

9th Annual Systems Engineering Conference
"Focusing on Improving Performance of Defense Systems Programs"

San Diego, CA

23-26 October 2006

Table of Contents

Agenda

Tuesday, 24 October 2006

Spanning the Government and the Globe by Mr. Mike Kern

General Session

Acquisition Transformation and Accelerating Change by The Honorable James Finley

USAF Systems Engineering by Mr. Terry Jaggers

OSD/Services Chief Engineers' Panel by Mr. Carl Siel

9th Annual NDIA Systems Engineering Conference by Mr. Mark D. Schaeffer

Track 1

Understanding the Technical Rationale and Intent of Requirements by Mr. John Chobany

Systems Engineering in Venus Satellite by Mr. Jacob Herscovitz

The Value of Systems Engineering byMr. Al Mink

Systems Engineering Revitalization Efforts by Mr. Bob Skalamera

Space Information & Intelligence System by Mr. Peter Sardella

Track 2

Advancing the Role of DT&E in the Systems Engineering Process: An Update on the NDIA Systems Engineering Division DT&E Committee by Dr. George Ka'iliwai, Mr. John Lohse, Mr. Tom Wissink

Test & Evaluation in the Virtual World by Dr. David R. Pratt and Dr. Robert W. Franceschini

Program Success Through SE Discipline in Technology Maturity by Mr. Chris DiPetto

Systems Engineers Provide a Key Contribution and Role in System Integration and Test by Mr. William Lyders

Track 3

Program Support: Perspectives and Systemic Issues by Mr. Dave Castellano

Systems Engineering –The Defense Acquisition System's Environmental Management System (EMS) by Mr. Sherman Forbes

A Closer Look at the Housing Bubble and Requirements Management by Mr. Jimmy Thai

Cost Efficient Risk Management Through Integrated T&E Throughout the Systems Engineering Life-Cycle by Mr. Josh Tribble

Track 4

Insight: Operability Testing for High Availability Systems by Mr. Edward Beck

Systems Approach of Prognostics by Mr. David K. Han, Mr. Michael G. Pecht, and Mr. Davinder K. Anand

Utilizing Current Test Strategies to Drive Diagnostics Development, Deployment and Support Through Software Tools by Mr. Duane Lowenstein

Track 5

Model Based Systems Engineering and How it Aids DoD Acquisition & Systems Engineering by Mr. Dwayne Hardy

Implementing the Acquisition M&S Master Plan by CAPT Mike Lilienthal, MSC, USN

Planning Modeling and Simulation Support to Systems Engineering by Mr. James W. Hollenbach

Model Driven Systems Engineering: Linking the "Vee" by Mr. Tim Tritsch, Ms. Janice Magill, and Mr. James Newbury

Track 6

Architecture, Requirement, and Software: A Cooperative Approach to Product Management byMr. Jonathan Casey and Mr. Mark Minnucci

Reference Architecture and The JCIDS Process Network Centric Systems by Mr. Chuck Sammons

DoD Enterprise Architecting: Joint Issues Derived From SOF Air Analysis by Major Todd L. Wieser, Major Gregory Miller, Major Aaron Piepkorn, Major James Kennedy, and Dr. Robert Mills, Dr. John Colombi

The Use of Patterns in Enterprise Architecture by Satya Moorthy, Dr. Robert Cloutier

Track 7

CMMI—Next Steps by Ms. Kristen Baldwin

How Does High Maturity Benefit the Customer? By Dr.Mr. Rick Hefner

Practical Experiences and Lessons Learned in Implementing CMMI by Mr. Michael T. Kutch, Jr. and Mr. Mike Knox

Track 8

How applying the Team Software ProcessSM (TSP) and Personal Software ProcessSM (PSP) can increase Software Supportability by Mr.Bradley Hodgins

Early Application of Computer Program Systems Integration, Test and Performance Measurement by Mr. Tom Sobieralski

Wednesday, 25 October 2006

System Engineering and Integration for Submarine Combat Systems in the COTS Environment by Mr. Dennis J. Cooper, Ms. Joan Sienkiewicz, and Mr. Mike Oliver

How to Create and Select High Value, Innovative, Competitive and Economic Concepts for New Systems? By Mr. Jacob Herscovitz

The Next Generation of Air Force SE to the Early Stages of Life Cycleby Mr. Jeff Loren

Step 1 for Systems Engineering: Establish a Tangible Requirement Management Process by Mr. Jim Miller

Systems Engineering for Rapid Prototyping: A Practical Application by Maj Monte Cannon, Maj Greg Buckner, Maj Greg Buttram, Maj Michael Jiru, Maj Arlene Collazo, Dr. Brian Hermann, Dr. John Colombi

Top 5 Issues Update, Mr. Bob Rassa

Top 5 Software Issues Update, Mr. Bob Rassa

Product-based Systems Engineering Requirements by Mr. Brian Shaw, Mr. Larry Pennell, and Mr. Dave Davis

Concept for an Enterprise Wide (EW) System Engineering Collaborative Engineering Environment by Dr. David Signori, Dr. Jimmie McEver, Dr. Kenneth Jordan,

and Dr. Stuart Starr

Track 2

The Test and Evaluation of EO Sensors by Mr. Raymond F. Beach

Toward Flight Testing Less, Better by Mr. Dean Carico

Test & Evaluation in the Virtual World by Dr. David R. Pratt and Dr. Robert W. Franceschini

DoD Weapons/Explosive Safety Service – Unique, Inconsistent, Duplicate and Common Testing Standards/Requirements - Are Yours Here? By Mr. Scott Rideout

Defense View on Considerations for System of Systems SE by Ms. Kristen Baldwin, Dr. Judith Dahmann, and Ms. Robin Gullifer

Implementing Systems Engineering in a Sustainment Environment by Mr. Jim Miller

Suitable Metrics for Measuring the Effectiveness of the Systems Engineering Process by Mr. Benjamin Q. Luong and Ms. Lauren L. Nguyen

A New Strategy for Submarine Payload Integration The VIRGINIA Multi -Mission Payload Module by Mr. John Pavlos

Performance-Based Earned Value by Mr. Paul J. Solomon

Track 3

Cost As An Independent Variable Balancing Performance and Affordability by Mr. Ed Casey

A Strategy for Program Success: Leading Indicators for Early Warning by Ms Rebecca Cowen-Hirsch

Quality / Systems Engineering Interfaces to Enhance Program Success by Dr. Jay Mandelbaum

Nunn-McCurdys Aren't Fun! By Mr. Gary Payton

Certification of Flight Critical Systems by Mr. Herbert Hecht

Acquisition Environment, Safety, and Occupational Health (ESOH) – ODUSD(I&E) Role and Activities by Ms. Patricia Huheey

Understanding the Joint Partnership between Program Management & Systems Engineering by Mr. Samuel Son and Mr. Benjamin Q. Luong
27 ACSG/ Miller
Seven Steps of an Effective Lessons Learned Process by Mr. Jimmy Thai

Lessons Learned from a Mature DMSMS Program by SQNLDR P.D.Weeding

Track 4

Update on the Process for Evaluating Logistics Readiness Levels (LRLs) by Ms. Elizabeth Broadus

Introduction to GEIA-STD STD-0007 0007 Logistics Product Data Logistics Product Data by

Mr. James Colson

Technical Data (an Output of Systems Engineering) in the Context of the LCMC by Mr. R. Miller

PBL Overview, Business and PBL Overview, Business and Metric Discussion Metric Discussion by Dr. David Nowicki & Dr. Dinesh Verma, and Mr. Tom Parry

A System-of-Systems Approach to Component Commonality by Mr. Ivan W. Wolnek

Track 5

Practical Design Issues of Simulation-Based Acquisition by Mr. Kevin Tang, Dr. Charles Cohen, and Mr. Glenn Beach

Modeling and Simulation (M&S) an Issue of Credibility by Mr. David Henry

Information Assurance for Distributed M&S Standards by Mr. Scott Holben

An Effective UML Process by Mr. Jeffrey O. Grady

Using Technical Data for Program Assessment by Mr. Henson Graves, and Mr. Jim Hollenbach

Interactive Visualization Development For Rapid Response by Ms. Therese Metcalf

Missile Operations and Support Simulation (MOSS) Method by Mr. Rob Slater

AIMS by Mr. John Rivers

Track 6

"The Net-Centric Foxhole" Perspectives from Army Future Combat Systems Mr. D. Emery

GES4 - Generic Environment Simulator for SoS (System of Systems)

New Perceptions in Coping with System of (SoS) by Dr. Daniel Leshem

Managing the "Trick-Bag" of Intersystem Coupling by Mr. Jeffrey S. Levin

Capability Acquisition Strategy Analysis: A Real Options Approach by Mr. Shin-Jyh Frank Chang,
Mr. Gary Backus, Ms. Michele Steinbach

Humans-In-The-Loop – Challenges in a Complex SoS Environment by Dr. Abe Meilich.

Open Architecture as an Enabler for FORCEnet by: Mr. Tom Hedge

Final Presentation for the Implication of FORCEnet on Coalition Forces

Track 7

Optimizing Risk Management by Mr. Rick Bollinger

Thursday, 26 October 2006

Track 1

Dominant Air Power: Design For Tomorrow…Deliver Today Global Hawk Integrated Risk Management Global
Trusted Information Management Framework by Dr. John F. Coughlin
Improving Systems Engineering Process Through Value Stream Mapping by Mr. Brent Theodore
Adapting the Vee Model to Accomplish Systems Engineering on Change Projects by Ms. Lauren Nguyen
Systems Engineering The Sequel 2006 TurboTax by Mr. Michael T. Kutch, Jr. and Mr. Mike Knox

Track 2

Safety of Unmanned Systems by Mr. Edward W. Kratovil
Integrating Environment, Safety, and Occupational Health Risk Management into Systems Engineering Using the System Safety Methodology by Mr. Mr. Sherman Forbes
Engineering Practices for System Assurance by Mr. Paul R. Croll
DoD Software Engineering and System Assurance New Organization – New Vision by Ms. Kristen Baldwin
Horizontal Integration of ESOH Requirements for Future Combat Systems by Ms. Elizabeth A. Miller

Track 3

Problem Reporting is not a Problem, It's an Opportunity by Mr. Scott Banks and Mr. Mark Pellegrini
Technology Program Management Model (TPMM) by Mr. Mike Ellis and Mr. Jeff Craver
Specifying Initial Design Review (IDR) and Final Design Review (FDR) Criteria by Ms. Mary Ann Lapham
Fostering Intra-Organizational Communication of Enterprise Systems Engineering Practices by Dr. Brian E. White
Anti-Tamper Overview and V&V Process by Major James Yurack
Effective Quality Assurance (QA) on Small Projects by Ms. Jean Swank, Ms. Jeanne Balsam, and Mr. Lee Sheiner

Track 4

Strategies for Systems Engineering Training by Dr. Rick Hefner
Comprehensive Training For Your Engineering Workforce by Mr. Michael T. Kutch, Jr.
Systems Engineering at Naval Postgraduate School by Mr. Eugene P. Paulo
Introducing Object Oriented Systems Engineering Methods to University Systems Engineering Curricula by Mr. Chris Ryder
Continuous Learning Module "Modeling & Simulation for Systems Engineering" by Mr. Michael Truelove

Track 5

How the Modeling and Simulation (M&S) Product Line Approach Supports Concept Exploration by Dr. David R. Pratt, Dr. Robert W. Franceschini, and Mr. Robert B. Burch
"Training" for Models: The Role of Knowledge Management in Applying Modeling and Simulation (M&S) to Systems Engineering by Dr. David R. Pratt and Dr.

Robert W. Franceschini
A Predictive Model of User Equipage Costs for Future Air Traffic Services and Capabilities: An ADS-B Example by Mr. Kent V. Hollinger, P.E., Mr. James D. Nickum, P.E., Mr. Doyle T. Peed, and Mr. Todd M. Stock
A Model-Driven Systems Engineering Approach for Unmanned Aircraft Airspace Integration by Mr. Joe Wolfrom, Ms. Jennifer Rainey, and Mr. Ken McKneely

Track 6

Acquiring Evolving Technologies: Web Services Standards by Mr. Harry L. Levinson
Leveraging Open Source e-Commerce Tools to Enable Joint Operations by Mr. Steve Rowe, Mr. Josh Band, and Dr. Charles Cohen
Moving Beyond SNMP by Mr. James A. Mazzei
Hypothetical Military CONOPs for Wireless Sensor Networks by Mr. David A. Stuart

Product Support Committee by Mr. Richard L. (Dick) Engwall

Determining System Interoperability Using an Integration Readiness Level by Stevens Institute of Technology

Track 7

The Quest for Practical DFSS (Design-for-Six-Sigma) Tools - PGMM Case Study by Mr. Doug Storsved and Mr. James Kalberer

“Pattern Library for use in Weapons System Engineering” by Mr. Frank Salvatore
Mission Assurance within the framework of CMMI by Ms. Kathy Stone

9TH ANNUAL SYSTEMS ENGINEERING CONFERENCE

"Focusing on Improving Performance of Defense Systems Programs"

Event #7870
October 23-26, 2006
San Diego, CA











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

Supported by the Office of Under Secretary of Defense for Acquisition, Technology and Logistics, Director, Systems and Software Engineering and Office of the DoD Chief Information Officer

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

INCOSE
INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

IEEE

9TH ANNUAL SYSTEMS ENGINEERING CONFERENCE

October 23 - 26, 2006

Conference Announcement

A major Conference focusing on improving acquisition and performance of Defense programs and systems, including net-centric operations and data/information interoperability, system-of-systems engineering, and all aspects of system sustainment, will be convened in San Diego, CA, October 23-26, 2006. This Conference is sponsored by the National Defense Industrial Association, Systems Engineering Division, with technical co-sponsorship by IEEE AES, IEEE Systems Council, and the International Council on Systems Engineering, and is supported by the Office of Under Secretary of Defense for Acquisition, Technology and Logistics, Director, Systems and Software Engineering and Office of the DoD Chief Information Officer.

Conference Objectives

This conference seeks to create an interactive forum for Program Managers, Systems Engineers, Chief Scientists, and engineers and managers from the government, industry, and academic communities whose interests converge on Defense acquisition, from capabilities analysis through disposal. This Conference will provide the opportunity to shape policy and guidance through the exchange of innovative procedures and lessons learned to address the following current issues:

- Interoperability & Systems Integration
- System-of-Systems Engineering
- Life Cycle Systems and Program Management
- Aging Aircraft
- Life Cycles Systems Management
- Sustainment & Upgrade of Legacy Systems
- Application of Government & Industry "Best Practices" Yools, Methodologies & Technologies
- Capability Maturity Model Integration (CMMI)
- Integrated Systems Engineering, Test, & Supportability Disciplines
- Network Centric Operations
- Application of DoD Initiatives:
  - Performance-Based Business Environment
  - System Safety
  - Open Systems
  - Simulation-Based Acquisition
  - COTS Integration
- Systems Engineering Effectiveness
- Modeling & Simulation
- Integrated Risk Management
- Performance Based Logistics
- Improved Cycle Times for Design, Manufacture & Repair Process
- Improved Mission Readiness & Systems Availablility
- Systems Engineering Training & Education

Background

The Department of Defense in undertaking a major transformation of our military capability in response to the new world environment and unforeseen threats. The ability to effect this transformation can only be realized if our Defense systems - space, air, land, sea, and under sea - can effectively satisfy mission area and capability requirements and achieve and sustain a high degree of interoperability, systems integration, systems safety, readiness, and availability. We believe that the greatest opportunity to achieve these objectives for new and legacy systems is through strong technical management embodied in systems engineering methodologies and processes, on the part of both industry and the DoD. Strong emphasis on systems engineering across the full acquisition life cycle, from concept refinement through sustainment, is a key enabler of incremental development and evolutionary acquisition. The Systems Engineering Conference is an annual event targeted at exploring the role of technical planning and execution in Defense programs and systems from a variety of perspectives, academic and pragmatic, by the entire Defense systems engineering community.

Brochure Contents

Hotel/Registration/Display/General Conference Information ..... pg. 2-3

Conference Agenda at a glance ..... pg. 5

Tutorial Tracks ..... pg. 7

Concurrent Session Listings ..... pg. 8-12

Conference Registration Form ..... pg. 13

Displayer Registration Form ..... pg. 14

For questions regarding the Conference, please contact : Britt Bommelje, Associate Director, at 703-247-2587 or bbommelje@ndia.org.

Hotel Information

•Hyatt Regency Islandia • • Hyatt Regency Islandia • • Hyatt Regency Islandia•

Hyatt Regency Islandia
1441 Quivira Road
San Diego, California 92109
(619) 224-1234



For more information about hotel and local attractions, please visit the hotel website at: http://islandia.hyatt.com/hyatt/hotels/index.jsp.

Please call the hotel directly in order to make your reservation. A block of rooms have been reserved at the Hyatt Regency Islandia. In order to ensure the discounted NDIA rate, you must make your reservations early, and ask for the NDIA room block. Rooms will not be held after Friday, September 29, 2006, and may sell out before then. Rates are also subject to increase after this date. The government per diem rate is available only to active duty or civilian government employees. ID will be required upon check-in. Retired military ID's do not qualify.

Government Rate: $129.00*
*(or prevailing government per diem rate at the time of the Conference)

Industry Rate: $169.00

Registration Information

• Registration Fees • • Registration Fees • • Registration Fees •

	• EARLY •	• REGULAR •	• LATE •
	before 8/30/06	from 8/30/06 to 10/6/06	after 10/6/06
Government/Allied/ Academia	$660	$725	$800
Industry NDIA Member	$775	$855	$940
Industry Non- NDIA Member	$825	$910	$1,000

Tutorial Registration: $200.00 - This registration is for the MONDAY TUTORIAL SESSION ONLY, and it is IN ADDITION TO the Conference registration fee

To register online for this Conference, please visit the following link: http://www.ndia.org/meetings/7870. Online registration will close on October 6, 2006. You must register onsite after this date. You can also download the registration form from the NDIA website or complete the form contained in this brochure. Fax the completed form to 703-522-1885 or mail to Event #7870, National Defense Industrial Association, 2111 Wilson Boulevard, Suite 400, Arlington, VA 22201-3061. Please do not fax or mail registration froms after October 6, 2006. You will need to register onsite after this date. Payment MUST be made at the time of registration. Registrations will not be taken over the phone. For additional questions, contact **Britt Bommelje,** Associate Director at 703-247-2587, or via email at bbommelje@ndia.org. Please see page 13 for the Conference Registration form.

CANCELLATIONS REMINDER: Cancellations received before August 30, 2006 will receive a full refund. Cancellations received from August 30 , 2006 until October 6, 2006 will receive a refund minus a cancellation fee of $75.00. REFUNDS WILL NOT BE GIVEN FOR CANCELLATIONS RECEIVED AFTER OCTOBER 6, 2006. Substitutions are welcome in lieu of cancellations.

Displayer Information

•Displayer Information • • Displayer Information • • Displayer Information •

NDIA invites you to display at the 9th Annual Systems Engineering Conference. An area will be available for the set-up of Corporate or Organization displays to demonstrate your company/organization's capability in Systems Engineering and Design expertise, Logistics Support, Systems Engineering and Design Tools, Modeling & Simulation Tools & Capability, expertise in Test & Evaluation, Reliability Analysis T ools & Capability, Process Improvement Capability & Tools including CMMI Appraisal Services & Tools, Engineering Services and related items. Displays will be table-top or "pop-up" style. Allocated display space will be 10 ft wide by 6 ft deep. Pipe and drape is not provided. Please see page 14 for the Display Registration Form.

For additional information on displays, please contact **Britt Bommelje**, at 703-247-2587 or at bbommelje@ndia.org.

General Conference Information

•Conference Information • • Conference Information • • Conference Information •

Identification Badges : During Conference registration and check-in, each participant will be issued an identification badge. Please be prepared to present a picture ID. Badges must be worn at all conference functions.

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

Promotional Partnership Opportunities: Increase your company or organization's exposure at this premier event by becoming a Promotional Partner. A Promotional Partnership will add your company name to the back cover of the on-site brochure as well as main platform recognition throughout the conference, signage at all events including the opening reception, a 350-word organization description in the on-site brochure, and a hotlink from the Conference webpage to your company website. For more information, please contact **Sam Campagna** at 703-247-2544 or via e-mail at scampagna@ndia.org.

Attire: Appropriate dress for this Conference is business casual for civilians and class B uniform for military.

ADA: NDIA supports the Americans with Disabilities Act of 1990. Attendees with special needs should call 703-522-1820 and refer to Event # 7870 prior to October 6, 2006.

National Defense Magazine: Advertise in National Defense and increase your company's exposure at this Conference! National Defense will be distributed to the attendees of this Conference and all other NDIA Conferences. For more information, please contact **Dino Pignotti** at 703-247-2582 or dpignotti@ndia.org.

Inquiries: For questions regarding the Conference, please contact **Britt Bommelje**, Associate Director at 703-247-2587 or at bbommelje@ndia.org.

For more information on the Conference, or to register online, please visit the Conference website at www.ndia.org/meetings/7870.

Conference Agenda -- At a Glance

•Sun, October 22, 2006 • • Sun, October 22 • • Sun, October 22 • •Sun, October 22 • • Sun, October

5:00 pm - 7:00 pm	**Registration for Tutorials and General Conference (Tutorials are an additional $200.00 registration fee)**

•Mon, October 23, 2006 • • Mon, October 23 • • Mon, October 23 • •Mon, October 23 • • Mon,

7:00 am - 5:00 pm	**Registration**
7:00 am - 8:00 am	**Continental Breakfast for Tutorial Attendees (Tutorials are an additional $200.00 registration fee)**
8:00 am - 12:00 pm	**Tutorial Tracks (Please refer to page 7 for Tutorial Schedule)**
12:00 pm - 1:00 pm	**Buffet Lunch for Tutorial Attendees**
1:00 pm - 5:00 pm	**Tutorial Tracks Continued**
5:00 pm - 6:00 pm Regency Annex	**Reception in Display Area (Open to All Participants)**

•Tue, October 24, 2006 • • Tue, October 24 • • Tue, October 24 • •Tue, October 24 • • Tue, October

7:30 am - 5:00 pm	**Registration**
7:30 am - 8:30 am	**Continental Breakfast**
8:30 am - 8:35 am	**Introductions** Mr. Sam Campagna, Director, Operations, NDIA
8:35 am - 8:45 am	**Opening Remarks** Mr. Bob Rassa, Director, Systems Supportability, Raytheon; Chair, Systems Engineering Division, NDIA
8:45 am - 9:45 am	**Keynote Address** HON James Finley, Deputy Under Secretary of Defense, Acquisiton & Technology
9:45 am - 10:15 am	**Break**
10:15 am - 12:00 pm	**Plenary Session : Executive Panel** **Moderator:** Mr. Mark Schaeffer, Director, Office of Under Secretary of Defense for Acquisition, Technology and Logistics, Director, Systems and Software Engineering **Panelists:** Mr. Carl Siel, ASN/RDA Chief Engineer (Acting) Mr. Terry Jaggers, SAF/AQ, Director, SAF/AQR (Science, Technology & Engineering) (invited) Mr. Doug Wiltsie, Assistant Deputy for ASM, HQDA, OASA (ALT) (Invited) Mr. Steven Kapurch, Chief Systems Engineer, NASA (Invited)

12:00 pm - 1:30 pm Regency Annex	Luncheon Awards Ceremony
1:30 pm - 5:00 pm	Concurrent Sessions (Please refer to pages 8-12 for session schedule)
5:00 pm - 7:00 pm	Reception in Display Area

• Wed, October 25, 2006 • • Wed, October 25 • • Wed, October 25 • •Wed, October 25 • • Wed,

7:00 am - 5:15 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:15 am - 12:00 pm	Concurrent Sessions (Please refer to pages 8-12 for session schedule)
12:00 pm - 1:30 pm Regency Annex	Luncheon Speaker Mr. Patrick Michael Kern, Deputy Assistnat Secretary of Defense, NII/DoD CIO for Enterprise Wide Systems Engineering
2:30 pm - 5:30 pm	Concurrent Sessions (Please refer to pages 8-12 for session schedule)

•Thurs, October 26, 2006 • • Thurs, October 26 • • Thurs, October 26• •Thurs, October 26 • • Thurs,

7:00 am - 3:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:00 am - 12:00 pm	Concurrent Sessions (Please refer to pages 8-12 for session schedule)
12:00 pm - 1:00 pm	Luncheon
1:00 pm - 3:00 pm	Concurrent Sessions (Please refer to pages 8-12 for session schedule)
3:00 pm	Conference Adjourns

"The Department of Defense finds this event meets the minimum regulatory standards for attendance by DoD employees. This finding does not constitute a blanket approval or endorsement for attendance. Individual DoD component commands or organizations are responsible for approving attendance of its DoD employees based on mission requirements and DoD regulations."

Monday, October 23, 2006 - Tutorial Sessions

7:00 am Registration & Continental Breakfast

	8:00 am - 9:45 am	10:15 am - 12:00 pm	1:00 pm - 2:45 pm	3:15 pm - 5:30 pm
Regency A	TRACK 1 Tutorial Practical Six Sigma Tools for Systems Engineering Session 1A1 Mr. Rick Hefner	TRACK 1 Tutorial Practical Six Sigma Tools for Systems Engineers (Continued) Session 1B1 Mr. Rick Hefner	TRACK 1 Tutorial Performability (Performance and Reliability) Modeling Session 1C1 Dr. Meng-Lai Yin	TRACK 1 Tutorial Performability (Performance and Reliability) Modeling (Continued) Session 1D1 Dr. Meng-Lai Yin
Regency B	TRACK 2 Tutorial Requirements Engineering Workshop: A Practical Approach to Modeling and Managing Requirements Session 1A2 Mr. William Deibler, II	TRACK 2 Tutorial Requirements Engineering Workshop: A Practical Approach to Modeling and Managing Requirements (Continued) Session 1B2 Mr. William J. Deibler, II	TRACK 2 Tutorial Integrated Project Management (IPM) – The CMMI and Collaborative Product Development Session 1C2 Mr. William Deibler, II	TRACK 2 Tutorial Integrated Project Management (IPM) – The CMMI and Collaborative Product Development (Continued) Session 1D2 Mr. William Deibler, II
Regency C	TRACK 3 Tutorial How to Define Lean Systems Engineering Processes Session 1A3 Mr. Tim Olson	TRACK 3 Tutorial How to Define Lean Systems Engineering Processes (Continued) Session 1B3 Mr. Tim Olson	TRACK 3 Tutorial How to Measurably Improve Your Requirements Session 1C3 Mr. Tim Olson	TRACK 3 Tutorial How to Measurably Improve Your Requirements (Continued) Session 1D3 Mr. Tim Olson
Mission A	TRACK 4 Tutorial What You Need to Know About Chaos, Complexity, and Complex Adaptive Systems to do Systems Engineering Well in the 21st Century Session 1A4 Ms. Sarah Sheard	TRACK 4 Tutorial What You Need to Know About Chaos, Complexity, and Complex Adaptive Systems to do Systems Engineering Well in the 21st Century (Continued) Session 1B4 Ms. Sarah Sheard	TRACK 4 Tutorial Leading Effective Technical Reviews and Meetings Session 1C4 Mr. David Walden, CSEP	TRACK 4 Tutorial Leading Effective Technical Reviews and Meetings (Continued) Session 1D4 Mr. David Walden, CSEP
Mission B	TRACK 5 Tutorial Systems Engineering Applications in Support of the Joint Capabilities Integration and Development System (JCIDS) Session 1A5 Mr. Christopher Ryder	TRACK 5 Tutorial Systems Engineering Applications in support of the Joint Capabilities Integration and Development System (JCIDS) (Continued) Session 1B5 Mr. Christopher Ryder	TRACK 5 Tutorial Improving Systems Engineering Effectiveness Through Assessment and Process Improvement Session 1C5 Mr. Ian Talbot	TRACK 5 Tutorial Improving Systems Engineering Effectiveness Through Assessment and Process Improvement (Continued) Session 1D5 Mr. Ian Talbot
Mission C	TRACK 6 Tutorial Integrated Specification Development Algorithm Session 1A6 Mr. Jeffrey Grady	TRACK 6 Tutorial Integrated Specification Development Algorithm (Continued) Session 1B6 Mr. Jeffrey Grady	TRACK 6 Tutorial Integrating Systems Engineering with Earned Value Management Session 1C6 Mr. Paul Solomon	TRACK 6 Tutorial Integrating Systems Engineering with Earned Value Management (Continued) Session 1D6 Mr. Paul Solomon
Island A	TRACK 7 Tutorial System Level Configuration Management Session 1A7 Mr. Al Florence	TRACK 7 Tutorial System Level Configuration Management (Continued) Session 1B7 Mr. Al Florence	TRACK 7 Tutorial Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) Session 1C7 Dr. Abe Meilich	TRACK 7 Tutorial Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) (Continued) Session 1D7 Dr. Abe Meilich
Island B	TRACK 8 Tutorial QUASAR: A Method for Assessing the Quality of the Architecture of Large and Complex Software-Intensive Systems Session 1A8 Mr. Donald Firesmith	TRACK 8 Tutorial QUASAR: A Method for Assessing the Quality of the Architecture of Large and Complex Software-Intensive Systems (Continued) Session 1B8 Mr. Donald G. Firesmith	TRACK 8 Tutorial Acoustic Rapid COTS Insertion and Advanced Processing Build – Integrating Test & Evaluation Philosophies into Systems Engineering Session 1C8 Mr. George Maris	TRACK 8 Tutorial Acoustic Rapid COTS Insertion and Advanced Processing Build – Integrating Test & Evaluation Philosophies into Systems Engineering (Continued) Session 1D8 Mr. George Maris

Break

Break

Buffet Lunch

Break

Break

5:30 pm - 6:30 pm Reception in Display Area

Tuesday, October 24, 2006

1:30 pm - 3:00 pm

Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 2C1	Defense SE Revitalization – A Work in Progress ***Mr. Robert Skalamara***	Understanding the Technical Rationale and Intent of Requirements ***Mr. John Chobany***
Regency B	TRACK 2 Test & Evaluation in Systems Engineering Mr. John Lohse Session 2C2	Advancing the Role of DT&E in the Systems Engineering Process: An Update on the NDIA Systems Engineering Division DT&E Committee ***Mr. John Lohse***	Assessing Technology Maturity Through Testing ***Mr. Chris DiPetto***
Regency C	TRACK 3 Program Management Mr. Bob Lyons Session 2C3	Cost Efficient Risk Management through Integrated T&E throughout the Systems Engineering Life Cycle ***Mr. Joseph E. Tribble***	A Closer Look at the Housing Bubble and Requirements Management ***Mr. Jimmy Thai***
Mission A	TRACK 4 Integrated Diagnostics Mr. Howard Savage Session 2C4	Energetic Material/Systems Prognostics ***Mr. David Han***	Insight: Operability Testing for High Availability Systems ***Mr. Edward Beck***
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 2C5	Implementing the Acquisition M&S Master Plan ***Mr. Fred Myers***	Planning M&S Support to Systems Engineering ***Mr. James Hollenbach***
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 2C6	Reference Architectures and the JCIDS Process ***Mr. Clifford Sammons***	Architecture, Requirements, and Software: A Cooperative Approach to Product Management ***Mr. Jonathan Casey***
Island A	TRACK 7 Best Practices & Standardization Mr. Paul Croll Session 2C7	How Does High Maturity Benefit the Customer? ***Mr. Rick Hefner***	CMMI—Next Steps ***Ms. Kristen Baldwin***
Island B	TRACK 8 Software Dr. Tom Christian Session 2C8	A Pragmatic Focus in Managing Subcontractor Performance in a Systems Engineering Services Program Via the CMMI ***Dr. Mary Anne Herndon***	Early Application of Computer Program Systems Integration, Test and Performance Measurement ***Mr. Tom Sobieralski***

Break in Display Area

3:30 pm - 5:00 pm

TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 2D1	Systems Engineering Used in Venus Satellite Design ***Mr. Jacob Herscovitz***	Value of Systems Engineering: Recap on What We've Learned and Insights on Late-breaking Research ***Mr. Al Mink***	Royal Air Force Fylingdales: Space Information and Intelligence System ***Mr. Dominick Peter Sardella***
TRACK 2 Test & Evaluation in Systems Engineering Mr. John Lohse Session 2D2	System Engineers Provide a Key Contribution and Role in System Integration & Test ***Mr. William Lyders***	The Value of Embedded Systems Engineering in Test and Evaluation ***Parvaneh Safaei***	
TRACK 3 Program Management Mr. Bob Lyons Session 2D3	Program Support: Perspectives and Systemic Issues ***Mr. David Castellano***	Using a Layered Definition of Capability to Align SE, T&E, and M&S ***Mr. Jack Sheehan***	Systems Engineering – The Defense Acquisition System's Environmental Management System ***Mr. Sherman Forbes***
TRACK 4 Integrated Diagnostics Mr. Howard Savage Session 2D4	Technical Content Sharing within IEDM IETM-IMI Common Operating Environments ***Mr. Patrick Young***	Utilizing Current Test Strategies to Drive Diagnostics Development, Deployment and Support Through Software Tools ***Mr. Duane Lowenstein***	
TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 2D5	Model-Based Systems Engineering ***Mr. Dwayne Hardy***	Model Driven SE and Verification: Linking the "Vee" ***Mr. Timothy Tritsch***	
TRACK 6 Net Centric Operations Mr. Jack Zavin Session 2D6	DoD Enterprise Architecting: Joint Issues Derived From SOF Air Analysis ***Dr. Robert Mills***	The Use of Patterns in Enterprise Architecture ***Mr. Satya Moorthy***	
TRACK 7 Best Practices & Standardization Mr. Paul Croll Session 2D7	Value Stream Mapping-Technical Requirements Flow-Down to Suppliers ***Santanu Sen***	Implementing a Standardized, Lean and Paperless Change Management Process in a Legacy, Multi-Program Environment ***Ms. Robin Lawson***	Practical Experiences and Lessons Learned Implementing CMMI in an SE Organization ***Mr. Michael Kutch, Jr.***
TRACK 8 Software Dr. Tom Christian Session 2D8	The Historical Results and Lessons Learned of a Software Reliability Prediction ***Mr. Jon Peterson***	How Applying the Team Software Process (TSP) and Personal Software Process (PSP) can increase Software Supportability ***Mr. Timothy Chick***	

5:30 pm - 7:00 pm Reception in Display Area

Register now!! Visit the conference website at http://www.ndia.org/meetings/7870

Wednesday, October 25, 2006

7:00 am Registration & Continental Breakfast

	8:00 am - 9:45 am			10:15 am - 12:00 pm		
Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 3A1	Step 1 for Systems Engineering: Establish a Tangible Requirement Management Process ***Mr. James Miller***	The Next Generation of Air Force Systems Engineering: Application of SE to the Early Stages of the Life Cycle ***Mr. Jeff Loren***	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 3B1	How to Create and Select High Value, Innovative, Competitive and Economic Concepts for New Systems? ***Mr. Jacob Herscovitz***	Systems Engineering and Integration for Submarine Combat Systems in the COTS Environment ***Mr. Dennis Cooper***
Regency B	TRACK 2 Test & Evaluation in Systems Engineering Mr. John Lohse Session 3A2	Applying the Systems Engineering Approach to the Test and Evaluation Process ***Mr. Raymond Beach***	Test and Evaluation Using Virtual Modeling and Simulation ***Dr. Robert Franceschini***	TRACK 2 Test & Evaluation in Systems Engineering Mr. John Lohse Session 3B2	Explosives Safety Testing Requirements ***Mr. Scott Rideout***	Toward Flight Testing Less, Better ***Mr. Dean Carico***
Regency C	TRACK 3 Program Management Mr. Bob Lyons Session 3A3	Nunn-McCurdy's Are Not Fun – But - They Are Instructive ***HON Gary Payton***	Acquisitions and Systems Engineering Metrics: Leading Indictors Versus Lagging Indicators ***Ms. Rebecca Cowen-Hirsch***	TRACK 3 Program Management Mr. Bob Lyons Session 3B3	Quality/Systems Enginering Interfaces to Enhance Program Success ***Dr. Jay Mandelbaum***	Cost as an Independent Variable ***Mr. Ed Casey***
Mission A	TRACK 4 Integrated Diagnostics Mr. Howard Savage Session 3A4	NDIA Electronics Prognostics Task Results - The E-Prog Technology Roadmap ***Dr. James Dill***		TRACK 4 Logistics & Supportability Mr. Chuck Silva Session 3B4	Identifying and Assessing Life Cycle Related Critical Technology Elements (CTEs) for Technology Readiness Assessments (TRAs) ***Dr. Jay Mandelbaum***	Update on the Process for Evaluating Logistics Readiness Levels (LRLs) ***Ms. Elizabeth Broadus***
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 3A5	Modeling and Simulation (M&S) an Issue of Credibility ***Mr. David Henry***	Practical Design Issues of Simulation-Based Acquisition ***Mr. Kevin Tang***	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 3B5	Improving the State of Distributed Simulation ***Mr. Frank Salvatore***	Information Assurance for Distributed M&S Standards ***Mr. Scott Holben***
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 3A6	New Perceptions in Coping with System of Systems ***Dr. Daniel Leshem***	The Trick Bag of Intersystem Coupling ***Mr. Jeffrey Levin***	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 3B6	"The Net-Centric Foxhole" - Perspectives from Army Future Combat Systems ***Mr. David Emery***	ASW FoS/SoS Acquisition Alignment ***Mrs. Colleen Cannon***
Island A	TRACK 7 Best Practices & Standardization Mr. Paul Croll Session 3A7	Navigating the Forest of Standards ***Ms. Cynthia Hauer***	Using Best Practices at NASA to Define a CMMI DAR Process that Addresses Dissent ***Mr. Tim Olson***	TRACK 7 Best Practices & Standardization Mr. Paul Croll Session 3B7	Defining and Partitioning Best-of-Team Processes in a Multi-Organizational Teaming Environment ***Mr. David Walden, CSEP***	Implementing an Effective Peer Review Process ***Ms. Jeanne Balsam***
Island B	TRACK 8 Software Dr. Tom Christian Session 3A8	Long-Term Software Support Requires Good Configuration Management ***Mr. Mark Pellegrini***	Parts Management Reengineering ***Mr. Michael Goy***	TRACK 8 Software Dr. Tom Christian Session 3B8	Solutions Analysis for Helicopter Brownout ***Lt Col John Colombi, USAF***	Integrated Structural Health Monitoring for Aging Aircraft ***Maj Joerg Walter, USAF***

Break in Display Area

12:00 pm Lunch in the Regency Annex

Wednesday, October 25, 2006

1:30 pm - 3:00 pm

Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al. Brown	Concept for an Enterprise Wide System Engineering Collaborative Engineering Environment	Product-Based Systems Engineering Requirements
	Session 2C1	***Dr. David Signori, Jr.***	***Mr. Brian Shaw***
Regency B	TRACK 2 Systems Engineering Effectiveness Mr. Al Brown	Performance-Based Earned Value®	Implementing Systems Engineering in a Sustainment Environment
	Session 3C2	***Mr. Paul Solomon***	***Mr. James Miller***
Regency C	TRACK 3 Program Management Mr. Bob Lyons	Understanding the Joint Partnership Between Program Management & Systems Engineering on a Multi-Purpose Airlift Program	Lessons Learned From a Mature DMSMS Program (E3)
	Session 3C3	***Mr. Benjamin Luong***	***SQNLDR Peter Weeding***
Mission A	TRACK 4 Logistics & Supportability Mr. Chuck Silva	Defining the Fundamental Framework of an Effective Performance Based Logistics (PBL) Contract	A Common Sense Approach to Component Commonality
	Session 3C4	***Dr. Dinesh Verma***	***Mr. Ivan Wolnek***
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach	An Effective UML Process	Missile Operations & Support Simulation (MOSS) Method
	Session 3C5	***Mr. Jeffrey Grady***	***Mr. Robert Slater***
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin	Humans-in-the-Loop – Challenges in a Complex SoS Environment	Capability Acquisition Strategy Analysis: A Real Options Approach
	Session 3C6	***Dr. Abe Meilich***	***Dr. Shin-Jyh Chang***
Island A	TRACK 7 Best Practices & Standarization Mr. Paul Croll	Rapidly Defining a Lean CMMI Maturity Level 3 Process	Defining a Lean Configuration Management Process at NASA JPL
	Session 3C7	***Mr. Zia Tufail***	***Ms. Kristine Blom***
Island B	TRACK 8 Software	A Second Life for the OHIO Class Ballistic Missile Submarine: Facilitating Future Multi-Mission Capability for the SSGN	Lessons Learned with Integration of Federated Systems on Legacy Aircraft
	Session 3C8	***Mr. John Pavlos***	***Mr. Adam McCorkle***

Break in Display Area

3:30 pm - 5:00 pm

Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown	Systems Engineering for Rapid Prototyping: A Practical Application	Bridging Systems Engineering and Complex Systems Sciences – Moving Systems Engineering into the Third Millennium	On The Derivation of a Program Total Status Metric with Statistical Correlation to Cost, Schedule and Normalized Technical Performance
	Session 3D1	***Dr. John Colombi***	***Ms. Sarah Sheard***	***Mr. James Lackey***
Regency B	TRACK 2 Systems Engineering Effectiveness Mr. Al Brown	Suitable Metrics for Measuring the Effectiveness of the Systems Engineering Process	A New Strategy for Submarine Payload Integration – The VIRGINIA Multi-Mission Module	System of Systems Engineering: Current Thinking for Defense
	Session 3D2	***Ms. Lauren Nguyen***	***Mr. John Pavlos***	***Ms. Kristen Baldwin***
Regency C	TRACK 3 Program Management Mr. Bob Lyons	Seven Steps of an Effective Lessons-Learned Process	Certification of Flight Critical Systems	Acquisition Environment, Safety, and Occupational Health (ESOH) – ODUSD (I&E) Role and Activities
	Session 3D3	***Mr. Jimy Thai***	***Dr. Herbert Hecht***	***Ms. Patricia Huheey***
Mission A	TRACK 4 Logistics & Supportability Mr. Chuck Silva	GEIA-STD-0007 Logistics Product Data - Data Exchange using GEIA and ISO Standards (Revitalizing the LSAR)	Technical Data (an output of Systems Engineering) in the LCMC Concept	
	Session 3D4	***Mr. Jim Colson***	***Mr. Russ Miller***	
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach	Analysis, Interaction, Modeling and Simulation Framework	Interactive Visualization Development For Rapid Response	Using Technical Data For Program Assessment
	Session 3D5	***Mr. David Owens***	***Ms. Therese Metcalf***	***Dr. Henson Graves***
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin	Open Architecture as an Enabler for FORCEnet	FORCEnet Implications for Naval Coalition Forces	
	Session 3D6	***Mr. Patrick Grates***	***Mr. Eric Romero***	
Island A	TRACK 7 Best Practices & Standarization Mr. Paul Croll		IGEIA-927 Common Data Schema for Complex Systems. (A Harmonization of US and ISO Data Standards)	Optimizing Risk Management
	Session 3D7		***Mr. Jim Colson***	***Mr. Richard Bollinger***
Island B	TRACK 8 Software	The System Safety Basis for DoD's Emerging Contaminants Program	Interdisciplinary Team Project Management Using TSP Concepts	Anti-Tamper Executive Agent
	Session 3D8	***Ms. Shannon Cunniff***	***Mr. Bradley Hodgins***	**TBD**

Thursday, October 26, 2006

7:00 am Registration & Continental Breakfast

8:00 am - 9:45 am

Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 4A1	Improving the Systems Engineering Process Through Value Steam Mapping ***Mr. Brent Theodore***	Knowledge Management (KM) and Risk Assessment (RA) Trusted Integrated Framework ***Mr. John Coughlin***
Regency B	TRACK 2 Systems Engineering Effectiveness Mr. Al Brown Session 4A2	Proposed Safety Precepts and Safety Design Guidance for Unmanned Systems ***Mr. Edward Kratovil***	Proposed Safety Precepts and Safety Design Guidance for Unmanned Systems (Continued) ***Mr. Edward Kratovil***
Regency C	TRACK 3 Program Management Mr. Bob Lyons Session 4A3	Specifying Initial Design Review (IDR) and Final Design Review (FDR) Criteria ***Ms. Mary Ann Lapham***	Technology Program Management Model (TPMM): A Systems-Engineering Approach to Technology Development Program Management ***Mr. Jeffrey Craver***
Mission A	TRACK 4 Education & Training Session 4A4	Strategies for Systems Engineering Training ***Dr. Rick Hefner***	Comprehensive Training for Your Engineering Workforce ***Mr. Michael Kutch, Jr.***
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 4A5	A Model-Driven Systems Engineering Approach for Unmanned Aircraft Airspace Integration ***Mr. Joseph Wolfrom***	How the Modeling and Simulation Product Line Approach Supports Concept Exploration ***Dr. Robert Franceschini***
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 4A6	Acquiring Evolving Technolgies: Web Services Standards ***Mr. Harry Levinson***	Leveraging Open Source e-Commerce Tools to Enable Joint Operations ***Mr. Steve Rowe***
Island A	TRACK 7 Best Practices & Standarization Mr. Paul Croll Session 4A7	Mission Assurance Within the Framework of CMMI ***Ms. Kathleen Stone***	RoHS and WEEE – How Will DoD Programs Manage the Lead-Free Transition? ***Mr. Vance Anderson***
Island B	TRACK 8 Session 4A8		

Break in Display Area

10:15 am - 12:00 pm

	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 4B1	Adapting the Vee Model to Accomplish Systems Engineering on Change Projects ***Ms. Lauren Nguyen***	Advances in Systems Engineering Measurement: Building Insight into Program Performance ***Mr. Garry Roedler***
	TRACK 2 Systems Engineering Effectiveness Mr. Al Brown Session 4B2	Integrating Environment, Safety, and Occupational Health Risk Management into Systems Engineering using the System Safety Methodology ***Mr. Sherman Forbes***	Handbook on Engineering for System Assurance ***Ms. Kristen Baldwin***
	TRACK 3 Program Management Mr. Bob Lyons Session 4B3	Problem Reporting is not a Problem, It's an Opportunity ***Mr. Scott Banks***	Fostering Intra-Organizational Communication of Enterprise Systems Engineering Practices ***Dr. Brian White***
	TRACK 4 Education & Training Session 4B4	Introducing Object Oriented Systems Engineering Methods in University Systems Engineering Curricula ***Mr. Christopher Ryder***	Systems Engineering at Naval Postgraduate School ***Dr. Eugene Paulo***
	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 4B5	"Training" for Models: The Role of Knowledge Management in Applying M&S to Systems Engineering ***Dr. Robert Franceschini***	A Predictive Model of User Page Costs for Future Air Traffic Services and Capabilities: An Automatic Dependent Surveillance - Broadcast Example ***Mr. Kent Hollinger***
	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 4B6	Strategies for Moving Beyond the Simple Network Management Protocol (SNMP) ***Mr. Sam Omar***	Hypothetical Military CONOP for Wireless Sensor Networks ***Mr. David Stuart***
	TRACK 7 Best Practices & Standarization Mr. Paul Croll Session 4B7	A Quest for Practical Design-for-Six-Sigma (DFSS) Tools - PGMM Case Study ***Mr. Douglas Storsved***	Pattern Library for Use in Weapons System Engineering ***Mr. Frank Salvatore***
	TRACK 8 Session 4B8		

12:00 pm Lunch in the Regency Annex

Thursday, October 26, 2006

1:30 pm - 3:00 pm

Regency A	TRACK 1 Systems Engineering Effectiveness Mr. Al Brown Session 4C1	Statistical Design Process for System Engineering ***Dr. William Thomas***	Turbo Tax for CMMI® - The Sequel ***Mr. Michael Kutch***	Risk Management Process Improvements on the Global Hawk Program ***Mr. Doug Atkinson***
Regency B	TRACK 2 Test & Evaluation in Systems Engineering Mr. Al Brown Session 4C2	Engineering Practices for System Assurance ***Mr. Paul Croll***	Getting Started With Measuring Your Security ***Ms. Michele Moss***	Horizontal Integration of ESOH Requirements within the Program Management Office for Future Combat Systems (Brigade Combat Team) ***Ms. Elizabeth Miller***
Regency C	TRACK 3 Program Management Mr. Bob Lyons Session 4C3	Effective QA on Small Projects ***Ms. Jean Swank***	Systems Management: Can It Help Forecast Future Program Performance? ***Mr. Adrio DeCicco***	
Mission A	TRACK 4 Education & Training Session 4C4	Continuous Learning Module – M&S for Systems Engineering ***Mr. Michael Truelove***		
Mission B	TRACK 5 Modeling & Simulation Mr. Jim Hollenbach Session 4C5	A Supply Chain Simulation for Program Managers in Manufacturing ***Mr. Swee Leong***	Modeling & Simulation in Systems Engineering - "Standardizing the Next Generation of Military Vehicle Cooling Systems" ***Mr. Neil Slyva***	
Mission C	TRACK 6 Net Centric Operations Mr. Jack Zavin Session 4C6	An Industry Situational Assessment of the Current Maturity of Data Standards, Processes and Infrastructure to Implement a Net-Centric Information Systems Common Data Environment ***Mr. Dick Engwall***	Determining System Interoperability Using an Integration Readiness Level ***Dr. Brian Sauser***	
Island A	TRACK 7 Best Practices & Standarization Mr. Paul Croll Session 4C7	Extending the Team Software Process (TSP) for Systems Engineering ***Mr. Dennis Linck***	Implementations of the STEP Systems Engineering Standard (AP233) ***Mr. James U'Ren***	
Island B	TRACK 8 Session 4C8			

Conference Adjourns

9th Annual Systems Engineering Conference
Hyatt Islandia, San Diego, CA
October 23-26, 2006 • Event #7870

National Defense Industrial Association
2111 Wilson Boulevard, Suite 400
Arlington, VA 22201-3061
(703) 522-1820 • (703) 522-1885 fax
www.ndia.org

3 Ways to sign up:
1. Online with a credit card at www.ndia.org
2. By fax with a credit card — Fax: 703-522-1885
3. By mail with a check or credit card

o Address change needed

NDIA Master ID/Membership # _____ Social Security # _____
(if known—hint: on mailing label above your name) *(last 4 digits – optional)*

Prefix _____
(e.g. RADM, COL, Mr., Ms., Dr., etc.)

Name First _____ MI _____ Last _____

Military Affiliation _____ Nickname _____
(e.g. USMC, USA (Ret.) etc.) *(for Meeting Badges)*

Title _____

Organization _____

Street Address _____

Address *(Suite, PO Box, Mail Stop, Building, etc.)* _____

City _____ State _____ Zip _____ Country _____

Phone _____ ext. _____ Fax _____

E-Mail _____

Signature* _____ Date _____

Preferred way to receive information

Conference information o address above o Alternate *(print address below)* o E-mail

Subscriptions o address above o Alternate *(print address below)*

Alternate Street Address _____

Alternate Address *(Suite, PO Box, Mail Stop, Building, etc.)* _____

City _____ State _____ Zip _____ Country _____

** By your signature above you consent to receive communications sent by or on behalf of NDIA, its Chapters, Divisions and affiliates (NTSA, AFEI, PSA, NCWG, WID) via regular mail, e-mail, telephone, or fax. NDIA, its Chapters, Divisions and affiliates do not sell data to vendors or other companies.*

By completing the following, you help us understand who is attending our meetings.

Primary Occupational Classification. *Check ONE.*
- o A. Defense Business/IIndustry
- o B. R&D/Laboratories
- o C. Army
- o D. Navy
- o E. Air Force
- o F. Marine Corps
- o G. Coast Guard
- o H. DOD/MOD Civilian
- o I. Gov't Civilian (Non-DOD/MOD)
- o J. Trade/Professional Assn.
- o K. Educator/Academia
- o L. Professional Services
- o M. Non-Defense Business
- o N. Other _____

Current Job/Title/Position. *Check ONE.*
- o A. Senior Executive
- o B. Executive
- o C. Manager
- o D. Engineer/Scientist
- o E. Professor/Instructor/Librarian
- o F. Ambassador/Attaché
- o G. Legislator/Legislative Aide
- o H. General/Admiral
- o I. Colonel/Navy Captain
- o J. Lieutenant Colonel/Commander/Major/Lieutenant Commander
- o K. Captain/Lieutenant/Ensign
- o L. Enlisted Military
- o O. Other _____

Year of birth _____
(Optional)

Registration Fees

	Early *before 08/30/06*	Regular *8/30/06-10/06/06*	Late *after 10/06/06*
Government/Academia	o $660	o $725	o $800
Industry/NDIA Member	o $775	o $855	o $940
Industry/Non-Member	o $825	o $910	o $1000

Tutorial Registration - MONDAY ONLY ☐ $200
Tutorial registration is for the Monday Tutorial Session ONLY, and it is in addition to the Conference Registration Fee

Cancellations received before August 12, 2006 will receive a full refund. Cancellations received between August 12, 2006 and October 6, 2006 will receive a refund minus a cancellation fee of $75. No refunds for cancellations received on or after October 6, 2006.

Substitutions welcome in lieu of cancellation.

Payment Options
- o Check *(payable to NDIA)*
- o Cash
- o Government PO/Training Form # _____
- o VISA
- o MasterCard
- o American Express
- o Diners Club

If paying by credit card, you may return by fax to (703) 522-1885.

Credit Card Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Exp. date ☐☐/☐☐

Signature _____ Date _____

Questions? Contact Britt Bommelje, Associate Director
(703) 247-2587 email: bbommelje@ndia.org

Mail to: NDIA, Event #7870
2111 Wilson Boulevard, Suite 400
Arlington, VA 22201

Fax to: (703)522-1885

Registration for Displays, Event # 7870
9th Annual Systems Engineering Conference
October 23-26, 2006
Hyatt Islandia
San Diego, CA

Name _____
Title _____
Company Name _____
Division/Dept. _____
Address _____
City/State/Zip _____
Phone _____ Fax _____
E-mail _____

Display Requirements:
All displays must be of the simple table-top/pop-up style standards. Space per display shall not exceed 10 ft. wide by 6 ft. deep. Minimal hardware to be utilized (computer systems for demonstrations are OK). No formal decorating company is involved. Companies must bring their own displays and plan to do their own set-up. Standard 2.5 x 6 ft. draped folding tables and chair will be provided for each display space. No other props or setups (pipe & drape, plants, etc.) will be utilized.

Display Hours:
Displays are to be set up by 4:00 PM October 23, 2006 and should remain in place until after the mid-morning break on October 26, 2006. Displays must be removed by 4:00 PM October 26, 2006.

Cost: Displays (includes one free registration and electrical hook-up for display): $ 1,000

Display Rules & Regulations:
1. If NDIA should be prevented from holding the conference for any reason beyond NDIA's control (such as, but not limited to, damage to the building, riots, strikes, acts of government, or acts of God) or if a displayer cannot occupy the assigned display space due to reasons beyond NDIA's control, then NDIA has the right to cancel the conference or any part thereof, with no further liability to the displayer other than a refund of display space fee, less a proportionate share of the conference cost incurred.
2. Neither the management of the host facility nor NDIA shall be liable for the damages, loss or destruction to the displays by reason of fire, theft, accident or other destructive causes. Displayer shall lease space at his sole risk. Neither the management of the host facility, NDIA nor any of their agents, servants or employees will be accountable or liable for accidents to displayers, their agents or employees.
3. The displayer shall be liable to the host facility and/or NDIA for any damage to the building and/or the furniture and fixtures contained therein which shall occur through acts or omissions of the displayer.
4. Displayer assumes the entire responsibility and hereby agrees to protect, indemnify, defend and hold harmless NDIA, the host facility, their officers, employees, and agents against all claims, losses and damages to persons and property, governmental charges or fines, and attorney's fees arising out of or caused by displayers installation, removal, maintenance, occupancy or use of the display premises or any part thereof, including any outside display areas.
5. Displayer acknowledges that NDIA does not maintain and is not responsible for obtaining insurance covering displayer's property. Displayers are advised to obtain business interruption and property damage and loss insurance to cover such occurrences.

Send this form with payment for display to:
Britt Bommelje, Associate Director, National Defense Industrial Association, 2111 Wilson Boulevard, Suite 400, Arlington, VA 22201-3061, Phone: (703)247-2587, Fax: (703)522-1885, E-mail: bbommelje@ndia.org.

Deadline for sign-up is Friday, October 13, 2006 . Make checks payable to NDIA - Event # 7870.

☐ Check (payable to NDIA - Event #7870)

☐ Visa ☐ Diner's Club ☐ Mastercard ☐ Amex

Credit Card #_____ Exp. Date_____
Authorized Signature_____

Looking for something to do in San Diego?



Ride the Giant Dipper Rollar Coaster at Mission Beach



Explore the San Diego Zoo





Experience a San Diego Charger Football game - Sunday, October 29 1:05 pm vs. St. Louis Rams



Tour the USS Midway in San Diego's Port

For more information on what to do in San Diego please visit www.sandiego.org



2111 Wilson Blvd.
Suite 400
Arlington, VA 22201-3061
www.ndia.org

9th Annual Systems Engineering Conference
"Focusing on Improving Performance of Defense Systems Programs"
October 23-26, 2006
San Diego, CA



Defense View on Considerations for System of Systems SE

25 October 2006

Kristen Baldwin
Systems and Software Engineering
Office of the Under Secretary of Defense (AT&L)

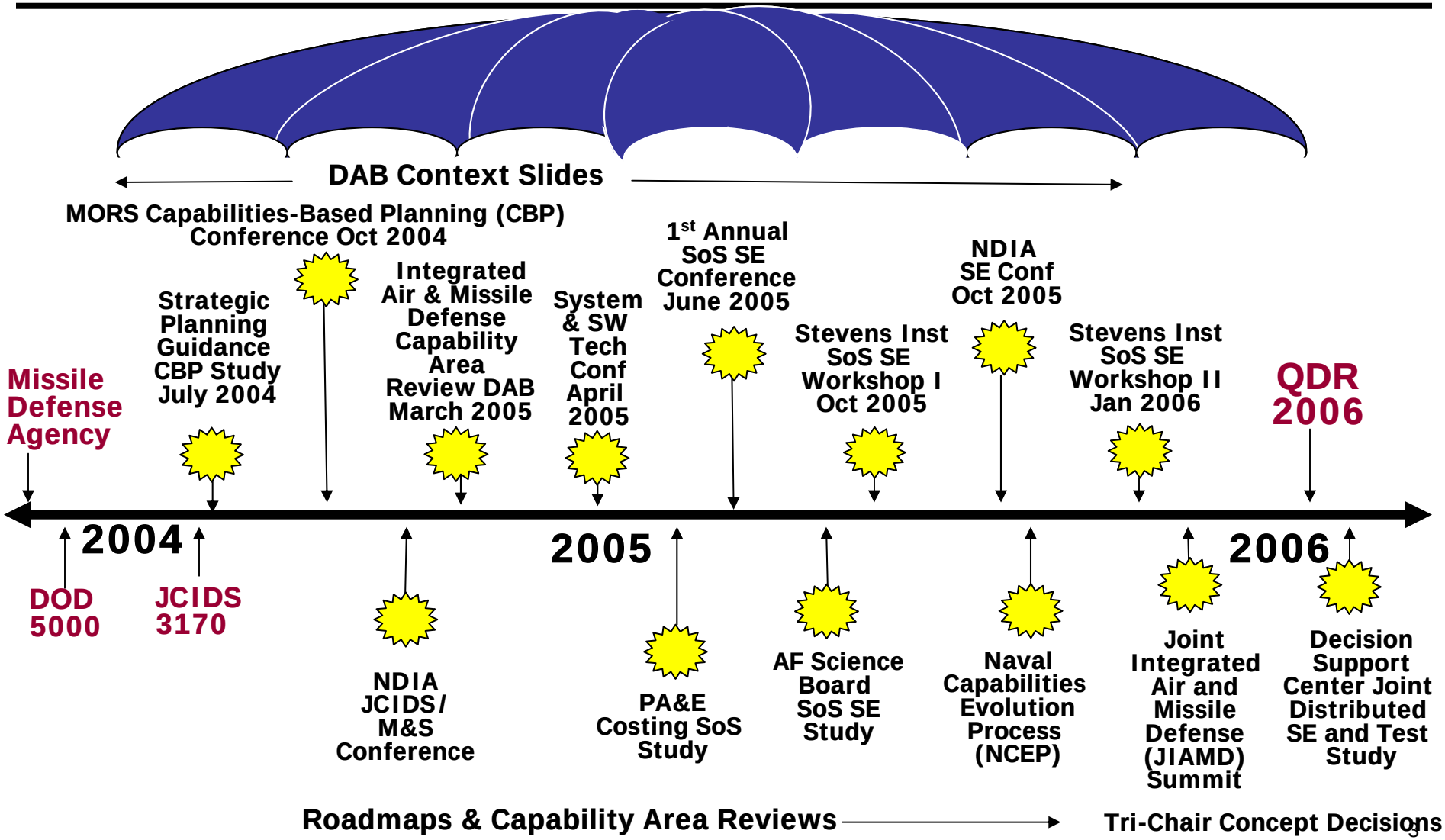
Dr. Judith Dahmann
The MITRE Corporation

Robin Gullifer
Systems and Software Engineering
Office of the Under Secretary of Defense (AT&L)

Purpose and Overview

- Purpose of Presentation
  - Provide an update on AT&L SE activities to support capabilities and systems of systems
- Overview of Topics
  - Background
  - Recent events
    - INCOSE, QDR Portfolio Test Cases, DoD SW Strategy Summit
  - New initiative
    - DUSD (A&T) directed OSD-led effort to develop and publish System-of-Systems (SoS) Systems Engineering Guide
  - Way Ahead

Evolving Perspectives on SoS SE



INCOSE Panel on System of Systems July 2006

- One of a number of events addressing issues of SOS
- Series of presentations from academia and industry
- Quotable quotes
  - "There is no nice line between Systems and SoS"
  - "There is no difference between SE for systems and SOS…"
  - "There is a simply a need for better requirements management for SoS…"
  - "Thinking that traditional SE methods/techniques are sufficient for SOS is dangerous.."
  - "Standard SE applies but requires extensions"
  - "Only difference is no one in control in a SOS…."
  - "Nothing is new. Any system that has sub-systems is a SoS. We have been doing this forever."

Wide range of perspectives on SOS and SE today

Defense Considerations for SoS

- **Scale**
  - Size of defense enterprise makes a single integrated architecture infeasible
- **Ownership / Management**
  - Individual systems are owned by the military component or agencies, introducing constraints on management and SE
- **Legacy**
  - Given defense budget projections, current systems will be part of the defense inventory for the long-term and need to be factored into any approach to SOS
- **Changing operations**
  - Changing threats and concepts mean that new (ad hoc) SoS configurations will be needed to address changing, unpredictable operational demands
- **Criticality of SW**
  - SOS typically focus on integration across systems through cooperative or distributed software
- **Role of network**
  - Conceptually DOD SoS will be network based; budget and legacy challenges of budgets and legacy mean uneven implementation

QDR Implementation
SE for Capability Portfolio Test Cases

... there is a **need for systems engineering support to** ensure that the set of **capability solutions** – including legacy, planned, and programmed efforts – is coordinated so as to maximize the solutions' effectiveness and ensure their timely delivery to the warfighter...

Systems engineering will provide the technical base for selecting components of the systems needed to support portfolio objectives, for identifying the technical aspects of the of those systems critical to meeting the larger portfolio capability goals, and **for defining and assessing the end-to-end performance of the system of systems**…

… engineering of the systems will remain the responsibility of the program managers or components… **system of systems engineering function will address technical aspects of design, configuration, and system integration that are critical to meeting joint capability objectives…**

Deputy Secretary of Defense Capability Portfolio Management Test Case Guidance, 14 Sept 2006

- Quadrennial Defense Review directed DOD move towards a portfolio approach to force development based on Joint capabilities
- Four test cases have been initiated
- In each case SE is seen as a portfolio level function

Defense SW Strategy Summit October 2006

Top Software Issues

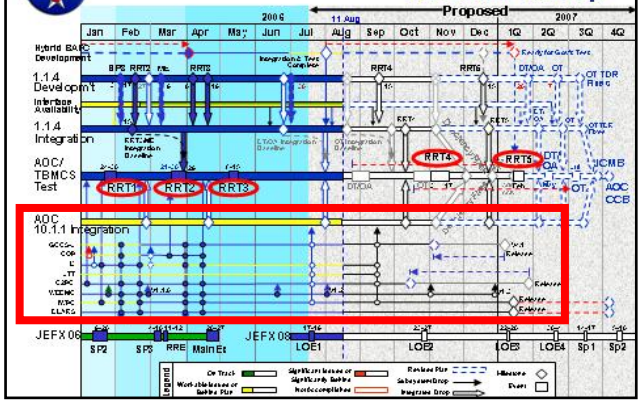
1. The impact of requirements upon software is not consistently quantified and managed in development or sustainment.
2. Fundamental system engineering decisions are made without full participation of software engineering.
3. Software life-cycle planning and management by acquirers and suppliers is ineffective.
4. The quantity and quality of software engineering expertise is insufficient to meet the demands of government and the defense industry.
5. Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.
6. There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.
7. Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

Opportunities for Improvement

- Development environments for net-reliant embedded systems must:
  - Readily embrace emerging data and knowledge management strategies
  - Automatically facilitate and assess interoperability and protocol implementation compatibility
  - Address system-of-systems design
    - Properties-in-the-large, composeability, security
  - Accommodate data and functional uncertainties associated with ad-hoc networks and transient application relationships
- System-of-Systems Verification

QDR highlights need for Systems of Systems

AOC 10.1.1 Target Integrated Master Schedule Roll Up



Strategic Initiatives

Focus Area	Initiative
Process and People Focus	**1. Acquisition Process Improvement** *Foster migration to a model-based approach for continuously improving the software and software intensive systems across the Army*
	2. Measurement *Increase the visibility of software metrics in system management/development*
	3. Training & Education *Prepare Army leadership, Program Managers, and Staffs to meet the technology and management challenges inherent to the acquisition of software intensive systems*
Technology Focus	**4. Architecture** *Institutionalize knowledge and practice of software architecture to improve quality, lower costs, and reduce cycle times for software and software intensive systems*
	5. System of Systems Integration *Develop strategies and techniques to identify and resolve issues in meeting system of systems, net-centric, capability-based requirements for interoperability and joint war fighting*
Future Focus	**6. Analysis & Strategic Planning** *Investigate new challenges and opportunities*

- Purpose
  - Focus efforts on top DOD SW issues
- Panels & workgroups
  - PEOs, SEs, SW experts
- Recurring topic of SOS
  - SW Challenges
  - PEO and Service initiatives
  - Research efforts

SW is a key element of SOS

Profiling the Context for SE: One Model



- **Typical program domain**
  - *Traditional systems engineering*
  - *Chief Engineer inside the program; reports to program manager*
- **Transitional domain**
  - *Systems engineering across boundaries*
  - *Work across system/program boundaries*
  - *Influence vs authority*
- **Messy frontier**
  - *Political engineering (power, control…)*
  - *High risk, potentially high reward*
  - *Foster cooperative behavior*

Source: Renee Stevens

© 2006 The MITRE Corporation. All rights reserved

SoS SE Guide

- DUSD (A&T) directed OSD-led effort to develop and publish System-of-Systems (SoS) Systems Engineering Guide
- Purpose
  - Leverage current experience to support ongoing efforts to develop, field and sustain SoS
  - Focus on technical aspects of SE applicable across SOS management constructs
- Version 1
  - 6 month effort addressing areas of agreement across the community
- Audience - Program Managers and Lead/Chief Engineers
- Development Participants
  - Lead by AT&L Systems and Software Engineering
  - IPT with representatives from Services and Agencies
  - Stevens Institute is the integrating author

Draft (Version .1) of Guide is now out for review

The Guide Addresses ....

- Definitions
- Scope
- Characteristics of the SOS environment
- Illustrative DOD use cases
- Challenges and approaches to SE processes

Definitions
Draft SOS SE Guide

System

An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective

Mil-Std 499B

System of Systems

A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities

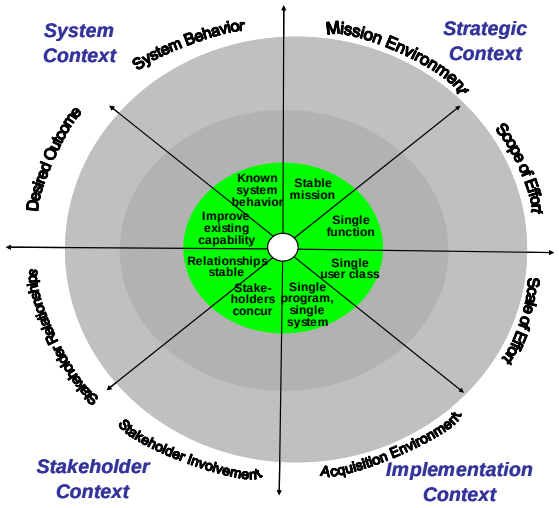
DoD Defense Acquisition Guide, System of Systems Engineering

System of Systems Engineering

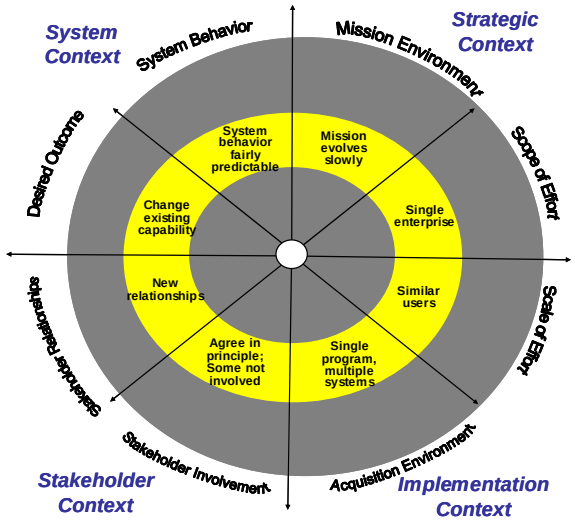
Planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a SoS capability greater than the sum of the capabilities of the constituent parts

DoD Defense Acquisition Guide, Chapter 4

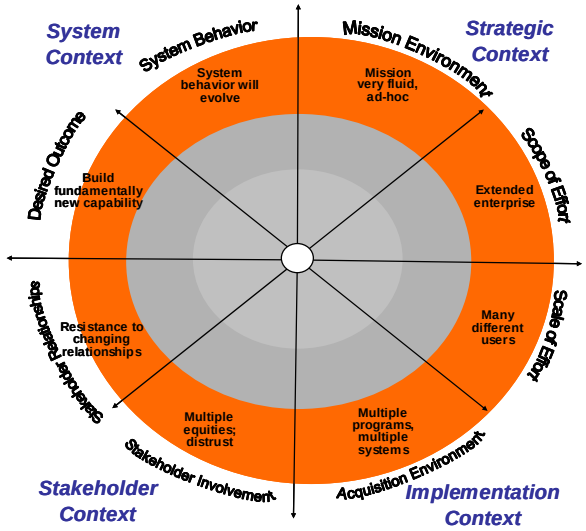
Scope
Spectrum Of Issues



Current Systems Engineering Practices



Focus of Initial Version of SOS SE Guide



Challenges

SoS cases under the well-defined circumstances where there is

(1) defined user need

(2) resources designated to address the need and

(3) someone has the responsibility to address the need

Draft SoS SE Guide
Characterizing the SoS Environment

Community Involvement: Stakeholders, Governance

System: stakeholders generally committed only to the one system

SoS: stakeholders more diverse; stakeholders from each system will have some interest in the other systems comprising the SoS

Employment Environment: Mission Environment, Operational Focus

System: mission environment is relatively stable, pre-defined, and generally well-known; operational focus is clear

SoS: emphasis on multiple missions, integration across missions, need for ad hoc operational capabilities to support rapidly evolving mission objectives

Implementation: Acquisition/Test And Validation, Engineering

System: aligned to ACAT Milestones, specified requirements, a single DoD PM, SE with a Systems Engineering Plan (SEP), test and validating the system is possible

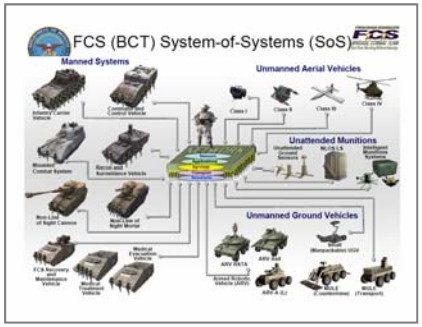
SoS: multiple system lifecycles across acquisition programs, involving legacy systems, developmental systems, and technology insertion with multiple DoD PEOs, PMs and operational and support communities; testing is more difficult, and test and validation can be distributed and federated

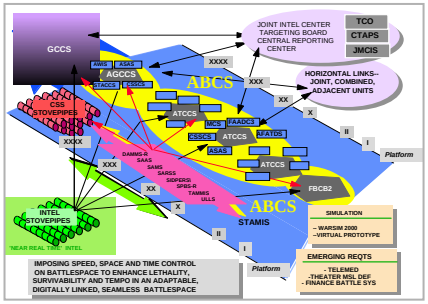


Defense Experience With SoS SE Several Examples

- New Development
  - Future Combat System (FCS) and Integrated Deepwater System (IDS)
- Development of New Capability by Integrating Current System
  - Army Battlefield Command System (ABCS)
- Mixed System Maturity Levels
  - Naval Integrated Fire Control-Counter Air (NIFC-CA) and Single Integrated Air Picture (SIAP)
- Sustaining Capabilities
  - Stryker Brigade Combat Team (BCT)
- IT/Business
  - Commissary Advance Resale Transaction System (CARTS)

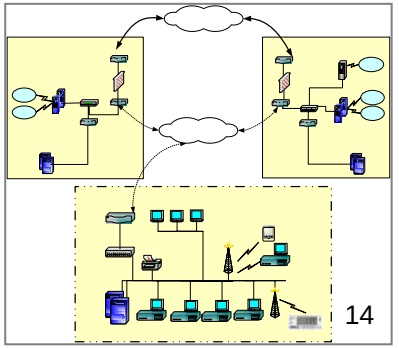




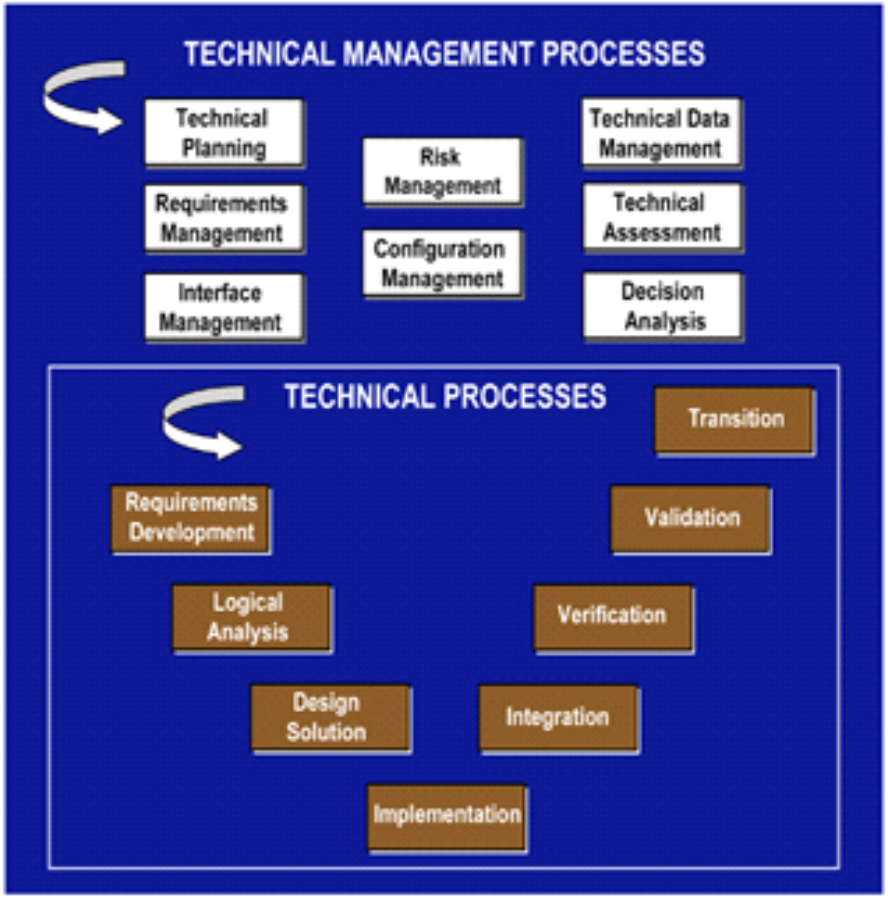








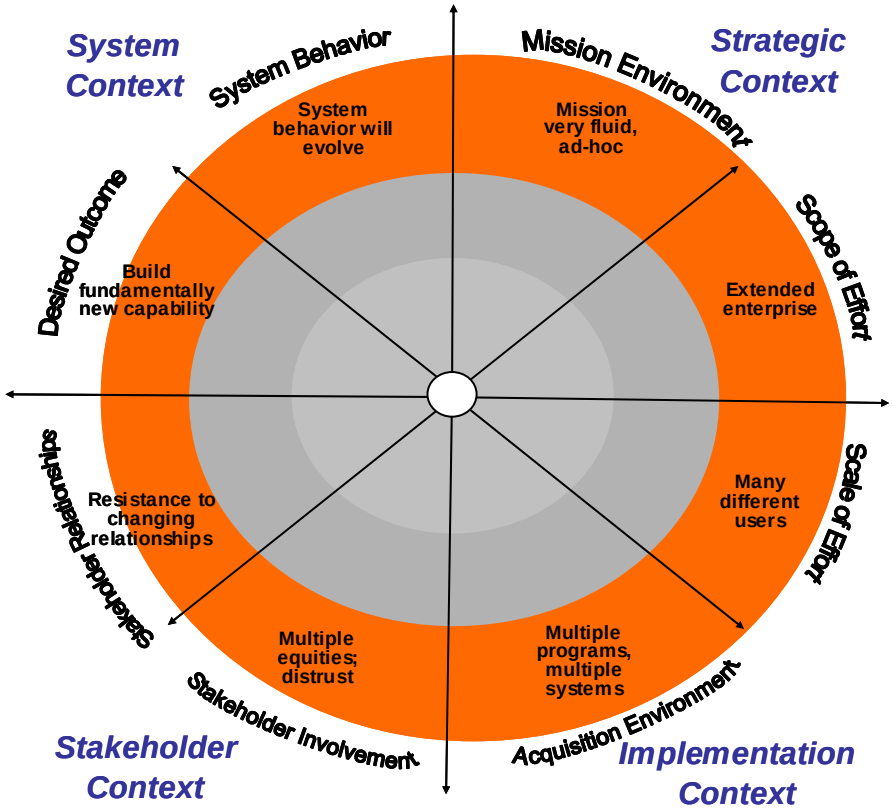
Draft SOS SE Guide
Challenges of SoS for SE Processes



From Chapter 4 Defense Acquisition Guide

- Technical and Technical Management Processes for SE
  - Identify implications of SOS for each process
  - Challenges these pose for the SE
  - Approaches to address the challenges
- Processes apply, but the SOS environment affects approaches, methods and tools needed by SE
  - More collaboration, less top down
  - More complexity to accommodate requirements, approaches and tools used by constituent systems
  - Balance between roles of SOS SE and the system SE
  - More need for experimentation to determine ways to employ existing systems and to discover effects of combined systems

Next Steps



Challenges

Version 2 and Beyond

NDIA
9th Annual Systems Engineering Conference
San Diego, California
October 23-26, 2006

Implementing an Effective Peer Review Process

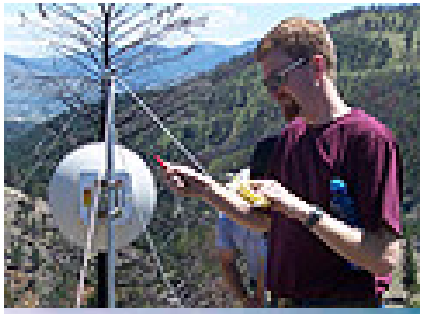
Jeanne Balsam
Jean Swank
Lee Sheiner

Electronic Systems Laboratory
Georgia Tech Research Institute
Georgia Institute of Technology



Georgia Tech Research Institute (GTRI) Overview

- Unit of the Georgia Institute of Technology
- 1200+ employees
- 70% of research employees hold advanced degrees
- Wide variety of products
- Customers include federal and state government; and industry
- Competitively bid projects range greatly in size and duration
- More Info: http://www.gtri.gatech.edu/







Outline

- Purpose of peer review
- Formalize the peer review process
- Plan peer reviews
- Apply the process of a peer review
- Secondary benefits of peer reviews

What is a Peer Review?

"The review of work products performed by peers during development of the work products to identify defects for removal."

- CMMI Guidelines for Process Integration and Product Improvement (Addison Wesley, 2003, page 622)

Why Do Peer Reviews?

- Verify the work product meets requirements
- Identify defects or problems early in the life-cycle
- Gain confidence in work products
- Reduce risk



An Informal Peer Review



“Does this seem right to you?”

An Inappropriate Peer Reviewer



“Farmer Bob, does this seem right to you?”

Why Do We Need Formalized Peer Review Processes?

A formalized process helps ensure:

- Peer reviews are taking place
- The right products are being peer reviewed at appropriate times
- Adequate resources are planned and allocated for peer reviews
  - The right reviewers are being selected
  - The reviewers are prepared adequately
- Defects are being recorded
- Defects are tracked to closure



Document the Peer Review Process

- Types of reviews
- What to review in each phase
- Planning
- Conducting
- Closing



Peer Review Types

Desk Check

- Single producer and single reviewer
- Cheapest, least effective review

Round Robin

- Single producer and at least two reviewers
- Reviewers examine work product sequentially
- A single defect log is used
- Moderator verifies defects are corrected

Structured Walkthrough

- One or more producers, at least two reviewers, a moderator, and a recorder
- All participants meet after reviewers have prepared
- More expensive and effective than a Round-Robin

Formal Inspection

- Roles and format similar to Structured Walkthrough
- Outside experts participate
- Advanced preparation is extensive and required
- Most expensive and effective review type

What to Review

Requirements

Design

Implementation

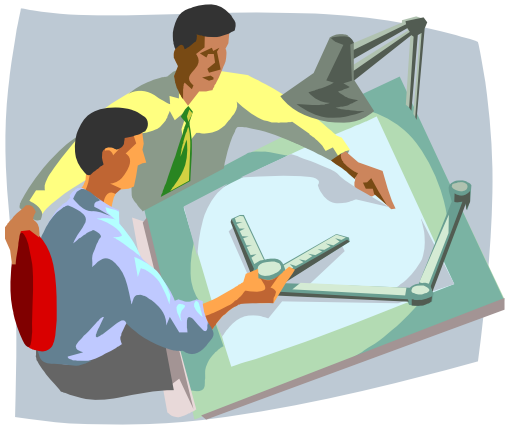
- **Critical components**
- **Complex components**
- **New employee's work**
- **New technology or platform**

Test Plans



Plan Peer Reviews

- Determine what will be peer reviewed
- Determine when it will be peer reviewed
- Provide adequate budget for peer reviews
- Plan for critical reviewers
- Plan for appropriate facilities

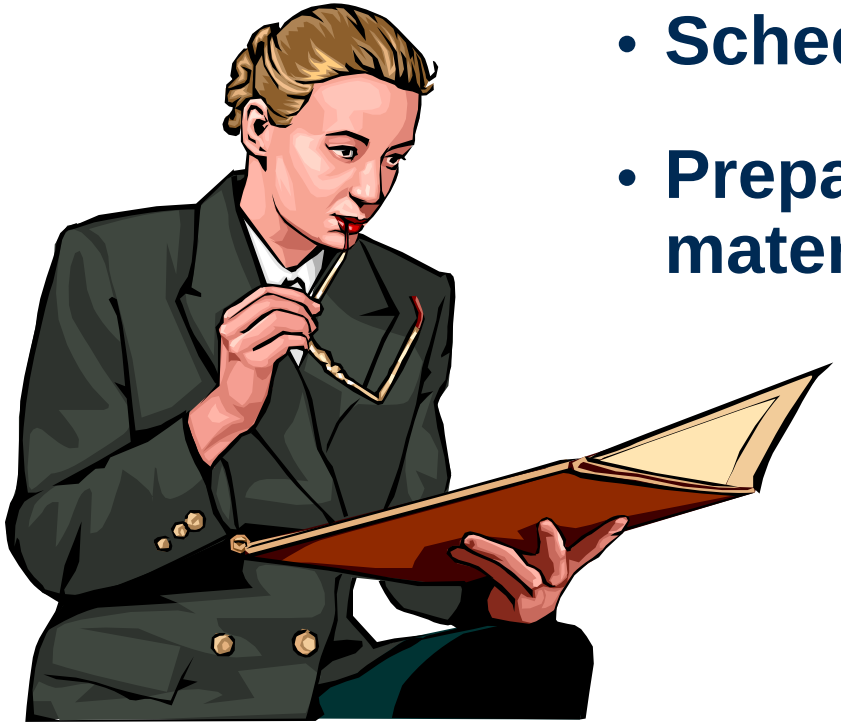


Applying the Process



Prepare for Peer Reviews

- Choose reviewers
- Schedule meeting
- Prepare review and reference materials



Choosing Reviewers



- Knowledgeable and trained
- Some project-independent reviewers are desirable
- Non-management, unless special circumstances require a manager's participation
- Committed to adequately prepare

Scheduling the Meeting

- Allow the reviewers adequate time to prepare defect logs
- Define clear objectives regarding the amount of time (min/max) for the review preparation
- Limit meeting time to two hours
- Ideally choose a location with a networked computer, overhead projector, and access to configuration management system



Review and Reference Materials



- Review materials must be under version control
- Provide controlled defect logs to reviewers
- Identify location and version of all review materials
- Provide reference materials



Preceding the Peer Review

- Verify producer has distributed product for review
- Verify that reviewers are prepared
- Tabulate all the defects into a summary log



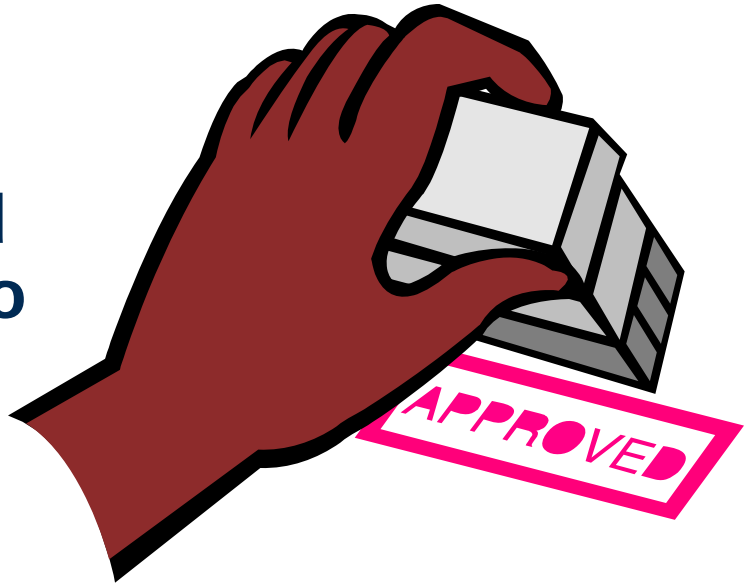
Conducting the Meeting

- Walk through the work product in its entirety; don't just look at the tabulated defects
- Ideally – use a projector so that everyone can see how defects are recorded
- Gain consensus during the review of the type, severity and disposition of each defect
- Identify, but don't try to fix the defects
- Determine if re-review is necessary



Closing the Peer Review

- Put peer reviews on the list of project deliverables so that closing them won't fall through the cracks
- Close out defects or write a change request
- Re-review if necessary
- Require project director and quality engineer signature to close the review



Secondary Benefits

- Create mini-milestones for work products
- Jump-start team communication
- Product quality increases when the author knows it will be reviewed
- An opportunity for team building within the project - everyone has to be reviewed and act as a reviewer

More Secondary Benefits

- Leverage team member skills
- Teach junior engineers “It’s OK to criticize senior people’s work”
- Exposes junior engineers to direct tutelage from experts
- Expose reviewers from outside the project team to new ideas, and vice-versa

Questions?



Contact Information

- **Jeanne Balsam**
  - jeanne.balsam@gtri.gatech.edu
- **Jean Swank**
  - jean.swank@gtri.gatech.edu
- **Lee Sheiner**
  - lee.sheiner@gtri.gatech.edu

- **More Info about GTRI:**
  http://www.gtri.gatech.edu/

NAVAIR

THE TEST AND EVALUATION OF EO SENSORS

NDIA Systems Engineering Conference, Oct 24 - 26 2006

San Diego, CA

Raymond F. Beach

NAVAIR ASSOCIATE FELLOW

EO/RADAR BRANCH HEAD

AGENDA

- **BACKGROUND**
- **APPROACH**
- **SPECIFICATION vs. REALITY**
- **FACTORS AFFECTING T&E**
- **DEVELOPMENT TEST AND EVALUATION**
- **FUTURE TRENDS**
- **QUESTIONS**

BACKGROUND

WHAT IS SYSTEMS ENGINEERING?

- … Focuses on *methods to solve problems*, not the solution of the problem….
- … Specifications and performance metrics ……..
- …. Optimization methods in presence of constraints… .
- Modeling and Simulation

APPROACH

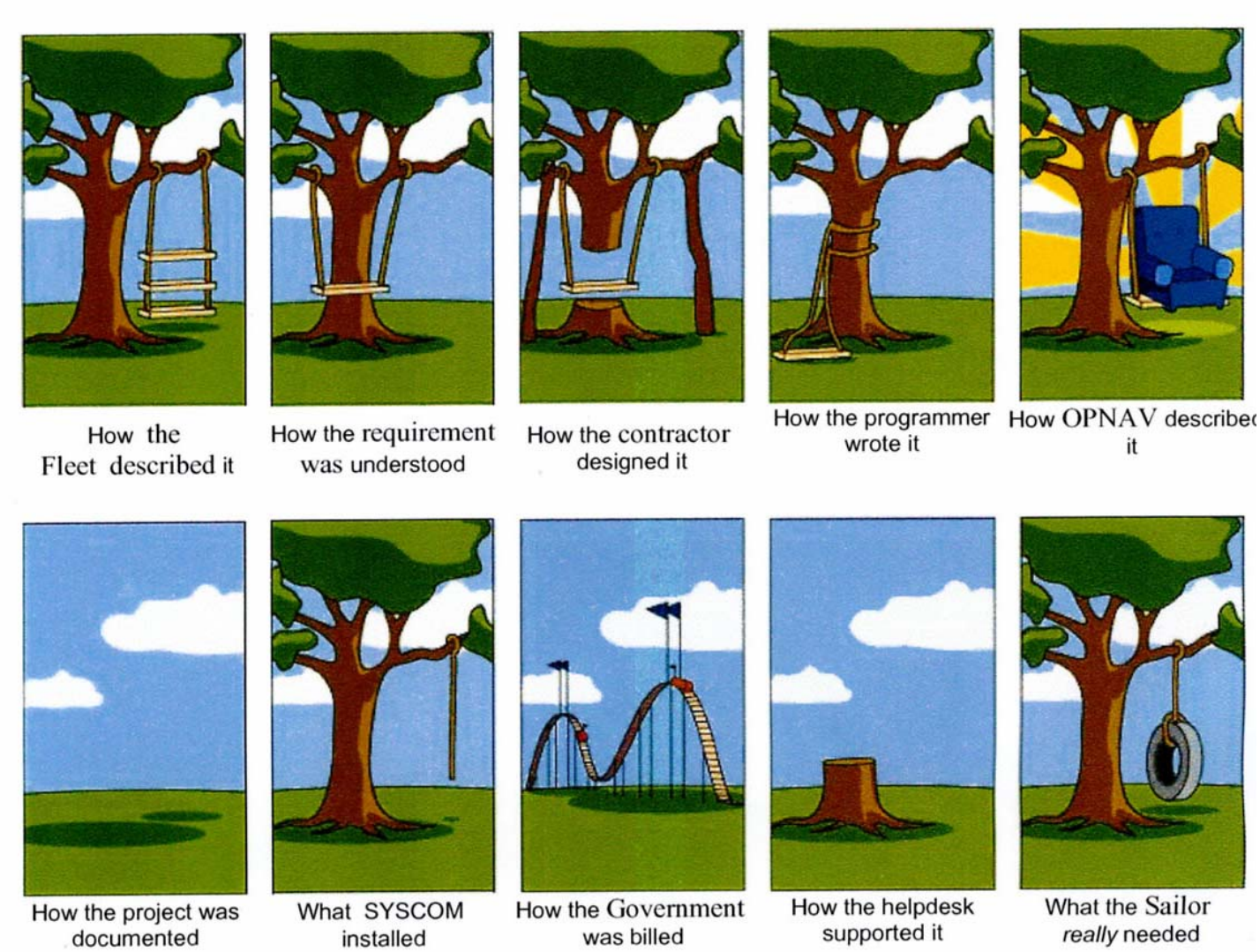
WHAT THE WARFIGHTER WANTS/NEEDS

SYSTEMS ENGINEERING



WHAT THE WARFIGHTER GETS

PERCEIVED ACQUISITION PROCESS



T&E PROCESS (CONCEPTUAL)



Concept/Design to meet Need

Vision for Need (Warfighter)

Articulate need (Service to Congress)

SPECS to Testers (PMA to us)

Build System

ETHER

Actual testing

Pound Pavement for Support

SPECIFICATION vs. REALITY

- **YARDSTICK OF PERFORMANCE DURING DT**
- **WHAT IS NEEDED vs. WHAT IS EXPECTED**
- **DT vs. OT**
  + Blurry Demarcation/Combined T&E
- **REQUIREMENTS "CREEP"**
  + Technology insertion/Spiral Development
- **PERFORMANCE BASED SPECIFICATION**



FACTORS AFFECTING T&E

- **ADVANCING TECHNOLOGY**
  + Visual Conformation of Target
  + Higher resolution Sensors (Radar and EO)
  + Laser Designation
  + Real Time Imagery

  TESTERS DRIVEN TO DEVELOP TESTS AND PROCEDURES TO HANDLE TECHNOLOGICAL DEVELOPMENTS

- **VEHICLE INTEGRATION**
  + Treat System Under Test (SUT) as ***complete system***: Front end – user
  + The aircraft/platform isn't the lab (Pay me now or ***really*** pay me later)
  + Pilot to Vehicle Interfaces

DEVELOPMENT TEST AND EVALUATION

- **CONSTRAINTS**
  - + LAB vs. Hangar
  - + Location of Equipment: Optical Bench vs. who knows where
  - + Variability of EO Sensors
    - * FOV's, Apertures, Scan Patterns, Lasers, etc.
  - + Test Equipment is never cheap or easy to maintain
  - + $$, Politics, Acquisition process, Sponsors, Time, blah blah blah

    ... Time to shoot engineers and get on with the project...

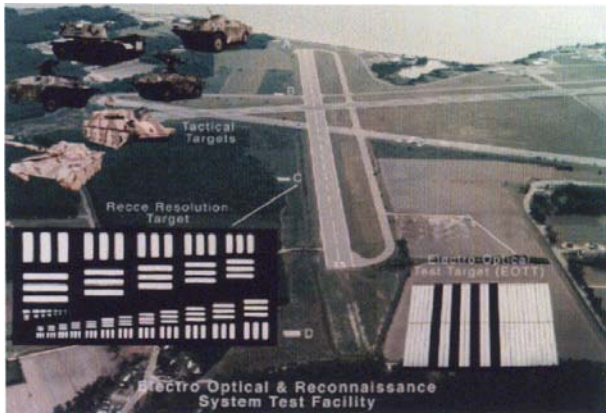
- **FLIGHT vs. GROUND**
  - + Important to exercise SUT under loads (see M&S later!)
    - * Hard to impossible to simulate A/C vibration and acoustics
  - + Can't request weather and environmental conditions
  - + Human in the loop
  - + Sophisticated Target Boards

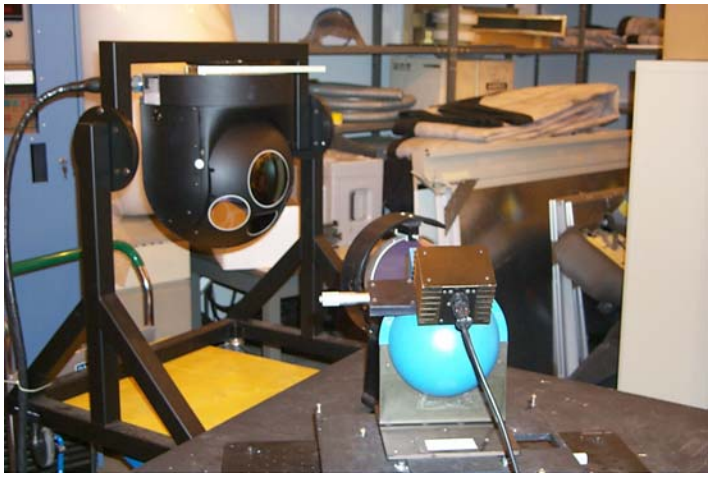
TESTER'S BIGGEST NO-NO

Unrealistic (stupid) or Unsafe TEST

EO T&E EQUIPMENT









MODELING AND SIMULATION

- **Move towards modeling based acquisition**
- **Integral part of T&E process**
  - + Should not replace flight test
    - * Reduce and refine flight tests
- **Pro's and Con's for DT**
- **Sometimes not as cheap as presented**
  - + Cost to develop, maintain and upgrade

MODELING AND SIMULATION

ADVANTAGES	DISADVATAGES
Allows 1000's of data runs	*Usually* not stochastic (Random inputs)
Early diagnostic tool for design decisions	Expensive to develop
Ability to test edge of envelope	Only as good as data in
Cheaper than Flight Test	Can't replicate all variables of platform
Provides "What if's?"	Verification, Validation & Accreditation (VV&A)
Can allow inclusion of other sensors to test integration	Accuracy/fidelity cost and time driven
Provides input for Fleet battlefield Experimentation—Allows insight into the "big picture" overview for operational implementation	Constant upgrades/maintenance

MODELING AND SIMULATION

HARDWARE IN THE LOOP

- **DIGITAL INJECTION**
  - + Repeatable High Clutter Environments
  - + Edge of Envelope Excursions
  - + GIGO
  - + Not end-end
  - + SUT must be duped into flight mode (AoA, INS, Alt, Airspeed, etc)
  - + Access points not always accessible

- **SCENE PROJECTION**

MODELING AND SIMULATION

HARDWARE IN THE LOOP

- **SCENE PROJECTION**

  + Project actual EO signals directly into optics
  + Assume digital model can drive projection equipment
  + Quick update rates over wide dynamic ranges
  + Collimated images into a wide range of FOV's
  + Single or Multiple sensors
    * Staring or slewing
    * More than one aperture
  + Expensive to build/develop

MODELING AND SIMULATION

BEST APPROACH

- **Combination of Digital Injection, Scene Projection then Flight Test**
- **No one "Silver Bullet"**
- **Utilize all tools in the inventory**
- **Limits regression testing**
- **Always use all of your available "Tools"**

MODELING AND SIMULATION

VERIFICATION, VALIDATION AND ACCREDIDATION

- **Convince T&E Engineer models are accurate and representative**
  + Must answer more questions than it raises
- **Only as good as data in**
  + Sometimes too expensive to collect data, and pursue VV&A
    (Spend $20M to get the $100 answer)
- **Who funds the effort**
- **Budget Time and $$ into program for "tweaks and upgrades"**
  + Collect real data to verify model (within error bars)
- **Get OT buy in– They need assurance that model reflects real world**
  + No "build it and they will come"

FUTURE TRENDS

- **Real-Time Tactical Imagery**
- **Active vs. Passive Imaging**
- **Multiple Sensor Fusion**
- **Information Dissemination**
  + NCW

QUESTI0NS/COMMENTS

POC:

Raymond F. Beach

NAVAIR Associate Fellow/EO-RADAR Branch Head

NAVAL AIR WARFARE CENTER

Mission Systems EvaluationDivision 5.1.2.7 BLDG 114 Room 209

22147 Sears Road Unit 4

Patuxent River, MD 20670

Phone: 301-342-6518

raymond.beach@navy.mil


NAV AIR

NATURAL SPI

Optimizing Risk Management

NDIA 9TH Annual Systems Engineering Conference
October 23-26, 2006 San Diego, CA

Rick Bollinger, PMP





SEI Partner

© 2006 Natural SPI

Optimizing Risk Management

Life at Level 3	3
Avoiding a Statistical Trap	5
Improving Risk Management	18
Risk Management System	21
Use in Higher Levels	31
Going Forward	37

© 2006 Natural SPI

Level 3 Risk Practices



Prepare for Risk Management — RSKM SG1

Identify and Analyze Risks — RSKM SG2

Identify Project Risks — PP SP2.2

Establish Budget and Schedule — PP SP2.1

Mitigate Risks — RSKM SG3

Monitor Project Risks — PMC SP13

Collect Improvement Information — RSKM GP3.2

© 2006 Natural SPI

Establish the Budget & Schedule

For each risk, multiply its impact times its probability, to get it's exposure

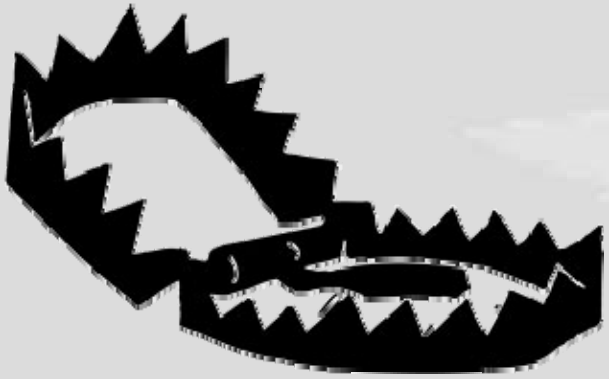
Add them all together to estimate a buffer or reserve

- Do this for effort
- Do this for duration
- Do this for costs

You could be falling into a trap!

© 2006 Natural SPI

Avoiding a Statistical Trap



© 2006 Natural SPI

Common Risk Planning Buffer Calculation

$$B = SUM(r_i * p_i)$$

Where:

r_i = impact of risk(i), i = 1 to n

p_i = probability of risk(i), between 0 and 1.0

B = total risk buffer estimated for any dimension of impact:

- cost
- duration
- effort, etc.



© 2006 Natural SPI

The Problem

Based on $B = SUM(r_i * p_i)$

HALF of your projects will be late!

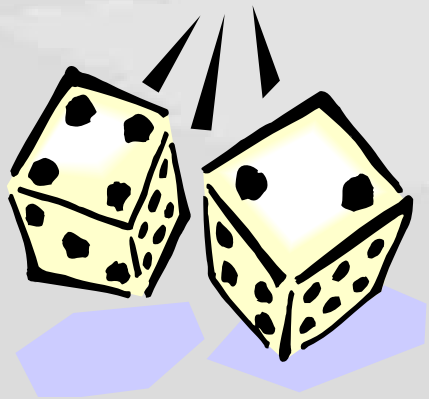


© 2006 Natural SPI

Big Questions

Would you start a project knowing there was a 50 percent chance it will be late based on risks alone?

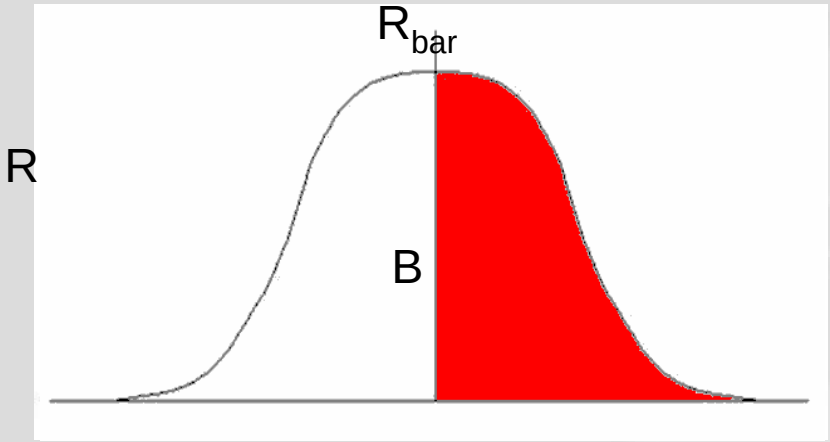
Would your customers accept having 50% of their projects being late?



© 2006 Natural SPI

Why the Problem?

The random variable to reflect the risk outcomes has a distribution that looks like this:

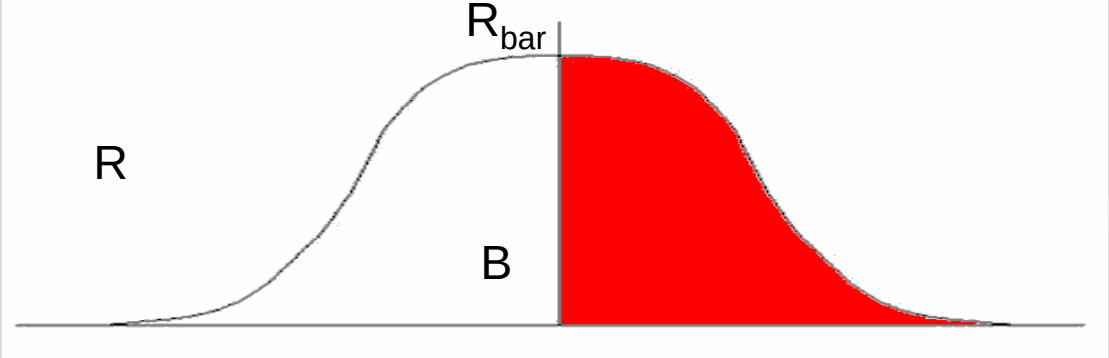


The buffer to protect the project from these risks, B, is commonly set to the expected value for the sum of manifested risks, R_{bar}.

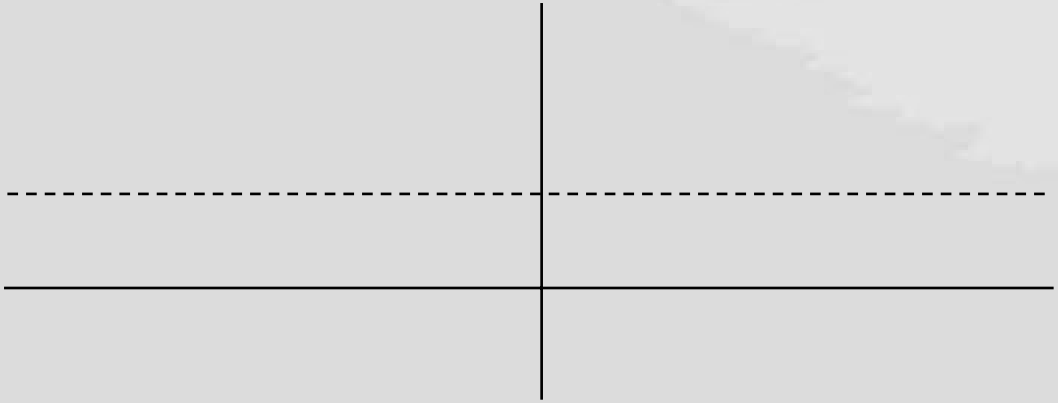
But, 50% of the outcomes will be greater than B.

© 2006 Natural SPI

On the Average You Will Break Even

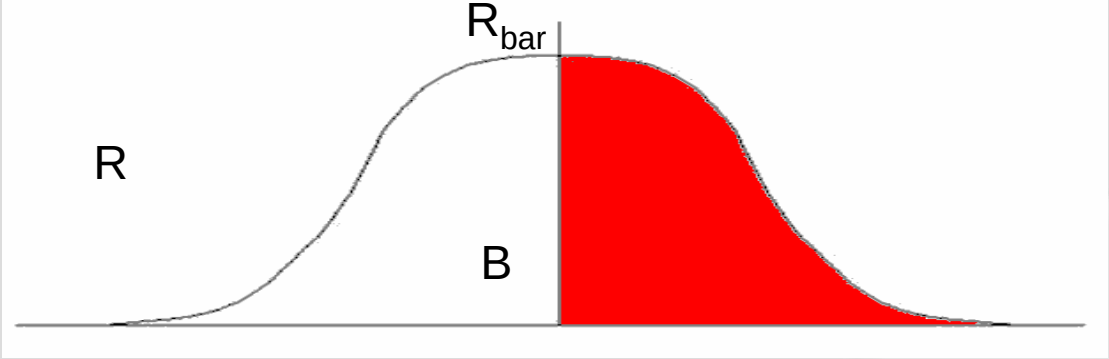


Assuming that the value of dollars or days to the left of B is the same of the units to the right.



© 2006 Natural SPI

But, the Assumption Does Not Always Hold



Dollars/days/units of estimate to the RIGHT of B can be much more expensive than units to the LEFT.

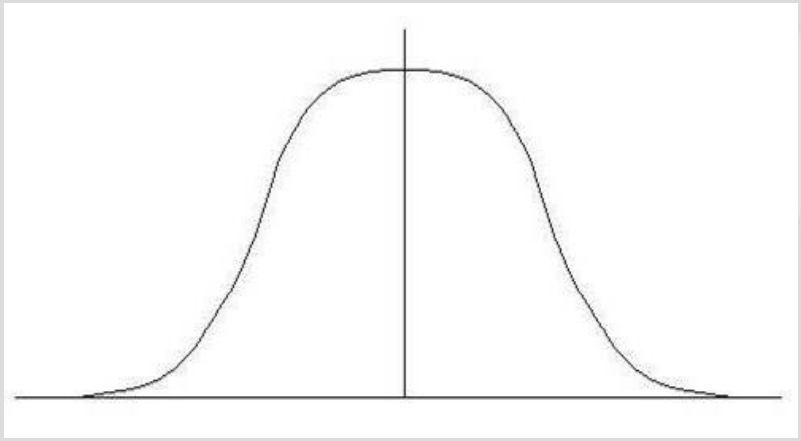


© 2006 Natural SPI



Central Limit Theorem to the Rescue

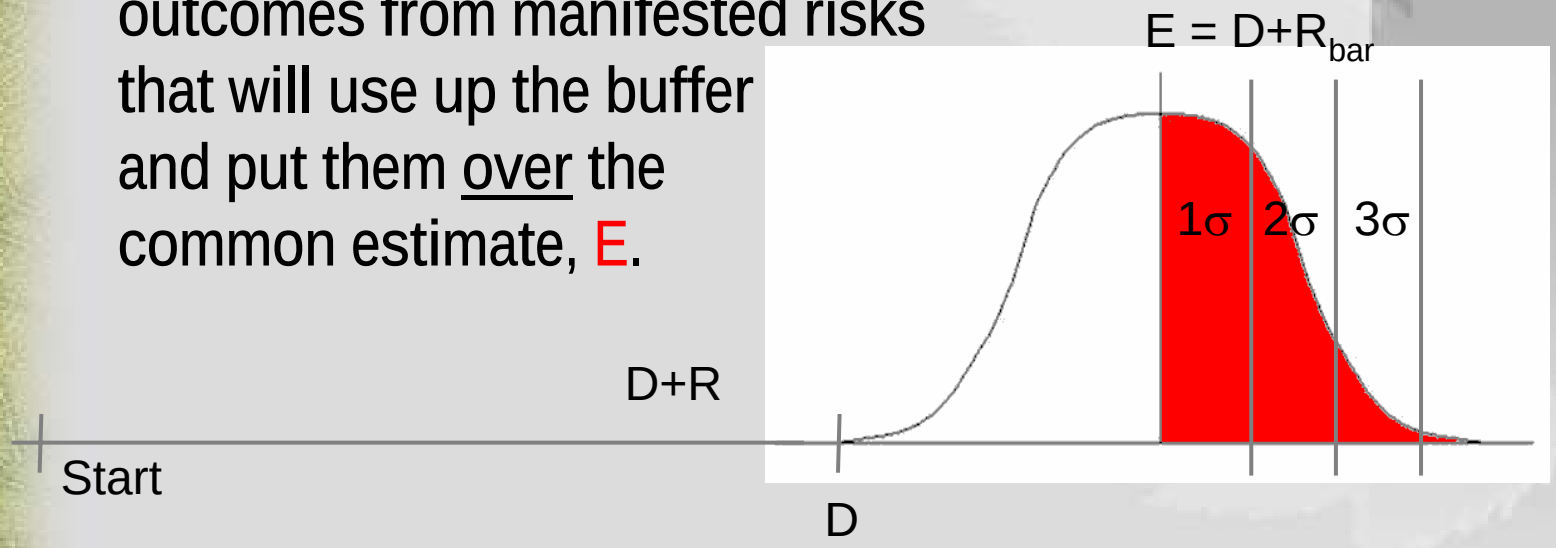
The Central Limit Theorem of statistics says that the sums of random variables tend to become approximately normal, i.e. they follow a Gaussian Curve.



© 2006 Natural SPI

How big should buffers be?

Applying this distribution to real projects with duration D means that half the projects will experience outcomes from manifested risks that will use up the buffer and put them over the common estimate, E.



We can estimate the standard deviation from the binomial nature of our risks: $\sigma = SQRT(SUM(r_i * p_i)/n)$.

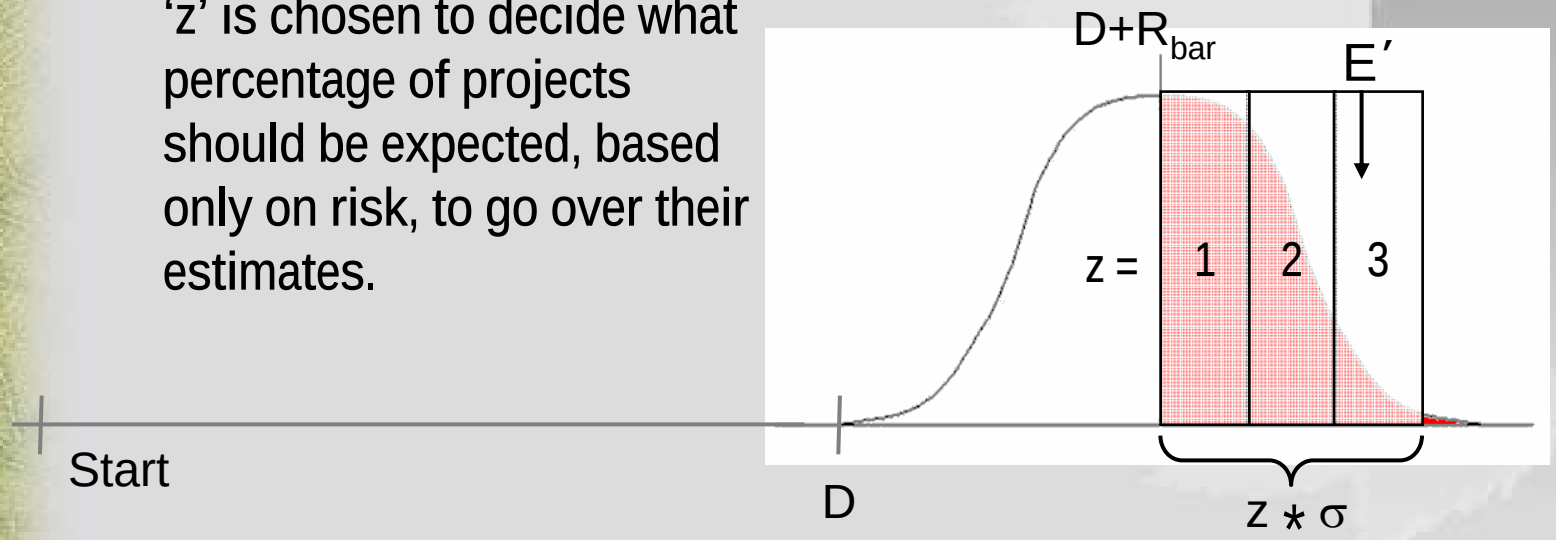
© 2006 Natural SPI

Choosing the Buffer

And use our estimate to calculate a new buffer, B′, and new Estimate,

$E' = D + B' = D + R_{bar} + (z * \sigma)$

'z' is chosen to decide what percentage of projects should be expected, based only on risk, to go over their estimates.



© 2006 Natural SPI



Choose your ‘z’

Select a standard value for ‘z’ to use to calculate risk buffers.

z = 0

will give you the protection you have now.

z = 2.0

will give you risk buffers to protect 97.72% of projects

(or phases of projects).

Only 2.28% would be expected to exceed their buffer.

z	% expected to be over
0.0	50.00%
0.5	30.85%
1.0	15.87%
1.5	6.68%
2.0	2.28%
2.5	0.62%
3.0	0.13%
3.5	0.02%

© 2006 Natural SPI

Using the New Buffer

The duration of projects will not increase.

The costs of projects will not increase.

Customers will not pay more or wait longer for projects.

Because…

Not all of risk buffers will be consumed! Some will. But, many won't.

Customers will actually find that you are early and under-budget (or late and over-budget) according to the 'z' factor that you chose.

© 2006 Natural SPI

Benefits

You will not over-promise.
You will not under-deliver.

You won't have to charge more.
You will just have to apologize less.

© 2006 Natural SPI

Improving Risk Management



© 2006 Natural SPI

How Do We Improve Risk Management?

- Learn more about risks:
  - estimate better
  - plan better
- Increase what we remember about problems and risks
- Leverage lessons learned
- Do all this systematically

© 2006 Natural SPI

Level 3 Risk Practices



Prepare for Risk Management — RSKM SG1

Identify and Analyze Risks — RSKM SG2

Identify Project Risks — PP SP2.2

Establish Budget and Schedule — PP SP2.1

Mitigate Risks — RSKM SG3

Risk Magic!

PMC SP13

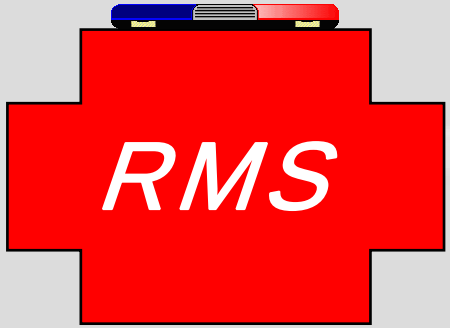
Monitor Project Risks

RSKM GP3.2

Collect Improvement Information

© 2006 Natural SPI

A Risk Management System



© 2006 Natural SPI

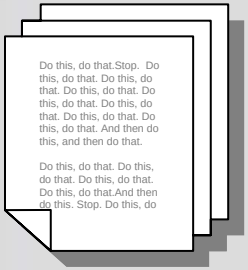
Elements of a System



People: trained and assigned with responsibilities to operate and maintain the system

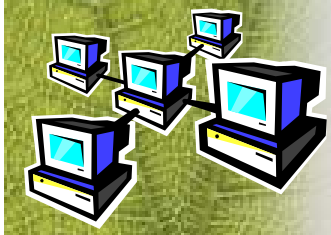


Technology: tools make it easier to operate the system. If people find activities too difficult they will not be done well



Processes: defined and available to guide activities and contribute to greater effectiveness, efficiency, and quality

© 2006 Natural SPI

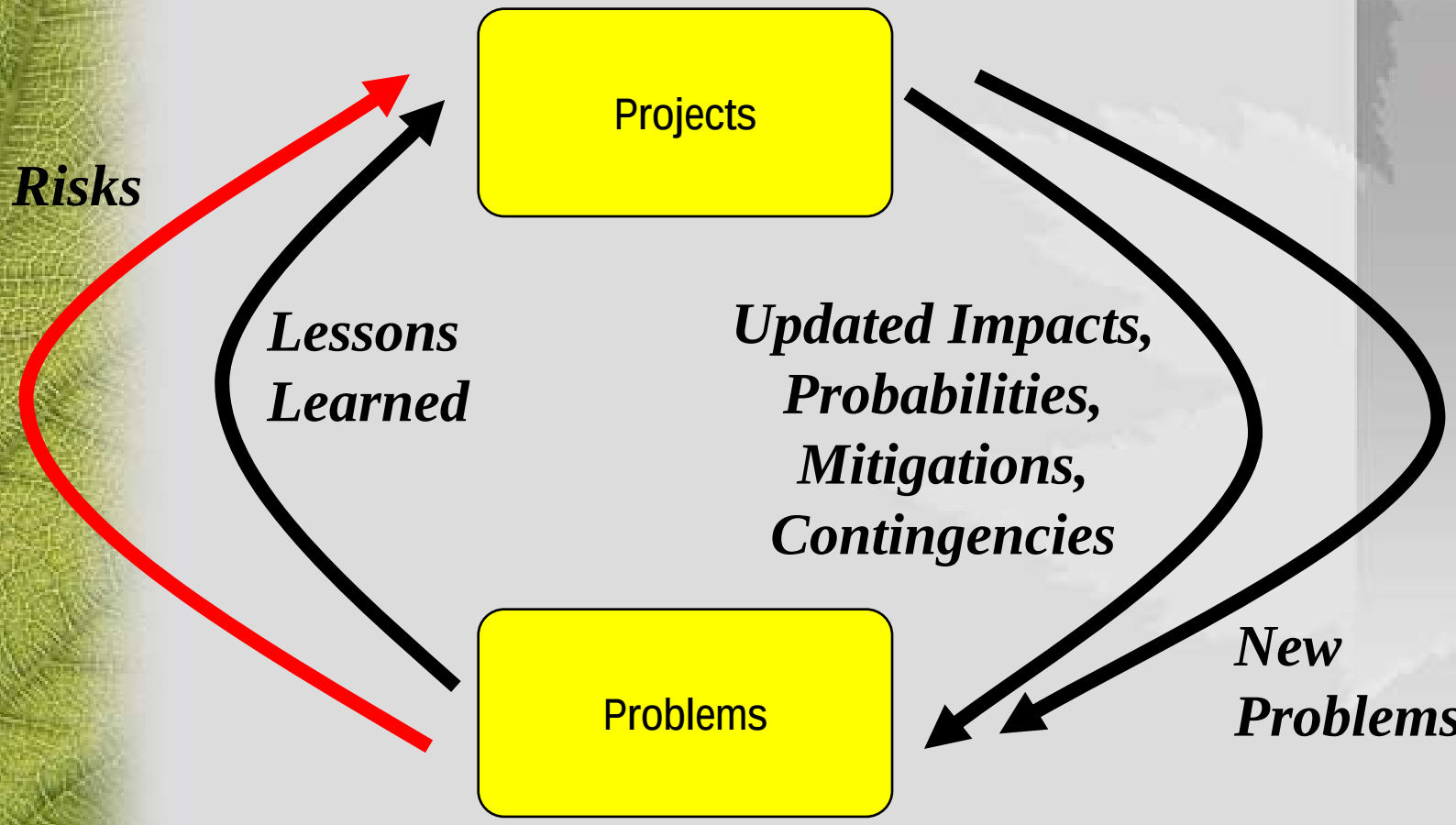


RMS Components

- People, training, support, responsibilities, stakeholders, monitoring and supervision of risk management
- Database of problems and risks with historical occurrences and supporting information
- Mechanism to collect data on problems, risks, and lessons learned on the success and costs of mitigations and contingency plans
- Processes, policies and plans defined to guide and give consistency to risk management activities

© 2006 Natural SPI

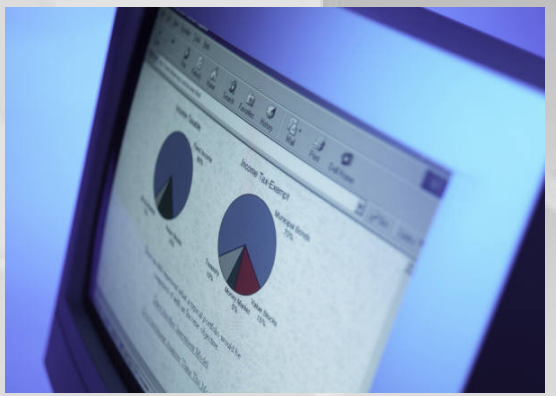
Projects Have Problems



© 2006 Natural SPI

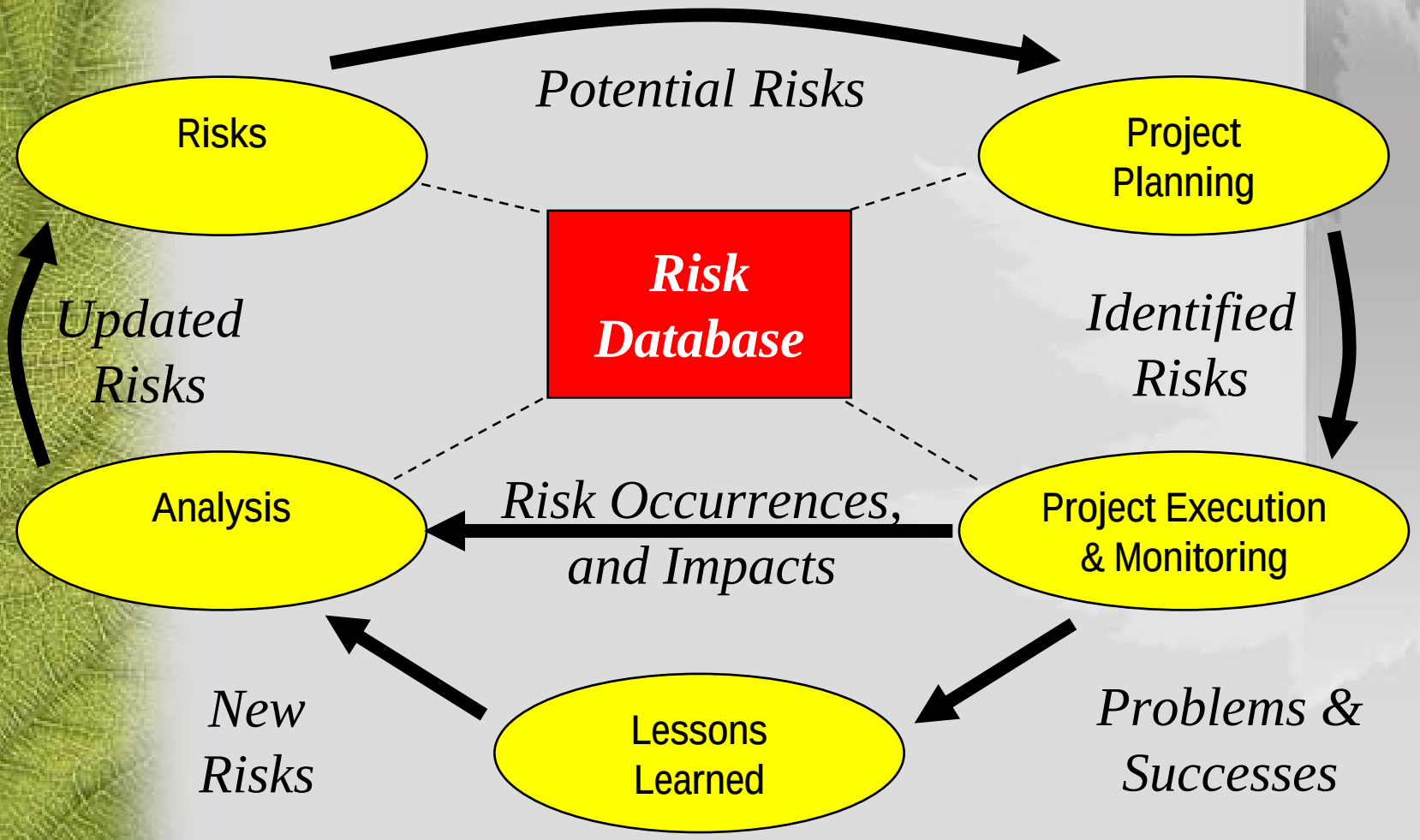
Learning About Risks

- Risk parameters and attributes
- Actual risk impacts
- Actual risk historical probabilities
- Mitigation plan successes
- Contingency plan successes



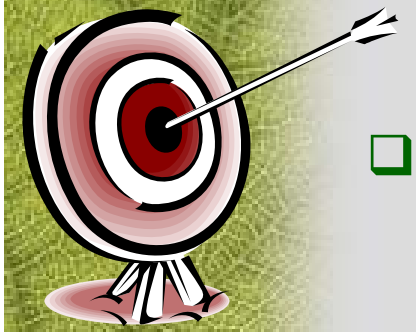
© 2006 Natural SPI

Risk Management System



© 2006 Natural SPI

Risk Management System Goals



- Improve accuracy of risk parameters and contingency buffers
- Improve identification of risks
- Improve mitigation of risks and effectiveness of contingency plans
- Reduce the impact of risks on project objectives

© 2006 Natural SPI

Goal Confirming Questions

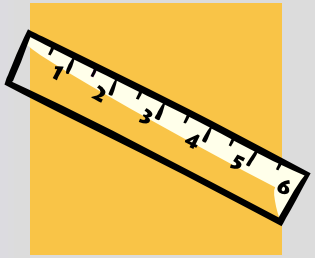
- How stable are risk parameters?
- How accurate are risk estimates of probability and impact?
- How often are projects surprised by new risks and problems?
- How effective are mitigation and contingency plans?



© 2006 Natural SPI

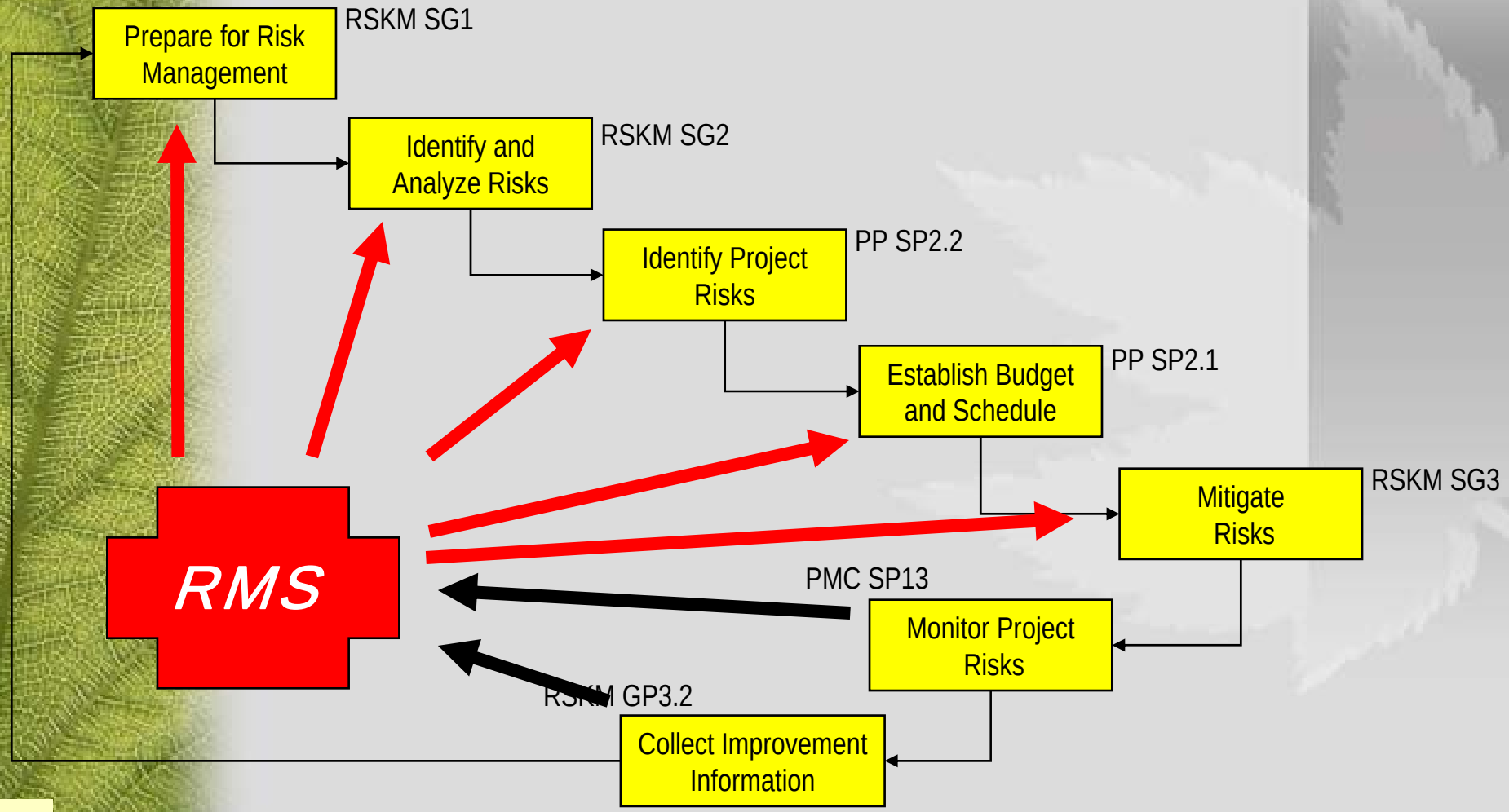
Goal Revealing Measures

- Risk impact estimates vs. actuals
- Risk probability estimates vs. actuals
- Frequency of new issues and problems
- Mitigation plan estimates vs. actuals
- Contingency plan estimates vs. actuals



© 2006 Natural SPI

Using the System at Level 3



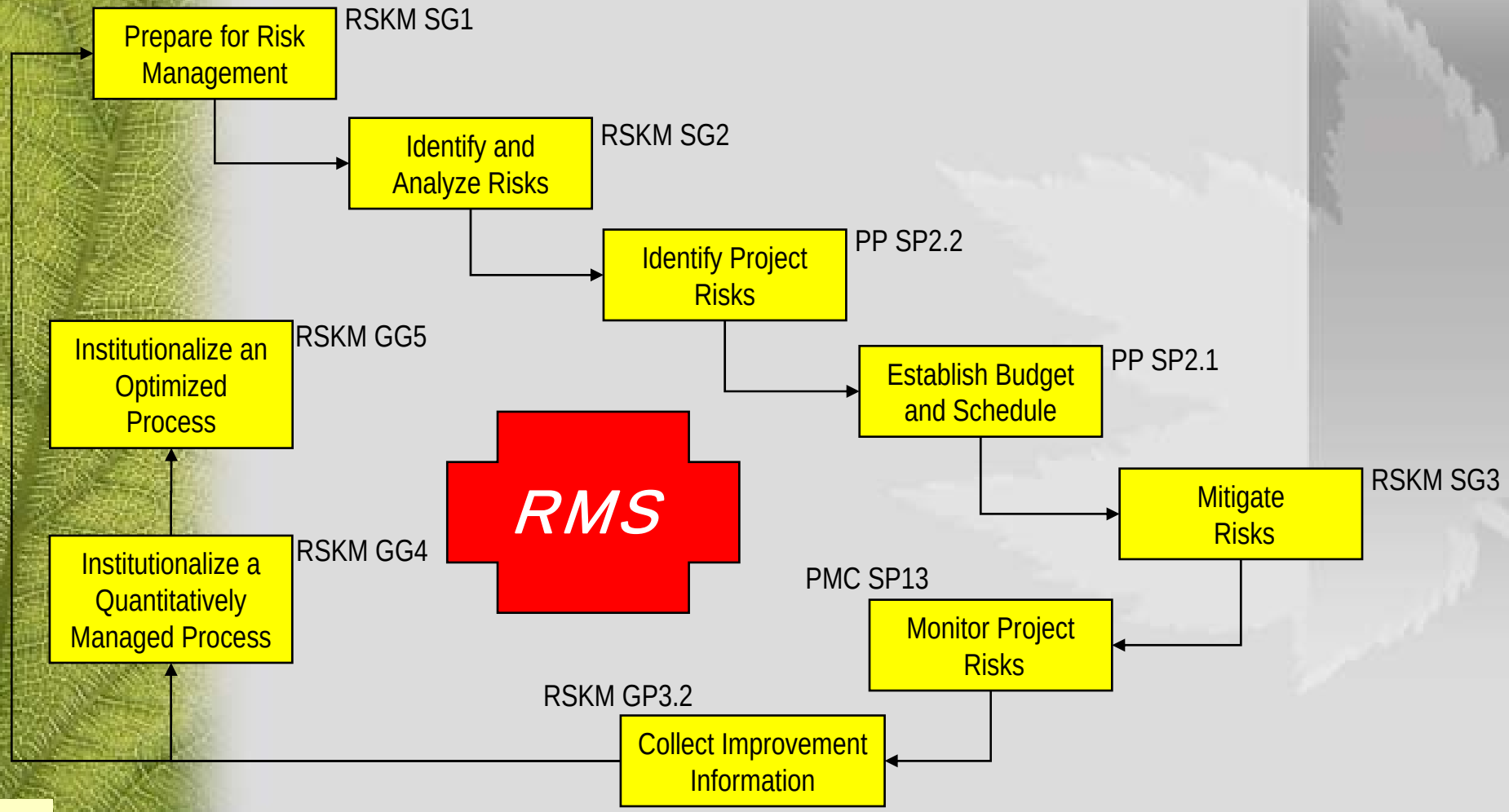
© 2006 Natural SPI

Using the System in Higher Maturity Levels



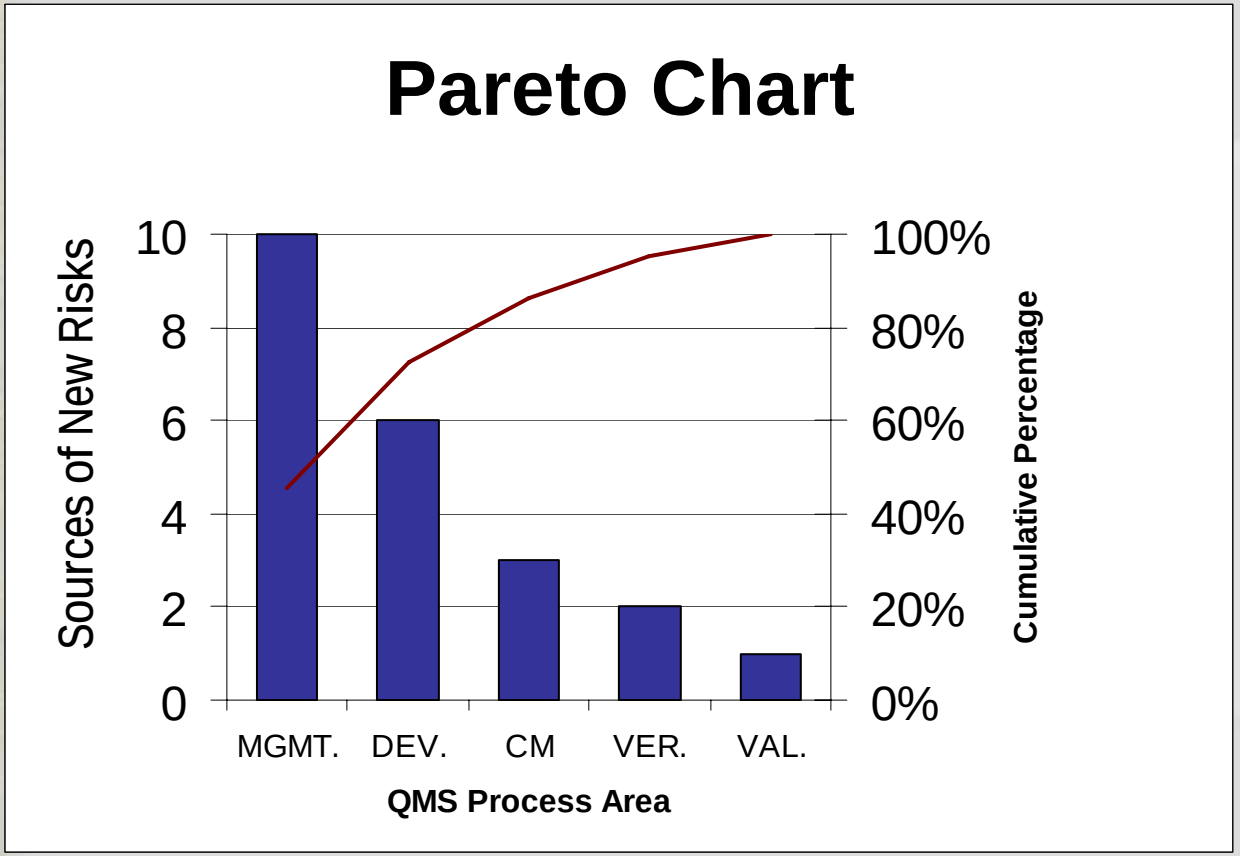
© 2006 Natural SPI

Level 4 & 5 Risk Practices



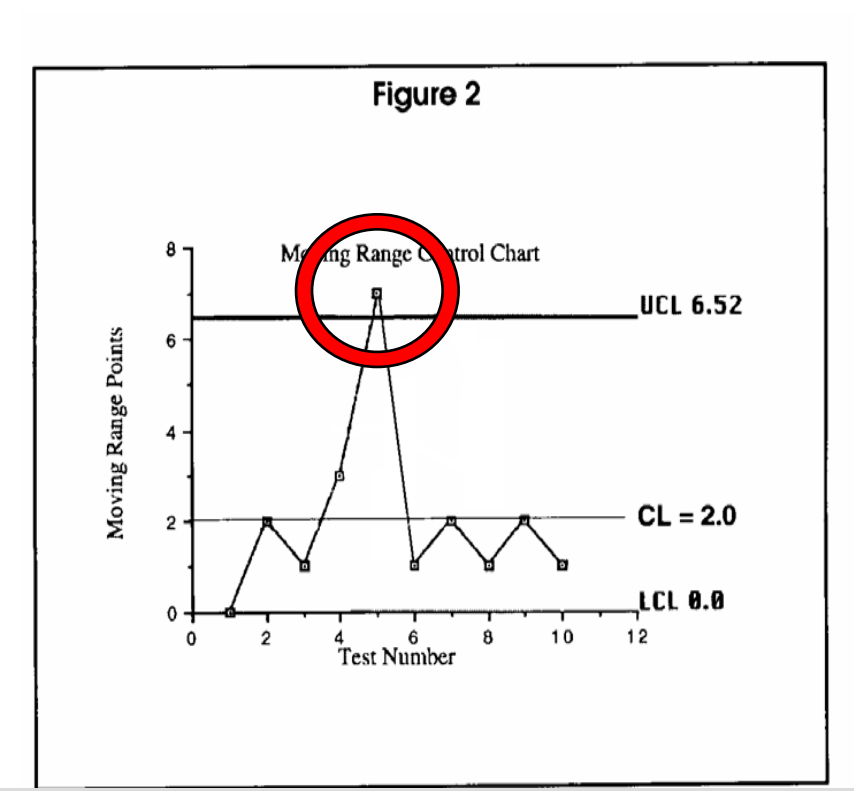
© 2006 Natural SPI

Correct Root Causes of Problems



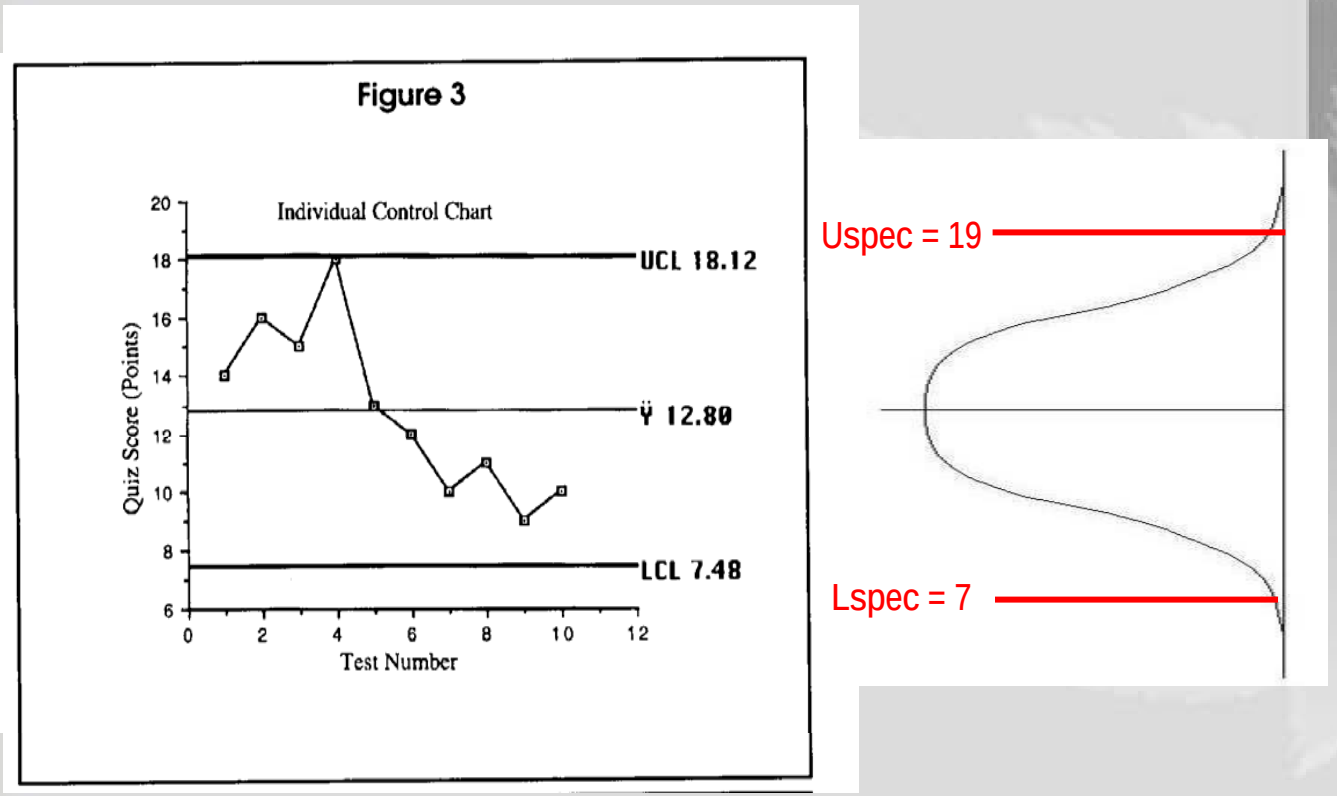
© 2006 Natural SPI

Stabilize Subprocess Performance



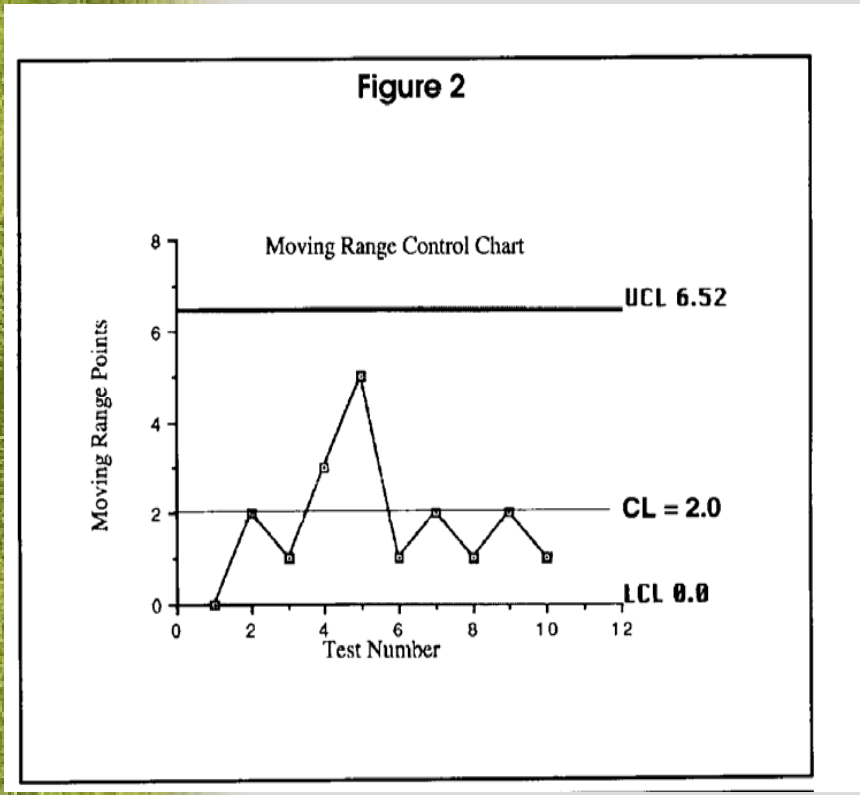
© 2006 Natural SPI

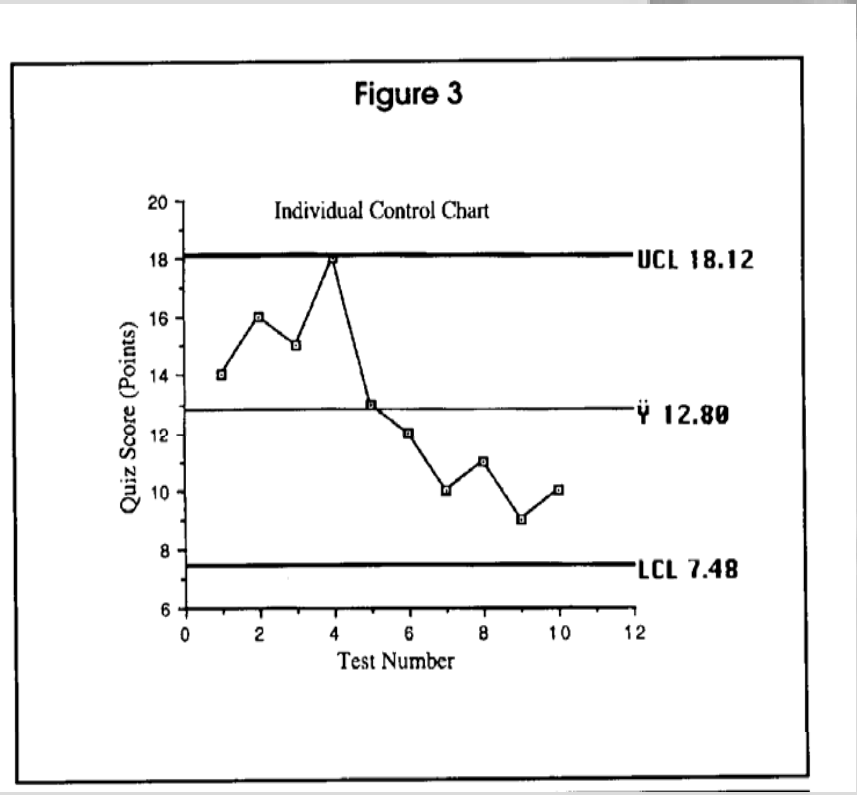
Quantitatively Managed Process



© 2006 Natural SPI

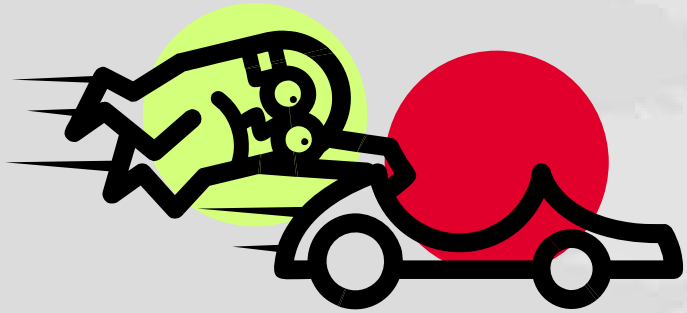
Ensure Continual Process Improvement





© 2006 Natural SPI

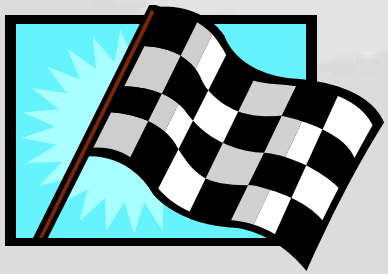
Going Forward



© 2006 Natural SPI

Summary

- Risk estimating can be improved by avoiding a common statistical trap
- Risk Management can be improved even at Level 3
- It takes a system to optimize Risk Management



© 2006 Natural SPI



Conclusion

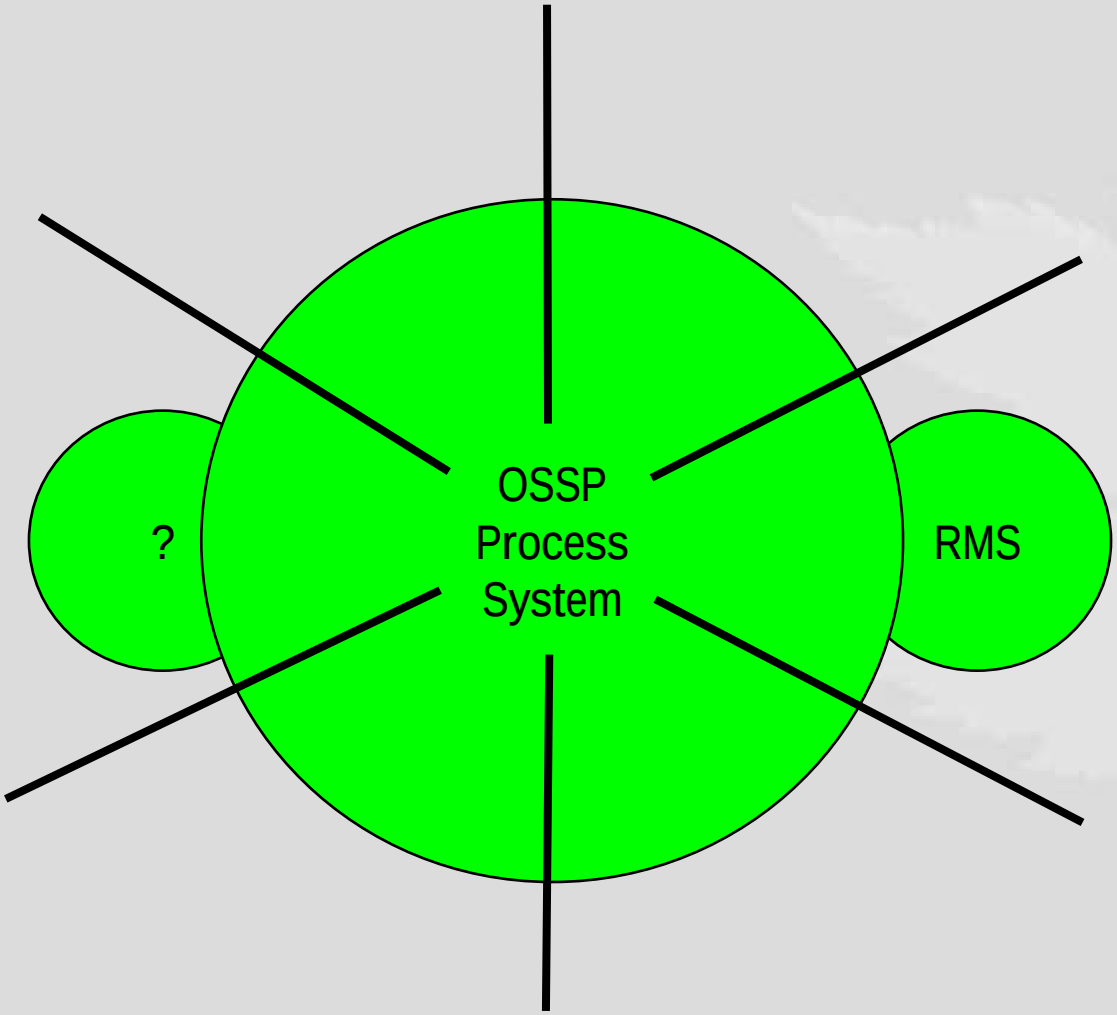
- It takes a system to optimize anything
- A system where that optimization is its AIM

Where can we apply such a system?

- Project estimating
- Requirements Management

© 2006 Natural SPI

Adding to your System



© 2006 Natural SPI

Thank You!



© 2006 Natural SPI

References/Reading

Grant, E. L., and R. S. Leavenworth: “Statistical Quality Control”, McGraw-Hill Book Company, New York, 1980.

DeMarco, T., and T. Lister: “Waltzing with Bears”, Dorset House Publishing, New York, 2003.

Galorath, D., and M. Evans: “Software Sizing, Estimation, and Risk Management”, Auerbach Publications, Boca Raton, 2006.

© 2006 Natural SPI

Thank You!

Contact information

Rick Bollinger

Natural SPI, Inc.

734-662-7752

rick@naturalspi.com

www.naturalspi.com

866-648-5508

NATURAL SPI

SEI Partner

© 2006 Natural SPI

NATURAL SPI

Optimizing Risk Management

NDIA 9TH Annual Systems Engineering Conference
October 23-26, 2006 San Diego, CA

Rick Bollinger, PMP





SEI Partner

© 2006 Natural SPI

Optimizing Risk Management

Life at Level 3	3
Avoiding a Statistical Trap	5
Improving Risk Management	18
Risk Management System	21
Use in Higher Levels	31
Going Forward	37

© 2006 Natural SPI

Level 3 Risk Practices



Prepare for Risk Management — RSKM SG1

Identify and Analyze Risks — RSKM SG2

Identify Project Risks — PP SP2.2

Establish Budget and Schedule — PP SP2.1

Mitigate Risks — RSKM SG3

Monitor Project Risks — PMC SP13

Collect Improvement Information — RSKM GP3.2

© 2006 Natural SPI

Establish the Budget & Schedule

For each risk, multiply its impact times its probability, to get it's exposure

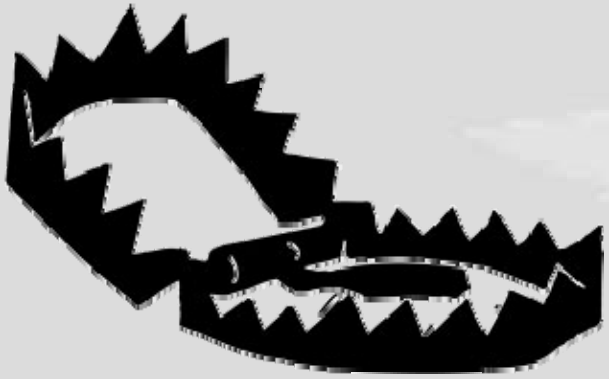
Add them all together to estimate a buffer or reserve

- Do this for effort
- Do this for duration
- Do this for costs

You could be falling into a trap!

© 2006 Natural SPI

Avoiding a Statistical Trap



© 2006 Natural SPI

Common Risk Planning Buffer Calculation

$$B = SUM(r_i * p_i)$$

Where:

r_i = impact of risk(i), i = 1 to n

p_i = probability of risk(i), between 0 and 1.0

B = total risk buffer estimated for any dimension of impact:

- cost
- duration
- effort, etc.



© 2006 Natural SPI

The Problem

Based on $B = SUM(r_i * p_i)$

HALF of your projects will be late!

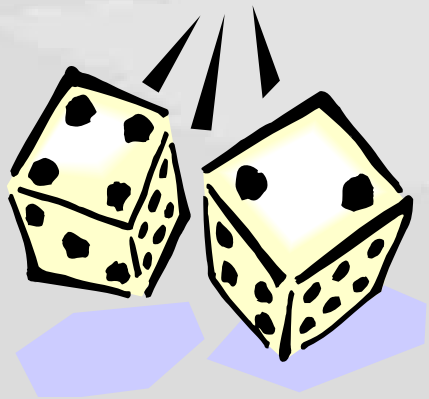


© 2006 Natural SPI

Big Questions

Would you start a project knowing there was a 50 percent chance it will be late based on risks alone?

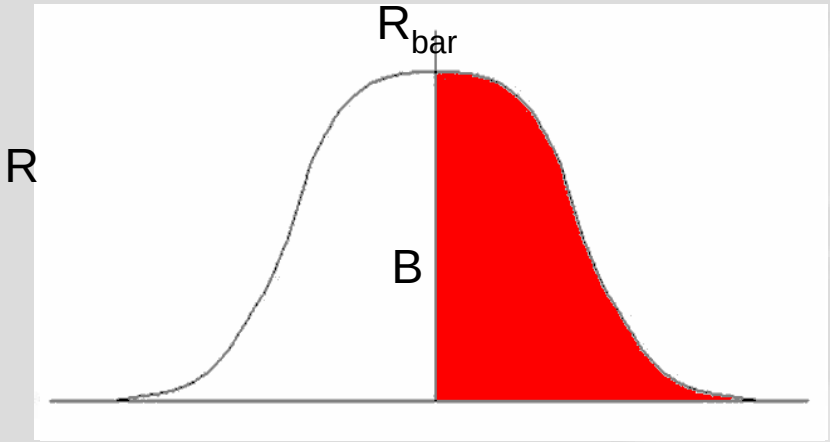
Would your customers accept having 50% of their projects being late?



© 2006 Natural SPI

Why the Problem?

The random variable to reflect the risk outcomes has a distribution that looks like this:

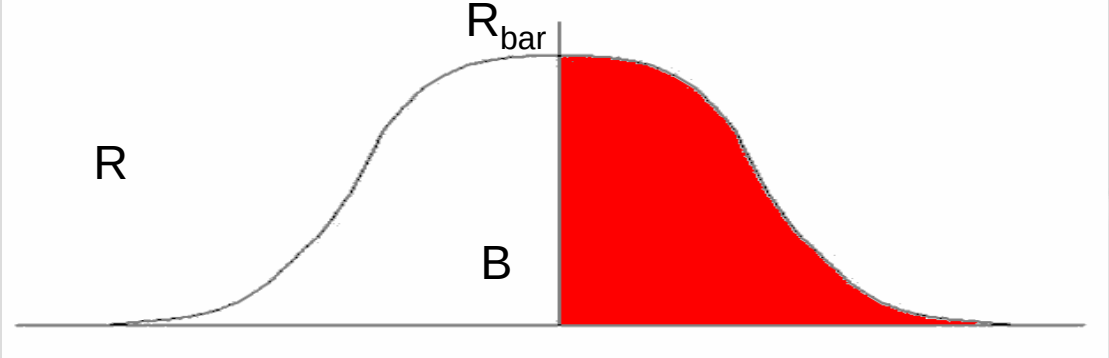


The buffer to protect the project from these risks, B, is commonly set to the expected value for the sum of manifested risks, R_{bar}.

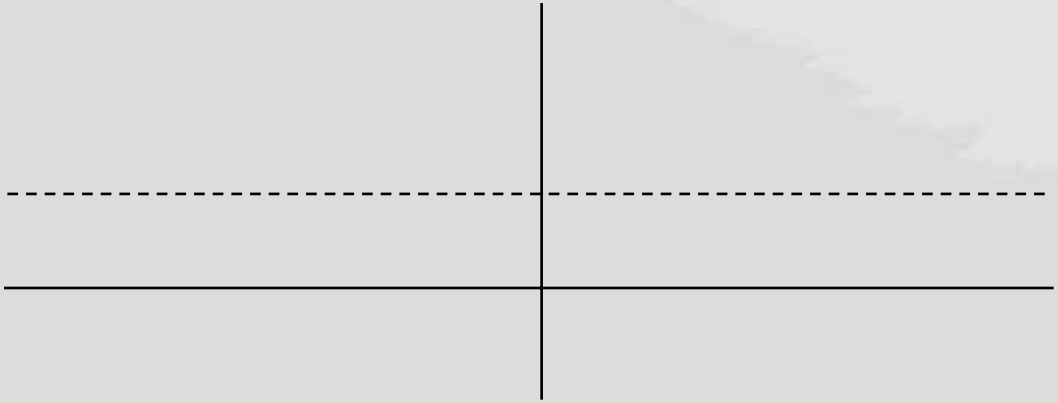
But, 50% of the outcomes will be greater than B.

© 2006 Natural SPI

On the Average You Will Break Even

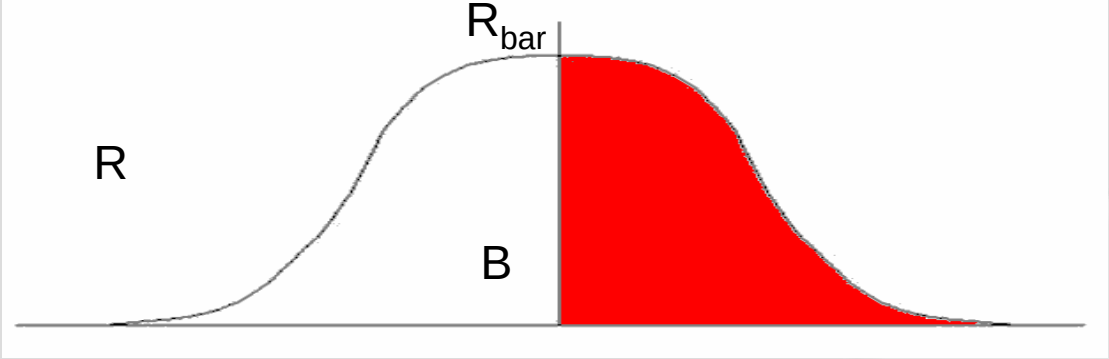


Assuming that the value of dollars or days to the left of B is the same of the units to the right.



© 2006 Natural SPI

But, the Assumption Does Not Always Hold



Dollars/days/units of estimate to the RIGHT of B can be much more expensive than units to the LEFT.

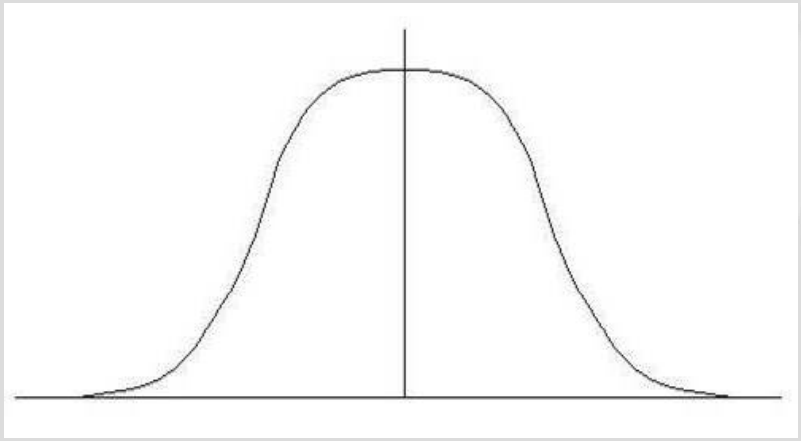


© 2006 Natural SPI



Central Limit Theorem to the Rescue

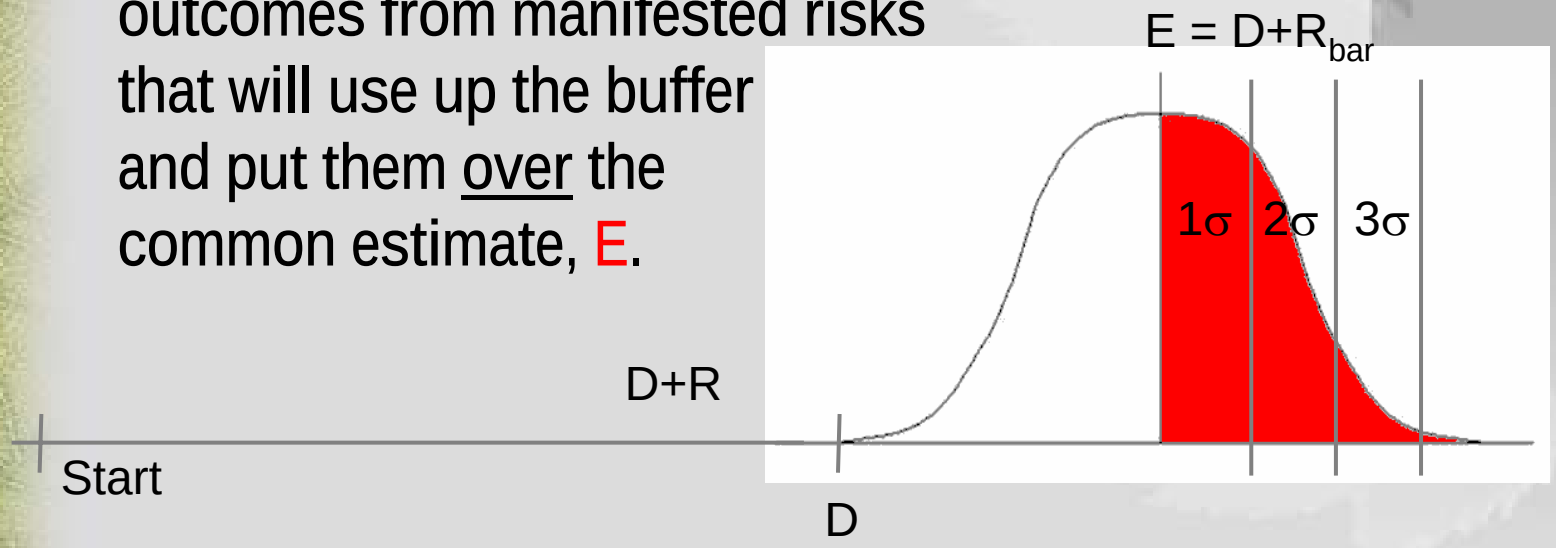
The Central Limit Theorem of statistics says that the sums of random variables tend to become approximately normal, i.e. they follow a Gaussian Curve.



© 2006 Natural SPI

How big should buffers be?

Applying this distribution to real projects with duration D means that half the projects will experience outcomes from manifested risks that will use up the buffer and put them over the common estimate, E.



We can estimate the standard deviation from the binomial nature of our risks: $\sigma = SQRT(SUM(r_i * p_i)/n)$.

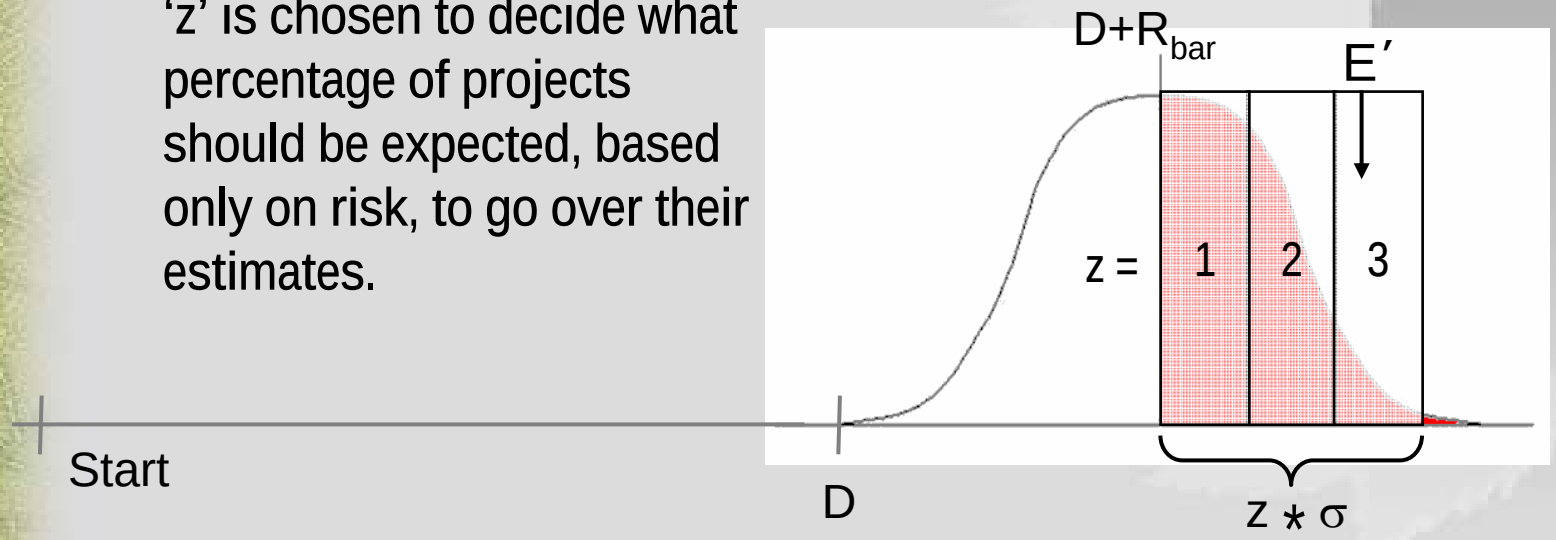
© 2006 Natural SPI

Choosing the Buffer

And use our estimate to calculate a new buffer, B′, and new Estimate,

$E' = D + B' = D + R_{bar} + (z * \sigma)$

'z' is chosen to decide what percentage of projects should be expected, based only on risk, to go over their estimates.



© 2006 Natural SPI



Choose your ‘z’

Select a standard value for ‘z’ to use to calculate risk buffers.

z = 0

will give you the protection you have now.

z = 2.0

will give you risk buffers to protect 97.72% of projects

(or phases of projects).

Only 2.28% would be expected to exceed their buffer.

z	% expected to be over
0.0	50.00%
0.5	30.85%
1.0	15.87%
1.5	6.68%
2.0	2.28%
2.5	0.62%
3.0	0.13%
3.5	0.02%

© 2006 Natural SPI

Using the New Buffer

The duration of projects will not increase.

The costs of projects will not increase.

Customers will not pay more or wait longer for projects.

Because…

Not all of risk buffers will be consumed! Some will. But, many won't.

Customers will actually find that you are early and under-budget (or late and over-budget) according to the 'z' factor that you chose.

© 2006 Natural SPI

Benefits

You will not over-promise.
You will not under-deliver.

You won't have to charge more.
You will just have to apologize less.

© 2006 Natural SPI

Improving Risk Management



© 2006 Natural SPI

How Do We Improve Risk Management?

- Learn more about risks:
  - estimate better
  - plan better
- Increase what we remember about problems and risks
- Leverage lessons learned
- Do all this systematically

© 2006 Natural SPI

Level 3 Risk Practices



Prepare for Risk Management — RSKM SG1

Identify and Analyze Risks — RSKM SG2

Identify Project Risks — PP SP2.2

Establish Budget and Schedule — PP SP2.1

Mitigate Risks — RSKM SG3

Risk Magic!

PMC SP13

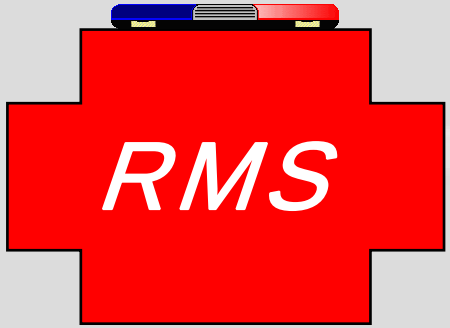
Monitor Project Risks

RSKM GP3.2

Collect Improvement Information

© 2006 Natural SPI

A Risk Management System



© 2006 Natural SPI

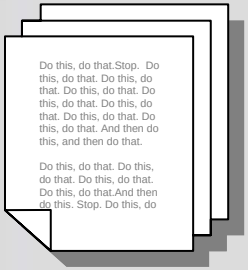
Elements of a System



People: trained and assigned with responsibilities to operate and maintain the system

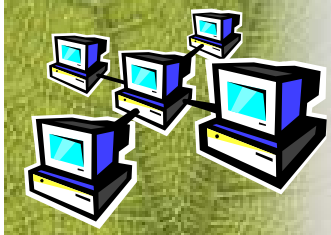


Technology: tools make it easier to operate the system. If people find activities too difficult they will not be done well



Processes: defined and available to guide activities and contribute to greater effectiveness, efficiency, and quality

© 2006 Natural SPI

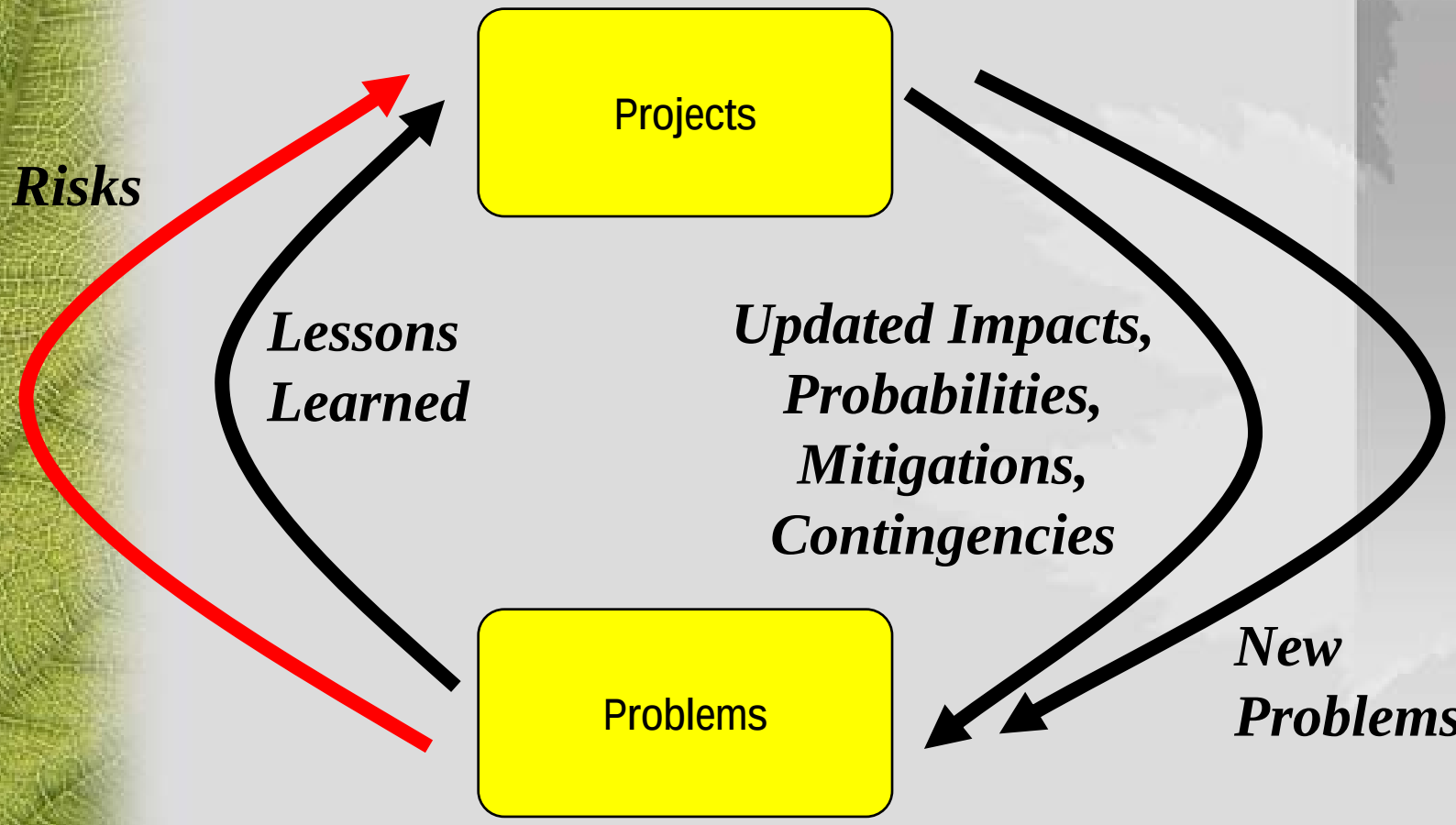


RMS Components

- People, training, support, responsibilities, stakeholders, monitoring and supervision of risk management
- Database of problems and risks with historical occurrences and supporting information
- Mechanism to collect data on problems, risks, and lessons learned on the success and costs of mitigations and contingency plans
- Processes, policies and plans defined to guide and give consistency to risk management activities

© 2006 Natural SPI

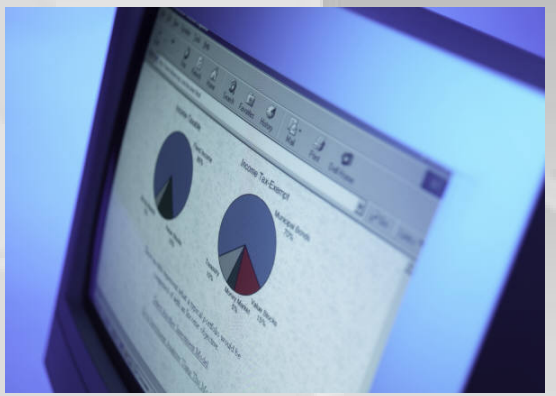
Projects Have Problems



© 2006 Natural SPI

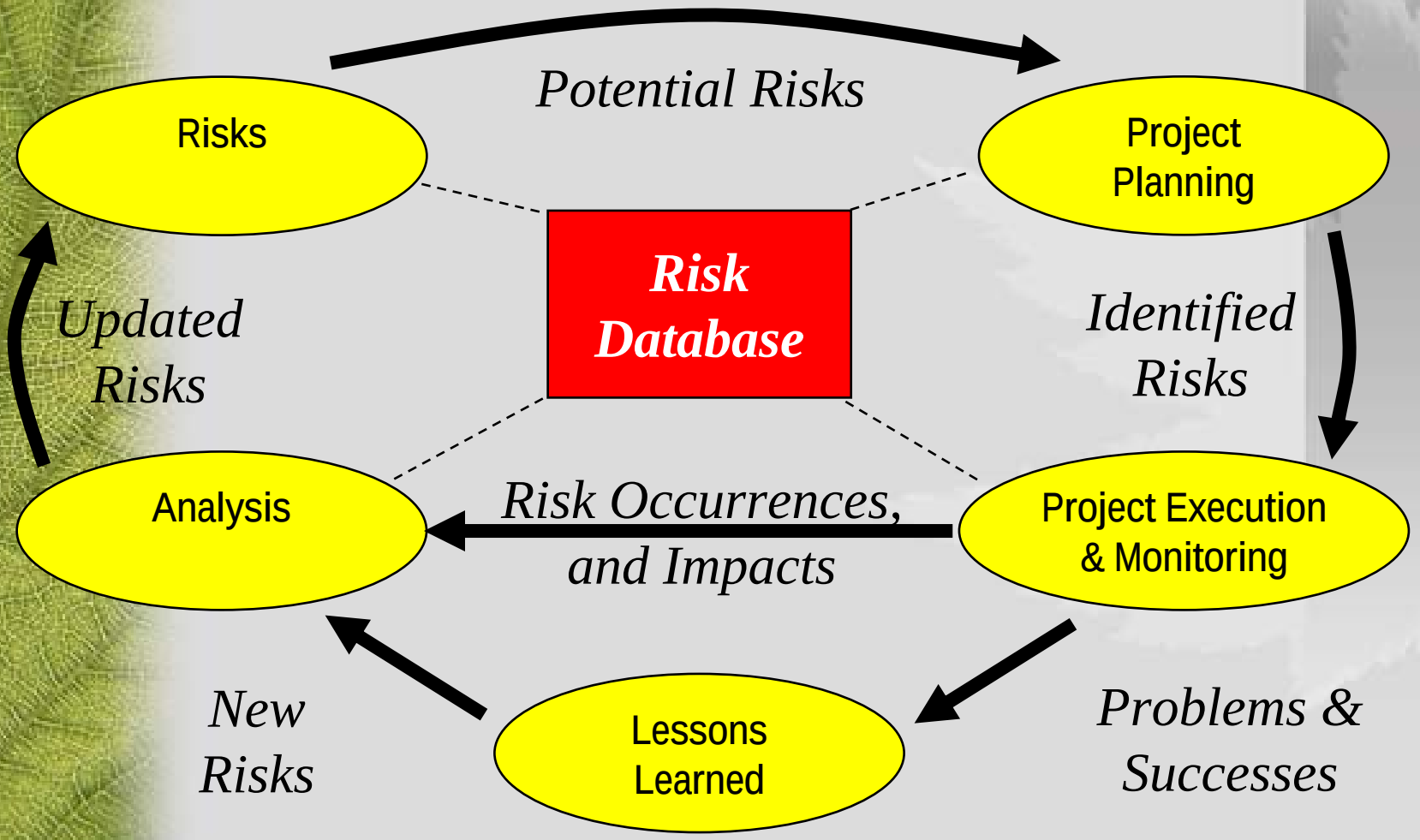
Learning About Risks

- Risk parameters and attributes
- Actual risk impacts
- Actual risk historical probabilities
- Mitigation plan successes
- Contingency plan successes



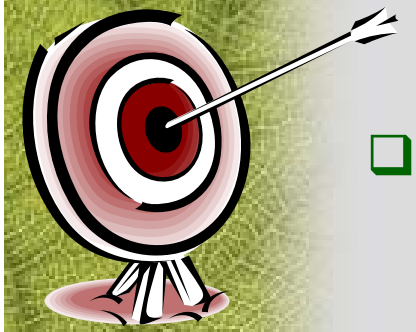
© 2006 Natural SPI

Risk Management System



© 2006 Natural SPI

Risk Management System Goals



- Improve accuracy of risk parameters and contingency buffers
- Improve identification of risks
- Improve mitigation of risks and effectiveness of contingency plans
- Reduce the impact of risks on project objectives

© 2006 Natural SPI

Goal Confirming Questions

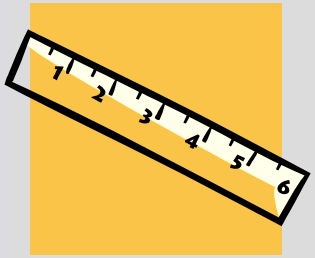
- How stable are risk parameters?
- How accurate are risk estimates of probability and impact?
- How often are projects surprised by new risks and problems?
- How effective are mitigation and contingency plans?



© 2006 Natural SPI

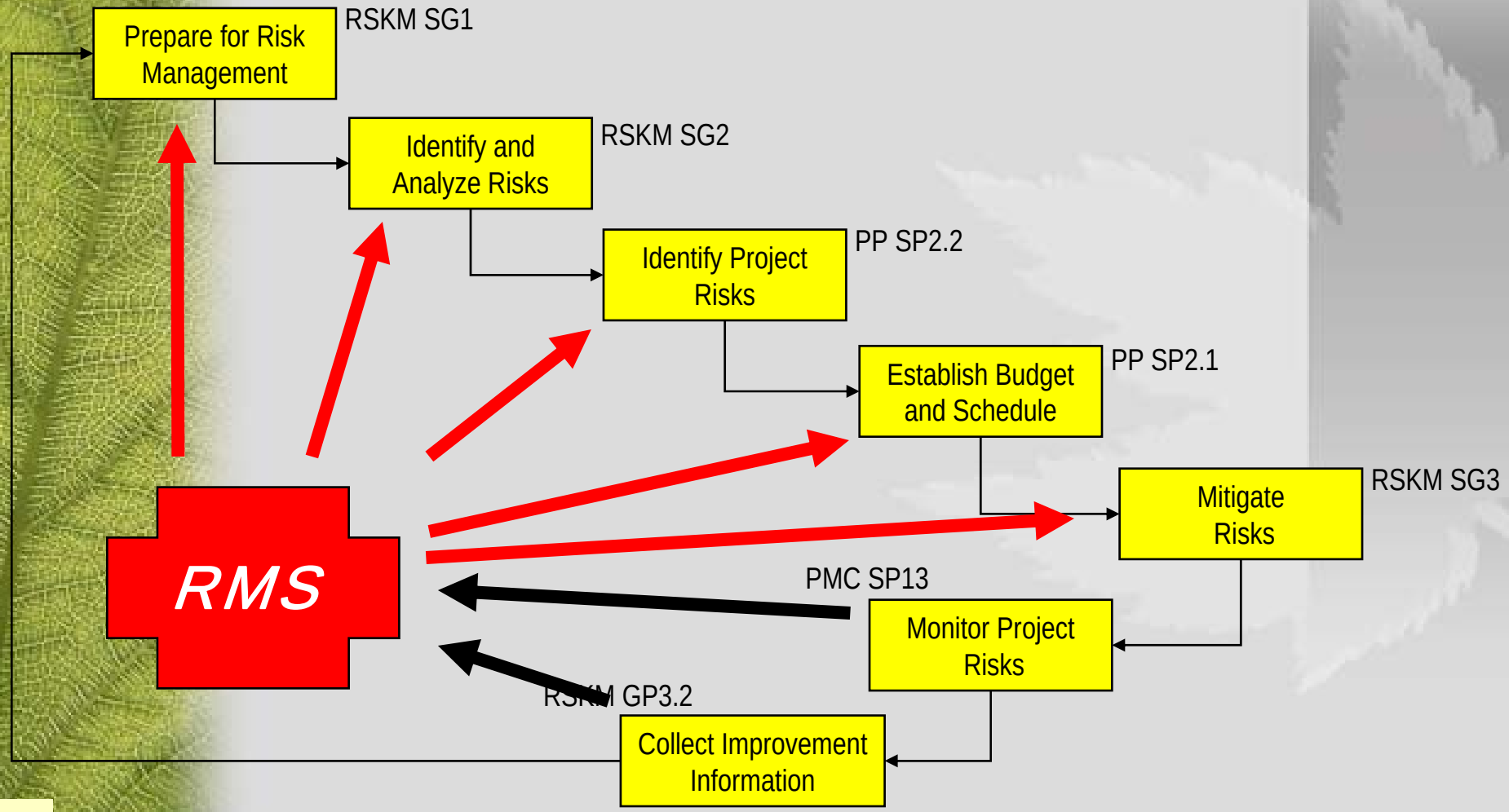
Goal Revealing Measures

- Risk impact estimates vs. actuals
- Risk probability estimates vs. actuals
- Frequency of new issues and problems
- Mitigation plan estimates vs. actuals
- Contingency plan estimates vs. actuals



© 2006 Natural SPI

Using the System at Level 3



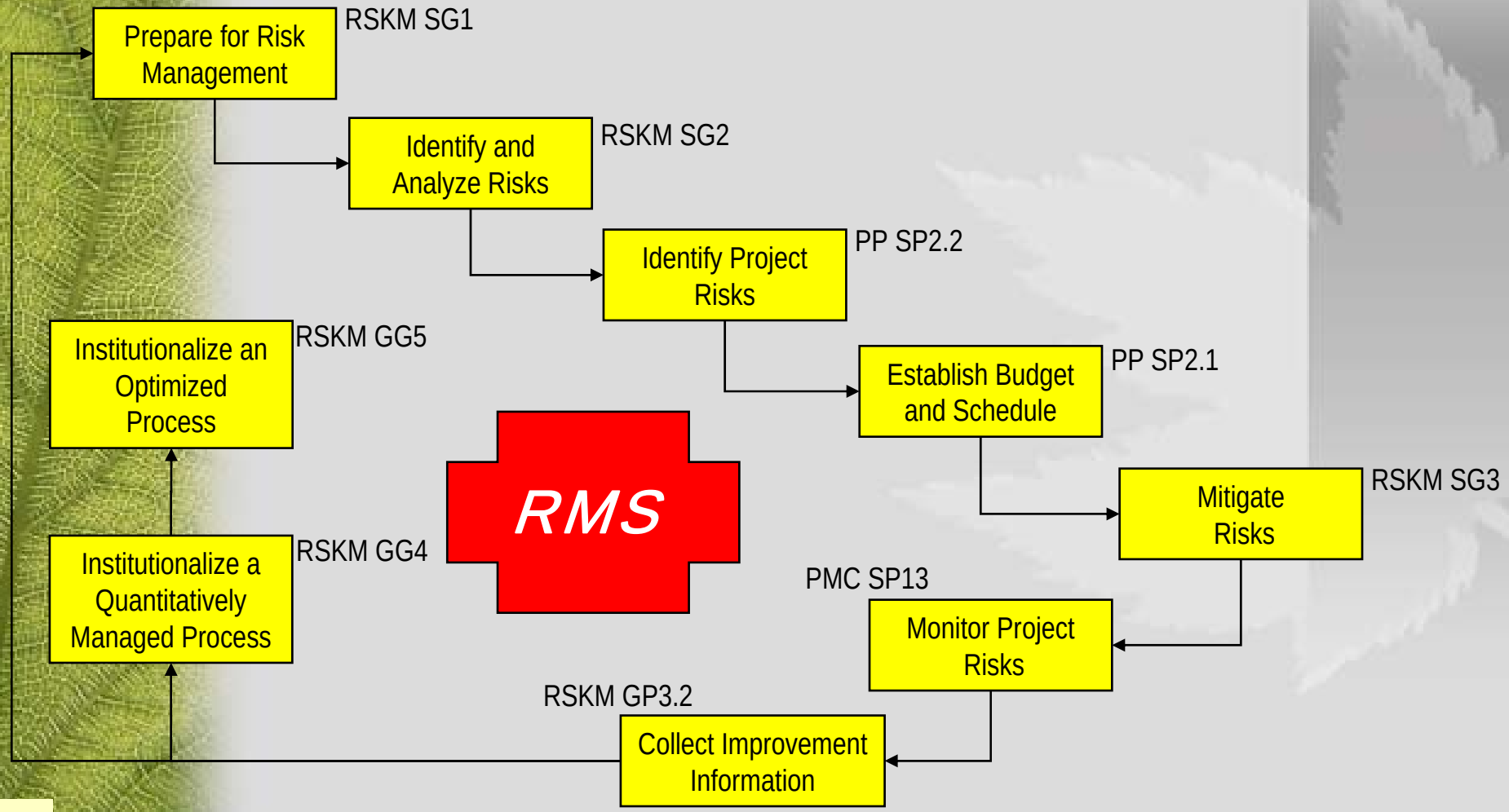
© 2006 Natural SPI

Using the System in Higher Maturity Levels



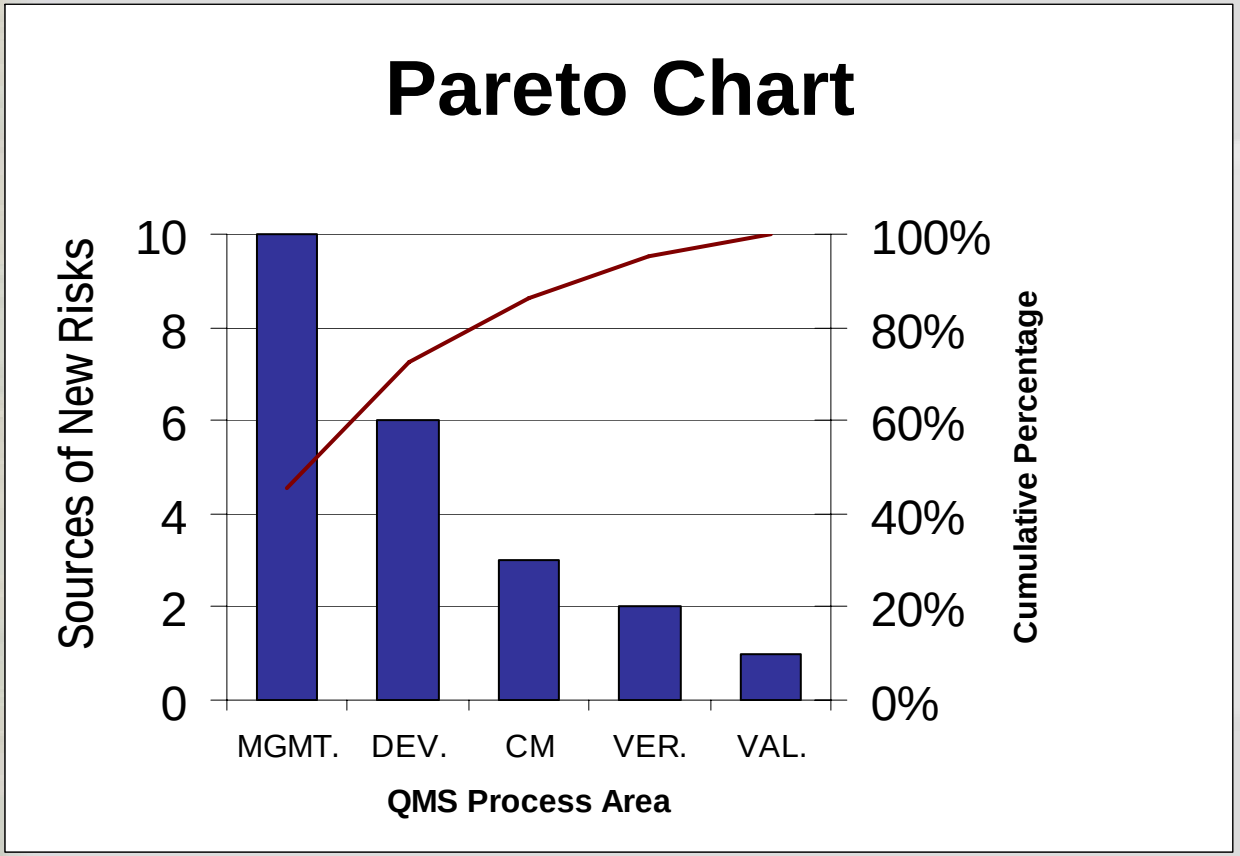
© 2006 Natural SPI

Level 4 & 5 Risk Practices



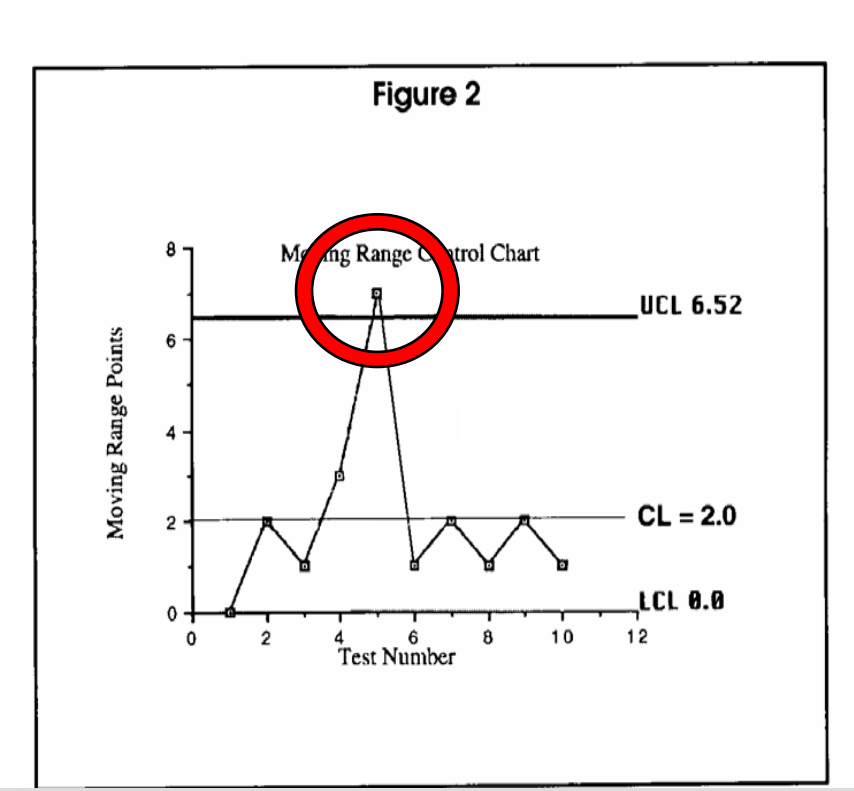
© 2006 Natural SPI

Correct Root Causes of Problems



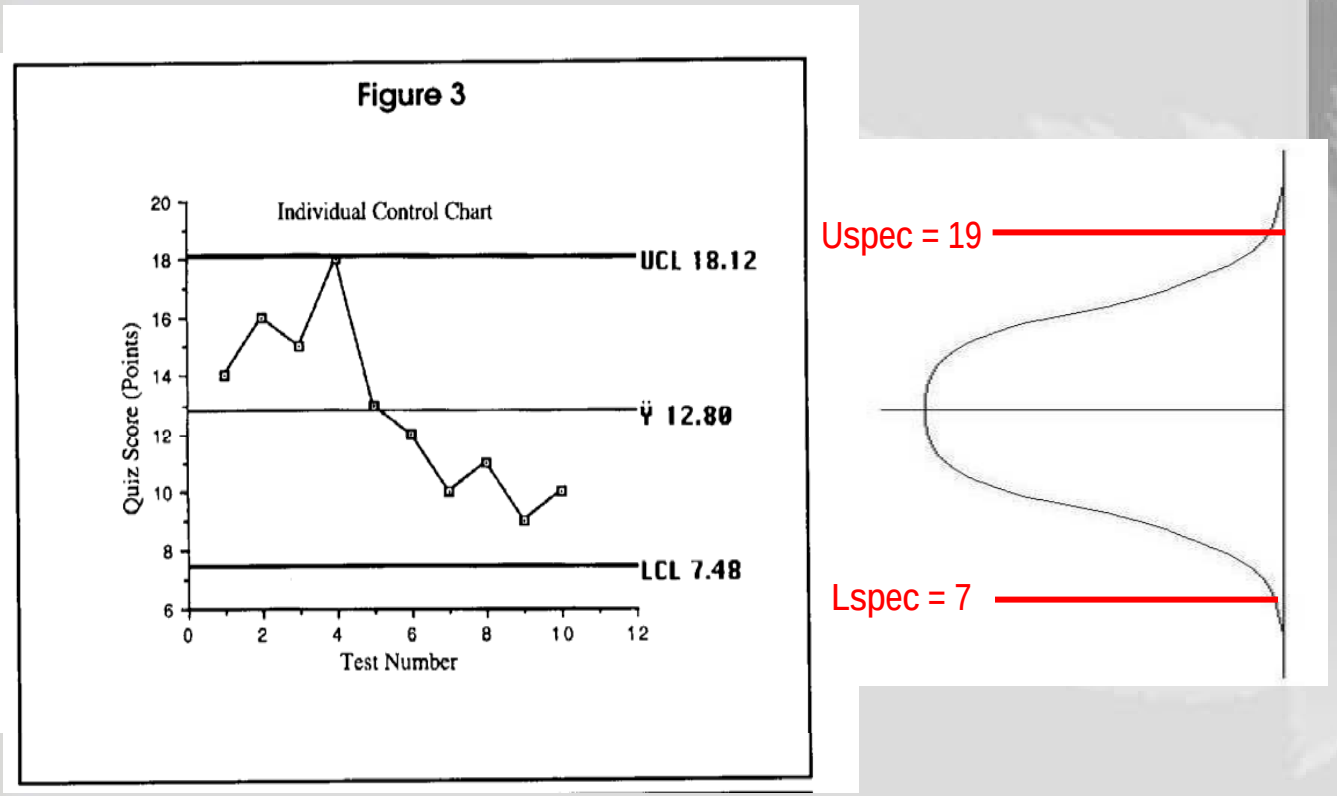
© 2006 Natural SPI

Stabilize Subprocess Performance



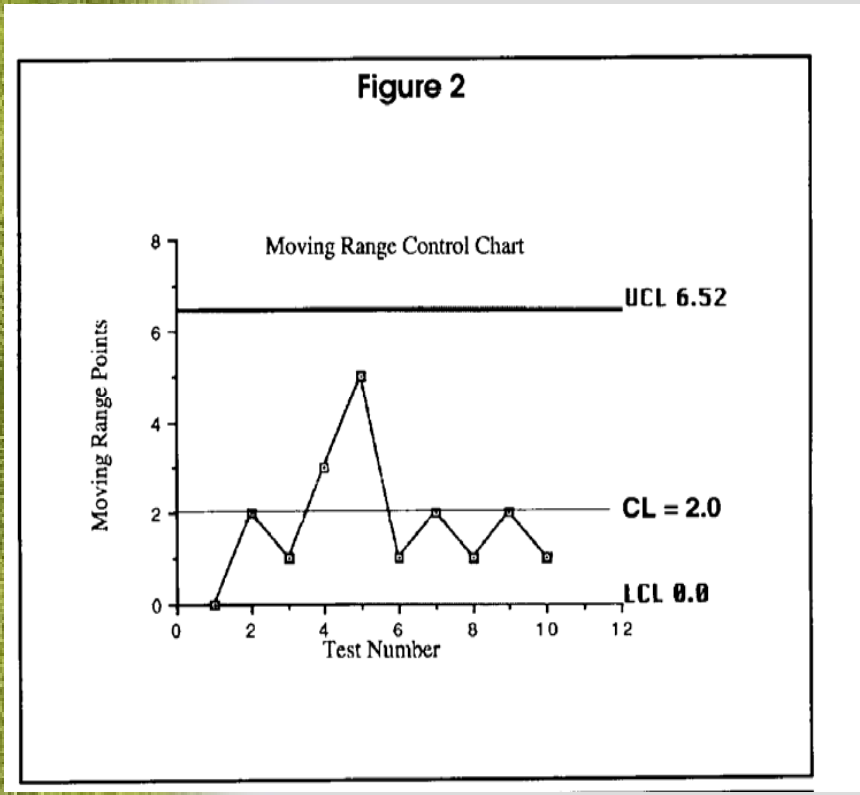
© 2006 Natural SPI

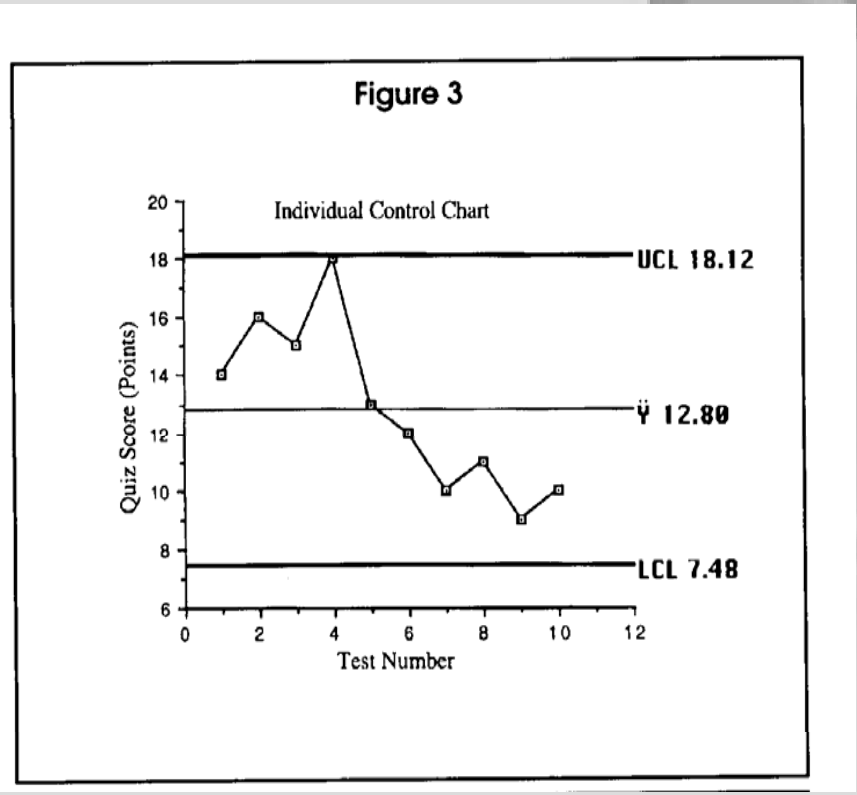
Quantitatively Managed Process



© 2006 Natural SPI

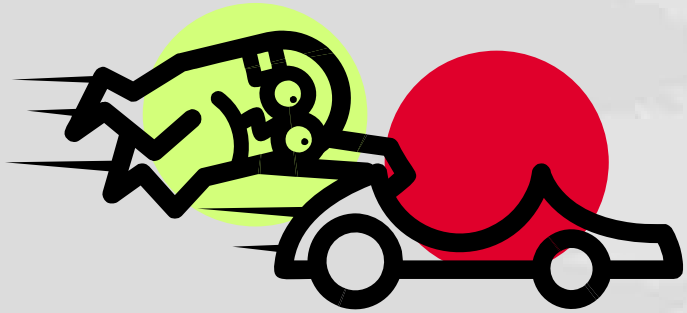
Ensure Continual Process Improvement





© 2006 Natural SPI

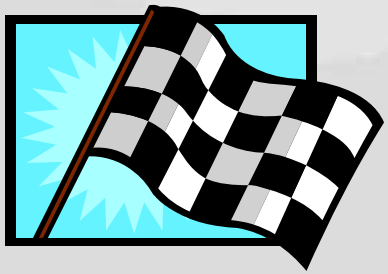
Going Forward



© 2006 Natural SPI

Summary

- Risk estimating can be improved by avoiding a common statistical trap
- Risk Management can be improved even at Level 3
- It takes a system to optimize Risk Management



© 2006 Natural SPI



Conclusion

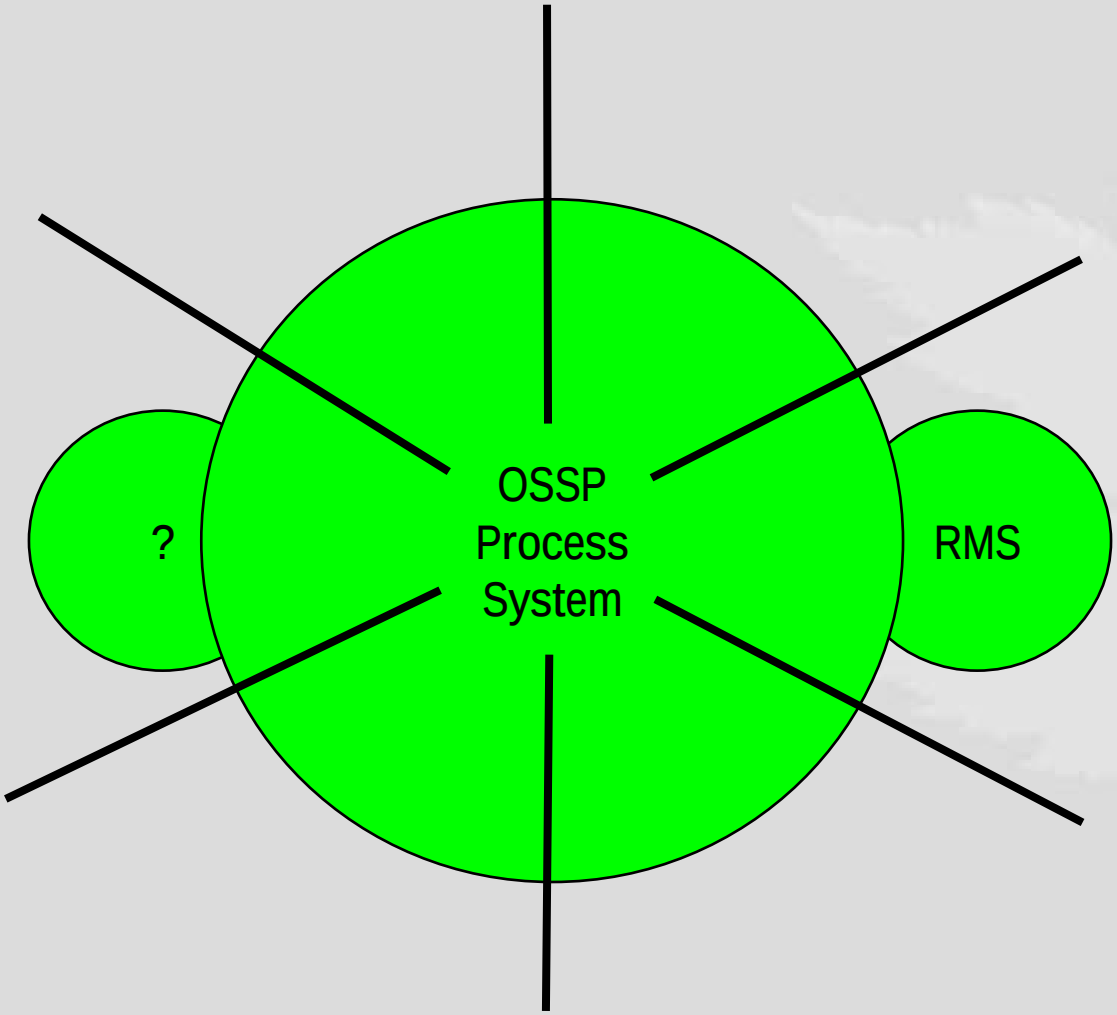
- It takes a system to optimize anything
- A system where that optimization is its AIM

Where can we apply such a system?

- Project estimating
- Requirements Management

© 2006 Natural SPI

Adding to your System



© 2006 Natural SPI

Thank You!



© 2006 Natural SPI

References/Reading

Grant, E. L., and R. S. Leavenworth: “Statistical Quality Control”, McGraw-Hill Book Company, New York, 1980.

DeMarco, T., and T. Lister: “Waltzing with Bears”, Dorset House Publishing, New York, 2003.

Galorath, D., and M. Evans: “Software Sizing, Estimation, and Risk Management”, Auerbach Publications, Boca Raton, 2006.

© 2006 Natural SPI

Thank You!

Contact information

Rick Bollinger

Natural SPI, Inc.

734-662-7752

rick@naturalspi.com

www.naturalspi.com

866-648-5508

NATURAL SPI

SEI Partner

© 2006 Natural SPI

Update on the Process for Evaluating Logistics Readiness Levels (LRLs)

October 25, 2006
Elizabeth Broadus
Booz Allen Hamilton, Inc.
301-862-7049
broadus_elizabeth@bah.com

Agenda

- Background of Logistics Readiness Level (LRL) concept
- LRL Defined
- LRL Tool
- Prototype Example
- Benefits
- Questions

Background

- LRL concept evolved from the DOD 5000.2 mandated Technology Readiness Levels (TRL) assessment process
  - TRLs provide:
    - Evaluation of critical technology **maturity**
    - Maturation plan (as needed)
    - Best practices/guidelines for each Milestone
      - MS B target is TRL = 6
      - MS C target is TRL = 7
      - MS C preferred is TRL = 8
- Logistics benchmark system for technology insertion was desirable
  - Aid in understanding what sustainment is required at different time phases
  - Technology can be mature with immature logistics support

LRL is a new concept intended to consider sustainment issues for tech insertion projects

LRL Definition

- LRL intent:
  - Provide a methodology and benchmarks for assessing Logistic Element Readiness for technology
  - Provide a management tool to forecast logistics workload, manpower requirements, identify gaps, etc.
  - LRL's evaluated for 6 project phases:
    - Lab Test/R&D
    - Project Definition (Fleet Need/metrics/BCA/Decision to proceed)
    - Project Development /Implementation (Finalized analysis, change recommended, ECP development, Class II change development, RAMEC, LECP, other)
    - Engineering Validation
    - Fleet Verification
    - Fleet Use

Engineers and Logisticians need clear definition of what is required for sustainment at each phase of a project

LRL Definition

- Evaluation criteria established for each phase
  - Determined the benchmark of required tasks appropriate for each logistics element at each time phase
  - Not all elements require same level or effort in the same time phase
- Answers question of "What tasks must be complete at each project phase for each logistics element?"
  - Training example:

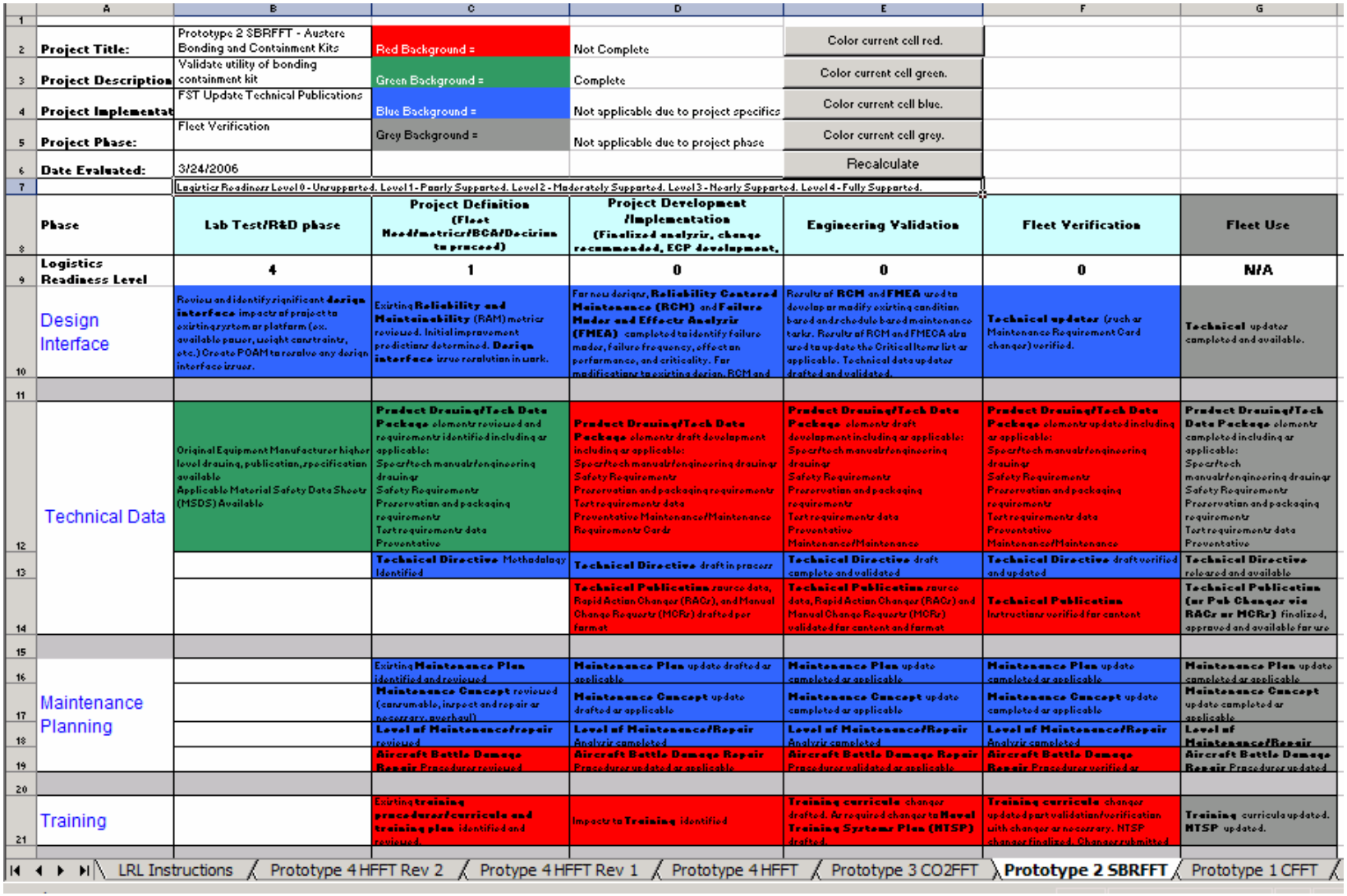
Phase	Lab Test/ R&D phase	Project Definition	Project Development/ Implementation	Engineering Validation	Fleet Verification	Fleet Use
Training		Existing **training procedures/ curricula and training plan** identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated post validation/verification with changes as necessary. NTSP changes finalized. Changes submitted for approval.	**Training** curricula updated. **NTSP** updated.

LRL Tool

- LRL tool created in Microsoft Excel (compatible with Microsoft Office 2003) includes instructions worksheet
  - Buttons allow a point and click use of color for evaluation
    - •Grey indicates the project is not yet in that project phase therefore benchmarks are not applicable
    - •Blue indicates the benchmark is not applicable due to the details of the project
    - •Red indicates the benchmark task is not complete
    - •Green indicates the benchmark task is complete
  - Detailed evaluation requires familiarity with the project and tasks completed to date
- Numeric LRL score evaluated for each project phase
  - LRL = 0 **Unsupported** (zero% required tasks completed)
  - LRL = 1 **Poorly Supported** (1-50% of required tasks completed)
  - LRL = 2 **Moderately Supported** (51-70% or required tasks completed)
  - LRL = 3 **Nearly Supported** (71-99% of required tasks completed)
  - LRL = 4 **Fully Supported** (100% of required tasks completed)
- Numeric LRL scale provides a reference framework for project comparison

An LRL of 4 is the goal for all phases

LRL Tool Screenshot – demo available



	A	B	C	D	E	F	G
1							
2	**Project Title:**	Prototype 2 SBRFFT - Austere Bonding and Containment Kits	Red Background =	Not Complete	Color current cell red.		
3	**Project Description**	Validate utility of bonding containment kit	Green Background =	Complete	Color current cell green.		
4	**Project Implementat**	FST Update Technical Publications	Blue Background =	Not applicable due to project specifics	Color current cell blue.		
5	**Project Phase:**	Fleet Verification	Grey Background =	Not applicable due to project phase	Color current cell grey.		
6	**Date Evaluated:**	3/24/2006			Recalculate		
7		Logistics Readiness Level 0 - Unsupported, Level 1 - Poorly Supported, Level 2 - Moderately Supported, Level 3 - Nearly Supported, Level 4 - Fully Supported.					
8	**Phase**	**Lab Test/R&D phase**	**Project Definition (Fleet Need/metric/BCA/Decision to proceed)**	**Project Development /Implementation (Finalized analysis, change recommended, ECP development,**	**Engineering Validation**	**Fleet Verification**	**Fleet Use**
9	**Logistics Readiness Level**	**4**	**1**	**0**	**0**	**0**	**N/A**
10	Design Interface	Review and identify significant **design interface** impacts of project to existing system or platform (ex. available power, weight constraints, etc.) Create POAM to resolve any design interface issues.	Existing **Reliability and Maintainability** (RAM) metrics reviewed. Initial improvement predictions determined. **Design interface** issue resolution in work.	For new designs, **Reliability Centered Maintenance (RCM)** and **Failure Mode and Effects Analysis (FMEA)** completed to identify failure modes, failure frequency, effect on performance, and criticality. For modifications to existing design, RCM and	Results of **RCM** and **FMEA** used to develop or modify existing condition based and schedule based maintenance tasks. Results of RCM and FMECA also used to update the Critical Items list as applicable. Technical data updates drafted and validated.	**Technical updates** (such as Maintenance Requirement Card changes) verified.	**Technical** updates completed and available.
11							
12	Technical Data	Original Equipment Manufacturer higher level drawing, publication, specification available Applicable Material Safety Data Sheets (MSDS) Available	**Product Drawing/Tech Data Package** elements reviewed and requirements identified including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative	**Product Drawing/Tech Data Package** elements drafted development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance Requirements Cards	**Product Drawing/Tech Data Package** elements drafted development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements updated including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements completed including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative
13			**Technical Directive** Methodology Identified	**Technical Directive** drafted in process	**Technical Directive** drafted complete and validated	**Technical Directive** drafted verified and updated	**Technical Directive** released and available
14				**Technical Publications** source data, Rapid Action Changes (RACs), and Manual Change Requests (MCRs) drafted per format	**Technical Publications** source data, Rapid Action Changes (RACs) and Manual Change Requests (MCRs) validated for content and format	**Technical Publications** Instructions verified for content	**Technical Publications (or Pub Changes via RACs or MCRs)** finalized, approved and available for use
15							
16	Maintenance Planning		Existing **Maintenance Plan** identified and reviewed	**Maintenance Plan** update drafted as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable
17			**Maintenance Concept** reviewed (consumable, inspect and repair as necessary, overhaul)	**Maintenance Concept** update drafted as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable
18			**Level of Maintenance/Repair** reviewed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair**
19			**Aircraft Battle Damage Repair** Procedures reviewed	**Aircraft Battle Damage Repair** Procedures updated as applicable	**Aircraft Battle Damage Repair** Procedures validated as applicable	**Aircraft Battle Damage Repair** Procedures verified as	**Aircraft Battle Damage Repair** Procedures updated
20							
21	Training		Existing **training procedures/curricula and training plan** identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated part validation/verification with changes as necessary. NTSP changes finalized. Changes submitted	**Training** curricula updated. **NTSP** updated.

LRL Instructions | Prototype 4 HFFT Rev 2 | Protype 4 HFFT Rev 1 | Prototype 4 HFFT | Prototype 3 CO2FFT | **Prototype 2 SBRFFT** | Prototype 1 CFFT

Prototype Example

- Project: Update and create a Joint General Series Hydraulic Publication (NA-01-1A)
- Project Implementation: New Manual Release
- Project Phase: Project Development

Prototype Example- First Assessment LRL = 0

First Assessment 3/24/06, LRL = 0, Issues with Technical Data and Training

	A	B	C	D	E	F	G
1							
2	**Project Title:**	Proto.4 HFFT-Update -17 Manual and create Joint Publication	Red Background =	Not Complete	Color current cell red.		
3	**Project Description**	Update GENERAL Series Technical Publication	Green Background =	Complete	Color current cell green.		
4	**Project Implementat**	New Manual Release	Blue Background =	Not applicable due to project specifics	Color current cell blue.		
5	**Project Phase:**	Project Development	Grey Background =	Not applicable due to project phase	Color current cell grey.		
6	**Date Evaluated:**	3/24/2006			Recalculate		
7		Logistics Readiness Level 0 - Unsupported, Level 1 - Poorly Supported, Level 2 - Moderately Supported, Level 3 - Nearly Supported, Level 4 - Fully Supported.					
8	**Phase**	**Lab Test/R&D phase**	**Project Definition (Fleet Need/metrics/BCA/Decision to proceed)**	**Project Development /Implementation (Finalized analysis, change recommended, ECP development,**	**Engineering Validation**	**Fleet Verification**	**Fleet Use**
9	**Logistics Readiness Level**	**N/A**	**0**	**0**	**N/A**	**N/A**	**N/A**
10	Design Interface	Review and identify significant **design interface** impacts of project to existing system or platform (ex. available power, weight constraints, etc.) Create POAM to resolve any design interface issues.	Existing **Reliability and Maintainability** (RAM) metrics reviewed. Initial improvement predictions determined. **Design interface** issue resolution in work.	For new designs, **Reliability Centered Maintenance (RCM)** and **Failure Mode and Effects Analysis (FMEA)** completed to identify failure modes, Failure Frequency, effects on performance, and criticality. For modifications to existing design, RCM and	Results of **RCM** and **FMEA** used to develop or modify existing condition based and schedule based maintenance tasks. Results of RCM and FMECA also used to update the Critical Items list as applicable. Technical data updates drafted and validated.	**Technical updates** (such as Maintenance Requirement Card changes) verified.	**Technical** updates completed and available.
11							
12	Technical Data	Original Equipment Manufacturer higher level drawing, publication, specification available Applicable Material Safety Data Sheets (MSDS) Available	**Product Drawing/Tech Data Package** elements reviewed and requirements identified including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance Requirements Cards	**Product Drawing/Tech Data Package** elements draft development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance Requirements Cards	**Product Drawing/Tech Data Package** elements draft development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements updated including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements completed including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative
13			**Technical Directive** Methodology Identified	**Technical Directive** drafts in process	**Technical Directive** draft complete and validated	**Technical Directive** draft verified and updated	**Technical Directive** released and available
14				**Technical Publications** source data, Rapid Action Changes (RACs), and Manual Change Requests (MCRs) drafted per format	**Technical Publications** source data, Rapid Action Changes (RACs) and Manual Change Requests (MCRs) validated for content and format	**Technical Publications** instructions verified for content	**Technical Publications (or Pub Changes via RACs or MCRs)** finalized, approved and available for use
15							
16	Maintenance Planning		Existing **Maintenance Plan** identified and reviewed	**Maintenance Plan** update drafted as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable
17			**Maintenance Concept** reviewed (consumable, inspect and repair as necessary, overhaul)	**Maintenance Concept** update drafted as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable
18			**Level of Maintenance/Repair** reviewed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair**	**Level of Maintenance/Repair**
19			**Aircraft Battle Damage Repair** Procedures reviewed	**Aircraft Battle Damage Repair** Procedures updated as applicable	**Aircraft Battle Damage Repair** Procedures validated as applicable	**Aircraft Battle Damage Repair** Procedures verified as	**Aircraft Battle Damage Repair** Procedures updated
20							
21	Training		Existing **training procedures/curricula and training plan** identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated part validation/verification with changes as necessary. NTSP changes finalized. Changes submitted	**Training** curricula updated. **NTSP** updated.
22							
				Current **Facilities** reviewed and impacts identified. When applicable, facilities	Approved with funding available		

LRL Instructions | Prototype 4 HFFT Rev 2 | Protype 4 HFFT Rev 1 | **Prototype 4 HFFT** | Prototype 3 CO2FFT | Prototype 2 SBRFFT | Prototype 1 CFFT

Prototype Example Second Assessment LRL = 1

Second Assessment 5/4/06, LRL =1, Issues with Training

	A	B	C	D	E	F	G
1							
2	**Project Title:**	Proto.4 HFFT-Update -17 Manual and create Joint Publication	Red Background =	Not Complete	Color current cell red.		
3	**Project Description**	Update GENERAL Series Technical Publication	Green Background =	Complete	Color current cell green.		
4	**Project Implementat**	New Manual Release	Blue Background =	Not applicable due to project specifics	Color current cell blue.		
5	**Project Phase:**	Project Development	Grey Background =	Not applicable due to project phase	Color current cell grey.		
6	**Date Evaluated:**	Rev 1 5/4/06			Recalculate		
7		Logistics Readiness Level 0 - Unsupported. Level 1 - Poorly Supported. Level 2 - Moderately Supported. Level 3 - Nearly Supported. Level 4 - Fully Supported.					
8	**Phase**	**Lab Test/R&D phase**	**Project Definition (Fleet Need/metrics/BCA/Decision to proceed)**	**Project Development /Implementation (Finalized analysis, change recommended, ECP development,**	**Engineering Validation**	**Fleet Verification**	**Fleet Use**
9	**Logistics Readiness Level**	**N/A**	**0**	**1**	**N/A**	**N/A**	**N/A**
10	Design Interface	Review and identify significant **design interface** impacts of project to existing system or platform (ex. available power, weight constraints, etc.) Create POAM to resolve any design interface issues.	Existing **Reliability and Maintainability** (R&M) metrics reviewed. Initial improvement predictions determined. **Design interface** issue resolution in work.	For new designs, **Reliability Centered Maintenance (RCM)** and **Failure Mode and Effects Analysis (FMEA)** completed to identify failure modes, failure frequency, effect on performance, and criticality. For modifications to existing design, RCM and	Results of **RCM** and **FMEA** used to develop or modify existing condition based and schedule based maintenance tasks. Results of RCM and FMECA also used to update the Critical Items list as applicable. Technical data updates drafted and validated.	**Technical updates** (such as Maintenance Requirement Card changes) verified.	**Technical** updates completed and available.
11							
12	Technical Data	Original Equipment Manufacturer higher level drawing, publication, specification available Applicable Material Safety Data Sheets (MSDS) Available	**Product Drawing/Tech Data Package** elements reviewed and requirements identified including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance Requirements Cards	**Product Drawing/Tech Data Package** elements draft development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance Requirements Cards	**Product Drawing/Tech Data Package** elements draft development including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements updated including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative Maintenance/Maintenance	**Product Drawing/Tech Data Package** elements completed including as applicable: Specs/tech manuals/engineering drawings Safety Requirements Preservation and packaging requirements Test requirements data Preventative
13			**Technical Directive** Methodology Identified	**Technical Directive** drafts in process	**Technical Directive** drafts complete and validated	**Technical Directive** drafts verified	**Technical Directive** released and available
14				**Technical Publications** source data, Rapid Action Changes (RACs), and Manual Change Requests (MCRs) drafted per format	**Technical Publications** source data, Rapid Action Changes (RACs) and Manual Change Requests (MCRs) validated for content and format	**Technical Publications** Instructions verified for content	**Technical Publications (or Pub Changes via RACs or MCRs)** finalized, approved and available for use
15							
16	Maintenance Planning		Existing **Maintenance Plan** identified and reviewed	**Maintenance Plan** update drafted as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable
17			**Maintenance Concept** reviewed (consumable, inspect and repair as necessary, overhaul)	**Maintenance Concept** update drafted as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable
18			**Level of Maintenance/Repair** reviewed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair**
19			**Aircraft Battle Damage Repair** Procedures reviewed	**Aircraft Battle Damage Repair** Procedures updated as applicable	**Aircraft Battle Damage Repair** Procedures validated as applicable	**Aircraft Battle Damage Repair** Procedures verified as	**Aircraft Battle Damage Repair** Procedures updated
20							
21	Training		Existing **training procedures/curricula and training plan** identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated part validation/verification with changes as necessary. NTSP changes finalized. Changes submitted	**Training** curricula updated. **NTSP** updated.
22							
				Current **Facilities** reviewed and impacts identified. When applicable, facilities	As needed with funding available		

LRL Instructions | Prototype 4 HFFT Rev 2 | **Protype 4 HFFT Rev 1** | Prototype 4 HFFT | Prototype 3 CO2FFT | Prototype 2 SBRFFT | Prototype 1 CFFT

Prototype Example Third Assessment LRL = 4

Third Assessment 5/30/06, LRL = 4, all benchmarks achieved

	A	B	C	D	E	F	G
1							
2	**Project Title:**	Proto.4 HFFT-Update -17 Manual and create Joint Publication	Red Background =	Not Complete	Color current cell red.		
3	**Project Description**	Update GENERAL Series Technical Publication	Green Background =	Complete	Color current cell green.		
4	**Project Implementat**	New Manual Release	Blue Background =	Not applicable due to project specifics	Color current cell blue.		
5	**Project Phase:**	Project Development	Grey Background =	Not applicable due to project phase	Color current cell grey.		
6	**Date Evaluated:**	Rev 2 5/30/06			Recalculate		
7		Logistics Readiness Level 0 - Unsupported. Level 1 - Poorly Supported. Level 2 - Moderately Supported. Level 3 - Nearly Supported. Level 4 - Fully Supported.					
8	**Phase**	**Lab Test/R&D phase**	**Project Definition (Fleet Need/metrics/BCA/Decision to proceed)**	**Project Development /Implementation (Finalized analysis, change recommended, ECP development,**	**Engineering Validation**	**Fleet Verification**	**Fleet Use**
9	**Logistics Readiness Level**	**N/A**	**4**	**4**	**N/A**	**N/A**	**N/A**
10	Design Interface	Review and identify significant **design interface** impacts of project to existing system or platform (ex. available power, weight constraints, etc.) Create POAM to resolve any design interface issues.	Existing **Reliability and Maintainability** (R&M) metrics reviewed. Initial improvement predictions determined. **Design interface** issue resolution in work.	For new designs, **Reliability Centered Maintenance (RCM)** and **Failure Mode and Effects Analysis (FMEA)** completed to identify failure modes, failure frequency, effect on performance, and criticality. For modifications to existing design, RCM and	Results of **RCM** and **FMEA** used to develop or modify existing condition based and schedule based maintenance tasks. Results of RCM and FMECA also used to update the Critical Items list as applicable. Technical data updates drafted and validated.	**Technical updates** (such as Maintenance Requirement Card changes) verified.	**Technical** updates completed and available.
11							
12	Technical Data	Original Equipment Manufacturer higher level drawing, publication, specification available Applicable Material Safety Data Sheets (MSDS) Available	**Product Drawing/Tech Data Package** elements reviewed and requirements identified including as applicable: *Spare/tech manual/engineering drawings* *Safety Requirements* *Preservation and packaging requirements* *Test requirements data* *Preventative Maintenance/Maintenance Requirements Cards*	**Product Drawing/Tech Data Package** elements draft development including as applicable: *Spare/tech manual/engineering drawings* *Safety Requirements* *Preservation and packaging requirements* *Test requirements data* *Preventative Maintenance/Maintenance Requirements Cards*	**Product Drawing/Tech Data Package** elements draft development including as applicable: *Spare/tech manual/engineering drawings* *Safety Requirements* *Preservation and packaging requirements* *Test requirements data* *Preventative Maintenance/Maintenance*	**Product Drawing/Tech Data Package** elements updated including as applicable: *Spare/tech manual/engineering drawings* *Safety Requirements* *Preservation and packaging requirements* *Test requirements data* *Preventative Maintenance/Maintenance*	**Product Drawing/Tech Data Package** elements completed including as applicable: *Spare/tech manual/engineering drawings* *Safety Requirements* *Preservation and packaging requirements* *Test requirements data* *Preventative*
13			**Technical Directive** Methodology identified	**Technical Directive** draft in process	**Technical Directive** draft complete and validated	**Technical Directive** draft verified	**Technical Directive** released and available
14				**Technical Publications** source data, Rapid Action Changes (RACs), and Manual Change Requests (MCRs) drafted per format	**Technical Publications** source data, Rapid Action Changes (RACs) and Manual Change Requests (MCRs) validated for content and format	**Technical Publications** Instructions verified for content	**Technical Publications (or Pub Changes via RACs or MCRs)** finalized, approved and available for use
15							
16	Maintenance Planning		Existing **Maintenance Plan** identified and reviewed	**Maintenance Plan** update drafted as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable	**Maintenance Plan** update completed as applicable
17			**Maintenance Concept** reviewed (consumable, inspect and repair as necessary, overhaul)	**Maintenance Concept** update drafted as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable	**Maintenance Concept** update completed as applicable
18			**Level of Maintenance/Repair** reviewed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair** Analysis completed	**Level of Maintenance/Repair**
19			**Aircraft Battle Damage Repair** Procedures reviewed	**Aircraft Battle Damage Repair** Procedures updated as applicable	**Aircraft Battle Damage Repair** Procedures validated as applicable	**Aircraft Battle Damage Repair** Procedures verified as	**Aircraft Battle Damage Repair** Procedures updated
20							
21	Training		Existing **training procedures/curricula and training plan** identified and reviewed.	Impacts to **Training** identified	**Training curricula** changes drafted. As required changes to **Naval Training Systems Plan (NTSP)** drafted.	**Training curricula** changes updated part validation/verification with changes as necessary. NTSP changes finalized. Changes submitted	**Training** curricula updated. **NTSP** updated.
22							
				Current **Facilities** reviewed and impacts identified. When applicable, Facilities	As needed with funding available		

LRL Instructions | **Prototype 4 HFFT Rev 2** | Protype 4 HFFT Rev 1 | Prototype 4 HFFT | Prototype 3 CO2FFT | Prototype 2 SBRFFT | Prototype 1 CFFT

LRL Benefits

- Benefits of LRLs include:
  - Template/benchmark to measure readiness by logistic element on a **project** level basis
    - Utilized to train/mentor new logisticians, engineering and program management personnel in sustainment requirements
    - Identifies logistic risk areas
  - Aid in planning manpower/funding/schedule requirements for projects as they mature from project concept to implementation
  - Dovetail with formalized logistics risk assessments for another perspective
  - Numeric evaluation offers a way to compare projects from a logistics readiness perspective

Value of LRL is the establishing the time phase benchmarks

Questions?



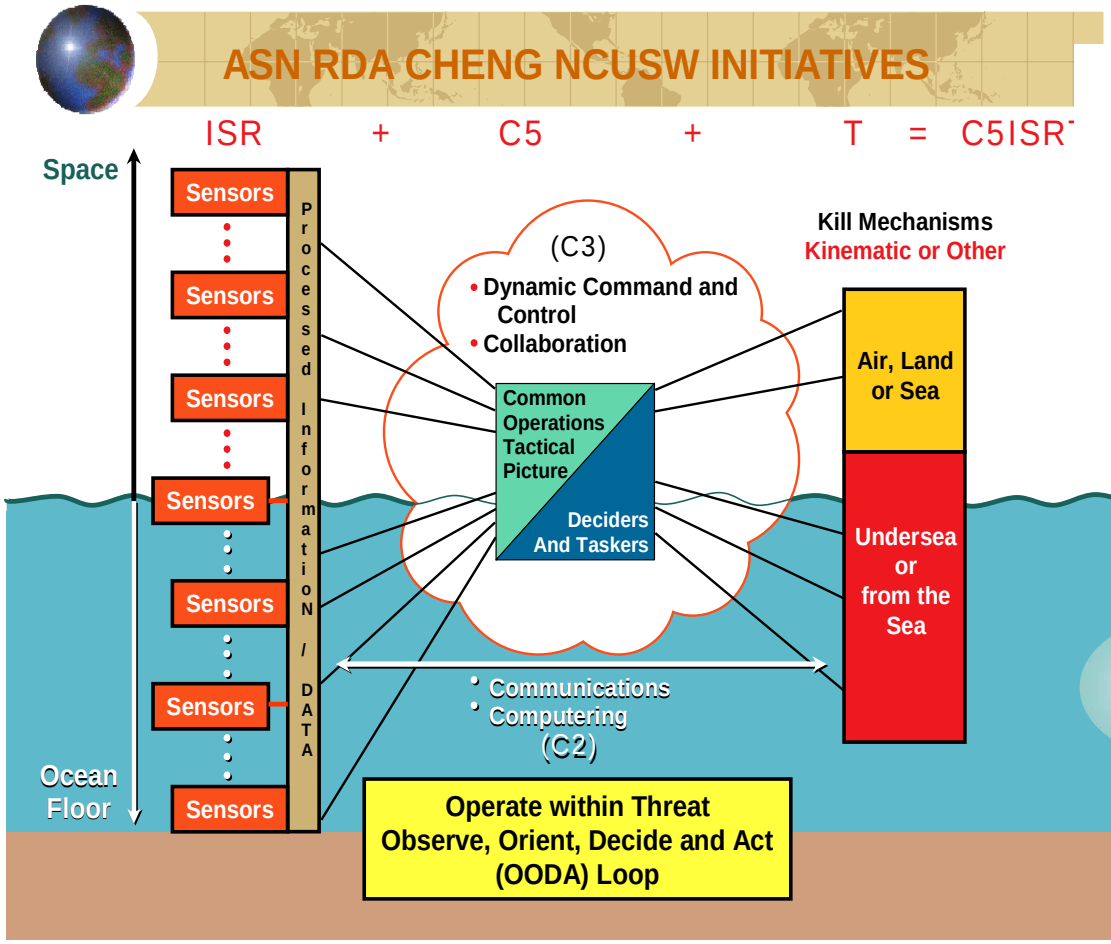
ASW Mission Capability Architecture To Support ASW System of Systems Acquisition Alignment Assessment

Presented By
Colleen Cannon, PEO IWS 5SE
And
Thomas G. DeLutis, Ph.D., ENX Group, Inc.

DISTRIBUTION STATEMENT D:
1) Distribution limited to DOD and DOD contractors only; Administrative/Operational Use; 01 December 2004. Other requests shall be referred to PEO IWS5SE.
2) No distribution of this document shall be made to DTIC.
3) No secondary distribution is authorized without prior written approval of PEO IWS5SE.
4) No publicity releases or public displays of any kind are authorized on this program.
DESTRUCTION NOTICE - Destroy by any method that will prevent disclosure of contents or reconstruction of the document.

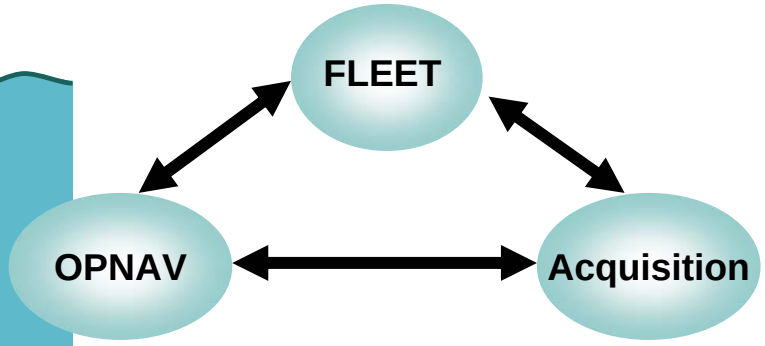
PREPARED FOR:
Program Executive Office Integrated Warfare Systems (PEO IWS)
Washington, DC 20362-5104

Net-Centric USW Construct



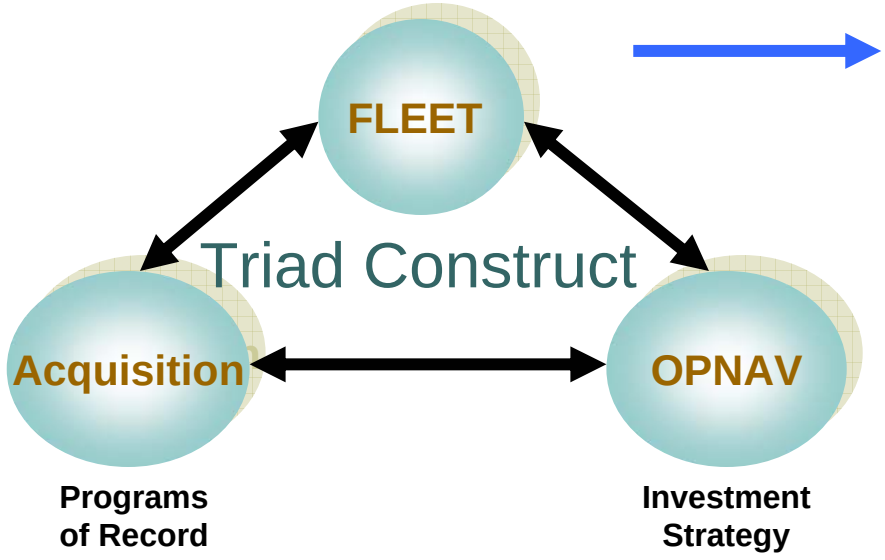
Various efforts related to FoS/SoS and Integrated Architectures conducted within Navy Enterprise

Triad Construct



ASW SoS System Engineering Operating Schematic

Desired Capability
Right Information, Right Time, Right Place
Resulting in desired effect
(Operational Views)



Programs of Record

Investment Strategy

Flag/SES Oversight
(Governance)

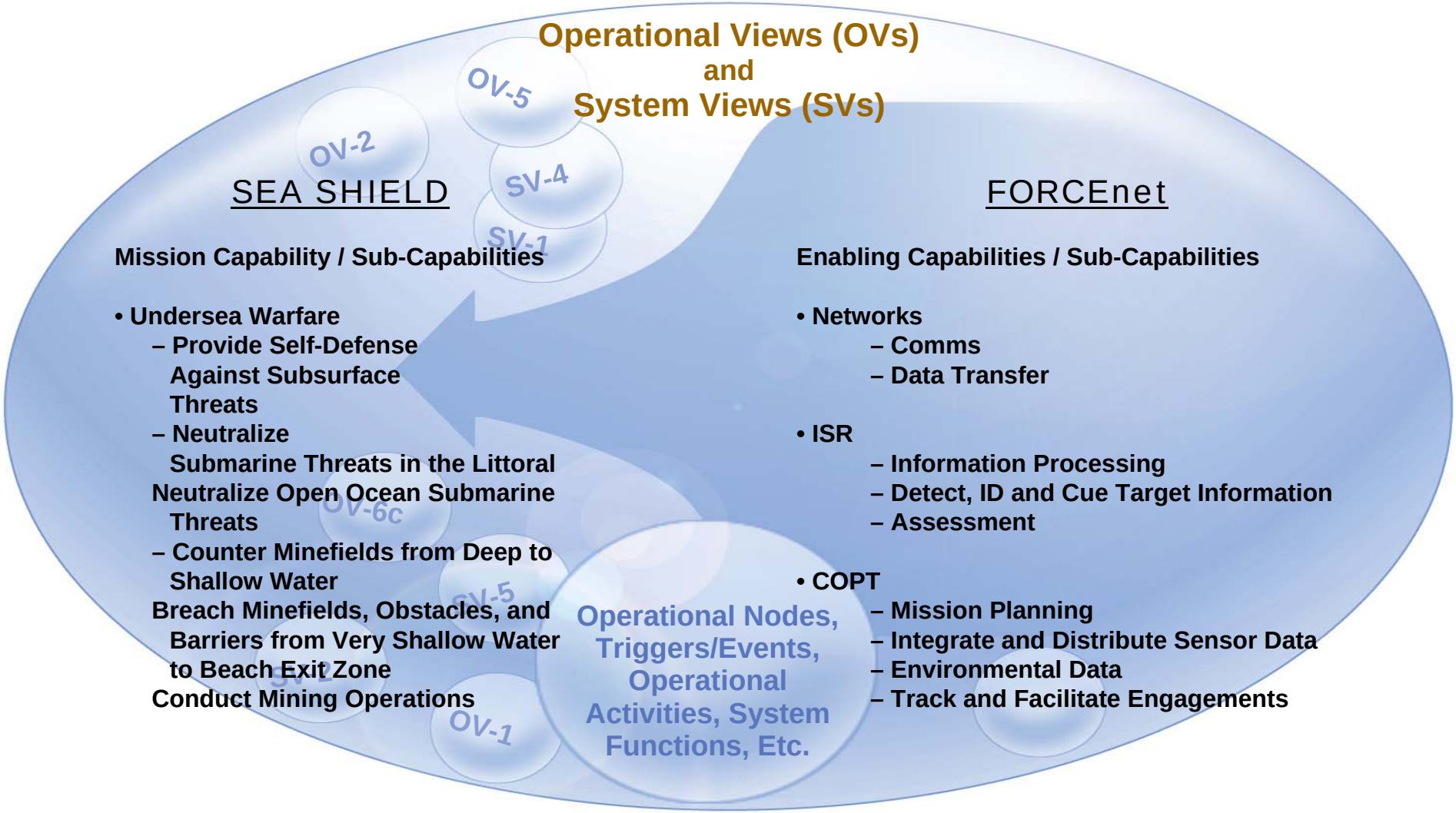
ASW Executive Steering Group
Material Solutions Aligned with
Desired Capability and Investment

ASW Systems Engineering Team (ASSET)
PEO IWS 5SE (chair)
PEO System Engineers
Subject Matter Experts (as required)
(System Views, Technical Views)

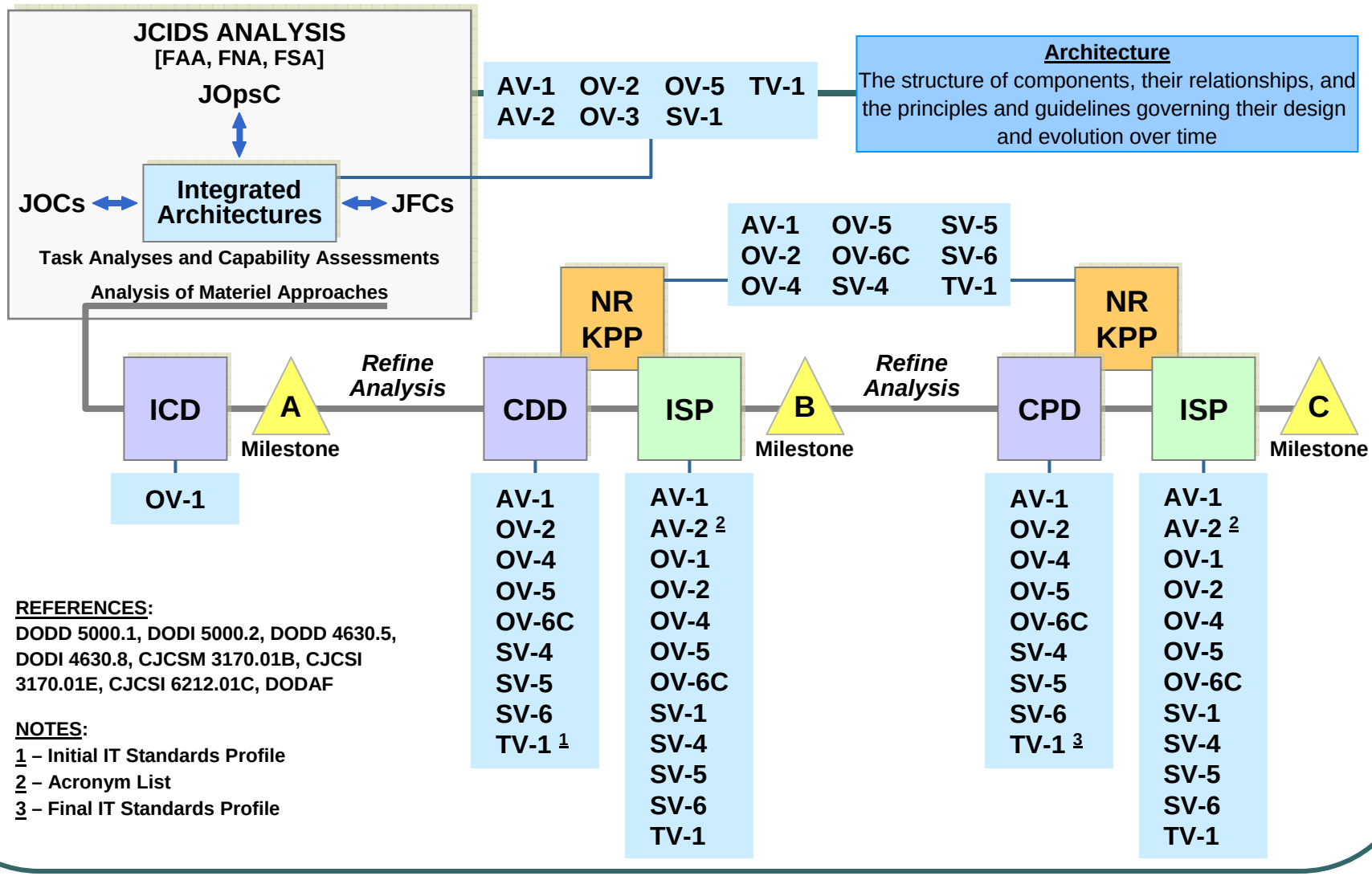
Coordination/Input

Undersea FORCEnet | **Virtual SYSCOM** | **ASN RDA CHENG** | **TBD**

USW Mission Capabilities and Enabling Capability Integrated Architecture



Capability Based Acquisition Process



REFERENCES:
DODD 5000.1, DODI 5000.2, DODD 4630.5, DODI 4630.8, CJCSM 3170.01B, CJCSI 3170.01E, CJCSI 6212.01C, DODAF

NOTES:
1 – Initial IT Standards Profile
2 – Acronym List
3 – Final IT Standards Profile

ASSET Products And Intent

Vetted Integrated ASW Mission Capability Architecture (MCA) for SoS acquisition alignment assessments

Assessments highlighting the impact on ASW mission capabilities arising from:

- ✓ Changes in the Program of Record
- ✓ Other Scenarios/Excursions
- ✓ Changes in SoS capabilities

Continuous Knowledge Management and collaboration

- ✓ SoS-based assessment tools and techniques
- ✓ Configuration managed ASSET repository

Intent

To ensure that the ASW architecture and assessments are aligned with program requirements, programs of record, and on-going capability assessments

Purpose of Mission Capability Architecture

The goal of this MCA is to create a common denominator across the Joint and Coalition Enterprise enabling:

Understanding,

Assessment,

Comparison,

And Integration

of FoS and SoS interoperability and capability evolution

Role of MCA Products to ASW Stakeholders

Architecture communicates desired capability to all involved in delivering the capability

- End User (Fleet)
- Investor (OPNAV)
- Material Providers (Acquisition Community)

Architecture provides a structured means for user needs to be translated into requirements describing the material solutions.

Success depends on Fleet involvement

3rd Fleet Operational Agent endorse ASW OVs

- NMAWC role as ASW ‘voice of the Fleet’

ASW OV context

- N81 Scenario alignment (Major Combat Operations)
- Global ASW CONOPs
- DRAFT OPNAV ASW Initial Capabilities Document (ICD)

Engage all ASW communities of interest

Desired Capability,
Right Information, Right Time, Right Place
Resulting in desired effect
(Operational Views)

Operational View Products

Operational Concept – high level abstraction of the problem to be solved endorsed by the end user (Fleet). Architecture frameworks defining the concept also serve as the foundation for 'systems' development by communicating end user desired capability to the acquisition community charged with developing material solutions. Architecture frameworks include:

- High Level Operational Concept Graphic (OV-1) –Provides a quick, high- level description of what the architecture is supposed to do, and how it is supposed to do it
- Operational Node Connectivity Description (OV-2) –Tracks the need to exchange information from specific operational nodes (that play a key role in the architecture) to others, however, it does not depict the connectivity between the nodes.
- Command Relationship Chart (OV-4) –Clarifies the various relationships that can exist between organizations and sub-organizations within the architecture and between internal and external organizations.
- Activity Model (OV-5) – Describes the operational activities and their sequencing that are normally conducted in the course of achieving ASW missions.

Systems View Products

Identifying ASW systems support to ASW operations is a three-step procedure: Identify and describe the ASW systems, link ASW system functionality to the ASW systems capable of providing the functionality, and link ASW systems to the ASW operational activities they support

- SV-4: Systems Functionality Description - Identifies and describes the functional support provided by systems to ASW operations
- SV-5: Operational Activity To Systems Function Traceability Matrix Depicts the mapping of operational activities (OV-5) to system functions and thus identifies the transformation of an operational need into a purposeful action performed by a system.
- SV-7: Systems Performance Parameters Matrix Specifies quantitative, performance characteristics of systems, their interfaces, and their functions.
- SV-8: Systems Evolution Description Describes the evolution plans that describe how the systems will evolve over a lengthy period of time.

System Views to be endorsed by Virtual SYSCOM and ASN RDA CHENG

Translating Operational Requirements to systems requirements

Architectures communicate desired capability to all involved in delivering the capability -

Desired capability
Right Information, right time, right place
Resulting in desired effect
(Operational Views)

Architectures provide a structured means for user needs to be translated into requirements describing the material solutions-

Map operational activities to systems functions
Map systems to functions
Map systems to protocols
Map systems to systems interoperability
(System Views)

System of Systems Definition

A set or arrangement of independent systems that are related or connected to provide a given capability. The loss of any part of a system will significantly degrade the performance or capabilities of the whole [1]

- If the system of systems has redundancy and fault tolerance, then the definition could be amended so that loss of any component **could** significantly degrade performance instead of will degrade performance.

[1] CJCSI 3170.01E, May 11, 2005

ASW SoS Assessment to Support Acquisition Management

Definition of ASW Operational Situations
Description of ASW Mission Capability

Definition

- ASW Mission Capability Packages
- ASW Operational Architecture
- ASW System Architecture
- Knowledge Management Tool
- Perform Acquisition SoS Assessments

Current baseline ASW Operational View Products (OV)
Current baseline ASW System View Products (SV)

Baselining

- Structure and Format MCPs
- Mission capabilities view product /description
- Mission Capabilities Traceability to Operational Activities Map
- Update Architecture Database
- Publish ASW MCPs
- Current As-Is Baseline (Leverage Navy Existing ASW Mission Caps)
- Target To Be Baseline (Leverage Navy Net Centric Environment and Mission Caps)
- Update ASW Architecture Database
- Publish ASW System Architecture

Target baseline ASW Operational View Products
Target baseline ASW System View Products

ReBaselining

- Current (As-Is) Baseline
- Target (To Be) Baseline
- Update Architecture Database
- Publish ASW Operational Architecture
- Additional Mission Capability Products
- MCP by System Matrix
- MCP evolution roadmap
- Vet MCP Systems product with ASW Mission MCP and Systems Subject Matter Experts input
- ASW Mission Acquisition Subject Matter Experts input
- Update ASW Architecture Database
- Publish ASW SoS

Define of ASW MCP FoS and SoS
Align with POR
Describe ASW MCP capability evolution

Documentation

- Definition of ASW Operational Situations
- Description of ASW Mission Capability
- Current baseline ASW Operational View Products
- Target baseline ASW Operational View Products
- Current baseline ASW System View Products
- Target baseline ASW System View Products
- Definition of ASW MCP FoS and SoS
- ASW MCP FoS and SoS Alignment with POR
- Description of ASW MCP Capability Evolution
- ASW Architecture Knowledge Mngmt System
- ASW Architecture Database
- ASW Acquisition SoS Assessment Plan

Knowledge Management

Choose and install selected product
Create ASW Architecture Database
Institute Configuration Control
Institute Access Control
Develop User Manual

ASW Acquisition SoS Assessment

Define assessment requirements
Develop operational concept
Develop implementation plan for operational concept

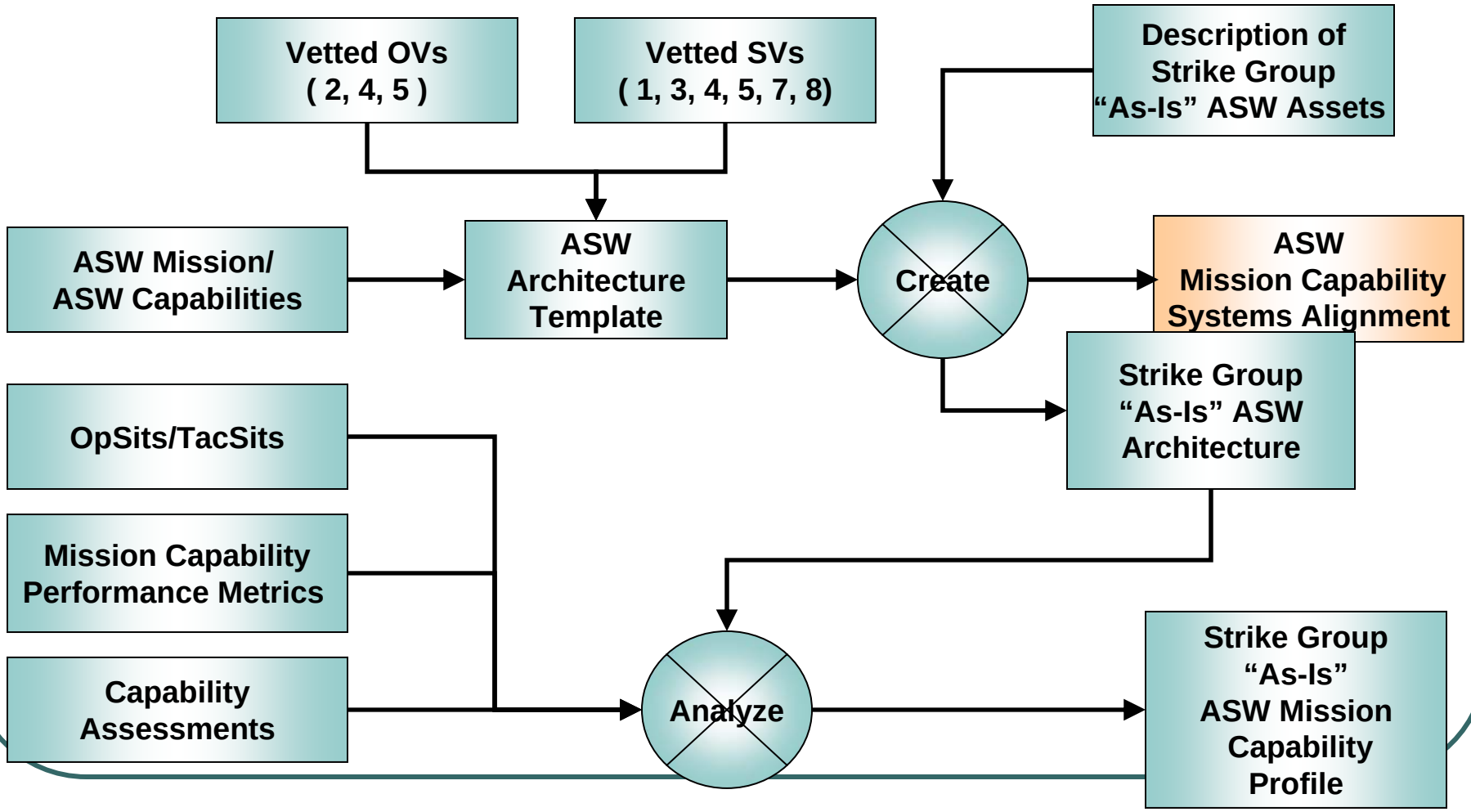
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

Architecture Knowledge Management System

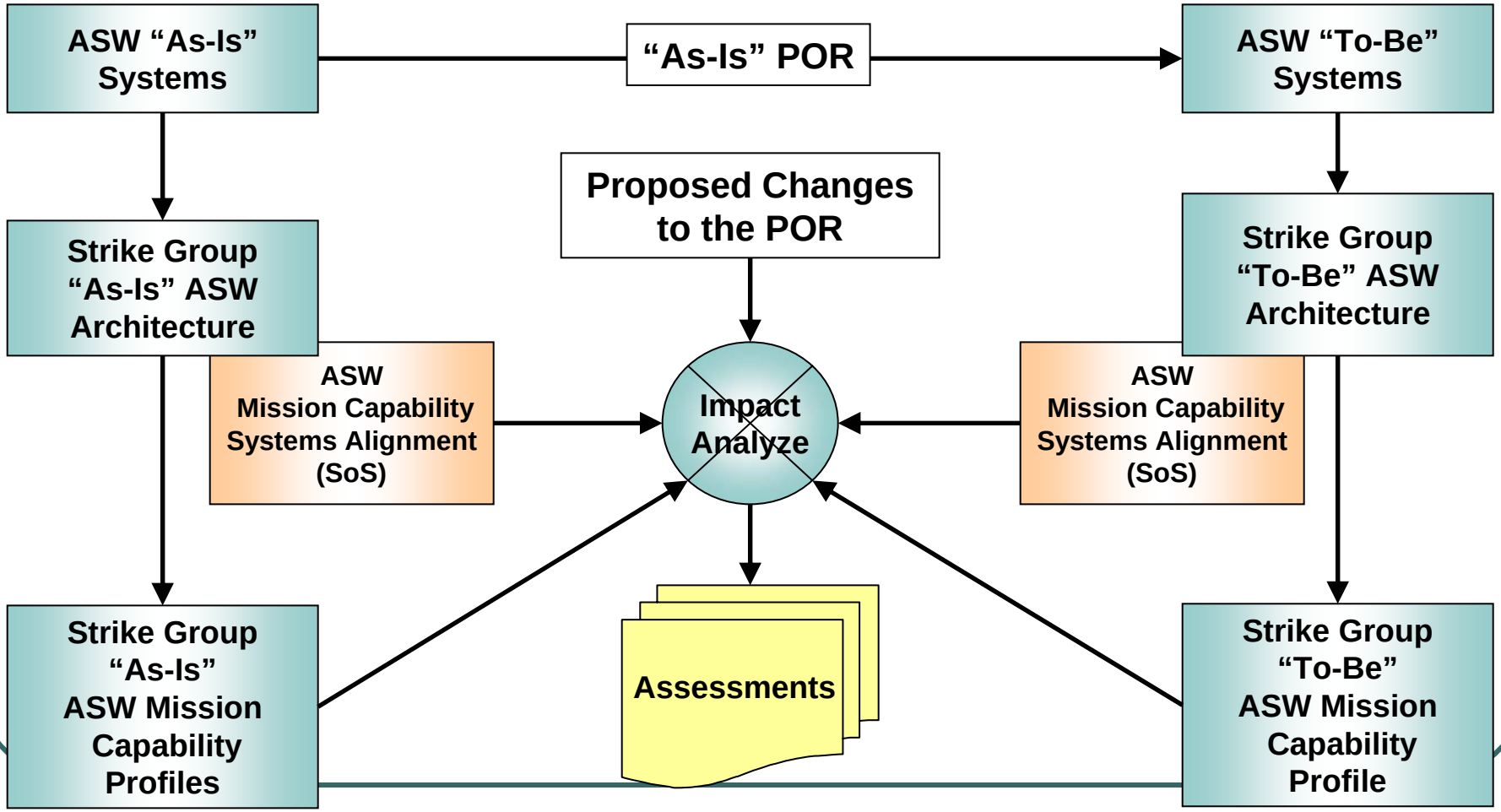
Architecture Database

ASW SoS Acquisition Alignment Assessment Strategy (1/2)

Creating an "As-Is" ASW Mission Capability Baseline



ASW SoS Acquisition Alignment Assessment Strategy (2/2)



SoS SE Initial Tasks and Products

Fleet inputs including endorsement process provide basis for engineering products

- All View (AV-1) Overview and Summary Information - In the initial phases of architecture development, it serves as a planning guide. Upon completion of the architecture, it provides summary textual information concerning the architecture
- (OV-1) - High-Level Operational Concept Graphic - Provides a quick, high- level description of what the architecture is supposed to do, and how it is supposed to do it.
- Operational Node Connectivity Description (OV-2) - Tracks the need to exchange information from specific operational nodes (that play a key role in the architecture) to others, however, it does not depict the connectivity between the nodes
- Organizational Relationships Chart (OV-4) –Clarifies the various relationships that can exist between organizations and sub-organizations within the architecture and between internal and external organizations
- Operational Activity Model (OV-5) – Describes the operational activities and their sequencing that are normally conducted in the course of achieving ASW missions.
- SV-5: Operational Activity To Systems Function Traceability - Depicts the mapping of operational activities (OV-5) to system functions and thus identifies the transformation of an operational need into a purposeful action performed by a system.
- SV-3a: System by Platform Map, SV-3b:Function by System Map, SV-3c: Systems by Systems Association Map, SV-3e: System by Operational Activity Map, SV-3f: ASW Systems of Systems

Summary

ASSET will provide the following results:

An end-to-end mission capability with enhanced integration and interoperability across ASW, using SoS artifacts:

- Mission Capability Architecture
- Open Architecture
- Risk Management

A structured SE approach, influencing acquisition decisions to:

Deliver ASW Fleet products faster and cheaper

Design commonality into software and processing

SoS architectures that are adaptive and flexible to meet evolving Navy vision and varying operational circumstances

Back-up slides

Table 1: Mission Capability Architecture Products

Name		Role
AV-1:	Overview and Summary Information	In the initial phases of architecture development, it serves as a planning guide. Upon completion of the architecture, it provides summary textual information concerning the architecture.
AV-2:	Integrated Dictionary	Provides a central repository for a given architecture's data and metadata and enables the set of architecture products to be read and understood with minimal reference to outside resources.
OV-1:	High-Level Operational Concept Graphic	Provides a quick, high- level description of what the architecture is supposed to do, and how it is supposed to do it.
OV-2:	Operational Node Connectivity Description	Tracks the need to exchange information from specific operational nodes (that play a key role in the architecture) to others, however, it does not depict the connectivity between the nodes.
OV-2a:	ASW Mission Description	Describes ASW Missions
OV-2b:	ASW Capability Description	Describes ASW Capabilities

Table 1: Mission Capability Architecture Products, Cont.

OV-2c: Map	ASW Mission by Capability	Associates ASW capabilities (OV-2b) with ASW missions (OV-2a) thereby defining the set of ASW capabilities required for each ASW mission.
OV-2d:	ASW Capability by Operational Activity Map	Associates operational activities and their sequencing (OV-5) with ASW Capabilities (OV-2b)
OV-2e:	ASW Mission Capability Profile	Describes the desired performance levels for the ASW Capabilities for each ASW mission supported (OV-2c)
OV-4: Chart	Organizational Relationships	Clarifies the various relationships that can exist between organizations and sub-organizations within the architecture and between internal and external organizations.
OV-5:	Operational Activity Model	Describes the operational activities and their sequencing that are normally conducted in the course of achieving ASW missions.
SV-1a:	Physical Node Description	Describes the platforms and facilities and their associated locations that house ASW operational nodes and/or ASW systems
SV-1b:	ASW Systems Description	Identifies and describes the Systems that provide functional support to ASW operational activities

Table 1: Mission Capability Architecture Products, Cont.

SV-2: Systems Communications Description	Depicts pertinent information about communications systems, communications links, and communications networks that link the physical nodes identified in the SV-1a and SV-1b.
SV-3a: System by Platform Map	Associates ASW systems (SV-1b) with physical nodes (SV-1a)
SV-3b: Function by System Map	Associates ASW functions (SV-4) that support ASW operational activities the ASW Systems (SV-1b) capable of providing the functionality.
SV-3c: Systems by Systems Association Map	Describes pair-wise relations between ASW systems including dependency of one system on another, shared interface protocols, connectivity
SV-3e: System by Operational Activity Map	Associates ASW systems (SV-1b) with ASW operational activities (OV-5) they support via their functionality.
SV-3f: ASW Systems of Systems	Identifies the systems that collectively provide the functional support to an ASW capability. The System of Systems definition is derived from information contained in the OV-2b, OV-2e, OV-5, SV-3b, SV-4, and SV-5 products.

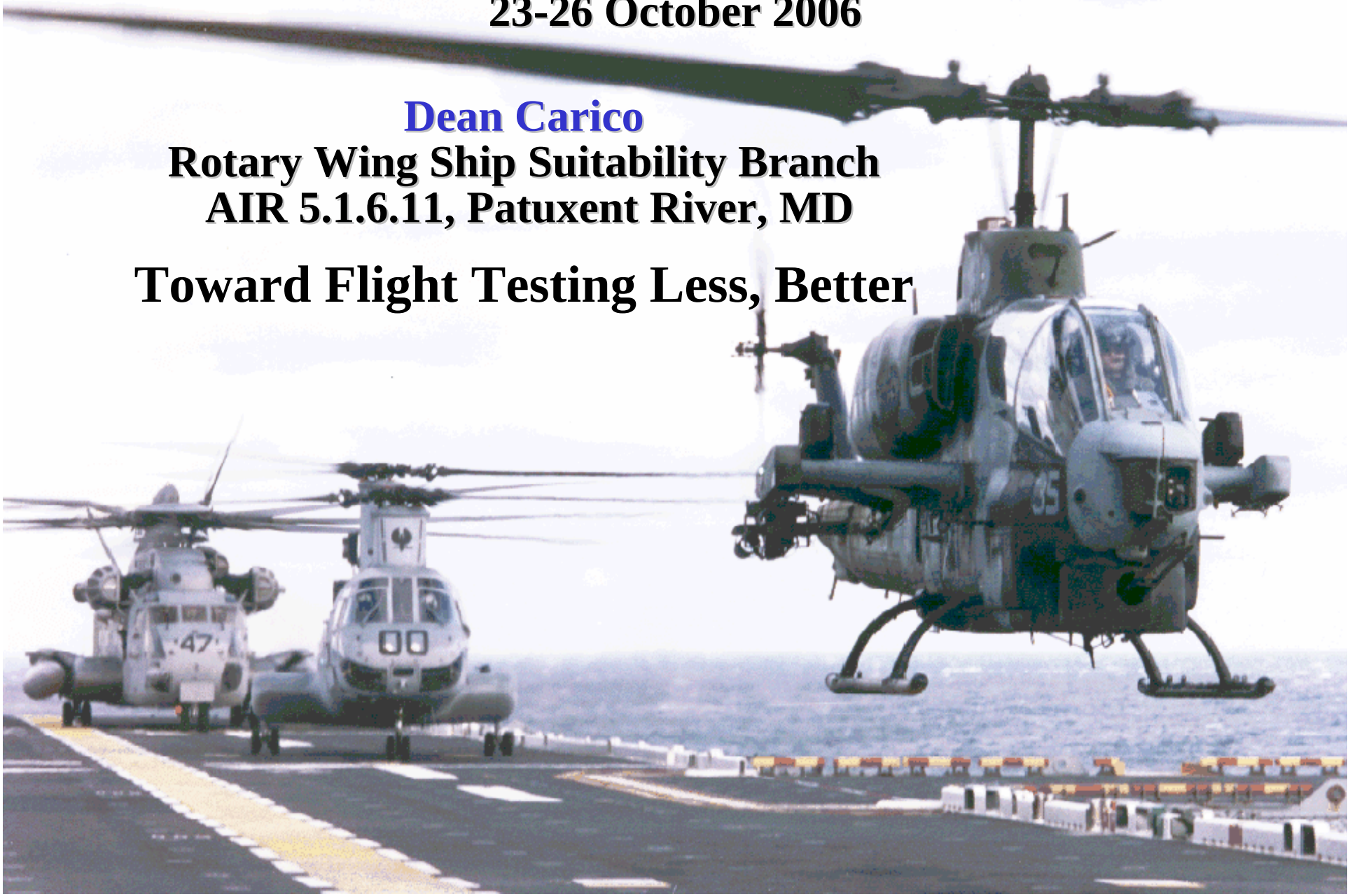
Table 1: Mission Capability Architecture Products, Cont.

SV-4: Systems Functionality Description	Identifies and describes the functional support provided by systems to ASW operations
SV-5: Operational Activity To Systems Function Traceability Matrix	Depicts the mapping of operational activities (OV-5) to system functions and thus identifies the transformation of an operational need into a purposeful action performed by a system.
SV-7: Systems Performance Parameters Matrix	Specifies quantitative, performance characteristics of systems, their interfaces, and their functions.
SV-8: Systems Evolution Description	Describes the evolution plans that describe how the systems will evolve over a lengthy period of time.

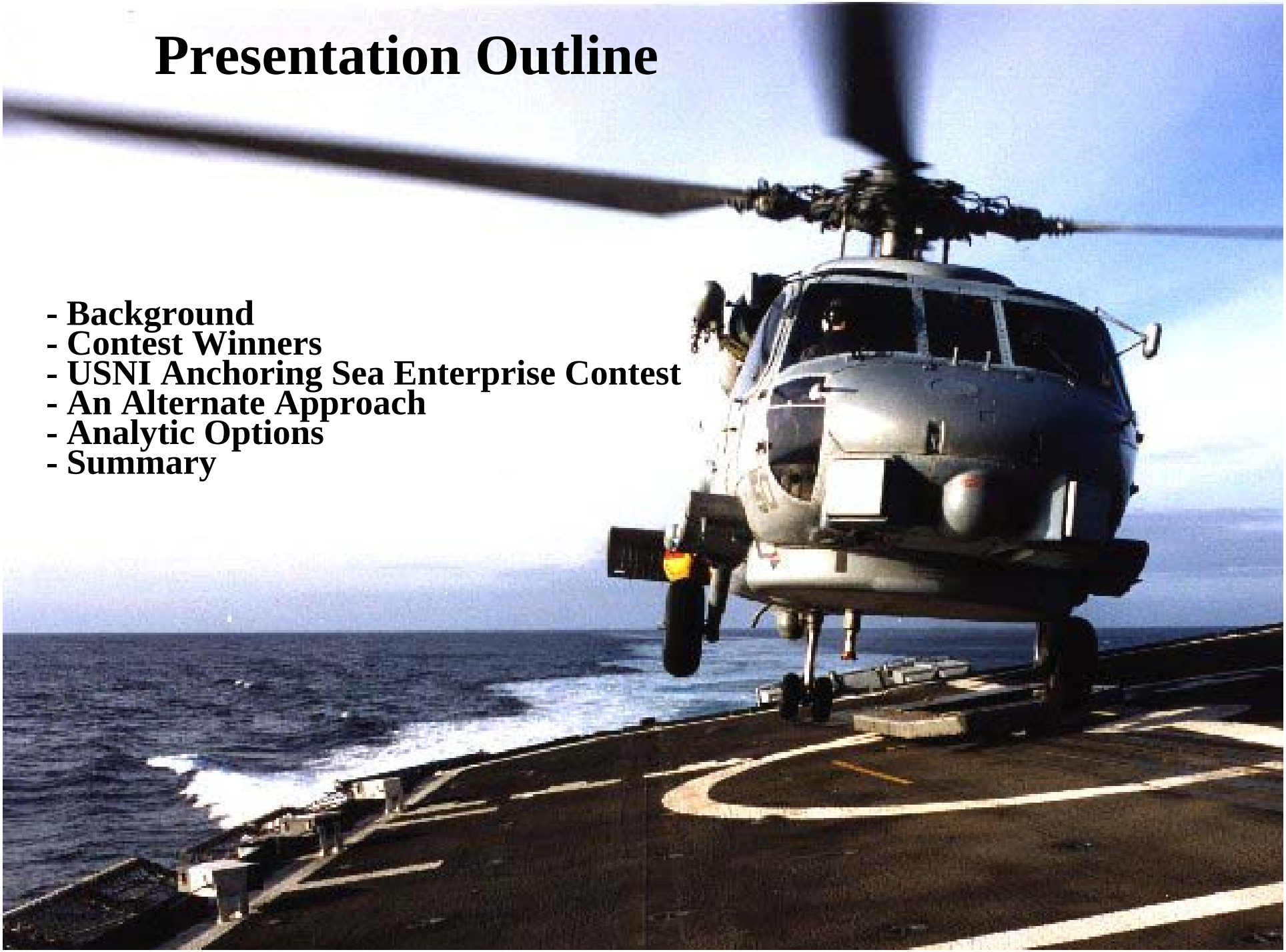
9th Annual Systems Symposium
San Diego, CA
23-26 October 2006

Dean Carico
Rotary Wing Ship Suitability Branch
AIR 5.1.6.11, Patuxent River, MD

Toward Flight Testing Less, Better



Presentation Outline



- Background
- Contest Winners
- USNI Anchoring Sea Enterprise Contest
- An Alternate Approach
- Analytic Options
- Summary

Background

- 1943 – First helicopter/shipboard landing
- 1945 – NATC established at Pax River MD
- 1949 – Rotary Wing Branch established in the Flight Test Division of the NATC at Pax River, MD
- 1982 – Dynamic Interface Section established
- 1980 – Deming – Total Quality Management
- 1990 – Reduce cost & cycle time of T&E
- 2000 + - Lean, Six Sigma, AIRspeed, Sea Enterprise (Doing less, better, etc)

US Naval Institute
Anchoring Sea Enterprise Essay Contest (1)

- Essay Contest announced in Jan 2006
  - 3,500 word essay; Several prizes (1^{st} = $15K)
- Areas of Emphasis
  - Increasing Efficiency and Effectiveness
  - Increasing Productivity (..doing less, better)
  - New Technology
  - Accelerating Innovation
  - Adaptive Organization Design
  - Outstanding Communication
  - Barriers, Incentives, and Mechanisms Necessary for Change
  - Leading Change
- Received 260 essays

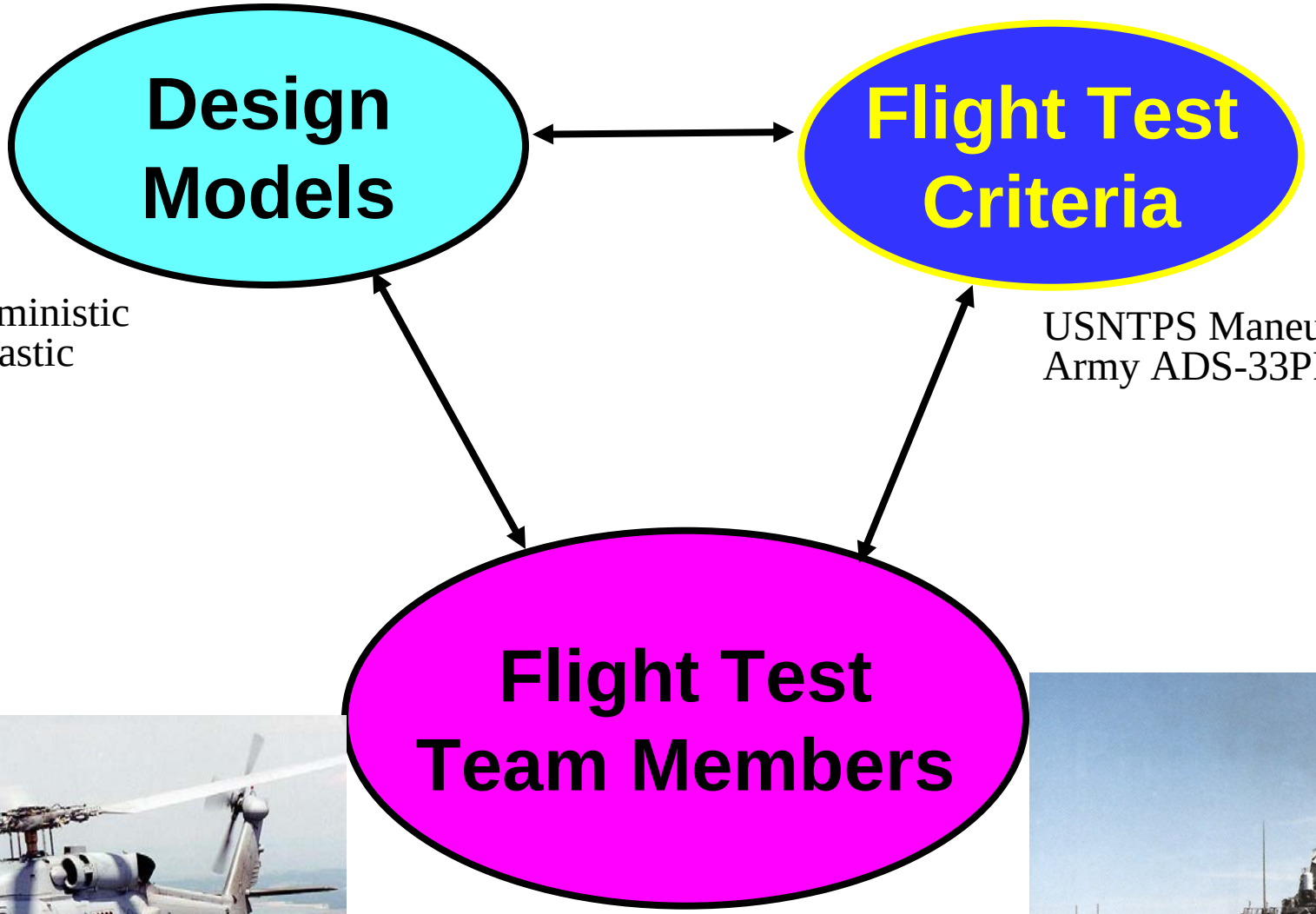
US Naval Institute
Anchoring Sea Enterprise Essay Contest (2)

- Winning essay: “Sea Wiki: How to Take the Navy’s Culture of Innovation to New Depths” LCDR Frederick Dini, Navy Supply Corp
  - A Wiki is a web page which contains all the information on a topic and anyone can add, delete, or edit its content.
- 2nd – “Retire the Twenty-Year System” Ben Atkins, GE Energy Financial Services
- 3rd – “Sea Enterprise: Get Under Way on Manpower” CAPT Ken Perry, Submarine Development Squadron 12
- Hon – “It’s the Network” ENS Tim Graczewski, USNR

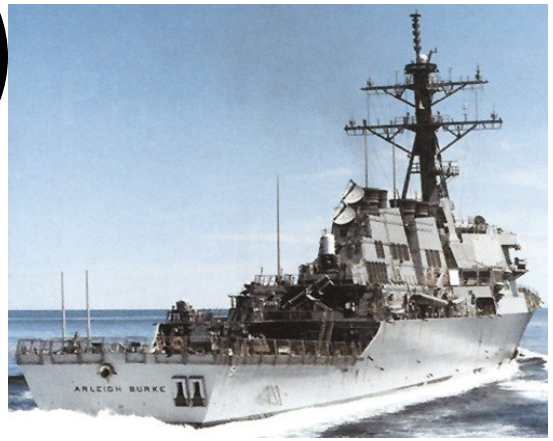
One of the 260 Essays: Technology Options to Enhance Rotorcraft/Ship Testing and Related Analysis

- Integrate design & flight test analytics
- Generic air vehicle model structure
- USNTPS & Army ADS-33PRT criteria
- High performance computing options
- Multimedia test planning & reporting
- Intelligent aircraft flight test database
- Advanced aircraft simulator MOE
- Aircraft/ship analytic options
- Advanced miniaturized data systems

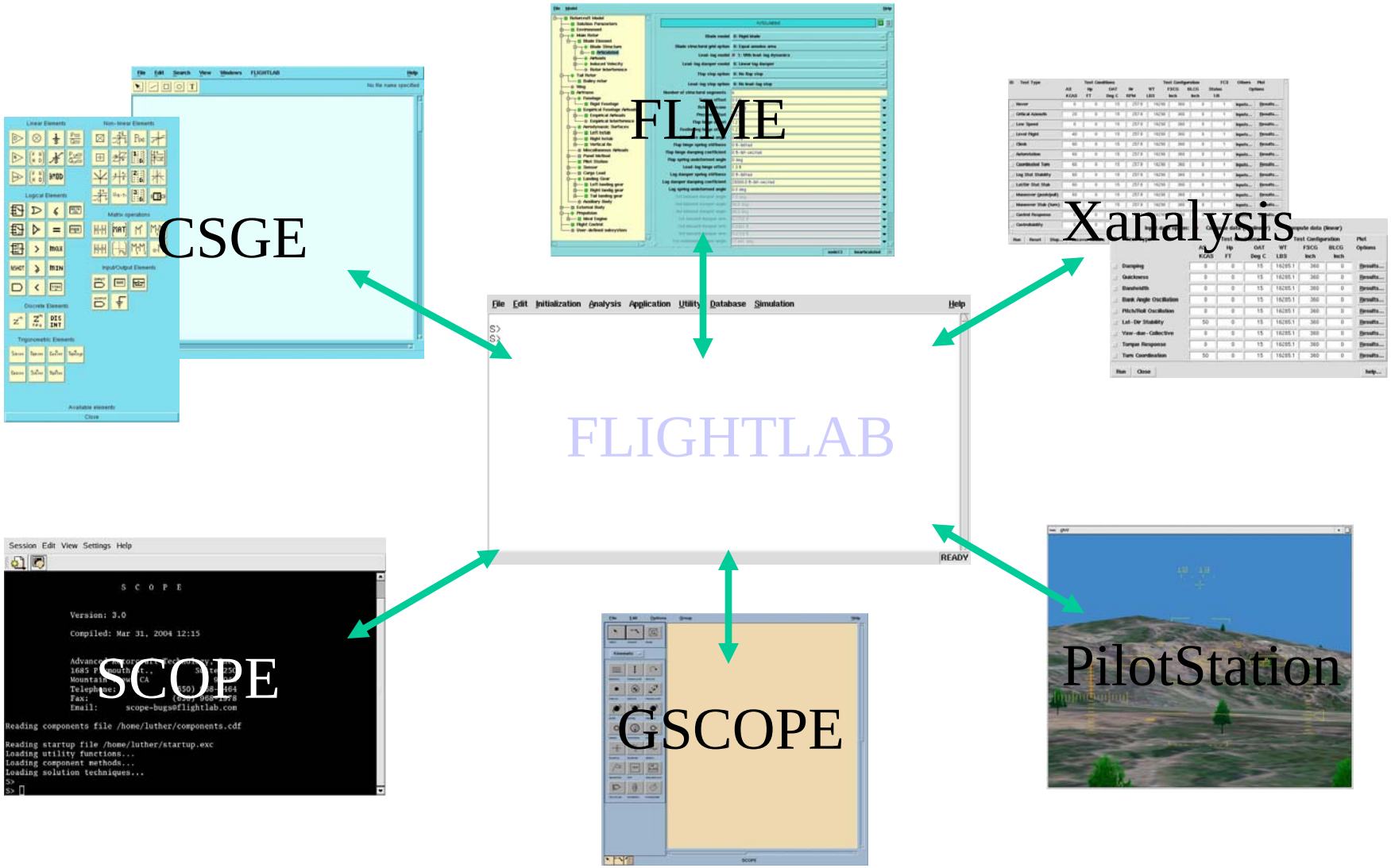
Integrating Design &Flight Test Analytics



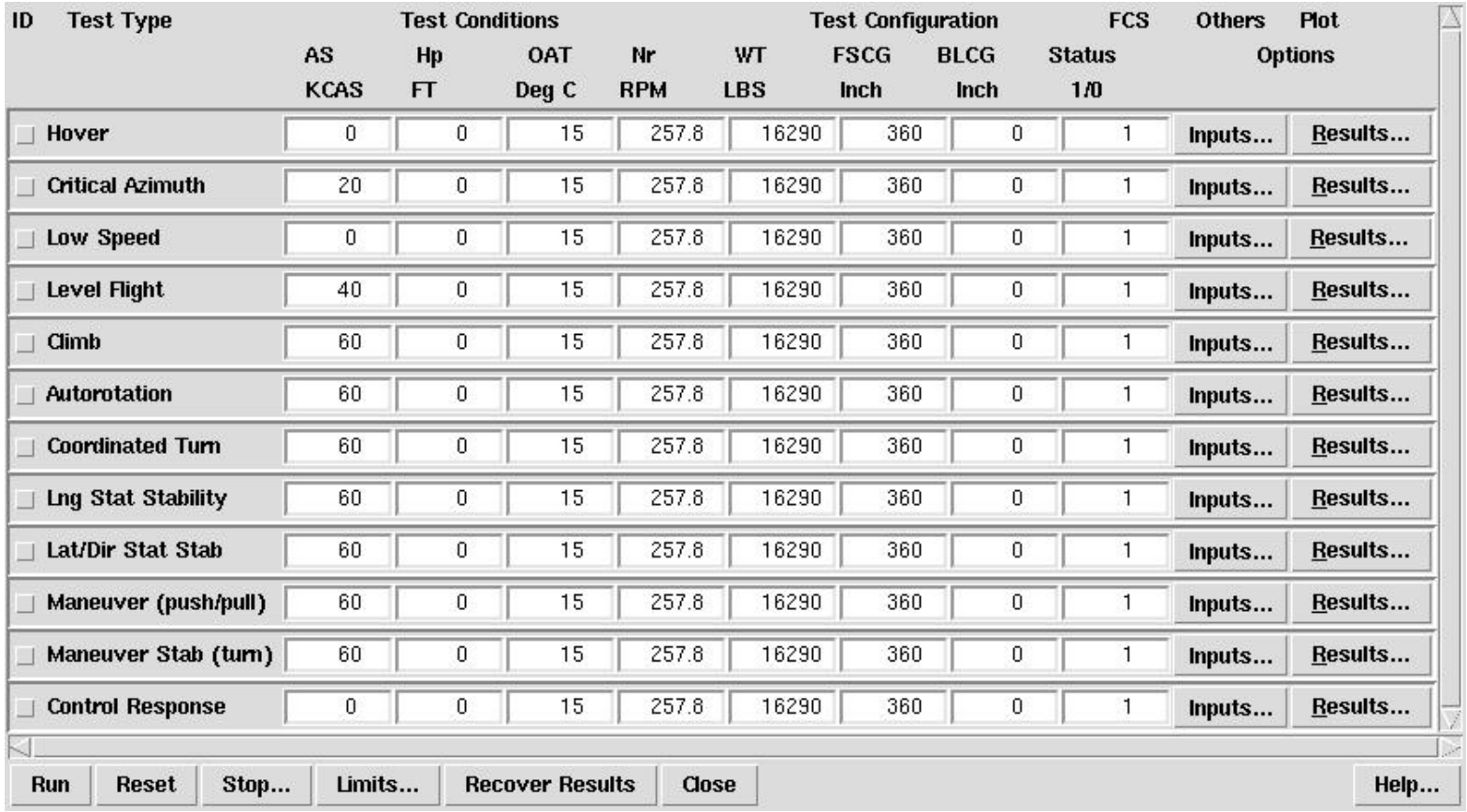




FLIGHTLAB Architecture

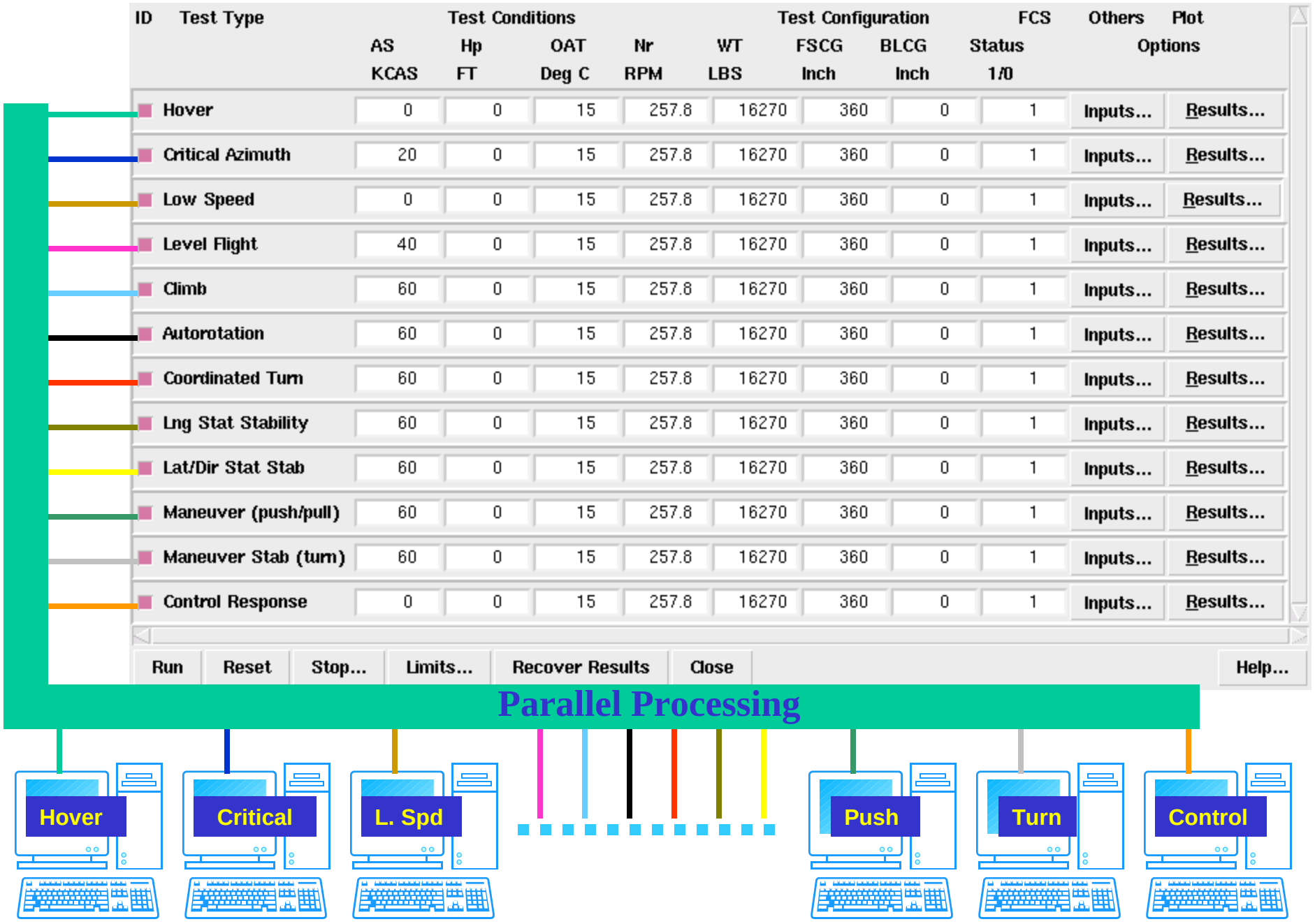


USNTPS FQ&P Tests Modeled in the FLIGHTLAB Environment

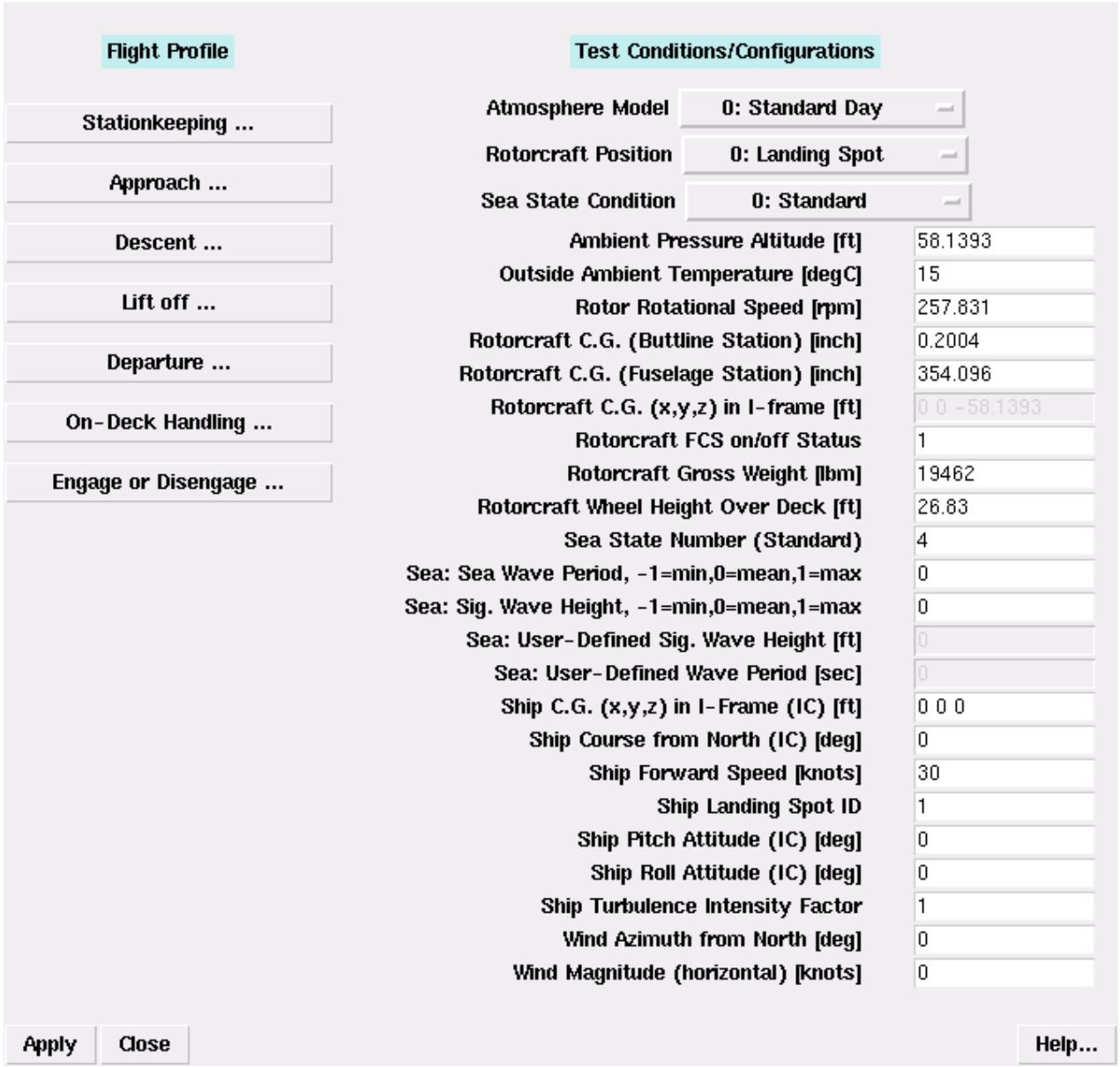


ID	Test Type	Test Conditions					Test Configuration		FCS	Others	Plot
		AS KCAS	Hp FT	OAT Deg C	Nr RPM	WT LBS	FSCG Inch	BLCG Inch	Status 1/0	Options	
☐	Hover	0	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Critical Azimuth	20	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Low Speed	0	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Level Flight	40	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Climb	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Autorotation	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Coordinated Turn	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Lng Stat Stability	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Lat/Dir Stat Stab	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Maneuver (push/pull)	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Maneuver Stab (turn)	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Control Response	0	0	15	257.8	16290	360	0	1	Inputs...	Results...

