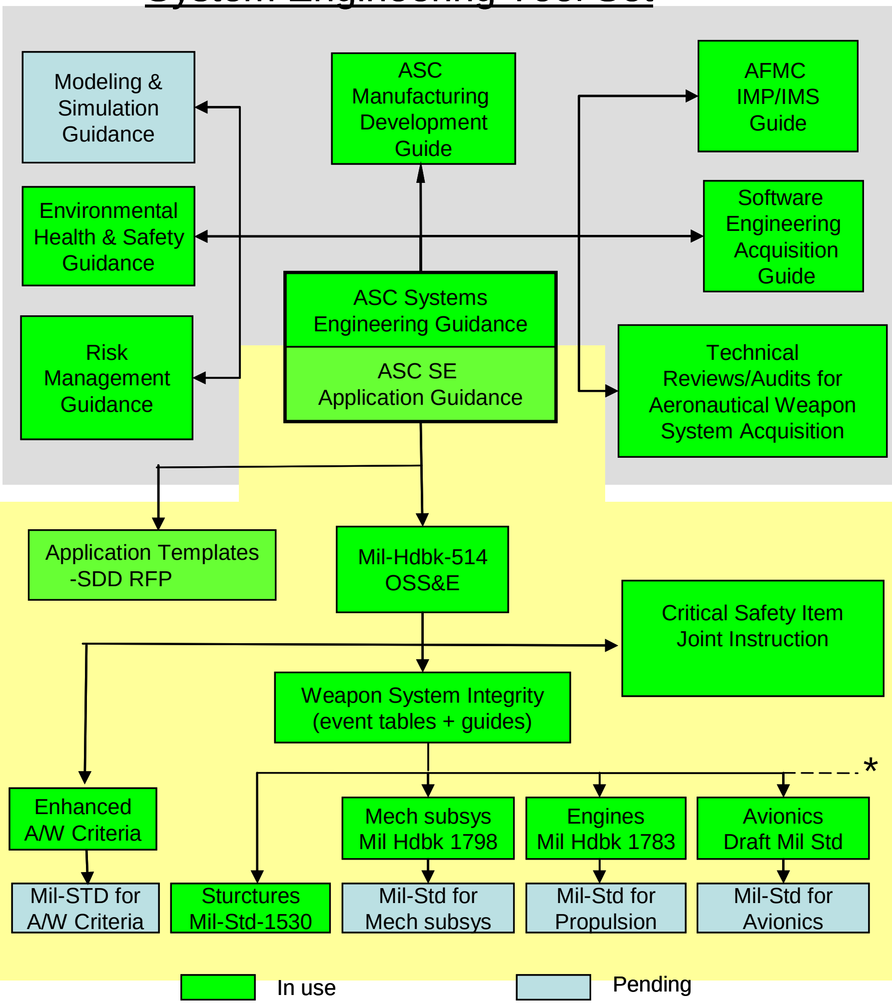
ASC/EN oral discussion is required part of this presentation.

U.S. AIR FORCE

Tool Set

Rapidly delivering war-winning capability

System Engineering Tool Set



Universal SE Guidance

- Single source for reference documents
- Guides for key processes
- Generic information – application beyond aeronautical systems
- “Basic training” material

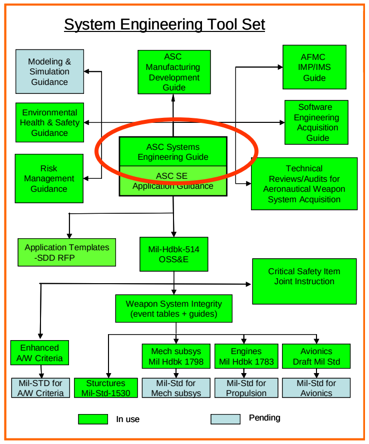
Aircraft-specific Guidance

- ASC/EN corporate knowledge & lessons learned
- Emphasis on event-based format
- Minimal essential contract content
- Detailed handbooks available for reference

ASC/EN oral discussion is required part of this presentation.

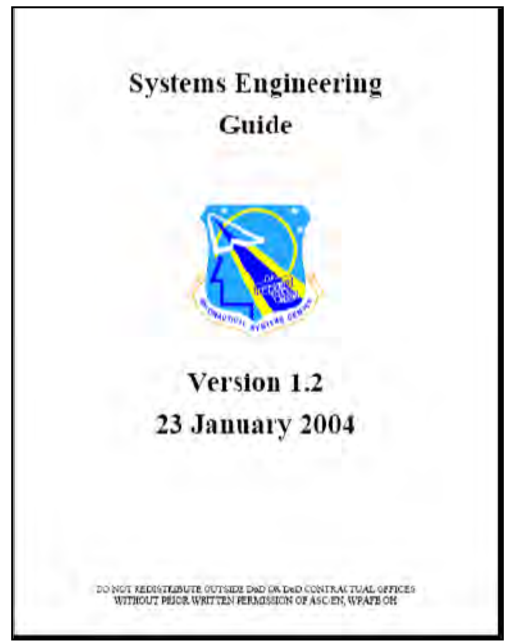
Example: ASC SE Guide

Rapidly delivering war-winning capability



- "Classical" systems engineering content
  - Minor update to unpublished draft of Mil-Std-499B
  - Consistent with current DoDI 5000 series

- Defines the "what" of SE
  - Overall concept and sub processes (e.g. requirements definition & allocation, incremental verification, etc)
  - Not a "how to do" document
- Useful background to establish context for SE application tools
  - Understand the big picture
  - "Pointers" to the rest of the toolset



Systems Engineering Guide

Version 1.2

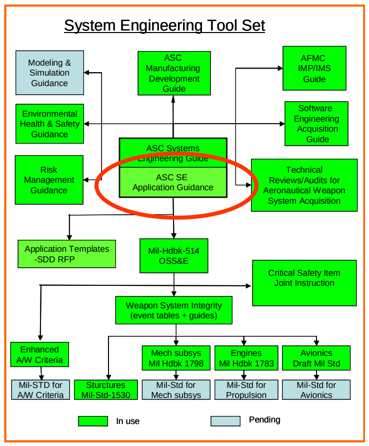
23 January 2004

DO NOT REDISTRIBUTE OUTSIDE DoD OR DoD CONTRACTUAL OFFICES WITHOUT PRIOR WRITTEN PERMISSION OF ASC/EN, WPAFB OH

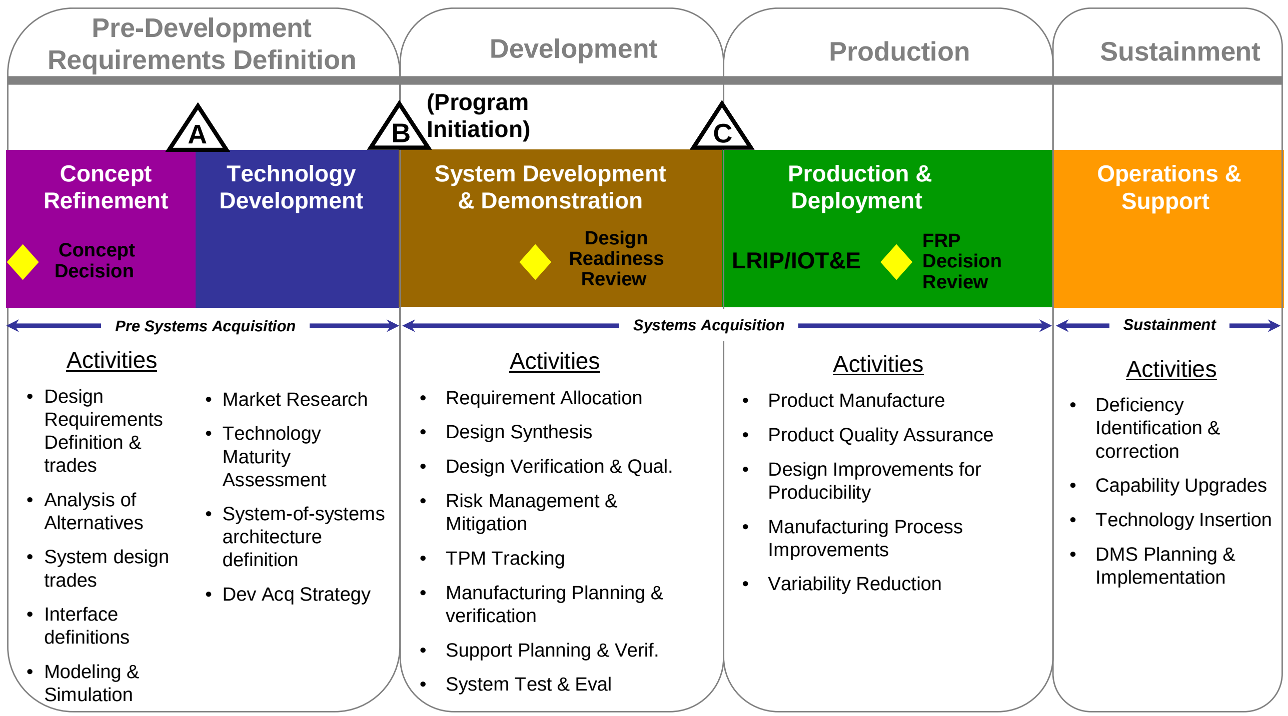
ASC/EN oral discussion is required part of this presentation.

Example: SE Application Guide

Rapidly delivering war-winning capability



- Event-based guide – performance-based approach
- Focus on key information from SE process that describes technical maturation of the system

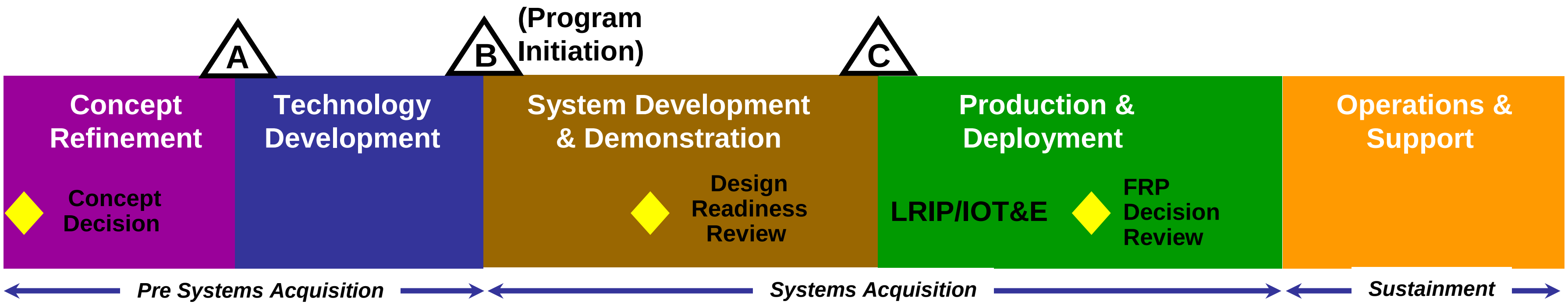


Under Construction

SE Application Guide

Information for Technical Maturation

Rapidly delivering war-winning capability



TECHNICAL MATURATION:
Evolution from general concepts to validated, producible products

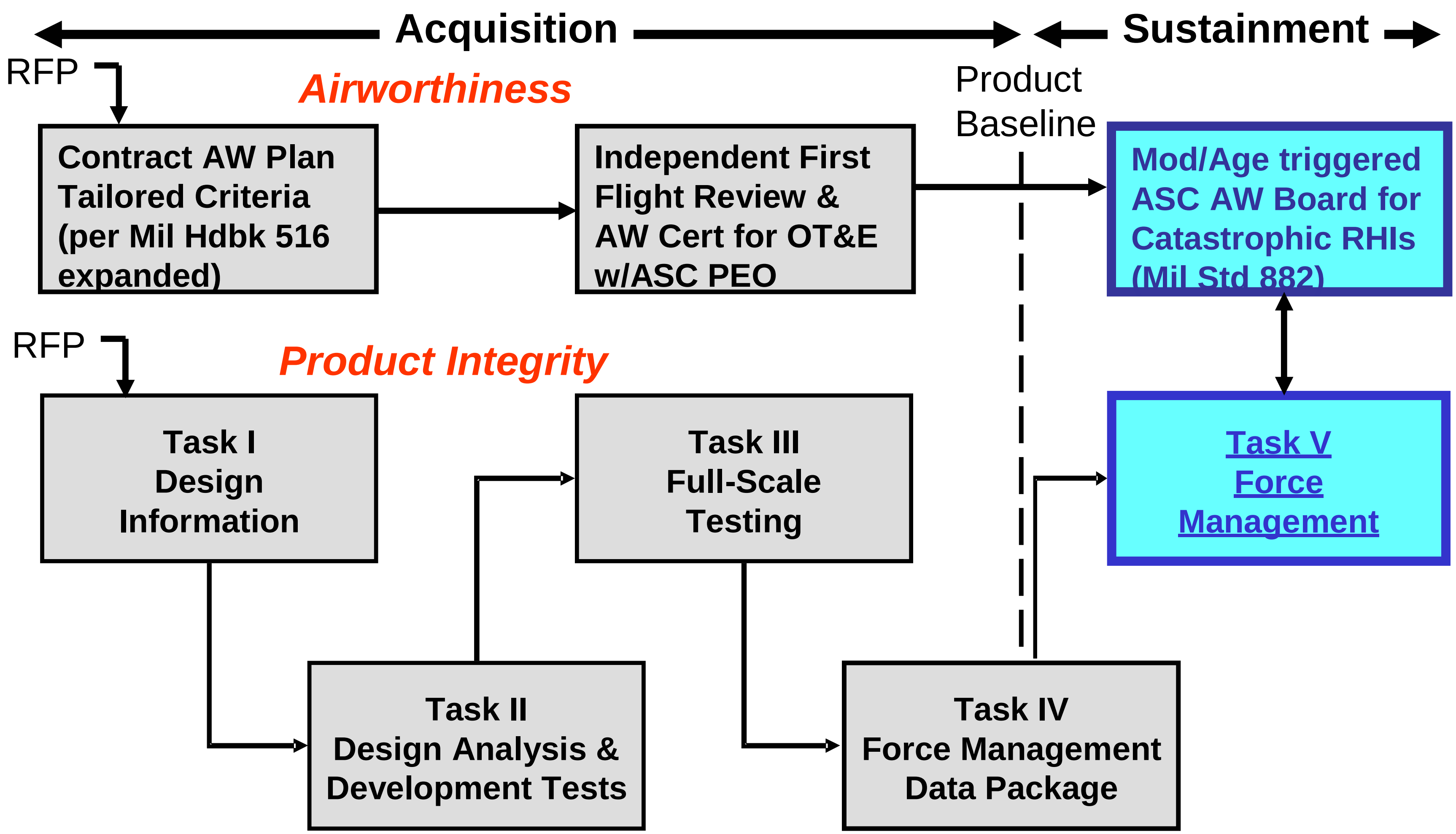
- **The systems engineering process guides maturation of the system**
- **Product definition moves from low to high fidelity – iterative "loops" of design-verification activities**
- **Baselines & technical reviews are used as anchor points**
- **Increasing understanding of system behaviors (M&S, test)**
- **Risk moves from high to low as experience increases**

SE Application Guide identifies information products that describe key aspects of technical maturation

Aeronautical Program SE Content

90% Solution

Rapidly delivering war-winning capability



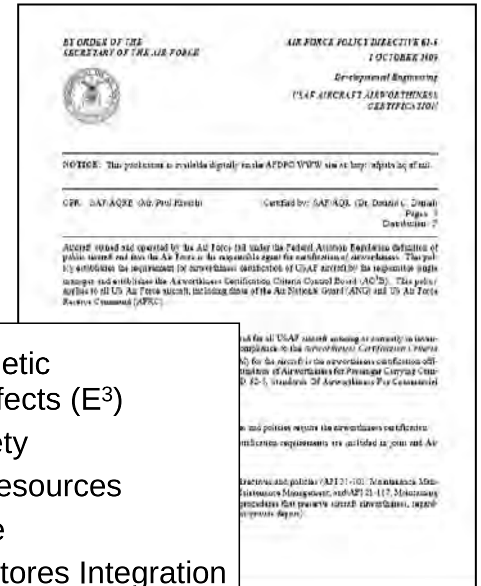
Frames the program's SE effort & Technical Baseline

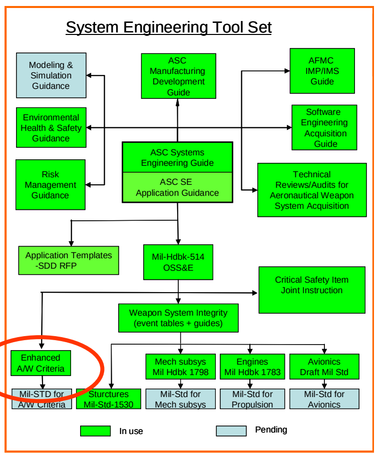
ASC/EN oral discussion is required part of this presentation.

Airworthiness

Rapidly delivering war-winning capability

Airworthiness certification – Repeatable process resulting in a decision by a Single Manager that pilots and maintainers can safely operate and maintain an aircraft within its documented operational and maintenance limits.





- 1.0 Scope
- 2.0 Applicable Documents
- 3.0 Definitions and Abbreviations
- 4.0 Systems Engineering
- 5.0 Structures
- 6.0 Flight Technology
- 7.0 Propulsion and propulsion installations
- 8.0 Air Vehicle Subsystems
- 9.0 Crew Systems
- 10.0 Diagnostic Systems
- 11.0 Avionics
- 12.0 Electrical System
- 13.0 Electromagnetic Environmental Effects (E^3)
- 14.0 System Safety
- 15.0 Computer Resources
- 16.0 Maintenance
- 17.0 Armament/Stores Integration
- 18.0 Passenger Safety
- 19.0 Materials
- 20.0 Other Considerations
- 21.0 Notes
- A.1 Scope
- A.2 Technical Points of Contact
- A.3 Cross-reference -516A to -516B

Expanded MIL-HDBK-516 contains over 350 pages of technical criteria for manned, unmanned, and fixed or rotary wing air vehicle development

ASC/EN oral discussion is required part of this presentation.

Tool Set Example

Structures Airworthiness Criteria

Entrance

5.1.3 *Verify that the **limit loads** used in the design of elements of the airframe subject to deterministic design criteria are the **maximum and most critical combination** of loads that can result from authorized **ground and flight use** of the air vehicle. These include **loads during maintenance activity, system failures** from which recovery is expected, and loads experienced throughout the **specific lifetime usage**.*

Standard*: **Airframe is designed** such that all loads whose frequency of occurrence is greater than or equal to **1 x 10-7 per flight** are used. Airframe is designed such that analytical loads are **correlated** against **measured ground and flight test loads.**

Exit

Compliance*: Correlated **ground and flight loads analyses** in which details of magnitudes and distribution of all applied external loads are identified for **multiple** air vehicle **configurations**, **weights, c.g. and maneuvers** covering all attainable **altitudes, speeds and load factors**. Establishment of the **service and maximum loads** expected to be encountered during operation under **all flight conditions**. **Wind tunnel tests** utilized for development of aerodynamic loads. **Stiffness** and **ground vibration tests** utilized to **update** flexibility vs rigid characteristics of loads **analytical model**. Flight controls and aerodynamic flight tests utilized to update aircraft **simulation models**. **Loads calibration tests** utilized to develop ground/flight load equations. 80% and 100% flight loads surveys/demonstrations utilized to correlate analytical model and to substantiate the design loads.

DoD/MIL Doc: JSSG-2006: A3.2.11, A4.2.11.

*Tailorable – Draft AWP with proposal, updated prior to PDR; AW baseline is declared final at PEO determination of readiness for dedicated OT&E

ASC/EN oral discussion is required part of this presentation.

ASC/EN oral discussion is required part of this presentation.

Integrity Process

Rapidly delivering war-winning capability

- Disciplined technical process for a weapon system
  – Ensures that it will meet Operational Safety, Suitability, and Effectiveness (OSS&E) directives
  – Applies to entire operating envelop & environment
  – Cradle to grave: addresses entire life cycle

Design **Analysis** **Qualification** **Production** **Life Management**

Modification

Sustainment

- Nine integrity programs:

Weapon System

Structures

Avionics

Mechanical Sys

Engines

Computing Sys

Crew Sys

Flight Mechanics

Mfg. & Quality

U.S. AIR FORCE

Example: Integrity Table

Engine Integrity Program

Rapidly delivering war-winning capability

Preliminary Design Review	Critical Design Review				Functional	
II - Design Analysis, Materials Characteristics & Development Tests		**III - Component & Core [...] Tests**				
ENSIP Master Plan Update	ENSIP Master Plan Update	**Comp[...]nt Tests:**	Core Engine T[...]	Data Acquistion &	**Ground Tests:**	
Duty Cycle	Materials Characterization	Strength	F[...]			
Design Development Tests	Detailed Analyses:	Vibration	Aeron[...]			
Preliminary Analysis:	Durability	Durability	Thermals	Test Plan	Damage Tolerance	
Thermal	Damage Tolerance	Dama[...]				
Strength	Strength	Containment				
Containment		Foreign Object Damage				
Aeromechanics						
Rotordynamics						
Vibration						
Loads						
Mass Properties						
Installed engine inspectability					Deterioration	
Manufacturing Process Controls					**Validated Analyses:**	

Event-based format:
- Technical review milestones
- WBS / SOW / IMP guidance

ENSIP Task (MIL-HDBK 1783B)
- SOW / IMP guidance

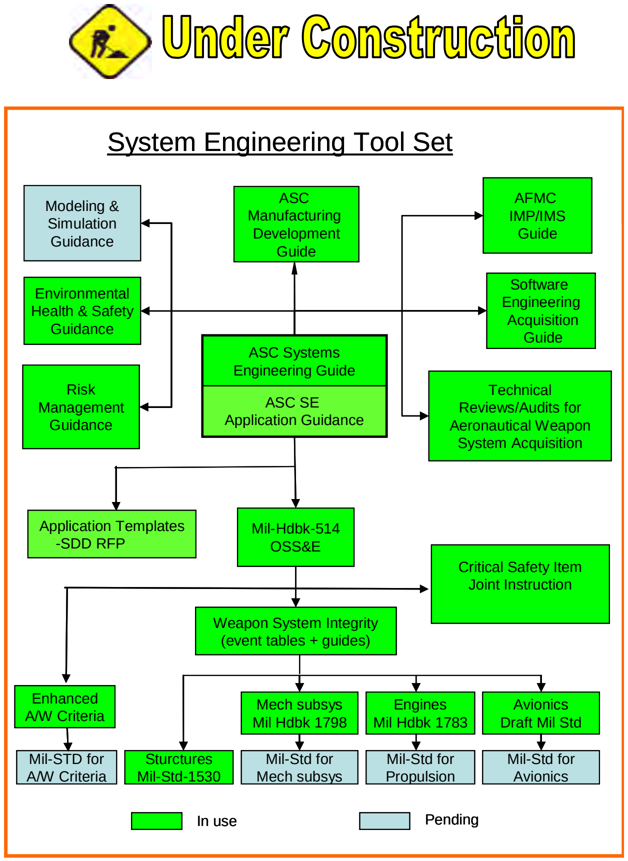
Detailed handbook criteria
- IMP entrance/exit criteria for tech milestone items
- Guidance for contractor – include in RFP
- Firm basis for high fidelity planning and cost estimates

ASC/EN oral discussion is required part of this presentation.

Future Efforts

Rapidly delivering war-winning capability

- Complete the “baseline” Tool Set
  - Additional guides: M&S, integrity programs
  - Activate & expand Application Guide, templates
  - 2005 Road Show for ASC Wings/Groups
- Ongoing efforts: update and refine tools
  - Acquisition process is not static – need to keep tools current
  - Incorporate feedback from working engineers on tool utility



Outline

- Background
- ASC/EN Perspective
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- Summary

Summary

- Sec Def Perry reform impact on SE
  - Ten years to understand and implement the paradigm
  - Tools were developed but not widely used
- ASC/EN objective: provide systems engineering guidance to program office engineers *now:* Tool Set
  - Quickly deploy available tools in web-based format
  - Incrementally refine and enhance tool set
  - Focus on execution and information content of contract
  - Emphasize event-based format
- Future: Build on the foundation, refine, improve

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N65236-ENGOPS-BRIEF-0012-1.0

Training Your Systems Engineering Workforce

Michael T. Kutch, Jr.

Chief Engineer Code 70 E
Intelligence & Information Warfare Systems Department
Director Engineering Operations Code 09 K
SSC Charleston

NDIA Systems Engineering Conference, October 27, 2005

Presentation Outline

- Introduction to SPAWAR Systems Center Charleston
- General Training
- Systems Engineering Training
- Development and Certification Opportunities
- Summary

N65236-ENGOPS-BRIEF-0012-1.0

Systems Center Charleston

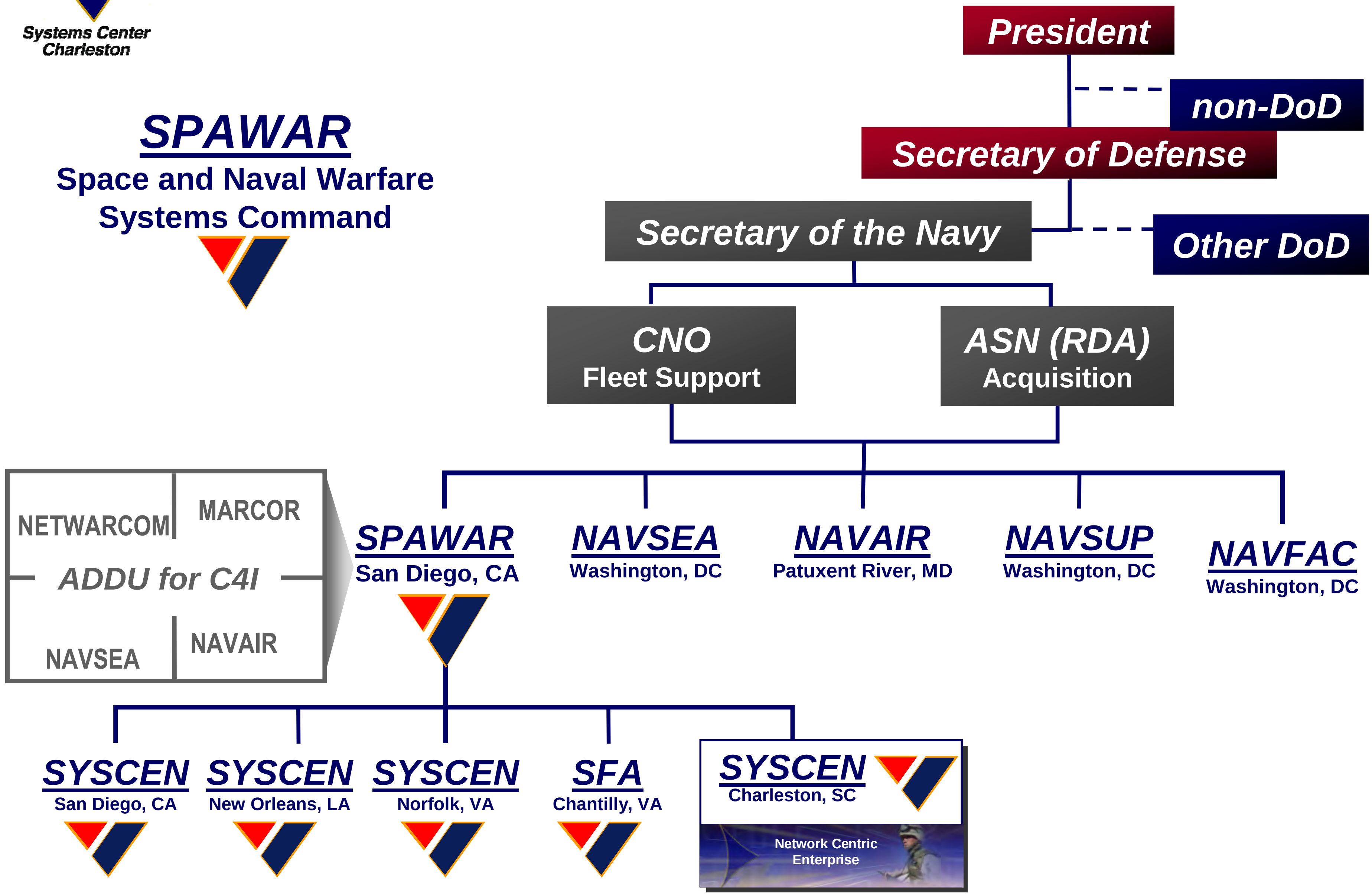
Introduction to SPAWAR Systems Center Charleston (SSC-Charleston)

- Where we fit
- What we do
- What we are known for
- Who we are
- Vision

Approved for release to the public - 30 Sept 2005

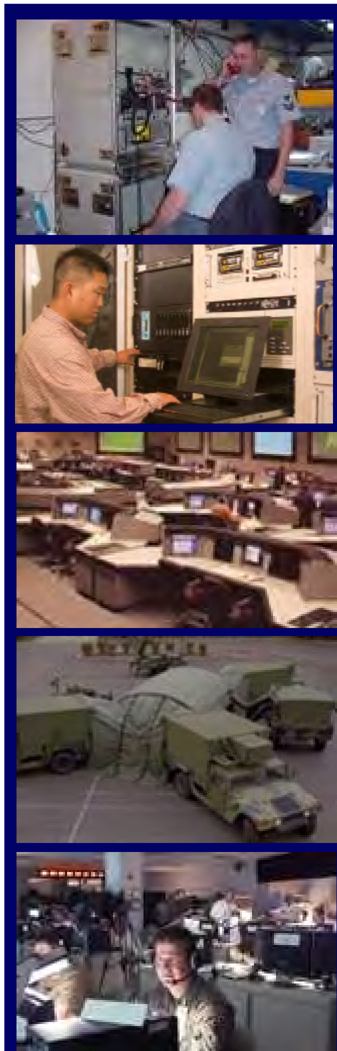
Systems Center Charleston

Where We Fit



Approved for release to the public - 30 Sept 2005

What We Do



C⁴ISR

Command
Control
Communications
Computers
Intelligence
Surveillance &
Reconnaissance

- *Modeling & Simulation*
- *Command & Control*
- *Navigation*
- *Physical & Computer Security*
- *Video Teleconferencing*
- *Information Assurance*
- *Sensors*
- *Communications*
- *Cryptologic & Intelligence*
- *Image Processing*
- *Meteorology*
- *Air Traffic Control*

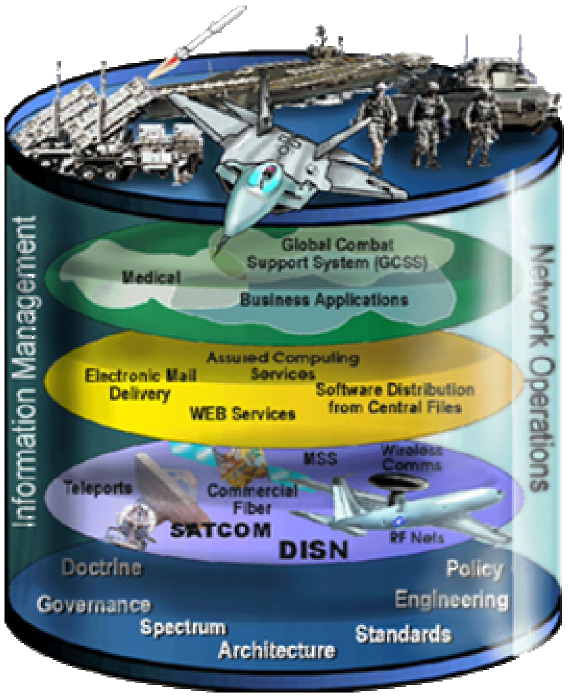
Systems Center
Charleston

What We're Known For

- **Developer of FORCEnet joint collaborative assessment tools** that promote netCentric interoperability and reduce system redundancy

- **Principal SPAWAR provider for Joint and Homeland Security** C4I solutions in a responsive manner.

- **Navy's most efficient provider of critical engineering** and acquisition expertise for Navy/Joint commands and other federal agencies



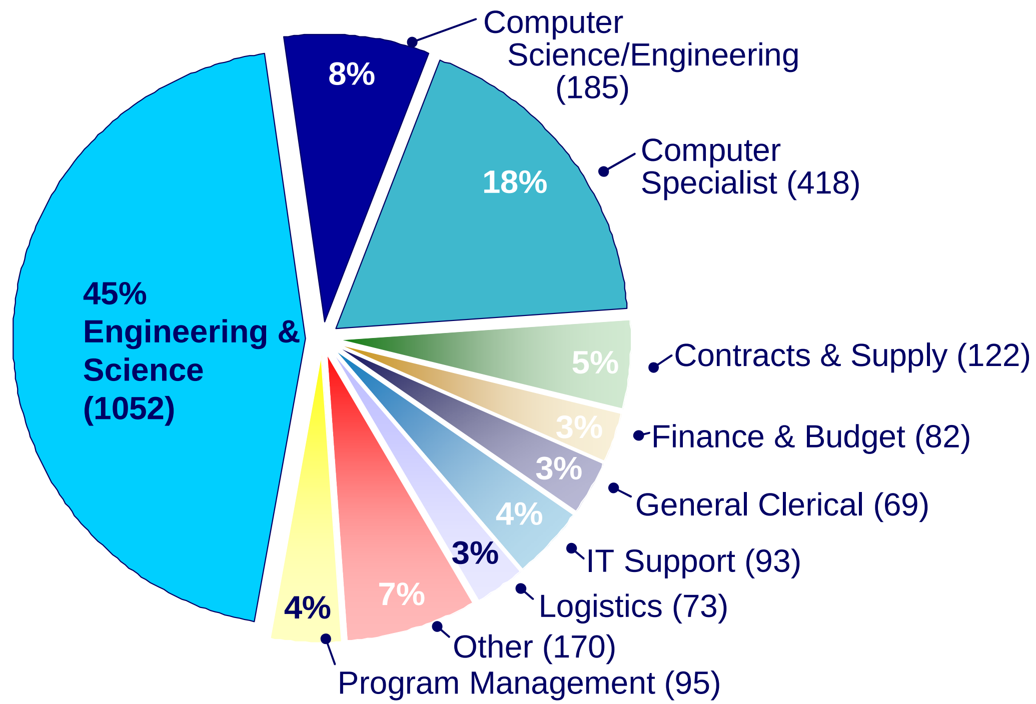
- **Rapid integrator and deployer of interoperable technologies** to the Navy, Federal Government, and Joint Warfighter

- **Developer and employer of life-cycle logistic support solutions** in a web-enabled portal environment

Systems Center Charleston

A Large Systems & Software Engineering Organization

Over 70% of workforce is in an engineering or computer-related discipline



- **The effective and efficient solutions to the global war on terror developed by SPAWAR result from good systems and software engineering.**
- **Systems engineering is our core competency.**
- **Total workforce of ~ 2300 employees.**

Vision

- **Vision**
  - Develop and maintain a World Class Systems Engineering Organization
- **Approach**
  - Achieve Command-wide operational consistency
  - Based on ISO 15288 – systems engineering
  - Based on ISO 12207 – software engineering
  - Measure using best practices of CMMI®
- **Benefits**
  - Facilitates sharing of tools, documentation, templates, and other artifacts needed by project engineers
  - Project Engineers will implement projects quicker; with improved monitoring, effectiveness, quality and efficiency

"Engineering is the key to our survival. Look to the future."
James Ward, Executive Director, SSC Charleston

Systems Center Charleston

General Training

- Competency Focus Areas
- Mandatory Training
- Employee Development Plans

Competency Focus Areas

- **Corporate Strategy**
  - Navy, SPAWAR, and SSC-Charleston
- **FORCEnet – NAVY integration initiative**
  - SPAWAR Alignment
- **CMMI and Process Improvement**
- **Lean Six Sigma**
- **DAWIA – Defense Acquisition Workforce Improvement Act**
- **Leadership Development - supervisors**
- **Human Systems Integration**
- **National Security Personnel System (NSPS)**

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Mandatory Training

	All Employees	Supervisors
Policy & Regulatory	Ex: Meet the Fleet; Anti-Terrorism, Info Assurance	Ex: Mgmt Control; EEO; Payroll; etc
Strategy	CNO, HQ, SSC-C Commander's Guidance	Balanced Scorecard
FORCEnet	SPAWAR Alignment; FORCEnet 101	FORCEnet 201
CMMI®	Process Improvement WBT	
Lean Six Sigma	Six Sigma Intro	
Leadership Development		Ex: Federal Executive Institute; Harvard Bus. School

Mandatory Training may be computer based or instructor delivered

SPAWAR
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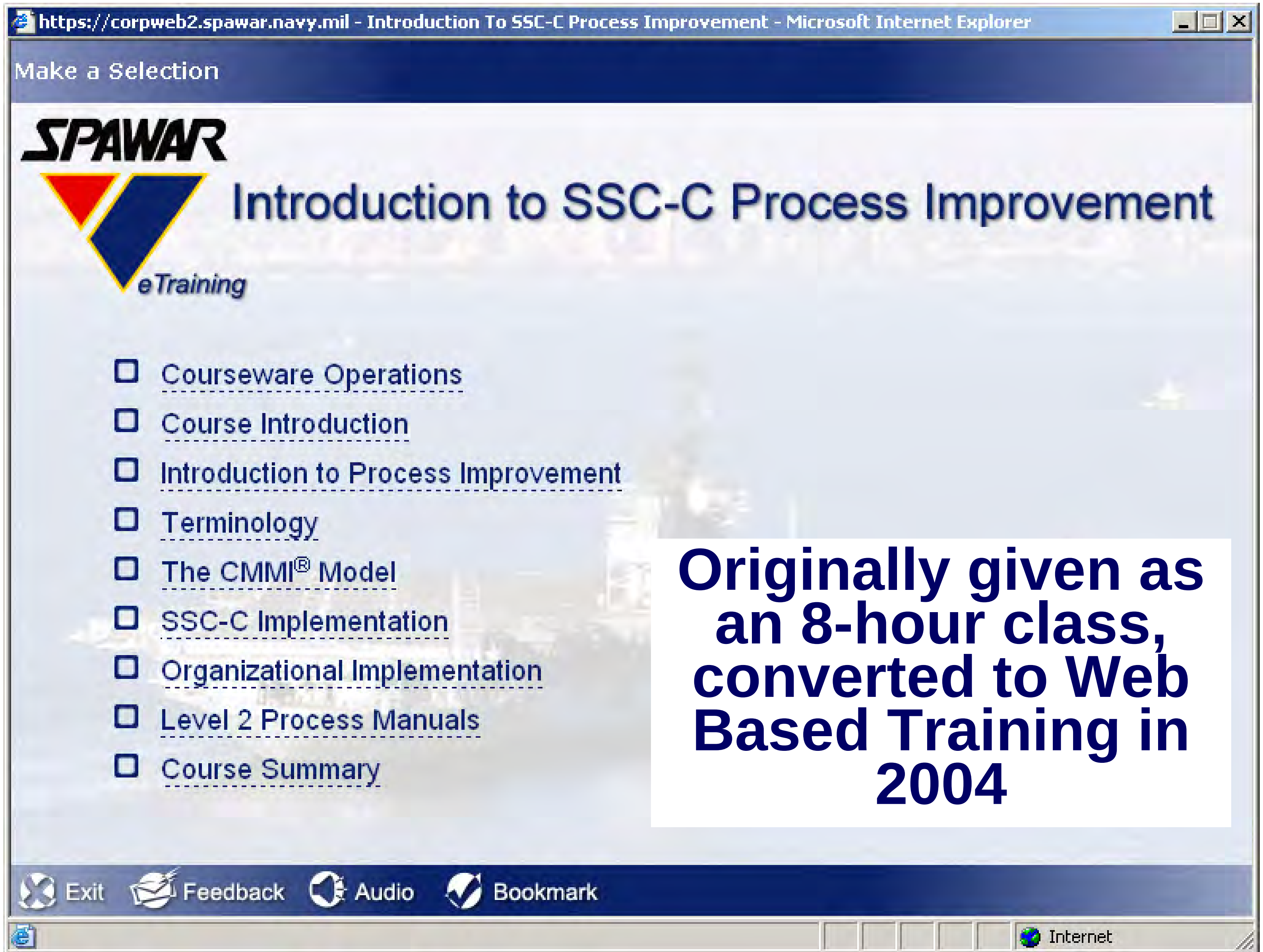
Charleston

Intro to Process Improvement



Originally given as an 8-hour class, converted to Web Based Training in 2004

Employee Development Planning

- **Career Intern New Professional – 2 year plan**
  - Required combination of DAU coursework, rotational experience, Project Management, Scientists to Sea, Technical Report
- **Supervisors**
  - Mandatory plus series of recommended
- **Project Managers / System Engineers**
  - Recommended list of available courses and workshops
- **Moving to a demand-driven training budget**
- **Goals set for training x% of population in CMMI® and Lean Six Sigma**

N65236-ENGOPS-BRIEF-0012-1.0

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Systems Engineering Training

- Plan
- Systems Engineering Fundamentals
- SE 101 WBT
- Introduction to Software Engineering
- DoDAF

SSC-C SE Revitalization Plan

Elements of SSC-C SE Revitalization

Policy / Guidance

- DoD SE Guidance & SE Instruction 54xx.1
- SSC-C SE Process Manual
- SSC-C SW Process Manual
- ePlan Builder

Training / Education

- Intro to PI WBT
- SE 101 WBT
- SE Fundamentals
- SW Fundamentals
- Certification Program

Assessment & Support

- CMMI® Level 2
- CMMI® Level 3
- Integrated Product Teams
- SITC - Tools
- Lean Six Sigma

Underway

Completed/Ongoing

Need for SE Training

- **Industry-wide issues (NDIA Study – Jan, 2003)**
  - Requirements definition, development, and management not applied consistently
  - Lack of systems engineering discipline and effective SE implementation
- **SSC-Charleston issues prior to 2004**
  - Limited number of skilled, experienced, trained subject matter experts
  - Processes not institutionalized
  - New professionals have not been taught a structured systems engineering process
  - Lack of alignment with process improvement and CMMI® initiative

Systems Engineering Fundamentals Classes

- **3-day on-site, classroom course**
  - – Based on SMU SE Masters course
  - – Customized to incorporate SSC-C SE process
  - – 180 SSC-C engineers trained in FY05
  - – Classes planned every 2 months
- **1-day *SE for Managers* course added**
  - – To align management with SE Process

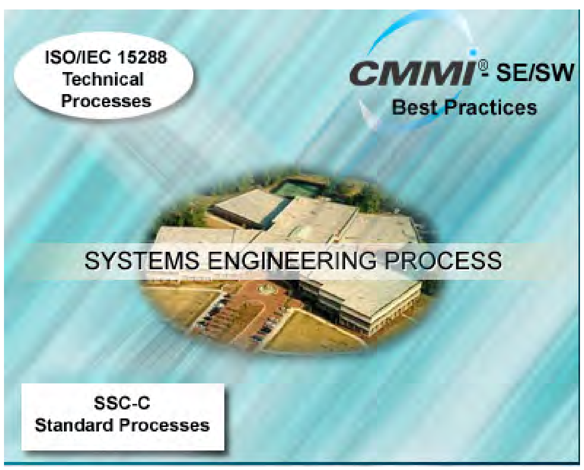
"The course was very educational. It helped me relate my current project to the overall system it was a part of, and how it fits in with the big picture."

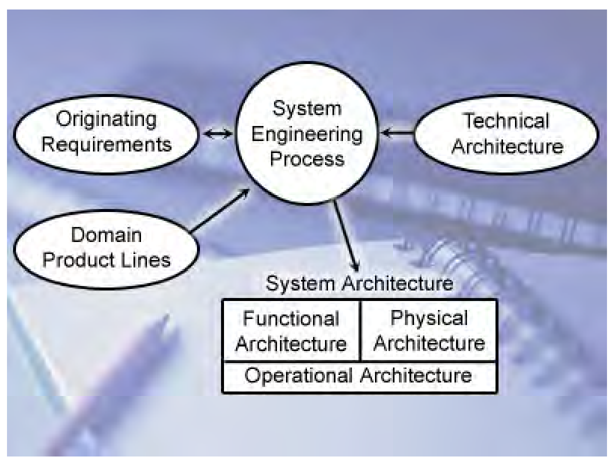
"The course was well presented and accurately covered the Systems Engineering Design Process Fundamentals. Continued/additional training on this subject is critically needed for this command to continue to develop as a professional engineering organization."

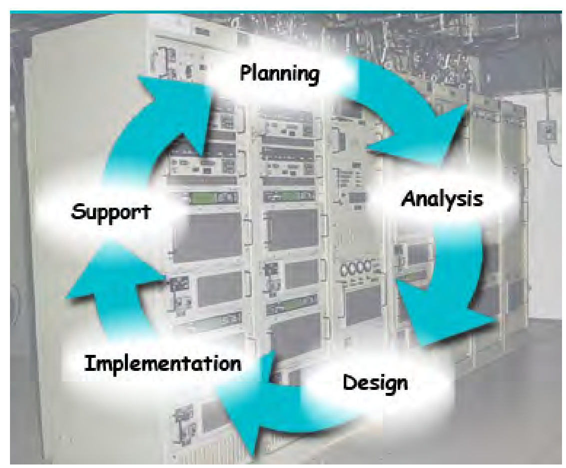
Student Feedback

Systems Center Charleston

- **Introduction to Systems Engineering WBT**
  - 10-module web based training
  - Closely aligned to SSC-C SE Process, SE Fundamentals Course, ISO/IEC 15288 and IEEE standards
  - Includes hotlinks to referenced documentation
    - Process manuals, policies, standards

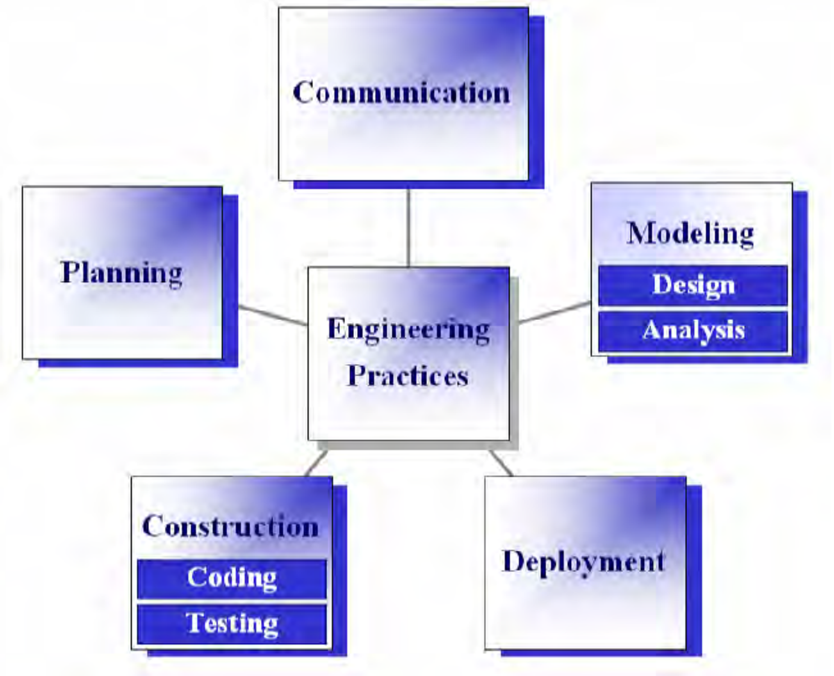






Introduction to Software Engineering

- **Similar format to the Systems Engineering Fundamentals**
  - 3 days, primarily lecture
  - Aligned with the SSC-C Software Development Process Manual
- **Course Outline**
  - Intro to Software Engineering
  - Roles
  - Software Engineering Practices
  - Software Development Process
  - Software Maintenance
  - Managing Software Projects
  - Tailoring



DoD Architecture Framework (DoDAF)

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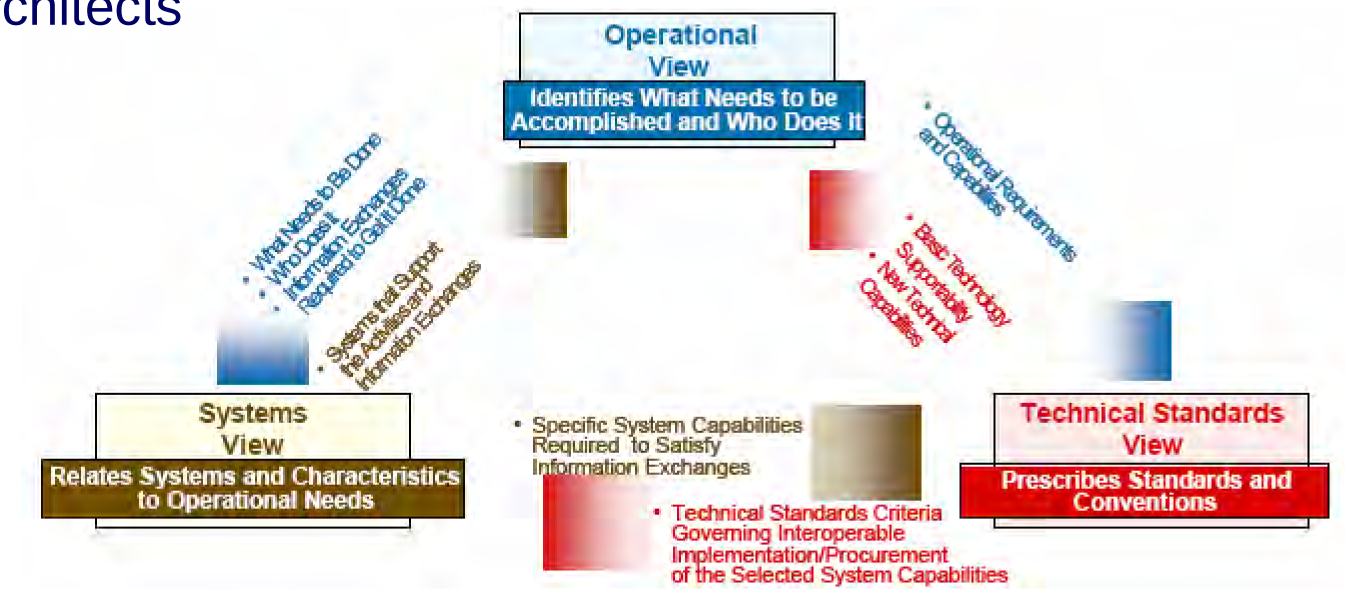
- **Developing Executable Architectures Using the DoDAF and SE**
  - 3 day on-site course for Systems Architects and Systems Engineers
- **Intro to Architecture Primer**
  - Currently in design
  - To educate and promote value of system architecture to non-architects



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Development and Certification Opportunities

- SE Certification Hierarchy
- SE Masters and Certification Programs
- Certification in Other Disciplines

SE Certification Hierarchy

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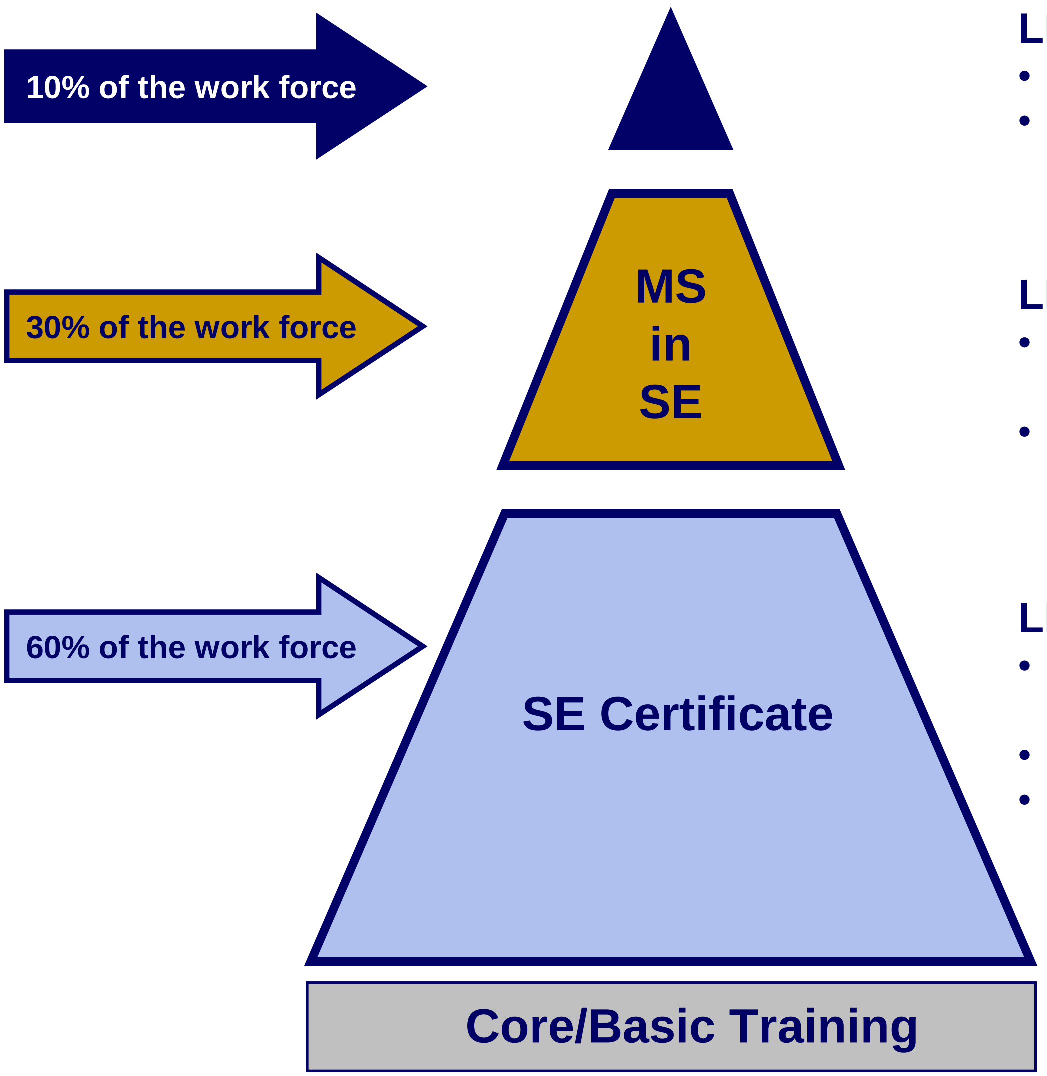

LEVEL 3
- MS (or PHD) in SE
- INCOSE SE Certification exam

LEVEL 2
- Five core courses plus five electives
- 2-4 years SE field experience

LEVEL 1
- SE Certificate based on SE core courses
- One year SE field experience
- BS in Engineering or Science

Master Degree/Certification in SE

- **Available to SSC-C engineers through**
  - Southern Methodist University
  - University of Alabama-Huntsville
  - Other approved programs
- **Certified Systems Engineering Professional (CSEP)**
  - Through INCOSE
- **Defense Acquisition University (DAU)**
  - Systems Planning, Research, Development and Engineering—Systems Engineering
  - Certification Levels 1, 2, and 3

Certification Hierarchy for Other Disciplines

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- **Software Certification**
  - Developing tiered hierarchy for SSC-C software professionals similar to SE hierarchy
  - IEEE Certified Software Development Professional (Level 3)
- **Architecture Development Certification**
  - FEAC Institute
    - Federal Enterprise Architecture Framework Certification
    - DoD Architecture Framework (DoDAF) Certification
  - Software Engineering Institute (SEI)
    - Software Architecture curriculum

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Summary

- Training Accomplishments
- Lessons Learned

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Process Improvement Training

- **Intro to Process Improvement**
  - Over 800 people trained
  - Provided via WBT
  - Now Mandatory for all employees
- **CMMI®**
  - SEI Intro to CMMI®
  - SSC-C Level 2 Processes
  - 875 people trained
- **Project Management/Project Monitoring & Control**
  - 625 people trained
- **Process-specific Workshops (CM, QA, REQ, M&A)**
  - 375 people trained

Over 1300 Individuals Trained

Total attendance over 2800 *

**** This accounts for some employees attending more than one course***

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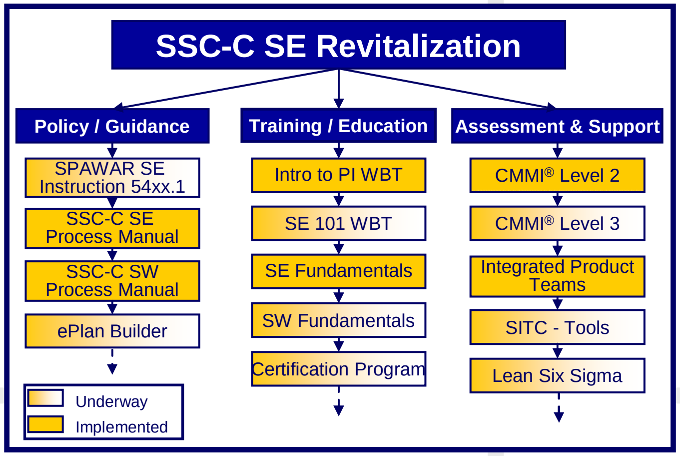
Lessons Learned

- **Senior Management support is critical to success**
- **Training Strategy**
  - Everyone needs to be engaged – “train the masses”
  - Create a foundation/baseline of understanding
  - Integrate/align additional courses to build on the baseline
  - Specific training for process owners/subject matter experts
- **Utilize Teams (IPTs) as champions of specific processes**
  - Multi-department representation
  - Each team addressing training and certification needs for their process
- **Resource Centrally**
  - Utilize your organization’s training group
  - Coordinate employee development planning with training implementation
  - Provide funding centrally for mandatory training and key initiatives

SPAWAR Systems Center Charleston

Summary

- **Aggressive SE Program**
- **Industry Standards**
  - Systems Engineering (SE)
  - Software Engineering (SW)
- **Best Practices**
  - CMMI®
  - ISO 9001
  - Lean Six Sigma



- **Training – 1,300 people***
- **Systems Engineering Fundamentals - 180**
- **Intro to SSC-C PI**
  - CMMI® Level 2 Processes
  - CMMI® Level 3 Processes
  - SE/SW Engineering Workshops
  - Web-Based Training (WBT) for Process Improvement

*includes industry partners

- **Successes**
  - Command Achieved CMMI® Maturity Level 2 in April 2005
  - 1st SPAWAR Systems Center to Achieve CMMI® Maturity Level 2
- **Plans**
  - World Class Systems Engineering
  - Support Command Balanced Scorecard
  - April 2007 CMMI® Maturity Level 3

Thank you !

Any Questions ?

Contact Information:

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SPAWAR Systems Center Charleston
michael.kutch@navy.mil
(843) 218-5706

NORTHROP GRUMMAN

DEFINING THE FUTURE

X-47, J-UCAS Overview

October, 2005

Rick Ludwig"Wigs"
Director, NGC UMS Business Strategy and Development

San Diego, CA

Why X-47, J-UCAS?

- **The Advantages Are Straightforward :**
  - Relief From Human Endurance Constraints : Step-Function Increase in Battlespace Persistence
    - Persistence : The Critical Attribute for Future Surveillance & Attack Systems
  - Strong Cost-Effectiveness Advantages
    - Enables Persistent Broad-area Coverage With Greatly Reduced Force Sizes
    - Significant Training and Operational Cost Savings
  - Relief From Human Mortality Constraints
    - Provides Greater Operating Freedom in Projected Threat Environments
    - Higher Perceived Usability Enhances Deterrent Effect of US Forces

J-UCAS Offers Survivable, Affordable, Joint, Theater-Wide Persistent Surveillance-Attack

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DARPA J-UCAS Program in Perspective

- **Not an acquisition program…yet**
- **Rather, a <u>demonstration</u> program designed to:**
  - Reduce technical risk
    - Prove feasibility of UCAS concept
    - Match manned systems' reliability, dynamic ops capability
  - *Examine the UCAS concept transformational utility through analysis & live/virtual operational assessment*
  - Develop future UCAS acquisition options, quantifying appropriate system attributes (range, payload, speed, stealth, mission systems)
- **While J-UCAS demonstration systems will yield initial military capability, the operational systems are in development**
- **NGC involved because of potential to provide major new transformational capabilities**

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NGC J-UCAS Program Organization

Northrop Grumman Corporation
Dr. Ron Sugar
Chairman, CEO and President

NG Integrated Systems
Scott Seymour
President, NGIS

NGIS Unmanned Systems
Chris Hernandez
Vice President, NGIS

NGIS/UMS J-UCAS Leadership
Scott Winship
J-UCAS Program Director

Lockheed Martin	Northrop Grumman	Pratt & Whitney
Frank Alvidrez *J-UCAS* *Project Manager*	Steve Sullivan *J-UCAS* *Deputy Program Director*	Marty Georges *J-UCAS* *Project Manager*

The NGC J-UCAS Team Legacy

Carrier/Fleet Operations

UAV Development, Integration and Operations

Combat Aircraft Design, Manufacturing and Operations

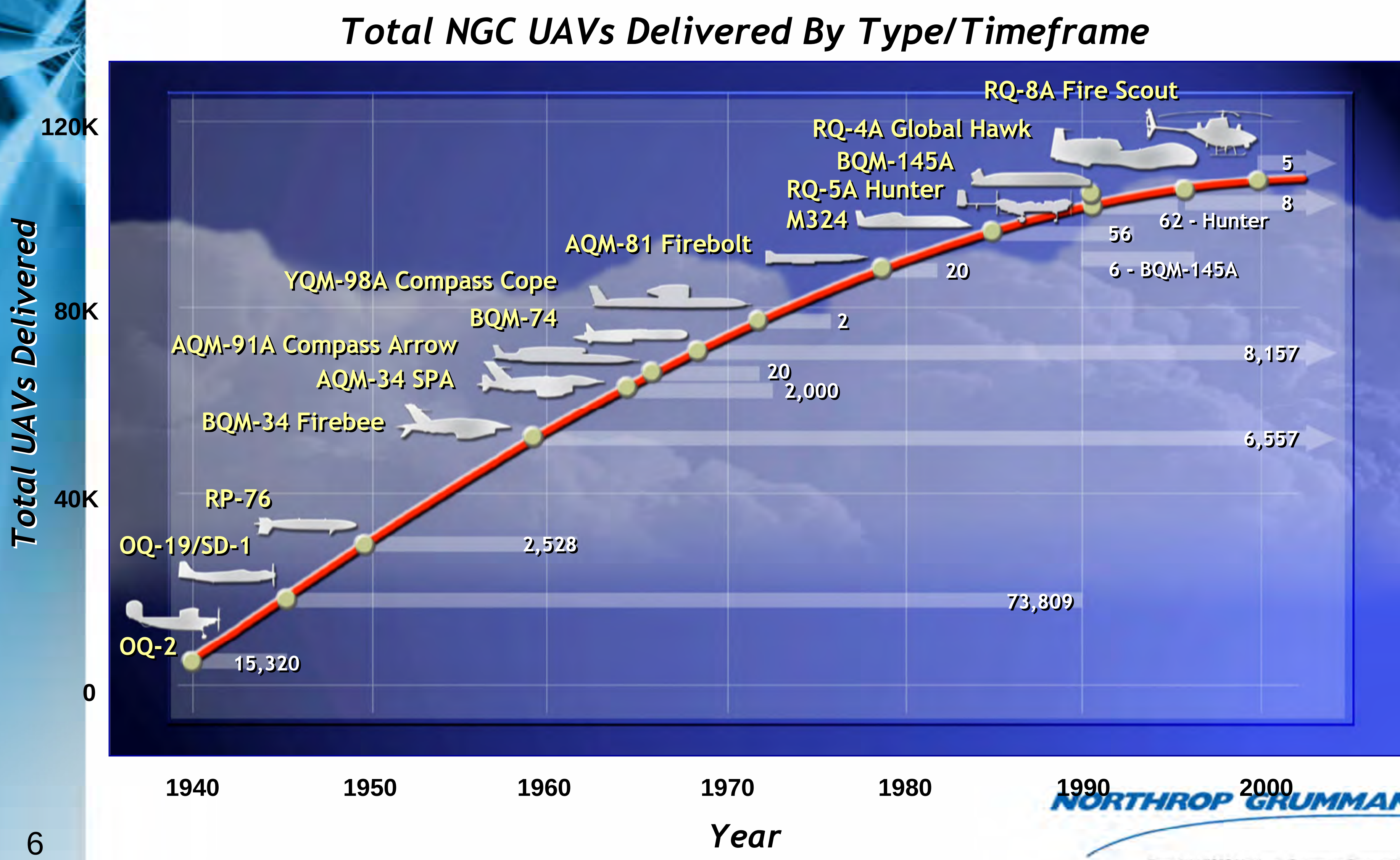
Network Centric Ops and Common Systems

Low Observables

SEAD and EA Systems and Operations

Air-Surface ISR Systems and Operations

>100K UAVs Delivered Since 1940



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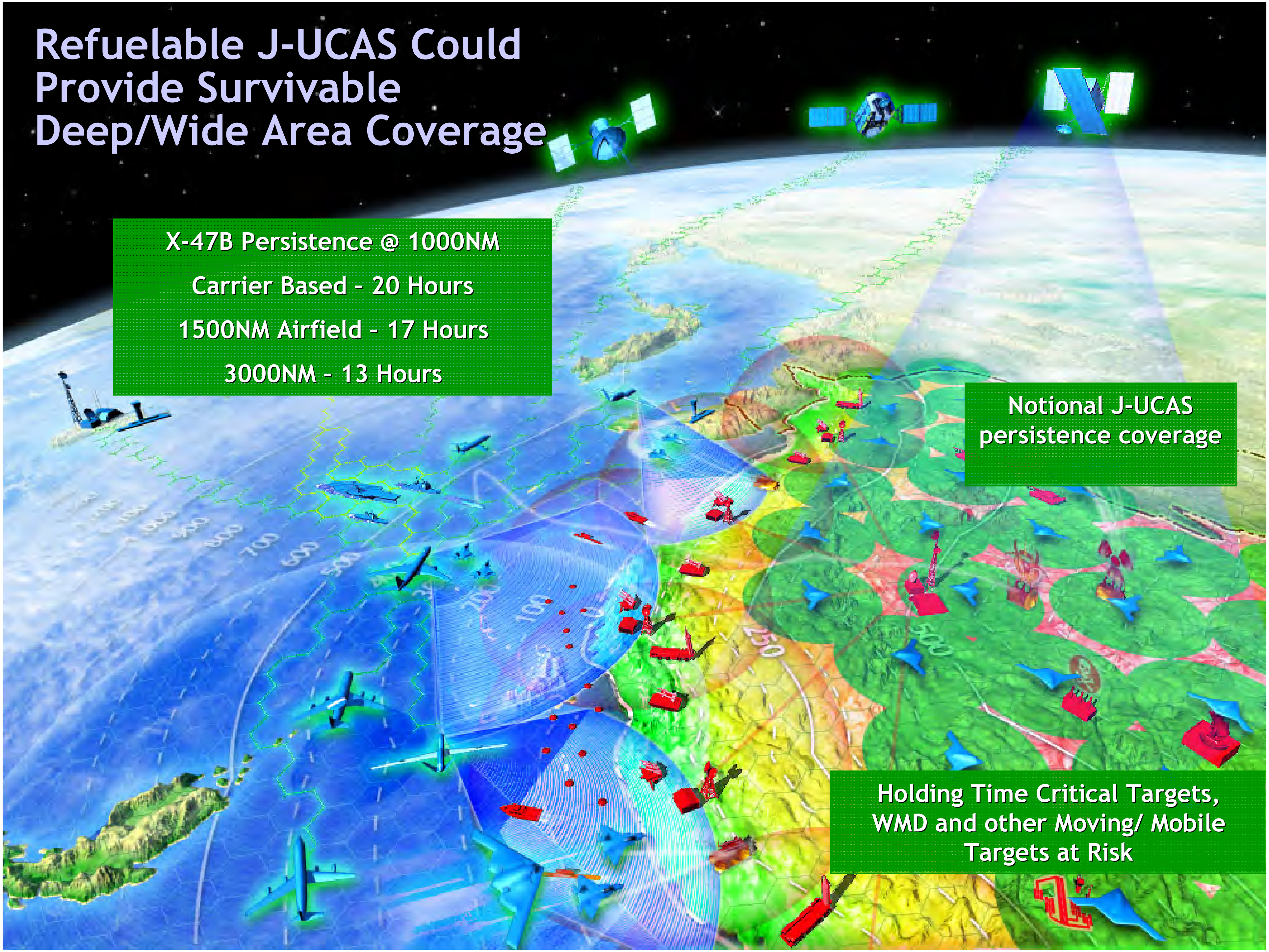
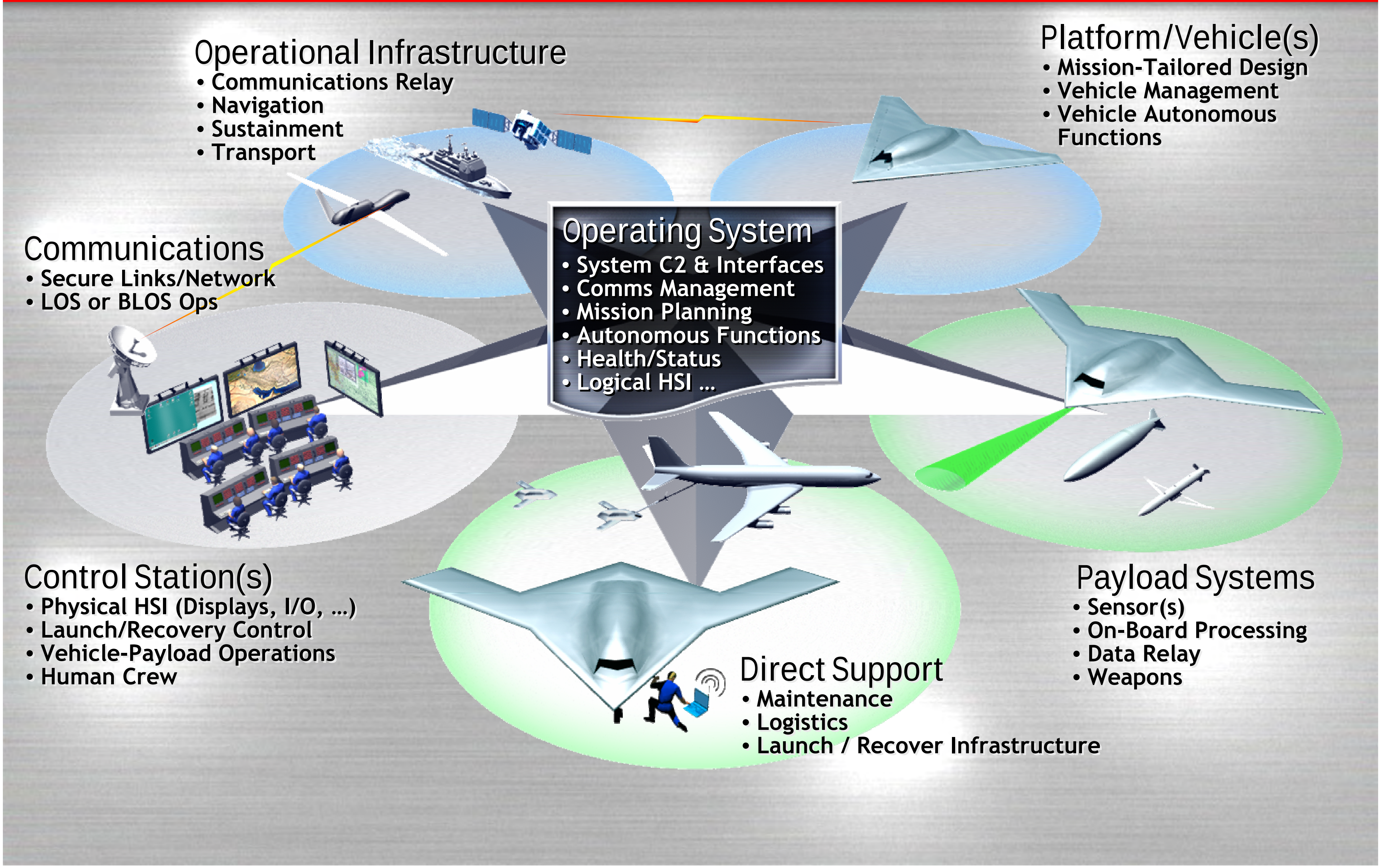
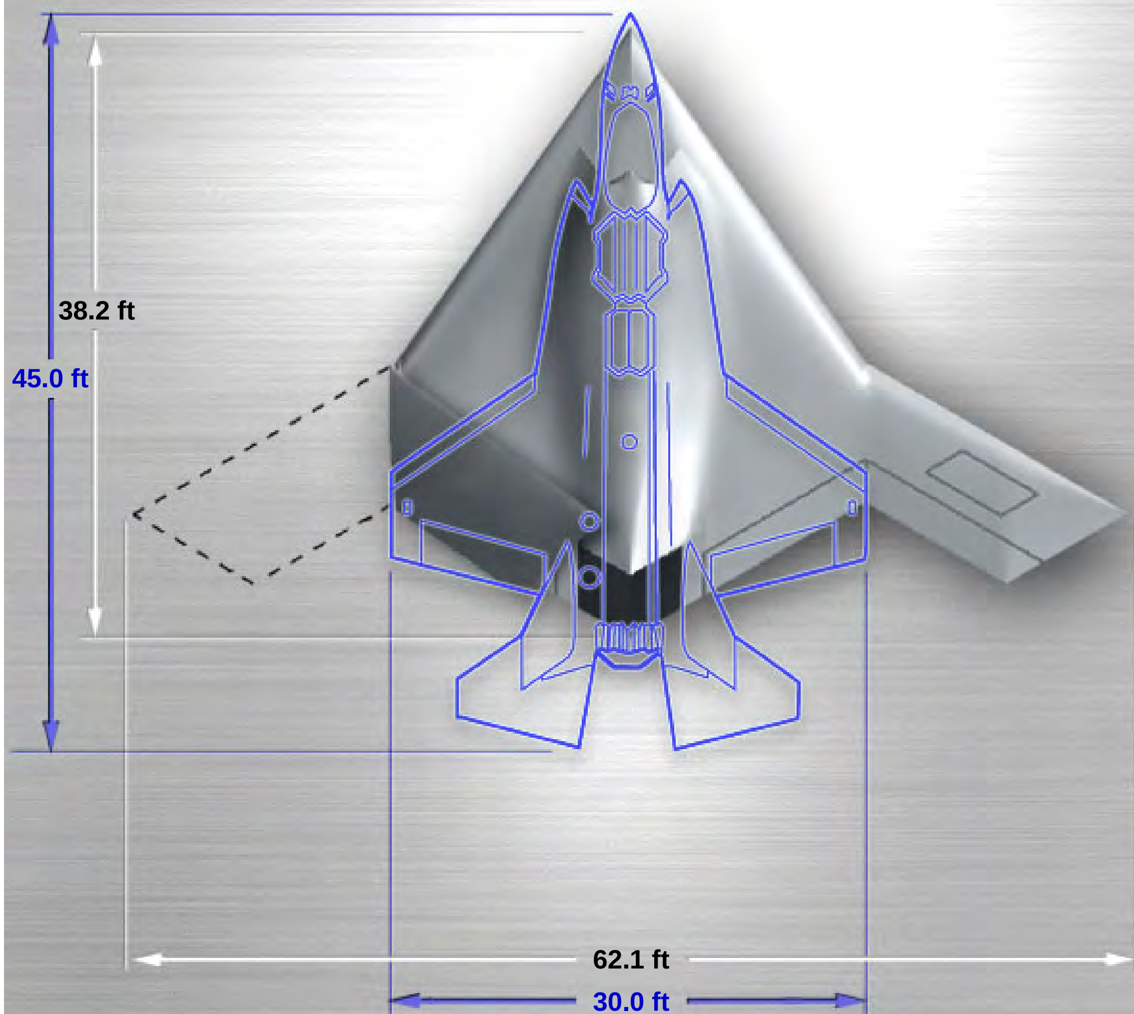

Refuelable J-UCAS Could Provide Survivable Deep/Wide Area Coverage
X-47B Persistence @ 1000NM
Carrier Based - 20 Hours
1500NM Airfield - 17 Hours
3000NM - 13 Hours
Notional J-UCAS persistence coverage
Holding Time Critical Targets, WMD and other Moving/ Mobile Targets at Risk

J-UCAS Program/System Elements



X-47B Air Vehicle

Size comparison to USAF F-35

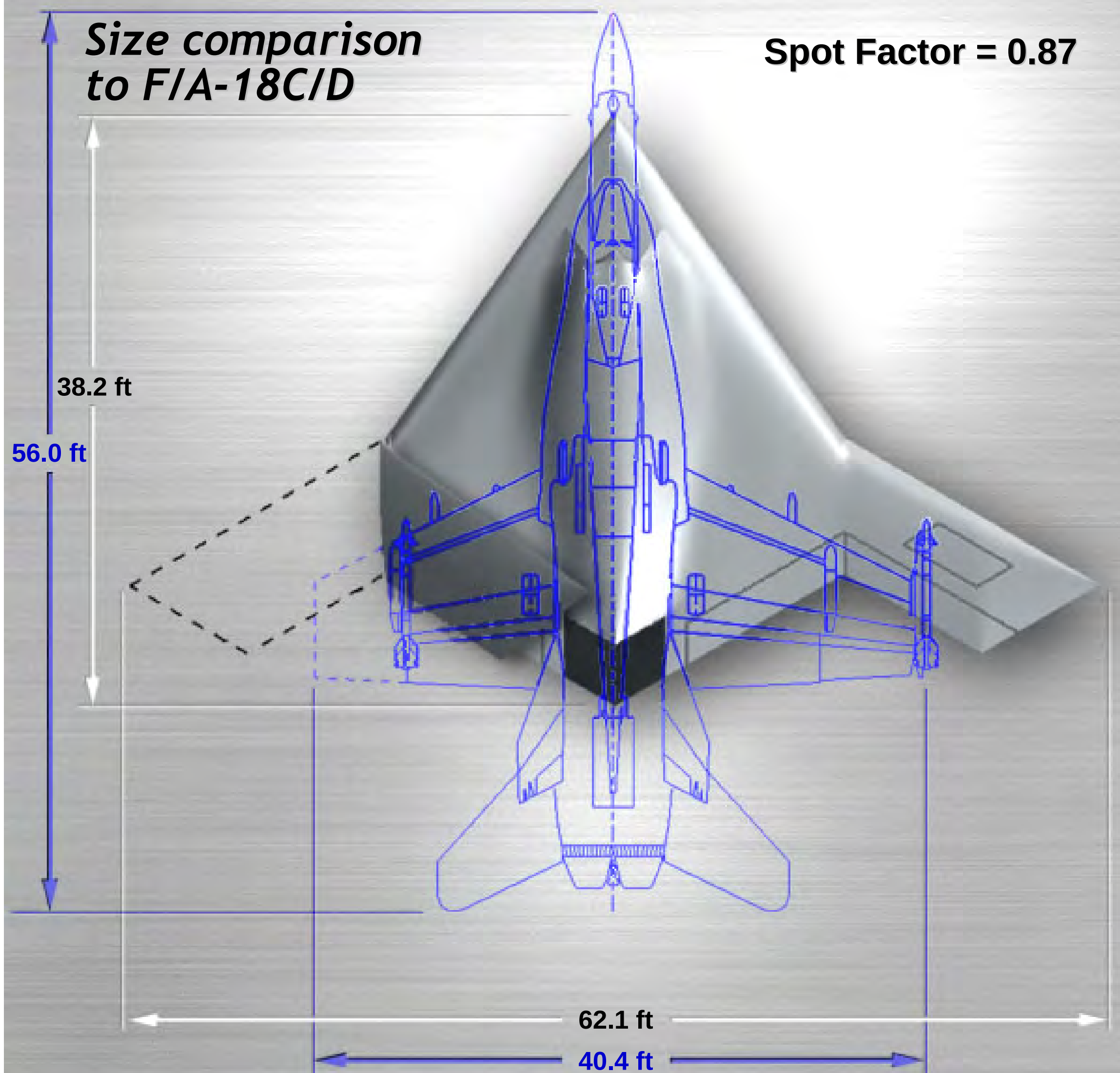


J-UCAS X-47B Air Vehicle

- **Altitude:** >40,000 ft
- **Speed:** High Subsonic
- **Payload:** >4,000 lb
- **Unrefueled range (w/max pyld):** >3,500NM
- **Sensor Provisions:** EO/IR/SAR/ GMTI/ESM
- **Air refueling provisions:** USAF style
- **Mission TOGW:** >45,000 lbs
- **Basing:** Land & CV

X-47B J-UCAS Demonstration System

Size comparison to F/A-18C/D



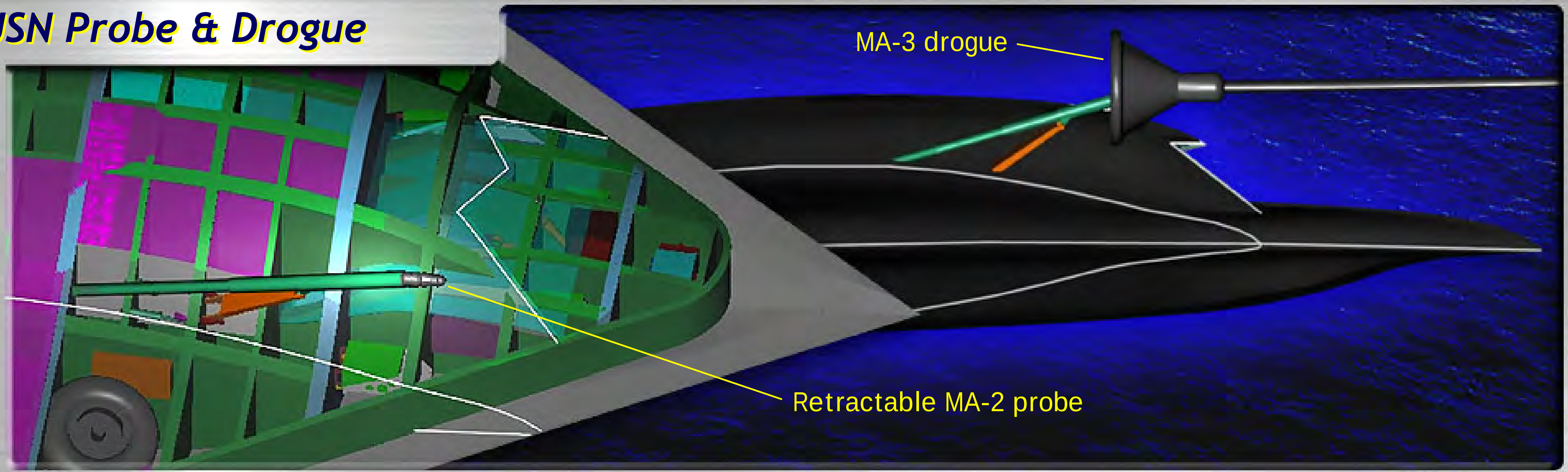
Spot Factor = 0.87

J-UCAS X-47B Air Vehicle

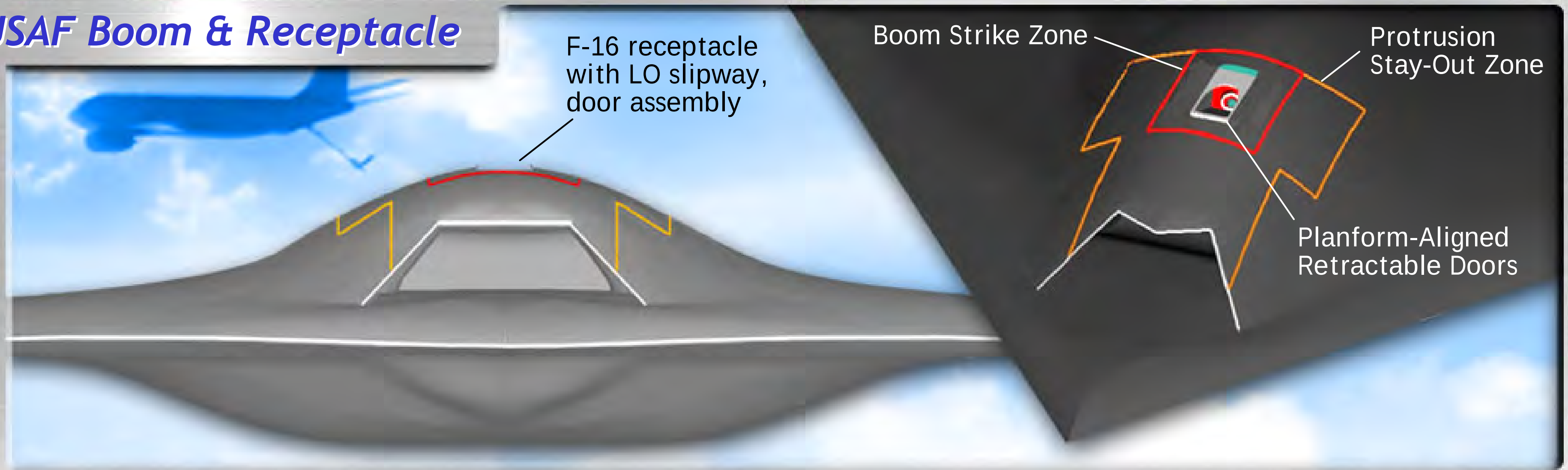
- **Altitude:** >40,000 ft
- **Speed:** High Subsonic
- **Payload:** >4,000 lb
- **Unrefueled range (w/max pyld):** >3,500NM
- **Sensor Provisions:** EO/IR/SAR/ GMTI/ESM
- **Air refueling provisions:** USN & USAF style
- **Mission TOGW:** >35,000 lbs
- **Basing:** Land and CV

X-47B In-Flight Refueling Provisions

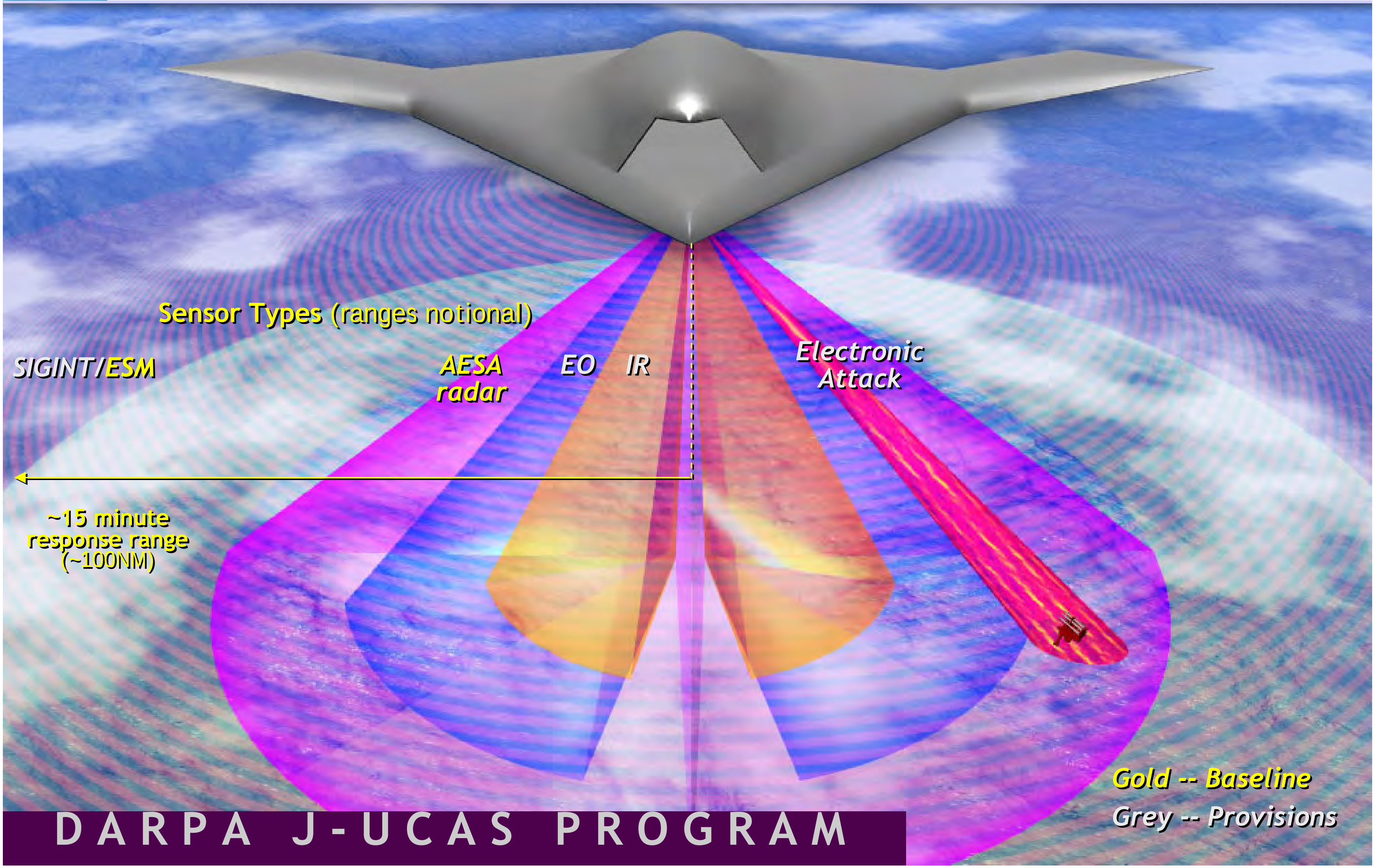
USN Probe & Drogue



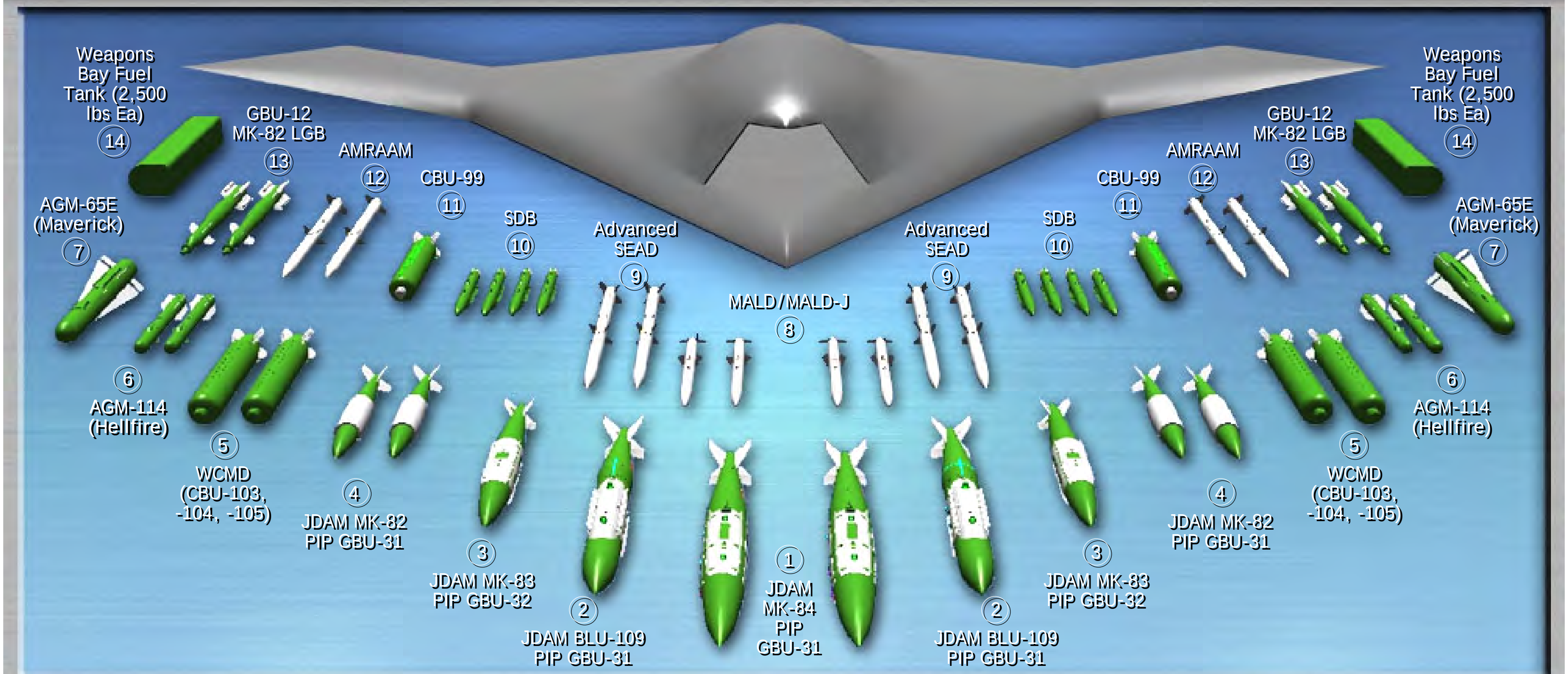
USAF Boom & Receptacle



Initial Mission Systems: Sensing, EA



Potential Weapon Carriage (4,500Lb payload)



No.	Weapon	Qty
1	JDAM MK-84 PIP GBU-31	2
2	JDAM BLU-109 PIP GBU-31	2
3	JDAM MK-83 PIP GBU-32	2
4	JDAM MK-82 PIP GBU-31	4
5	WCMD (CBU-103, -104, -105)	4

No.	Weapon	Qty
6	AGM-114 (Hellfire)	4
7	AGM-65E (Maverick)	2
8	MALD/MALD-J	4
9	Advanced SEAD	4
10	Small Diameter Bomb	8

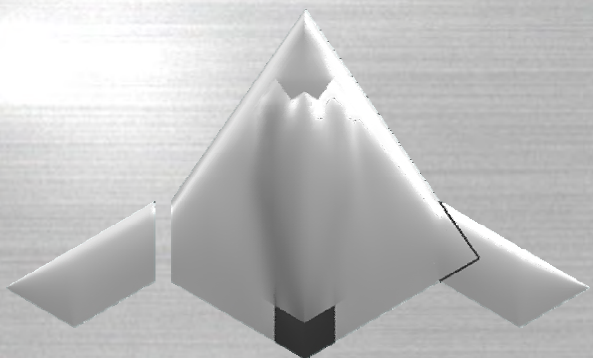
No.	Weapon	Qty
11	CBU-99	2
12	AMRAAM	4
13	GBU-12 MK-82 LGB	4
14	Wpns Bay Fuel Tank	1-2

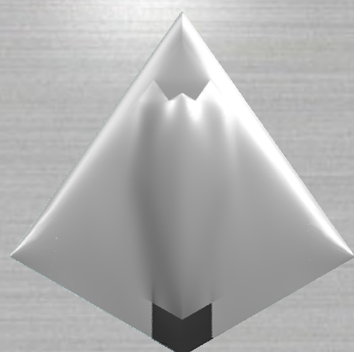
“Gateway” Design

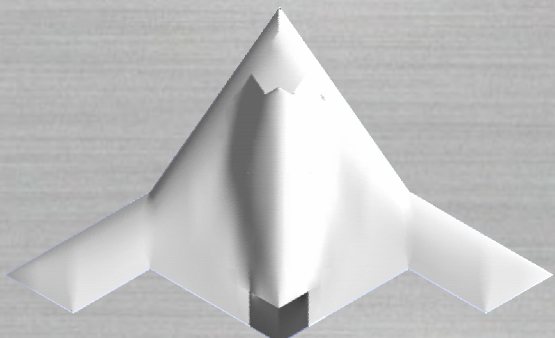
Common Center Body
- Avionics & sensor integration
- Propulsion integration
- Subsystems

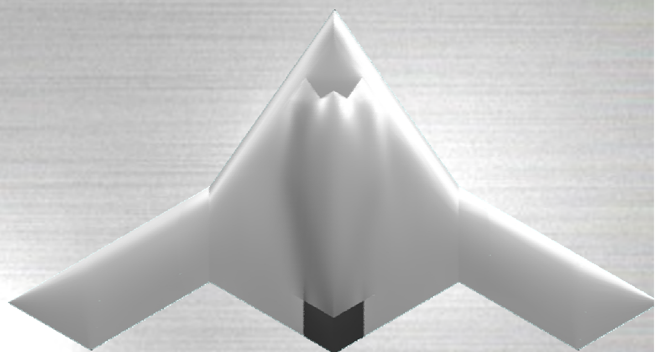
Kite Planform
- Efficient Signature
- Compact Size

“Cranked” Kite Planform
- Efficient aerodynamics
- Carrier suitable
- Wing size variable as per range/endurance requirements









X-47B permits development of wide range of production system options

Persistence is Key

*Source: Joint Staff (J-8), *CJCSI 3170.01C: The Joint Capabilities Integration and Development System (JCIDS)*, 2003

JOINT FUNCTIONAL CONCEPTS / CAPABILITY AREAS

Battlespace Awareness	Protection	Force Application	Command & Control	Focused Logistics
▪ All source Intel collection	▪ Personnel and infrastructure protection	▪ Land, sea, air and space ops	▪ CROP	▪ Deployment distribution
▪ Environmental data collection	▪ CND	▪ Joint targeting	▪ JFC2	▪ Sustainment
▪ Own force info collection	▪ Counter-proliferation	▪ Conventional attack	▪ Comms and computer environment	▪ Medical
▪ Predictive analysis	▪ Non-proliferation	▪ Nuclear attack		▪ Mobility
▪ Knowledge management	▪ Consequence management	▪ CNA		▪ Logistics C2
	▪ Missile defense	▪ Electronic attack		
		▪ PSYOPS		
		▪ Special ops		
		▪ Joint fires		
		▪ SEAD		
		▪ Military deception		

Assessing Relative Persistence Capability

Alternative Near- to Medium-Term Surveillance-Strike System Types

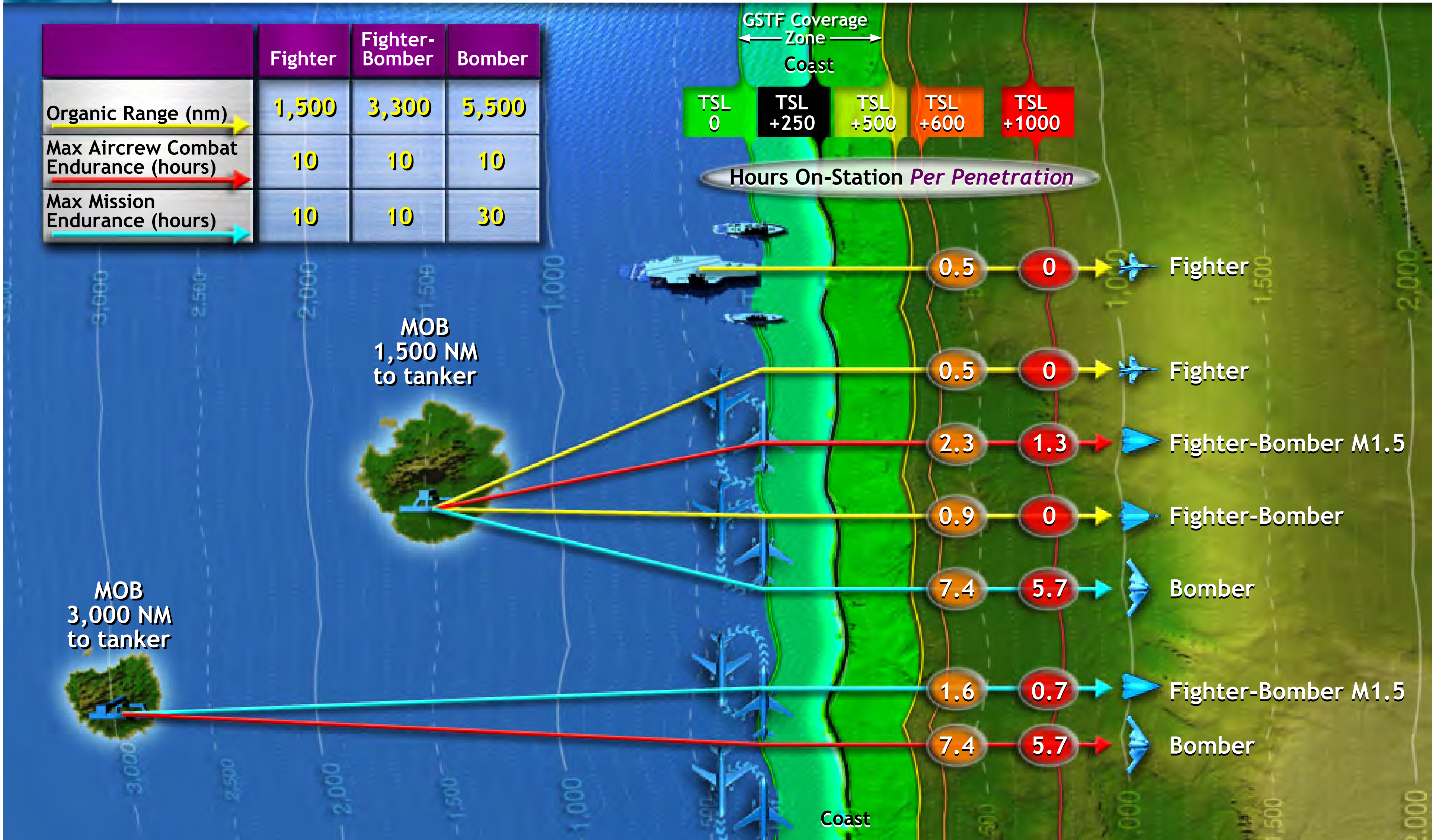
System Performance Characteristics	Notional Manned Systems				Unmanned Combat Air System**
	Strike Fighter	Fighter Bomber	Sustained Supersonic Ftr-Bomber	Bomber	
Cruise Speed (kts)	460	460	860	460	460
Unrefueled Range (NM)	1,500	3,300	3,300	5,500	3,700
Vehicle Endurance Limit	N/A*	N/A*	N/A*	N/A*	50
Sustainable Aircrew Total Mission Endurance (hrs)	10	10	10	30	N/A
Aircrew Combat Endurance (hrs)	10	10	10	10	N/A

**Aircrew endurance constraints preclude manned aircraft surpassing system endurance limits*

*****Approximates projected performance of X-47B demonstration system — a robust precursor for TBD USAF/USN operational systems***

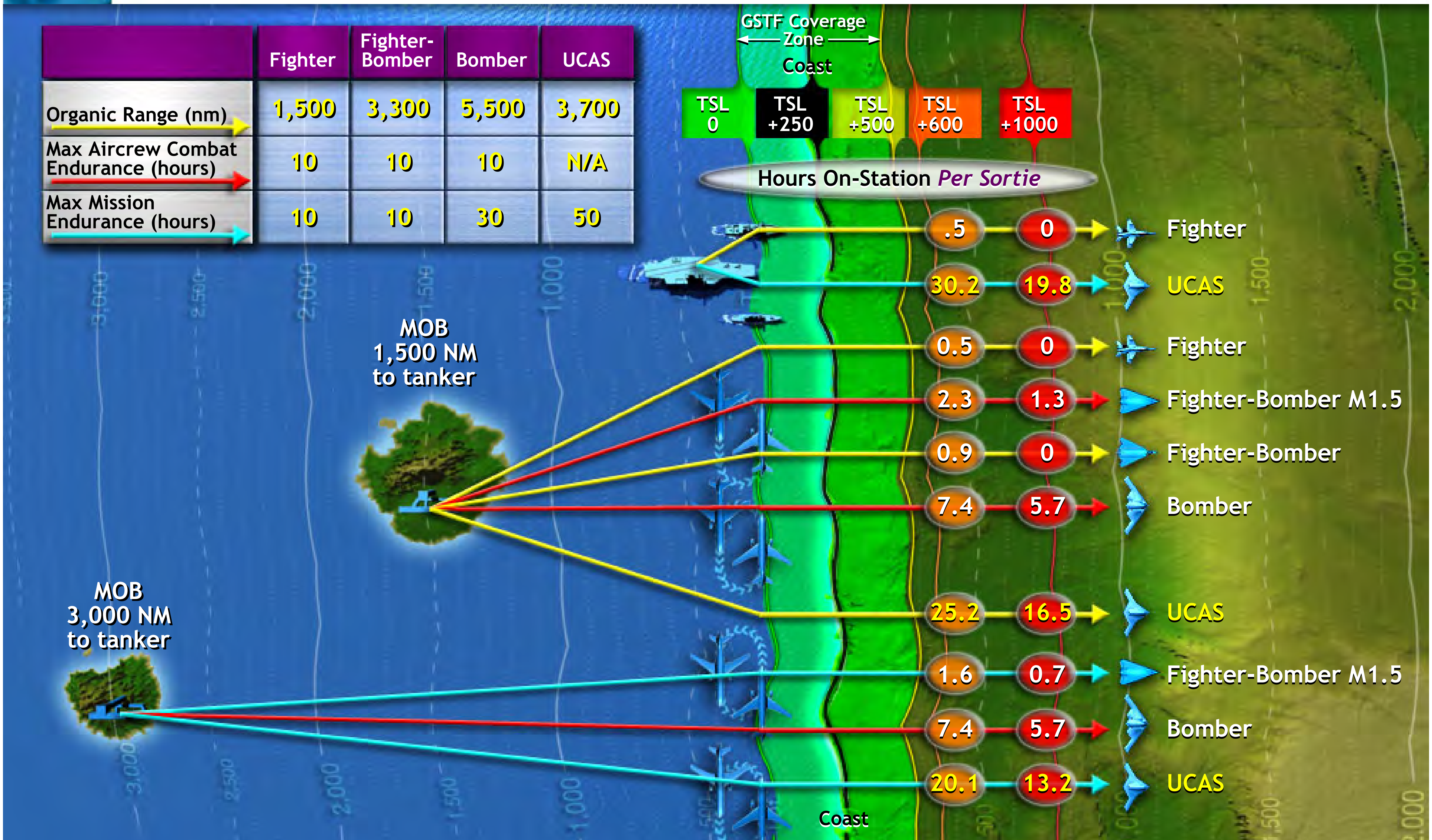
"Simple" Persistence Comparison

	Fighter	Fighter-Bomber	Bomber
Organic Range (nm)	1,500	3,300	5,500
Max Aircrew Combat Endurance (hours)	10	10	10
Max Mission Endurance (hours)	10	10	30



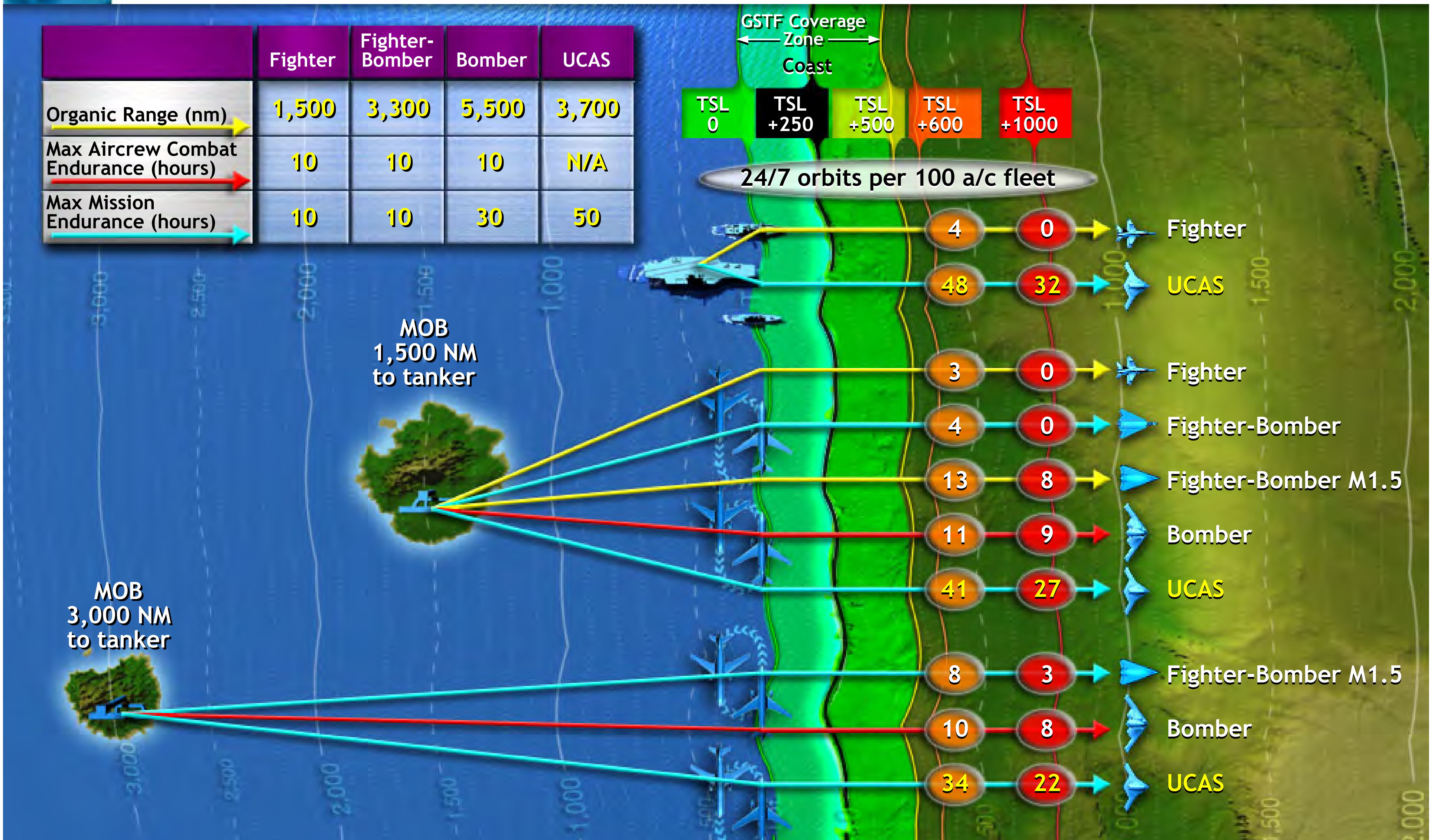
"Compound" Persistence Comparison

	Fighter	Fighter-Bomber	Bomber	UCAS
Organic Range (nm)	1,500	3,300	5,500	3,700
Max Aircrew Combat Endurance (hours)	10	10	10	N/A
Max Mission Endurance (hours)	10	10	30	50



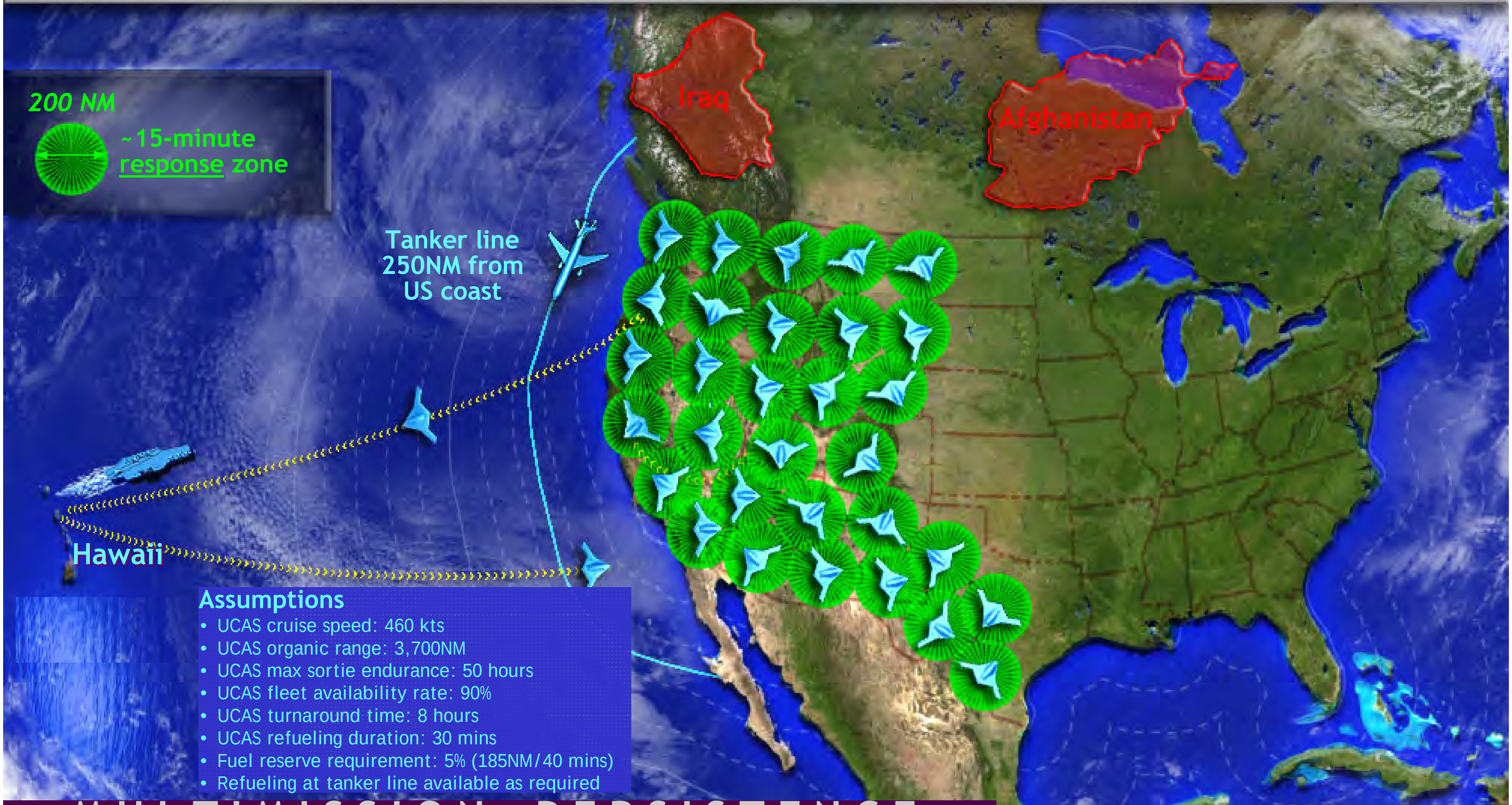
Persistent Coverage Generation

	Fighter	Fighter-Bomber	Bomber	UCAS
Organic Range (nm)	1,500	3,300	5,500	3,700
Max Aircrew Combat Endurance (hours)	10	10	10	N/A
Max Mission Endurance (hours)	10	10	30	50



UCAS Multi-mission Persistent Coverage in Perspective

Illustrative 24/7 Surveillance-Attack Coverage of 100 a/c Fleet of X-47B-Class UCAS



Assumptions

- UCAS cruise speed: 460 kts
- UCAS organic range: 3,700NM
- UCAS max sortie endurance: 50 hours
- UCAS fleet availability rate: 90%
- UCAS turnaround time: 8 hours
- UCAS refueling duration: 30 mins
- Fuel reserve requirement: 5% (185NM/40 mins)
- Refueling at tanker line available as required

NGC X-47 Air Vehicle Plan

- **Commit to CV-capable baseline demonstration vehicle**
  - CV suitability a non-negotiable objective of a truly Joint demonstration program
  - Only one configuration is guaranteed with baseline contract—CV-suitable vehicle required to ensure achievement of joint demonstration objectives
  - CV operations most challenging vehicle-centric demo objective
- **Field highly capable vehicles as fast as possible to ensure timely capability demonstrations**
  - AV1 is CV demo bird
  - AV2 is mission demo bird
  - AV3 is all-up bird (LO, mission systems)
  - AVs 1/2 retrofittable to full mission capability

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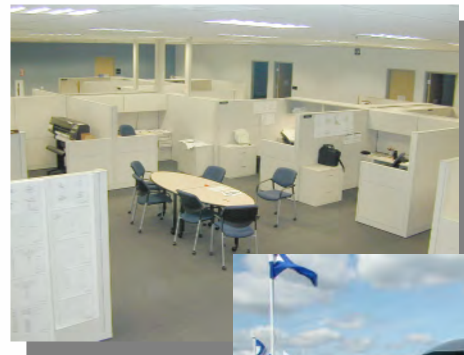
J-UCAS 2004 Accomplishments

- **Full Scale Mock- Up Built**
  - **RIAT/Farnborough/Miramar**
- **Low/High Speed Wind Tunnel Test**
- **J-UCAS Industry Team (JIT) Established**
- **OA Contract Definitized/Award - $1.03B**
- **Successful Key Program Reviews**
  - **CAIG, SRR & IBR**
- **Program Execution on Track**



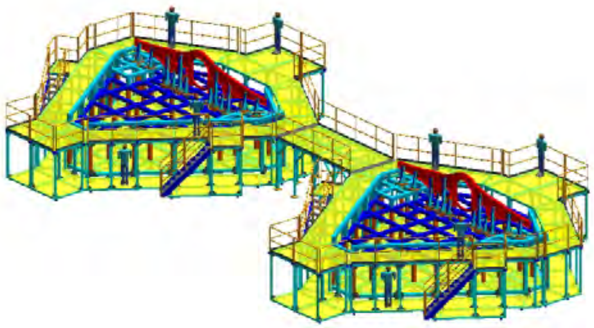
NORTHROP GRUMMAN

J-UCAS Program Look Ahead

FY '05 Activities

- Inlet Wind Tunnel Tests – 17 Feb, 2005
- Preliminary Design Review (PDR) – 15-16 Mar, 2005
- A/V-1 Jig Load Palmdale – Summer 05
- Critical Design Review (CDR) – 24 Aug, 2005
- Full Scale Pole Model Fabrication & Assembly – Summer 05

FY '06 Planned Activities



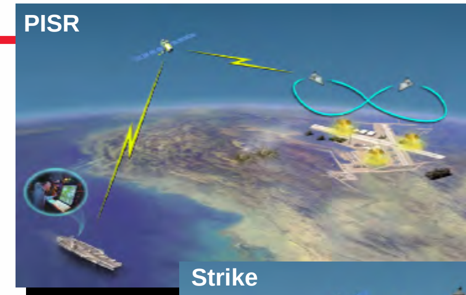
- Control Law and Analysis
- Surrogate JPALS Testing
- Utility System Schematics
- EO/IR Design and Integration
- Electronic Attack Design and Integration
- Landing Gear and Hook Development

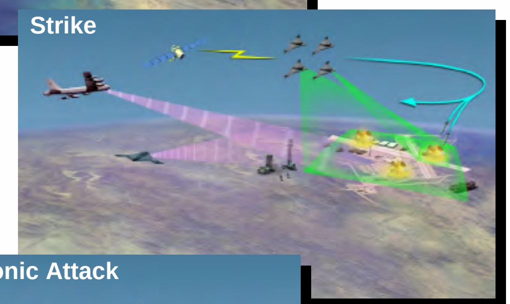
A/V-1 First Flight – Summer 07

NORTHROP GRUMMAN

X-47, J-UCAS…

- **Enables Transformational Capabilities**
  - Persistence
  - Survivability
  - Global Persistent Attack
  - Deep Strike
- **Converges Emerging Technologies, Operational Needs and Demonstration Capabilities Near Term**
- **Is a Joint Program**
  - Baseline meets CV requirements
  - Compliments F/A-22, F-35 and B-2
- **Provides OSD a Competitive Approach**
  - Reduces Cost
  - Promotes Innovation





The President's Budget Allows Continued Advancement of This Critical Warfighting Capability


505
NE

Mature and Secure:
Creating a CMMI® and ISO/IEC 21827 Compliant Process Improvement Program

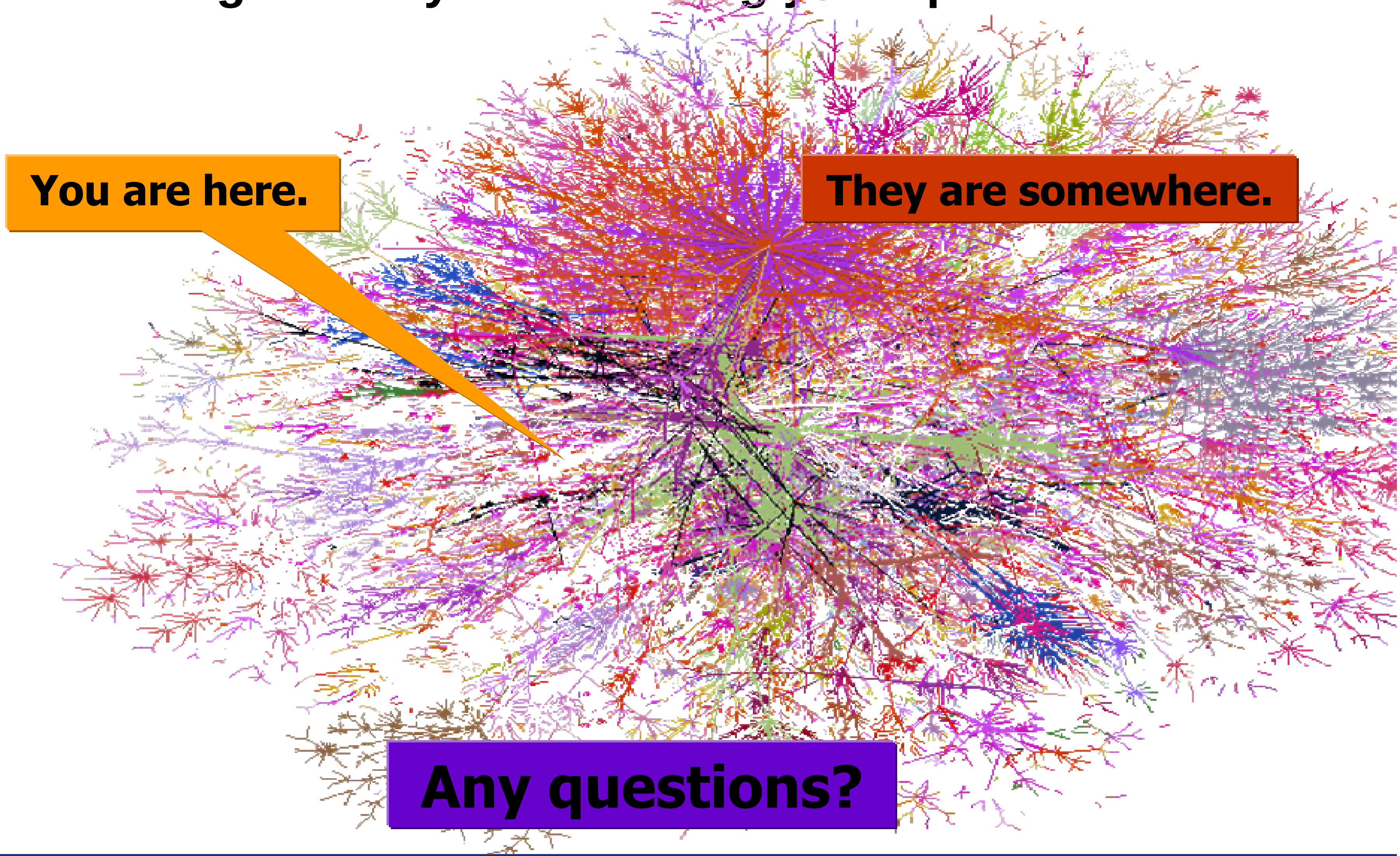
Michele Moss
San Diego, CA
October 27, 2005

Booz | Allen | Hamilton

Security needs are continuously evolving, which makes security implementation increasingly challenging

- Global interconnection
- Massive complexity
- Release of beta versions of software
- Evolutionary development

Addressing security is increasingly complex



Business drivers help shape the integration of security into our systems/software efforts

- Headline News
  - Microsoft: "Code Red" Worm
  - Air Force: “Hacker Steals Air Force Officer’s Personal Information”
- Legislation
  - e-Gov Act
  - OMB A-11 Exhibit 300 Section II. B
  - FISMA
- Market recognition
  - Assurance that security is appropriately addressed
  - Security implementation should be transparent

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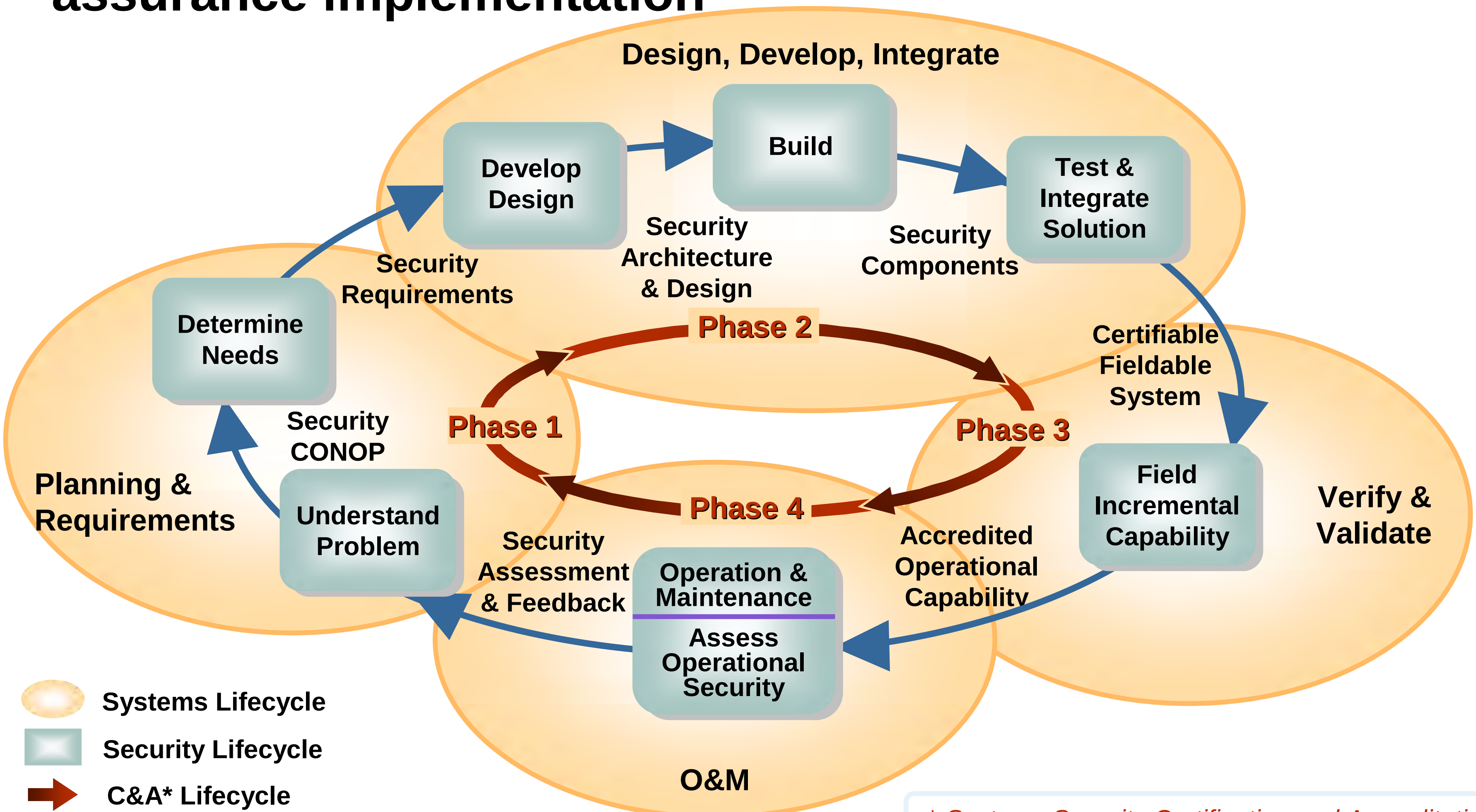
Integrating security engineering into the systems engineering lifecycle enables successful information assurance implementation



** Systems Security Certification and Accreditation*

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The CMMI is an existing business requirement that provides guidance for defining, implementing and improving the systems lifecycle

5 Optimizing
- Organizational Innovation and Deployment
- Causal Analysis and Resolution

4 Quantitatively Managed
- Organizational Process Performance
- Quantitative Project Management

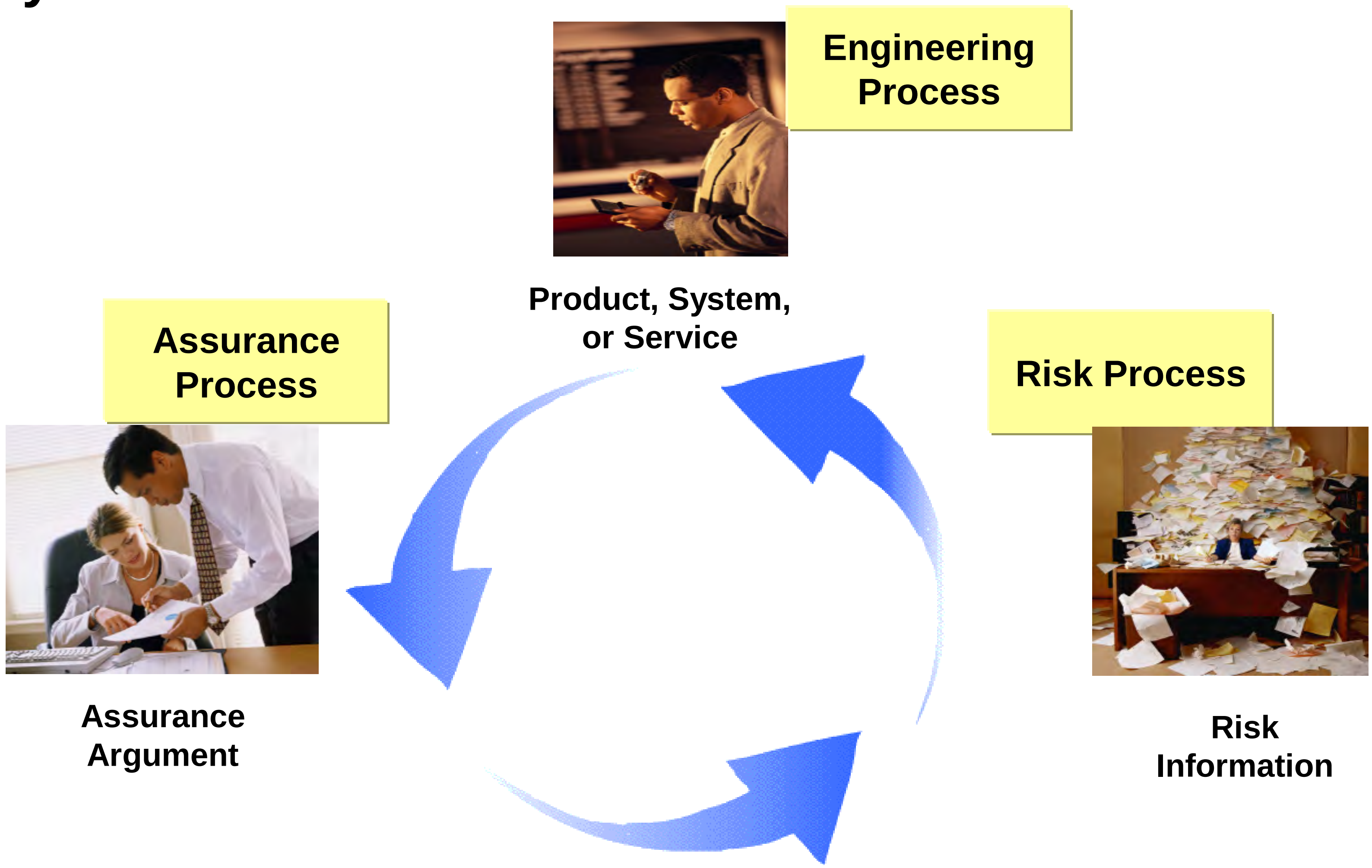
3 Defined
- Requirements Development
- Technical Solution
- Product Integration
- Verification
- Validation
- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Integrated Project Management
- Risk Management
- Integrated Teaming
- Integrated Supplier Management
- Decision Analysis and Resolution
- Organizational Environment for Integration

2 Managed
- Configuration Management
- Process and Product Quality Assurance
- Supplier Agreement Management
- Project Monitoring and Control
- Project Planning
- Requirements Management
- Measurement and Analysis

1 Initial

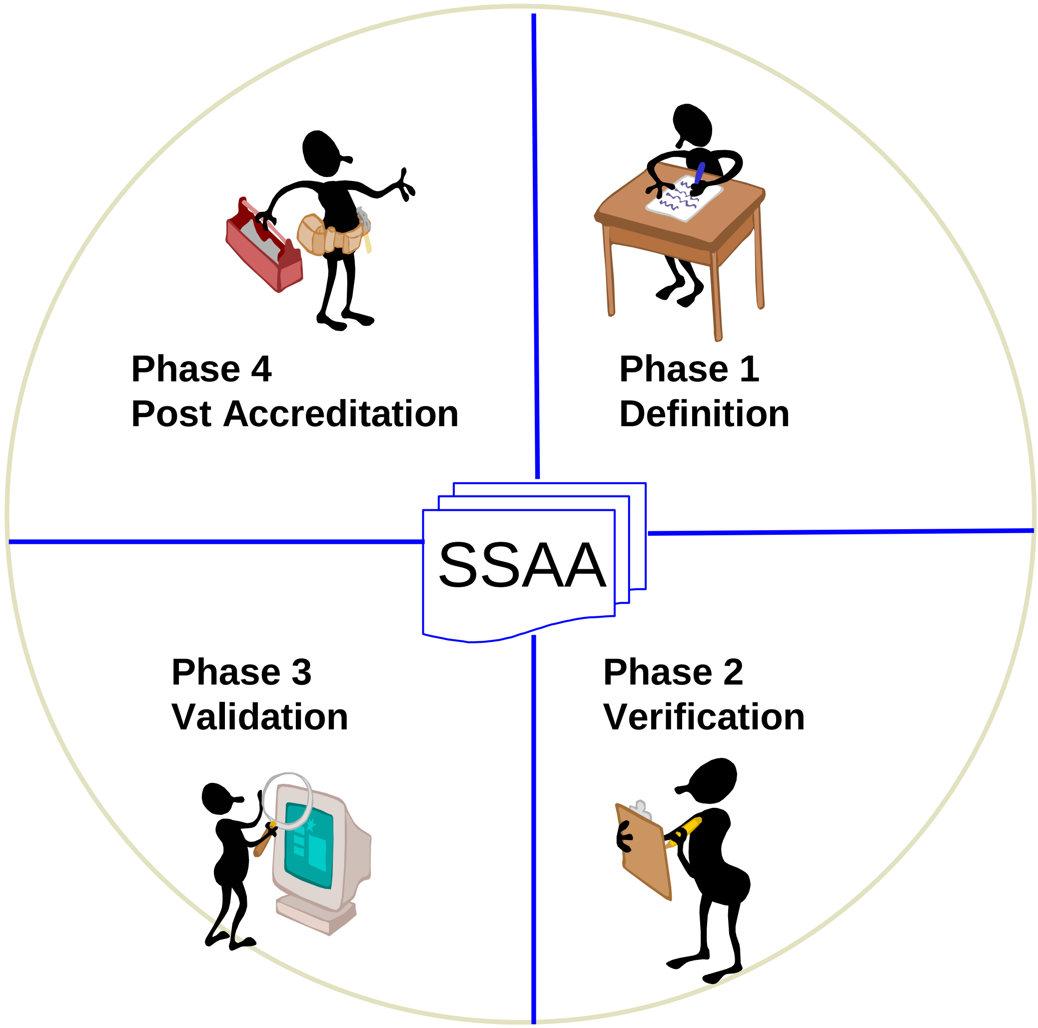
Staged Representation

The ISO 21827 SSE-CMM* provides guidance for defining, implementing and improving the security lifecycle

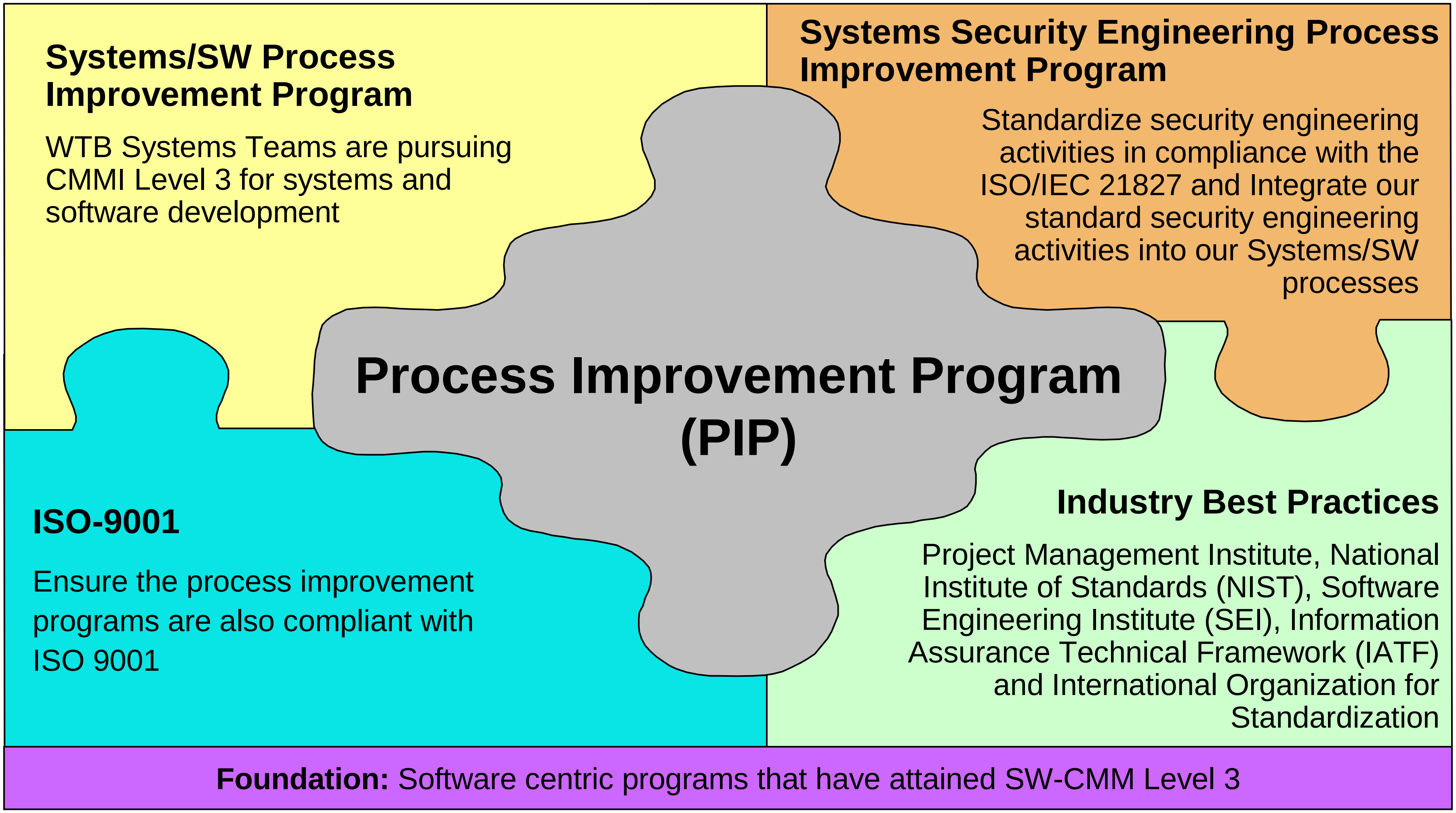


* Systems Security Engineering Capability Maturity Model

DITSCAP defines the certification and accreditation lifecycle



Organizational Standard Processes leverage industry standards that support diverse clients



CMMI = Capability Maturity Model Integration
ISO = International Organization for Standardization

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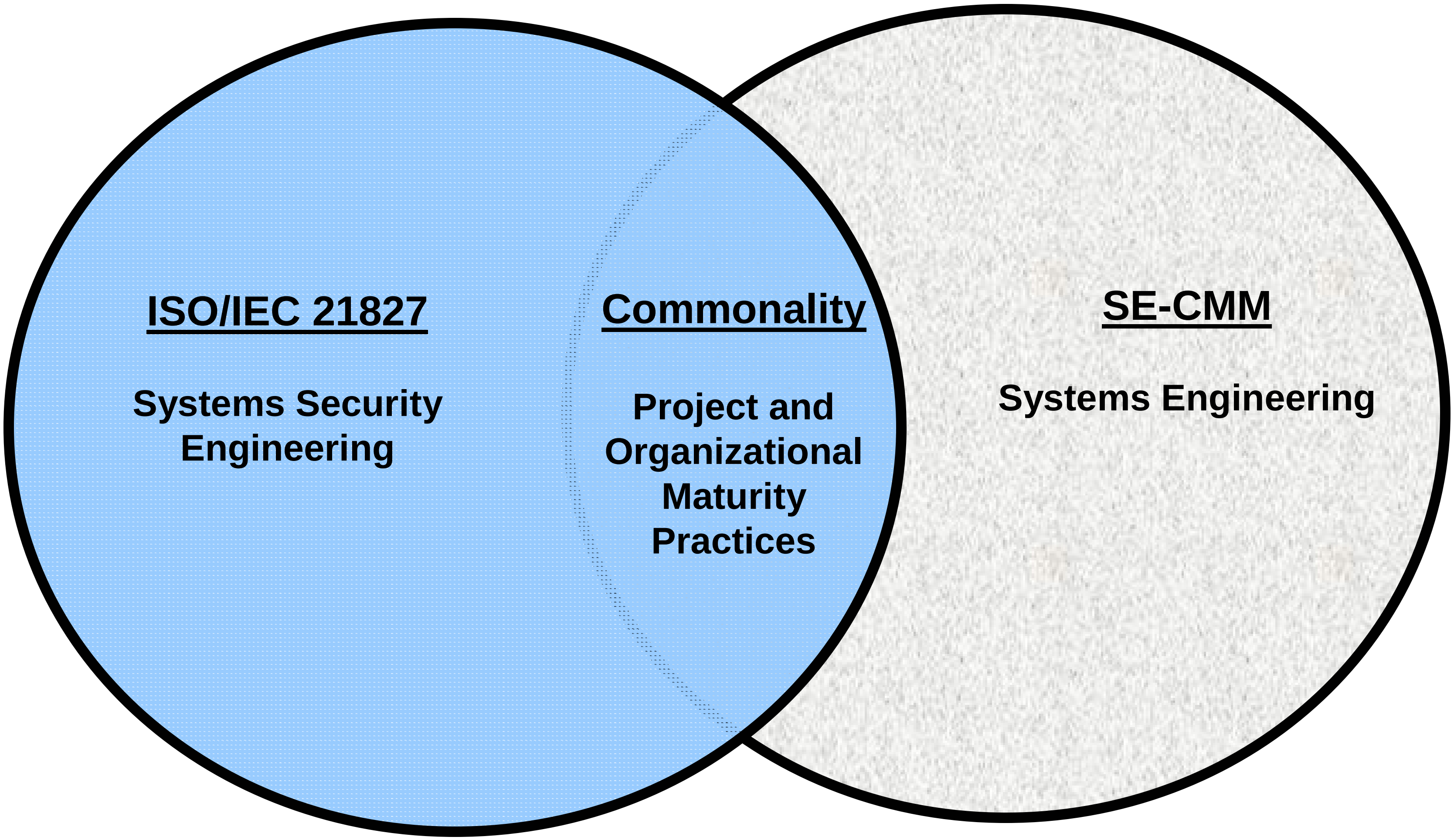
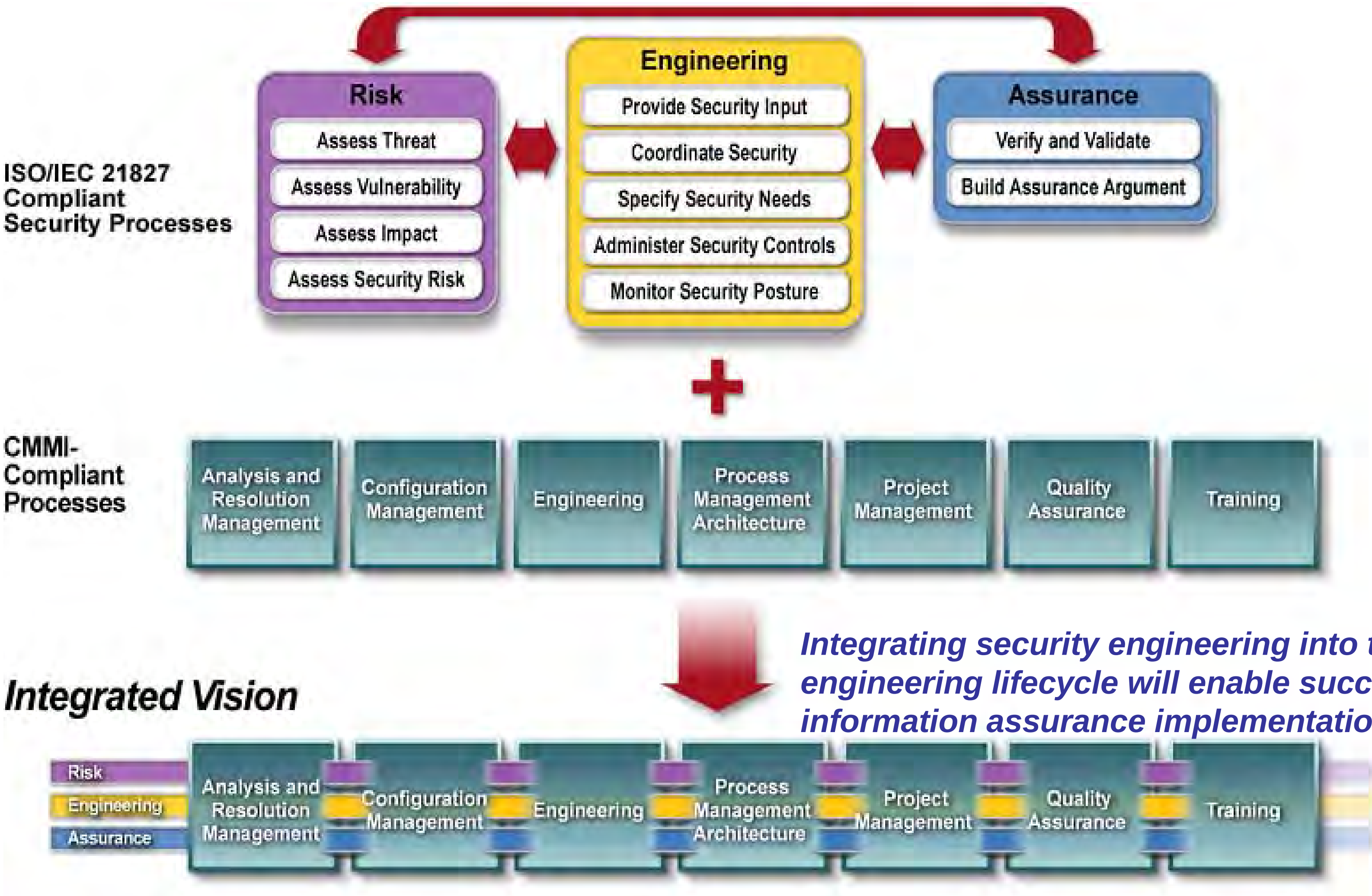
The ISO 21827 is based on the Systems Engineering CMM (SE-CMM), adding security engineering practices to enable improvement of security specific practices



Our CMMI approach integrated security engineering processes with our systems/software processes



Integrating security engineering into the systems engineering lifecycle will enable successful information assurance implementation

There are different CMM Representations

- **Staged**[1] - process areas are assessed using specific practices. Predefines the process areas required to attain each maturity level (1-5) and thereby provides a roadmap for institutionalizing best practices.

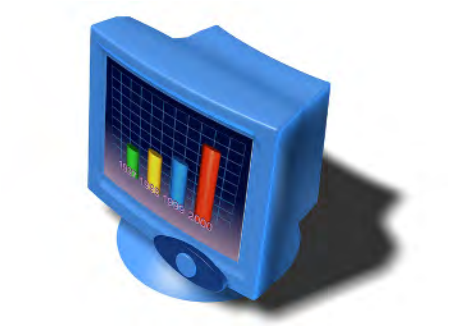
- **Continuous**[1] – process areas are assessed using specific practices within an area and the generic practices required for a specific level. Based on its business objectives, an organization selects the process areas in which it wants to improve and to what degree.

[1]**Software Productivity Consortium, Integrated Processes on the Horizon, Carlos Galvan, Aug 25, 2000**

The SSE-CMM is a continuous model and a target profile is used to scope the appraisal and prioritize the process areas

- A target profile is based on
  - An analysis of the "Business and Mission Imperatives" and an assessment of which Process Areas are most important to support them
  - Industry "best practices" for the type of product, project or service, published Industry sector profiles, or a published profile from another organization in the same or related industry

- Organizations may develop their own unique target profiles
  - The SSE-CMM does not mandate specific profiles



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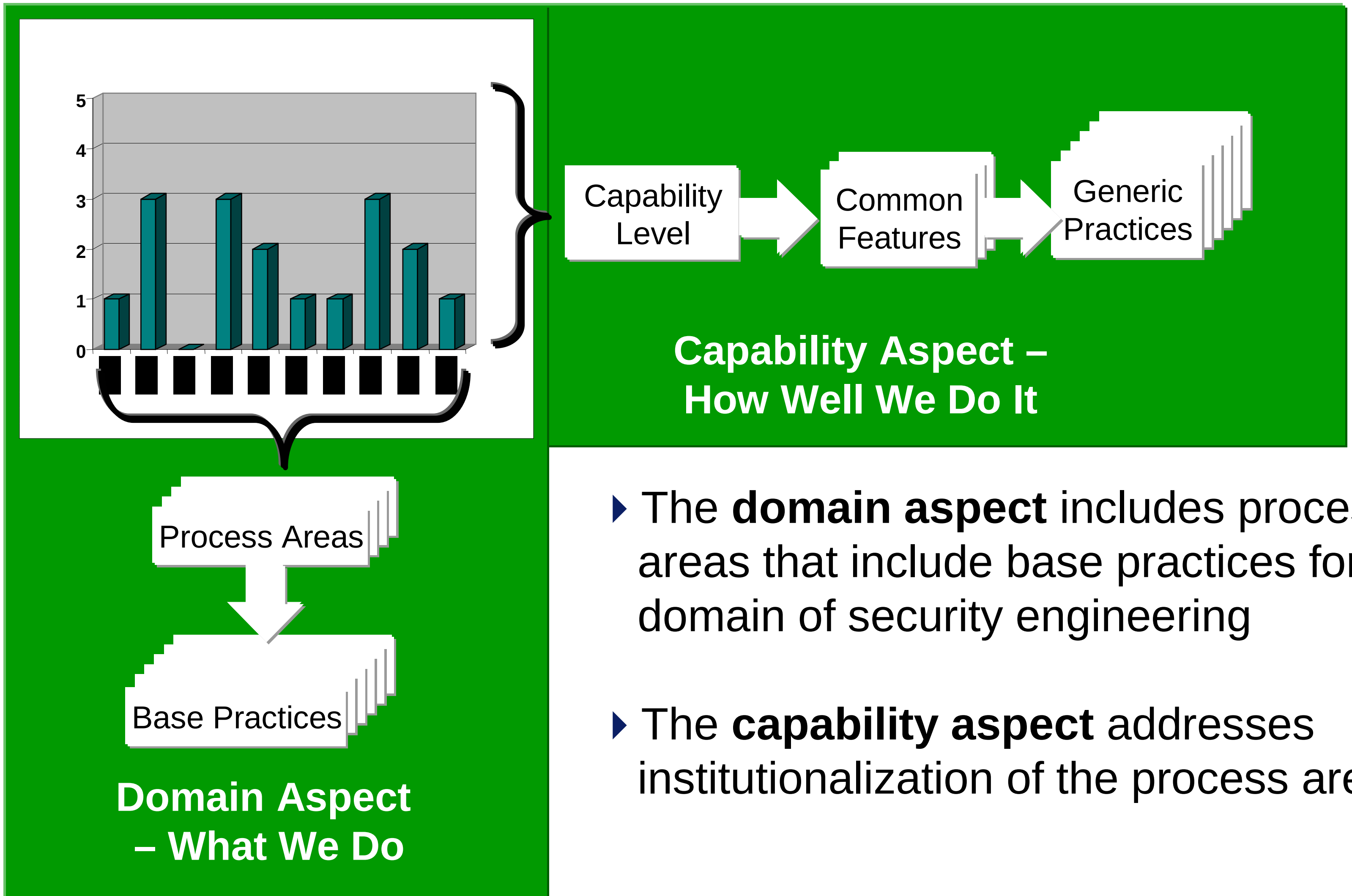
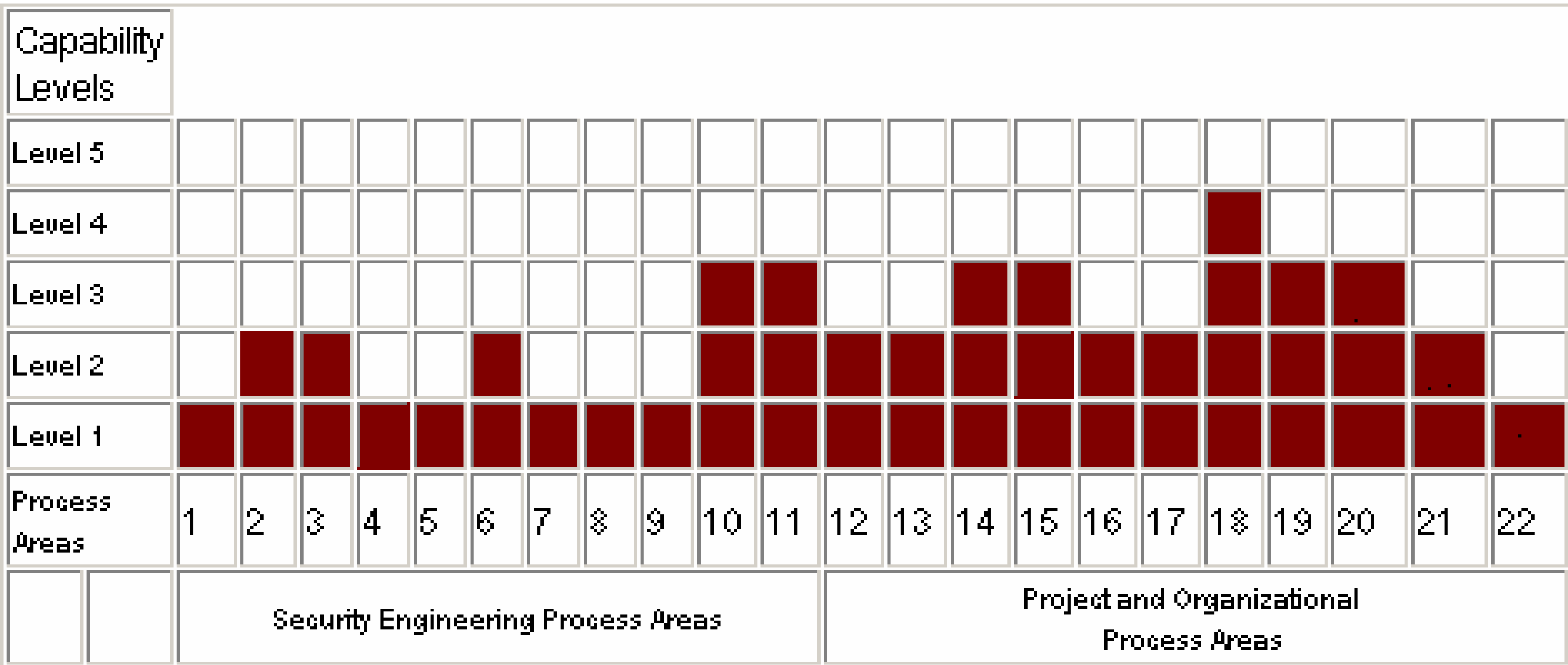
The ISO 21827 addresses the organization's selected process areas from two dimensions or aspects



- The **domain aspect** includes process areas that include base practices for the domain of security engineering
- The **capability aspect** addresses institutionalization of the process areas

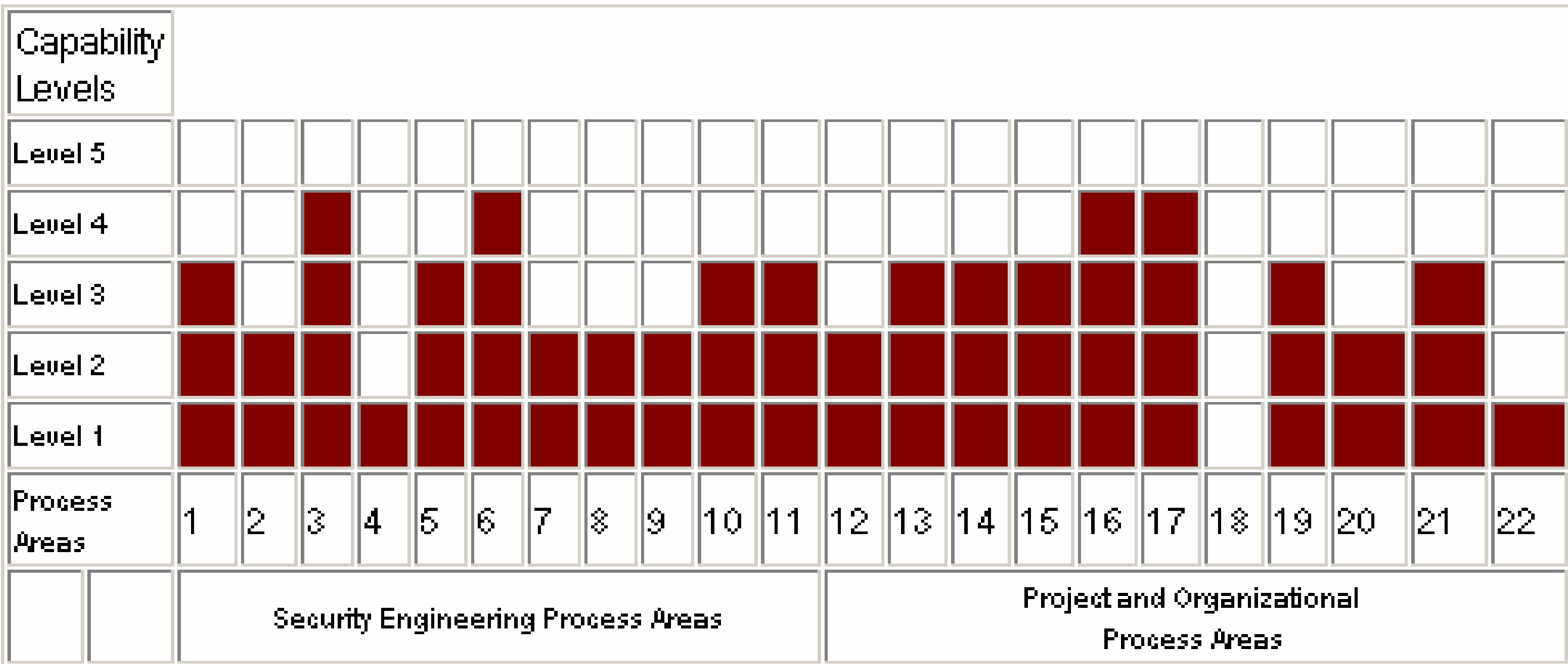
Sample Profile for a Security Product Developer

- For a security product developer, the process areas related to product development activities might target a higher level of maturity.



Sample Profile for a Systems Integrator

- In this case, the highest level of maturity is required in those process areas that contribute most significantly to fulfilling the customers expectations.



CMMI processes provided the foundation for implementation of security practices

CMMI	ISO/IEC 21827 SSE-CMM
Org Process Focus (L3) Org Process Definition (L3) Org Process Performance (L4) Org Innovation and Deployment (L5)	Define Organization's Systems Security Engineering Process Improve Organization's Systems Security Engineering Process Manage Systems Engineering Support Environment Manage Product Line Evolution
Organizational Training (L3)	Provide Ongoing Skills and Knowledge
Project Planning (L2) Project Monitoring and Control (L2) Supplier Agreement Management (L2) Integrated Project Management (L3) Risk Management (L3) Quantitative Project Management (L4)	Plan Technical Effort Monitor and Control Technical Effort Coordinate with Suppliers Coordinate Security Manage Project Risk Build Assurance Argument
Requirements Management (L2) Requirements Development (L3) Technical Solution (L3) Product Integration (L3) Verification (L3) Validation (L3)	Specify Security Needs Provide Security Input Verify and Validate Security Administer Security Controls Assess Impact Assess Security Risk Assess Threat Assess Vulnerability Monitor Security Posture
Configuration Management (L2)	Manage Configurations
Process & Product Quality Assurance (L2)	Ensure Quality
Measurement and Analysis (L2) Decision Analysis and Resolution (L3) Causal Analysis and Resolution (L5)	

An integrated team to advocates process implementation

- Appraisers
  - Role: Provide CMMI model and OSP subject matter expertise
- Process Engineers
  - Role: Mentor and assist project personnel in implementing project processes
- Security Process Engineers
  - Role: Provide SME support and guidance for security process implementation

The SCAMPI and ISO/IEC 21827 Appraisal Method have similar steps

SSE-CMM Appraisal Method

Planning Phase
- Scope Appraisal
- Plan Appraisal

Preparation Phase
- Prepare Appraisal Team
- Administer Questionnaire
- Consolidate Evidence
- Analyze Evidence/ Questionnaire

Onsite Phase
- Executive Brief/ Opening Meeting
- Interview Leads/ Practitioners
- Analyze Data
- Establish Findings
- Develop Rating Profile
- Manage Records
- Conduct Wrap Up

Reporting Phase
- Develop Findings Report
- Report Appraisal Outcomes to Sponsor
- Manage Appraisal Artifacts
- Report Lessons Learned

CMMI SCAMPI

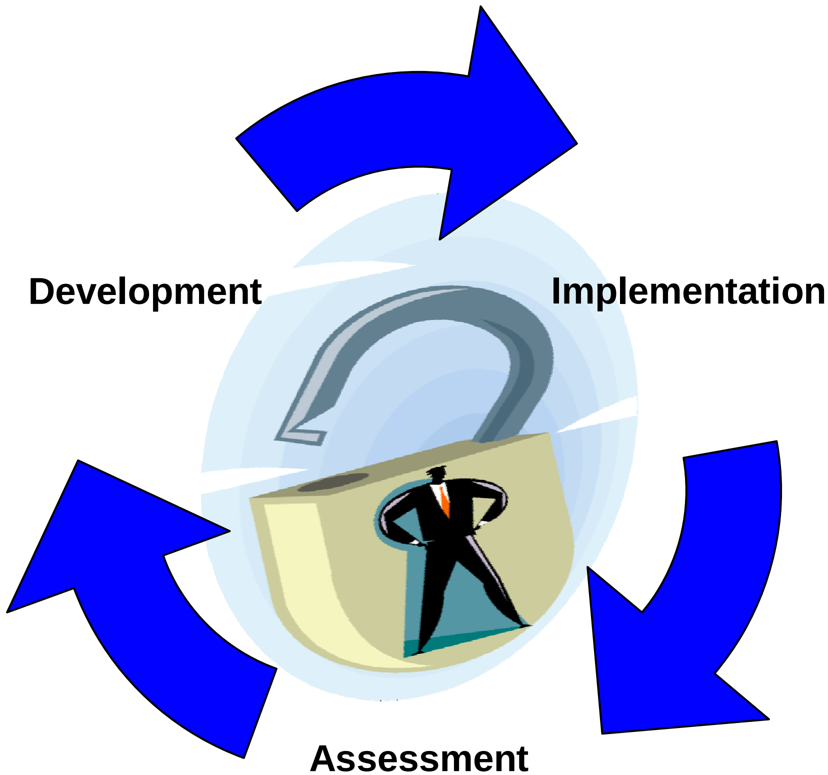
Plan and Prepare for Appraisal
- Analyze Requirements
- Develop Appraisal Plan
- Select and Prepare Appraisal Team
- Obtain and Analyze Initial Objective Evidence
- Prepare for Collection of Objective Evidence

Conduct Appraisal
- Examine Objective Evidence
- Verify and Validate Objective Evidence
- Document Objective Evidence
- Generate Appraisal Results

Report Results
- Deliver Appraisal Results
- Package and Archive Appraisal Assets

SM SCAMPI is a service mark of Carnegie Mellon University

Integrating security into a Process Improvement Program results in increased assurance and transparency of security implementation



For More Information

- ISO/IEC 21827
  - www.sse-cmm.org
  - www.issea.org
- CMMI
  - http://www.sei.cmu.edu/cmmi/Information
- Assurance
  - http://iase.disa.mil/
  - http://iac.dtic.mil/iatac/
  - http://www.iatf.net/
  - http://www.sei.cmu.edu/programs/nss/nss.html

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Back up slides

History of ISO/IEC 21827

- 1993 NSA initiated funding for development of a CMM for security engineering
- 1995 Working groups established to develop the SSE-CMM
- 1996 SSE-CMM v1.0 published
- 1996-98 SSE-CMM piloted in 7 organizations
- 1999 SSE-CMM v2.0 published

  The International System Security Engineering Association (ISSEA) was established as a non-profit professional membership organization to be a liaison with ISO for standardization, model maintenance, and appraiser certification
- 2002 SSE-CMM approved as ISO/IEC 21827
- 2004-05 ISSEA submitting application for approval as ISO/IEC 21827 Appraiser Certification Body under ISO/IEC 17024, *General Requirements For Bodies Operating Certification Schemes For Persons*

The ISO 21827 facilitates achieving several of security engineering goals

- Tool for provider organizations to evaluate their security practices and focus improvements → **Process Improvement**
- Basis for evaluation of organizations (e.g., certifiers, evaluators) to establish organizational capability-based confidence in results → **Assurance**
- Mechanism to measure and monitor an organization's capability to deliver a specific security engineering capability → **Risk Management**
- Standard mechanism for customers to select appropriately qualified security engineering providers → **Capability Evaluation**

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There are 129 bases practices categorized into either Security Engineering Process Areas or Project and Organizational Process Areas

Security Engineering Process Areas	# of Base Practices	Project and Organizational Process Areas	# of Base Practices
1) Administer Security Controls	4	Ensure Quality	8
2) Assess Impact	6	Manage Configurations	5
3) Assess Security Risk	6	Manage Project Risk	6
4) Assess Threat	6	Monitor and Control Technical Effort	6
5) Assess Vulnerability	5	Plan Technical Effort	10
6) Build Assurance Argument	5	Define Organization’s Security Engineering Process	4
7) Coordinate Security	4	Improve Organization’s Security Engineering Process	4
8) Monitor Security Posture	7	Manage Product Line Evolution	5
9) Provide Security Input	6	Manage Systems Engineering Support Environment	7
10) Specify Security Needs	7	Provide Ongoing Skills and Knowledge	8
11) Verify and Validate Security	5	Coordinate with Suppliers	5

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Systems Security Certification & Accreditation

- Certification
  - Provides a comprehensive **evaluation** of technical and non-technical security features of an information system
  - Establishes the **extent to which** a particular design and implementation meets a set of specified security requirements
  - Provides **proof** of compliance with security requirements
  - **Leads** to accreditation

- Accreditation
  - Formal **declaration** by the designated approving authority (DAA):
    - An information system is approved to operate in a particular security mode at an **acceptable level of risk**
    - Based on the implementation of an **approved set of** technical, managerial, and procedural **safeguards**
  - Approval is granted to operate the system with the identified residual risk
  - Upon accreditation, the DAA formally accepts full responsibility for the security of the system

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Staged vs. Continuous Models

Staged Model

5 Optimizing
Organizational Innovation and Deployment
Causal Analysis and Resolution

4 Managed
Organizational Process Performance
Quantitative Project Management

3 Defined
Requirements Development
Technical Solution
Product Integration
Verification
Validation
Organizational Process Focus
Organizational Process Definition
Organizational Training
Integrated Project Management
Risk Management
Integrated Teaming
Integrated Supplier Management
Decision Analysis and Resolution
Organizational Environment for Integration

2 Repeatable
Configuration Management
Process and Product Quality Assurance
Supplier Agreement Management
Project Monitoring and Control
Project Planning
Requirements Management
Measurement and Analysis

1 Initial

Process Areas

Continuous Model

5 Continuously Improving
Improving Organizational Capability
Improving Process Effectiveness

4 Quantitatively Controlled
Establishing Measurable Quality Goals
Objectively Managing Performance

3 Well-Defined
Defining a standard process
Perform the defined process
Coordinate practices

2 Planned and Tracked
Planning Performance
Disciplined Performance
Verifying Performance
Tracking Performance

1 Performed Informally
Process Area Base Practices Performed

Process Areas

Generic Practices

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Staged and Continuous Model Comparison

Staged	Continuous
Less Flexible	More Flexible
Provides a definitive direction for improvement	Organizations can chart their own direction for improvement
Applies to only specific type of organization	Applies across all industries or types of organizations
All processes addressed at each level	

The Role of the Operator and System Engineer in the Force Modernization Environment

Tom Nelson
General Manager
SAFTAS Group

Purpose

- Present one person's perspective of the advantages of the operator-system engineer "team" in today's force modernization environment
- Illustrate some analytic approaches to consider in addressing your operational and systems engineering issues
- Illustrate some data framing concepts to consider in your future systems engineering work
- Find you <u>one good idea</u> that helps your own corporate "operator-system engineer" teams solve problems

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PM's Are Under Acquisition Assault

- Brief the link between national need and operator need
- Demonstrate the correlation between the design's focus and the user's priorities
- Show adjustments in operational concepts which have allowed cost containment and a reduction in complexity
- Show the relationship between high LCC drivers and critical needs
- Identify to oversight authority the areas of trade zones which are available to reduce cost and risk yet still fulfill service needs in capability

The Basic Team-Based Solution

System Engineering Environment

Operational Execution Environment

Force Modernization Environment

Strategic Balance

Op/Sys Eng Teams

JACOBS SVERDRUP

Fundamental Op/Sys Eng Team Triad

System

An interacting combination of elements to accomplish a defined objective. These include hardware, software, firmware, people, information, techniques, facilities, services, and other support elements.

Operator

A person who is "well-trained and well-motivated" with respect to the operation of a particular system

- Has a set of reasonably well specified goals with respect to operation and performance of a system
- Has a set of reasonably well-defined activities with respect to system operation and maintenance

Systems Engineer

A person "well-trained and well motivated" in interdisciplinary approaches to enable the realization of successful systems.

- Selectively uses a logical, systematic set of processes to accomplish Systems Engineering tasks.
- Assesses the arrangement of elements and subsystems and the allocation of functions to meet system requirements

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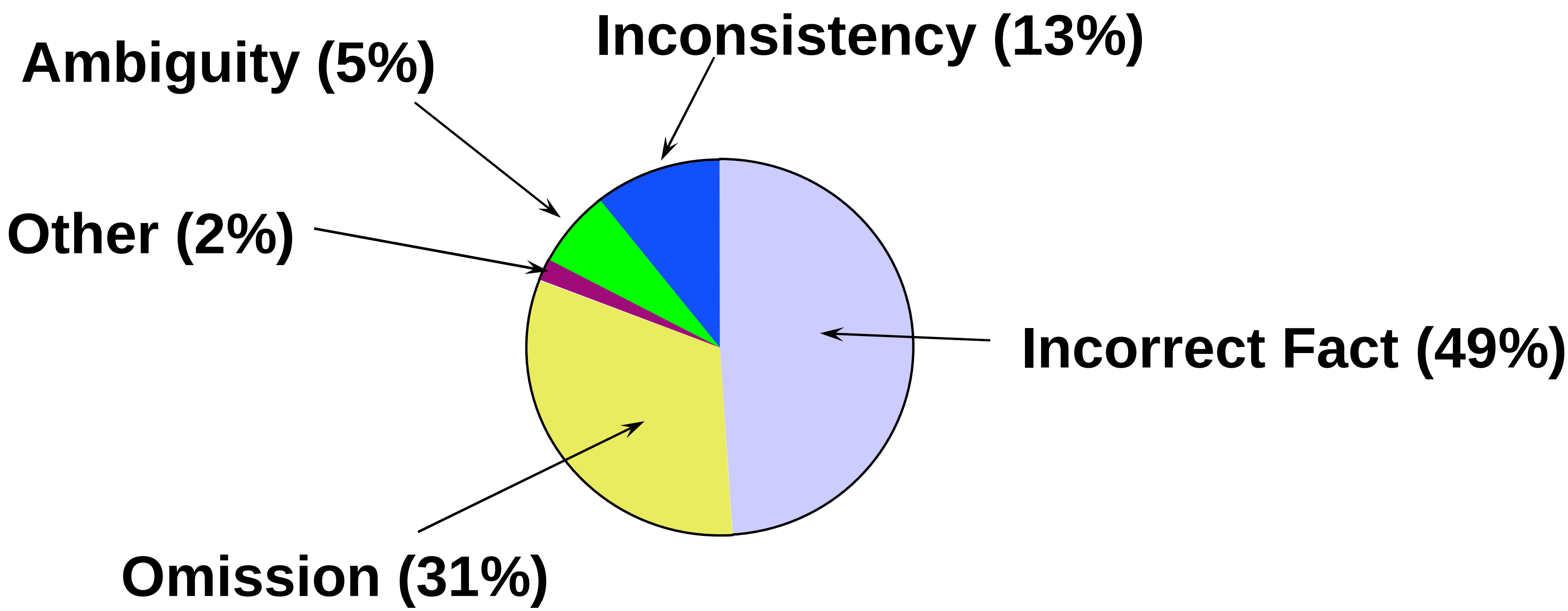
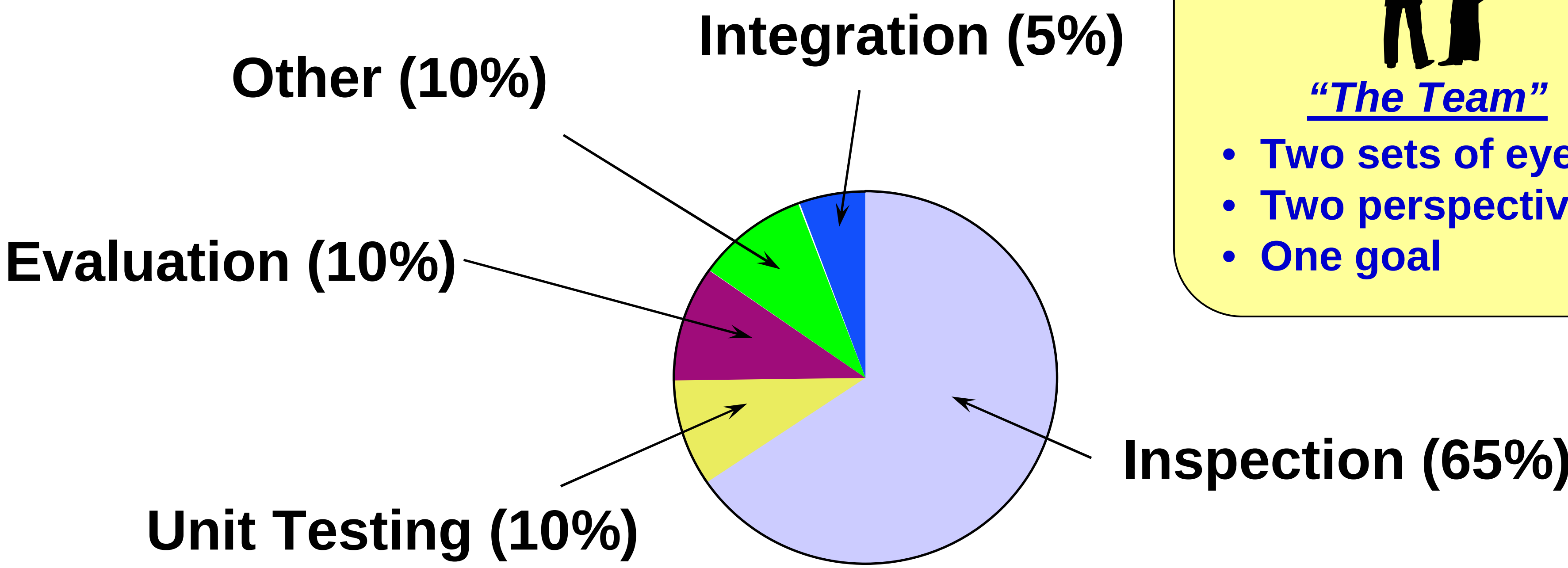
Where Errors Come From



"Evaluation of a Software Requirements Document by Analysis of Change Data"
by Basili, V. and Weiss, D.
Fifth IEEE International Conference on Software Engineering
1981, Washington D.C.

How Errors Are Detected



"The Team"

- **Two sets of eyes**
- **Two perspectives**
- **One goal**

"Software Engineering Management, Personnel, and Methodology"
by Bruggere, T.
Fourth IEEE International Conference on Software Engineering
1979, Washington D.C.

Op/Sys Eng Team Battlespace

Requirements/acquisition strategy package updated prior to each Budget Review cycle

FY XX → | FY XX →

PB | SERVICE TESTIMONY | COM MARKS | RE-CESS | CONF MRKS || PB | SERVICE TESTIMONY | COM MARKS | RE-CESS | CONF MRKS

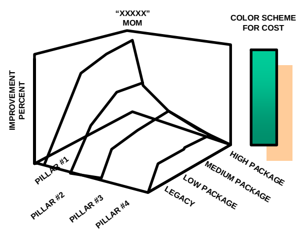
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

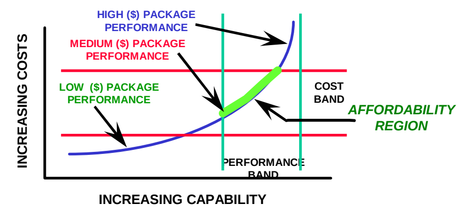
COALITION
- Leadership
- Operators
- Maintainers
- Laboratories
- Simulators
- Analysts
- IPT/IPPDs

"The Team"

CONTRACTOR DESIGN
- Design Compliance Analysis
- Leveraging Opportunities
- Trade Recommendations
- Fiscal/Schedule Reality

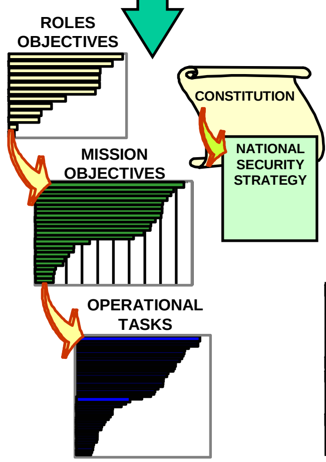
ANALYSIS
- Op Rqmts - Msn Spec Profiling
- R&D Technology Assessments
- Integrated Baseline Review
- Preliminary Design Review
- Critical Design Review
- Op/Sys Eng Leadership



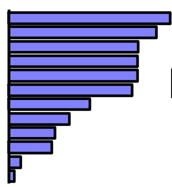


CONTRACT
- SOW
- Deliverables
- Areas of Interest
- Special Analysis Issues
- Performance Based Spec (PBS)

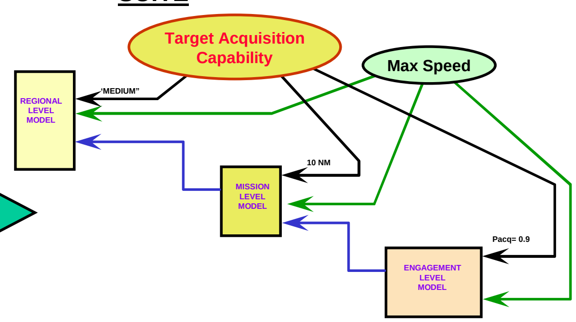
STT



DESIRED ATTRIBUTES



CORE MODEL SUITE



DATA BASES
- Strategy-To-Task
- Correlation Assessments
- Consensus Investigations
- Simulation Based Acquisition (SBA)
- Cost Containment (CAIV)
- Etc.

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Synergistic Traits of the Team

Stronger Links

SCIENCE

SYSTEM ENGINEER'S WORLD

ABSTRACT

Weaker Links

- PROCESSES
- TECHNIQUES
- TOOLS
- PROTOCOLS
- AGGREGATIONS
- DIVISIONS

- FEELINGS
- IMPRESSIONS
- PERCEPTIONS
- TIMEFRAMES
- PHASINGS
- SWEAT
- UNKNOWN
- WINNING
- LOSING
- CONFIDENCE
- WEAKNESS
- STRENGTH

Weaker Links

QUANTIFIED ENVIRONMENT

OPERATOR'S WORLD

EXPERIENTIAL ENVIRONMENT

Stronger Links

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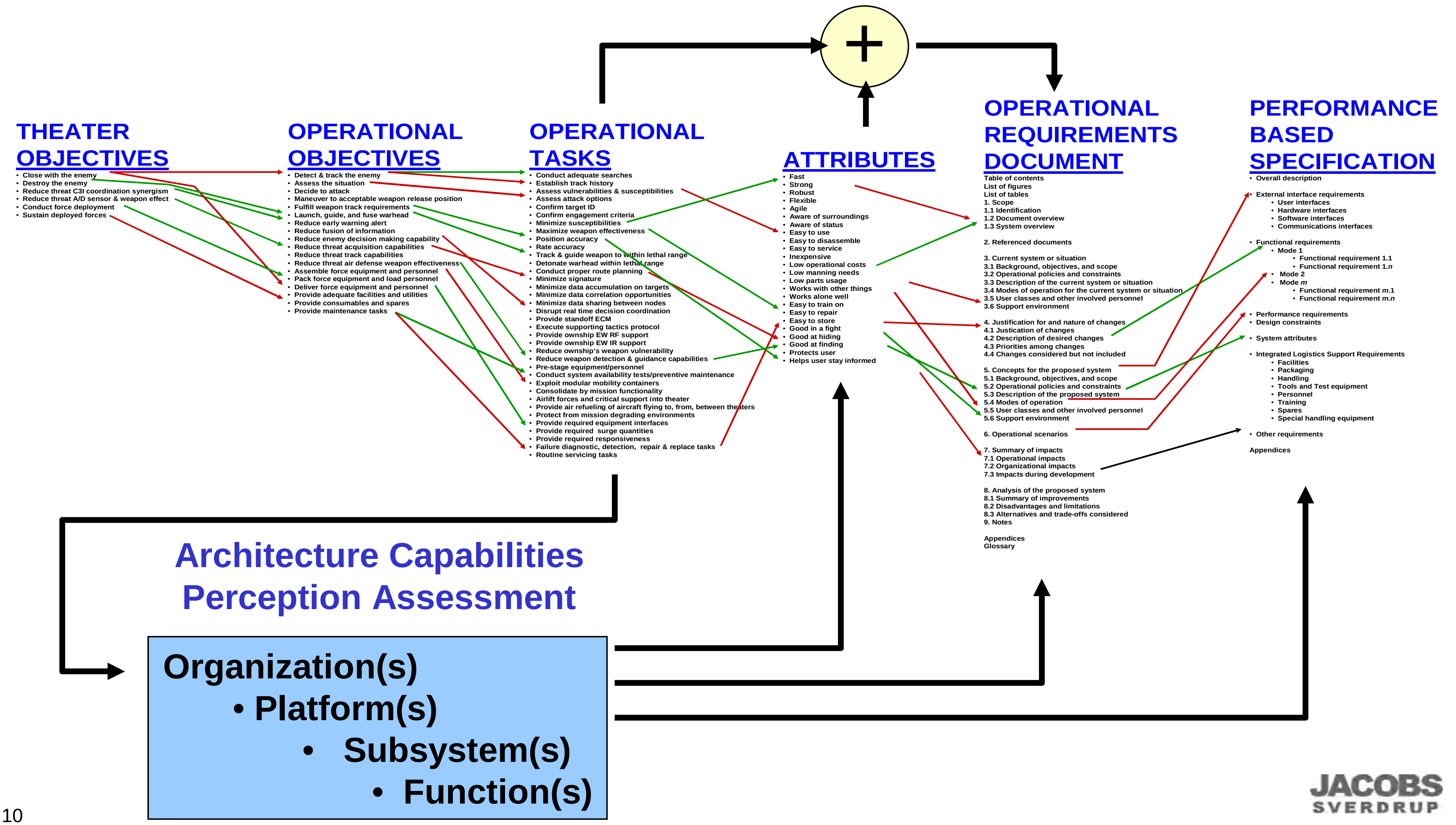
The Team Detects Critical Linkages

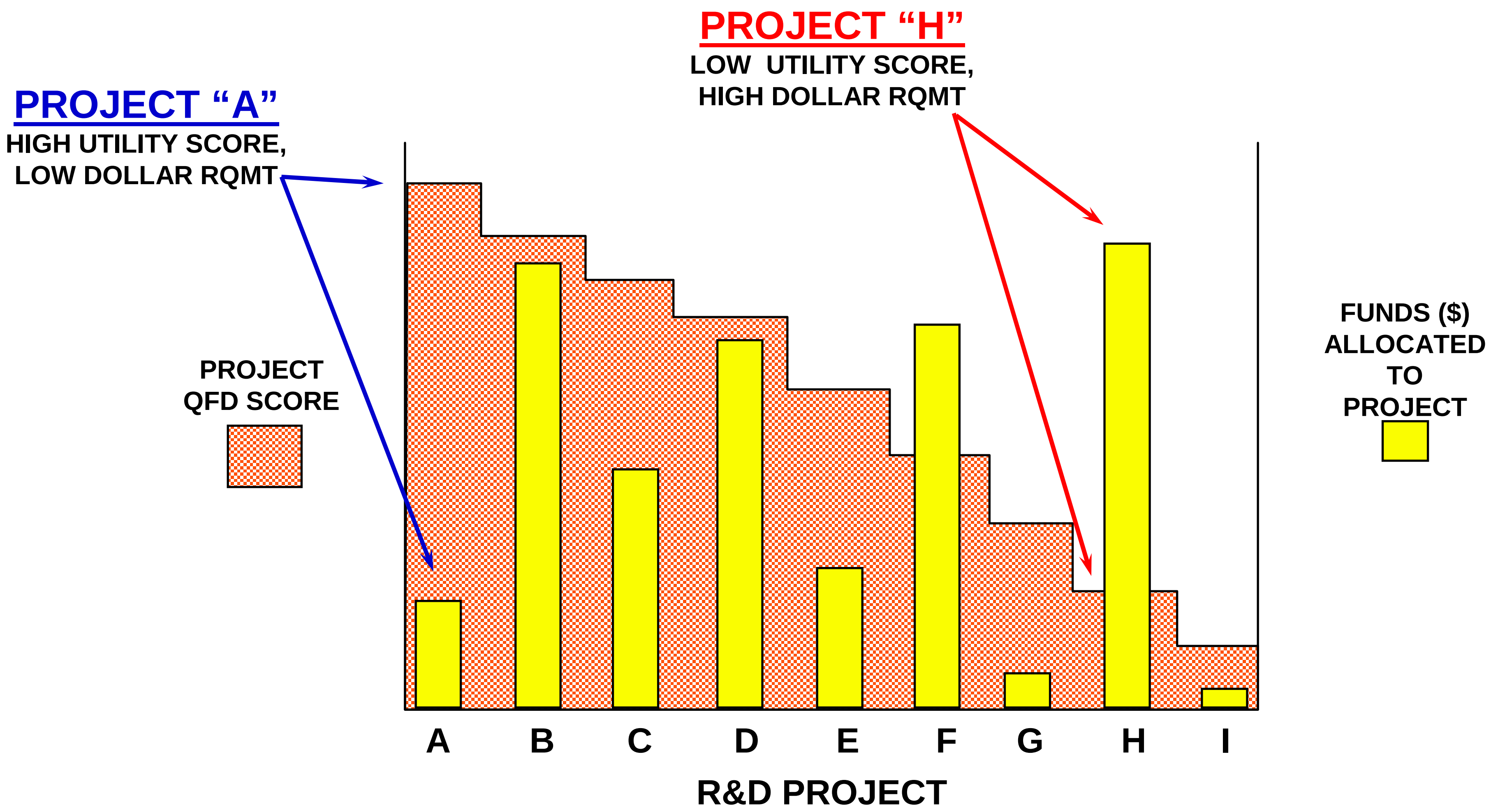


Operator-System Engineer Product Line

The foundation for formulating answers to questions often starts with discovering the fundamental requirement priorities of the operators

The Operator-System Engineer Team must show where dollars can be saved,…or, where dollars are to be spent, they will have the most impact

The Team Finds R&D Cost Effectiveness



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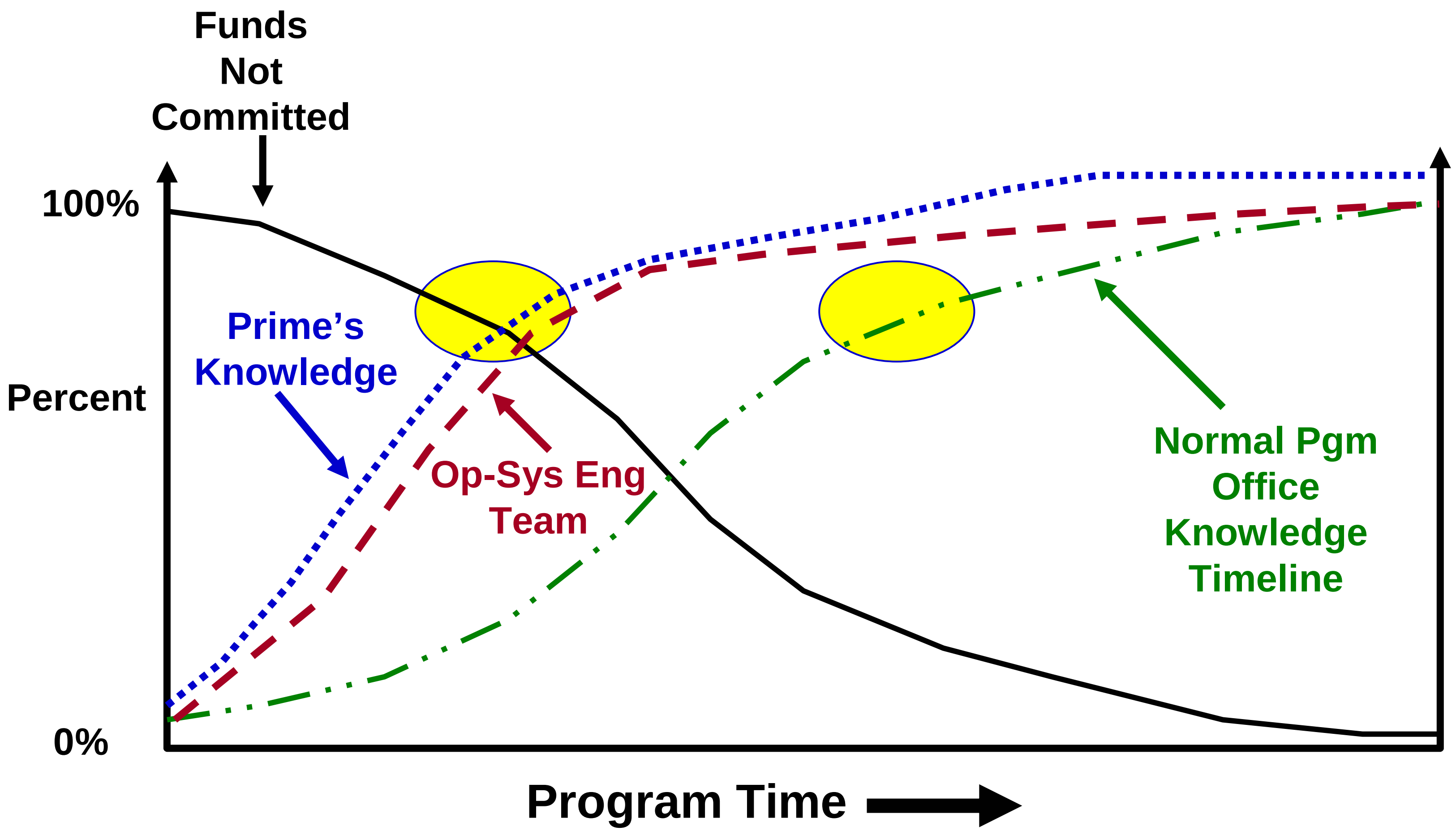
Force Modernization CONOPS

The idea is to devise a way to visualize and integrate into your decision process all the tangible and intangible ideas, concepts and facts that influence your reasoning process. You do this <u>first</u>,... to give yourself the most comprehensive understanding possible (for knowledge is power), and <u>secondly</u>,... to frame and articulate your solutions and decisions in such a logical manner that you are able to persuade both your colleagues and oversight authorities that your path is the right path.

The Race for Knowledge

Everyone on a program gets total enlightenment,…the question is will it be before or after your money is committed?



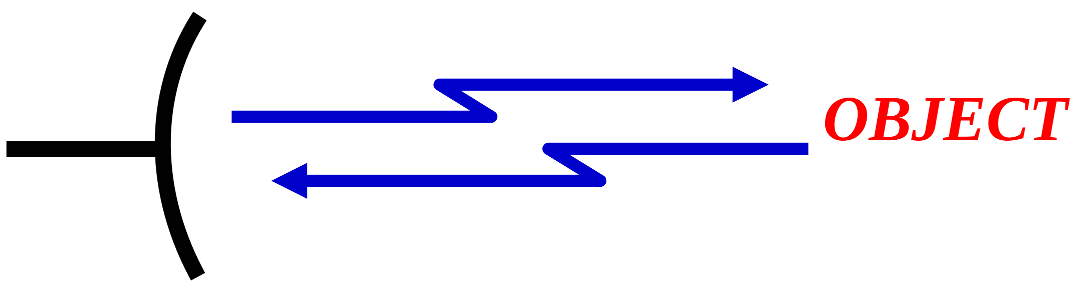
Aggressive Op/Sys Eng Interplay is Key

Simplified
Radar Range Equation

Transmitting Antenna Gain   Average Transmitted Power   Radar Cross Section   Effective Antenna Area   Integration Time

---

(4 π)*2   (Range*4)



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Modernization Knowledge State Options

- They don't know what they don't know (Unknown Unknowns)
- They know they don't know something (Known Unknowns)
- They don't understand all they know (constrained awareness)
- They understand what they know

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“Unknown Unknowns” State

- Serenity
- Acceptance
- Contentment
- Comfortable routine

Strategic planner’s nightmare

Acquisition manager’s nightmare

- **Low accountability regardless of personal traits**
- **High levels of “reactiveness” to problems**

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“Known Unknowns” State

“Why aren’t we better…..”

I want to know where
my targets and threats are,
...and what are they doing.

Threat Firing Doctrine

I want to know where the
friendlies are,...and
what are they doing.

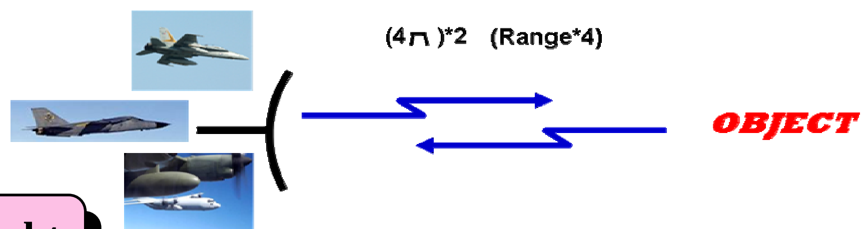
Max “G” Turn Rate

I want to know how
reliable my current
information is.

Simplified
Radar Range Equation

Transmitting Antenna Gain	Average Transmitted Power	Radar Cross Section	Effective Antenna Area	Integration Time

(4π)*2 (Range*4)



Engagement Geometry

Weapon-Target Match

Thrust-to-Weight Ratio

I want to know all my
current options
for offense and defense.

“Constrained Awareness” State

MANUFACTURER

“We have the solution to your getting better…”

	Radar Improvement Functions
•$20,000	•Constant false alarm rate (CFAR) detector
•$16,000	•Active guidance
•$7,000	•Discrete Fourier Transform (DFT)
•$4,000	•Linear frequency modulation
•$1,500	•Digital automatic gain control (DAGC)
•$28,000	•Angle tracking
•$8,000	•Pulse compression
•$1,800	•Mainlobe clutter
•$3,000	•Amplitude weighting
•$9,000	•Blanking
•$5,000	•Automatic gain control
•$7,000	•Multi-look capability
•$19,000	•Doppler beam sharpening (DBS)
•$7,000	•Beam steering
•$4,000	•Interferometry
•$15,000	•Lowpass filter
•$28,000	•Injection locking
•$3,000	•Illumination tapering
•$1,000	•Electronic scanning
•$8,000	•Ensemble detection
•$28,000	•Coherent on receive
•$8,000	•Envelope detector
•$1,800	•Clutter referenced MTI
•$3,000	•Ground moving targets (GMT)
•$6,000	•Pulse delay ranging
•$3,000	•Clutter canceller

INTRODUCTION TO AIRBORNE RADAR
George W. Stimson
Library of Congress catalog card number - 83-83041
From Glossary (pg 593)

JACOBS SVERDRUP

“Understand” State – Level 1

MISSION SPECTRUM

SUBSYSTEM FUNCTIONS	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6	Mission 7	Mission 8	Mission 9	Mission 10	Mission 11	Mission 12	Mission 13	Mission 14	Mission 15	Mission 16
Constant false alarm rate (CFAR) detector	3.70	4.30	3.00	7.40	2.90	3.60	4.90	3.20	3.30	1.70	2.50	4.00	2.70	3.20	3.20	2.50
Active guidance	9.10	28.70	13.60	26.40	4.30	25.50	23.30	26.40	12.50	27.30	12.50	14.70	29.40	24.70	16.40	25.30
Discrete Fourier Transform (DFT)	2.40	6.30	4.50	2.40	3.00	4.30	4.70	6.10	5.70	3.20	5.80	5,5	8.90	3.80	4.60	2.20
Linear frequency modulation	4.80	18.40	5.40	16.50	5.90	13.40	9.50	16.40	3.70	16.30	5.70	9.40	16.20	8.50	8.80	9.40
Digital automatic gain control (DAGC)	3.90	3.80	2.60	3.80	3.00	2.90	4.60	7.50	5.30	4.30	4.50	3.60	4.30	2.60	3.20	1.90
Angle tracking	7.80	26.50	6.30	24.60	2.40	23.50	16.70	24.90	15.30	19.90	12.60	15.80	15.50	16.40	7.70	22.30
Pulse compression	7.30	8.30	7.30	9.80	2.00	8.90	7.40	8.80	3.50	8.50	7.10	5.40	8.80	7.80	8.40	9.90
Mainlobe clutter	4.90	27.50	16.90	9.00	8.50	23.10	19.50	27.80	15.30	27.00	8.90	16.90	13.30	24.30	16.90	24.60
Amplitude weighting	5.40	7.80	2.40	8.40	3.00	8.90	8.30	8.30	3.70	7.90	9.40	7.60	9.60	8.40	7.70	8.20
Blanking	3.60	8.80	3.50	114.80	5.40	17.30	7.30	11.40	6.70	14.60	6.40	7.60	16.70	9.50	5.20	14.80
Automatic gain control	3,8	10.40	3.60	13.30	6.90	8.50	2.40	10.50	7.40	9.90	9.90	8.60	9.90	3.50	7.50	6.40
Multi-look capability	9.30	28.90	18.40	27.40	7.90	24.80	14.70	25.70	17.50	27.80	12.10	18.40	16.70	17.30	12.40	27.10
Doppler beam sharpening (DBS)	3.20	6.40	6.10	5.30	3.00	6.60	6.30	8.30	2.90	7.60	8.70	7.40	6.30	6.20	3.90	5.30
Beam steering	4.30	25.50	13.90	24.30	4.90	25.40	16.80	27.40	7.80	18.30	6.70	18.40	26.70	8.90	18.40	23.50
Interferometry	3.40	16.40	2.80	18.90	4.60	14.50	8.50	17.90	4.20	13.50	7.80	8.50	13.90	9.60	6.30	9.90
Lowpass filter	3.20	13.40	8.90	16.30	8.40	12.70	7.70	12.80	4.50	8.40	4.50	8.90	9.40	6.90	6.30	9.30
Injection locking	4.10	19.40	6.50	18.40	5.30	16.90	13.60	18.90	6.40	12.90	7.40	12.90	18.40	13.60	7.50	17.50
Illumination tapering	3.50	7.60	9.90	4.20	2.40	7.00	4.70	6.70	1.50	7.30	4.90	6.80	7.30	4.80	7.50	9.60
Electronic scanning	5.20	29.10	16.20	28.50	2.10	27.50	19.30	29.20	19.40	28.70	11.90	16.20	26.20	22.80	13.20	25.60
Ensemble detection	3.00	12.80	6.20	11.50	7.40	5.90	4.70	11.90	4.40	5.60	8.40	8.40	6.70	5.30	4.20	5.50
Coherent on receive	8.90	22.10	15.30	19.60	3,3	24.40	15.30	17.50	8.90	17.40	7.30	13.90	16.60	15.60	13.90	19.30
Envelope detector	3.60	9.00	4.50	9.30	7.30	8.70	3.70	8.70	6.30	7.40	7.70	8.80	7.70	7.40	6.30	3.20
Clutter referenced MTI	5.80	26.30	5.30	22.10	3.30	13.90	15.30	9.50	13.40	28.50	11.50	8.70	15.20	19.90	7.90	17.30
Ground moving targets (GMT)	5.80	7.30	4.50	7.10	4.30	6.20	7.50	7.30	2.40	8.90	5.80	4.30	4.30	4.60	3.50	6.60
Pulse delay ranging	5.40	8.30	4.20	10.10	1.00	13.90	5.60	8.10	2.30	9.60	4.50	5.70	7.60	8.70	6.20	13.30
Clutter canceller	2.70	15.50	5.90	12.90	3.90	18.30	19.60	12.30	8.90	16.90	6.30	7.90	14.40	18.30	6.70	13.30

INTRODUCTION TO AIRBORNE RADAR
George W. Stimson
Library of Congress catalog card number - 83-83041
From Glossary (pg 593)

Cell Score = Subsystem Mission Contribution

JACOBS SVERDRUP

“Understand” State – Level 2

SUBSYSTEM FUNCTIONS | **MISSION SPECTRUM**

Subsystem Functions	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6	Mission 7	Mission 8	Mission 9	Mission 10	Mission 11	Mission 12	Mission 13	Mission 14	Mission 15	Mission 16
Constant false alarm rate (CFAR) detector	3.70	4.30	3.00	7.40	2.90	3.60	4.90	3.20	3.30	1.70	2.50	4.00	2.70	3.20	3.20	2.50
Active guidance	9.10	28.70	13.60	26.40	4.30	25.50	23.30	26.40	12.50	27.30	12.50	14.70	29.40	24.70	16.40	25.30
Discrete Fourier Transform (DFT)	2.40	6.30	4.50	2.40	3.00	4.30	4.70	6.10	5.70	3.20	5.80	5,5	8.90	3.80	4.60	2.20
Linear frequency modulation	4.80	18.40	5.40	16.50	5.90	13.40	9.50	16.40	3.70	16.30	5.70	9.40	16.20	8.50	8.80	9.40
Digital automatic gain control (DAGC)	3.90	3.80	2.60	3.80	3.00	2.90	4.60	7.50	5.30	4.30	4.50	3.60	4.30	2.60	3.20	1.90
Angle tracking	7.80	26.50	6.30	24.60	2.40	23.50	16.70	24.90	15.30	19.90	12.60	15.80	15.50	16.40	7.70	22.30
Pulse compression	7.30	8.30	7.30	9.80	2.00	8.90	7.40	8.80	3.50	8.50	7.10	5.40	8.80	7.80	8.40	9.90
Mainlobe clutter	4.90	27.50	16.90	9.00	8.50	23.10	19.50	27.80	15.30	27.00	8.90	16.90	13.30	24.30	16.90	24.60
Amplitude weighting	5.40	7.80	2.40	8.40	3.00	8.90	8.30	8.30	3.70	7.90	9.40	7.60	9.60	8.40	7.70	8.20
Blanking	3.60	8.80	3.50	114.80	5.40	17.30	7.30	11.40	6.70	14.60	6.40	7.60	16.70	9.50	5.20	14.80
Automatic gain control	3,8	10.40	3.60	13.30	6.90	8.50	2.40	10.50	7.40	9.90	9.90	8.60	9.90	3.50	7.50	6.40
Multi-look capability	9.30	28.90	18.40	27.40	7.90	24.80	14.70	25.70	17.50	27.80	12.10	18.40	16.70	17.30	12.40	27.10
Doppler beam sharpening (DBS)	3.20	6.40	6.10	5.30	3.00	6.60	6.30	8.30	2.90	7.60	8.70	7.40	6.30	6.20	3.90	5.30
Beam steering	4.30	25.50	13.90	24.30	4.90	25.40	16.80	27.40	7.80	18.30	6.70	18.40	26.70	8.90	18.40	23.50
Interferometry	3.40	16.40	2.80	18.90	4.60	14.50	8.50	17.90	4.20	13.50	7.80	8.50	13.90	9.60	6.30	9.90
Lowpass filter	3.20	13.40	8.90	16.30	8.40	12.70	7.70	12.80	4.50	8.40	4.50	8.90	9.40	6.90	6.30	9.30
Injection locking	4.10	19.40	6.50	18.40	5.30	16.90	13.60	18.90	6.40	12.90	7.40	12.90	18.40	13.60	7.50	17.50
Illumination tapering	3.50	7.60	9.90	4.20	2.40	7.00	4.70	6.70	1.50	7.30	4.90	6.80	7.30	4.80	7.50	9.60
Electronic scanning	5.20	29.10	16.20	28.50	2.10	27.50	19.30	29.20	19.40	28.70	11.90	16.20	26.20	22.80	13.20	25.60
Ensemble detection	3.00	12.80	6.20	11.50	7.40	5.90	4.70	11.90	4.40	5.60	8.40	8.40	6.70	5.30	4.20	5.50
Coherent on receive	8.90	22.10	15.30	19.60	3,3	24.40	15.30	17.50	8.90	17.40	7.30	13.90	16.60	15.60	13.90	19.30
Envelope detector	3.60	9.00	4.50	9.30	7.30	8.70	3.70	8.70	6.30	7.40	7.70	8.80	7.70	7.40	6.30	3.20
Clutter referenced MTI	5.80	26.30	5.30	22.10	3.30	13.90	15.30	9.50	13.40	28.50	11.50	8.70	15.20	19.90	7.90	17.30
Ground moving targets (GMT)	5.80	7.30	4.50	7.10	4.30	6.20	7.50	7.30	2.40	8.90	5.80	4.30	4.30	4.60	3.50	6.60
Pulse delay ranging	5.40	8.30	4.20	10.10	1.00	13.90	5.60	8.10	2.30	9.60	4.50	5.70	7.60	8.70	6.20	13.30
Clutter canceller	2.70	15.50	5.90	12.90	3.90	18.30	19.60	12.30	8.90	16.90	6.30	7.90	14.40	18.30	6.70	13.30

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Subsystem Mission Contribution

1 - <10 = White
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20 - <30 = Red

“Understand” State – Level 3

MISSION SPECTRUM

SUBSYSTEM FUNCTIONS	Mission 1	Mission 11	Mission 9	Mission 7	Mission 14	Mission 16	Mission 10	Mission 2	Mission 8	Mission 4	Mission 6	Mission 13	Mission 12	Mission 15	Mission 3	Mission 5	
Constant false alarm rate (CFAR) detector	3.7	2.5	3.3	4.9	3.2	2.5	1.7	4.3	3.2	7.4	3.6	2.7	4.0	3.2	3.0	2.9	56.1
Digital automatic gain control (DAGC)	3.9	4.5	5.3	4.6	2.6	1.9	4.3	3.8	7.5	3.8	2.9	4.3	3.6	3.2	2.6	3.0	61.8
Discrete Fourier Transform (DFT)	2.4	5.8	5.7	4.7	3.8	2.2	3.2	6.3	6.1	2.4	4.3	8.9	5.5	4.6	4.5	3.0	73.4
Doppler beam sharpening (DBS)	3.2	4.2	2.9	6.3	6.2	5.3	7.6	6.4	8.3	5.3	6.6	6.3	7.4	3.9	6.1	3.0	89.0
Amplitude weighting	5.4	5.1	3.7	8.3	8.4	8.2	7.9	7.8	8.3	8.4	8.9	9.6	7.6	7.7	2.4	3.0	110.7
Pulse compression	7.3	7.1	3.5	7.4	7.8	9.9	8.5	8.3	8.8	9.8	8.9	8.8	5.4	8.4	7.3	2.0	119.2
Pulse delay ranging	5.4	4.5	2.3	5.6	8.7	13.3	9.6	8.3	8.1	10.1	13.9	7.6	5.7	6.2	4.2	1.0	114.5
Blanking	3.6	6.4	6.7	7.3	9.5	14.8	14.6	8.8	11.4	12.8	17.3	16.7	7.6	5.2	3.5	5.4	151.6
Clutter canceller	2.7	6.3	8.9	19.6	18.3	13.3	16.9	15.5	12.3	12.9	18.3	14.4	7.9	6.7	5.9	3.9	183.8
Clutter referenced MTI	5.8	11.5	13.4	15.3	19.9	17.3	28.5	26.3	9.5	27.5	13.9	15.2	8.7	7.9	5.3	3.3	229.3
Angle tracking	7.8	12.6	15.3	16.7	16.4	27.3	19.9	26.5	24.9	21.3	23.5	15.5	15.8	7.7	6.3	2.4	259.9
Multi-look capability	9.3	12.1	17.5	14.7	17.3	27.1	27.8	28.9	25.7	29.5	21.9	16.7	18.4	12.4	18.4	7.9	305.6
Active guidance	9.1	12.5	12.5	23.3	24.7	27.4	27.3	28.7	26.4	27.4	23.1	29.4	14.7	16.4	13.6	4.3	320.8
Electronic scanning	5.2	11.9	19.4	19.3	22.8	25.6	28.7	29.1	29.2	28.9	23.1	26.2	16.2	13.2	16.2	2.1	317.1
Mainlobe clutter	4.9	7.4	15.3	19.5	24.3	24.6	27.0	27.5	27.8	9.0	23.1	13.3	16.9	16.9	16.9	8.5	282.9
Beam steering	4.3	6.7	7.8	16.8	8.9	28.5	18.3	25.5	27.4	24.3	22.9	26.7	18.4	18.4	13.9	4.9	273.7
Coherent on receive	8.9	7.3	8.9	15.3	15.6	19.3	17.4	22.1	17.5	19.6	21.5	16.6	13.9	13.9	15.3	3.4	236.5
Injection locking	4.1	7.4	6.4	13.6	13.6	17.5	12.9	19.4	18.9	18.4	16.9	18.4	12.9	7.5	6.5	5.3	199.7
Interferometry	3.4	5.8	4.2	8.5	9.6	9.9	13.5	16.4	17.9	13.2	14.5	13.9	8.5	6.3	2.8	4.6	153.0
Linear frequency modulation	4.8	5.7	3.7	9.5	8.5	9.4	16.3	18.4	16.4	11.7	13.4	16.2	9.4	8.8	5.4	5.9	163.5
Lowpass filter	3.2	4.5	4.5	7.7	6.9	9.3	8.4	13.4	12.8	12.9	12.7	9.4	8.9	6.3	8.9	8.4	138.2
Automatic gain control	3,8	3.5	7.4	2.4	3.5	6.4	9.9	10.4	10.5	10.3	8.5	9.9	8.6	7.5	3.6	6.9	109.3
Ensemble detection	3.0	5.3	4.4	4.7	5.3	5.5	5.6	12.8	11.9	11.5	5.9	6.7	8.4	4.2	6.2	7.4	108.8
Envelope detector	3.6	2.1	6.3	3.7	7.4	3.2	7.4	9.0	8.7	9.3	8.7	7.7	8.8	6.3	4.5	7.3	104.0
Ground moving targets (GMT)	5.8	5.8	2.4	7.5	4.6	6.6	8.9	7.3	7.3	7.1	6.2	4.3	4.3	3.5	4.5	4.3	90.4
Illumination tapering	3.5	4.9	1.5	4.7	4.8	9.6	7.3	7.6	6.7	4.2	7.0	7.3	6.8	7.5	2.5	2.4	88.3
	124.3	173.4	193.2	271.9	282.6	345.9	359.4	398.8	373.5	359.0	351.5	332.7	254.3	213.8	190.3	116.5	

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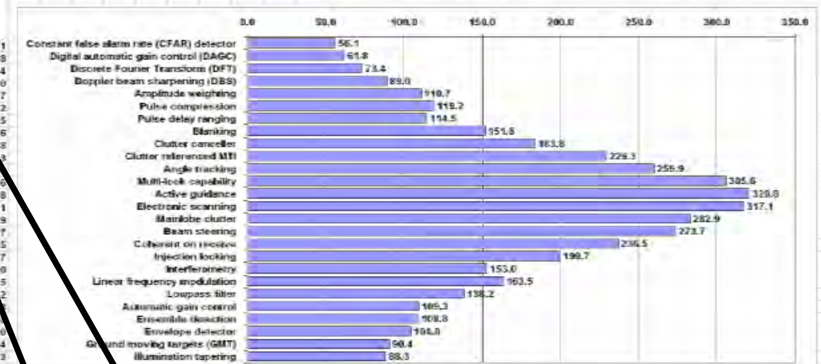
Subsystem Mission Contribution

Decision Quality “Understanding”

MISSION SPECTRUM

SUBSYSTEM FUNCTIONS	Mission 1	Mission 11	Mission 9	Mission 7	Mission 14	Mission 16	Mission 10	Mission 2	Mission 8	Mission 4	Mission 6	Mission 13	Mission 12	Mission 15	Mission 3	Mission 5	
Constant false alarm rate (CFAR) detector	3.7	2.5	3.3	4.9	3.2	2.5	1.7	4.3	3.2	7.4	3.6	2.7	4.0	3.2	3.0	2.9	56.1
Digital automatic gain control (DAGC)	3.9	4.5	5.3	4.6	2.6	1.9	4.3	3.8	7.5	3.8	2.9	4.3	3.6	[illegible]	[illegible]	[illegible]	61.8
Discrete Fourier Transform (DFT)	2.4	5.8	5.7	4.7	3.8	2.2	3.2	6.3	6.1	2.4	4.3	8.9	5.5	4.6	4.5	3.0	73.4
Doppler beam sharpening (DBS)	3.2	4.2	2.9	6.3	6.2	5.3	7.6	6.4	8.3	5.3	6.6	6.3	7.4	3.9	6.1	3.0	89.0
Amplitude weighting	5.4	5.1	3.7	8.3	8.4	8.2	7.9	7.8	8.3	8.4	8.9	9.0	7.6	2.7	2.4	3.0	110.7
Pulse compression	7.3	7.1	3.5	7.4	7.8	9.9	8.5	8.3	8.8	9.8	8.9	8.8	5.4	8.4	7.3	2.0	119.2
Pulse delay ranging	5.4	4.5	2.3	5.6	8.7	13.3	9.6	8.3	8.1	10.1	13.9	7.6	5.7	6.2	4.2	1.0	114.5
Blanking	3.6	6.4	6.7	7.3	9.5	14.8	14.6	8.8	11.4	12.8	17.3	16.7	7.6	5.2	3.5	5.4	151.6
Clutter canceller	2.7	6.3	8.9	19.6	18.3	13.3	16.9	15.5	12.3	12.9	18.3	14.4	7.9	6.7	5.9	3.9	183.8
Clutter referenced MTI	5.8	11.5	13.4	15.3	19.5	17.3	[illegible]	[illegible]	9.5	[illegible]	13.9	15.2	8.7	7.9	5.3	3.3	229.3
Angle tracking	7.8	12.6	15.3	16.7	16.4	[illegible]	15.9	[illegible]	[illegible]	[illegible]	[illegible]	15.5	15.8	7.7	6.3	2.4	259.9
Multi-look capability	9.3	12.1	17.5	14.7	17.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.7	18.4	[illegible]	[illegible]	7.8	305.6
Active guidance	9.1	12.5	12.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.7	16.4	13.6	4.3	320.8
Electronic scanning	5.2	11.9	18.4	19.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.2	13.2	18.2	2.1	317.1
Mainlobe clutter	4.9	7.4	15.3	19.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.0	[illegible]	13.3	16.9	16.9	16.9	8.5	282.9
Beam steering	4.3	6.7	7.8	16.8	8.9	[illegible]	18.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.4	18.4	18.9	4.9	271.7
Coherent on receive	8.9	7.3	8.9	15.3	15.6	19.3	17.4	[illegible]	17.5	19.5	[illegible]	16.6	13.9	13.8	15.5	3.4	236.5
Injection locking	4.1	7.4	6.4	13.6	13.6	17.5	12.9	19.4	18.0	18.4	16.9	18.4	12.9	7.5	6.5	5.3	199.7
Interferometry	3.4	5.8	4.2	8.5	9.6	9.9	13.5	16.8	17.9	13.2	14.5	13.9	8.5	6.3	2.8	4.5	153.0
Linear frequency modulation	4.8	5.7	3.7	9.5	8.5	9.4	16.3	18.4	16.4	11.7	13.4	16.2	9.4	8.8	5.4	5.9	163.5
Lowpass filter	3.2	4.5	4.5	7.7	6.9	9.3	8.4	13.4	12.8	12.9	12.7	9.4	8.9	6.3	8.9	8.4	138.2
Automatic gain control	3.8	3.5	7.4	2.4	3.5	6.4	9.9	10.4	10.5	10.3	8.5	9.9	8.6	7.5	3.6	6.9	109.3
Ensemble detection	3.0	5.3	4.4	4.7	5.3	5.5	5.6	12.6	11.9	11.5	5.9	6.7	6.4	4.2	6.2	7.4	108.3
Envelope detector	3.8	2.1	6.3	3.7	7.4	3.2	7.4	9.0	8.7	9.3	8.7	7.7	8.8	8.3	4.5	7.3	104.0
Ground moving targets (GMT)	5.8	5.8	2.4	7.5	4.6	6.6	8.9	7.3	7.3	7.1	6.2	4.3	4.3	3.5	4.5	4.3	98.4
Illumination tapering	3.5	4.9	1.5	4.7	4.8	9.6	7.3	7.6	6.7	4.2	7.0	7.3	6.8	7.5	2.5	2.4	88.3
	124.3	173.4	193.2	271.9	282.6	345.9	359.4	398.8	373.5	359.0	351.5	332.7	254.3	213.8	190.3	116.5	



$20,000	Constant false alarm rate (CFAR) detector
$16,000	Digital automatic gain control (DAGC)
$7,000	Discrete Fourier Transform (DFT)
$4,000	Doppler beam sharpening (DBS)
$1,500	Amplitude weighting
$28,000	Pulse compression
$8,000	Pulse delay ranging
$1,800	Blanking
$3,000	Clutter canceller
$9,000	Clutter referenced MTI
$5,000	Angle tracking
$7,000	Multi-look capability
$19,000	Active guidance
$7,000	Electronic scanning
$4,000	Mainlobe clutter
$15,000	Beam steering
$28,000	Coherent on receive
$3,000	Injection locking
$1,000	Interferometry
$8,000	Linear frequency modulation
$28,000	Lowpass filter
$8,000	Automatic gain control
$1,800	Ensemble detection
$3,000	Envelope detector
$6,000	Ground moving targets (GMT)
$3,000	Illumination tapering

Cost of Functions in the Radar

INTRODUCTION TO AIRBORNE RADAR
George W. Stimson
Library of Congress catalog card number - 83-83041
From Glossary (pg 593)

QUESTION

Can you see how the mathematics of the system engineer’s analysis *enables* the warfighter to orient and develop rationale for a desired recommendation?

Op/Sys Eng Team Lessons Learned

- **Team mates must be <u>equally adept and authorized</u> to both persuade and compromise on major issues**

- **A <u>learning curve</u> period of time is always necessary to preclude forming a hasty fundamental relationship architecture**

- **<u>Accountability</u> speeds up <u>exposure</u> of the issues and assessment process**

- **<u>Decisions</u> will always be made with <u>some concerns still unresolved</u>**

JACOBS SVERDRUP

Modernization Teams - Path Ahead

SYSTEM ENGINEERS MUST LEARN A MILITARY DECISION CAN BE BASED AS MUCH ON AWARENESS AS ON A MATHEMATICAL COMPUTATION

Stronger Links

SCIENCE

- PROCESSES
- TECHNIQUES
- TOOLS
- PROTOCOLS
- AGGREGATIONS
- DIVISIONS

Weaker Links

QUANTIFIED ENVIRONMENT

OPERATORS MUST LEARN TO TAKE “FIRST BLOOD” IN THE SPECIFICATION OF PERFORMANCE NEEDS

SYSTEM ENGINEER’S WORLD

OPERATOR’S WORLD

ABSTRACT

- FEELINGS
- IMPRESSIONS
- PERCEPTIONS
- TIMEFRAMES
- PHASINGS
- SWEAT
- UNKNOWN
- WINNING
- LOSING
- CONFIDENCE
- WEAKNESS
- STRENGTH

EXPERIENTIAL ENVIRONMENT

Stronger Links

Weaker Links

SYSTEM ENGINEERS MUST LEARN THAT HAVING “TIME TO THINK” IS NOT ALWAYS AN OPTION

OPERATORS MUST BECOME MORE ANALYTIC AND DEVELOP AN APPRECIATION FOR THE CONSTRAINTS AND LIMITATIONS OF THE TRADEOFF PROCESS

JACOBS SVERDRUP

Summary

- **Manage coalition expectations with facts**
- **Focus on the whole,…not just familiar parts**
- **Identify detailed components and functionality**
- **Recognize restrictions, caveats, assumptions**
- **Recognize the nature of conflicting truths**
- **Perform subject matter analysis & decomposition**
- **Identify metrics and range of value zones**
- **Discriminate between activity,…and actual progress**
- **Discriminate between pgm milestones & sys eng criteria**
- ***Hunt down and destroy ambiguity***

Profiling and Testing Procedures for a Net-Centric Data Provider

Derik Pack
Special Communications Project Support
SPAWAR Systems Center Charleston

Approved for public release 04 October 05

Net-Centricity

- **Definition**
  - A global web-enabled environment that promotes information sharing, sense making, and decision making.
- **Pillars of Net-Centricity**
  - Physical Infrastructure
  - Software Concepts and Infrastructure
  - Business Logic and Policy

Outline

- **Approaching Net-Centricity: Services**
  - Advantages
  - Barriers to Acceptance
- **An SOA Example: Net-Centric Diplomacy**
  - Specifications
  - Architecture
  - Testing Metrics, Procedures, and Results
  - Operational Dashboard
- **Lessons Learned**

An Intro to Service Oriented Architecture

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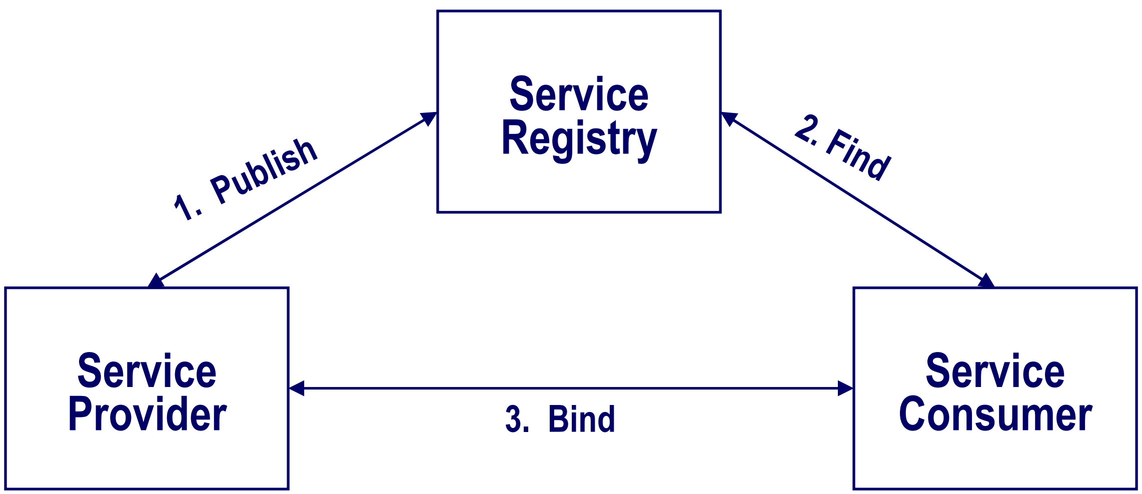
- Operating system and programming language independent
- Expose business processes
- Loosely coupled



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Web Services

- **Transport over HTTP or HTTPS**
- **Specifications**
  - XML, SOAP, SAML, UDDI, WSDL
- **Competing Organizations**
  - WS-I
  - W3C
  - Vendors

Advantages of SOA

- Lower cost of development
- Higher component reuse
- Process streamlining
- Smoother integration paths

SOA Barriers to Acceptance

- **Standards**
  - Misunderstanding of Standards
    - Standards can be complex and documentation may be sparse
    - A certain level of knowledge is needed to understand the interaction between standards
  - Policy Issues
    - An implemented standard may impose requirements contrary to the accepted policy of an organization
  - Interoperability
    - Vague or poorly documented areas in a standard may lead to interoperability issues

SOA Barriers to Acceptance

- **Technical**
  - Security
    - XML is plain text
    - No explicit security model with SOAP
  - Performance
    - Processing SOAP is CPU intensive
    - Security information can further decrease performance
  - Quality of Service
    - Web services implemented using transfer mechanisms that do not ensure quality of service
  - Transaction Support
    - No implicit support for ACID (Atomicity, Consistency, Isolation, and Durability) transactions

SOA Example: Net-Centric Diplomacy

- **Department of State Program**
- **Electronic Publishing of Post Information**
  - Biographic reports
  - DoS telegraphs
- **Initiative of Horizontal Fusion Portfolio**
- **Uses DISA's Net-Centric Enterprise Services**

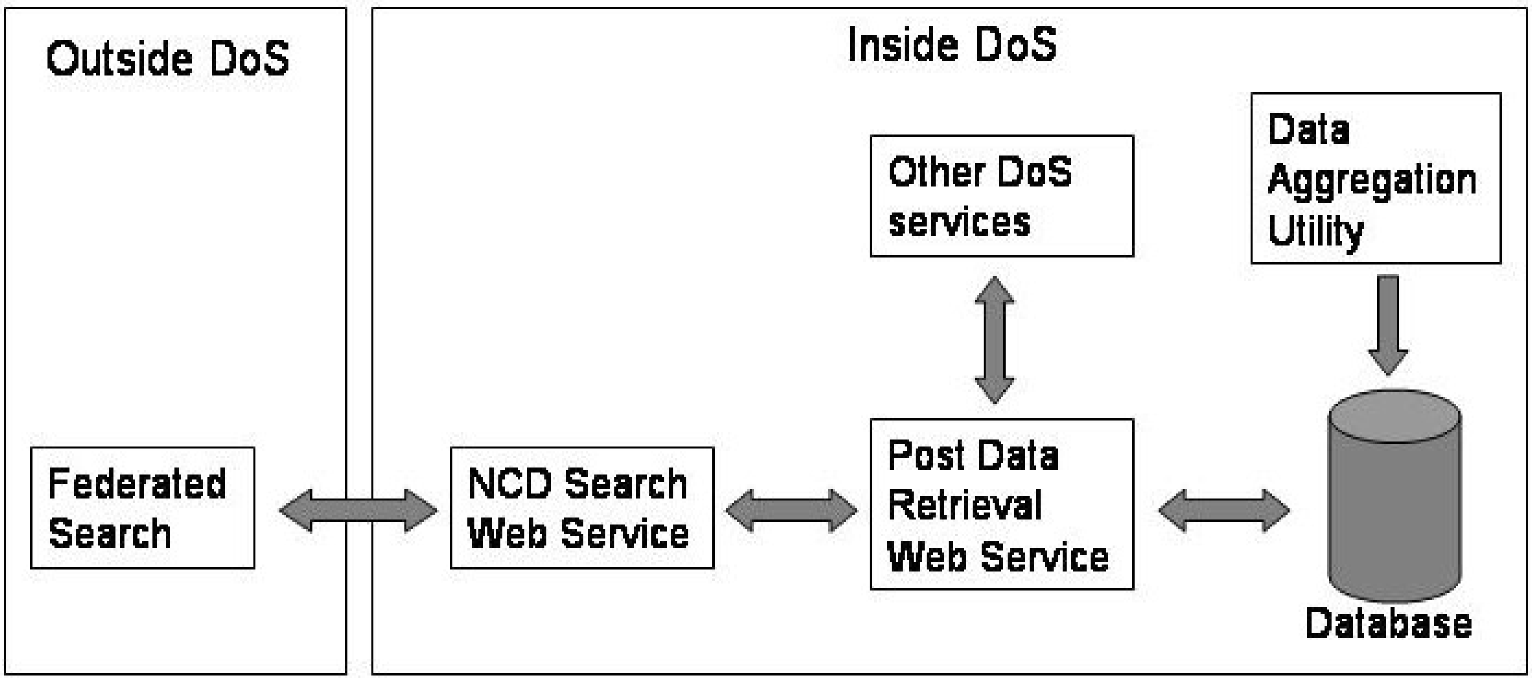
Horizontal Fusion

- Department of Defense Portfolio
- Providing example application layer of Global Information Grid (GIG)
- Using DISA's Net-Centric Enterprise Services (NCES)
- More information can be found at http://horizontalfusion.dtic.mil/

NCD Data Provider Implementation

- **NCES interaction**
  - – Security Services
  - – Discovery Services
- **Intelligent Federated Index Search (IFIS) WSDL**
  - – Web Service Interface
  - – Query Syntax
    - Person Search
    - Keyword Search
- **ncd_search_1_2**
  - – search
  - – cancelSearch
  - – getMoreResults

NCD Architecture



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Problems of measuring web service performance

- **Few exhaustive web service performance tools exist**
- **Web services are not websites**
  - The same metrics may not apply
  - Services may call other servers/services
  - Service(s) may encompass business logic to be tested
  - Semantic use of the service is not clearly defined

Solutions for Web Service Performance Testing

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- Define web service specific performance metrics and tests
- Monitor dependent environment during performance testing
- Create dashboard application for production environments for quick diagnostics of all dependencies

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Web Service Performance Metrics

- ***Round Trip Time (RTT)***
  - The time required for a request to be sent from a client, processed by the server and returned
- ***Error***
  - Incorrect results or error messages received from the web service
- ***Connections per Second (CPS)***
  - The number of connections that are being sent to the web application each second
- **(IFIS specific) Queries per Second**
  - The number of queries (search+getMoreResults calls) till a client has received all possible results

Test Types

- **Continuous test**
  - Set a constant connection rate and time of the test
- **Ramped Test**
  - Set a start and end connection rate and a number of steps to increment the rate between the start and end of the test
- **Burst Test**
  - Set a one time burst of connections
- **Adaptive Test**
  - Search for the steady state connection rate for the service in an adaptive manner

Dependency Testing

- **Required while using web service metrics**
  - To map low performance to a given component
  - Determine which components can provide greatest speedup to service
- **Testing includes**
  - Unit testing
  - Application profiling (CPU and memory)
  - Correct software configuration for given hardware

Testing Procedures

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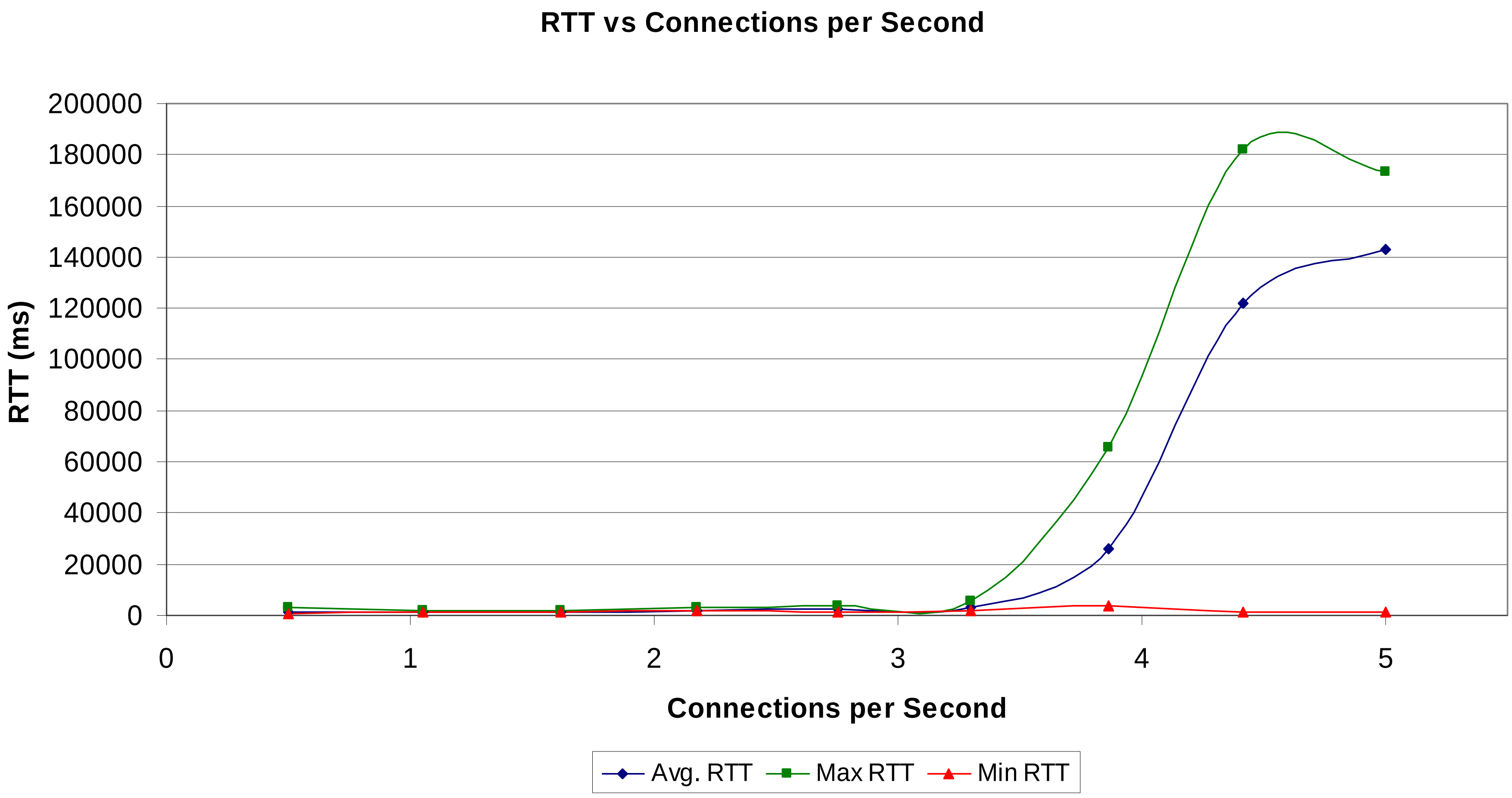
- Burst tests and profiling for memory problems
- Continuous tests and error logging for functional testing
- Ramped tests to determine point of failure for server
- Adaptive tests based on the point of failure to find steady state connection rate of the server

Ramped Test



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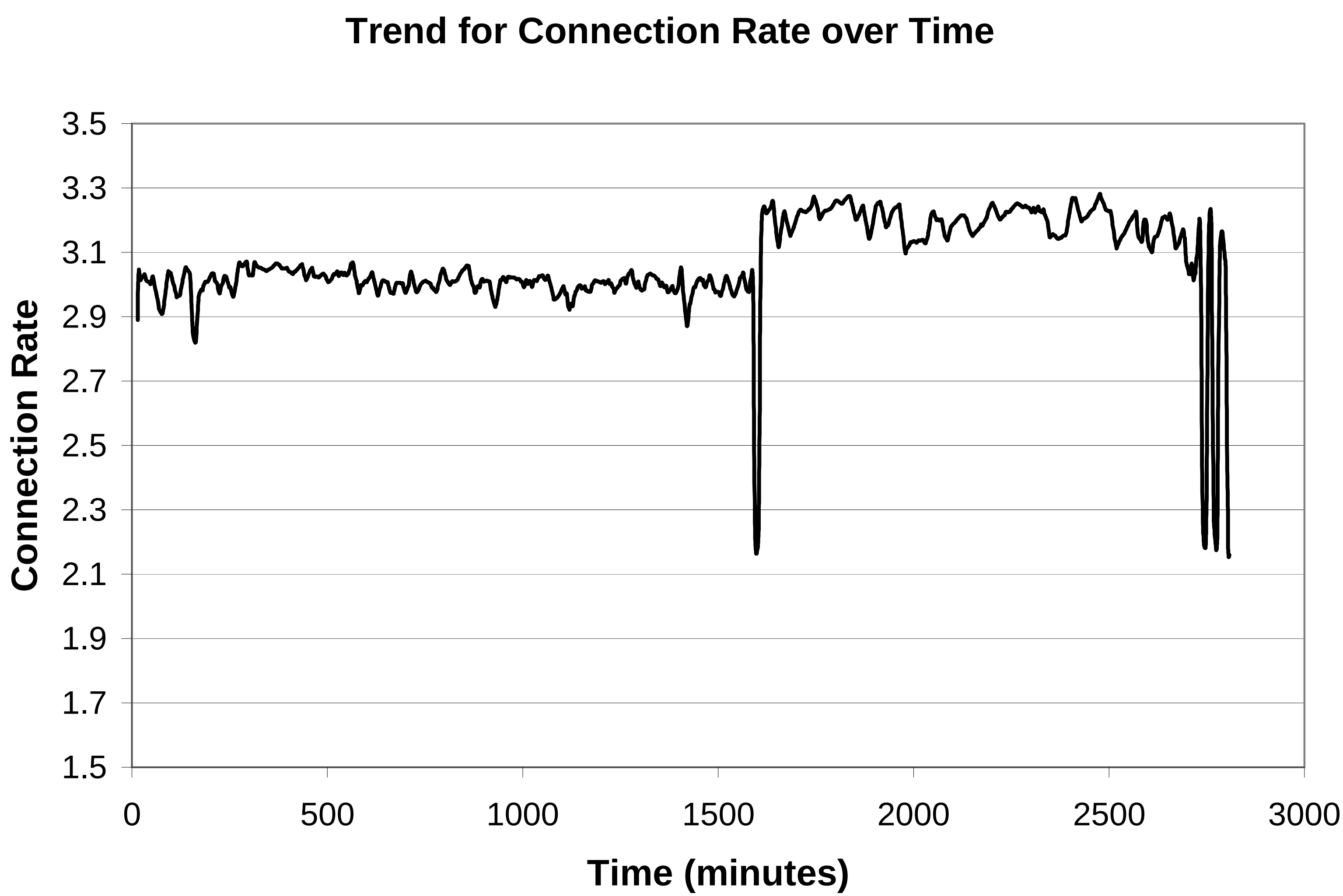
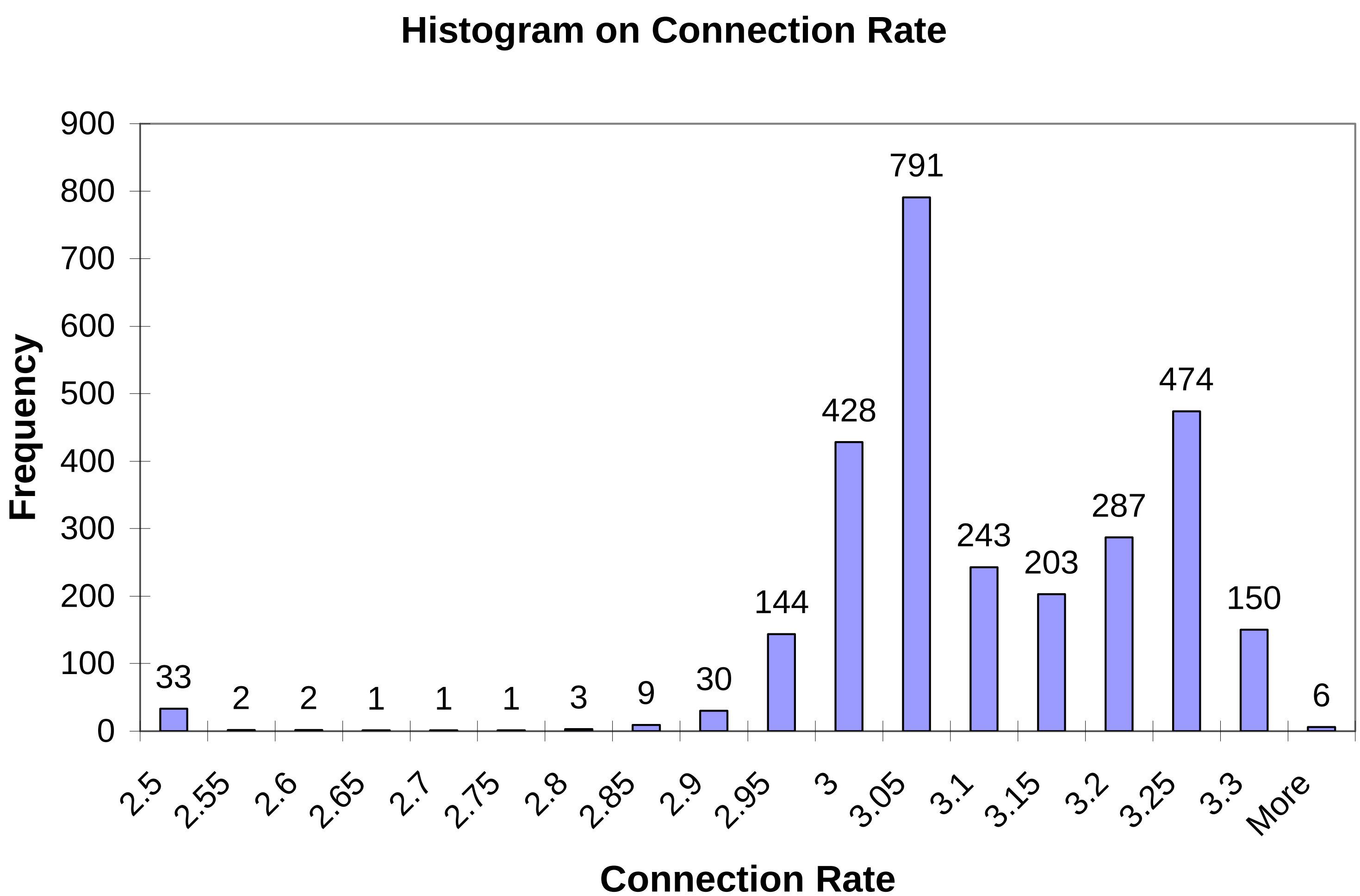
Adaptive Test over 48 hours



Histogram of Connection Rate



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Adaptive Test Results

- **Spikes at 26 and 48 hours**
  - Not consistently reproduced in other tests
  - Can be attributed to environmental factors when testing at a nominally stable service load
- **Mean connection rate of 3.06 connections/second with a 99% confidence of 0.01**
- **Test covers a likely query method for service not all query methods for the service.**

Dashboard

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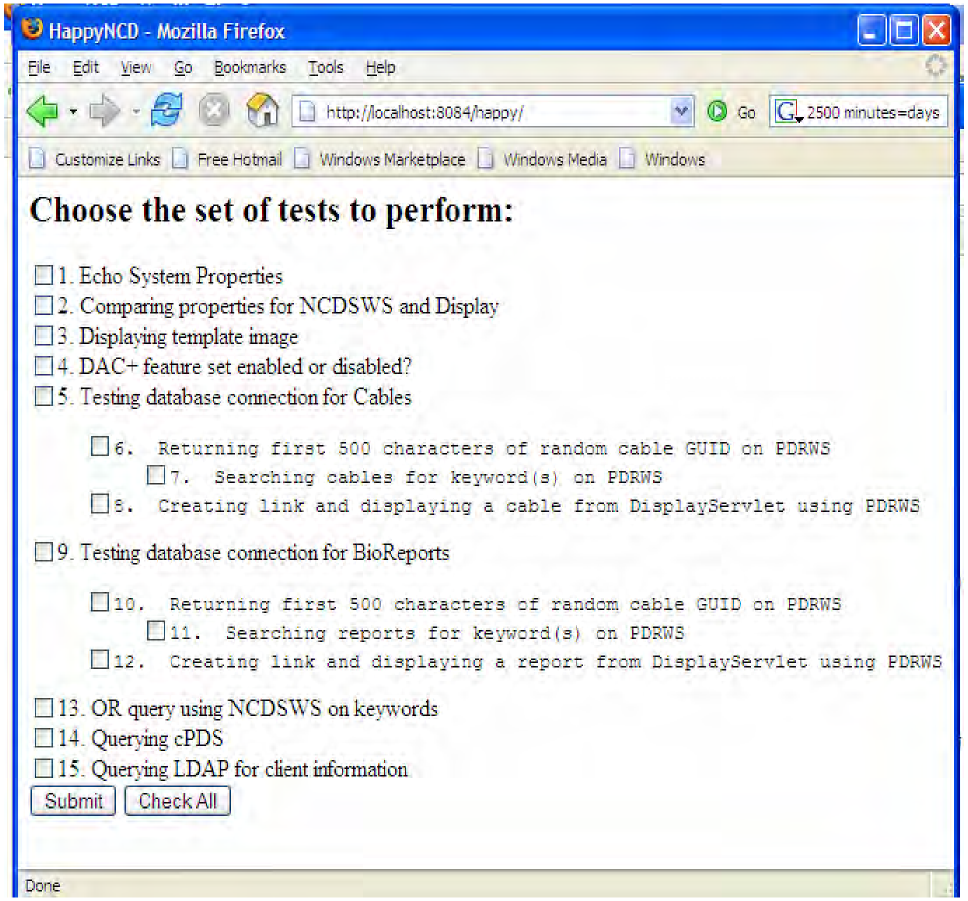
- **Web based client that monitors**
  - Department of State web services
  - Required external web services
  - Database
  - Current application configuration
- **Decreases diagnostic time in development and operations**



Conclusions

- Web services can make testing more iterative and time consuming
- Constant race to best characterize the operational environment because web service interface makes it easily change
- Best test plan covers many possible uses of web service interfaces

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Questions?