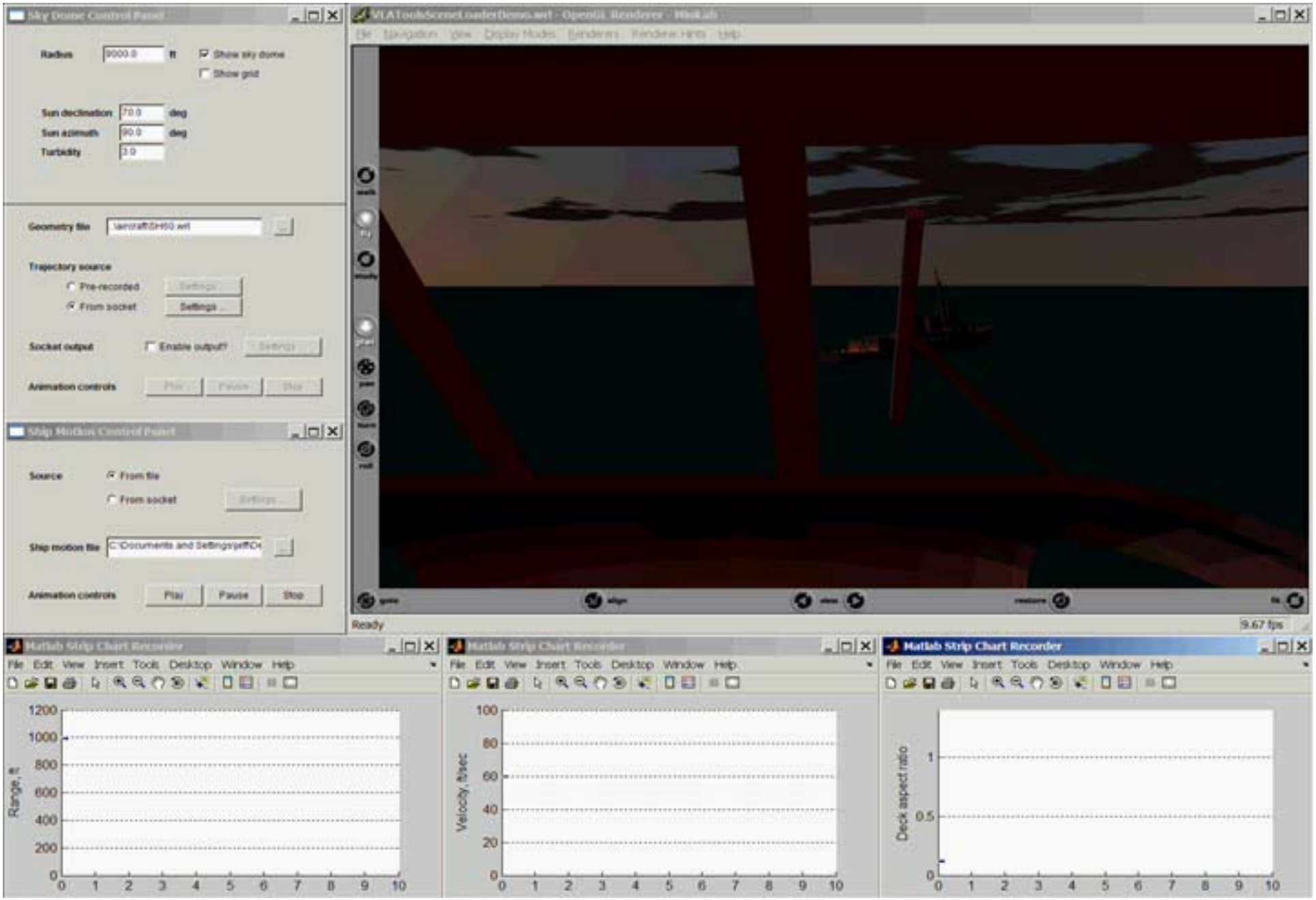
Run | Reset | Stop... | Limits... | Recover Results | Close | Help...


ID
Test Type
Test Conditions
AS
KCAS
Hp
FT
OAT
Deg C
Nr
RPM
WT
LBS
Test Configuration
FSCG
Inch
BLCG
Inch
FCS
Status
1/0
Others
Plot
Options
Hover 0 0 15 257.8 16270 360 0 1 Inputs... Results...
Critical Azimuth 20 0 15 257.8 16270 360 0 1 Inputs... Results...
Low Speed 0 0 15 257.8 16270 360 0 1 Inputs... Results...
Level Flight 40 0 15 257.8 16270 360 0 1 Inputs... Results...
Climb 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Autorotation 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Coordinated Turn 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Lng Stat Stability 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Lat/Dir Stat Stab 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Maneuver (push/pull) 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Maneuver Stab (turn) 60 0 15 257.8 16270 360 0 1 Inputs... Results...
Control Response 0 0 15 257.8 16270 360 0 1 Inputs... Results...
Run
Reset
Stop...
Limits...
Recover Results
Close
Help...
Parallel Processing
Hover
Critical
L. Spd
Push
Turn
Control

FLIGHTLAB Dynamic Interface GUI



PC-Based VLA Test Tool - CDI



PC-Based VLA Test Tool - SHAI



Rotorcraft Flight Test Analytic Options

- Aircraft/Ship Models
  - Helicopters & Rotorcraft (type DI flight)
    - Rotors, Fuselage, Engines, Flight control systems, landing gear arrangement, etc
- Aircraft/Ship Environment
  - Ship Airwake/Turbulence
  - Ship Motion
  - Visual Cues
- Component Integration
  - Rotor wake and ship airwake
  - Ship airwake and ship motion
  - Visual cues

Dynamic Interface Database History

Early (1960s-1970s)

- Limited computer facilities
- Prevented widespread data storage/search capability

1987, "Toward Automating the Helo/Ship DI Database"

- Called for automated, electronic databases
  - a) Program Management Information (correspondence, personnel info, project status, etc…)
  - b) Quantitative Test Data

1991, "The DI Database"

- Implemented 1987 "Quantitative Test Data" Database
- Centralized data storage + flexible search criteria
- Facilitated comparison with previous data

1997, "Summary of DI Database Files"

- Summarized all existing DI database files, formats
- NONE were linked together

2004, "Intelligent Aircraft/Ship Data Analysis Options"

- Attempt to link components, facilitate searching

RTO AGARDograph 300 Helo/Ship Qualification Testing
The Netherlands, UK, & USA

RTO-AG-300 Vol. 22
AC/323(SCI-038)TP/53

RTO-AG-300 Vol. 22

NORTH ATLANTIC TREATY ORGANISATION



RESEARCH AND TECHNOLOGY ORGANISATION

BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

© RTO/NATO 2003

Single copies of this publication or of a part of it may be made for individual use only. The approval of the RTA Information Management and Systems Branch is required for more than one copy to be made or an extract included in another publication. Requests to do so should be sent to the address above.

RTO AGARDograph 300

Flight Test Techniques Series – Volume 22

Helicopter/Ship Qualification Testing

(Les essais de qualification hélicoptère/navire)

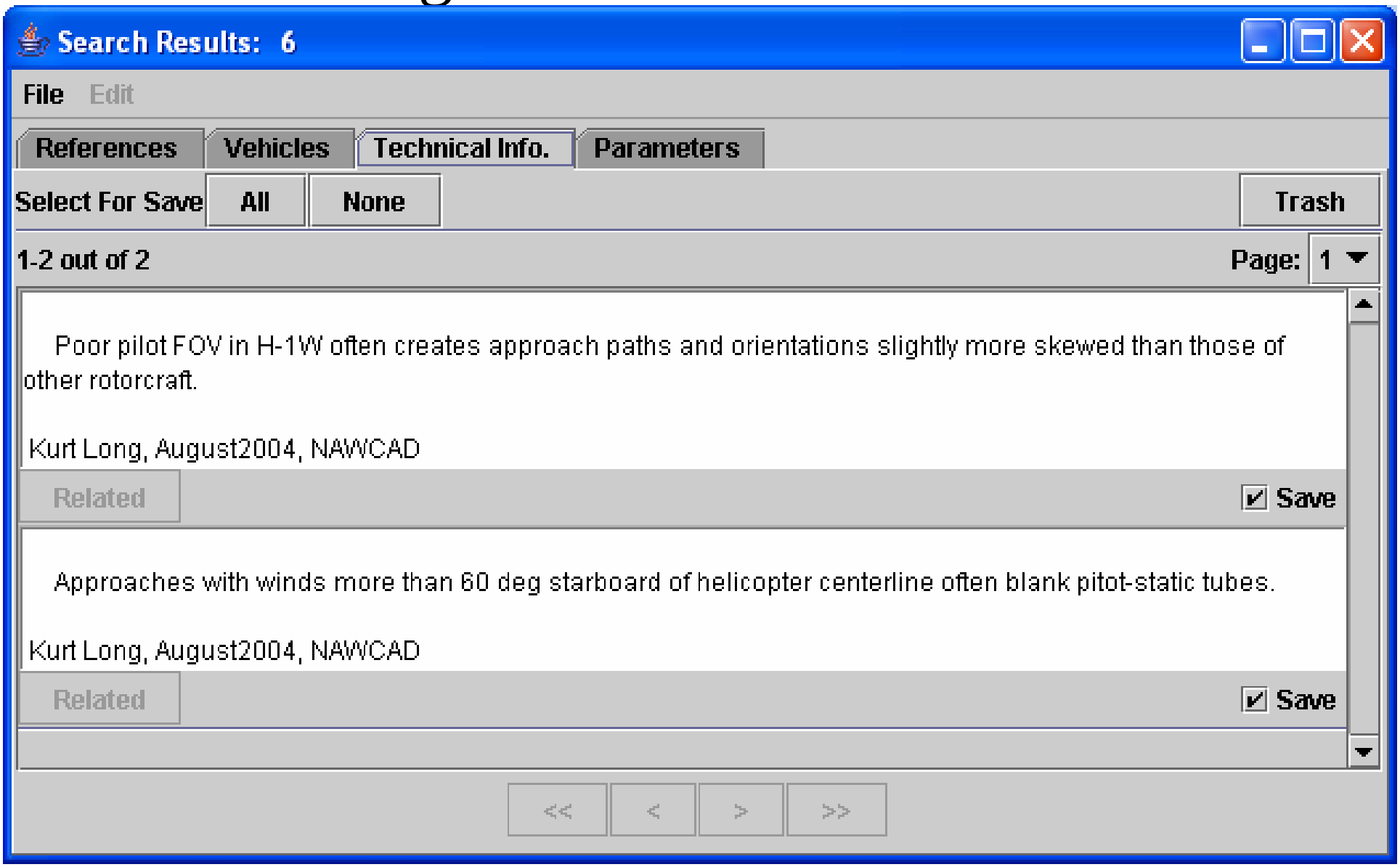
Nielsen Engineering Intelligent Aircraft/Ship Database

- Dynamic Interface eXpert Integration Environment

DIXIE

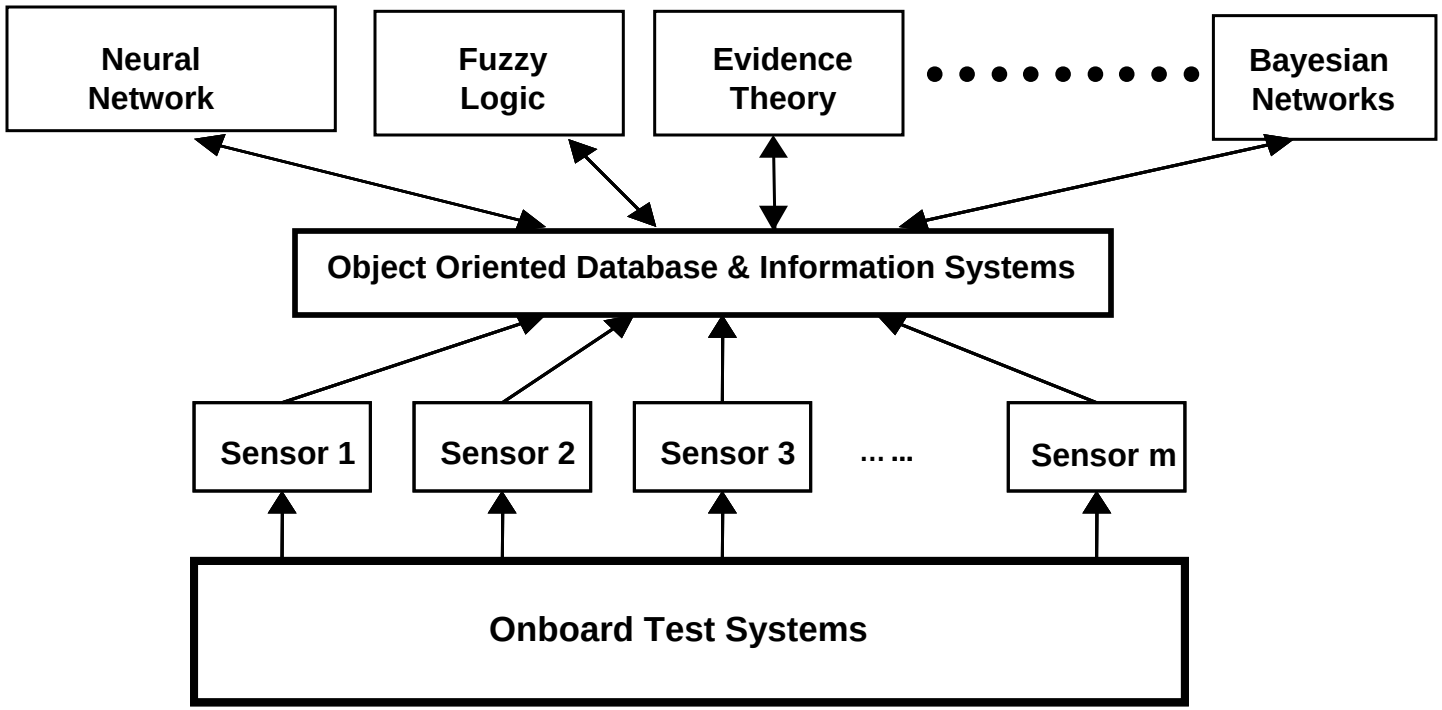
- Components
  - Data Databases
  - Knowledge Databases
  - Rule-Based Expert System
  - Administration Server
  - Remote Object Server
  - HTTP Server
  - FTP Server

DIXIE Client
Knowledge Database Results Window



American GNC

An Adaptive Data Fusion and Analysis System



Components

- Neural Network
- Fuzzy Logic
- Theory of Evidence
- Bayesian Network
- Clustering
- Classification
- Data Consistency Checking

Kinematics based Data Consistency

The kinematics based consistency check of the data relies on the kinematics of the platform which describe the characteristics of motion.

Establishing the kinematics based consistency of the data includes three key steps:

(1) Formulating the kinematics model

(2) Defining the measurements error model

(3) Using a Kalman filter/smoother to verify the test results and isolate the invalid data

Flight Testing Less, Better
A Few Options

- **Develop the ability run the flight test matrix analytically while developing the test plan to check how close planned flights approach limits and to perform parameter sensitivity studies**

- **Flight test planning and reporting require a large portion of time allotted to a test program**
  - **Advanced multi-media test planning and reporting options could be used to generate flight test matrices and help reduce the test cycle time**
  - **Design of Experiment options could be used to help optimize (minimize) the flights listed in the flight test matrix**
  - **A Wiki engine could be used to consolidate all the information associated with the project**

Summary

- **The Concept of Flight Testing Less, Better can be achieved**
- **The Concept of Flight Testing Better, Faster, Cheaper, and Safer can also be achieved**
- **It will require improved flight test support analytics**
- **It will require improved flight test support databases**
- **It will also require integrating the design and flight test analytics and the related databases**
- **Considerable progress has been made, but more is needed**

Raytheon

Cost As An Independent Variable
--
Balancing Performance and Affordability



Ed Casey **DeWayne Allen**

System Engineering's Cost Engineering
Raytheon Missile Systems
Bldg. M12, MS. 6
1151 E. Herman's Road
Tucson, Arizona 85706

Cleared for public release.
Copyright © 2006 Raytheon Company.
All rights reserved.

Areas to be Covered

1. Background
2. Cost As an Independent Variable
3. Caiv Metrics
4. Lessons Learned

Raytheon

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

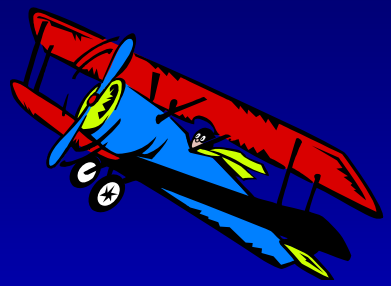
CAIV and DTC

- Cost as an Independent Variable (CAIV) **is a management discipline. The DOD CAIV policy sets cost as a military requirement and requires that programs establish aggressive, realistic cost objectives and to manage to obtain those objectives. Cost objectives must balance mission needs with projected out-year resources.** CAIV balances cost, performance, risk, and schedule.

- Design to Cost (DTC) **is an engineering discipline that meets customer cost requirements through an iterative process that balances cost, performance, and supportability while eliminating non-value added activity. DTC is an inherent element of Integrated Product Development (IPD) and is implemented within the common Integrated Product Development System (IPDS).** DTC is the process of designing at product to meet a cost requirement.

DoD's Challenge





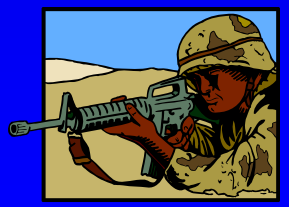
DoD's CHALLENGE:

HOW TO SUSTAIN AND MODERNIZE FORCES ON DRASTICALLY REDUCED BUDGETS WITHOUT "MORTGAGING THE FUTURE TO SURVIVE?"







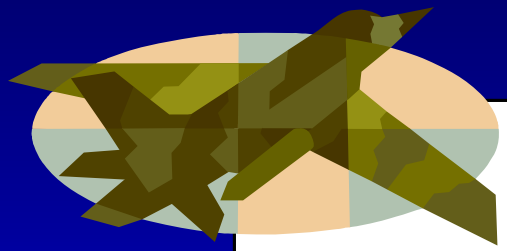






The Death Spiral

Raytheon





Deferred Modernization

5.

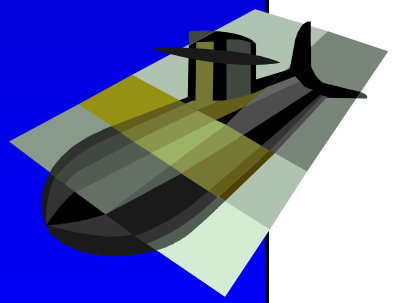
Funding Migration from Procurement to O&S

4.

The Death Spiral

1.

Aging Weapon Systems

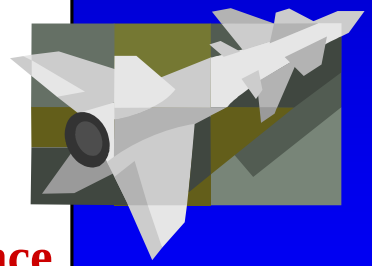


Increased O&S Costs or Decreased Readiness

3.

2.

Increased Maintenance





CAIV and DoD

Raytheon

- CAIV is a DOD acquisition initiative applicable to all programs
  - CAIV assures an affordable program
  - CAIV reduces program Total Ownership Cost (TOC)
  - CAIV encompasses Design To Cost (DTC)

- Cost as an Independent Variable (CAIV): An acquisition management discipline wherein cost goals (constraints) are achieved through tradeoffs between requirements and performance.

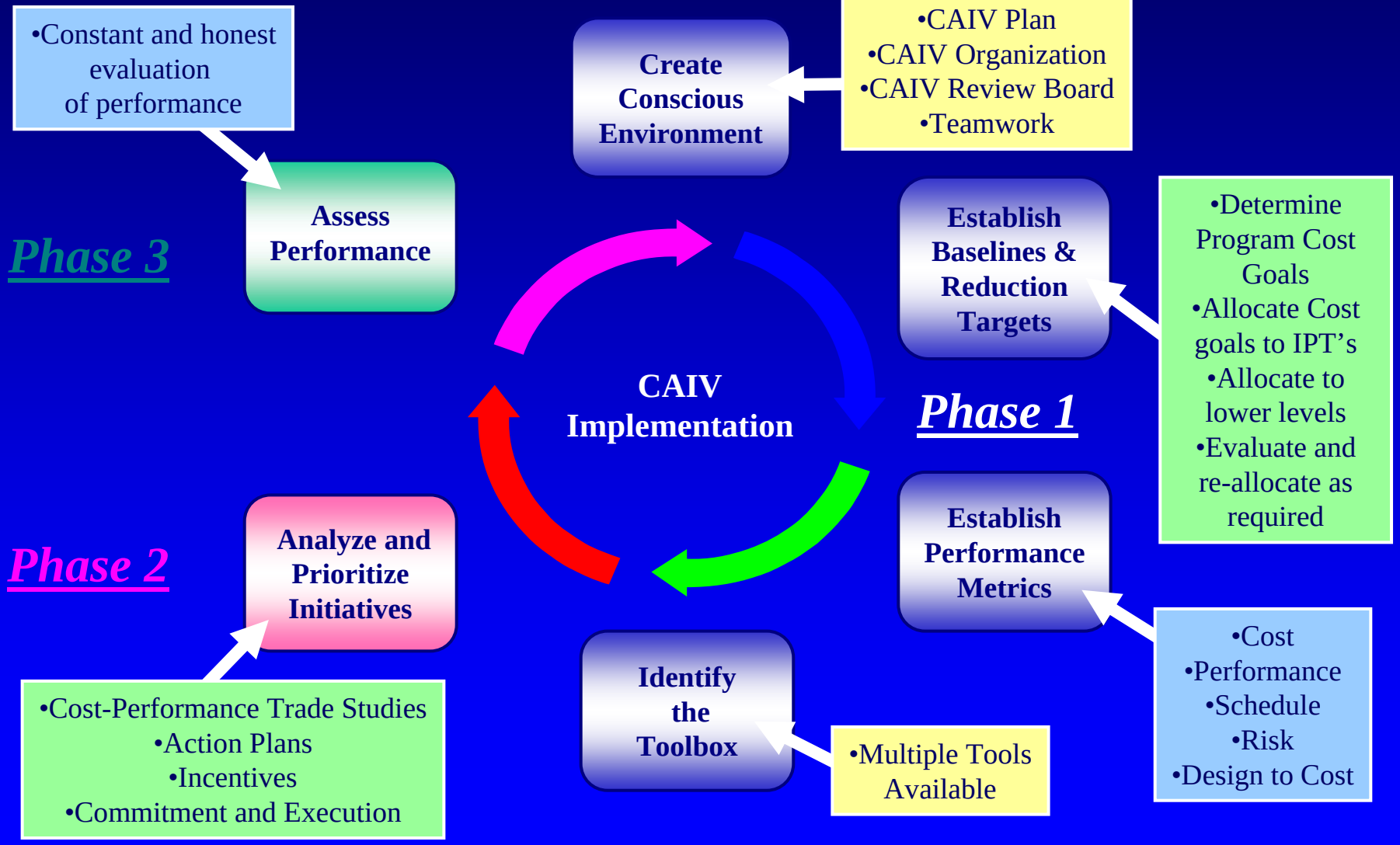
- Tenets
  - Schedule, performance, and requirements are tradable (DoD 5000.2R)
  - Cost is treated as a constraint -- a Military Requirement (DoD 5000.2R)
  - Additional development funding may be considered an investment to reduce production and O&S cost
  - Government may establish Cost/Performance IPTs (CPIPT)
  - User participates in trade studies to determine affordable requirements
  - Risk is included in all estimates

DTC & CAIV at Raytheon Missile Systems

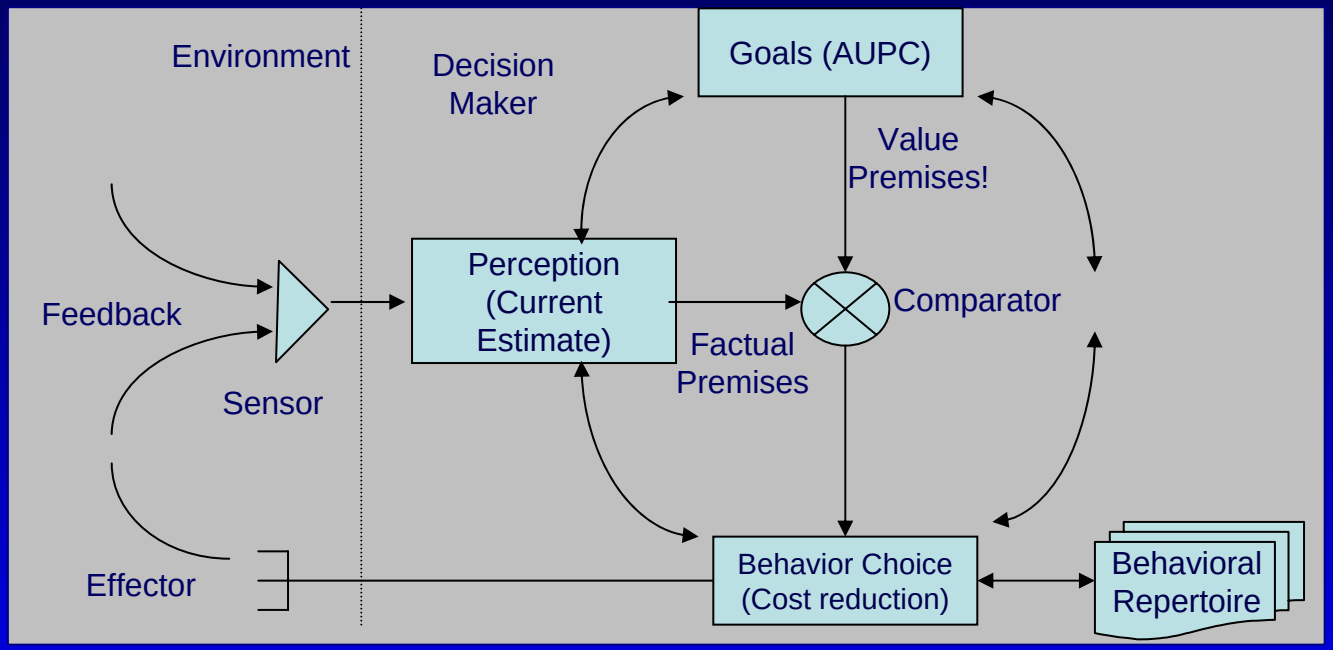
- DTC and CAIV are blended into Business Development under the heading of Affordability.
- Within the process at RMS:
  - Defined cost targets are assigned to each IPT
  - Focus is on identified cost drivers
  - Cost vs performance tradeoffs are conducted that lead to best value solutions
  - Metrics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

CAIV – Cost As an Independent Variable

CAIV Implementation and Flow



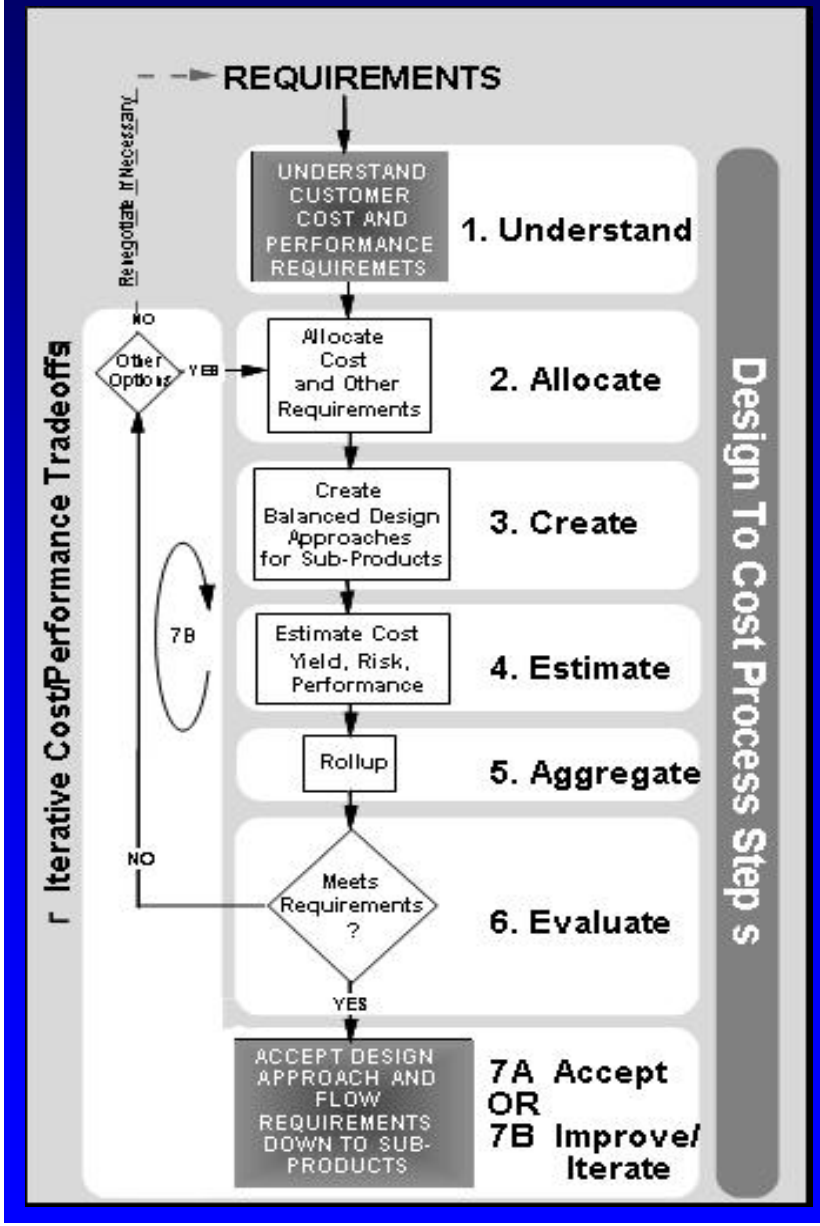
CAIV as a Management Control System



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

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

Seven Steps to an Affordable Design



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

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

Plus, an often overlooked 8th step to:

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

Raytheon



CAIV Metrics
The Balancing Act in Practice



Metrics and System Engineering

Raytheon

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

INCOSE
INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

Systems Engineering Measurement Primer



A Basic Introduction to Systems Engineering Measurement Concepts and Use

Version 1.0

March 1998

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

Metrics

The purpose of any metric is to drive proper behavior.

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

CAIV Metrics

Raytheon

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

Critical to the utilization of these primary metric comparisons is the need for an established baseline. Without it, comparison is meaningless.

CAIV Metric	Threshold	Goal	Current	% Current/Goal	Plan of Action
Cost					
Performance					
Schedule					

Other metrics that are used to evaluate how well a program is implementing CAIV:

Establishment of the CAIV Team (PM, User and Contractor)
Office personnel familiarity with the CAIV technique
Availability of CAIV guidance
Number of CAIV Trade Studies
CAIV accomplishments
CAIV database

CAIV Metrics -- An Example

CAIV Metric	Threshold	Goal	Current	Current/Goal	Risk Assess	Cost Driver	Latency	Plan of Action
Cost - System	$ 32,775.00	$ 31,500.00	$ 37,790.00	1.20				
Sub-System	$ 5,000.00	$ 4,500.00	$ 6,200.00	1.38			2	no
Sub-System	$ 1,500.00	$ 1,500.00	$ 1,400.00	0.93			4	no
Sub-System	$ 12,275.00	$ 12,000.00	$ 17,890.00	1.49			1	yes
Sub-System	$ 8,000.00	$ 7,500.00	$ 6,000.00	0.80			6	yes
Sub-System	$ 2,500.00	$ 2,500.00	$ 2,700.00	1.08			3	yes
Sub-System	$ 3,500.00	$ 3,500.00	$ 3,600.00	1.03			2	yes
Sub-System								
Sub-System								

Performance	Requirement	Goal	Current	Req/Current	Risk Assess	Cost Driver	Latency	Plan of Action
speed mph	200	220	180	1.11			1	no
range nm	500	550	575	0.87			1	no
load lbs	750	750	900	0.83			1	no
KPP-4								

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

How much information can you get from this chart?
Where would you concentrate efforts? What might you want to re-visit?

CAIV Metrics Sample Chart

CAIV Metrics chart at a glance:

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

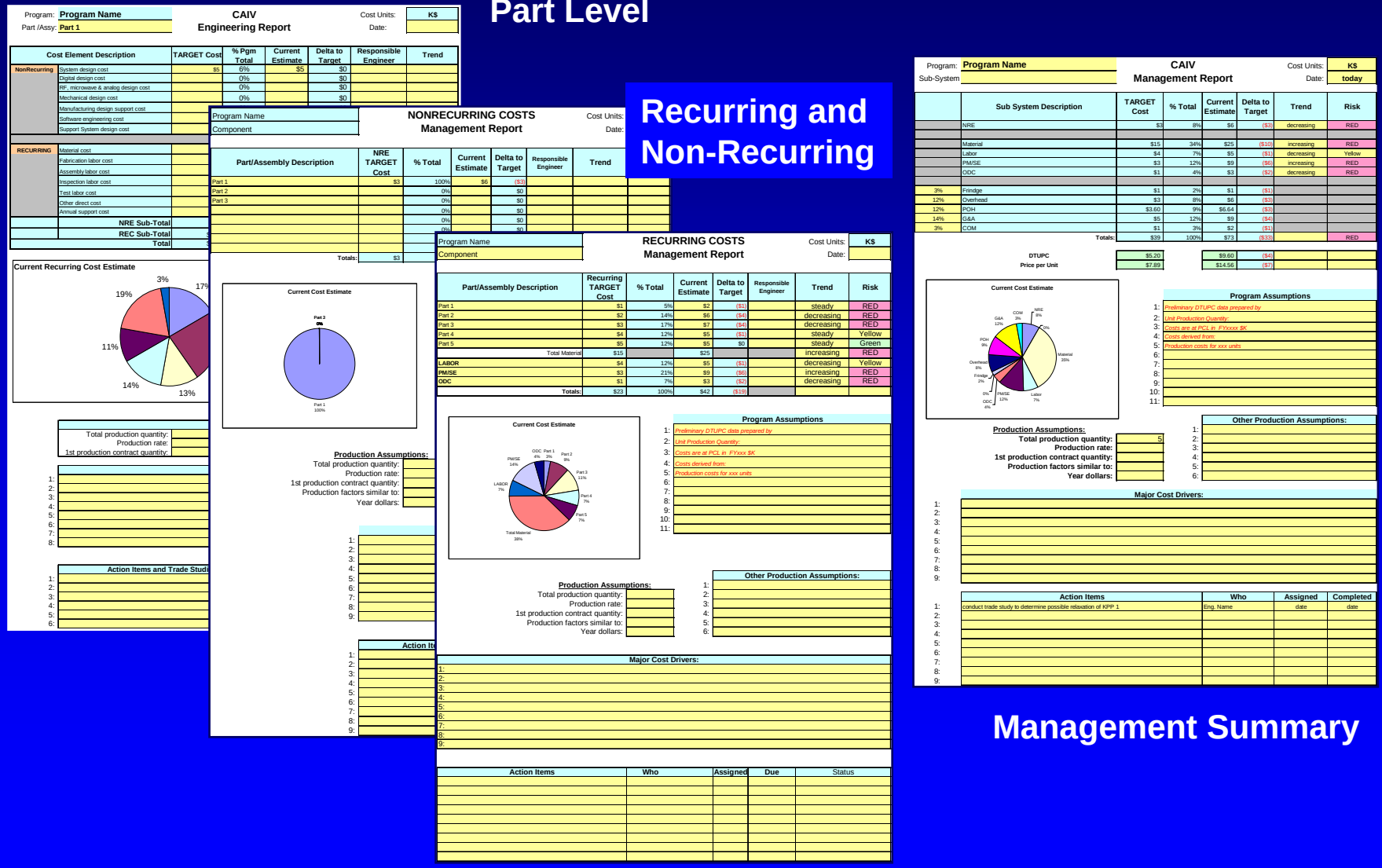
CAIV and DTC Reports

Raytheon

Part Level

Recurring and Non-Recurring

Management Summary



CAIV and DTC Reports

Raytheon

CAIV Cost History

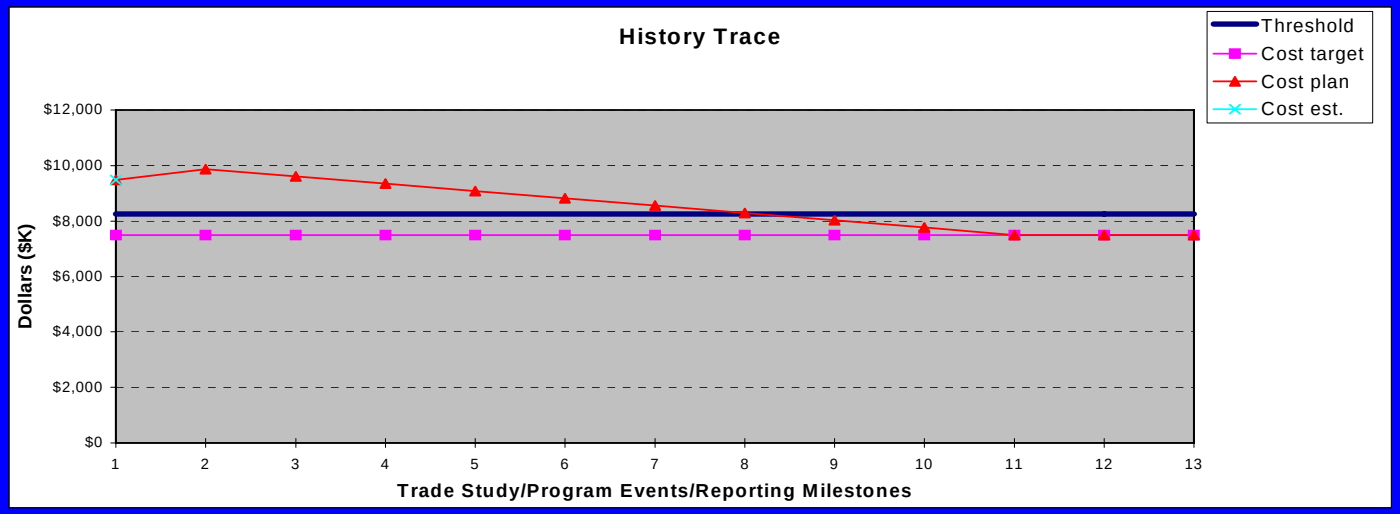
Planning Curve

10

Program Name: **Program Name**
Assy or Rollup:

Cost target:	$7,500
Cost Threshold	$8,250

	Design trade study/program events	Date	Threshold	Cost target	Cost plan	Cost est.	Status
0	**Baseline Design**	01/01/03	$8,250	$7,500	$9,475	9,475.0	1.000
1			$8,250	$7,500	$9,870		0.000
2			$8,250	$7,500	$9,607		0.000
3			$8,250	$7,500	$9,343		0.000
4			$8,250	$7,500	$9,080		0.000
5			$8,250	$7,500	$8,817		0.000
6			$8,250	$7,500	$8,553		0.000
7			$8,250	$7,500	$8,290		0.000
8			$8,250	$7,500	$8,027		0.000
9			$8,250	$7,500	$7,763		0.000
10			$8,250	$7,500	$7,500		0.000
11			$8,250	$7,500	$7,500		0.000
12			$8,250	$7,500	$7,500		0.000



Program, System, Component History Charts

Raytheon

Lessons Learned

Lessons Learned

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

Any Questions?

- Now is a good time to ask.



Capability Acquisition Strategy Analysis: A Real Options Approach

Shin-Jyh Frank Chang
Gary Backus
Michele Steinbach

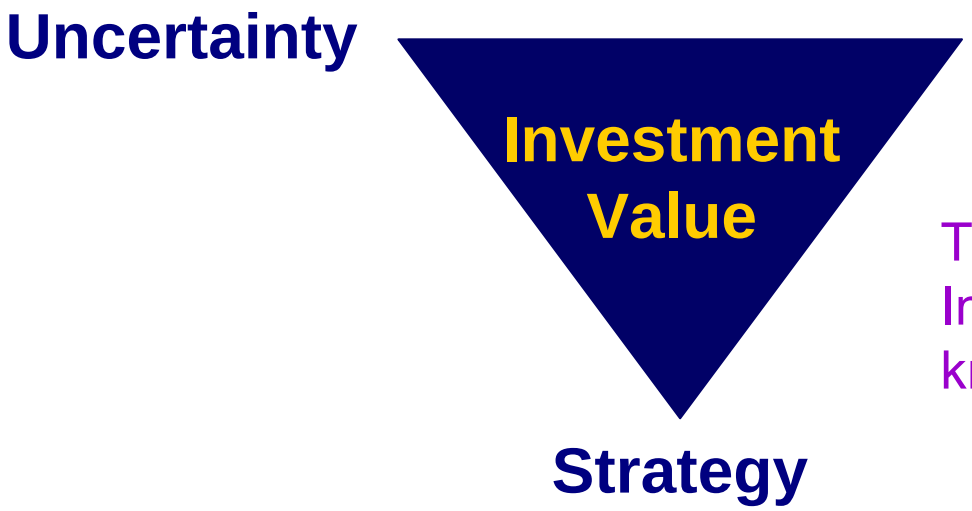
The MITRE Corporation

© 2006 The MITRE Corporation. ALL RIGHTS RESERVED.
Approved for Public Release; Distribution Unlimited. 06-1106

What is “Real Options”?

- An option confers a *right*, but not obligation, to take an action in the future for managing an asset.
- The Real Options methodology is a framework for valuing and planning of real assets.
- Examples of real options:
  - A stronger foundation and structure for a multistory parking garage
  - A rocket with extra fuel on each satellite to reconfigure a constellation
  - Application “hooks” built into the architecture of a software system
  - A foundation IT asset enabling future high-value applications
  - Pilot projects, feasibility studies, and prototypes can all create options

Real Options Triad



The Return on Investment can only be known *probabilistically*.

Viewing investment value through a Real Options lens:

The value of a project must be assessed not just from the technical/engineering aspect, but also on how the management would dynamically respond to uncertainties to achieve better Return on Investment.

Real Options supports strategic intuition with analytical rigor

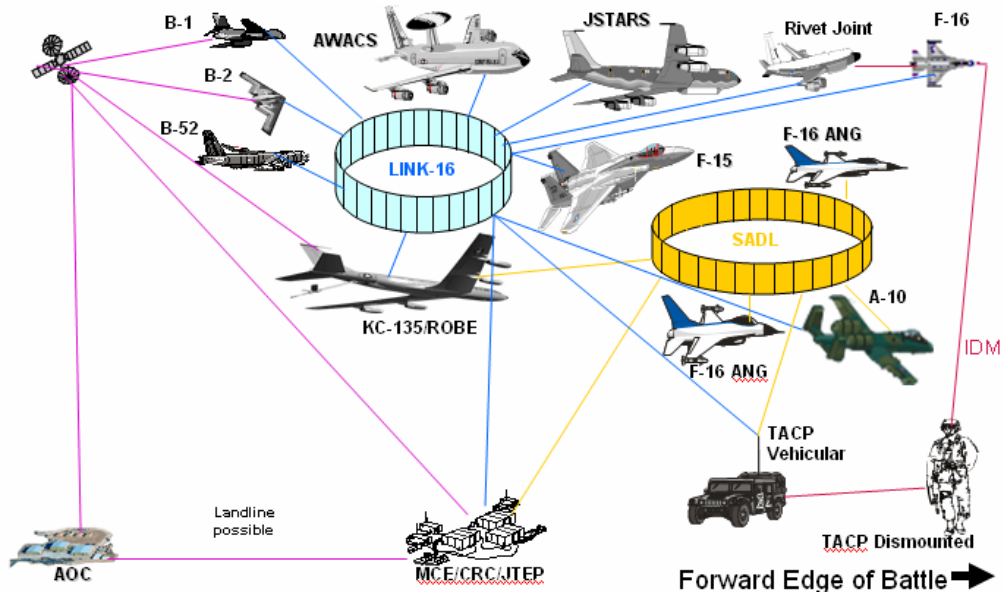
- The traditional investment valuation tends to be
  - Optimistic: assume the project will *finish* and achieve *optimal* value
  - Simplistic: model uncertainty by an *"average scenario"*
  - Deterministic: can't handle scenario-dependent cash flows caused by *optionality*
- Through a Real Options lens, the risk and strategy context of the project is examined; potential evolution paths are accounted for. The value of an investment is assessed probabilistically.
- 4 major methods for Real Options Valuation:
  - Black-Scholes formula
  - Binomial lattice model
  - **Decision tree analysis**
  - **Monte Carlo simulation**

Real Options can offer a flexible systems engineering approach for capability acquisition

- Consider these concepts:
  - Field operationally acceptable capability earlier and make evolutionary increments over time. Considered contingency plans and exit opportunities. (Defense Acquisition Performance Assessment Report, 2006)
  - Take evolutionary steps to increase learning of a product's usefulness and consider an option to terminate a project if it is no longer beneficial. (GAO-04-744, 2004)
  - Structure major acquisitions into useful segments with a narrow scope and brief duration. (OMB Circular A-11, 2005)
- How would you assess the value of a project being shaped by these concepts?
  - We use a case study with notional data to demonstrate an analysis methodology based on a Real Options approach.

MITRE

Case: Improving Tactical Data Link (TDL) systems to support the Close Air Support (CAS) mission





Two major problems in current TDL systems for CAS:

- Lack common data communication medium for all participants
- Need more effective message contents and delivery protocols

2 TDL Solutions for the CAS Mission

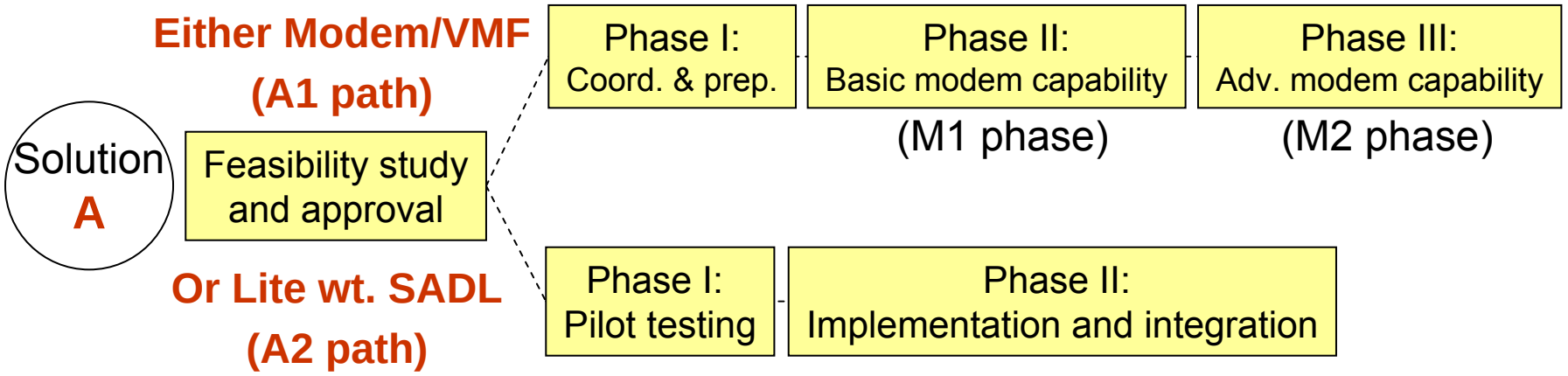
✓: existing or programmed capabilities Proposed solutions: A B

Participants / Systems	Primary CAS aircraft		Secondary CAS aircraft			Joint Terminal Attack Controller (JTAC)	CAS Gateway
	A-10	F-16 C+	F-16 CG	F/A-18	AV-8B		
Modem+AFAPD			✓			✓	
Modem+VMF	A	A		✓		✓	B
Modem+MTS					✓	✓	
Situational Awareness Data Link (SADL)	✓	✓				A	B
Link 16			✓				B

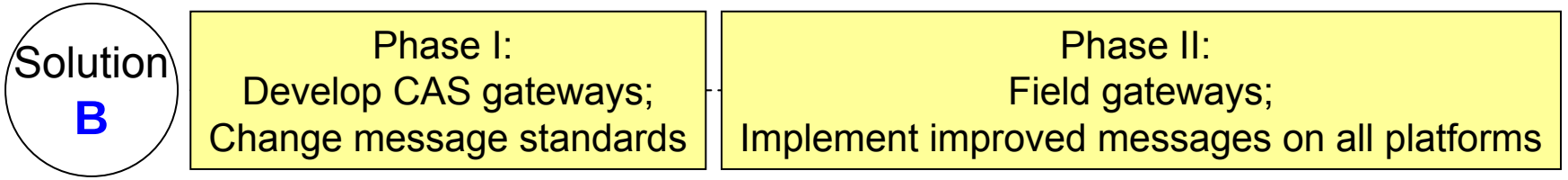
Two Solution Strategies

- Solution Strategy **A** : Equip primary CAS participants with a common data communication device
  - **A1**: Install improved data modems with VMF message format on all primary CAS aircraft.
  - **A2**: If **A1** is not feasible, provide a light-weight SADL device to each tactical air controller.
- Solution Strategy **B** : Use CAS gateways to translate and forward messages for all CAS participants
  - Develop and field CAS gateways; extend the existing TADIL-J message standard and implement on CAS aircraft.

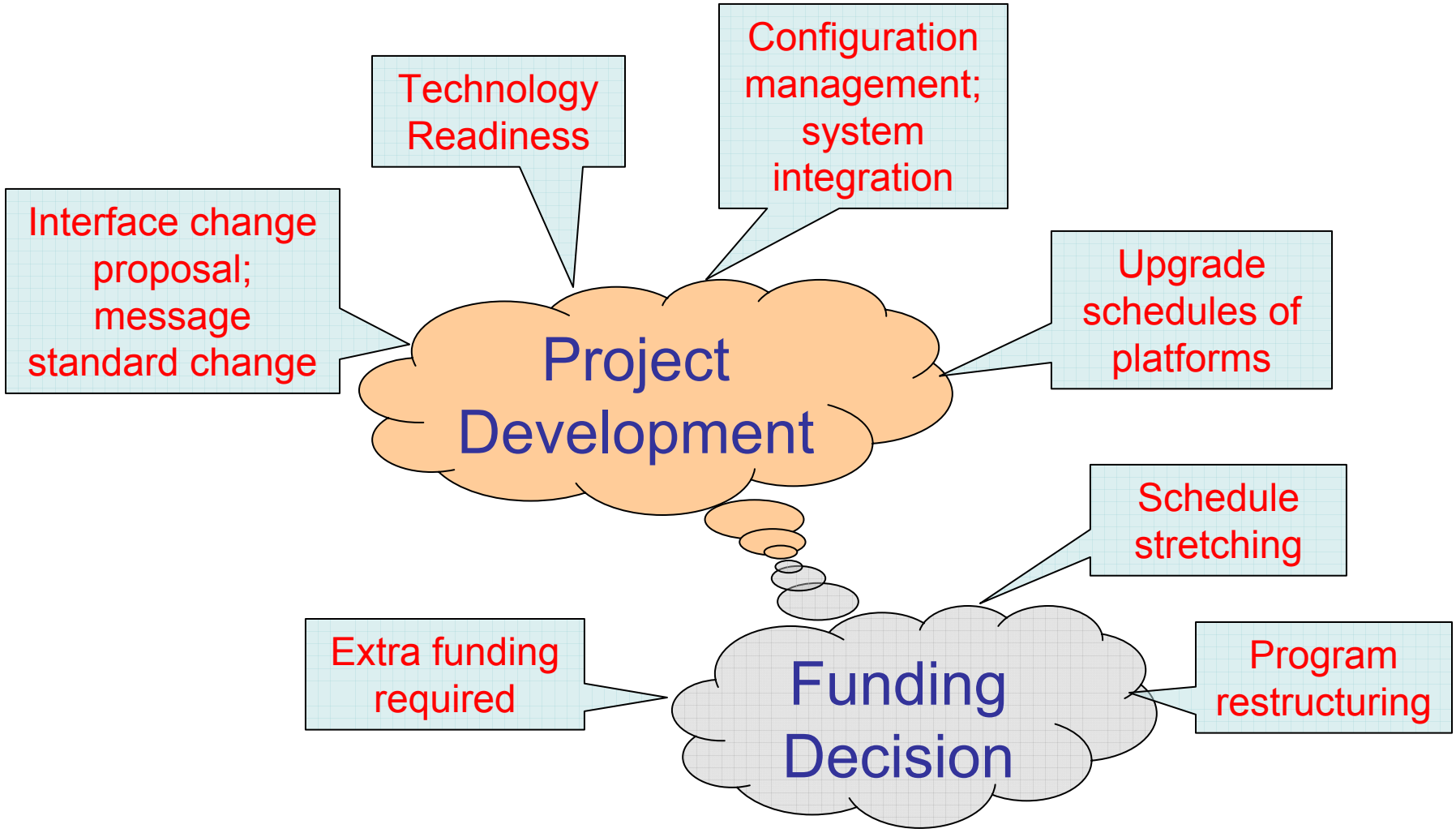
Staged Development and Implementation



Gateways + TADIL-J extension



Uncertainties in TDL Capability Acquisition



Which solution should be chosen?

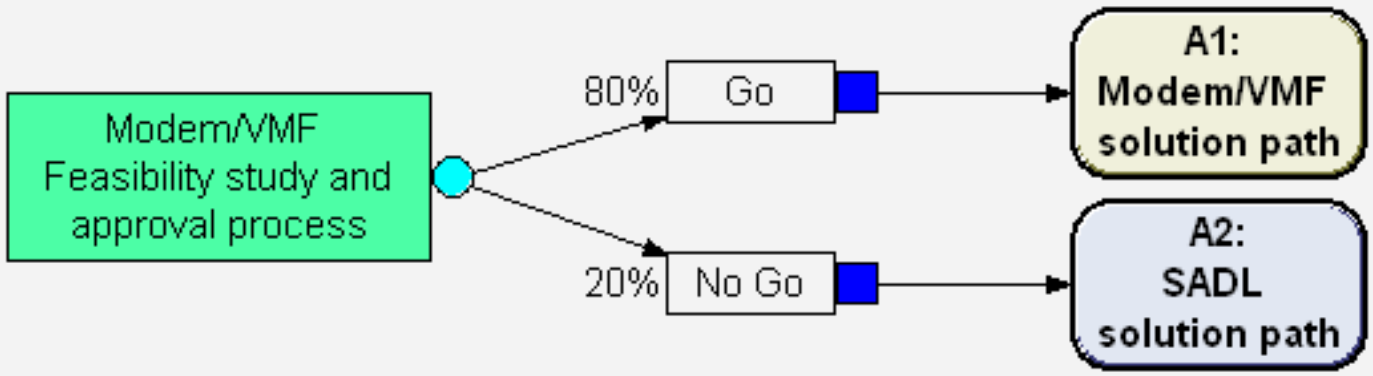
- Conventional approach: trade off benefit, cost, and schedule; use sensitivity analysis or scenario analysis to understand the impact of uncertainties.
- The conventional approach ignores possible actions that could be taken by the manager to dynamically respond to uncertainties.
- **Our remedy:**
  - Use **Decision Tree** to model the interplays between technical development and management actions.
  - Use **Monte Carlo simulation** to compute scenario-dependent benefit, cost, and schedule.

Starting off a Decision Tree for Solution A

Solution Strategy A - either Modem/VMF or SADL

A1: Modem/VMF
M1 - Provide standalone capabilities for primary CAS aircraft pilots to receive digital 9-Line briefing
M2 - Digitally integrate the 9-Line briefing with the aircraft Operational Flight Program (OFP)

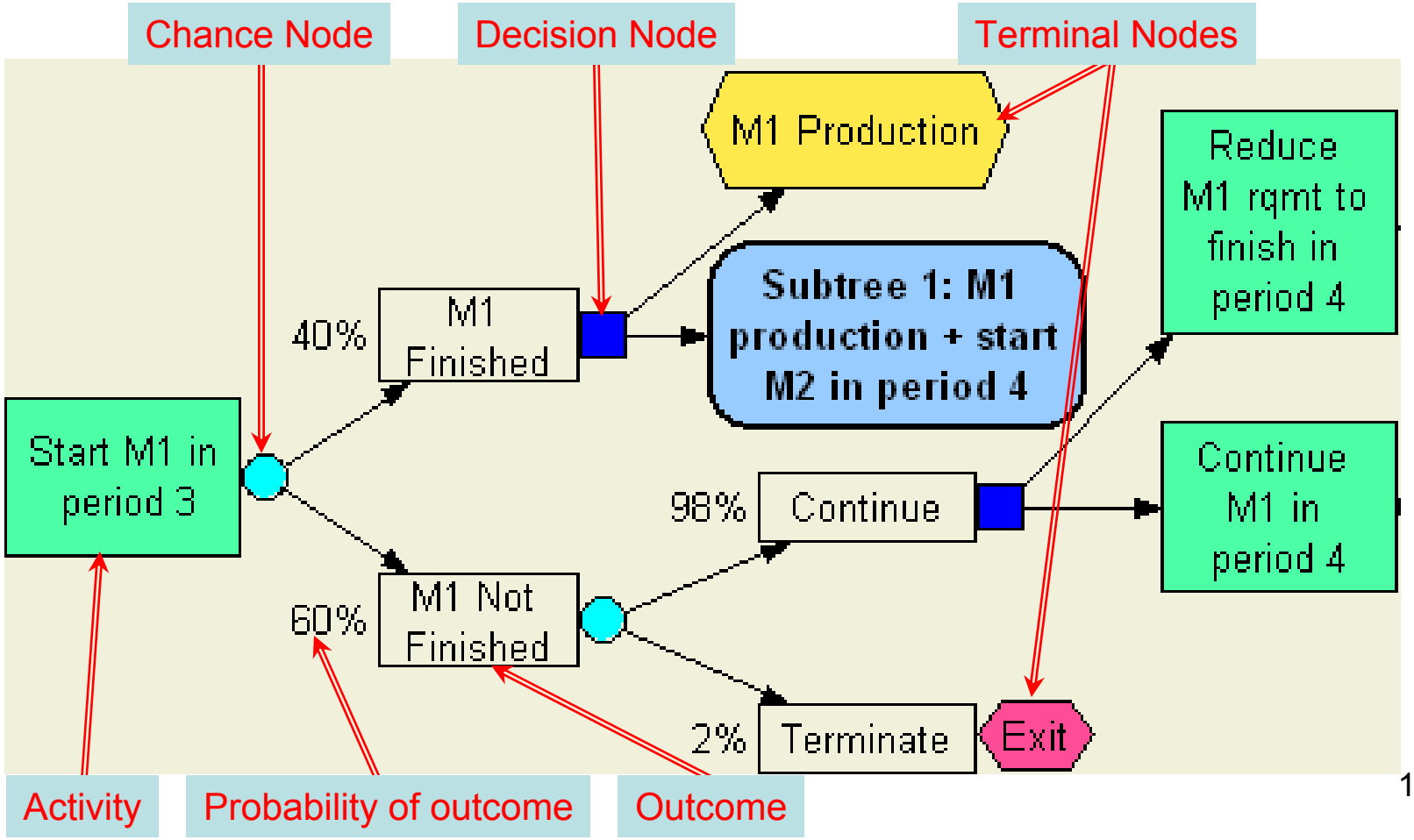
A2: SADL
Develop and field light-weight SADL to JTAC with suitable TACP system interface to enable direct connectivity to SADL aircraft.



(Analytica screen shot)

Anatomy of a Decision Tree

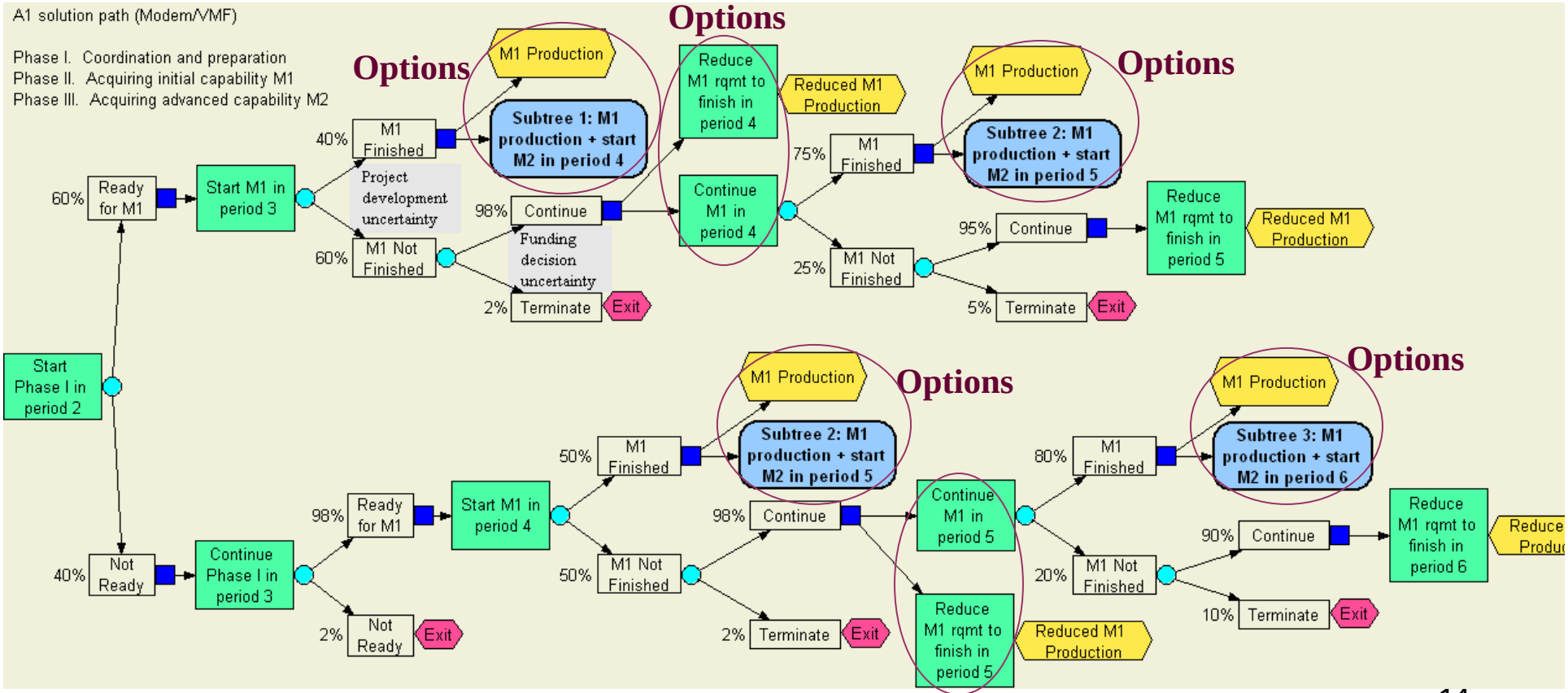
Each solution strategy is modeled as a decision tree containing a series of chance nodes and decision nodes. Each path of the tree ends at a terminal node.



MITRE

Decision Tree for the A1 (Modem/VMF) Branch

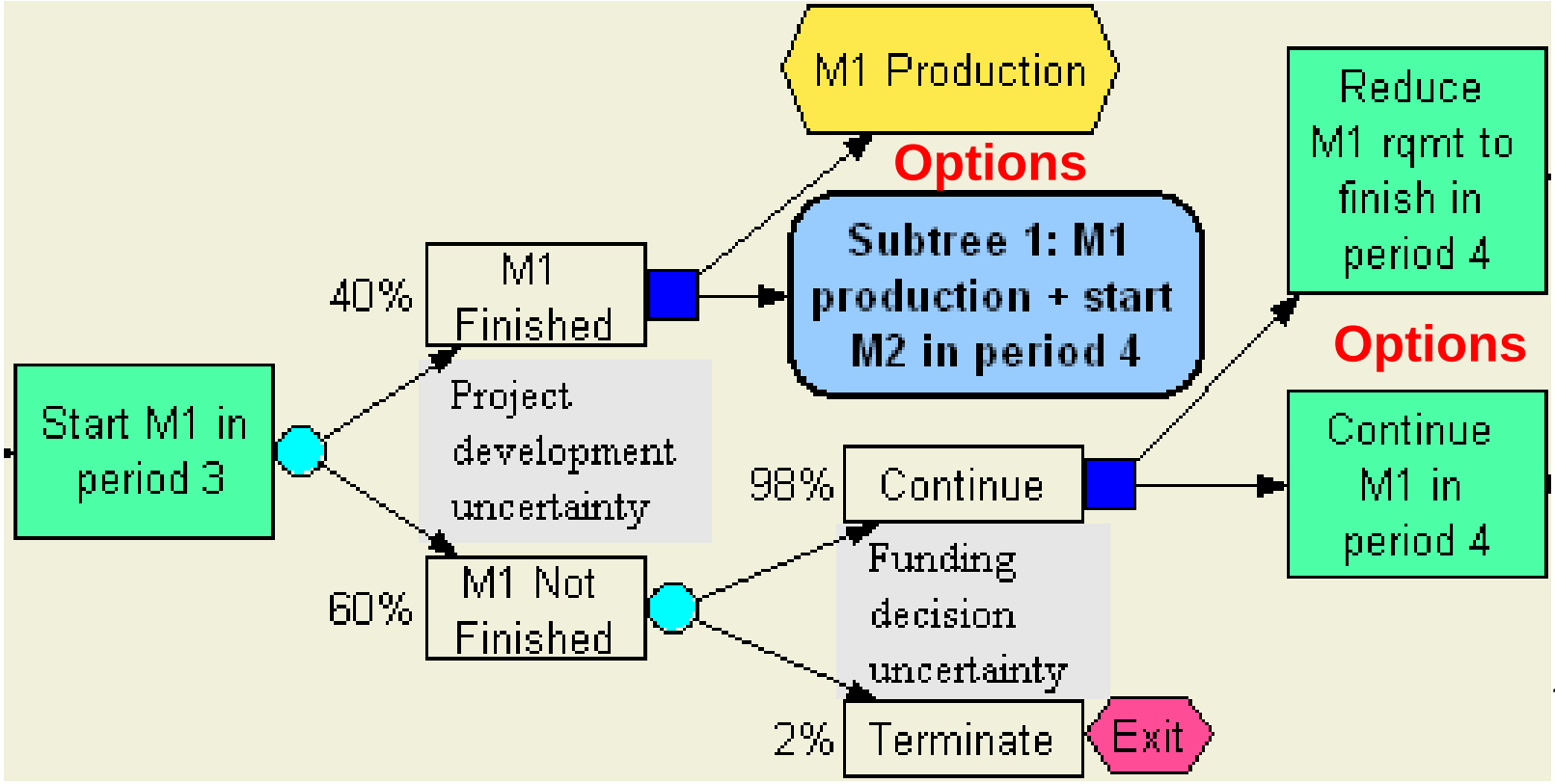
This decision tree is organized around two kinds of uncertainties considered in tandem. Each outcome is followed by one or more decision options.



(Analytica screen shot)

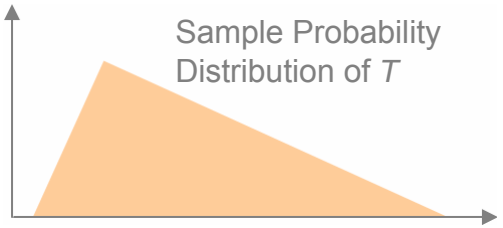
The Core Module of the A1 Decision Tree

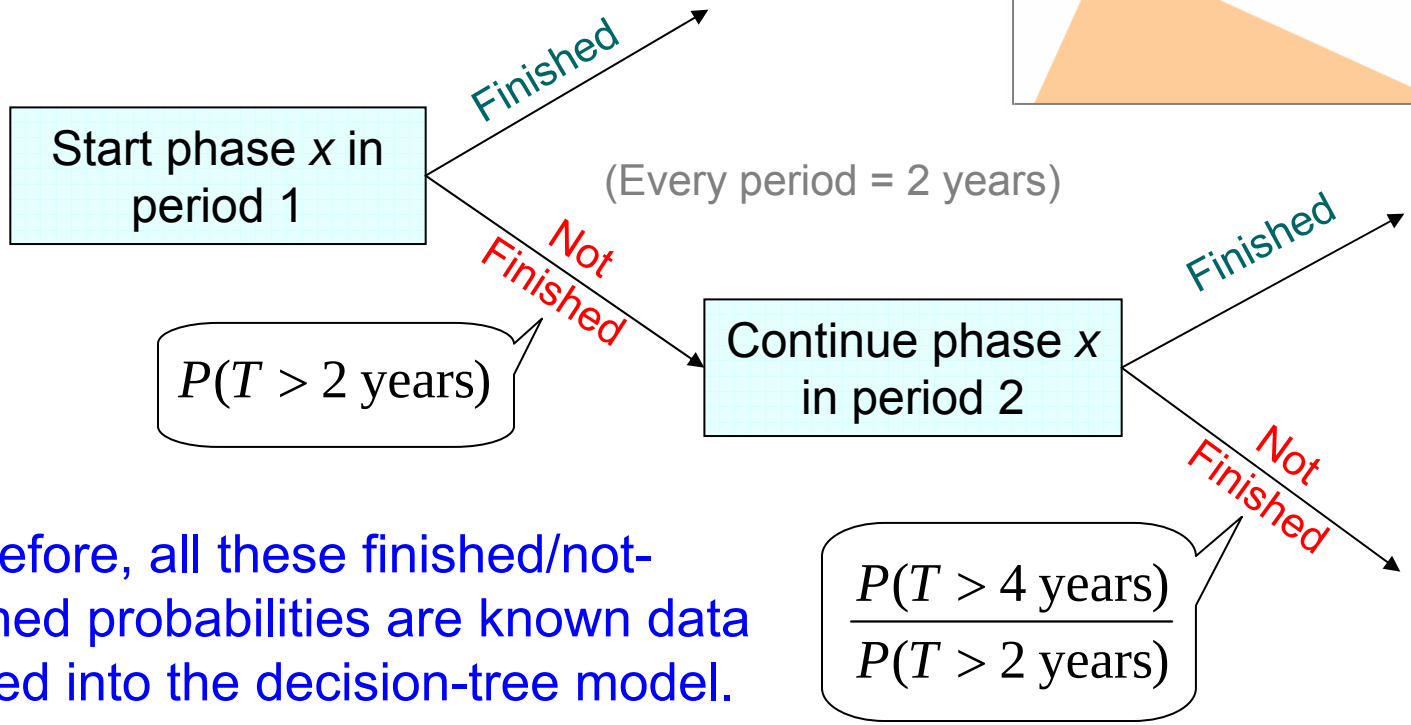
- Each phase may span across multiple time periods.
- Progress status and outlook are reviewed after each period.
- The manager will decide which option to take; the project could embark on a different course of action.



Progress status probabilities can be *easily* derived from the probability of duration time

Duration time *T* of each phase has a probability distribution. Every project planning must have estimated this distribution.



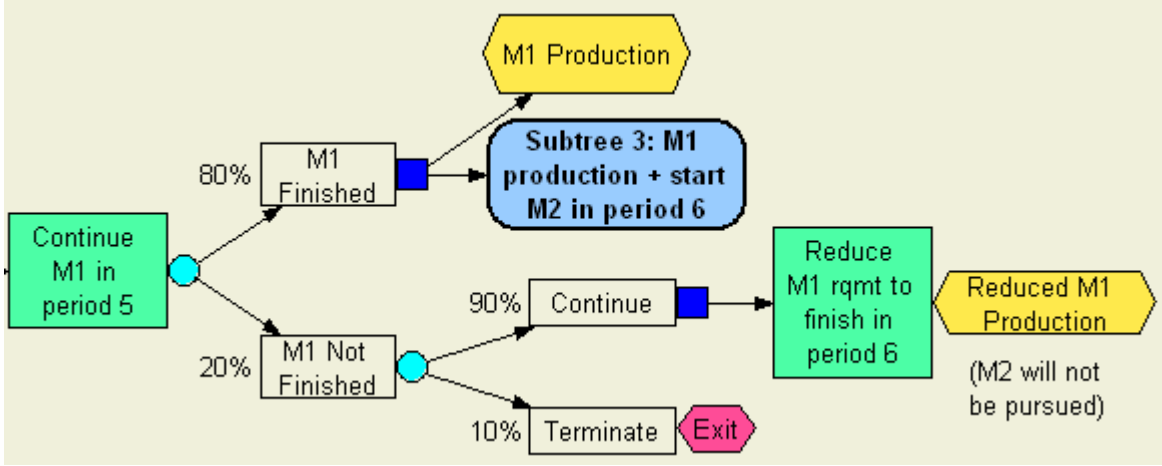


Therefore, all these finished/not-finished probabilities are known data to feed into the decision-tree model.

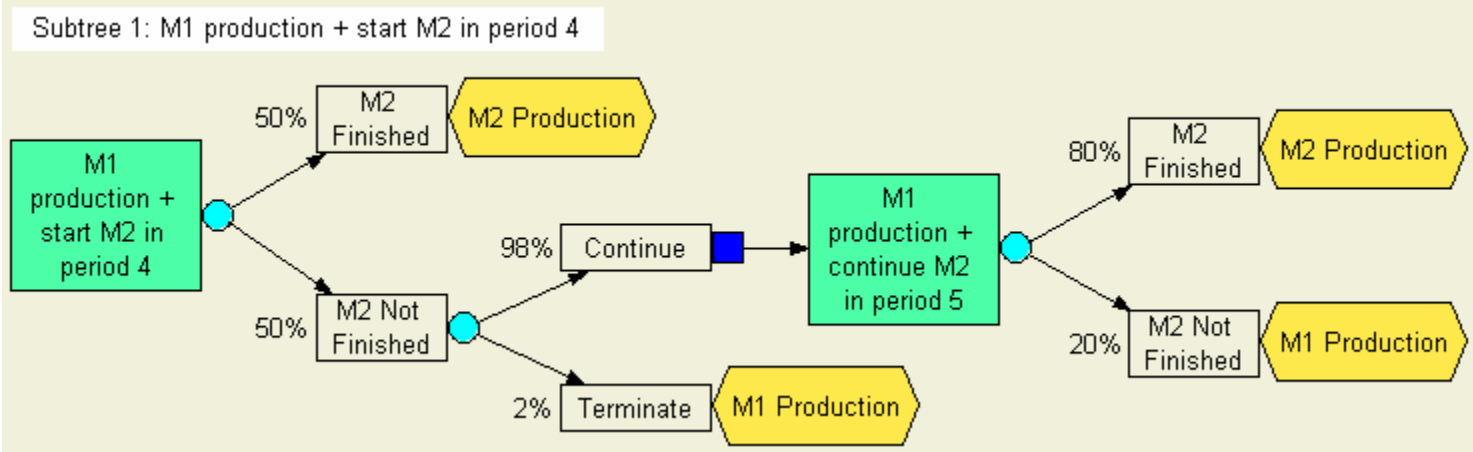
No guesswork is needed !

Exit Criteria for the A1 Solution

- The entire effort should not take more than 6 periods.
- M1 development should not take more than 3 periods. Can wrap up the M1 effort with reduced requirements (Plan B).



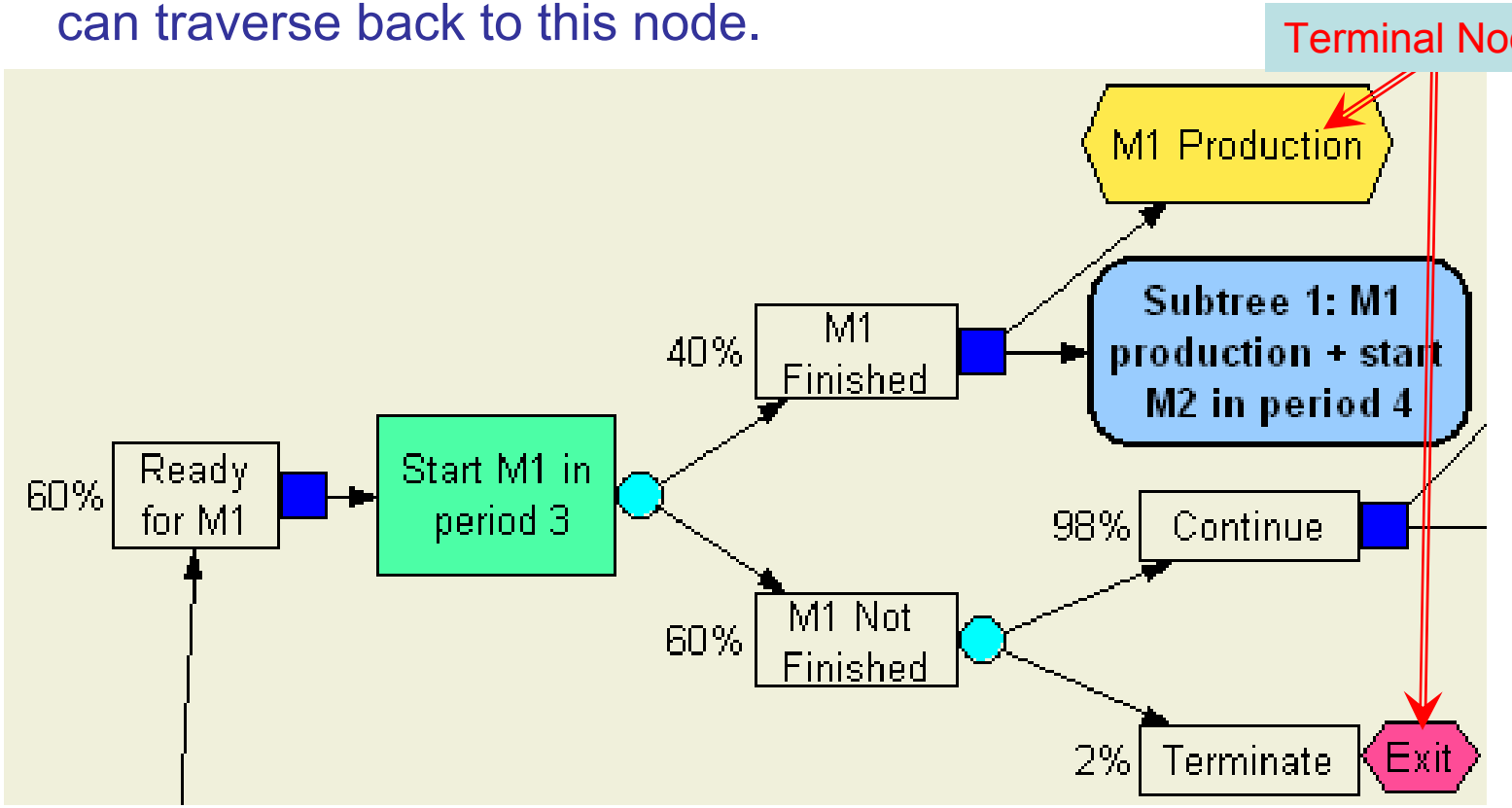
- M2 development should not take more than 2 periods.



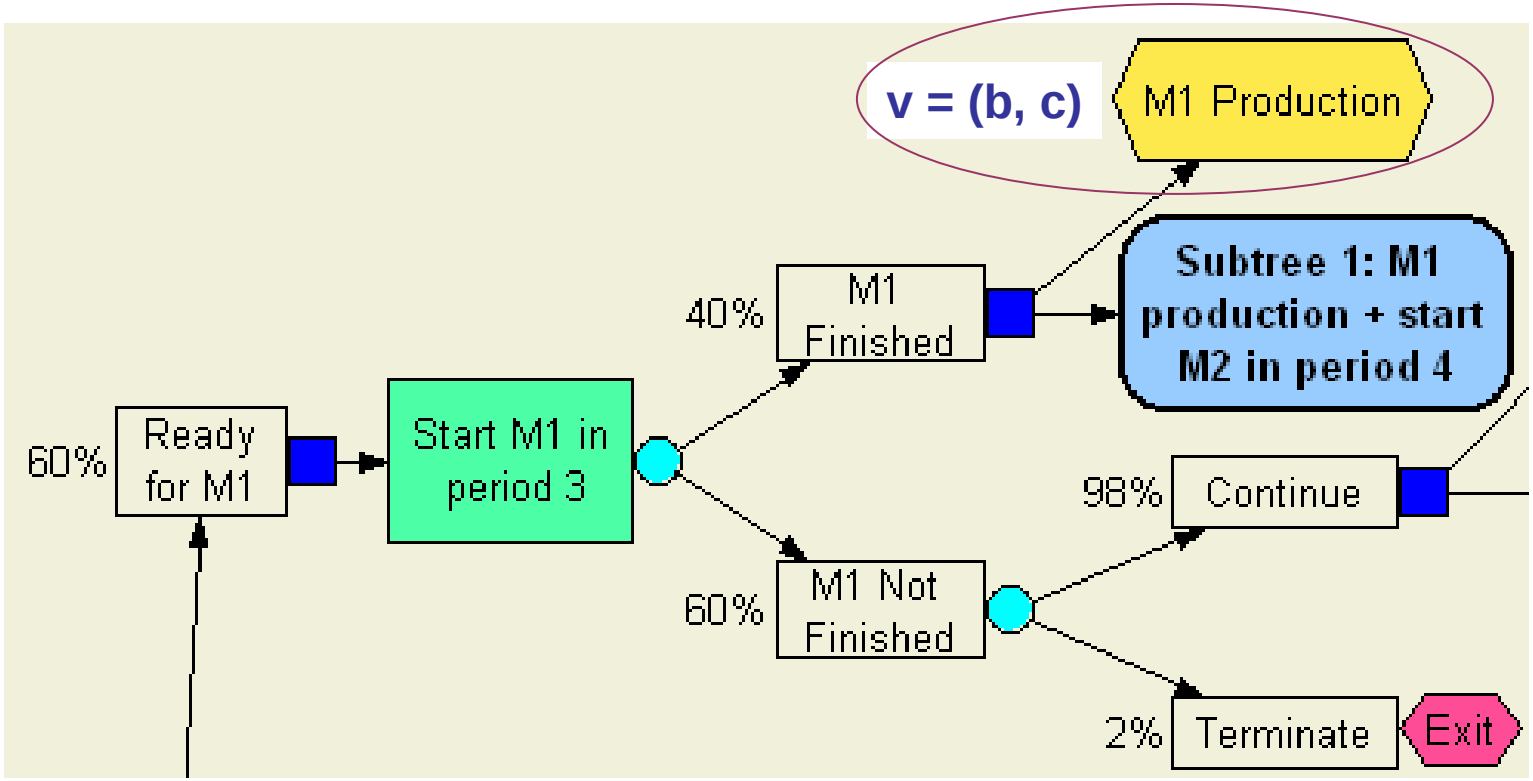
Decision Tree Valuation

A decision tree is evaluated starting from terminal nodes back to the root.

Each node keeps a **value vector (b, c)**, which represents the **benefit** and **cost** rolled back from all terminal nodes that can traverse back to this node.



Valuation at a Production Node



Let m denotes the length of the planning horizon, and the project takes n years to reach a **Production node**, then the value vector at this node is:

$$\left(b = \sum_{i=0}^{m-n-1} \frac{\text{product benefit per year}}{(1+\text{benefit discount rate})^i} \;,\quad c = \sum_{i=0}^{m-n-1} \frac{\text{O \& M cost per year}}{(1+\text{cost discount rate})^i} \right)$$

Discount Rates

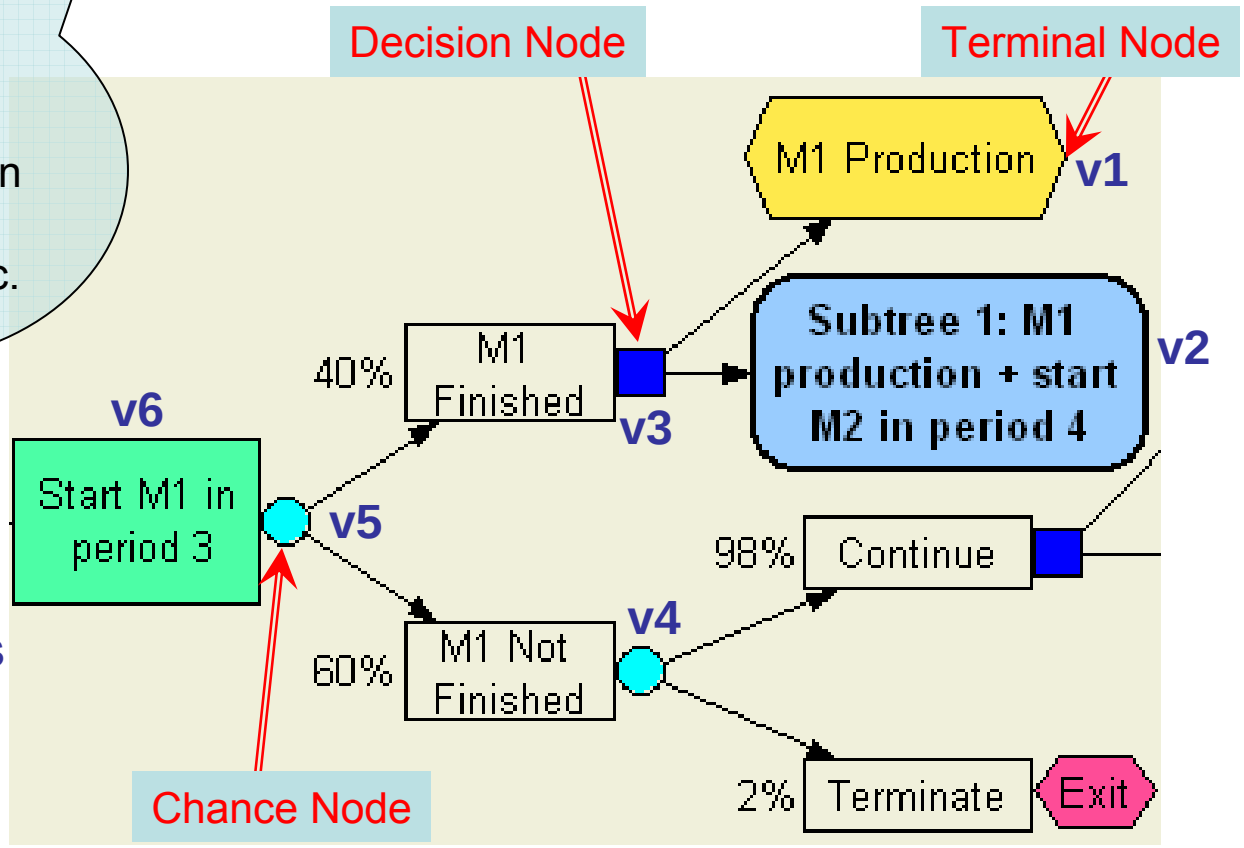
- **Cost discount rate**: a measure of the time value of money for investments and expenses.
- **Benefit discount rate**: to express the urgent need for a timely solution or to penalize a delay in delivering required capabilities. (OMB Circular A-4 has an example.)
- With the use of discount rates, time preference is embedded in the decision rule – an alternative branch will be chosen if it has a higher ratio of discounted benefit / discounted cost.
  - *Performance, affordability, and timeliness are all molded into a single metric for solution comparison*.

Decision Tree Valuation (cont.)

$$\sum_{i=0}^{m-n-1} \frac{v}{(1+r)^i}$$

Decision rule: choose the branch having the best benefit/cost ratio

Can also include constraints on budget, schedule, etc.



v6 = Value of this activity + v5 discounted back one period

Simulation:
x = Bernoulli(40%)
v5 = *x* * **v3** + (*1-x*) * **v4**

Comparing Benefit and Cost of Solutions A and B

input data are notional

Their values can only be known *probabilistically*.



Benefit	A	B
Min	0	0
Median	771	871
Mean	**747**	**867**
Max	880	1122
Std. Dev.	138	223



Cost ($M)	A	B
Min	5.7	9.7
Median	21.1	31.1
Mean	**21.0**	**31.0**
Max	22.0	32.6
Std. Dev.	2.0	2.7

No clear winner.

B may get better benefit but at higher cost.

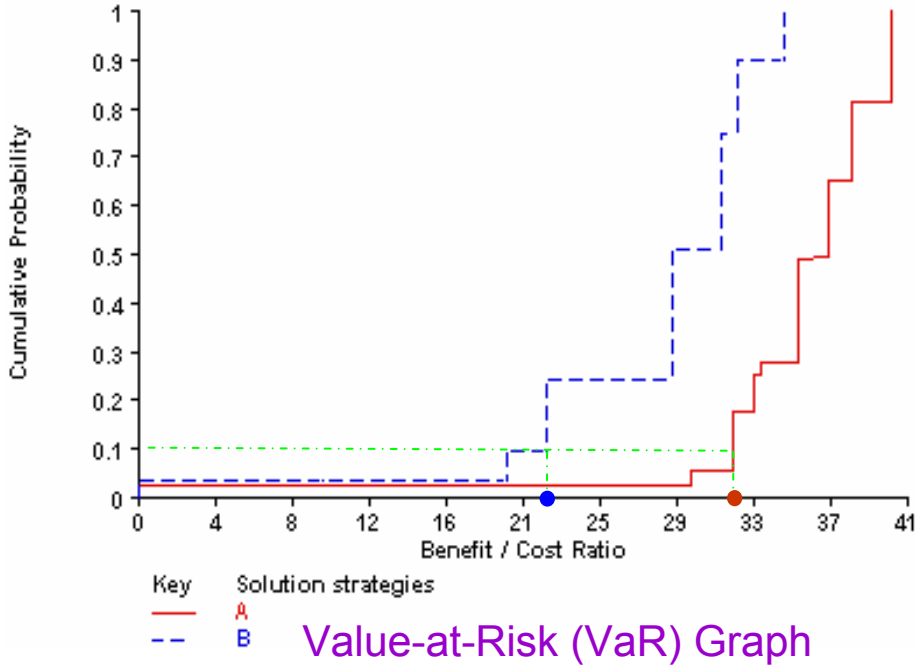
Comparing Solutions A and B based on Benefit / Cost Ratio

input data are notional

Return on Investment (ROI)

Benefit / Cost ratio	A	B
Min	0	0
Median	37	28
Mean	**35**	**28**
Max	40	34
Std. Dev.	7	7

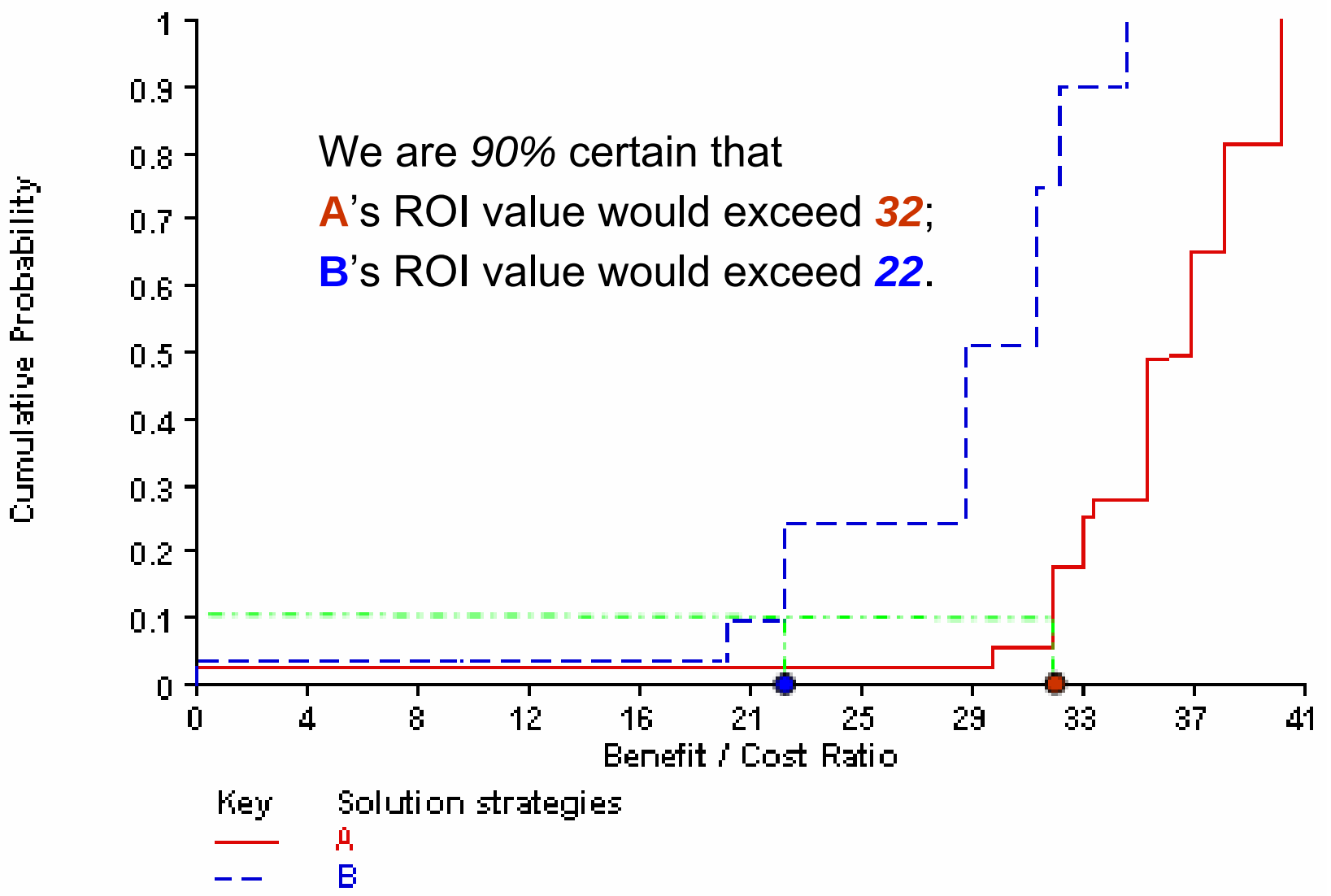
We are *90%* certain that
A's ROI value would exceed ***32***;
B's ROI value would exceed ***22***.



Value-at-Risk (VaR) Graph
a.k.a. Risk Profile

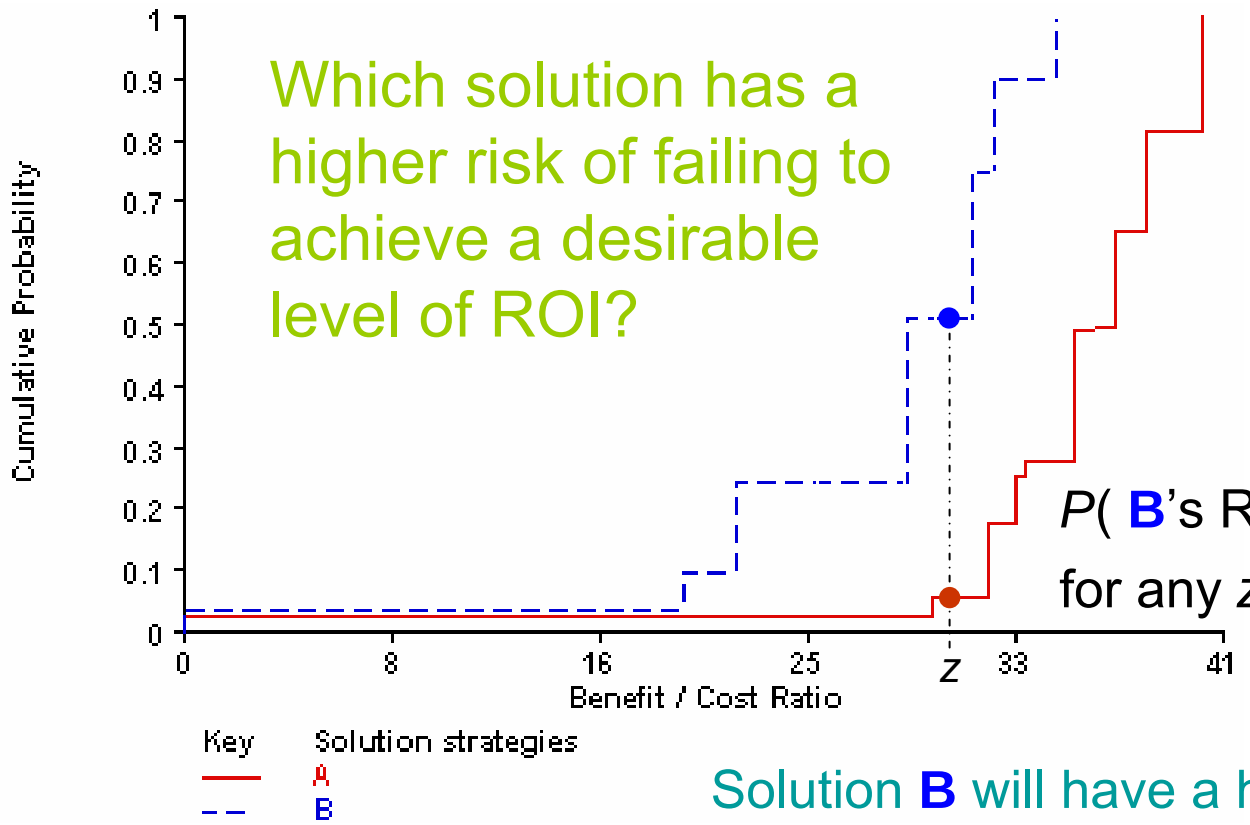
Conclusion: With all potential outcomes considered,
A is probabilistically better than **B** for Return on Investment.

Value-at-Risk Graph Magnified



Another Look at the Value-at-Risk Graph

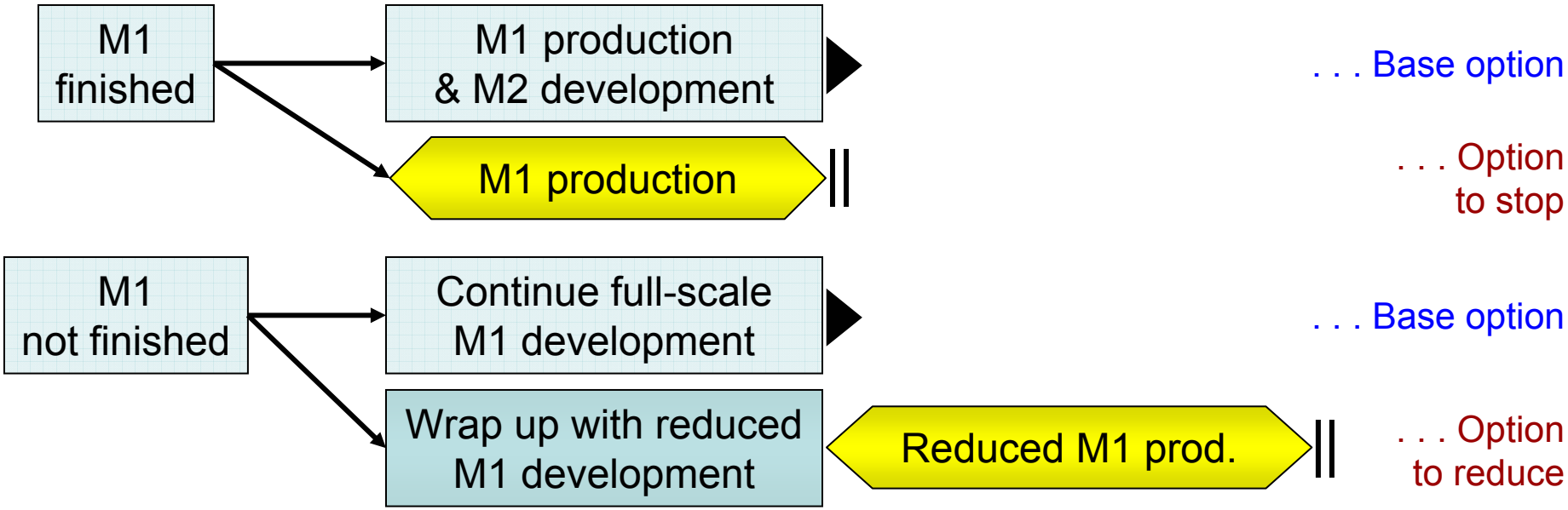
Uncertainties in project development and funding decision have been translated into **Risk in ROI**.



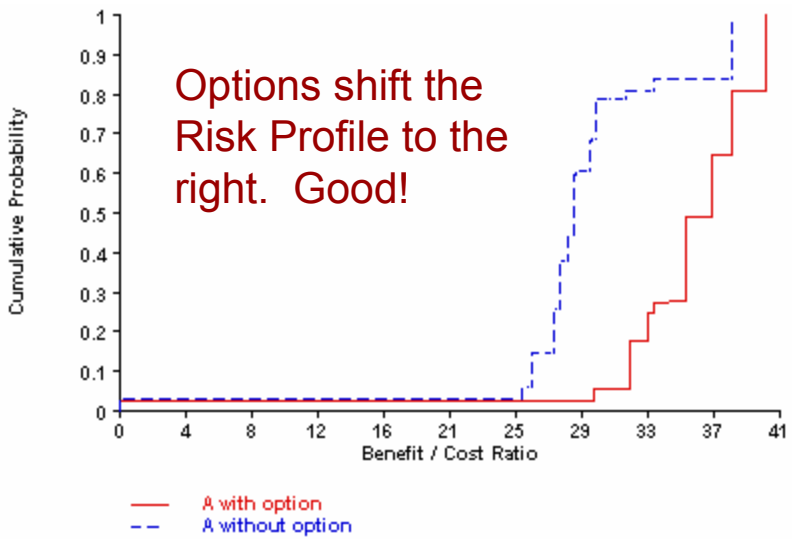
$P($ **B**'s ROI $\le z$ $) >$ $P($ **A**'s ROI $\le z$ $)$ for any $z > 0$

Solution **B** will have a higher probability of failing to achieve *any* desirable level of ROI. Hence, Solution **A** is better.

Options can enhance Solution A's ROI

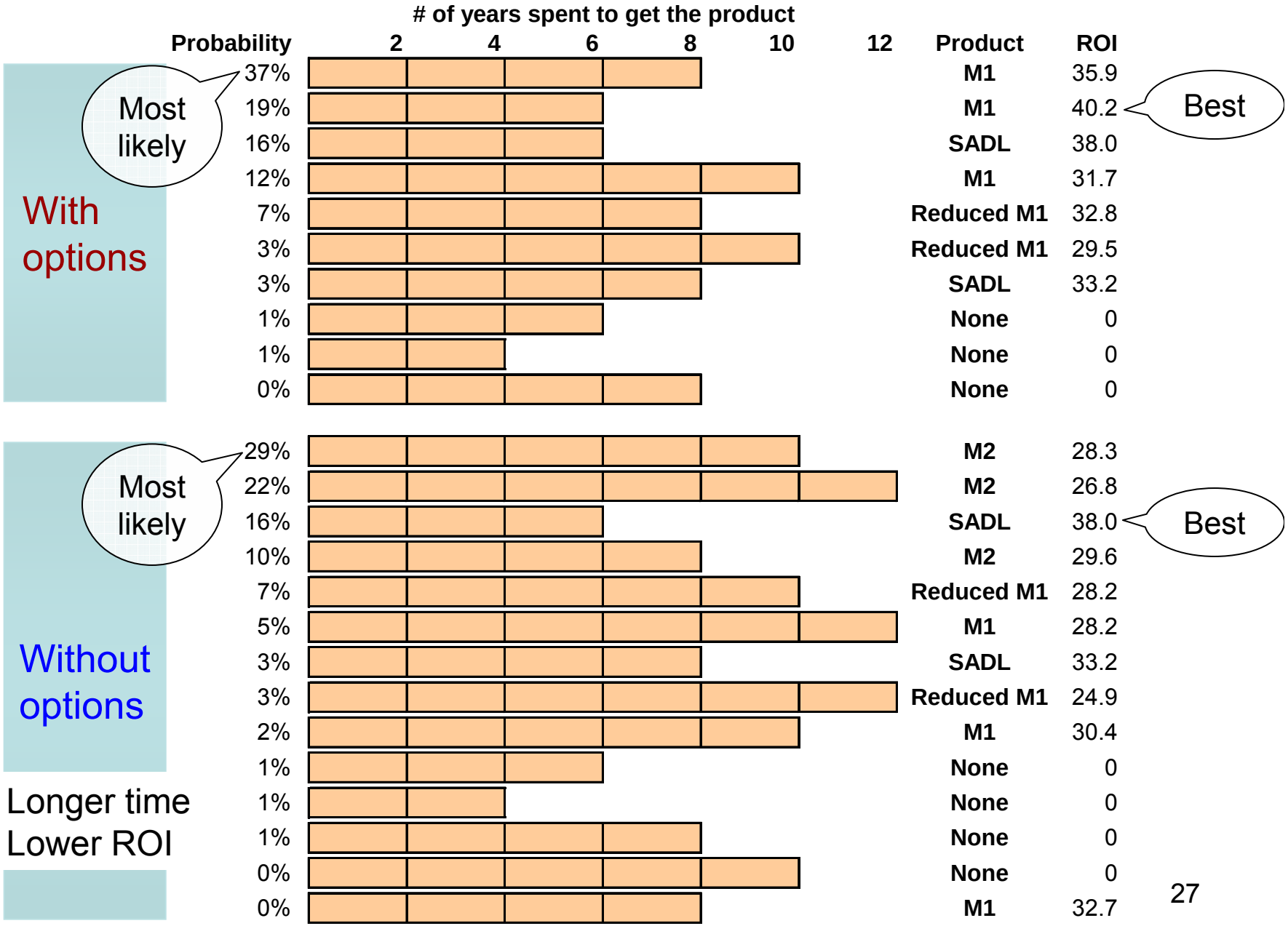


ROI	A without options	A with options
Min	0	0
Median	28	37
Mean	**29**	**35**
Max	38	40
Std. Dev.	7	7



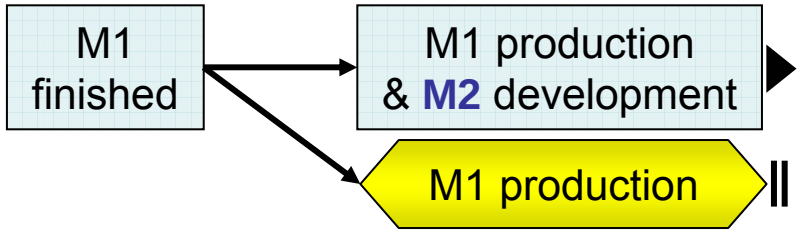
Possible Outcomes of Solution A

MITRE



- Longer time
- Lower ROI

Strategy Analysis for the "M2 option"



Under what conditions would the "M2 option" become attractive?

M2 starting inv.

	68	69	70
$8M	M1	M1	M1	M1
$7M	M1	M1	M1	M1
$6M	M1	M1	M1	M1
$5M	M1	M1	M1	M1
$4M	M1	M1	M1	M1
$3M	M1	M1	M1	M1
$2M	M1	M1	M1	M1
$1M	M1	M1	M2	M2
	M1	M1	M2	M2

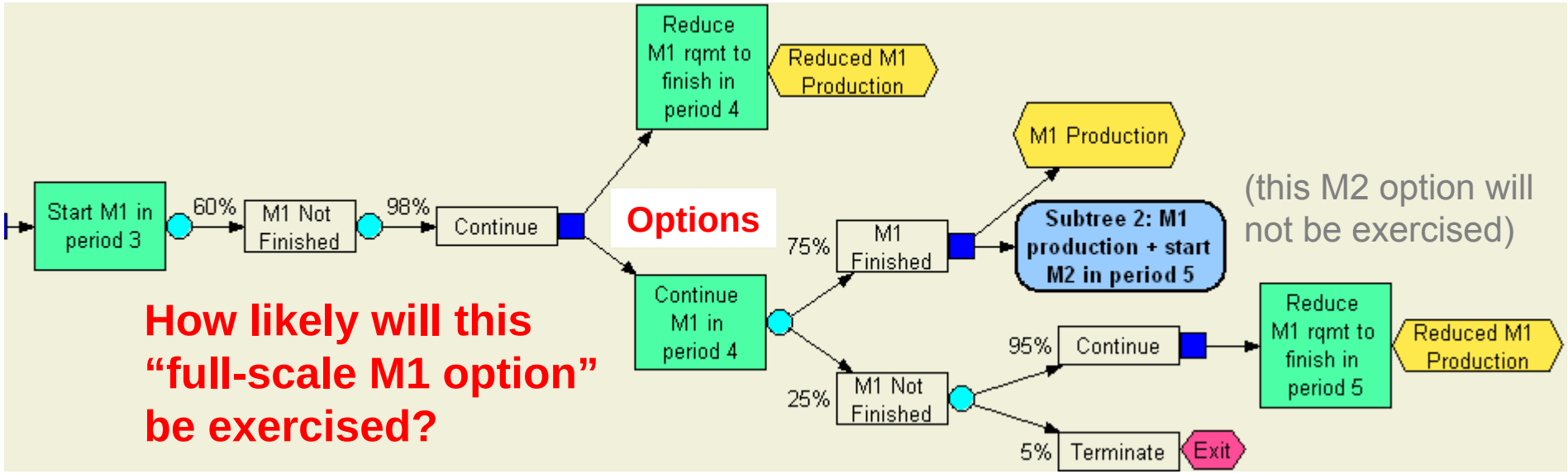
M2 annual benefit value

strategy map derived from sensitivity analysis

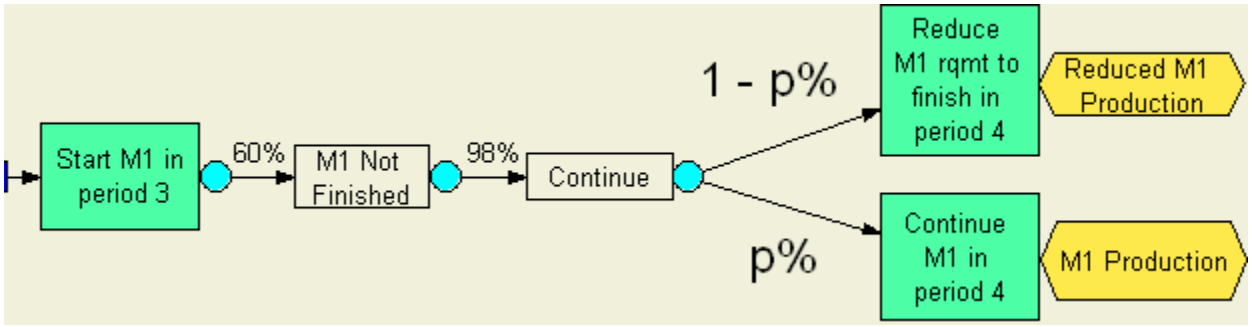
- Most critical factor: M2 starting investment
- ( ): current estimates of M2 starting investment and yearly benefit
- **Green zone**: favorable conditions for taking the M2 option

  Based on the given data, the M2 option is unlikely to be exercised.

Strategy Analysis for the "full-scale M1 option"



It can be proved that the above decision tree can be transformed into:



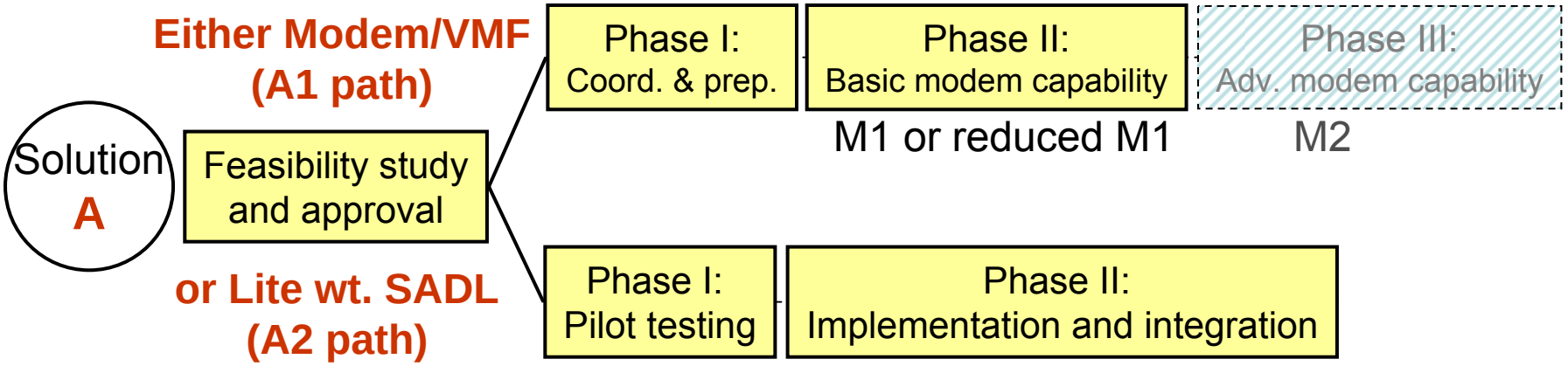
If the upper branch is more cost effective, then p% = 0%; otherwise, p% = probability of completing M1 in period 4.

Based on the given data, the lower branch is more cost effective, so there is a 75% chance that the "full-scale M1 option" will be exercised in period 4.

Further Sensitivity Analyses on Discount Rates and Planning Horizon

- **A** is increasingly better than **B** when the cost discount rate increases.
- **A**'s advantage over **B** gets diminished as the benefit discount rate increases
  - When benefit discount rate ≥ 19%, **B** becomes the preferred solution.
  - The benefit discount rate models "time preference" or urgency for a solution. If you want a solution so "bad", **B** might be a better choice.
- **A** is increasingly better than **B** for longer planning horizon. If it's shorter than 16 years, there is no clear winner.

A solution selected, a strategy suggested



Gateways + TADIL-J extension



***Strategy*:**

- If the A1 path is feasible to go, just develop the basic capability M1.
- May need to consider reduced M1 development (as Plan B).
- After each period, reassess the strategy with most current data.

Real Options Thinking for the TDL-CAS Case

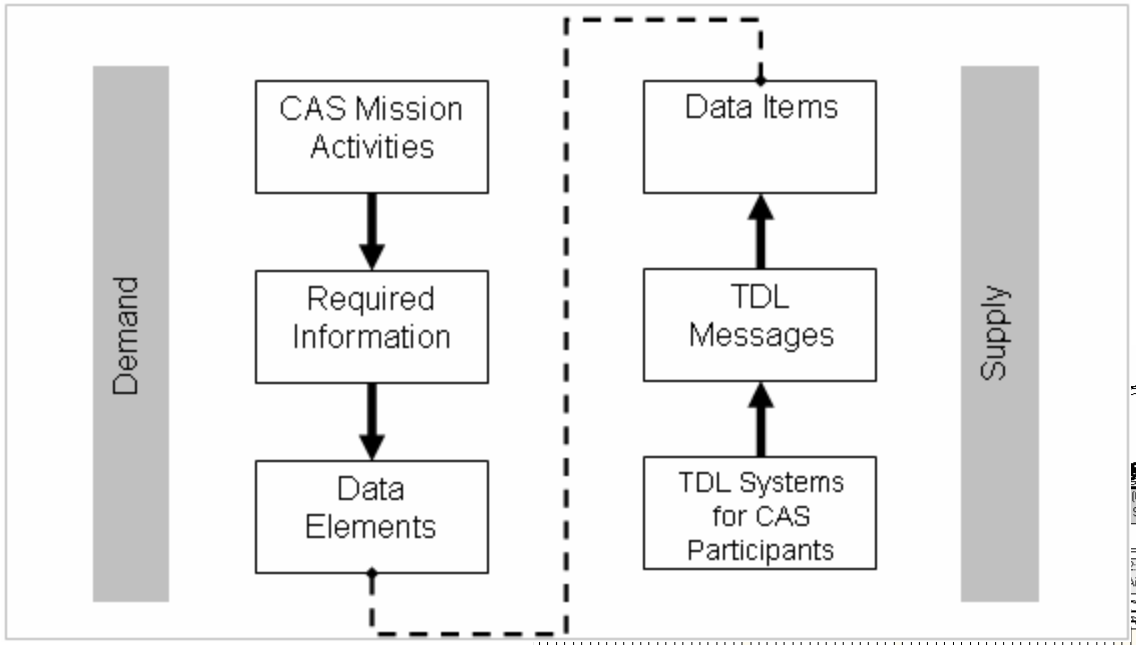
- **Uncertainty:**
  - Convoluted schedule risk in system and platform upgrade
  - Technology readiness
  - Funding
- **Flexibility:**
  - Deliver operationally acceptable capability in near term
  - Prepare to acquire capability incrementally
  - Consider contingency plans and exit opportunities
- **Strategy:**
  - Field initial capability and give up further development
  - Reduce requirements and wrap up effort after n years

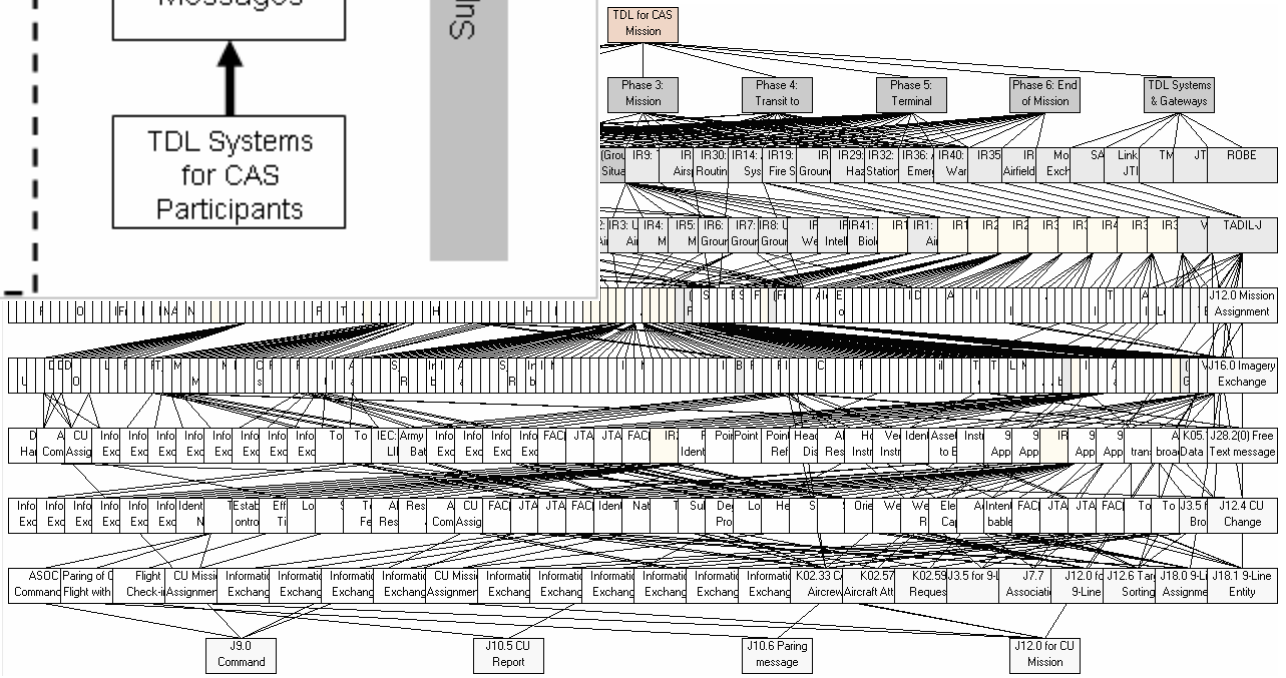
Conclusion

- Managerial flexibility can make significant difference in investment value of capability acquisition programs.
- Decision-tree analysis and Monte Carlo simulation are useful tools:
  - **Decision trees** can model flexible systems engineering concepts. The Decision Maker will be well informed of decision consequences. The decision tree should be a live one with refreshed data every period to provide updated advice.
  - **Monte Carlo simulation** with risk profile analysis enables probabilistic evaluation of Return on Investment.

Backup Slides

Solution benefit is estimated from a multi-attribute value analysis





(developed using **PALMA**)

MITRE

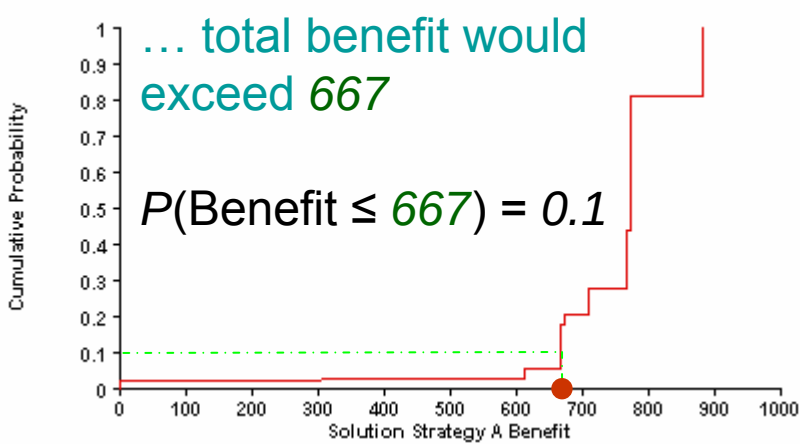
Probabilistic Evaluation of Solution A

input data are notional

We are *90%* certain that **A**'s…

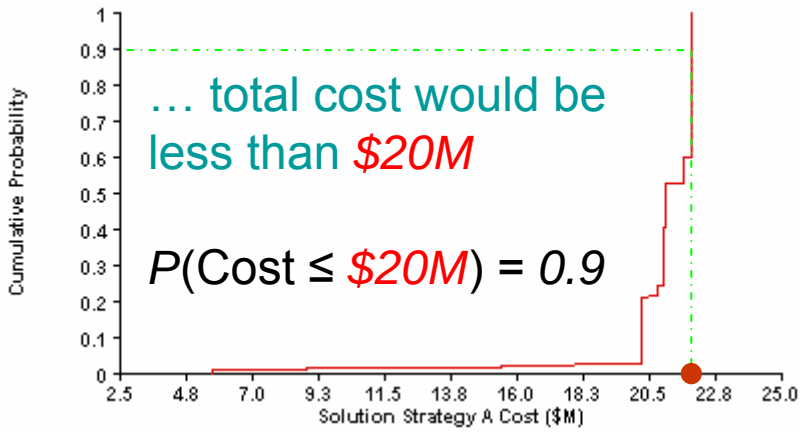
Benefit

Min	0
Median	771
Mean	747
Max	880
Std. Dev.	138



Cost

Min	5.7
Median	21.1
Mean	21.0
Max	22.0
Std. Dev.	2.0



MITRE

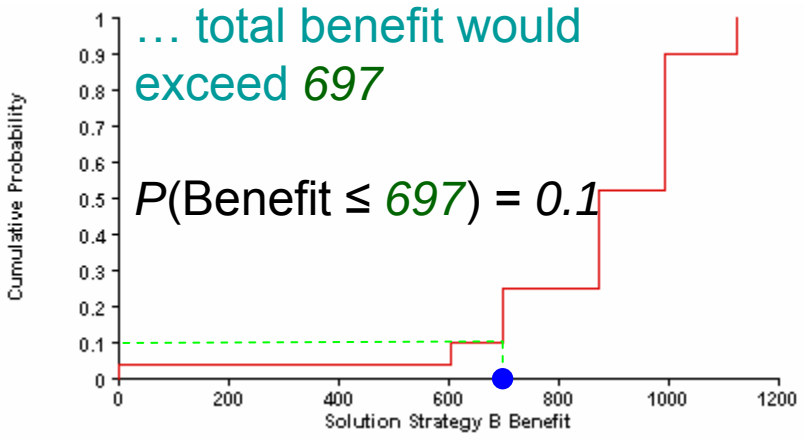
Probabilistic Evaluation of Solution B

input data are notional

We are *90%* certain that **B**'s…

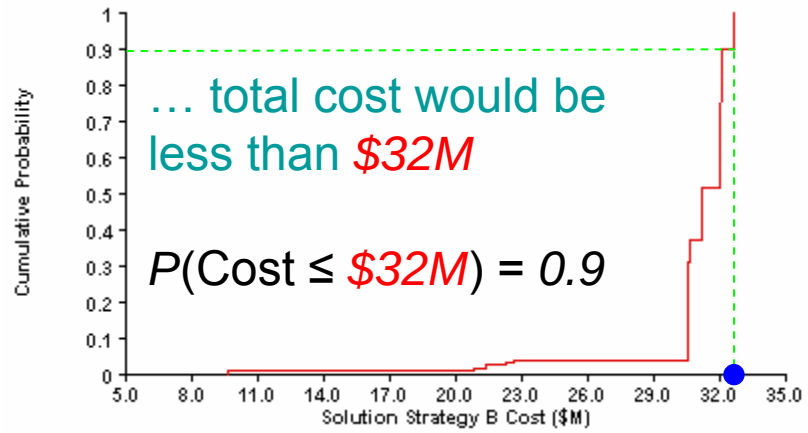
Benefit

Min	0
Median	871
Mean	867
Max	1122
Std. Dev.	223

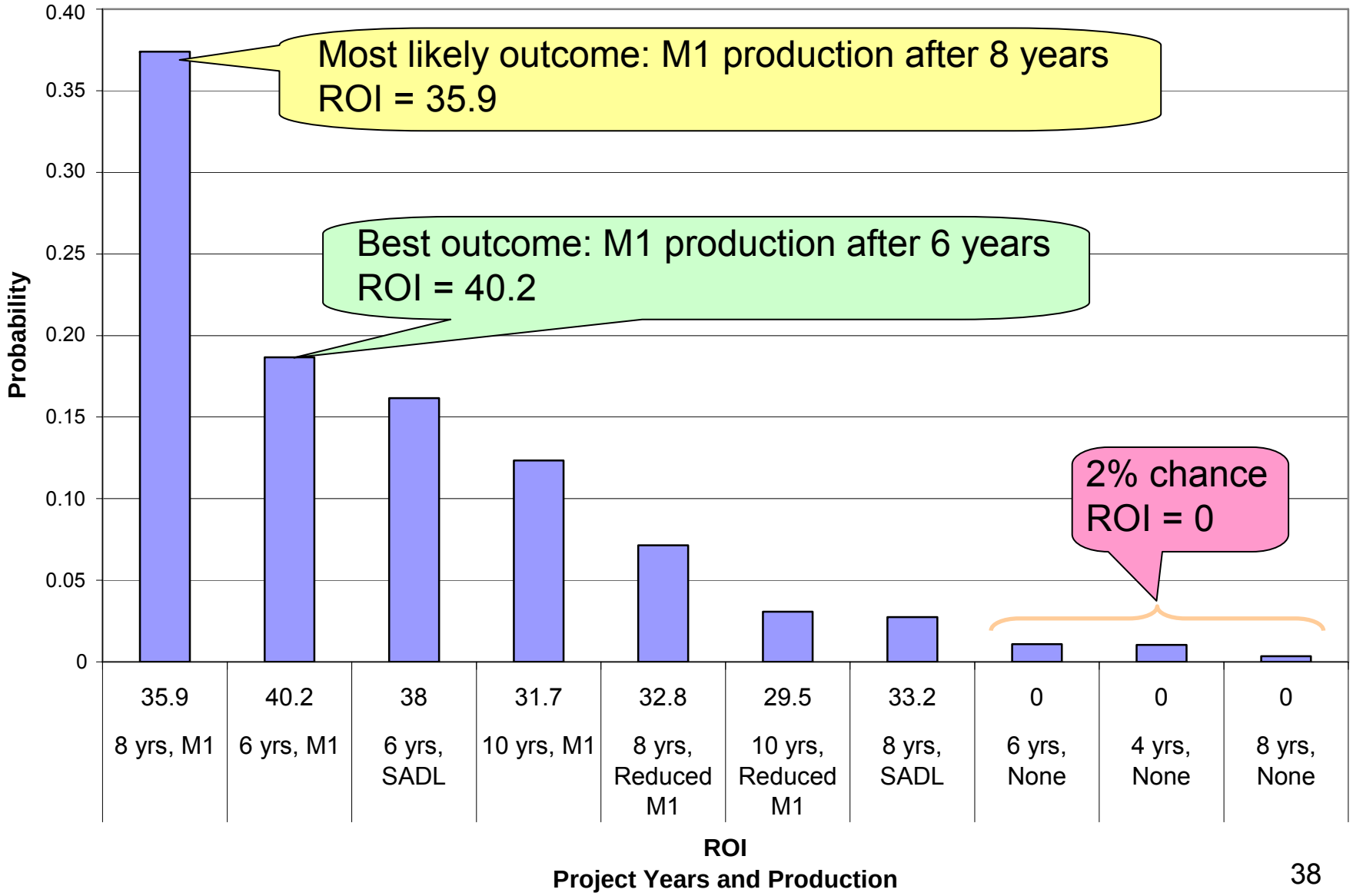


Cost

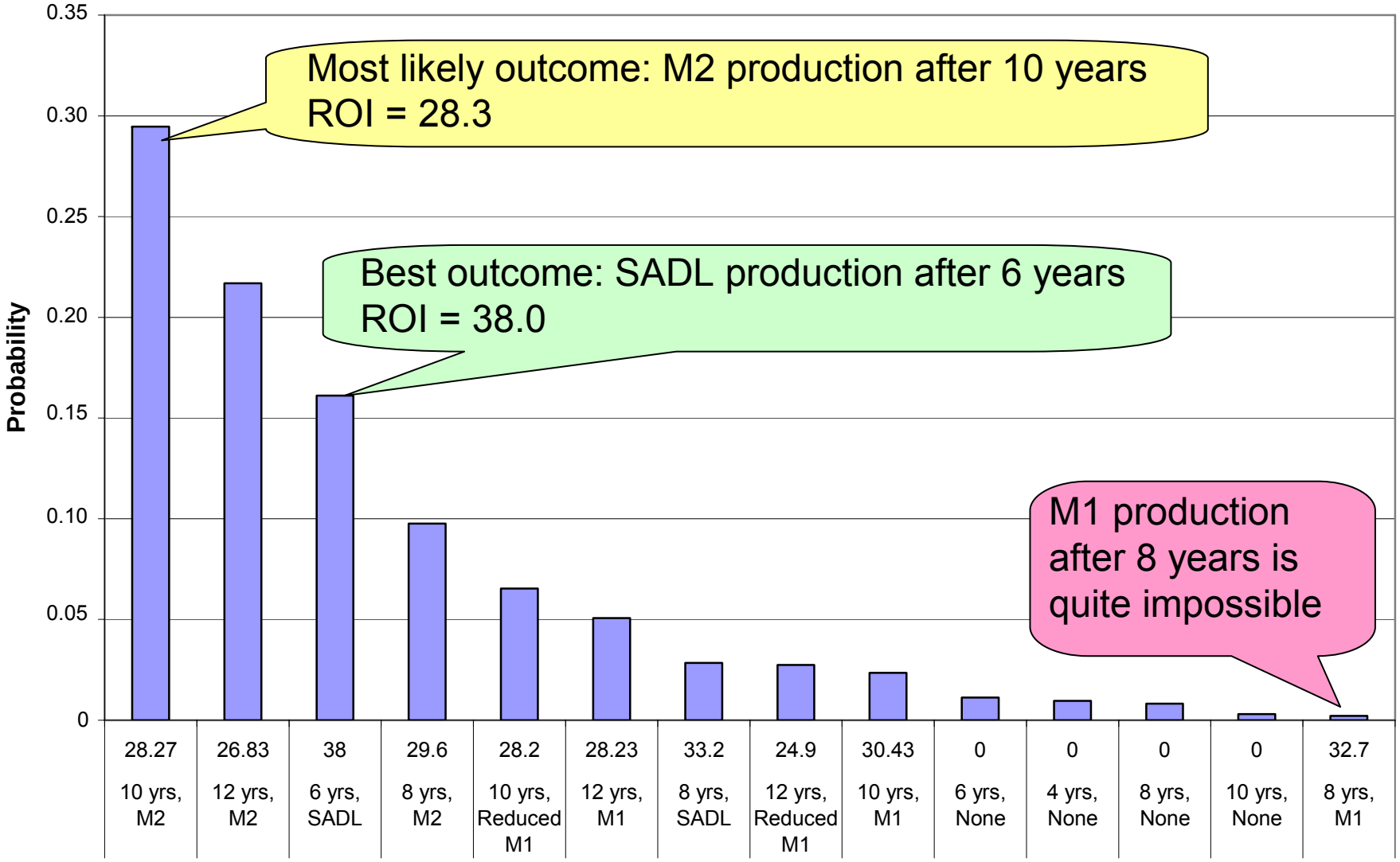
Min	9.7
Median	31.1
Mean	31.0
Max	32.6
Std. Dev.	2.7



Possible Outcomes of Solution A with Options



Possible Outcomes of Solution A without Options



This analytic approach can be applied to projects with similar characteristics

- There exist significant uncertainties in project development and funding decisions.
- There is time-to-market pressure, but the product development process will be long and has multiple phases with uncertain duration in each.
- An initial useful capability can be defined and it can enable the development of more advanced capabilities.
- The project is not destined to acquire a “100%” solution; contingency plans and exit strategies are allowed and encouraged.

Practical Design Issues of Simulation-Based Acquisition

-

Kevin Tang

Charles Cohen, Ph.D.

Glenn Beach

Cybernet Systems Corporation

Acknowledgements

- This work was funded by the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) under contract DAAE07-03-C-L151

Overview of Presentation

- Simulation-Based Acquisition (SBA)
- Design Issues
- Case Study
  - Virtual Systems Integration Lab for the Army
- Recommendations
- Conclusions
- Questions?

Simulation-Based Acquisition circa 1998

- Definition from U.S. ARMY PEO STRI (1998)*:
  - "Simulation Based Acquisition (SBA) is a major initiative…intended to make smart use of M&S technologies to equip our forces with quality systems of high military worth, in less time, and at lower cost than traditional means.

    "The concept behind SBA is that the M&S tools can be integrated and matured throughout the system lifecycle process ..."

- Overall Goal: Field the best systems for the future military force in the shortest time and at the lowest cost.

*http://www.peostri.army.mil/PRODUCTS/SBA/definition.jsp

Simulation-Based Acquisition circa 2006

- We have not achieved full-adoption of SBA across the DoD
- SBA success has been limited
  - OSD study suggests that over 80% of models developed on 22 major programs are unique to that program.
  - Most are owned by the prime, not the government
  - Leads to increased development time
  - Leads to increased cost to the government

- We remain on the ground floor of SBA
- The Overall Goal is still the same

What are the Design Issues?

- Two major kinds: Technical and Political

- Both are co-dependent but can be analyzed separately
- Both present thorny challenges, but are not insurmountable

Technical Challenges

Government Perspective	Industry Perspective
-Need high fidelity models	-Need accurate data
-Need data security	-Need IP protection
-Need system of systems	-Need subsystem requirements
-Need interoperability	-Need cooperation

- SUMMARY: We need a solution for the Govt to maintain control of model assets, while providing Industry the data it needs to do its job.

Technical Challenges

- Main challenge is data access
- Model validation cannot be done without access to accurate data
- The current workaround is to maintain isolated model repositories
- However, this workaround defeats interoperability and cooperation
- There is no unified tool for virtual systems integration

- The result is that full systems cannot be simulated reliably or at all under current resource constraints

Political Challenges

Government Perspective	Industry Perspective
-Want to own models	-Want to own models
-Want more control	-Want job security
-Want best solution	-Want less competition
-Want more cost-savings	-Want fewer restrictions

- SUMMARY: We need a solution that allows the sharing of simulation models in a way that does not penalize or overly burden the creators.

Political Challenges

- Main challenge is simulation reuse
- The Govt will not get cost-effective SBA without model reuse
- The biggest Industry players stand to lose the most from SBA
- The current environment breeds specialized simulations of limited reuse that are costly to build

- Simulation reuse and interoperability is painful for industry to implement, and will not happen without greater Govt mandate

Other Challenges: Myths of SBA

- Myth 1: Job security is endangered by SBA.
  - Truth: Existing designers are given new tools to do their jobs better. Potential for new service contracts are created by model maintenance.

- Myth 2: SBA processes will "break the system."
  - Truth: The current system is unlikely to accomplish all DoD transformation goals under shrinking budgets. The current system has mission-critical problems and SBA is a feasible and mandated solution.

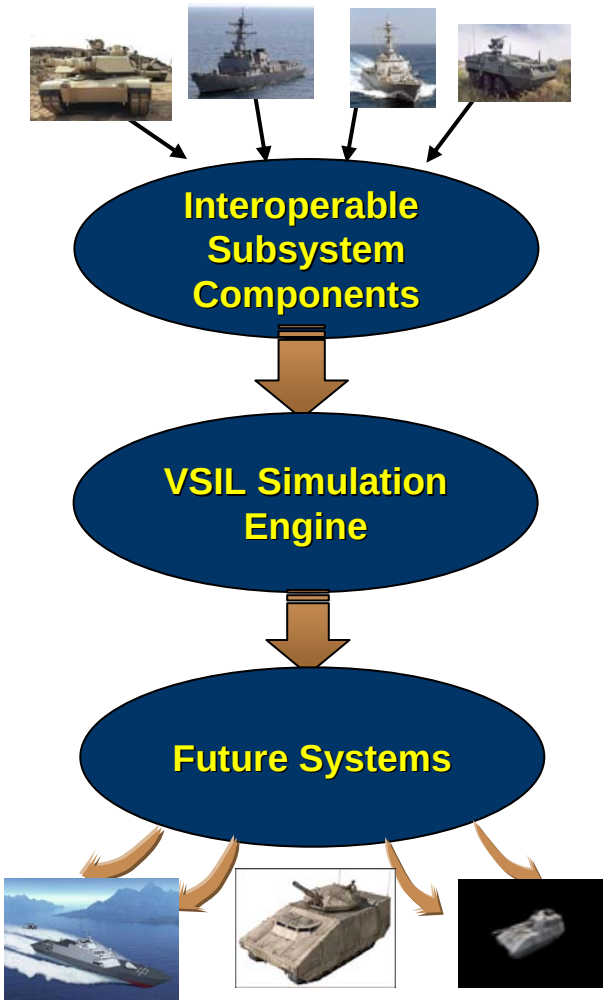
Case Study

- Virtual System Integration Lab (VSIL) for the U.S. Army
  - VSIL is an SBA toolset for accelerating systems engineering
  - VSIL is a flexible system integration suite for virtual prototyping & simulation that tests all aspects of prototype designs prior to committing to a physical prototype

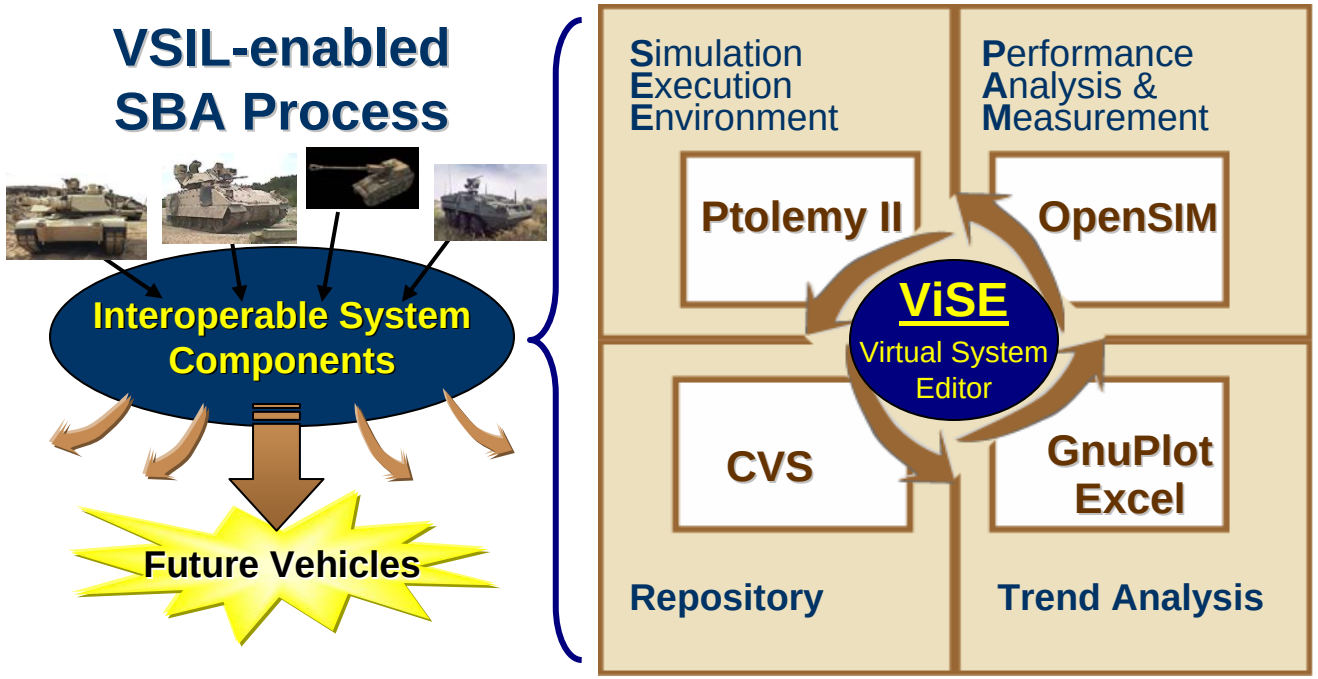


VSIL Objectives

- Enhance next-generation vehicle design and development
- Improve efficiency of simulation development
- Perform cost-benefit analysis on component models up to full deployments

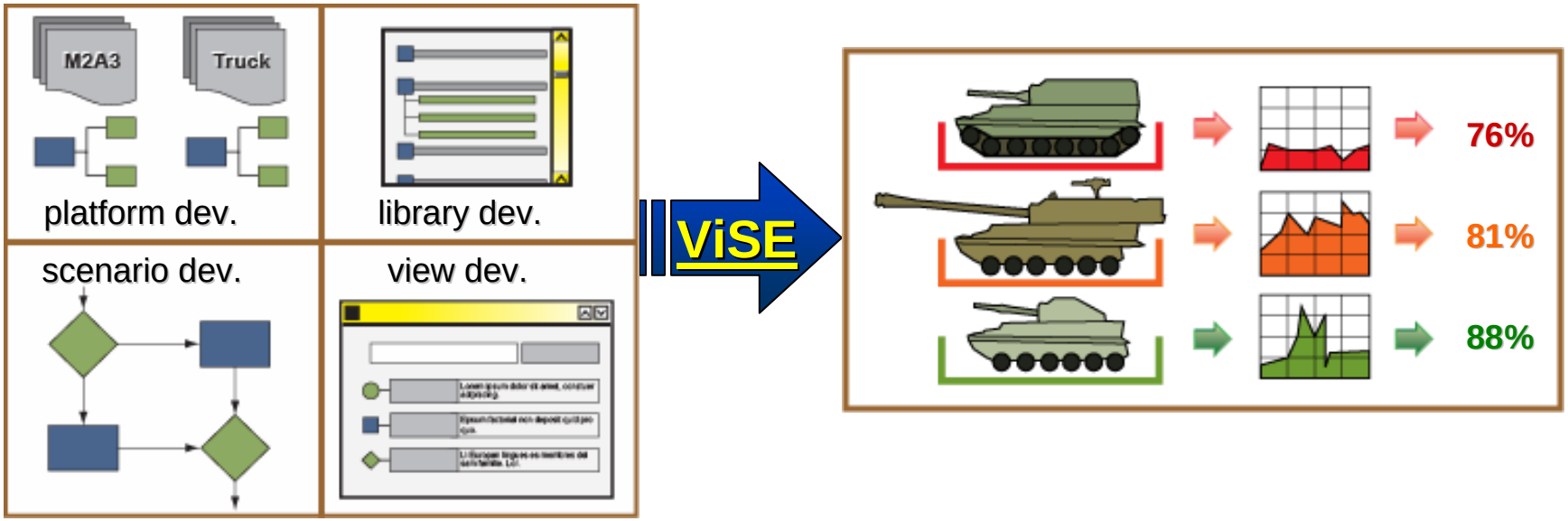


Results: VSIL-enabled SBA



- Transforms development process from one where a vehicle design is based on history of direct ancestors to a process where new vehicle design benefits from development of all previous vehicles

Results: Virtual Systems Editing



- Through the Virtual Systems Editor (ViSE), VSIL provides an integrated design, development, and simulation toolset to enable automated component trade off analysis and requirements generation.

Lessons Learned from VSIL

- SBA process adoption depends on the availability and fidelity of component models of interest
  - (e.g., Mobility, Drive-train, Suspension, Mechanical)
- SBA processes require well-populated component libraries
  - The components should be modeled at level which they are swapped for tradeoff analysis (e.g., Line Replaceable Units)
- Need model import capabilities for industry-standard formats
  - Flexibility is key for leveraging existing models and new models
  - Domain expertise is critical and an underestimated bottleneck

Lessons Learned from VSIL

- Powerful and user-friendly tools make a world of difference
  - Increases the efficiency of Govt validation
  - Reduces the penalty on Industry for adopting SBA
  - Actual usage reduces anxiety and builds confidence in the tool
- Interface-based Modeling & Simulation solves many IP issues
  - Enables reusability, gives Industry a layer of abstraction to protect its IP
- Time savings can be roughly calculated by the number of engineering iterations reduced
  - The VSIL enabled the vehicle systems engineer to do trade-off studies over 4x faster by reducing development iterations

Recommendations for Effective SBA Tools & Processes

- Populate centralized repositories that are government owned and operated. But let Industry maintain proprietary repositories with interface-based model access.
  - Interface with decentralized repositories based on service agreements
  - Provides Govt and support contractors real data to use
- Require the delivery of component models developed under contract
  - Govt & Industry need standardized tools to handoff and evaluate models
- Govt needs tools to effectively manage SBA and M&S
  - Govt needs more automated M&S capabilities

Conclusions

- SBA has not failed – we simply need more adoption
- SBA design challenges can be overcome – but more buy-in and mindset change required
- SBA has many circular dependencies between Government & Industry
- Govt will not get best solution when the competition is limited

Conclusions

- Ultimately, the Government's degree of push for SBA will determine its effectiveness. For SBA to be truly effective there needs to be more give and take between government control and industry free reign
- Need more leadership from within Govt to make this happen
- War-time atmosphere makes process change harder but motivating
- More transformation is required, SBA is key to Defense transformation

Questions?

- Please address questions to Kevin Tang, ktang@cybernet.com

Air Force Institute of Technology

Integrity - Service - Excellence

Solutions Analysis for Helicopter Brownout



9th SE Conference

Oct 2006

Major Lee Anderson, Major Pete Doty
Major Manuel Griego,
Major Ken Timko,
Dr Brian Hermann, Dr John Colombi

U.S. AIR FORCE

Overview

- Background (Helicopter Brownout)
- Requirements
  - Mishap Analysis
  - Operational Tasks
- Solutions Analysis
- Conclusion



Hovering Flight

Not as easy as it looks



Changing flight dynamics during approach to hover require large control inputs

Flight Controls

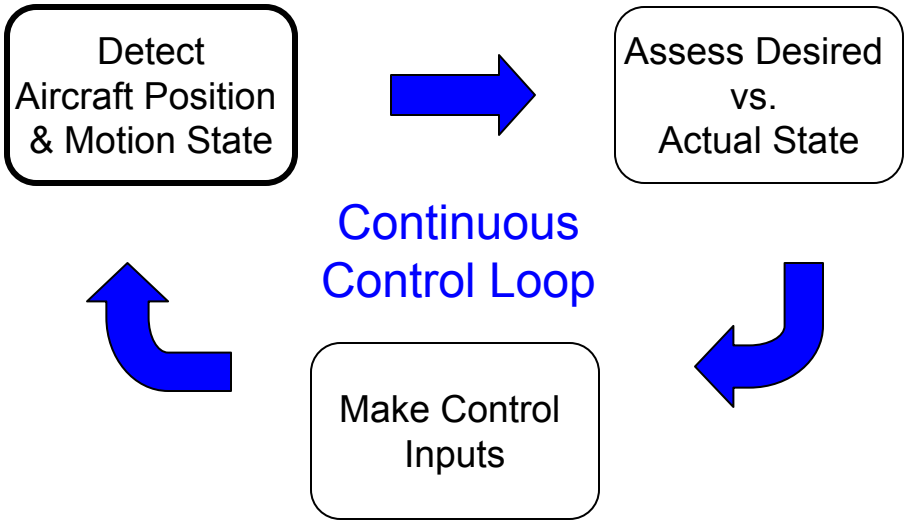
Main Rotor Thrust Axis
Main Rotor Thrust Magnitude
Directional Control Inputs (Anti-Torque)

All 3 Controls are Interdependent



Flight Regime

Static Instability
Dynamic Instability
Constant Perturbations



Pitch + Power ≠ Aircraft Control

The Question

How to safely perform a vertical landing when you can't see outside due to recirculating dust/snow?

Do something different to keep visibility

or

Replace and/or degrade the effects of lost information

Do Something Different to Keep Visibility



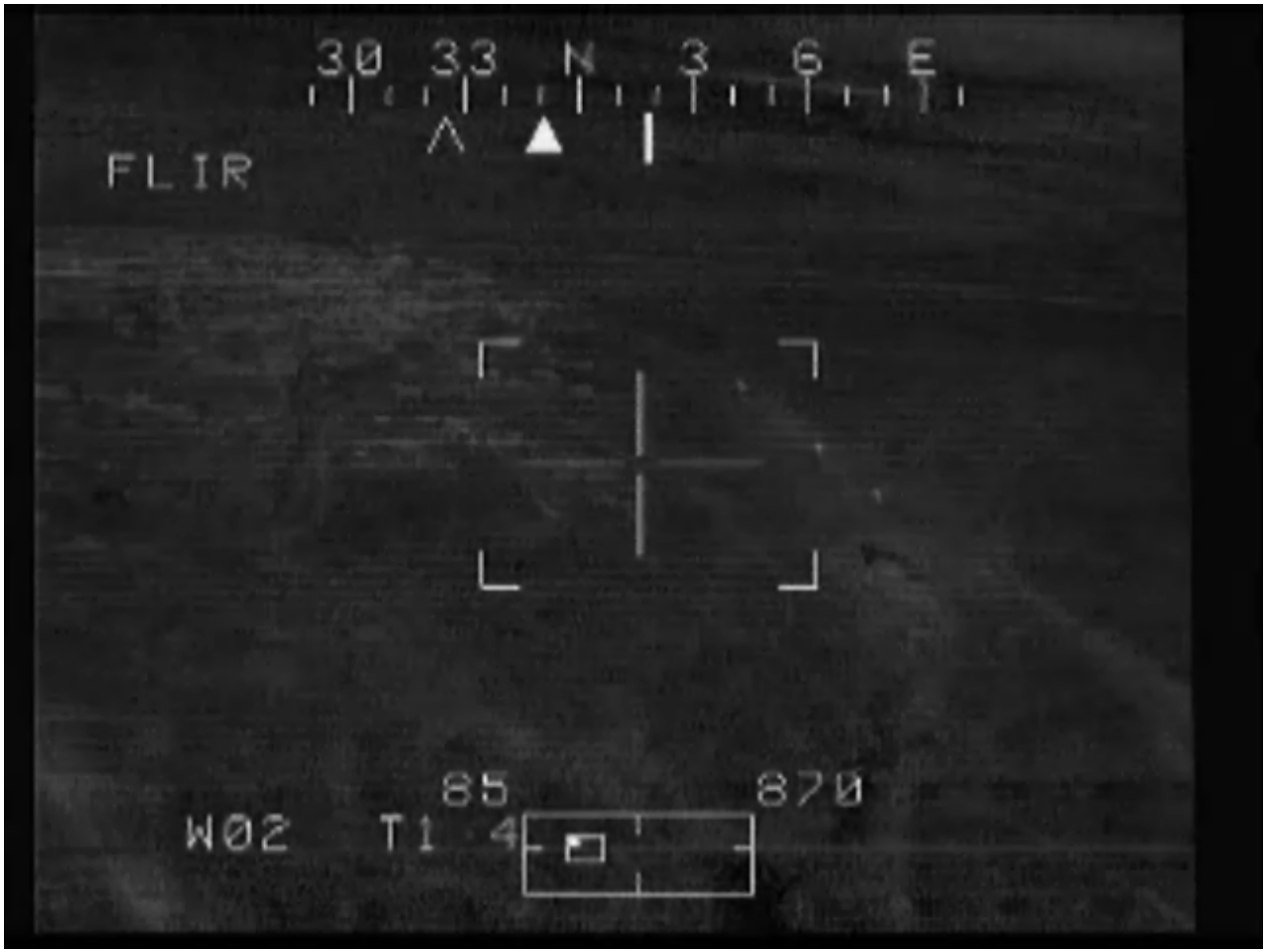
- Land fast to stay ahead of the dust cloud
  - Requires suitable long flat/smooth LZ
  - Requires High Decel Rates at touchdown
  - Dependent on surface winds
  - Aircraft Specific
    - Allowable Landing Attitude (Deceleration)
      - H-60, H-46, H-47 Good (Tail Wheels)
      - MH-53M, Bad (No Tail Wheels)
  - May or may not work out well in formation

Do Something Different to Keep Visibility



Sometimes it works…

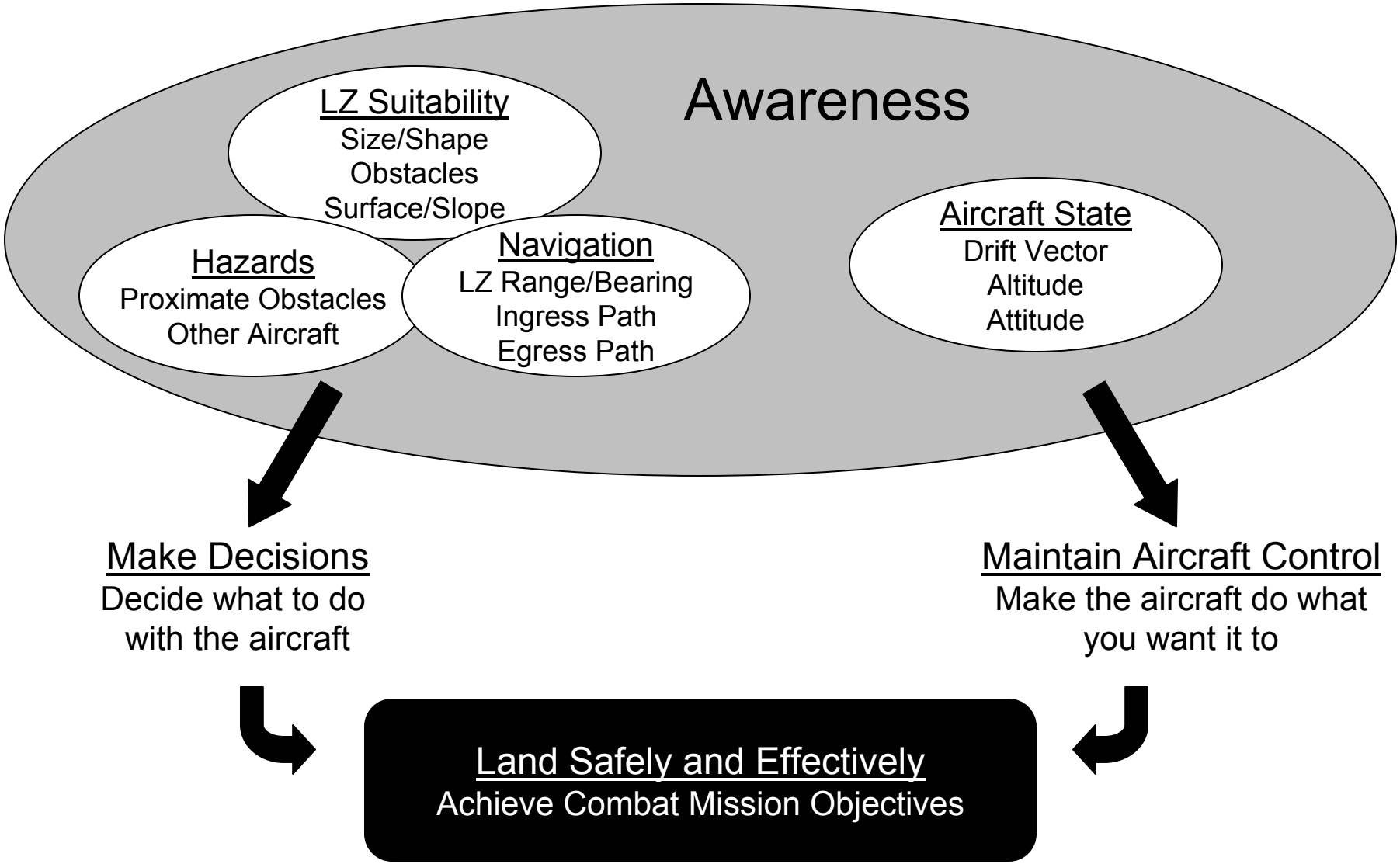
Do Something Different to Keep Visibility



Sometimes it doesn’t work

Replacing Lost Information

(and degrading loss of capability)



Replacing Lost Information
(and degrading loss of capability)

- **Aircraft Navigation Systems**
  - GPS/INS, Doppler, Radar Altimeter
  - Mission Computer (Waypoint Navigation)
- **Low Speed Aircraft Control Symbology**
  - Drift Vector, Vertical Velocity, Altitude, Heading, etc.
- **Geospatial Information (What's out there?)**
  - Digital Map (Imagery, Terrain, etc.)
  - Sensor Information (FLIR, Radar, etc.)
- **Reduced Aircraft Control Workload**
  - Stability Augmentation
  - Self Contained Approach Guidance
  - Coupled Approach/Hover Capabilities



V-22 Hover Display

What can be done to improve the situation?

Mishap Analysis

Long known problem, just more prevalent

- 33 Identified USAF Mishaps (1971 – 2006)
  - Loss of effective visibility causal
  - Landing/Takeoff phase of operations
  - HH-3E, MH-53H/J/M, HH-60G & UH-1F
- Mishap Costs
  - $72M Total pre 9/11 (30 Years)
  - $72M Total post 9/11 (5 Years)
  - DoD Costs estimated at $100M per year
- Mishap Factors
  - Inadequate Aircraft Control
  - Undetected Surface Hazards
  - Undetected Lateral Obstacle



1980 - Desert One (Operation Eagle Claw)
Failed rescue of American hostages, Iran





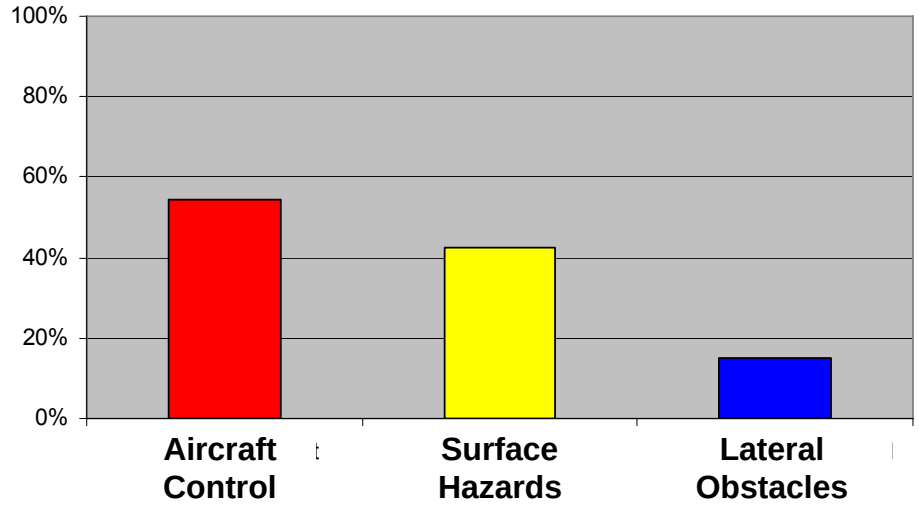
CSAR-X (~$45 Million)



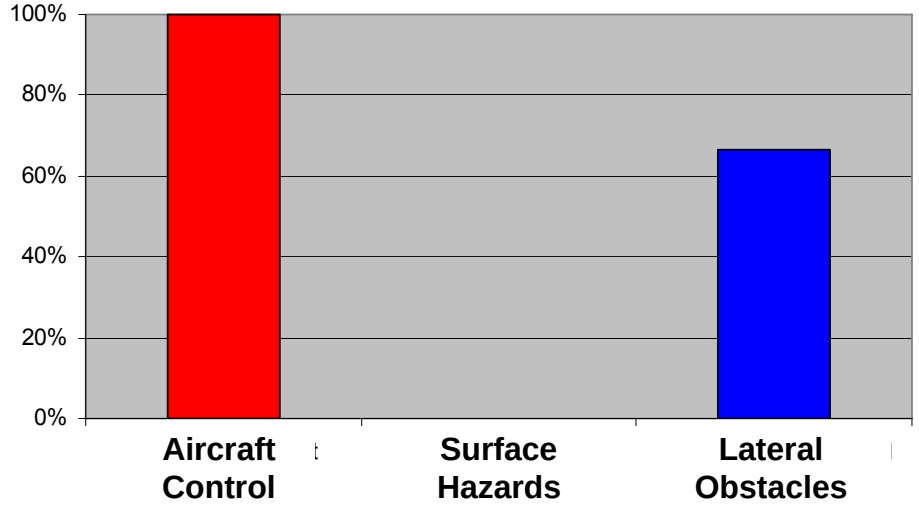


CV-22 ($80+ Million)

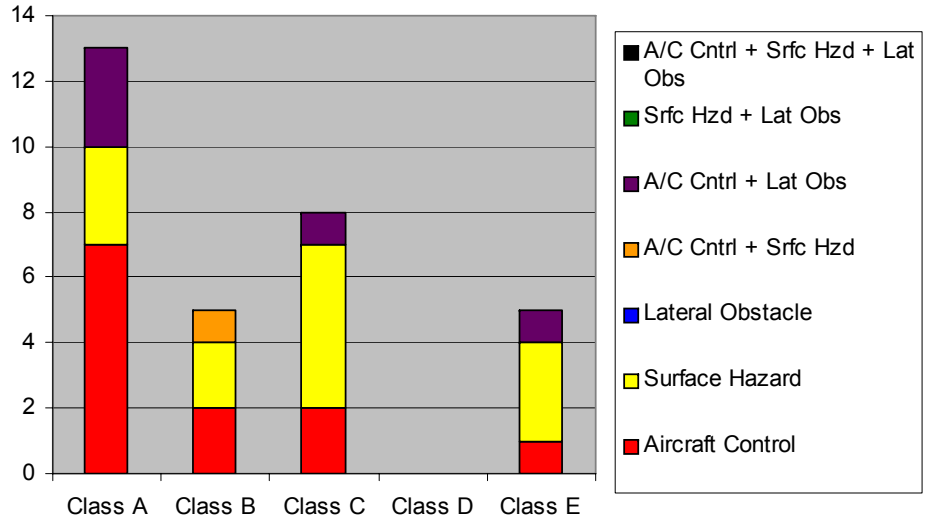
Mishap Factor Inclusion
33 Total Mishaps



Mishap Factor Inclusion
5 Fatal Mishaps



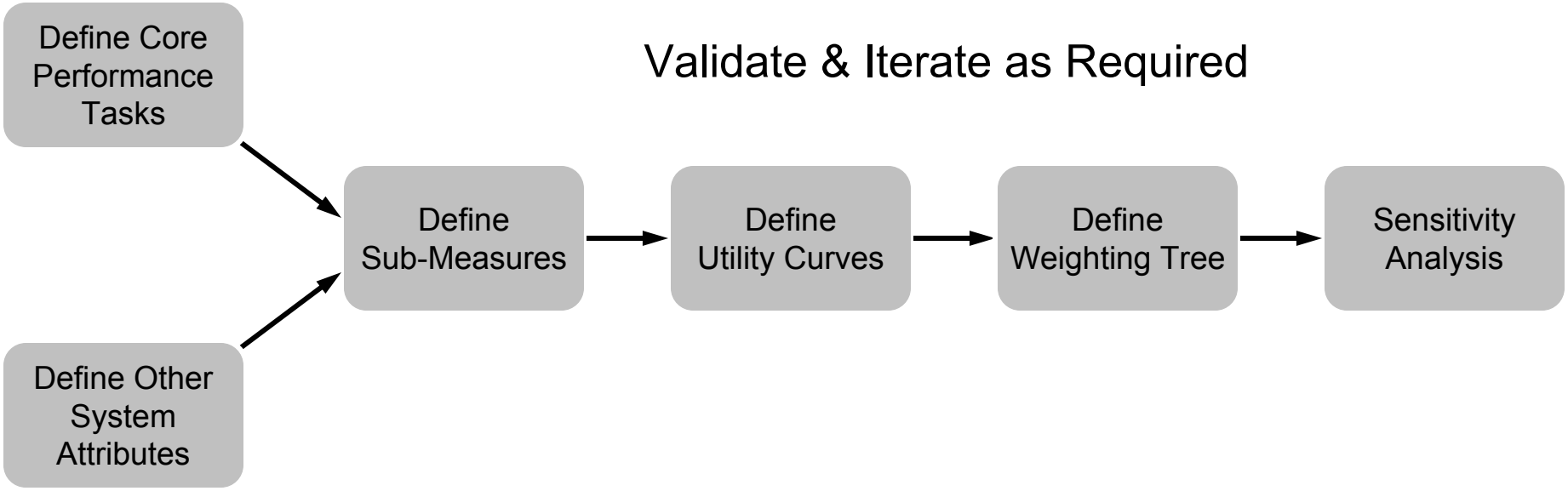
Mishap Factors by Class
(33 Identified USAF Mishaps)



Conclusions

- Maintaining aircraft control is Problem #1
- Better awareness of hazards is important
- Reducing aircraft control workload is key if added sensor information is to be effective
- Capabilities/Tactics that allow zero roll vertical landings could significantly reduce mishaps due to surface hazards

Measurable Requirements



Used to compare relative value between alternative solution sets

Starting point for tech demo system development

Framework for future combat system development

Major Tasks & Attributes

- Core Operational Tasks
  - Maintain Geospatial Awareness of Intended Landing Point
  - Confirm LZ Size & ID/Refine Landing Point
  - Locate Surface Hazards
  - Locate Proximate Obstructions
  - Successfully fly to safe landing point and land/hover as required

- Other Requirements (System Attributes)
  - Human Factors
  - Programmatic
  - Physical Characteristics
  - Sustainability
  - Operating Environment

Note: Related requirements sources: AFSOC No/Low Visibility ICD, Cable Warning/ Obstacle Avoidance ICD, CSAR-X CDD

Core Operational Tasks (OV-5)

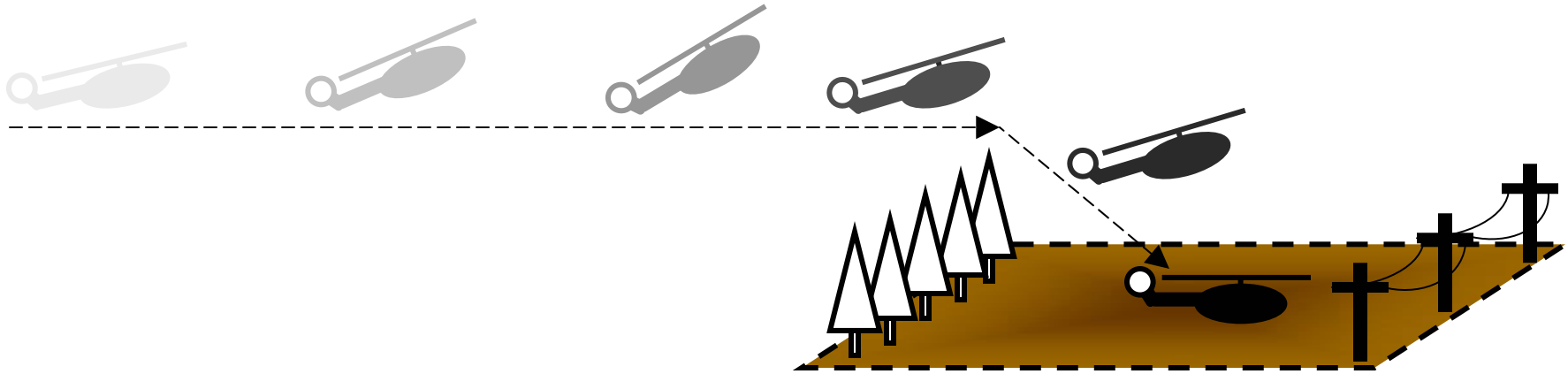
Execution Timeline

1. Maintain Geospatial Awareness

2. Assess LZ

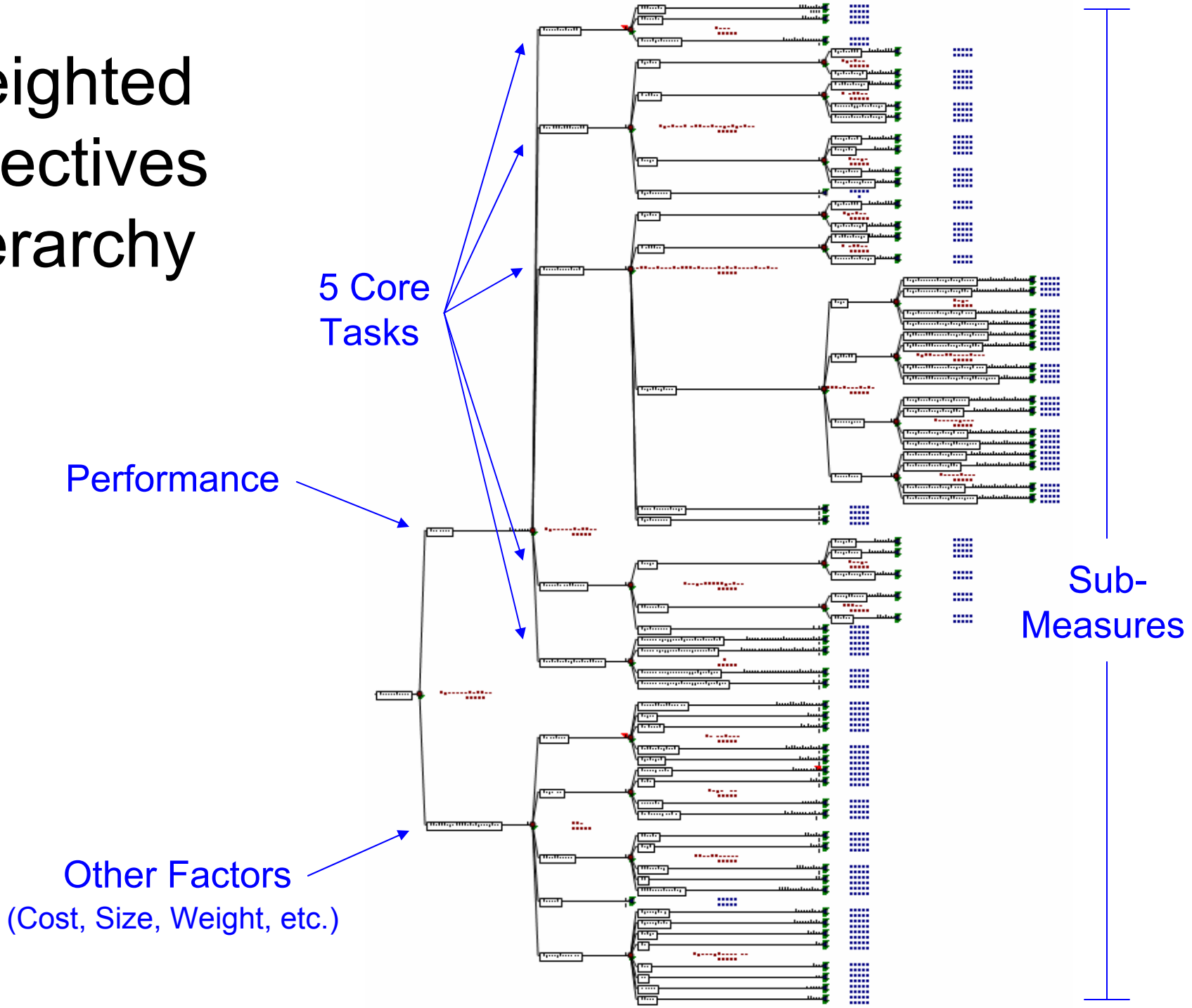
3. Locate Surface Hazards

4. Locate Proximate Obstructions



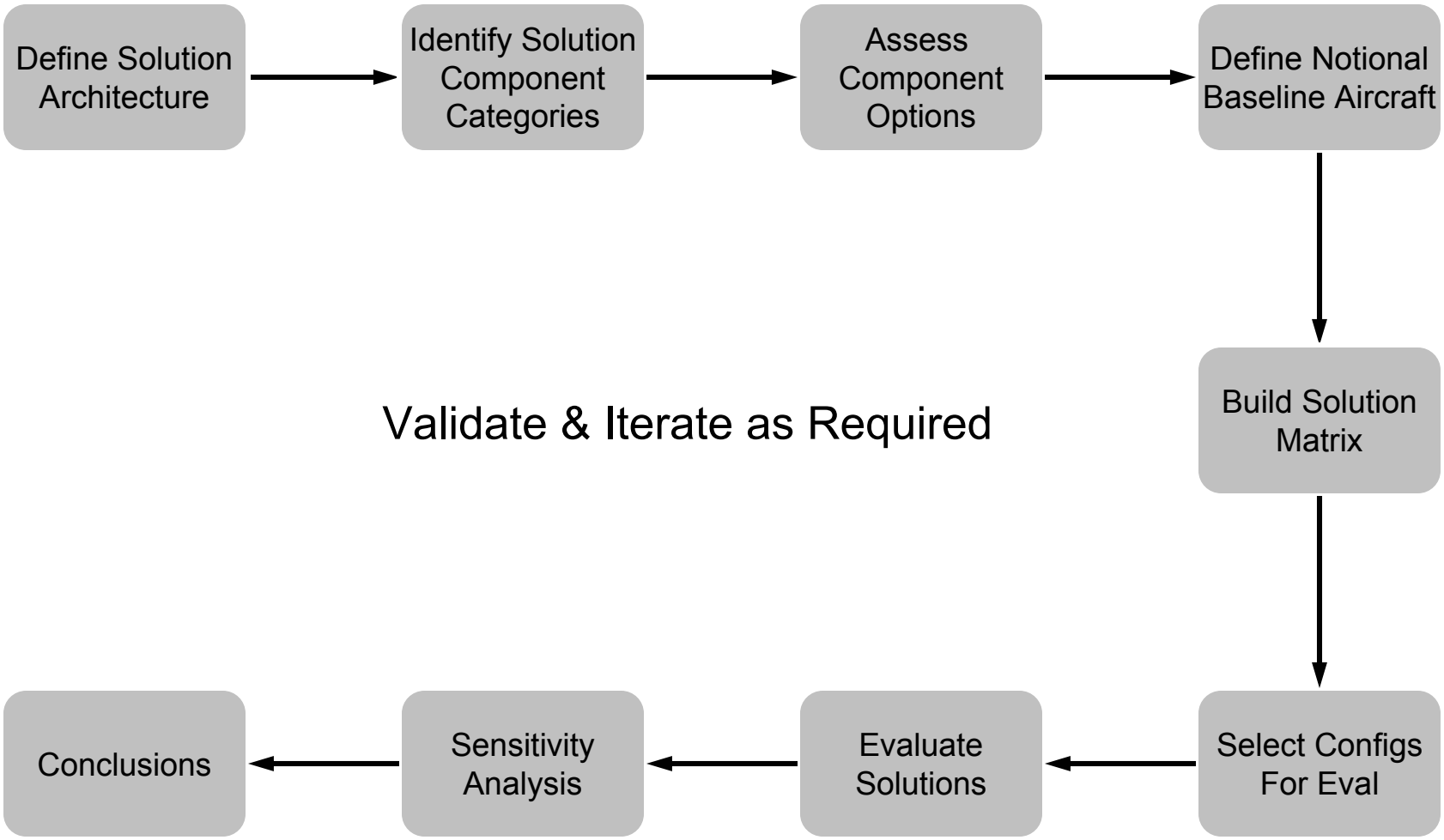
5. Maintain Aircraft Control

Weighted Objectives Hierarchy



Solutions Analysis

Process Overview



Objective System Architecture (SV-1) & Focus Areas



Aircraft State (Position, Attitude, Motion, etc.)

Aircraft State Sensors

Flight Control Commands

Manual Control Inputs

Pilot/Crew

Flight Control System & Interface

Flight Control System Commands

Aircraft State Data

Information System Commands

Information

Navigation Data

Information Human Interface

Mission Management

Sensor System Commands

Mission Management Commands

External Sensors

Sensor Data

World Model Data

Aircraft State Data

Digital World Model

External Data Link

World Model Data

Aircraft State Data

The Notional Baseline Aircraft






(MH-53M + HH-60G + CSAR-X + CV-22)

4

=

INS/GPS

Turreted FLIR

Radar Altimeter

Digital World Model
(Digital Map)

Mission Computer / Flight Director

Automatic Flight Control System
(Waypoint Nav & Coupled Approach)

Cockpit Digital Displays (VSD/HSD)

External Sensors

Range, Resolution, Penetration

3D Capable

3D Active MMW
LADAR
Sparsely Populated Radar Array
IFSAR
Active Acoustic System
Image Stereo Pair Modeling

2D Capable

IR Video
Image Intensified (I^2 Video)
Fused IR/I^2 Video
2D Active MMW
Passive MMW (w/ external illuminator)
Passive MMW
SAR
Geo-rectified Digital Image

Preloaded Data

Digital Terrain
Vertical Obstruction Data
Digital Maps & Imagery (CIB)

Other Systems

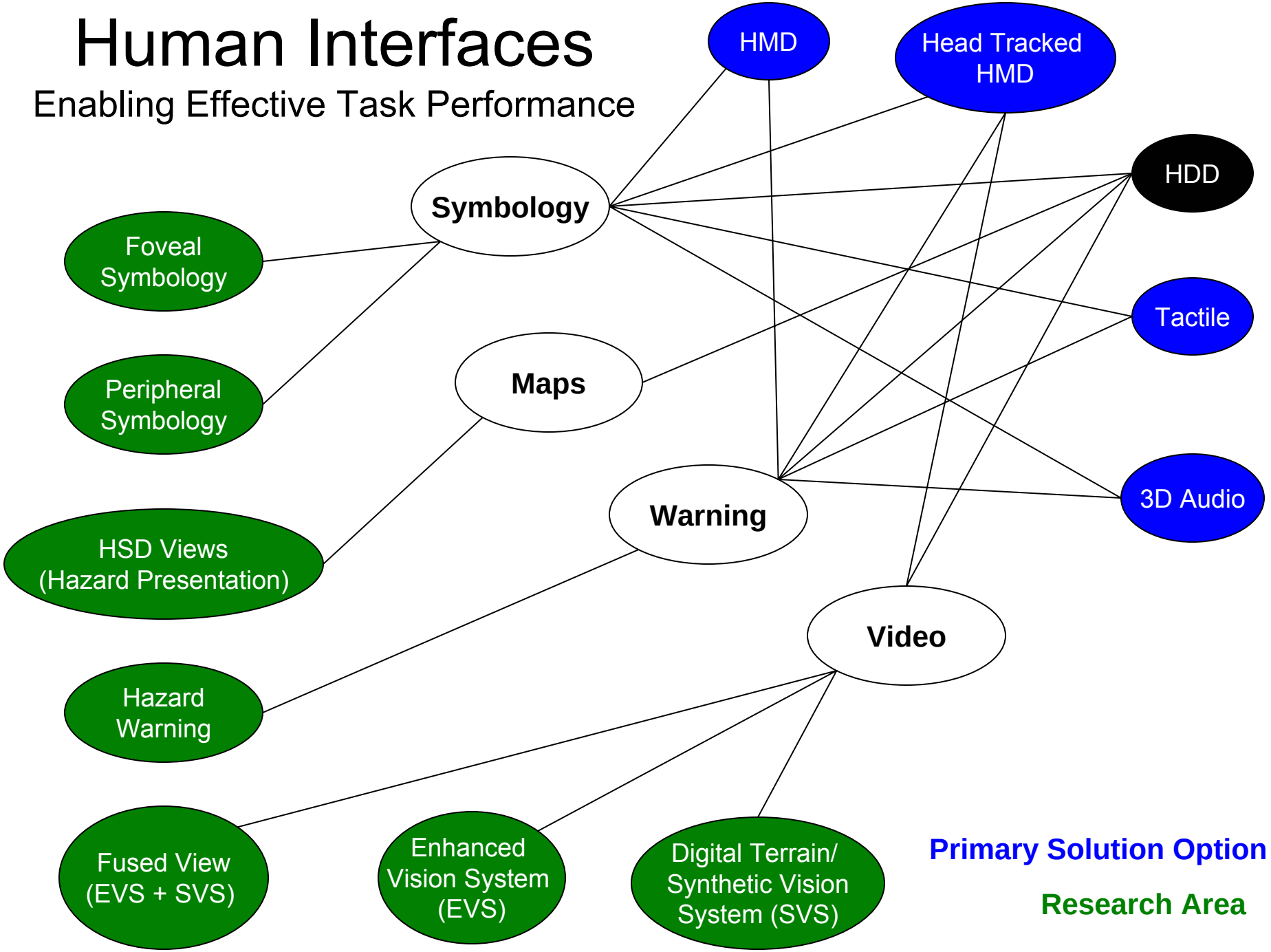
Station Keeping Equipment (range/bearing)
DataLink (aircraft range/bearing + sensor data)

Primary Solution Option

Technology Interest Area

Human Interfaces

Enabling Effective Task Performance



Aerodynamics & Flight Controls

Effective Aircraft Control

Manual Aircraft Control

Self Contained Approach Guidance
Improved Low Speed Stability (Handling Qualities)
Performance Based Flight Controls
Approach Guidance with Enhanced Obstacle Avoidance

Coupled Aircraft Control

Coupled Hover
Coupled Approach
Coupled Approach with Enhanced Obstacle Avoidance

Aerodynamics

Modeling & Simulation
Visible Null Areas (H-101 & H-53E)

Primary Solution Option

Research Area

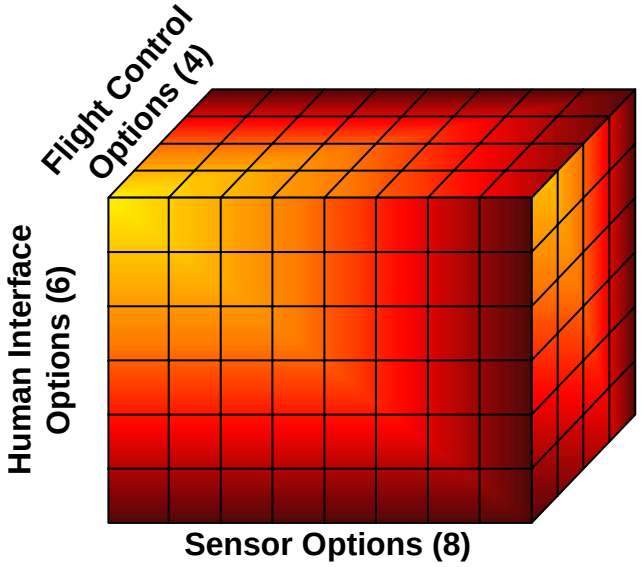
Flight Controls

No Addition

Improved Aircraft Handling Qualities

Coupled Approach with Enhanced Obstacle Avoidance

Coupled Approach with Enhanced Obstacle Avoidance + Improved Aircraft Handling Qualities



Solution Configuration Matrix of 192

Sensors

No Addition

Sparse Array

MMW

LADAR

Sparse Array + MMW

Sparse Array + LADAR

MMW + LADAR

Sparse Array + MMW + LADAR

Human Interface

No Addition

Helmet Mounted Display (Symbology)

Head Tracked HMD (Video & Symbology)

3D Audio & Tactile

HMD + 3D Audio/Tactile

Head Tracked HMD + 3D Audio/Tactile

Selecting Solution Configurations for Evaluation

Resource/Time Constrained (Can't Assess all 192)

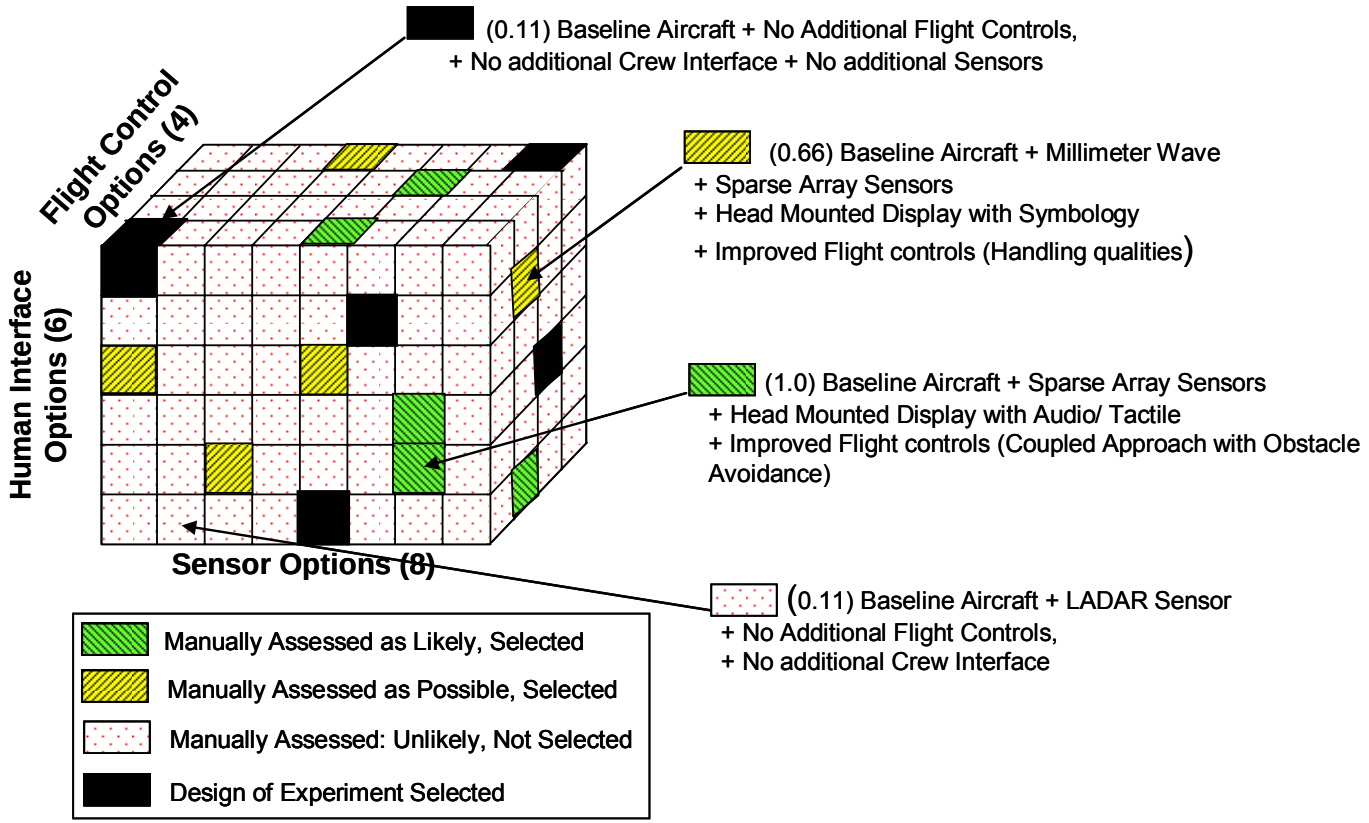
Assess Acquisition Likelihood
(Cost Balance, Synergy)

→

Select Minimum Matrix Sample
(Design of Experiments)

→

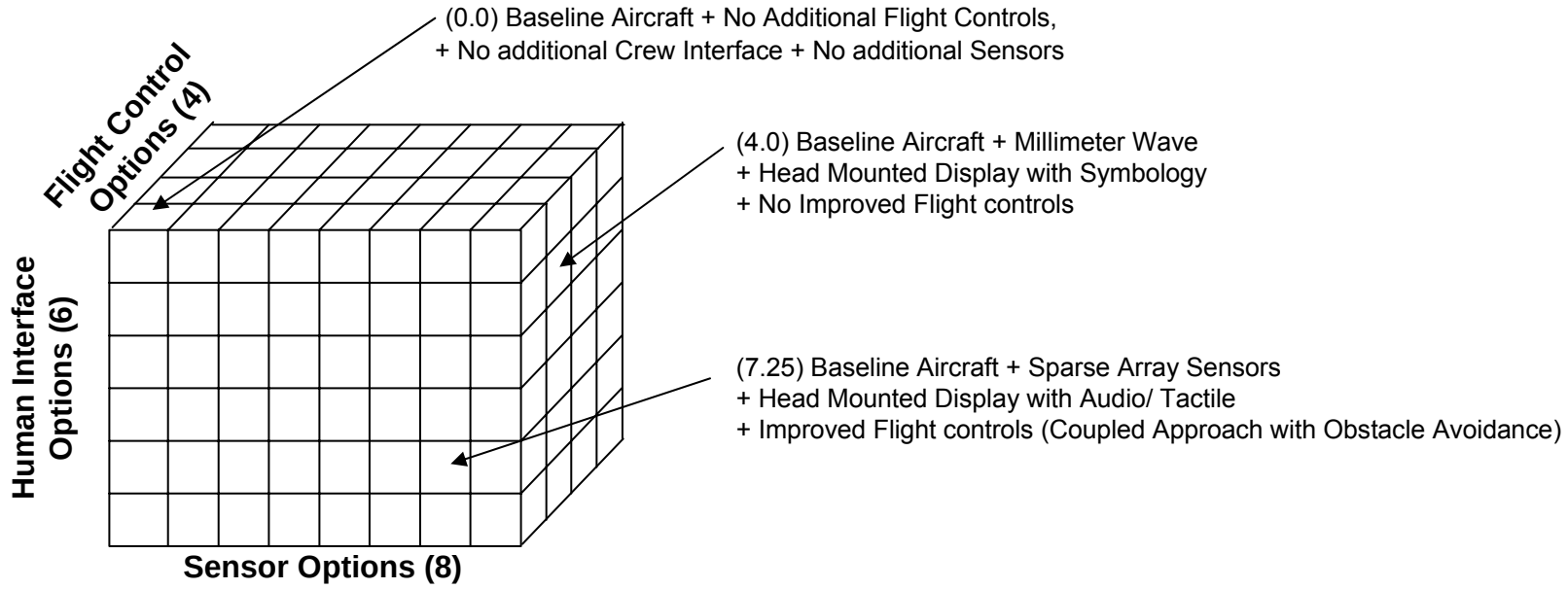
Select Additional Configurations Based on Likelihood



System Configuration Assessment

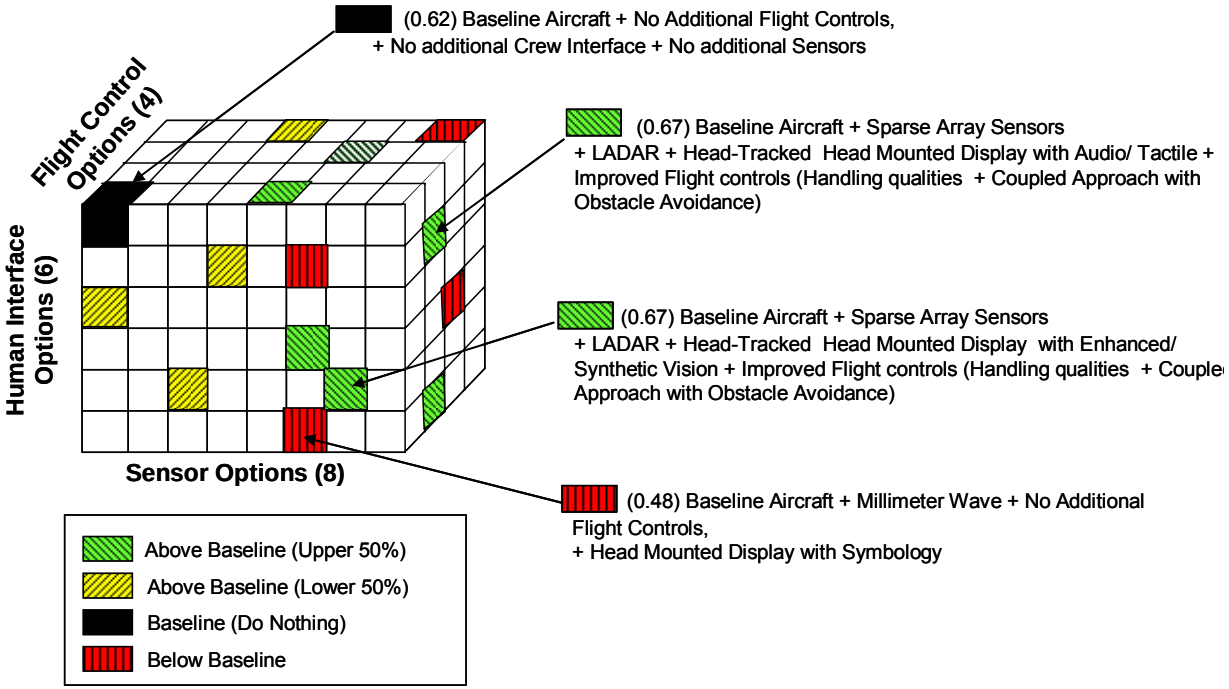
Generating Relative Solution Value





Evaluate Solutions

- **Sensors**
  - Millimeter Wave System
    - Low Task Performance
    - High Cost & Size/Weight
  - Sparse Array
    - Moderate Task Performance
    - Low Cost & Size/Weight
  - LADAR
    - High Task Performance
    - High Cost & Size/Weight

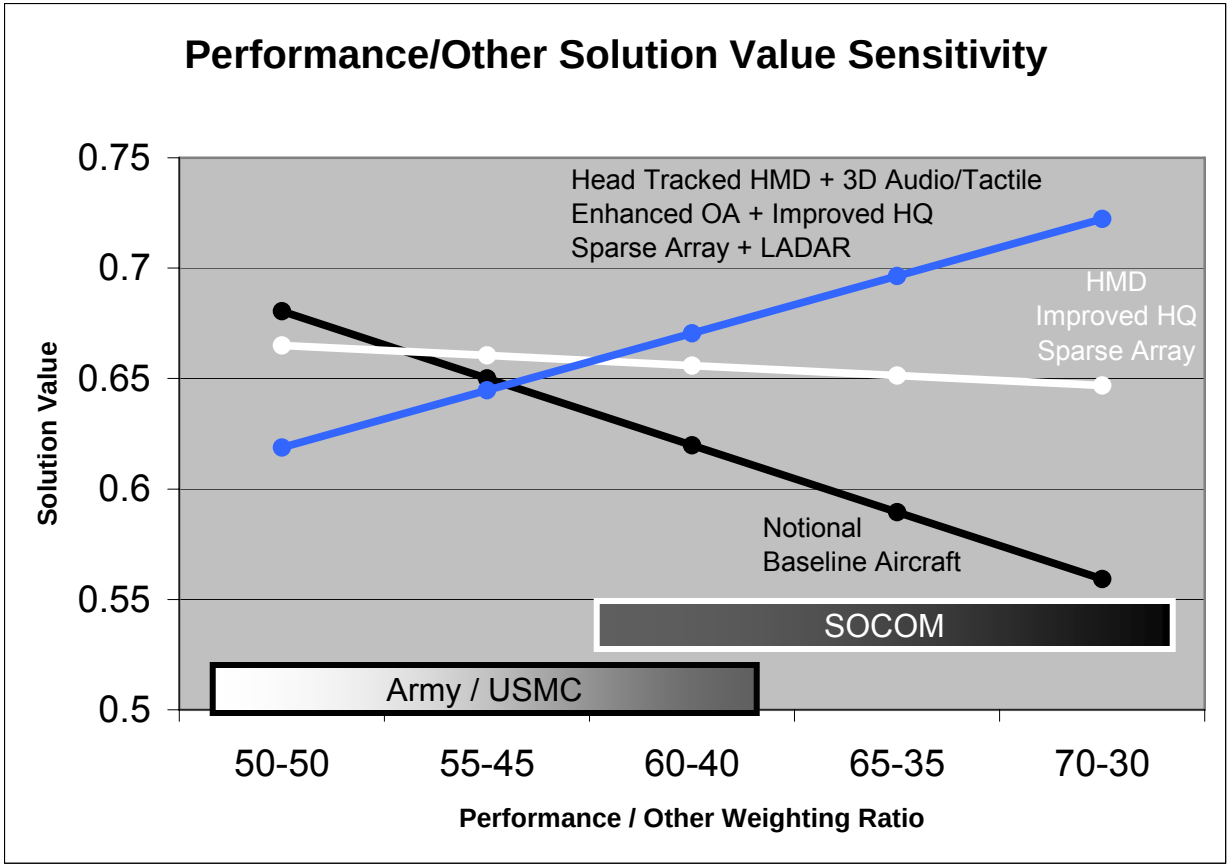


- **Human Interfaces**
  - Head Tracked HMD
    - Slim Benefit in High Cost Solutions
    - Slim Penalty in Low Cost Solutions
  - 3D Audio/Tactile
    - Penalty in Low Cost Solutions
    - Neutral in High Cost Solutions
    - High Cost for Stereo ICS

- **Flight Controls**
  - High Benefit
    - Improved Handling Quality -> Enhanced Ops
    - Both > Either

Sensitivity Analysis

Performance vs. Other Factors (Cost, Weight, Etc.)



Helicopter Brownout Conclusions

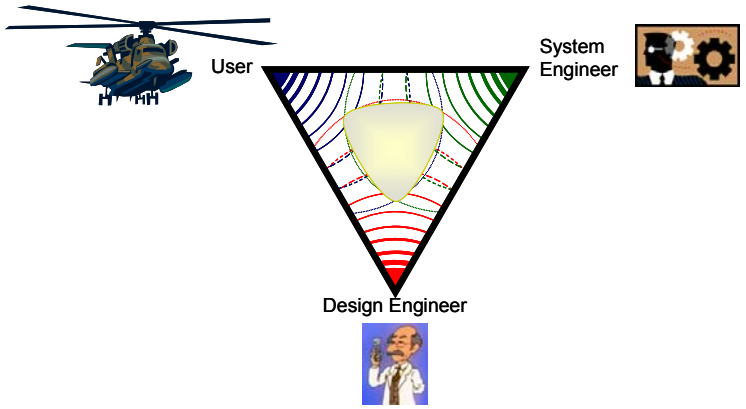
- High Performance System (SOF)
  - Sparse Radar Array + LADAR Sensors
    - Fusion Processing & Persistent 3D World Model
  - Head-tracked Helmet Mounted Display
    - Symbology
    - Enhanced and/or Synthetic Vision
- Lower Performance System (Conventional)
  - Sparse Radar Array
  - Helmet Mounted Display (Symbology)
- Flight Control Systems & Guidance
  - Handling Qualities
  - Flight Directed & Coupled Approach Capabilities
  - Assess and Develop per Aircraft MDS
    - Tiltrotor vs. Helicopter Issues
    - Digital FCS vs. Augmented Mechanical Controls

SE Wisdom

- **Clear measurable requirements are the most useful in situations when they are hardest to generate**

- **There is nothing more potentially complicated than a blank sheet of paper**
  - **It is impossible to effectively consider and choose from an infinite number of design options when developing a new system**
  - **Overcome analysis paralysis with active management and hard decisions to create a manageable number of potential solutions**

- **Use systems engineers with actual ops experience**
  - **Operate in the Region of Effective Communication (REC)**



Questions?







Air Force Institute of Technology

Integrity - Service - Excellence

Systems Engineering for Rapid Prototyping: Friendly Marking Device





NDIA 9th SE Conference
Oct 2006

Maj Monte Cannon
Maj Greg Buckner, Maj Greg Buttram
Maj Michael Jiru, Maj Arlene Collazo
Dr Brian Hermann, Dr John Colombi

“Can a prototyping development effort be responsive enough to react to critical needs while still benefiting from the rigor of systems engineering?”

U.S. AIR FORCE

Introduction

- Close Air Support (CAS) Background
- Prototyping Approach
- Friendly Marking Device (FMD) Results
- Conclusion/ Observations

U.S. AIR FORCE

The Problem



U.S. AIR FORCE

Background

- **IAW JP 3-09.3 (2 Sep 05):**
  - **Close air support (CAS) is air action by fixed- and rotary-wing aircraft against hostile targets that are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.**



- **Urban CAS considerations**
  - **Closer proximity to the enemy**
  - **Reduced communication time**
  - **Presence of noncombatants**
  - **Potential for collateral damage**
  - **Increased risk of fratricide**

U.S. AIR FORCE

Challenge/ Constraints

- **AF Research Lab Rapid Reaction (Core Process 3)**
  - **Compressed schedule - 5 months from emerging need to prototypes**
  - **No modifications to the CAS aircraft or pods**
  - **Technology maturity**
  - **Resource availability**
  - **Operational limitations**
  - **Cost**

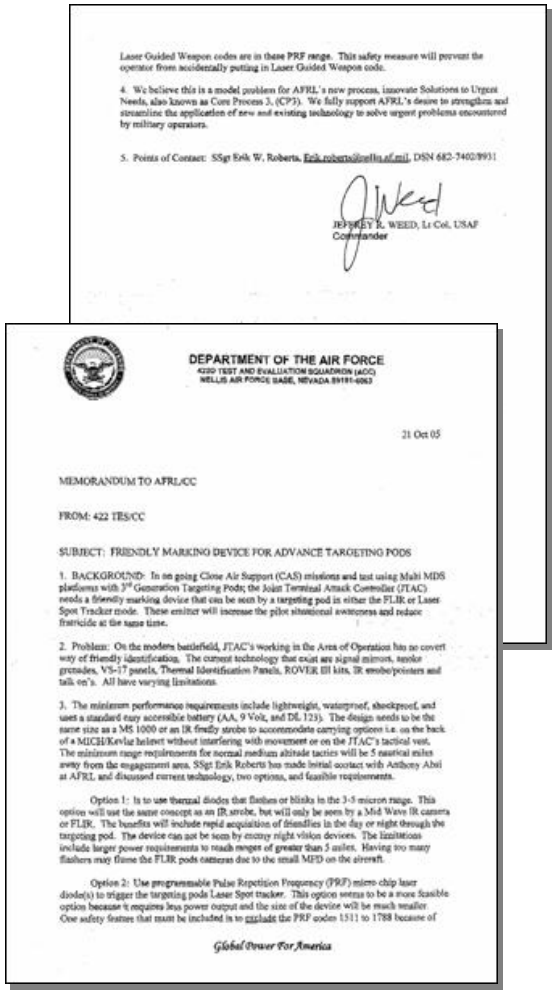
- **Project Objective: *Develop, demonstrate and transition a marking solution that enables a Joint Terminal Attack Controller (JTAC) to establish a common point-of-reference with a Close Air Support (CAS) asset such that the CAS asset can attack an intended target while avoiding fratricide.***

U.S. AIR FORCE

Background

"In on going Close Air Support (CAS) missions and test using MDS platforms with 3rd Generation Targeting Pods; the Joint Terminal Attack Controller (JTAC) working in the Area of Objective has no covert way of friendly identification."

"The JTAC needs a friendly marking device that can be seen by a targeting pod in either the FLIR or Laser Spot Tracker mode. These emitters will increase the pilot situational awareness and reduce fratricide at the same time."



Laser Guided Weapon codes are in these PRF range. This safety measure will prevent the operator from accidentally putting in Laser Guided Weapon code.

4. We believe this is a model problem for AFRL's new process, innovate Solutions to Urgent Needs, also known as Core Process 3, (CP3). We fully support AFRL's desire to strengthen and streamline the application of new and existing technology to solve urgent problems encountered by military operators.

5. Points of Contact: SSgt Erik W. Roberts, Erik.roberts@nellis.af.mil, DSN 682-7402/8931

JEFFREY R. WEED, Lt Col, USAF
Commander

DEPARTMENT OF THE AIR FORCE
422D TEST AND EVALUATION SQUADRON (ACC)
NELLIS AIR FORCE BASE, NEVADA 89191-6052

21 Oct 05

MEMORANDUM TO AFRL/CC

FROM: 422 TES/CC

SUBJECT: FRIENDLY MARKING DEVICE FOR ADVANCE TARGETING PODS

1. BACKGROUND: In on going Close Air Support (CAS) missions and test using Multi MDS platforms with 3rd Generation Targeting Pods; the Joint Terminal Attack Controller (JTAC) needs a friendly marking device that can be seen by a targeting pod in either the FLIR or Laser Spot Tracker mode. These emitter will increase the pilot situational awareness and reduce fratricide at the same time.

2. Problem: On the modern battlefield, JTAC's working in the Area of Operation has no covert way of friendly identification. The current technology that exist are signal mirrors, smoke grenades, VS-17 panels, Thermal Identification Panels, ROVER III kits, IR strobe/pointers and talk on's. All have varying limitations.

3. The minimum performance requirements include lightweight, waterproof, shockproof, and uses a standard easy accessible battery (AA, 9 Volt, and DL 123). The design needs to be the same size as a MS 1000 or an IR firefly strobe to accommodate carrying options i.e. on the back of a MICH/Kevlar helmet without interfering with movement or on the JTAC's tactical vest. The minimum range requirements for normal medium altitude tactics will be 5 nautical miles away from the engagement area. SSgt Erik Roberts has made initial contact with Anthony Abel at AFRL and discussed current technology, two options, and feasible requirements.

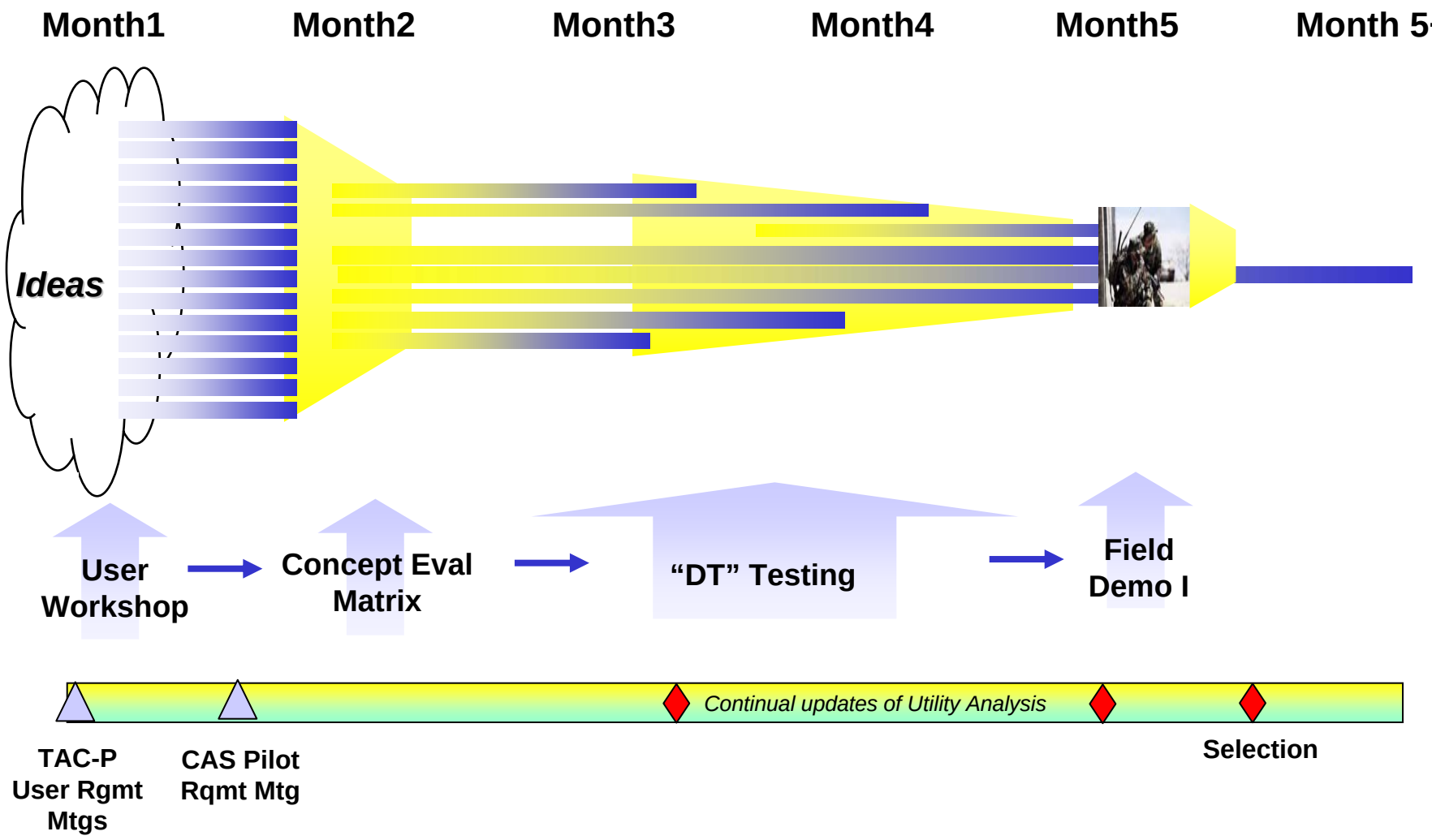
Option 1: Is to use thermal diodes that flashes or blinks in the 3-5 micron range. This option will use the same concept as an IR strobe, but will only be seen by a Mid Wave IR camera or FLIR. The benefits will include rapid acquisition of friendlies in the day or night through the targeting pod. The device can not be seen by enemy night vision devices. The limitations include larger power requirements to reach ranges of greater than 5 miles. Having too many flashers may flame the FLIR pods cameras due to the small MFD on the aircraft.

Option 2: Use programmable Pulse Repetition Frequency (PRF) micro chip laser diode(s) to trigger the targeting pods Laser Spot tracker. This option seems to be a more feasible option because it requires less power output and the size of the device will be much smaller. One safety feature that must be included is to exclude the PRF codes 1511 to 1788 because of

Global Power For America

U.S. AIR FORCE

Rapid Reaction Prototyping

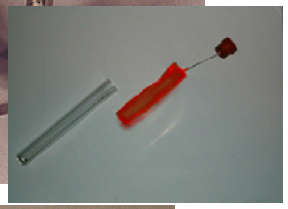


U.S. AIR FORCE

Ideas









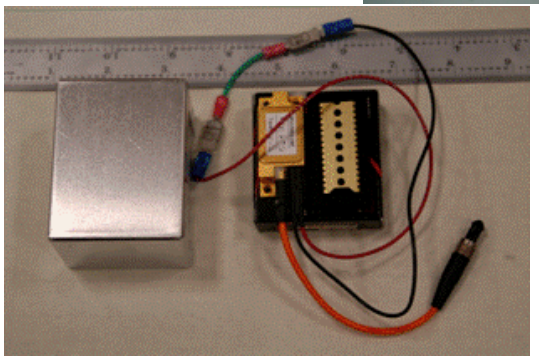


* Patent Pending











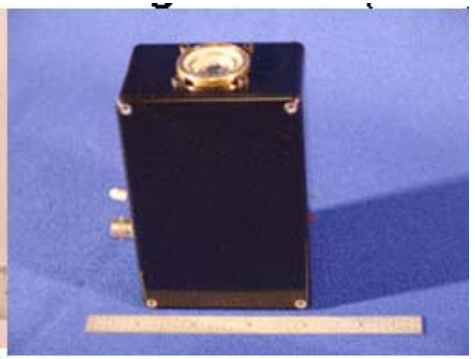








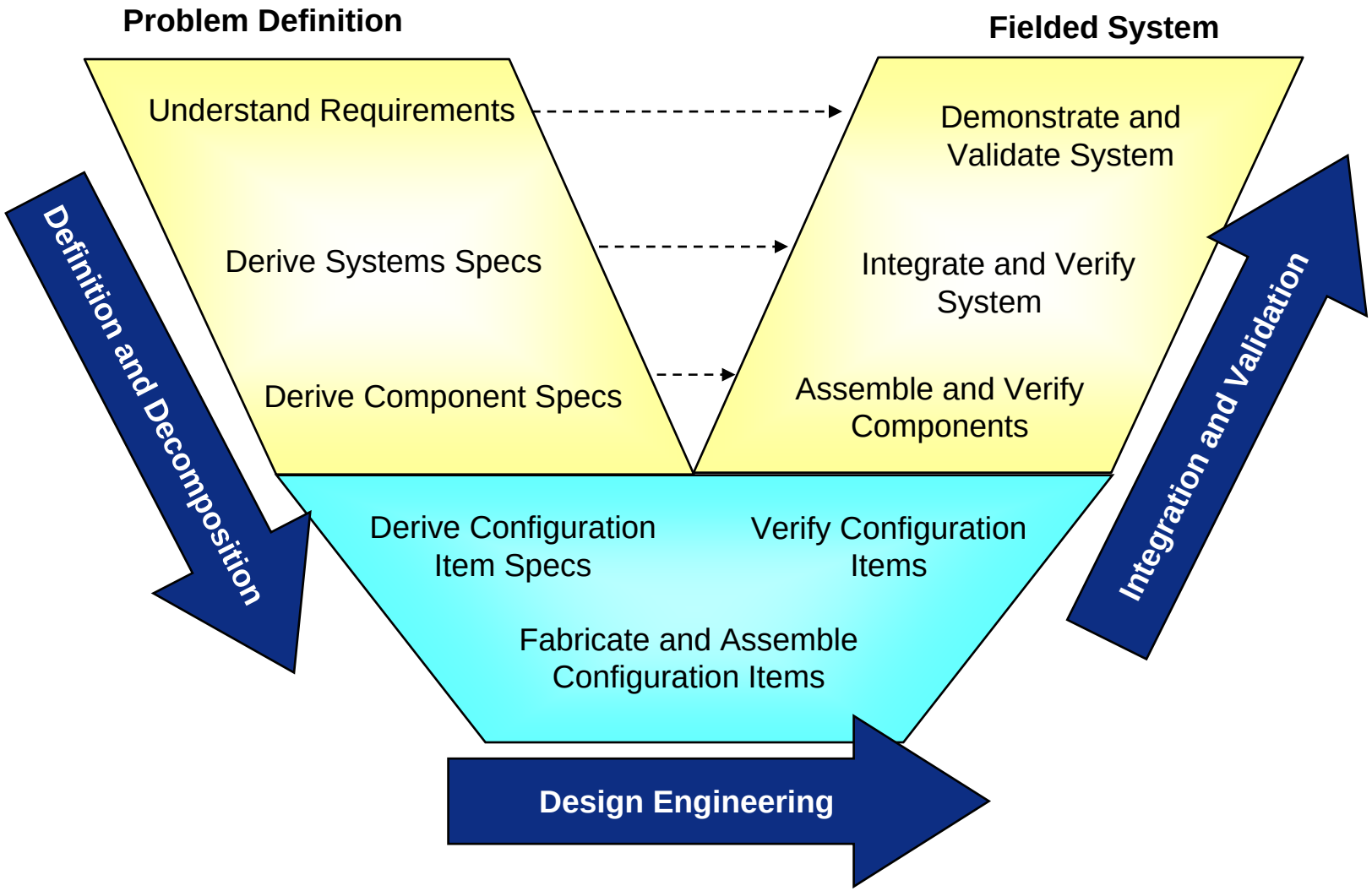




Integrity - Service - Excellence

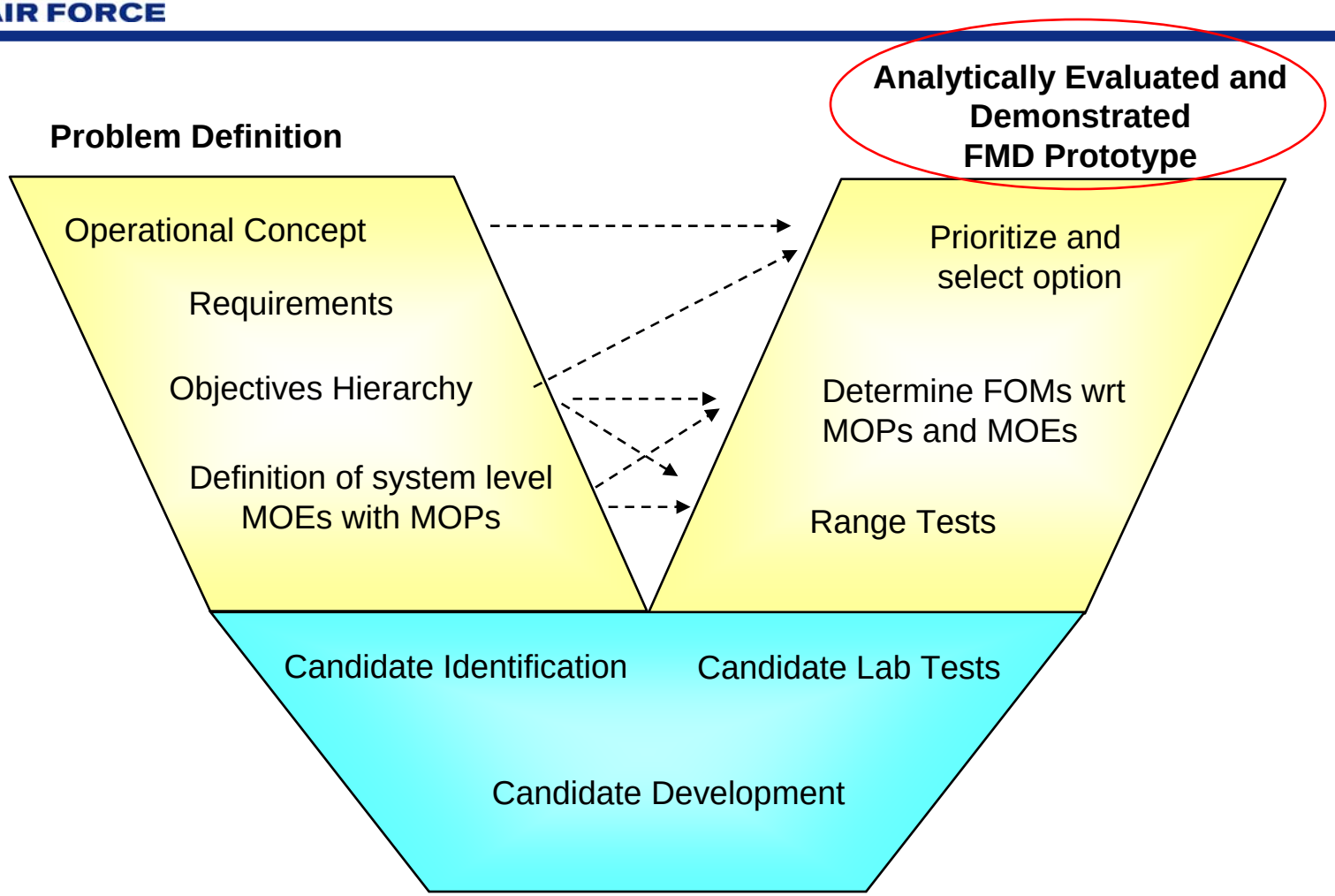
U.S. AIR FORCE

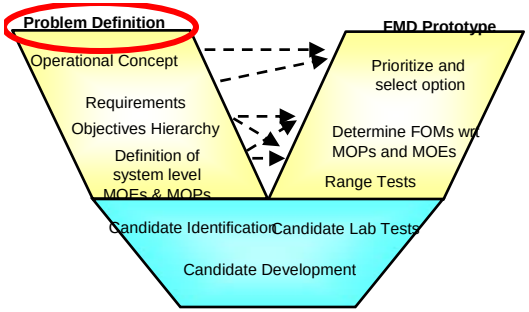
Classic V-Model



U.S. AIR FORCE

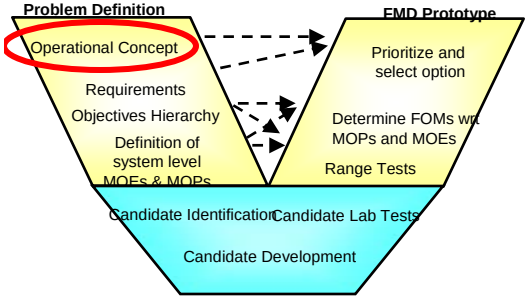
Prototyping





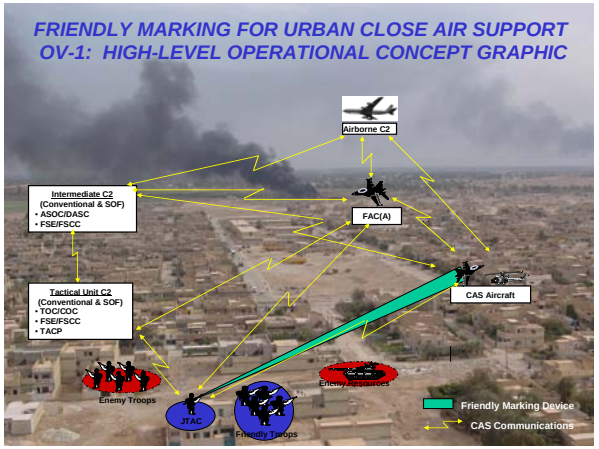
Problem Definition

- **Pubs on Close Air Support (JP 3-09.3, Sep 05):**
- **Stakeholder Interviews (JTACs and CAS pilots)**
  - **User Requirement Questions**
- **Analysis Criteria**
- **Constraints identification**
- **Restated problem as:**
  - ***The Joint Terminal Attack Controller (JTAC) lacks a covert means to quickly and accurately mark the location of friendly forces as a common point-of-reference with a Close Air Support (CAS) asset such that the JTAC can direct a CAS attack with minimum risk of fratricide.***



Develop an Operational Concept

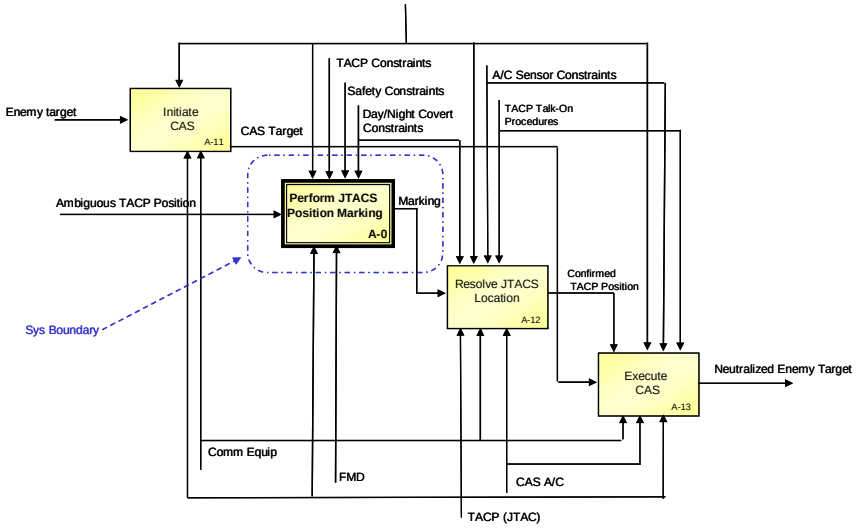
- **DoDAF OV-1, High-Level Operational Concept Graphic**
- **DoDAF OV-5 External Systems Diagram**
- **Use Cases (RUP template)**

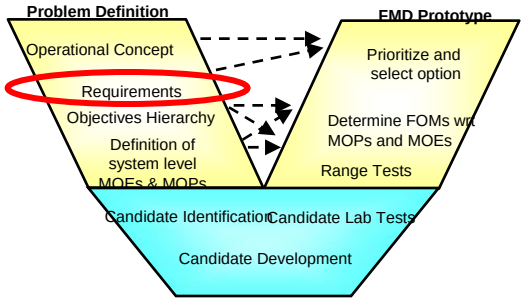


Success Guarantee	• CAS aircraft provides bombs on target. • There is no fratricide of friendly forces.

Urban Close Air Support Use Case

Use Case Name	Name: Urban Close Air Support
	Brief Description: This use case describes the process of briefing target location to the CAS aircraft when the target's coordinates are unknown, target is a moving target, the close proximity to friendly forces requires higher degree of accuracy, or when time/situation does not allow for a long CAS brief.
Actors Involved	Joint Tactical Air Controller (JTAC) – "A qualified (certified) Service member who, from a forward position, directs the action of combat aircraft engaged in close air support and other offensive air operations" (JP 3-09.3). • Goal – To accurately identify CAS target and friendly position to the CAS Aircraft. • To prevent fratricide. Close Air Support (CAS) aircraft – Aircraft tasked to support close air support operations. • Goal – To accurately and quickly acquire CAS target and friendly position. • To prevent fratricide. Air Support Operations Center (ASOC) – "The principal air control agency of the theater air control system responsible for the direction and control of air operations directly supporting the ground combat element. It processes and coordinates requests for immediate air support and coordinates air missions requiring integration with other supporting arms and ground forces" (JP 3-09.3).
Preconditions	• JTAC has constant communication with ASOC. • Target coordinates are not known, target is a moving target, the close proximity to friendly forces requires higher degree of accuracy, or when time/situation does not allow for a long CAS brief. • JTAC contacts the ASOC to request CAS • ASOC contacts CAS aircraft and passes them CAS information (coordinates, frequencies, JTAC info, etc.) • CAS Aircraft contacts JTAC



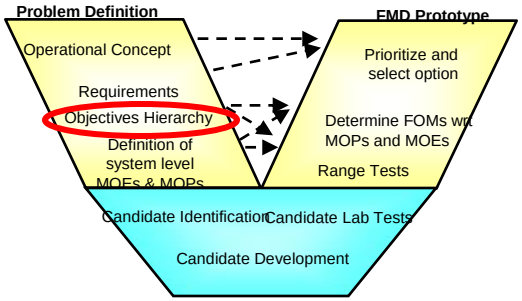


Requirements Analysis

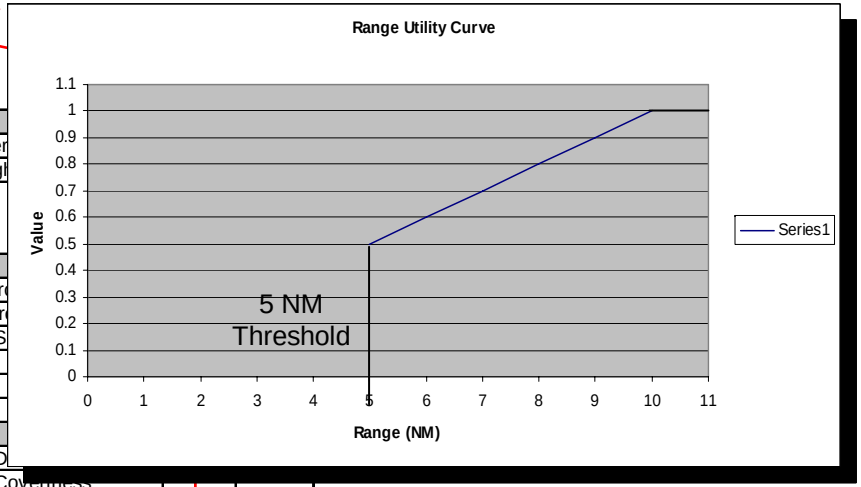
- Use Case refinement
- User Requirements with weights
  - JTACs
  - CAS Pilots
- FURPS+ model
  - Functional
  - Usability
  - Reliability
  - Performance
  - Supportability
  - "plus" other requirements such as Implementation, Interface, Operations, Packaging, Legal, etc.

User requirements with weights	
Types of Requirements	**Requirements**
Environmental	Weather Limitations
	Day/Night Limitations
Physical	Waterproof
	Shockproof
	Power Source
	Weight
	Size Dimensions
Operational (signal)	Signal Duration
	Signal Covertness
	Signal Field of View
	Signal Range
	Accuracy Resolution
	Signal Spectrum
	System Compromise
	Unique Signal
	Signal Transmission Delays
Operational (system)	Ease of use / training required
	Modification required
	Unique Signal display
Acquisition (Long term)	Long-term unit cost
	Product Feasibility
Acquisition (Short term)	Estimated cost
	Prototype availability
	System Maturity/ estimated TRL
	Factors influencing prototype development

Objectives Hierarchy



User defined



Weights

0.1	Environmental	
		0.9
		0.8
	Score	0
0.2	Physical	
		0.9
		0.8
	Score	0
0.3	Ops - Signal	
		0.9
		0.8
	Score	0
	Mark Position	
		0.9
		0.8

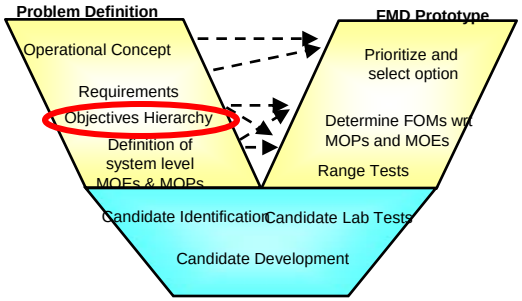
Element Value	
0	Weather
0	Day/Night
0	Waterproof
0	Shockproof
0	Power S
0	Weight
0	Size
0	Signal D
0	Signal Covertness
0	Signal FOV
0	Signal Range
0	Accuracy/Resolution
	Signal Spectrum
	Signal Compromise
	Unique Signal
	Signal Trans Delays

	Weight	Score
Ease of Use		
Modification Rqd		
Unique Signal Display		

	Weight	Score
Long Term Unit Cost		
Production Feasiblity		

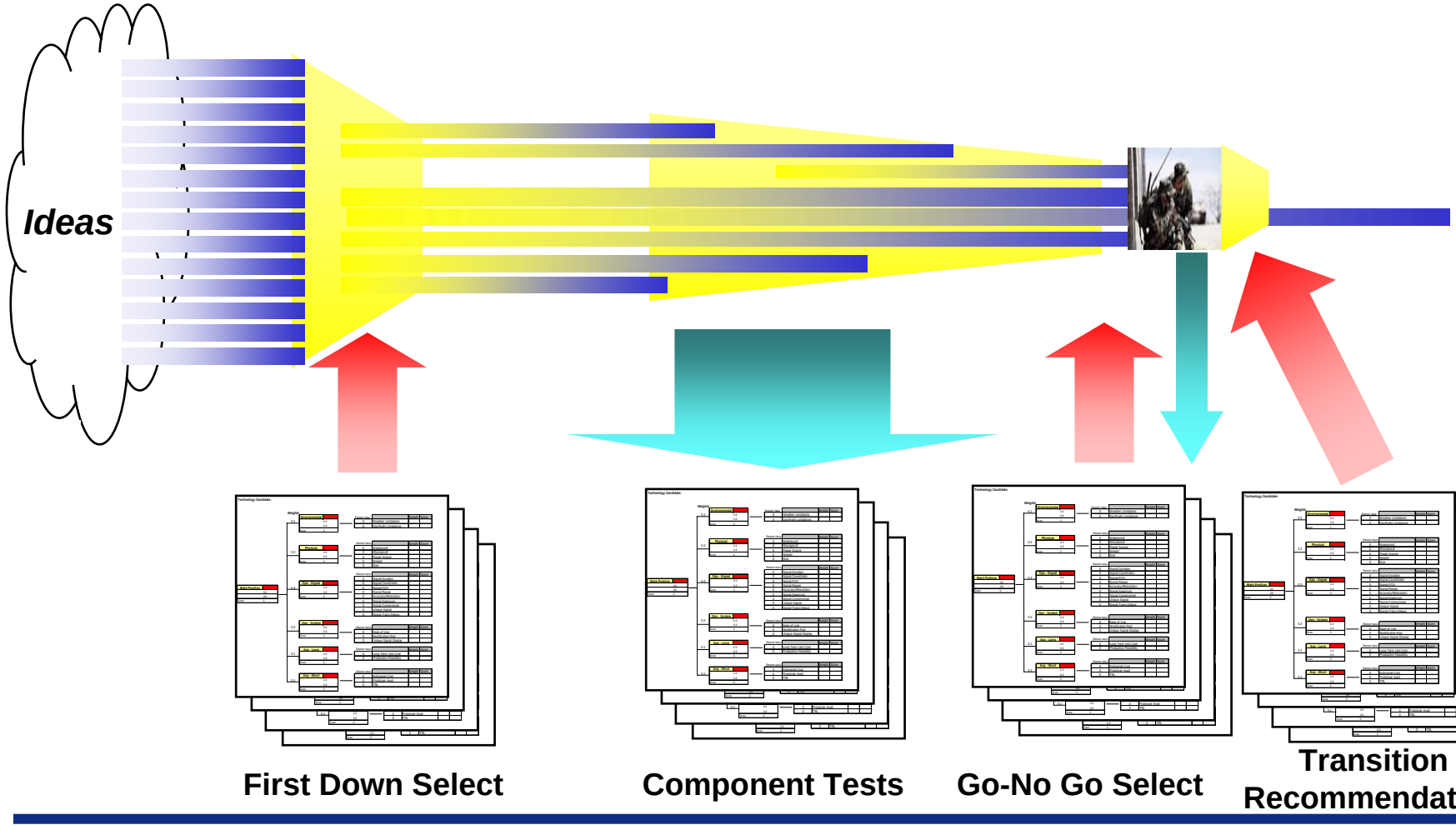
	Weight	Score
Estimated Cost		
Prototype Avail		
TRL		

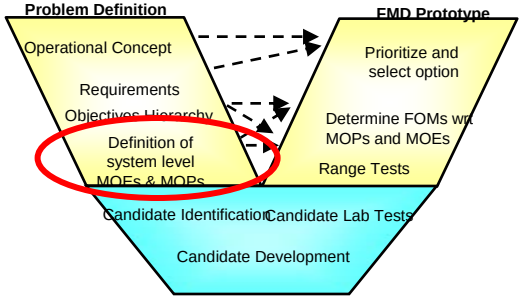
- **Risk-Neutral Utility curves**
- **Based upon user requirements & expressed desires**
- **Each candidate is scored**
- **Updated as candidates matured (ie: test data)**
- **Long/short term acquisition elements based upon engineering judgement**



Objectives Hierarchy: "Living Tool"

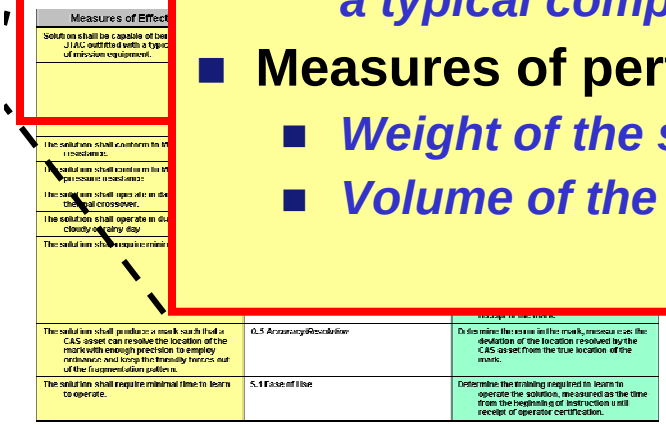
Month1 **Month2** **Month3** **Month4** **Month5** **Month 5+**

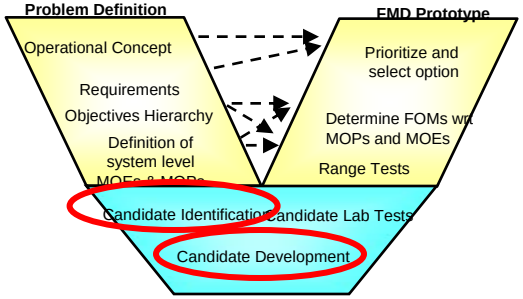




Definition of system level MOEs and MOPs

- **Originating Requirements**
  - *Weight : 4 – 6 oz without batteries*
  - *Volume : 25.1 in³ , "Less than a Coke can "*
- **Critical operational issues (COI)**
  - *The JTAC carries a variety of mission equipment to execute a mission. The JTAC has limited excess space and weight capacity for carrying new mission equipment.*
- **Measures of effectiveness (MOE)**
  - *Solution shall be capable of being carried by a JTAC outfitted with a typical complement of mission equipment.*
- **Measures of performance (MOP)**
  - *Weight of the solution including packaging and expendables.*
  - *Volume of the solution including packaging and expendables.*

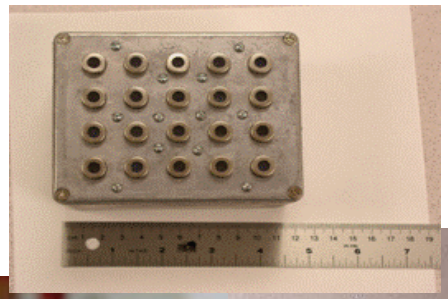




Identify/ Develop Technology Candidates

- **AF Research Lab (AFRL) already had many concept ideas**
- **Team utilized several "*brain storming*" sessions to refine possible technologies**

1064 Laser	1064 Laser	1064 Laser	1064 Laser	1064 Laser
3-5 micron LED	3-5 micron LED	3-5 micron LED	3-5 micron LED	3-5 micron LED
3-5 micron LED Beacon	3-5 micron LED Beacon	3-5 micron LED Beacon	3-5 micron LED Beacon	3-5 micron LED Beacon
873 Laser	873 Laser	873 Laser	873 Laser	
Box Thermal Emitter Array		Box Thermal Emitter Array	Box Thermal Emitter Array	Box Thermal Emitter Array
Halogen Bulb Flashlight	Halogen Bulb Flashlight	Halogen Bulb Flashlight	Halogen Bulb Flashlight	Halogen Bulb Flashlight
Israeli COTS Emitter				Israeli COTS Emitter
Krypton Bulb Flashlight	Krypton Bulb Flashlight	Krypton Bulb Flashlight	Krypton Bulb Flashlight	Krypton Bulb Flashlight
Laser Beeper	Laser Beeper			
Laser Marker	Laser Marker			
Laser Warning Receiver		Laser Warning Receiver	Laser Warning Receiver	Laser Warning Receiver
Rescue Laser Flare				Rescue Laser Flare
RF Tag	RF Tag			
Special Material Locator	Special Material Locator	Special Material Locator	Special Material Locator	Special Material Locator
TRON 1	TRON 1			
Thermal Beacon	Thermal Beacon			
Thermal Signaling Device I	Thermal Signaling Device I	Thermal Signaling Device I	Thermal Signaling Device I	
TRON 2 (TBD)	TRON 2 (TBD)			
TRON 3 (Blanket)	TRON 3 (Blanket)			
TSD II (Helio Triad)				TSD II (Helio Triad)
TSD III (Cal Triad)				TSD III (Cal Triad)
TSD IV (Single Space Heater)				TSD IV (Single Space Heater)
TSD V (Space Heater Triad)				TSD V (Space Heater Triad)



Thermal Emitter Box Array



Thermal Emitters



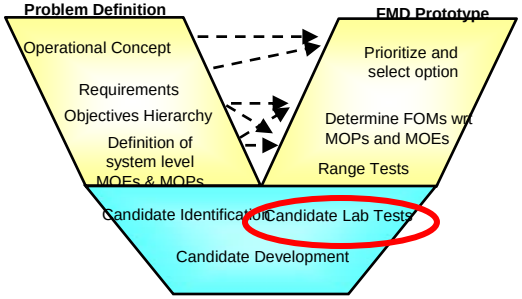
Special Materials



LEDs

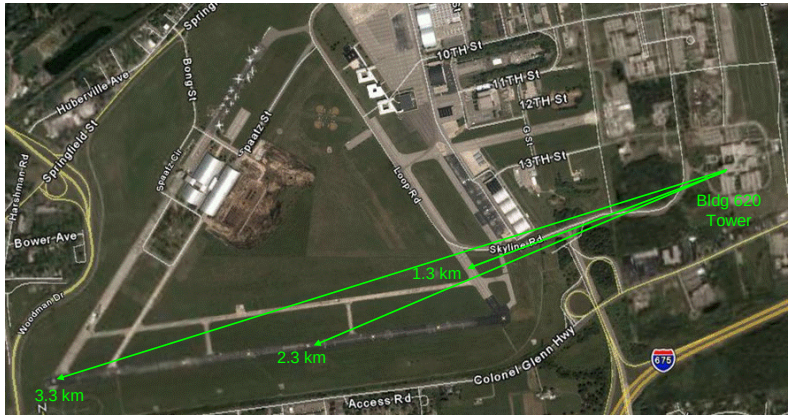


Laser

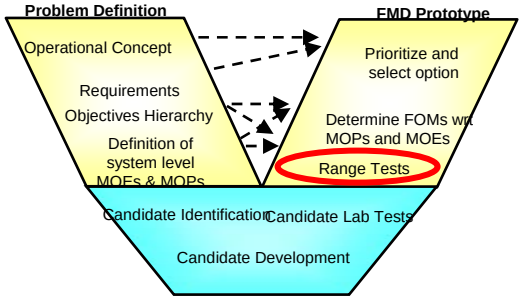


Candidate Lab Tests

- **Component level testing conducted during prototype development**
  - Integration of all the pieces
  - Evaluate Signal Quality / Duration
  - Determine a Signal Detection Range
  - Identify Risk Areas / Limitations

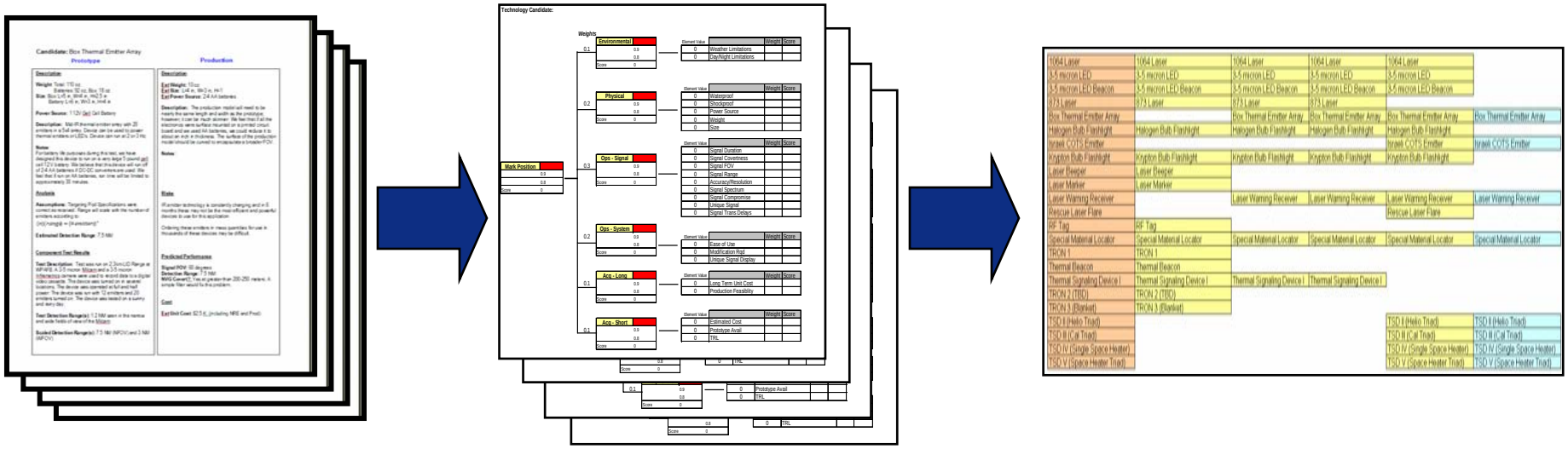


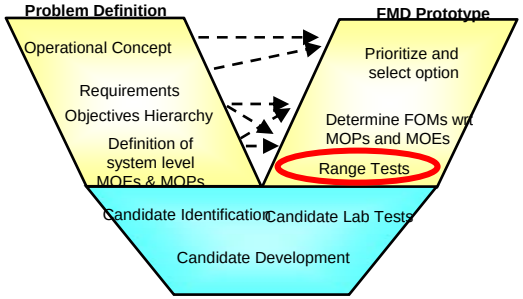




Range Test Go/No-Go Selection

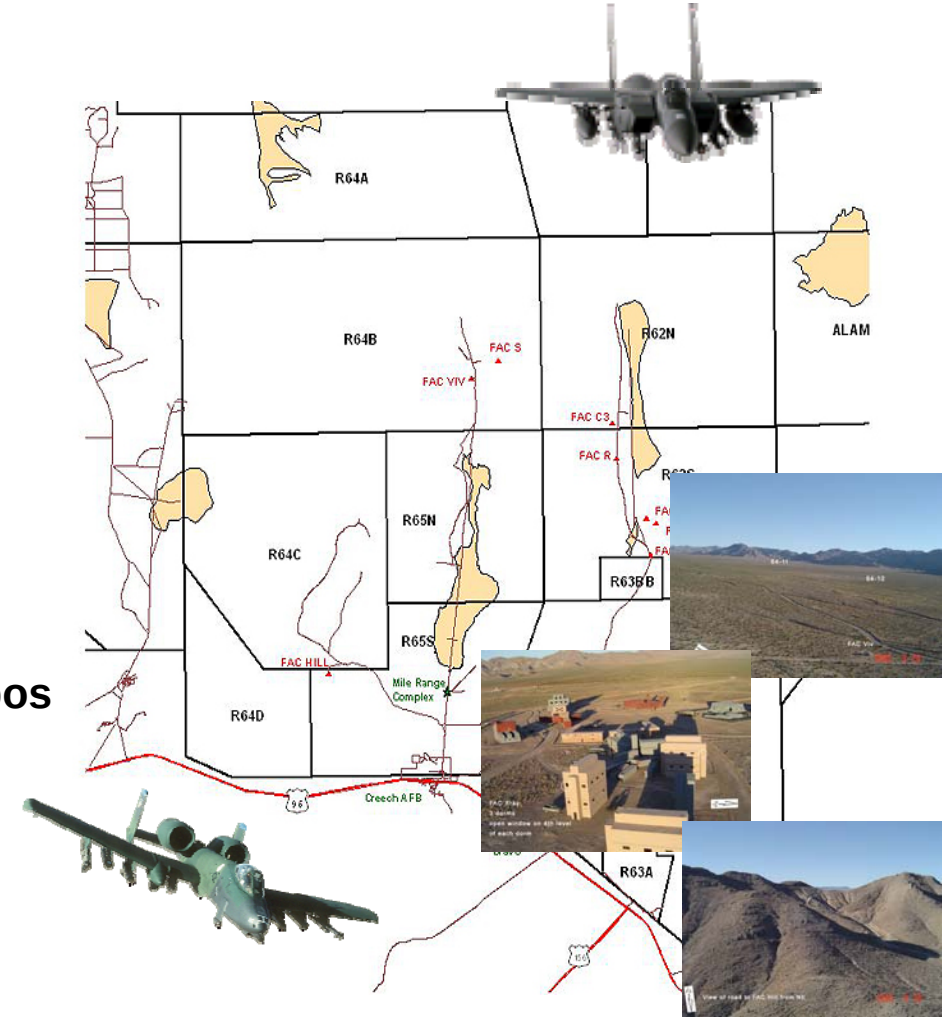
- **Prototype Testing & Production Estimates**
  - **Confirming pre test mathematical analysis**
  - **Component test results – *Detection Range***
- **Objective Hierarchy updates**
- **Final Go / No-Go Selection**



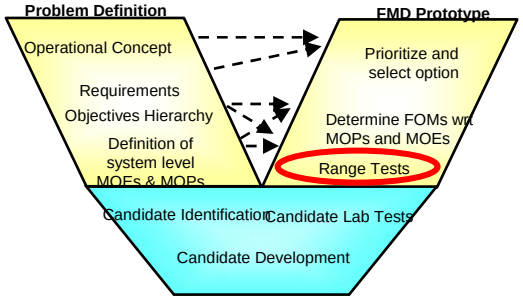


Range Test Plan

- **Development of Prototype Test Plan**
  - **Prioritized Test Point Matrix**
  - **Highest weighted areas in Objective H**
- **Objectives**
  - **Determine Detection Range**
  - **Operator Usability Assessment**
- **Flight Profiles**
  - **Profile 1 - Open, flat terrain**
  - **Profile 2 - Urban complex**
  - **Profile 3- Elevated terrain, stand- off pos**
- **Evaluation**
  - **Sniper & LITENING pods**
  - **F-15E, F-16, A-10 aircraft mix**

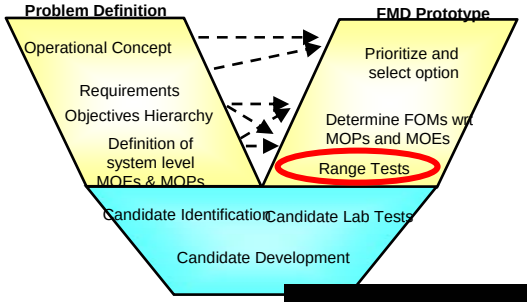


Nevada Test & Training Range



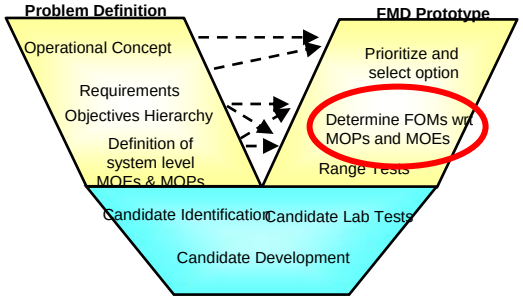
Example Test Setup





Range Test (A-10 at 11nm)



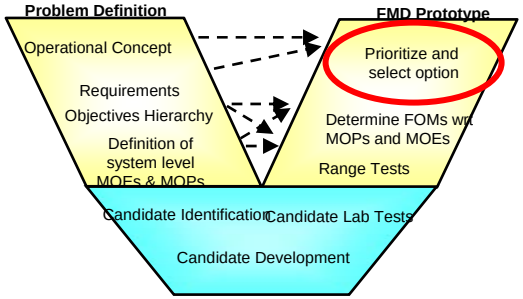


Summary Test Results

- TEB & TSD V longest detection range
- Aircrew assessment
  - Pod Narrow Field of View - best
  - Modulated signal easier to pick out
  - Current configurations good for convoy support now
- JTAC assessment
  - Detection ranges exceed expectation
  - Instant turn on and off
  - Hands free operation preferable
  - NVG Covert still nice to have
  - Multiple modulation rates



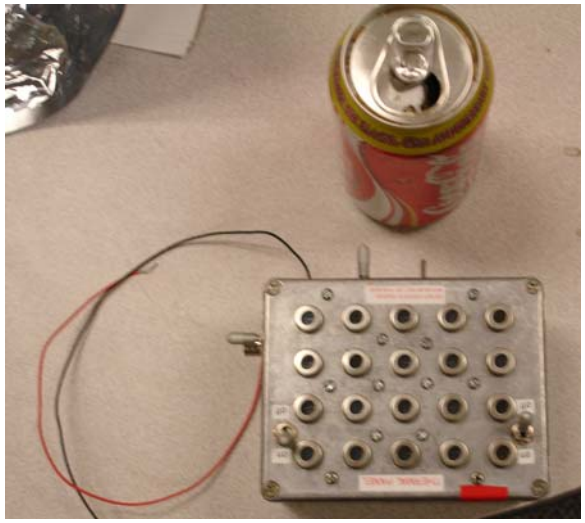
Device	F-15E Sniper	Predator	A-10 - LITENING
TEB (20)	12 nm	9.5 nm	18 nm
TEB (12)	6 nm	10 nm	not tested
TSD II	4 nm	11 nm	11 nm
TSD III	3 nm	12 nm	11 nm
TSD IV	11 nm	11.5 nm	10 nm
TSD V	not tested	10 nm	18 nm
LED	no detection	no detection	not tested
Israeli	not tested	no detection	not tested
LWR	not tested	not tested	dead battery



Prioritize and Select Options

Thermal Emitter Box

- **Detection distance greater than 10 nm**
- **Potential to miniaturize for helmet mounting (hands-free)**



Thermal Emitter Box Array

Thermal Emitter Beacon (Box array)	0.86
Special Material Locator Marker	0.82
Thermal Signalling Device II	0.65
Thermal Signalling Device III	0.65
Thermal Signalling Device IV	0.60
Thermal Signalling Device V	0.60
LED (3-5 mic)	0.47



Special Material Locator Marker

U.S. AIR FORCE

Conclusion

- Application of systems engineering rigor compatible under “rapid response”
- Technology available to identify friendly forces during urban CAS
- Several SE Observations
  - SE can be tailored to rapid prototyping while maintaining rigor
  - Understanding key constraints and the larger context provided a decision-making framework for the project
  - Proven techniques from software engineering were applicable in a rapid hardware prototyping effort
  - Selection of SE tools facilitated the decision-making process
  - The systems engineering team helped link users and technology providers together to produce an effective collaboration
  - Parallel COTS Integration reduced overall risk of the project
  - Priority given to the project varied across participants
  - Rapid prototyping requires a creative transition plan

? QUESTIONS ?



Dr John Colombi
john.colombi@afit.edu
AF Center for Systems Engineering
937-255-3355 x3347

GOVERNMENT ELECTRONICS AND INFORMATION TECHNOLOGY ASSOCIATION
A Sector of the Electronic Industries Alliance

Introduction to GEIA-STD-0007 Logistics Product Data

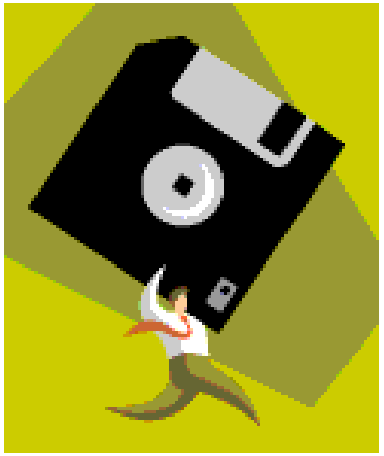
James Colson
U. S. Army
Logistics Support Activity (LOGSA)

U.S. Army Materiel Command
Logistics Support Activity
Sparkman Center, Bldg 5307
Redstone Arsenal, AL 35898-7466
www.logsa.army.mil

Oct 2006

Outline

- Introduction – Why GEIA-STD-0007?
- Content
- Supportability Analysis Relationships
- Supportability Products/ Contracting
- Relationship to AP239
- Summary/Schedule



Acquisition Reform

- **OSD Mandate For Change**
  - **Dr. Perry's Guidance June 1994**



- **DOD Will Rely on Commercial Products and Processes**
- **MIL-STD-1388 STDs Cancelled – 1996**



- **Ten Years Since MIL-STD-1388-2B was Eliminated**
  - **What are program offices using?**



LSAR Utilization Survey

Survey Results Of Army Major Weapon Systems

	Number Of Responses	Number With Logistics Data Delivery Rqmts	Number Using LMI Spec	Number Using LSAR Standard	Number Using LSAR System For Data Delivery
ACAT I	23	19	13	5	19
ACAT II	14	10	4	4	6
TOTAL	37	29	17	9	25

Note: 25 of 29 (86%) Contractors Provided data in 1388/LSAR format!

Where are we Going?

- **Fact: Re-establishing MIL-STD-1388, Will NOT happen!**



- **Direction → Industry Standards**
- **Utilizing the Defense Acquisition Life Cycle Framework**
  - **Effectively Replacing MIL-STD-1388-1A LSA Processes**



- **Working within the Framework of the Government Electronics and Information Technology Association (GEIA)**
  - **GEIA-STD-0007, Logistics Product Data**
  - **GEIA-HB-0007, Handbook and Guide for Logistics Product Data**
  - **Effectively Replacing MIL-STD-1388-2B, LSAR Data Exchange**





The "BIG Picture"

DoD Framework

Supportability Analysis

AP239 Activities

GEIA-STD-0007

Logistics Product Data



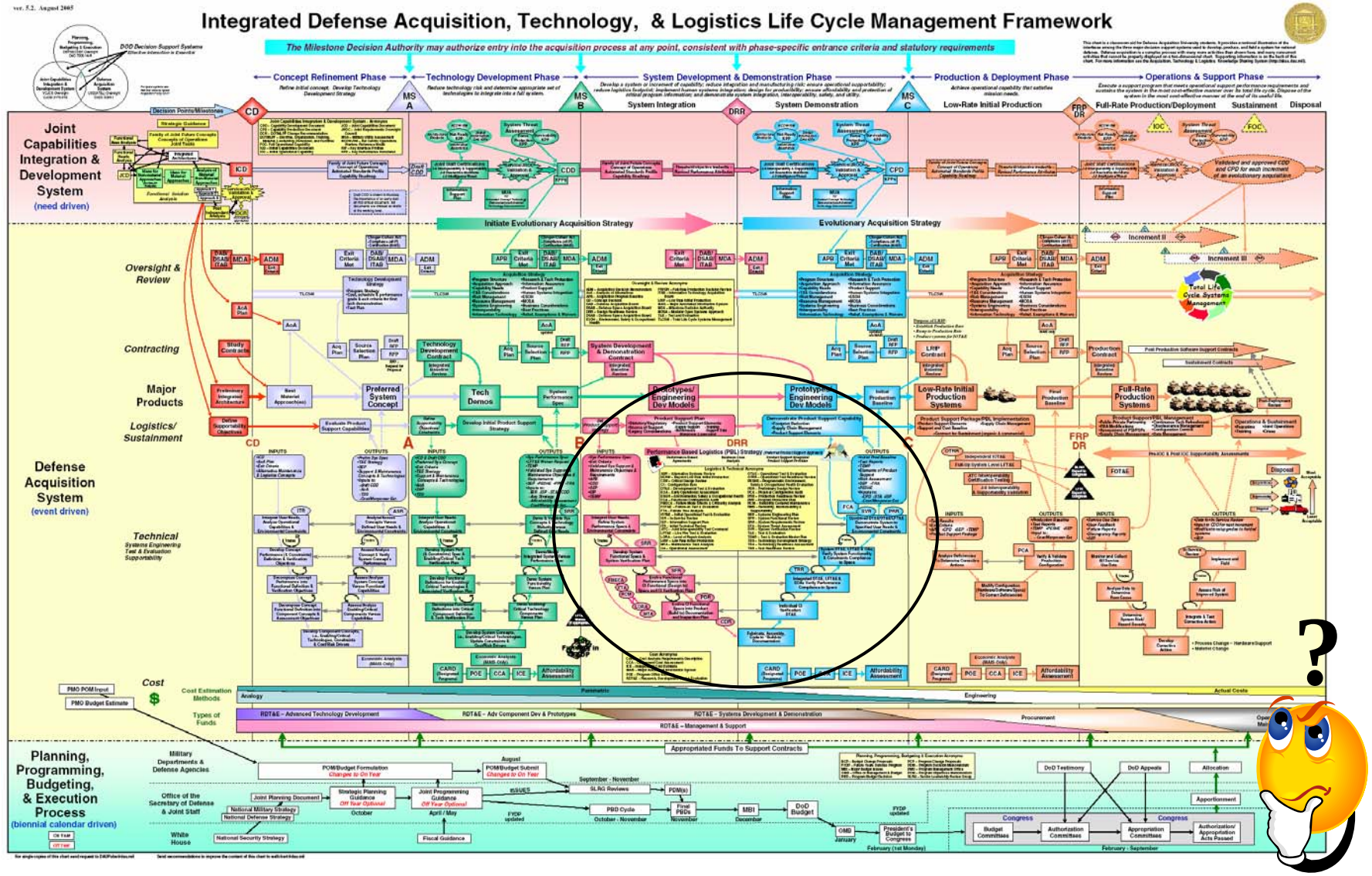




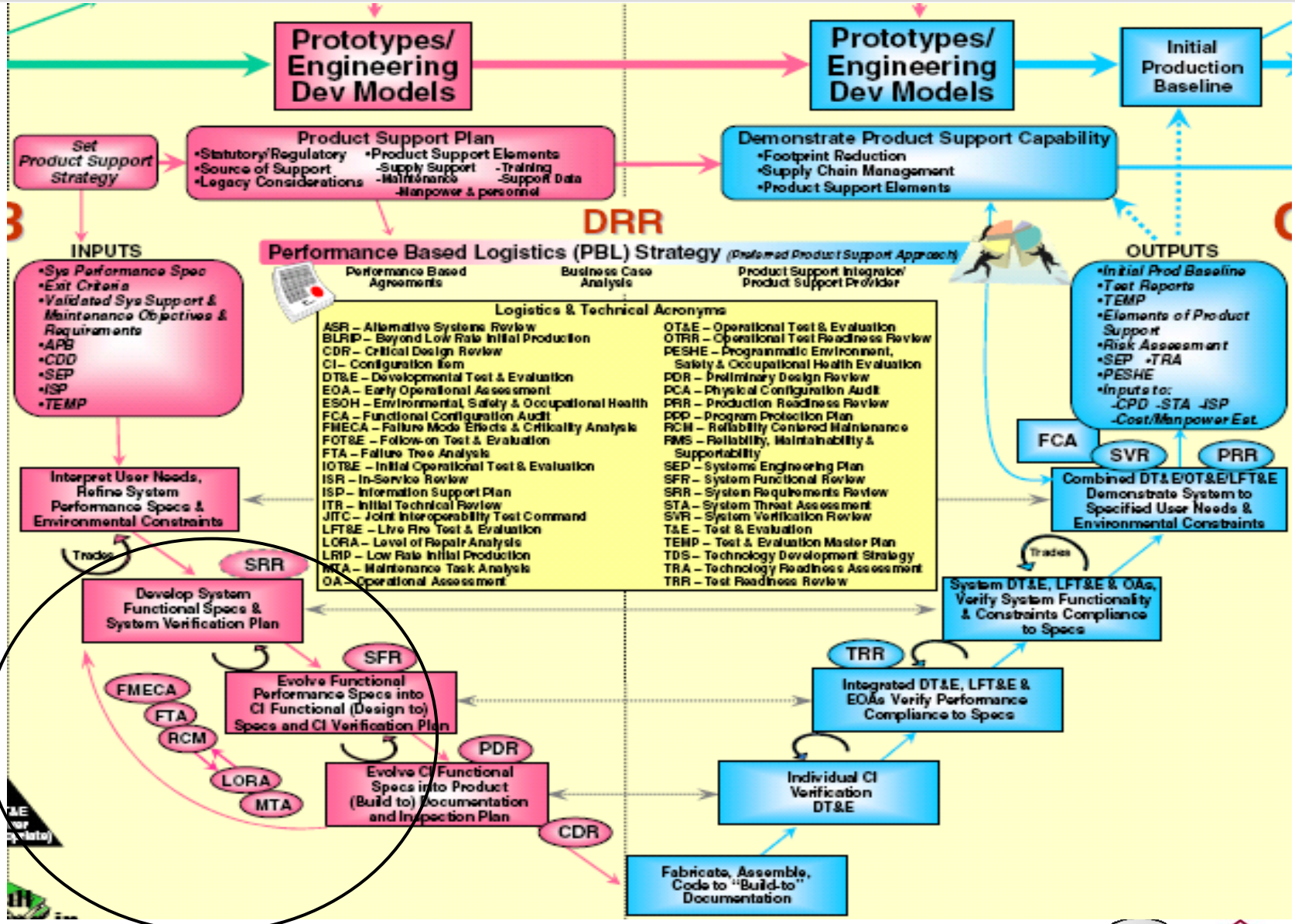
System Support

IETM
Training
Provisioning
Parts Lists
Etc…

DOD Life Cycle Management Framework



DOD Life Cycle Management Framework

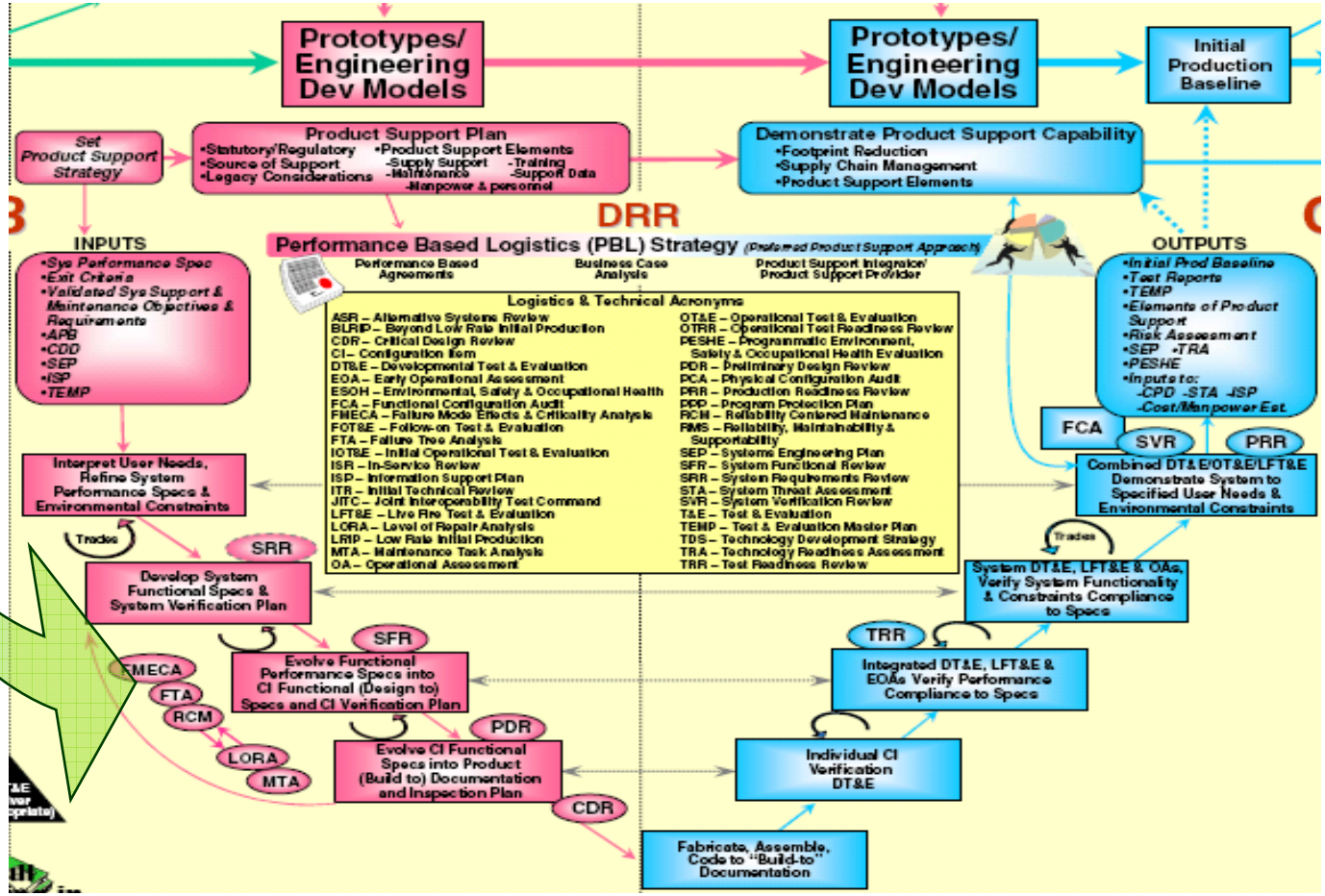


GEIA-STD-0007

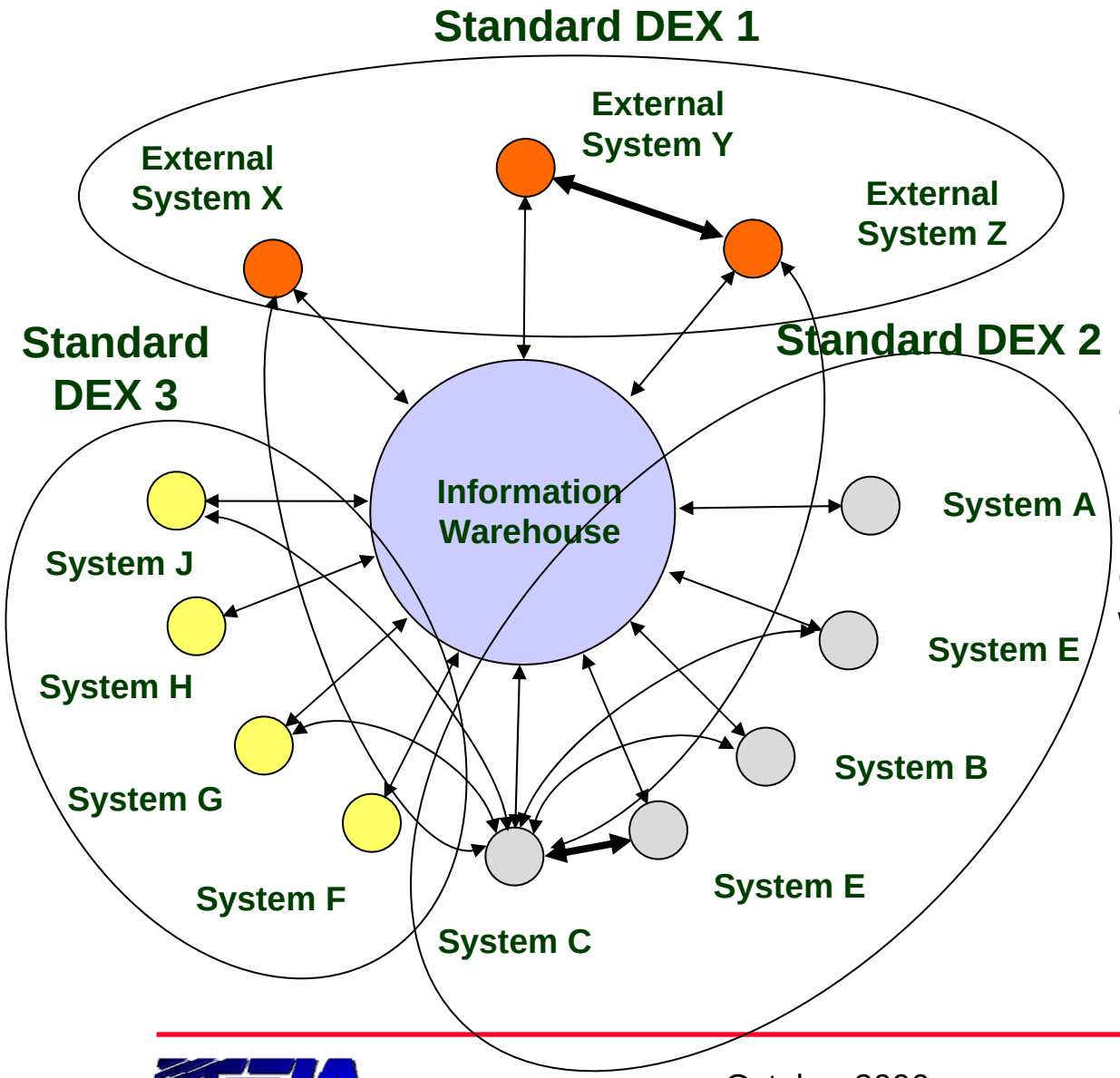
- **Define Logistics Product Data Generated During Design of a System, End Item, or Product**



- **Define Data Exchange Mechanisms**



Exchange Mechanisms



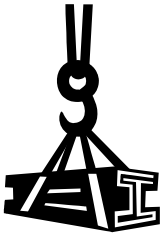
- **Central Exchange**
  Federated database, must establish exchange agreements with each "Partner".

- **Point to Point**
  Simple exchange, must establish exchange agreements and Protocols with each Partner

- **Closely Tied**
  Related exchange, typically similar data and structure

GEIA-STD-0007 Content

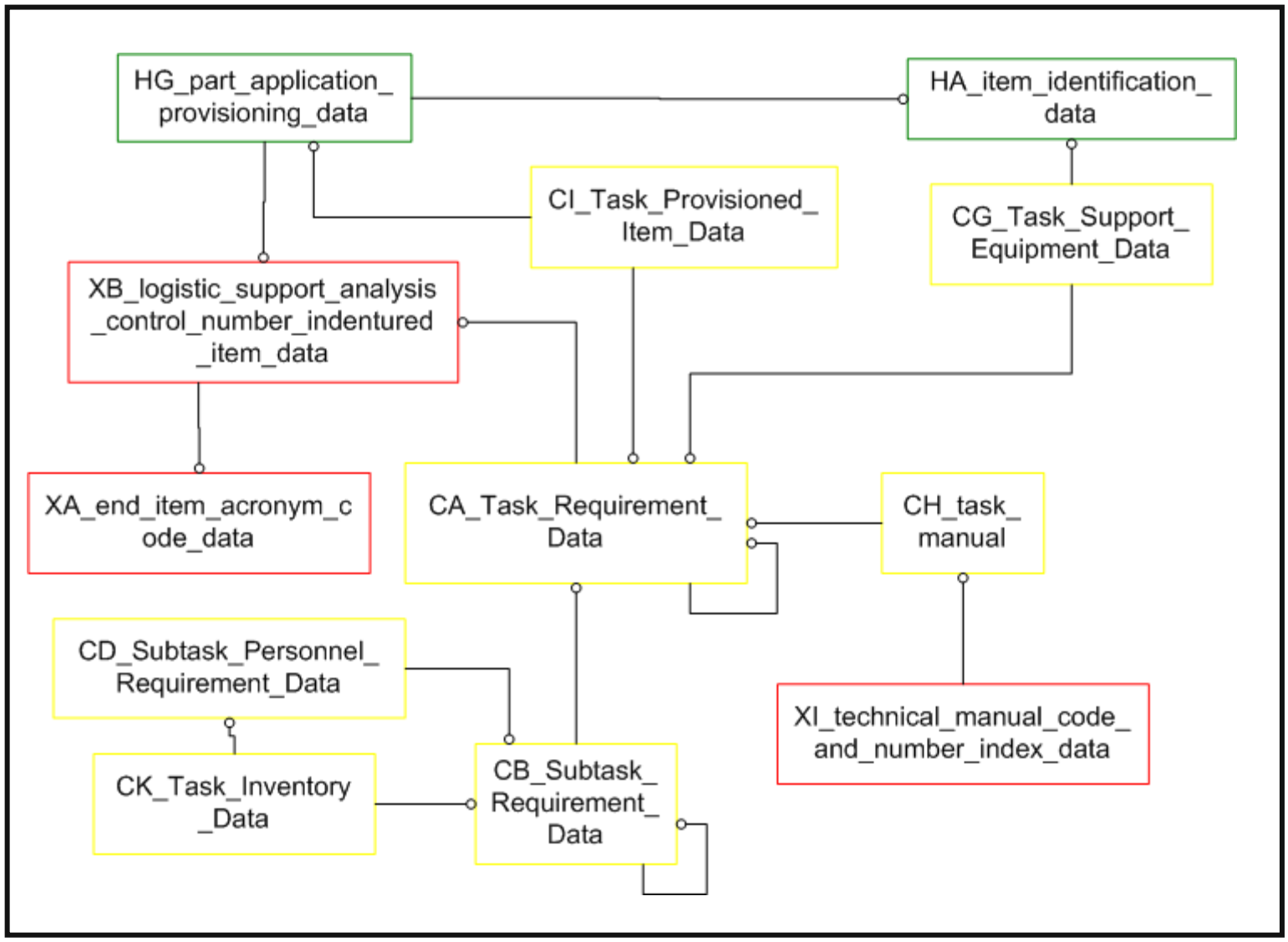
- **Functional Area Entities/Attributes**
  - Cross Functional Requirements
  - Operations and Maintenance
  - Reliability Requirements and Analysis
  - Task Analysis
  - Skill and Training
  - Support Equipment
  - Unit Under Test
  - Facility
  - Transportability
  - Provisioning and Cataloging Requirements
- **Data Types Dictionary**
- **XML Schema for Logistics Product Data**
  - Update/Change Process
- **XML Schemas for Transaction Sets**
  - Provisioning & Style Sheet
  - Packaging & Style Sheet
  - Task Analysis
- **LCN, ALC, UOC Assignment Guidance**








GEIA-STD-0007 Data Model Example



GEIA-STD-0007 Data Element Dictionary Example

ELEMENT TYPE	TYPE	MAX LENGTH	DEFINITION
achieved _availability _Type	decimal (0-2)N[.(0-6)N]	9	The probability that, when used under stated conditions in an ideal support environment, a system will operate satisfactorily at any time. This differs from Inherent Availability only in its inclusion of consideration for preventive action. A_a excludes supply downtime and administrative downtime. The measurement bases for MTBM and M must be consistent when calculating A_a. A_a may be expressed by the following formula: $A_a = \frac{MTBM}{MTBM + M}$ where $MTBM = \left(\frac{1}{MTBF} + \frac{1}{MTBM\text{-}ND} + \frac{1}{MTBPM}\right)^{-1}$ $M = \frac{\sum_{i=1}^{N} (ETi)(TFi)}{\sum_{i=1}^{N} TFi}$ M = Mean active maintenance downtime (where corrective and preventive actions are considered) ETi = Elapsed time for task i TFi = Task frequency for task i N = Total number of tasks performed Note: The measurement bases for MTBF, MTBM-ND, and MTBPM must be consistent when calculating the MTBM parameter.