Approved for public release 04 October 05

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PROFILING AND TESTING PROCEDURES FOR A NET-CENTRIC DATA PROVIDER

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ABSTRACT

A key focus for the success of Net-Centric operations is the testing procedures for web services and the environments where those web services exist. Quite often the ability of a given service to reach a specific performance goal is dependent on many factors found in the operating system itself, the language used to implement the service, the service's code quality, and related applications servers and services. A failing in the design of many test procedures is to capture one particular measure of performance while failing to quantify the many variables that affect that measure of performance. This often leads to lost development cycles trying to achieve a small performance increase in one part of the system while overlooking several other easily modifiable system components that could increase performance far more significantly. This paper presents testing procedures and examples from the development of the Net-Centric Diplomacy (NCD) initiative of Horizontal Fusion. The examples will primarily focus on the web services created by the initiative and the backend environment interactions that take place. Through this description, the reader will realize the interrelated nature of many different types of testing procedures and the necessity of good test design in order to find the most efficient means to address a given goal.

1. INTRODUCTION

With the advent of web services, the paradigm on the web is shifting from a server-to-client model to a model where web based components are combined to build distributed applications. For the purpose of this work, a web service is defined as any service that is accessible through the use of standard web protocols like Extensible Markup Language (XML) and Simple Object Access Protocol (SOAP0. This also implies the use of facilitating specifications like Web Services Descriptive Language (WSDL) and Universal Description, Discovery, and Integration (UDDI) in order to specify the interface to the service [1, 3]. The maturation of these standards will allow businesses and governments to design applications that achieve far more than a platform independent interface to a given data set. These web services will be able to register with, naturally discover, and use other web services that can deliver information or a function that would benefit the originating organization of the service. The resulting composable applications would allow for a true service-oriented architecture (SOA) where defined business processes and policies could be executed by a set of loosely coupled services built on top of available software infrastructure [2]. Such a paradigm shift in web design would have vast implications. Effective use of services could result in a lower cost of development, higher component reuse, process streamlining, and smooth integration paths [4].

In order for web services to reach this point, several impediments need to be overcome. Collectively, these issues can be thought of as areas of future work for a distributed component based application. The issues are broken into two groups: standards barriers and technical

Approved for public release 30 September 05

barriers. The standards barriers include non-maturity of standards and semantic issues. This area covers the misunderstanding of standards, and policy and interoperability issues that are taking place in the adoption of web services. The technical barriers to adoption of web services include security, performance, quality of service and reliability, and transaction support [4, 5]. Proposing a solution to all these barriers to adoption is well outside the scope of this paper. The purpose of this work is limited to the discussion of performance and in some instances quality of service and reliability of web services. The scope is limited to these areas because they are heavily affected when trying to surmount other barriers to adoption. They should, in many cases, be considered the most important design goals for a usable net-centric system. Unfortunately, few realize the complexity that must be taken into account when attempting to quantitatively measure the performance and reliability when dealing with web services. The basic performance measures and procedures need to be studied and defined for a basic system in order to facilitate a more complex distributed environment.

The rest of the paper will highlight the NCD initiative as an example of a net-centric data provider based upon web services. The choice of performance measures and procedures that were used to test this initiative will be explained. Section 2 will give a short example of the NCD web services and backend. Section 3 will define the testing measures and procedures used. Section 4 will give some example results from NCD and Section 5 will give conclusions and future areas of work.

2. NET-CENTRIC DIPLOMACY

Net-Centric Diplomacy (NCD) is the Department of State initiative in the Horizontal Fusion Portfolio. NCD provides Department of State cable and biographic reports to Horizontal Fusion's Federated Search. NCD implemented the Intelligent Federated Index Search (IFIS) WSDL and other Horizontal Fusion specifications to create a search web service that can be accessed by the Federated Search client. The specifications detail security, dynamic discovery, messaging, and authentication of services within the Horizontal Fusion Collateral Space. A full list of these specifications can be found in the Horizontal Fusion Developer Reference and Guidance [6, 7, 8]. A full description of the entire NCD implementation is beyond the scope of this paper, but a summary is provided (Figure 1). Figure 1 shows requests coming to NCD from Federated Search. These requests are received by the Net-Centric Diplomacy Search Web Service (NCDSWS). NCDSWS is the piece of the architecture that implements the Horizontal Fusion specifications. It validates the digital signing of SOAP messages it receives, checks the security information, and determines if the query is valid. If the request passes all these tests, it is passed to the Post Data Retrieval Web Service (PDRWS) which translates the requests to SQL and accesses the database to retrieve the information. The database returns the results to PDRWS which sends them back to NCDSWS to return to Federated Search.

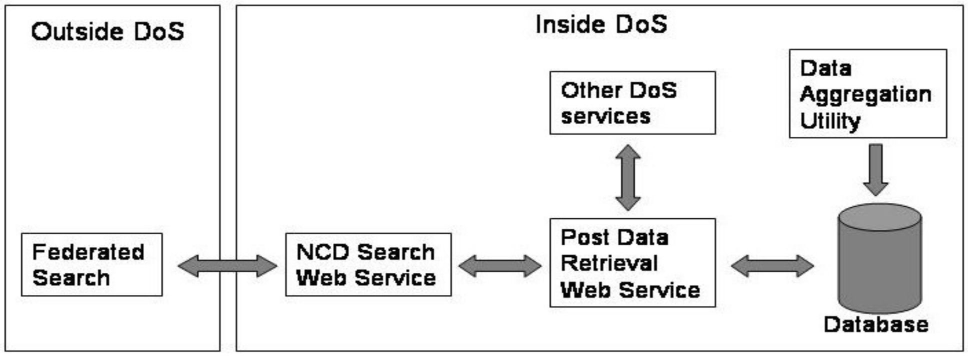

Figure 1. NCD Architecture

The prime advantage of this layered architecture is the benefit to Department of State's other web services. Since they are on the same trusted network as the PDRWS, they can directly access it without going through the security checking that is mandated by the Horizontal Fusion specification.

The architecture is implemented using Apache Axis' SOAP engine, JAVA 1.4.2 SDK, Apache Tomcat, and MS SQL Database 2000.

3. PERFORMANCE MEASURES AND PROCEDURES

One of the many goals in testing NCD is to quantify the boundaries of performance for the services that exist. In reviewing standard testing procedures for web applications, performance testing often focused on stressing the user interface. When dealing with web services, this standard for performance testing will no longer hold. Although performance tools exist that directly stress web services, two secondary considerations exist that must be considered. The first of these considerations is all the other services and application servers that a service calls in order to fulfill its function. These services and application servers affect the overall performance of any web service that calls them. In many instances the organization creating a service will not have direct control of its dependencies. Downtime on the part of a service's dependency will also cause downtime in that service. The second consideration is external specifications for a service. Essentially, the business processes that define the use of a service as an application reside outside the service. A WSDL defines the interface to a service, but the valid use of an implementation of that interface is not specified. These external specifications can have an effect on the performance of a service that cannot easily be seen using non-customizable testing tools. A prime example of external specifications is a web service that implements a query syntax. The query syntax may allow for highly recursive but semantically meaningless queries that would decrement the performance of the service if multiple client applications sent them. This issue is as much an initial design issue as a testing issue. With the composable nature of services, one must be wary of making one's service dependent on other services that may have such problems. In order to overcome these problems, NCD's testing procedures are based upon understanding and maximizing the performance through the use of characterization testing and profiling of a service's many dependencies along with testing the web service directly.

The procedure for testing performance during development is two-stage. The first stage is to define metrics that directly measure some element of a web service's performance. The second-stage is to create tests that measure individual system components to determine the best methods to increase overall system performance through the defined metrics. The following sections will be constrained to the metrics and tests used in the development stages of the project. As the project has progressed into an operational phase, different metrics and tests must be used in order to maintain the highest uptime available. This led to a set of diagnostic tools for the operational environment. These tools serve as a dashboard to monitor the internal and external services and servers that NCDSWS relies upon that are maintained by other initiatives or organizations. The results from these tools are used to replicate problems that occur in the operations environment in the development environment where the following tests and procedures are used.

3.1 First Stage Testing

Design of the first stage tests started with researching the differences between the error states of many web applications and web services. Web servers tend to reach their break point when so oversaturated with requests that they can no longer service them. This can cause the server itself to go down or simply report the unavailability for a large majority of its requests. The deserialization of SOAP requests is far more processor intensive; and as a result, the number of requests that will cause a web service to fail is far lower than for a web server. To compound the problem, web service errors do not always map to Hypertext Transfer Protocol (HTTP) service codes, and the application environment and programming language can cause unforeseen behavior depending upon their configuration. After considering these factors, the following metrics were defined for the first stage testing:

- *Round Trip Time (RTT)*: The time required for a request to be sent from a client, processed by the server and returned
- *Error*: Incorrect results or error messages received from the web service
- *Connections per Second (CPS)*: The number of connections that are being sent to the web application each second

RTT was used as a metric because it gave the most accurate simulation of the time the client would spend waiting for results. Error can be attributed to many different sources including incorrect functionality of the web service or web server and database failure. For the purpose of our testing, error was specified as anything that was not a correctly returned result. Measuring error consisted of logging to determine the most likely cause of error and capturing the percentage of errors for a set number of connection and query attempts. CPS is used because it gives a quantitative measure of a given amount of load. It was also believed that this metric could be used to find the optimal operational conditions for the server.

After finding these metrics, a survey was conducted among several different stress testing utilities to determine which ones had the best abilities to capture all this information. In the end, NCD opted to develop its own test harness (NCD LoadTest Utility) in order to better catch and analyze incorrect results and to initiate self-developed test cases where CPS could be explicitly set and controlled. Effective testing using the test harness requires a server or servers hosting the web services and a separate equivalent server running the test harness which collects data from queries it sends. During testing, processor use due to other applications is limited on the testing server to ensure results remain objective.

The test harness provided the following types of tests: continuous tests, ramped tests, burst tests, and adaptive tests. Continuous tests allowed the user to set the CPS and the time of the test. The test would then run at the defined connection rate until finished. Ramped tests allow the user to set a start and end CPS and a number of steps to take between the start and endpoint along with a time to stay at each step. The test increments its rate as it progresses until it reaches the maximum rate. Burst tests are a one time burst of a set number of connections a second. These tests are used to find average RTT for burst traffic the server could theoretically receive. Adaptive tests allow the user to specify a start point and search for the steady state CPS that the server can maintain. All these tests report back the RTT, CPS, and error.

3.2 Second-Stage Testing

Second stage testing consists of testing the code, application servers, runtime environment, and operating system to determine what modifications to these components can increase overall system performance that is measured in the first-stage tests. Several examples of testing in each of these areas will be provided.

Code testing is the most obvious method of improving performance. This is most often done with unit (regression) testing and profiling. Profiling will be focused on here because of its usefulness in conjunction with some of the first stage tests. Profiling tools give a developer insight into the amount of time spent in each method during code execution, Central Processing Unit (CPU) usage, number of objects created, and memory allocation. Profiling is especially useful for finding unused sections of code and discovering memory leaks. On occasion it may be necessary to start a web service inside a profiler while applying a load in order to identify a very slow memory leak.

When dealing with an application server, testing is not really required as long as the limitations and best settings of the application server are known. An example would be an Apache Tomcat server that provides the web container for the web services. In order to provide faster servicing of requests, Domain Name System (DNS) lookup was disabled in the server's configuration file.

Depending on the programming language, testing the runtime environment will not be necessary. For the case of NCD, it was important to examine the runtime environment because of the use of Java. The performance of the Java Runtime Environment (JRE) was affected not only by its configuration settings, but also the hardware the Java Virtual Machine (JVM) was running on. After configuring the runtime environment to use the server JVM, garbage collection monitoring was employed. This test allowed the developer to determine the throughput drop due to garbage collection and helped to select the best garbage collection algorithm to use for the given system hardware.

Tests taking place in the operating system are typically used to monitor memory and CPU usage. These tests are especially useful when using the test harness to test for several days continuously. They can correlate any unusual results that take place while sending results.

3.3 Procedures

Testing procedures for NCD were initiated with first stage testing. Cycles of burst, continuous, and ramped testing were conducted until failure levels were reached. These levels were based on whether RTT and error exceeded certain thresholds. The initial thresholds for error were either complete unresponsiveness of the server or a percent error greater than 15%. The initial failure threshold for RTT was an average RTT for a test greater than 90 seconds. Each cycle of testing would be repeated on the same server instance. After the repeat of a test, if the results from the later test were worse than the initial test, second stage testing would be used to determine if there was a memory leak, application error, or configuration problem.

After finding and correcting a problem, a few cycles of first stage testing would be repeated. If the results remained consistent for these cycles, then testing was limited to continuous testing with increasing time limits. Sustained testing over several hours helped to pinpoint problems in memory management and repetitive connections to backend data sources. If no irregularities were found in RTT and error rate after several hours, then the tester proceeded to adaptive testing.

The adaptive test was given a range for the highest RTT and error that is reasonable for the service to reach. These ranges were considered the highest values possible for the system that would still allow it to be effectively used by a user. The test then attempted to find the highest CPS where those values existed. If the CPS generated RTT and error lower than this range, the CPS increased. If CPS generated RTT and error higher than this range, the CPS decreased. This testing usually ran with CPU monitoring enabled, and lasted for at least forty-eight hours. The results for this test were used to generate a histogram to determine the optimum CPS for system.

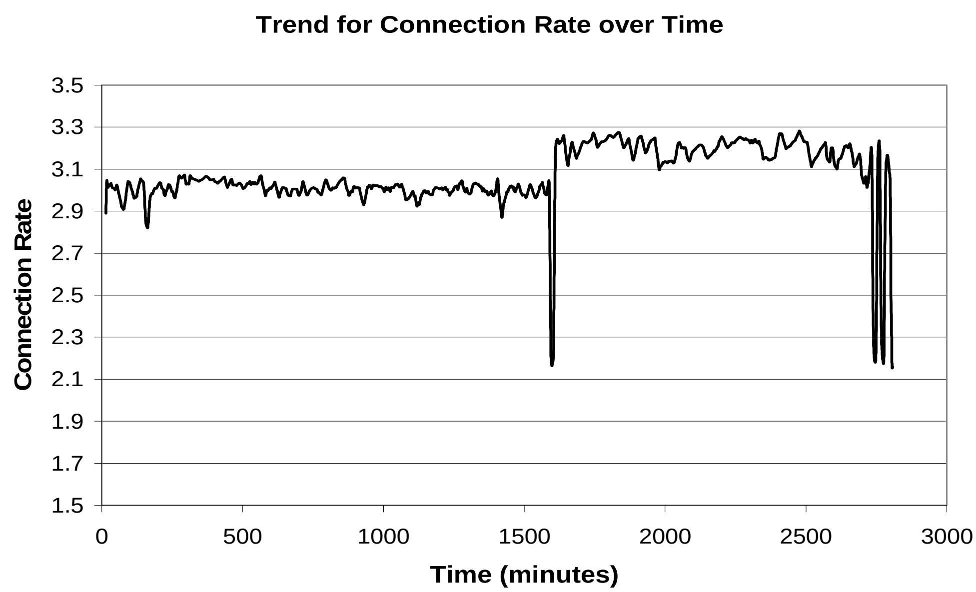

Figure 2. Connection Rate Fluctuation

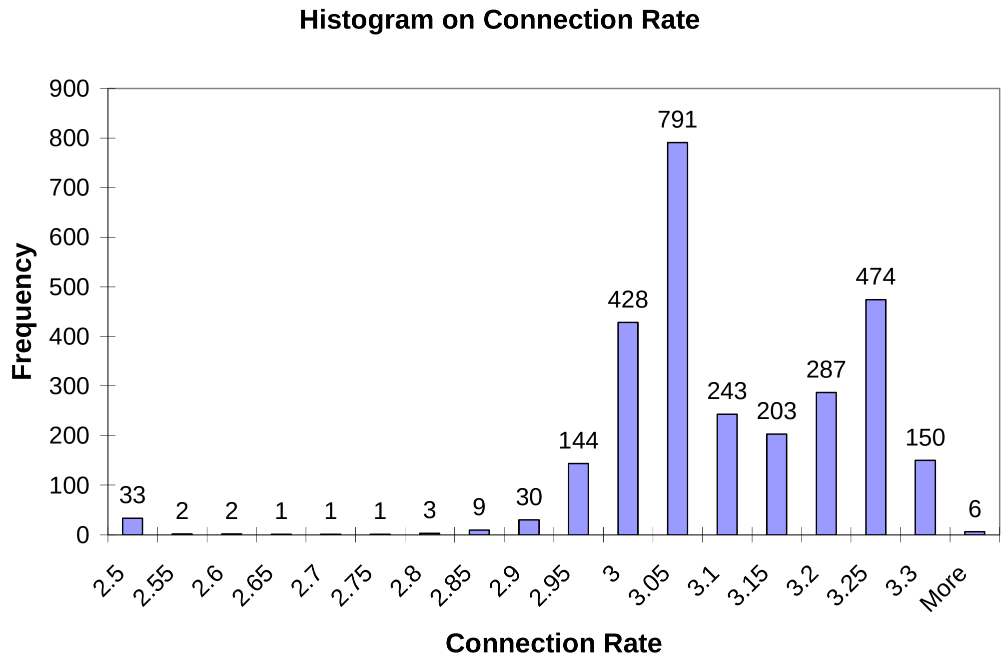

Figure 3. Connection Rate Histogram

4. TESTING EXAMPLE

A testing example is given to illustrate the usefulness of effective testing tools and plans. In the example, testing has proceeded to the point where adaptive testing is taking place. The connection rate in the test will increase or decrease to achieve a RTT between 3.5 and 4.5 seconds and an error rate that is less than 0.05% for a given one minute sample of queries. An error was defined as any query that did not return a result or returned an incorrect result. The maximum test time is set at 48 hours. The connection rate over time is shown in Figure 2. A histogram of CPS is shown in Figure 3. Although the histogram yielded a relatively high concentration between 2.95 and 3.3 connections a second, Figure 2 shows downward rate spike at around 26 and 48 hours. Although these spikes accounted for less than 0.34% of operating time, secondary testing was used to find possible causes. The accompanying second stage testing, including garbage collection and CPU monitoring, did not reveal an underlying factor that caused this fluctuation. This fluctuation was logged for further review and monitoring.

Future plans include attempting to replicate the results in another development environment and designing operational testing to monitor for such aberrations. Looking at the rest of the results from the adaptive test showed that the mean CPS was 3.06 with a 99% confidence value of 0.01.

5. CONCLUSIONS

The greatest conclusion that can be realized from the testing procedures is that even though exhaustive testing is not possible, testing is still iterative and time intensive. Various levels and types of tests had to be repeated in order to characterize the architecture's performance and to find implementation errors and flaws. A major benefit of development testing was the realization of the bottlenecks within system components. This knowledge was vital to the development of the operational system monitoring tools. With these tools, the ability to diagnose failure within a loosely coupled web services architecture was facilitated.

NCD will also continue its ongoing activities in developing its test harness. This tool has helped in testing functionality and measuring performance of various web services. The ability to test functionality was extremely important since anyone can generate client classes from the accompanying web service's WSDL. This means that clients can submit requests that are syntactically correct but semantically meaningless. The ability to test for such problems added robustness to the initiative's web services.

The last area of continued research and development for NCD will be in developing test cases that better characterize the operational environment. Differences between the testing and production environment like database size and server configuration can cause characterization curves to be incorrect. By closely modeling the end environment, these problems will be minimized.

6. REFERENCES

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[2] M. S. Pallos, "Service-Oriented Architecture: A Primer", *eAI Journal*, pp. 32-35, December 2001.

[3] Glossery of XML Key Management Requirements. http://www.w3.org/2003/glossary/subglossary/xkms2-req/

[4] M. Chen, A. Chen, B. Shao, "The implications and impacts of web services to electronic commerce research and practices", Journal of Electronic Commerce Research, VOL. 4, NO. 4, 2003

[5] P. Vita, "Challenges in the Adoption and Diffusion of Web Services in Financial Institutions", Working Paper CISL# 2004-07, 2004, http://web.mit.edu/smadnick/www/wp/2004-07.pdf

[6] Horizontal Fusion Developer's Reference, http://horizontalfusion.dtic.mil/docs/specs/20041118_Final_Developers_Ref.pdf

[7] Horizontal Fusion Developer's Guidance, http://horizontalfusion.dtic.mil/docs/specs/20041118_Final_Developers_Guide.pdf

[8] Horizontal Fusion Standards and Specifications, http://horizontalfusion.dtic.mil/docs/specs/20041112_HF_Standards.pdf

The Performance Learning Model

An Architecture to Enhance Systems Engineering Practitioner Learning

Steve Parker

Defense Acquisition University

NDIA 8th Annual Systems Engineering Conference

Briefing Purpose

Provide an overview of the
Performance Learning Model
and explain how the
Defense Acquisition University
is using it to
support the engaged learner

Briefing Overview

- Defense Acquisition University (DAU) Overview
- Performance Learning Model (PLM) Description
- DAU support of the PLM

Transformation

"…a future force that is defined less by size and more by *mobility and swiftness*, one that is *easier to deploy and sustain*, one that *relies more heavily on stealth, precision weaponry and information technologies."*

George W. Bush on Transformation

Defense Acquisition University

Overview

Defense Acquisition Workforce Improvement Act (DAWIA)

A November, 1990 Act of Congress requiring the Secretary of Defense to establish policies and procedures for the effective management (including accession, education, training, and career development) of persons serving in Department of Defense acquisition positions.

DAWIA Also Established DAU

The Secretary of Defense, acting through the Under Secretary of Defense for Acquisition, shall establish and maintain a defense acquisition university structure…

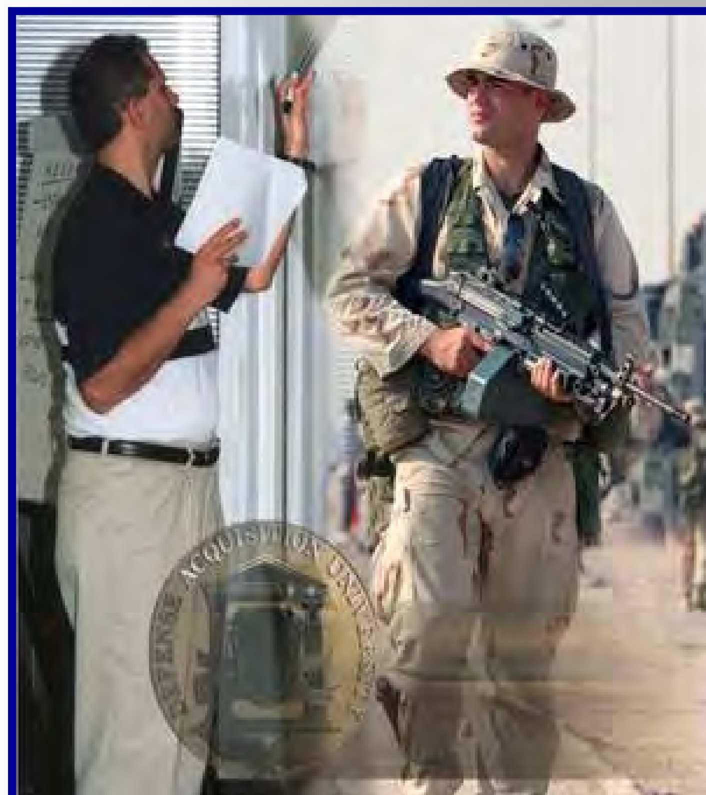
DoD AT&L Workforce

Career Field	Army	Navy/ USMC	Air Force	DoD	Other Total
Program Management	4,566	3,491	4,689	560	13,306
Contracting	8,183	5,296	7,487	5,282	26,248
Facilities Engineering	5,584	3,559	0	0	9,143
Production, Quality, & Manufacturing	2,226	2,232	408	4,414	9,280
Business, Cost Estimating & Financial Management	4,461	1,838	1,779	111	8,189
Life Cycle Logistics	4,936	4,156	1,953	76	11,121
SPRDE – Sys. Eng.	11,271	16,853	6,473	483	35,080
Test & Evaluation	2,452	2,479	2,181	180	7,192
5 Other Career Fields	4,509	1,648	2,805	6,018	14,980
Total	48,188	41,552	27,775	17,024	134,539

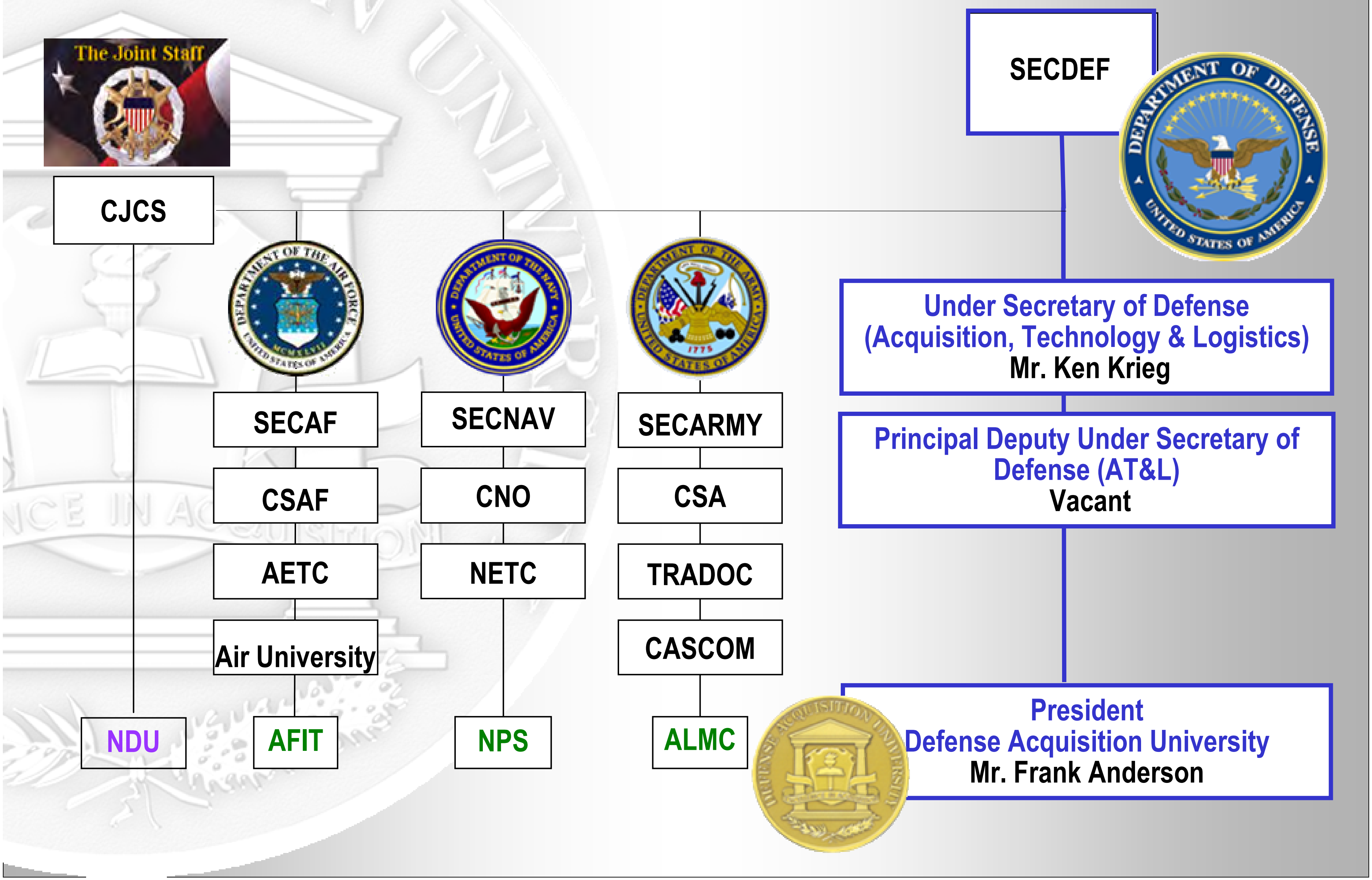
DAU Mission

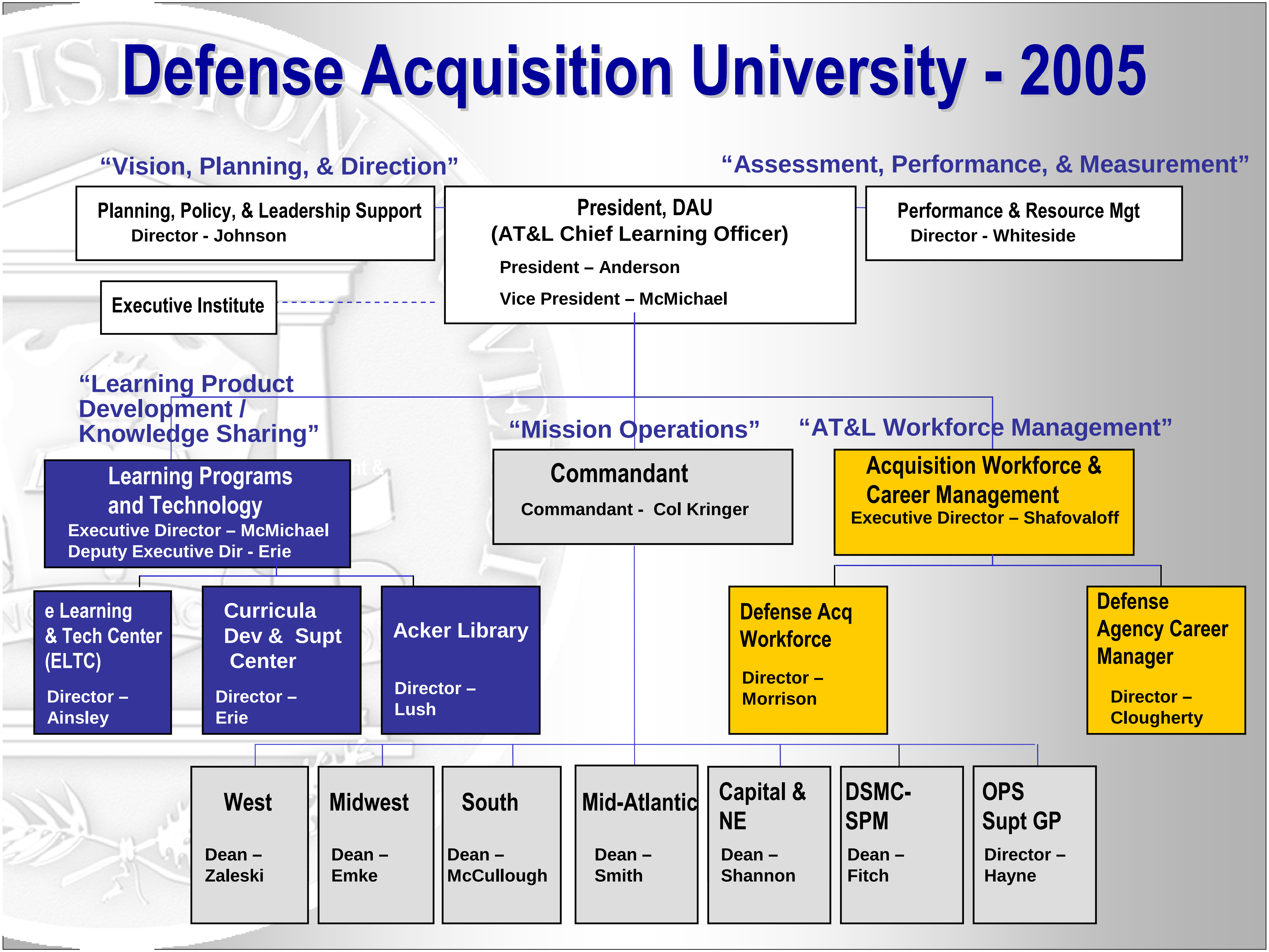
Provide practitioner training, career management, and services to enable the AT&L community to make smart business decisions and deliver timely and affordable capabilities to the warfighter.

- ✓ We train the AT&L Workforce through certification and assignment-specific courses
- ✓ We promote career-long learning through our Continuous Learning Center
- ✓ We offer performance support to the AT&L Workforce through consulting, Rapid Deployment Training, and targeted training
- ✓ We facilitate knowledge sharing through on-line resources and communities of practice



DAU within DoD





Defense Acquisition University - 2005
"Vision, Planning, & Direction"
"Assessment, Performance, & Measurement"
Planning, Policy, & Leadership Support
Director - Johnson
President, DAU
(AT&L Chief Learning Officer)
President – Anderson
Vice President – McMichael
Performance & Resource Mgt
Director - Whiteside
Executive Institute
"Learning Product Development / Knowledge Sharing"
"Mission Operations"
"AT&L Workforce Management"
Learning Programs and Technology
Executive Director – McMichael
Deputy Executive Dir - Erie
Commandant
Commandant - Col Kringer
Acquisition Workforce & Career Management
Executive Director – Shafovaloff
e Learning & Tech Center (ELTC)
Director – Ainsley
Curricula Dev & Supt Center
Director – Erie
Acker Library
Director – Lush
Defense Acq Workforce
Director – Morrison
Defense Agency Career Manager
Director – Clougherty
West
Dean – Zaleski
Midwest
Dean – Emke
South
Dean – McCullough
Mid-Atlantic
Dean – Smith
Capital & NE
Dean – Shannon
DSMC-SPM
Dean – Fitch
OPS Supt GP
Director – Hayne

DAU Regional Orientation

We are part of the community not just a place to go to take classes.

Located with our Customers

"The legacy of obsolete institutional structures and processes and organizations does not merely create unnecessary cost…it also imposes an unacceptable burden on national defense."

Swift response to changing processes, structure and threats requires *Engaged Learning*

The Engaged Learner

Vision of the Engaged Learner

- *Responsible for Learning.*
- *Energized by Learning.*
- *Collaborative.*

Tasks for the Engaged Learner

- *Challenging.*
- *Authentic.*
- *Integrative/interdisciplinary.*

Instructional Models and Strategies for Engaged Learning

- *Interactive*
- *Generative.*

Learning Context for the Engaged Learner

- *Knowledge-Building Learning Community.*
- *Collaborative.*
- *Empathetic.*

Roles for the Engaged Learner

- *Explorer.*
- *Cognitive Apprentice.*
- *Producers of Knowledge.*

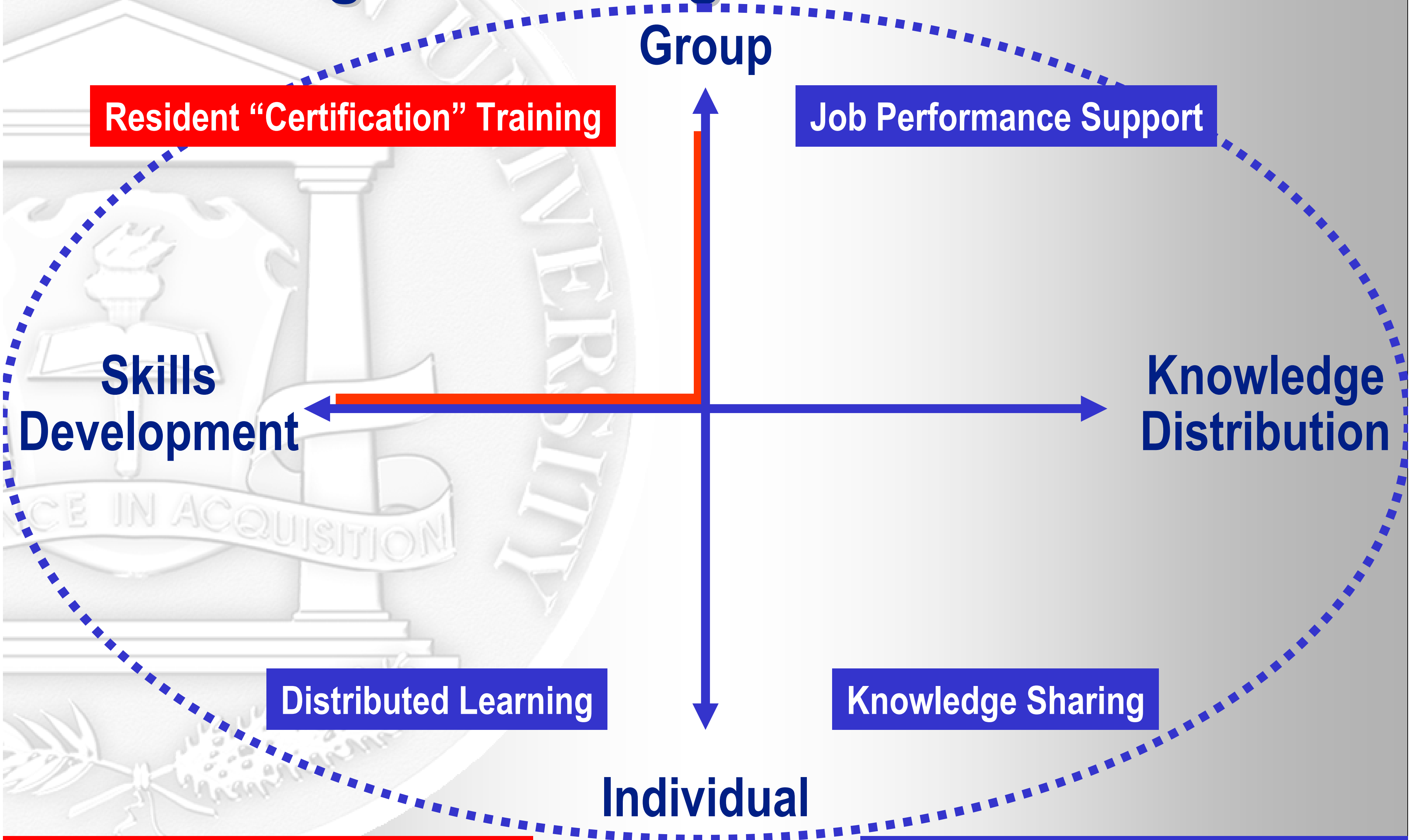
Excerpted and summarized from *Designing Learning and Technology for Educational Reform*, by Beau Fly Jones, Gilbert Valdez, Jeri Nowakowski, and Claudette Rasmussen (NCREL, 1994).

Performance Learning Model

A Learning Architecture to Support the Engaged Learner

Performance Learning Model – 24/7 Learning Assets for the Classroom and the Workplace

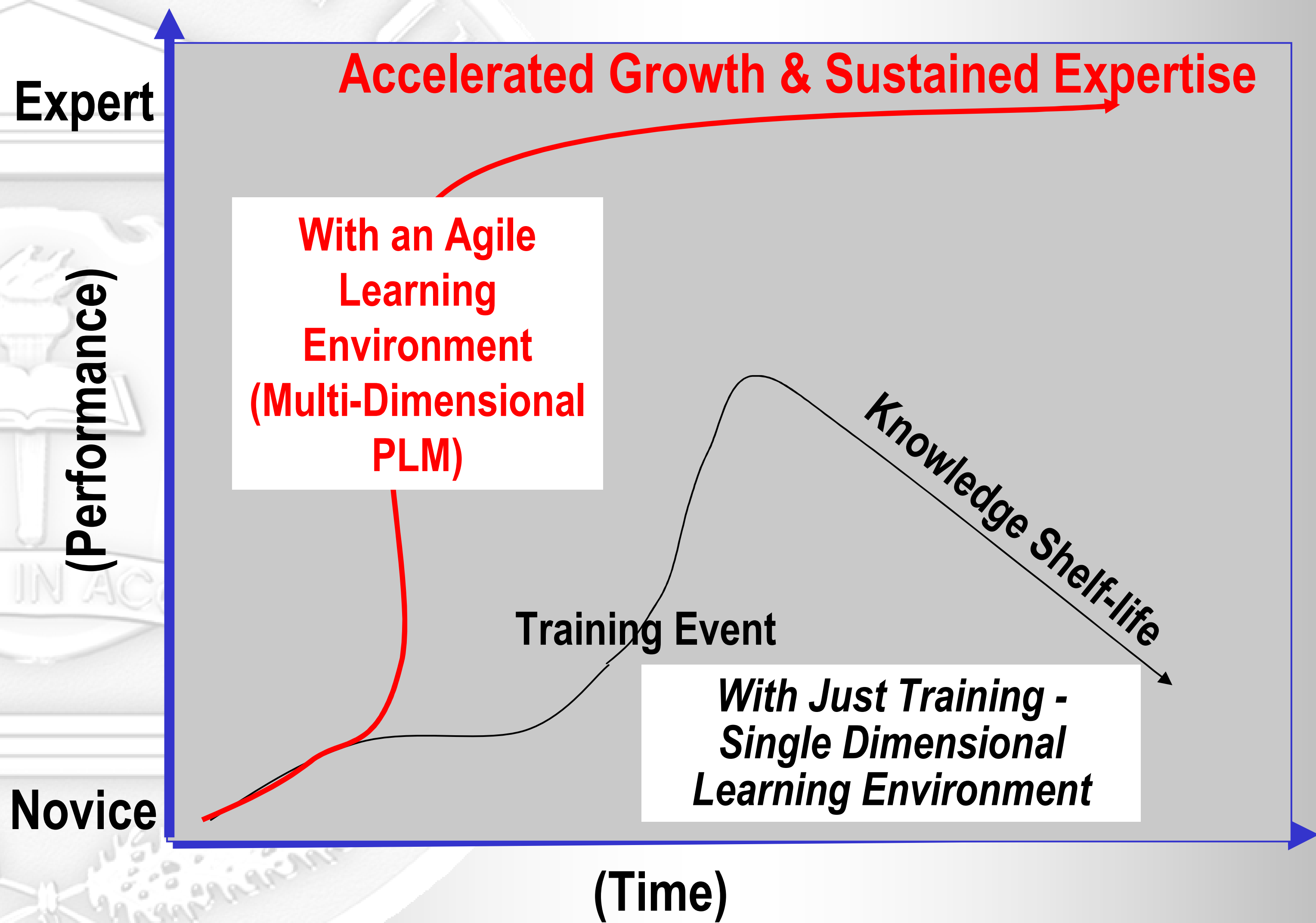
Framing the Learning Strategy for an Agile Learning Environment



Single dimension learning paradigm (old)

Multi-dimensional learning paradigm (new)

Benefits of Engaging the Learner on the Job



Performance Learning Model – 24/7 Learning Assets for the Classroom and the Workplace

Acquisition Knowledge Sharing Systems

Online gateway to AT&L Systems Engineering information & tools

Acquisition Community Connection

Online Systems Engineering collaboration communities

Training Courses

DAWIA certification, assignment-specific, and executive & international courses – in the classroom and on-line

Consulting

Practitioner experts available when & where needed to improve performance execution

Rapid Deployment Training

on-site & on-line training on latest Systems Engineering Policies and Practices

DAU Virtual Library

Keeping Systems Engineers virtually connected to research tools when and where they need them

Continuous Learning Modules

Online modules built around Systems Engineering tasks, procedures or functional areas

Targeted Training

tailored learning for your organization or task

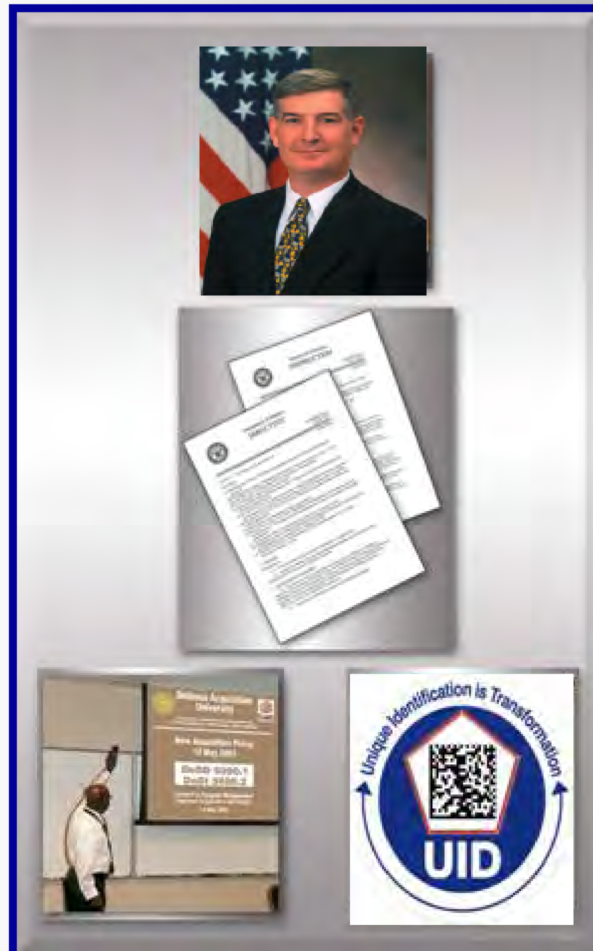
DAU Performance Support

- Consulting
- Rapid Deployment Training
- Tailored Training

Experience our rapidly delivered business solutions

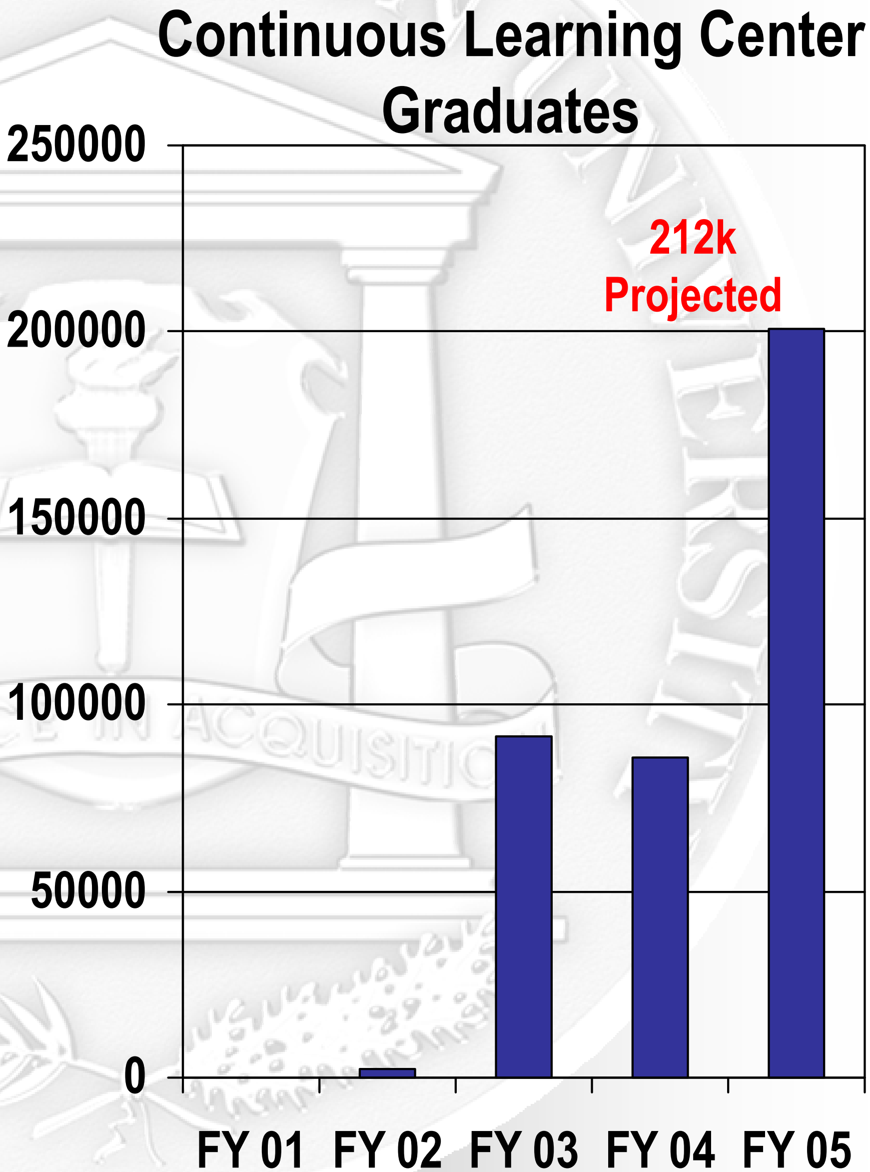
Rapid Deployment Training

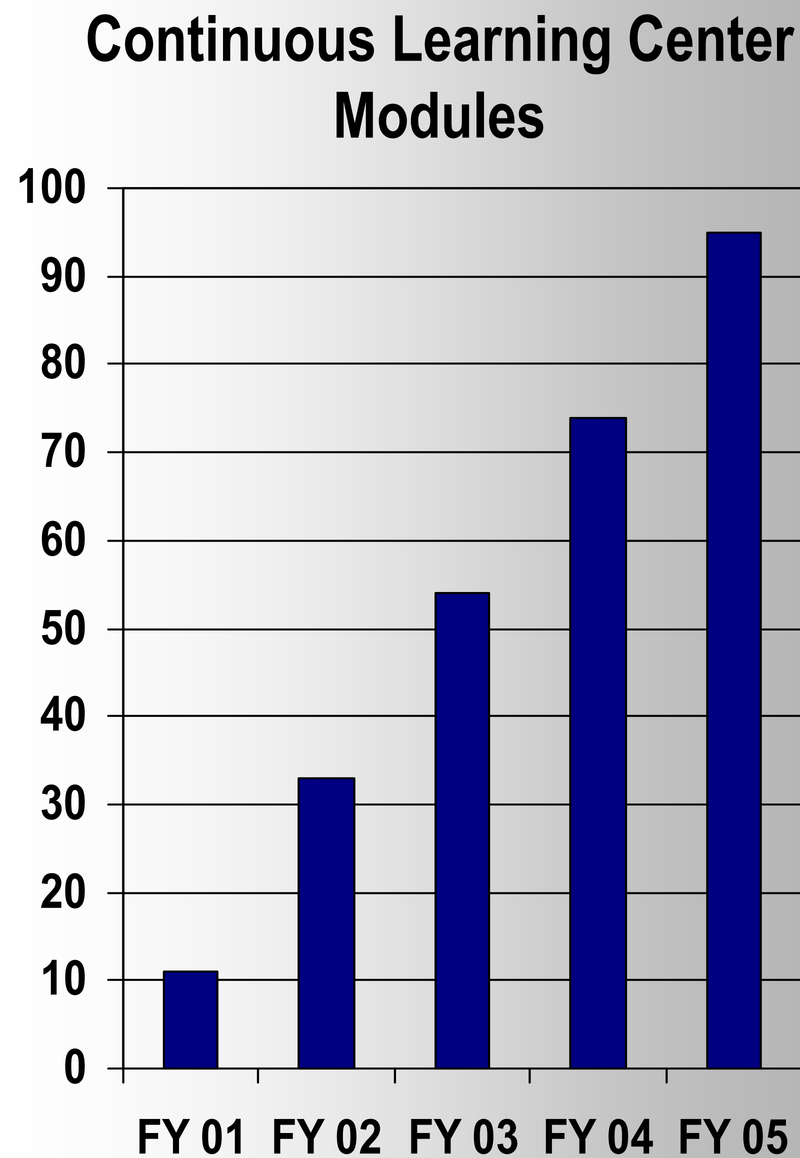
- Initiated May 2003 with new DoD 5000 Series
  - Within 48 hours Overview brief and online resource center available (averaged 700 hits per day)
  - Over next 4 months, 200 presentations given to more than 12,000 members of the AT&L community
- Continued with
  - CJCS 3170
  - Comptroller PBD
  - AT&L PBL
  - Corrosion Control
  - Unique Identification of Items

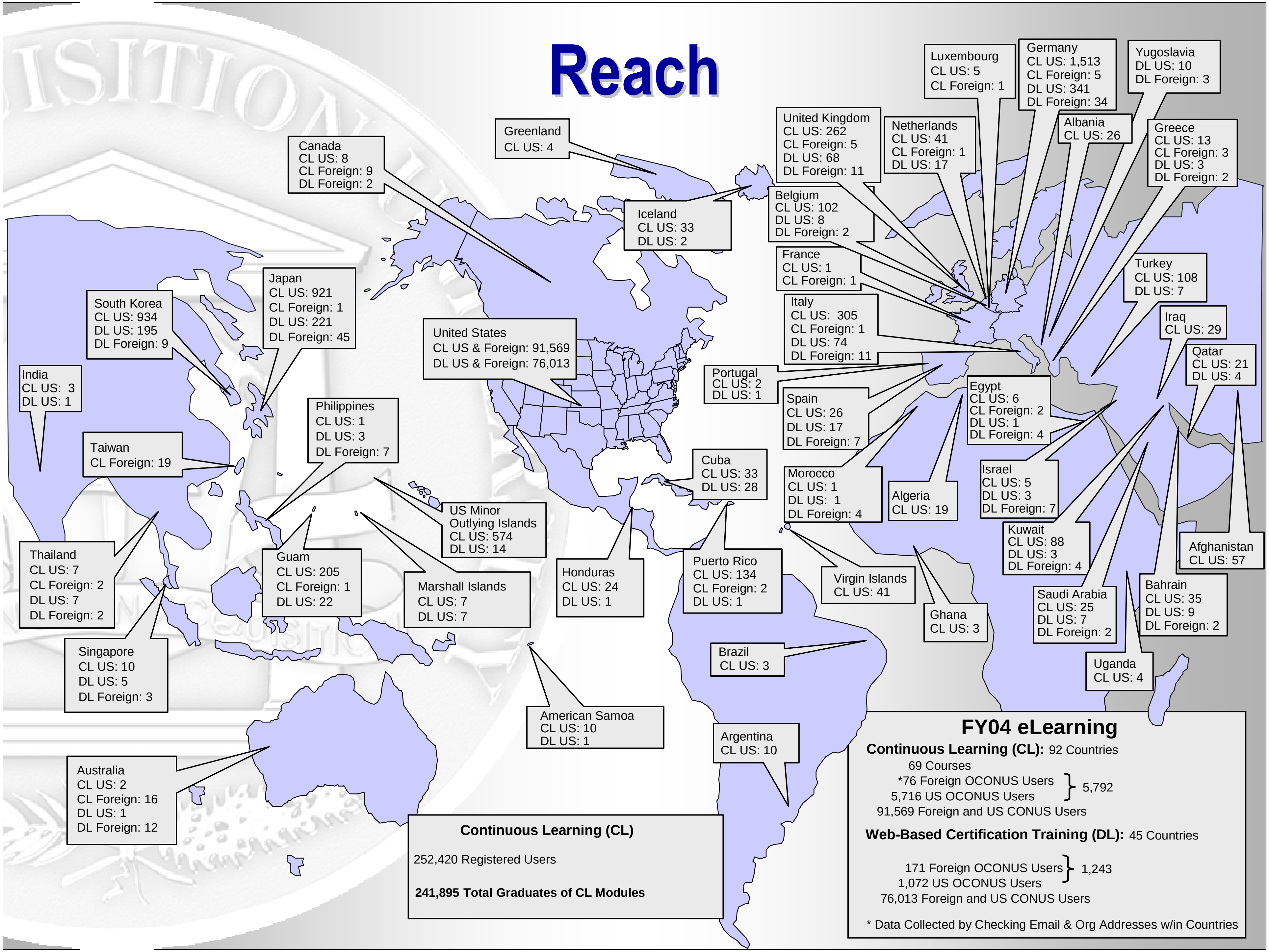


Provides quick notification and training on new initiatives and policy changes

Continuous Learning Growth







Reach
Luxembourg CL US: 5 CL Foreign: 1
Germany CL US: 1,513 CL Foreign: 5 DL US: 341 DL Foreign: 34
Yugoslavia DL US: 10 DL Foreign: 3
United Kingdom CL US: 262 CL Foreign: 5 DL US: 68 DL Foreign: 11
Netherlands CL US: 41 CL Foreign: 1 DL US: 17
Albania CL US: 26
Greece CL US: 13 CL Foreign: 3 DL US: 3 DL Foreign: 2
Greenland CL US: 4
Canada CL US: 8 CL Foreign: 9 DL Foreign: 2
Iceland CL US: 33 DL US: 2
Belgium CL US: 102 DL US: 8 DL Foreign: 2
France CL US: 1 CL Foreign: 1
Turkey CL US: 108 DL US: 7
Japan CL US: 921 CL Foreign: 1 DL US: 221 DL Foreign: 45
South Korea CL US: 934 DL US: 195 DL Foreign: 9
United States CL US & Foreign: 91,569 DL US & Foreign: 76,013
Italy CL US: 305 CL Foreign: 1 DL US: 74 DL Foreign: 11
Iraq CL US: 29
Qatar CL US: 21 DL US: 4
Portugal CL US: 2 DL US: 1
India CL US: 3 DL US: 1
Egypt CL US: 6 CL Foreign: 2 DL US: 1 DL Foreign: 4
Spain CL US: 26 DL US: 17 DL Foreign: 7
Philippines CL US: 1 DL US: 3 DL Foreign: 7
Taiwan CL Foreign: 19
Cuba CL US: 33 DL US: 28
Morocco CL US: 1 DL US: 1 DL Foreign: 4
Algeria CL US: 19
Israel CL US: 5 DL US: 3 DL Foreign: 7
US Minor Outlying Islands CL US: 574 DL US: 14
Kuwait CL US: 88 DL US: 3 DL Foreign: 4
Afghanistan CL US: 57
Thailand CL US: 7 CL Foreign: 2 DL US: 7 DL Foreign: 2
Guam CL US: 205 CL Foreign: 1 DL US: 22
Honduras CL US: 24 DL US: 1
Puerto Rico CL US: 134 CL Foreign: 2 DL US: 1
Virgin Islands CL US: 41
Marshall Islands CL US: 7 DL US: 7
Ghana CL US: 3
Saudi Arabia CL US: 25 DL US: 7 DL Foreign: 2
Bahrain CL US: 35 DL US: 9 DL Foreign: 2
Singapore CL US: 10 DL US: 5 DL Foreign: 3
Brazil CL US: 3
Uganda CL US: 4
American Samoa CL US: 10 DL US: 1
Argentina CL US: 10
Australia CL US: 2 CL Foreign: 16 DL US: 1 DL Foreign: 12
Continuous Learning (CL)
252,420 Registered Users
241,895 Total Graduates of CL Modules
FY04 eLearning
Continuous Learning (CL): 92 Countries
69 Courses
*76 Foreign OCONUS Users
5,716 US OCONUS Users
5,792
91,569 Foreign and US CONUS Users
Web-Based Certification Training (DL): 45 Countries
171 Foreign OCONUS Users
1,072 US OCONUS Users
1,243
76,013 Foreign and US CONUS Users
* Data Collected by Checking Email & Org Addresses w/in Countries

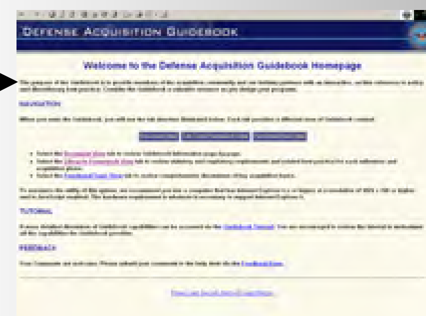
DoD AT&L Knowledge Sharing System AKSS

FAR/DFARS

GSA & Hill FARSITE

New AT&L Policy

Acquisition Resource Center With 5000 and JCIDS

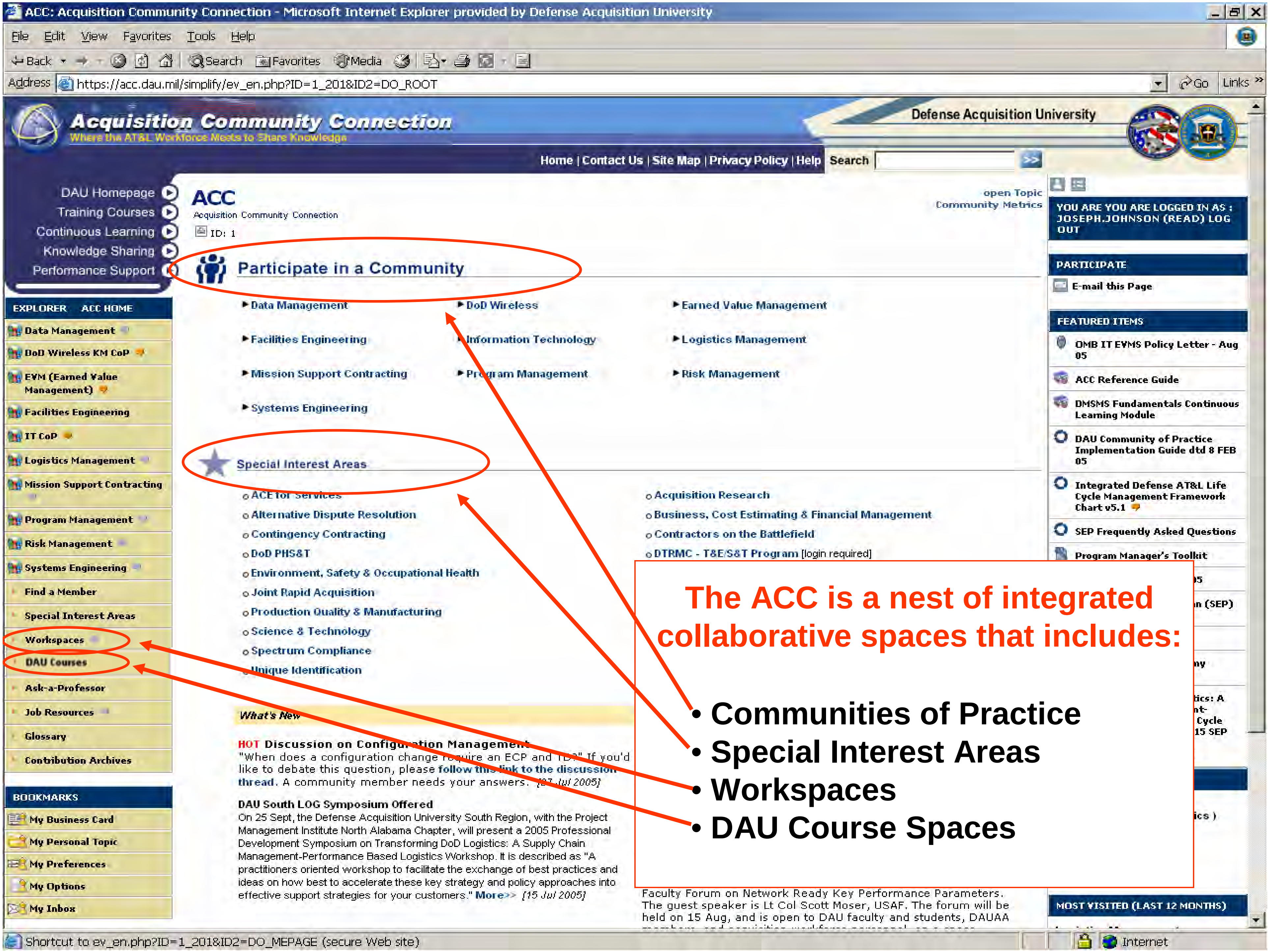


Defense Acquisition Guidebook

Guidance and Experts

Career Field and Business Process On-Line Knowledge Communities

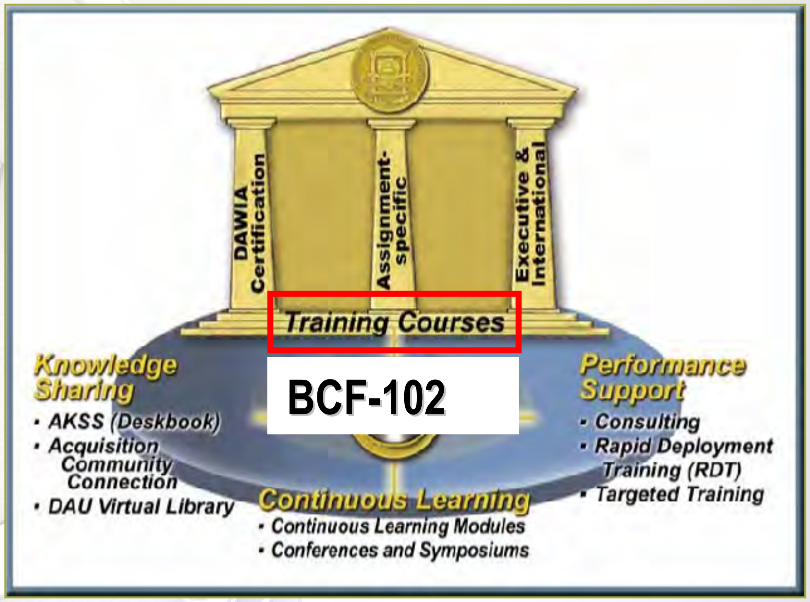
Gateway to Policy, Processes, Tools and Experts



The ACC is a nest of integrated collaborative spaces that includes:

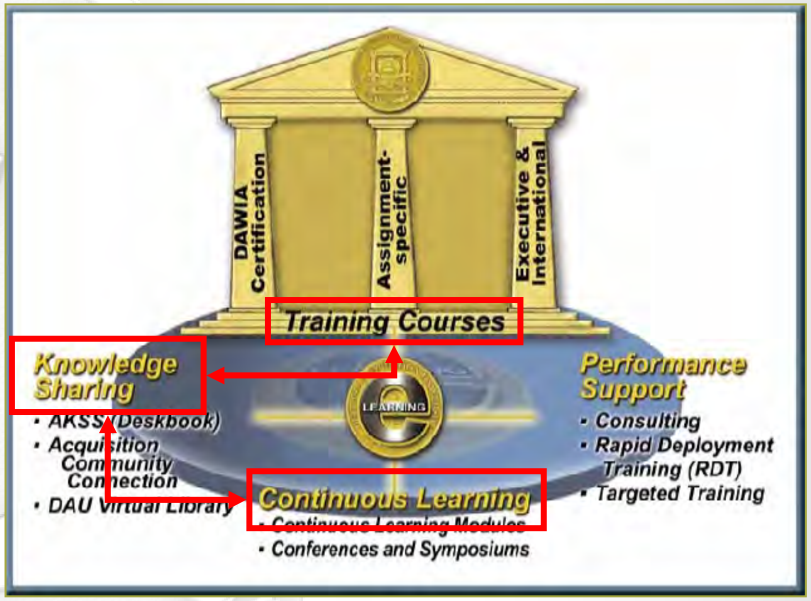
- Communities of Practice
- Special Interest Areas
- Workspaces
- DAU Course Spaces

Application of the Performance Learning Model



- Eight Day Residence Course converted to a distance learning
- 20 Hour COTS course
- Augmented with five DAU developed tutorials
- First FAI Offering – Oct 05

Application of the Performance Learning Model



ACC Tutorials

- OCT03 EV1 – 20,022
- JAN04 EV2 – 10,161
- AUG03 EV3 – 11,316
- FEB04 EV4 - 5,877
- APR04 EV5 – 15,010

BCF-102

- Eight Day Residence Course
- 20 Hour COTS CBT course
- Augmented with five DAU developed tutorials
- First FAI Offering Oct 05

Application of the Performance Learning Model

ACC Tutorials

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- JAN04 EV2 – 10,161
- AUG03 EV3 - 11,316
- FEB04 EV4 - 5,877
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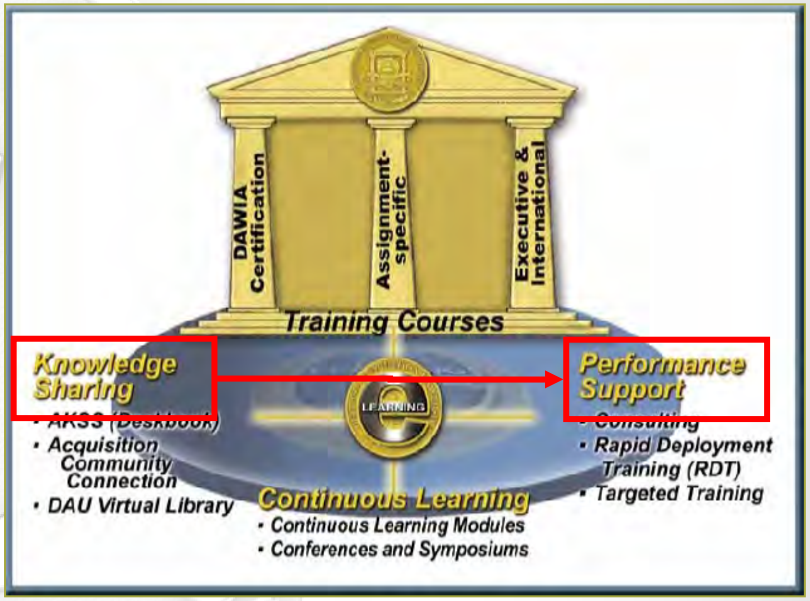

BCF-102

- Eight Day Residence Course
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U.S. Senate Committee on Armed Services
228 Russell Senate Office Building
Washington, D.C. 20510
(202) 224-3871

OFFICE OF MANAGEMENT AND BUDGET

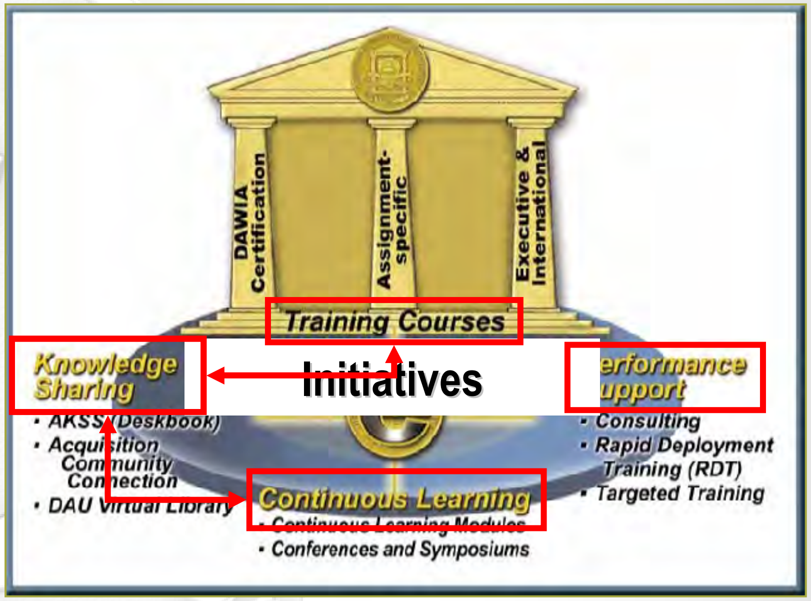
ACC Performance Support Referrals

- SASC Staff EVM Training Feb 04
- OMB Selected ACC for EVM references
- United Technologies WEBEX meeting
- Industry and DoD Web Conferences - Aug 05

Application of the Performance Learning Model

ACC Tutorials

- OCT 03 EV1 – 20,022
- JAN 04 EV2 – 10,161
- AUG 03 EV3 – 11,316
- FEB 04 EV4 - 5,877
- APR 04 EV5 – 15,010
- OCT04 ST1 – 5,897



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Office of Management and Budget

ACC Performance Support Referrals

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BCF-102

- Eight Day Residence Course
- 20 Hour COTS CBT course
- Augmented with five DAU developed tutorials
- First FAI offering – Oct 05

- BCF-203 Tutorials
- EVM Research Library
- EVM Tools

Strategic Partnerships

Enhancing learner opportunities by establishing partnerships with institutions of higher learning, industry, professional associations, and other agencies.

University College (UMUC) and University of Maryland - Baltimore

Florida Institute of Technology

AFIT

ADL Co-Lab (Partner)
Academic Co-Lab (U of WI)
Joint Co-Lab (UCF)

Bachelor's Degree

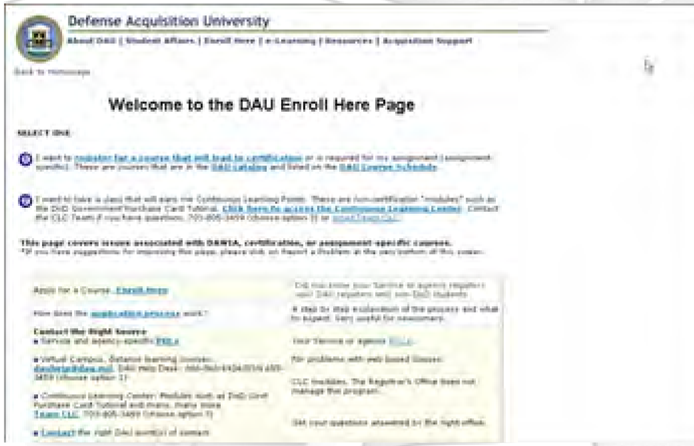
NPS

- Credit for DAU courses toward degrees
- Joint DAU-Industry curriculum development
- International defense Educational Arrangement
- Training MOU with Australia
- GAO training
- Federal Acquisition Institute Seminars

Find out more about DAU Products

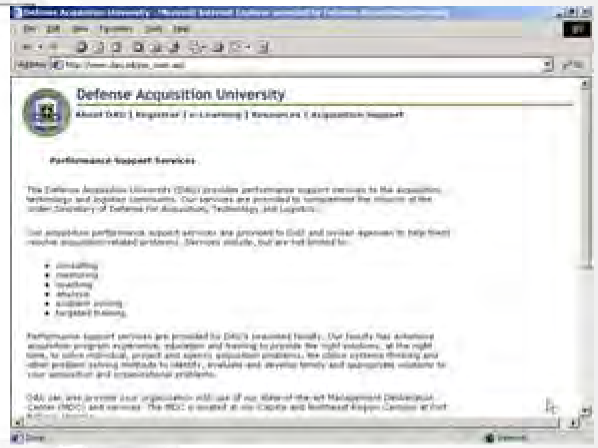
www.dau.mil

DAU Training Courses



http://www.dau.mil/registrar/apply.asp

Performance Support



http://www.dau.mil/pss_main.asp

Continuous Learning Center

http://clc.dau.mil

AT&L Knowledge Sharing System (AKSS)

http://akss.dau.mil

Credit for DAU Courses toward Degrees

http://www.dau.mil/about-dau/partners.asp

Equivalencies

http://www.dau.mil/equivalency

Contact

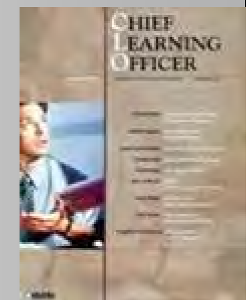
Steve Parker
(256) 722-1039
steve.parker@dau.mil

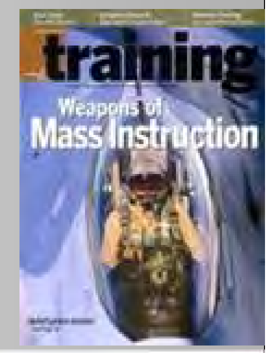
Experience the value of the Performance Learning Model at

www.dau.mil

Defense Acquisition University

- ASTD Best Awards 2003 and 2004 (First Place)
- CLO Magazine Learning in Practice Awards 2004 – Gold, Bronze, & CLO-of-the-Year
- Brandon Hall Gold Award for PLM as a Best Practice - Excellence in e-Learning 2003
- Training Top 100 2003
- Corporate University Xchange Excellence Awards - Best Practices 2003
- CUBIC Best Overall Corporate University 2002
- CUBIC Best Virtual Corporate University 2002
- CUBIC Most Innovative Corporate University 2002
- CUBIC Leader of the Year 2002
- USDLA Awards 2001 and 2002





Applying the Systems Engineering Method for the Joint Capabilities Integration and Development System (JCIDS)

Chris Ryder and Dave Flanigan

27 October 2005

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

APL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

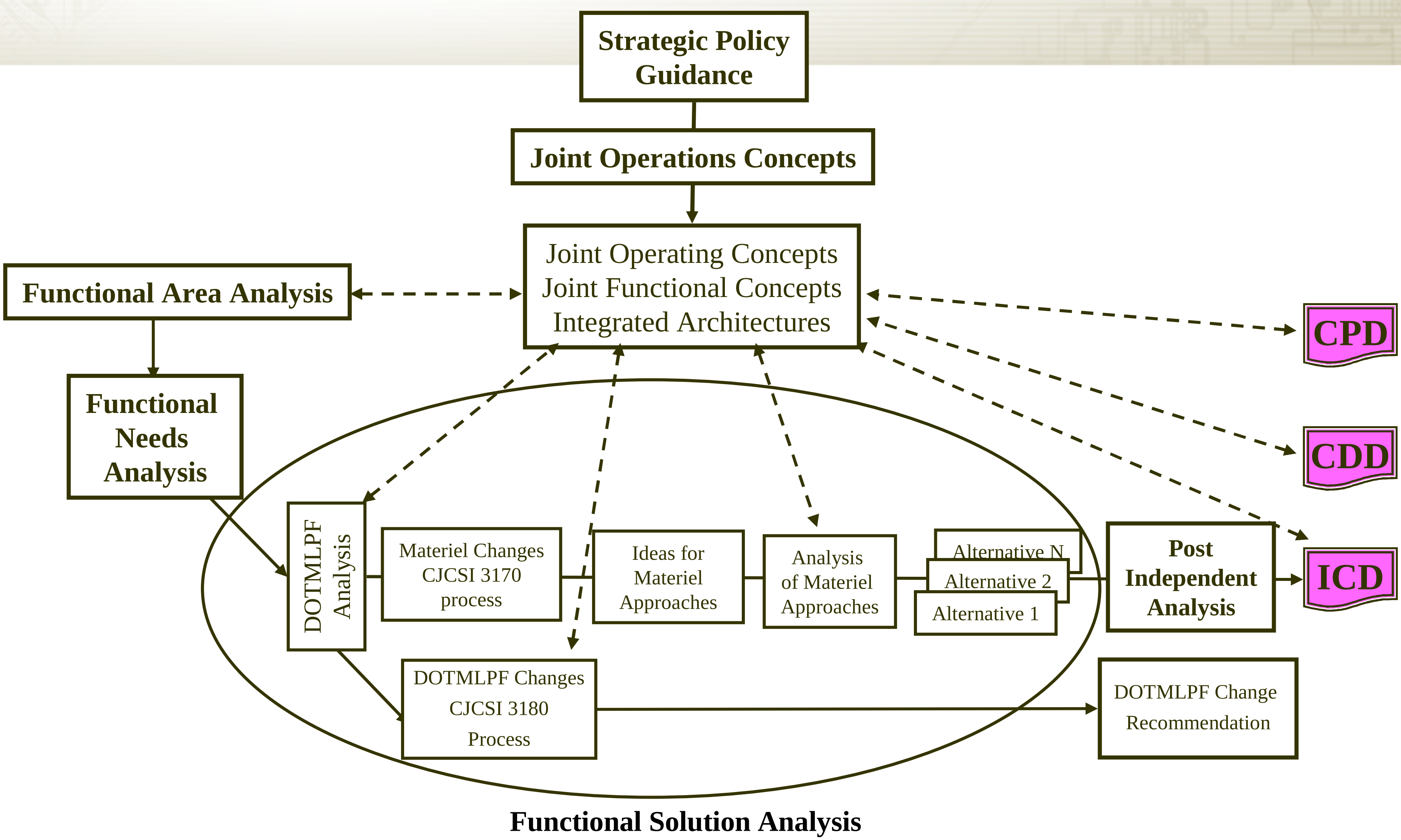
Purpose

- JCIDS prescribes a joint forces approach to identify capability gaps against current force capability needs
- The Systems Engineering (SE) Method applies to each iteration of the systems life-cycle from capability inception through system retirement
- Good systems engineering practice is necessary for successfully implementing JCIDS
- Use of model-driven SE facilitates JCIDS throughout the systems life-cycle

Agenda

- The Joint Capabilities Integration and Development System (JCIDS)
- The Systems Engineering Method
- Model-Driven Systems Engineering for JCIDS
- Why use the Systems Engineering Method JCIDS?

JCIDS Analysis



JCIDS Events

- Functional Area Analysis (FAA)
  - Identify operational task, conditions, and standards needed to accomplish military objectives
  - Result: Tasks to be accomplished
- Functional Needs Analysis (FNA)
  - Assess ability of current and programmed capabilities to accomplish the tasks
  - Result: List of capability gaps
- Functional Solutions Analysis (FSA)
  - Operational based assessment of DOTMLPF approaches to solving capability gaps
  - Result: Potential DOTMLPF approaches to capability gaps
- Post Independent Analysis
  - Independent analysis of approaches to determine best fit
  - Result: Initial Capabilities Document

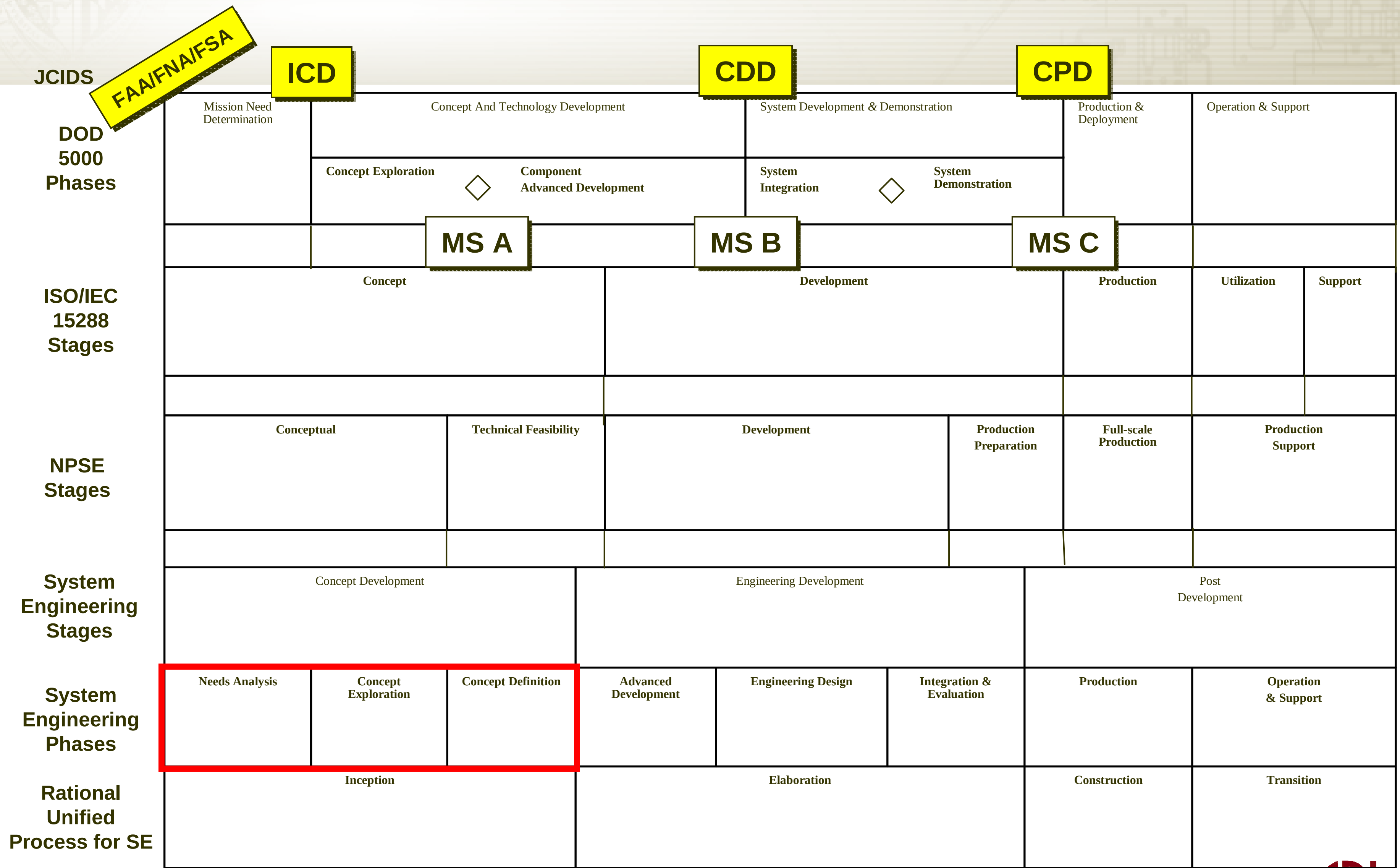
JCIDS

- JCIDS analytical process stresses the fundamentals for applying an effective systems engineering program by any accepted standard
- It guides the “front-end” phases of the SE process for each capability iteration
  - Enterprise (operational) analysis
  - Requirements definition
  - Life-cycle phase
- The analysts must have a thorough understanding of existing capabilities as well as the capability needs
- The JCIDS analysis team eventually determines the optimum combination of material and non-material alternatives to achieve the capability needs to the Battle Force

Systems Engineering Method

- Regardless of the analytical phase performed by the JCIDS SE team,
  - The basic application of the SE method is constant throughout the process
- Each SE Method activity is performed in some form in each phase of the system life-cycle

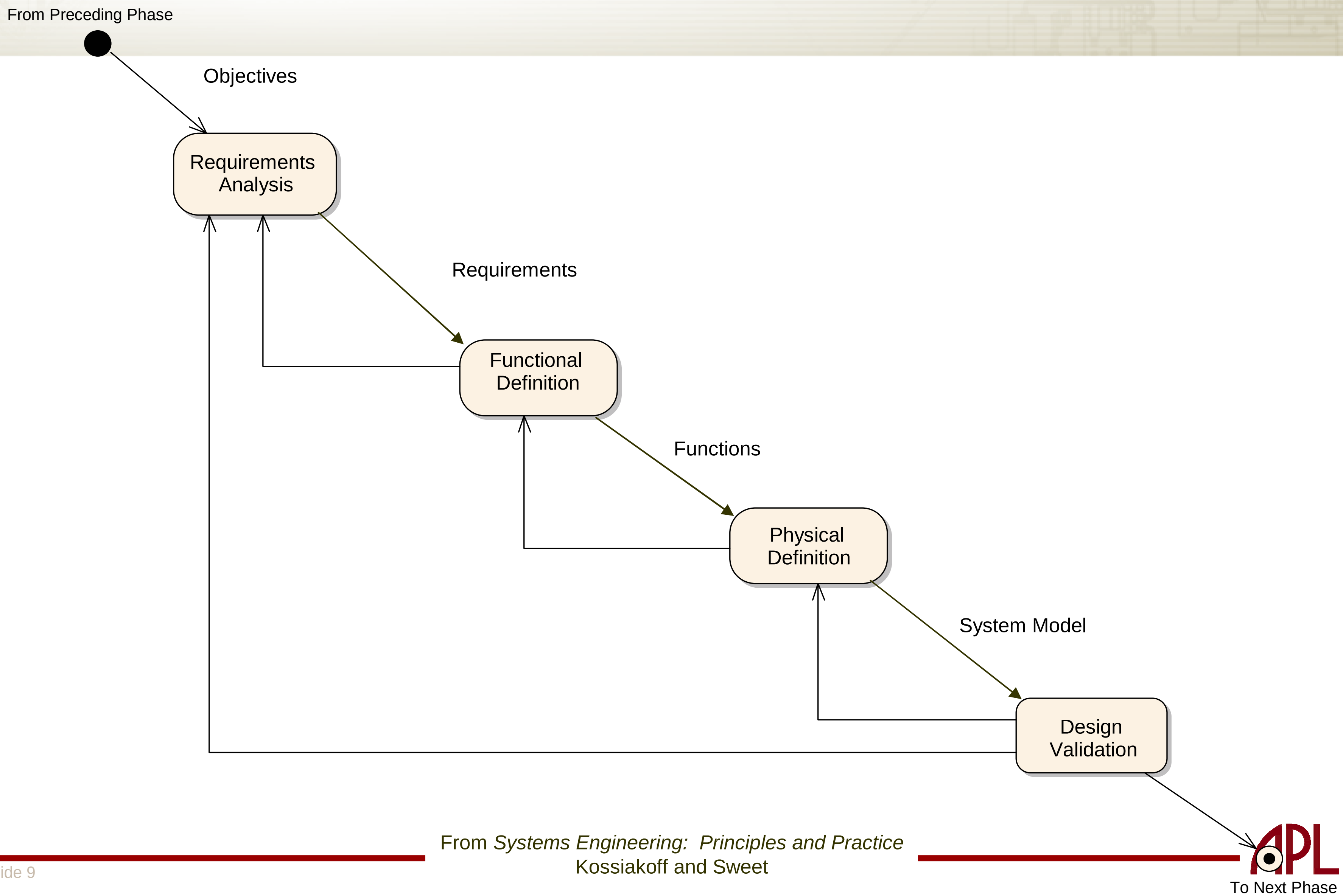
Systems Engineering Method Over Life Cycle



From *Systems Engineering: Principles and Practice*
Kossiakoff and Sweet

APL

The Systems Engineering Method



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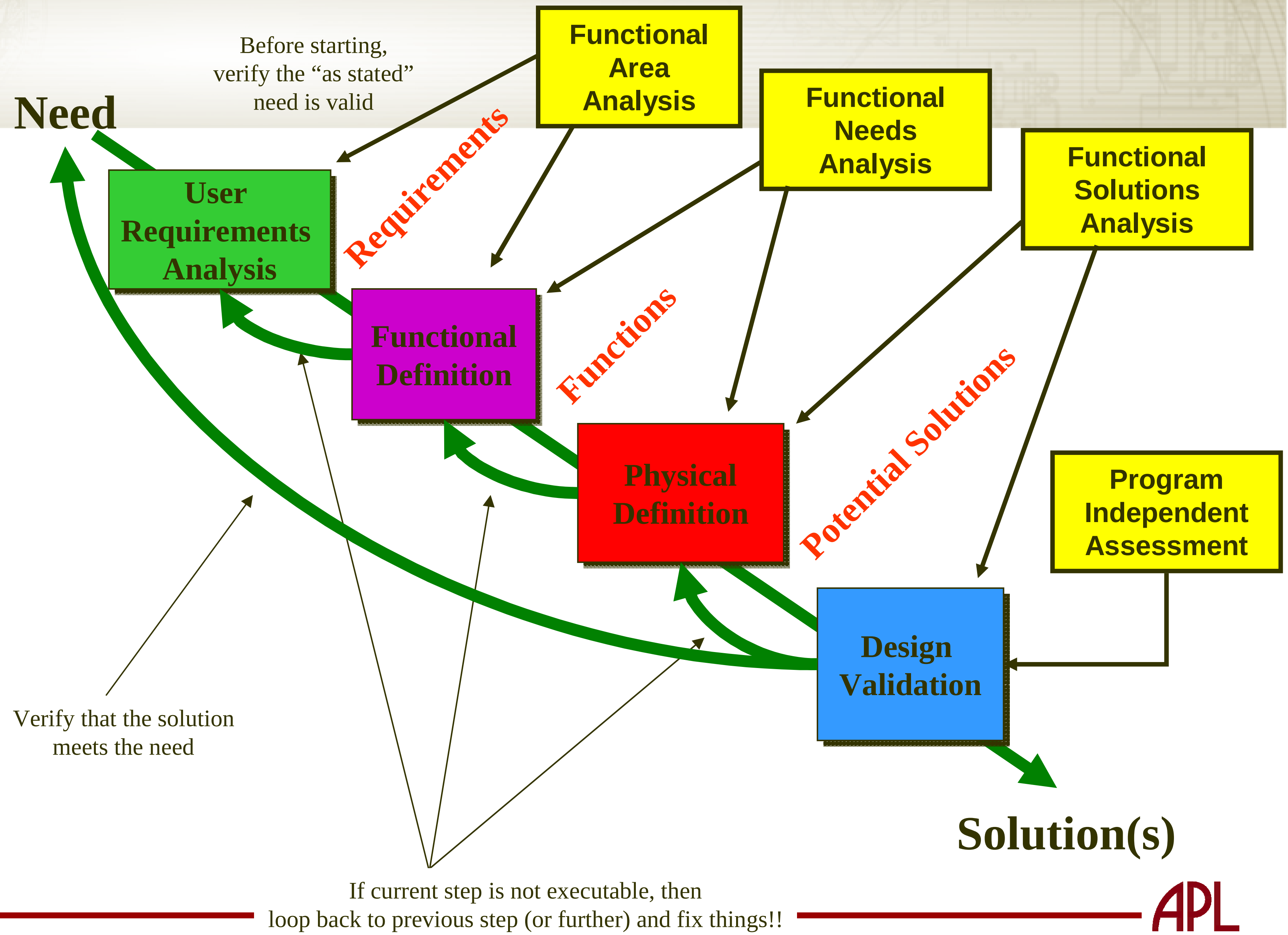
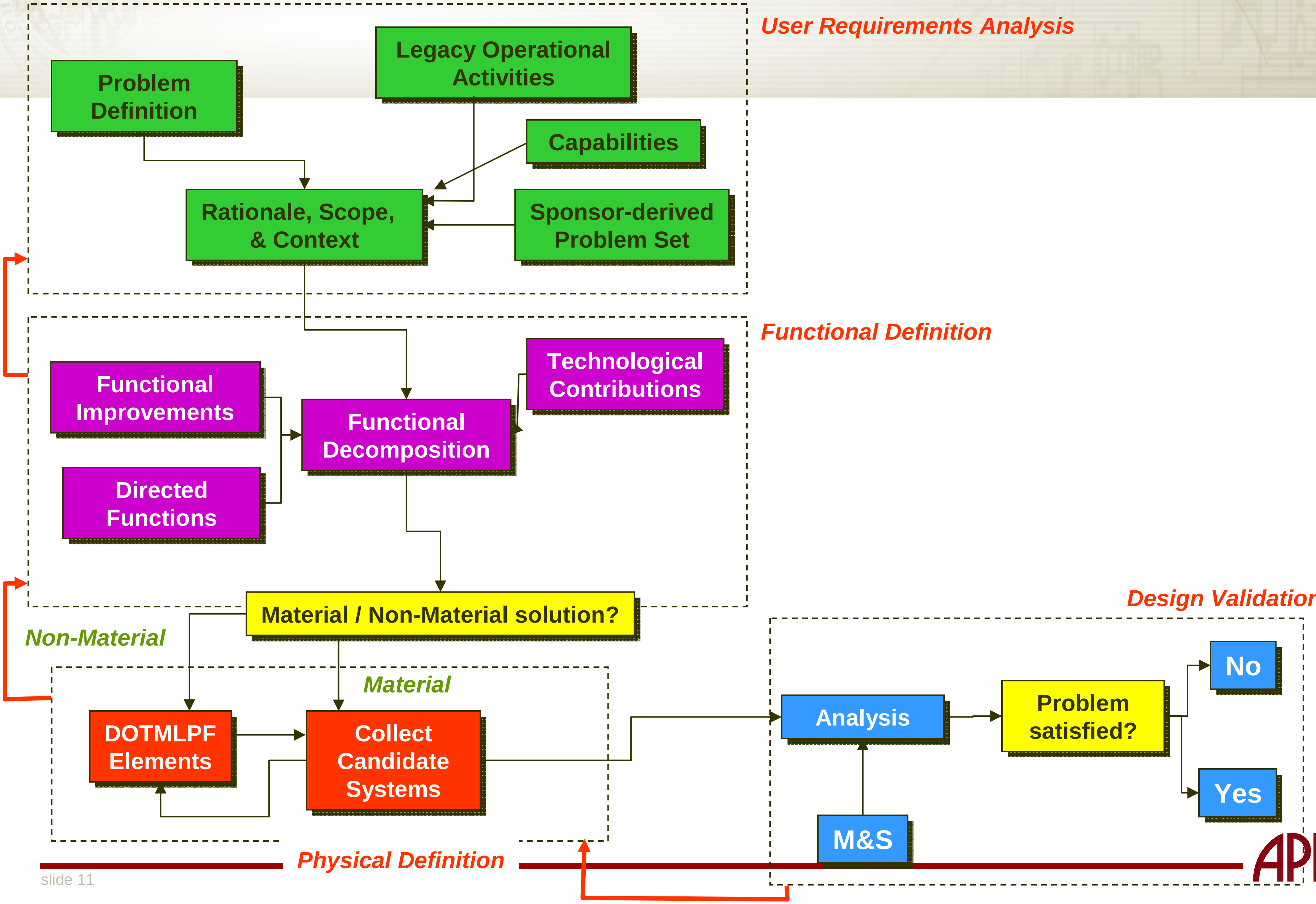
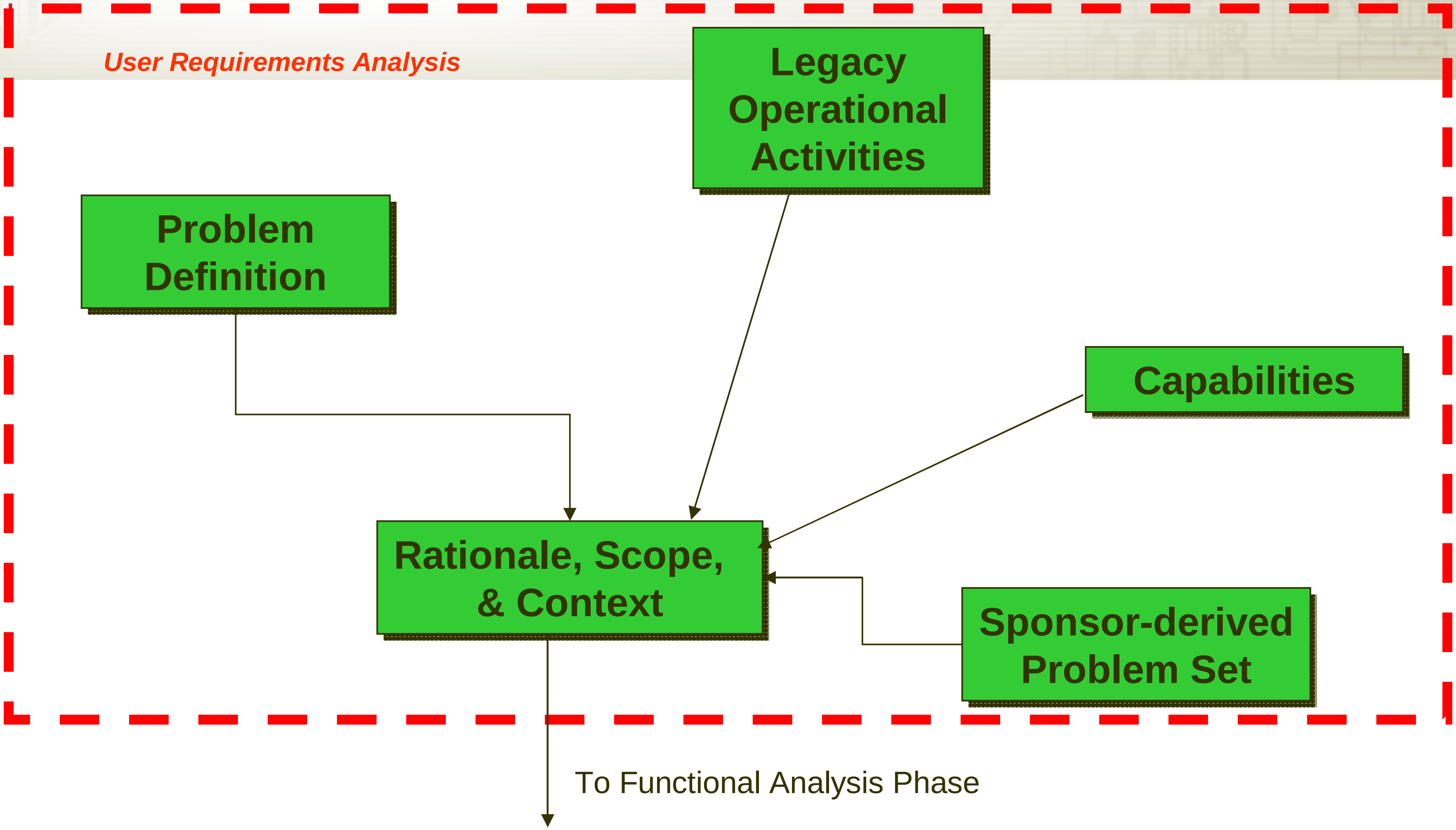
Systems Engineering Method



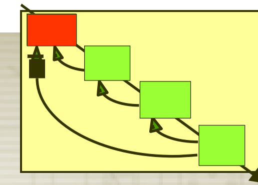
Systems Engineering Method



Systems Engineering Method

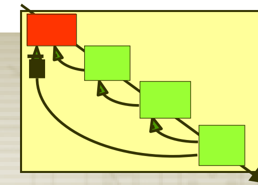


Problem Definition



- At one point in time there is a problem that must be solved due to:
  - Deficient capability with existing systems
  - Desire to improve existing performance
- Need to understand what the objectives are to provide the desired capability
- Define the operational context within the Capability Enterprise!

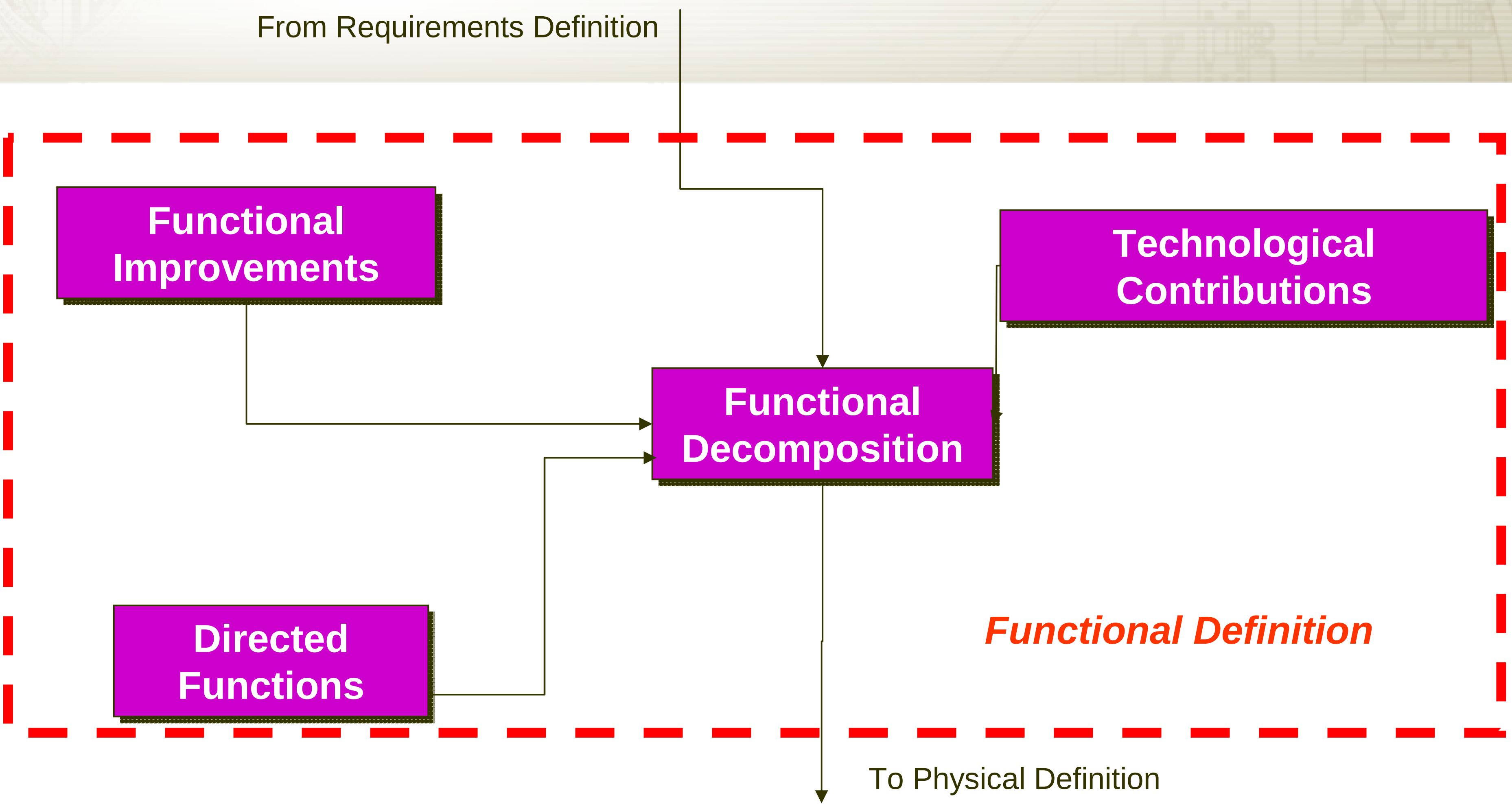
Requirements Analysis Products



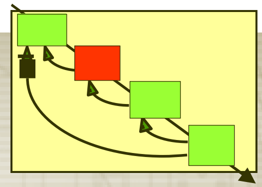
- A clear definition of the problem
- A proper scope of the problem
- Operational context documents and data bases
  - o Design Reference Mission
  - o Strategy-to-Task Mapping
  - o Concept of Operations
  - o Physical Environment Database
  - o Threat Representation Database
  - o Blue Capabilities Database
- Relevant Operational Views

Captured within a SE Requirements Model

Systems Engineering Method



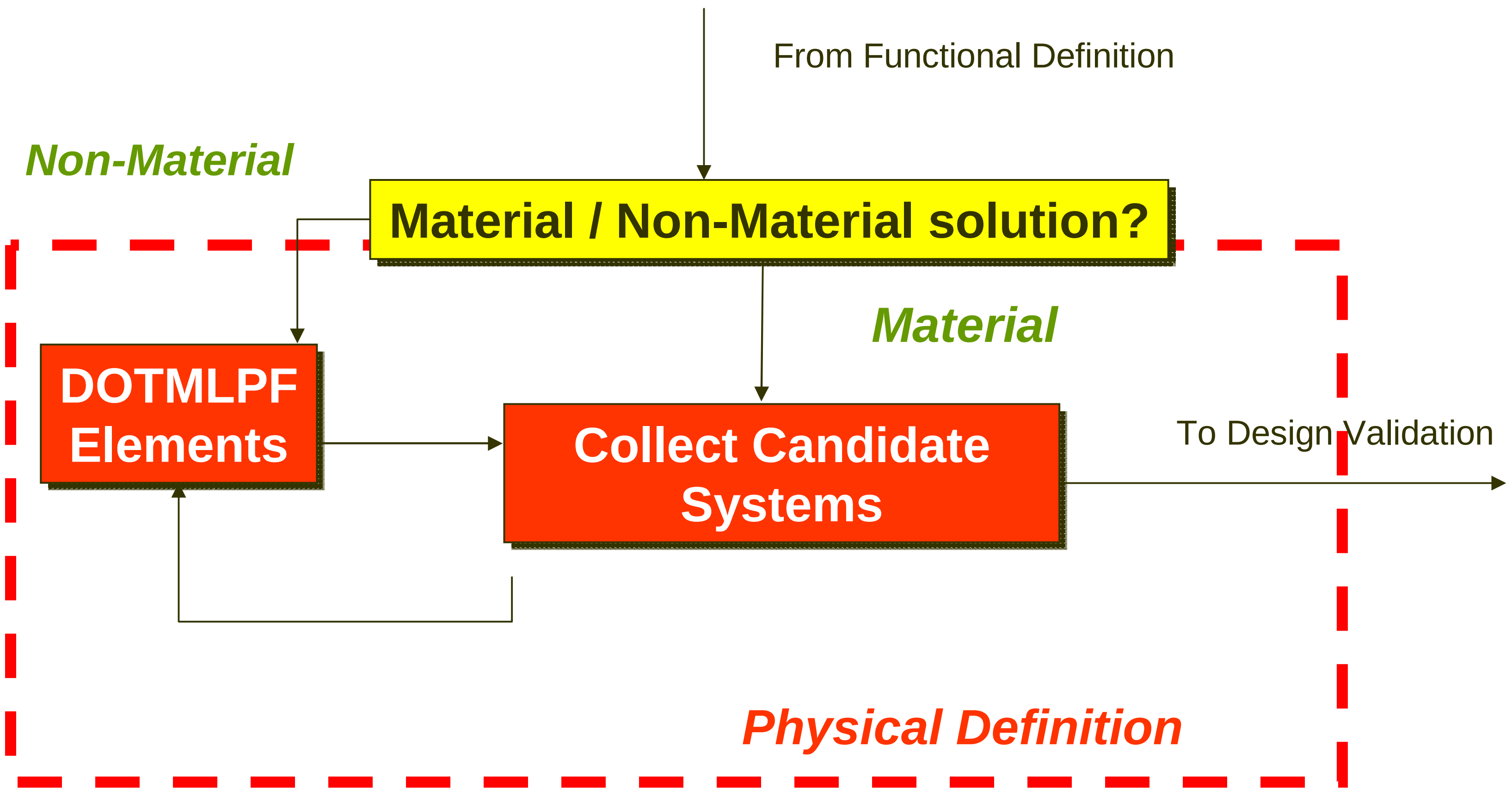
Functional Definition Products



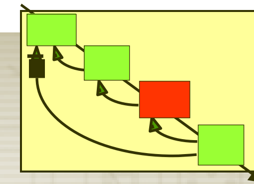
- Functional Decomposition of required activities
  - Functional diagrams (FFBD, UML AD)
- Associated metrics with these functions (threshold / objective?)
- Analysis process that determines if you can solve with a material / non-material / both solution
  - Be able to document and defend this process
- How do we know it's right?
  - The functions are legitimate, correct, and validated by users
- Functional Area Analysis
- Relevant operational views

Functional Analysis Documented in a SE Functional or Logical Model

Systems Engineering Method



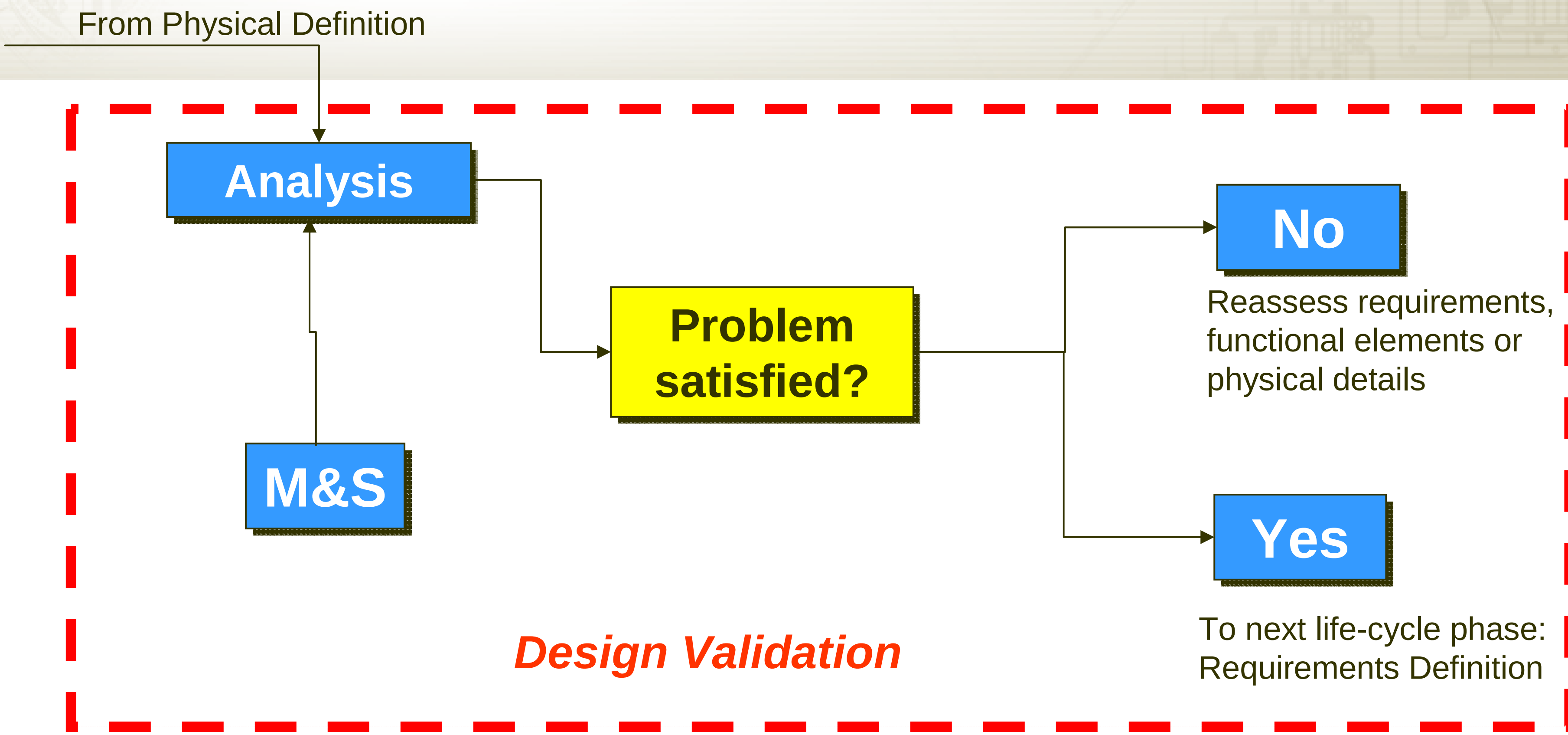
Physical Definition Products



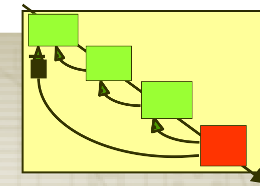
- Provide system alternatives towards satisfying required functionality
  - Assignment of functions to physical elements
- DOTMLPF analysis products
  - Based on the functional definition phase
- CONOPS changes / recommendations
  - Based on DOTMLPF analysis
- Risk management strategies of the system
- System roadmaps to bridge the gap between the current and future capabilities
- Functional Needs Analysis
- Relevant operational and SYSTEMS views

SE Logical Model with Physical Definition Begins Evolution Toward a Systems Model

Systems Engineering Method



Design Validation Products



- Demonstrate the analysis documents the assumptions, follows a rigorous process, and arrives at meaningful conclusions that are justifiable
  - There may be multiple processes and products dependent on the sponsor, personnel/time availability, experience
  - This may be an iterative process for ICD, CDD, CPD
- Trade studies
- VV&A
- Risk Management
- Cost Analysis
- Force Allocation
- Functional Solutions Analysis
- Program Independent Assessment

Attain a Fully Validated Systems Engineering Model

Architectures in JCIDS

- “Integrated Architectures” are a foundation for the analytical process
  - Stated requirements, attributes and measures
- Direct reference to DoD Architecture Framework (DoDAF), however:
  - Architecture is misused term within the realm of SE
- It is important to differentiate “architecture” from “architectural views”
- The JCIDS SE Model is the foundation for the architecture and the architectural views

Systems Engineering Model

- Model is a simplified view of a complex system
  - Assists stakeholders, including engineers, to understand something that is not easily comprehensible
  - Communicates the organization of the system to the stakeholders
- Rechtin
  - "Contributes to the structural stability of a system."
  - Enhances understanding of interfaces, relationships, operations and risk

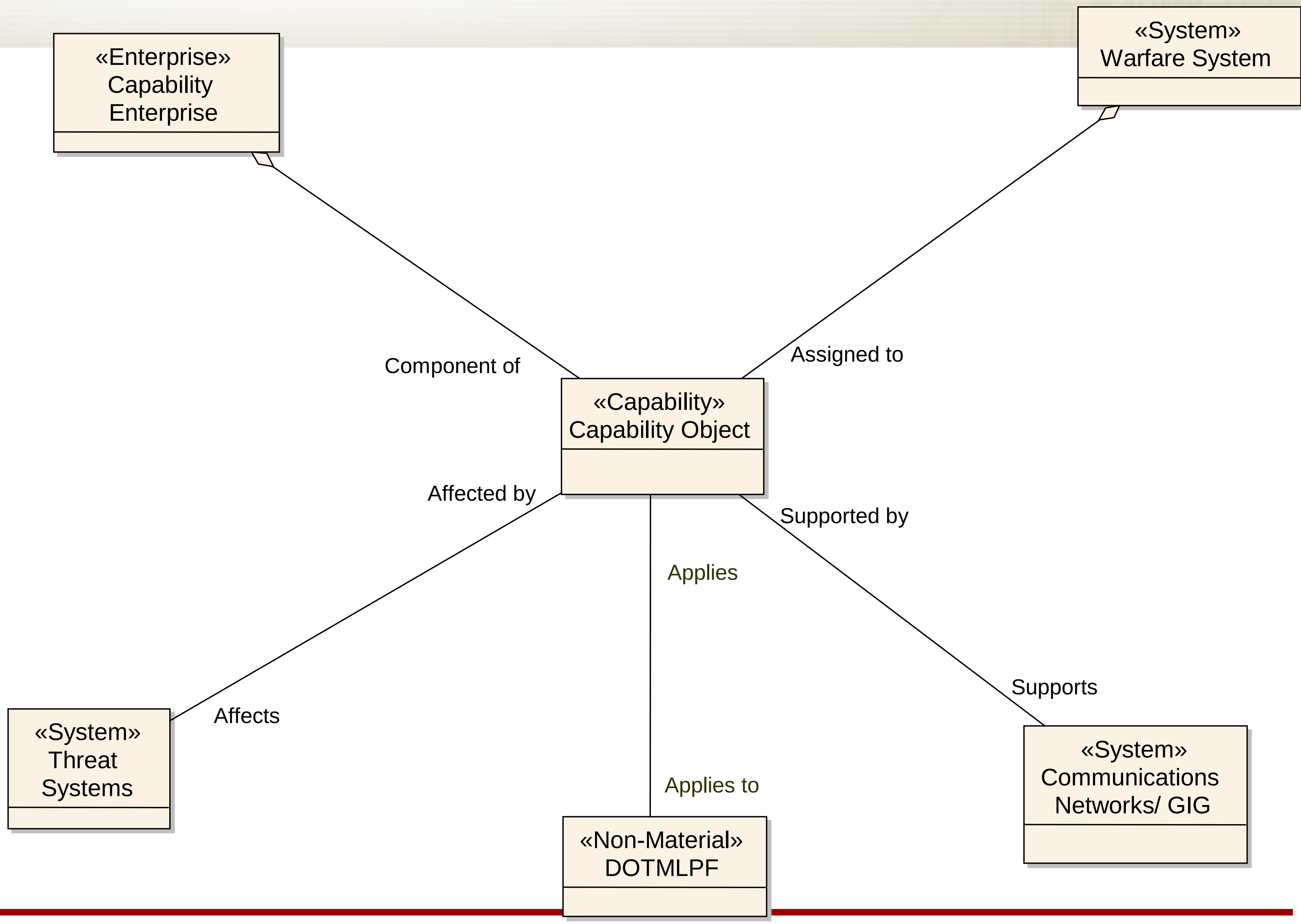
"If you don't model it, you won't understand it."
Ivar Jacobson

Model-Driven SE

- An Systems Engineering model captures the essential elements of the systems engineering life-cycle
- "Dynamic and recursive process" (Bootch, Rumbaugh, Jacobson)
  - Iteratively captures enterprise capabilities and systems requirements
  - Promotes incorporation of technology evolution
- Forms basis for a sound, long-term SE and analysis
  - Fully compliant with precepts of DoDAF and JCIDS

Model-Driven SE in Defense Systems Acquisition becomes Model-Driven JCIDS

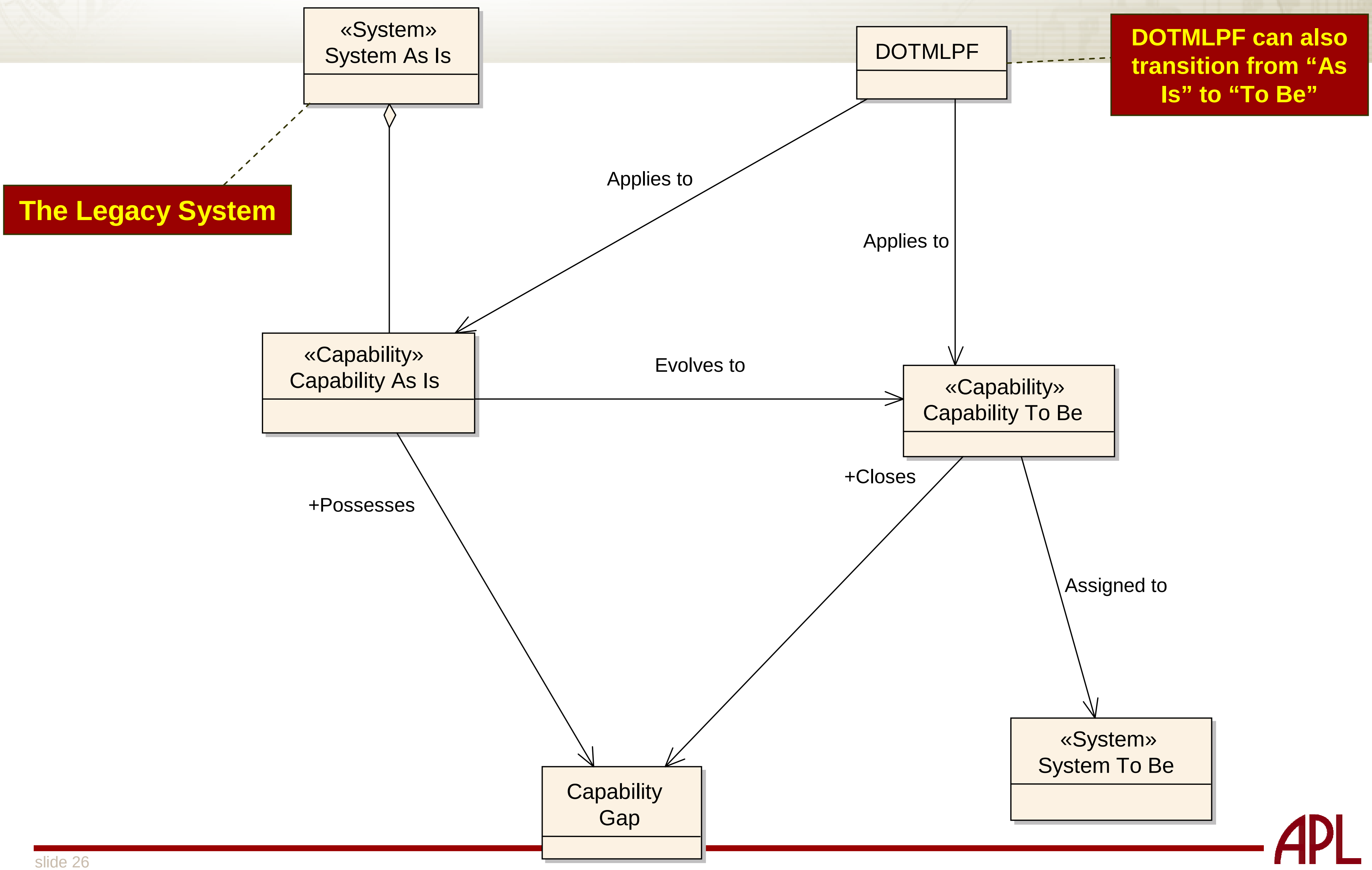
Context of the Capability Enterprise



DOTMLPF

- **Dot-mil-pe-ef'**
- **The "Non-Material" elements of the capability**
  - **D**octrine
  - **O**rganization
  - **T**raining
  - **M**aterial
  - **L**ogistics
  - **P**ersonnel
  - **F**acilities
- **Investigate if a modification to any element except the "M" will enhance the Capability Enterprise**
  - **A far less expensive option**

Transition from Capability to System



JHU/APL SE Methodology Linkage to JCIDS

- JHU/APL SE methods can be used to produce JCIDS products/artifacts
- JHU/APL SE methods can iterate throughout the DoD 5000 lifecycle
- Good SE methods can produce JCIDS
- Bad SE methods can produce JCIDS
- Producing JCIDS does not guarantee good SE

Good SE ⟷ Effective JCIDS

Final Thoughts

- JHU/APL has consistently provided SE expertise to numerous programs, following a rigorous and structured SE approach to the problem
  - "It's all about the data"
  - "It's all about the rigor"
- Program Offices have anchored their programs to our approaches and data

Summary

- Description of JHU/APL SE process
- JCIDS is consistent with good systems engineering practices
- JHU/APL SE process is consistent with JCIDS

The C-17 Systems Engineering Journey

Kenneth Sanger/John Slye/Chantal Joubert-Honacki

27 October 2005

Overview

- **More than 5,000 design changes per year have been made to the C-17, for the past three years (more than 1,000 major design changes per year)**
- **Formal systems engineering (SE) process established in 1998, instrumental in design development implementation**
- **Integral tie between C-17 SE process and overall process based management (PBM) plan**
- **Mission Assurance philosophy embedded in culture and processes**
- **Open communication and shared vision support true USAF/Boeing system engineering partnership**

Integration of Processes, Tools and Training to Reinforce the Role of SE in the C-17 Development Process

C-17 Systems Engineering

Strong and Getting Stronger

USAF/Boeing C-17 Program

1990 — 2000 — 2005

- Malcolm Baldrige National Award Winner
- CAPE Gold Level
- PMBP 4 of 5
- CMMI L5
- LEAN
- PMBP (SE) 3+/5
- ISO/BQMS 10,000 Perfect Score

Processes

PBM
- Defined processes and process hierarchy
- Process Discipline

9-Step Change Process
- Effective management of change

C-17 SEMP
- Based on value stream mapping
- Ensure full traceability and application across weapons system
- Risk-based qualification

C-17 SE Manual
- Defined SE Process, Products, linkage to PBM and Tailoring Approach

AV/FC/SE-SEMP
- Follows SE Manual
- Tailored to Avionics needs

C-17 SE Manual
- Updating to reflect ties to ISO, CMMI, Malcolm Baldrige, etc

Tools

SEAMS
- Repository for Project SE data
- Design Review Entry/Exit Criteria
- Used to develop/track SE Metrics

SEAMS Upgrade
- Program/block/project hierarchy
- Internal assessments
- Mission Assurance module

People

SE Training
- Systems Engineers

SEAMS Training
- Systems engineers and project managers

SE Training
- All Air Vehicle IPT engineers and managers

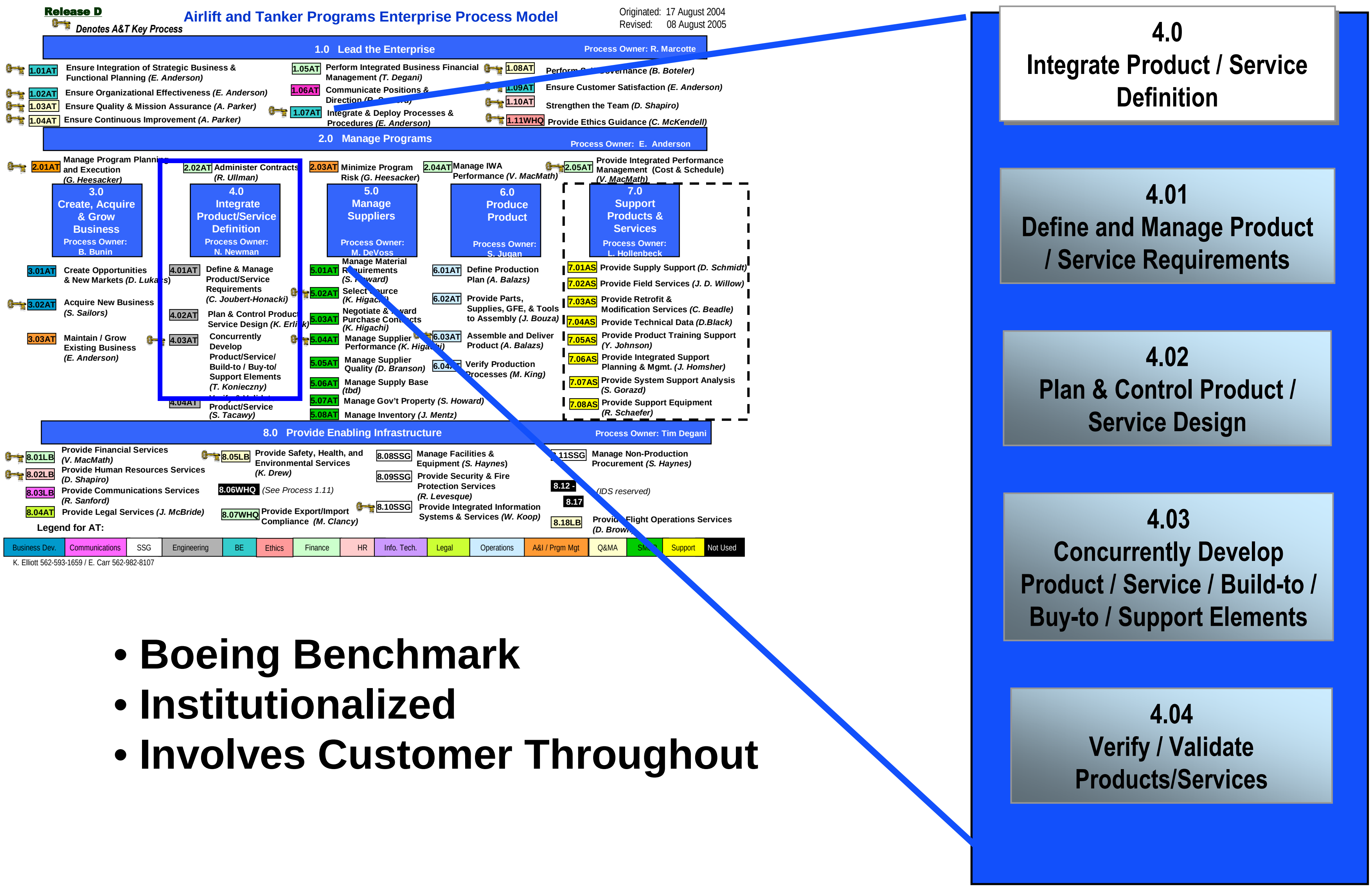
SE Organization
- Formed SE Group

IPT Deployment
- Systems Engineers Deployed to IPT Groups

SE Aligned
- Enrolled/Assigned
- Best Practices

Process Based Management Enterprise Model

USAF/Boeing C-17 Program



- **Boeing Benchmark**
- **Institutionalized**
- **Involves Customer Throughout**

Mission Assurance – The Third Dimension

USAF/Boeing C-17 Program

Domain expertise & experience - Independent Reviews

Baldrige National Quality Program

Overarching Framework
- Management Leadership
- High level visibility

Business Excellence

CMMI

Capability Maturity Model Integration

Doing
- Implementation
- Metrics driven

PMBP

Program Management Best Practices

Managing
- Maturity matrix
- Review feedback

Lean

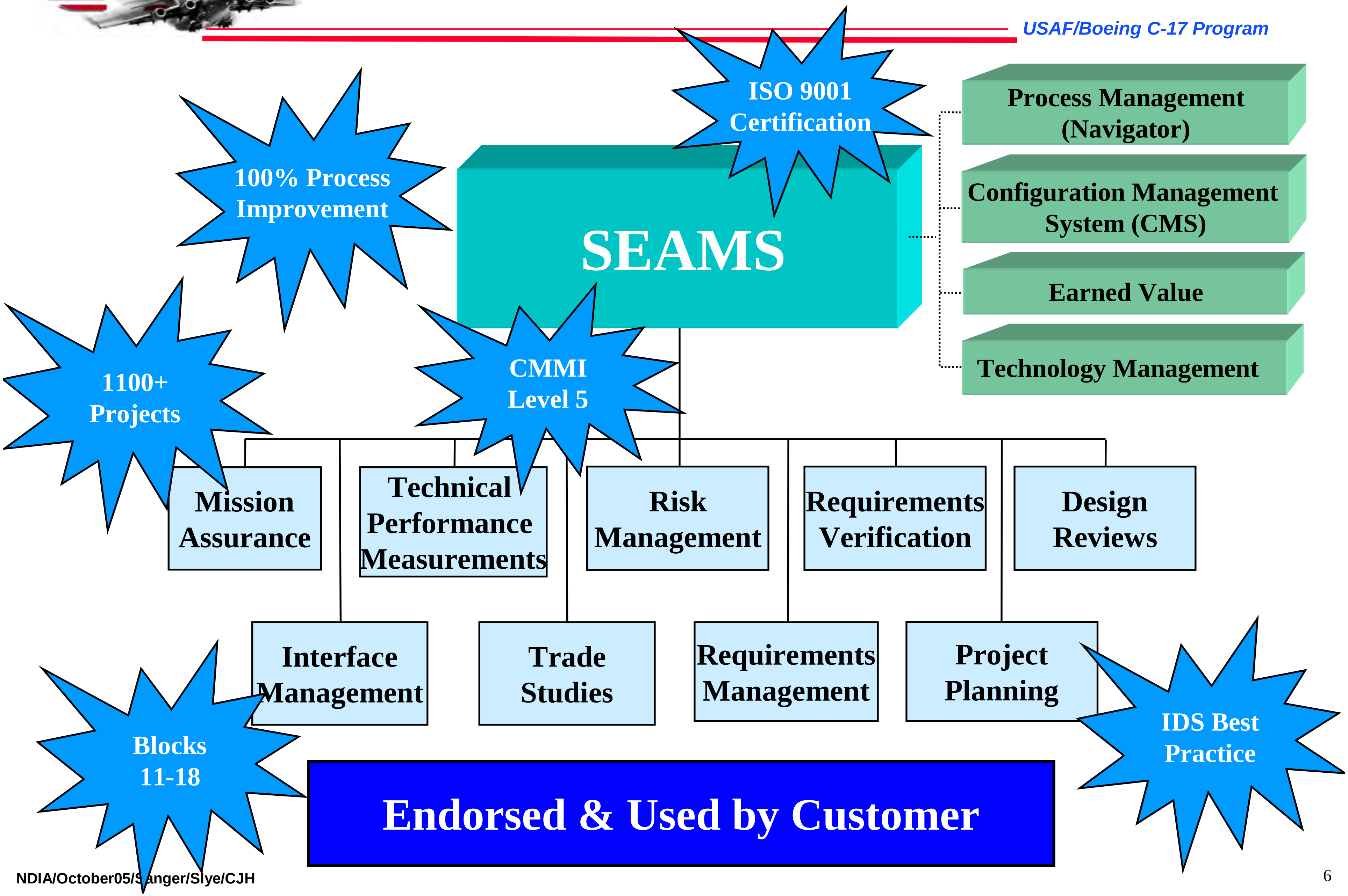
Lean Enterprise

Thinking
- End to End
- Value Stream Analysis

BOEING QUALITY BQMS MANAGEMENT SYSTEM

Being
- Quality in everything/culture
- Fundamental supporting concept

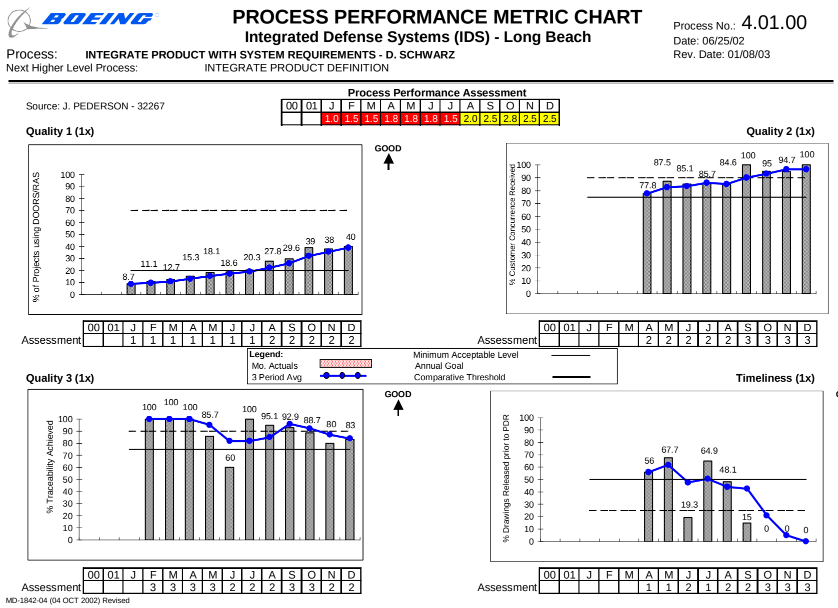
SEAMS Deployment Summary

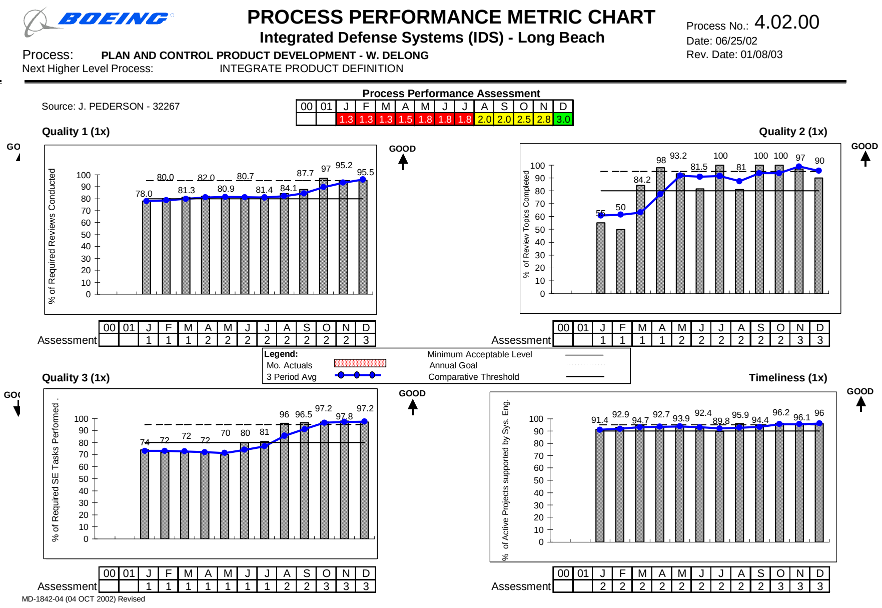


SEAMS Directly Supports Metrics

USAF/Boeing C-17 Program

- **Performance Metrics Defined and Coordinated With Internal and External Customers**
- **Project Data Used to Measure and Manage the Related Processes**
- **Root Cause and Corrective Action Triggered by Variances to Plan**





IDS Systems Engineering Training Plan

USAF/Boeing C-17 Program

Basic

- SE Methodology 40-hour course
- 1-day SE Overview
- Web-based training modules on SE
- Best Practices on-line training
- On the job Protégé Training

Intermediate

- Advanced SE Class
- 2 day SE Process Update
- Workshops on SE Tasks
- "How to" training in SE process areas
- Non-SE to SE Training/Mentoring
- SE Certificate Programs – UA Huntsville, UC Irvine

Advanced

- USC/UM Rolla Certificate and Masters in SE
- Stevens Institute of Technology Certificate, Masters and PhD in SE
- NPS/MIT Certificate and Masters in SE
- BLC 5-day Leadership in SE Training (in work)
- Mentor Junior Engineers

Lean VSM Process Outline

1. **Define the boundaries**
2. **Define the value**
3. **“Walk” the process**
   - **Identify tasks and flows of material and information between them**
4. **Gather data**
   - **Identify resources for each task and flow**
5. **Create the “current state” map**
6. **Analyze current conditions**
   - **Identify value added and waste**
   - **Reconfigure process to eliminate waste and maximize value**
7. **Visualize “ideal state”**
8. **Create the “future state” map**
9. **Develop and track action plans**

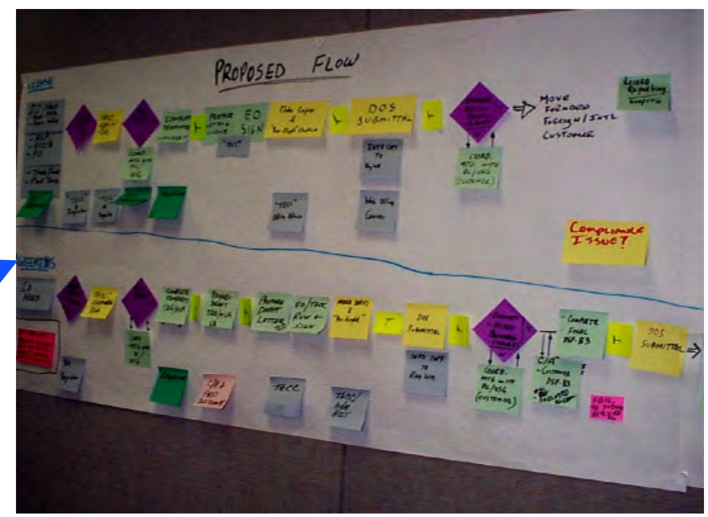


Photo source: Raytheon

SE Strategy Implementation Plan Integrates Short-Term and Long-Term Actions

USAF/Boeing C-17 Program

2005 — 2006 — 2016

☆ SEAMS V5 (Nov 2005)

☆ CAPE (Nov 2005)

☆ CMMI L5 Re-appraisal (Jun 2006)

C-17 SEMP
- Based on value stream mapping
- Ensure full traceability and application across weapons system
- Risk-based qualification

C-17 SE Manual
- Updating to reflect ties to ISO, CMMI, Malcolm Baldrige, etc

SEAMS Upgrade
- Program/block/project hierarchy
- Internal assessments
- Mission Assurance module

SE Training
- All Air Vehicle IPT engineers and managers

SE Aligned
- Enrolled/Assigned
- Best Practices

9 Focus Areas

SE Certification

Value Stream Mapping Process

Common Tools & Processes

SE Strategic Imperative

Best Practice (SE Survey)

Architecture

9 Improvement Projects

Conduct Accelerated Improvement Workshop (AIW) on requirements management

Template Procurement Specification

Implement Enrolled/Assigned
- Common processes
- Common training
- Shared vision

Engineering Best Practices CAP

Discipline to Processes

Rotation of People

Summary

- We Are Moving Toward Our Vision of Systems Engineering Excellence
- Process Based Management and Integrated Tools are Essential to Accomplishing Our Goals
- Training Is Essential to Deployment/ Sustainment
- Process Application Is Key to Institutionalization
- Application of Systems Engineering Process Execution Encompasses Everyone

BOEING®

Filling the Expertise Gap

LtCol Brad Smith
Deputy Director, AAC/EN

Briefing Outline

- Who are we?
- What are the challenges?
- What are we doing?

Who We Are

- *Eglin AFB* -- Nation's Center of Excellence for Air Armament
  - Develops, acquires, tests, fields, and sustains the Air Force's munitions inventory
  - Becoming a key joint training location, supporting joint training, testing and experimentation
  - A major provider of expeditionary combat support
- *AAC/EN* -- The Air Force's Center of Technical, Logistics and Program-Management Expertise
  - Develops and advances over 900 people and $48B in policies, processes and tools to deliver precision-strike capabilities to the warfighter.
  - Serves as the Acquisition Center of Excellence for the AAC, creating innovative strategies to rapidly field weapons to the warfighter.

Weapons to Warfighters…as promised!

Air Armament Center

What are the challenges?

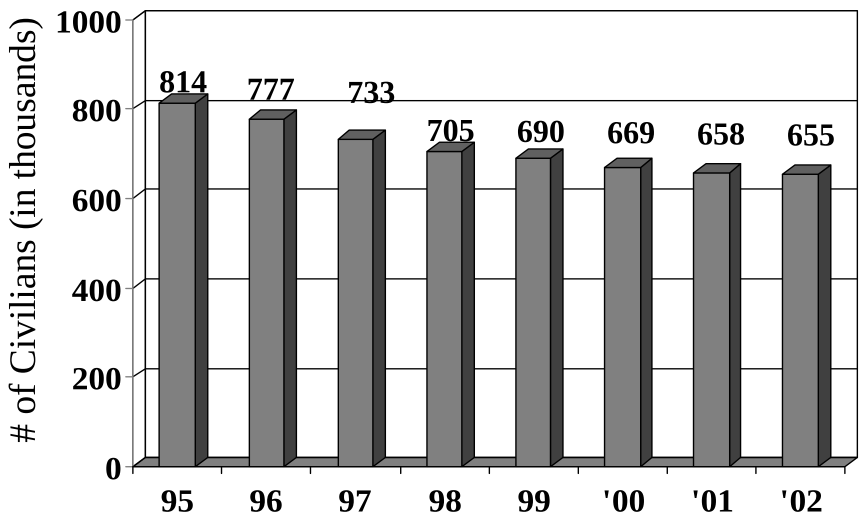
- Fewer program start-ups
- Employment downsizing
- Increasingly older workforce
- Declining graduate school enrollment

What are the challenges?

- Decline in number of new program starts
- Historically, infusion of weapon new starts (ACAT I) occurs every 3 years
  - Now focusing on incremental improvements
  - Fewer new starts, but weapons systems complexity continues to increase
- Reduced opportunity for workers to develop breadth by working across different programs and phases

What are the challenges?

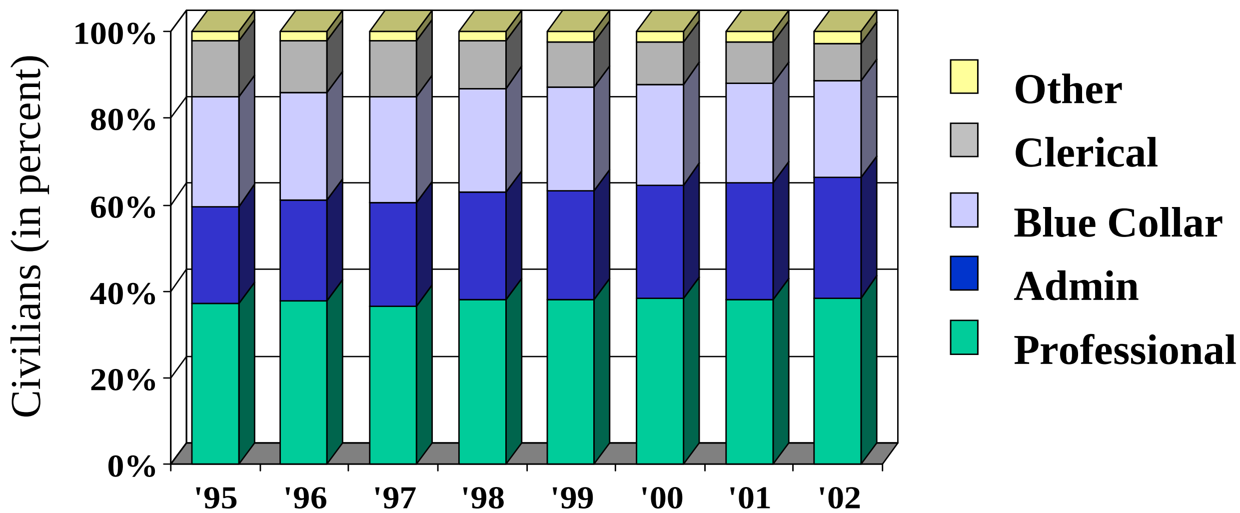
DoD Civilian End Strength



- **19.5% workforce reduction**
- **Fewer organic manpower slots in our program offices**

What are the challenges?

DoD Civilian Workforce

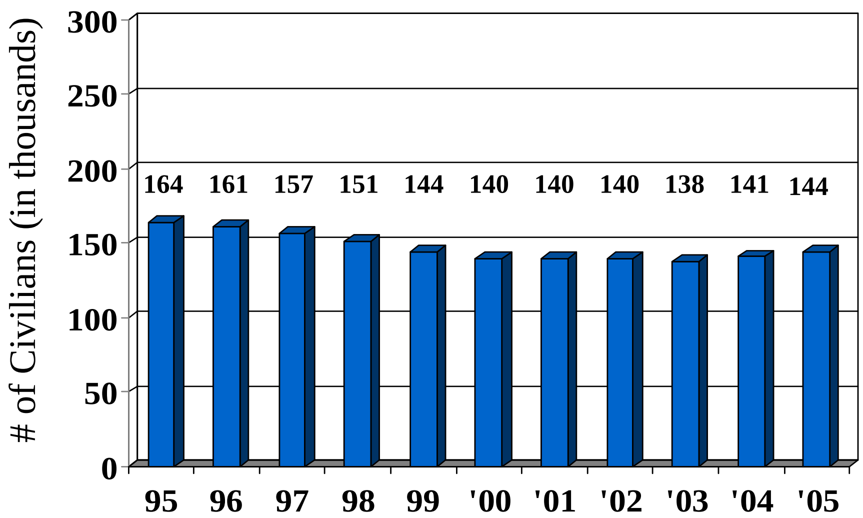


- **As civilian workforce shrinks, number of employees in professional career fields have remained constant**
- **Not seeing an increase in technical/professional workforce**
    - **AAC has come to rely heavily on A&AS contractors to meet increasing technical demand**

http://www.cpms.osd.mil/dlamp/education/conf2003/raney.ppt

What are the challenges?

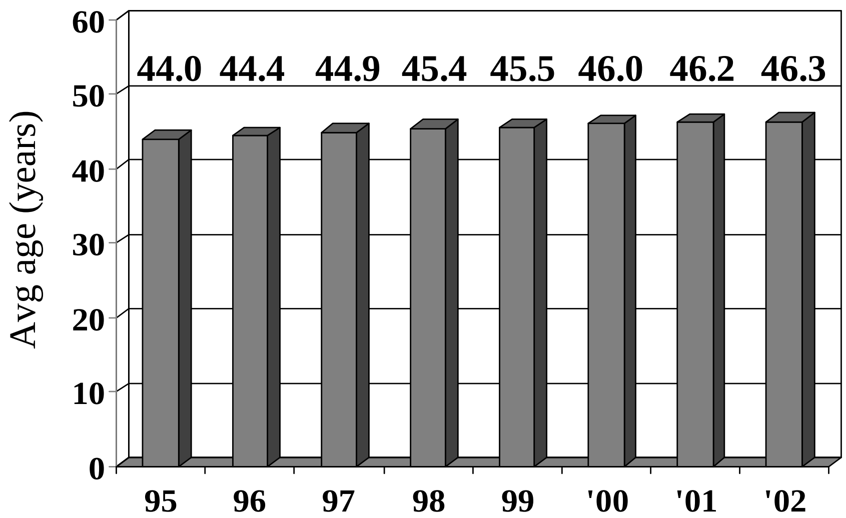
AF Civilian End Strength



- **Workforce strength "flat" for last 7 years**
- **Hiring and retaining skilled civilian workers have not changed significantly**

What are the challenges?

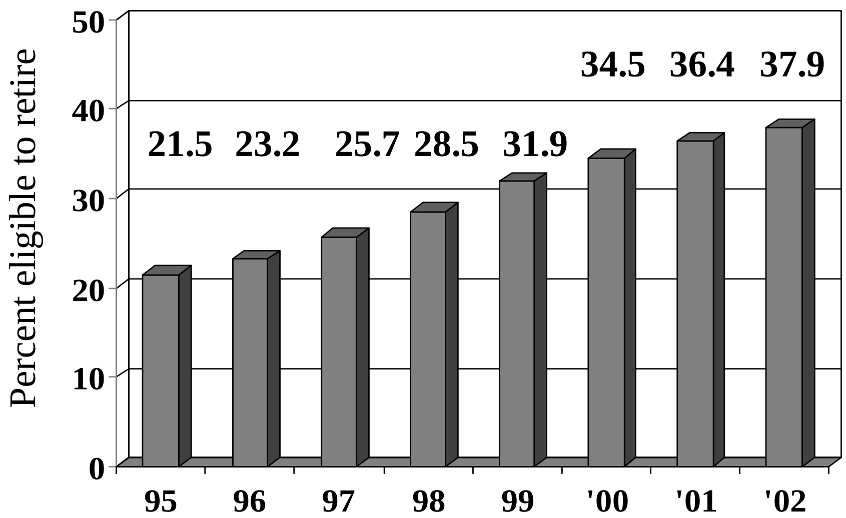
Age of DoD Civilian Workforce



- **Phenomena driven by baby boom population**
- **Currently 48.2% of US work is 40+ years old; will increase to 51.4% in 2010**
- **DoD workforce shows same aging trend**

What are the challenges?

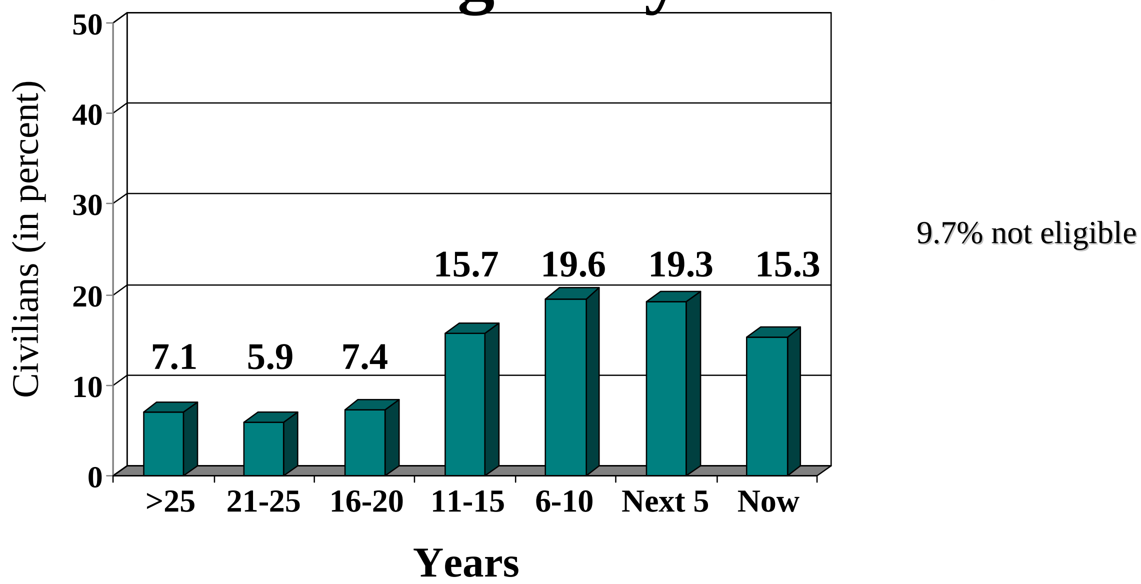
Retirement Eligibility of DoD Civilian Workforce



- **Retiring baby boomers make up about 1/3 of US workforce**
- **Estimated 40% DoD employees currently eligible to retire; increases to 60% in next 3 to 5 years**
- **Not enough younger workers to replace retiring workers**

What are the challenges?

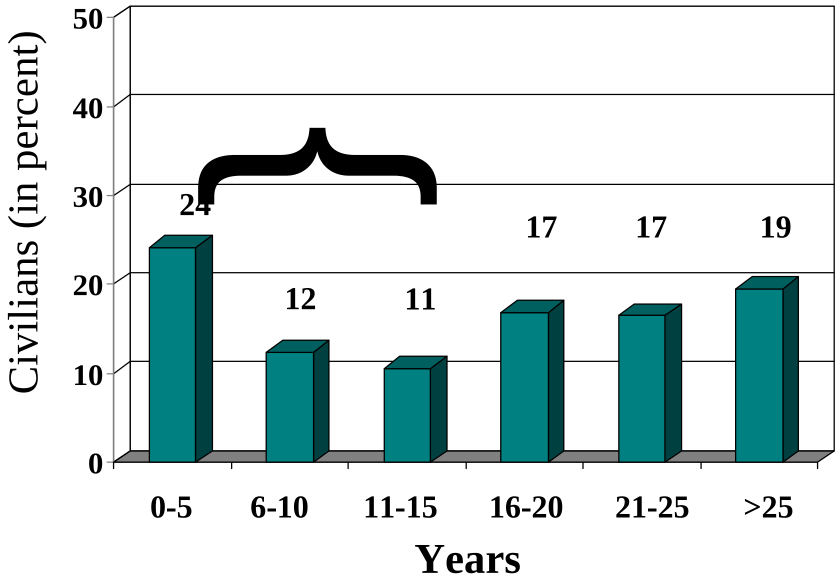
Retirement Eligibility of AF Civilian Workforce (2005)



- **Technical workforce make up the majority of retirement eligible**
- **Translates into severe workforce shortage of skilled, educated and experienced workers**
- **Affects IT, Science & Technology, and Engineering careers**

What are the challenges?

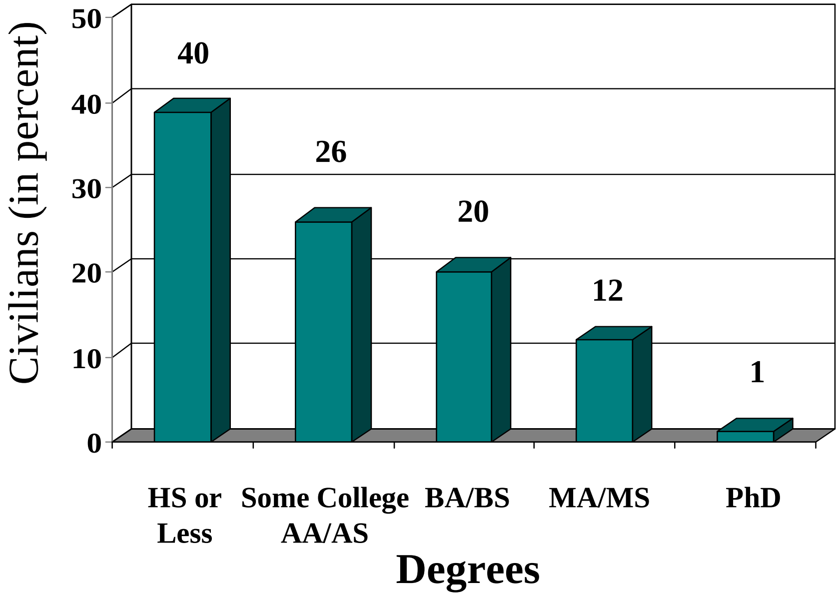
Career Tenure of AF Civilian Workforce (2005)



- **Must focus attention on junior workforce to balance retirement-eligible workforce**
- **Need to identify and accelerate organization-specific training to improve capabilities of junior workforce**
- **Requires intervention to groom junior workforce to fill vacating leadership positions**

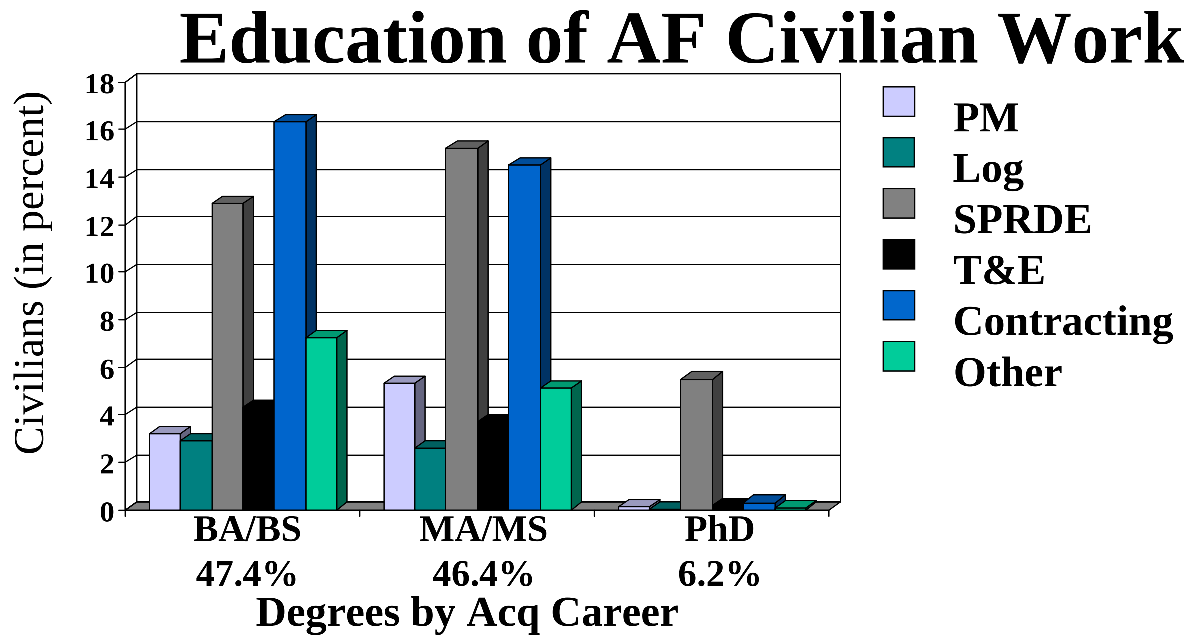
What are the challenges?

Education of AF Civilian Workforce (2005)



- **Majority of workforce does not possess an advanced degree**
- **Increased technical complexity of systems creates additional demand for advanced degrees**

What are the challenges?



- S&E career fields – government positions often considered less attractive that many commercial technical positions
- Significant time and financial commitment of earning an S&E graduate degree compared to other professional degrees
- Complexity of systems creates increased demand

Our Solution

To capture knowledge, wisdom, and experience by:

- Recruiting new talent
  – PALACE ACQUIRE Program
  – Local University/Education Programs
  – NSPS
- Educating & Preserving Knowledge
  – System Engineering Certification
  – Air Armament Academy
  – Acquisition Excellence Organization

Our Solution

Recruiting

- Uses Air Force PALACE ACQUIRE program to maintain a leading edge in today's technology-intensive recruiting environment
  - Offers 2-3 year training programs for college graduates
  - Tuition reimbursement for graduate school
  - Frequently leads to full time employment
- AAC has acquired 64 of the 873 Air Force Interns
- AAC also has a very active college recruiting program to attract new talent to the center

Education

University of Florida (satellite campus)

- Supports graduate engineering education and research needs
- Academic programs lead to Master of Science and PhD degrees in Aerospace, Mechanical, Electrical/Computer Engineering, and Industrial/Systems Engineering
- Allows cross flow of students into AAC
  - Education for AAC workforce
  - Students support research & technology development
- Also offer a number of other university degree programs on base to encourage education

National Security Personnel System

- AAC closely examining proposed NSPS system
- Improved Hiring Flexibility
  - Provisions for direct hiring authority of critical needs and severe shortages
  - Speed up hiring process
- Performance Management
  - Ties job performance to new pay band system
  - Intended to attract, develop retain and reward high performing employees

AAC's Solution

Systems Engineering Certification

- Senior leaders communicated support throughout enterprise
- Program develops and trains engineers and scientists to implement systems engineering with rigor within their individual programs/projects
- Closely aligned with new OSD & Air Force initiatives to enhance DoD system engineering processes

AAC's Solution

A3 – Air Armament Academy

- Transformed AAC into a learning organization
- Captures and shares collective learning assets (the "know-how" and the "know-why")
- Designated training days integrates learning as a part of everyone's daily activities
- Everyone in the center is involved in teaching, learning and supporting continuing education

A3 Structure

President
MG Chedister

Vice President
AAC/CV

A3 Provost
AAC/DP

A3 Project Manager
AAC/DP

College of Acquisition

Dean – AAC/CA

Associate Dean
AAC/EN

College POC
Acting: A3

Departments

Air-to-Air Wg
Air-to-Ground Wg
Combat Supt Gp
XR EN FM PK AE

College of Test & Evaluation

Dean – Test Wing

Associate Dean
Test Wing

College POC

Departments

DT SK
MX TS
XP OG
OT (53rd WG)

College of Science & Technology

Dean – AAC/CA

Associate Dean
ARL/MN

College POC

Departments

MNA MNO
MNG MNK
MNM MNF

College of Install Sustainment & Management

Dean – ABW

Associate Dean
Air Base Wing

College POC

Departments

CE CG MD MS
CPTS CONS MEO
AAC Staff (IG EEO PA
DP SE HO XP)

A3 Curriculum Board Members

Acquisition Excellence

- New division within AAC Engineering Directorate
- Acquisition Center of Excellence
  - Repository for lessons learned
  - Center for acquisition policy & strategy
  - Assist in all phases of acquisition
- Program Management Division
  - Home office for Program Managers
  - Central role in Program Management career development and career broadening
    - Better manage rotation of Program Managers to ensure we are developing people with the right experience
    - Manage training, education and experience to assure proper development for future leaders

Challenge Summary

- Our senior expertise is moving towards retirement (both organic and contractor support)
  - Strong need to replace retiring workers
  - Must train, educate & mentor new workforce
  - Challenge due to reduced pool of S&E recruits
- ***AAC/EN*** has designed initiatives to capture knowledge, wisdom, and experience for developing future workforce

Questions?

Who Are We?


SDB
FLIGHT TESTING
REAL WORLD...
REAL SUCCESS!
Small Diameter Bomb
"Sometimes BIG things come in small packages"
SDB

JASSM

PBEV℠

Performance-Based Earned Value®

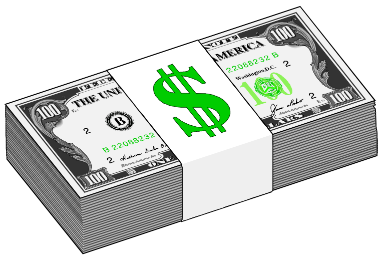
NDIA Systems
Engineering Conference
San Diego, CA
October 27, 2005

Paul J. Solomon PMP
Performance-Based Earned Value
SolomonPBEV@msn.com

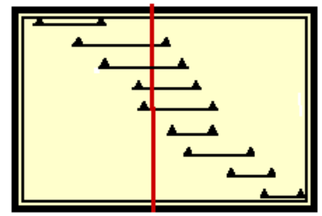
Agenda

- Is Earned Value Management (EVM) Working?
- DoD Acquisition Policy
- Systems Engineering (SE) Standards
- Performance-Based Earned Value® (PBEV℠)
- Supplier Acquisition Management
- Process Improvement

Does EVMS Really Integrate?

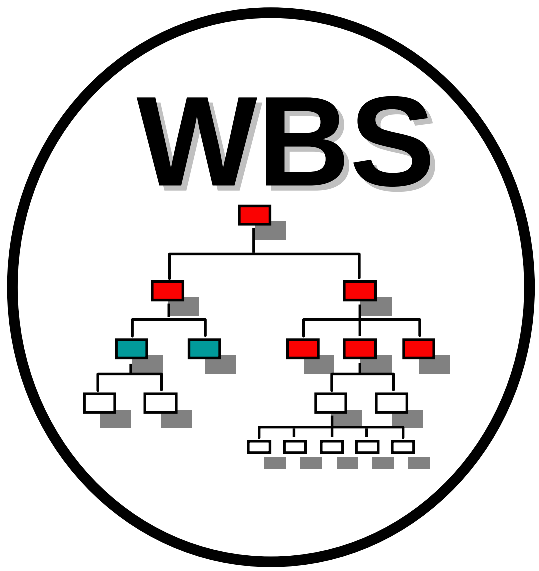


EVMS



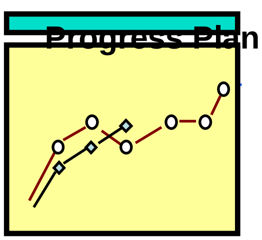
COST

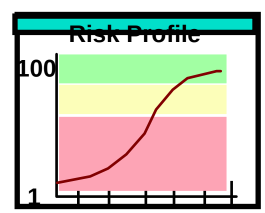
SCHEDULE



TECHNICAL PERFORMANCE

RISK





Technical Performance Measures (TPM)

Value of Earned Value

EVM data will be reliable and accurate only if:

- The right base measures of technical performance are selected and
- Progress is objectively assessed.

EVMS 3.8: EVMS measures quantity of work, <u>not</u> quality and technical content

Revitalization of SE

M. Wynne and M. Schaeffer, OUSD Acquisition, Technology & Logistics (AT&L):

"Definite linkage between

- **Escalating costs and**
- **Ineffective application of SE."**

"The earlier that requirements are intensively managed by the SE processes,

the greater the likelihood that the program's cost and schedule estimates will be on target."

PBEV℠

DoD Policy & Guidance on SE

Policy for Systems Engineering in DoD (Policy), 2/20/04

Defense Acquisition Guidebook (DAG), 10/8/04

Systems Engineering Plan Preparation Guide (SEP), 10/8/04

"DoD Handbook, Work Breakdown Structures MIL-HDBK-881A (WBS), 7/30/05

PBEV℠

DoD Policy & Guides

Policy or Guideline (1 of 2)	Policy	DAG	SEP	WBS
Develop ***Systems Engineering Plan (SEP)***	P	4.2.3.2	1.0	
Event-Driven Timing of ***Technical Reviews***	P	4.5.1	3.4.4	3.2.3.1
Success Criteria of Technical Reviews	P	4.5.1	3.4.4	3.2.3.1
Assess ***Technical Maturity*** in Technical Reviews		4.5.1	3.4.4	3.2.3.1
Integrate SEP with: • ***Integrated Master Plan*** • ***Integrated Master Schedule*** • ***Technical Performance Measures (TPM)*** • ***EVM***		4.5.1	 3.4.5 3.4.5 3.4.4 3.4.5	

DoD Policy & Guides

Policy or Guideline (2 of 2)	Policy	DAG	SEP	WBS
Use *TPMs* to Compare: Actual vs. *Planned Technical Development* and *Design Maturity*		4.5.5	3.4.4	
Use *TPMs* to Report Degree to Which *System Requirements are Met* in Terms of Performance, Cost, and Schedule		4.5.5	3.4.4	
Use *Standards and Models* to Apply SE		4.2.2 4.2.2.1		
Requirements Management and Traceability		4.2.3.4	3.4.4	2.2.3
Use *EVM*		11.3.1		1.4.2

PBEV℠

Product Requirement

<u>IEEE 1220: Product Requirement</u>

Requirement: Statement that identifies a product characteristic or constraint.

- **Operational, functional or design**
- **Unambiguous, testable or measurable**
- **Necessary for product acceptability by**
  - **consumer or**
  - **internal quality assurance guidelines**

Functional Requirement

IEEE 1220:

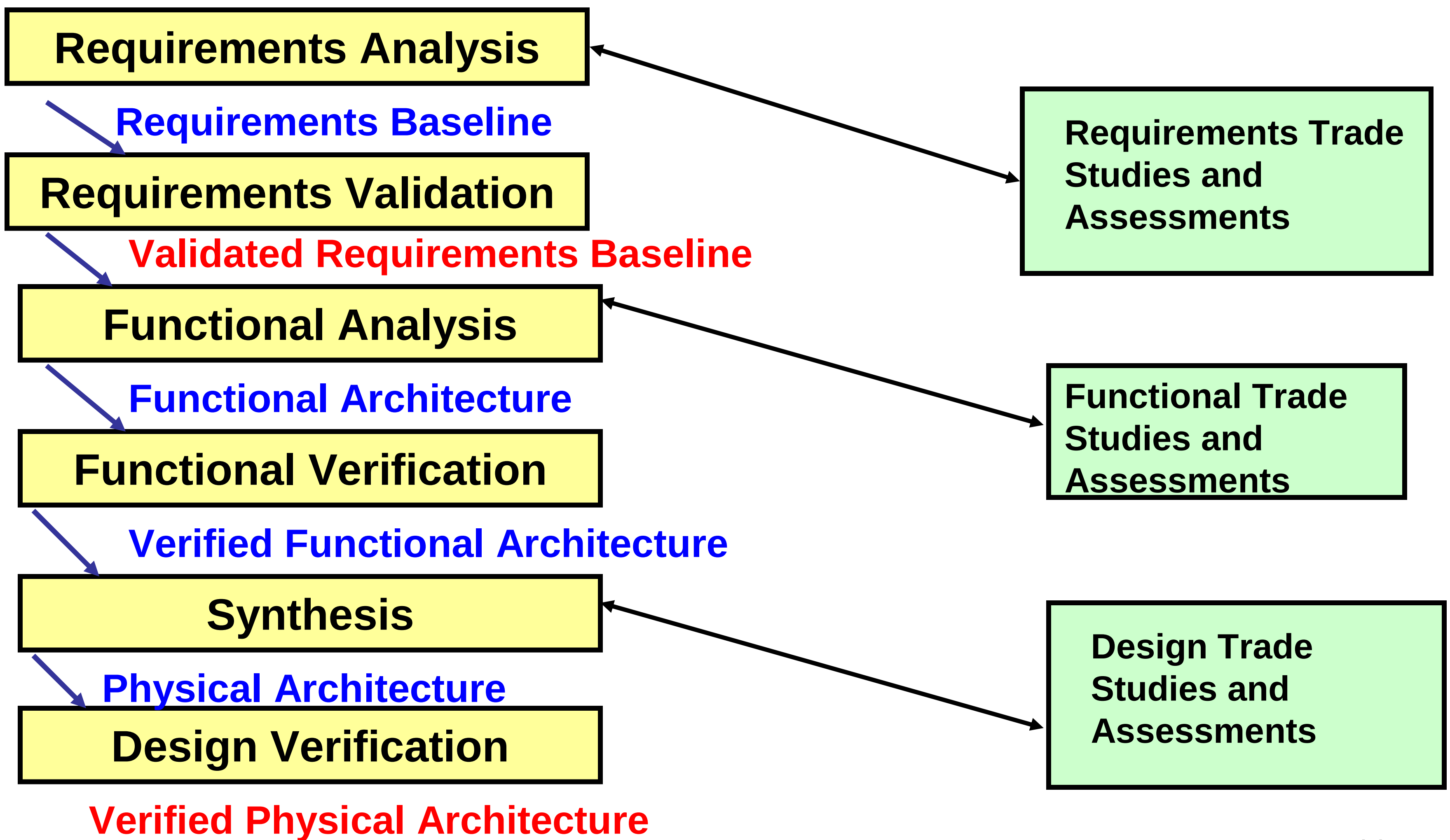
Define the functional requirements

- ***What* the system must *do* (6.1.10)**

For each function, define the performance requirements

- ***How well* the functional requirements must be *performed* to satisfy the Measures of Effectiveness (MOE) (6.1.11)**

SE Life Cycle Work Products IEEE 1220

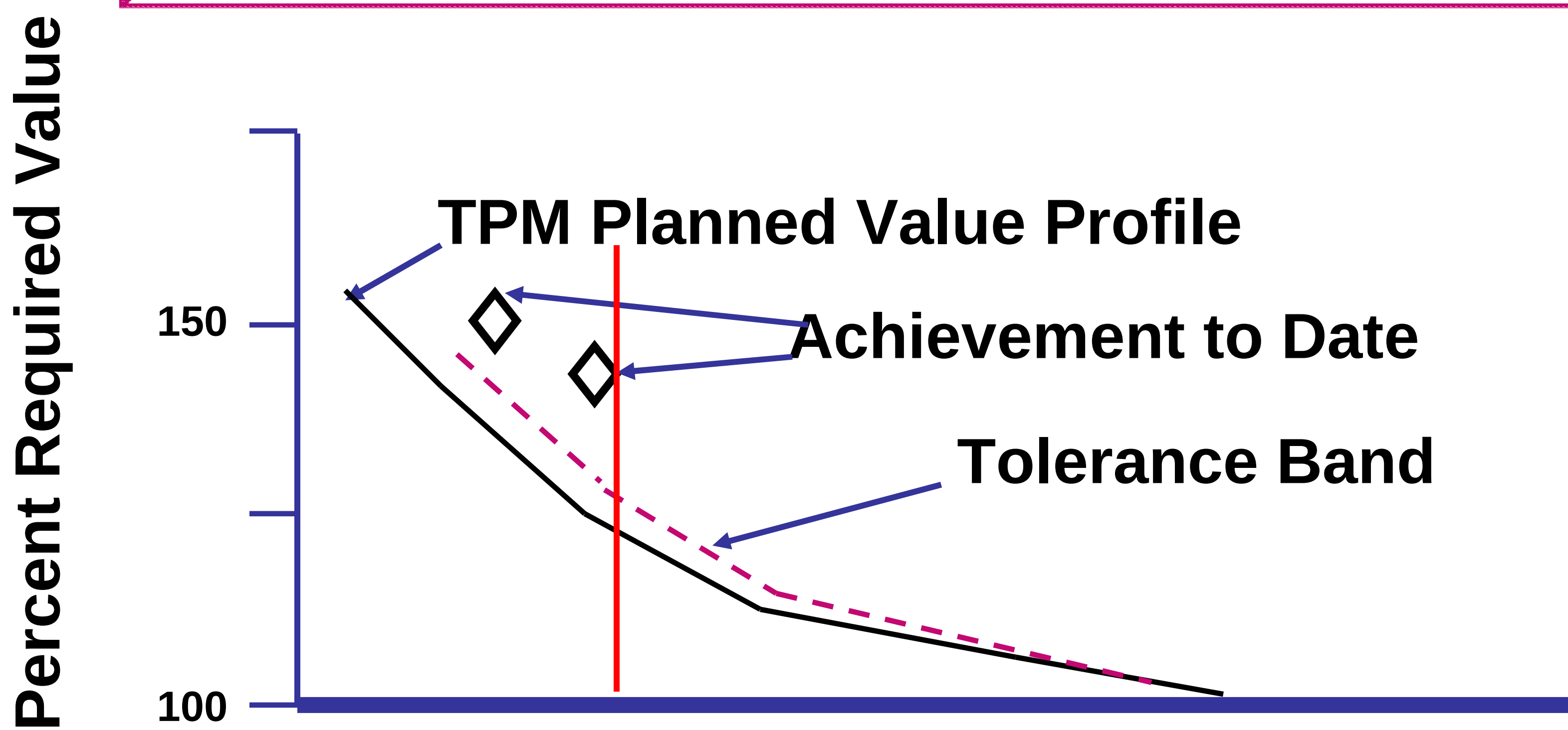


Requirements Progress

Performance-Based Progress Measurement	IEEE 1220	EIA 632
Product metrics:	☑	☑
• Ability to satisfy requirements	☑	☑
• Quality of product	☑	☑
• Development maturity	☑	
• TPMs	☑	☑

TPM

Use TPMs as a Base Measure of Earned Value

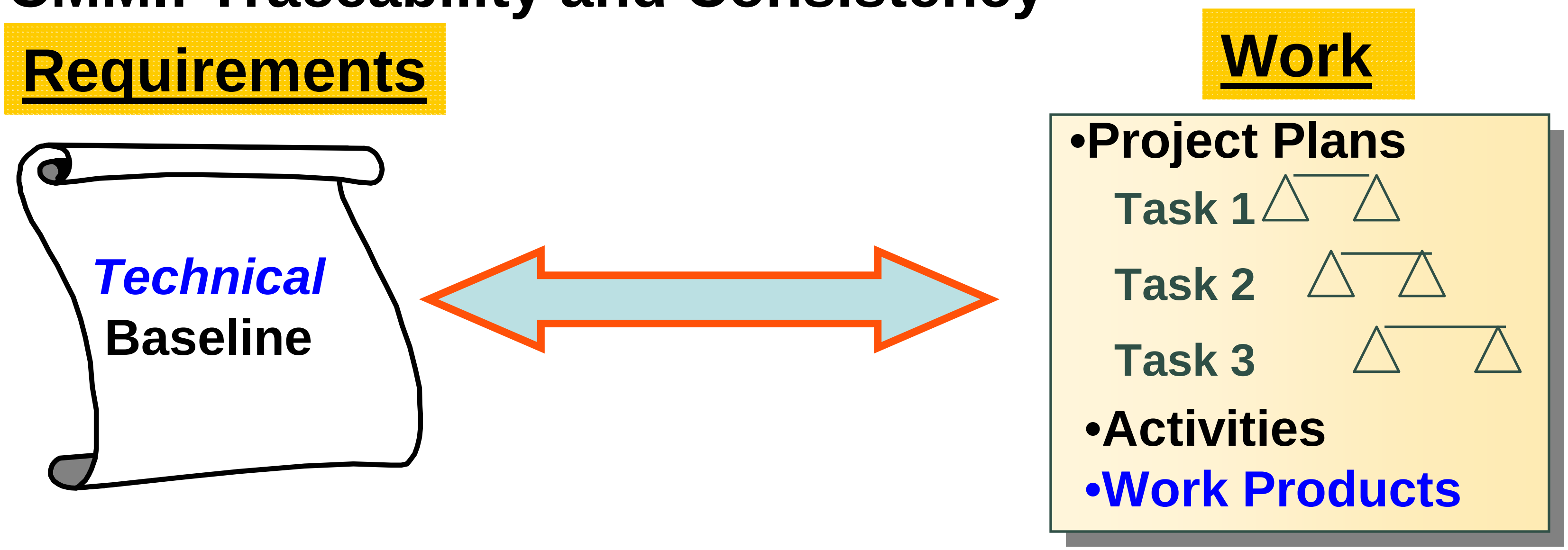


Success Criteria of Technical Reviews

IEEE 1220: Detailed design stage
System review • **Detailed design satisfies system baseline (5.3.4.3)** • **Design solution meets (6.5.11)** – Allocated functional and performance requirements – Interface requirements – Constraints • **Design verification complete (6.6)** – Each requirement and constraint is traceable to the verified physical architecture (6.6.2) – Design element solutions satisfy the validated requirements baseline (6.6.2)

Product Requirements

- **CMMI: Traceability and Consistency**



PBEV

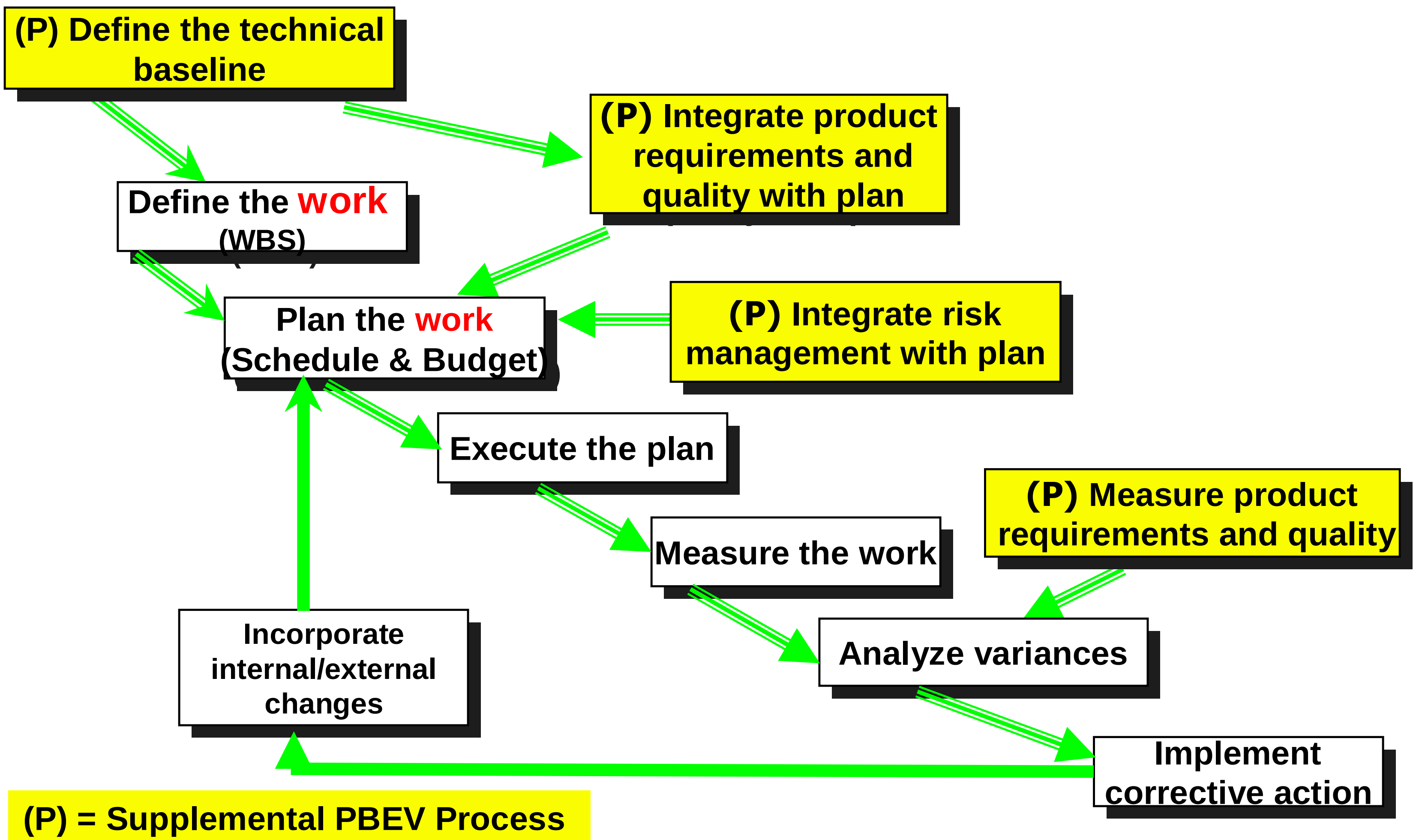
- 4 Principles
  - 16 Guidelines
- Requirements-driven plan
- Measures technical performance
- Consistent with standards and models
- Tailorable according to risk
- Lean

PBEV℠

Principles of PBEV

1. Integrate product requirements and quality into the project plan.
2. Specify performance towards meeting product requirements, including planned quality, as a base measure of earned value.
3. Integrate risk management with Earned Value Management.
4. Tailor the application of PBEV according to the risk.

EVMS and PBEV Process Flows



PBEV℠

PBEV Guidelines

1.1 Establish the *technical* and *product baselines* and *allocate* the *product requirements* to the product components.

1.2 Maintain *bidirectional traceability* of *product* and product component *requirements among:*

- **Project plans**
- **Work packages**
- **Planning packages**
- **Work products.**

PBEV Guidelines

2.2 Specify *work products* and performance-based *measures* of progress for meeting *product requirements* as *base measures of earned value*.

2.4 Identify *event-based success criteria* for technical reviews (entry and exit criteria):

- ***Development maturity to date***
- **Product's *ability to meet product requirements*.**

PBEV Guidelines

2.5 Establish:

- **Time-phased, planned values for measures of progress towards meeting product requirements**
- **Dates or frequency for checking progress**
- **Dates when full conformance will be met.**

2.6 Allocate budget in discrete work packages to measures of progress towards meeting product requirements.

TPM Example

- Work Package Statement of Work and Budget
  - 100 drawings over 5 months
  - TPM constraint: 300 pound limit
  - TPM measurable by analytical model when drawings are 80 % complete (4th month)
  - Budget at Completion (BAC): 5000 hours
  - TPM Achievement worth 10% (500 hours)
- EV Method and Values
  - Take EV @ 50 hours / drawing
  - Negative EV of 500 hours if 300 pounds not achieved when planned

PBEV℠ Requirements Met Example

EV based on drawings and requirements

- **50 drawings @ 36 hours = 1800**
- **2 structural requirements met @ 25 = 50**
- **15 other requirements met @ 10 = 150**

Time-phased BCWS based on schedule

Total design BCWS	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
Drawings	288	360	432	360	360			1800
Requirements			30	30	40	70	30	200
Total BCWS	288	360	462	390	400	70	30	2000

Trade Study Example

Trade Study Base Measures: Evaluate Alternatives	Time Period
Initial evaluation of each of 5 candidates has three milestones: • Start test set up • Tests executed to completion • Analyze and document	 1 2 3
Down select from 5 candidates to 2 candidates	3
Document recommendation	4

Supplier Acquisition Management

How to Get Contractors to Integrate SE with EVM?

- SE standards and SEP in solicitation, contract
- Integrated Baseline Review (IBR):
  - Review SEP
    - Entry and success criteria for technical reviews
    - Requirements management and traceability process
    - TPMs
  - Review IMS
    - Event-driven technical reviews
    - Milestone success criteria
    - SE life cycle work products
    - Control points for product metrics, including TPMs

Supplier Acquisition Management

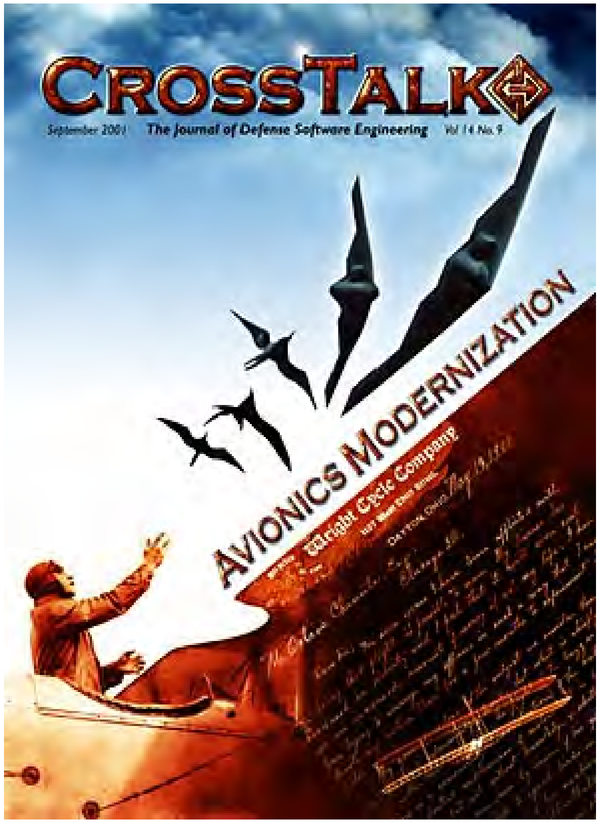
How to get contractors to integrate SE with EVM?

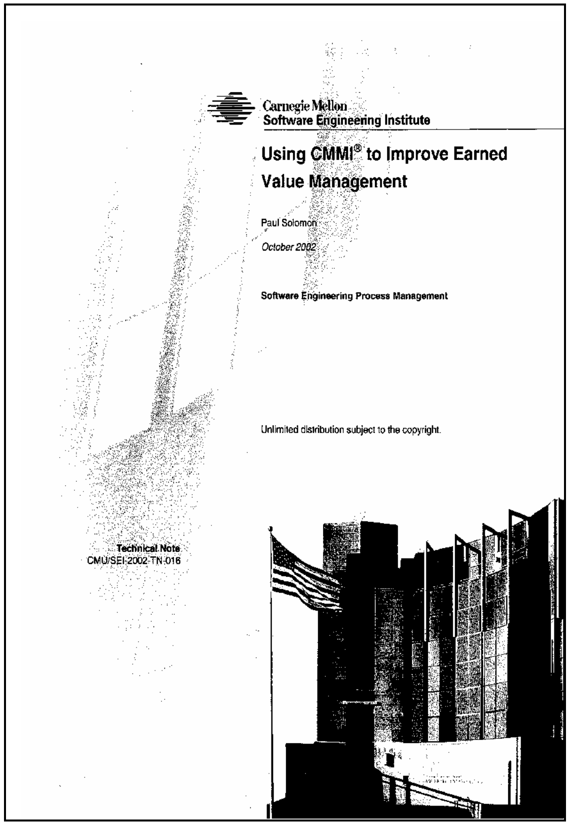
- **IBR continued:**
  - **Confirm integration with EVM**
  - **Review product requirement measures**
  - **Review approach for requirements traceability**
- **Monitor progress and process**
- **Incentives to meet success criteria and planned TPM values**
- **Perform independent assessments**

PBEV Benefits

- Integrate
  - Systems Engineering with EVM
    - Product requirements and quality baseline
    - SE life cycle work products
    - Technical performance measures
    - Success criteria of technical reviews
  - Technical>schedule>cost performance
- Lean process
  - Less work packages with right base measures
- Agile

Process Improvement





Carnegie Mellon
Software Engineering Institute

Using CMMI® to Improve Earned Value Management

Paul Solomon

October 2002

Software Engineering Process Management

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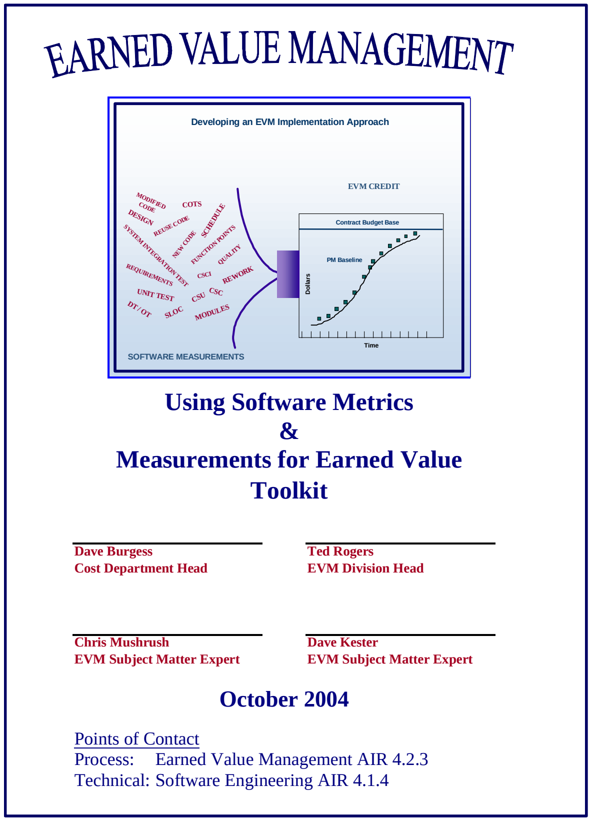
Technical Note
CMU/SEI-2002-TN-016



EARNED VALUE MANAGEMENT

Developing an EVM Implementation Approach

Using Software Metrics
&
Measurements for Earned Value
Toolkit

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Dave Kester
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October 2004

Points of Contact
Process: Earned Value Management AIR 4.2.3
Technical: Software Engineering AIR 4.1.4

DoD **SEI / CMMI** **NAVAIR**

Performance-Based Earned Value®
By Paul Solomon & Ralph Young

To be Published by:

IEEE COMPUTER SOCIETY

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PBEV℠

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State Machine Modeling of TPED and TPPU

Mr. Ron Funk (DRDC)

Mr. Rick Sorensen (Vitech Corp.)

NDIA 8th Sys Engr Conference, San Diego

27 October 2005

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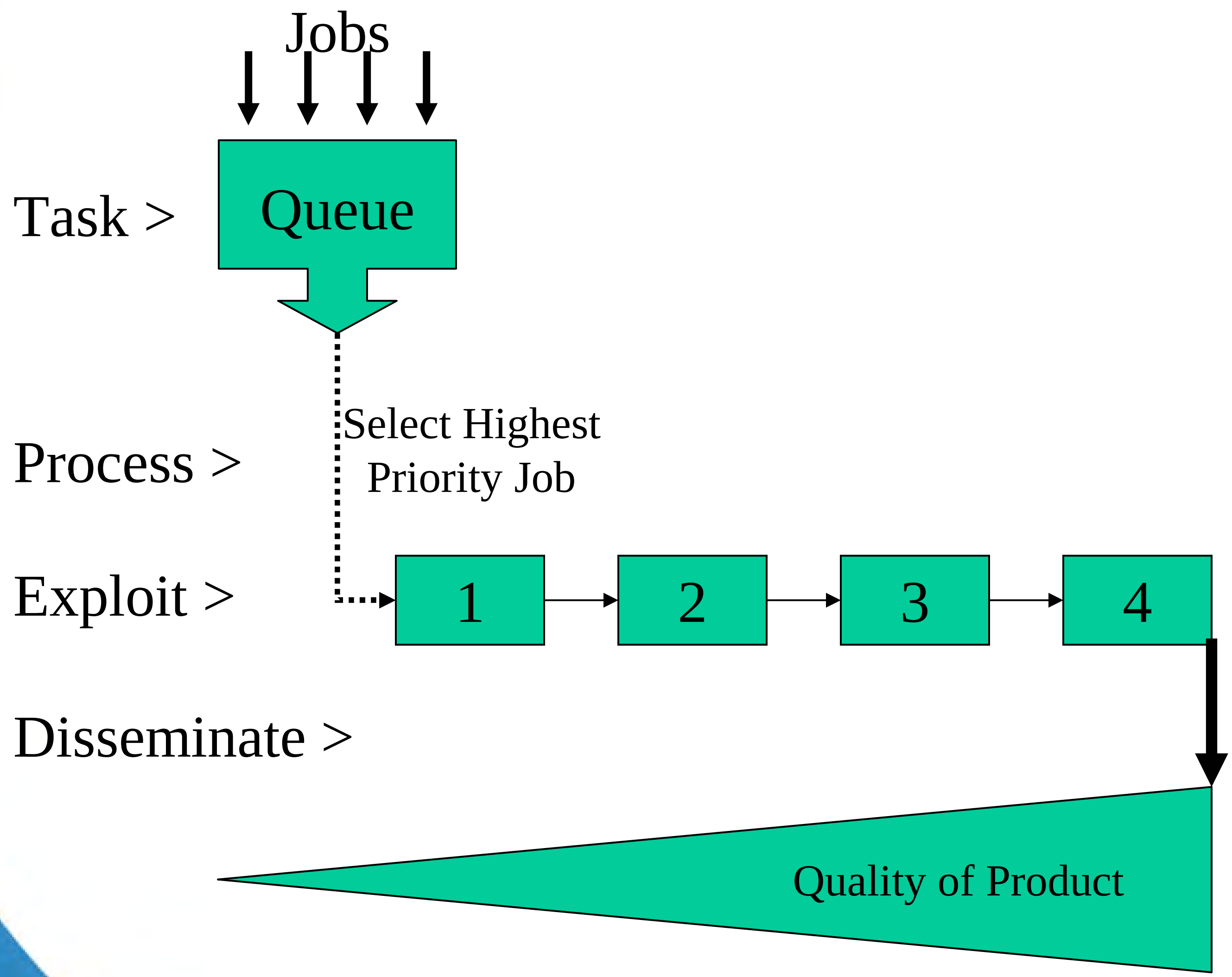
Outline of Presentation

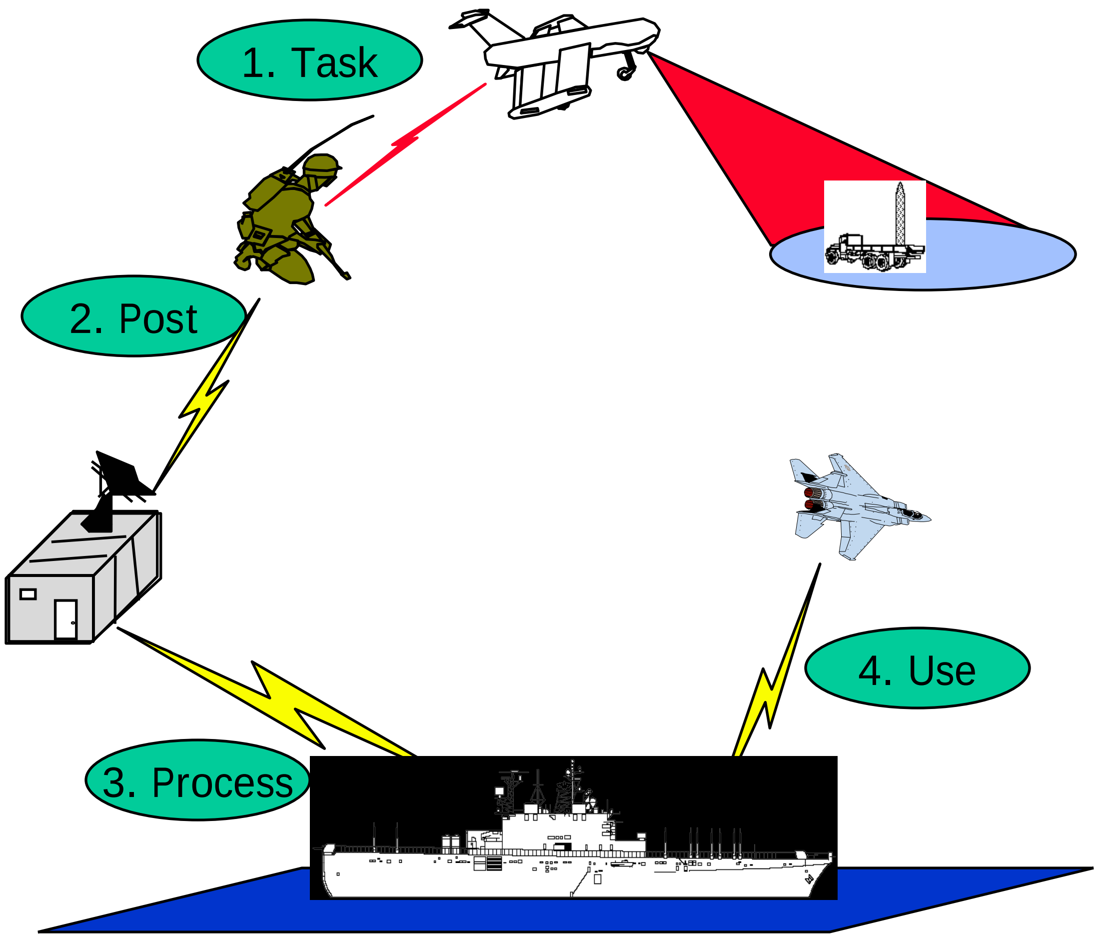
- Operational Activity Modeling
  - Task, Process, Exploit, Disseminate (TPED)
  - Task, Post, Process, Use (TPPU)
- State Machine Concepts
- Description of TPPU State Machine
- Modeling Process
- Examples
- Q&A

How Task, Process, Exploit and Disseminate (TPED) Manages Jobs



Task, Post, Process and Use (TPPU): Single Iteration

- TPPU
  - Task
  - Post
  - Process
  - Use



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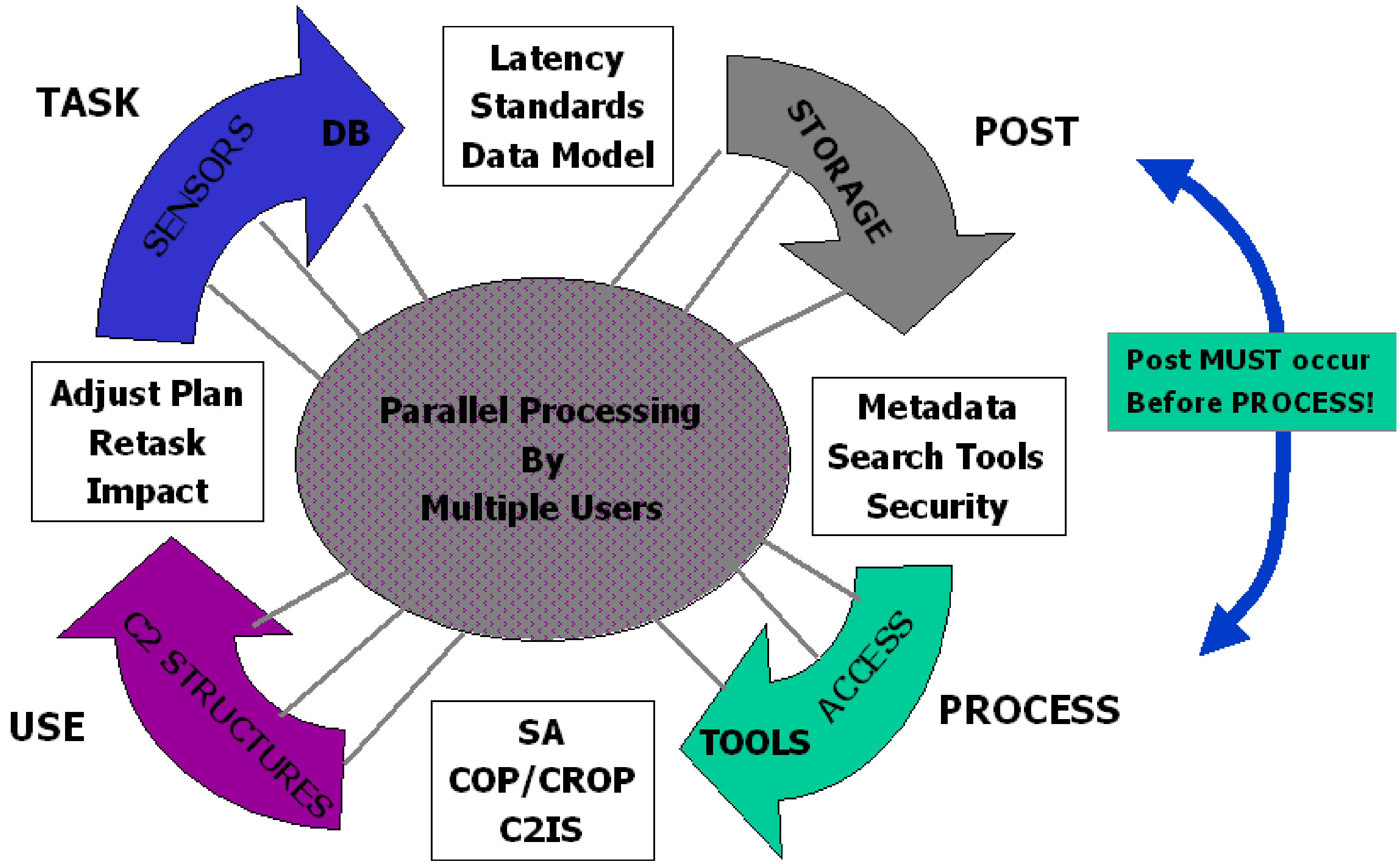
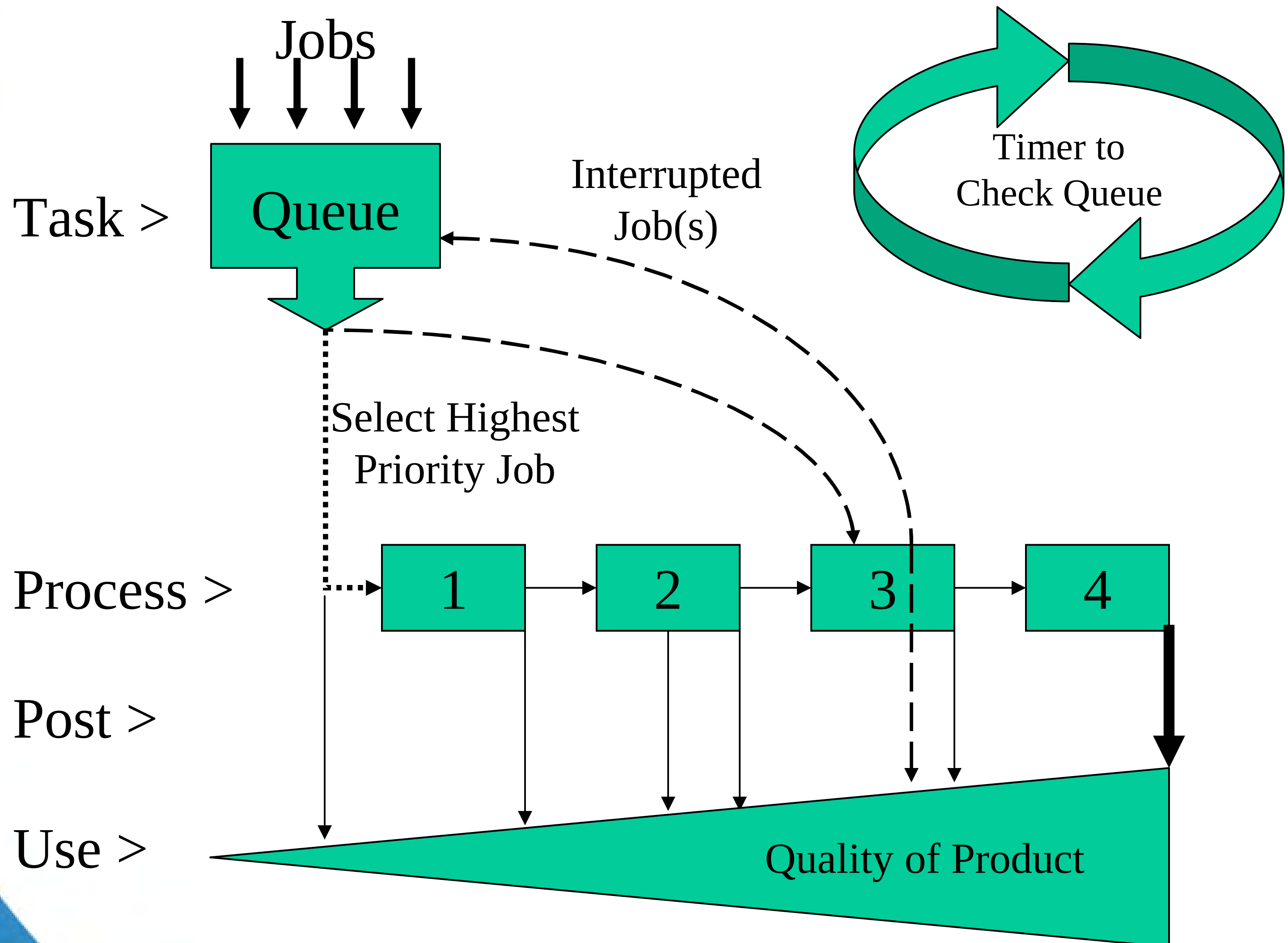
TPPU as Repeating Sequence of Activities



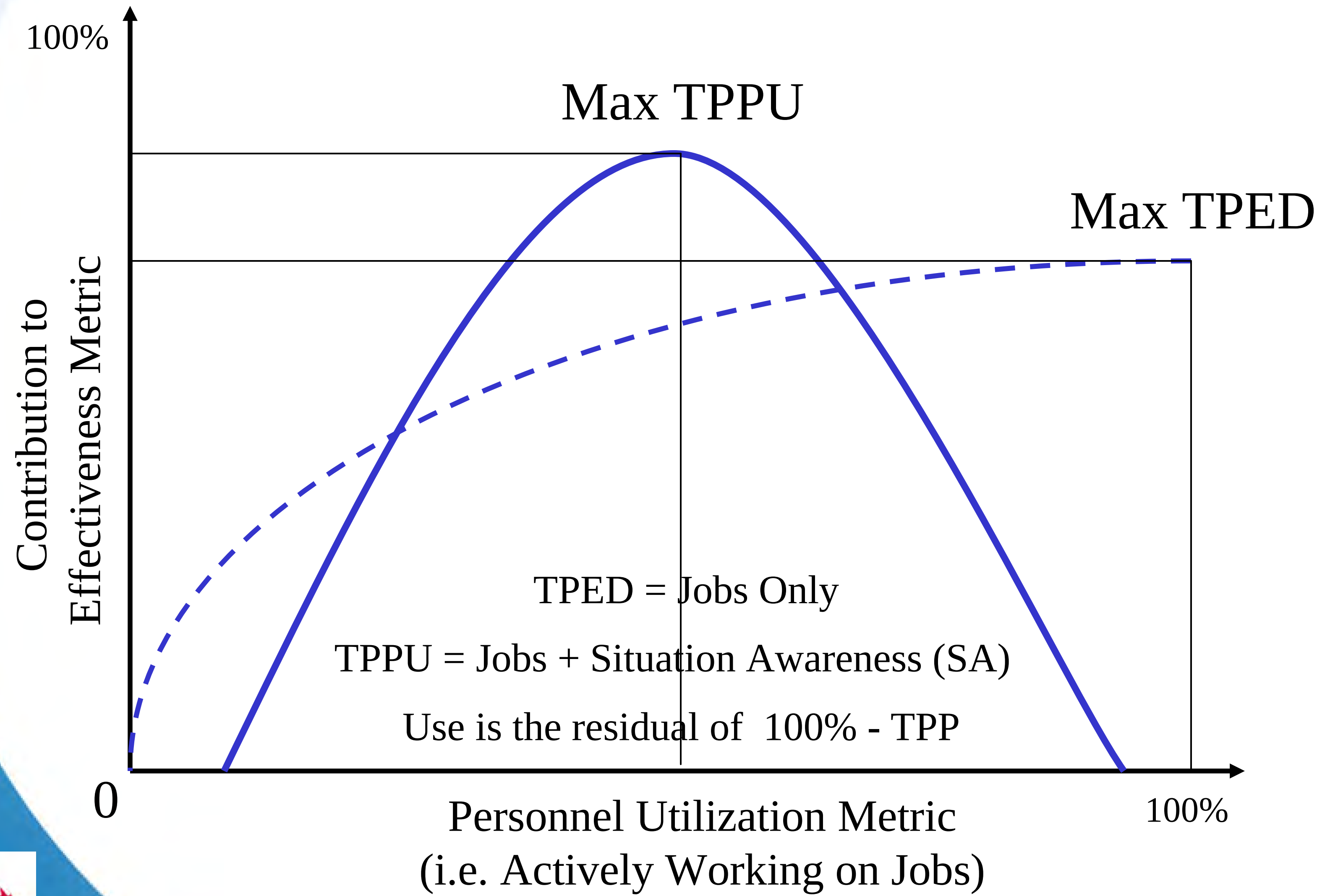
How TPPU Manages Jobs



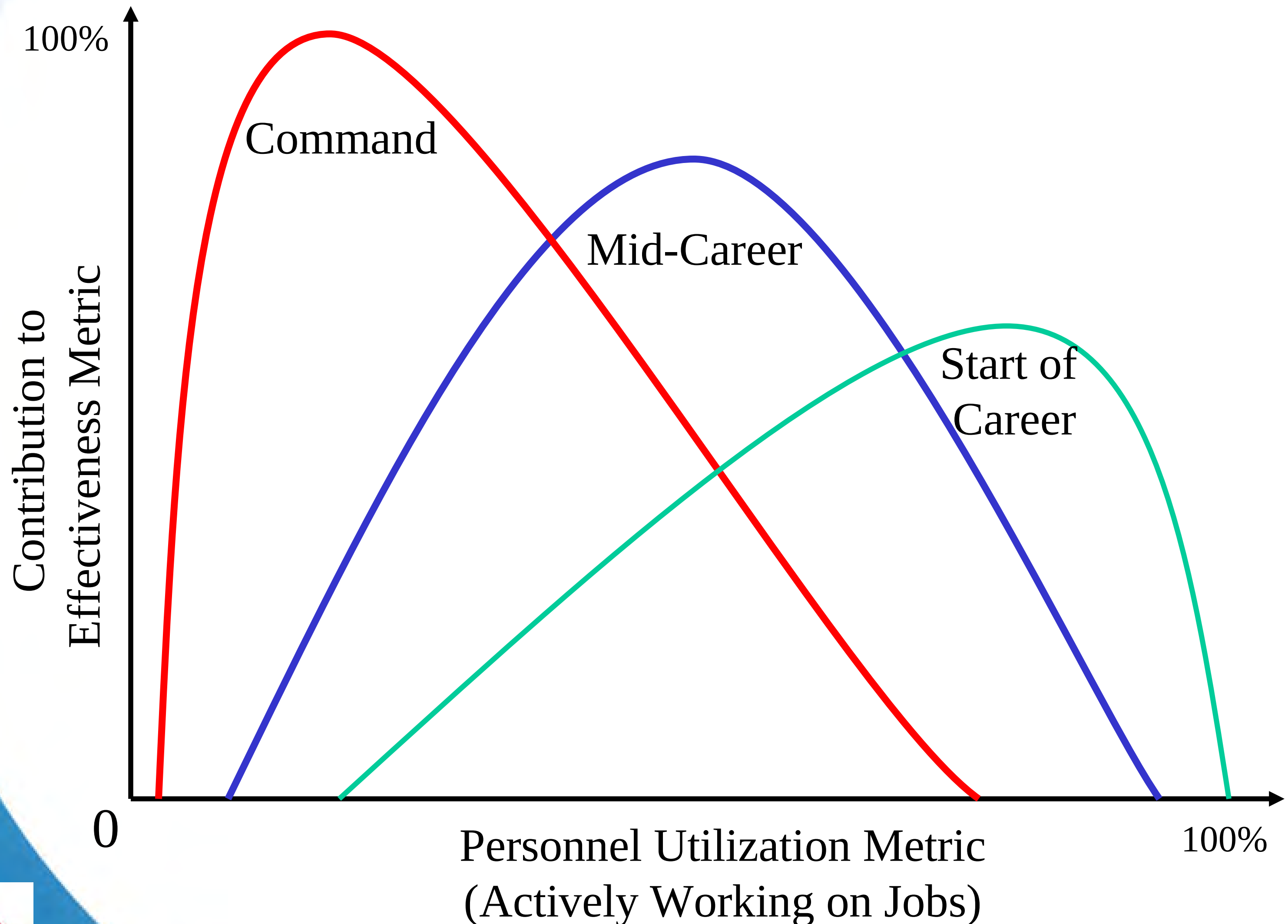
How TPED/TPPU Deal With Situation Awareness (SA)

- TPED
  - Centralized control of all activity
  - Only describes assigned jobs
  - Worker utilization maximized when jobs are 100% of time
  - No way for operators to do SA except as a separate job
- TPPU
  - Decentralized and uncoordinated independent activities
  - Becomes self synchronizing when queue checked frequently
  - Cycle based on doing jobs and maintaining SA
    - Jobs are composed of TPP, but not Use
    - Use is residual time when no jobs (i.e. 100% - TPP)
    - SA automatically distributed everywhere as Use
  - Effectiveness is maximized when job utilization < 100%

How Utilization Metric Differs from TPED to TPPU



How TPPU Utilization Metric Shifts During Career



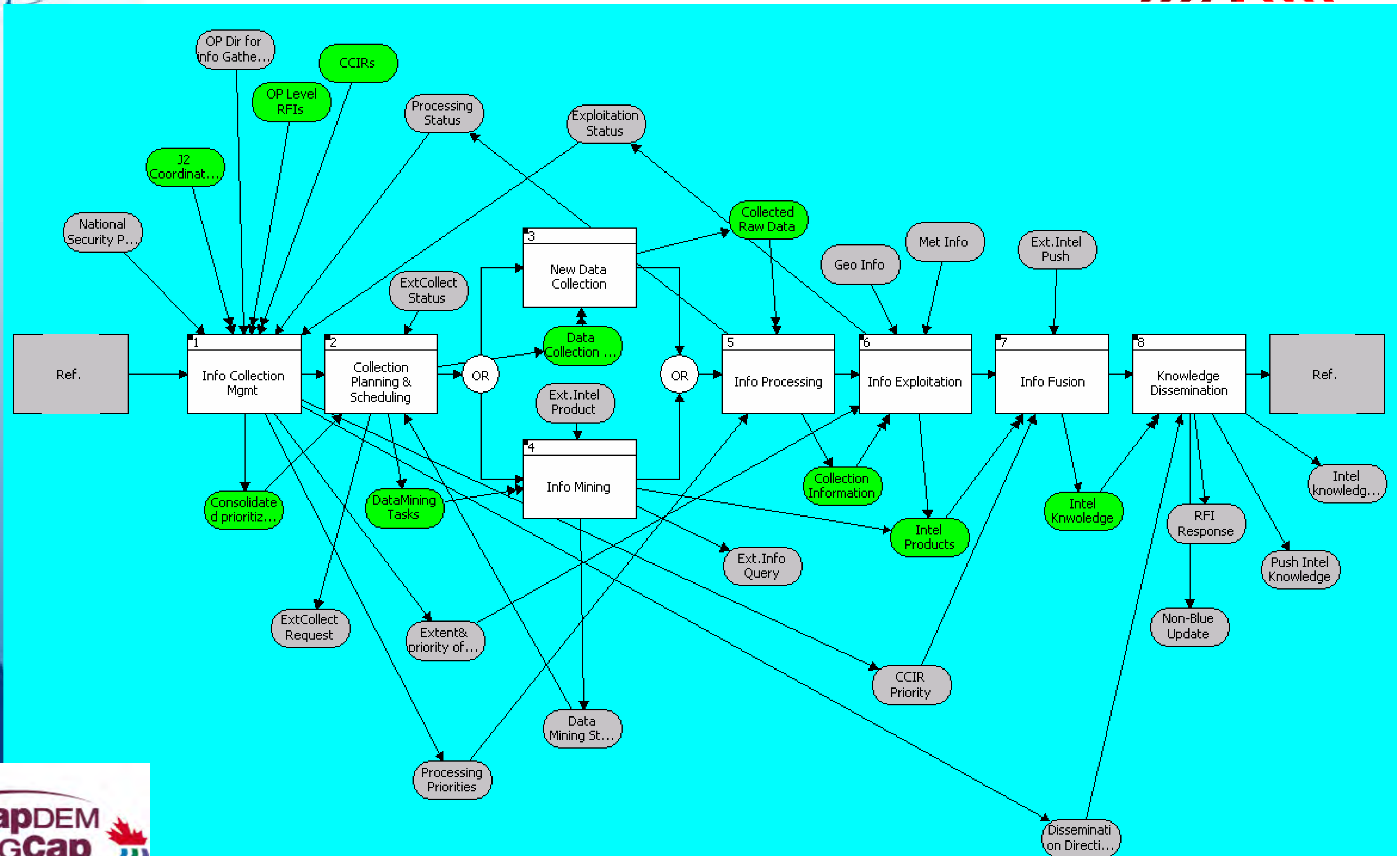
TPPU Business Rules Being Modeled

- Concurrent Independent Cycles are modeled:
  - Cycles automatically repeated
  - Activity logic is easily amended
  - Model is scalable
- Improved realism of business rules by explicitly modeling:
  - Regular checking of queue for highest priority job
  - Pre-empted jobs returned to queue to complete later
    - Credited for work already completed
  - Job status tracked continuously once it enters queue
    - Checks remaining time needed to complete job
    - Jobs abandoned once expected completion time exceeds deadline

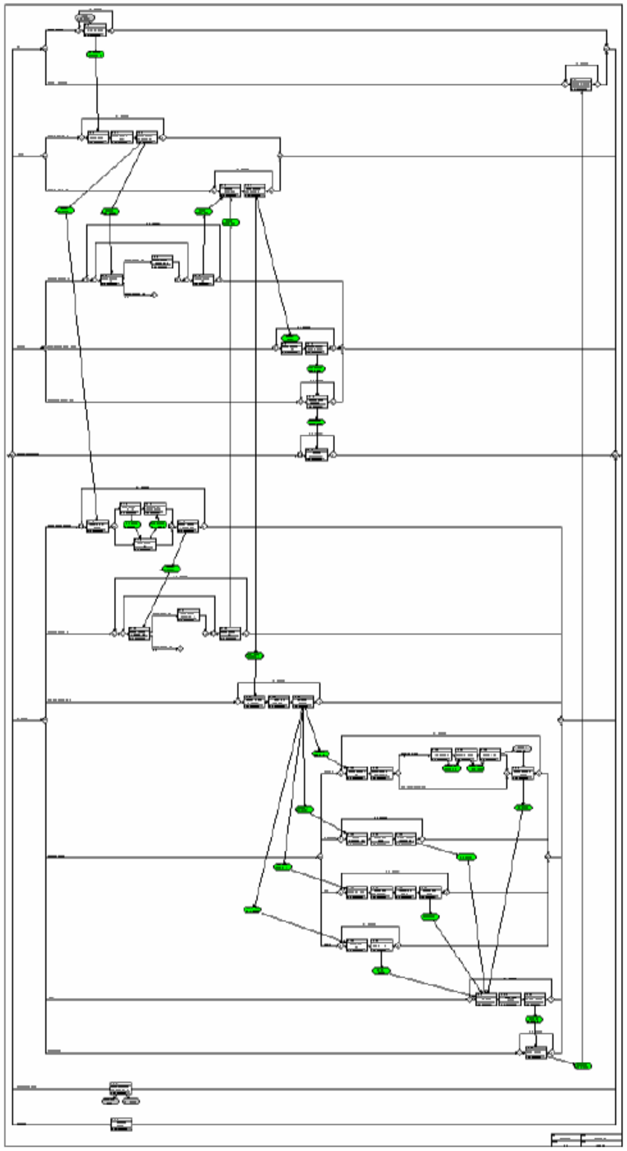
DODAF Operational Activities (OV-5) Modeling Efforts

- Summer 2003
  - Conceptual TPED from first principles
    - Elegant model but too conceptual to actually work
- Spring 2004
  - Data Fusion Using TPED
    - Integrated behavior of basic TPED components
    - Data stovepipes shown but no description of fusion
- Summer 2004
  - Integrated ISR Architecture Examples
    - Modeled sequence of C2 changes for UAV flight
    - TPPU used to describe OPCEN activities
- Spring 2005 to Present
  - Describe TPPU as State Machine
    - Articulate TPPU with robust business rules
    - Model can also handle TPED

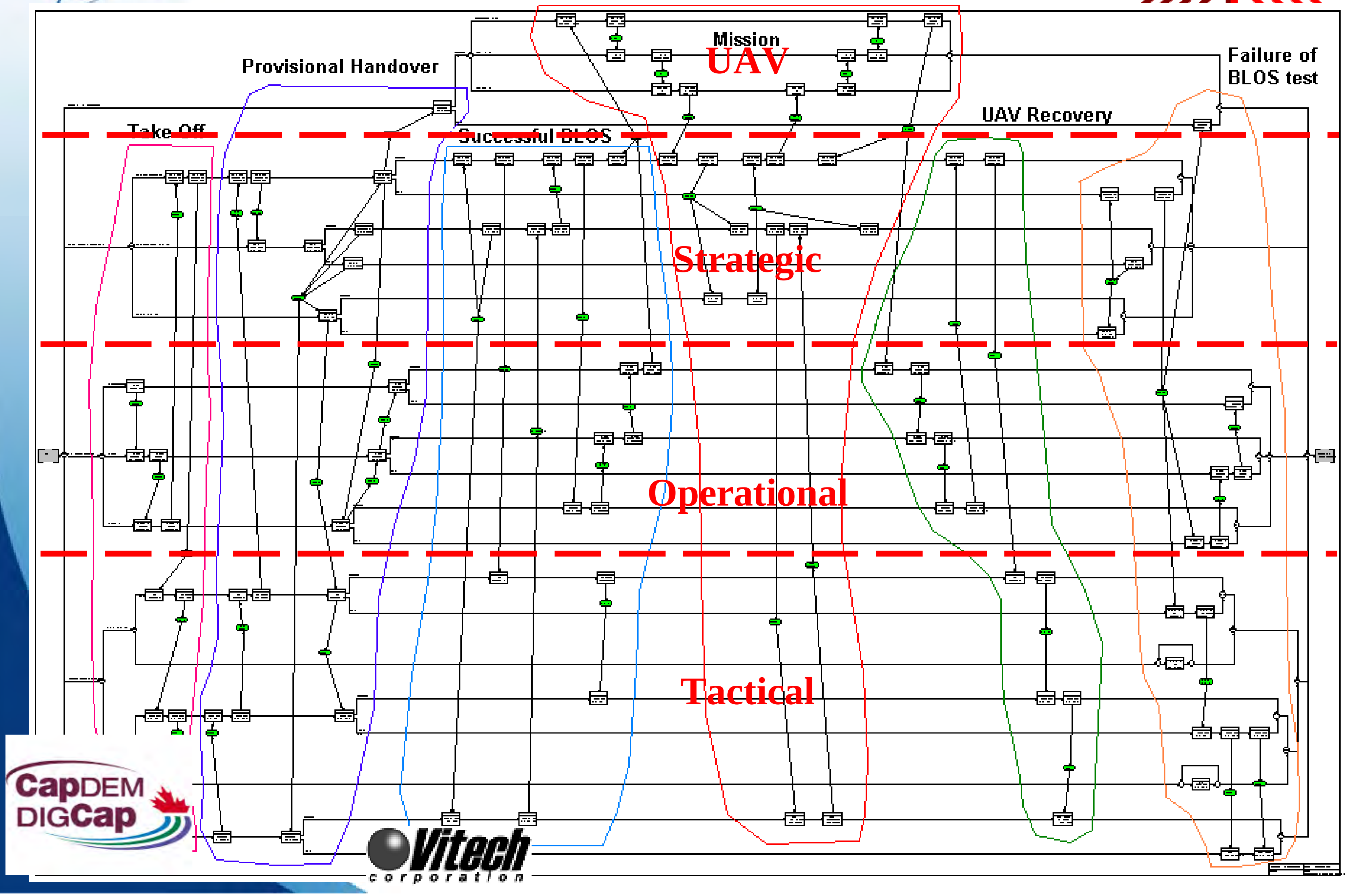
CORE® Model of Conceptual TPED: Summer 2003



CORE Model of TPED Work Flow: Spring 2004

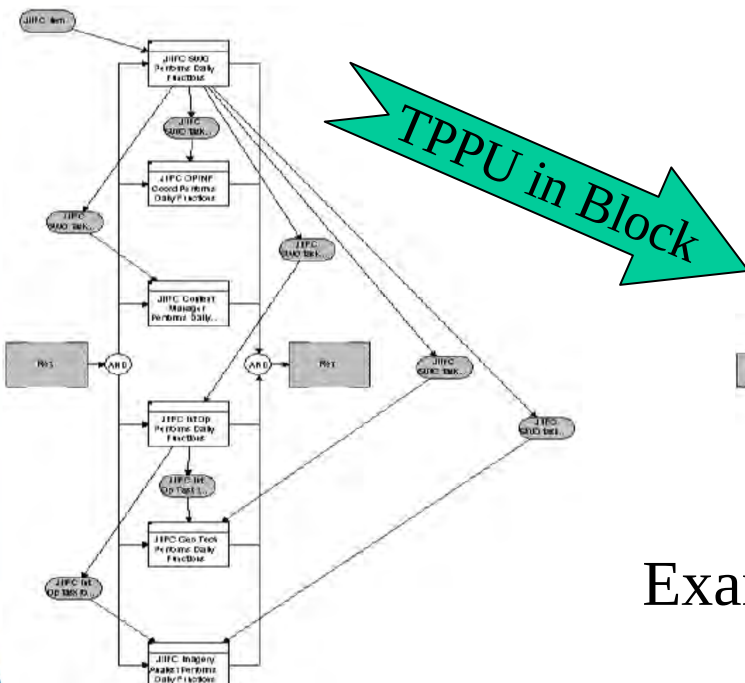


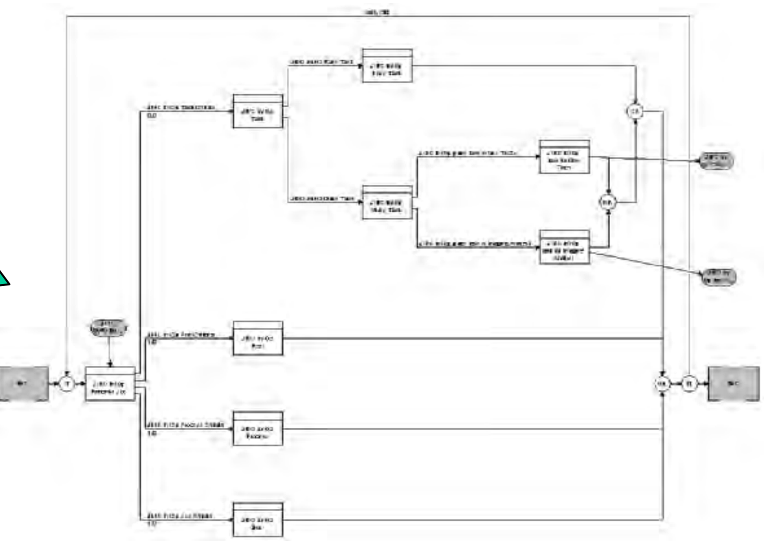
CORE Model of UAV C2 Changes: Summer 2004



Initial CORE Model of TPPU Job Activity

Example of Top-Level Model





Example of TPPU within One Block

Modeling the Processes Using CORE

- CORE used to capture behavior models
  - Document known processes
  - Capture timelines, data flow, business rules
  - Expose unknowns for further exploration
- COREsim used to execute models
  - Validate our understanding
  - Exercise to-be processes

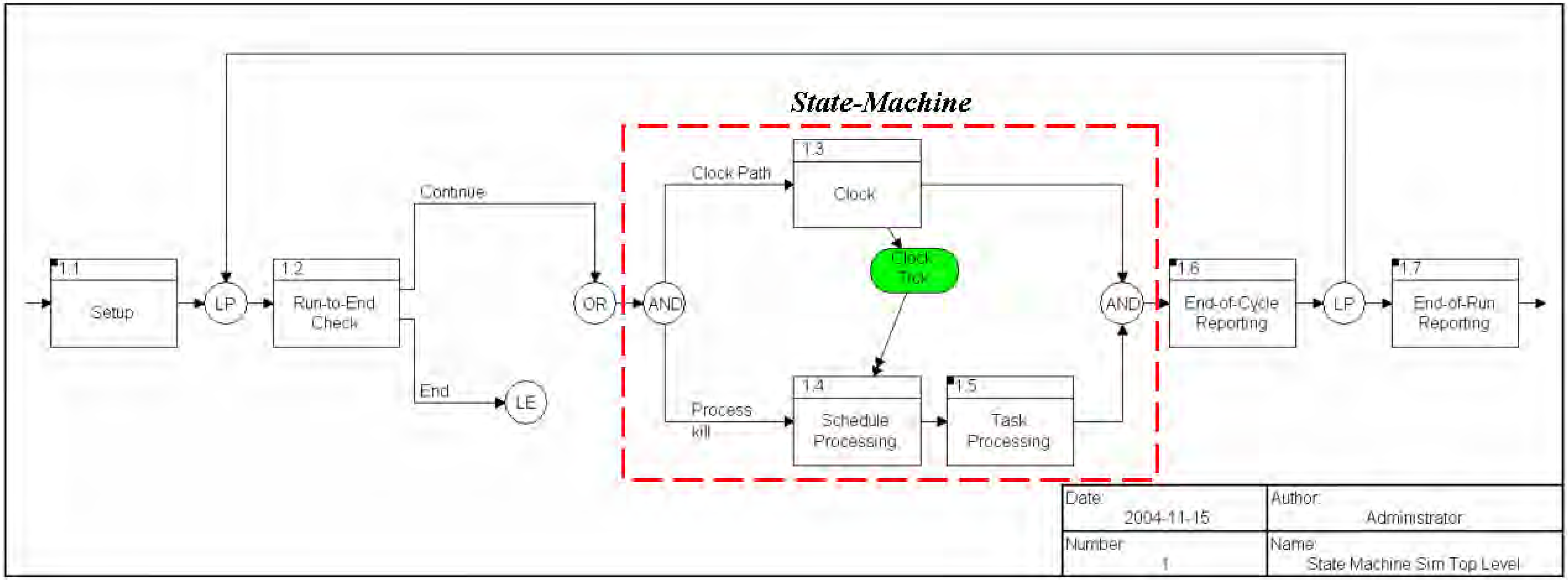
Process to Efficiently Build Behavior & SM Models

1. **Threads** : Work process of each job by an operator
   – Articulates specific job activities for each operator
2. **Integrated** : Common themes between jobs & operators
   – Calculates minimum resource demand
3. **Allocated** : Differentiation of skills
   – Added cost of specialization
   – Determine any offsets when generic work is done during idle time
4. **State Machine** : Schedule and track concurrent activity
   – Impact of Business Rules (i.e. Job priorities & time remaining)
   – <u>Caution</u>: Logic is not as visible to users as usual behavior models

State Machine Characteristics

- State Machine has the following key **characteristics**:
  - Initial state or record of something stored someplace
  - Set of possible input events
  - Set of new states that may result from the input
  - Set of possible actions or output events that result
  - It is composed of the following elements:
    - Description of the initial state;
    - Set of states;
    - Set of input events;
    - Set of output events;
    - Function that maps states and input to output;
    - State transition function.