GEIA-STD-0007 XML Schema Example

```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- xmlns:geia is needed by xpath in key/keyref as xpath does not work with default namespace  -->
_ <xs:schema
      xmlns:geia="http://www.geia_STD_0007.com/2006/schema"
      xmlns:lsartypes="http://www.geia_STD_0007.com/2006/types"
      xmlns:xs="http://www.w3.org/2001/XMLSchema"
      targetNamespace="http://www.geia_STD_0007.com/2006/schema"
      elementFormDefault="qualified" attributeFormDefault="unqualified">
      <xs:import
         namespace="http://www.geia_STD_0007.com/2006/types"
         schemaLocation="GEIA_STD_0007_Types.xsd" />
 _ <xs:complexType name="XA_end_item_acronym_code_data_type">
   _ <xs:all>
       <xs:element name="end_item_acronym_code"
          type="lsartypes:end_item_acronym_code_Type" />
       <xs:element name="logistic_support_analysis_control_number_structure"
          type="lsartypes:logistic_support_analysis_control_number_structure_Type" minOccurs="0" />
       <xs:element name="administrative_lead_time"
          type="lsartypes:administrative_lead_time_Type" minOccurs="0" />
       <xs:element name="contract_team_delay_time"
          type="lsartypes:contact_team_delay_time_Type" minOccurs="0" />
       <xs:element name="contract_number"
          type="lsartypes:contract_number_Type" minOccurs="0" />
       <xs:element name="cost_per_reorder_action“
          type="lsartypes:cost_per_reorder_action_Type" minOccurs="0" />
```

GEIA-HB-0007 Handbook

- **GEIA-HB-0007 (The Handbook!)**





GEIA-HB-0007 Outline

- Overview of how (e.g. what analysis) and when Logistics Product Data is generated during the development process (AP239 and DOD Lifecycle Models)
- Description of the Logistics Product Data Entities and Attributes (When Required, Sources, Indenture Level Relationships, Primary Use)
- Contracting for Logistics Product Data



- Appendices
  - Sample Relational Tables
  - Test Data Set
  - LCN, ALC and UOC Guidance to Include Relationship to S1000D SNS
  - Data Cross Reference List (0007, DEF STAN 00 60, MIL-STD-1388-2B)
- Publish Dec 06

Supportability Analysis Process

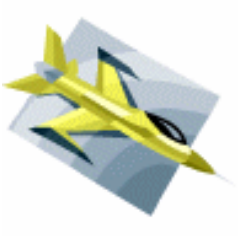
Concept Refinement Phase/Generate Support Solution

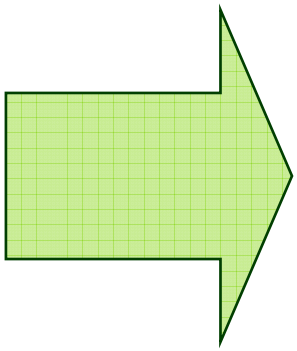
DOD Life Cycle Framework Analyses

- Perform Use Study
- Perform Comparative Analysis
- Identify Standardization Opportunities
- Functional Requirements Analysis
- Define Supportability Factors

AP239, Product Life Cycle Support Activities

- Define Support Context
  - Life & Usage Profile
  - Available Resources
- Establish Requirements
  - Elicit Stakeholder Needs
  - Define Support Requirements







GEIA-STD-0007

- X Entities – Cross Functional Requirements
- A Entities – Operations & Maintenance Requirements

Supportability Analysis Process

Technology Development Phase/Generate Support Solution

DOD Life Cycle Framework Analyses

- Update Comparative Analysis
- Identify Standardization Requirements
- Define Functional Requirements
- Conduct Tradeoff Analysis
- Conduct Sensitivity Analysis
- Conduct Limited Task Analysis

AP239, Product Life Cycle Support Activities

- Define Support Solution
  - Establish Support Drivers
  - Task Analysis - Potential Tasks
  - Predict Support Performance & Resource Use





GEIA-STD-0007

- X Entities – Cross Functional Requirements
- B Entities – Reliability Requirements & Analysis
- C Entities – Task Analysis





Supportability Analysis Process

System Development & Demonstration Phase/Generate Support Solution

DOD Life Cycle Framework Analyses

- Define Functional Requirements
- FMECA
- Failure Tree Analysis
- RCM
- Task Analysis
- LORA
- Supportability Testing

AP239, Product Life Cycle Support Activities

- Predict Support Performance & Resource Use
- Task Analysis
- Define Support Solution
  - Support Policy
  - Support Plan
  - Task Procedures
  - Assemble Solution
- Assess Support Performance





GEIA-STD-0007

- X Entities – Cross Functional Requirements
- B Entities – Reliability Requirements & Analysis
- C Entities – Task Analysis
- E Entities – Support Equipment
- U Entities – Unit Under Test
- F Entities – Facilities
- G Entities – Skills & Training
- H Entities – Provisioning & Cataloging





Supportability Analysis Process

Production & Deployment Phase/Commission Support Solution

DOD Life Cycle Framework Analyses

- Supportability Testing
- Provisioning
- Provisioning Screening (Cataloging)
- Early Fielding Analysis



AP239, Product Life Cycle Support Activities

- Assess Support Performance
- Define Support Solution
- Provisioning



GEIA-STD-0007

- X Entities – Cross Functional Requirements
- H Entities – Provisioning & Cataloging
- All Other Entities Affected by Testing

Supportability Analysis Process

Operation & Support Phase/Provide Support

DOD Life Cycle Framework Analyses

- Materiel Fielding Analysis
- Post Production Support Analysis





AP239, Product Life Cycle Support Activities

- Analyze Support Feedback
- Collect Data and Provide Feedback



GEIA-STD-0007

- All Entities Affected by Data Collection and Feedback

The "BIG Picture"

DoD Framework

Supportability Analysis

AP239 Activities

GEIA-STD-0007

Logistics Product Data







System Support

IETM
Training
Provisioning
Parts Lists
Etc…

Logistics Product Data Uses



- **Maintenance Planning**
  - Maintenance Plan
  - Maintenance Allocation Chart
  - Preventive Maintenance Checks & Services
  - Maintenance Procedures for IETMs (Task Analysis XML Schema)



- **Support and Test Equipment**
  - Support Equipment Recommendation Data
  - Calibration Maintenance Requirements Summary
  - TMDE Registration

- **Supply Support**
  - Provisioning Technical Documentation Lists (Long Lead, Post Conference, Common, Bulk Items, etc.) (Provisioning XML Schema & Style Sheet)
  - Design Change Notice Information
  - Cataloging/Screening/Parts Breakout
  - Indentured Parts List (for IETMs)



Logistics Product Data Uses (Continued)

- **Manpower, Personnel & Training**
  - Qualitative & Quantitative Personnel Requirements Information
  - Manpower Authorization Criteria
  - Task Inventory/Training Task List
  - New/Modified Skill/Training Requirements
  - Identification of Training Devices



- **Packaging, Handling, Storage, and Transportation**
  - Packaging and Preservation Data (Packaging XML Schema and Style Sheet)
  - Transportability Requirements



- **Facilities**
  - New/Modified Facilities Requirements
  - Maintenance Tasks Requiring New/Modified Facilities

- **Reliability and Maintainability**
  - Reliability Centered Maintenance Results
  - FMECA Results



Contracting for Logistics Product Data

- **Identify the Data Uses and Analyses Needed for Logistics Product Data**
- **Document Required Data on the Attribute Selection Sheet**
- **Identify the Appropriate XML Schema for Data Transfer**
  - **Logistics Product Data**
  - **Provisioning**
  - **Packaging**
  - **Task Analysis**



- **Use MIL-PRF-49506, Logistics Management Information, DID-ALSS-81529 Citing:**
  - **Appropriate GEIA-STD-0007 XML Schema**
  - **Attribute Selection Sheet**



Standards Content

GEIA-927

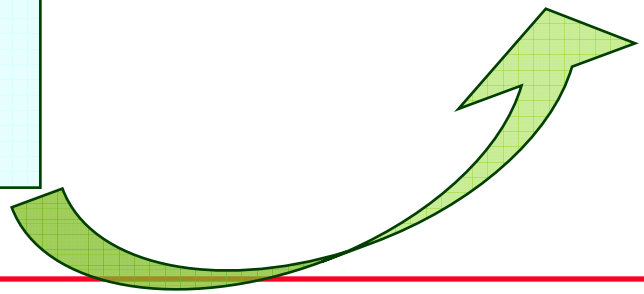
- Multi-Domain Entity Model
  - Lexical
  - Graphical
- Multi-Domain Entity Mapping Tables
- Entity/Attribute Dictionary

ISO 10303, AP239

- IDEF0 Activity Model – PLCS Process Model
- Entity/Attribute Model for PLCS
  - Lexical
  - Graphical
- Data Exchange Sets
  - Capability Modules
  - Entity Templates
  - Reference Data Library

GEIA-STD-0007

- Logistics Product Data Implementation Model
- Data Element Dictionary
- Data Delivery Reqts



GEIA-STD-0007 & DEXs

- **AP239 DEXs are Developed based upon Business DEXs.**
- **GEIA-STD-0007 Represents DoD Business DEX.**
- **LOGSA Objective: Work with the Organization for the Advancement of Structured Information Standards (OASIS) to Incorporate GEIA-STD-0007 Logistics Data into the Appropriate DEX's (1-5) and Create New DEXs where Gaps exist. (1-2 year Timeframe).**
- **Must Retain Ability for DOD to Contract for Delivery of Structured Logistics Product Data.**

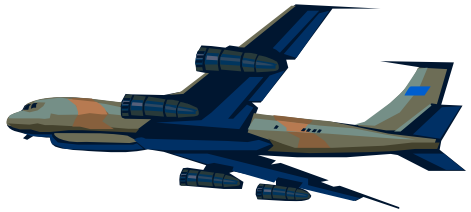






GEIA-STD-0007 Spiral Development

- S1000D Data Requirements (IETM)
- S2000M Data Requirements (Provisioning)
- S3000L Data Requirements (LSA/LSAR)
- Def-Stan-0060 Data Requirements (UK LSA/LSAR)
- Documents
  - Drawings
  - Illustrations
- Level of Repair Analysis Data
- Improved Task/Subtask Referencing



GEIA-STD-0007 Summary





- Re-Establishes Industry/DOD Exchange of LSAR Data
- Balloting Completed Sep 06 – Resolving Comments
- Publish – Oct/Nov 06
- Develop/Participate in ISO PLCS DEXs – ongoing
- Develop, Ballot & Publish GEIA-HB-0007 – Dec 06





Contact Information

- **Jim Colson (US AMC LOGSA)**
  - multiview@logsa.army.mil
  - 256-955-9928
- **GEIA-927 & GEIA-HB-927**
  - www.geia.org
- **GEIA-STD-0007 (Ballot Version)**
  - Balloted
  - Publish – Oct/Nov 06
- **GEIA-HB-0007**
  - Draft Completed
  - Publish – Dec 06



Backup Slides

International Standards Efforts

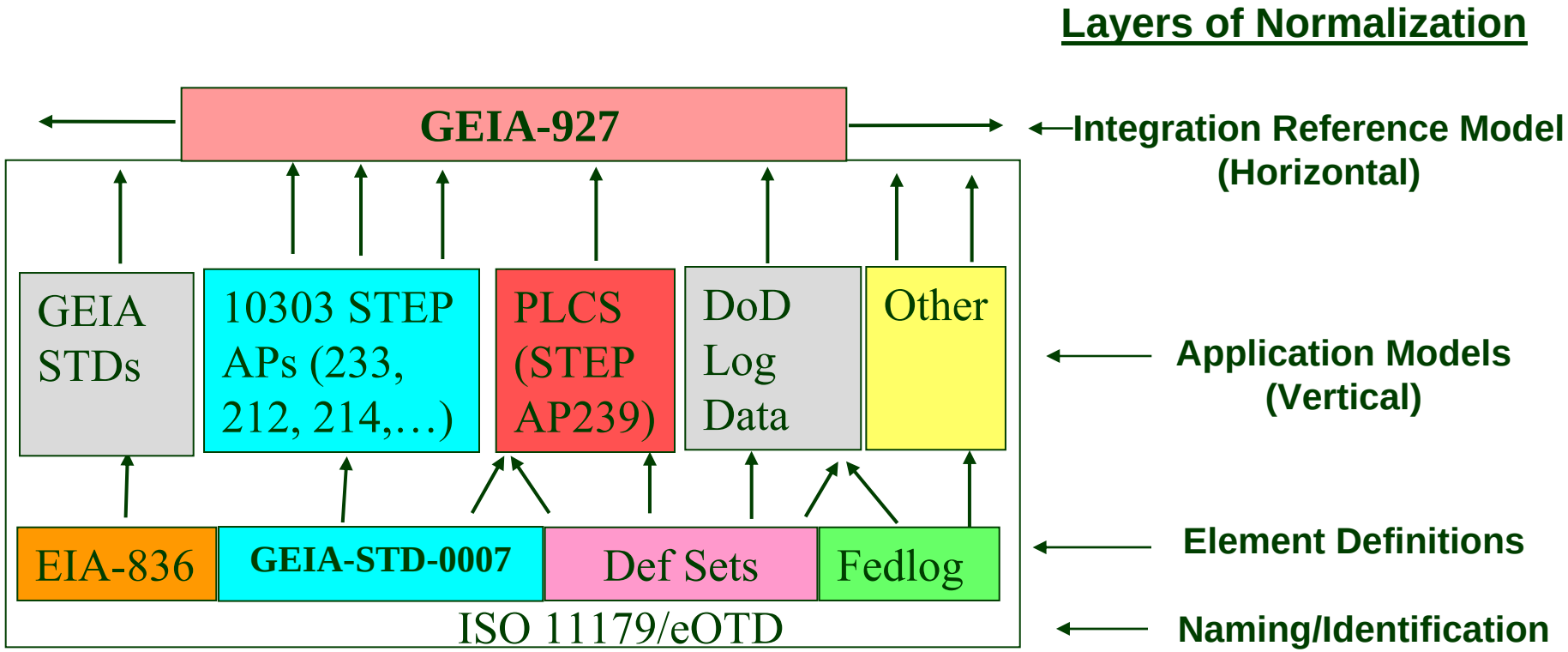
- **Organization for the Advancement of Structured Information Standards (OASIS)**
  - International Consortium promoting development of international e-business standards
  - Driving Development of AP239 PLCS Data Exchange Sets (DEX's)
    - » DEX1, Product Breakdown for Support
    - » DEX2, Fault States
    - » DEX3, Task Specification
    - » DEX5, Maintenance Plan
    - » DEX7, Operational Feedback
    - » DEX8, Product as Individual
    - » DEX4/9, Work Package Definition and Report
    - » Others
  - LOGSA is Voting Member

NONE COMPLETED

ASD S3000L
Application Handbook for the LSA of Defence Products

- AeroSpace Defense Association (ASD) Sponsored Effort
- Companies Committed Resources for Development of Spec
  - Boeing
  - Dassault Aviation
  - EADS/Airbus
  - BAE
  - Saab Aero
- Minimal Government participation (Industry Driven)
  - UK MoD
  - USA LOGSA
- Content will follow a Task focused approach (FMECA, RCM, Task Analysis, etc.)
- Data Requirements will be defined later (early 07)
  - DEX's (AP239 Approach)
  - GEIA-STD-0007 data model?
- One Year Effort – 1 Jun 06 Start
- Quarterly reviews
  - Sep – SE
  - Dec – FR
  - Mar – GE
  - Jun – US
- S4000A (Specific Analysis: RCM, LORA, etc..) TBD.
- Complimentary to S1000D (Tech Pubs) and S2000M (Provisioning)

Data Standards and Relationships



A Reference Model that integrates across domains, facilitates the normalization of information. Each functional domain must only validate with 1 reference model and they become harmonized with all other domains.





GEIA-927 Common Data Schema for Complex Systems

James Colson
U. S. Army
Logistics Support Activity (LOGSA)

U.S. Army Materiel Command
Logistics Support Activity
Sparkman Center, Bldg 5307
Redstone Arsenal, AL 35898-7466
www.logsa.army.mil

16 Oct 2006

Outline

- GEIA-927 Design/Purpose
- GEIA-927 Version 1.0 Content and Status
- Implementation approach
- GEIA-STD-0007 Content
- GEIA-HB-0007 Content

GEIA-927 Purpose

- **Facilitate the exchange of data concepts between product data domains (e.g. systems engineering, product life cycle, mechanical, etc.) for complex systems by harmonizing disparate standards into a single object model**

- **Primary elements**
  - Entity/Attribute Mapping between domain standards and the GEIA-927 Entity Model
  - GEIA-927 Entity Model (lexical and graphical)

GEIA-927 Version 1.0 Content

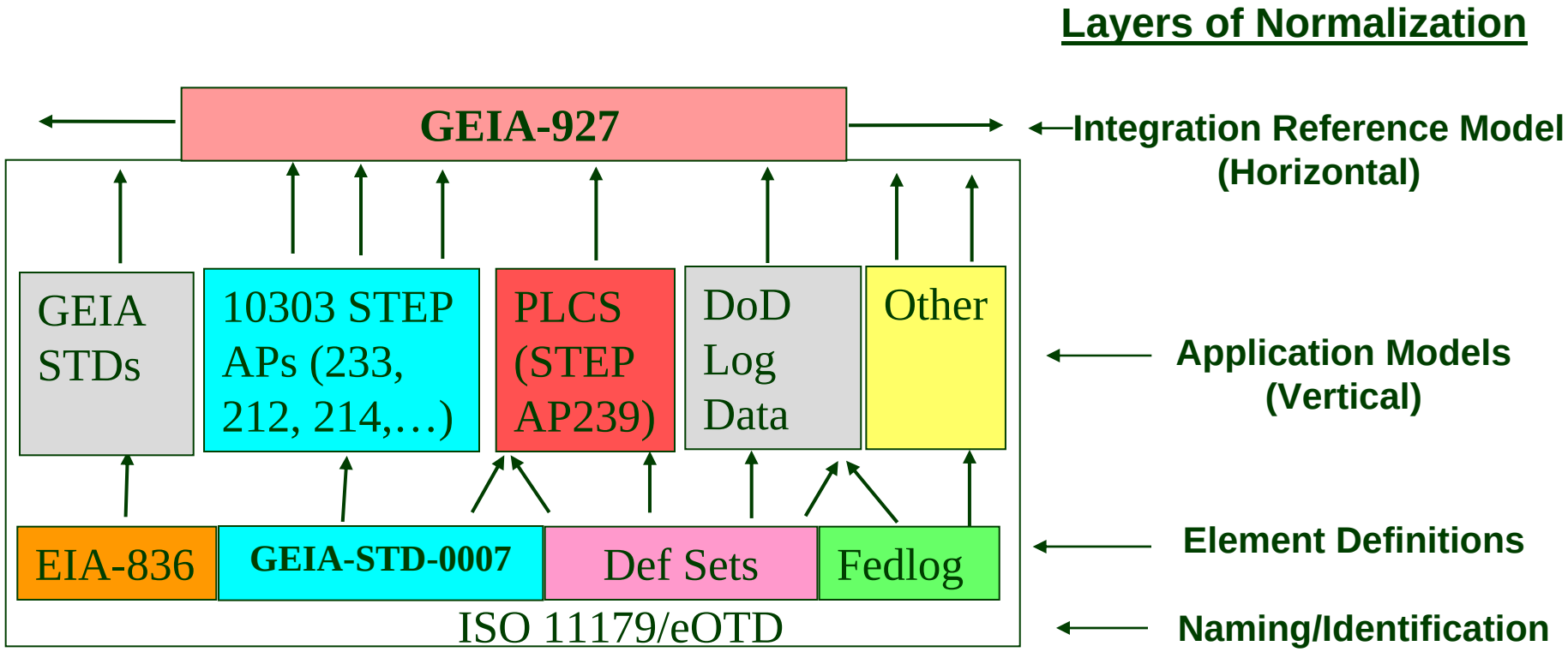
- **Standard Based On:**
  - ISO 18876 (IIDEAS) Basis for Data Modeling Methodology
  - ISO 15926-2 (EPISTLE Core Model (ECM)) Initial Integration

- **Currently Integrates:**
  - PAS 20542 - Systems Engineering
  - ISO 10303 (STEP) AP212 – Electrotechnical Design and Installation
  - ISO 10303 (STEP) AP239 – Product Life Cycle Support
  - ISO 10303 (STEP) AP214 - Core Data Model for Automotive Mechanical Design Processes
  - Logistics Support Analysis Record Data
  - Field Logistics Data (Inventory, Requisition, Maintenance, Usage)
  - Logistics Modeling Data (level of repair, cost analysis, post fielding analysis)

- **Functional Views of Model**
  - Activity
  - Common
  - Documentation
  - Functional Architecture
  - Logistics (2)
  - Effectivity
  - -Physical Architecture
  - -Product
  - -Property
  - -Requirement
  - -System Architecture
  - -Product Life Cycle

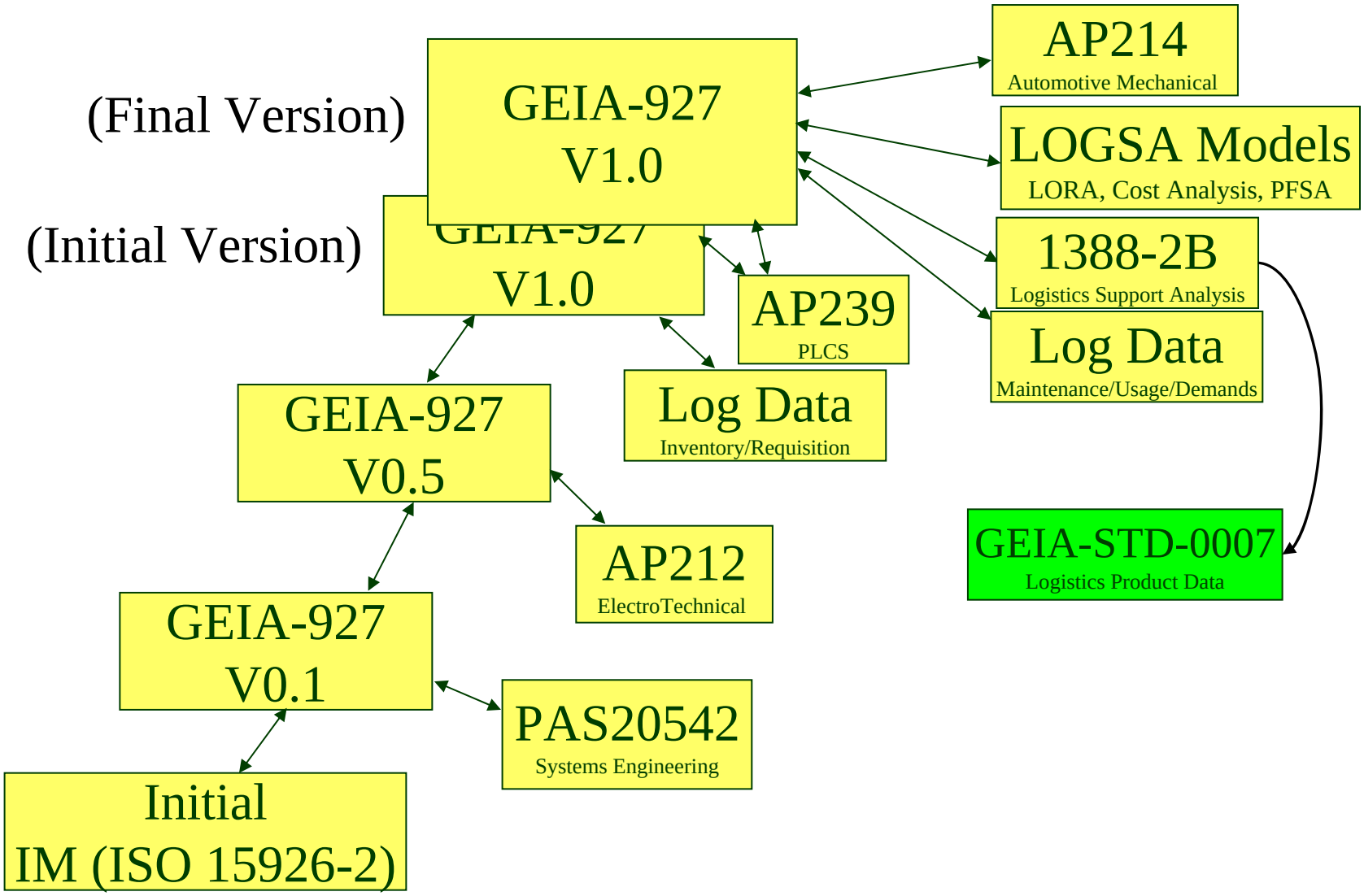
- **Entity/Attribute Model in HTML Format**
- **Entity/Attribute Definitions (~800)**

Data Standards and Relationships

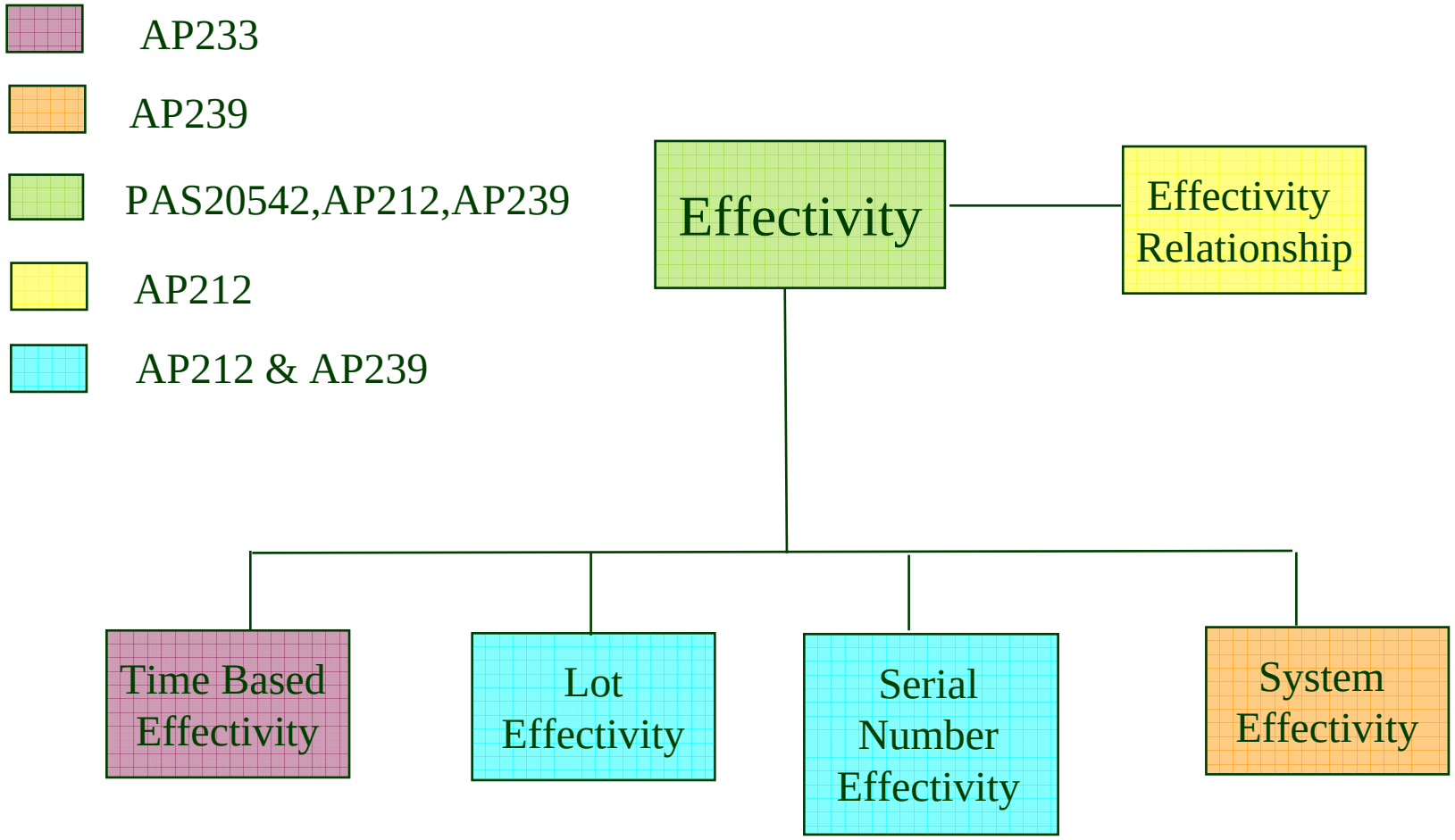


A Reference Model that integrates across domains, facilitates the normalization of information. Each functional domain must only validate with 1 reference model and they become harmonized with all other domains.

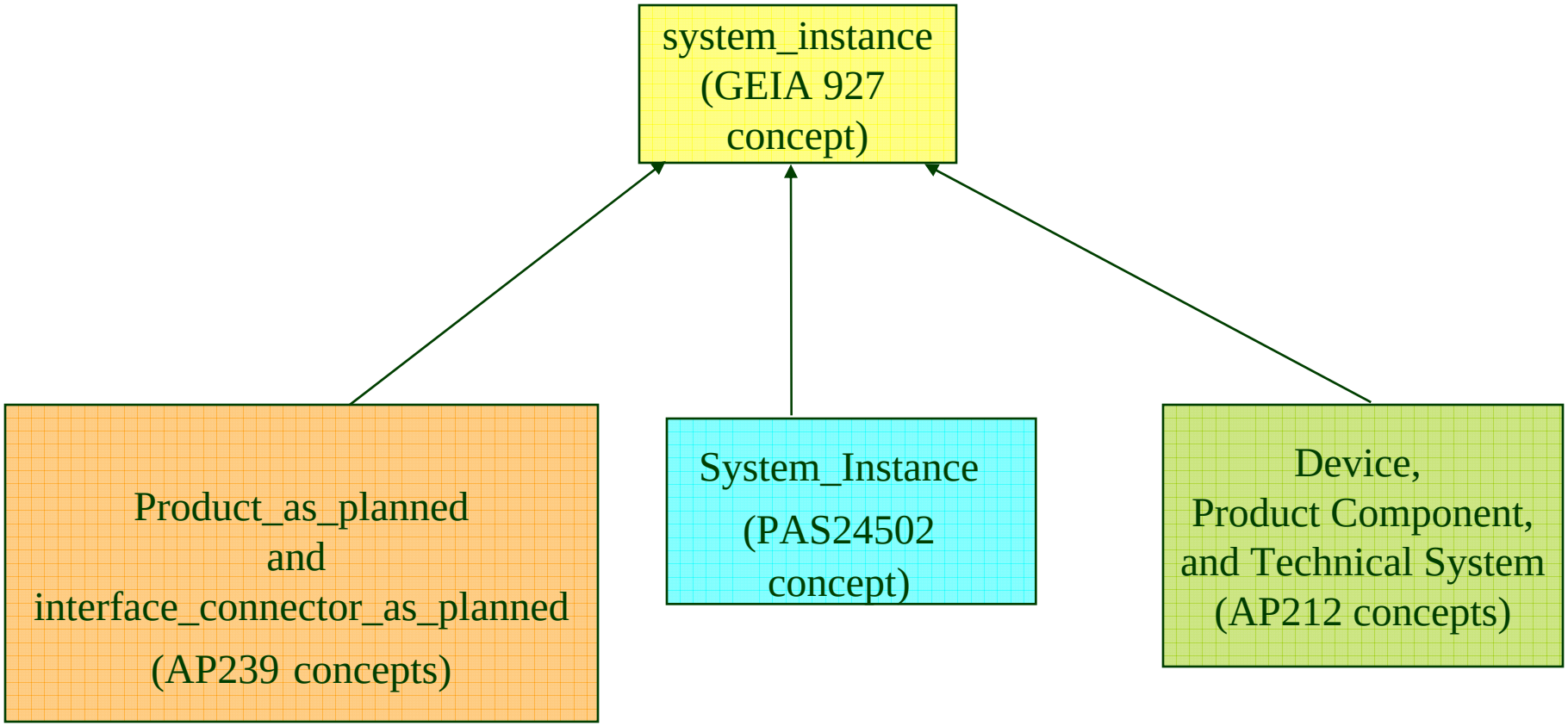
Development Process



Example – 927 Effectivity View
(Simplified)



Mapping Example – 927 System Instance

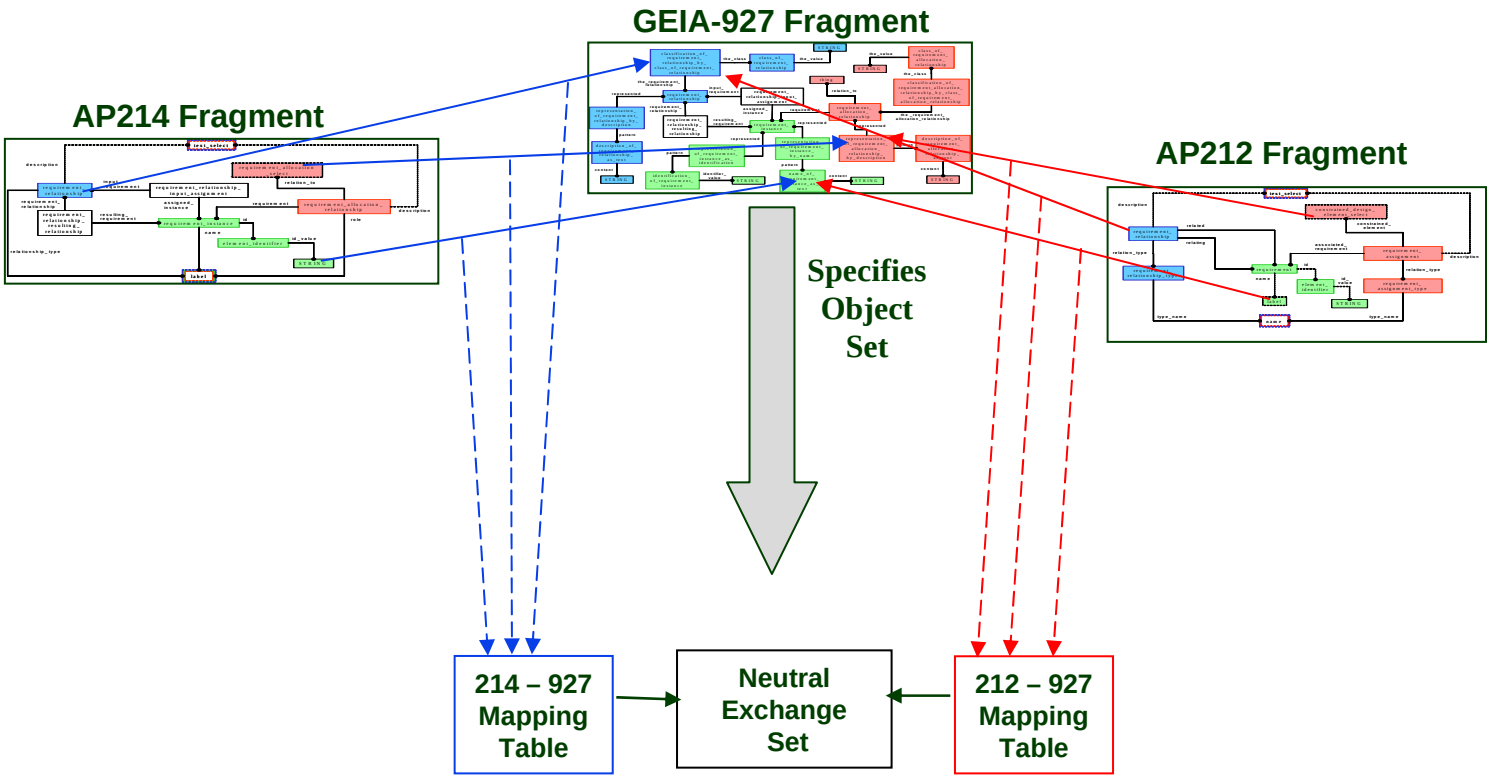


Example - Mapping Table AP212

AP212 - Effectivity UoF Mapping Table				
Form 1 - Base Analysis			**Form 3 - Mapping Information**	
Application Element Number	**AM Term**		**Reference path**	**Comments**
	Entity Name	**IM Element**		
4.2.79	date_time	point_in_time	point_in_time <= temporal_boundary_ of_state	Existing entity concept.
4.2.120	effectivity	effectivity	effectivity <= single_individual_ state	Existing entity concept.
4.2.120.1	effectivity to organization (as concerned_ organization)	effectivity_ organization_ relationship	effectivity effectivity <- effectivity_organization _relationship.valid_ effectivity effectivity_organization_relationship effectivity_organization_relationship .concerned_ organization -> organization organization	This is an existing attribute promoted to entity status concept which is represented by a PATH.
4.2.120.2	description	description_of_effectivity _as_ text.content	/DESCRIBE_AS_ TEXT(thing)/	This is an existing attribute concept inherited from

Application Example

GEIA-927 Provides a roadmap for the
Exchange Of Entities between standards/domains



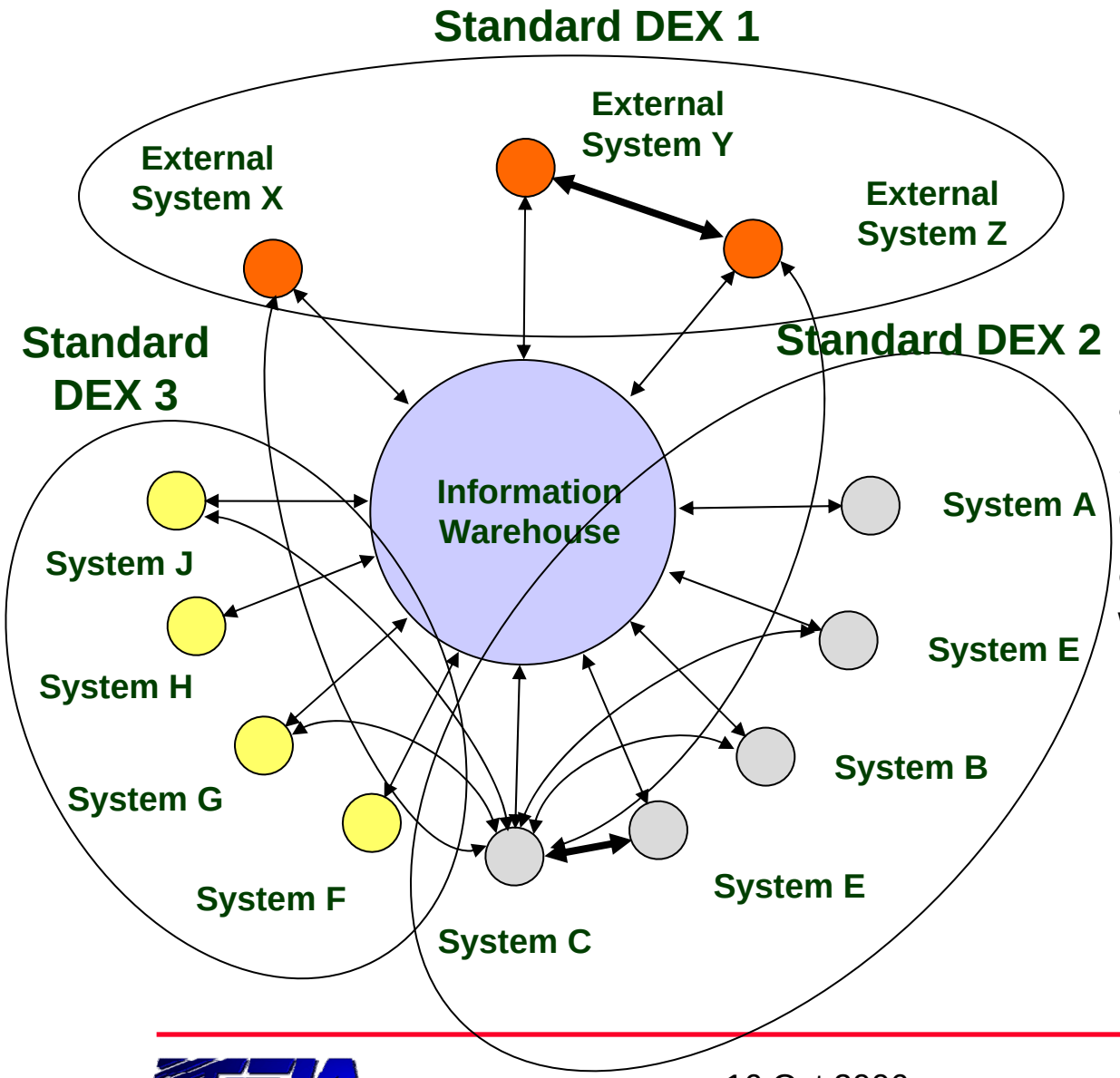
GEIA-HB-927, Handbook and Guide for GEIA-927

- **Content**
  - Data Modeling Guidelines (Principles of Modeling)
  - Data Model Usage Guide (Explanation of EXPRESS)
  - Integration Procedure (GEIA-927 Modeling Procedures)
  - Schema Tailoring Guidelines (How to Apply to Specific Application)
- **At GEIA for Publication**

To Summarize GEIA-927

Next Chart

Exchange Mechanisms



- **Central Exchange**
  Federated database, must establish exchange agreements with each "Partner".

- **Point to Point**
  Simple exchange, must establish exchange agreements and Protocols with each Partner

- **Closely Tied**
  Related exchange, typically similar data and structure

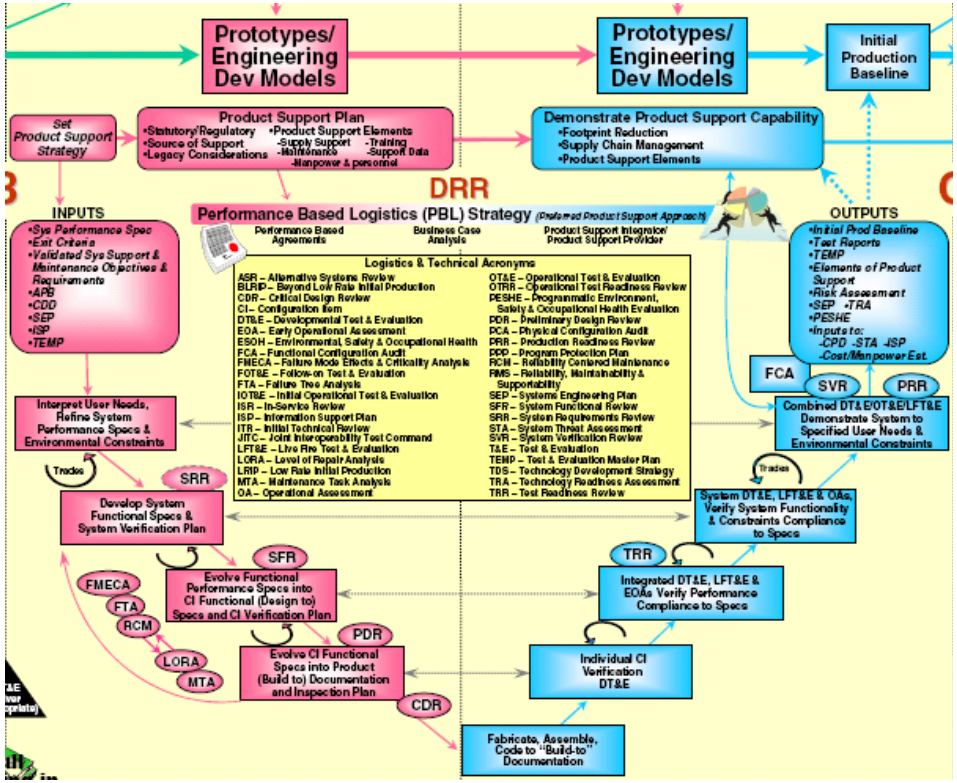
GEIA-STD-0007 Purpose

- **Define Logistics Product Data Generated During Design of a System, End Item, or Product**
- **Define Data Exchange Mechanisms (A "DEX")**



DoD Processes Defined!

DAU "Wall Chart"



No Data Products Defined!



GEIA-STD-0007, Logistics Product Data

- **Content:**
  - **Implementation Model of the Logistic Support Analysis Record (LSAR) Data**
  - **LSAR XML Schema**
  - **LSAR Data Definitions**



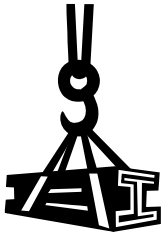
- **Objectives:**
  - **Provide Industry Standard for Acquisition and Exchange of Logistics Product Data by Industry/DoD**
- **Publication Timeframe:**
  - **Initial Balloting Completed 19 Sep 06**
  - **Re-Ballot in Nov 06 per Request of Air Force and Navy**

GEIA-STD-0007 Content

- **Functional Area Entities/Attributes**
  - Cross Functional Requirements
  - Operations and Maintenance
  - Reliability Requirements and Analysis
  - Task Analysis
  - Skill and Training
  - Support Equipment
  - Unit Under Test
  - Facility
  - Transportability
  - Provisioning and Cataloging Requirements









- **Data Model- Graphical View**
- **Data Element Dictionary**
- **XML Schema for Logistics Product Data**
- **XML Schemas for Transaction Sets**
  - Provisioning & Style Sheet
  - Packaging & Style Sheet
  - Task Analysis
- **LCN, ALC, UOC Assignment Guidance**

GEIA-HB-0007

- Overview of how (e.g. what analysis) and when Logistics Product Data is generated during the development process (AP239 and DOD Lifecycle Models)
- Description of the Logistics Product Data Entities and Attributes (When Required, Sources, Indenture Level Relationships, Primary Use)
- Contracting for Logistics Product Data
- Appendices
  - Sample Relational Tables
  - Test Data Set
  - LCN, ALC and UOC Guidance to Include Relationship to S1000D SNS
  - Data Cross Reference List (0007, DEF STAN 00 60, MIL-STD-1388-2B)
- Publish Dec 06

Standards Content

GEIA-927

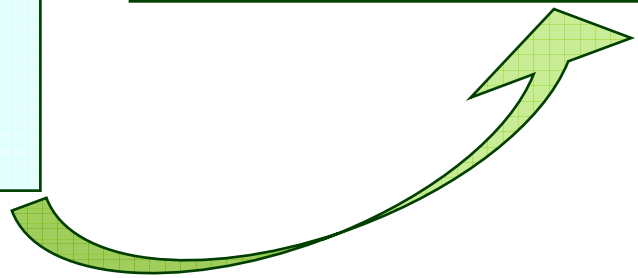
- Multi-Domain Entity Model
  - Lexical
  - Graphical
- Multi-Domain Entity Mapping Tables
- Entity/Attribute Dictionary

GEIA-STD-0007

- Logistics Product Data Implementation Model
- Data Element Dictionary
- Data Delivery Reqts

ISO 10303, AP239

- IDEF0 Activity Model – PLCS Process Model
- Entity/Attribute Model for PLCS
  - Lexical
  - Graphical
- Data Exchange Sets
  - Capability Modules
  - Entity Templates
  - Reference Data Library



Summary

- **GEIA-927**
  - Facilitates Exchange of Data Concepts between Product Data Domains
  - Publication Pending
- **GEIA-HB-927**
  - How Standard Was Developed
  - How to Implement Standard
- **GEIA-STD-0007**
  - Re-Establishes Industry/DOD Exchange of LSAR Data
- **GEIA-HB-0007**
  - Establishes Relationship of Analysis to the Data
  - Establishes Relationship of Data to Logistics Products
  - How to Contract for GEIA-STD-0007
- **Working Toward AP239 Business DEX**

Contact Information

- **Jim Colson (US AMC LOGSA)**
  - multiview@logsa.army.mil
  - 256-955-9928
- **GEIA-927 & GEIA-HB-927**
  - www.geia.org
- **GEIA-STD-0007 (Draft Version)**
  - Re-Ballot Version in Nov 06
- **GEIA-HB-0007 (Draft Version)**
  - Ballot Version in Nov 06 (Concurrent with Standard)



Backup Slides

International Standards Efforts

- **Organization for the Advancement of Structured Information Standards (OASIS)**
  - International Consortium promoting development of international e-business standards
  - Driving Development of AP239 PLCS Data Exchange Sets (DEX's)
    - » DEX1, Product Breakdown for Support
    - » DEX2, Fault States
    - » DEX3, Task Specification
    - » DEX5, Maintenance Plan
    - » DEX7, Operational Feedback
    - » DEX8, Product as Individual
    - » DEX4/9, Work Package Definition and Report
    - » Others
  - LOGSA is Voting Member

NONE COMPLETED

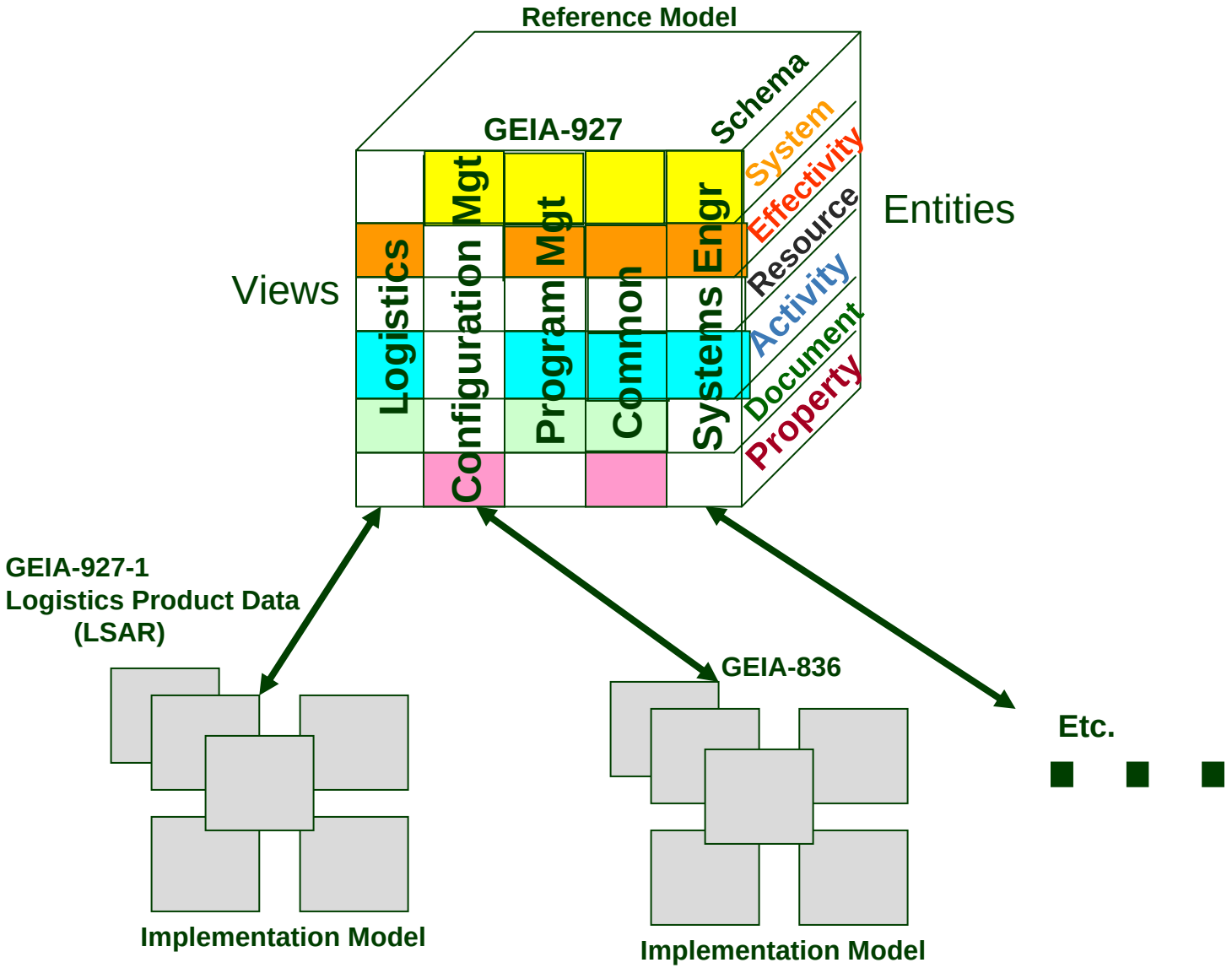
ASD S3000L
Application Handbook for the LSA of Defence Products

- AeroSpace Defense Association (ASD) Sponsored Effort
- Companies Committed Resources for Development of Spec
  - Boeing
  - Dassault Aviation
  - EADS/Airbus
  - BAE
  - Saab Aero
- Minimal Government participation (Industry Driven)
  - UK MoD
  - USA LOGSA
- Content will follow a Task focused approach (FMECA, RCM, Task Analysis, etc.)
- Data Requirements will be defined later (early 07)
  - DEX's (AP239 Approach)
  - GEIA-STD-0007 data model?
- One Year Effort – 1 Jun 06 Start
- Quarterly reviews
  - Sep – SE
  - Dec – FR
  - Mar – GE
  - Jun – US
- S4000A (Specific Analysis: RCM, LORA, etc..) TBD.
- Complimentary to S1000D (Tech Pubs) and S2000M (Provisioning)

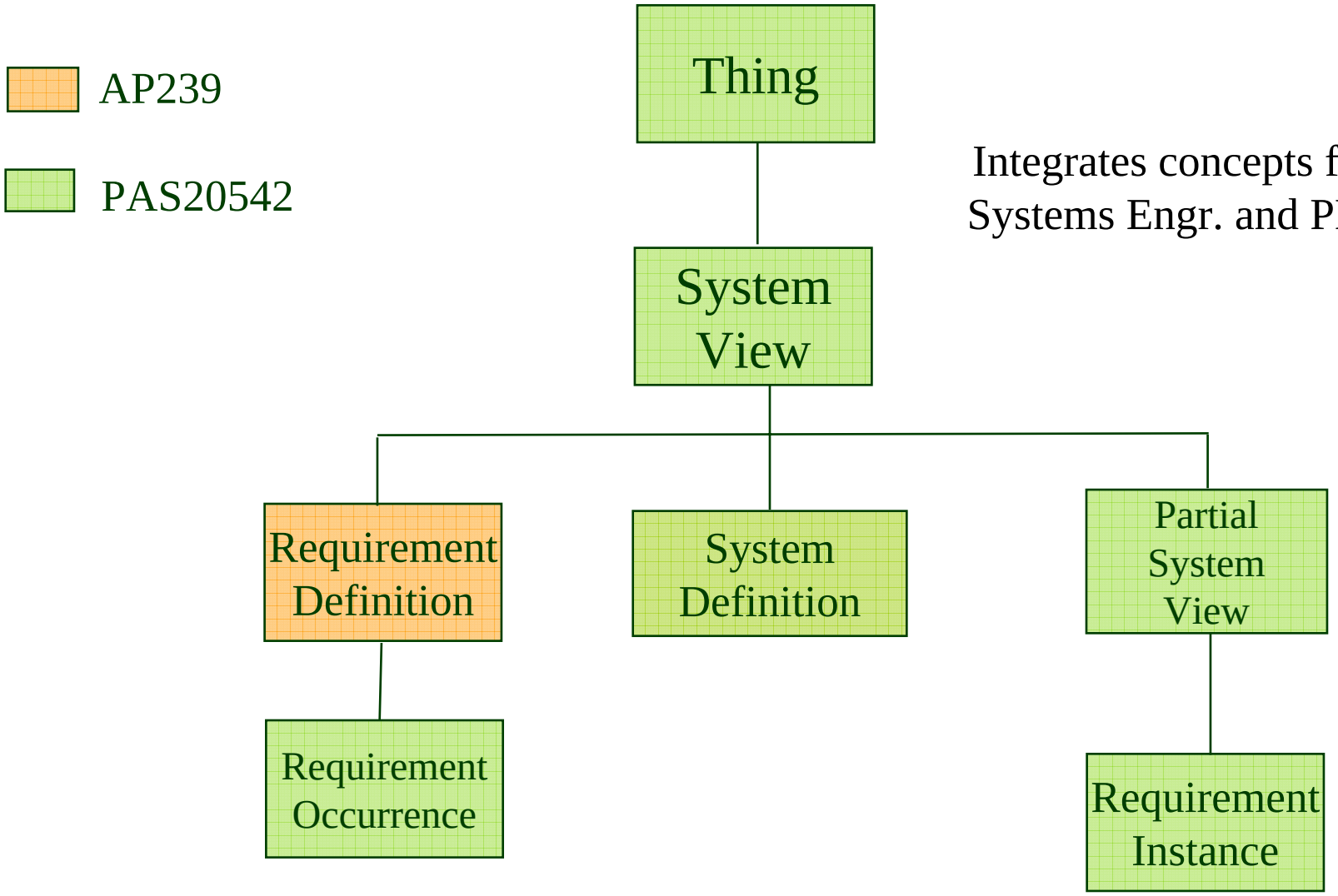
Example - Mapping Table PAS20542

AM element Number	AM element	IM element	Reference path	Comments
49	CONFIGURATION_ELEMENT_ VERSION	configuration_ element_ version	configuration_element_version <= class_of_class	New entity. Attributes of this entity are not mapped at this time. The configuration_element_version is an PAS20542 concept whose integration unit has not yet been integrated into MultiView. The above issue referred to in this comments column will remain an open issue as of the revised document date noted above as that specific Uof referred to was not touched upon as of the end of Multi-view Year Two efforts.
59	DATA_TRANSFER	data_transfer	data_transfer <= relation	New entity. PAS20542 note on data transfer indicates that it may be used to depict a physical interaction as well as data interactions. With regards to the above comments, after the analysis of the Physical and Functional architecture Uofs, it turns out that the composition of function instances pointed to by

GEIA-927 Relationships

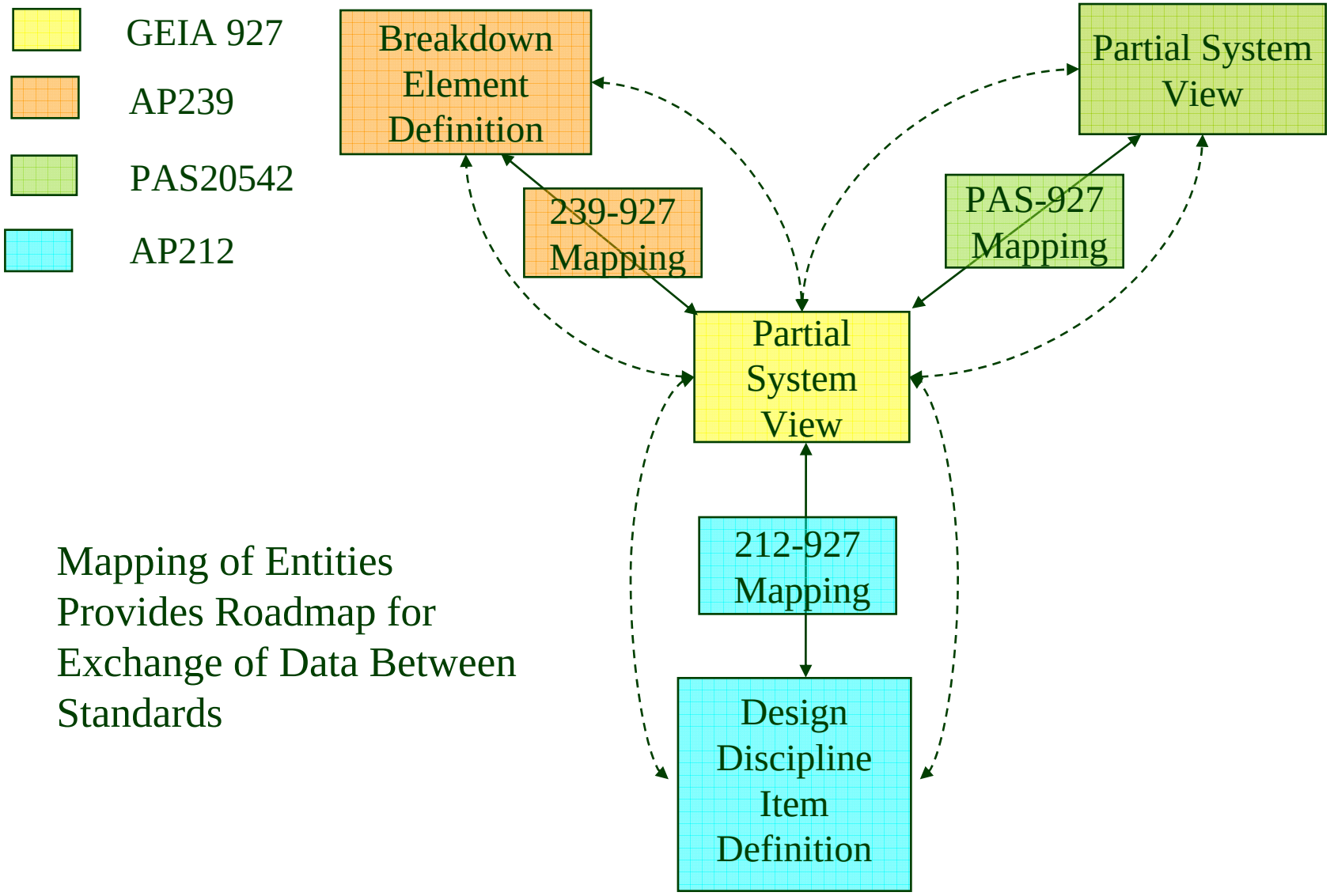


Example – 927 Requirements View
(Simplified)



Integrates concepts from Systems Engr. and PLCS

GEIA-927 Mapping Table Results

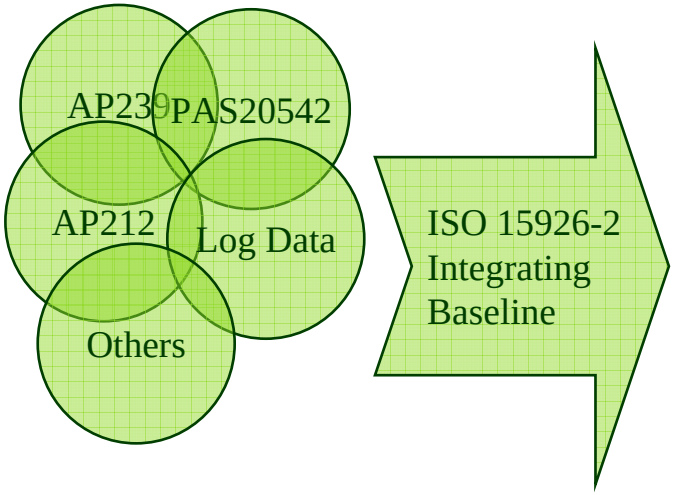


Mapping of Entities Provides Roadmap for Exchange of Data Between Standards

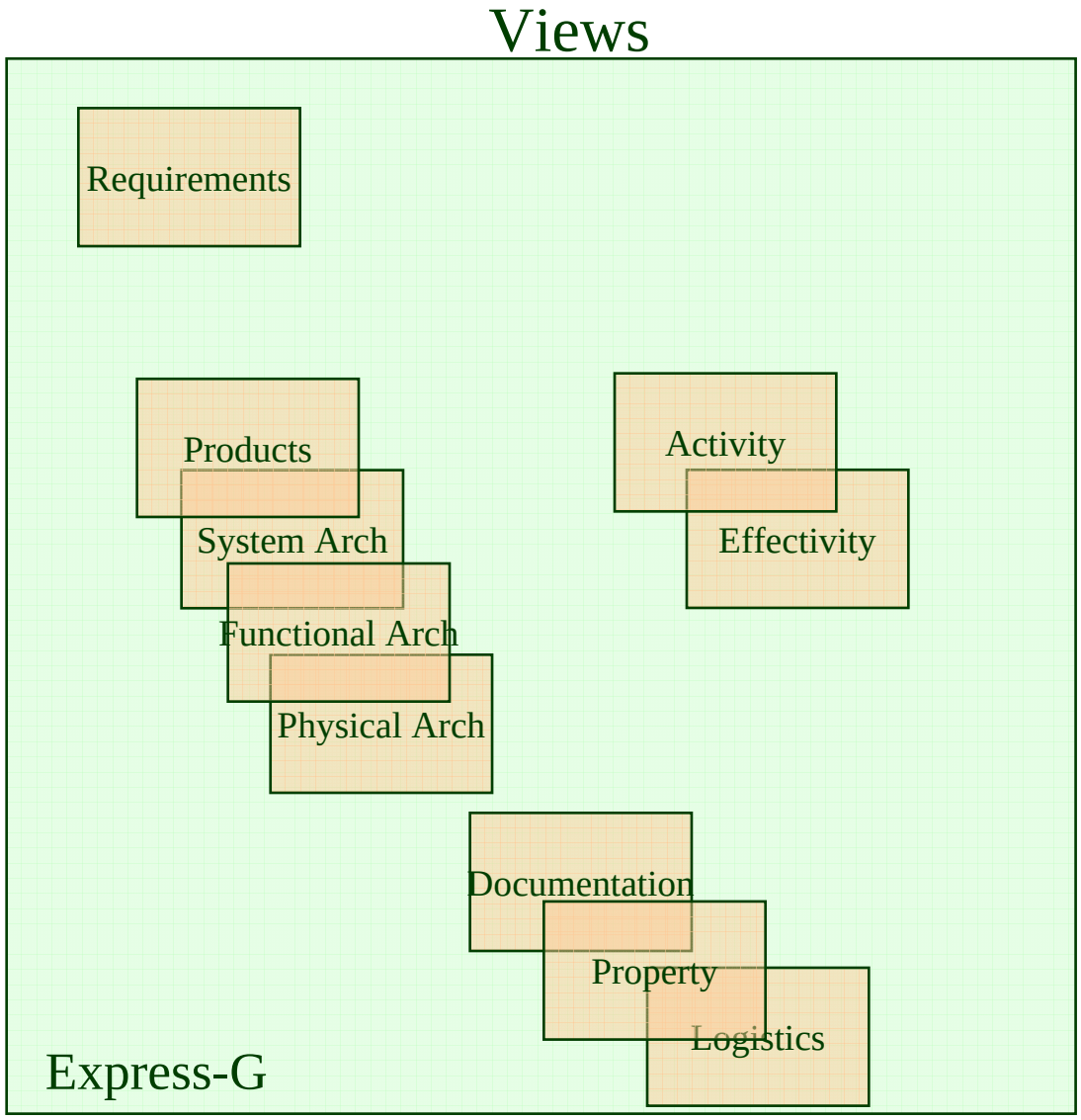
GEIA-927 Integration Process

- Entities from a standard or product area are organized into a series of relationship diagrams.
- The diagrams are parsed and converted into a format suitable for analysis.
- Each entity and its related attributes are abstracted from an application specific level to a general level to fit into the GEIA-927 model.
- Entities are analyzed considering existing concepts, superseded concepts or new concepts to test fit into the GEIA-927 model.
- Upon completion of analysis, entities, attributes and entity to entity relationships are added to the GEIA-927 master model.

GEIA-927 Design Approach



Views allow users to "digest" model

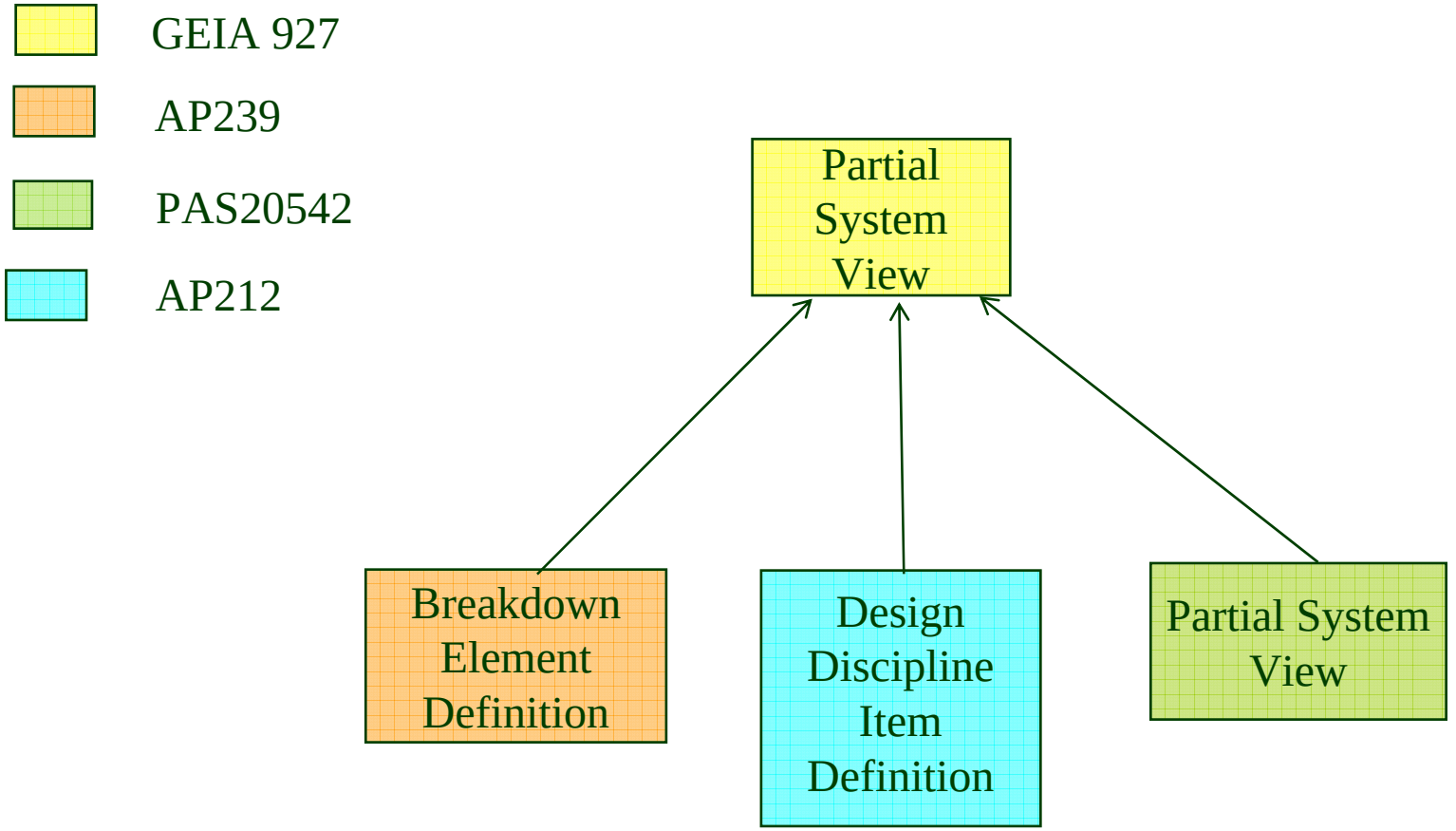


GEIA-927 Integration Results



PAS24502	AP239	AP212	Log Data
	Activity View		Activity View
Common View	Common View	Common View	Common View
	Documentation View		Documentation View
Effectivity View	Effectivity View	Effectivity View	
Functional Architecture View		Functional Architecture View	Functional Architecture View
			Logistics View
Physical Architecture View		Physical Architecture View	
	Product Life Cycle View		Product Life Cycle View
Product View	Product View	Product View	Product View
Property View	Property View	Property View	Property View
Requirement View	Requirement View	Requirement View	Requirement View
System Architecture View		System Architecture View	

Mapping Example – Data Object Level



Mapping of Entities Provides Roadmap
for Exchange of Data Between Standards

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

System Engineering and Integration for Submarine Combat Systems in the COTS Environment

Dennis J. Cooper
SWFTS Program Manager
Lockheed Martin Integrated Systems

Joan Sienkiewicz
SWFTS Program Manager
General Dynamics Electric Boat

Mike Oliver
SWFTS Program Manager
Lockheed Martin Maritime Systems and Sensors

Submarine Combat System Paradigm Shift

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- Submarine combat systems employ Commercial-Off-The-Shelf technology and open system standards to provide:
  - An affordable path to leverage commercial technology in parallel with the build-test-build development cycle
  - Asynchronous rapid transition of advanced functional improvements through modular software builds in a networked environment
- Harnessing this capability required a change to the system engineering, interface, integration, and configuration management processes

This SE&I Model Was Proven Successful on the Virginia Class Combat System

Today's Dynamic Environment

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- Varying acquisition "cycle times" between subsystems
- Fleet driven rapid introduction of warfighting capability
- Technology transition from custom to COTS
- Radical reductions and gaps in funding
- Spiral Development
- Increasing system complexity
- Software Intensive Systems
- Desire for commonality across platforms
- Network Centric / Interoperability
- Information Security and Assurance

Business Models have evolved to adapt to the changing environment

Architecture Contrast

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Closed System

- Use of closely held, private interfaces, languages, data formats and protocols
- Critical importance given to unique design and implementation
- Use of individual company preferences to set and maintain interface specifications
- Vendor and technology dependence
- Difficult and more costly integration
- Use of sole-source vendor
- Expansion and upgrading usually requires considerable time, money and effort
- Components, interfaces, standards, and implementations are selected sequentially

Open System

- Use of publicly available and widely used interfaces, languages, data formats and protocols
- Critical importance is given to interface management and widely used conventions
- Use of group consensus process to maintain interface specifications
- Vendor and technology independence
- Easier and more cost effective to integrate
- Use of multiple vendors
- Easier, quicker and less expensive to upgrade
- Components, interfaces, standards, and implementations are selected interactively

Interface Management is the Key to Success

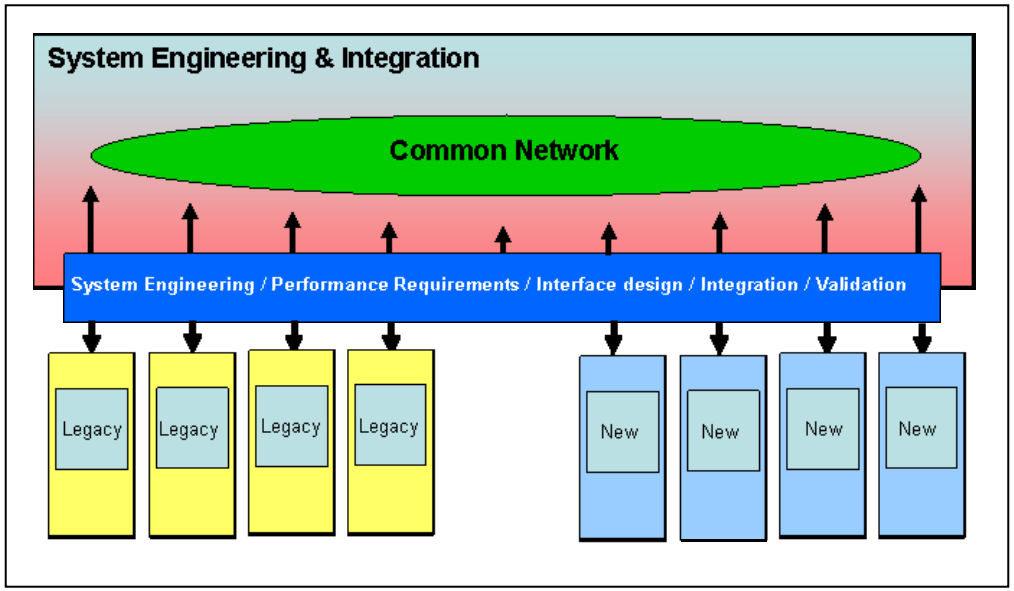
Source: ITEA Journal: September/October 2001 (Volume 22, Number 3)

Open System Model

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- Focus on the network and subsystem to subsystem domains to define and manage:
  - Open Architecture / Open System Standards
  - Interface Design and Definition
    - Functional not physical
  - Network Design, Services and system performance
  - Network software solutions
  - Technology Evolution
  - Standardized processes and products

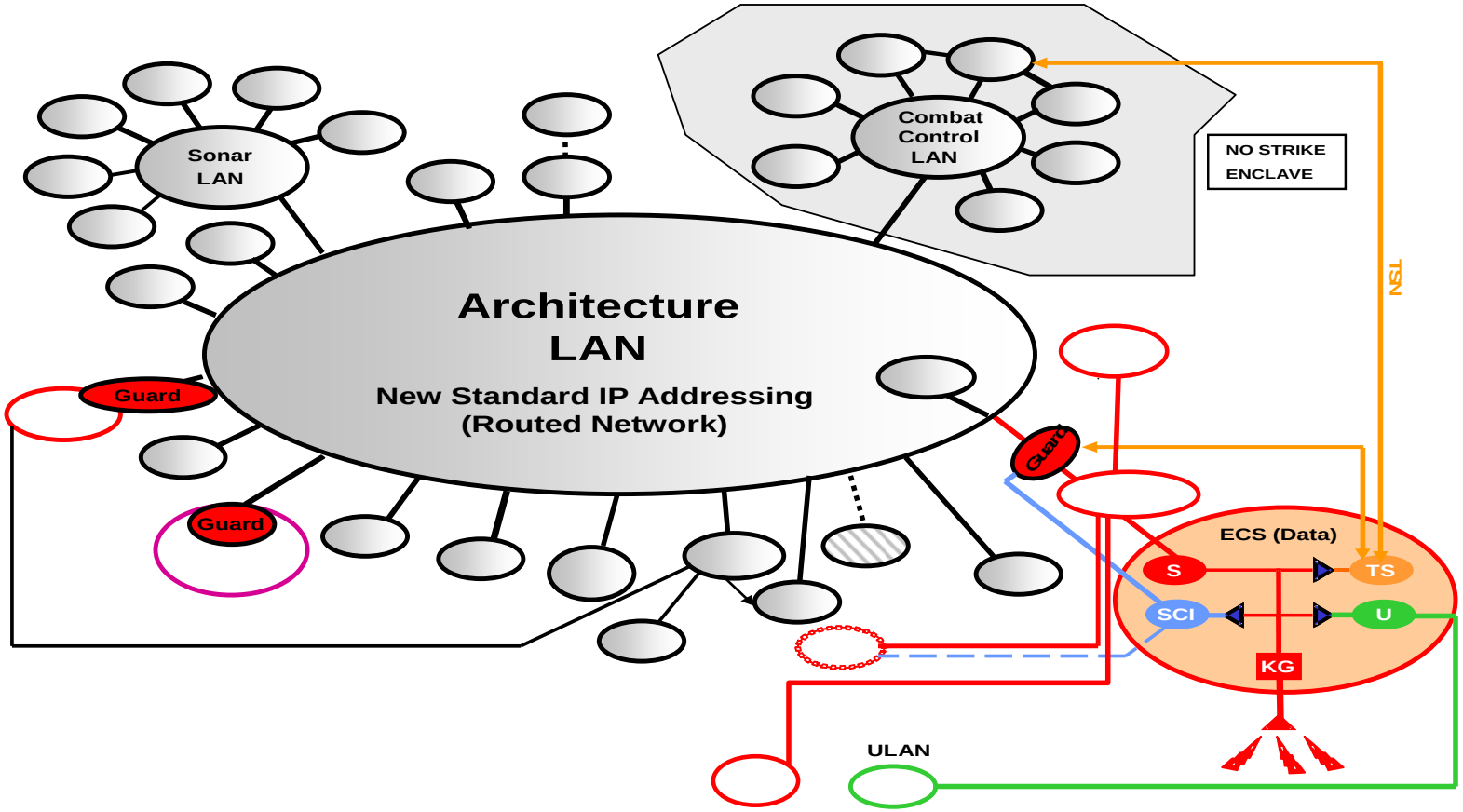


This Open System Model has been implemented on the Submarine Functional Interface Baselines by a disciplined and measured approach to interface development and data flow management

Virginia Class Submarine Combat System

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat



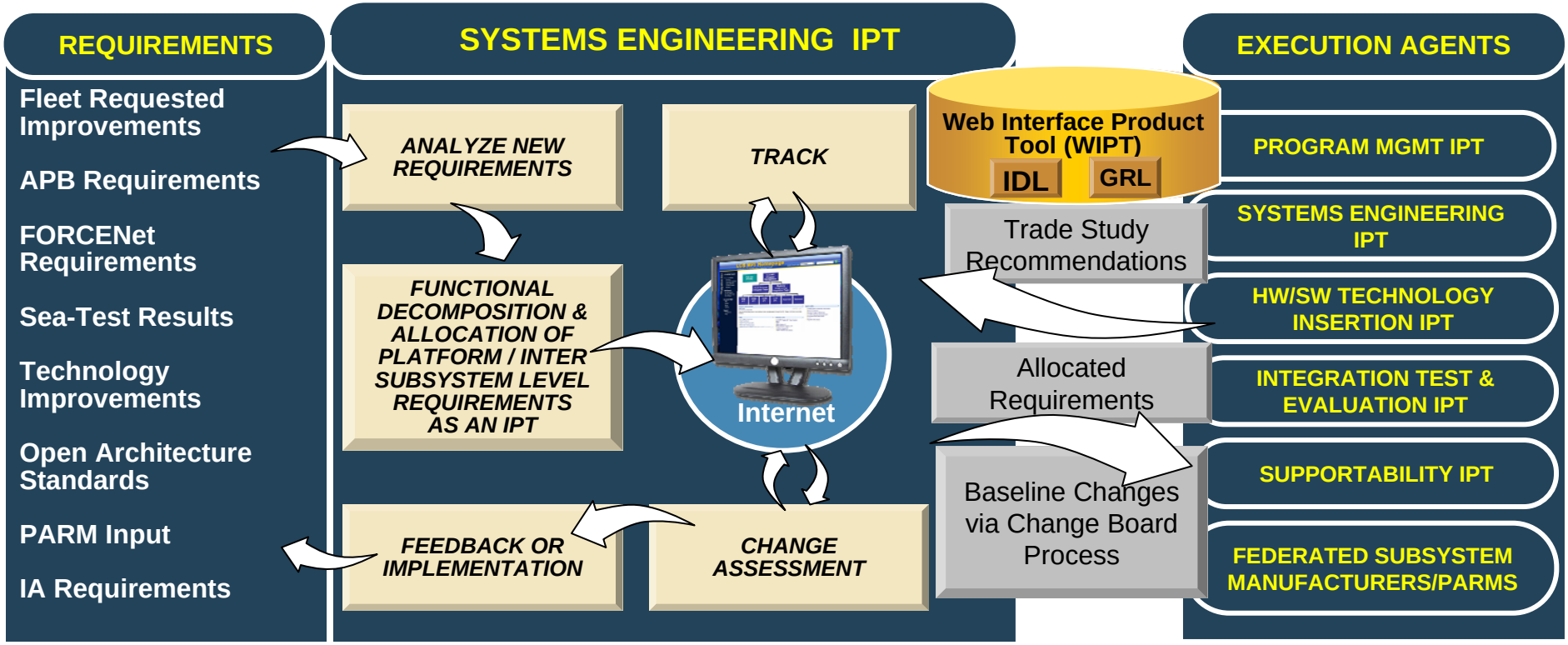
Need to manage and control the interfaces for the 23 subsystems of the Virginia Class Submarine Combat System

It Starts with Requirements Management

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

SE&I provides Top Level Combat System and Interface requirements. All other requirements are managed by the Federated subsystems

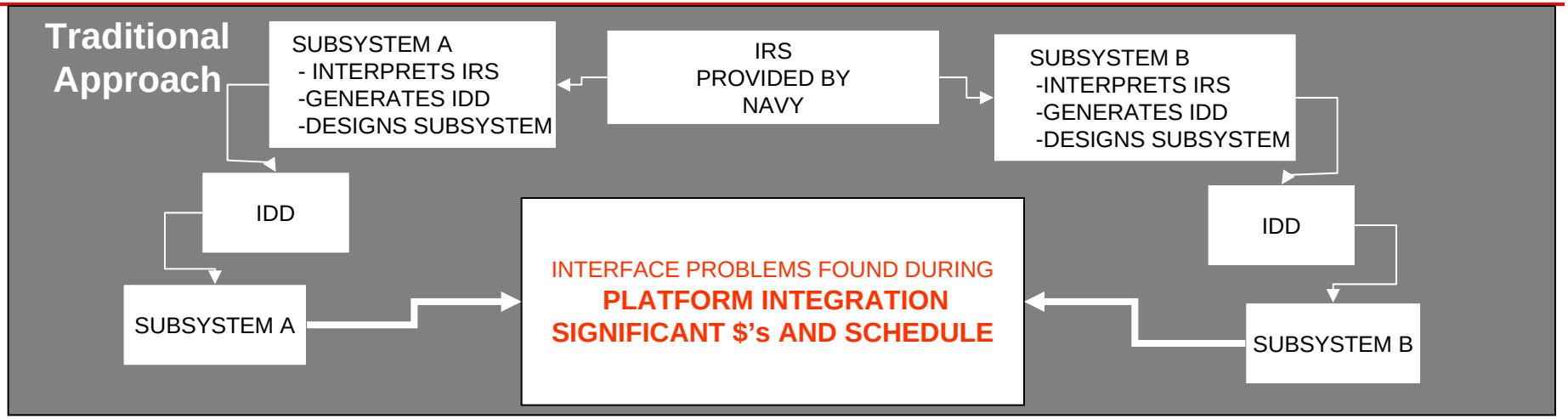


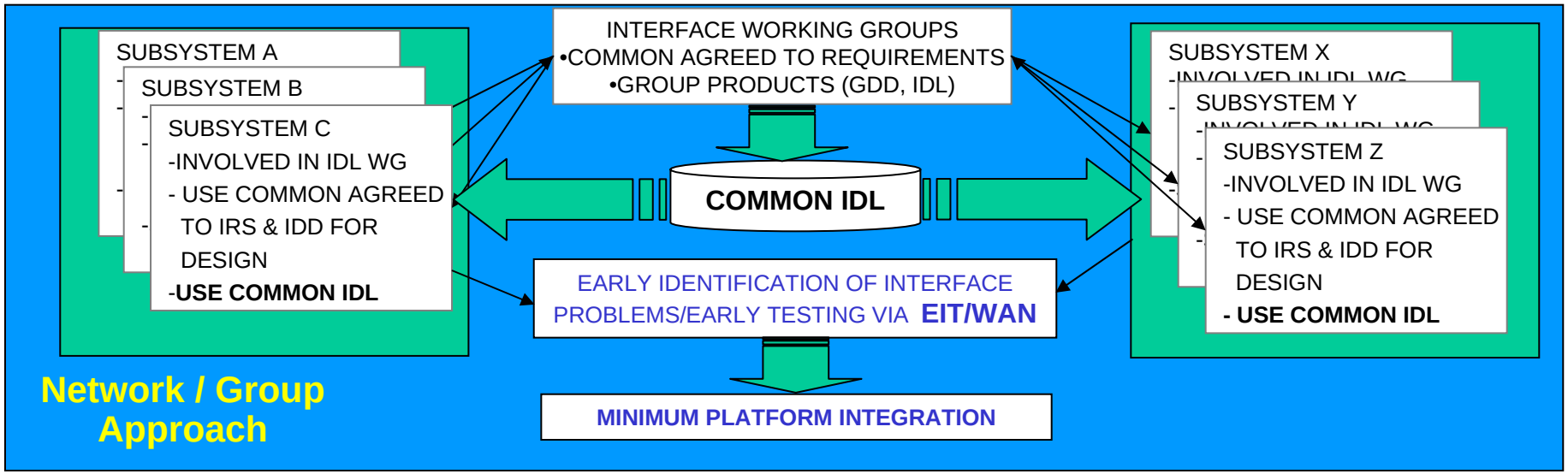
A Streamlined System Engineering Approach

Evolution of Interface Standardization

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat





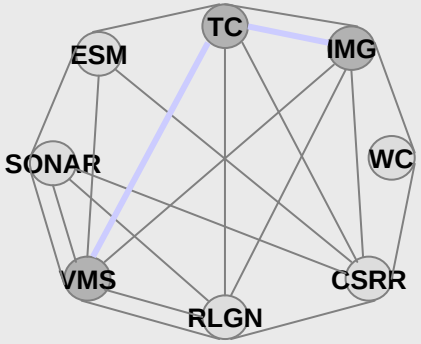
System Engineering
Network Architecture, Interface Design

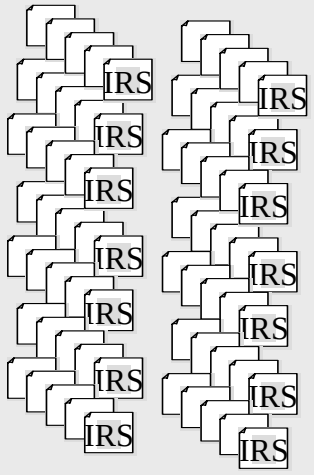
LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Yesterday

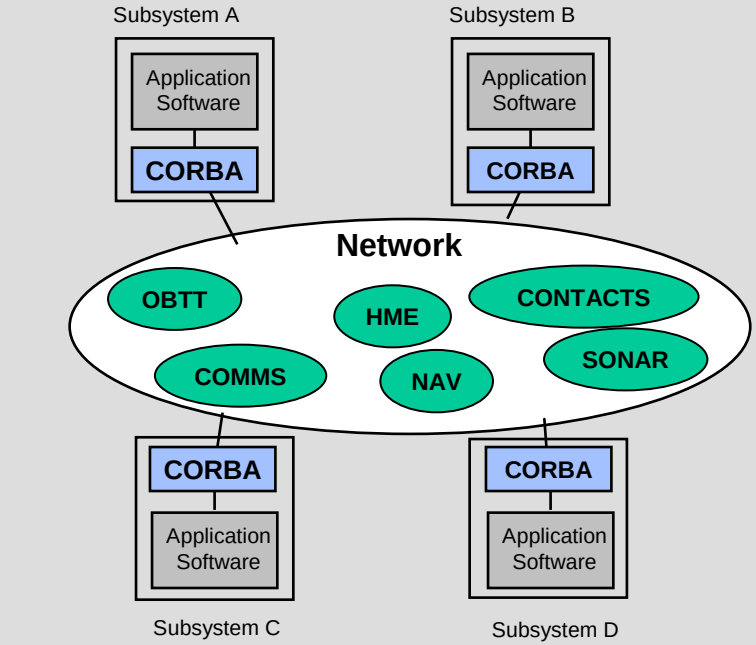
Traditional Point to point Design Process

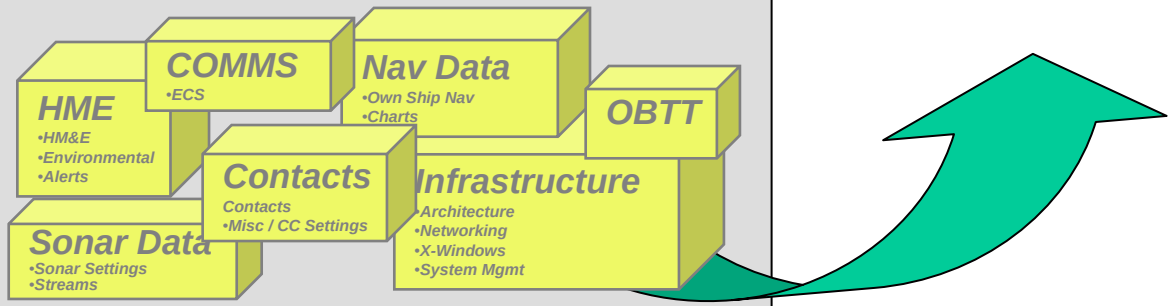




Today

Network / Group Product Design Process





Interface Working Groups

Group Products

- Open System Architecture Requirements and Standards (OSA)
- Group Requirements List (GRL)
- Interface Definition Language (IDL)
- Group Data Dictionary (GDD)
- System Network Design

SE&I Interface Product Definitions

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- **SE&I Interface Products under Configuration Management:**
  - **Group Requirements List (GRL)**
    - Database that contains all interface requirements for all subsystems.
  - **Group Data Dictionary (GDD)**
    - Contains definitions for all Interface Data Elements (IDEs) and IDE Assemblies (IDEAs) produced and consumed by subsystems within a Data Group
  - **Interface Definition Language (IDL)**
    - IDL provides the standard interface between objects, and is the base mechanism for object interaction between subsystems.
  - **Interface Integration Data Base (IIDB)**
    - Provides details of what interfaces are required for each subsystem on a per hull basis. Grouped by interface types and contains the Interface / method / Name Space Name (CORBA), Service Name (Services), Subsystems, GRL linkages, GDD linkages and indications of Provider, Recipient, Originator.

SE&I Product Relationships

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Request For Subsystem Requirement Change/Enhancement

Facilitators develop requirements and products based on request

GRL

Data Group	GRL Sequence Number	Role	Requirement	PP:ACINT	PP:ARCH	PP:ASDS	PP:CC	PP:CKTD	PP:DSVL	PP:ECS:NDP	PP:ESM	PP:IA	PP:Imaging	PP:LMDS
Contact	12800	O	The Sensor Report Event provider shall support a 1 Hertz rate for sending Events. This means, that the Sensor Report Event provider can generate Events and will have them in the queue for sending out, on a 1 Hz basis.				O, P						O	
Contact	12820	R	Sensor Report Event recipients shall support a 1 Hertz rate for receiving Events.				1						1	
Contact	12822	O	The Sensor Report Event provider shall provide sensor report events which reference sensor reports containing ownship position data.				O							

Sequence No.

Subsystem Allocation

Subsystem Allocations

Facilitators work with subsystems to generate IDL per requirement

IDL

```
/** @file soundingDepths_cs.idl
 * @b Classification: UNCLASSIFIED
 *
 * @version 0.0 1 August 2001 Initial
 */
#ifndef _soundingDepths_cs_idl_
#define _soundingDepths_cs_idl_
#include "navigation_t.idl"
/**
 * Description: The following is the definition for the sounding depths
 *              client/server interface.
 */
interface soundingDepths_cs {
   /**
    * Description:
    * @return navigation_t::soundingsDepths_t
    */
   navigation_t::soundingsDepths_t getSoundingDepths( );
}; // end soundingDepths_cs
#endif // _soundingDepths_cs_idl_
```

IDL Embedded In Subsystem Application

IIDB (CORBA) - Used to verify subsystem I/F

Data Group	Interface Name	Namespace Name	Method	GRL Sequence Numbers	Comments	PP:ACINT	PP:ARCH	PP:ASDS	PP:CC	PP:CKTD	PP:DSVL	PP:ECS:NDP	PP:ESM	PP:IA	PP:Imaging
Contact	npes_SensorReportEv ents_ev::imagingSens orReportEvent_ev	NPES-.CONTACTS-.Imaging_Sensor_Report_ev-active	npes_SensorReportEvents_ev::imagingSensorReportEvent_ev::newImagingSensorReportEvent	2660, 12800, 12820, 13240, 13260, 15170, 15650, 16570	NBCR 021				O, P, 1						0, 1
Contact	npes_SensorReportEv ents_ev::imagingSens orReportEvent_ev	NPES-.CONTACTS-.Imaging_Sensor_Report_ev-active	npes_SensorReportEvents_ev::imagingSensorReportEvent_ev::updatedImagingSensorReportEvent	2660, 12800, 12820, 13160, 13180, 15170, 15650, 16570	NBCR 021				O, P, 1						0, 1
Contact	npes_SensorReportEv ents_ev::imagingSens orReportEvent_ev	NPES-.CONTACTS-.Imaging_Sensor_Report_ev-active	npes_SensorReportEvents_ev::imagingSensorReportEvent_ev::updatedImagingStaticReportEvent	2660, 12800, 12820, 13120, 13140, 15170, 15650, 16570	NBCR 021				O, P, 1						0, 1
Contact	npes_SensorReportEv ents_ev::radarSensor ReportEvent_ev	NPES-.CONTACTS-.Radar_Sensor_Report_ev-active	npes_SensorReportEvents_ev::radarSensorReportEvent_ev::deleteRadarSensorReportEvent	2660, 12800, 12820, 13560, 13580, 15170, 15650, 16570	NBCR 021				O, P, 1						0, 1

Subsystem Allocations

Linked to a particular interface data rate

Auto generated from IDL

GDD

IDL File Name	Method(s) Producing Data
npes_SensorReportEvents_ev.idl	npes_SensorReportEvents_ev::esmSensorReportEvent_ev::newEsmSensorReportEvent, npes_SensorReportEvents_ev::imagingSensorReportEvent_ev::newImagingSensorReportEvent, npes_SensorReportEvents_ev::radarSensorReportEvent_ev::newRadarSensorReportEvent, npes_SensorReportEvents_ev::sonarSensorReportEvent_ev::newSonarSensorReportEvent, npes_SensorReportEvents_ev::srwsSensorReportEvent_ev::newSrwsSensorReportEvent
npes_SensorReportEvents_ev.idl	npes_SensorReportEvents_ev::esmSensorReportEvent_ev::newEsmSensorReportEvent, npes_SensorReportEvents_ev::imagingSensorReportEvent_ev::newImagingSensorReportEvent, npes_SensorReportEvents_ev::radarSensorReportEvent_ev::newRadarSensorReportEvent, npes_SensorReportEvents_ev::sonarSensorReportEvent_ev::newSonarSensorReportEvent, npes_SensorReportEvents_ev::srwsSensorReportEvent_ev::newSrwsSensorReportEvent

Method: programmed procedure within an interface

Interface Working Group Participants

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Infrastructure:	***Navigation:***	***Contact Data:***	***On-Board Training:***	***Hull/Mechanical Data***	***Communications:***	***Environmental Data:***
Lockheed Martin *Progeny* *Electric Boat* *GD-AIS* *NUWC*	*Lockheed Martin* *Northrop Grumman*	*Raytheon* *GD-AIS* *Lockheed Martin* *Kollmorgan* *NUWC*	*Electric Boat* *Lockheed Martin*	*Electric Boat* *NUWC*	*Electric Boat* *Lockheed Martin* *NUWC* *SPAWAR*	*Lockheed Martin* *GD-AIS* *Electric Boat*

- Integrated Product Team structure to develop and maintain interface specifications and products (GRL, IDL, GDD, Network Design, Information Assurance)
- Adopts widely used standards, data formats, and protocols
- Defines key attributes of the network and services
- Consensus-based interface definition and design

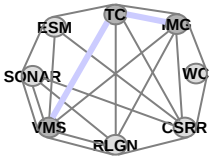
"The key is in designing an architecture that is going to take advantage of commercial standards, the ability to pull pieces out and reuse them in other systems and platforms, and that allows third parties access"
Delores Etter, Assistant Secretary of the Navy for RDA

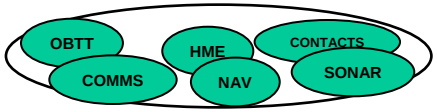
Interface Layers

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Yesterday → Today





Generic Data Transfer Model

- **Semantic**
  - •Data Interpretation
- **Behavioral**
  - •Message Sequencing
  - •Fault/Fail Schema
- **Syntax**
  - •Data Field Definition
- **Interface Protocol**
  - •I/O HW and SW

NTDS Data Transfer Model

Subsystems Domain

- Application Code (IDS / SRS)
- I/O Application Code (IDS)
- NTDS Protocol / Driver (NTDS Spec)
- NTDS | NTDS

CORBA Data Transfer Model

Subsystem Domain

- Application Code (GRL / SRS / GDD)

Shared (System and Subsystem) Domain

- CORBA Application Code (GRL, SIFT, GDD)
- Common IDL

System Domain

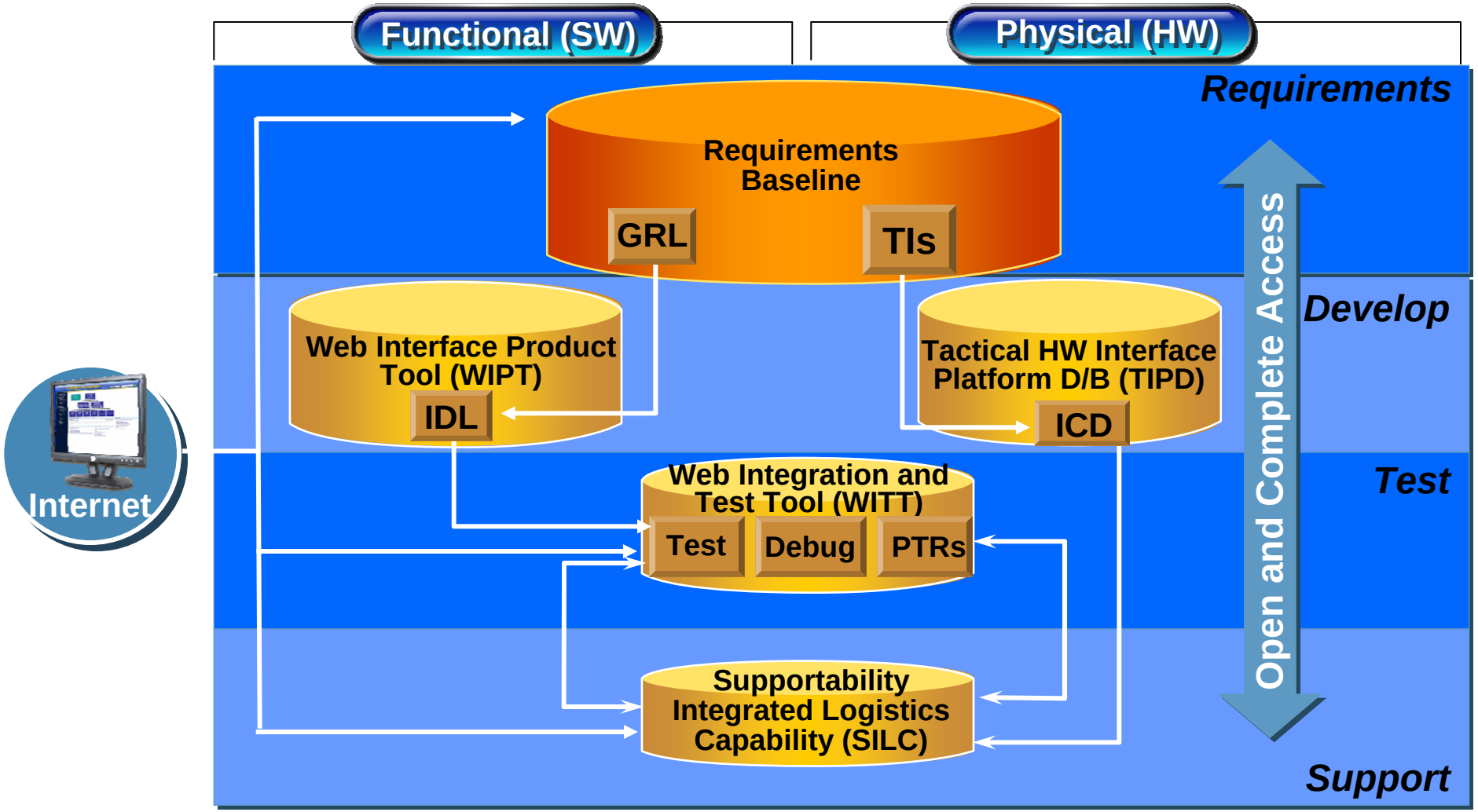
- Network Protocol (Network Spec)
- NIC | NIC
- Network
- Name Services | Time Services

Interface Management designed in to streamline integration by reducing/eliminating at each of the layers of the Interface

SE&I Toolset

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat



Fully integrated and web-enabled toolset for SE&I

What's next?

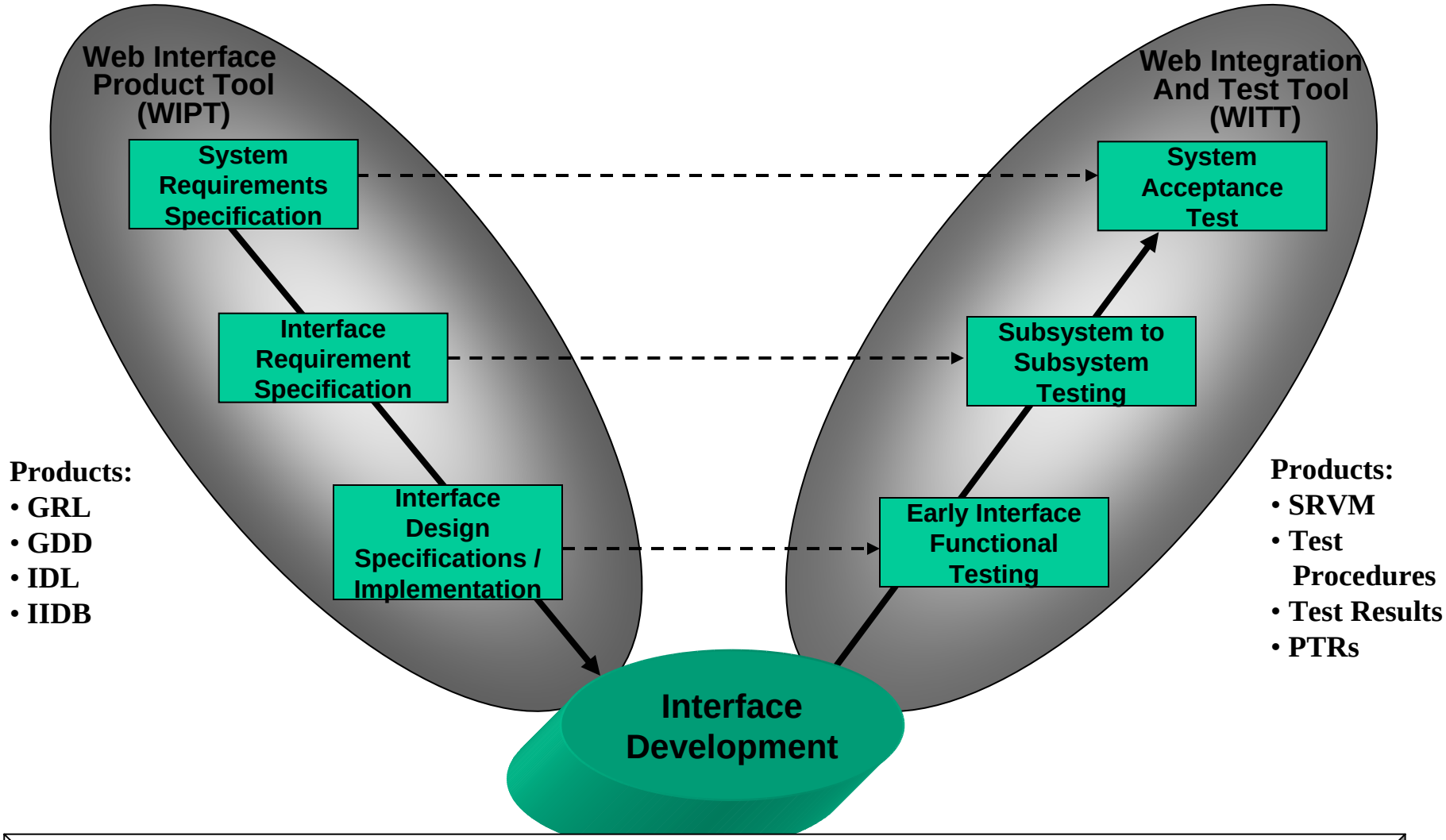
LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- It doesn't end with Interface Management!
  - Systems engineering processes and products must be balanced with integration products and processes
  - There is an inherent relationship between standards, interface engineering and system integration
    - System definition
    - Interface design and development
    - System test and integration
  - The confluence of an open systems architecture, standards and system integration leads to:
    - Easier technology insertion
    - Fielding capability faster
    - Streamlined system integration

SE&I is a balanced approach between interface management, standards and system integration

SE&I Process and Products



Fully integrated and web-enabled toolset for SE&I

Test and Integration
(The "I" in SE&I)

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

Goals:

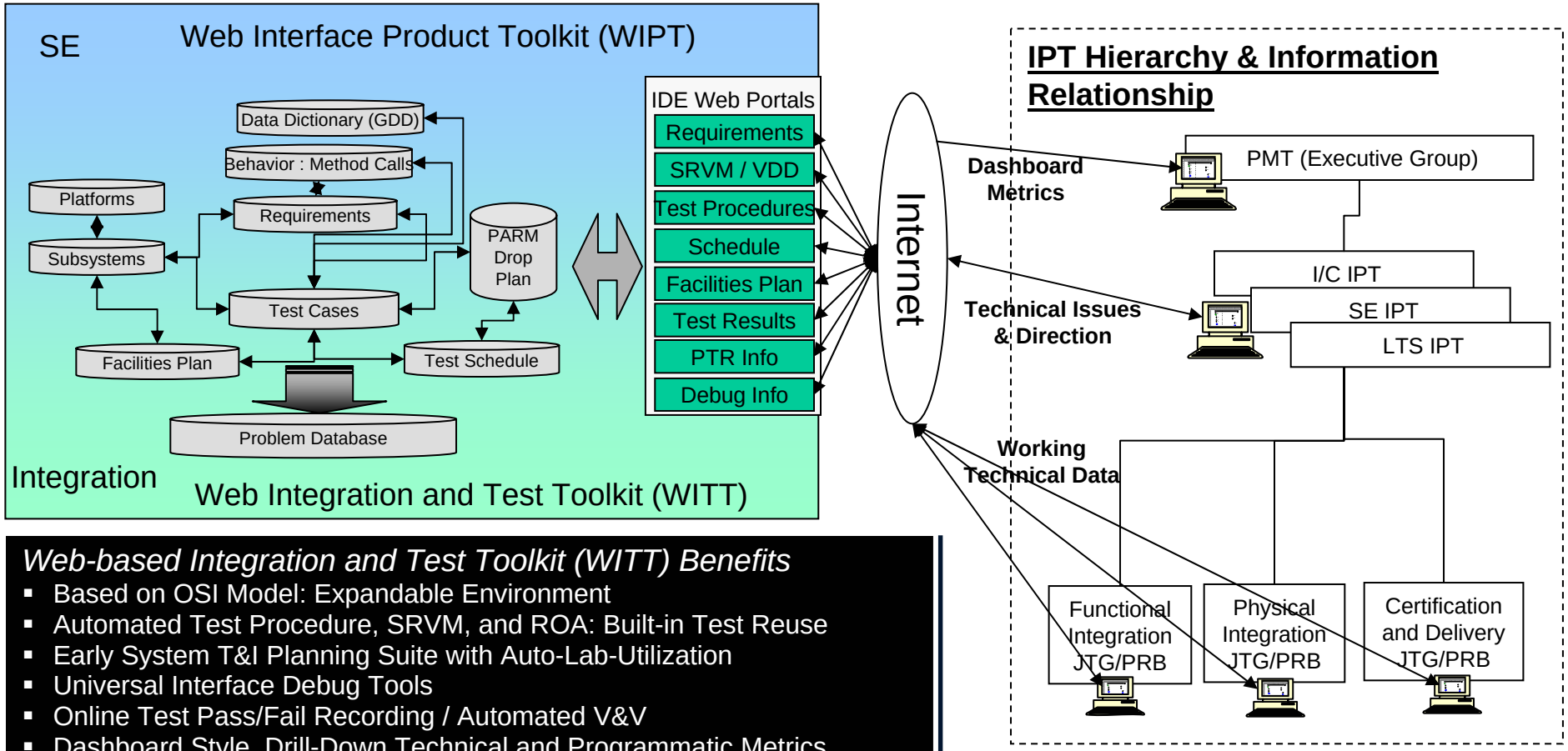
- Achieve a single integrated, cohesive working Combat System
- Risk Mitigation
- Cost containment
- Schedule Control
- Optimize Government and Industry Lab resources
- Early integration and test of interfaces
- Pull integration and Lifetime Support issues from the fleet and solve in labs

Approach:

- Virtual Integration Facilities to optimize capital investments
- Structured interface testing
- Allow collaborative debug of problems from development lab
- Distribution of software builds/patches
- Remote access to development environments
- Responsiveness to Fleet needs
- Support Certification

Networked Labs and Collaboration Provide Mechanisms for Early Integration Testing to Minimize Risk

Automated SE&I Toolkit



Web-based Integration and Test Toolkit (WITT) Benefits

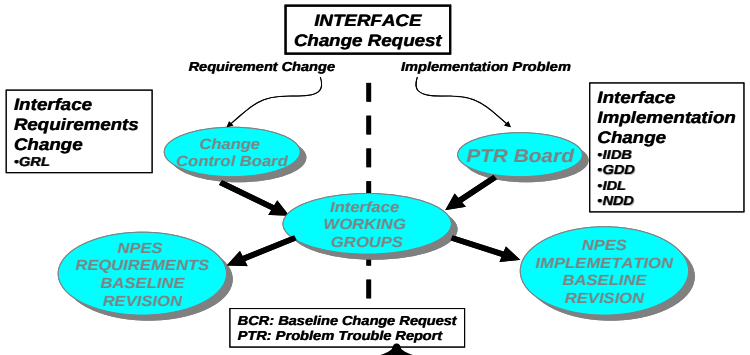
- Based on OSI Model: Expandable Environment
- Automated Test Procedure, SRVM, and ROA: Built-in Test Reuse
- Early System T&I Planning Suite with Auto-Lab-Utilization
- Universal Interface Debug Tools
- Online Test Pass/Fail Recording / Automated V&V
- Dashboard Style, Drill-Down Technical and Programmatic Metrics

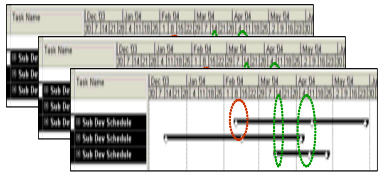
Web-Enabled SE&I Toolkit Connects all Stakeholders

System Engineering & Integration Approach: Test What has Changed; When it is ready

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat



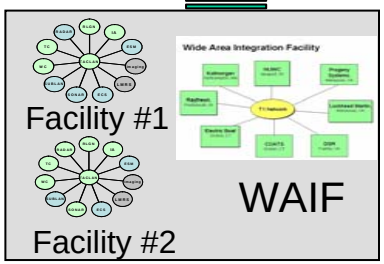


Subsystem Schedules

- Prioritization
- Debug
- Problem Isolation
- Resolution
- Verification

Interface Requirements → Group Products → Test Case Matrix → Test Schedule & Conduct → PTR Adjudication

Test Case Matrix → Facilities Plan



		Subsystem Assessment											IT&E	
NBCR #	Title	TC	WC	Taclan	Sonar	NAV	RADAR	SUBLAN	RADIO	ESM	Imaging	Implemen-tation	Schedule
xxx-750	Update to IPv06	C	C	P	C	C	C	P	P	C	C	H	L
1132-	Net-Centric Warfare (NCW) Distance Support	P			P			C	C			M	L
1133-	Digital Navigation Computer to Computer Information Transfer	P	C	C	C	C	C		P		C	M	L
xxxx-	Consolidation of Displays	PC	PC	PC	PC	PC	PC			PC	PC	H	M
968-	GRL Mapping in IIDB is incorrect	P			C							M	L
047-750	Add Transverse coordinate system data elements to sensor and contact reports	C	C		P		P			P	P	M	M
Other	Network Loading	M	H	M	M	M			M	M	H	H	L
Other	Off-Hull Bandwidth	M		M					M		H	H	M
Other	Taclan Switch Changes	L	H	L	L	L	L	L	L	L	L	H	L

System Integration approach has evolved through several iterations and provides complete management of Requirements, Tests, Facilities, Drops, and PTRs

Lessons Applied

LOCKHEED MARTIN

GENERAL DYNAMICS
Electric Boat

- Be prepared for a major cultural change and manage it!
- Adopt standards widely developed/recognized by industry
- Focus on interface management not subsystem development
- Strive for consensus-based interface definition on all key interfaces early
- New business models and processes will be required
- Link functionality updates (APBs) to bundled interface baseline updates
- Be prepared to migrate with technology (standards lag the technology curve)
- All interfaces are not created equal
- Consider and develop a strategy for information assurance, fault management and fail-over early. Most standards ignore these areas!
- Plan for change!

Interface management is the key!

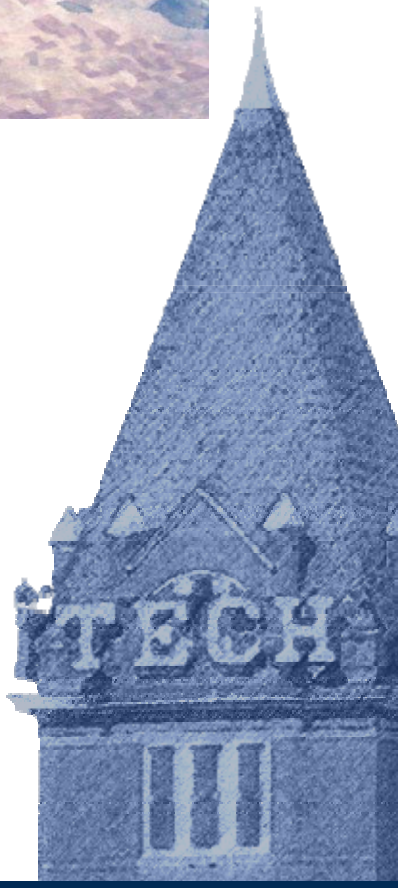




Lessons Learned with Integration of Federated Systems on Legacy Aircraft

Adam McCorkle
GTRI/ELSYS
adam.mccorkle@gtri.gatech.edu
Phone: 404-407-6427

Kendal Hinton
GTRI/ELSYS
kendal.hinton@gtri.gatech.edu
Phone: 404-407-6042



Georgia Tech Research Institute

F-16C+ Fighting Falcon



- F-16C+
  - F-16 Preblock 40
  - Blocks 25, 30, and 32
- Approximately 600 Active Aircraft
  - ANG
  - AFRC
  - ACC
- EW Suite
  - ALQ-213 Countermeasures Set (CMS)
  - ALR-69 Radar Warning Receiver (RWR)
  - Electronic Countermeasures (ECM) Pods
    - ALQ-131
    - ALQ-184
  - ALE-47 Countermeasures Dispenser System (CMDS)
    - Partial
  - Theater Airborne Reconnaissance System (TARS)
  - ALE-50 Towed Decoy

A-10 Thunderbolt

- A-10A
  - “Warthog”
- A-10C
  - Upgrade to Avionics, Weapons, and Cockpit Display Systems
- Approximately 400 Active aircraft
  - ACC
  - AFRC
  - ANG
- EW Suite
  - ALQ-213 CMS
  - ALR-69 RWR
  - ECM Pods
    - ALQ-131
    - ALQ-184
  - AAR-47 Missile Warning System (MWS)
  - ALE-47 CMDS
  - Comet IR Dispense System



ALQ-213 Countermeasures Set (CMS)

- **Replaces All Existing Discrete EW Control Panels**
- **Single Point of Control of All EW Systems**
- **Semi-Automatic and Automatic Capabilities That Adapt to Threat Environment**



ALR-69 Radar Warning Receiver (RWR)

- **Purpose – Detect, Identify, and Output Visual/Audio Information for Friendly and Hostile RF Radar Emitters**
- **Quadrant Detection**
- **Visual Output of Symbology and Angle of Arrival**
- **Audio Output via Aircraft Intercom**



Electronic Countermeasures (ECM) Pods/Jammers

- **Purpose – Provide Defensive Protection for Aircraft Through Defeat or Deception of Radar Systems Attempting to Track the Weapons Platform**
  - **ALQ-131**
  - **ALQ-184**



ALQ-131 ECM Pod

ALE-47 Countermeasure Dispense System

- **Purpose – Provide Defensive Protection for the Weapons Platform Through Ejection of Materials Designed to Distract or Decoy RF and IR Based Systems.**
  - **Chaff – Counters RF-Based Tracking Systems**
  - **Flares – Counters IR-Based Tracking Systems**



AAR-47 Missile Warning System (MWS)

- **Purpose – Detect and Identify IR Emissions Near the Weapons Platform, and Output Visual Information to the Aircrew.**
- **Automatically Triggers an Appropriate Countermeasure to Protect the Pilot and Aircraft**



Theatre Airborne Reconnaissance System (TARS)

- **Purpose – Provide Under-the-Weather, Medium to High Threat, Daytime Imagery Collection**
- **Tactical Reconnaissance Pod System**



ALE-50 Towed Decoy

- **Purpose – Provide a Radar Target Decoy for an Incoming Missile**
- **Towed Behind the Aircraft When Deployed and Protects the Aircraft Against RF-Homing Missiles by Drawing Them Away From the Host Aircraft**



COMET Dispenser Pod

- **Purpose – Provides Extended Duration Protection for Aircraft in Infrared Threat Environment**
- **MIL-STD-1553 Control Interface**
- **Developmental System Not Currently Fielded**



History of System Integration

- 1950s and 1960s – Aviation Electronics are Mainly Analog and Stand-alone Systems
- Late 1960s and 1970s – Became Necessary to Share Information Between Systems
  - Accomplished Primarily via Discrete Analog Signal Interfaces and/or A/D Converters
  - Required Increasingly Complex Wiring and Connections

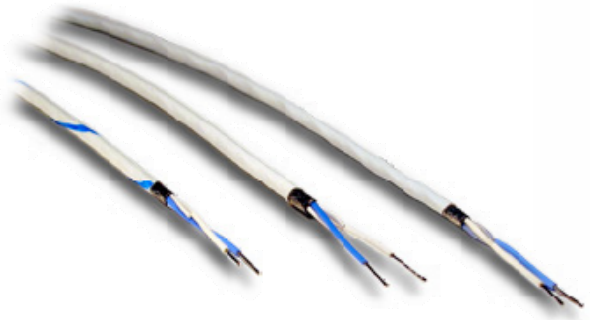
History of System Integration

- **Late 1970s – Advent of Digital Technology Made Possible Increasingly Sophisticated Systems Powered by Computers**
  - **Led to a Need for Higher Speed Transfer of Data Between Systems**
  - **Digital Interfaces Conceived to Address this Problem But With an Increase in the Amount of Wiring and Connector Complexity Required**
  - **Eventually the Need Arose for a Transmission Medium that Would Allow Multiple Systems to Share a Single, Common Set of Wires**

Purpose of MIL-STD-1553

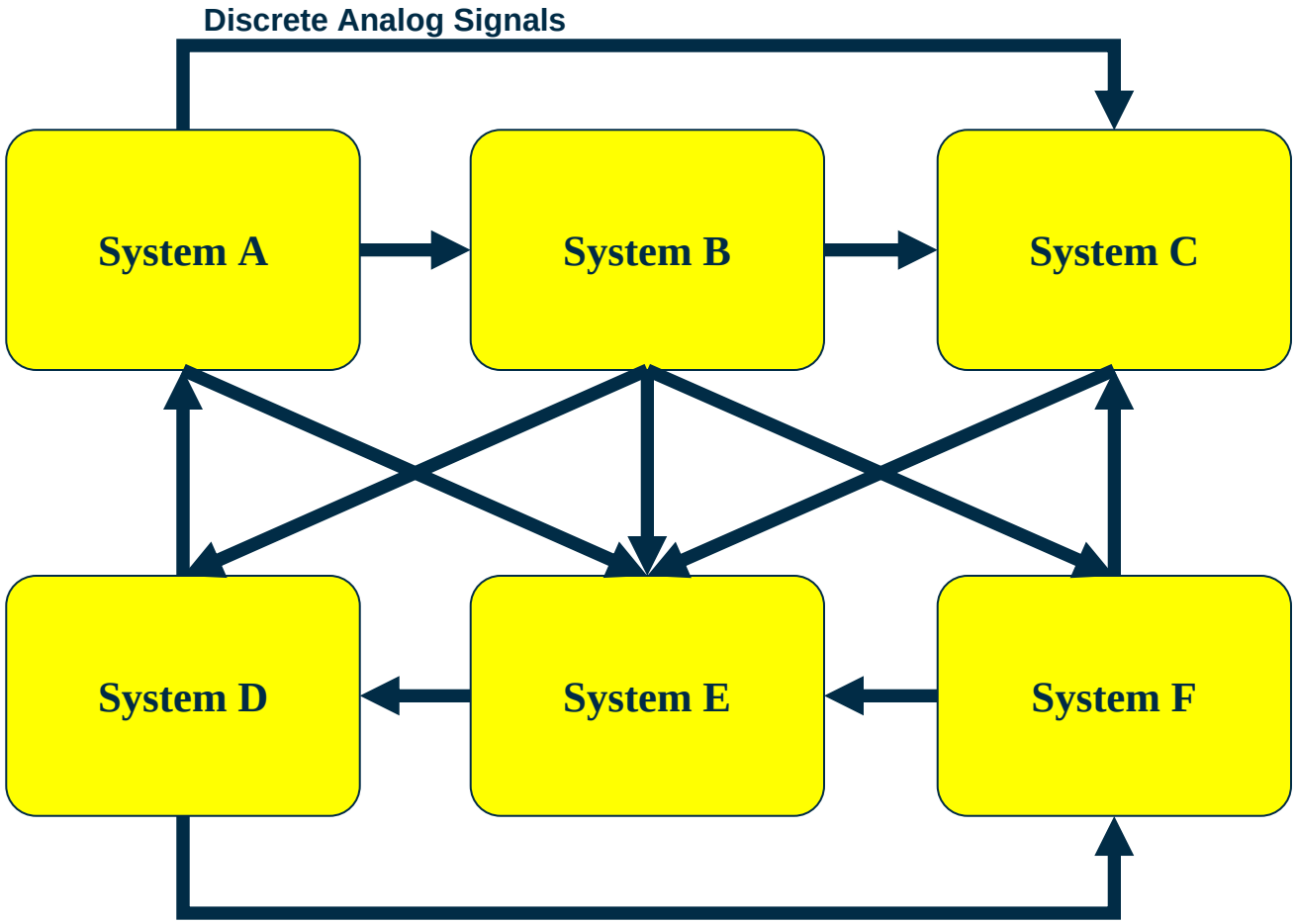
- **MIL-STD-1553 Was Developed to Provide a Standard Solution that Would Allow Multiple Systems to Share a Single Common Set of Wires (Data Bus) in Order to Efficiently Move Data Between Systems**



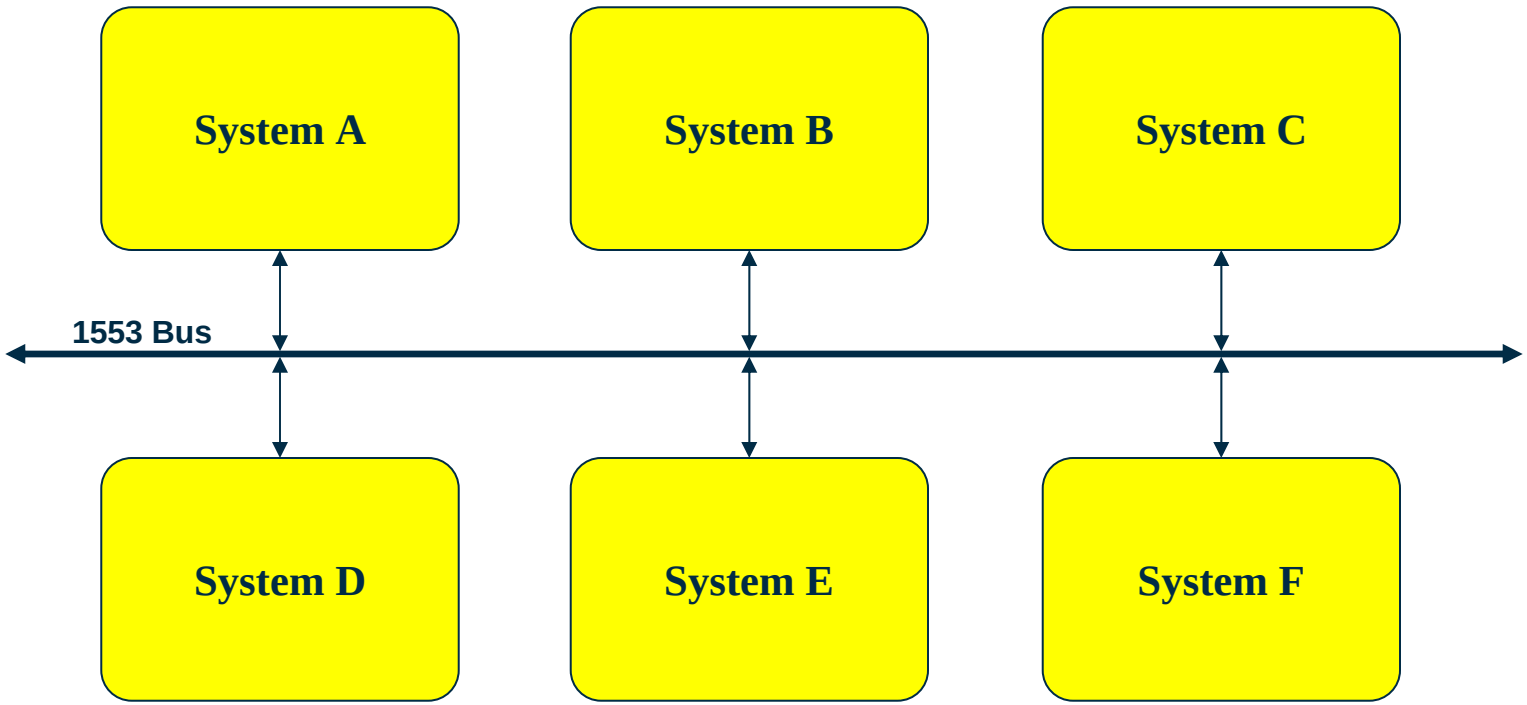




Purpose of MIL-STD-1553



Purpose of MIL-STD-1553



History of MIL-STD-1553

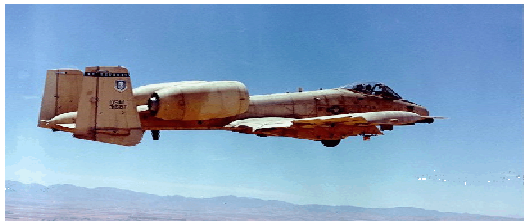
- Late 1960's – H-009 Data Bus Specification Used on the F-15 (Early Forerunner of 1553)
- 1968 – SAE Establishes Subcommittee to Define a New Serial Bus Standard for the Military Avionics Community
- 1970 – First Draft (From SAE/A2K) Developed
- 1973 – MIL-STD-1553 Released
  - USAF Only Version of the Standard
  - Primary User was the F-16

History of MIL-STD-1553

- 1975 – MIL-STD-1553A Released
  - First Tri-Service Version of the Standard
  - F-16
  - AH-64A
- 1978 – MIL-STD-1553B Released
  - Standard “Frozen” at Revision “B”
  - Allowed for Component Manufacturers to Develop Standard Products That Provide for Easy Implementation
- 1996 – Release of Notice 4
  - Current Version Used by Military

Applications of MIL-STD-1553

- Air Force
  - Virtually Every Platform
  - Avionics and EW
  - F-15, F-16, A-10, C-5, C-130, C-141
- Navy
  - Surface and Subsurface Ships
- Army
  - Helicopters, Tanks, Howitzers
- Other
  - Satellites
  - Space Shuttle Payloads
  - International Space Station
  - Bay Area Rapid Transit (BART)
  - Manufacturing Production Lines



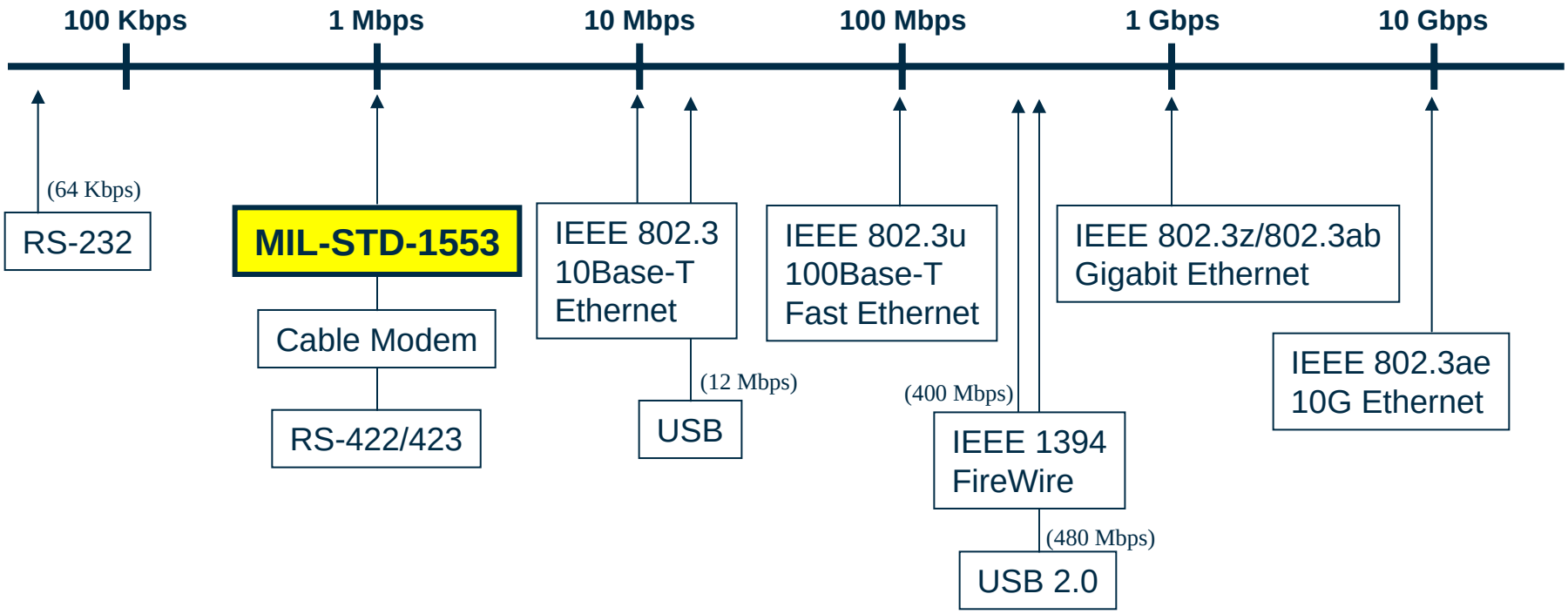
MIL-STD-1553 Basics: Overview

Data Rate	1 MHz
Word Length	20 bits
Data Bits / Word	16 bits
Message Length	Maximum of 32 Data Words
Transmission Technique	Half-Duplex
Operation	Asynchronous
Encoding	Manchester II Bi-Phase
Protocol	Command / Response
Bus Control	One BC at a Time
Fault Tolerance	Dual Redundant (A & B bus)

MIL-STD-1553 Basics: Overview (Continued)

Message Formats	BC-RT RT-BC RT-RT Broadcast System Control (Mode Codes)
Number of Remote Terminals	Maximum of 31
Terminal Types	Remote Terminal (RT) Bus Controller (BC) Bus Monitor (BM)
Transmission Media	Twisted Shielded Pair
Coupling	Transformer and Direct

MIL-STD-1553 Basics: Comparison to Other Standards



Hardware Upgrades for 1553 Integration



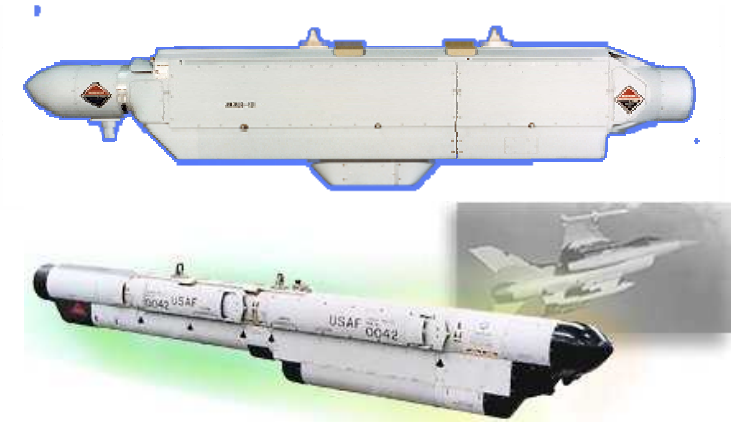
ALR-69 RWR 1553 Upgrade

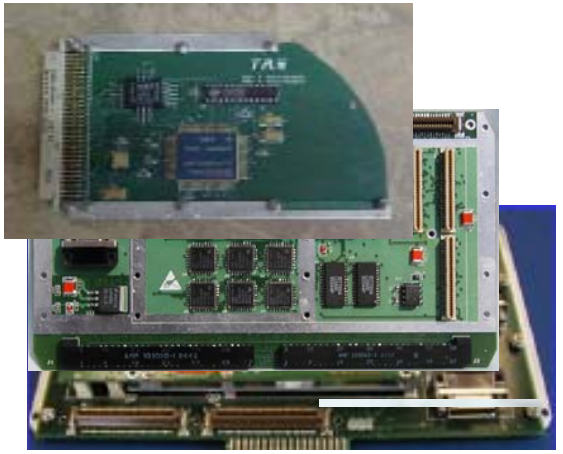
- ALR-69 was Originally Controlled with System Control Panels via Bi-Directional Discrete Signals
- The ALR-69 Class IV Upgrade Fielded in the Mid '90s Provided Two 1553 Interfaces for the System
- The System was Then Capable of Sharing Data and Being Controlled Over 1553



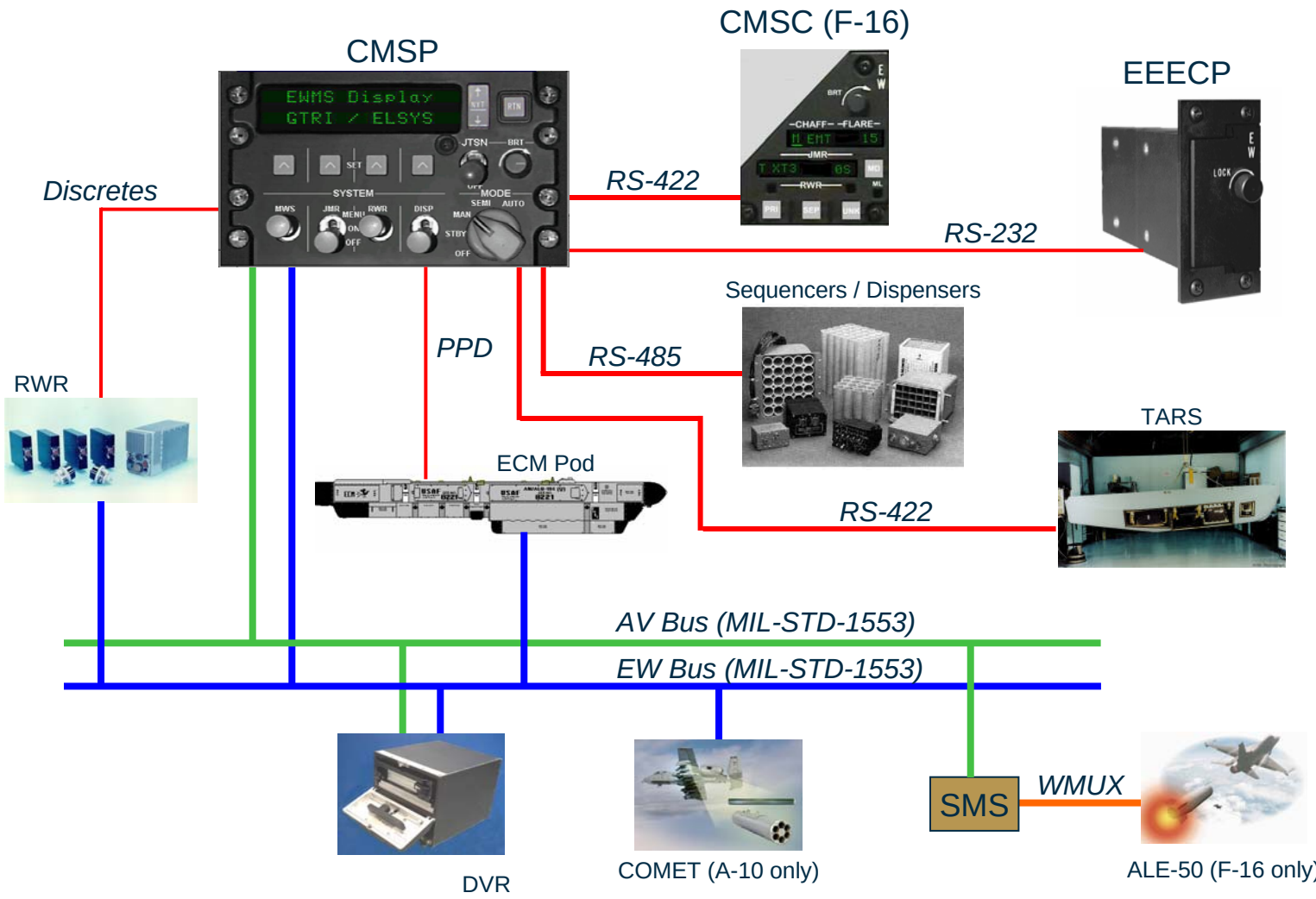
ALQ-131/ALQ-184 ECM Pods

- Both the ALQ-131 and ALQ-184 Pods Were Originally Designed to Interface with the Pulse Position Data (PPD) Bus
- 1553 Interfaces Have Been Developed for Both Pods, But Have Not Been Used Due to Limitations
- Northrop Grumman's RePLACE Hardware Solutions Offer New 1553 Interfaces That Meet EW Suite Requirements





ALQ-213 System Block Diagram



Message Protocol Schemes

- **Three Basic Types of Message Protocol Schemes**
  - **All Messages are Periodic, or**
  - **All Messages are Aperiodic, or**
  - **Mixture of Periodic and Aperiodic Messages**

Time Division Multiplexing

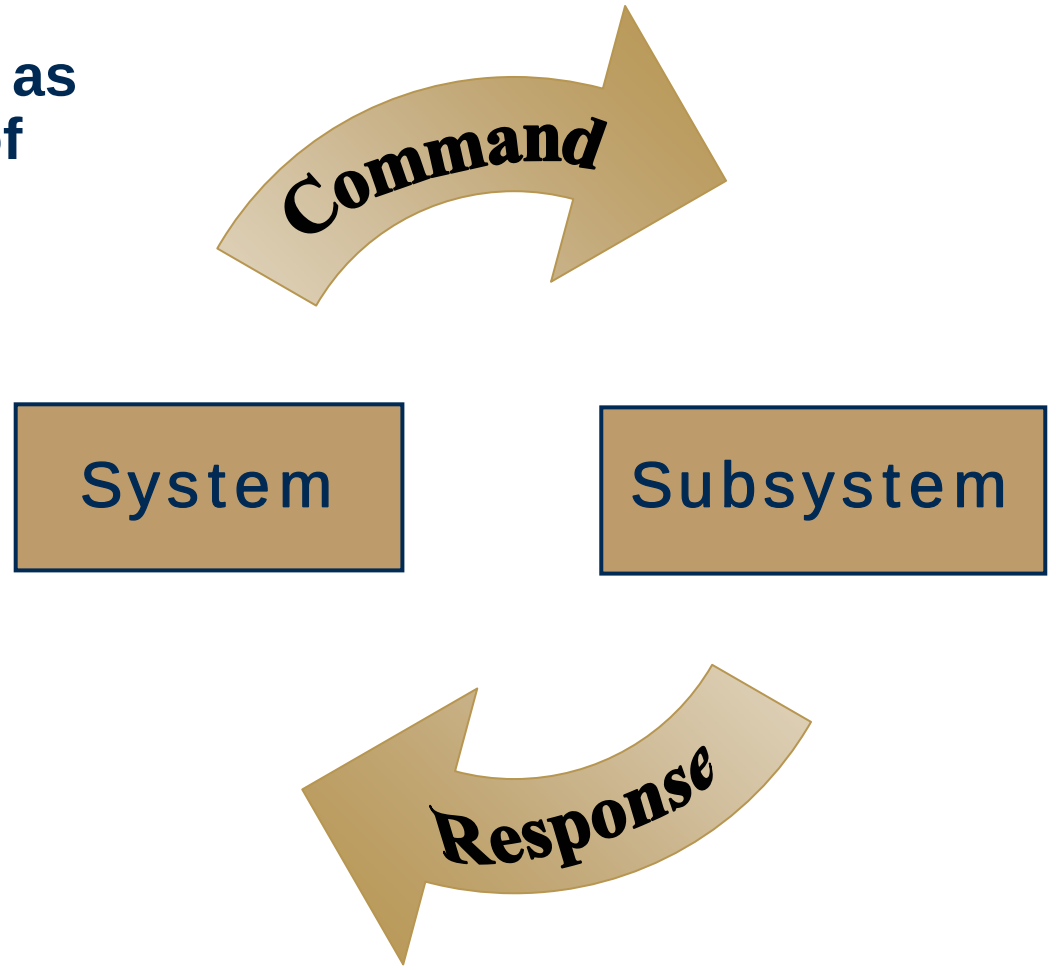
- **Time Division Multiplexing (TDM) Is a Structured Architecture-Level Protocol Design Methodology**
  - **All Messages are Periodic**
  - **Messages are Transmitted at Pre-Defined Rates**
  - **Traffic is *NOT* Sent on Basis of a Special Condition**
  - **Fixed Bandwidth – Data is Always on the Bus**

Time Division Multiplexing

- Advantages
  - Helps Ensure the Integrity of Data Traffic
  - Guarantees Bus Throughput
    - Bandwidth Can be Calculated in Advance
  - Fixed and Known Maximum Latency for Data Transfers
- Disadvantages
  - Always Uses the Same Amount of Bandwidth

System Control Over 1553 Interface

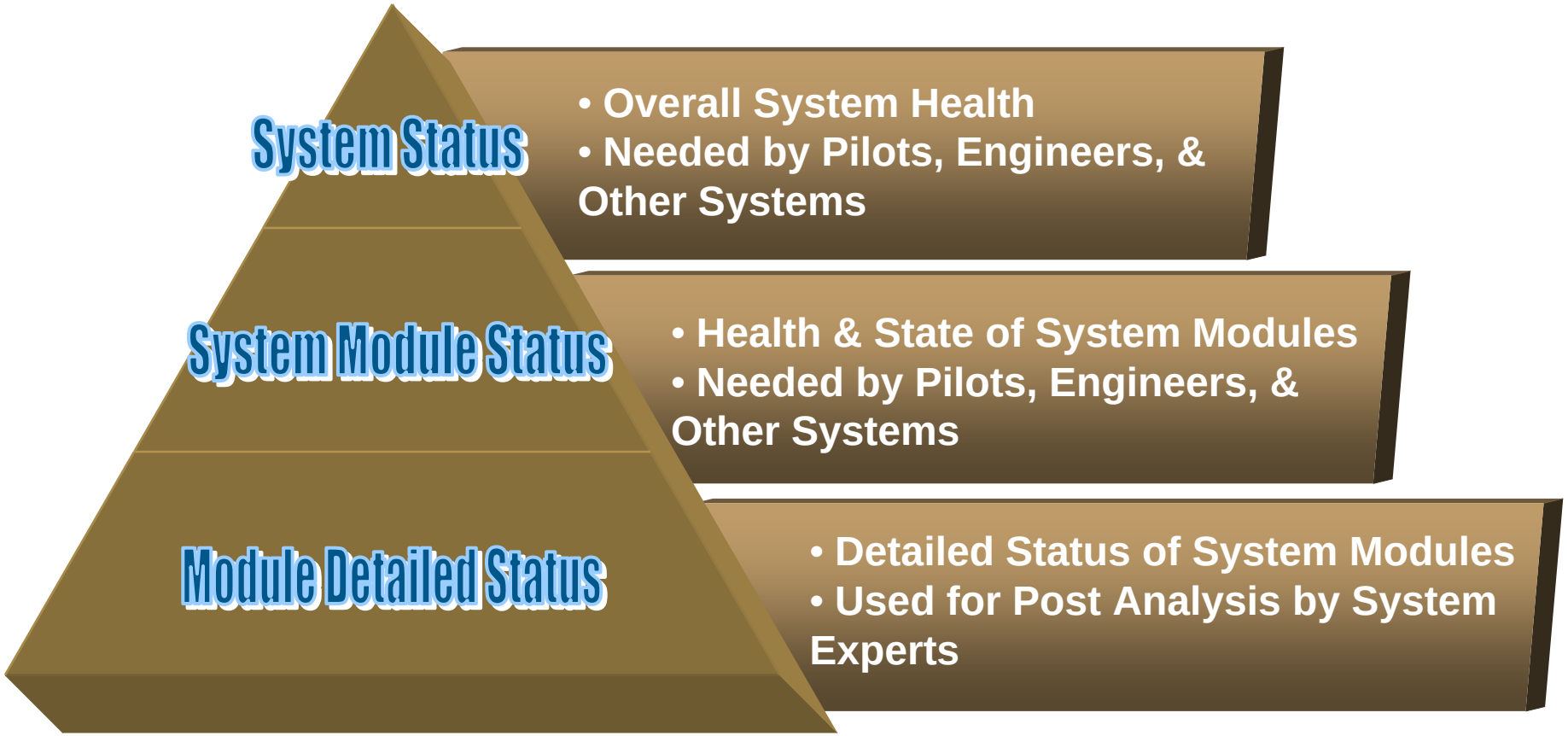
- The 1553 Interface Serves as a Replacement for Many of the Older Discrete Signal Interfaces
- Every Single Control Function Should Have an Associated Response
  - This is Typically Accomplished Using a Control Message and a Status Message



System Status Message

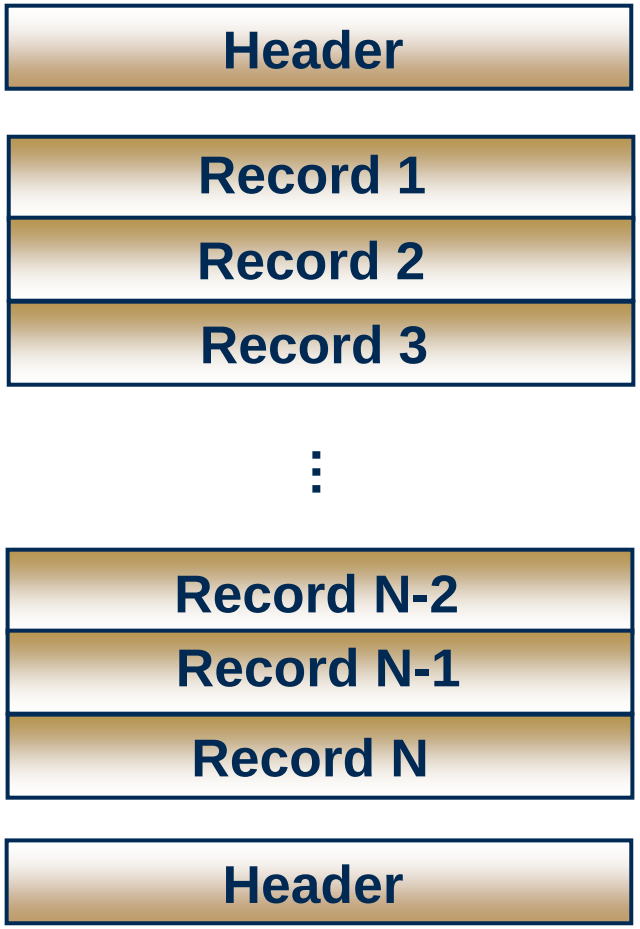
- Overall Health of the System
- Real-Time State of the System (i.e. Warm-up, Test Mode, Power Down Mode, etc.)
- Used for Mission Critical & Non-Mission Critical Failure Determination
- Detailed Modules' Status is Rolled Up into Overall System State

System Status Roll-up



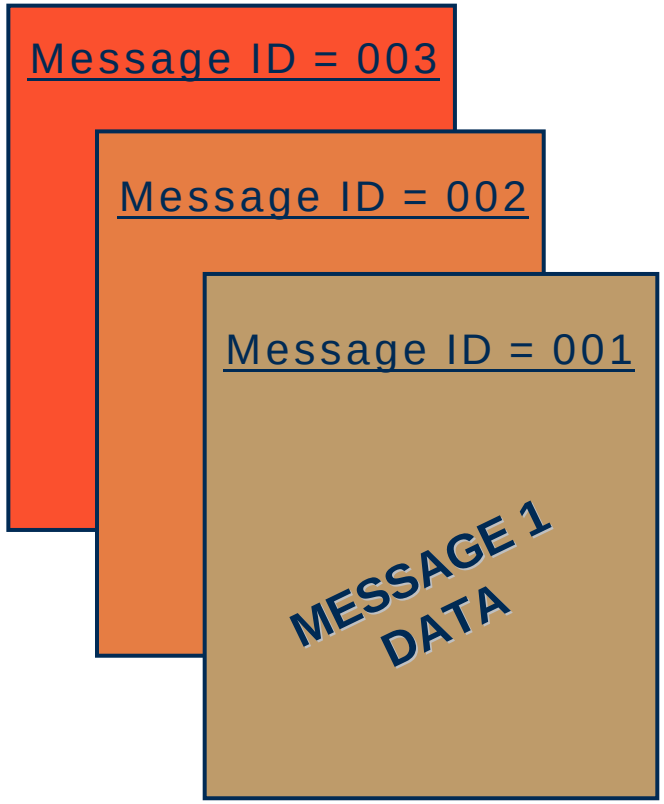
Header/Record Data Formats

- Used When There are Multiple Entries of Data with the Same Format
- Commonly Used with Track Files
- Frequency of Header is Proportional to the Number & Frequency of Records



Message Overloading

- **Overloading is Used When:**
  - **Limited Number of Subaddresses are Available**
  - **Information with Similar Data Formats**
- **Advantage: Reduces Overall Bandwidth**



Instrumentation Messages

- Typically Assigned to 1 Subaddress
- Message Overloading May be Necessary
- Usually Sent at Fastest Rate Possible
- Contents of Instrumentation Messages Should Not Be Used by Other Systems for Integration Purposes
- Data Used by System Experts for Trouble Shooting and Post Analysis



Extending the Standard

- Zero-Fill Unused Data
  - Attempt to Have “0” as an Undefined Value
- Subaddress Assignment
  - Unassigned Subaddresses Should Always Respond With Zero-Filled Data
  - Similar Systems Should Have Similar Subaddress Assignments
- Multiple Busses on an Aircraft Should be Synchronized
  - Accomplished via Timing Messages & 1553 Mode Codes

Benefits of 1553 Integration

- Less Hardware & Software Support
  - Discrete Signal & Serial Interfaces are Replaced
- Migration Towards an Integrated Suite
  - Mission Data & Techniques Can be Coordinated
  - Systems Can Share Information
- Everybody Speaks the Same Language
  - Protocol Governs What Can and Cannot be Done
  - Format of Documentation is Standardized
  - Reduction in System Integration Time & Effort

Questions?



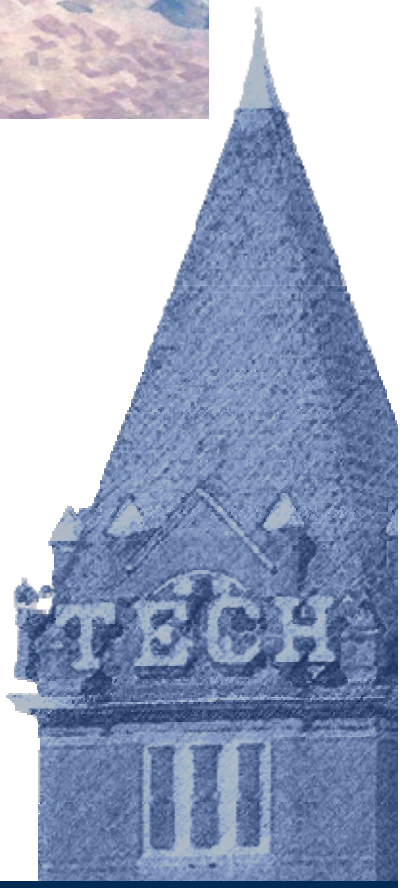




Lessons Learned with Integration of Federated Systems on Legacy Aircraft

Adam McCorkle
GTRI/ELSYS
adam.mccorkle@gtri.gatech.edu
Phone: 404-407-6427

Kendal Hinton
GTRI/ELSYS
kendal.hinton@gtri.gatech.edu
Phone: 404-407-6042



Georgia Tech Research Institute

F-16C+ Fighting Falcon



- F-16C+
  - F-16 Preblock 40
  - Blocks 25, 30, and 32
- Approximately 600 Active Aircraft
  - ANG
  - AFRC
  - ACC
- EW Suite
  - ALQ-213 Countermeasures Set (CMS)
  - ALR-69 Radar Warning Receiver (RWR)
  - Electronic Countermeasures (ECM) Pods
    - ALQ-131
    - ALQ-184
  - ALE-47 Countermeasures Dispenser System (CMDS)
    - Partial
  - Theater Airborne Reconnaissance System (TARS)
  - ALE-50 Towed Decoy

A-10 Thunderbolt

- A-10A
  - “Warthog”
- A-10C
  - Upgrade to Avionics, Weapons, and Cockpit Display Systems
- Approximately 400 Active aircraft
  - ACC
  - AFRC
  - ANG
- EW Suite
  - ALQ-213 CMS
  - ALR-69 RWR
  - ECM Pods
    - ALQ-131
    - ALQ-184
  - AAR-47 Missile Warning System (MWS)
  - ALE-47 CMDS
  - Comet IR Dispense System



ALQ-213 Countermeasures Set (CMS)

- **Replaces All Existing Discrete EW Control Panels**
- **Single Point of Control of All EW Systems**
- **Semi-Automatic and Automatic Capabilities That Adapt to Threat Environment**



ALR-69 Radar Warning Receiver (RWR)

- **Purpose – Detect, Identify, and Output Visual/Audio Information for Friendly and Hostile RF Radar Emitters**
- **Quadrant Detection**
- **Visual Output of Symbology and Angle of Arrival**
- **Audio Output via Aircraft Intercom**



Electronic Countermeasures (ECM) Pods/Jammers

- **Purpose – Provide Defensive Protection for Aircraft Through Defeat or Deception of Radar Systems Attempting to Track the Weapons Platform**
  - **ALQ-131**
  - **ALQ-184**



ALQ-131 ECM Pod

ALE-47 Countermeasure Dispense System

- **Purpose – Provide Defensive Protection for the Weapons Platform Through Ejection of Materials Designed to Distract or Decoy RF and IR Based Systems.**
  - **Chaff – Counters RF-Based Tracking Systems**
  - **Flares – Counters IR-Based Tracking Systems**



AAR-47 Missile Warning System (MWS)

- **Purpose – Detect and Identify IR Emissions Near the Weapons Platform, and Output Visual Information to the Aircrew.**
- **Automatically Triggers an Appropriate Countermeasure to Protect the Pilot and Aircraft**



Theatre Airborne Reconnaissance System (TARS)

- **Purpose – Provide Under-the-Weather, Medium to High Threat, Daytime Imagery Collection**
- **Tactical Reconnaissance Pod System**



ALE-50 Towed Decoy

- **Purpose – Provide a Radar Target Decoy for an Incoming Missile**
- **Towed Behind the Aircraft When Deployed and Protects the Aircraft Against RF-Homing Missiles by Drawing Them Away From the Host Aircraft**



COMET Dispenser Pod

- **Purpose – Provides Extended Duration Protection for Aircraft in Infrared Threat Environment**
- **MIL-STD-1553 Control Interface**
- **Developmental System Not Currently Fielded**



History of System Integration

- 1950s and 1960s – Aviation Electronics are Mainly Analog and Stand-alone Systems
- Late 1960s and 1970s – Became Necessary to Share Information Between Systems
  - Accomplished Primarily via Discrete Analog Signal Interfaces and/or A/D Converters
  - Required Increasingly Complex Wiring and Connections

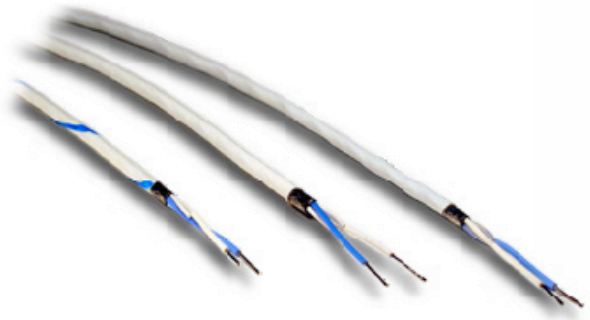
History of System Integration

- **Late 1970s – Advent of Digital Technology Made Possible Increasingly Sophisticated Systems Powered by Computers**
  - **Led to a Need for Higher Speed Transfer of Data Between Systems**
  - **Digital Interfaces Conceived to Address this Problem But With an Increase in the Amount of Wiring and Connector Complexity Required**
  - **Eventually the Need Arose for a Transmission Medium that Would Allow Multiple Systems to Share a Single, Common Set of Wires**

Purpose of MIL-STD-1553

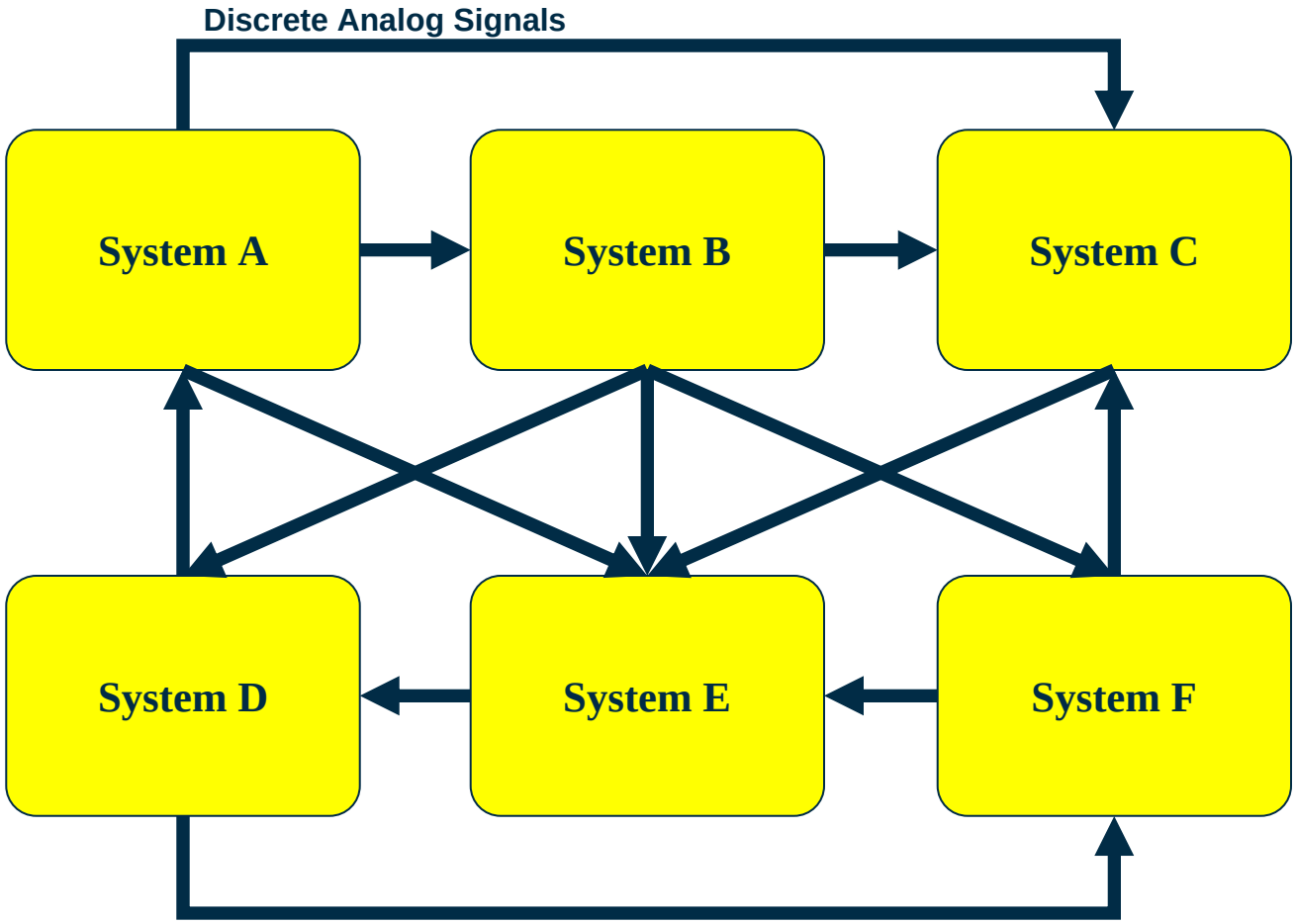
- **MIL-STD-1553 Was Developed to Provide a Standard Solution that Would Allow Multiple Systems to Share a Single Common Set of Wires (Data Bus) in Order to Efficiently Move Data Between Systems**



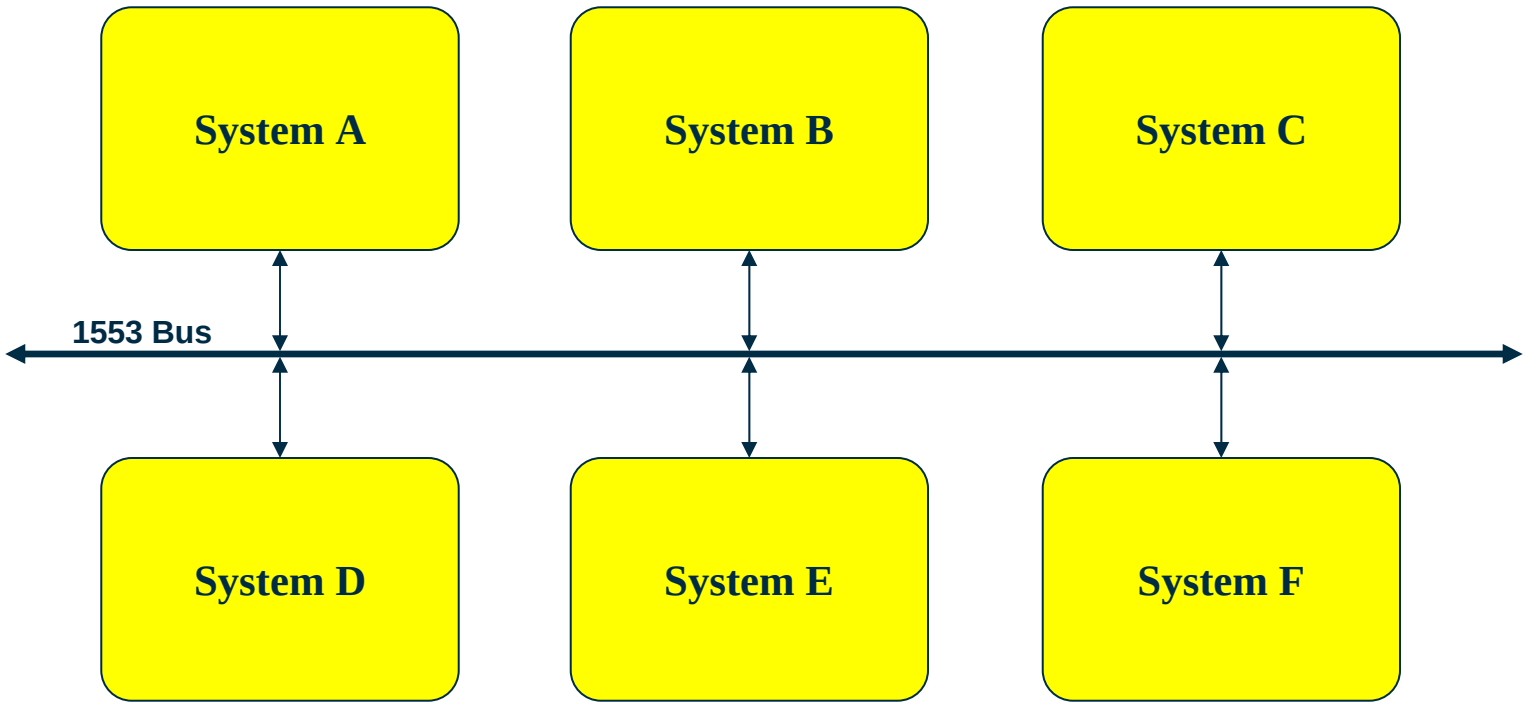




Purpose of MIL-STD-1553



Purpose of MIL-STD-1553



History of MIL-STD-1553

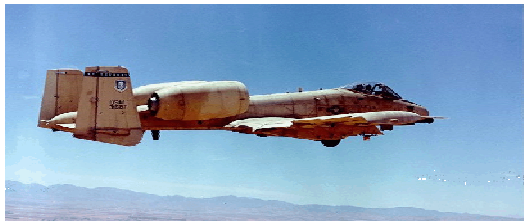
- Late 1960's – H-009 Data Bus Specification Used on the F-15 (Early Forerunner of 1553)
- 1968 – SAE Establishes Subcommittee to Define a New Serial Bus Standard for the Military Avionics Community
- 1970 – First Draft (From SAE/A2K) Developed
- 1973 – MIL-STD-1553 Released
  - USAF Only Version of the Standard
  - Primary User was the F-16

History of MIL-STD-1553

- 1975 – MIL-STD-1553A Released
  - First Tri-Service Version of the Standard
  - F-16
  - AH-64A
- 1978 – MIL-STD-1553B Released
  - Standard “Frozen” at Revision “B”
  - Allowed for Component Manufacturers to Develop Standard Products That Provide for Easy Implementation
- 1996 – Release of Notice 4
  - Current Version Used by Military

Applications of MIL-STD-1553

- Air Force
  - Virtually Every Platform
  - Avionics and EW
  - F-15, F-16, A-10, C-5, C-130, C-141
- Navy
  - Surface and Subsurface Ships
- Army
  - Helicopters, Tanks, Howitzers
- Other
  - Satellites
  - Space Shuttle Payloads
  - International Space Station
  - Bay Area Rapid Transit (BART)
  - Manufacturing Production Lines



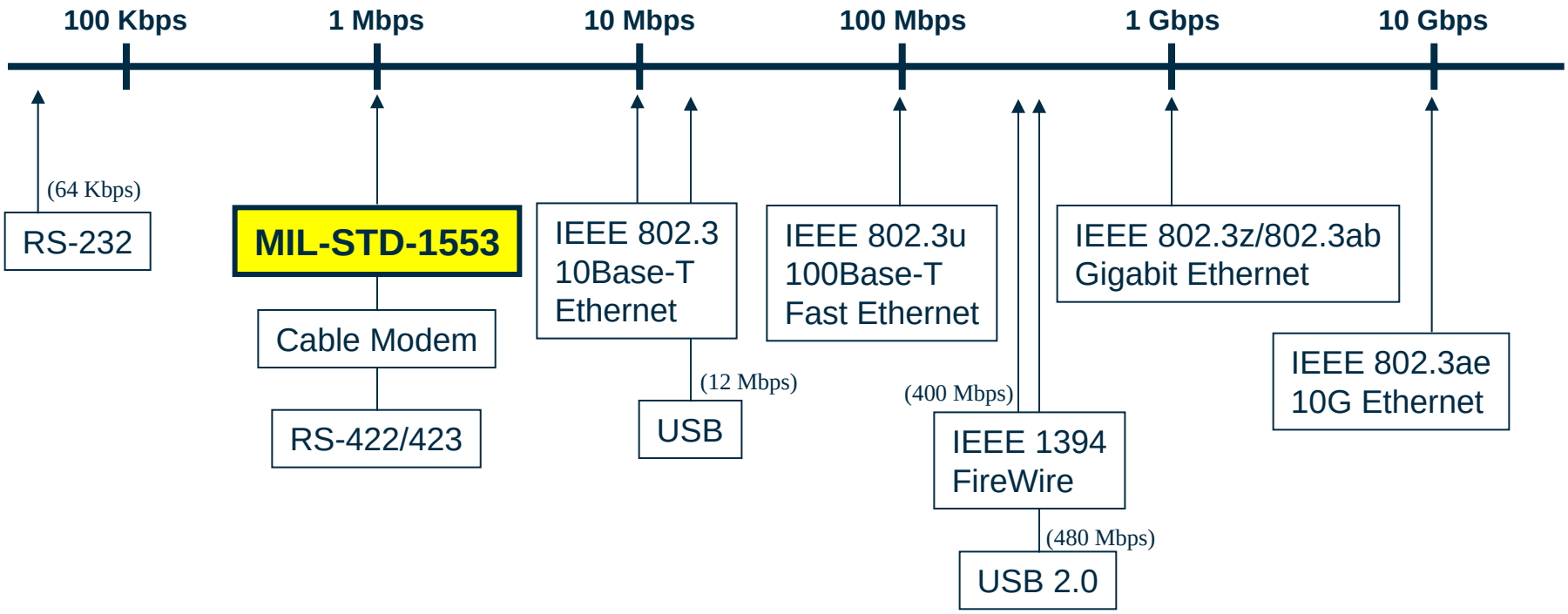
MIL-STD-1553 Basics: Overview

Data Rate	1 MHz
Word Length	20 bits
Data Bits / Word	16 bits
Message Length	Maximum of 32 Data Words
Transmission Technique	Half-Duplex
Operation	Asynchronous
Encoding	Manchester II Bi-Phase
Protocol	Command / Response
Bus Control	One BC at a Time
Fault Tolerance	Dual Redundant (A & B bus)

MIL-STD-1553 Basics: Overview (Continued)

Message Formats	BC-RT RT-BC RT-RT Broadcast System Control (Mode Codes)
Number of Remote Terminals	Maximum of 31
Terminal Types	Remote Terminal (RT) Bus Controller (BC) Bus Monitor (BM)
Transmission Media	Twisted Shielded Pair
Coupling	Transformer and Direct

MIL-STD-1553 Basics: Comparison to Other Standards

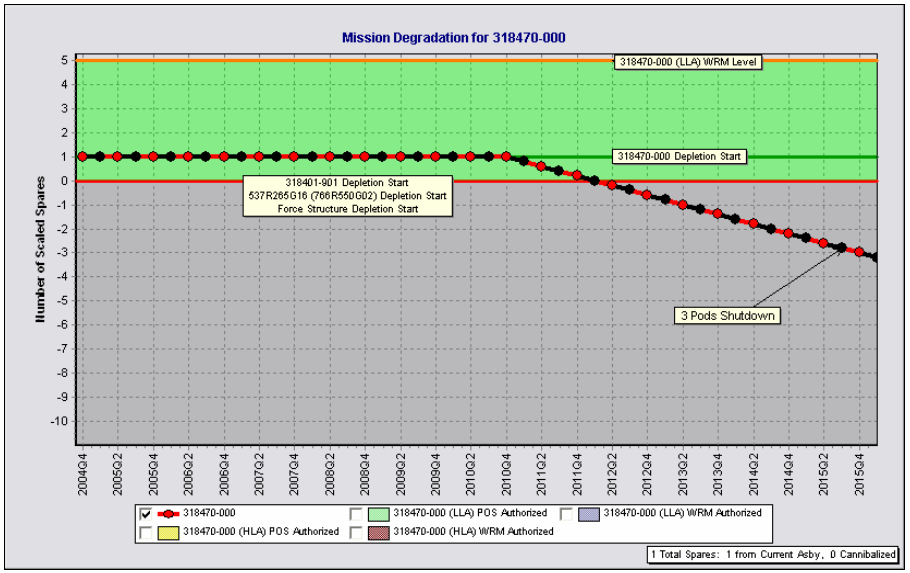


Hardware Upgrades for 1553 Integration



Diminishing Manufacturing Sources

- GTRI Developed SUSTAIN Tool Helps Catalog High Risk DMS Components
- SUSTAIN Reports From System Level Down to Lowest Level Assemblies (LLA)
- Concerned With:
  - High Number of Mission Incapable Supplies (MICAPS)
  - Low Mean Time Between Failures (MTBFs)
  - High Cost Components
  - Obsolete Components
  - Spare Assemblies in Stock
- SUSTAIN Predicts Mission Degradation Based on These Factors



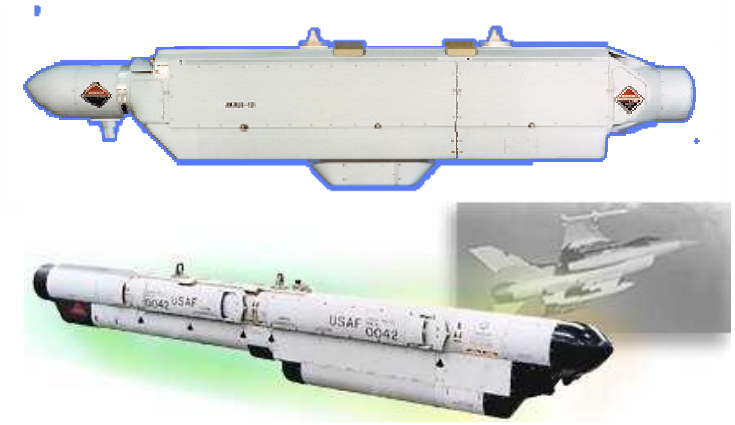
ALR-69 RWR 1553 Upgrade

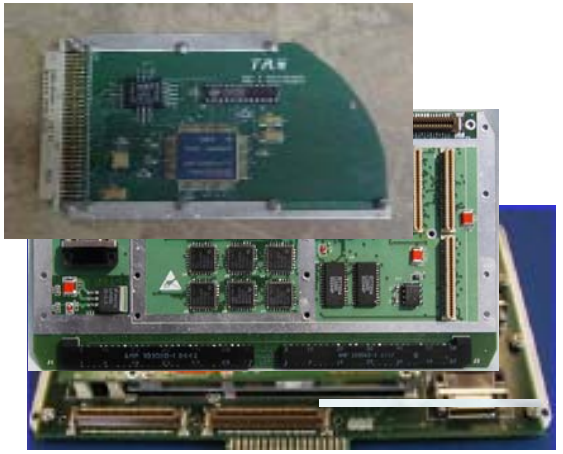
- ALR-69 was Originally Controlled with System Control Panels via Bi-Directional Discrete Signals
- The ALR-69 Class IV Upgrade Fielded in the Mid '90s Provided Two 1553 Interfaces for the System
- The System was Then Capable of Sharing Data and Being Controlled Over 1553



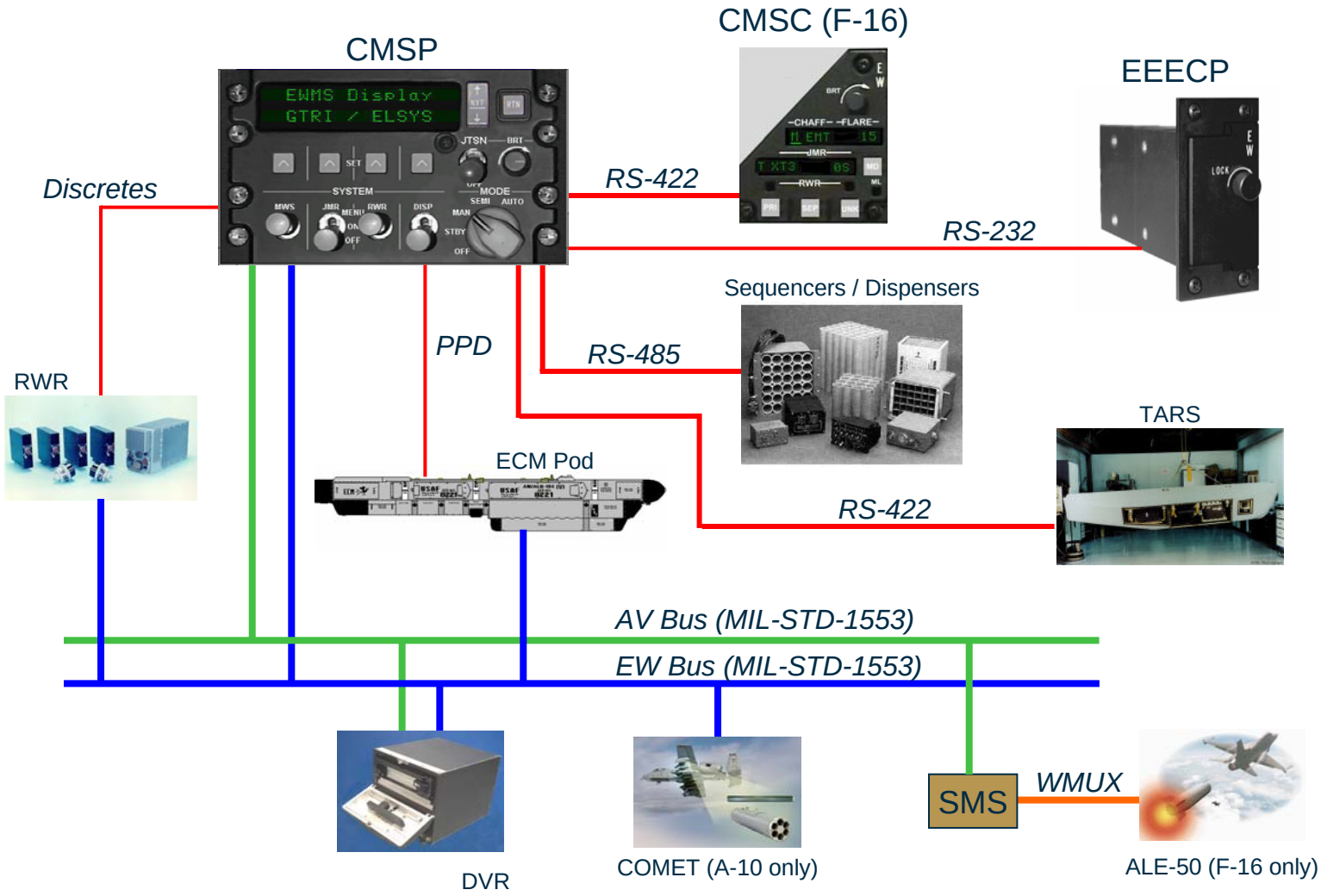
ALQ-131/ALQ-184 ECM Pods

- Both the ALQ-131 and ALQ-184 Pods Were Originally Designed to Interface with the Pulse Position Data (PPD) Bus
- 1553 Interfaces Have Been Developed for Both Pods, But Have Not Been Used Due to Limitations
- Northrop Grumman's RePLACE Hardware Solutions Offer New 1553 Interfaces That Meet EW Suite Requirements





ALQ-213 System Block Diagram



Message Protocol Schemes

- **Three Basic Types of Message Protocol Schemes**
  - **All Messages are Periodic, or**
  - **All Messages are Aperiodic, or**
  - **Mixture of Periodic and Aperiodic Messages**

Time Division Multiplexing

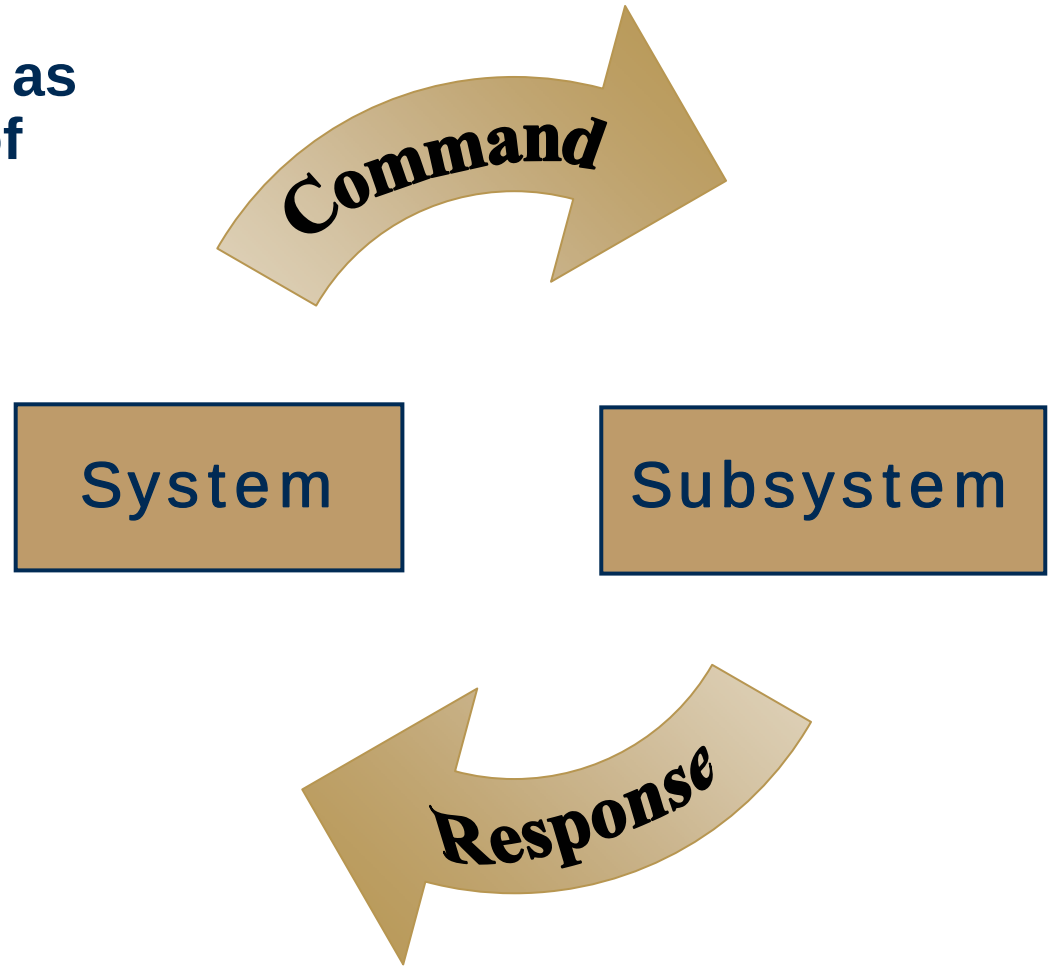
- **Time Division Multiplexing (TDM) Is a Structured Architecture-Level Protocol Design Methodology**
  - **All Messages are Periodic**
  - **Messages are Transmitted at Pre-Defined Rates**
  - **Traffic is *NOT* Sent on Basis of a Special Condition**
  - **Fixed Bandwidth – Data is Always on the Bus**

Time Division Multiplexing

- Advantages
  - Helps Ensure the Integrity of Data Traffic
  - Guarantees Bus Throughput
    - Bandwidth Can be Calculated in Advance
  - Fixed and Known Maximum Latency for Data Transfers
- Disadvantages
  - Always Uses the Same Amount of Bandwidth

System Control Over 1553 Interface

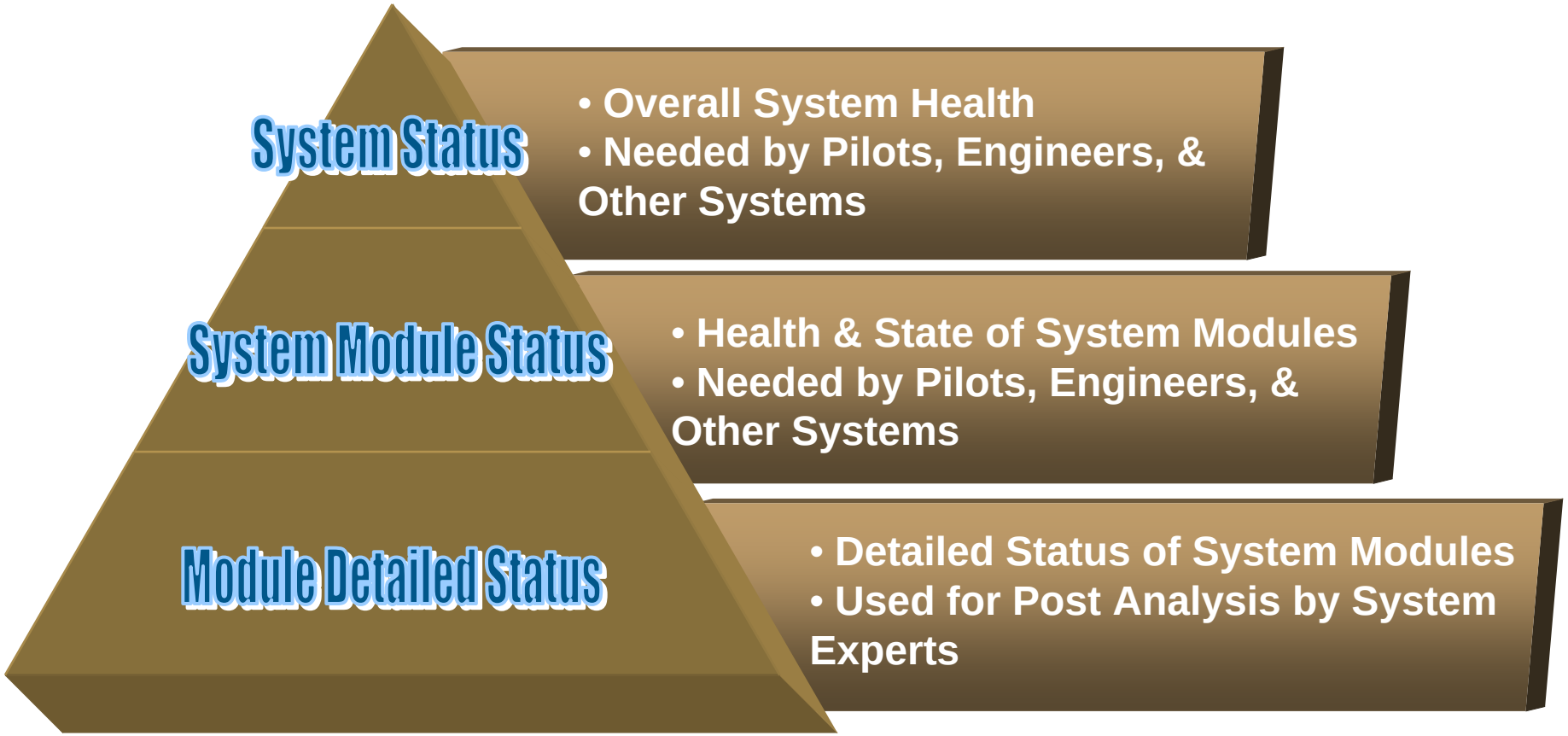
- The 1553 Interface Serves as a Replacement for Many of the Older Discrete Signal Interfaces
- Every Single Control Function Should Have an Associated Response
  - This is Typically Accomplished Using a Control Message and a Status Message



System Status Message

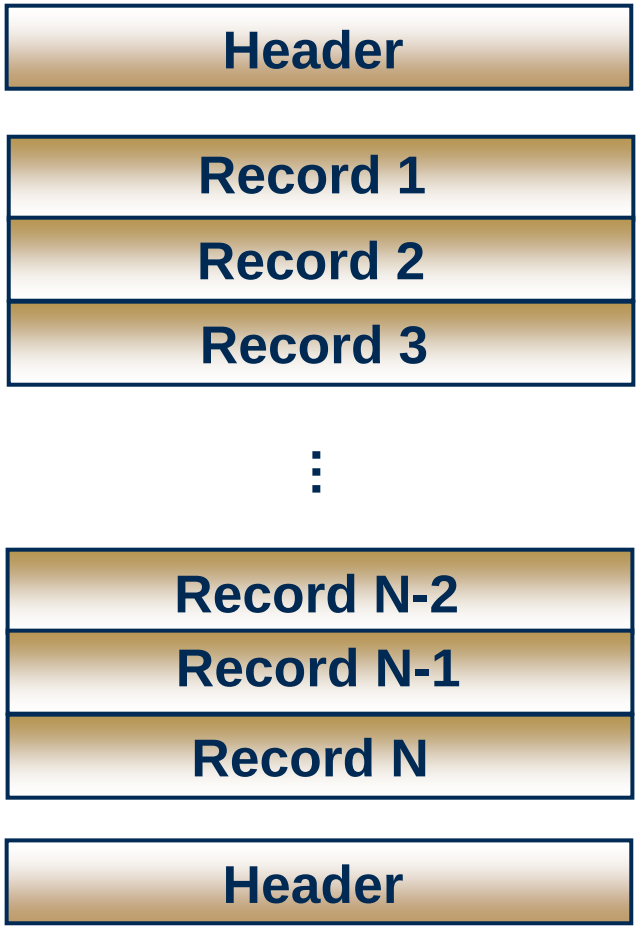
- **Overall Health of the System**
- **Real-Time State of the System (i.e. Warm-up, Test Mode, Power Down Mode, etc.)**
- **Used for Mission Critical & Non-Mission Critical Failure Determination**
- **Detailed Modules' Status is Rolled Up into Overall System State**

System Status Roll-up



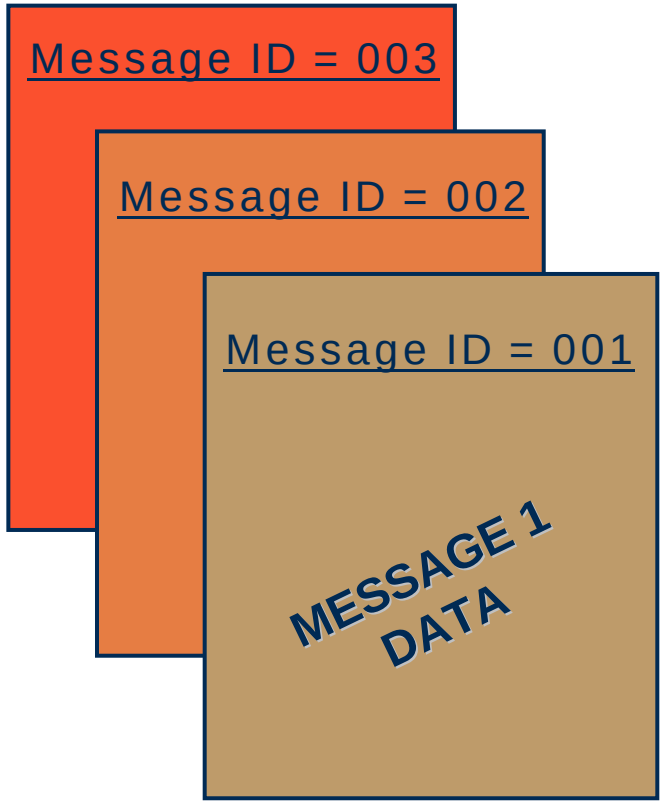
Header/Record Data Formats

- Used When There are Multiple Entries of Data with the Same Format
- Commonly Used with Track Files
- Frequency of Header is Proportional to the Number & Frequency of Records



Message Overloading

- **Overloading is Used When:**
  - **Limited Number of Subaddresses are Available**
  - **Information with Similar Data Formats**
- **Advantage: Reduces Overall Bandwidth**



Instrumentation Messages

- Typically Assigned to 1 Subaddress
- Message Overloading May be Necessary
- Usually Sent at Fastest Rate Possible
- Contents of Instrumentation Messages Should Not Be Used by Other Systems for Integration Purposes
- Data Used by System Experts for Trouble Shooting and Post Analysis



Extending the Standard

- Zero-Fill Unused Data
  - Attempt to Have “0” as an Undefined Value
- Subaddress Assignment
  - Unassigned Subaddresses Should Always Respond With Zero-Filled Data
  - Similar Systems Should Have Similar Subaddress Assignments
- Multiple Busses on an Aircraft Should be Synchronized
  - Accomplished via Timing Messages & 1553 Mode Codes

Benefits of 1553 Integration

- Less Hardware & Software Support
  - Discrete Signal & Serial Interfaces are Replaced
- Migration Towards an Integrated Suite
  - Mission Data & Techniques Can be Coordinated
  - Systems Can Share Information
- Everybody Speaks the Same Language
  - Protocol Governs What Can and Cannot be Done
  - Format of Documentation is Standardized
  - Reduction in System Integration Time & Effort

Questions?



Defense Information Systems Agency
Department of Defense

A Strategy for Program Success: Leading Indicators for Early Warning

DISA Office of the CAE
Ms Rebecca Cowen-Hirsch
703-882-2533
Rebecca.Cowen-Hirsch@disa.mil
25 October 2006

UNCLASSIFIED

Agenda

- Context
- Purpose of Briefing
- A Framework for Indicators
- Typical Indicators of Success and Problems
- Leading Indicators and What They Offer
  - Some Examples
- Case Studies
- Future Work

Context - 1



If only we had known in advance...

Context - 2

- **DISA's systems engineering & acquisition foci have driven this research**
  - **Communications systems and managed services acquisition**
  - **Information systems infrastructure development and managed services acquisition**
  - **Information systems C2 applications development and managed services acquisition**
- **Other organizations' systems engineering & acquisition environments may require different or additional leading indicators**
  - **Weapons platform hardware development**
  - **Weapons subsystem hardware development**
  - **Aerospace platform hardware development**
  - **Aerospace subsystem hardware development**
  - **Hard-real-time software development**

Purpose

- **Track major programs from acquisition & systems engineering perspectives as part of responsible technical and program management**
  - **Using conventional metrics**
    - **Often lagging indicators**
  - **Using unconventional indicators**
    - **Early warning system**
- **Assess indicators over time to capture lessons and refine indicators for early warning of problems**

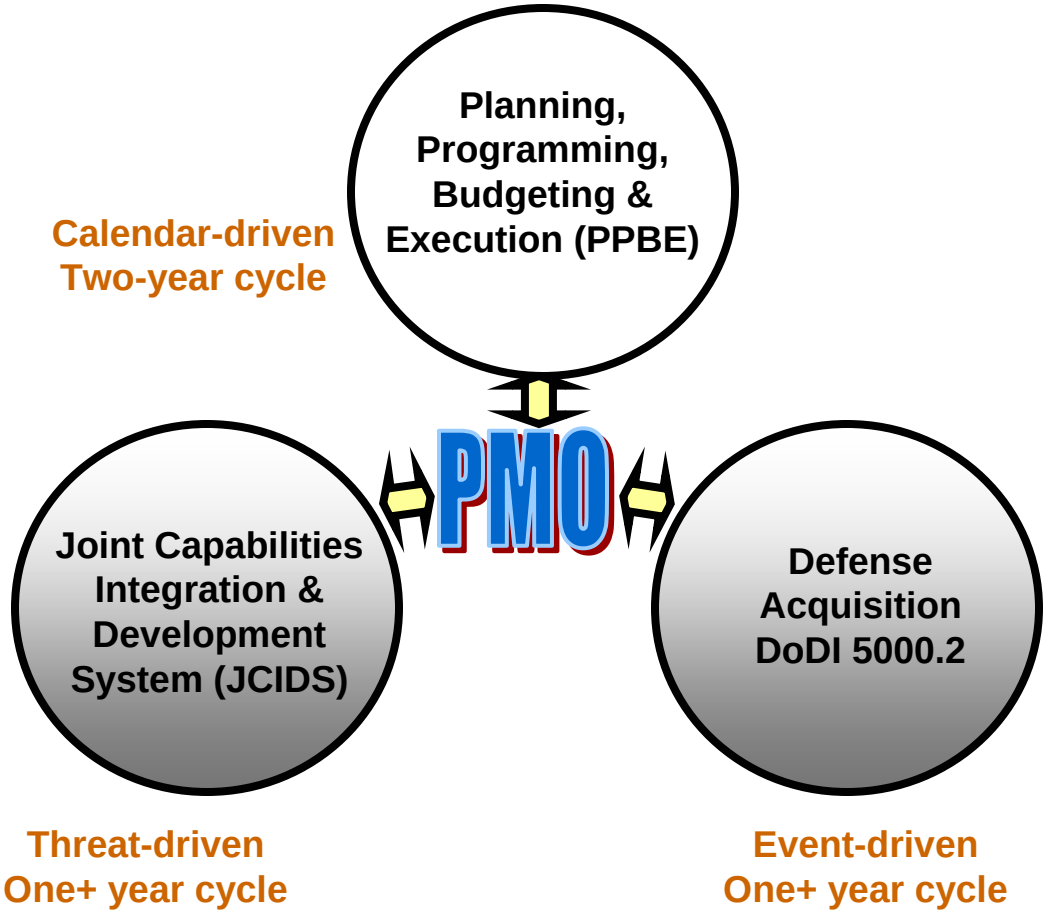
About Leading Indicators

- **Leading indicators give a sense of problems downstream in a system or service acquisition or development**
- **These indicators help a program manager or chief engineer identify potential problems earlier than otherwise**
- **Once identified, problems may be amenable to more traditional risk management and remediation**
- **Leading Indicators may first appear subtly rather than as a waving red flag**

Tenets about Leading Indicators

- **Indicators need to identify problems that have tractable solutions**
  - **Confirming a future wreck that cannot be avoided is only so valuable**
- **Indicators should not require yet another data call**
  - **If a simple "yes," "no," or "the answer off the top of my head is 6" response to a simple question isn't possible without gathering further data, then we have the wrong indicator**
- **Indicators should be readily understandable by all**
  - **If it needs an explanation, it's a complex metric, not an indicator**

The Program Manager's Challenge



Source: NDIA-NAU Course in Defense Systems Acquisition Management

These DoD processes should interact & overlap.
The program manager must orchestrate across all three.

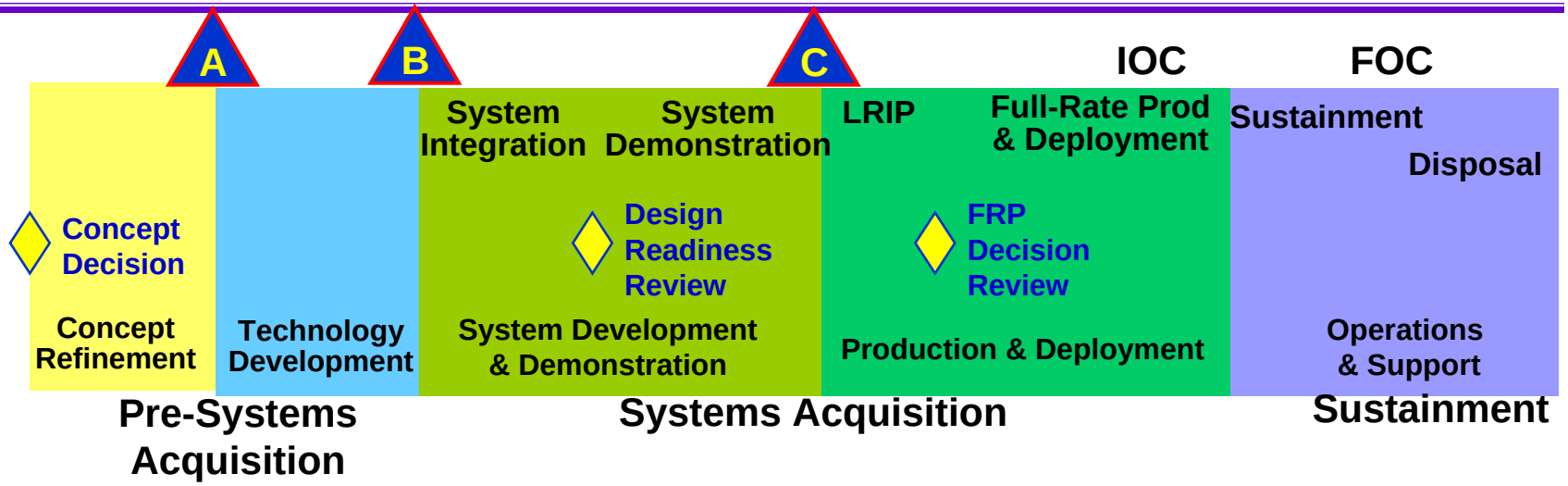
A Framework for Indicators

Program Factors	Examples of Indicators
Program Management	Degree of commitment to program from other relevant organizations Degree of program management engagement in the program
Communications	Cordiality, frequency of communications between program personnel and stakeholders Speed of stakeholder issues resolution
Fiscal Issues	Degree of agreement among stakeholders on funding approach & commitments Fiscal unanimity among key organizations (e.g., Congress, OSD, Military Services)
Requirements	Stability of requirements Realism of requirements versus maturity of technology to meet them
Schedule	Schedule stability Evidence of unrealistic scheduling
Staffing	Government / contractor management stability, lack of gaps in management Key government / contractor staff stability
Technology	Technology readiness to be employed in DoD systems Technological skills available in government and contractor base

Framework (concluded)

- **Dimensions of the indicator framework**
  - **Stage in the system or service life cycle**
    - **Some indicators are more significant for some milestones than others**
      - **E.g., technology can be less mature prior to Milestone A than prior to Milestone C**
  - **Duration of an indicator problem**
    - **Some indicators show more sensitivity to duration of an indicated problem than others**
      - **E.g., a gap in a key government management position of any duration can portend downstream problems in a program**

Indicators & Their Relevance in the System or Service Life Cycle



Prgrm Factrs	Representative Indicators Associated with Milestones
Program Management	Degree of PM engagement with staff
Communication	Reduction in face to face communication with stakeholder
Fiscal Issues	Disagreement among stakeholders on program funding
Requirements	Lack of realism
	Scope Creep
Schedule	Unrealistic Schedule
Staffing	High Turnover in Contractor Staffing
Technology	Moderate-to-High Technology Readiness Risk

What Indicators Can Indicate

Indicator	Possible Consequences
Reduction in face-to-face communications	Can result in failure to resolve stakeholder issues that can get pushed aside and reappear later in the process when correction costs more. In extreme cases, can lead to funding cuts through lack of advocacy by key stakeholders.
Lack of realism regarding financial constraints	Most likely will result in significant cost overruns if the parties do not understand the nature of contract funding. Can result in IG and GAO involvement for significant overrun.
Requirements scope creep	Generally will result in cost overruns or incomplete capability being delivered, and will also cause issues regarding contract compliance between government and contractor. Can also result in IG and GAO oversight for significant overrun.
Unrealistic schedule	Most likely will result in a program off the critical path from the start. Can affect other programs under development (via dependencies). Can affect costs if the contractor has to add more personnel to try to get a program back on track. Quality of delivered product or service may be reduced while trying to meet schedule.
Technology not yet ready	Can result in failure to deliver required product or service, or at least will result in delayed delivery.

Correcting the Problem

Indicator	Possible Solutions
Reduction in face to face communications	Primary solution is to identify the cause of the reduction in communications. If necessary set mandatory meetings with posted agenda. Have senior management attend the meetings to oversee interaction between parties.
Lack of realism regarding financial constraints	Proper training can usually correct this problem. A closer scrutiny of spending and program budget may be required by senior management. Have PM explain 5% or great variance.
Requirements scope creep	A watchful contracting officer should help significantly to reduce requirements creep. Educating the COTR can also aid in reducing creep.
Unrealistic Schedule	This problem is easier to prevent that correct. Upon identification, meet with team to define realistic schedule and re-baseline to that schedule. Costs may be affected.
Technology not yet ready	Identify less risky technology, experiment with it, pilot it, demonstrate how well it scales. Alternatively, pilot the riskier technology, work out the bugs and deliver in smaller increments, if feasible. Either solution results in schedule delays, possible capability reduction.

Case Study 1: The Problems

- **Context: complex suite of information services; many diverse users, DoD-wide; some applications services, some infrastructure services**
- **Leading indicators getting to Milestones A & B**
  - ✔ **Program management, Staffing**
    - **Leadership (government, contractor) absence, turnover, weak leadership**
    - **Key technical staff (government, contractor) absence, turnover**
  - ✔ **Communication**
    - **Turnover of key stakeholder caused schedule slip while working to win over the replacement stakeholder**
  - ✔ **Fiscal issues**
    - **Disagreement among stakeholders on program funding**
  - OK **Requirements**
  - ✔ **Schedule**
    - **Realistic until personnel churn caused program to lose focus**
  - ✔ **Technology maturity, skills to use**
    - **Technology not yet widely used in commercial world**
    - **Lack of available skills in government, among government contractors**

Case Study 1: The Resolution*

- **Context: complex suite of information services; many diverse users, DoD-wide; some applications services, some infrastructure services**
- **Leading indicators getting to Milestones A & B**
  - ✔ **Program management, Staffing**
    - **Leadership (government, contractor) – gained longer-term commitments from new talent, stabilized situation**
    - **Key technical staff (government, contractor) – attracted talented new players with commitment to complete the first spiral at least**
  - ✔ **Communication**
    - **Turnover of key stakeholder – still building trust via intensive communication campaign**
  - ✔ **Fiscal issues**
    - **Disagreement among stakeholders – still a challenge**
  - OK **Requirements -**
  - ✔ **Schedule**
    - **Realistic until personnel churn – working hard but with possible slip**
  - ✔ **Technology maturity, skills to use**
    - **Technology not yet widely used – still experimenting; outcome not clear**
    - **Lack of skills on program – OJT, experience building but likely schedule slips downstream**

***So far …**

Case Study 2: The Problems

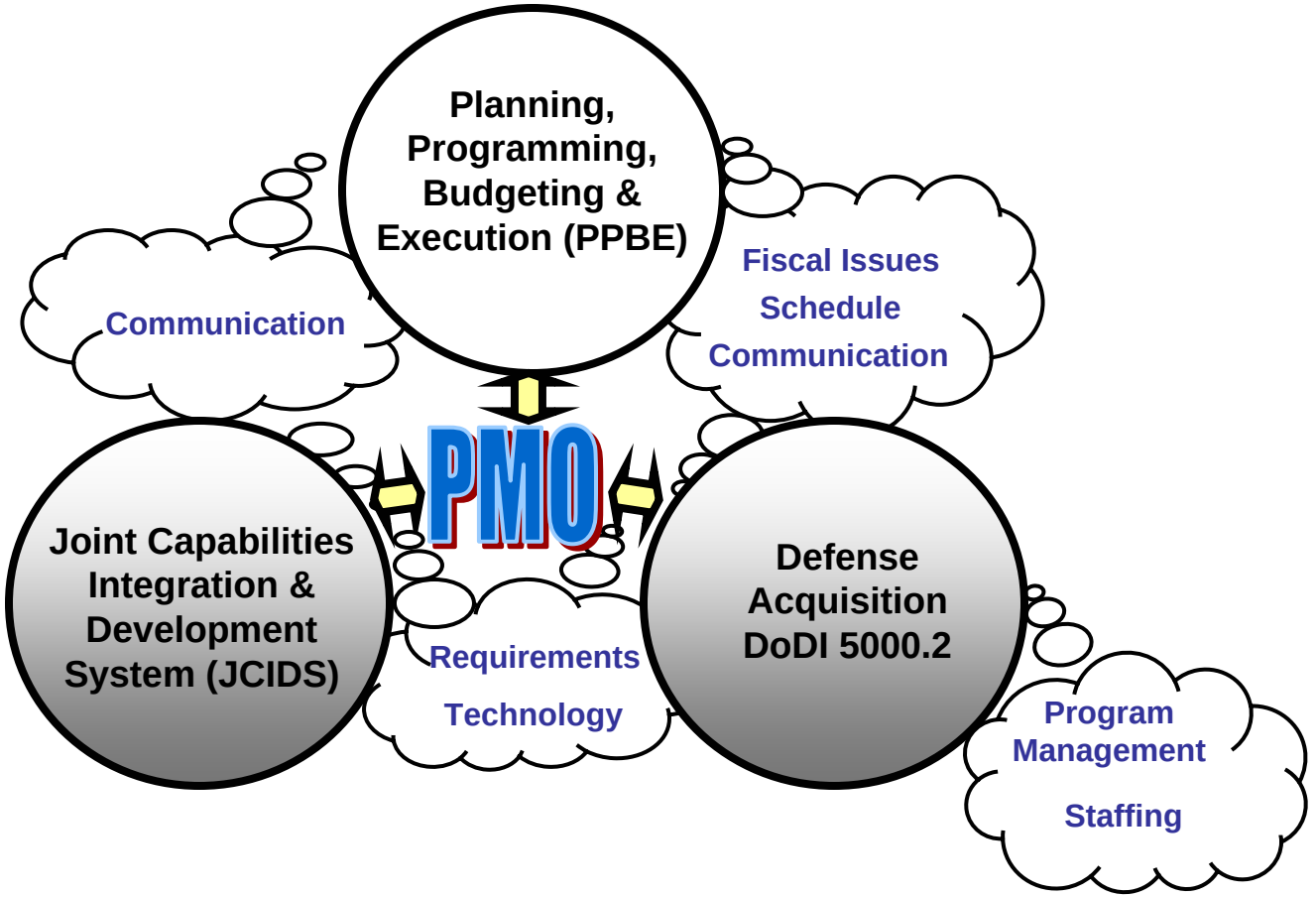
- **Context: worldwide communications system ground-based infrastructure, being developed & fielded in multiple spirals**
- **Leading indicators getting to MSs A & B of Spiral N**
  - **OK Program management, Staffing**
  - **✓ Communication**
    - **Multiple Military Service stakeholders have proven challenging for a small-staff PMO**
  - **OK Fiscal issues**
  - **✓ Requirements**
    - **One key requirement dependent on immature technology**
  - **✓ Schedule**
    - **Realistic except for immature technology, errant stakeholders**
  - **✓ Technology maturity**
    - **One key product still in development**
    - **Reliant on multiple stakeholders for agreement on technological way-ahead**

Case Study 2: The Resolution*

- **Context: worldwide communications system ground-based infrastructure, being developed & fielded in multiple spirals**
- **Leading indicators getting to MSs A & B of Spiral N**
  - **OK Program management, Staffing**
  - **✔ Communication**
    - **Multiple Military Service stakeholders – focused on most challenging player(s)**
  - **OK ✔ Fiscal issues – cost increase due to delayed requirement**
  - **✔ Requirements**
    - **Dependent on immature technology – delaying fielding of new technology; extending life of older technology by two years**
  - **✔ Schedule**
    - **Immature technology, errant stakeholders – generally acceptable schedule slip accorded to technology problem**
  - **✔ Technology maturity**
    - **Key product in development – too early to tell if new schedule realistic**
    - **Reliant on multiple stakeholders for agreement – achieved grudging agreement**

***So far …**

Summary



Source: NDIA-NAU Course in Defense Systems Acquisition Management

Most of the leading indicators address Defense Acquisition, but without acting to correct indicated problems, damaging effects can occur in all three domains

Future Work

- **Refine number and variety of leading indicators**
  - **Most significant effects likely on program**
  - **Modest data collection demands**
- **Gather data across a greater variety of programs**
  - **Hardware-intensive**
  - **Software-intensive**
  - **Leading-edge technology application**
  - **Complex dependencies on programs inside, outside the Agency**
- **Analyze results**
- **Refine indicators**
- **Define dashboard with watch list of indicators**

Questions?

Backup Slides

Candidate Early Warning Indicators - 1

Program Advocacy

- **Weak/Ineffective Program Manager**
- **Lack of Management Continuity and Oversight**
- **Lack of Involvement from Stakeholders (contracting officers, COTRs, OSD, etc.)**
- **Reluctant or ambiguous statements from public officials**
- **Programs not clearly specified in budget submissions, FYDP, Program Element Descriptions Summary (PEDS), etc.**

Communications

- **Principals do not attend regular meetings and do not send an alternate**
- **Reduction in face-to-face communications**
- **Inadequate resolution of issues**
- **Prime contractor not engaged**
- **Lack of proactive stakeholder communication**
- **Lack of information sharing**
- **Lack of visibility on executive status or priority list**

Candidate Early Warning Indicators - 2

Fiscal Issues

- **Inability to tie performance to well articulated payoff**
- **Lack of realism regarding fiscal constraints at time of contract award**
- **Submission of multiple engineering change proposals (ECPs)**
- **Large underruns or overruns inconsistent with contractor proposal within three months of award**
- **Military Services/Components disagreeing on funding approach or commitments**
- **Contractor proposal estimates significantly exceed IGCE**

Candidate Early Warning Indicators - 3

Requirements

- Ambiguity of requirements
- Unrealistic requirements
- Requirements not testable
- Scope creep
- Mission needs/requirements not adequately defined in Statement of Work
- Key DoD 5000 requirements documents not developed, approved, or updated

Candidate Early Warning Indicators - 4

Schedule

- **Unrealistic schedules**
- **Unilaterally set schedules**
- **Frequent schedule slips – especially w/in first 3-6 months**
- **Poor or no design/test schedules**
- **Integrated Master Schedule not linked with contractual delivery schedule**

Staffing

- **Turnover ratios greater than 5%, especially among staff with scarce skills**
- **Changes to contractor staffing within first six months not identified in contractor proposal**
- **Change in program management of contractor or government**
- **Time gaps between managers**
- **Oversight officials lacking proper certification**
- **Contracting officer not assigned or insufficient contracting office support**

Candidate Early Warning Indicators - 5

Technology

- **Proposed technology is below Technology Readiness Level of 6 at Milestone B**
- **Technology has not been or has been only rarely demonstrated successfully in commercial world**
- **Skills among government and contractor teams insufficient to apply chosen technology**

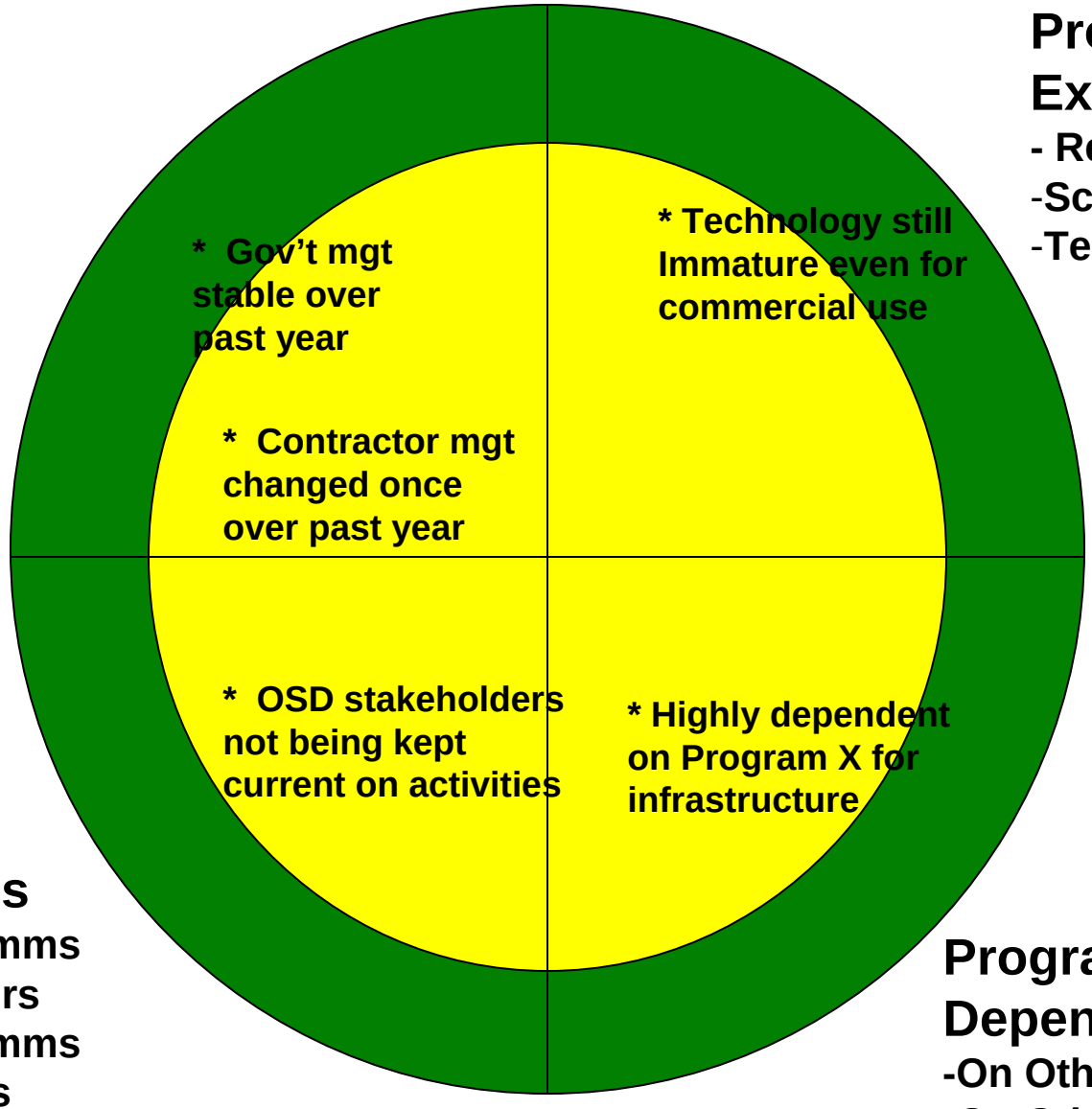
Other?

- **Program dependencies – on other programs; others dependent on it; on outside-the-Agency organizations**

A Framework for Indicators(1)

Program Resources
-Stability of Mgrs
-Stability of Staff
-Financial Status

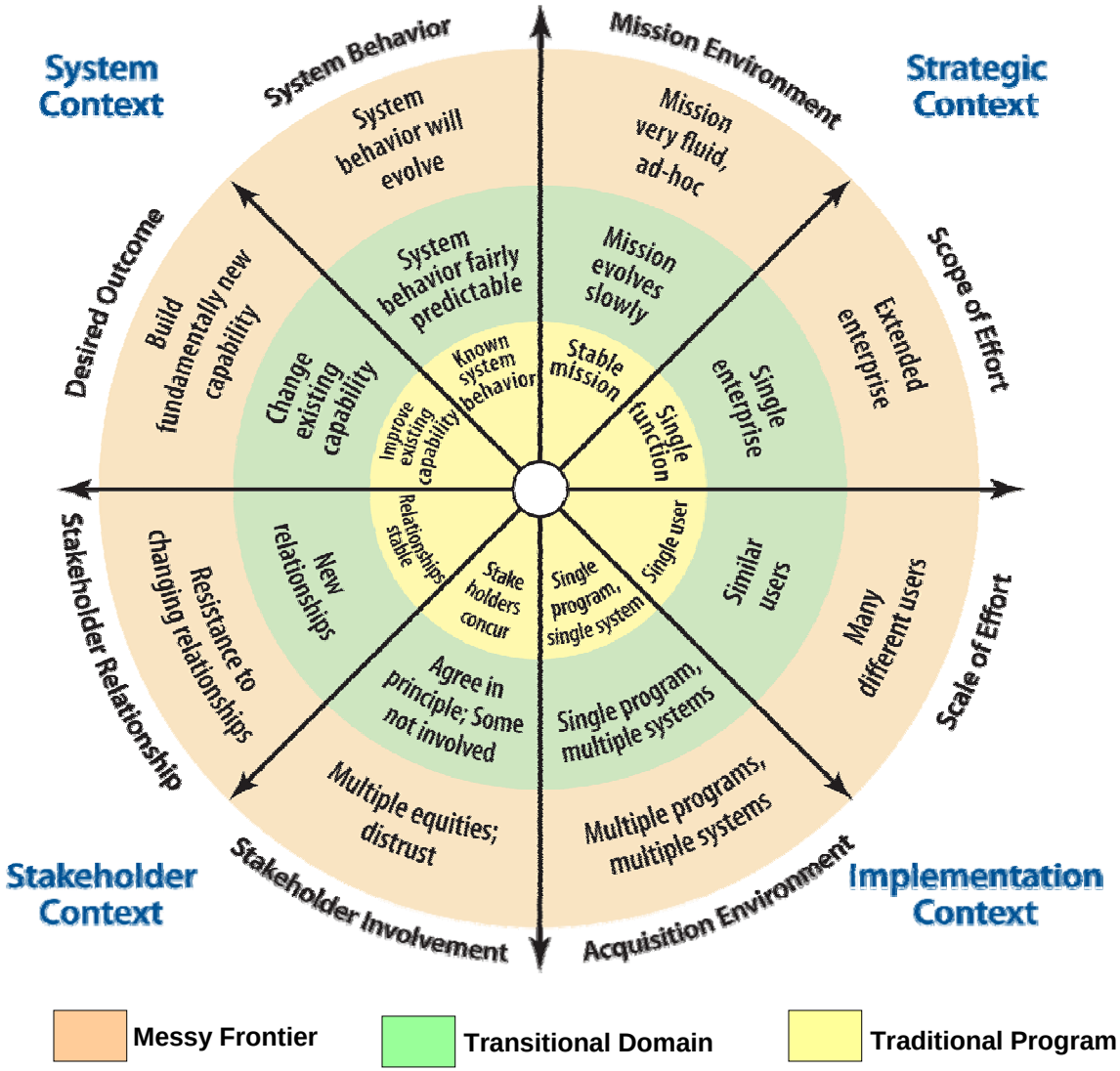
Program Execution
- Requirements
-Schedule
-Technical Maturity



Program Communications
-Degree of open comms with key stakeholders
-Degree of open comms with internal players

Program Dependencies
-On Other Programs
-On Other Organizations

A Framework for Indicators(2): Enterprise Systems Engineering Profiler™



Messy Frontier | Transitional Domain | Traditional Program

Sector	Indicators
Mission Environment	Requirements Stability Schedule Realism
Scope of Effort	Requirements Realism
Scale of Effort	Technology Readiness?
Acq. Environment	System Dependencies Organizational Dependencies
Stakeholder Involvement	Communication w/Stakeholders - Degree of Agreement, Advocacy - Frequency of Communication
Stakeholder Rel'nship	Communication w/Stakeholders - Cordiality
Desired Outcome	Technology Readiness
System Behavior	Technology Readiness?

Important Indicators not Fitting Framework

Management Stability
- Government
- Contractor

Staff Stability
-Government
- Contractor

Fiscal Unity?

© 2006 The MITRE Corporation. All rights reserved

Bibliography

- **"Defense Acquisition Performance Assessment" Report, Lt.Gen. Ronald Kadish, USAF (Ret) Panel Chairman, January 2006**
- **MITRE Enterprise Systems Engineering studies**
- **DAU course materials at www.acc.dau.mil**
- **"Acquisition – System Engineering Planning for the Ballistic Missile Defense System (D-2006-060)", Department of Defense Office of Inspector General, 2 March 2006**
- **"The Federal Bureau of Investigation's Management of the Trilogy Information Technology Modernization Project" Audit Report No. 05-07, Office of the Inspector General, February 2005**
- **"Analyses Of A Sampling Of Major Acquisition Systems How A Definite Linkage Between Escalating Costs And The Ineffective Applications Of Systems Engineering", Michael W. Wayne & Mark D. Schaeffer. March – April issue of *Defense AT&L***
- **Department of Defense Instruction 5000.2**
- **Department of Defense Directive 5000.1 and 5010.38**
- **"A Model for Leading Change: Making Acquisition Reform Work" Defense Systems Management College, Lt. Col. Charles L. Beck, Jr., USAF, Lt. Col. Nina Lynn Brokaw, USA, Commander Brian A. Kelmar, USN**
- **"Chapter 4, Systems Engineering," Defense Acquisition Guidebook**
- **"Executability Metrics for SMC Programs" (Version 3.0), P.L. Smith and P.G. Cheng, G. S. Arnold. Aerospace Report No. TOR-2004(8583)-3470 under contract no. FA8802-04-C-0001, 15 June 2004.**
- **General Accounting Office, *BUSINESS MODERNIZATION NASA's Integrated Financial Management Program Does Not Fully Address Agency's External Reporting Issues*, November 2003, GAO-04-151**
- **"DOD Acquisitions Contracting for Better Outcomes", General Accounting Office, Statement of David M. Walker, Comptroller General of the United States, 7 September 2006**
- **"Defense Acquisitions Restructured JTRS Program Reduces Risk, but Significant Challenges Remain", General Accounting Office, Report to Congressional Committees, September 2006**



"The Net-Centric Foxhole" Perspectives from Army Future Combat Systems

25 OCT 06
D. Emery,
LTC D. Bassett,
LTC M. Schnaidt
Product Manager,
FCS (BCT) Software Integration

Approved for Public Release, Case 06-6147 (PM FCS (BCT)

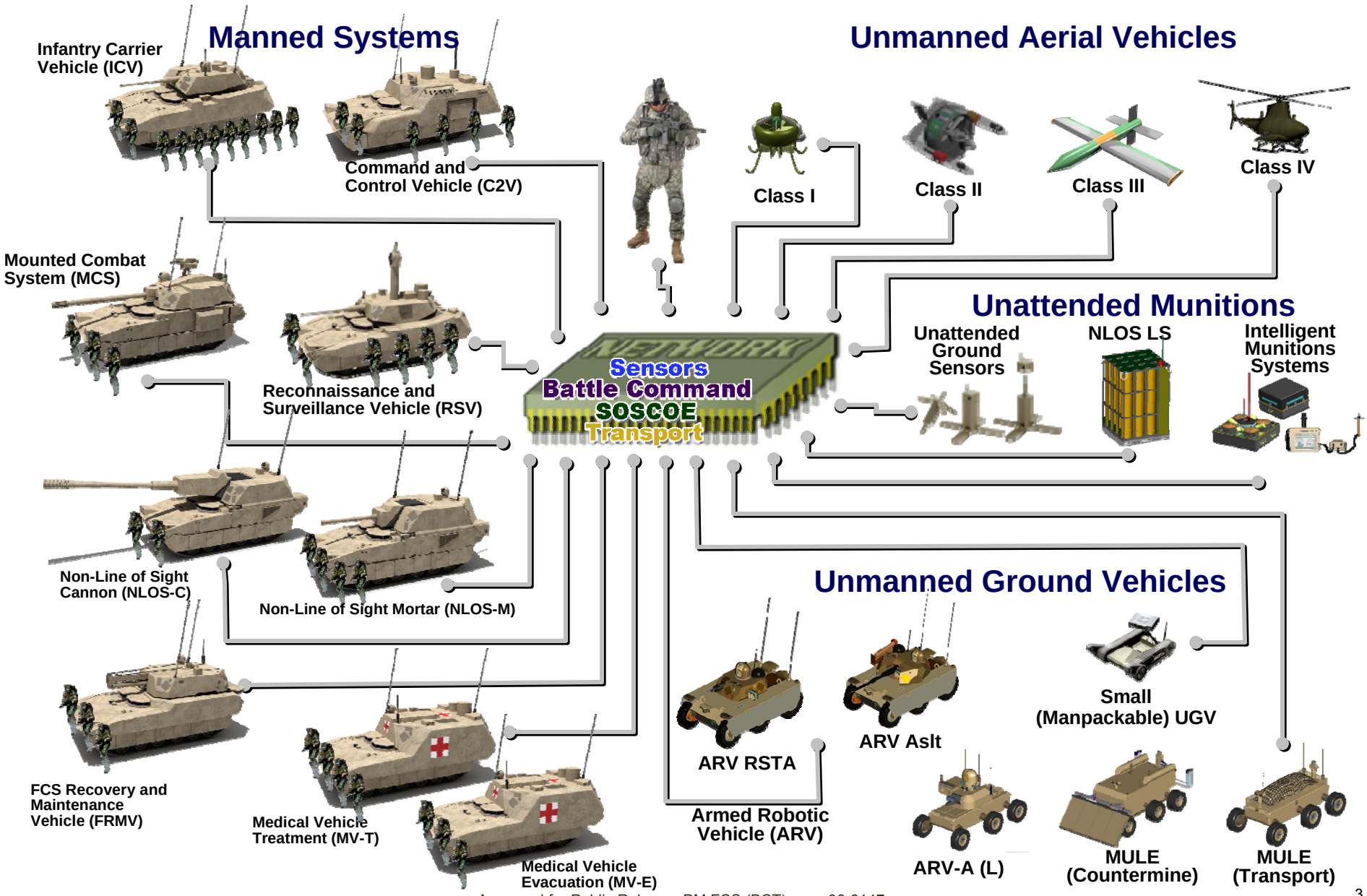
Outline

- FCS Program Overview
- FCS "Distributed System" architecture and Net-Centric Concerns
- Issues from each of the 4 Net-Centric Checklist areas
  - Transport
  - IA
  - Core Services
  - Data & Applications
- FCS approach to the Net Ready KPP
- Lessons Learned

Approved for Public Release: PM FCS (BCT) case 06-6147

FCS System-of-Systems (SoS)

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry



Approved for Public Release: PM FCS (BCT) case 06-6147

FCS Unit of Action Elements
Software resides in all Prime Items

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry

Manned Ground Vehicles

General Dynamics / United Defense



Infantry Carrier



Command & Control



Mounted Combat Sys



Recon & Surveil.



NLOS Cannon



NLOS mortar



Maint. & Recovery



Medical

C4ISR

Battle Command & Mission Execution – Raytheon
SOSCOE / Warfighter Machine Interface – Boeing
Level 1 Fusion – Lockheed Martin
Sensor Data Mgmt / Planning & Prep – GDDS
Situation Understanding – Austin Info Systems
Network Management – Northrop Grumman
Integrated Computer System – General Dynamics
Unattended Ground Sensors – Textron
Ground Sensor Integration – Raytheon
Air Sensor Integration – Northrop Grumman
Ground Comm & Air Comm – BAE Systems

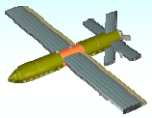








Unmanned Air Vehicles



Class III



Class II
Class I



Class IV
Northrop Grumman

Logistics & Training

LDSS – Northrop Grumman
PSMRS – Honeywell
Training Support
– Northrop Grumman
– Dynamics Research Corp
– Computer Science Corp

Unmanned Ground Vehicles





Armed
Robotic Vehicle
United Defense



Small UGV
iRobot





Mule
Lockheed Martin



Auto. Navigation - GDRS

Unattended Munitions

NLOS LS (LAM)
Intelligent Munition System

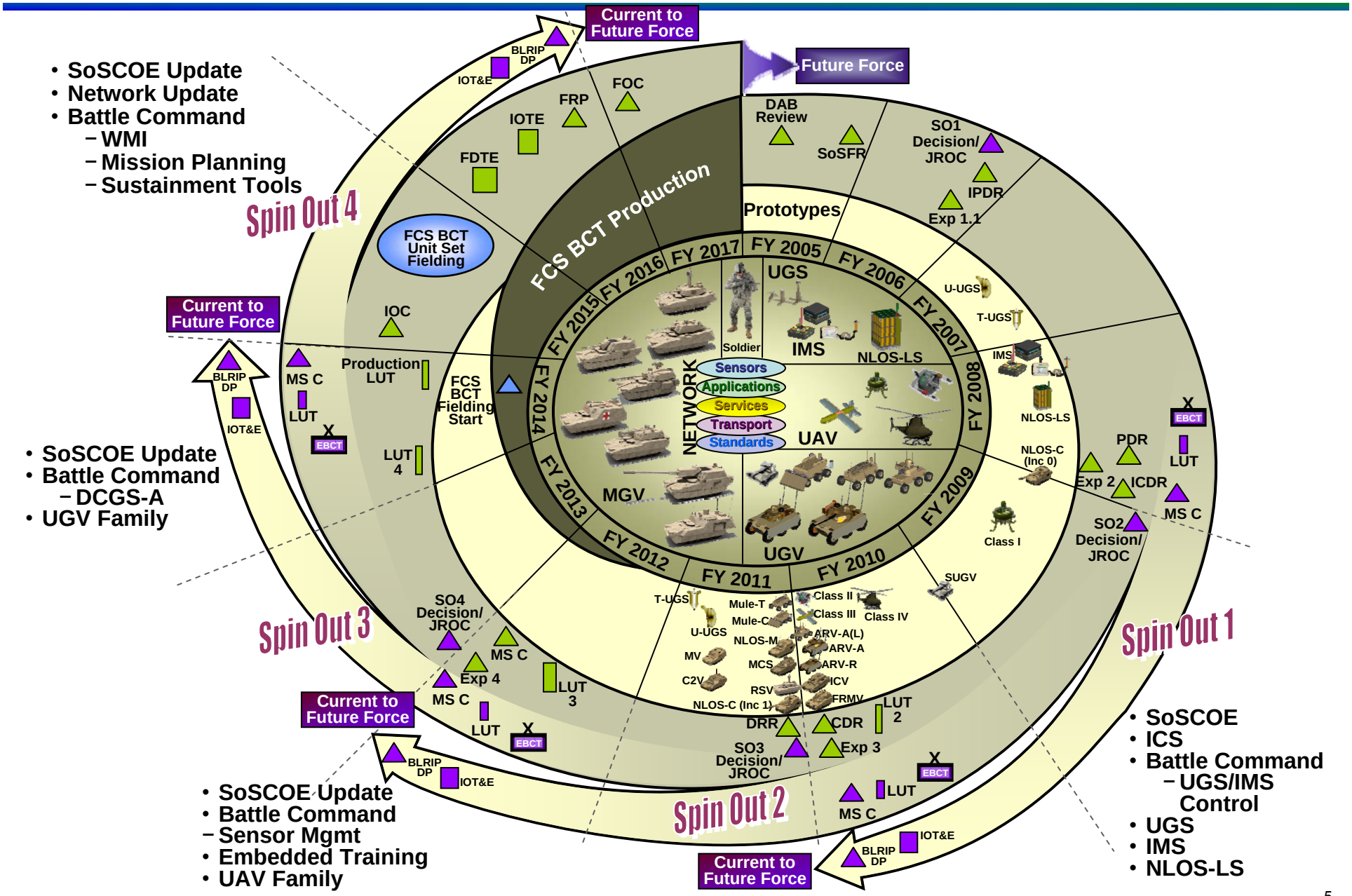
Non-FCS Elements

Trucks
81 mm Mortar
AAFARS HTARS

Approved for Public Release: PM FCS (BCT) case 06-6147

FCS (BCT) System-of-Systems Schedule

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry



Approved for Public Release: PM FCS (BCT) case 06-6147

Challenges unique to FCS

- Goal is to produce a fully integrated Brigade Combat Team
  - LSI contractor performs procurement and integration of material
  - Build to evolving doctrine - increased TRADOC/User involvement
  - Focus on 'Quality of Firsts'
    - See First, Understand First, Act First, Finish Decisively
  - Spin-Outs field selected capabilities to the Current Force BCTs over next 8 years
- FCS is 'born net-centric'
  - First Army system to undergo Net-Centric Reviews, current focus of OSD NII/FCS Network IPT (OIPT at 3-star level)
  - Evaluated against OSD Net-Ready KPP (transitioning from Interop KPP)
  - Implements and extends GIG engineering requirements in a tactical environment
    - Tactical mobile vs tactical 'short halt'
  - Net-Centric information sharing concepts underly the FCS 'Distributed System' architecture
- Massive amounts of sensor data
  - ~400m bits/sec raw sensor data with variety of methods to translate into usable information
- Battle Command on-the-move; no more TOC 'tent farms'
- Transport systems procured outside of FCS
  - JTRS, WIN-T for FCS BCT
  - SINCGARS, EPLRS, JNN for Current Force

FCS is the largest, most complex program in Army history

Approved for Public Release: PM FCS (BCT) case 06-6147

OV-1: FCS as part of the Joint Fight

FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry



Figure 1 - Operational View 1 (OV-1)

SEE FIRST

UNDERSTAND FIRST

ACT FIRST



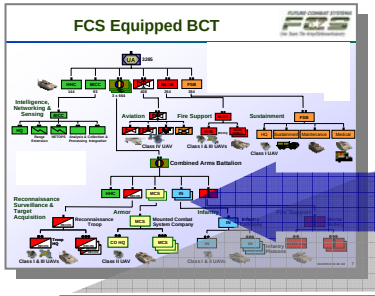
FINISH DECISIVELY

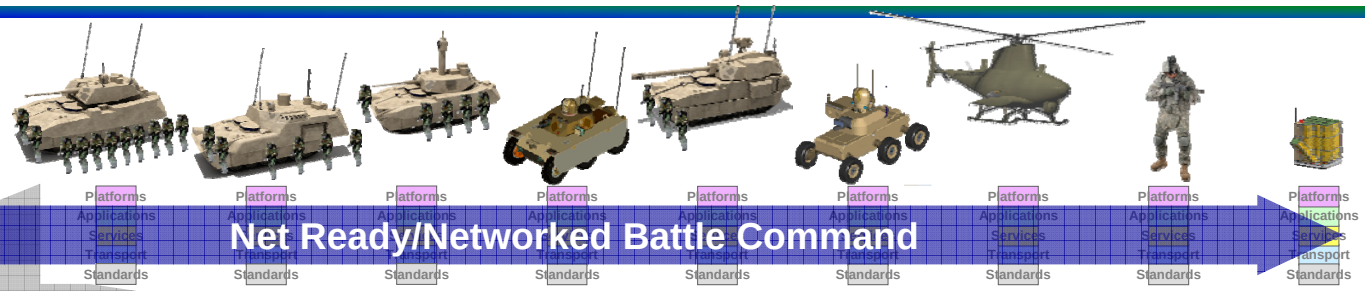
Transition to next engagement

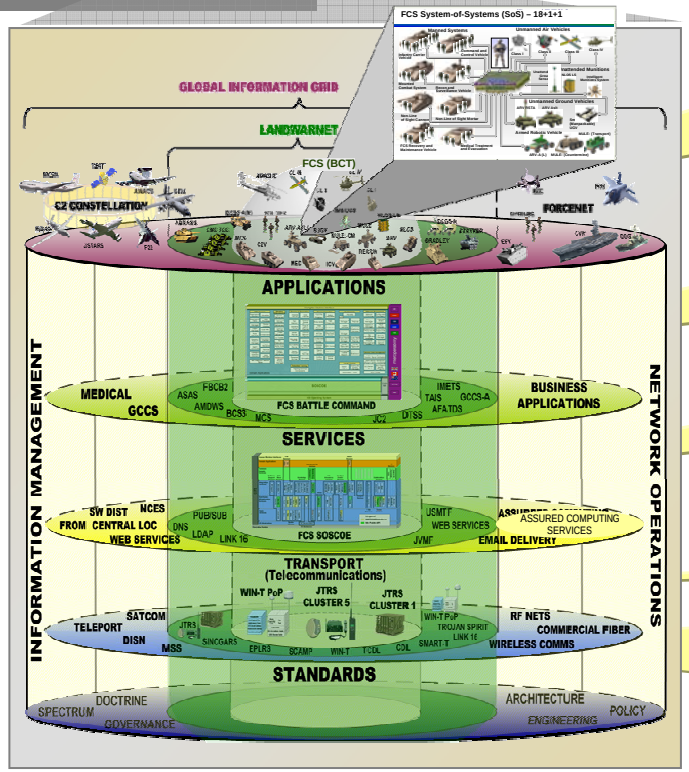
Approved for Public Release: PM FCS (BCT) case 06-6147

FCS Layered, Networked Architecture

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry







- **Command BCT system elements are commonly developed to integrate FCS platforms into a larger geographically dispersed yet Functionally integrated machine**
- **Battle Command incorporates C2, Intelligence, Surveillance, and Reconnaissance (ISR), Embedded Training, and Sustainment**
- **Net ready information management element of service based architecture**
- **Heterogeneous transport layer enables robustness**
- **Networked battle command, embedded training, and supportability developed Technical View (TV-1) integrated into SoS level TV-1 standards supporting integration**

Integrated Architecture Provides Design-Phase Flexibility and Tactical Adaptability For The Networked FCS (BCT)

Approved for Public Release: PM FCS (BCT) case 06-6147

Supporting Net-centric Operations
(OSD NII Net Centric Checklist, v 2.1.3, 12 May 04)

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry

- Data Tenets
  - Make Data Visible
  - Make Data Understandable
  - Make Data Accessible
  - Make Data Trustable
  - Make Data Interoperable
  - Provide Data Management
  - Be Responsible to User Needs

- IA / Security Tenets
  - Identify Management and Authentication
  - Mediate Security Assertions
  - Cross Security Domains Exchange
  - Manage Identity and Privileges
  - Encryption and HAIPE
  - Employment of Wireless Technologies

- Service Tenets
  - Service-Oriented Architecture
  - Open Architecture
  - Scalability
  - Availability
  - Accommodate Heterogeneity
  - Decentralized Operations and Maintenance
  - Enterprise Service Management

- Transport Tenets
  - IPv6
  - Packet Switched Infrastructure
  - Layering, Modularity
  - Transport Goal
  - Network Connectivity
  - Concurrent Transport of Information Flows
  - Differentiated Management of QoS
  - Inter Network Connectivity
  - DISR
  - Joint Net Centric Capabilities
  - Operations and Management of Transport and Services

OSD's Checklist frames the FCS approach

Approved for Public Release: PM FCS (BCT) case 06-6147

Transport Radio Systems

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry

JTRS GMR

- Provides ground vehicle based terrestrial connectivity with Advanced Waveforms (i.e. WNW, SRW, ANW*)
- Programmable Waveforms to Support Multiple Missions



*Airborne Network Waveform

AMF*

- Provides airborne vehicle based terrestrial connectivity with Advanced Waveforms (i.e. WNW, SRW, ANW)
- AMF will meet SWAP requirements for FCS CLIV UAV comms relay package
- ARC-210 Form Factor



*Airborne Maritime Fixed Station

WIN-T Point of Presence (PoP)

- Provide reach, reach back, interoperability
- Functionality
  - NCW
  - HNW
  - GBS receive
  - Interoperability gateway



JC4ISR Radio

JTRS HMS

- Provides small form fit (SFF) for integration into FCS platforms:
  - Dismount Soldier
  - Unattended Ground Sensors (UGS)
  - Unmanned Aerial Vehicle (UAV) control
  - Intelligent Munition Systems (IMS)
  - Small Unmanned Ground Vehicle (SUGV)
  - Non Line of Sight – Launch System (NLOS-LS)



SFF-B (Soldier)



SFF-A (IMS/UGS)



SFF-D (UAV)

Range Extension

- Provide communication relay through the WIN-T PoP vehicles



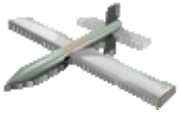
Recon and Surveillance Vehicle



ARV RSTA



Class II



Class III



Class IV

Provides the Warfighter with superior Interoperability, Flexibility, and Adaptability

Approved for Public Release: PM FCS (BCT) case 06-6147

Transport Considerations

- BCT supported with a two-tier 'network of networks'
  - JTRS for lower echelons, multiple waveforms and radio form factors
  - WIN-T for upper echelons and connectivity to the GIG
  - Spin-Outs use existing and interim/prototype radios (e.g. JNN, JTRS surrogates)
- IPv6 capable, will have to support IPv4 for current force/coalition issues after conversion
- Throughput concerns
  - Throughput (including error rates) for each waveform: predicted vs delivered/actual
  - Spectrum allocations for the waveforms across the BCT area are likely to limit theoretic throughput for the BCT
- Mobile Ad Hoc Network (MANET) requires tailoring of GIG standards
  - GIG upper protocols like HTTP over TCP don't work in MANET environment
  - Throughput, availability, network topology stability/rate of change
- Voice, Video and Quality of Service concerns
  - Demand far exceeds supply
  - Need for transport-level QoS and then application level network management
  - Integration of FCS net management with Joint NetOps

Transport is oversubscribed - must get right info to right user to right time

Approved for Public Release: PM FCS (BCT) case 06-6147

IA Considerations

- Cross Domain Solutions – provide interaction between classified, unclassified, and coalition networks; issues include:
  - Metadata standards needed to ensure interoperability
  - Data sharing policies to allow automated release and provide for need-to-share and need-to-know
  - Improved certification procedures for multiple instantiations
- Key Management Infrastructure – provide automated cryptographic key distribution; issues include:
  - Specific interface requirements for KMI capabilities
  - Size, Weight, and Power constraints on KMI compliant equipment
  - Timely delivery of national KMI capabilities to support FCS needs
- Public Key Infrastructure (PKI) – provide authentication capabilities in line with DoD PKI strategy; issues include:
  - DoD Standard Token suitable for battlefield use
  - Use of token for classified networks
  - PKI protocols and architecture suitable for mobile ad hoc networks

Distributed tactical systems provide challenges to current IA approaches

Approved for Public Release: PM FCS (BCT) case 06-6147

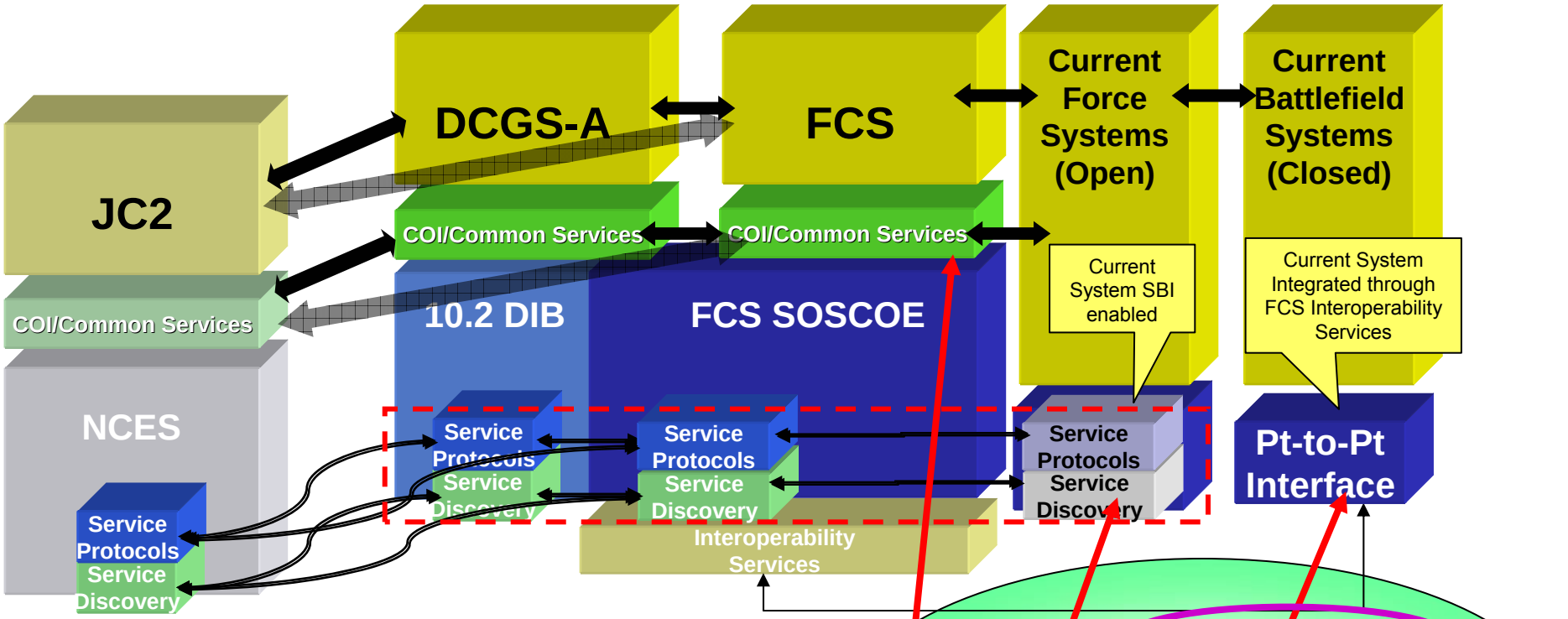
Core Services - SOSCOE

- System of Systems Common Operating Environment - SOSCOE - provides the Core Service implementation for FCS
  - SOSCOE fills 4 functions within FCS
    - Integrates info over tactical networks according to net-centric tenets
    - Extends and federates FCS with GIG (I.e. NCES) Core Services
    - Product line weapon system/embedded software applications
    - Infrastructure for FCS Battle Command/Distributed Systems applications
  - SOSCOE is developed by the LSI, and is 85% COTS (by SLOC)
- Multiple OSD evaluations have focused on SOSCOE
  - Implicit starting point has been “Does SOSCOE duplicate NCES?”
  - Each study has concluded tactical transport considerations limit potential code reuse between NCES and SOSCOE
    - Limited bandwidth, effect of ad-hoc networking, rate-of-change on the network
    - FCS safety-critical & real-time processing requirements
  - Most recent study emphasizes federating core services across the GIG
    - Study examined multiple programs of record that implement GIG Core Services
    - IA, Collaboration (e.g. chat/IM), service management are high payoff targets
    - NCES has privileged role to drive the core service Key Interface Profiles (KIPs) for GIG integration

Common infrastructure within FCS and to the rest of the GIG

Approved for Public Release: PM FCS (BCT) case 06-6147

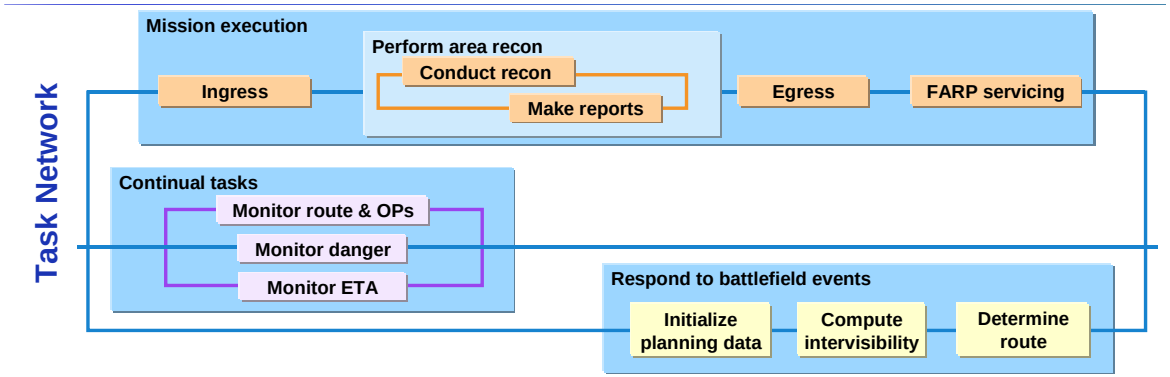
FCS Open Architecture Provides Multiple Levels of Interoperability and potential for early "spiral out"



Approved for Public Release: PM FCS (BCT) case 06-6147

FCS approach to Service Oriented Architecture (SOA) - Task Integration Networks (TINs)

- FCS implements its SOA using Task Integration Networks
  - A Task Integration Network is the definition of a job (the work to be performed by a user) as a network of tasks that must be executed in some order
  - Controls and Sequences Services (both FCS-hosted and Services provided by other parts of the GIG) via a 'scripting language'
  - Separates doctrinal considerations from hard-coded software implementations
  - Executed by SOSCOE TIN Services
- In FCS, a TIN is associated with a user role (e.g. Bn Cdr, Bde XO)
- FCS TINs federate with Web-Service based SOA infrastructures
  - E.g. NCES UDDI/WSDL
  - Federation occurs at WIN-T PoP (where we can best support transport assumptions



TIN-based SOA implements FCS Battle Command, Training and Sustainment

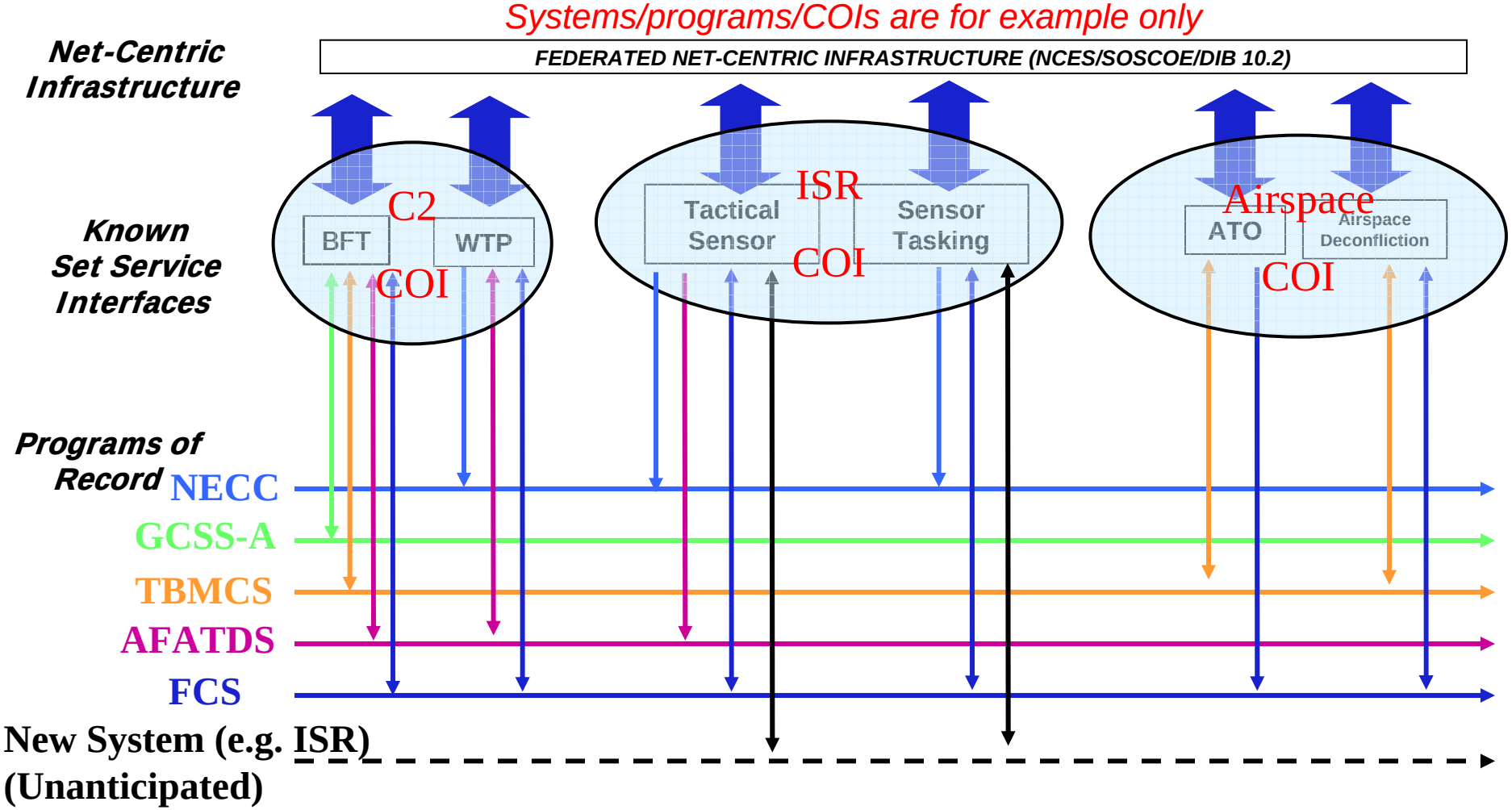
Approved for Public Release: PM FCS (BCT) case 06-6147

Data & Applications - COI interfaces

- OSD's intent is for Communities of Interest (COIs) to drive application integration
  - COIs are to be collaborations of users, material developers, Service/Agency oversight, etc.
  - COIs specify data items/data relationships of interest to that COI
  - COIs should also specify services of interest to a COI
    - E.g. Blue Force Tracker COI may specify a "deconflict-this-target" service interface that each program would implement
    - A Battle Command application would invoke the common interface across the systems on the GIG, asking each "OK to shoot here?"
- COIs will define a 'data and service bus' that each program of record will implement
- However, COI governance is still a concern
  - What exactly does a COI produce? Schemas, Services, CONOPS?
  - When and how will COIs produce their products? (including schedule & funding)
  - How is a COI 'good idea' translated into formal program requirements?
  - How will overlaps/conflicts between COIs be adjudicated?
  - How will COI guidance be maintained/evolve over time (including changes to existing systems)?
  - How many COIs are there, and how do you find the right COI?

COIs are critical to the success of the DoD Data Strategy

COI based Net-Centric Service Interfaces (our end-state vision)



Each System Implements Service Interfaces
Coordinated Through COI Activities
KNOWN INTERFACES – UNANTICIPATED (but validated) USERS

Approved for Public Release: PM FCS (BCT) case 06-6147

Net Ready KPP approach

- NR KPP has four components
  - Required DoDAF Architecture Products
  - IA
  - KIPs
  - NCOW-RM
- FCS is actively working with J6, OSD and DISA (e.g core service standards) on selecting KIP standards and validation approaches
  - KIP definitions are in flux; J6 has a schedule for the first set of KIPs
  - Test and evaluation of KIP conformance is still evolving
  - FCS is working with JITC, CTSF and ATC on who and how FCS established KIP conformance
- NCOW-RM is a useful tool for organizing net-centric information
  - 'Conformance' being worked - current expectation is a mapping of program/system components to each leaf node
  - Some NCOW-RM nodes are not just 'material solutions' - e.g. "Manage the network" (where there is both a material component and a DOTL PF component for who/when/where the tools get used)

NR-KPP consolidates activities FCS was already executing

Approved for Public Release: PM FCS (BCT) case 06-6147

FCS Lessons Learned

- Net Centricity has been a major impact on FCS
  - Net-Centricity is really a property of the System-of-Systems, not of any individual platform
  - Approaches within DoD (e.g. Web Service SOA) need to be tailored to work in a tactical transport and platform environments
  - FCS has had to defend its approach across multiple OSD reviews
    - Net-Centric Review/Net-Centric Checklist
    - Program Networks IPT structure
    - PA&E/QDR/PDM-III challenges on potential duplication of core services
    - All of these take PM and contractor time to support
- Net-Centric Review focuses on 4 areas
  - Transport, IA, Core Services, Data & Apps
  - These are not easily supported from DoDAF products or other standard formats
- COI impacts are a big unknown
  - Governance, schedule, content of COI recommendations not clear
  - COIs are key to the Data Strategy, so we have to make them successful

"Be Joint or Die" - Net-Centricity is a PM survival imperative

Approved for Public Release: PM FCS (BCT) case 06-6147

Test & Evaluation in the Virtual World

David R. Pratt, PhD

Robert W. Franceschini, PhD

Science Applications International Corporation (SAIC)

prattda@saic.com

From Science to Solutions™

Motivation

- Changes in weapons systems
  - Increased ranges
  - Complexity of environment
- Horizontal convergence
  - Live – Virtual – Constructive
- Vertical convergence
  - Analysis
  - Testing
  - Training
  - Mission rehearsal
  - Operations

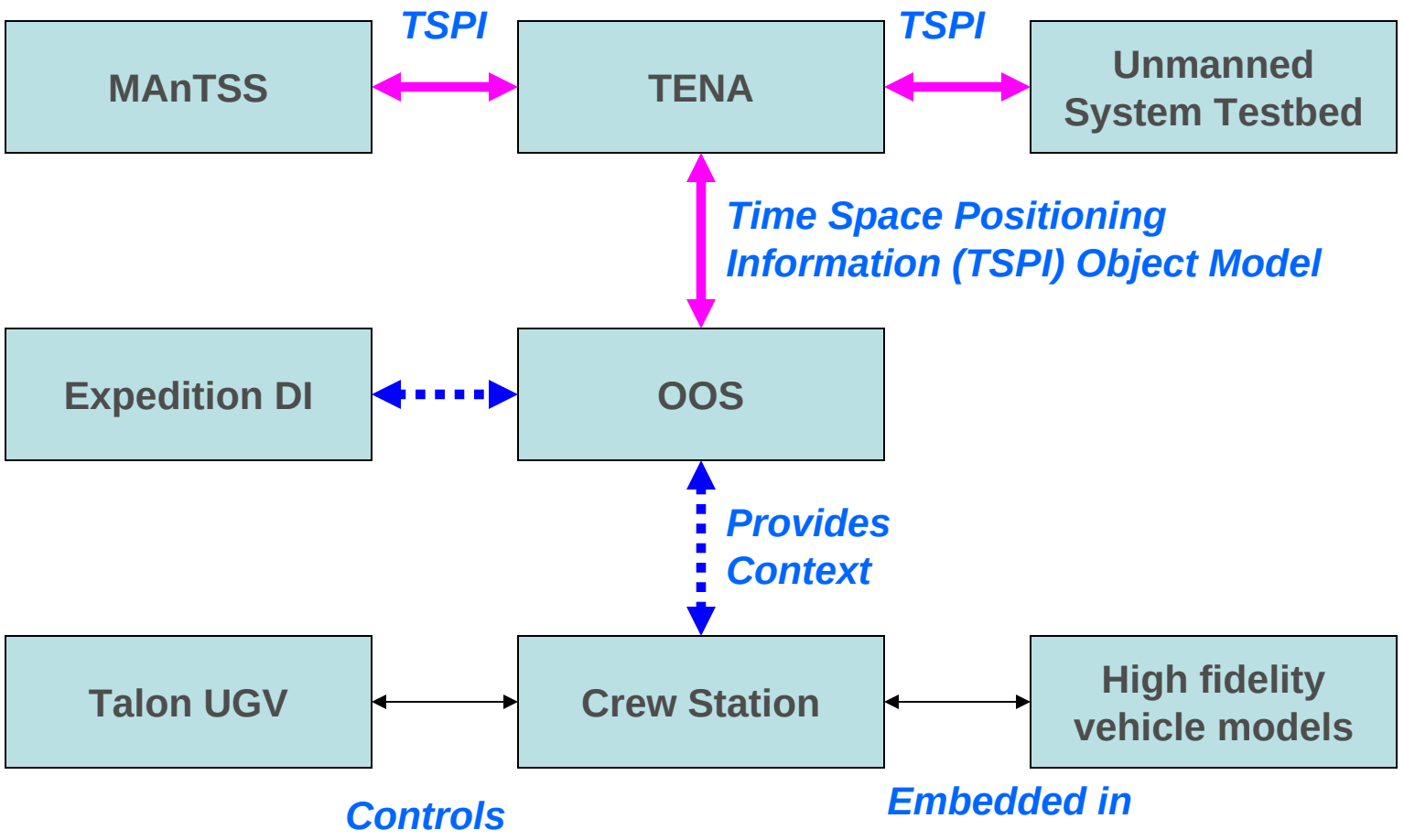
SAIC
From Science to Solutions™

Component Systems

- OneSAF Objective System (OOS)
  - Provides context, environment and synthetic convoy
- Common Architecture Desktop/Embedded Trainer (CADET)
  - Provides a virtual simulator with the embedded high fidelity vehicle simulation using MATLAB/C++ model
- Talon Robot
  - A live robot that is capable of interacting in the synthetic environment
- Expedition Dismounted Infantry (DI) representation
  - Provides a dismounted infantry immersive environment
- Test and Training Enabling Architecture (TENA)
  - Functions as middleware for live testing
- Unmanned Systems Test Bed (USTB)
  - Emulates an unmanned aerial vehicle (UAV)
- Modular Analysis Test Support System (MAnTSS)
  - Collects and analyzes testing data

SAIC
From Science to Solutions™

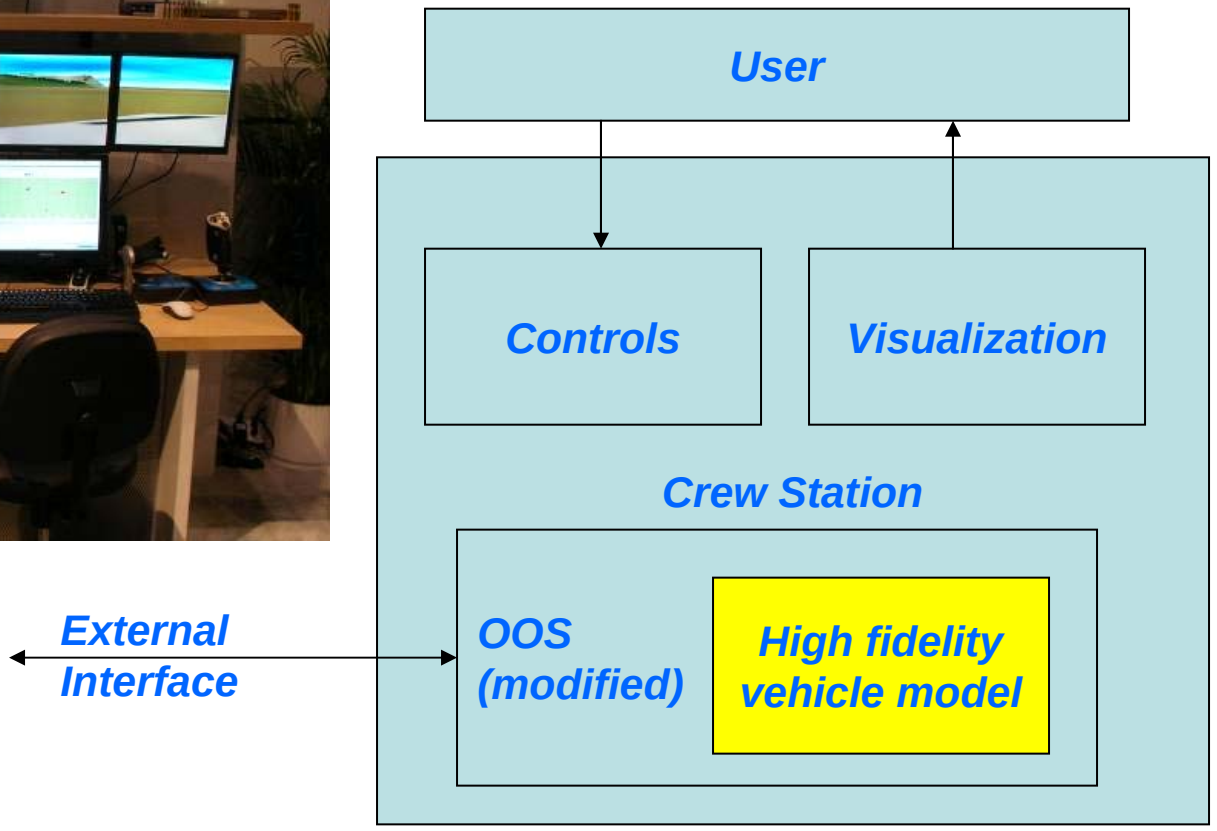
Notional System Architecture



SAIC
From Science to Solutions™

CADET Crew Station

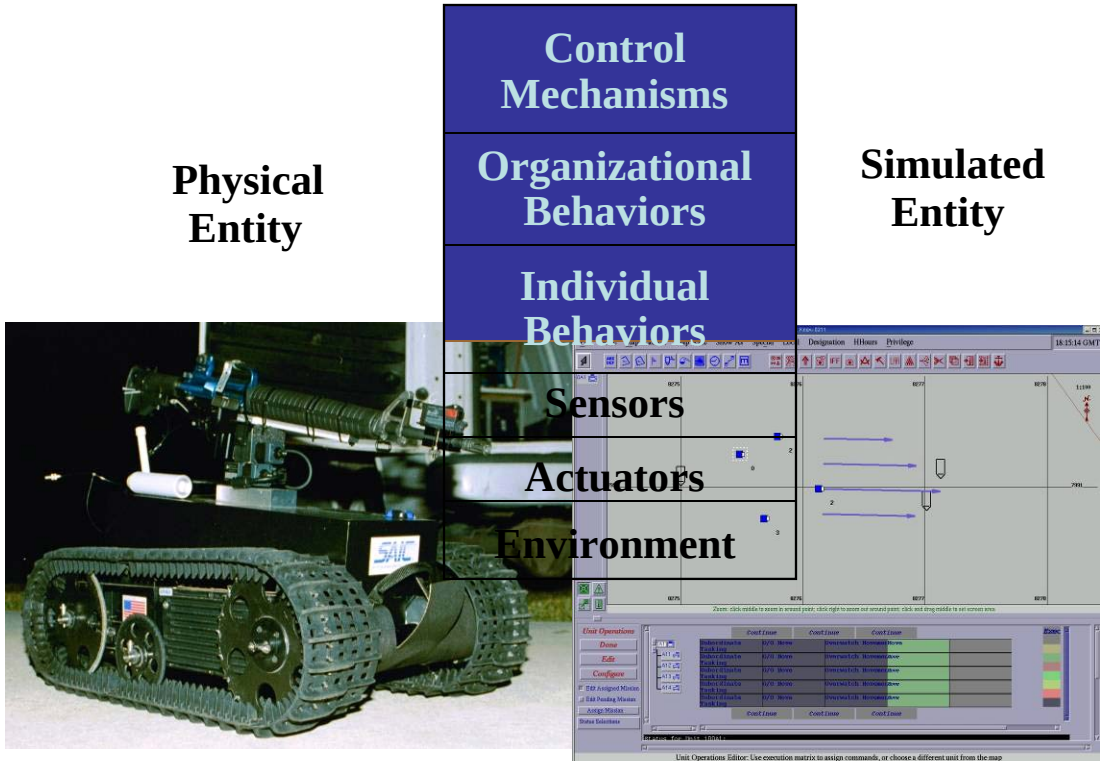




From Science to Solutions™

Talon UGV

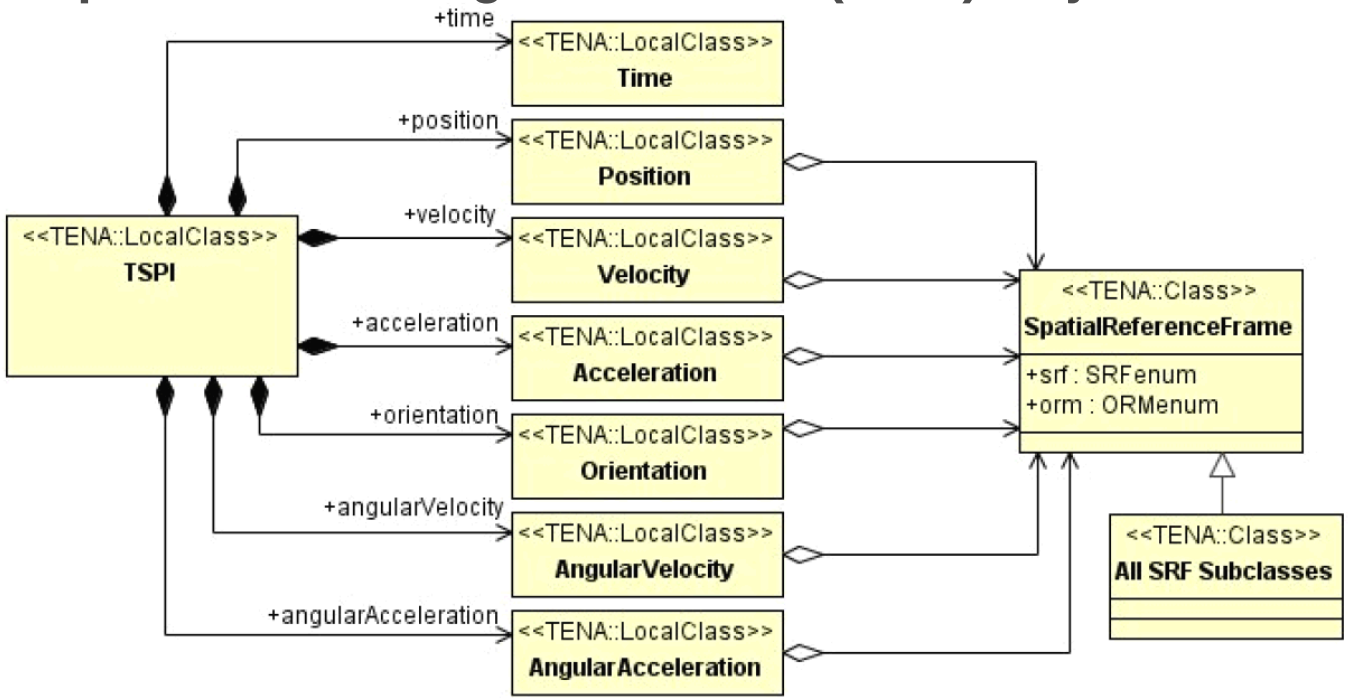
- Live system
  - Controlled by OOS
    - Replaced lower level synthetic elements with actual drivers
  - Teleoperated by joystick
- Turret
  - Remote camera
  - Blank firing M-16
- Wireless Networked
  - 802.11



SAIC
From Science to Solutions™

TENA

- Lightweight communication designed to connect live systems
- Domain specific optimization over traditional interoperability protocols
- Emerging standard for range systems
- Time Space Positioning Information (TSPI) Object Model



From Science to Solutions™

Notional Scenario

- Location
  - Kauai Pacific Missile Range Facility (PMRF)
- Entities
  - UAV (synthetic from USTB)
  - Robotic entity (live on blocks)
  - Stryker variant (controlled by crew station)
  - Trucks / Targets (synthetic from OOS)
  - Human (synthetic from Expedition DI)
- Actions
  - The UAV sees a small (3-4) convoy of trucks
  - The Stryker moves to and engages the trucks
  - The human and robot inspect the damage to the trucks

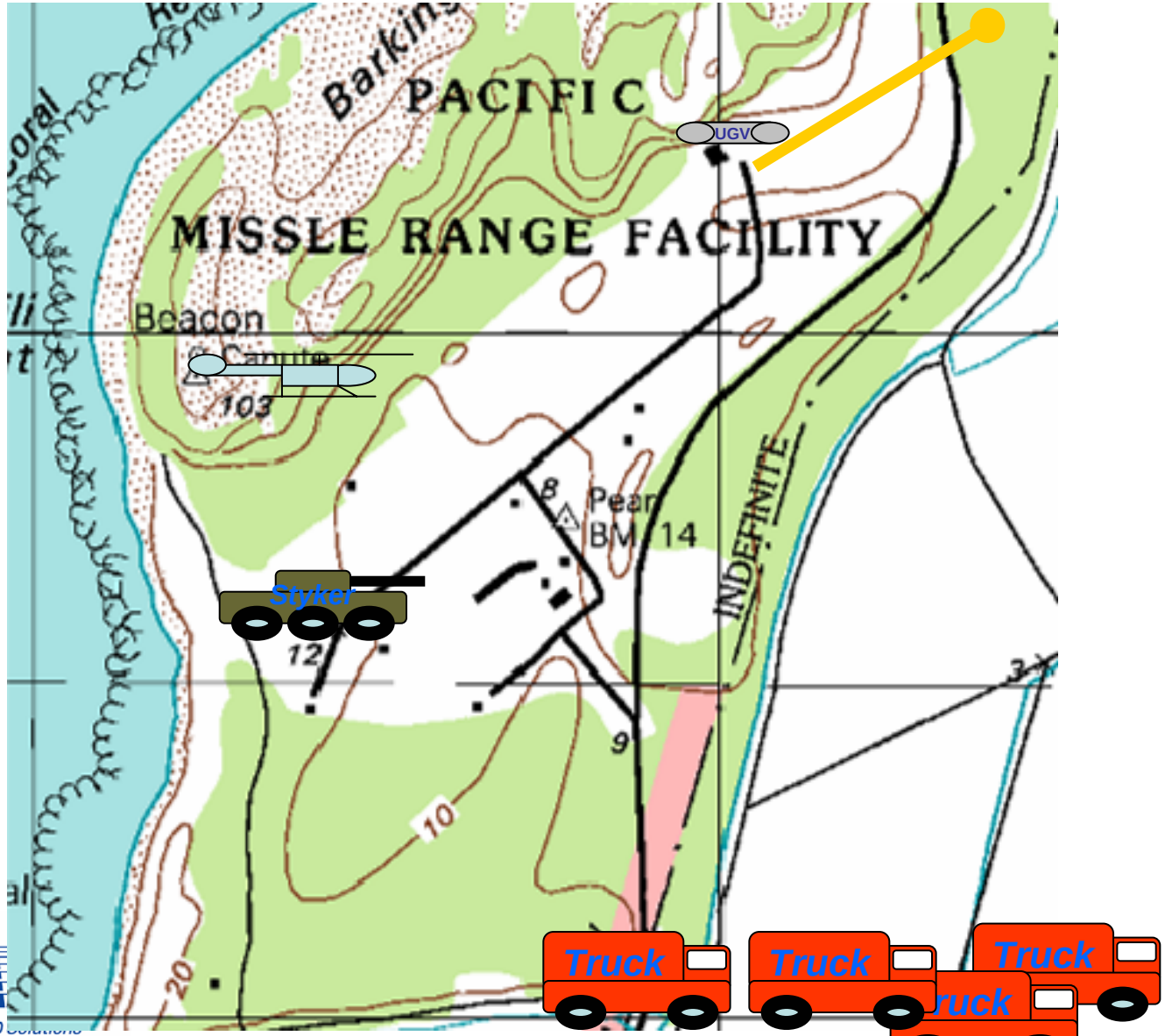
SAIC
From Science to Solutions™

Scenario Participants

- Vigilante UAV
  - Driven from the USTP
  - In reconnaissance mode
- Four trucks (targets)
  - Generated from OOS
  - Convoy driving down road
- Stryker Vehicle
  - Driven by the crew station
  - Hybrid electric drive model controls dynamics
  - Attacks convoy
- UGV
  - Physical device on blocks
  - Tasked by OOS/Crew Station
  - Inspects convoy after attack by Stryker

SAIC
From Science to Solutions™

Scenario


PACIFIC
MISSLE RANGE FACILITY
Barking
UGV
Beacon
Camp Pt
103
8
Pear
BM
14
INDEFINITE
Styker
12
9
10
20
3
Truck
Truck
Truck
ruck

Interoperability Issues

- TENA
  - TSPI object model
  - Reference version was used
- HLA
  - TBD FOM
  - Version: RTI-1.3, Matrex version 4.2
- Terrain Data
  - Kauai Pacific Missile Range Facility (PMRF) High Res
  - The digital raster graphics is at: http://www.hinhp.org/website/hawaii/kauai/data/drg.zip.
  - Shape files and some others are at: http://www.hinhp.org/website/hawaii/kauai/data.html.

SAIC From Science to Solutions™

Results

- Success!
  - By the time the show opened everything worked
  - And then extended on the show floor
- Terrain registration
  - Common source
  - Control over generation process
- OOS Modular Communication Interface modification
  - Modified HLA interface with TENA
- High Fidelity Engine/Suspension Model
  - Wrapped in OOS component model
  - Proxy implementation to remote computer
- Transparent interaction among elements

SAIC
From Science to Solutions™

Parts Management Reengineering

9th Annual Systems Engineering Conference

6 October 2006

Michael J. Goy, DSPO

Outline

- History
- Definitions/Descriptions
  - PM as an Engineering Discipline
  - PM as a Requirement
  - PM in support of the Warfighter
- Reengineering
  - Challenges
  - Findings
  - Conclusions
  - Recommendations
- Where do we go from here?

History

- 1977: MIL-STD-965, Parts Control Program
- 1983: SECDEF Weinberger Spare Parts Acq Memo
- 1984: DESPECDEF Taft DoD Parts Control Memo
- 1994: SECDEF Perry Acquisition Reform Memo
- 1996: MIL0HDBK-965, Parts Management Program
- 2000: MIL-HDBK-512, Parts Management
- 2004: Reengineer Processes

What is Parts Management?

- A multi-disciplined process designed to improve system supportability
  - Reduce Life Cycle Costs
  - Improve Reliability
  - Improve Readiness
  - Improve Interoperability
  - Control growth of Logistics Footprint
  - Mitigate DMSMS Issues

What is Parts Management?

- Collaboration between industry and Government
- Selection of parts in the design phase
- Analyzing reliability, availability, and quality
- Screening for commonality
- Reducing the number of unique parts

Why Parts Management?

- Selecting the right parts drives downstream outcomes
  - Cost reduction
  - Interoperability
  - Readiness
- Current parts management practices are not adequate
- PMRWG recommendations address these issues

Making Parts Management A "Requirement"

- Requirement will add needed discipline
- Requirement will address Parts Selection and DMSMS
- Requirement will address Parts Management in Program Reviews
- Requirement will ***NOT*** be a return to past "prescriptive" practices

Parts Management in Support of the Warfighter

Parts Management will ensure optimum parts are used in design and provide:

- **Better reliability**
- **Better availability**
- **Better logistics support**
- **Better cost savings**
- **Better metrics on readiness data and ROI**

The Reengineering Process

- Included DoD and Industry
- Researched Best Practices
- Analyzed and Explored Alternatives
- Examined Parallel Efforts (PBL, SE, CSI)
- Developed Findings, Conclusions, Recommendations

Findings

- Footprint is growing
- Acquisition environment lacks adequate emphasis on Parts Management
- Systems Engineering lacks emphasis on Parts Management

Conclusions

- Parts Management:
  - needs to be a requirement
  - needs to take a total system approach
  - decision-makers need better tools
  - can be fully accomplished in a performance-based environment

PMRWG Recommendations

- Restore Parts Management as an engineering discipline
- Make Parts Management a contractual requirement
- Develop Parts Management Tools
- Build key partnerships and relationships

Where do we go from here?

- Aggressive implementation through phases:
  - Systems Engineering
  - Acquisition Policy
  - Training
  - Industry Participation
  - Advocacy

Any Questions?

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

AN EFFECTIVE UML PROCESS

Presented at the
NDIA System Engineering Conference
24 October 2006
By
Jeffrey O. Grady
President JOG System Engineering
6015 Charae Street
San Diego, CA 92122
jgrady@ucsd.edu

©JOG System Engineering, Inc.

Who Is Jeff Grady?

CURRENT POSITION

President, JOG System Engineering, Inc.
System Engineering Assessment, Consulting, and Education Firm

PRIOR EXPERIENCE

1954 - 1964 U.S. Marines

1964 - 1965 General Precision, Librascope Div

Customer Training Instructor, SUBROC and ASROC ASW Systems

1965 - 1982 Teledyne Ryan Aeronautical

Field Engineer, AQM-34 Series Special Purpose Aircraft
Project Engineer, System Engineer, Unmanned Aircraft Systems

1982 - 1984 General Dynamics Convair Division

System Engineer, Cruise Missile, Advanced Cruise Missile

1984 - 1993 General Dynamics Space Systems Division

Functional Engineering Manager, Systems Development

FORMAL EDUCATION

BA Math, SDSU
MS Systems Management, USC

INCOSE **First Elected Secretary, Founder, Fellow**

AUTHOR **System Requirements Analysis (1993, 2006), System Integration, System Validation and Verification, System Engineering Planning and Enterprise Identity, System Engineering Deployment**

©JOG System Engineering, Inc.

There's a Problem Out There

- There are problems in the way UML is often applied
- The application of this powerful model should:
  - Follow Sullivan's encouragement for unprecedented developments
  - Identify SW entities and requirements from the top-down so as to coordinate better with the system engineering and HW work
  - Employ a common product entity structure with the system and HW development
  - Provide for hierarchical traceability across the HW-SW gap
- Available DIDs do not clearly coordinate with application of UML
- Models not always saved or configuration managed
- Traceability problems at the HW-SW gap

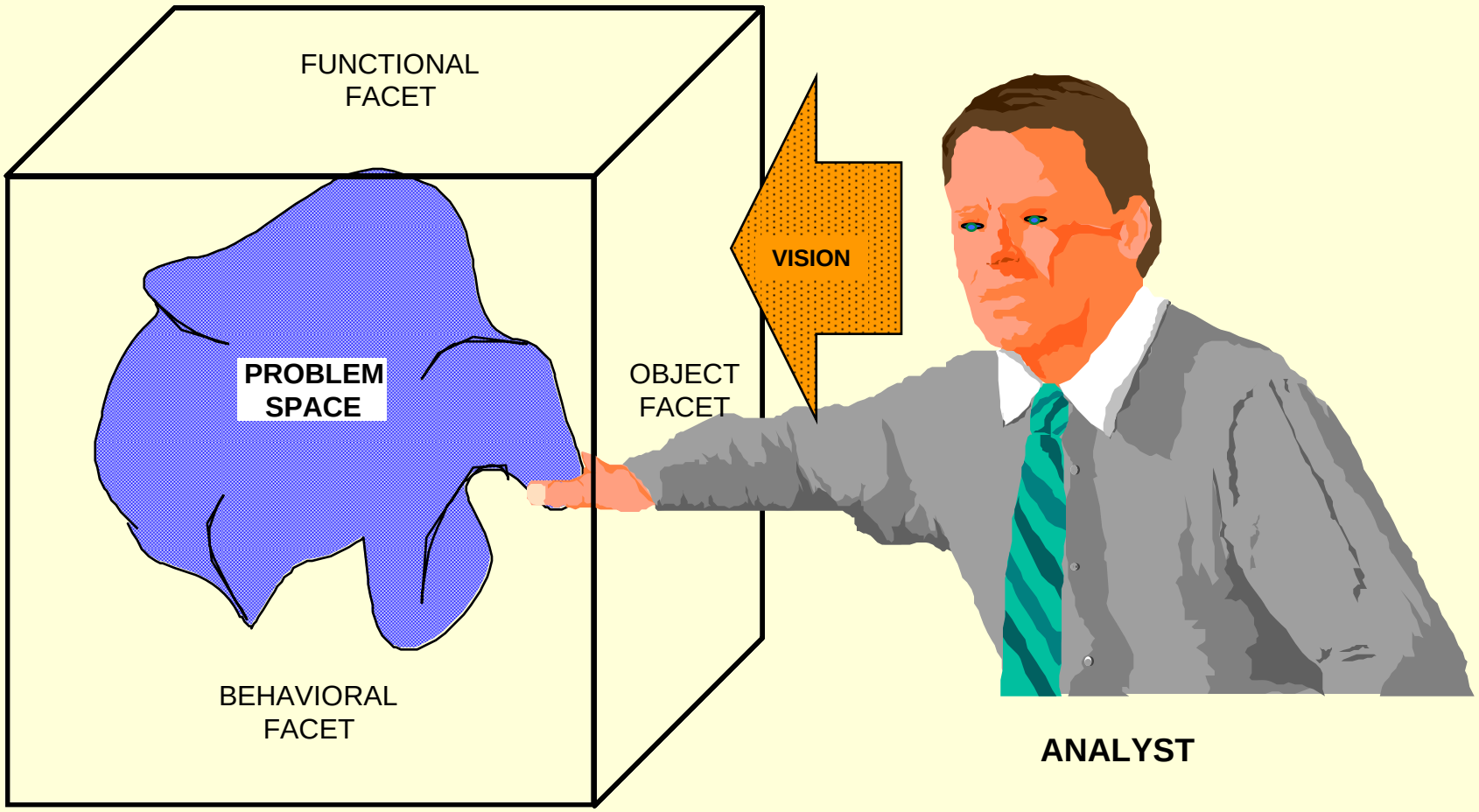
©JOG System Engineering, Inc.

Agenda

- Fundamentals of structured analysis
- UML fundamentals using a top-down approach
- Hardware-software requirements traceability
- The future of requirements analysis modeling

©JOG System Engineering, Inc.

Structured View of a Problem Space



©JOG System Engineering, Inc.

Structured Analysis Methods Comparison

MULTI-FACETED APPROACHES	PRODUCT ENTITY FACET	FUNCTIONAL FACET	BEHAVIOR FACET
TRADITIONAL STRUCTURED ANALYSIS	PRODUCT ENTITY BLOCK DIAGRAM	FUNCTIONAL ● FLOW DIAGRAM	SCHEMATIC BLOCK DIAGRAM
MODERN STRUCTURED ANALYSIS	HIERARCHICAL DIAGRAM	DATA FLOW ● DIAGRAM	P SPEC, STATE DIAGRAM
EARLY OBJECT-ORIENTED ANALYSIS	CLASS AND OBJECT DIAGRAM ●	DATA FLOW DIAGRAM	STATE DIAGRAM
UML	CLASS/OBJECT , COMPONENT, & DEPLOYMENT DIAGRAMS	USE CASES AND ACTIVITY DIAGRAMS ●	STATE, SEQUENCE, AND COMMUNICATION DIAGRAMS

● UNPRECEDENTED ANALYTICAL ENTRY FACET

©JOG System Engineering, Inc.

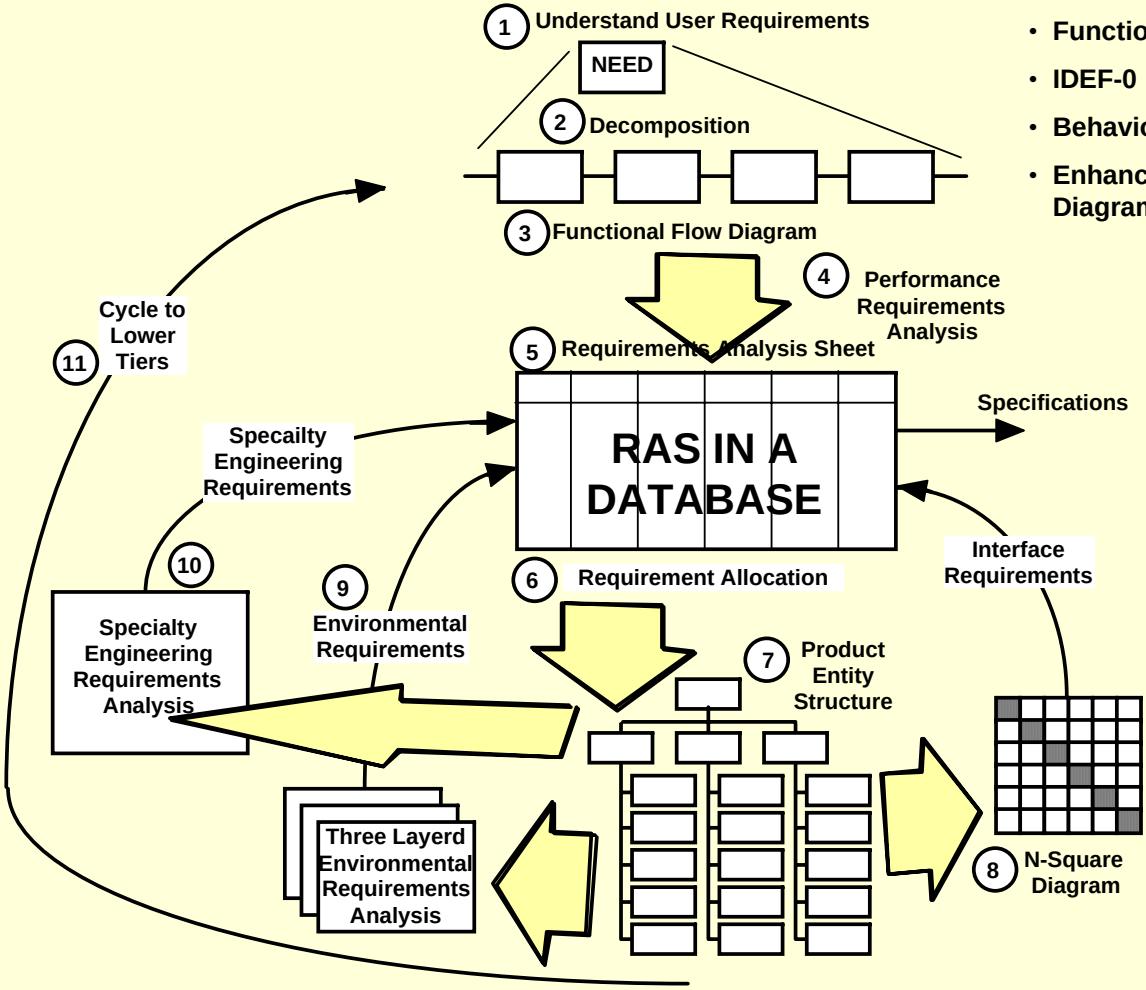
NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

How Should I Enter Problem Space?

- It is not clear how one can have a system that at the highest level is software
- Software must operate inside of some kind of hardware entity
- Therefore, I would elect to use a system modeling approach for initial problem space entry where the need is the ultimate function
- Traditional structured analysis is such an approach

©JOG System Engineering, Inc.

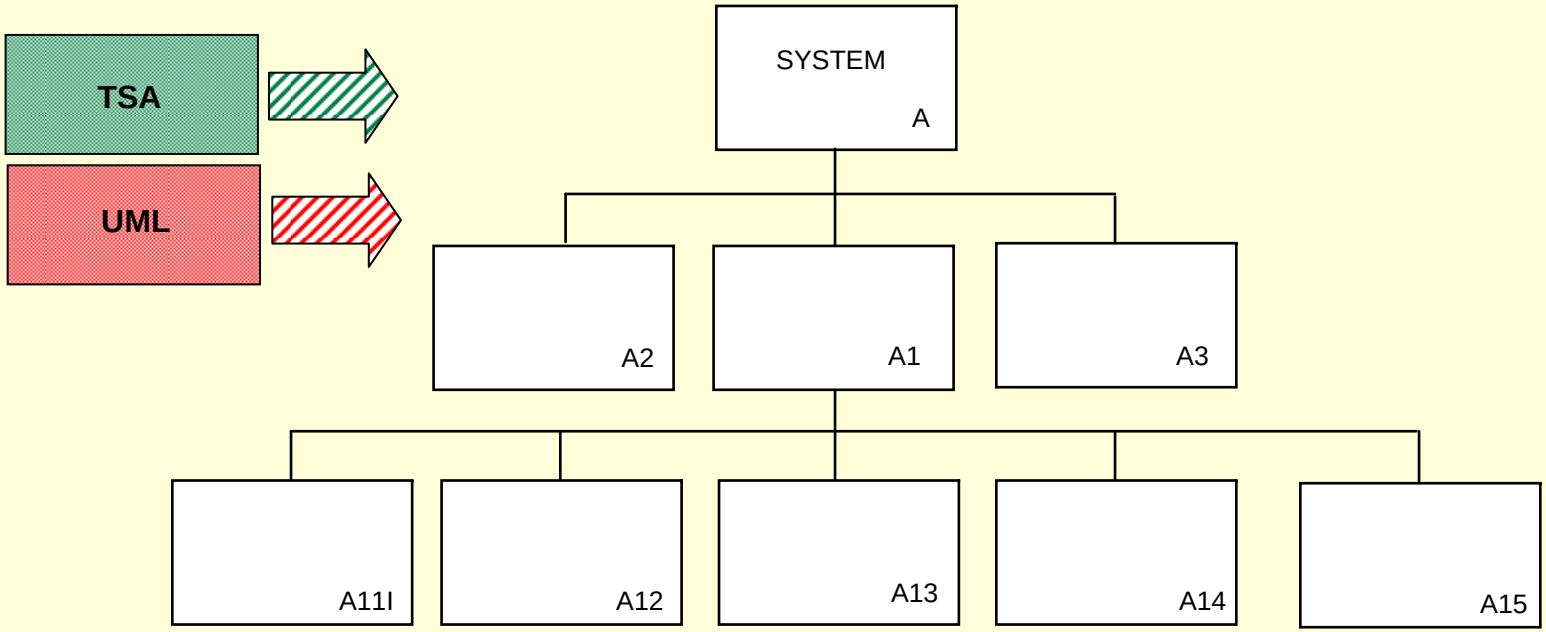
Traditional Structured Analysis Model Overview



- Functional Flow Diagrams
- IDEF-0
- Behavioral Diagrams (RDD)
- Enhanced Functional Flow Block Diagrams (CORE)

©JOG System Engineering, Inc.