CORE Model of State Machine: Overall Structure



- Excel spreadsheets are used to store model data for:
  - Schedule of Events (i.e. time and location of next work item)
  - Initial Status of Threads (i.e. result of occurred before)
  - Thread Attributes (i.e. duration of work)
- Event states and schedule updated using COREscript

How Specialization Can Affect Personnel Requirements

Functionality	Original Personnel Demand (No Transfer)	Specialists Do Generic Work 50% of Idle Time	Personnel Required (if 50% transferred)	Specialists Do Generic Work 100% of Idle Time	Personnel Required (if 100% transferred)
Generic	3.2	-0.7	2.5	-1.4	1.8
Specialist Type 1	0.2	+0.4	0.6	+0.8	1.0
Specialist Type 2	1.4	+0.3	1.7	+0.6	2.0
Bodies Needed	**7**		**6**		**5**

NOTE: Have to round up to account for fractional headcounts.
3.2 becomes 4, 0.2 becomes 1, 1.4 becomes 2, and total equals 7!

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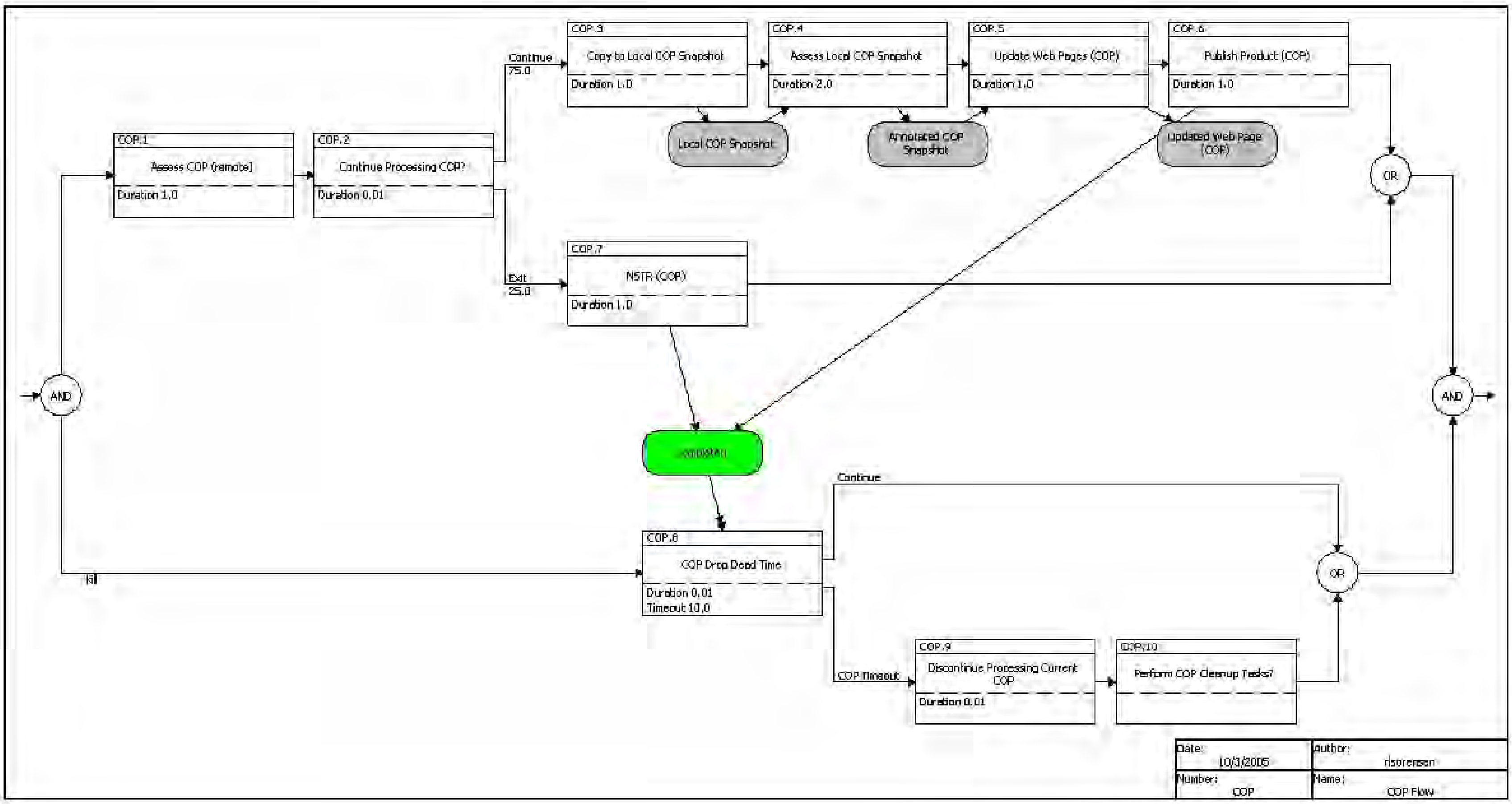
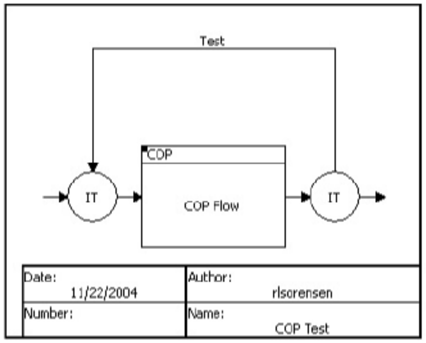
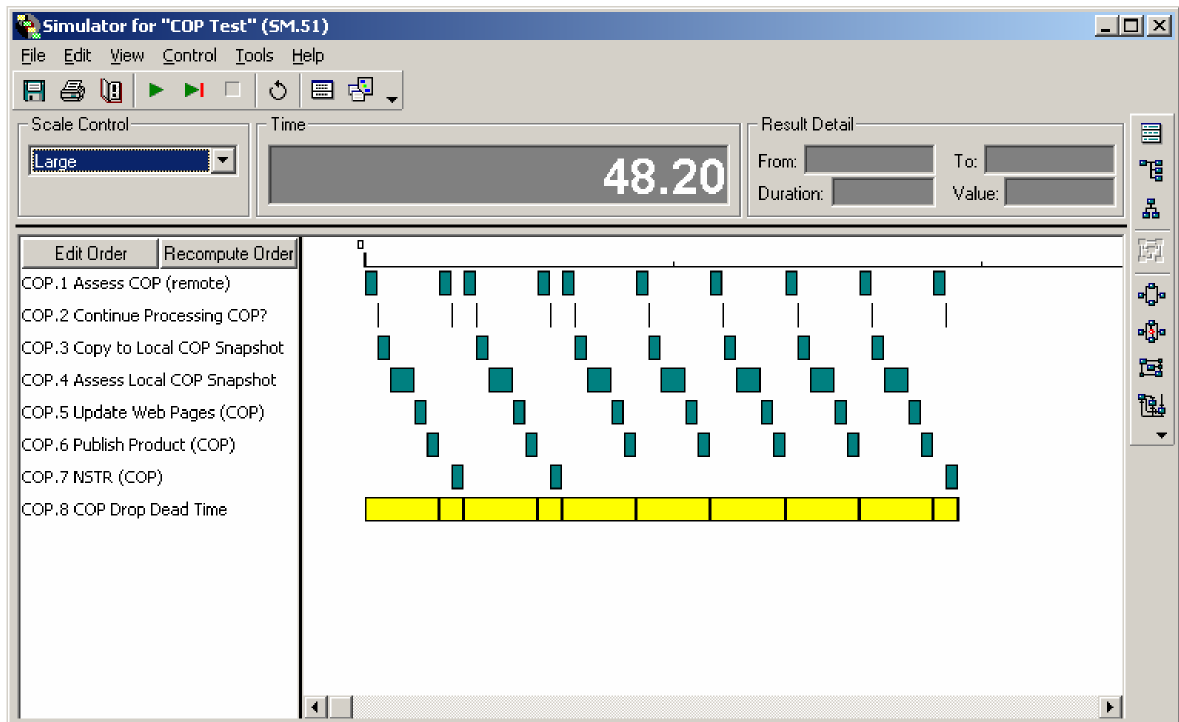
Example Thread



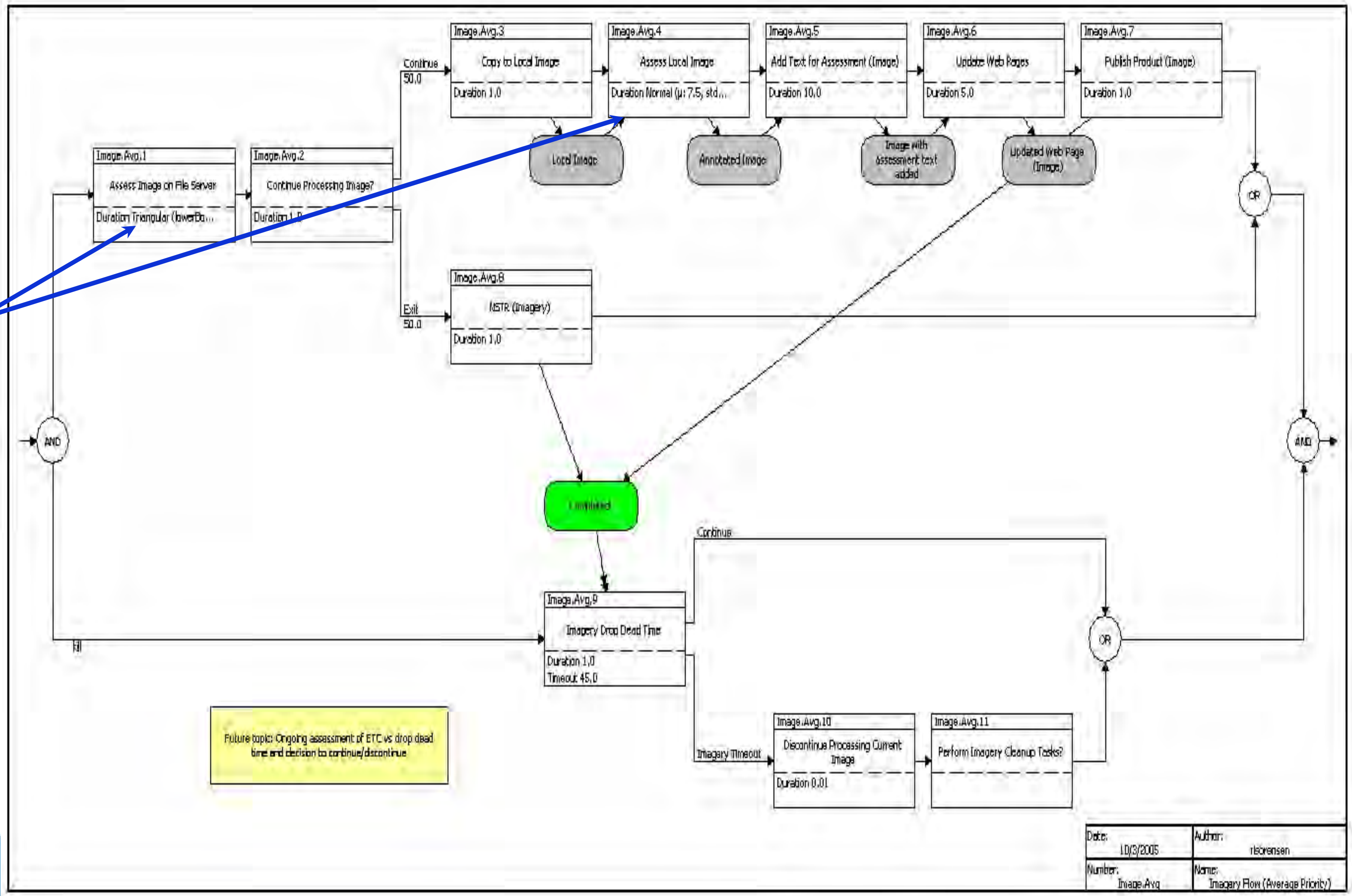
Testing


Test
COP
COP Flow
IT
IT
Date: 11/22/2004
Author: rlsorensen
Number:
Name: COP Test

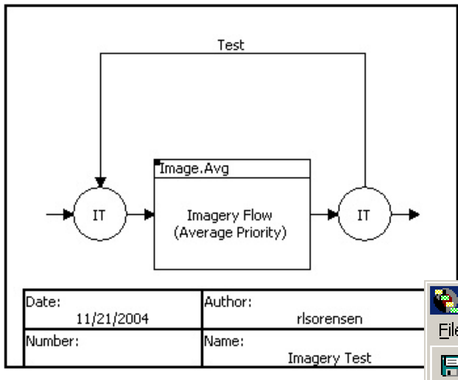

Simulator for "COP Test" (SM.51)
File Edit View Control Tools Help
Scale Control
Large
Time
48.20
Result Detail
From:
To:
Duration:
Value:
Edit Order
Recompute Order
COP.1 Assess COP (remote)
COP.2 Continue Processing COP?
COP.3 Copy to Local COP Snapshot
COP.4 Assess Local COP Snapshot
COP.5 Update Web Pages (COP)
COP.6 Publish Product (COP)
COP.7 NSTR (COP)
COP.8 COP Drop Dead Time

Example Thread [Take 2]

NOTE



Testing [Take 2]



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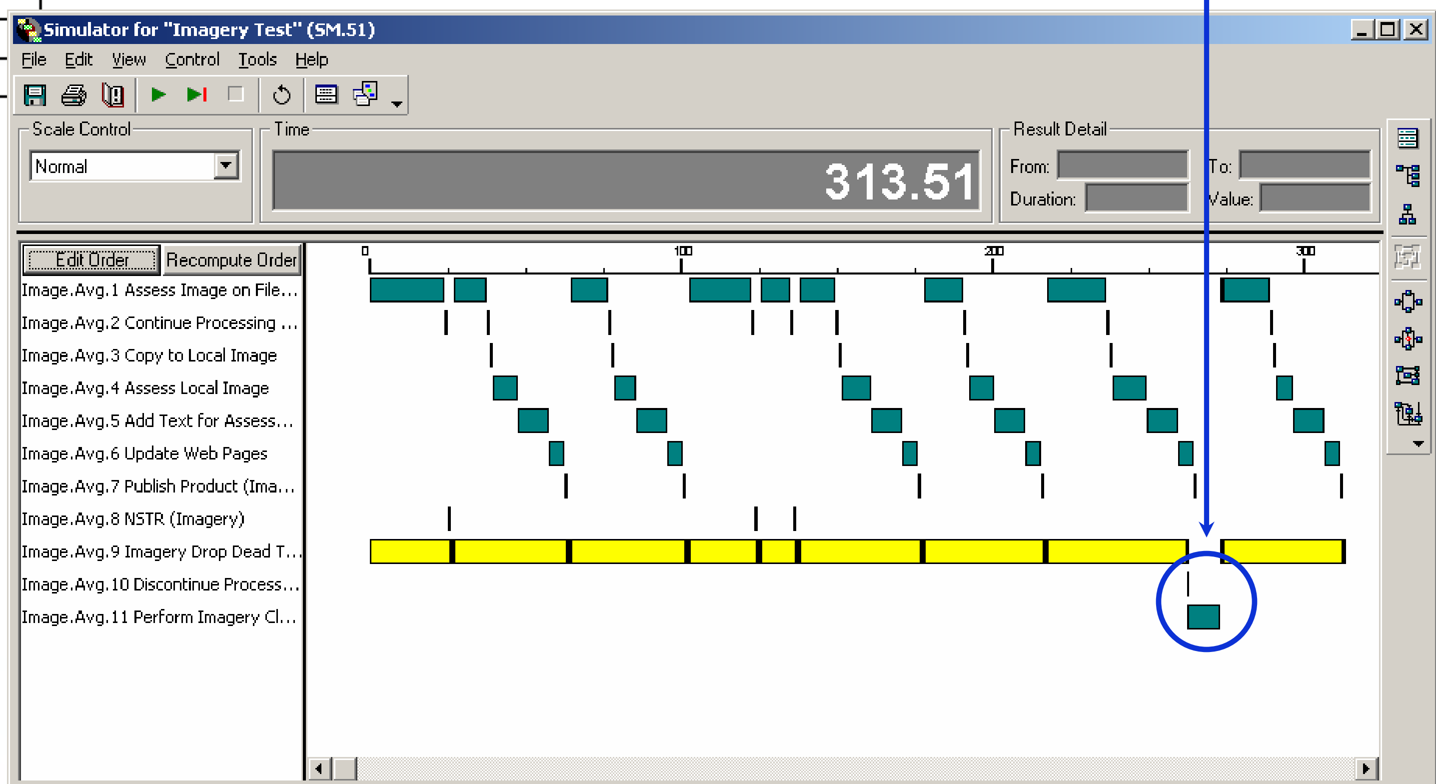

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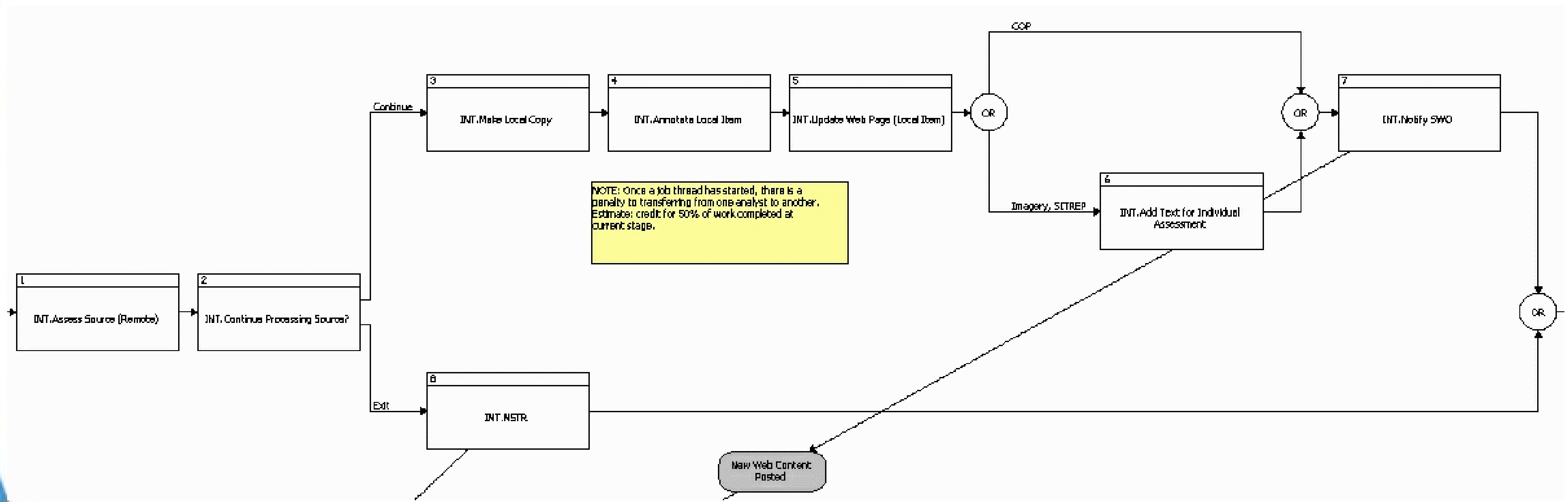
   – Caution: Logic is not as visible to users as usual behavior models

Integrated Behavior



See Allocated Behavior slide

Process to Efficiently Build Behavior & SM Models

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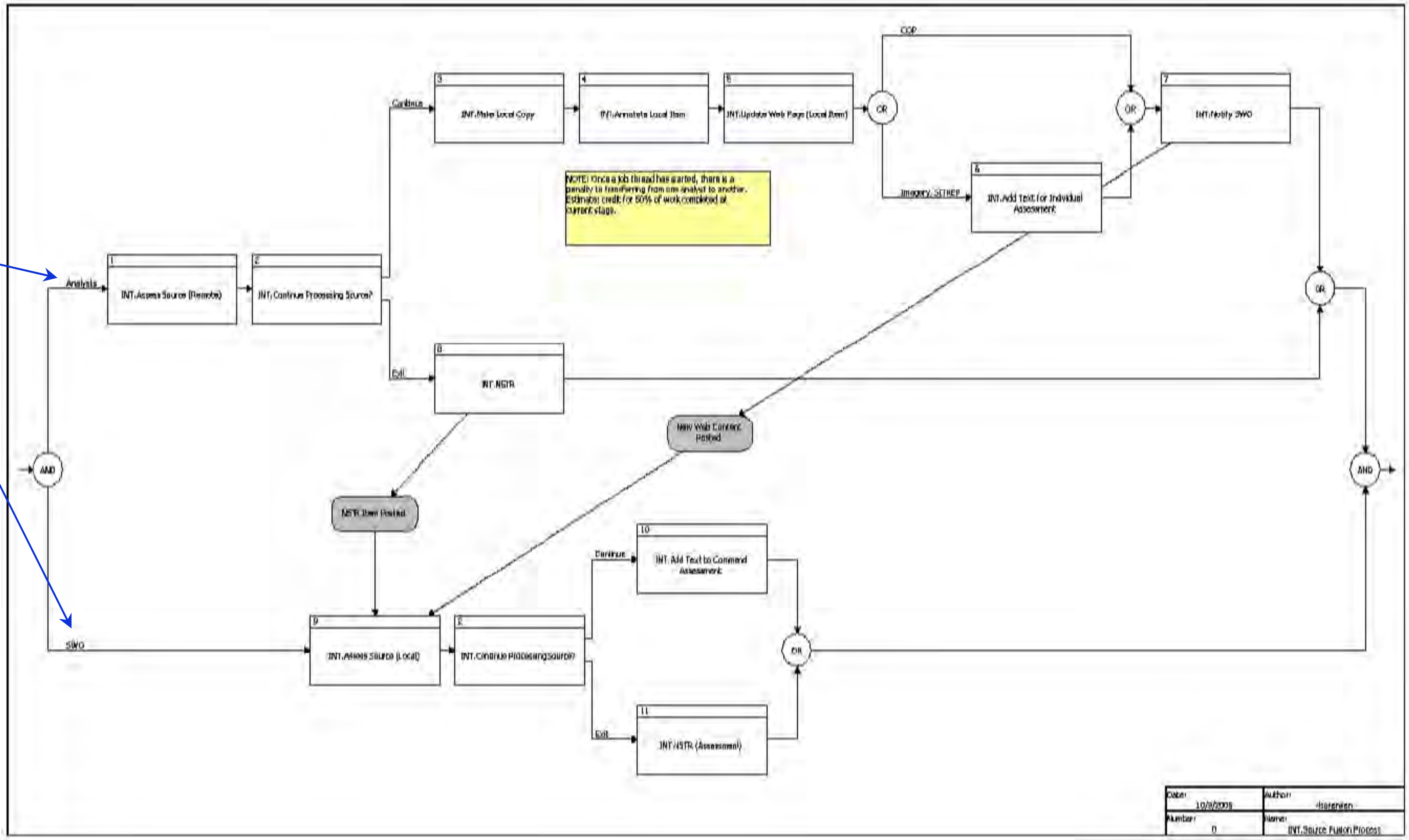
Allocated Behavior

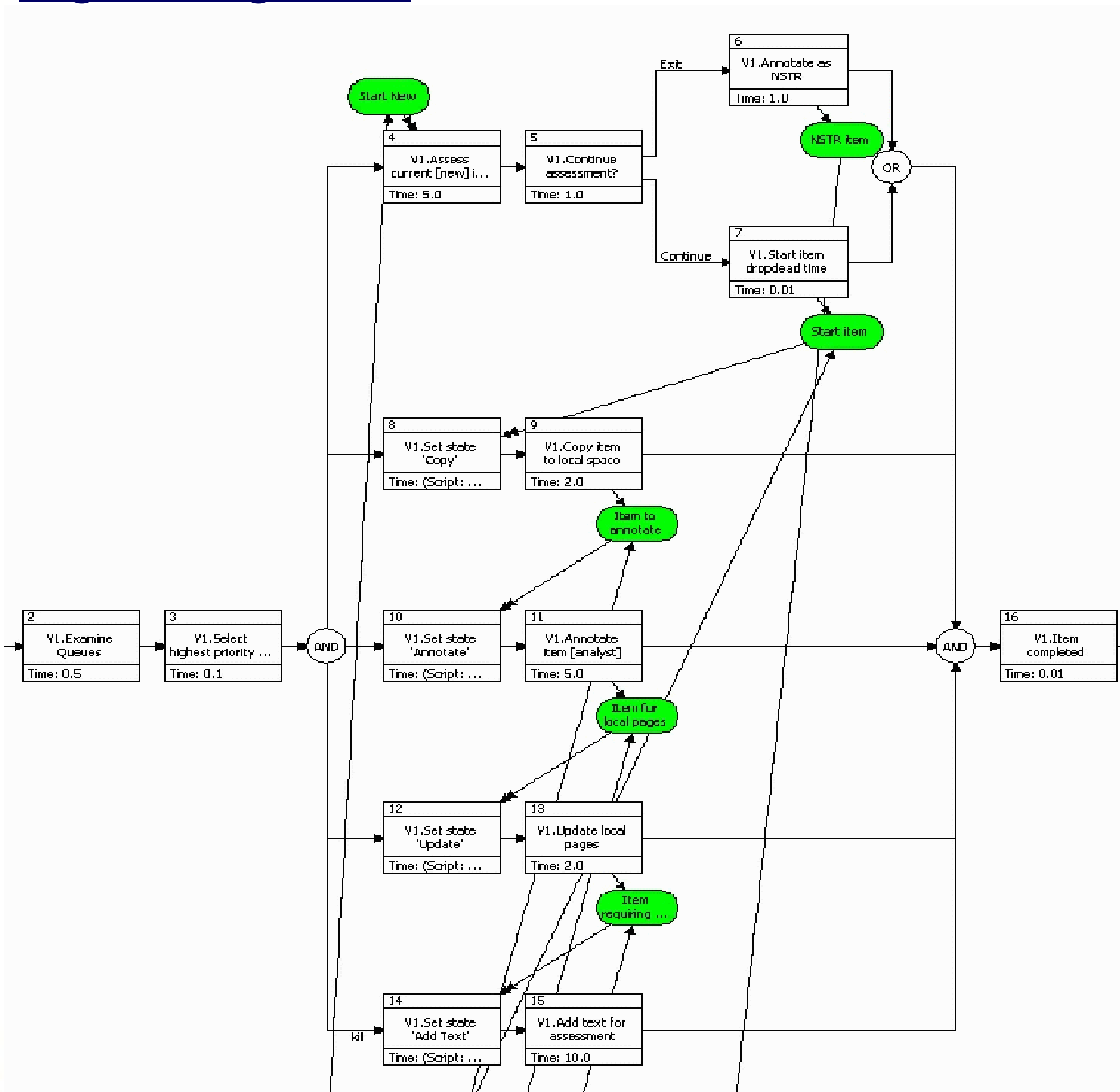
Allocations



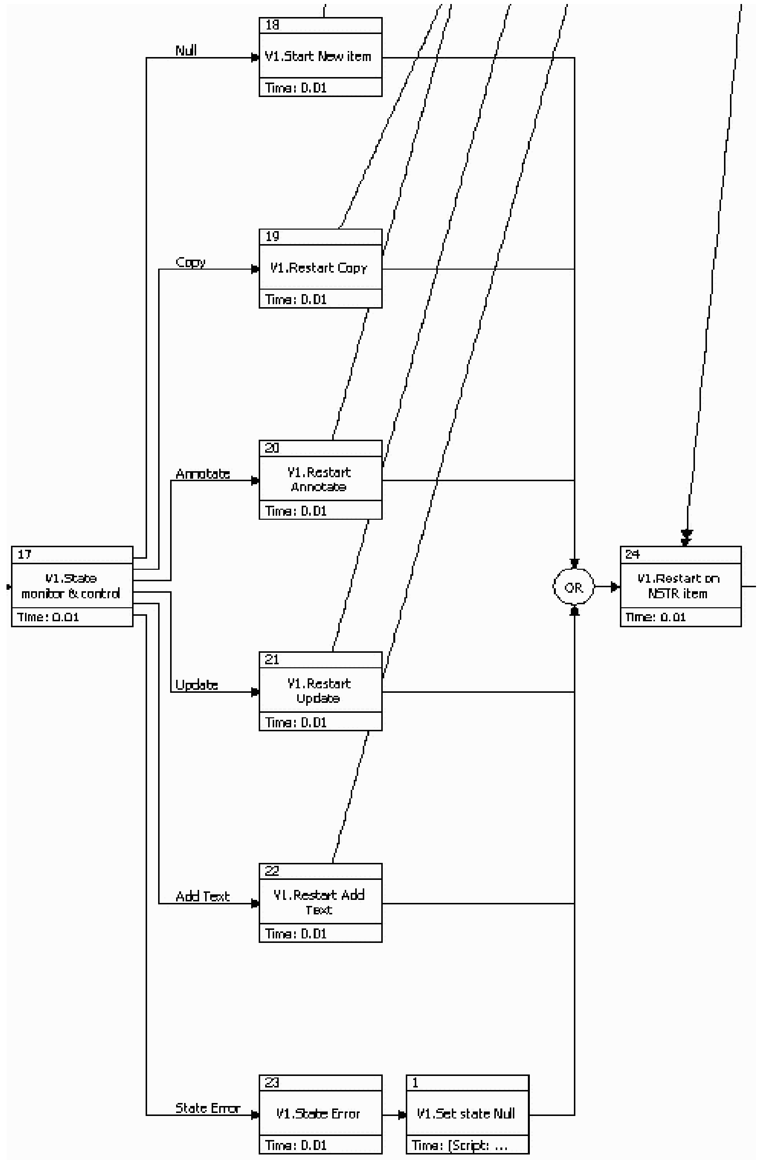
Other Aspects to Explore

- Our target environment has clear notion of interruptible processes. Need to explore:
  - Impacts of interrupts on timelines
  - Business rules for interrupt handling
- Our target environment exhibits queuing of products. Need to explore:
  - Queuing logic

Interrupt Model v1
- <u>Segmenting Tasks</u> for Re-entrant Behavior

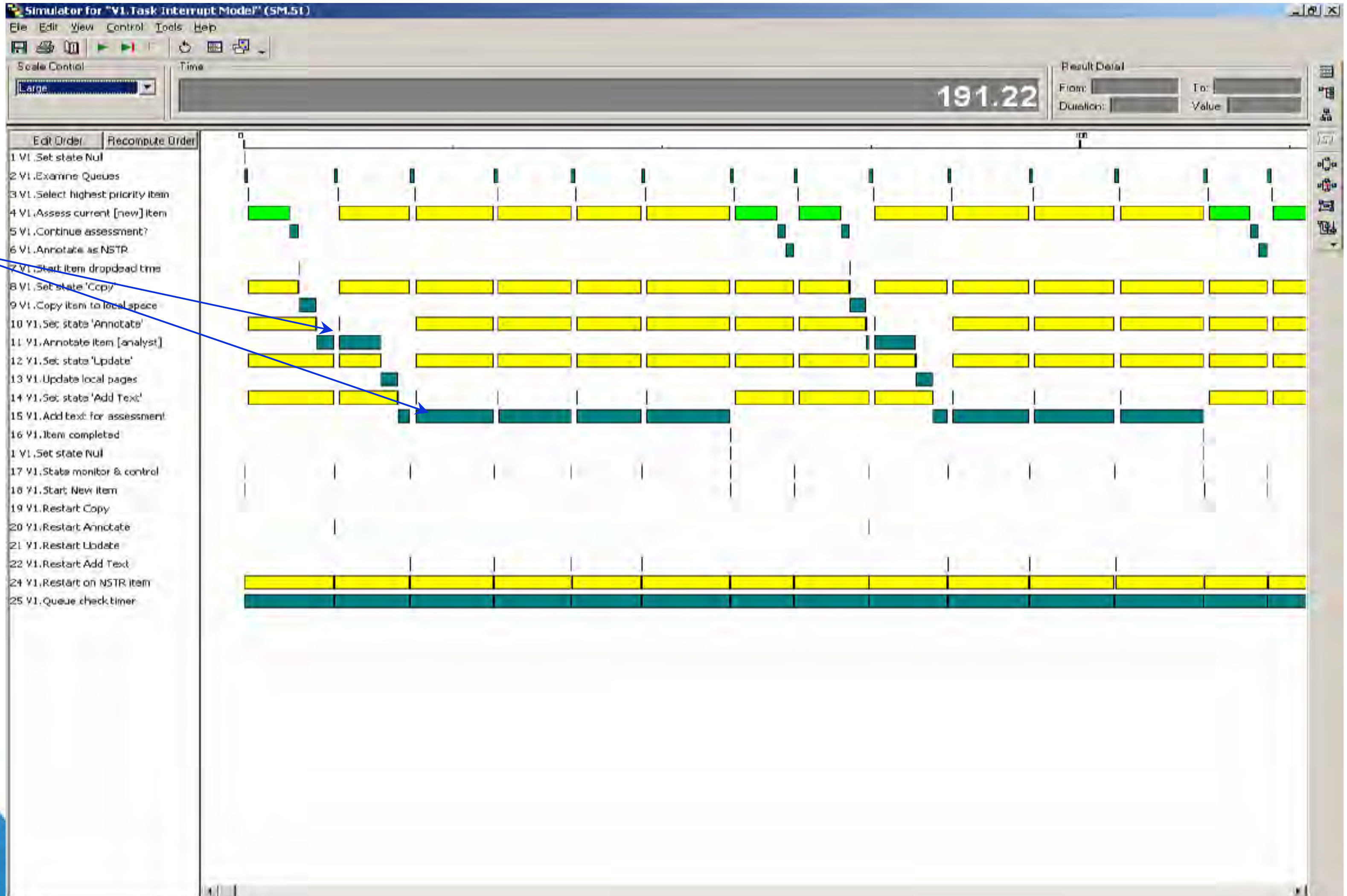


Interrupt Model v1
- Control Logic for Re-entrant Behaviour

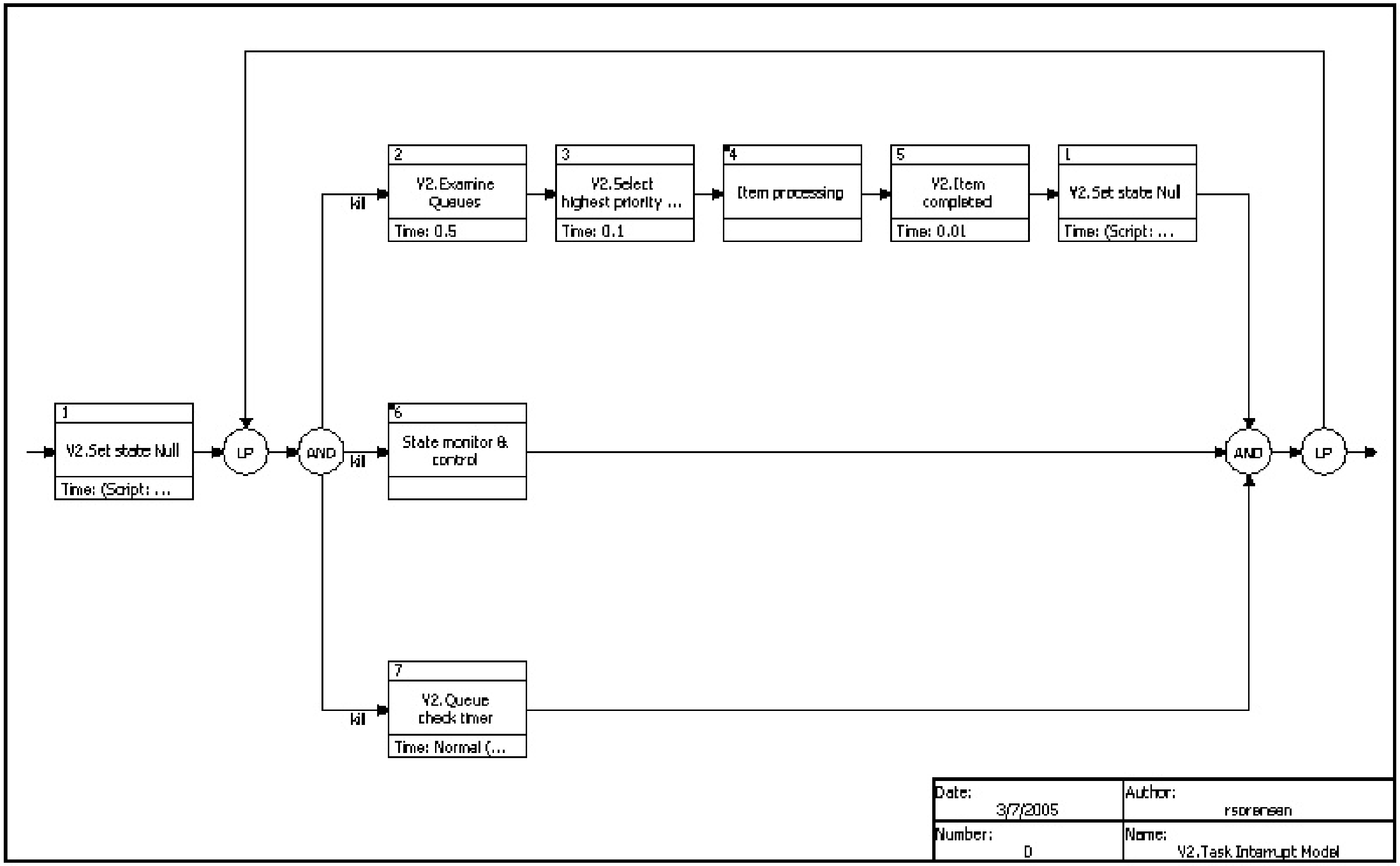


Interrupt Model v1 Execution

Interrupted &
Re-entered tasks

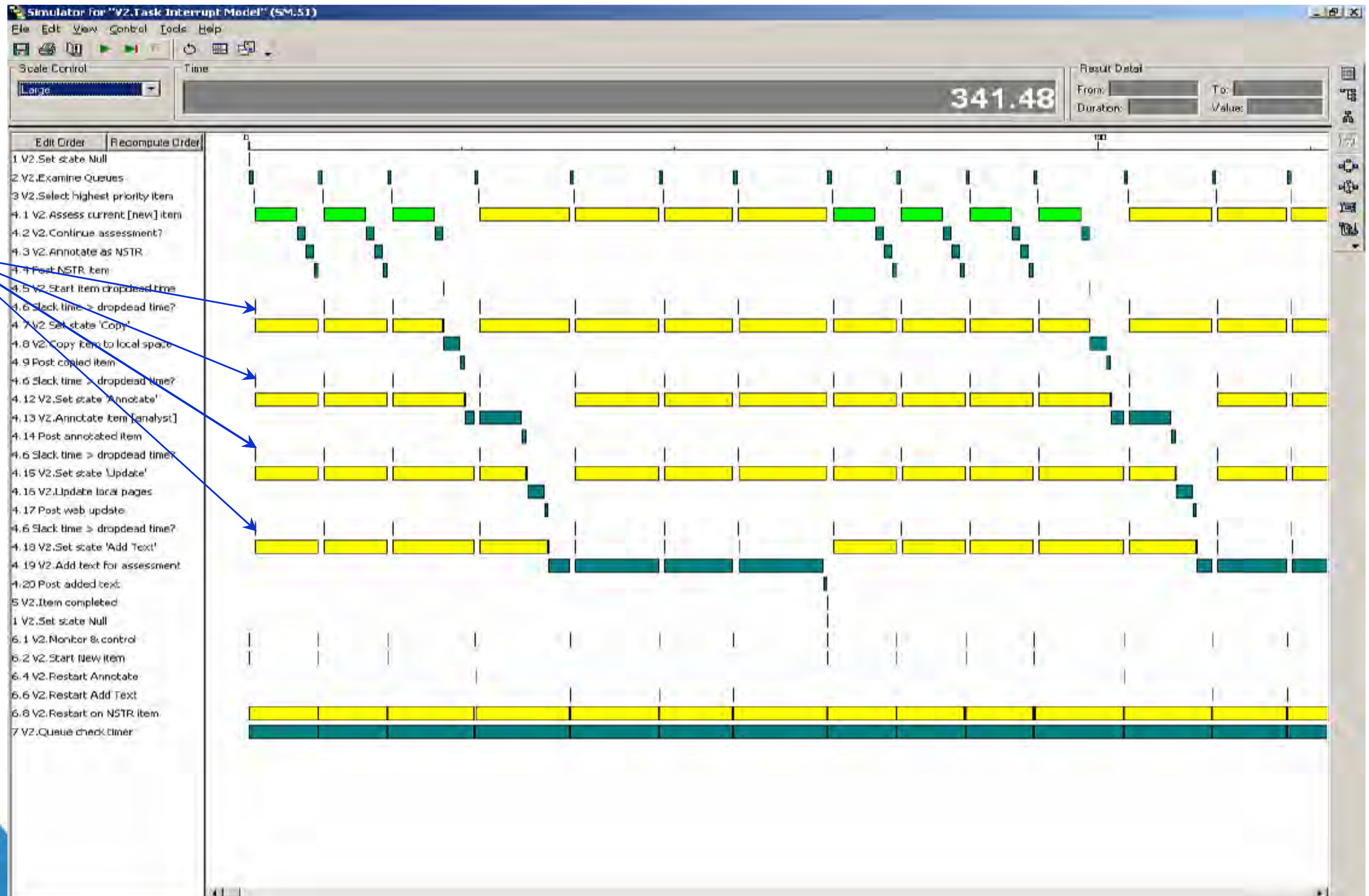


Interrupt Model v2
- Adding Impacts of Queuing

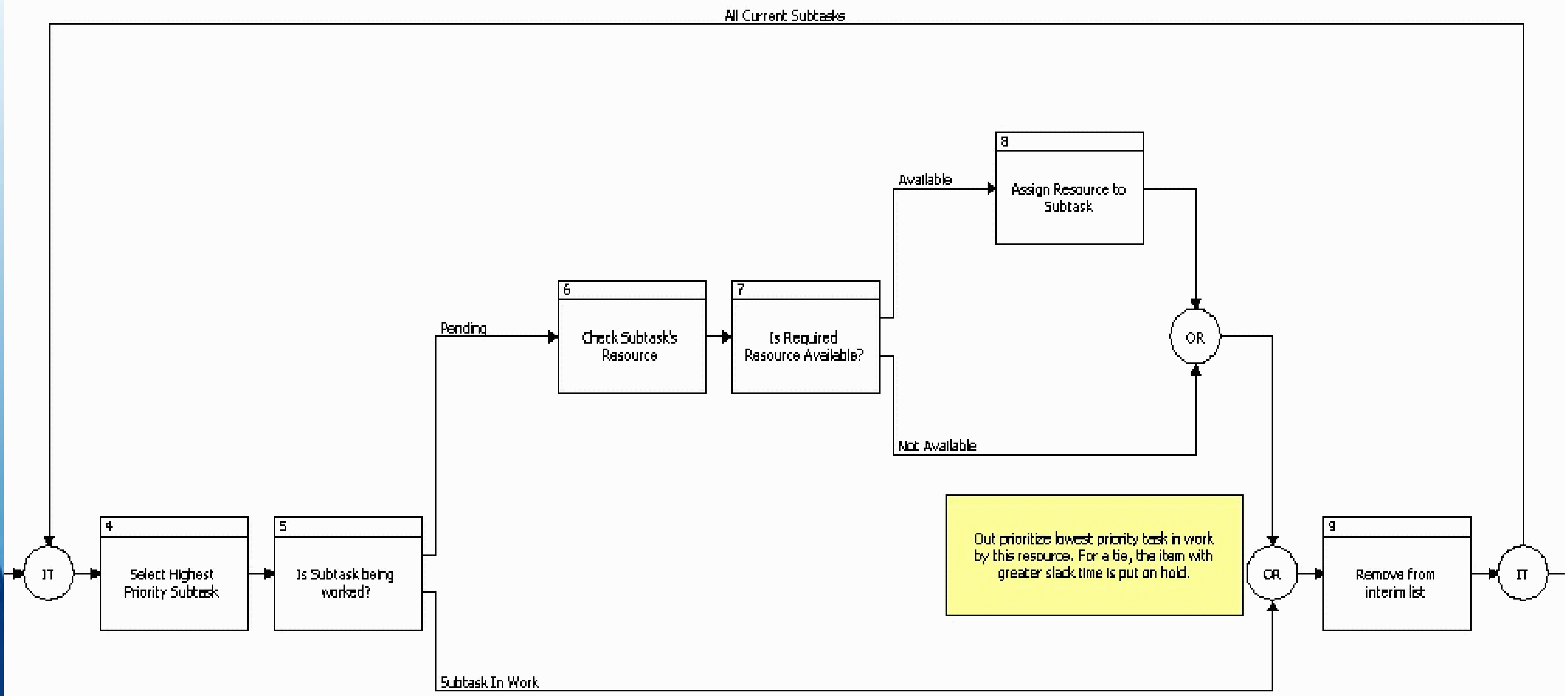


Interrupt Model v2 Execution

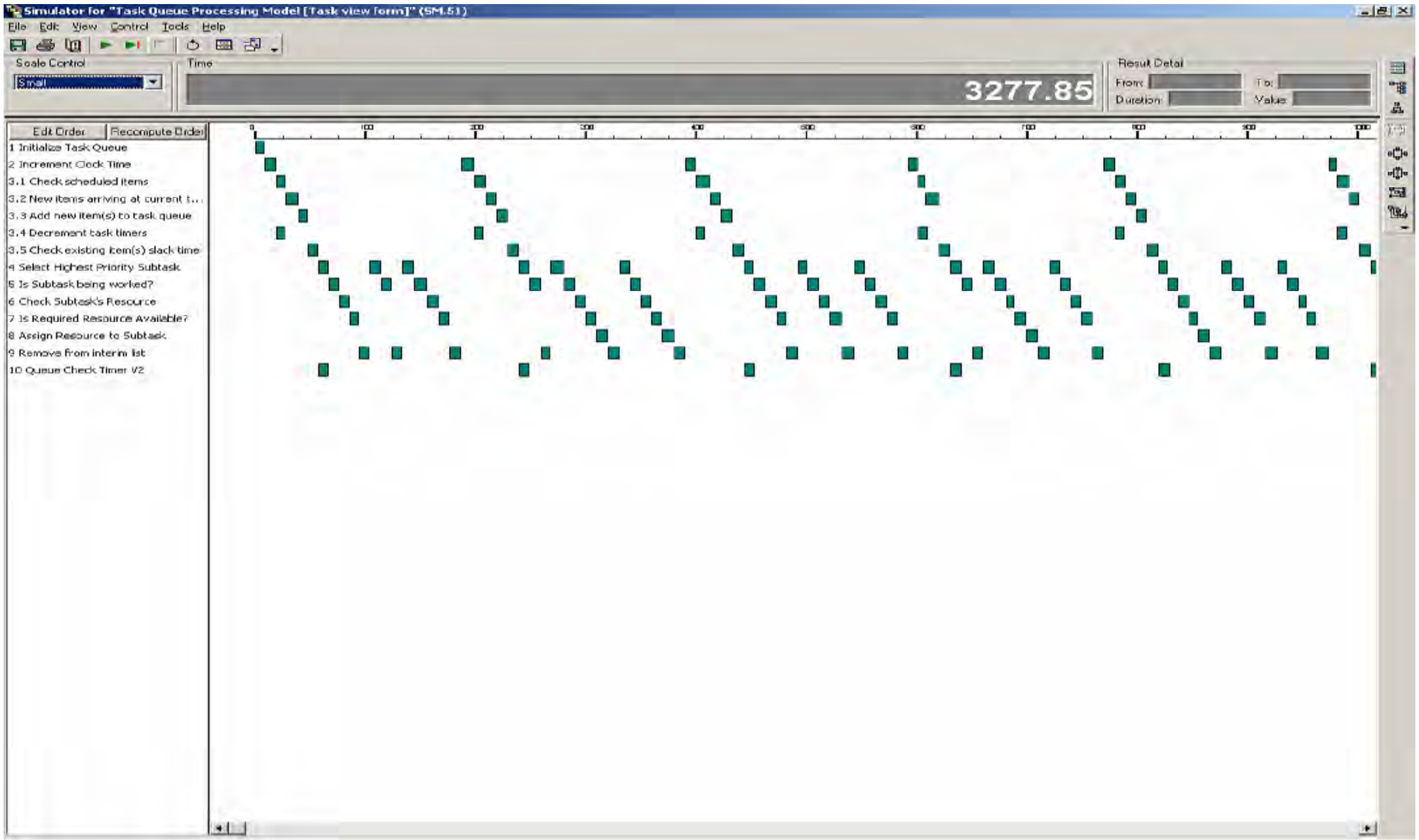
Item processing time checks



Task Queue Processing



Task Queue Processing - Execution



Process to Efficiently Build Behavior & SM Models

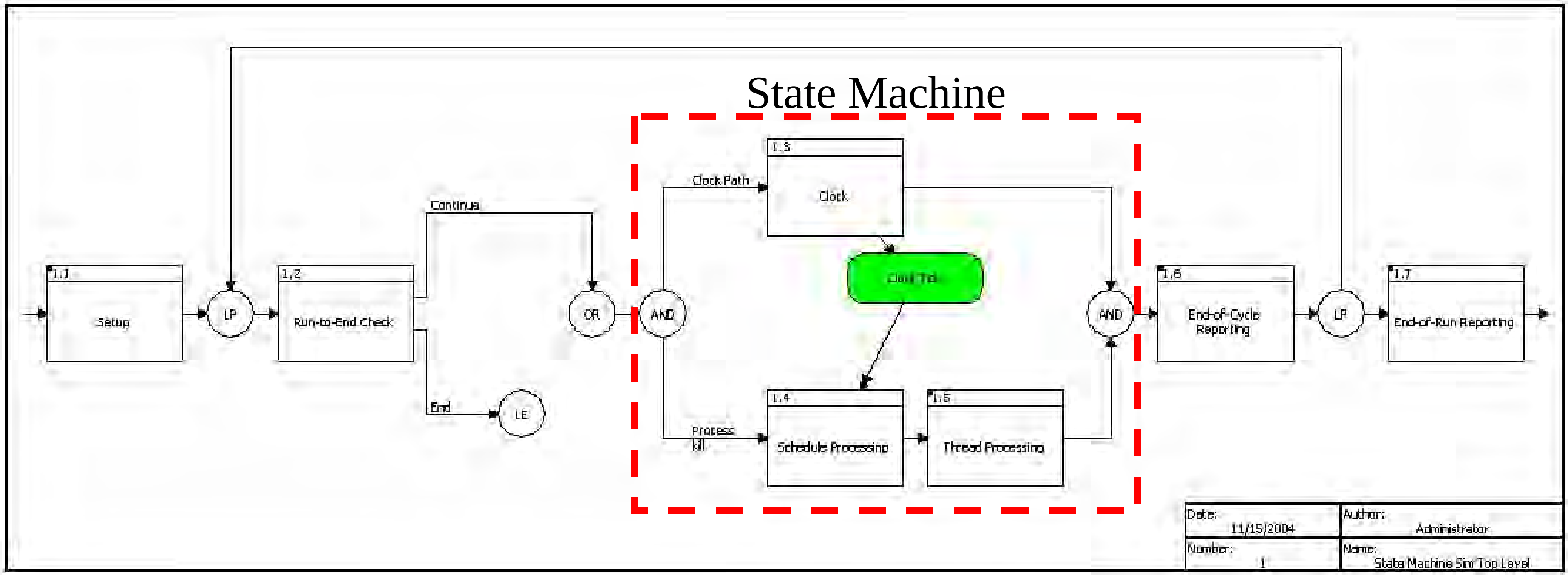
1. **Threads** : Work process of each job by an operator
   – Articulates specific job activities for each operator
2. **Integrated** : Common themes between jobs & operators
   Calculates minimum resource demand
3. **Allocated** : Differentiation of skills
   Added cost of specialization
   – Determine any effects when generic work is done during idle time
4. **State Machine** : Schedule and track concurrent activity
   – Impact of Business Rules (i.e. Job priorities & time remaining)
   – <u>Caution</u>: Logic is not as visible to users as usual behavior models

State Machine Form

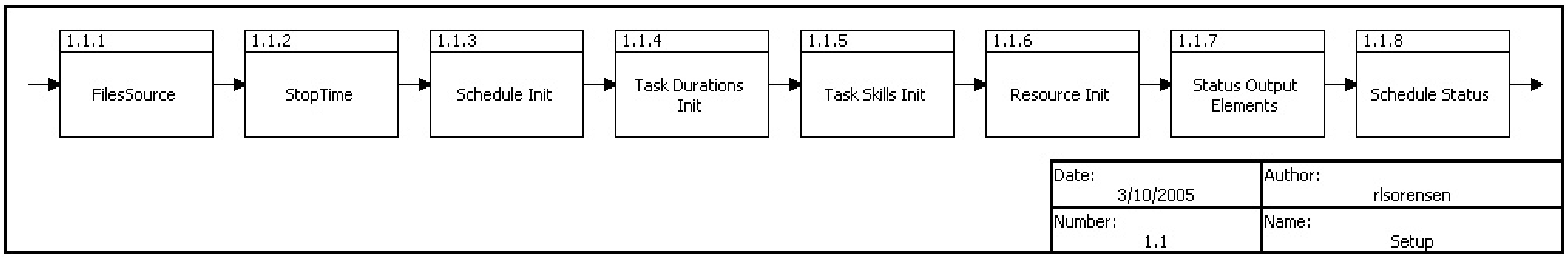
- Orthogonal to FFBD* forms
  - FFBDs are single-threaded, single-instance temporal domains
  - State machine is multi-threaded, multi-instance
- Essentially an 'engine' for processing scenarios
  - Task flow, resource, and queue logic in model
  - Tasks, resources, timelines instantiated at runtime
- Uses pre- and post- processing (Excel)

*FFBD: Functional Flow Block Diagram

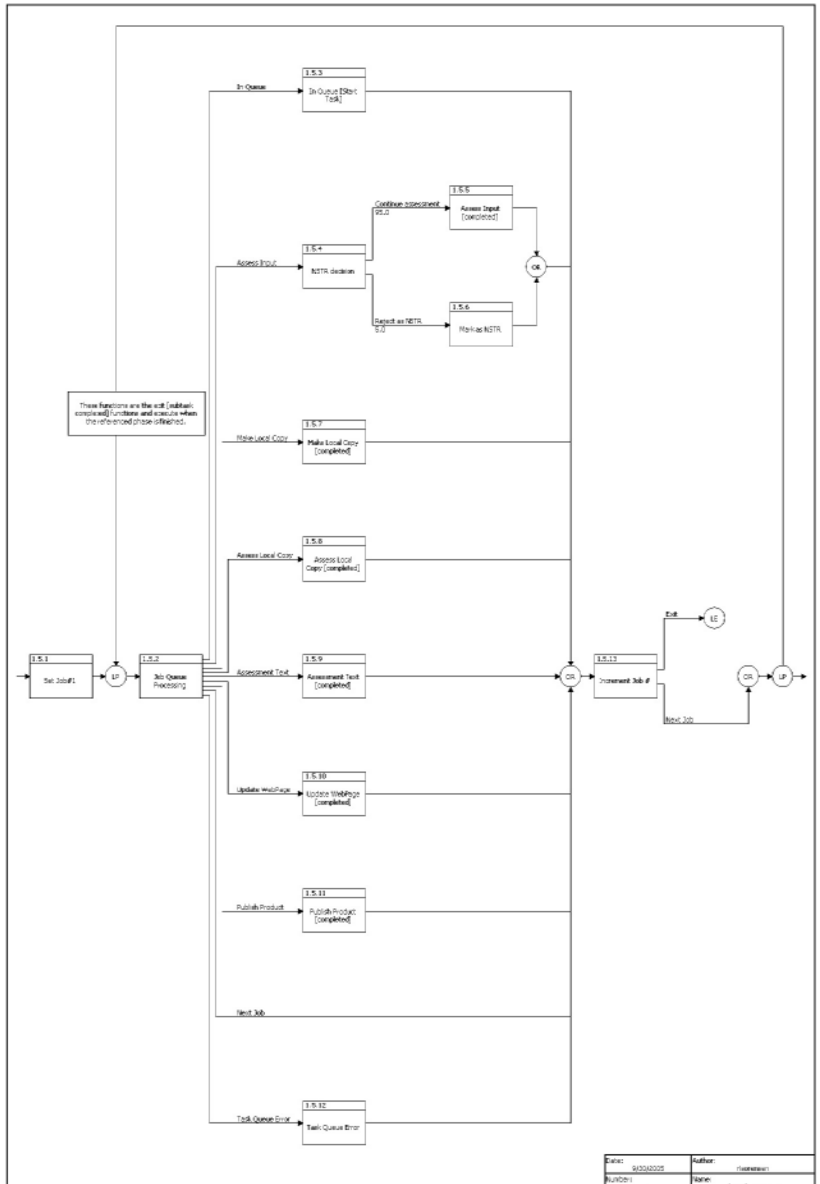
State Machine



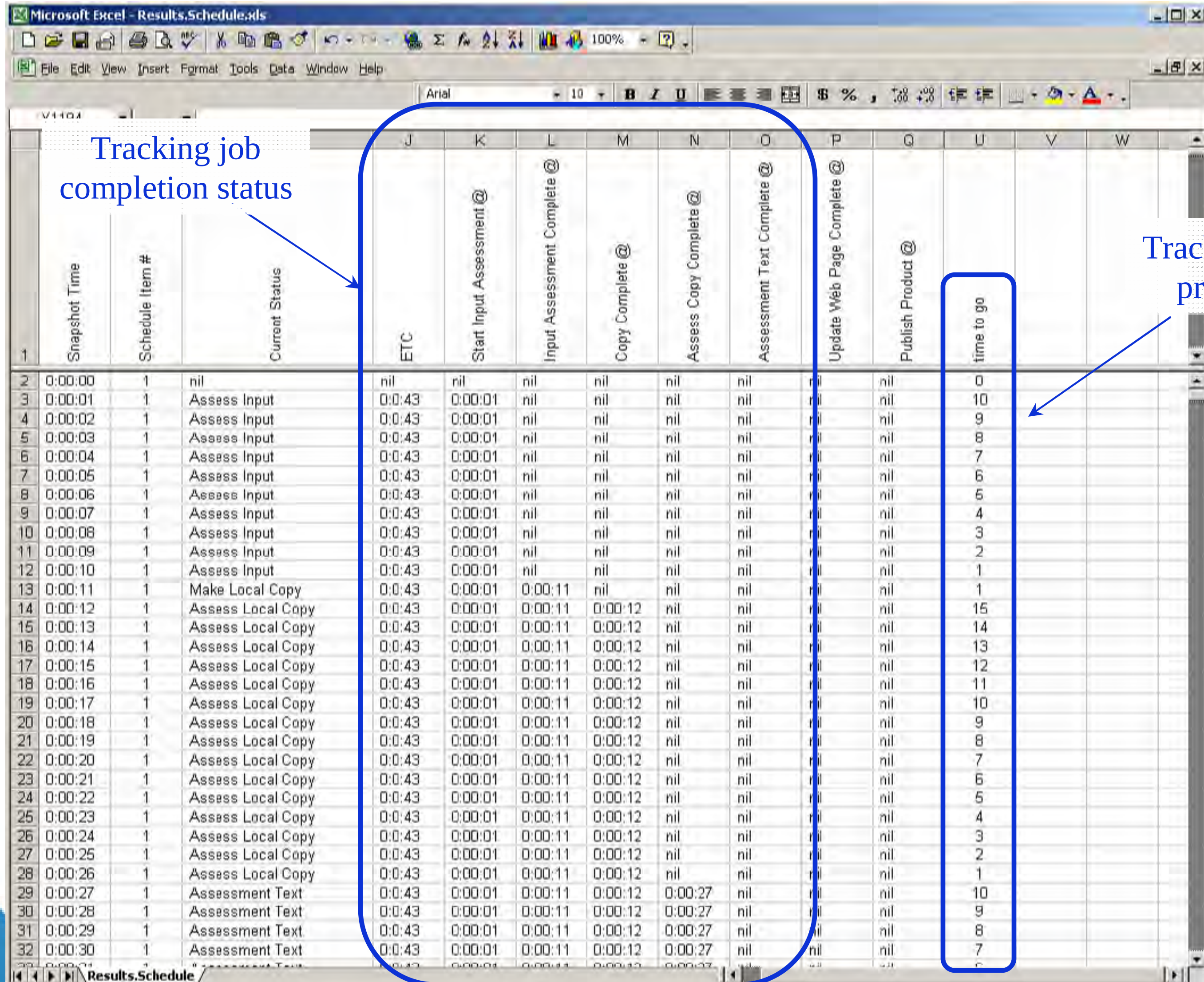
State Machine - Setup



State Machine – Thread Processing



Execution Results – Example



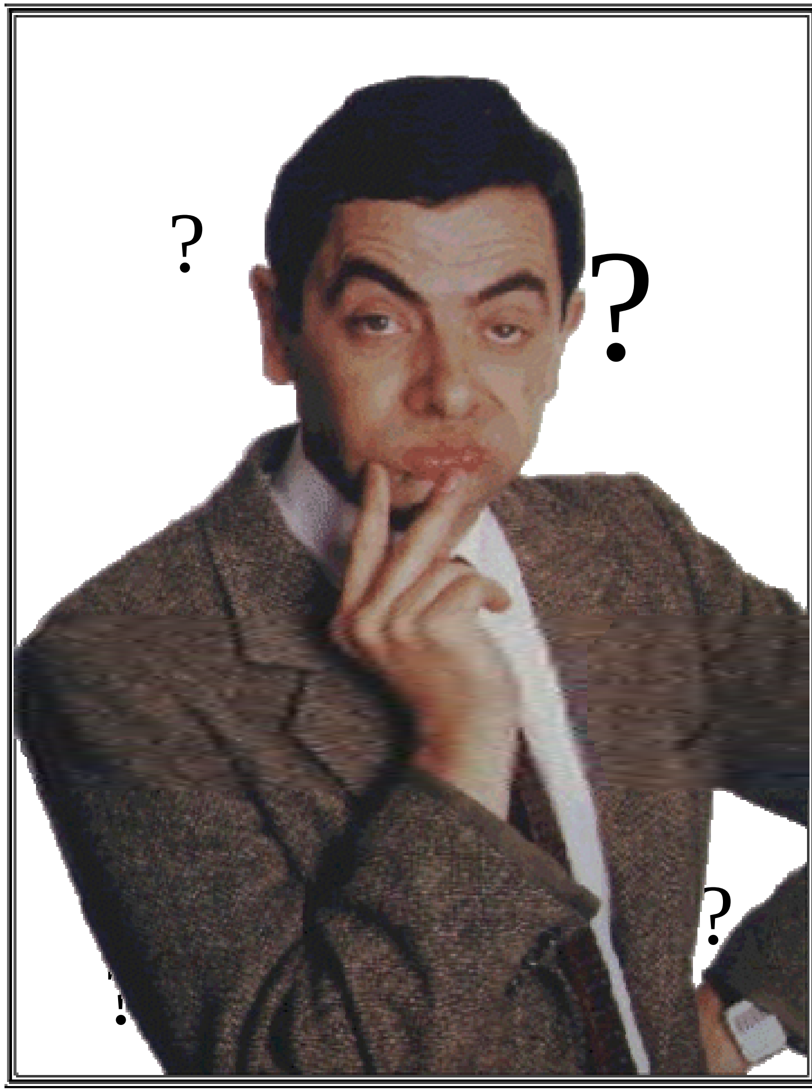
1	Snapshot Time	Schedule Item #	Current Status	ETC	Start Input Assessment @	Input Assessment Complete @	Copy Complete @	Assess Copy Complete @	Assessment Text Complete @	Update Web Page Complete @	Publish Product @	time to go
2	0:00:00	1	nil	nil	nil	nil	nil	nil	nil	nil	nil	0
3	0:00:01	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	10
4	0:00:02	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	9
5	0:00:03	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	8
6	0:00:04	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	7
7	0:00:05	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	6
8	0:00:06	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	5
9	0:00:07	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	4
10	0:00:08	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	3
11	0:00:09	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	2
12	0:00:10	1	Assess Input	0:0:43	0:00:01	nil	nil	nil	nil	nil	nil	1
13	0:00:11	1	Make Local Copy	0:0:43	0:00:01	0:00:11	nil	nil	nil	nil	nil	1
14	0:00:12	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	15
15	0:00:13	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	14
16	0:00:14	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	13
17	0:00:15	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	12
18	0:00:16	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	11
19	0:00:17	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	10
20	0:00:18	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	9
21	0:00:19	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	8
22	0:00:20	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	7
23	0:00:21	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	6
24	0:00:22	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	5
25	0:00:23	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	4
26	0:00:24	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	3
27	0:00:25	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	2
28	0:00:26	1	Assess Local Copy	0:0:43	0:00:01	0:00:11	0:00:12	nil	nil	nil	nil	1
29	0:00:27	1	Assessment Text	0:0:43	0:00:01	0:00:11	0:00:12	0:00:27	nil	nil	nil	10
30	0:00:28	1	Assessment Text	0:0:43	0:00:01	0:00:11	0:00:12	0:00:27	nil	nil	nil	9
31	0:00:29	1	Assessment Text	0:0:43	0:00:01	0:00:11	0:00:12	0:00:27	nil	nil	nil	8
32	0:00:30	1	Assessment Text	0:0:43	0:00:01	0:00:11	0:00:12	0:00:27	nil	nil	nil	7

Recap

- Operational Activity Modeling
  - Task, Process, Exploit, Disseminate (TPED)
  - Task, Post, Process, Use (TPPU)
- State Machine Concepts
- Description of TPPU State Machine
- Modeling Process
- Examples
- Way Ahead

Questions

? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

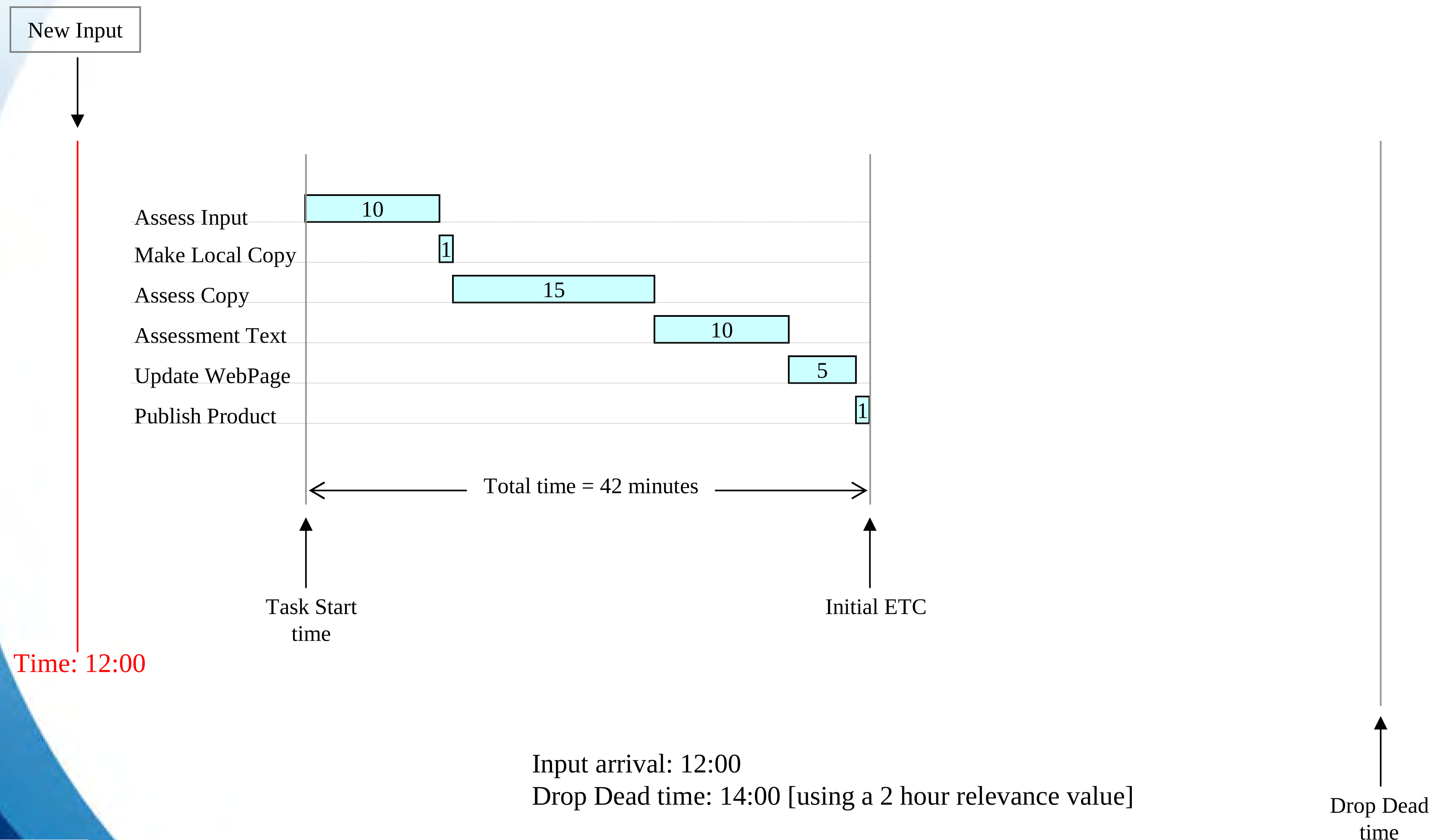


DEFENCE DÉFENSE

Execution Scenario 1

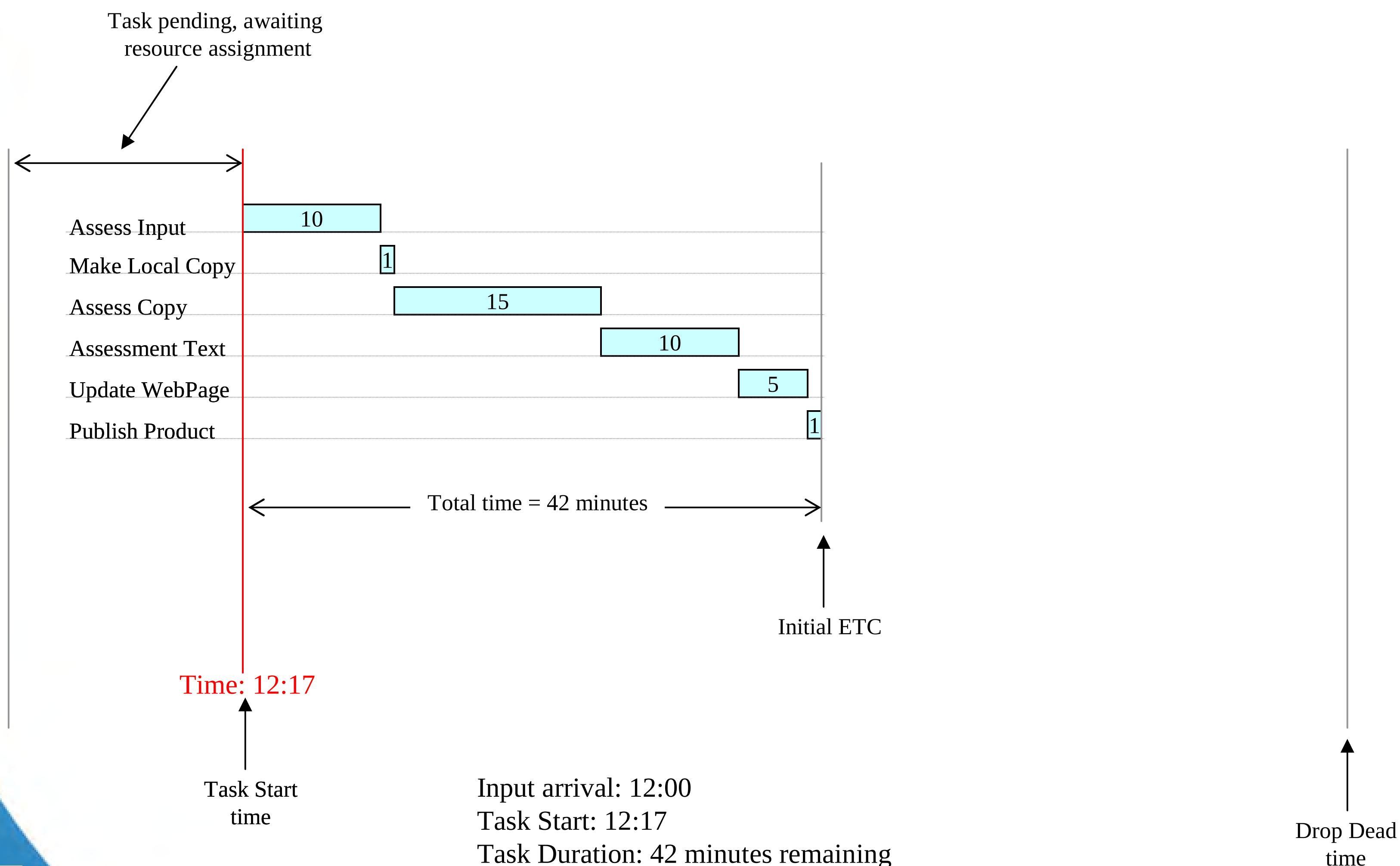
Normal Completion

Scenario 1-1



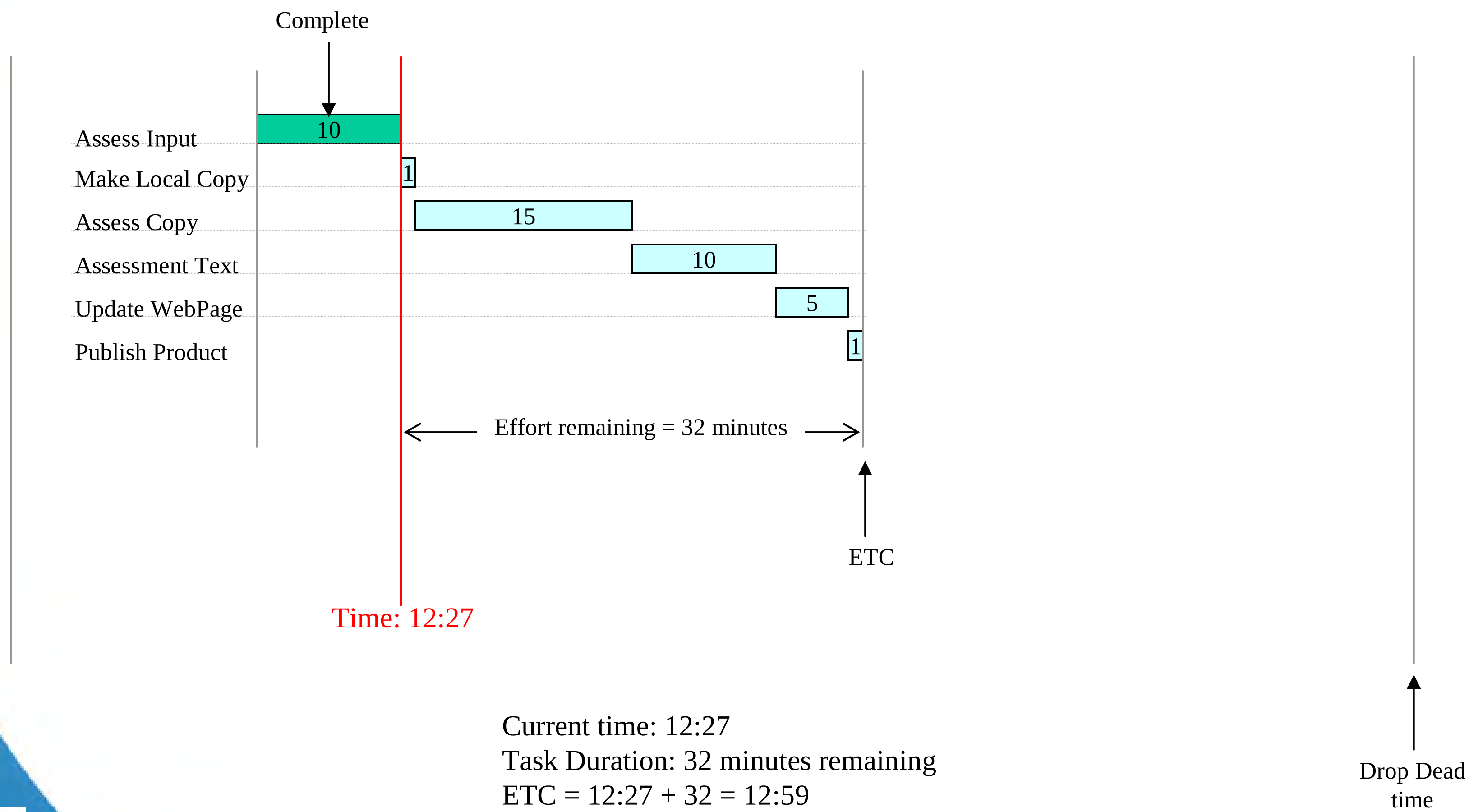
Input arrival: 12:00
Drop Dead time: 14:00 [using a 2 hour relevance value]

Scenario 1-2



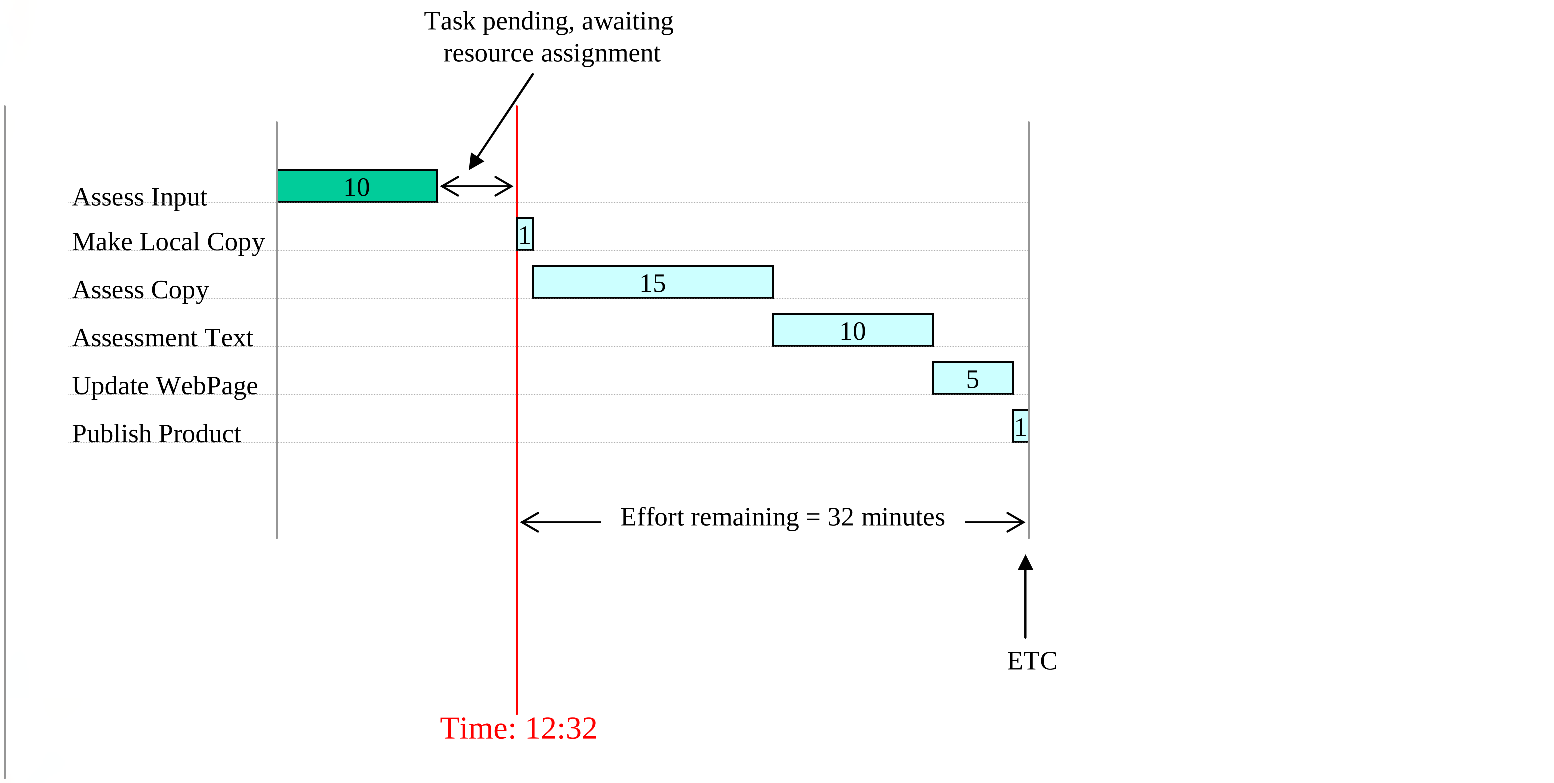
Input arrival: 12:00
Task Start: 12:17
Task Duration: 42 minutes remaining
ETC = 12:17 + 42 = 12:59
Slack time = 14:00 – 12:59 = 1:01

Scenario 1-3



Current time: 12:27
Task Duration: 32 minutes remaining
ETC = 12:27 + 32 = 12:59
Slack time = 14:00 – 12:59 = 1:01

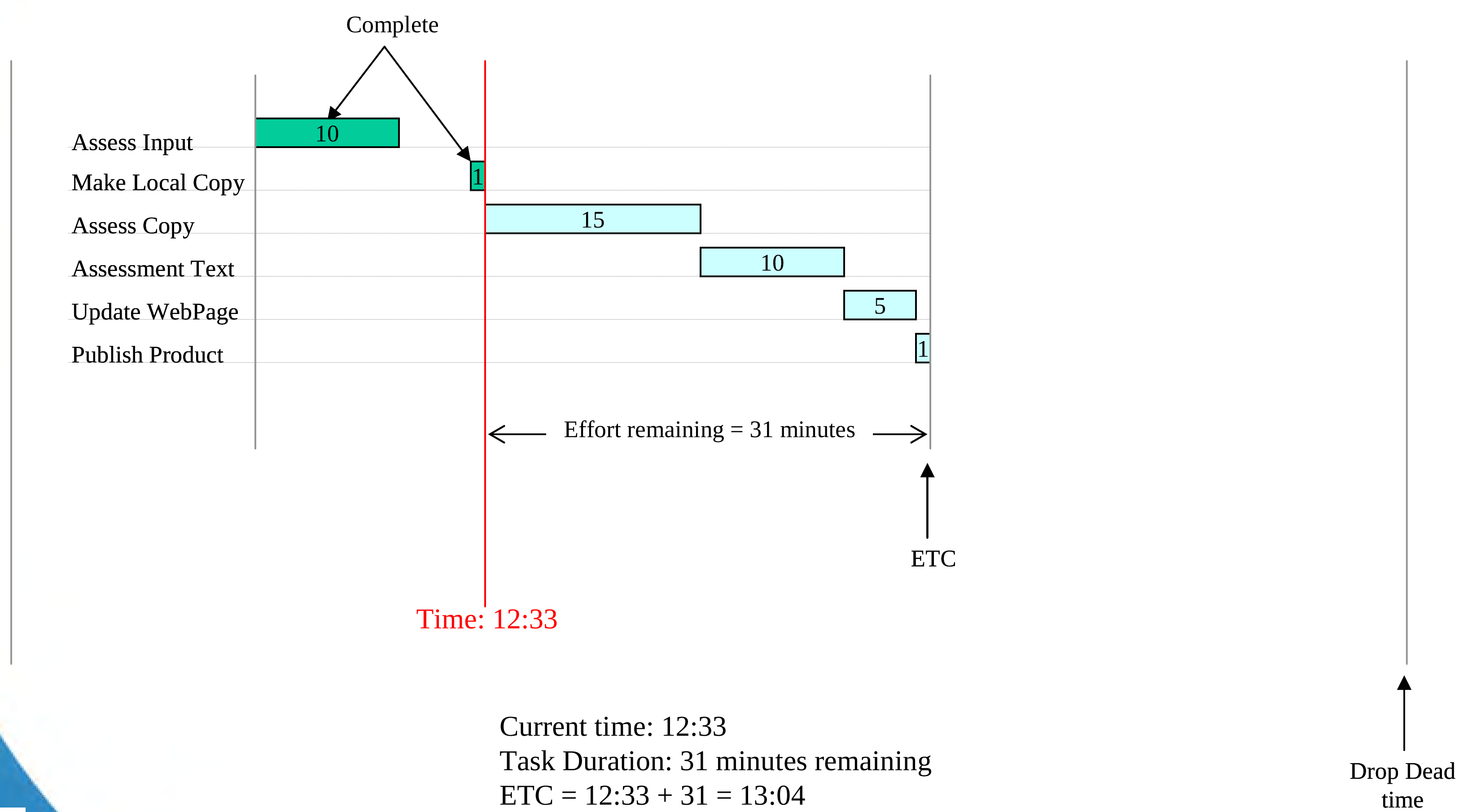
Scenario 1-4



Drop Dead time

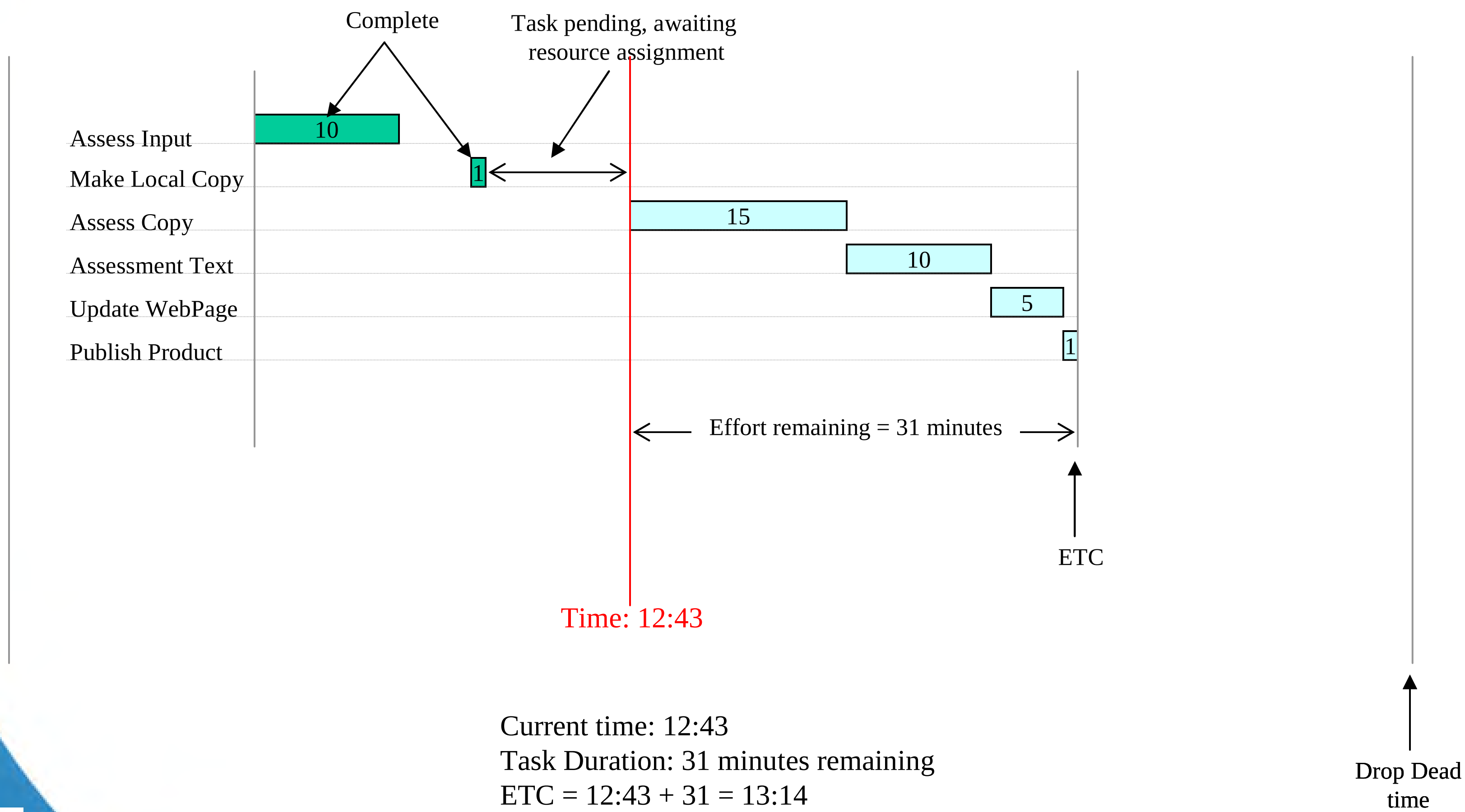
Current time: 12:32
Task Duration: 32 minutes remaining
ETC = 12:32 + 32 = 13:04
Slack time = 14:00 – 13:04 = 0:56

Scenario 1-5



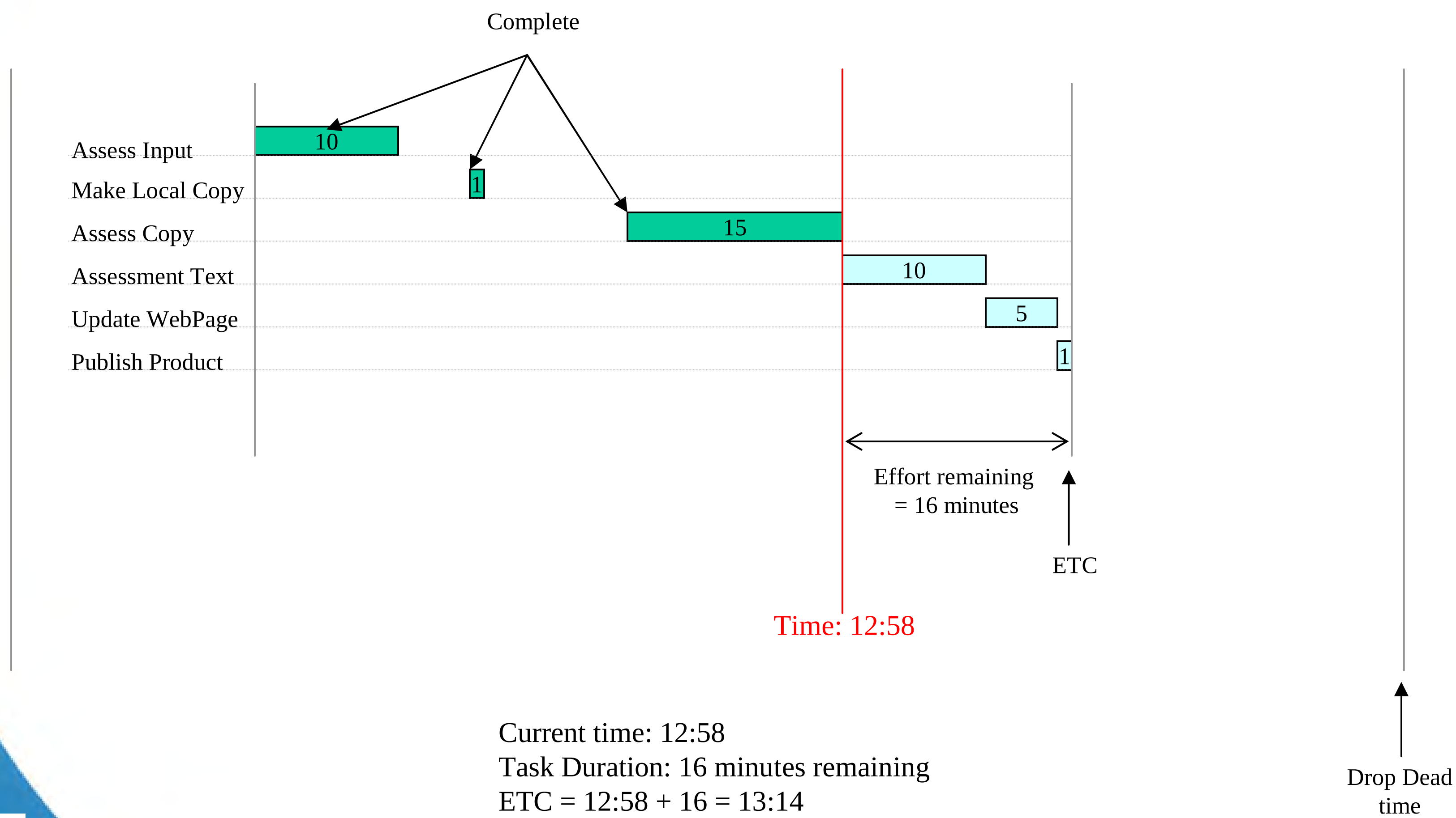
Current time: 12:33
Task Duration: 31 minutes remaining
ETC = 12:33 + 31 = 13:04
Slack time = 14:00 – 13:04 = 0:56

Scenario 1-6



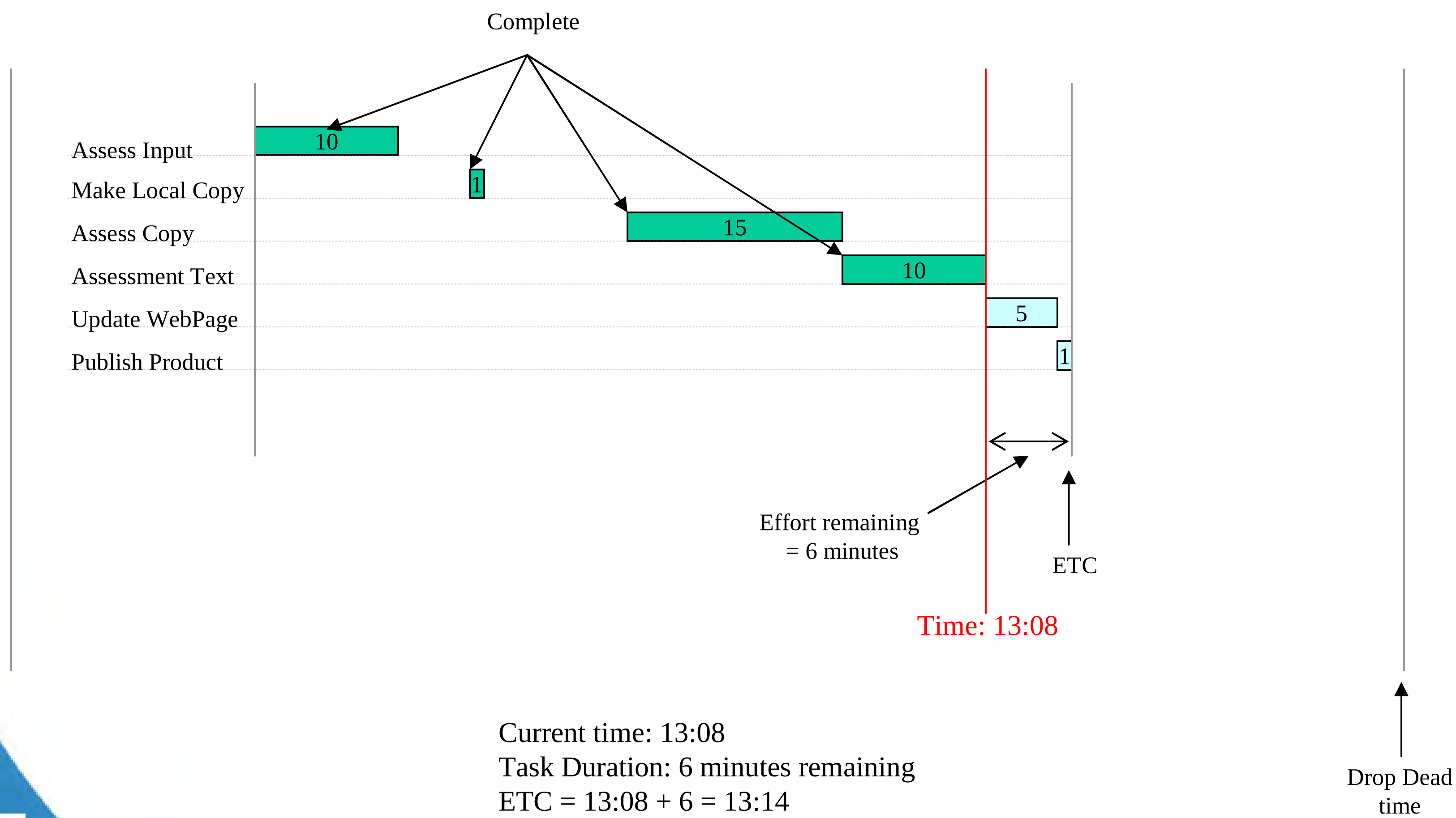
Current time: 12:43
Task Duration: 31 minutes remaining
ETC = 12:43 + 31 = 13:14
Slack time = 14:00 – 13:14 = 0:46

Scenario 1-7



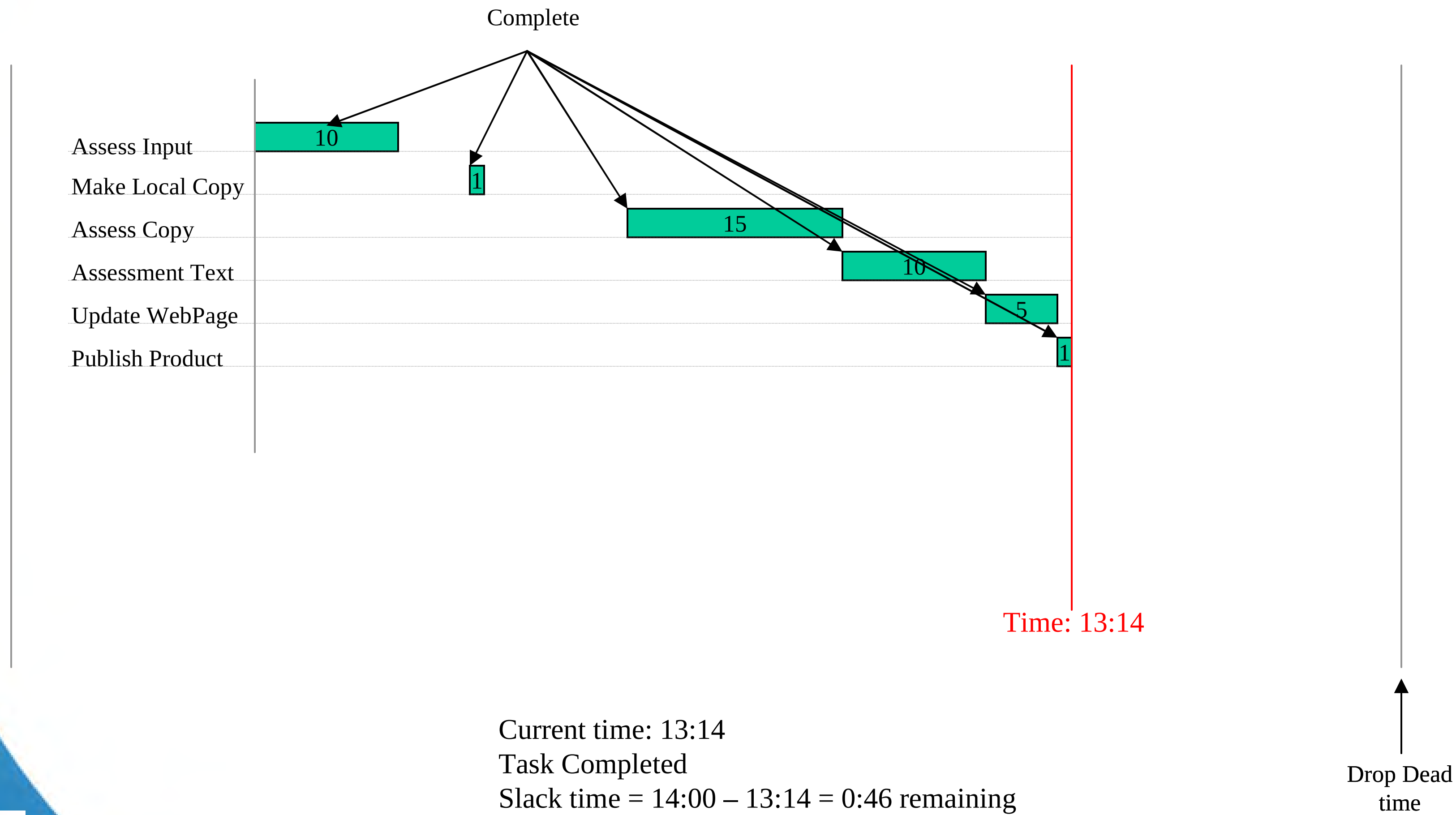
Current time: 12:58
Task Duration: 16 minutes remaining
ETC = 12:58 + 16 = 13:14
Slack time = 14:00 – 13:14 = 0:46

Scenario 1-8



Current time: 13:08
Task Duration: 6 minutes remaining
ETC = 13:08 + 6 = 13:14
Slack time = 14:00 – 13:14 = 0:46

Scenario 1-9



Current time: 13:14
Task Completed
Slack time = 14:00 – 13:14 = 0:46 remaining

DEFENCE R&D DÉFENSE

Execution Scenario 2

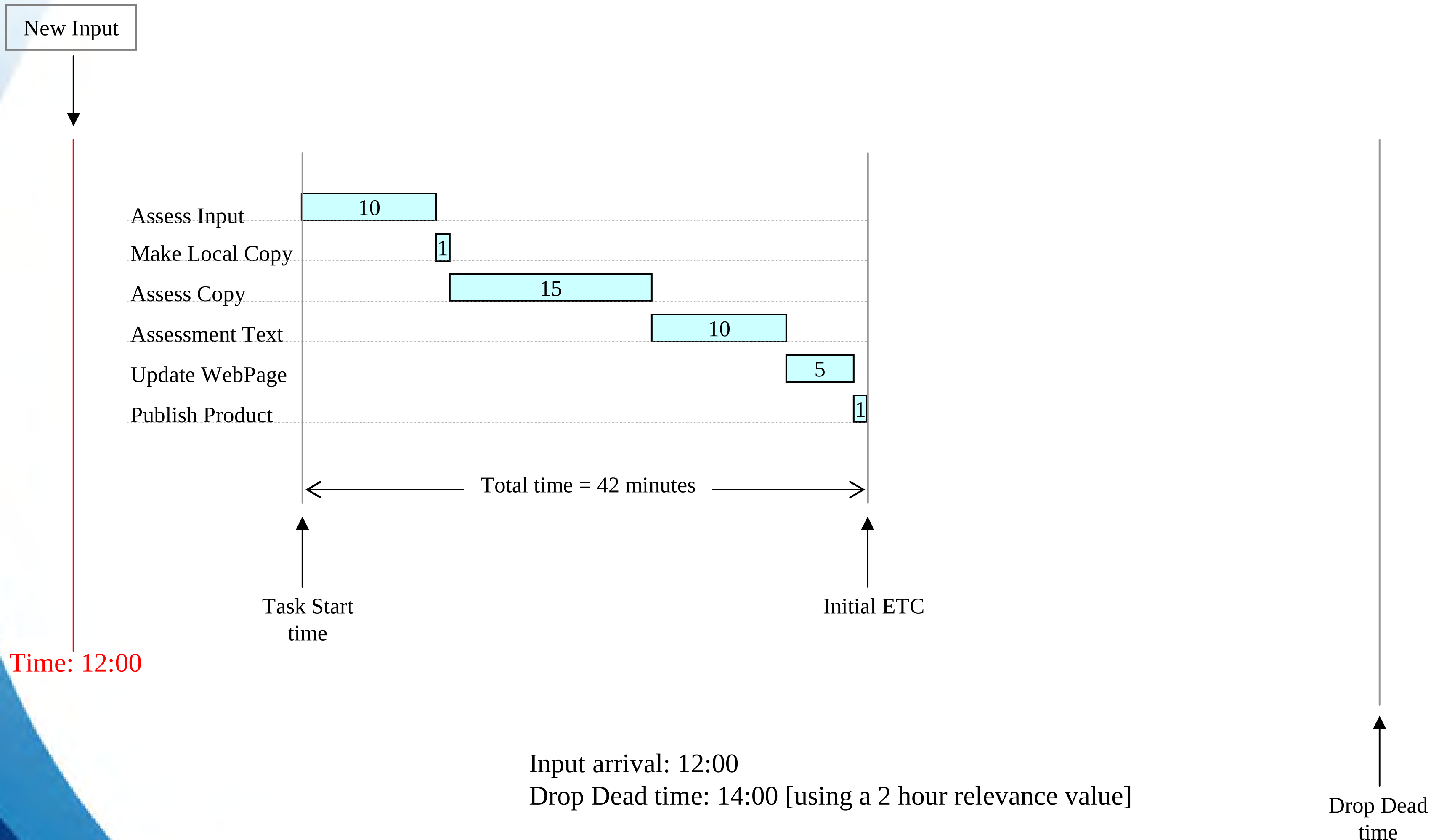
Job Abandoned

Defence Research and Development Canada

Recherche et développement pour la défense Canada

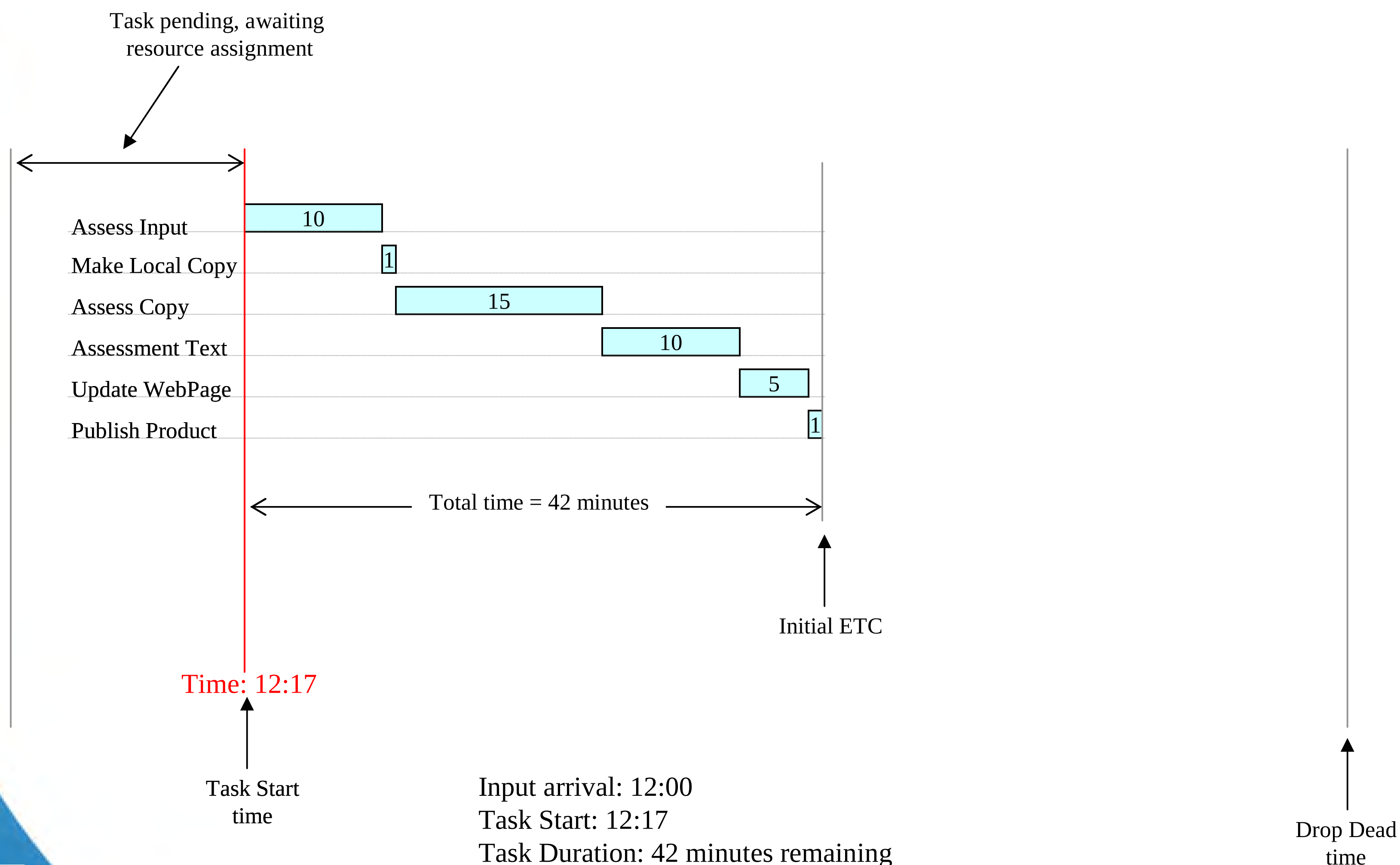
Canada

Scenario 2-1



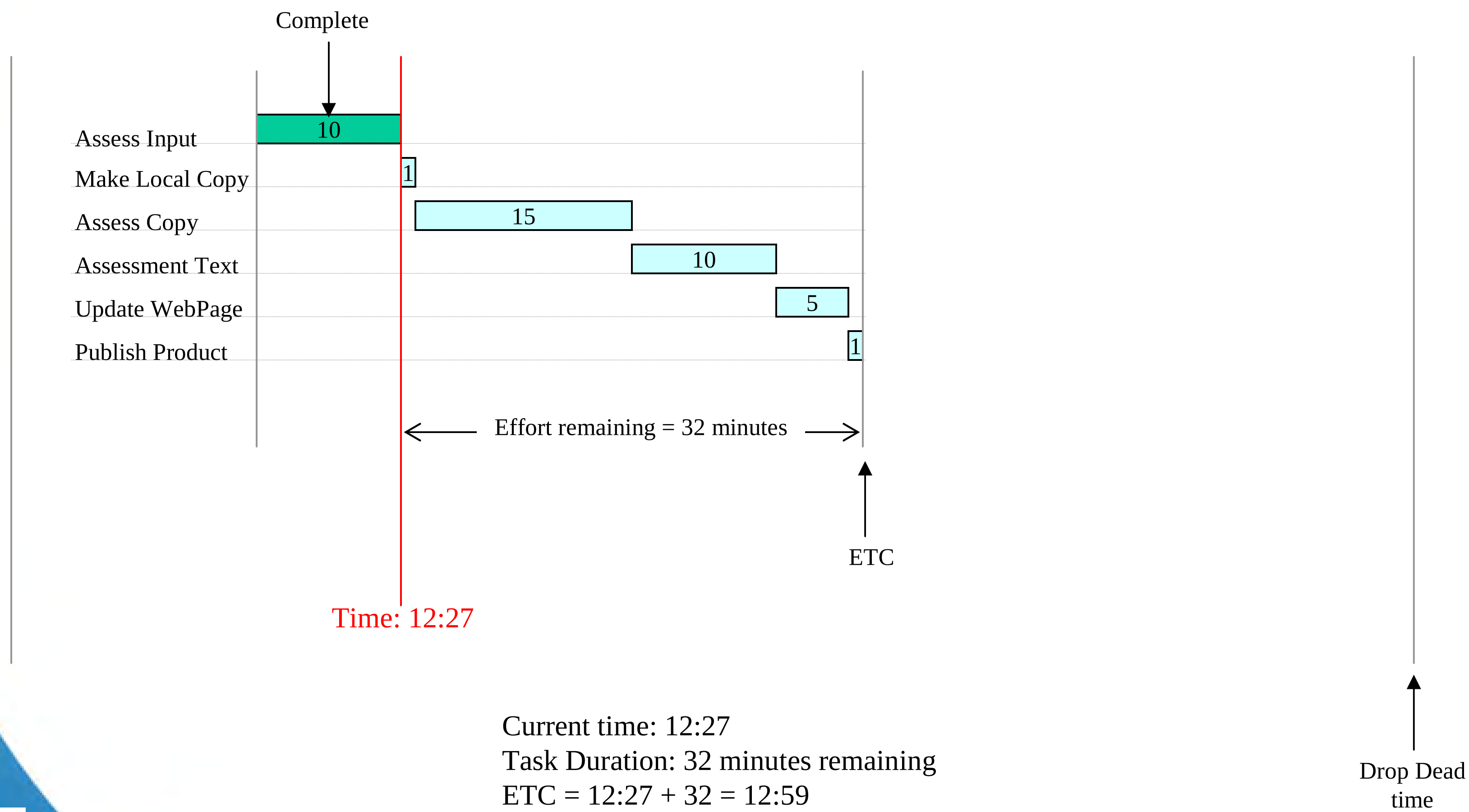
Input arrival: 12:00
Drop Dead time: 14:00 [using a 2 hour relevance value]

Scenario 2-2



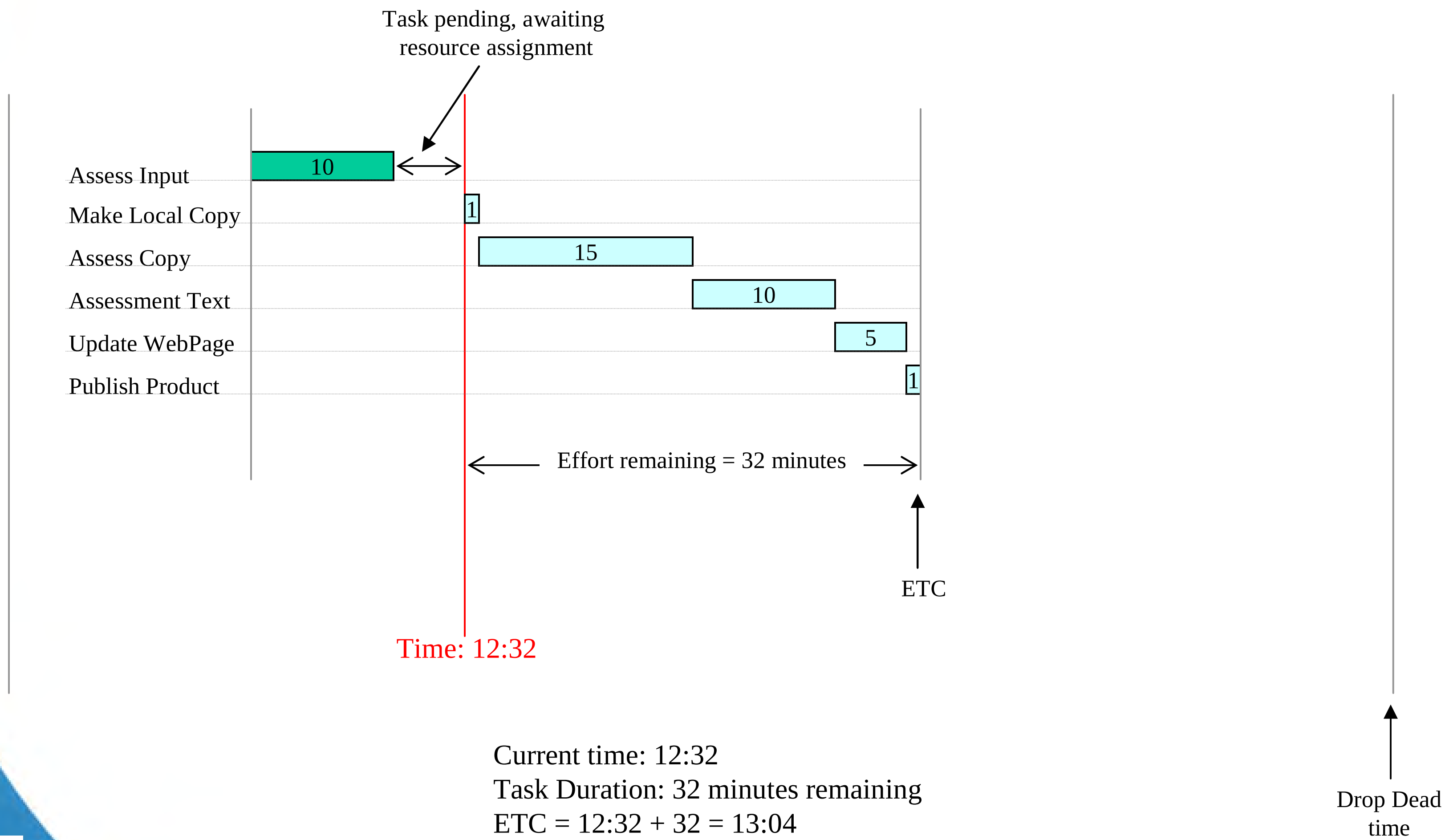
Input arrival: 12:00
Task Start: 12:17
Task Duration: 42 minutes remaining
ETC = 12:17 + 42 = 12:59
Slack time = 14:00 – 12:59 = 1:01

Scenario 2-3



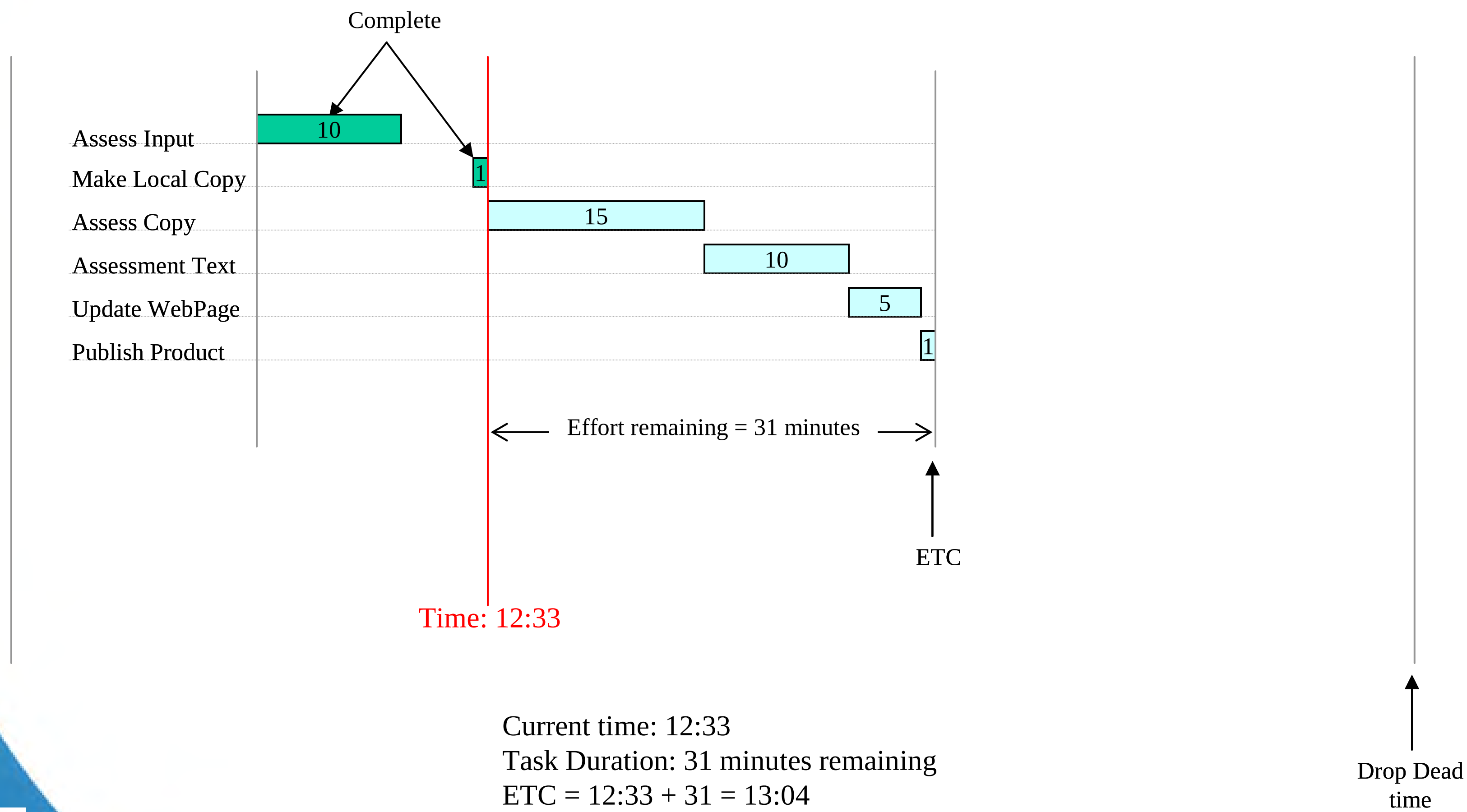
Current time: 12:27
Task Duration: 32 minutes remaining
ETC = 12:27 + 32 = 12:59
Slack time = 14:00 – 12:59 = 1:01

Scenario 2-4



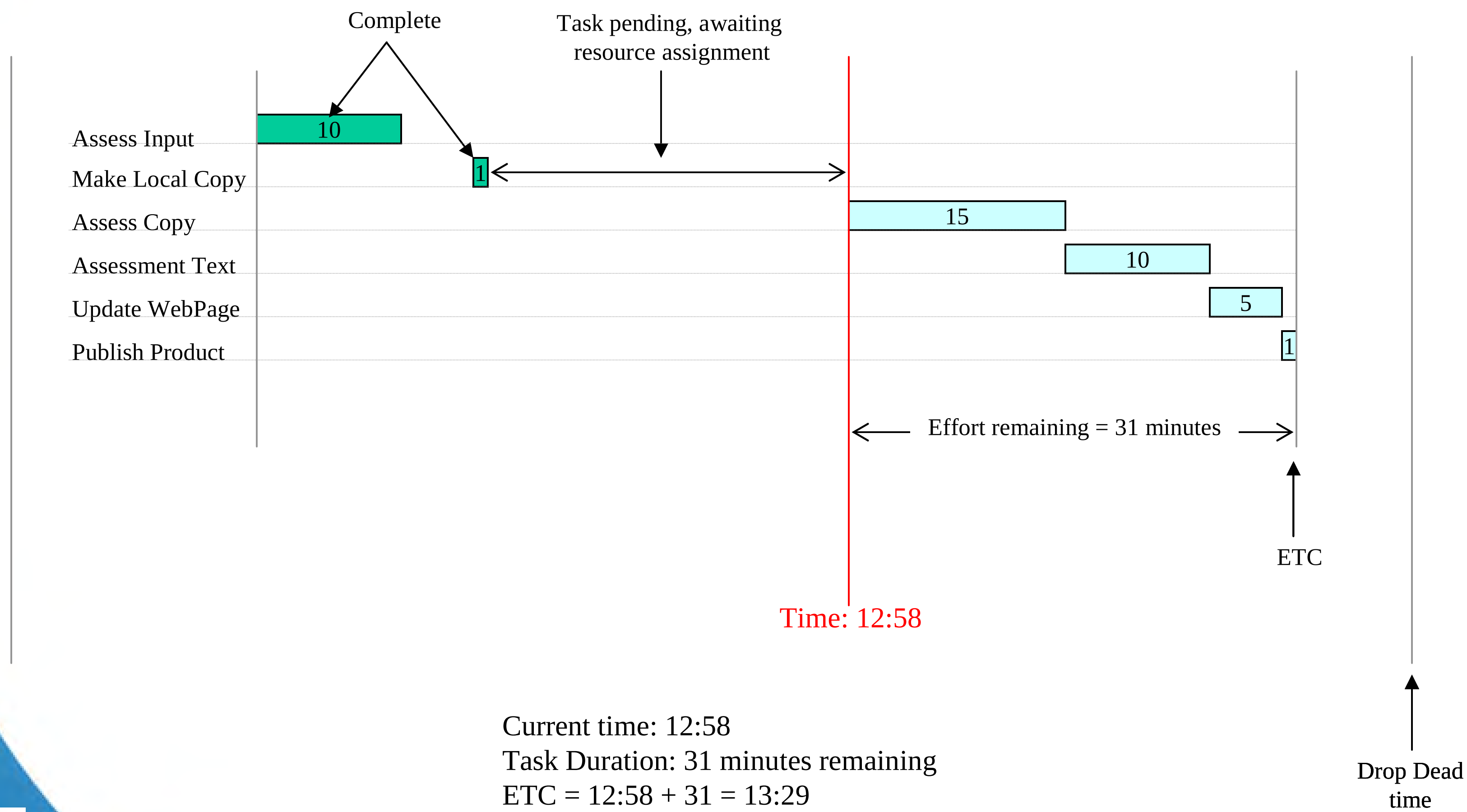
Current time: 12:32
Task Duration: 32 minutes remaining
ETC = 12:32 + 32 = 13:04
Slack time = 14:00 – 13:04 = 0:56

Scenario 2-5



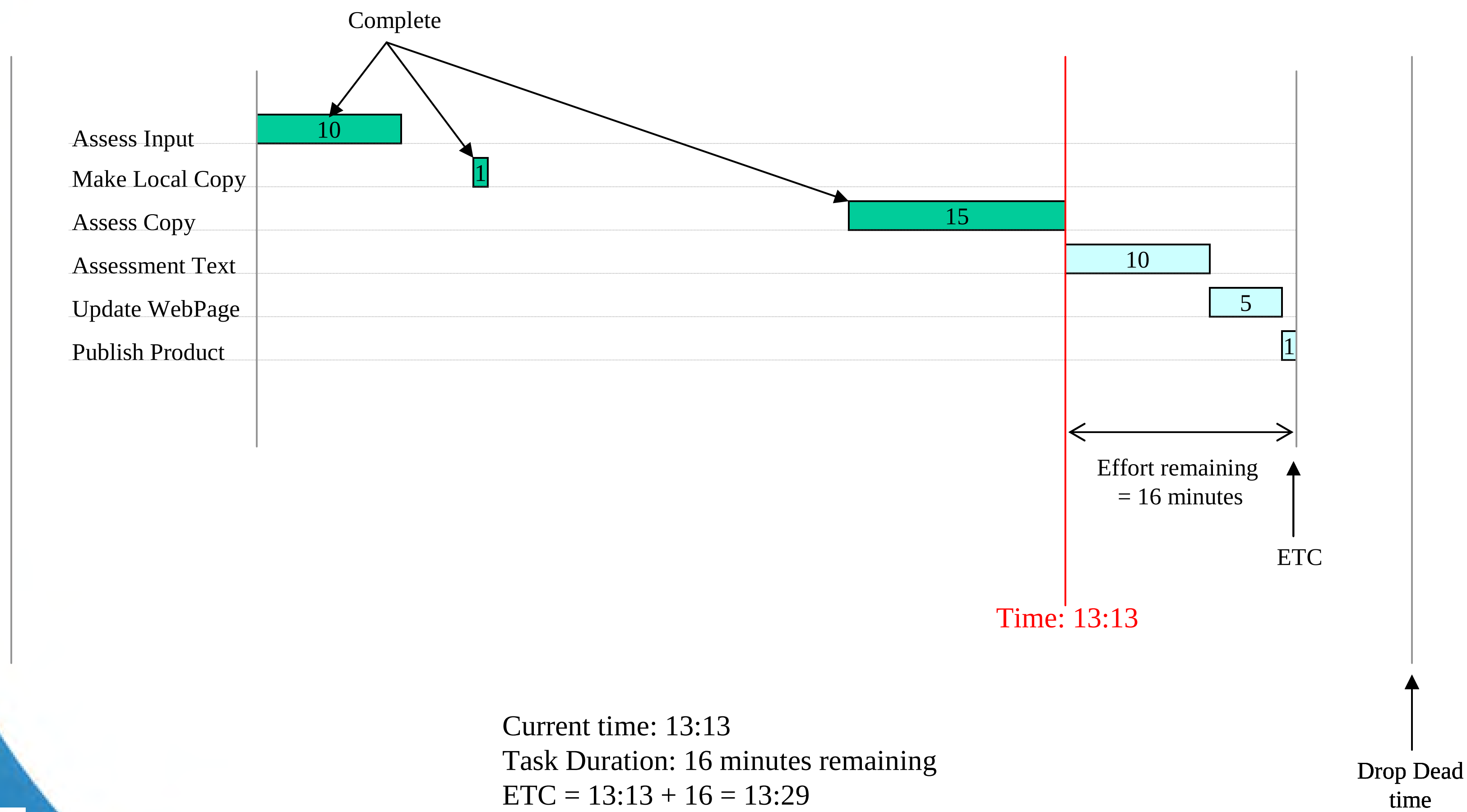
Current time: 12:33
Task Duration: 31 minutes remaining
ETC = 12:33 + 31 = 13:04
Slack time = 14:00 – 13:04 = 0:56

Scenario 2-6



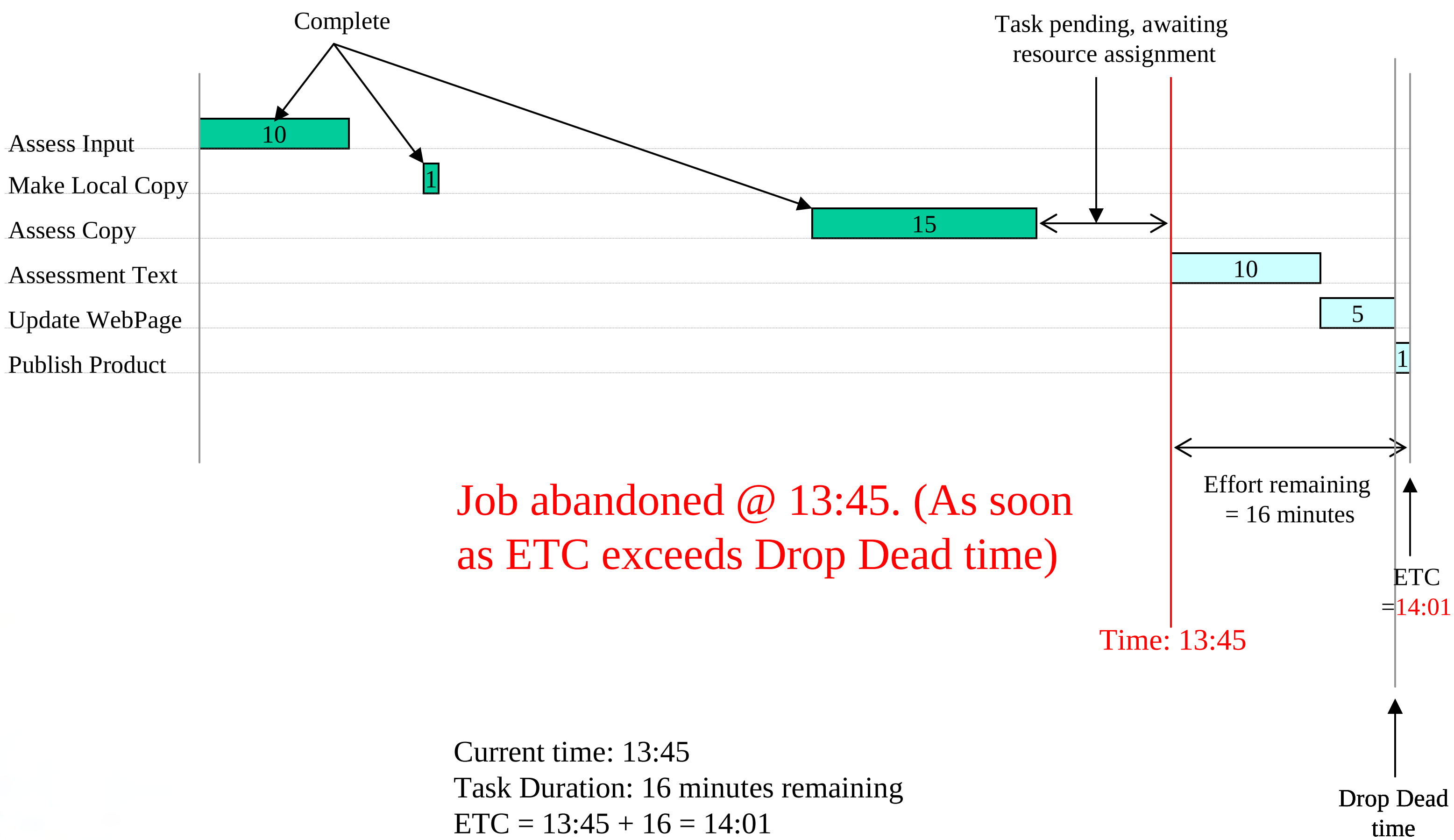
Current time: 12:58
Task Duration: 31 minutes remaining
ETC = 12:58 + 31 = 13:29
Slack time = 14:00 – 13:29 = 0:31

Scenario 2-7



Current time: 13:13
Task Duration: 16 minutes remaining
ETC = 13:13 + 16 = 13:29
Slack time = 14:00 – 13:29 = 0:31

Scenario 2-8



Job abandoned @ 13:45. (As soon as ETC exceeds Drop Dead time)

Current time: 13:45
Task Duration: 16 minutes remaining
ETC = 13:45 + 16 = 14:01
Slack time = 14:00 – 14:01 = -0:01

Contact

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DEFENCE R&D DÉFENSE

Air Force Institute of Technology

Integrity - Service - Excellence

Are New Acquisition Programs Taking Longer to Develop / Field and, if so, Why?

U.S. AIR FORCE

Dennis Strouble, PhD, JD

Major Steve Dobronski

Major Brad Harroff

Major Dwight Pavek

Major Scott Ward

U.S. AIR FORCE

- The views expressed in this presentation are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States government.

U.S. AIR FORCE

Overview

- Background
- Budget
- Technology
- Climate
- Acquisitions
- Schedule
- Conclusions

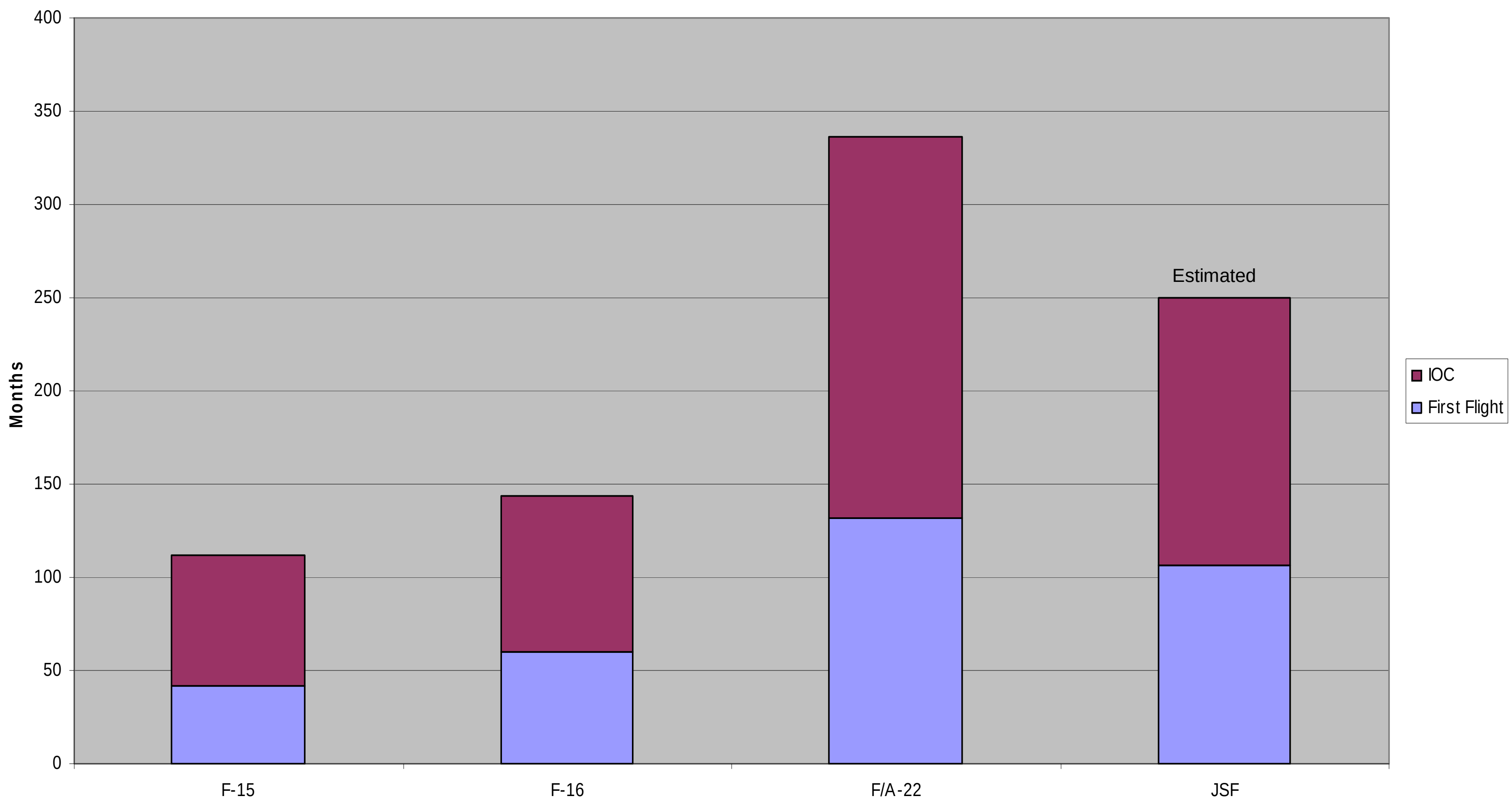
Background

- Our charter, loose leash, group determined direction
- Scope of our research
  - Fighter acquisitions from the 1970s to the present
  - Primarily F-15, F-16, F/A-22, F-35
- Methods
  - Personal interviews
  - Archive research (ASC/HO)
  - Extensive Literature Study

The Short Answer

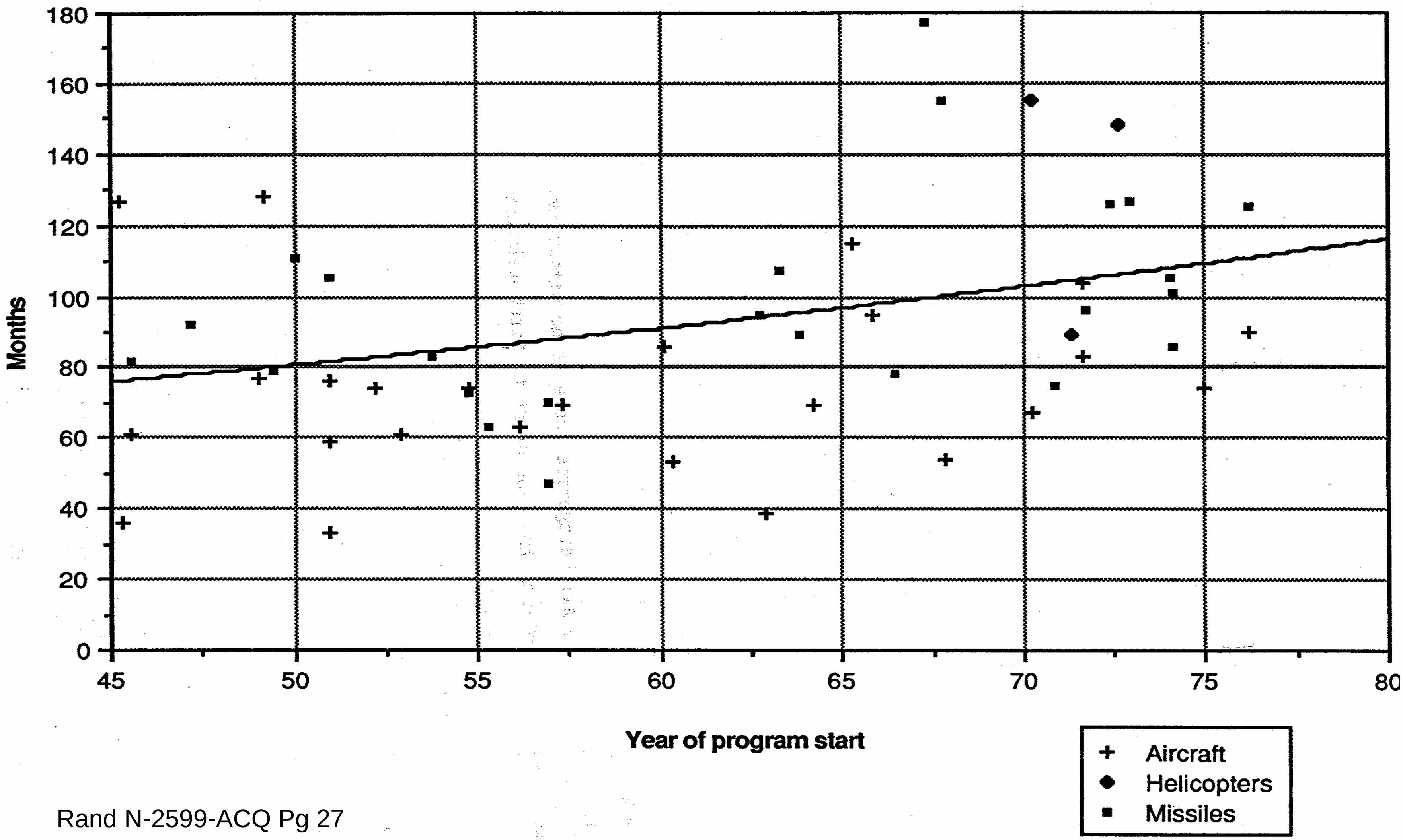
Yes

The Short Answer



Fighter Aircraft Development Times, Gebhard, 2005

The Short Answer



Rand N-2599-ACQ Pg 27

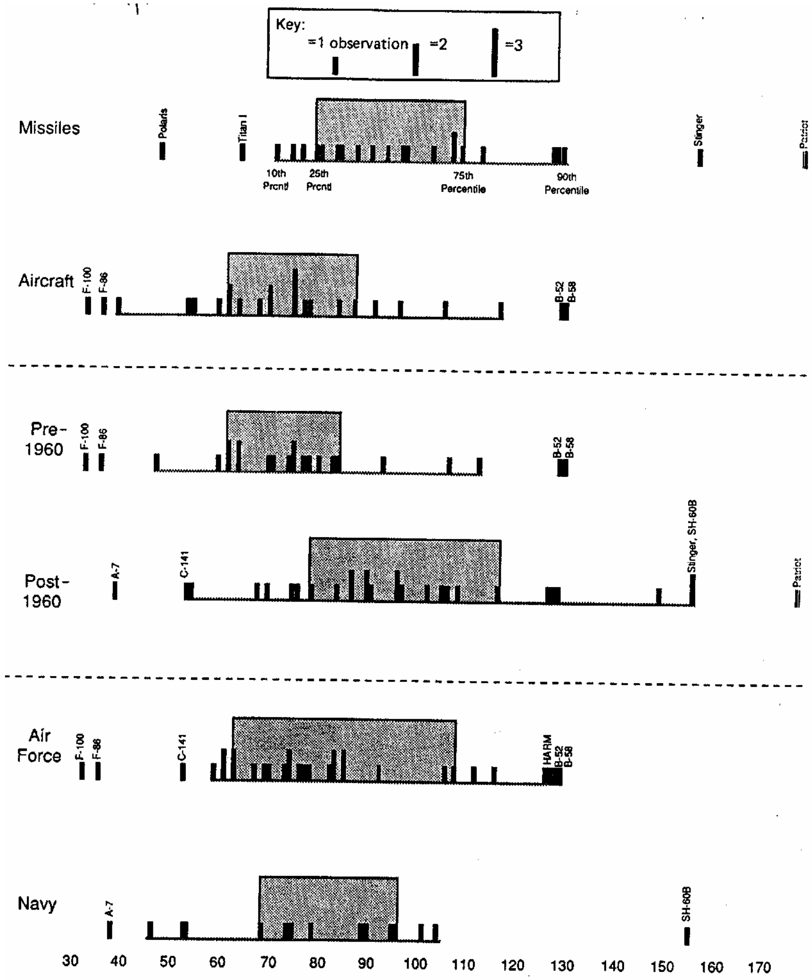
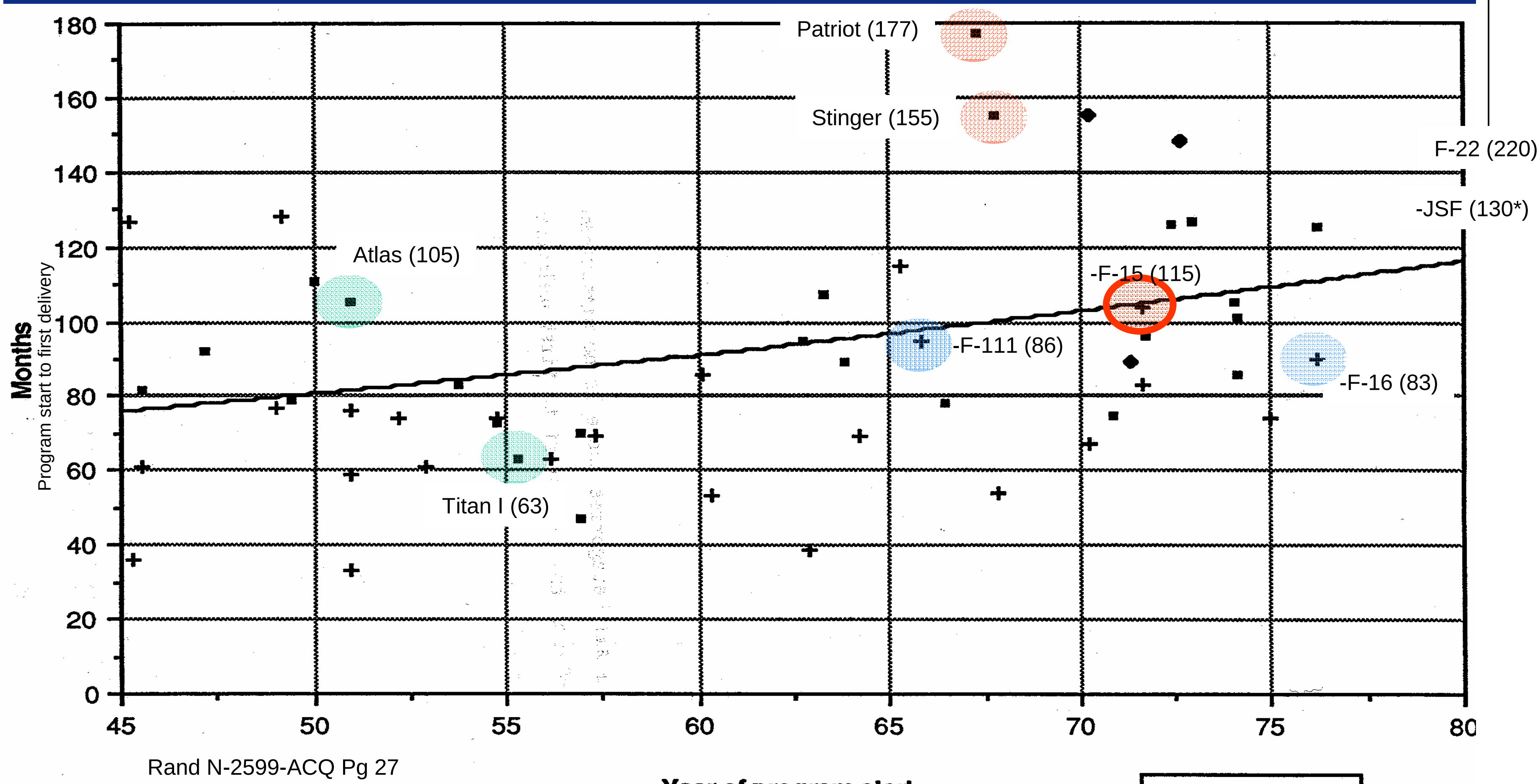


Fig. 1 — Distribution of months from program start to first delivery

Rand N-2599-ACQ Pg 14

The Short Answer



Rand N-2599-ACQ Pg 27

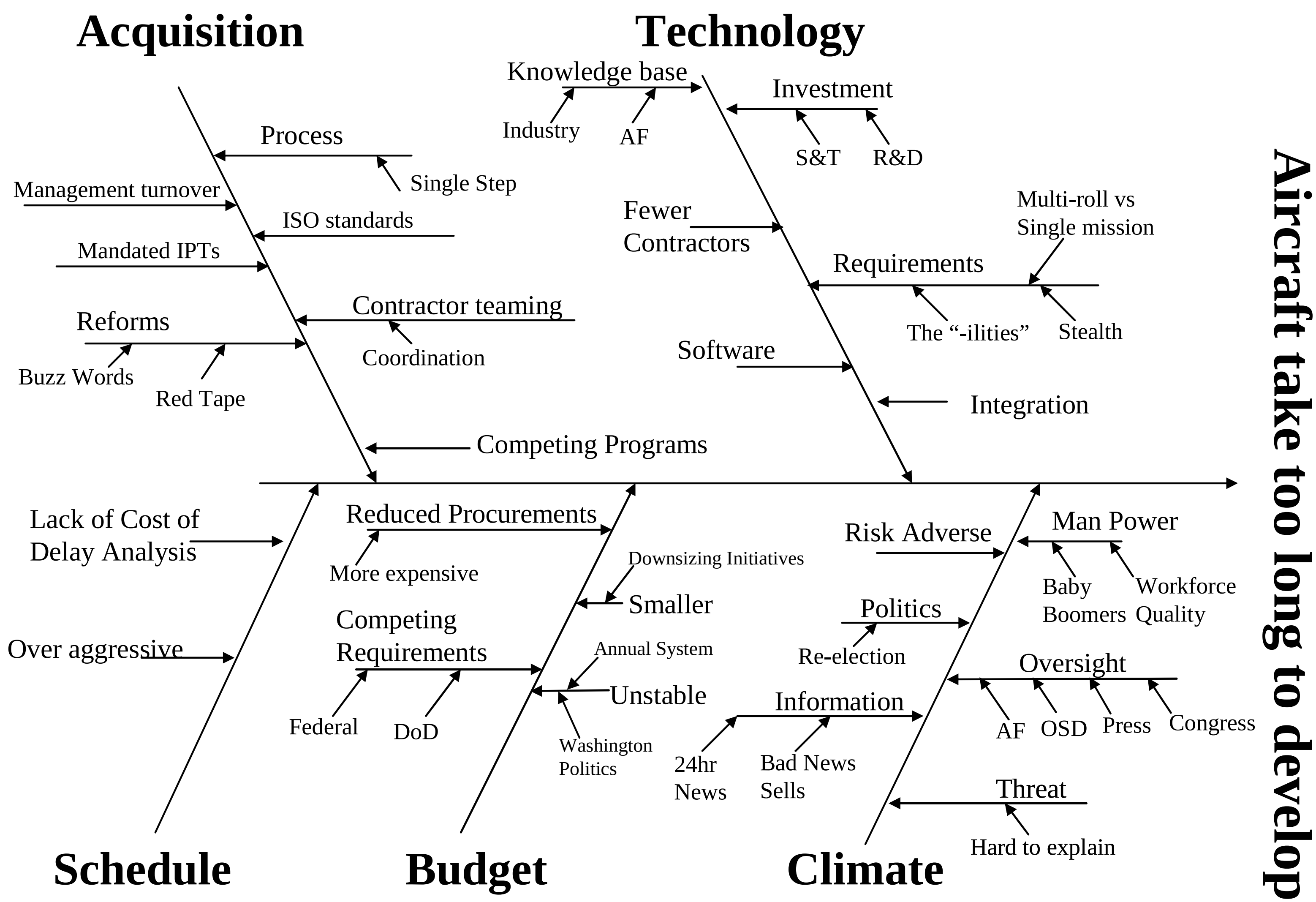
- Comparison of Atlas (105 mths) to Titan I (63 mths)

- Examples: Patriot (177 mths) and Stinger (155 mths)

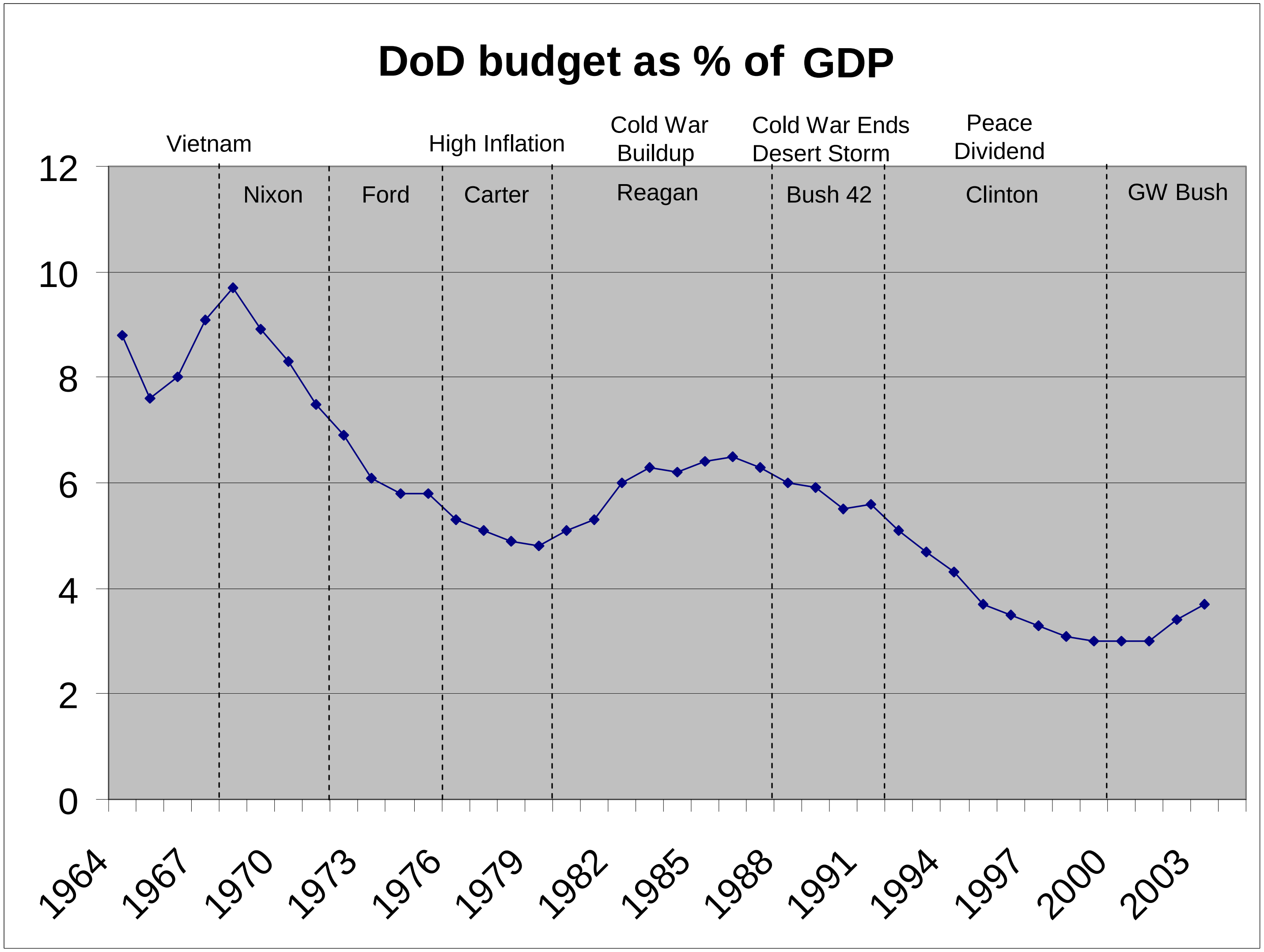
The Long Answer

- List of contributing factors is long
  - This is an issue that requires systems thinking
- We broke it into five areas
  - Budget
  - Technology
  - Climate
  - Acquisition
  - Schedule

The Long Answer

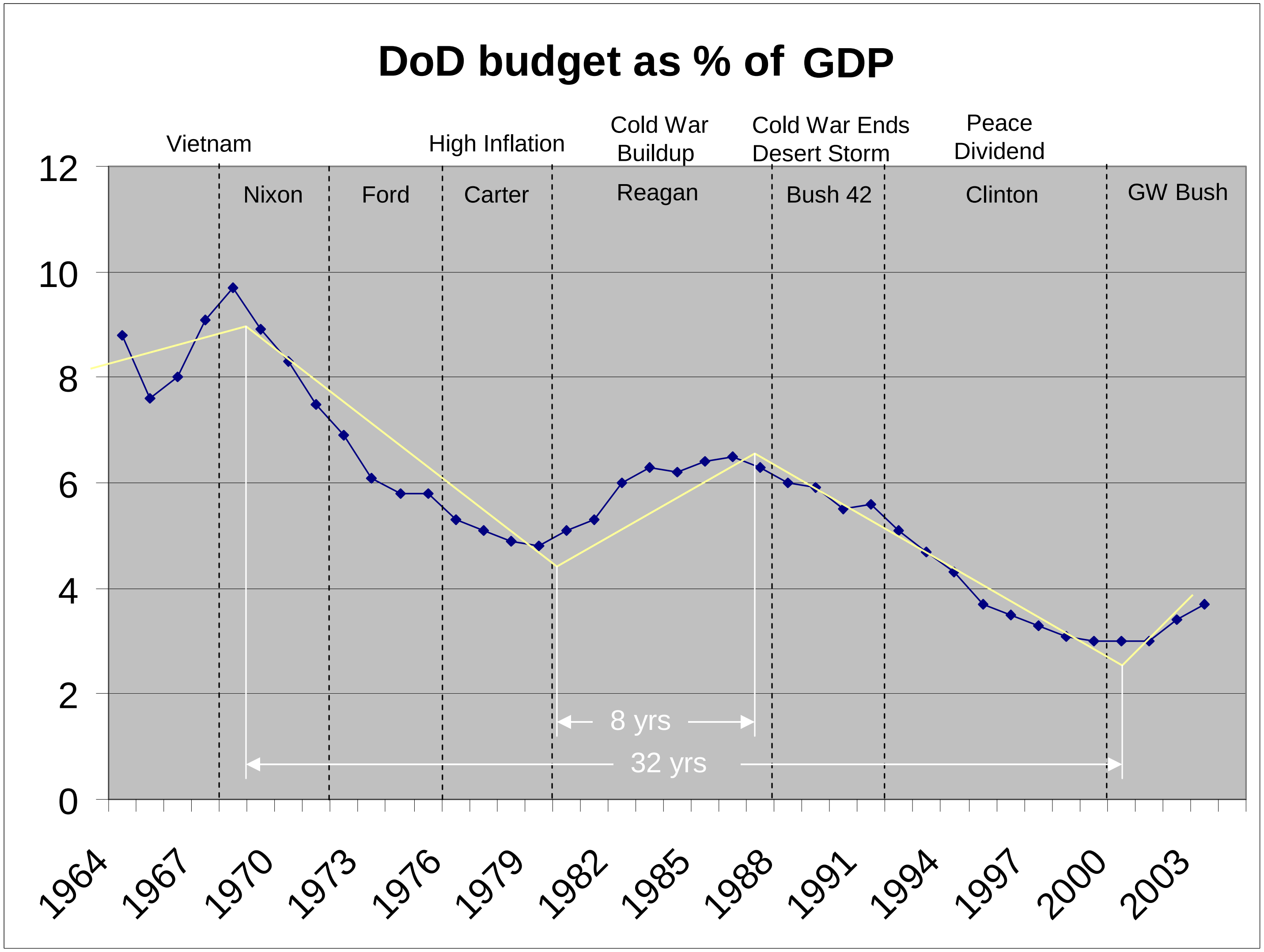


Budget



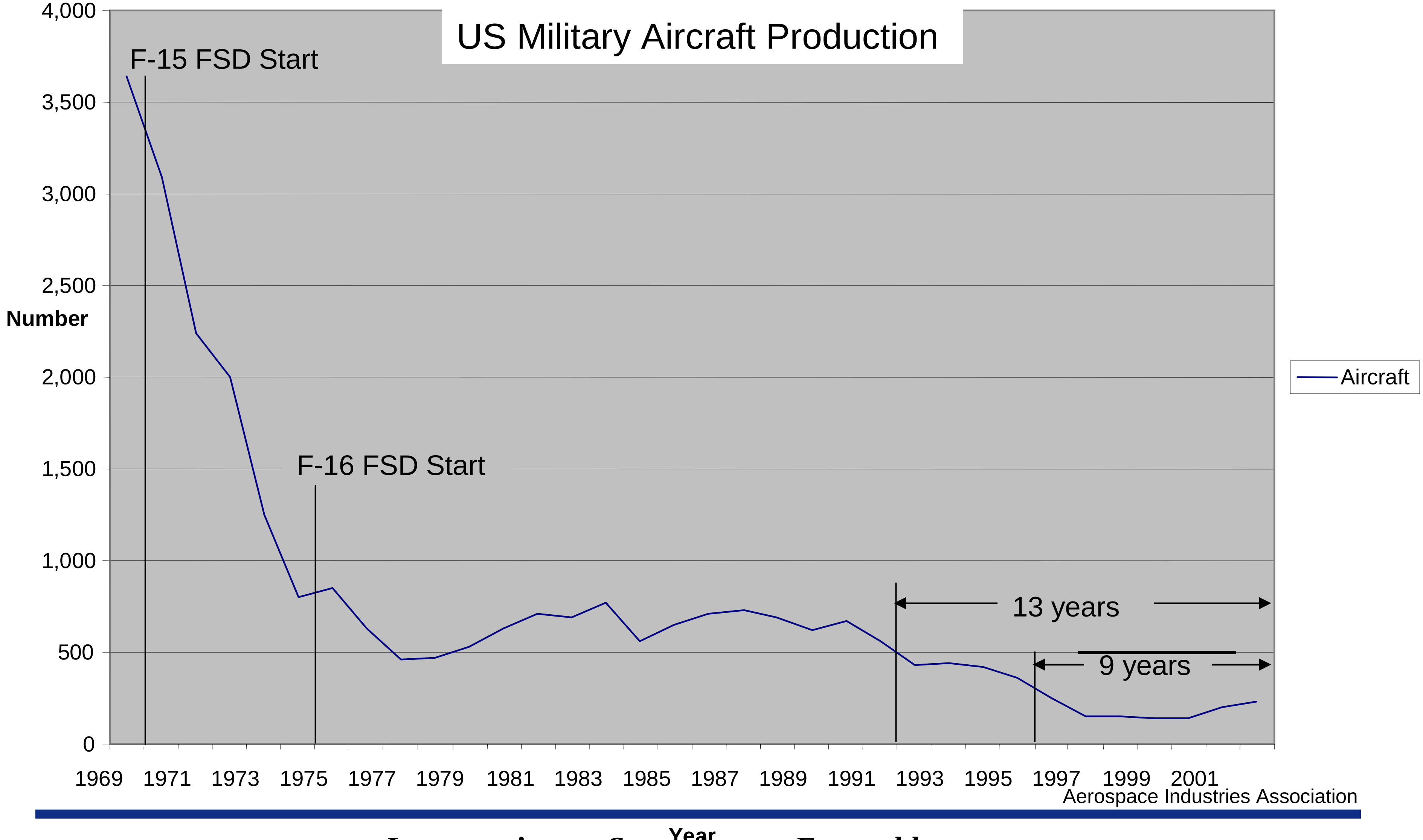
DoD budget as % of GDP
Vietnam
High Inflation
Cold War Buildup
Cold War Ends Desert Storm
Peace Dividend
Nixon
Ford
Carter
Reagan
Bush 42
Clinton
GW Bush
12
10
8
6
4
2
0
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003

Budget



DoD budget as % of GDP
Vietnam
High Inflation
Cold War Buildup
Cold War Ends Desert Storm
Peace Dividend
Nixon
Ford
Carter
Reagan
Bush 42
Clinton
GW Bush
12
10
8
6
4
2
0
8 yrs
32 yrs
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003

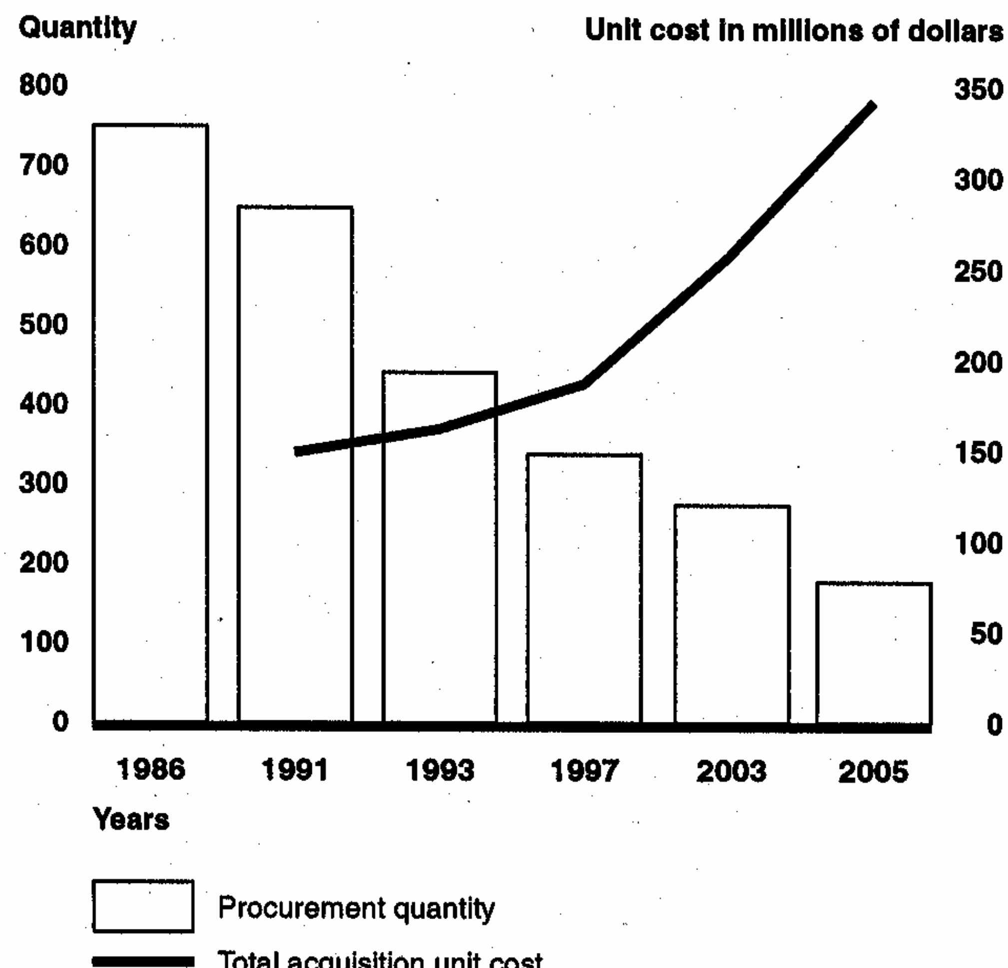
Budget


US Military Aircraft Production
F-15 FSD Start
F-16 FSD Start
13 years
9 years
Number
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Year
Aircraft
Aerospace Industries Association

Budget

- The simple issue of Economies of Scale
  - More expensive programs are stretched out over more budget cycles in order to “afford” them
  - Critics and opponents of expensive programs propose, and many times win, reductions in total quantities acquired to “save” money.
  - Fewer items purchased = more cost per item. Sounds simple to me but appears to get overlooked quite often.
    - RDT&E costs don’t change with quantity purchased
    - Tooling costs usually don’t change either

Budget

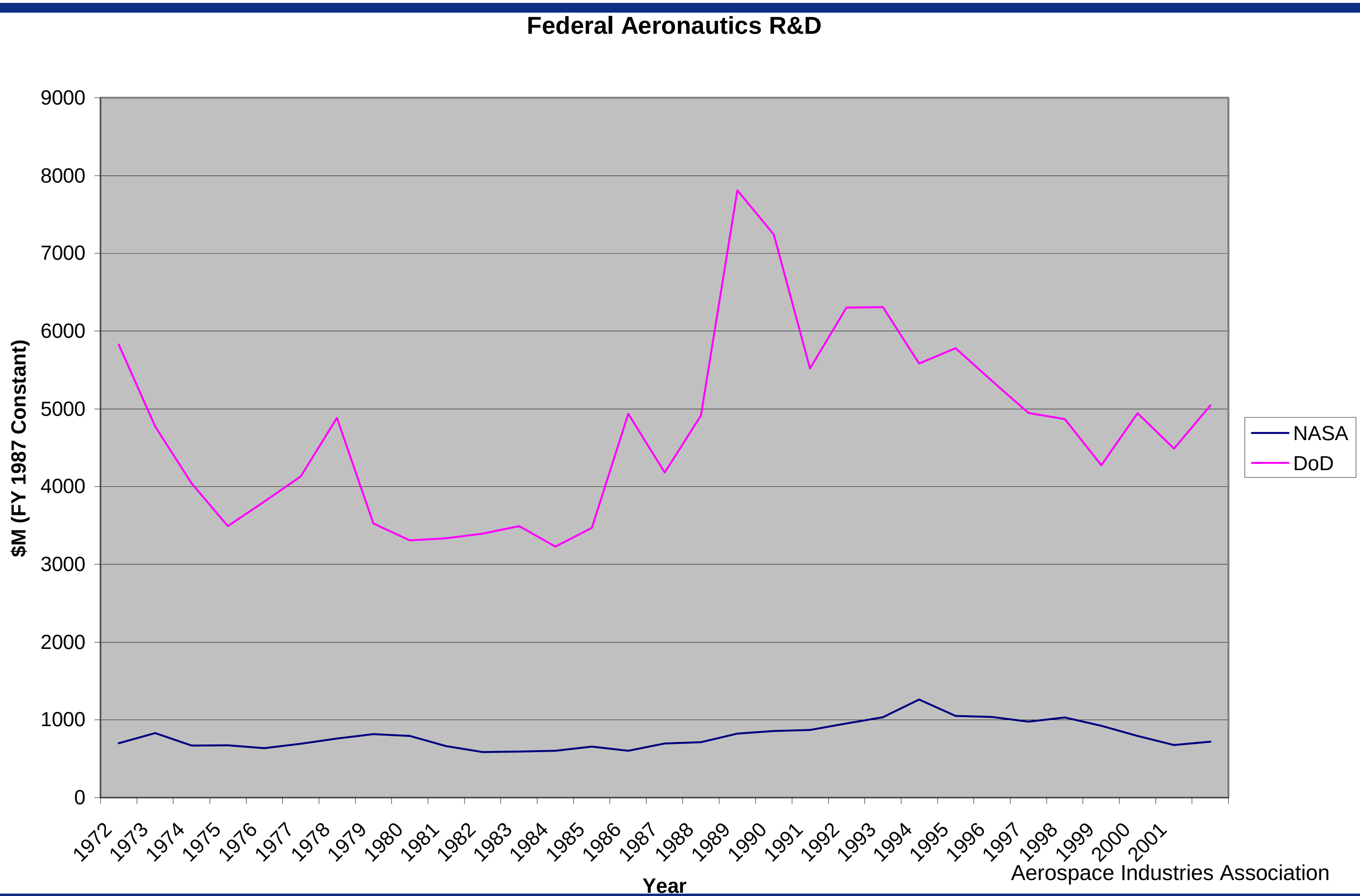


Source: U.S. Air Force (data); GAO (presentation).

Budget

- Research and Development Test and Evaluation Spending
  - Critical to development of new higher-performance aircraft
  - Major technology breakthroughs have come more often from government labs or by government sponsored R&D than from the commercial sector
    - Supersonic flight in 50s from R&D of the 40s
    - Stealth combat aircraft of today were generated by sustained research in government and industry labs in the 1950's and 1960's
- Health of R&D budget 10 years ago drives the technology in use today

Budget

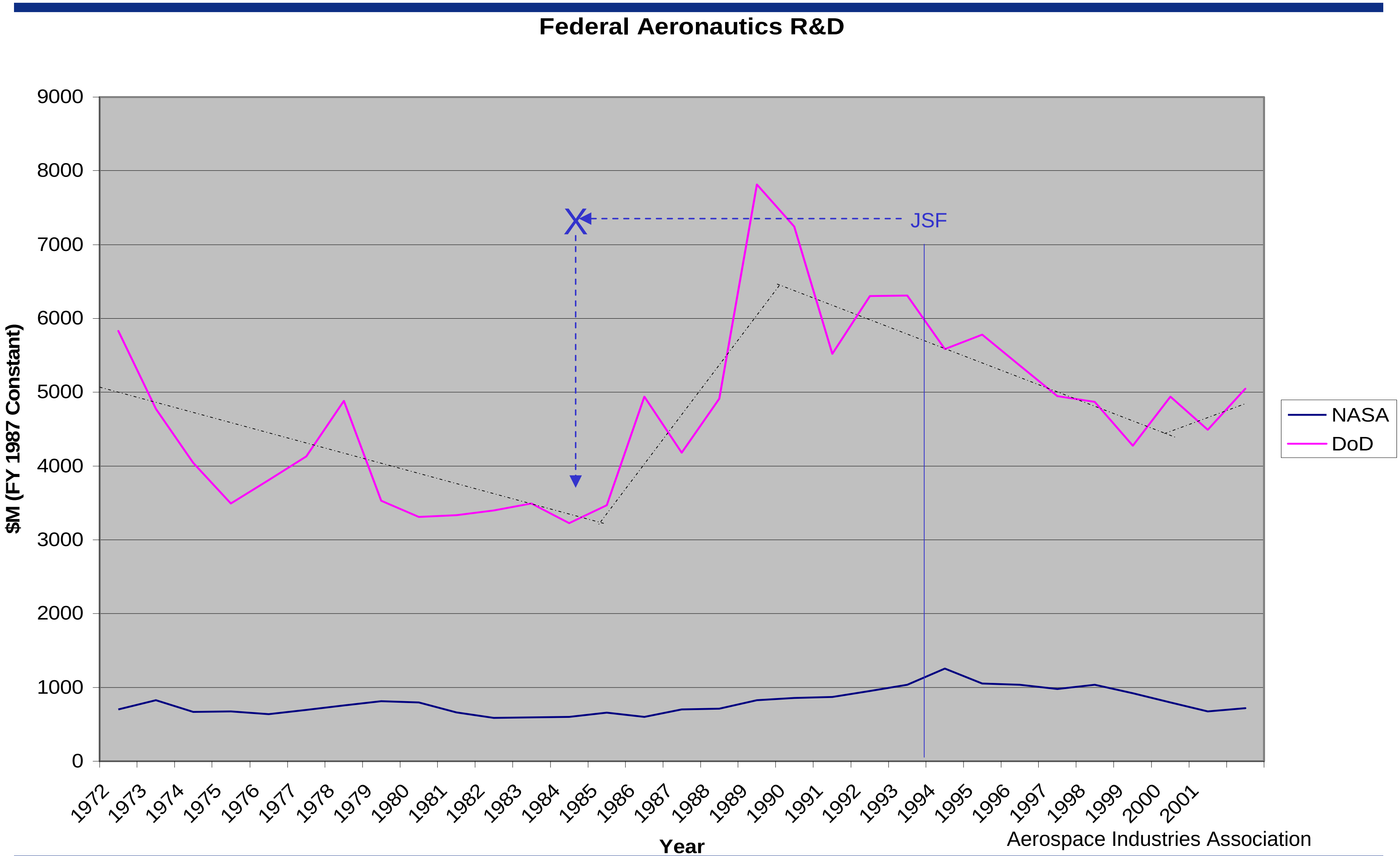


Aerospace Industries Association

Integrity - Service - Excellence

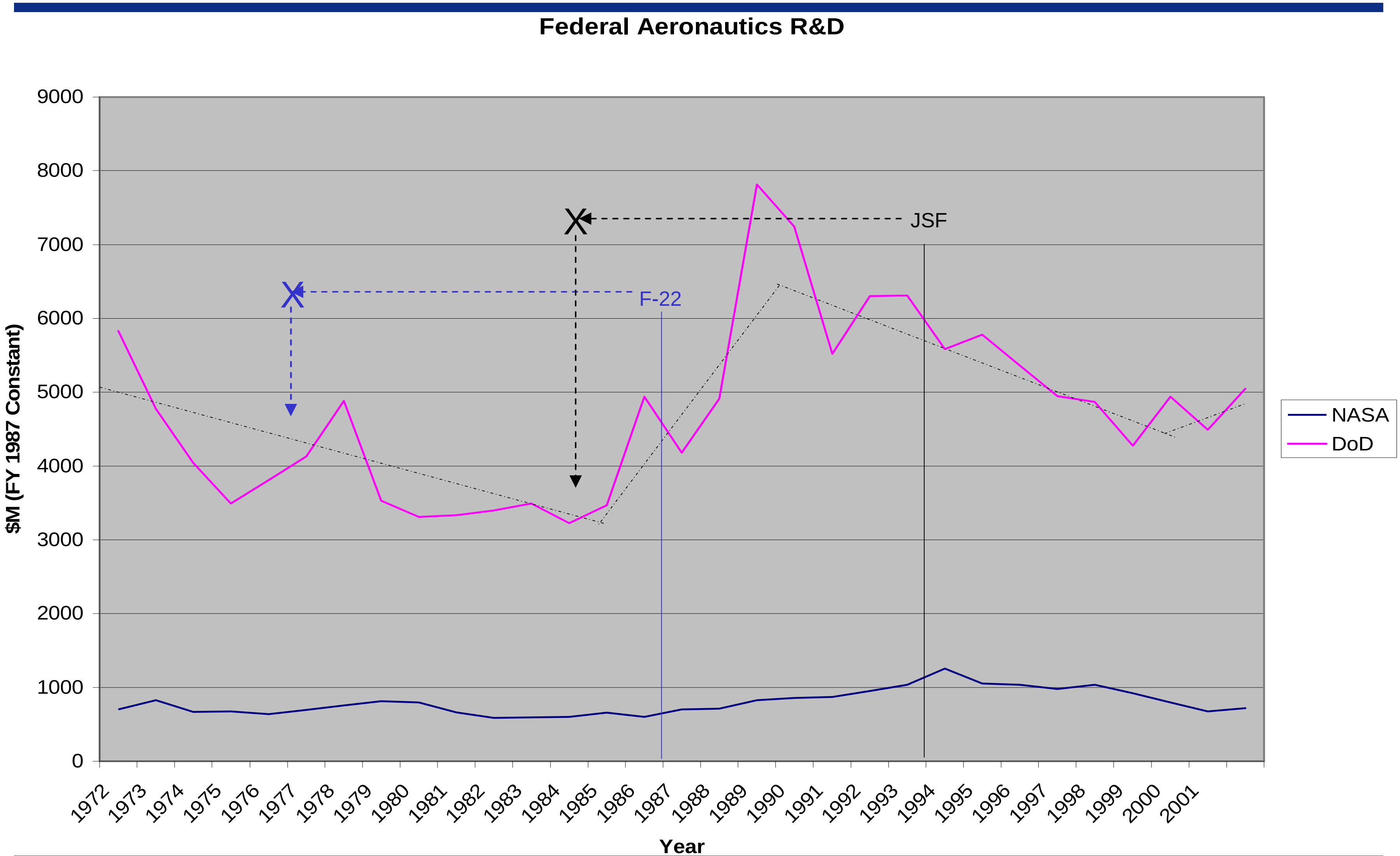
U.S. AIR FORCE

Budget



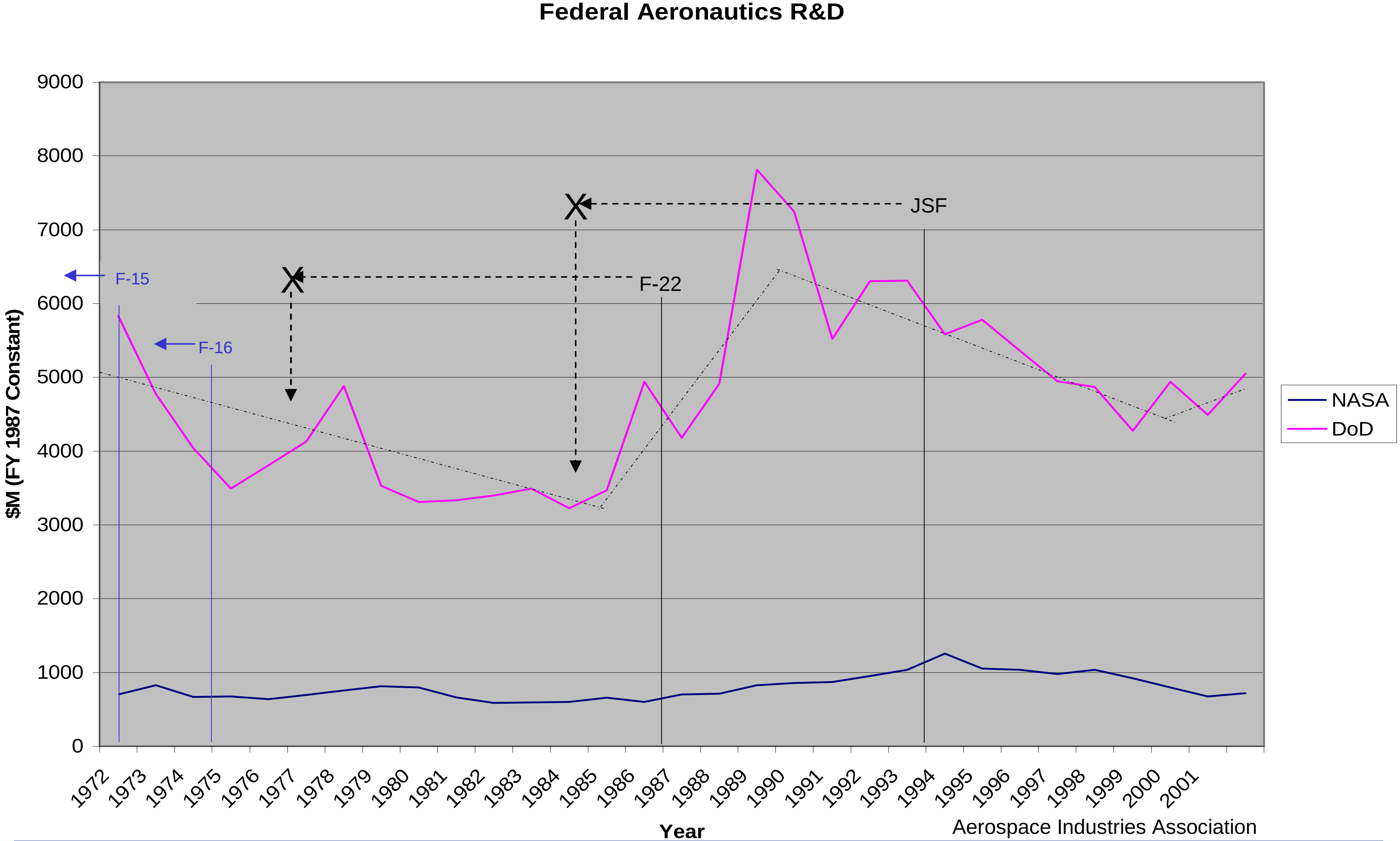
Integrity - Service - Excellence

Budget



Integrity - Service - Excellence

Budget



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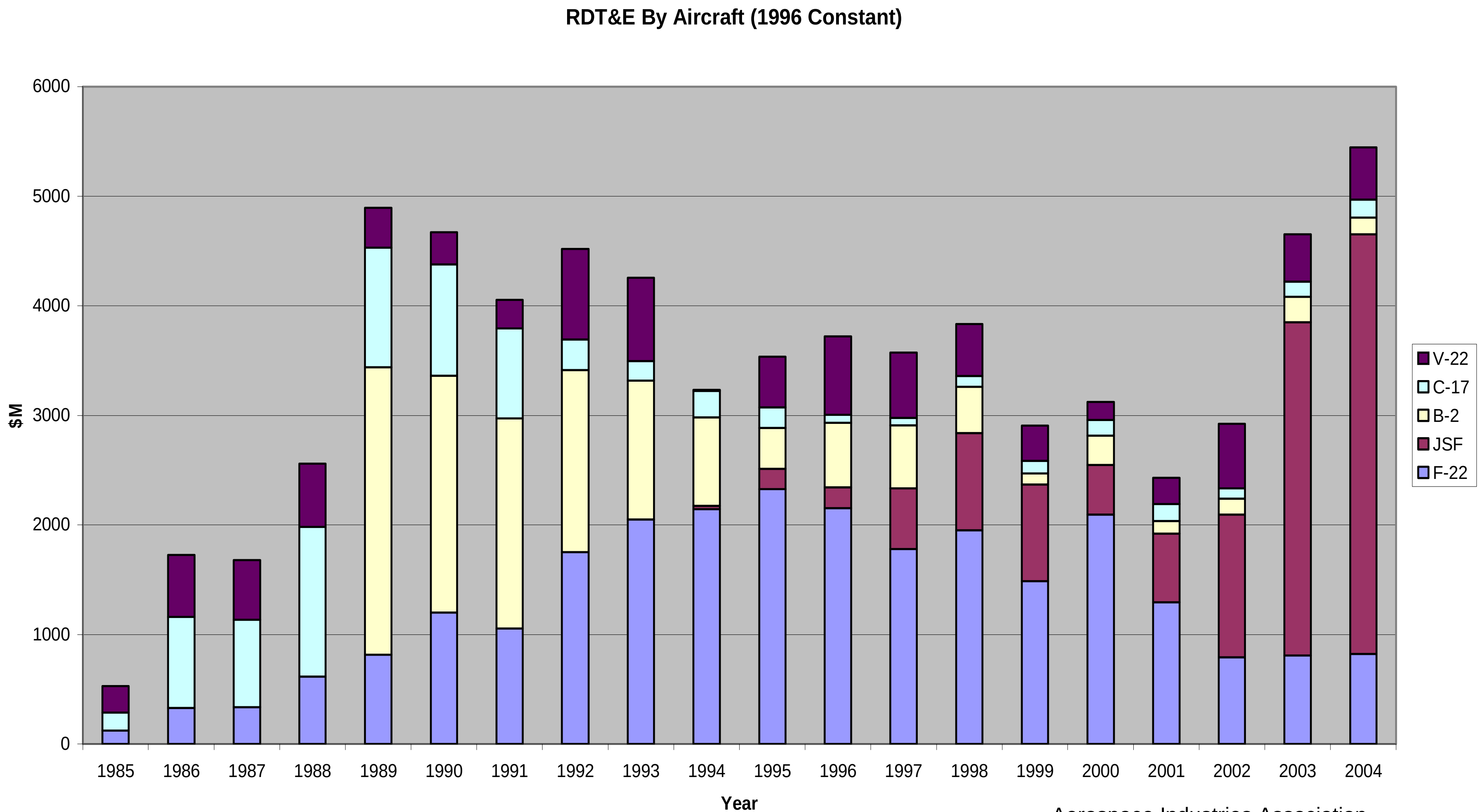
U.S. AIR FORCE

Budget

- **Digging one level deeper into the chart, we see that one line does not paint the entire picture. As always, it is more complex than first glance.**
- **During any particular year, there is fierce competition within the RDT&E community for funding. This competition will can negatively affect other program's budgets but is very difficult to trace on a large graph.**

Budget



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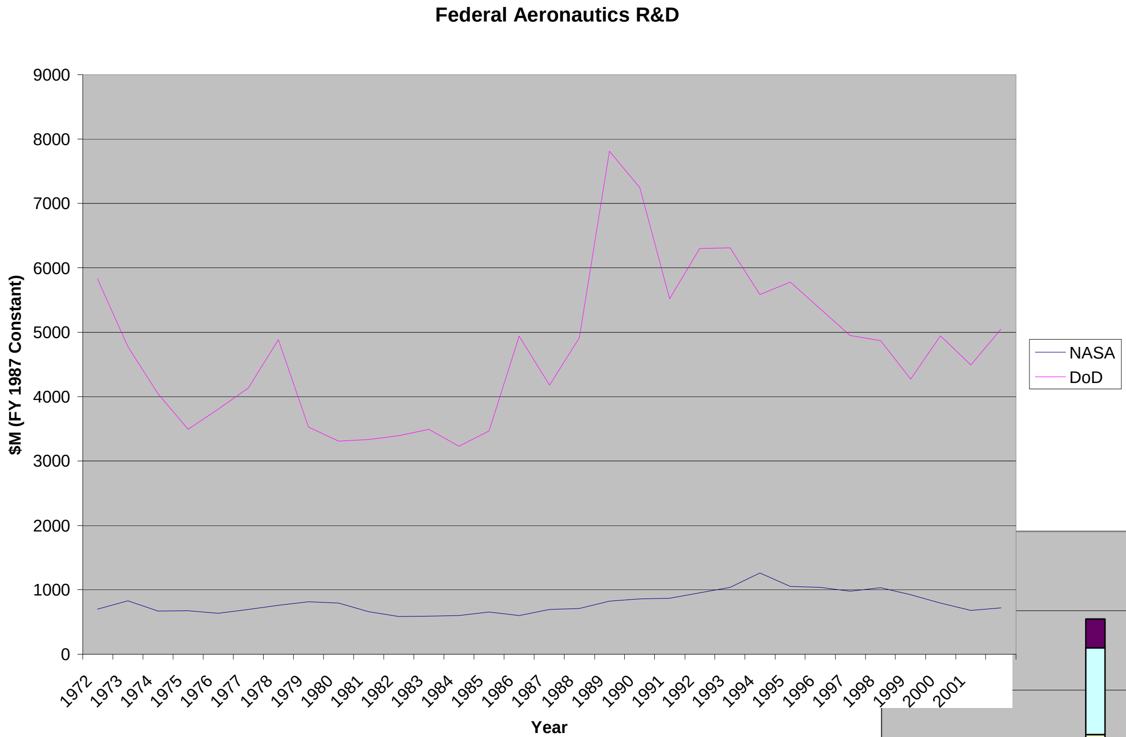
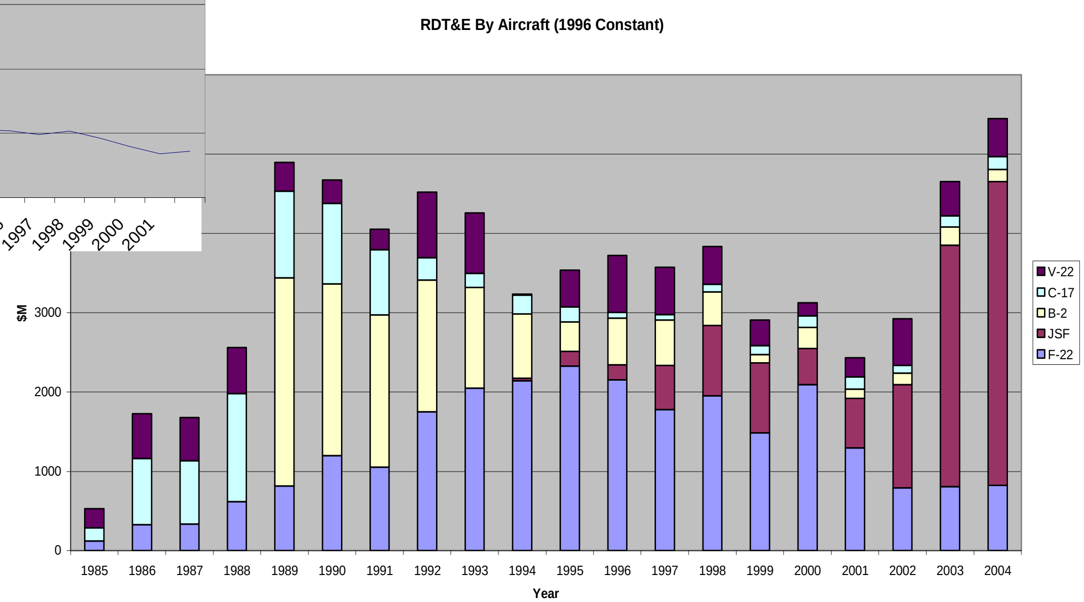
Budget



Federal Aeronautics R&D
$M (FY 1987 Constant)
Year
NASA
DoD



RDT&E By Aircraft (1996 Constant)
$M
Year
V-22
C-17
B-2
JSF
F-22

Budget

- Budget Conclusion
  - Less DoD spending reduces available resources for acquisition across the board
  - Industry is in a very unhealthy state due to low procurement quantities
    - Simple Economy of Scale concept
  - Reductions in R&D spending causes negative affects 5-10yrs down the road
    - Difficult to quantify historical R&D affects on present day acquisition programs

- According to Mr. Augustine (former CEO Lockheed) – "In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day."

Technology

- "Historically, the performance requirements generated for new fighter designs have often pushed the outer limits of design and engineering knowledge during any given period." – RAND
- Our Process
  - Determine the technology challenges for F-15, F-16, F/A-22 and JSF
  - Determine differences between the 1970's and today
  - Determine any quantifiable reasons

Technology

- Technology Challenges Then
  - F-15
    - Engine – Requirement for High Thrust/Weight
    - Radar – Look Down Shoot down capability
  - F-16
    - Fly by Wire
    - Relaxed static stability

Technology

- Technology Challenges Now
  - F/A-22
    - Supersonic Low Observables
    - The "-illities"
      - Deployability, Maintainability, Supportability, Reliability
    - Integrated Avionics
  - JSF
    - Supersonic Low Observables
    - Commonality
    - The "-illities"
    - Integrated Avionics

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Technology

What are the differences?

- **F-15 "KPPs"**
  - **Max Speed @ S.L.**
  - **Max Speed @ Altitude**
  - **Mission Range - Cruise**
  - **Mission Range - Dash**
  - **Thrust/Weight**
  - **Thrust/Engine weight**
  - **T.O. & Landing distance**
- **F/A-22 KPPs**
  - **Supercruise**
  - **Maneuverability**
  - **Acceleration**
  - **Airlift Support**
  - **Sortie Generation Rate**
  - **Radar Cross Section**
  - **MTB/M**
  - **Payload**
  - **Combat Radius**
  - **Radar Detection Range**

F-15, F-16 designed for single missions – F/A-22 and JSF Multi-role

Technology

- What is the Technology Long Pole?
  - Avionics/Software
- Software development is still more of an art than a science
- Software is invisible and intangible and hard to visualize – CSCE 593
- Software development is our most significant problem - Eisner
- "Software is like entropy, it is difficult to grasp, weighs nothing, and obeys the second law of thermodynamics, i.e., it always increases." – Norman Augustine former Lockheed Martin CEO

Technology

- **Software use has increased dramatically**

Aircraft	Year	% Functions Performed by software
F-4	1960	8
A-7	1964	10
F-111	1970	20
F-15	1975	35
F-16	1982	45
B-2	1990	65
F/A-22	2000	80

Hallion, 1990

Technology

- Software Lines of Code (SLOC) has increased
  - F-15A – 60,000
  - F/A-22 – 2,100,000
  - JSF – 17,000,000
- Increases Testing requirements
  - F/A-22 has twice the avionics test aircraft the F-15 had
  - F/A-22 will require a new computer architecture and processor
    - The old ones are "Obsolete"
- F/A-22 took 9 years for avionics to reach a mature enough level to BEGIN production development
- The cost of the F/A-22's avionics has increased by over $980M

Technology

- JSF Issues
  - Only about 40 percent of the 17 million lines of code needed for the system's software have been released (April 2005)
  - Software required for mission systems integration will not be ready until 2010 - 3 years after JSF is scheduled to enter production.
  - "The JSF, like many past DOD weapons programs, is very susceptible to discovering costly problems late in development when the more complex software and advanced capabilities are tested." - GAO April 2005

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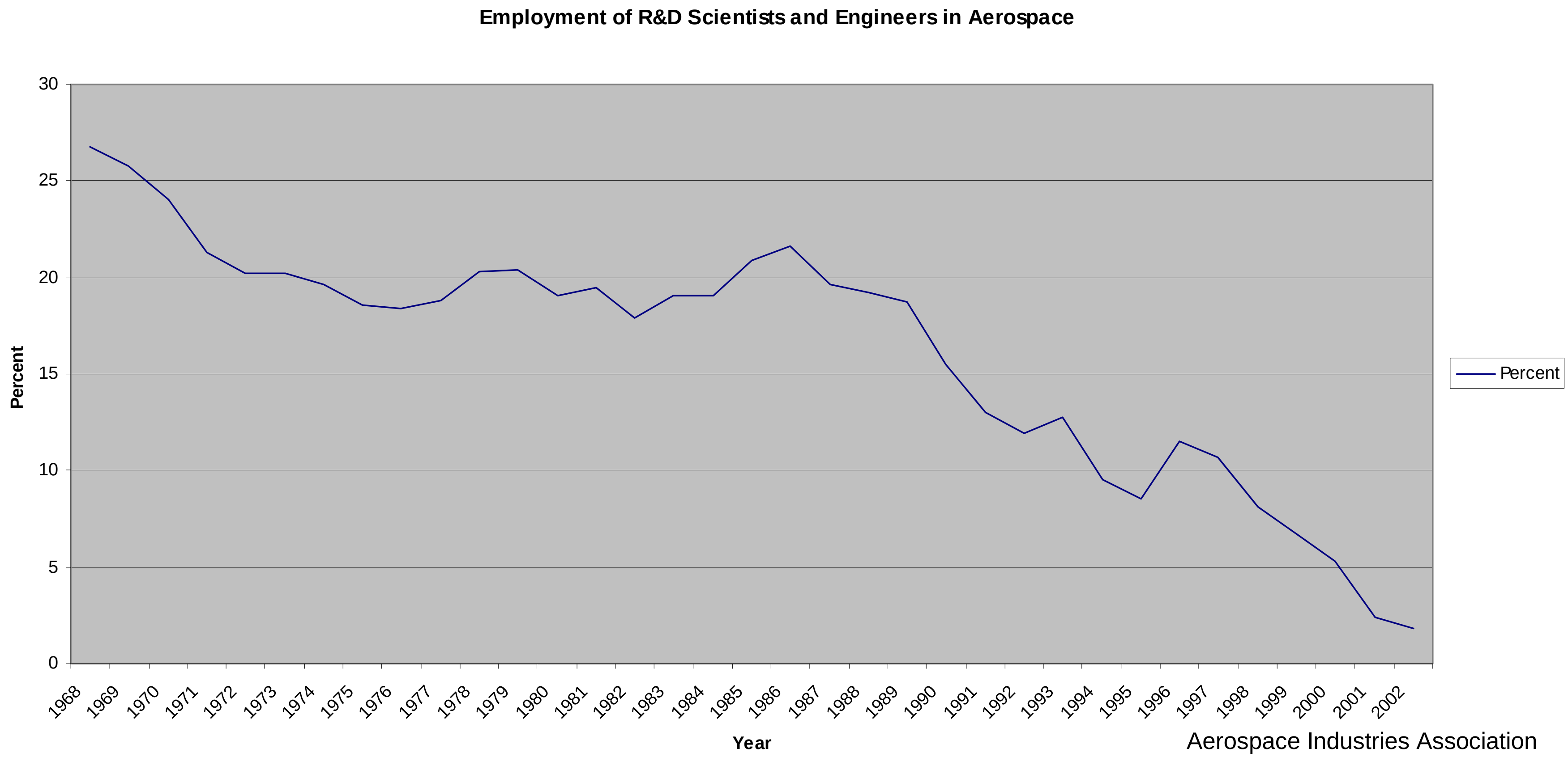
Technology

- **Fewer Aerospace Contractors Today**
- **Fewer Scientists and Engineers working in Aerospace Fields**



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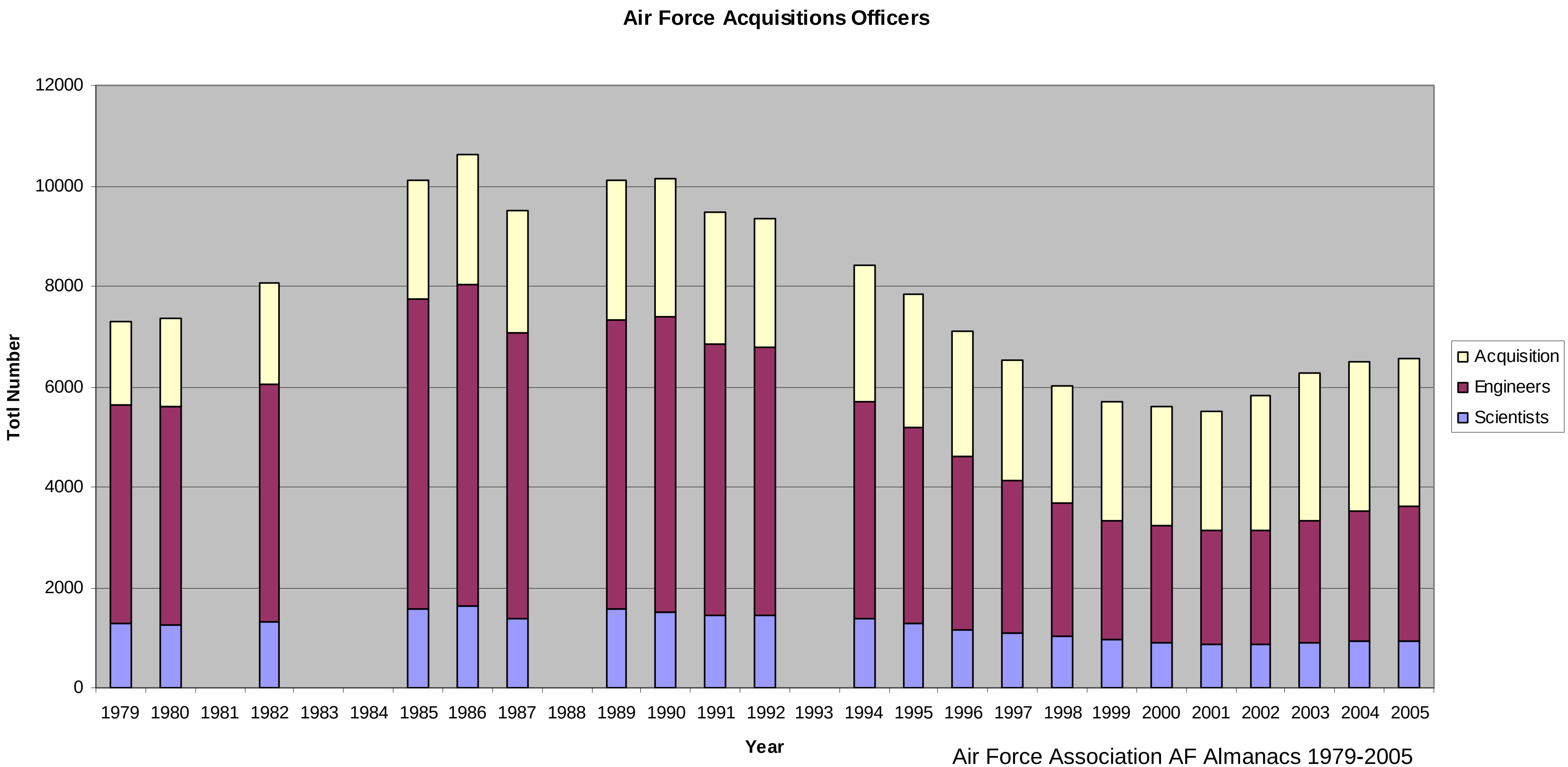
Technology

- **Fewer Blue Suit S&E's**



Air Force Association AF Almanacs 1979-2005

Technology

- Technology Conclusions
  - Fighter aircraft push the edge of technology
  - The largest growth area has been avionics/software
  - There are fewer people in the business – government and contractor
  - Technology is definitely a contributing factor in why the F/A-22 and JSF developments are taking longer

Climate

- The Systems Approach dictates we look at the external system
  - Threat
  - Culture
  - Organization

Climate

- The Threat – 1970's
  - Poor showing in Vietnam War – 2.5 to 1 Kill Ratio vs Russian MiGs
  - New MiGs released – MiG-25 and MiG-23
    - Didn't think F-4E was a match

Climate

- The Threat – 1970's
  - Air Force hasn't developed an air-to-air fighter since the F-86
  - Thanks to failed commonality of the F-111 – specialized aircraft
    - F-15 air superiority
    - F-16 light weight "inexpensive" fighter
    - A-10 CAS
    - Navy F-14 fleet defense
  - 1970 – F-15 development is the Air Force's #1 priority

Climate

- The Threat – 1990's
  - Cold War is won – We should have a peace dividend
  - F-15 is undefeated in air-to-air combat
  - Gulf War I – Air Power success
  - Gulf War II – Iraqi Air Force buries itself in the sand

Climate

- American Culture Today
  - Inundated with news
  - Multiple 24 hour new sources
  - Perceived fraud and waste of the 1980's
    - $400 hammer, $500 toilet seat
  - Mistrust of government spending in the press
  - Leads to additional oversight
- Government Accounting Office By Law investigates F-22 and JSF programs for "performance, schedule and cost"
  - F/A-22 – 45 studies; JSF – 16
  - F-15 – 4; No F-16 studies
- Drop of congressional military experience

Climate

- "If I wanted an airplane and the secretary of the Air Force agreed, we had four key congressional committee chairman to deal with and that was that. The same was true of the stealth fighter project -- except we had eight people to deal with on the Hill instead of four. But by the time we were dealing with the B-2 project, we had to jump through all the bureaucratic hoops at the Pentagon and on the Hill."

\- General Larry Welch, former CSAF

Climate

- Air Force Organizational changes
- 1970
  - Deputy Chief of Staff for R&D
  - F-15 SPO Director reported directly to DCSR&D
  - Air Force Systems Command handled funding
- Currently
  - DCSR&D position doesn't exist
  - JSF Program Director (also PEO) reports to AF Acq Executive thru OSD(AT&L) except when an Air Force PEO is in charge, then it goes to the Navy Acq Executive thru OSD(AT&L)
  - AFSC merged with AFLC to form AFMC
  - Funding comes through MAJCOMS (PEMs in SAF/AQ)

Climate

- Climate conclusions
  - Threat is different today – harder for the novice to understand
  - American Culture is different today
  - More oversight
- The climate has an effect on the length of time to develop weapon systems

Acquisition

- Maybe the Acquisition System is part to blame
  - Acquisition Reforms
  - Acquisition Process
  - Acquisition Professionals
  - Spiral Development

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Acquisition

- Acquisition Reforms
  - Since Revolutionary War to 1996
    - Congress passed over 4000 acquisition related statutes
    - GAO issued over 900 acquisition related reports
  - Since WWII
    - 12 major commissions

Acquisition

1949	Hoover I
1953	Rockefeller Committee
1953	Hoover II
1961	McNamara Initiative
1970	Fitzhugh Commission
1972	Commission on Government Procurement
1983	Grace Commission
1985	Packard Commission
1989	Defense Management Review
1993	Section 800 Panel Report
1993	National Performance Review
1994	Federal Acquisition Streamlining Act

Reeves, 1996

Acquisition

- Acquisition Process
  - Consequences of heavy bureaucratic system
    - Briefings
    - Road shows
    - Justifications
  - All lead to slow, inefficient process
- "...the most obvious place to start in achieving greater efficiency is to ferociously attack unnecessary bureaucratic red tape and paperwork." (Rich, pg. 328)

Acquisition

- Acquisition Professionals
  - Similar impact from the technological section

  - High turnover is also an issue
    - 'Passing the buck'
    - Typical 11 year program (McNutt, pgs. 48-49)

Position	Number
Program Director	4
Program Executive Officer	5
Service Acquisition Executive	8
Defense Acquisition Executive	8
Chairman of Joint Chiefs	5
Secretary of Defense	7
President	3
Budget Cycles	11

Acquisition

- Spiral Development
  - Recent programs seek 'Whole Enchilada'
  - F-15
    - F-15A – F-15C – F-15C MSIP – F-15E
    - F/A-22

    - "…the F/A-22's acquisition approach was not knowledge based or evolutionary. It attempted to develop revolutionary capability in a single step. This caused technology and design uncertainty, which led to cost overruns and schedule delays." (GAO-05-390T)

Acquisition

- Contractor Teaming
  - Leads to Inefficiencies
    - More communication
    - More meetings
    - Etc.

  - Fewer contractors for the government
    - Fewer ideas / less originality
    - Inferior designs?

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Acquisition

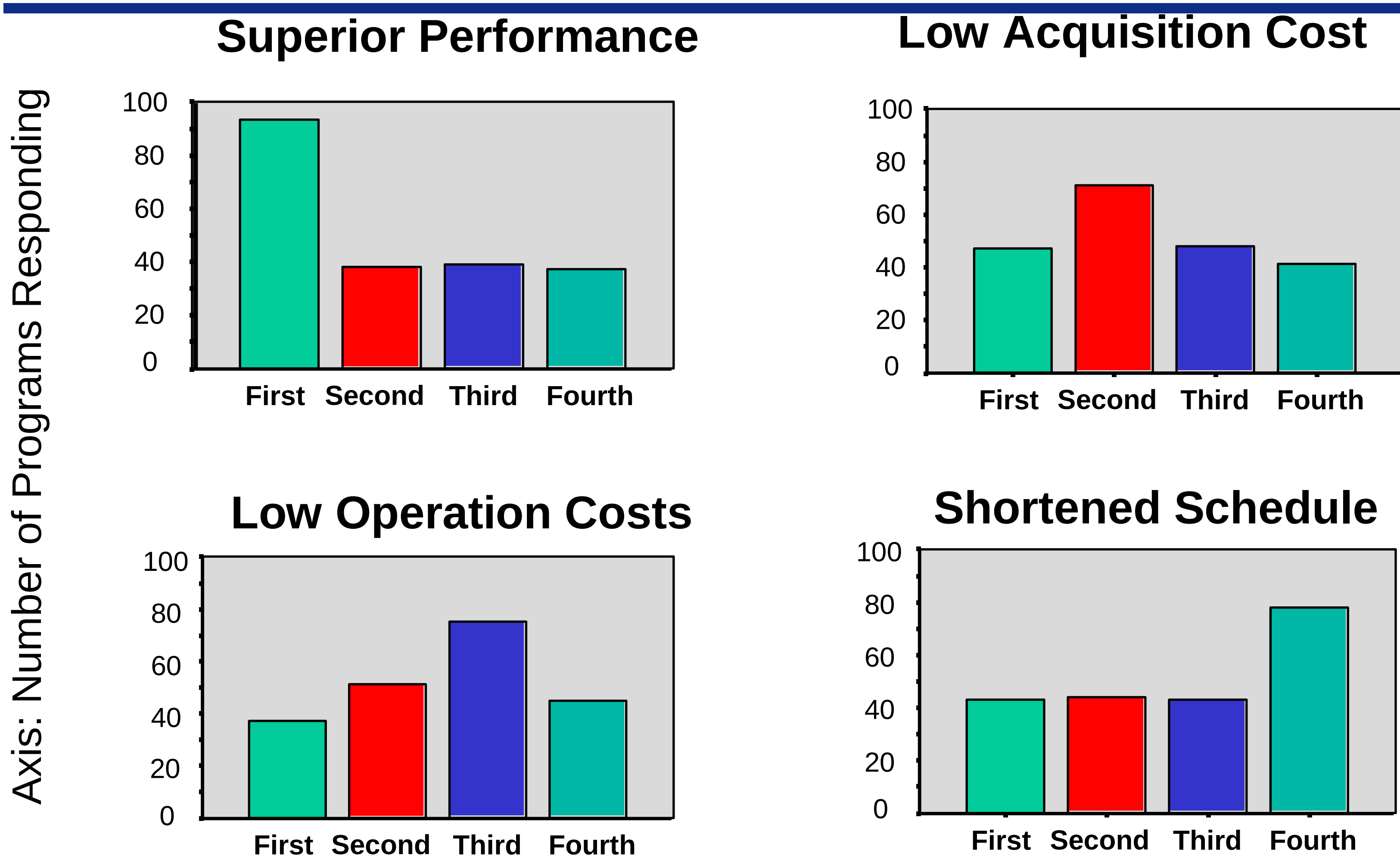
- Acquisition system has ballooned into a cumbersome, slow process
- "The pace at which we develop weapon systems is too slow to keep up with the pace of technological change. Because of this mismatch, the acquisition process produces 'yesterday's capabilities for tomorrow.'" (Vollmecke)
- May 2003 changes (DOD 5000.1 and DOD 5000.2)?

Schedule

- Interviewed Lt Col Ross McNutt, read dissertation on reducing cycle time
  - Great insights into SPO, Pentagon, and Contractor attitudes
  - We do not value time
  - The contractor bids the schedule we ask for
  - We base our schedule on funding and judgment, not minimum time to complete
- Highly instructive, recommendations will help…we're just not sure these attitudes are new

Schedule

Pentagon & SPOs asked to rank 1 to 4

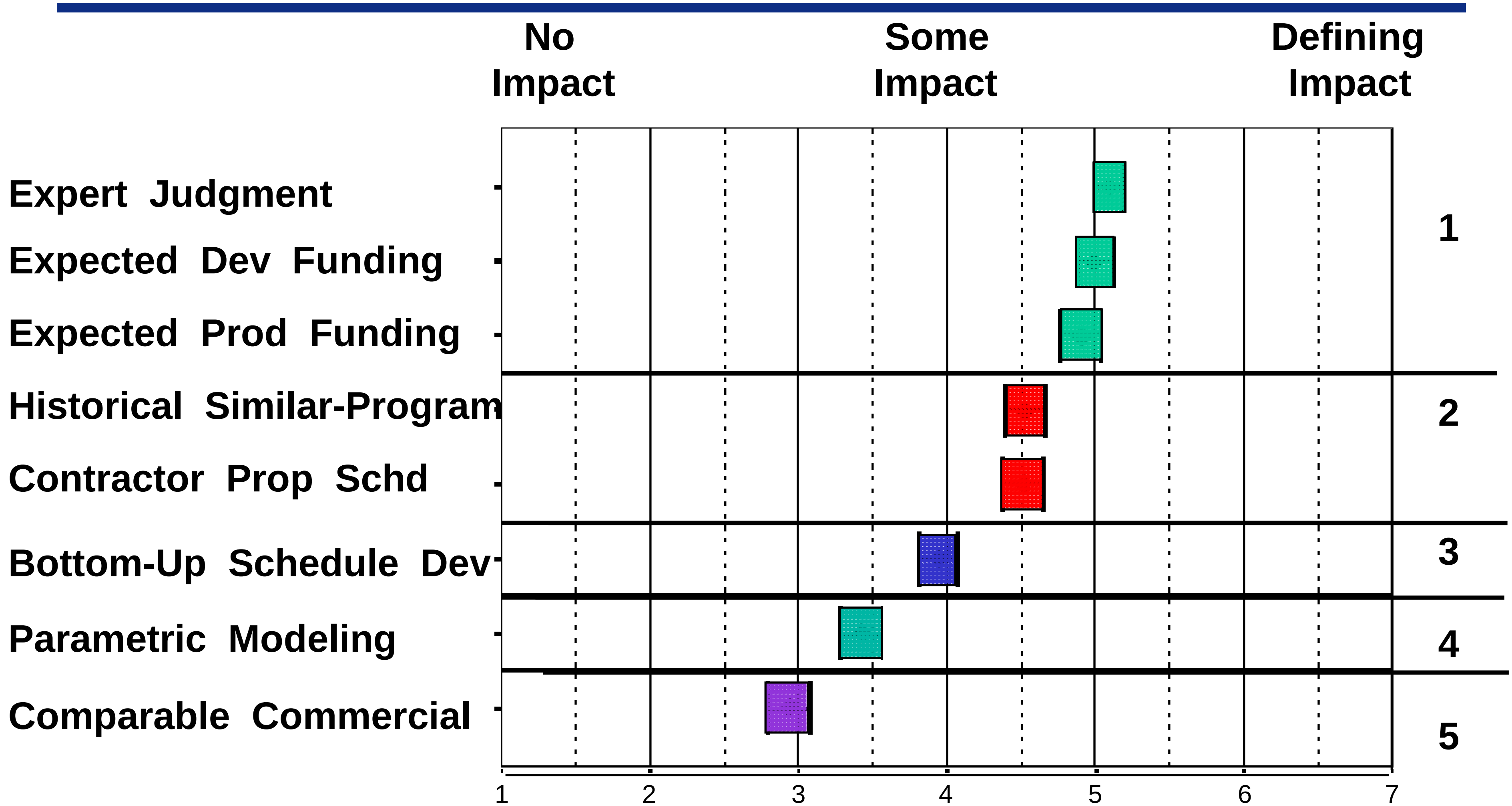


PEM and SPO Surveys N=208

McNutt, Pgs 188-189

Schedule

SPOs, "What is initial schedule based on?"

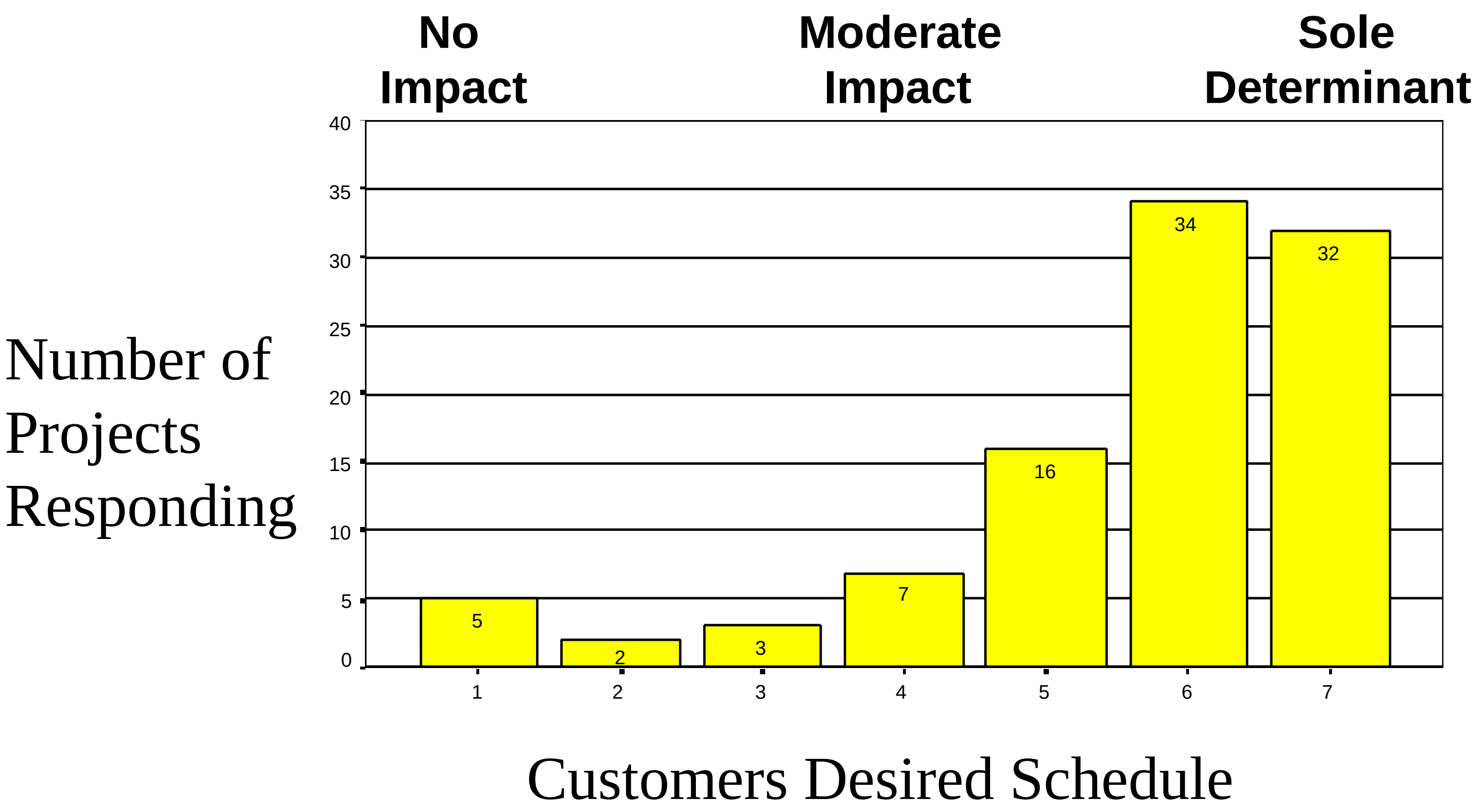


SPO and Pentagon Survey N = 178
Mean +- 1 SE

McNutt, pg 214

Schedule

Contractor, "What is yours based on?"