Common
Product Entity Structure

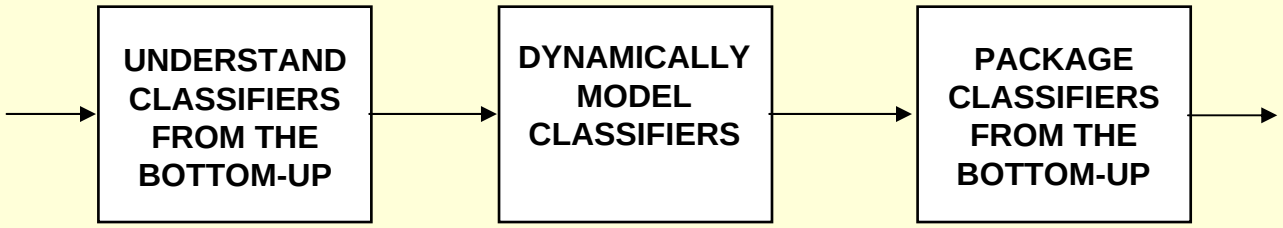


- **Use a common structure that includes hardware and software.**
- **Apply a top-down analysis for both that contributes to the identification of entities in the common product entity structure.**

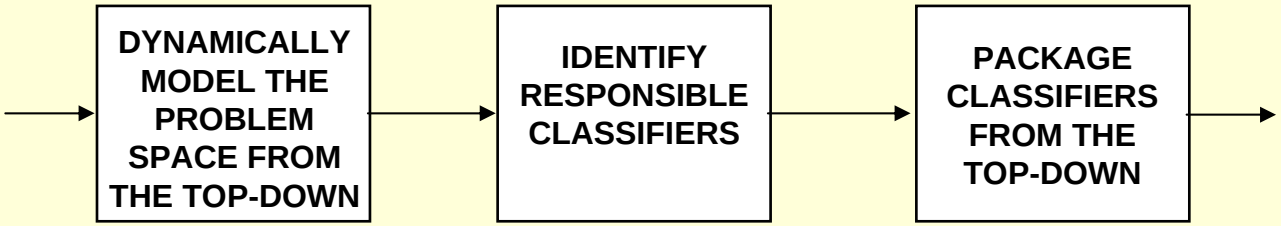
©JOG System Engineering, Inc.

A Preferred Modeling Order

- **Early object oriented analysis encouraged this pattern.**



- **We will follow Sullivan's encouragement in this case - form follows function - because it coordinates with traditional structured analysis.**



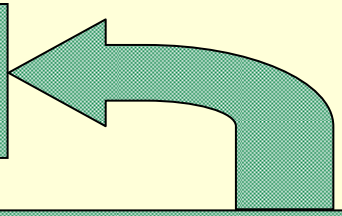
- **UML can actually support either direction like any good modeling approach.**

Note: A classifier is a general term for a software product entity represented by a node, component, or class in UML but by a block on the product entity diagram like any other entity.

©JOG System Engineering, Inc.

The Software Development Process Using UML

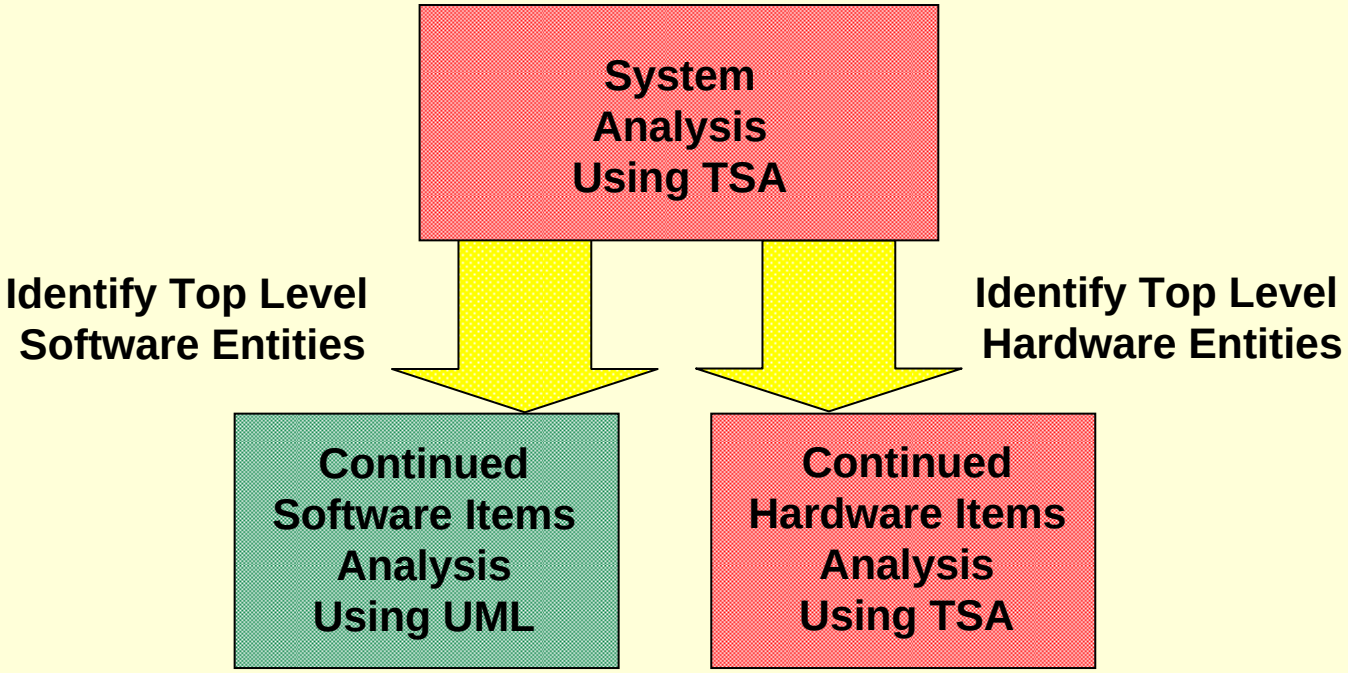
- Identify an initial product entity that will be developed as computer software using traditional structured analysis.
- Dynamically analyze the entity using UML.
  - Use cases
  - Sequence diagram
  - Communication diagram
  - Activity diagram
  - State diagram



- In the sequence, communication, and activity diagramming analysis you will have to identify next lower tier software product entities.
- And the process continues to expand and move deeper translating problem space into solution space.
- At the bottom are classes about which code can be written based on requirements derived from the dynamic modeling work.

©JOG System Engineering, Inc.

Surprise!



Note that the SW work pattern encouraged exactly parallels that employed in TSA.

©JOG System Engineering, Inc.

The Diagrams of UML 2

- For modeling dynamic aspects of the system
  - Use case diagram
  - Sequence diagram
  - Communication diagram (renamed in 2)
  - State diagram
  - Activity diagram
  - Timing diagram
  - Interaction overview diagram (2)
- For modeling static aspects of the system
  - Object and class diagrams
  - Component diagram
  - Deployment diagram
  - Composite structure diagram (2)
  - Package diagram (2)

Classifiers

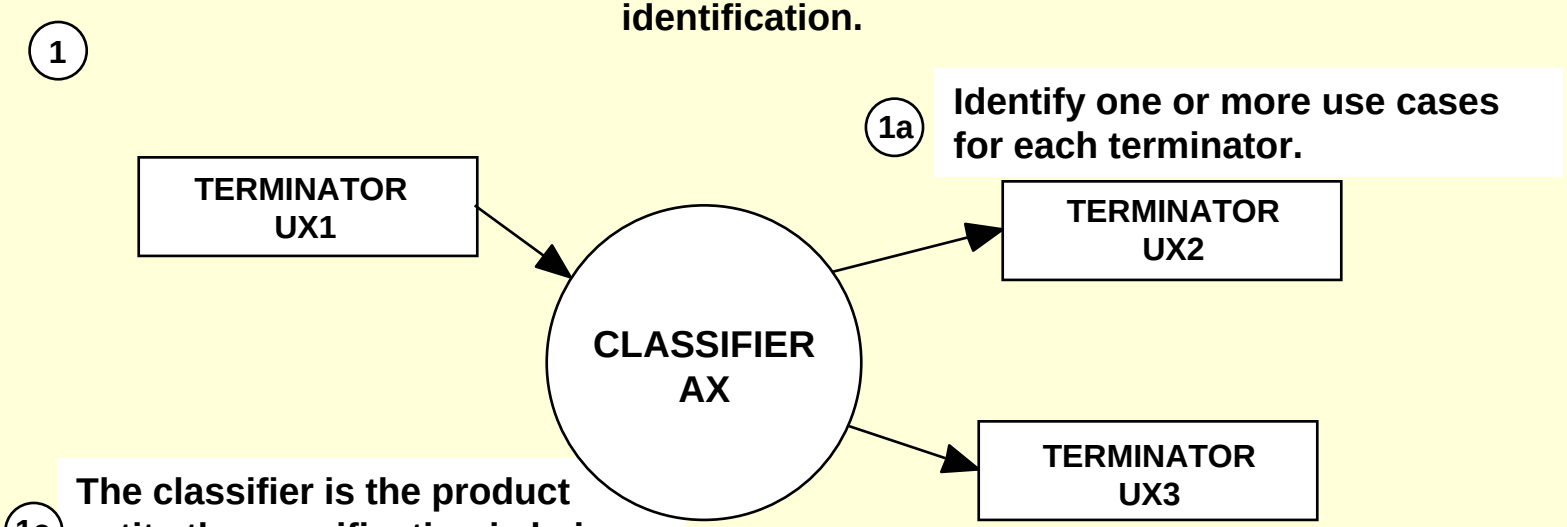
Covered in this discussion

(2) = added in UML 2.0

©JOG System Engineering, Inc.

Context Diagram

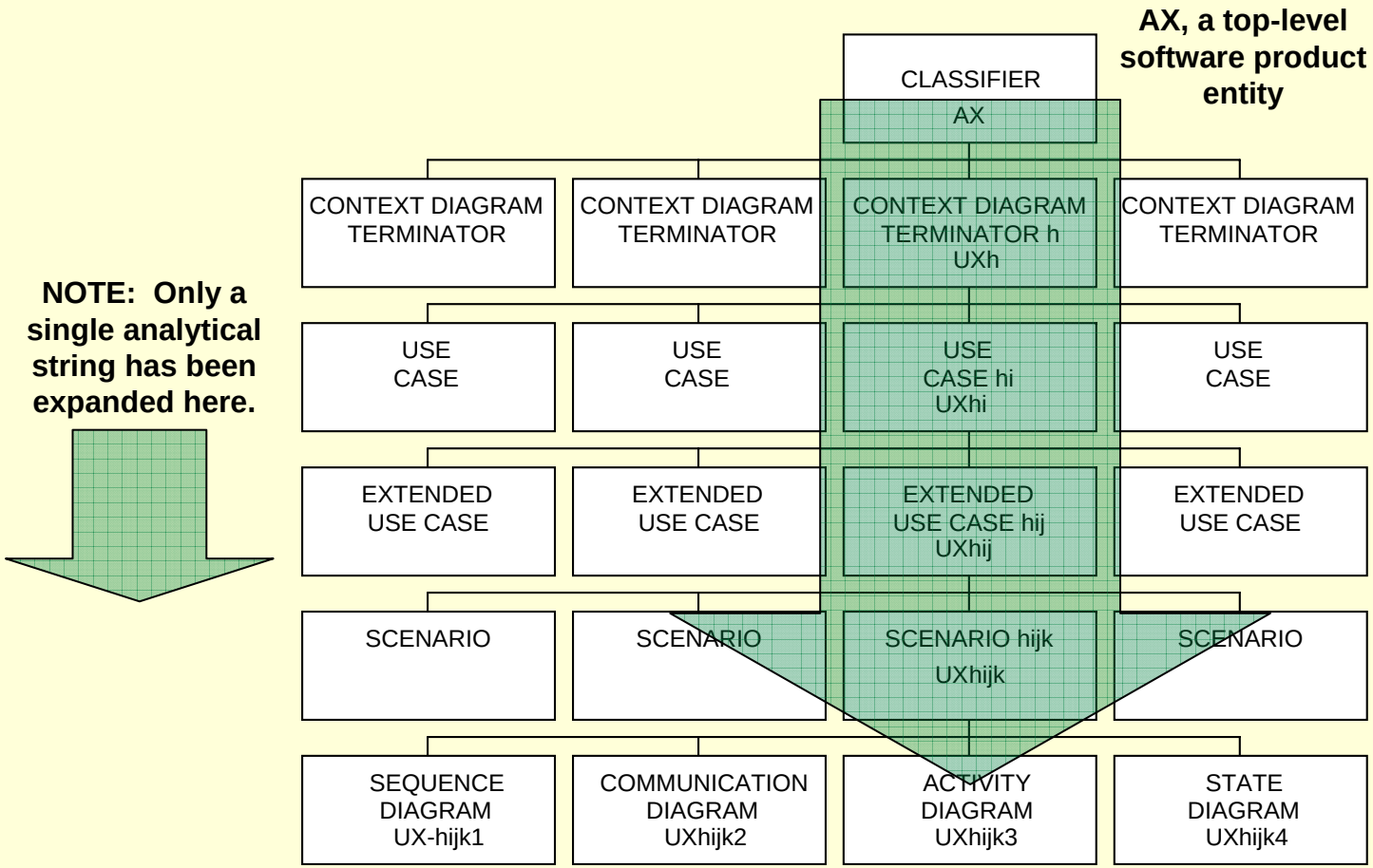
Borrowed from Modern Structured Analysis to provide an organized approach to use case identification.



©JOG System Engineering, Inc.

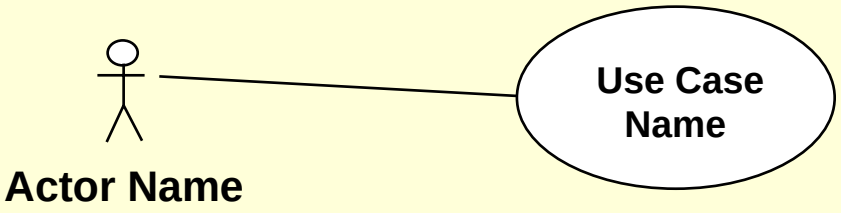
Hierarchical Modeling Relationships

- The Supporting Dynamic Modeling Artifacts



©JOG System Engineering, Inc.

Use Case Fundamentals

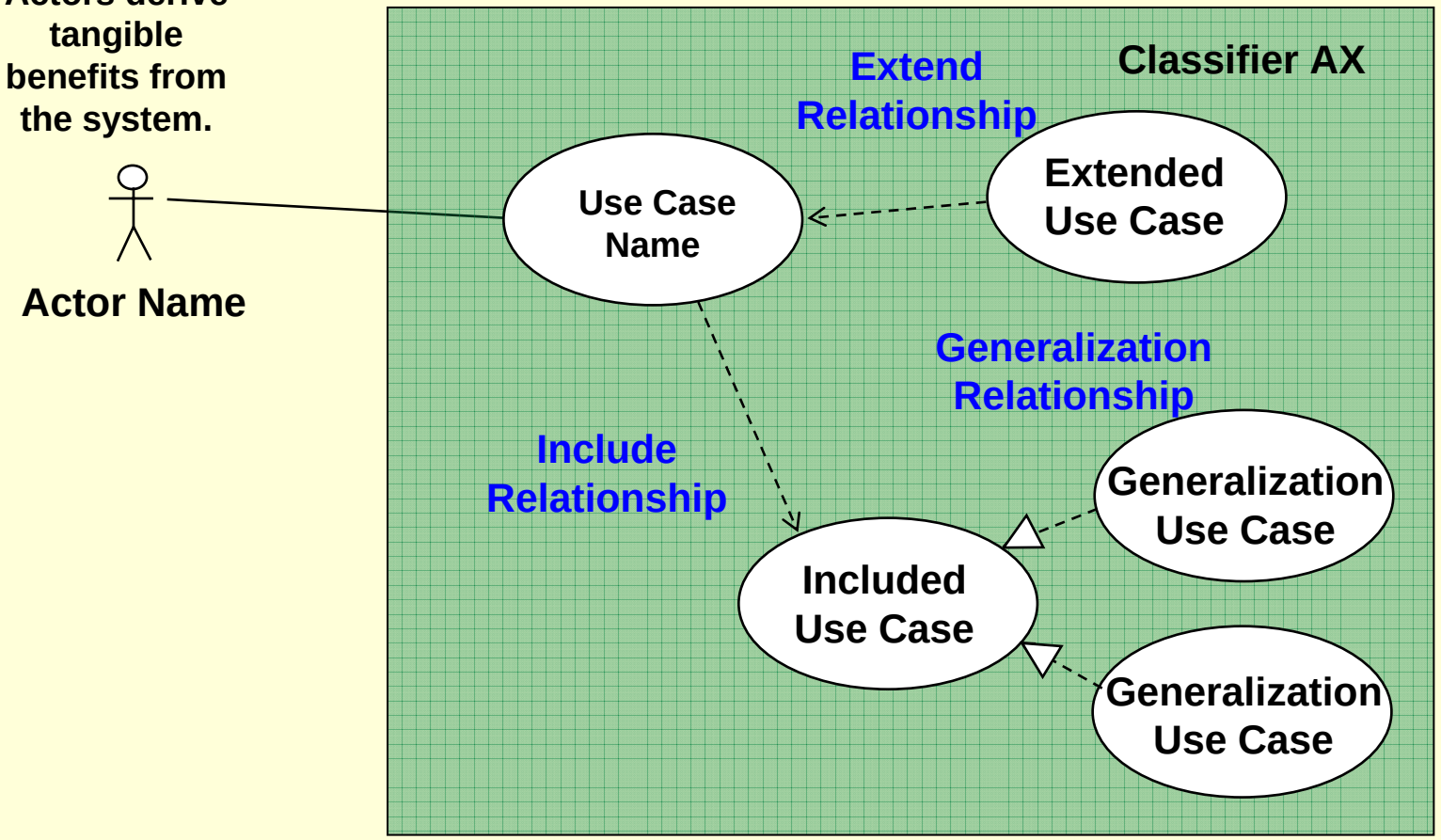


- A use case is a more expressive form of the context diagram used in modern structured analysis.
- A use case bubble represents some aspect of the system being developed.
- An actor represents some external agent gaining benefit from the system.

©JOG System Engineering, Inc.

Use Case Relationships

Actors derive tangible benefits from the system.



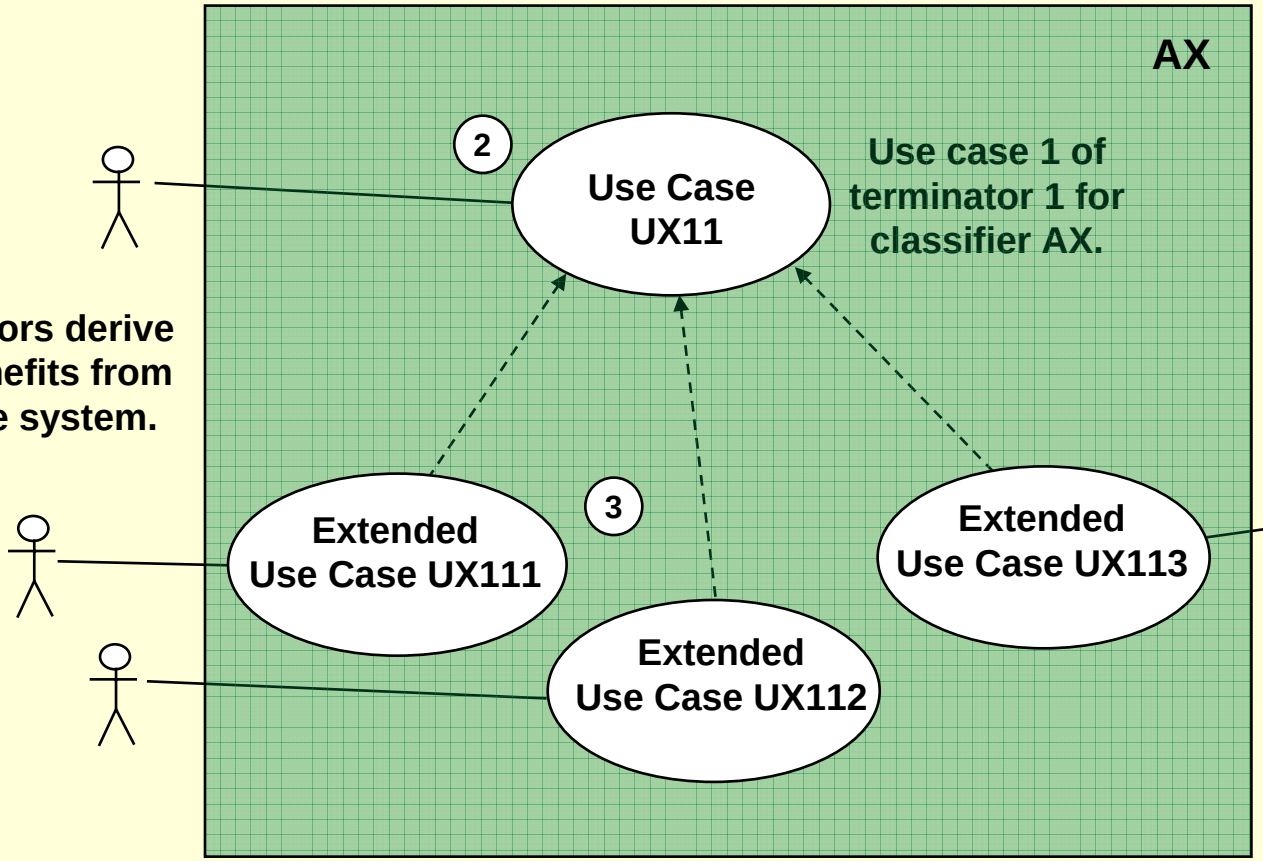
©JOG System Engineering, Inc.

Use Case Relationships

- **Extend**
  - **Pushes common behavior into other use cases that extent a base use case**
- **Include**
  - **Pulls common behavior from other use cases that a base use case includes**
- **Generalization**
  - **A child use case inherits behavior and meaning of the base use case**
  - **The child use case may add or override the behavior of the base use case**

©JOG System Engineering, Inc.

Use Case UX11

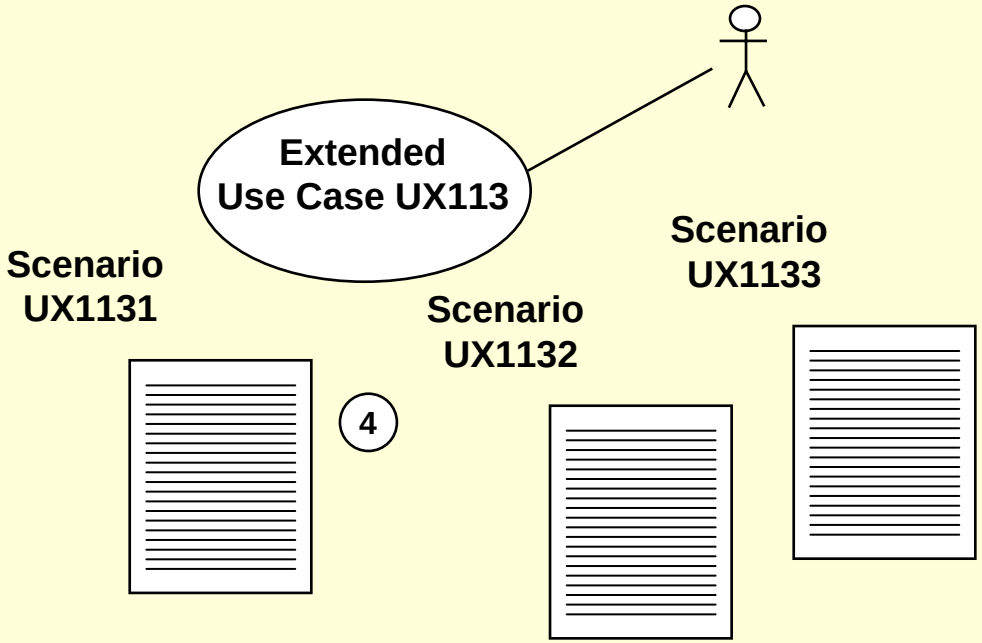


Actors derive benefits from the system.

The word extend is used here in a generic way here to embrace extend, include, and generalization relationships.

©JOG System Engineering, Inc.

Possible Multiple Scenarios



The word extend is used in a generic way here to embrace extend, include, and generalization relationships.

Textual scenario descriptions (use case specifications)

©JOG System Engineering, Inc.

Scenario

- A sequence of actions that illustrates behavior.
- A scenario may be used to illustrate an interaction or execution of a use case instance.
- Text description that can be captured in paragraph 3.1.2.h.i.j.k of the classifier specification.

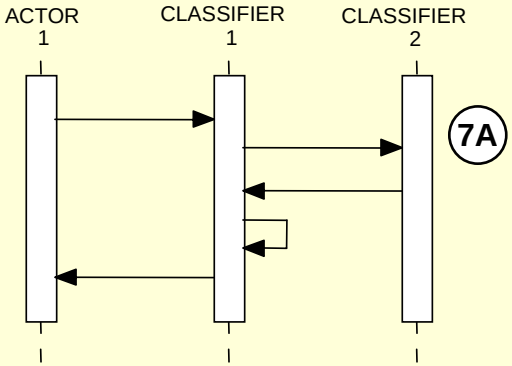


If you want a copy of a DID email jgrady@ucsd.edu

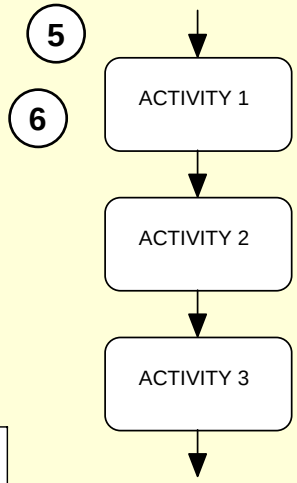
©JOG System Engineering, Inc.

The Other Dynamic Models

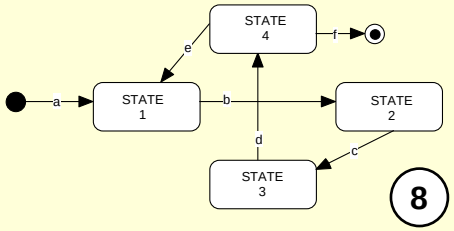
Sequence Diagram UX11321



Activity Diagram UX11323



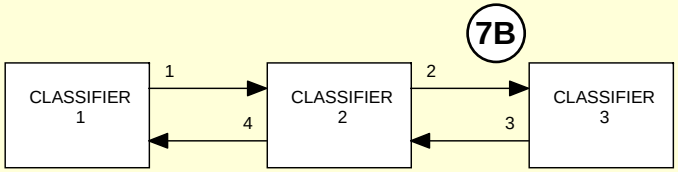
State Diagram UX11324



STATE	DESCRIPTION
1 2 3 4	

TRANSITION	DESCRIPTION
a b c d e f	

Interaction Diagrams

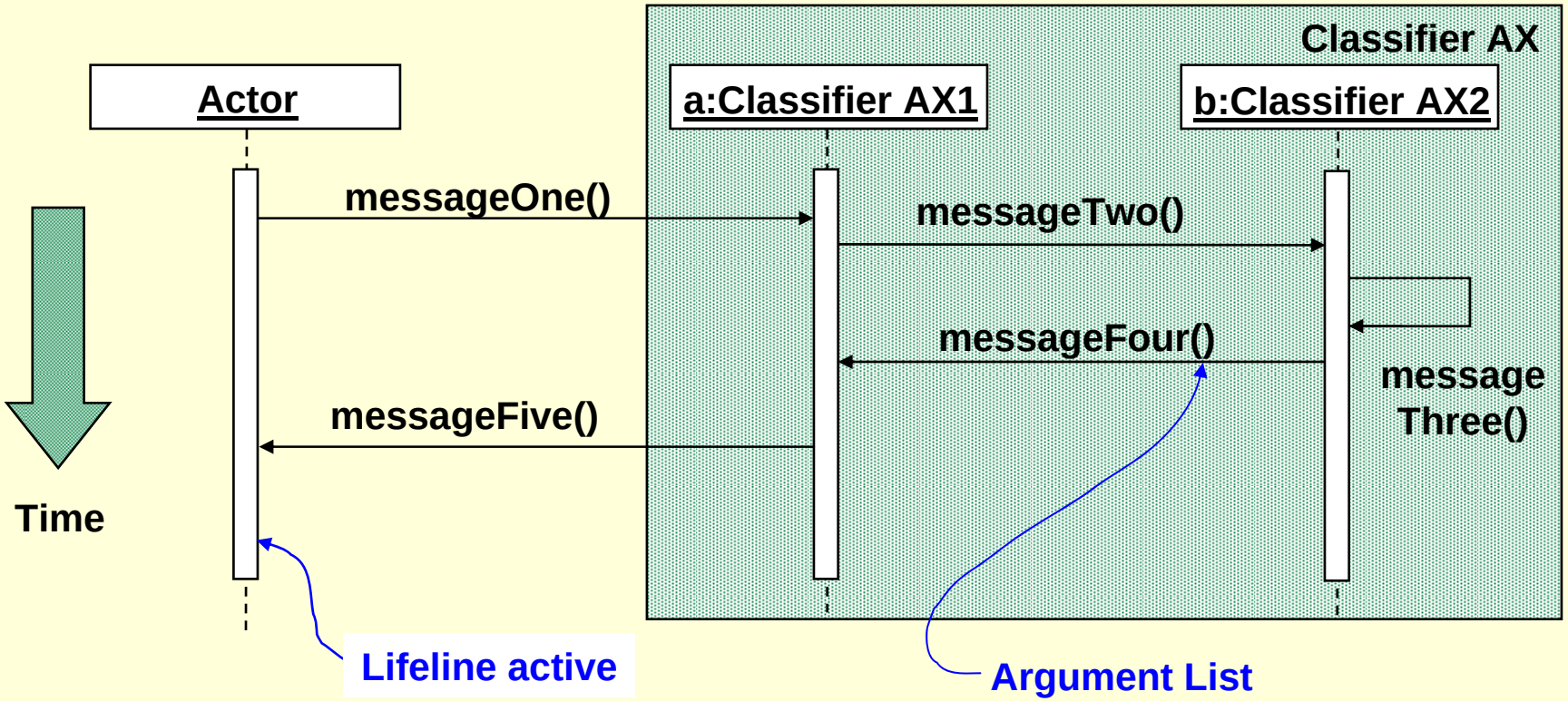


Communication Diagram UX11322

©JOG System Engineering, Inc.

Sequence Diagram UX11321

Emphasizes the time ordering of messages



It is understood that the classifiers are performing operations, possibly modeled in activity or state diagrams, relative to the message content.

©JOG System Engineering, Inc.

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

Messages Between Lifelines

- A message is the specification of a communication among classifiers on a class or object diagram or between the classifier represented by life lines on the sequence diagram or blocks of a communication diagram.
- When a message is passed from one classifier to another some action usually results on its receipt.
- The action may result in a change of state in the classifier on the arrow head.
- Describe the related requirements in terms related to the target classifier.

©JOG System Engineering, Inc.

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

Sequence Diagram Message Types

- **Call**
  - Invokes an operation on an object represented by the lifeline
  - An object can send a call to itself resulting in a local invocation
- **Return**
  - Returns a value to the caller
- **Send**
  - Sends a signal to an object
- **Create**
  - Creates an object
- **Destroy**
  - Destroys an object

©JOG System Engineering, Inc.

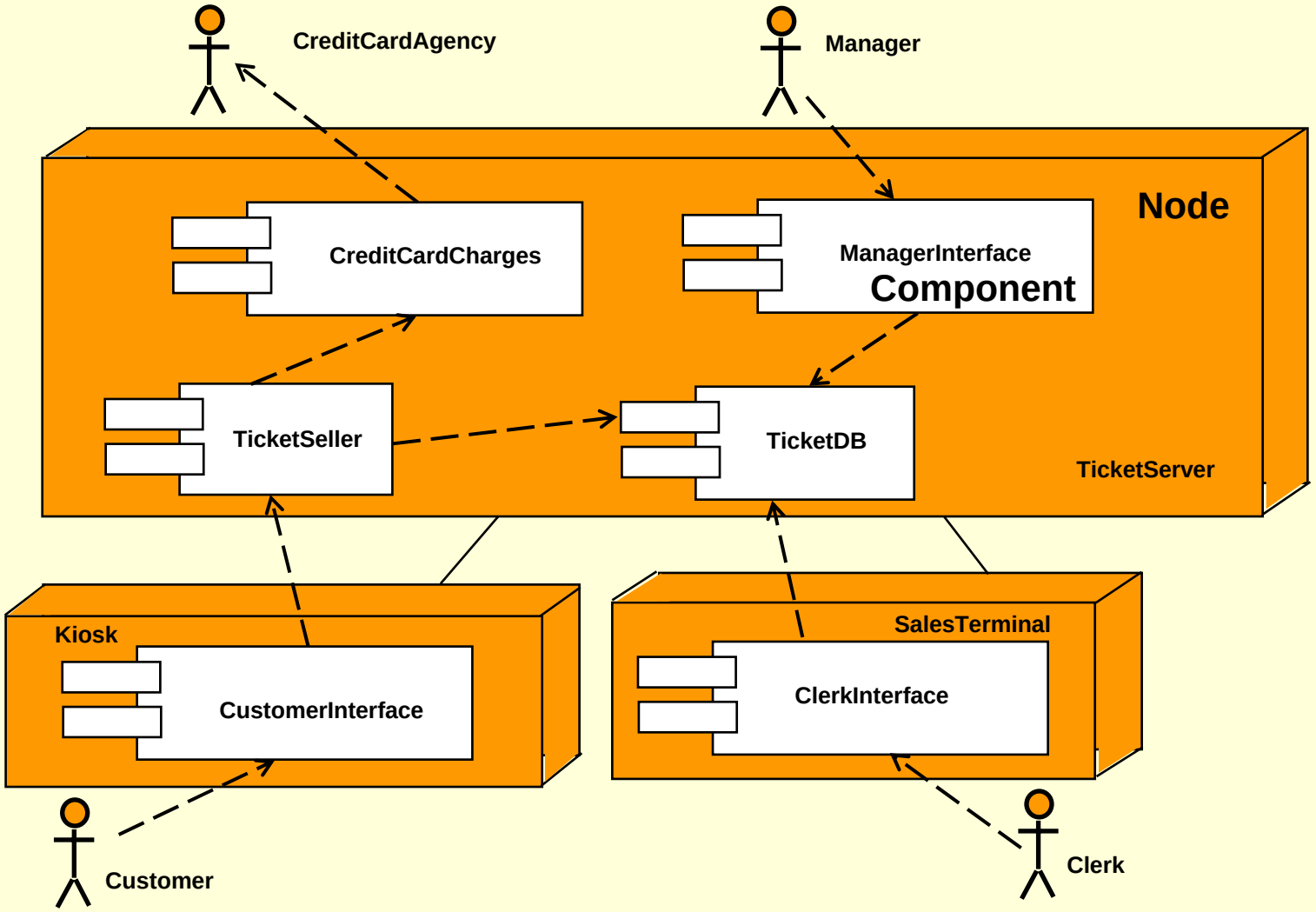
NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

The UML Static Entities

- **System/Subsystem**
  - **The highest level software entity. There can be many of these entities in a real system composed of hardware and distributed software. A collection of subsystems composed of nodes or simply nodes.**
- **Node**
  - **Appears on a deployment diagram that exists at run time and is a computational resource, generally having at least some memory and often processing capability. A collection of components.**
- **Component**
  - **A modular part of the system consisting of other components or directly of classes.**
- **Class**
  - **A description of a set of objects that share the same attributes, operations, relationships, and semantics.**
- **Object**
  - **An instance of a class.**

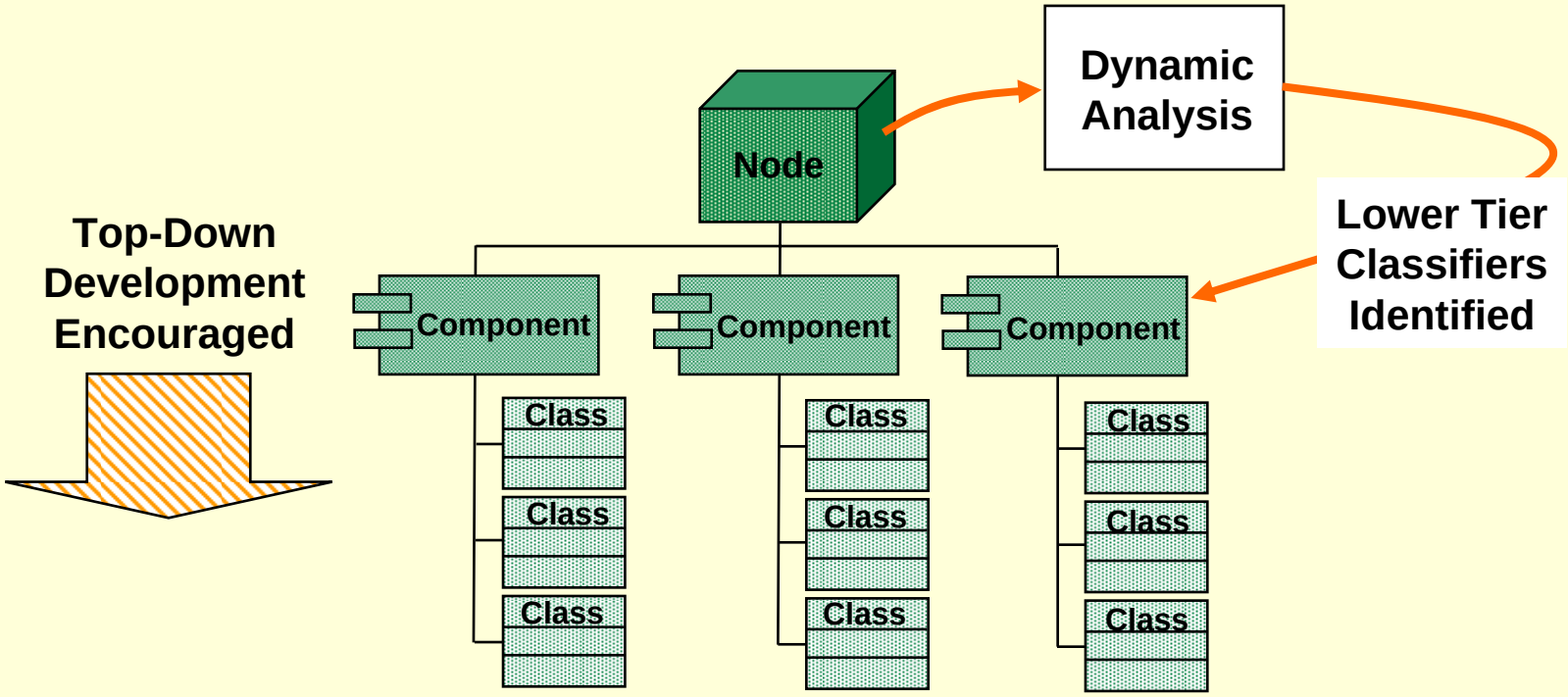
©JOG System Engineering, Inc.

Deployment and Component Diagrams



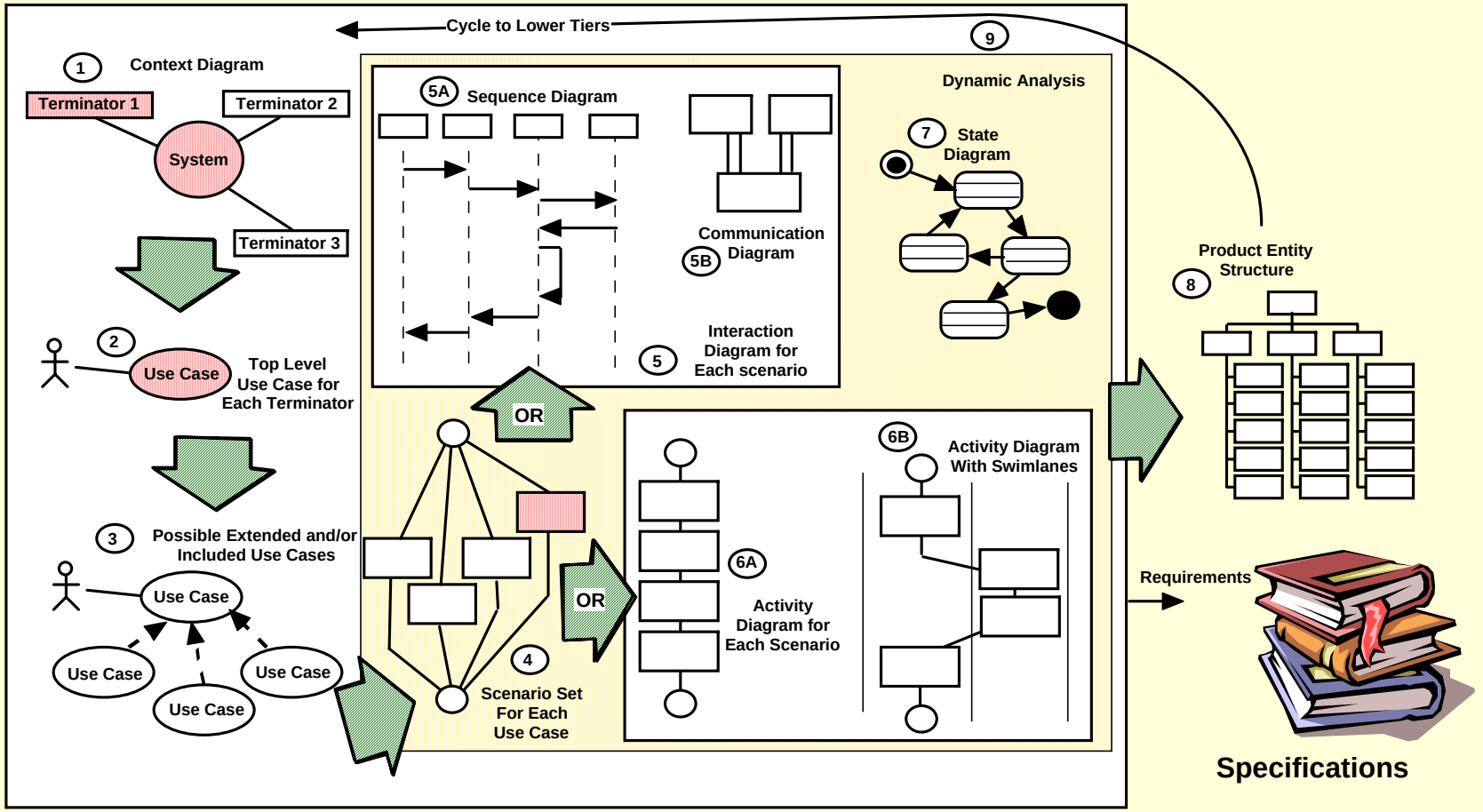
©JOG System Engineering, Inc.

UML Structural Artifacts in a Product Entity Structure



©JOG System Engineering, Inc.

A Flexible Dynamic Modeling Overview



©JOG System Engineering, Inc.

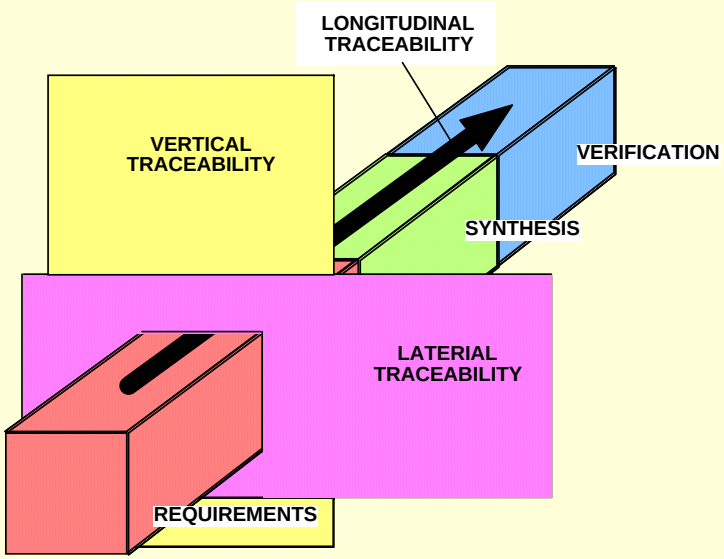
Organizing the Dynamic Modeling

- Use a context diagram to organize the use cases.
- Recognize a family of use cases if necessary.
- If use cases complex, recognize two or more scenarios for each lowest tier use case.
- For each scenario, build a sequence or activity diagram and in the process identify next lower tier classifiers and messages between the actors and lower tier classifiers.
- Apply communication, activity or sequence, and state diagrams as needed.
- Derive requirements from dynamic modeling artifacts and relationships.

©JOG System Engineering, Inc.

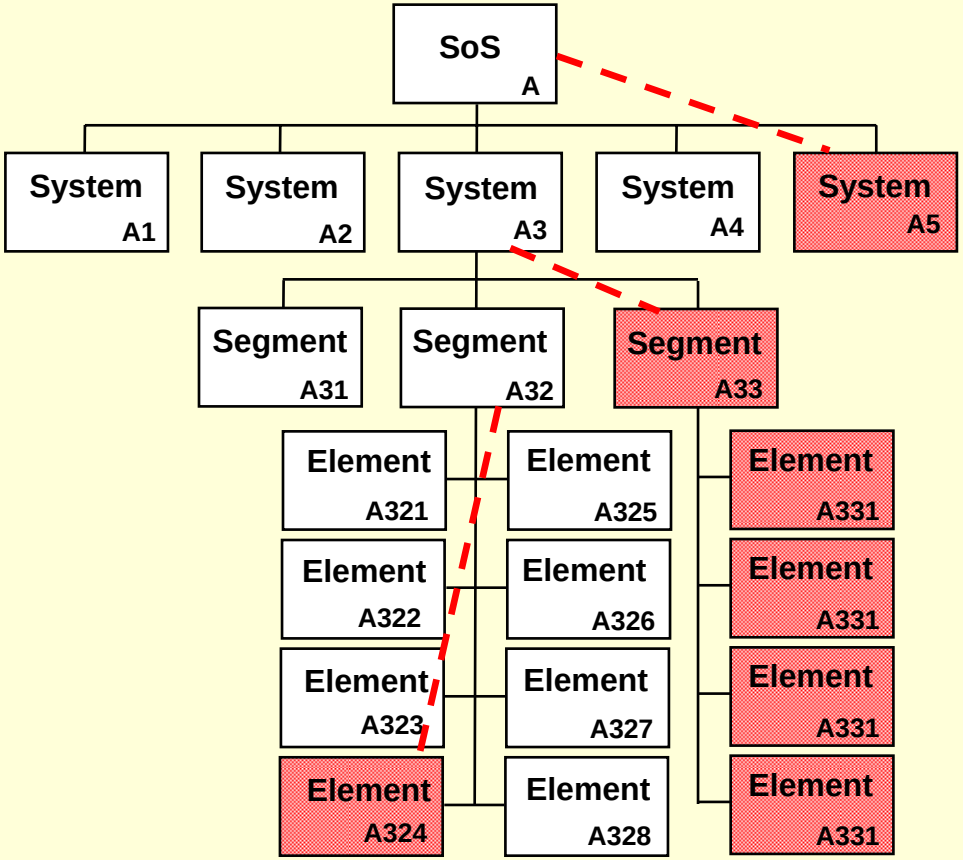
Traceability Forms

- **Vertical requirements traceability**
  - Hierarchical or parent-child
  - Requirements source traceability
  - Requirements rationale traceability
- **Longitudinal traceability**
  - Requirements to synthesis and verification
- **Lateral traceability**
  - Traceability to method
- **Applicable document**
  - Internal integrity



©JOG System Engineering, Inc.

System Product Entity Structure



Software Entities

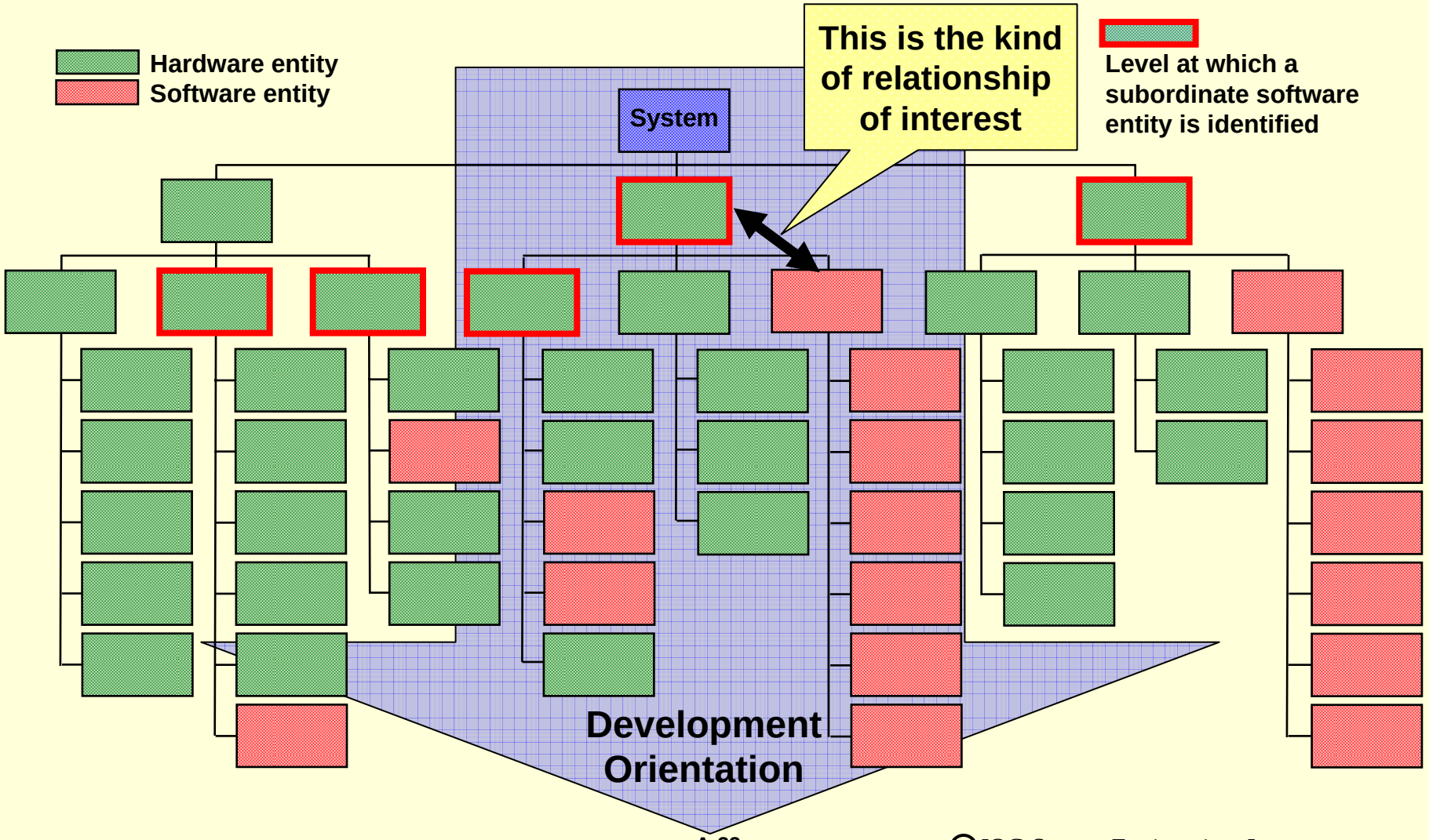
Requirements Traceability Concerns

Downward Traceability Situation

		FROM	
		HW	SW
TO	HW	No Problem	Not Going To Happen
	SW	Problem	No Problem

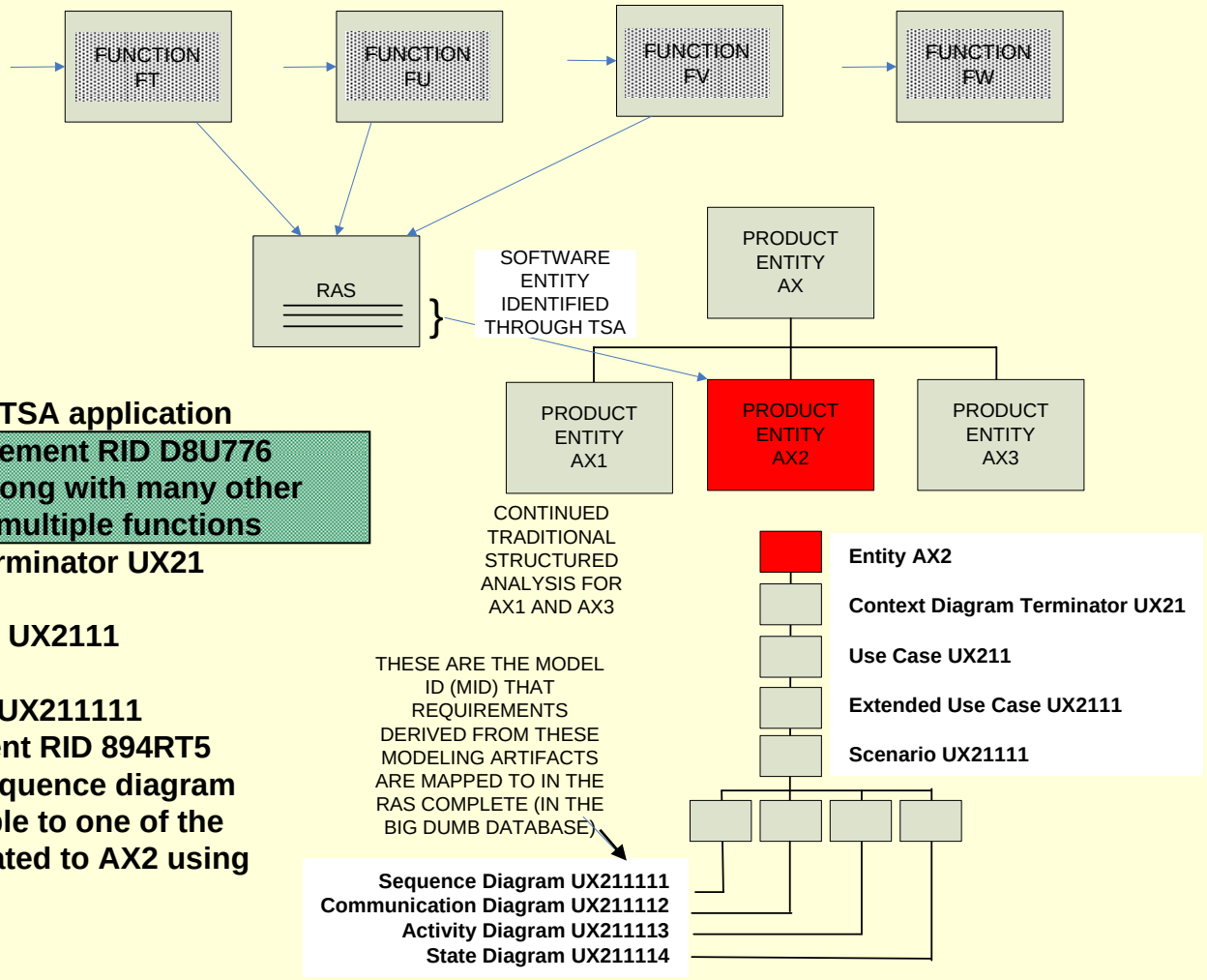
©JOG System Engineering, Inc.

The System Product Entity Structure



©JOG System Engineering, Inc.

Traceability Across the Gap

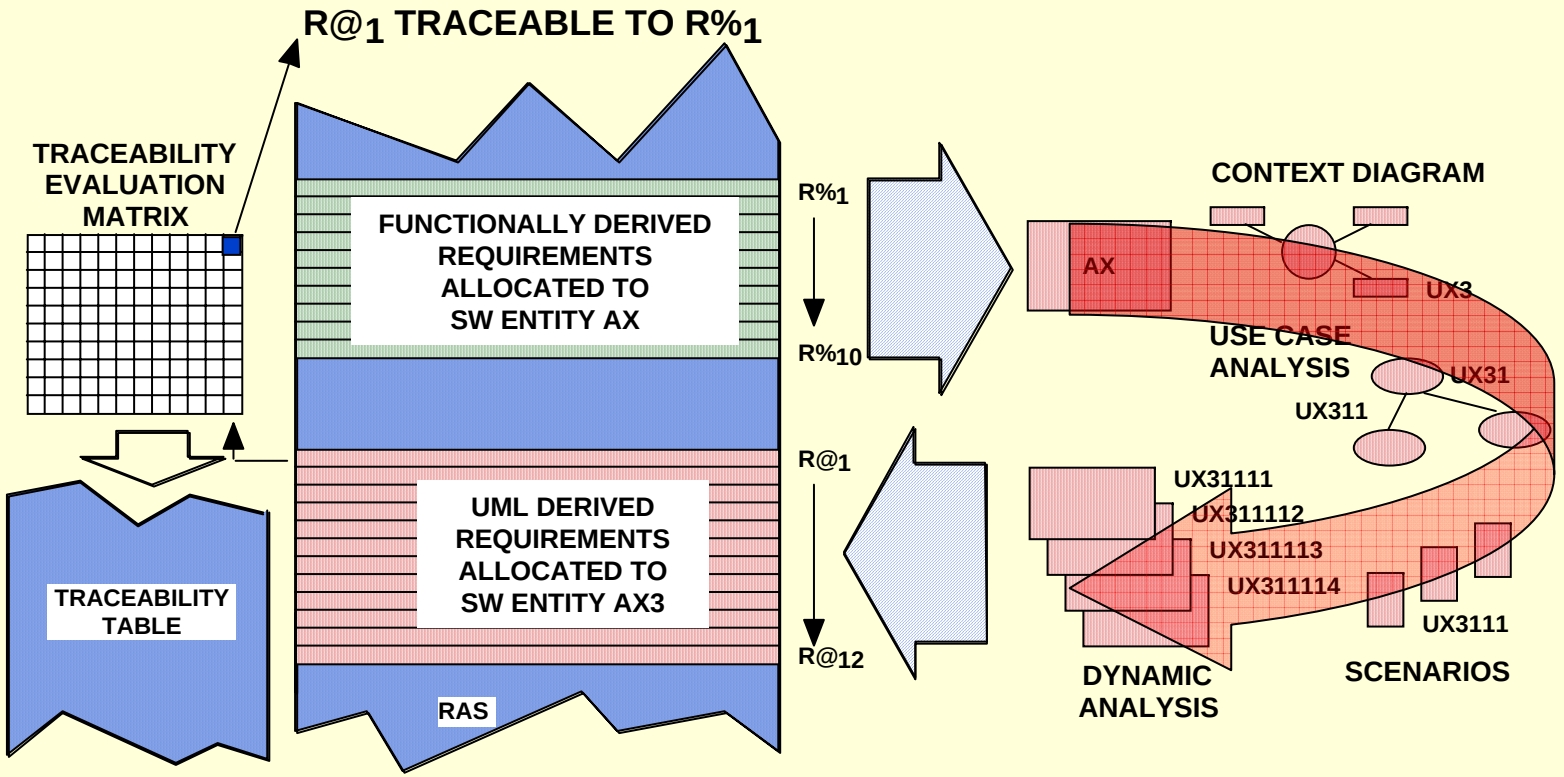


The Gap

- **Function FT within TSA application**
- **Performance requirement RID D8U776 allocation to AX2 along with many other requirements from multiple functions**
- **Context diagram terminator UX21**
- **Use case UX211**
- **Extended Use Case UX2111**
- **Scenario UX21111**
- **Sequence diagram UX211111**
- **Software requirement RID 894RT5 derived from the sequence diagram**
- **RID 894RT5 traceable to one of the requirements allocated to AX2 using TSA.**

©JOG System Engineering, Inc.

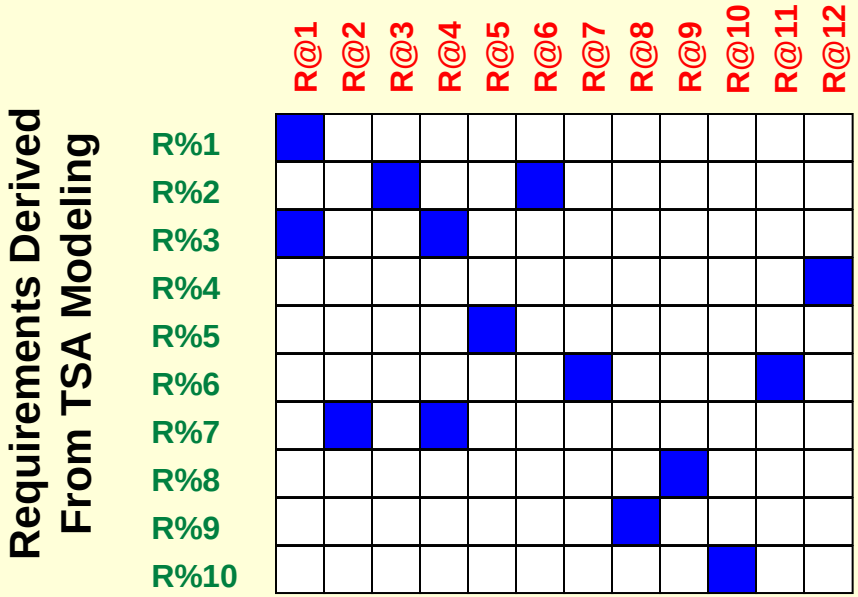
Traceability Evaluation Matrix



©JOG System Engineering, Inc.

Traceability Evaluation Matrix

Requirements Derived From UML Modeling



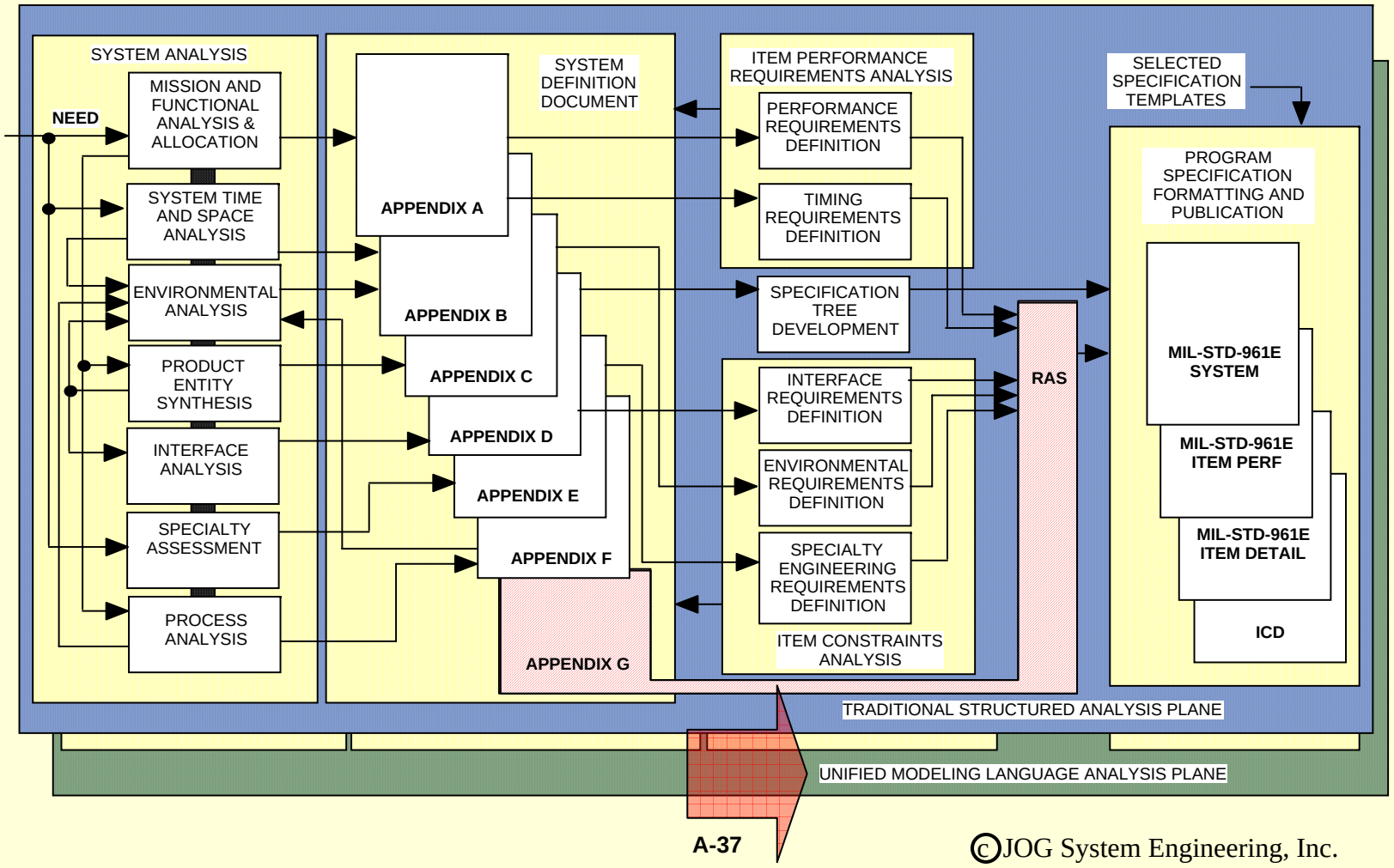
POSSIBLE RID EXAMPLE

R%1	RU7Z7H
R%2	R9IER6
R%3	R937YF
R%4	RJ8E6G
R%5	RJYT6T
R%6	RHGT5T
R%7	RID87W
R%8	RBJ8S7
R%9	RL34DF
R%10	R456HD

Alternatively, one could rely upon experienced inspection without the organizing influence of the matrix.

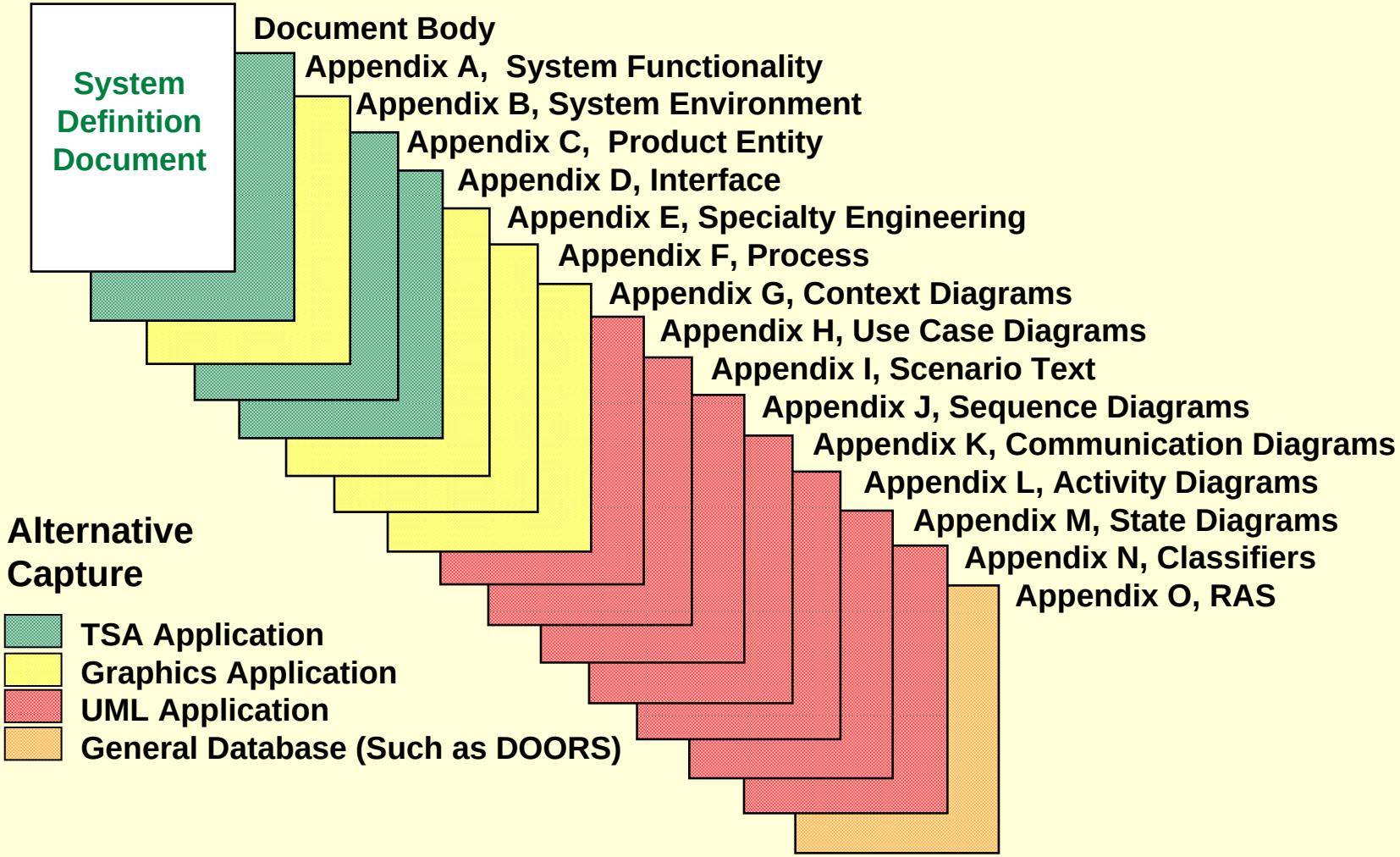
©JOG System Engineering, Inc.

Save the UML Models Too!



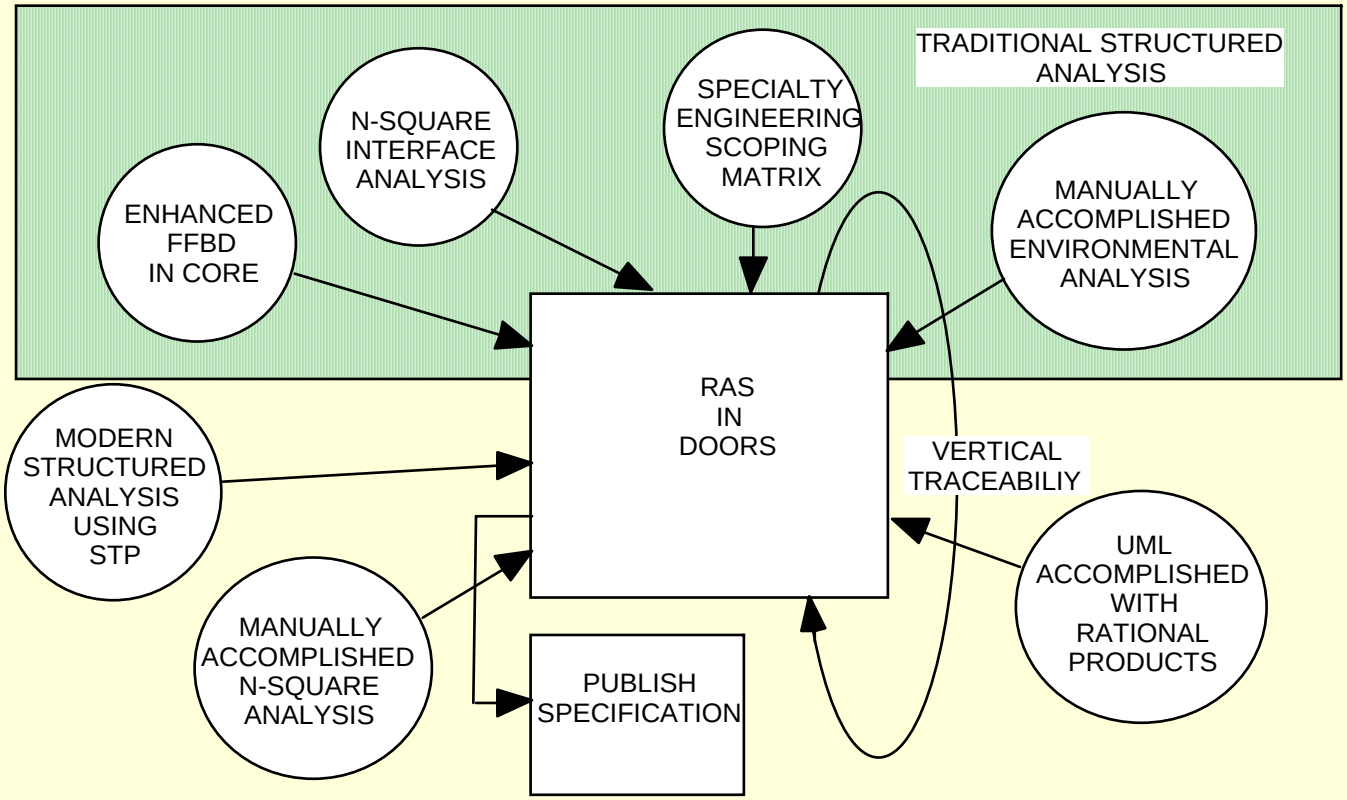
©JOG System Engineering, Inc.

Combined SDD



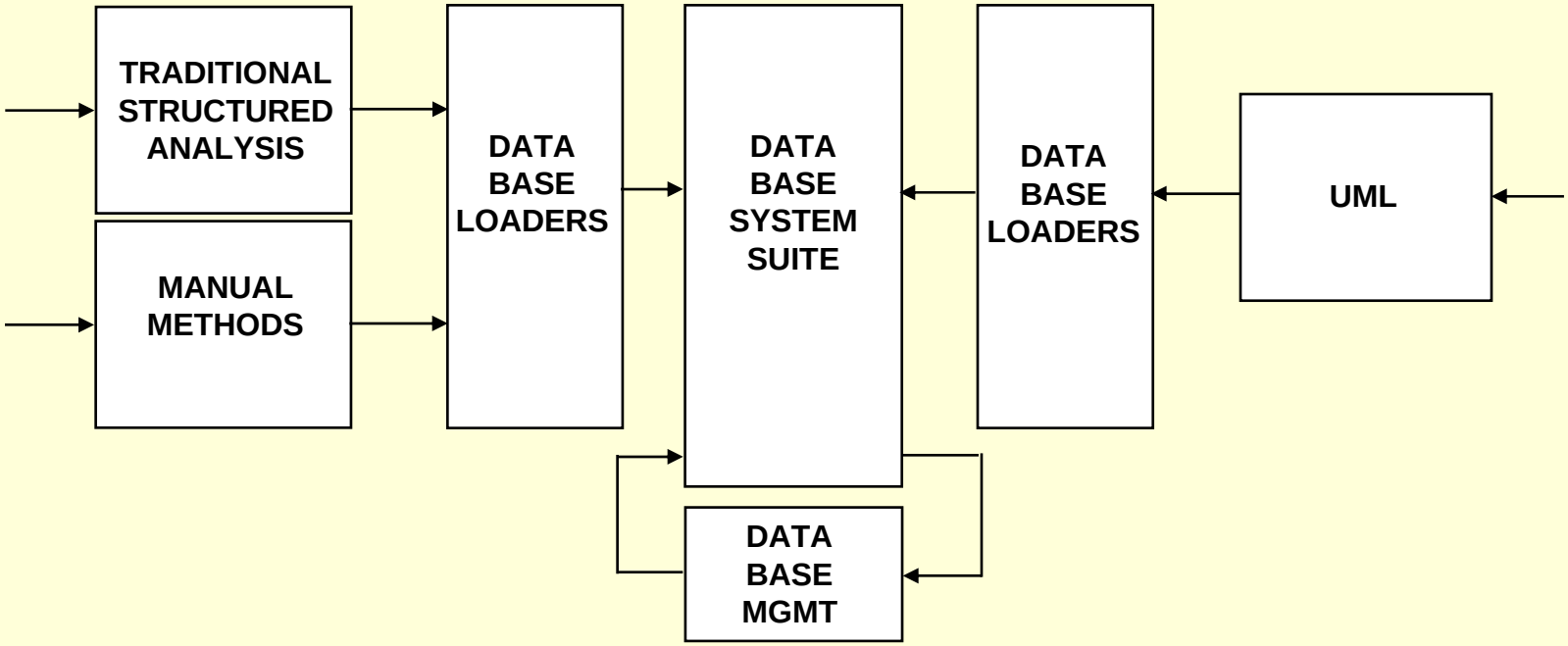
©JOG System Engineering, Inc.

A Near Term Tool Set Solution



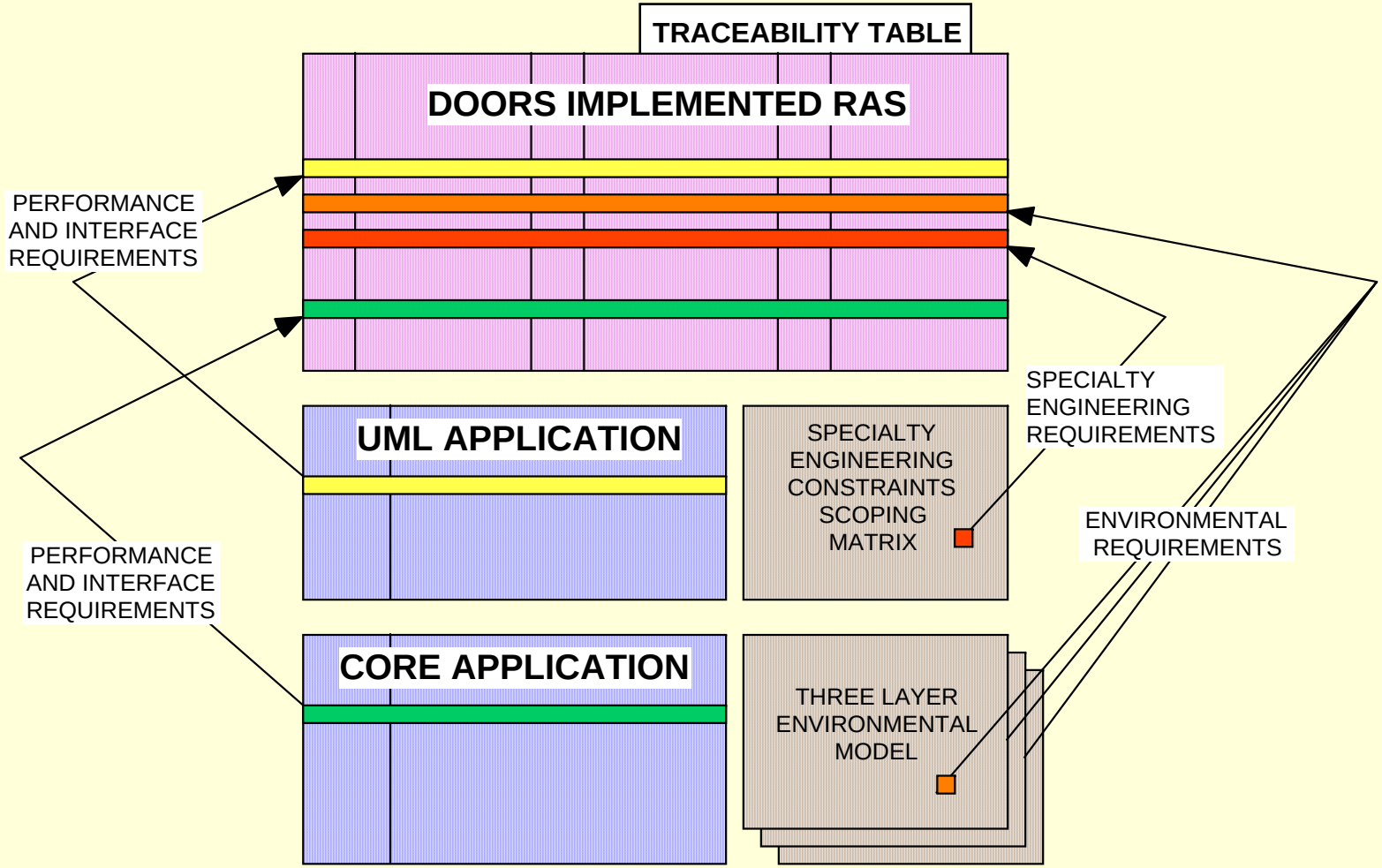
©JOG System Engineering, Inc.

Tools Integration



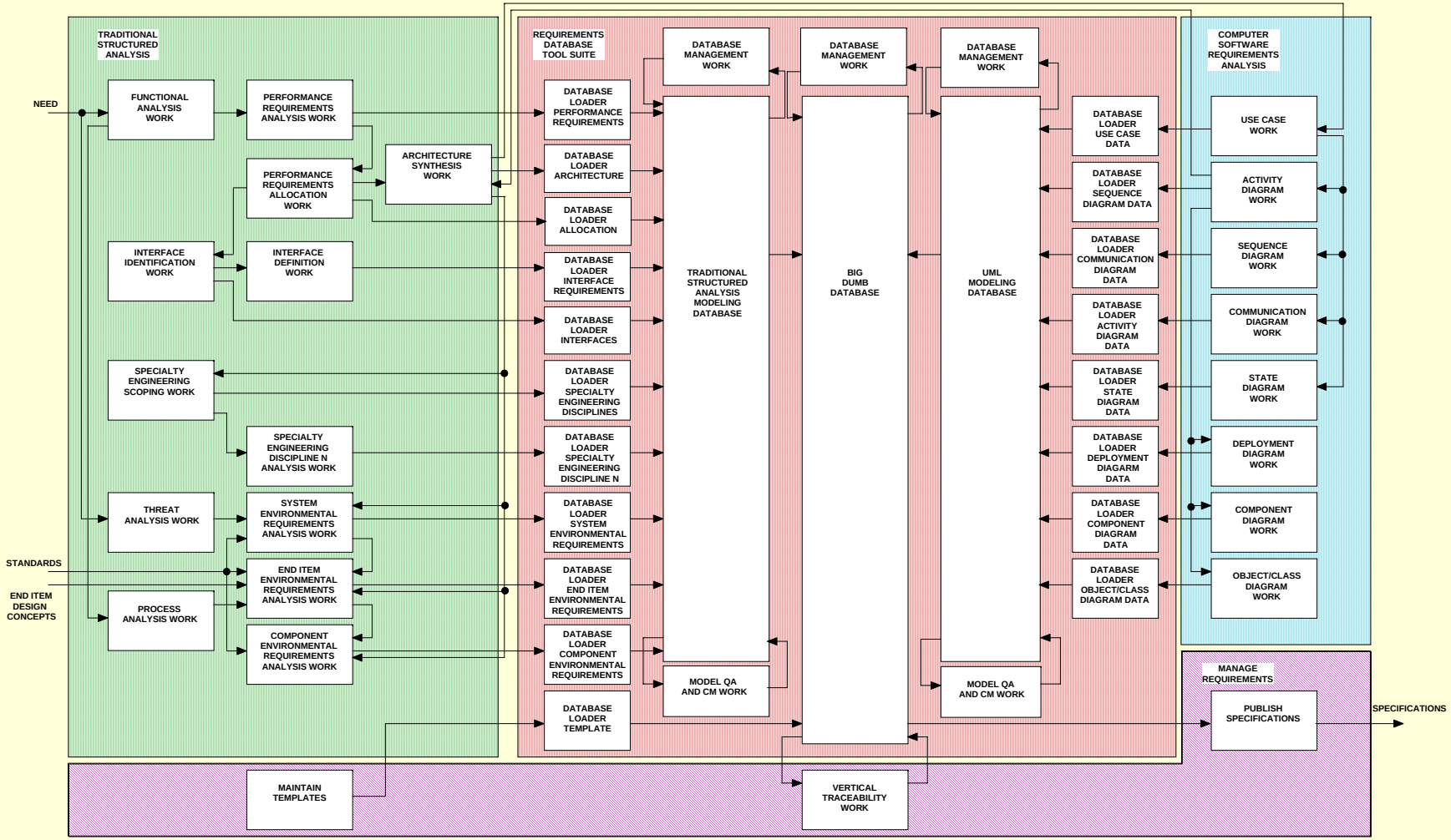
©JOG System Engineering, Inc.

Tools Integration



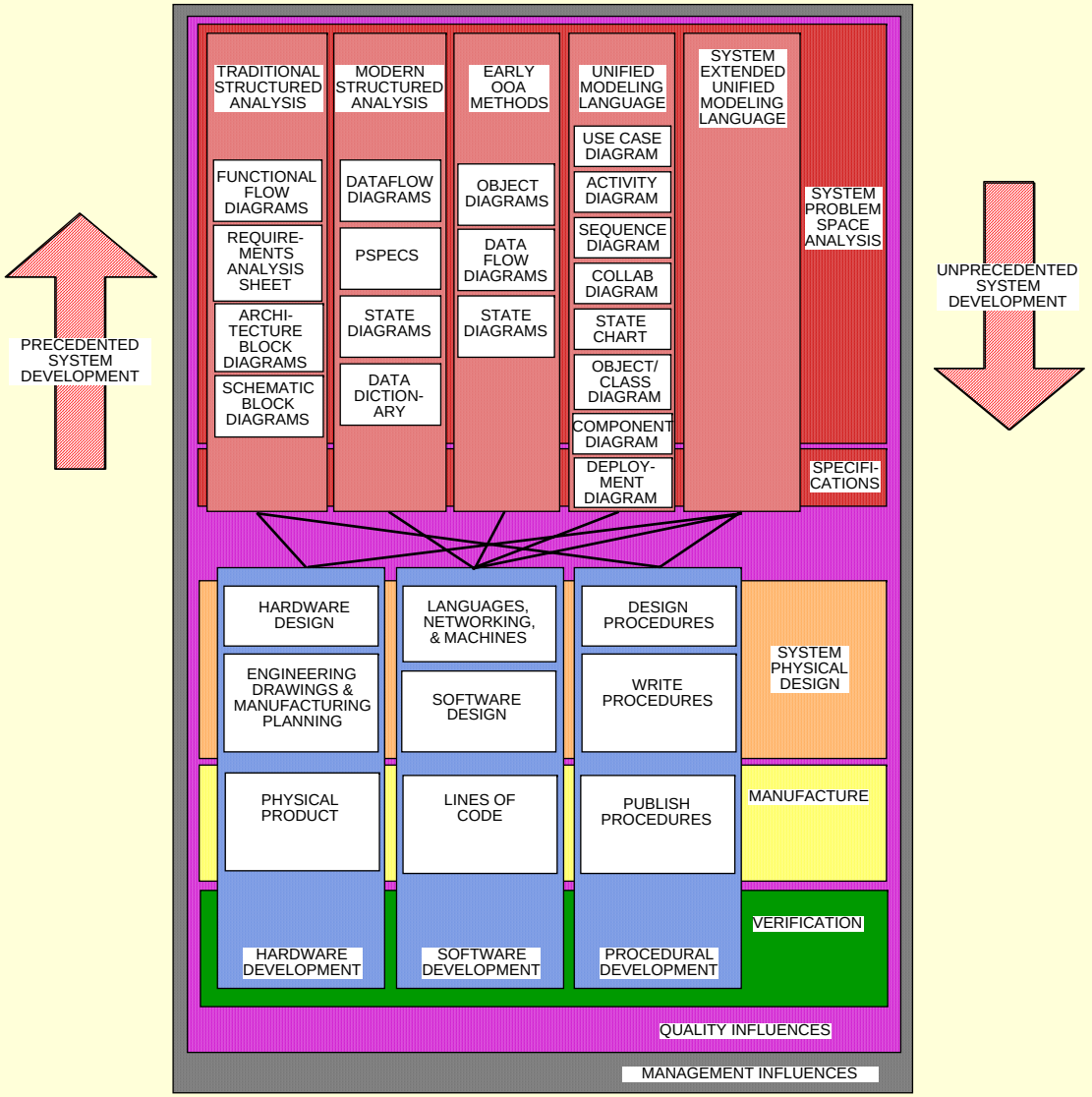
©JOG System Engineering, Inc.

An Interim Integrated Tool Set



©JOG System Engineering, Inc.

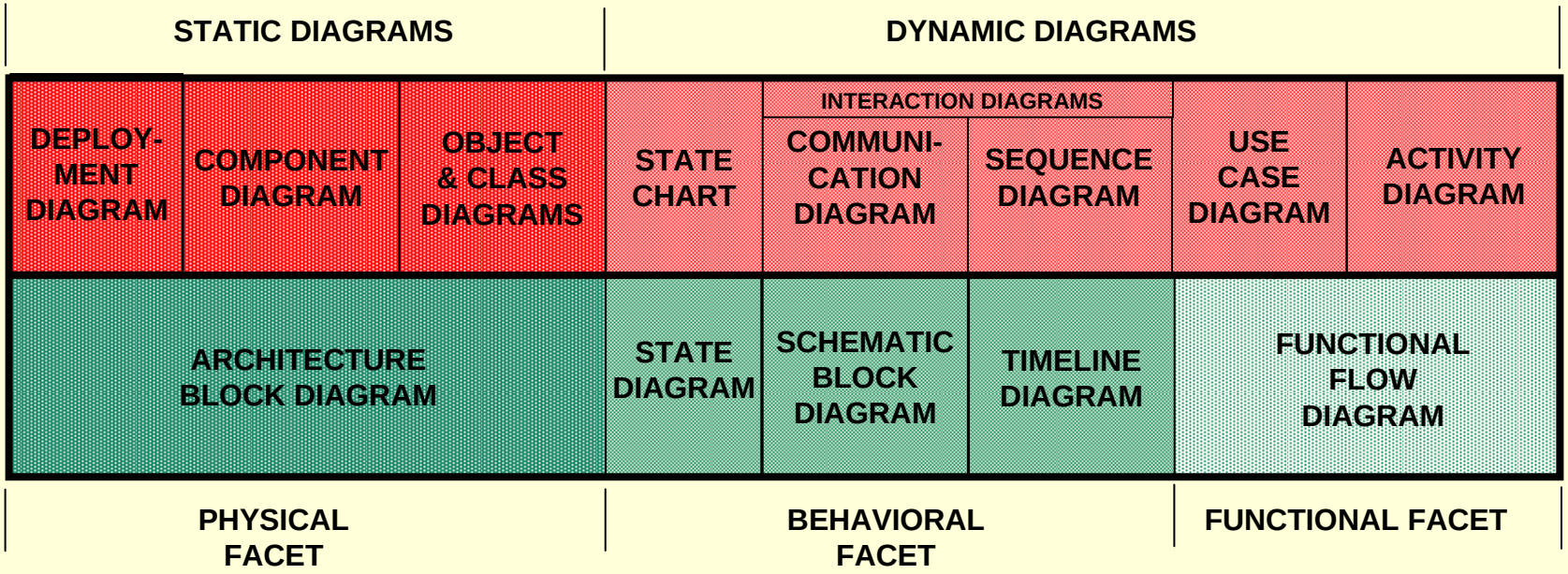
Movement To Universal Method



©JOG System Engineering, Inc.

UML and Functional Analysis

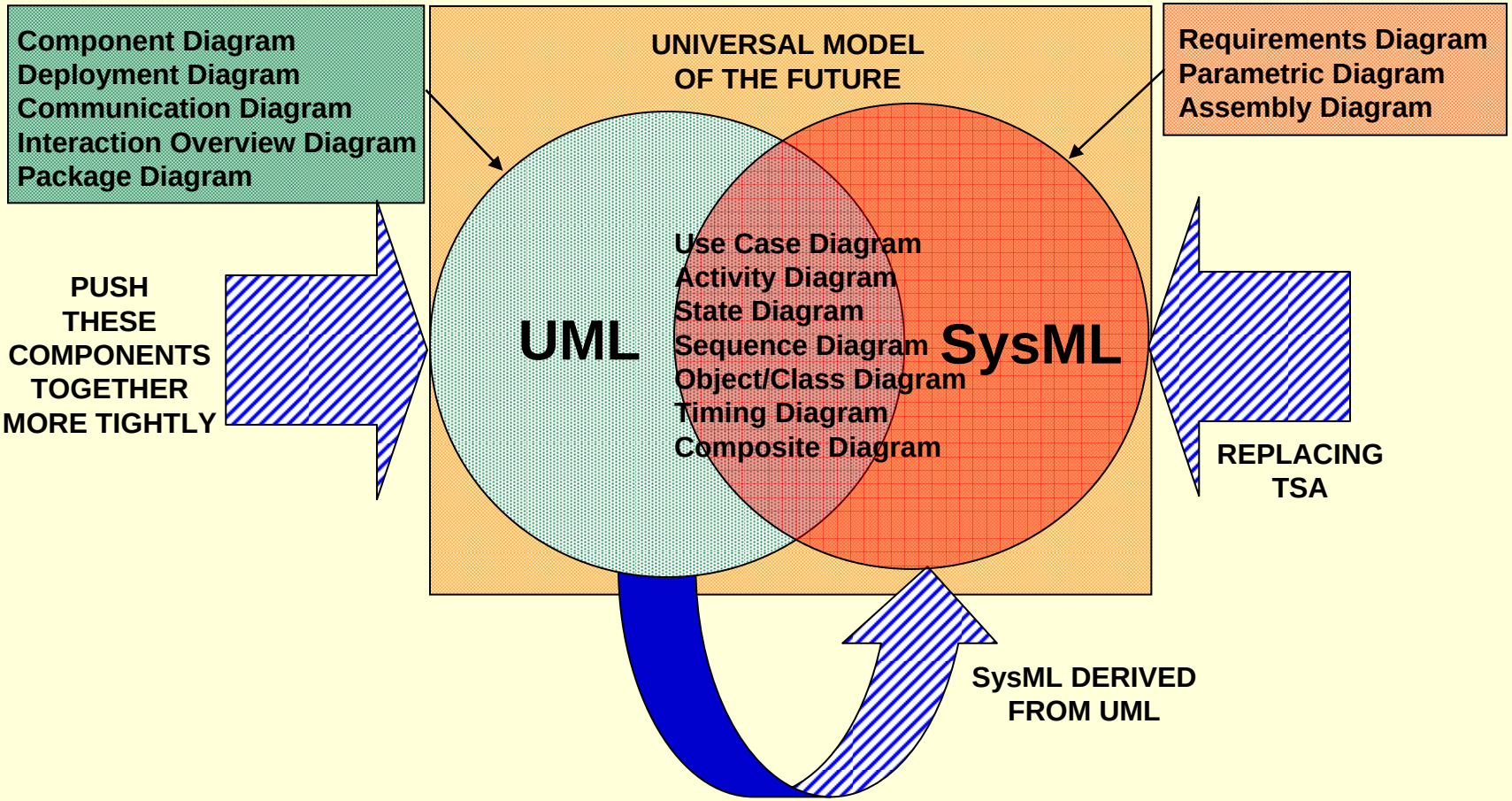
Unified Modeling Language (UML)



Traditional Structured Analysis
A Subset of UML?

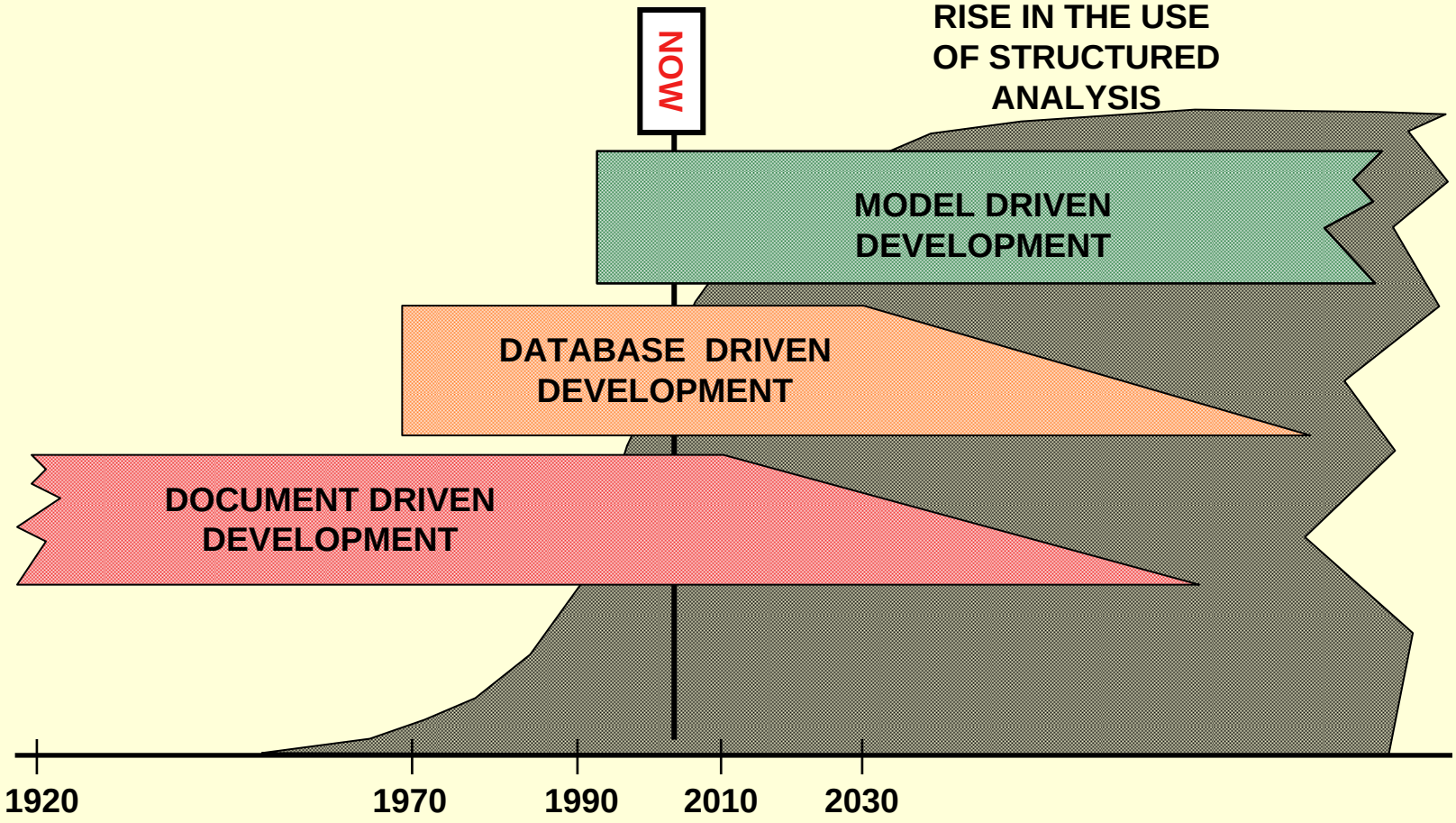
©JOG System Engineering, Inc.

Modeling Changes In the Near Term



©JOG System Engineering, Inc.

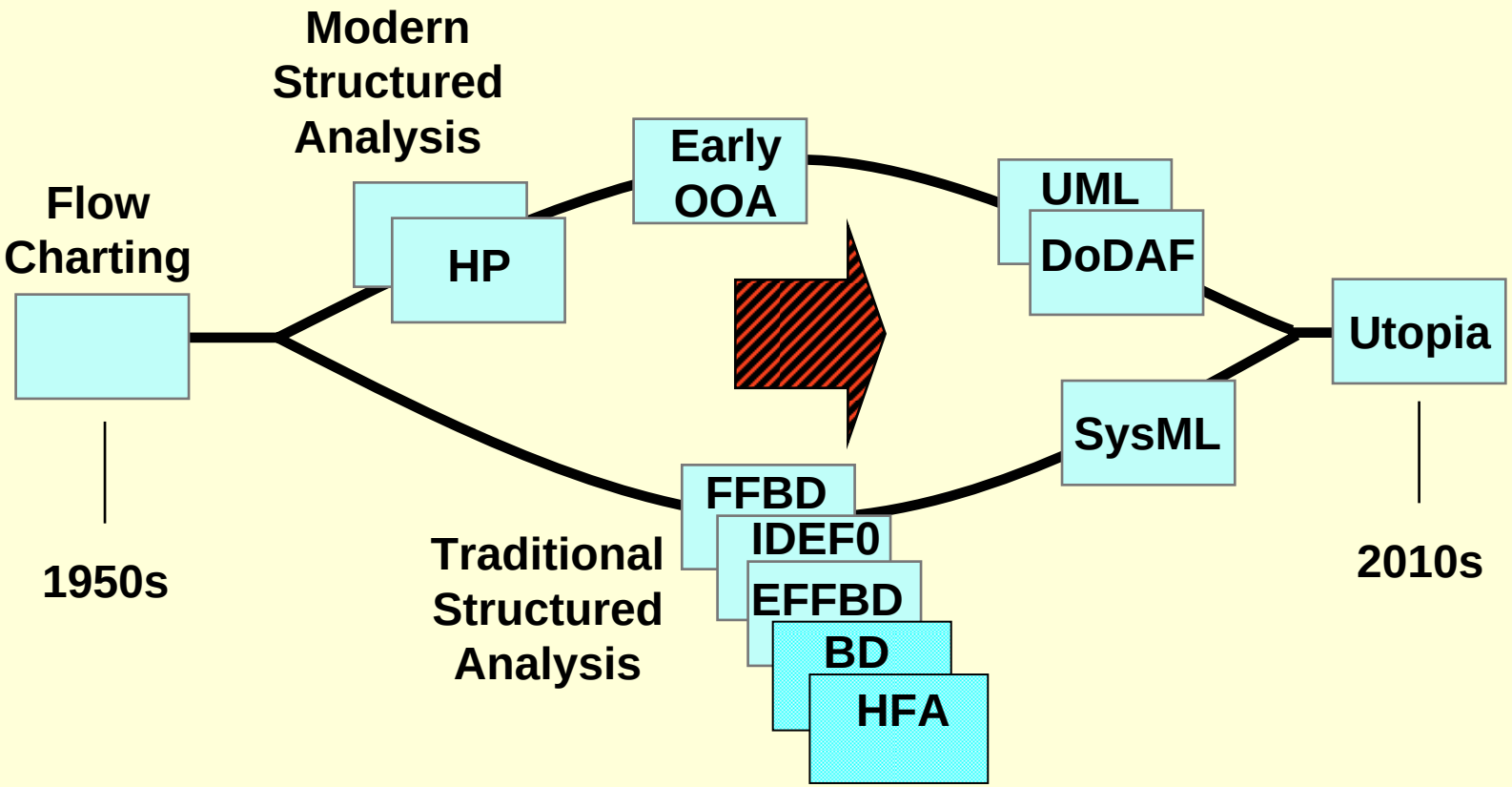
System Modeling Evolution Timeline



05-15-2002 DATA UNSUBSTANTIATED
DATES ARE APPROXIMATE

©JOG System Engineering, Inc.

Over the Hill and Through the Woods to Utopia



©JOG System Engineering, Inc.

Using Technical Data for Program Assessment



October 2006

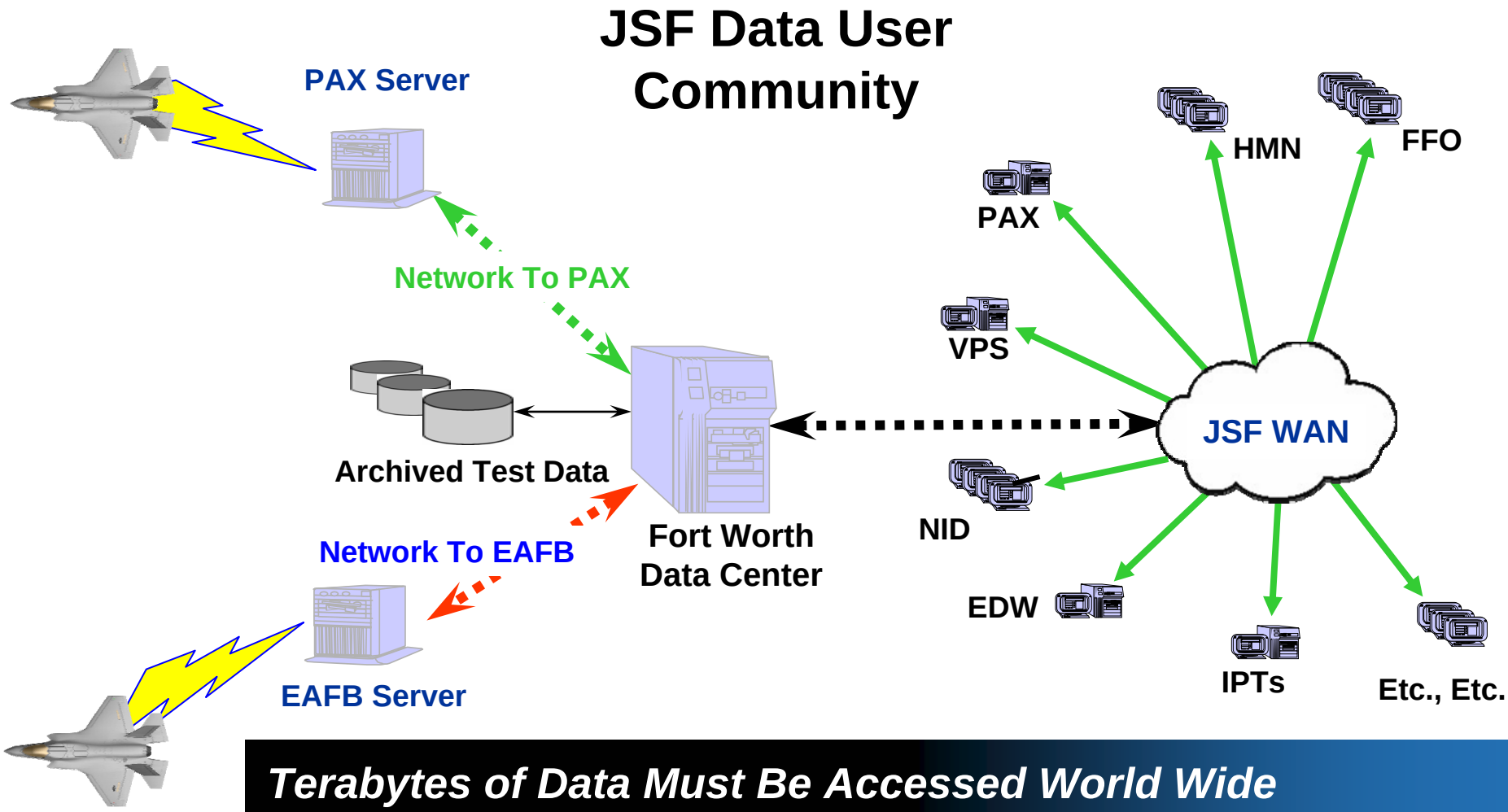
Henson Graves
Lockheed Martin Aeronautics
henson.graves@lmco.com
817.935.5911

Jim Hollenbach
Simulation Strategies, Inc.
jimh@simstrat.com
202.543.2538

Agenda

- **Recap implications of complex product development**
  - Geographical distribution; explosive growth in technical data and management challenges
- **Analyze technical data management infrastructure requirements**
  - Program planning
  - Data production and use
  - Program performance assessment
- **Outline an approach to managing work products**
  - Based on using work product descriptions to specify templates with verification conditions
  - Which enables better evidence-based program performance assessment
- **Challenges**
  - Finding/developing usable technical standards
  - Integration across distributed legacy data repositories
  - Cultural change
- **Where we go from here**
  - Adopting/developing technical data standards

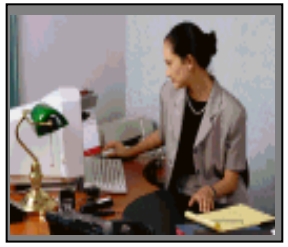
Complex Product Development Environments Are Globally Distributed



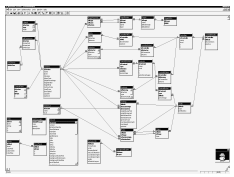
Terabytes of Data Must Be Accessed World Wide

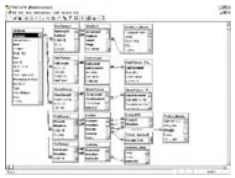
Explosive Growth In Digital Data Volume

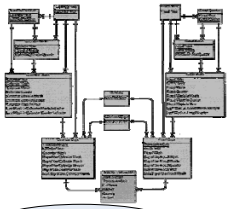
… overwhelms the ability of humans to know where data is, how data is organized, and what it means

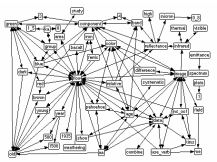


Data models & schemas used to organize data

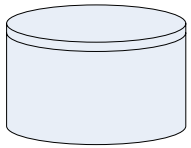


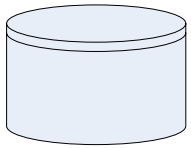


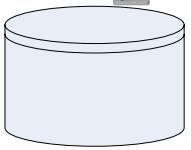


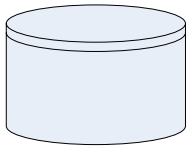


Gigabytes of metadata







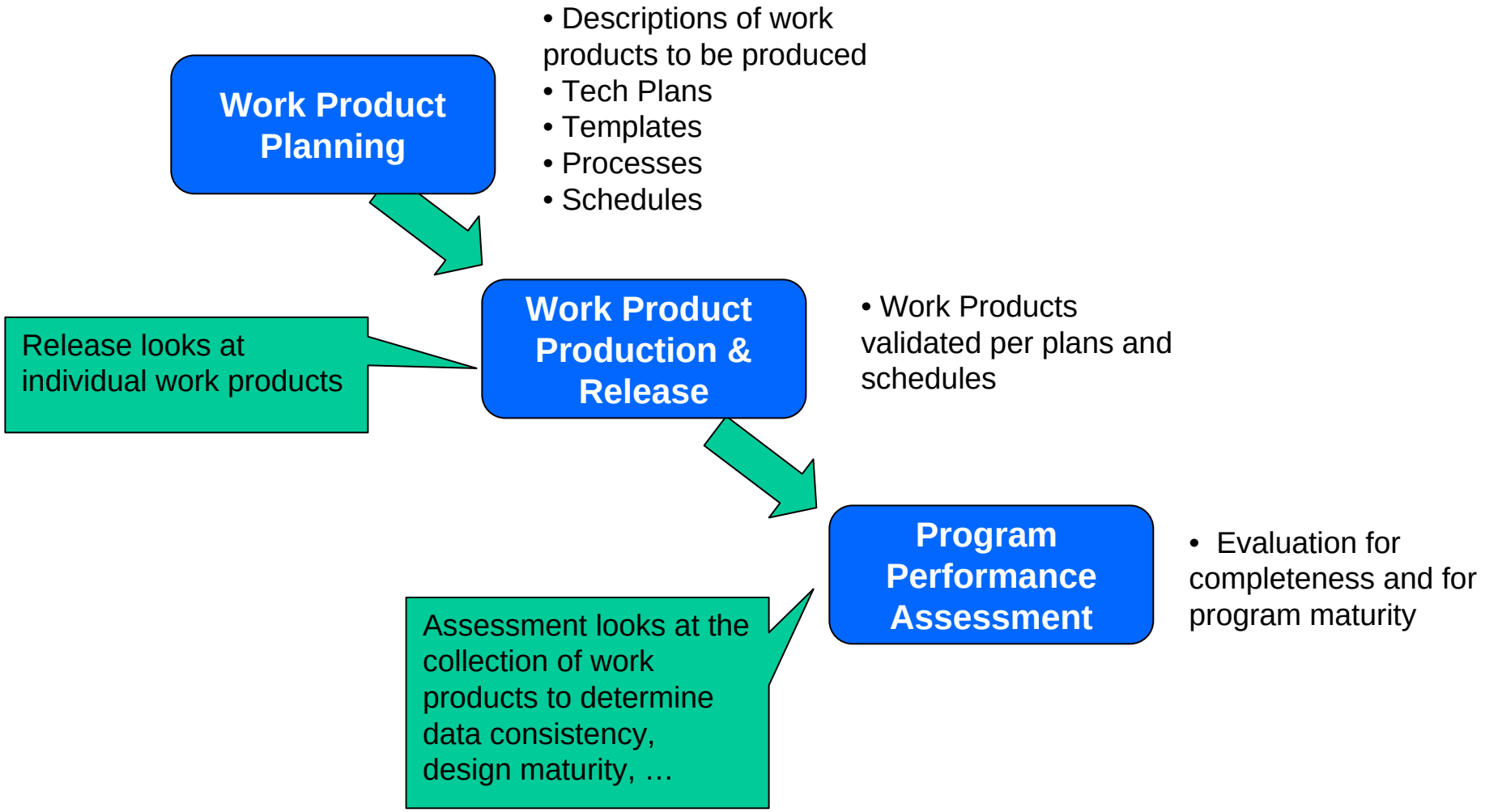


Terabytes of data

The volume of data on programs is now in the terabytes. Individuals are generally forced to rely on specifics of how each repository is organized, which varies enormously.

Work Products (Technical Data) Provide

…the evidence of program performance

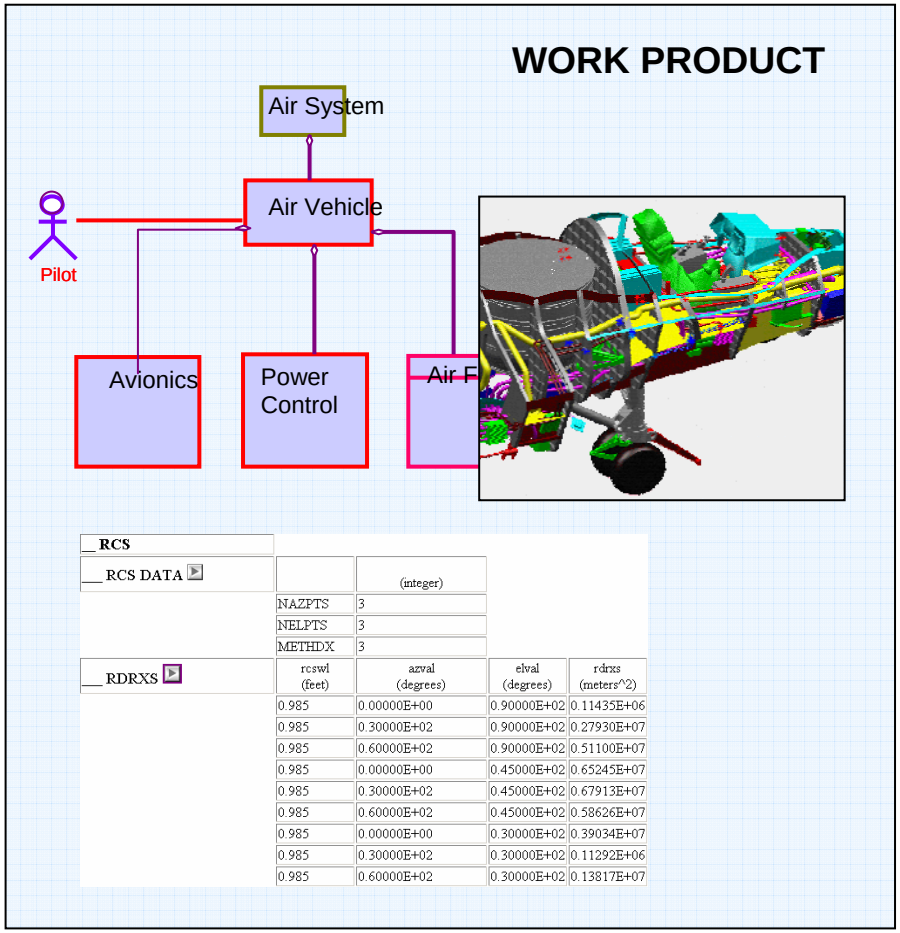


Managing Technical Data Requires

- **Descriptions of work products for**
  - Identification and validation
  - Locating and understanding
- **Specification for each work product that**
  - Defines format and content
  - Facilitates quality and maturity assessment
- **Specifications that apply to collections of work products for assessment at decision events**
  - Completeness
  - Consistency
  - Program technical maturity
  - Impact of changes

A Work Product Is …

- **A document, report, analysis, test result, plan, etc. that is generated by the product development process**
- **Specified with a well-defined purpose in the development lifecycle with identified producers and consumers**
- **With unique identification, release and configuration control**
- **A work product may contain components including models and drawings**

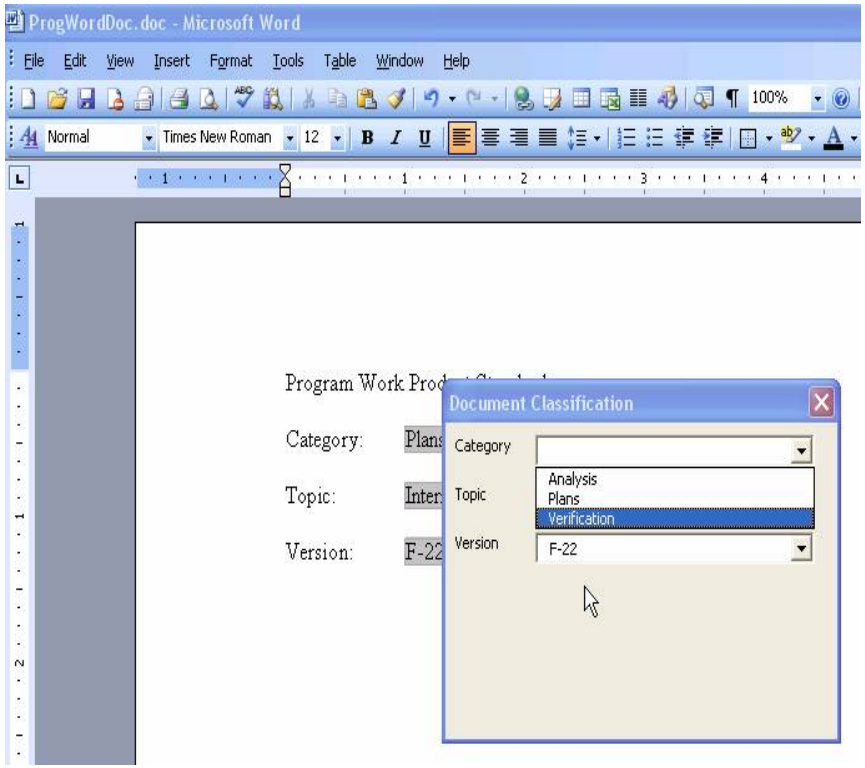


_ RCS				
__ RCS DATA		(integer)		
	NAZPTS	3		
	NELPTS	3		
	METHDX	3		
__ RDRXS	rcswl (feet)	azval (degrees)	elval (degrees)	rdrxs (meters^2)
	0.985	0.00000E+00	0.90000E+02	0.11435E+06
	0.985	0.30000E+02	0.90000E+02	0.27930E+07
	0.985	0.60000E+02	0.90000E+02	0.51100E+07
	0.985	0.00000E+00	0.45000E+02	0.65245E+07
	0.985	0.30000E+02	0.45000E+02	0.67913E+07
	0.985	0.60000E+02	0.45000E+02	0.58626E+07
	0.985	0.00000E+00	0.30000E+02	0.39034E+07
	0.985	0.30000E+02	0.30000E+02	0.11292E+06
	0.985	0.60000E+02	0.30000E+02	0.13817E+07

…work products are the primary evidence of program execution

A Work Product Template …

- **Describes the structure and content of a work product**
- **Specifies valid choices for work product attributes such as IPT names, product versions, etc.**
- **Specifies verifiable requirements for work products**
- **A template represents the starting point for author of a work product**
- **A template supplies pre-filled in content and relationships where possible**
- **A template can be used to generate an interactive form to construct the work product with choice lists for attribute values (automated validation)**



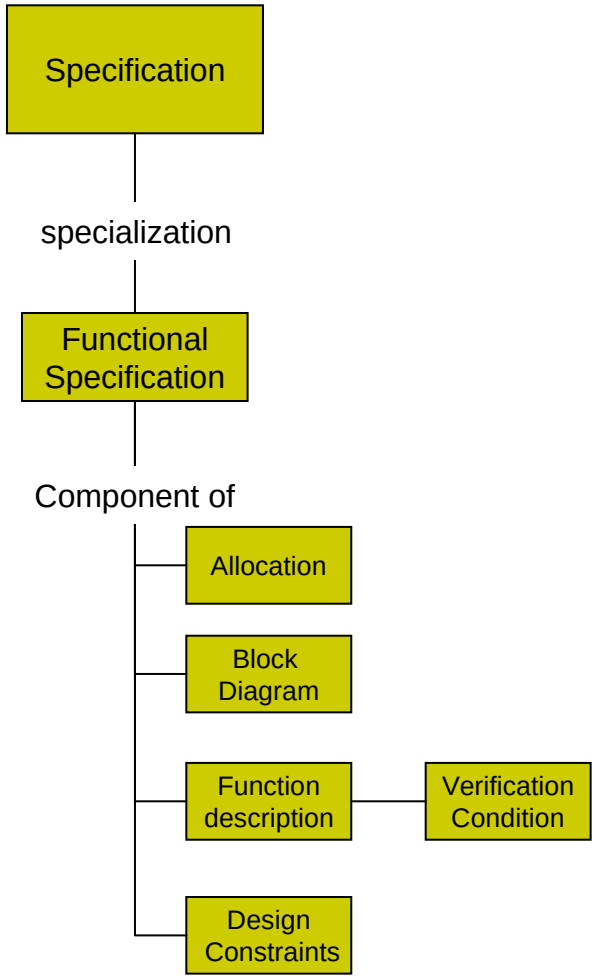
Problem: How To Construct Templates That

- **Cover all planned work products**
- **Provide maximum uniformity and commonality across all work products**
- **Provides a specification of identity up to versioning**
  - Any work products developed from the same template are versions of each other
- **Are machine-interpretable with rules for machine processing**
  - used to provide validation for structure and content requirements on work products

Work Products Have Structure

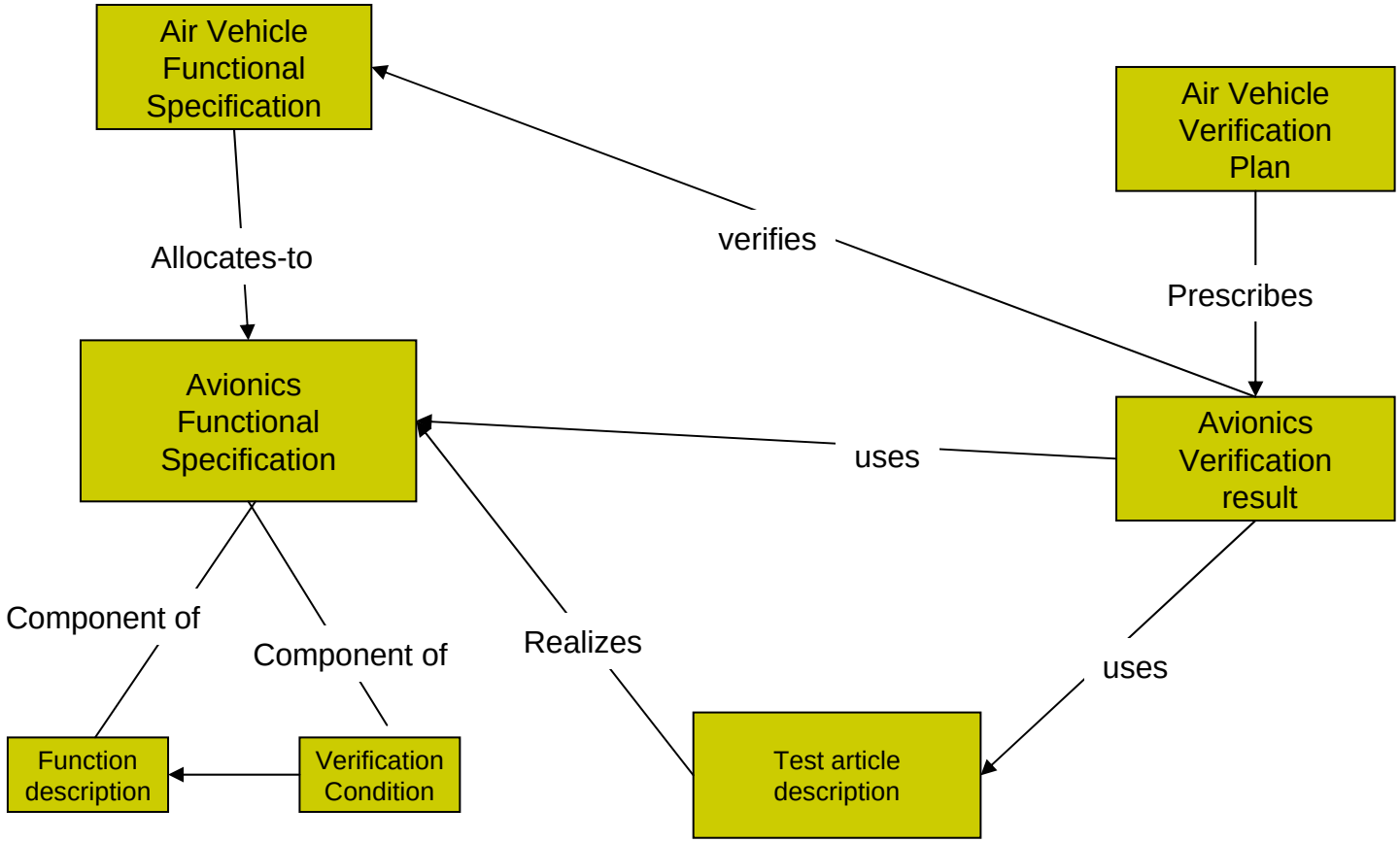
… that defines commonality and uniformity that need to be specified by templates

- **Specialization**
  - Level of detail, e.g., functional, system, physical specifications
  - Different tiers in the product structure, e.g., avionics, radar
- **Specific components and interrelationships**
  - E.g., a functional specification contains or references many specific component work products



Work Products Participate In Relationships

… that are used for design traceability and product maturity assessment that need to be defined by templates



Our Approach Uses a Work Product Description

…to specialize a generic template to produce a template for a work product with a given description

User Authoring Scenario

1. User presented with a valid list of versions
2. Choice of version used to determine possible components/subsystems
3. Choice of version, product component determines admissible work product categories
4. User determines category from filtered list of categories, which determines valid topics
5. User choice then builds content and organization for template

Description

Product Version: F-35 Carrier Version
Product Structure: Avionics
Work product category: Specification
Topic: Functional

Template

TITLE: CV Avionics Functional Specification
Allocation of Air Vehicle
Functional Block Diagram
Functions with performance conditions and verification conditions
External Interfaces

… the work product category with its topic specialization, as well as the product version and product structure component all contribute to defining a specific template

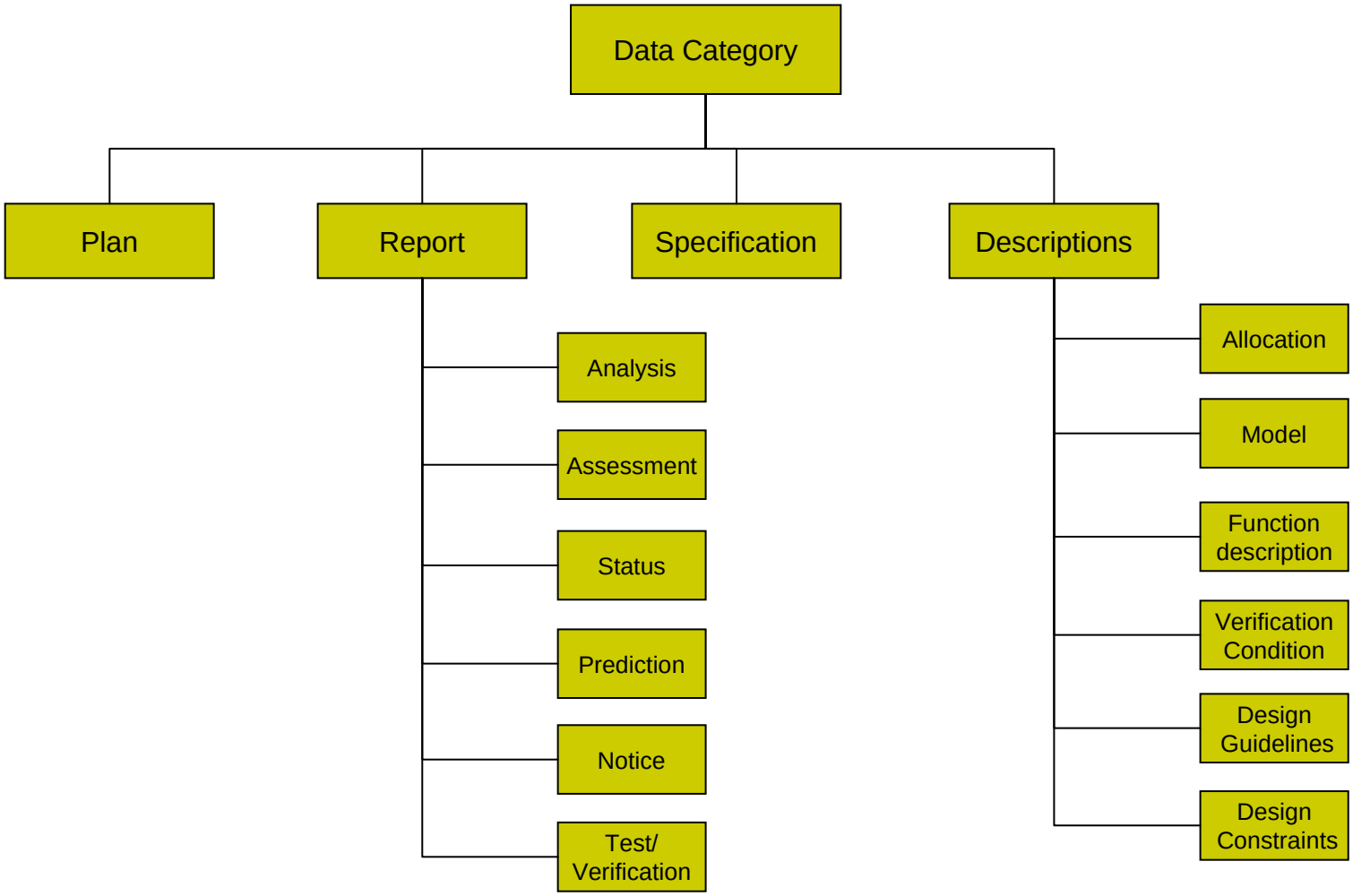
Template Specialization Depends on Work Product Descriptive Attributes

… the attributes below determine work product templates

- **Product Version**
  - The specific configuration description of the product, e.g., Carrier Version
- **Product Component**
  - The specific subsystem or configuration item of the product version
- **Work Product Category**
  - Specifies structural components of a template, e.g., plans, specifications
- **Topic**
  - Specializes the category for a specific subject matter domain, e.g., external loads

… the work product category with its topic specialization, as well as the product version and product structure component all contribute to defining a specific template

Work Product Categories Can Be Defined From Bottom Up or Top Down



…there are lots of gray areas here and choices to be made concerning whether the categories are descriptive or prescriptive

The Benefits of the Description & Template Approach

- **Planners**
  - Provides sufficiently detailed descriptions of planned work products that can be for machine validation
- **Producers**
  - User friendly way to author work products with pre-filled in content and machine checked work product validation
- **Users**
  - Enables location, access, understanding through descriptions
- **Examiners**
  - Enables completeness checking for events
  - Identification of supersession

The description and template approach can be used for program assessment even when approach is not fully automated

Determining Descriptive Classifications & Relationships

… is an example of "ontology engineering" in the domain of technical data management

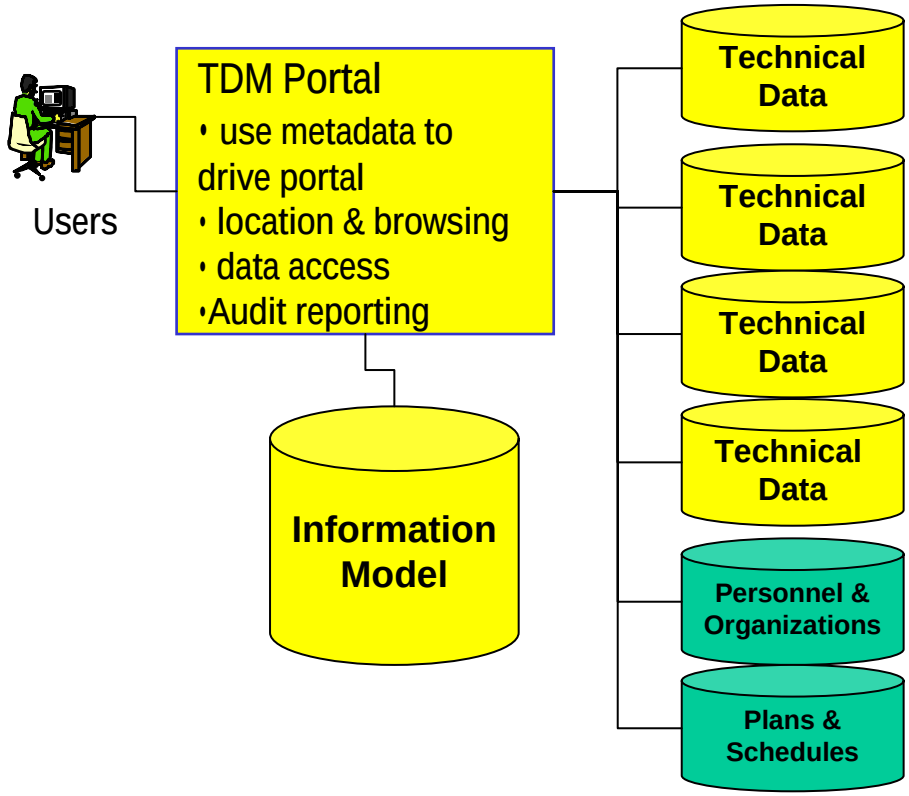
Ontology Engineering: Defining terms and relations among the terms for a domain

- Defining concepts in the domain (classes)
- Arranging the concepts in a hierarchy (subclass-superclass hierarchy)
- Defining which attributes and properties (slots) classes can have and constraints on their values
- Defining relationships between classes
- Defining individuals and filling in slot values

The class model represents the general domain knowledge, the instance information represents specific program knowledge

Challenges

- **Standardizing the concepts**
  - Defining classes & relationships
  - Populating classes with instances of program specific information
- **Implementing templates to capture and validate data**
  - Capture metadata separately
  - Use templates for interactive form validation
- **Providing a portal with application logic to manage data**
  - With services to integrate distributed data repositories



…is the approach practical? The answer is yes

Where To Go From Here

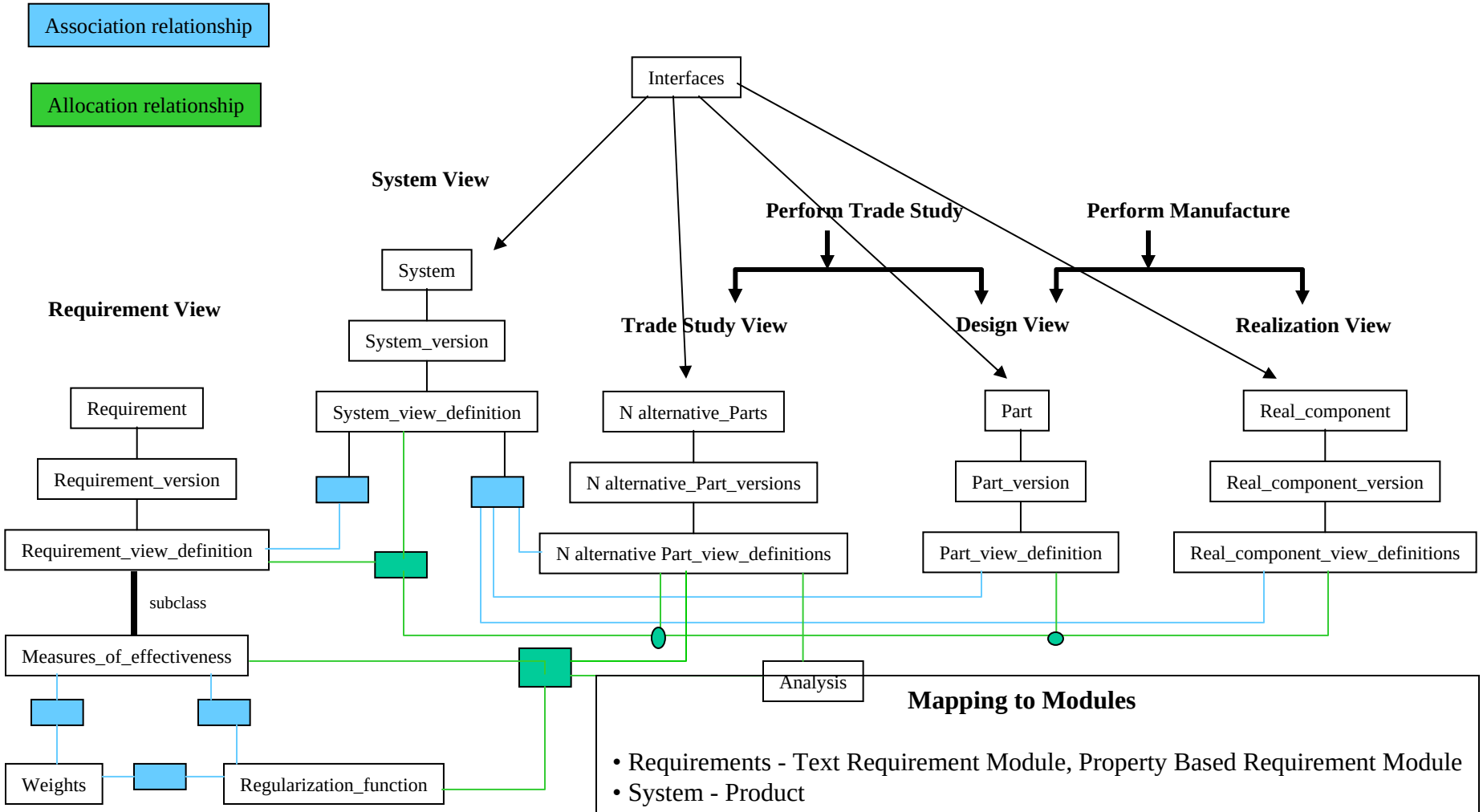
- **Develop a full Technical Data Management (TDM) ontology**
  - Expand the scope from data required for design and development to data required for operation and sustainment
- **Use Semantic Web framework including the ontology languages OWL**
  - TDM and Information Portal are 2 of 5 use cases listed for requirements development of the ontology language, OWL
- **Integrate TDM ontology with PLM standards (e.g., GEIA-927, AP233, AP239)**
- **Leverage this assessment capability to improve earned value management**

Questions/Comments

What Is An Ontology (Natalya Noy)

- An ontology is an explicit description of a domain:
  - concepts
  - properties and attributes of concepts
  - constraints on properties and attributes
  - Individuals *(often, but not always)*
- An ontology provides a shared understanding
  - the common vocabulary and rules of use

This Diagram Illustrates the Scope of the STEP AP239



Mapping to Modules

- Requirements - Text Requirement Module, Property Based Requirement Module
- System - Product
- Part (design only) - Part Modules
- Real_component - Product_as_Individual Module, Product_as_realized entity
- Analysis - Realized with several AP210 modules in the Structure Module Set
- Interfaces - Interface Module or Product Interface Module, choice under review



Navigating the Forest of Standards

Choosing the Right Standard for the Right Outcome

Presented at the NDIA SE Conference
San Diego, California
October 2006

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

Denise Duncan
LMI Government Consulting

AGENDA

- Review of standards
  - Type
  - Purpose
  - Applicability
- Primary standards-making organizations
- Establishing the Standards Framework
  - Rules of Engagement
  - Urban Myths
- Legacy or new program?
  - Two example case studies
- Harmonizing standards

Standards

- Consistent methods
- Non-proprietary
- Based on best practices, core principles, open systems considerations
- Address consensus challenges
- Outcome-based
- Frequently already codify ongoing practices and innovation

Catalogue of Standards

- Architecture Framework
- System Engineering
- Configuration Management
- Data Management
- Data Exchange
- Information Technology
- Model and Simulation
- …

Primary Standards-Making Organizations

- AIA
- GEIA
- IEEE
- ISO
- ANSI
- SCC
- AFEI
- DARPA
- ITI
- AIIM
- ITU
- Open Group
- NIST

Types of Standards

- Manufacturing
- Telecommunication
- Information Technology
- Engineering
- Library/cataloguing
- Testing
- Configuration Management
- Data Management
- ….

- Conformance
- …..

Measurement Standards

Documentary Standards

Conformity Assessment/Accreditation

Information Technology

Urban Myths

- Standards are expensive to implement
- Standards are hard to put on contract
- Standards don’t model open exchange formats
- They cost a lot to buy

Rules of Engagement

- Core principles
- Open standards
- Consensus based
- Practitioner led
- Application focused
- Harmonizing what is there, against what is needed
- Adding to the aggregate base, instead of creating a conflict

The Essential Challenge

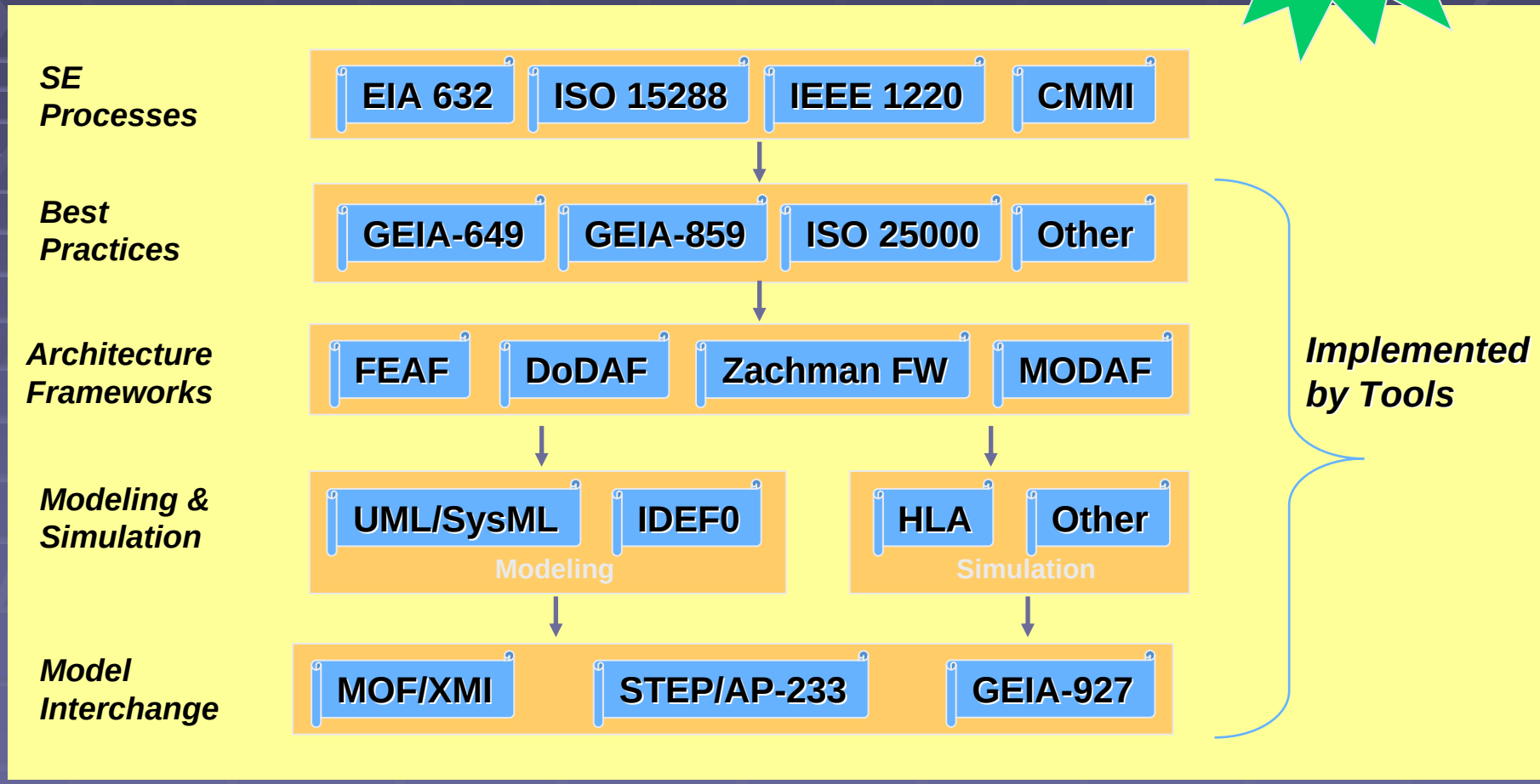
- Deciding what/which standards are appropriate
  - How they will support life cycle development objectives
  - How they can interoperate
  - Whether or not they are open systems or best practices approaches
- Figuring out what comes first, in the navigation process or pathway
- Discovering synergies or contradictions
  - Identifying those things
  - Developing workarounds to them

Choosing the Case Studies

- For purposes of example, we chose “data” which is the common factor for functions and program planning
  - Identifying, managing, controlling, archiving, exchanging data is key for all program functions
- We selected a legacy program, and a new program for illustration purposes

Context Diagram for Systems Engineering and Related Standards

Appreciation to Dwayne Hardy



Contemporary Systems Engineering depends on numerous related standards
We need to ensure that they complement and interoperate with each other

Legacy Program Challenges

- Generically …
  - Practices are based on old guidance
  - The contract has established the rules, based on past circumstances and objectives
  - Prescriptive approach has been taken
  - Some contract requirements are dated and based on an old paradigm
- Compromises must be made
- Workarounds must be created
- Prescriptive advice must be reconciled against new objectives and goals
  - Adjustments made to recalibrate as needed



Case 1: A Legacy Program
Government Data Provider and ANSI-859

- Data base with metadata and links to documents inside other data systems
  - Portal architecture in existence for 10+ years
- Approach they used
  - Evaluated their processes against best practices and core capabilities codified in 859
  - Measured the gaps or any shortfall
  - Adjusted accordingly and asked for further guidance

New Start Program Challenges

- This is an easier case
  - Opportunities exist for innovation from the beginning
  - Mergers and acquisitions have created groundswell for use of standards
- Special attention must be paid to the lifecycle issues
  - identifying areas where issues may occur/have occurred
  - Creating ways to end run trouble through predictive analysis and action

Case 2: A New Program
Space Agency Initiative and ANSI-859

- Opportunities for new methods and objectives to be addressed
- Approach they used
  - Examined 859 for target areas to improve or address
  - Redressed their requirements process to incorporate and encourage best practices in DM
  - Considered how they could embrace industry best practices through clear outcomes they desire to create

Summary

- In the case of 859, no costs to include the methods in the standard were incurred
  - Adjustments in processes were made
  - Some metrics were changed/added
- Adopting and using standards frequently cost little to nothing and the results yield tremendous offsetting savings
- This is a work in progress
  - We are examining other standards areas and cases in order to develop a better understanding

CERTIFICATION

OF

FLIGHT CRITICAL SYSTEMS

Herbert Hecht
SoHaR Incorporated
herb@sohar.com

Michael Gomez
Northrop Grumman Corp.
m.gomez@ngc.com

AC 25.1309-1A/AMJ 25.1309

- *…condition which would prevent the continued safe flight and landing of the airplane [must be] extremely improbable< 1 × 10-9 per flight hour*
- *…conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions [must be] improbable. < 1 × 10-5 per flight hour, less for severe conditions*

*"In general, the means of compliance described in this AC are not directly applicable to **software assessments** because it is not possible to assess the number and kinds of software errors, if any, that remain after the completion of system design, development and test."*

Refers for software to RTCA DO-178B

SOFTWARE CERTIFICATION
DO-178B

1. SYSTEM ASPECTS
2. SOFTWARE LIFE CYCLE
3. SOFTWARE PLANNING PROCESS
4. SOFTWARE DEVELOPMENT PROCESS
5. SOFTWARE VERIFICATION PROCESS
6. SOFTWARE CONFIGURATION M'GMNT PROCESS
7. SOFTWARE QUALITY ASSURANCE PROCESS
8. CERTIFICATION LIAISON PROCESS

.....

NOT TRACEABLE TO FAR 25.1309

FROM Y2K EFFORTS

"The main line software code usually does its job. Breakdowns typically occur when the software exception code does not properly handle abnormal input or environmental conditions – or when an interface does not respond in the anticipated or desired manner."

C. K. Hansen, *The Status of Reliability Engineering Technology 2001*, Newsletter of the IEEE Reliability Society, January 2001

4-UNIVERSITY EXPERIMENT

TEST RESULTS W/ ACCELEROMETER. FAILURES

PROGRAM TO FURNISH ORTHOGONAL OUTPUT FROM 6 NON-ORTHOGO-NAL ACCELEROMETERS

PROGRAM SHOULD TOLERATE UP TO **THREE** ACCELEROMETER FAILURES

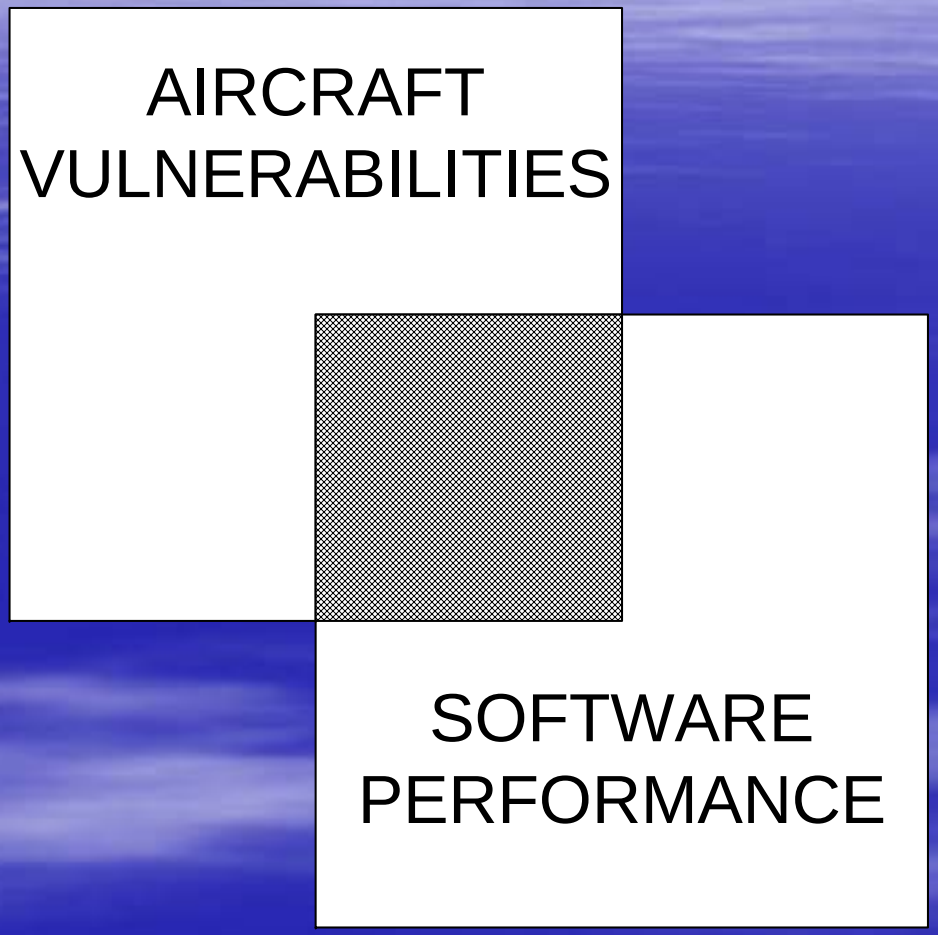
No. accel. failed	Total tests	Tests failed	Failure fraction
1	**134,135**	**1,268**	**0.01**
2	**101,151**	**12,921**	**0.13**
3	**143,509**	**83,022**	**0.58**

ECKHARDT, CAGLAYAN ET AL., *AN EXPERIMENTAL EVALUATION OF SOFTWARE REDUNDANCY,* TSE, 7/91

WHAT CAN BE LEARNED?

- EXCEPTION CONDITIONS, AND PARTICULARLY MULTIPLE EXCEPTION CONDITIONS, ARE LIKELY TO BE OMITTED
  - IN PROGRAM DESIGN
  - IN PROGRAM TESTING
- TEST CASES INVOLVING MULTIPLE EXCEPTIONS ARE
  - MORE DIFFICULT TO CONSTRACT
  - MUCH MORE PRODUCTIVE IN DETECTING PROGRAM WEAKNESSES

THE CRITICAL AREA

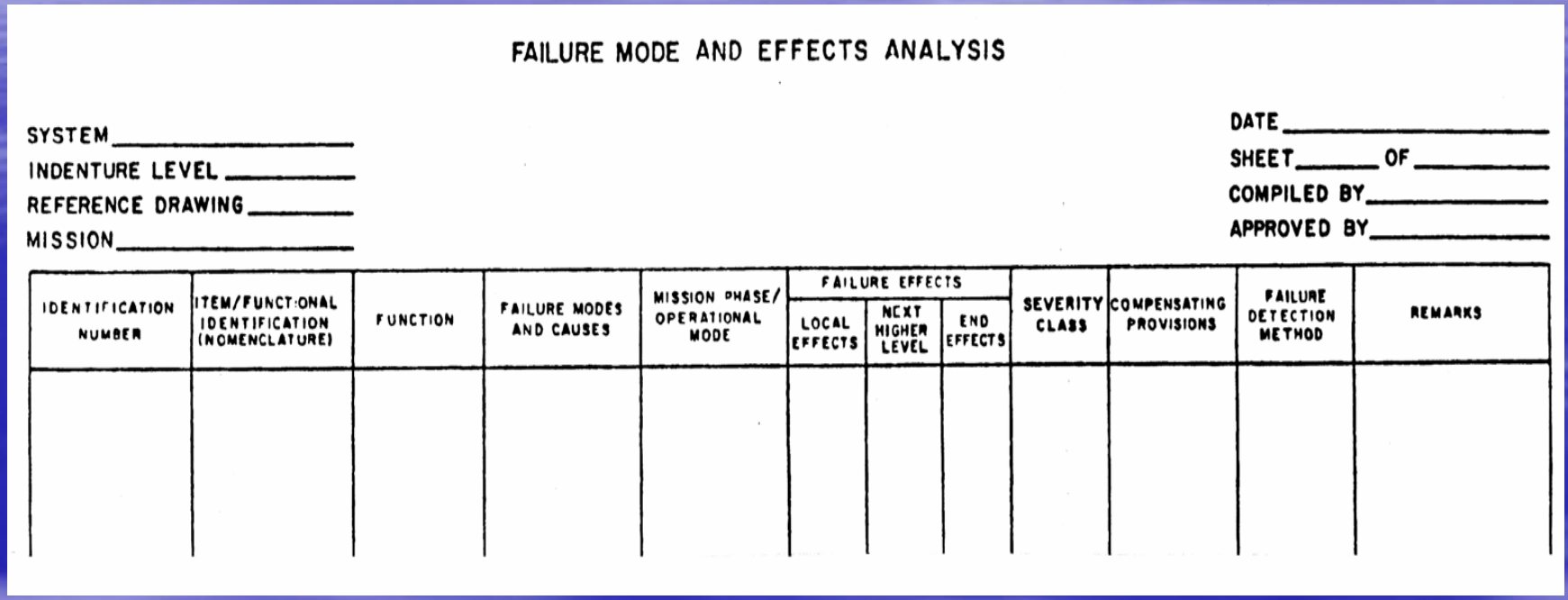


REQUIRED: INVOLVE SYSTEM ENGINEERING

FMEA AS THE BRIDGE

- SYSTEM ENGINEERING:
  - END LEVEL FAILURE EFFECTS
  - SEVERITY
- BOTH
  - DETECTION METHODS
  - COMPENSATION (MITIGATION)
- SOFTWARE ENGINEERING
  - FAILURE MODES
  - LOW LEVEL FAILURE EFFECTS

FMEA WORKSHEET



FAILURE MODE AND EFFECTS ANALYSIS

SYSTEM _____
INDENTURE LEVEL _____
REFERENCE DRAWING _____
MISSION _____

DATE _____
SHEET _____ OF _____
COMPILED BY _____
APPROVED BY _____

IDENTIFICATION NUMBER	ITEM/FUNCTIONAL IDENTIFICATION (NOMENCLATURE)	FUNCTION	FAILURE MODES AND CAUSES	MISSION PHASE/ OPERATIONAL MODE	FAILURE EFFECTS			SEVERITY CLASS	COMPENSATING PROVISIONS	FAILURE DETECTION METHOD	REMARKS
					LOCAL EFFECTS	NEXT HIGHER LEVEL	END EFFECTS				

IDENTIFICATION

CAUSES AND EFFECTS

DISPOSITION

IDENTIFICATION

- IDENTIFICATION NUMBER, E. G. 1.2.1.4
  - MAJOR COMPONENT 1
  - ASSEMBLY 2
  - SUBASSEMBLY 1
  - PART 4
- ITEM (PART NAME)
- FUNCTION

FAILURE CAUSES AND EFFECTS

- FAILURE MODE AND CAUSE
  - FAILURE MODE (FUNCTIONAL) E. G., NO OUTPUT
  - FAILURE CAUSE (ENGINEERING) E. G., 1. OXIDE FAILURE 2. BOND BREAKAGE
- MISSION PHASE, OPERATIONAL MODE
- EFFECTS
  - LOCAL
  - NEXT HIGHER LEVEL
  - END EFFECTS
- SEVERITY CLASSIFICATION BASED ON END EFFECTS

DISPOSITION

- FAILURE DETECTION METHOD
  - CAN BE AT SEVERAL LEVELS
- COMPENSATION PROVISIONS
  - REDUNDANCY, RETRY, BACK-UP MODE
- REMARKS
  - WHAT IS THE EFFECT IF BACK-UP FAILS

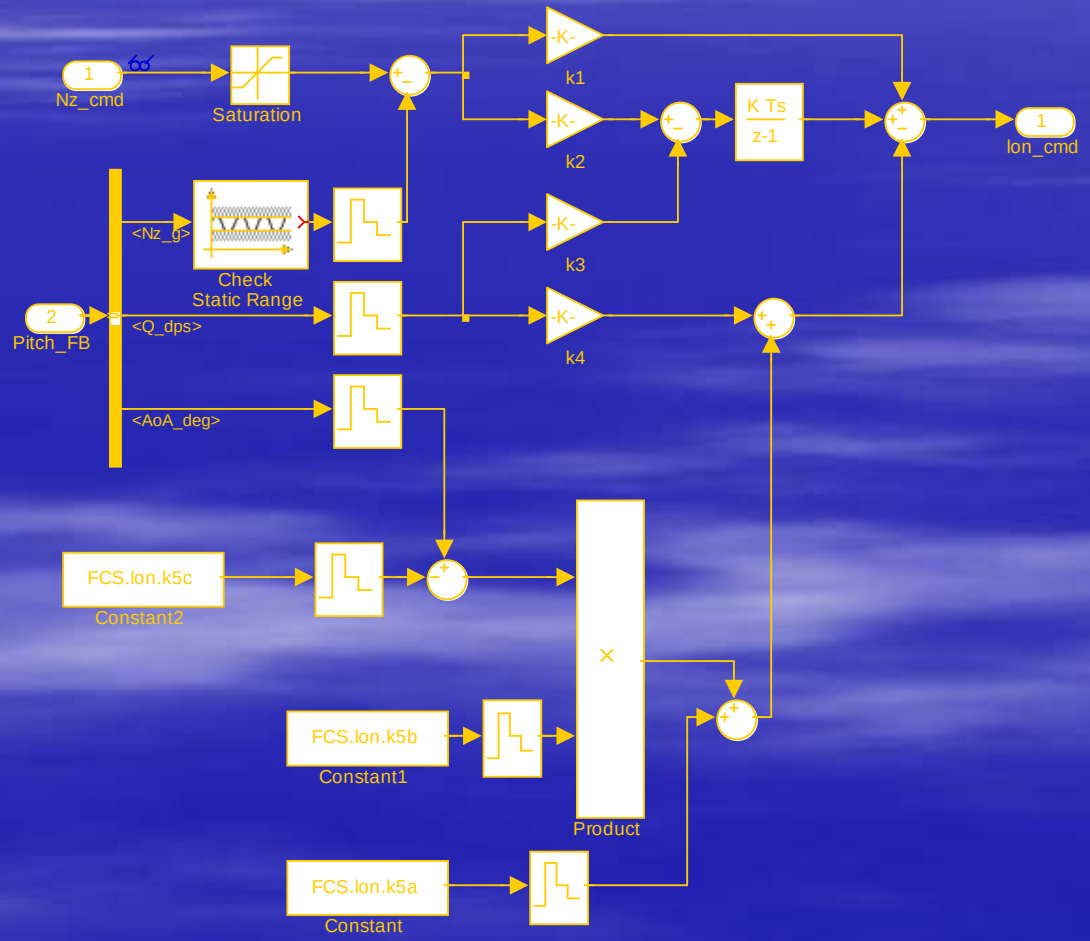
MOCET

- Model-based Certification Tool
- Computer Aided generation of FMEA
- Evaluation of robustness provisions
- TPNs for exploration of timing problems

LONGITUDINAL CONTROL

Longitudinal FCS

Generate longitudinal command for psuedo longitudinal surface

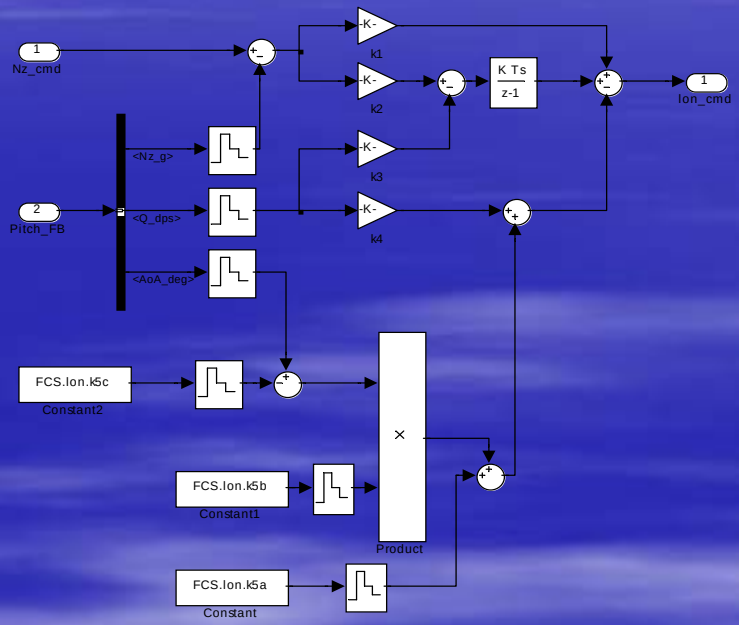


MODEL STRUCTURE

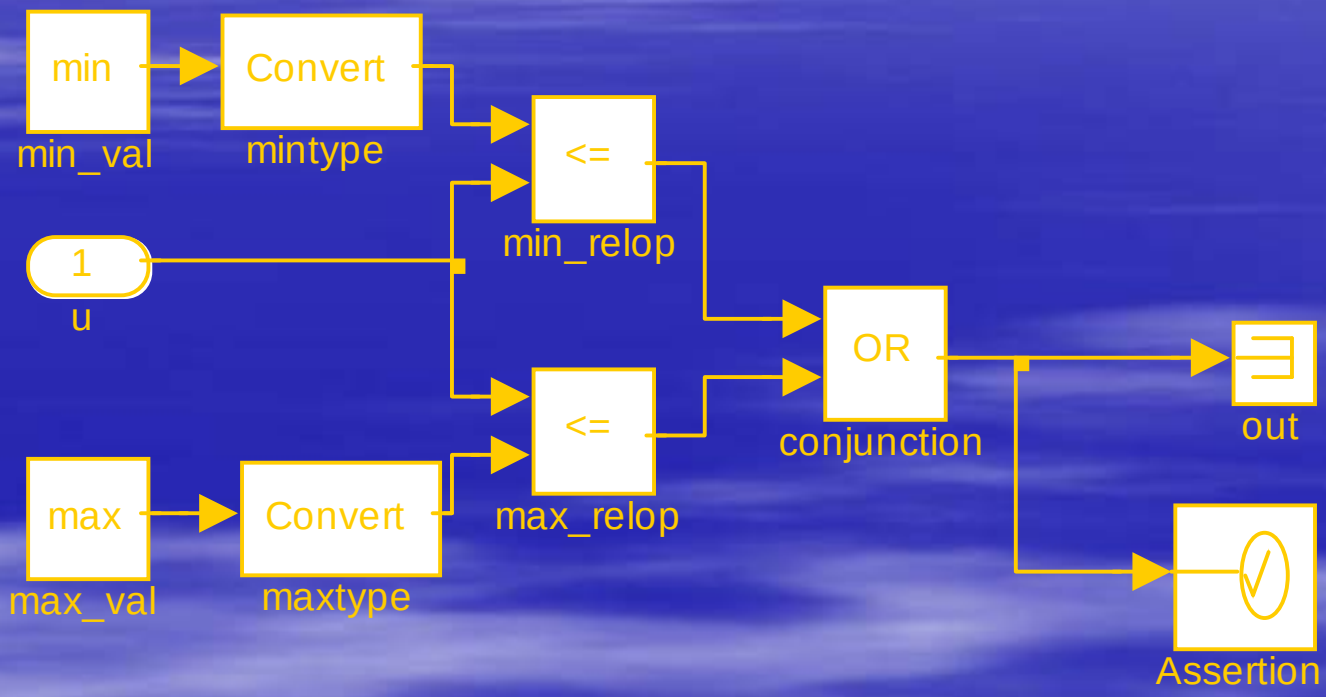
```
Block {
  BlockType                 Constant
  Name                      "Constant1"
  Position                  [155, 496, 240, 524]
  Value                     "FCS.lon.k5b"
}
Block {
  BlockType                 Constant
  Name                      "Constant2"
  Position                  [35, 411, 120, 439]
  Value                     "FCS.lon.k5c"
}
Block {
  BlockType                 DiscreteIntegrator
  Name                      "Discrete-Time\nIntegrator"
  Ports                     [1, 1]
  Position                  [395, 160, 430, 200]
  ShowName                  off
  IntegratorMethod          "Forward Euler"
  ExternalReset             "none"
  InitialConditionSource  "internal"
  SampleTime                "FCS.T_Samp"
}
Block {
  BlockType                 Product
  Name                      "Product"
  Ports                     [2, 1]
  Position                  [310, 383, 345, 552]
  InputSameDT               off
}
```

PARSED BLOCKS

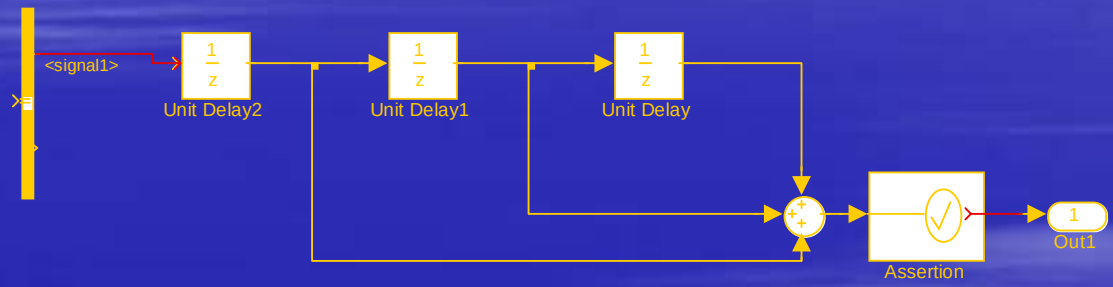
- 1 longitudinal_claw
- 1.1 Lon
- 1.1.1 Lon
- 1.1.1.1 Nz_cmd
- 1.1.1.2 Pitch_FB
- 1.1.1.3 Bus\nSelector
- 1.1.1.3.1 <Nz_g>
- 1.1.1.3.2 <Q_dps>
- 1.1.1.3.3 <AoA_deg>
- 1.1.1.4 Constant
- 1.1.1.5 Constant1
- 1.1.1.6 Constant2
- 1.1.1.7 Discrete-Time\nIntegrator
- 1.1.1.8 Product
- 1.1.1.9 Sum
- 1.1.1.10 Sum1
- 1.1.1.11 Sum2
- 1.1.1.12 Sum3
- 1.1.1.13 Sum4
- 1.1.1.14 Sum5
- 1.1.1.15 Zero-Order\nHold1



EXAMPLE OF DETECTION CHECK RANGE



EXAMPLE OF DETECTION DETECT ZERO OUTPUT



FMEA BY MOCET

ID	Item/Function	Failure Mode	Local Effect	Detection
1.1.1.1	N_z Command	a. Absent b. Jump c. > Limit	No output Hi rate None (limiter)	N-wait* Chck rate*
1.1.1.2	Pitch FB	See 1.1.1.3		
1.1.1.3	Bus selector	Stuck	No FB	N-wait*
1.1.1.3.1	N_z FB	a. Absent b. Jump c. Xtrm value	No signal Hi rate Hi/lo signal	N-wait Chck rate Chck range
1.1.1.7	Product	a. Absent b. Jump	No signal Hi rate	N-wait* Chck rate*

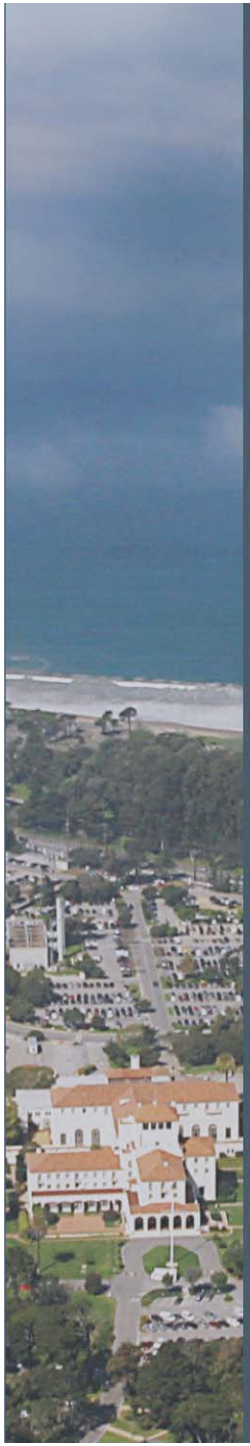
* Not in current model

CONCLUSIONS

- SOFTWARE CERTIFICATION BY DO-178B
  - IS UNNECESSARILY COSTLY
  - DOES NOT ADDRESS BASIC CERTIFICATION REQUIREMENTS
- MOCET WILL
  - SIMPLIFY THE CERTIFICATION EFFORT
  - ADDRESSES CERTIFICATION REQUIREMENTS MORE DIRECTLY

ACKNOWLEDGEMENT

MOCET is being developed under an AFRL contract for which Dave Hohman and Ray Bortner are the technical points of contact



NAVAL
POSTGRADUATE
SCHOOL

Open Architecture as an Enabler for FORCEnet

Presented by:

Tom Hedge

NSWC PHD San Diego

25 October 2006

The Nation's Premier Defense Research University

Monterey, California
WWW.NPS.EDU

Project Team

NSWC PHD Project Team

- Viviane Deering
- Patrick Grates
- Tom Hedge
- Sein Kung
- Maria Martinez
- Percival Mcarthy
- Kevin Pugh
- Sasha Radojkovic

Advisor - John M. Green, NPS

Agenda

- Objectives
- Methodology
- Definitions and Models
- Battle Space
- Engagement Scenarios
- Design Principles
- Conceptual Design / Architecture
- Simulation Model
- Conclusions / Recommendations
- The Road From Here

Objectives

Project Objective:

Evaluate and assess NAVSEA PEO IWS FORCEnet Open Architecture (OA) functional architecture against three (3) air defense engagement scenarios to either validate the model or identify recommended alternatives and / or improvements.

Presentation Objective:

Provide overview of project research methodology, including descriptions of models and architectural frameworks used to bound research, and present recommended model improvements.

Methodology

- Characterize the Problem / Battle Space – identify operational environment, including actual engagement scenarios, to bound problem space
- Formulate Design Principles – consider operational environment & available FORCEnet / OA models and strategies in formulating principles for architecting OA system with Integrated Fire Control (IFC) capabilities
- Develop Conceptual Design – develop architectural framework for distributed system with automated decision aids for optimally managing warfare resources within the problem space
- Functional Decomposition – develop models and methods to express automated resource collaboration in the context of the FORCEnet/OA architecture domain
- Simulation Modeling – develop computer simulation model to assess proposed functional system architecture against the engagement scenarios
- Analyze Simulation Results – Assess results of simulation to determine validity of previously identified FORCEnet OA model

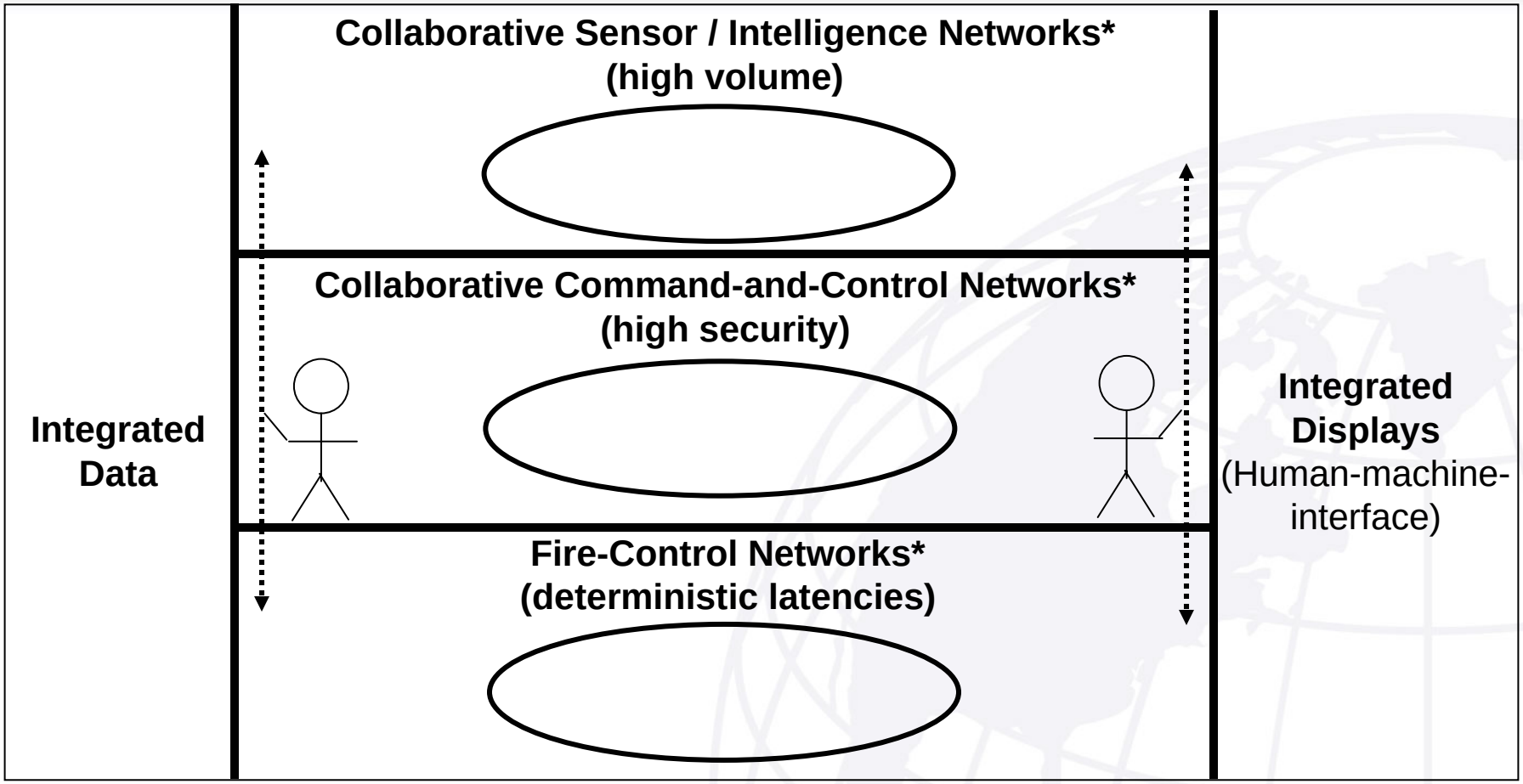
Definitions

- FORCEnet: operational construct and architectural framework for naval warfare in the information age, integrating warriors, sensors, command and control, platforms, and weapons into a networked, distributed, combat force
- Open Architecture:
  - Technical and Functional Architectural
  - Interfaces at system boundaries must be described in detail using established commercial or DoD standards
  - Well-defined and easily understandable system boundaries at various levels
  - Subsystem descriptions and interface definitions capable of two or more layers of decomposition using established system engineering practices
  - ***Foundation for 21st Century Combat System Designs***

Definitions (cont'd)

- Time-Critical Targeting: ability to detect, track, engage, and assess threats having extremely limited windows of vulnerability or opportunity for detection
- Integrated Fire Control: ability of a weapon system to develop fire control solutions from information provided by one or more non-organic sensor sources, conduct engagements based on these solutions, and either provide mid-course guidance or allow this guidance to be provided by another warfare unit

FORCEnet Information Architecture

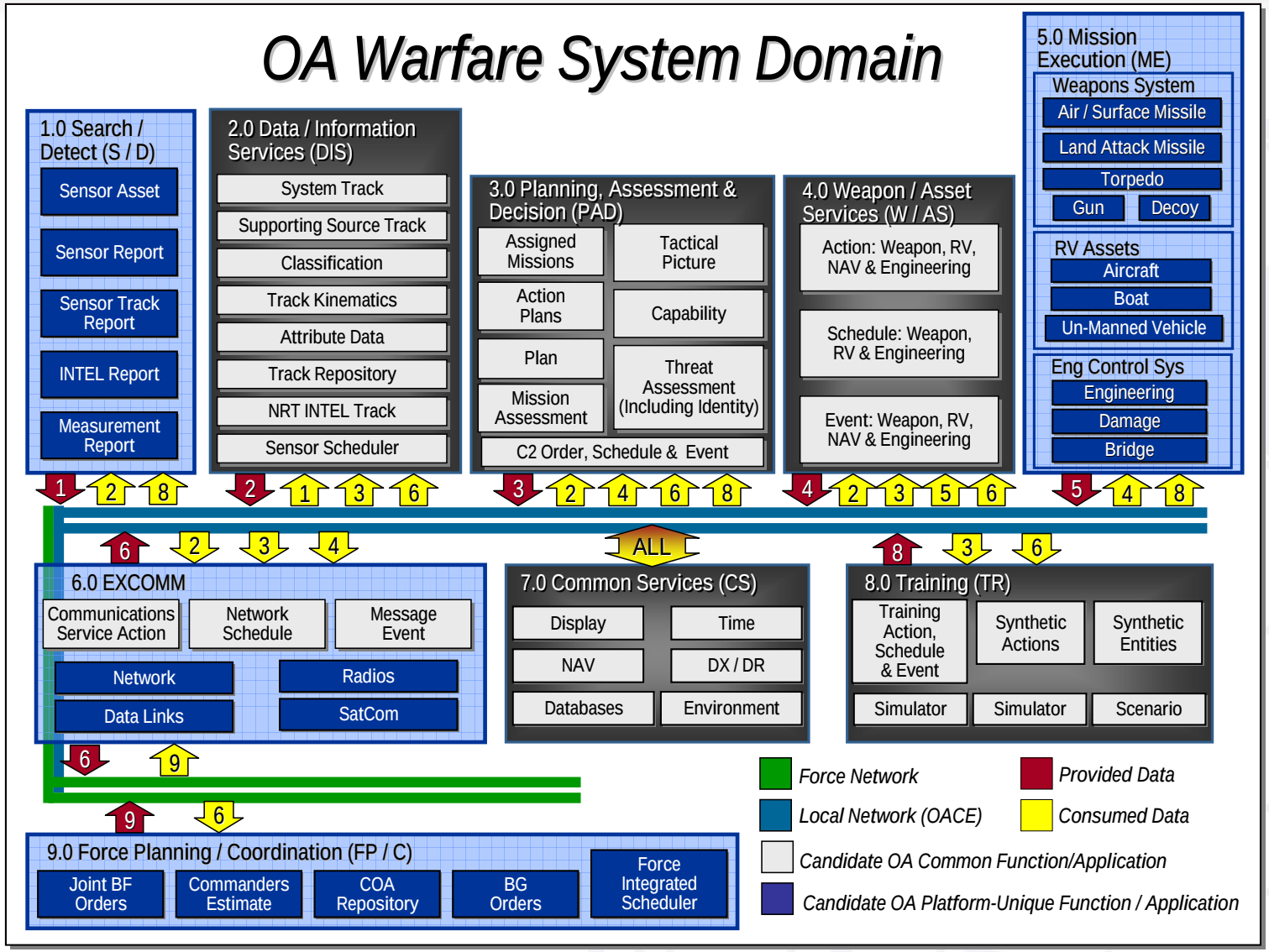


Legend:

- Invariant architectural boundaries with network control system "throttles" to assure the metrics
- Kill chains
- * Networks trace to communities of interest
- Networks

Source: FORCEnet Implementation Strategy, National Research Council, 2006

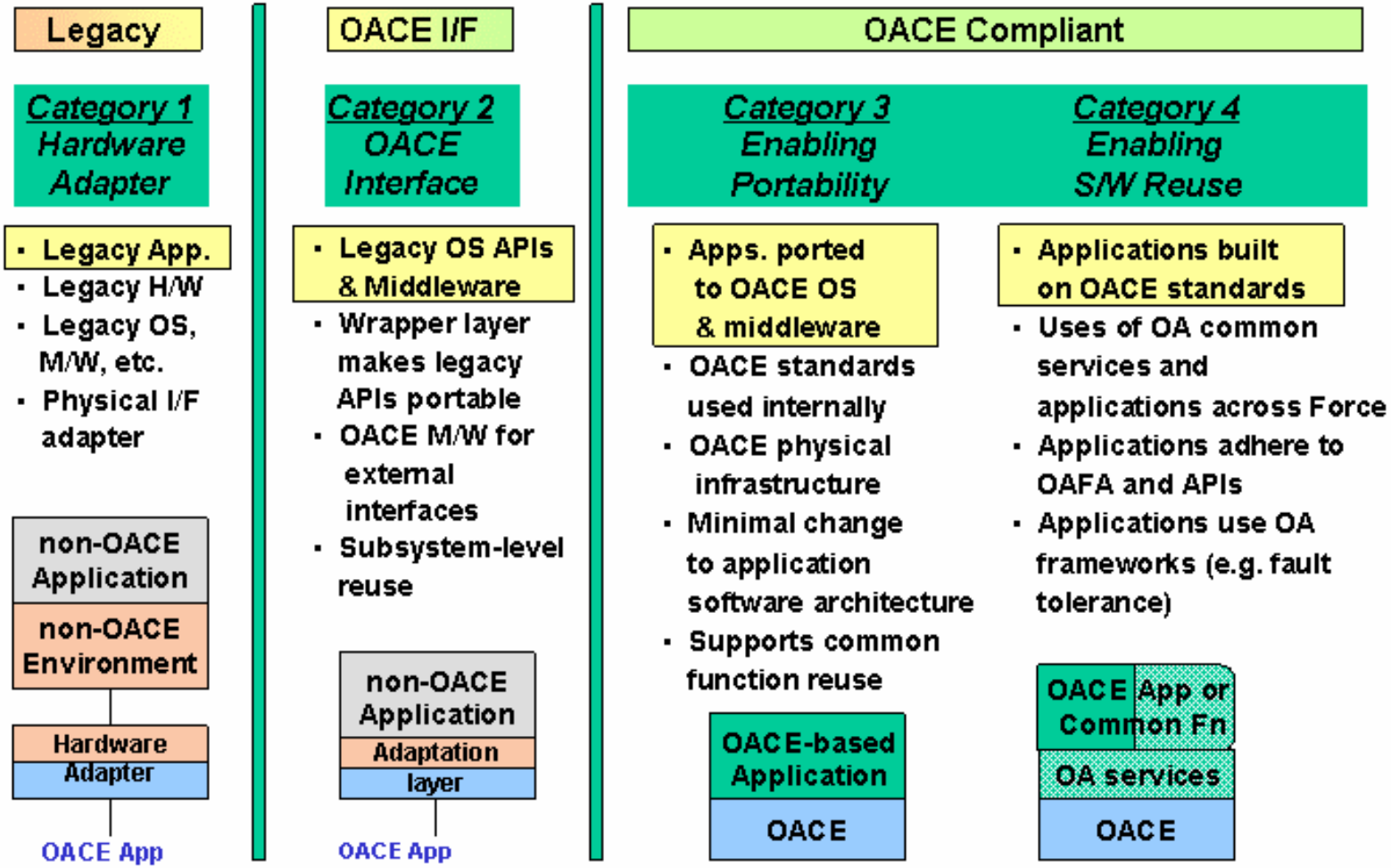
OA Warfare System Domain



Source: Combat Identification for Naval Systems in an Open Architecture,Young, 2006

OA Compliance Categories

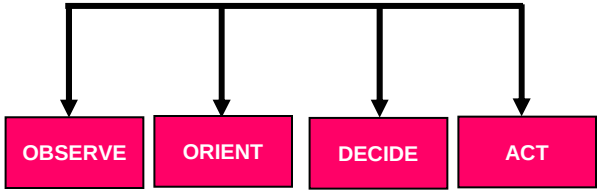
Compliance Categories



Source: OACE Technologies and Standards, NSWC, Dahlgren Division, 4 Sep 2003

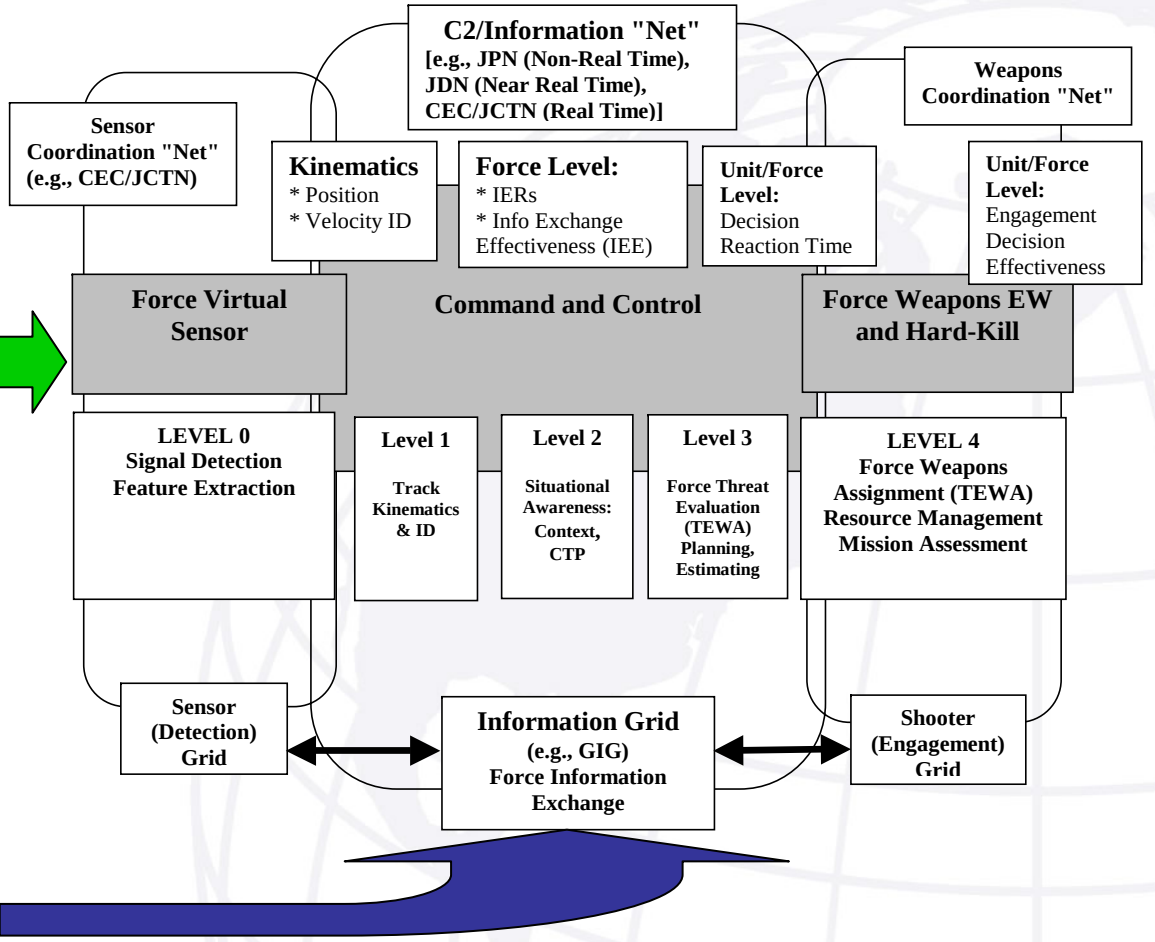
Legacy Models Considered

OODA Loop

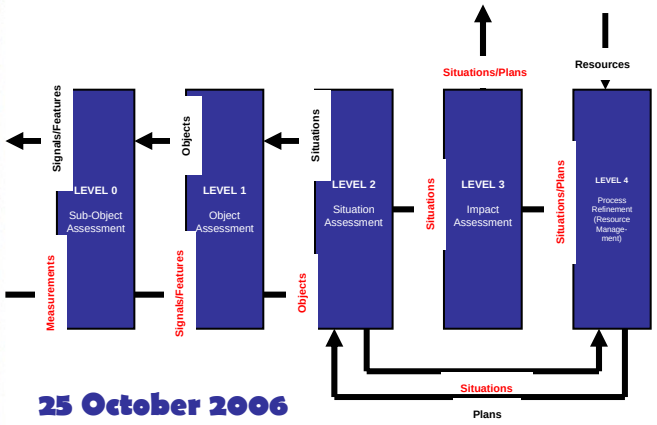


DCE Sequence





Data Fusion Model



Source: A Self-Consistent Context for Unit and Force Level Tactical Decision-Making, Luessen, 2003

Integrated Fire Control

- Fundamental IFC System Characteristics
  - Dynamically updateable doctrine
  - Decentralized architecture and synchronized information
  - Doctrine and decision aids
- Key IFC Capability Requirements
  - Shared Situational Awareness (SA)
  - Determining best Course of Action (COA)
  - Distributed Resource Management (DRM)
  - Embedded IFC planning

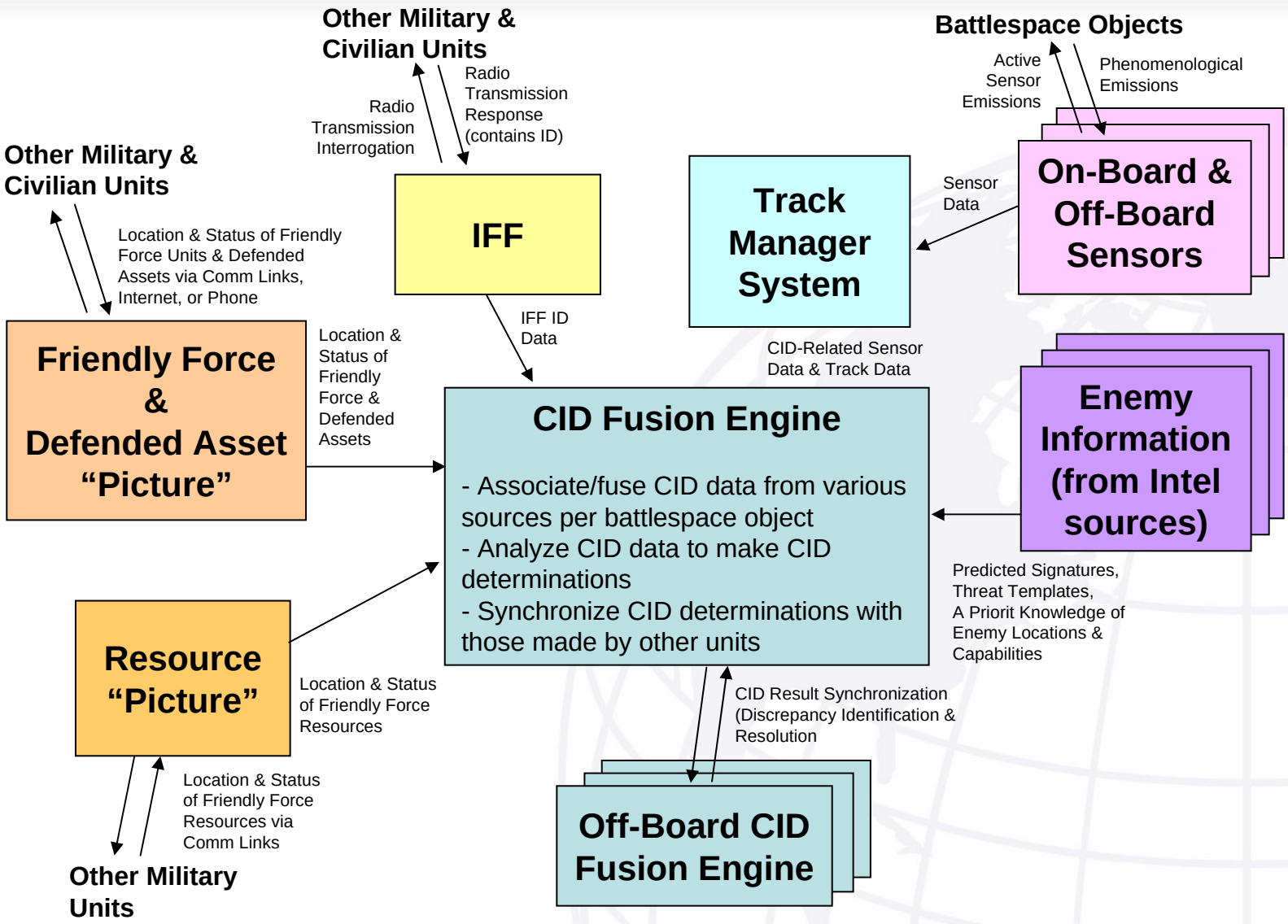
Source: Integrated Fire Control for Future Aerospace Warfare, Young, 2004

Common Identification (ID)

- Objective: accurate, timely, and sustainable characterization and classification of tracks to facilitate early threat and resource awareness, and enable optimal weapon engagement planning
- Current methods: Identification Friend or Foe (IFF), Local sensor data Intelligence, Surveillance, and Reconnaissance (ISR)
- Future Capability Requirements
  - Centralized geographical database
  - Shared resource picture
  - Common CID deterministic results
  - Common CID functionality
  - Support Joint Warfare operating environment
  - Effective CID data strategy
  - Span Warfare areas
  - Increased level of automation
  - Isolate CID processes (OA design)

Source: Combat Identification for Naval Systems in and Open Architecture, Young, 2006

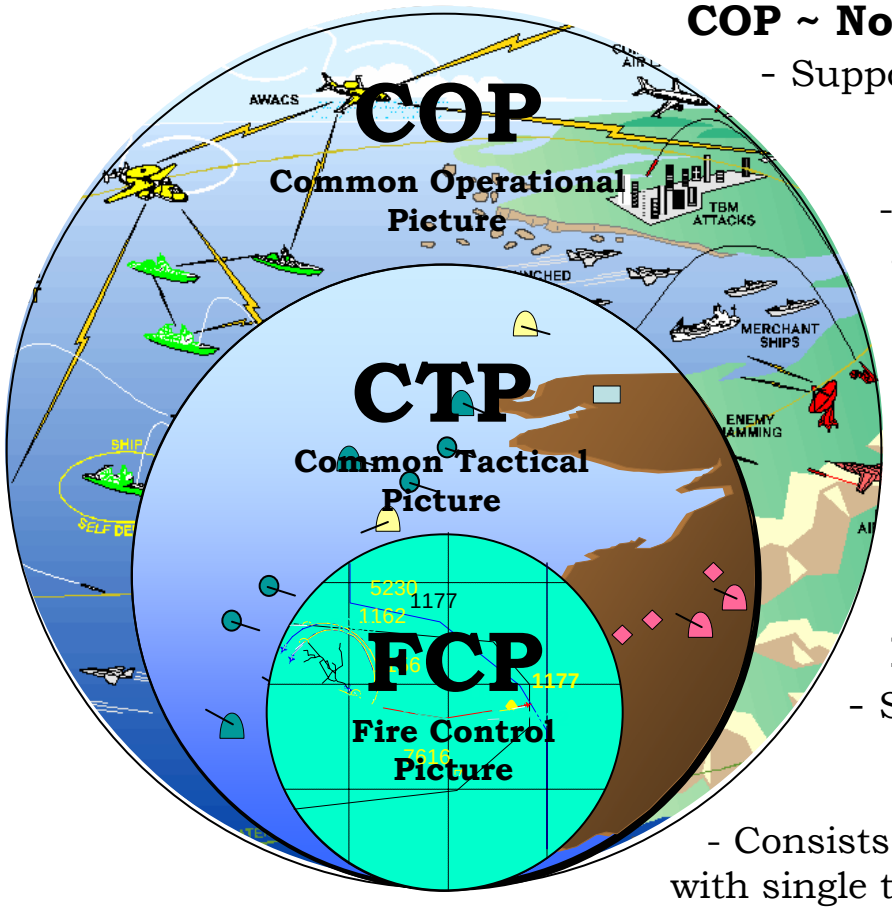
Future Common ID Capability



Source: Future CID Capability, Young, 2006

Battle Space Information Realms

The FORCEnet OA operational concept will enable ideal threat/weapon pairings by maintaining BF-wide shared situational awareness across the three information realms



COP ~ Non-Real Time (minutes)
- Supports Planning/Force Mgt:
  - Deployment
  - Movement
- Consists of: tactical info, courses of action, enemy order of battle info

CTP ~ Near-Real Time (seconds)
- Supports Cueing/Force Mgt:
  - Maneuver
  - Asset Control
  - Weapon/Sensor Cueing
  - Target Weapon Pairing
- Consists of: tactical information

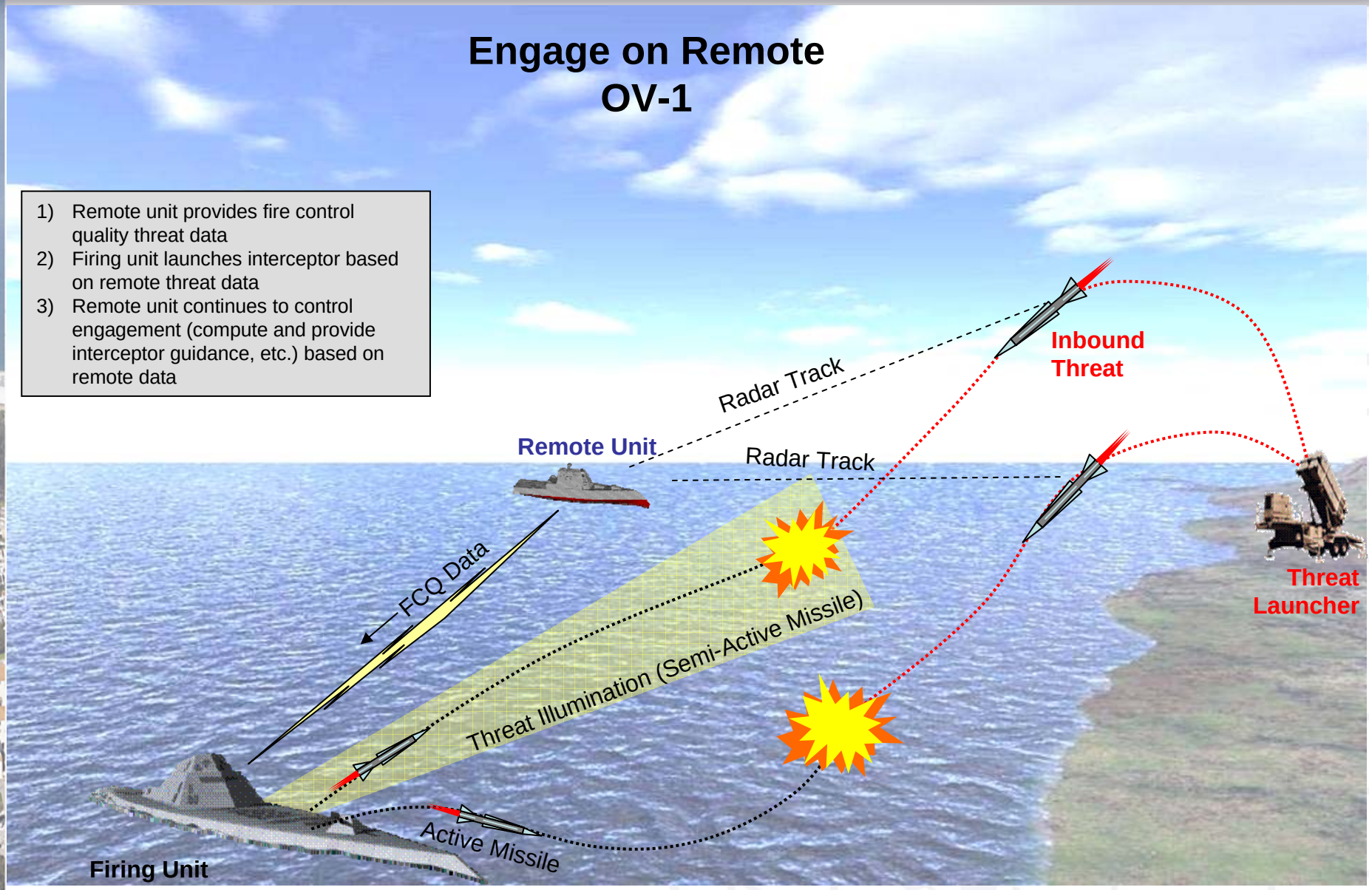
FCP ~ Real Time (sub-seconds)
- Supports Fire Control:
  - Launch & In-Flight Fire Support
  - Engage on Remote
- Consists of: fire control quality measurements with single threat focus

Source: Naval Network-Centric Sensor Resource Management, Worth/Green, 2006

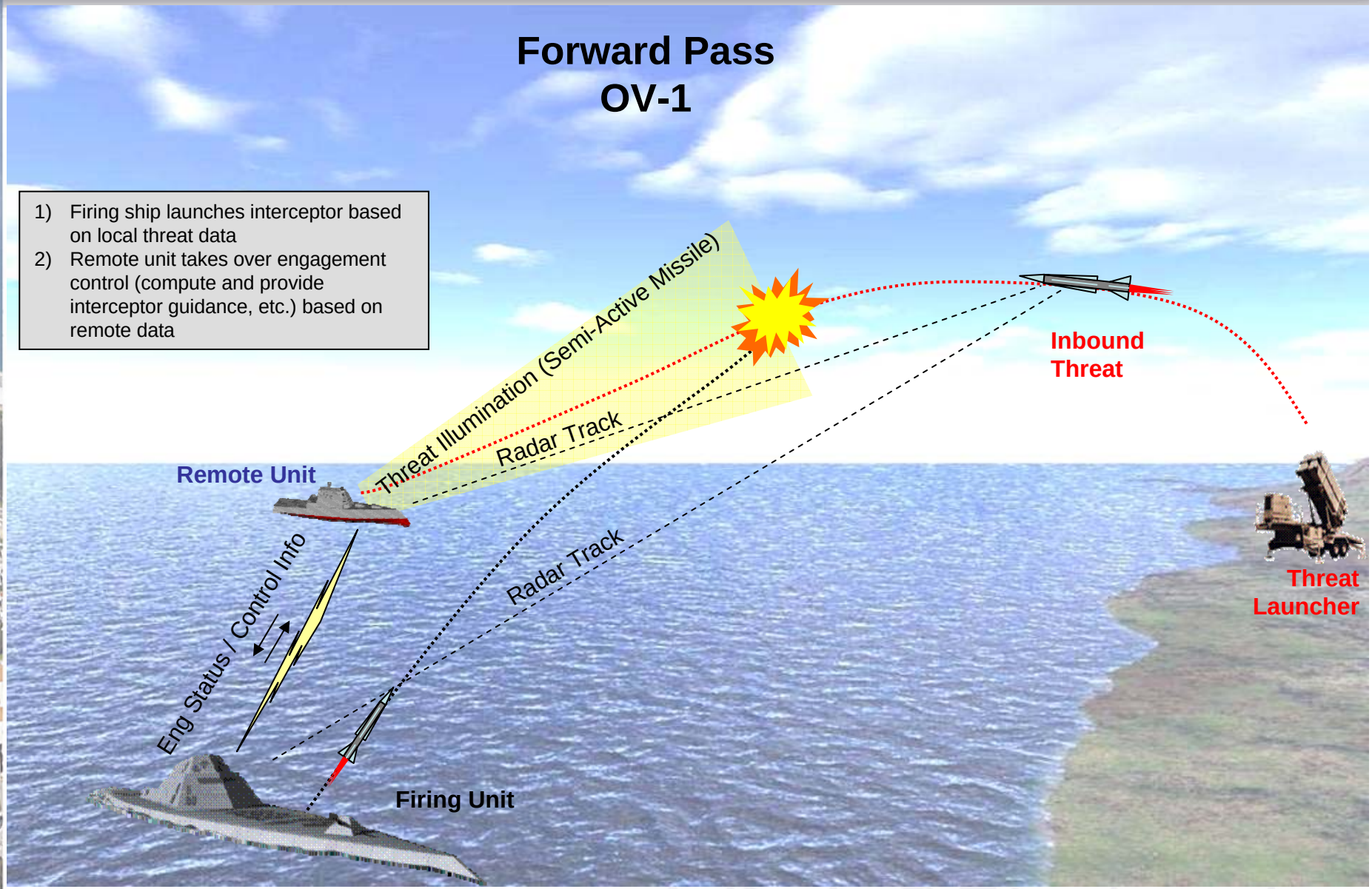
Engage on Remote

Engage on Remote
OV-1

1) Remote unit provides fire control quality threat data
2) Firing unit launches interceptor based on remote threat data
3) Remote unit continues to control engagement (compute and provide interceptor guidance, etc.) based on remote data



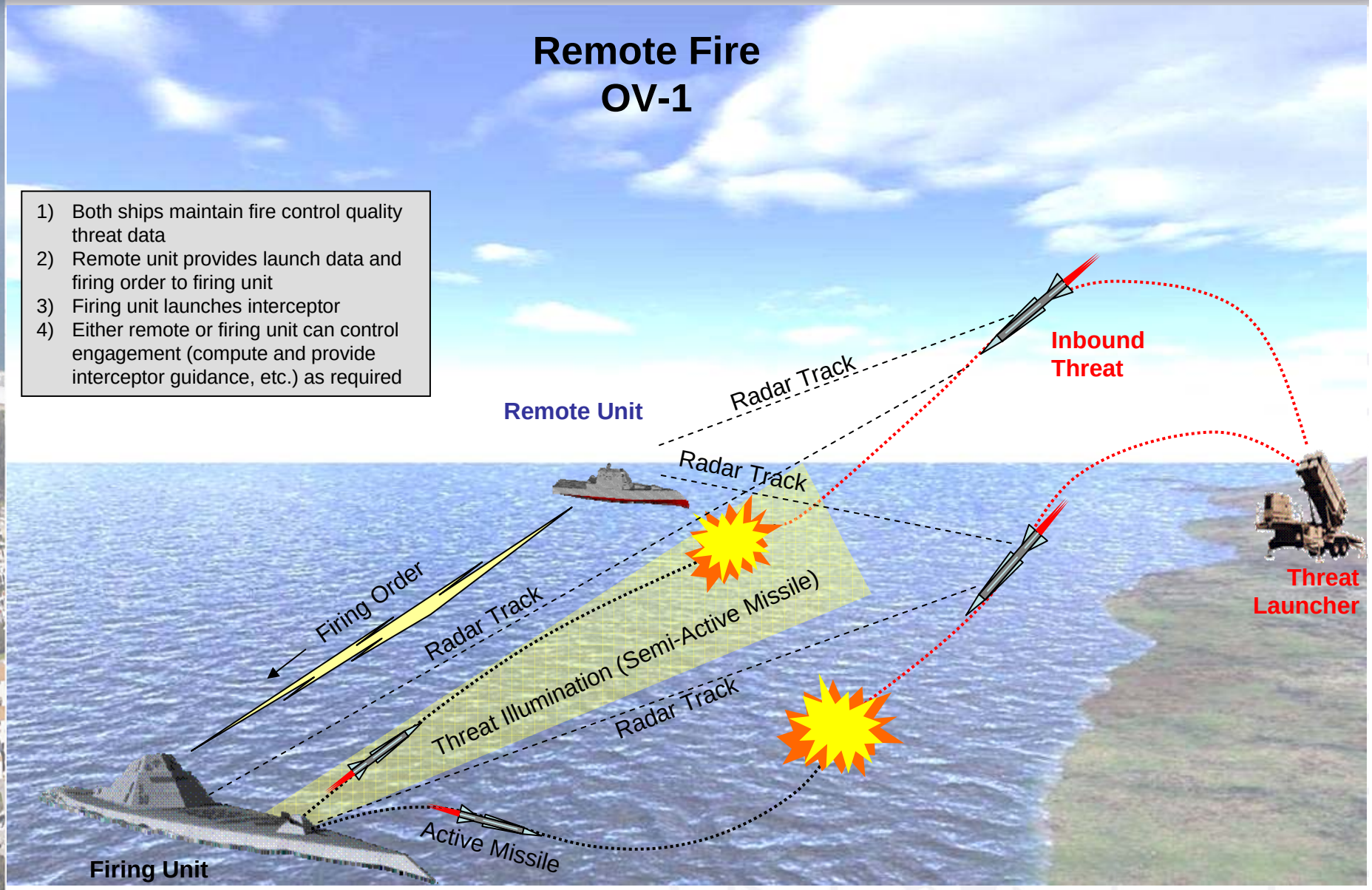
Forward Pass



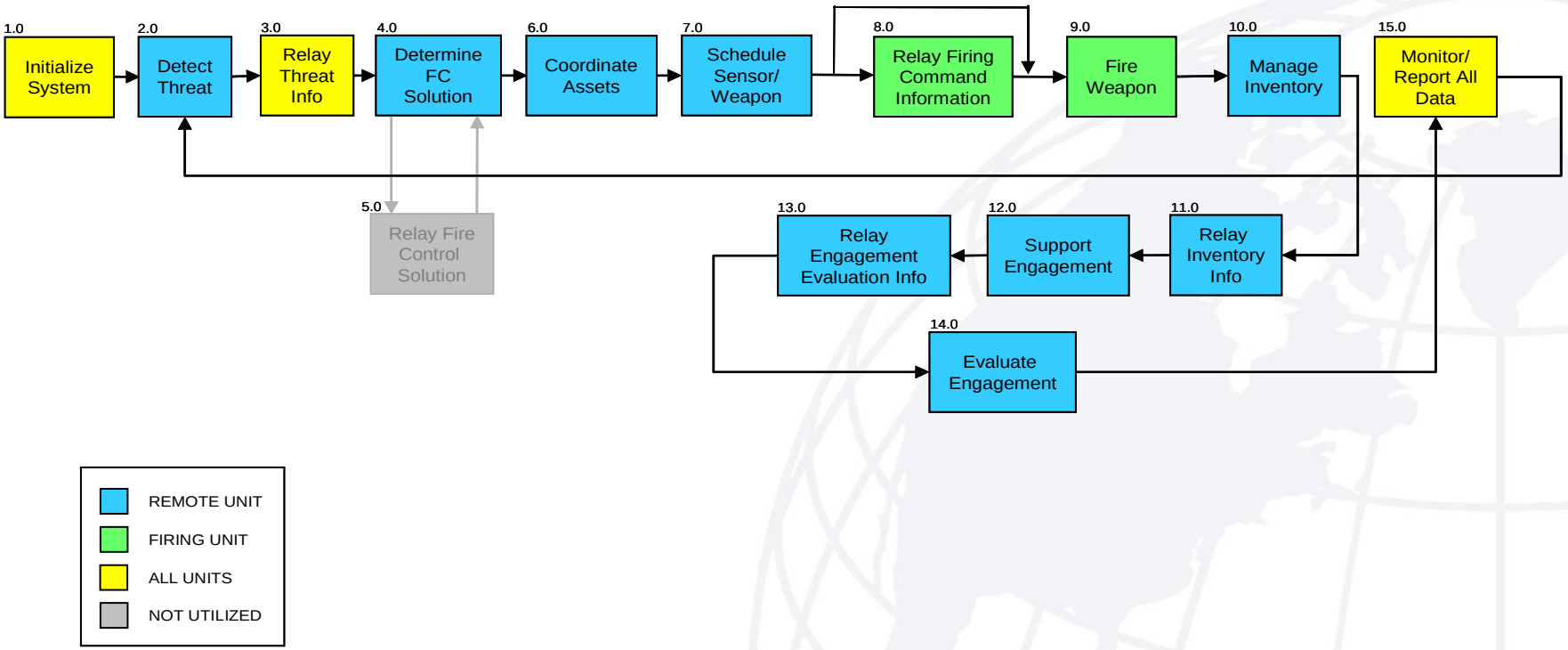
Remote Fire

Remote Fire OV-1

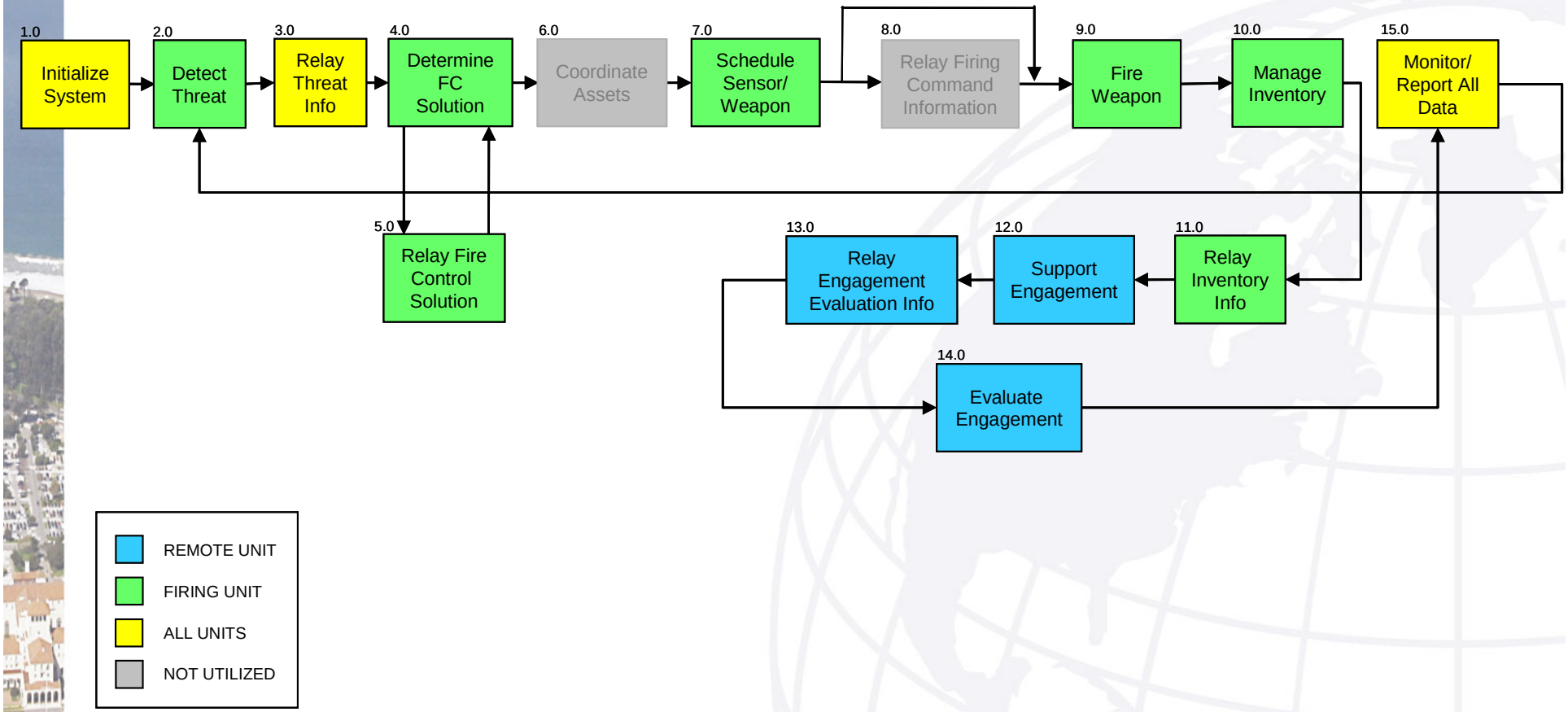
1) Both ships maintain fire control quality threat data
2) Remote unit provides launch data and firing order to firing unit
3) Firing unit launches interceptor
4) Either remote or firing unit can control engagement (compute and provide interceptor guidance, etc.) as required



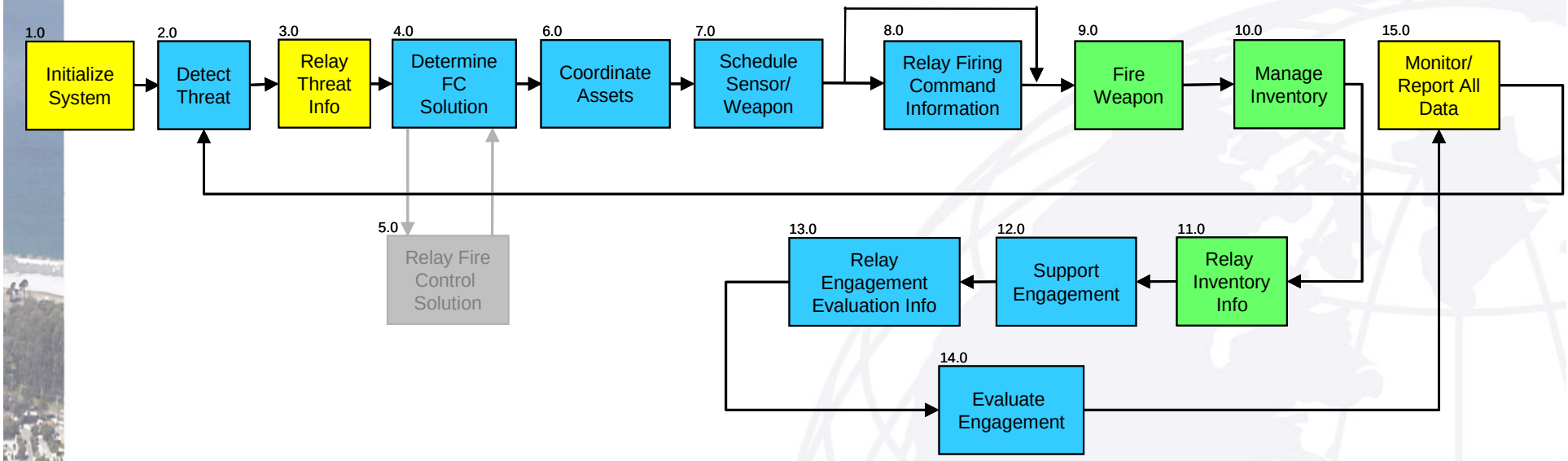
Engage on Remote FFBD

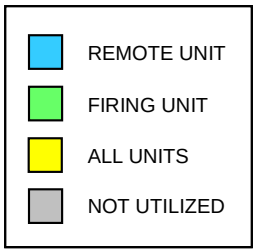


Forward Pass FFBD

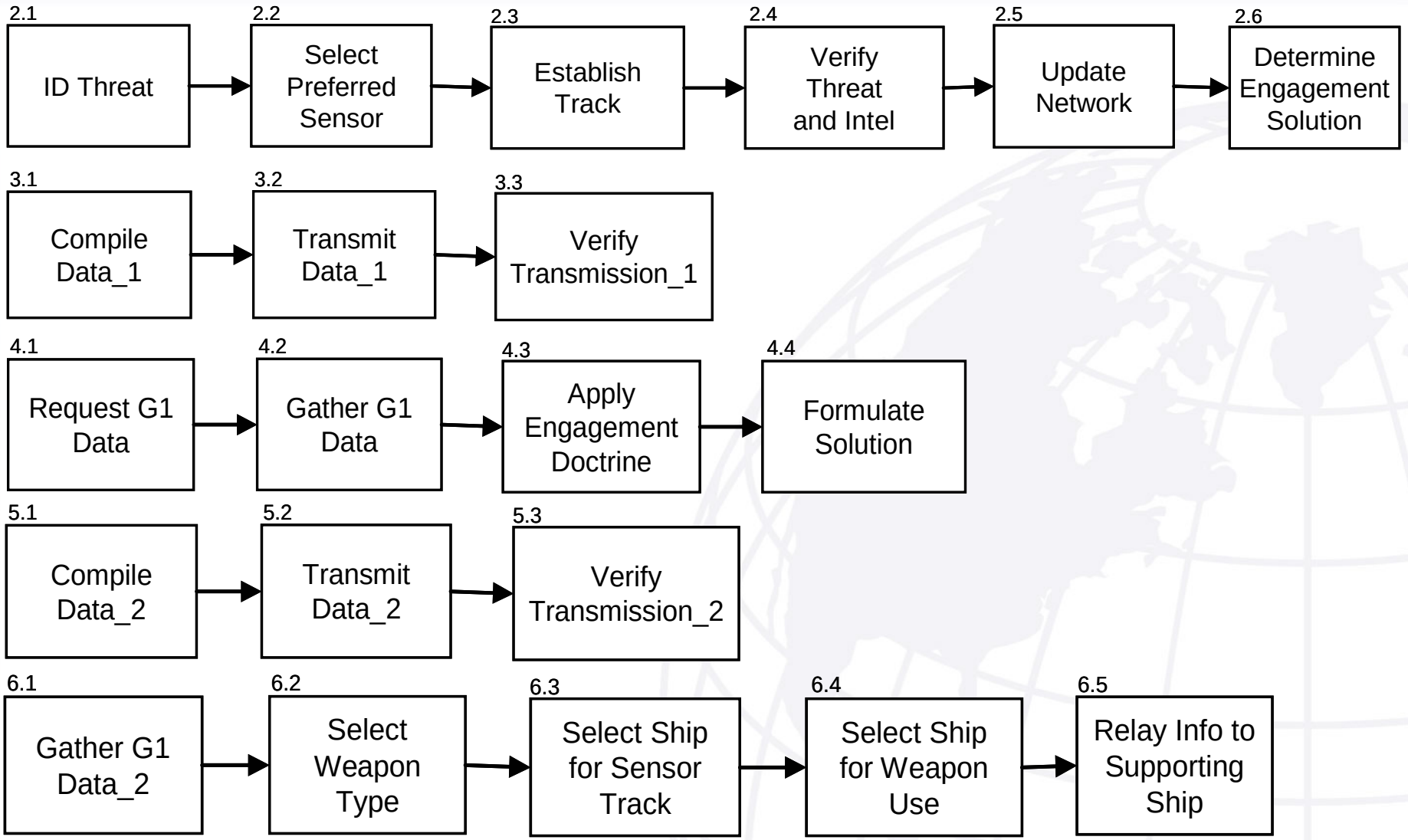


Remote Fire FFBD

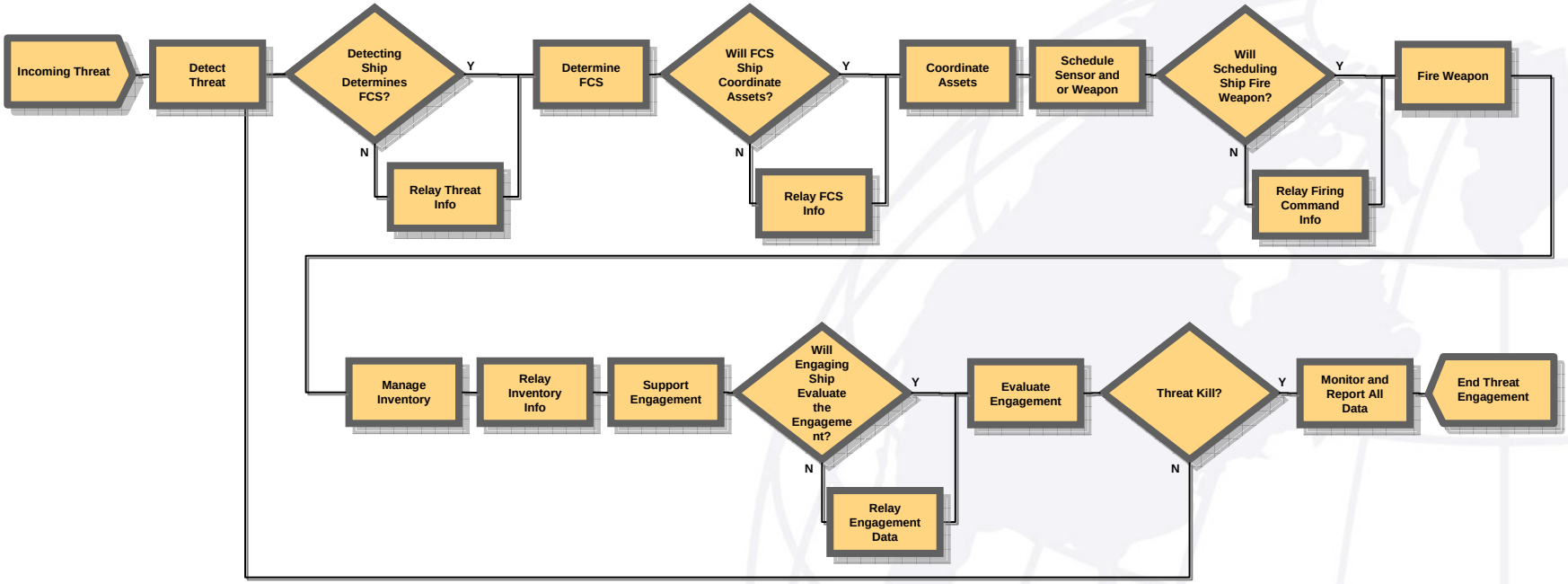




Representative Sub-Function FFBDs



Simulation Model



Simulation Model Results

# of Incoming Threats	Threat Interval (seconds)	% of Successful First-time Engagements	WIP [Saturation] (seconds)	Average Total Time (seconds)	Limiting Process #1	Limiting Process #1 Time (seconds)	Limiting Process #2	Limiting Process #2 Time (seconds)
1	60	90	**0.5166**	**25.1135**	"ID the Threat"	0.3694	"Establish a Track"	0.2561
1	60	100	**0.4974**	**23.4344**	"ID the Threat"	0.3551	"Establish a Track"	0.2648
1	30	90	**1.2893**	**34.8877**	"ID the Threat"	0.872	"Determine an Engagement Solution"	0.5203
1	30	100	**1.2033**	**32.1173**	"ID the Threat"	0.8961	"Establish a Track"	0.4846
2	60	90	**2.3242**	**63.4865**	"Transmit All Data"	2.0821	"Compile Inventory Data"	1.7562
2	60	100	**2.2656**	**59.8616**	"Transmit All Data"	2.3936	"Compile Inventory Data"	1.9017
2	30	90	**5.8229**	**120.15**	"Transmit All Data"	3.3926	"Compile Inventory Data"	3.0117
2	30	100	**5.7013**	**111.14**	"Transmit All Data"	3.7807	"Compile Inventory Data"	3.271

Revised FORCEnet OA Model

	PEO IWS OA Warfare System / Functional Domain	Revised FORCEnet OA System / Functional Domain
Detect	Search / Detect • Sensor Asset • Sensor Report • Sensor Track Report • INTEL Report • Measurement Report	Search / Detect • Sensor Asset • Sensor Report • Sensor Track Report • INTEL Report • Measurement Report

Revised FORCEnet OA Model (cont'd)

PEO IWS OA Warfare System / Functional Domain

Control

Data / Information Services
- Sensor Track
- Supporting Source Track
- Classification
- Track Kinematics
- Attribute Data
- Track Repository
- NRT INTEL Track
- **Sensor Scheduler**

Planning, Assessment & Decision
- Assign Missions
- Tactical Picture
- Action Plans
- Capability
- Plan
- Mission Assessment
- Threat Assessment
- C2 Order, Schedule, & Event

Revised FORCEnet OA System / Functional Domain

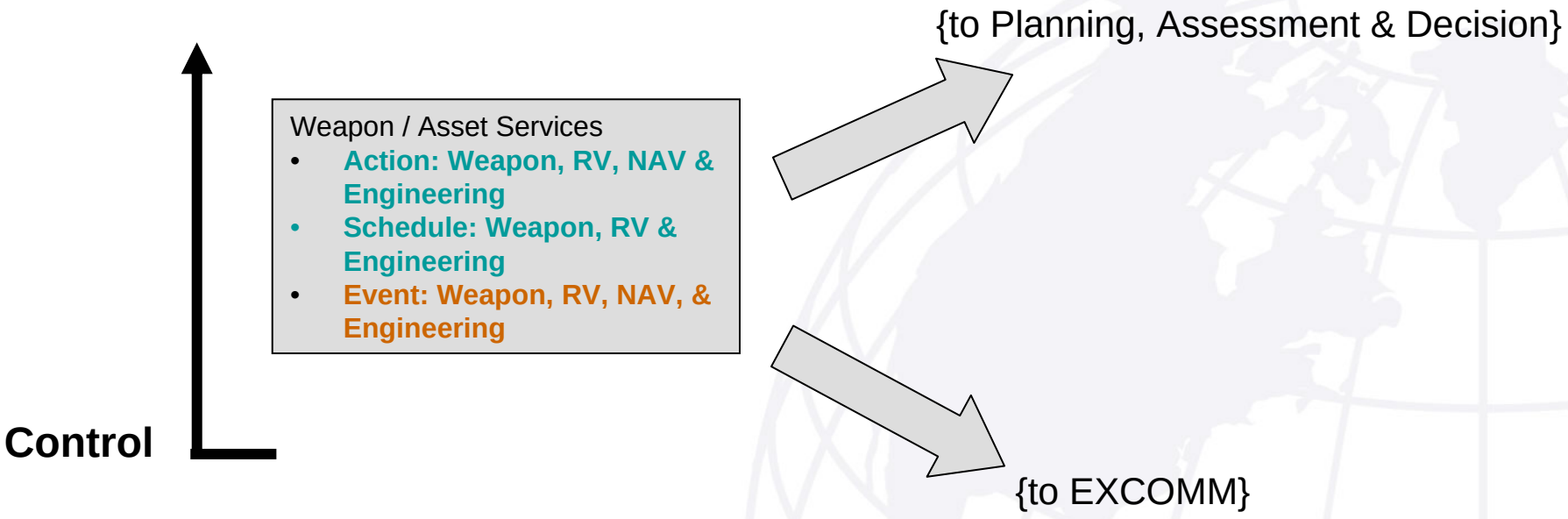
Data / Information Services
- Sensor Track
- Supporting Source Track
- Classification
- Track Kinematics
- Attribute Data
- Track Repository
- NRT INTEL Track

Planning, Assessment & Decision
- **Sensor Scheduler**
- Assign Missions
- Tactical Picture
- Action Plans
- Capability
- Plan
- Mission Assessment
- Threat Assessment
- C2 Order, Schedule, & Event
- **Schedule: Weapon, RV, NAV & Engineering**
- **Action: Weapon, RV, NAV & Engineering**

Revised FORCEnet OA Model (cont'd)

PEO IWS OA Warfare System / Functional Domain

Revised FORCEnet OA System / Functional Domain



Revised FORCEnet OA Model (cont'd)

Engage

PEO IWS OA Warfare System / Functional Domain

Mission Execution
- Air / Surface Missile
- Land Attack Missile
- Torpedo
- Gun
- Decoy

RV Assets
- Aircraft
- Boat
- Un-manned Vehicle

RV Assets
- Engineering
- Damage
- Bridge



Revised FORCEnet OA System / Functional Domain

Mission Execution
- Air / Surface Missile
- Land Attack Missile
- Torpedo
- Gun
- Decoy

RV Assets
- Aircraft
- Boat
- Un-manned Vehicle

RV Assets
- Engineering
- Damage
- Bridge

Kill Assessment

Midcourse Guidance

Revised FORCEnet OA Model (cont'd)

PEO IWS OA Warfare System / Functional Domain

Common Services
- Display
- NAV
- Database
- Time
- DX / DR
- Environment

EXCOMM
- Communications Service Action
- Network Schedule
- Message Event
- Network
- Radios
- Data Links
- SatComm

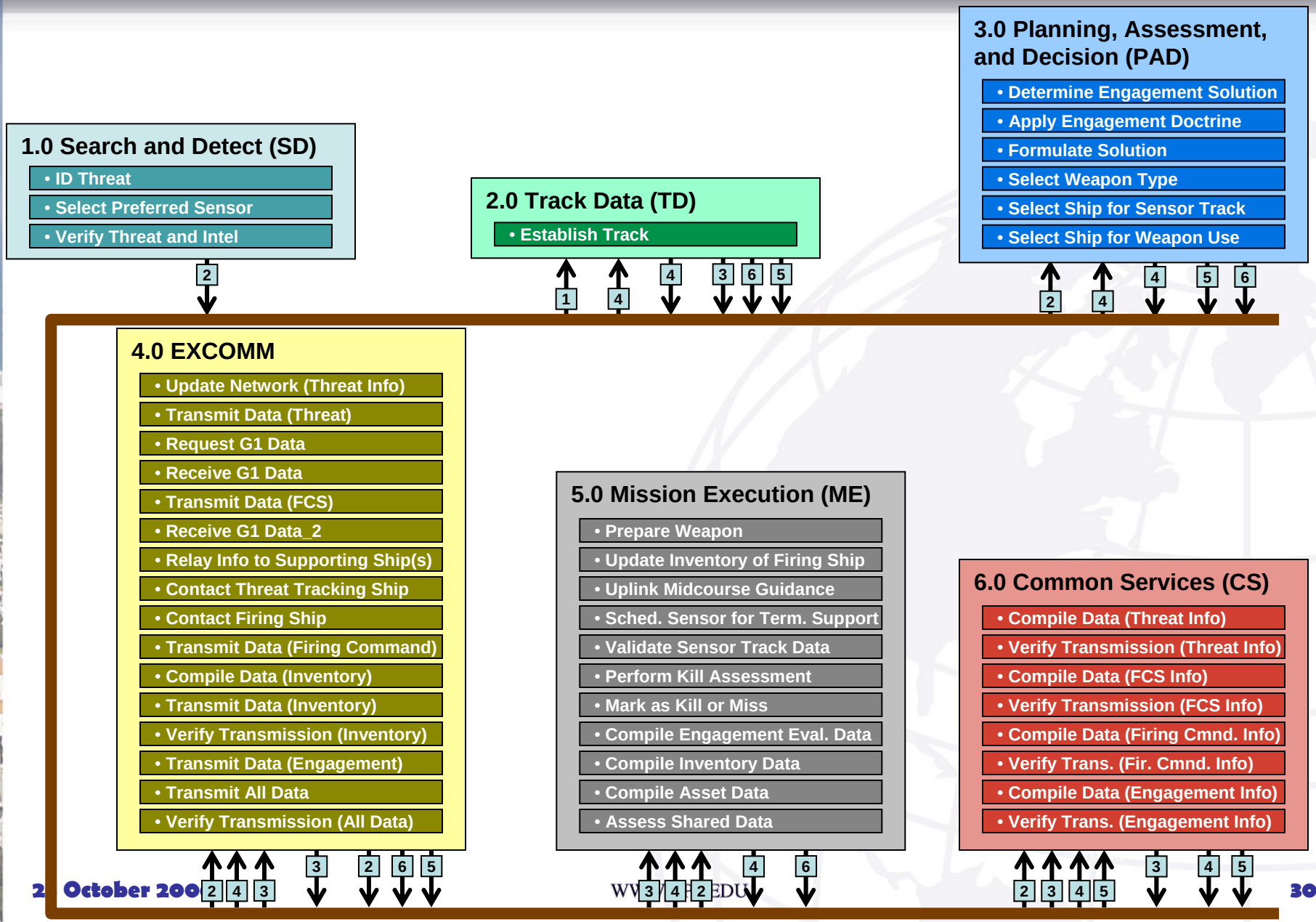
Revised FORCEnet OA System / Functional Domain

Common Services
- Display
- NAV
- Database
- Time
- DX / DR
- Environment

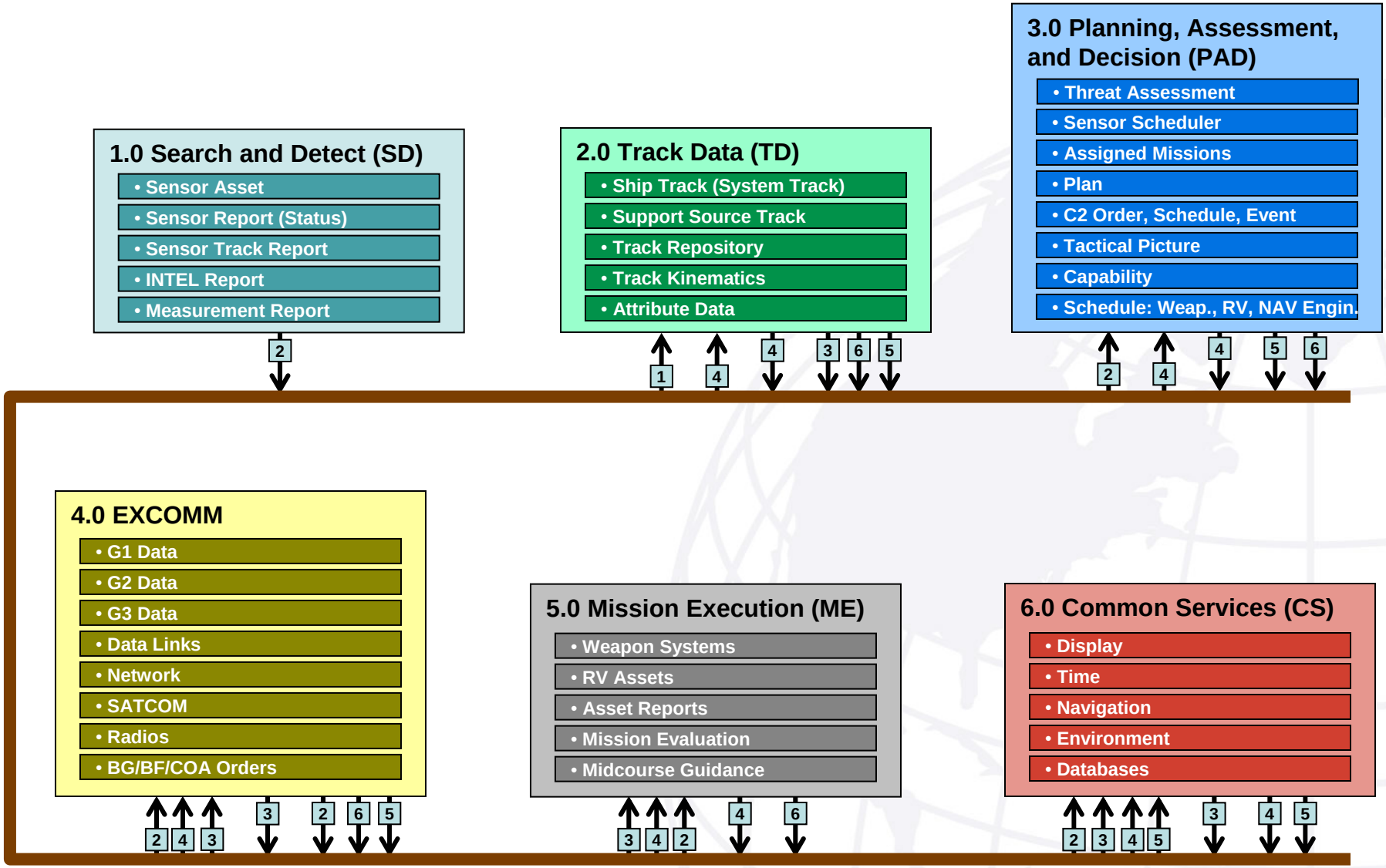
EXCOMM
- Communications Service Action
- Network Schedule
- Message Event
- Network
- Radios
- Data Links
- SatComm
- **BG /BF COA Orders**
- **Event: Weapon, RV, NAV & Engineering**

NAVAL POSTGRADUATE SCHOOL

Revised FORCEnet OA Functional Model



Revised FORCEnet OA System Domain



Conclusions / Recommendations

- Functional analysis of PEO IWS OA Functional Domain model resulted in revised FORCEnet OA model
- Simulation validated logical functional flow of revised FORCEnet OA model
- Simulation validated system timing of revised FORCEnet OA model
- Revised FORCEnet OA model and Simulation used for model validation merit further scrutiny and refinement

Recommended Future Actions

- Incorporate real-world timing parameters of current/future combat systems
- Incorporate real-world threat characteristics and parameters into simulation model
- Use simulation model to determine threat “processing” time using
- Refine simulation model based on results from using real-world combat system and threat parameters
- Use refined simulation model to assess combat system network architectures for saturation nodes and choke points
- Assess simulation model against other likely engagement scenarios
- Continue to revise NAVSEA FORCEnet OA model for use in architecting future single ship and strike group systems and networks

LOCKHEED MARTIN

Modeling and Simulation (M&S) an Issue of Credibility

David Henry

Lockheed Martin

MS2-Moorestown

“The Challenge”

- Develop an “acceptable” representation of reality
- Produce desirable and acceptable results

How does the M&S developer/analyst offer reasonable grounds for being believed?

Background

- Things to overcome: (the way it is)
  - Traditionally placed in the engineering tool category
  - The benefit is at the task level (one who can wield the hammer is the benefactor)
  - The “it-wasn’t-built-here” syndrome

- Things to reach for: (the way to go)
  - Increase to primary use (reduce cost, reduce risk)
  - Re-use (stop re-inventing a wheel)
  - Leverage to gain greater sophistication/complexity

Takes an incredible level of knowledge to transport the level of belief needed. The more complex the more knowledge base required.

Approach

- Move from a tool concept to a knowledge base concept
- Define common processes and approaches to represent consistent knowledge levels

Three (3) levels of representation:

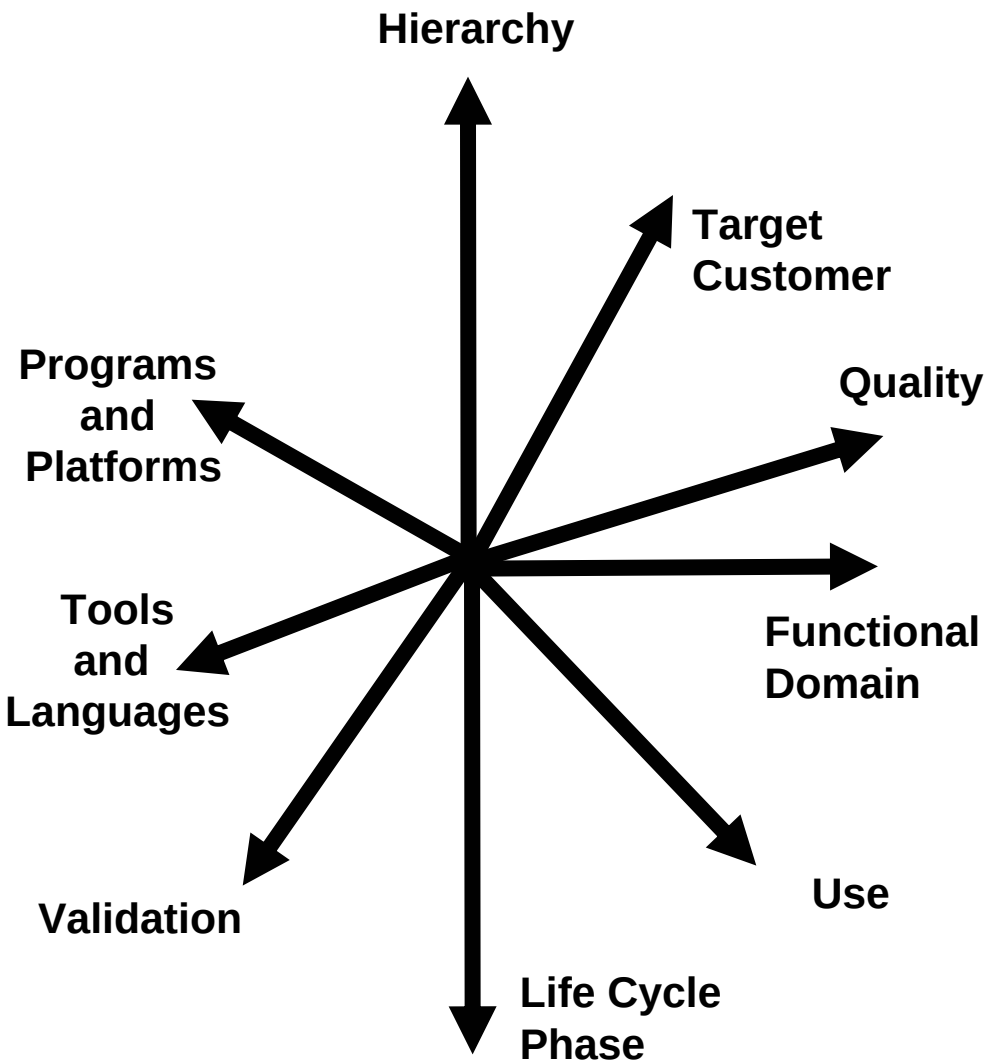
Registration, Certification, Accreditation

Registration

- Implement common practice to recognize models (subsystem/engineering) by a specific group/body of experts
- Institute formal process (as simple as):
  - Cataloguing models
  - Generating Read-Me files
  - Performing comparative analysis (similar algorithms/models)

Easy way to capture/present models of various types in multiple categories
THE KEY – Common Taxonomy

Taxonomy Structure Example



Certification

- Clearly and fully document characteristics of models/simulations (platform/system) beyond Read-Me files/cataloguing
- Must meet verification and validation requirements (customer satisfaction)
- Demonstrates adherence to a credible CM process

Most cases certified M&S will be built from registered M&S

Clear contribution to growth of maturity of M&S at this level

Larger community commitment and interest – Process Bar Raised

Accreditation

- Most widely recognized/implemented quality assurance method (Well Documented)

"Accreditation: the official determination that a computer model is acceptable for a specific purpose. [MORS]".

- M&S (platform/system to warfare/campaign) must convey reality (as much as possible)
- M&S intent of use is clear and agreed to (official approval process)

Certification efforts direct contribution to this level

Knowledge level boundary crossed from "what" is represented to "how well"

Thought For the Day!

Broaden the approach of accreditation of models and simulations across communities (training, analysis, acquisition, testing, planning, experiment) extending the specific use portion of the definition to a different level.

The statement that most appropriately applies here is that models and simulations are rapidly evolving into a major vehicle through which the intuition and insight regarding combat capabilities will be developed and proven.

Will drive reuse consideration/determination early in the planning process

M&S Potential Use

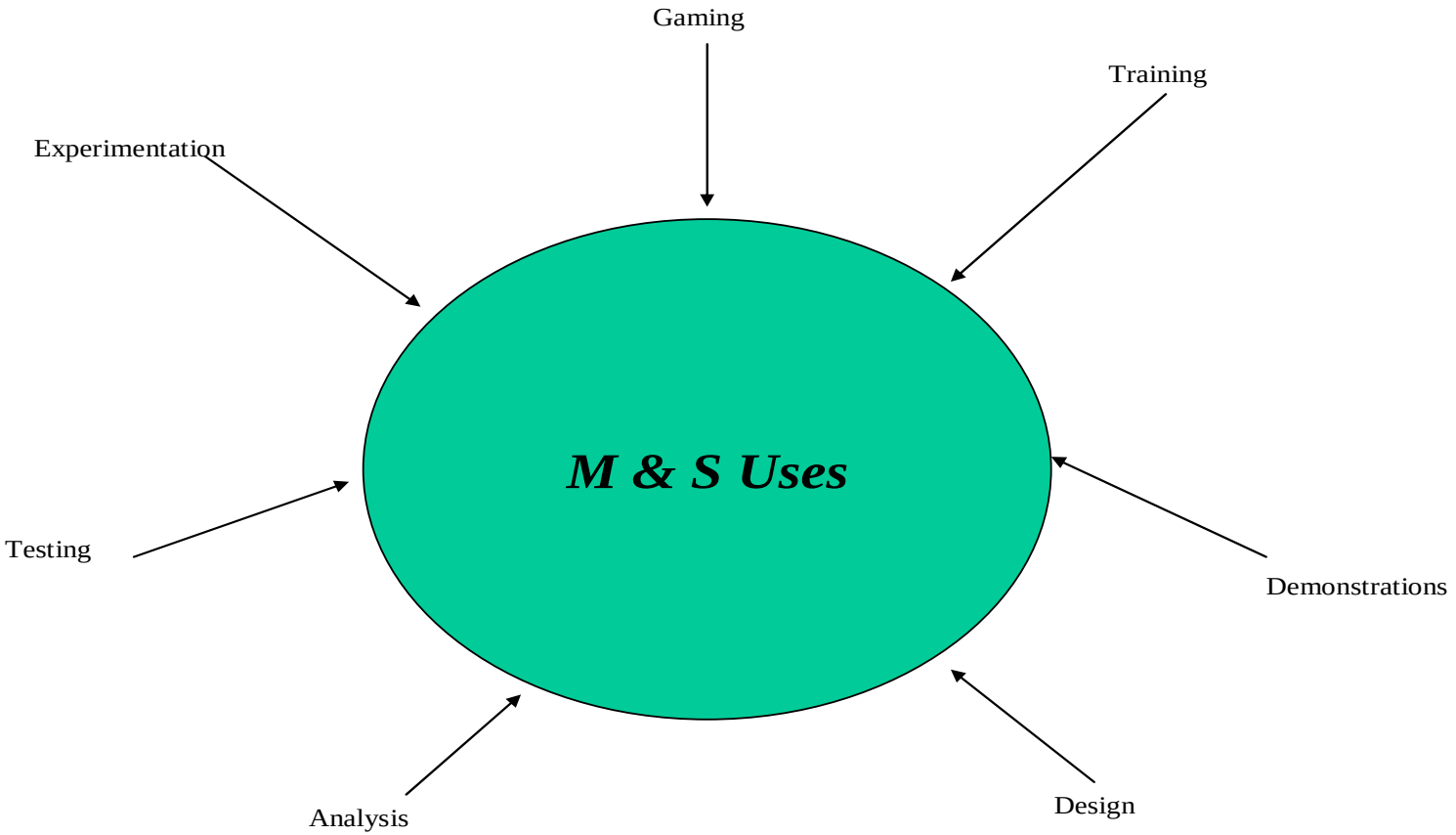


Figure 1

Environment leads to reuse – true enabler of knowledge exchange…….

Some Notes on M&S Potential Use

- Experimentation – addresses problems and situations that can not be done any other way or it is the only way
- Such applications could reach down into Testing and Demonstrations
- Gaming is a whole new perspective from the game itself to being a “player” of/in it
- Such applications could reach down into Training, Testing, and Demonstrations

To “maintain” certification or accreditation models and simulations must continue to be well-developed, well-documented, well-calibrated

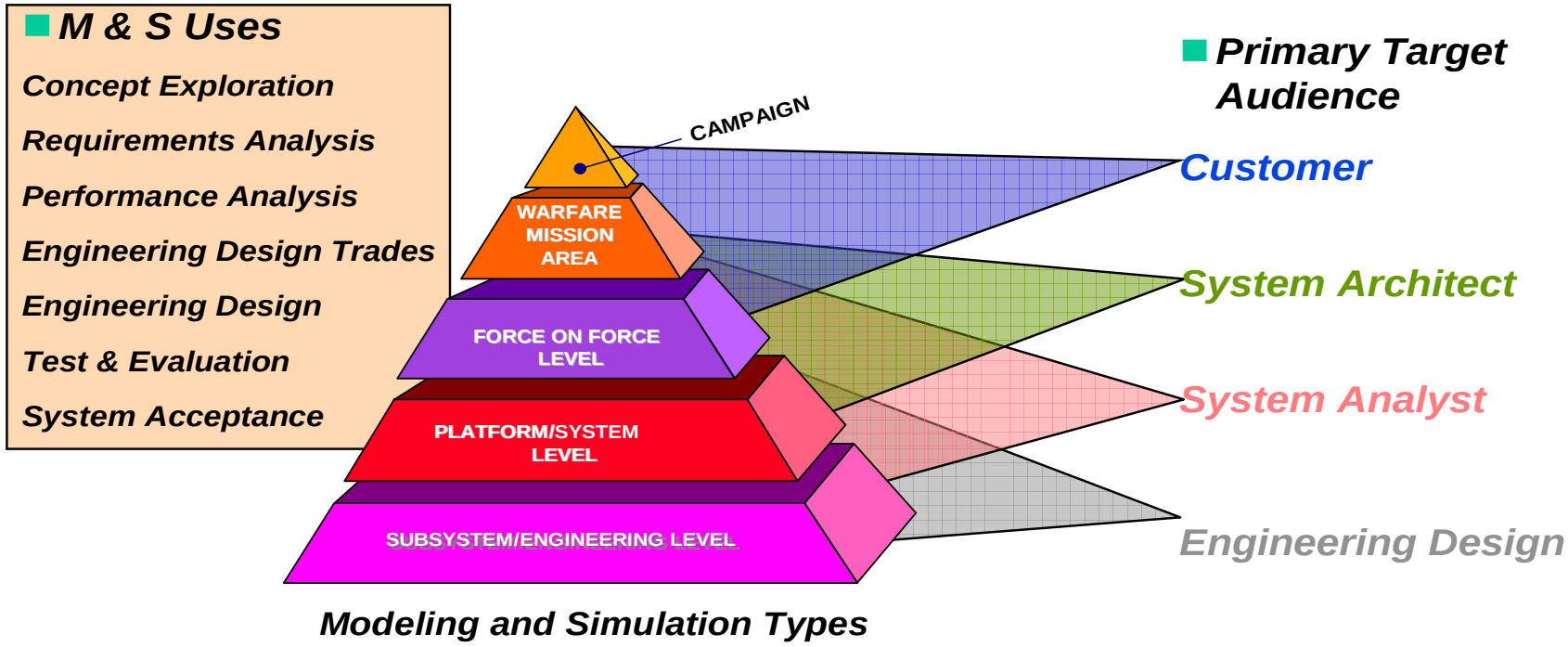
Conclusion

- Need to establish additional methods to characterize credibility
- Further refinement of definitions associated with M&S goodness and clearer defined roles and responsibilities (agents, authorities, review panels)
- The emphasis on M&S credibility has stimulated V&V activities to begin earlier in model development and part of the M&S life cycle

It is believed that other industries could easily adopt this strategy

Back Up Slides

System Level M&S Context (Hierarchy)

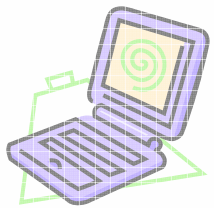
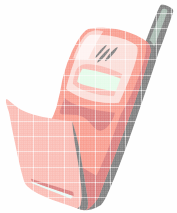
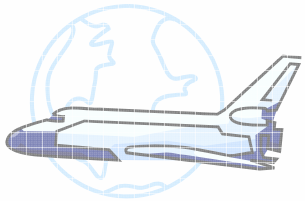
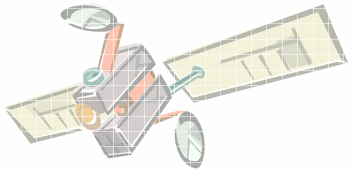


Use the Right M&S Tool For The Job

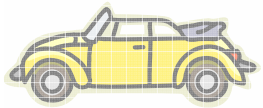
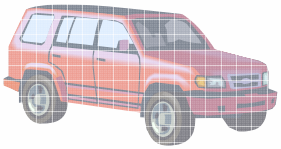
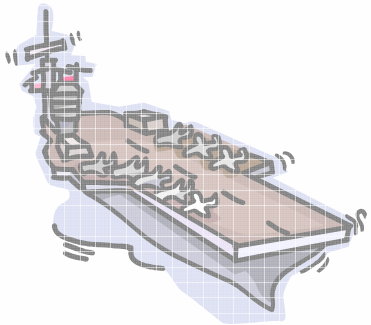
Figure 2

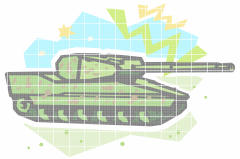
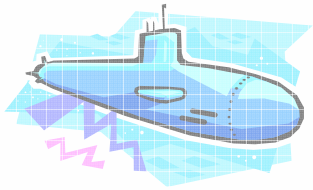
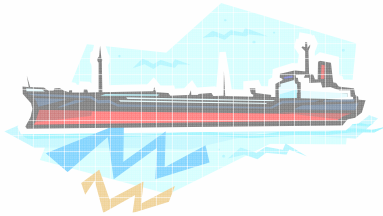
Taxonomy Value

- Basis for classification of analytical modeling and simulation techniques
- Standardized vernacular that may be used to describe these techniques
- Stimulate more communication between the various Analysis, Modeling, and Simulation communities
- Intended to be framework for comparing and contrasting various techniques
- Envisioned as a standard template of attributes to be addressed in descriptions of analytical modeling and simulation efforts

How to Create and Select High Value, Innovative, Competitive and Economic Concepts for New Systems?

An Integrated Methodology for the Conceptual Design of New Systems

Jacob Herscovitz
RAFAEL
Space Systems Directorate
Haifa, Israel

Dr. Amihud Hari
Design Speedovation
Israel

Prof. Menachem P. Weiss
TECHNION
Faculty of Mech. Eng.
Haifa, Israel

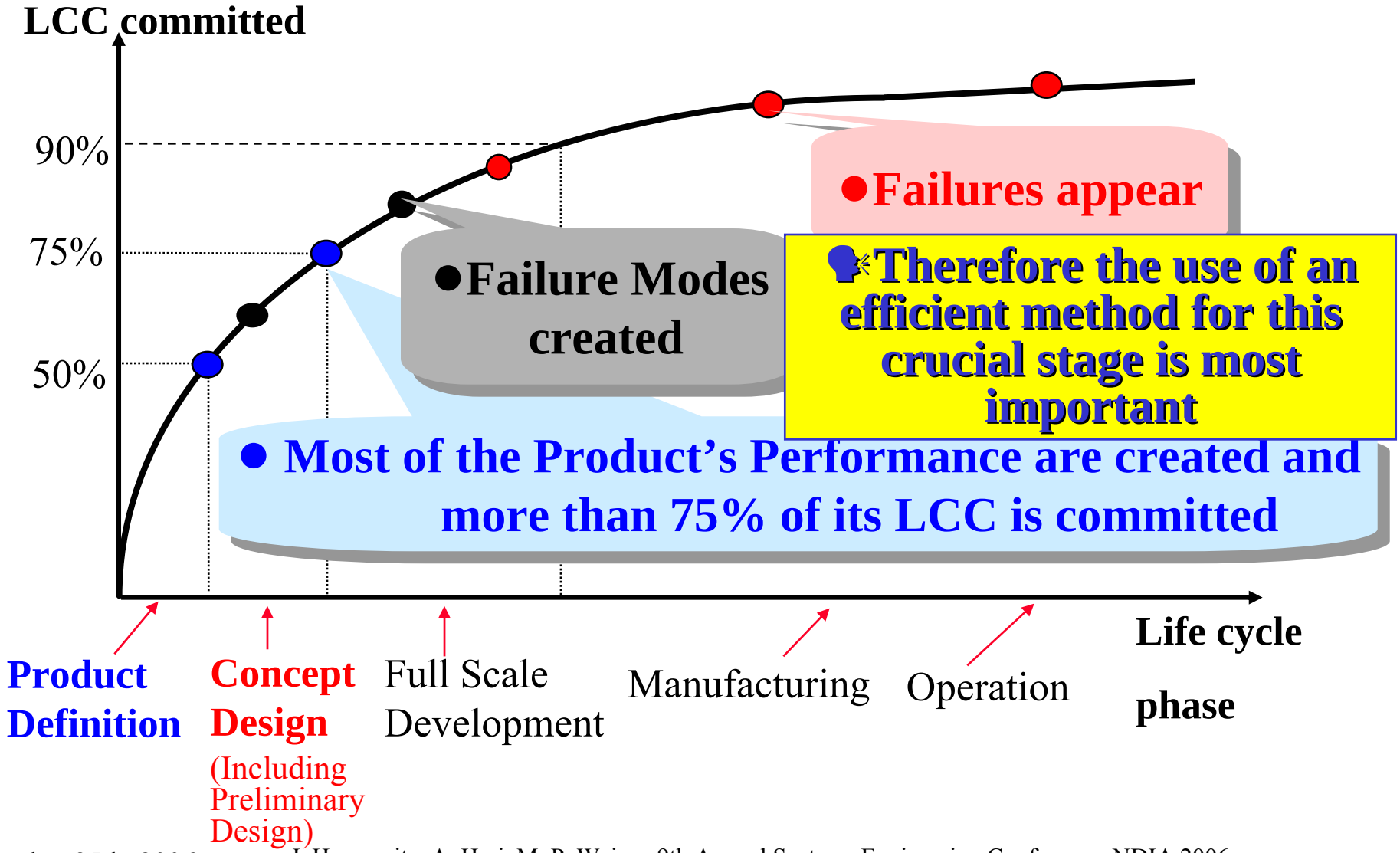
Topics

- **Introduction**
- Overview of ICDM
- Case Study
- Research
- Application of ICDM
- Conclusions

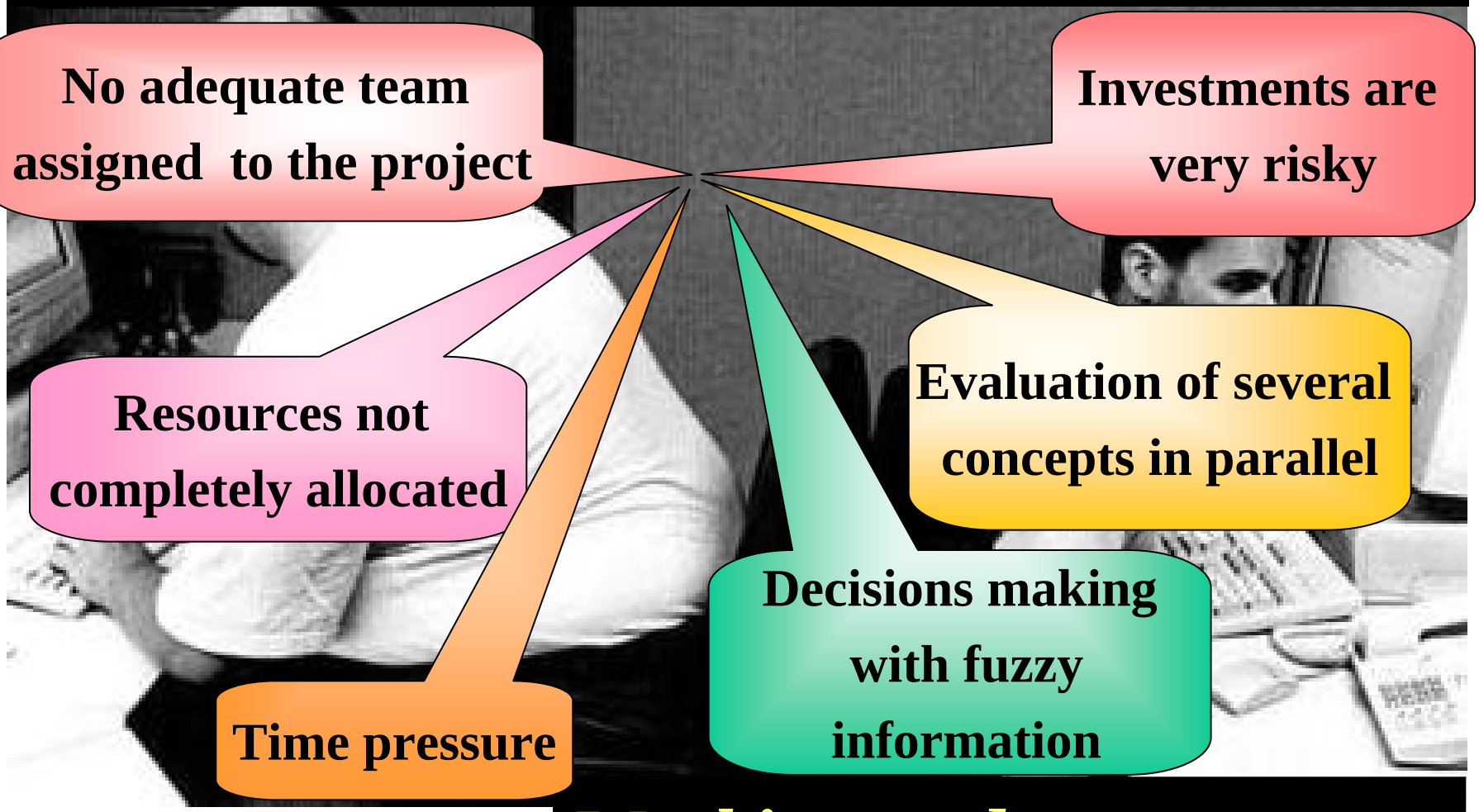




The Early Phases of the System Life Cycle Process are the Most Critical to the Success of a New System

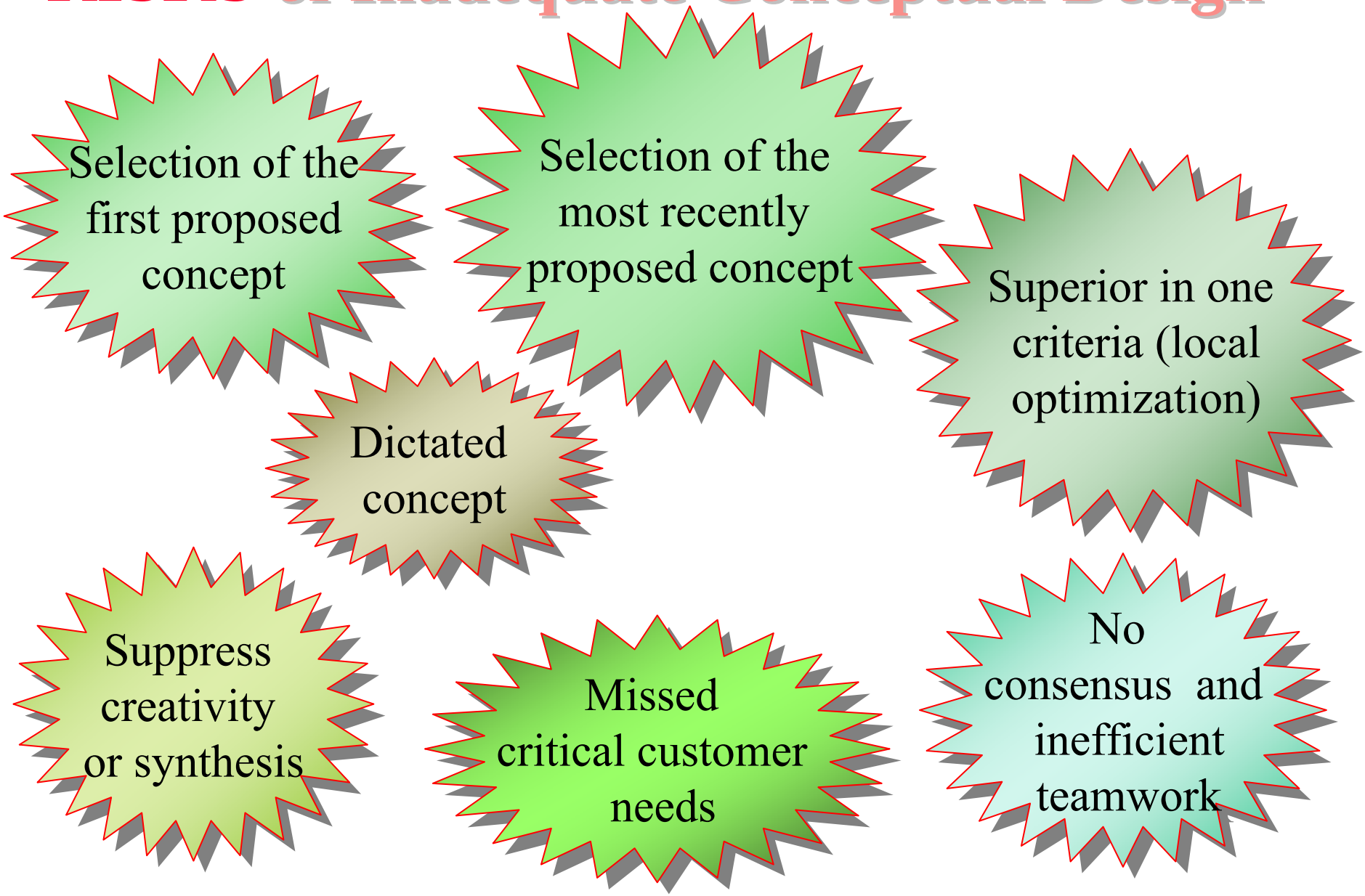


Common difficulties in the Conceptual Design Phase:

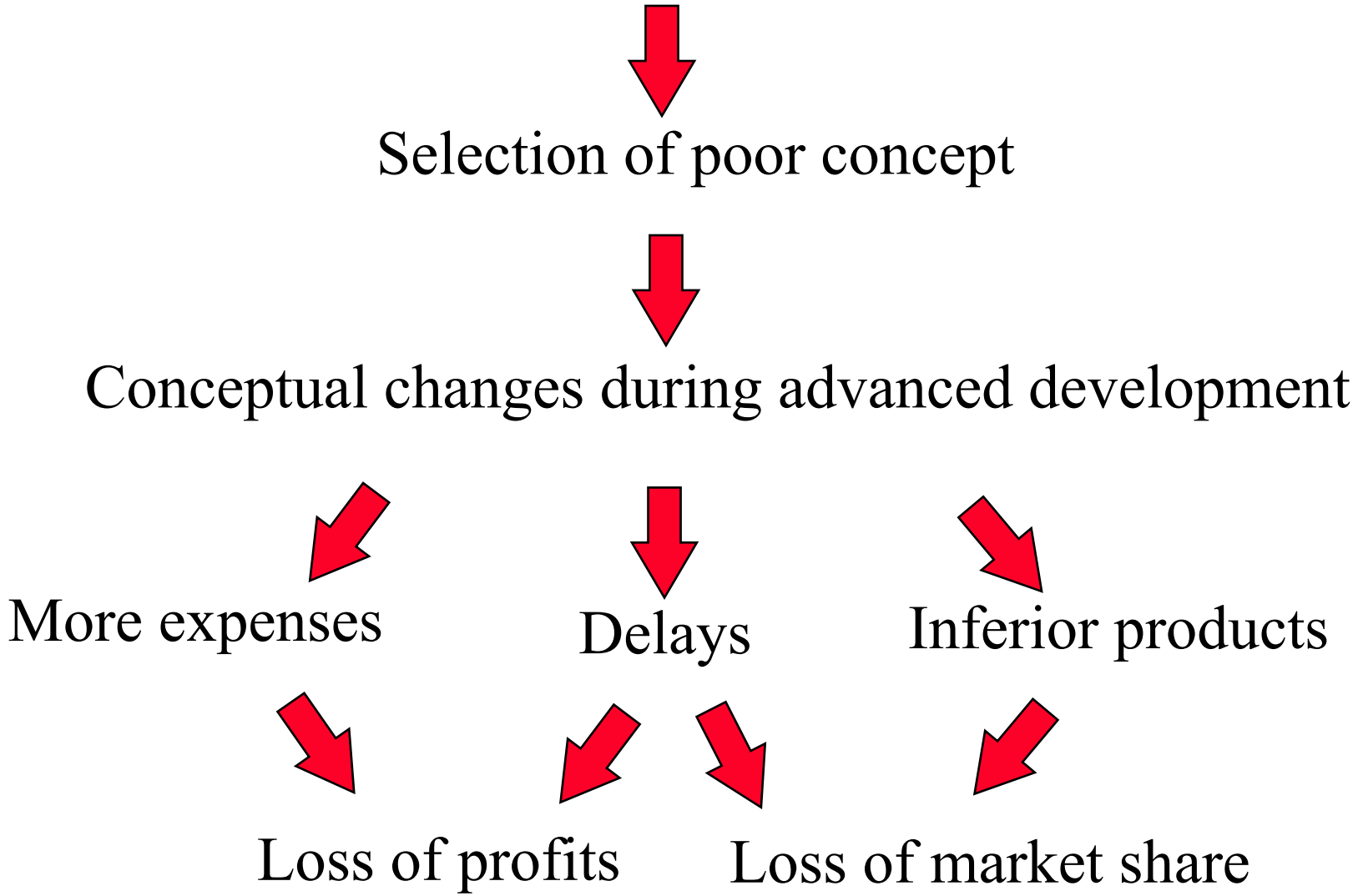


Working under pressure…

RISKS of Inadequate Conceptual Design

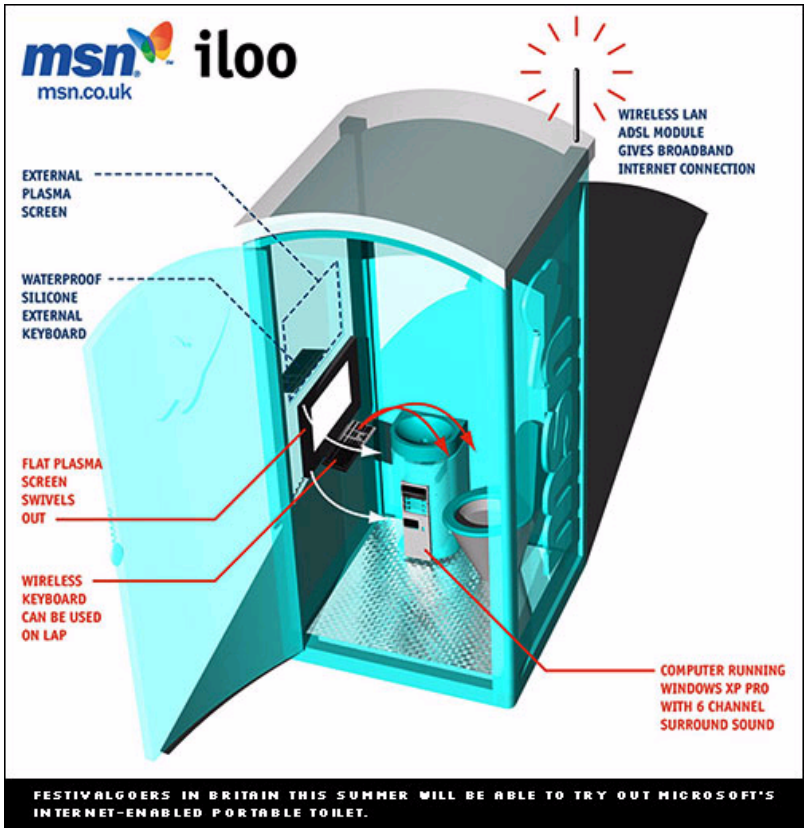


RISKS of Inadequate conceptual design (cont.)



Topics

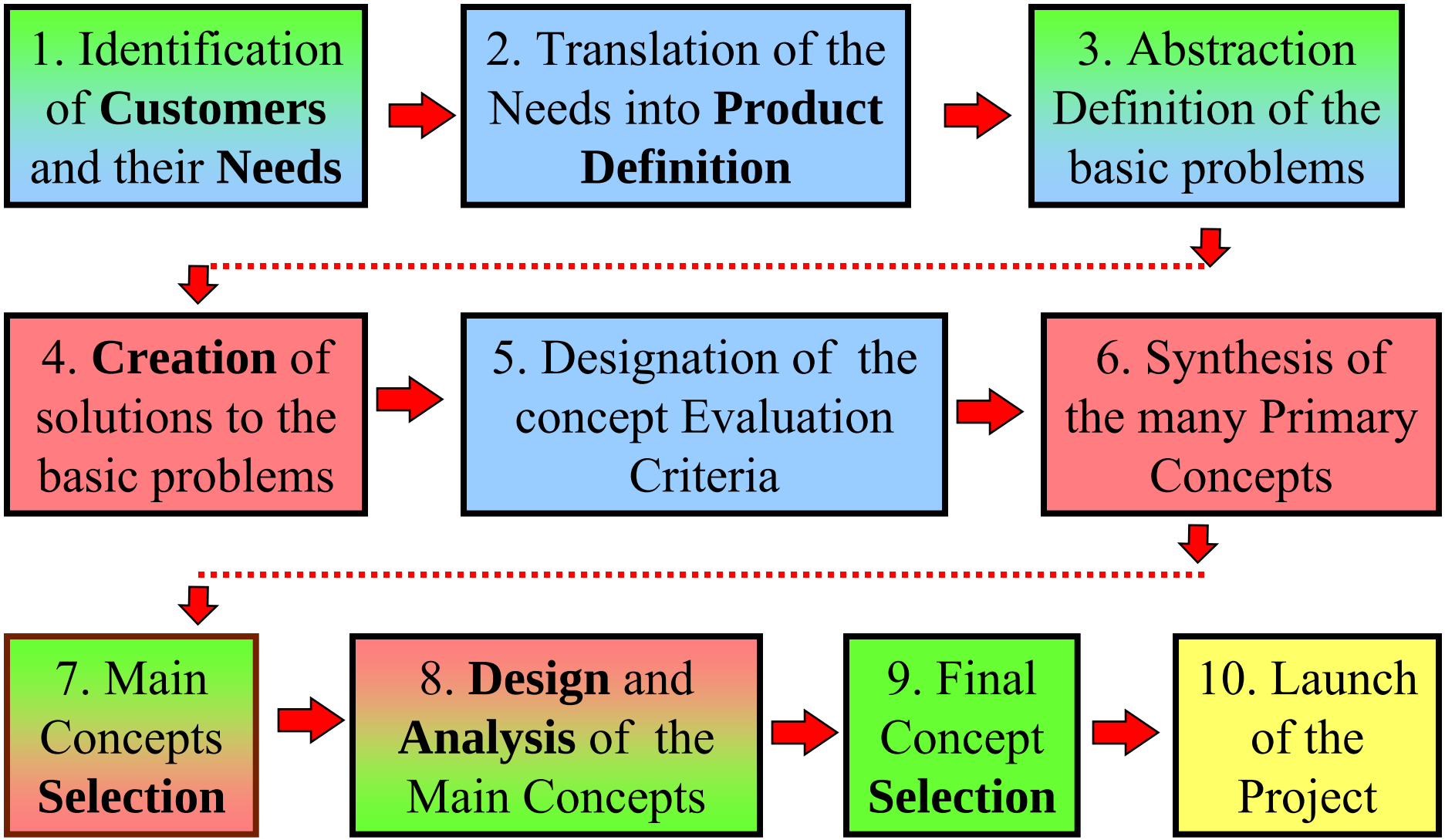
- Introduction
- **Overview of ICDM**
- Case Study
- Research
- Application of ICDM
- Conclusions



ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD

Covers the
entire process of the
conceptual design
and
preliminary design stages

ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD



ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD

1. Identification of **Customers** and their **Needs**

2. Translation of the

3. Abstraction finition of the asic problems

Integrates and modifies

methods and techniques, provides a selection of tools for each step



4. **Creation** of solutions to the basic problems

6. Synthesis of the many Primary Concepts

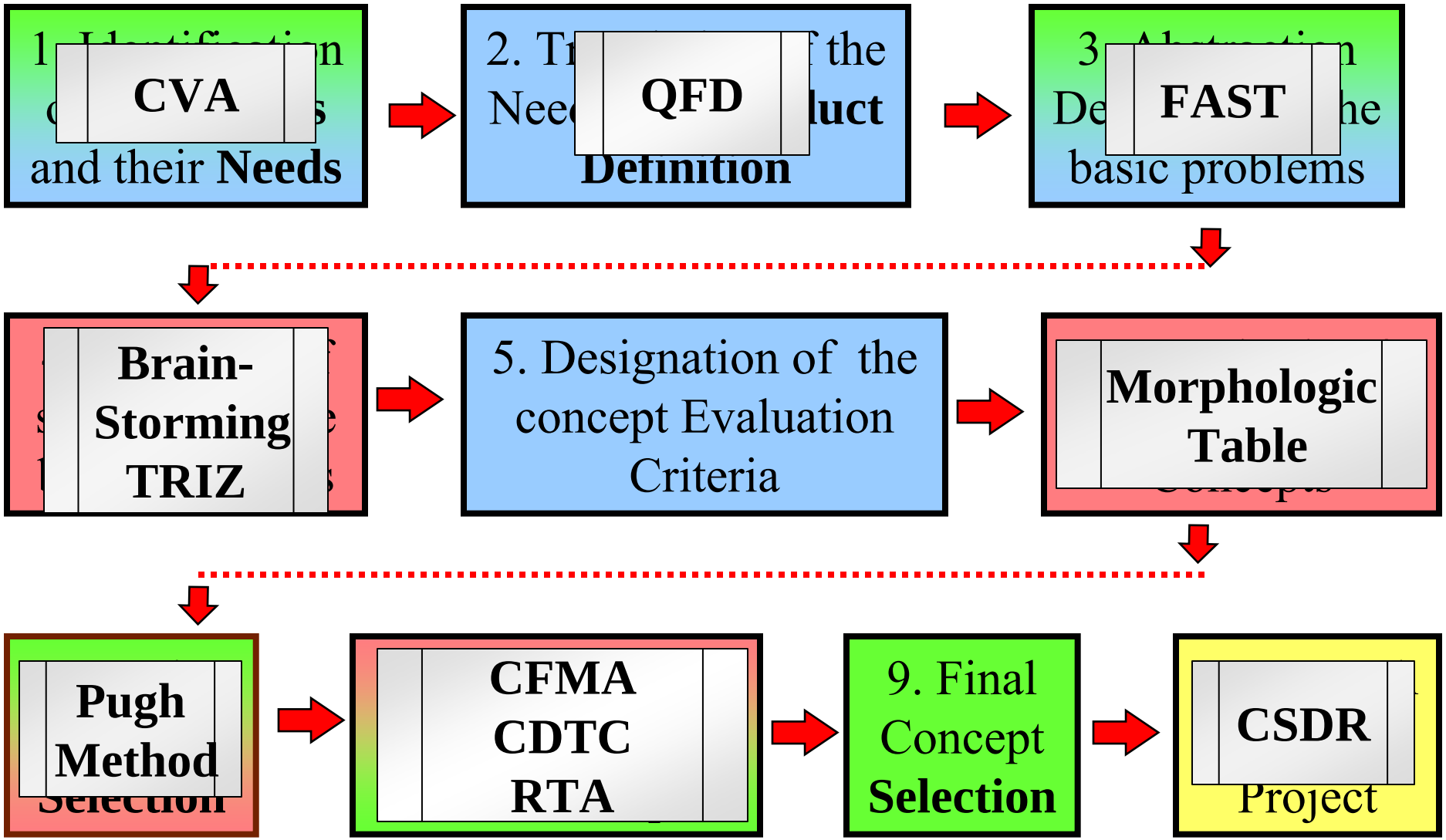
7. Main Concepts **Selection**

Analysis of the Main Concepts

Concept **Selection**

10. Launch of the Project

ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD



ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD

✶Tailoring Guidelines:

ICDM has an open architecture, is flexible and can be **tailored** to the unique needs of each case and organization.

✶The Human (soft) Aspect:

ICDM Provides the means to improve **motivation** and **creativity** of new product development teams

✶Design Quality Measurement (DQM)

ICDM includes an on-line customer value based **DQM system**

Topics

- Introduction
- Overview of ICDM
- **Case Study**
- Research
- Application of ICDM
- Conclusions



Step 1: Identification of Customers and their Needs

Problem Definition:

Due to repetitive cases in which anti-terrorist or infantry forces were injured by rifle shooting, from friendly forces, a need emerges for an identification device. This device will warn the shooter when he aims at his own forces.



Product to Design: *"PIFF2000"*

Personal IFF (Interrogator of Friend or Foe)

Customers

The users

- Infantry combat teams
- Anti-terror squads

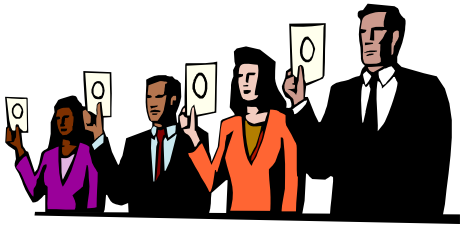


Stakeholders (Army):

- purchasing authorities
- logistics support authorities
- combat doctrine authorities

Stakeholders (Civil):

- Investors
- Regulatory & environment authorities



Customer Needs

Prevent firearms shooting on friendly forces



- Operate in reference scenarios
  - Warn shooter from friendly force
  - System works anywhere: (Urban areas, Dense jungles, Wilderness)
  - A friendly and hostile soldiers In close proximity and the system discriminates
- Easy to use
  - For shooter and target
  - Does not interfere with combat activity
  - Low weight
  - Integrate into combat gear
- Safe
  - Immune to spoofing
  - From shooting
  - Does not scratch, wound, hurt or press
- Works reliably
  - No false alarms
  - Works when needed
  - Resistant to rain, shocks, dust, moisture
  - Alarms when removed or unsafe install
- Maintenance
  - Simple service
  - Comprehensive self test
- Affordable
  - Purchasing
  - Service
- Delight the customer
  - Integrate in C4I networks
  - Compass, Navigation

Step 2: Translation of the Needs into Product Definition

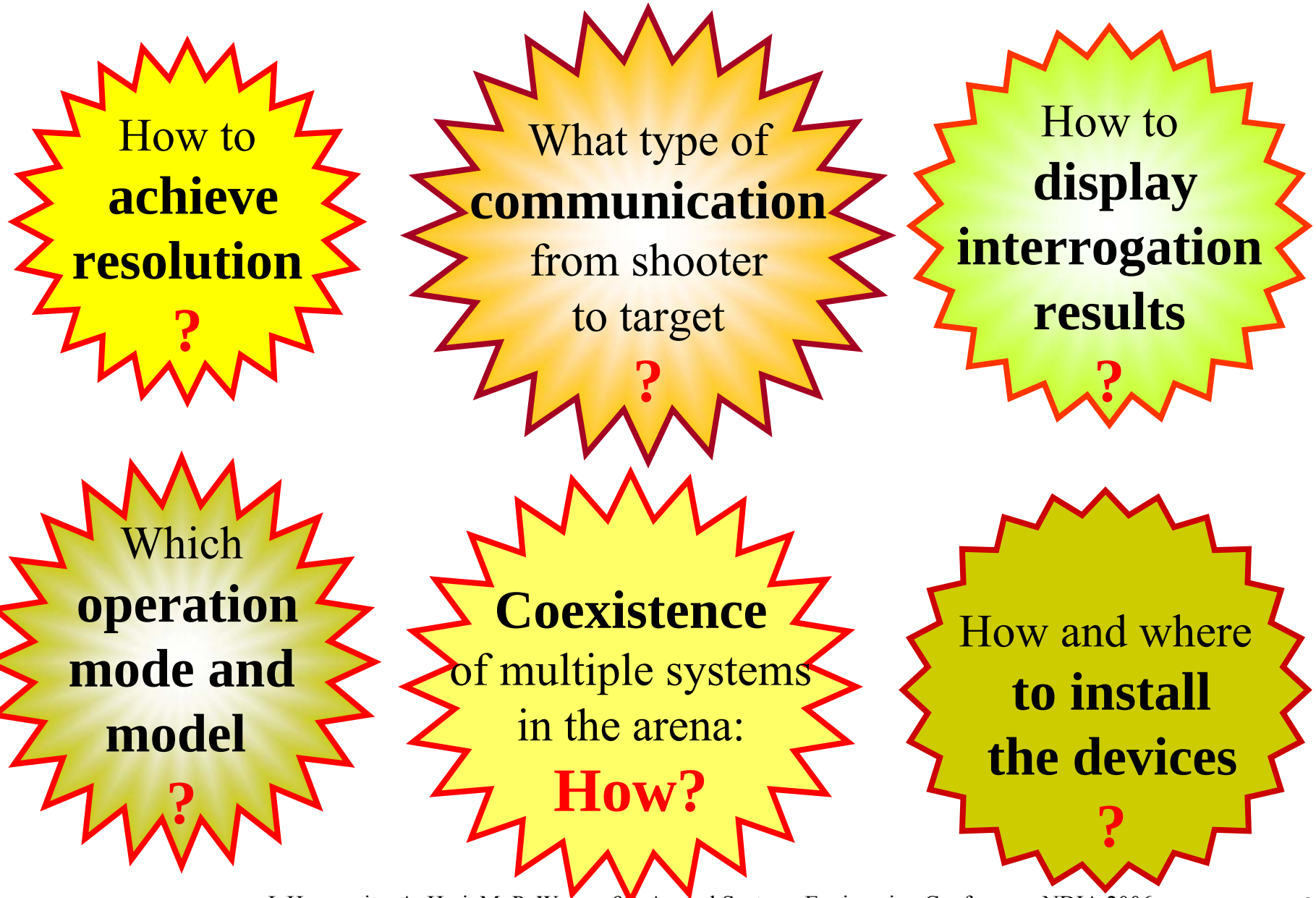
	Operation Range	Autonomy	Mounting time	Optical radiation	Electromagnetic radiation	False Alarm Rate (FAR)	Maintainance	Price	Continuous Operation	Resolution	Volume	Weigth	Importance	Binoculars	Wireless comm.
unit:	m	y/n	min	uJ/cm^2	W/cm^2	%	$/mo.	$	hr	m	cm^3	g			
Warn friend	●	○		●	○	●			●	●			5	2	2
Work anywhere		●		○	○	●			△		△	△	5	5	5
Discrimination	○			△	△	●		○		●	○	△	4	2	1
FOE at LOS	●			△	△	●				○			4	1	5
Easy in use		△	△			△					●	●	3	4	1
Safe	△			●	●								4	5	4
Reliable		○	△			○	○	○	○	△			4	4	3
Maintenance		△	●			○	○	△	△		○	△	1	5	3
Affordable	△		△				●	●	○				2	5	3
Rel. Importance	99	76	18	104	74	180	33	43	69	97	47	37	877		
Rel. Imp. %	11.3	8.7	2.1	11.9	8.4	20.5	3.8	4.9	7.9	11.1	5.4	4.2	100		
Rank	3	5	12	2	6	1	11	9	7	4	8	10			

Contribution: △ weak (1) ○ medium (3) ● strong (9)

Performance Based Specification Decision Table

	Spec	Weight	Trade offs	Wireless	Binoculars	Target value	Diff.	Cost	TTM	Concept
1	False Alarm Rate	20.5		N/A	N/A	$2 \cdot 10^{-4}$	●	●	○	No
2	Optical Radiation	11.9	1	0.0	0.0	0.5	△	△	△	Yes
3	Range	11.3	2	comply	comply	1000.0	△	○	○	Yes
4	Resolution	11.1		bad	bad	20.0	●	●	○	Yes
5	Autonomy	8.7		yes	yes	yes	△	△	△	No
6	EM Radiation	8.4	1,3	Over spec.	0.0	0.2	△	△	△	No
7	Cont. Operation	7.9	1,2,6	20.0	20.0	24.0	●	●	△	No
8	Volume	5.4	7,4	large	500.0	200.0	○	△	△	No
9	Price	4.9	1,2	expensive	cheap	750.0	○	○	○	No
10	Weight	4.2	7,8	large	500.0	200.0	○	○	△	No
11	Maintenance	3.8	9,5,2	moderate	cheap	50.0	○	△	△	No
12	Mounting time	2.1	8,9,11	N/A	N/A	5.0	△	△	△	No

Step 3: Abstraction, Definition of the Basic Problems



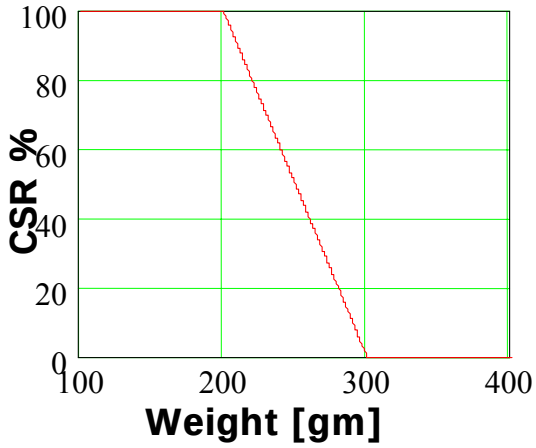
STEP 4: CREATING SOLUTIONS TO THE BASIC PROBLEMS

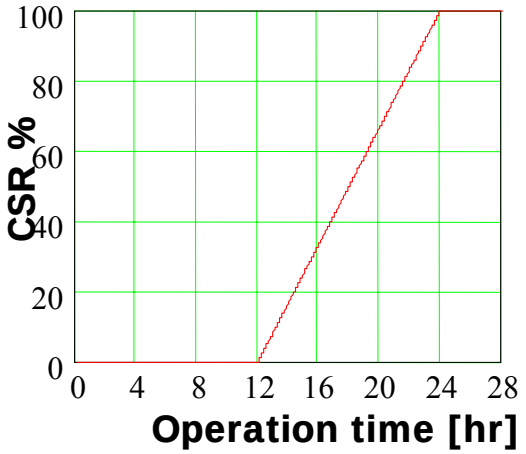


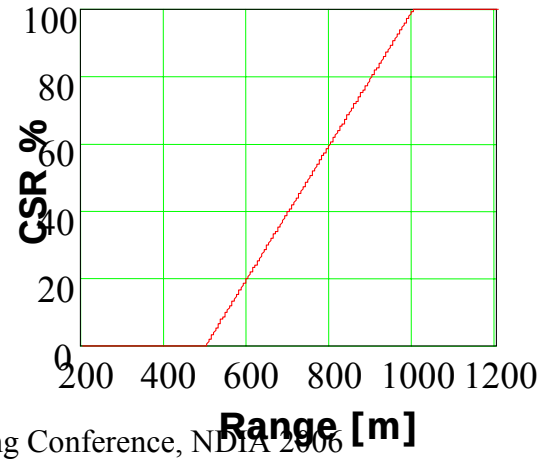
Problem	Solution	Potential Performance	Lack of dev. Problems	Selection
Resolution	ElectroOptics	5	5	++
	ElectroMagnetics	2	2	-
	GPS	5	3	+
	Triangulation with directional ant.	3	3	+
Communication Type	Radio	3	5	++
	Microwave	5	3	++
	Optics (laser)	5	5	++
Display	Graphics LCD	5	3	++
	LED	5	5	++
	Flag	5	3	++
	Speaker	2	5	+
	Buzzer	2	5	+
	Vibrator	2	3	-

STEP 5: EVALUATION CRITERIA

#	Criteria	A	B	Target value (QFD)
1	Technology gaps	+	+	
2	Mission reliability		+	**0.95**
3	FAR		+	**$2 \cdot 10^{-4}$**
4	Operation range	+	+	**1000 m**
5	Soldier suitability	+	+	
6	Radiation	+	+	**$5e^{-7}$ mj/cm^2**
7	Resolution	+	+	**20 m**
8	Operation cost		+	**50 $/month**
9	Volume/ weight		+	**200 cc / 200 g - target** **200 cc / 200 g - shooter**
10	Continuous operation		+	**24 hours**
11	Cost		+	**750$ total (250+500)**
12	Manufacturing capability	+	+	
13	Installation, removal and ease of use	+	+	**2 min preparation**
14	Customer attraction		+	
15	Serviceability	+	+	

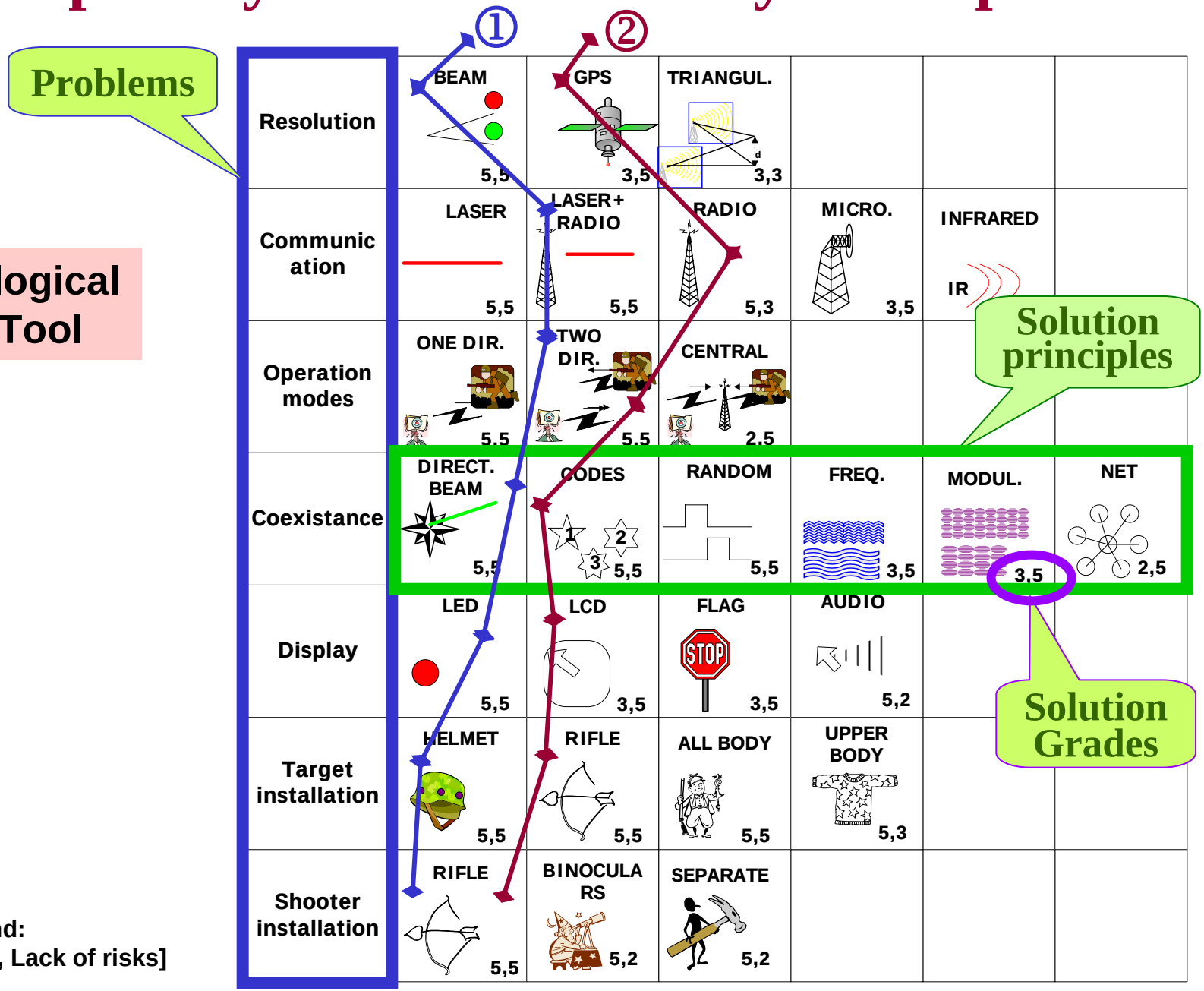






Step 6: Synthesis of Primary Concepts

Morphological Table Tool

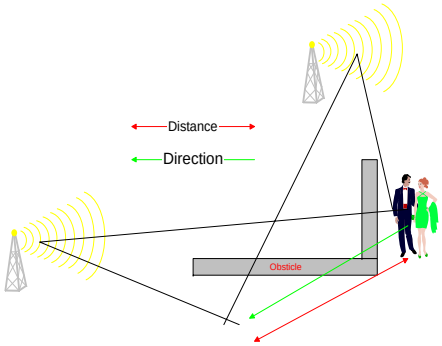


Grades Legend:
[Performance, Lack of risks]

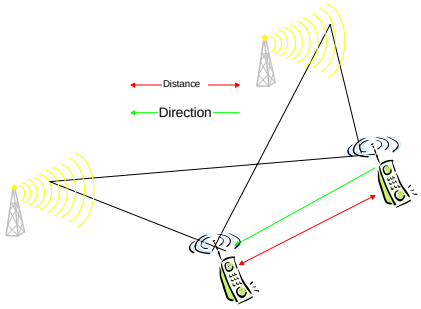
Step 7: Evaluation of the primary *PIFF* concepts using PUGH method

Concept / *Criterion*		Local Triangulation	Cellular Triangulation	Optical Helmet - Sensors	Optical Helmet - Fisheye	Optical Helmet - Fibers	Optical Helmet - Radio	Centralized GPS	Distributed GPS
Technology gaps	D	S	S	S	S	S	S	S	S
Performance:									
Operation range	A	S	- -	- -	- -	-	S	S	
Soldier suitability		S	+	+	+	+	S	+ +	
Radiation	T	S	- -	- -	- -	-	S	S	
Resolution		-	+ +	+ +	+ +	+ +	+	+	
Manufacture capability	U	S	+	+	+	+	S	+	
Inst., rem. and ease of use		S	-	-	-	-	S	+	
Serviceability	M	S	S	S	S	+	S	+	
Σ+		0	4	4	4	5	1	6	
Σ-		1	5	5	5	3	0	0	
Total		-1	-1	-1	-1	2	1	6	

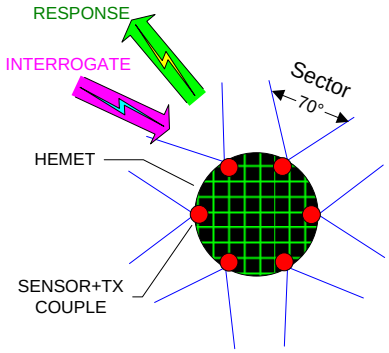
The Final Concepts



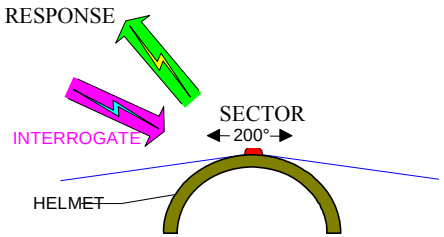
Local Triangulation



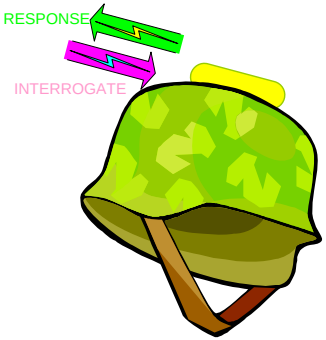
Cellular Triangulation



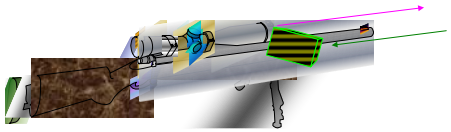
Optical Helmet - Sensors



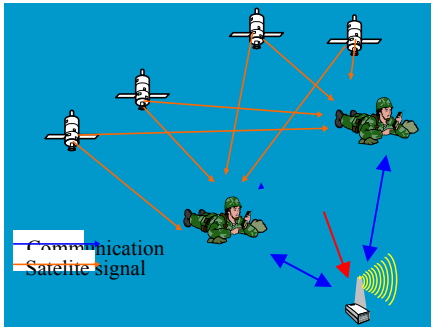
Optical Helmet - Fisheye



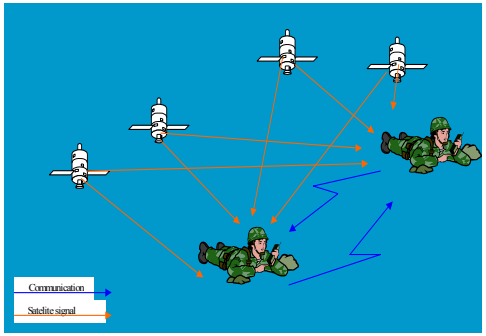
Optical Helmet - Fibers



Optical Helmet - RADIO



Centralized GPS

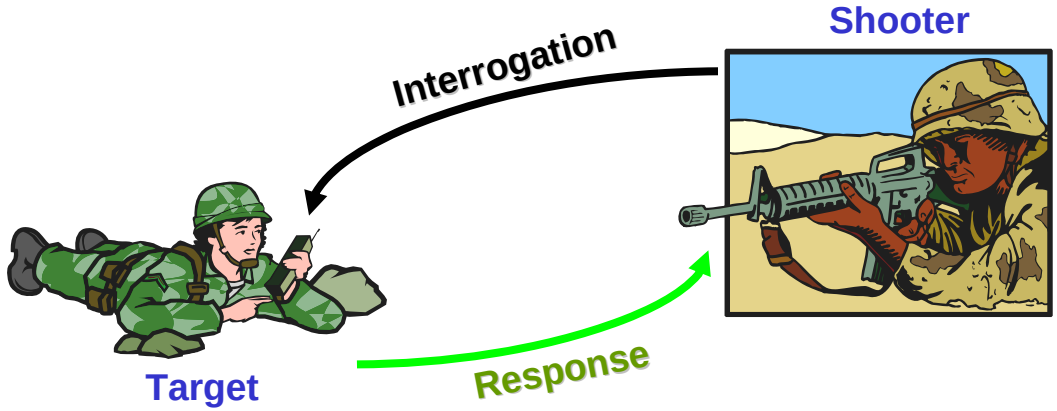


Distributed GPS

ICDM: INTEGRATED CUSTOMER DRIVEN CONCEPTUAL DESIGN METHOD

8. **Design** and **Analysis** of the Main Concepts

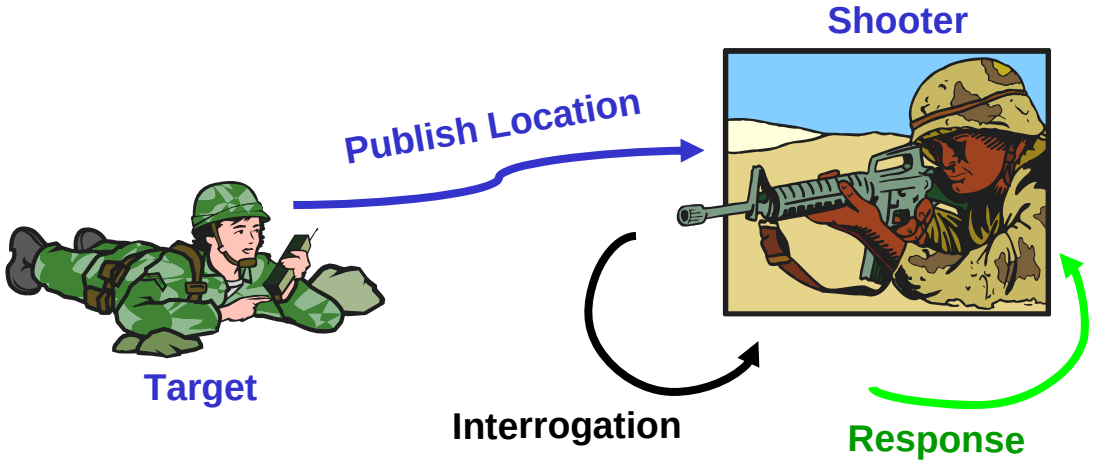
Conceptual Architecture and Operation Logic Design



Scenario

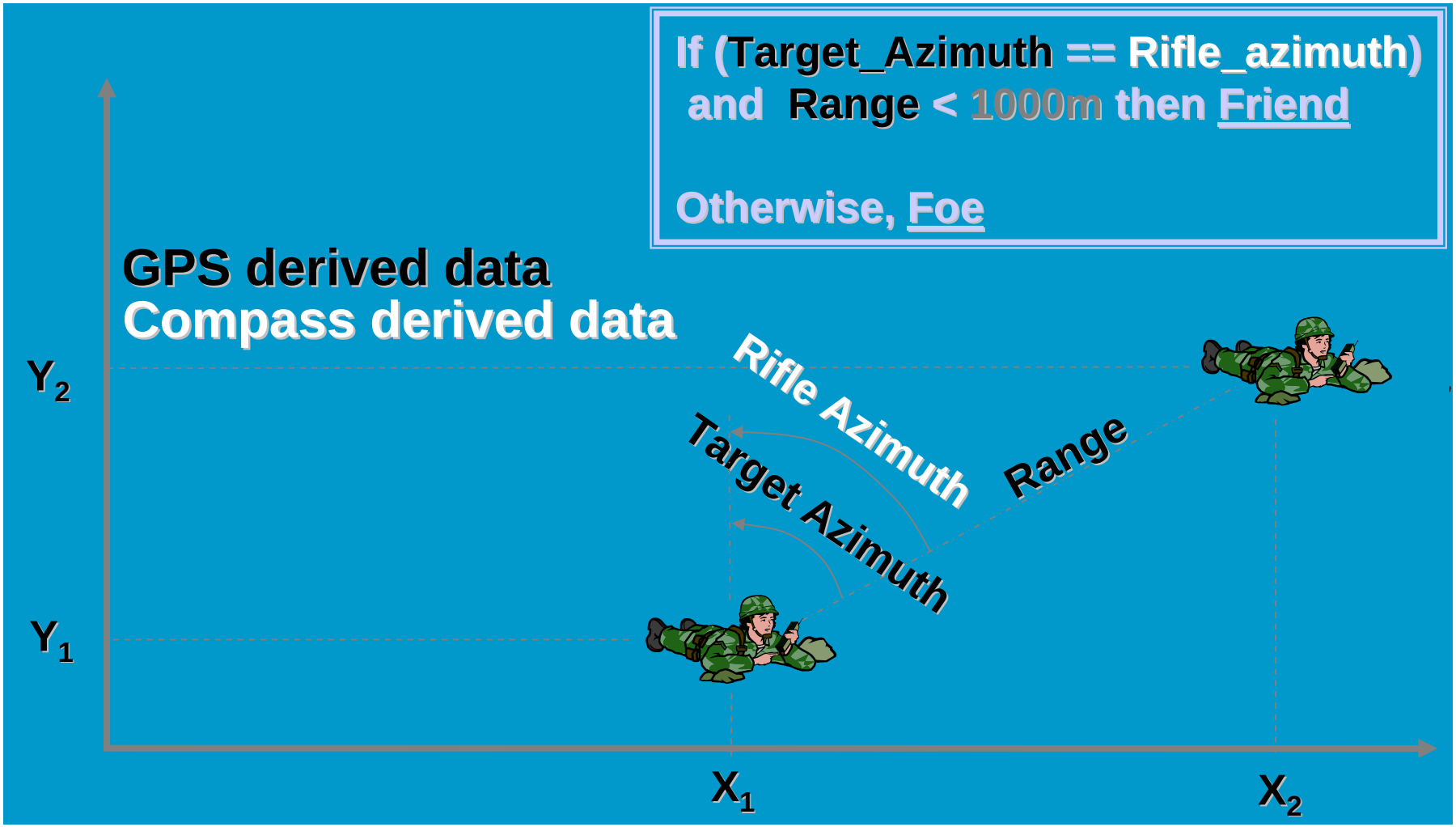
Shooter aims at ***target*** and interrogates
If FRIEND, ***target*** responds to shooter
If no response, then ***target*** is FOE

Basic Principles of IFF System



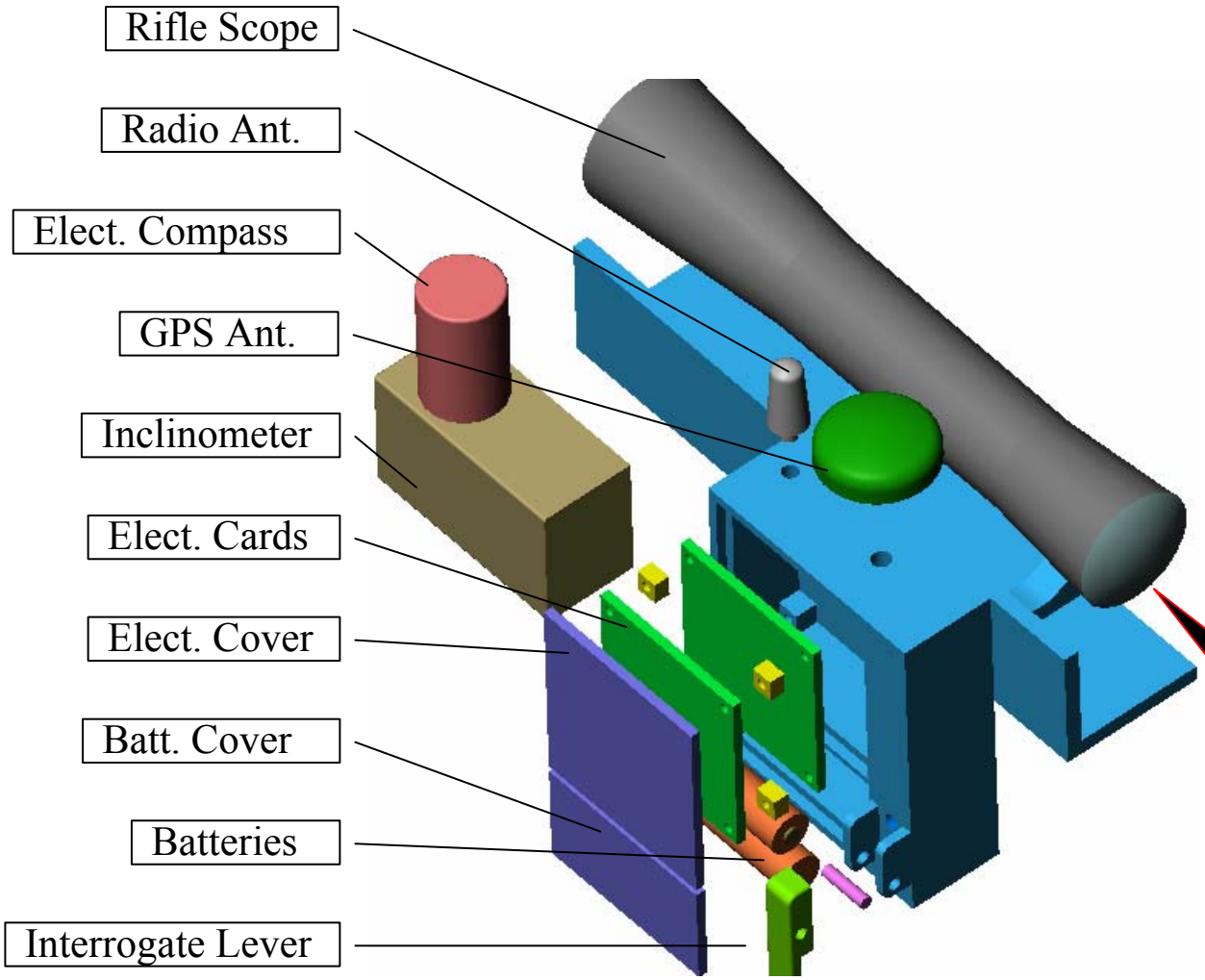
Architectural Concept in Distributed GPS PIFF

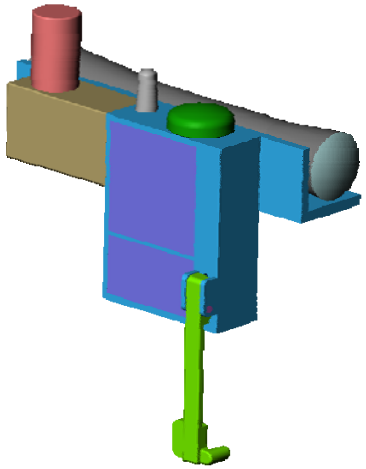
Distributed GPS IFF – Principle of Operation

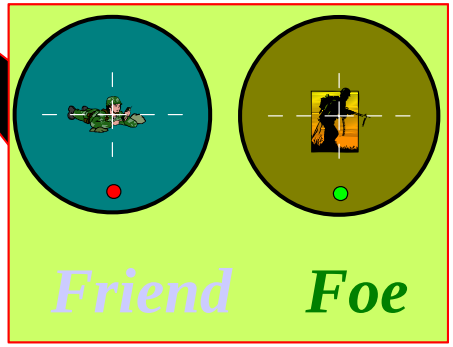


Mechanical Conceptual Design

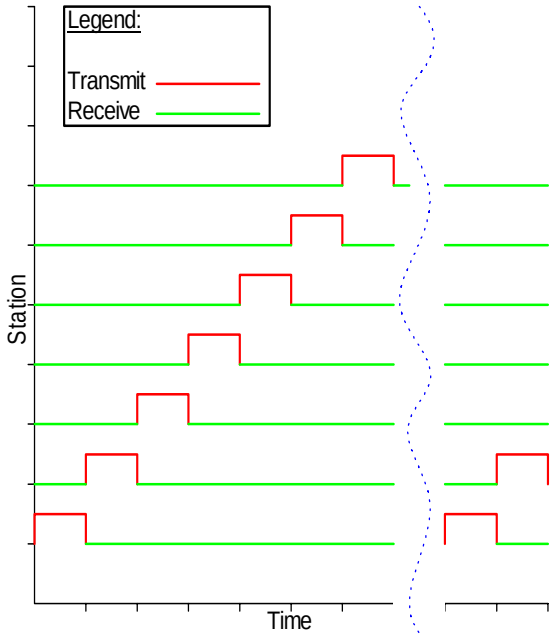


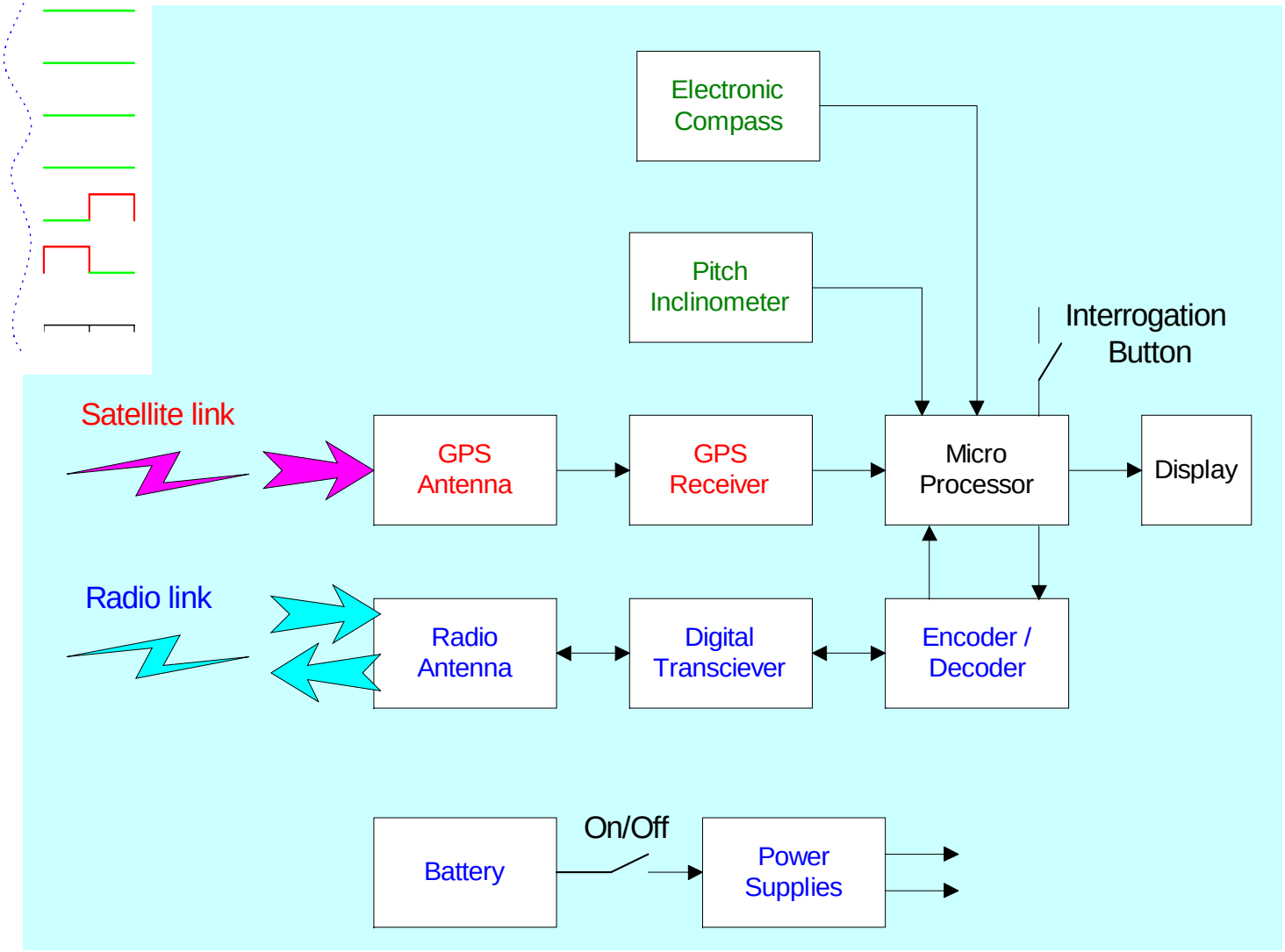




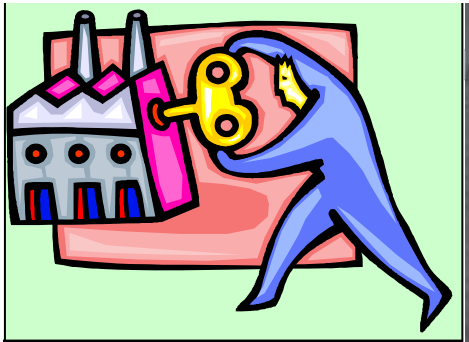


Electronics Principle





Conceptual Operation and ILS Decisions



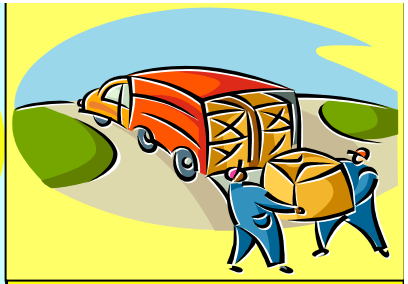
Manufacturing and Assembly concept



Operation and Usage concept



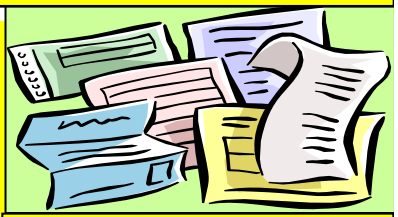
Personnel – skills requirements and training policy



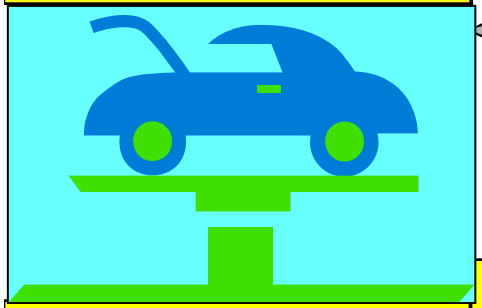
Transportation, handling and packaging concept



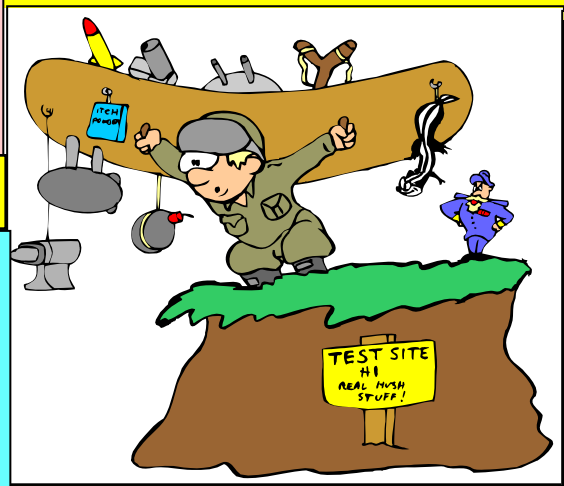
Installation concept



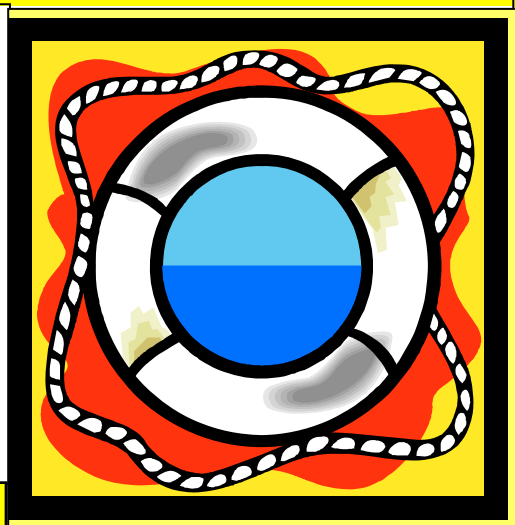
Documentation concept



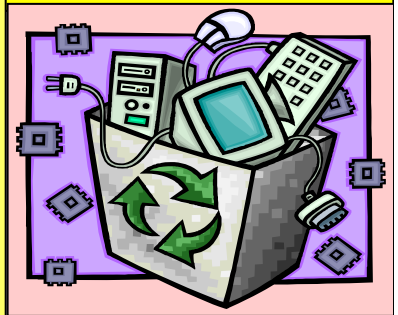
Maintenance policy



Verification, Validation and Test concept



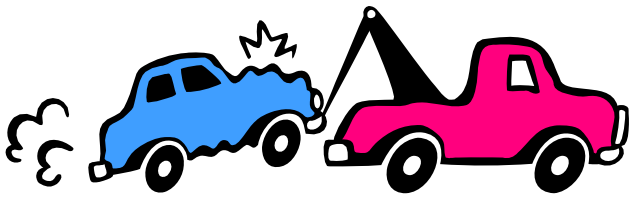
Safety requirements



Disassembly and Recycling concept

CFMA Table for "*Interrogation*" Function

Failure mode	Failure Result	S	Failure causes	F	Ways to detect	D	SFD	Corrective action	New SFD
No Transmission	Mission Failure	8	Weak Batt.	1	Data sheet	1	8		
		8	Faulty PS	3	Samples testing	4	96	Env. Test for samples. D=2	48
		8	Optic. Dirt	7	Test prototype	5	280	Add protectors: F=5 Detector Self test: S=3 Build a prototype: D=4	60
		8	Faulty Switch	4	Test prototype	5	160	2 switches: F=1	40
		8	**Faulty Trans.**	**4**	**Test first batch**	**5**	**160**	**Continuous self test: F=1 Env. Test for prototype: D=2**	**16**
		8	Faulty PC	3	Test first batch	5	120	Add watch-dog: F=1 Env. Test for prototype: D=2	16
Weak Signal	Perform. Degrad.	6	Faulty Trans.	5	Test first batch	5	150	Self test: F=1 Env. Test for prototype: D=2	12
		6	Optic Dirt	10	Test similar systems	7	420	Add protectors: F=5 Detector Self test: S=3 Build a prototype: D=4	60
No GPS Fix	Mission Failure	8	No vis. Sat.	6	Analysis and Simulation	2	96	Manual location	72



Improved Design After CFMA

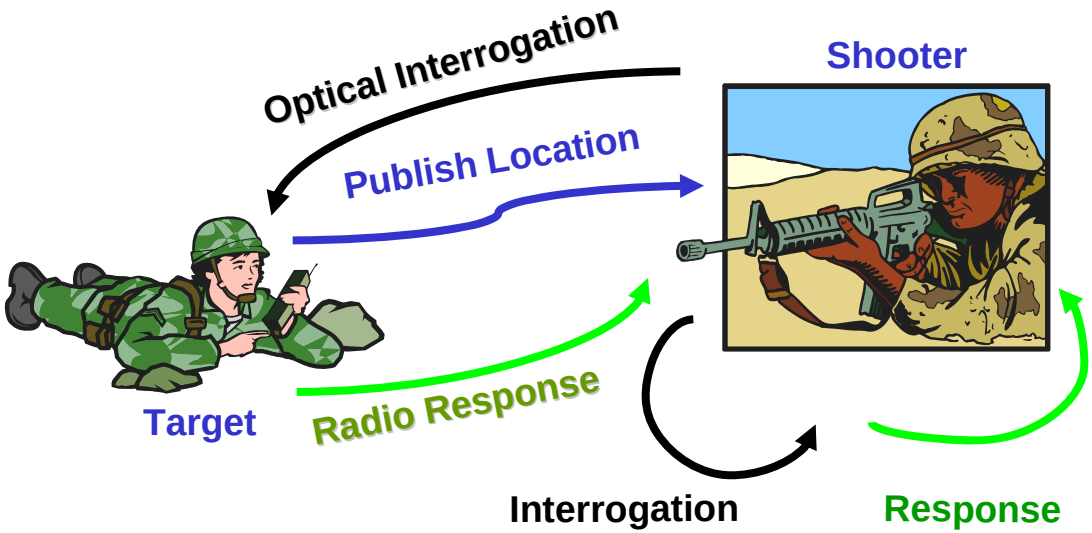
Insert REDUNDANT mechanisms:

- Original: Geolocation with GPS
- Add: *Optics* interrogation with *Radio* response
- Combined logic: perform an AND check from both sub-systems.

Result: Improvement in RELIABILITY (both Type 1 and Type 2)

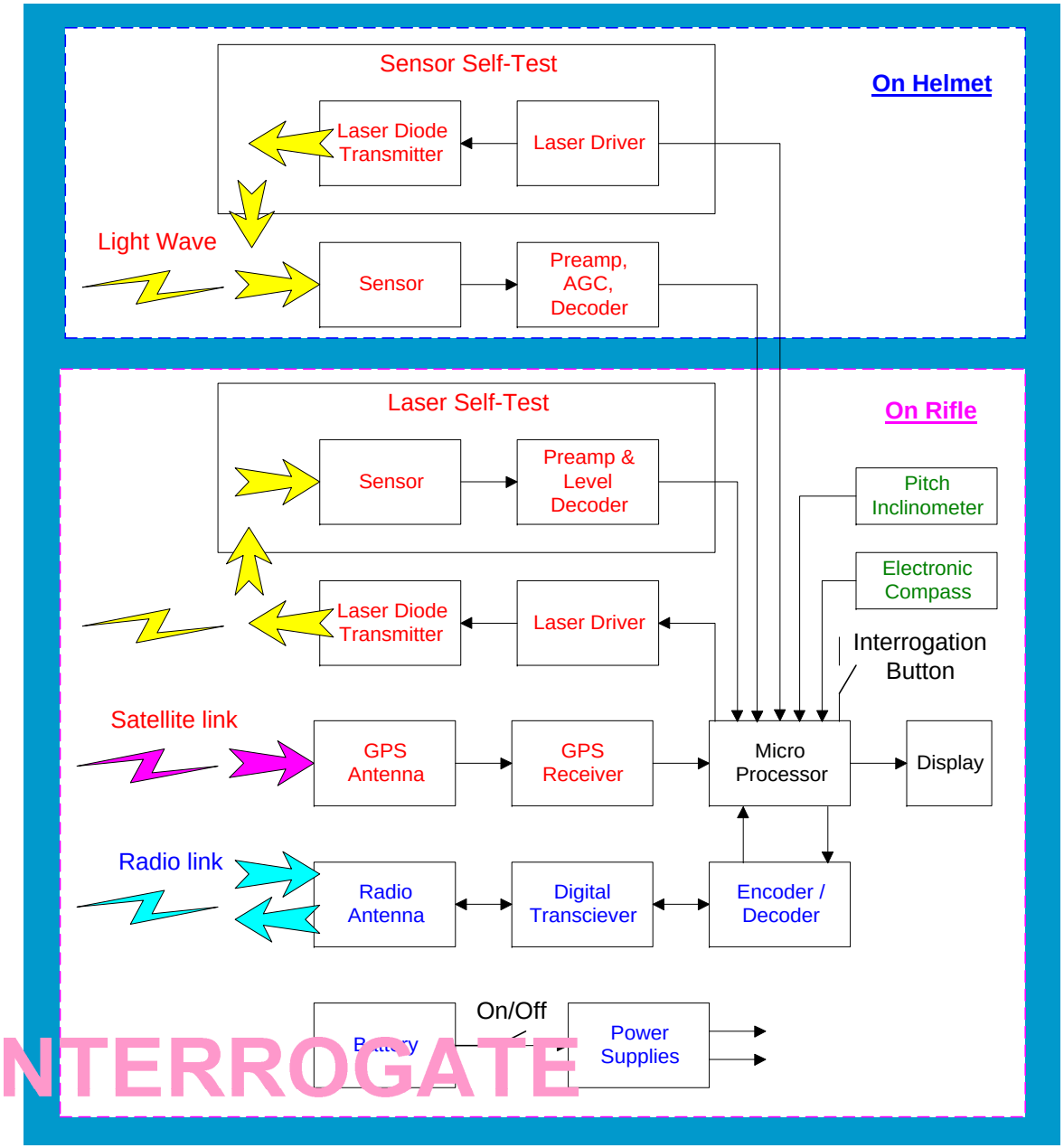
Improved redundant performance:

- In urban areas, GPS may not receive adequately. Laser will perform.
- In open battlefield, Laser beam may be obstructed by smoke, dust, etc. GPS will perform.



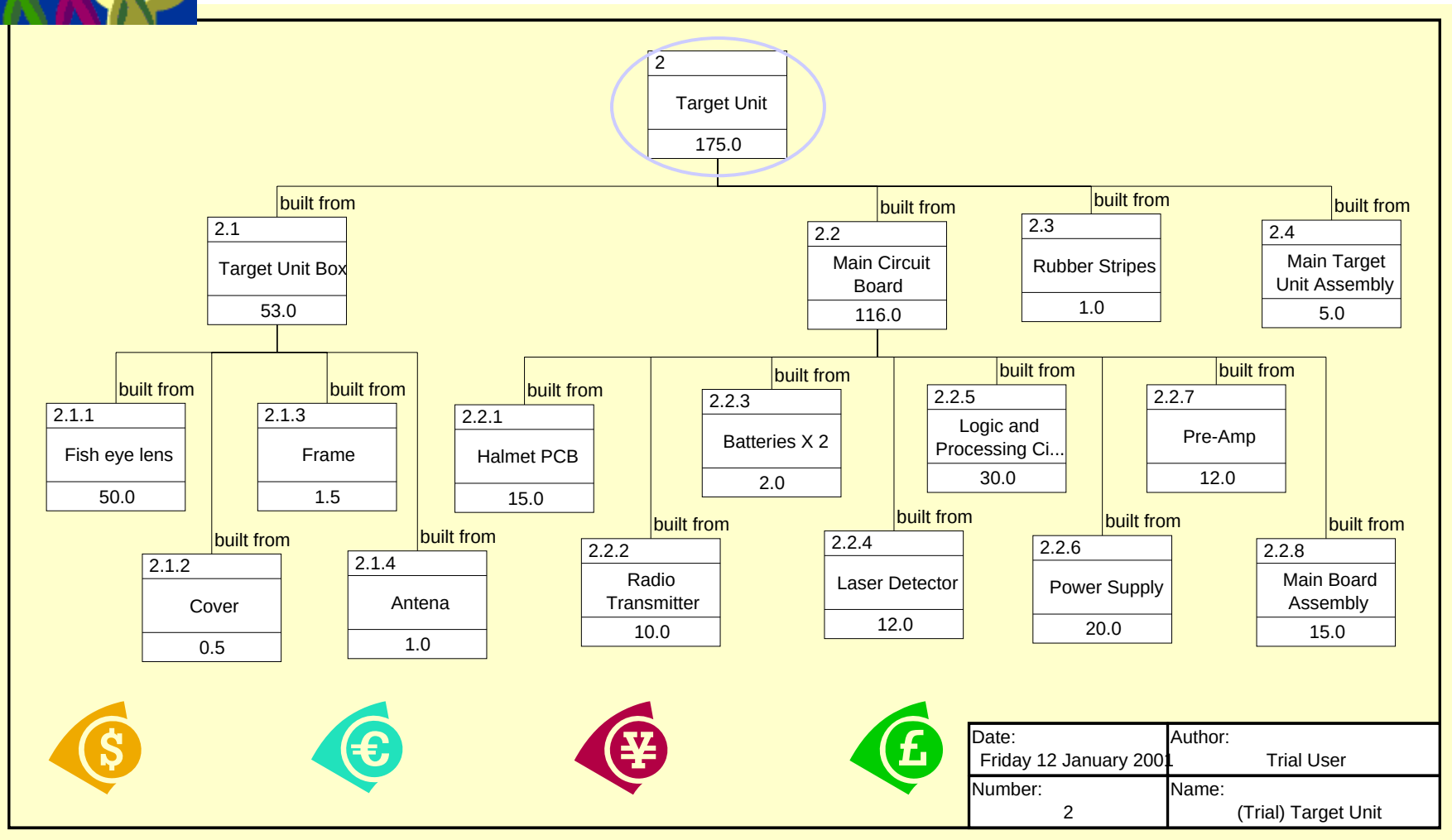
Improved Concept Principle - Add Self-Test

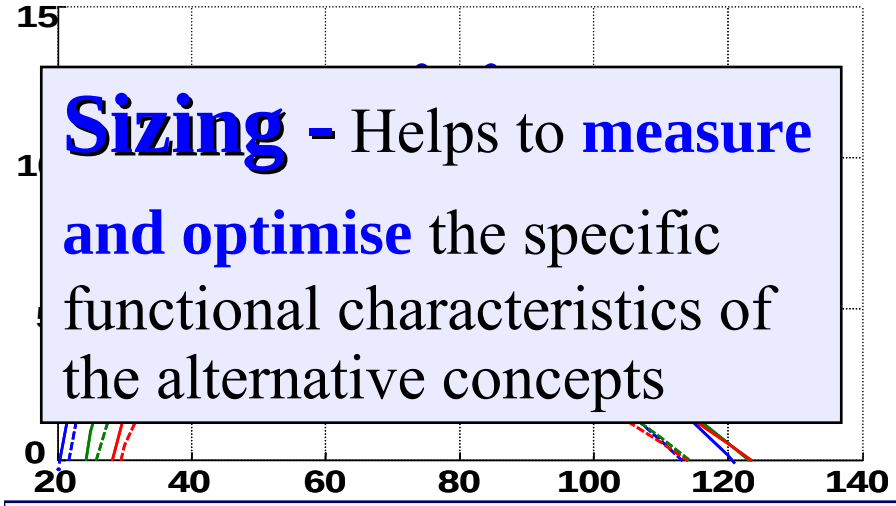




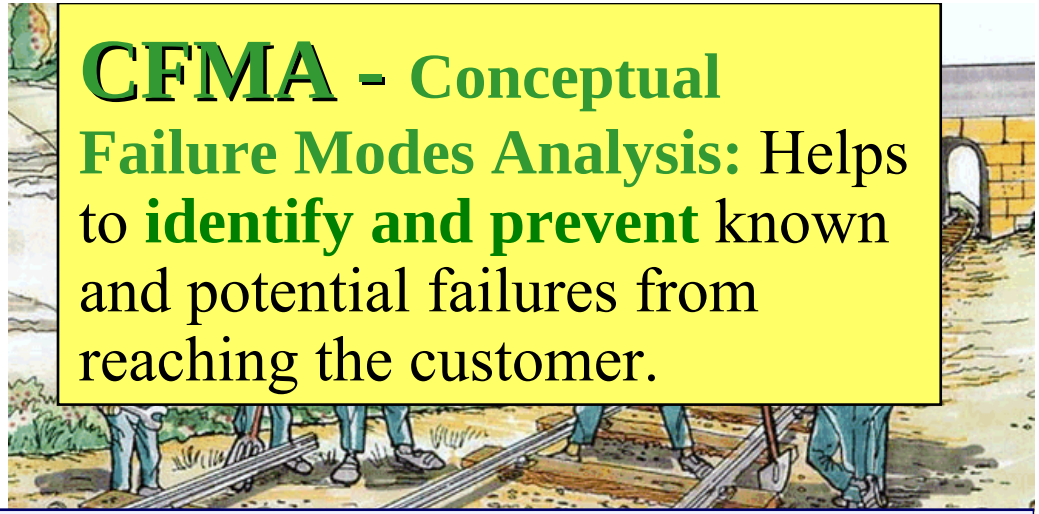


Cost Estimation



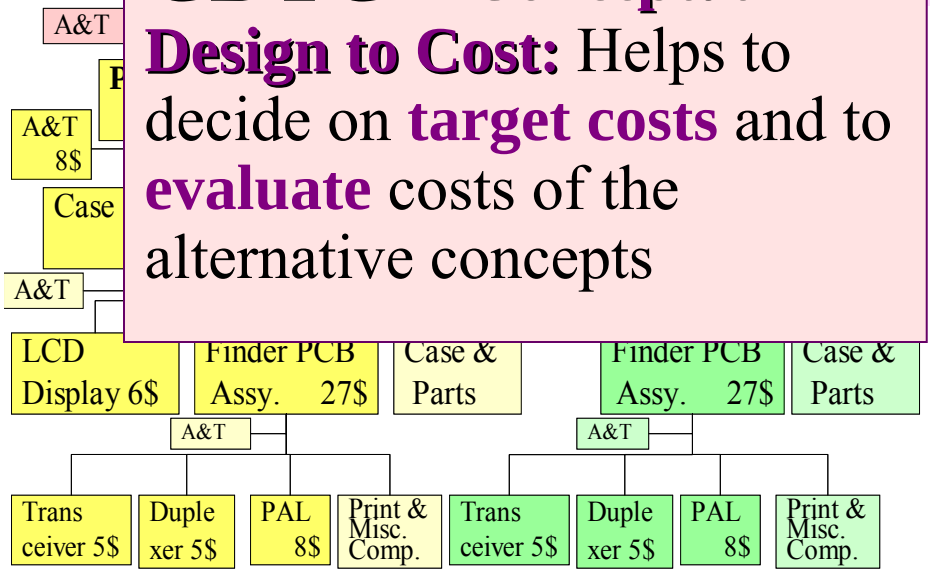


Sizing - Helps to **measure and optimise** the specific functional characteristics of the alternative concepts



CFMA - **Conceptual Failure Modes Analysis:** Helps to **identify and prevent** known and potential failures from reaching the customer.

Methods for Analysis, Improvement and Evaluation of the Alternative Concepts



CDTC – Conceptual Design to Cost: Helps to decide on **target costs** and to **evaluate** costs of the alternative concepts



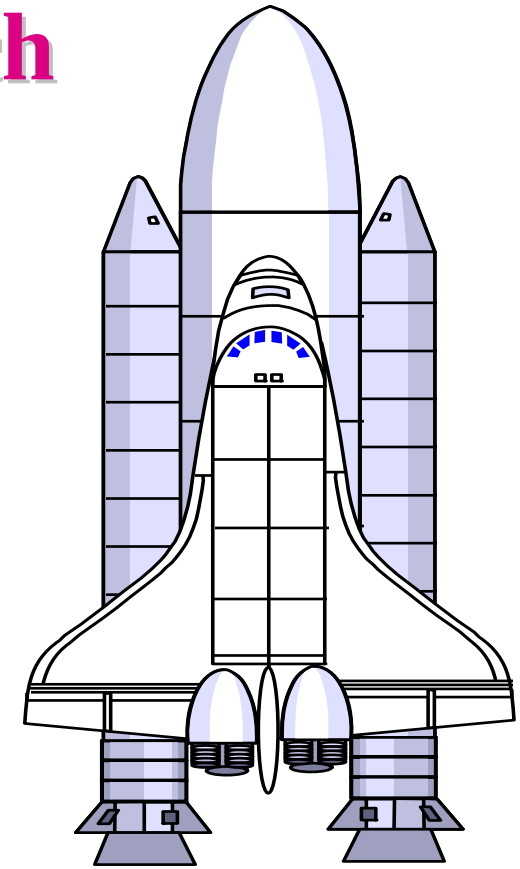
RTA-Risk & Time to Market Analysis: Helps to define and analyze **Risks, Plan** the development process and **evaluate** the TTM of the alternative concepts

Step 9: Final Concept Evaluation

	Spec	Weight	Target value	Result Achieved	CSR
1	FAR	20.5	$2 \cdot 10^{-4}$	10^{-6}	100
2	Radiation .Opt	11.9	510^{-5} [J/cm^2]	< 15 μJ/cm^2	100
3	Range	11.3	1000 [m]	1000	100
4	Resolution	11.1	20 [m]	< 20 m	100
5	Autonomy	8.7	Full	Full	100
6	Radiation .EM	8.4	0.2 [w/cm^2]	0.024	100
7	Cont. Operation	7.9	24 [h]	20.0	60
8	Volume	5.4	200 [cm^3]	245	70
9	Price	4.9	750 [$]	454	100
10	Weight	4.2	200 [g]	200	100
11	Maintenance	3.8	50 [$/month]	50	100
12	Mount / Dismount	2.1	5 [min]	< 5	100

Total: 94.5%

Step 10: Project Launch



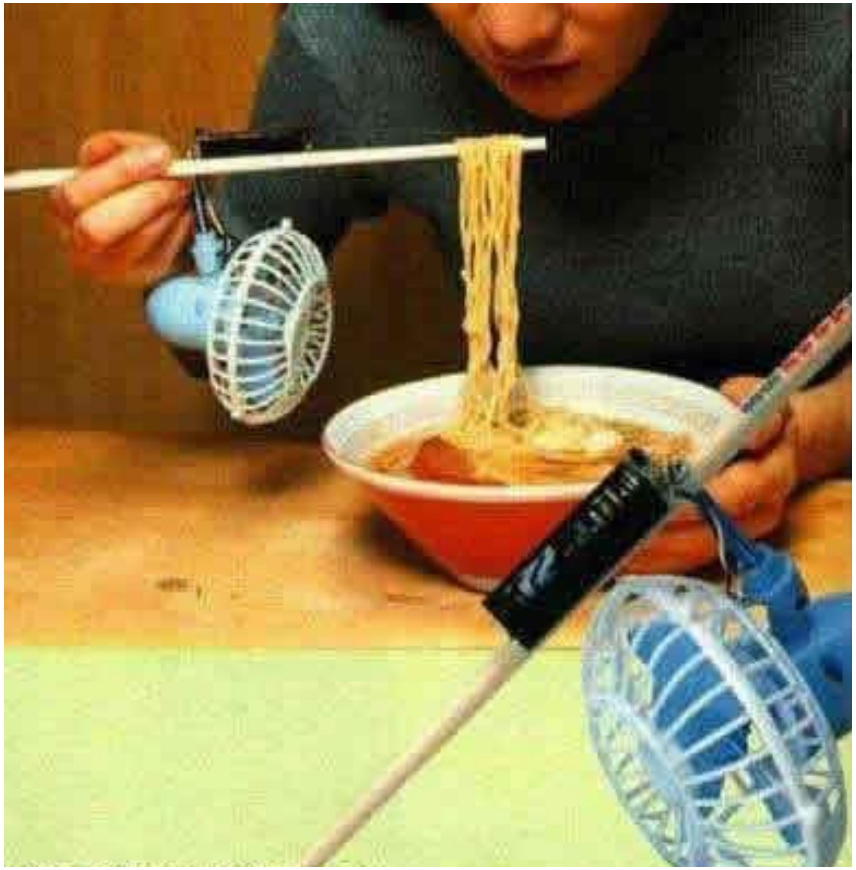
Goals:

1. To approve the specification and the concept
2. To approve the resources required for the full scale development.

When complex system is involved, **step 10 serves as the starting point of the next lower tier in the Systems Engineering Process (SEP)**.

Topics

- Introduction
- Overview of ICDM
- Case Study
- **Research**
- Application of ICDM
- Conclusions



29 new product development teams (129 members) were instructed to apply the **ICDM** methodology step by step and evaluate the results by the **DQM** (Design Quality measurement) system.

Which approach created higher CSR (better concepts)

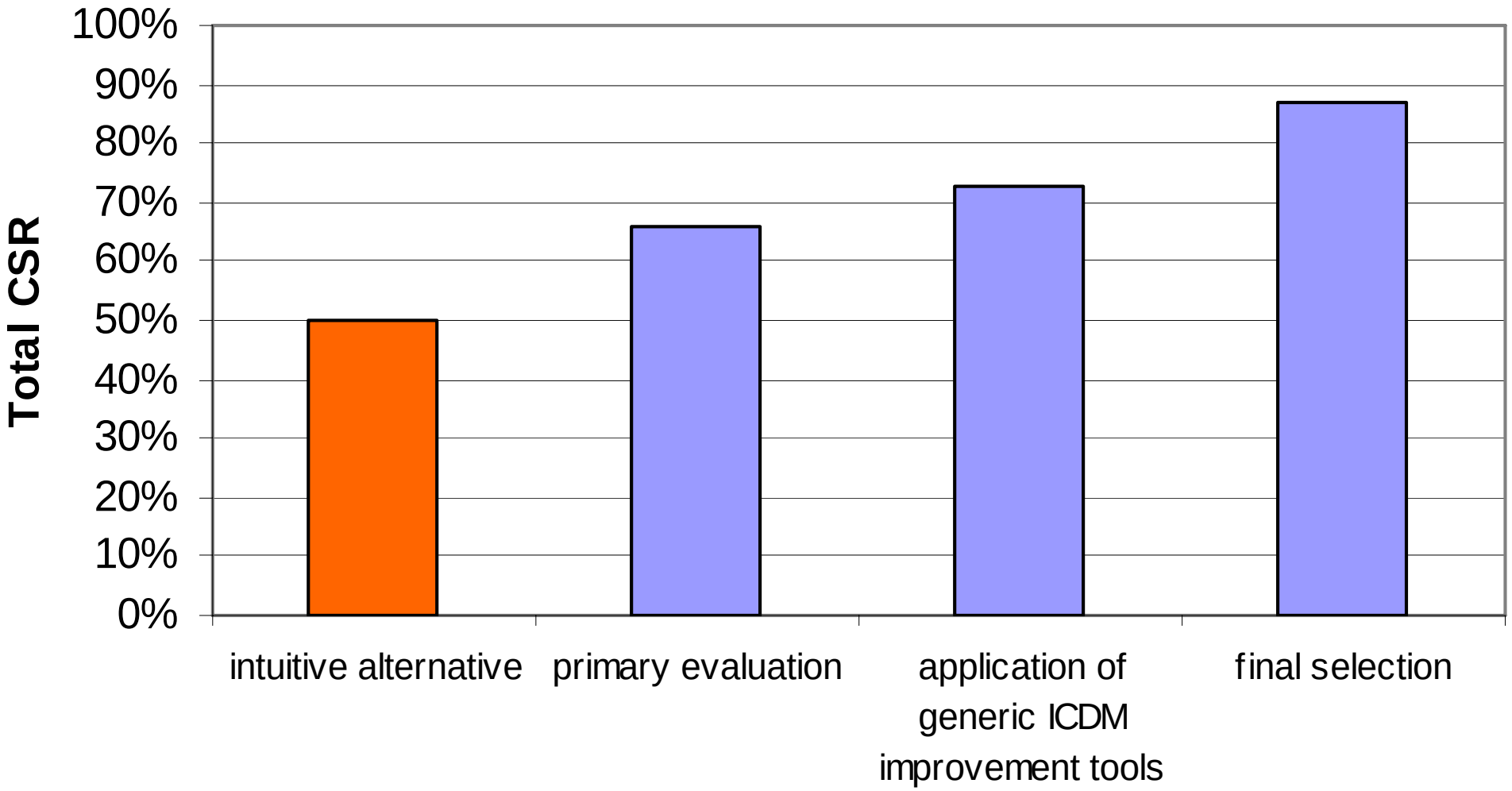
Intuitive Concept

or

concept created by using ICDM

?

❶ The quality of a concept achieved by **ICDM** was on the average **1.75 times better** than the **intuitive alternative**.

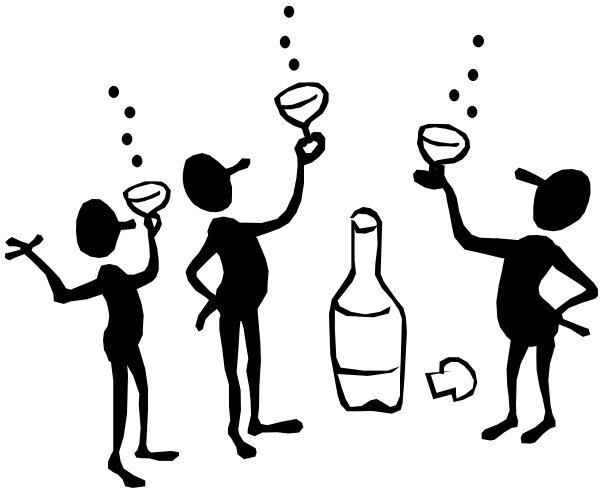


The Paradigm Shift (1)

The Traditional Paradigm:
Intuitive concepts are **the best**



The New Paradigm:
Methodology can help in creating **better** concepts

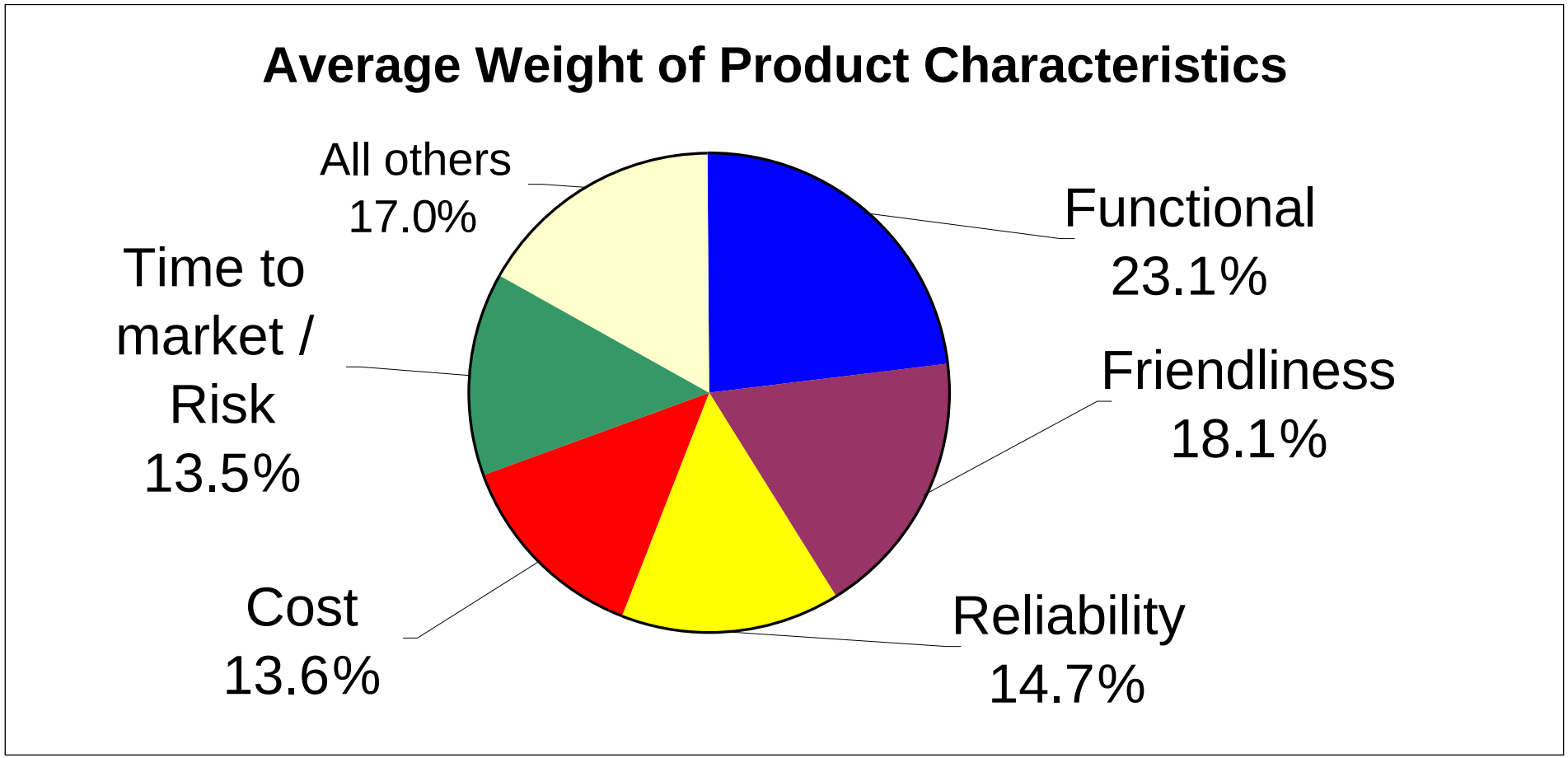


What types of metrics were used by most of the teams

?

- Safety
- Functional
- Design level / aesthetics
- Interface and compatibility
- Environment Friendliness
- Manufacturability
- Cost
- Time to market / Risk
- Reliability
- Maintainability & Support
- Friendliness
- Operation time

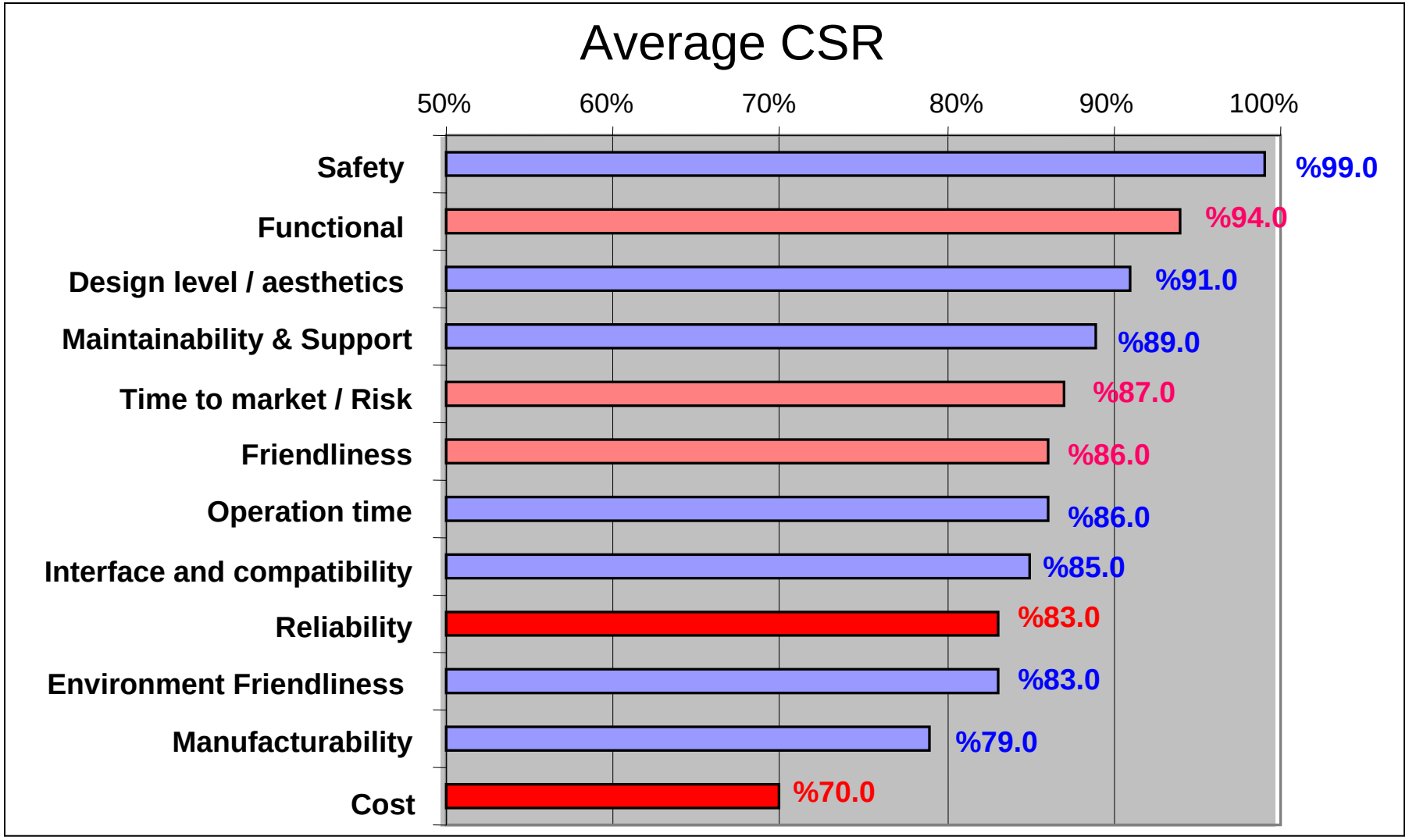
❷ The 5 metrics that were used by most of the teams covered, on average, **more than 80%** of the customer satisfaction.



- **Which type of metrics achieved the highest Customer Satisfaction Rating (CSR) ?**
- **Which type of metrics achieved the lowest Customer Satisfaction Rating (CSR) ?**

- Safety
- Functional
- Design level / aesthetics
- Interface and compatibility
- Environment Friendliness
- Manufacturability
- Cost
- Time to market / Risk
- Reliability
- Maintainability & Support
- Friendliness
- Operation time

❸ The teams achieved the best scores for the functional and safety metrics on account of other Product Characteristics like: user friendliness, reliability, cost and time to market.



❹ The Design Quality Measurement system detected **cost, reliability and risk problems** very early in the design process, when it is relatively **easy to correct** them and **prevent them from reaching the customers.**

❺ The research revealed that the generic tool of **Conceptual Failure Mode Analysis (CFMA)** reduced the criticality of the selected concept by more than 50%.

The Paradigm Shift (2)

The Traditional Paradigm: **Cost, reliability and risk problems can be solved** only during the Full Scale Development **(FSD)** phase



The New Paradigm: We can **detect , prevent and correct cost, reliability, and risk problems** during the Conceptual Design Phase **(CDP)**



Topics

- Introduction
- Overview of ICDM
- Case Study
- Research
- **Application of ICDM**
- Conclusions



Special Application of ICDM

Formal SE requires time and resources which are not always available and therefore SE processes are sometimes totally skipped

Two options for **short and cost effective processes**

- **Agile** workshop (Agile SE): 2-3 Month

Steps 1,2	Steps 3 - 7	Step 8	Step 9	Step 10
1- 4 weeks	**2-5 days**	**1-6 weeks**	**1-2 days**	**2 half days**

- **Slim** workshop (Slim SE): 5 Days !!!

Day 1: Needs and Requirements	**Day 2:** Benchmark and Abstraction	**Day 3:** Solutions and Concepts	**Day 4:** Design and Analysis	**Day 5:** Selection and Verification

Training Options

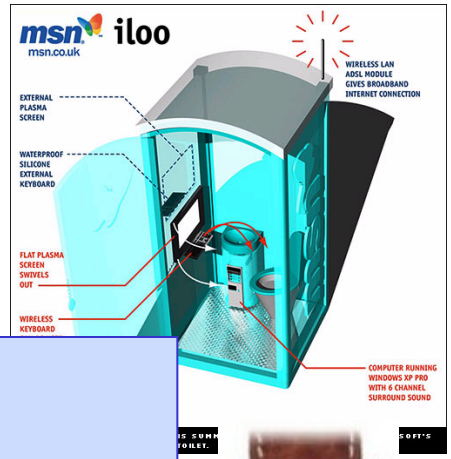
- One day ICDM overview
- Two days workshop on new product definition (NPD) and Conceptual Design
- Two days workshop on ICDM methodology and tools
- 5 days class action learning workshop - ICDM applied on the company project
- One semester academic graduate and undergraduate course on ICDM

Conclusion









- **ICDM - I**ntegrated **C**ustomer **D**riven **C**onceptual **D**esign **M**ethod.
- **ICDM** is a proven method for performing the critical task of **conceptual design in the SE process** and to make the best choice.



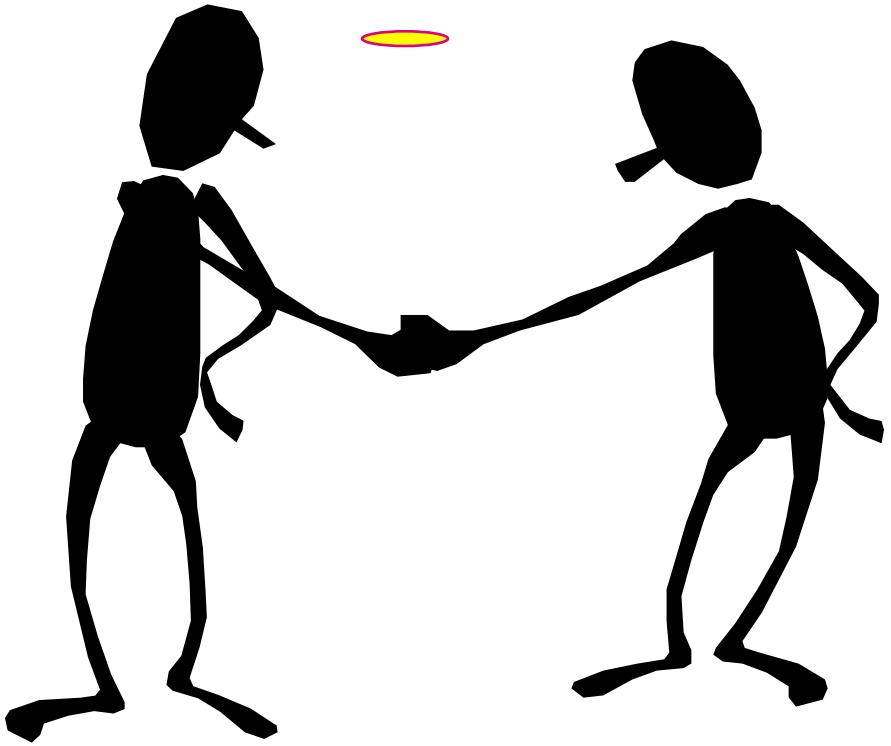








Thank You, Questions?



Jacob Herscovitz
Space Systems Directorate
RAFAEL
Tel: +972-4-879-2379
Email: jacobh@rafael.co.il



Interdisciplinary Team Project Management Using TSP^{SM} Concepts

Prepared For:
NDIA Systems Engineering Conference
Oct. 25, 2006

Prepared By:
Bradley Hodgins
NAVAIR Systems/Software Support Center (NSSC)

Presentation Objectives

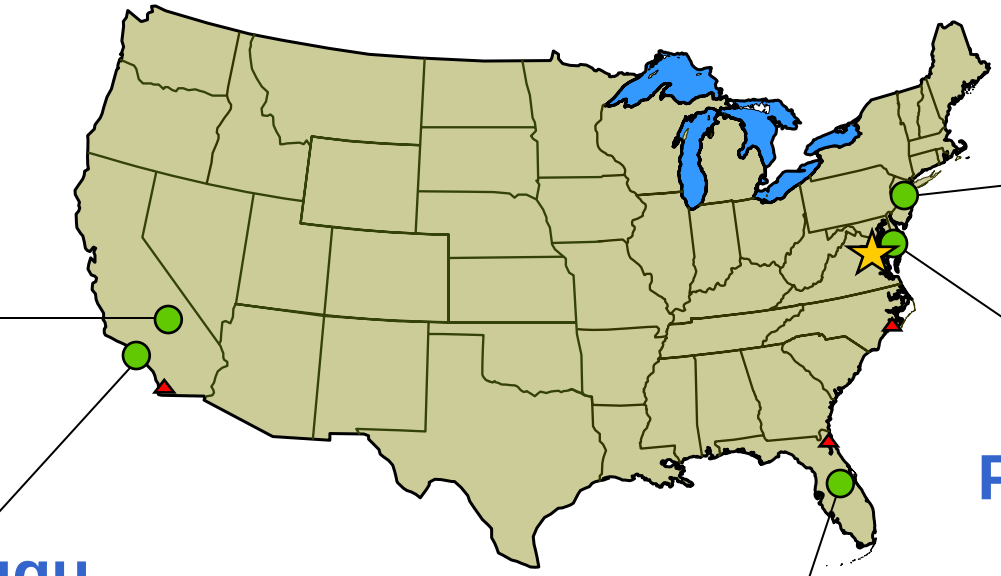
- Background
  - NAVAIR and SPIKE
  - Personal Software Process (PSP) and Team Software Process (TSP)[1]
- SPIKE Project Planning
  - Project Results (before and after)
  - Initial Project Planning
  - Project Execution (day-to-day)

[1]Personal Software Process, PSP, Team Software Process, and TSP are service marks of Carnegie Mellon University

Who is NAVAIR?

- NAVAIR is the Naval Air Systems Command.
- We develop, acquire, and support the aircraft and related weapons systems used by the U. S. Navy and Marine Corps.
- We translate the needs of the Navy and Marine Corps into the technical and financial requirements needed by industry to actually produce an aircraft or other weapon system.
- Our goal is to provide the fleet with quality products that are both affordable and available when they are most needed.
- Our support extends across the entire life span of a product, including all upgrades and modifications to that product.

Where is NAVAIR?



China Lake
WEAPONS
DIVISION

Pt Mugu
WEAPONS
DIVISION

Lakehurst
ALRE - SUPPORT EQ
AIRCRAFT DIVISION

Patuxent River
NAVAIRHQ, PEOs
AIRCRAFT DIVISION

Orlando
TRAINING
SYSTEMS
DIVISION

NAVAIR Headquarters

Acquisition/Test/Development Centers

Who is SPIKE?

- SPIKE Project Office is part of NAVAIR Weapons Division at China Lake, Ca.
- Developing a low-cost, lightweight guided weapon for U.S. ground forces.

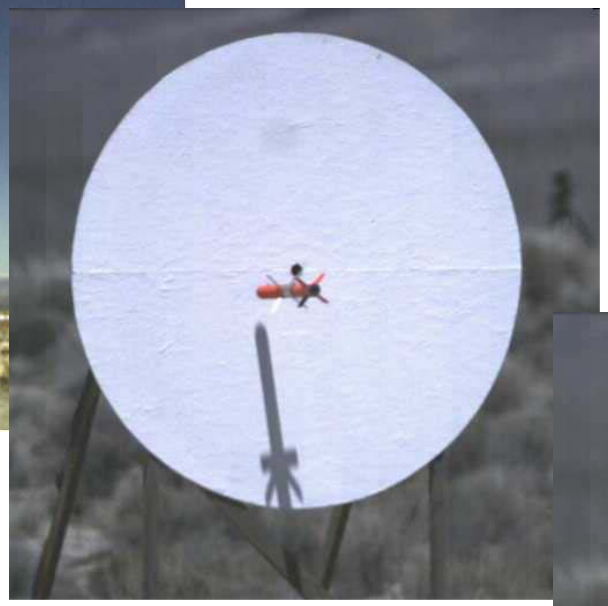


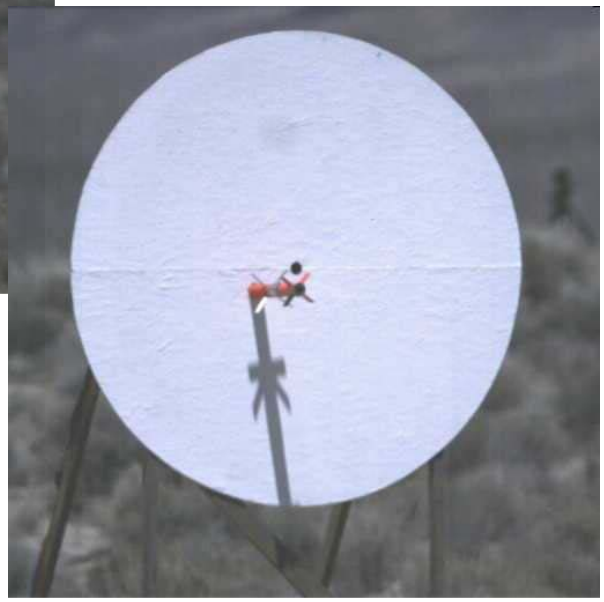
- Using TSP in their software projects since August 2002.

Accomplishments

Guided Missile Field Test







- 12 April 2006 at NAVAIR Weapons Division
- Target Range: 1000 meters
- Target Diameter : 2 meter
- Impact: 8 inches from center
- Missile bore sighted 35 meters left and 105 meters above the target

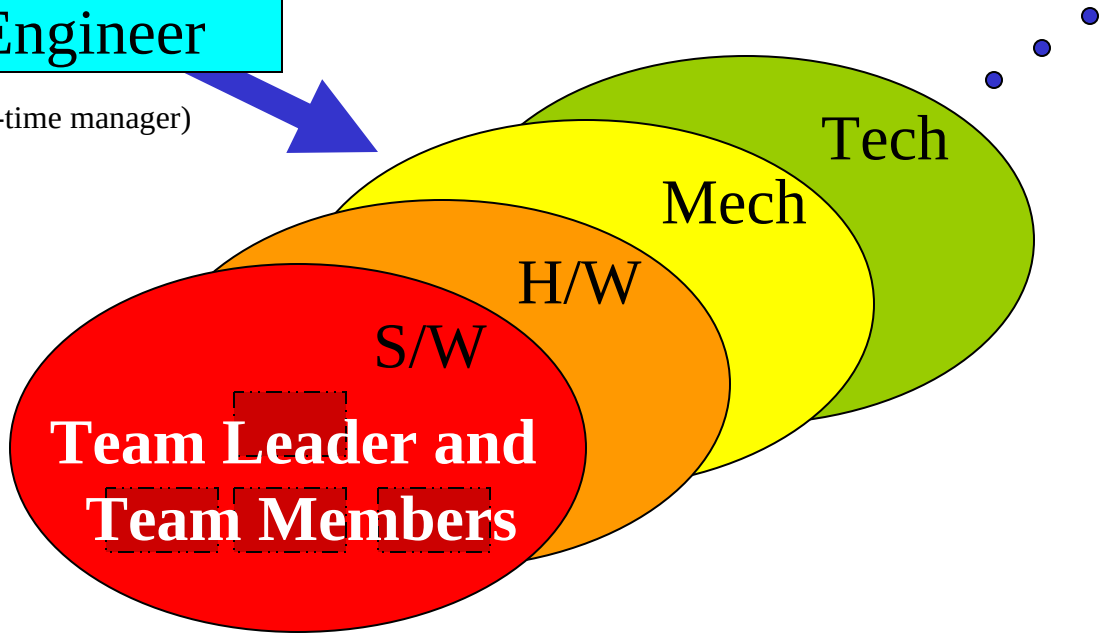
Who is SPIKE?

Project Management

SPIKE Organizational Structure

Systems Engineer

(part-time manager)



What is PSP/TSP?

- PSP shows software professionals how to
  - plan and track their personal work
  - define processes that best suit them
  - measure and manage cost, schedule, and quality
- TSP shows teams of PSP-trained professionals how to
  - establish realistic commitments
  - keep management informed
  - deliver quality products
  - minimize project cost and schedule

PSP/TSP Benefits

- PSP/TSP quickly improves the performance of software groups.
- Planning and tracking is accurate, timely, and precise.
- Product quality is managed and measured from the beginning of the job.
- By finding and fixing problems before test, project cycle time is substantially reduced.

Typical TSP Launch

Review Management goals and project objectives.

Set Software Team goals.

Produce development strategy and process.

Produce top-down plan.

Review quality plan.

Produce bottom-up plan (detailed individual plans).

Perform risk assessment.

Brief plan to Management.

SPIKE Team Planning Meeting

Review Management goals and project objectives.

Set Software Team goals.

Produce development strategy and process.

Produce top-down plan.

Review quality plan.

Produce bottom-up plan (detailed individual plans).

Perform risk assessment.

Brief plan to Management.

SPIKE Team Project Results

Project Cycle	Completion Date	Planned Weeks	Actual Weeks	Difference in Weeks	% Error	Final Test
1	03/2003	26	29	3	+12%	Successful
2	05/2004	47	60	13	+28%	Successful
3	10/2005	15	19	4	+27%	Successful
4	04/2006	12	14	2	+17%	Successful
5	09/2006	15	15	0	0%	Successful[1]

Cycles 1, 2, and 3: Software Team used TSP

Cycles 4 and 5: Software Team used TSP;
SPIKE Team Planning Meeting using TSP concepts

[1]COTS hardware failure during Final Test caused some test criteria to be inconclusive

SPIKE Team Planning Meeting

- Who should be there (or not)?
- How to talk to the whole system?
- What are the required activities?
- How detailed should the planning be?
- What are the task-to-task dependencies?

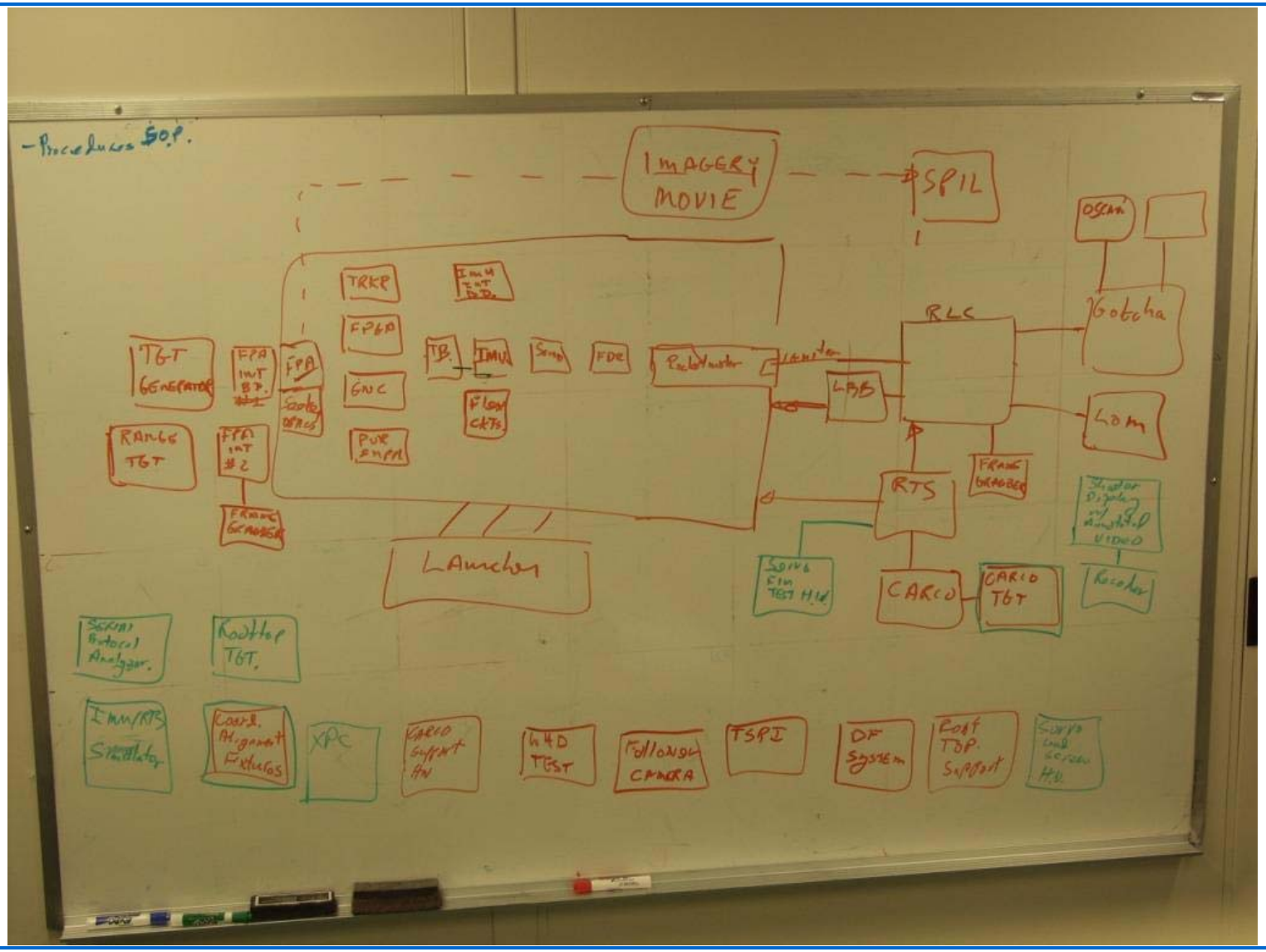
Who Should Be There?

- Everyone in the trenches (Producers)
  - Hardware, Software, Mechanical, Systems, Algorithms, Technical Support
- Get buy-in from producers
- Whole system solutions
- No one from high-level management
  - Detract from the details

How To Talk To The Whole System?

- Create diagram of the existing system
- “red line” diagram with changes and additions
- Discuss every block on the diagram
  - Identify tasks needed

Conceptual Design - Before



Conceptual Design - After



How To Talk To The Whole System?



- Create diagram of the existing system
- “red line” diagram with changes and additions
- Discuss every block on the diagram
  - Identify tasks needed
- Let discussion go where it goes
- Take notes on the side
  - Lots of data (on and off the board)
  - Lessons learned from previous efforts
  - Logistics (material) needs

How Detailed Should The Planning Be?

- Only S/W team had formal PSP training
- Two-pass approach to estimating tasks
  - 1st pass: Task assigned to Engineer
    Engineer gives Small-Medium-Large
  - 2nd pass: Engineer gives "number of days/weeks"
- Estimates are challenged real-time to ensure realistic basis for task sizes

What Are The Required Activities?

- It's not just about software anymore
- Sample workflow for creating multi-layer circuit board (involves EE, ME, S/W Engr, others)

Design circuits	6 wks
Test design (through simulation)	4 wks
Lay out design (w/ inspections)	4-6 wks
Manufacture blank circuit board	4 wks (of waiting)
Inspect board	1 wk
Get board "stuffed" (attach components)	2 wks
Inspect board	1 wk
Debug board	2-4 wks

What Are The Task-to-Task Dependencies?

- Every task is given a Project Priority and a Milestone Priority
- Project Priorities
  - 1 – High – Critical to Next Firing -- Have to Do
  - 2 – Medium – Not Critical to Next Firing -- Should Do
  - 3 – Low – Not Critical to Next Firing -- Ought to Do

What Are The Task-to-Task Dependencies?

- Within each Project Priority, tasks are categorized into Milestone Priorities
- Milestone Priorities
  - #1 – Now
  - #2 – After now
  - #3 – For Bench Integration Testing
  - #4 – For Carco Table Testing
  - #5 – For Live Fire Testing

Wrapping Up Planning Session

- Once all tasks are assigned, sized, and given priorities, load leveling is performed.
- Risks are identified
  - Impact an event would have on the end goal
  - Systems Engineer tracks these during development
- Team members all give a “thumbs-up” that they are good with the plan
- Plan is briefed to management by Systems Engineer

Project Execution (day-to-day)

- Collecting/reporting status
- Tracking progress
- Dealing with problems

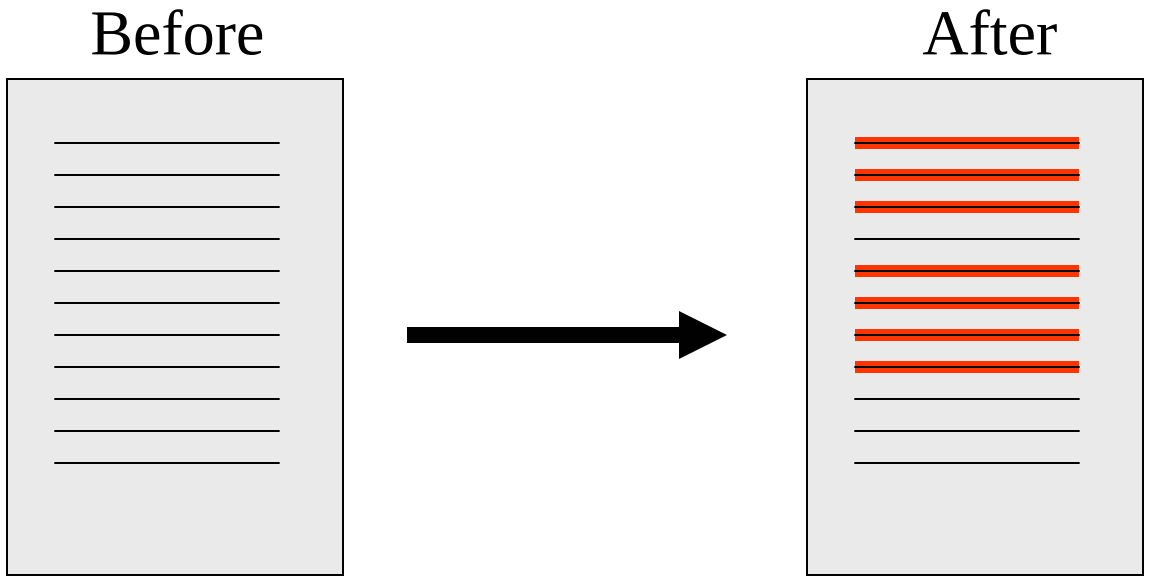
- Everybody has the task list from the SPIKE Team Planning Meeting

Collecting/Reporting Status

- Systems Engineer meets with Team Leads every other week
- On the off weeks, Engineers send in their status to Systems Engineer
  - Refer to the task list
  - Use a common template (< 5 mins to fill out)
  - Statuses are forwarded to Senior Management
- 6 weeks before live fire testing, daily standup meetings are held (15 mins)
  - Focuses on the task list

Tracking Progress

- Systems Engineer uses a paper copy of the task list
  - Task list sorted by priorities
  - Tasks marked off as they are completed



Dealing With Problems

- Systems Engineer is the problem solver
  - Tracks risks identified during project planning meeting
  - Looks for scheduling problems and tasking conflicts
  - Resolves deadlocks
  - Encourages interdisciplinary communication

Summary Conclusions

- Weaknesses
  - Hard to estimate intangibles
  - Shared resources are still sometimes beyond your control (Carco Table and Test Ranges)
- Strengths
  - Low-tech tracking is easy to use (and works!)
  - Everyone knows the big picture (and what they are responsible for)
  - Everyone talks the same language (common vocabulary)

Contact Information



- Dan Crabtree (SPIKE Systems Engineer)
  - phone: (760) 939-4406
  - e-mail: daniel.crabtree@navy.mil
- Vic Walkling (SPIKE Software Lead)
  - phone: (760) 939-1592
  - e-mail: victor.walkling@navy.mil
- Brad Hodgins (NAVAIR TSP Coach supporting SPIKE)
  - phone: (760) 939-0666/4446
  - e-mail: bradley.hodgins@navy.mil

Abbreviations

- NAVAIR – Naval Air Systems Command
- NSSC – NAVAIR Systems Software Support Center
- PSP – Personal Software Process
- SEI – Software Engineering Institute
- TSP – Team Software Process

Information Assurance for Distributed M&S Standards

9th Annual NDIA SE Conference

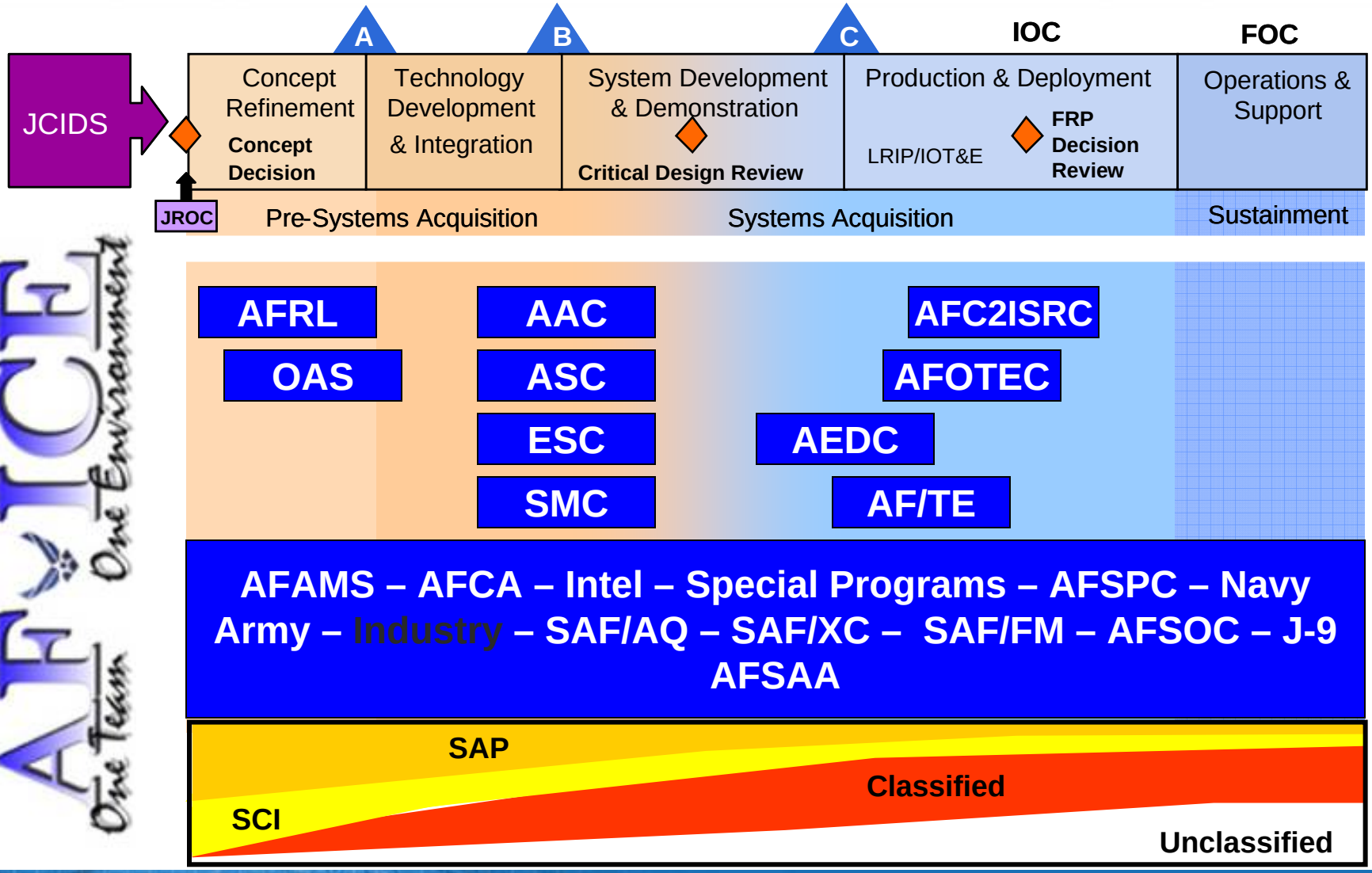
Wednesday October 25th, 2006

Author: Scott Holben

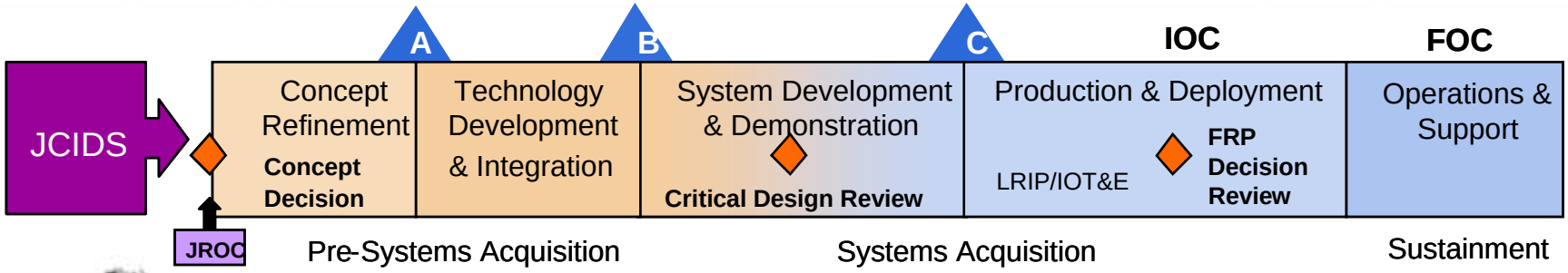




AF-ICE Security Problem Space

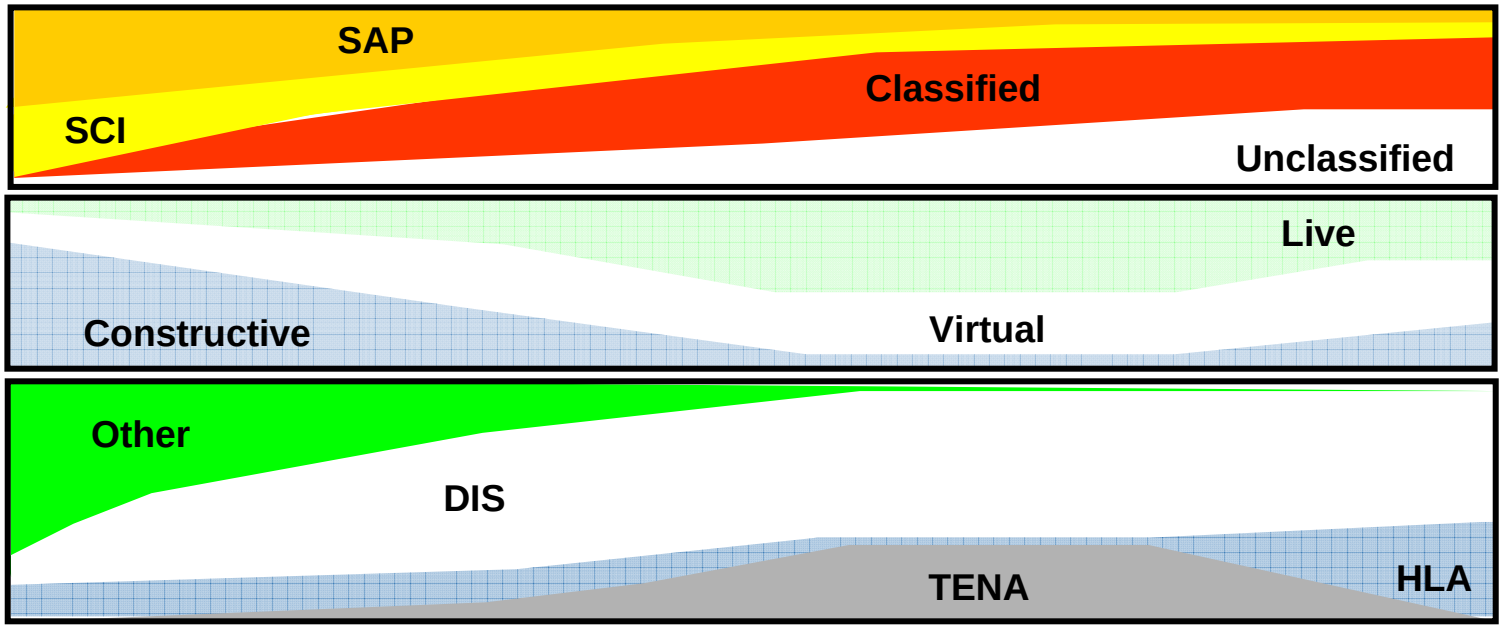


AF-ICE Distributed M&S Contexts



Evaluation Continuum

Mission Environment



Security Regulations (1 of 3)

Gestalt

- Mandatory

  - All Classified Data – **NISPOM/**DoD 5220.22-M, (National Industrial Security Protection Operating Manual) regulations
    - Available at http://www.dss.mil/isec/nispom.htm, 141 pages
    - Also see 5220.22-R at http://www.cfisac.org/FSO%20Library/Misc/ISR-DRAFT.html

  - SAP/SAR Data – **JAFAN 6/3** (Joint Air Force - Army - Navy) Manual regulations
    - FOUO, 162 pages

  - DIA SCI Data – **JDCSISSS** (Joint DoDIIS/Cryptologic SCI Information Systems Security Standards) regulations
    - FOUO but can be found on the Internet, 111 pages
    - Available at http://www.fas.org/irp/doddir/dod/jdcsisss-rev2.doc

Security Regulations (2 of 3)

Gestalt

•Mandatory

- CIA SCI Data - **DCID 6/3** (Director of Central Intelligence Directive) regulations
  - Flow down requirement from JDCSISSS regulation
  - FOUO but can be found on the Internet, ~90 pages
  - Available at http://www.fas.org/irp/offdocs/DCID_6-3_20Manual.htm
- IT systems on the GIG must comply with **DoD 8500** regulations
  - Available at http://iase.disa.mil/policy.html#8500s
- "Defense-In-Depth IA Computer Network Defense" **CJCSM 6510.01** Manual regulations
  - Flow down requirement of 8500 regulations, 354 pages
  - Available at www.namrl.navy.mil/FORMS/CJCSM_651001.pdf

Security Regulations (3 of 3)

Gestalt

- Mandatory

  - Exports with Military Use – **ITAR** (International Traffic in Arms Regulations)
  - Exports with Commercial Use – **EAR** (Export Administration Regulations)
  - National Security Systems - **CNSS** (The Committee for National Security Systems) regulations
    - Available at http://www.cnss.gov
    - See http://csrc.nist.gov/publications/nistpubs/800-59/SP800-59.pdf for criteria for identifying National Security Systems

Valid AF-ICE Data Type Combinations

Gestalt

For Each DoD Service

3rd Dimension for each Protocol or unique HLA implementation

Valid AF-ICE Data Labeling Combinations for Acquisition Centers	Edge Enclave Responsibility Intellectual Property (IP)	Edge Enclave Responsibility EAR & ITAR	NOSC Enclave Responsibility Collateral	NOSC Enclave Responsibility SAP	Edge Enclave Responsibility SCI
1	MCSOA with (SIParator or CASPER) and (Sidewinder or PIX or Checkpoint or …)		DTNG or RMG PL3		
2					
3					
4					
5				DTNG, RMG, or CASPER PL3 & PL4	
6					
7					
8					
9					SAVANT/ VIPRE, CASPER PL3 & PL4
10					
11					
12					
13	Sources and Methods Information (SAMI) Data Will Be Very Challenging for AF-ICE to Handle				
14					
15					
16					

Information Assurance Security Services

Gestalt

National Information Assurance (IA) Glossary, CNSS Instruction No 4009

- **Identification** is the process an Information system uses to recognize an entity.
- **Authentication** is the security measure designed to establish the validity of a transmission, message, or originator, or a means of verifying an individual's authorization to receive specific categories of information.
- **Authorization** is the access privileges granted to a user, program, or process.
- **Nonrepudiation** is the assurance the sender of data is provided with proof of delivery and the recipient is provided with proof of the sender's identity, so neither can later deny having processed the data.
  - **Accounting** is the tracing of information activities to a responsible source.
- **Confidentiality** is the assurance that information is not disclosed to unauthorized individuals, processes, or devices.
- **Integrity** is the quality of an information system reflecting the logical correctness and reliability of the operating system; the logical completeness of the hardware and software implementing the protection mechanisms; and the consistency of the data structures and occurrence of the stored data. Note that, in a formal security mode, integrity is interpreted more narrowly to mean protection against unauthorized modification or destruction of information.
- **Availability** is the timely, reliable access to data and information services for authorized users.

Funding Net-centric IA Efforts

Gestalt

- CJCSI 6212.01D “Interoperability and Supportability of Information Technology and National Security Systems” (8 March 2006)

1. Joint Interoperability Test Command (**JITC**) Joint Interoperability Test and Certification Policy:
   - IT system meets operational needs
   - Interoperable with existing and proposed IT and National Security Systems (NSS)
   - Supportable over existing and planned Global Information Grid (GIG)
   - Are interoperable with allies and coalition partners
   - Are net-ready
   - Allow US forces to protect mission essential data; detect and respond to network intrusion/system compromise; and restore mission essential data
2. Net Ready Key Performance Parameters (**NR-KPPs**) are a mandatory element of Joint Capability Integration and Development System (**JCIDS**) Capability Development Documents (**CDDs**) and Capability Production Documents (**CPDs**) and Information Support Plans (**ISPs**). Four J-6 defined NR-KPP elements:
   - Compliance with the Net-Centric Operations and Warfare Model (NCOW-RM)
   - DoDAF Integrated Architecture Products
   - Compliance with GIG Key Interface Profiles (KIPs)
   - Verification and compliance with DoD information assurance requirements (**8500 series regulations** and **DIACAP**/DITSCAP accreditation process)

Today's Internet Application Security

Gestalt

HTTP/S

- Supports the "**Admission Control Security Model**" understood by all CIO Security Officers for providing identification, authentication, authorization and accounting services
- Allows both the resource holder and enterprise security administrator to set explicit access control privileges to maintain confidentiality of specific Web resources

HTTP/S and SIP/S sessions are authenticated before being authorized

- **RFC 2617** uses challenges involving private keys
  - To authenticate clients or consumers
  - To optionally allow the client to authenticate the server to provide mutual authentication
- **TLS encryption**
  - Requires servers or producers to have X.509 PKI certificates
  - Since client certificates are optional, RFC 2617 may still be used to authenticate the client to provide mutual authentication

Authorization Mechanisms

- Identity Based Access Controls (**IBAC**), includes Access Control Lists (**ACL**)
- Role Based Access Controls (**RBAC**)
- Attribute Based Access Controls (**ABAC**)

DoD Regulatory Confidentiality Terms

- **Clearance** is eligibility, it requires background checks sponsored by a government agency to determine if resources can be trusted for holding or processing classified information.
- **Authorization** is determined and enforced at the enterprise-level often using Mandatory Access Controls (MAC), especially for multi-security domain transfers. Regular system users are not to be trusted to enforce authorization policies. The ISSM, NSO or ISSO will set the DoD authorization policies contained within the AIS system Security Support Structure (SSS).
- **Need-to-know** is determined and enforced by the **Data Holder** of the information with Discretionary Access Controls (DAC), e.g., Identity Based Access Controls (IBAC), Access Control List (ACL) and Role Based Access Controls (RBAC) or need-to-know is established by the **Information Owner** and enforced by RBAC.
  - *Note, an exclusive need-to-know RBAC mechanism requires a firmly established OV-7 "Logical Data Model" to demonstrate traceability to a role's operational need to access data. OV-7 diagrams are easier to develop for C2 systems than modeling and simulation networks, because data tends to belong to fewer data owners and processes are static and are not as intellectually complex.*

DoD Confidentiality Levels

Gestalt

Protection Levels

PL1 (Dedicated Mode)

- All resources (e.g., users, systems…) have proper clearance, formal access approval and need-to-know
- Most of today's modeling and simulation resources natively operate in a PL1 environment even when interfacing to MLS guards

PL2 (System High Mode)

- All resources have proper clearance and formal access approval
- Not all resources have need-to-know
- Requires principals to authenticate themselves before they can access resources

PL3 (Compartmented Mode)

- All resources have proper clearance
- Not all resources have formal access approval
- Not all resources have need to know
- Requires principals to authenticate themselves before they can access resources

PL4 and PL5 (Multi-level Modes)

- True Multi-Level Security (MLS)
- Requires principals to authenticate themselves before they can access resources

M&S Security Capability Gaps



•Network security requires a Network Operation Security Center (**NOSC**) to perform PL2 service-level routing and PL3 transaction-level authorization services to persist physical connectivity to mitigate the pains of establishing event specific MOAs.

•Application-level security is not part of DIS nor HLA and is new to TENA.

- Application-level **Identification & Authentication (I&A)** must be explicit, not PL1 implicit, to persistent network connections in PL2+ environments
- Application-level **Labeling** must be explicit, not PL1 or PL2 implicit, to foster persistent network connections in PL3+ environments
- Simulation architecture needs to accommodate proxy-based Policy Enforcement Points (**PEP**) and Policy Decision Points (**PDP**) to implement mediated net-centric access controlled security services

•**Data aggregation** (event OPSEC) challenges are driven by Security Classification Guidelines (**SCG**) and Program Security Directives (**PSD**). Data aggregation will remain a manual Systems Engineering process until strong data management, explicit labeling and IA minded compositioning processes are established. Simulation resources sensitive to data aggregation must have event-level access controls to mitigate chances of unauthorized disclosures to aggregated information.

Intellectual Property (IP) Protection Requirements

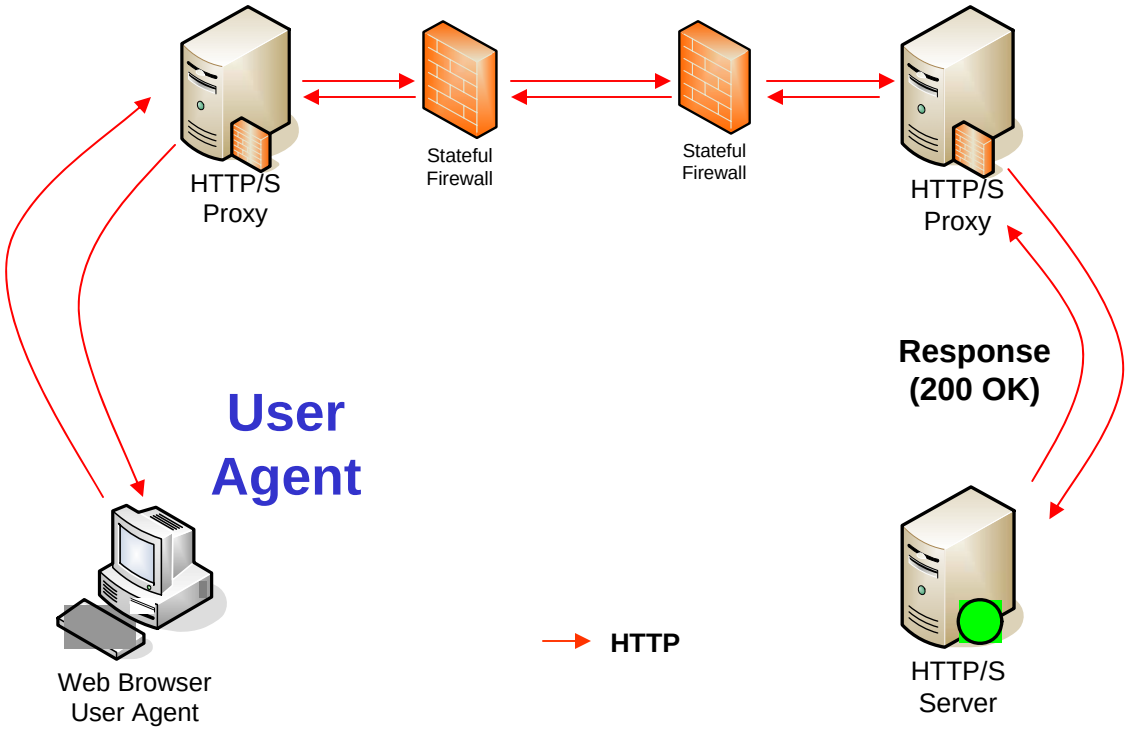
Gestalt

Protecting IP on Classified Networks

- Identities must be established to prevent unauthorized disclosure
  - Identities can be established local to the private enterprise
  - Identities can be established and asserted by a trusted 3rd party
- Accounts are provisioned internal to the enterprises owning the IP
- Auditing will be similar to **PL2 auditing requirements**
- Authentication will be mutual similar to **PL4 authentication requirements**
- Authorization to IP must be implemented by private enterprises owning the IP
- WAN communications for IP within NSA Type I encrypted tunnels must be encrypted once again using industrial strength hop-by-hop or end-to-end commercial encryption (e.g., FIPS 140-2) similar to non Sources and Methods Information (SAMI) **PL3 encryption mechanisms**

Cross Enterprise HTTP/S Transactions

- Supports the “Admission Control Security Model” and DoD PL3+ Confidentiality services
- RFC 2617 digest-based challenge produced by a proxy server or user agent prompts the user with an identity-based challenge and realm
- HTTP/S proxy server acts as a Policy Enforcement Point (PEP)
- User supplies the appropriate username and password
- Unfortunately HTTP/S can’t provide real-time application services because there is not a separation between the real-time streams and controlling transactions
- To scale, distributed M&S synchronous real-time streaming applications require asynchronous peer-to-peer (P2P) communication, preferably using a proven Web user agent technology



Simulation Entity User Agents



SIP Modeling & Simulation User Agents (UA)

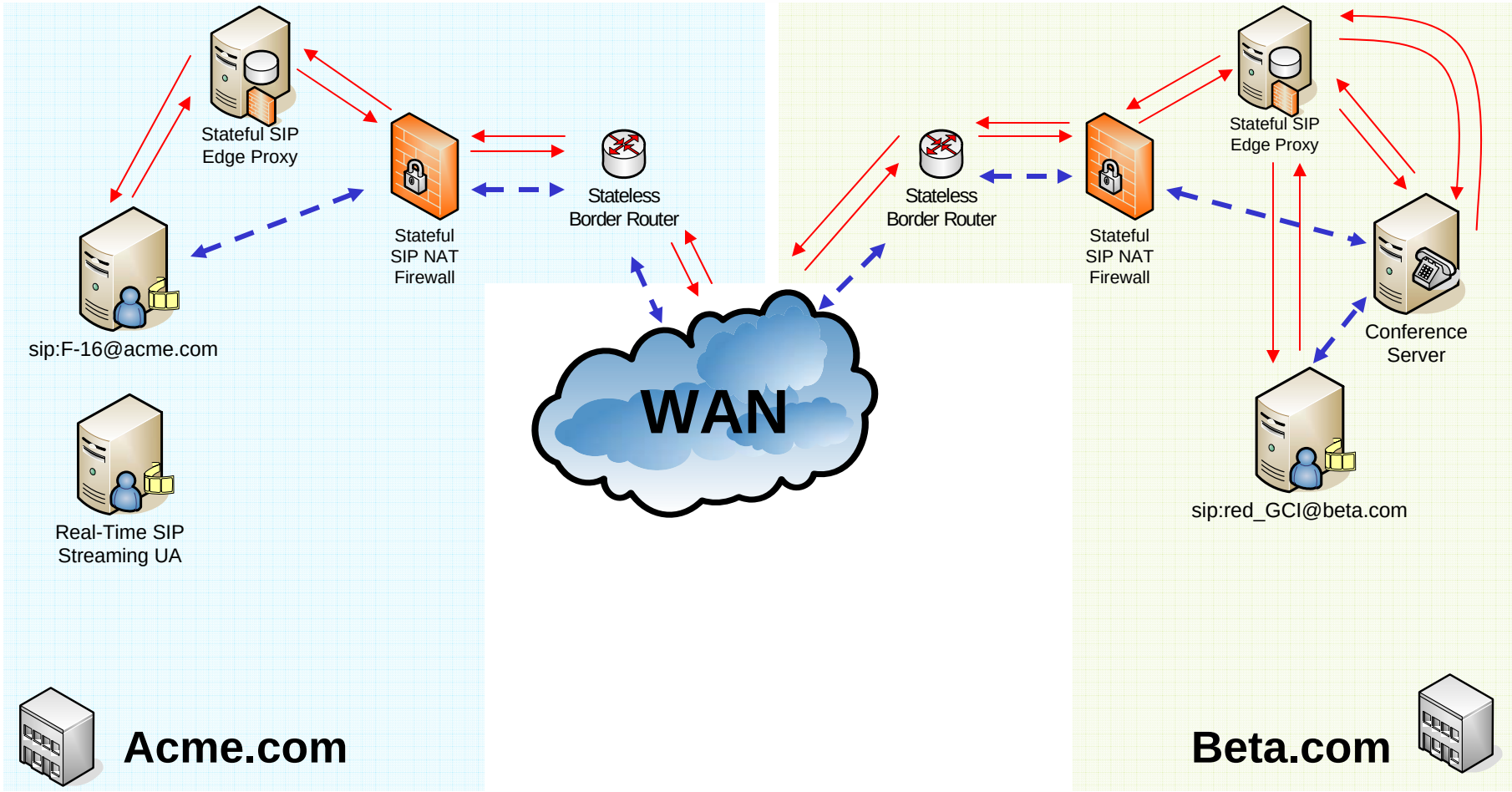
- Is the convergence of **scalable** VoIP phone technology
- SIP UAs have URIs associated with them that are **routed at the session-layer** to establish, modify and tear-down SIP sessions
- Once sessions are established SIP UAs are the **sources and sinks of real-time information**, typically Real-time Protocol (RTP) streams
  - RTP is a Web standard like SIP and RTP can carry DIS payloads
  - RTP is built on top of UDP

SIP UA Integration with DIS

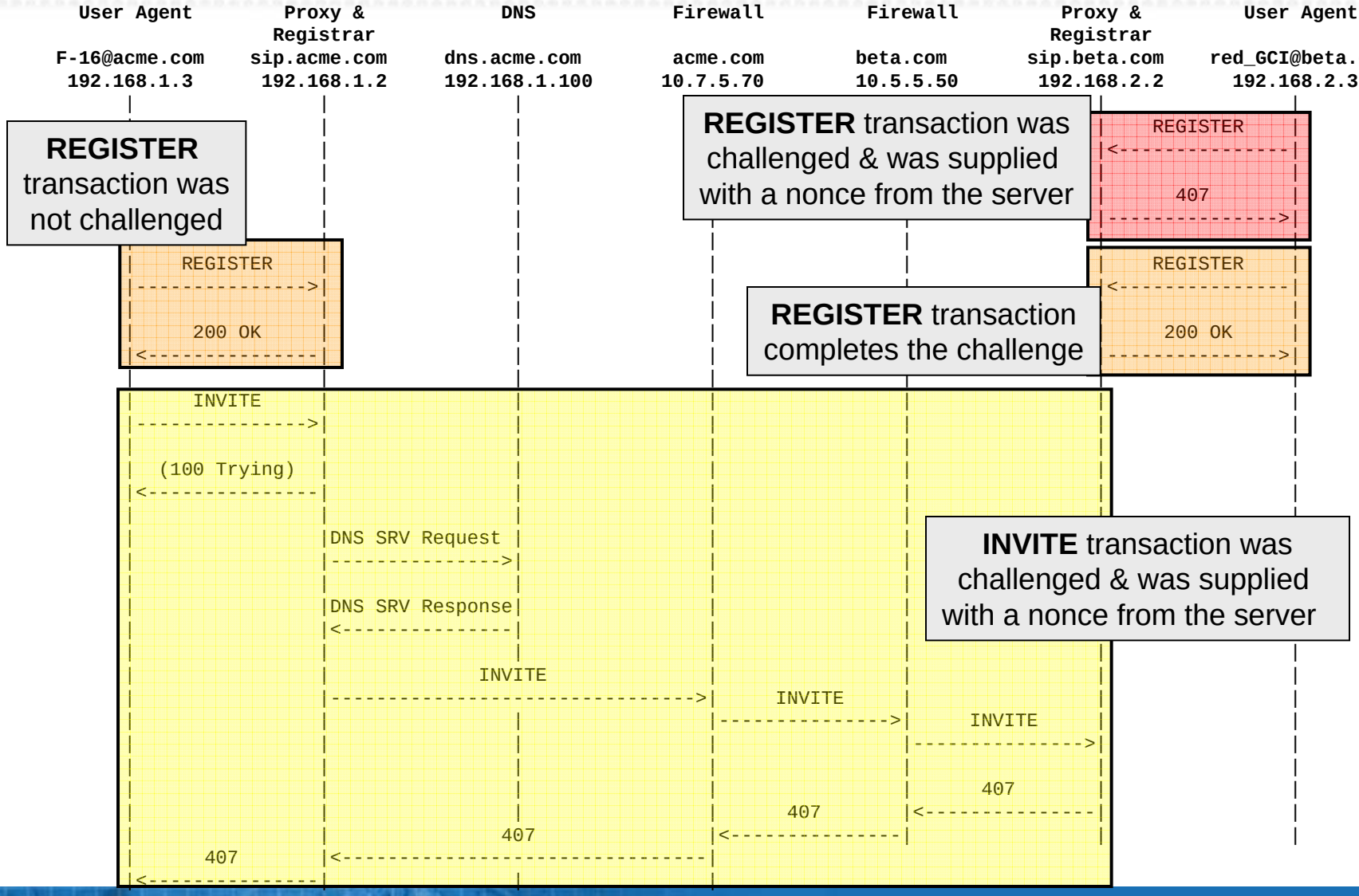
- User agents can be integrated with DIS simulations by one of three means:
  - UAs act as dedicated **very loosely coupled hardware relays** on separate hosts
  - UAs are **loosely coupled software shims** that are installed on existing simulation hosts
    - » capture broadcast traffic with a virtual network adapter
    - » user agent listens on that port, bundles traffic in RTP packets and relays them via RTP sessions
  - UA APIs support two forms of **tight coupling** using an API
    - » Tightly integrated RTP stack with loosely coupled SIP stack
    - » Tightly integrated RTP and SIP stacks

Protecting Real-Time Streaming Intellectual Property (IP)

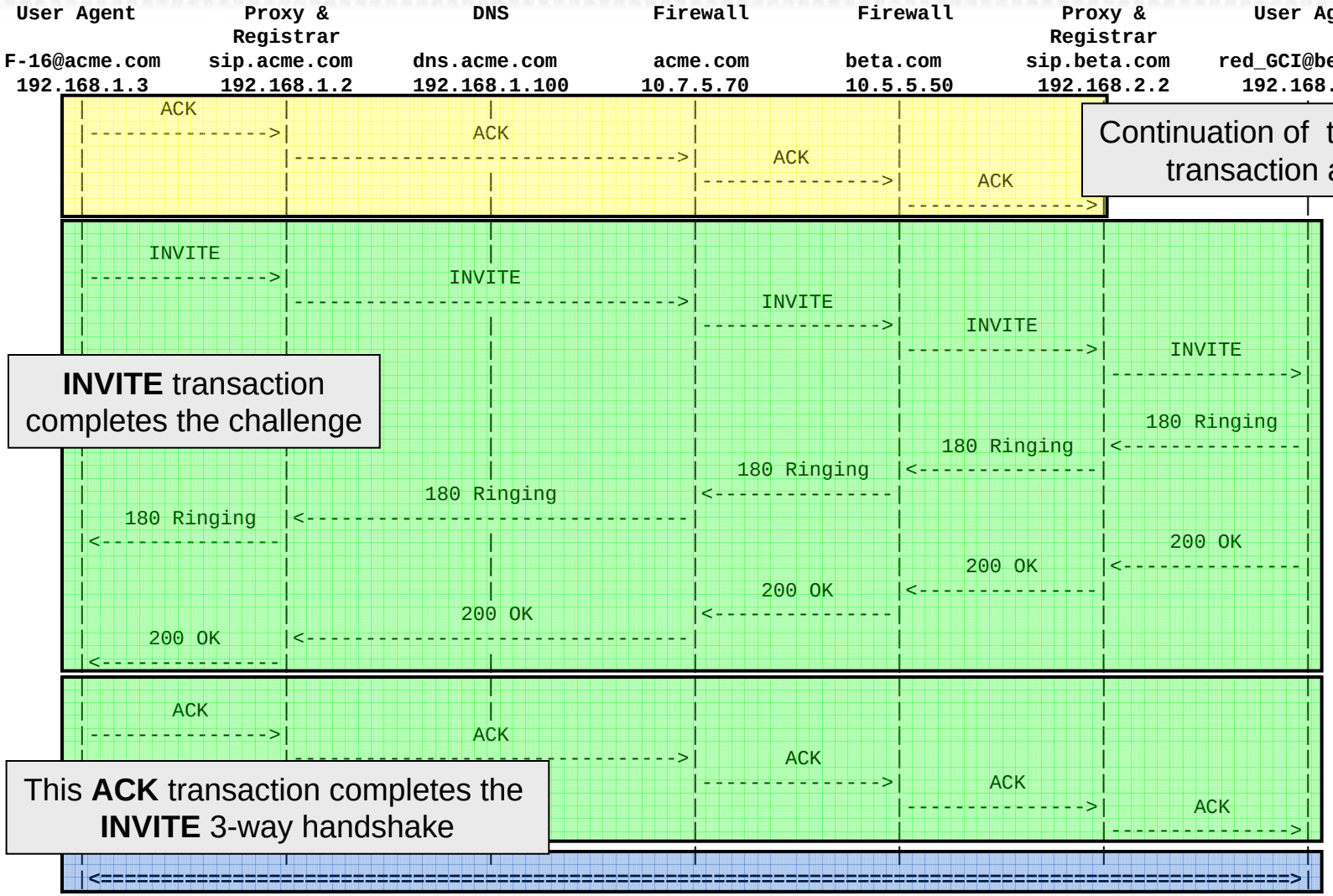
Gestalt



RFC 3261 SIP Call Flow Diagram



RFC 3261 SIP Call Flow Diagram



Continuation of the **INVITE** transaction above

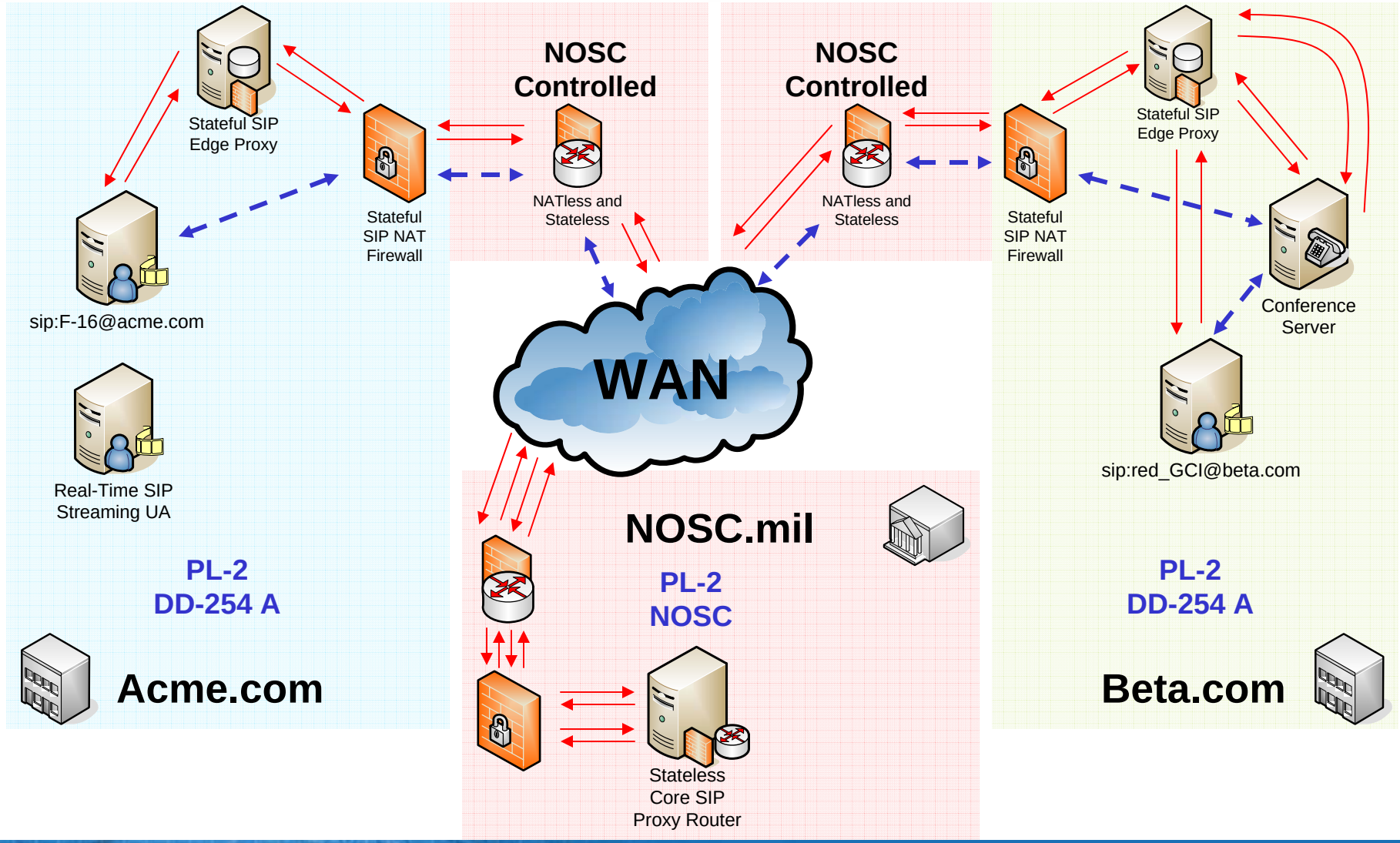
INVITE transaction completes the challenge

This **ACK** transaction completes the **INVITE** 3-way handshake

Unidirectional or Bidirectional RTP Stream

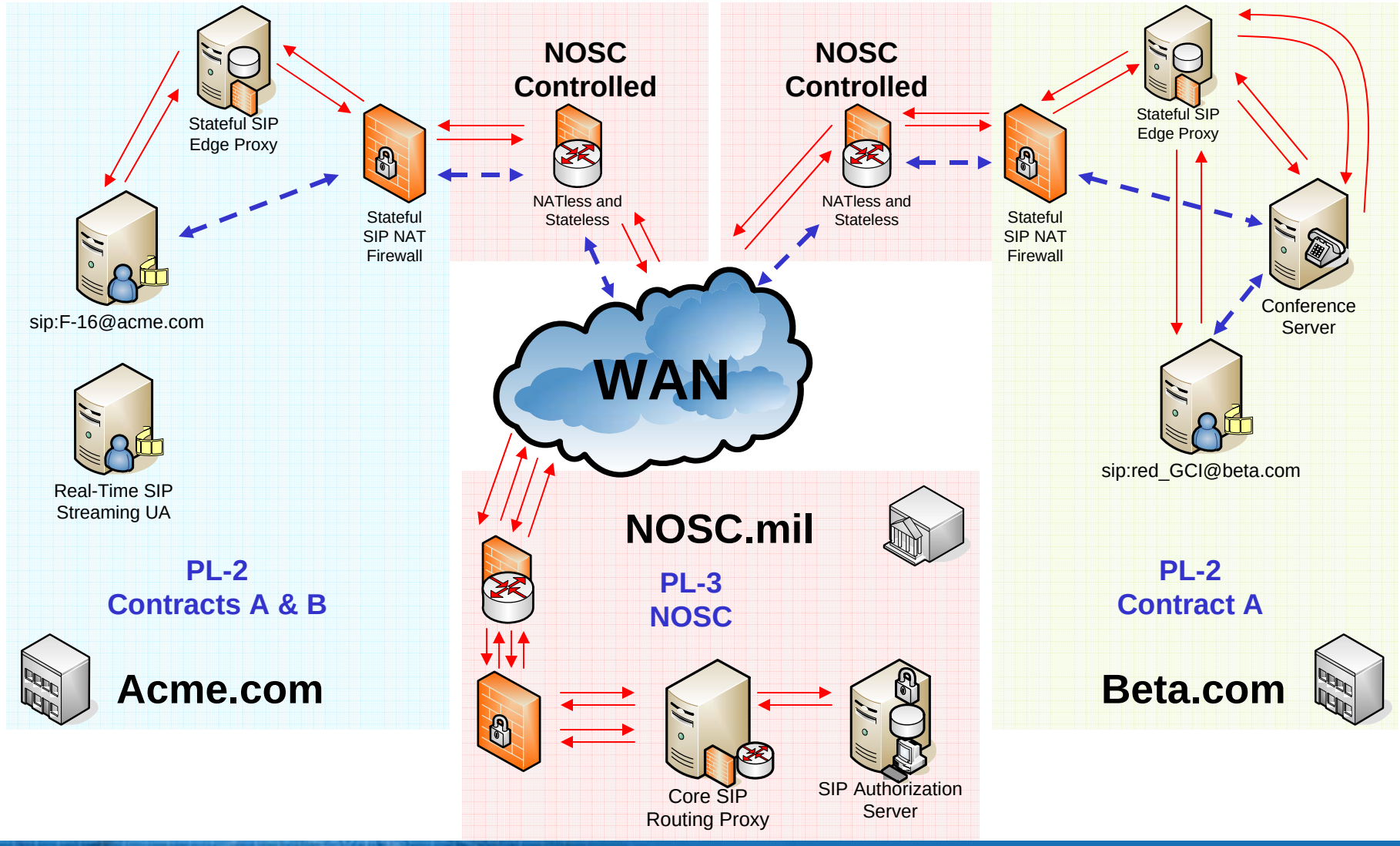
Protecting Intellectual Property and DoD Classified Information

Gestalt



Protecting Intellectual Property and Classified Multi-contract Information

Gestalt



Benefits of SIP VoIP Technologies



- SIP network resources (C2 systems, simulators, etc.) are **treated as opaque URIs**
- SIP components may be integrated into a **Multi Channel Service Oriented Architecture (MCSOA)** with Web Service Description Language (WSDL) interfaces
- SIP supports both perimeter and application-level security models for real-time applications
- **SIP URI resources can have privileges** (e.g., IBAC, RBAC or ABAC) associated with them to implement discretionary or mandatory access controls
- SIP can utilize **RFC 2617 or TLS authentication mechanisms** that can take advantage of LDAP, RADIUS, or Diameter services
  - These technologies are understood and trusted by many CIO Security Officers
- SIP supports stateful NAT firewalls used by most enterprises to **protect intellectual property** and export controlled information
- SIP allows existing enclaves to be added into larger networks without requiring IP **address re-alignments**
- SIP can support **persistent PL2+ networks** without requiring re-accreditation of networks, PL1 rated systems require frequent re-accreditation
  - Zero network configuration
- **SIP is strong candidate for providing common integrated wire-level net-centric Security and Quality of Service (QoS) capabilities to DIS, HLA and TENA**

Extra Slides

AF-ICE Event Management Process

Gestalt

Process Steps Below Must Be Neutral to the DIS, TENA and HLA Standards and Workflow Services are Innate to all Seven Steps

1. **Formulate Event**
2. **Specify Battlespace**
   - Scheduling/Reservation Services
   - Discovery Services
3. **Build Battlespace**
   - Composition Services
   - Orchestration Services
     - Resource Provisioning Services
4. **Integrate Battlespace**
   - Registration Services
   - Presence Services
   - Availability Services
5. **Execute Event**
   - Resolve Resource Services
   - **Distributed Dynamic Networks Services**
   - Monitoring Services
   - Execution Services
   - Network Bandwidth Throttling and Packet Latency Services
6. **Analyze and Report on Event**
7. **Sustain Event Documentation and Environment**

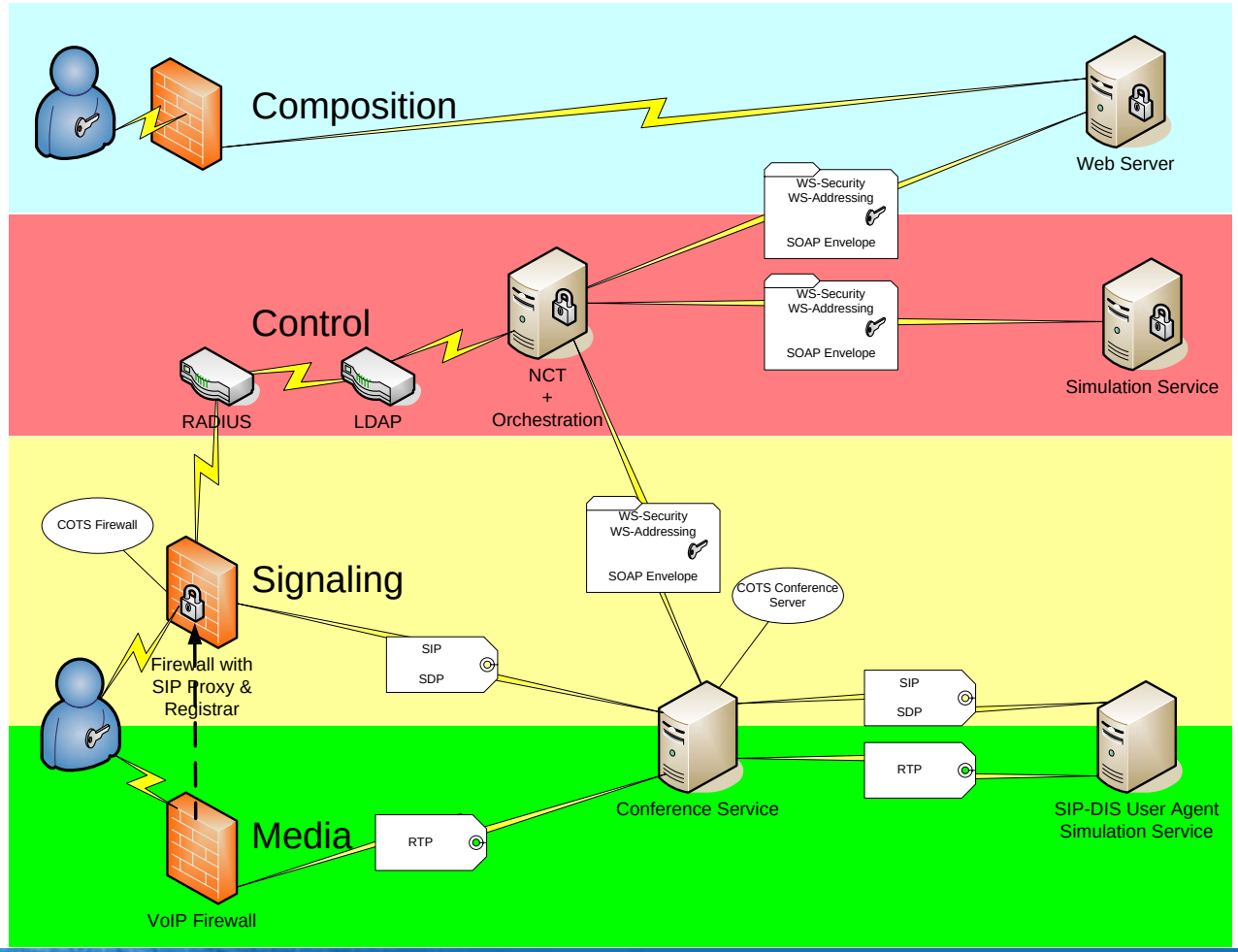
Dynamic Distributed Network IA

Gestalt

Single Enclave View

External Web Browser

External SIP User Agent



Questions?

Scott Holben sholben@gestalt-llc.com

Gestalt, LLC
9432 Baymeadows Road Suite 155
Jacksonville, FL 32256
904-899-0290 x1702

Acquisition Environment, Safety, and Occupational Health (ESOH) – ODUSD(I&E) Role and Activities

NDIA Systems Engineering Conference
San Diego, CA
October 23 – 26, 2006

Ms. Patricia Huheey
Acquisition ESOH Lead
Office of the Deputy Under Secretary of Defense
(Installations & Environment)

Table of Contents

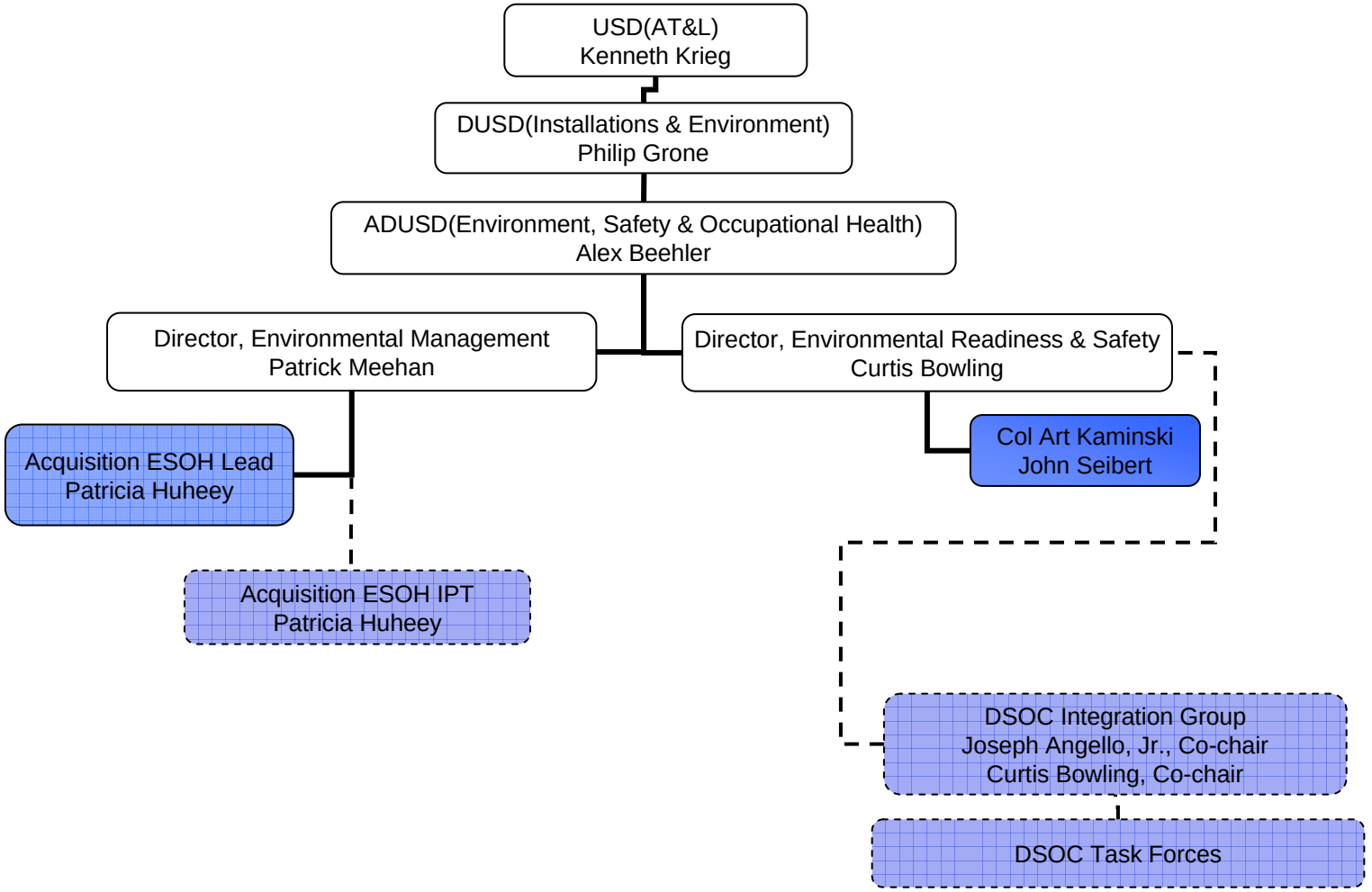
- Role in AT&L
- ODUSD(I&E) Perspective
- ESOH Policy Requirements
- Acquisition ESOH Activities
  - Program Oversight
  - Risk Acceptance Policy
  - Guidance
  - DAU Curricula
  - MIL-STD-882
  - ESOH Evaluation Criteria



ODUSD(I&E) in AT&L Role

- Base Realignment & Closure
- Business Enterprise Integration
- Environmental Management
- Environmental Readiness & Safety
- Emerging Contaminants
- Housing & Competitive Sourcing
- Installation Requirements & Management
- DoD Explosives Safety Board
- Pest Management Board
- Manage DoD facilities and infrastructure
- Defense Facilities Strategic Plan
- Key metrics to provide quality facilities and infrastructure that directly support mission needs and readiness
- Manage Natural Infrastructure assets at installations and ranges in an environmentally sound manner to prevent encroachment and support military force operational needs

ODUSD(I&E) Acquisition ESOH Leadership



ODUSD(I&E) Role in Acquisition

- DAB/ITAB Special Advisor for ESOH issues
- Oversight of ACAT 1D, IAM, and Special Interest programs
- Focus on DoD 5000 -- ESOH in acquisition policy development
- Develop guidance for acquisition ESOH policy
- ESOH input to CJCS 3170.01 series - JCIDS

ODUSD(I&E) Role in Acquisition

- Chair DoD Acquisition ESOH IPT
  - Consensus on ESOH policy and guidance
  - Influence NSS Acquisition Policy and JCIDS
- Member of the DAPWG/DAPSG
  - DoDI 5000.2 and Defense Acquisition Guidebook
  - Acquisition Community Connection (ACC) site
- Member of Defense Safety Oversight Council
  - Co-chair DSOC Integration Group
  - Acquisition and Technology Programs Task Force

ODUSD(I&E) Perspective

- Why be concerned with ESOH in Acquisition?
- ESOH considerations affect the operational effectiveness and sustainability of the system
  - There is a relationship between the natural infrastructure and the military mission
  - Compliance requirements and encroachment influence how DoD maintains and trains with the system
  - System design, operation, and maintenance parameters determine the installation and workforce needs to train and maintain the system

ODUSD(I&E) Perspective

- The goal is to identify life-cycle ESOH risks early and influence system design, not address them afterwards as operational considerations
- E, S, and OH considerations are inter-related and should be assessed holistically
- ESOH hazards are best addressed using a rigorous, analytical process
- System design is most effectively influenced through the system engineering (SE) process

ODUSD(I&E) Perspective

- ESOH risks include:
  - Hazardous materials and waste
  - Environmental and occupational noise
  - Personnel safety and occupational health
  - Regulatory compliance
  - System safety and explosives safety
- Need to manage ESOH risks associated with:
  - Routine operation and maintenance of the system
  - System failures
  - ESOH compliance requirements

ESOH Policy Requirements

- Top level principles:
  - Address safety throughout the acquisition process
  - Use a total systems approach to minimize or eliminate characteristics that produce environmental, safety or health hazards, where practicable and cost effective
  - Use the system safety methodology to minimize ESOH hazards where possible and manage ESOH risks where they cannot be avoided
  - Accept risks at designated management level
  - During system design, document HAZMAT in the system and plan for demilitarization/disposal

ESOH Policy Requirements

- Programmatic ESOH Evaluation (PESHE)
  - Updated at major milestones and must document:
    - Strategy for integrating ESOH considerations into the systems engineering process
    - Identification of ESOH responsibilities
    - Identification of ESOH risks
    - Method for tracking progress in the management and mitigation of ESOH risks
    - NEPA/EO 12114 Compliance Schedule

ESOH Policy Requirements

- USD(AT&L) Memorandum, Defense Acquisition System Safety, 23 September 2004
  - DoD Standard Practice for System Safety, MIL-STD-882D, must be used in all developmental and sustaining engineering activities
  - Systems Engineering Plan must include the strategy to integrate ESOH risk management into the systems engineering and overall risk management processes
  - ESOH risk status and acceptance decisions must be reported at technical reviews and in the Program Review Process

Acquisition ESOH Activities

- Program oversight and assistance
- ESOH risk acceptance policy
- Guidance – DAG and ACC
- Acquisition education and training – DAU
- System safety process – MIL-STD-882
- System safety-ESOH management evaluation criteria

Activities: Oversight

- Participate in MS and program review process
  - Attend program WIPT/OIPT/DAB
  - Review documents for ESOH coverage
    - PESHE and Acquisition Strategy
  - Exploring cooperation on DAPS and SEP Reviews
  - Work with programs to
    - Clarify DoD 5000 ESOH policy requirements
    - Emphasize integration of ESOH into SE
    - Focus on ESOH risk management

Activities: Risk Acceptance

- Draft revision to system-related ESOH risk acceptance policy to clarify existing DoD system-related ESOH risk acceptance requirements
  - Requires the user representative to be part of the ESOH risk acceptance process
  - Requires the user representative to formally concur with all Serious and High ESOH risk acceptance decisions
  - Requires formal acceptance of ESOH risks prior to exposing people, equipment, or the environment to a known system-related ESOH hazard

Activities: Guidance

- Defense Acquisition Guidebook
  - System Safety Analyses added as Input and Output on systems engineering Vee-charts
  - Incorporate ESOH steps/activities into Section 4.3 Systems Engineering Activities and 4.4 Design Considerations
  - Update Section 4.4.11 ESOH
- Acquisition Community Connection (ACC)
  - Update and expand ESOH Special Interest Area

Activities: DAU Curricula

- System Safety in Systems Engineering Continuous Learning Module (April 2005)
  - Identifies System Safety activities supporting each of the SE activities in each phase of a systems life cycle
  - Course (CLE009) available on-line http://www.dau.mil/basedocs/continuouslearning.asp
- Conduct review of prioritized courses and provide ESOH input consistent with current policy
  - Acquisition core, SPRDE, Program Management, Acquisition Logistics, and Test and Evaluation

Activities: MIL-STD-882

- DoD Acquisition ESOH IPT had concerns with "E" version and agreed to revise
  - More clearly reflect DoD intent of document
  - Connect to all segments of SE and ESOH
  - Clarify "ESOH" is an acronym, not a discipline
  - Return Section 4 (only) to 882D language and revise only as necessary for currency with DoD policy
  - Include some tasks as non-mandatory guidance
  - Standardize risk definitions

Activities: Evaluation Criteria

- Focus on assessing overall management of System Safety - ESOH considerations as a part of the SE process – not specific ESOH risks
- Established four evaluation categories
  - ESOH Planning
  - ESOH Hazard Identification, Analysis, and Risk Acceptance
  - ESOH Requirements for the System and Associated Infrastructure
  - Personnel and Funding for ESOH

Activities: Evaluation Criteria

- Metrics for the four evaluation categories were developed for each acquisition phase
- Selected key activities or documentation that would be a strong indicator of a system safety (E, S, and OH) for each acquisition phase, and rated them as Green, Yellow, or Red (G/Y/R)
- Weighted each category metric for summing to a single overall rating (G/Y/R) for each life cycle phase

Activities: Evaluation Criteria

Four Categories covered in O&S Phase

ESOH Planning	ESOH Hazard Identification, Analysis, and Risk Acceptance	ESOH Requirements for the System and Associated Infrastructure	Personnel and Funding for ESOH
What are the mishap rates for class B and C mishaps during the reporting period, and how many class A mishaps for the system or subsystem occurred during the current calendar year? Green – No class A mishaps; no increase in mishap rates for either class B or C as compared to the prior calendar year Yellow – No class A mishaps; Mishap rate increasing for either class B or C mishaps as compared to the prior calendar year. Red – One or more class A mishaps reported in the current calendar year class A mishaps reported.	What is the highest risk category, are there any system level hazards with formally accepted high risks, and are there any system level hazards without formal risk acceptance? Green – No hazards with formally accepted high risks and no hazards without formal risk acceptance Yellow –One or more hazards with formally accepted high risks, or any hazards with medium and low risks that have not been formally accepted Red – One or more hazards with serious or high risks that have not been formally accepted	How many open technical data change requests (e.g. Technical Orders, Technical Manuals, etc.) have been submitted through the formal technical data change system to resolve hazardous material or safety issues for the system? Green – All open requests were received during the last six months Yellow – One or more requests has been open for six – 12 months Red – one or more requests have remained open for more than 1 year.	What is the level of effort (LOE) in man-years (recurring) expended by the program (organic, matrix, and contract) for environment, safety, and occupational health (ESOH) management? Green – constant LOE compared to the prior fiscal year. Yellow – decreasing LOE compared to the prior fiscal year. Red – zero LOE

Activities: Evaluation Criteria

ESOH Hazard Identification, Analysis, and Risk Acceptance Category across all Phases

Acquisition, Technology and Logistics

Concept Refinement	Technology Development	System Development and Demonstration	Production and Deployment	Operations and Support
Is there a Preliminary Hazard List (PHL) developed for each concept and is it used in developing the Analysis of Alternatives (AoA)? Green – Yes Yellow – Incomplete PHL or complete PHL, but not used to influence the AoA Red - No	Does the updated PHL evaluate enabling/critical technologies? Green – Yes Yellow – Some, but not all, of the enabling/critical technologies have been assessed for ESOH hazards Red - No	Are the appropriate levels of hazard analyses completed and presented at each major design review? For example, is the Preliminary Hazard Analysis (PHA) completed and status of hazards presented at Preliminary Design Review (PDR), the majority of hazard analyses completed and presented at Critical Design Review (CDR), and status of ESOH risks presented at Production Readiness Review (PRR)/System Verification Review (SVR)? Green – Yes Yellow – Not all the necessary hazard analyses have been completed, and/or presented at the design reviews Red – No, hazard analyses have not been completed in time to influence the design review process	Has the program (1) continued to evaluate the system's test and operational performance to identify new hazards, (2) continued to track all hazards, and (3) obtained formal acceptance, at the appropriate management levels, of all residual ESOH risks and communicated those risks to the receiving activities? Green – Yes Yellow – Satisfying two of the three criteria Red – Satisfying one or none of the three criteria	What is the highest risk category, are there any system level hazards with formally accepted high risks, and are there any system level hazards without formal risk acceptance? Green – No hazards with formally accepted high risks and no hazards without formal risk acceptance Yellow –One or more hazards with formally accepted high risks, or any hazards with medium and low risks that have not been formally accepted Red – One or more hazards with serious or high risks that have not been formally accepted

Activities: Evaluation Criteria

- Published an OSD Guide version 1.0
  - Technical and Program Reviews (self assessment)
  - Milestone Review Process (oversight assessment)
- Working with AT&L SSE to incorporate into the Defense Acquisition Program Support (DAPS) SE Assessment Methodology
- Include in:
  - Acquisition Community Connection, Defense Acquisition Guidebook, DAU curricula

Questions?

Trish Huheey

ODUSD(I&E) Acquisition ESOH Lead

(703) 604-1846

patricia.huheey@osd.mil

ODUSD(I&E) Perspective

- Integrating ESOH considerations into systems engineering early in the acquisition process:
  - Protects military and civilian personnel by reducing hazards/risks to personnel and equipment
  - Reduces accidents proactively
  - Improves warfighting capability and combat readiness
  - Reduces total ownership costs
  - Lowers risk of environmental damage
  - Prioritizes hazards for corrective action
  - Reduces need for system retrofits

Activities: MIL-STD-882

- MIL-STD-882D, FEB00, DoD Standard Practice for System Safety
- Use of “D” version is mandatory for DoD
- Product of Specs & Stds reform
  - 7 of 26 pages mandatory
  - Prescribes “What” not “How”
  - Not popular with many System Safety practitioners
- Preparing Activity sent out final draft “E” version out for informal review
  - Significant departure from MIL-STD-882D
  - G-48 “E” version seeks to restore lost guidance on "How" from "C" rejected during Acquisition Reform
- DoD Acquisition ESOH IPT asked to review by Lead Standardization Activity

Interactive Visualization Development For Rapid Response

Therese Metcalf

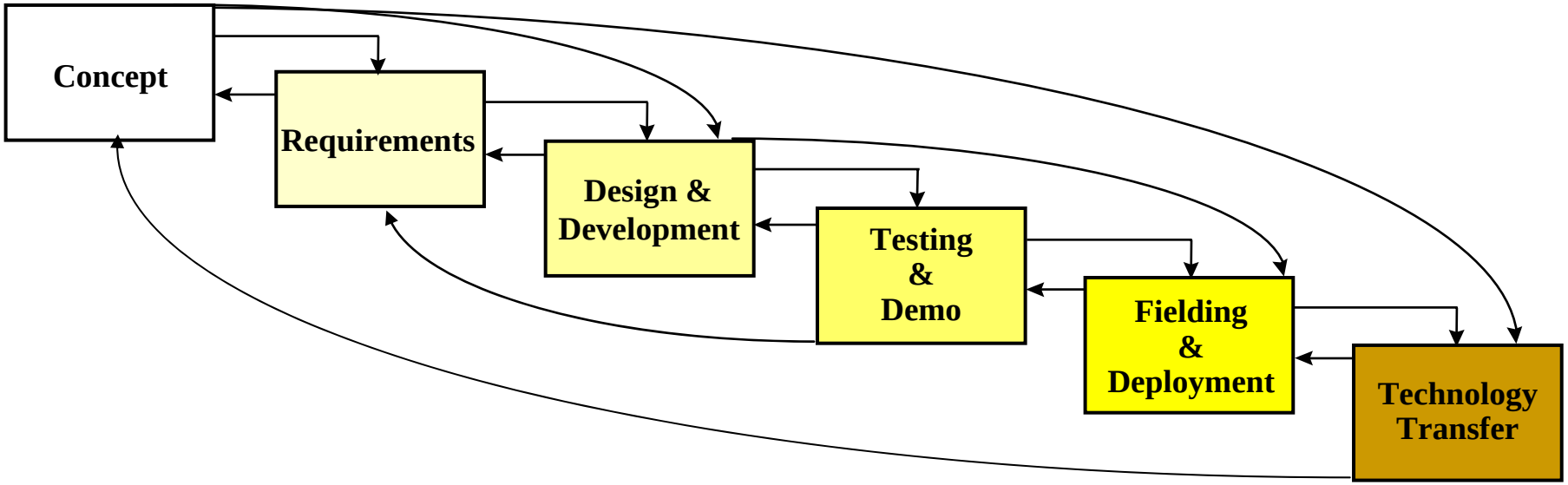
October 2006

Approved for Public Release; Distribution Unlimited - 06-1271

MITRE

© 2006 The MITRE Corporation. All rights reserved

Overview - Modified Systems Development Approach



- Accelerated system engineering process presented through an example development effort

© 2006 The MITRE Corporation. All rights reserved

Concept – Problem/Solution

- **Problem: No global view of Computer Network Defense (CND) status – Results in limited data for decision making and lack of integrated defense tactics**
  - **Limited data presentation integration**
  - **Fragmented situational awareness**
  - **Need for overall understanding**
  - **Lack of global visualization**

Current data is disparate and presented in a tabular format limits quick assessment

Differing products present their unique, but restricted view of the global situation

- **Capabilities not available in Commercial-Off-The-Shelf (COTS) software**
- **"The [display] requirement has been around since day one of the mission inception**

Basic Data (Data Points)
→ **Information (integrated display)**
→ **Knowledge (layered Information)**
→ **Understanding (scenarios)**
→ **Decision Making (response)**

Solution: Interactive three dimensional (3D) Graphical User Interface (GUI) display presenting a fusion of actual NetD attack status in real-time across the cyber domain, enhancing user perception of dense defensive Information Warfare (IW) data for situational awareness, quick assessment, decision-making, and immediate response to experienced threat activity

Requirements - Tracking

- #: Requirement tracking number
- Requirements: A brief description
  - White: Open Requirements
  - Gray: No longer relevant, OBE
  - Blue: Details TBD, Priority 5
  - Green: Implemented & Tested
- Suggestion: description of enhancement provided by a user –
- Modules: Requirement applied to
- Related Modules: Potential module(s) effected
- Priority: Original & New Priority
  - 1: Immediate, next release
  - 2: Following release
  - 3: Will be completed in designated timeframe if enough resources
  - 4: Will investigate possibility
  - 5: Will consider in the future
  - D: Delivered in operational prototype
- Source: Requirement submitter
  - UD: User Derived Requirement
  - DD: Developer Derived Requirement, may be suggestions from the field or the Display team
- Status Type: The status of the suggested enhancement
  - Reviewed: By Display Team, disposition indicated
  - Evaluation: Under evaluation by Display Team
  - Pending: Evaluation by Display Team
- Disposition:
- Release: Version requirement will be included within
- Questions/Comments
- Query: Query tool required
- Wks: Weeks to work

© 2006 The MITRE Corporation. All rights reserved

User Derived Needs

Requirements

- First glance should tell overall health and what's up and what's down (i.e., core services)
- Want as much information presented as possible (i.e., aggregation) on one screen
- Global display that provides a status of alerts and sensor status
- Pull data and consolidate relevant facts into an integrated display (i.e., provides summary information by layer – e.g., TCP/IP model)
- Drill down for additional information
- Accurate and timely, to include IW and general status notifications
- Easy on the eyes (i.e., salience)
- Standardized views
- Easy to use (i.e., intuitive - not much training needed, people are changing all the time)

© 2006 The MITRE Corporation. All rights reserved

Community Requirements

- **Primarily**
  - Situational Awareness/Common Operational Picture (COP)
  - Dynamic Performance Monitoring
  - Ability to centrally monitor and collect configuration information
  - Need visualization tools for analyst, operator, and decision support and effective indications and warnings
- **Secondarily - Related**
  - Computer Network Defense (CND) Concept Exploration
  - Dynamic Mapping of Systems and Connections
  - Need to provide commander with positive control of information resources
  - Need to prioritize and dynamically allocate access
  - Need ability to centrally manage security posture of enterprise applications and equipment
- **Other Efforts**
  - Present different views of managed objects on the display to meet the need of users
  - Provide multiple level drill-down capabilities (additional linkages to be established between modules in the future for
  - Provide the capability of launching element managers and other network/system managers for a physical object
  - Present information associated with the managed objects including object dependency data

© 2006 The MITRE Corporation. All rights reserved

Human Machine Interface (HMI) Factors

- User Interface: Specification of a conversation between the user and the computer
  - GUI
  - Display
  - Zones
  - Messaging
  - Dialogue Tone and Terminology
  - Function Keys
  - Color Selection
- Reporting: Major output functionality, accuracy and clarity are fundamental, focus on formatting and generation
- System Functionality: Applicability of functions, data capture and format, processing capabilities, and system support to retain usefulness
  - Usability
  - Processing
  - System Errors
  - Data
  - Audio Outputs
  - Maintenance
- Support Documentation & Training: Proper and effective use, complete routine and unique tasks, and troubleshoot problems
  - System Documentation
  - Training and Training Material

© 2006 The MITRE Corporation. All rights reserved

HMI Considerations

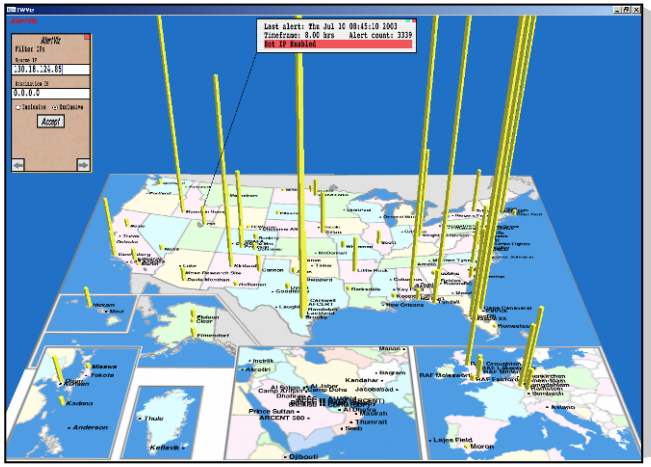
- User should expect:
  - To be aware of what to do next
  - To know system expectation
  - Data checking--has been entered correctly or not
  - Explanation of delays
  - Task completion notification
  - Standardized formatting, information, instructions
  - Messages appear in the same general area and remain long enough to ‘read’ them
  - Dialogue be limited to one idea per frame, whether paging or scrolling through the zone

- Criteria:
  - Ease of use
  - Human Factors Engineering
  - Documentation
  - Training
  - Security
  - Maintainability
  - Reliability
  - Interoperability

© 2006 The MITRE Corporation. All rights reserved

Operational Platform Requirements

- **Best viewed on a large screen display**
  (Note: plasma screens have burn in issues)
- **High-end graphics card:**
  - **ATI Radeon**
  - **Visiontek NVIDIA GeForce**
  - **Appian Jeronimo Graphics Card**



- **Personal Computer (PC) based systems**
  - **Desktops**
    (e.g., Dell Dimension)
  - **Laptops**
    (e.g., Dell Inspiron)
- **Windows Operating Systems (OSs)**
  - **XP (Experience)**
  - **Windows 2000**
  - **NT (New Technology)**



© 2006 The MITRE Corporation. All rights reserved

Systems Design and Development

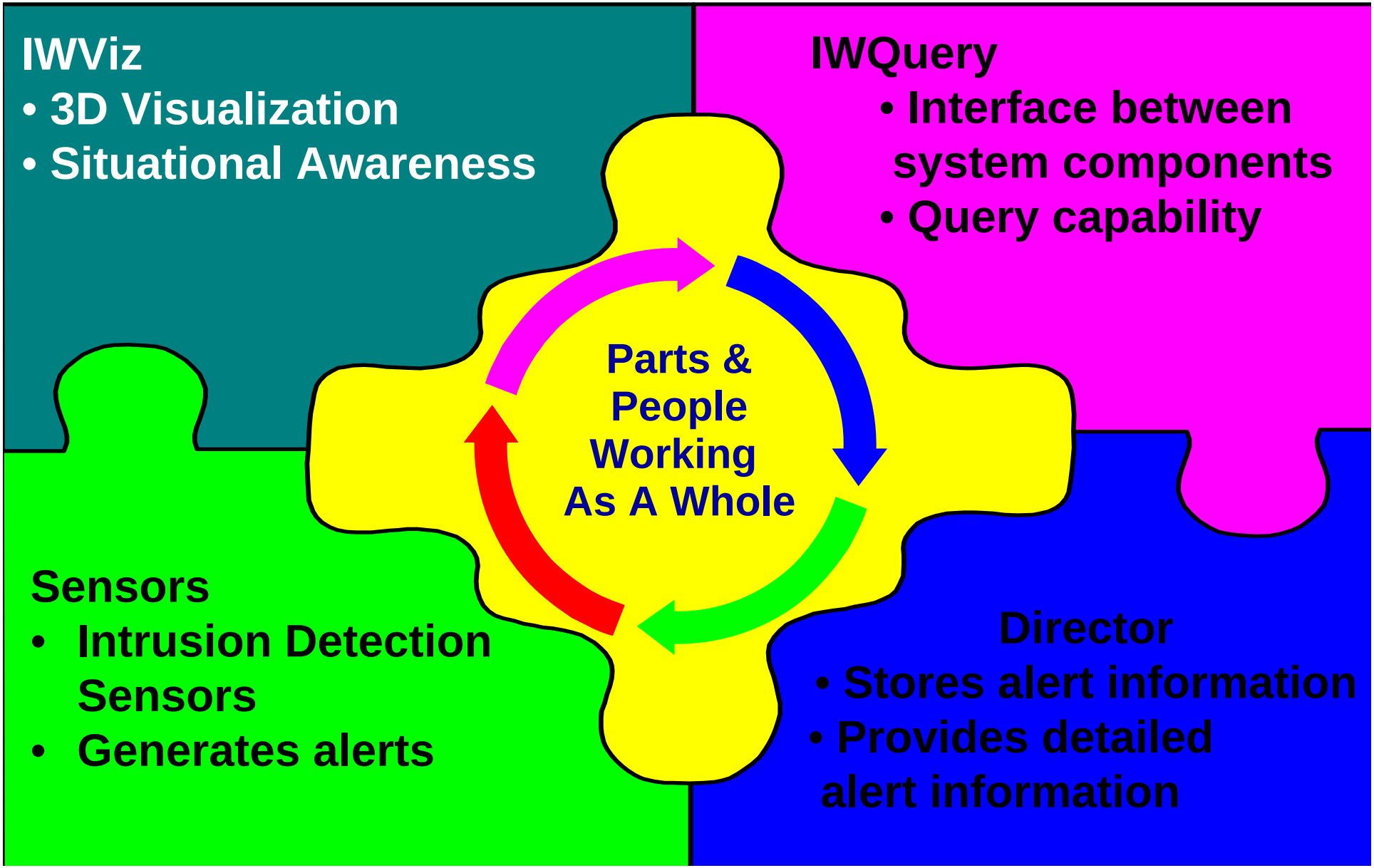
Design & Development

- Identify related components and needed integration
  - Conflicts
  - Similarities
- Breakdown the problem into workable modules
  - Alert Visualization (AlertViz) provides global alert visualization
  - Exploration Visualization (ExViz) provides the same data with queried data for specific time frames
  - Connection Visualization (ConnViz) provides connection log visualization in a grid sorted by Source (Src) or Destination (Dst) Internet Protocol (IP) on one axis, time on a second axis, and quantity of connections in the third axis
- Prioritize development focus based on requirements
- Design to Concept - Provide a viable 3D-display prototype to meet network operational needs
- Interactive development – Frequent updates – Quick turn around

© 2006 The MITRE Corporation. All rights reserved

Integration

Design & Development



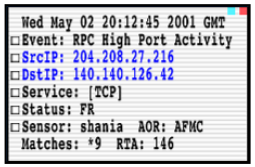
AlertViz

Design & Development

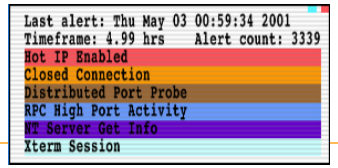
- **Represent Alerts:**
  - Cubes over designated sites
  - Information Window containing relevant alert data
  - Date and time of last alerts received and destination location indicator
- **Usability:**
  - Configurable files for tailoring
    - Filter designators and descriptors
    - Coordinates (e.g., site latitude/longitude)
    - Sensor collectors
    - Hot IP list with blinking option
  - User selectable color coding
  - Point and click/auto data fill
  - User defined profiles
  - Visual sizing

- **Alerts filtered on:**
  - String Match Events (e.g., BAD_PASSWORDS)
  - Events (e.g., Distributed Port Probe)
  - Protocols (e.g., Transmission Control Protocol [TCP])
  - Source or Destination IP
  - Area of Responsibility (AOR)
  - Sensor

General Information Window



Last Alert Information Window



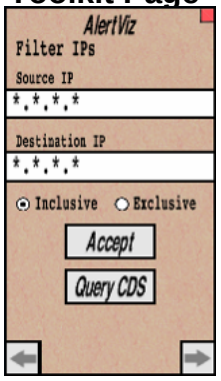
Area of Responsibility Toolkit Page



Events Toolkit Page



Filter IPs and CDS IP Search Toolkit Page

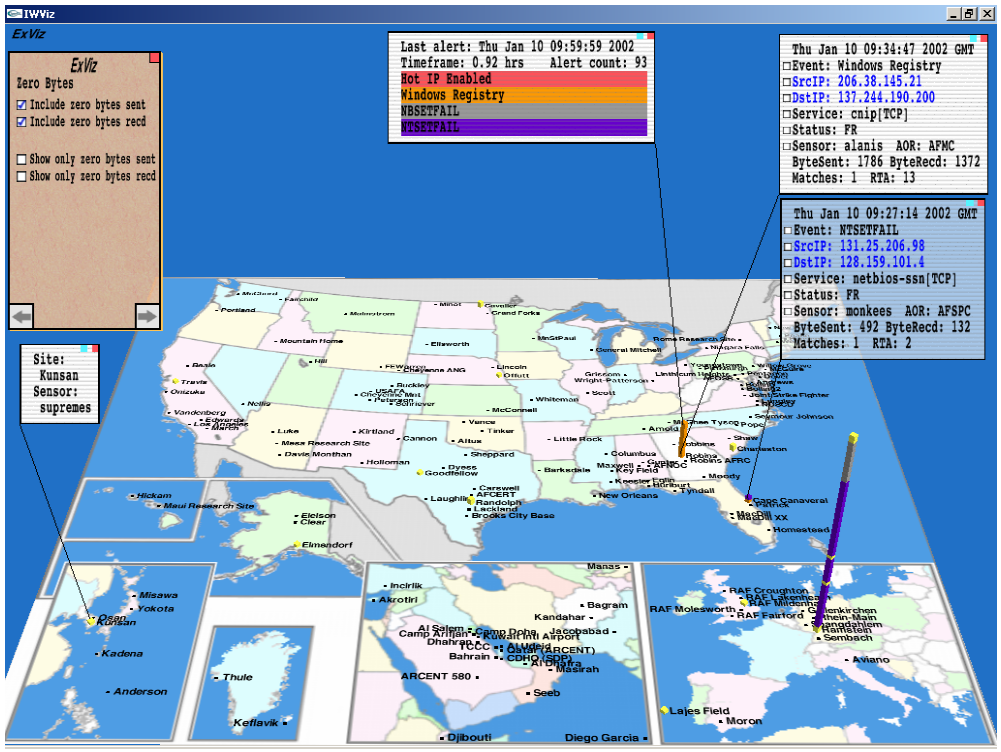


© 2006 The MITRE Corporation. All rights reserved

ExViz

Design & Development

- Includes all functional capabilities included on the AlertViz module as well as:
  - Information Window containing bytes sent and received
  - Date and time of last alerts received and destination location indicator
- Query capability on:
  - Source IP/Destination IP
  - Date
  - Time range
  - Status
  - Bytes transferred
  - Destination Port #



- Alerts filtered on:
  - Capabilities included on the AlertViz module
  - Zero Bytes Filtering

MITRE

© 2006 The MITRE Corporation. All rights reserved

Testing & Demonstration

Testing & Demo

- IWViz Functionality
  - Installation
  - Configuration
  - Starting Up
  - Shutdown
  - Modules
  - Popup Menubar Operations
  - File Options
  - Profile Options
  - Tools Options
  - Display Options
  - Filters Options
  - Windows
  - Navigation & User Interface
  - Maintenance
- Test Areas Covered
  - Module
    - AlertViz (A)
    - ExViz (E)
    - ConnViz (C)
  - Unit
    - Date
    - Pass / Fail
    - Tester
  - System
    - Date
    - Pass / Fail
    - Tester
    - Regression Date
    - Pass / Fail
  - Government Acceptance
    - Date
    - Yes / No
    - Approver
  - User Acceptance
    - Date
    - Yes / No
    - Approver

Fielding and Deployment Activities

Fielding & Deployment

- Pre-Deployment Activities (Preparation)
  - Coordination activities
  - Build contact list and locations
  - Interim Certificate to Operate (ICtO) approval
  - Prepare platform and support documents
  - Survey requesting configuration information
  - Baseline software
  - Coordinate travel with Points of Contact (POCs)
  - Accreditation
- Deployment Activities (Fielding)
  - General briefing
  - Check setup and configuration (e.g., Director connection)
  - Test run setup
  - Train target users
  - Review System Change Request (SCR) process
  - Question and Answer (Q&A)/collect initial comments
  - Out brief
- Post-Deployment Activities (Sustainment)
  - Update deployment process
  - Prepare after action report
  - Follow-up on submitted enhancements
  - Send out software and documentation updates to deployed locations
  - Review CND visualization needs and support options
  - Provide maintenance and help desk support
  - Finalize documentation – worked throughout process

© 2006 The MITRE Corporation. All rights reserved

Deployment Rationale

Fielding & Deployment

- IWViz offers capabilities not available in Commercial-Off-The-Shelf (COTS) software
- No licensing fees
- Satisfies Intrusion Detection System (IDS) related visualization requirements
- Conditions—Provides prototypes to users "as is" with ongoing support from government sponsor until successful sustainment transition occurs, currently:
  - Working assessment of network impact or interoperability—
    None expected or experienced in the laboratory operation
  - User's manual provided—
    Includes setup directions
  - Training provided—
    Initially at deployment, On-The-Job, Call in technical support
  - Initial load and configuration—
    Users to support updates and new version installs

© 2006 The MITRE Corporation. All rights reserved

Technology Transfer

- IWViz moved from the prototype stage and was ready to migrate to an operational technology
  - MITRE not chartered or staffed to provide product sustainment
  - Necessary to implement an IWViz technology transfer plan
- Concerns
  - Intellectual Property
  - Conflict of Interest
  - Legal & Ethical (Contact)
  - Lose of Direction
- Select best way forward
  - Which is the easiest and least confining?
  - Which ones do we want to pursue, could be one or many?
- Options
  - Commercial License – Nonexclusive: Can require them to give back copies
    - We transfer the software directly to selected companies
    - Sponsor transfers the software to contractors and/or companies
  - Open Source
    - Need Public Release
    - Open to all folks national and abroad
    - Hard to track who has it
  - Cooperative Research And Development Agreement (CRADA) – Joint government/industry R&D partnerships which share resources
  - Industry Standards – Influence
  - External Publications – Public domain

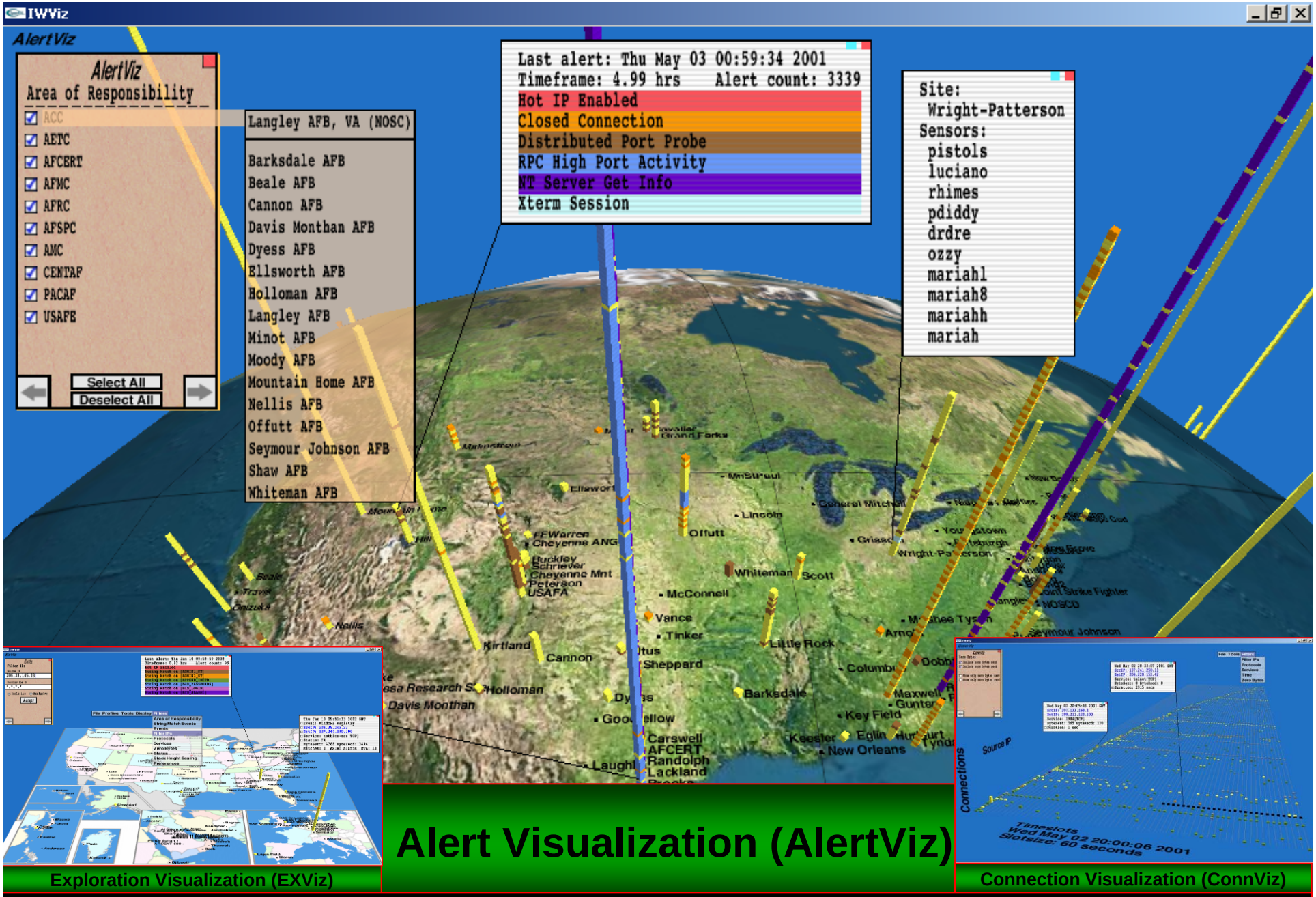
© 2006 The MITRE Corporation. All rights reserved

Growing Interest in Technology Transfer

Technology Transfer

- Venture investors looking for solid technology underpinnings in investment opportunities—reaction to dot com era mistakes
- Research institutions increasingly willing to partner with venture community for additional revenue opportunities
- Homeland Security and other government initiatives driving interest in potential applications of advanced technologies being developed in research institutions
- Mid-Atlantic technology commercialization organizations ideally positioned at the crossroads of industry and government technology hubs
- Tech transfer still relatively new (Bayh-Dole Act passed in 1980)

© 2006 The MITRE Corporation. All rights reserved



Exploration Visualization (EXViz)

Alert Visualization (AlertViz)

Connection Visualization (ConnViz)

Real time situational awareness allowing for quicker response in decision making

Allows for initial situational assessment and predictive support

Primary Support Team

- Therese Metcalf—Technical Lead-MITRE
- Ken Beyer—Government Project Lead
- Dr. Mike Wingfield—Lead Developer-MITRE
- Tim Farias—Testing & Technical Support-MITRE
- Interface Developer—Varied Government Support
- Users—Government Personnel

© 2006 The MITRE Corporation. All rights reserved

Assistant Secretary of Defense for Networks and Information Integration/ DoD Chief Information Officer

Mr. Mike Kern
Deputy to the ASD(NII)/DoD CIO
Enterprise Wide System Engineering



EWSE | Enterprise-Wide Systems Engineering

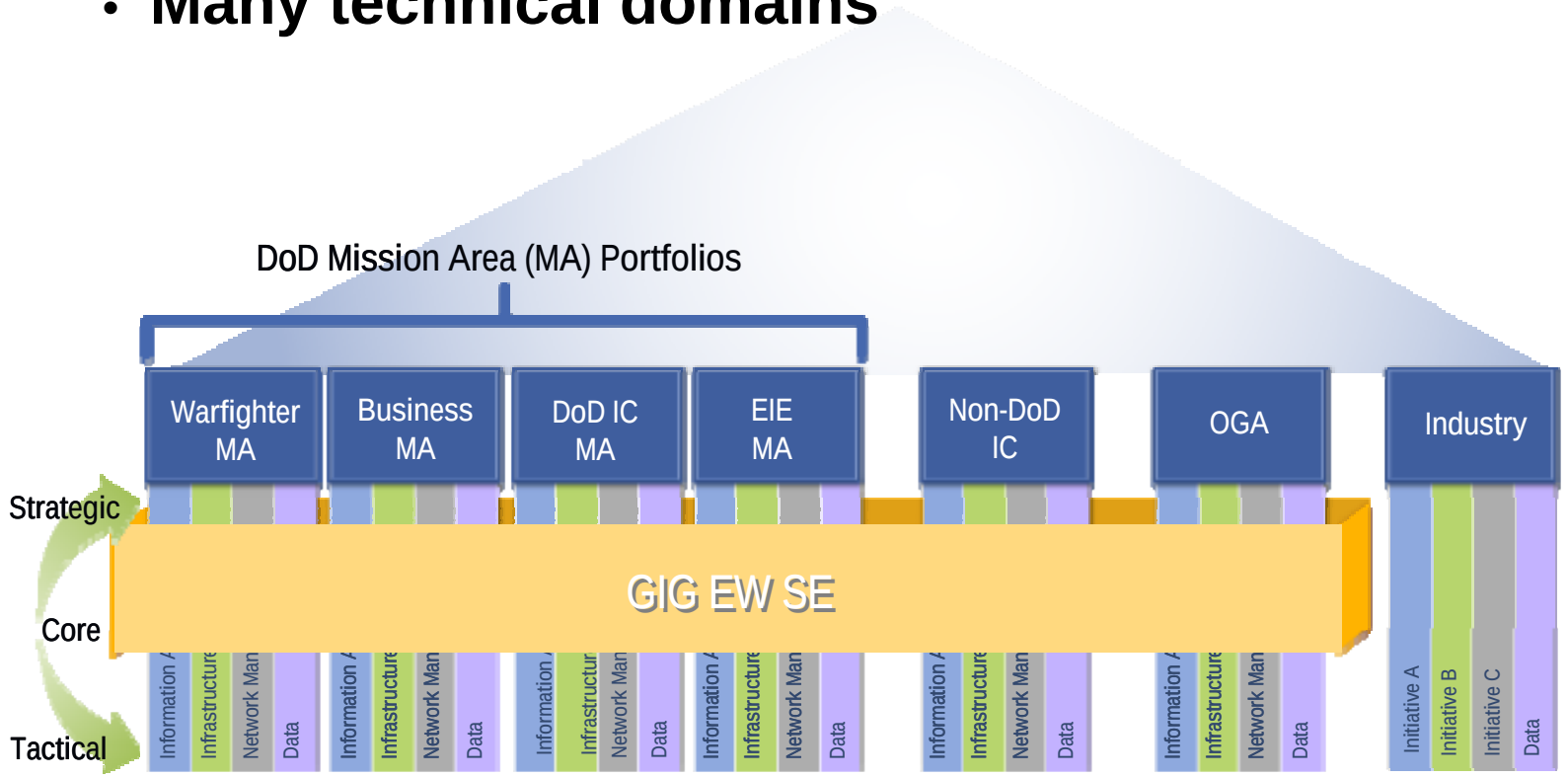
Spanning the Government and the Globe

GIG EW SE Mission

Ensure the GIG meets the End-to-End *interoperability and performance* requirements needed to support DoD business, intelligence, enterprise information environment and war fighting operations.

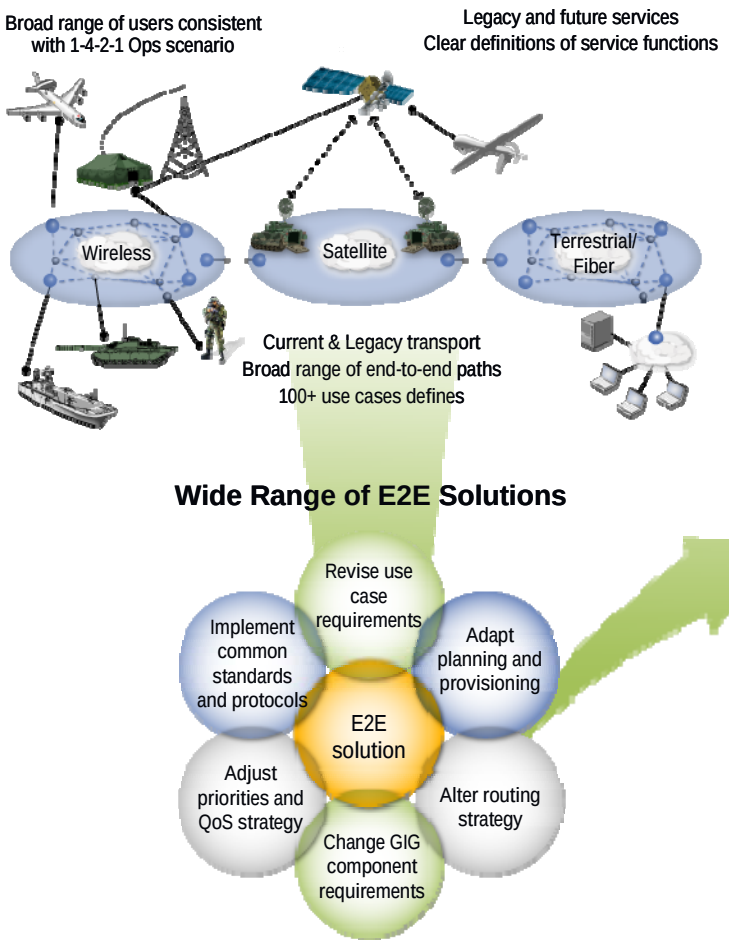
Global Information Grid EW SE Environment spans across...

- **The entire Federal Government**
- **Multiple programs and statutory authorities**
- **Many technical domains**



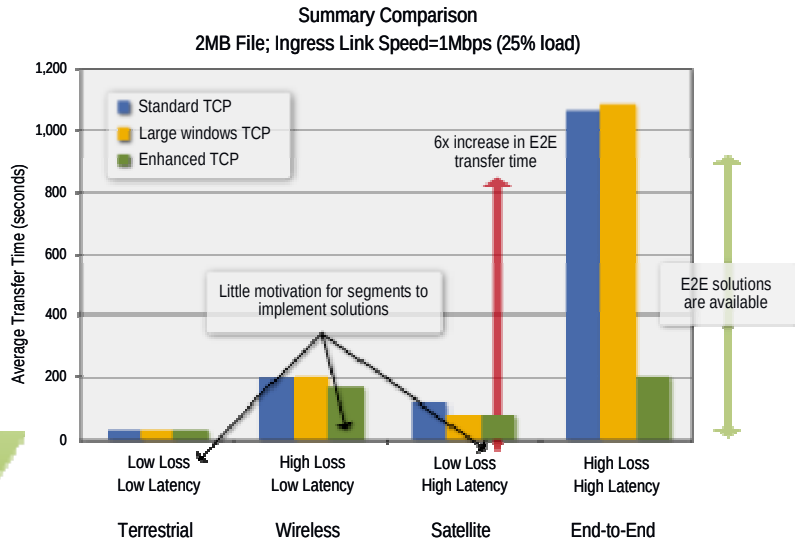
GIG EW SE Challenge - Ensure technical integrity, interoperability, and performance across the GIG

Packet Level End-to-End (E2E) Models



Wide Range of E2E Solutions

Significant E2E Performance Reduction



Individual network / program solutions DO NOT ensure E2E performance

EW SE Approach - Lead a community effort to enable a portfolio decision process to:

- Provide **EW SE services needed to oversee** GIG evolution
- Maintain a GIG **enterprise-wide coherent technical and operational baseline to insure interoperability**
- Establish GIG enterprise-wide **analysis capabilities for E2E Performance Assessment**
- Oversee GIG enterprise-wide **experiments & federated emulation/test**
- Establish a GIG **compliance management** program

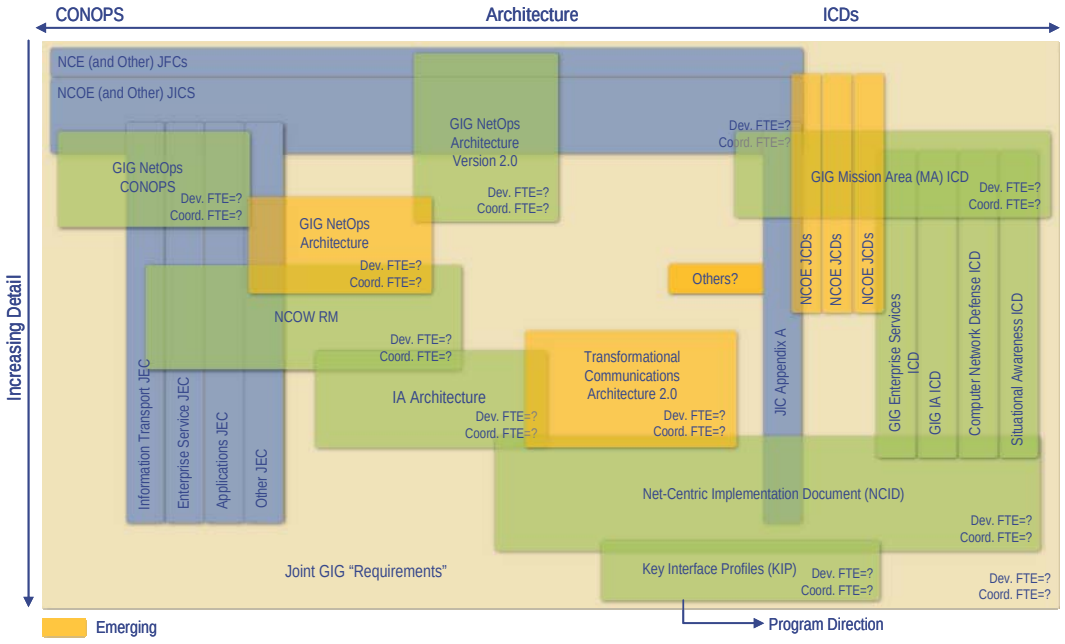


EW SE

Maintain a GIG EW coherent operational and technical baseline

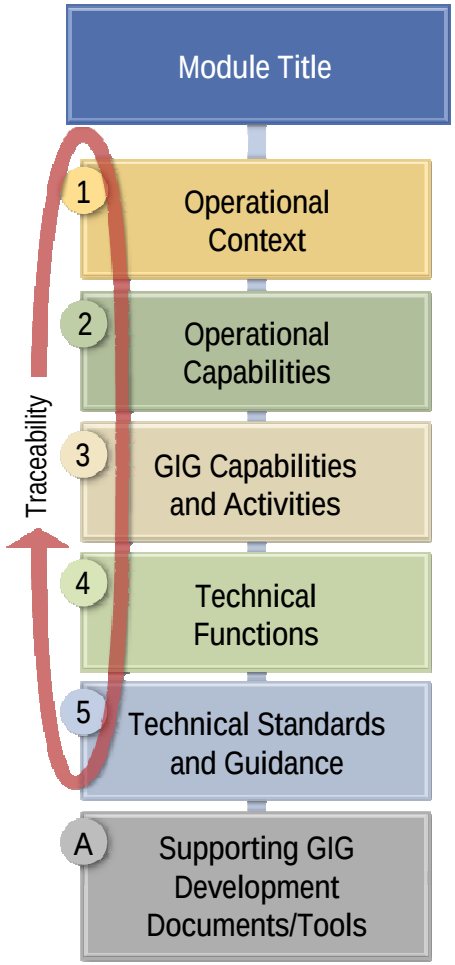
Align documentation framework for Program Managers

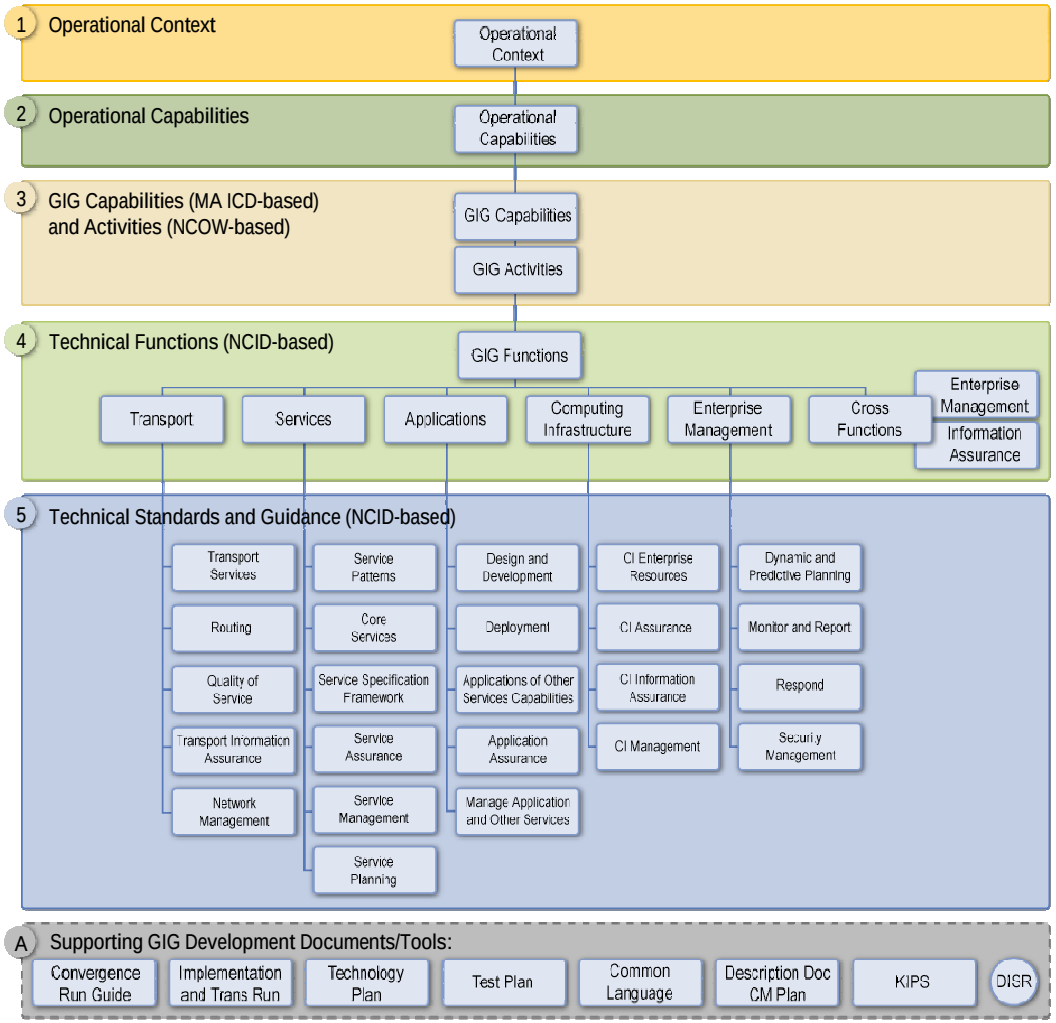
- GIG description **documentation is unclear**
- Test plans **difficult to develop**
- **Weak linkage** to operational needs
- Business and Intelligence mission areas **not currently included**
- ~7000 pages of conflicting guidance





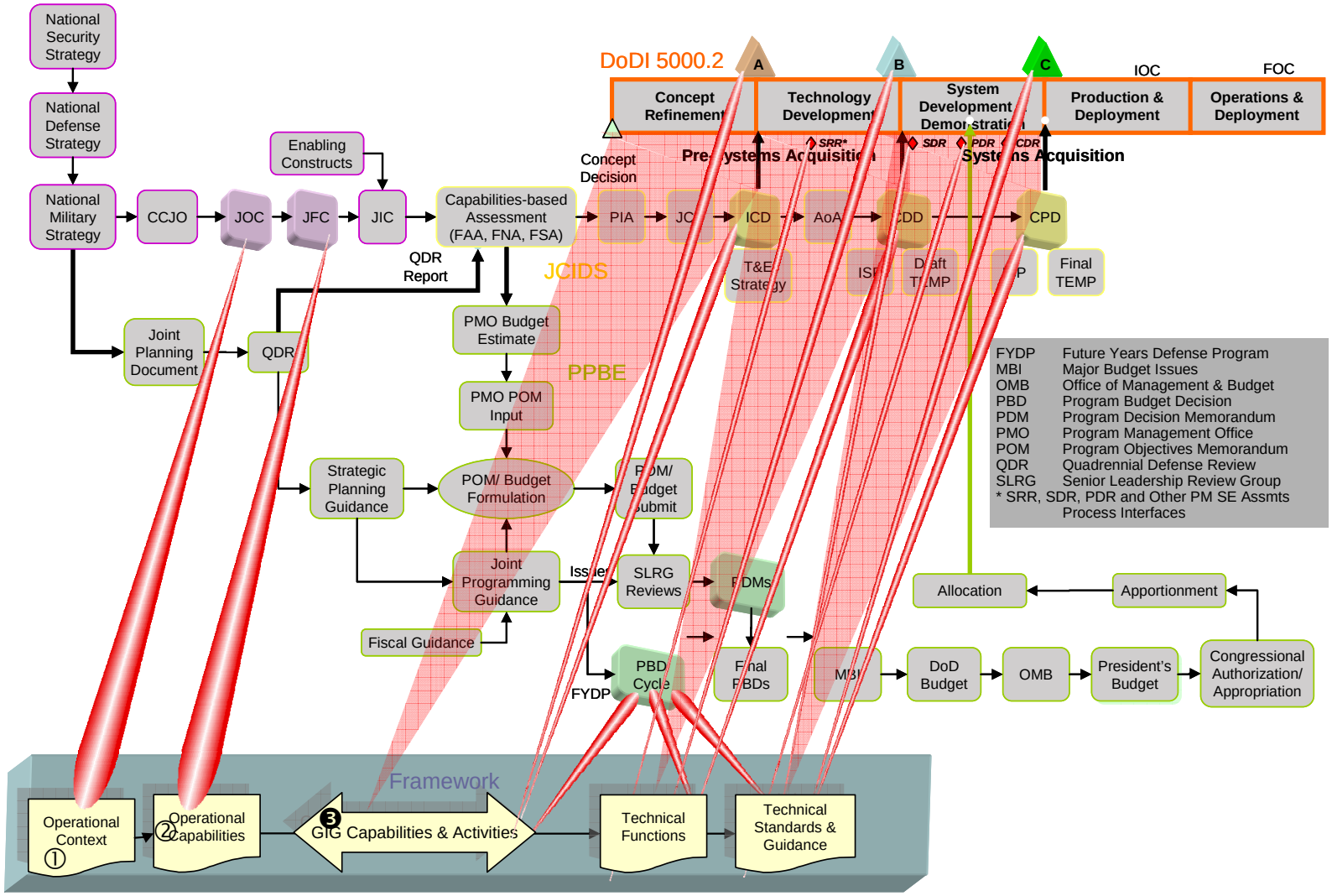
New Coherent operational/technical baseline improves stability and raises confidence in guidance



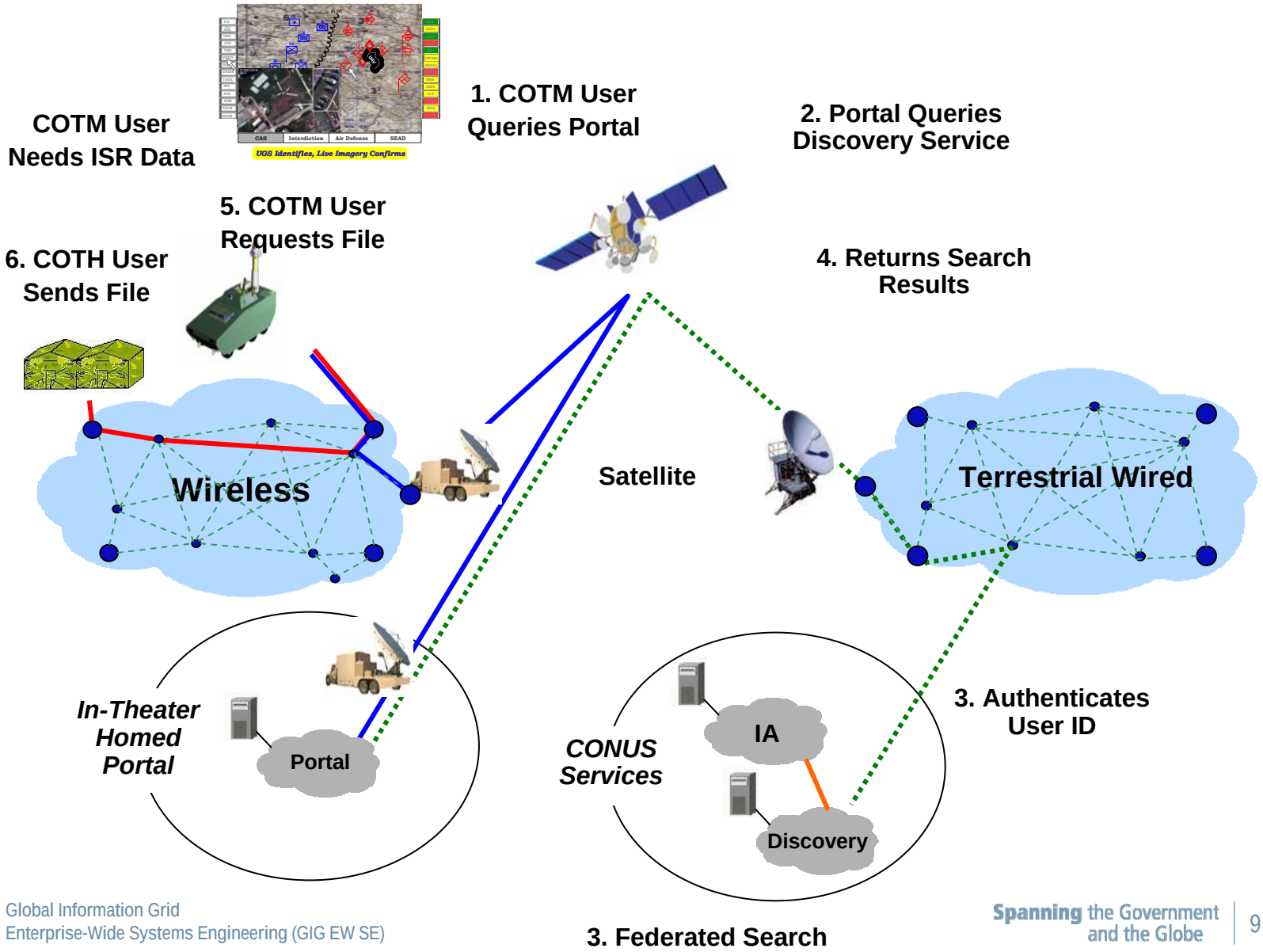


Revised framework will provide structure and traceability similar to that of a document tree

New Baseline feeds directly into established oversight and decision processes



End-to-End Performance - why is it so complicated?



GIG performance questions across the community

- End-User
  - Which applications can I successfully use over the GIG?
  - What performance can I expect on GIG?
  - Which technologies should I employ?
  - What are the impacts of different operating conditions?

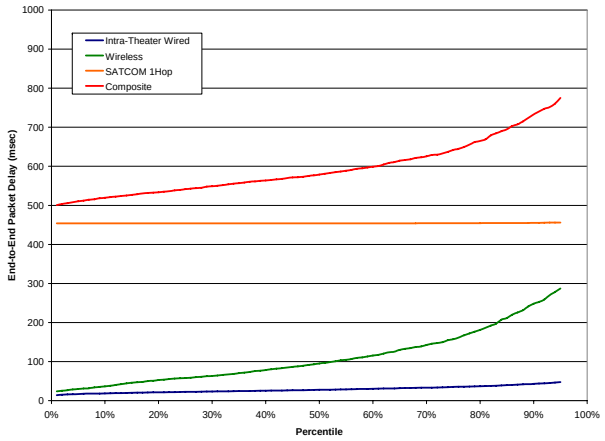
- Transport Developer
  - What service and applications must I support?
  - Is the E2E performance acceptable?
  - What are inter-segment interface impacts?
  - What are the E2E impacts of segment performance trades?

- Application & Services Developer
  - How will my application perform across the GIG?
  - Is the E2E performance acceptable?
  - What are acceptable service architectures?
  - What are the E2E impacts of protocol and messaging trades?

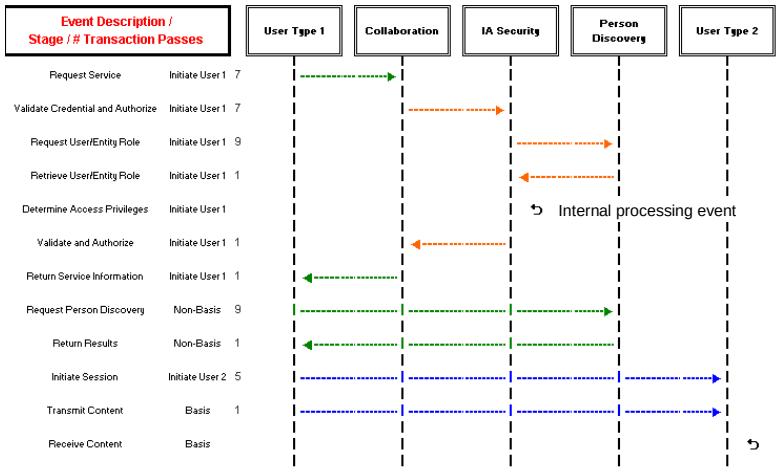
- Operator
  - Where should servers be deployed?
  - What are acceptable operating loads?
  - What SLA performance do I need?

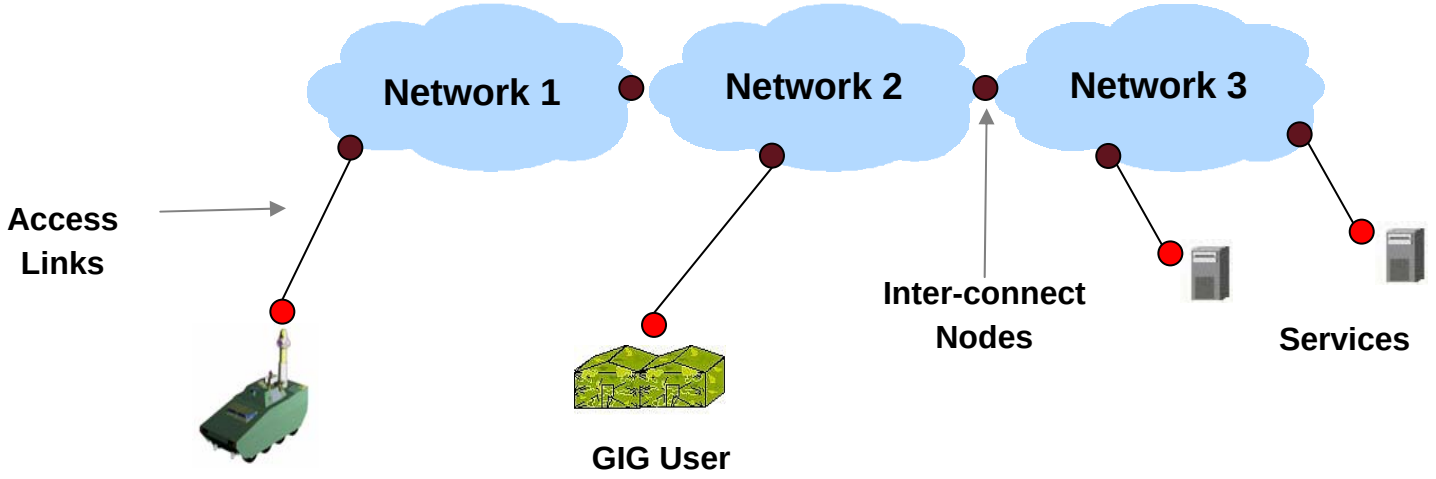
Performance Assessment Framework highlights critical problems to guide end-to-end trades and implementation

Composite Network Performance

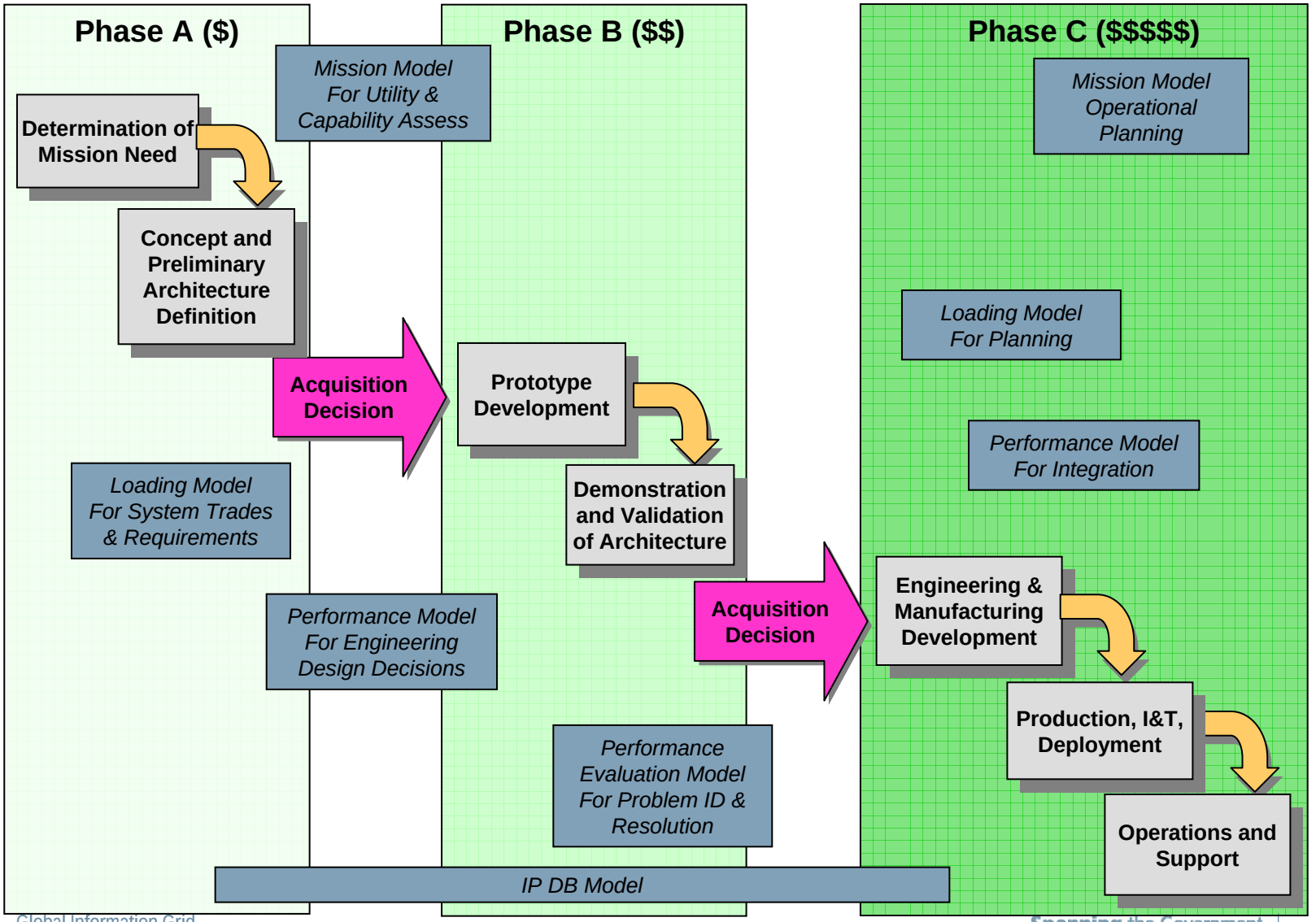


Application & Service Messaging





Global Information Grid analysis, emulation and test in the acquisition lifecycle

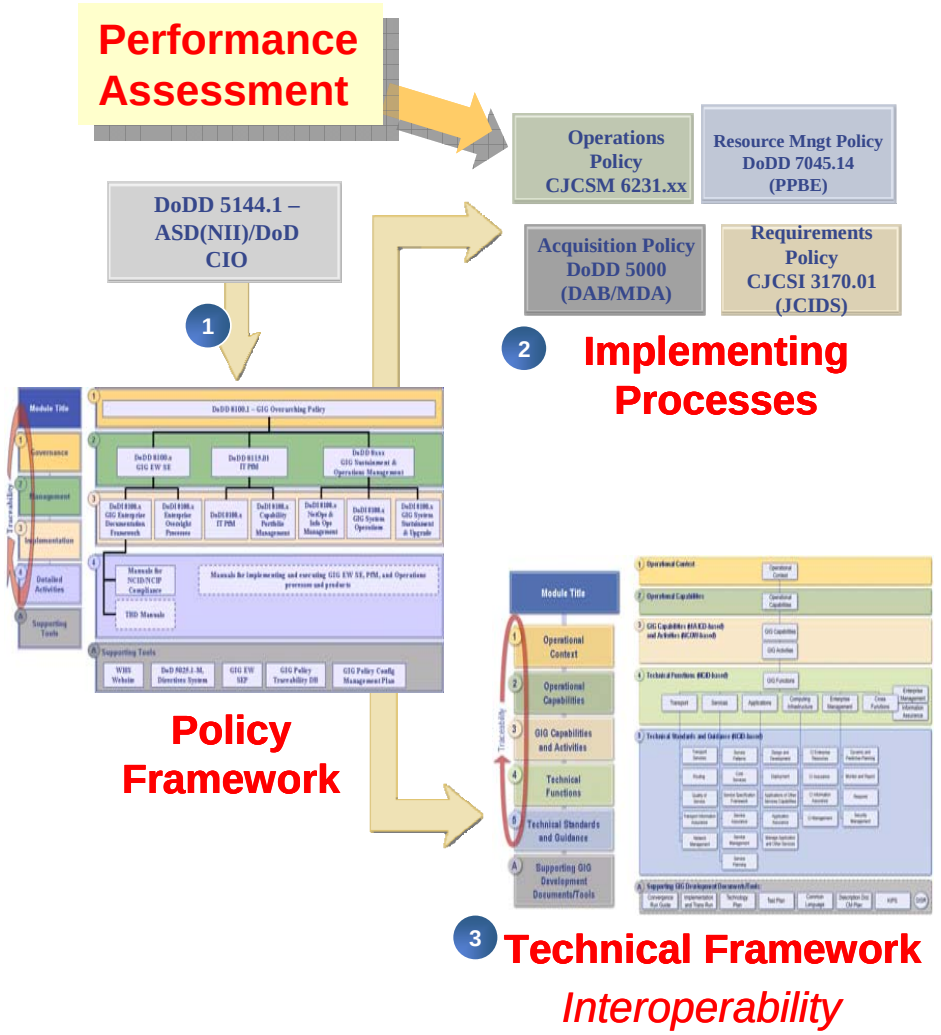


Summary - EW SE provides the Technical Framework for DOD's GIG Business Process Improvement

1. **DoDD 5144.1 provides DoD CIO authority and responsibilities for defining and implementing GIG**

2. **GIG Policy must support existing decision processes (Requirements Generation, Acquisition, Budget and Operations) beyond-GIG**

3. **GIG Policy establishes authority for *EW SE processes* and *GIG Technical Baseline* development and establishes authority for *GIG program compliance* with Technical Baseline**



For further information...

- Dr. Tony DeSimone
  - Tony.Desimone@osd.mil
  - (703) 607-0344
- Mr. Ed Tavares
  - Edward.Tavares.ctr@osd.mil
  - (703) 607-0356
- ASD(NII) DoD CIO Web Page
  - www.dod.mil/cio-nii

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

New Perceptions in Coping with System of Systems (SoS)

Dr. Daniel Leshem

Corporate Chief Scientist

Rafael Armament Development Authority Ltd.,
Haifa, Israel

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

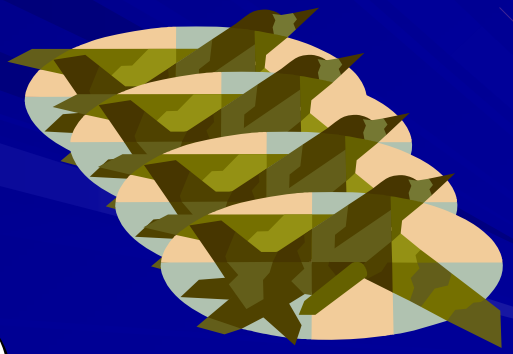
New Perceptions in Coping with SoS

- SoS Definitions
- OSoS Characterizations, Parameters and Types
- Rationale for Defense Industry Entry in OSoS Development
- OSoSE Versus Systems Engineering
- OSoSE Recommendations
- OSoS Management Highlights

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

How to Define SoS?

- Family of Systems? Enterprise SoS? Complex System? or Super System?
- For example: one fighter aircraft incorporates many systems, but SoS refers to entire squadron!



- To be clear, I propose the term

Operational SoS (OSoS)

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

Operational SoS Definition

Ensemble of platforms, armaments, equipment, C^4I, personnel, training and maintenance facilities.

These synergistically work together to achieve set of tasks within a defined mission, according to operational methodologies driven by combat doctrine

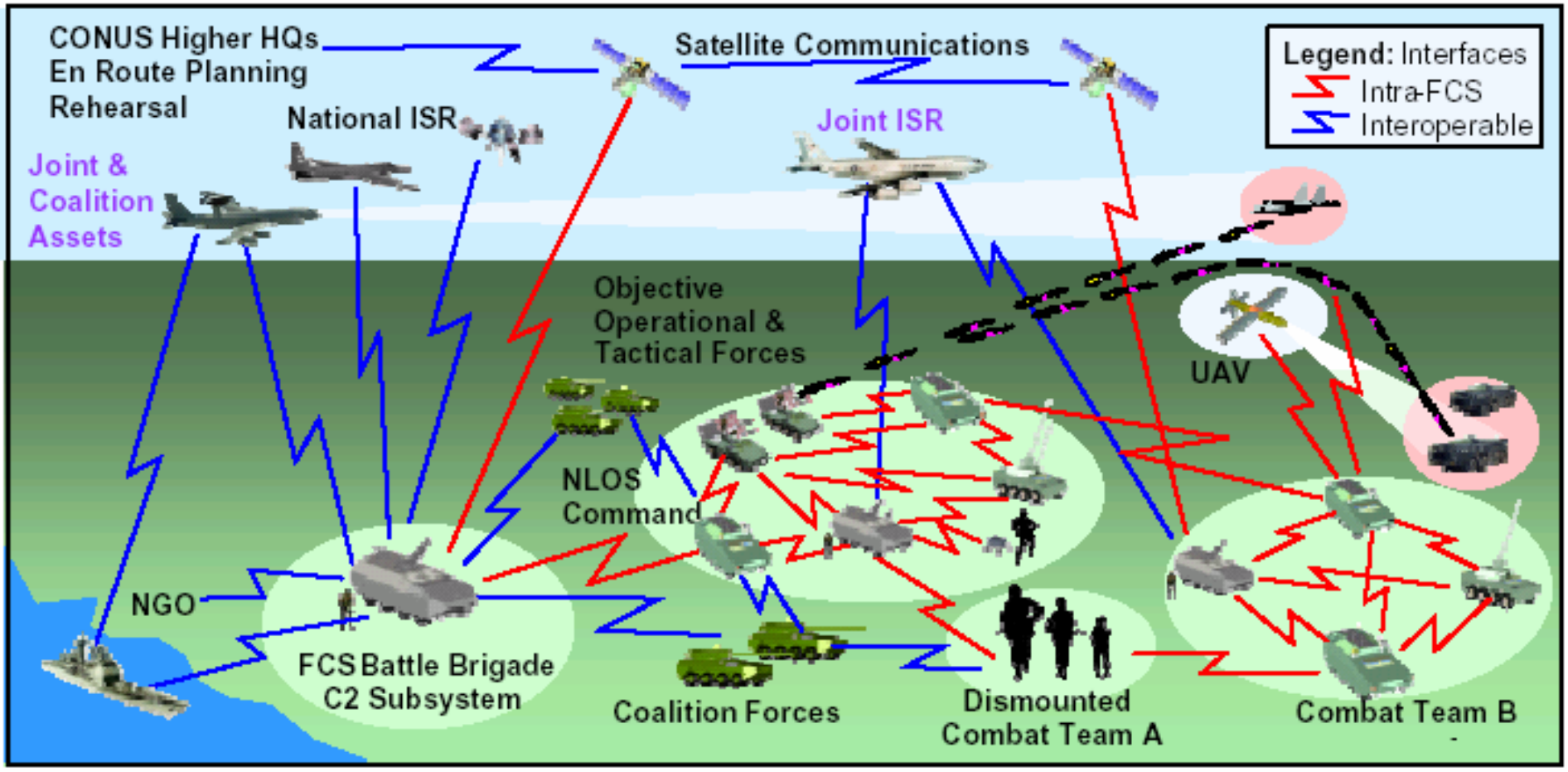
OSoS Example
FCS (Future Combat System)

- OSoS includes
  - Platforms
  - Weapons
  - C^{4}I2SR
  - Doctrine
  - Training facilities
  - Fighting Units
  - Soldiers
  - Maintenance
  - ILS
    (Integrated Logistic Support)



RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

FCS OSoS - Concept of Operations



RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoS Characterizations

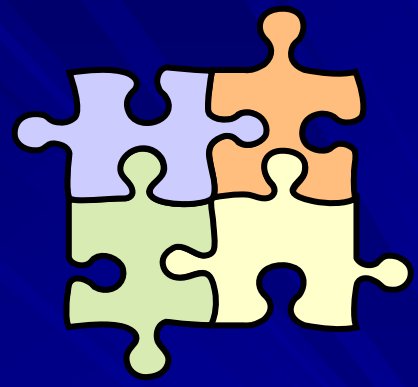
- Trained personnel are integral part of OSoS
- OSoS building blocks can be distributed at remote locations and interconnected by communication networks
- C^4I systems are critical "glue" for combining separate systems into OSoS



- Coordinated operation of all OSoS building blocks is key factor in effective and efficient mission accomplishment
- OSoS concept, architecture and capabilities are being consolidated in parallel with evolutionary development of its operational methodology

OSoS Types

- Dedicated vs Virtual OSoS



- Preplanned vs gradually-developed OSoS

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

Rationale for Defense Industry Entry into OSoS Development

- Defense market customers new attitude is to deal with OSoS - defining requirements, evaluating and ordering OSoS - and not separate systems

- Many advantages for main contractor
  - Increasing reputation as leading defense industry
  - Enabling direct interaction with customers including End Users
  - Improving opportunity to incorporate own advanced technologies
  - Improving own capabilities when coping with OSoS Systems Engineering (OSoSE)

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation and management
- Functional Analysis
- Interfaces definition
- Modeling and Simulation
- Defining and executing V&V
- Evolutionary behavior of OSoS
- Architectural analysis of OSoS
- Deep involvement of interested parties

OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation a[illegible]gement
- Fun[illegible]
- Int[illegible]
- Mo[illegible]
- De[illegible]
- Ev[illegible]
- Ar[illegible]
- De[illegible]

  - Very long processes together with interested parties and customers to refine concept
  - Early consolidation of Strategic Partners
  - Considerations of using state-of-the-art or just Foreseen Technologies
  - Starting interim developments to reduce risks and/or to verify new concept (usually the proven concepts become constraint in the full scale program)

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation and management
-
  - Very high level of complexity in consolidating requirements for new OSoS:
    - many customers with different interests,
    - evolutionary nature of development, and
    - necessity for interoperability
  - Requirements develop and are updated during entire OSoS life cycle
  - Connectivity and interfaces with neighboring OSoS under development
  - Advanced software tool is needed to handle the huge requirements scope (the original + derived ones) and their complex linkages

OSoSE vs Systems Engineering

- Starting an OSoS Program
- Requirements consolidation and management
- **Functional Analysis**
- Interfaces defi[illegible]
- Modeling [illegible]
- Defini[illegible]
- Evolu[illegible]
- Archi[illegible]
- Deep [illegible]

- **Processes, tasks and scenarios in OSoS are complex, involving many components**
- **These create interactive constraints and mutual effects**
- **Conclusion: Methodical Functional Analysis is critical for architectural consolidation of OSoS**

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starting OSoS Progra
- Requirements conso
- Functional Analysis
- **Interfaces definition**
- Modeling & Simulatio
- Defining and executi
- Evolutionary behavio
- Architectural Analys
- Deep involvement of

- **Systems Engineering defines mechanical, electrical, computational - connectivity and MMI interfaces**
- **OSoS provides upper layer of different types of scenarios and tasks: Physical: different configurations and Logical: different tasks**
- **Result: Different interface requirements for various applications**

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starting an OSoS Progr
- Requirements consolid
- Functional Analysis
- Interfaces definition
- **Modeling & Simulation**
- Defining and executi
- Evolutionary behavior
- Architectural Analysis
- Deep involvement of inter

- **Not possible to produce complete model of OSoS to simulate all its functionality as:**
  - **Infinite cases of possible events and scenarios included**
  - **Very difficult to simulate human behavior**

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolid
- Functional Analysis
- Interfaces definition
- **Modeling & Simulation**
- Defining and executing
- Evolutionary behavior c
- Architectural Analysis
- Deep involvement of int

These situations require:

- **Using many models to cover all hierarchy levels**
- **Simulating tasks management with Humans-in-the-Loop**
- **Developing special simulation concepts and tools to cope with OSoS**

Example: GES4

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE vs Systems Engineering

- Starti
- Requ
- Func
- Interfa
- **Modeling & Simulation**
- **Defining and executing V&V**
- **Evolutionary behavior of OSoS**
- **Architectural Analysis of OSoS**
- **Deep involvement of interested parties**

- **Complex V&V procedures: analysis, simulations, integrations and tests**
- **Verification of the design in stages, combined with risk analysis and plans**

OSoSE vs Systems Engineering

- Starting an OSoS Program
- Requ… mana…
- Func…
- Interfac…
- **Modeling & Simulation**
- **Defining and executing V&V**
- Evoluti…
- Archit…
- Deep i…

- **Complex V&V procedures: analysis, simulations, integrations and tests**
- **Verification of the design in stages, combined with risk analysis and plans**

- **Interfaces verification at all levels, scenarios and tasks**
- **OSoS validation in series of high-level preplanned test scenarios**

OSoSE vs Systems Engineering

- **OSoS Life Cycle Concept:** taking into account existing systems, future development and stages in life cycle and life time
- **Adaptive development:** considering unexpected changes in directions as result of operational lessens learned by early fielded models
- **Development environments:** as teams, subcontractors, knowledge, experts, tools – **are changing!**
- Evolutionary behavior of OSoS
- Architectural Analysis of OSoS
- Deep involvement of interested parties

OSoSE vs Systems Engineering

- **Definition: Model description (physical, functional, operational, software etc) at OSoS upper level in its relevant environment, considering its evolutionary and open system natures**
- **Architectural Analysis of OSoS require very high level of professionalism in following issues:**
  - **Methodology**
  - **Tools**
  - **Training**
  - **Experts**
- **Evolutionary behavior of OSoS**
- **Architectural Analysis of OSoS**
- **Deep involvement of interested parties**

OSoSE vs Systems Engineering

- Range of interested parties usually with contradictory interests! - including main contractor and subcontractors, customers taking part in development and end users
- OSoS military aspects require close involvement of customer as early as possible with professional teams who can make difficult decisions!
- Close cooperation with customer and mutual obligations are essential for successful building of OSoS!

- E
- Architectural Analysis of
- Deep involvement of interested parties

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE Recommendations

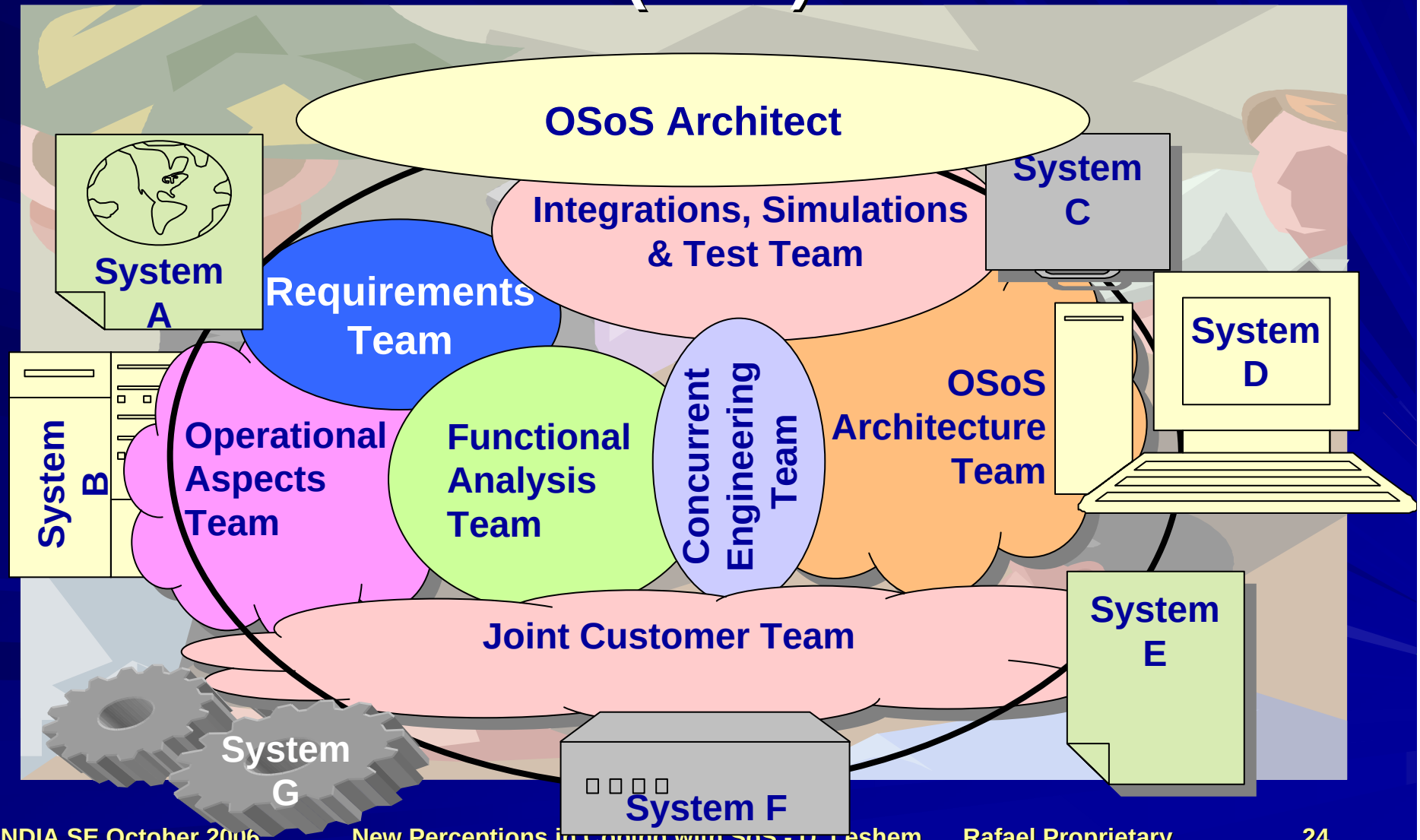
- Methodology
  - New special upper level of Systems Engineering Process to be defined (V model recommended)
  - Interoperability and MOSA (Modular Open System Approach) in OSoS to be adopted
  - Professionalism of OSoS Architecture and function of Chief Architect (compared to Chief Systems Engineer) to be cultivated

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE Recommendations

- Organization
  - Chief Architect, responsible for all aspects of OSoS Engineering, directly subordinate to Program Manager/Management
  - Working with Integrated SE Team (ISET)

Integrated SE Team for OSoS (ISET)



RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE Recommendations

- Tools
  - Central database
  - Creating and preserving logical connections with full traceability
  - On-line coordination between all development bodies
  - Automatic documents production
  - Fast transformation from UC analysis to working software implementation
  - Massive supportability
    - Examples: Core, Requisite Pro, Clear Case, Rhapsody, Doors

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoSE Recommendations

- **Critical technology disciplines and infrastructure required for OSoSE**
  - **Information (collecting, processing, distribution)**
  - **Intelligence (collecting, decoding, data fusion, processing, distribution)**
  - **Sensing (electro- optical, acoustics, RF,…)**
  - **C^4I2SR**
  - **Interdisciplinary and multidisciplinary know-how such as:**
    - **Image processing with navigation**
    - **Communication with missile guidance, control and navigation**
    - **Intelligence with signal processing, pattern recognition;**
    - **and more…**

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoS Managements Highlights

- Coping with OSoS provides main contractor with many advantages and benefits - and it's worth it!
- Spiral development of OSoS ensures use of most updated technologies and capabilities available while dealing with enemy emergent threats, in process that allows step-by-step fielding

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

OSoS Management Highlights

- Recommended to manage OSoS architecture and systems engineering processes through Chief Architect and Integrated SE Team
- Use specific gates and checklists as necessary management tool in building OSoS
- Common methodologies, tools and Infrastructure for all parties and bodies involved in development of OSoS is key to success!

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

New Perceptions in Coping with OSoS
Summary

- OSoS (Operational SoS) is proposed as common term to which Defense industry can refer
- New level of complexity - not just “more” regular Systems Engineering – it requires development of new concepts, approach and methodologies
- It’s a challenge!
- It’s worth it!

New Perceptions in Coping with System of Systems



Dr. Daniel Leshem
Corporate Chief Scientist
Rafael – Armament Development Authority Ltd., Israel
dleshem@rafael.co.il

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

New Perceptions in Coping with System of Systems

Speaker background:

Daniel Leshem

B.Sc. (1969, *Cum Laude*), and **M.Sc.** (1976) in Aeronautical Engineering, Technion -Israel Institute of Technology.

Ph.D. in Aeronautics & Astronautics, 1985, Stanford University, California, USA. (Thesis: "Composite Barriers and Corner Conditions in Differential Games")

Rafael – Armament Development Authority Ltd., Israel:

Since 1969: group leader, systems engineer, chief engineer, manager of Antitank missile directorate, VP for R&D, VP Chief Systems Engineer, Corporate Chief Scientist

GE Medical Systems, Israel (NM): VP for R&D (1997-1999)

Prize: Israel National Defense Prize (1984)

RAFAEL
ARMAMENT DEVELOPMENT AUTHORITY Ltd.

- C4I2SR
  - Command Control, Communication, Computers
  - Intelligence, Information
  - Surveillance
  - Reconnaissance

Managing the "Trick-Bag" of Intersystem Coupling

Jeffrey S. Levin

Presented to:
NDIA 9th-Annual Systems Engineering Symposium, San Diego, CA

25-October-2006



The Johns Hopkins University
APPLIED PHYSICS LABORATORY

"Law of Strong Connections"

"A system is a collection of parts, no ***one*** of which can be changed."

"In systems, all other things are rarely equal."

Weinberg, Gerald M. (2001). *General Systems Thinking (Silver Anniversary Edition)*. New York: Dorset House Publishing, p. 162.

Coupling versus Autonomy

(OSD AT&L, Air Warfare (December 2002). "Unmanned Aerial Vehicles Roadmap, 2002-2027," p. 41)

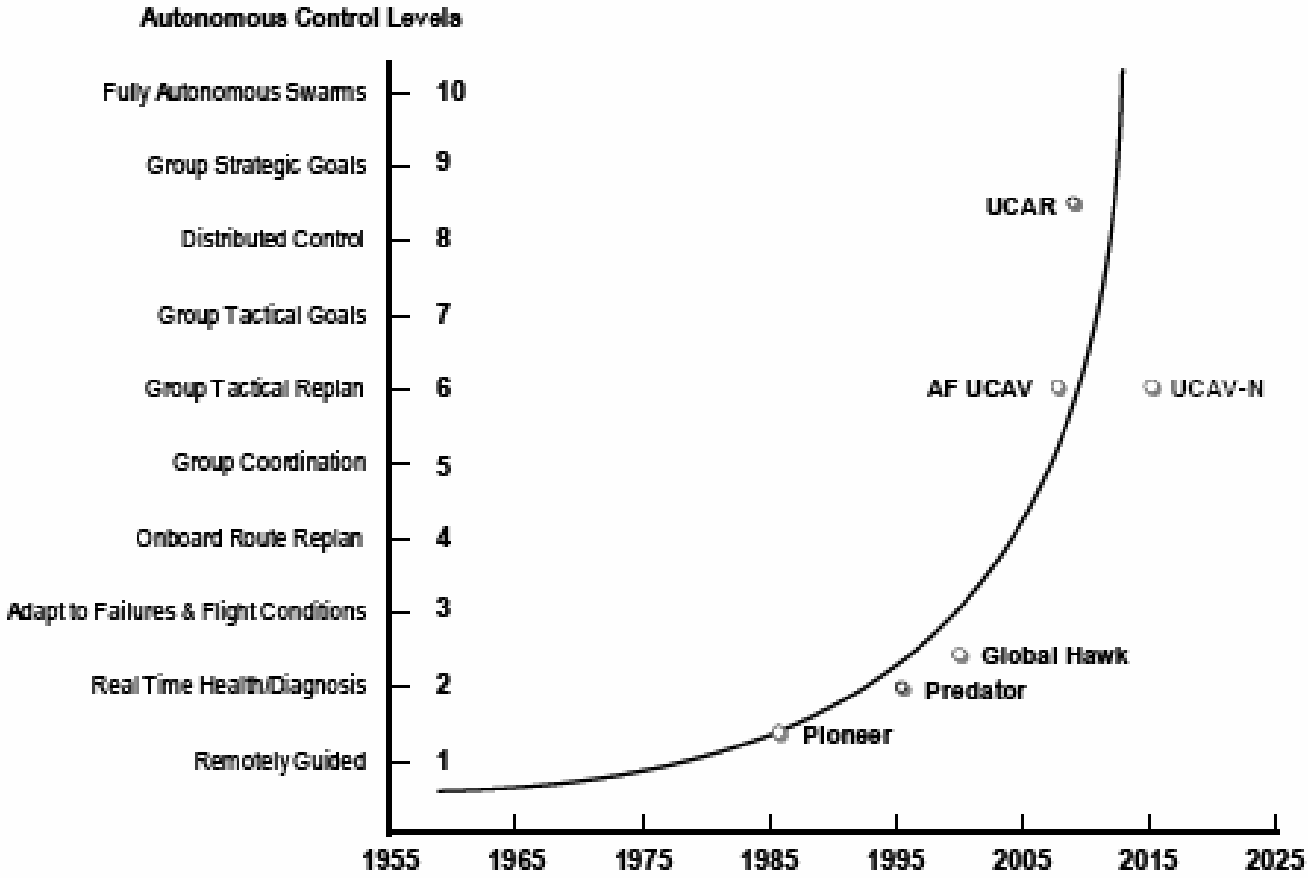


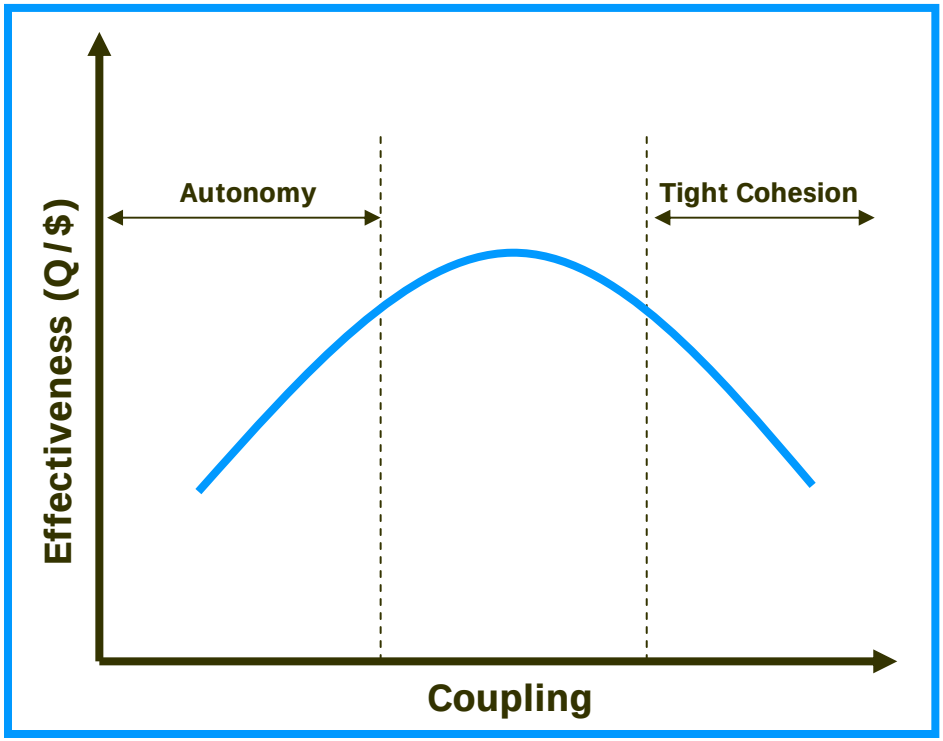
FIGURE 4.4-1: AUTONOMOUS CONTROL LEVEL TREND.

Closed systems are artificial creations of scientists and engineers

Propositions

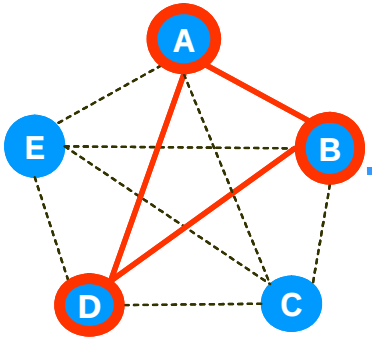
- **P1: A modicum of coupling achieves best results**
  - ***Either end of the coupling spectrum should be avoided***
- **P2: View Coupling as the effect, not just a cause**
  - ***The operational situation should dictate Coupling Required, not vice versa***

A General Model of Coupling



Coupling: Types & Measures

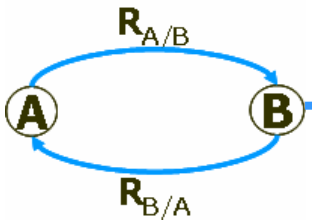
1) Inter-Capability:



$$Q = f(q_1, q_2, \ldots q_n)$$

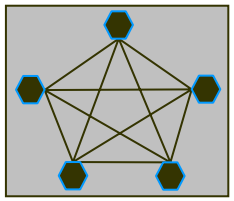
$$Y = \beta_0 + \sum_{i=1}^{p} \beta_i X_i + \sum_{i=1}^{p} \sum_{\substack{j=1 \\ i \neq j}}^{p} \beta_{ij} X_i X_j + \sum_{i=1}^{p} \sum_{\substack{j=1 \\ i \neq j}}^{p} \sum_{\substack{k=1 \\ i \neq j \neq k}}^{p} \beta_{ijk} X_i X_j X_k + \cdots$$

2) Complex-Dynamic:

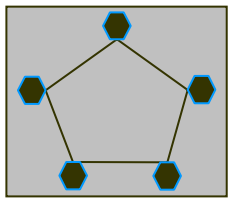


$$\frac{dQ_1}{dt} = f_1[Q_1, Q_2, \ldots, Q_n]$$
$$\frac{dQ_2}{dt} = f_2[Q_1, Q_2, \ldots, Q_n]$$
$$\vdots$$
$$\frac{dQ_n}{dt} = f_n[Q_1, Q_2, \ldots, Q_n]$$

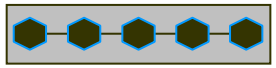
3) Inter-Nodal:



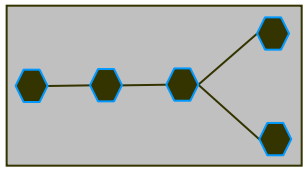
C = 5.0
C_{Index} = 0.00
N * K = 50
E/E_{max} = 1.00



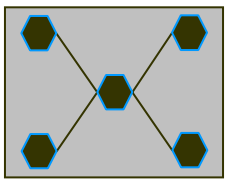
C = 5.0
C_{Index} = 0.00
N * K = 25
E/E_{max} = 0.50



C = 6.7
C_{Index} = 0.40
N * K = 20
E/E_{max} = 0.40



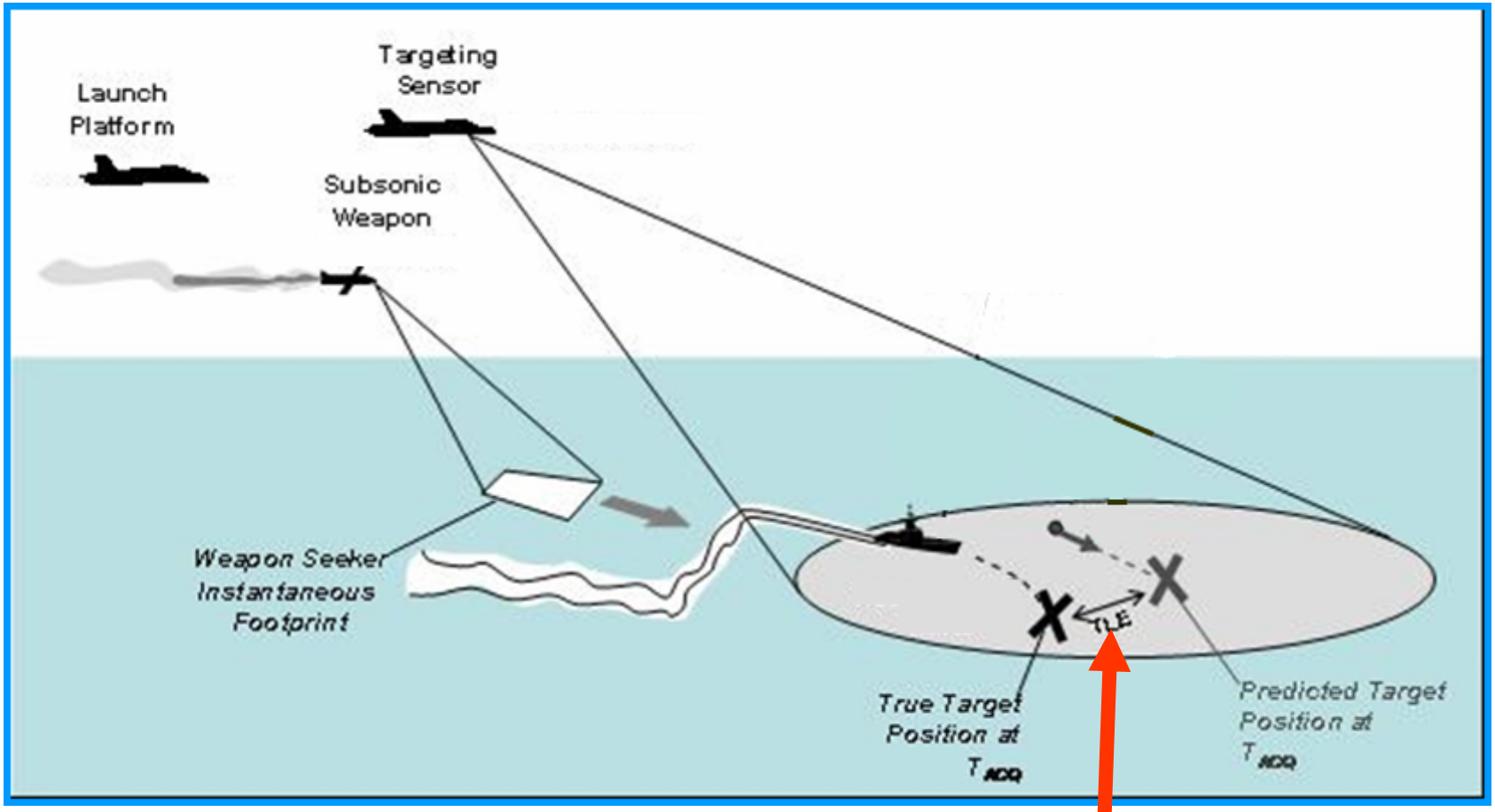
C = 7.2
C_{Index} = 0.44
N * K = 20
E/E_{max} = 0.40



C = 8.0
C_{Index} = 0.42
N * K = 20
E/E_{max} = 0.40

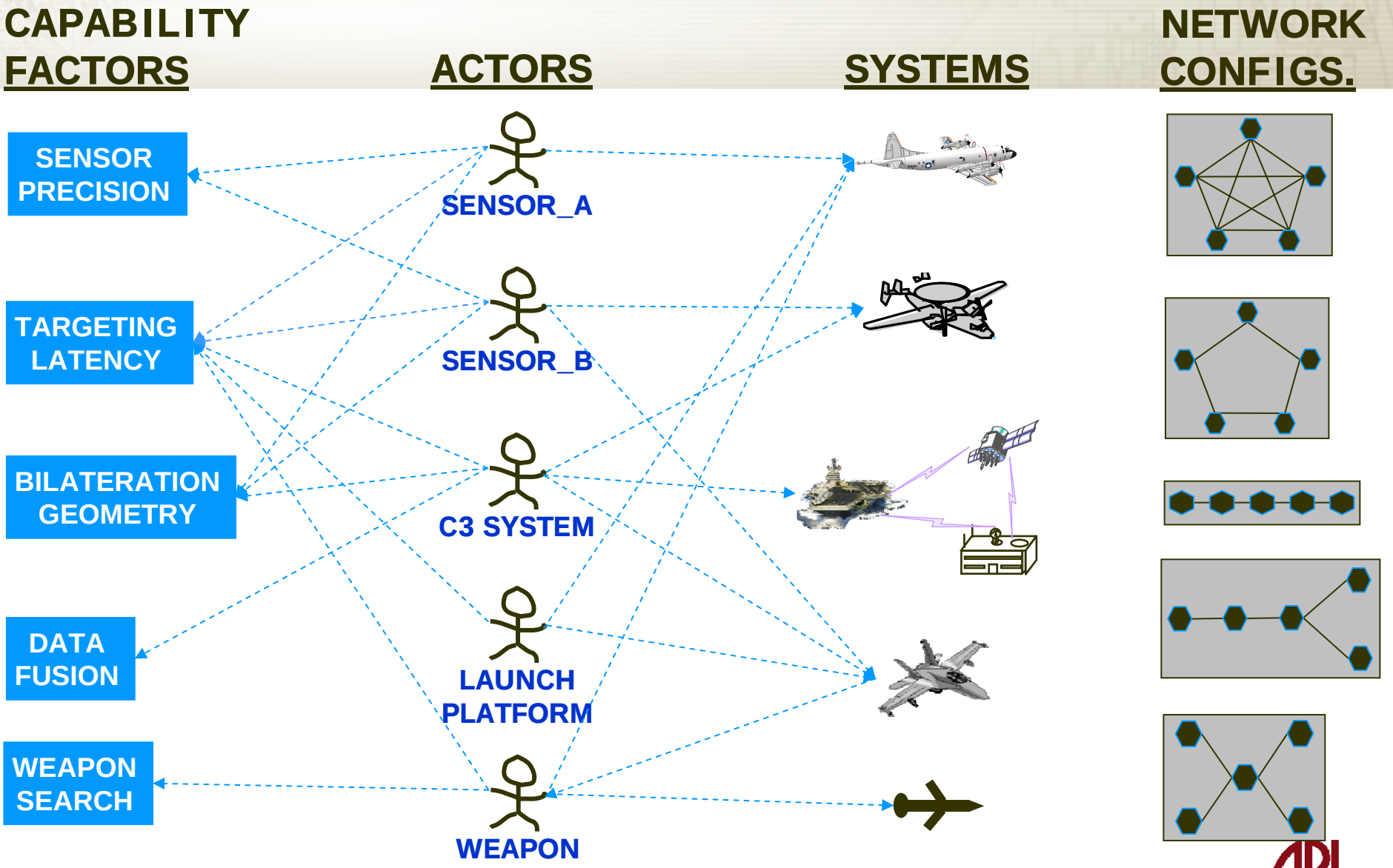
"Law of Mass Action" or "The System Concept"

Notional Problem Application: Standoff Attack of Moving Targets



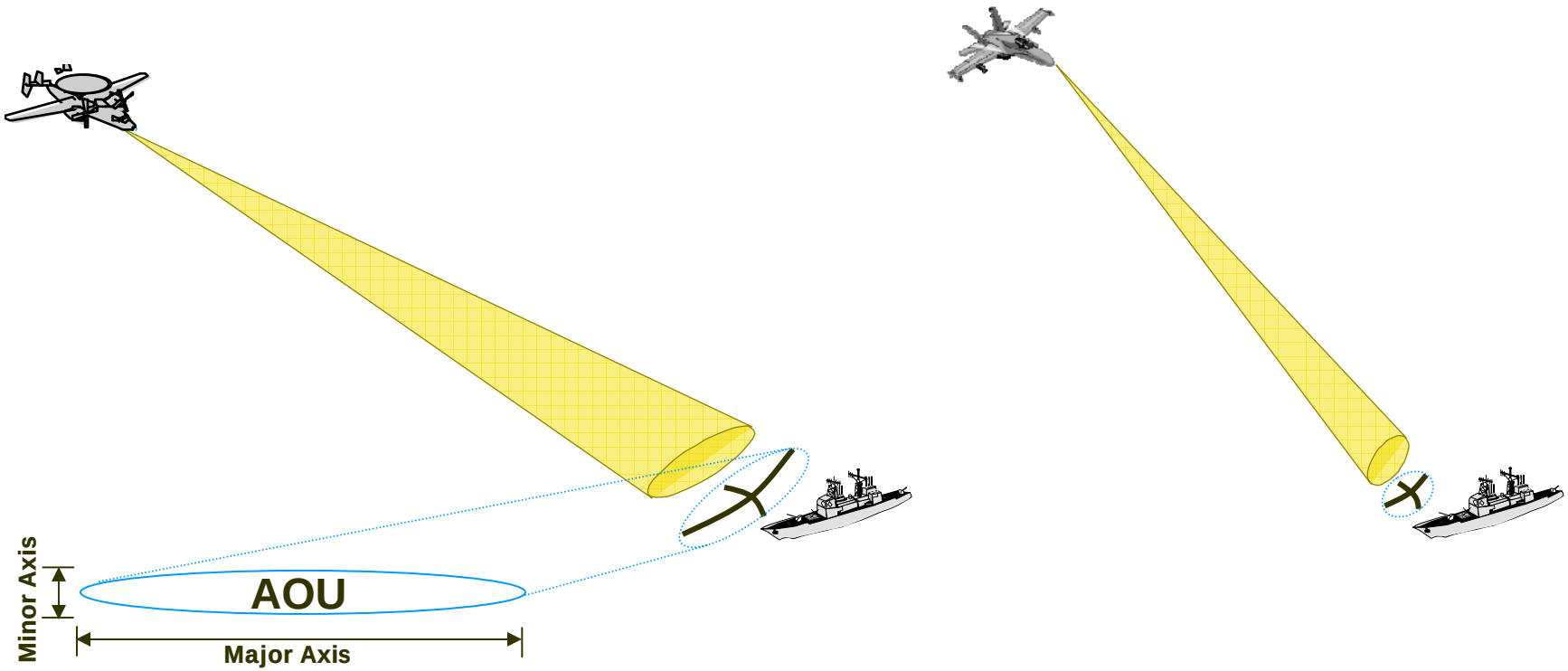
PROBLEM: "Target Location Error" (TLE) is dynamic

Actor → Factor Linkages



Sensor Precision

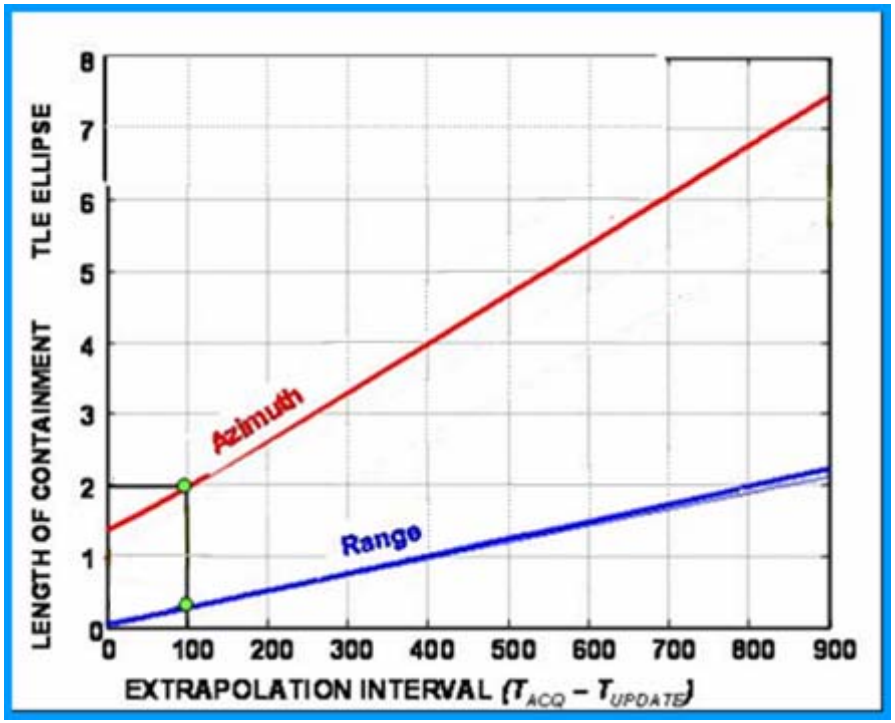
- **Values: Low Precision Vs High Precision**



All else being equal, high sensor precision decreases AOU size

Targeting Latency

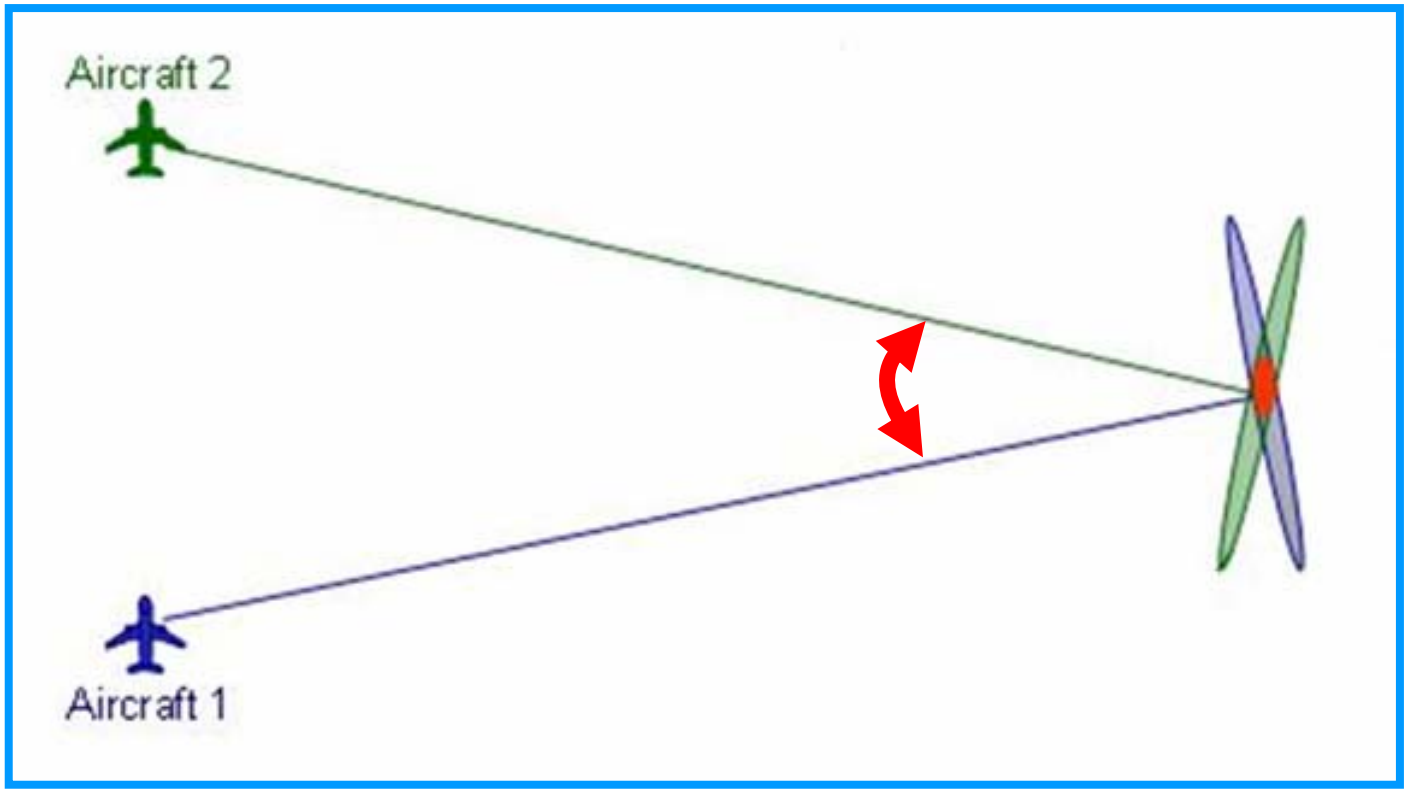
- **Values: High (min) Vs Low (sec)**



All else being equal, low latency decreases AOU size

Sensor Bilateration Geometry

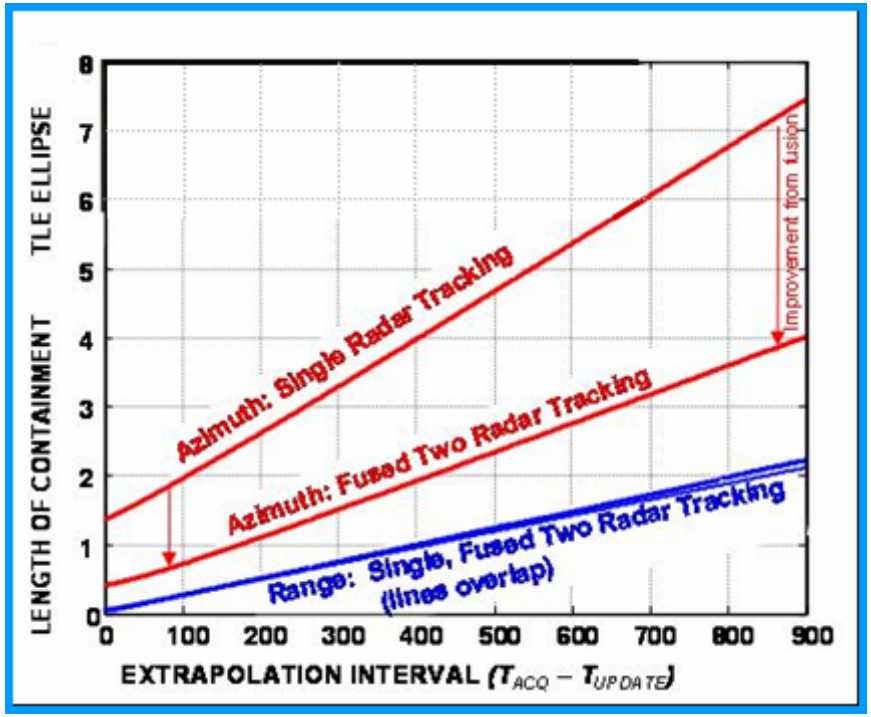
- **Values: Low Azimuth Vs High Azimuth**



All else being equal, high-azimuth geometry decreases AOU size

Sensor Data Fusion

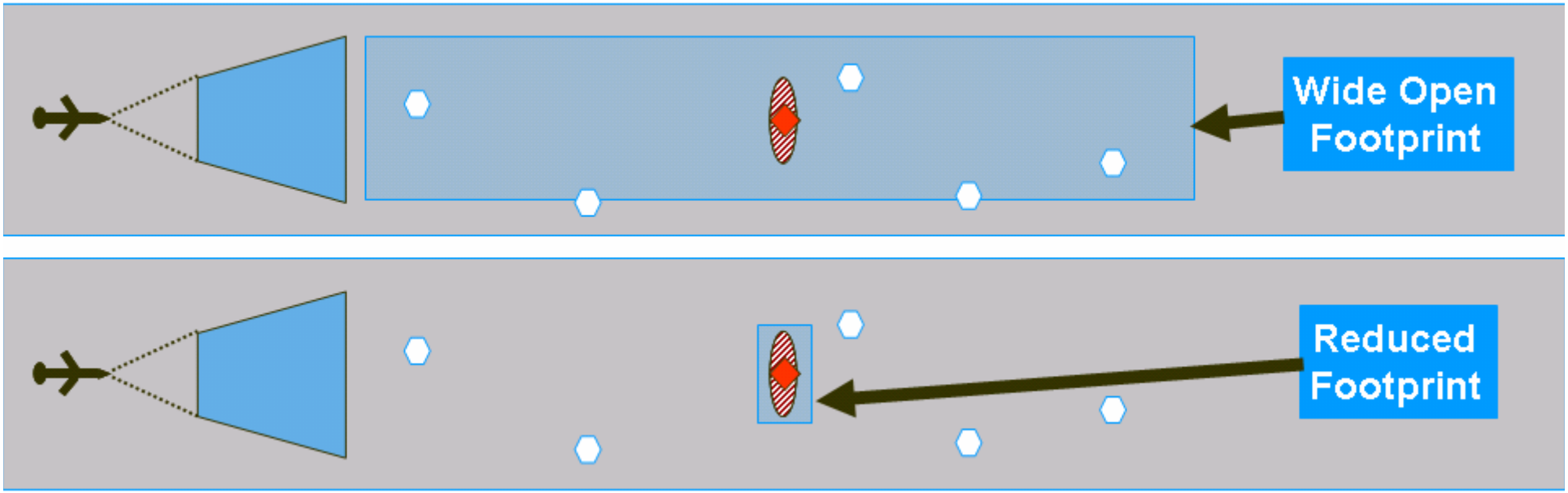
- **Values: Not Available Vs Available**



All else being equal, sensor data fusion decreases AOU size

Weapon Search

- **Values: Wide_Open Vs Reduced**



MOE = Target Selectivity

All else being equal, reduced search decreases the probability of detecting a neutral vessel

Data from Design of Experiment

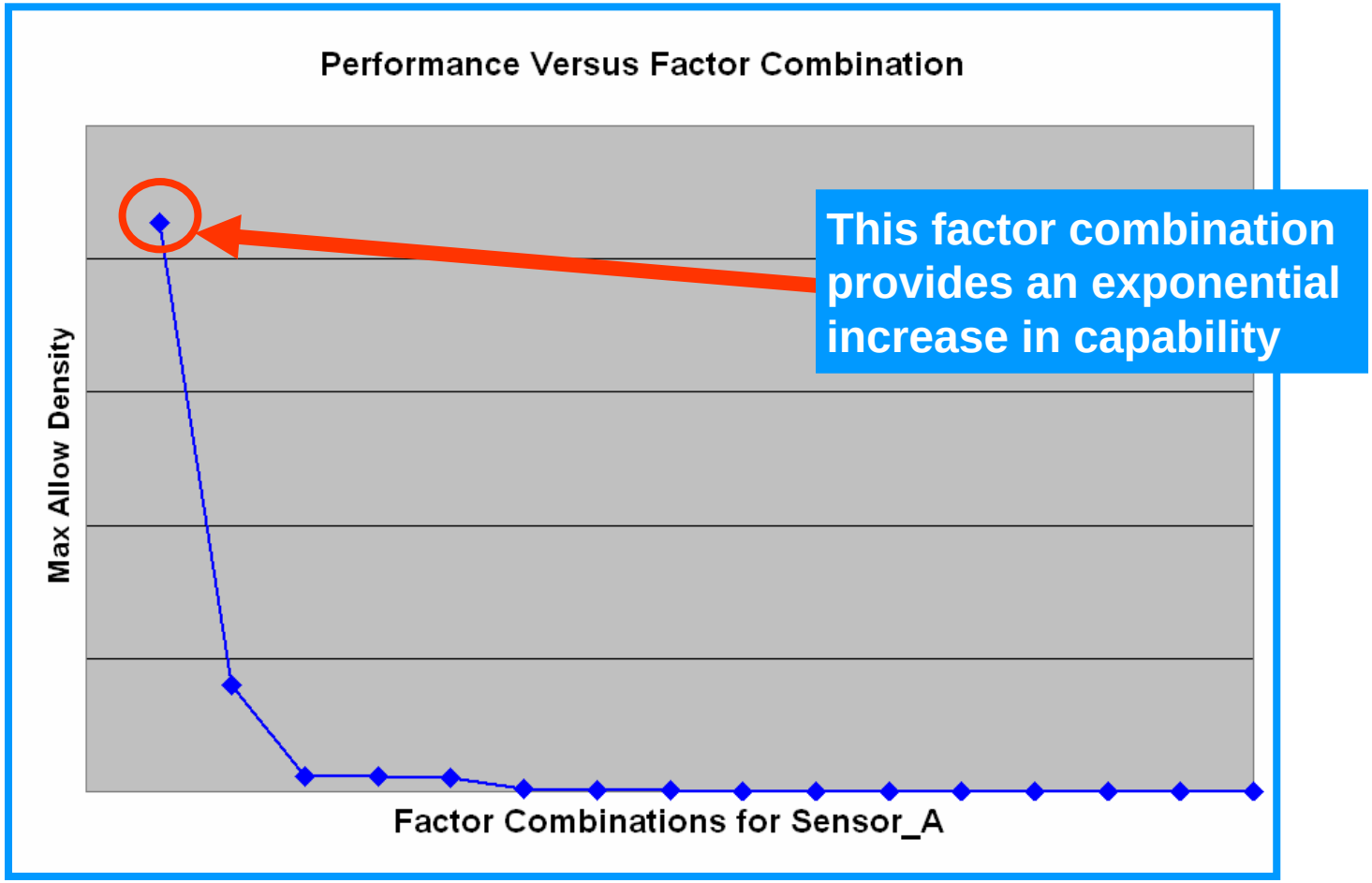
	Seeker_Search (Reduced Vs Open)	Sensor_Precision (High Vs Low)	Fusion (Yes Vs No)	Latency (Low Vs High)	Bilat_Geometry (Hi-Az Vs Low-Ax)		Y1a: Max_Allow_Density (Partial_Wide-Open_Skr)
1	Reduced	High	Yes	Low	Hi-Az		213,800
2	Reduced	High	Yes	Low	Lo-Az		40,100
3	Reduced	High	Yes	High	Hi-Az		247
4	Reduced	High	Yes	High	Lo-Az		247
5	Reduced	High	No	Low			5,940
6	Reduced	High	No	Low			5,940
7	Reduced	High	No	High			230
8	Reduced	High	No	High			230
9	Reduced	Low	Yes	Low	Hi-Az		7,517
10	Reduced	Low	Yes	Low	Lo-Az		548
11	Reduced	Low	Yes	High	Hi-Az		197
12	Reduced	Low	Yes	High	Lo-Az		107
13	Reduced	Low	No	Low			700
14	Reduced	Low	No	Low			700
15	Reduced	Low	No	High			91
16	Reduced	Low	No	High			91
17	Open	High	Yes	Low	Hi-Az		5,365
18	Open	High	Yes	Low	Lo-Az		1,006
19	Open	High	Yes	High	Hi-Az		179
20	Open	High	Yes	High	Lo-Az		164
21	Open	High	No	Low			298
22	Open	High	No	Low			298
23	Open	High	No	High			164
24	Open	High	No	High			164
25	Open	Low	Yes	Low	Hi-Az		94
26	Open	Low	Yes	Low	Lo-Az		94
27	Open	Low	Yes	High	Hi-Az		164
28	Open	Low	Yes	High	Lo-Az		89
29	Open	Low	No	Low			94
30	Open	Low	No	Low			94
31	Open	Low	No	High			76
32	Open	Low	No	High			76

Tightly Coupled Condition

- **Q1: Which factor is most important?**
- **Q2: Which factor combination is most important?**

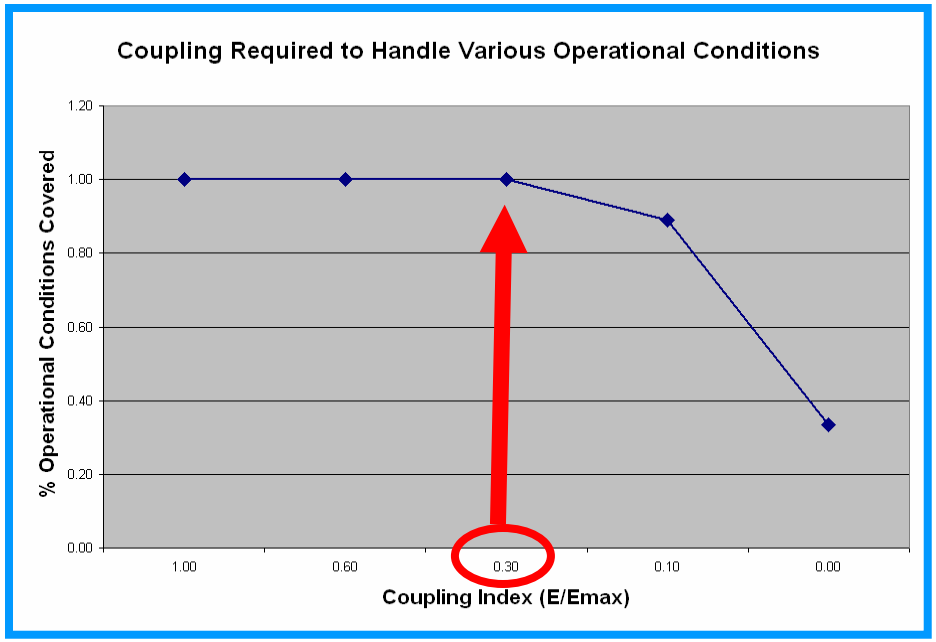
Loosely Coupled Condition

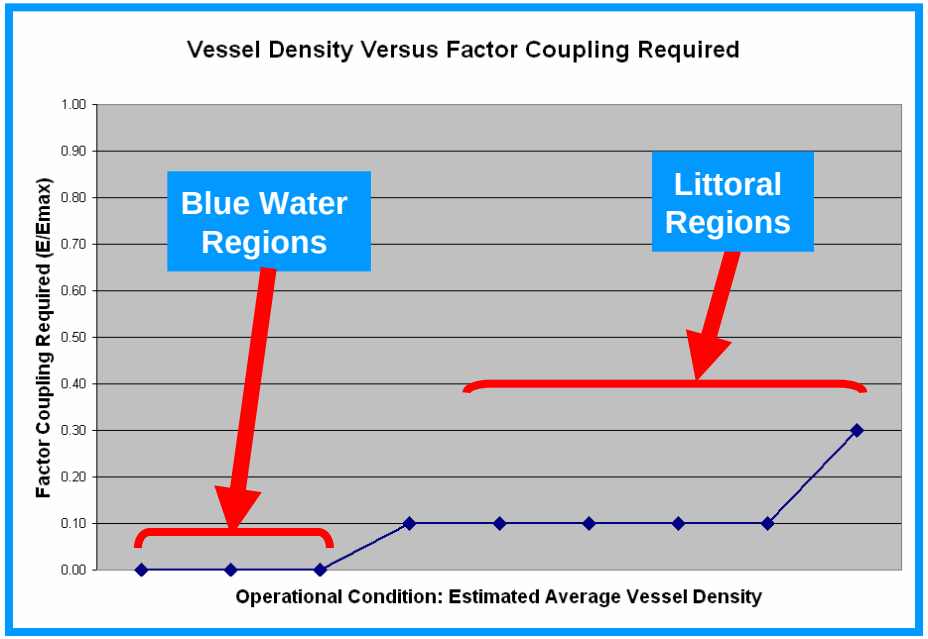
Data Analysis → Benefit of Tight Coupling



CAUTION: Tight coupling will be hard to achieve operationally & programmatically

Data Analysis → Requirement for Coupling

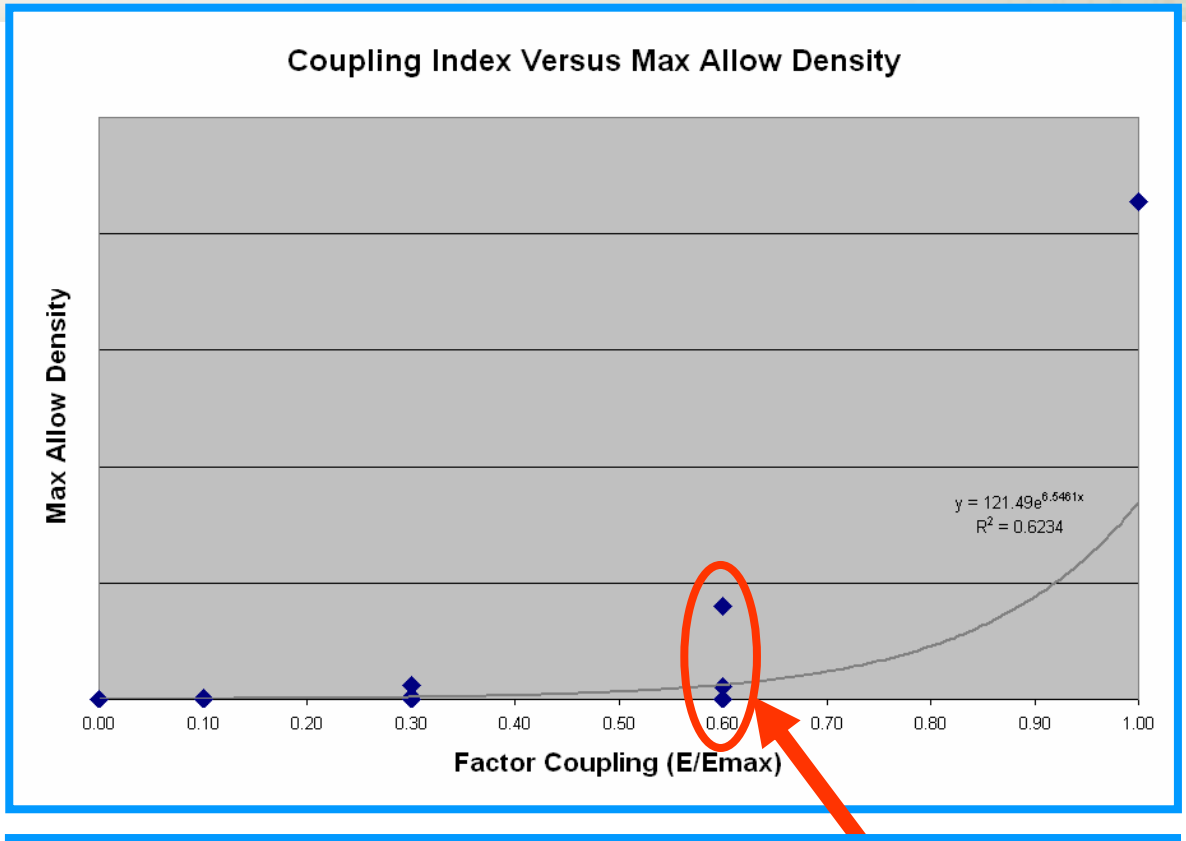




30% coupling covers 100% of all operational conditions studied

Only an extreme condition requires tight coupling

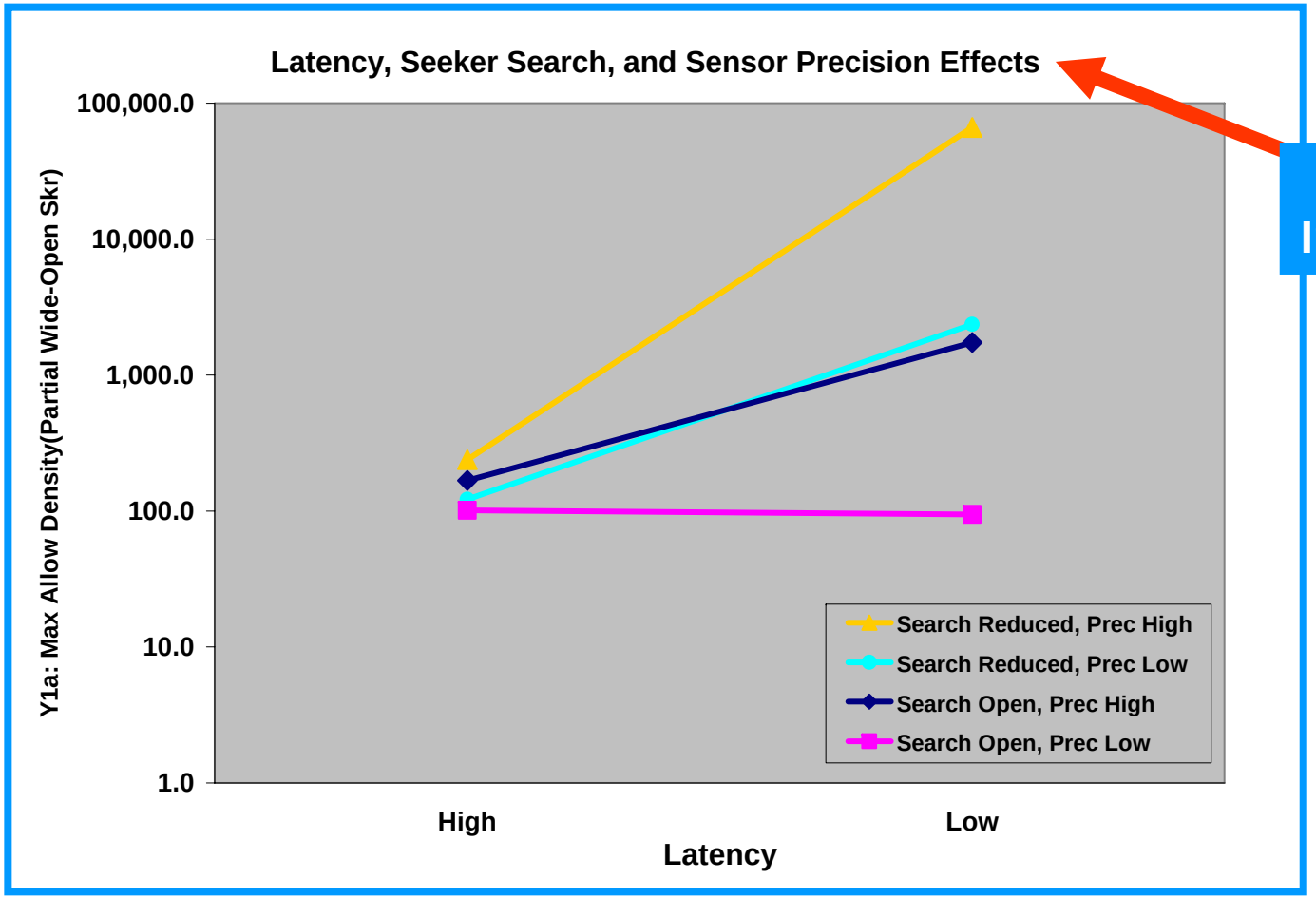
Data Analysis → Performance Sensitivity to Coupling



NOTE: In some cases, the same value of coupling results in high variation in performance → WHY?

Clearly it matters which capability factors are coupled together

Data Analysis → Capability Interaction

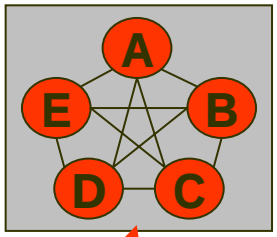


NOTE: Latency is the most important driver

Basic Network Configurations

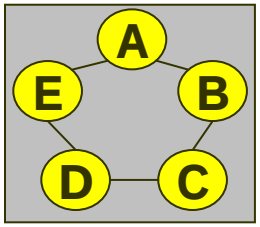
- 3rd Question: In general which network configuration works best?