McNutt, pgs 225-226

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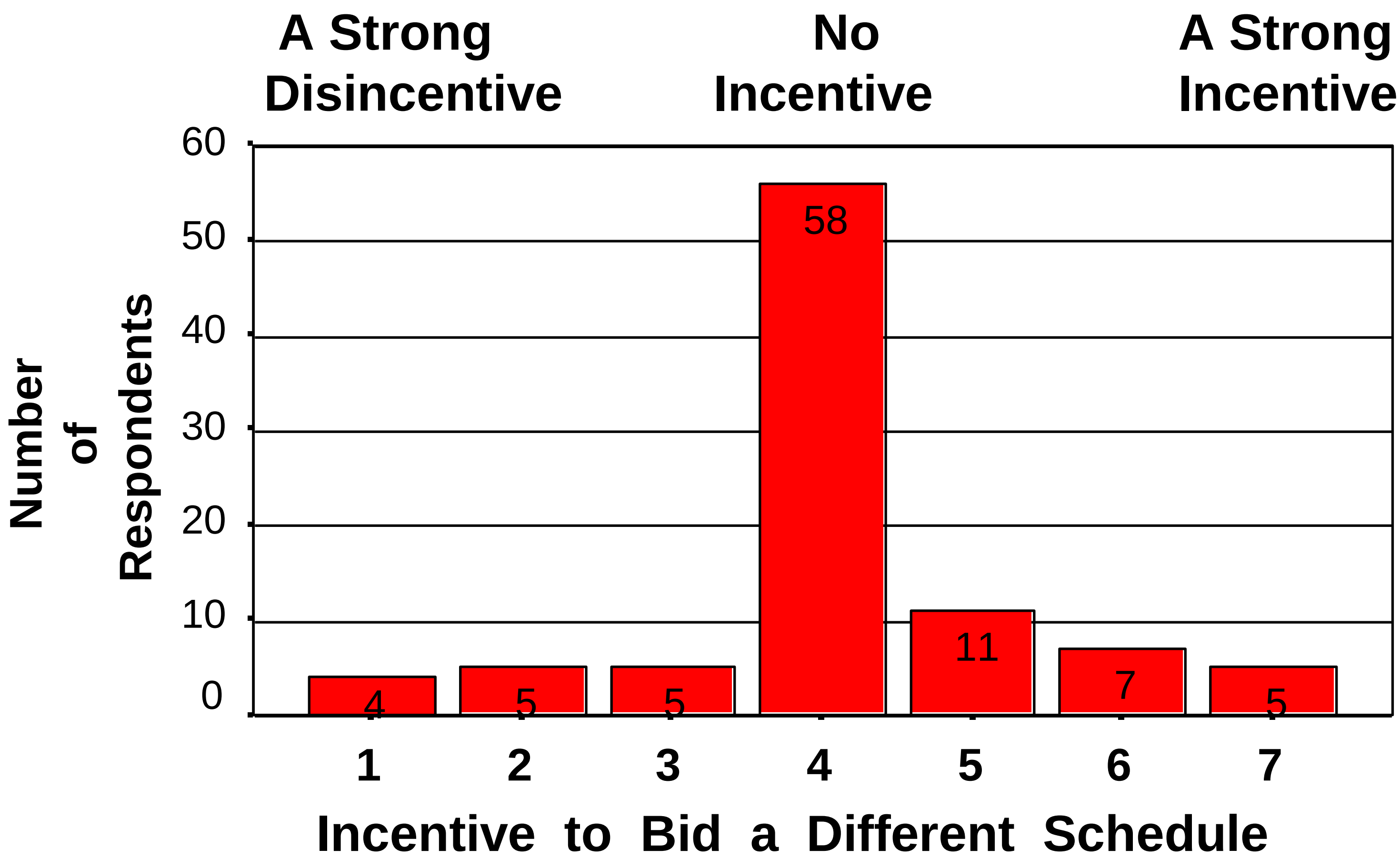
Schedule

Contractor, “Why not bid something else?”



Contractor Survey N=97

Adapted from McNutt, pg 260

Schedule

- Schedule conclusion
  - Schedule is viewed as an outcome, not a goal
  - Initial project schedules are based on funding
  - The contractor bids the requested schedule
  - There is no incentive for quicker work
- SPO survey: 37 projects with 1 yr or more remaining
  - "…asked project managers how long it would take to field the first system if it was deemed essential in a war…project managers estimated that the time required…was 52 percent of the current schedule." (McNutt, pg 279)

Conclusions

- Are New Acquisition Programs Taking Longer to Develop / Field?
  - YES

- Why?
  - Well…

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Conclusions

- Applying Systems Thinking
  - "So many important problems that plague us today are complex, involve multiple actors, and are at least partly the result of past actions that were taken to alleviate them."

    -- Daniel Aronson

  - No "Silver Bullet"
  - AF Product Development System is just that – a system
  - Many, if not most, if not all of the constituent parts tend toward slower

Conclusions

- To develop a new weapon system we need:
  - Money, Gov't Acquisition folks, Aerospace workforce, A Sense of Urgency
  - We have less of all of these

- We do NOT need:
  - More Mangement, Oversight, Reports, Technology Challenges
  - We have more of all of these

Air Force Institute of Technology

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

Questions?

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“10 Golden Questions” for Concept Exploration & Development

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Overview

- Definitions
- 10 “Golden Questions”
- Apply to Audience Examples
- Summary
- Q & A

Definitions

- Concept Exploration
- CONOPS
- Systems Engineering Life Cycle
- System, Product, Component
- Concurrent Engineering
- Failure Modes and Effects Analysis (FMEA)

“10 Golden Questions”

Raytheon

1. Who are the SYSTEM stakeholders?
2. What are the SYSTEM goals/objectives?
   a) User/Maintainer/Sustainer
      1) Operations, Support.
      2) Mission scenarios.
      3) Production, sustainment, supply chain.
      4) Life cycle needs for growth/improvement (P^3I)
   b) Enterprise stakeholder goals, objectives and constraints?
3. What is the market for this SYSTEM?
   a. Where?
   b. When?
   c. Why?
   d. How funded?

“10 Golden Questions”

4. What are the external constraints the SYSTEM must satisfy?
5. What is the operating and support concept for the SYSTEM ?
    a. Major states, modes, transitions
    b. Environments
        1) Operating & Maintaining
        2) Storage & Shipping/Transportation
    c. Measures of Effectiveness
    d. Life Cycle Cost, CAIV & Cost of Ownership
    e. Maintenance levels & supply chain

"10 Golden Questions"

6. What is the SYSTEM architecture context?
   a. People
   b. Facilities
   c. Support equipment (tools & testers)
   d. Manufacturing process capabilities
   e. Training
   f. Products (knowledge, goods, services)
7. What are the man-machine interface criteria to be satisfied by the SYSTEM ?
   a. Operators & Maintainers
   b. Market-driven standards (ISO, ANSI, etc.)

“10 Golden Questions”

8. What are the key SYSTEM attributes?
   a. Four (4) types of attributes, or ‘requirements’:
      1) Performance
      2) Environmental
      3) Interface
      4) Design Constraints
   b. Format of ‘requirements’:
      1) Value, Relation, Units
      2) Method of Verification (IADTS)

Raytheon

“10 Golden Questions”

9. What are the SYSTEM functions (behaviors) that will satisfy the SYSTEM attributes?
   - Derive from System Context
   - Compatible with System CONOPS
   - Help “allocate” System-level requirement

"10 Golden Questions"

Raytheon

10 What happens if the SYSTEM fails to satisfy or perform as defined by 1-9?

a. Potential "effects of failure" (qualitative, worst case; mission success, users, maintainers, by-standers)
   1) Severity
   2) Likelihood of occurrence

b. What should be done to control or mitigate the potential for those SYSTEM failures?
   1) Design
   2) Manufacturing
   3) Training
   4) Usage limitations or advisories

Questions 1-10 are **repeated** using **PRODUCT** or **COMPONENT**.

Questions from the Audience!!

Summary

- Customers often want more than they will tell us, or even understand that they want it.
- Ask questions to find out what is most important (to all the stakeholders).
- Think of the life cycle, the user & those who must support and sustain the system:
  - Product Development
  - Product's in-service life
- Systems have several layers in their architectures, think it through from multiple perspectives.
- Ask "what if it fails to ------?!" Often!!!!

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Biography

Dr. Surber is an INCOSE Certified Systems Engineering Professional, and has worked as a pilot, engineer and manager in avionics systems and heavy equipment engineering for over 30 years with three large defense contractors and a large, commercial corporation. He is an experienced senior pilot, flight examiner/ instructor, human factors engineer, systems safety engineer, and military accident investigator. He has accumulated over 5,000 hours of flight and simulator time in 17 types of military and commercial aircraft; holds a pilot rating in single and multi-engine aircraft; and, is a rated parachutist. In 1998 he retired after 29 years of military service with the United States Air Force, and with the Army National Guard and Reserve in various armor, mechanized infantry, aviation and military intelligence units. He is a Principal Systems Engineer for Raytheon, where he works on the V-22 Osprey program, and supports process improvements as a Raytheon Six Sigma Specialist. Dr. Surber has been a member of INCOSE since 1998, and is currently Past-President for the INCOSE Crossroads of America chapter in Region IV.

Abstract

- Project engineers and development teams must be able to quickly understand the customer's need. There are many tools, methods, and processes suggested for conducting "Concept Exploration" and "Concept Development". The author believes that there are "10 golden questions" which get the requirements elicitation done right. They apply to any Product (knowledge, good or service), system, or organizational structure. The "10 Questions" go a bit further than grammar school's: "who, what, where, when, why, and how." Interaction with the customer/user illumines a key aspect of the system solution, "How does failure affect customer satisfaction?" Asking, "What if the product, (seen at its various levels of decomposition such as, "system/product/component"), FAILS to satisfy these 'requirements'?", leads the designer to a better system solution. These answers take one to the next important discovery, answering, "how do we achieve mitigation and control of any critical failure modes and their effects on mission success, (through design, manufacturing, materials, and training)."
- This is the true purpose of the systems engineering lifecycle.

10 Golden Questions for Concept Exploration and Development

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Abstract. Project engineers and development teams must be able to quickly understand the customer's need. There are many tools, methods, and processes suggested for conducting "Concept Exploration" and "Concept Development". The author believes that there are "10 golden questions" which get the requirements elicitation done right. They apply to any Product (knowledge, good or service), system, or organizational structure. The "10 Questions" go a bit further than grammar school's: "who, what, where, when, why, and how." Interaction with the customer/user illumines a key aspect of the system solution, "How does failure affect customer satisfaction?" Asking, "What if the product, (seen at its various levels of decomposition such as, "system/product/component"), FAILS to satisfy these 'requirements'?", leads the designer to a better system solution. These answers take one to the next important discovery, answering, "How do we achieve mitigation and control of any critical failure modes and their effects on mission success, (through design, manufacturing, materials, and training)." This is the true purpose of the systems engineering lifecycle.

Overview

Faster, Cheaper, Better. Today's environment for systems developers is ultra-competitive, whether it is for the Department of Defence (DoD), commercial products, medical systems, automotive or consumer electronics. Managers and business analysts want pinpoint precision on cost and schedule, and the customer wants ultimate satisfaction with "no failures". Yet the crush of business demands on the developer's time, money and performance have not altered the basic challenge for any system development: what must the system do? Expanding this line of questioning usually leads to a number of "aha" events as the customer/user is led by the developer to explain the answers to the same questions most 5th grade English teachers spouted: Who, What, Where, When, Why, How?

There are standards and guides, used by NASA, AIAA/ANSI, and DoD to help with processes for answering these questions. What does a system developer in the commercial world do for some guidance and help? That is what this paper and its accompanying presentation will endeavour to explain. The fancy word is "CONOPS", short for Concept of Operations and Support.

The Basic Premise

First Things. The developer's fundamental challenge is get from concept to producible design. There are tools like Enterprise Architectures, Popkin Tool for architectures, IDEF diagrams, Use Cases, the 9 views in the UML, and entire processes like the Quality Function Deployment (all four tiers) that are touted for their power to help define a system from a concept. (Cohen, 1995). Most of them can be learned and mastered given enough time and effort, and with a lot of OJT (on-the-job training). Many of them require an "enabling tool", such as a database, and all tool vendors require an on-going licensing agreement. So where does that leave system developers in smaller companies with restricted resources? The author believes the answer is neither "not helpless", nor "hopeless", nor "out in the cold."

Next Things. The Software Engineering Institute at Carnegie-Mellon University has developed an entire family of capability maturity models for enterprises that desire to develop systems in a repetitive, effective manner that promotes continuous, incremental improvement and delivers high quality products at competitive cost. At the heart of the CMM-I for Software, Systems, Supply Chain and Integrated Product and Process Development is the premise that systems can not be developed without understanding the needs of all the stakeholders, and the constraints imposed on the system solution (both internal and external). (SEI, 2000)

Middle Things. The list of "10 Golden Questions" seek to explore the system concept using the same abstracted, three-tier approach used in the CMM-I: System level, Product level, and Component Level. (SEI, 2000) The list also includes a key question underlying the customer's responses to the questions: What effect on satisfaction does a failure have, seen through the customer's eyes. The importance of getting the customer to explain the CONOPS for the system can not be emphasized enough, since it forms the context of "what does failure to do 'x' mean?" Most customers come in the door with "wants and needs". It is the task of the systems engineer to "elicit the customer's real requirements…" through dialogue and exploration of the underlying concept of operation, maintenance, support and disposal. (Hooks, 2000)

Last Things. Using the questions does not guarantee that the developer will create the right system for the customer's need, nor that the system will be done right. However, using them does ensure that the developer is armed with much more of the knowledge about what will most satisfy the customer's need, at the beginning of the product development life cycle. Use of good systems engineering principles, processes, tools and project management discipline will help ensure the right system is built right. The author recommends that the answers obtained through the use of these questions be used to "seed" the requirements analysis, development and preliminary design processes within the enterprise product development process. Retention of this data in DOORS or other suitable requirements database will help trace the concept to the solution space and its methods of verification.

The "10 Golden Questions"

The Big Picture. This paper will provide a brief look at each of the "10 Questions" in the remainder of this discussion. Usage of the questions is meant to first explore the SYSTEM level; then into the PRODUCT level; and, finally into each product's COMPONENTS. Implicit in the answers to each question is to also understand the "effect of failure to meet/satisfy that question". Keep this in mind as the questions are reviewed. There is also an implicit "iteration" loop between these levels, as knowledge is gained at each hierarchical level. This "sharing" is meant to go both vertically and horizontally within the system hierarchy.

This early activity, while called Concept Exploration and Development, is a powerful ‘driver’ on the end result: the system architecture, its design, and success of the integration, verification and system validation effort. Time and money spent in the Concept Exploration and Development phase is well invested, based upon the author’s own experience. Remember also that systems are composed of hardware, software, tools, training, technical data, people, facilities, and system data. (Rechtin, 2002) Architecture decisions made in the first 20% of system’s development can affect almost 70% of its ultimate cost. (Blanchard, 1998; Buede, 2000)

1. **Who are the System Stakeholders.** Most authors writing on the subject of requirements development emphasize the importance of understanding the customer’s need. Jeffrey Grady argues that there is truly just one requirement, the “need”, as everything else is derived from it (Grady, 1993). The CMMI model stresses the importance of understanding the INTERNAL, as well as the EXTERNAL, stakeholders’ expectations. Clarity of stakeholders is just as important as understanding the system context (item 6) and the system concept of operations and support (item 5). Consider this question as the understanding of the concept development within the enterprise and its environment.

2. **What are the System Goals and Objectives.** The perspective of the person, or the organization, making inputs will affect the stated Goals and Objectives for the system under investigation. Perceptions are an enormous influence in what is said, and how it is weighted. The systems engineer must gather “all” the points of view, and then filter through them to see the FULL picture of the system concept, as it is envisioned by the group of stakeholders. Fundamental questions regarding the maturity, or risk factor, of the technology and the market(s) targeted by the system can yield a large number of implied requirements, constraints, and other expectations.

3. **What is the market for this System.** The commercial product development “world” starts with an analysis of the customers, their needs and expectations, and the markets for a product. Then the firm risks its own capital to do the product development. A DoD acquisition is quite the opposite. However, both “markets” affect one significant source of requirements: product safety, reliability, and homologation. DoD systems often have these sources of requirements called out in their Statement of Work (SOW) or their System Specification. Such is not often the case for commercial products. The market of intended sale often defines the regulations to be satisfied for safety, reliability and homologation. The firm must have a solid and repeatable process for developing products if it is to ensure a reasonable profit on the finished system.

4. **What are the external constraints on the System.** The systems engineer is interested in the external interfaces, and the external and internal constraints, which will be imposed on the system. A constraint is seen as a type of requirement, and most often it means that the system being developed will have to ADAPT to the constraint…this means early definition and then rigorous control of that “interface” in order to ensure the system meets its requirement during integration and testing. Mr. Thomas Stephens, Chief Engineer for the Engineering and Production Support business unit of Raytheon Technical Services Company, LLC has noted that “Constraints can be any external influence on the system – including org structure of implementation team, teaming relationships, cost.... as well as technical.” This is an important distinction for the successful development of a full understanding of external constraints on the system.

5. **What is the CONOPS for the System.** Most commercial, and many military, product

development programs fail to adequately staff, develop, and design for the SUPPORT needs of the system after it becomes OPERATIONAL. The author believes that the only way to remedy this behavior is to DEMAND that the Concept Exploration Phase includes an explicit discussion with the customer, acquisition, and end users. This discussion must specifically detail the SUPPORT concept for the system, even at this conceptual stage. There most definitely going to be REQUIREMENTS defined in these expectations, goals and objectives. An enormous part of a system's Life Cycle Cost is its support needs during its operational phase. (Blanchard, 1998)

The DoD acquisition process mandates that a Concept of Operations, or Operational Concept, document be developed as part of the system concept exploration and serve as an input to the System Functional Review (SFR). The Use Case view in the UML is also an excellent way to extract the answers to "Who, What, Where, When, Why, and How?" The stakeholders and the CONOPS will help to understand the goals and objectives of the system.

6. **What is the System Architecture context.** This question is meant to focus on the people, facilities, support equipment, tech pubs, hardware, software, data and processes that will comprise the system once it is defined, designed, built and tested. (Rechtin, 2000) This question is asking the team to visualize how the concept will be produced, packaged, shipped, stored, readied for operational use, supported, and finally its disposal. Expectations for Pre-planned Product Improvement (P^3I), technology refreshing, dealing with obsolescence, and future systems integration (growth), will all affect decisions about the final architecture selected for the system.

7. **What are the man-machine interfaces to be satisfied by the System.** Operators and maintainers need to be considered in understanding the expectations for the man-machine interface, and the machine-to-machine interfaces. Networking technologies are making it much more likely that a great deal of the system communications will be on a network, and may not require a man-in-the-loop or even desire to have that interface. Many systems are adopting a report-by-exception method of reporting health and status as well. Use of any existing interface protocols is an important expectation to discover during this early phase of the system definition.

8. **What are the Key System Attributes.** There are many methods and tools for discovering and documenting the key requirements of system attributes. This author likes the approach offered by Jeffrey Grady in *System Requirements Analysis, 1993.* He proposes that there are four types, or categories, of requirements for a system. They are (1) performance; (2) environmental; (3) interface; and, (4) design constraint. The key factor in determining if they are true requirements is "can they be stated as a value, relation, units and method of verification." If the answer is "NO", then the systems engineer is still working with "needs" and must decompose further. In DoD systems they often identify Measures of Effectiveness (MOE) that relate to mission success. Commercial system developers can define similar "requirements" for their systems.

9. **What are the System functions (behaviors) that satisfy the Key Attributes.** Now the systems engineer can start to have some fun. Identifying WHAT the system must do is an essential task to begin before the designers (hardware or software) start to "leap" to the solution. Remember that the key to innovation and customer delight is maintaining the "solution space" at its maximum during concept exploration and system definition. Early commitment to design solutions often causes a sub-optimized system with problems that are

not found until integration and test…very expensive. (Blanchard, 1998; Buede, 2000)

10. **What happens to "success" if the System FAILS to meet any of the above.** A chief intent of this method of using "10 questions" is to intentionally ask the question "What if the system fails to do this?" The concept is to do something akin to the Functional Hazard Assessment demanded by the Federal Aviation Administration (FAA) when a commercial transportation system is being developed. The developer must answer the question "How does your design mitigate and control the potential hazards this system may encounter?" By doing so, the developer understands which system functions are CRITICAL, and which parts of the design perform those functions. Systems engineers are interested in interfaces, functional, logical and physical…because most of the failures occur at the interfaces. (Leveson, 1995) This information can then be passed to the design engineer(s) for a more robust implementation of this concept through preliminary design and detailed design. Traceability of criticality and mitigation through design to verification also helps ensure key system behavior that is essential to customer-defined success is not lost during iterations and change.

SUMMARY

The fundamental challenge for the developer will not go away…they must still move as quickly as possible from concept to design and finally to manufacturing. Along the way the designer must be systems engineer and find the "needs" that the customer has not made known. Prioritized requirements that are the system's key attributes for the chain of understanding leading to effective designs. The developer (team) must see the system's life cycle, and "be" the maintainer as well as the operator. A successful developer (team) must also understand the inherent architecture in which the system's end design will operate, and how failure of a system's individual requirements (key attributes) will affect the architecture, mission success, and ultimately, the customer's need.

It is essential that the initial analysis team that developed the concept(s), requirements, and any trade studies capture this data in the "requirements database" so that further elicitation and decomposition of the requirements and their deployment through the design process can be traced to functions, interfaces and methods of verification. The insight the team gains from use of these 10 questions can accelerate the product development process and improve the hand off of a solid concept to the functional analysis team and the identification of key measures of effectiveness and initial technical performance measures.

CONCLUSIONS

More formalized structures and methodologies can be used for concept exploration and definition. However, most of them demand tools with databases, and licenses, and some amount of learning by the tool user. The author has suggested a more brief, but concise, list ten (10) questions which can be used to rapidly elicit the system requirements and expectations from the customer's "need". These requirements can be understood at three (3) abstract levels: first at the system; second, at the product; and, third at the components. The author believes that this is the best, and fastest, way for a team to achieve their understanding of the system concept. This approach employs systems engineering principles, requires use of cross-functional team members, and follows a top-down, hierarchical approach that seeks functions, then form (design), and applies this understanding to the system's architecture (functional, logical, and physical). Interfaces are key points of understanding, because failures most often occur at those interfaces, internal and external. Any team can use this approach, even with a simple tool like a spreadsheet. The author hopes developers and teams in the wide world of product development will use these "10 Golden Questions", and offer feedback and lessons learned on their utility.

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BIOGRAPHY

Dr. Surber is an INCOSE Certified Systems Engineering Professional, and has worked as a pilot, engineer and manager in avionics systems and heavy equipment engineering for over 30 years with three large defense contractors and a large, commercial corporation. He is an experienced senior pilot, flight examiner/ instructor, human factors engineer, systems safety engineer, and military accident investigator. He has accumulated over 5,000 hours of flight and simulator time in 17 types of military and commercial aircraft; holds a pilot rating in single and multi-engine aircraft; and, is a rated parachutist. In 1998 he retired after 29 years of military service with the United States Air Force, and with the Army National Guard and Reserve in various armor, mechanized infantry, aviation and military intelligence units. He is a Principal Systems Engineer for Raytheon, where he works on the V-22 Osprey program, and supports process improvements as a Raytheon Six Sigma Specialist. Dr. Surber has been a member of INCOSE since 1998, and is currently Past- President for the INCOSE Crossroads of America chapter in Region IV.

Contrasting CMMI and the PMBOK

Systems Engineering Conference

October 2005

Wayne Sherer
U.S. Army ARDEC

Sandy Thrasher, PMP
Anteon Corporation

Overview

- Purpose
- Considerations for Comparison
- Similarities Between CMMI and PMBOK
- “Grey” Areas
- How PMBOK Supplements CMMI
- How CMMI Supplements PMBOK
- Conclusions

Purpose

Purpose

- Contrast process requirements contained in CMMI and the PMBOK
- Overview
  - PMBOK provides additional project management processes for CMMI Organizations
  - CMMI provides a process management structure and Systems and Software Engineering Best Practices
  - Combining them will result in better and more complete project management of engineering projects

Considerations for Comparison

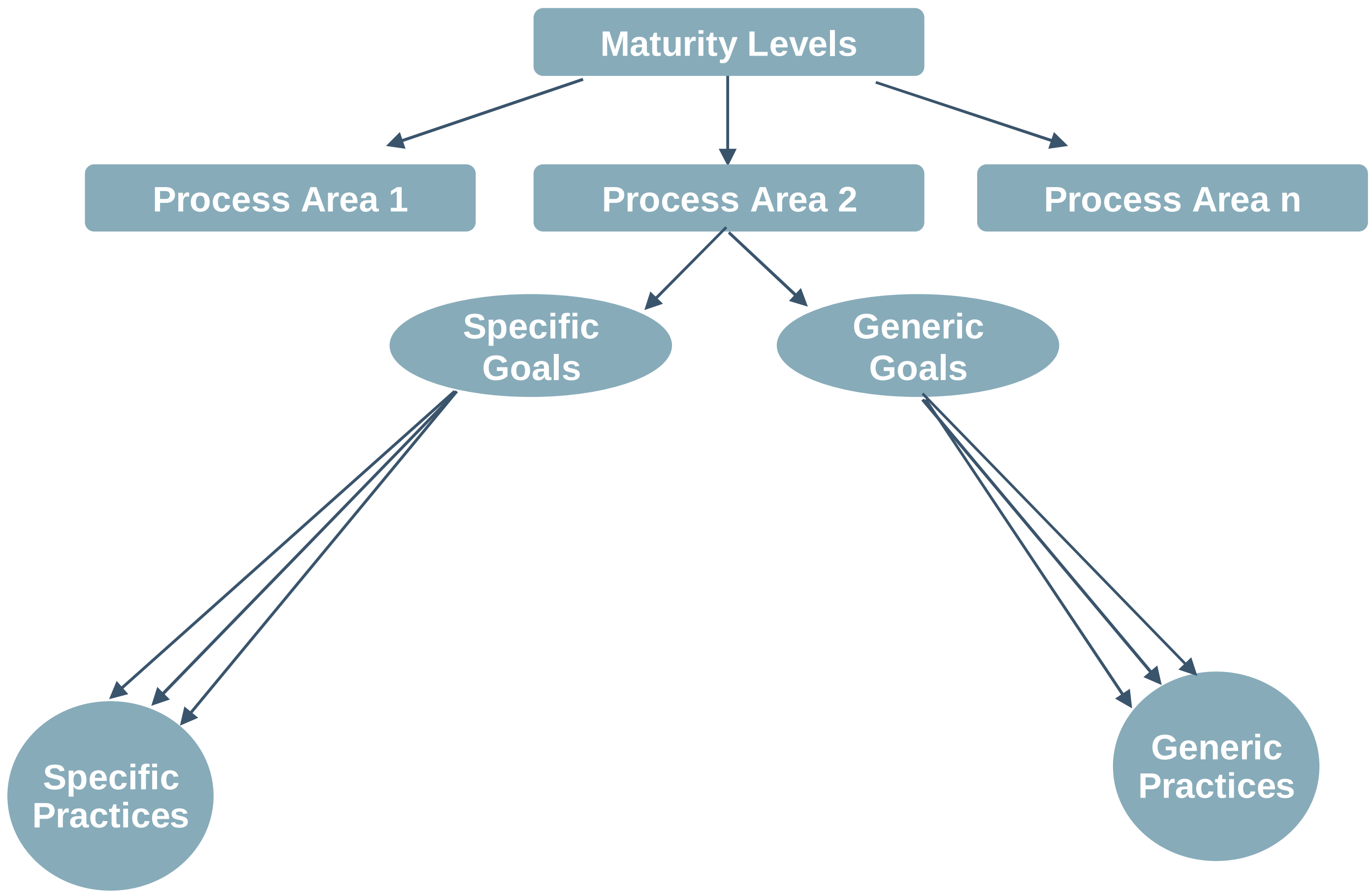
Coverage

- CMMI
  – Addresses Project Management of engineering endeavors
  – Addresses a larger organization composed of engineering projects
- PMBOK
  – Addresses Project Management without addressing the type of project or directly addressing the larger organization
- The depth of coverage varies between the documents

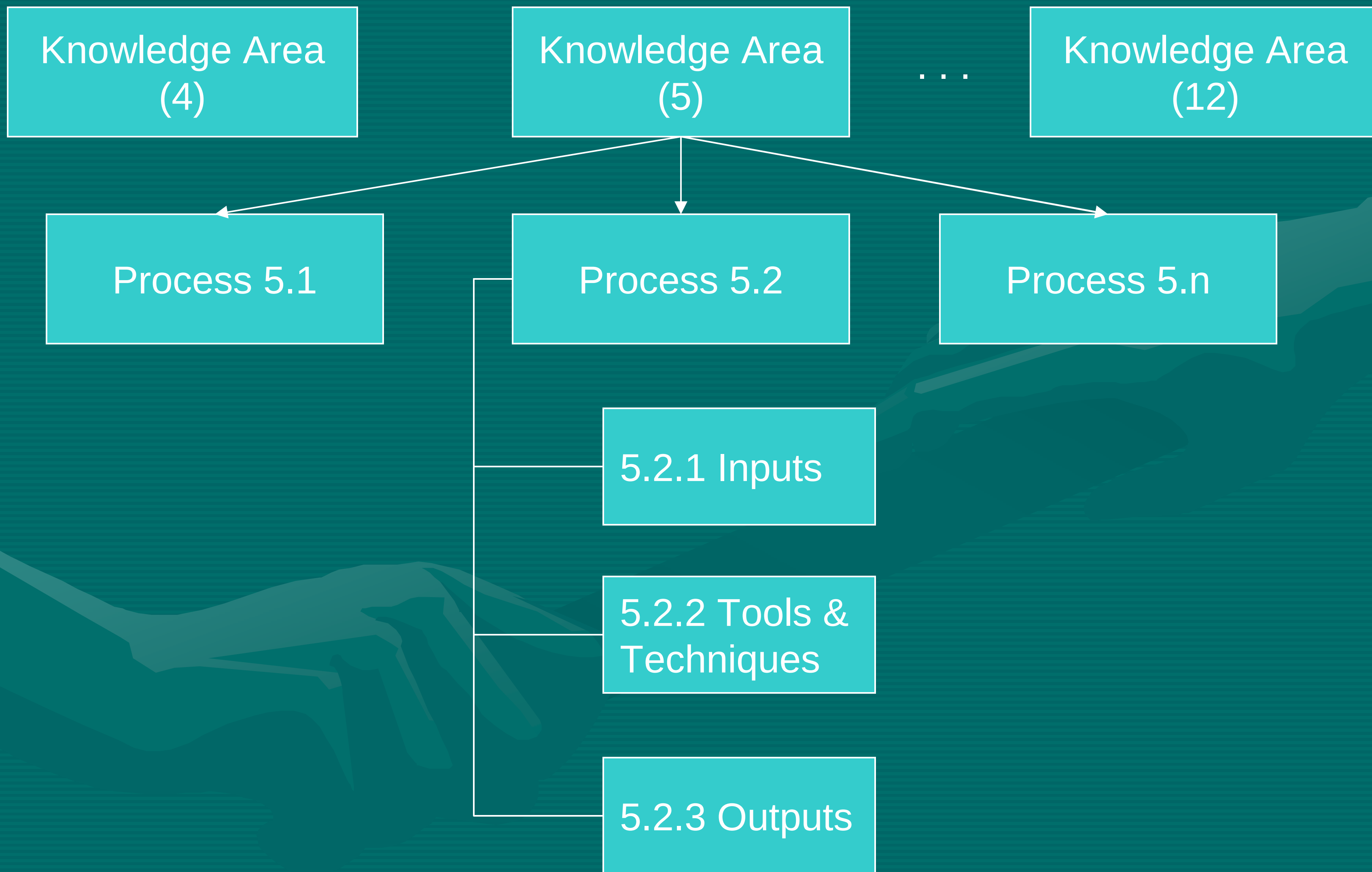
Structure

- It should be noted that while both have a project management focus, the structure of these documents is different
  - PMBOK supports training Project Managers for Project Management Professional (PMP) certification
  - CMMI supports organizational process improvement for achievement of maturity/capability levels

Model Components in the Staged Representation



PMBOK Components



Similarities Between CMMI and PMBOK

Processes Addressed by Both

- Requirements Management or Scope Control
- Project Planning
- Managing and Controlling Project Execution
- Quality Assurance
- Supplier Management
- Risk Management
- Measurement

"Grey" Areas

- The following are implied or partly addressed by PMBOK
  - Configuration Management
  - Causal Analysis
  - Generic Practices
- The following is partly addressed by CMMI
  - Human Resource Management
- The following are definition or context differences
  - Verification and Validation – Definitions in both documents are basically reversed
  - Risk – In PMBOK, risk is an uncertainty and can be positive or negative
  - Procurement Management - PMBOK considers buyer and seller points of view
  - Progressive Elaboration Vs. Establish and Maintain

How PMBOK Supplements CMMI

How PMBOK Supplements CMMI

- Project Charter
- More guidance and details on
  - planning,
  - management and control,
  - Human Resource Management,
  - Quality Assurance,
  - Risk, and
  - contracting
- Close Project + Accepted Deliverables

How PMBOK Supplements CMMI

- Project Charter
  - Issued by sponsor external to the project organization
  - Provides reasons for selecting a project
  - Formally authorizes existence of a project
  - Identifies and gives authority to project manager

How PMBOK Supplements CMMI

- More guidance and details on planning
  - Additional Planning Documents (Scope Management Plan, Schedule Management Plan, Cost Management Plan, Staffing Management Plan, Communications Management Plan, Procurement Management Plan)
  - Project Time Management (Activity Definition, Activity Sequencing, Activity Resource Estimating, Activity Duration Estimating, Schedule Development, and several possible support tools)

How PMBOK Supplements CMMI

- More guidance and details on management and control
  - Performance measurement analysis and forecasting using earned value calculations - formulas and examples are provided
  - Integrated change control details

How PMBOK Supplements CMMI

- More guidance and details on Human Resource Management
  - Human resource planning
  - Acquiring the project team
  - Developing the project team
  - Managing the project team

How PMBOK Supplements CMMI

- More guidance and details on Quality Assurance
  - Quality Planning
    - Considers Cost of Quality
    - Suggests tools with descriptions: Design of Experiments, Cost-Benefit Analysis, Benchmarking
  - Quality Control
    - Suggests tools with descriptions and some examples: cause and effect diagram, control charts, flowcharting, histogram, Pareto chart, run chart, scatter diagram, statistical sampling, defect repair review
    - Links outputs back into other processes

How PMBOK Supplements CMMI

- More guidance and details on risk
  - Risk planning and budgeting
  - Example risk parameters
  - More information on how to identify risks
  - Qualitative and quantitative risk analysis
  - Risk response planning

How PMBOK Supplements CMMI

- More guidance and details on contracting or Procurement Management
  - Considers buyer and seller
  - Request seller responses (solicitation)
  - Considerations for evaluation
  - Includes contract closure and payment

How PMBOK Supplements CMMI

- Close Project + Accepted Deliverables
  - Part of Project Management Plan
  - Administrative closure procedures
  - Contract closure procedures
  - Formal acceptance of product

How CMMI Supplements PMBOK

How CMMI Supplements PMBOK

- Engineering Best Practices
- Organizational Process Management
- Data Management
- Decision Analysis

How CMMI Supplements PMBOK

- Engineering Best Practices
  - Requirements Elicitation
  - Requirements Decomposition & Design
  - Requirements Traceability
  - Manage Interfaces
  - Planning and Environment for Integration, Verification, and Validation
  - Product Integration

How CMMI Supplements PMBOK

- Organizational Process Management
  - Process Needs (drivers & improvements)
  - Process Asset Library
  - Process Training
  - Quantitative Quality and Process Performance Objectives
  - Process Innovation and Deployment

How CMMI Supplements PMBOK

- Data Management
  - Planning for Data Management
  - Monitoring Data Management

How CMMI Supplements PMBOK

- Decision Analysis
  - Formal Decision Analysis and Resolution with expectations on how to structure the decision process

Conclusions

Conclusions

- CMMI and the PMBOK
  - Can support each other and
  - Supplement each other
- Implementing PMBOK can help CMMI organizations support and maintain their Project Management Professionals (PMP)
- Implementing CMMI can help PMBOK based organizations structure their Process Management and provides engineering best practices

The Mappings Are Available

- Link to - https://bscw.sei.cmu.edu/pub/bscw.cgi/0/79783
- Click on "Comparisons of CMMI & Other Standards/References"
- Then click on "CMMI and PMBOK"
- There will be three files, start with "CMMI and PMBoK Mappings"

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Oct. 27, 2005

Systems Engineering Approach to Analyze and Model the Performance of Containerized Shipping and Its Interdependencies with the United States Critical Infrastructure

SMU. SCHOOL OF ENGINEERING

Department of Engineering Management, Information & Systems

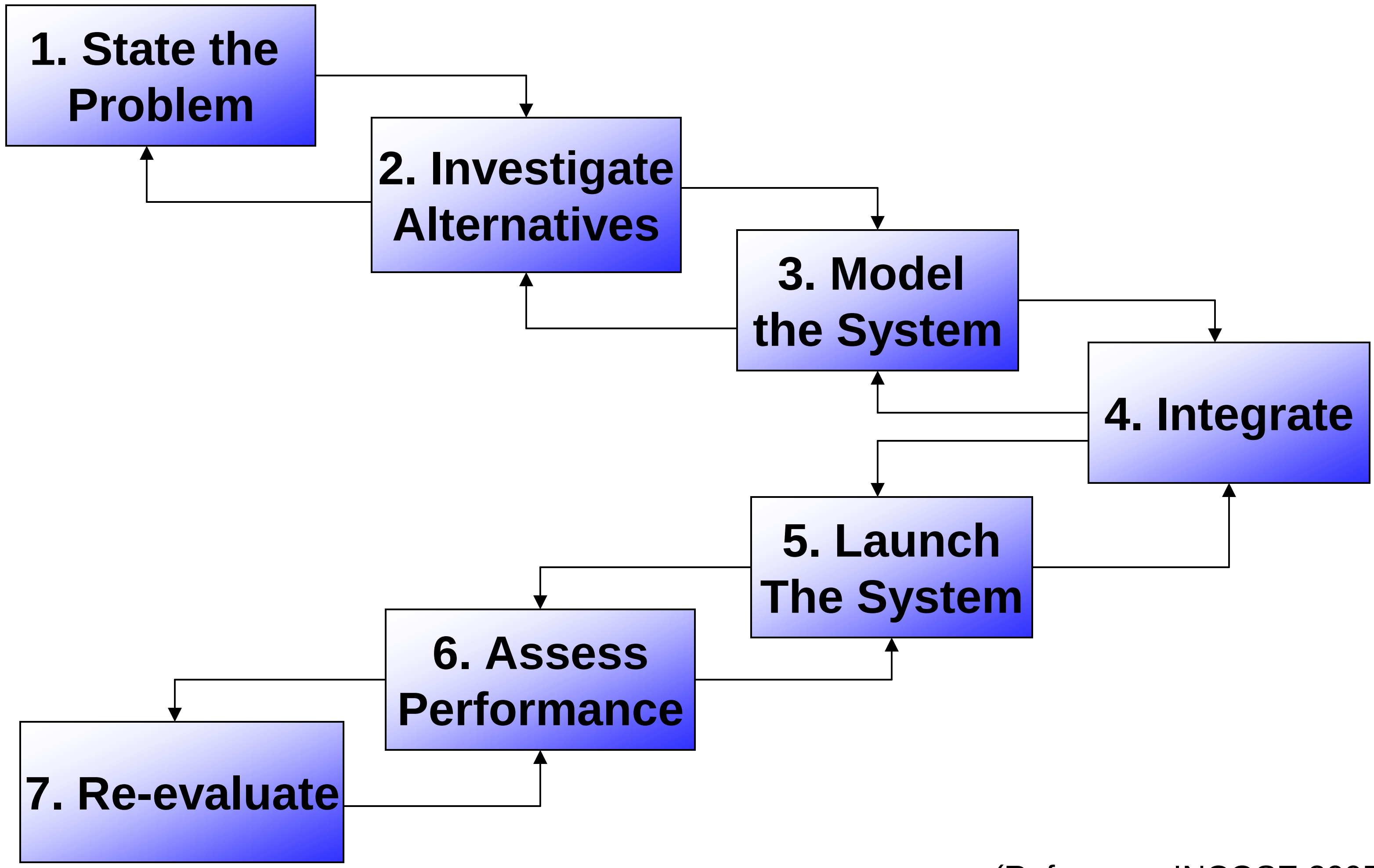
SYSTEMS ENGINEERING PROGRAM

Contents of Presentation

Objective

- This paper presents a systems engineering approach to the research, analysis, modeling, and simulation of containerized shipping performance and the interdependencies of containerized shipping with the complex United States infrastructure.
- Identifying, understanding, and analyzing the interdependencies among infrastructure systems has taken on increasing importance in the last few years.
- This research is for the benefit of the stakeholders and society.

Systems Engineering Process



(Reference: INCOSE 2005)

1. State the Problem

a. The problem is to understand and model the performance of containerized shipping and its interdependencies with the U.S. critical infrastructure.

b. Interdependencies are bidirectional.

c. This research encompasses physical interdependencies; defined to be when a commodity produces or is modified by one infrastructure (an output) is required by another infrastructure for it to operate (an input).

USA Patriot Act

Section 1016 - Critical Infrastructures Protection Act of 2001

Definition of Critical Infrastructure

Systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.

Critical Infrastructures Protection Act of 2001 (cont.)

- Private business, government, and the national security apparatus increasingly depend on an interdependent network of critical physical and information infrastructures, including telecommunications, energy, financial services, water, and transportation sectors.
- This national effort requires extensive modeling and analytic capabilities for purposes of evaluating appropriate mechanisms to ensure the stability of these complex and interdependent systems.
- It is the policy of the US that any physical or virtual disruption of the operation of the critical infrastructures of the US be rare, brief, geographically limited in effect, manageable, and minimally detrimental to the economy, human and government service, and national security of the US.

Identifying the U.S. Critical Infrastructure

PDD-63 (May 1998)	Patriot Act (October 2001)	National Strategy for Homeland Security (July 2002)	National Plan for Research and Development in Support of Critical Infrastructure Protection (2004)
Telecommunications Banking and Finance Transportation Energy Water Systems Emergency Services	Telecommunications Financial Services Transportation Sectors Energy Water	Information and Telecommunications Banking and Finance Transportation Energy Water Public Health Chemical Food Agriculture Postal and Shipping Government Defense Industry	Telecommunications Banking and Finance Transportation Systems Energy Water Public Health and Healthcare Chemical Agriculture and Food Postal and Shipping Defense Industrial Base Emergency Services Information Technology
		Key Assets	Key Resources
		Historic Attractions National Monuments Icons Events	National Monuments and Icons Dams Government Facilities Nuclear Reactors Materials and Waste

GAO Homeland Security Testimony before Congress

Preliminary Observations of Cargo Containers

"A terrorist incident at a seaport, in addition to killing people and causing physical damage, could have serious economic consequences. In a 2002 simulation of a terrorist attack involving cargo containers, every seaport in the United States was shut down, resulting in a loss of $58 billion in revenue to the U.S. economy, including spoilage, loss of sales, and manufacturing slowdowns and halts in production."

Port Security Strategies and Requirements

The National Strategy for Homeland Security – 2002

– Pre-screen containers before they arrive in America,
– Develop technologies to track in-transit containers.

Maritime and Transportation Security Act (MTSA) of 2002

– US Facility and Vulnerability Assessment
– Vessel and Facility Security Plans
– Automated ID Systems (AIS)

The Container Security Initiative (CSI)

– CBP uses intelligence to screen information on 100% of cargo entering our seaports, and all cargo that presents a risk to our country is inspected using large x-ray and radiation detection equipment

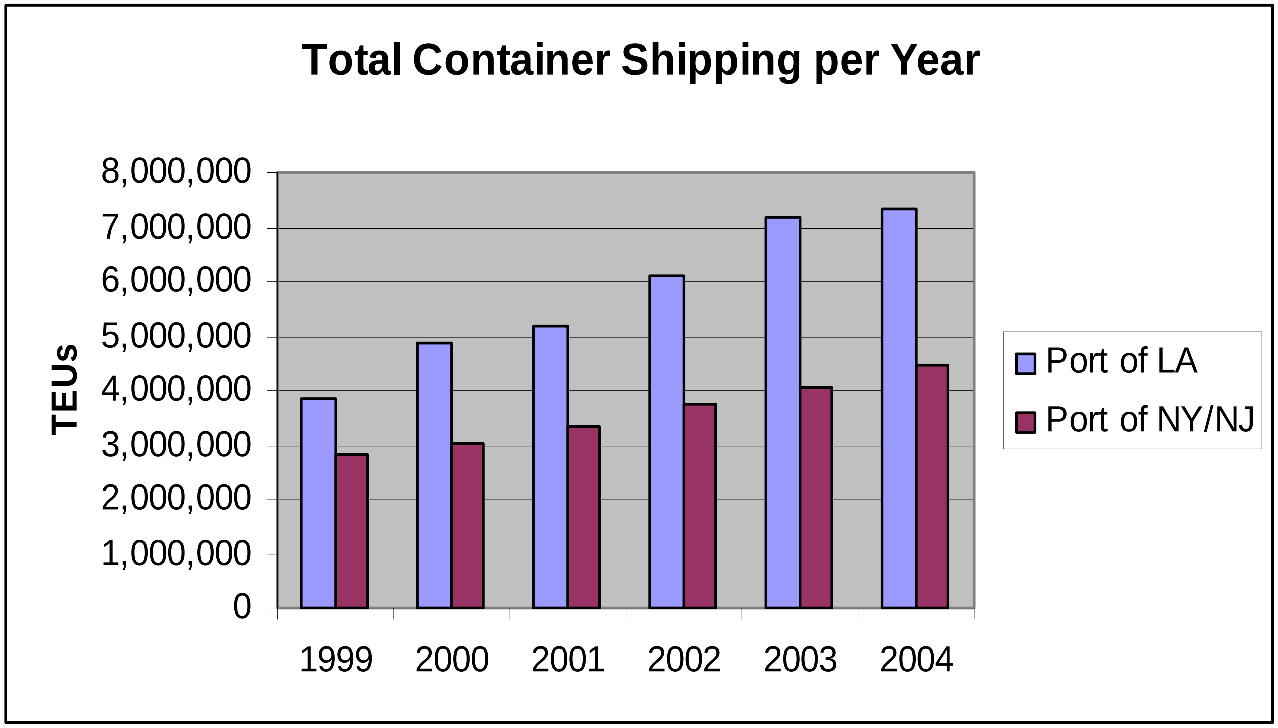
Customs-Trade Partnership Against Terrorism (C-TPAT)

– Cooperative program

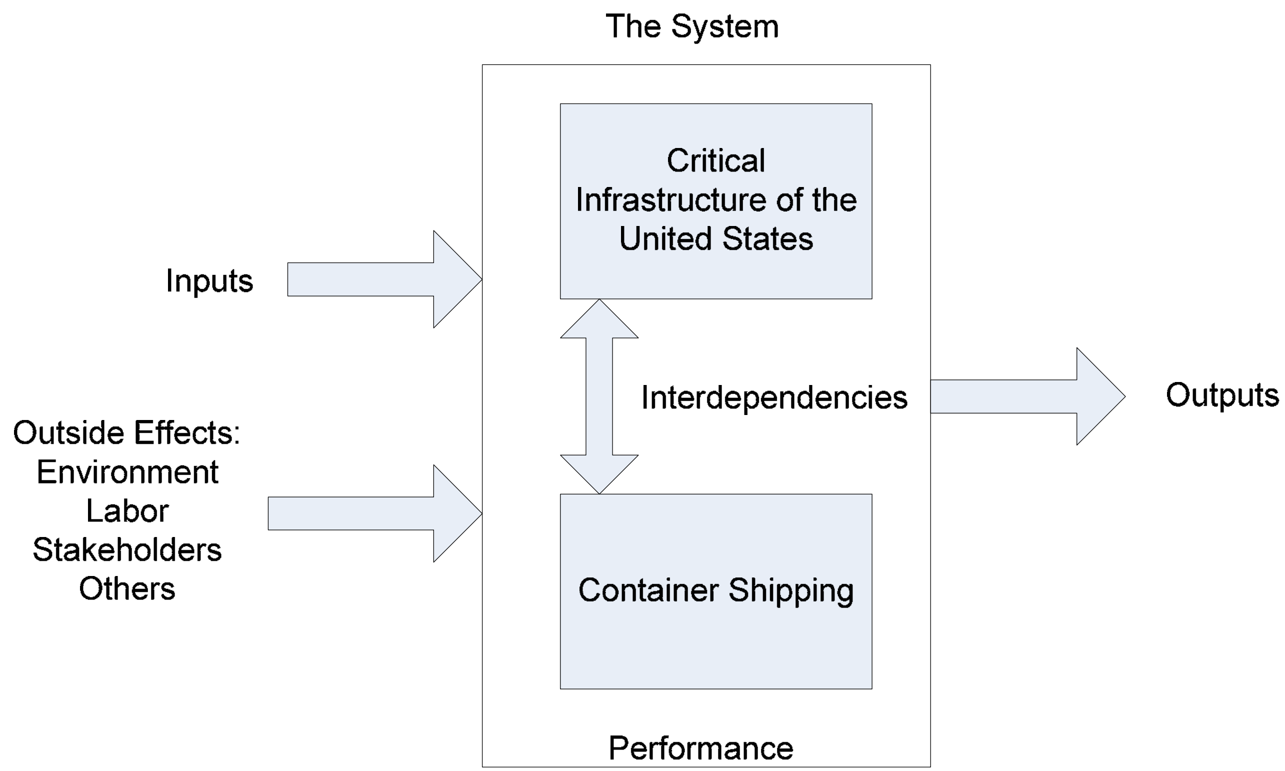
International Ship and Port Security Code

– Risk management concept with requirements for ships and ports

Containerized Shipping has been Continuously Increasing across the Ports of the U.S.

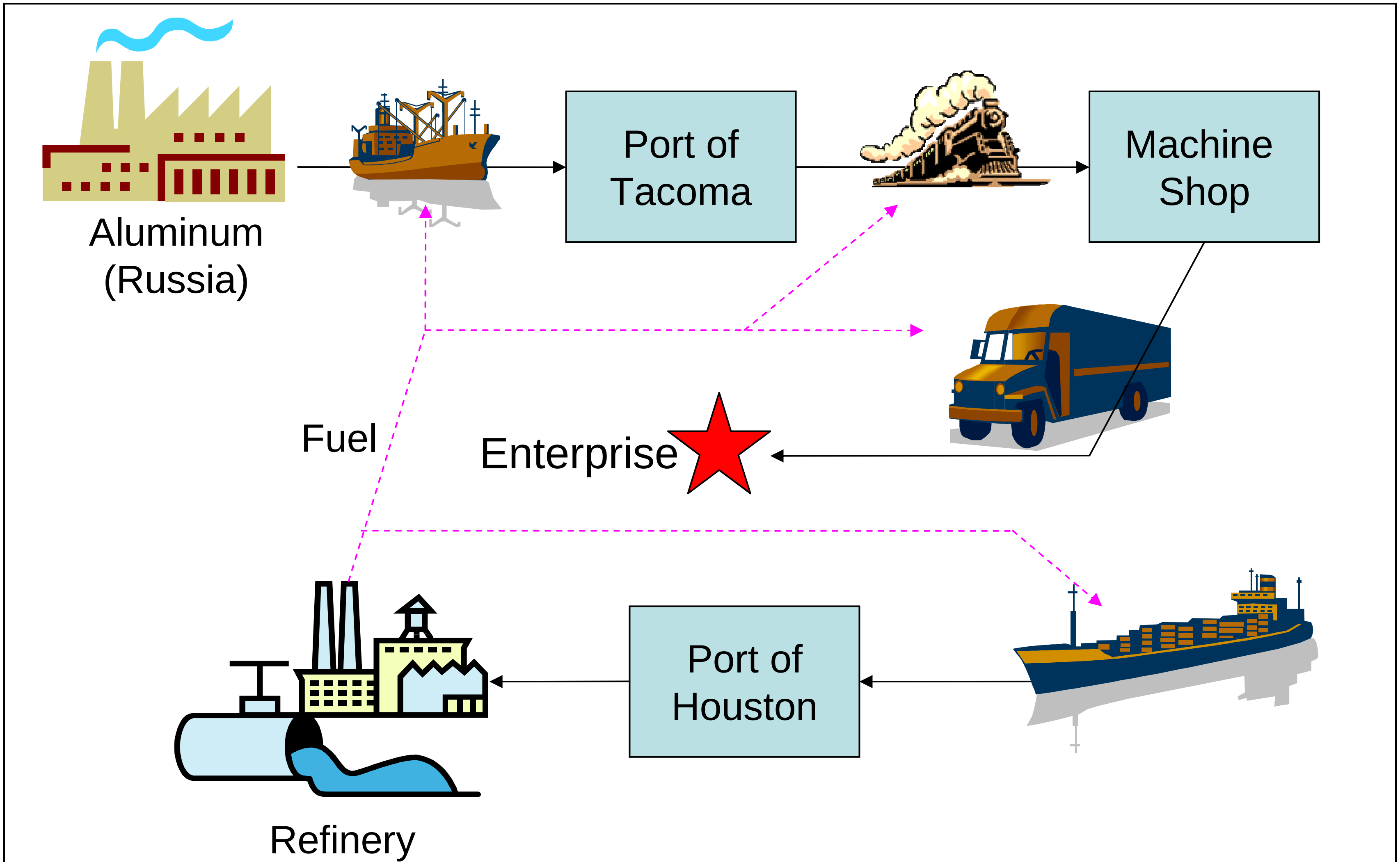


Top Level System Block Diagram



2. Investigate the Alternatives

Infrastructure - Example of Interdependencies



Items which Impact Container Shipping Performance

- Threat Level – MARSEC Two, MARSEC Three
- Weather – Hurricane, fog, rain
- Accidents
- Security/Technology
- Available Workers

Maritime Security Conditions

MARSEC Three
"Incident Imminent"

Physical Control

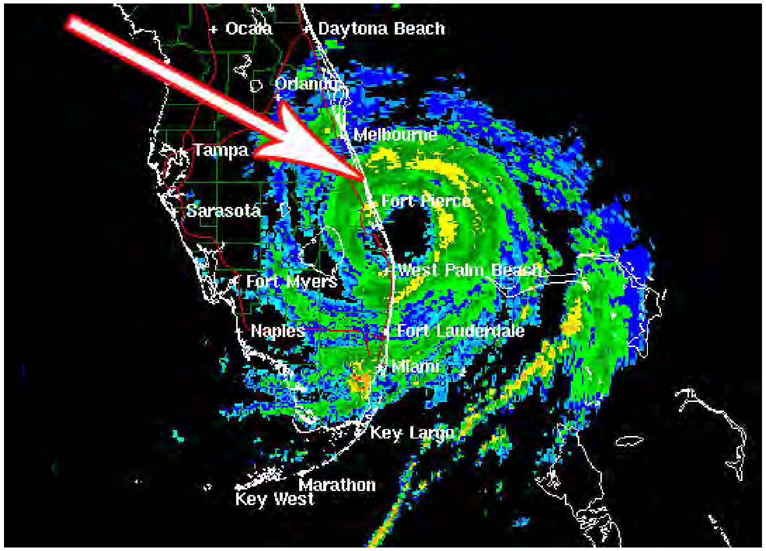
MARSEC Two
"Heightened Risk"

Targeted Control

MARSEC One
"New Normalcy"

Intel & Partnering
Harbor Patrol
Air Surveillance

Weather Effects



Effects due to Accidents

Environmental Accidents

On Friday, November 26, 2004 approximately 265,000 gallons of oil spilled into the Delaware River from the *T/S Athos.* After a three-day shutdown of the Port of Philadelphia immediately after the spill, commercial vessels were allowed back into the port, but must undergo a decontamination process prior to leaving the affected area.

Technology

Baltimore's Seagirt Marine Terminal's seven 20-story high-speed computerized cranes are among the most productive in the industry, averaging 33 to 35 containers an hour. Three of the cranes feature the latest dual-hoist systems, which lift two containers simultaneously.

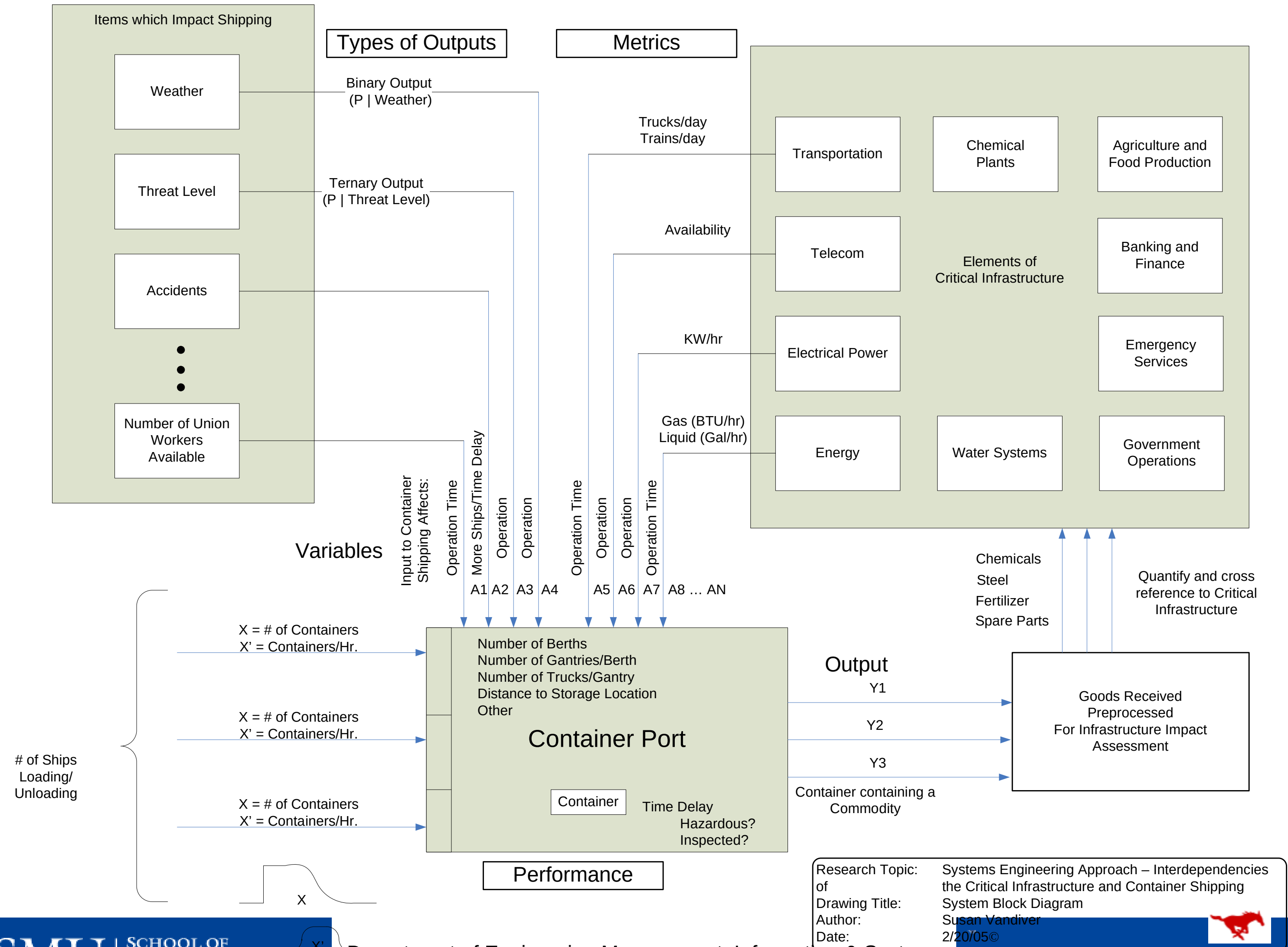
The Portal VACIS® system provides gamma ray images of intermodal cargo containers, semi trailers, and delivery vehicles.

Labor Availability

- We are experiencing very **significant disruptions to both import and export** ocean freight. The shutdown has effectively stopped virtually all activity. Even if back-to-work legislation is introduced quickly, it will be some time before the backlog of vessels and containers can be cleared. Port and Steamship Line officials noted this morning that **each day the shutdown continues, at least four to five days** will be added to the delivery times of Import containers.West Coast Shutdown Still Unresolved Issue 368, October 2, 2002 - 11:30 EDT
  The labor dispute disrupting U.S. West Coast port activity continues, with the negotiations between the two sides still at an impasse as of this morning. A scheduled meeting today between the Pacific Maritime Association and the ILWU was cancelled this morning.

  As of yesterday, President Bush was urging both sides to use mediation in an effort to reach a negotiated settlement. However, with the unwillingness of the two sides to meet today, major USA importers are now demanding President Bush to take immediate action. The Westcoast Waterfront Coalition, in a letter today, is imploring the President to "take whatever steps are necessary to re-open the nation's west coast ports".
- WASHINGTON, Oct. 8 - President Bush intervened in the **11-day shutdown of 29 West Coast ports today**, successfully seeking a court order today to halt the employers' lockout of 10,500 longshoremen, because the operation of the ports is "**vital to our economy and to our military**."

System Block Diagram



3. Model the System

The system model will integrate the following two models:

1. Model 1 – The time for a container to transfer from arrival at the port domain to departure from the container port a) under normal operating conditions and b) under not-normal conditions due to outside influences such as changes in MARSEC level, weather, technology, stakeholder decisions and dependence on the commodities provided by the US critical infrastructure.
2. Model 2 – The dependence of the critical infrastructure on the commodity provided by container shipping.

Developing Model 1

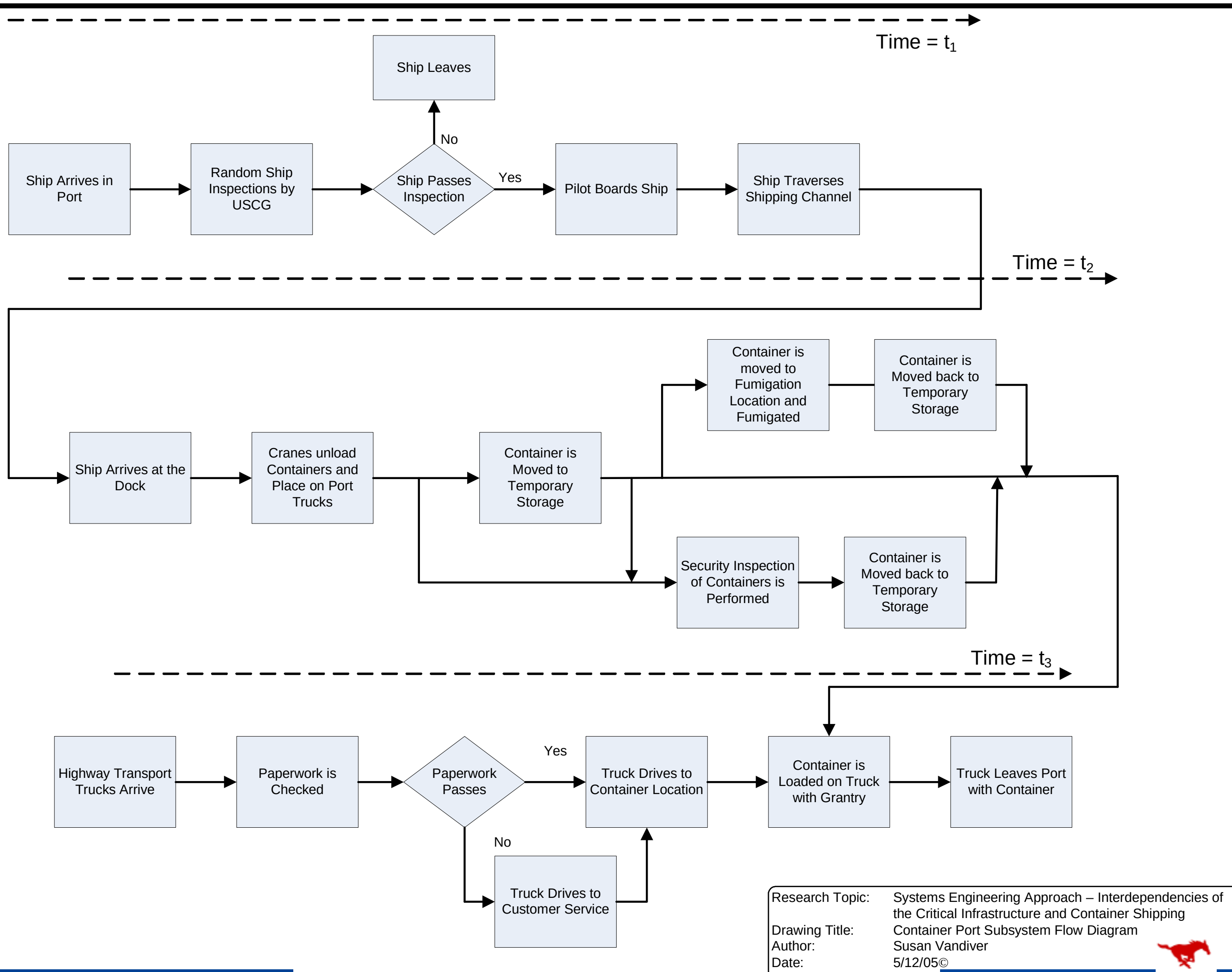
The performance of container shipping is defined as the amount of time, T, such that

$$T = t_1 + t_2 + t_3$$

where:

- t_1 = the time the ship waits in the port open sea area until authorized, moved, and docked at the port
- t_2 = the time for the unloading process in which the container is unloaded and moved to a temporary storage location
- t_3 = the time for the container to move from storage out of the port by truck or rail.

Flow Diagram of Port Operation



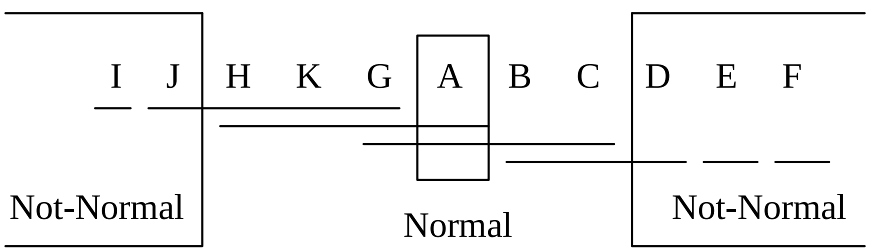
t_1: Time from Arrival at Sea to the Container Dock

Data Analysis for t_1

Table 1 . Number of Daily Ship Arrival Categories

Hours Closed	Category	When the Day before Is
0 – 4	A	
5 – 8	B	
9 – 12	C	
13 – 16	D	
17 – 20	E	
21 – 24	F	
	G	C
	H	D
	I	E
	J	F
	K	The 2nd day after

Using this categorization, a Duncan's Range Test (with an alpha of 5%) provides the following results.



During normal operating conditions the channel is open

Plots for Poisson Distribution of Ship Arrivals – t_1

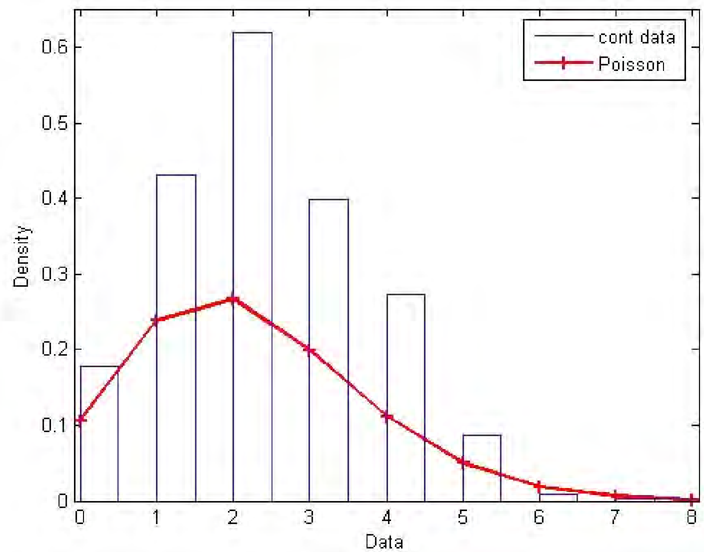


Figure 7. Histogram for the Daily Number of Container Ship Arrivals

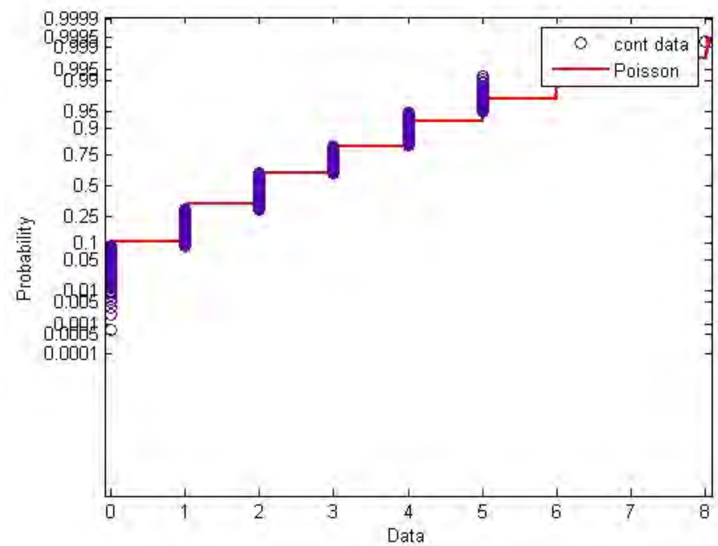


Figure 8. Poisson Probability Plot of the Daily Number of Container Ship Arrivals

Normal Distribution for Time to Move to the Dock Results for t_1

The time for the ship to move from the sea to the dock is determined to be a normal distribution with parameters of mean = μ and variance = σ^2. It is compared to some other distributions on a probability graph in Figure 9.

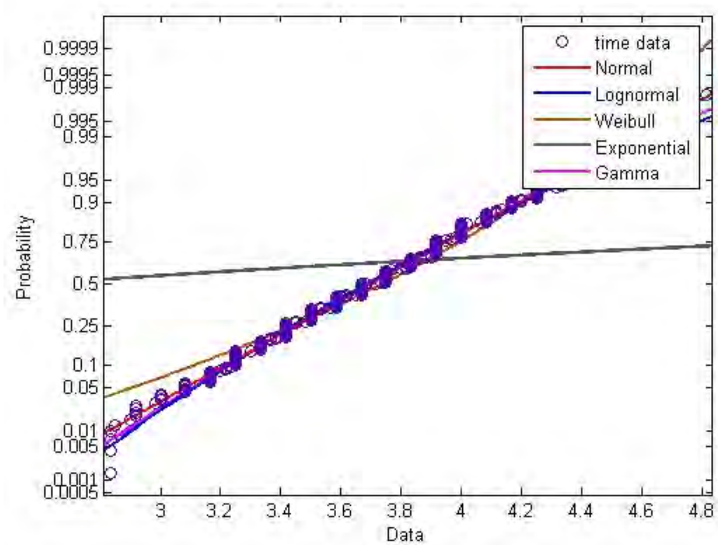
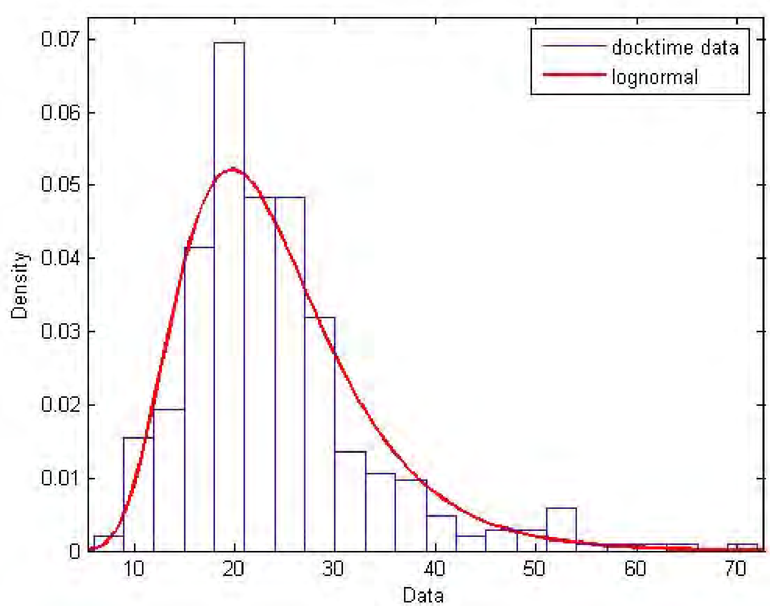


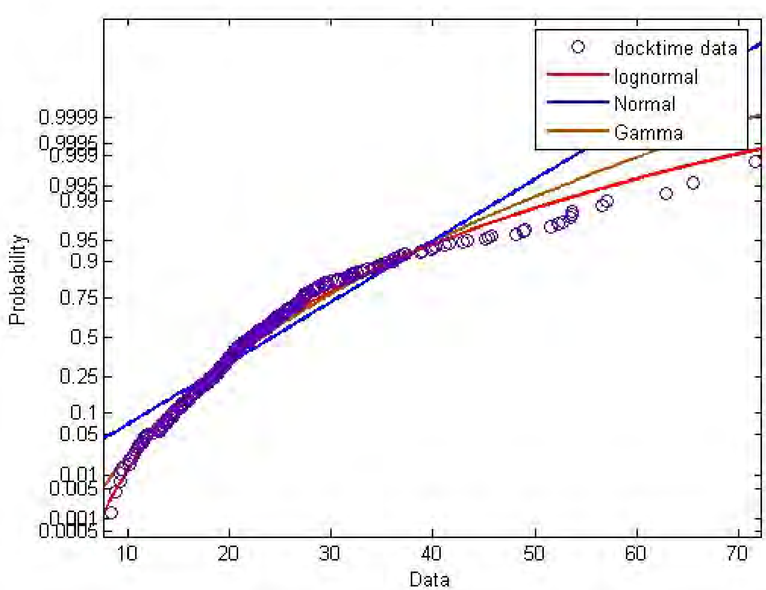
Figure 9. Probability Plot of the Time for a Ship to Move from the Sea to the Dock

t_2: Time to Unload the Container, Move to Storage and Wait for Intermodal Truck Transport

Ship Time in Dock (Time to Unload and Load)

The Time in Dock (TID) is determined to be a lognormal distribution as shown in the following figures.





Step-Wise Regression of Time in Dock (TID)

$$y = -7.22517 + .02705x_1 - .00000554x_1^{\ 2} + .00998x_3^{\ 2}$$
$$-15.79114x_4 + 1.83433x_4^{\ 2} + 33.02215x_5$$

y	Time in Dock
x_1	Number of Containers (Cont)
x_2	Dock Number (DockRO)
x_3	Hours Channel Closed (TotHcl)
x_4	Cranes (RRatio)
x_5	Shipping Company (Desig)

Regression yielded an R^2 of 67%.

t_3: The Time for the Container to Move from Storage out of the Port

Developing Model 2

Identify the commodities which are important to the infrastructure that are imported in containers.

Imports of Goods by End-Use Category and Commodity

Commodity	$M Ytd	% Increase
• Foods, feeds, and beverages		
– (1) Fish and shell fish	6,787	4.48
– (2) Meat products	4,175	6.13
– (9) Green coffee	1,482	29.22
• Industrial Supplies and materials		
– (5) Industrial supplies, other	11,617	11.98
– (7) Chemicals-organic	9,706	11.89
– (14) Chemicals-fertilizers	4,508	27.24
• Capital goods, except automotive		
– (2) Telecommunication equipment	20,801	17.25
– (3) Computers	17,160	19.48
• Consumer goods		
– (1) Pharmaceutical preparations	32,600	3.2

(US Census Foreign Trade Bureau – Exhibit 8)

4 & 5. Systems Integration and Launch

- The two models are to be integrated into a system performance model.
- The model is then launched in a graphical visual simulation.

6. Assess System Performance

- The system model will be evaluated for accuracy, tolerance intervals, residuals, and coefficients of determination (R and Cp values).
- The system model will be validated with the acquired data through demonstration.
  - The demonstration will show the changes in system performance due to interdependencies and external events.

7. System Re-evaluation

- The systems engineering process and model development will be documented such that it may be updated when additional data is available.

Conclusions

- The research is currently in the data analysis phase.
- The final model determination will be based upon the data analysis.
- The outcome of the research will be a graphical simulation which illustrates the performance of containerized shipping with the interdependencies of the U.S. critical infrastructure.
- This research is for the benefit of society and protection of the United States critical infrastructure.

Future Research

- This research is paving the way for significant future research.
  - Container shipping viewed as a service provider for exporting.
  - Application of the system block diagram to the other subsystems of the infrastructure to analyze its interdependencies with the critical infrastructure.
  - Other categories of interdependencies, i.e., logical, geographical, and cyber.

Air Force Institute of Technology

Integrity - Service - Excellence

A SYSTEMS ARCHITECTURAL MODEL FOR MAN-PACKABLE/OPERABLE ISR MINI/MICRO AERIAL VEHICLES

U.S. AIR FORCE

<u>Presented By</u>

Maj Joerg Walter
AFIT/SY

Air Force Institute of Technology
Air Force Center for
Systems Engineering

U.S. AIR FORCE

Acknowledgements

- Advisors
  - Lt Col Eric Stephen
  - Maj Joerg Walter
- Students
  - Capt Cory Cooper
  - Capt Matthew Ewoldt
  - Capt Steaven Meyer
  - 2dLt Edward Talley

Overview

- **Introduction**
  - *Research Goal, Scope and Assumptions*
- **Background**
  - *User, UAV/MAVs, Systems Engineering*
- **Methodology**
  - *DoD Architecture Framework*
- **Results**
  - *Architecture Products, and Future Capabilities*
- **Conclusion**
  - *Concluding Remarks*

Introduction

- **<u>Research Goal</u>**

Apply good systems engineering principles to develop a baseline Mini/Micro Aerial Vehicle (MAV) architectural model describing their use in three separate but closely related Intelligence, Surveillance, and Reconnaissance (ISR) mission areas:

- Over-the-Hill-Reconnaissance
- Battle Damage Information (BDI)
- Local Area Defense (LAD)

Introduction

- **Scope**
  - The Three ISR Mission Areas Define the Application of MAVs for this Thesis

    Scope: MAV can be thought of a single man-packable and single man-operable system that does not require the carrier to sacrifice normal mission essential gear in place of the MAV system.

- **Assumptions**
  - Used by small tactical teams synonymous with special operations forces (SOF)
  - Primarily used for close-in (~<3km range) tactical reconnaissance

Background: Overview

- **Background**
  - *User*
  - *Unmanned Aerial Vehicles (UAV)*
  - *Mini/ Micro Aerial Vehicles (MAV)*
  - *Systems Engineering (SE)*

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Background: User

- **<u>Special Operations Forces (SOF)</u> conduct fast, surgical operations at great distances from established bases by using state-of-the-art communications, aircraft, and specially trained forces**
- **Responsible for nine principal missions or core tasks ⇒**

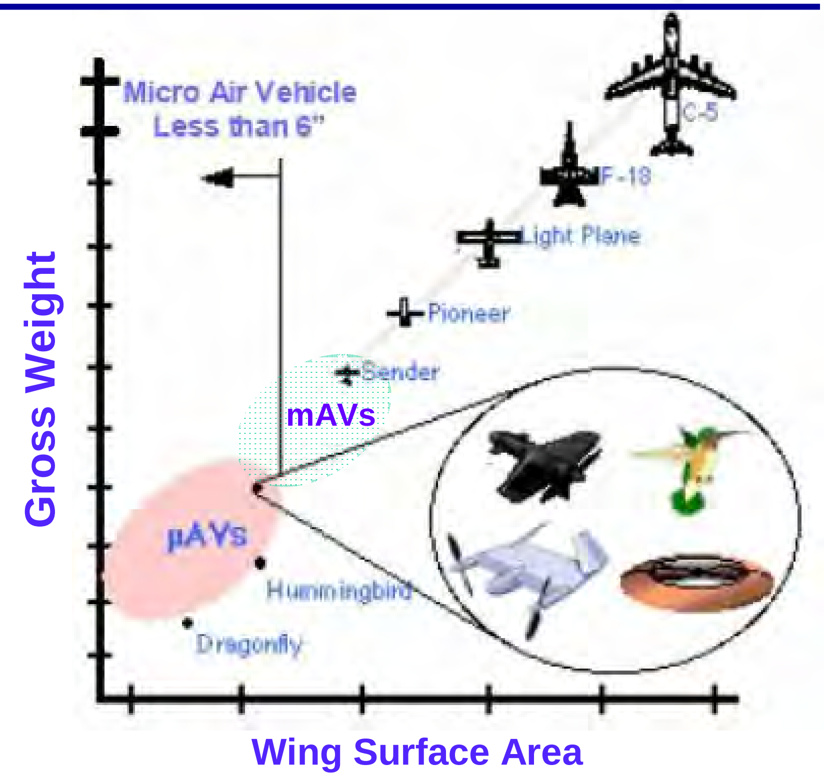
Special Operations Forces

- Direct Action
- **Special Reconnaissance**
- Unconventional Warfare
- Foreign Internal Defense
- **Counter-Terrorism**
- Information Operations
- Psychological Operations
- Civil Affairs Operations
- Counter-Proliferation of Weapons of Mass Destruction

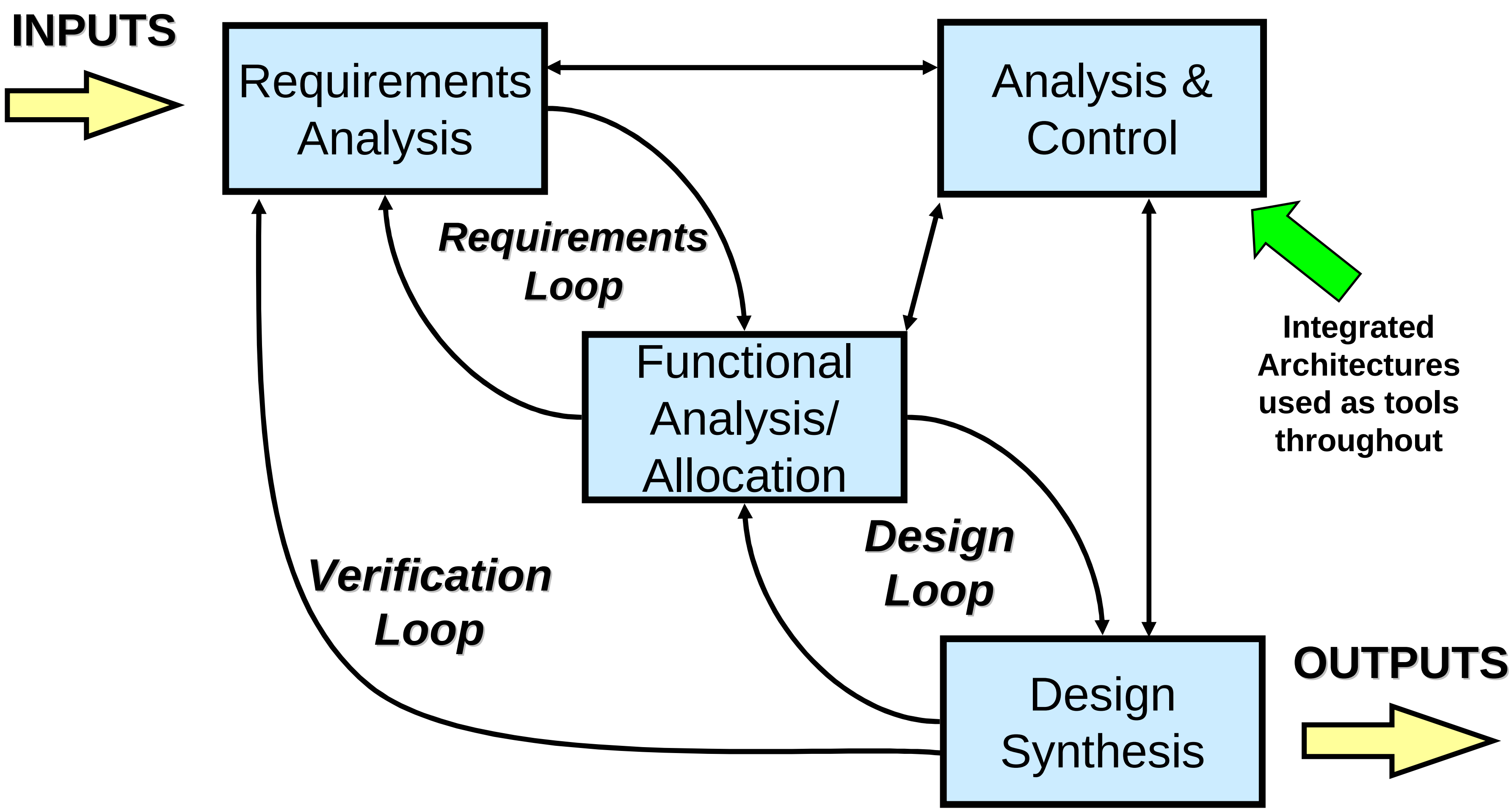
Background: MAVs

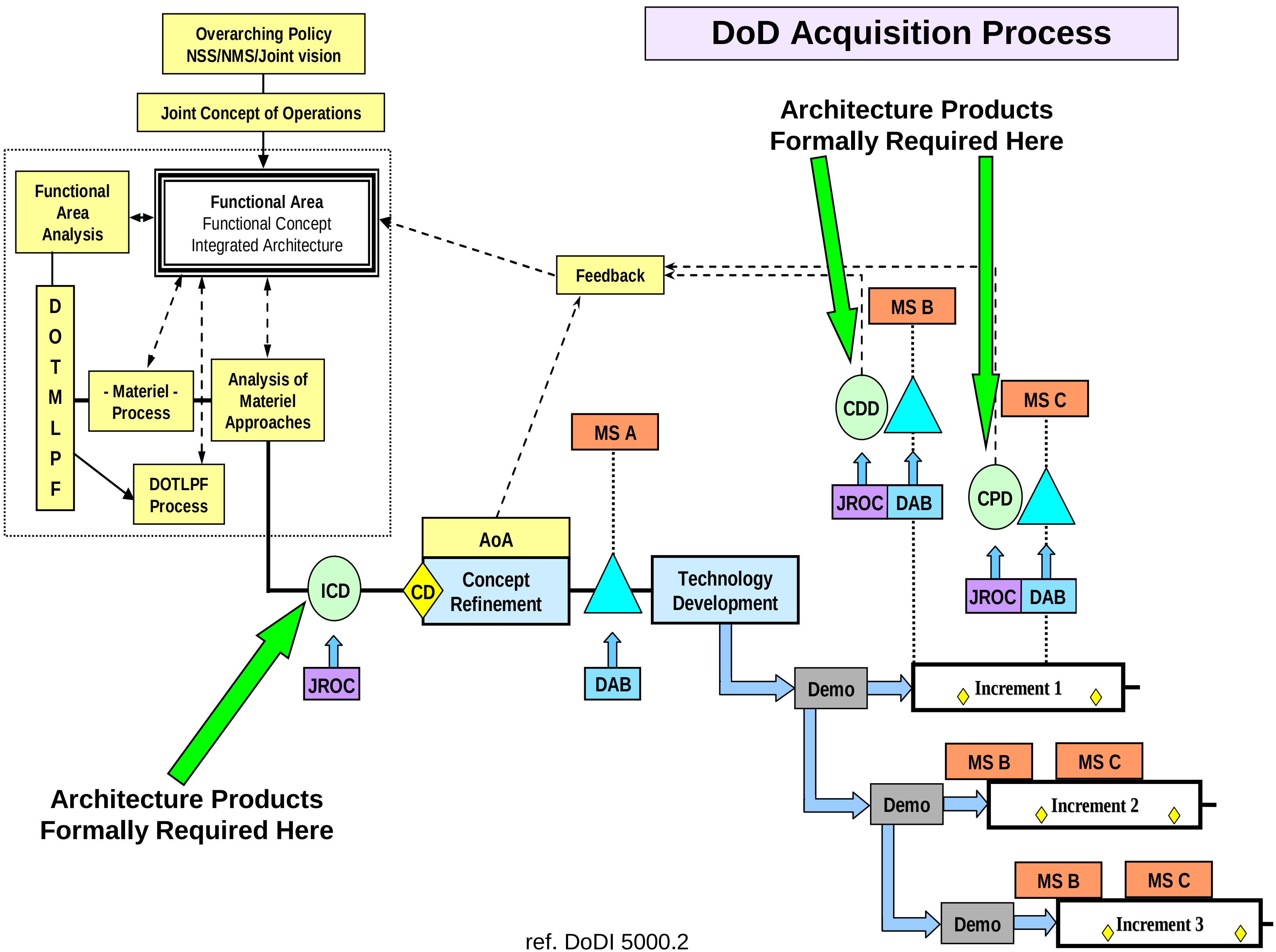
- Unmanned Aerial Vehicles (UAVs) include aerial vehicles that can operate using pre-programmed data and those that can accept mission changes while in flight

- Subsets of Mini and Micro Aerial Vehicles (MAVs) are closely related
  - Mini Aerial Vehicles: scale of hobbyist remote controlled aircraft
  - Micro Aerial Vehicles: scale of small birds and dragonflies
- MAV's introduce new challenges
  - Miniaturization of flight and sensor components



Background: Systems Engineering



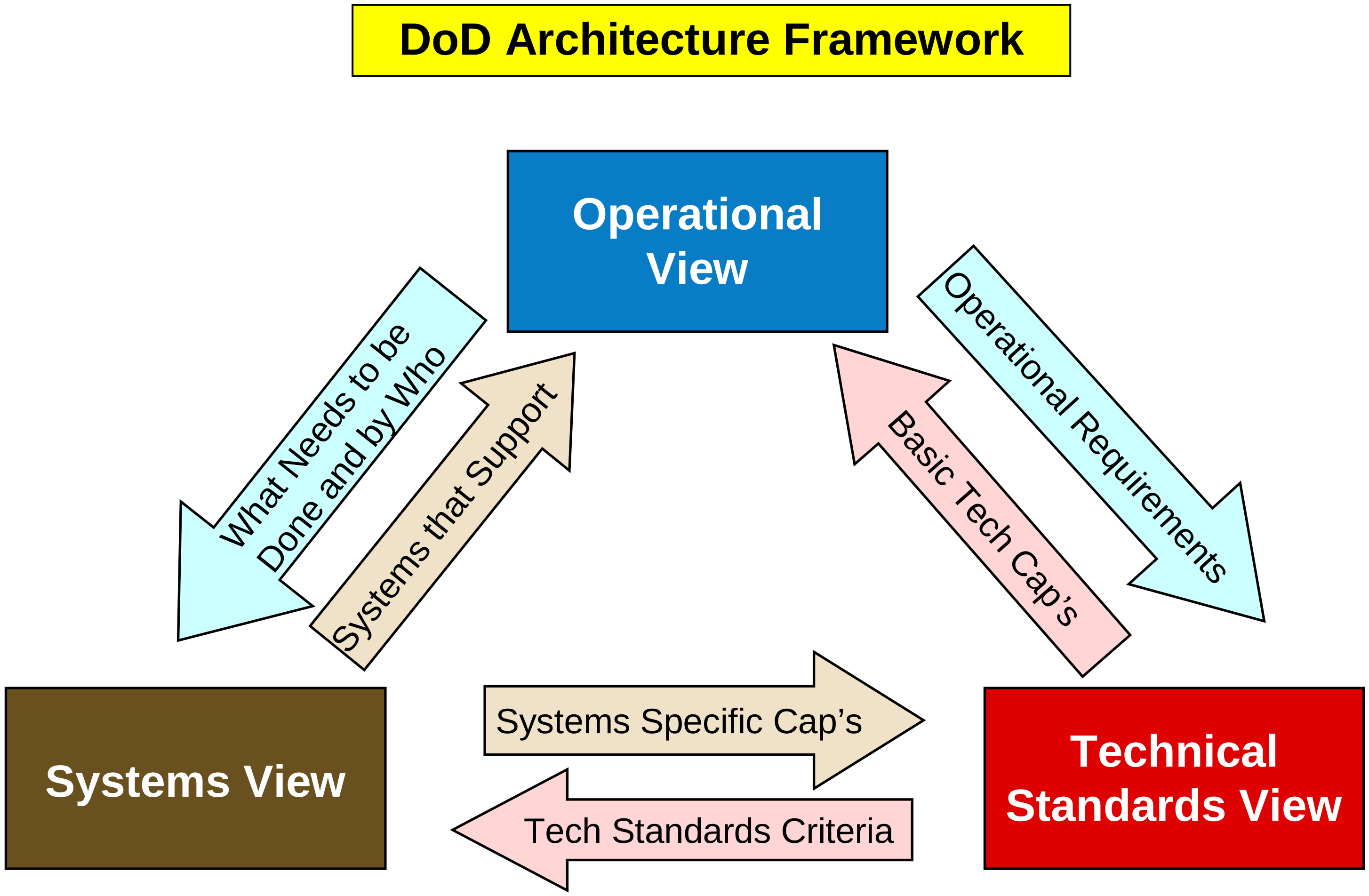


ref. DoDI 5000.2

Methodology: Overview

- **Methodology**
  - *DoD Architecture Framework*
  - *Architecture Products*

Methodology: Integrated Architectures



Methodology: Products

OPERATIONAL (OV)

- 1: High-Level Operational Concept Graphic*
- 2: Operational Node Connectivity Description*
- 3: Operational Information Exchange Matrix*
- 4: Command Relationships Chart
- 5: Activity Model*
- 6c: Operational Event/Trace Description
- 7: Logical Data Model

SYSTEMS (SV)

- 1: System Interface Description*
- 4: Systems Functionality Description
- 5: Operational Activity to System Function Traceability Matrix
- 6: Sys Information Exchange Matrix

TECHNICAL (TV)

ALL (AV)

- Overview & Summary*
- Integrated Dictionary*

*** Denotes critical products**

Spreadsheets	Static Models & Graphics	Text	Dynamic Models

I n t e l l

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Results: Overview

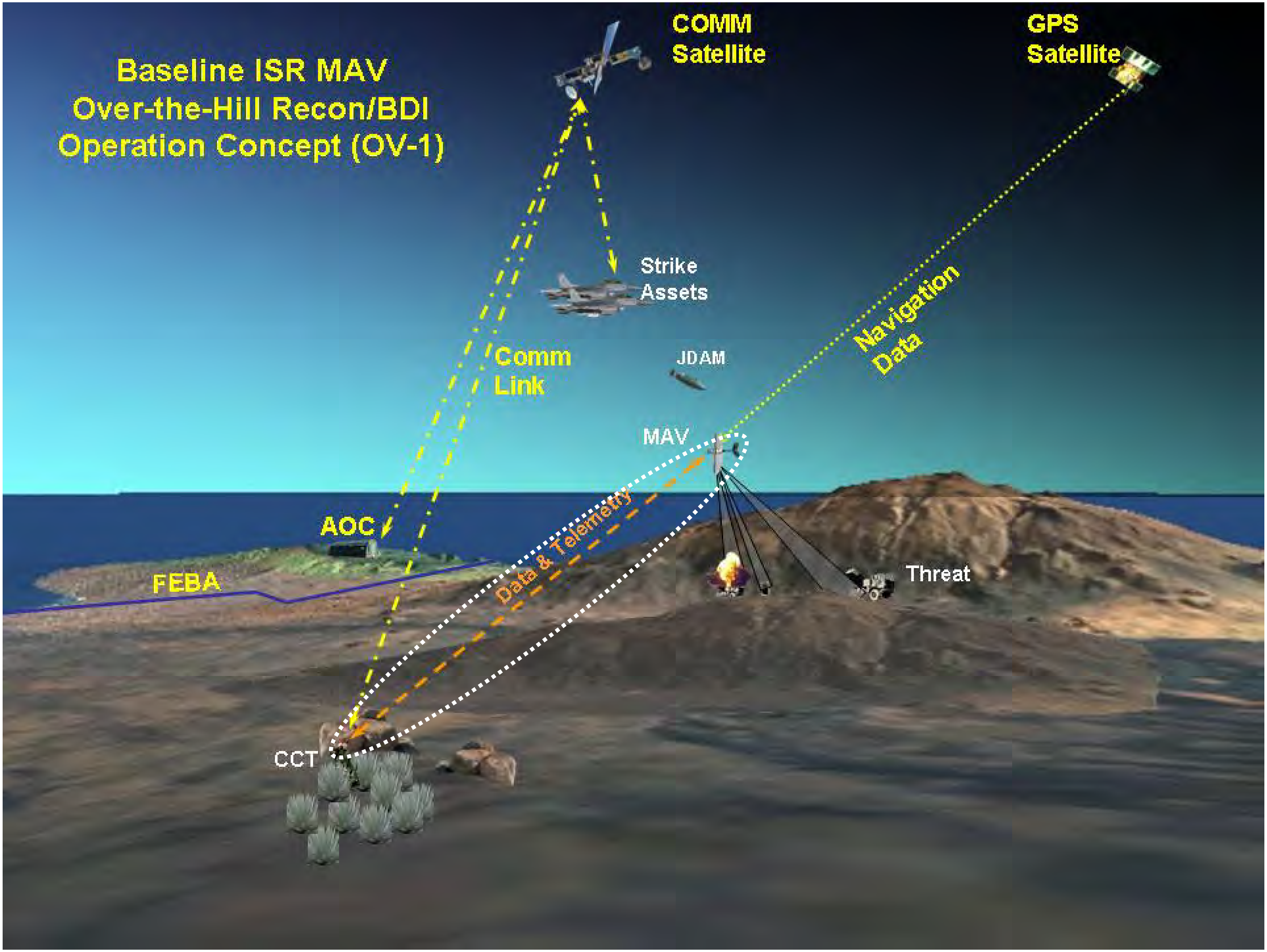
- **Results**
  - *Current Baseline or "AS-IS" Architecture Products*
  - *Future Capabilities*

Results: Operational Scenario's

- **Over-the-Hill Reconnaissance**
  - **Provide enhanced Situational Awareness**
  - **Identify enemy location/strength**
  - **Identify enemy armament**
- **Battle Damage Information**
  - **Provide feedback on strike success**
- **Local Area Defense**
  - **Locate potential/attacking threats**
  - **Provide relative position**
  - **Follow retreating enemy**
- **All missions assume "close-in" deployment**
- **MAV flown in auto or manual mode**

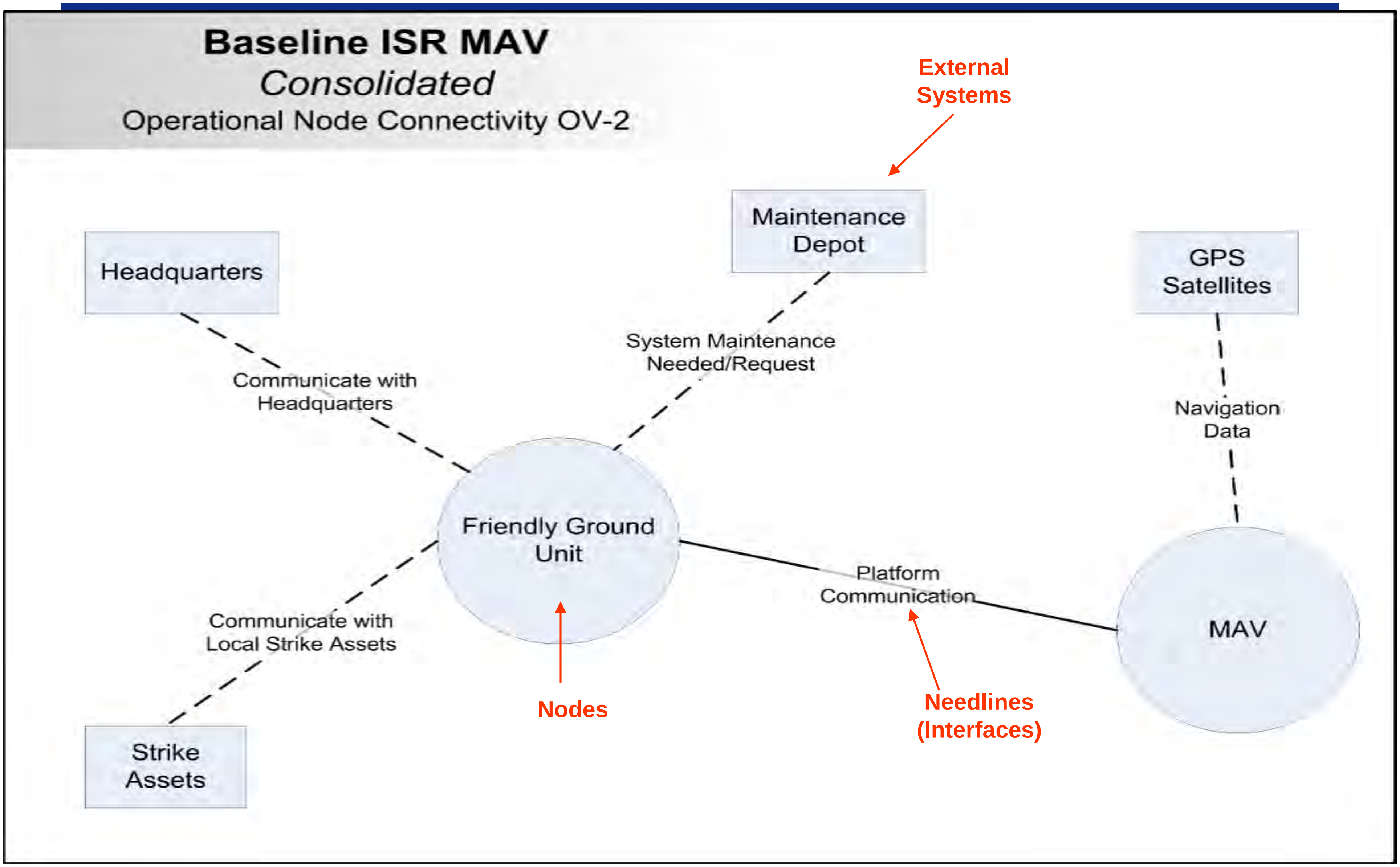
Results: OV Architectures

- **Operational Views (OV)**
  - **Identifies what needs to be accomplished and who does it**
- **OV Products Completed for ISR MAV**
  - **OV-1: High Level Operational Concept**
  - **OV-2: Operational Node Connectivity**
  - **OV-3: Operational Information Exchange Matrix**
  - **OV-4: Organizational Relationships Chart**
  - **OV-5: Operational Activity Model**
  - **OV-6c: Operational Event Trace Diagram**
  - **OV-7: Logical Data Model**



Baseline ISR MAV
Over-the-Hill Recon/BDI
Operation Concept (OV-1)
COMM
Satellite
GPS
Satellite
Strike
Assets
Comm
Link
JDAM
Navigation
Data
MAV
AOC
FEBA
Data & Telemetry
Threat
CCT

Results: OV Architectures

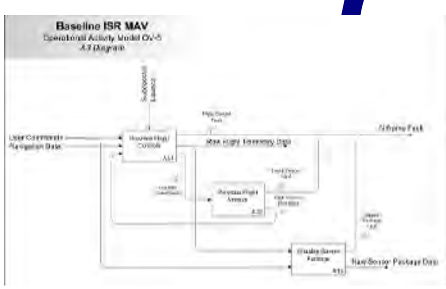


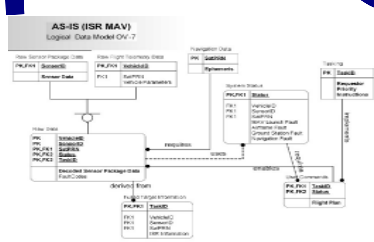
Results: OV Architectures

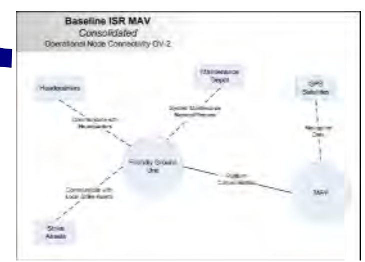
- **OV-3 – Operational Info Exchange Matrix**
- **Details info exchanges**
  - **who, what, why, & how**
- **Includes AFTL references**
- **Expands on info associated with OV-2, OV-5, OV-6C and OV-7**

Needline Identifier	Information Exchange Identifier	Information Element Description					Producer		Consumer	
		Information Element Name and Identifier	Content	Scope	Accuracy	Language	Sending Op Node Name and Identifier	Sending Op Activity Name and Identifier	Receiving Op Node Name and Identifier	Receiving Op Activity Name and Identifier

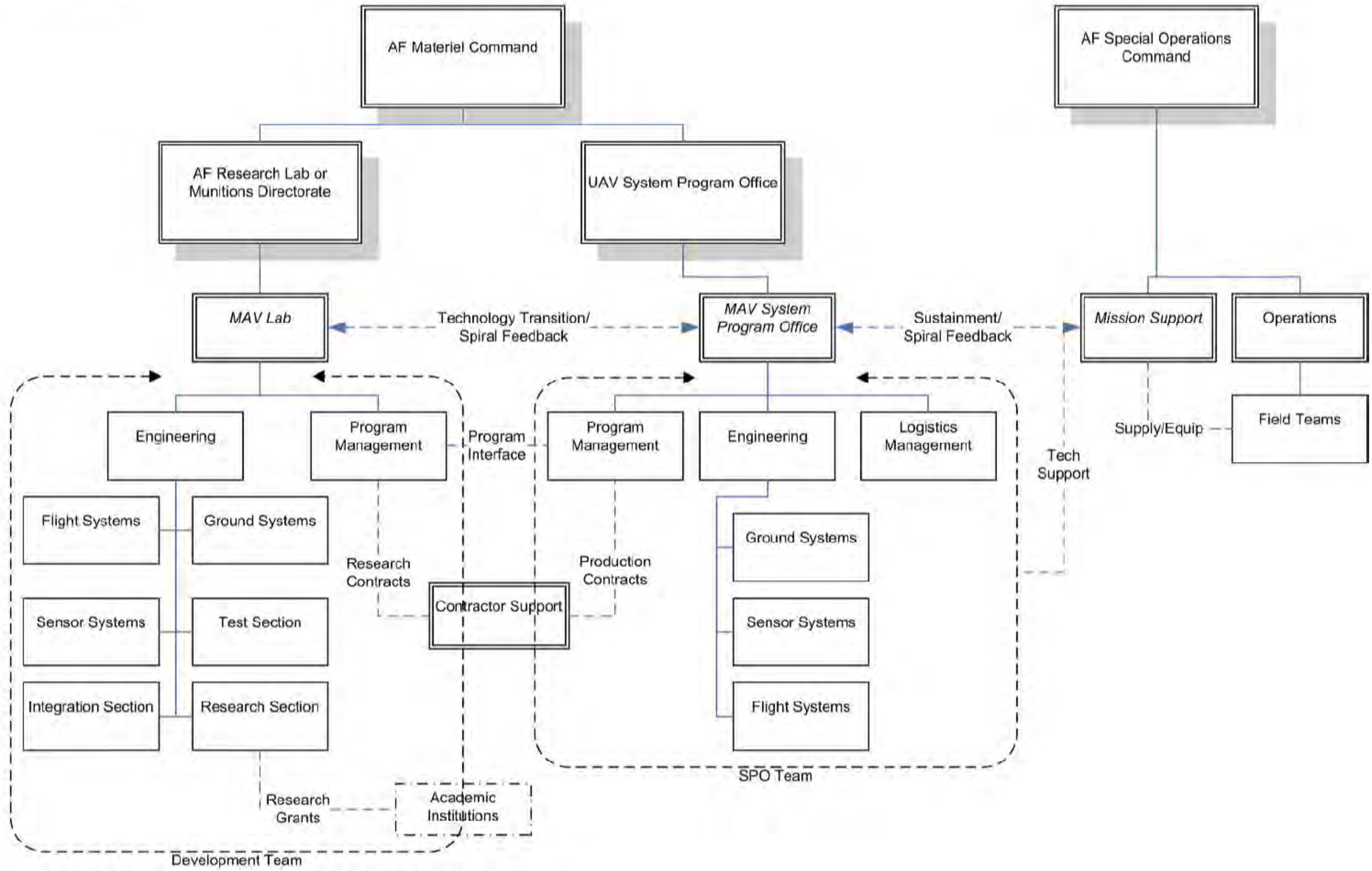
Needline Identifier	Information Exchange Identifier	Nature of Transaction					Performance Attributes		Information Assurance					Security			
		Mission/Scenario UJTL or METL	Transaction Type	Triggering Event	Interoperability Level Required	Criticality	Periodicity	Timeliness	Access Control	Availability	Confidentiality	Dissemination Control	Integrity	Accountability	Protection (Type Name, Duration, Date)	Classification	Classification Caveat







Baseline ISR MAV
OV-4 Organizational Relationships Chart



Results: OV Architectures

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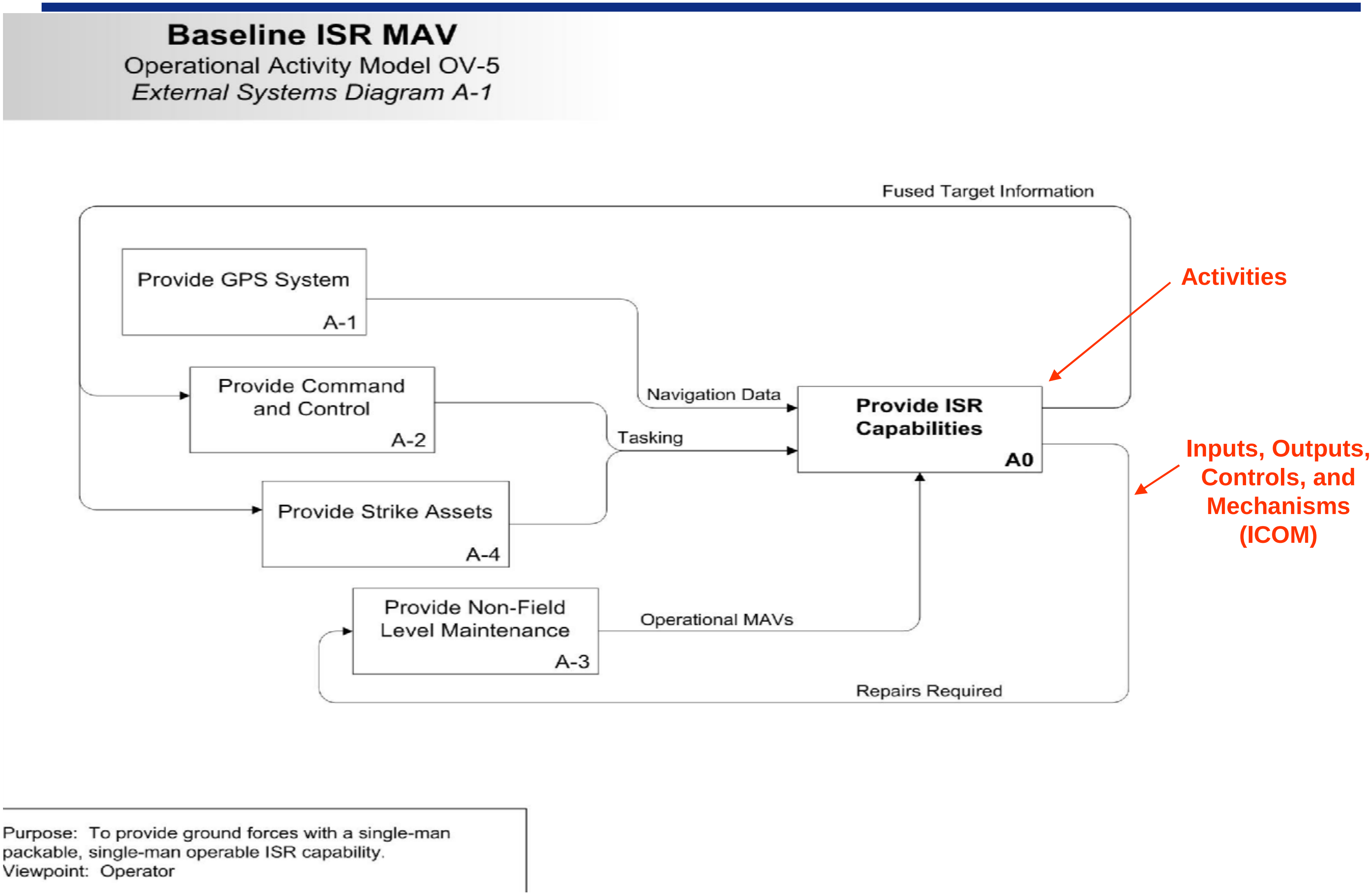
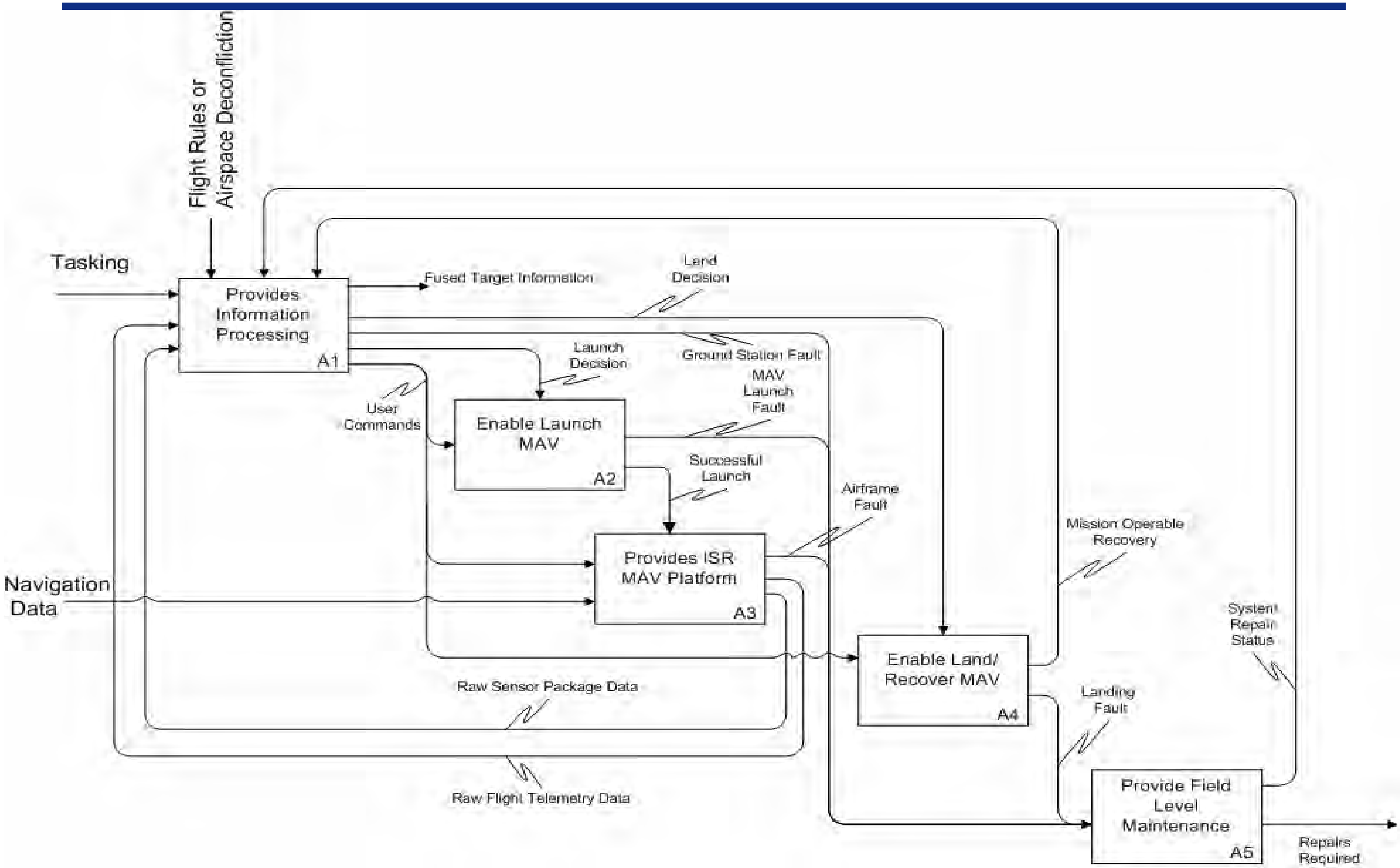
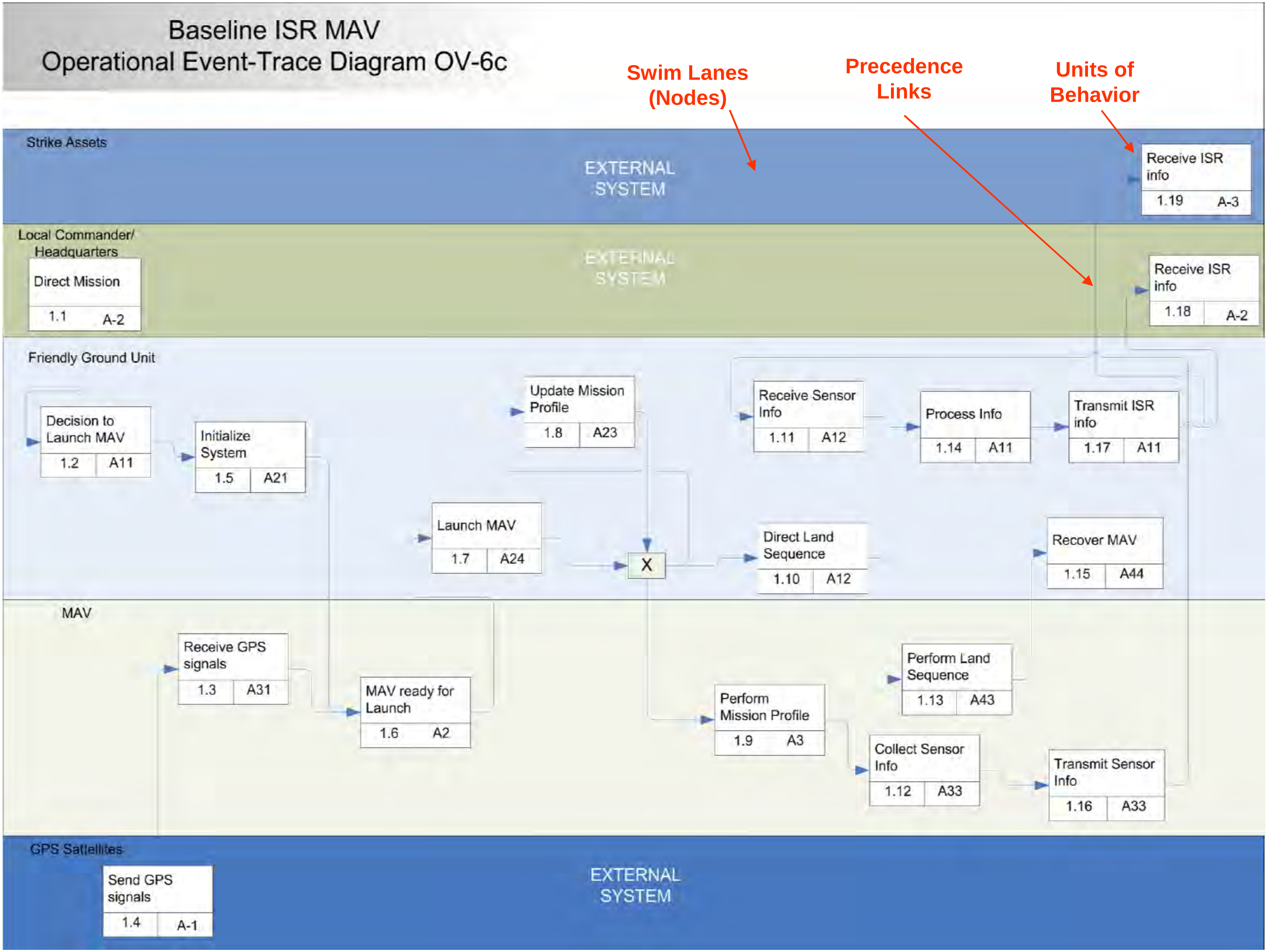