I. Fully Connected

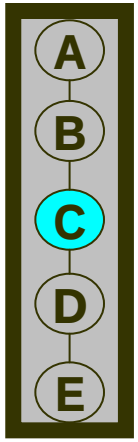


Tightly Coupled
Decentralized

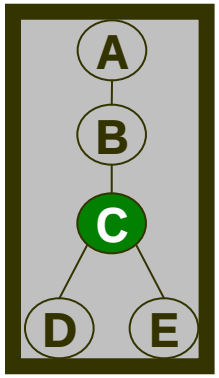
II. Circle



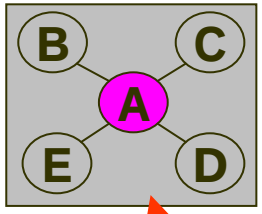
III. Chain



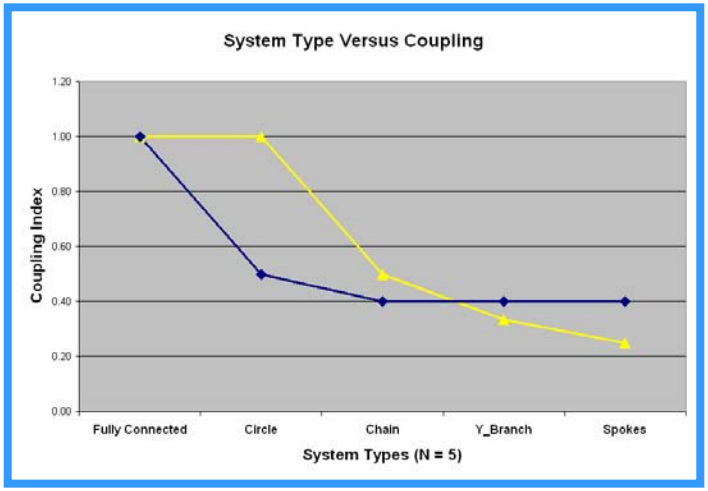
IV. Y-Branch

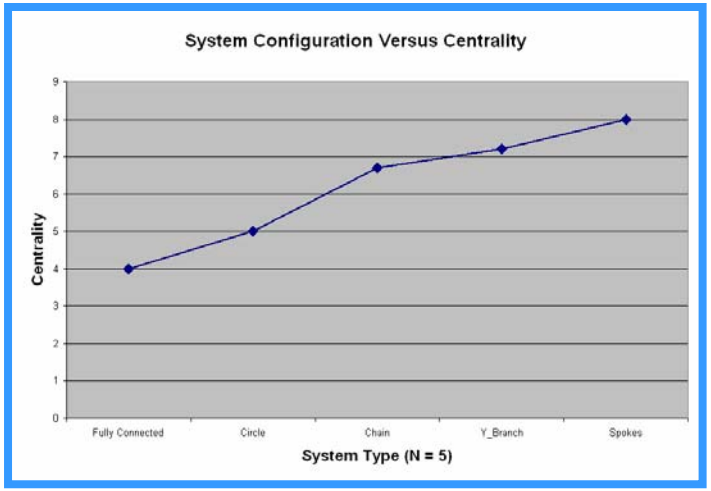


V. Spokes



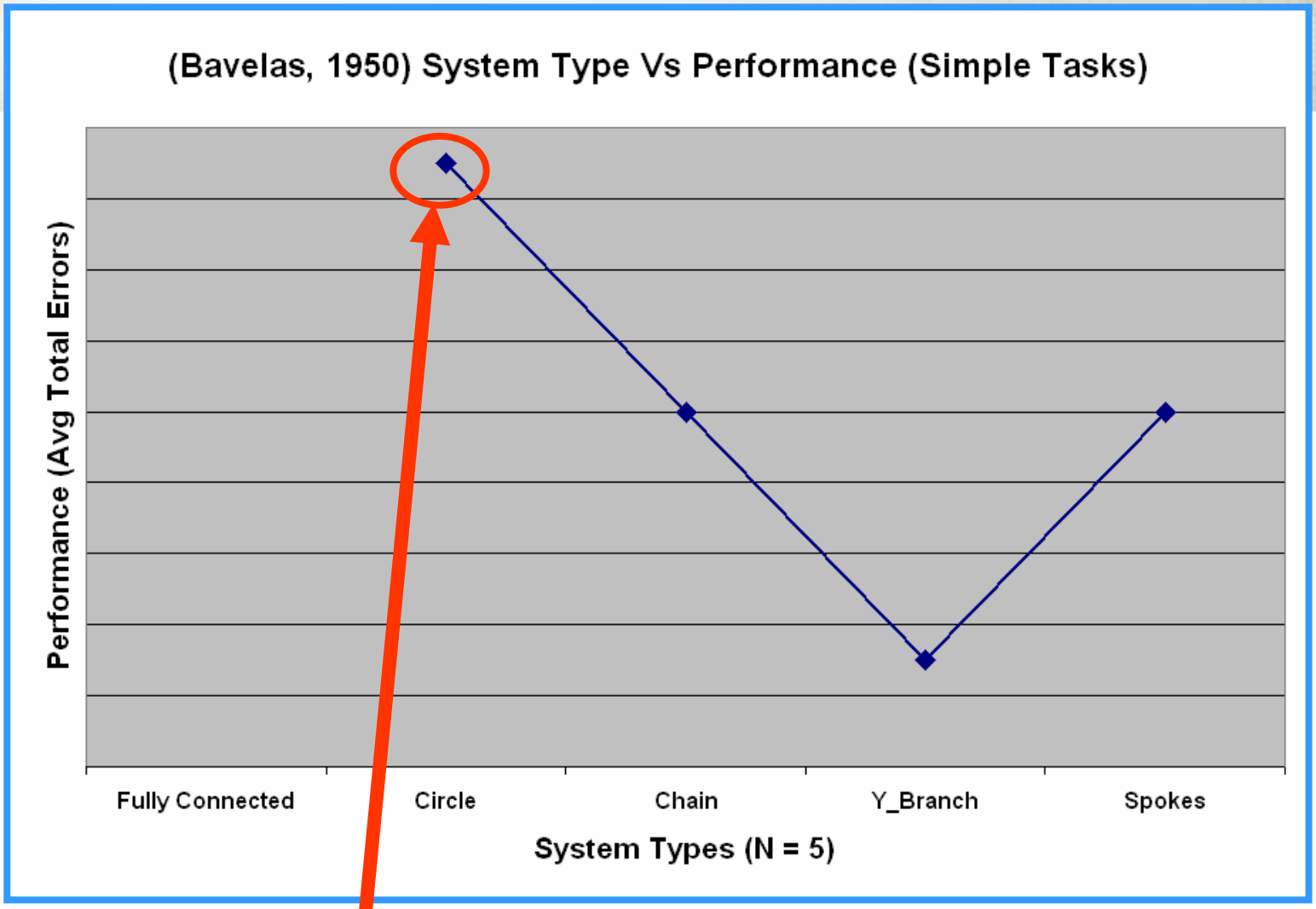
Moderately Coupled
Highly Centralized





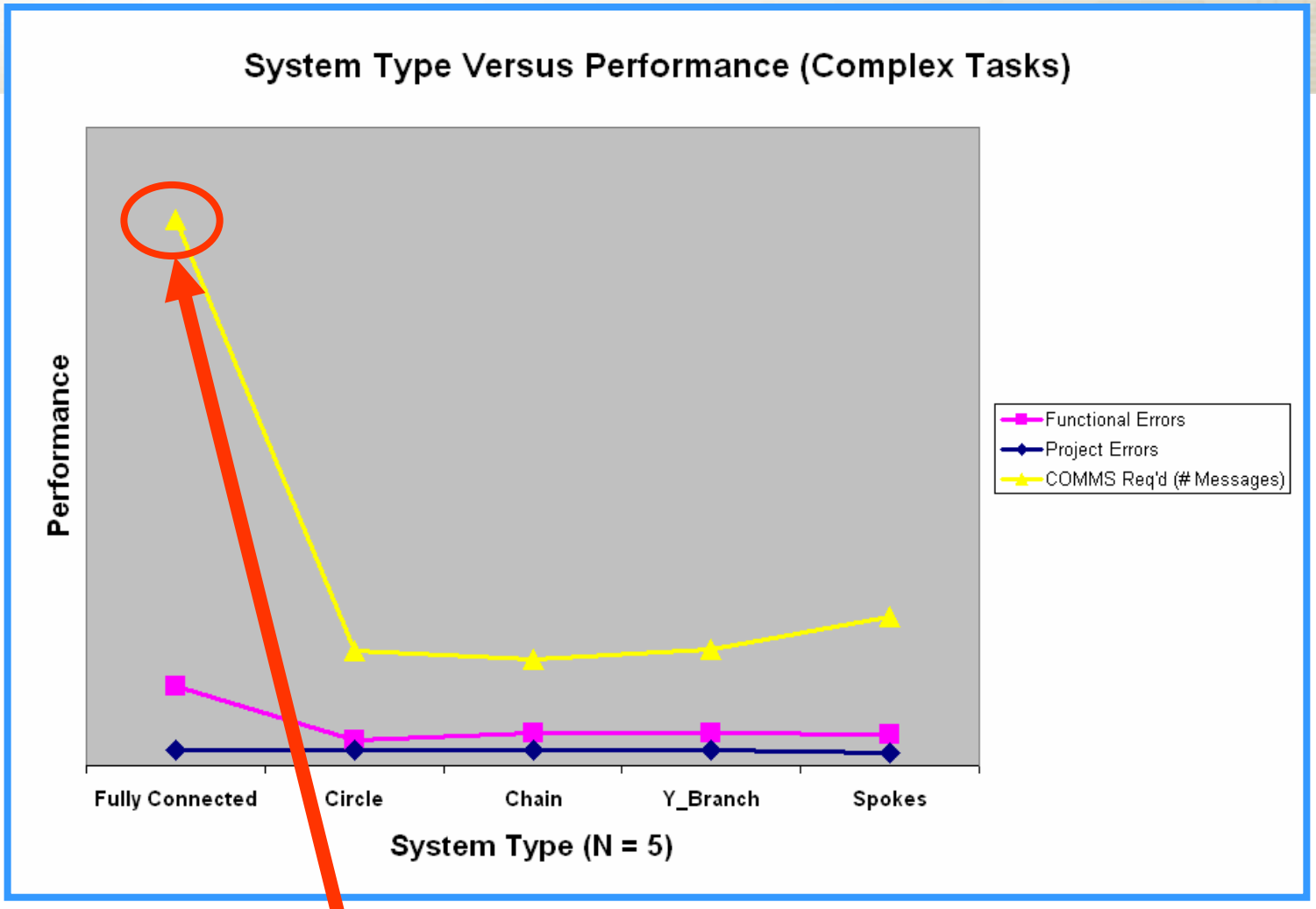
A system's organizational structure influences its performance

System Structure Vs Performance



NOTE: Tightly coupled structure has lowest performance

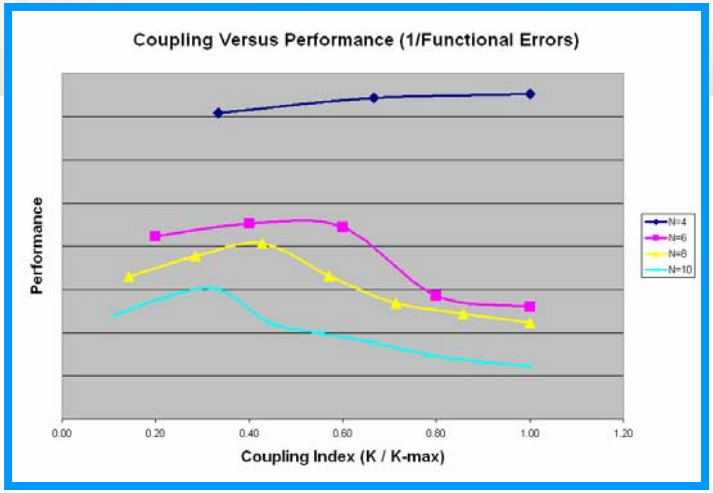
System Structure Vs Performance

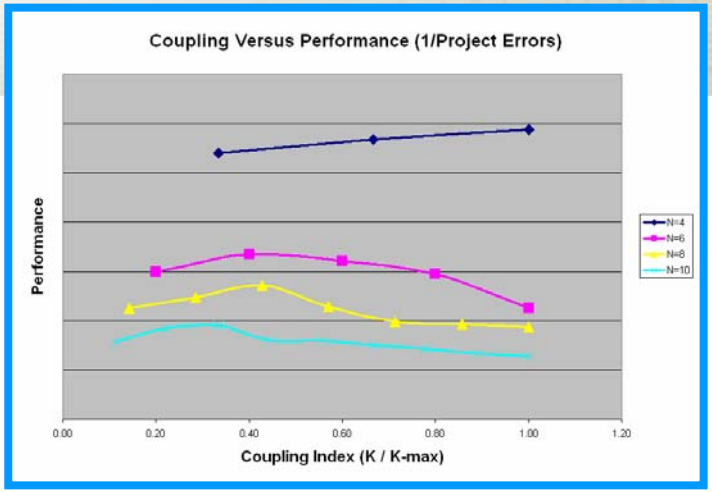


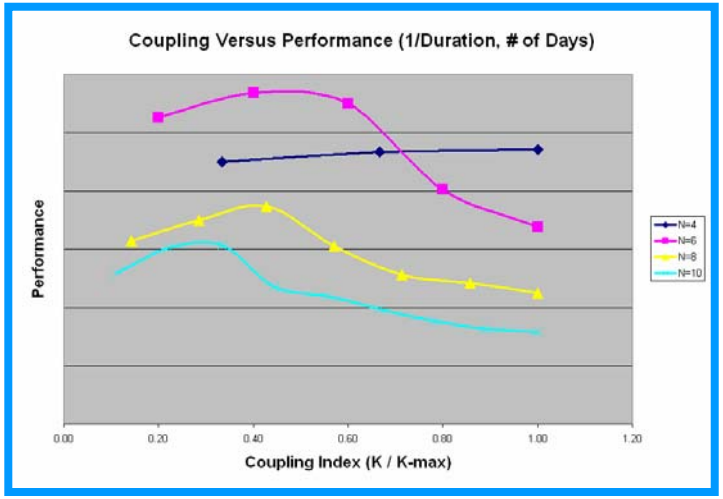
NOTE: Tightly coupled structure has lowest performance

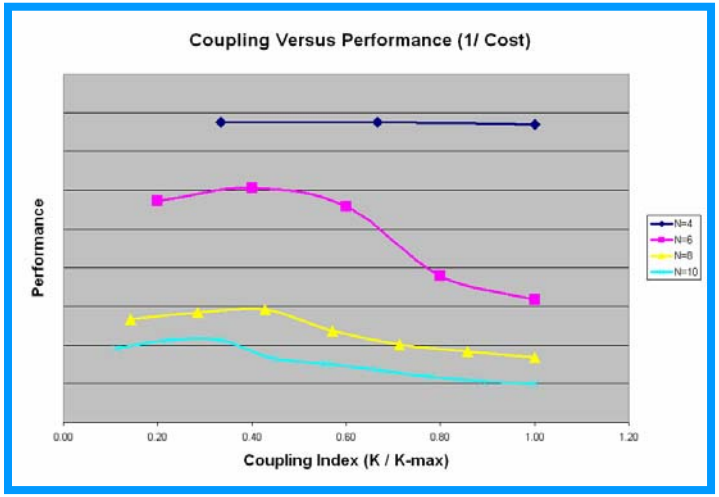
Coupling Vs Organizational Efficiency

(Caroll & Burton, 2000)



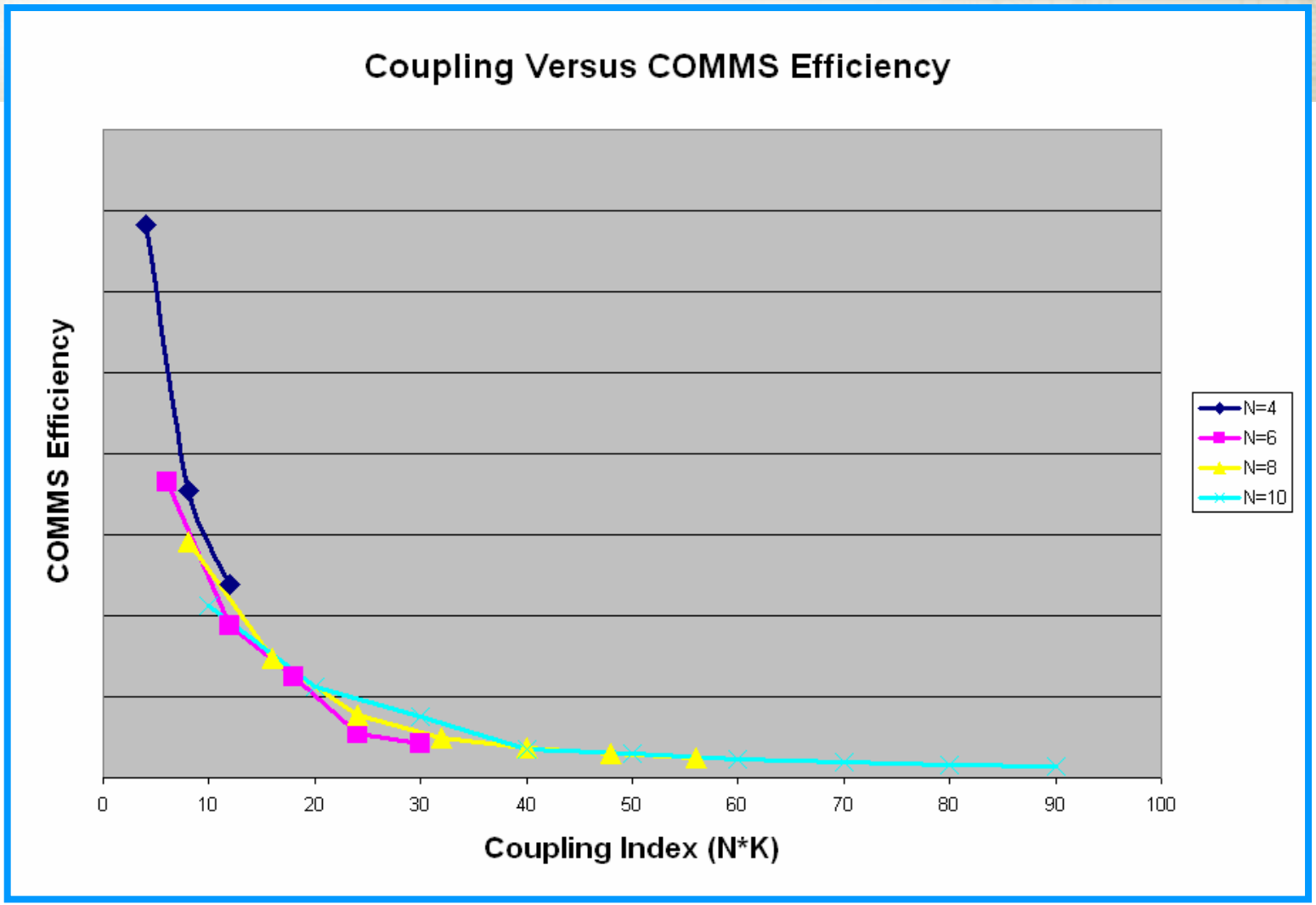






NOTE: Best performance occurs when coupling = 0.30–0.50 (~Chain & Y_Branch)

Coupling Vs Communication Efficiency



NOTE: As coupling increases, COMMS efficiency decreases exponentially

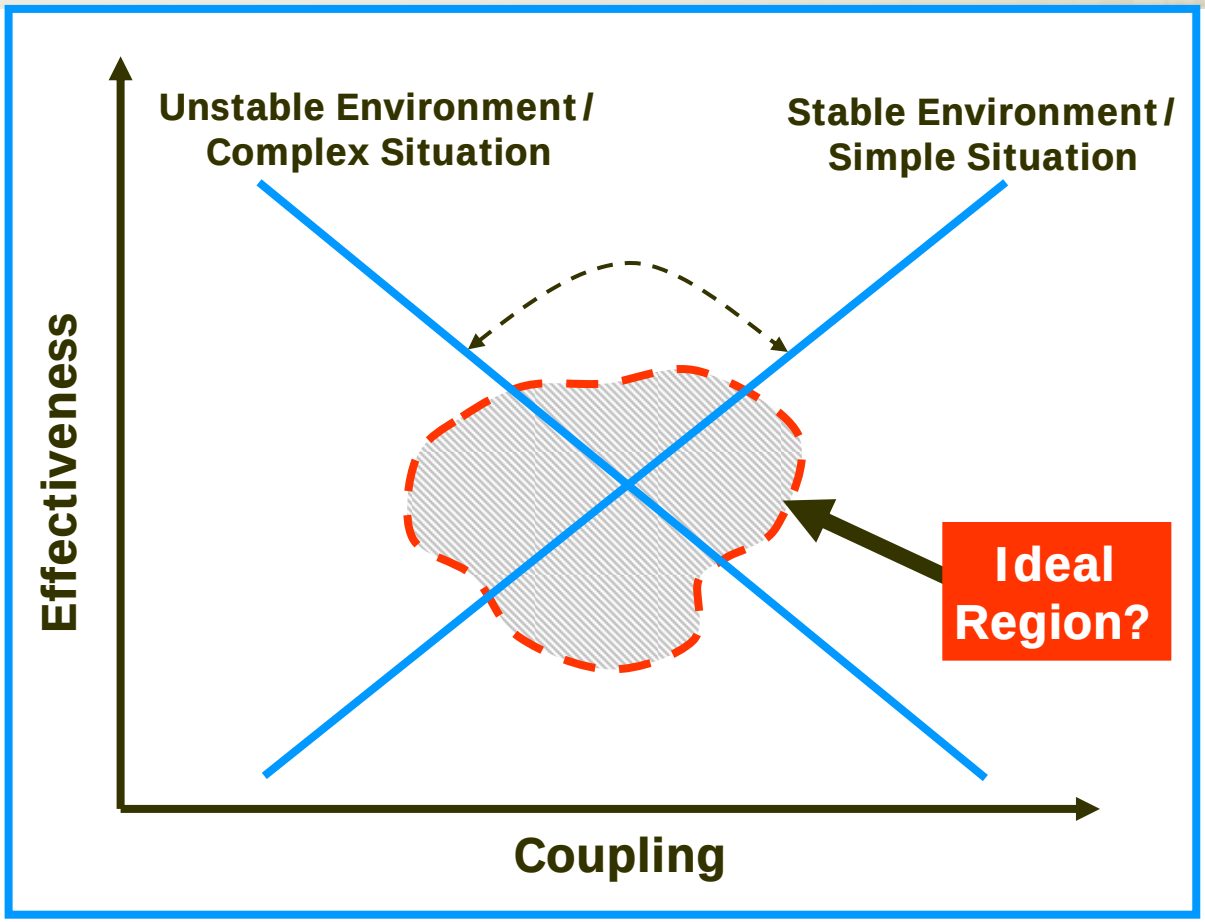
Conclusions on Tight Coupling → One size does not fit all

- Can exponentially increase your capability +
- Hard to achieve operationally & programmatically -
- Requires holistic acquisition strategy + / -
- Results in decreased COMMS efficiency & organizational performance -
- Risky → "Normal Accidents" & single points of failure -
- Need to view entire system holistically +
- It's hard to achieve holistic view of entire system -
- Tight coupling may not be an operational requirement +

Moderate coupling may be best way to manage environmental uncertainty?

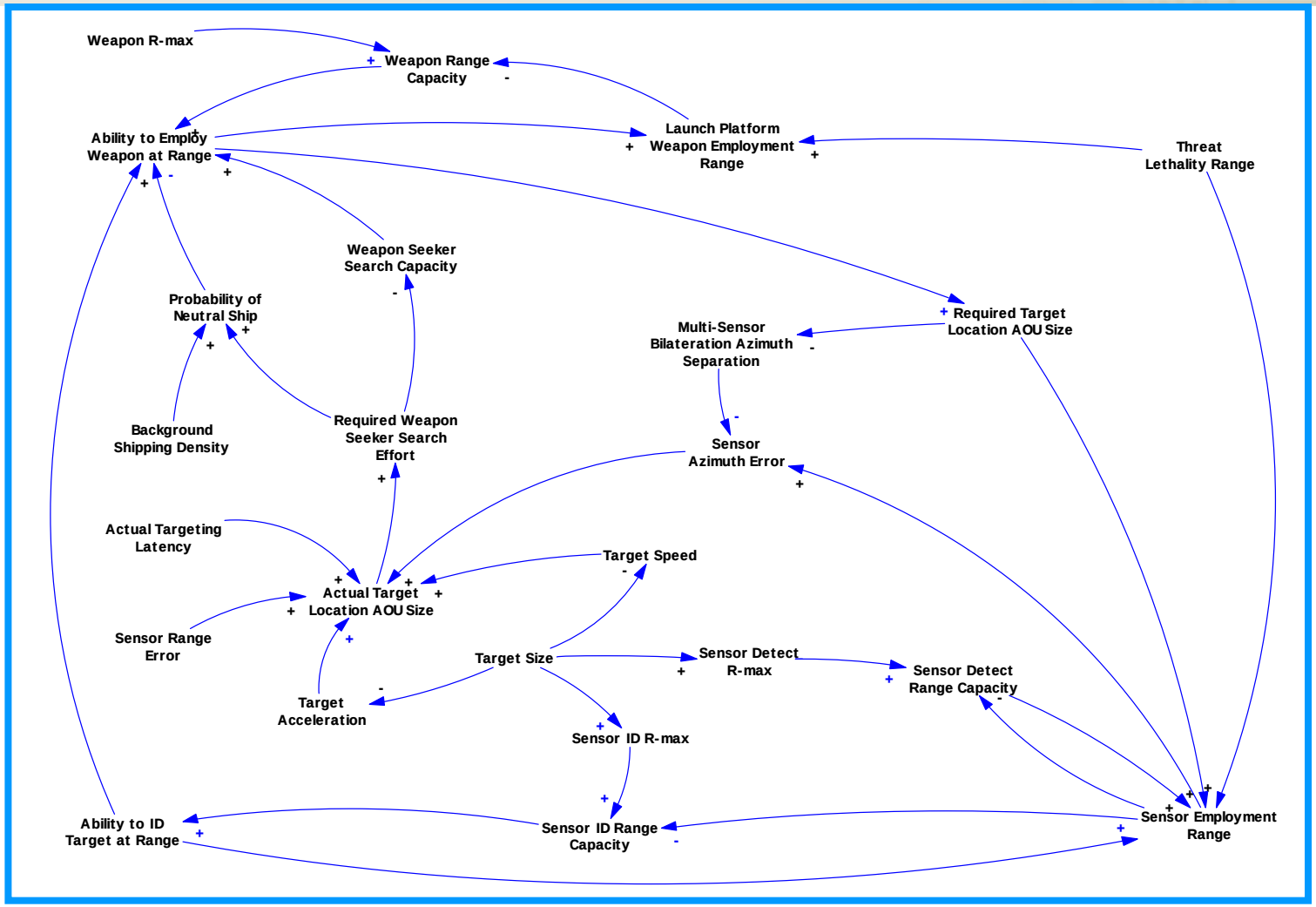
Further Research

Basis: Daft (1998), Perrow (1984) , Weick (1976)



PROBLEM: Socio-technical Systems = Leadership + Organizational + Technology

Coupling ~ Circular Causality?



QUESTIONS?

Jeffrey S. Levin
Johns Hopkins University Applied Physics Lab
Aviation Systems Engineering Group
Jeffrey.Levin@jhuapl.edu
240-228-3533

References

Barut, Mehmet; Faisst, Wolfgang; Kanet, John J. (2002). Measuring Supply Chain Coupling: An Information System Perspective. ***European Journal of Purchasing & Supply Management, 8,*** pp. 161-171.

Bavelas, Alex (November 1950). Communication Patterns in Task-Oriented Groups. ***The Journal of the Acoustical Society of America, 22,*** 6, pp. 725-730.

Bavelas, Alex (1948). A Mathematical Model for Group Structures. ***Applied Anthropology, 7,*** pp. 16-30.

Bertalanffy, Ludwig von (1950). An Outline of General Systems Theory. ***The British Journal for the Philosophy of Science, 1,*** 2, pp. 134-165.

Carroll, Tim; Burton, Richard M. (2000). Organizations and Complexity: Searching for the Edge of Chaos. ***Computational & Mathematical Organization Theory, 6,*** pp. 319-337.

Daft, Richard L. (1998). ***Organization Theory and Design (6th Edition).*** Cincinnati, OH: South-Western College Publishing, p. 87-90.

References

Hicks, Louis (1993). Normal Accidents in Military Operations. ***Sociological Perspectives, 36,*** 4, pp. 337-391.

Kelly, Harold H. (1951). Communication in Experimentally Created Hierarchies. ***Human Relations, 4,*** pp. 39-56.

Leavitt, Harold J. (1951). Some Effects of Certain Communication Patterns on Group Performance. ***Journal of Abnormal Social Psychology, 46,*** pp. 38-50.

Olmstead, Michael S. (1959). ***The Small Group***. New York: Random House.

OSD AT&L, Air Warfare (December 2002). "Unmanned Aerial Vehicles Roadmap, 2002-2027," p. 41

Perrow, Charles (1984). ***Normal Accidents.*** New York: Basic Books.

Guetzkow, Harold; Simon, Herbert A. (April-July 1955). The Impact of Certain Communication Nets upon Organization and Performance in Task-Oriented Groups. ***Management Science, 1,*** 3, pp. 233-250.

References

Sprott, W.J.H. (1958). ***Human Groups***. Baltimore MD: Penguin Books, p. 125-126.

Sterman, John D. (2000). ***Business Dynamics: Systems Thinking & Modeling for a Complex World.*** Boston: Irwin: McGraw-Hill.

Stewart, Ian (12 February 2004). Networking Opportunity. ***Nature, 427,*** pp. 601-604.

Weick, Karl E. (April 1990). Loosely Coupled Systems: A Reconceptualization. ***The Academy of Management Review, 15,*** 2, *pp. 203-223.*

Weick, Karl E. (March 1976). Educational Organizations as Loosely Coupled Systems. ***Administrative Science Quarterly, 21***, 1, pp. 1-19.

Weinberg, Gerald M. (2001). ***General Systems Thinking (Silver Anniversary Edition)***. New York: Dorset House Publishing, p. 162.

Xia, Franck (2000). On the Concept of Coupling, Its Modeling and Measurement. ***The Journal of Systems and Software, 50,*** pp. 75-84.

Headquarters U.S. Air Force

Integrity - Service - Excellence

The Next Generation of Air Force SE

NDIA 9th Annual Systems Engineering Conference

San Diego, CA

25 October 2006

Mr. Jeff Loren
MTC Technologies, Inc. (SAF/AQRE)
703.588.7845
jeff.loren@pentagon.af.mil

Overview

- Strategic Interests
- Life Cycle SE
  - SE in Pre-Acquisition (Prior to Milestone / Key Decision Point A)
  - Early SE Pilot
- SE for Systems of Systems (SoS)
  - ROE and Perspectives
  - Enabling Capabilities
  - Cases and Issues
- Focus Areas for SE Planning and Measuring
- SE Perspectives
- AF SE Vision

Strategic Interests

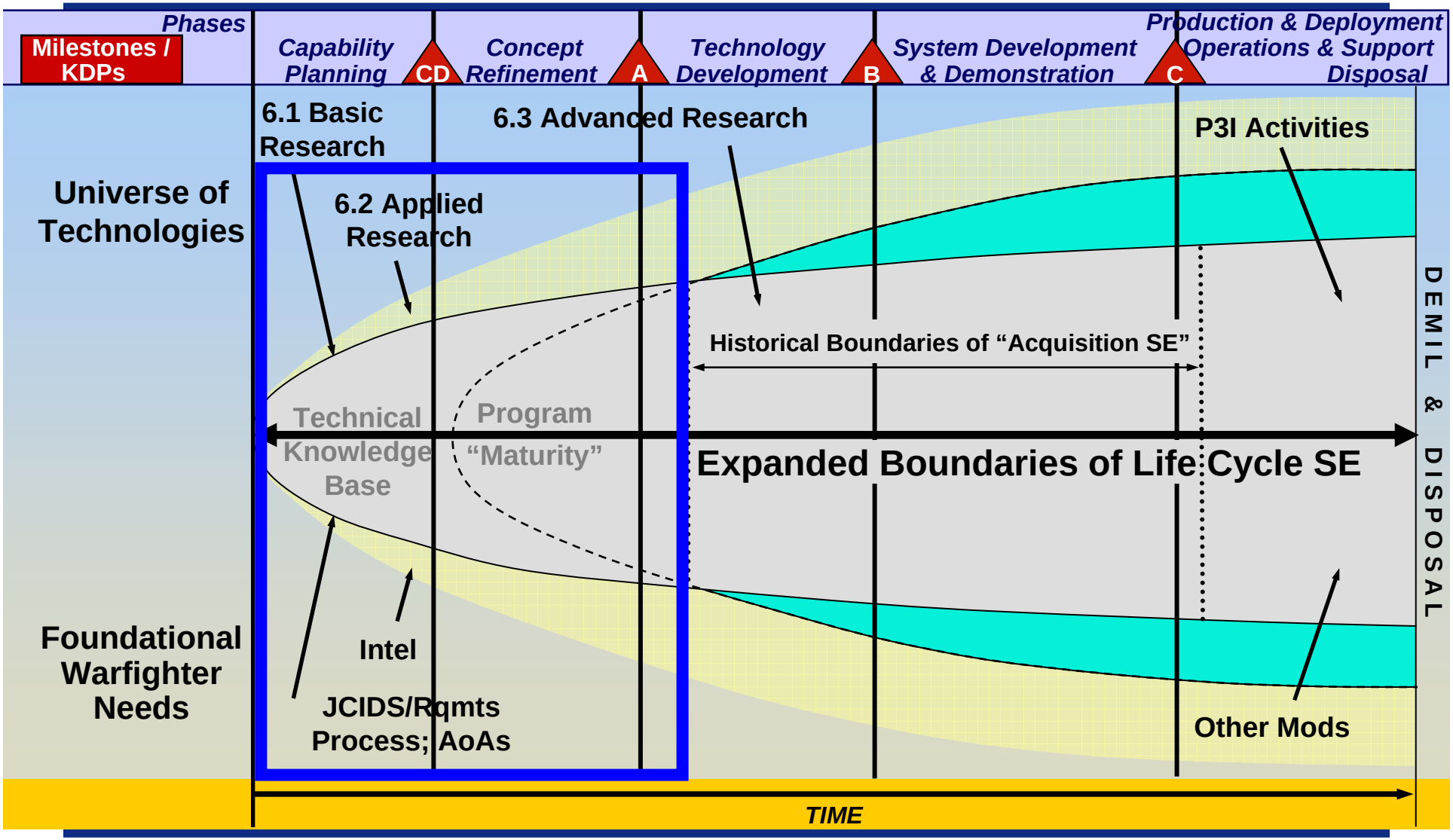
- **Implement a robust engineering vision across the life cycle in all four Air Force product lines (air, space, weapons, command and control)**
- **Institutionalize the role of Chief Engineer as the senior technical advisor supporting the Air Force Acquisition Executive**
- **Grow and mentor the next generation of Air Force technical leaders**

Life Cycle SE

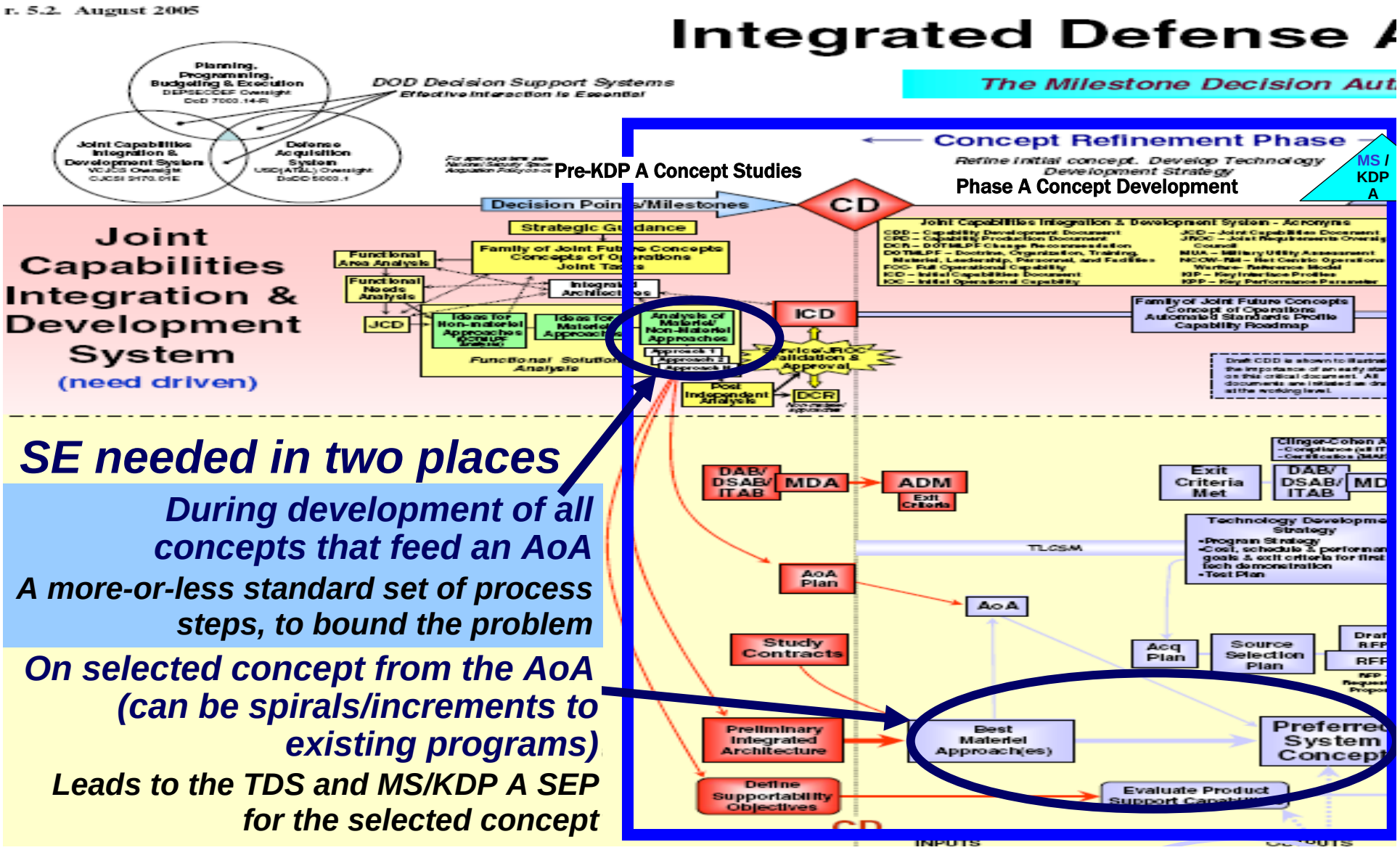
- ***"Life Cycle SE"*** **encompasses the entire set of scientific, technical, and managerial efforts needed to plan, develop, acquire, integrate, verify, field, operate, maintain, improve, and sustain a system to provide a needed capability**
  - **Core SE Technical Processes**
  - **Technical Management Processes**
  - **System-of-Systems (SoS)**
  - **System Safety and ESOH**
  - **Software**
  - **Human Systems Integration**
  - **Specs and Standards**
  - **Program Protection**
  - **Manufacturing Readiness**
  - **Maintenance Engineering**
  - **Integrity Programs**
  - **… numerous others …**

OUTCOME: Mission Assurance -- Operational Safety, Suitability, and Effectiveness (OSS&E) -- Throughout the Product / System Life Cycle

Life Cycle SE
Focus on Pre-Acquisition



SE in Pre-Acquisition
Disciplined Application Required



SE needed in two places

During development of all concepts that feed an AoA

A more-or-less standard set of process steps, to bound the problem

On selected concept from the AoA (can be spirals/increments to existing programs)

Leads to the TDS and MS/KDP A SEP for the selected concept

SE in Pre-Acquisition

- **What it is:**
  - **The tie between JCIDS and the Analysis of Alternatives (AoA)**
  - **A disciplined process to scope capability needs and *develop concepts***
  - **The process required to do necessary *groundwork for a successful AoA***
  - **A means to identify candidate technologies and assess their TRLs**
  - **Good SE**
- **What it is *not*:**
  - **An actual AoA**
  - **"Gaming the system" to favor a solution**

SE in Pre-Acquisition
Early Documentation

- **Standard methodology -- "Analysis of Problem" as precursor to formal Analysis of Alternatives**
  - **Describes how SE processes translate capability statements into families of concept designs/approaches**
    - **Trade study process**
    - **Key ground rules/constraints**
    - **Decision criteria**
    - **Methodology for populating knowledge base**
  - **Describes how operational context (architectures and military utility) drives these translations**
- **Basis for Technology Development Strategy**
  - **TDS should make up ~75% of content of SEP submitted at Milestone / Key Decision Point A for selected concept**

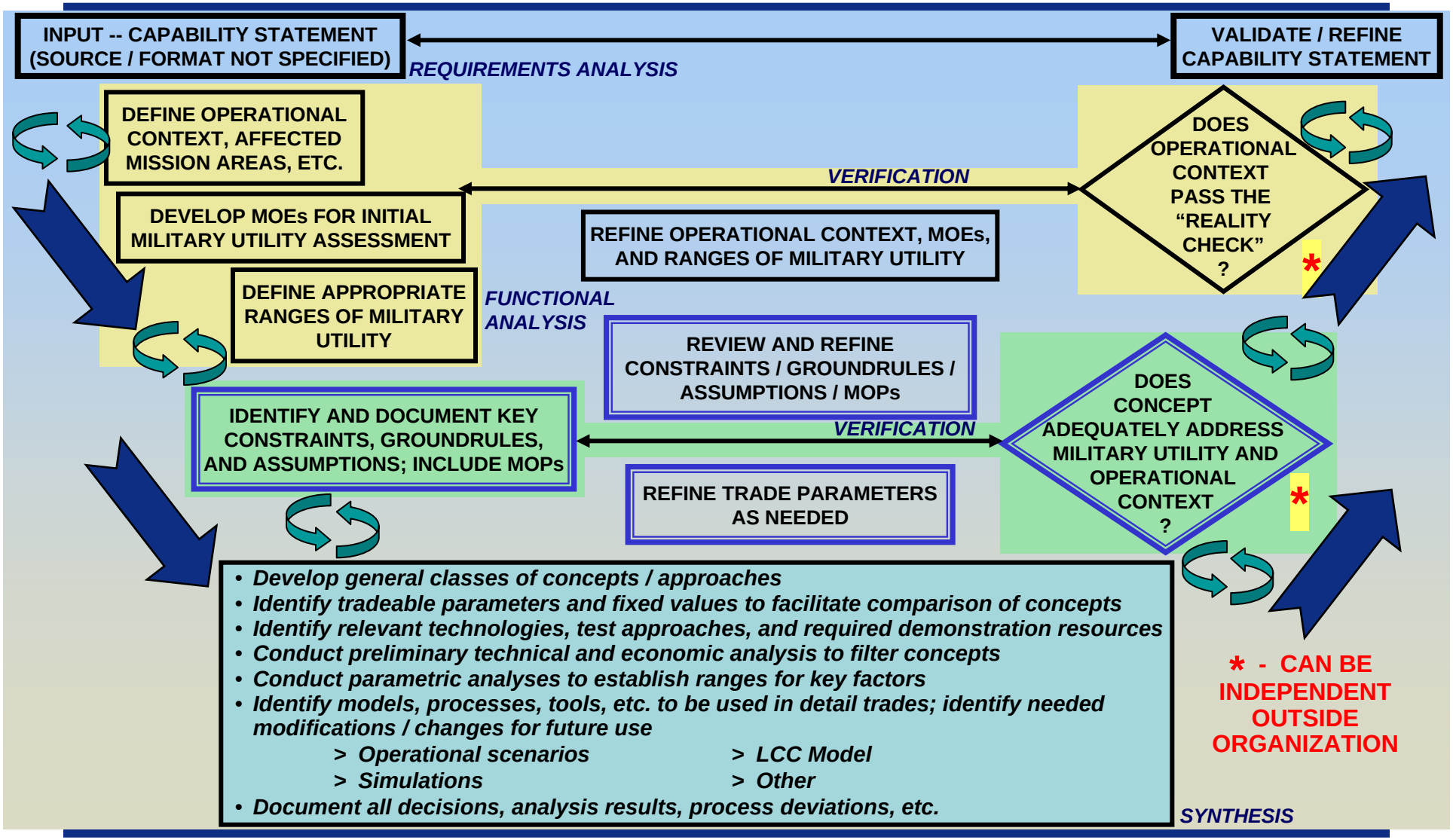
SE in Pre-Acquisition Example

- **Warfighter needs the capability to cross a body of water**
- **Initial pass through this process yields various methods**
  - **Airlift**
  - **Bridge**
  - **Catapult**
  - **Drive around**
  - **Drive through**
  - **Ferry**
  - **Tunnel**
  - **etc.**
- **Further analyses offer parametric trades within a method (*e.g.,* bridge), considering depth, width, current, etc.**
  - **"If you build 400 yards upstream where the channel is narrower, you will only need 3 support pilings instead of 4 …"**
  - **"If you build 1000 yards downstream where the current is slower, you'll need 5 pilings and 20% more material for the road, but you can finish 10% sooner and the span can take 15% more live load …"**
- **Applying this process, the Acquirer will *NOT* determine what type of bridge is best -- that comes out of the AoA**

Early SE Pilot

- SMC effort began June 06
  - SMC/XD to select candidate need from AFSPC Mission Needs Statement library
  - Selected needs will be used to validate entire process by developing at least two concepts
  - Deliverables include details of each step in process diagram, guide to implementation criteria, and draft SEP for each concept
- Project will expand to AFMC Product Centers in FY07
  - Best Practices and Lessons Learned will shape policy

Early SE Pilot
Concept Development Process Diagram



SE in Pre-Acquisition
Expectations

- **Disciplined application of Pre-A SE will:**
  - Flow operational needs through concepts into programs
  - Integrate the “illities” up front into concept definition
  - Build a technical knowledge base that migrates with concepts to programs
- **Policy for Pre-A SE will:**
  - Drive linkage of concepts to operational architectures (Air Force, Coalition, and Joint)
  - Facilitate better decision-making at MS/KDP A and B
- **Policy for Pre-A SE will not:**
  - Provide guidance idea generation
  - Direct conduct of AoA or EoA studies
  - Guide overall capabilities integration activities

SE in Pre-Acquisition
Summary

- **Aim to institutionalize disciplined and consistent SE application throughout the life cycle, across all AF product lines (air, space, weapons, C2)**
  - ***MUST*** **start in the earliest stages of concept development,** ***BEFORE*** **formal program initiation**
  - **Early SE is an** ***investment to reduce risk*** **in later program phases**
- **Pilot project will define rigorous Early SE process**
  - **Policy will follow validation in FY07**

ULTIMATE RESULTS

- **Better technical planning, better integrated**
- **More confidence in programs entering acquisition**

SE for Systems of Systems (SoS)
Rules of Engagement

- **Systems of Systems (SoS)** ***result when independent and useful systems are integrated into a larger system that delivers unique capabilities***
  - **Both the SoS and the constituent systems consist of parts, relationships, and a whole that is greater than the sum of the parts**
  - **While the SoS is a system, all systems are not SoS**
- **SE for SoS** ***deals with planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a SoS capability greater than the sum of the capabilities of the constituent parts***

  (Defense Acquisition Guidebook, Chapter 4)
- **Keys: Definitions, Development, Acquisition, Operations**

Guide to Systems of Systems (SoS) Engineering: Considerations for Systems Engineering in a SoS Environment -- draft OUSD (AT&L) publication; anticipated release Dec 2006

SE for SoS
Perspectives - 1

- **Definitions**
  - System of Systems
  - Family of Systems
  - Federation of Systems
  - Architecture
  - Enterprise
  - Others ??
- **Development**
  - Holistic view
  - Aggregation of platform-level efforts
    - Focus on physical interfaces and functional / information exchanges
    - Degree of integration often vague

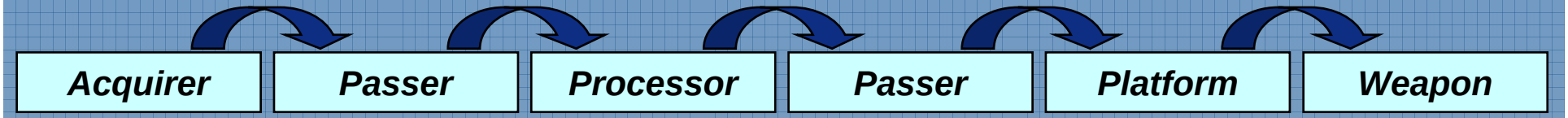
SE for SoS Perspectives - 2

- **Acquisition**
  - DoD processes largely specific to each Service/Agency
  - Systems acquired independently, even to satisfy similar sets of requirements
  - Contractor development processes differ greatly, even for similar systems in similar product areas
  - Further cultural differences in AF
    - Space systems ⟷ Non-space systems
    - Weapon systems ⟷ Business and IT systems
    - Product Centers ⟷ Logistics Centers ⟷ Test Centers
- **Operations / Employment**
  - Often used in new combinations
    - Near-infinite number of subsets of constituent elements/systems, etc.
    - Near-infinite number of dynamic configurations
  - Often used in new environments and operational scenarios
  - Often used with new supporting cast

SE for SoS
Enabling Capabilities - Example

Capability: Targeting of Coordinate-Seeking Weapon (CSW)
(all-weather, air-to-ground, GPS/INS-guided munitions)

SoS Architecture

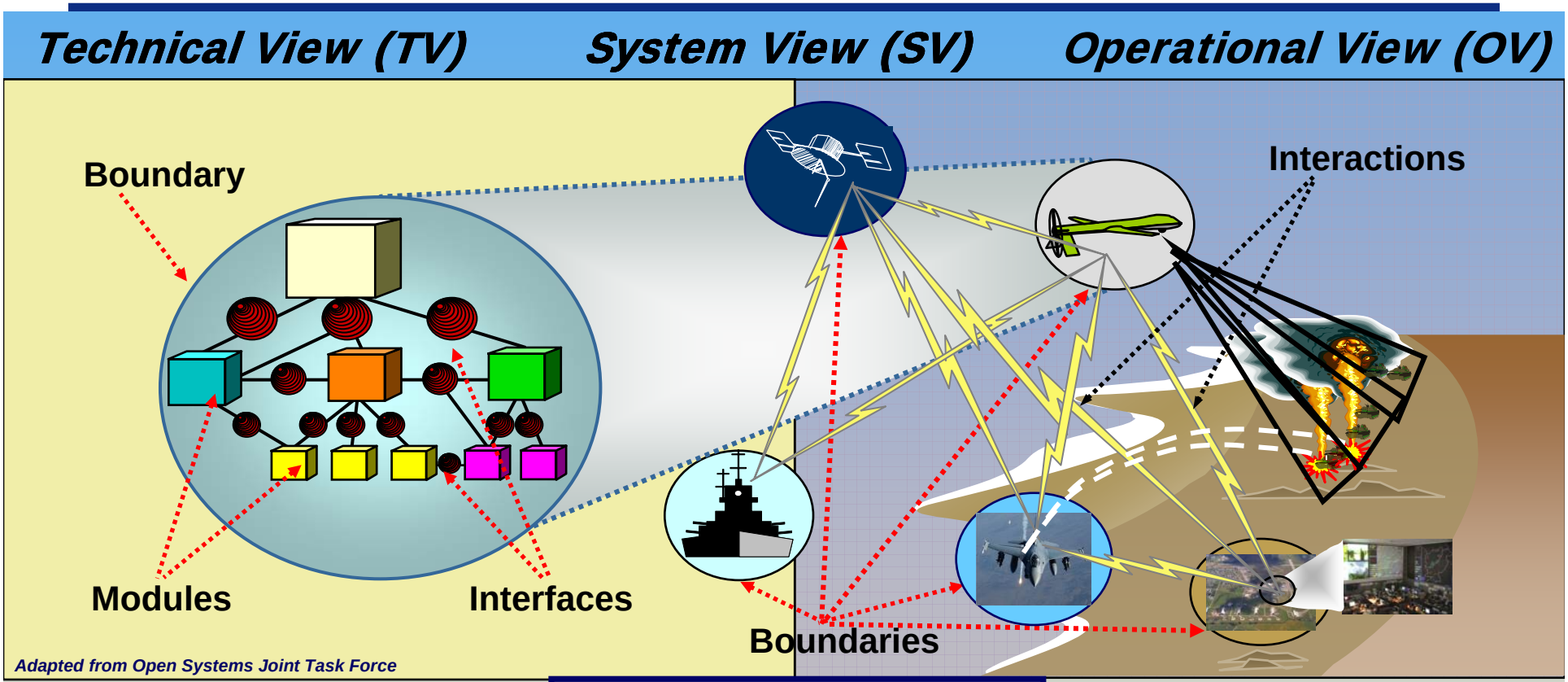


Representative Constituent Systems

Sniper	Link 16	AOC	Link 16	F-22A	GBU-38 (JDAM)
JSTARS		DCGS	AWACS	B-52	GBU-39 (SDB)
Predator		GCS		F-15E	
BAO / TAC		AWACS		F-16C/D Blk 50	

None of these systems was designed with CSW targeting in mind, and only a few of the systems were designed to interface with each other

SoS Enabling Capabilities
Defined by Architectural Views



How the contractor builds it How we support & maintain it	What we buy	Where & how we use it, and assess value & effectiveness
TV "Success Criteria"	**SV "Success Criteria"**	**OV "Success Criteria"**
All system/subsystem components function properly; robust designs use "plug-&-play" open interfaces and industry standards	All robust platforms/systems operate safely & function properly to deliver discrete capability in the battlespace	All assets safely interoperate as SoS; integrated capability delivery in the battlespace is essentially "plug-&-fight"

SE for SoS
Cases & Issues - 1

- New developments
  - Seen as the exception rather than the rule
  - Affordability constraints
  - Centralized funding and management
  - Role of integrator vs. role(s) of developer(s)
- Integrated legacy systems for new capability
  - Will probably be the most common approach
  - Defined in interoperability ("plug-and-fight") context
  - Discovery of interactions, especially in ad hoc configurations
  - Inconsistent and disparate management of configurations, data, etc.
  - Test / M&S: formal test, verification and validation, experimentation

SE for SoS
Cases & Issues - 2

- **Collaboratively developed constituent systems**
  - Defined in terms of a common architecture to guide development of new systems and platforms
  - Greater number of stakeholders, with both parochial and holistic interests
  - Data sharing among multiple contractors
  - Definition and management of common architecture(s)
- **Sustainment of existing systems**
  - Different pace of updates for different systems at different points in their life cycle
  - Increase capabilities by technology refresh / insertion
  - Often with different levels of documentation and data
  - Diminishing (and often volatile) sources of support
  - Local management / funding (particularly true for business and IT systems)

SE for SoS
Summary

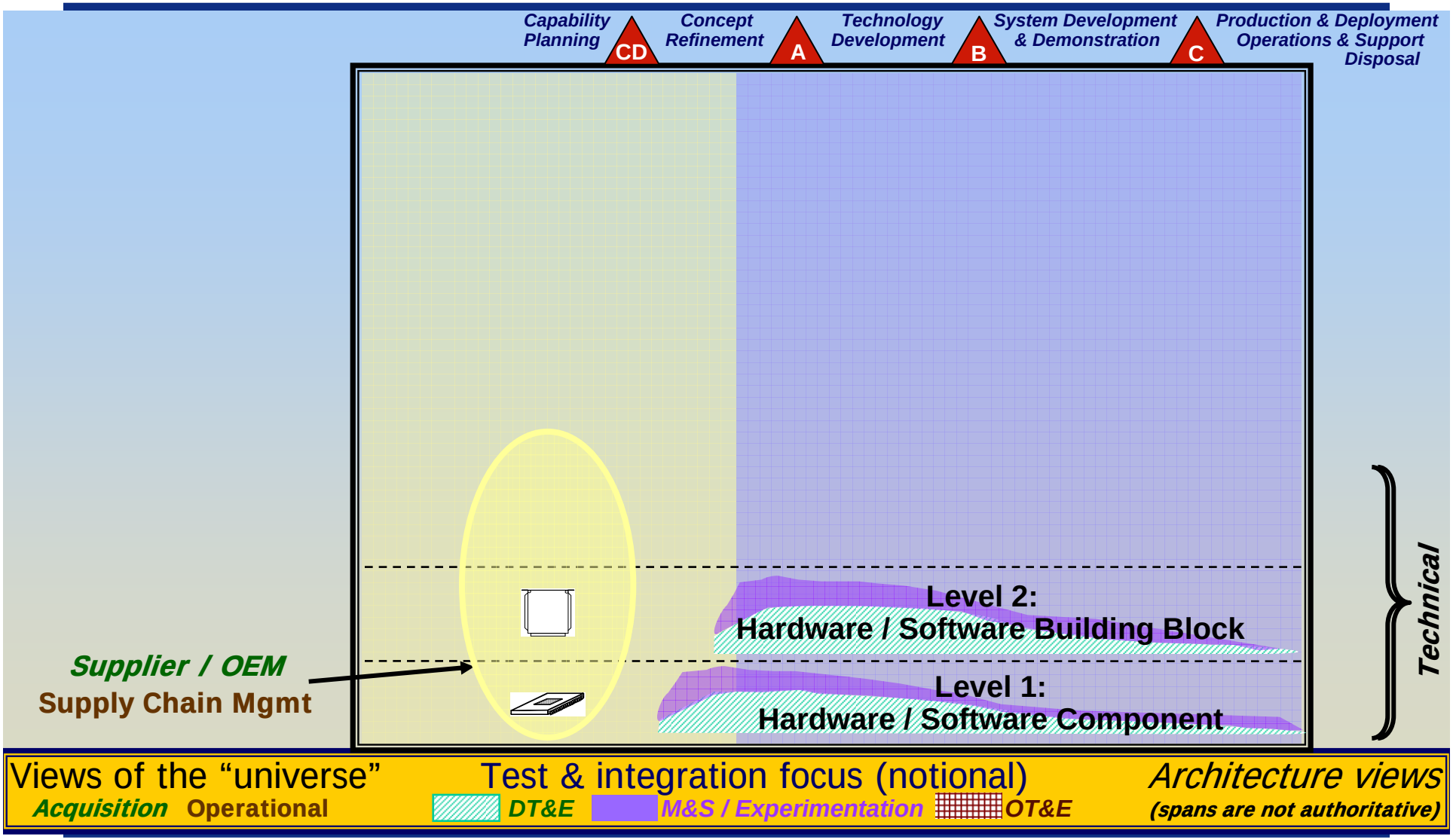
- Driven by fiscal and operational realities
- Fundamental SoSE processes (technical & technical management) largely the same as for "classical" SE
  - Greater emphasis on architecting and interfaces
- Integration challenges: test & real-world environments
  - Defining architectures to link systems and platforms
  - Experimentation as a development tool
  - Managing utilization of assets acquired and operated under disparate systems and policies
- Unique management and governance issues

ULTIMATE RESULTS

- Robust, responsive capabilities delivery; better integrated
- More confidence in system performance

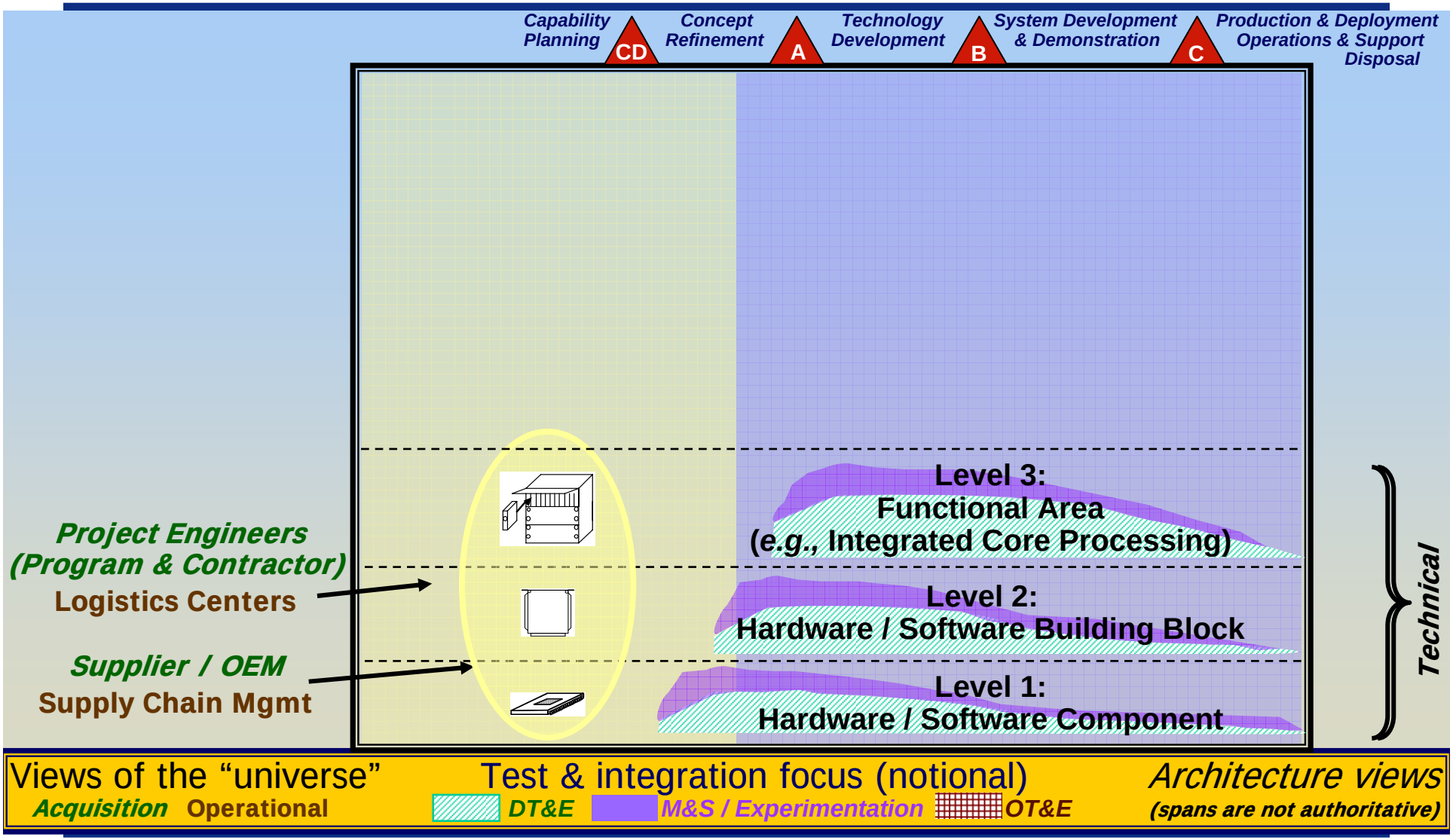
SE Perspectives

Acquisition, Operations, Integration, Architecture



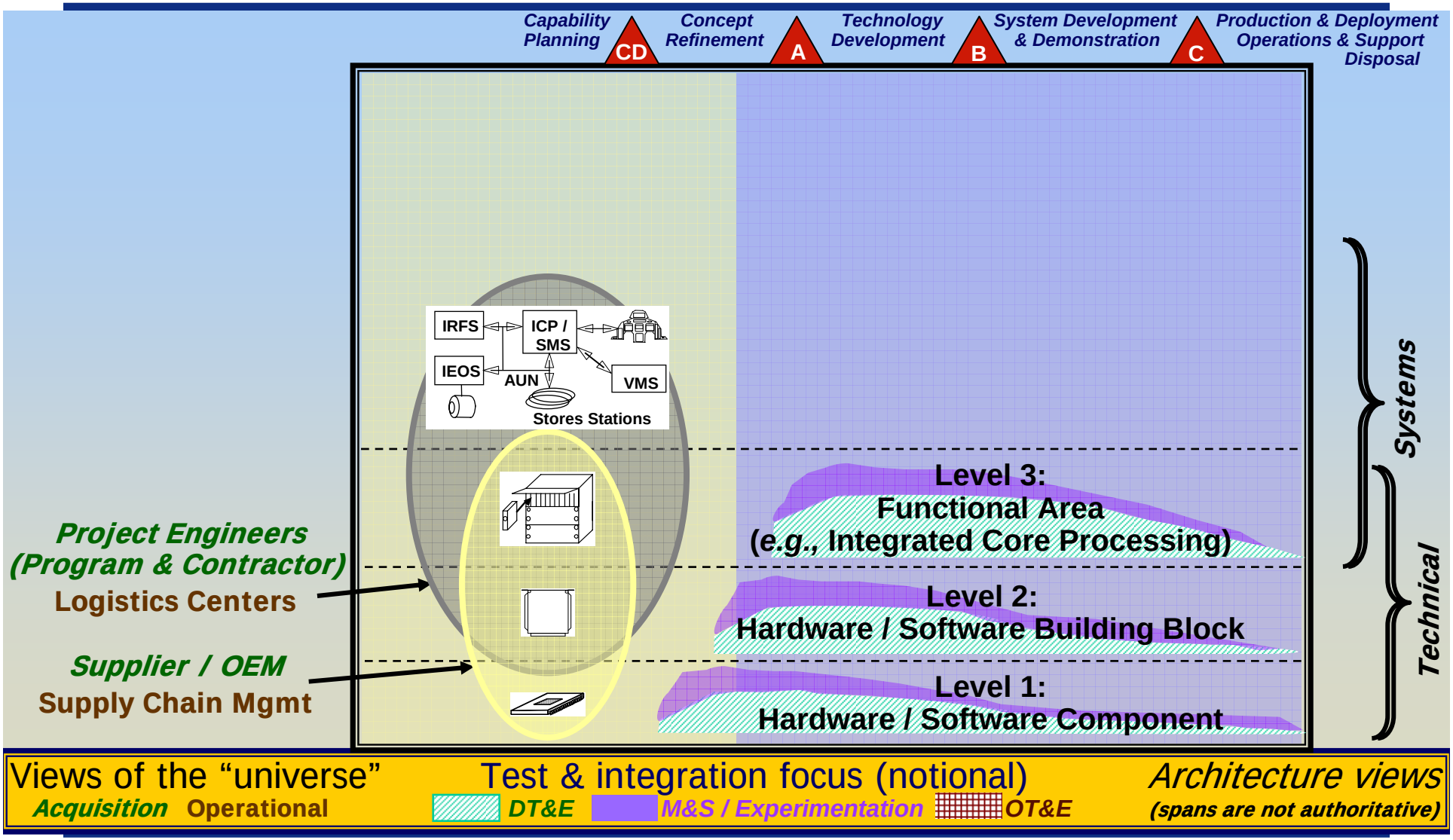
SE Perspectives

Acquisition, Operations, Integration, Architecture



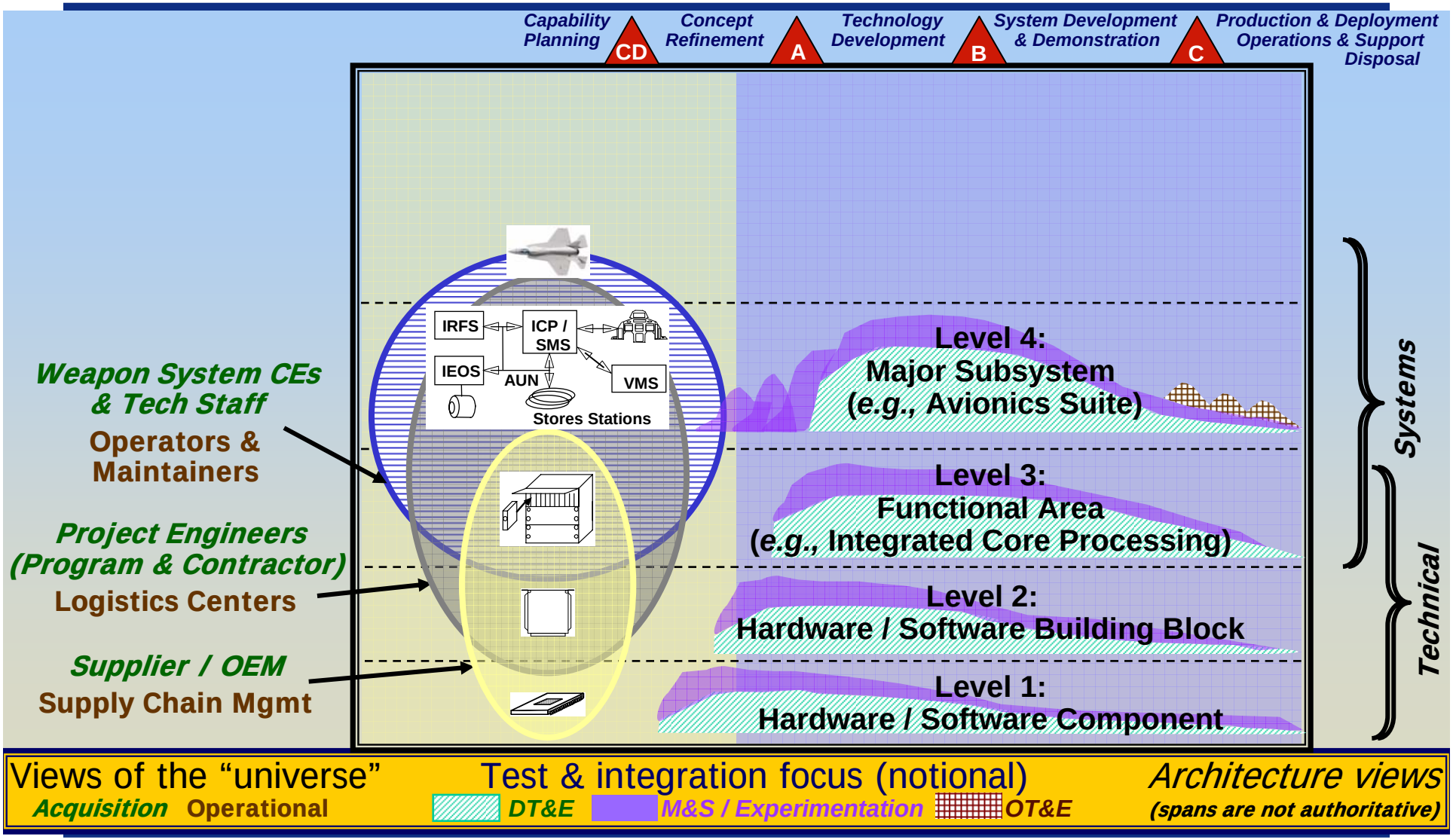
SE Perspectives

Acquisition, Operations, Integration, Architecture



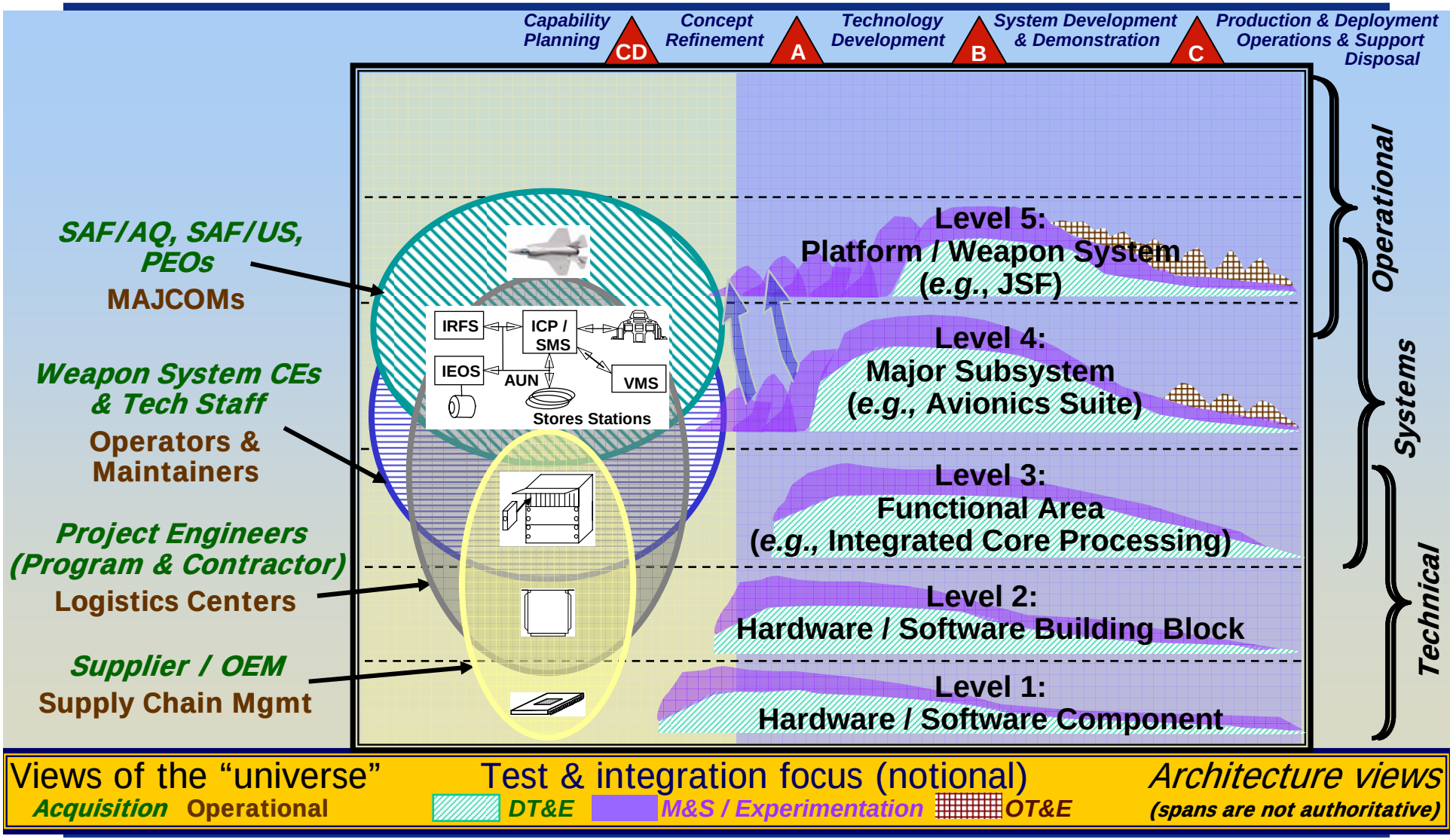
SE Perspectives

Acquisition, Operations, Integration, Architecture



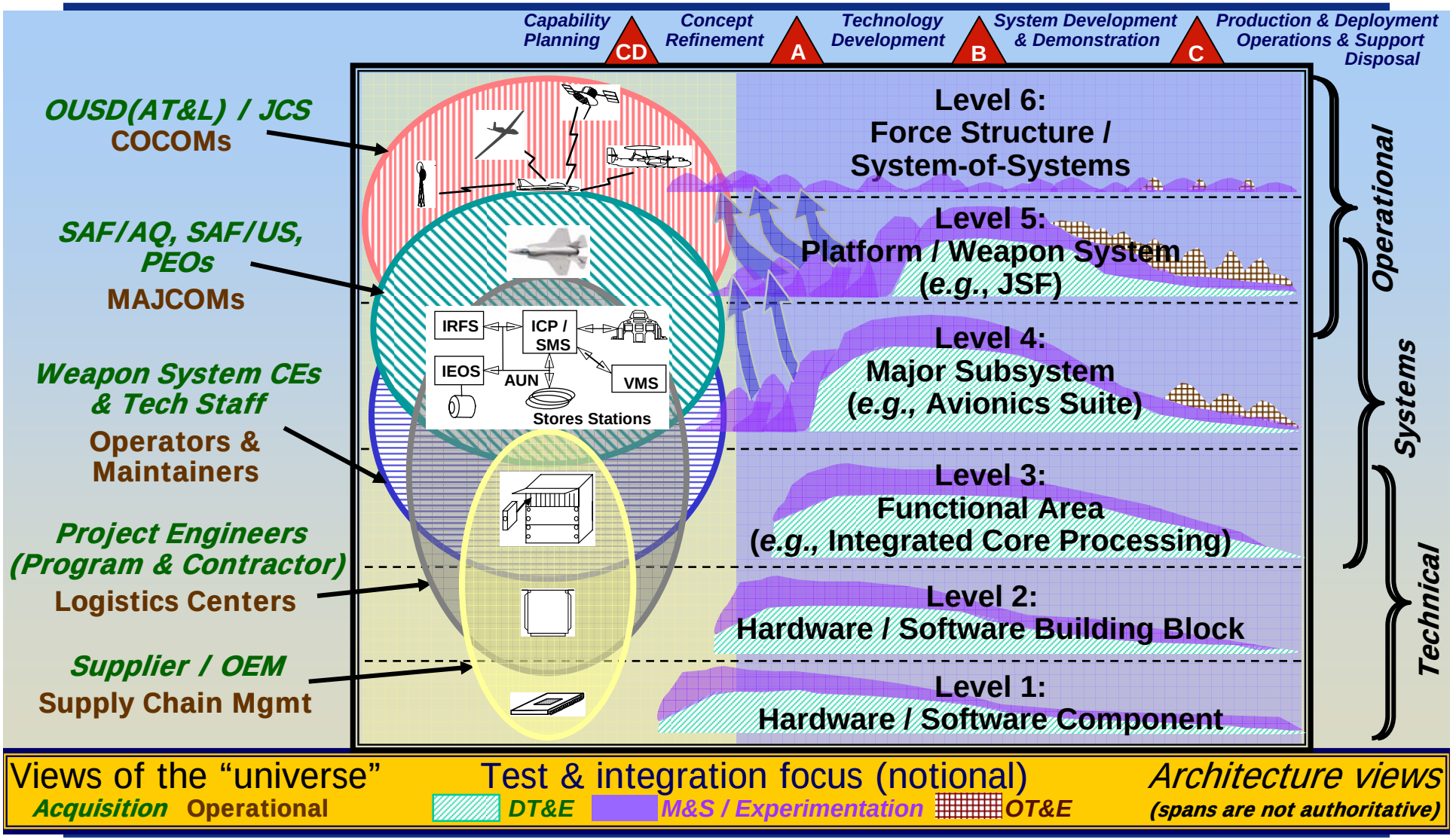
SE Perspectives

Acquisition, Operations, Integration, Architecture



SE Perspectives

Acquisition, Operations, Integration, Architecture



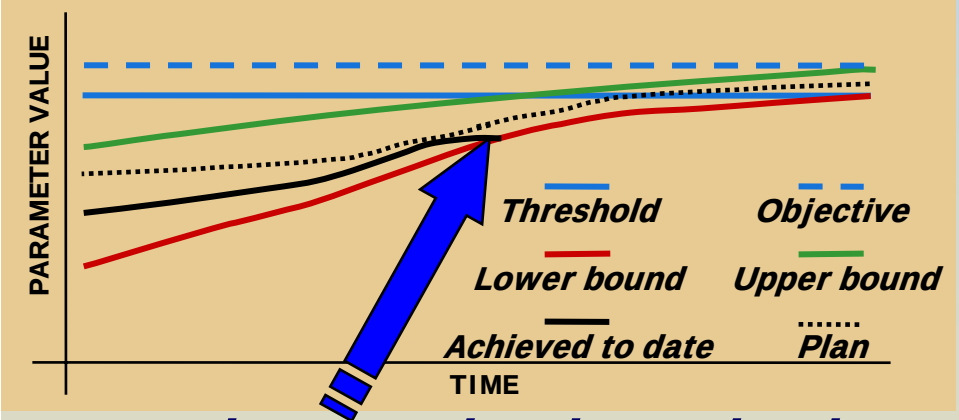
Focus Areas for SE Planning *

- **Program Requirements**
  - Capabilities, CONOPS, KPPs
  - Statutory / regulatory
  - Specified / derived performance
  - Certifications
  - Design considerations
- **Technical Staffing / Organization**
  - Technical authority
  - Lead Systems Engineer
  - IPT coordination
  - IPT organization
  - Organizational depth
- **Systems Engineering Process**
  - Technical Processes
  - Technical Management Processes
  - Process Improvements
  - Key Tools and Resources
  - Trade Studies
  - Linkage to Contractor SE Effort
- **Technical Baseline Management**
  - Who is responsible
  - Definition of baselines
  - Requirements traceability
  - Specification tree and WBS link
  - Technical maturity and risk
- **Technical Review Planning**
  - Event-driven reviews
  - Management of reviews
  - Technical authority chair
  - Key stakeholder participation
  - Peer participation
- **Integration with Overall Management of the Program**
  - Linkage with other program plans
  - Program manager's role in technical reviews
  - Risk management integration
  - Test and logistics integration
  - Contracting considerations

* - Based on OSD SEP Preparation Guide

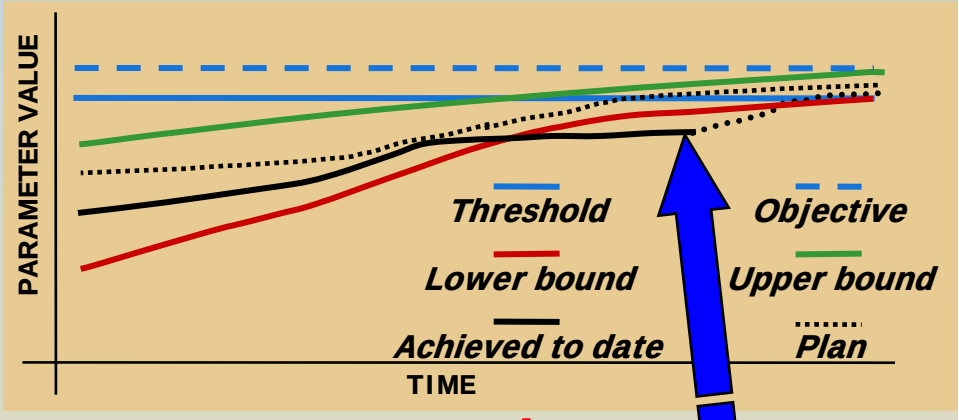
Focus Areas for Measuring Progress

- Representative Technical Performance Measures (TPM) parameters
  - Hardware – weight, speed, power, cooling, cross-section, bandwidth
  - Software – throughput, lines of code
  - Verification – test asset deliveries, test points completed with valid data
  - Logistics – reliability, maintainability
- Integration – physical and information interface definitions; verification plans
- Earned Value Management System (EVMS) data
  - Cost variances
  - Schedule variances
- Program planning
  - Staffing
  - Subcontracting
  - Specification approvals
  - Closure of review actions



Monitor trend; take action here

Plan is probably achievable



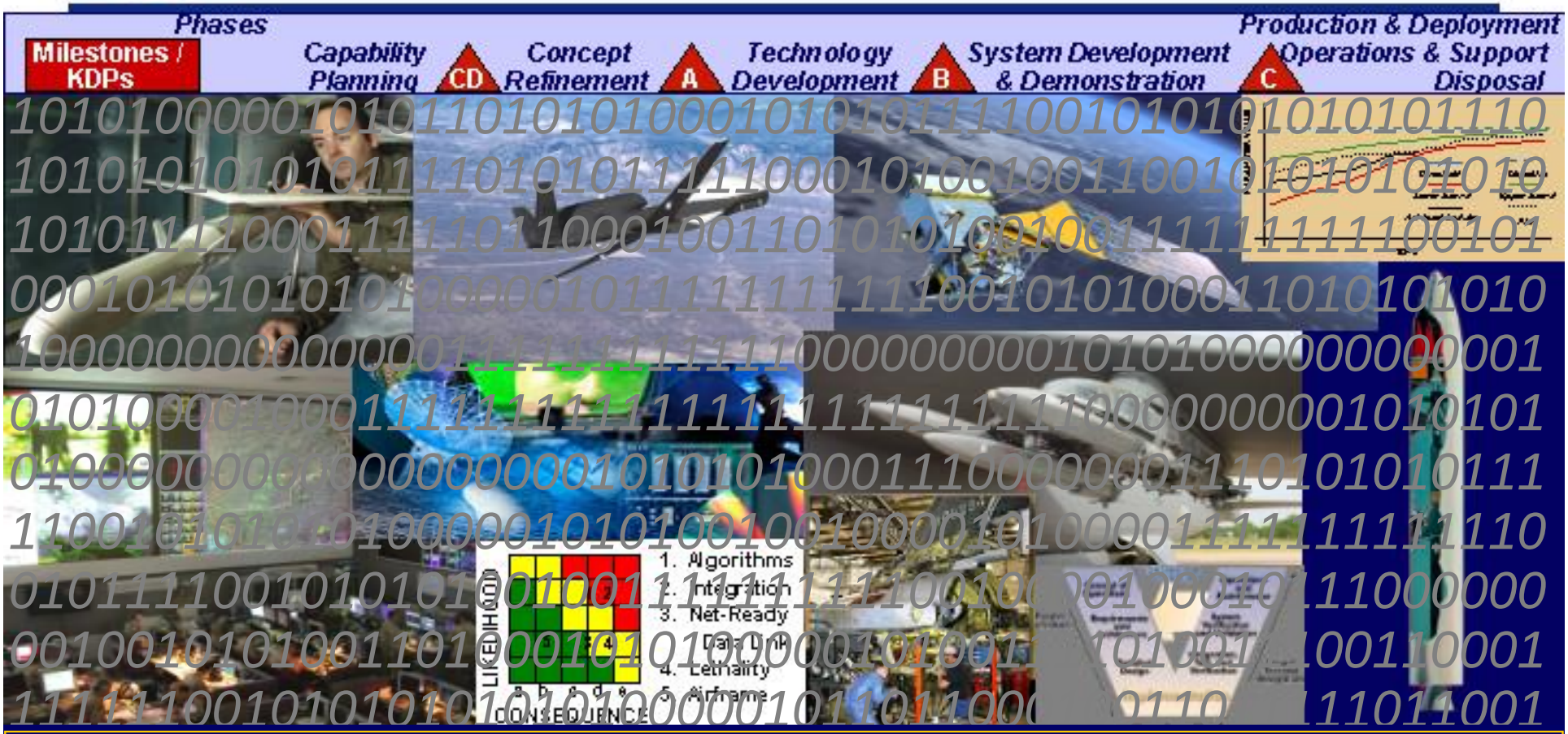
Not here

Overly optimistic "get-well" plan

Focus Areas -- Emerging

- **Technical**
  - Manufacturing Readiness
  - Human Systems Integration (AF/SG lead)
  - Specifications and Standards
- **Governance & Oversight**
  - MDA Certification (Section 801 of National Defense Authorization Act for FY06 [Pub. L. 109-163])
  - System & Software Assurance (Security & Program Protection)
- **Multi-Faceted**
  - Enterprise-level SE
  - Industrial Base

Visions



- ***Consistent application of rigorous life cycle SE in all AF product lines, enabled by a skilled workforce and a policy framework with an integrated life cycle perspective***
- ***Delivery and support of quality systems/SoS/software, on cost and on schedule***


“We demand rigidly defined areas of doubt and uncertainty!”
Douglas Adams,
The Hitchhiker's Guide to the Galaxy
http://www.noao.edu/image_gallery/images/d3/02676a.jpg



Understanding the Joint Partnership between Program Management & Systems Engineering

Samuel Son

and

Benjamin Q. Luong

Copyright © Boeing 2006

Abstract

- Program Management oversees an expansive umbrella that carries a bundle of business and technical activities. Within that umbrella, Systems Engineering supports Program Management by integrating these independent and dependent activities into one synergistic entity that will develop and deliver systems. Indeed Systems Engineering is a foundation and an enabler for Program Management.

- On a mature multi-purpose airlift program, Program Management concentrates on several key program items, such as costs, timely delivery, people, quality, risks, and ultimately customer satisfaction and confidence. These program items are a natural part of the systems engineering process. In view of these program items, Systems Engineering focuses on stabilizing and enhancing the systems engineering process.

- As joint partners, Program Management and Systems Engineering organizations must work together to define and understand their diverse objectives. Convergence of these objectives will lead to best practices that accomplish business goals, such as reducing cycle time without impacting quality, and deliver a product(s) or system(s) to the satisfied customer.

- For feedback to Program Management, a Systems Engineering Scorecard measures systems engineering performance across the multi-purpose airlift program. Inherently, this metric will positively benefit the corporate enterprise. Company financial results and performance can meet or exceed shareholders' expectations because good application of systems engineering will provide total cost visibility and will lead to reducing system life-cycle costs, including design and development costs.

- Also within this umbrella, the users, such as Project Integrators and Project Managers, of the systems engineering process can then apply and utilize it to manage product development(s) that add new capabilities to the multi-purpose airlift system. Systems engineers are critical members of the project team that aligns program management items and objectives with product development. In sum, a strong relationship between Program Management and Systems Engineering is essential to product or system development.

Copyright © Boeing 2006

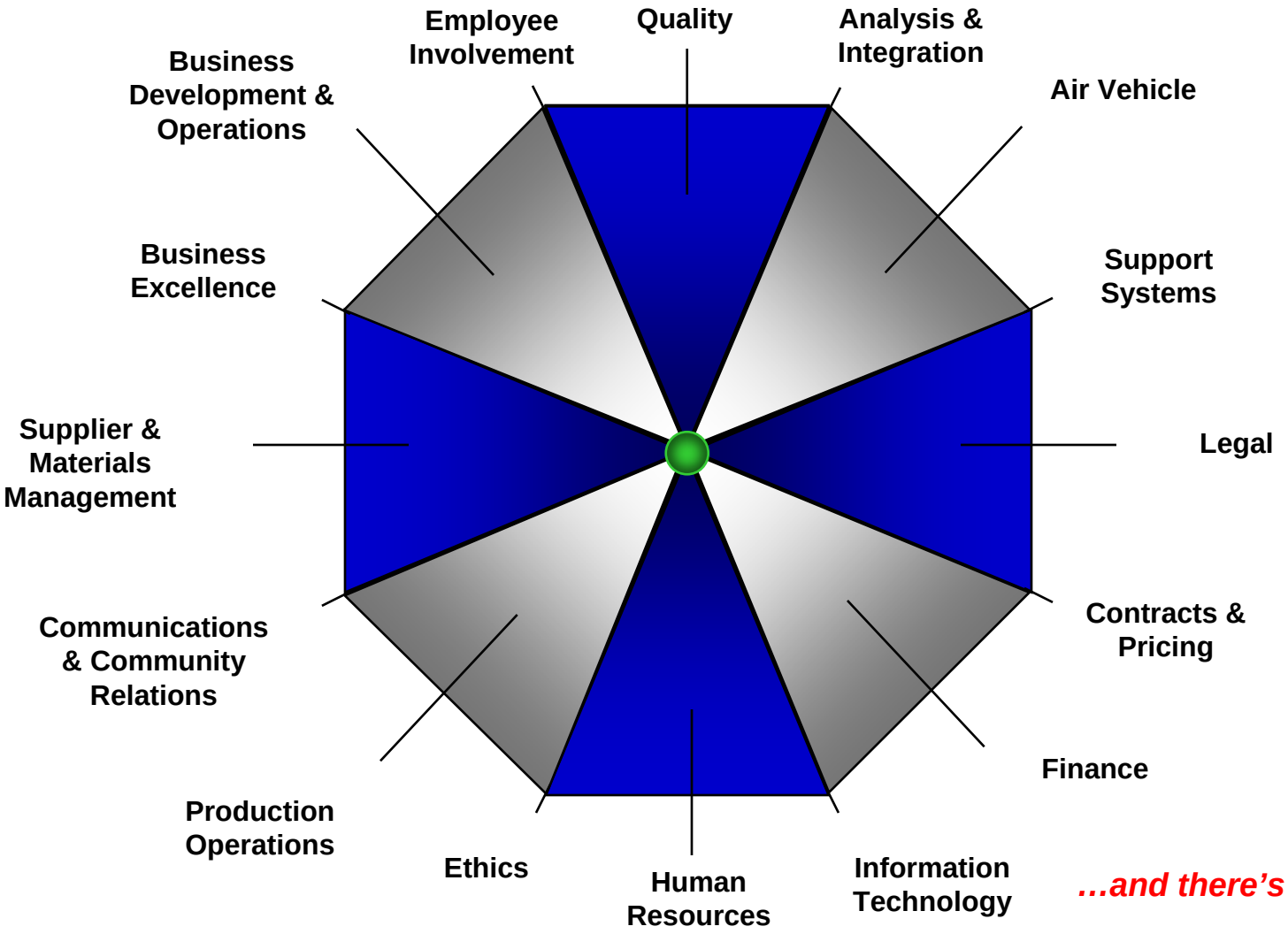
Topics of Discussion

- The Partnership Umbrella
- Systems Engineering Process Stabilization & Enhancement
- Users of the Systems Engineering Process at Multiple Organization Levels
- Conclusion



Copyright © Boeing 2006

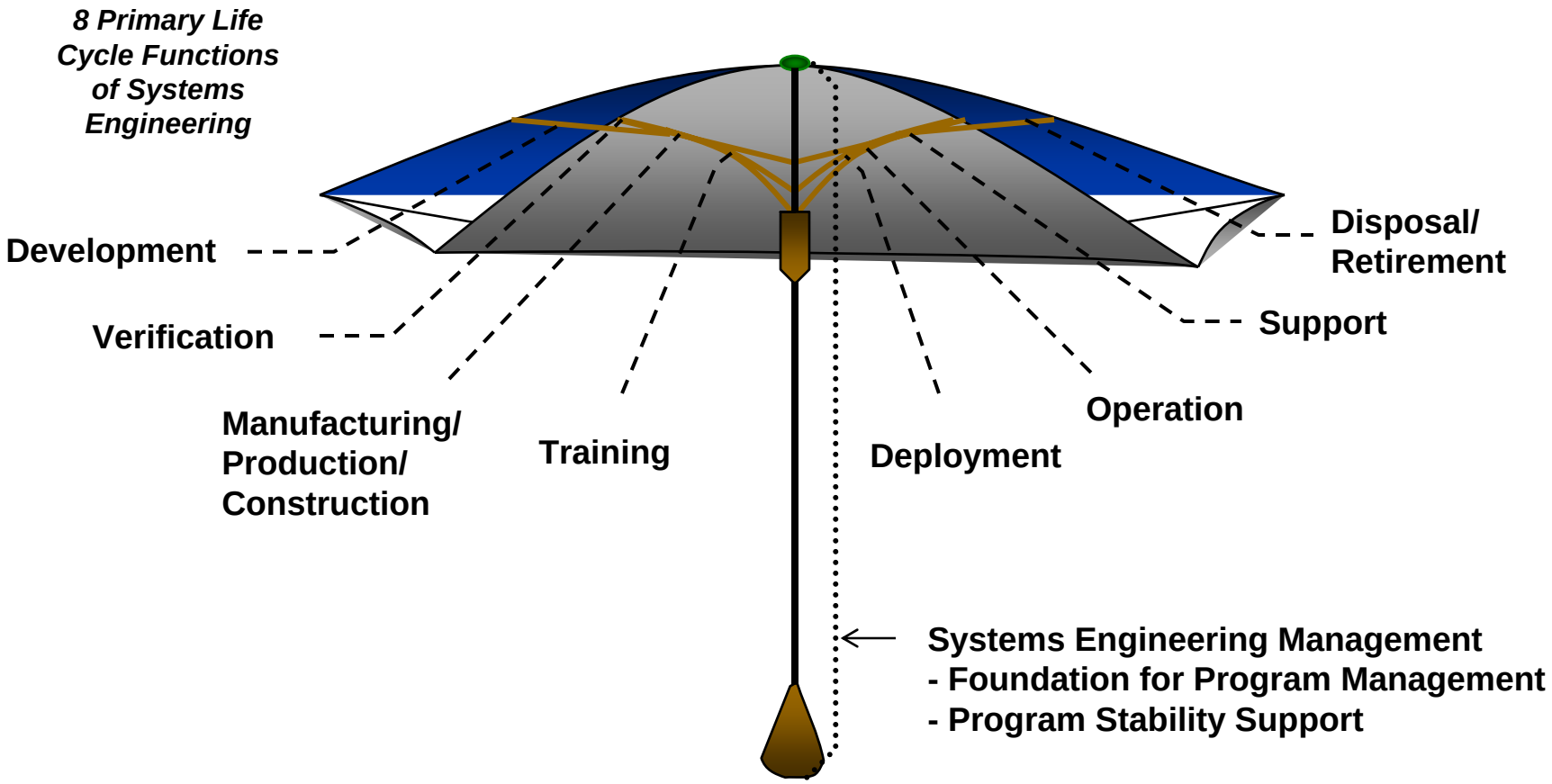
The Partnership Umbrella: Program Management



…and there's many more.

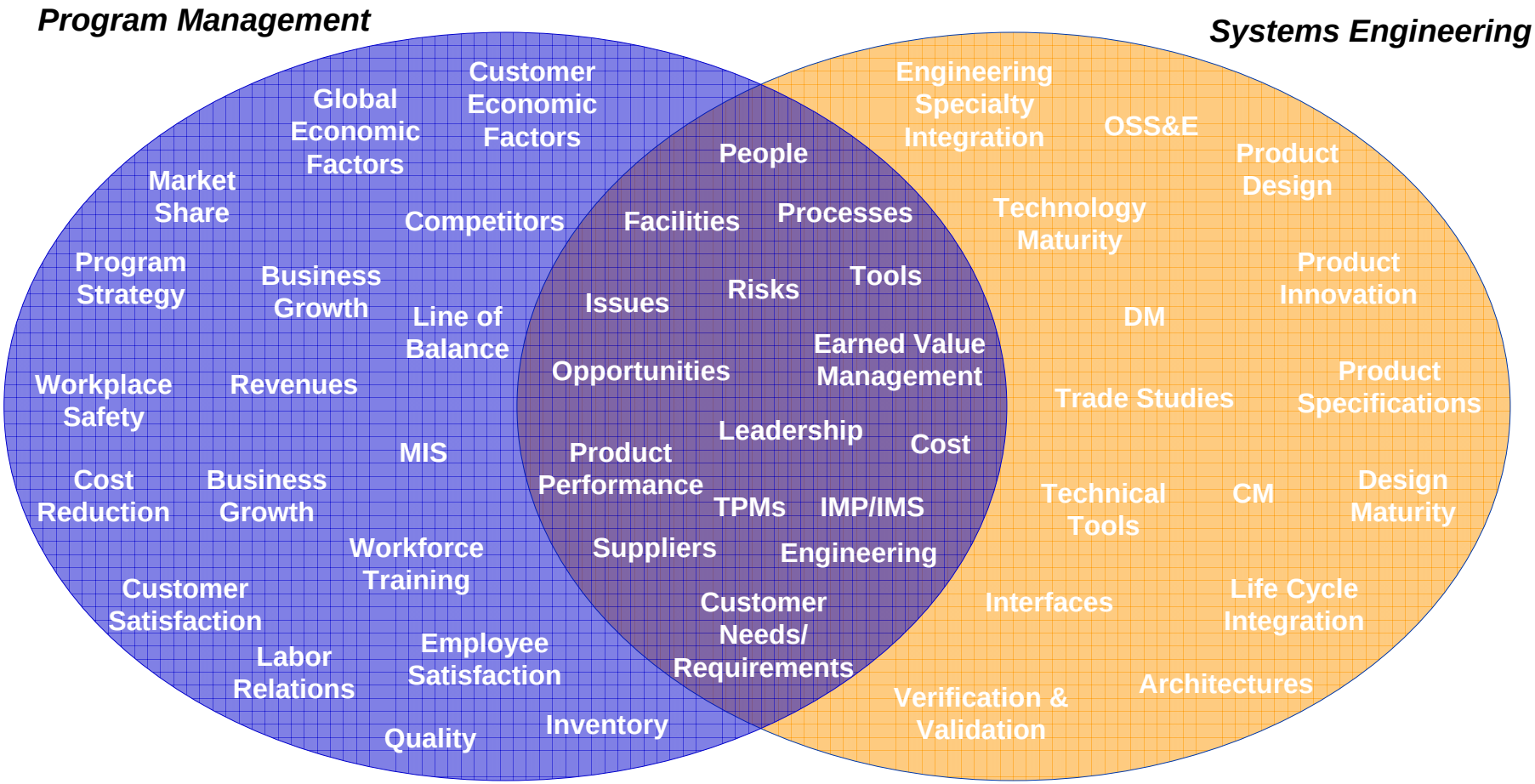
Copyright © Boeing 2006

The Partnership Umbrella: Systems Engineering



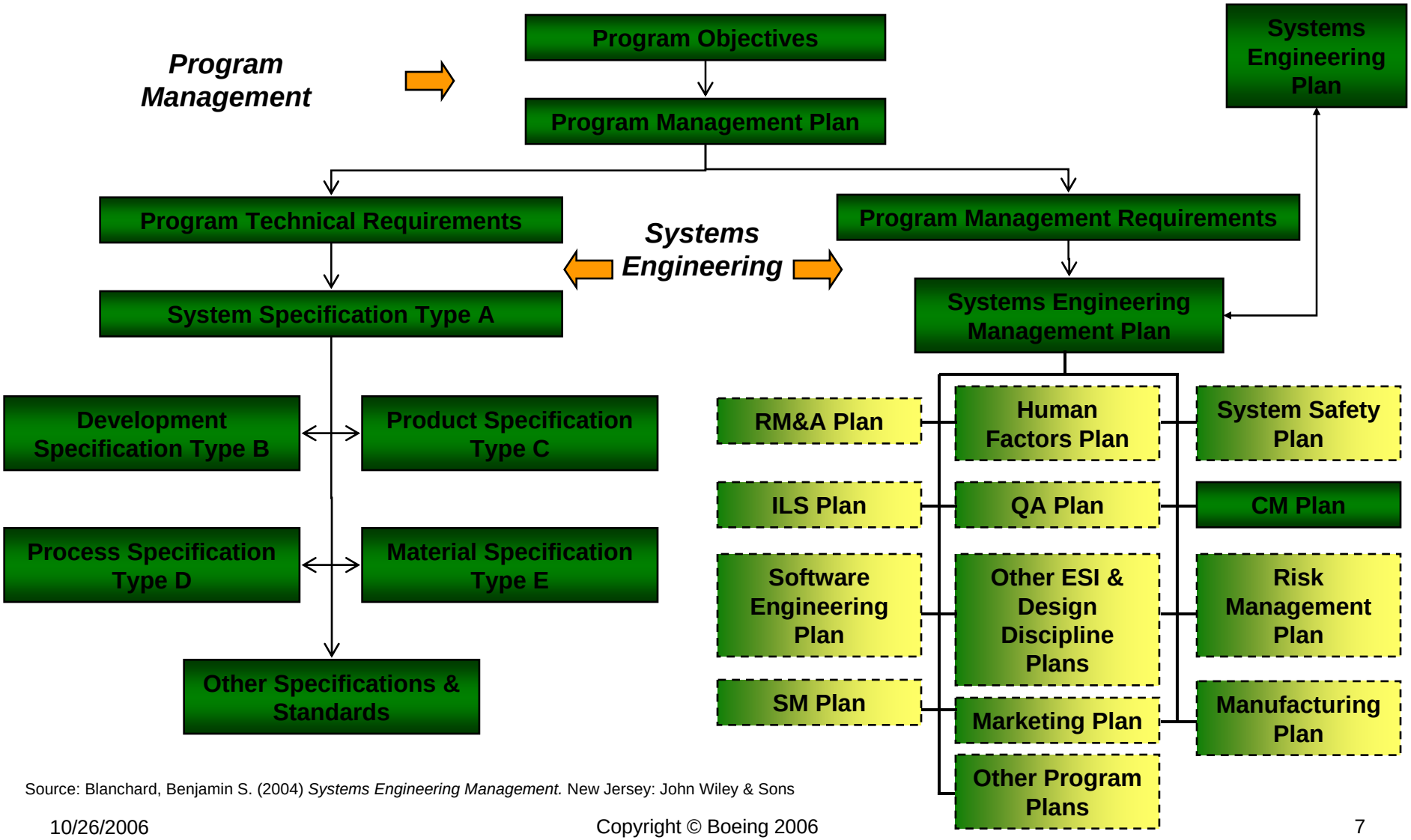
Copyright © Boeing 2006

The Partnership Umbrella: Interrelationships



Copyright © Boeing 2006

The Partnership Umbrella: Interrelationships



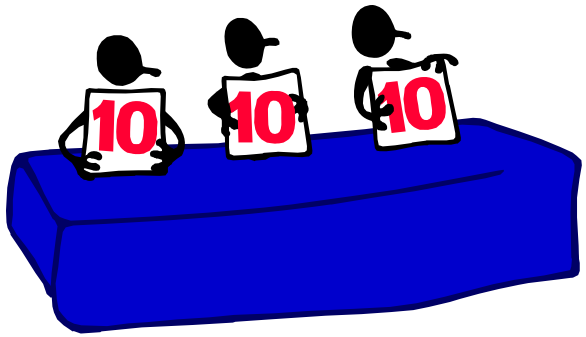
Source: Blanchard, Benjamin S. (2004) *Systems Engineering Management.* New Jersey: John Wiley & Sons

Copyright © Boeing 2006

SE Process Stabilization & Enhancement (examples)

- Systems Engineering Supporting Program Management
  - Product Development
  - Assessments & Best Practices
    - Contractor Performance Assessment Reporting (CPAR) Review
    - TA-314 Project Performance Assessment & Review
    - Program Management Best Practices
    - Engineering Best Practices
    - Systems Engineering Scorecard Review

- Assessments & Best Practices provide total visibility on strengths and weaknesses in Systems Engineering as well as progress of improvement efforts



Copyright © Boeing 2006

Contractor Performance Assessment Reporting (CPAR)

- Objectives:
  - Ensure that accurate data on contractor performance is current and available for use in source selections
  - Consistently provide quality, on-time products and services that conform to contractual requirements
  - Effectively communicate contractor strengths and weaknesses to source selection officials

- Systems Engineering Supporting Program Management:
  - Use Award Fee Rating Criteria
  - Review Customer's AFAST Database
  - Review Award Fee Review Charts
  - Review Project Integration Weekly Reports
  - IMP/IMS Performance



Copyright © Boeing 2006

TA-314 Project Performance Assessment and Review

- Objectives:
  - To rate, assess, and report project performance to management and the customer

- Systems Engineering Supporting Program Management:
  - Review Technical Performance Measurement (TPM)
  - Review Systems Engineering Compliance
    - Requirements
    - Risk
    - Verification
    - Formal Review
    - Critical Action Item(s)



Copyright © Boeing 2006

Program Management Best Practices

- Objectives:
  - To achieve successful program development, implementation and support based on an integrated set of Program Management Best Practices

- Systems Engineering Supporting Program Management:
  - Review maturity level for program execution & control
  - Use program execution & control best practice criteria
    - Establishment of the program's systems engineering methodology
    - Allocation and traceability of program requirements
    - Verification of program requirements
    - Program identification of TPMs
    - Allocation and reporting of TPMs



Copyright © Boeing 2006

Engineering Best Practice

- Objectives:
  - Vision Support Plan: Strengthen Systems Engineering
  - Maintain the Capability Maturity Model Integration (CMMI) Level 5

- Systems Engineering Supporting Program Management
  - Develop Engineering Best Practices Self Assessment Plan
  - Review overall attributes associated with each of the Best Practices
  - Improve training materials
    - Requirements Management
    - Interface Management
    - Technical Performance Measures
    - Trade Studies
    - Verification & Validation
  - Conduct trainings



Copyright © Boeing 2006

Systems Engineering Scorecard Review

- Objectives:
  - To develop the method and criteria for measuring the effectiveness of SE at a program level
  - To define and ensure common application of World-Class SE processes and tools to meet customer expectations

- Systems Engineering Supporting Program Management:
  - Monthly assess program-level systems engineering performance
    - PMBP, Engineering BP, CPAR, PBMs, and TA-314
  - Monthly assess each IPT's compliance to systems engineering process
    - AV/FC/SE IPT, Aircraft System IPT, Airframe IPT, AV/SS IPT, Engineering Integration IPT, and NCO IPT
  - Generate Monthly Systems Engineering Rollup Report



Copyright © Boeing 2006

Users of the SE Process at Multiple Organization Levels

SE ALIGNMENT



Enterprise Level

Program Level

Project Integration Level

Project Level

Image Source: University of Toronto Magazine

Copyright © Boeing 2006

Conclusion

- While the focus of Program Management lies in the business arena and Systems Engineering in technical, the two disciplines share many fundamental principles, elements, and activities
  - Program performance and product performance are inter-dependent in many parameters
- These parameters can be integrated, mapped, aligned, and mutually supported to create a comprehensible and synergistic relationship
  - Clear visibility of overall key performance parameters
  - Consistency in assessment of overall key performance parameters
- This synergistic relationship is an essential enabler for the effective management of a program
- Good applications of the SE Process is seen at all levels of an organization to encourage consistency and alignment for product development

Copyright © Boeing 2006

Contact Information

- Samuel Son, Systems Engineer
  - Phone: (562) 982-2209
  - Email: samuel.k.son@boeing.com

- Benjamin Q. Luong, Systems Engineer
  - Phone: (562) 593-4668
  - Email: benjamin.q.luong@boeing.com

Thank you!



Copyright © Boeing 2006

Quality / Systems Engineering Interfaces to Enhance Program Success

National Defense Industrial Association
9th Annual Systems Engineering Conference
October 23-26, 2006

Dr. Jay Mandelbaum
Institute for Defense Analyses
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

Acknowledgment

Boeing Integrated Defense Systems volunteered to support the initial development of this work to provide an industry perspective. As such, Boeing was the source of much of the original input to the analyses as well as a sounding board for initial results. Boeing's contributions are greatly appreciated; they were vital to the development of the product.

Outline

- **How quality impacts technical risk**
- **Involving quality early**
- **Encouraging a quality focus**
- **Incorporating quality in the systems engineering technical reviews**
- **Concluding remarks**

Quality Matters

V-22 Osprey story



USS Thresher story



Firestone tire story





Flaw Could Shorten Raptors' Lives
The News Herald, Panama City, Fla. May 3, 2006

"Officials discovered that the titanium components [of the forward boom frames] may have been improperly treated, creating the possibility that the metal would not last as long as it is supposed to. … This is not a result of improper design, but an issue with one supplier's manufacturing process."

therefore • • •

Industry Has Adopted a New Paradigm for Quality

- **Quality is no longer limited to a centralized functional organization for:**
  - **Auditing / compliance with standards (certification)**
  - **Implementation of a quality management system**
  - **Inspections / searching for defects**

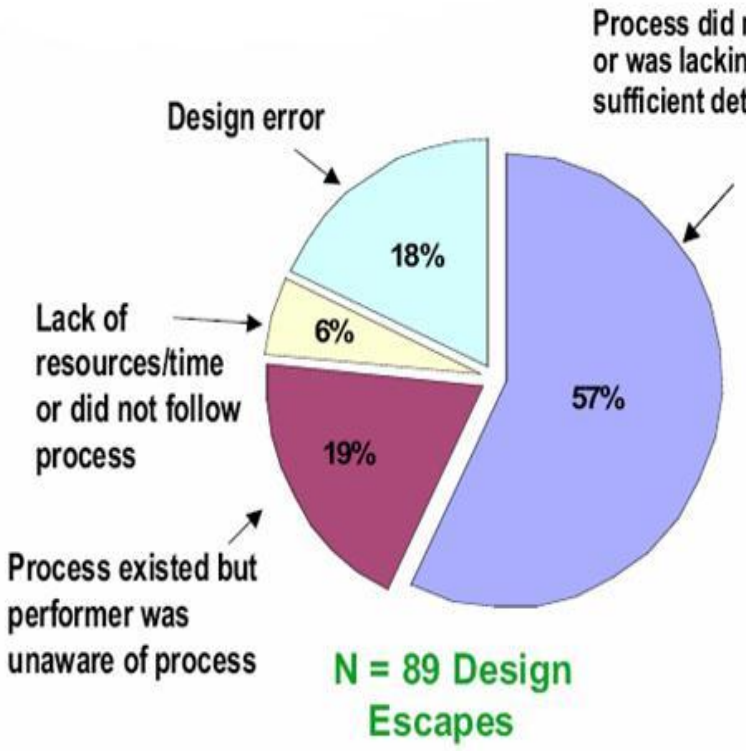
- **Today, quality engineers/SMEs are typically matrixed to a product or project early in development**
  - **Valued member of IPTs**
  - **Closely linked with a company's process improvement initiatives**
  - **Assess if processes are working as designed using objective criteria**

Process carelessness leads to technical risk

Risks that Quality Identifies and Mitigates

Quality engineers/SMEs identify situations	. . .	*that may lead to potential risks to be mitigated*
– Inappropriate application of technical processes and/or inadequate procedures		– Ill-defined requirements, a breakdown in requirements flow down, or uneconomically producible designs
– Ineffective supplier management		– Suppliers with inadequate capabilities; decreasing leverage with subtiers
– Ineffective customer engagement		– Dissatisfied customers
– Unidentified verification technologies		– Undetected product defects

Analyses Show Prevalence of Process-Based Risks



Summary Root Causes

- Lack of clear standard design process
- Insufficient process compliance accountability and enforcement requirement
- Ineffective design reviews

Root cause analysis showed 82% of design escapes attributed to "no established process" or "process non-compliance"

Presented by Lisa Kohl
Vice President, Northrop Grumman Space Technology
Lean Aerospace Initiative Plenary Conference
23-24 March 2004

Why are these Risks Important?

- **If not managed and mitigated, these risks may start a chain of events resulting in undesirable outcomes**
  - **Product defects discovered in production or testing lead to expensive and time-consuming rework**
  - **Product may not meet customer needs**
  - **Product failures discovered in the field lead to degraded mission effectiveness or mishaps**
- **The later these risks are identified, the greater the cost of corrective action and the greater the delays in schedule**

Early identification, management, and mitigation of important process-based risks to a program leads to less expensive and less disruptive preventive actions that break the chain of events

Best Practices for Reducing Process-Related Risk to a Program

- Early Quality involvement with the product line to ensure that processes are implemented correctly
- Create conditions that encourage the entire workforce to focus on quality along with cost, schedule, and performance
  - Clear, unambiguous and visible commitment from management
- Develop strong linkages between the quality engineers/SMEs on the product or project and the SE technical reviews

DoD should encourage industry to apply these best practices and follow them consistent with its oversight responsibilities

Outline

- How quality impacts technical risk
- Involving quality early
- Encouraging a quality focus
- Incorporating quality in the systems engineering technical reviews
- Concluding remarks

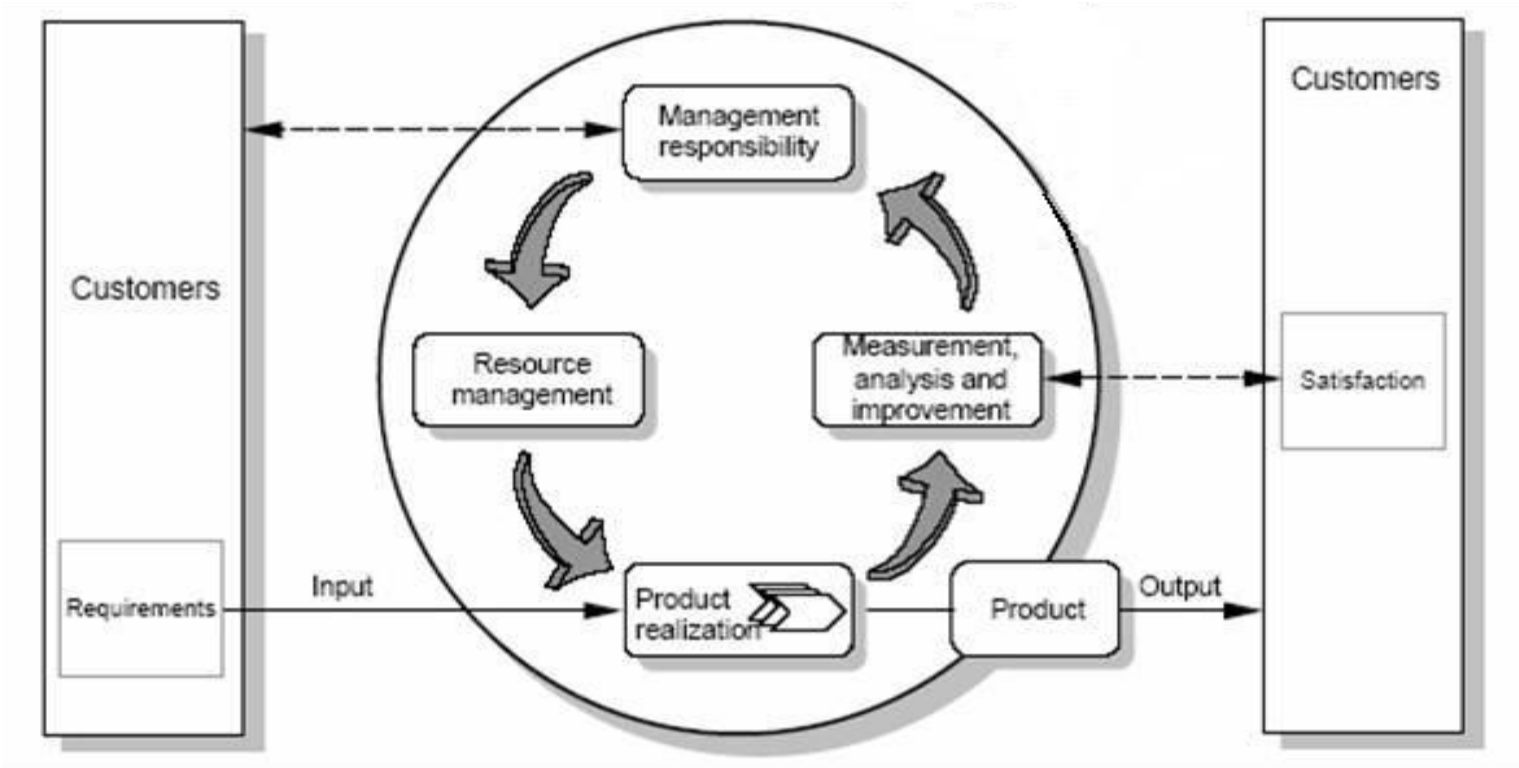
Early Quality Involvement (slide 1 of 3)

- A "process approach" is the identification, interaction, application, and management of a system of processes over the life cycle
- Quality engineers/SMEs involvement means implementing processes correctly in order to
  - Understand and meet requirements
  - Evaluate processes in terms of value added
  - Obtain results of process performance
  - Improve performance based on objective measurement

Don't wait for production before engaging Quality;
Don't delay interactions until there is a problem

Early Quality Involvement (slide 2 of 3)

ISO's Model of a Process Based QMS



Early systematic use of a process based quality management system (QMS) improves outcomes

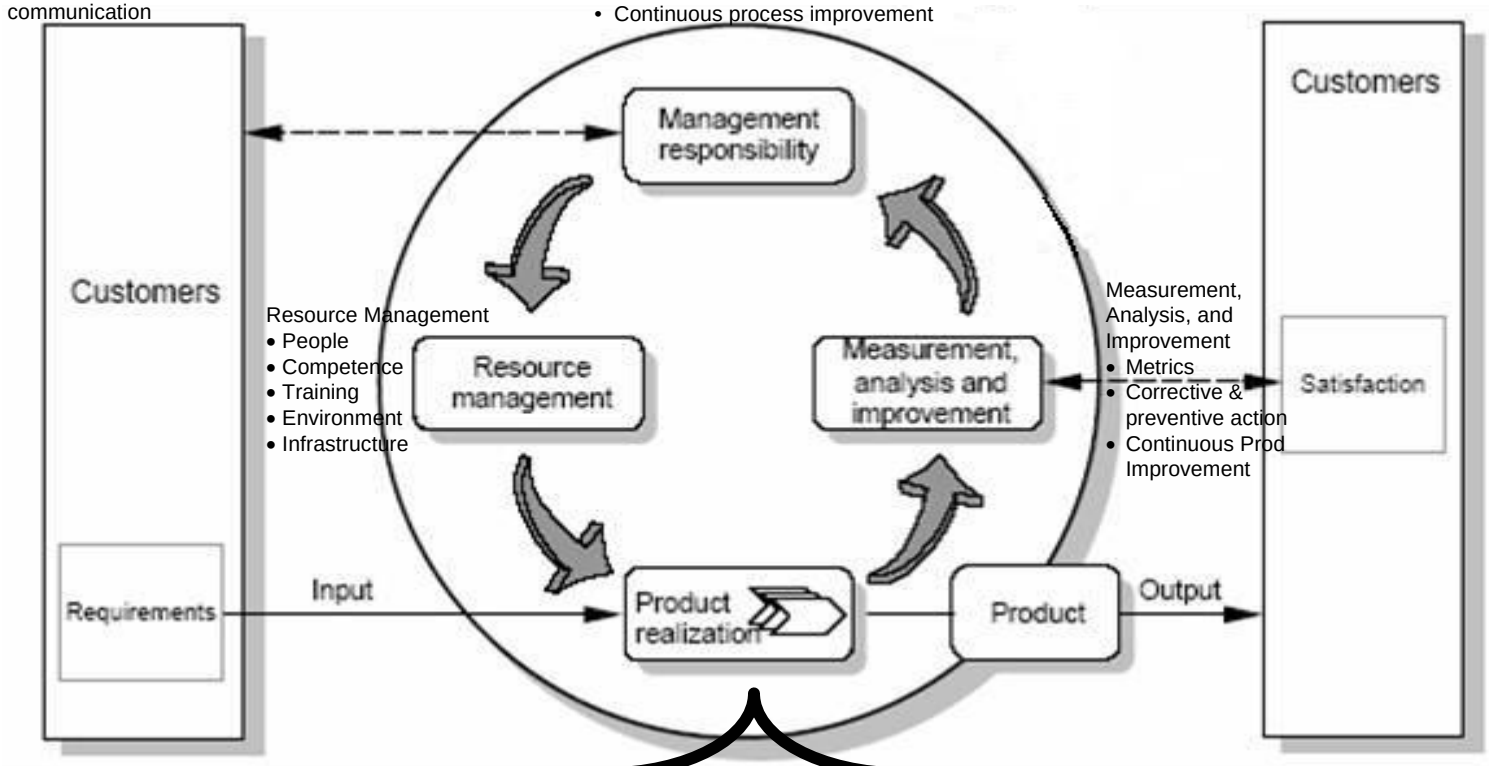
Early Quality Involvement (slide 3 of 3)

A Process Based QMS's Interactions with a Program

Customer Requirements
- Product requirements documentation
- Program cost and schedule performance data
- Formal customer communication

Management Responsibility
- Management Review
- Quality policy
- Customer focus
- Risk, issue & opportunity mgmt
- Program Independent Analysis
- Continuous process improvement

Customer Satisfaction
- Customer Reporting
- Training System
- Publications
- Post delivery support



Resource Management
- People
- Competence
- Training
- Environment
- Infrastructure

Measurement, Analysis, and Improvement
- Metrics
- Corrective & preventive action
- Continuous Prod Improvement

Systems Engineering
- Prod Reqts Alloc
- Allocation, verification & validation plan
- Configuration, data, risk mgmt

Software Engineering
- Design
- Integration
- Code
- Testing

Integrated Product Definition
- Design
- Specialty Engineering
- Support Functions

Product Support
- Performance based logistics
- Field support requirements

Test Engineering
- Test reqts
- Test planning
- Test conduct
- Reports

Supplier Management and Procurement
- Purchasing process
- Purchase order reqts
- Purchase process verification

Manufacturing Engineering
- Manufacturing and inspection work instructions
- Producibility
- Work flow

Manufacturing Product
- Fabrication
- Assembly

Outline

- How quality impacts technical risk
- Involving quality early
- Encouraging a quality focus
- Incorporating quality in the systems engineering technical reviews
- Concluding remarks

Encourage Quality Focus (slide 1 of 3)

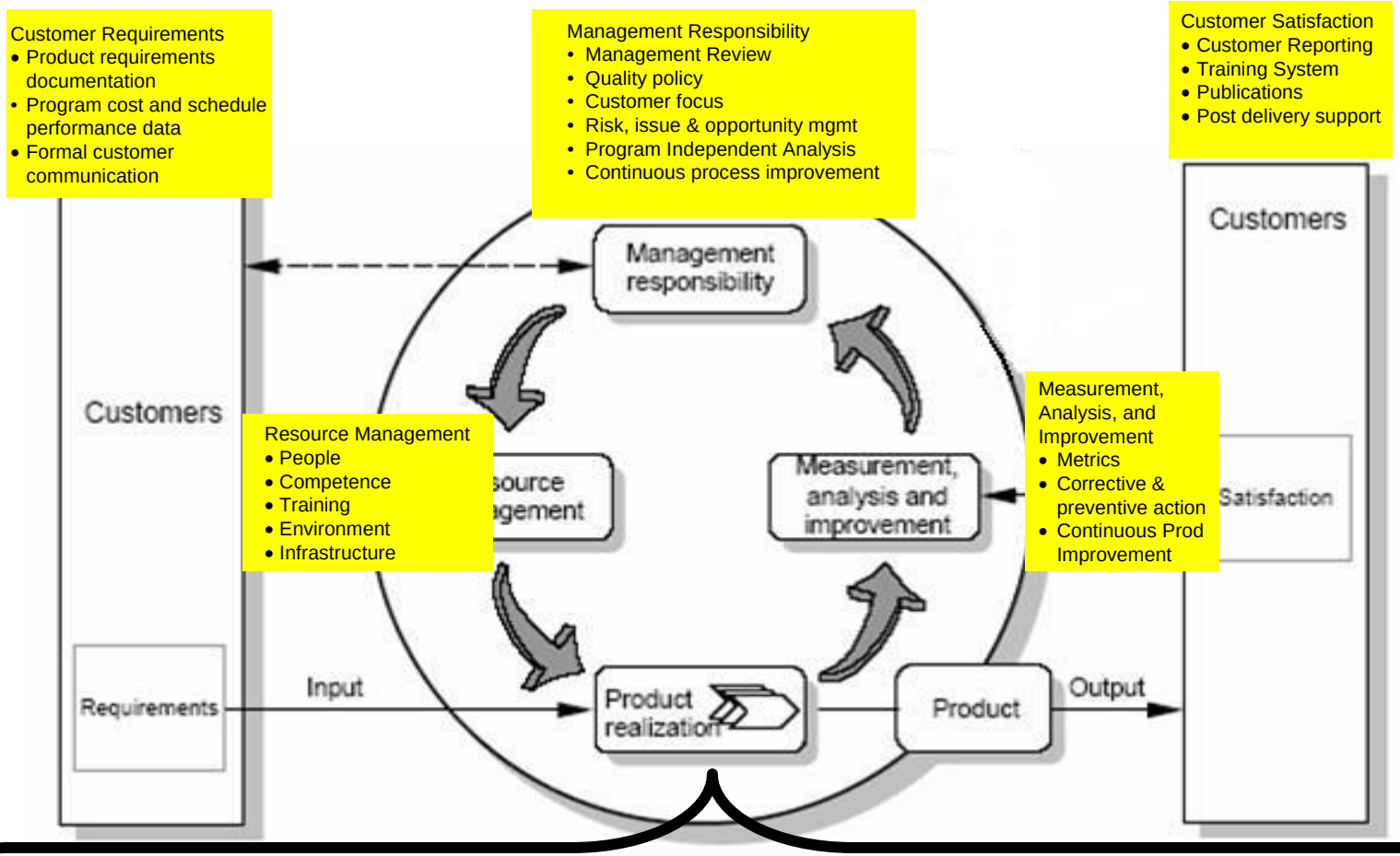
- ***Values*** **are ideas or things accepted as good, desirable, and important as codified by policy and guidance**
  - **Example: "nothing goes out the door if it's not done right"**
- ***Beliefs*** **are what people really think**
  - **Example: people do not ask penetrating questions in meetings to avoid elevating issues**
- ***Behaviors*** **are what the workers really do**
  - **Example: due to schedule or cost pressures, workers draw conclusions from incomplete or inadequate data thereby accepting, ignoring, underestimating, or hiding risks**

Avoid mismatches among values, beliefs and behaviors

Adapted from David Leetsma, Manager Advance Planning Office, Johnson Space Center, as presented to the 2006 Conference on Quality in the Space and Defense Industries

Encourage Quality Focus (slide 2 of 3)

Emphasis in the ISO Context



Systems Engineering
- Prod Reqts Alloc
- Allocation, verification & validation plan
- Configuration, data, risk mgmt

Software Engineering
- Design
- Integration
- Code
- Testing

Integrated Product Definition
- Design
- Specialty Engineering
- Support Functions

Product Support
- Performance based logistics
- Field support requirements

Test Engineering
- Test reqts
- Test planning
- Test conduct
- Reports

Supplier Management and Procurement
- Purchasing process
- Purchase order reqts
- Purchase process verification

Manufacturing Engineering
- Manufacturing and inspection work instructions
- Producibility
- Work flow

Manufacturing Product
- Fabrication
- Assembly

Encourage Quality Focus (slide 3 of 3)

Understand/Evaluate Key Practices

- ***At Program Startup***
  - **The process for establishing the product or project Quality budget**
  - **Where Quality responsibility is placed in the program**
  - **How quality skills have been assigned to the project**
  - **The process for analyzing quality requirements and mitigating associated risks**
  - **The quality strategy's consistency with industry best practices**
- ***Throughout the Life Cycle***
  - **How management uses quality data**
  - **The contractor's approach for continuous process improvement**
  - **The contractor's approach for preventive and corrective action**
  - **The contractor's approach for achieving customer satisfaction**

DoD should encourage and participate with industry to apply effective practices in these areas

Outline

- How quality impacts technical risk
- Involving quality early
- Encouraging a quality focus
- Incorporating quality in the systems engineering technical reviews
- Concluding remarks

Develop Strong Linkages to the SE Technical Reviews (TRs) (slide 1 of 5)

- **The purpose of these reviews is to provide the program manager with an integrated technical assessment of program technical risk and readiness to proceed to the next technical phase of the effort**
- **Process-based technical risks affect readiness to transition**
  - **System engineers develop, manage and execute processes**
  - **Quality engineers independently assess if they are working as designed**

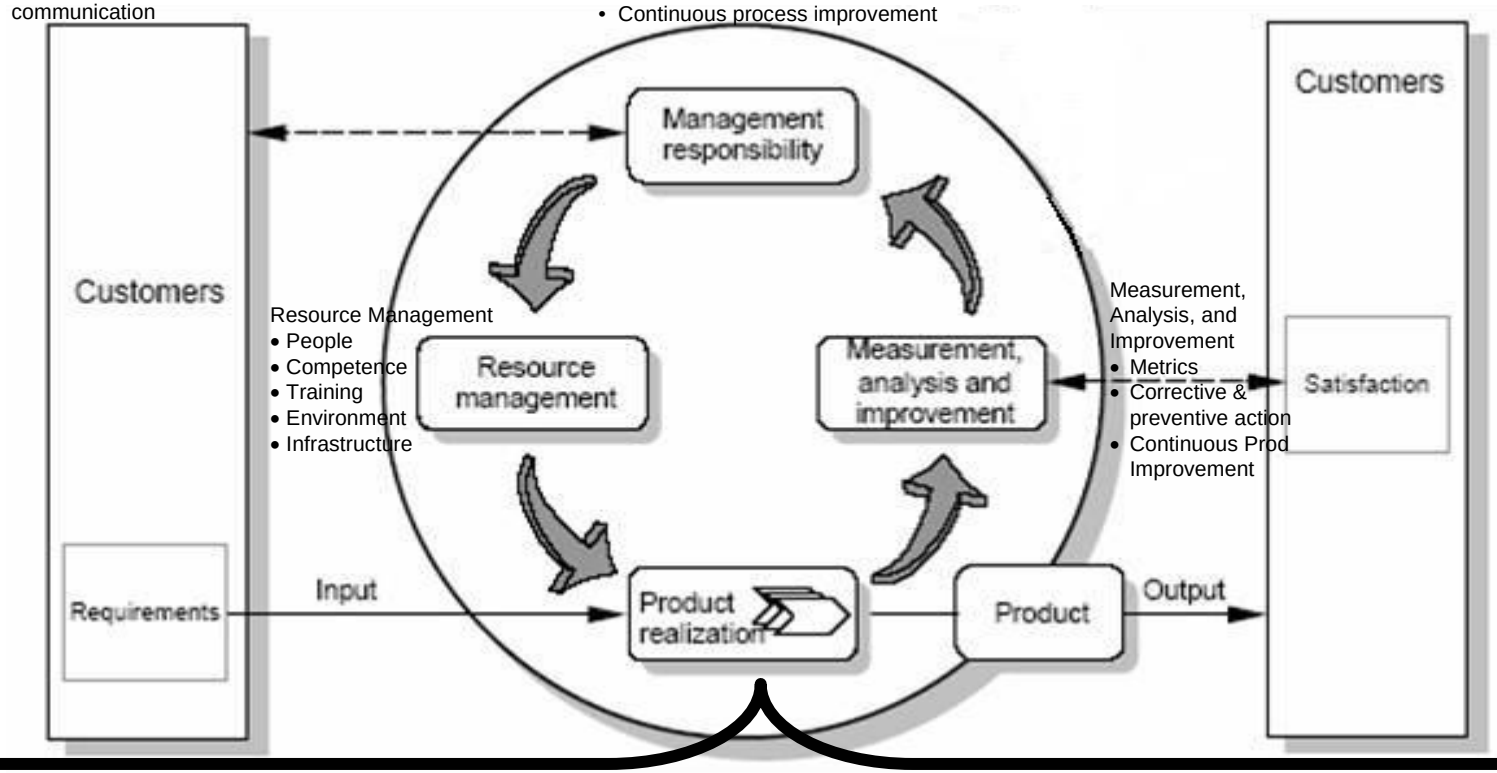
Develop Strong Linkages to the SE TRs (slide 2 of 5)

Sharper Focus on Product Realization

Customer Requirements
- Product requirements documentation
- Program cost and schedule performance data
- Formal customer communication

Management Responsibility
- Management Review
- Quality policy
- Customer focus
- Risk, issue & opportunity mgmt
- Program Independent Analysis
- Continuous process improvement

Customer Satisfaction
- Customer Reporting
- Training System
- Publications
- Post delivery support



Systems Engineering
- Prod Reqts Alloc
- Allocation, verification & validation plan
- Configuration, data, risk mgmt

Software Engineering
- Design
- Integration
- Code
- Testing

Integrated Product Definition
- Design
- Specialty Engineering
- Support Functions

Product Support
- Performance based logistics
- Field support requirements

Test Engineering
- Test reqts
- Test planning
- Test conduct
- Reports

Supplier Management and Procurement
- Purchasing process
- Purchase order reqts
- Purchase process verification

Manufacturing Engineering
- Manufacturing and inspection work instructions
- Producibility
- Work flow

Manufacturing Product
- Fabrication
- Assembly

Develop Strong Linkages to the SE TRs (slide 3 of 5)

Best Practices Check List Process Description

- **Quality engineers/SMEs at the prime should:**
  - **Tailor quality questions for each component of the product realization process to the specific situation for the technical review**
  - **Pose the questions to the quality teams at the prime contractor and the principal subs during their technical reviews**
  - **Assign a red-yellow-green indicator to reflect an assessment of the situation based on the answer to each question**

Develop Strong Linkages to the SE TRs (slide 4 of 5)

Red-Yellow-Green Indicator Example

Legend:	R	Y	G	U	NA		
1. Customer						**Comments/Mitigation**	**Criteria**
Has the local DCMA been involved and or briefed on program reviews, (for example have they been activiely involved, and/or participating in PMR, SRR, PDR's and FAI's etc.)?							**Green -** Involved & Integated **Yellow -** briefed, little involvement **Red -** No Involvement
If GSI is required, is there delegation in place?							
Does the program have a customer contact plan?							**Green** - working to Plan **Yellow** -no documented Plan **Red** - No plan
Are Boeing Supplier Quality Source Reps (PQA) identified and engaged?							**Green** - frequent visiit and engaged **Yellow** - not engaged on specific program **Red** - Not identified and or engaged
Is the program measuring customer satisfaction? How Often?							**Green** - feedback is avaialble on a routine basis **Yellow** - inconsistent **Red** - no measurement
2. Design for Producibility							
Has Quality has been established in the Design review process							**Green** - Yes **Red** - No
Are verifications and acceptance criteria being incorporated into the design							**Green** - is yes **Red** - is No
3. SVR/FAI							
Has the SVR been incorporated into the master schedule and identified as a major milestone							**Green** - Tier I thru Tier II or III schedules to support **Yellow** - no tier II, III schedule to backup major milstone accomplishment **Red** - not

Develop Strong Linkages to the SE TRs (slide 5 of 5)

Best Practices Check List Process Description cont'd

- **Situation should be summarized at prime's technical review with the DoD program office**
  - **Summary could be done using the eight categories of the product realization process**
  - **Further aggregations may be made, e.g.,**
    - **Product development**
    - **Software development**
    - **Verification and validation**
    - **Supplier management**
    - **Manufacturing**
  - **Utilize a red-yellow-green scale**
    - **Judgment is needed**
    - **Aggregation should be based on organizational needs, program complexity, etc.**
  - **Mitigation actions underway (if needed) should also be presented**

Outline

- How quality impacts technical risk
- Involving quality early
- Encouraging a quality focus
- Incorporating quality in the systems engineering technical reviews
- Concluding remarks

Summary

- **Quality engineers / SMEs help identify and mitigate process-based technical risks to a project**
- **Industry should involve quality early in a project's life cycle**
- **DoD should encourage and participate with industry on the application of effective practices to encourage a quality focus throughout a project's life cycle**
- **Quality engineers / SMEs at the prime contractor should summarize the status of the product realization process at systems engineering technical reviews**

Next Steps

- **Further refinement through government review**
  - **Being circulated among members of Quality Advisory Group**
- **Further refinement through industry review**
  - **NDIA Quality Assurance Committee members**
  - **AIA Quality Assurance Committee**
  - **MMA suppliers**
- **Incorporate into Defense Acquisition Guidance**
  - **How quality impacts technical risk, involving quality early, establishing quality focus material to be incorporated into new Quality Management Section (11.3.3)**
  - **Incorporating quality in the systems engineering technical reviews to be incorporated into section 4.5 on SE Execution: Key SE tools and techniques**



Factors behind "encourage quality focus" evaluation areas

The Process for Establishing the Product or Project Quality Budget

Example evaluation considerations:

- **Project quality administration, product verification, quality engineering (hardware and software), quality planning, and supplier quality**
- **Specific quality deliverables**
- **Capital, equipment, and software verification needs**
- **How the estimates are modified when there are changes to the strategy and/or scope of the program**
- **Measurement technology needs**



Where Quality Responsibility is Placed in the Program

Example evaluation considerations:

- **Role in the general risk identification, classification, and mitigation process**
- **Involvement in the design change control and release process**
- **Role in processing waivers, deviations and engineering change proposals**
- **Representation on Integrated Process Teams and boards (e.g., change control board, risk) for all product and process development activities**
- **Involvement in test plans, material reviews, design reviews, build/buy/support to packages**
- **Participation in the integration of inspection points into processing and test documentation**
- **Role in the supplier management, development, incentivization, and control process**



How Quality Skills Have Been Assigned to the Project

Example evaluation considerations:

- **The process to identify the need for quality management, quality engineering (hardware and software), quality planning, supplier quality, and product verification skills across the life cycle**
- **The process to identify quality skills and any associated certifications and qualifications**
- **The process for addressing quality staffing ratios and skill shortfalls**



The Process for Analyzing Quality Requirements and Mitigating Associated Risks

Example evaluation considerations:

- **The process for identifying and achieving quality tasks in support of contract deliverables**
- **How a post award contract analysis for Quality's tasks was performed / has been updated**
- **An evaluation of how the Quality plan matches the program requirements and their integration across program sites, IPTs, partners and suppliers**
- **How quality activities factored into the Integrated Master Plan and Integrated Master Schedule**



The Quality Strategy's Consistency with Industry Best Practices

Example evaluation considerations:

- **The use of lessons learned**
- **How similar programs' quality past performance have been reviewed**
- **How the quality plan addresses program unique processes**
- **How plans include verification approaches, nonconformance handling, operator verification manufacturing self-examination, nondestructive inspection, manufacturing systems, measurement approach, special measuring and test equipment**
- **Adequacy of the quality plan to address all other program plans (manufacturing, systems engineering, subcontract management, delivery, …)**
- **Periodic review and update**
- **Early involvement in the program**



How Management Uses Quality Data

Example evaluation considerations:

- **Audit needs and addressing audit findings**
- **The process for analyzing and performing trend analysis of internal/external audit findings**
- **How quality is defined, measured, analyzed, controlled, and used to drive management decisions and actions on the program**
  - **The process for developing and identifying requirements for quality metrics and measurement systems**
  - **The system for monitoring supplier performance, including their product development activities**
  - **The process for review and update**



The Contractor's Approach for Continuous Process Improvement

Example evaluation considerations:

- **Baldridge business model**
- **CMMI**
- **Lean**
- **Six sigma**
- **ISO recertification**
- **Actions taken to address feedback from assessments performed**



The Contractor's Approach for Preventive and Corrective Action

Example evaluation considerations:

- **The process for addressing test and inspection findings and discrepancies**
- **The process for addressing supplier nonconformances**
- **Establishment and maintenance of a closed loop corrective action system that includes the reporting, root cause analysis, and implementation of actions necessary to correct and preclude recurrence of problems, failures, quality issues, defects/nonconformances**
- **The process for using lessons learned to drive continuous improvement**



The Contractor's Approach for Achieving Customer Satisfaction

Example evaluation considerations:

- **The process to collect, monitor, and analyze information for measuring customer satisfaction**
- **The process to rapidly mitigate customer concerns**
- **The process to communicate with customers at all levels**
- **The process / organizational structure for reacting to customer inquiries and needs**



Extract from SE TR Questions
Systems Engineering

- **Determine/evaluate the process for identifying, allocating, and documenting product requirements including safety and environmental requirements**
- **Determine/evaluate the configuration management approach for hardware**
- **Describe/evaluate how verification plans are being developed for new products and manufacturing/measurement processes**
- **Describe/evaluate how trade studies been completed, and are incorporated into the design baseline**
- **Identify and assess the overall Risk Management Program and determine if it is adequately documented**



Extract from SE TR Questions
Software Engineering

- **Determine/evaluate the processes and equipment for performing software unit testing, integration testing, software qualification, regression testing, and operational testing**
- **Determine/evaluate the software acceptance process for assuring deliverable software complies with contractual requirements, and that all discrepancies and nonconformances are properly documented and resolved**
- **Determine/evaluate the processes, procedures, and tools for performing software quality assurance, software quality assessments, verification, validation, configuration control, metrics, management review, audits, etc.**
- **Determine/evaluate the process for determining the quality requirements for non-deliverable software**
- **Determine/evaluate the root cause analysis and corrective action process for software quality issues**



Extract from SE TR Questions
Integrated Product Definition

- **Describe/evaluate the verification plans for "non-tooling" concepts (e.g., determinant assembly, self locating parts, etc.); describe/evaluate how verification is accomplished**
- **Describe/evaluate the process for integrating the verification requirements into the work instructions**
- **Describe/evaluate the process that identifies key characteristics (i.e., the features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, or producibility)**
- **Determine/evaluate the process for integrating verification requirements and key design characteristics**
- **Describe/evaluate the process for design evolution**



Extract from SE TR Questions
Product Support

- **Describe/evaluate any field support requirements for quality (hardware/software)**
- **Determine/evaluate if there are any post-production considerations or topics, such as spares, technical bulletins, support equipment, modifications/retrofit that must be considered**
- **Describe/evaluate any training requirements for quality such as simulators**



Extract from SE TR Questions
Test Engineering

- **Determine/evaluate the plan and process for conducting verification and validation including those accomplished for Spares, Kits and Support Equipment**
- **Describe/evaluate the processes to validate that tests adequately assess the requirements such as interface definition and control**
- **Describe/evaluate the contractual test plan requirements, if applicable**
- **Describe/evaluate how verification and test plans were developed concurrently with the design**



Extract from SE TR Questions
Supplier Management and Procurement

- **Describe/evaluate the process for defining and flowing down to suppliers the quality requirements, special processes, tools, design criteria and specifications**
- **Describe/evaluate how quality requirements are incorporated into supplier Statements of Work (SOW) and Supplier Data Requirements Lists**
- **Determine/evaluate the process being used to transfer work to other sites and to define the quality requirements for this work**
- **Describe/evaluate any partnering arrangements with other suppliers/customers that impact quality (hardware/software)**
- **Describe/evaluate how the program utilizes the company's preferred supplier certification process**



Extract from SE TR Questions
Manufacturing Engineering

- **Describe/evaluate the configuration management (including change control) process**
- **Describe/evaluate the current documented Geometric Dimensioning and Tolerancing (GD&T) approach (Common datums being utilized, and datum management)**
- **Describe/evaluate the program approach for verifying that prescribed manufacturing methods have produced an item conforming to engineering drawings, planning, purchase order, engineering specifications and/or other applicable design documents**
- **Describe/evaluate the process for validation and periodic verification of production tooling**
- **Describe/evaluate the process for determining the capability of processes and measurement systems (e.g., Process Capability, Measurement Systems Analysis, SPC); Describe/evaluate the mitigation plan, if applicable**



Extract from SE TR Questions
Manufacturing Product

- **Determine/evaluate the process for identifying, documenting and segregating nonconforming materials**
- **Determine/evaluate the process for identifying and controlling purchased items awaiting test and inspection, those which have been accepted, those which have been rejected, and those awaiting material review action**
- **Describe/evaluate tests and inspections used as a basis for government acceptance of contract end items and the Acceptance Test Procedure process**
- **Describe/evaluate the program for the control of limited-life items in production and storage areas**
- **Determine/evaluate the adequacy and implementation of test and inspection procedures**



Humans-In-The-Loop - Challenges in a Complex SoS Environment

Abe Meilich, Ph.D.

Lockheed Martin Corporation

Advanced Concepts, NetCentric Integration

abraham.w.meilich@lmco.com

National Defense Industrial Association
9th Annual Systems Engineering Conference
San Diego, CA
October 25, 2006



Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Topics

- The Human As a Key Consideration in SoS
- Some Conclusions from US AF SAB
- Implication from DOTMPLF on System Engineering
- Observations on Human Systems Integration (HSI)
- Observation from the Perspective of Operations Analysts
- Considerations for Systems Engineering
- Net Centric Operations Conceptual Framework (NOCF)
- Observations on Experimentation
- Summary Comments on Engineering in the Cognitive and Social Domains

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

The Human As a Key Consideration in SoS

- **Several items of note in the US AF Science Advisory Board (SAB) Report [1] referring to the human in the equation:**
  - "An effective system-of-systems will promote collaborative decision-making and shared situation awareness amongst the human operators."
  - "…we should recognize that human-to-human and human-to-system interactions would continue to be critical components of effective systems-of-systems.
- Research in human system interaction and decision-making is required to understand better how to integrate these elements into an effective system-of-systems architecture.
  - Systems Engineering: human machine interface (HMI) was the focus for a single system; human-to-system and human-to-human interaction is the focus for SoS

[1] ***US AFSAB,*** **Executive Summary and Annotated Brief, SAB-TR-05-04, July 2005**

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Some Conclusions from US AF SAB

- "We have identified four main factors that require consideration in improving System-of-Systems Engineering in the Air Force:
  - The first of these were the need to include human system interaction as a part of System-of-Systems Engineering
  - ….. The last is the need to incorporate discovery learning through experimentation at the system-of-systems level"[1]

- "… the current state of systems engineering does not adequately support the development of complex, adaptive, and software-intensive system-of-systems (SoS) in which humans are parts of the system."[1]

- "While significant progress has been made with the network dimension, only preliminary work to scope the requirements for the human dimension of NCW has been undertaken. The cumulative effort required to realise the human dimension of NCW could well outstrip the more readily understood network aspects of NCW." "…[A key goal is to] Explore the human dimensions of the networked force and initiate changes in doctrine, education and training with appropriate support mechanisms."[2]

[1] ***US AFSAB,*** **Executive Summary and Annotated Brief, SAB-TR-05-04, July 2005**

[2] **NCW Roadmap, Australian Government, Department of Defence, 2005**

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Background

- **Net Centric Operations Imply**
  - Leverage SoS in new and different ways
  - "Potential" for decision makers and operators to
    - Unprecedented access to information and assets over the network
    - More effective and efficient human "networking"
    - Faster and more effective resource utilization
    - Faster versus smarter decisions?
- **Engineering for the Human –In-The-Loop (HITL) in a SoS**
  - Evolving area of research
    - But, implementation ahead of application of theory
      - e.g., in NCO - more sources, more deconfliction, more sensemaking required
    - Solution: Historically, engineer through experimentation
    - Dilemma: But what do we need to measure and for what purpose?

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Implication from DOTMPLF on System Engineering

- NetCentric SoS implies breaking organizational barriers
- The key human element here is Trust
  - We must not only re-engineer our system to leverage NetCenricity, we must also re-engineer the enterprise
    - Will the system from organization A be there to support the system from organization B?
- Today – Mismatch between rate of applying technology to the problem versus the organizational and business implication of the transformation
  - All facets pf DOTMPLF must be re-evaluated when a new capability must be assessed against NetCentric principles

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observations on Human Systems Integration (HSI)

- "In HSI, decision makers and facilitators take advantage of technological developments in systems engineering and systems management. Inherent in several of these advances is the capability to quantify and measure human characteristics. These newer methods also allow better decisions to be made early in the design and development process where changes are relatively inexpensive to make."[1]
  - Supports the broad implications of DOTMPLF in Capability Development
  - Need: Greater focus on HITL as a measurable component of capability MOE and its implementation in SoS (systems + humans) MOP
  - Trend: Systems and products that can be operated and repaired by fewer people, by lesser skilled people, and/or people with lesser training will be in greater demand.
    - Manpower, personnel, and training (example: UAV and takeoff/landing expertise) are becoming key consideration in cost effectiveness and mission effectiveness
- Need to make the human component an "inherent part of the system," and the drive toward "quantification of people variables" in the overall system engineering of the system or SoS

[1] *"Handbook of Human Systems Integration", Harold Booher, Wiley & Sons, 2005*

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observations on Human Systems Integration (HSI)

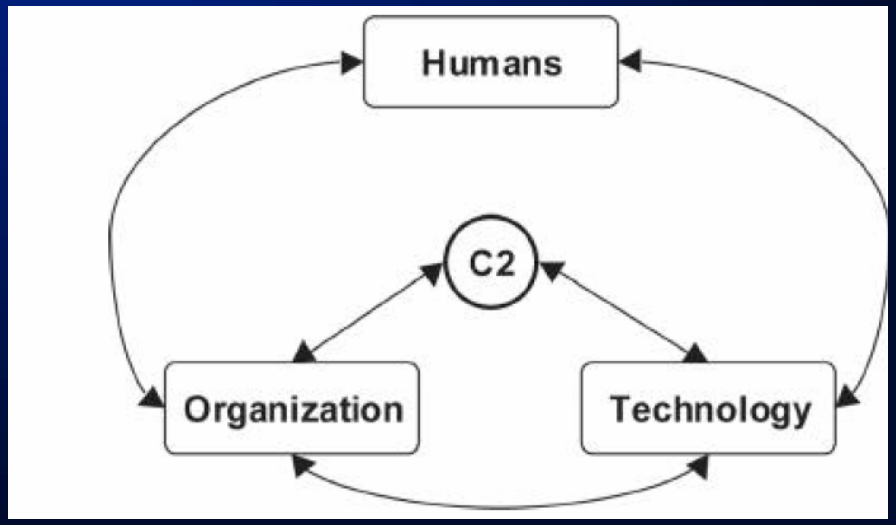
- NetCentric SoS - The human is now taking an active and leading role in combining systems to provide new capabilities (at run time versus at design time)
  - How that is done and how effectively is now an art.
  - Can we bring science to this?
  - If we are passing Power to the Edge, we have a new training paradigm with new SoS assets to configure and use.
  - Commanders are challenged to plan tasks in hours vs. days; planning in minutes versus hours
    - Paradigm shift: Less decision and information flow up and down the chain of command
    - Commander now "shepherds" or "monitors" versus "commands"
    - What is the minimum information required to make decisions at the Edge?
  - How do we capture and analyze the impact of an operational architecture, and its complementary system architectures, when we are asked to accommodate responsive, agile, dynamic (on-the-fly changes to) operational approaches in a NetCentric environment?
- "….it can be expected that HSI activities will become more closely associated with constructive, virtual, and live simulations" [1]
  - Measurement of Human-in-the-loop parameters (primarily cognitive and social parameters) has been problematic for SEs to define and measure
  - Experimentation, in lieu of engineering, has been pursued

[1] *"Handbook of Human Systems Integration", Harold Booher, Wiley & Sons, 2005*

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

The C2 Environment Triad

- "…the character and performance of a C2 system may change as anyone of elements in these three categories changes." [1]
- "…since the human, organizational and technological elements are closely linked in most cases, optimizing each one of them at a time under ceteris paribus [other things being equal] assumptions for the other two rarely ever results in an efficient C2 system."[2]



[1] NATO Code of Best Practice for C² Assessment, CCRP, 2002

[2] Schot, J., & Rip, A. (1996). The past and future of constructive technology assessment. In *Technological forecasting and social change, 54*, 251-268. New York: Elsevier Science. [Chapter 6]

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observation from the Perspective of Operations Analysts

- **Pearls of Wisdom[1]**
  - We can no longer expect to "bend" people to technology; rather, we need to study how best to produce creativity at the nexus of people and technology
  - Needs are not always task related
  - Needs may be cognitive, behavioral, or social, such as how information is displayed, how teams operate, how tasks are shared
  - We must recognize the importance of relationships [read “trust”]
  - Technical solutions cannot replace human judgment

[1] MORS Workshop Report: How Cognitive and Behavioral Factors Influence Command and Control, Military Operations Research Society, 22 April 2005

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observation from the Perspective of Operations Analysts

- **Pearls of Wisdom[1] (cont'd)**
  - Decision making tasks
    - How much information is enough to make a decision?
    - The lower the tolerance for risk, the higher the demand for information to avoid that risk
    - Commanders manage information differently, therefore, information must be shaped for the individual commander
  - Tasks do not always require quantifiable information
  - Just because something cannot be measured or quantified, doesn't mean it isn't important
    - Qualitative methods, such as observation, have their uses as well
  - Commanders must perform their tasks in a timely manner
    - Concern that they will wait for more or better information rather than act or make a decision
    - Need to balance the need for quick decision making with informed decision making

[1] MORS Workshop Report: How Cognitive and Behavioral Factors Influence Command and Control, Military Operations Research Society, 22 April 2005

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observation from the Perspective of Operations Analysts[1]

- On the Network - Email, phone, and chat proliferate workload irrespective of the chain of command
- Increased capability may decrease effectiveness (more technology, information overload)
- Concern - In Network-Centric Warfare, everything depends on the network - What if it doesn't work?

[1] MORS Workshop Report: How Cognitive and Behavioral Factors Influence Command and Control, Military Operations Research Society, 22 April 2005, p.22

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Considerations for Systems Engineering

- **System Engineering tradeoffs**
  - Drivers in the problem space
    - Changing nature of military operations (sectarian-based urban vs national armies
    - Call for certain cognitive and social behavior
      - e.g., each system optimized for human in that domain – SoS human behavior yet to be characterized
  - Requirements in terms of the human component of the architecture
    - As opposed to mission, task, or technology
      - Examples
        - Agility and adaptability refers to the human, rather than the command and control process.
        - Distributed collaboration refers to the people who collaborate, rather than the tools used to collaborate.
  - Technology can work well, but still not contribute to battlefield performance

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Net Centric Operations Conceptual Framework (NOCF)

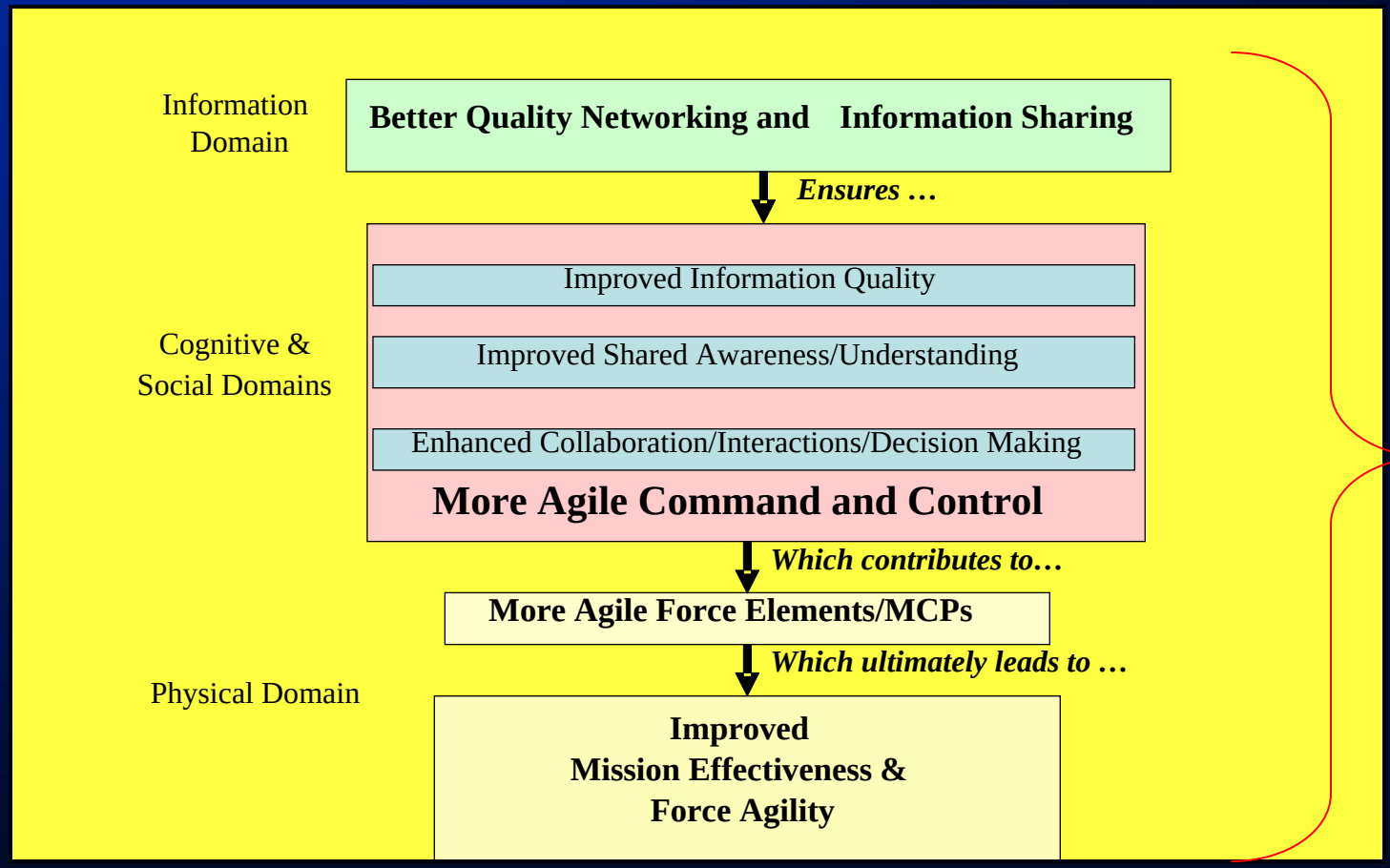
- NOCF[1] consist of the physical, information, cognitive, and social domains
- The domains are inextricably linked in the NCO environment
- All the domains must support processes carried out during Effects-Based Operations, if they are to be of any value
- The ingestion of information about the battlespace, conversion into information, and creating awareness as the basis for action are fundamental tasks in the cognitive domain
  - These are uncomfortable attributes for systems engineers to deal with in their design
  - Yet they are central to successfully leveraging NCO
- How do we design for the mantra "the right information to the right person at the right place in the right form"?
  - If requirements are static, engineering is straightforward
  - Challenge: How do human decision makers perceive the actions in the physical domain as reported to them? And then how do they make the decision?
  - Understanding this comes down to how people process information and under what mental models
  - Complexity and uncertainties are the norm here

[1] *Net Centric Operations Conceptual Framework, Version 2, OSD/OFT/NII, June 2004*

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

NetCentric Operational Conceptual Framework (NOCF)

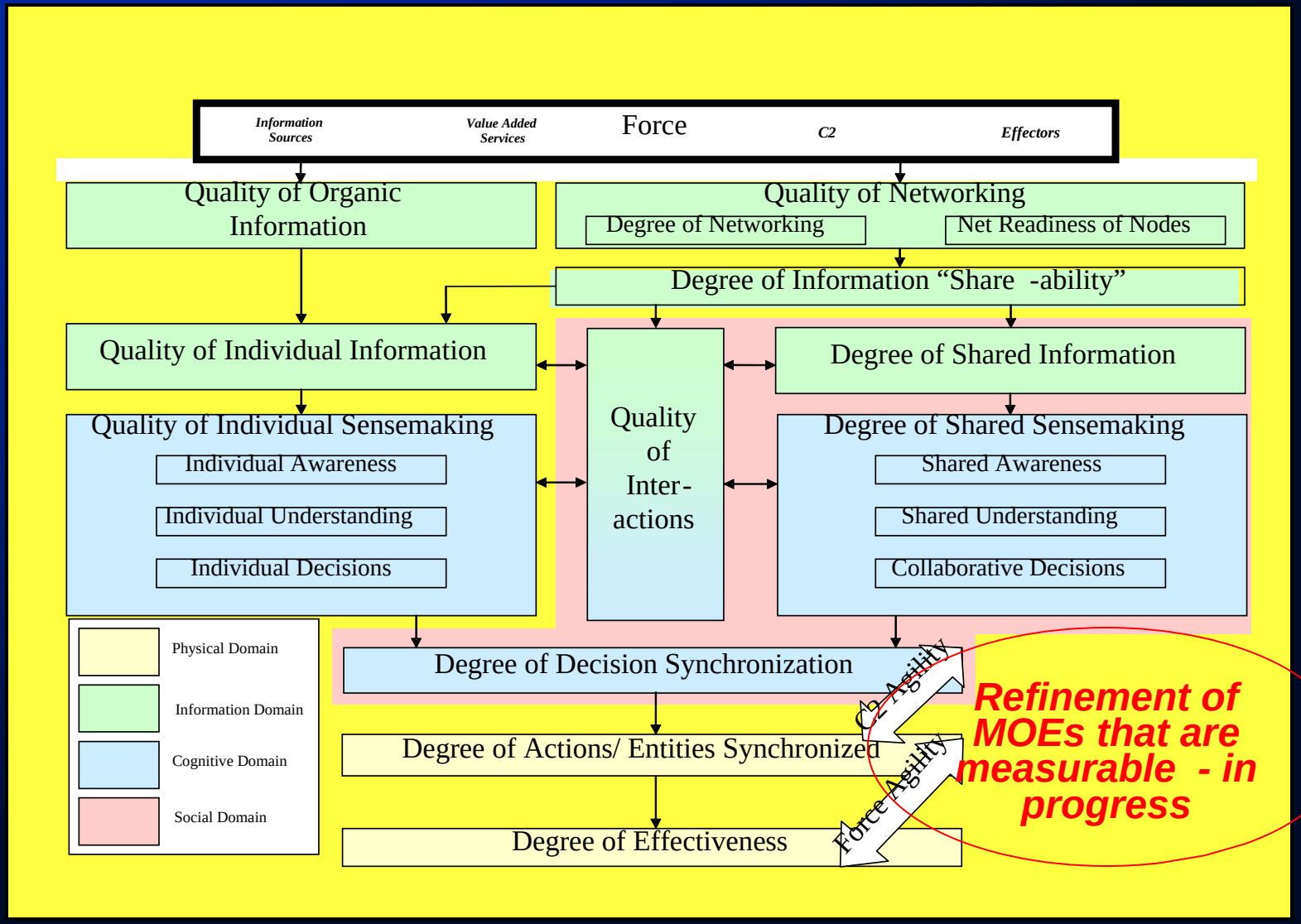
- **The human and organizational components will influence the cognitive and social domains of the NCOF**



[1]*Net Centric Operations Conceptual Framework, Version 2, OSD/OFT/NII, June 2004*

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Measurement using the NOCF



[1]Net Centric Operations Conceptual Framework, Version 2, OSD/OFT/NII, June 2004

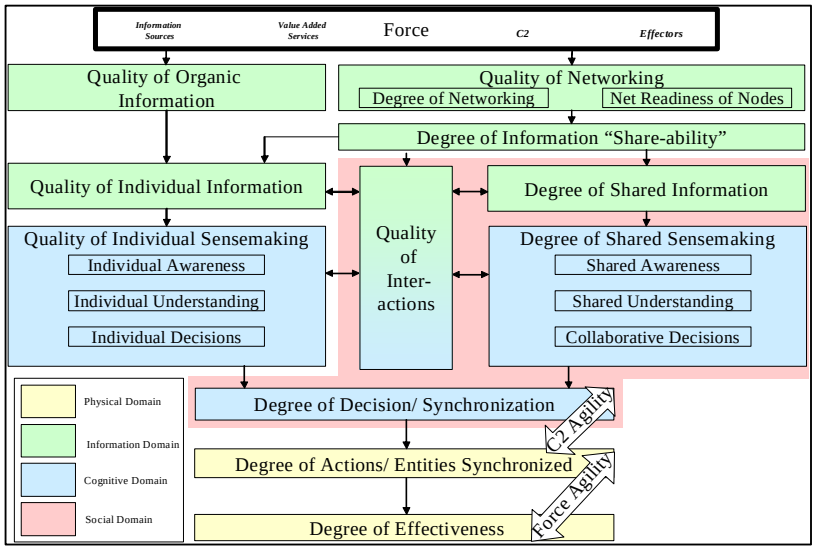
Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

NCOF support to Future Capability Development

Past Investments

D O T M L P F

Assessment of How We Fight Today
(Based on Evidence & Analysis)



NCW Conceptual Framework

Informs

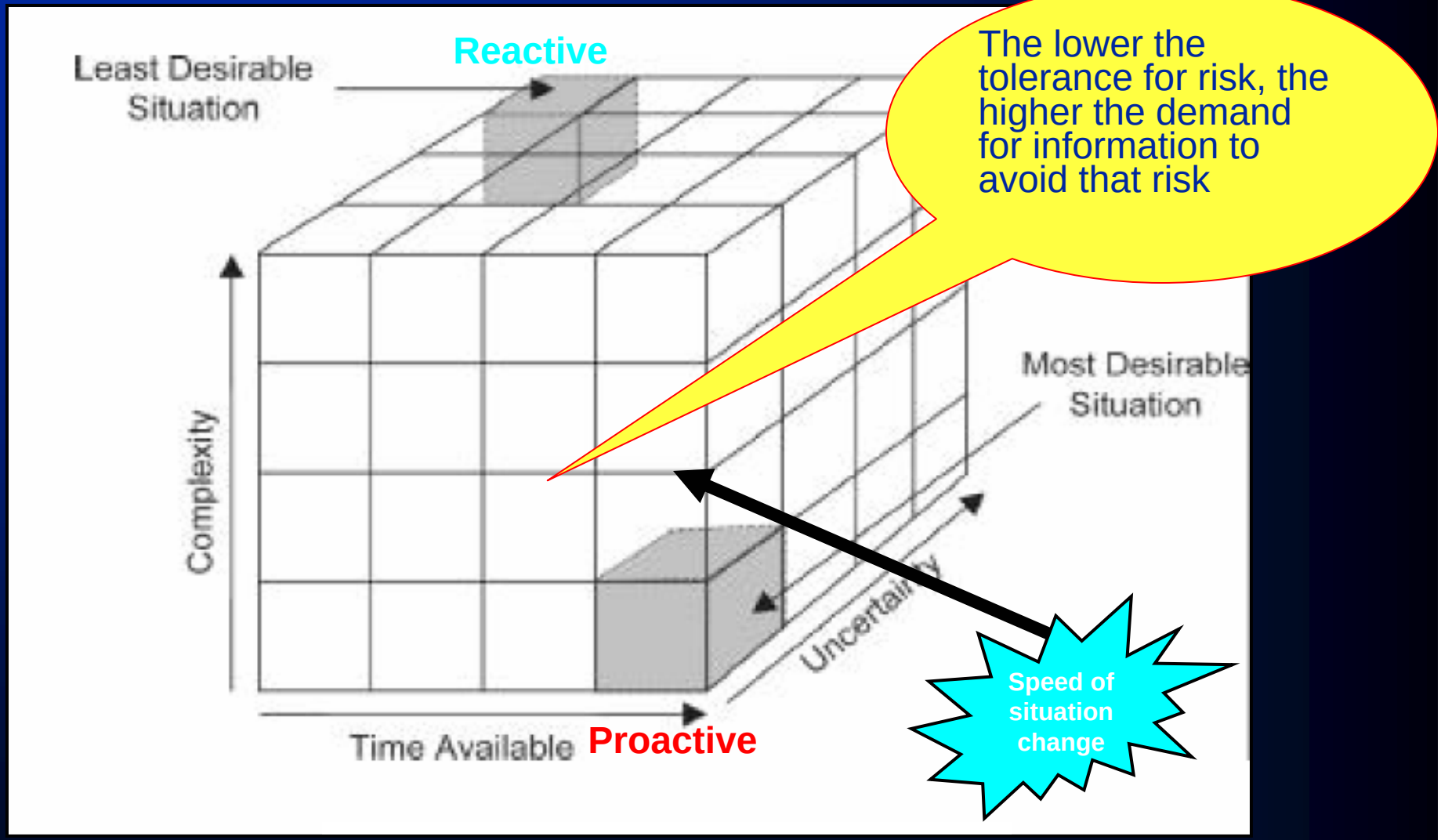
Future Investments

D O T M L P F

[1]Net Centric Operations Conceptual Framework, Version 2, OSD/OFT/NII, June 2004

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Drivers of Decision-making



[1] NATO Code of Best Practice for C² Assessment, CCRP, 2002

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observations on Experimentation

Challenge of extracting meaningful data from experimentation with HITL:

- "Decision-making that is rule or algorithmically based can be modeled directly, but error rates should be estimated if humans are involved in the relevant decision-making
  - Implications for SE: FMEA of technology based on effects of the HITL on Mission success
- Operational knowledge of human issues is still weak in many areas [of C2]. Systematic effort is required for organizing a consistent program for experiments on human issues."[1]

[1] NATO Code of Best Practice for C² Assessment, CCRP, 2002

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Summary of Approaches for Engineering in the Cognitive and Social Domains

- **Observation and feedback**
  - Expensive if done late in development during prototyping
  - Needs to be done very early to minimize cost of development
- **Stimulus/response analysis**
  - Paper simulation
  - War gaming
    - Concept exploration with instrumentation
- **Isolation of components of cognitive domain and social domains**
  - Use NCOCF model attributes

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Summary

- We need to provide systems and services to our warfighters quickly, but not without understanding how they are used both cognitively and socially on the battlefield
- This is broader than the Human Computer Interface (HCI) used in systems engineering today
- Just as bio-engineering revolutionized medicine, Cognitive Engineering and HSI as key considerations in systems engineering are and will revolutionize the conduct of on both the strategic and tactical levels of warfare
- Resource to review Human Performance Engineering
  - ONR >>SC-21/ONR S&T Manning Affordability Initiative (FY96-FY00)
    - http://www.manningaffordability.com/s&tweb/index.htm

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Other Observations

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Humans and Complexity on the Network

- It has been noted[1] that good commanders have dealt with the complexities of the battlespace by inserting a "human in the loop"—whether themselves, subordinate commanders, staff, or watch personnel—to make complex decisions, to assess ambiguous information, and to fill in the blanks where information is wanting.
- The human is at the root of *network-enabled* effects-based operations.
- Whereas success in "classic" effects-based approaches largely depended on the abilities of the humans in the loop to deal with the complexity in their heads, in network-enabled operations they need no longer be left to their own devices.
  - Better and more meaningful support from networking can enable decision-makers to bound complexities and deal with ambiguities better and thereby increase the probability of a correct decision.

[1]Complexity, Networking and Effects Based Approaches to Operations, Edward A Smith, CCRP, 2006

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

World War IV and implications for SE and the HITL

It was noted by *Maj. Gen. ROBERT H. SCALES (ret.)* that:

THE EVOLUTION OF WARFARE

THE CHEMISTS' WAR

The decisive strategic advantage on the World War I battlefield was driven by new applications of chemistry and chemical engineering. Germany, for example, exhausted its supplies of gunpowder nitrates in 1915, but the synthesis of nitrates by German scientists allowed the war to continue for another three years.

THE PHYSICISTS' WAR

The atomic bomb ended World War II, but exploitation of the electromagnetic spectrum in the form of wireless communications and radar won it for the allies.

THE INFORMATION RESEARCHERS' WAR

In World War III, intelligence and the ability to fully exploit it allowed the U.S. to defeat the Soviet Union. Information-age concepts of transformation and net-centrism mark the end of this epoch.

THE SOCIAL SCIENTISTS' WAR

To win World War IV, the military must be culturally knowledgeable enough to thrive in an alien environment. Victory will be defined more in terms of capturing the psycho-cultural rather than the geographical high ground. Understanding and empathy will be important weapons of war.

[1] ***Maj. Gen. ROBERT H. SCALES (ret.) , "Clausewitz and World War IV" , Armed Forces Journal, July 2006***

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Observations from Maj. Gen. ROBERT H. SCALES (ret.)

- "Machines and processes might make intelligence easier to parse and read. But knowing the enemy better than he knows us is inherently a psycho-cultural rather than a technological, organizational or procedural challenge."[1]
- "The enemy has drawn us unwillingly into fighting him at the tactical level of war where the importance of technology diminishes in proportion to the value of intangibles. "
- "Models of human cognition can also be used to diagnose performance failures during simulated exercises. "
- "We are in a race, and the times demand change. World War IV can only be won by harnessing the social and human sciences as the essential amplifiers of military performance, just as the physical sciences were the amplifiers of past world wars. "
- "Of course, new planes, ships and combat vehicles will have to be built to win World War IV, but building new social, cultural and learning structures will have to become the first priority for resources within the Defense Department. There is an old saying that the Navy and the Air Force man the equipment and the Army and Marine Corps equip the man. Surely those services that focus on the man rather than the machine should receive a disproportionate share of future defense budgets? "
- "What will the new amplifiers be? ….. Will new human and behavioral developments make us more effective in battle? Only time will tell. But none of these questions can be answered by speculation alone. The Defense Department must invest the resources now to realize the potential of psycho-cultural sciences to winning World War IV."

[1] *Maj. Gen. ROBERT H. SCALES (ret.) , "Clausewitz and World War IV" , Armed Forces Journal, July 2006*

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Implications of Agent Based-Simulation

- Agent =-based simulation (e.g., SEAS) now takes into account the Cognitive Domain (via Programmed behaviors - Behavioral and decision-making logic)
  - Good enough for SE trade studies?
  - Good enough to go operational?
  - How much can we trust the outcomes of these simulations where 100s (if not 1000s) of entities interact to end in an effect

Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Beyond the OODA[1] loop

- OODA is the foundation for understanding Effects-Based Operations
- OODA has different implications at the strategic and tactical levels
- How do we engineer a capability to improve the OODA without considering the HITL?
- Clearly, the cognitive processes that allow the human to perceive and decide are at the center of the human dimensions of war
- Capabilities are written in terms of what the human needs to accomplish , not what the machine must do

[1]OODA: observe, orient, decide, act

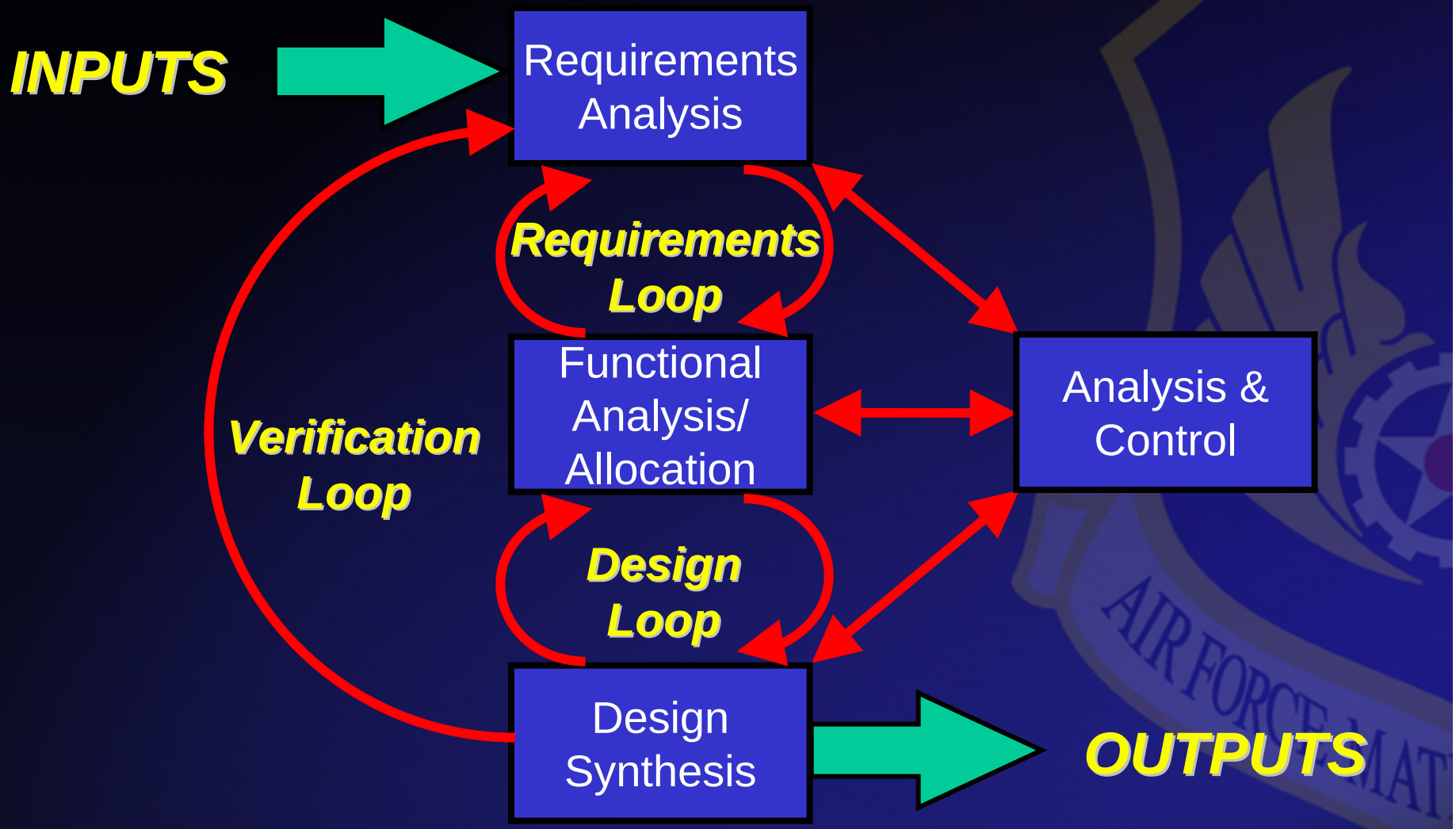
Copyright 2006 Lockheed Martin Corporation, All Rights Reserved

Step 1 for Systems Engineering: Establish a Tangible Requirements Management Process

25 Oct 06

Jim Miller
727 ACSG/EN
Phone: (405) 736-5771
james.c.miller@tinker.af.mil

Basic Systems Engineering Process



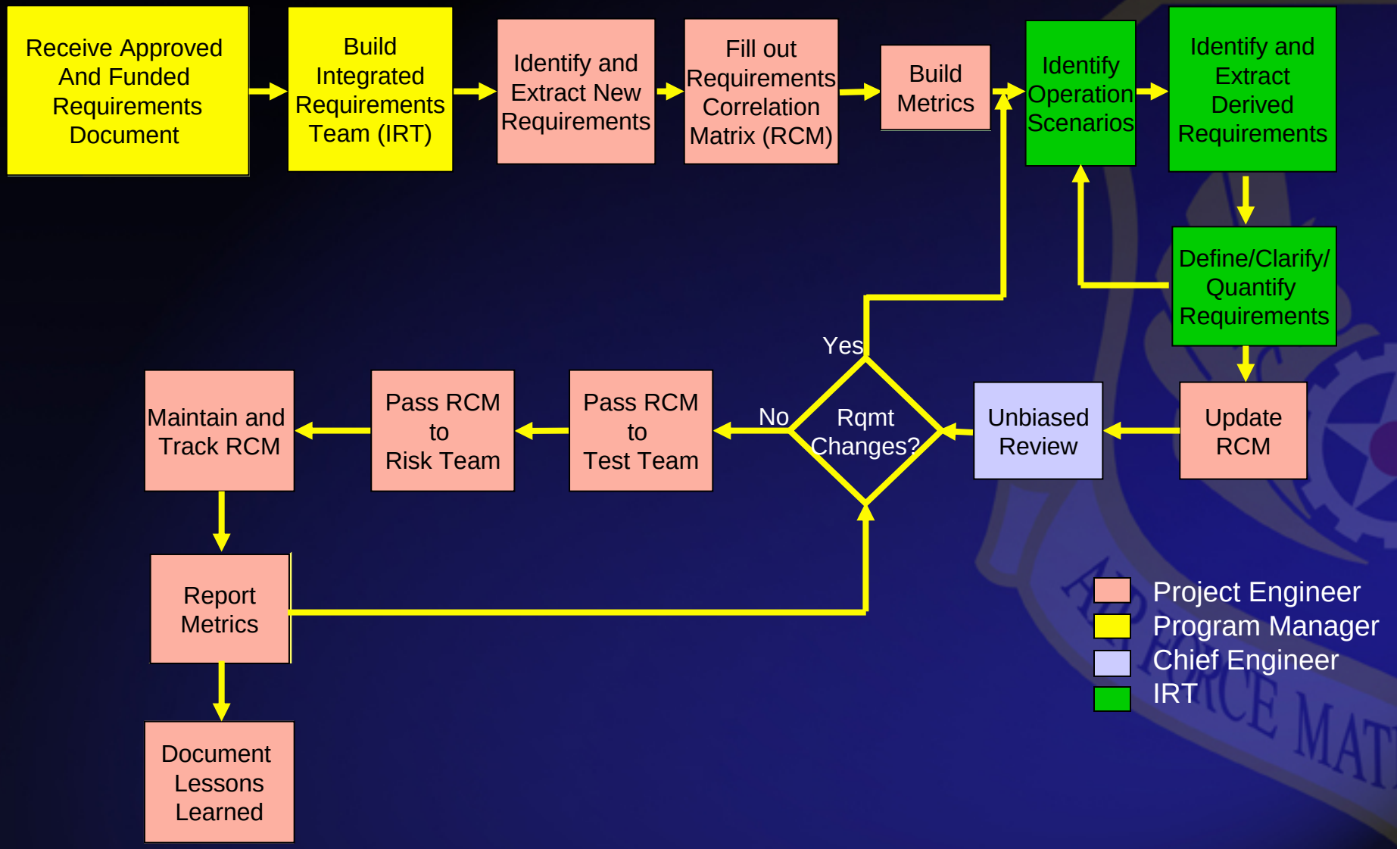
Purpose

- **Published Operating Instruction to provide:**
  - **An organization-wide process to ensure the development of concise, quantifiable, and unambiguous requirements**
  - **Guidance for a requirements management process including the preparation, update, and maintenance of requirements documentation to support the program office**
  - **Means to implement a consistent application of a disciplined systems engineering process for the management of requirements**

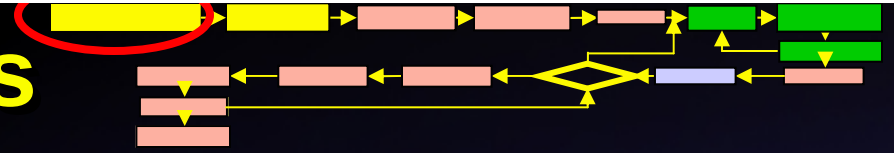
Purpose (Cont)

- Is an iterative process
- Intended for the working level
- Orderly, team-oriented process involving:
  - Project engineers - Contractors
  - Program managers - Users/Customers
- Requirement process to work with contractor's processes/timelines—not duplicative
- Documented output via Requirements Correlation Matrix (RCM)

Requirements Mngt Process Flowchart

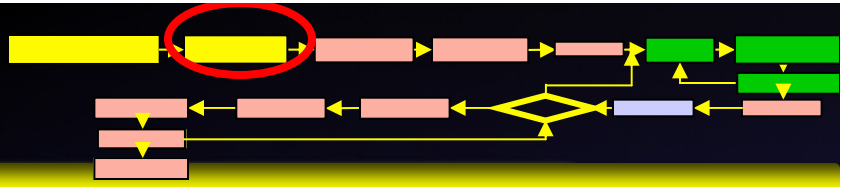


Step 1: Receive Req's



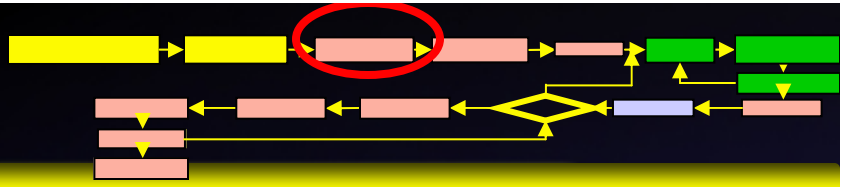
- **Receive Approved and Funded Requirements Document:**
  - **Formally starts this process**
  - **Document can be anything that is recognized as "official" by the Program Manager**
    - **Contract**
    - **SOW/PWS**
    - **AF Form 1067**
    - **Email**
  - **OPR: Program Manager**

Step 2: Build IRT



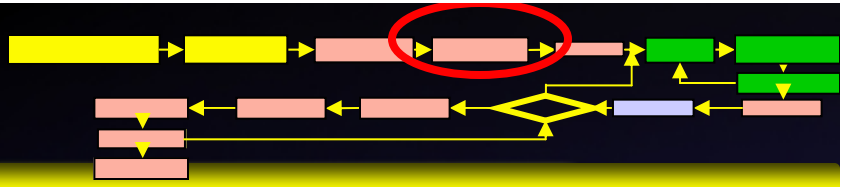
- **Build Integrated Requirements Team (IRT):**
  - **Formally established in writing**
  - **Will include at a minimum:**
    - **Project Engineer**
    - **Program Manager**
    - **Representative(s) from the User**
    - **Representative(s) from the contractor**
  - **Each member there to ensure entire IRT:**
    - **Fully understands each requirement**
    - **Concurs with all derived requirements**
    - **Quantifies each requirement**
    - **Provides detailed operational uses/cases for each req**
  - **Intended to meet regularly**
  - **OPR: Program Manager**

Step 3: ID New Req's



- **Identify and Extract New Requirements:**
  - **Identify, extract and list all requirements from the requirements document in Step 1**
  - **Identify the specific reference (e.g. paragraph and document)**
  - **OPR: Project Engineer**

Step 4: RCM



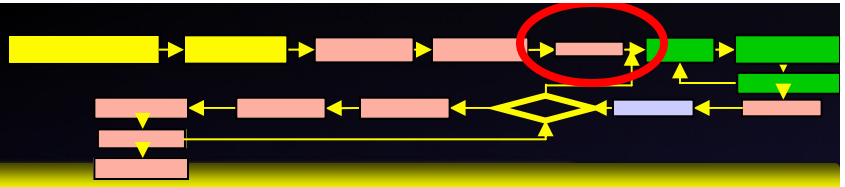
- **Fill Out Requirements Correlation Matrix (RCM):**
  - **Document in a software application to allow for future updates (e.g. spreadsheet)**
  - **Intended Fields:**
    - **Requirement title**
    - **Requirement source (specific reference, e.g. para & doc)**
    - **Derived Requirements (logical breakdown of req)**
    - **Brief requirement definition (1-3 sentences only)**
    - **Quantification of the requirement (this is key)**
    - **Operational Assessment (all scenarios and uses)**
    - **Initial Risk Assessment (e.g. red/yellow/green)**
  - **Review any lessons learned from previous teams**
  - **OPR: Project Engineer**

Step 4: RCM (Cont)

Each IRT member is a SME

- **Requirement title** ← Program Manager
- **Requirement source** ← Program Manager
- **Derived Requirements** ← Project Engineer(s) (Government & Contractor)
- **Brief requirement definition** ← Project Engineer(s) (Government & Contractor)
- **Quantification of the requirement** ← Project Engineer(s) (Government & Contractor)
- **Operational assessment** ← User
- **Initial risk assessment** ← All: PM, Engineers, contractors and Users

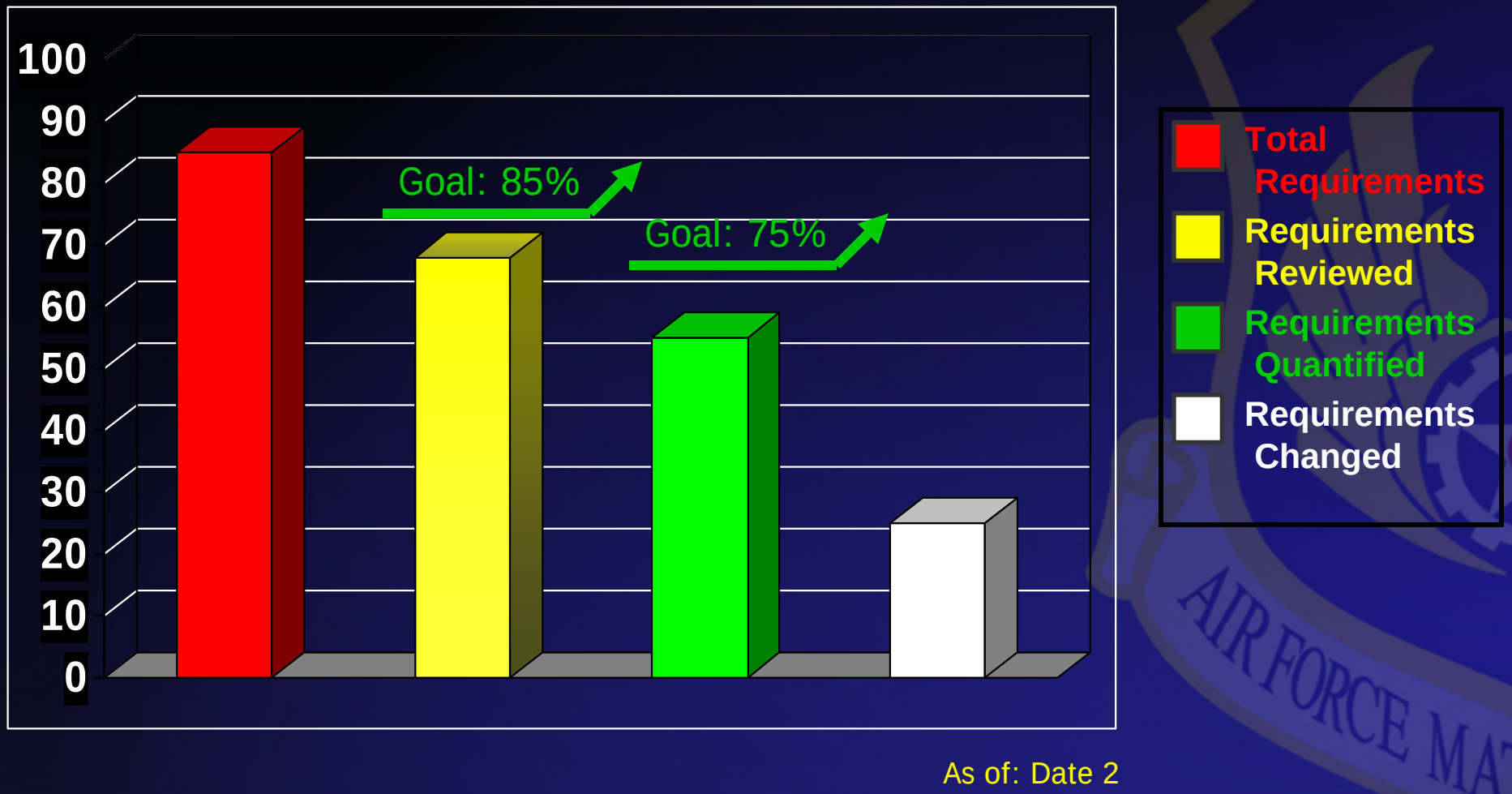
Step 5: Build Metrics



- **Build Metrics:**
  - **Two Metrics:**
    - **Requirement Management Metric (i.e. a snapshot)**
    - **Requirement Growth (i.e. a trend)**
  - **Must be updated throughout process**
  - **Must be shown regularly to management**
    - **Quarterly Weapon System Review**
    - **Once a Month Staff Meeting**
    - **Any significant event (e.g. PMR, PDR, CDR, TIM, …)**
  - **OPR: Project Engineer**

Requirement Management Metric

Example 2

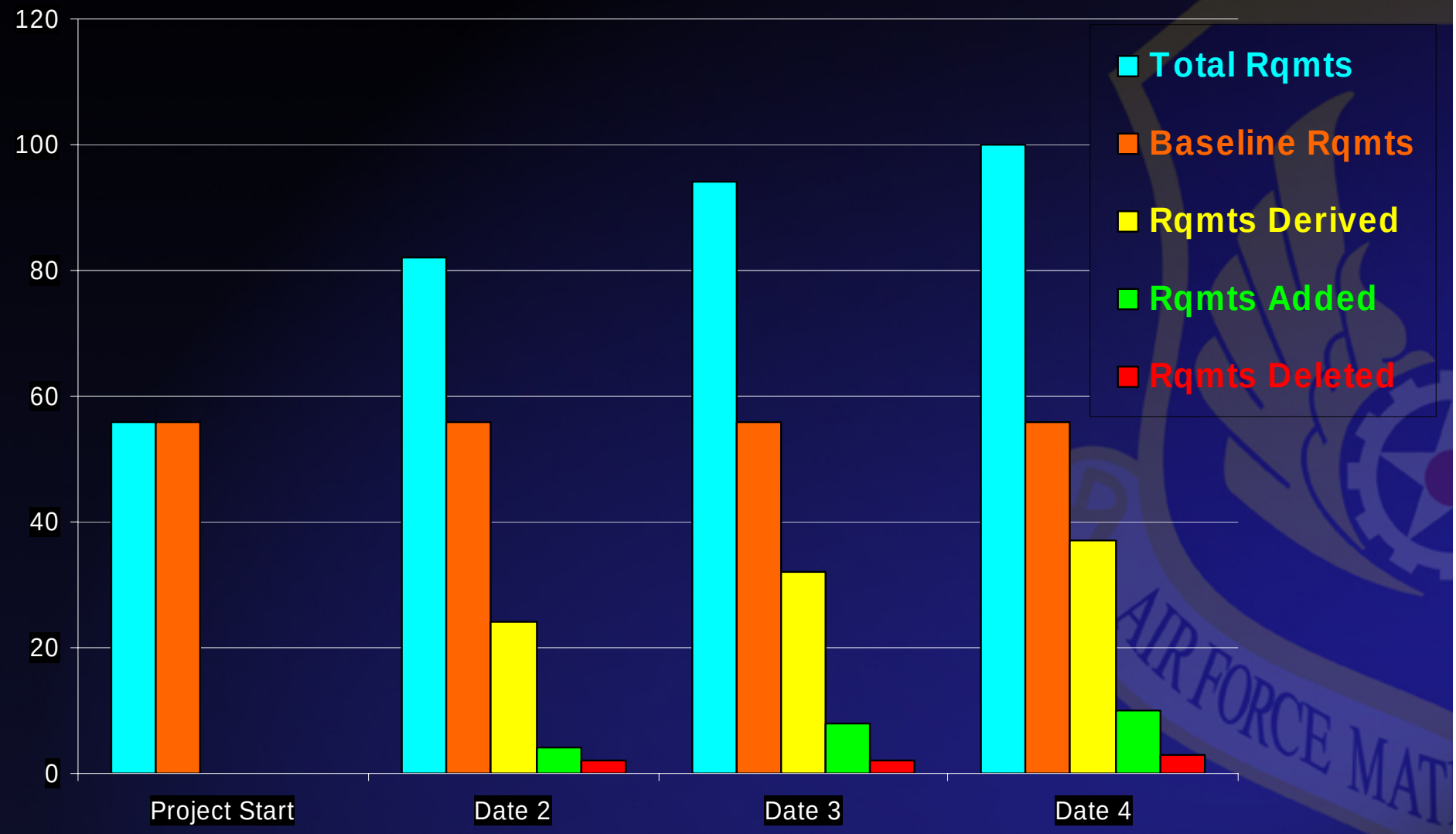


As of: Date 2

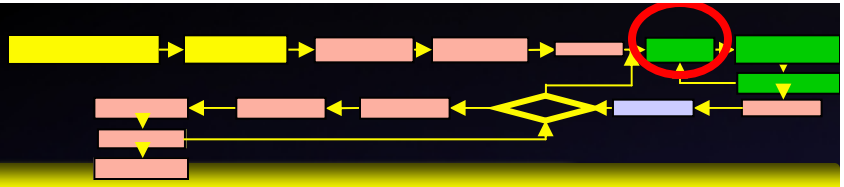
Total Requirements = Requirements + Derived Requirements

Requirement Growth

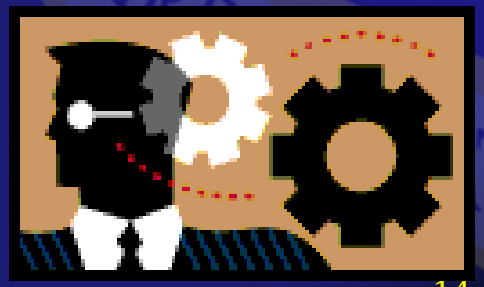
Example 2



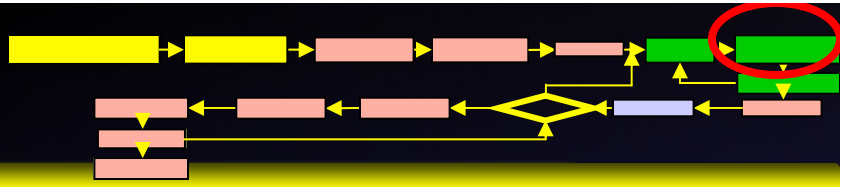
Step 6: ID Use Cases



- **Identify Operational Scenarios:**
  - **Clearly list all operational uses and scenarios**
  - **Done for each req and derived req**
  - **Necessary to ensure design:**
    - **Encompasses all user's intentions**
    - **Helps identify all potential special cases**
    - **Comprehensive list of what to test/measure**
  - **OPR: Integrated Requirements Team**



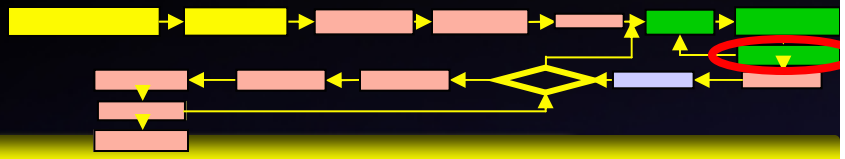
Step 7: Derived Req's



- **Identify and Extract Derived Requirements:**
  - **This is an iterative, spiral process**
  - **Expect derived requirements to increase/clarify as user discusses all operational uses**
  - **Key is not to "assume" anything**
  - **OPR: Integrated Requirements Team**

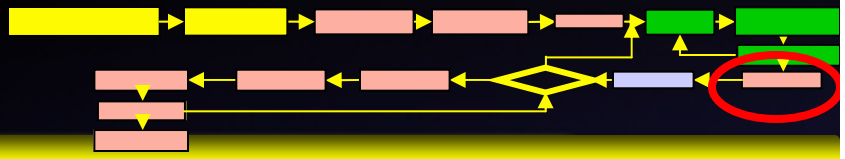


Step 8: Quantify



- **Define/Clarify/Quantify Requirements:**
  - **The heart of the RCM**
  - **Specific, unambiguous quantification of each req**
    - **Key for later testing**
    - **Provide agreed on pass/fail criteria**
    - **Not open to interpretation**
  - **Resolve all "TBDs"**
  - **Document in minutes how quantification determined on requirements and indication of concurrence from all members**
  - **OPR: Integrated Requirements Team**

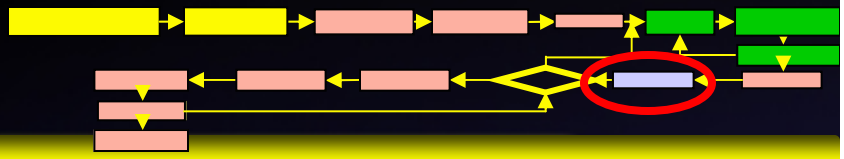
Step 9: Update RCM



- **Update RCM:**
  - **Update with each spiral from the IRT**
  - **Serves as the “common sheet of music” for the IRT**
  - **This is the source of data for the metrics**
  - **OPR: Project Engineer**

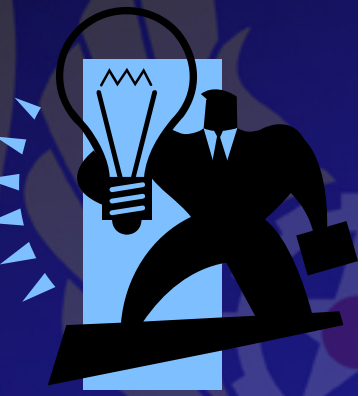


Step 10: Req Review

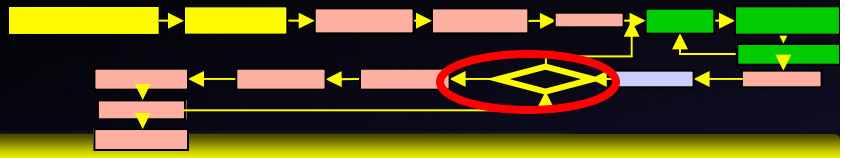


- **Unbiased Review:**
  - **Purpose to validate the RCM**
    - **Sufficient level of detail via derived requirements**
    - **Proper quantification of each requirement**
    - **Strong review of non-quantified and TBD req's**
    - **Comprehensive review of use cases and what-ifs**
  - **Project Engineer presents the RCM to review board**
  - **Chief Engineer is the Chair**
  - **Other members are SMEs and experienced personnel**
  - **Members from both inside and outside organization**

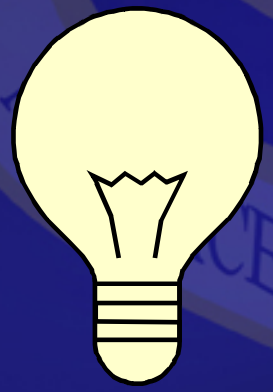
  - **OPR: Chief Engineer**



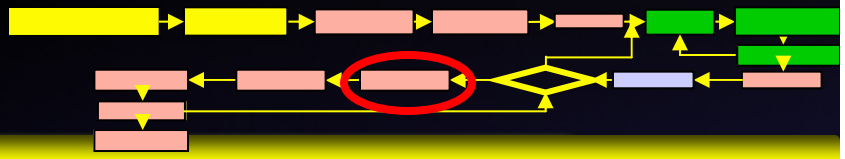
Step 11: Changes



- **Requirements Changes:**
  - **Project Engineer takes Review Board results back to IRT**
    - **Requests for clarification**
    - **Recommendations**
    - **Corrections**
  - **Can also result from IRT meetings or program events (PDR, CDR, PMRs, etc..)**
  - **OPR: Project Engineer**

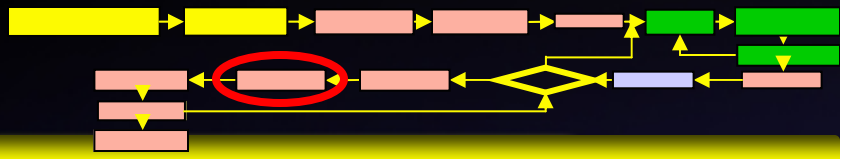


Step 12: RCM to Test



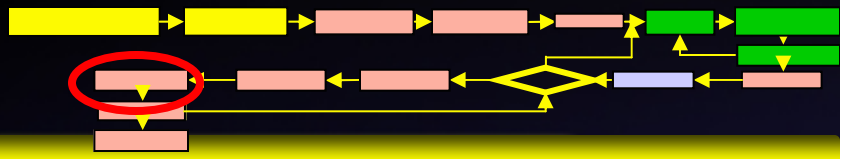
- **Pass RCM to Test Team:**
  - **Test Team uses this a core input to build successful test program:**
    - **Are the quantified requirements testable**
    - **Determine method of testing**
    - **Awareness of problem, or risk, areas**
    - **What resources are needed**
    - **Ensure test plan is comprehensive**
    - **How handle non-quantified requirements**
  - **Another OI is in work to describe this process**
  - **OPR: Project Engineer**

Step 13: RCM Risk



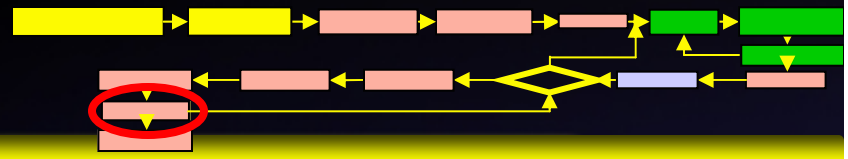
- **Pass RCM to Risk Team:**
  - **Risk Management Team uses this a key input for risk management plan:**
    - **Review all requirements the IRT initially flagged as red or yellow**
    - **What resources are needed to mitigate**
    - **Ensure risk plan is comprehensive**
    - **Incorporate into program schedule**
  - **Another OI is in work to describe this process**
  - **OPR: Project Engineer**

Step 14: Maintain RCM



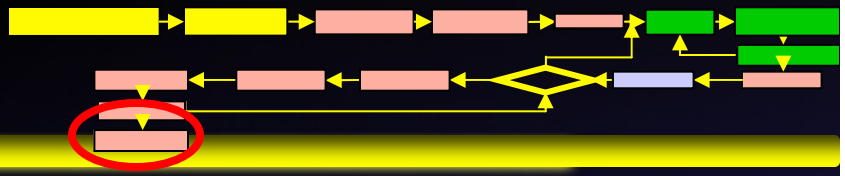
- **Maintain and Track RCM:**
  - **Have regular IRT Meetings to continually update RCM**
    - **Eliminate TBDs**
    - **Review quantification**
    - **Ensure have all operational uses/scenarios**
    - **Ensure included all derived requirements**
  - **OPR: Program Manager**

Step 15: Report

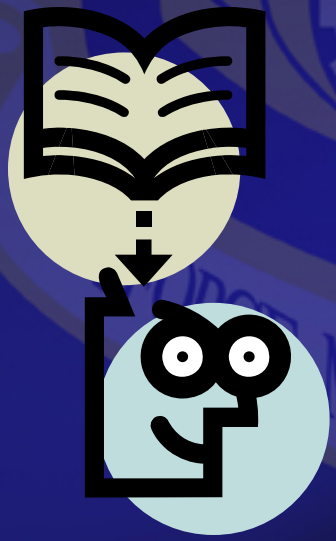


- **Report Metrics:**
  - **Regularly update metrics**
  - **Ideal Goal is 100% reviewed and 100% quantified**
  - **OPR: Project Engineer**

Step 16: Lessons Learned



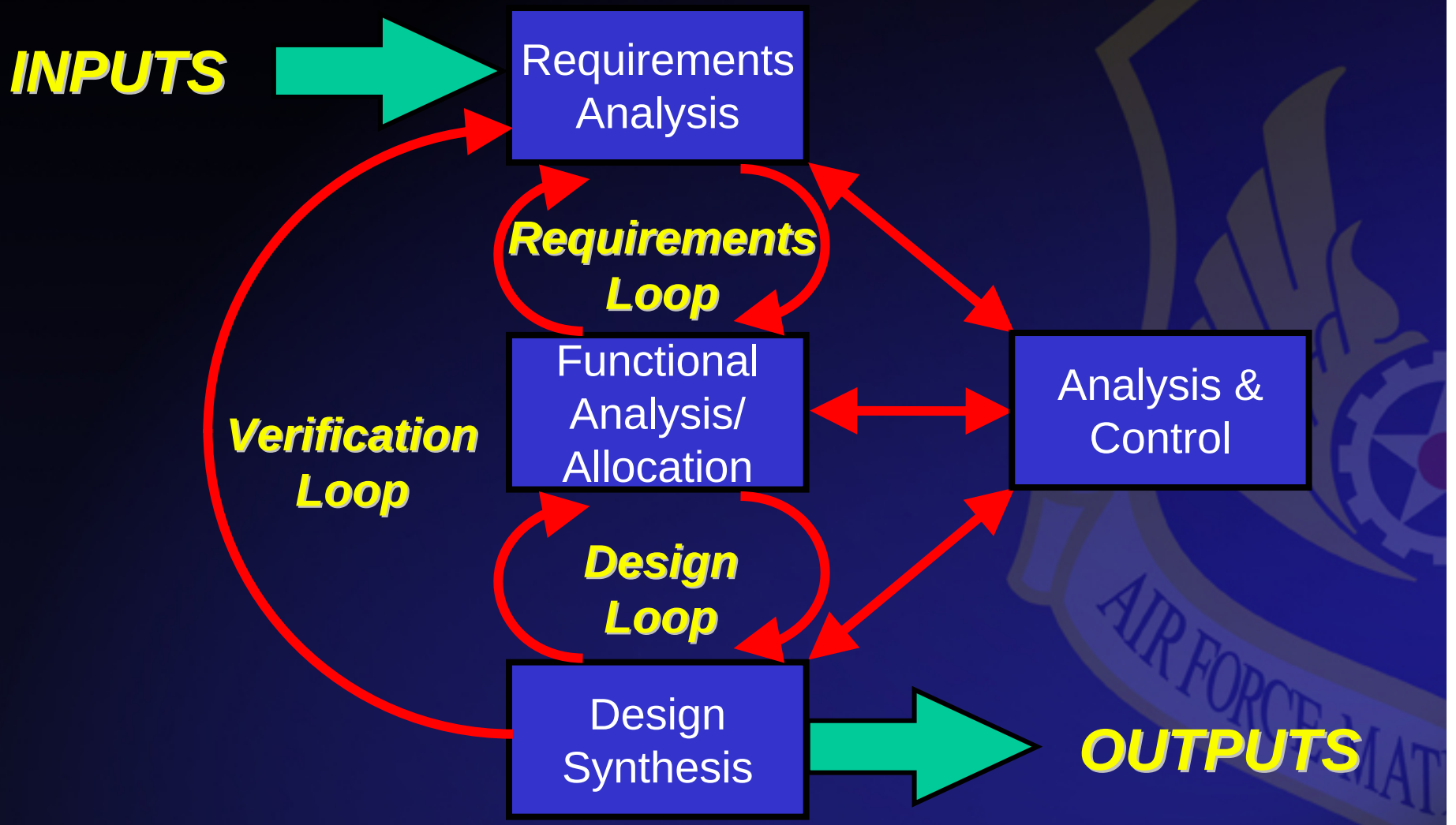
- **Document Lessons Learned:**
  - **Develop a place for the organization to log this (if not have already)**
  - **Good place to start developing "standard" quantification to common requirements**
    - **Light brightness on aircraft**
    - **Noise levels on headphones**
    - **VTC standards**
  - **OPR: Project Engineer**



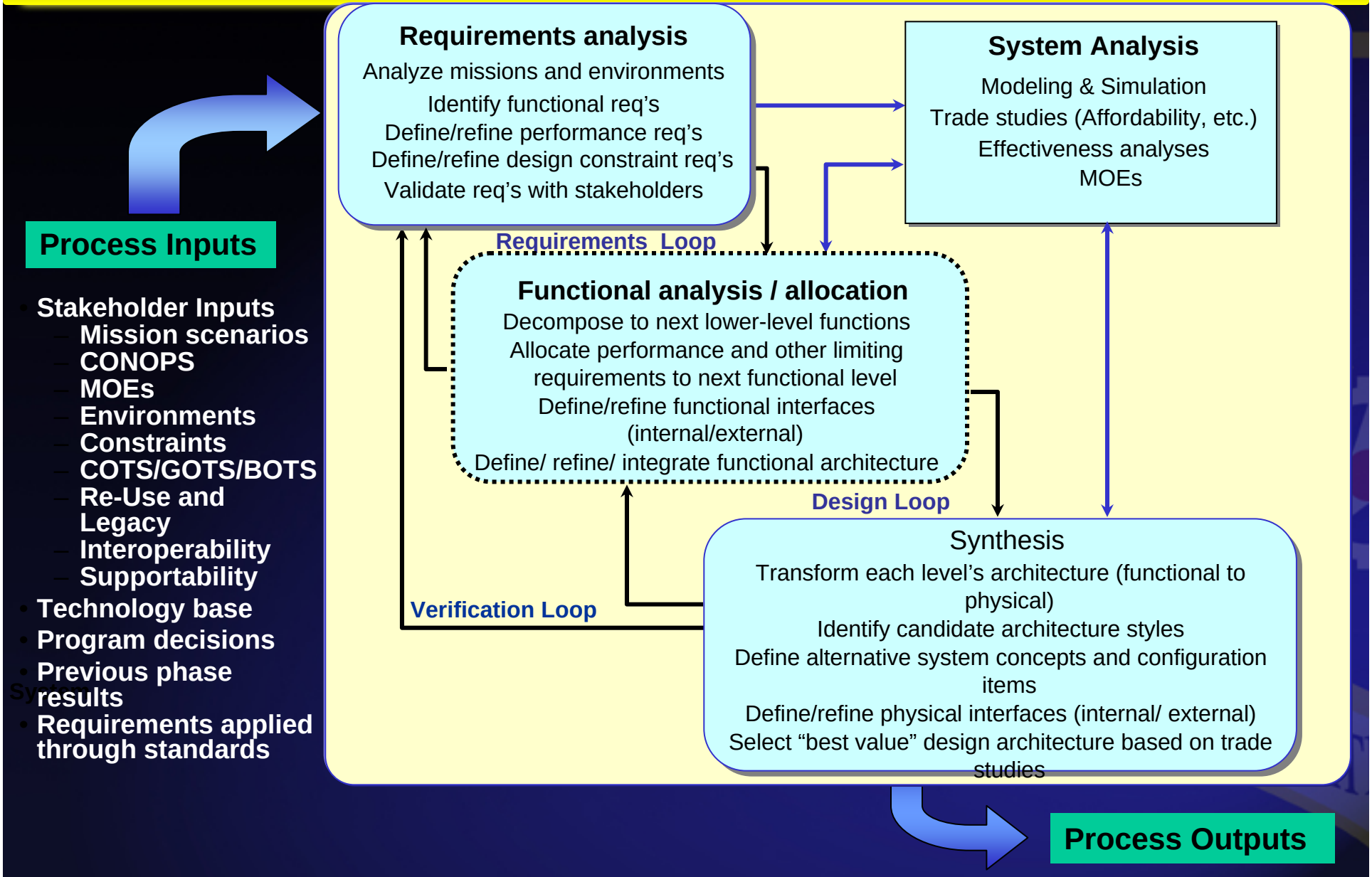
Typical Schedule

- **Show the Flow days here**
  - **Recommend basing on Requirement receipt plus days**

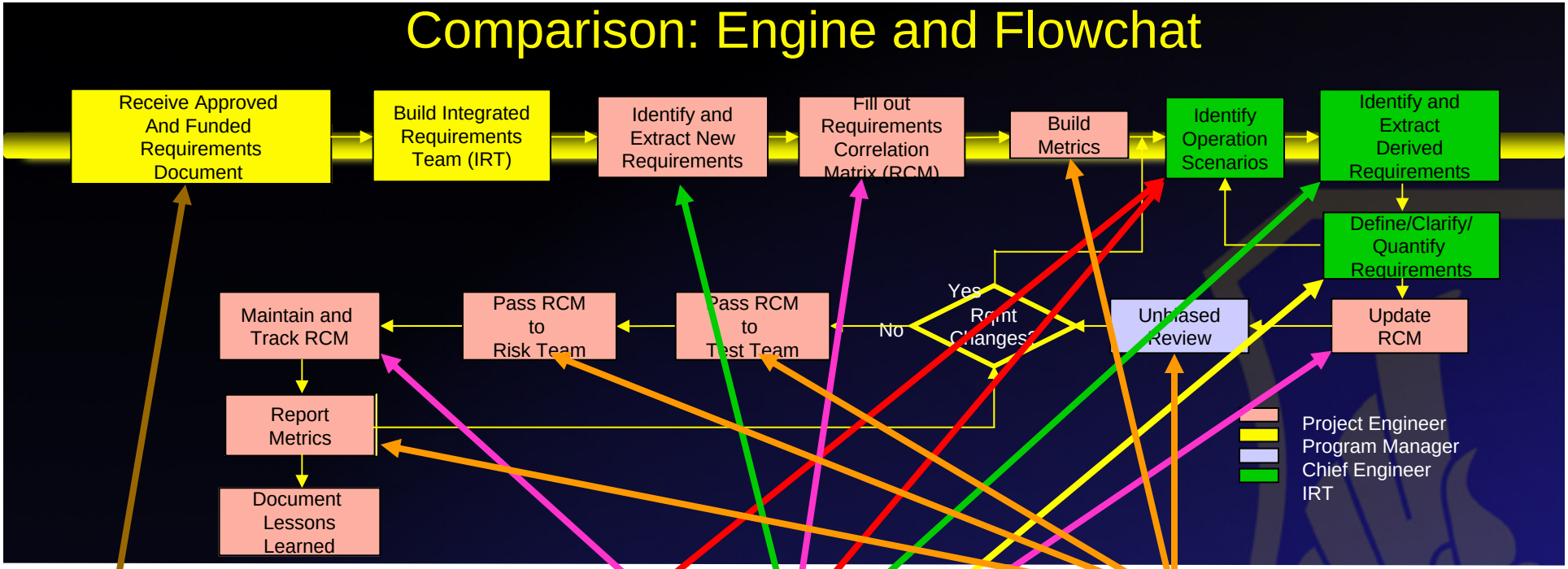
Basic Systems Engineering Process

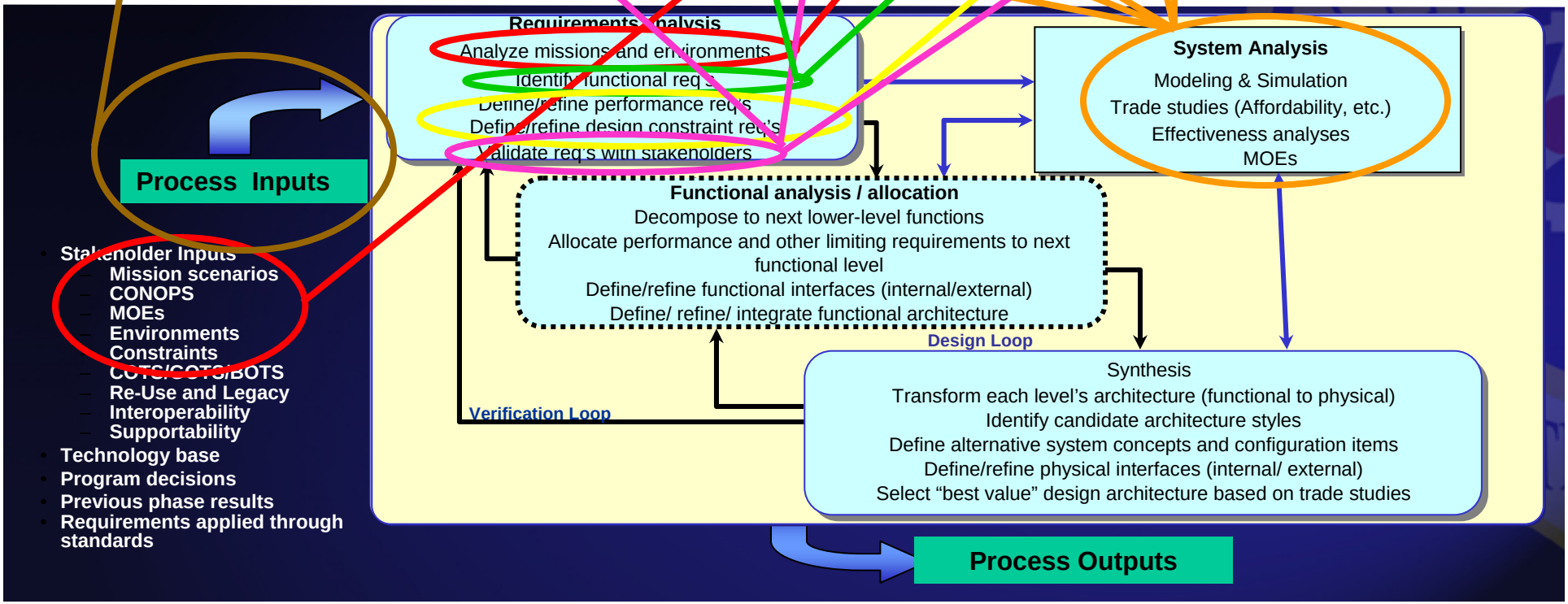


Detailed Systems Engineering Engine



Comparison: Engine and Flowchat







Questions?

Detailed Systems Engineering Functional Instructions



Systems Engineering Process Manual

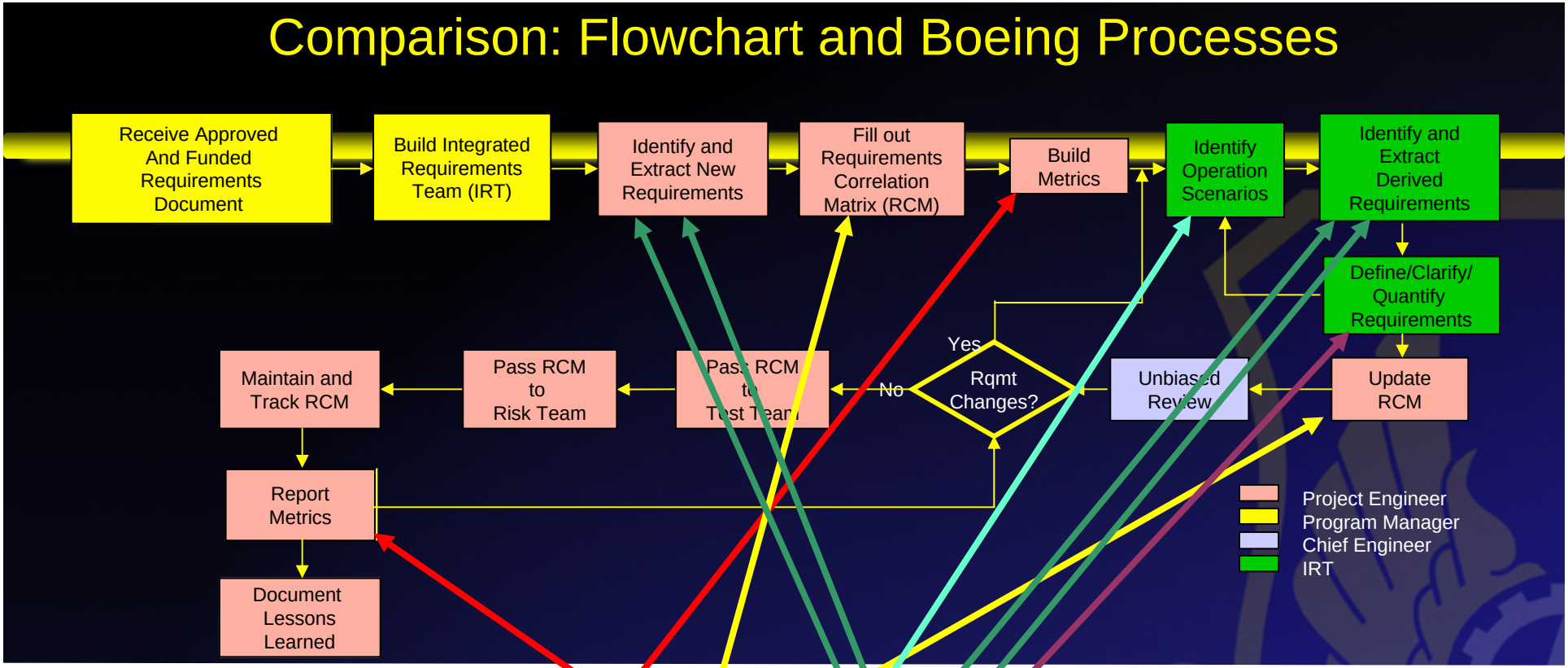
Expand Collapse Previous Next Create

Launch No.	Title
000 General - Systems Engineering	
WH-SE-000.01	PRO-3751 Systems Engineering Process Documents
WH-SE-000.02	PRO-6188 Define and Manage Product/Service Requirements
WH-SE-000.03	PRO-6189 Plan and Control Product/Service Development and Definition
WH-SE-000.04	PRO-6190 Concurrently Develop and Define Products/Services
WH-SE-000.05	PRO-6191 Verify & Validate Products/Services
WH-SE-000.06	D950-10459-1 Common Systems Engineering Process Framework (CSEPF)
WH-SE-000.07	D950-10446-1 Systems Engineering Process Manual (SEPM)
100 Manage Product Traceability	
WH-SE-100	Manage Product Traceability
WH-SE-100.01	BPI-3472 Manage Product Requirements Traceability
WH-SE-101	Requirements Traceability
WH-SE-FI.102	Product Requirements Traceability at IDS Wichita
200 Define and Analyze System Requirements	
WH-SE-200	Define and Analyze System Requirements
WH-SE-200.01	BPI-3471 Manage Requirements
WH-SE-200.02	BPI-3473 Perform Systems Analysis
WH-SE-200.03	BPI-3483 Define and Develop Requirements
WH-SE-201	Requirements Analysis
WH-SE-202	Requirements Parse
WH-SE-203	Requirements Allocation Sheet
WH-SE-204	Prepare Specifications
WH-SE-206	System of Systems Engineering Process
WH-SE-207	System/Segment Specification Template
WH-SE-209	System/Subsystem Specification DID (DI-IPSC--81431A)
WH-SE-210	Analyze and Define Hardware Requirements
WH-SE-211	Hardware Requirements Documentation
WH-SE-212	Nuclear Hardness and Survivability – Requirements Flowdown
300 Define and Analyze System Functions	
WH-SE-300	Define and Analyze System Functions
WH-SE-300.01	BPI-3479 Define and Develop Functions
WH-SE-301	Define System States and Modes
WH-SE-302	Functional Analysis Allocation

Launch No.	Title
400 System Design Synthesis	
WH-SE-400	Perform System Design Synthesis
WH-SE-400.01	BPI-3464 Develop Integrated Design
WH-SE-400.02	BPI-3468 Integrate System
WH-SE-402	System Design Procedure
WH-SE-403	Manage Technology and Product Line Evolution
WH-SE-404	Technology Management
WH-SE-405	Tailoring the Systems Engineering Process
WH-SE-407	Operational Concept/Mission Analysis/Measures of Effectiveness
WH-SE-408	Define System States and Modes
WH-SE-410	Technical Performance Measurement
WH-SE-411	Technical Performance Measures Template
500 Plan System Verification and Validation	
WH-SE-500	Plan System Verification and Validation
600 Manage Interfaces	
WH-SE-600	Manage Interfaces
WH-SE-600.01	BPI-3470 Manage Interfaces
WH-SE-601	Interface Design/Control Procedure
WH-SE-603	ICP No. 208, Strategic Systems Interface Control Plan

Launch No.	Title
700 Perform Verify and Validate Systems	
WH-SE-700	Validate System
WH-SE-700.01	BPI-3475 Perform Verification
WH-SE-700.02	BPI-3474 Perform Validation
900 Miscellaneous	
WH-SE-901	Simulation Performance Analysis Procedure
WH-SE-904	Human-System Integration Process
WH-SE-905	System Safety Program Implementation, Management and Control
WH-SE-906	System Safety Process
WH-SE-907	System Safety Analysis
WH-SE-908	Joint Tasks - Safety, Health & Environmental Affairs (SHEA) Support Procedure

Comparison: Flowchart and Boeing Processes



WH-SE-000.07 D950-10446-1 Systems Engineering Process Manual (SEPM)

100 Manage Product Traceability

- WH-SE-100 Manage Product Traceability
- WH-SE-100.01 BPI-3472 Manage Product Requirements Traceability
- WH-SE-101 Requirements Traceability
- WH-SE-[illegible] Product Requirements Traceability at IDS Wichita

400 System Design Synthesis

- WH-SE-400 Perform System Design Synthesis
- WH-SE-400.01 BPI-3464 Develop Integrated Design
- WH-SE-400.02 BPI-3468 Integrate System
- WH-SE-402 System Design Procedure
- WH-SE-403 Manage Technology and Product Line Evolution
- WH-SE-404 Technology Management
- WH-SE-405 Tailoring the Systems Engineering Process
- WH-SE-407 Operational Concept/Mission Analysis/Measures of Effectiveness

200 Define and Analyze System Requirements

- WH-SE-200 Define and Analyze System Requirements
- WH-SE-200.01 BPI-3471 Manage Requirements
- WH-SE-200.02 BPI-3473 Perform Systems Analysis
- WH-SE-200.03 BPI-3483 Define and Develop Requirements
- WH-SE-201 Requirements Analysis
- WH-SE-202 Requirements Parse
- WH-SE-203 Requirements Allocation Sheet
- WH-SE-204 Prepare Specifications
- WH-SE-206 System of Systems Engineering Process
- WH-SE-207 System/Segment Specification Template
- WH-SE-209 System/Subsystem Specification DID (DI-IPSC--81431A)
- WH-SE-210 Analyze and Define Hardware Requirements
- WH-SE-211 Hardware Requirements Documentation
- WH-SE-212 Nuclear Hardness and Survivability – Requirements Flowdown

300 Define and Analyze System Functions

- WH-SE-300 Define and Analyze System Functions
- WH-SE-300.01 BPI-3479 Define and Develop Functions
- WH-SE-301 Define System States and Modes
- WH-SE-302 Functional Analysis Allocation

Implementing Systems Engineering in a Sustainment Environment

25 Sept 06

Jim Miller
Chief Engineer
727 ACSG/EN
Phone: 736-5771
james.c.miller@tinker.af.mil

So What is the Problem?

- High-level policy is a good and necessary first step, however, more detailed direction is essential to turn the policy into a workable, grass-roots program
- Sustainment different than acquisition
- Our organization had insufficient direction, documentation, and procedures to begin implementing an effective, comprehensive Systems Engineering program



So What Are Doing About It?

- Instigated a step-by-step approach to begin implementing systems engineering throughout the sustainment organization
- Tangible approach that is:
  - Aimed at the working level
  - Affects all phases of a program's lifecycle
  - Applicable throughout entire organization
  - Accounts for organization's progress through metrics



Systems Engineering Implementation Phases

- Phase 1: Awareness of Need
- Phase 2: Workforce Training
- Phase 3: Identify Applicable Programs/Orgs
- Phase 4: Identify and Define Processes
- Phase 5: Incentivize Contractors/Partners
- Phase 6: Develop Library of Tools
- Phase 7: Track Progress via Metrics



Phase 1: Awareness of Need

- ✓ Brief senior leadership and got documented buy-in
- ✓ Identify focal point for organization
- ✓ Prepare SE re-invigoration briefing
- ✓ Present briefing to all:
  - ✓ Supervisors (Squadron Commanders/Directors)
  - ✓ Program Manager's
  - ✓ Logisticians
  - ✓ Engineers
  - ✓ Equipment Specialists
  - ✓ Telecommunication Specialists



Phase 2: Workforce Training

- ✓ Determine appropriate amount/level of training by working with:
  - ✓ Internal engineering management
  - ✓ Center-level functional offices
  - ✓ Higher headquarters (HQ AFMC)
  - ✓ Senior Program Managers
- ✓ Ensure training consistent with other ALC, AFMC and DoD efforts
- ✓ Determine training plan robust enough to make a difference yet realistic based on workload
- ❑ Train Workforce



Phase 2: Workforce Training

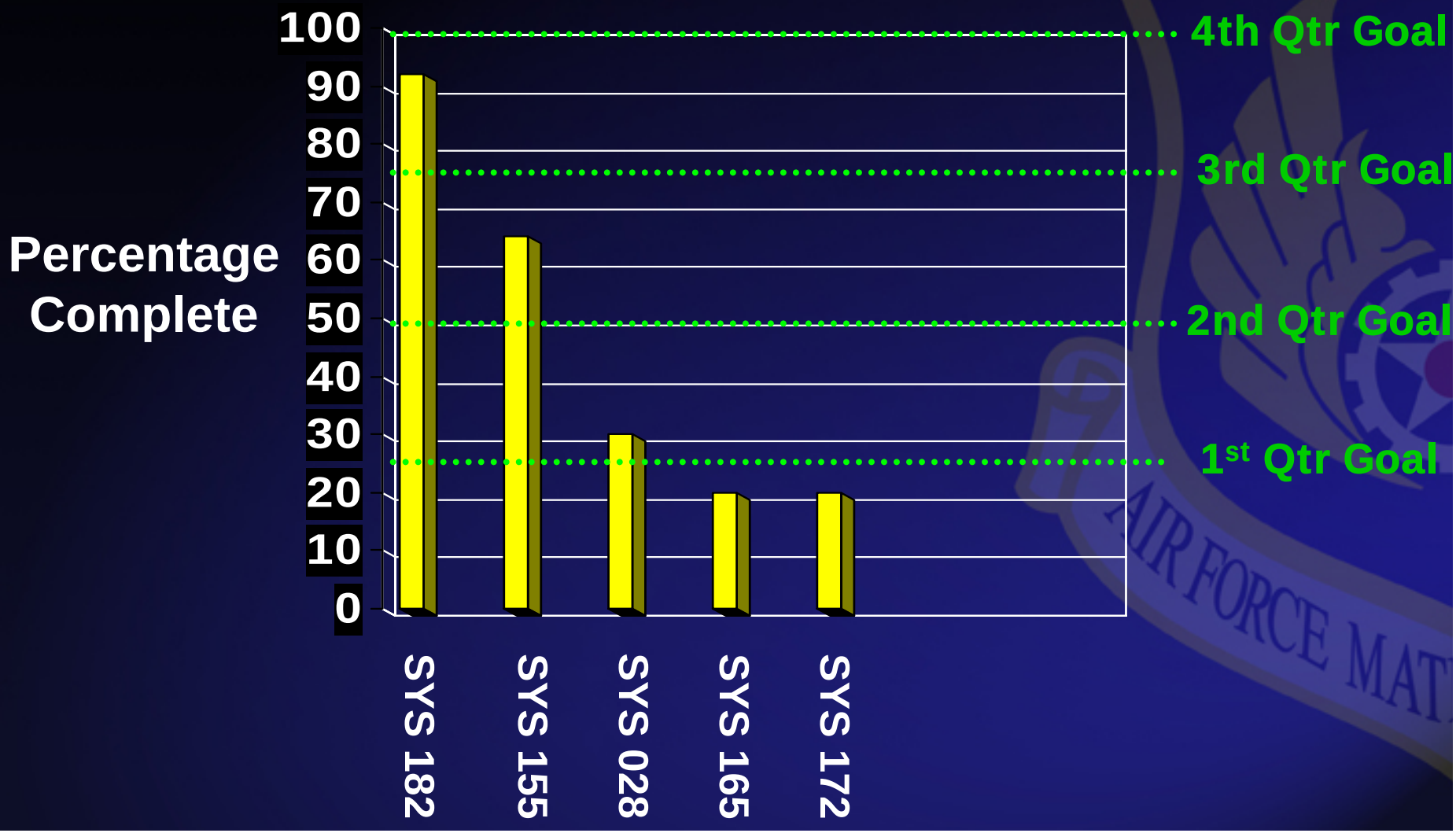
Courses Selected (All CBT):

- SYS 182 Intro to Systems Engineering ~ 3 hrs
- SYS 155 Operational Safety, Suitability & Effectiveness ~ 9 hrs
- SYS 028 Intro to Configuration Management ~ 16 hrs
- SYS 165 Intro to Risk Management ~ 21 hrs
- SYS 172 Modification Management Process ~ 6 hrs

Who: All PM's, Equipment Specialists and Engineers
When: Complete in 12 months

Phase 2: Workforce Training

Org A Training Progress (45 People)



Phase 3: Identify Applicable Programs/Orgs

- ✓ Determine Applicable Programs Criteria:
  - ✓ All OSS&E Programs
    - * C-9
    - * C-20
    - * C-21
    - * C-38
    - * KC-10
    - * Peace Lotus
    - * Academy Fleet
    - * VC-25
    - * C-12
    - * C-21
    - * C-26
    - * E-9
    - * KDC-10
    - * T-43
    - * E-4B
    - * HFGCS



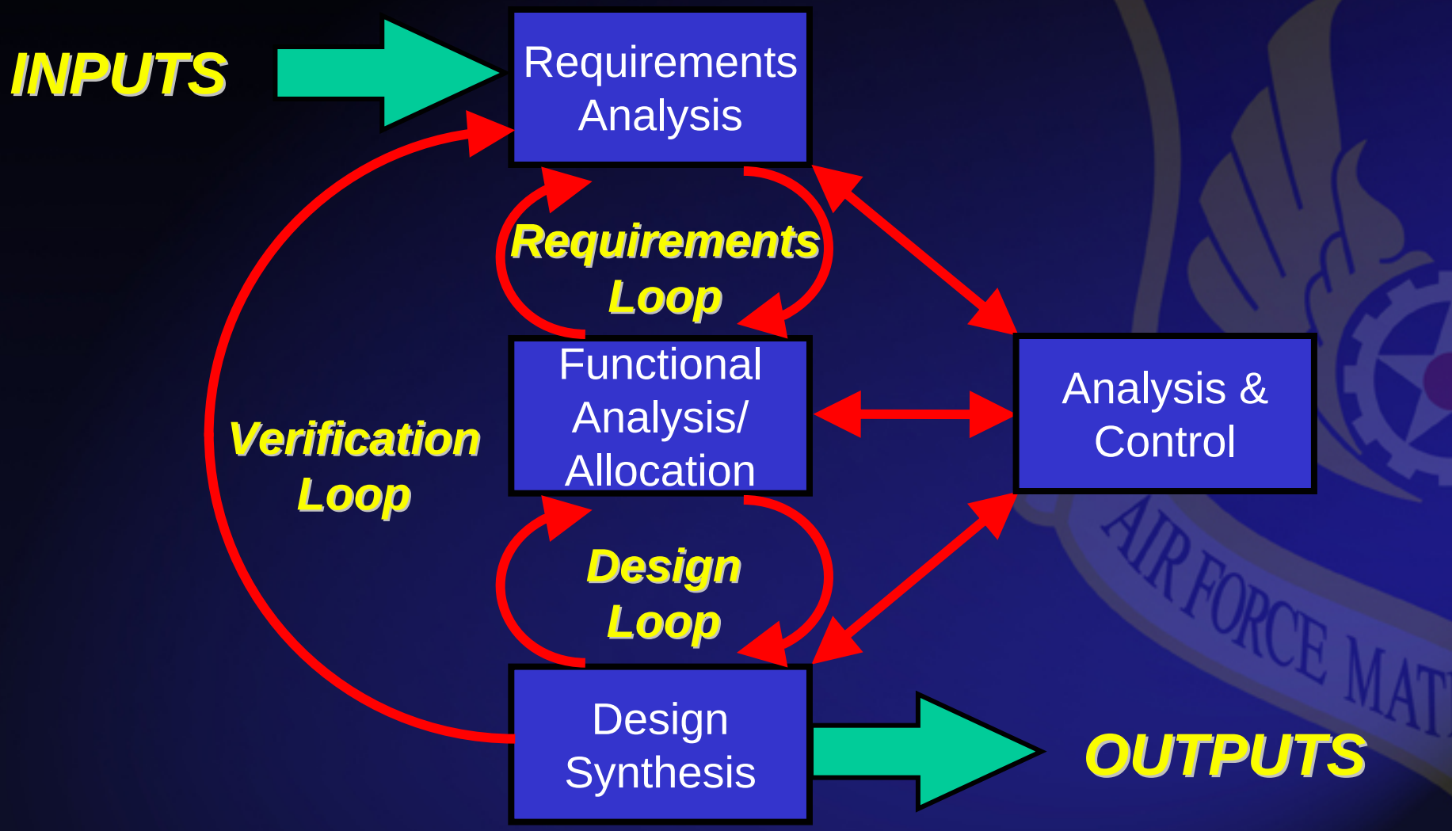
Phase 4: Identify and Define Processes

- ✓ Ensure processes incorporate systems engineering
  - ✓ Jumpstarted SE revamp with 3 Key Processes:
    - ✓ Requirement Management OI
    - ✓ Risk Management OI
    - ✓ Test Management OI
- ❑ Will springboard into other organizational processes
- ❑ Goal to standardize and share Best Practices across organization



Phase 4: Identify and Define Processes

Basic Systems Engineering Process

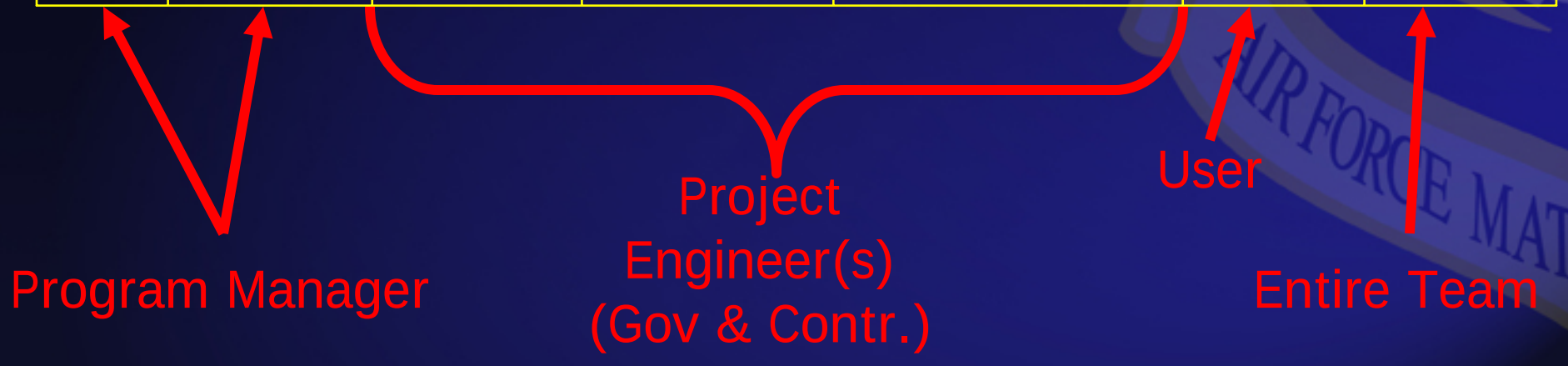


Phase 4: Identify and Define Processes

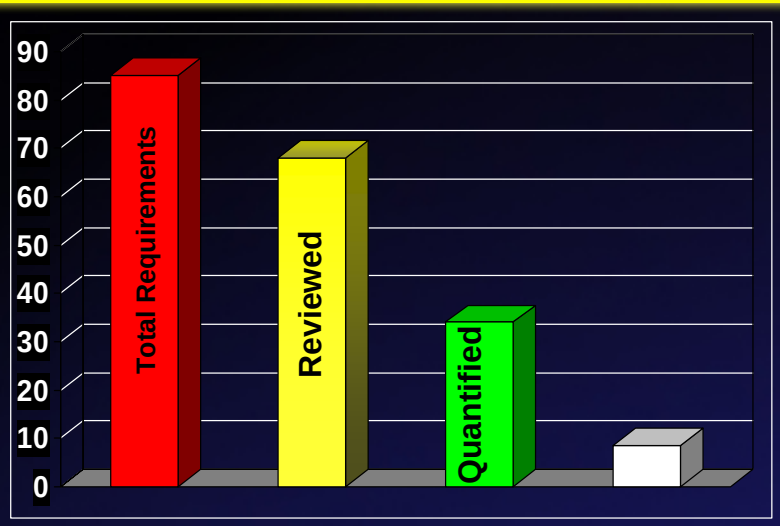
- Break requirements down in a Requirements Correlation Matrix (RCM):
- Spreadsheet with following columns:
  - Requirement
  - Requirement Source
  - Derived Requirements
  - Quantification
  - Initial Risk Assessment
  - Operational Conditions
- Give RCM to
  - Test Team for their planning
  - Risk Mngt Team for their planning

RCM

Req Title	Req Source	Derived Req	Req Definition	Quantification	Op Cases	Risk (R/Y/G)



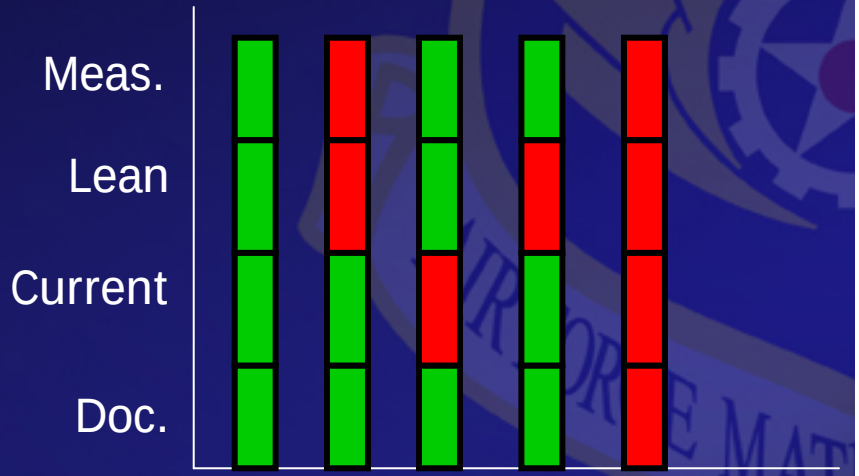
Phase 4: Identify and Define Processes



Requirements

	Low	Med.	High
High	0	2/4	1/2
Med.	1/6	0/1	3/4
Low	1/3	2/4	2/3

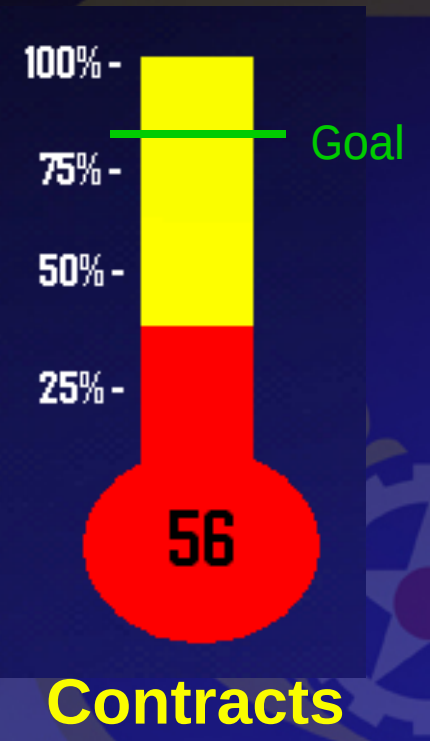
Risk



Processes

Phase 5: Incentivize Contractors/Partners

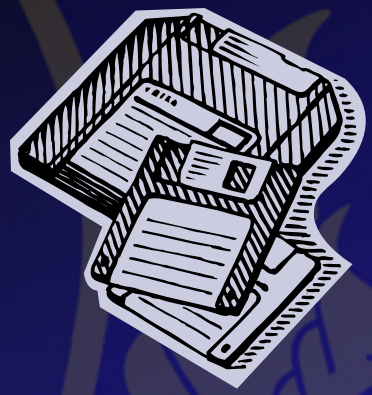
- ❑ Ensure Systems Engineering is an incentivized factor in all applicable contracts
- ✓ List all Contracts
  - ❑ Determine which should have SE
  - ❑ Determine appropriate SE wording
  - ❑ Develop plan, so as contracts renewed, incorporate SE incentivization
- ❑ Work with contractor/partner to improve implementation of systems engineering



Already incorporated in two major contracts!

Phase 6: Develop Library of Tools

- Need good SE "toolbox"
  - Templates
  - Metrics
  - How-to's (fishbone, 5-whys, paredo, …)
  - Lessons Learned
  - Explanations
  - Best Practices
  - Peer Review
  - Case Studies
  - Life Cycle Cost consideration
  - Contractual language
  - Etc…



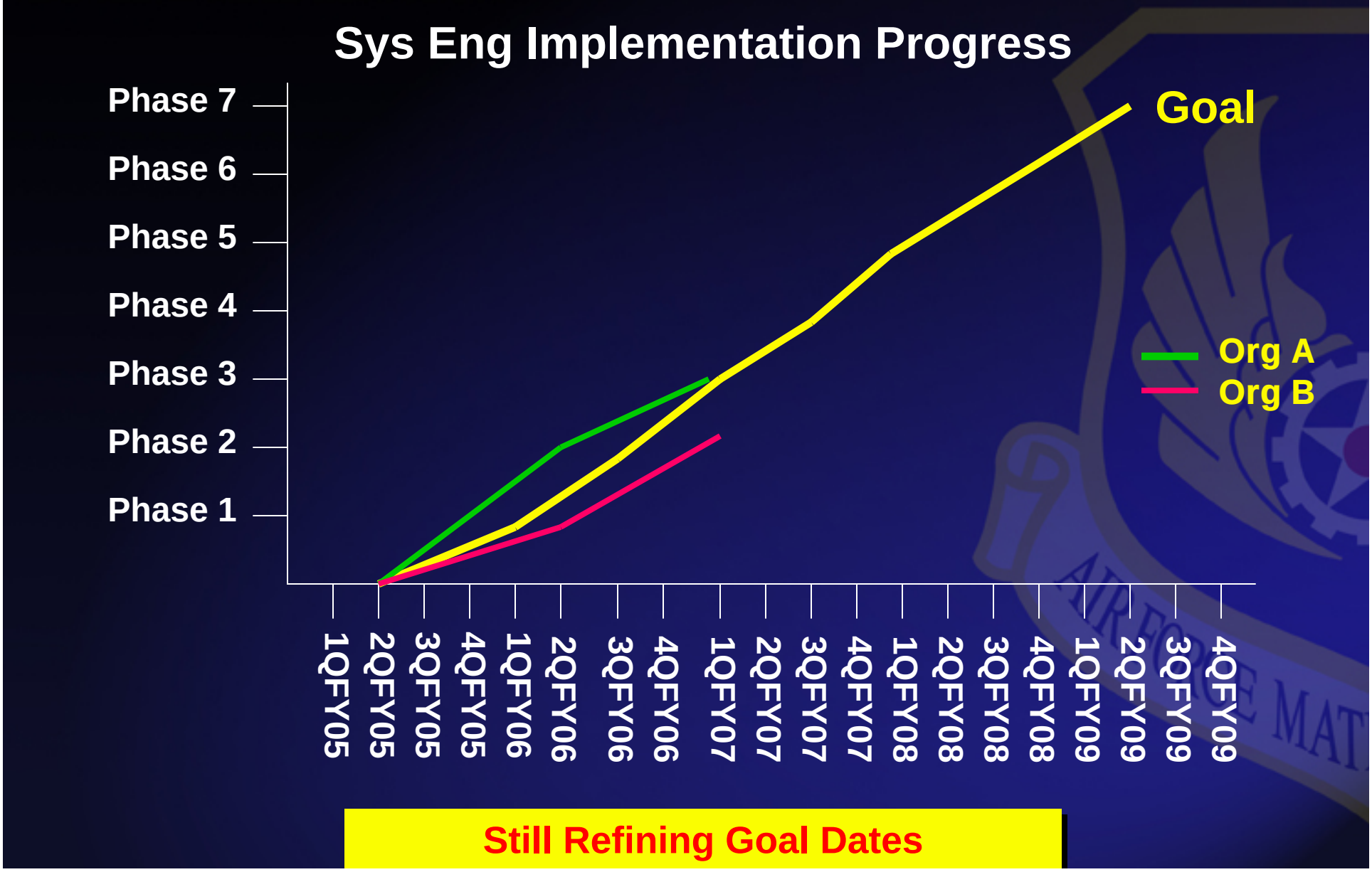
Functional Office to Develop/Obtain….Not Started Yet

Phase 7: Track Progress via Metrics

- ✓ Metrics developed to track progress
- ✓ Metrics shown regularly to upper management
  - ❑ 1st staff meeting of month
  - ❑ Quarterly Weapon System Reviews
  - ✓ Metrics must be able to roll up
- ✓ Metrics will track:
  - ✓ Systems Engineering Implementation
  - ✓ Requirements
  - ✓ Risk
  - ✓ Processes
  - ✓ Training
  - ✓ Contracts

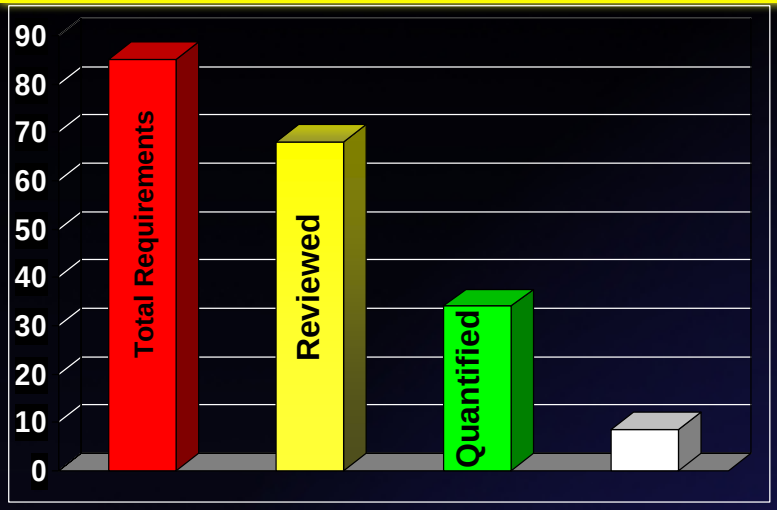


Phase 7: Track Progress via Metrics

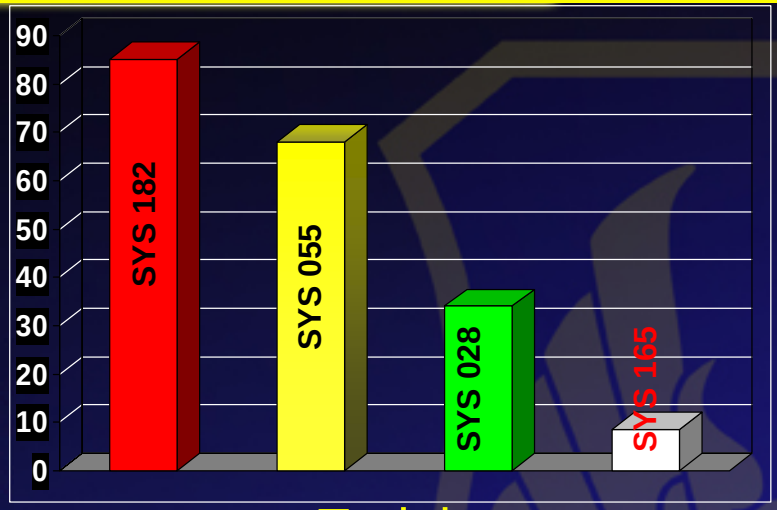


Still Refining Goal Dates

Sample Program Sys Eng "Dashboard"



Requirements



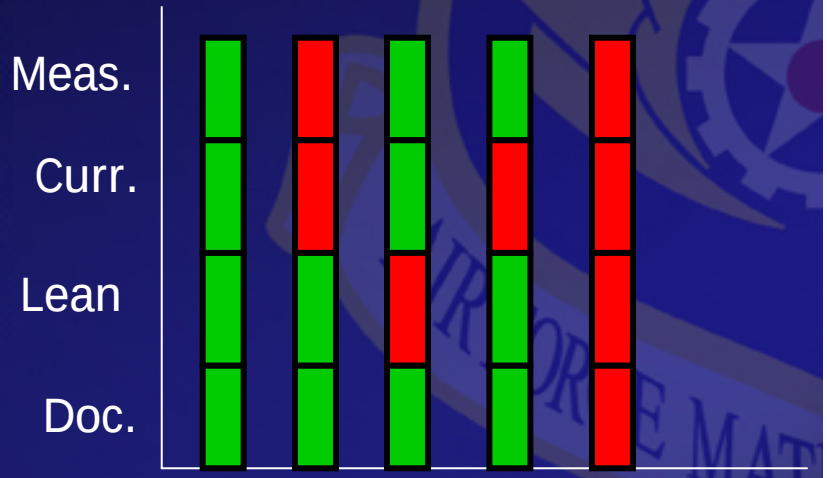
Training

	Low	Med.	High
High	0	2/4	1/2
Med.	1/6	0/1	3/4
Low	1/3	2/4	2/3

Risk

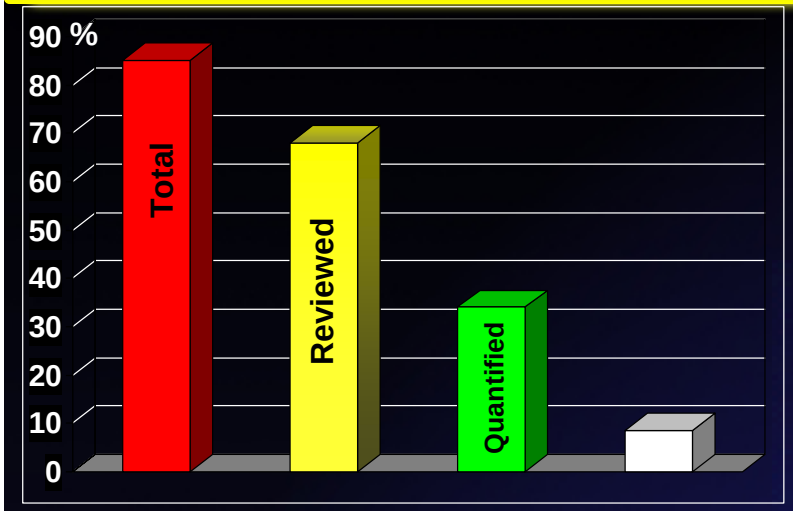


Contracts



Processes

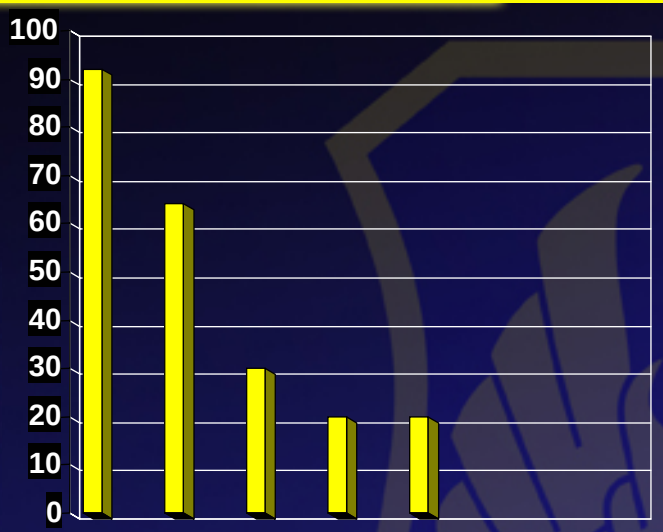
Sample Organization Sys Eng "Dashboard"



Requirements (%)



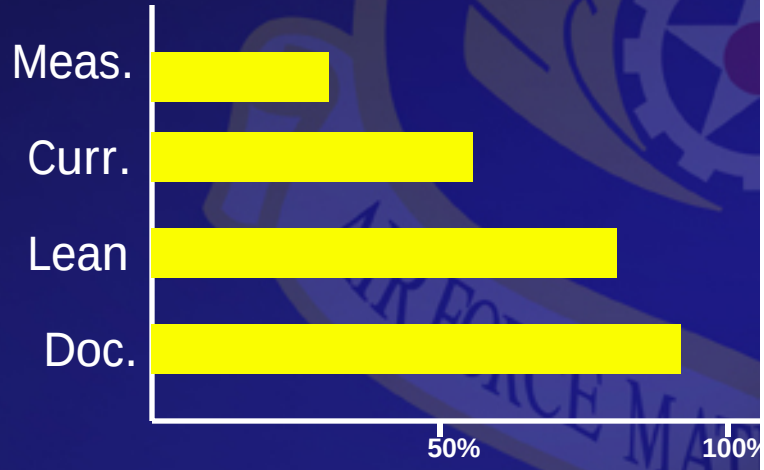
Contracts



Training (%)

	Low	Med.	High
High	20	40	80
Med.	5	50	60
Low	10	5	40

Risk (%)



Processes (%)

What's Next



- Continue implementation throughout organization
- Measure/Track results
- Increase and standardize systems engineering presentation in quarterly Weapon System Reviews and Staff Mtgs
- Start configuration management Process Improvement Team

Systems Engineering can be implemented, applied AND make a difference

Summary

- Recent high-level policy issued
- 727th ACSG developed grass-roots means to implement SE in Sustainment Environment
- Clear-cut, tangible processes steps for the working-level; metrics to measure progress for management



In Place and In Use Now

Questions ?



Technical Data
(an Output of Systems Engineering)
in the Context of the LCMC

9th Annual Systems Engineering Conference
23-26 October 2006
San Diego, CA
R. Miller

Today’s Agenda

- Statement of Purpose
- Government's Weapon system (sustainment) mission
- Background
- Challenges
- Path Ahead
- Overview of the SE Process from a DOD perspective
- Technical Data as a specific SE Output and Metric
- Life Cycle Management Command (LCMC) Org.
- Electronic Data Transfer
- Product Data and Engineering Working Group (PEWG)
- Summary

Statement of Purpose

The importance of technical data and its benefits within the Government is resurfacing with the revitalization of Systems Engineering by OSD

The Government's Weapon System (sustainment) Mission

- The OSD/Army missions requiring TD
  - FAR/DFAR compliant contracting
  - Contingency sustainment strategies
  - Spare part technical designs and reviews
  - Rapid Warfighter and or Operational solutions
  - Continuous technology refreshment
  - Support to the AM LCMC depots
  - Competition initiatives
  - Reliability Improvements
  - Value Engineering
  - Hosting standardized TD formats for seamless transfers

Background

- Acquisition Reform [1]
  - Contractor-maintained design/configuration
    - Use of technical data within Government deemphasized
    - Technical Data access preferred over delivery
  - Decentralized program management
  - Performance-based development heralded as the panacea
  - Streamlined ECP approval
  - Elimination of Mil Specs and Mil Standards
  - Elimination of non-value added reporting
  - Rights in technical data deemphasized

Savings expected, but not yet realized [1]

Challenges

- Understanding/Overcoming execution issues of the past
  - Practices of the past that were based in paper, presented significant issues
- Understanding that development costs are equivalent to Rights in Data (RID) costs [12]
  - Costs to *acquire* TD rights are incorrectly viewed as duplicative
- Understanding the USC and FAR/DFAR establishes significant RID advantages for OSD
  - DOD has claim even to privately funded TD
- Understanding there are no free lunches in TD maintenance
  - TD left with an OEM offers little advantage while presenting significant sole-source challenges
  - Access only; TD strategies are not adequate for long-term LCMC missions [3]
- Understanding PBL and performance strategies/outcomes are necessarily complex
  - PBL contracts being awarded require technical data contingency or exit strategies [2]
  - Success is nebulous at best (GAO)
  - PBL strategies confuse roles of Army and contractor [13]
  - Performance in general adds cost/risk due to complex preparation [1]
- Decentralized program management adds cost/risk:
  - Standardized TD delivery
  - PMOs must support collaborative product data management
  - Requires core logistics capability [1]
  - Performance Specifications beneficial….*when practical* [1]

Confluence of Solutions

Today with:

1. The revitalization of Systems Engineering is ushering in the reemergence and importance of technical data
2. Meaningful reorganizations (Army LCMC)
3. Electronic data transfer
4. Product Data Initiatives by Army leadership 10

A suitable path ahead is beginning to take shape

Systems Engineering a DOD Overview [11]

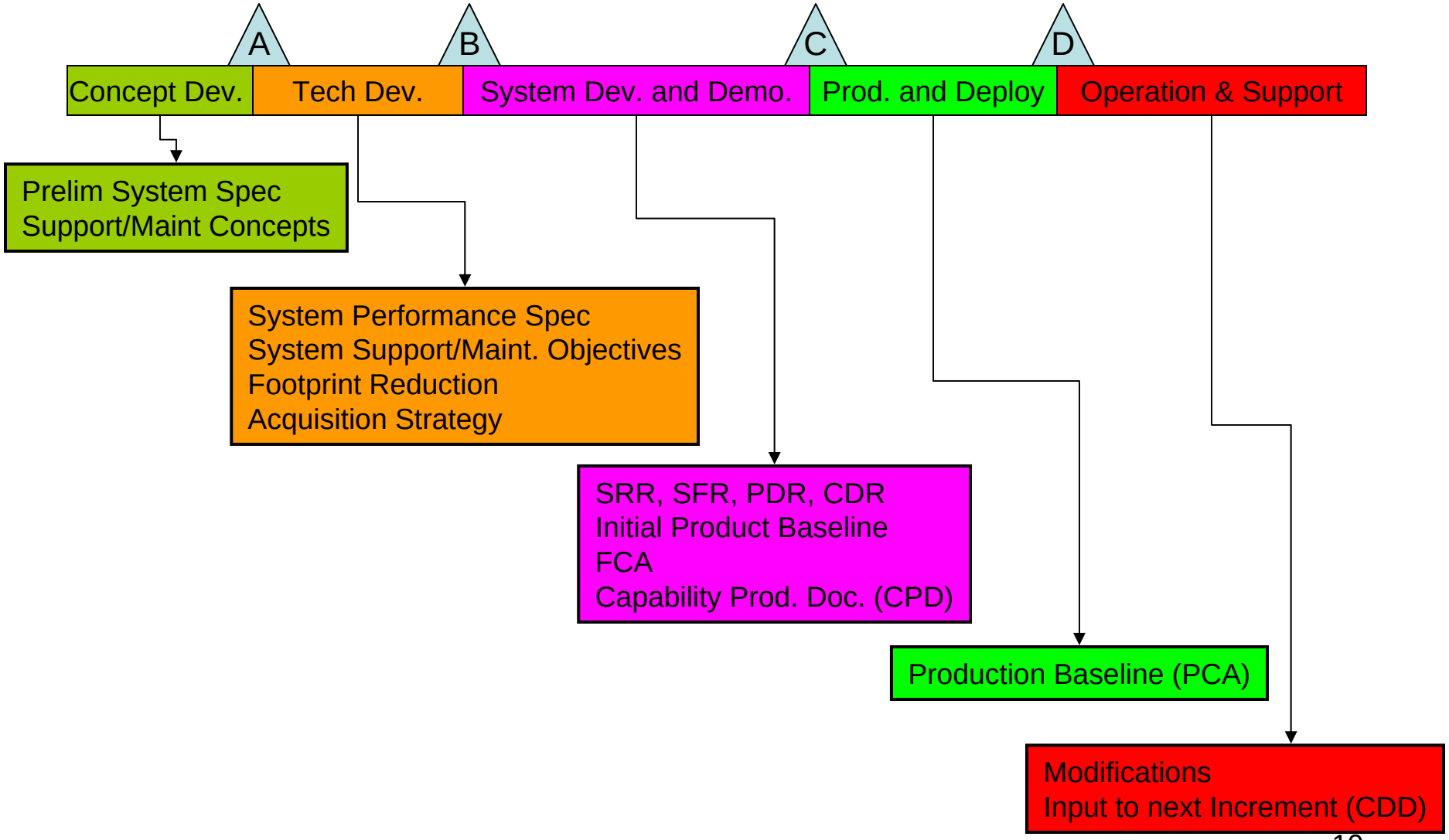
- Requirements Development
  - Performance Parameter Objectives
  - Affordability constraints
  - Scheduling constraints
  - Technical constrains
- Logical Analysis….Functional Analysis/allocation
  - Partitions a system in to logical groupings
  - Disciplined definitions of interfaces
- Design solution
  - People Products and process entities
  - Related internal and external interfaces
  - Upward and downward traceability
  - Interoperability and open system requirements

Systems Engineering a DOD Overview cont.

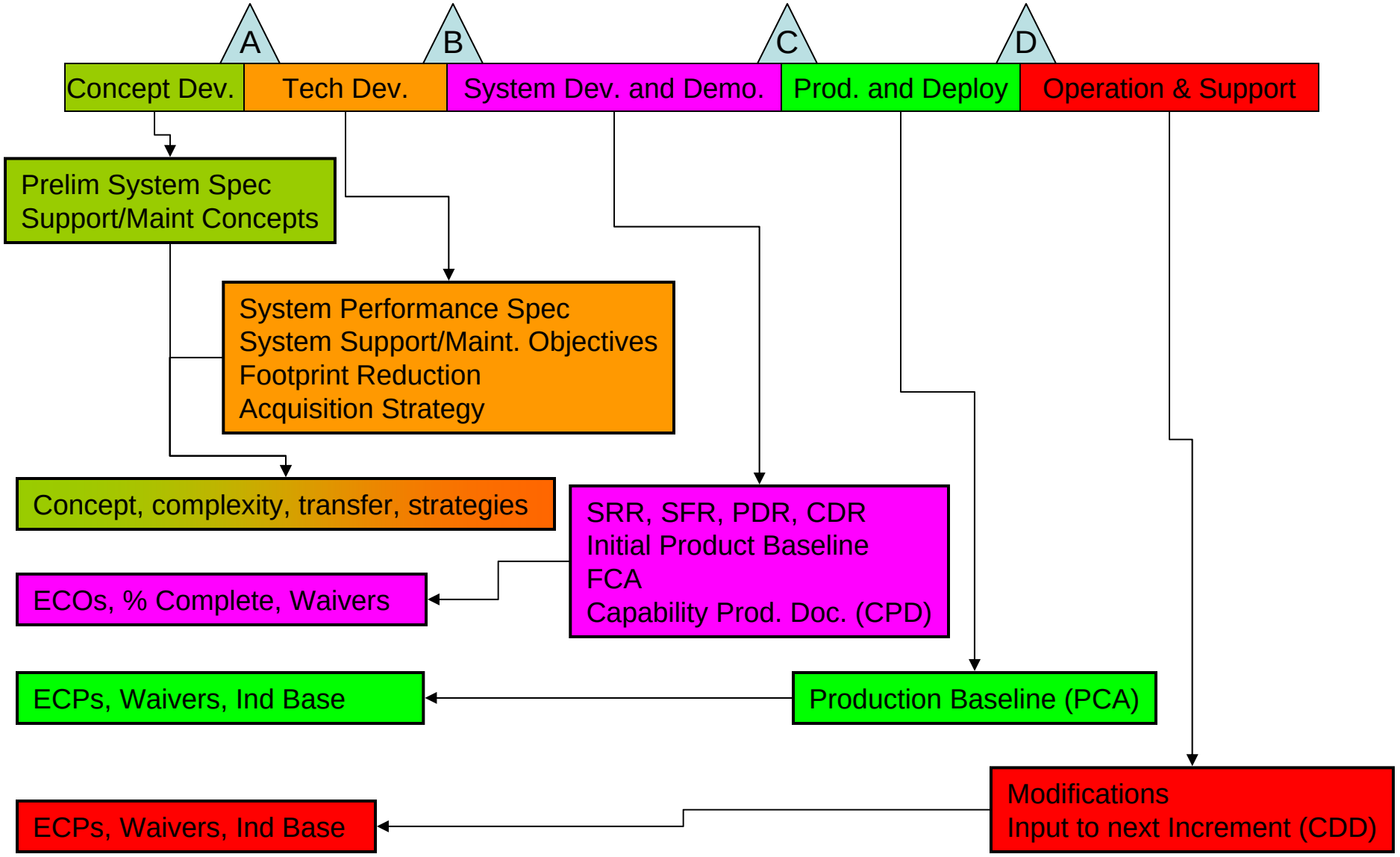
- Implementation
  - System elements formed/fabricated
  - Some testing
  - Packaging handling and storage
  - Operations, maintenance, installation
- Integration
  - Interfaces
  - Putting it all together
- Verification
  - Confirmation that the system meets design specifications
- Validation
  - Confirmation that we “..built the right thing..”
- Transition
  - Movement of the system to the ultimate user

Technical data performance = Program performance

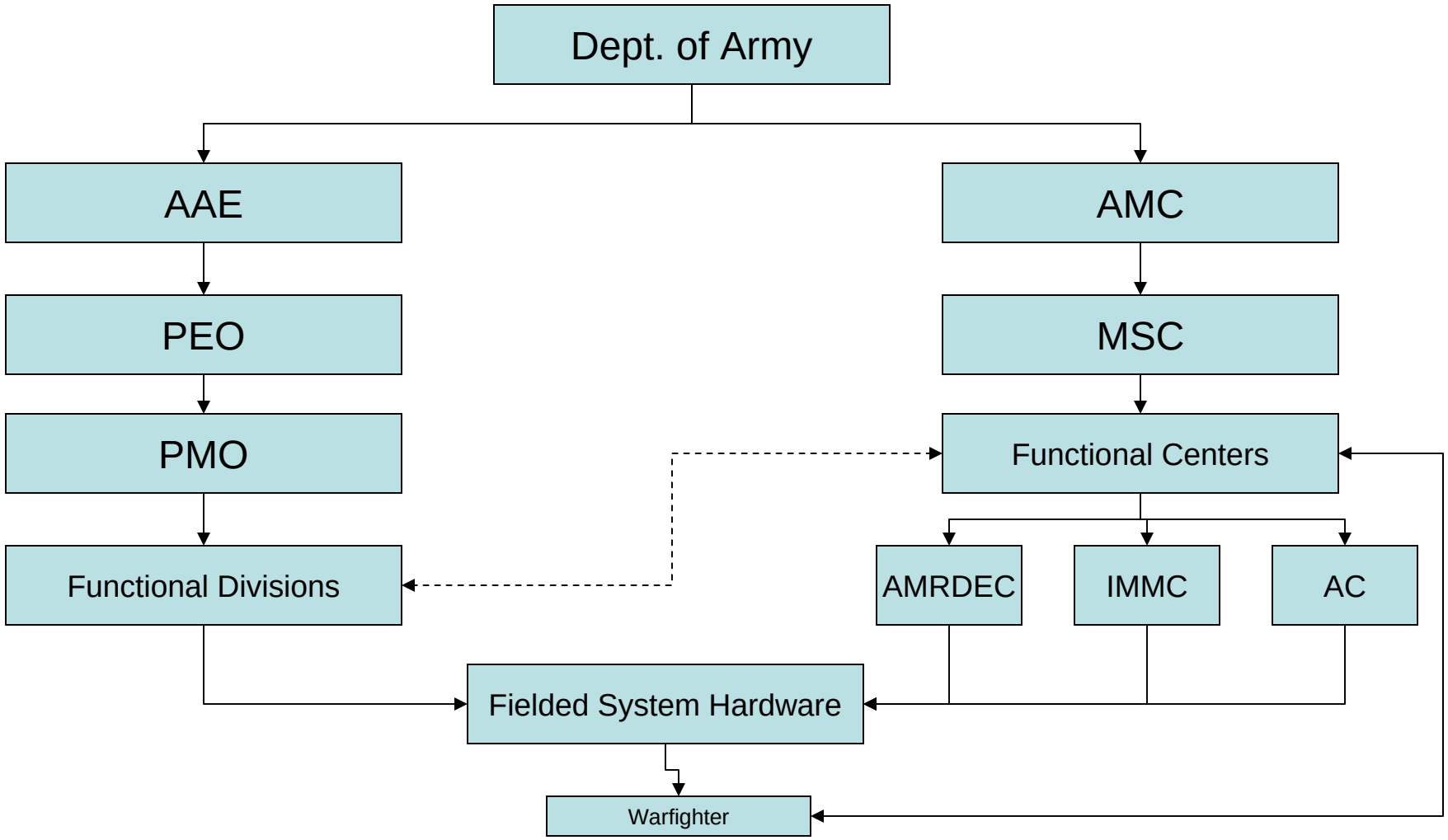
Technical Data Outputs of the SE Process



Technical Data as an SE Metric

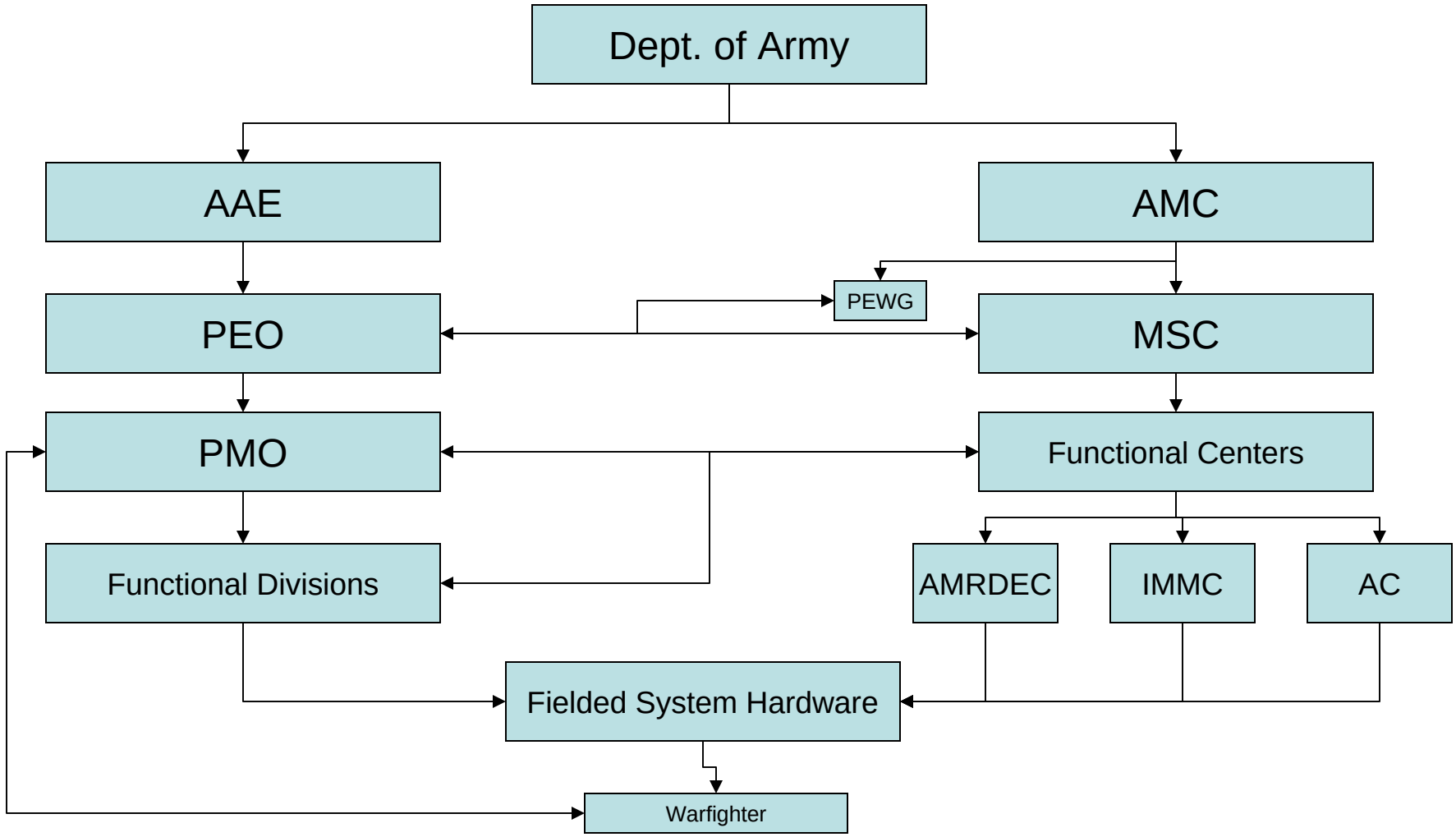


LCMC Re-Organization



Impact from PMO decisions rested with those outside the PMO

LCMC Re-Organization



Impact of PMO decisions rest in the PMO

Electronic Data Transfer

- Technical data today can be moved electronically
- Technical data today can be audited electronically
- A “Government” copy of the TDP no longer required
- Lean Six-sigma and good SE practices ‘should’ be driving maintenance (ECP) costs lower
- Model based Definitions becoming better defined/standardized

Legacy paper-based issues are no longer relevant

PEWG Focus

- **Philosophy:** Getting Back To Basics
  - Army manages Army weapon programs
  - Supports OSD revitalization of Systems Engineering
  - Compliments Acquisition Reform
  - PD in the Army is essential going into the future

- **Task Description:**
  - Review and correct existing acquisition policy, instructional material and contracting package templates, to insure the Army contracts for and receives weapon system product data and appropriate rights to use that data in a knowledge-based future of organic, contracted and contingency life cycle support.

Getting back to the basics

PEWG Initiatives

- Mandate the delivery of PD to the Army in all development and S&T programs through clear and concise direction
- Insure the Army's intellectual property rights to PD, are identified, correctly/consistently marked and challenged (if necessary)
- Insure that DAU reinforces the importance of PD and clearly identifies the potential benefits, legitimate costs and uses of PD when instructing PMs and acquisition professionals
- Stem the vast diversity in Army contracting today whose PD approaches range from abandonment of PD to the delivery of the full technical data package….with the former often occurring in conjunction with PBL strategies
- Develop/adopt mutually acceptable standardized product data formats

Getting the Government's role right

PEWG Actions

- The Defense Acquisition System (DODD 5000.1)
  - E1.1.3 *Competition* (edit)
  - E1.1.4 *Cost and Affordability* (edit)
  - E1.1.16 *Performance-Based Acquisition* (edit)
  - E1.1.17 *Performance-Based Logistics* (edit)
  - E1.1.29 *Total Systems Approach* (edit)
  - E1.1.30 *Intellectual Property/Technical Data Rights*
    - Product data and intellectual property rights shall be vigorously protected
- The Defense Acquisition System (DODI 5000.2)
  - *E 10 ENCLOSURE 10*
- Army Acquisition Strategy (AR 70.1)
  - Chapter 4 *Acquisition Strategy* (edit)
  - Chapter 6; *Program Design* (edit)
  - Chapter 8; *Army-Unique Policies* (new)
- Leverage ASME Y14.41, MIL-T-3100C standardized formatting

Adequate policy is being made better..more practical

Summary

- Technical Data is an essential output and metric of the SE process
- LCMC Reorganization long overdue
  - PMs are not always right
- Preparation, control, management and distribution of technical data can be conducted electronically
- PEWG is correcting our course…getting back to basics
  - Acquisition Reform was the beginning, adjustments are now needed..
- Define (redefine) our mission/function
  - Policy is interesting….Execution is essential
- Industry is a *business* partner
  - The contract and PD should form all critical communications
  - There are no free lunches
- Performance is not the panacea
  - Performance is still transactional, for industry or Government
  - Discreet/effective performance metrics are very difficult to conceive

References

1. *Reexamining Military Acquisition Reform, Are We there Yet*?, RAND ARROYO CENTER, pg 11, 2005
2. *Opportunities to Enhance the Implementation of Performance-based Logistics,* GAO Report 04-715, page 4
3. *10 USC 2320*, (b) (2)
4. Reserved
5. *Reexamining Military Acquisition Reform, Are We there Yet*?, RAND ARROYO CENTER, pg 53, 2005
6. *10 USC 2320*, (a) (2) (C)
7. *DOD Needs to Demonstrate that Performance-based Logistics Contracts are Achieving Expected Benefits* GAO 05-966, Pg 3, Sept 2005
8. *Army Acquisition Policy*, Section 6, page 45, Dec 2003
9. *Army ALT Magazine*, pg 15, Nov-Dec 2004
10. *CHARTER FOR PRODUCT DATA and ENGINEERING WORKING GROUP (PEWG)* Army Materiel Command, Page 1, Mar 2005
11. *DOD Acquisition Desktop Guidebook*, Date, Chapter 4
12. *10 USC 2320*, (a) (2) (A)
13. *Performance Based Logistics: A Program's Manager's Product Support Guide*, Pg 4-1, March 2005,
14. *Opportunities to Improve the Army's and the Navy's Decision-making Process for Weapons Systems Support* GAO Report 02-306,, Pg 3, Feb 2002
15. *Reexamining Military Acquisition Reform, Are We there Yet*?, RAND ARROYO CENTER, pg 41 Footnote 13, 2005
16. *Army Acquisition Policy*, Section 4, page 36, Dec 2003
17. *Army Acquisition Policy*, Section 6, page 40, Dec 2003

Definitions

1. PEWG: Product Data and Engineering Working Group
2. Army Material Command: AMC, Responsible for all aspects of system sustainment
3. Functional Centers: Local centers of support with a specific focus
   a. AMRDEC: Aviation and Missile Research Development and Engineering Center, provides all aspects of technical support, SE, Test, CM, Quality, etc.
   b. IMMC: Integrated Material Management Center provides all aspects of supply and inventory management
   c. AC: Acquisition Center supports all aspects of the formal contracting process
4. MSC: Major Support Center provides dedicated support for specific commodities, aviation, missile, etc. By merging collocated acquisition offices (PMO) with the AMC functional organizations, the LCMC is formed
5. AAE: Army Acquisition Executive provides component (Army) acquisition leadership
6. PEO: Program Executive Office provides executive oversight of assigned project management offices (PMO) within a specific commodity
7. PMO: Project Management Offices provide acquisition support to develop a capability requirements into fielded hardware (materiel developer).
8. Functional Divisions: Organized groups of support personnel within the PMO organization. Engineering Group, Logistics Group, etc.