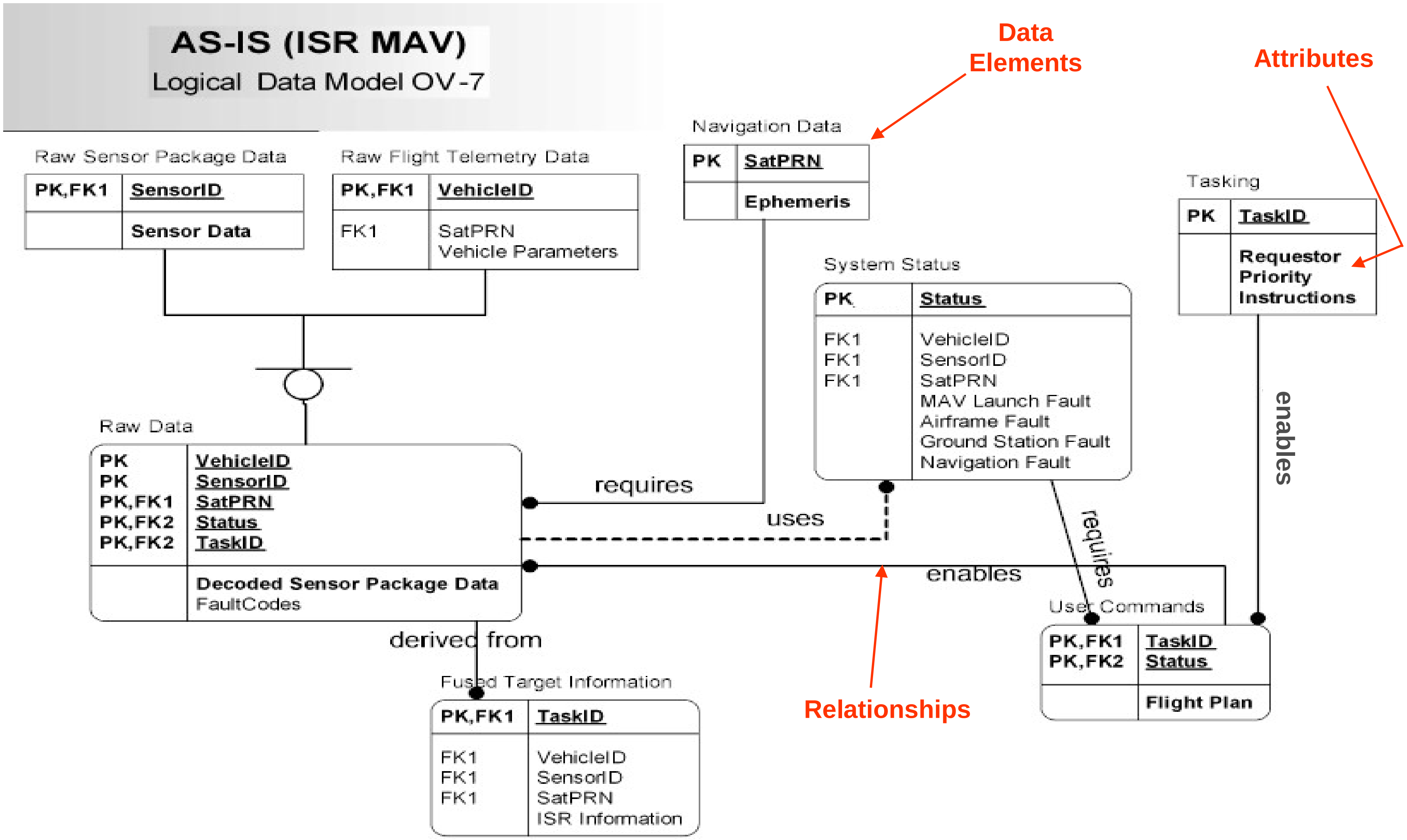
Results: OV Architectures





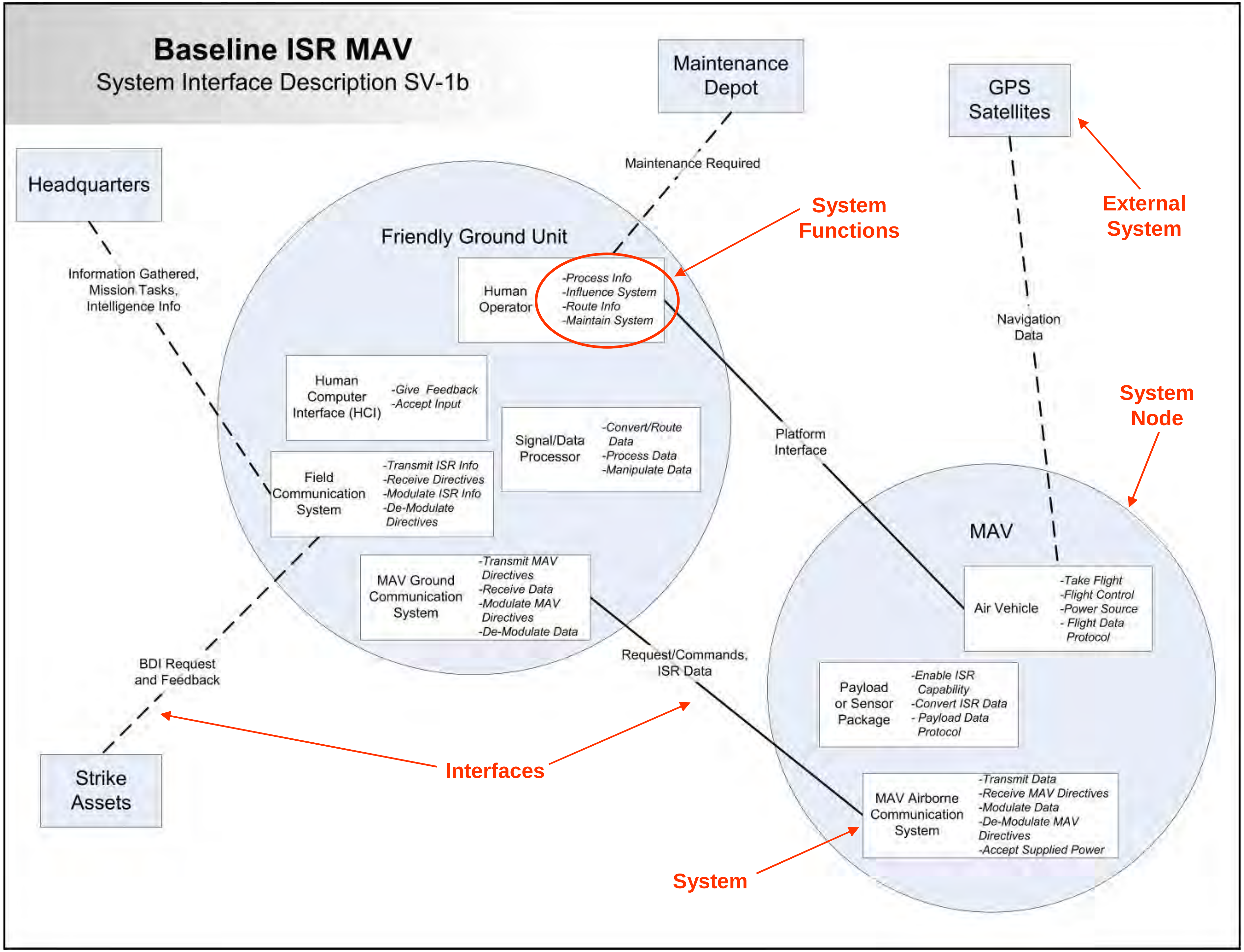
Baseline ISR MAV
Operational Event-Trace Diagram OV-6c
Swim Lanes (Nodes)
Precedence Links
Units of Behavior
Strike Assets
EXTERNAL SYSTEM
Receive ISR info
1.19
A-3
Local Commander/ Headquarters
EXTERNAL SYSTEM
Direct Mission
1.1
A-2
Receive ISR info
1.18
A-2
Friendly Ground Unit
Decision to Launch MAV
1.2
A11
Initialize System
1.5
A21
Update Mission Profile
1.8
A23
Receive Sensor Info
1.11
A12
Process Info
1.14
A11
Transmit ISR info
1.17
A11
Launch MAV
1.7
A24
X
Direct Land Sequence
1.10
A12
Recover MAV
1.15
A44
MAV
Receive GPS signals
1.3
A31
MAV ready for Launch
1.6
A2
Perform Mission Profile
1.9
A3
Perform Land Sequence
1.13
A43
Collect Sensor Info
1.12
A33
Transmit Sensor Info
1.16
A33
GPS Satellites
Send GPS signals
1.4
A-1
EXTERNAL SYSTEM

Results: OV Architectures



Results: SV Architectures

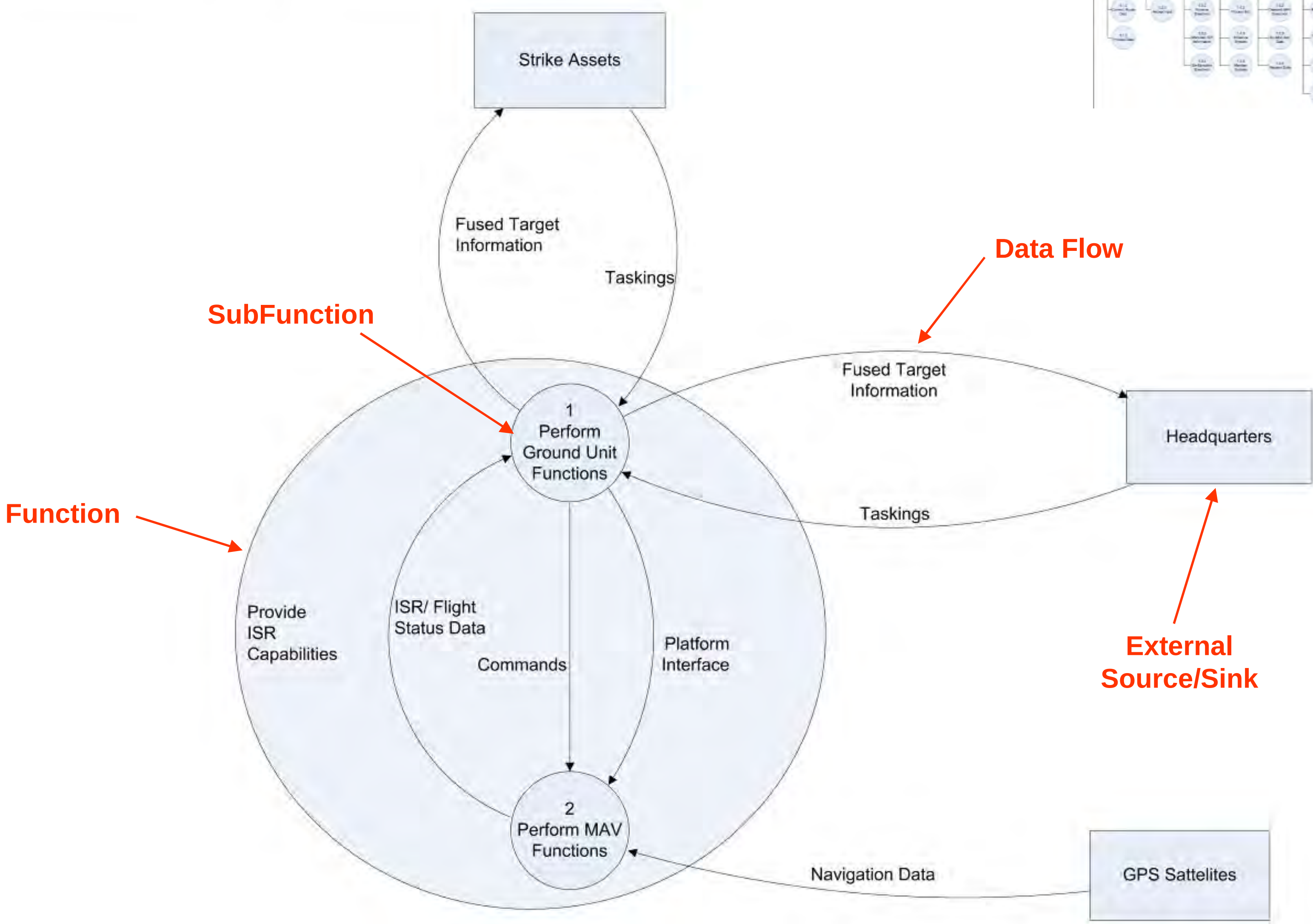
- Systems Views (SV's)
  - Relates Systems and Characteristics to Operational Needs
  - Provides Systems that support OV Activities and Information Exchanges
- SV Products Completed for ISR MAV
  - SV-1: Systems Interface Description
  - SV-4: Systems Functionality Description
  - SV-5: Function to Activity Traceability Matrix
  - SV-6: System Data Exchange Matrix



Baseline ISR MAV
System Interface Description SV-1b
Maintenance Depot
GPS Satellites
Headquarters
Maintenance Required
System Functions
External System
Friendly Ground Unit
Information Gathered, Mission Tasks, Intelligence Info
Human Operator
-Process Info
-Influence System
-Route Info
-Maintain System
Navigation Data
Human Computer Interface (HCI)
-Give Feedback
-Accept Input
System Node
Signal/Data Processor
-Convert/Route Data
-Process Data
-Manipulate Data
Platform Interface
Field Communication System
-Transmit ISR Info
-Receive Directives
-Modulate ISR Info
-De-Modulate Directives
MAV
MAV Ground Communication System
-Transmit MAV Directives
-Receive Data
-Modulate MAV Directives
-De-Modulate Data
Air Vehicle
-Take Flight
-Flight Control
-Power Source
- Flight Data Protocol
BDI Request and Feedback
Request/Commands, ISR Data
Payload or Sensor Package
-Enable ISR Capability
-Convert ISR Data
- Payload Data Protocol
Strike Assets
Interfaces
MAV Airborne Communication System
-Transmit Data
-Receive MAV Directives
-Modulate Data
-De-Modulate MAV Directives
-Accept Supplied Power
System

Baseline ISR MAV

System Functionality Description SV-4
0-Level Diagram



Results: SV Architectures

- **SV-5: Operational Activity to System Function Traceability Matrix**
  - Relationships rated based on support status codes

Operational Activities (OV)

Systems and System Functions (SV)

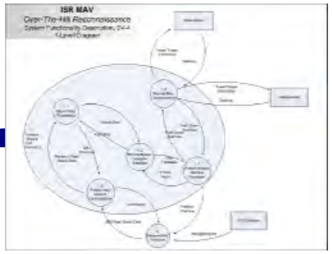
Relationships

System	System Function / Op Activity	Capability to perform Recon, BDI, and LAD													
		Information Processing		Launch MAV				ISR MAV Platform			Recover MAV				
		Process Information	Provides Vehicle Control and Communication	Initialize MAV	Calibrate MAV	Upload Mission Profile	Launch MAV	Provides Flight Controls	Provides Flight Vehicle	Enables Sensor Package	Calculate Flight Plan to Landing Zone	Fly to Landing Zone	Perform Landing Sequence	Recover MAV	Provide Field Level Maintenance
Human Operator	Process Info														
	Influence System														
	Route Info														
	Maintain System														
Field Communication System	Transmit ISR Information														
	Receive Directives														
	Modulate ISR Information														
	De-Modulate Directives														
Human Computer Interface	Give Feedback														
	Accept Input														
Signal/Data Processor	Convert/Route Data														
	Process Data														
	Manipulate Data														
MAV Ground Communication System	Transmit MAV Directives														
	Receive Data														
	Modulate MAV Directives														
	De-Modulate Data														

Results: SV Architectures

■ SV-6: System Data Exchange Matrix

- **Specifies characteristics of the system data exchanged between systems**
- **Focuses on automated information exchanges, however some non-automated exchanges were included**
- **Columns that were application specific are not filled in**



Interface Identifier	Data Exchange Identifier	Data Description							Producer		Consumer		Nature of Transaction			
System Interface Name and Identifier	System Data Exchange Name and Identifier	Data Element Name and Identifier	Content	Format Type	Media Type	Accuracy	Units of Measurement	Data Standard	Sending System Name and Identifier	Sending System Function Name and Identifier	Receiving System Name and Identifier	Receiving System Function Name and Identifier	Transaction Type	Triggering Event	Interoperability Level Achieved	Criticality

Interface Identifier	Data Exchange Identifier	Performance Attributes				Information Assurance							Security				
System Interface Name and Identifier	System Data Exchange Name and Identifier	Periodicity	Timeliness	Throughput	Size	Access Control	Availability	Confidentiality	Dissemination Control	Integrity	Non-Repudiation Producer	Non-Repudiation Consumer	Protection (Type Name, Duration, Date)	Classification	Classification Caveat	Releasability	Security Standard

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Results: Future Capabilities

Future Capability Timeline:

Short Term

Acquire Precise Target Coordinates
Biological and Chemical Sniffer Platform
Communication Eavesdropping
Mobile Ground Station When Deployed

Night Reconnaissance
Psychological Operations
Target Tracking or Following

Mid Term

Air-to-Air or Anti-MAV
Communication Relay
Distinguish Facial Features
GPS Jamming
IR Reconnaissance

Small Ordinance Delivery Platform
Suppression of Enemy Air Defenses
Target Painting or Designation
Locate Targets Through General Land Obstacles
Weather Intelligence Platform
Operation in Urban or GPS Denied Environments

Long Term

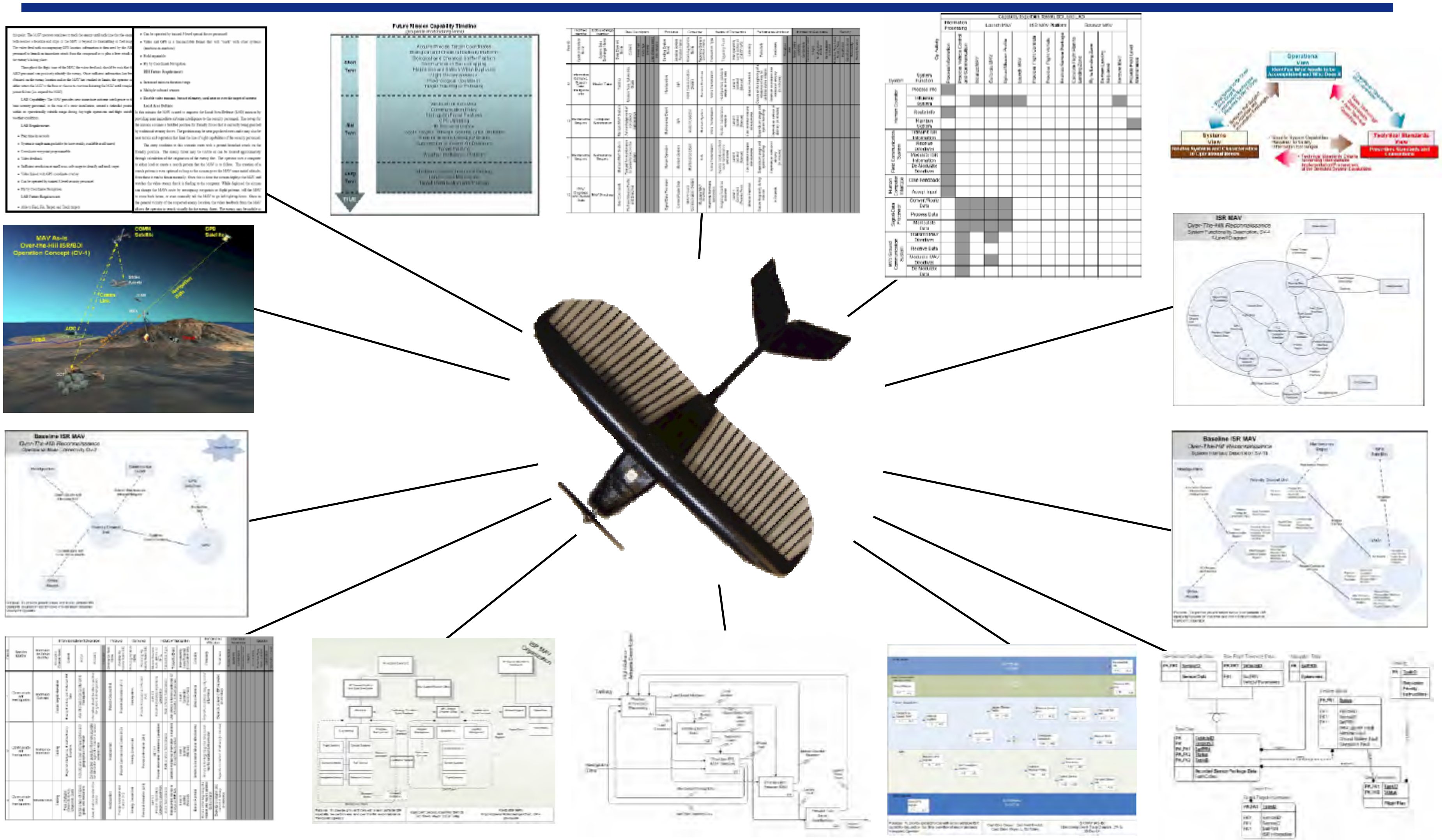
Electronic Signal Directional Finding
Land or Sea Mine Scout
Target Identification and Tracking
Localized Deployment with External Control

TIME

Conclusion: Remarks

- MAVs Represent a New Realm of Capability Enablers
- Architectures are Required in the DoD Acquisition Process
- ISR MAVs Now Have a Baseline Architecture
- Requirements Can Now Be Derived from the ISR MAV Architecture (Interfaces, Information Exchanged, Etc.)

Questions?



Acknowledgements

We would like to thank the following individuals for their help and guidance in this research:

Maj Joerg Walter

(Committee Chair)

Lt Col Eric Stephen

(Reader)

Dr. Dave Jacques

(Reader)

Lt Col John Colombi

(Architecture Guidance)

Background: User

United States Special Operations Command
USSOCOM

- Army Special Operations Command **USASOC**
- Air Force Special Operations Command **AFSOC**
- Navel Special Warfare Command **NSWC**
- Joint Special Operations Command **JSOC**
- Joint Special Operations University **JSOU**

Special Operations are those operations conducted in hostile, denied, or politically sensitive environments to achieve military, diplomatic, informational, and/or economic objectives.

Special Operations Forces (SOF) conduct fast, surgical operations at great distances from established bases by using state-of-the-art communications, aircraft, and specially trained forces.

Background: User

SOF Capability Deficiencies

Domain	*Capability Deficiencies*
Command, Control, and Communications	-Potential for enemy to monitor or destroy our information systems
Intelligence	-No real/near-time imagery from national systems -No real-time interface between aircraft, planners, and intel systems -No real-time imagery for target study -No all-source threat location data -Enhanced target identification and marking capability required
Resupply	-Need resupply of expendables (batteries, food, water, medical, ammo)

Extracted from Maj Stephen Howard's Special Operations Forces and Unmanned Aerial Vehicles

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Background: UAVs

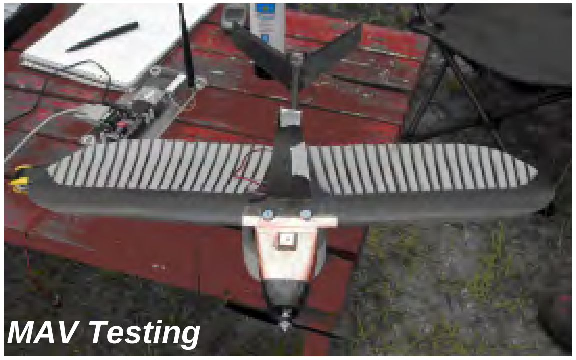
- **Unmanned Aerial Vehicles (UAVs)**
  - Consist of both Remotely Piloted Vehicles (RPVs) and Drones
  - Also encompass those vehicles that can operate using preprogrammed data and can also accept mission changes while in flight
  - Classifications:
    - **Tactical** and Endurance
    - Lethal and **Non-Lethal**
    - **Very Low Cost Close Range**, **Close Range**, Short Range, and Medium Range
    - **Expendable** and Recoverable

RQ-1 Predator

RQ-2A Pioneer

Background: MAVs

- **Mini and Micro Unmanned Aerial Vehicles (MAVs)**
  - + Subset of UAVs characterized by their size
  - + Provides new capabilities to small field units
  - + Not as Expensive as larger UAVs
  - + Changeable Payloads
  - + Small Footprint
  - - Limited Payload Weight
  - - Limited Mission Efficiency (range)
  - - Aerodynamics and Stabilization



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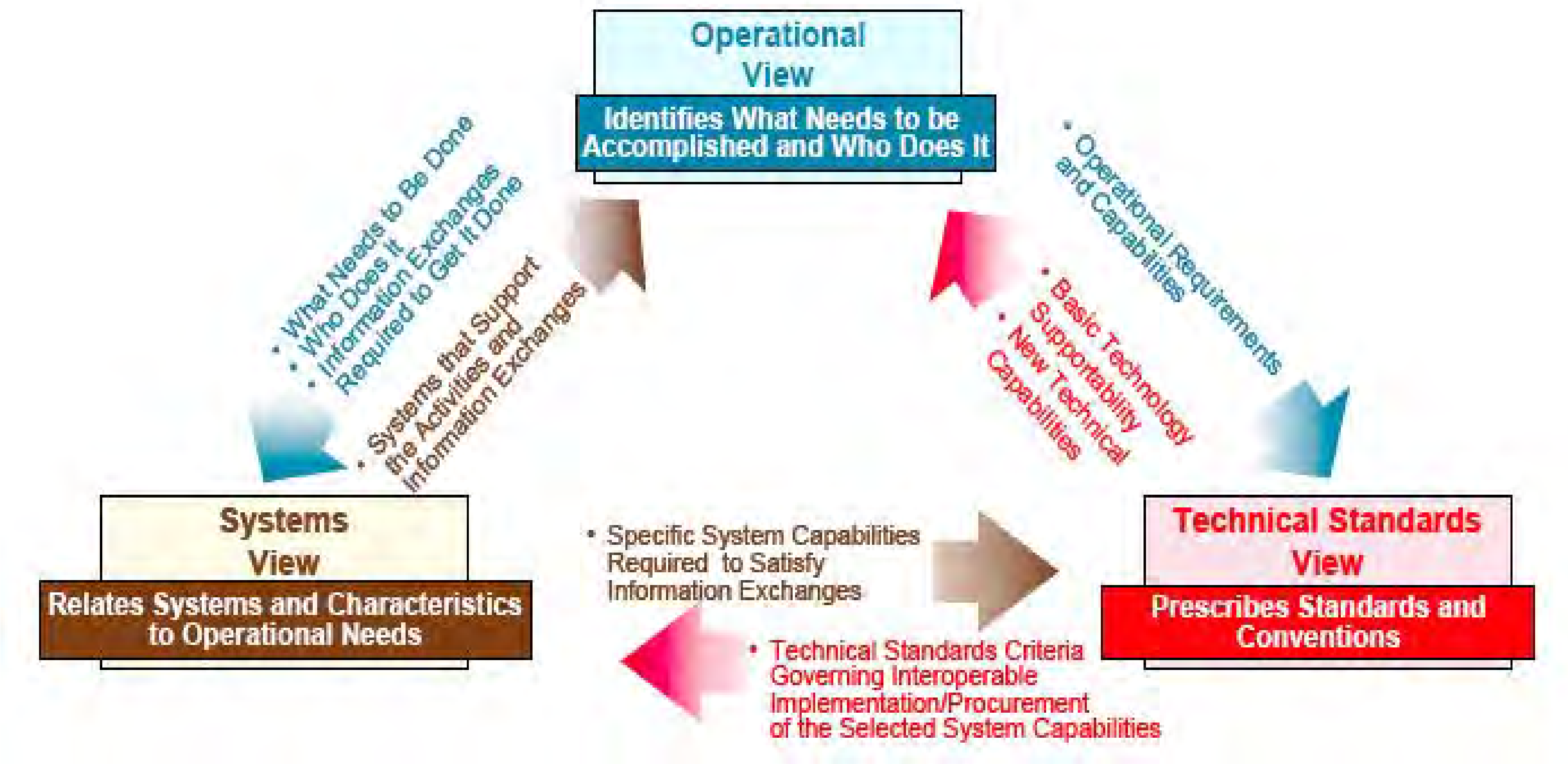
Background: Systems Engineering

- **Systems Engineering and Policy**
  - **Clinger-Cohen Act of 1996 required the DoD to use Architectures for National Security Systems**
  - **OMB Circulars A-130 and A-11 directed all federal organizations have architecture frameworks**
  - **CJCSM 3170.01 "Operation of the Joint Capabilities Integration and Development System (JCIDS)" require the use of Integrated architectures for Acquisition Milestones**

Methodology: Integrated Architectures



Methodology: Products

OPERATIONAL (OV)	SYSTEMS (SV)	TECHNICAL (TV)
1: High-Level Operational Concept Graphic*	1: System Interface Description*	1: Technical Architecture Profile*
2: Operational Node Connectivity Description*	2: Systems Communications Desc.	2: Standards Technology Forecast
3: Operational Information Exchange Matrix*	3: Systems Matrix	
4: Command Relationships Chart	4: Systems Functionality Description	
5: Activity Model*	5: Operational Activity to System Function Traceability Matrix	
6a: Operational Rules Model	6: Sys Information Exchange Matrix	
6b: Operational State Transition Description	7: Sys Performance Parameters Matrix	
6c: Operational Event/Trace Description	8: System Evolution Description	
7: Logical Data Model	9: System Technology Forecast	
	10a: Systems Rules Model	
	10b: System State Transition Description	
	10c: Systems Event/Trace Description	
	11: Physical Data Model	

ALL (AV)

- Overview & Summary*
- Integrated Dictionary*

* Denotes critical products

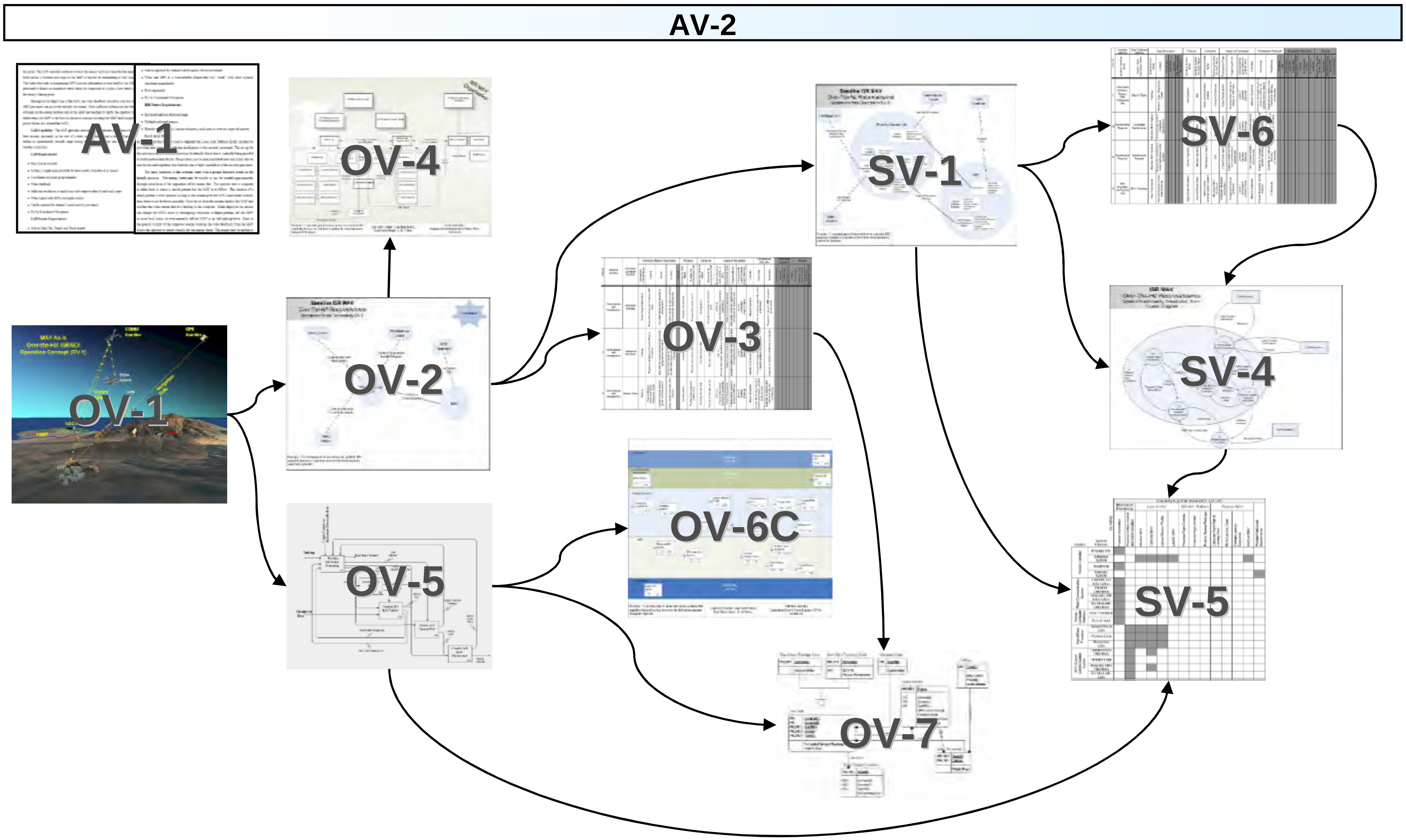
CADM: Core Architecture Data Model

Spreadsheets | Static Models & Graphics | Text | Dynamic Models

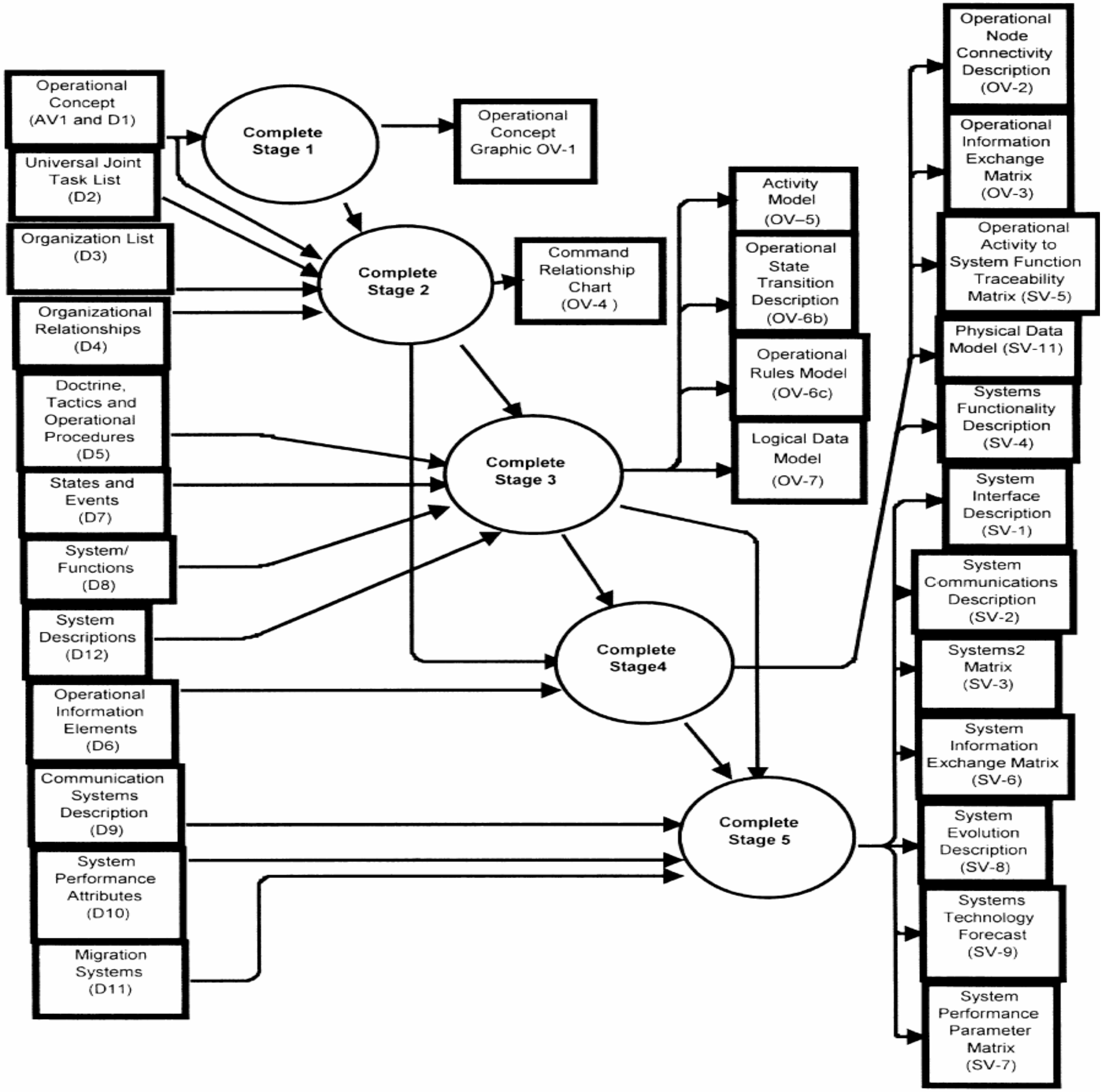
I n t e l l

ref. AFIT SENG 640 Lesson 1-2 Slides

Methodology: Process

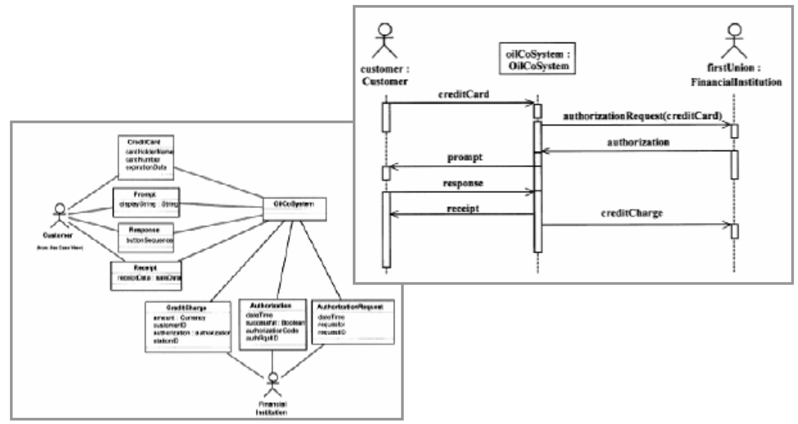


Dr. Levis' Architecture Product Process

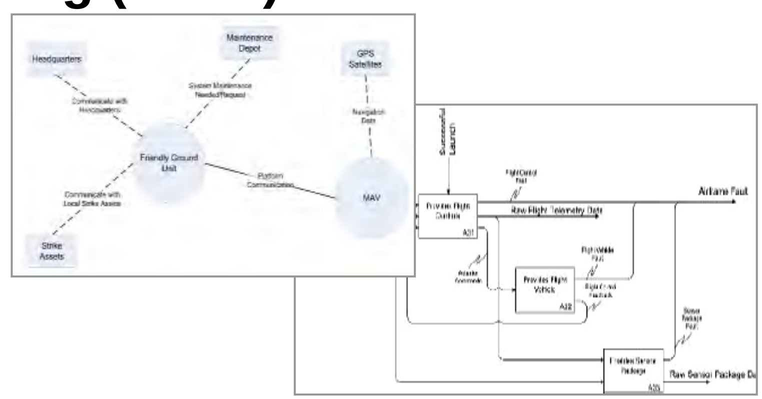


Methodology: Languages

- Unified Modeling Language (UML)
  - Object-Oriented (OO) approach
  - Based on data elements and their handling
  - Works well for software-based systems



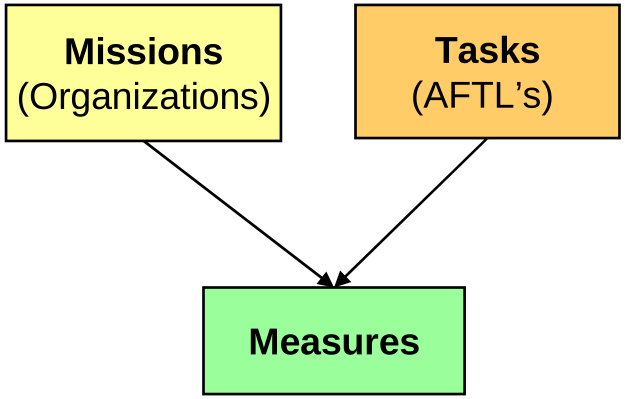
- Integrated Computer Aided Manufacturing (ICAM) Definition (IDEF)
  - Structured Analysis (SA) approach
  - Based on functions and activities
  - Works well for physical systems



- This research uses IDEF languages through the SA approach.

Methodology: Traceability

- **Traceability**
  - “The ability to describe and follow the life of a requirement, in both a forward and backward direction, i.e. from its origins, through its development and specification, to its subsequent deployment and use, and through periods of ongoing refinement and iteration in any of these phases.” [Gotel]
  - All encompassing effort during architecture development
  - Requirement derivation from top-level national organizations and tasks



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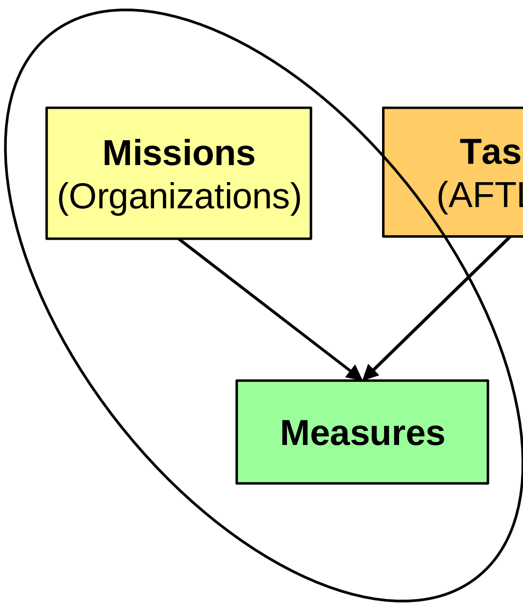
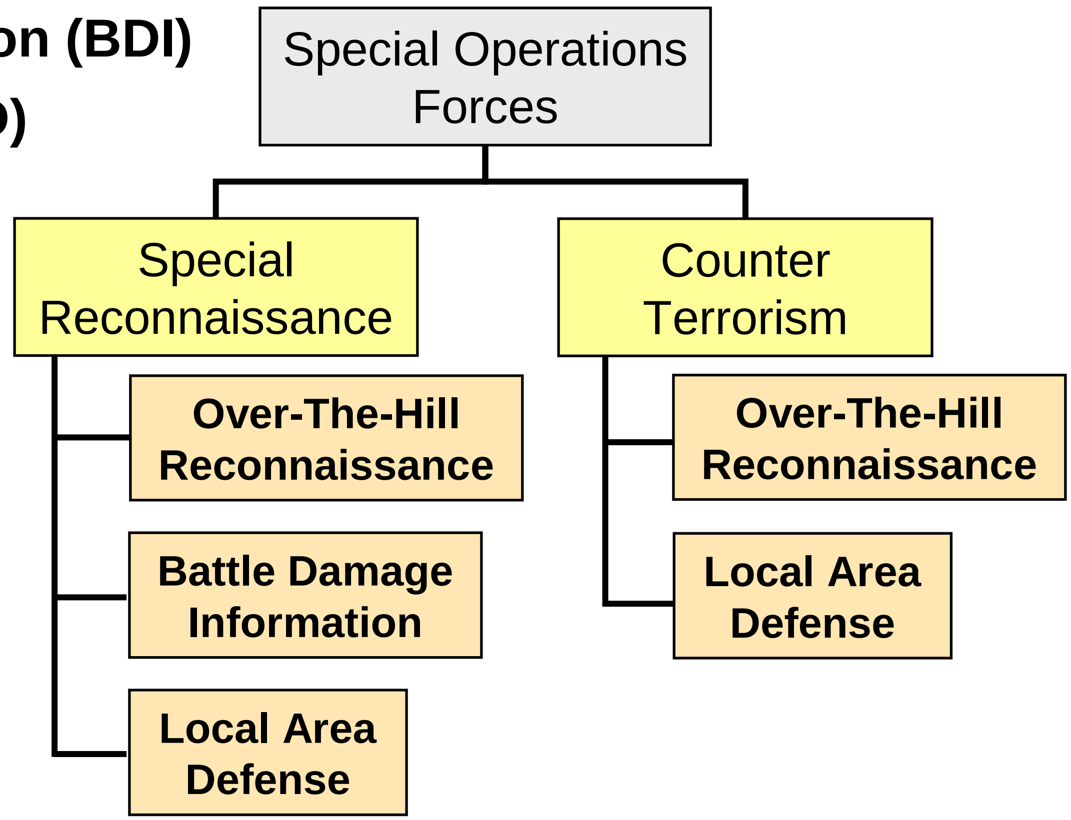
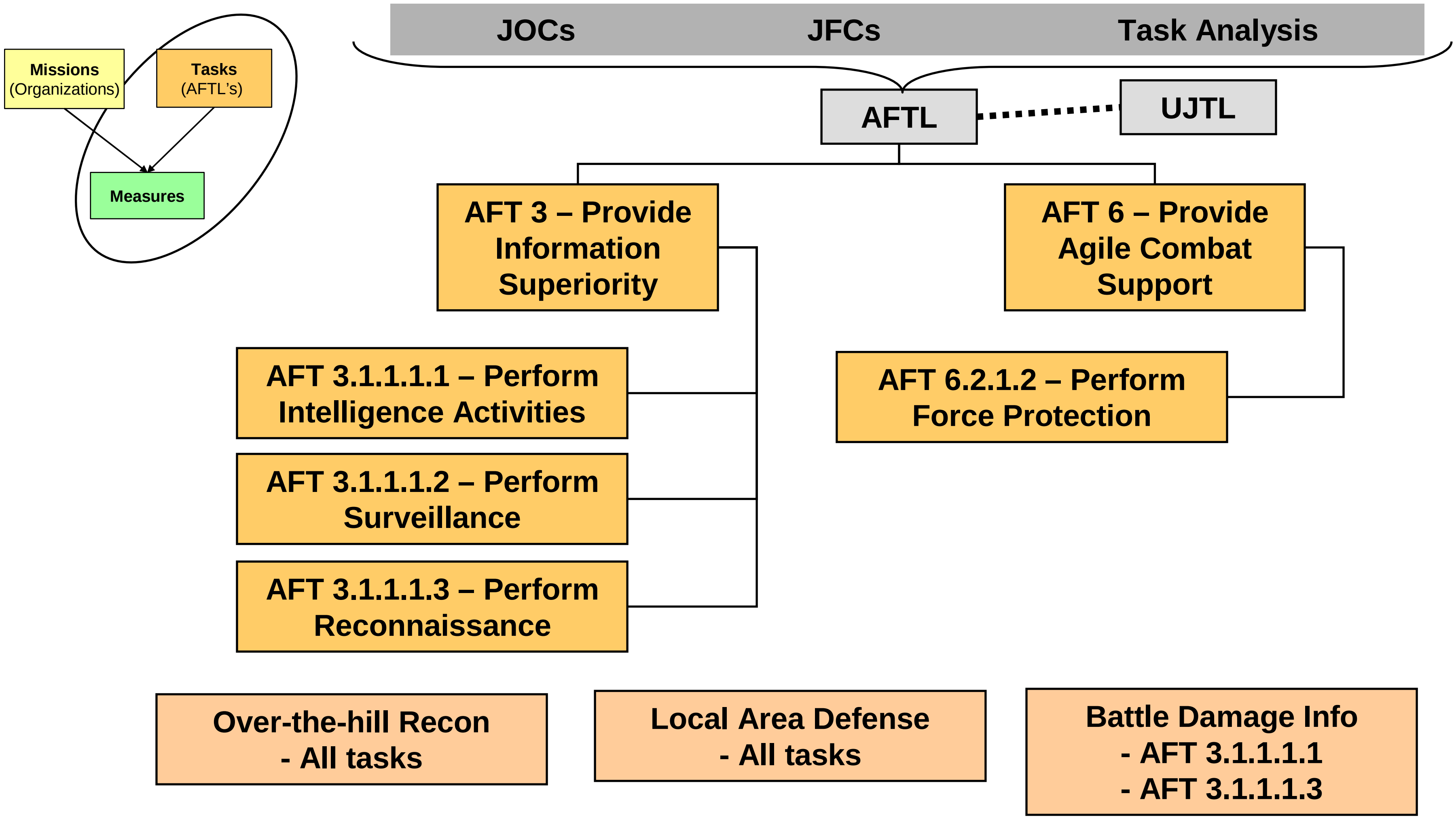
Results: Mission Traceability

- **Missions**
  - **- Over-The-Hill Reconnaissance**
  - **- Battle Damage Information (BDI)**
  - **- Local Area Defense (LAD)**

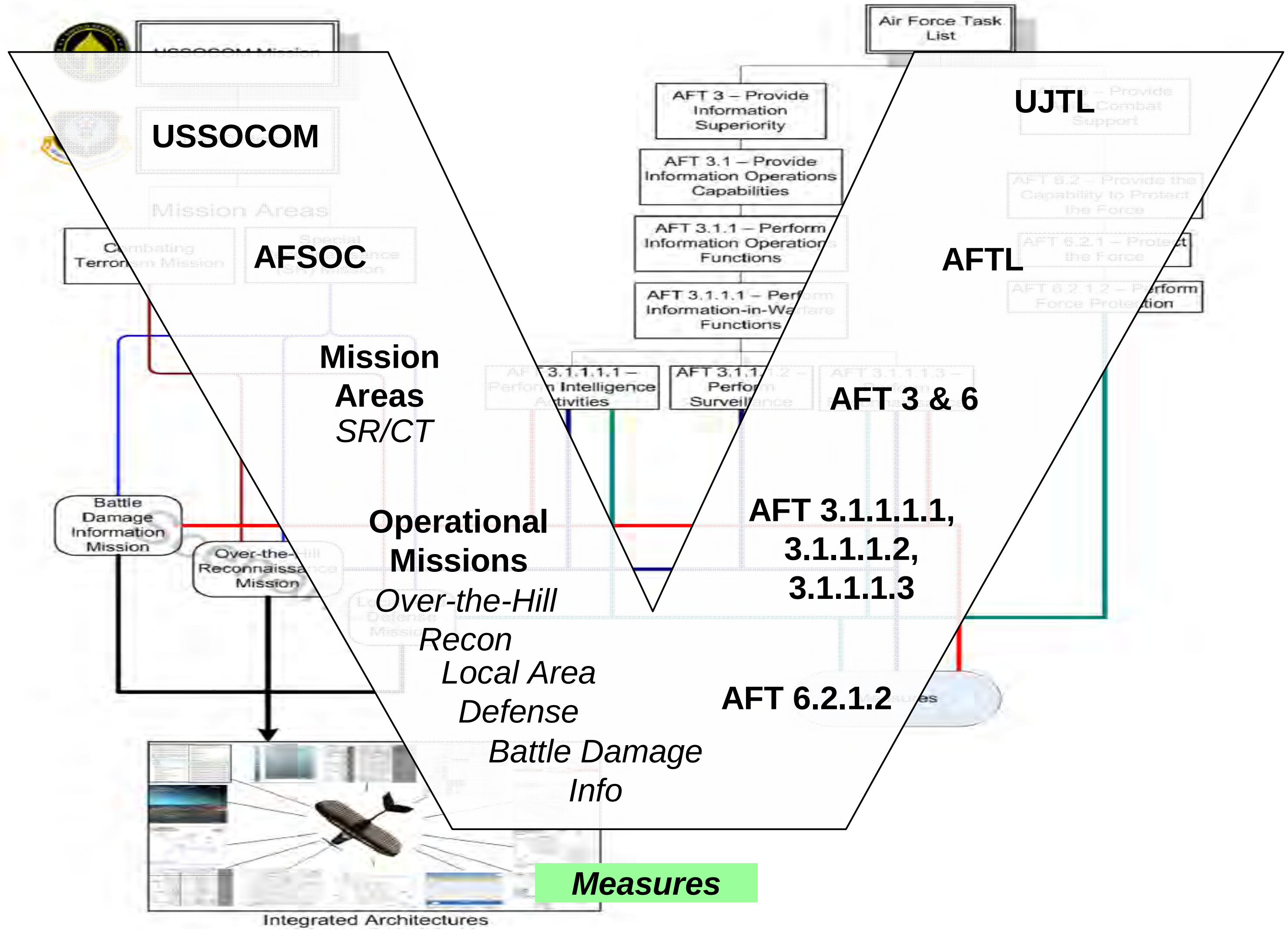




Results: Task Traceability



Results: Combined Traceability



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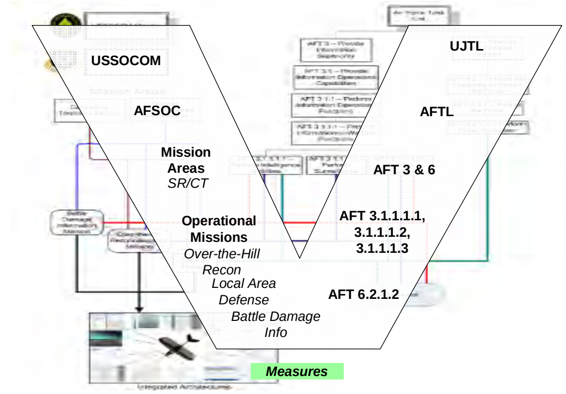
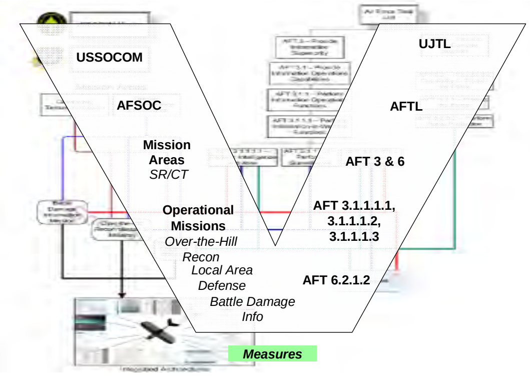
Results: Measures

Task	*Criterion*	*Measure*
AFT 3.1.1.1.1 Perform Intelligence Activities	Time	To conduct adequate, timely, and reliable intelligence activities for the USAF and other agencies.
	Percent	Of accuracy to which adversary COGs are identified to accomplish predetermined objectives.
	Cost	To Perform tactical intelligence activities.
AFT 3.1.1.1.2 Perform Surveillance	Time	To systematically observe air, or surface areas, places, persons, or things by visual, aural, electronic, photographic, or other means.
	Percent	Of accruacy to which air or surface areas, places, persons, or things can be observed by visual, aural, electronic, photographic, or other means.
	Cost	To perform surveillance.
AFT 3.1.1.1.3 Perform Reconnaissance	Time	To obtain, by visual observation or other detection methods, specific information about the activities and resources of an adversary or potential adversary.
	Percent	Of accuracy to which specific information about the activities and resources of an adversary or potential adversary is obtained.
	Cost	To perform reconnaissance.



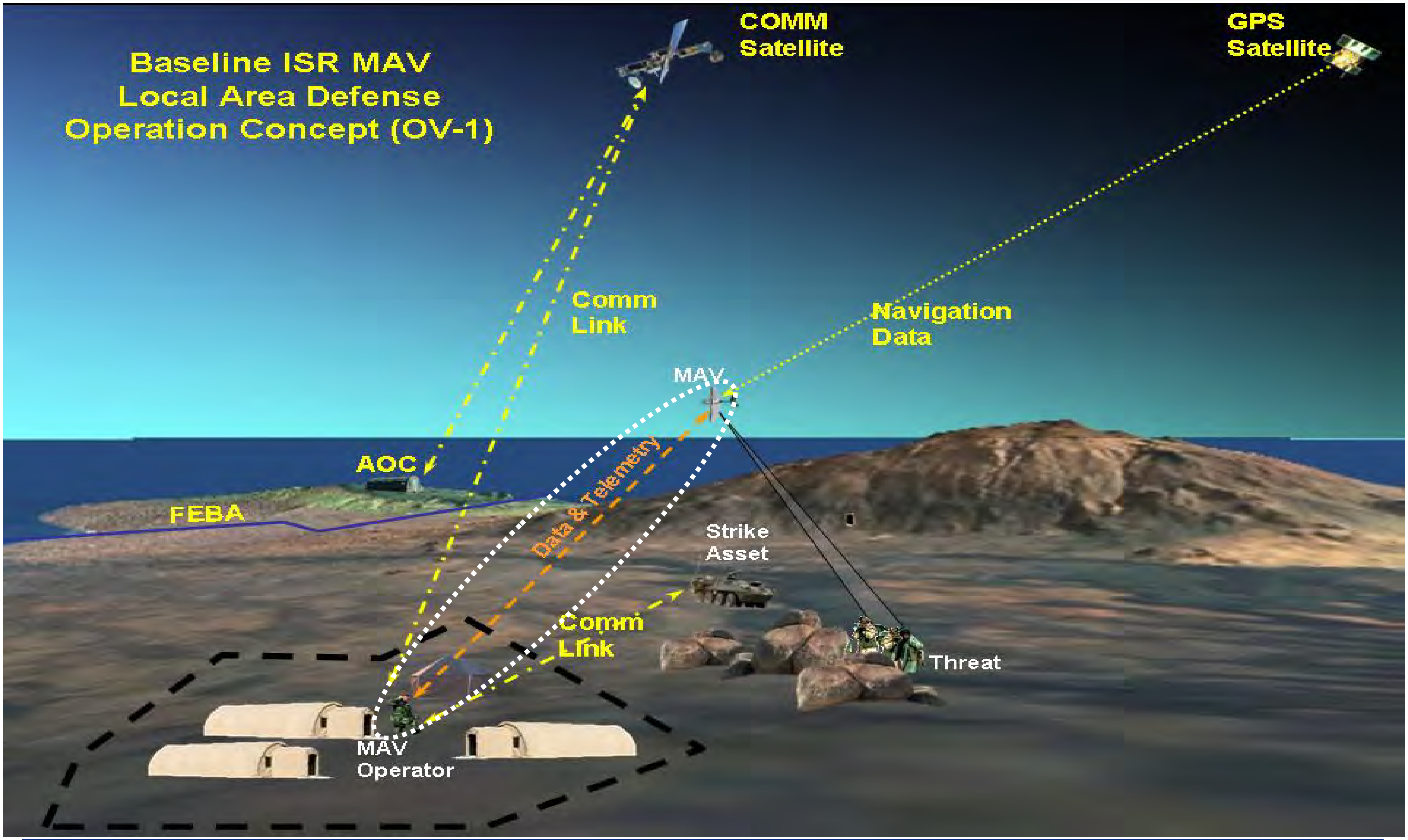
Results: Measures



Measures from Mission Scenarios and Architecture

- Percent of current field pack configuration
- Time to prepare the system for deployment
- Percent of coordinates properly programmed into the system
- Percent of video received by the user
- Percent of accuracy of visual interpretation
- Percent of accuracy of coordinates through user observation
- Percent of trained personnel fully capable of operating the system
- Percent of Nighttime Mission Effectiveness
- Degree to determine adequately repair needs and properly make the repairs
- Percent of loiter time that the intended coordinate is being observed
- Degree to which the system is capable of switching to/from automated/manual flight
- Time that the system can stay aloft
- Percent of locations that the system reaches

Results: OV Architectures



Results: OV Architectures

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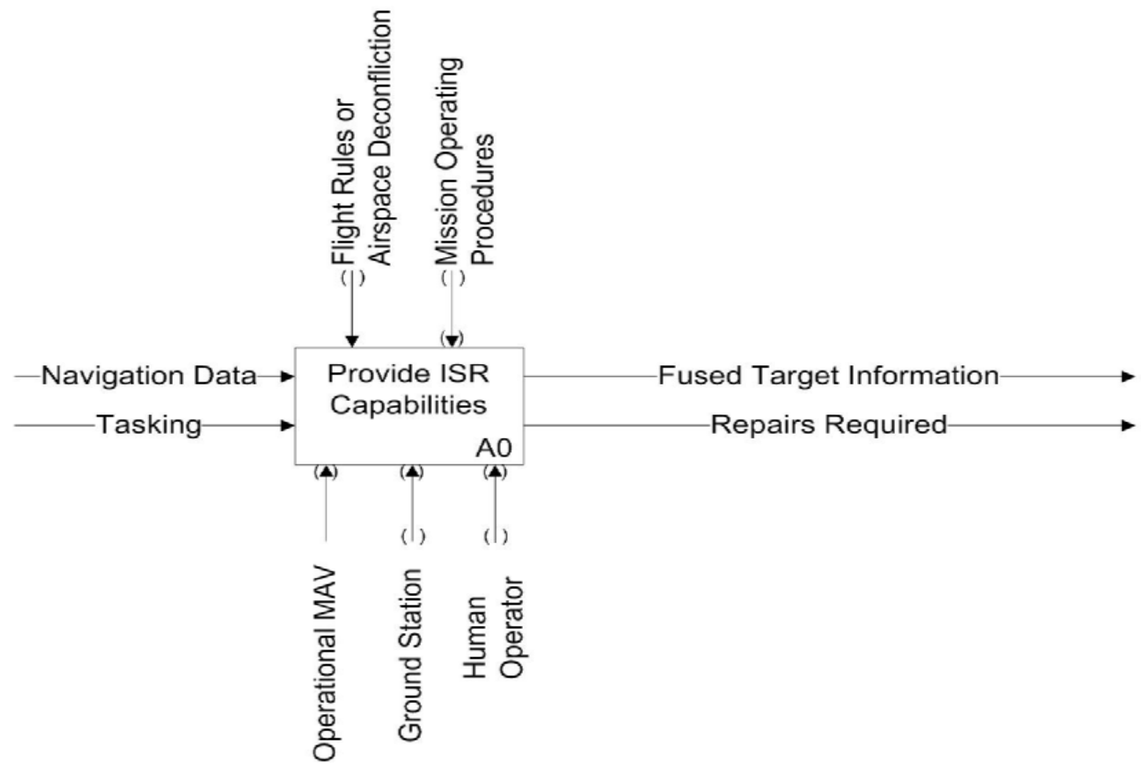
Row ID	Needline Identifier	Information Exchange Identifier	Information Element Description					Producer		Consumer		Nature of Transaction					Performance Attributes		Information Assurance					Security			
			Information Element Name	Content	Scope	Accuracy	Language	Sending Op Node Name	Sending Op Activity Name & ID	Receiving Op Node Name	Receiving Op Activity Name & ID	Mission/Scenario UJTL, METL, or AFTL	Transaction Type	Triggering Event	Interoperability Level Required (from C4ISR WG)	Criticality	Periodicity	Timeliness	Access Control	Availability	Confidentiality	Dissemination Control	Integrity	Accountability	Protection (Type, Name, Duration)	Classification	Classification Caveat
1	Communicate with Headquarters	Information Gathered	Fused Target Information	Enemy Positions and Collected ISR Data	Any information being returned to Headquarters	Information should be able to get from the system to Headquarters		Friendly Ground Unit	Process Information (A11)	Headquarters	Provide Command and Control (A-2)	AFT 3.1 Provide Information Operations Capabilities	Data or Voice Transmission	User wishes to forward gathered ISR information to Headquarters	Level 1 Connected (Peer-to-Peer)	Mission Essential	Depends on mission, may only occur a few times	Depends on level of ISR requested (in minutes)									
2	Communicate with Headquarters	Intelligence Information	Tasking	Regional Intelligence, Possible Enemy Locations	Includes any known enemy positions and geographical information	Can be a best guess but the more accurate the Intel is the higher the chance of mission completeness		Headquarters	Provide Command and Control (A-2)	Friendly Ground Unit	Process Information (A11)	AFT 3.1 Provide Information Operations Capabilities	Data or Voice Transmission	Updated intelligence information is available through Headquarters	Level 0 Isolated (Manual)	Needed to increase Mission effectiveness	Occurs at the beginning of a mission and may be updated during mission	Depends on method of delivery (in minutes)									
3	Communicate with Headquarters	Mission Tasks	Tasking	Type of Mission (Recon/BDI/LAD), Waypoints, Goals	Contains type of mission, goals, and instructions	Users should understand the mission		Headquarters	Provide Command and Control (A-2)	Friendly Ground Unit	Process Information (A11)	AFT 3.1 Provide Information Operations Capabilities	Voice Transmission	Headquarters wishes to assign an ISR task	Level 0 Isolated (Manual)	Mission Essential	Occurs at the beginning of a mission and may be updated during mission	Depends on mission and method of delivery (in minutes)									

Results: OV Architectures

Baseline ISR MAV

Operational Activity Model OV-5

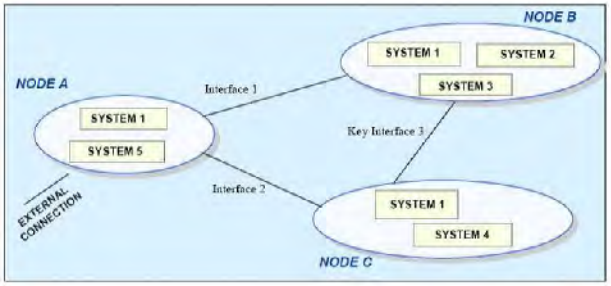
Context Diagram A-0



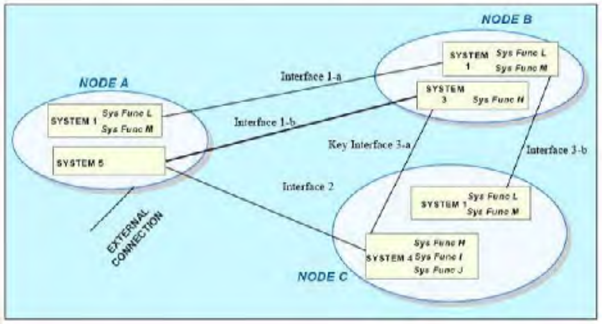
Purpose: To provide ground forces with a single-man packable, single-man operable ISR capability.
Viewpoint: Operator

Results: SV Architectures

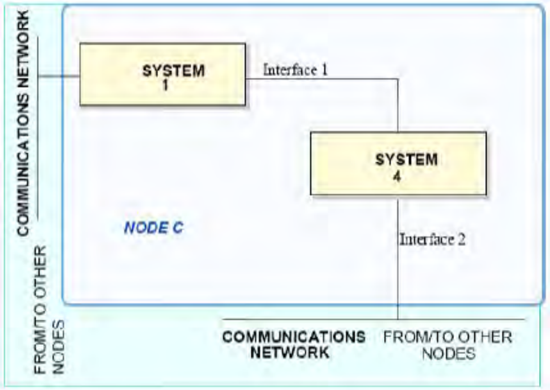
- **SV-1: System Interface Description**



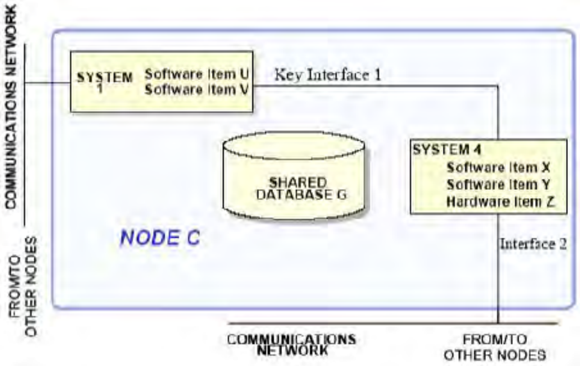
SV-1a: Internodal showing node-to-node interfaces



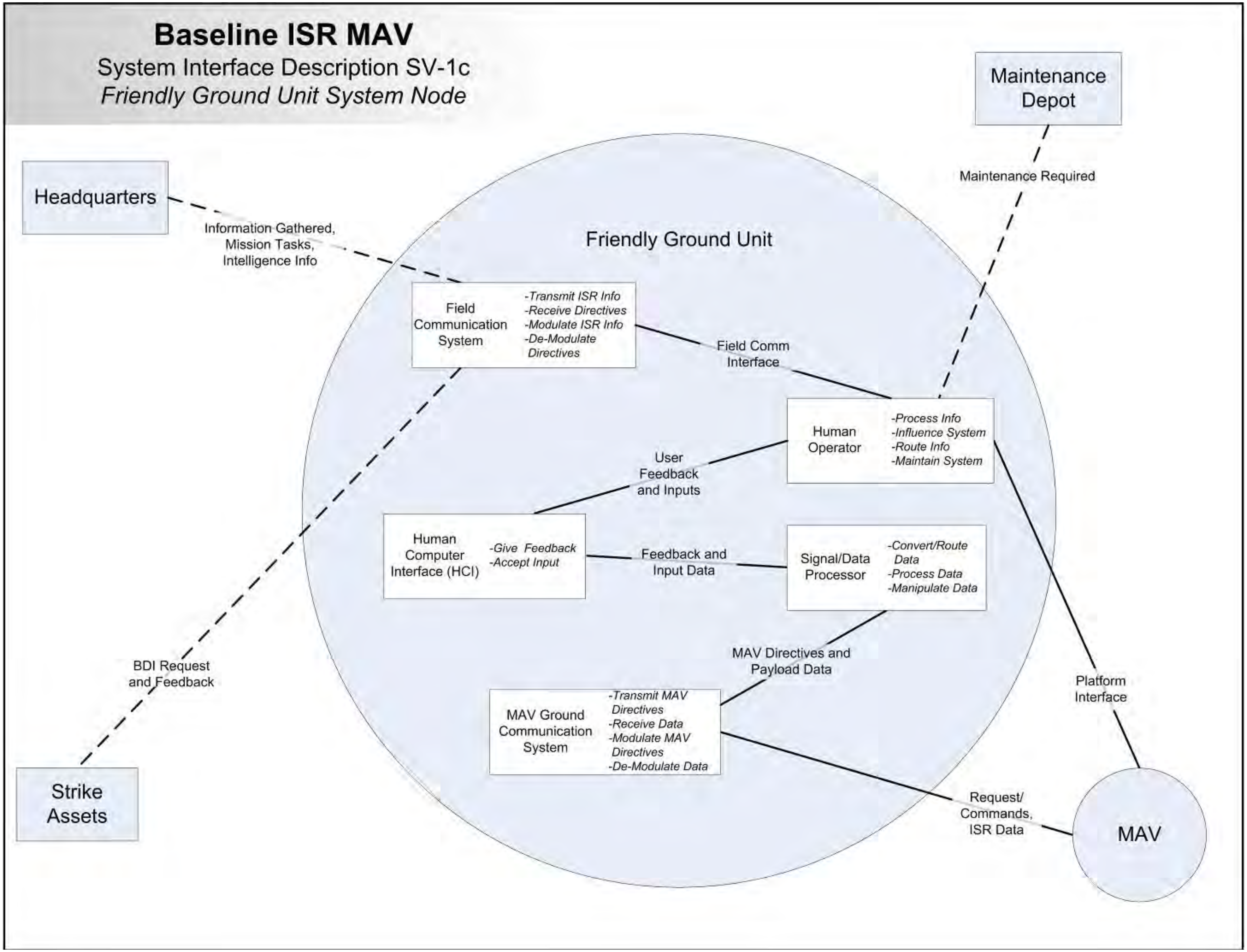
SV-1b: Internodal showing system-to-system interfaces

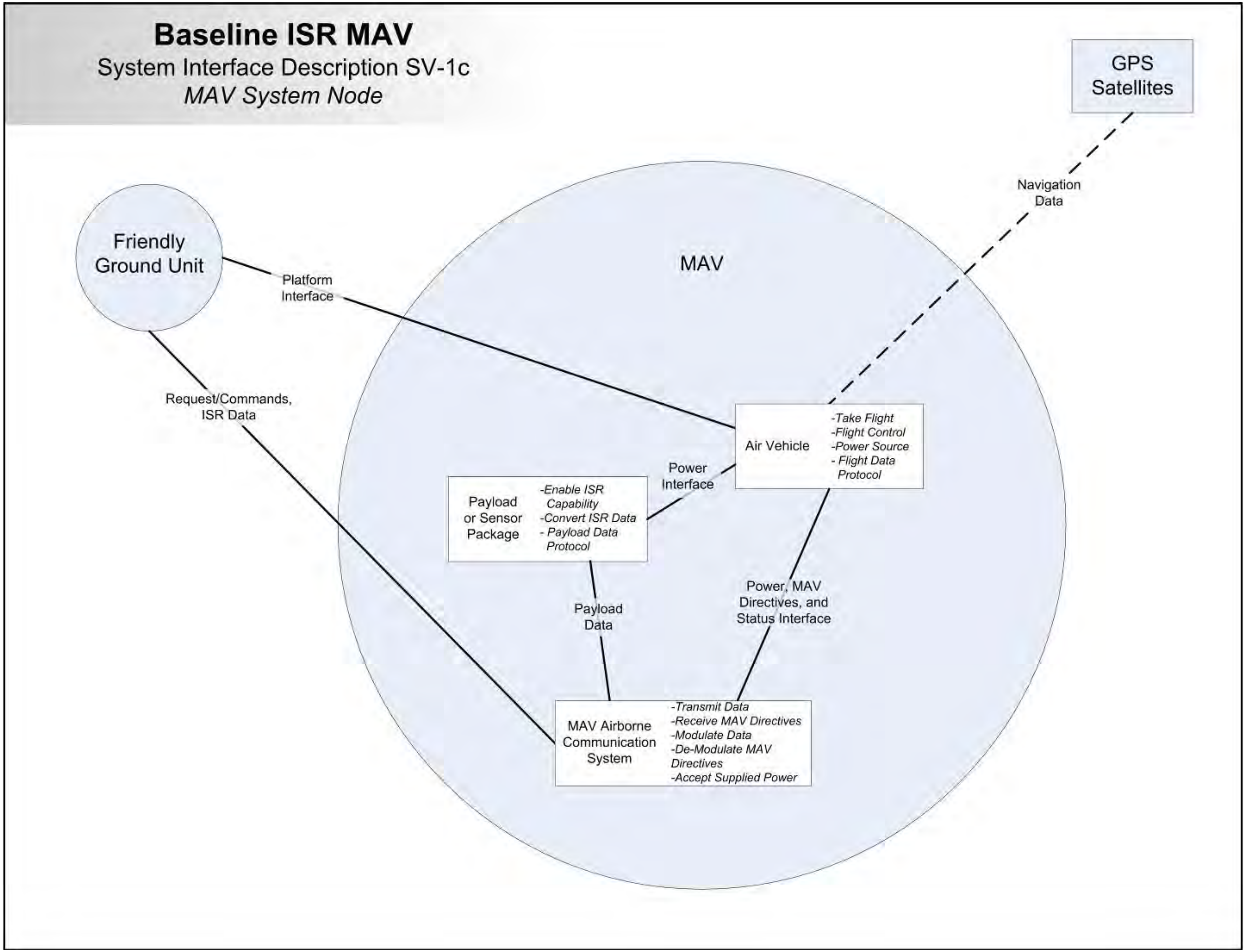


SV-1c: Intranodal showing interfaces within each node



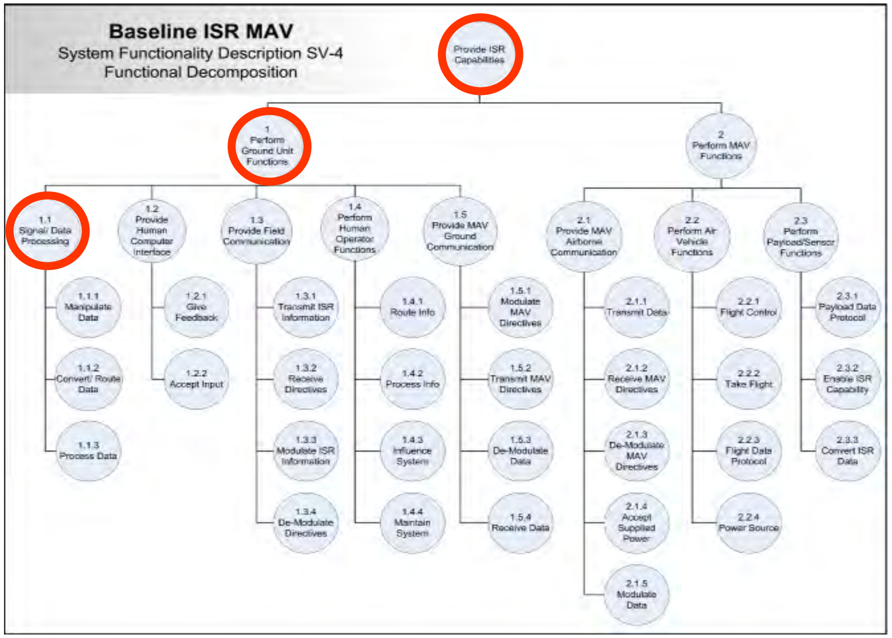
SV-1d: Intrasystem showing hard/software items

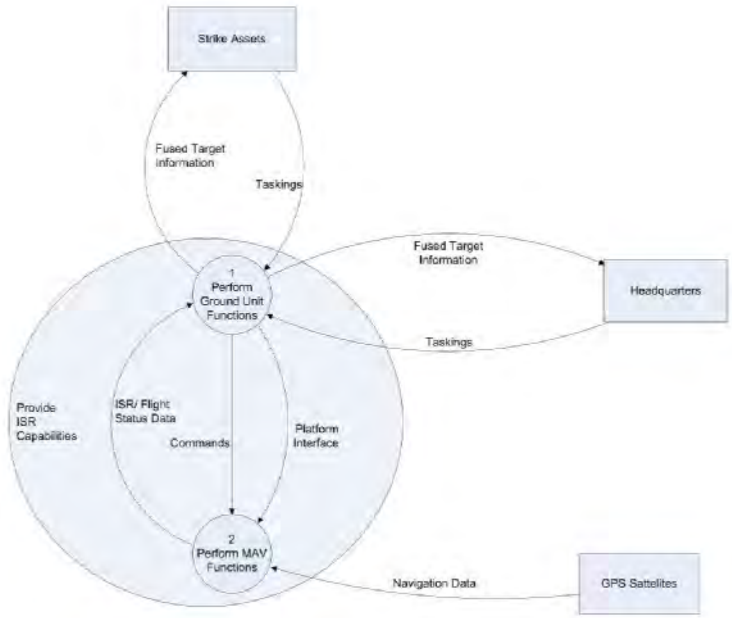

Baseline ISR MAV
System Interface Description SV-1c
Friendly Ground Unit System Node
Maintenance Depot
Maintenance Required
Headquarters
Information Gathered, Mission Tasks, Intelligence Info
Friendly Ground Unit
Field Communication System
-Transmit ISR Info
-Receive Directives
-Modulate ISR Info
-De-Modulate Directives
Field Comm Interface
Human Operator
-Process Info
-Influence System
-Route Info
-Maintain System
User Feedback and Inputs
Human Computer Interface (HCI)
-Give Feedback
-Accept Input
Feedback and Input Data
Signal/Data Processor
-Convert/Route Data
-Process Data
-Manipulate Data
MAV Directives and Payload Data
BDI Request and Feedback
Platform Interface
MAV Ground Communication System
-Transmit MAV Directives
-Receive Data
-Modulate MAV Directives
-De-Modulate Data
Request/ Commands, ISR Data
Strike Assets
MAV

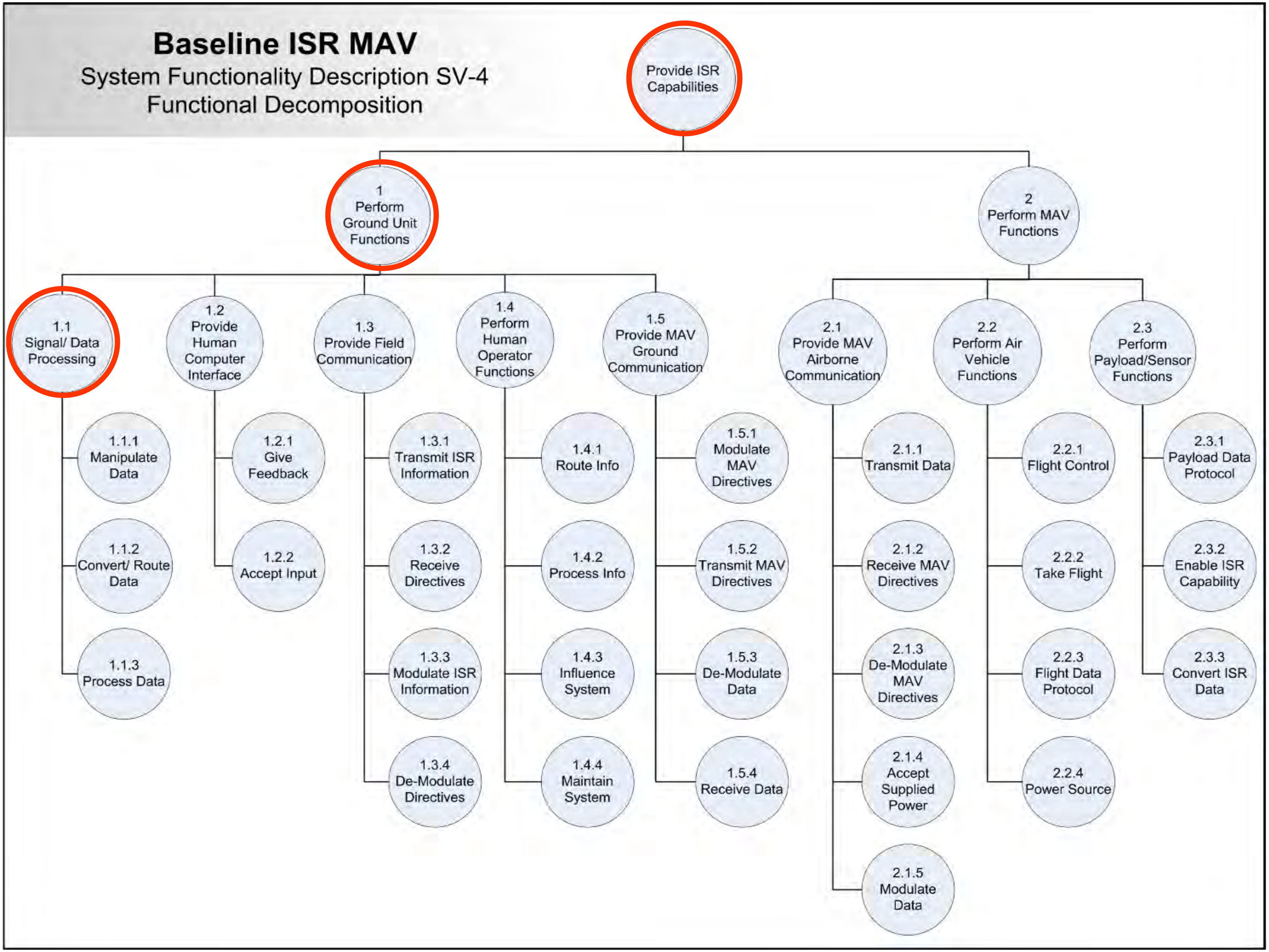

Baseline ISR MAV
System Interface Description SV-1c
MAV System Node
GPS Satellites
Navigation Data
Friendly Ground Unit
Platform Interface
MAV
Request/Commands, ISR Data
Air Vehicle
-Take Flight
-Flight Control
-Power Source
- Flight Data Protocol
Power Interface
Payload or Sensor Package
-Enable ISR Capability
-Convert ISR Data
- Payload Data Protocol
Payload Data
Power, MAV Directives, and Status Interface
MAV Airborne Communication System
-Transmit Data
-Receive MAV Directives
-Modulate Data
-De-Modulate MAV Directives
-Accept Supplied Power

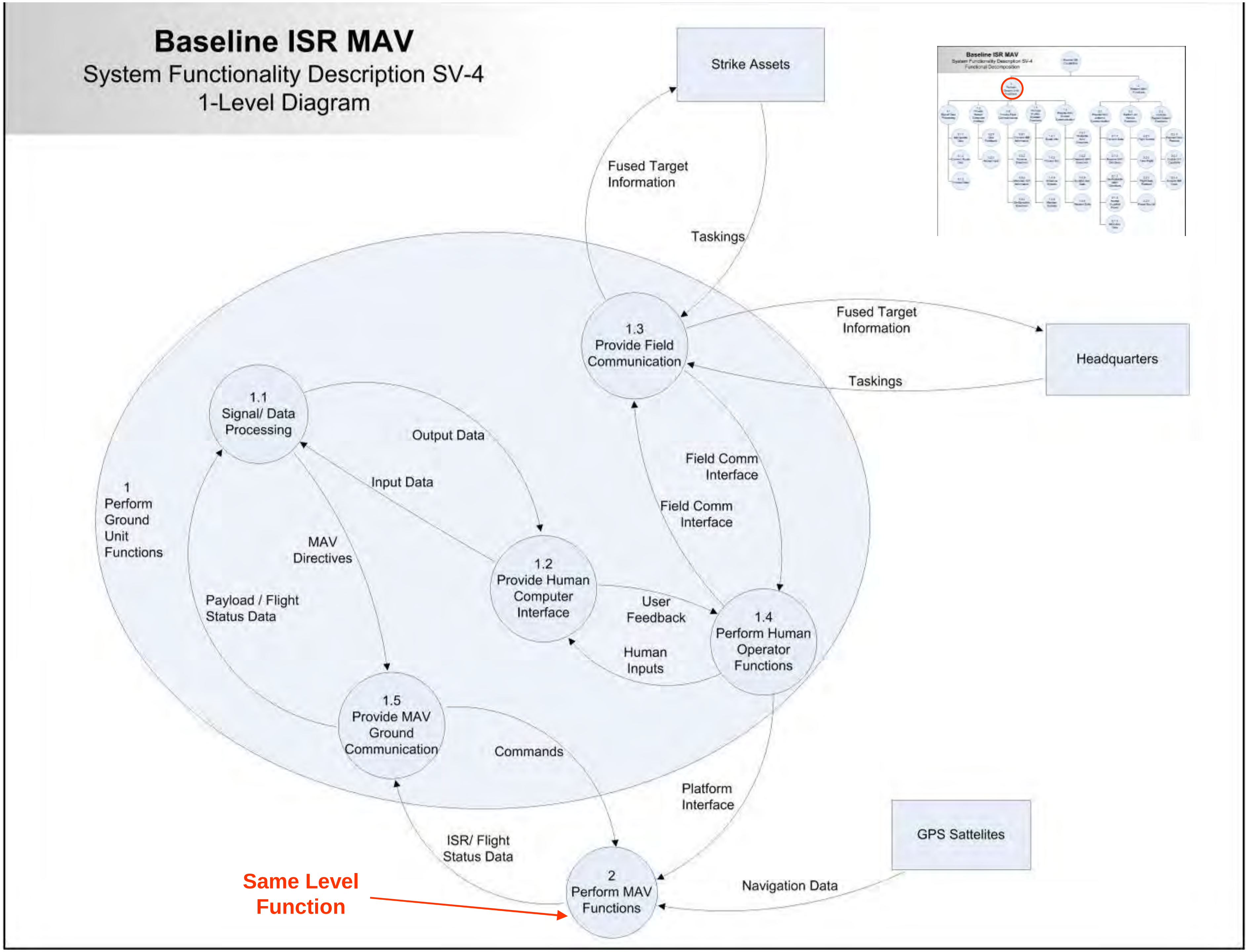
Results: SV Architectures

- SV-4: Systems Functionality Description
  - Documents system functional hierarchies and system functions, and the data flows between them





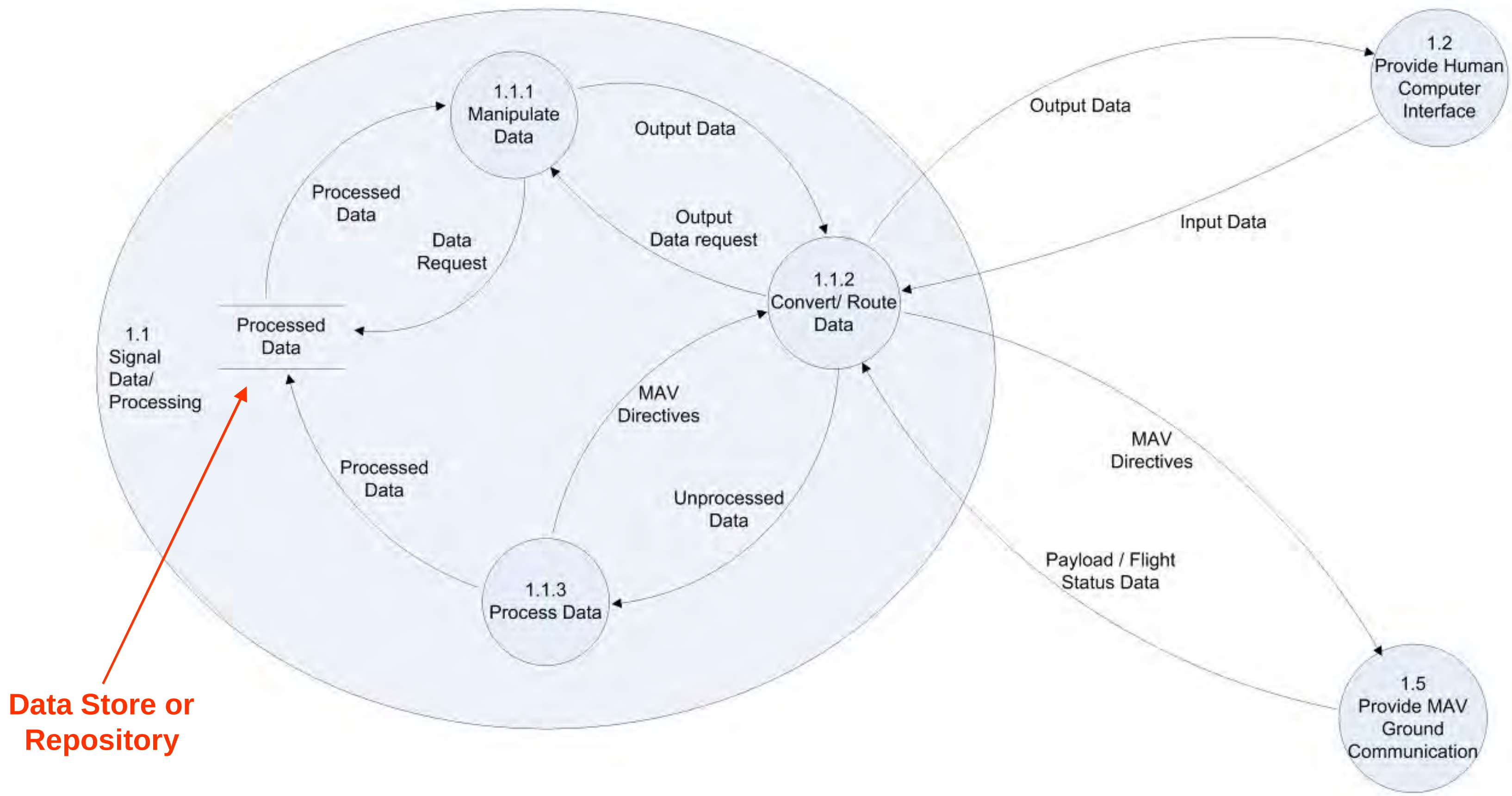

Baseline ISR MAV
System Functionality Description SV-4
Functional Decomposition
Provide ISR Capabilities
1 Perform Ground Unit Functions
2 Perform MAV Functions
1.1 Signal/ Data Processing
1.2 Provide Human Computer Interface
1.3 Provide Field Communication
1.4 Perform Human Operator Functions
1.5 Provide MAV Ground Communication
2.1 Provide MAV Airborne Communication
2.2 Perform Air Vehicle Functions
2.3 Perform Payload/Sensor Functions
1.1.1 Manipulate Data
1.1.2 Convert/ Route Data
1.1.3 Process Data
1.2.1 Give Feedback
1.2.2 Accept Input
1.3.1 Transmit ISR Information
1.3.2 Receive Directives
1.3.3 Modulate ISR Information
1.3.4 De-Modulate Directives
1.4.1 Route Info
1.4.2 Process Info
1.4.3 Influence System
1.4.4 Maintain System
1.5.1 Modulate MAV Directives
1.5.2 Transmit MAV Directives
1.5.3 De-Modulate Data
1.5.4 Receive Data
2.1.1 Transmit Data
2.1.2 Receive MAV Directives
2.1.3 De-Modulate MAV Directives
2.1.4 Accept Supplied Power
2.1.5 Modulate Data
2.2.1 Flight Control
2.2.2 Take Flight
2.2.3 Flight Data Protocol
2.2.4 Power Source
2.3.1 Payload Data Protocol
2.3.2 Enable ISR Capability
2.3.3 Convert ISR Data


Baseline ISR MAV
System Functionality Description SV-4
1-Level Diagram
Strike Assets
Fused Target Information
Taskings
1.3 Provide Field Communication
Fused Target Information
Headquarters
Taskings
1.1 Signal/ Data Processing
Output Data
Input Data
Field Comm Interface
Field Comm Interface
1 Perform Ground Unit Functions
MAV Directives
1.2 Provide Human Computer Interface
User Feedback
1.4 Perform Human Operator Functions
Payload / Flight Status Data
Human Inputs
1.5 Provide MAV Ground Communication
Commands
Platform Interface
GPS Sattelites
ISR/ Flight Status Data
Same Level Function
2 Perform MAV Functions
Navigation Data

Baseline ISR MAV

System Functionality Description SV-4

1.1-Level Diagram



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Results: SV Architectures

	Interface Identifier	Data Exchange Identifier	Data Description							Producer		Consumer		Nature of Transaction				Performance Attributes	
Row ID	System Interface Name	System Data Exchange Name	Data Element Name	Content	Format Type	Media Type	Accuracy	Units of Measurement	Data Standard	Sending System Name	Sending System Function Name	Receiving System Name	Receiving System Function Name	Transaction Type	Triggering Event	Interoperability Level Achieved (C4ISR WG)	Criticality	Periodicity	Timeliness
1	BDI Request and Feedback	BDI Feedback	Fused Target Information	BDI Confirmation and general ISR information gathered						Field Communication System	Transmit ISR Info	Strike Assets	N/A	Voice Transmission	User needs to communicate to Strike Assets	Level 0 Isolated (Manual)	Can increase mission effectiveness	Does not occur often however it depends on the battlefield situation	Depends on method of delivery (in minutes)
2	BDI Request and Feedback	BDI Request	Tasking	BDI Type, Enemy Positions, Status/Type of Strike						Strike Assets	N/A	Field Communication System	Receive Directives	Voice Transmission	Strike Asset cannot perform BDI therefore request a BDI mission	Level 0 Isolated (Manual)	Mission Essential	Does not occur often however it depends on the battlefield situation	Depends on method of delivery (in minutes)
3	Feedback and Input Data	Feedback Signal	Decoded Sensor Package Data	Audio and Video Signals						Signal/Data Processor	Convert/Route Data	Human Computer Interface	Give Feedback	Internode Hardware Connection	Processor Sends Feedback Signal	Level 1 Connected (Peer-to-Peer)	Mission Essential	Feedback constantly being supplied	Feedback in seconds
4	Feedback and Input Data	Input Data	Flight Plan	Keyboard, Mouse, Touch Screen Signals						Human Computer Interface	Accept Input	Signal/Data Processor	Process Data	Internode Hardware Connection	HCI detects input	Level 1 Connected (Peer-to-Peer)	Mission Essential	Varies by user and mission (at least twice)	Input in seconds

	Performance Attributes		Information Assurance							Security				
Row ID	Throughput	Size	Access Control	Availability	Confidentiality	Dissemination Control	Integrity	Non-Repudiation Producer	Non-Repudiation Consumer	Protection (Type Name, Duration, Date)	Classification	Classification Caveat	Releasability	Security Standard
1														
2														
3														
4														

Results: DOTMLPF

- **DOTMLPF Considerations**
  - **JCIDS places emphasis on addressing a capabilities' impact in the areas of DOTMLPF**
  - **Doctrine**
    Real-Time Situational Awareness will influence mission decisions and possibly increase force employment to areas of unknown conditions.
  - **Organization**
    Changes can occur in the tactical realm and developmental/sustainment realm

Results: DOTMLPF

- **DOTMLPF Considerations**
  - **Training**
    Original requirement of 'operable by trained personnel' remains. Types of training can include classroom, field, virtual, verbal, written, on-the-job-training, etc.
  - **Material**
    The ISR MAV architected serves as a material solution to the capability gap identified

Results: DOTMLPF

- **DOTMLPF Considerations**
  - **Leadership and Education**
    - ***Increased local area situational awareness can impact leaders decisions in the field***
    - ***The units education would need to include this new tactical capability.***
  - **Personnel**
    - ***Impacts depend on manner in which the ISR MAV is employed***
    - ***Tactical Specialty Codes could emerge***

Results: DOTMLPF

- **DOTMLPF Considerations**
  - **Facilities**
    - ***Should be minimal***
    - ***Largely dependant on how their development, sustainment and logistics are managed***

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Results: Future Capabilities

Future Capability Timeline:

Short Term

Acquire Precise Target Coordinates
Biological and Chemical Sniffer Platform
Communication Eavesdropping
Mobile Ground Station When Deployed

Night or IR Reconnaissance
Psychological Operations
Target Tracking or Following

Mid Term

Air-to-Air or Anti-MAV
Communication Relay
Distinguish Facial Features
GPS Jamming

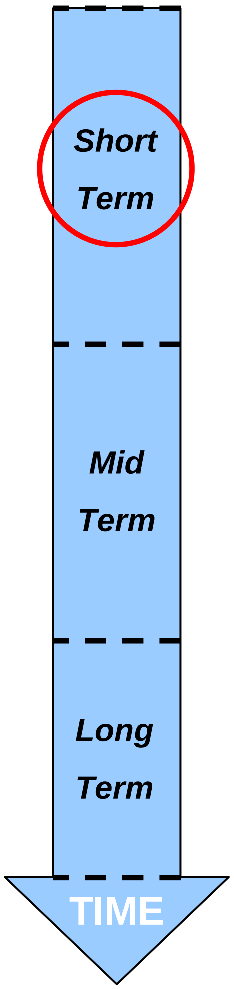
Small Ordinance Delivery Platform
Suppression of Enemy Air Defenses
Target Painting or Designation
Locate Targets Through General Land Obstacles
Weather Intelligence Platform
Operation in Urban or GPS Denied Environments

Long Term

Electronic Signal Directional Finding
Land or Sea Mine Scout
Target Identification and Tracking
Localized Deployment with External Control

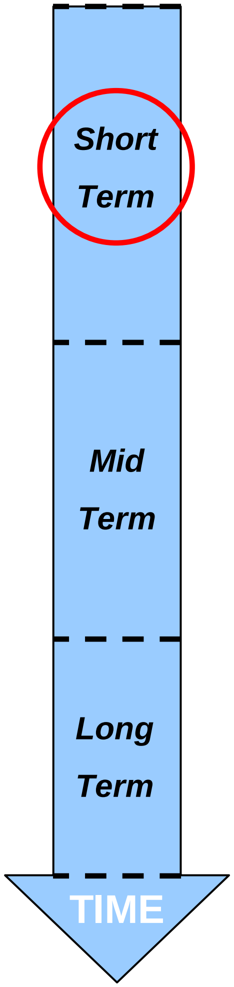
TIME

Future Capabilities



- **Capability -** Acquire Precise Target Coordinates
- Enabling Technologies
  - Improved Precision Of MAV GPS Sensor
  - Range Finder For Use With EO Or IR Sensors
  - Possible Height Above Ground Sensor or DTED
- Architecture Impacts
  - Range/Height can morph into the “Raw Sensor Package Data” link to the ground station
  - Minimal Changes To OV and SV Products
  - New Hardware Impacts System Design
    - Ensure Tx/Rx Can Process The Data
    - Target Coordinates Calculated by Ground Station

Future Capabilities



- **Capability –** Mobile Ground Station When MAV Deployed
- Enabling Technologies
  - Geolocation Capability For The Ground Station
  - Improved Human Interface Enabling Mobility
- Architecture Impacts
  - Minimal Changes To OV Or SV Products As Information Flows To And From The Ground Station Are The Same
  - New Hardware Impacts System Design And Ground Station Requirements

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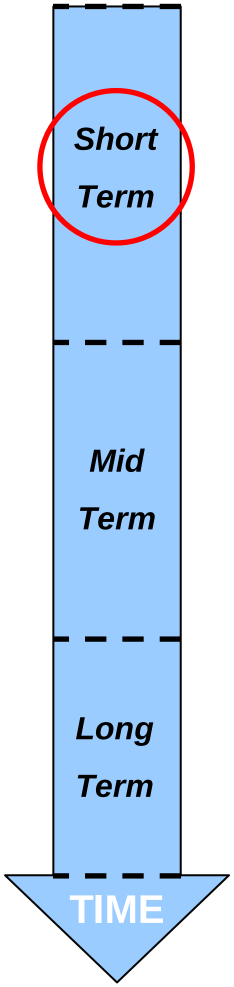
Future Capabilities



- **Capability –** Night Or IR Reconnaissance
- Enabling Technologies
  - Modular Payload Bay In MAV
  - Miniaturized Night Or IR Sensor
  - Possible Sensor Fusion
- Architecture Impacts
  - Minimal Changes To OV Or SV Products If Only One Camera Is Used At A Time
  - New Hardware Impacts System Design And Modular Payload Bay Impacts MAV And Payload Requirements

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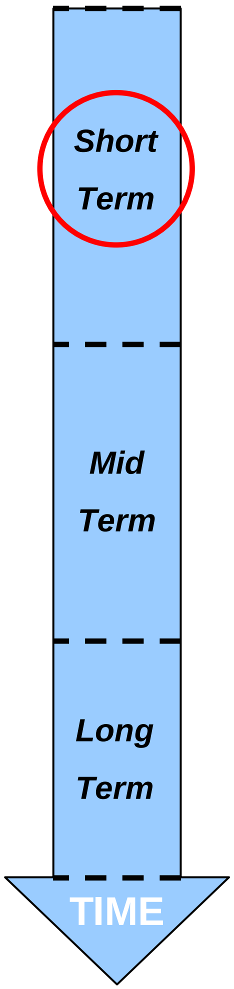
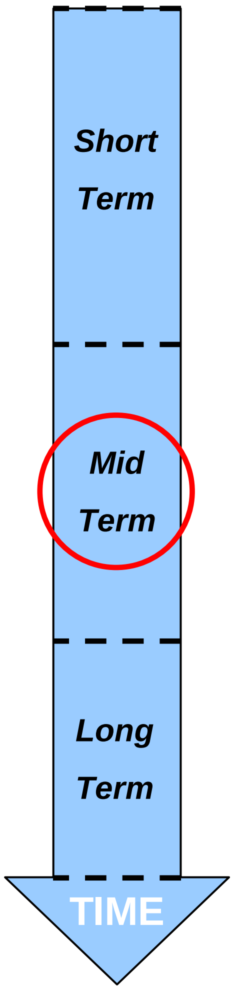
Future Capabilities



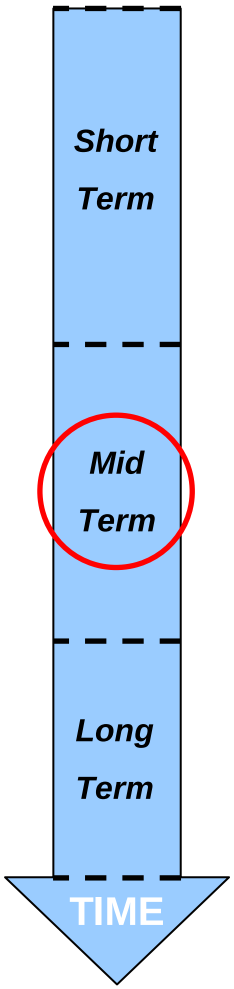
- **Capability –** Target Tracking Or Following
- Enabling Technologies
  - Image Recognition Hardware/Software In MAV Or High Data Rate Communication If Processing In Ground Station
  - Improved Loiter Time Via Fuselage Improvements Or Improved/Better Power Source
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities
  - Changes To SV Products Since The Target Dictates The Flight Plan Not Just The GPS Waypoints
  - New Hardware Impacts System Design

Future Capabilities



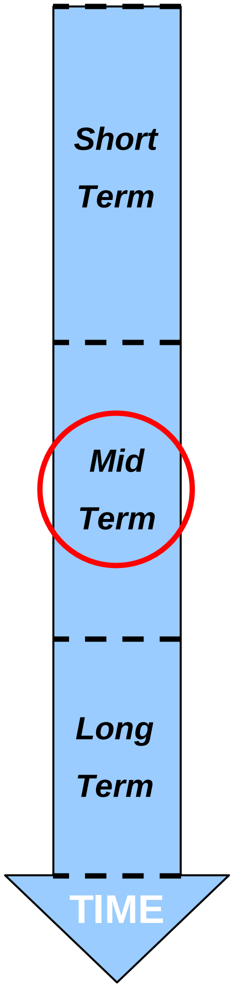
- **Capability –** Air-to-Air or Anti-MAV/UAV
- Enabling Technologies
  - Miniaturized Friend or Foe Sensor
  - Onboard sensors to locate enemy MAVs
  - Development of Anti-MAV tactics/doctrine
  - Offensive Anti-MAV capability via MAV or ground unit
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities
  - Changes To SV Products Due To New Intranodal Communication and Interfaces
  - System Design Impacted By New Hardware For MAV And Software Changes To Ground Station

Future Capabilities



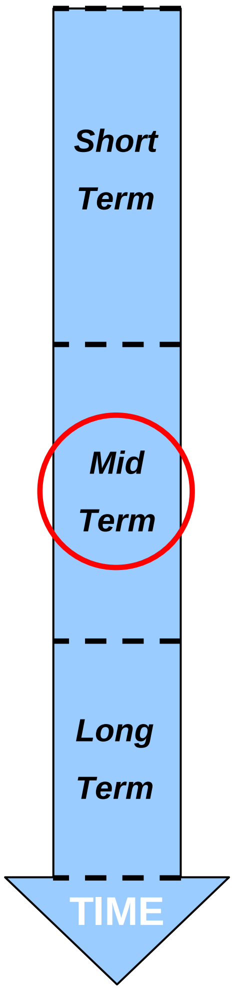
- **Capability –** Communication Relay
- Enabling Technologies
  - Miniaturizing A Ground Station Receiver Into The MAV
  - Improved Loiter Time Via Fuselage Improvements Or Improved/Better Power Source
  - Ability To Send Either Raw Or Processed Sensor Data To External Users
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities And A New Communication Node
  - Changes To SV Products Due To New Intranodal Communication And Interfaces
  - System Design Impacted By New Hardware For MAV And Software Changes To Ground Station

Future Capabilities



- **Capability –** Operation In Urban Or GPS Denied Environments
- Enabling Technologies
  - Non Line-of-sight Communications
  - Autonomous Navigation Aided By DTED, Collision Avoidance Sensors, Environment Map, Etc.
  - Communication Relay To Other MAVs
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities
  - Changes To SV Products Due To New Intranodal Communication And Interfaces
  - System Design Impacted By New Hardware For MAV And Software Changes To Ground Station

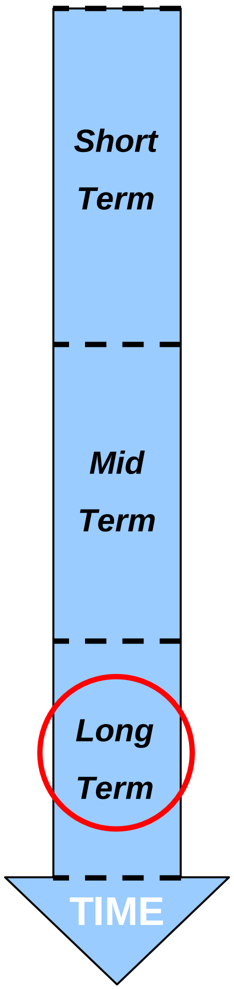
Future Capabilities



- **Capability –** Target Painting or Designation
- Enabling Technologies
  - Acquire Precise Target Coordinates
  - Target Tracking or Following
  - Sufficiently Powered Laser for the MAV
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities
  - Changes To SV Products Due To New Intranodal Communication and Interfaces
  - System Design Impacted By New Hardware For MAV And Software Changes To Ground Station

U.S. AIR FORCE

Future Capabilities



- **Capability –** Target Identification And Tracking
- Enabling Technologies
  - Target Tracking Or Following
  - Either Onboard Or Ground Station Based Identification
  - Increased Resolution Cameras
- Architecture Impacts
  - Changes To OV Products Due To New Operational Activities
  - Changes To SV Products Due To New Intranodal Communication And Interfaces
  - System Design Impacted By New Hardware For MAV And Software Changes To Ground Station

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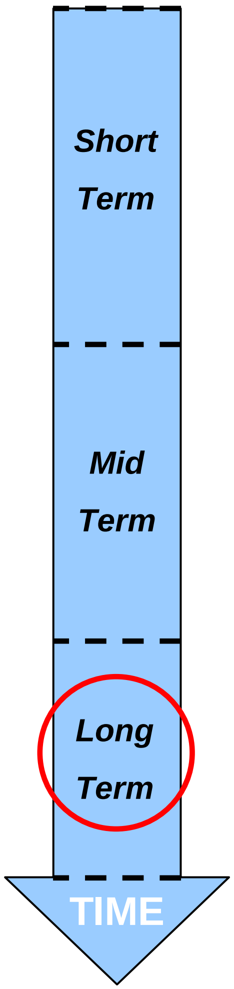
Future Capabilities



- **Capability –** Localized Deployment with External Control
- Enabling Technologies
  - Network-centric control structure
  - Ability to transmit sensor data and receive control direction beyond current system boundary
- Architecture Impacts
  - All Products Require Changes Due to New Nodes, Communication Lines and Functions
  - System Design Impacted By New Hardware For MAV And Hardware/Software Changes To Ground Station

Results: Future Techs

Future MAV Technology Capabilities

- Enhanced Optical Sensor Capabilities
- GPS Integration into Ground Station
- Integrated Ground Station
- Low Light Emitting Display
- Low Probability of Intercept Communications
- Modular and Swappable Payloads
- Multiple Sensor Payload
- Non-Line-Of-Sight Communications
- Reduce DTED Level 2 in Real-Time
- Sensor and/or Image Stabilization

Results: Future Techs

- **Other Future MAV Technology Capabilities**
  - Common Power supply system for all ground based systems
  - Communications Intelligence (COMINT) sensors
  - Daylight Imaging System (DIS)
  - Diesel Powerplant
  - Enhanced Aerodynamics for increased lift and power efficiency
  - Enhanced Battery Power
  - Enhanced Field of View optical sensors or sensor array
  - Fuel Cells
  - Forward looking infrared (FLIR)
  - HF/VHF/UHF Directional Finding Equipment
  - Increased Data Processing Onboard Air Platform (lightweight, low power)
  - Infrared line scanner (IRLS)
  - Reduce DTED Level 5 data in near real time
  - SATCOM
  - Small, Low Power Lasers (for range finding, target designation)
  - Small, Low Power Optical Sensors for Night Vision
  - Solar Power (alternate fuel or in flight recharge)
  - Synthetic Aperture Radar (SAR)

Conclusion: FAS

- Swarming MAV Detailed Architectures
- DoD Integration Of MAV Use
- MAV Observation/Targeting Stabilization Study And Analysis
- Fully Develop Future Architectures

Conclusion: Recommendations

- Recommendations
  - Accept And Update This As The Baseline ISR MAV Architecture
  - Expand This Architecture Into The Dynamic Realm To Look At Performance Comparisons Of Proposed Systems