Point of Contact

Russell F. Miller, russell.f.miller@us.army.mil, 256-876-1335
Chief, Technical Data Management Division
Engineering Directorate
Aviation and Missile Research, Development and Engineering Center
Huntsville, AL 35898-5000

Missile Operations and Support Simulation (MOSS) Method

Raytheon

9th Annual NDIA Systems Engineering Conference

Rob Slater

Raytheon Missile Systems

Tucson, Arizona

rdslater@raytheon.com

Missile Operations and Support Simulation (MOSS) Method

Raytheon

Modeling Objective:
Model and Analyze Hardware Stockpile over Multiple years or Program Life-Cycle to Predict Repair, Readiness, Cost, etc…

- Basic Needs
- Solution through MOSS
- Follow-on Work

Basic Needs to Assess Stockpile Life-Cycle Repair, Readiness, Cost, etc…

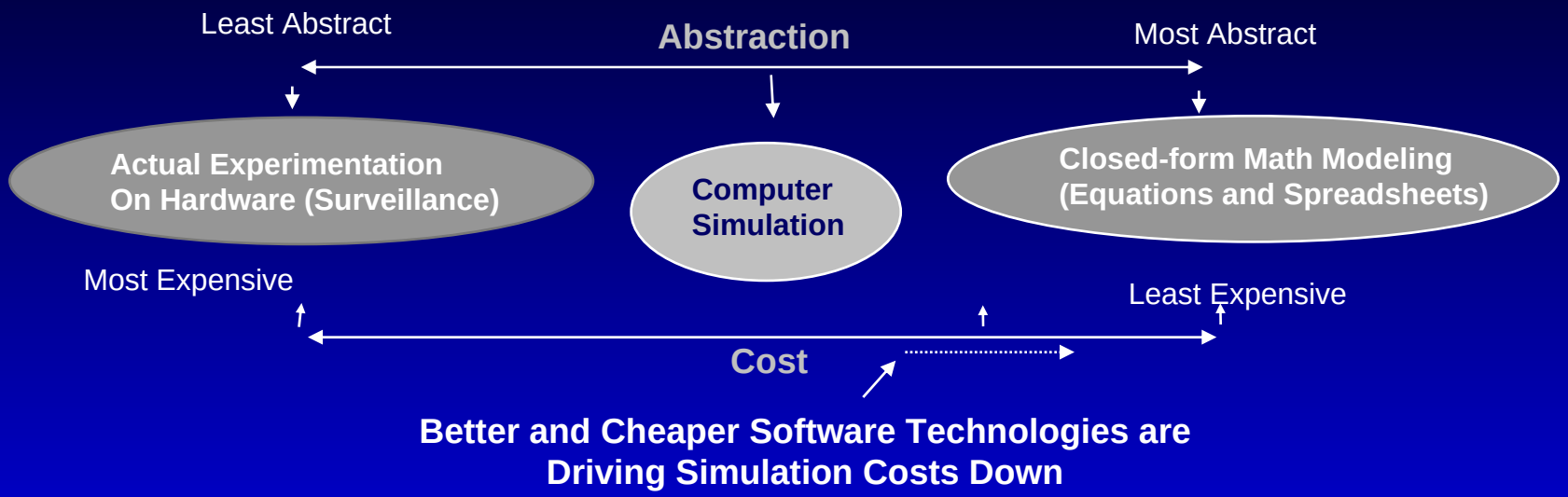
Raytheon

Account for…

- Maintenance, Testing, Training, Operational Tempos
- Dynamically Changing Utilization of Inventories
- Hardware Reliability in Diverse Environments
- Reliability Growth and Wear-out
- Upgrade / Retrofit Programs
- Effectiveness of Test Equipment
- Expediency of Logistics Supply and Transport Chain

Factors Interact to Affect
Repair, Readiness and Cost

Discrete Event Simulation Path



Benefits

- Systems Approach
- Track/Update Items through Process
- Easily Characterize Random Variables
- Easy to Capture System Dynamics
- Easy to Characterize Complicated Process Flows

Cons

- Non-Repeatable Model Build
- Difficult Validation & Verification
- Still Relatively High Cost

Logistics Modeling and Simulation with MOSS

MOSS : Raytheon Simulation-Based Method for Modeling O&S Processes of Military Fielded Inventory

Purpose – Predictive Analyses

- Readiness of Inventory (Stored & Deployed)
- Estimate O&S Cost
- Logistics Pipeline Capacity Requirements
- High Fidelity Estimate of Depot Returns over System Life-Cycle for Maintenance Planning and Warranty Analysis

Elements of MOSS

Common Attributes, Common Blocks, and Sub-Models

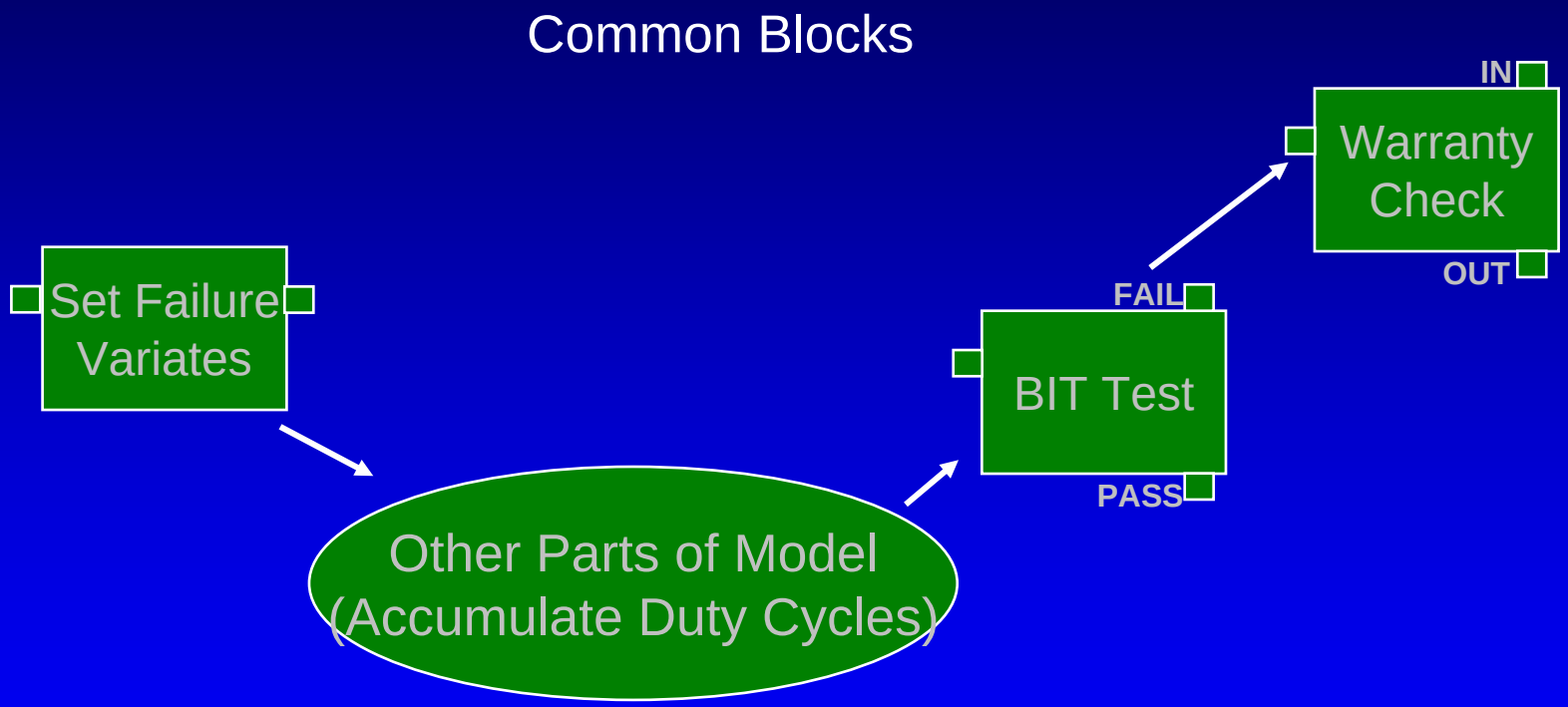
- Common Attributes : Characteristics of Missile–Items that are Prevalent for Most Missile O&S Systems
- Common Blocks: Provide Functionality that is Prevalent in Most O&S Systems. Stored in Libraries
- Sub-Models: General Arrangements of Common Blocks that provide Higher Level, More Complex Functionality

Common Blocks, Attributes and Sub-models provide Pre-Validated Mathematics, Are Re-Usable and Streamline O&S Modeling

Also Promote Model Repeatability

Common Blocks of MOSS To Help Define Static Logistics Network

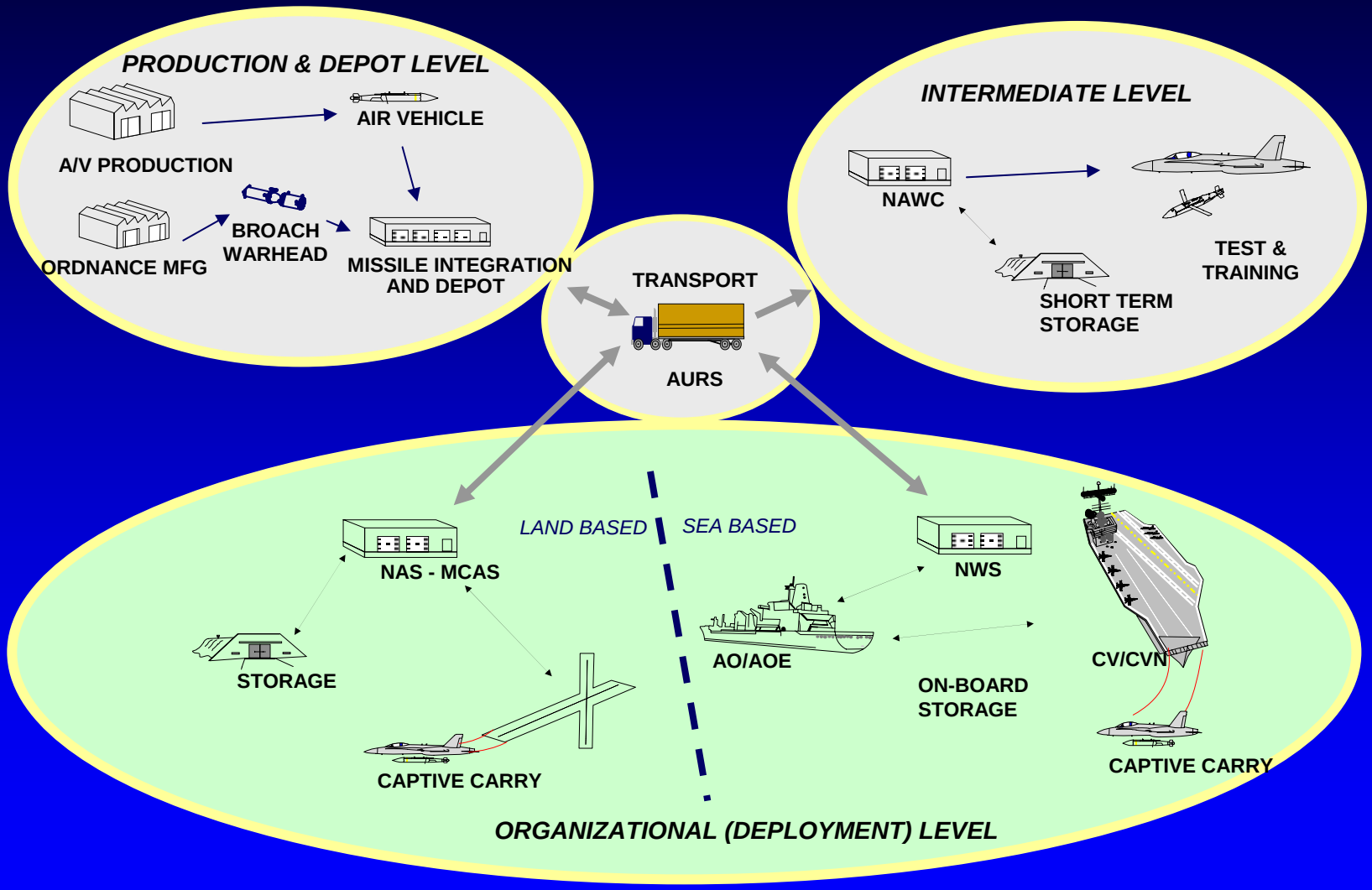
Raytheon



Common Blocks Contain Pre-Validated Logic and Math, and They Are Stored in Libraries to Promote Re-Use

MOSS Modeled System
An Example

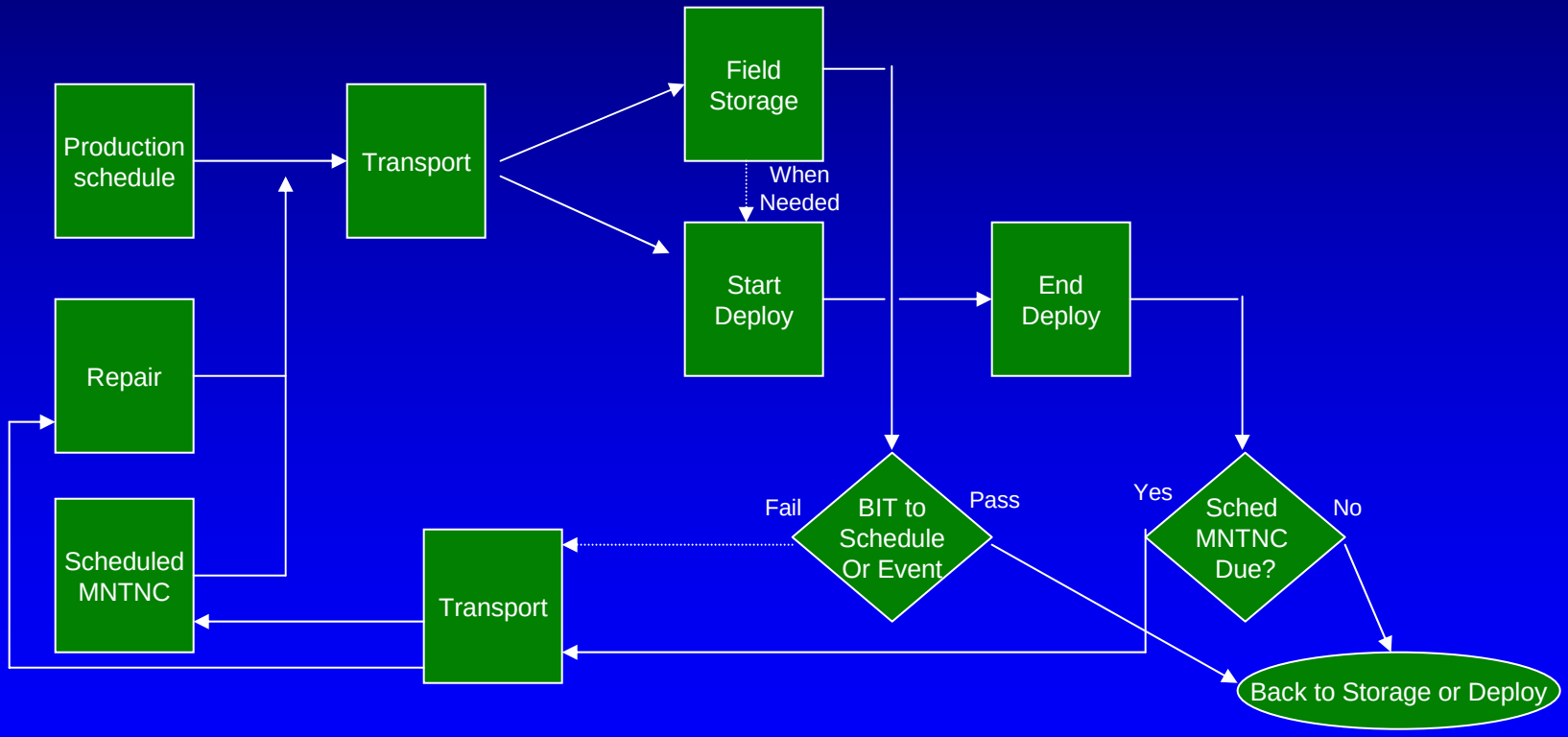
Raytheon



Life Cycle States/Environments

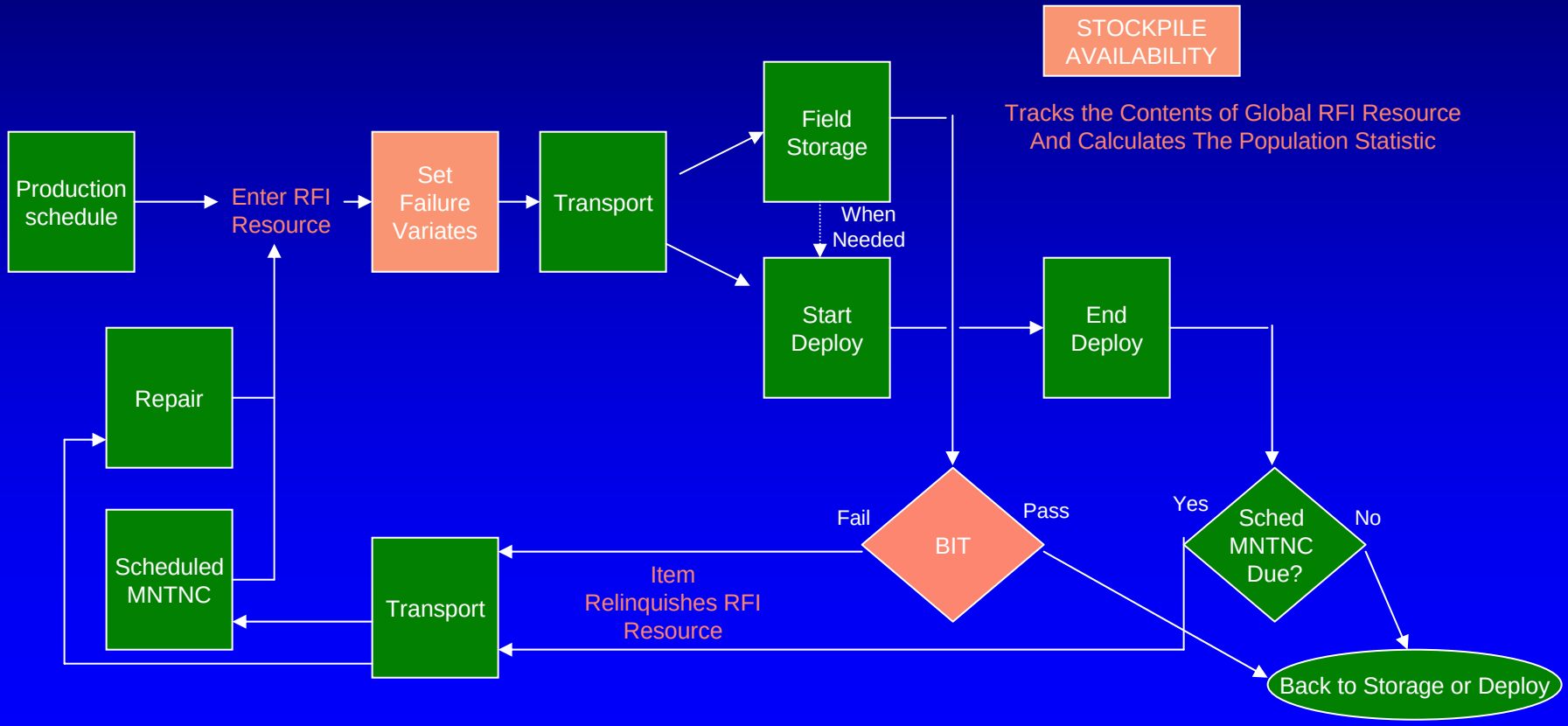
MOSS Broad-Block Approach

Model the Static Life Cycle Network from Flow Diagram



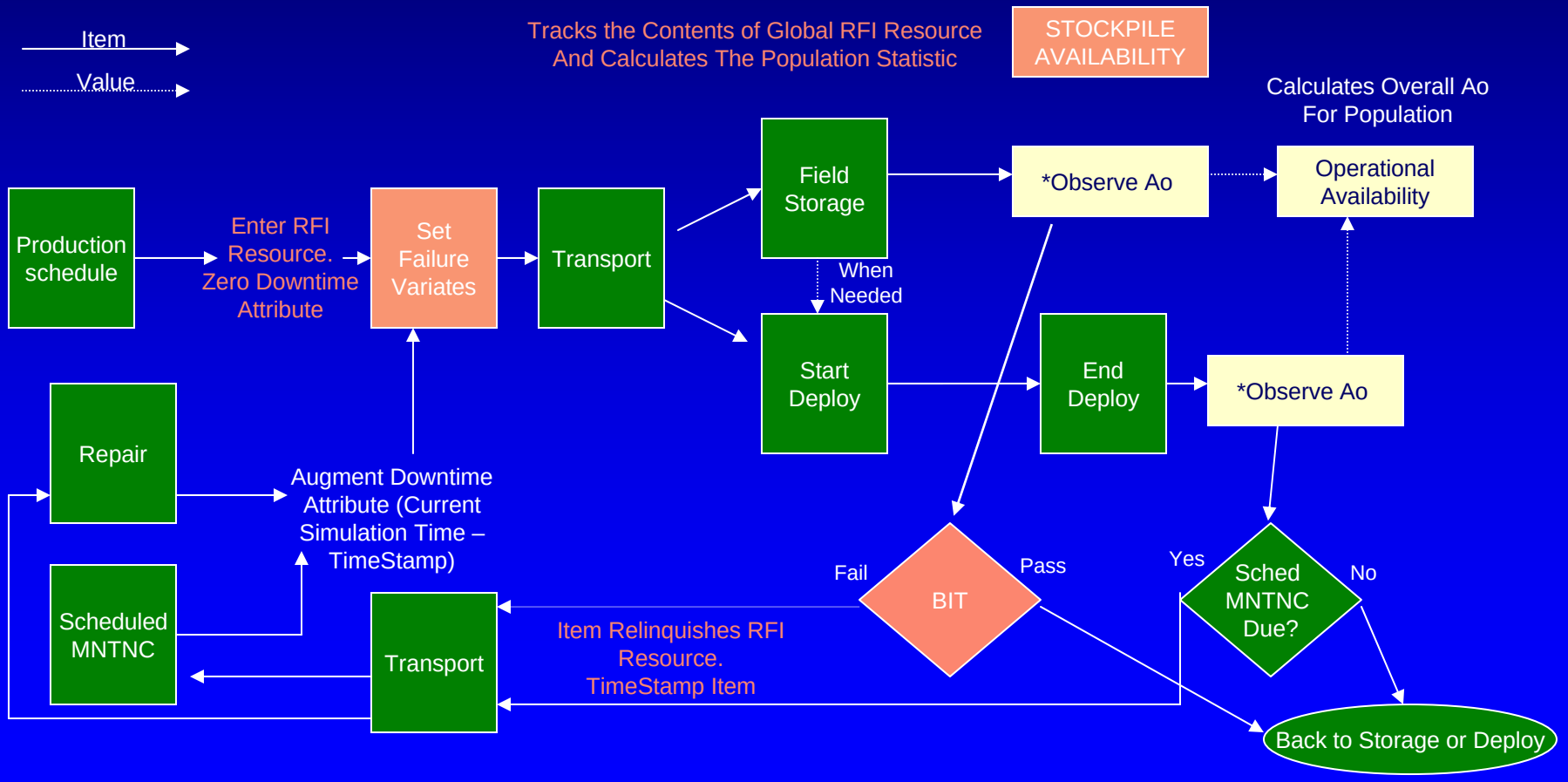
MOSS Broad-Block Approach → Apply Sub Models (Arranged Common Blocks) for Specific Functionality

Sub-Model for Stockpile Availability Applied



MOSS Broad-Block Approach → Apply Sub Models (Arranged Common Blocks) for Specific Functionality

Now Apply Sub-Model for Operational Availability



MOSS Method Addresses Needs

1) Larger-Scope System Approach Compared to Spreadsheets and Equations
   - Can Track and Update Items as They Move through Process
   - Can Easily Characterize Random Variables
2) Easy to Capture Dynamic State Changes
3) Easy to Characterize Complicated Process Flows
4) Standardized Logistics Tool Set in Pull-Down Menu
5) Tools are Pre-validated
6) Tool Set Induces Repeatable Structure, Level of Detail, and Speed of Creation for Future Models

NEEDS		
	Maintenance, Testing, Training, Operational Tempos	1) 2) 3)
	Dynamically Changing Utilization of Inventories	2) 3)
	Hardware Reliability in Diverse Environments	1) 3)
	Reliability Growth and Wear-out	1) 2)
	Upgrade / Retrofit Programs	1) 2)
	Effectiveness of Test Equipment	3) 4)
	Expediency of Logistics Supply and Transport Chain	1)
	Non-Repeatable Model Build	4) 6)
	Validation & Verification	5)
	Cost	4) 5) 6)

Benefits of MOSS - Summary

"Environmental Fidelity" equates to High Fidelity Prediction

- Tracks and Accumulates Time Spent in Various Environments for Each Item in the Inventory. Accurate Estimate of Duty Cycle → Accurate Failure Prediction

Integration of Analyses

- Sub Models for Failure Prediction, Warranty Failures, Availability Analysis, Spares and More → Consistency Between Different Studies in the O&S Arena.

Re-usable and Repeatable

- Common Blocks are Pre-defined, Pre-validated and Stored in Pull-Down Library. Attributes and Sub Models are Pre-defined

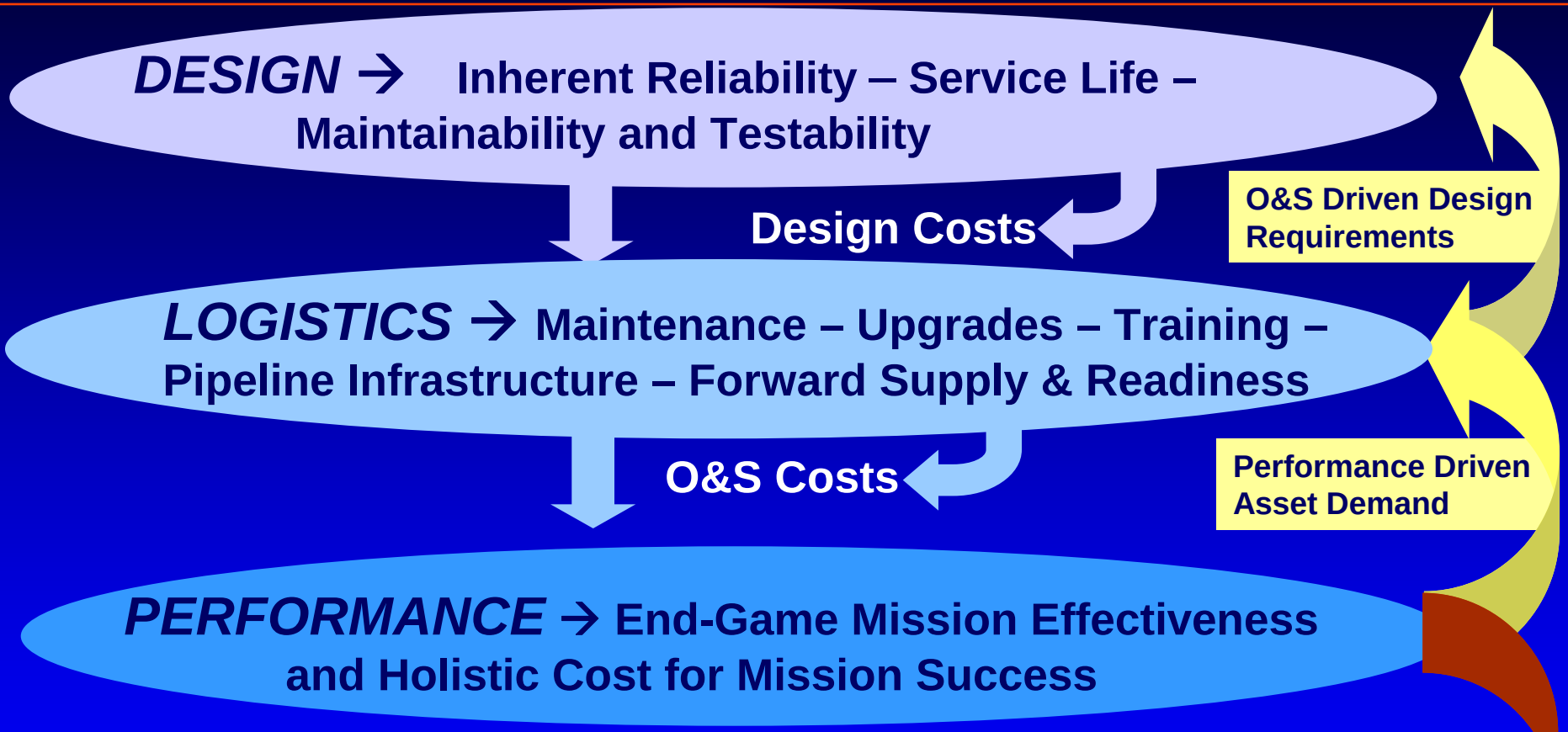
"Transparent" Interface

- MOSS Models are Designed For Making the System more Understandable Through use of Time-based Statistics and Charts, Graphics, Hierarchy and Animation.

The Act of Building Models with the MOSS Method Aids and Promotes Model Verification and Validation

Follow-On Work: Enable Direct Life-Cycle / Mission Trade Analyses

Raytheon



Benefit: "Cradle-to-Target" Insight into Performance & Cost Shortfall: Vertical Chain. Real World can be Horizontal

Follow-On Work: Integrate Logistics Modeling with Other Initiatives

Raytheon

Integrate Logistics / Mission Performance Modeling and Simulation

Example : Total Asset Visibility and Prognostics could Update Predictive Models with Actual Field Data



Suitable Metrics for Measuring the Effectiveness of the Systems Engineering Process

Benjamin Q. Luong

and

Lauren L. Nguyen

Copyright © Boeing 2006



Abstract

- As we strive to develop resilient large-scale integrated products and enterprise systems that are entirely inventive and/or significantly better than their predecessors, the Systems Engineering discipline leads us to improve product definition, product development, and overall performance of businesses, particularly commercial and defense programs.

- In recent years, Boeing has made significant leaps in improvement to the application of the Systems Engineering Process, especially in the areas of requirements management, risk management, trade studies, and verification and validation. During our continuous improvement journey, there is a need for a way to measure the effectiveness of Systems Engineering on program performance. This presentation describes a set of Systems Engineering 'program-level' predictive and reactive metrics that give clear visibility into the benefit of Systems Engineering on program performance.

- Further, these program-level metrics are also flags that help forecast positive or negative events. Each predictive metric has a high or low correlation counterpart(s), its reactive metric(s). As we determine the relationship between predictive and reactive metrics, they can be mapped to different pinpoints in the Systems Engineering Process. Also, a reactive metric within the process may be predictive, which may map to another reactive metric. By understanding and evaluating the results of these metrics, we can continuously improve the application of Systems Engineering and ultimately, program performance.

Copyright © Boeing 2006

Topics of Discussion

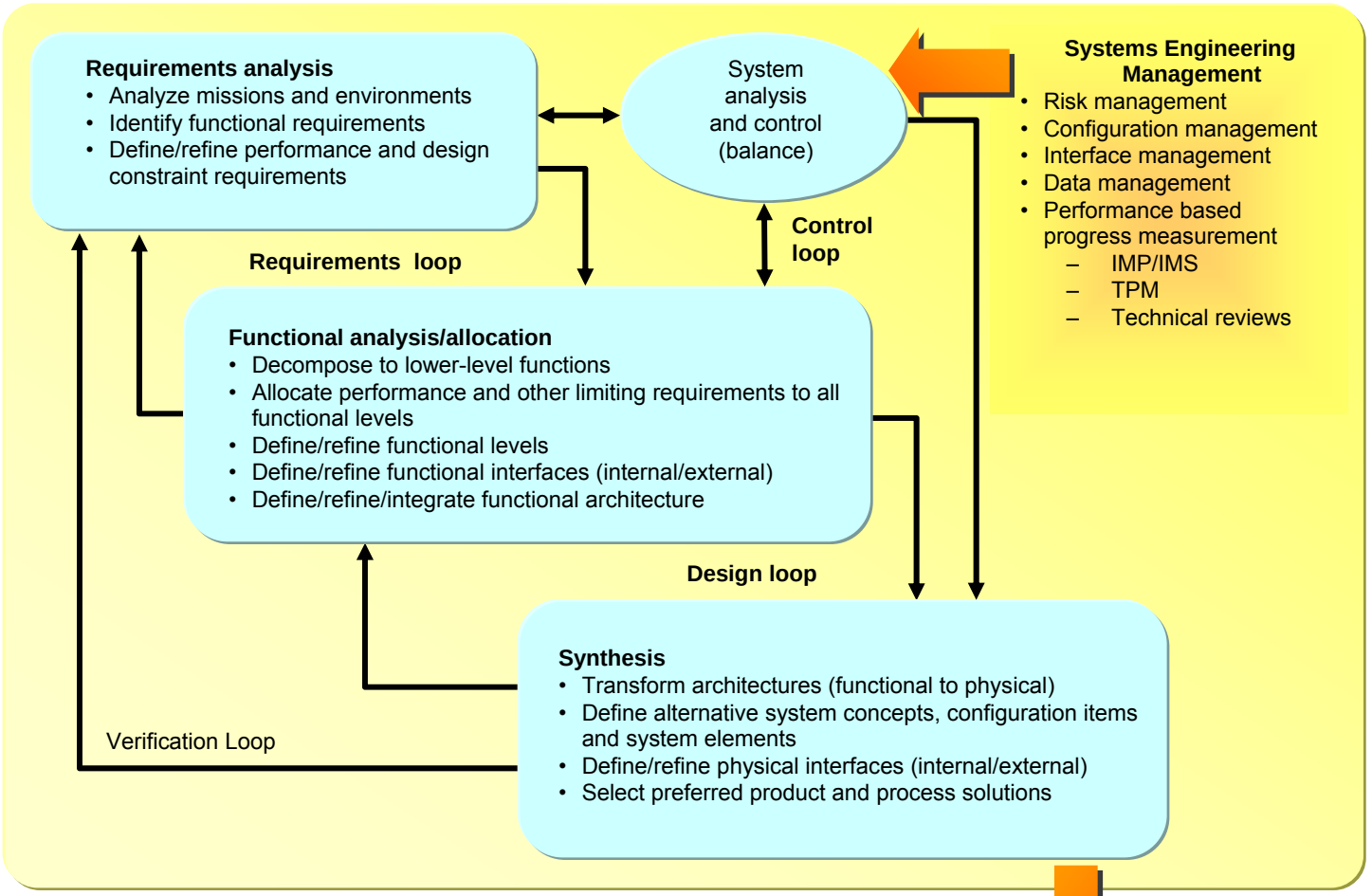
- Systems Engineering Process Fundamentals
- Thinking about Effectiveness
- Thinking about Performance
- Measures of Effectiveness & Performance
- Suitable Measures of Effectiveness & Performance for Systems Engineering Process
- Suitable Systems Engineering Index
- Predictive and Reactive Metrics: Examples
- Predictive and Reactive Relationships
- Corporate / Program Performance
- Conclusion



Copyright © Boeing 2006

Systems Engineering Process Fundamentals

- **Process input**
- Customer needs/ objectives/ requirements
  - Missions
  - **Measures of Effectiveness**
  - Environments
  - Constraints
- Technology base
- Outputs from prior phase
- Program decision requirements
- Requirements applied through specifications and standards



Process output
- Balanced Product
- Phase dependent
  - Decision support data
  - System architecture
  - Specifications and baselines

Copyright © Boeing 2006

Thinking About Effectiveness

- Take off your Engineering Cap
- Put on your Business Cap
- Ask the Fundamental Business Questions:
  - What does effectiveness really mean?
  - What are everyday examples or types of effectiveness?
  - How do we measure effectiveness?

Copyright © Boeing 2006

Thinking About Effectiveness

- Definition of Effectiveness
  - Adequate to accomplish a purpose; producing the intended result or expected result
  - Descriptions: Influence, Efficiency, Capability

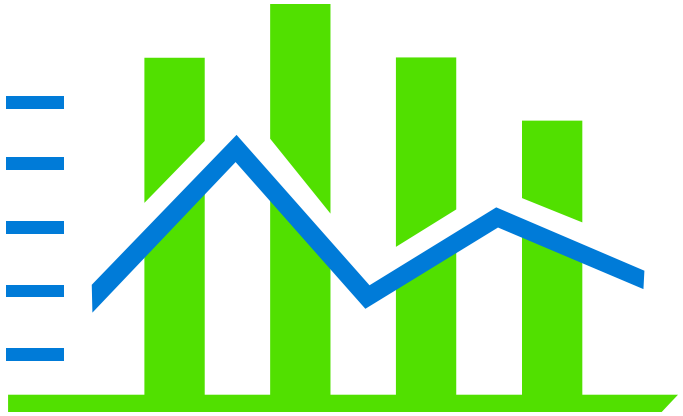
- Various Types of Effectiveness
  - Corporate Effectiveness
  - Organizational Effectiveness
  - Product Effectiveness
  - Individual Effectiveness

Copyright © Boeing 2006

Thinking About Effectiveness

- Measures of Effectiveness (MOE)
  - Corporate Effectiveness → Performance!
  - Organizational Effectiveness → Performance!
  - Product Effectiveness → Performance!
  - Individual Effectiveness → Performance!
  - SE Process Effectiveness → Performance!

- What are the common Measures of Performance (MOP)?



Copyright © Boeing 2006

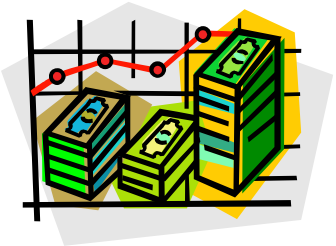
Thinking About Performance

- Common Types of Measures of Performance (MOP)

Quality



Cost



Schedule



Productivity

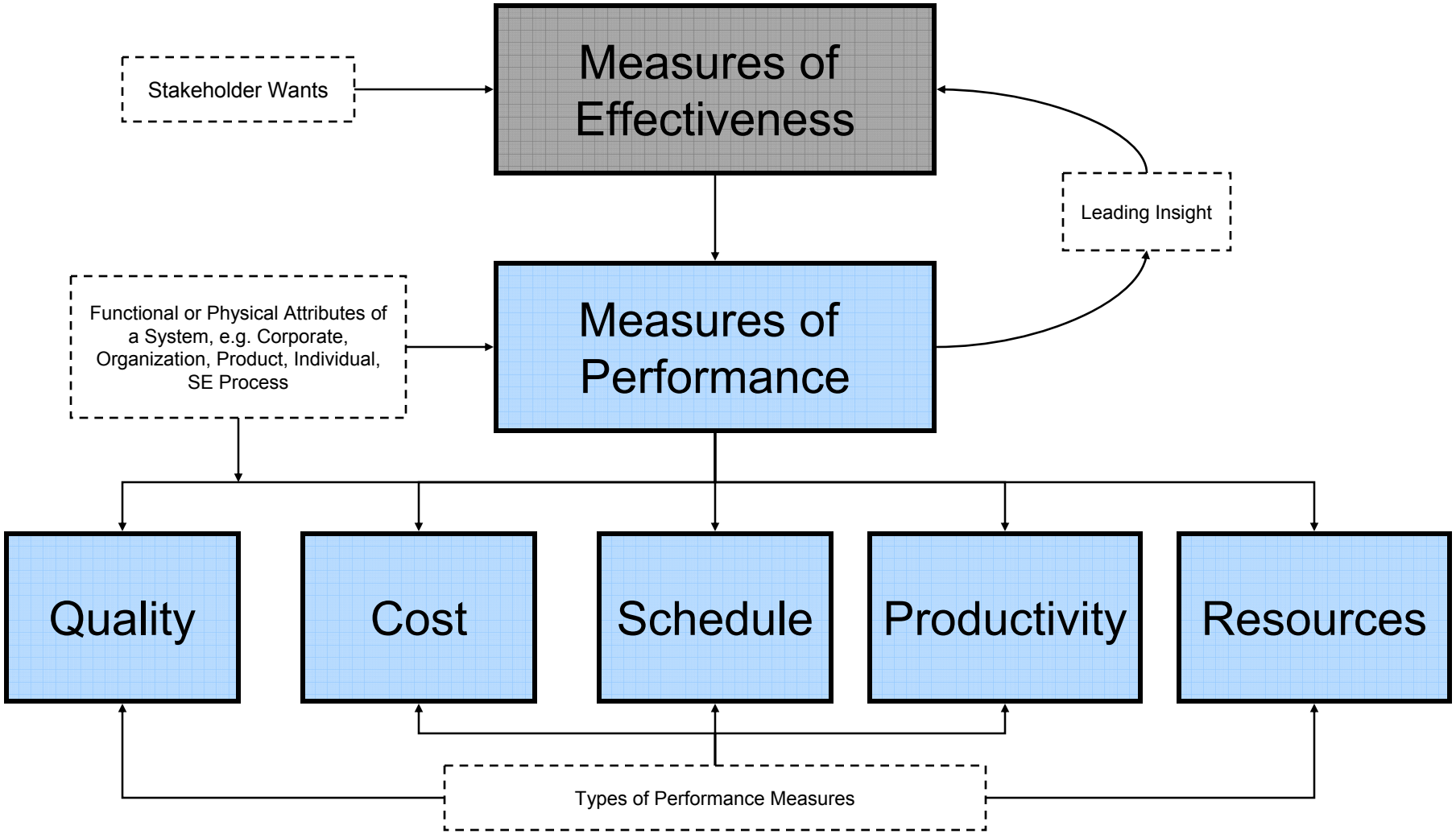


Resources



Copyright © Boeing 2006

Measures of Effectiveness & Performance



Copyright © Boeing 2006

Measures of Effectiveness & Performance for the SE Process

- Now, put your Engineering Cap back on

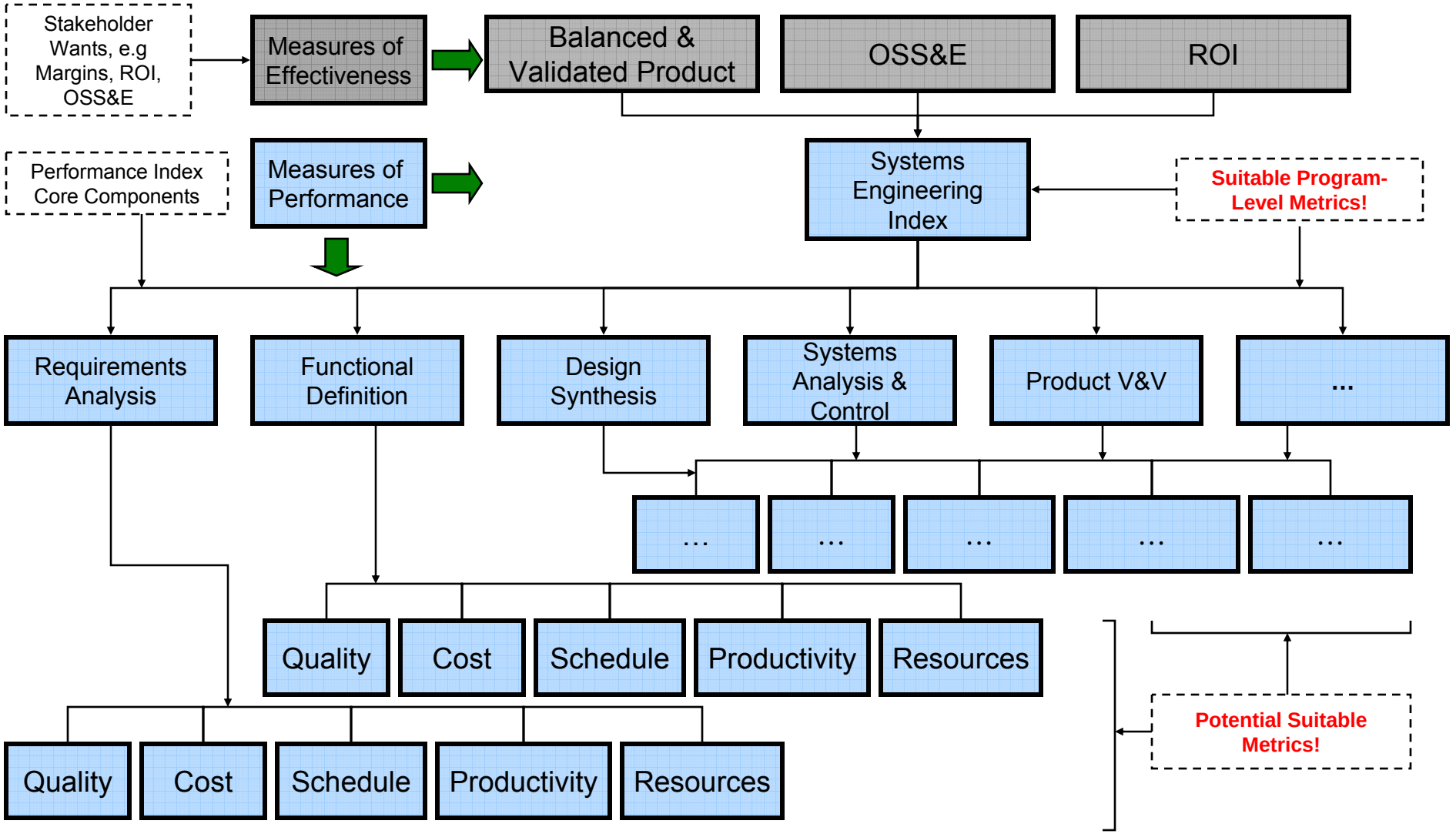
- Measures of Effectiveness 'for' the SE Process
  1. Balanced & Validated Product
  2. Product Operational Safety, Suitability & Effectiveness
  2. Return on Investment (ROI)

- Measures of Performance 'from' SE Process
  - Apply the business fundamentals to each core SE Process Element
    - Requirements Analysis
    - Functional Definition
    - Design Synthesis
    - System Analysis & Control
    - Product Verification & Validation

  - Other SE Elements
    - Suppliers & Supplier Management
    - Production
    - Operations Support
    - Sustainment

Copyright © Boeing 2006

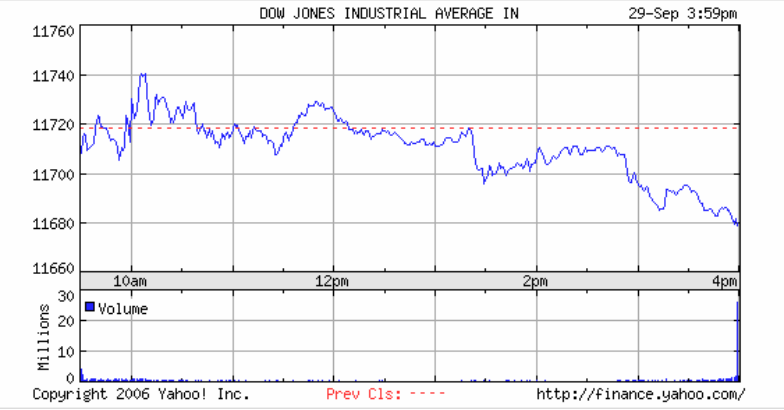
Suitable Measures of Effectiveness & Performance for SE Process



Copyright © Boeing 2006

Suitable Systems Engineering Index

- Comprised of Several, Weighted Components with Trend Curves
  - Requirements Analysis Performance
  - Functional Definition Performance
  - Design Synthesis Performance
  - System Analysis & Control Performance
  - Product Verification & Validation Performance
  - Suppliers & Supplier Management Performance
  - Production Performance
  - Operations Support Performance
  - Sustainment Performance



Copyright © Boeing 2006

Predictive & Reactive: Examples of Suitable Metrics

• Requirements	
- Requirements Quality	Predictive
• Design Synthesis	
- On-Time Engineering Release	Reactive – Predictive
- After-Initial-Release (AIR) Traffic	Reactive – Predictive
• System Analysis & Control	
- Design Reviews: Number of Critical Action Items	Reactive – Predictive
- Risk Management: Number of Risks Identified, Mitigated, Retired, Realized & Elevated	Reactive – Predictive
• Product Verification & Validation	
- Requirements Compliance	Reactive – Predictive
• Production	
- LRU Tag Trend	Reactive
- Deviations & Waivers	Reactive

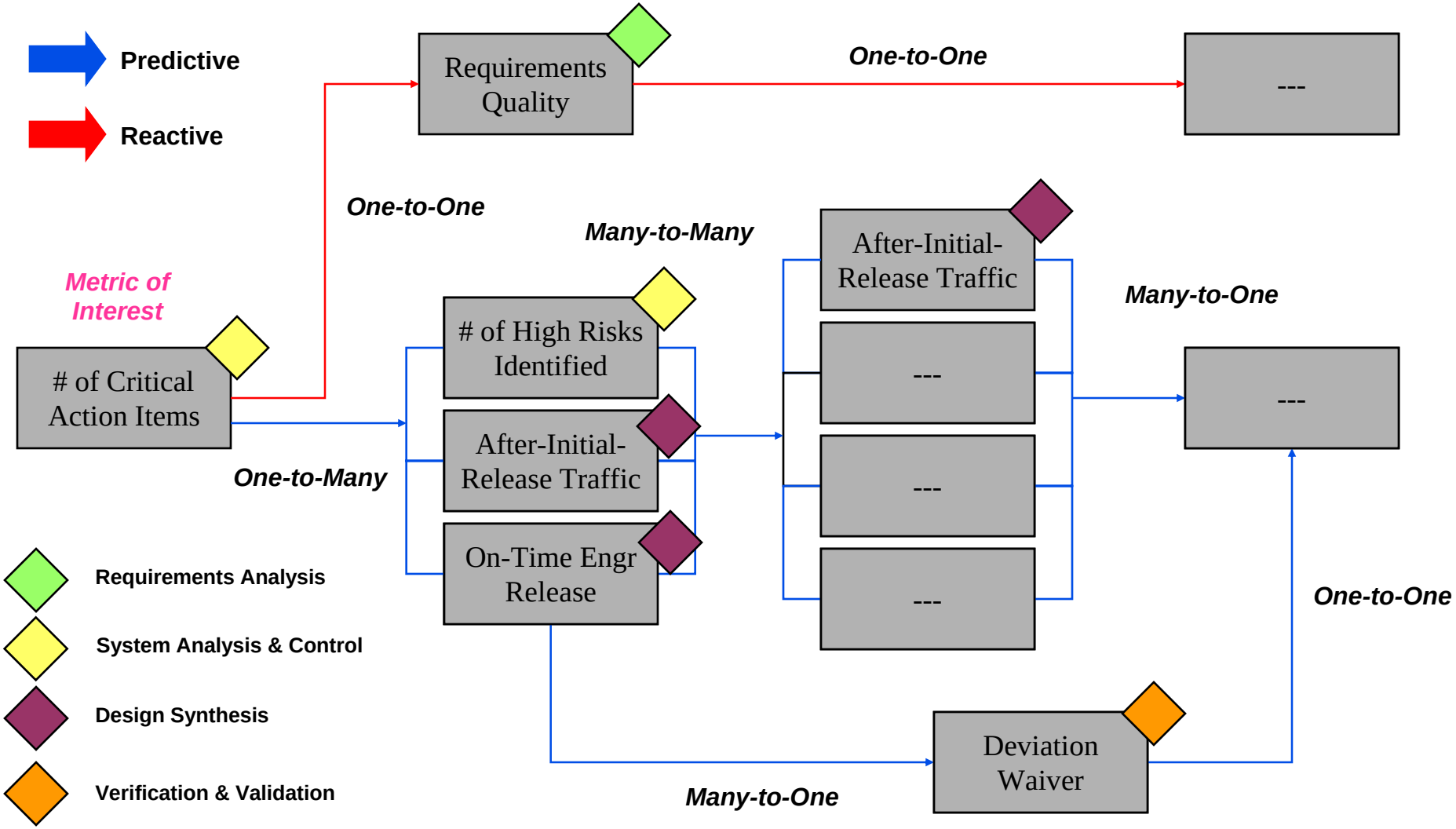
Copyright © Boeing 2006

Predictive and Reactive Metrics – Industry Examples

- **Reactive Indicators** of Economic Growth (Common Examples)
  - Gross Domestic Product (GDP)
  - Stock Market Indices:
    - Dow Jones
    - NASDAQ
    - S&P 500
    - Nikkei 225
  - These can be predictive in a different context when they provide leading insight into any specific economic segment
- **Predictive Indicators** of Economic Growth (Common Examples)
  - Inflation
  - Manufacturing & Housing Index
  - Interest Rates
  - Employment Rate
  - Oil Prices
  - Corporate

Copyright © Boeing 2006

Typical Predictive and Reactive Relationships (snapshot)



Copyright © Boeing 2006

Corporate / Program Performance

- Higher-Level MOEs
  - Profit Margins → **Financial Performance**.
  - Cost Reduction → **Financial Performance**.
  - Return on Investment → **Financial Performance**.
  - Customer Satisfaction → **Financial Performance**.
  - Customer Confidence → **Financial Performance**.
  - Program Mgmt Indicators → **Financial Performance**.

- Higher-Level MOPs
  - Quality → Malcolm Baldridge, ISO, CMMI Level 5
  - Cost → Lean, Six Sigma, Savings, Rework
  - Schedule → Timely Product Delivery
  - Productivity → Employee Satisfaction
  - Resources → People, Processes & Tools

Copyright © Boeing 2006



Conclusion

- Systems Engineering effectiveness can be gauged through performance of Systems Engineering elements
- Typical performance indicators may include Quality, Cost, Schedule, Productivity, and Resources
- Suitable metrics can be derived from performance indicators
- Metrics can be Predictive, Reactive or both
- Relationship between Predictive and Reactive metrics can be correlated to specific elements/phase of the Systems Engineering Process
- Continuous evaluation of these metrics increases Systems Engineering effectiveness and overall Program performance

Copyright © Boeing 2006

Contact Information

- Benjamin Q. Luong, Systems Engineer
  - Phone: (562) 593-4668
  - Email: benjamin.q.luong@boeing.com

- Lauren L. Nguyen, Systems Engineer
  - Phone: (562) 593-4489
  - Email: lauren.l.nguyen@boeing.com

Thank you!



Copyright © Boeing 2006

PBL Overview, Business and Metric Discussion

Dr. David Nowicki & Dr. Dinesh Verma
Stevens Institute of Technology

Mr. Tom Parry
Decisive Analytics Corporation

Agenda

- General Insights and Findings
- PBL Structure
- Literature Results
- PBL Analytical Framework
- Performance Metrics
- Future Research

General Insights

PBL Intent

- Satisfy warfighter requirements
- Create an optimized weapons system support infrastructure which capitalizes on the best of government and industry capabilities
- Total weapons system support structure designed to meet end user needs
- Utilizes the best of both contractor and government capabilities to achieve support objective
- Purchase total lifecycle support versus the components of support
- Implements best commercial practices associated with supply chain management
- Spreads risk traditionally born exclusively by the government
- Reduces the transactional intensity associated with a traditional support system
- Leverage commercial investment in technologies and industry best practices

Is it Really PBL?

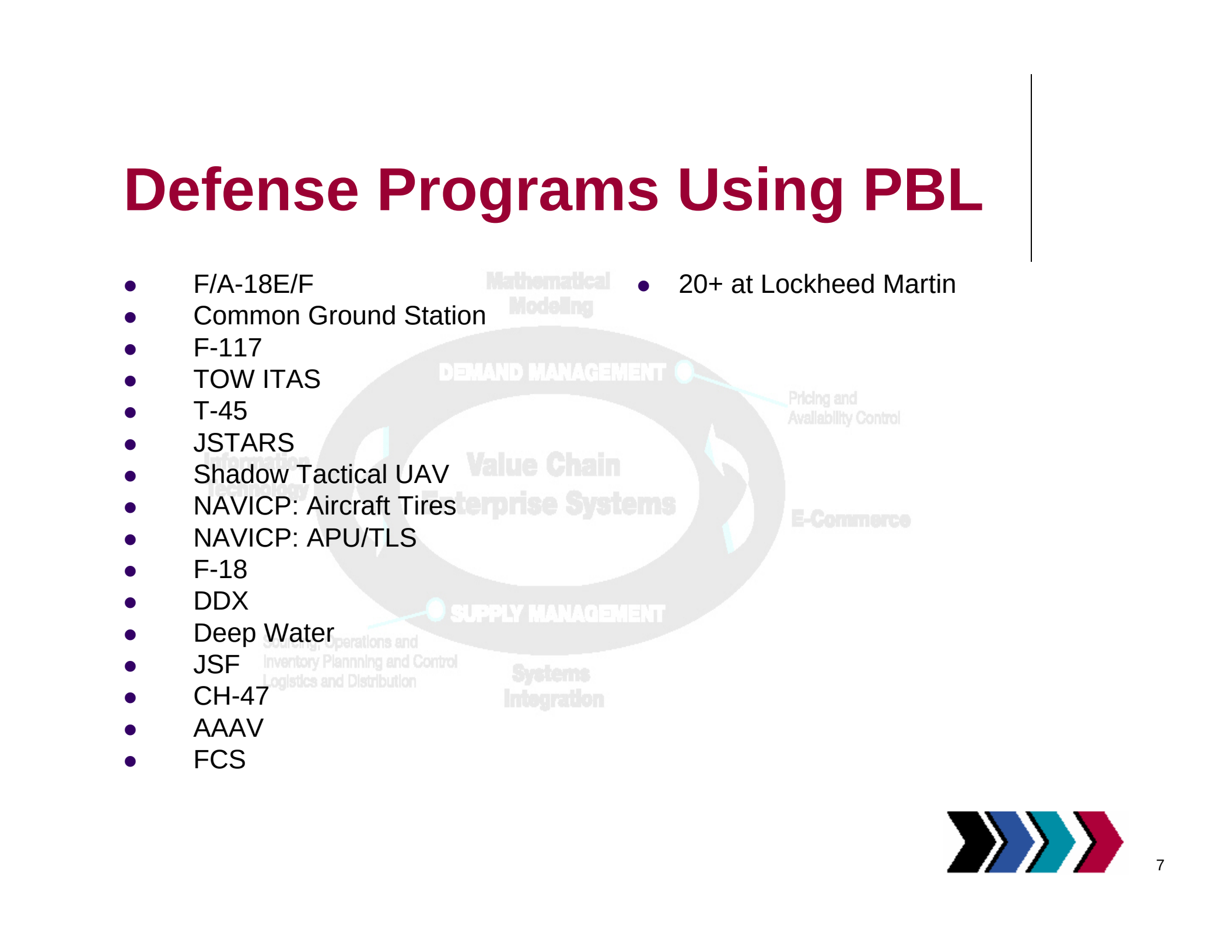
- Not every contract with “performance based” written into it is a PBL contract
  - Performance based contracting in place for years
    - Value based contract awards based on factors other than cost
    - Performance Metrics
    - Incentive fees and penalties
  - True PBL is much more expansive
    - Fixed-price-per-unit of output (i.e., flight hour, cycles of operation); efficiency assured
    - Fixed-price-per-unit-per-period
    - Higher profits because contractors share risk
    - Incentive to continuously improve product reliability (effectiveness)
    - Improve capabilities through system modernization

Commercial Precedence to PBL

- PBL has been in use by Commercial Industry for over 20 years and is emerging as an Industry best practice.
- Aircraft Industry has led the way with concepts such as Power by-the-hour (unit of output)
  - GE - Jet Engines
  - UT Jet Engines
  - Pratt Whitney - Jet Engines
  - Rolls Royce - Jet Engines
  - Honeywell - Avionics
  - Rockwell Collins – Avionics
  - Lucas Aerospace - Landing Gears
  - Garrett - Auxiliary Power Units

Defense Programs Using PBL

- F/A-18E/F
- Common Ground Station
- F-117
- TOW ITAS
- T-45
- JSTARS
- Shadow Tactical UAV
- NAVICP: Aircraft Tires
- NAVICP: APU/TLS
- F-18
- DDX
- Deep Water
- JSF
- CH-47
- AAAV
- FCS
- 20+ at Lockheed Martin



PBL: Difference from Traditional Logistics Support

- Traditional Log Support
  - Time and material contracts
  - Contractor paid as service is delivered regardless of impact on warfighter
  - Government owns all of the performance risk
  - Under defined or lack of defined scope
  - No investment by contractor beyond that paid for by government
  - Government sunk cost in materials
  - Government owns the results if they accept the product or service
  - Contractor gets paid for correcting deficiencies he may have created
  - Government responsible for mitigating obsolescence issues
  - No incentive to introduce improvements

PBL: Difference from Traditional Logistics Support

- PBL represents a state change
  - Focuses directly on meeting warfighter defined goals
  - Shifts weapons system lifecycle sustainment responsibility to the PM
  - Payment based on results not delivery
  - Fixed price per unit of output
  - Performance Metrics driven incentives and penalties
  - Long term contracts
  - Contractor profits based on level of risk sharing
  - Implicit assumption that the contractor will invest in infrastructure and inventory
  - Freedom to execute the work the most efficient manner
  - Oversight based on performance metric results rather than inspection, cost and pricing data certification, etc.
  - Incentive to improve reliability to lower operating costs
  - Incentive to upgrade to maintain product viability
  - Simplifies financial transactions

PROFITS RESULT FROM AVOIDING COST AND DOING THE RIGHT THING but.....

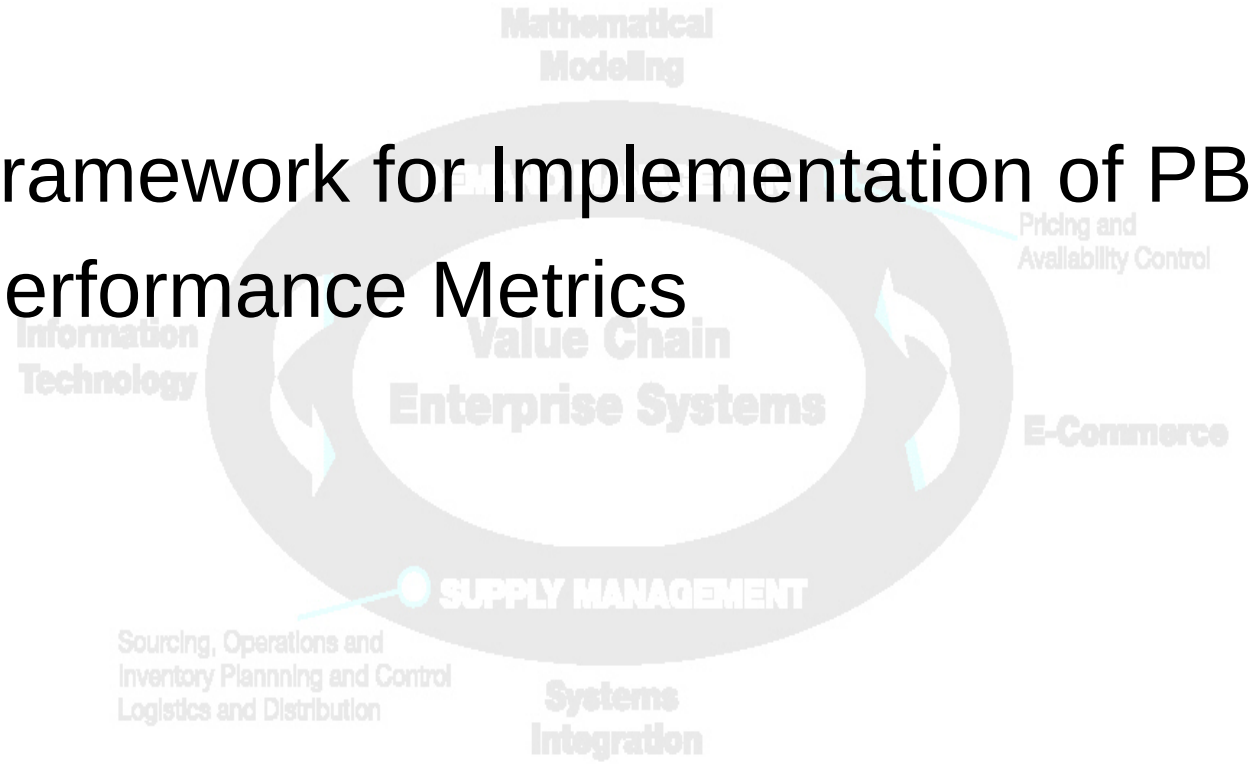
PBL Literature Review

PBL Literature

- Most of the research on PBL is dedicated to developing definitions and framework for implementation of PBL.
- Just two refereed publications in scholarly journals.
- Most of the research are in the form of in-company reports.

What Exists

- Framework for Implementation of PBL.
- Performance Metrics



What is Missing

- Strategies for operationalization of PBL.
- Models for evaluation of PBL metrics
- Optimization models for management of various asset classes under PBL
- Obsolescence Management
- Risk Analysis

Publications in Refereed Journal

- Berkowitz, D., Gupta, J N D., Simpson, J T and Mcwilliams, J B., 'Defining and Implementing Performance Based Logistics, *Defence Acquition Review Journal*, 255-267, 2005.
- Cunic, B. Performance Based Contracting, *Hydrocarbon Processing*, December 2003, 43-46.

Literature outside Public Sector

- Buyer-Supplier relationships have been studied extensively in the marketing channels and supply chain management literature.
- Even in supply chain management literature, little research has considered the performance outcomes.

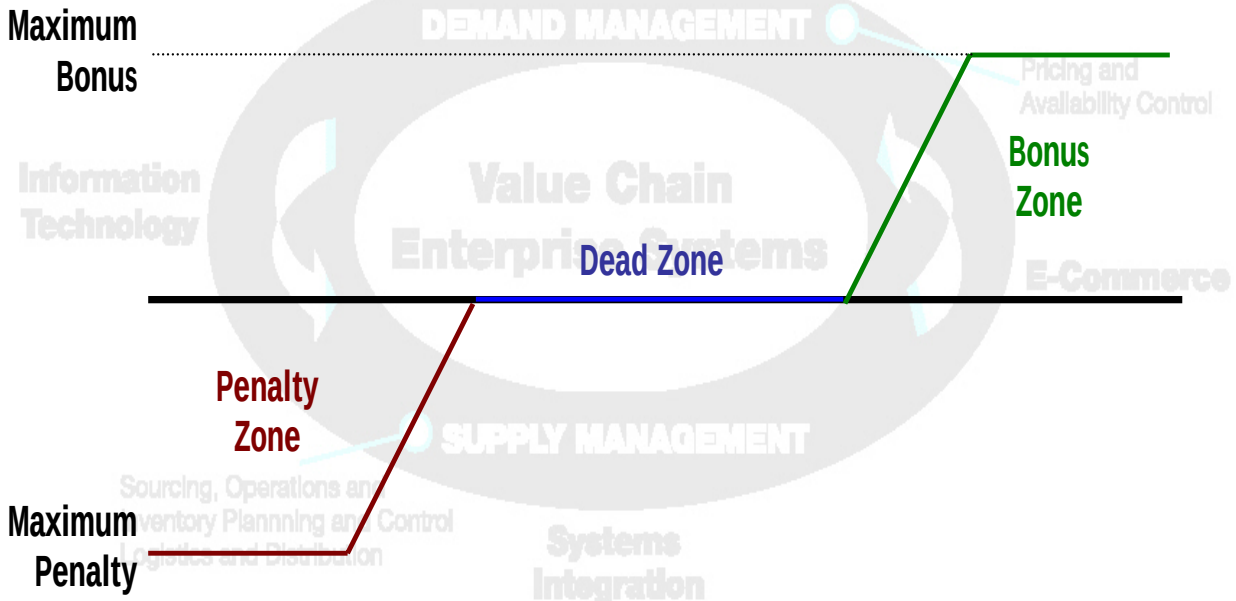
PBL Structure

PBL Key Findings

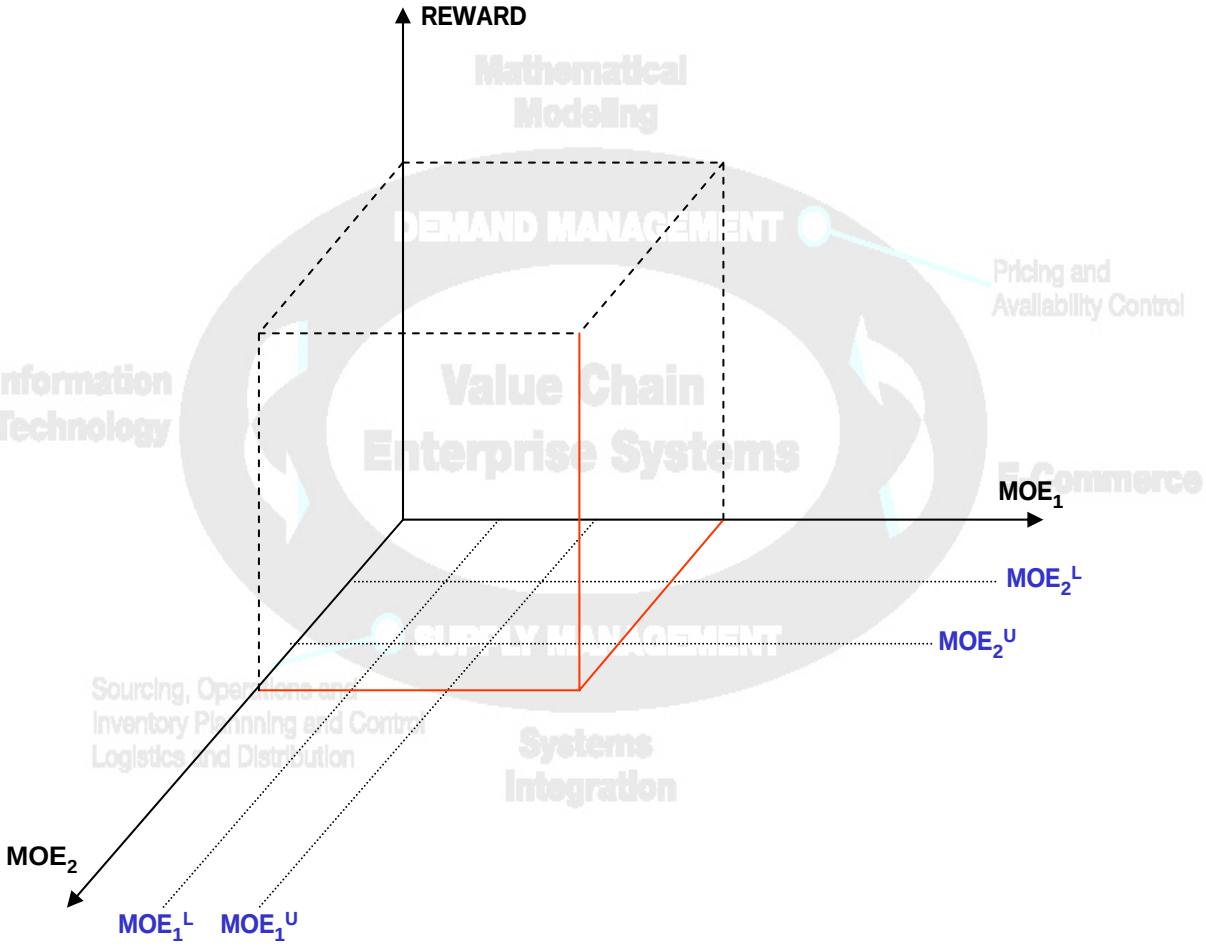
Author	Domain	Key Findings
Berends	Oil, Chemical (Netherlands)	• Incentives for demonstrated performance should be attractive to the contractor over the entire contract duration. • Critical staff on both parties should have continuity over contract duration.
Billinton	Utilities (Canada)	• System performance is to be evaluated against a performance baseline based on historical data.
Billinton, Pan	Utilities (Canada)	• Continuous risk assessments should be carried out, based on actual data.
Brown, Burke	Utilities (US)	• The payment scheme should differentiate between a dead, reward and penalty zones, delimited by upper and lower performance thresholds. • Clients can mitigate their risks through the adequate definition of the geometry of the mentioned zones.
Cunic	Chemical sector	• Essential or strategic aspects of performance need to be identified, and ad-hoc contracts should be arranged.
Fearnley, Bekken, Norheim	Public transportation (Norway)	• Historical performance data are essential in setting sound objectives in PBLS contracts • Clear delimitation of responsibilities of client and contractor will diminish likelihood of eventual disputes. • Performance guarantees or bonds are recommended to cover potential difficulties for clients in materializing penalties imposed on contractors for system under-performance.
Gilbertson	Defense	• Ad-hoc warranties should be set for essential system performance requirements. • Objectives of operational performance are to be set with regards to a reference point.
Hensher, Houghton	Public transportation (Australia)	• System utilization profiles need to be adequately defined. • Communications and data exchanged between client and contractor should be transparent. • As important as the transition or migration to a PBSL scheme is the definition of a post-transition growth strategy.
Rogers	Communications (US)	• Application of a PBLS strategy from the early stages of product design and development can lead, by controlling the dominating design parameters, to significant reductions in life-cycle costs.
Smith	Defense (US)	• Performance goals and schedule for achieving them are the main elements of a PBLS contract. • A plan should be set for the refurbishment of critical components over the useful life of the system.
Wasserman, Lamberson	Defense (US)	• A reliability growth program has to be set to compensate for the decline over time of the system reliability characteristics.
(1)	Defense (Spain)	• Multiple contracts, not always duly cross-referenced, complicate the true determination of responsibilities when assessing fulfilment (or not) of system performance goals, and thus consistency and coherence of all inter-related contracts is a must.
(1)	Public transportation (Spain)	• Appropriate delimitation of responsibilities is essential, as failure to do it may mean that the contractor is eventually held responsible for under-performance of the system caused in part for reasons beyond his control.

(1) Based on the authors' experience and the interviews conducted as part of this research effort.

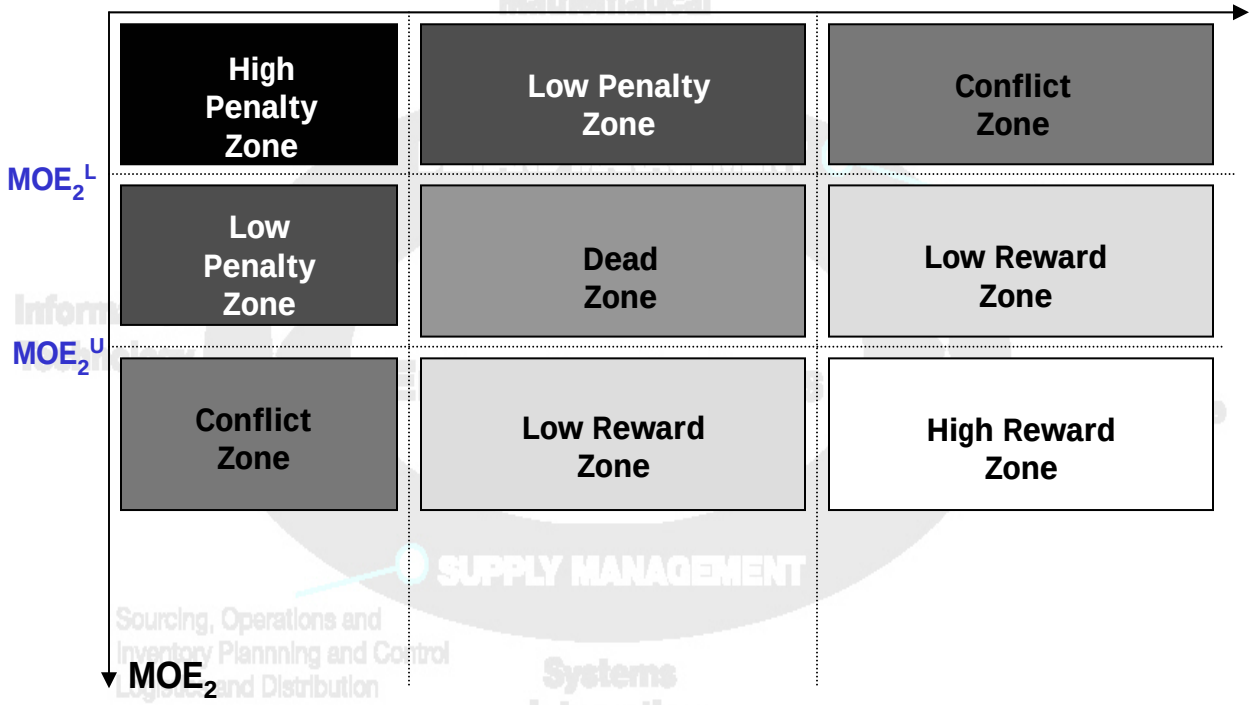
Concept of Dead, Bonus and Penalty Zones



3-D of Dead, Bonus and Penalty Zones



3-D of Dead, Bonus and Penalty Zones

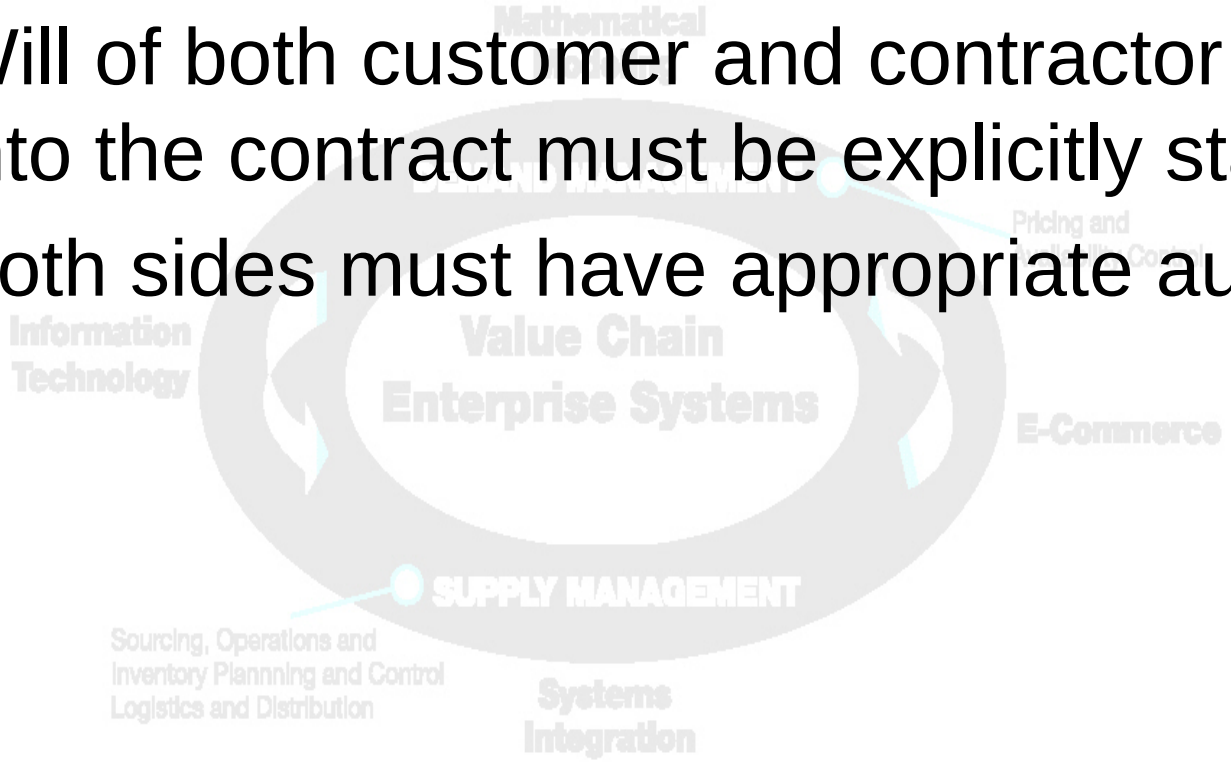


Contract Framework

- Three Critical Aspects
  - Will and capability of entering into commitments
  - Contract Purpose
  - Rewarding/Penalty Scheme
- Additional Recommendations
  - Legal
  - Policies
  - Information
  - Supportability

Will and Capability

- Will of both customer and contractor to enter into the contract must be explicitly stated
- Both sides must have appropriate authority



Contract Purpose

- Must clearly define the system for which support is sought
- Must include
  - Definition of boundaries
  - Primary external interfaces
  - Definition of primary system elements
    - Hardware, software, human actions, activities
- Details of support objectives
- Contract exclusions
- System operational life defined
- Mission profiles and durations
- Measures of performance, how they are measured including frequency of measurement
- Continuity of key personnel
- Identify key focal points

Legal

- Fuzzy and/or ambiguous statements and clauses are to be avoided.
- The contract, both in its spirit and in the specific wording of its clauses, is to be in full accordance with all applicable laws and regulations.
- The contract is to be fair and balanced, avoiding being one-sided in either direction.
- The contract is to define applicable jurisdiction, in case of litigation, as well as the procedures for arbitration

Policies

- regarding confidentiality and the non-disclosure to third parties of sensible information, without the pertinent approval of the other party
- The contract is to reflect that both parties, customer and contractor, commit to sharing all the needed information and to revealing it to each other with transparency and objectivity.
- The contract is to identify the applicable language for exchange of communications in the program

Information

- The contract is to clearly identify the inputs required from third parties, whether they are information, services or products, that may affect system performance and that fall out of the responsibility domains of both the customer and the contractor.
- The contract is to define the scope, frequency and details of the reports to be submitted by the contractor to the customer relative to the development and results of the reliability growth program, to be agreed upon between customer and contractor.

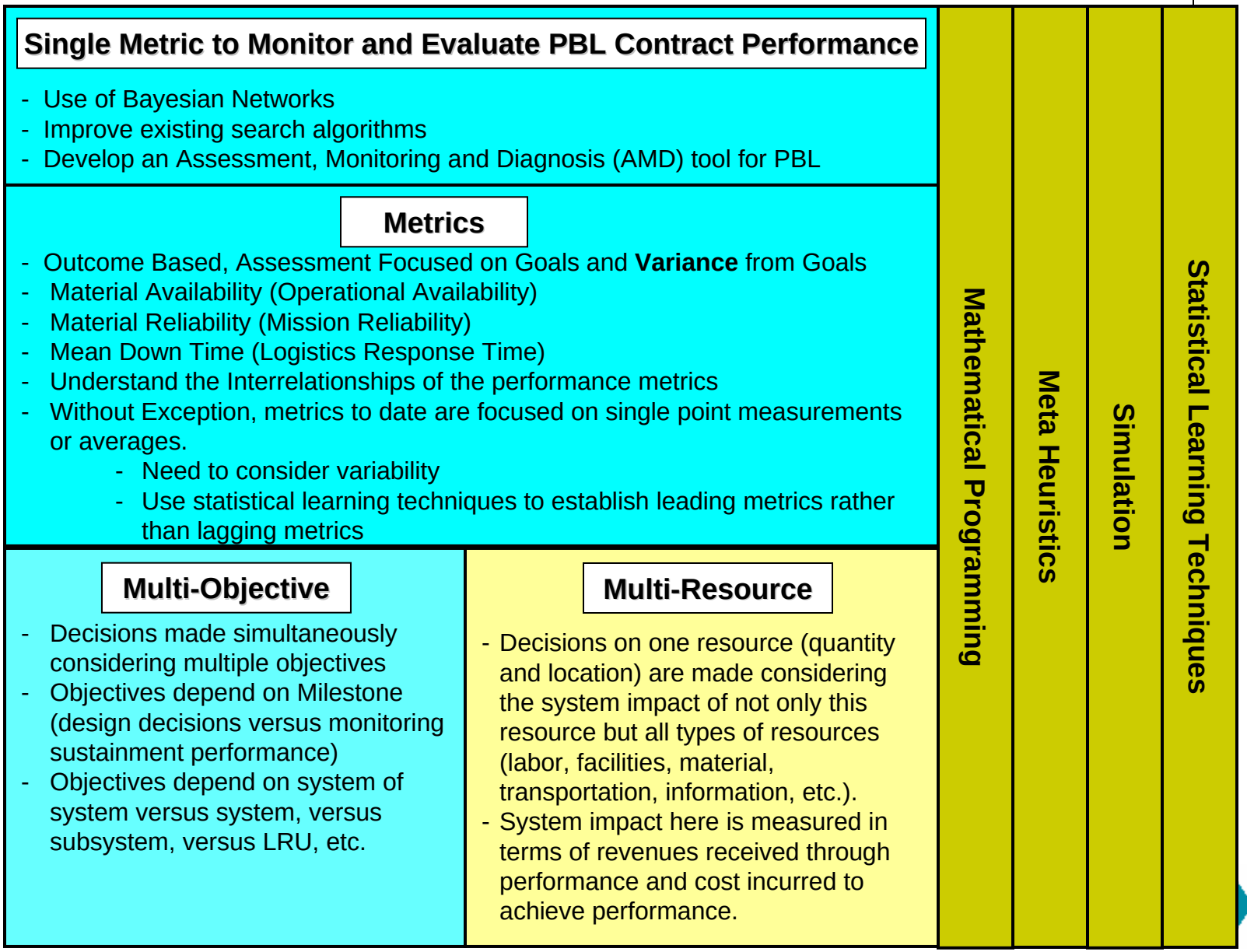
Supportability

- The contract is to define the procedures to be followed by the contractor and the customer in order to reduce to the minimum the risk of components obsolescence and consequently its negative effect on system performance.
- The contract is to include a technology refreshment program for all system COTS elements.
- The contract is to define the scope and details of a reliability growth program aimed at compensating the wear-out or negative effect of time and use on system reliability.
- The procedures for dealing with refurbishment of critical components and for the pro-active replacement of marginal reliability components prior to failure (conditional maintenance) are to be defined and agreed upon between customer and contractor.
- The contract is to define the configuration management procedures, essential for the effective and efficient conduction of other activities aimed at ensuring system performance.



PBL Analytical Models and Metrics

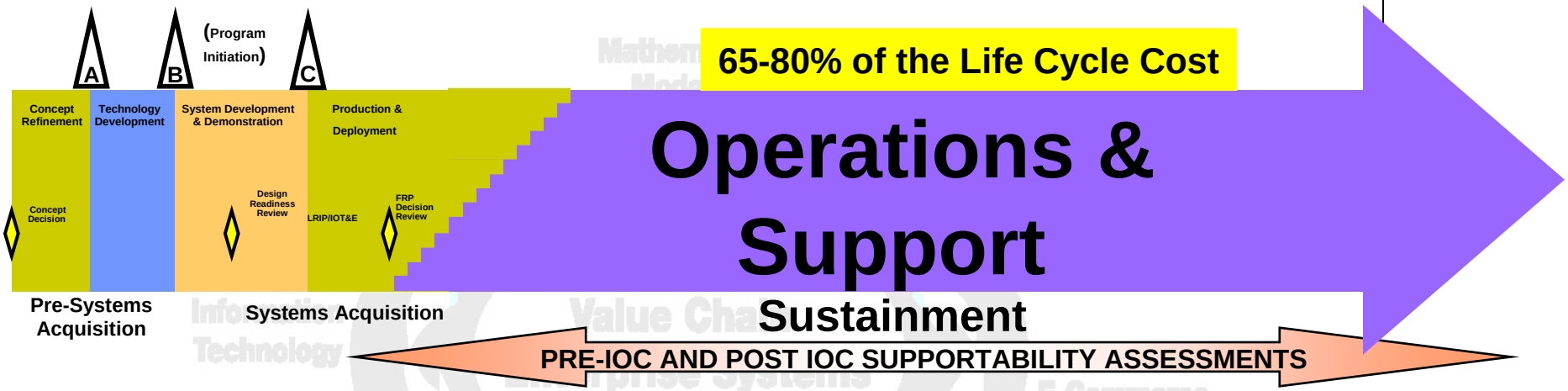
A Framework of Analytical Models to Support Initiating, Tracking and Evaluating PBL Contracts



Performance Metrics

- Material Availability
- Material Reliability
- Mean Downtime
- Outcome Based Assessment Focused on Goals and Variances from Goals

Life Cycle Metrics



JCIDS → KPP → SEP → DAES → DAES-S → Warfighter Support

One set of Metrics throughout the System Life Cycle

Emphasis on Materiel Readiness

Materiel Availability

$$\text{Materiel Availability} = \frac{\text{Number of End Items Operational*}}{\text{Total Population of End Items}}$$

* Operational means in a materiel condition such that the end item is capable of performing an identified mission.

Materiel Reliability

Materiel Reliability = Mean Time Between Failure

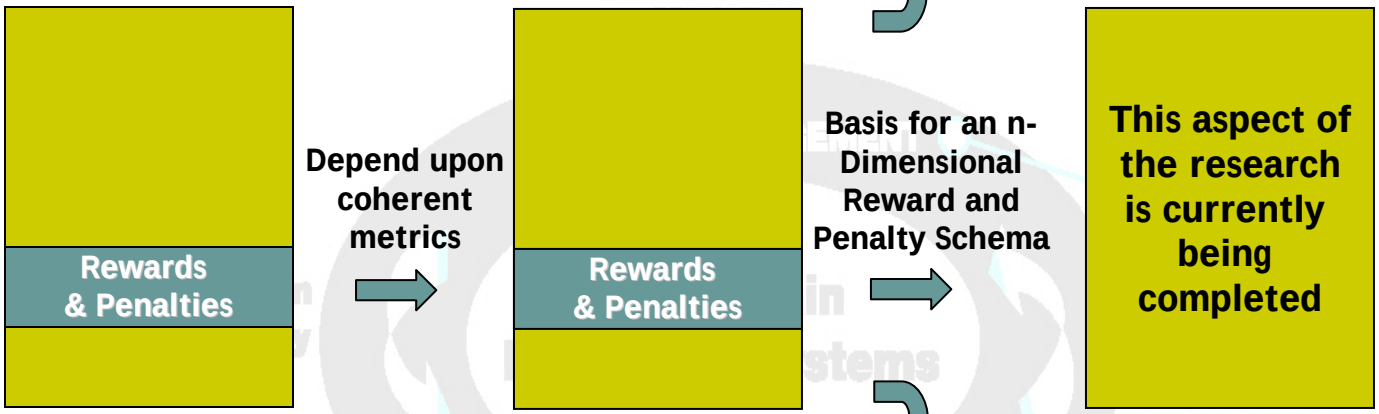
measured as $\frac{\text{Total Operating Hours}}{\text{Total Number of Failures}}$

The research alluded to an absence of good models for the modeling of multiple resources simultaneously. This aspect of the research (multi-resource optimization) is being led by Dr. David Nowicki.

PBL Contractual Structure

Performance Outcome Metrics/Models

N-Dimensional R&P Scheme



Initially, the research involved studying PBL contracts in the commercial and public sector to understand their structure. This research resulted in the development of a PBL contract structure template. The focus from this point forward was on the reward and penalty aspect of Performance or outcome based contracts.

Given the dependence of good performance based contracts on coherent and sound metrics, the research next involved a considerable survey and review of metrics and models.

The research alluded to an absence of good models for systems with degraded modes of operation. This research took a deep dive into this aspect of system reliability modeling. The research was accepted for publication in *Reliability Engineering and System Safety*.

Rapidly Defining a Lean CMMI Maturity Level 3 Process



Zia Tufail, zia@hp.com, 301.233.4228
Julie Kellum, Julie.Kellum@hp.com, 404.731. 52.63
Tim Olson-QIC, Tim.Olson@qic-inc.com, 760.804.1405

© 2004 Hewlett-Packard Development Company, L.P.
The information contained herein is subject to change without notice

Presentation Objectives

Describe CMMI compliant online HP process
- Outline Components for a cost effective, lean process

Describe HP's improvement objectives.
- Identify problems addressed by the streamlined CMMI L3 HP process

Describe the approach that was used to achieve CMMI Maturity Level 3.
- Unique techniques for defining & implementing an effective, lean CMMI L3 process in 8 months

Present some challenges and lessons learned.

Answer any questions.

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



FY05 C&I EAS/Federal Initiatives

EAS & Public Sector Initiative	*CMMI Relation*
• CMMI L3 Achievement	• Development of EAS HPGM-AS methodology, rollout and assessment.
• Expand Application Services	• L3 methodology is unifying force for consistent standards and practices.
• Increase Pursuit Capabilities	• CMMI allows us to pursue opportunities we would not get otherwise • Better estimation and marketing of services
• Delivery Excellence	• Standardization and enforcement of best practices.
• Profit Improvement	• Disciplining delivery execution and preventing margin leakage by fostering reuse and minimizing risk

Existing Methods Revised to Meet CMMI Level 3

2004

A $1.5 Million dollar, 8 month project started to revise Success Program to meet CMMI level 3 and improve project controls. Some current and new FY05 Federal Contracts at risk without a CMMI level 3 compliant process.

- Sept — CMMI Level 3 Gap Analysis on Current Methodology
- Oct -Nov — HPGM-AS Methodology Customizations - define per Sharepoint portals
- Dec — Pilots Start :
  - •PM Orientations/Planning Sessions per project
  - •CMMI & Methodology Classroom Training

Pilots Underway

2005

Success Program Office (SEPG team) and Pilot Projects start leveraging Success Program revised with the new CMMI level 3 compliant process

- Jan — Envisioning & Maintenance Phase Pilots start
- Feb — Design & Maintenance Phase Pilots
- Mar — Build & Maintenance Phase Pilots
- April — Pilots Continue & CMMI Assessment begins
  - April 29 EAS and Public Sector Achieve CMMI level 3 maturity

Components of the HP CMMI L3 Process



Technology

- Sharepoint based portals:
  - Success Program Office
  - Success Manager
  - Success Reviews
  - HPGM-AS Roadmap
  - RADM Virtualization

Process

- SEI CMMI L3 framework
- HP Global Method Application Services (HPGM-AS - methodology)
- Success Reviews (PPQA audit process)
- Success Manager (Team Collaboration process)
- Adaptive Assets (Knowledge Capture & Reuse process)



People

- Success Program Office (SEPG function)
- SQA Coaches (per team)
- Program Management
- Organization & Culture



Success Program Office

EAS HP Global method Application services (HPGM-AS)	• Delivery Workflow portal/process • CMMI level 3 compliant • Phase deliverables & Signoffs
Success Manager	• Team Collaboration web/process • Pre-Loaded HPGM-AS • Customer accessible
Success Reviews	• Process Review (PPQA) portal/process • Mentoring Support By Field PMs
Adaptive Assets Knowledgebase	• Process and Tech Asset KB portal/process • Reuse tool
Rapid ADM	• Supports HPGM-AS Configuration Mgt • Virtualization and Software Configuration • Management (SCM) services

Home - HPGM-AS Roadmap R2.6 - Microsoft Internet Explorer provided by Hewlett-Packard

File Edit View Favorites Tools Help

Back Search Favorites Media

Address https://h20224.www2.hp.com/sites/ProjectsCMMi/SuccessPath_HPGM-AS_Roadmaps/Roadmap_v6/default.aspx Go Links

Home Documents and Lists Create Site Settings Help Up to Success Manager HPGM-AS Roadmaps

HPGM-AS Roadmap R2.6

Home

This Site

Modify Shared Page

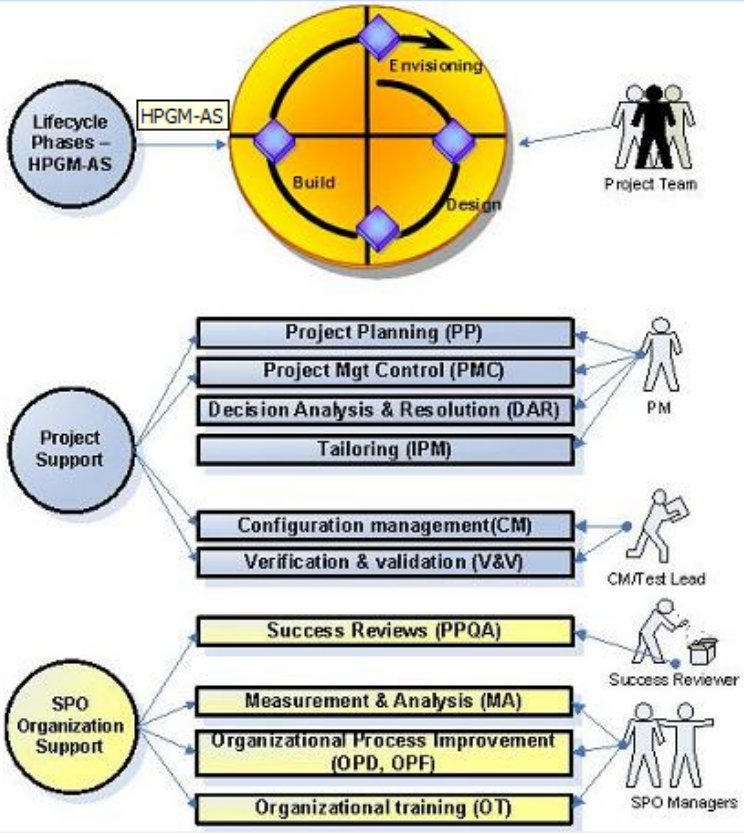
Documents
- HPGM-AS ZIPed Templates

Pictures

Lists
- New Projects START HERE
- Lifecycles
- ENVISIONING PHASE
- DESIGN PHASE
- BUILD PHASE
- ARTIFACTS
- Project Planning (PP)
- Project Management (PMC)
- Configuration Management (CM)
- Verification and Validation (V&V)
- Peer Review (V&V)
- Decision Analysis Resolution (DAR)
- Tailoring (IPM)
- SPO Success Reviews (PPQA)

Second Release of HP Global Method for Application Services which is a level 3 CMMI application development methodology supporting iterative, waterfall and maintenance lifecycles in HP's Consulting and Intergration (C&I) area

HPGM-AS



CMMI Links

- SUBMIT Success Program Improvements Here!
- Adaptive Assets
- Success Reviews
- CMMI project webs (currently USPS only - special clearance required)
- HPGM-AS Lifecycles Overview
- SPO Portal
- SPO Lessons Learned Analysis
- HPGM-AS Impact Analysis Tool
- SPO Configuration Management Plan
- SPO Training Plan
- SPO Improvement Plan (SIP)
- SPO Quality Policy
- SPO Quality Assurance (QAP) Plan
- CMMI Scope & Design Decisions

Add new link

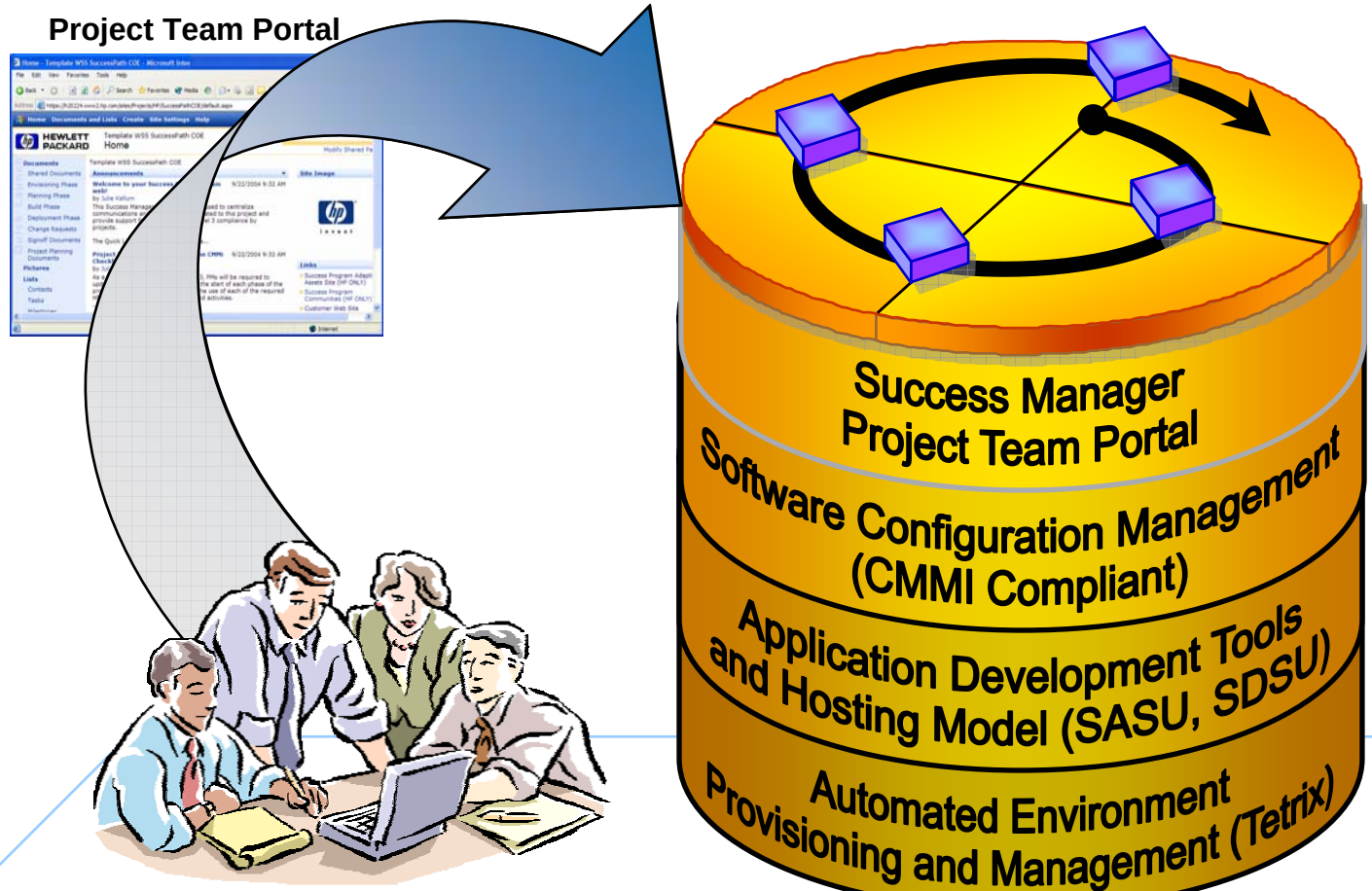
Contacts

Last Name	First Name	Role
Galvan	Carlos	April 18-29 Lead CMMI Assessor
Erwin	Brian	Centers of Excellance Manager

Done Local intranet

start 3 Microsof... 5 Microsof... Training 20... HP4 2006 Home - HPG... 10:46 PM

Rapid ADM Components and Features



Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Success Program Vision

- Using a sales and delivery integrated approach, leverage existing, as well as grow new process and technical Adaptive Assets to :
  - Increase ability to compete in Federal bids through CMMI Level 3 compliance
  - Win more business through improved differentiation
    - IBM differentiation point
  - Increase Success of Projects
    - Synergistic Teams
    - Referencable Clients
    - On Time
    - In Budget/Profitable
    - Effective HP Global Methods Applied

Success Program ➔ What & Why

- Collection of specific process and technical assets used in pre-sales for differentiation and in delivery to increase project success
- CMMM Maturity Level 3 compliant to meet Federal bid requirements
- Externally accessible outside HP Firewall by delivery teams
- Major Areas:
  - Success Path HPGM-AS
  - Success Manager
  - Success Reviews
  - Adaptive Assets KB
  - Communities & Forums
- Best of breed IP from HP

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



HP Approach

Leverage existing HP processes and templates:

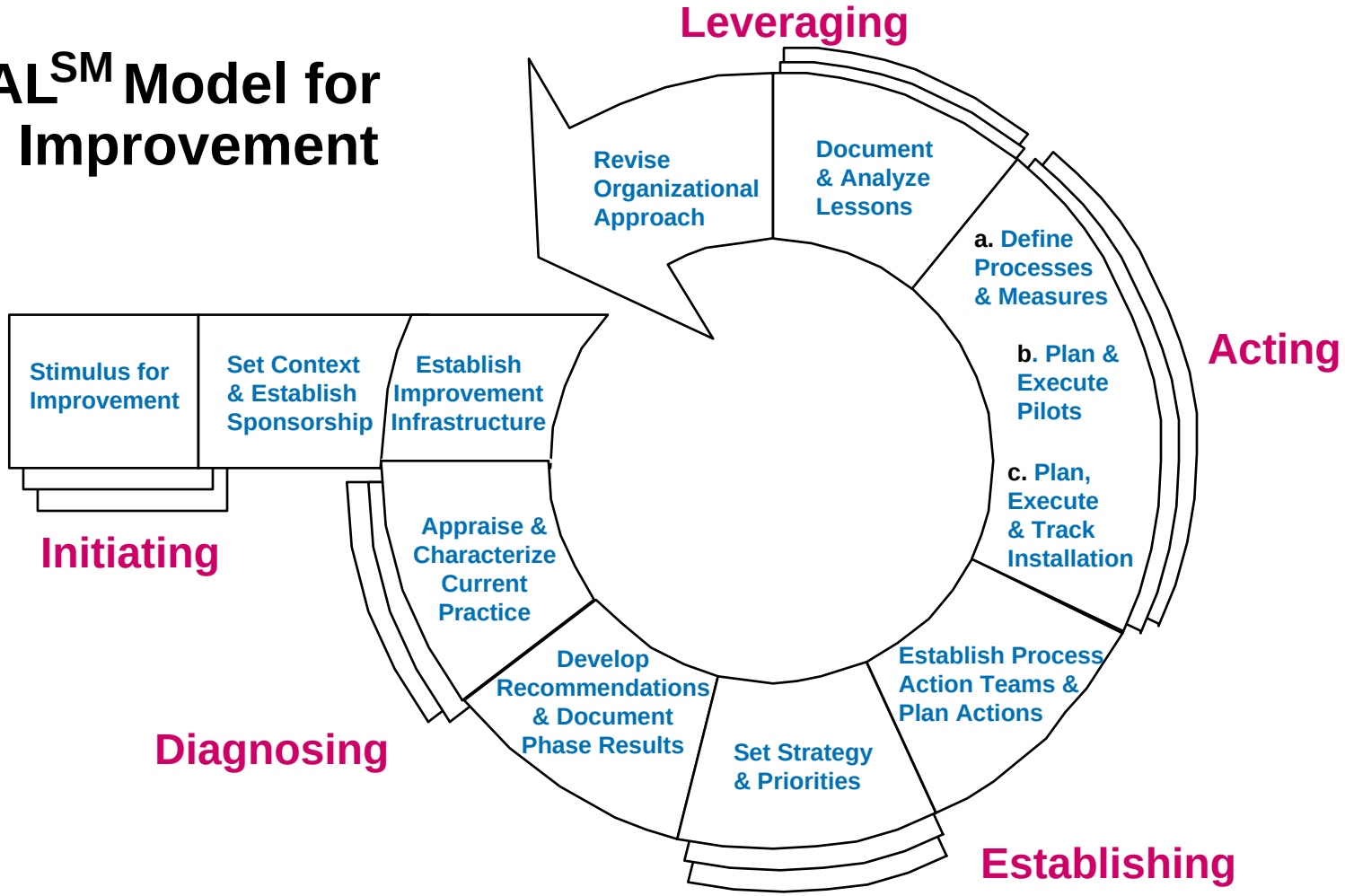
- Success Program
- HP India (CMMI Maturity Level 5)
- HP Global Methods for Application Services (HPGM-AS)
- HPGM for Project Management (HPGM-PM)

Deploy Tailored SEI IDEAL^{SM} Model and reuse existing processes to be CMMI compliant.

Leverage Best of breed IP from HP

SEI IDEAL^{SM} Model

SEI IDEAL^{SM} Model for Process Improvement



- SM IDEAL is a service mark of Carnegie Mellon University; Slide Adapted from SEI

Tailored SEI IDEAL^{SM} Model

Initiating: Sponsor sold idea to HP senior management.

Diagnosing: HP India performed a mini-appraisal (e.g., Class B).

Establishing: CMMI Consultant established high-level plan and HP established a CMMI Team.

Acting: Architected HP processes to be CMMI compliant in 2 months; Skipped piloting; Trained and implemented experienced projects.

Success: Performed independent SCAMPI A.

HP's "Lean" Process

HP Success Program is a very "lean" CMMI compliant process (about 25% of the size of the HP India process).

The process is completely online, and uses Microsoft SharePoint.

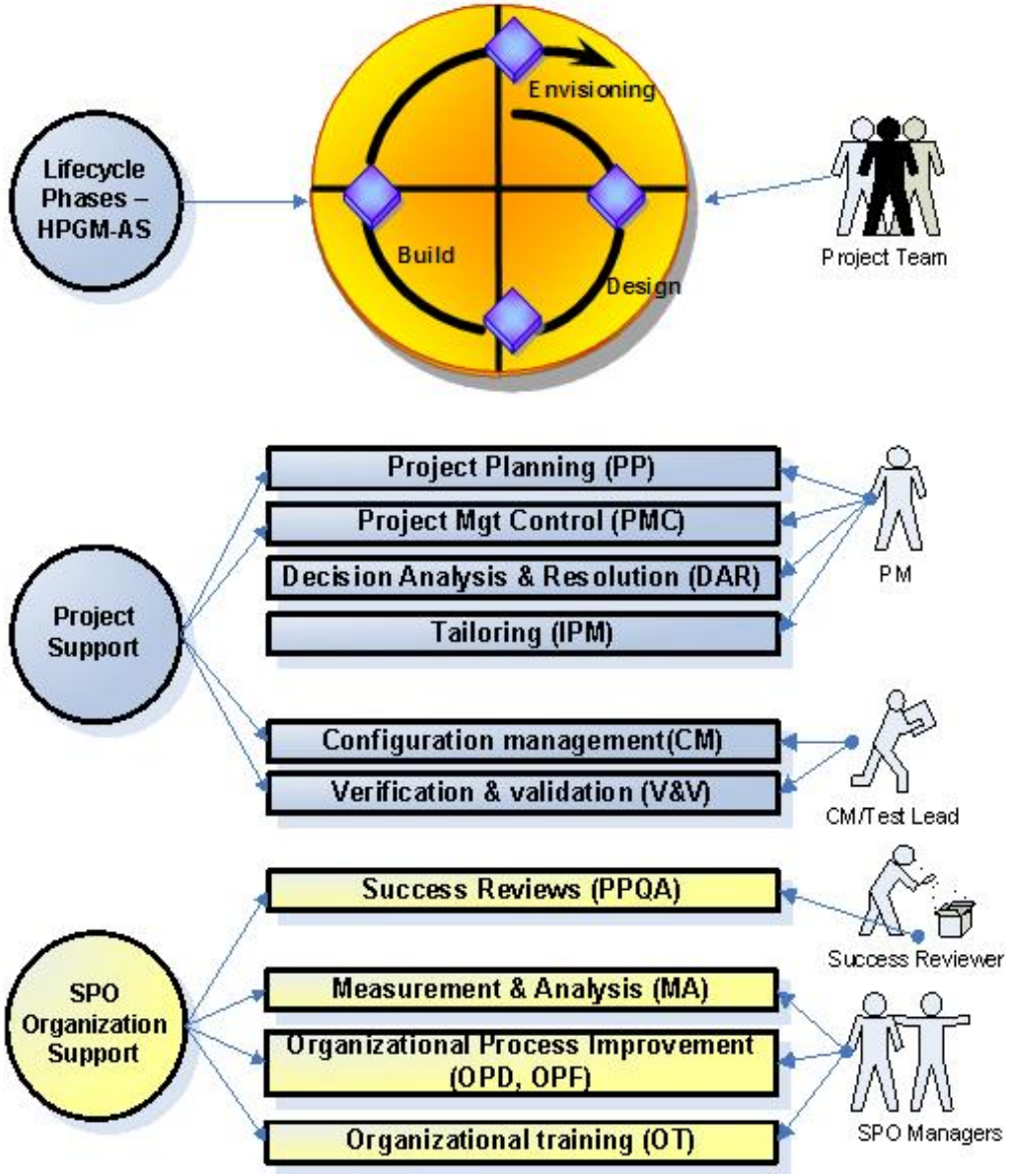
HP's process is only ~25web pages in size.

HP incorporated best practices in process definition

- e.g., "Defining Short, Usable Processes and Procedures", CrossTalk, Olson, Timothy G., June 2006.

HPGM-AS CMMI L3 Methodology

- 2 Paths depending on project profile
  - Large HPGM-AS CMMI Implementation
  - Small HPGM-AS CMMI Implementation
  - Excluded are projects required to use the customer's app dev methodology & staff aug
  - No existing projects asked to convert – new only
  - Large and Small Project implementations differ mainly
    - on use of Success Reviews and Deliverables Required



HPGM-AS Artifact Comparison Example

Small/Low Risk	Large/High Risk
Success Manager site (Issues List & Change Req/PR List)	Success Manager site (Issues List & Change Req/PR List)
Project Plan & Configuration Mgt Plan	Project Plan & Configuration Mgt Plan
Schedule	Schedule
Mini-Spec (Contains sections from all of these ➔)	Bus Req Spec (BRS) Systems Req Spec (SRS) Systems Architecture (SA) Detail Design (DD) V&V /Test Plan Req Traceability Matrix (RTM)
Peer Review Log/Checklist – Mini-Spec CM Audit Checklists – Success Manger, Product Milestone Review Phase Checklists	Peer Review Log/Checklist – Project plan, SRS, SA, V&V Plan CM Audit Checklists – Success Manager, Code, Product Milestone Review Phase Checklists

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Challenges

- CMMI Resources were reallocated to the new high priorities.
- Resistance to change when people have gone through several changes without tangible results.
- Aggressive schedule
- Unexpected events such as team health and organizational changes



Lessons Learned

- It takes time, senior management support, and mentoring to change behavior
- Traditional Classroom training not enough – critical to have a local resource to mentor team on methodology/CMMi activities and artifacts
- Success Reviews critical for monitoring and mentoring on process use
- Critical to use centralized team collaboration tool for process support (i.e. PPQA, Peer Reviews, Lessons Learned, Issue Tracking/Project Change control, etc)



Lessons Learned

- Spend ample time in planning phase to lock down the scope of the project.
- Obtain and maintain executive sponsorship to keep driving the project on schedule.
- Define Configuration Management early in the process.
- Follow the Configuration Management process.
- There is no substitute for one-on-one mentoring for the late adopters.
- Ensure core team understands the entire process.
- Ensure the process is lean and relevant.



Lessons Learned

- Engage stakeholders throughout the process.
- Third party consultants can provide objective feedback.
- Build a diverse team and leverage diversity.
- Ensure CMMI expert resources are on the team.
- CMMI really does require continuous process improvement.



What Went Well

- Teams reap benefits of Peer Reviews, and Milestone Reviews
- Pilot projects implement a consistent delivery approach
- Improved metrics to track trends across projects
- Integration of virtualization through CM process
- Increased value to customer through improved communications thru SPO:
  - Success Manager Team Webs
  - Status Reporting
  - Automated Issues and Change Request tracking

What Went Well

- Expanded Rollout of Success program to ~300
- Implemented new Success Program processes:
  - HPGM-AS Bid Review (Pre-sales)
  - HPGM-AS Quickstarts (Pre-Delivery, 1 week) ➔ tailoring of the process by SEPG with PM and SA
- Implemented scalable training to replace classroom training:
  - PM CMMI Training Track (14 webinars)
  - Engineering CMMI Training Track (9 webinars)

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Questions?



NDIA Systems Engineering Conference

A New Strategy for Submarine Payload Integration

The VIRGINIA Multi-Mission Payload Module

John Pavlos - Electric Boat

GENERAL DYNAMICS
Electric Boat

Approved for Public Release Per SOS
Ltr 5720/OODT; 2003 - 0839 2/5/04

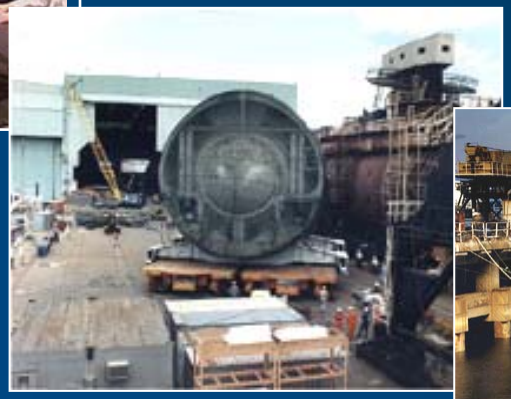
NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

ELECTRIC BOAT



Engineering
& Design

Premier Resource for Submarine Design and Construction Technology



Construction



Sea Trials
& Test



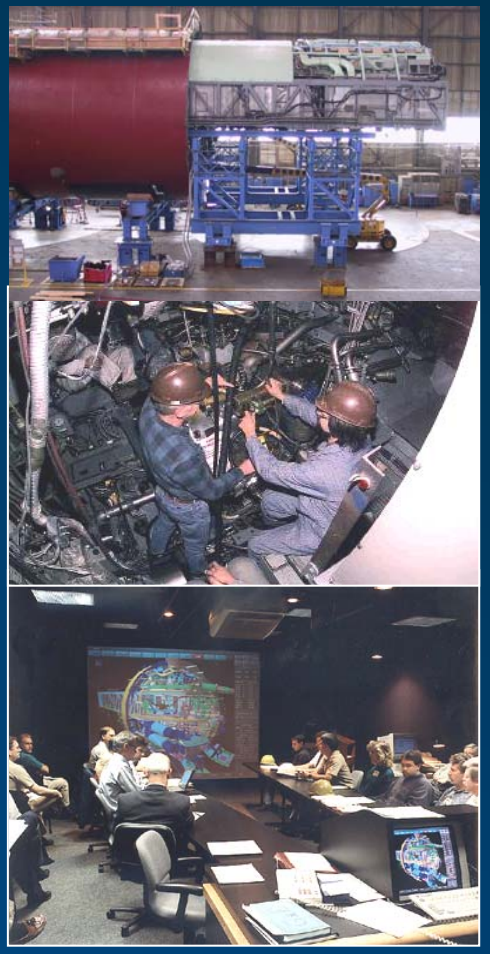
Life-Cycle Support



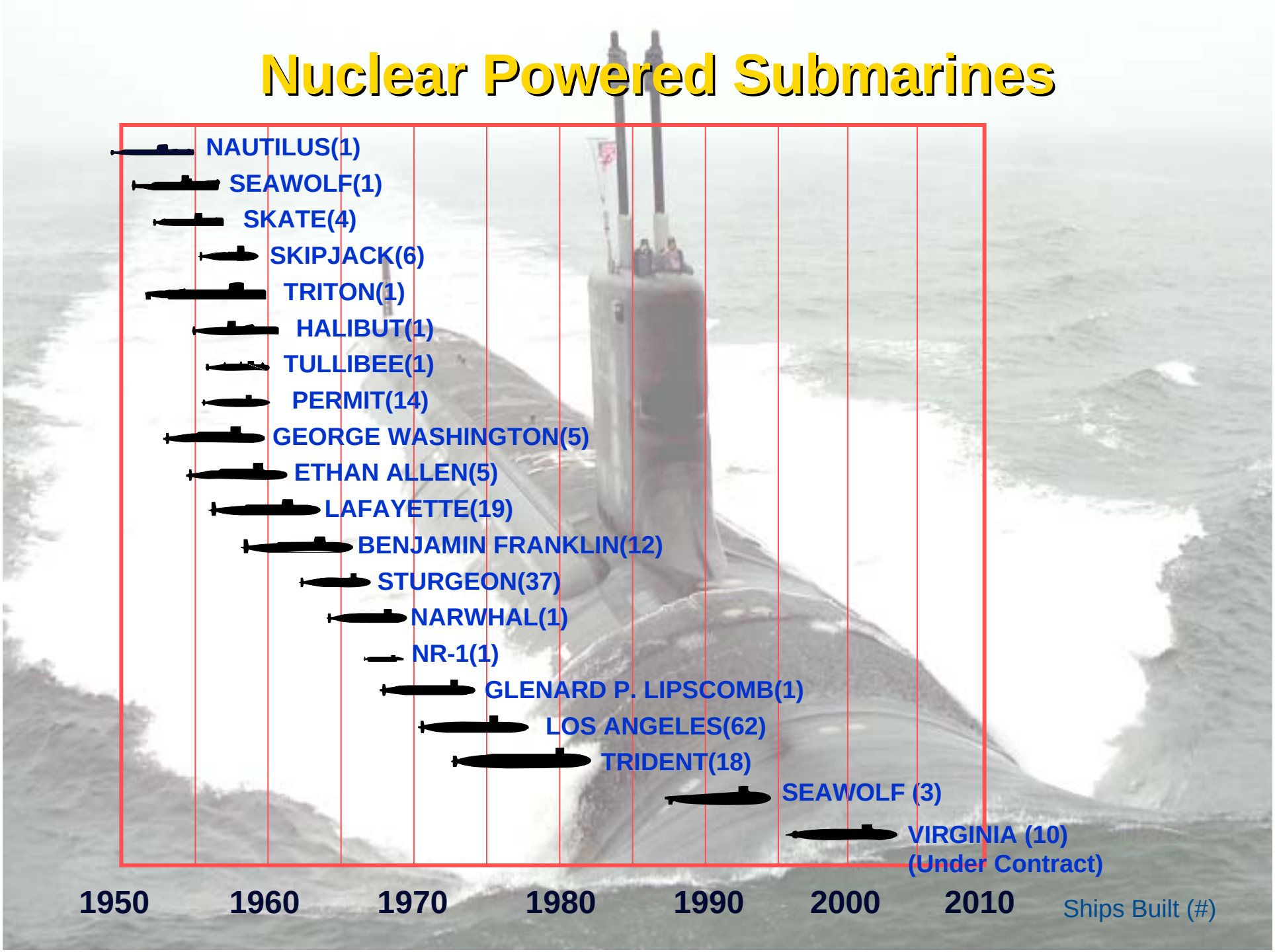
Advanced
Development

Electric Boat
Locations and Staffing (As of October 7, 2006)

• **CONNECTICUT**	
Operations and Support	3,901
Engineering	3,456
• **RHODE ISLAND**	
Quonset Point Facility	1,907
Newport Engineering	53
• **NEW YORK**	
Knolls Atomic Power Lab	183
• **GEORGIA**	
Kings Bay Trident Base	125
• **WASHINGTON**	
Bangor Trident Base	108
Puget Sound NSY	250
• **WASHINGTON, D.C.**	**15**
• **VIRGINIA**	**365**
• **UK / Australia / Other**	**68**
TOTAL	10,431



Nuclear Powered Submarines



The VIRGINIA Class Submarine is One of the Most Complex Systems in Production

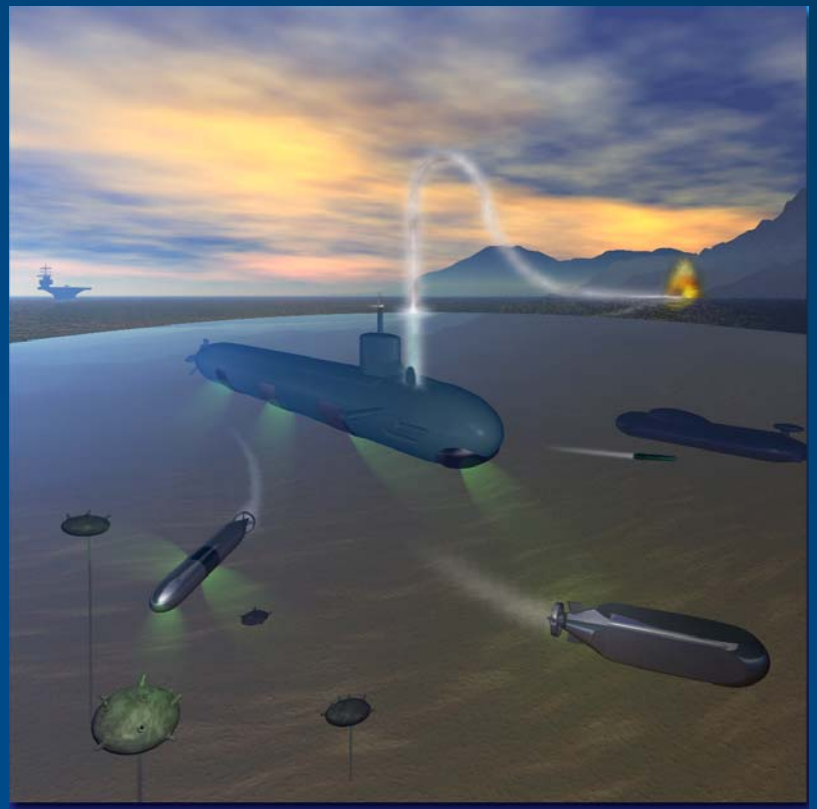
- Electric Boat: Prime contractor and lead design yard
- Awarded 10 ships of an anticipated 30-ship class – valued at $13B
- Lead ship SSN 774 VIRGINIA delivered October, 2004

	M1 Tank	Boeing 777	VIRGINIA Class Submarine
Weight (T)	65	250	7,800
Length (Ft.)	25	200	377
Number Systems	25	40	200
Crew Size	4	10	113
Patrol Duration (Hr.)	24	8-14	2,000
Number of Parts to Assemble	14,000	100,000	1,000,000
Assembly Man-hours/Unit	5,500	50,000	>10,000,000
Production Time (Mo.)	7.5	14	55
Production Rate (Units/Yr.)	600	72	0.5-3

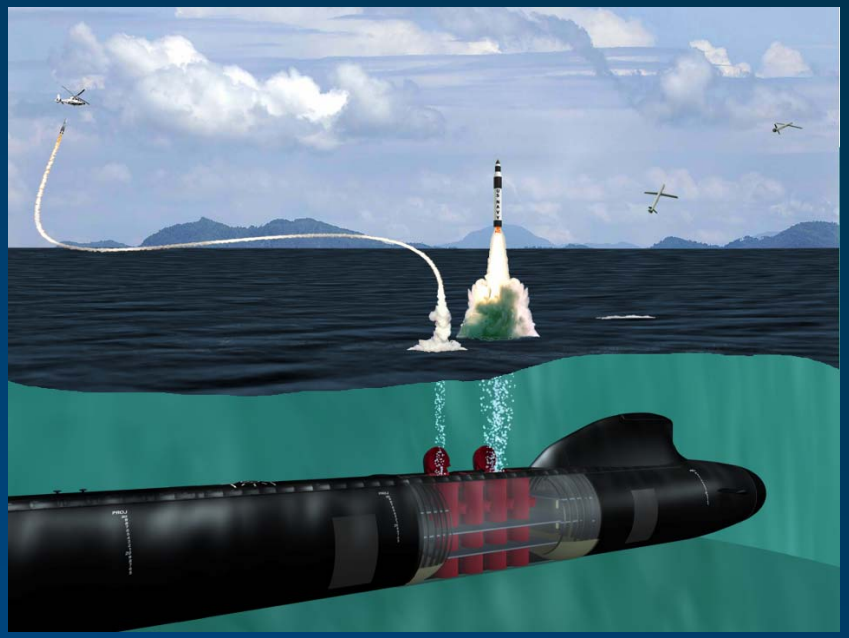


Challenge: Moving From Today's Capability to Tomorrows Mission Needs

Today's Capability



Tomorrow's Capability

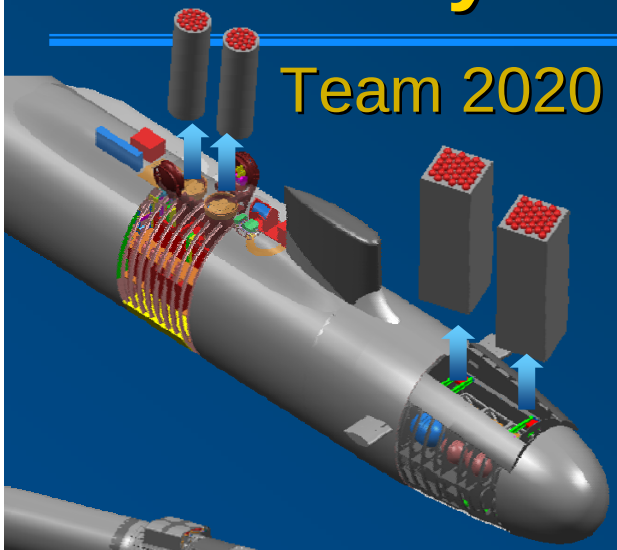


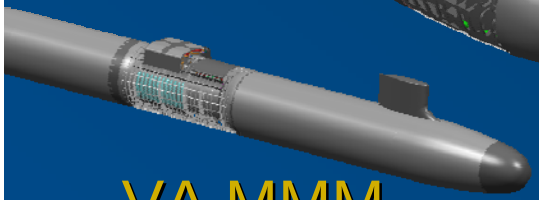


Approved for Public Release Per SOS
Ltr 5720/OODT; 2005 - 0235 3/15/05

The Concept Was to Minimize the Impact to the Payload and the Platform

Team 2020 VA Plus Concept





VA MMM



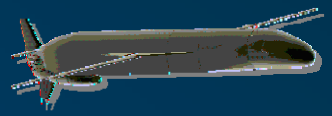
SSBN/SSGN

Universal Payload Adapter



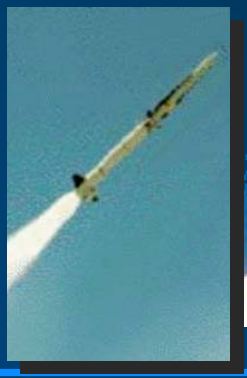












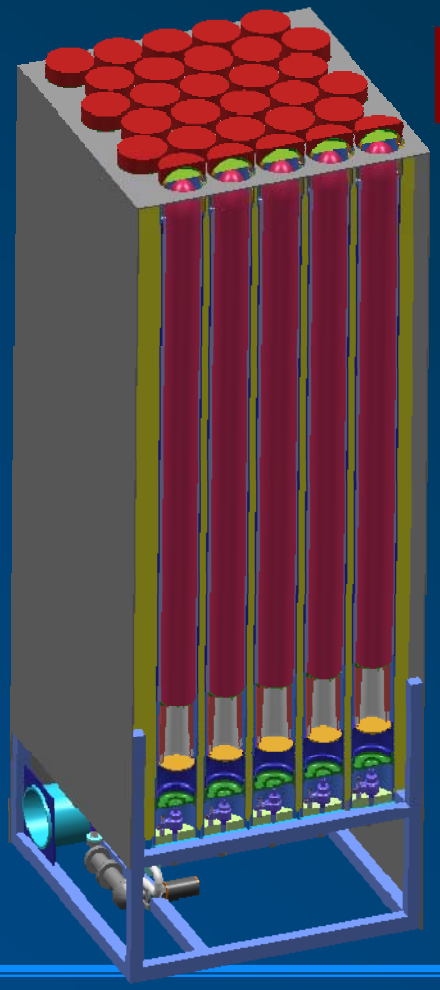




Key Technologies Can Enable the Concept

Conceptual Requirements

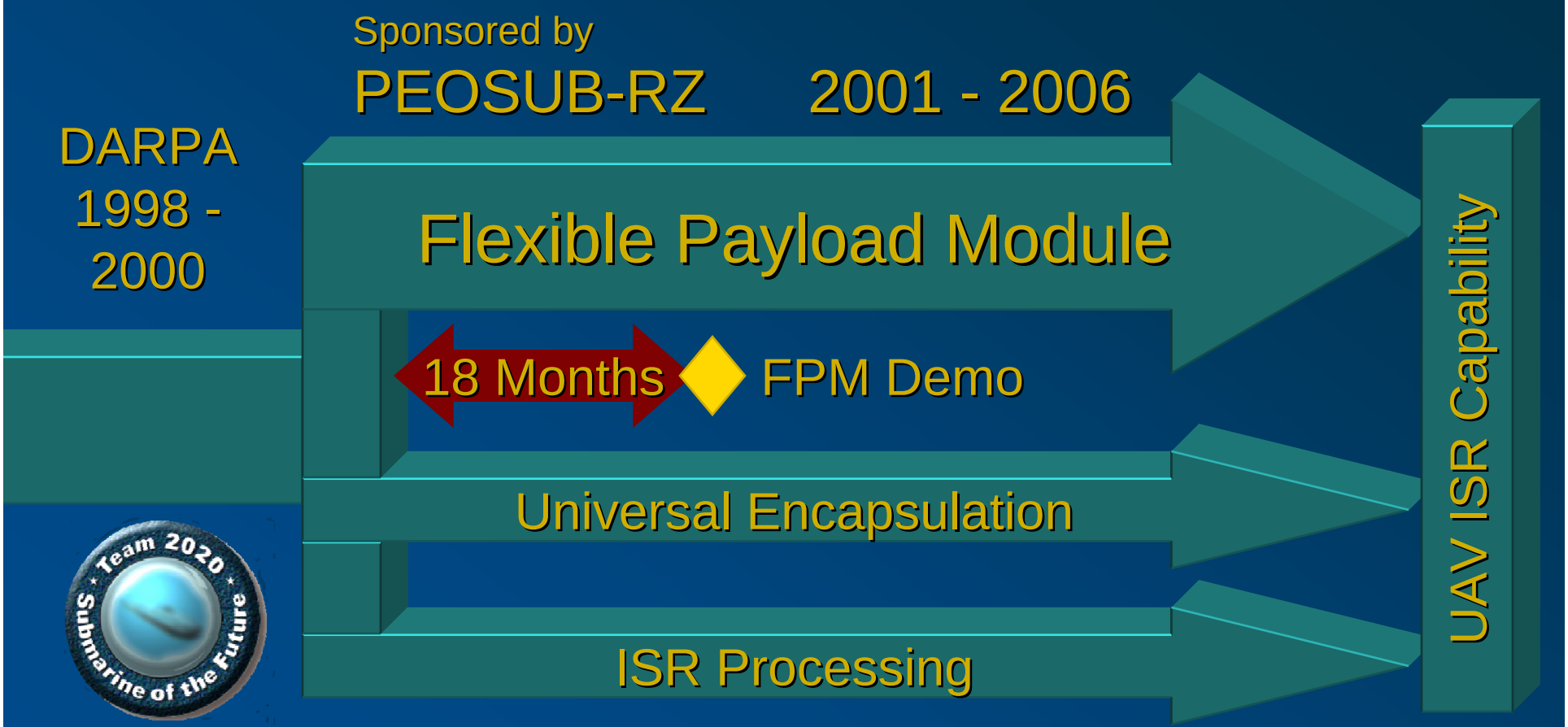
- Standardized Interface
- External Payload Enabler
- High Payload Density
- Fast Logistics
- Reloadable, Recoverable, Reusable
- Adaptable to Many Sizes and Shapes
- Work in conjunction with a payload capsule



Key Technologies

- Composite Structure
- Compact Expendable Hatch
- Shock Mitigation
- Network-Based Control System
- Wireless Communications
- Inductive Power Transfer

Payloads and Sensors Studies Transitioned into Risk Reduction Demonstrations

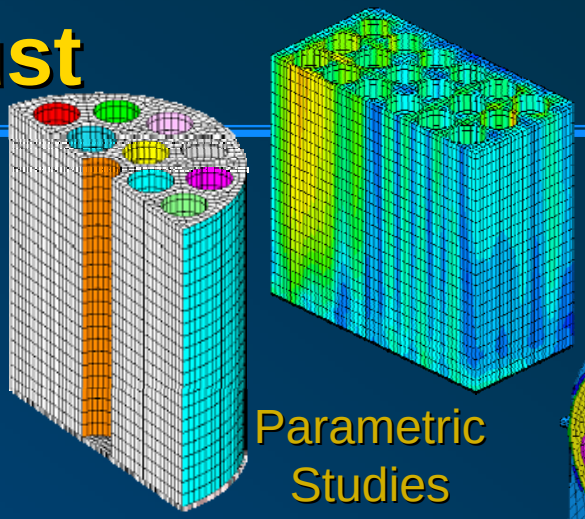


The Flexible Payload Module is moving from Concept Exploration through Risk Reduction

Phase 0	Phase 1	Phase 2	Phase 3
Concept Exploration	Program Definition & Risk Reduction	Engineering & Manufacturing Development	Production, Fielding, & Operational Support
System Analysis Reqts. Definition Conceptual Design Technology & Risk Assessment Prelim. Cost, Sched. & Perf. Concept	Concept Design Update Sub-system Tradeoffs Preliminary Design Prototype Testing Manufacturing & Supportability Considerations	Detail Design Development Risk Management Development Test & Evaluation System Integration, Test & Evaluation Manufacturing Process Verification	Production Rate Verification Operational Test & Evaluation Deployment Operational Support & Upgrade Retirement Replacement Planning

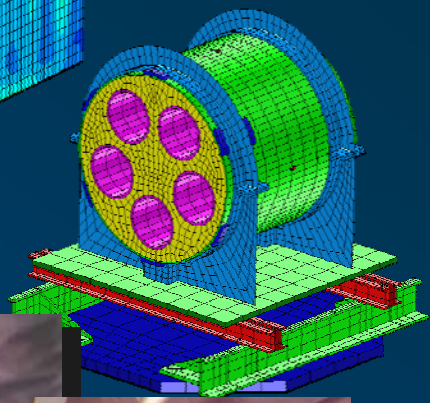
The Composite Construction Proved to be Simple and Robust

- Analyzed for Pressure and Shock Loads
  - Robust structure in any configuration
  - Shock testing validated the analysis
- Built at Quonset Point
  - Completed in 23 days
  - Exothermic reaction easily accommodated



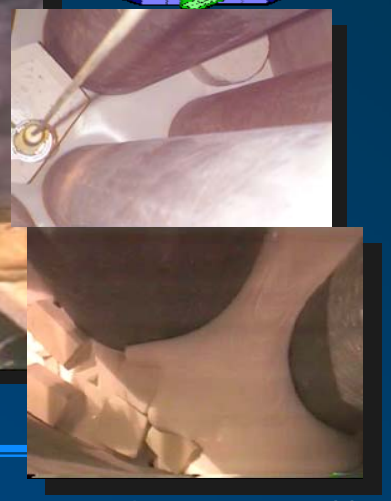
Parametric Studies

Shock Test Article





Syntactic Pour in FPM



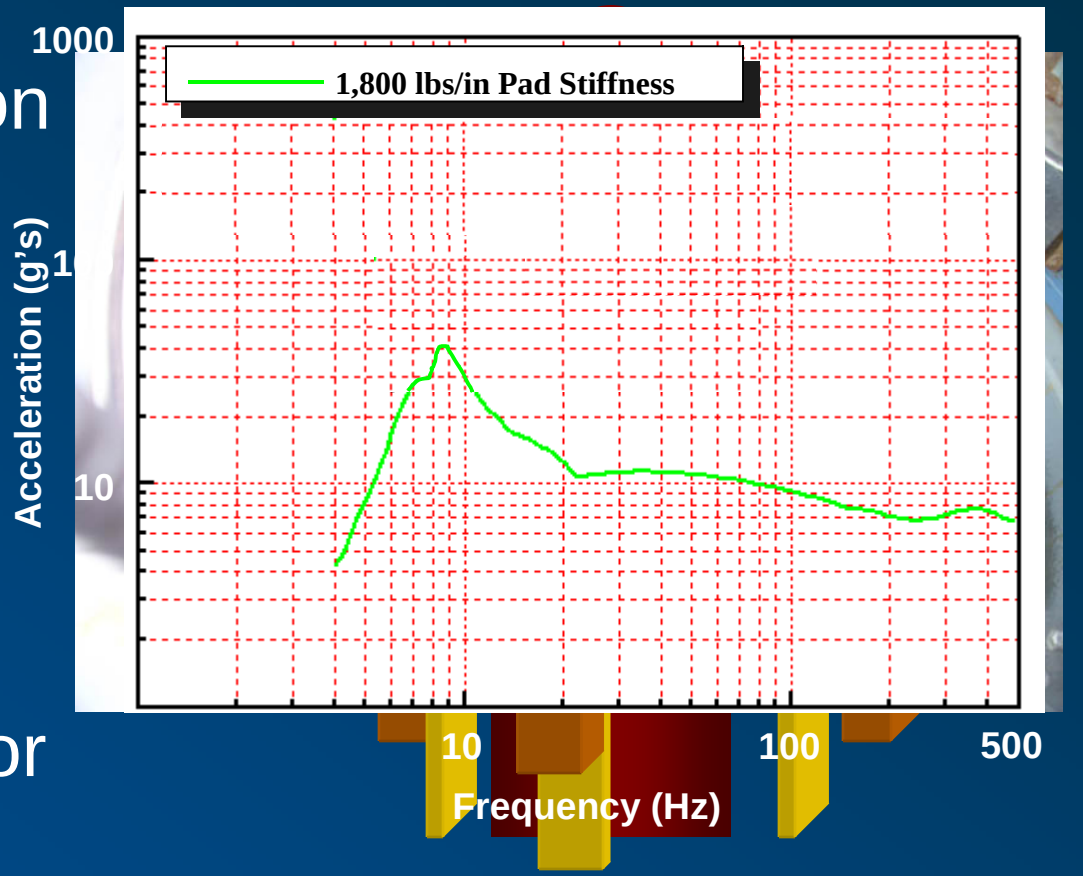
Compact Expendable Hatch Supports High Payload Density

- Combination of Steel Shell and Syntactic Buoyancy Element
- Eliminates Hinges and Actuators to Open and Close
- Hatch Release Actuator Designed to Maximize Packing Factor
- Floodable Air Volume Allows Hatch to Scuttle at Desired Time



Shock Mitigation Pads/Launch Rails Accommodate Joint Forces Payloads

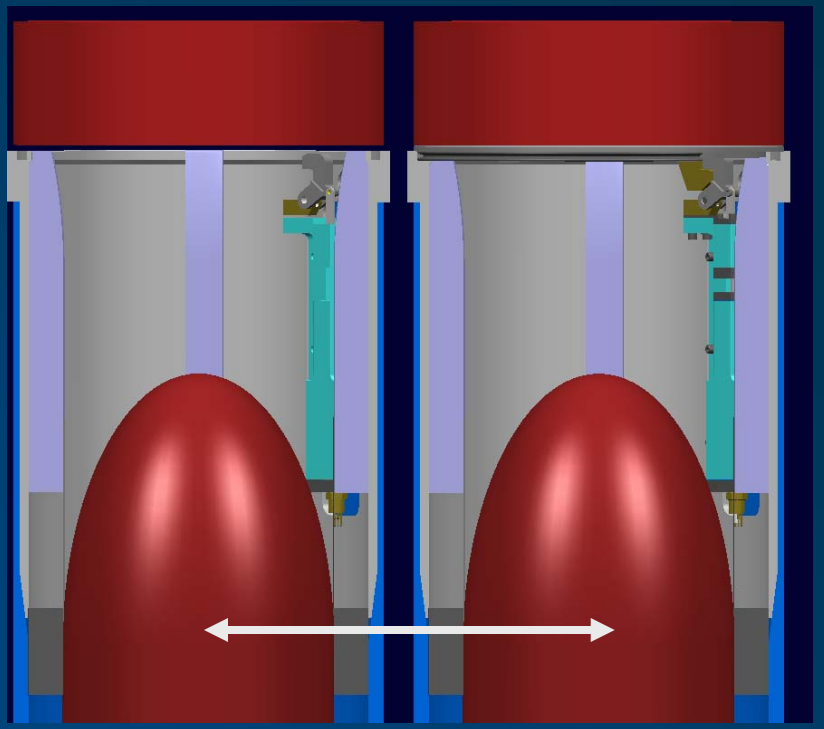
- Closed cell foam provides the mitigation for lighter payloads
  - Compresses under pressure to release capsule for launch
  - Reduces capsule accelerations to 10 - 30 g's
- Easily reconfigured for the next payload



Many of the Key Technologies Serve to Increase Payload Density

- Expendable hatch minimizes mechanical systems
- Foam filled structure allows closely packed tubes
- Shock mitigation pads reduce the accelerations and maximize packing factor

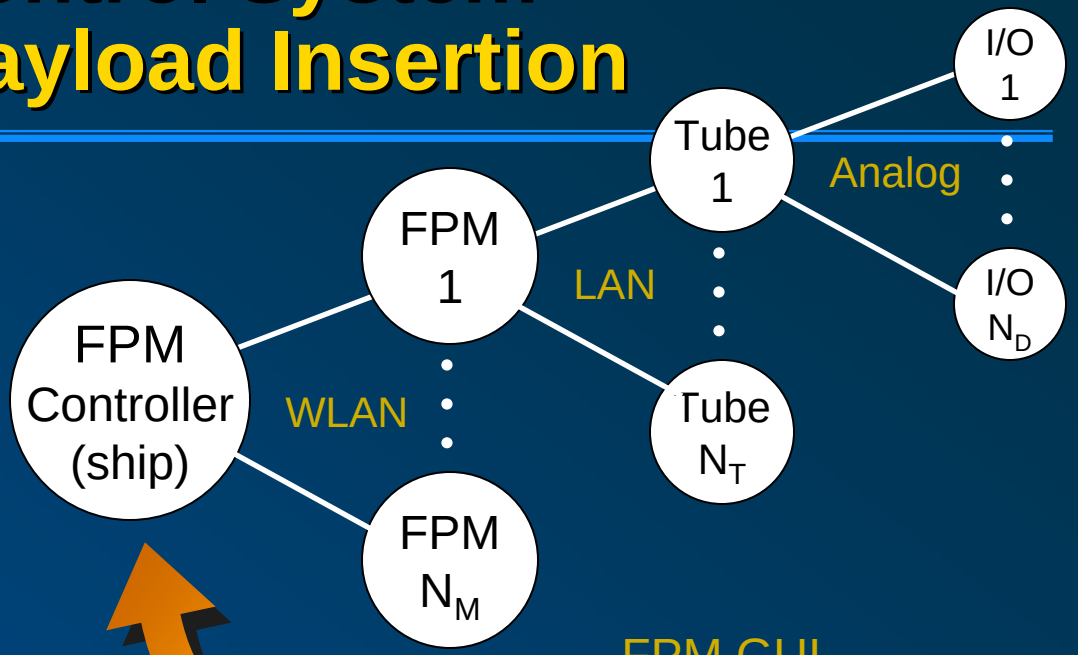
Section View of FPM



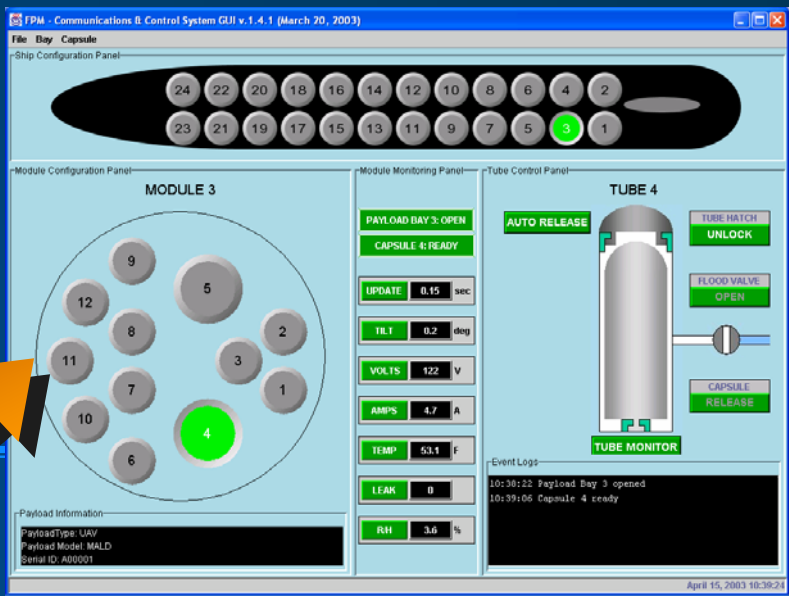
16.2” Centers Between
11” OD Capsules

Network-Based Control System Supports Rapid Payload Insertion

- Scalable, Flexible Architecture
- Built upon COTS Technology
- Provide intelligence onboard FPM platform
  - ↗ Enables “plug and fight”
- Shipboard User Interface uploads FPM configuration



FPM GUI



GENERAL DYNAMICS
Electric Boat

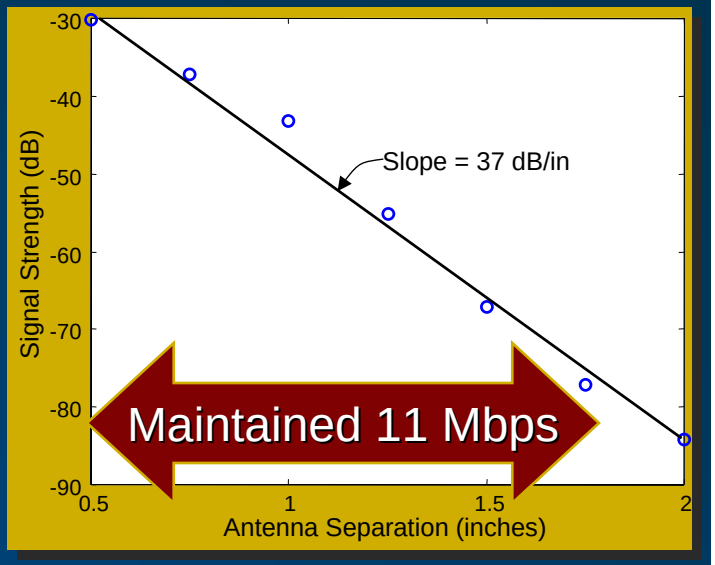
Commercial Wireless Networking Employed for the Ship/FPM Interface

- Leverages Network Based Architecture
- Commercial Standard IEEE 802.11b WLAN
- Capable of maintaining 11 Mbps over small seawater gap



Waterproof
Dipole Antennas

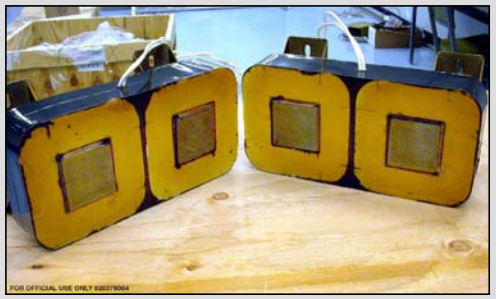
Attenuation of
2.4GHz RF in Seawater



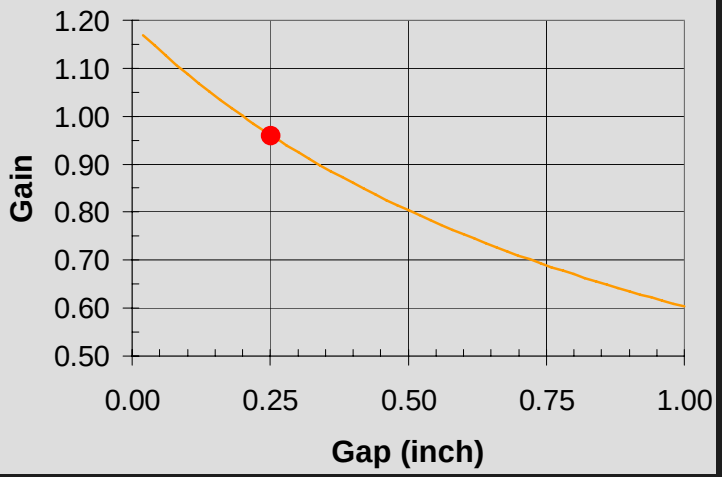
Inductive Power Transfer was Demonstrated Using a Split Core Transformer

- Demonstrated transfer of power from ship to FPM
  - ↗ 20 kW ultimate rating
  - ↗ 2 kW for demo FPM
- Environmentally sealed
- FPM-to-Capsule inductive coupler is under development





Output Voltage Regulation as a Function of Gap with a 200 Watt Load and a 120uF PFC Capacitor

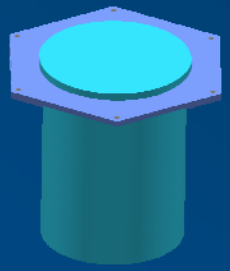


These Technologies Were Integrated Into a Demonstration FPM

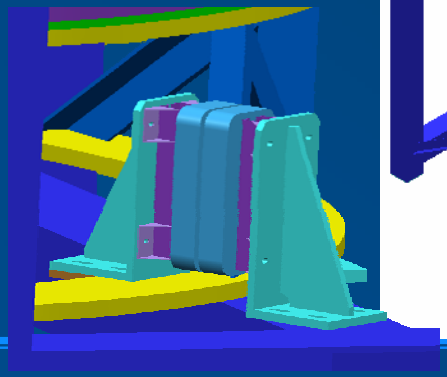
Shipboard GUI

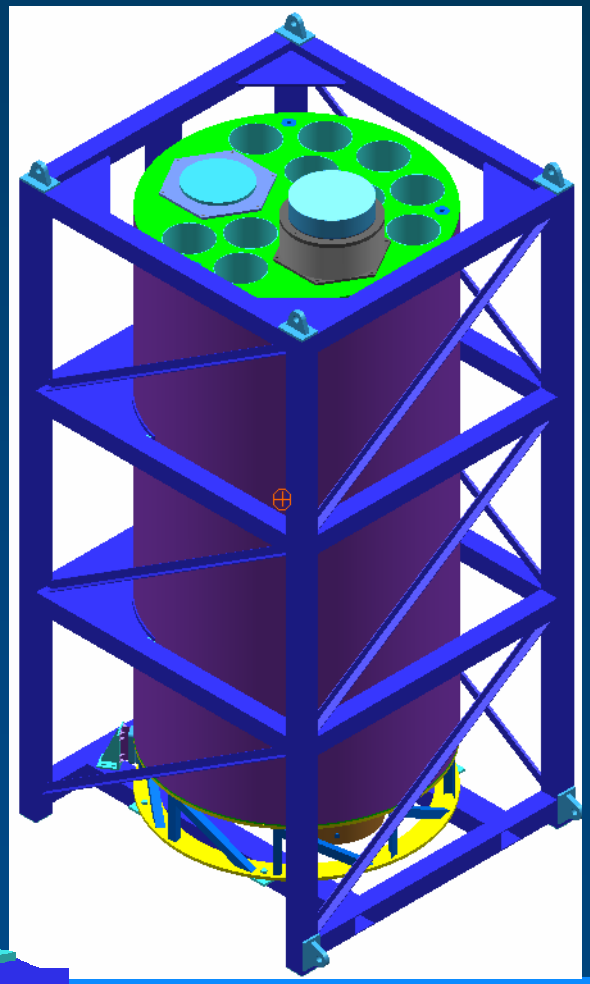


Onboard Electronics



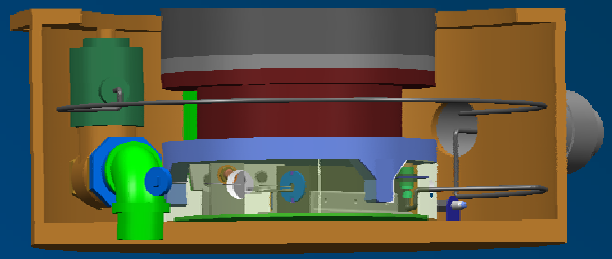
Wireless Connectivity & Inductive Coupler





Upper Housing





Lower Housing

These Technologies Were Integrated Into a Demonstration FPM

Shipboard GUI



Onboard Electronics

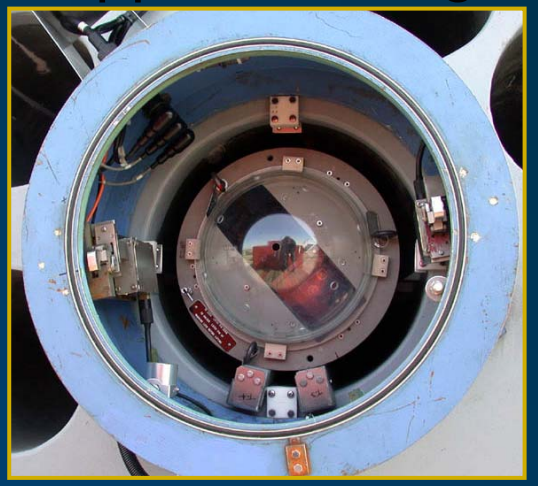


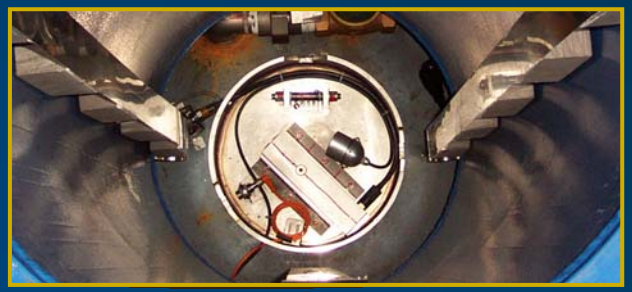
Wireless Connectivity & Inductive Coupler





Upper Housing

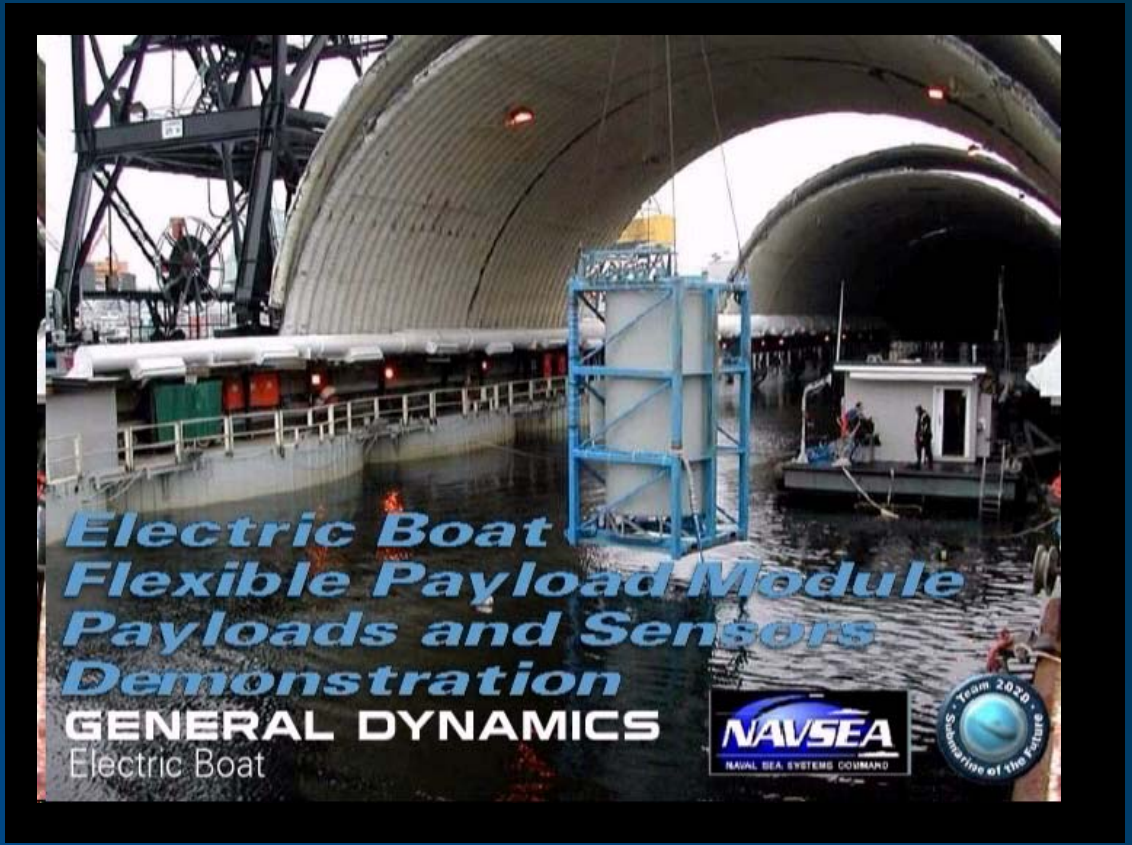




Lower Housing

The Full Size FPM Was Successfully Demonstrated at Electric Boat

- Employed all key technologies
- Demonstrated full system functionality
- Executed an automatic launch sequence
- Test-fit into a D5-sized missile tube



A Second Generation Flexible Payload Module Was Built For the 2004 Navy Silent Hammer Experiment

FPM Concept Refinement

- Full Scale Production Methods
- Network Based Control
- Wireless Technology
- Buoyant Capsule Integration



Flexible Payload Module (FPM)

Under Construction in Shipping Cradle



FPM integrated into a missile tube on USS Georgia

The Flexible Payload Module Provides an Open Architecture - System Level Solution To Meet Future Mission Needs

- Reduced cycle time to field new mission capability by minimizing payload specific ship modifications
- Decoupled payload development cycle from the ship development cycle
- Maintains critical warfighting performance
- Risk reduction on critical technologies has been accomplished

Electric Boat Is Moving Forward With The Payload Module Concept For The VIRGINIA Class Submarine



Headquarters U.S. Air Force

Integrity - Service - Excellence

Nunn-McCurdys Aren't Fun!

Mr. Gary Payton
Air Force Deputy Under Secretary
for Space Programs

Agenda

- National Security Space Enterprise (NSSE) acquisition programs health concerns & Nunn McCurdy breach
- Role of systems engineering
- “Back to Basics” block strategy

Our programs are only as good as our people

Nunn-McCurdy Breach Defined

- **Breach definition**
  - **“Infraction or violation of a law, obligation, tie, or standard”… and**
  - **“Broken, ruptured, or torn condition…”**
- **Nunn-McCurdy breach when PAUC or APUC exceed baseline value by 25%**
- **Two 1990’s flagship programs experienced Nunn-McCurdy breaches**

Nunn-McCurdy Law Requires

- **SecDef must address four questions:**
  - **Is the program essential to national security?**
  - **Are there alternatives?**
  - **Are new cost estimates reasonable?**
  - **Can management control costs?**
- **SecDef has three program certification options:**
  - **Certify “as is” with updated cost & schedule**
  - **Certify “as restructured”**
  - **“Not Certify” - TERMINATE**

Space Breach Programs - SBIRS

- **Part of Total System Program Responsibility (TSPR) experiment**
- **SBIRS breach in 2001**
  - **Restructured, BUT…**
- **2005 breach again**
  - **IPT – restructure**
  - **Management changes**
  - **Other impacts**

SBIRS Breach Root Causes

- **Systemic shortfalls in systems engineering:**
  - **No systems engineering master plan**
  - **No consistent requirements management**
  - **No single/linked integrated master schedule**
- **Systemic industrial base issues with:**
  - **Business practices**
  - **Personnel**
  - **Economics**
  - **Industrial capacity**

Space Breach Programs - SBIRS



Space Breach Programs - NPOESS



Space Breach Programs - NPOESS

- **NPOESS strategy: sacrifice cost and schedule to maintain performance with overruns paid from management reserves, program slips and accepting increasing risk**
- **When NPOESS Nunn-McCurdy breach announced**
  - **PAUC = 82% APUC = 202%**
- **NPOESS Nunn-McCurdy certification strategy:**
  - **IPP + restructure (fewer spacecraft and fewer sensors)**
  - **Government and contractor management structure change**
  - **NPOESS PEO established**
  - **Chief Systems Engineer position established**

Lessons Learned

- **Unbridled optimism regarding cost, schedule, performance, and risks is a recipe for failure**
- **Lexington paper scenario**
  - **Understated costs leads to lower budget**
  - **Leads to industry bidding price less than budget**
  - **Leads to lower award price**
  - **Leads to government repeatedly changing scope, schedule, budget profile, etc.**
  - **Leads to five to ten years later recognition "real" cost multiple of bid**
  - **Leads to Nunn-McCurdy Breach**

Lessons Learned

- **Reward “Being Honest”**
- **Budget to probable costs**
- **Break programs into more manageable blocks**
- **Recognize that TSPR doesn’t work**
- **Incorporate “Back to Basics” strategy**

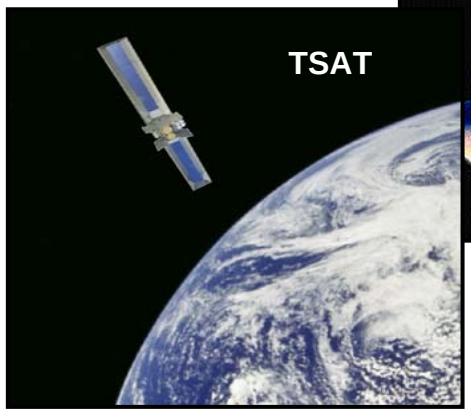
"Back to Basics" Acquisition

- **Four-stage process**
  - **Science & Technology**
  - **Technology Development**
  - **Systems Development**
  - **System Production**
- **Apportion risk among the stages**
  - **Highest risk in S&T**
  - **Base production on mature technology for lowest risk**
  - **Shorten cycle time**
- **Incremental deliveries**
  - **Block approach**









Closing

- **Every program is vulnerable**
- **Keep it simple**
- **Close program management**
- **Realistic budgets**

Systems engineering underpins success

NDIA
9th Annual Systems Engineering Conference
San Diego, California
October 23-26, 2006

Long-Term Product Support Requires Good Configuration Management

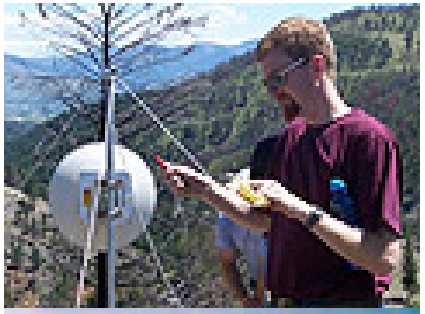
Mark Pellegrini
Jeanne Balsam
Lee Sheiner

Electronic Systems Laboratory
Georgia Tech Research Institute
Georgia Institute of Technology



Georgia Tech Research Institute (GTRI) Overview

- Unit of the Georgia Institute of Technology
- 1200+ employees
- 70% of research employees hold advanced degrees
- Wide variety of products
- Customers include federal and state government; and industry
- Competitively bid projects range greatly in size and duration
- More Info: http://www.gtri.gatech.edu/





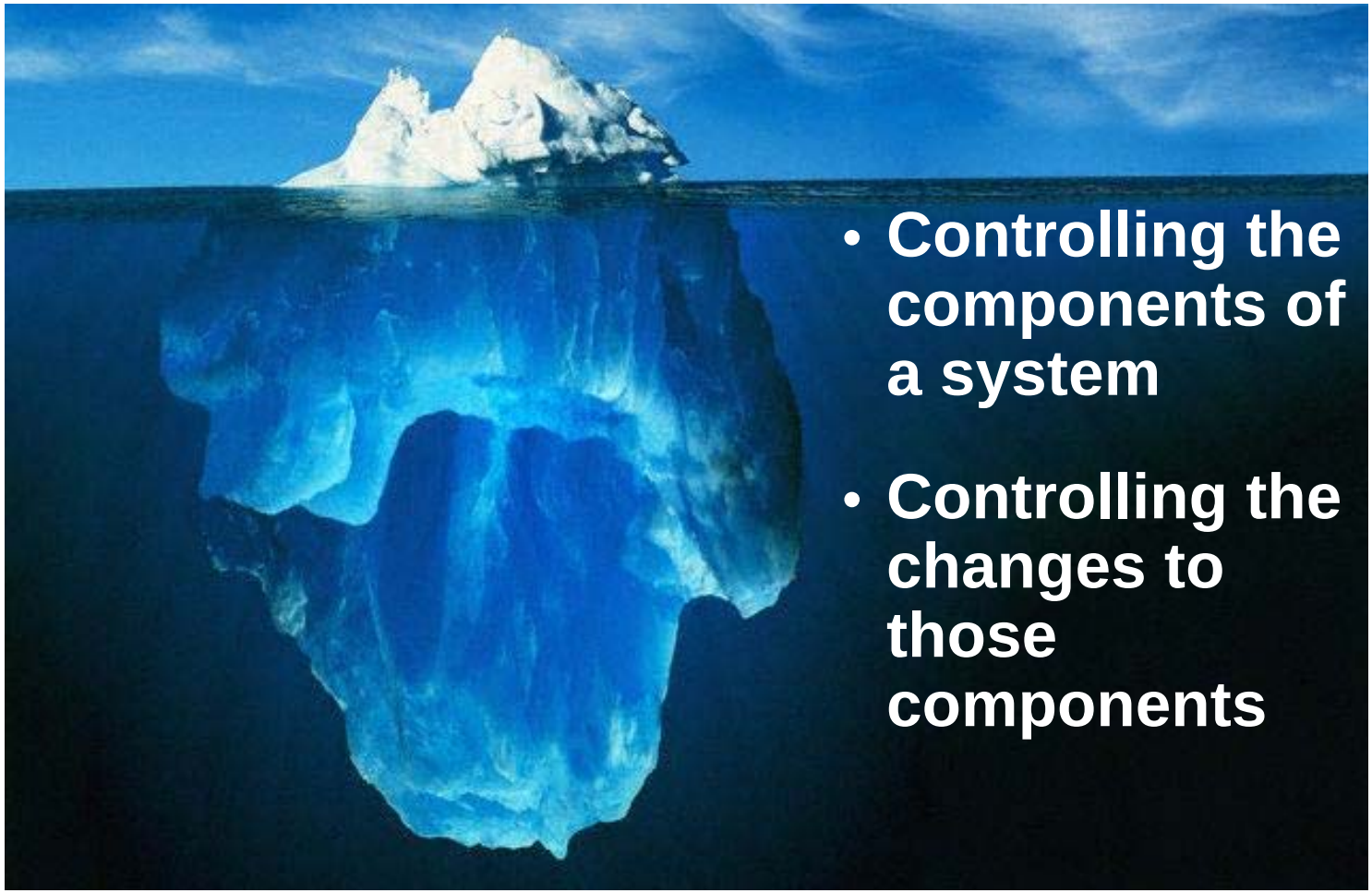


Overview



- Risks
- Some Configuration Management (CM) fundamentals
- CM environments
- Baselining
- Auditing baselines
- Summary & Conclusions
- Questions

What is Configuration Management?



- Controlling the components of a system
- Controlling the changes to those components

Important Things to Remember About Configuration Management

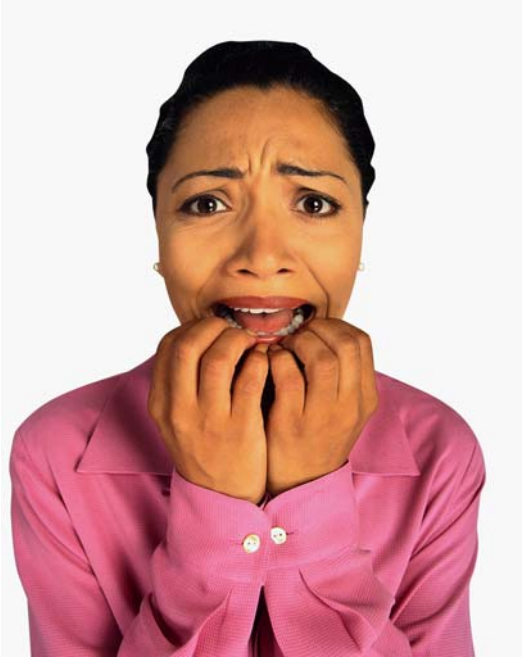
- Configuration management is not only for us, but for those who will follow in our footsteps
- Software products can consist of many different types of components
  - Source files used to build the product
  - Documentation
  - Released executables, DLLs, etc.
  - Third Party Components
  - Bitmaps, audio files
  - Test data, test results
  - And so on….



Risky Business



Some of the Risks



- Missing source files
- Wrong files used in builds
- Missing build instructions
- Missing deliverables
- Missing tools (e.g. compilers)
- Missing 3rd party software
- Unknown versions of 3rd party SW incorporated into releases
- Undocumented baselines
- Missing development environment information (e.g. IDEs)

The Result of Realized Risks

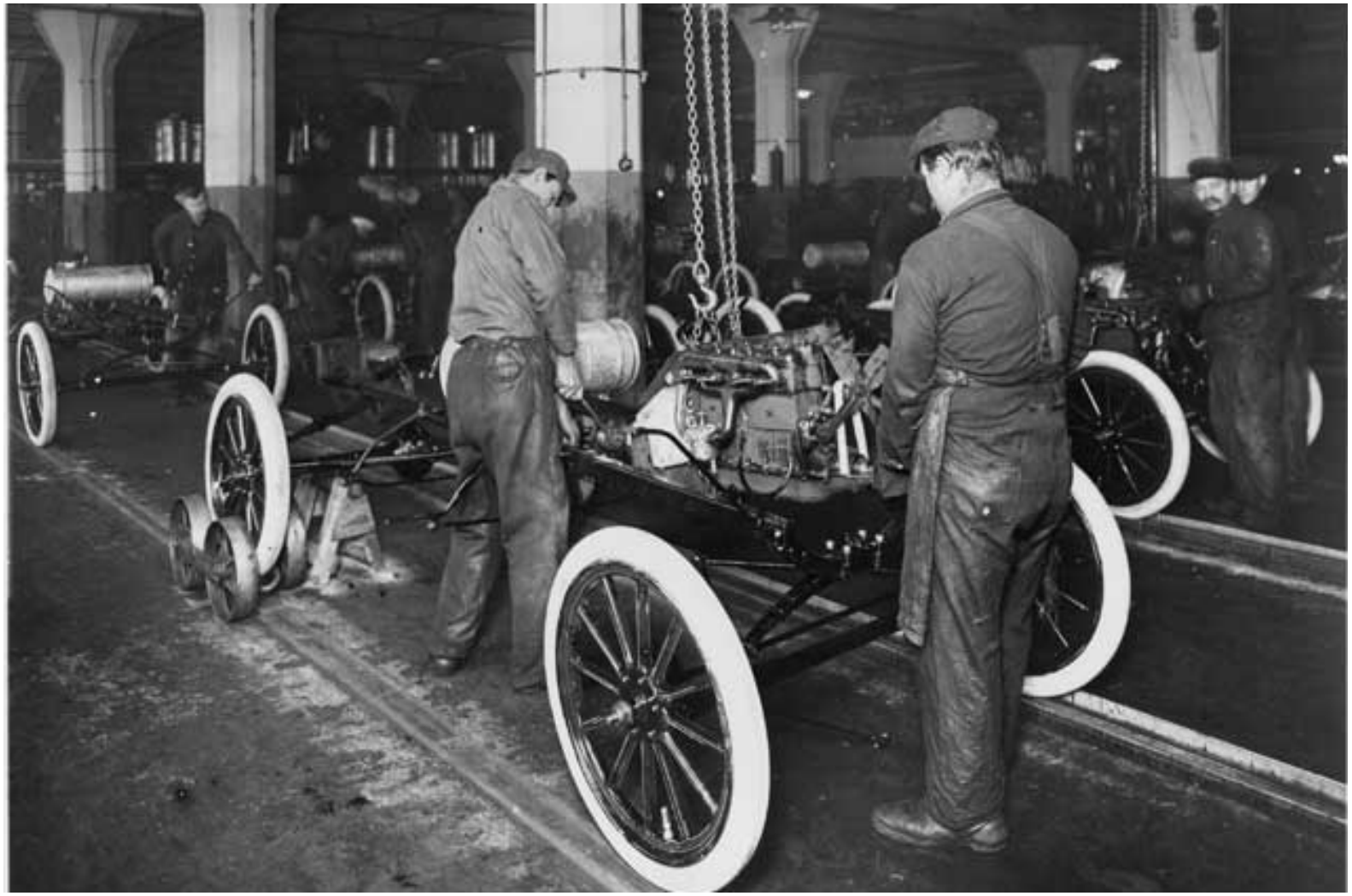
- Releasing the wrong products
- Can’t create variants
- Can’t re-build releases
- Can’t continue development
- Can’t take that vacation you were planning



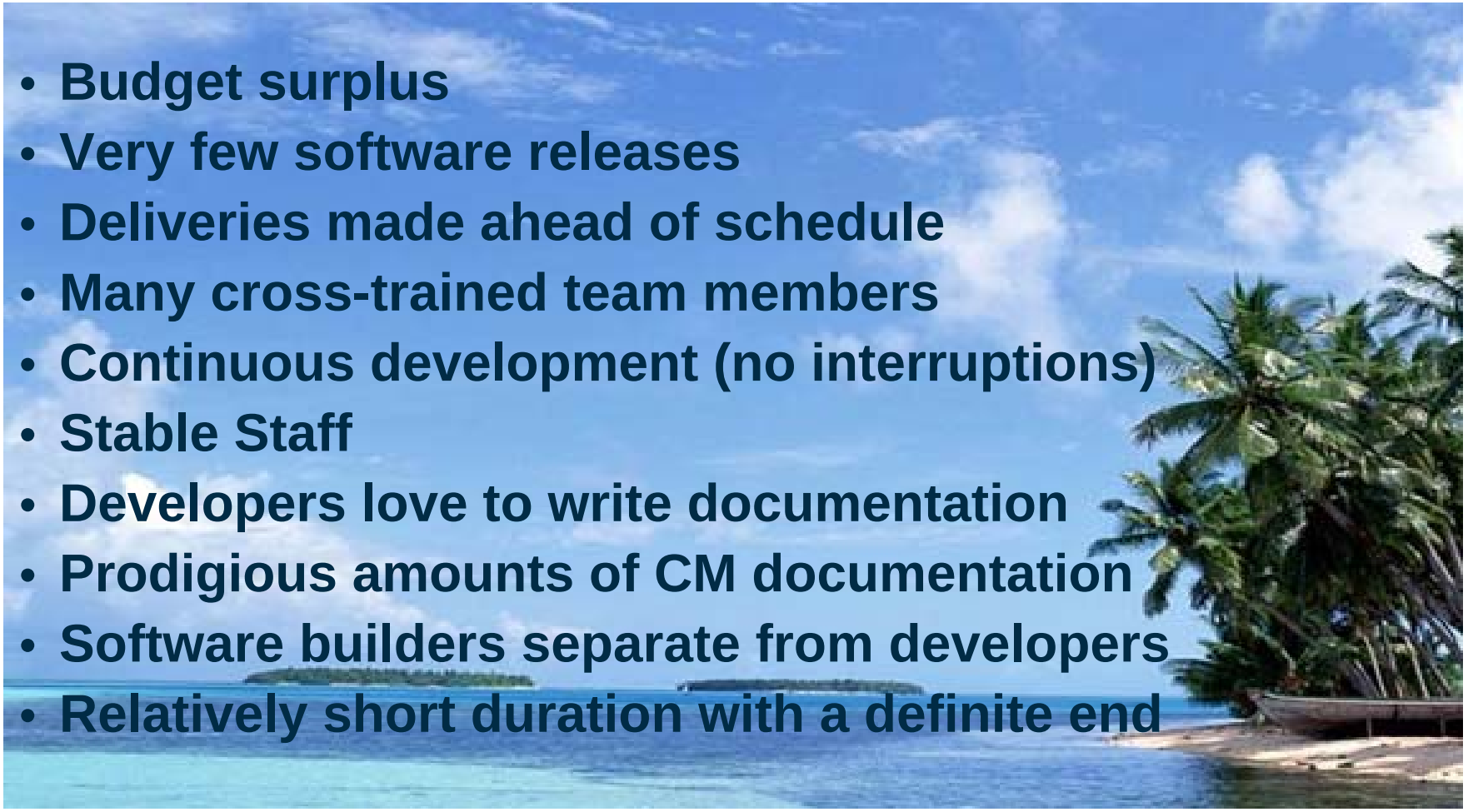
Comprehensive CM is Insurance



Development Environments

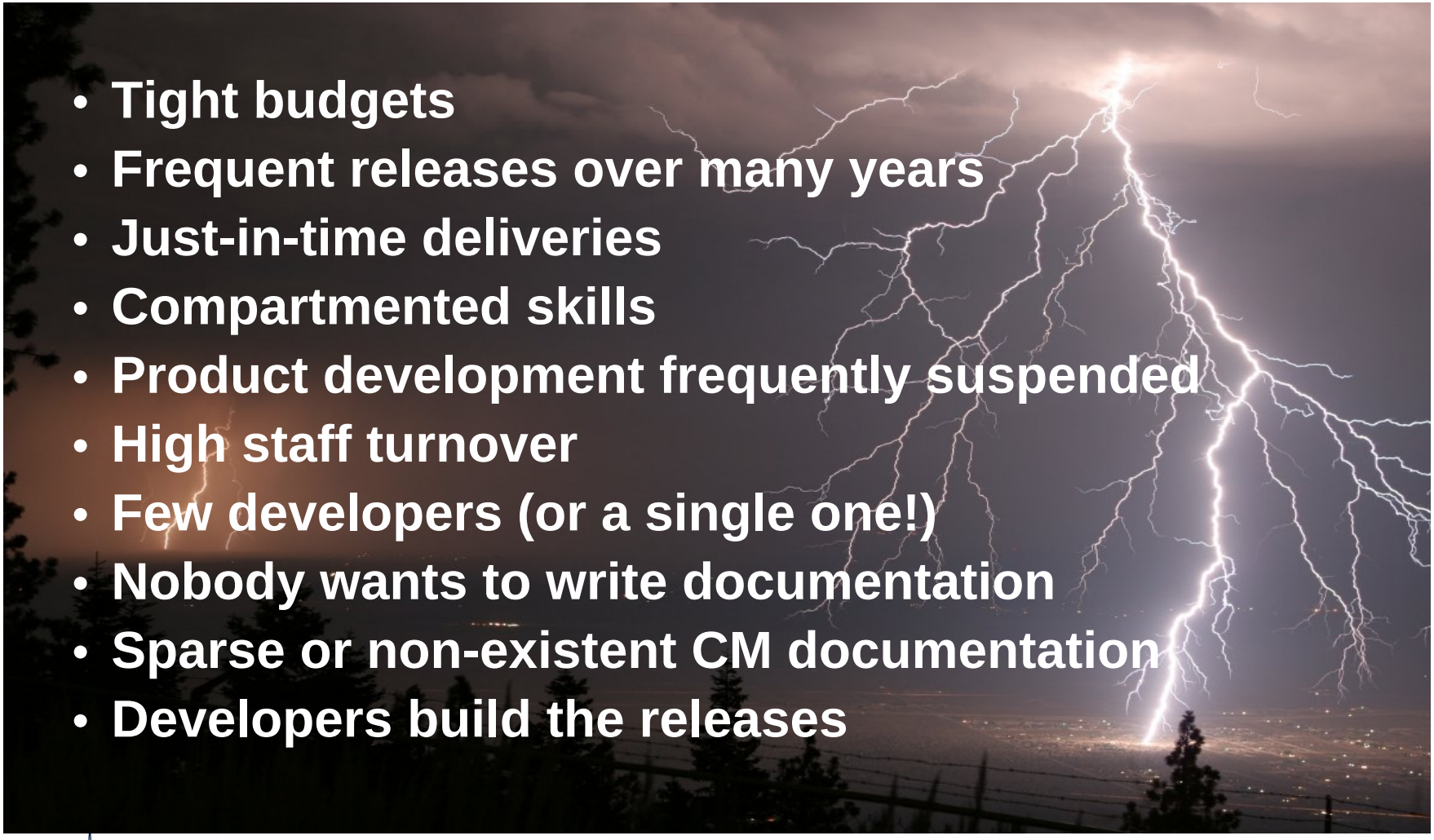


Ideal Software Development Environment for Good CM



- Budget surplus
- Very few software releases
- Deliveries made ahead of schedule
- Many cross-trained team members
- Continuous development (no interruptions)
- Stable Staff
- Developers love to write documentation
- Prodigious amounts of CM documentation
- Software builders separate from developers
- Relatively short duration with a definite end

Worst-Case Software Development Environment for Good CM



- Tight budgets
- Frequent releases over many years
- Just-in-time deliveries
- Compartmented skills
- Product development frequently suspended
- High staff turnover
- Few developers (or a single one!)
- Nobody wants to write documentation
- Sparse or non-existent CM documentation
- Developers build the releases

Our Assumed Environment

- Small project team
- Developers build and maintain their own source code and executables
- Product is expected to go through multiple releases, spanning years and perhaps decades
- Project team will likely change over the lifecycle of the product
- Product development may become dormant during lifecycle; developers may move from project to project

Long-Term, Small Projects Will Stress-Test Your CM Practices



Things Can Suddenly Change



- **Do not confuse the delivery of correct products with a process that delivers the correct products**
- **In other words, everyone is lucky sometimes; very few are lucky all the time**
- **In a weak CM environment, loss of key personnel can precipitate a CM disaster**

“Bus Number”

- The minimum number of developers you would have to lose to seriously affect your project
- Higher is better
- We prefer “Lottery Number”
- Don’t forget that buses can hit your development systems, too





Documenting Baselines



Proper Identification of Baselines

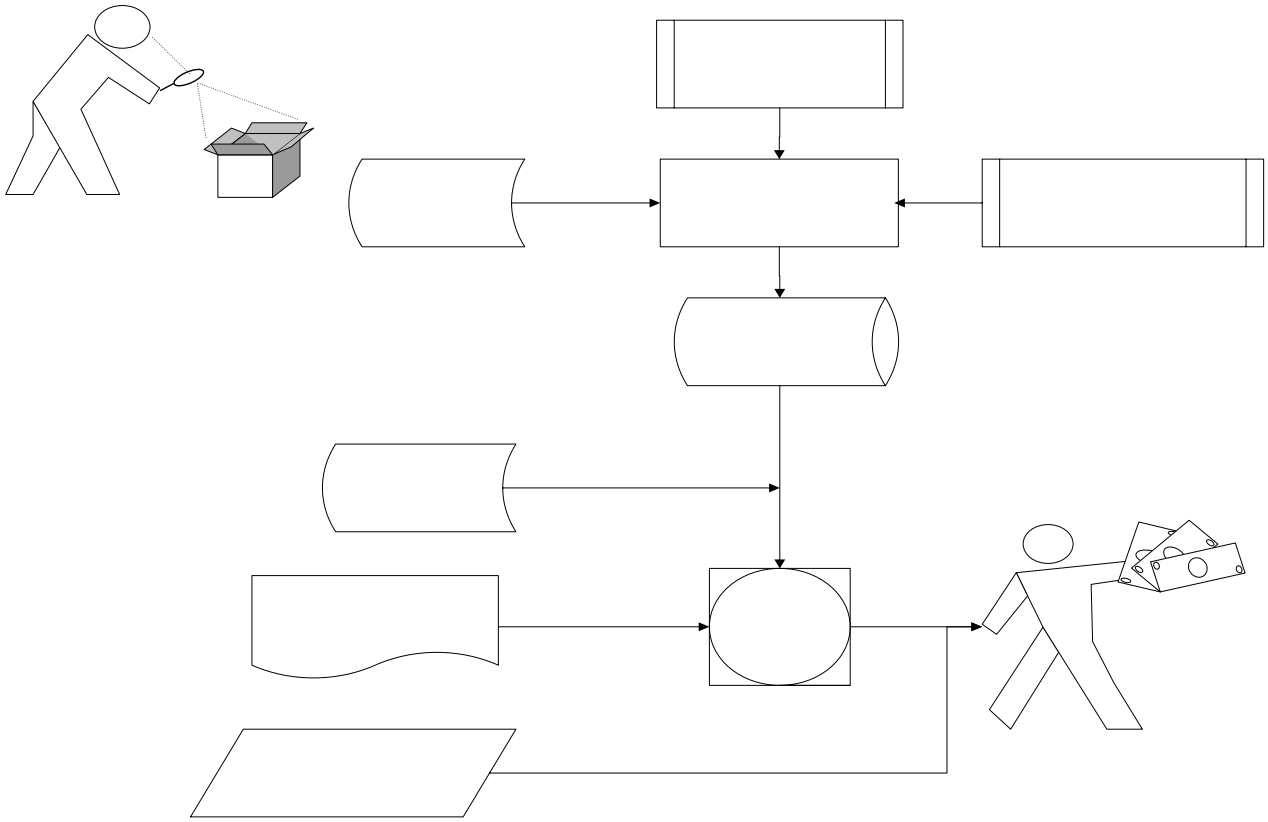
- All configuration items must be recoverable from the CM Library
- All configuration items must be identified
- Do not include extraneous items
- Good planning (and re-planning) helps to make defining baselines simpler



Product Version Description

- Developed for all Product Baselines
- Draft developed early to capture critical information
- Documents not only what is needed to build the product but how to build it
- Critically important, particularly if product development is suspended and/or product development team changes

Product Version Description: Bringing it all together



Product Version Description: Release & Build Descriptions

- Release
  - Physical inventory of materials released
  - Inventory of released product contents
  - Installation instructions
  - Changes from previous release
  - Operating instructions
- Build
  - Configuration items built
  - Inventory of configuration items needed to create the built items
  - Applications/tools required to build
  - Build procedures

Product Version Description: Other Information

- **Instructions for building installation disk**
  - Include CM Library location and version of script files, if a script is used
- **Known problems/planned upgrades**
  - Workarounds
  - ECRs (Engineering Change Requests)

***In general, more detail is better than less*.**

Someone who has not developed the product must be able to build it from the PVD!

Baseline Audits



Auditor Questions

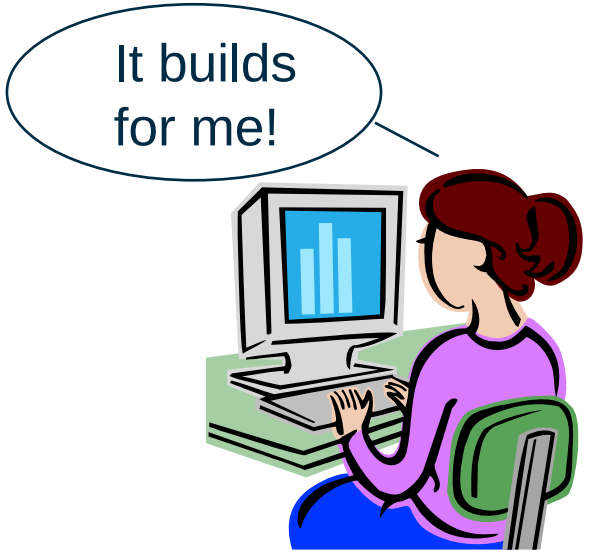
- Exactly what are we delivering?
- Which of these delivered items are we responsible for building?
- Where are the components we need to build those items?
- What are the tools we need to build them? Where are these tools?
- How do we build the items we need to build?
- How do we know we built the right thing?



Independent Audits are Indispensable



Auditor



Developer

Verification of Baselines

- **“Clean Machine” must be used for verification of the integrity of the baseline as documented in the Product Version Description**
- **Clean Machine must not use networked drives during build (unless specified by PVD)**
- **Use virtual machines and ghost images to efficiently create Clean Machines**
  - **Development environment**
  - **Runtime environment**



Summary and Conclusions



Some Things to Remember…

- Control all items needed to build the product (including install disk), not just source files
- Control all tools needed to build the product
- Control all scripts, IDE configuration files, or other files used in the build process
- Capture development environment nuances or problem solutions in real-time – don't wait
- Document baselines thoroughly, including build instructions
- Audit baselines independently, on clean machines; install on a clean machine too

Determine the Best Practices for You



- Discover your weaknesses
- Evaluate what your risks are
- Estimate your costs for failure
- Trying to address everything all at once may be impractical - prioritize
- Use approaches that are practical for your situation
- Do what makes sense

Wrap-Up



Contact Information

- **Mark Pellegrini**
  - mark.pellegrini@gtri.gatech.edu
- **Jeanne Balsam**
  - jeanne.balsam@gtri.gatech.edu
- **Lee Sheiner**
  - lee.sheiner@gtri.gatech.edu

- **More Info about GTRI:**
  http://www.gtri.gatech.edu/

Top 5 Systems Engineering Issues within DOD and Defense Industry

Task Report

July 26-27, 2006

Task Description

Identify Top 5 Systems Engineering problems or issues prevalent within the defense industry

- Update status and re-validate SE issues from 2003
- Agree upon Top 5 SE issues for 2006

Document issues

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

Generate task report

- Submit to OSD mid-August 2006

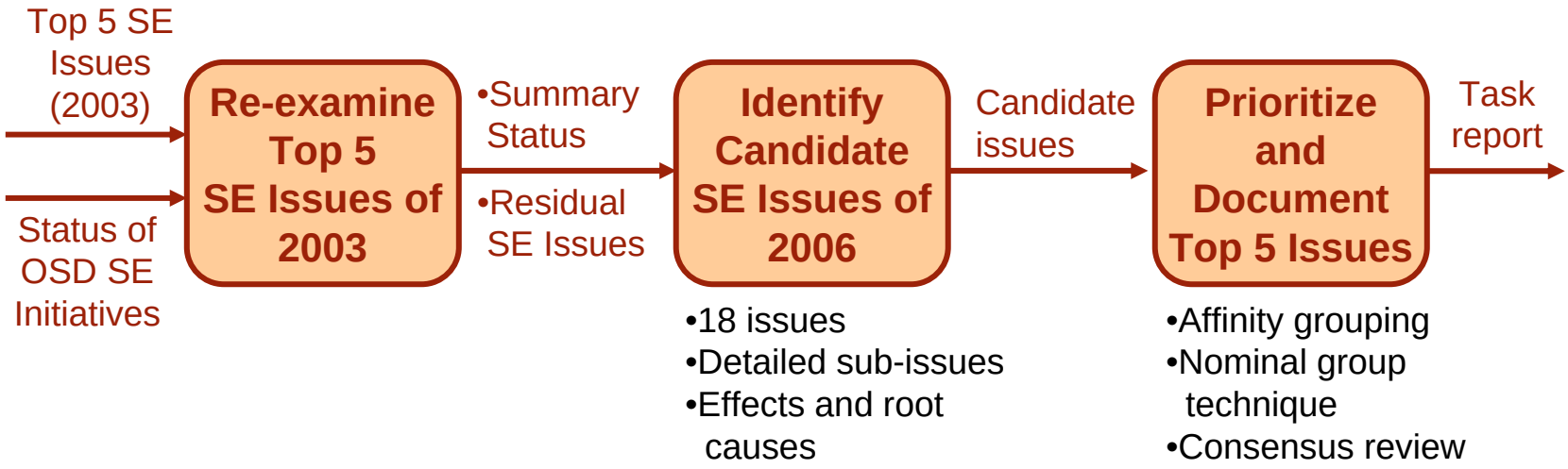
Task Group Participants

18 participants from industry and government

Alion Science and Technology
Boeing IDS
Harris
Lockheed Martin
Northrop Grumman
Orbital Sciences Corp
Simulation Strategies
SPARTA, Inc.
Raytheon SAS
Marine Corp Systems Command
National Defense University, Industrial College of the Armed Forces (ICAF)
SAF/AQRE
Software Engineering Institute
USAF Center for Systems Engineering

- Task Group Leads: Geoff Draper, Harris Corp, and Hal Wilson, Northrop Grumman

Task Group Activities



Background – Top 5 SE Issues of 2003

Top 5 Systems Engineering Issues (2003)

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

Details on NDIA Systems Engineering Division web site

http://www.ndia.org/Content/ContentGroups/Divisions1/Systems_Engineering/PDFs18/Modeling_Committee_PDFs/February2003_top_5_issues.pdf

Summary of OSD Initiatives for SE Issues

OSD Initiative	Summary
Policy updates	• Systems Engineering Plan (SEP) on all programs • OSD SEP reviews for ACAT 1D and 1AM programs • Each PEO shall have a lead or chief systems engineer who monitors SE implementation within program portfolio • Event-driven technical reviews with entry criteria and independent subject matter expert participation
Improved SE Guidance	• Defense Acquisition Guidebook • SEP Preparation Guide • IMP/IMS Guide • Risk Management Guide • Capability Maturity Model Integration-Acquisition Module (CMMI-AM)
Education and Training	• Strengthened SE curricula via Defense Acquisition University (DAU) • Certifications • Continuous Learning Modules for R&M, Technical Reviews, System Safety, M&S in SE • Enhanced career paths
System level assessments	• Non-advocate program support reviews • Technical Planning Review
Integrating Development T&E with policy and assessments	• Effective early engagement
Outreach	• SE Forum • Leverage partnerships with industry and academia • Standup and participation in SE WIPTs

Reference: Systems Engineering Update, NDIA Top 5 Issues Workshop. July 26, 2006. Briefing by Mr. Robert Skalamera, Deputy Director, Systems and Software Engineering (Enterprise Development), Office of the Deputy Under Secretary of Defense (A&T)

Assessment of Top 5 SE Issues from 2003

Issue (2003)	Summary Assessment (2006)
Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs	• Awareness achieved by top-down policy, guidance, training, organizational structures, etc. • Others aspects, such as buy-in, recognition of value, or behavioral changes are not yet consistently evident. • Measures of effectiveness are needed
Adequate, qualified SE resources are generally not available within Government and industry for allocation on major programs	• Qualifications addressed via training and certifications, but not necessarily the depth of the pipeline • Availability of adequately skilled SEs remains an issue for both government and industry (diminishing availability to support growing needs and increasing complexity)
Insufficient SE tools and environments exist to effectively execute SE on programs	• Model-based tools, methods, and repositories are improving, and are applied in training • Still need better integration of tools and methods across SE and other disciplines • Modeling and simulation plans need to be implemented
Requirements definition, development and management is not applied consistently and effectively	• Improved guidance has yet to be consistently implemented • Must address capabilities as well as specified requirements
Poor initial program formulation	• SEP policy, guidance, and event criteria should improve program plans and estimates, but effectiveness not yet clear • Greater coordination and integration of government/contractor plans needed early in acquisition life cycle • Greater integration of interfaces between acquisition, requirements, and programmatics needed

Top 5 SE Issues - 2006

- **Key systems engineering practices known to be effective are not consistently applied across all phases of the program life cycle.**

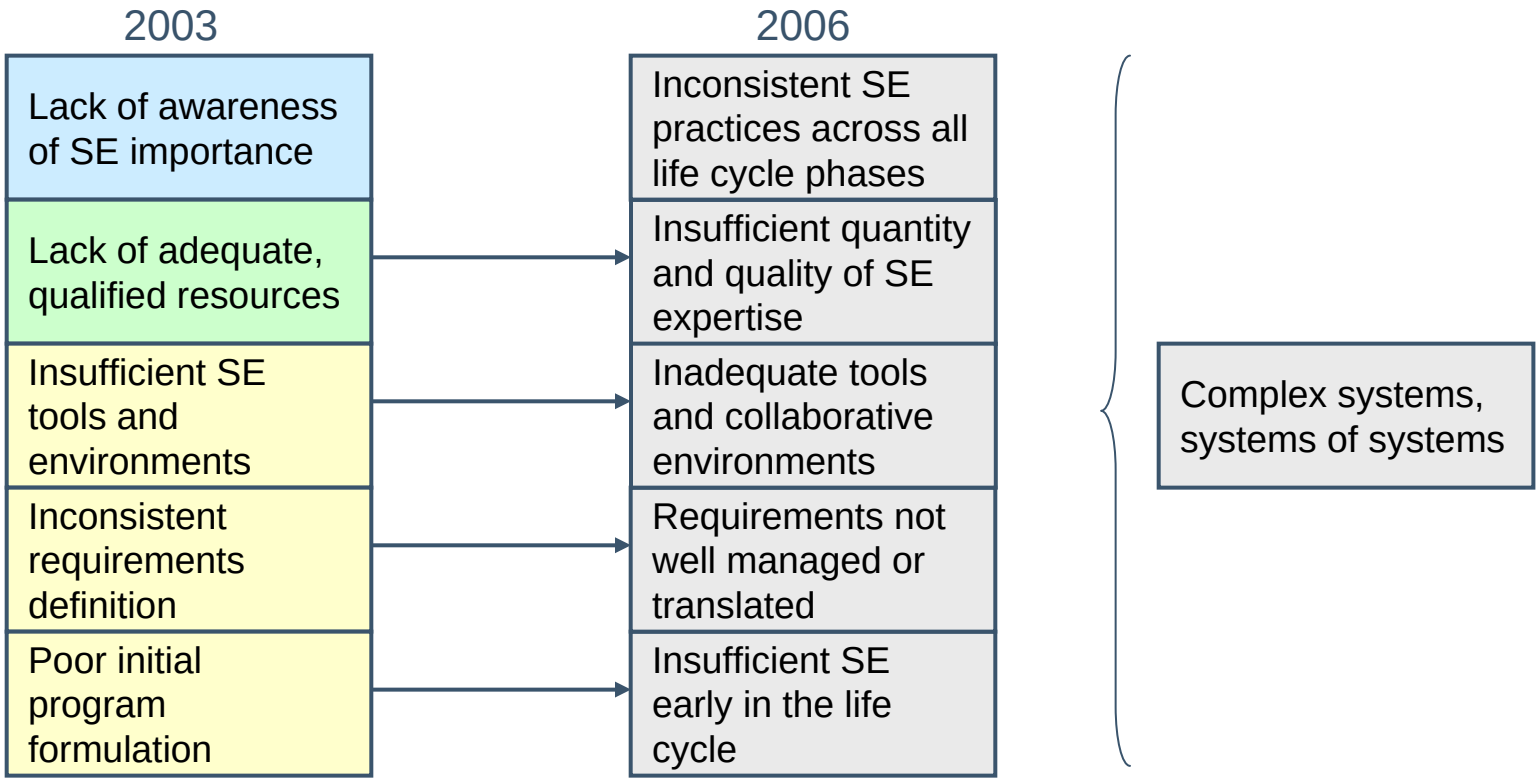
- **Insufficient systems engineering is applied early in the program life cycle, compromising the foundation for initial requirements and architecture development.**

- **Requirements are not always well-managed, including the effective translation from capabilities statements into executable requirements to achieve successful acquisition programs.**

- **The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and the defense industry.**

- **Collaborative environments, including SE tools, are inadequate to effectively execute SE at the joint capability, system of systems (SoS), and system levels.**

Summary - Evolution of Top SE Issues



Though progress is being made, the environment is changing and many underlying issues still remain.

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Details of Top 5 SE Issues of 2006

Issue 1: Key systems engineering practices known to be effective are not consistently applied across all phases of the program life cycle.

Discussion Points:

- Inconsistent SE practices for program planning and execution
- Companies do not always execute at claimed CMMI® levels
- Confusion between architecting, SE, frameworks (DODAF)
- Lacking consistent SE measures (effectiveness, value, ROI)
- Technical baselines not always established, controlled, and maintained
- Risk management inconsistent; guidance lacks specificity, opportunities
- Dependencies on external interfaces outside program control (e.g., SoS)

Recommendations:

Ensure institutionalization of effective SE practices into program planning and execution

- Define and monitor required SE practices (e.g., DAG) for each phase
- Strengthen CMMI® for deployment of appraised processes on all programs
- Require appropriate SE measures across the life cycle (e.g., PSM, LAI)
- Require use of DOD Risk Management Guide, per joint working group
- Define and promulgate interface change control processes for SoS

®CMMI is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

Issue 2: Insufficient SE is applied early in the life cycle, compromising the foundation for initial requirements and architecture development.

Discussion Points:

- Requirements, budgets, schedules established without adequate SE.
- Optimistic cost and schedule estimating.
- SE and PM functions are not well integrated, roles/responsibilities unclear.
- SE compromised in planning and design when SE value not understood.
- SoS inter-program complexity not accommodated in SE planning.

Recommendations:

Integrate engineering planning within the acquisition life cycle to ensure adequate time and effort for SE early in the program life cycle.

- Expand SEP policy to address risks of inadequate SE prior to Milestone A
- Establish guidance on SE/PM roles, responsibilities, communications
- PMs ensure distribution of SE effort among prime and subcontractors
- Increase PM awareness of value of effective SE
- Provide guidance for SE activities needed for SoS
- Integrate acquisition processes with requirements, programmatics to ensure procurement is consistent with schedule, resources, constraints
- Expand independent, non-advocate reviews of program formulation

Issue 3: Requirements are not always well-managed, including the effective translation from capabilities statements into executable requirements to achieve successful acquisition programs.

Discussion Points:

- Management structures and roles not well understood for SoS, capabilities
- Critical common element areas across capability areas must be identified, managed
- Capabilities broaden engineering trade space due to less specific requirements.
- Do not always have adequate access to trained SE resources for defining capabilities
- SoS environment strains capability process due to extended complexity, governance
- Inadequate understanding of true capabilities needed by warfighters
- Translating SoS capabilities into insertable technology across legacy systems requires series of feedback loops

Recommendations:

Emphasize the application of SE practices and resources to the capability definition process to address warfighter needs and translation into executable programs

- Lead the effort to require roles and structure that include SE in capabilities definition
- Standardize terms, processes, and methods for SoS and enterprise SE
- Enhance the application of SE to capabilities development to better define systems elements common across capabilities
- Emphasize technical planning for systems adaptability and technology insertion from program onset
- Emphasize the need for expanded contractor communications and interactions in early requirements definition process
- Encourage adoption of CMMI best practices for requirements (acquisition, development)

Issue 4: The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and the defense industry.

Discussion Points:

- Short supply of experienced, trained SE in government and industry.
- PM/SE turnover and fewer opportunities for OJT.
- Inconsistent SE certification methods across government and industry.
- Inconsistent roles and responsibilities across services results in inefficient use of government and industry resources

Recommendations:

Grow SE expertise through training, career incentives, and broadening "systems thinking" into other disciplines.

- Modify SEP template to clearly specify required SE qualifications for program staffing
- Work with academia to include introductory SE course in degree programs, establish recommended curricula for consistent skills
- Establish SE job code and career incentives for promotion into PM
- Require "systems thinking" training for other disciplines and PM to expand SE candidate pool
- Encourage an integrated and consistent SE certification definition between industry and govt.

Issue 5: Collaborative environments, including SE tools, are inadequate to effectively execute SE at the joint capability, system of systems (SoS), and system levels.

Discussion Points:

- Collaborative, information-sharing environments are needed to enable all stakeholders to work together effectively (M&S, workflow, design tools)
- Policies, guidance, standards inadequate for interoperability/sharing/reuse
- Expanded complexity of the SE trade space due to capabilities, SoS, PBA, etc. exceeds capabilities of current tools and environments (M&S, MBSE)

Recommendations:

Strengthen and clarify policy and guidance regarding use of collaborative environments, models, simulations, and other automated tools.

- De-conflict policies and standards to enable data sharing, tool interoperability
- Establish partnerships and roadmaps for evolving tool capabilities
- Define best practices and education to foster use/sharing of tools and data
- Sponsor definition of and encourage the use of a DoD business model facilitating shared information and tools
- Implement Acquisition Modeling and Simulation Master Plan

Top Software Engineering Issues in the Defense Industry

NDIA Systems Engineering Division

and Software Committee

September 26, 2006

Task Description

Identify Top 5 Software Engineering problems or issues prevalent within the defense industry

- NDIA Workshop August 24-25, 2006, Washington D.C.

Document issues

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

Generate task report

- Submit to OSD

Task Group Participants

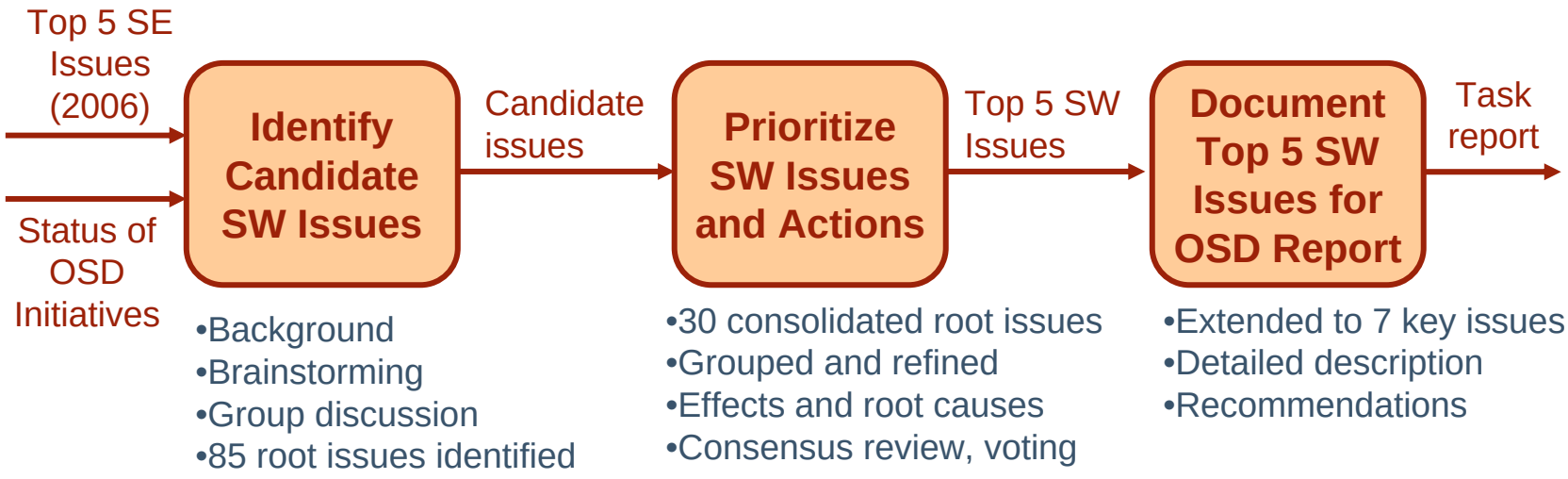
26 workshop participants from industry, government, academia

- **Additional inputs received via email**

BAE Systems
The Boeing Company
Center for Strategic and Intl. Studies
Computer Sciences Corporation
Department of Defense (DoD)
Defense Contract Mgmt. Agency (DCMA)
Florida Institute of Technology
Harris Corporation
Jacobs Technology
Lockheed Martin Corporation
Massachusetts Institute of Technology (MIT)
The MITRE Corporation
Naval Air Systems Command
OUSD (A&T)
Open Systems Joint Task Force
Raytheon Company
RDECOM ARDEC
Asst. Secy. of the Air Force (Acq), SE Division
Software Engineering Institute (SEI)
Systems and Software Consortium
U.S. Air Force Aeronautical Systems Center

Task Group Leads:
Geoff Draper (Harris)
Jeff Dutton (Jacobs Technology)

Task Group Activities



Common Themes Noted

Increasing demands for rapid response to changing threats

- New warfighter capabilities
- Unprecedented complexity
- Increasing dependence on large, software-intensive systems

Evolving acquisition environment

- Innovative and aggressive acquisition strategies
- Extensive reuse of legacy components and system portfolios
- Reductions in acquisition work force due to force-shaping measures

Current approaches for acquiring, developing, verifying, and sustaining software enabled systems are inadequate to deal with the complexities of a dynamic and changing acquisition environment.

Top Software Issues

1. The impact of requirements upon software is not consistently quantified and managed in development or sustainment.
2. Fundamental system engineering decisions are made without full participation of software engineering.
3. Software life-cycle planning and management by acquirers and suppliers is ineffective.
4. The quantity and quality of domain-knowledgeable software engineering expertise is insufficient to meet the demands of government and the defense industry.
5. Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.
6. There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.
7. Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

Issue 1: The impact of system requirements upon software is not consistently quantified and managed in development or sustainment.

Discussion Points:

- Impacts of changes to requirements not addressed consistently.
- SW requirements are not always adequately addressed in system level requirements or solicitations/contracts.
- Conditions leading to SW reqts changes are not clearly understood.
- Weak linkage to SW requirements for capabilities, portfolios.

Recommendations:

Enforce effective software requirements development and management practices, including assessment of change impacts, for both the acquirer and supplier organizations.

- Strengthen policies/guidance for full requirements traceability.
- Evaluate effectiveness of models for estimating SW and changes.
- Improve involvement of SW and acquisition expertise
  - Early requirements definition (JCIDS)
  - Balance user requirements with cost/schedule constraints
  - Impact assessment and communication of requirement changes

Issue 2: Fundamental system engineering decisions are made without full participation of software engineering.

Discussion Points:

- SW not consistently involved in architectural decisions early in the life cycle.
- Must have authority to participate in system-level decision making and trades.
- SE and SW life cycles, processes, and products are not always consistent or harmonized for meaningful cross-discipline integration to occur.
- Segregation of SE/SW proposal inputs can impede coordination.
- System development methods do not properly leverage SW ability to rapidly field enhanced capabilities.

Recommendations:

Institutionalize the integration and participation of software engineering in all system engineering activities.

- Designate an empowered SW architect (acquirer and supplier) early.
- Update policies, standards, guidance to emphasize SW in decision-making.
- Promote effective SE/SW communications and cross-training.
- Adopt acquisition strategies and development approaches that leverage rapid SW development cycles (iterative capability, sustainability).

Issue 3: Software life cycle planning and management by acquirers and suppliers is ineffective.

Discussion Points:

- SW risks and life cycle costs are not consistently accommodated in planning.
- Realistic schedule and effort (cost) estimates are often rejected or constrained.
- Pressure to rapidly procure new capabilities can inhibit balance of life cycle cost, schedule, performance expectations to achieve executable programs.
- Lack of SW expertise applied in planning and management.
- SW processes/methods improperly selected, tailored, executed, monitored.
- SW measures are not used effectively or acted upon.

Recommendations:

Establish a culture of quantitative planning and management, using proven processes with collaborative decision-making across the software life cycle.

- Establish collaborative contractual relationships enabling joint ownership of issues.
- Change culture to base expectations on historical data and realistic constraints.
- Emphasize selection of appropriate processes/methods and codify in contract.
- Incentivize life-cycle perspective and iteration to circumvent near-term thinking.

Issue 4: The quantity and quality of domain-knowledgeable software engineering expertise is insufficient to meet the demands of the government and the defense industry.

Discussion Points:

- Insufficient highly skilled domain-knowledgeable SW professionals to meet the growing demand, due to inadequate funding, insufficient career incentives, competition, downsizing, etc.
- Insufficient infrastructure to rapidly transition skilled staff to new programs.
- Inadequate SW staffing across the system life cycle (architecture, trades, etc.)
- Career path incentives are insufficient to attract SW professionals.

Recommendations:

Collaborate on innovative strategies to staff to appropriate levels and to attract, develop, and retain qualified talent to meet current and future software engineering needs in government and industry.

- Develop a Software Competency Roadmap, with strategic decisions about the future workforce (competencies, downsizing, R&D, etc.)
- Establish joint government, industry, academia working group to identify strategies for expanding SW resource pool and skill sets.
- Cross-train among functional disciplines (PM, SE, etc.) to expand SW engineering pool and extent of domain knowledge.

Issue 5: Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.

Discussion Points:

- Over-reliance on testing alone rather than robust SW verification techniques.
- Manual testing techniques are labor-intensive, scale poorly, and are unproductive relative to the large investment of resources.
- Compliance-based tests do not adequately cover risks or failure conditions.
- Tests are over-documented with disproportionate effort on detailed procedures.
- Education, training, certifications are inadequate to develop effective test skills.

Recommendations:

Study current software verification practices in industry, and develop guidance and training to improve effectiveness in assuring product quality across the life cycle.

- Sponsor a study of state-of-the-practice verification and testing approaches.
- Review/update testing policies and guidance to emphasize robust, productive approaches that maximize ROI.
- Review adequacy of verification plans/approaches early in the acq. life cycle.
- Emphasize skilled investigation throughout the life cycle, based on coverage, risk mitigation, high volume automation.
- Strengthen curricula, training, certifications, career incentives for testing roles.

Issue 6: There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.

Discussion Points:

- SW is inherently vulnerable to widespread SW assurance threats – we must be confident in the supply chain pedigree.
- Current techniques are inadequate to verify assured components with well-understood properties.
- Assurance of systems, and SoS, cannot be easily inferred from components due to issues such as composability, emergent behavior.
- Exhaustive testing to rule out vulnerabilities is not feasible.

Recommendations:

Collaborate with industry to develop approaches, standards, and tools addressing system assurance issues throughout the acquisition life cycle and supply chain.

- Establish collaborative initiatives to develop and deploy comprehensive system assurance approaches.
  - Resistance to intrusion and compromise
  - Commercial standards to address vulnerability throughout the supply chain
- Define SW assurance quality attributes for addressing in architectural trades.
- Sponsor system assurance research, policy, guidance, training..

Issue 7: Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

Discussion Points:

- Inadequate estimating methods for COTS/NDI (reuse, open source, GOTS, …)
- COTS/NDI best practices are known but not consistently implemented.
- Inadequate attention to sustainment issues early in the life cycle.
- Open source licensing issues can expose organizations to liability, loss of data rights, potentially large rework.
- Customer expectations for customization reduce benefits of COTS solutions.
- Insufficient infrastructure to create and facilitate reuse across organizations.

Recommendations:

Improve and expand guidelines for addressing total lifecycle COTS/NDI issues.

- Encourage adoption of COTS/NDI best practices (SEI, AIAA, etc.)
- Ensure COTS/NDI life cycle processes are addressed in program plans.
- Review COTS/NDI life cycle support issues and tradeoffs at program milestones and reviews.
- Ensure COTS/NDI issues are addressed in OSD policy and SW Assurance initiative.

Summary Recommendations
Top SW Issues 2006

1. Enforce effective software requirements development and management practices, including assessment of change impacts, for both the acquirer and the supplier organizations.
2. Institutionalize the integration and participation of software engineering in all system engineering activities.
3. Establish a culture of quantitative planning and management, using proven processes with collaborative decision-making across the software life cycle.
4. Collaborate on innovative strategies to staff to appropriate levels, and to attract, develop, and retain qualified talent to meet current and future software engineering needs in government and industry.
5. Study current software verification practices in industry, and develop guidance and training to improve effectiveness in assuring product quality across the life cycle.
6. Collaborate with industry to develop approaches, standards, and tools addressing system assurance issues throughout the acquisition life cycle and supply chain.
7. Improve and expand guidelines for addressing total lifecycle COTS/NDI issues.

DoD Weapons/Explosive Safety Service – Unique, Inconsistent, Duplicate and Common Testing Standards/Requirements - Are Yours Here?

An OSD Study Led by the U.S. Marine Corps Systems Command

October 25, 2006

Presentation to:

9th Annual Systems Engineering Conference
San Diego, CA

Presentation by:

Scott Rideout, Safety Officer
U.S. Marine Corps Systems Command

Agenda

- Study Overview
- Methodology
- Data Collection and Analysis
- Results and Conclusions
- Next Steps

Agenda

- **Study Overview**
  - **Task Description**
  - **Problem**
  - **Phase I Objectives**
  - **What I Need From You**
- Methodology
- Data Collection and Analysis
- Results and Conclusions
- Next Steps

Problem

- The Services' safety review boards use different safety testing criteria.
- When one Service wants to use another Service's existing weapon system, additional safety testing is typically required by the new Service's safety board when the equipment has already been approved by a safety board. Some of these tests are essentially redundant.
- Common safety standards become of greater importance as the Services develop more explosive weapon systems with planned use in a joint operating environment.
- Study was initiated with the following long term goals
  - Determine a common definition of "acceptable" weapon safety test criteria and acceptable results for each and every possible environment the weapon could be certified for.
  - Develop a common understanding of the attributes that constitute a safe weapon.

Phase I Objectives

- Clearly define the requirements for explosive weapon systems safety tests and execution methodologies required by the Services and Service review boards.
  - Identify safety tests across the Services
  - Analyze safety tests among different operating environments and within each Service
- Assess requirements for current safety tests to identify common, inconsistent, duplicate and singular tests.
  - What are the drivers for inconsistent and duplicate safety tests
  - What are the processes behind inconsistent and duplicative safety test
  - Identify Service specific board processes
- Identify specific differences in safety tests between the Services.
  - Identify differences in how the tests are conducted and measured by each Service
  - Identify the drivers for the differences resulting in opportunities and benefits
- Identify potential opportunities or benefits.
  - What are the facing opportunities for fixing duplicate and inconsistent tests?
- Gather content on the known and existing problems that are faced in the field, potentially resolved by common safety tests.

What I Need from You

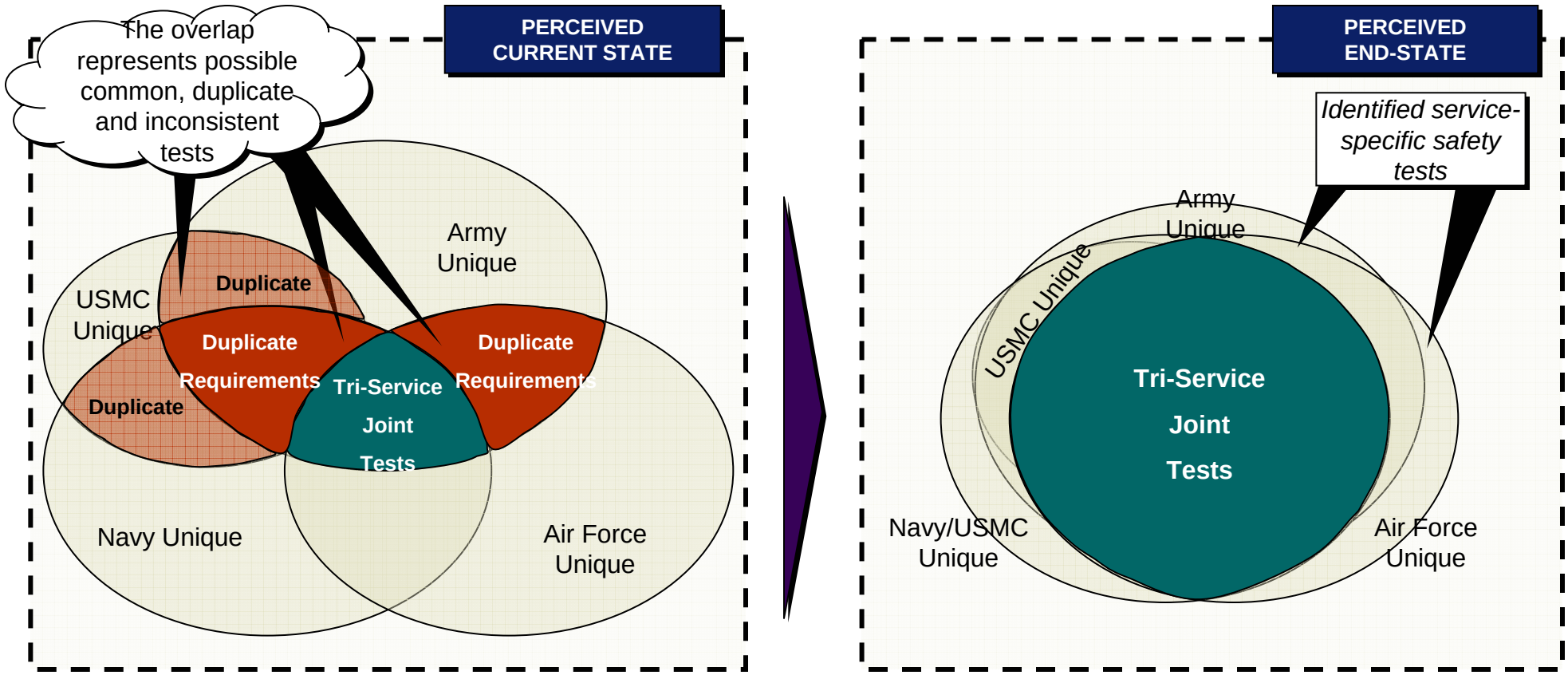
- Needs
  - Do you agree with the approach?
  - Do the modes cover all operational environments?
  - Where do you see / have you seen differences in safety testing requirements among the Services?
  - Where have you seen differences in implementation of the same safety testing requirements?
- Contacts
  - Paige Ripani, Booz Allen Hamilton, (703) 412-7702, ripani_paige@bah.com
  - Kristin Norris, Booz Allen Hamilton, (540) 288-5078, norris_kristin@bah.com

Agenda

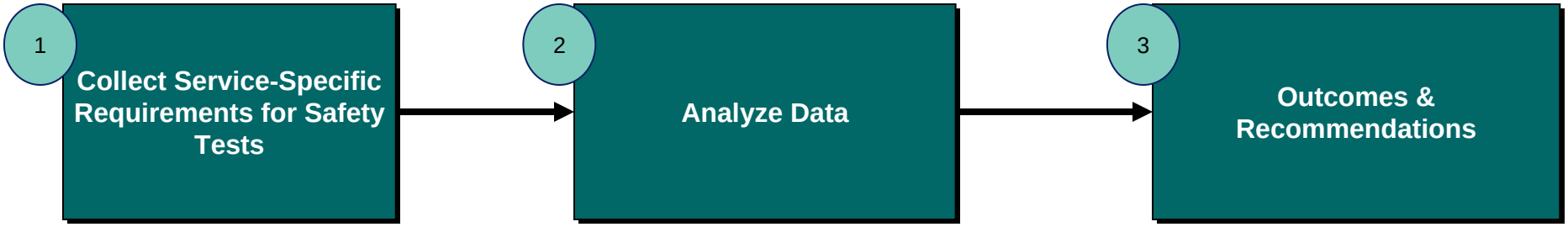
- Study Overview
- **Methodology**
  - **Hypothesis Statement**
  - **Work Plan and Detailed Approach**
  - **Data Structure Hierarchy**
  - **Definitions of Key Terms**
- Data Collection and Analysis
- Results and Conclusions
- Next Steps

Hypothesis Statement

- Given the increasingly joint nature of American military deployment, services are increasingly hindered and delayed by the current need to require duplicate and inconsistent safety tests in order to qualify for use and shipment to a deployed site.



Work Plan and Detailed Approach



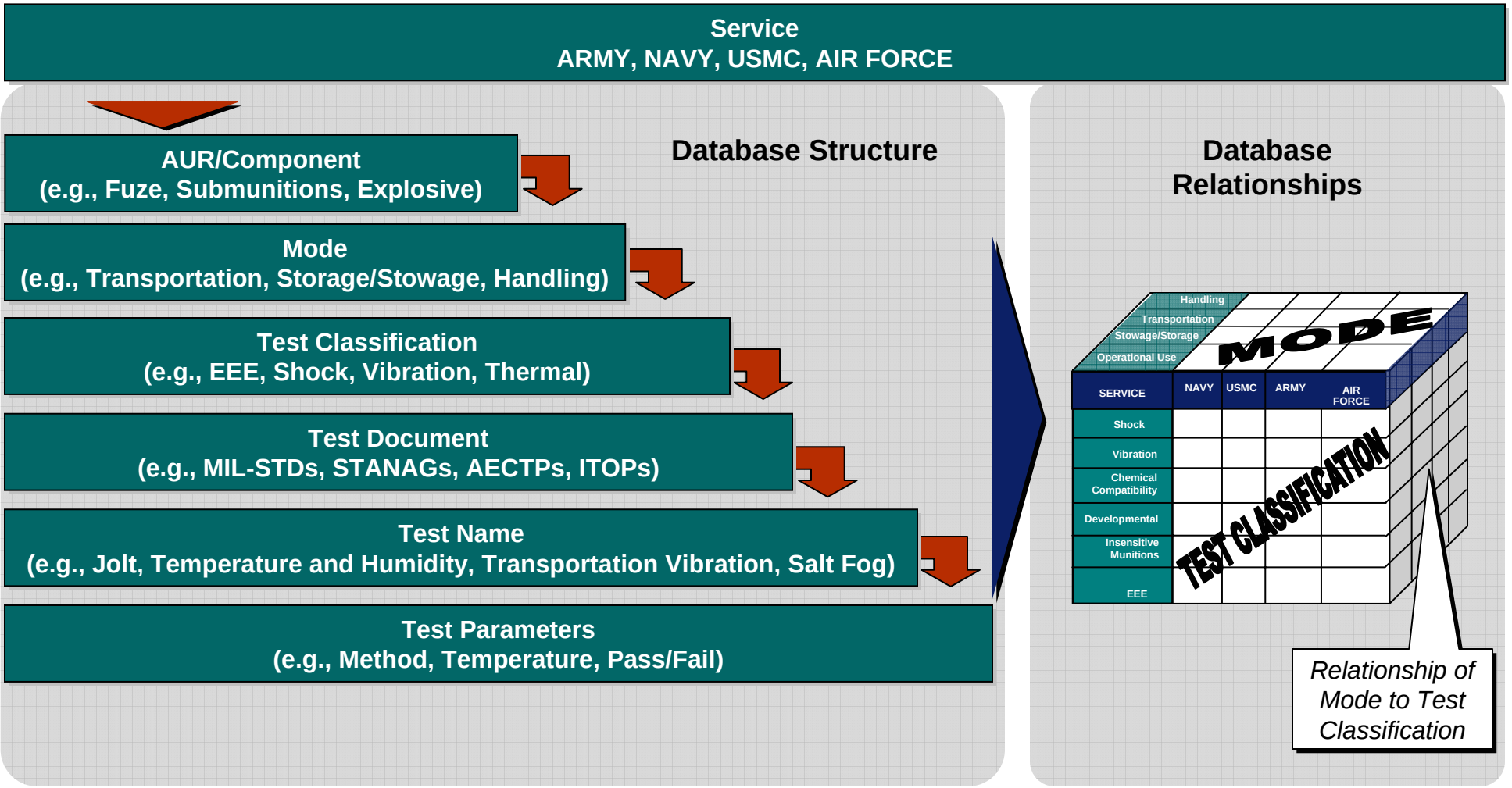
- Data gathering of existing and required DOD weapons safety tests.
- Interviews with safety board representatives, program managers, system safety leads and service-specific testers to confirm tests identified, gather additional tests and identify differences among the services about how the tests are setup, implemented and assessed.
- Relational database to assist with the gathering and organization of data.

- Data analysis for potential test duplication, inconsistency and single service instances exist.
- Select comprehensive sample of data collected by the team.

- Vetting of conclusions based on the analysis and collection efforts.

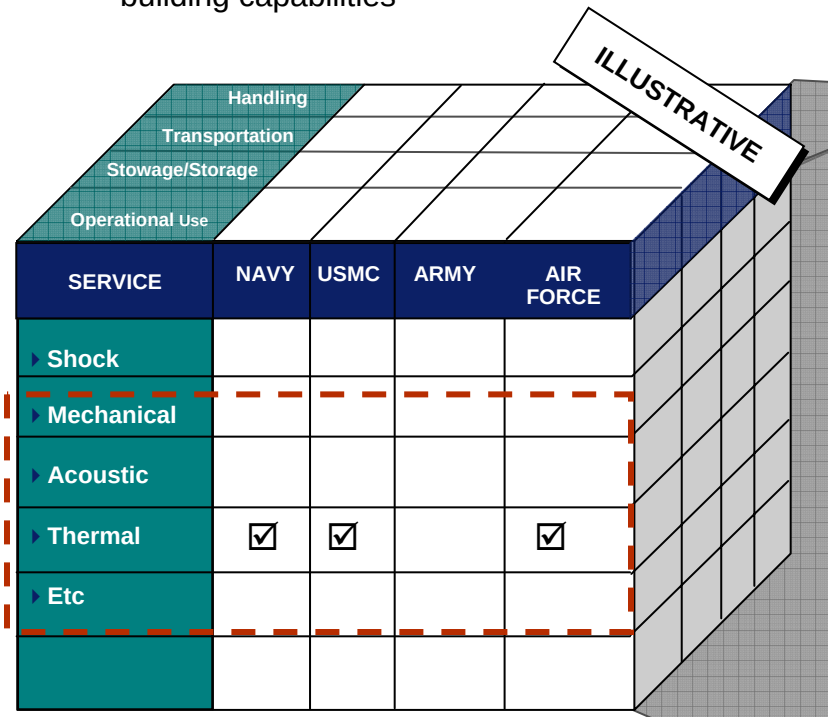
No Stovepipe Mentality - Approach is Representative of All Types of Systems for All Services.

Data Structure Hierarchy provides the means to compare the Mode to the Test Classification



The database provides insight into identifiable inefficiencies (details in the following pages) by service…

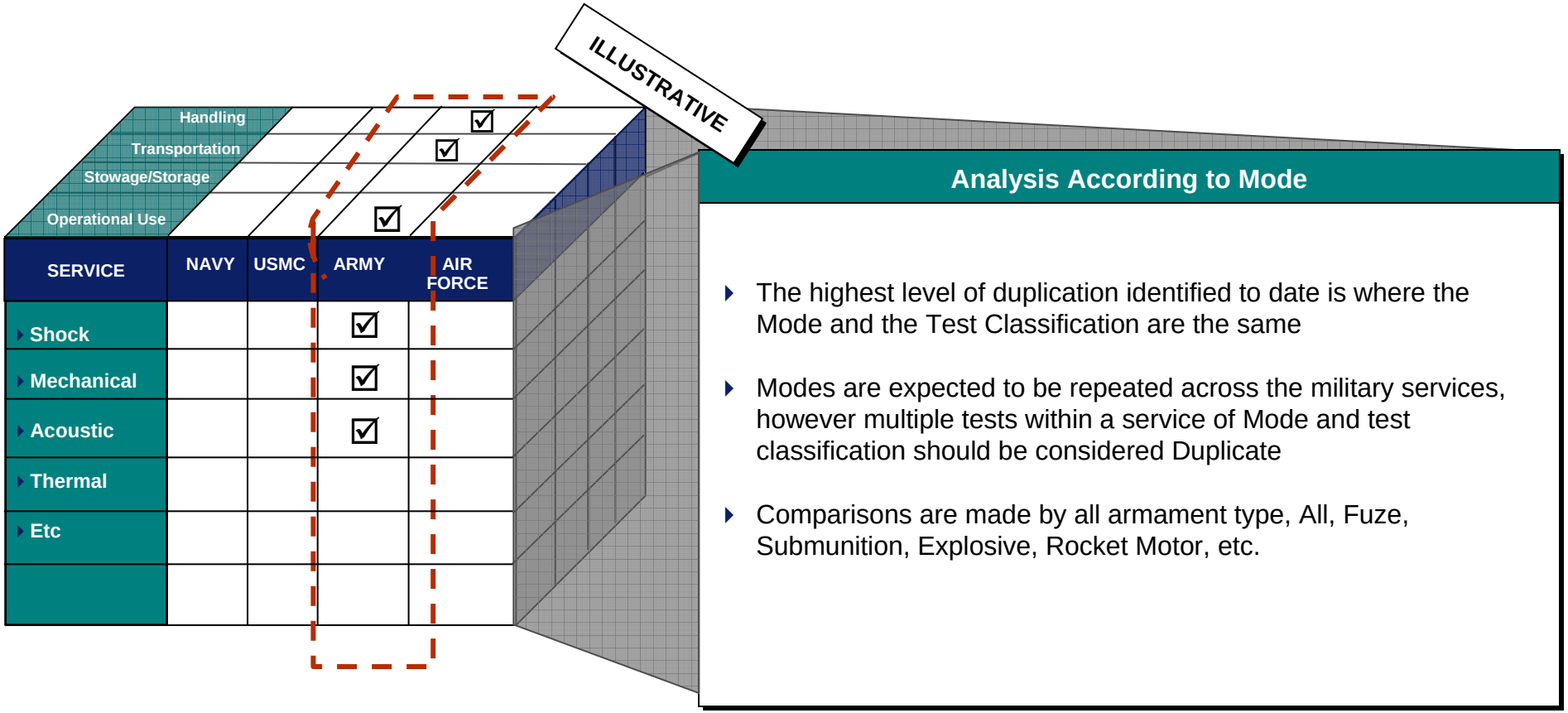
- Current data is in the form of picture and text based documents that was parsed to fit into the database tables
- Utilizing a complex set of queries the database was produced a detailed cross-sectional report of the requirements for common, inconsistent, duplicate and singular tests used within the services
- The database output can be easily incorporated into any MS Office application for refined graphical analysis or added report building capabilities



Analysis According to Test Classification

- The database houses information according to Mode and Test Classification
- The data detailed by Test Classification allows for comparison by all similar test types (shock for example), within and across all military services
- The replication of similar tests by Test Classification expands when tests within a certain classification (Mechanical) also include test types within another Test Classification (Acoustic)

…and identifiable inefficiencies by Mode

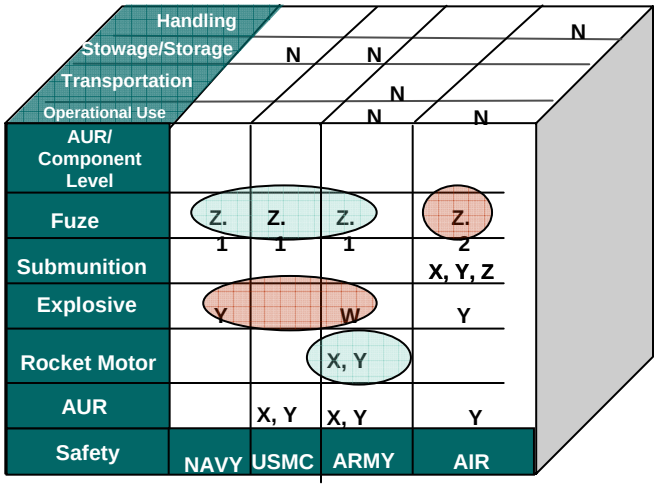


Analysis According to Mode

- The highest level of duplication identified to date is where the Mode and the Test Classification are the same
- Modes are expected to be repeated across the military services, however multiple tests within a service of Mode and test classification should be considered Duplicate
- Comparisons are made by all armament type, All, Fuze, Submunition, Explosive, Rocket Motor, etc.

Data Analysis Methodology – Database supports validation of hypothesis

Form Hypothesis based on Database Content

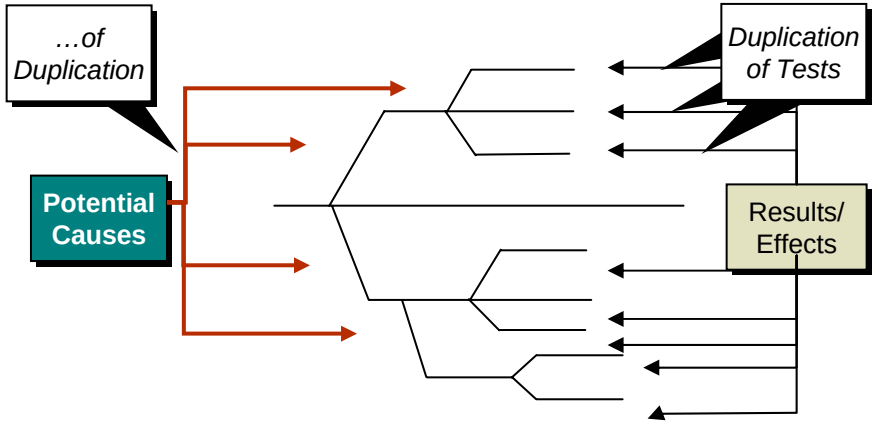


Assumptions

- The Army has the highest level of duplication evident in the database
- Duplication and Redundancy (if any) may be the result of identified needs over time

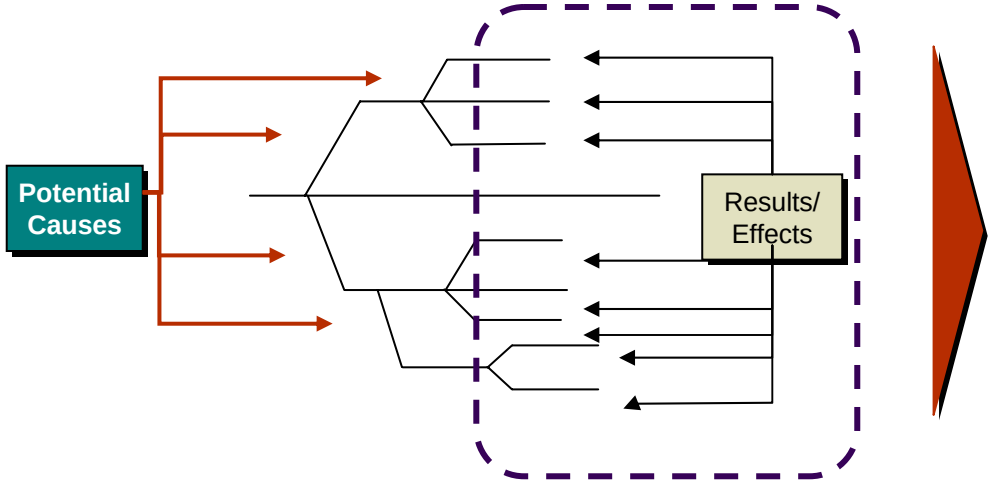
Set-Approach to Find Proof Hypothesis is Correct

	Army	Navy	USMC	Air Force	ALL
Mode					
Handling	☑	☑		☑	☑
Operational Use	☑			☑	☑
Packaging					
Storage/Stowage					
Transportation	☑				☑
ALL UP ROUNDS/COMPONENTS					



Scoring Methodology: Five different weights were employed to gain a high level sense of the varying levels of duplication…

Where the Database Identifies Duplication, the Level of Duplication is Addressed using the Scoring Criteria



Scoring Criteria	
4	Duplication of effort identified
3	Potential duplication
2	Limited duplication
1	Marginal duplication
0	No duplication evident

…Yielding initial proof of the hypothesis that duplication exists

Assumptions
▸ The Army has the highest level of duplication evident in the database
▸ Duplication and Redundancy (if any) may be the result of identified needs over time

Definitions of Key Terms

- Opportunity - Where duplicate and inconsistent test requirements exists, causing inefficiencies, loss or waste and providing an opportunity for improvement.
- Benefit - Where common and singular test requirements exists.
- Test Types
  - Common - More than one Military Service uses the same safety test, test parameters and test parameter values given the same AUR/Component, mode and test classification.
  - Inconsistent - More than one Military Service uses the same safety test and test parameters and at least one of the test parameter values is different given the same AUR/Component, mode and test classification.
  - Duplicate - More than one Military Service uses different safety tests for the same AUR/Component, mode and test classification. Different safety tests may be driven by the following reasons:
    - Lack of coordination, knowledge or focus on joint requirements during development
    - Higher levels of rigor applied to one test over another
    - Programmatic legacy
    - Unique mission environment
  - Singular - Only one Military Service uses the safety test for the same AUR/Component and test classification and either the same or different mode.

AUR/Components

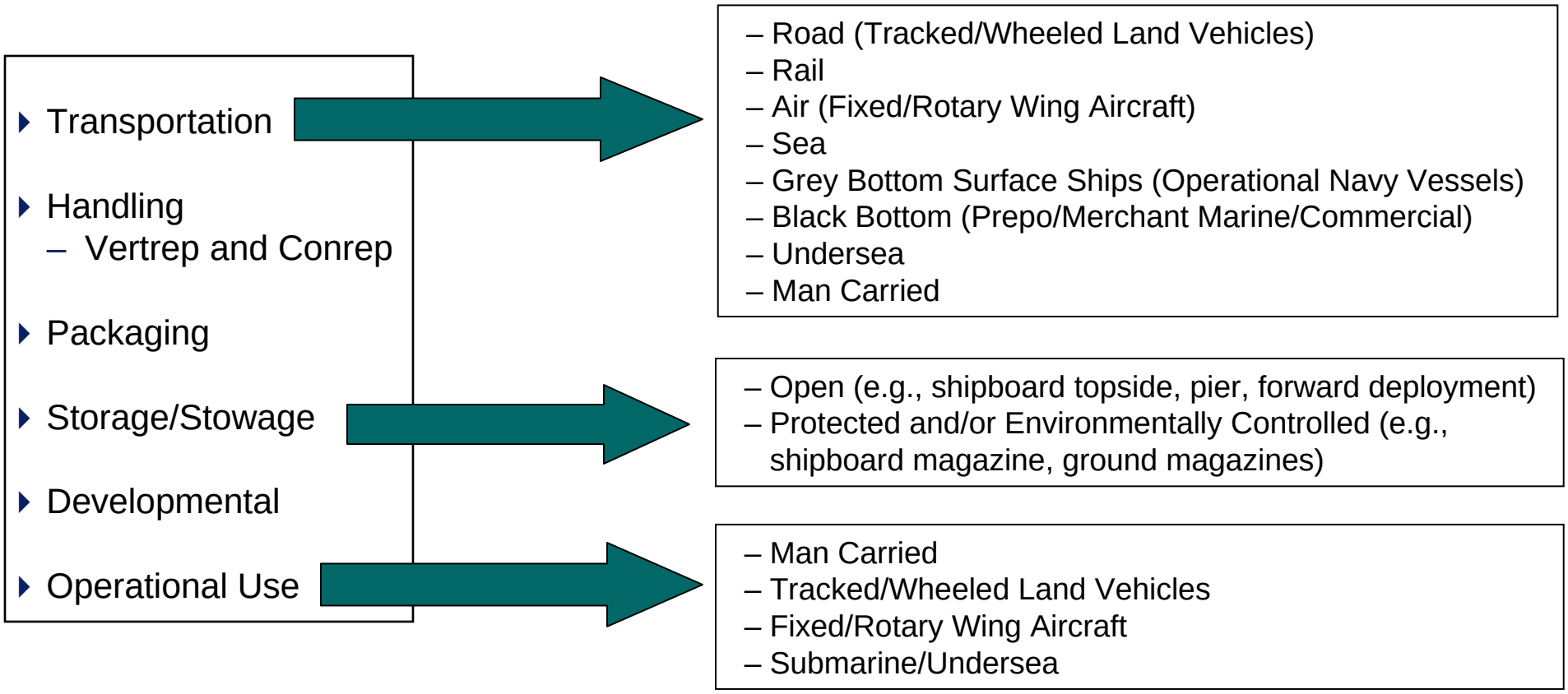
- System, Subsystem, All (Generic)
- System-Specific
- Ammunition
- Cannon
- Electric Initiators
- Explosives
- Fuze
- Power Sources
- Rocket Motors
- Software
- Submunitions
- Unmanned Targets



- Field Mortar Munitions
- Munitions Carried in Tracked Vehicles
- Munitions with EEDs
- Shipboard Equipment
- Shipboard Machinery Equipment
- Surface Launched Munitions
- Underwater Launched Munitions
- Underwater Munitions

AUR/Components were determined by the safety testing documents.

Modes



Ground Rules

(1) Mode is determined by when the mode will actually influence the item; not when the item will be affected by the influence of the mode.

(2) Tests assigned to the Developmental Mode define the characteristics of the item; are not typically tested in a shipping or operational configuration; and do not simulate a mechanical, climatic or electrical environment.

Safety Test Classifications

- Chemical Compatibility
- Contamination
- Corrosion
- EEE
- Electrical
- ESD
- Explosive Characteristics
- Function
- Icing
- Impact
- Initiation
- Insensitive Munitions
- Leak (external)
- Leak (internal)
- Lifting
- Pressure – High
- Pressure – Low
- Safe Separation
- Sequential
- Shock
- Shock – Acoustic
- Shock – Mechanical
- Shock – Thermal
- Shock and Temperature
- Shock/Vibration
- Shock-Mechanical (long drop)
- Shock-Mechanical (short drop)
- Software
- Storage - Long Term
- Temperature
- Temperature – Extreme
- Temperature – High
- Temperature – Low
- Temperature and Humidity
- Temperature Shock Humidity
- Transportation
- Unknown
- Various
- Vibration
- Wear/Fatigue

Ground Rule - Tests assigned a test classification must simulate a mechanical, climatic or electrical environment.

Agenda

- Study Overview
- Methodology
- **Data Collection and Analysis**
  - **Data Collection**
  - **Data Analysis**
- Results and Conclusions
- Next Steps

Data Collection and Analysis - Data Collection

- Coordinated with Stakeholders
  - Briefed JWSTAP - June 06
  - Briefed DDESB Seminar - August 06
  - Briefed NDIA's Systems Engineering Conference - October 2006
- Selected Comments from Selected Service SMEs, Safety Board Members and POCs at Testing Facilities
  - Preston Parker, AAC/SES Eglin AFB
    - The Air Force will not accept any other Service's Safety Certification "Carte Blanche".
  - Sharon Craven, Navy Explosive Qualifications
    - The Navy will consider archived explosives that have been proven safe for use over many years; however, instead of qualifying it – the explosives would be Final (Type) Qualified only for use under certain/individual circumstances. The explosives would not be considered "Qualified."
  - Dr. Rao Surapaneni, Co-Chair Army's Energetic Materials Qualification Board
    - MIL-STD-1751A is still being used along with AOP-7 primarily because it is uncertain if AOP-7 captures all of the MIL-STD requirements.
  - Chau Nguyen, Army's Explosives Safety and Quality Assurance Department
    - The Navy will not deviate from specific Gap Card test requirements that they have done forever.
  - Jeff Craven, Testing, Army's Huntsville, AL
    - There are subtle differences in the implementation of EEE tests due to available testing equipment, facility limitations, or that it has always been done that way.

Data Collection and Analysis - Data Collection (cont'd)

- Selected Comments from Selected Program Managers/System Safety Leads
  - TOW and JAVELIN (Army/Marine Corp), Mr. Sam Taylor (Marine Corps); Principal for Safety
    - For Submunitions: Navy relies on "WSESRB Position on Submunitions" 8020 Ser N7133/860, dated 6 Sept 2000 and Army relies on "DoD Policy on Submunitions Reliability" dated 10 Jan 2001.
  - Joint Direct Attack Munition (Navy/Air Force), Ms. Larraine Hebb (Air Force), System Safety Lead
    - For JDAM, she specifically noted the HERO requirements for the Navy are often more stringent than the Air Force's requirements; however, as a rule the Air Force will yield to the more stringent requirement.
  - Lightweight 155 (Army/Marine Corps), Gaby Jarani (Army), Principal for Safety
    - The WSESRB's safety requirements and the Army's Material Release process are completely different approaches.
- Identified and Collected Testing Requirements
  - Over 75 different testing documents collected resulting in 530 distinct tests
- Established and Maintaining the Explosive Safety Testing Knowledge Center

Data Analysis - Content of database shows that some duplication of safety tests exists when defined by Mode and Military Service

Identified Area of Duplication by Mode & Test Classification

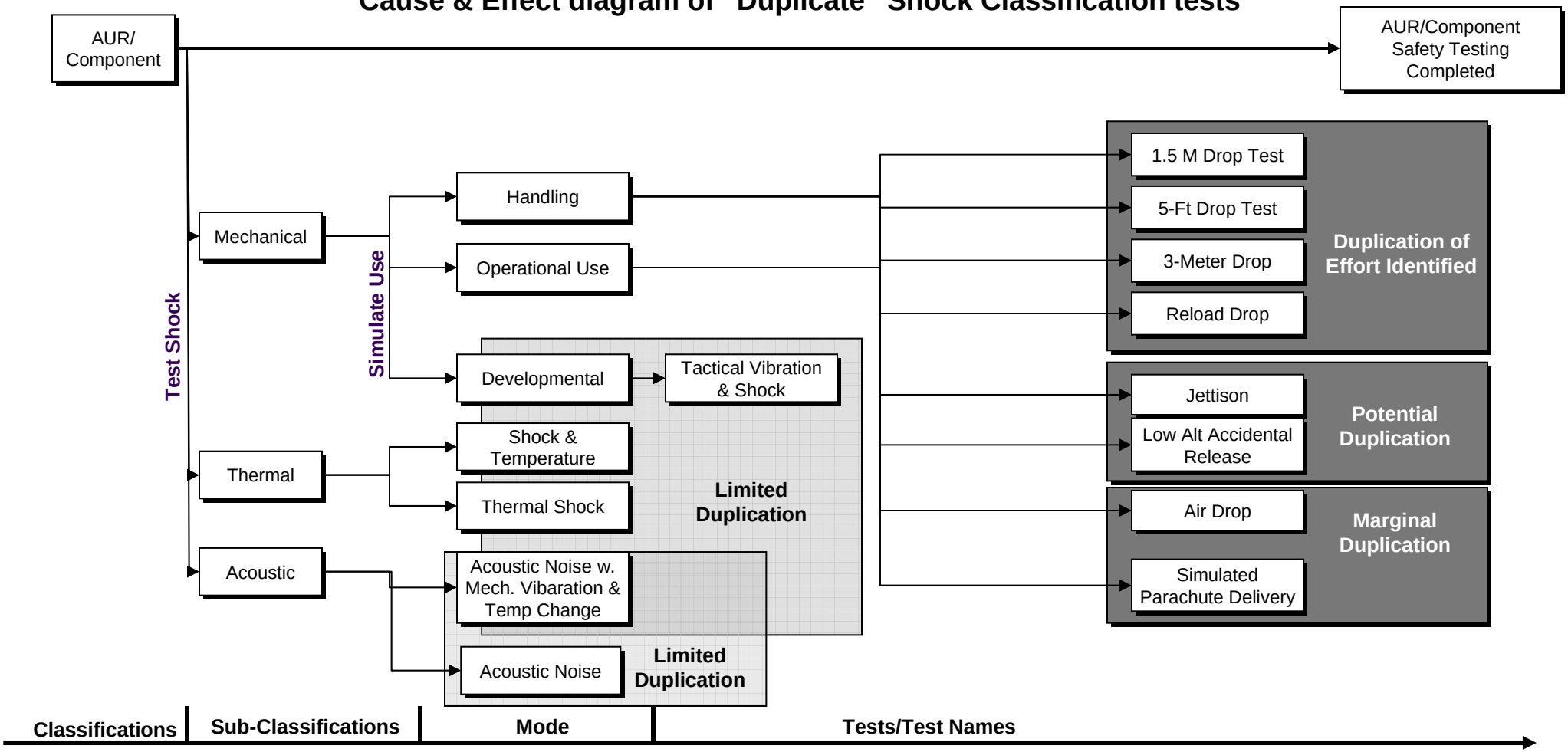
	Army	Navy	Marine Corps	Air Force	ALL
Mode					
Handling	☑	☑		☑	☑
Operational Use	☑			☑	☑
Packaging					
Storage/Stowage					
Transportation	☑				☑
ALL UP ROUNDS/COMPONENTS					

Initial Results of Analysis

- Preliminary analysis shows that duplication exists, but singularities, commonalities, and inconsistencies have yet to be determined.
- Although duplication has been identified, we can not be certain to what degree of duplication exists in each mode; varying levels have been established.
- Duplication appears both across different services as well as within a single service.

Data Analysis - Within Shock Testing a range of duplication exists, from limited overlap to identifiable duplication of effort

Cause & Effect diagram of "Duplicate" Shock Classification tests



Data Analysis - The level of estimated duplication for Shock Testing is more evident in the mechanical short drop testing area

Level of Duplication by Short Drop Tests

TESTS	1.5-M Drop	5-Ft Drop	3-M Drop	Reload Drop
1.5-M Drop		4	3	2
5-Ft Drop	4		4	2
3-M Drop	3	4		4
Reload Drop	2	2	4	

Short Drop Results

- Duplication of existing tests appears to exist
  - Causes for duplication are unknown as all are Army tests, hypothesis is due to lack of transparency into other program testing
  - 3-Meter Drop and Reload drop are executed from the exact same height
  - 1.5M and 5-Ft tests also from the same height
- Research indicates all tests would be run on the same explosive round (munitions)
- Duplication at equal height is apparent (Reload Drop vs. 3M Drop)
  - Recommend further analysis on cost and pass/fail differential between 3M and 1.5M tests to gauge the performance difference between tests

Data Analysis - The level of estimated duplication for Shock Testing is more evident in the mechanical short drop testing area

Level of Duplication by Long Drop Tests

TESTS	Jettison	Low Altitude Accidental Release	Air Drop	Simulated Parachute Delivery
Jettison		3	1	1
Low Altitude Accidental Release	3		2	1
Air Drop	1	2		3
Simulated Parachute Delivery	1	1	3	

High Drop Results

- Duplication may exist and should be subject for further review
  - Causes for duplication are suspected to be due to perceived unique mission need of each test.
- Duplication is assumed to be between Army and Air Force Safety Tests
- Given the different operating environments and modes identified, duplication should be further explored but is not expected to be area of considerable inefficiency

Data Analysis - Vibration is constantly measured against additional safety considerations

Level of Duplication by Vibration Tests

TESTS	Tactical Vibration & Shock	Shock & Temperature	Thermal Shock	Acoustic Noise	Acoustic Noise w/ Mechanical Vibration & Temp Change
Tactical Vibration & Shock		2	0	0	1
Shock & Temperature	2		2	0	1
Thermal Shock	0	2		0	1
Acoustic Noise	0	0	0		4
Acoustic Noise w/ Mechanical Vibration & Temp Change	1	1	1	4	

Vibration Tests Results

- Lower levels of duplication exist than at the Short Drop Test, yet areas of overlap may merit consideration for additional analysis
- Overlap is likely due to expansion of tests to create and simulate extreme tests under a variety of environments (hypothesis)
  - In testing extreme and variety of environments, elements of overlap emerges
  - Thermal Shock and Shack & Temperature address same elements
  - Acoustic Noise with Mechanical Vibration & Temp change tests acoustic noise

Agenda

- Study Overview
- Methodology
- Data Collection and Analysis
- **Results and Conclusions**
- Next Steps

Results and Conclusions

- Derived hypothesis from the defined problem and objectives
- Mapped out work plan and approach
- Defined database structure hierarchy
- Built relational database to capture analysis
- Defined key terms for the purpose of this study
- Classified test modes and test classifications
- Collected comments from Service Board SMEs
- Performed analysis on database input and SME input
- Phase I clearly indicates that there are potential savings to support a Phase II effort

Agenda

- Study Overview
- Methodology
- Data Collection and Analysis
- Results and Conclusions
- **Next Steps**

Next Steps – Phase II

- The next phase will focus on general agreement of the required tests for each mode.
- Continue identifying commonalities and differences between test requirements.
- Conduct benefits and opportunity analysis on duplicate, inconsistent and unique test requirements.
- Provide recommendations for duplicate and inconsistent tests to JWSTAP.
- Prepare draft JWSTAP document describing the required tests by mode.

Modeling & Simulation - Session 3D5

alysis, Interaction, Modelin
ulation Framework (AIMS)

John Rivers, Lockheed M
Chief Mission Advocate - AOC

9th Annual Systems Engineering Confere
National Defense Industrial Associa

Space Operations Center Weapon System (AOC

apid Operational Improveme

Engineering Solutions





ase Study: Applying OMEGA Methodologie

for AOC WS Program Solutions

Air and Space Operations Center (AOC)

C is the operational-level command and control (C2) center
s the Joint Force Air Component Commander (JFACC) with
ity to direct and supervise the activities of assigned and atta
and to monitor the actions of both enemy and friendly forces

C is the senior element
Theater Air Control
(TACS)

C requires connectivity to
ons centers of higher
arters, lateral headquarters,
oordinate units



Primary Engineering Task – The Weapon System

ORGANIZATIONAL LAYER - PEOPLE

DIVISION	COMBAT PLANS DIVISION	COMBAT OPERATIONS DIVISION	ISR DIVISION	AIR MOBILITY DIVISION

Source: AFI 13-1 AOC V3

DUCTION LINE – AIR TASKING CYCLE (UNWRAPPED) - PROCESS

fects, e	Target Development	Weaponeering & Allocation	ATO Production & Dissemination	Execution Planning & Force Execution	Asses
AOD	JITPL/ALLOREQ	MAAP & BRIEF	ATO/ACO/SPINS	BDA & MISREPS	

TACTICAL/OPERATIONAL/CAMPAIGN ASSESSMENTS & COA

(Source AFOT

10.1 ARCHITECTURE - TECHNOLOGY

APPLICATIONS: CMMA - CS/EL - C2IPS - C2PC – GALE Lite - GCCS – IPL - IWPC – ITS – JDISS – PCI3 - PRMS – PFPS – PDSM – IDROP – SBMCS – TBMCS – ADOCS - ASSET – CTII – GCCS-I3 – JWS - Falconview TST Enhancements – WSV

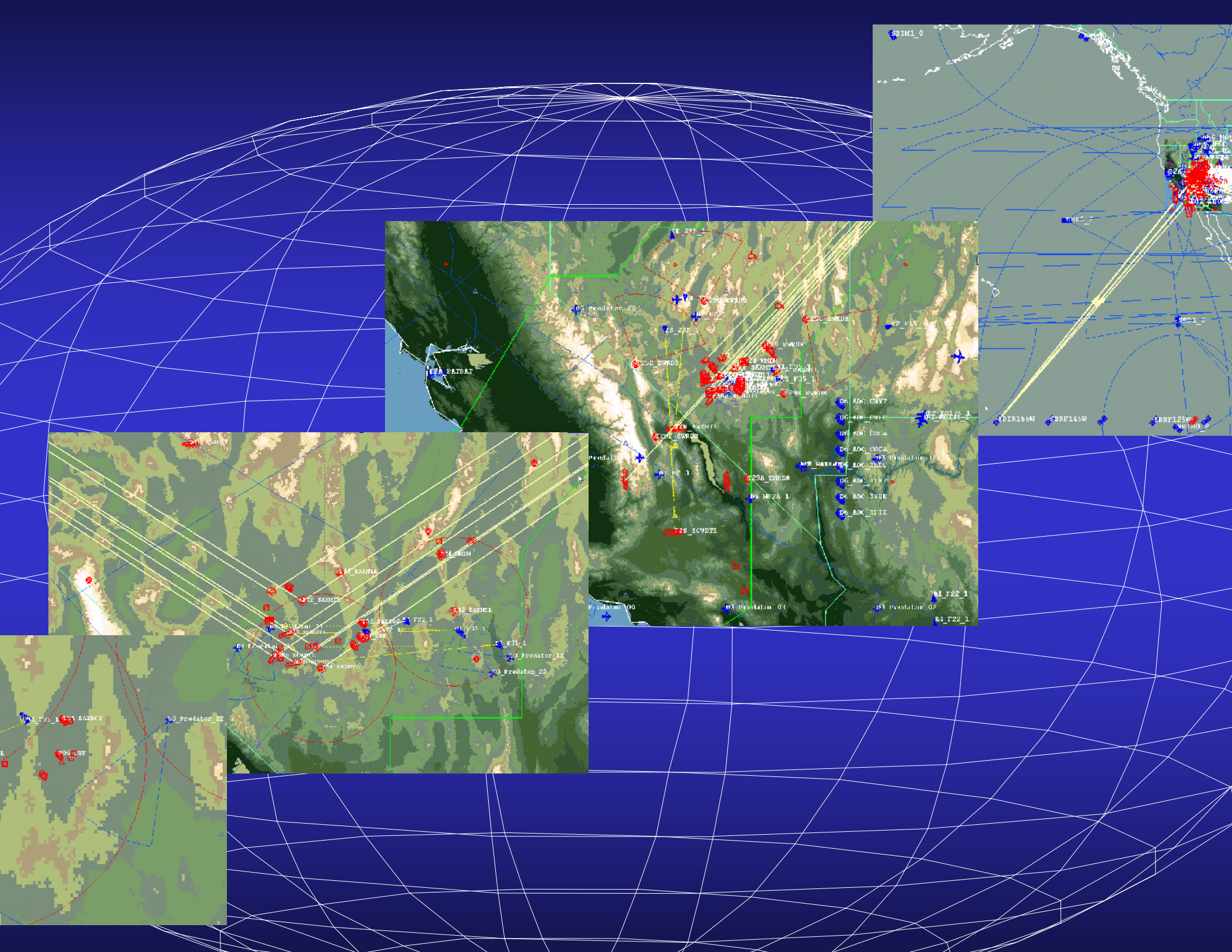
S: Air Operations Net – DMS - GBS – IWS - Predator Video - Purple Net – GPL - - Multimedia Message Manager

SED TOOLS: GDSS - GTN - INTELINK and INTELINK-S - RMS

RUCTURE: AOC Comm Enhancement Pkg - C2 Weapon System Part Task Trainer - ADSI - Deployable Transit-Case System – PLGR - cal Receive Suite/Client - C2 Network Access - Infrastructure Core - Cross Domain Solutions - IBS - Boundary Security System

Source: ESC/AOC WS SI

WS Support – Sustainment, Training, Maintenance



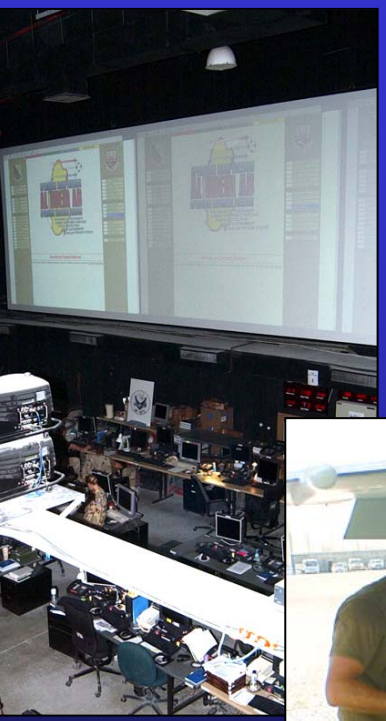
Challenge - Meeting Warfighter Expectations

ge is we are constantly presented with great ideas on combat ca
nts but not being told the leverage points for best return on each

overnment-Industry team decision-making on modernization effo
ag approach to find the leverage points between effectiveness &
."

General Ron Keys, Commander, Air Combat

During orientation visit to the Center for Innovation (Lighthouse) c

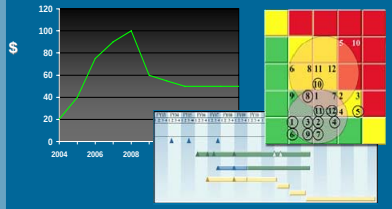










Integrated Architectures	Executable Architectures	Operational Analysis	Cost & Risk Analysis
DoDAF  SoS Architectural Solutions	**Dynamic CONOP Analysis**  Operational Behavior / Interoperability	**Effects-Based M&S**  System Performance (MOP) Operational Utility (MOE, MOO)	**Cost, Schedule & Risk Analysis** 
Role Provide organizing construct to support engineering process through systematic creation of product views and extensions **Tools** System Architect DOORS Rational Rose	Role Provide advanced architecture modeling and simulation capabilities Tools CONOPS Simulator System Architect CORE Satellite ToolKit SATSIM	**Role** Identify Scenarios and provide Campaign / Mission Performance Modeling & Analysis results **Tools** EADSIM JWARS JSAF	**Role** Provide Parametric Cost & Risk Modeling capability to support architecture trades **Tools** ACAM, RCAM, PCAM SEER SEM RiskWeb Cocomo

Credible, Defensible, Knowledge-Based Analyses

Evaluate & Improve

OMEGA Provides Integrated Methodologies, Approaches an

neering | Integrated Architectures | Executable Architectures | Operational Analysis | Cost & Risk Analysis | Busines Re-En

Decision ork
Goals
Effects
Capabilities

DoDAF



SoS Architectural Solutions

Dynamic CONOP Analysis



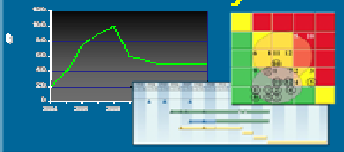
Operational Behavior / Interoperability

Effects-Based M&S



System Performance (MOP) | Operational Utility (MOE, MOO)

Cost, Schedule & Risk Analysis





ating
credible,
gram
oped to
sion needs
at-if"

Role
Provide organizing construct to support engineering process through systematic creation of product views and extensions
Tools
System Architect
DOORS
Rational Rose

Role
Provide advanced architecture modeling and simulation capabilities
Tools
CONOPS Simulator
System Architect
CORE
Satellite ToolKit
SATSIM

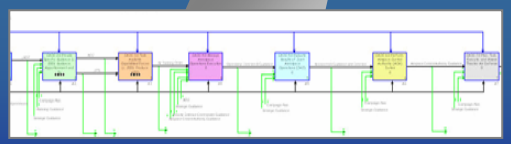
Role
Identify Scenarios and provide Campaign / Mission Performance Modeling & Analysis results
Tools
EADSIM
JWARS
JSAF

Role
Provide Parametric Cost & Risk Modeling capability to support architecture trades
Tools
ACAM, RCAM, PCAM
SEER SEM
RiskWeb
Cocomo

Role
Provide a statistica change c program
Tools
WebSphe Integrat
Verity
DataDrill
SAS, Exc

COTS **GOTS**

OMEGA Encourages the Use of Any Needed COTS/GOTS M&S Tool – Usrer Need Drives Selection



DODAF System Architect
- Plus -



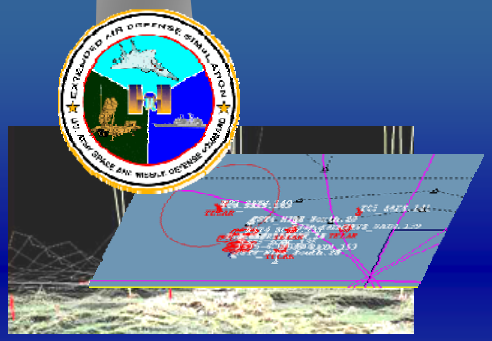
People, Process & Equipment

Rational®

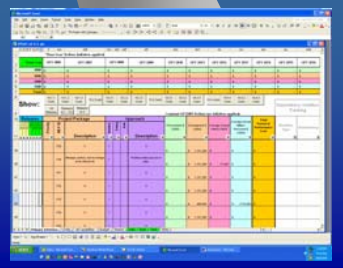
WebSphere®

Advanced Architecture Modeling & Sim

IBM®



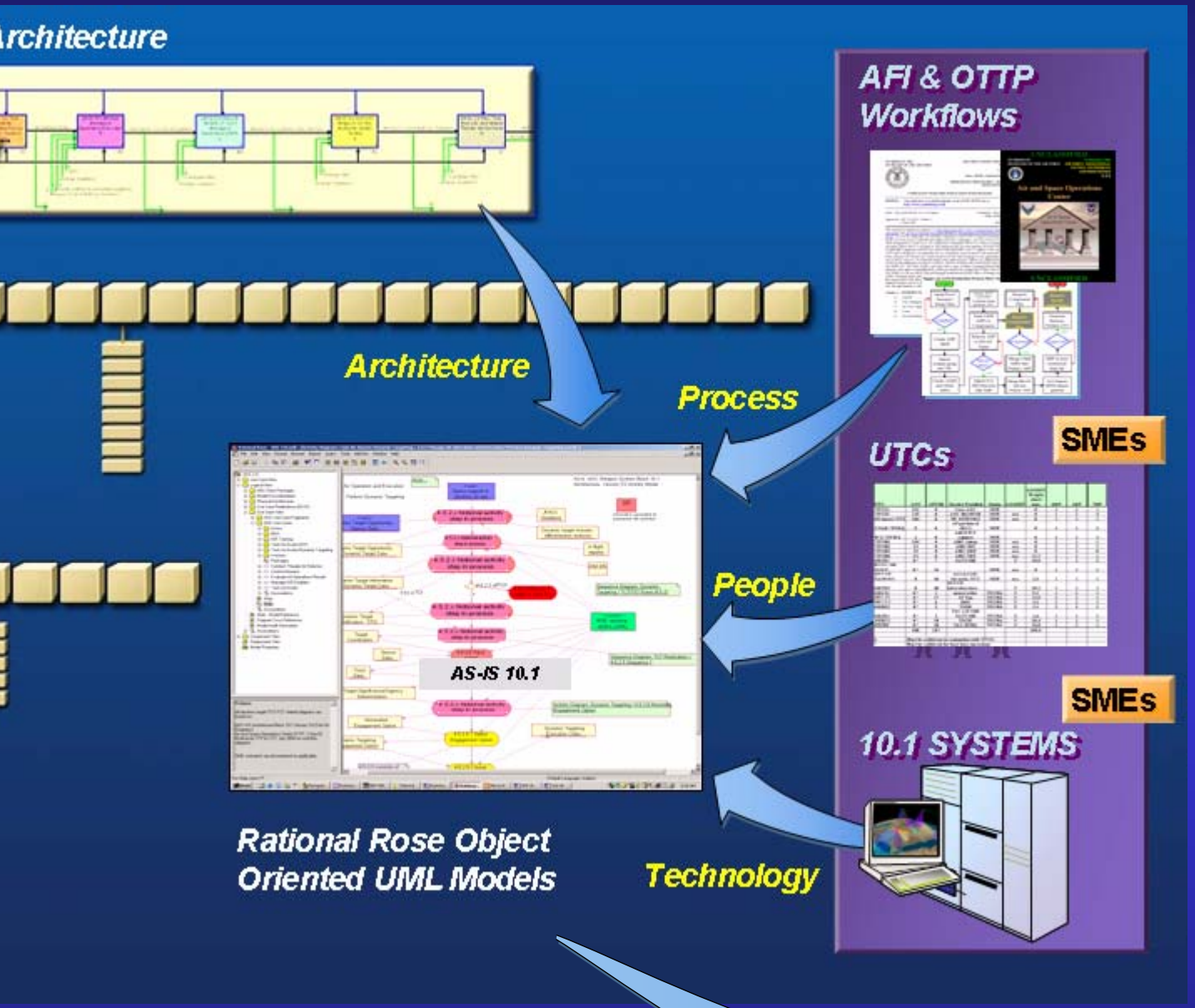
EADSIM for Combat Utility M&S



EPCAT What-If Analysis

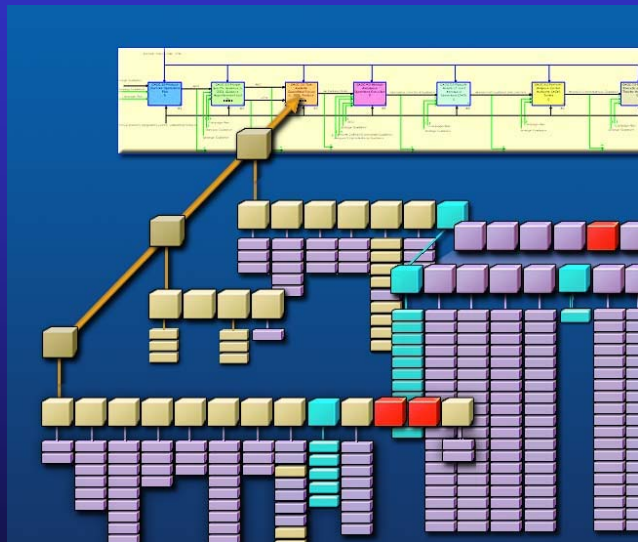


am OMEGA Based Analysis, Interactions, Modeling & Simulation (AIMS) Framework and Tool

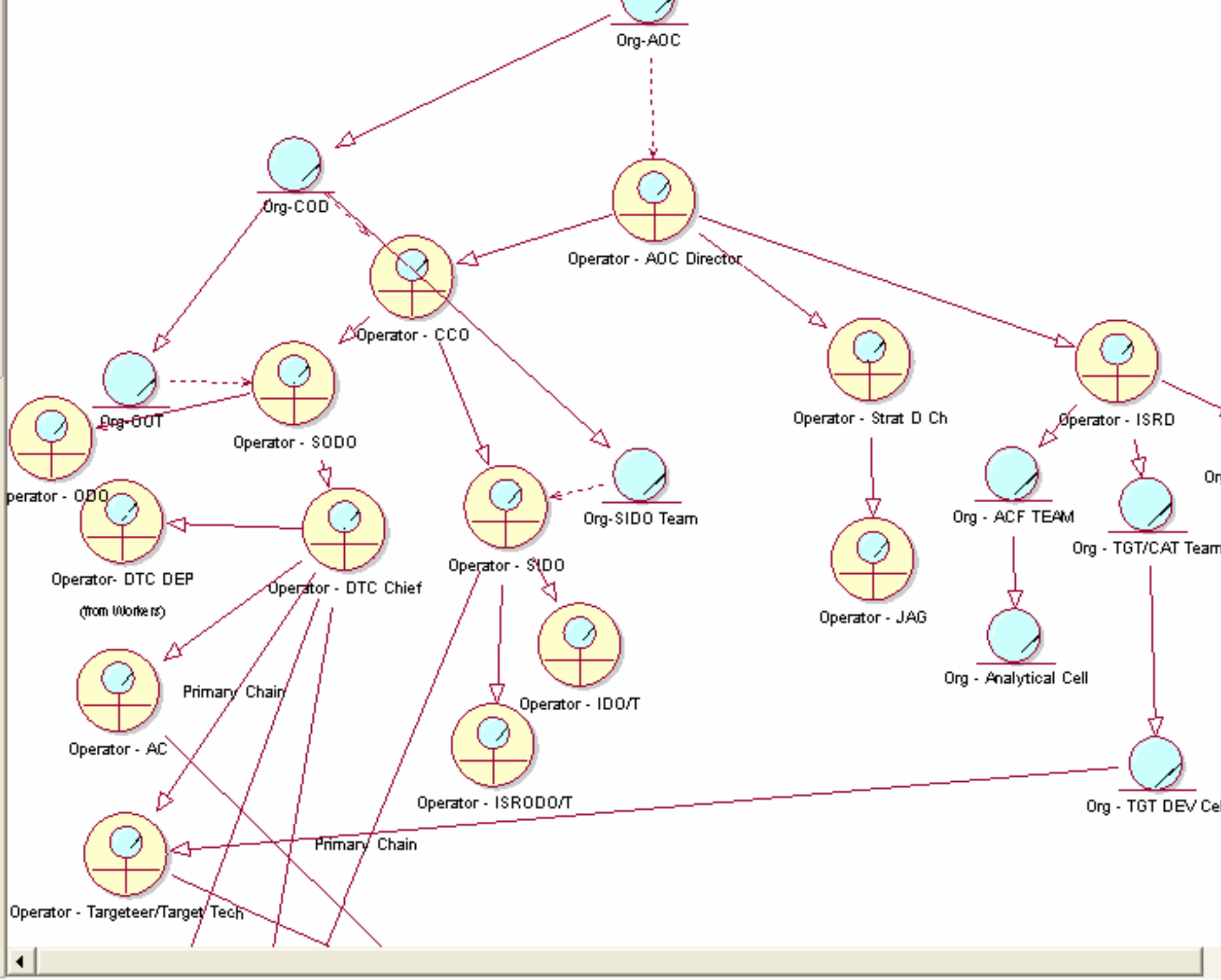


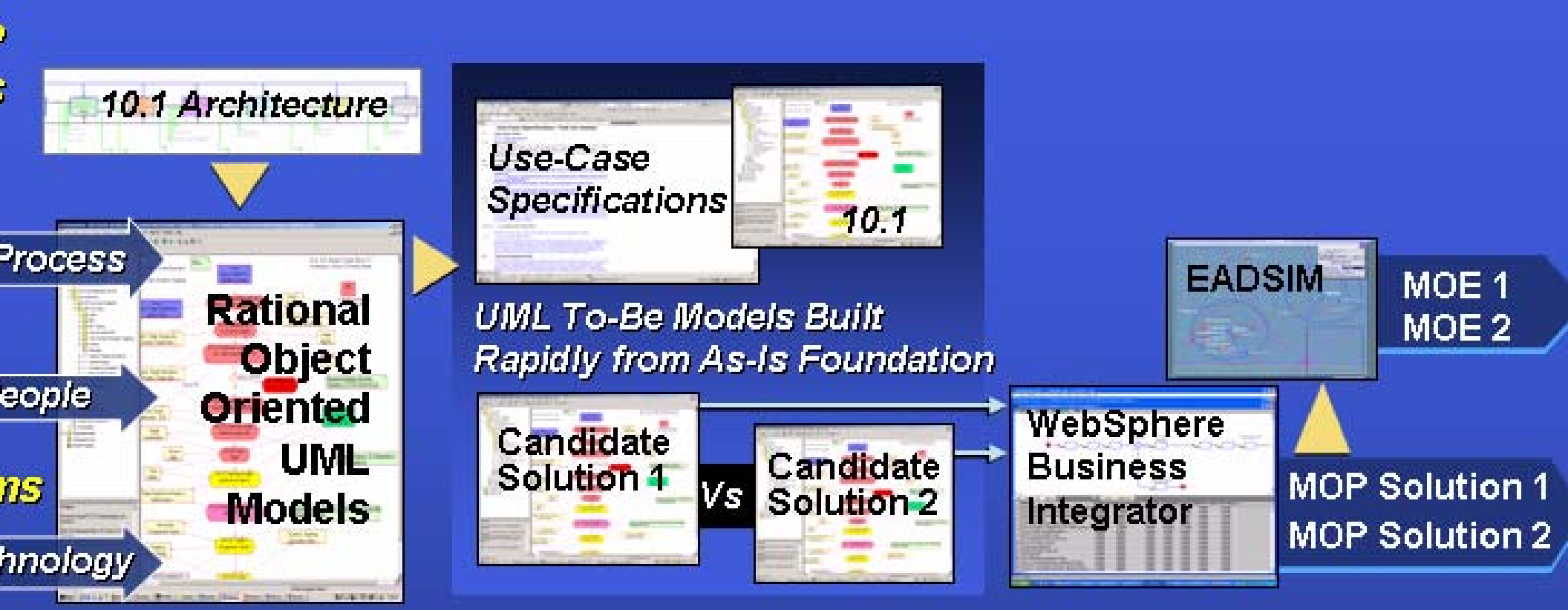
AIMS Integrated
Team (I

- Merge Archite
  People, Proces
  Equipme
- Full Definition of
  of Systems and
  Interactio



nding of How the Current System
Downstream AIMS Capability Needs
is of Alternatives, Trades and BPR

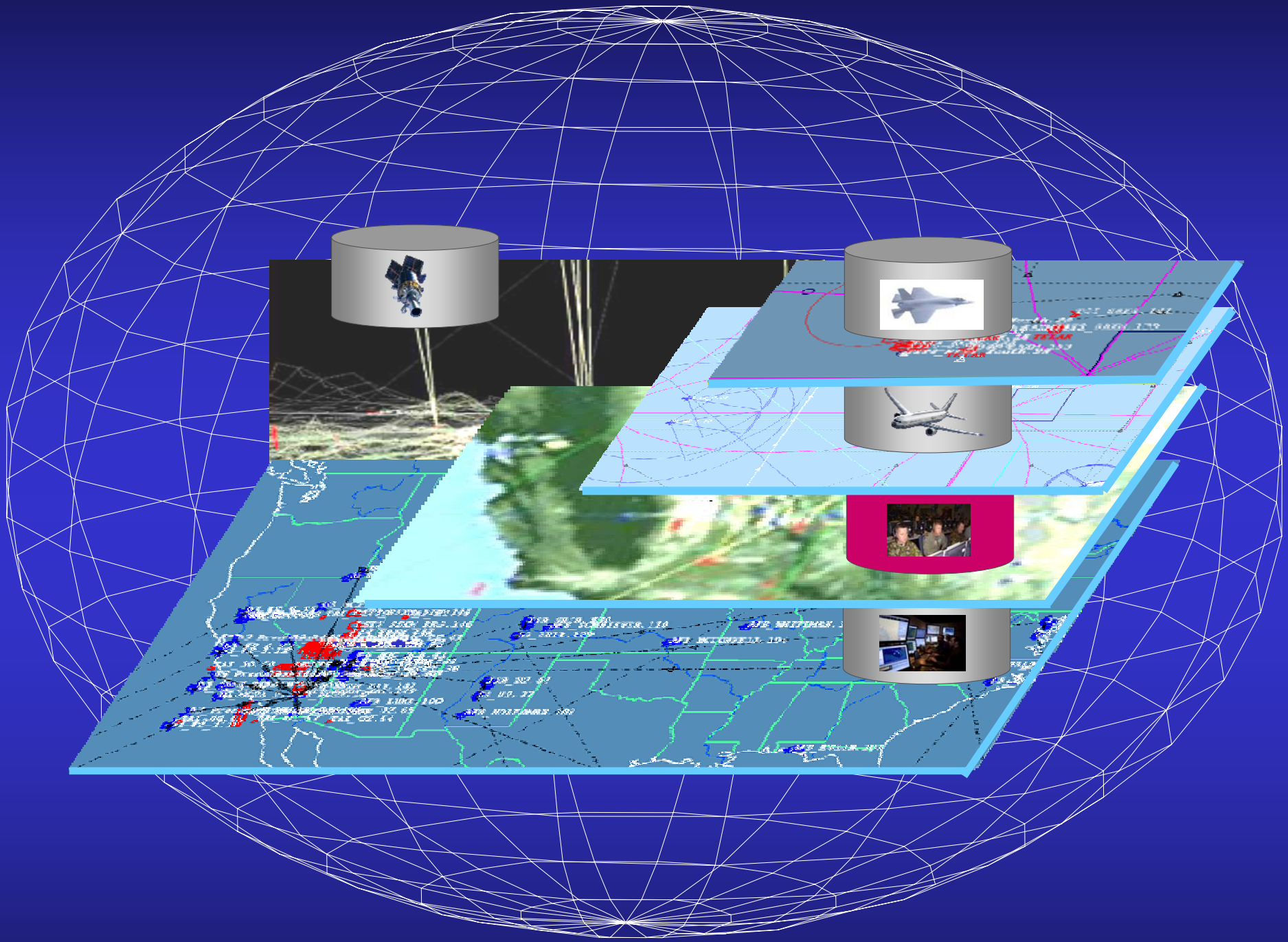

Org-AOC
Org-COD
Operator - AOC Director
Operator - CCO
Org-GOT
Operator - SODO
Operator - ODO
Operator - Strat D Ch
Operator - ISRD
Org-SIDO Team
Org - ACF TEAM
Org - TGT/CAT Team
Operator- DTC DEP
(from Workers)
Operator - DTC Chief
Operator - SIDO
Operator - JAG
Org - Analytical Cell
Primary Chain
Operator - AC
Operator - IDO/T
Operator - ISRODO/T
Org - TGT DEV Cel
Primary Chain
Operator - Targeteer/Target Tech



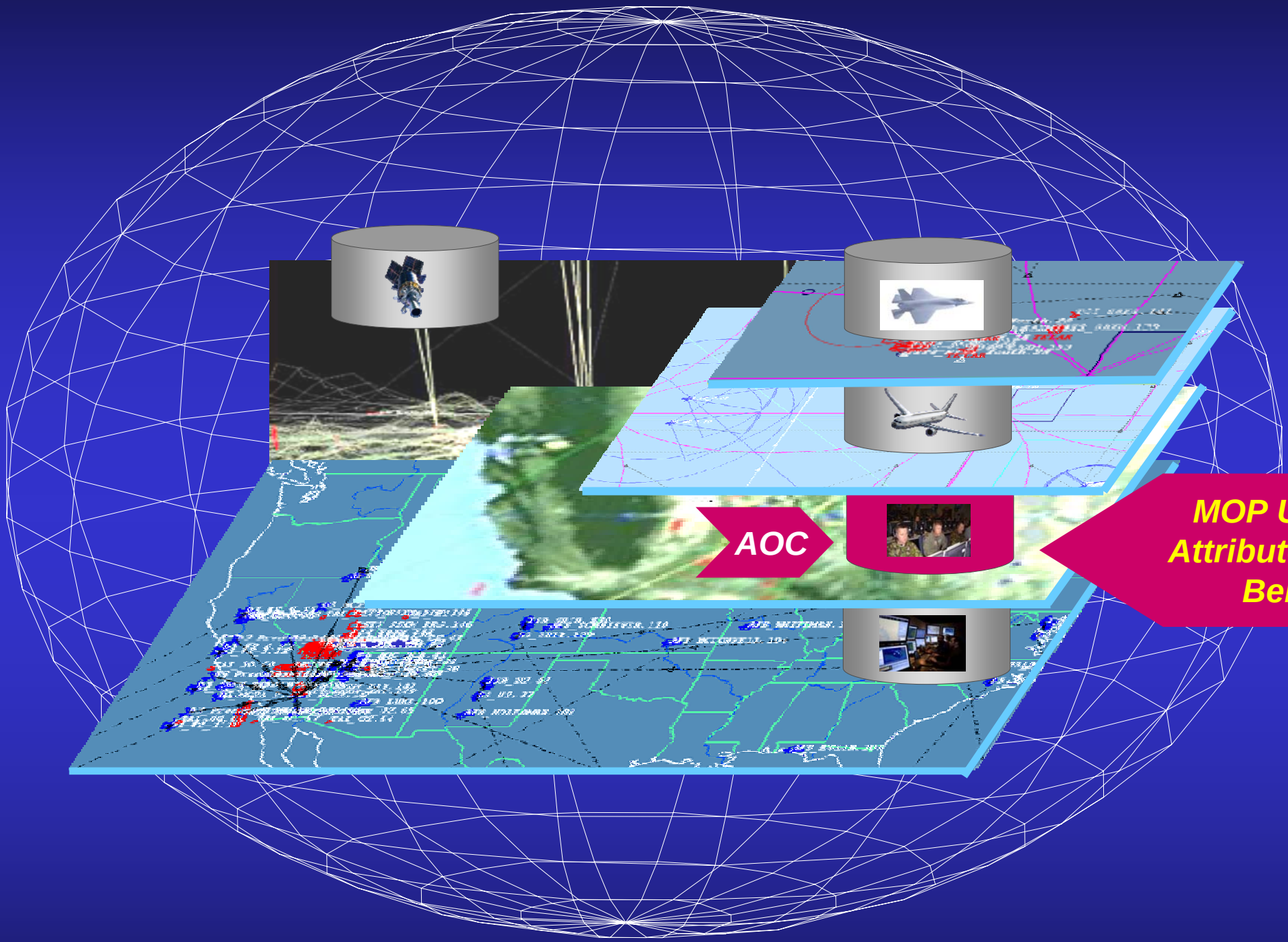
ted Modeling Team Rapidly Generates Object-Oriented UML M

- Activities Modeled
- Dynamic Models
- ission Scenario Executable Models and Simulations
- -Based Orchestrated Service Thread
- upport for 3rd Party Innovators

Smart Solutions Into Warfighters' Hands Faster



for Capability and Investment Leverage Points

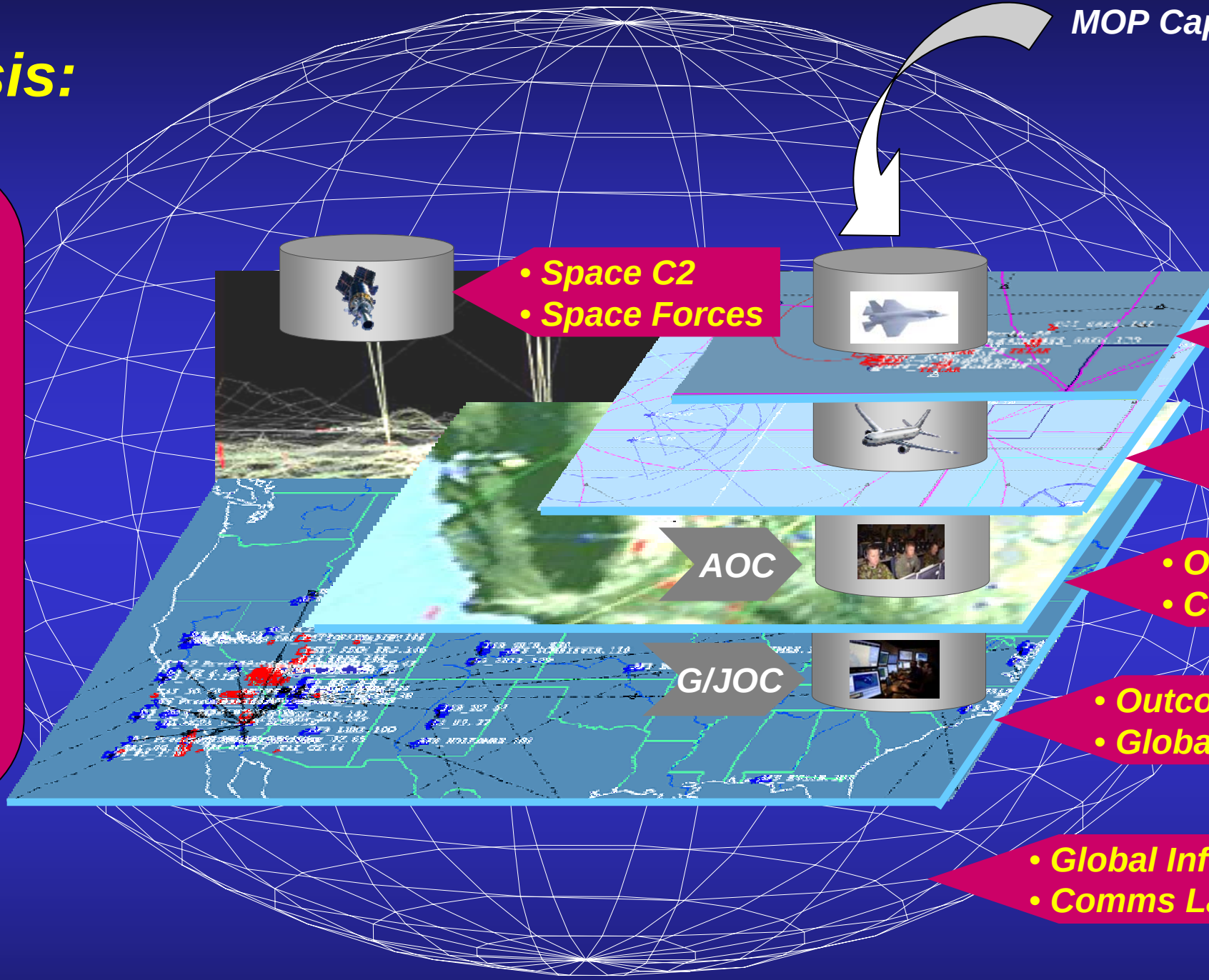

AOC
MOP Used to
Attributes of C
Being An

lored
nalysis:

& IO
s
ern
Ranges
current
espace
vities
lity

Improvement
MOP Captured





• Engi
• Sens

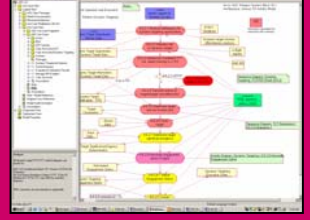
• Engage
• Airborn

• Ops/Mission
• Component

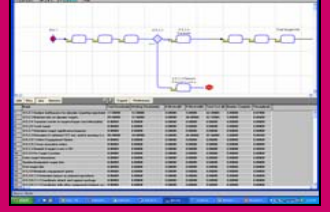
• Outcome Level
• Global/COCOM/

• Global Information
• Comms Lay Down

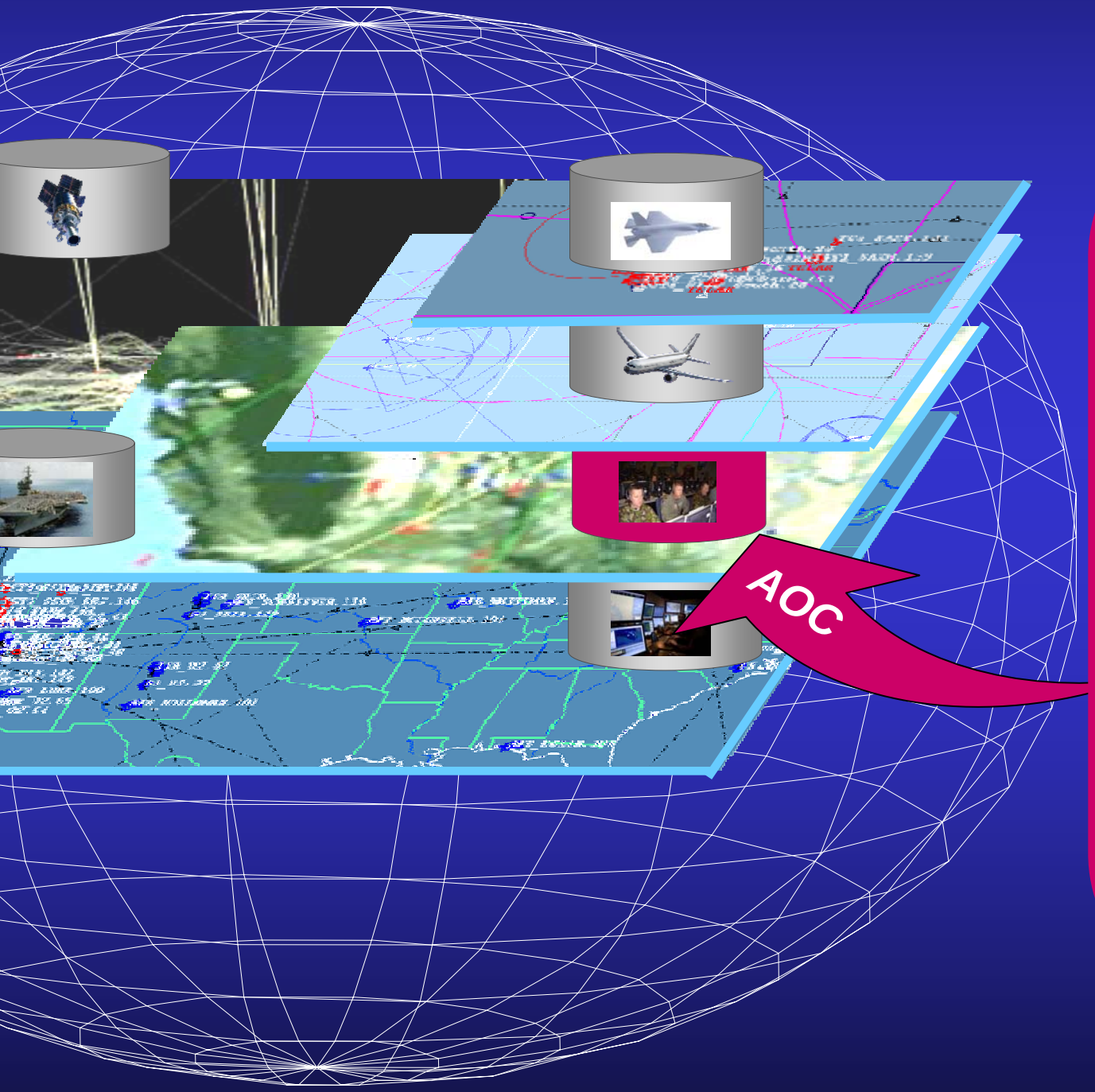
vered MOP Inputs (IBM Web Sphere Business Integra



AOC Performance Simulations Run



Improvement MOPs Captured



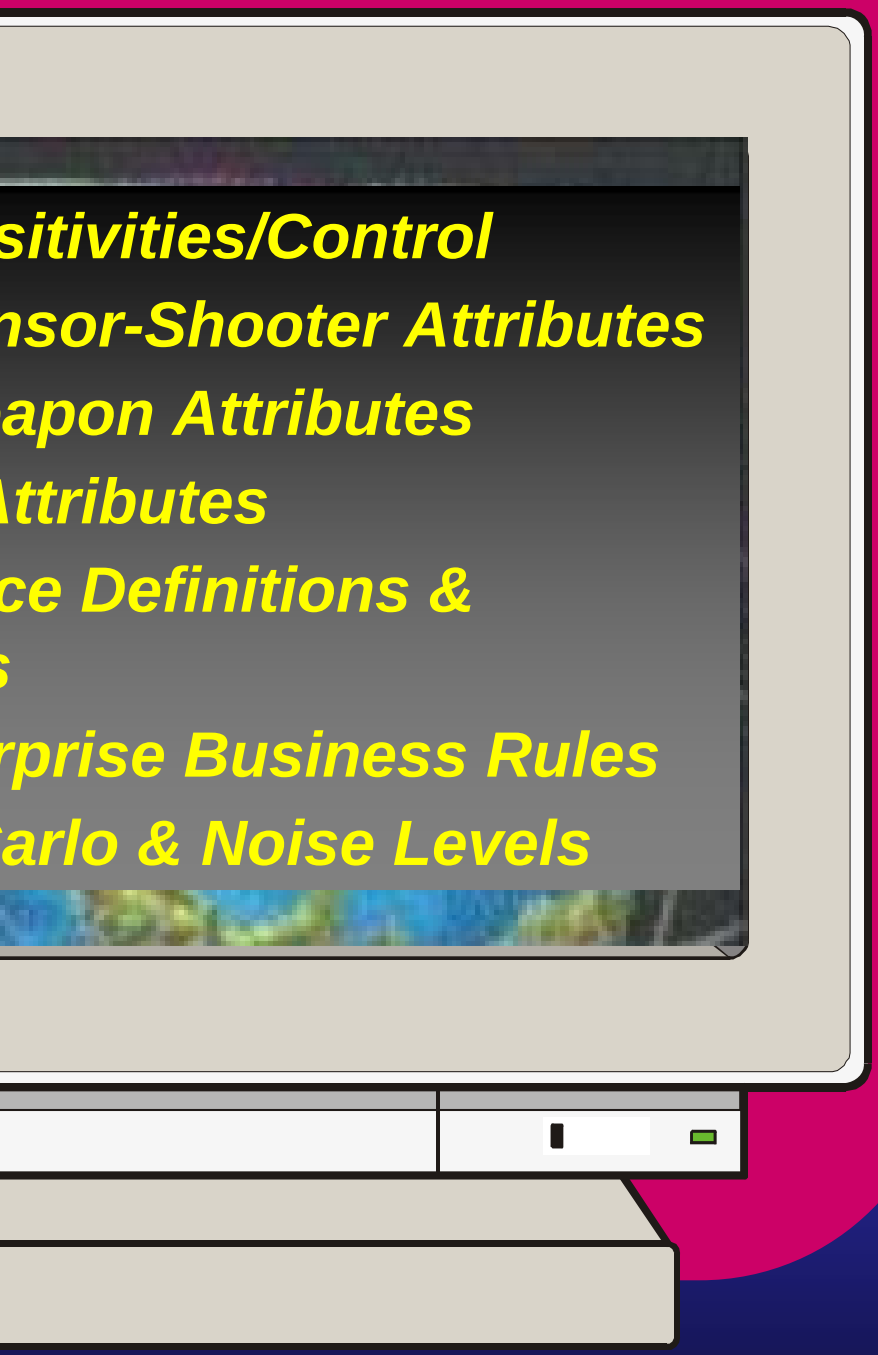
Model In

MOP Converted to Cha
of C2ISR Node Candida

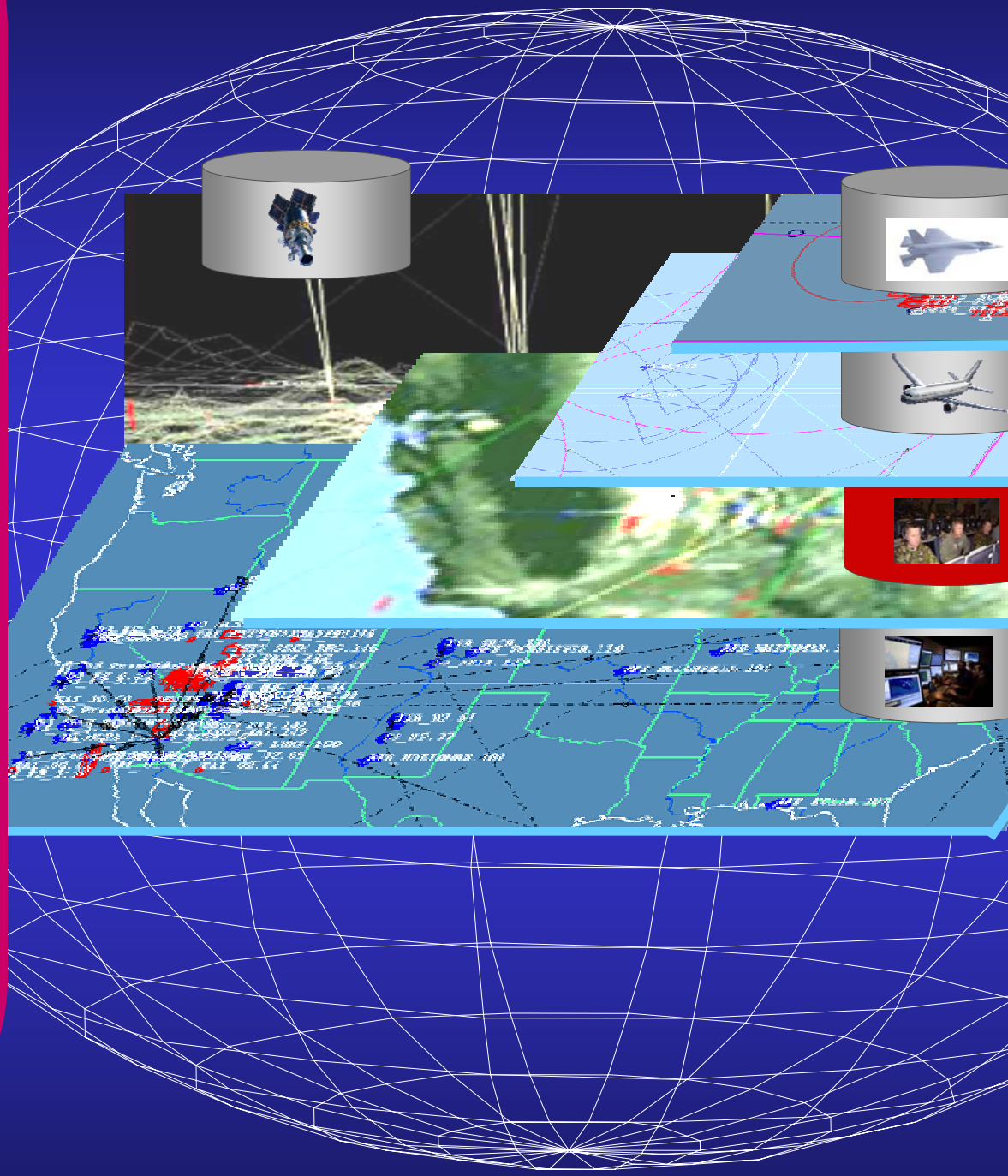
- **Process Cycle Times**
- **Bandwidth Use**
- **Task Cycle Times**
- **Comms**

rol Inputs:

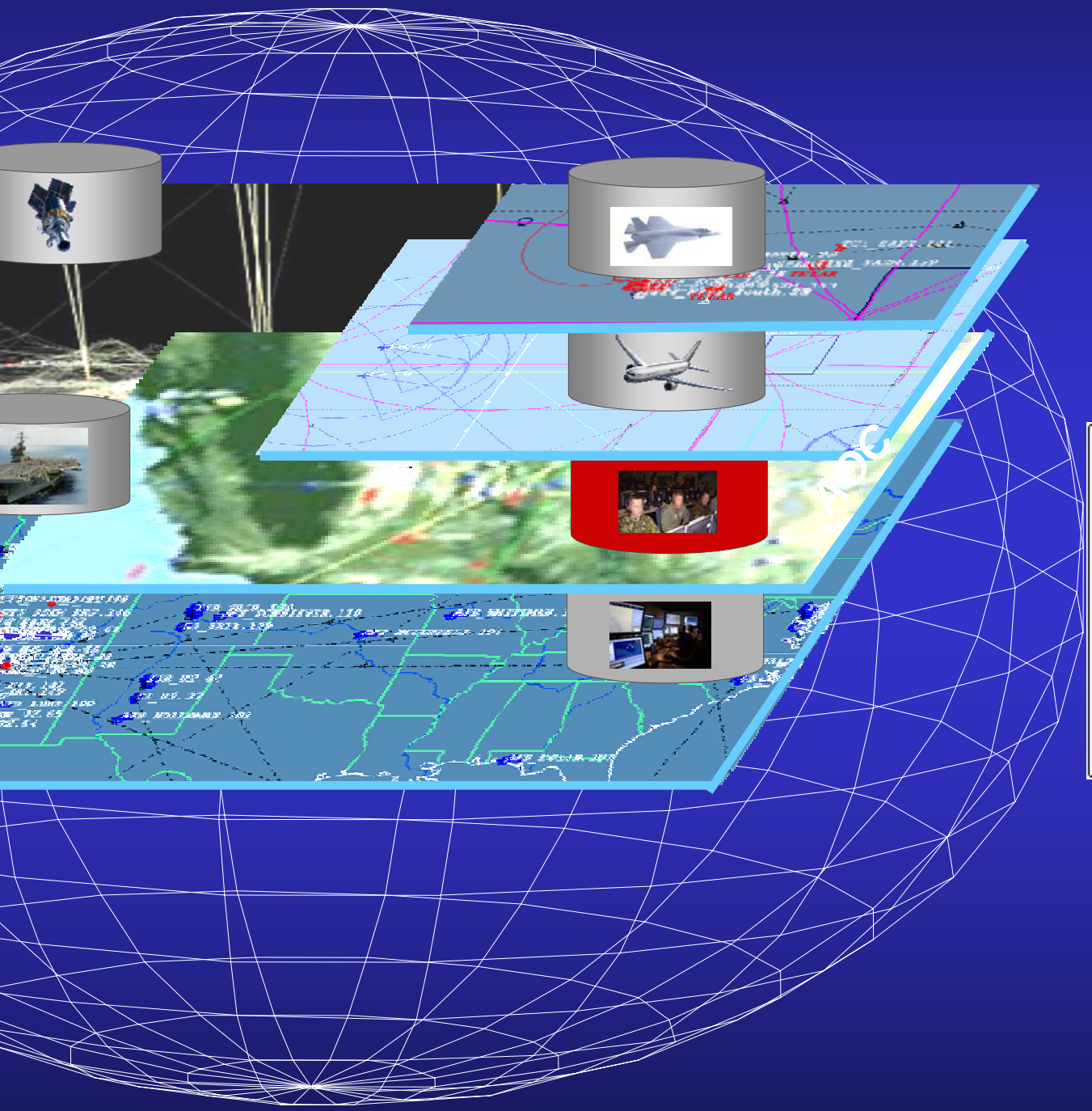
espace Characteristics

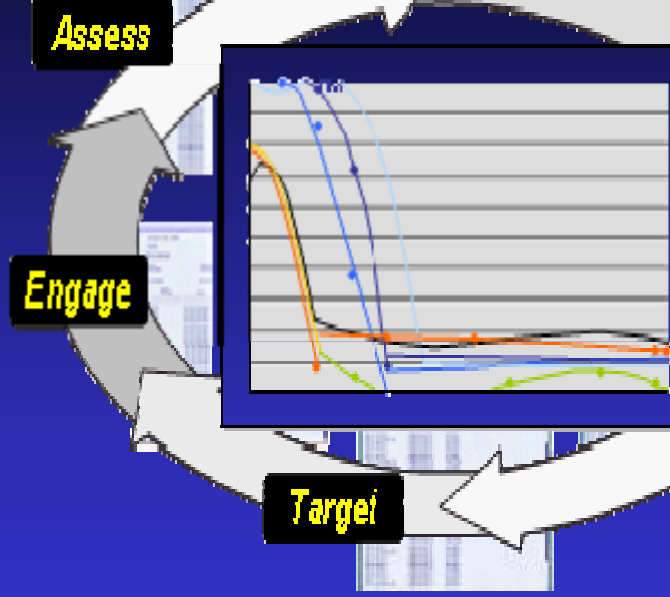


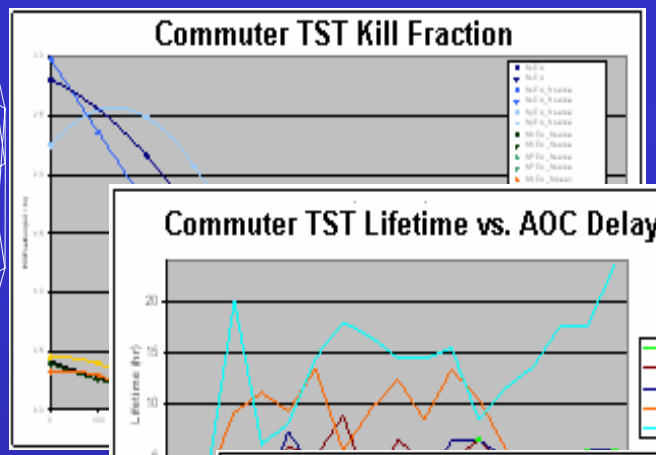
Realistic Battlespace for Improvement Asse

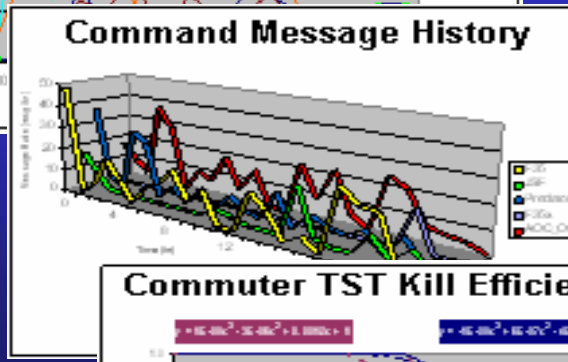


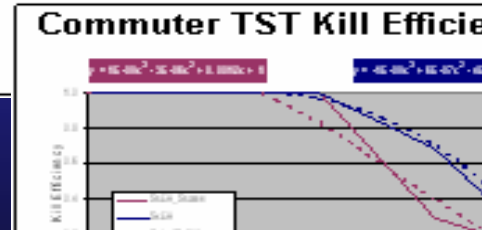
Combat Utility MOE











Summary

About the Warfighter (Customer)

A Provides Methodologies, Approaches and Tool Sets That S
tion for Tailoring Solutions To the Warfighters' Need – Addr
for Challenges

MEGA To Design Fact-Based Solutions for Our Programs

SI Used OMEGA Foundation To Design AIMS Engineering S
t AOC WS Integration Cycle System Engineering and Progra

Need - C2ISR Wind Tunnel – Role for NDIA

Final Presentation for the Implication of FORCEnet on Coalition Forces

October 25, 2006

Port Hueneme – COHORT 4

Distribution Statement A - This is approved for public release: distribution is unlimited.

Agenda



- Purpose
- Schedule
- Scenario
- Modeling and Simulation
- Financial Analysis
- Conclusion

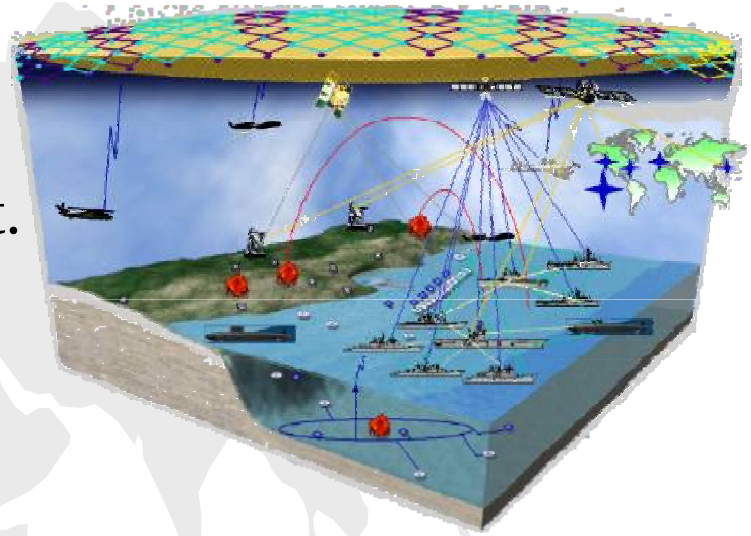
Supporting Information from previous IPR presentations are available upon request.– Scenario, Flow and Entity Diagrams, Notional Formations, Detection Analysis, SV Diagrams.

Purpose

- The purpose of this presentation is to report the PHD Cohort #4 group analysis of the Implication of FORCEnet on Coalition Forces.

Project Objectives

- To provide analysis and guidance on the technical requirements for coalition maritime warfare interoperability in a FORCEnet construct.



- Develop a high level system architecture to accomplish maritime coalition littoral warfare operations.

- Assess the incremental value of higher levels of FORCEnet interoperability (not fully networked to 100%)

- If it is determined that FORCEnet is a “good thing’ to implement with coalition navies, then determine what is the cost of entry into the USN version of Network-Centric Warfare.

Schedule



- Project Plan ✓
- Initial Capabilities Document (ICD) ✓
- Architecture Framework ✓
- Modeling & Simulation ✓
- Financial Analysis ✓
- Capability Development Document ✓

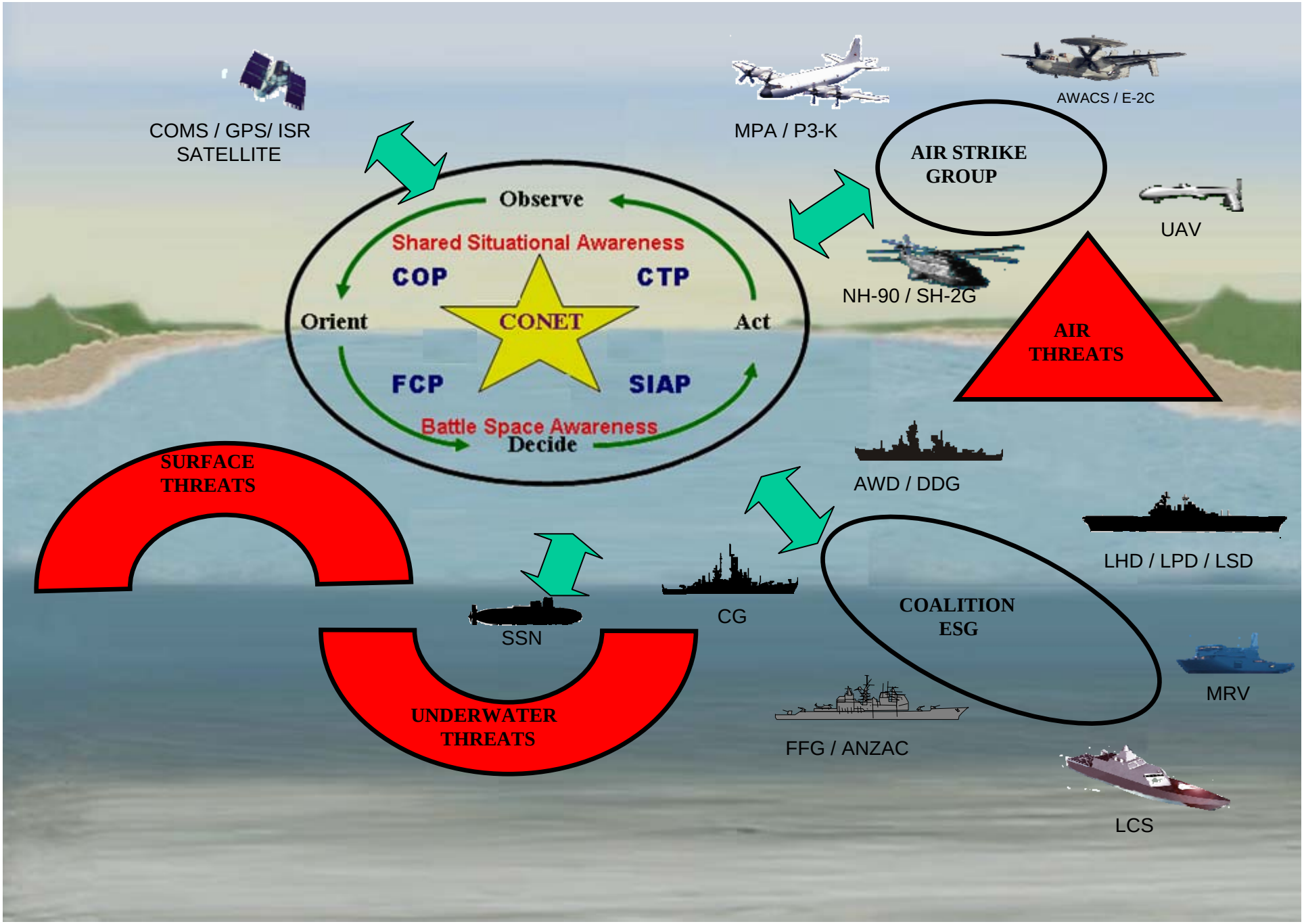


Figure A.1. Overall Coalition FORCEnet OV-1

Modeling and Simulation

What did we consider and what were the results?

Assets Available



Non-Organic & Organic Assets
Active / Passive
Space / Air / Surface / Sub-Surface

Model snapshots shown here were accomplished using AGI software

Financial Analysis

What did we consider and what were the results?

Financial Analysis Assumptions



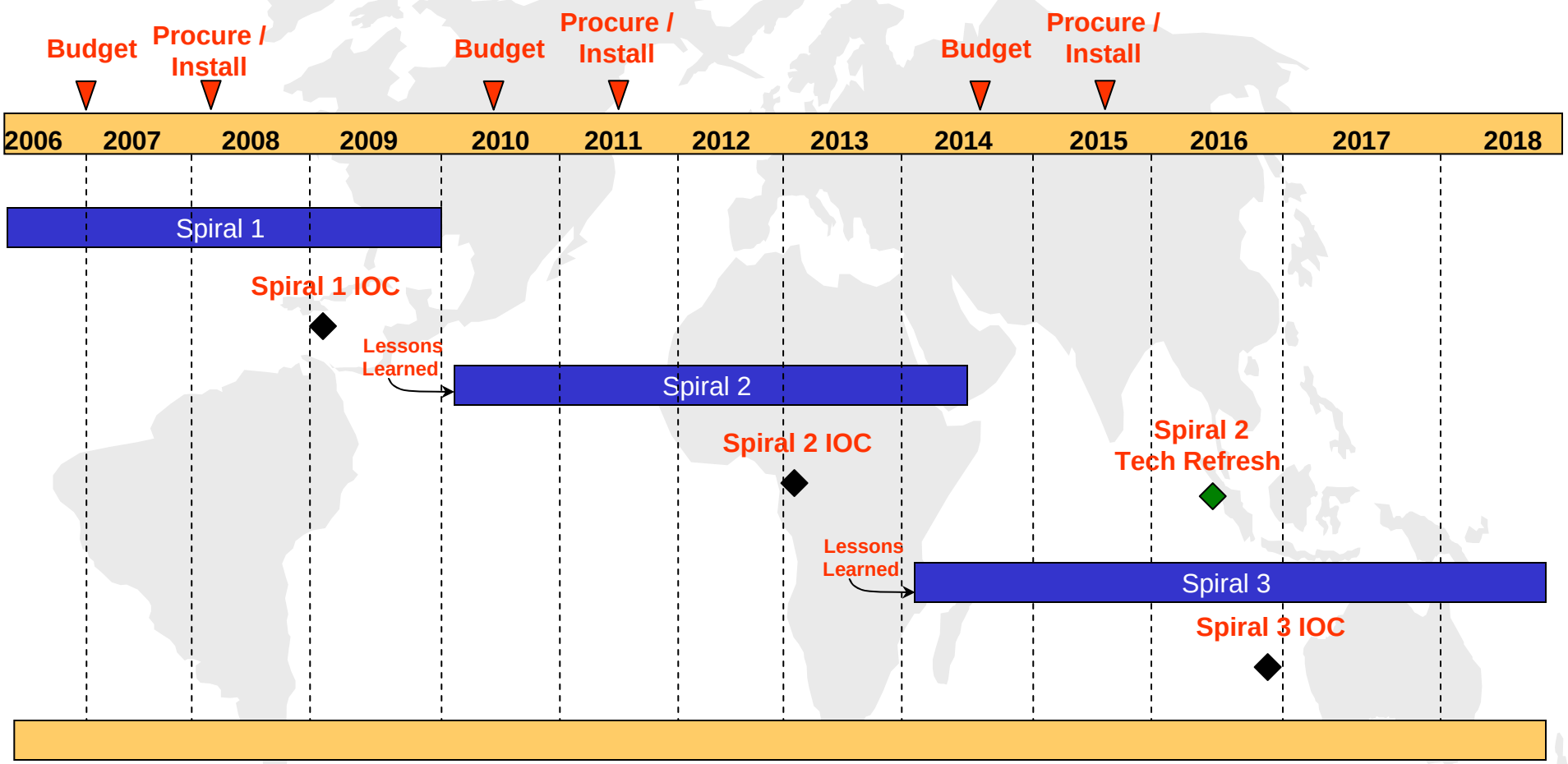
- The dollar amount assigned to each element in the cost model is based on information gathered from comparable systems.
- Procurement Cost includes:
  - System Integration Cost (R&D)
  - Acquisition Cost
  - Installation Cost
  - Initial Training Cost
  - Cost of Initial Spares
  - Administrative and Logistics Cost
- Operation & Support Cost includes:
  - Ongoing Technical Support Cost
  - Cost of Replenishment and Spare Parts

Coalition FORCEnet Fielding Plans



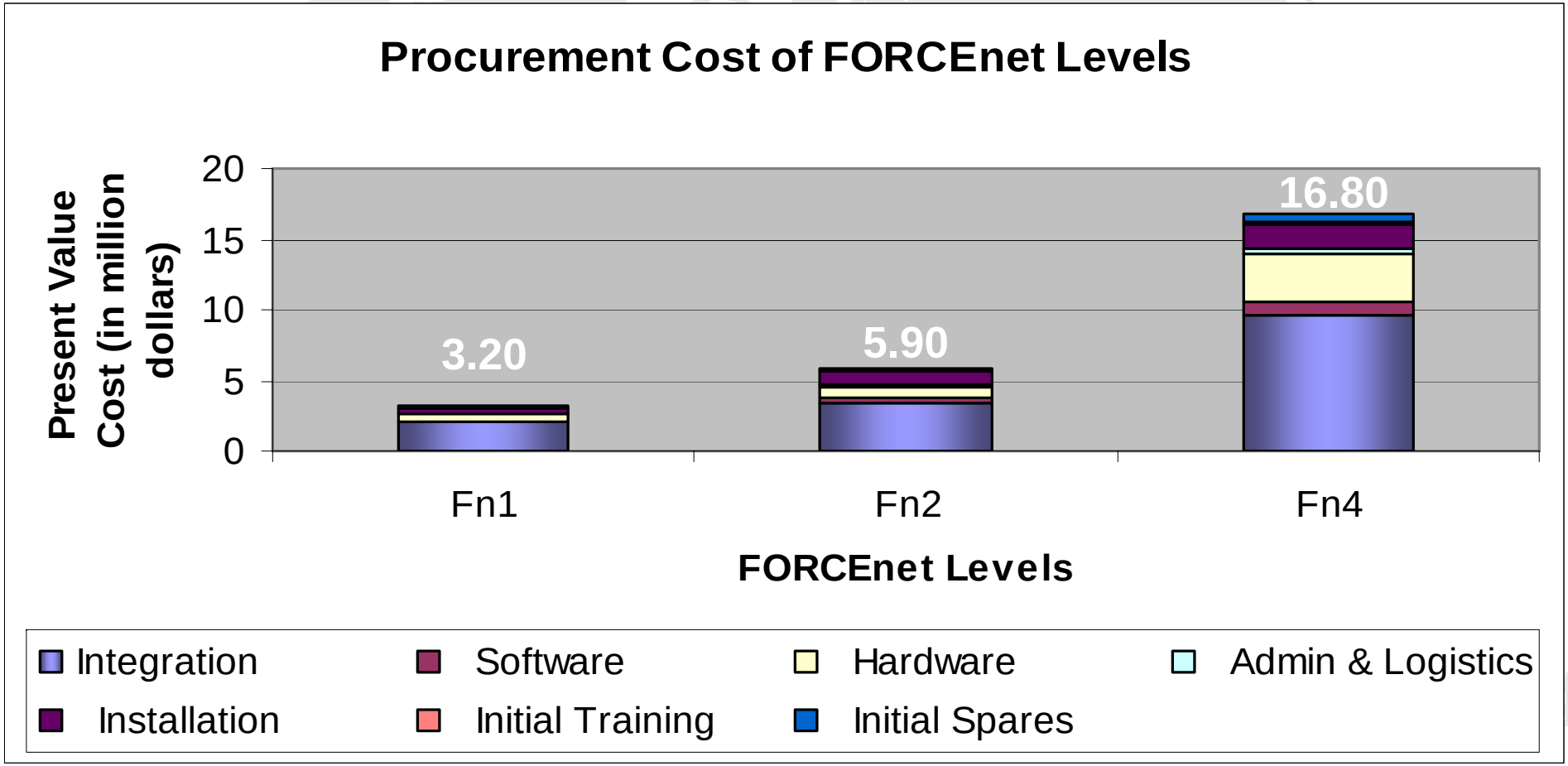
- FORCEnet Level I
  - Spiral 1 Acquisition (Command & Control) (FY2006)
- FORCEnet Level II
  - Spiral 1 Acquisition (Command & Control) (FY2006)
  - Spiral 2 Acquisition (Enhanced Tactical Data Capability) (FY2010)
- FORCEnet Level IV
  - Spiral 1 Acquisition (Command & Control) (FY2006)
  - Spiral 2 Acquisition (Enhanced Tactical Data Capability) (FY2010)
  - Spiral 3 Acquisition (Shared Engagement Capability) (FY2014)

Program Implementation



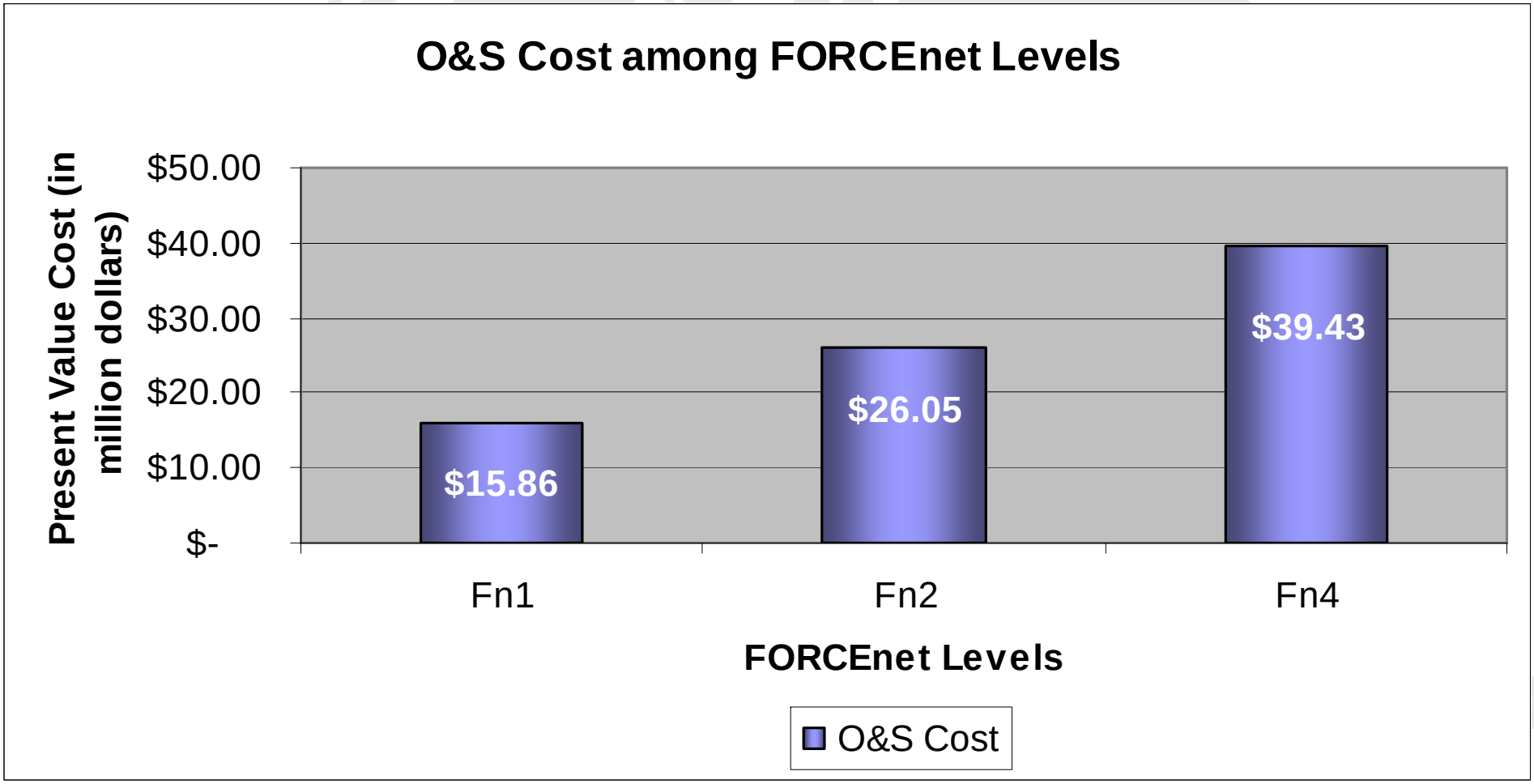
Spiral 1 =Basic IP Based C2 Integration
Spiral 2 = Enhanced Comms / Enhanced Tactical Data Capability
Spiral 3 = Enhanced Network / Shared Engagement Capability

Procurement Costs



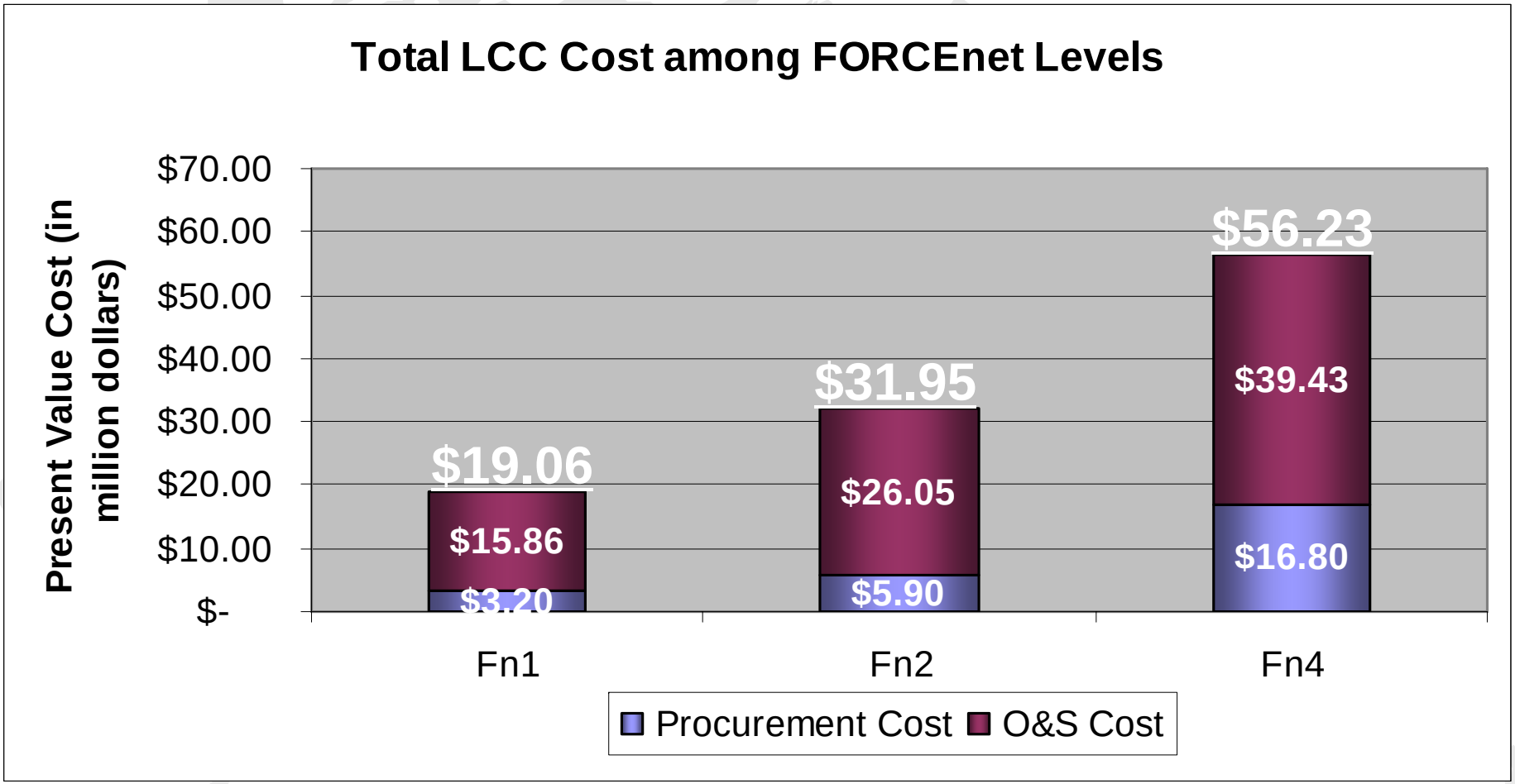
Note: Costs are estimated based upon existing systems historical costs. Costs are per ship.

O&S Costs



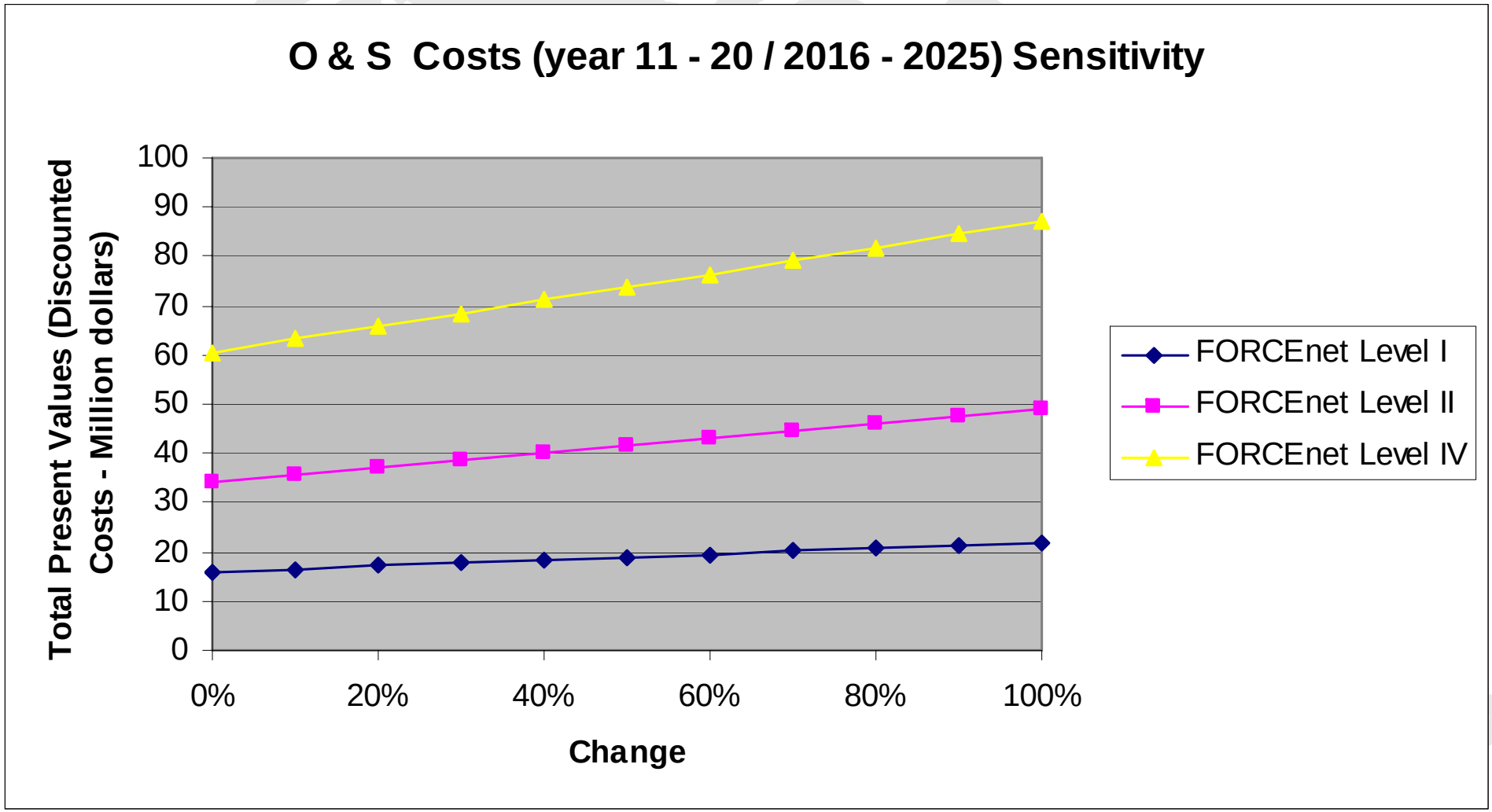
Note: Costs are estimated based upon existing systems historical costs. Costs are per ship over 20 years.

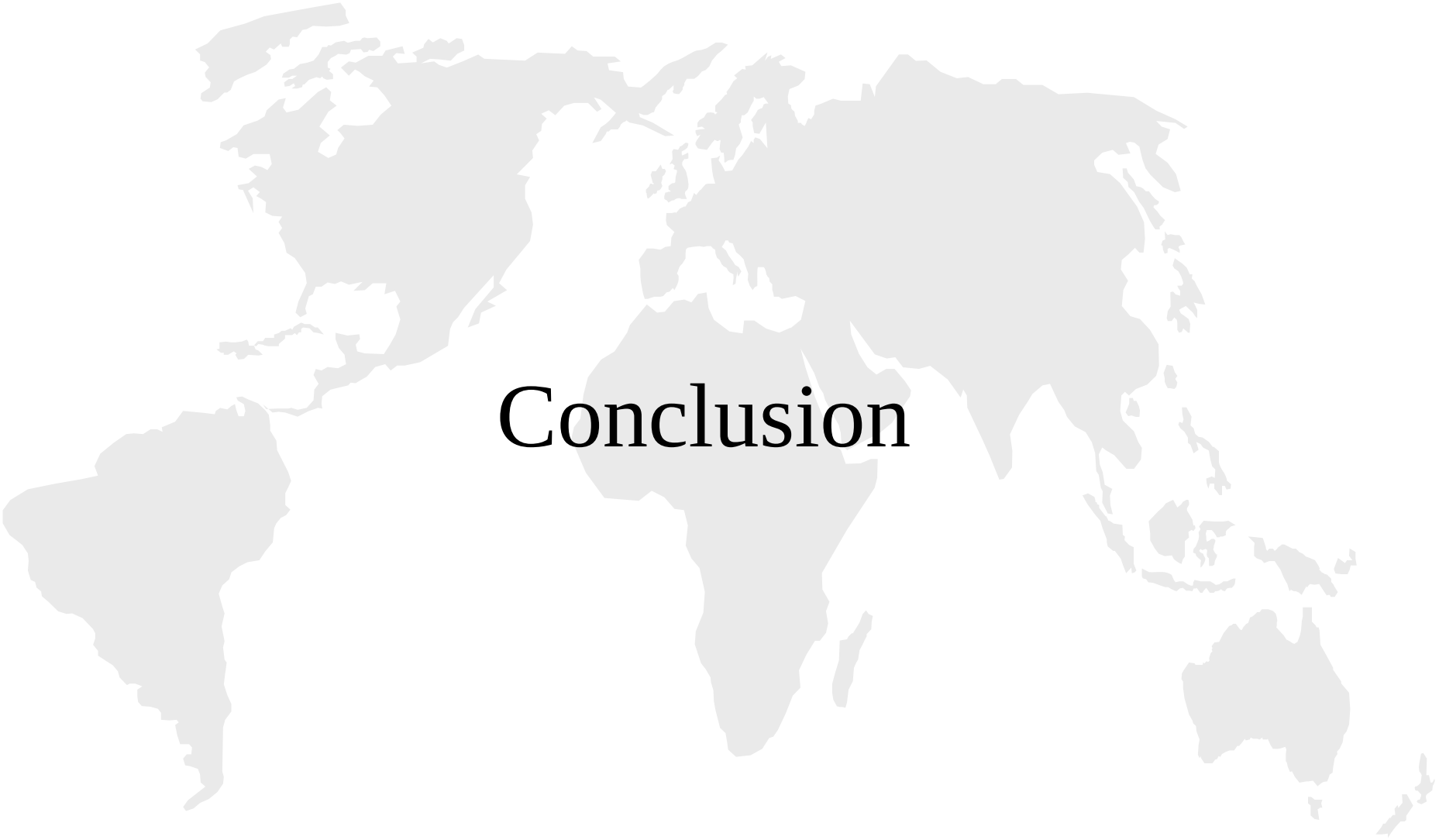
Total LCC Costs



Note: Costs are estimated based upon existing systems historical costs. Costs are per ship over 20 years.

Sensitivity Analysis





Conclusion

Conclusion



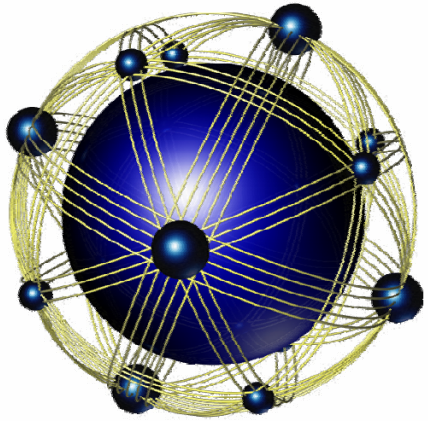
- FORCEnet Level 4 provides the higher performance
- FORCEnet Level 4 associated costs are higher
- FORCEnet Level 2 provides comparable performance levels at ~ 40% less cost than FORCEnet Level 4.

NDIA 9th Annual Systems Engineering Conference

"Improving the State of Distributed Simulation"

October, 2006

Frank Salvatore
High Performance Technologies, inc.
3159 Schrader Road
Dover NJ, 07801
(973) 442-6436 ext 249
fsalvatore@hpti.com



HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Outline

- Purpose
- Scope
- Status
- Architecture
- Opportunities
- Questions

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Purpose

M&S frameworks have the potential to change how M&S collaboration is performed.

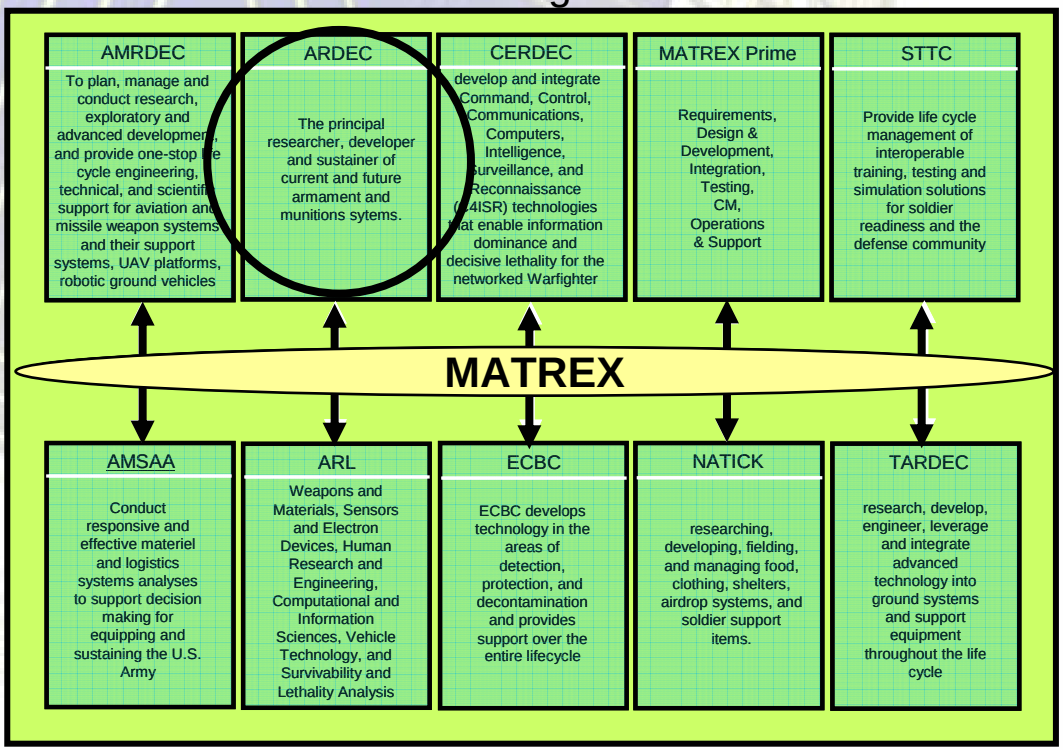
The M&S Framework and "Flexible Syntax" developed at the US Army Armament Research Development Engineering Center (ARDEC) as part of the Armaments Server and MATREX NEC2 projects has broad application and potential to become a standard framework for distributed interoperability between models.

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Background

Modeling Architecture for Technology, Research & Experimentation (MATREX)

Delivers effects on target



Benefits:

- Reduces time and resources required to initialize a distributed simulation
- Promotes reuse of standardized scenario data format
- Improves configuration management via centralized data set
- Allows incorporation of additional components that are compliant with the MSDL format

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Project Goals

- Develop an M&S framework that will support ARDEC M&S interoperability and distributed simulation.
- Deliver Effects on Target as a vital piece of RDECOM MATREX (Armaments Server).
- Integrated Process for Network Effects Command and Control (NEC2).
- Provide modular interface for both models and distributed simulation network interfaces.
- Minimize the impact of changes (from models, desired behavior).
- Use a “Flexible Syntax” for configuration and rules files to.

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

What Problems Does This Solve?

- Allows disparate Engineering models to participate in distributed simulation exercises with minimal tailoring of the model.
- Enables model to model interoperability.
- Minimize the impact of changes.

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Framework Status

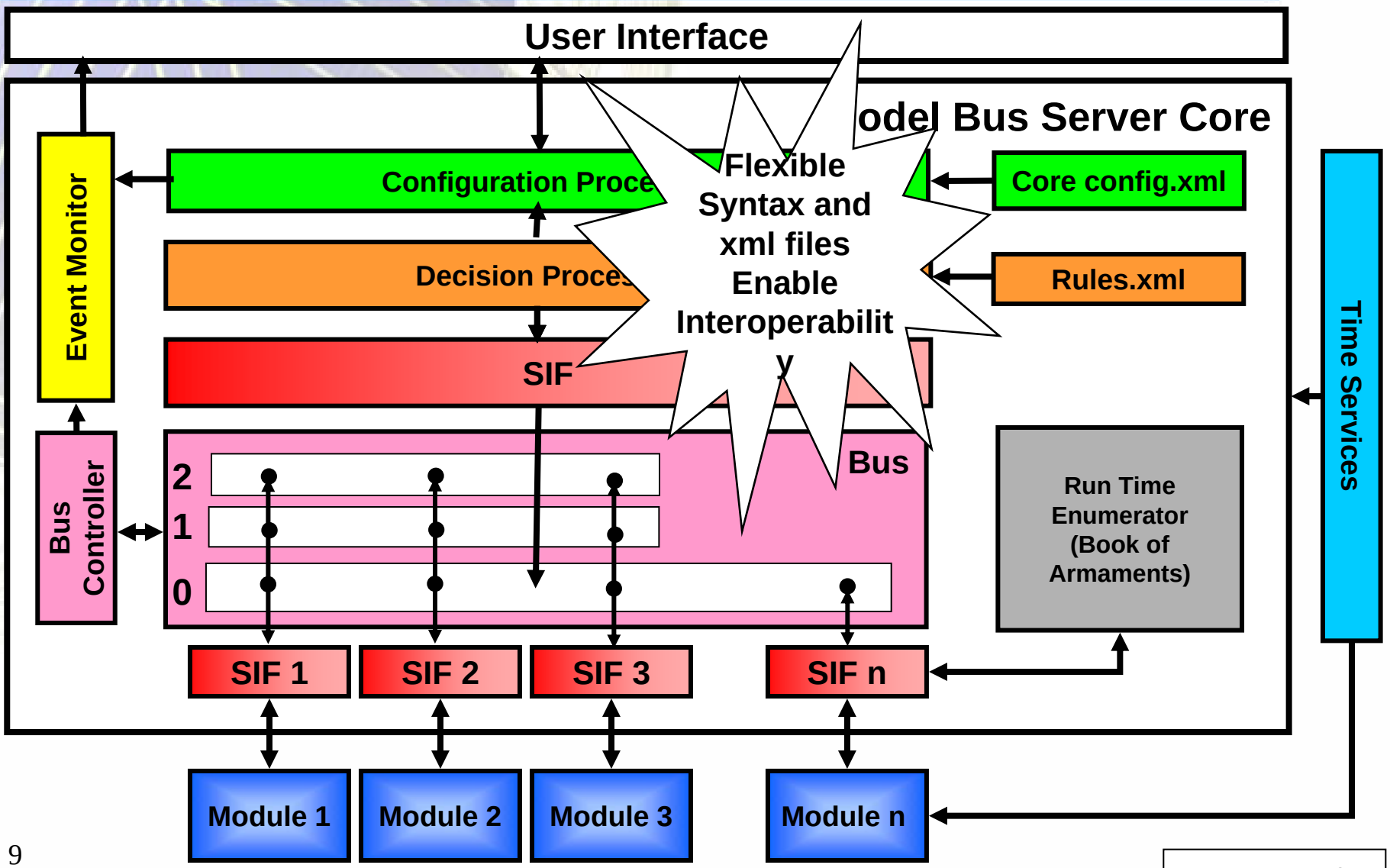
- **Continuous Development Since Nov 2002**
  - **4 contracts**
  - **2-3 FTE Govt.**
  - **6 SME on and off.**
- **Accomplishments**
  - **Designed and Built Framework**
  - **Develop and Maintain Armaments Server**
    - ✓ **Used in 1st App.**
    - ✓ **Involved in MATREX (Selected by FCS LSI)**
  - **NEC2 is considering using the Framework.**
  - **Supporting the Development of NEC2**
    - ✓ **Effects Engine**
- **Ammunition Trajectory Models Available**
  - **PGMM**
  - **SADARM**
  - **Etc……**

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Architecture Overview

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

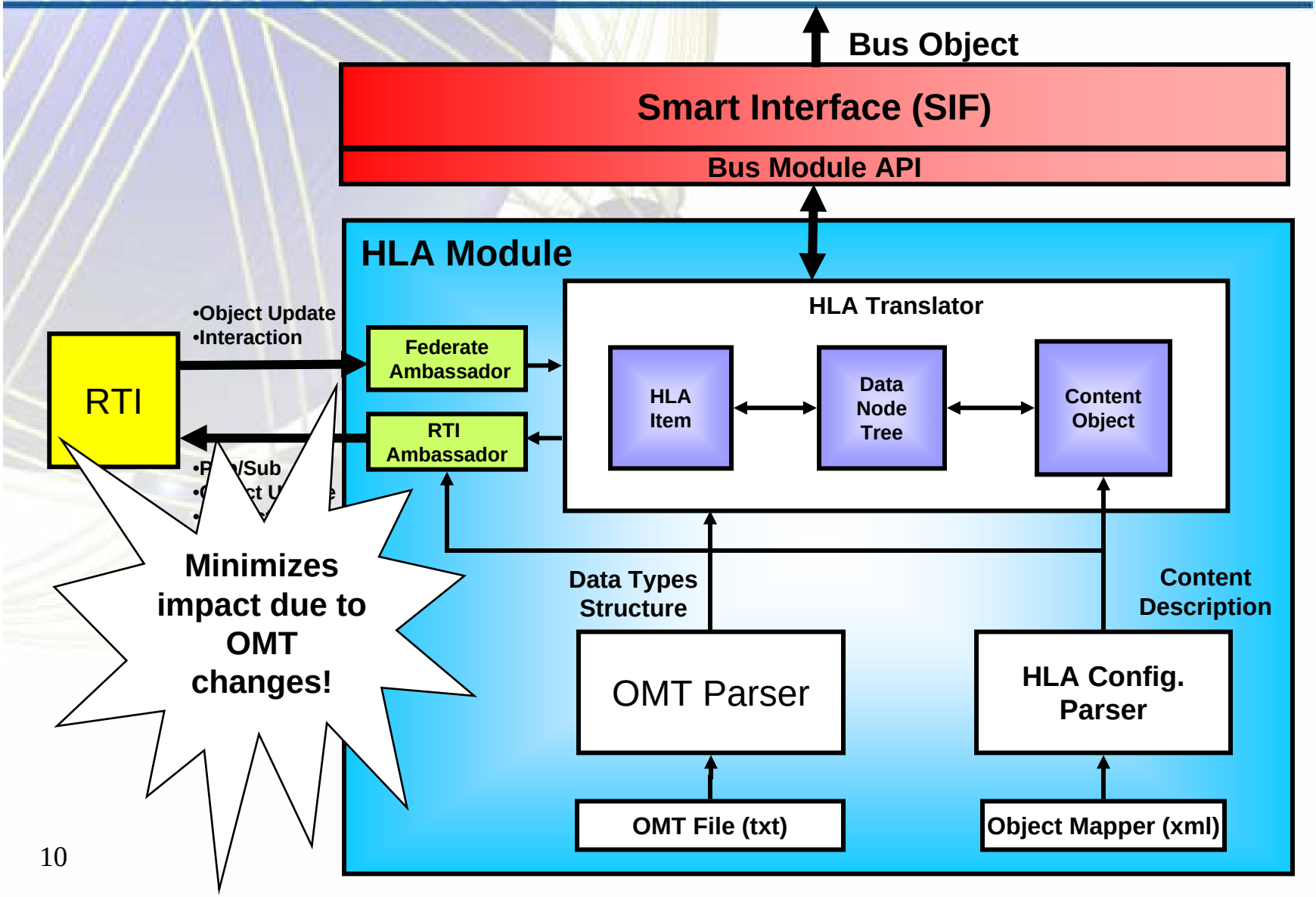
Model Bus Server Architecture



SIF = Smart Interface

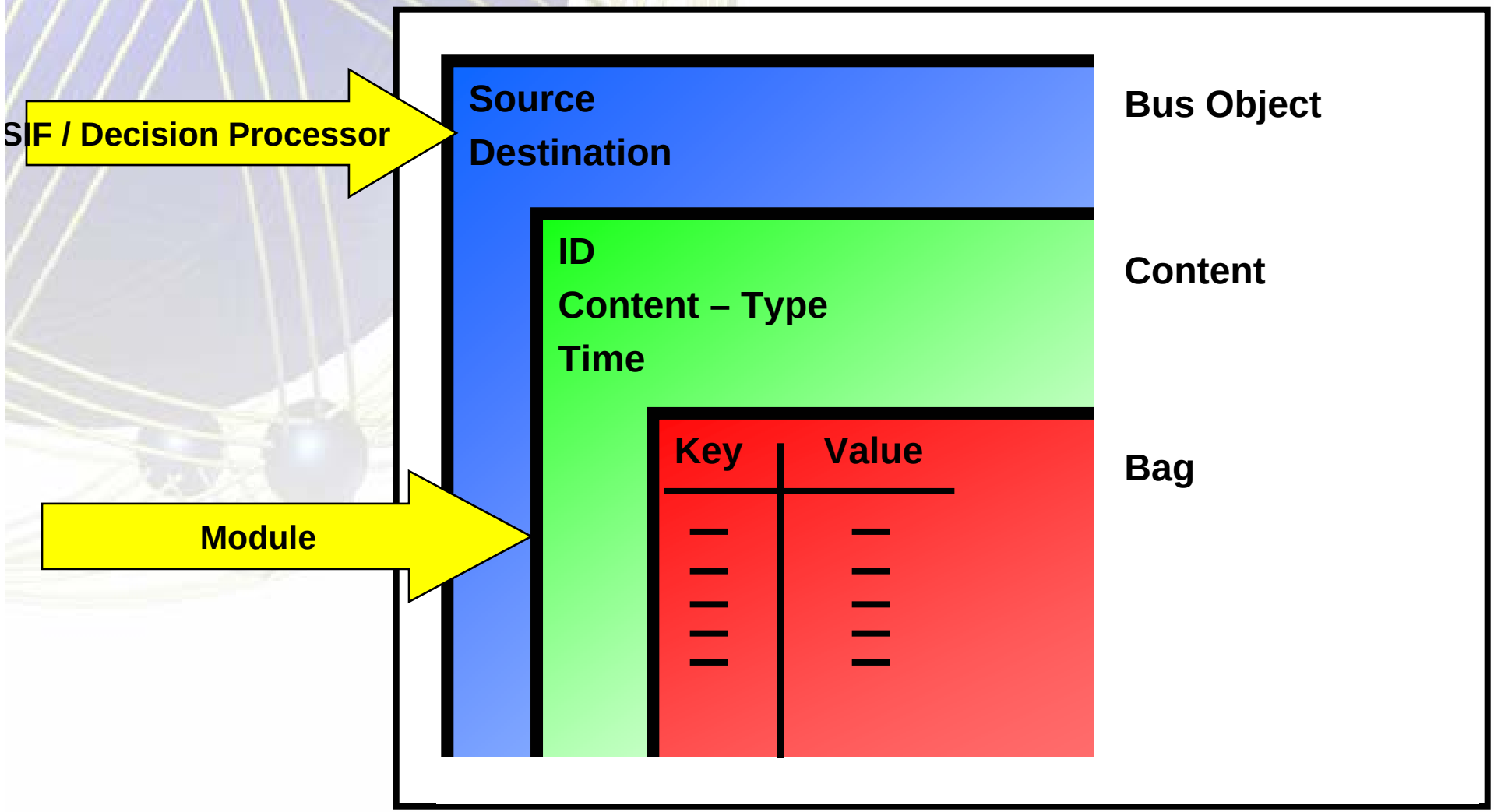
HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

HLA Module Architecture



HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Bus Object Data Encapsulation



HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

What makes this different?

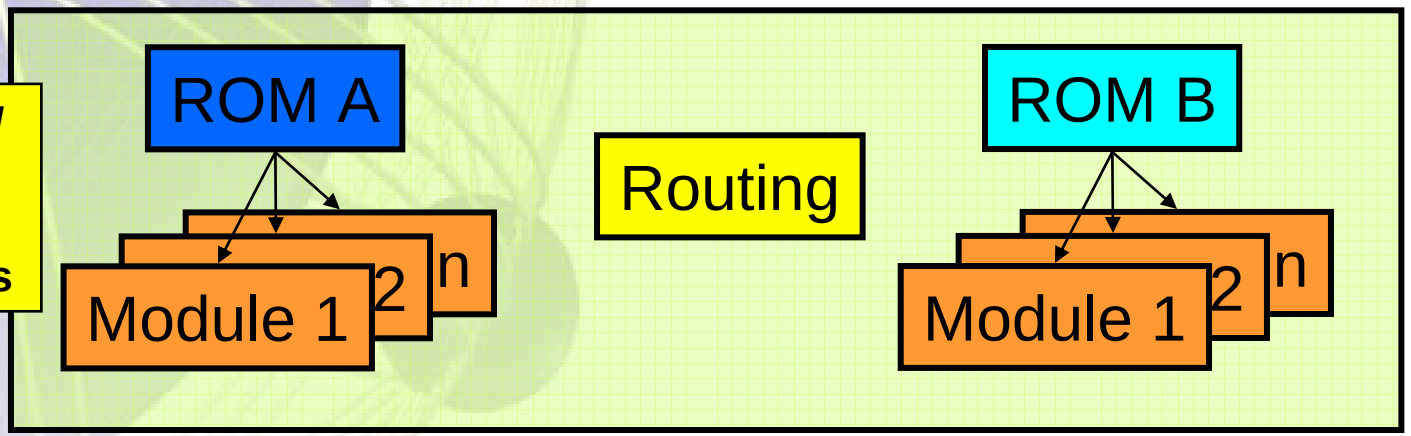
The architecture is unique in that it adapts to FOM changes without the need to recompile.

- **Most Federates need to recompile.**
- **This framework only requires a changed OMT.txt file along with the XML object mapper XML file**

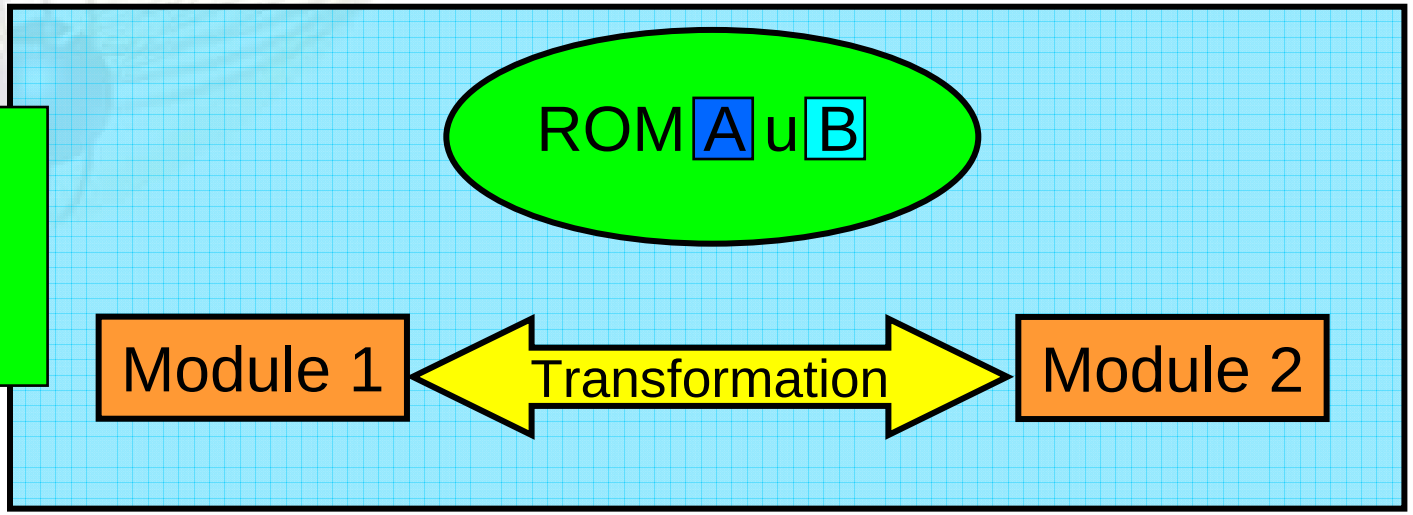
HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Data Routing & Transformation

Data is *Routed* between modules with different ROM's

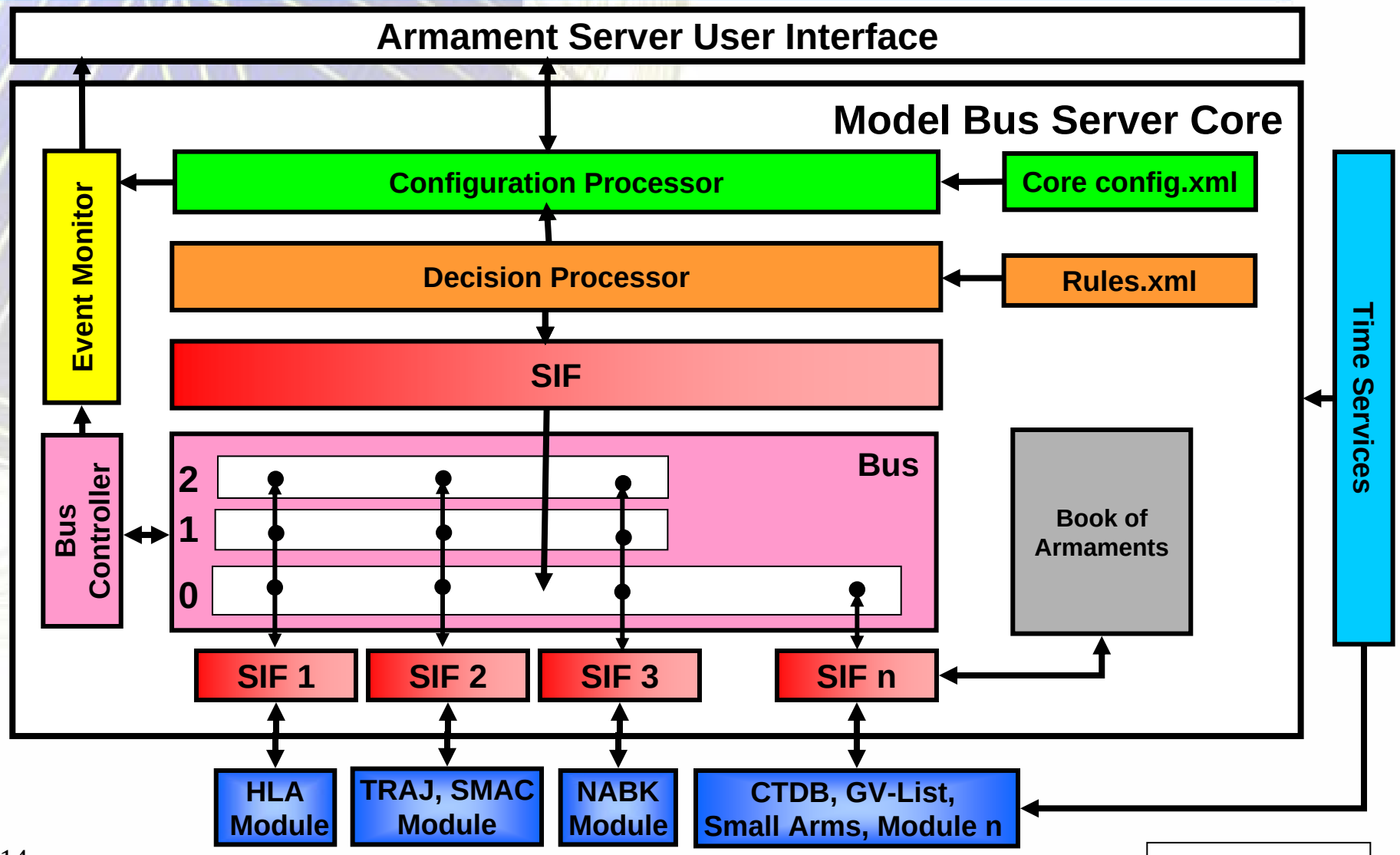


Data is *Transformed* between modules with the same ROM's



HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Armaments Server



SIF = Smart Interface

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

What Technology was used?

- Core Server Written in C++
  - uses standard template library
- Runs in Windows OS
  - can be ported to other OS's
- Rules Based Routing & Transformation
- "Flexible Syntax"
- Server API

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

What are the Opportunities?

- Could be used to develop other simulation frameworks.
- Could be used to replace existing simulation frameworks that are more complicated to interface with or maintain.
- Enable interoperability between models, Simulators, and hardware

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.

Interested in Building a Server?

- Need API
  - HPTi License agreement – unless govt.
- Develop interface SW according to API
- Generate Rules file
- Revise Configuration file
- User Interface
- For HLA
  - HLA module Licensed or
  - Build your own
- Contact
  - US Army ARDEC for govt. – govt. work
  - HPTi for contractor to commercial or contractor to govt.

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.



Questions?

HPTi Proprietary. Use or disclosure of information contained in these slides is prohibited.



THE AEROSPACE CORPORATION

SPARTA
Pride in Performance

NDIA
9th Annual
Systems Engineering Conference

Product-based Systems Engineering Requirements

25 October 2006

Brian Shaw, The Aerospace Corporation
Larry Pennell, Sparta, Inc.
Dave Davis, USAF SMC/EAE

Agenda

- Background
  - Space System Acquisition Challenges
  - SMC Specifications and Standards Program
- SMC Approaches to Systems Engineering (SE)
  - SE Processes and Requirements Vision
  - Development of “SE Products and Requirements”
- SE Products and Requirements
  - Sample Products and Requirements
- Summary and Conclusions

Agenda

- **Background**
  - **Space System Acquisition Challenges**
  - **SMC Specifications and Standards Program**
- **SMC Approaches to Systems Engineering (SE)**
  - **SE Processes and Requirements Vision**
  - **Development of "SE Products and Requirements"**
- **SE Products and Requirements**
  - **Sample Products and Requirements**
- **Summary and Conclusions**

Space Systems Acquisition Challenges

- **Space capabilities are essential for successful military operations**
  - **Requires:**
    - **high reliability**
    - **assured delivery of mission data**
- **Many new space programs exist; success hampered by**
  - **Industry-wide shortage of systems engineers**
  - **Serious lack of acquisition experience at SMC**
- **Congressional confidence in space systems acquisition is low**
- **Space programs are more complex than ever…**
  - **Hardware/software, including COTS infusion**
  - **System integration**
  - **System-of-system/Family-of-systems interoperability**

Systems Engineering Framework

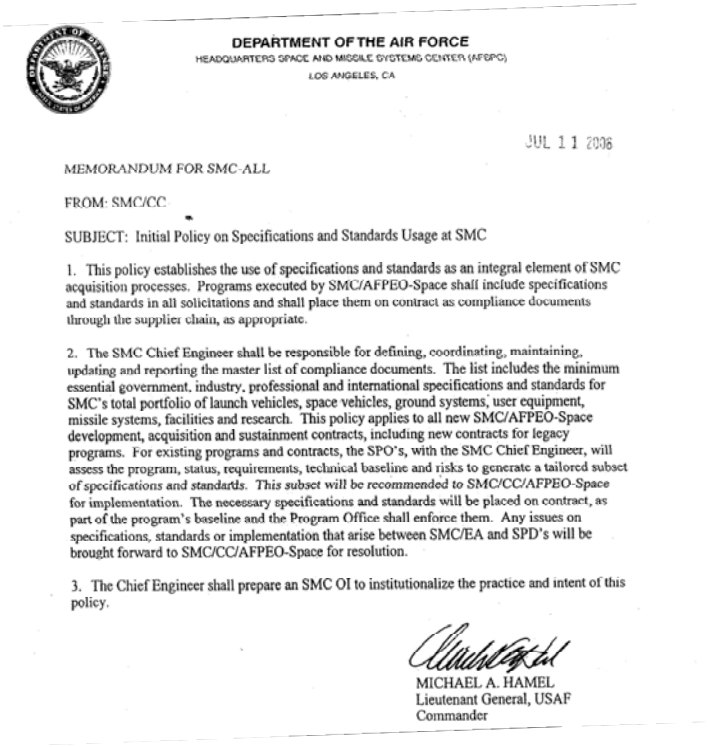
Contract:

- ***Defines SE Relationship***
- ***Establishes what Govt considers to be an acceptable level of quality***
- ***Levels playing field in bidding process***
- ***Requires Government control/oversight***



New SMC S&S Policy

- Issued by Lt. Gen. Michael Hamel 11 July 2006
- Establishes specifications and standards as an integral element of SMC acquisition processes
- Applies to all new development, acquisition and sustainment contracts, including new contracts for legacy programs
- Contractual compliance through the supplier chain, as appropriate



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SPACE AND MISSILE SYSTEMS CENTER (AFSPC)
LOS ANGELES, CA

JUL 11 2006

MEMORANDUM FOR SMC-ALL

FROM: SMC/CC

SUBJECT: Initial Policy on Specifications and Standards Usage at SMC

1. This policy establishes the use of specifications and standards as an integral element of SMC acquisition processes. Programs executed by SMC/AFPEO-Space shall include specifications and standards in all solicitations and shall place them on contract as compliance documents through the supplier chain, as appropriate.

2. The SMC Chief Engineer shall be responsible for defining, coordinating, maintaining, updating and reporting the master list of compliance documents. The list includes the minimum essential government, industry, professional and international specifications and standards for SMC's total portfolio of launch vehicles, space vehicles, ground systems, user equipment, missile systems, facilities and research. This policy applies to all new SMC/AFPEO-Space development, acquisition and sustainment contracts, including new contracts for legacy programs. For existing programs and contracts, the SPO's, with the SMC Chief Engineer, will assess the program, status, requirements, technical baseline and risks to generate a tailored subset of specifications and standards. *This subset will be recommended to SMC/CC/AFPEO-Space* for implementation. The necessary specifications and standards will be placed on contract, as part of the program's baseline and the Program Office shall enforce them. Any issues on specifications, standards or implementation that arise between SMC/EA and SPD's will be brought forward to SMC/CC/AFPEO-Space for resolution.

3. The Chief Engineer shall prepare an SMC OI to institutionalize the practice and intent of this policy.

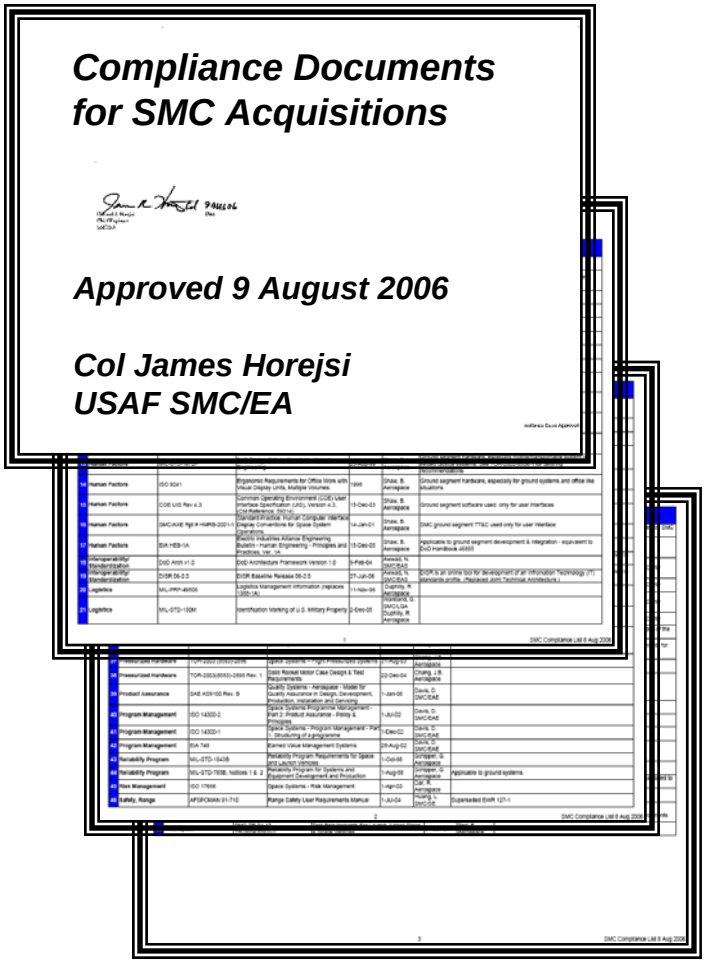
MICHAEL A. HAMEL
Lieutenant General, USAF
Commander

SMC Specs & Standards Initiative

- **SMC Specs & Standards Initiative**
  - SMC initiative to apply specs & standards as key element of acquisition practices and toolset
- **Prior to acquisition reform, SMC used military specifications & standards to specify contractual and prescriptive requirements**
- **Re-institute standards responsible for mission assurance**
  - Select group of military and industry space standards
  - Define government's expectations and specify proven technical practices

S&S Status

- **Revised SMC S&S List published 8/9/2006: 65 essential documents**
  - **Military, international, and industry standards, and Aerospace Corp reports**
  - **Updated to reflect current best practice**
    - **Example standard: *Systems Engineering Requirements and Products* The Aerospace Corporation Report, TOR-2005(8583)-3, Rev A**
      - **Contractually binding requirements defined in terms of required SE products and required attributes of those products**
      - **Consistent with existing industry standards (ANSI/EIA 632 and IEEE 1220)**
  - **Additional updates to current document versions**



Collaboration Ensures Consistency

National Security Space Integration

Co-Chaired by DoD EA Space & DNRO

Space Industrial Base Council

"Bring Senior-Level Attention to Space Industrial Base Issues on a Recurring Basis and Develop 'Actionable' Recommendations to Industrial Base Issues."

Specs & Standards Working Group

- Ensure sound technical practices applied on NSS programs
- Ensure NSS community takes a consistent approach in the application of specs & standards
- SMC; NSSO; NRO; Navy; NASA; MDA; NOAA

SMC / NRO Collaboration

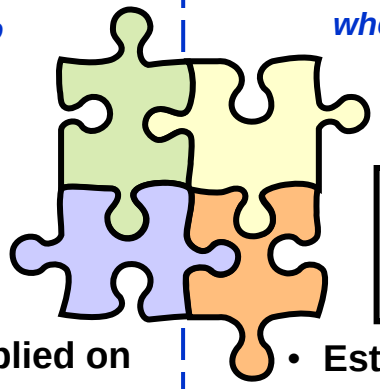
Mission Assurance Improvement Task Force

Co-Chaired by NRO DDSE & SMC/EA

"Identify and implement areas where a common SMC / NRO approach provides benefit."

Specs & Standards Working Group

- Establish a common set of preferred specifications and standards
- Quarterly interchange meetings
- Joint insight into formal standards rationale and approval processes
- SMC; NRO



SMC Specifications and Standards Functional Areas

MANAGEMENT

- Configuration Management
- Design Reviews
- Manufacturing Management / Producibility
- Parts Management
- Product Assurance
- Program Management
- Risk Management
- Systems Engineering
- Safety
- Subcontract Management

TECHNICAL

- Electrical Power, Batteries
- Electrical Power, Solar
- EMI / EMC
- Environmental Eng & Cleanliness
- Human Factors
- Interoperability
- Logistics
- Maintainability
- Mass Properties
- Moving Mechanical Assemblies
- Ordnance
- Pressure Vessels
- Parts, Materials & Processes
- Reliability
- Security
- Software Development
- Structures
- Survivability
- Test, Ground
- Test, Space

Agenda

- Background
  - Space System Acquisition Challenges
  - SMC Specifications and Standards Program
- **SMC Approaches to Systems Engineering (SE)**
  - **SE Processes and Requirements Vision**
  - **Development of "SE Products and Requirements"**
- SE Products and Requirements
  - Sample Products and Requirements
- Summary and Conclusions



SMC's Vision and Perspective

- **Compliance document for contractor**
  - **Requirements for contractor's SE program**
  - **Characteristics for technical areas important to SMC**
  - **Industry standards for guidance, not direction**
- **Requires associated handbook and tools**
- **Assumes a knowledgeable and intelligent audience**
- **Must be priceable – concise without redundancy**

Author/Team Goals/Vision Consensus

SE Requirements and Product standard should…

- **Cover entire life cycle – 'lust to dust'**
- **Be consistent with DAG*, Mission Assurance initiatives, etc.**
- **Meet SMC's needs for enforceability on contract**
  - **Consist of a specification plus a suite of tools such as handbook, CDRLs, and DIDs**
- **Be supportive of 5000.2, Directive 7, and NSS 03-01**
- **Be systems engineering <u>product</u> oriented**
- **Integrate and/or use any existing products, such as those developed under Mission Assurance initiatives**

* Defense Acquisition Guidebook

Relationship of SE Process Documents

Periodic revision is anticipated

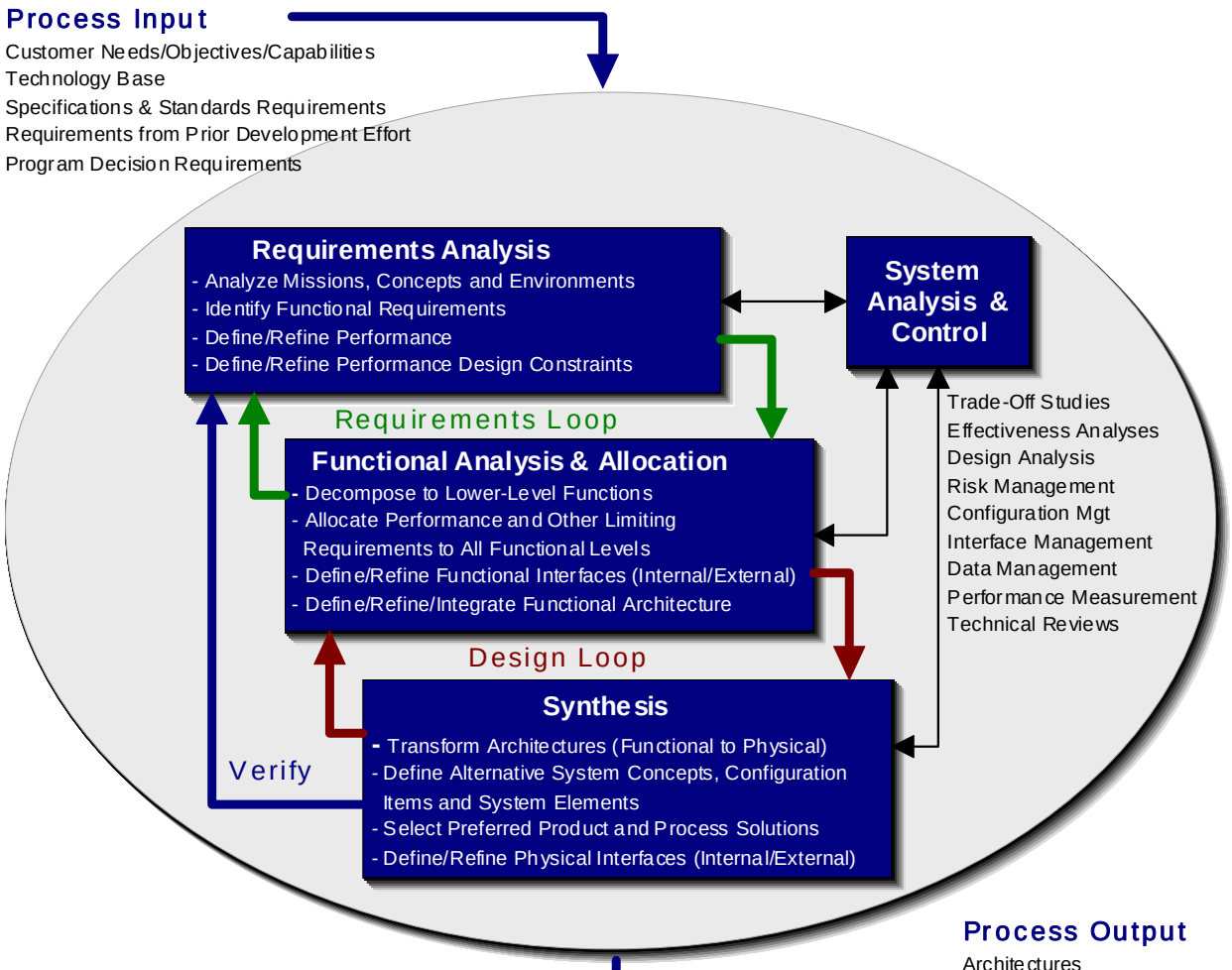
Navy SE Guidebook

INCOSE EIA 632 Revision

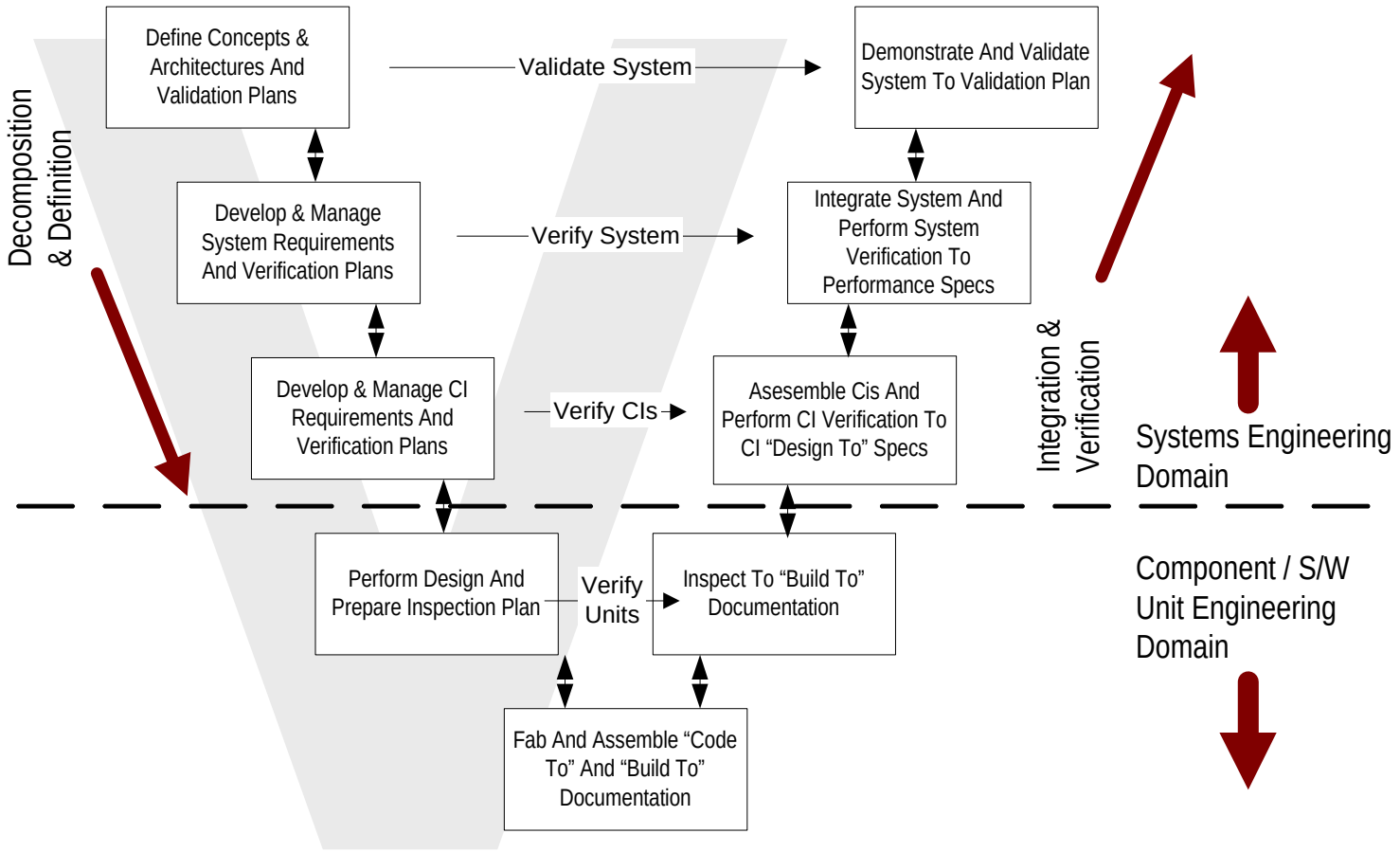
Ever-growing Space Acquisition Experience base

SE Requirements and Products	**Aerospace TOR Revision A**		
Draft SE Standard	**Mil-Std 499C (Draft) Aerospace TOR**		
Military Standards	**Mil-Std 499A**	**Mil-Std 499B (Draft)**	
SE Models and Processes	**EIA 632/IEEE 1220**	**Defense Acquisition Guidebook**	**SMC SE Handbook**
DOD Acquisition Policy	**DoDD 5000.1**	**DoDD 5000.2**	**NSS 03-01**

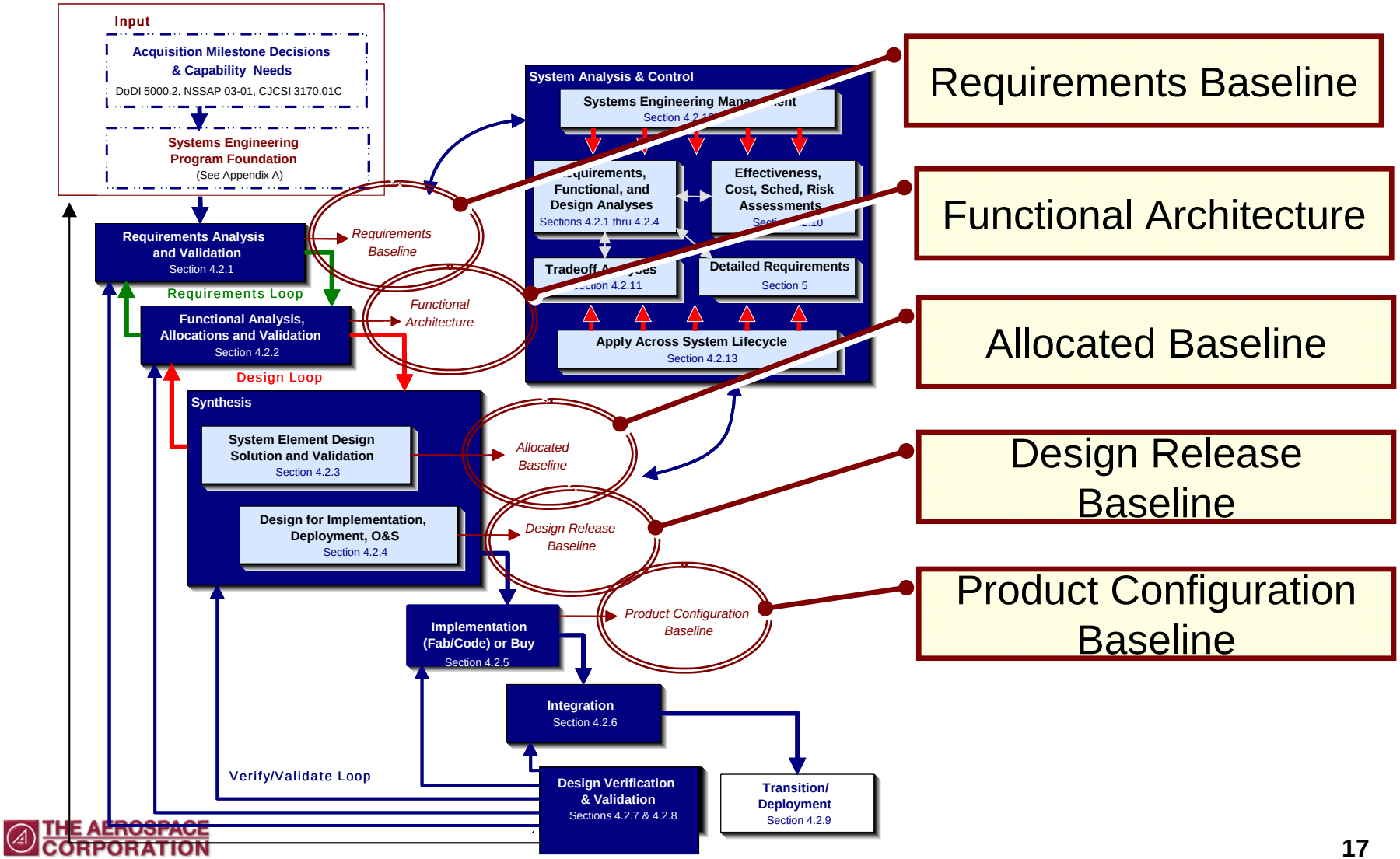
Example SE Process



SE Process – Typical Vee depiction



SE Process, Requirement and Baseline Flow



Agenda

- Background
  - Space System Acquisition Challenges
  - SMC Specifications and Standards Program
- SMC Approaches to Systems Engineering (SE)
  - SE Processes and Requirements Vision
  - Development of “SE Products and Requirements”
- **SE Products and Requirements**
  - **Sample Products and Requirements**
- Summary and Conclusion

Table of Contents *(1 of 2)*

4. GENERAL REQUIREMENTS

4.1 SYSTEM ENGINEERING PROCESS APPLICATION

4.1.1 SUPPORT TO THE CAPABILITY NEEDS PROCESS

4.1.2 SYSTEM LEVEL CONSTRAINTS, CONCEPTS AND ARCHITECTURES

4.2 SYSTEMS ENGINEERING REQUIREMENTS

4.2.1 REQUIREMENTS ANALYSIS AND VALIDATION

4.2.2 FUNCTIONAL (LOGICAL) ANALYSIS

4.2.3 SYSTEM ELEMENT DESIGN SOLUTION AND VALIDATION

4.2.4 DESIGN FOR IMPLEMENTATION, DEPLOYMENT, OPERATIONS, AND SUPPORT

4.2.5 IMPLEMENTATION

4.2.6 INTEGRATION

4.2.7 DESIGN SOLUTION VERIFICATION

4.2.8 DESIGN SOLUTION VALIDATION

4.2.9 TRANSITION (DEPLOYMENT) ANALYSIS AND ASSESSMENT

4.2.10 ASSESSMENTS OF SYSTEM EFFECTIVENESS, COST, SCHEDULE, AND RISK

4.2.11 TRADEOFF ANALYSES

4.2.12 MANAGEMENT OF THE SYSTEMS ENGINEERING PROCESS

4.2.12.1 PLANNING

4.2.12.2 MONITORING

4.2.12.3 DECISION ANALYSIS

4.2.12.4 RISK MANAGEMENT

4.2.12.5 CONFIGURATION MANAGEMENT

4.2.12.6 INTERFACE MANAGEMENT

4.2.12.7 DATA MANAGEMENT

4.2.12.8 TECHNICAL MANAGEMENT OF SUBCONTRACTORS/ VENDORS

4.2.13 APPLICATION ACROSS THE LIFE CYCLE

Table of Contents *(2 of 2)*

5. **DETAILED REQUIREMENTS**

5.1 SPECIALTY ENGINEERING ACTIVITIES

5.1.1 PARTS, MATERIALS AND PROCESSES (PMP)
5.1.2 STRUCTURES
5.1.3 MANUFACTURING
5.1.4 QUALITY ENGINEERING
5.1.5 TEST
5.1.6 SURVIVABILITY
5.1.7 ENVIRONMENTAL, SAFETY AND HEALTH (ESOH)
5.1.8 CONTAMINATION
5.1.9 MASS PROPERTIES
5.1.10 LOGISTICS
5.1.11 HUMAN SYSTEMS INTEGRATION
5.1.12 PROGRAM SECURITY
5.1.13 RELIABILITY
5.1.14 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY (EMI/EMC)
5.1.15 SYSTEM SAFETY

5.2 SYSTEM/COST EFFECTIVENESS

5.2.1 OPERATIONAL ANALYSIS AND ASSESSMENT
5.2.2 SUPPORTABILITY ANALYSIS AND ASSESSMENT
5.2.3 TRAINING ANALYSIS AND ASSESSMENT
5.2.4 DISPOSAL ANALYSIS AND ASSESSMENT
5.2.5 ENVIRONMENTAL ANALYSIS AND IMPACT ASSESSMENT

SE Requirement and Product Sample

4.2.3 System Element Design Solution and Validation

The Contractor SHALL determine the design solution, support validation of the design solution, and develop the associated required systems engineering products with the product attributes specified in this documen

4.2.3.1 Required ystem Engineering Products

a. The validated, approved, an d allocated (d) baseline in specifications and interface documents or their elec lement such as segment, subsystem, component (and part

4.2.3.2 Required P

a. The allocated baseline:

(1) Identifies all system p

(2) Documents the asse criteria; and analyzes decisi

(3) Includes the design- constraints for each p

(4) Includes all derived de t.

(5) Includes all interfaces an well as the logical issues such as

(6) Includes the verification metho

Contractor Requirement

Perform activity; produce product

SE Requirement and Product Sample

4.2.3 System Element Design Solution and Validation

The Contractor SHALL determine the design solution, support validation of the design solution, and develop the associated required systems engineering products with the product attributes specified in this document.

4.2.3.1 Required System Engineering Products

a. The validated, approved, and maintained allocated (design-to) baseline in specifications and interface documents or their electronic equivalent grouped by each system element such as segment, subsystem, component (hardware and software), computer software unit, and part

4.2.3.2 Required Product Attributes

a. The allocated baseline:

(1) Identifies all system products and

(2) Documents the assessment and analyzes decision u

(3) Includes the design-to constraints for each

(4) Includes all derived

(5) Includes all interface the logical issues such

(6) Includes the verification

Product Description

SE Requirement and Product Sample

Product content/quality metrics

4.2.3 S…ign Solution and Validation

Th…nport validation of the design solution, and …ts with the product attributes

…ring Products

a. …sign-to) baseline in specifications and interfac…ped by each system element such as segment, subsyst…are and …ware), computer software unit, and part

4.2.3.2 Required Product Attributes

a. The allocated baseline:

(1) Identifies all system products and establishes the interactions of the system.

(2) Documents the assessment of alternative solutions; identifies and quantifies decision criteria; and analyzes decision uncertainties.

(3) Includes the design-to technical functional and performance requirements and design constraints for each product.

(4) Includes all derived design-to requirements and design constraints for each product.

(5) Includes all interfaces and addresses how the interface will be implemented, as well as the logical issues such as data formats, data semantics, etc.

(6) Includes the verification method(s) selected for each requirement.

Specialty Engineering Requirement and Product Sample

5.1.13 Reliability

a. Space system specific reliability requirements are defined, allocated, baselined, and traceable to system requirements.

(1) Parameters and limits defined and provided within the System Specification

(2) Reliability requirements reviewed against functional requirements, customary design practices

b. Applicable specific design tasks and analyses conducted, including:

(1) Failure Reporting Analysis, Corrective Action System (FRACAS)

(2) Source selection and vendor control procedures

(3) Failure Modes Effects and Criticality Analysis (FMECA)

(4) Derating and margins of safety

(5) Fault coverage

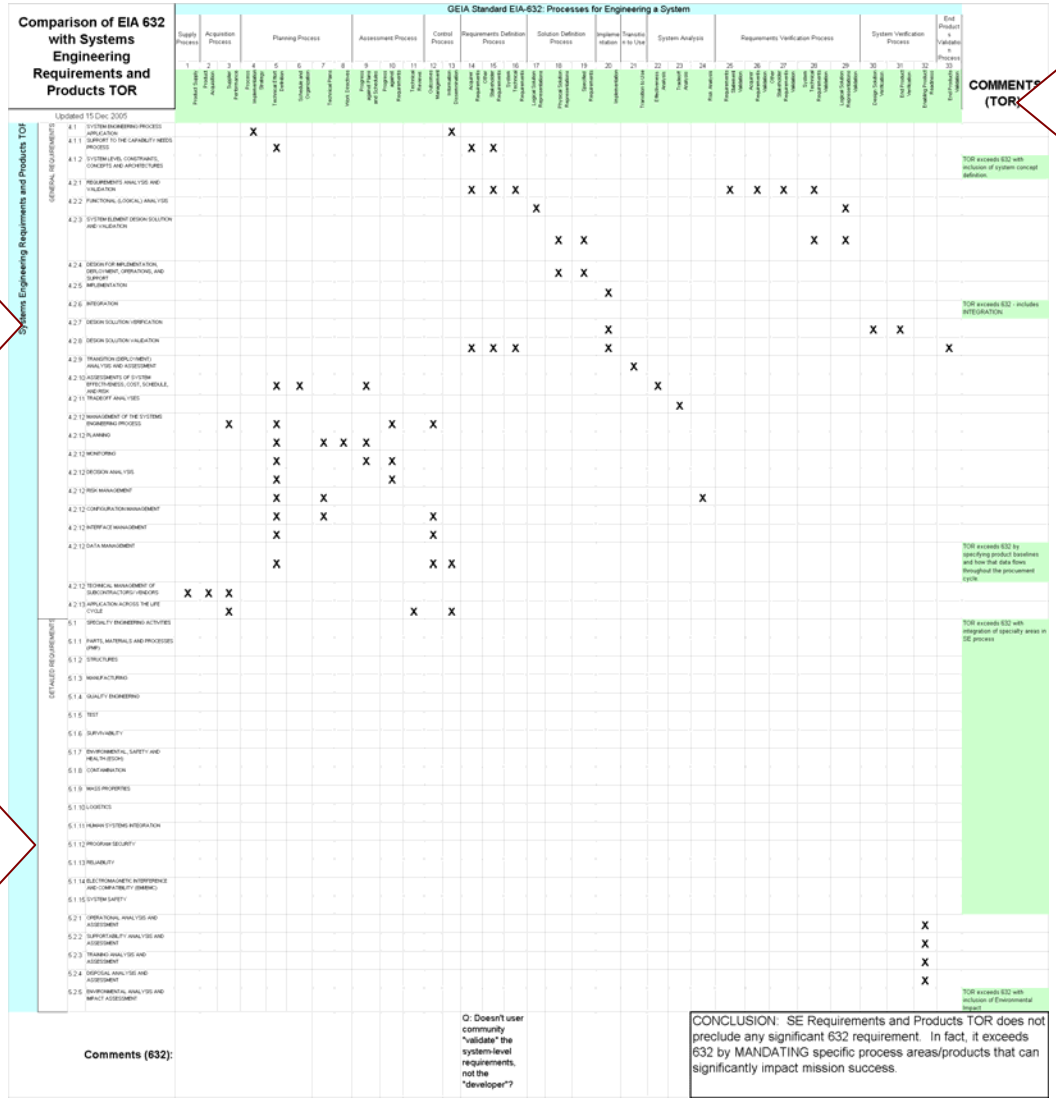
(6) Single point failure

(7) Redundancy/single string

c. Reliability Program Plan and Risk Management Plan developed for final top-level space system

d. Items in development that have impact on support resources identified, including time, people, money, parts, tools, storage, and transportation assets.

SE Requirements and Products and EIA 632 Mapping



EIA 632 SE Requirements

TOR Products & Requirements

Specialty Area Products & Requirements

- **Systems Engineering Requirements and Products *Exceeds* EIA 632 Requirements**
- Basic SE Requirements

PLUS

- Specialty Engineering Product Integration

Agenda

- Background
  - Space System Acquisition Challenges
  - SMC Specifications and Standards Program
- SMC Approaches to Systems Engineering (SE)
  - SE Processes and Requirements Vision
  - Development of “SE Products and Requirements”
- SE Products and Requirements
  - Sample Products and Requirements
- **Summary and Conclusions**

Summary

- **Systems Engineering is critical to overall mission success**
  - **Baselines are the product of SE process**
  - **Control of baselines is key to SE success**
- **SE products facilitates SE verification**
  - **Verification requires products with known attributes**
- **Contracting (buying) SE must be done differently**
  - **<u>Products</u> must be contractually required (purchased)**

Conclusion

- **Systems Engineering (SE) Requirements and Products**
  - **Supports government and industry SE initiatives**
  - **Provides clear SE tasking and evaluation criteria**
  - **Being integrated with Mil-Std-1521 C (Technical Reviews)**
  - **Is coordinated with national security space community**
  - **Has become the SE Compliance document for SMC**



Back-up Charts



Contributors to the SE Requirements & Products Report

- ***The author acknowledges the contributions of:***

Mr. Frank Knight

- The Aerospace Corporation, Systems Director Corporate Chief Architect/Engineer Division

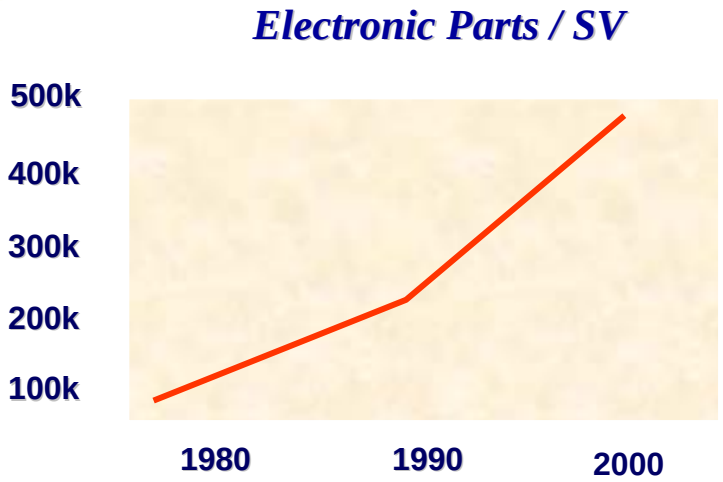
Mr. Barry Portner

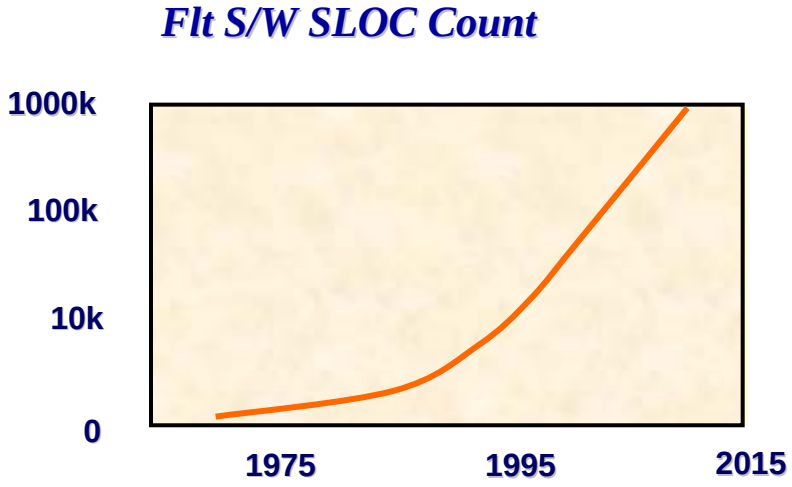
- Innovative Space Engineering Services, Inc.

… and a large number of subject matter experts from The Aerospace Corporation

- Systems Engineering Division; Engineering and Technology Division
- National Systems Division

Increased Space System Complexity





- **Increased complexity also results in:**
  - **More latent defects (increased late build-cycle and orbital failures)**
  - **Greater test challenges related to changes in technology, manufacturing and materials**
    - Increasing electronic part or device complexity (e.g., ASIC, FPGA)
    - Increased use and complexity of software
    - Increased system design and subsystem complexity
    - Lack of robust testing
      - Ability and willingness to “test like you fly”
      - Inclusion of off-nominal test regimes

SMC Compliance Documents

Compliance documents for SMC Acquisitions

Approved by:



9 AUG 06

Colonel J. Hoeji
Chief Engineer
SMC/EA

Date

Compliance Docs Approval

SMC Compliance List

Compliance Documents for SMC Acquisitions dated 08/08/06

	Functional/ Technical Area	Document Number	Title	Pub Date	Tech POC	Comments
1	Configuration Management	TOR-2006(8583)-1	Configuration Management	15-Aug-05	Donahue, C Aerospace	
2	Contamination	ASTM E 1548-03	ASTM E1548, Standard Practice for Preparation of Aerospace Contamination Control Plans	10-May-03	Luey, K. Aerospace	Must be tailored to change 'should' to 'shall' and to specify that 'buyer' includes the U.S. government.
3	Design Reviews	MIL STD 1521B Notice 3	Technical Reviews & Audits for Systems, Equipment and Computer Software	10-Apr-95	Davis, D. SMC/EAE	
4	Electrical Power	TOR-2005(8583)-2	Electrical Power Systems, Direct Current, Space Vehicle Design Requirements	11-May-05	Lenertz, B. Aerospace	
5	Electrical Power	DOD-W-83575A Rev A Notice 1	Wiring Harness, Space Vehicle, Design And Testing	1-Sep-92	Simpson, M. Aerospace	Tailoring available - from Mark Simpson
6	Electrical Power, Batteries	TOR-2004(8583)-5 Revision 1	Space Battery Standard	1-Apr-05	Hwang, W. Aerospace	
7	Electrical Power, Solar Cells	AIAA Std-111 2005	Qualification and Quality Requirements for Space-Qualified Solar Cells	15-Aug-05	Reed, B. Aerospace	
8	Electrical Power, Solar Panels	AIAA Std S-112 2005	Qualification and Quality Requirements for Space-Qualified Solar Panels	15-Aug-05	Reed, B. Aerospace	
9	Electromagnetic Interference/ Compatibility	TOR-2005(8583)-1	Electromagnetic Compatibility Requirements For Space Equipment and Systems	8-Aug-05	Dunbar, M. Aerospace	
10	Electromagnetic Interference/ Compatibility	MIL-STD-461E	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	1-Aug-99	Dunbar, M. Aerospace	
11	Electromagnetic Interference/ Compatibility	MIL-STD-1542B	EMC Grounding Requirements for Space System Facilities	1-Nov-91	Dunbar, M. Aerospace	
12	Environmental Safety and Occupational Health	NAS 411	Hazardous Materials Management Program	19-Jan-95	Caponpon, V. SMC/AXFV	
13	Human Factors	MIL-STD-1472F	DoD Design Criteria Standard - Human Engineering	23-Aug-99	Shaw, B. Aerospace	Ground segment hardware, especially mobile/transportable system or fielded tactical systems. See TOR-2002-8506-1 for tailoring recommendations
14	Human Factors	ISO 9241	Ergonomic Requirements for Office Work with Visual Display Units, Multiple Volumes.	1998	Shaw, B. Aerospace	Ground segment hardware, especially for ground systems and office like situations
15	Human Factors	COE UIS Rev 4.3	Common Operating Environment (COE) User Interface Specification (UIS), Version 4.3, (CM Reference: 59314)	15-Dec-03	Shaw, B. Aerospace	Ground segment software used only for user interfaces
16	Human Factors	SMC/AXE Rpt # HMRB-2001-1	Standard Practice: Human Computer Interface Display Conventions for Space System Operations.	14-Jan-01	Shaw, B. Aerospace	SMC ground segment TT&C used only for user interface
17	Human Factors	EIA HEB-1A	Electric Industries Alliance Engineering Bulletin - Human Engineering - Principles and Practices, Ver. 1A	15-Dec-05	Shaw, B. Aerospace	Applicable to ground segment development & integration - equivalent to DoD Handbook 46855
18	Interoperability/ Standardization	DoD Arch v1.0	DoD Architecture Framework Version 1.0	9-Feb-04	Awwad, N. SMC/EAS	
19	Interoperability/ Standardization	DISR 06-2.0	DISR Baseline Release 06-2.0	27-Jun-06	Awwad, N. SMC/EAS	DISR is an online tool for development of an Information Technology (IT) standards profile. (Replaced Joint Technical Architecture.)
20	Logistics	MIL-PRF-49506	Logistics Management Information (replaces 1388-1A)	11-Nov-96	Duphilly, R Aerospace	
21	Logistics	MIL-STD-130M	Identification Marking of U.S. Military Property	2-Dec-05	Wantland, G. SMC/LGA Duphilly, R Aerospace	

SMC Compliance List

	Functional/ Technical Area	Document Number	Title	Pub Date	Tech POC	Comments
22	Logistics	MIL-STD-1367A	Packaging, Handling, Storage, and Transportability Program Requirements for Systems and Equipments	1-Oct-89	Duphily, R Aerospace	
23	Logistics	TM-86-01	Air Force Technical Manual Contract Requirements (TMCR)	1-Jun-97	Duphily, R Aerospace	Tailoring available from SMC/LGA
24	Logistics	MIL-PRF-29612B	Training Data Products	31-Aug-01	Duphily, R Aerospace	Tailoring available from SMC/LGA
25	Maintainability	MIL-STD-470B	Maintainability Program for Systems and Equipment	1-Jun-95	Duphily, R Aerospace	
26	Manufacturing Management / Producibility	MIL-STD-1528A	Production Management	1-Sep-86	Davis, D., SMC/EAE	
27	Mass Properties	TOR-2005 (8583)-3970	Mass Properties Control Standard for Space Vehicles	20-Jul-05	Yang, L. Aerospace	
29	Moving Mechanical Assemblies	AIAA S-114-2005	Moving Mechanical Assemblies for Space and Launch Vehicles	30-Jun-05	Gore, B. Aerospace	
30	Ordnance	AIAA S-113-2005	Criteria for Explosive Systems and Devices Used on Space and Launch Vehicles	10-Nov-05	Goldstein, S. Aerospace,	
31	Parts Management	ANSI / AIAA R-100A	Recommended Practice for Parts Management	16-Aug-01	Davis, D SMC/AXE	Applicable to ground systems
32	Parts Management	TOR -2004(3909)-3315 Rev. A	Parts, Materials, & Processes Control Program for Space Vehicles - Revision A	12-Aug-04	Robertson, S. Aerospace	Replacement TOR [TOR-2006(8583)-5235] anticipated to be published in August 2006
33	Parts Management	TOR-2004(3909)-3316 Rev. A	Technical Requirements for Electronic Parts, Materials, and Processes Used in Space Vehicles - Revision A	12-Aug-04	Robertson, S. Aerospace	Replacement TOR [TOR-2006(8583)-5236] anticipated to be published in August 2006
34	Parts Management	TOR-98(1412)-1 Rev A	Parts, Materials, and Processes Control Program for Expendable Launch Vehicles - Revision A	1-Jan-04	Chang, G. E. Aerospace	
35	Pressurized Hardware	AIAA S-080-1998	Space Systems, Metallic Pressure Vessels, Pressurized Structures, and Pressure Components	1-Sep-98	Chang, J.B. Aerospace	
36	Pressurized Hardware	AIAA S-081A-2000	AIAA Standard for Space Systems — Composite Overwrapped Pressure Vessels (COPVs)	1-Dec-00	Chang, J.B. Aerospace	
37	Pressurized Hardware	TOR-2003 (8583)-2896	Space Systems – Flight Pressurized Systems	31-Aug-03	Chang, J.B. Aerospace	
38	Pressurized Hardware	TOR-2003(8583)-2895 Rev. 1	Solid Rocket Motor Case Design & Test Requirements	22-Dec-04	Chang, J.B. Aerospace	
39	Product Assurance	SAE AS9100 Rev. B	Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing	1-Jan-06	Davis, D. SMC/EAE	
40	Program Management	ISO 14300-2	Space Systems Programme Management - Part 2: Product Assurance - Policy & Principles	1-Jul-02	Davis, D. SMC/EAE	
41	Program Management	ISO 14300-1	Space Systems - Program Management - Part 1: Structuring of a programme	1-Dec-02	Davis, D. SMC/EAE	
42	Program Management	EIA 748	Earned Value Management Systems	28-Aug-02	Davis, D. SMC/EAE	
43	Reliability Program	MIL-STD-1543B	Reliability Program Requirements for Space and Launch Vehicles	1-Oct-88	Schipper, G. Aerospace	
44	Reliability Program	MIL-STD-785B, Notices 1 & 2	Reliability Program for Systems and Equipment Development and Production	1-Aug-88	Schipper, G. Aerospace	Applicable to ground systems
45	Risk Management	ISO 17666	Space Systems - Risk Management	1-Apr-03	Dar, R. Aerospace	
46	Safety, Range	AFSPCMAN 91-710	Range Safety User Requirements Manual	1-Jul-04	Huang, L. SMC/SE	Superseded EWR 127-1

SMC Compliance List

	Functional/ Technical Area	Document Number	Title	Pub Date	Tech POC	Comments
47	Safety, System	MIL-STD-882C	System Safety Program Requirements	19-Jan-93	Huang, L. SMC/SE	Version D is most current; SMC/SE requires Version C to be used on SMC contracts.
48	Satellite Disposal	TOR-2006 (8583)-4474	Requirements for End-of-Life Disposal of Satellites Operating at Geosynchronous Altitude	3-Nov-05	Allor, W. Aerospace	
49	Security	DoD 8510.1-M	DoD Information Technology (IT) Security Certification and Accreditation (C&A) Process (DITSCAP) Application Manual	31-Jul-00	Dupuis, J. Aerospace	Tailoring to generate requirements language available from SMC/PIP
50	Security	DoDI 8500.2	Information Assurance Implementation	06-Feb-03	Dupuis, J. Aerospace	Tailoring to generate requirements language available from SMC/PIP
51	Security	DODD 5200.39	Security, Intelligence, and Counterintelligence Support to Acquisition Program Protection	10-Sep-97	Dupuis, J. Aerospace	Tailoring to generate requirements language available from SMC/PIP
52	Security	MIL-HDBK 1785A	System Security Engineering Program Management Requirements	1-Aug-95	Dupuis, J. Aerospace	Tailoring to generate requirements language available from SMC/PIP
53	Security	DCID 6/3 Manual	Protecting Sensitive Compartmented Information Within Information Systems	11-Dec-03	Dupuis, J. Aerospace	Tailoring required to generate contractor requirements for portions of the system processing SCI. Available from SMC/PIP
54	Security	TSRD	Telecommunications Security Requirements Document	Written for each application	Dupuis, J. Aerospace	NSA-provided, system specific document that specifies requirements for cryptography and key management
55	Software Development	ISO/IEC STD 15939	Software engineering -- Software Measurement Process	11-Jul-02	Zambrana, M. SMC/EAS	
56	Software Development	RTCA-DO-278	Guidelines For Communication, Navigation, Surveillance And Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance - DO-278	5-Mar-02	Zambrana, M. SMC/EAS	Applicable to AIRBORNE systems only.
57	Software Development	RTCA-DO-178B	Software Considerations In Airborne Systems and Equipment Certification	1-Dec-92	Zambrana, M. SMC/EAS	Applicable to AIRBORNE systems only.
58	Software Development	TOR-2004(3909)-3537 Rev B	Software Development Standard for Space Systems	11-Mar-05	Zambrana, M. SMC/EAS	
59	Structures	AIAA S-110-2005	Space Systems — Structures, Structural Components, and Structural Assemblies	12-Jul-05	Chang, J.B. Aerospace	Tailoring available from POC
60	Structures, Loads	TOR-2003(8583)-2886	Independent Structural Loads Analyses of Integrated Spacecraft, Launch Vehicle Systems	22-Aug-03	Kabe, A. Aerospace	
61	Survivability	TOR-92(2904)-5	Survivability Program Management Requirements For Space Systems	1-Jan-93	Cuevas, G. Aerospace	
62	Systems Engineering	TOR-2005 (8583) -3 Rev. A	Systems Engineering Requirements and Products	29-Sep-05	Shaw, B. Aerospace	Significantly revised to specify SE requirements and products; validated to be EIA 632 and IEEE 1220 compliant.
63	Test, Ground	MIL-STD-1833	Test Requirements for Gnd Equipt & Assoc Computer S/W Sptng Space Vehicles	4-May-98	Maynard, R. Aerospace	
64	Test, Ground	MIL-STD-810F	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests	14-Jul-89	Davis, D. SMC/EAE	Applies to vehicle mountings, or ground support in various environments
65	Test, Space	SMC-TR-04-17 TR-2004(8583)-1	Test Requirements For Launch, Upper-Stage, & Space Vehicles	31-Jan-04	Perl, E. Aerospace	

Space Quality Improvement Council

Sponsors



Lt Gen Michael A. Hamel
Commander, Space and Missile Systems Center
USAF Space Command



Lt Gen Henry A. "Trey" Obering, III
Director
Missile Defense Agency



Maj Gen James B. Armor, Jr.
Director
National Security Space Office



Maj Gen Robert H. Latiff
Deputy Director for Systems Engineering
National Reconnaissance Office



Mr. Bryan D. O'Connor
Chief Safety and Mission Assurance Officer
NASA

Membership

THE AEROSPACE CORPORATION
LOCKHEED MARTIN
ATK
NORTHROP GRUMMAN
Space Technology
Ball
Orbital
BOEING
Pratt & Whitney
A United Technologies Company
GENERAL DYNAMICS
Raytheon
ITT Industries
SPACE SYSTEMS
LORAL



Concept for an Enterprise Wide (EW) System Engineering (SE) Collaborative Engineering Environment (CEE)

Dr. David Signori

Dr. Jimmie McEver

Dr. Kenneth Jordan

Dr. Stuart Starr

October 25, 2006

Agenda

- Selected Definitions
- Key Questions
- Strategy
- Summary

Selected Definitions: SoS, SoSE

- SoS (source: B. E. White)
  - "A collection of systems that functions to achieve a purpose not generally achievable by the individual systems acting independently"
- SoSE (source: J. E. Kaplan)
  - "The cross-system and cross-community process
  - That ensures the development and evolution of mission-oriented capabilities
  - To meet multiple stakeholders' evolving needs
  - Across periods of time that exceed the lifetimes of individual systems"

SoSE Is Performed on Many Scales

Individual Systems

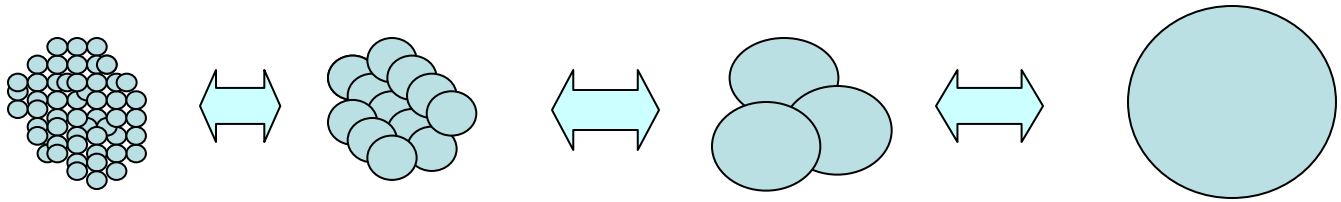
Service Functional Collections

[e.g., FCS]

Joint Service Capabilities (JCIDS FCBs)

The GIG Enterprise

[Our Focus]



Faster individual system evolution and better individual system optimization,…but may lead to problems in overall interoperability and integration

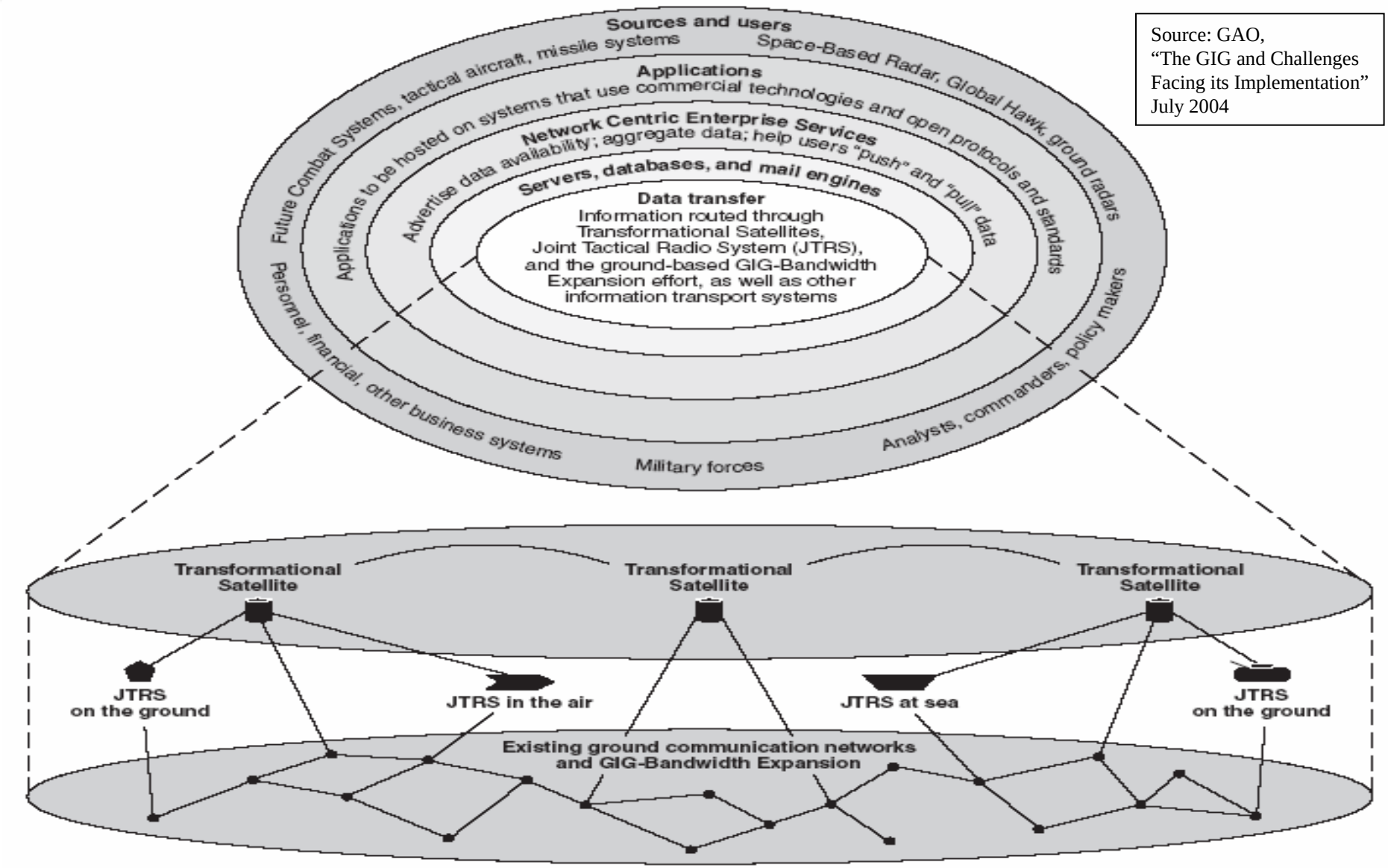
Better overall Interoperability and Integration,… but, may lead to individual system sub-optimization; not well matched to existing processes

GIG Definition

- An integrated, scalable, fully distributed processing and transport environment, commercial-technology based, that:
  - Moves information from any source to any destination
  - Provides tailored information through intelligent pull
  - Is dynamic, adaptive, self reconfiguring, robust, and secure
  - Integrates legacy C4ISR systems
  - Permits full exploitation of sensor, weapon, and platform capabilities
    - Joint cooperative component
    - Sensor-to-sensor for cueing

Source: Mike Frankel, former DASD(C3I Systems)

A Characterization of the GIG Vision



Source: GAO,
"The GIG and Challenges Facing its Implementation"
July 2004

Agenda

- Key Definitions
- Key Questions
- Strategy
- Summary

Selected Issues: GAO (1 of 2)

The DoD's 3 major decision-making processes are not structured to support cross-cutting, department-wide development efforts such as the GIG

- JCIDS
  - The new process is not yet identifying shortfalls and gaps in joint military capabilities on a department-wide basis
  - Requirements setting continues to be driven by Service perspectives
- PPBES
  - Is structured in terms of individual Service programs and outdated mission areas instead of cross-cutting capabilities such as net-centricity
  - It is not flexible enough to quickly accommodate requirements resulting from lessons learned or from rapidly emerging technologies

Selected Issues: GAO (2 of 2)

- Acquisition
  - **Is unsuited to developing a system of interdependent systems such as the GIG**
  - DoD has struggled to achieve Service buy-in on joint Service development programs to address interoperability problems
- Overall
  - The lack of integration among these three processes makes it difficult to ensure that development efforts are affordable and technically feasible

Tenets of Net-Centricity

- A robustly networked force improves
  - Information sharing
- Information sharing and collaboration enhances
  - Quality of information
  - Shared situational awareness
- Shared situational awareness enables
  - Collaboration
  - Self-synchronization

Bottom Line: Dramatic increase in mission effectiveness

Key Questions

- Can we adapt the tenets of net-centricity to guide SoSE for the GIG?
- If so, what Enterprise Wide (EW), System Engineering (SE) Collaborative Engineering Environment (CEE) would be needed to implement that concept?

Agenda

- Selected Definitions
- Key Questions
- Strategy
- Summary

The Collaborative Engineering Environment (CEE)

- CEE -- features and purpose
  - An SE force networked together and with stakeholders
  - Supported by shared tools, services and information
  - That empower various communities of interest to solve a range of problems collaboratively
- Key attributes
  - Empower culture change, guidance and management
  - Provide repositories and websites for posting and sharing information
  - Support continual assessment and decision making through
    - Analytical tools and services
    - Integrated M&S environments
    - Distributed test beds

CEE Desirable Characteristics

- Accessed through an easy-to-use web portal
- Navigational aids to help users find the information they need
- Incentives to provide up-to-date information
- Designated Points of Contact (POCs) to feed the CEE
- FAQs and help desk

Empowering Culture Change, Guidance and Management

- The CEE should serve to empower culture change, guidance and management by providing
  - Access to education resources
  - Top level guidance for end-to-end (E2E) capabilities
  - POCs for all levels of management and systems – responsibility matrix
  - Access to latest products (e.g., NCIDs, JCIDS products)

Repositories and Websites for Posting and Sharing Information

- The CEE should provide access to the following
  - Enterprise and individual program schedules
  - Enterprise-wide standards
  - Current performance and interface issues
  - System emulations to support interface development and testing (supplied and updated by programs)
  - Clearing house for suggestions for E2E system improvement

Elements of a CEE Tool Box: "Soft" Tools

- These tools should be useful in rapidly
  - Performing exploratory analyses
  - Identifying the "interesting" parts of solution space
- Representative "soft" tools include
  - Expert elicitation techniques; e.g.,
    - RAND's Subjective Transfer Function approach
    - Polling techniques
    - Multi-attribute Utility Theory (e.g., Analytical Hierarchy Procedure)
  - System dynamics models (e.g., CAPE)
  - Simple, agent based models (e.g., MANA)

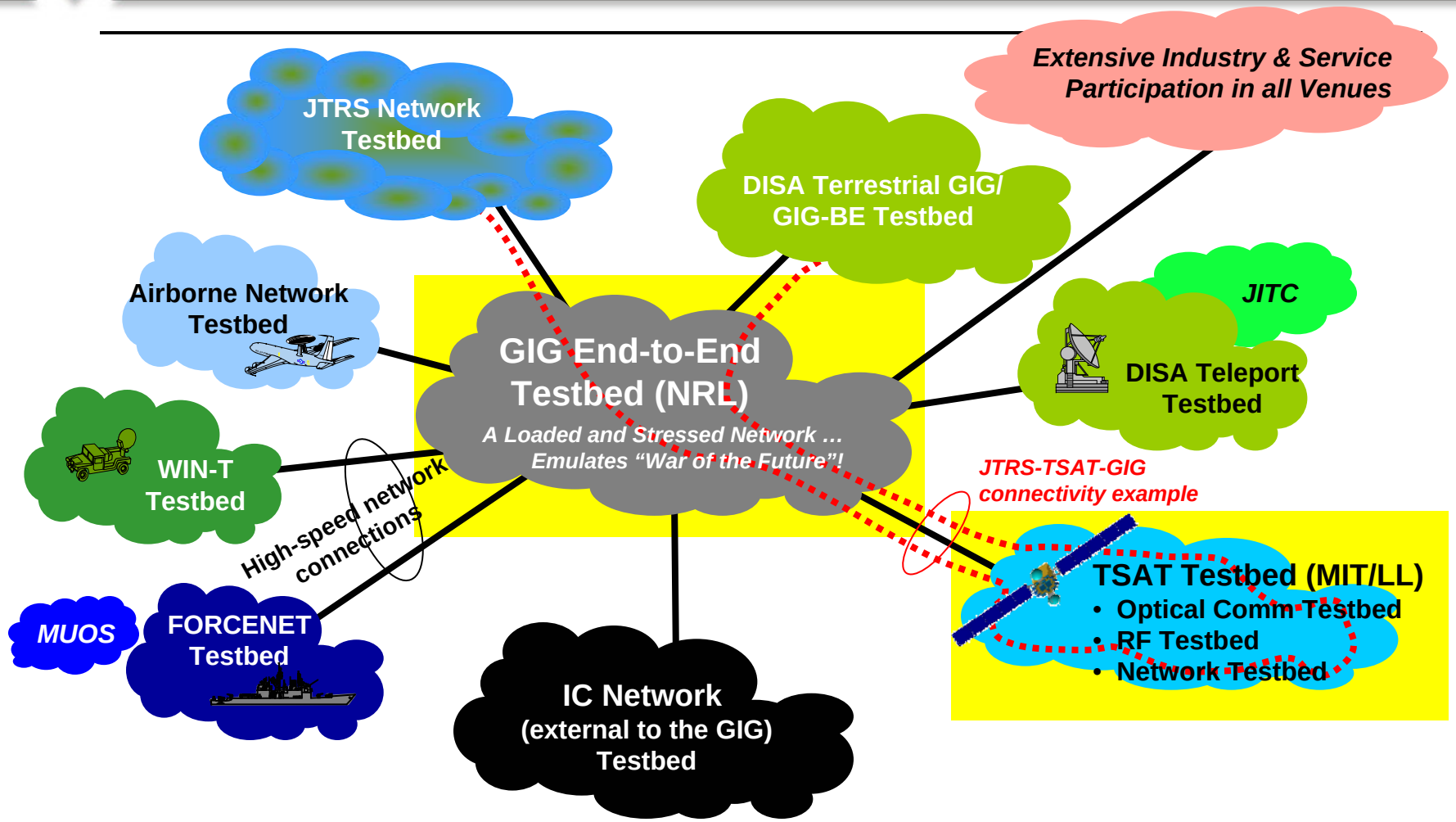
Elements of a CEE Tool Box: Constructive M&S

- These constructive M&S tools should be used to
  - Build on the results of “soft” tools to support more detailed, quantitative analyses
  - Provide baseline results to
    - Guide the conduct of testbed assessments
    - Extend testbed results
- Representative constructive M&S include
  - OPNET/NETWARS (transport layer analyses)
  - NESTOR (service layer analyses)
  - JWARS (military mission analyses)

Elements of a CEE Tool Box: Testbeds

- It is anticipated that these testbeds will
  - Support the more credible assessment of key Measures of Merit (drawing on the insights developed from constructive M&S)
  - Facilitate the harmonization of the GIG with Service visions (e.g., LandWarNet, FORCEnet, Constellation Net)
  - Provide insights to enhance the quality of existing constructive M&S
- A variety of testbeds are envisioned
  - System-of-systems testbeds (e.g., NRL-orchestrated testbeds)
  - Mission-oriented testbeds; e.g.,
    - FCS SoSIL (USA)
    - Distributed Mission Operations Center (DMOC) (USAF)

Key Testbeds to Exploit



Provides inter-network demonstration and validation

Strategy: Use of the CEE

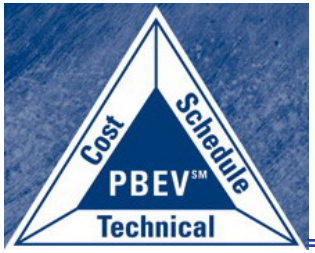
- Become knowledgeable about NATO Code of Best Practice (COBP) for C2 Assessment
- Apply Net-Centric Data Strategy to guide the collection, conversion, storage of data generated through application of the CEE tool box
- Develop experimental design skills that enable you to apply the designated models efficiently and effectively

Agenda

- Selected Definitions
- Key Questions
- Strategy
- Summary

Summary

- A CEE may enable a net-centric approach to SoSE for the GIG
- The CEE should serve to
  - Empower culture change, guidance and management
  - Provide repositories and websites for posting and sharing information
  - Support continual assessment and decision making
- If the CEE is to be viable, it must be
  - Evolvable and scalable to be consistent with the nature of the GIG
  - Consistent with the Services' plans to create and apply CEEs to address their own SoSE issues (e.g., FORCEnet, LandWarNet, ConstellationNet)

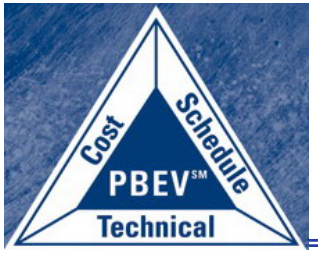


Performance-Based Earned Value®

NDIA Systems Engineering Conference
San Diego, CA
October 25, 2006

Paul J. Solomon, PMP
Performance-Based Earned Value®
Paul.Solomon@PB-EV.com

© 2006 Paul J. Solomon



Agenda

- **DoD Policy and Guidance, Customer Expectations**
- **Standards, Models, and Best Practices**
- **Project Management with Performance-Based Earned Value® (PBEV℠)**
- **Better Acquisition Management**

© 2006 Paul J. Solomon

Copyright Attribution

Copyright© 2006 by Paul Solomon.
This material contains excerpts from the book, *Performance-Based Earned Value.*®
The excerpts were reprinted courtesy of John Wiley & Sons, Inc. and the IEEE Computer Society Press. *Performance-Based Earned Value*® was written by Paul Solomon and Ralph Young and copyrighted by the IEEE, 2007.

Project Management Shortfalls

- Inadequate early warning
- Schedules, EV overstate true progress
- Remaining work underestimated



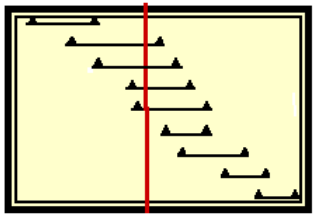
© 2006 Paul J. Solomon

Does EVMS Really Integrate?



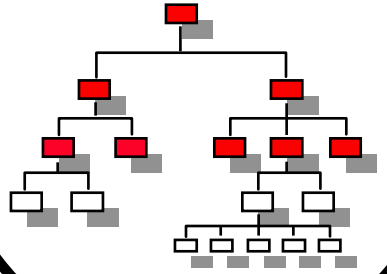
COST

EVMS

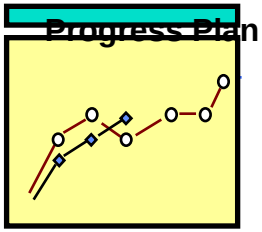


SCHEDULE

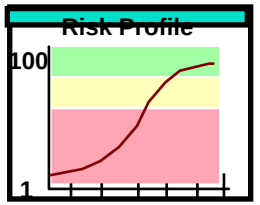
WBS



TECHNICAL PERFORMANCE



RISK



© 2006 Paul J. Solomon

Value of Earned Value

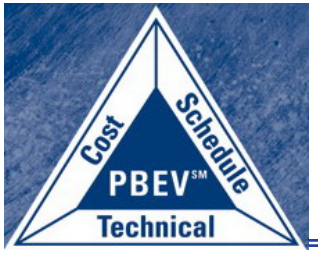
EVM data will be reliable and accurate only if:

- **The right base measures of technical performance are selected**

  and

- **Progress is objectively assessed.**

© 2006 Paul J. Solomon



DoD Policy and Guidance, Customer Expectations

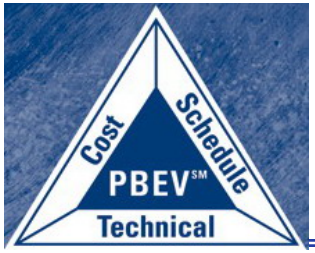
© 2006 Paul J. Solomon

Government Pays But Fails to Get Desired Outcomes

GAO Report	Title	Findings and Recommendations
06-66	Defense Acquisitions: DOD Paid Billions in Award and Incentive Fees *Regardless of Acquisition Outcomes*	• Contractors not held accountable for achieving desired outcomes: o Cost goals o Schedule goals o *Desired capabilities* • Programs do not capture early on the requisite knowledge needed to effectively manage program risks
06-391	Defense Acquisitions: Assessments of Major Programs	DOD needs to change its *requirements* and *budgeting* processes to get desired outcomes from the acquisition process

(a) Government Accountability Office

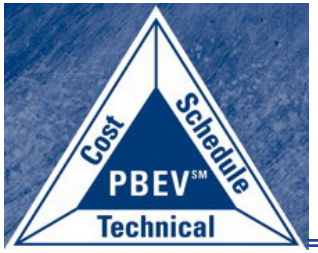
© 2006 Paul J. Solomon



GAO Best Practices

GAO Report	Title	Findings and Recommendations
04-722 06-215	Information Technology: DOD's Acquisition Policies and Guidance DOD Systems Modernization	Best Practices and Controls: • Ensure that *requirements* are traceable, verifiable, and controlled. • Trace requirements to system design specifications and testing documents. • Continually measure an acquisition's *performance*, cost, and schedule against *approved baselines*.

© 2006 Paul J. Solomon



DOD Policy & Guidance on SE

Policy for Systems Engineering in DOD Policy 2/20/04

Defense Acquisition Guidebook (DAG) 10/8/04

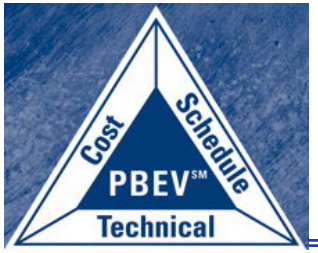
Systems Engineering Plan Preparation Guide (SEP) 2/10/06

WBS Handbook, Mil-HDBK-881A (WBS) 7/30/05

Integrated Master Plan (IMP) & Integrated Master Schedule Preparation & Use Guide (IMS) 10/21/05

Risk Management Guide for DOD Acquisition (RISK) Aug. 06

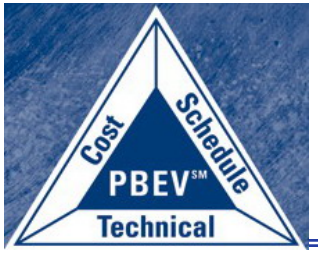
© 2006 Paul J. Solomon



DOD Policy & Guides

Policy or Guide (1 of 3)	Policy	DAG	SEP	WBS	IMS
Develop SEP	P	4.2.3.2	1.0		
Technical reviews:					
• Event-driven timing	P	4.5.1	3.4.4	3.2.3.1	2.3, 3.3.2
• Success criteria	P	4.5.1	3.4.4	3.2.3.1	
• Assess technical maturity		4.5.1	3.4.4	3.2.3.1	
Integrate SEP with:					
• IMP		4.5.1	3.4.5		1.2, 2.3
• IMS		4.5.1	3.4.5		1.2, 2.3
• Technical Performance Measures (TPM)		4.5.1	3.4.4		1.2, 2.3
• EVM			3.4.5		1.2, 2.3

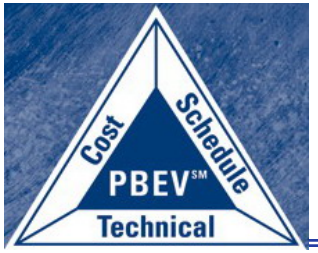
© 2006 Paul J. Solomon



DOD Guides

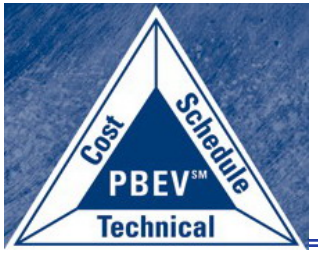
Guide (2 of 3)	DAG	SEP	WBS	IMS
Integrate WBS with requirements specification, statements of work (SOW), IMP, IMS, and EVMS			2.2.3, 3.2.3.3	3.4.3
TPMs to compare actual vs. plan: • Technical development • Design maturity	4.5.5	3.4.4		3.3.2
TPMs to report degree to which system requirements are met: • Performance • Cost • Schedule	4.5.5	3.4.4		
Standards and models to apply SE	4.2.2 4.2.2.1			
Institute requirements management and traceability	4.2.3.4	3.4.4		

© 2006 Paul J. Solomon



Standards, Models, and Best Practices

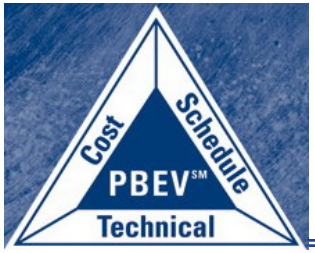
© 2006 Paul J. Solomon



DOD Technical Baselines

DAG Technical Review	DAG Baseline	DAG	IEEE 1220
System Functional Review	System Functional Baseline	4.3.3.4.3	Validated Requirements Baseline
Preliminary Design Review	System Allocated Baseline	4.3.3.4.4	Verified Physical Architecture
Critical Design Review	System Product Baseline	4.3.3.4.5	Verified Physical Architecture
Production Readiness Review	System Product Baseline	4.3.3.9.3	Verified Physical Architecture

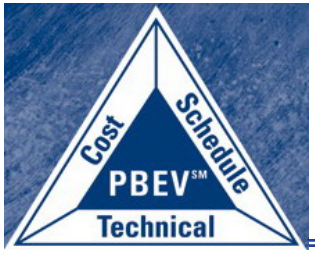
© 2006 Paul J. Solomon



Requirements Progress

IEEE 1220	EIA-632
6.8.1.5 Performance-based progress measurement 6.8.6 Track product … metrics	4.2.1 Planning process, Req. 10: Progress against requirements
6.8.1.5 d) Assess •*Development maturity* to date •Product's ability to *satisfy requirements* 6.8.6 *Product metrics*…at *pre-established control points* enable: • Overall system *quality* evaluation • Comparison to *planned goals and targets*	Assess *progress* … • Compare system definition *Against requirements* a) Identify *product metrics* and *expected values* ▪ *Quality* of product ▪ Progress towards *satisfying requirements* D) *Compare* results against requirements

© 2006 Paul J. Solomon



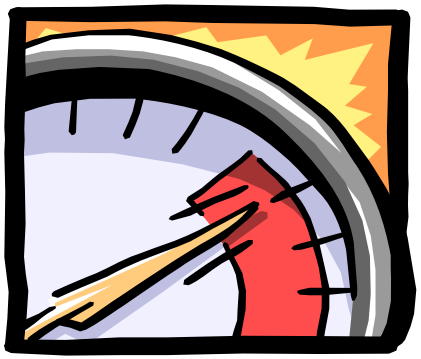
Technical Performance Measures (TPM)

IEEE 1220: 6.8.1.5, *Performance-based progress measurement*	EIA-632: Glossary
TPMs are key to progressively assess technical progress	*Predict* future value of *key technical parameters* of the end system based on current assessments
•Establish *dates* for – Checking Progress – Meeting full conformance to requirements	*Planned value* profile is time-phased achievement projected • *Achievement to date* • *Technical milestone where TPM evaluation is reported*

© 2006 Paul J. Solomon

TPM

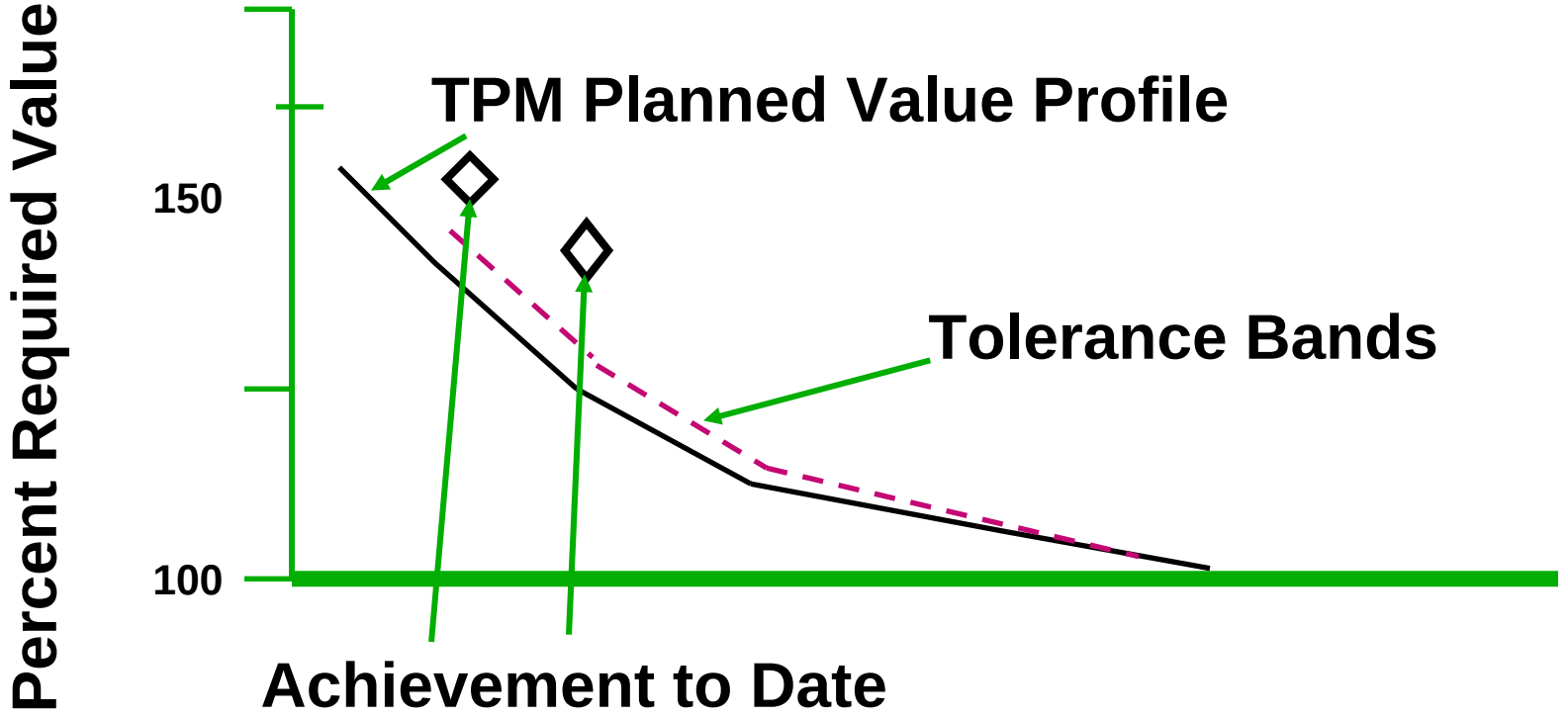
- How well a system is achieving performance requirements
- Use actual or predicted values from:
  - Engineering measurements
  - Tests
  - Experiments
  - Prototypes
- Examples:
  - Payload
  - Response time
  - Range
  - Power
  - Weight



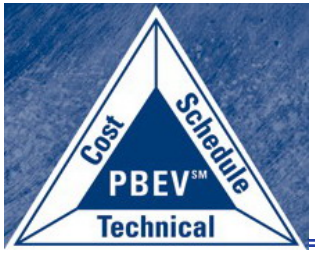
© 2006 Paul J. Solomon

TPM

Use TPMs as a base measure of EV



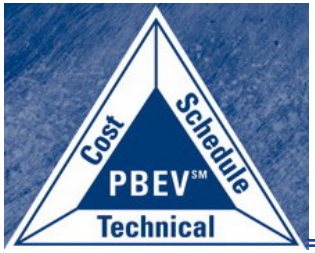
© 2006 Paul J. Solomon



Success Criteria of Technical Reviews

IEEE 1220, Preliminary design stage
5.2.4.1 Subsystem reviews a. Subsystem definition • Mature – Meet SE milestone criteria a. Component allocations and specifications – Provide a sound subsystem concept c. Subsystem risks assessed and mitigated d. Trade-study data...substantiate that subsystem requirements are achievable

© 2006 Paul J. Solomon



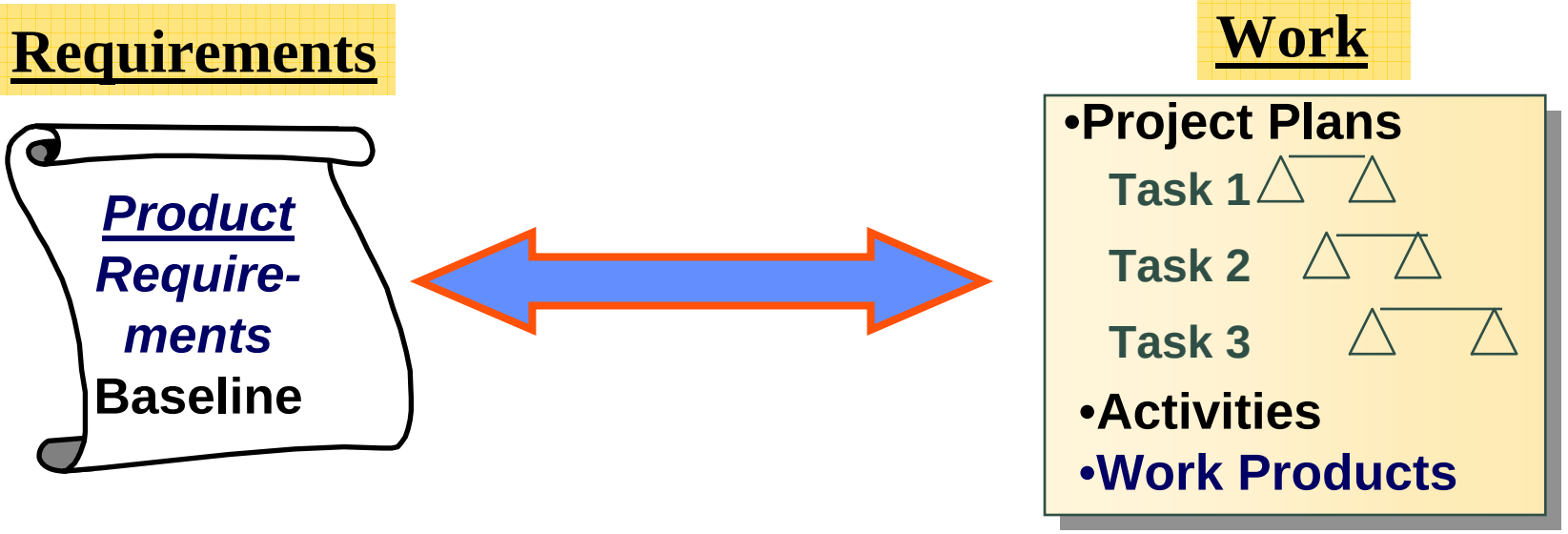
Synthesis (Design)

IEEE 1220, (6.6): Success Criteria
• Design solution meets: – Allocated performance requirements – Functional performance requirements – Interface requirements – Workload limitations – Constraints – Use models and/or prototypes to determine success

© 2006 Paul J. Solomon

Product Requirements

- CMMI, PMBOK Guide: Traceability and consistency

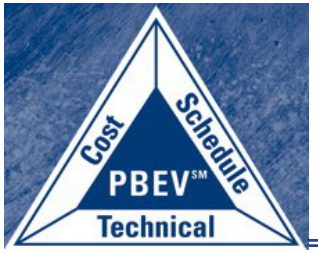


© 2006 Paul J. Solomon

Process and Product QA

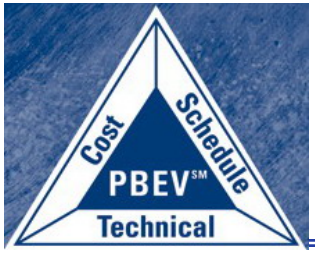
- **Product QA**
  - **CMMI:**
    - ***Objectively*** **evaluate work products against** ***clearly stated criteria***
    - ***Minimize subjectivity***
  - **EVMS:**
    - **EV is measurement of** ***quantity*** **of work**
    - **"*Quality* and *technical* content of work performed are *controlled by other means!*"**

© 2006 Paul J. Solomon



Project Management with Performance-Based Earned Value® (PBEV℠)

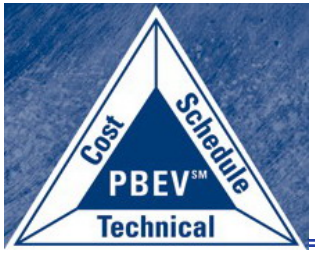
© 2006 Paul J. Solomon



PBEV

- 4 Principles and 16 Guidelines
- Specify most effective measures of project performance
- Requirements-driven plan
- Consistent with standards and models
- Tailorable and scalable, depending on risk
- Lean

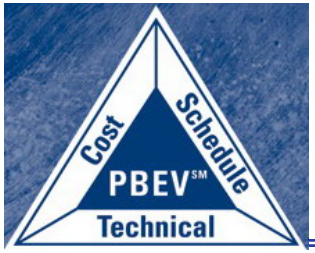
© 2006 Paul J. Solomon



PBEV Based on Standards and Models

- **ANSI/EIA-632**
- **IEEE 1220**
- **CMMI®**
- **PMBOK® Guide**
- **INCOSE SE Handbook**
- **PSM. *Practical Software and Systems Measurement: A Foundation for Objective Project Management***
- **Earned Value Management Systems (ANSI/EIA-748-A-1998, reaffirmed August 28, 2002) (EVMS)**

© 2006 Paul J. Solomon

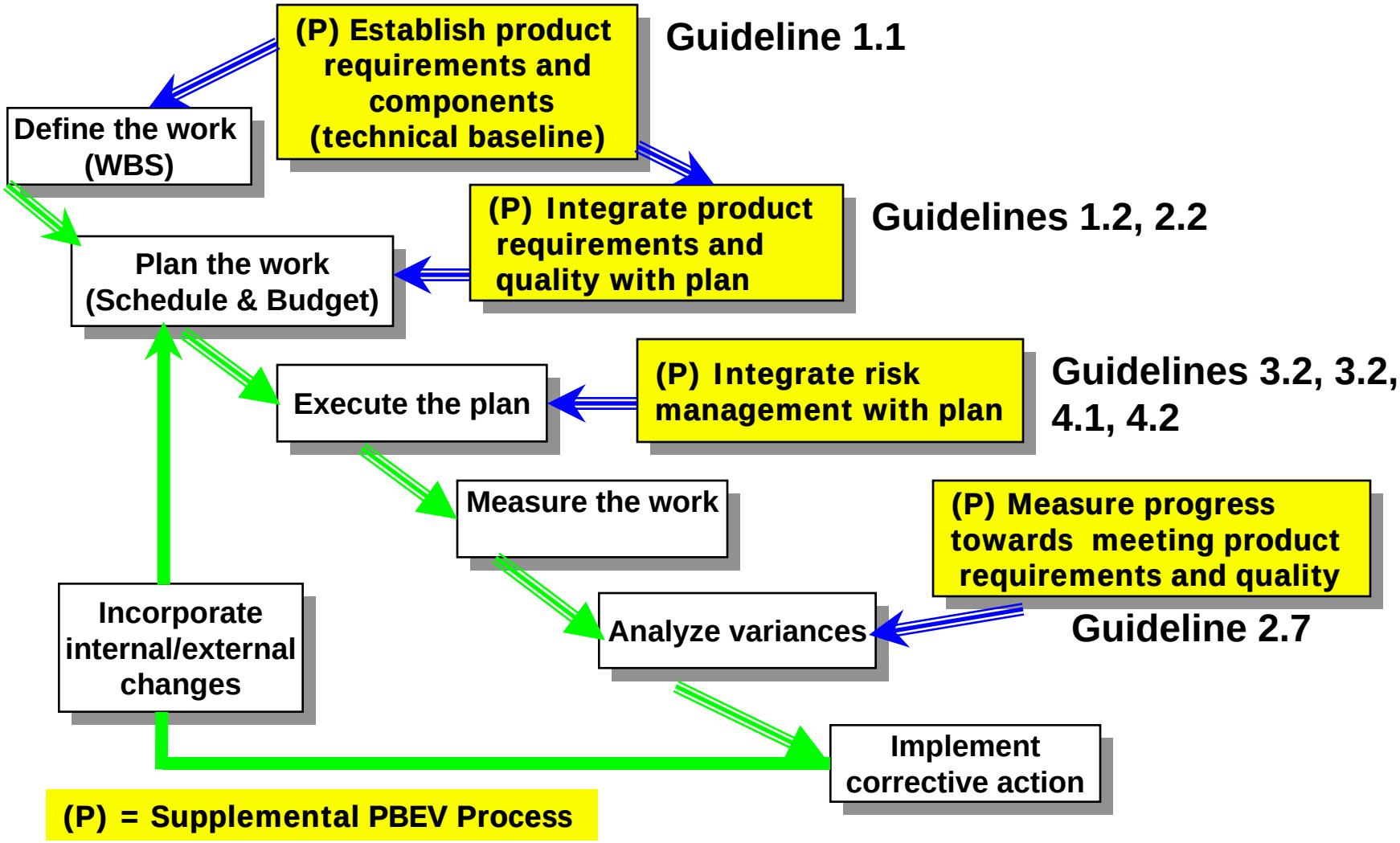


Principles of PBEV

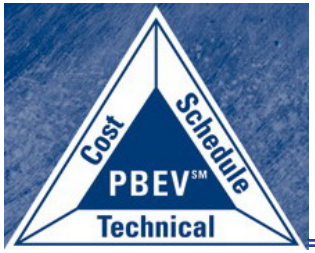
1. Integrate product requirements and quality into the project plan.
2. Specify performance towards meeting product requirements, including planned quality, as a base measure of earned value.
3. Integrate risk management with EVM.
4. Tailor the application of PBEV according to the risk.

© 2006 Paul J. Solomon

Supplemental PBEV Process Flow



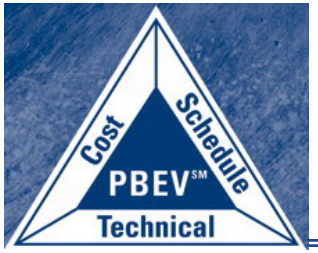
© 2006 Paul J. Solomon



PBEV Techniques

- Measure quality
  - Work products (partial and complete)
  - Technical maturity of evolving product
  - Use analysis, models, simulations, prototypes
- Base EV on
  - Work products (drawings, code) and
  - Quality

© 2006 Paul J. Solomon



EX 1: Schedule Plan and Status

Schedule Plan	Jan.	Feb.	Mar.	Apr.	May	Total
Drawings	8	10	12	10	10	50
Requirements met:						
Weight				1		1
Diameter				1		1

Status at April 30

- **Drawings completed: 41**
- **Weight requirement *not* met**
- **Diameter requirement met**

© 2006 Paul J. Solomon

EX 1: Earned Value

Design (drawings)	Jan.	Feb.	Mar.	Apr.	May	Total
Planned drawings cur	8	10	12	10	10	50
Planned drawings cum	8	18	30	40	50	
BCWS cur	320	400	480	400	400	2000
BCWS cum	320	720	1200	1600	2000	2000
Actual drawings completed cur	9	10	10	12	8	
Actual drawings completed cum	9	19	29	41	49	
EV (drawings) cum	360	760	1160	1640	1960	
Negative EV Reqs cum					-100	
Net EV cum	360	760	1160	1640	*-1860*	

SV = - 140

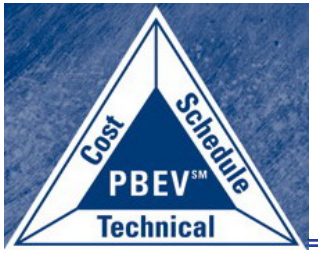
© 2006 Paul J. Solomon

EX 1: Variance Analysis

Variance analysis (drawings and requirements):

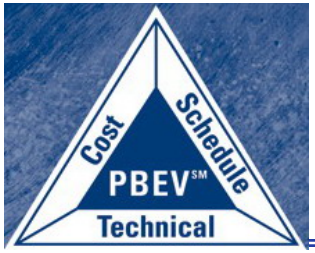
• 1 drawing behind schedule	- 40
• Diameter requirement met	- 0
• Weight requirement *not* met:	- 100
Schedule variance	**- 140**

© 2006 Paul J. Solomon



Better Acquisition Management

© 2006 Paul J. Solomon

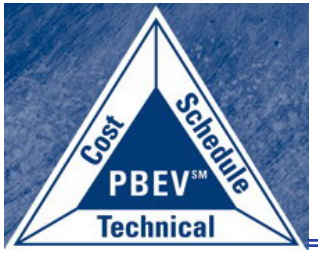


Acquisition Management

Ensure Contractors Integrate SE with EVM

- **Requirements, incentives, insight:**
  - **Solicitation/Request for Proposal (RFP)**
  - **Integrated Master Plan (IMP)**
  - **Integrated Baseline Review (IBR)**
  - **Integrated Master Schedule (IMS)**
  - **EVMS compliance assessments**
  - **Independent technical assessments**
  - **Monitor consistency and validity of reports**
  - **Independent EAC and risk assessments**
  - **Award fee criteria**

© 2006 Paul J. Solomon



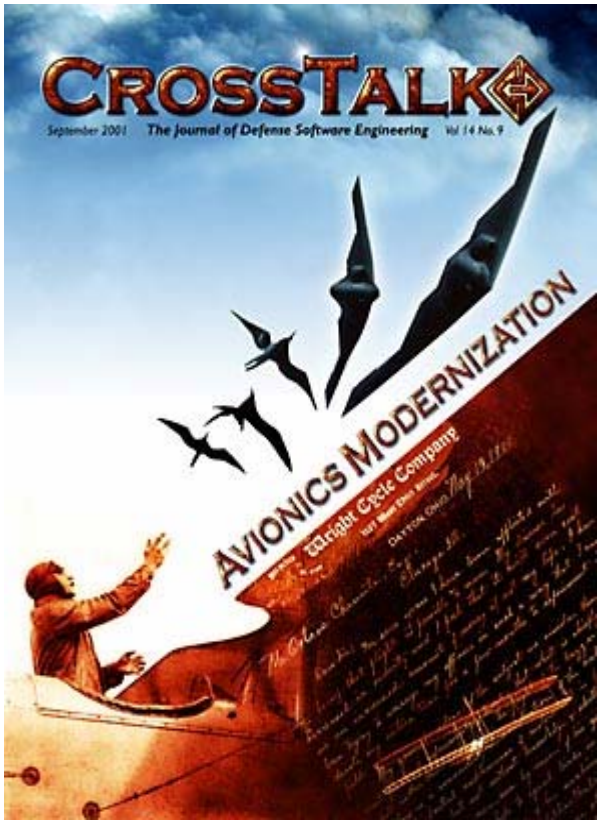
Summary



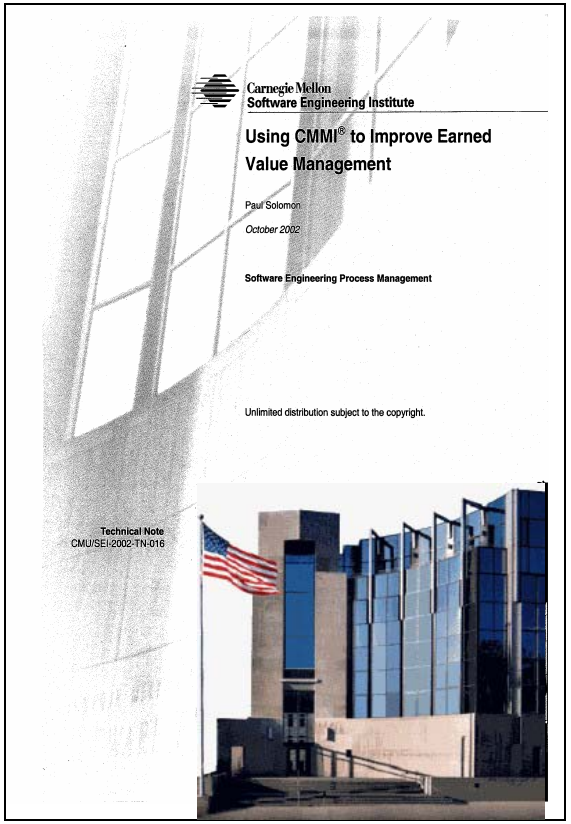
- Integrate
  - Systems engineering with PBEV
    - Product requirements
    - Manage the technical baseline
    - Technical performance measures
    - SE life cycle work products
  - Technical>schedule>cost performance
- Lean process
  - Less work packages with right base measures
- Agile

© 2006 Paul J. Solomon

Process Improvement

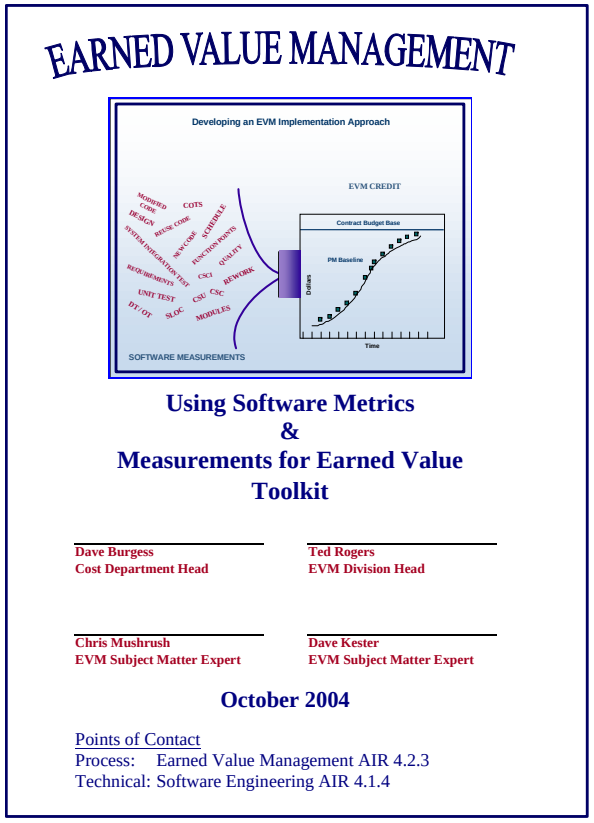


Sept. 2001



Aug. 2005

SEI / CMMI



May 2006

NAVAIR

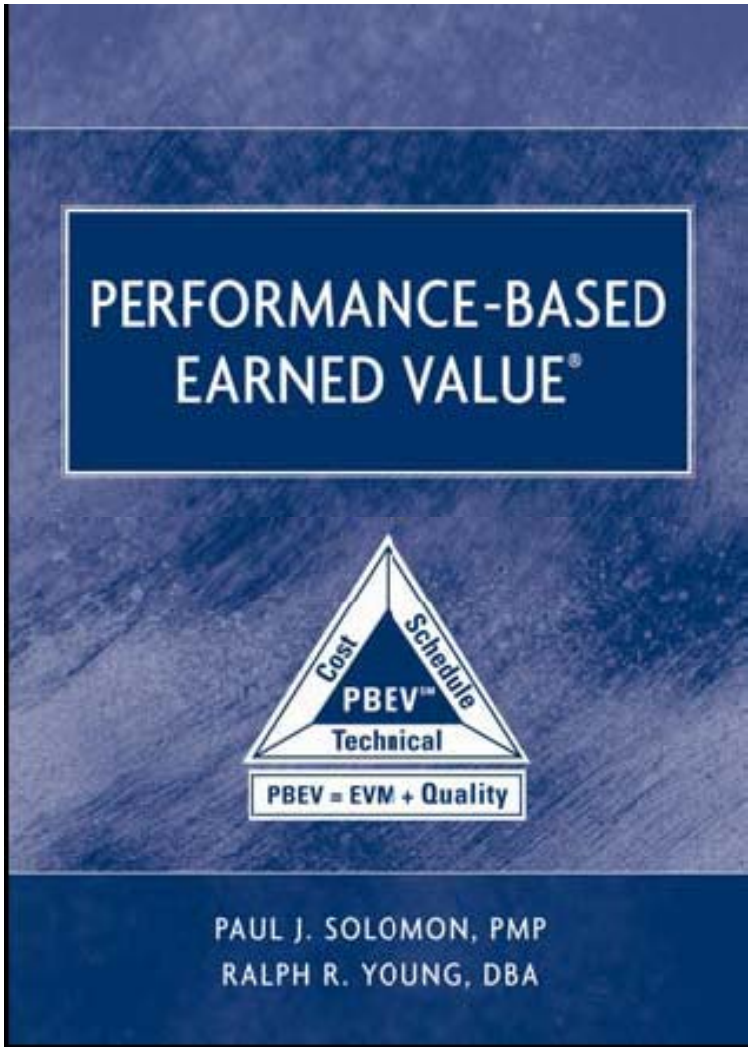
© 2006 Paul J. Solomon

Process Improvement

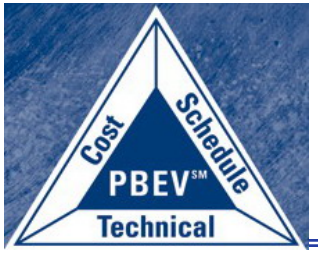
But wait.

There's more!

- **Examples**
- **Templates**
- **Tips**
- **Standards**
- **FAR**



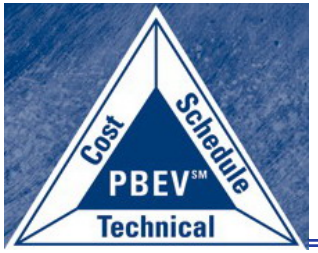
© 2006 Paul J. Solomon



References

- ®CMMI Is Registered by Carnegie Mellon University in the U.S. Patent and Trademark Office.
- ® Performance-Based Earned Value is registered by Paul Solomon in the U.S. Patent and Trademark Office. PBEV is a Service Mark of Paul Solomon.
- ® PMBOK is registered by the Project Management Institute in the U.S. Patent and Trademark Office
- American National Standards Institute (ANSI)/Electronics Industries Alliance (EIA). ANSI/EIA 632, *Processes for Engineering a System*, EIA, Arlington, VA, 1998.
- CMMI, *Capability Maturity Model Integration-Systems Engineering/Software Engineering/Integrated Product and Process Development, Version 1.1*, 2002.
- INCOSE 2006. International Council on Systems Engineering (INCOSE). *INCOSE Systems Engineering Handbook, version 3.* June 2006. page 7.11
- Institute of Electrical and Electronics Engineers (IEEE). IEEE Std 1220™-2005*, IEEE Standard for Application and Management of the Systems Engineering Process. New York, 2005.*
- Naval Air Systems Command (NAVAIR*). "Using Software Metrics & Measurements for Earned Value Toolkit.*" Department of the Navy (October 2004).

© 2006 Paul J. Solomon



References

- PSM. *Practical Software and Systems Measurement: A Foundation for Objective Project Management*, Version 4.0b, October 2000 (www.psmsc.com).
- Solomon, Paul . "Practical Software Measurement, PBEV", *CrossTalk* (September 2001) www.stsc.hill.af.mil/crosstalk/2001/09/index.html.
- Solomon, Paul. "Going From PBEV to the CMMI", *CrossTalk* (September 2002) www.stsc.hill.af.mil/crosstalk/2002/09/index.html.
- Solomon, Paul , "Using CMMI to Improve Earned Value Management" (CMU/SEI-2002-TN-016) (October 2002). www.sei.cmu.edu/publications/documents/02.reports/02tn016.html
- Solomon, Paul , "Integrating Systems Engineering with Earned Value Management", *Defense Acquisition, Technology and Logistics (AT&L) Magazine* (May 2004). www.dau.mil/pubs/dam/05_06_2004/may-june04.pdf.
- USAF Space & Missile Systems Center, "Systems Engineering Primer and Handbook" (January 2004)
- Young, Ralph R. *Effective Requirements Practices* (Addison-Wesley, 2001).
- Solomon, Paul. "Performance-Based Earned Value", *CrossTalk* (August 2005) www.stsc.hill.af.mil/crosstalk/2005/08/index.html.
- Solomon, Paul. "Practical, Performance-Based Earned Value", *CrossTalk* (May 2006)

© 2006 Paul J. Solomon

Seven Steps of an Effective Lessons Learned Process

NDIA 9th Annual Systems Engineering Conference

October 24, 2006

Mr. Jimmy Thai

thaij@saic.com

SAIC
From Science to Solutions™

Presentation Outline



- *The Issue*
- *The Challenge*
- *The 7-Step Solution*
- *Recommendations*
- *Q&A*

SAIC®
From Science to Solutions™

The Issue

- Does any of these problems sound familiar to your team?
  - We keep making the *same* mistakes over and over.
  - We thought *someone* on our team knows how to do this.
  - Oh yeah! We had *that* problem with project X too.
  - Chuck just quit and there goes the *corporate knowledge*.
- Solution: Having lessons learned
- Challenges: We are all busy, don't have time, no funding, etc.

SAIC® From Science to Solutions™

Step 1: Free Food

- Everybody loves free lunch
- Attendants get instant benefit
- Do it during lunch break
- Free loaders are okay
- Benefits outweigh cost



SAIC
From Science to Solutions™

Step 2: Regularly

- Consistence is the key
- The Pavlov's conditioning
- At least monthly
- A habit needs 21 repetitions



SAIC
From Science to Solutions™

Step 3: Relevant Content

- WIIFM challenge
- Listen to your audience
- Seek volunteer presenters
- Always have backup plan
- Don’t waste their time



SAIC
From Science to Solutions™

Step 4: Commitment

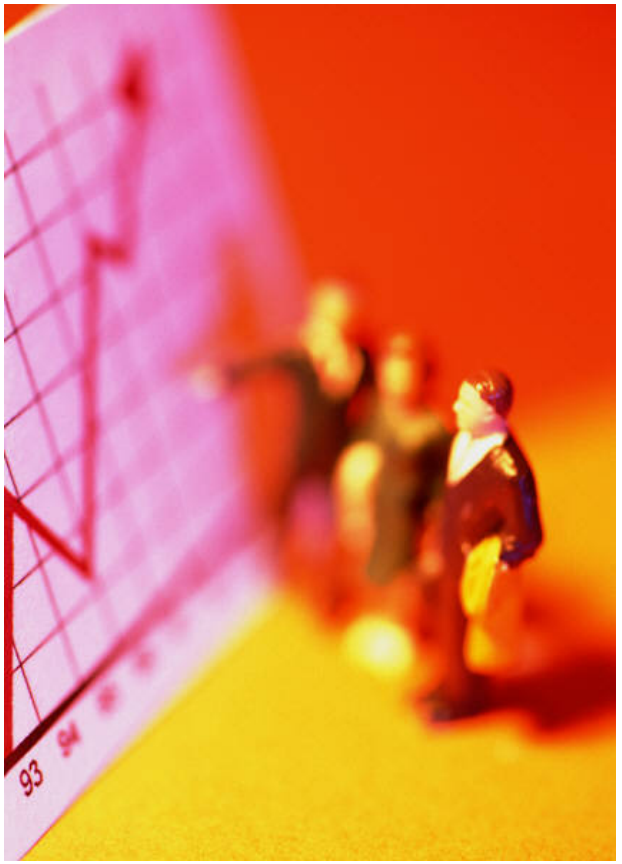
- It's a marathon, not a sprint!
- Keep your words
- Audience saw many "rah rah" initiatives before
- Be resilient
- Send reminders



SAIC
From Science to Solutions™

Step 5: Part of a Process

- Project Closeout
- Review technical, management, financial, and people as well
- Keep it semi-formal
- Bad news is okay



SAIC
From Science to Solutions™

Step 6: Archive

- Not everyone can make it today



- Shared access promotes collaboration

- Data -> Information -> Knowledge -> Power

SAIC
From Science to Solutions™

Step 7: Application



- Proposal development check list (i.e.: Has the team review LL?)
- Technical design review check list

SAIC
From Science to Solutions™

Recommendations

- Tailor to your specific goals
- Start strong – Get your ducks in a row
- Keep cost low
- Measure ROI
- Remember why you want to do this in the first place



SAIC
From Science to Solutions™

This is Your Conference...
Please Ask Questions



SAIC
From Science to Solutions™

Rapidly Defining a Lean CMMI Maturity Level 3 Process



Zia Tufail, zia@hp.com, 301.233.4228
Julie Kellum, Julie.Kellum@hp.com, 404.731. 52.63
Tim Olson-QIC, Tim.Olson@qic-inc.com, 760.804.1405

© 2004 Hewlett-Packard Development Company, L.P.
The information contained herein is subject to change without notice

Presentation Objectives

Describe CMMI compliant online HP process
- Outline Components for a cost effective, lean process

Describe HP's improvement objectives.
- Identify problems addressed by the streamlined CMMI L3 HP process

Describe the approach that was used to achieve CMMI Maturity Level 3.
- Unique techniques for defining & implementing an effective, lean CMMI L3 process in 8 months

Present some challenges and lessons learned.

Answer any questions.

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



FY05 C&I EAS/Federal Initiatives

EAS & Public Sector Initiative	*CMMI Relation*
• CMMI L3 Achievement	• Development of EAS HPGM-AS methodology, rollout and assessment.
• Expand Application Services	• L3 methodology is unifying force for consistent standards and practices.
• Increase Pursuit Capabilities	• CMMI allows us to pursue opportunities we would not get otherwise • Better estimation and marketing of services
• Delivery Excellence	• Standardization and enforcement of best practices.
• Profit Improvement	• Disciplining delivery execution and preventing margin leakage by fostering reuse and minimizing risk

Existing Methods Revised to Meet CMMI Level 3

2004

A $1.5 Million dollar, 8 month project started to revise Success Program to meet CMMI level 3 and improve project controls. Some current and new FY05 Federal Contracts at risk without a CMMI level 3 compliant process.

- Sept — CMMI Level 3 Gap Analysis on Current Methodology
- Oct -Nov — HPGM-AS Methodology Customizations - define per Sharepoint portals
- Dec — Pilots Start :
  - •PM Orientations/Planning Sessions per project
  - •CMMI & Methodology Classroom Training

Pilots Underway

2005

Success Program Office (SEPG team) and Pilot Projects start leveraging Success Program revised with the new CMMI level 3 compliant process

- Jan — Envisioning & Maintenance Phase Pilots start
- Feb — Design & Maintenance Phase Pilots
- Mar — Build & Maintenance Phase Pilots
- April — Pilots Continue & CMMI Assessment begins
  - April 29 EAS and Public Sector Achieve CMMI level 3 maturity

Components of the HP CMMI L3 Process



Technology

- Sharepoint based portals:
  - Success Program Office
  - Success Manager
  - Success Reviews
  - HPGM-AS Roadmap
  - RADM Virtualization

Process

- SEI CMMI L3 framework
- HP Global Method Application Services (HPGM-AS - methodology)
- Success Reviews (PPQA audit process)
- Success Manager (Team Collaboration process)
- Adaptive Assets (Knowledge Capture & Reuse process)



People

- Success Program Office (SEPG function)
- SQA Coaches (per team)
- Program Management
- Organization & Culture



Success Program Office

EAS HP Global method Application services (HPGM-AS)	• Delivery Workflow portal/process • CMMI level 3 compliant • Phase deliverables & Signoffs
Success Manager	• Team Collaboration web/process • Pre-Loaded HPGM-AS • Customer accessible
Success Reviews	• Process Review (PPQA) portal/process • Mentoring Support By Field PMs
Adaptive Assets Knowledgebase	• Process and Tech Asset KB portal/process • Reuse tool
Rapid ADM	• Supports HPGM-AS Configuration Mgt • Virtualization and Software Configuration • Management (SCM) services

Home - HPGM-AS Roadmap R2.6 - Microsoft Internet Explorer provided by Hewlett-Packard

File Edit View Favorites Tools Help

Back Search Favorites Media

Address https://h20224.www2.hp.com/sites/ProjectsCMMi/SuccessPath_HPGM-AS_Roadmaps/Roadmap_v6/default.aspx Go Links

Home Documents and Lists Create Site Settings Help Up to Success Manager HPGM-AS Roadmaps

HPGM-AS Roadmap R2.6

Home

This Site

Modify Shared Page

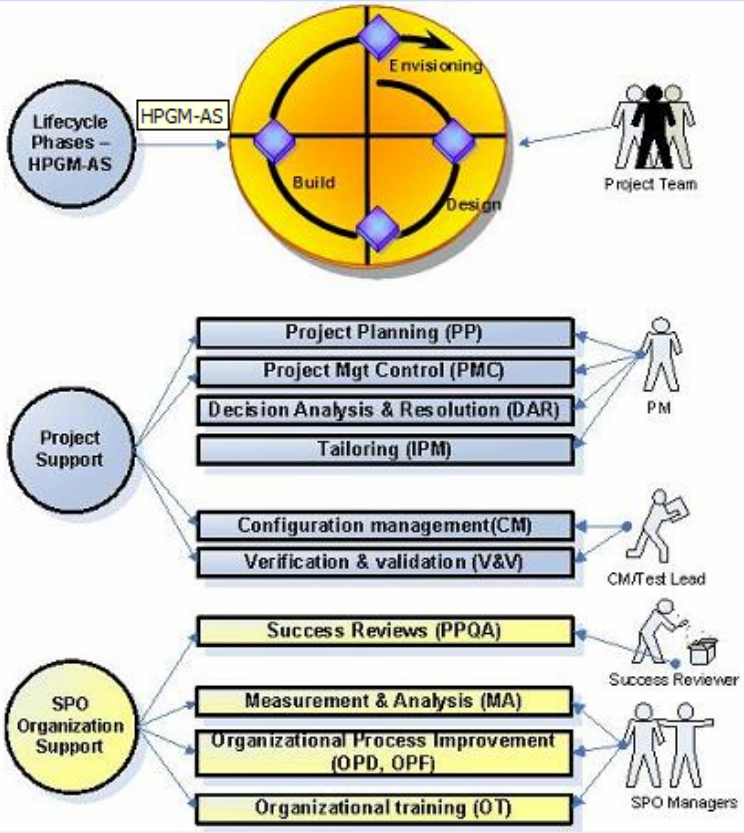
Documents
- HPGM-AS ZIPed Templates

Pictures

Lists
- New Projects START HERE
- Lifecycles
- ENVISIONING PHASE
- DESIGN PHASE
- BUILD PHASE
- ARTIFACTS
- Project Planning (PP)
- Project Management (PMC)
- Configuration Management (CM)
- Verification and Validation (V&V)
- Peer Review (V&V)
- Decision Analysis Resolution (DAR)
- Tailoring (IPM)
- SPO Success Reviews (PPQA)

Second Release of HP Global Method for Application Services which is a level 3 CMMI application development methodology supporting iterative, waterfall and maintenance lifecycles in HP's Consulting and Intergration (C&I) area

HPGM-AS



CMMI Links

- SUBMIT Success Program Improvements Here!
- Adaptive Assets
- Success Reviews
- CMMI project webs (currently USPS only - special clearance required)
- HPGM-AS Lifecycles Overview
- SPO Portal
- SPO Lessons Learned Analysis
- HPGM-AS Impact Analysis Tool
- SPO Configuration Management Plan
- SPO Training Plan
- SPO Improvement Plan (SIP)
- SPO Quality Policy
- SPO Quality Assurance (QAP) Plan
- CMMI Scope & Design Decisions

Add new link

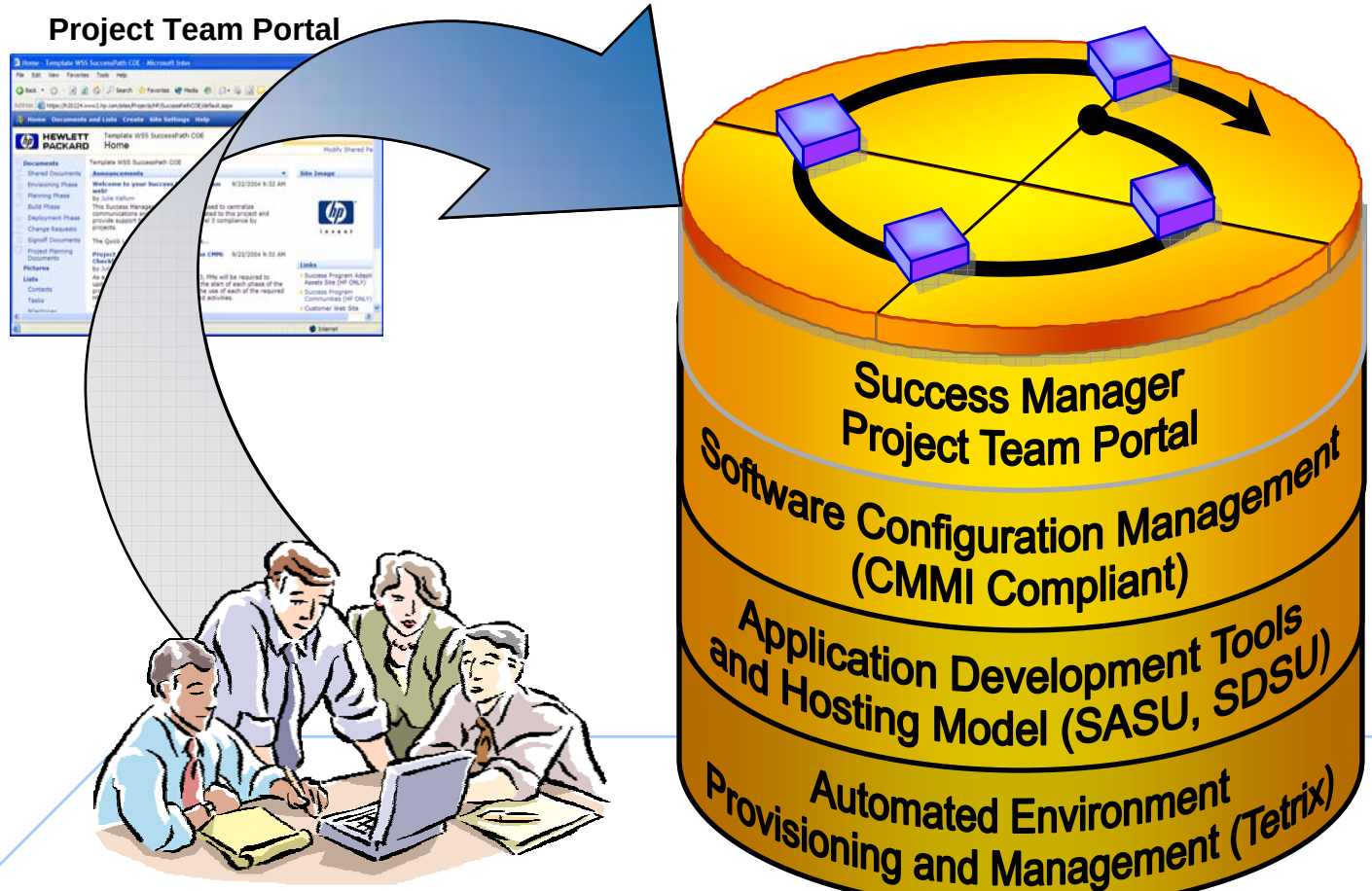
Contacts

Last Name	First Name	Role
Galvan	Carlos	April 18-29 Lead CMMI Assessor
Erwin	Brian	Centers of Excellance Manager

Done Local intranet

start 3 Microsof... 5 Microsof... Training 20... HP4 2006 Home - HPG... 10:46 PM

Rapid ADM Components and Features



Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Success Program Vision

- Using a sales and delivery integrated approach, leverage existing, as well as grow new process and technical Adaptive Assets to :
  - Increase ability to compete in Federal bids through CMMI Level 3 compliance
  - Win more business through improved differentiation
    - IBM differentiation point
  - Increase Success of Projects
    - Synergistic Teams
    - Referencable Clients
    - On Time
    - In Budget/Profitable
    - Effective HP Global Methods Applied

Success Program ➔ What & Why

- Collection of specific process and technical assets used in pre-sales for differentiation and in delivery to increase project success
- CMMM Maturity Level 3 compliant to meet Federal bid requirements
- Externally accessible outside HP Firewall by delivery teams
- Major Areas:
  - Success Path HPGM-AS
  - Success Manager
  - Success Reviews
  - Adaptive Assets KB
  - Communities & Forums
- Best of breed IP from HP

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



HP Approach

Leverage existing HP processes and templates:

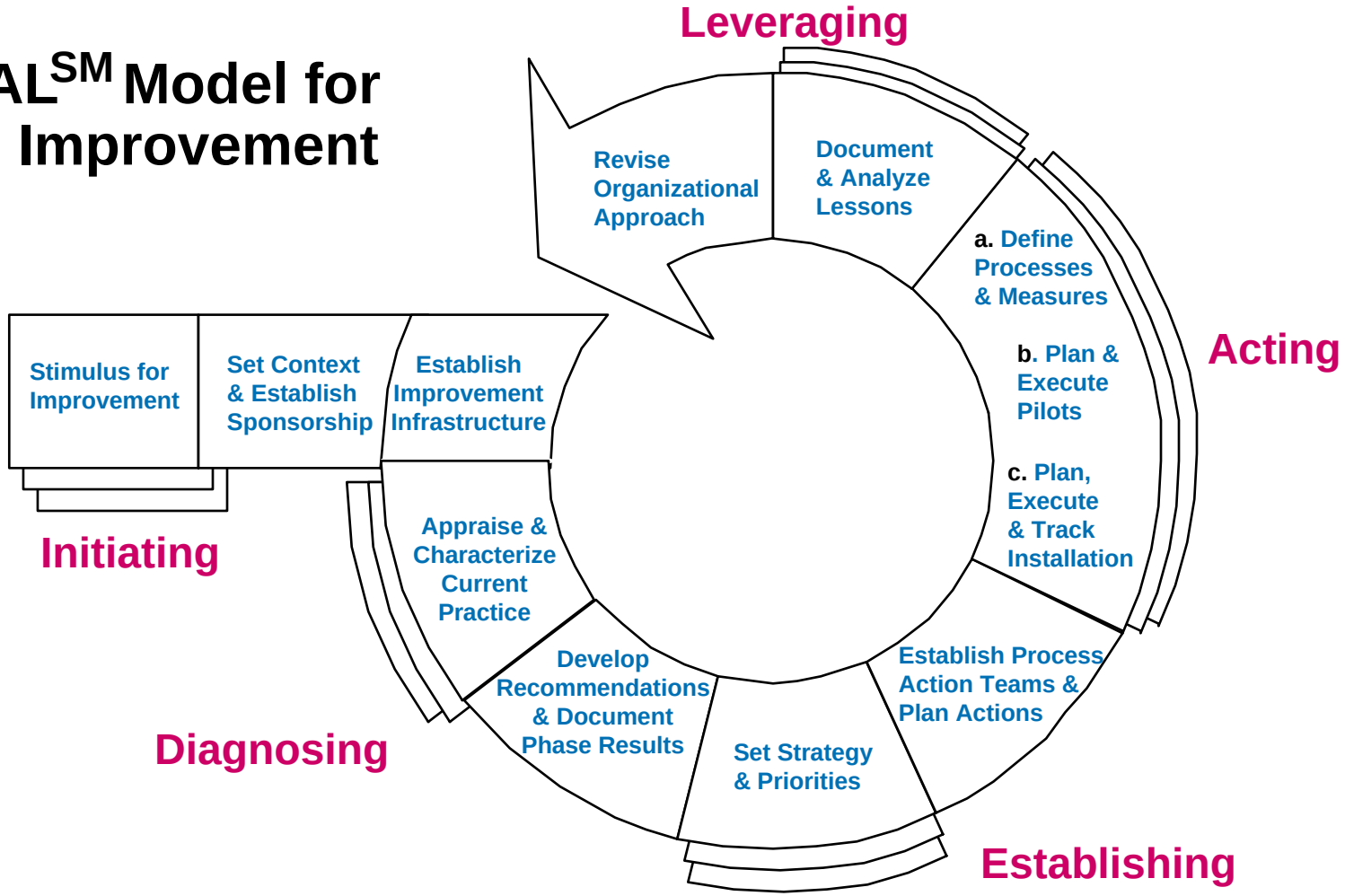
- Success Program
- HP India (CMMI Maturity Level 5)
- HP Global Methods for Application Services (HPGM-AS)
- HPGM for Project Management (HPGM-PM)

Deploy Tailored SEI IDEAL^{SM} Model and reuse existing processes to be CMMI compliant.

Leverage Best of breed IP from HP

SEI IDEAL^{SM} Model

SEI IDEAL^{SM} Model for Process Improvement



- SM IDEAL is a service mark of Carnegie Mellon University; Slide Adapted from SEI

Tailored SEI IDEAL^{SM} Model

Initiating: Sponsor sold idea to HP senior management.

Diagnosing: HP India performed a mini-appraisal (e.g., Class B).

Establishing: CMMI Consultant established high-level plan and HP established a CMMI Team.

Acting: Architected HP processes to be CMMI compliant in 2 months; Skipped piloting; Trained and implemented experienced projects.

Success: Performed independent SCAMPI A.

HP's "Lean" Process

HP Success Program is a very "lean" CMMI compliant process (about 25% of the size of the HP India process).

The process is completely online, and uses Microsoft SharePoint.

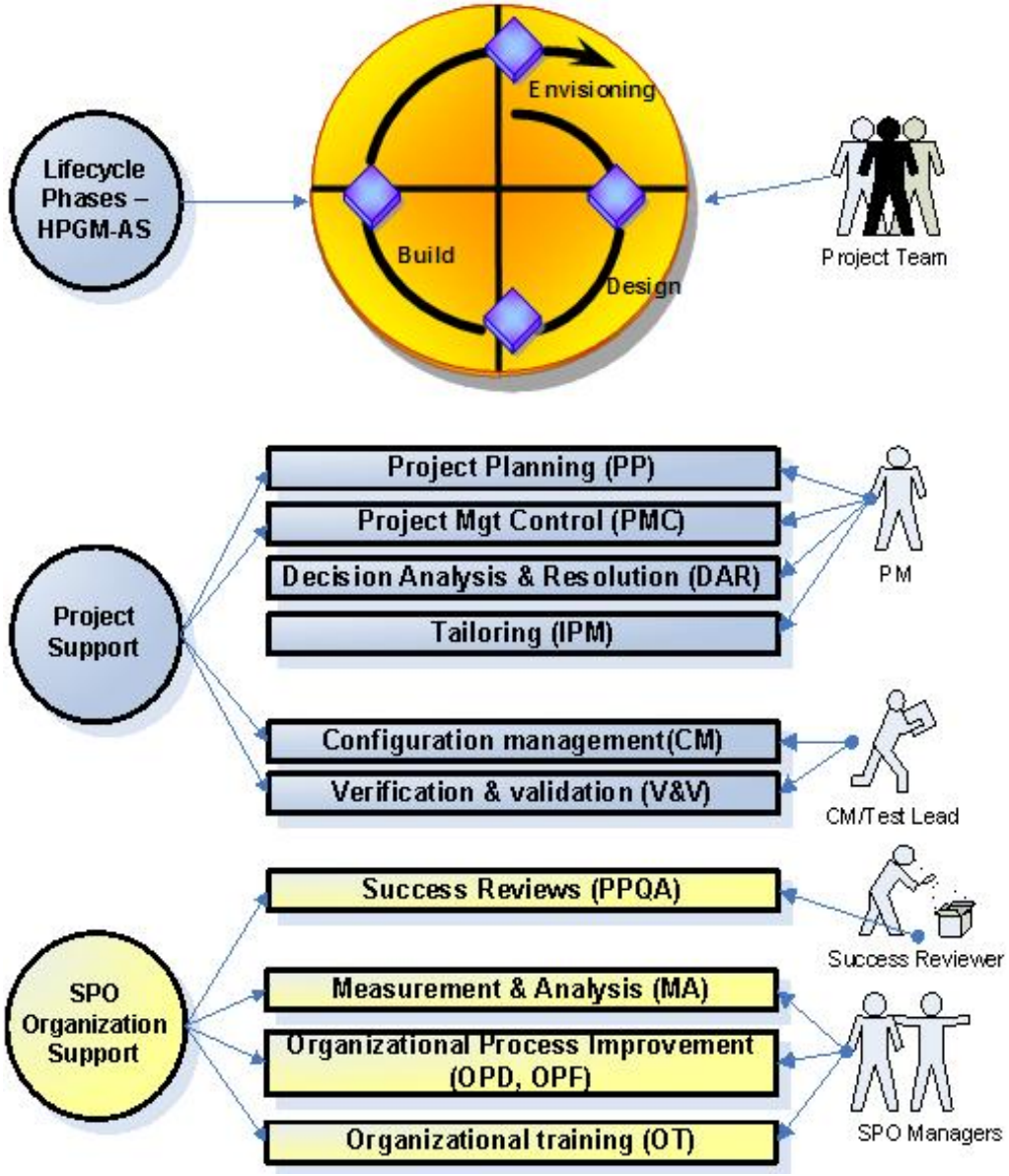
HP's process is only ~25web pages in size.

HP incorporated best practices in process definition

- e.g., "Defining Short, Usable Processes and Procedures", CrossTalk, Olson, Timothy G., June 2006.

HPGM-AS CMMI L3 Methodology

- 2 Paths depending on project profile
  - Large HPGM-AS CMMI Implementation
  - Small HPGM-AS CMMI Implementation
  - Excluded are projects required to use the customer's app dev methodology & staff aug
  - No existing projects asked to convert – new only
  - Large and Small Project implementations differ mainly
    - on use of Success Reviews and Deliverables Required



HPGM-AS Artifact Comparison Example

Small/Low Risk	Large/High Risk
Success Manager site (Issues List & Change Req/PR List)	Success Manager site (Issues List & Change Req/PR List)
Project Plan & Configuration Mgt Plan	Project Plan & Configuration Mgt Plan
Schedule	Schedule
Mini-Spec (Contains sections from all of these ➔)	Bus Req Spec (BRS) Systems Req Spec (SRS) Systems Architecture (SA) Detail Design (DD) V&V /Test Plan Req Traceability Matrix (RTM)
Peer Review Log/Checklist – Mini-Spec CM Audit Checklists – Success Manger, Product Milestone Review Phase Checklists	Peer Review Log/Checklist – Project plan, SRS, SA, V&V Plan CM Audit Checklists – Success Manager, Code, Product Milestone Review Phase Checklists

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Challenges

- CMMI Resources were reallocated to the new high priorities.
- Resistance to change when people have gone through several changes without tangible results.
- Aggressive schedule
- Unexpected events such as team health and organizational changes



Lessons Learned

- It takes time, senior management support, and mentoring to change behavior
- Traditional Classroom training not enough – critical to have a local resource to mentor team on methodology/CMMi activities and artifacts
- Success Reviews critical for monitoring and mentoring on process use
- Critical to use centralized team collaboration tool for process support (i.e. PPQA, Peer Reviews, Lessons Learned, Issue Tracking/Project Change control, etc)



Lessons Learned

- Spend ample time in planning phase to lock down the scope of the project.
- Obtain and maintain executive sponsorship to keep driving the project on schedule.
- Define Configuration Management early in the process.
- Follow the Configuration Management process.
- There is no substitute for one-on-one mentoring for the late adopters.
- Ensure core team understands the entire process.
- Ensure the process is lean and relevant.



Lessons Learned

- Engage stakeholders throughout the process.
- Third party consultants can provide objective feedback.
- Build a diverse team and leverage diversity.
- Ensure CMMI expert resources are on the team.
- CMMI really does require continuous process improvement.



What Went Well

- Teams reap benefits of Peer Reviews, and Milestone Reviews
- Pilot projects implement a consistent delivery approach
- Improved metrics to track trends across projects
- Integration of virtualization through CM process
- Increased value to customer through improved communications thru SPO:
  - Success Manager Team Webs
  - Status Reporting
  - Automated Issues and Change Request tracking

What Went Well

- Expanded Rollout of Success program to ~300
- Implemented new Success Program processes:
  - HPGM-AS Bid Review (Pre-sales)
  - HPGM-AS Quickstarts (Pre-Delivery, 1 week) ➔ tailoring of the process by SEPG with PM and SA
- Implemented scalable training to replace classroom training:
  - PM CMMI Training Track (14 webinars)
  - Engineering CMMI Training Track (9 webinars)

Outline

HP Overview

HP Improvement Objectives

HP Approach

Challenges and Lessons Learne

Questions and Answers



Questions?



Defining and Partitioning Best-of-Team Processes in a Multi-Organizational Teaming Environment

9th Annual NDIA Systems Engineering Conference
October 23-26, 2006

Sysnovation, LLC
13741 Johnson Memorial Drive
Shakopee, MN 55379
www.sysnovation.com

Copyright © 2006 Sysnovation, LLC

David D. Walden
Voice: 952-807-1388
Email: David.Walden@incose.org
AIM: daviddwalden

Topics

- Definitions and Key Concepts
- Examples of Multi-Organizational and Geographically Distributed Teams
- Our Hypothetical Teaming Scenario
- Strategies & Approaches
- Summary and Conclusions

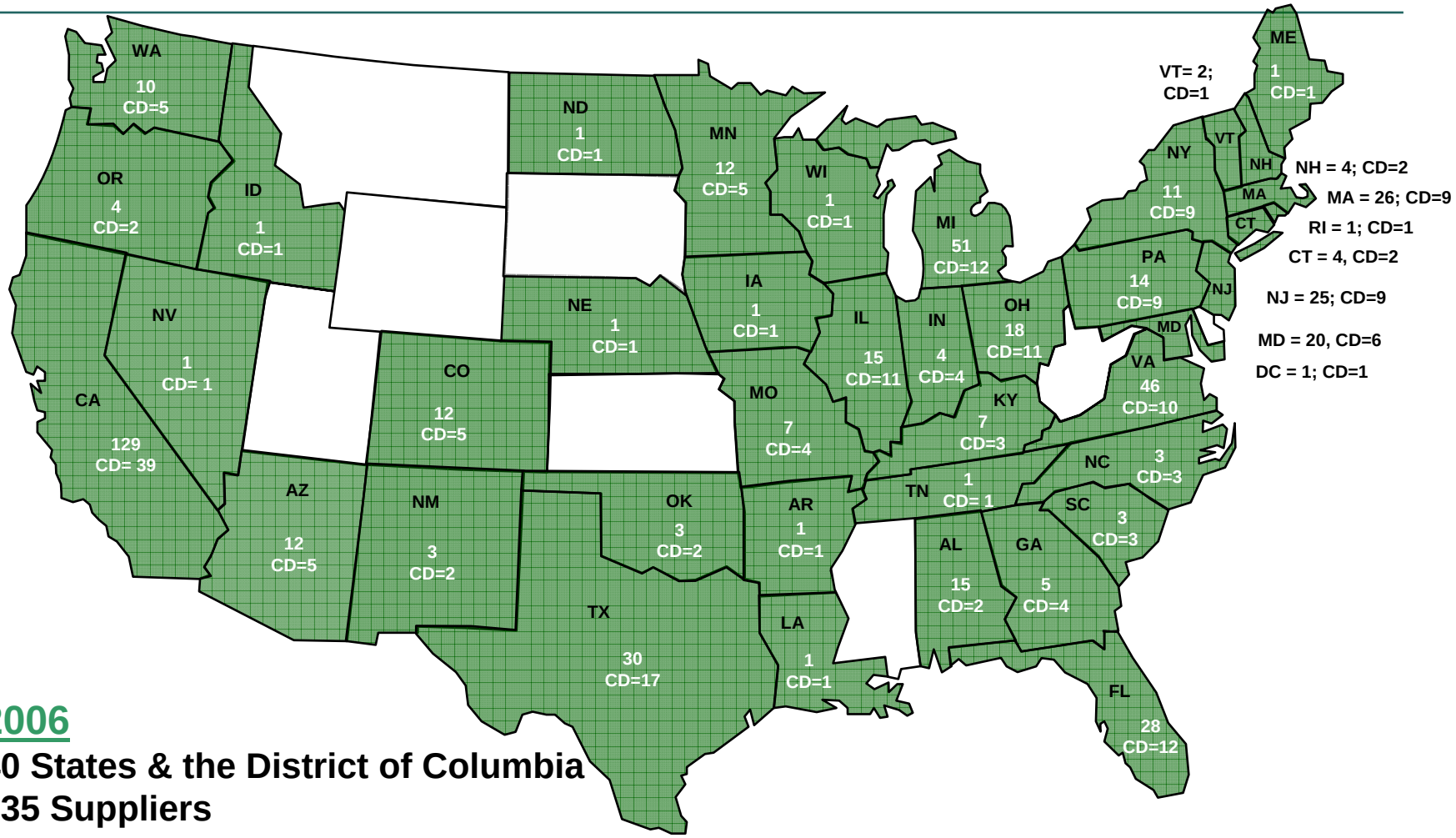
Definitions

- Process
  - Organizational Processes –the set of processes that defines what and how the organization executes its business
  - Project Processes – a tailoring of the organizational processes to match the needs and requirements of the particular project
- Team – a set of people brought together for a particular cause or purpose
- Multi-Organizational – more than one organization (relationship can be acquirer/supplier, team, joint venture, etc.)
- Geographically Distributed – the team is located in more than one physical location

Topics

- Definitions and Key Concepts
- Examples of Multi-Organizational and Geographically Distributed Teams
- Our Hypothetical Teaming Scenario
- Strategies & Approaches
- Summary and Conclusions

USA Example of Business and Teaming Relationships – Future Combat Systems



2006

40 States & the District of Columbia
535 Suppliers
220 Congressional Districts

SYSNOVATION
Systemic Innovation for Business Results

Adapted from TACOM, FCS Case 06-068

European Example of Business and Teaming Relationships – Airbus A380

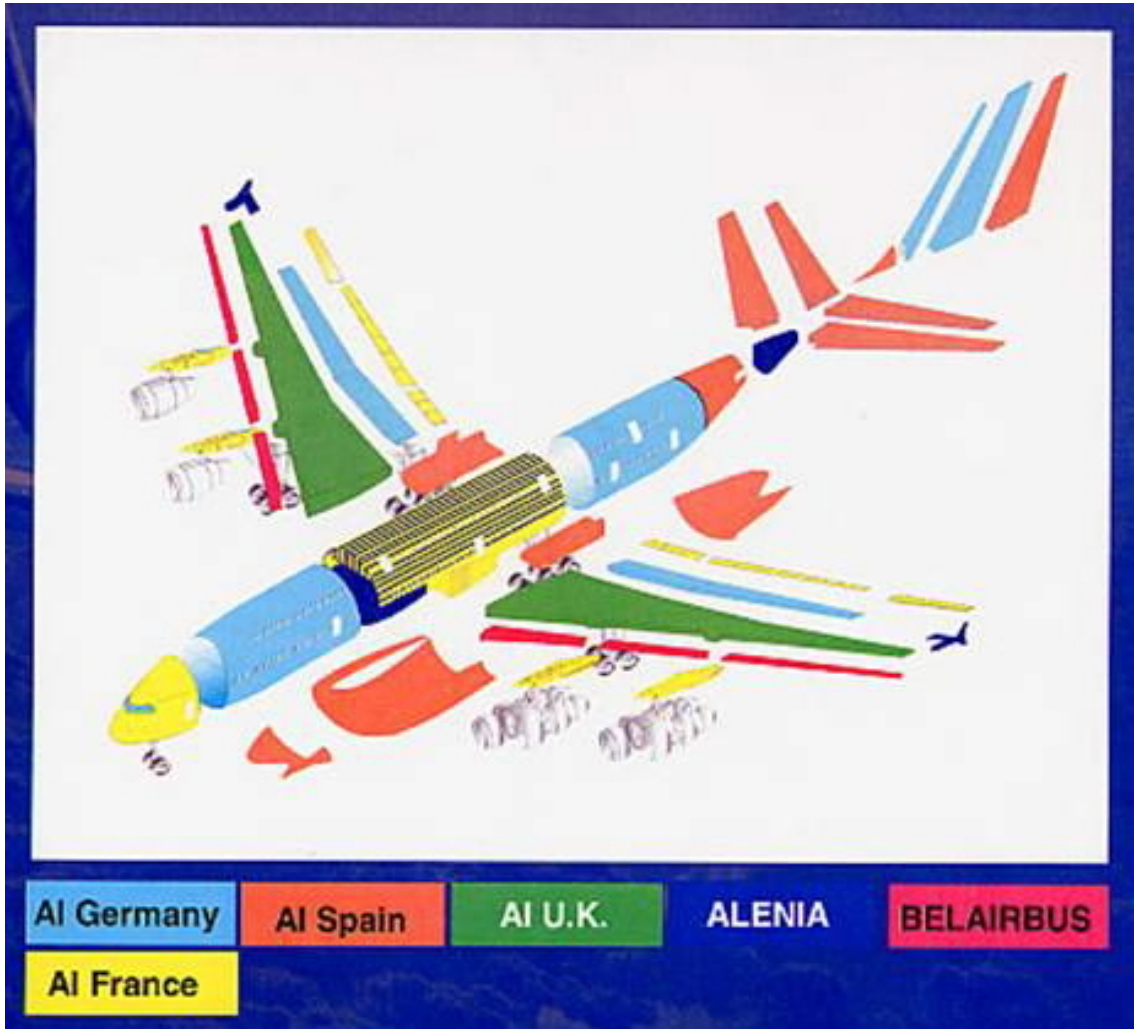
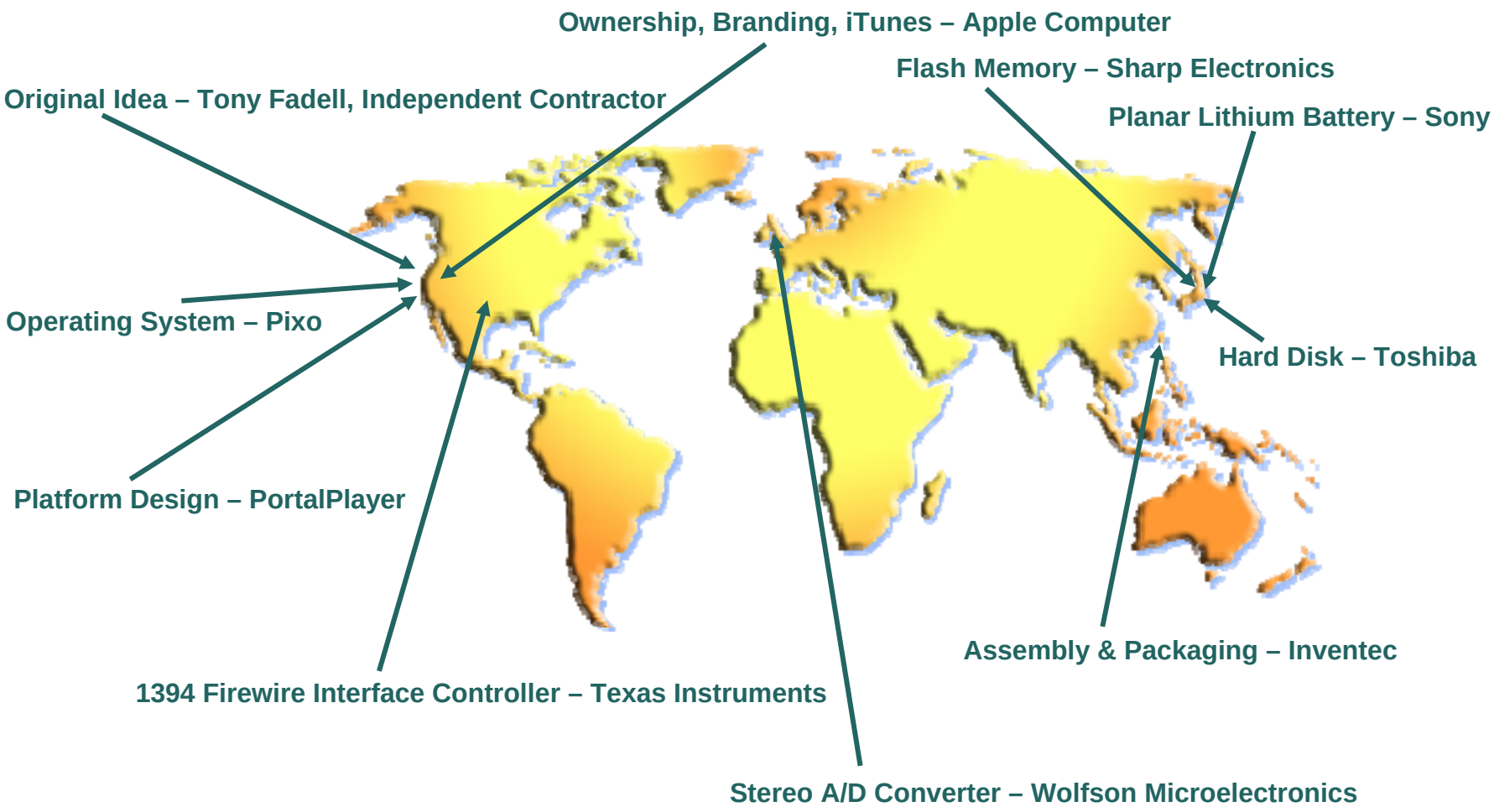


Image Source: Airbus

Apple Computer's iPod Global Network of Innovation



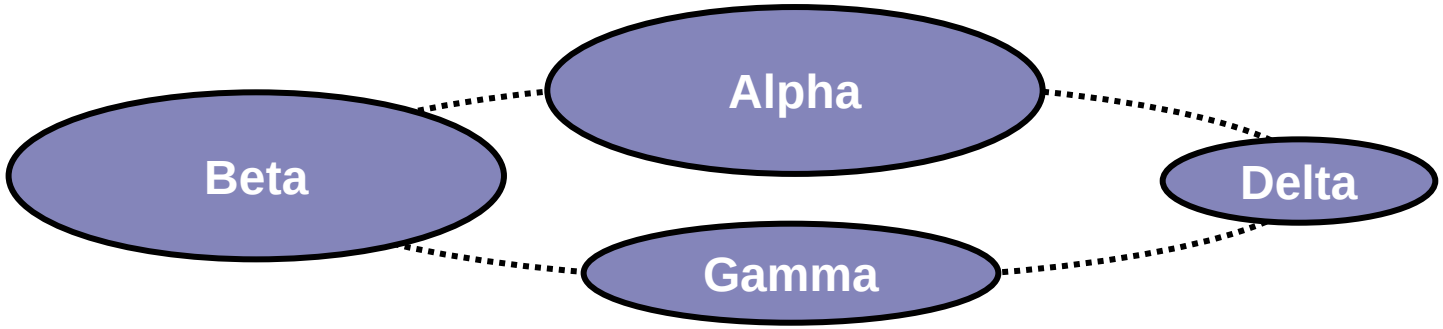


SYSNOVATION
Systemic Innovation for Business Results

Topics

- Definitions and Key Concepts
- Examples of Multi-Organizational and Geographically Distributed Teams
- Our Hypothetical Teaming Scenario
- Strategies & Approaches
- Summary and Conclusions

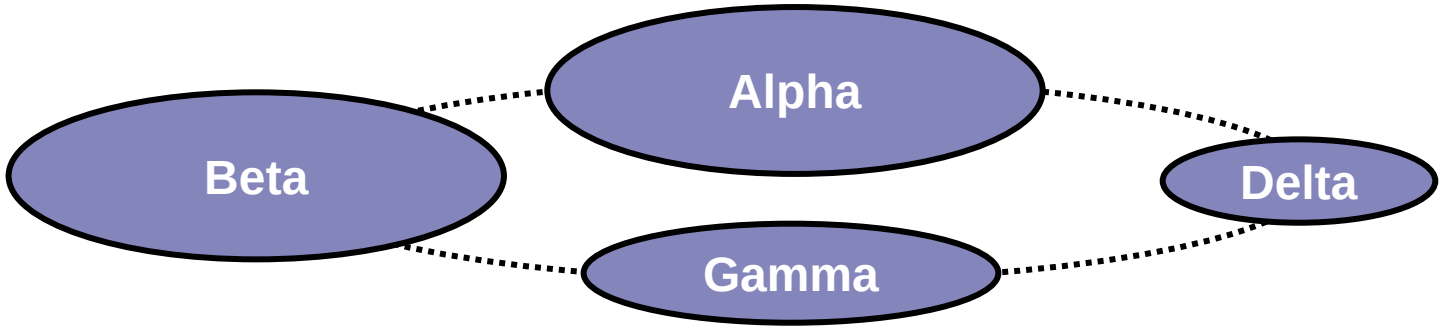
Hypothetical Teaming Scenario



Company	Size	Maturity	Role
Alpha	Large	CMMI Level 3	Prime Contractor System Design Lead Subsystem 2 Lead
Beta	Large	CMMI Level 5	Subsystem 1, 3 Lead System Test Lead
Gamma	Medium	CMM Level 5	SW Lead (All Subsystems) System Integration Lead
Delta	Small	ISO 9001:2000	Key Innovative Technology

So the question is…

- Assuming we actually want to execute as a team (and not just four separate companies)…
  - How do we define and partition the set of processes the team is going to use?



Topics

- Definitions and Key Concepts
- Examples of Multi-Organizational and Geographically Distributed Teams
- Our Hypothetical Teaming Scenario
- Strategies & Approaches
- Summary and Conclusions

Some Obvious Challenges

- This project is one of many projects in each organization
- Each organization has its own culture
- Teammates on this project may very well be competitors on different (and future) projects
- Any unique team processes must have a corresponding infrastructure and investment
- The team needs to understand (through communications, training, leadership, etc.) the way forward

The Key is Balance…

One Extreme:

All companies follow their own processes

The Other Extreme:

All companies follow a single "project" processes



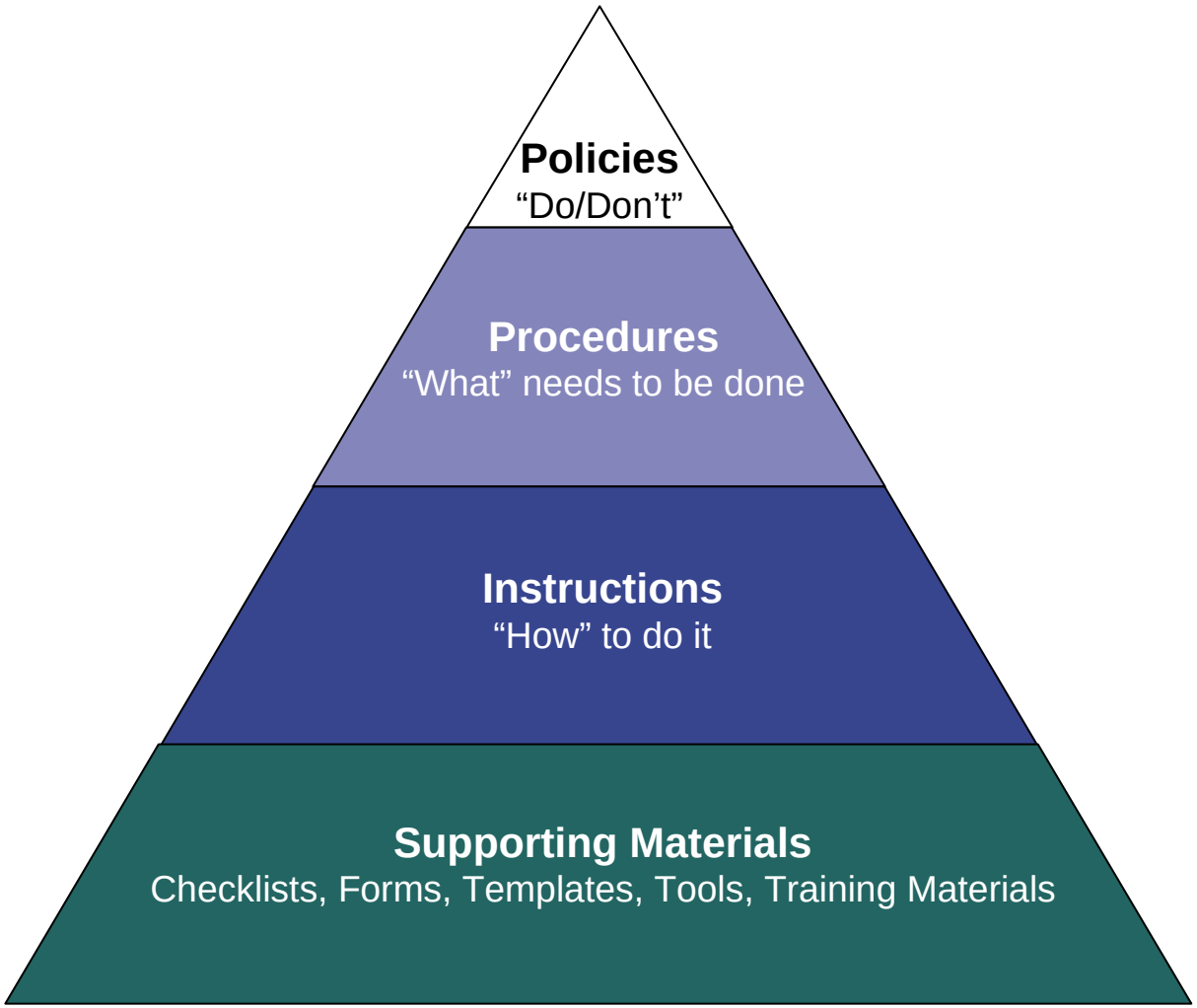
Balanced Alternative:

All companies follow a combination of company processes and "Best of Team (BoT)" processes

Key Considerations…

- Best of Team (BoT) Processes should be Determined based on
  - "Type" of process
    - Policy, Procedure, Instruction
  - "Scope" of process
    - Organizational vs. Realization vs. Infrastructure
  - "Level" of process
    - System vs. Subsystem vs. Component
  - Strength/maturity/role of each team member
- Also need consideration for
  - Organizational Implications
  - Audits & Assessments

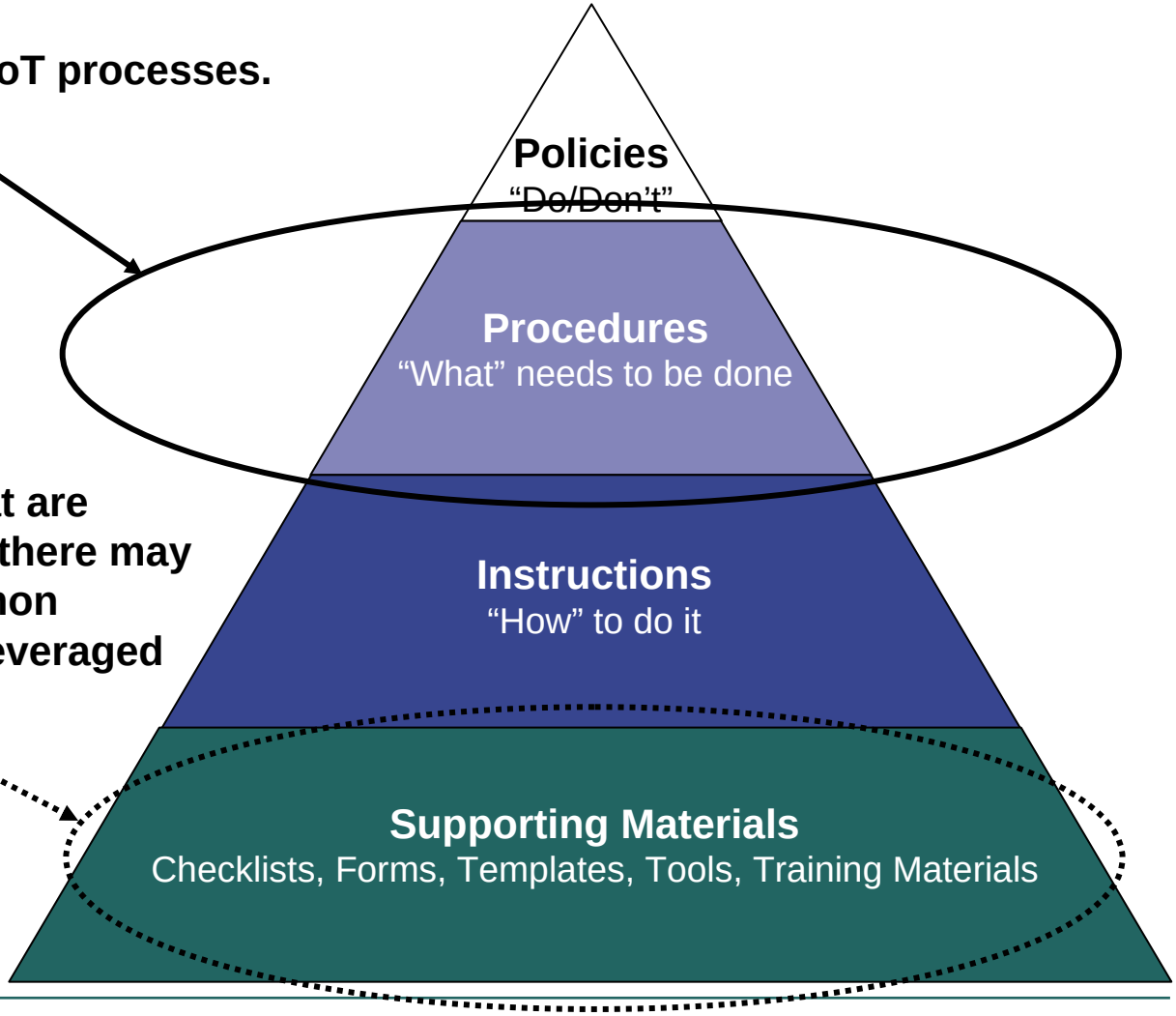
“Type” of Process



SYSNOVATION
Systemic Innovation for Business Results

“Type” of Process

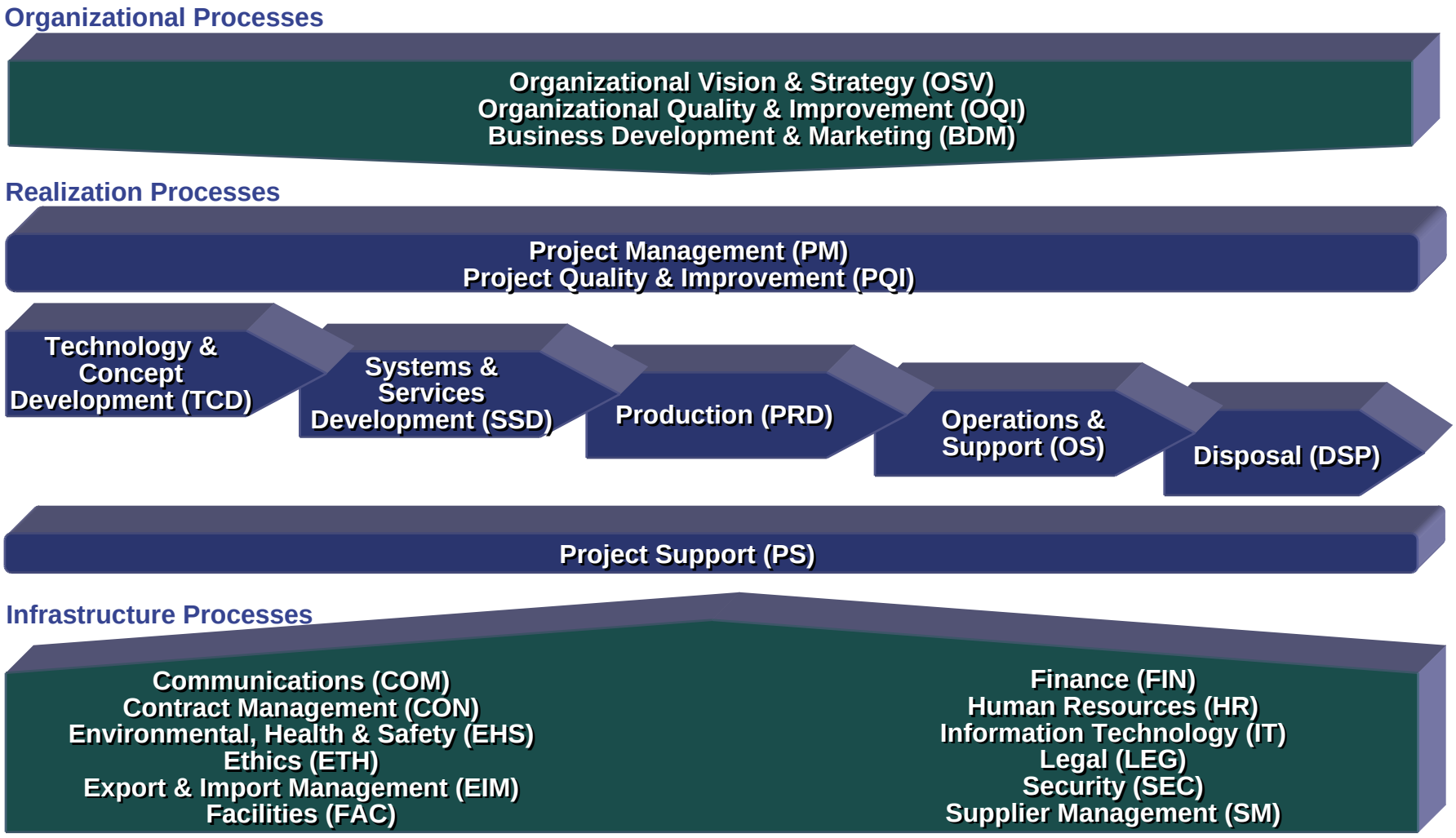
Primary focus of the BoT processes.



For the Procedures that are determined to be BoT, there may need to be some common Supporting Materials leveraged as well.

SYSNOVATION
Systemic Innovation for Business Results

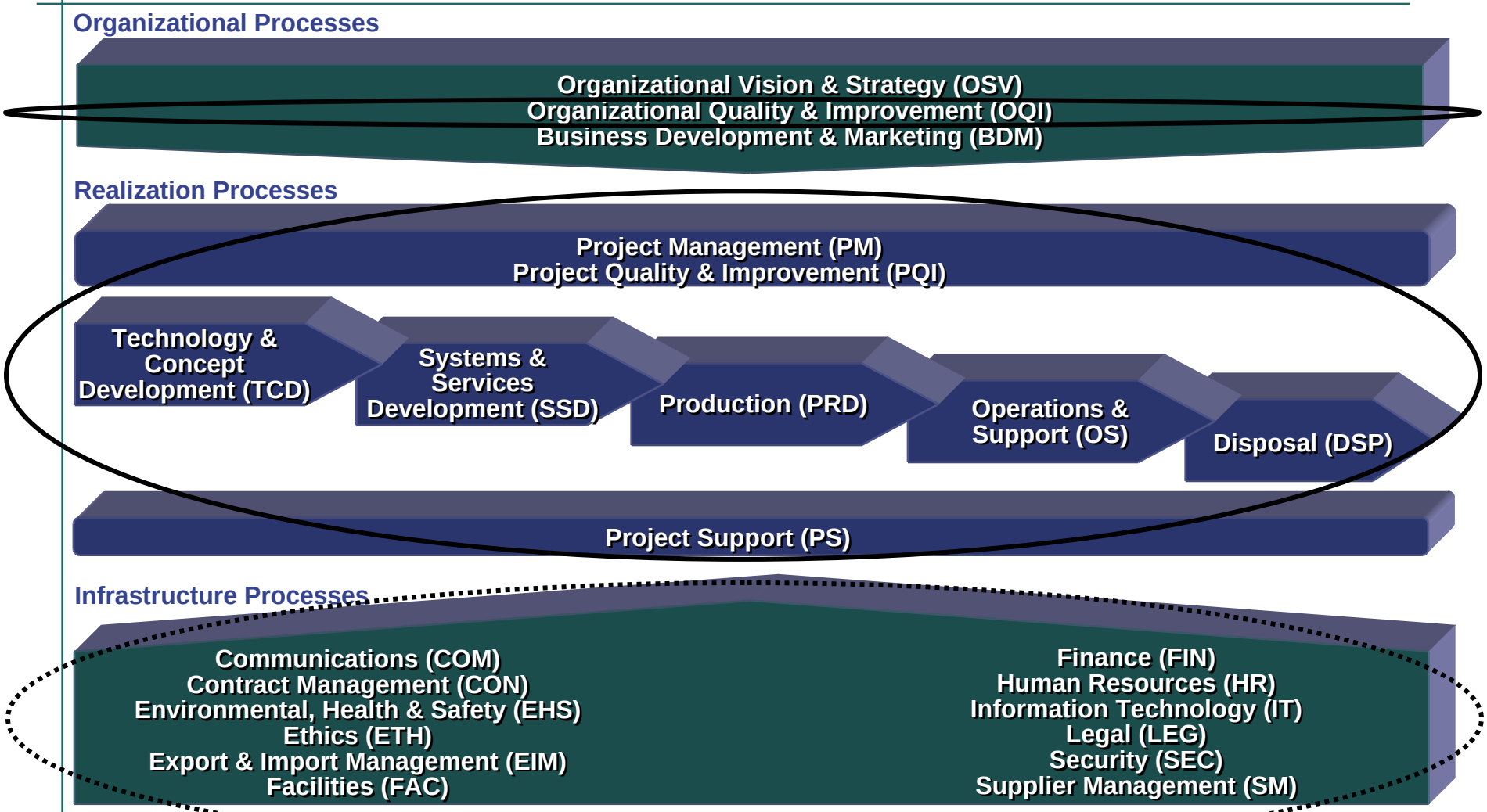
“Scope” of Process



SYSNOVATION
Systemic Innovation for Business Results

Source: Sysnovation Enterprise Process Framework (SEPF) ©2006 Sysnovation, LLC

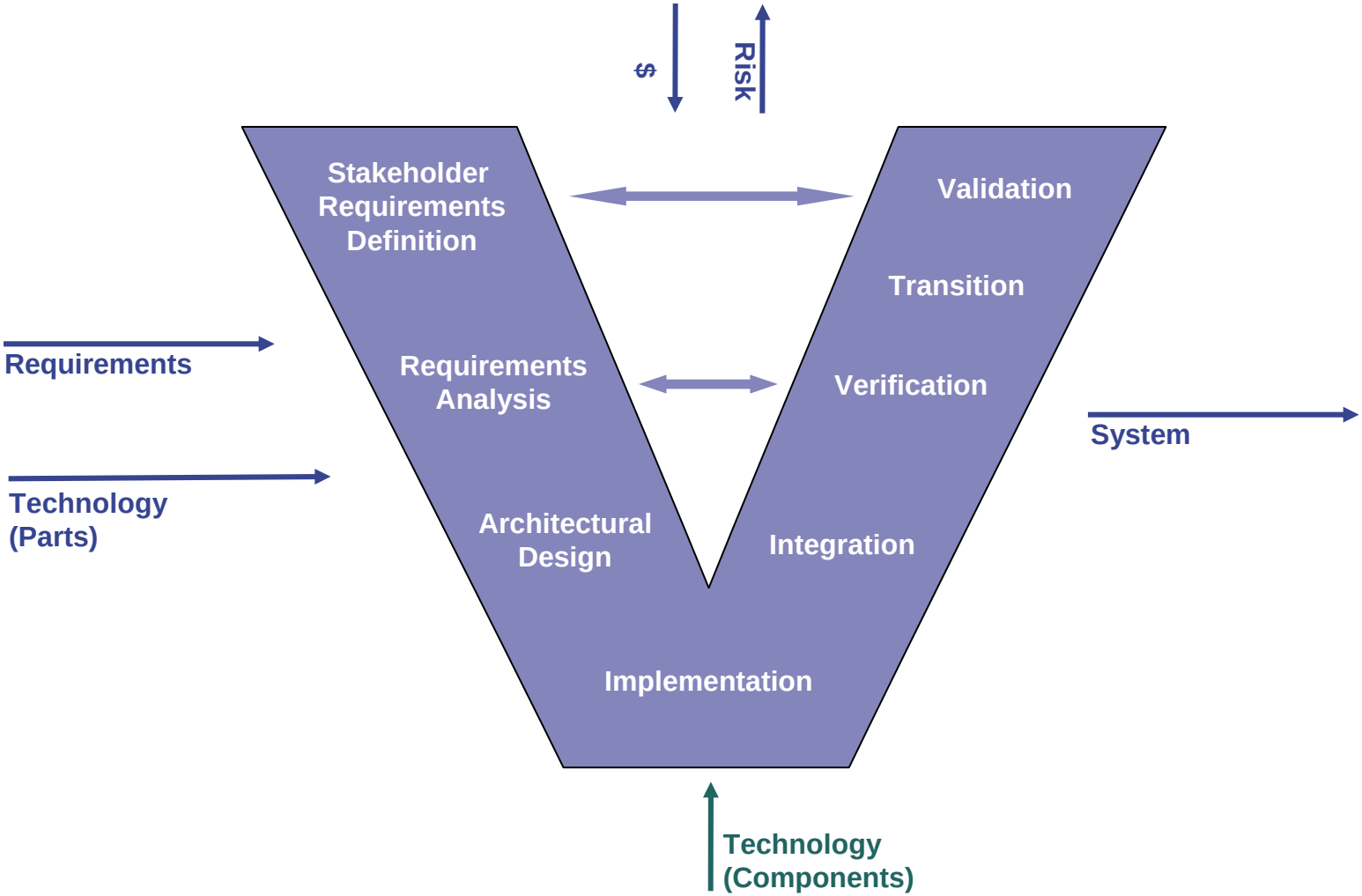
“Scope” of Process



SYSNOVATION
Systemic Innovation for Business Results

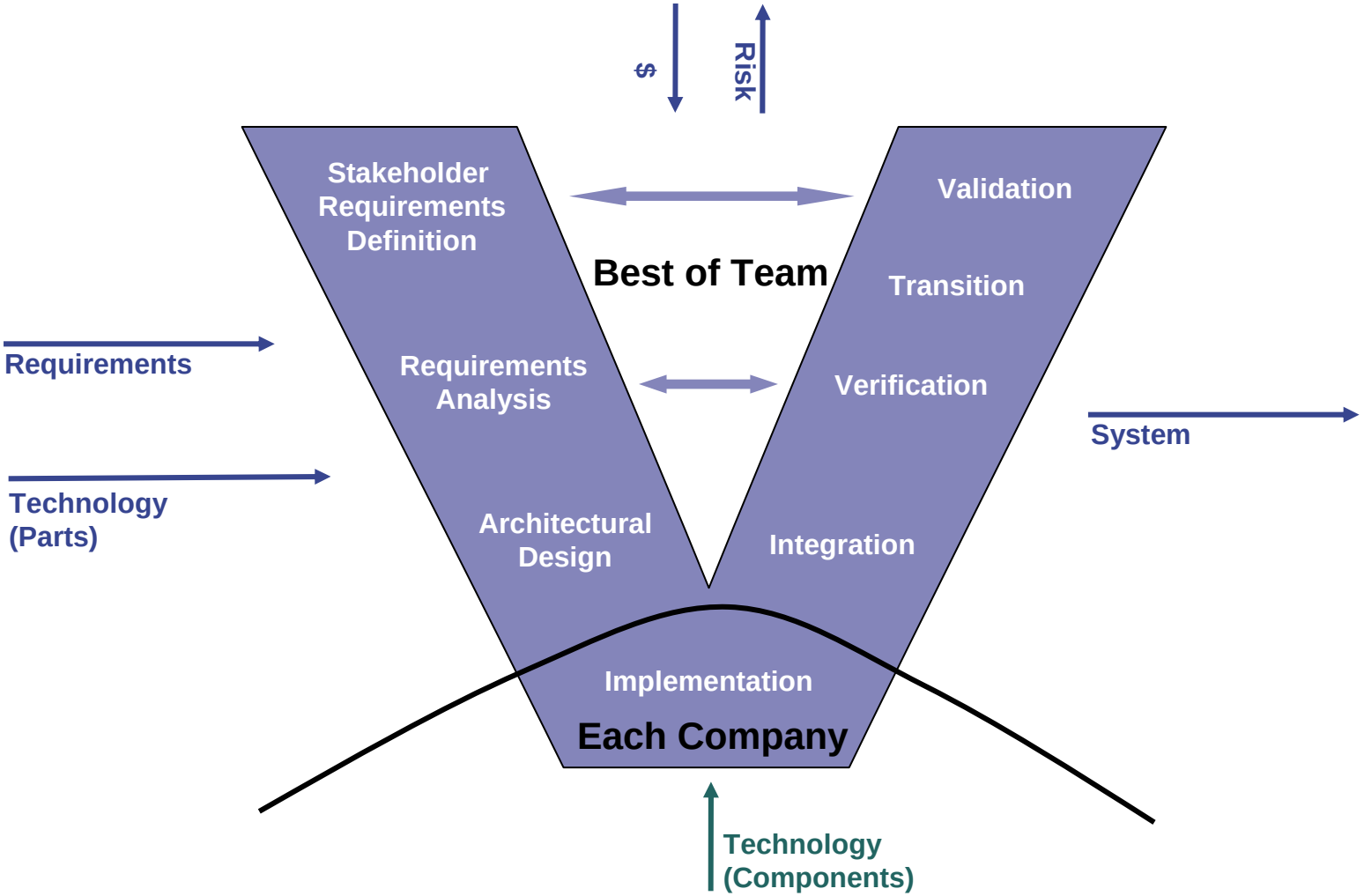
Source: Sysnovation Enterprise Process Framework (SEPF) ©2006 Sysnovation, LLC

The Development Process



Adapted from ISO/IEC 15288:2002

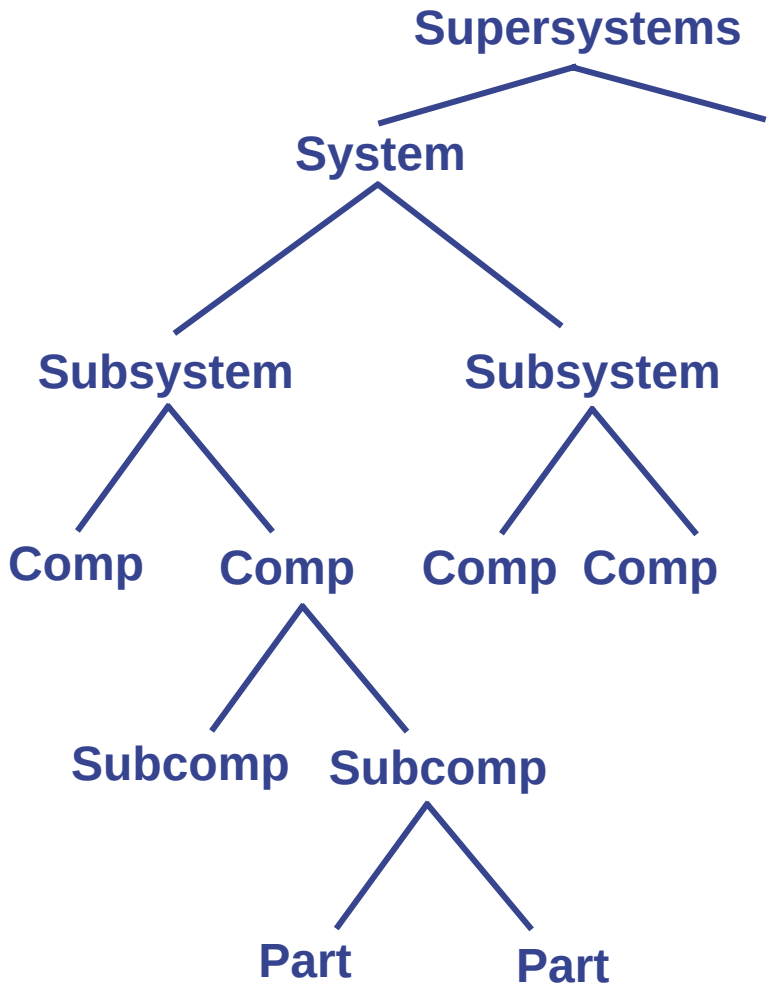
The Development Process



Adapted from ISO/IEC 15288:2002

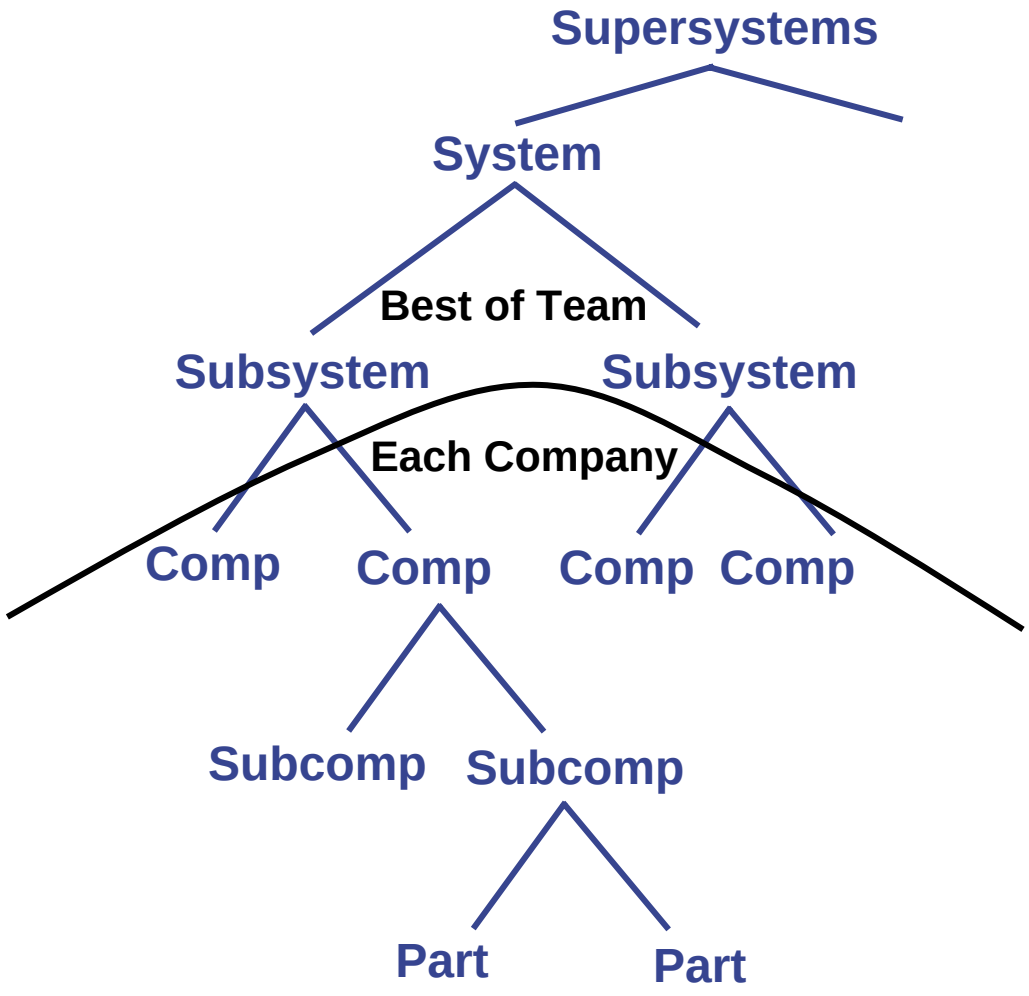
“Level” of Process

- Systems can be organized in a hierarchical manner
- Here is a typical hierarchical definition where the system is designed from:
  - supersystem (if applicable)
  - to system
  - to subsystems
  - to components
  - to subcomponents
  - to parts
- Typically, the system is integrated in the reverse order
- Of course there can also be special considerations such as legacy systems and COTS



Adapted from Kossiakoff & Sweet, 1998

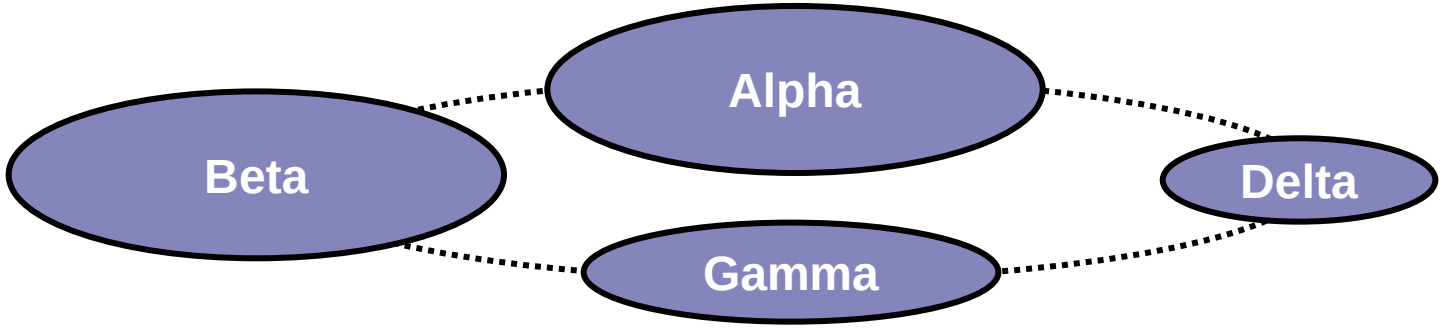
“Level” of Process



SYSNOVATION
Systemic Innovation for Business Results

Strength/Maturity/Role of Team

- Another key factor in picking BoT processes is what each teammate has to offer and what their role is on the team



- In our example
  - Alpha is the prime, but only CMMI Level 3, they have the lead on system design, likely they have solid project management and subcontracts processes as well
  - Beta is CMMI Level 5, so perhaps some of their quantitative measurement processes would be appropriate for BoT
  - Gamma is a SW house, so they are likely to have BoT SW practices (but the CMM Level 5 nature of them may not be “culturally acceptable” to Alpha and Beta)
  - Delta is a small outfit and is likely best left to its own processes, BoT should be minimized both ways

Organizational Implications

- Considerations include:
  - Process creation
  - Process accessibility/medium
  - Process training
  - Process measurement & effectiveness
  - Process improvement
  - Process “synchronization”
- All of these items require investment and resources
  - People
  - IT Infrastructure

BoT-Based Audits & Assessments

- For example:
  - ISO 9001:2000 audits
  - CMMI assessments
- Key decision:
  - Rely on individual company's evaluations
  - Perform audits & assessments on the "project" processes
- Each has its own set of challenges

Audits & Assessments: Individual Company

- Rationale:
  - Processes are core to each company
  - All companies have numerous projects
  - This project is just another example of tailoring
- Challenges
  - Translation/mapping of BoT processes to company processes
  - Training of the practitioners to communicate use the BoT processes to the evaluators
  - Dealing with the parts of the BoT processes that are done external to your company by your teammates

Audits & Assessments: Project Processes

- Rationale:
  - The BoT processes are unique to this project
  - One audit for the team vs. separate audits for each company
  - Customer may require it

- Challenges
  - May need to bid/budget for evaluations under project funds
  - Extra expenses for separate evaluations if individual organization will still be doing their own evaluations
  - How to define and sustain the project's "organizational" processes
    - Definition, improvement, measurement, evaluation (separate "Project EPG" required?)
    - Training
  - How to leverage this project in your other company evaluations

Topics

- Definitions and Key Concepts
- Examples of Multi-Organizational and Geographically Distributed Teams
- Our Hypothetical Teaming Scenario
- Strategies & Approaches
- Summary and Conclusions

Summary

- Many projects are utilizing multi-organization, geographically distributed teams
- Special considerations need to be made for determining what set of processes the team will be using.
- These decisions should be made based on the type, scope, and level of the processes and the relative strengths and weaknesses of each teammate.

Comments? Questions?



Sysnovation, LLC
13741 Johnson Memorial Drive
Shakopee, MN 55379
www.sysnovation.com

Copyright © 2006 Sysnovation, LLC

David D. Walden
Voice: 952-807-1388
Email: David.Walden@incose.org
AIM: daviddwalden

Air Force Institute of Technology

Educating the Leaders of America's Air Force

A Systems Engineering Approach To Integrated Structural Health Monitoring For Aging Aircraft

U.S. AIR FORCE

Advisors:

Maj Joerg Walter

Dr Som Soni

Capt Alan Albert

Capt Stephen Leggiero

Maj Kimberly Tooman

Capt (HAF) Efstathios Antoniou

Capt Ramon Veglio

Integrity - Service - Excellence

25 October 2006

Disclaimer

The views expressed are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, United States Government, the corresponding agencies of any other government, NATO or any other defense organization.

Agenda

- Problem Background
- Systems Engineering Process
- Benefit Analysis:
  - Modeling
  - Simulation
- Conclusions

Background

- Thesis Proposal
  - SAF/IA – ISHMS Aging Aircraft
    - Constrained budgets for new aircraft…aircraft fleets getting older & increasing maintenance costs
  - Initial ISHMS Goals
    - Extend service life, maintain SOF, & reduce maintenance burden
      - Reduce time to inspect
      - Reduce amount of inspection items
      - Increase time between inspections
      - Cost (cheaper), schedule (faster), performance (better)

Purpose Statement

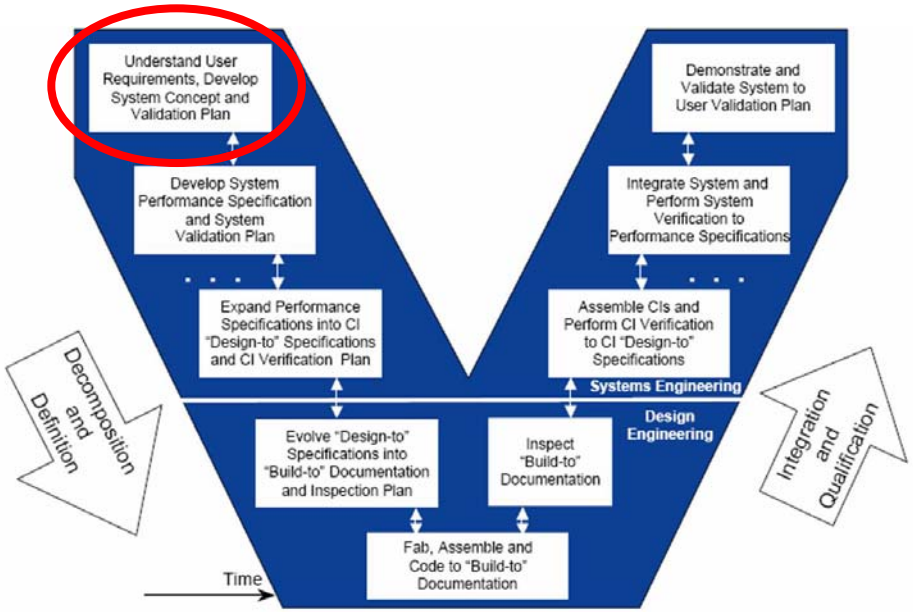
- Purpose Statement – Two-Fold
  - To provide an SE process to help identify the top-level operational concept and stakeholder requirements of an ISHMS for a generic aging aircraft
  - To perform a preliminary analysis to demonstrate the potential benefit of developing an ISHMS for aging aircraft

Stakeholders' Perspective and Operational Concept

- Life-cycle Phases
- Identify Stakeholders
- Operational Concept Definition
  - Stakeholders' vision
  - Scenarios for each life-cycle phase

Seven-Step Process

- Step 1: Develop Operational Concept
- Step 2: Define System Boundary With External Systems
- Step 3: Develop Weighted Objectives Hierarchy
- Step 4: Develop, Analyze And Refine Requirements
- Step 5: Ensure Requirements Feasibility
- Step 6: Define Qualification System Requirements
- Step 7: Obtain Approval Of Requirements

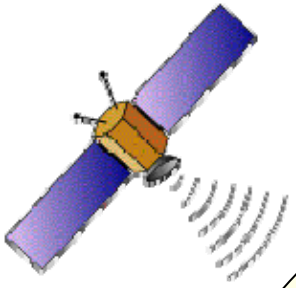


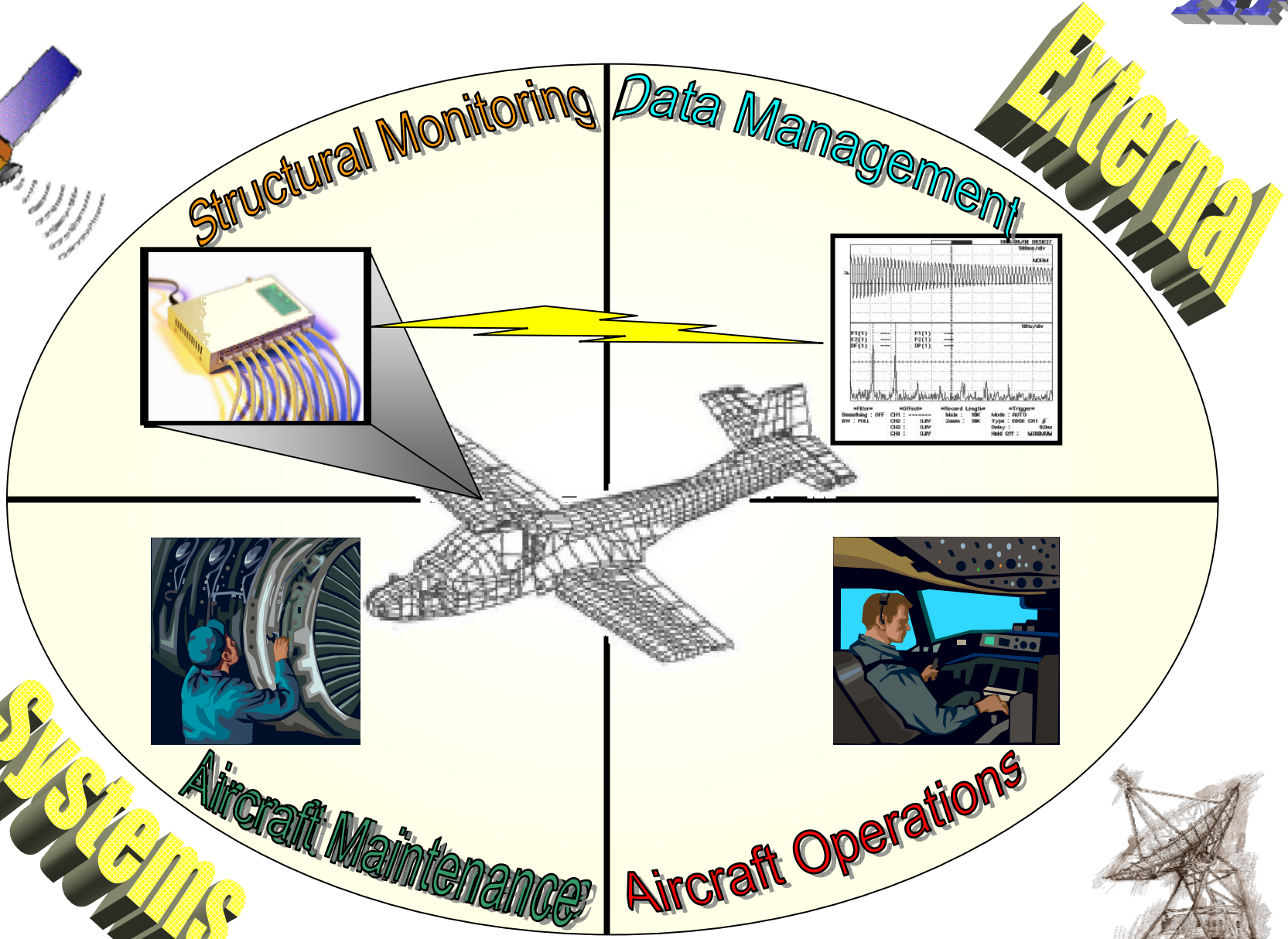
DoDAF
Architecture Building Process

- DoDAF Provides Architecture Guidelines
  - Six-step Architecture Building Process

1. **Determine the intended use of the architecture**
2. **Determine the scope of the architecture**
3. **Determine characteristics to be captured**
4. **Determine views and products to be built**
5. **Gather data and build the requisite products**
6. **Use architecture for intended purpose**

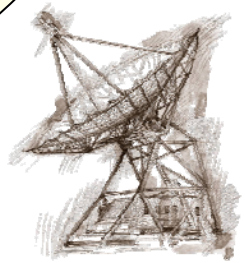
High-level Operational Concept





Systems

Aerospace



Stakeholders' Vision

- Engineers
  - Must deal with aging A-37 problem
  - Must decide whether to *retire* A-37 aircraft or *extend* their life
  - If an extension is decided:
    - How it will be accomplished?
    - How long the extension will be?

- Engineers' Vision of ISHMS
  - Real-time *recording* of aircraft usage (*loading*) data
  - Real-time *damage monitoring*
  - On-board and ground station *analysis of recorded data*
  - Assessment of A-37 condition
  - Predict *remaining useful life* of structure
  - Development of *customized maintenance schedule*
  - High reliability

Their goal is to make decisions on A-37's *life extension and maintenance policy*

Stakeholders' Vision

- HQ Maintainers
  - Must find a solution to the following problems:
    - Increased downtime
    - Reduced number of operational aircraft
    - Extensive inspections and repairs
    - Inspections consume more resources (facilities, equipment, personnel) than provisioned
    - Maintainers at base and squadron levels not able to provide on time mission ready aircraft
- Maintainers' Vision Of ISHMS
  - *Record actual usage* of the aircraft
  - *Monitor* structural *damages*
  - Allow inspections/repairs to be conducted *only* on the problem areas of the aircraft
  - *Reduce* amount of teardown and overall maintenance effort
  - Inspections performed *when required*, not according to a predetermined schedule (which *may not reflect* true condition of aircraft)

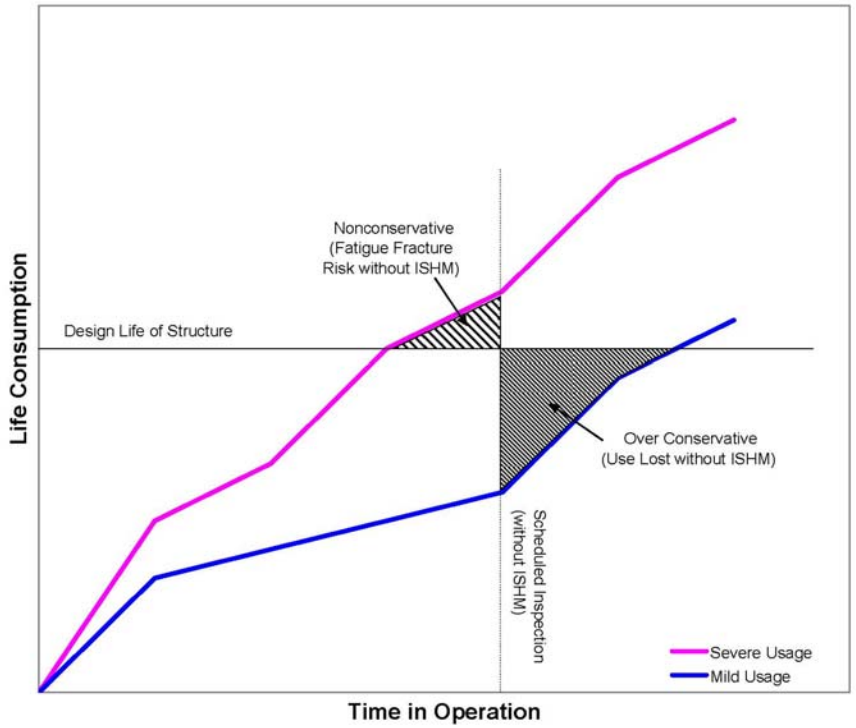
Their goal is to have more *efficient use of resources* at Base and Squadron levels

Assumptions

- The ISHMS will maintain or increase the Safety of Flight
- Maintenance history data available to determine FCLs
- Sensor technology available to monitor all of the FCLs
- Sensor data capture possible for all FCLs
- Installation of the sensors on the FCLs will not cause damage
- ISHMS data can be downloaded and analyzed

Background/Purpose

Vision: *CAF needed an integrated system that reduces the cost of safely operating Cessna A-37 legacy aircraft beyond design safe life*

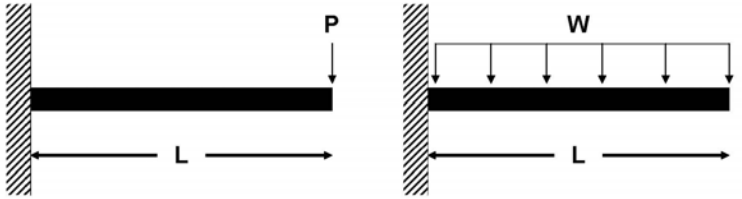


- Periodic Inspection Intervals Are Based On Estimates Of Fatigue Crack Growth At FCLs
- Safety/Cost Impacted If Inspection Schedule Not Accurate
- ISHMS Optimizes Inspection/Repair Cycles…max Safety & Min Cost

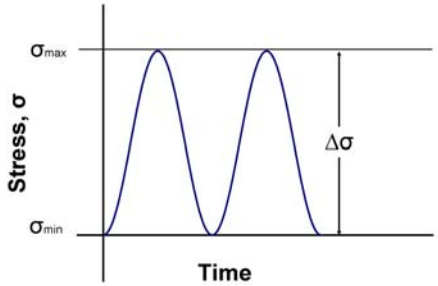
Estimate Cost/Safety Benefit Of ISHMS On Single FCL

Mech Theory

- Loading…Stress



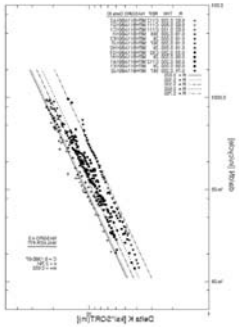
- Stress Amplitude…Fatigue



- Fatigue…Crack Growth Rate

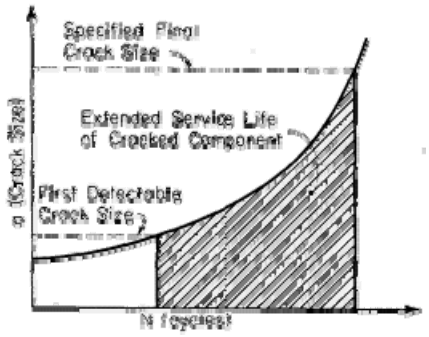
$$\frac{da}{dN} = C\left(\frac{\Delta K}{(1-R)^{1-m}}\right)^{n}$$

1 $\Delta K = K_{max} - K_{min} = f(g)\cdot\Delta\sigma\cdot\sqrt{\pi a}$



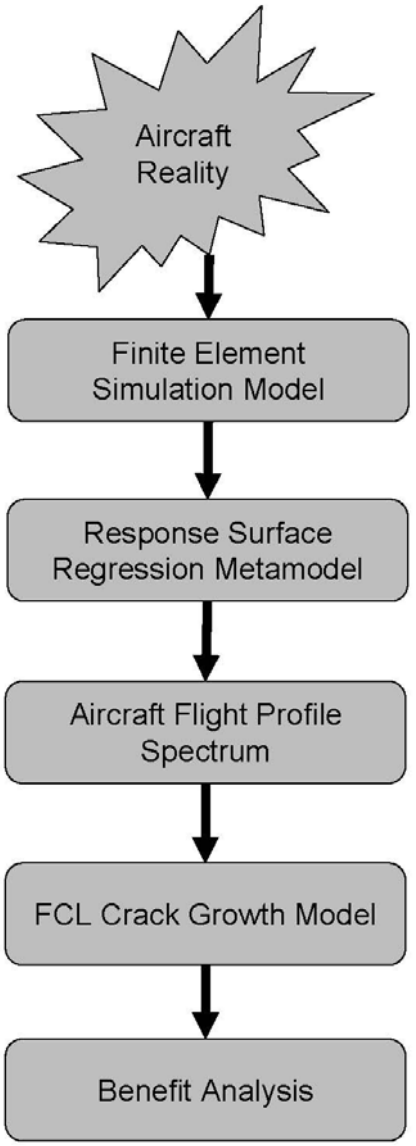
- Rate…Cycles Until Failure

2 $N_f = \int_{a_i}^{a_f} \frac{da}{C(\Delta K)^n}$



Design Objectives

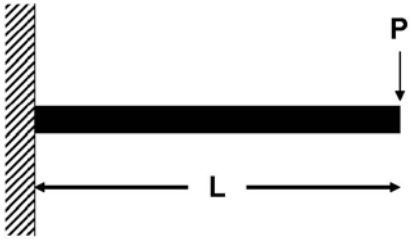
- Understand Aircraft Reality FCLs
- Create FE Simulation Model
- Create FCL Max Stress Response Surface Metamodel
- Calculate Max Stress And Critical Crack Length
- Calculate Delta Stress Per Flight Hour Cycle (pfhc)
- Delta Stress pfhc And Critical Crack Length Into Walker
- Estimate ISHMS Benefit Using Walker Crack Model

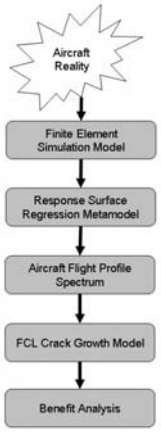


Find delta stress per flight hour cycle…

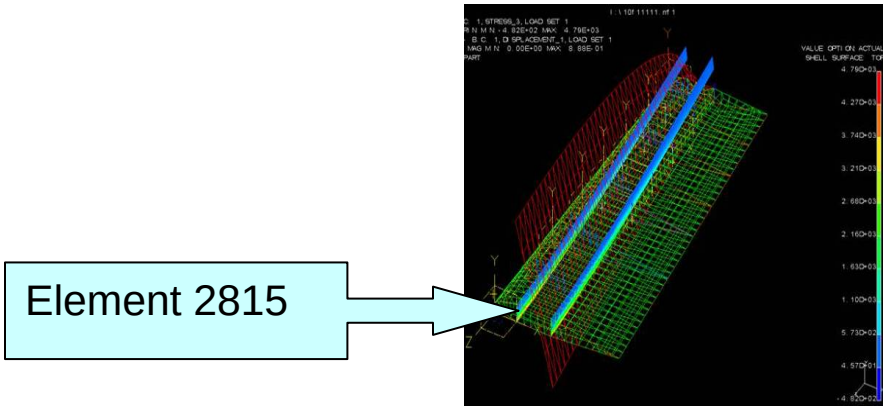
Boundary Conditions

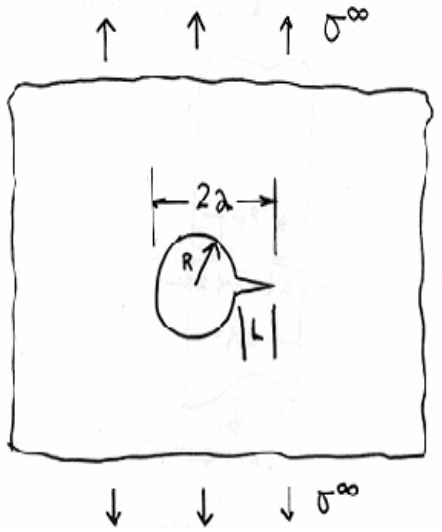
- Cantilever (Fixed-Free)
  - Clamped (BCs…x,y,z=0)





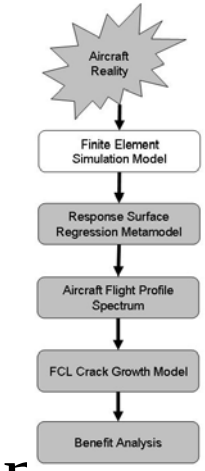
- Fatigue Critical Location
  - Front Spar Wing Attach Fitting
  - Crack growth geometry…hole with edge crack

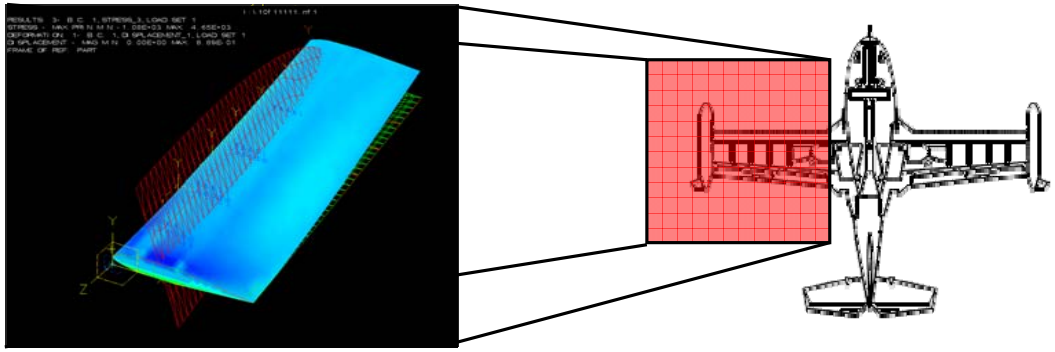


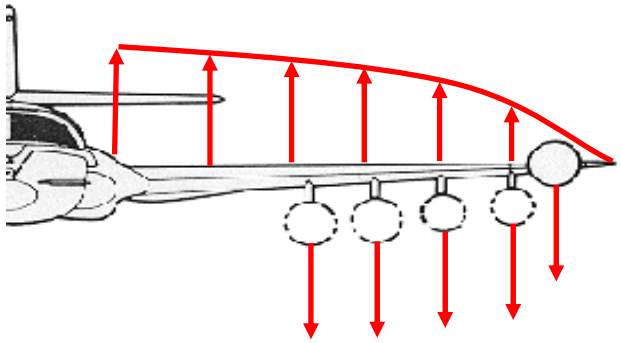


Simplifying Assumptions

- Half-wing Model
- Simplified Spar Geometry (No Spar Caps)
- Interior Ribs Not Meshed (Stitching)
- Skin And Spars Both 7075-T6 (Verification)
- Elliptical Lift Distribution And Pressure Distribution
- Lift Loading Isolated To Wing Box

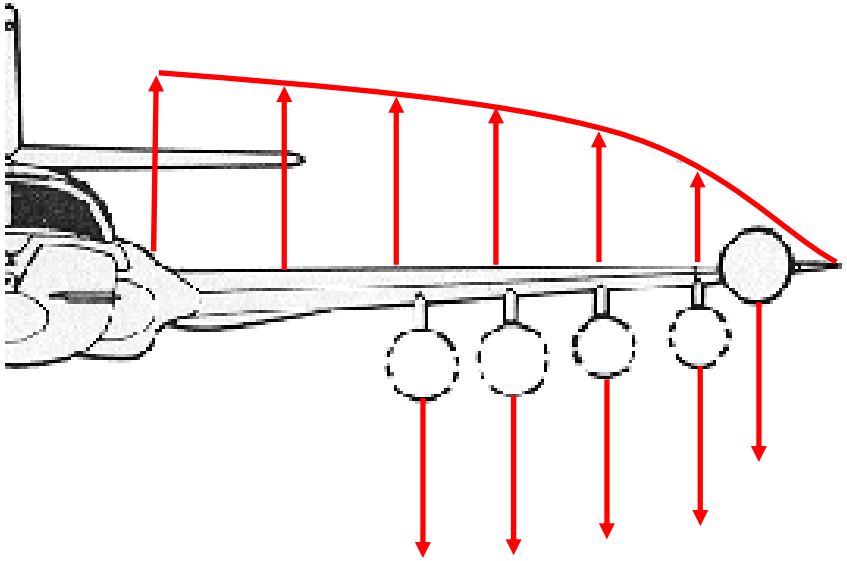




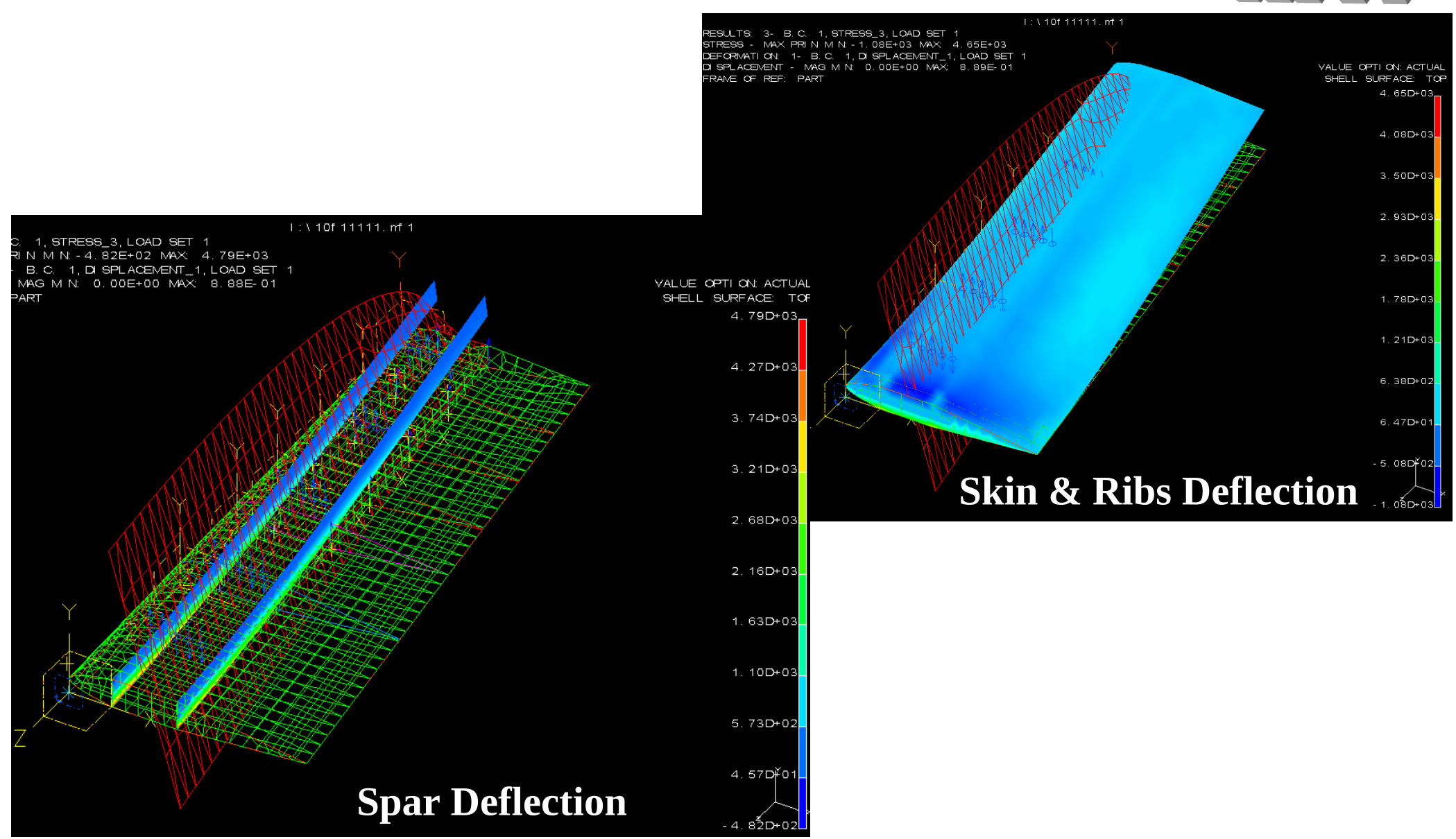


Loading Conditions

- Point Weapon Loads
- Distributed SLUF 1-g Lift Load

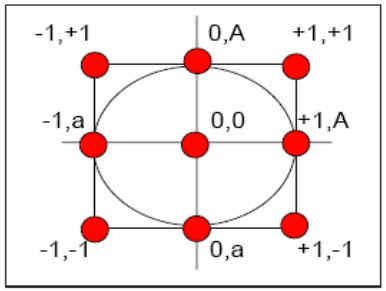


Loading Conditions

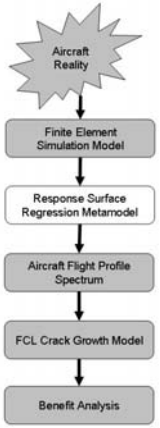


Stress Response Surface

- Constructed A Central Composite Design For Front Spar Wing Attach Fitting
  - Generated orthogonal fractional factorial design to min confounding
  - Determined design factor input ranges

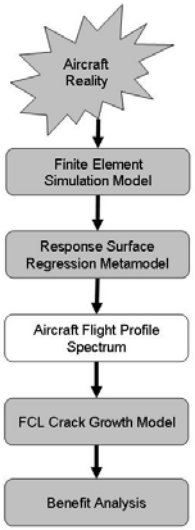


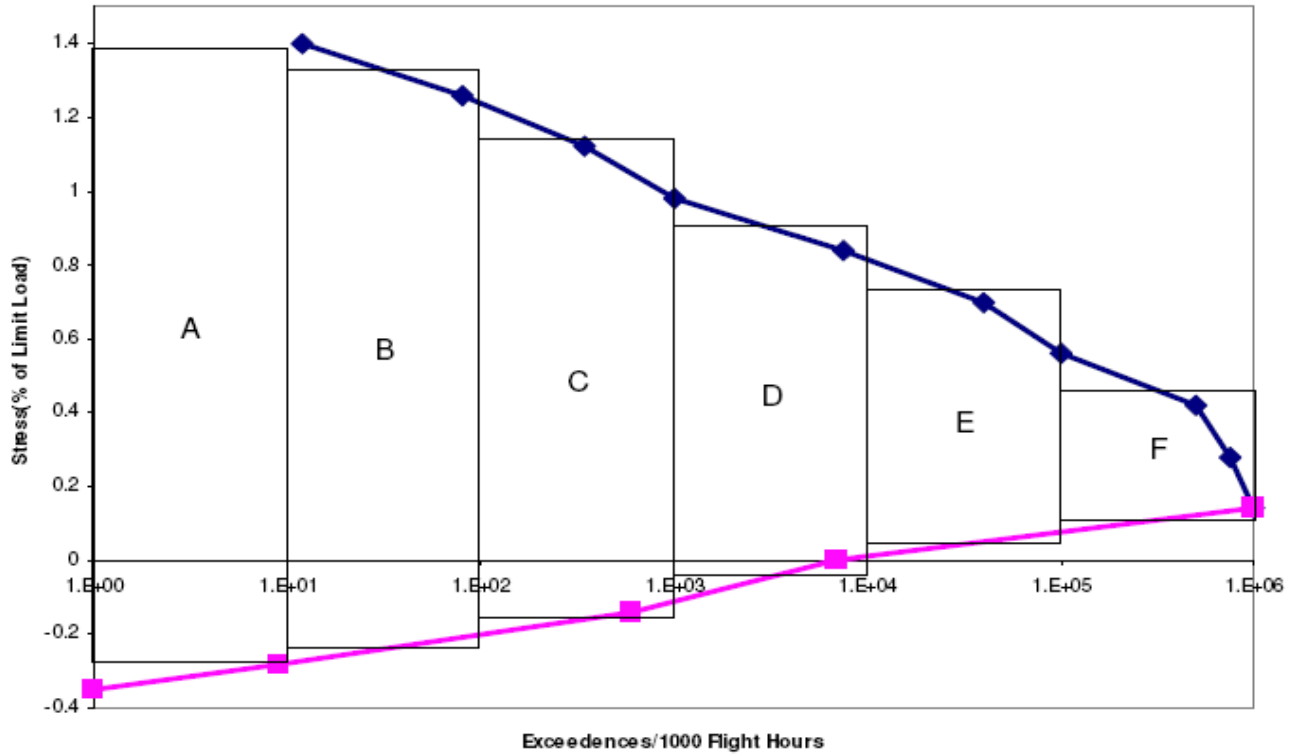
Simulation Number	CCD Pattern	X1	X2	X3	X4	X5	Y
1	- - - - -	-1	-1	-1	-1	-1	2907
2	- - - + +	-1	-1	-1	1	1	4569
3	- - + - +	-1	-1	1	-1	1	3679
4	- - + + -	-1	-1	1	1	-1	1805
5	- + - - +	-1	1	-1	-1	1	2765
6	- + - + -	-1	1	-1	1	-1	1993
7	- + + - -	-1	1	1	-1	-1	2018
8	- + + + +	-1	1	1	1	1	4569
9	+ - - - +	1	-1	-1	-1	1	2515
10	+ - - + -	1	-1	-1	1	-1	1773
11	+ - + - -	1	-1	1	-1	-1	3459
12	+ - + + +	1	-1	1	1	1	4348
13	+ + - - -	1	1	-1	-1	-1	1986
14	+ + - + +	1	1	-1	1	1	4536
15	+ + + - +	1	1	1	-1	1	4561
16	+ + + + -	1	1	1	1	-1	3789
17	a 0 0 0 0	-1	0	0	0	0	2285
18	A 0 0 0 0	1	0	0	0	0	3167
19	0 a 0 0 0	0	-1	0	0	0	2175
20	0 A 0 0 0	0	1	0	0	0	3277
21	0 0 a 0 0	0	0	-1	0	0	2269
22	0 0 A 0 0	0	0	1	0	0	3183
23	0 0 0 a 0	0	0	0	-1	0	2281
24	0 0 0 A 0	0	0	0	1	0	3171
25	0 0 0 0 a	0	0	0	0	-1	1895
26	0 0 0 0 A	0	0	0	0	1	3557
27	0 0 0 0 0	0	0	0	0	0	2726
28	0 0 0 0 0	0	0	0	0	0	2726



Fighter Stress Sequence

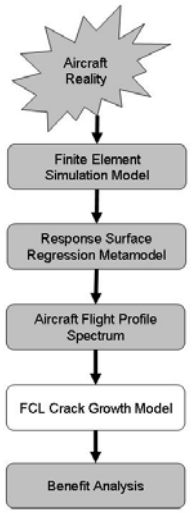
- Weighted General Fighter Stress Sequence
  - Missions
  - Weighted average effect on stress by # of missions





Analysis

- Front Spar Wing Attach Fitting Findings:
  - 20,152 psi stress per 100 cycles per flight hour
  - 0.4781 inches critical crack length





Simulation Introduction

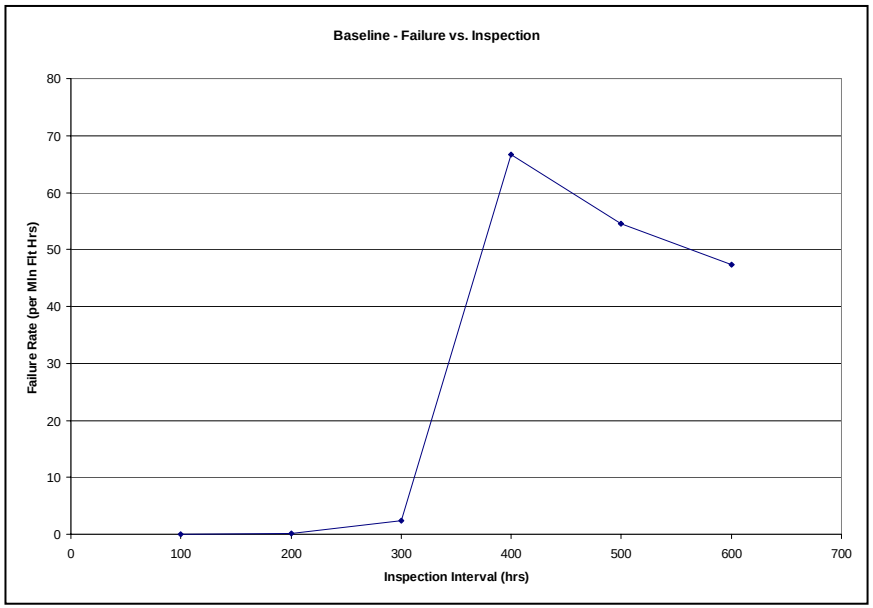
- Simple Mathematical Models
  - Simulating crack growth over 5000 flight hours
  - Single crack in a single fatigue critical location
- Assumed Damage Monitoring Concept
- Primary Variable - Time Between Scheduled Inspections

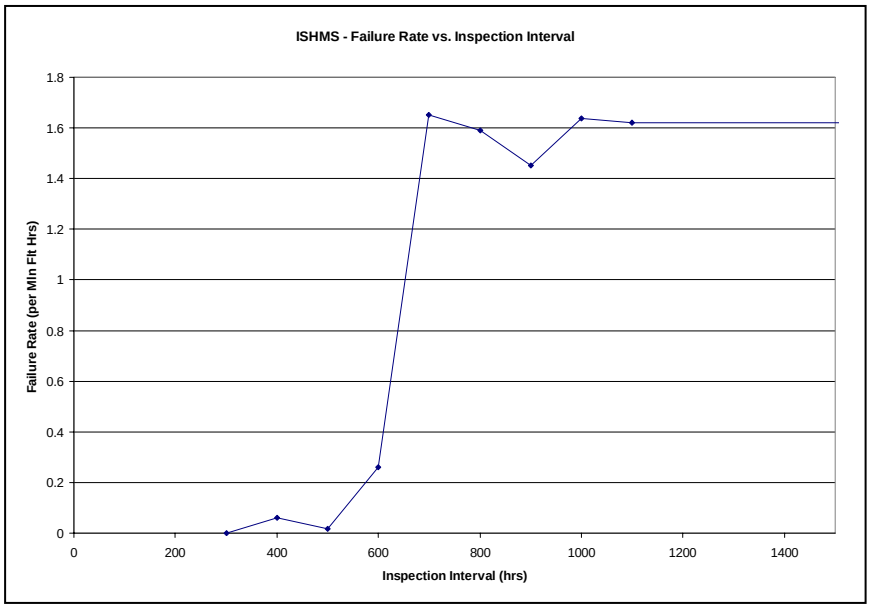
Benefit analysis to quantify the cost and safety benefits of an ISHMS installed on an aged A-37 aircraft *as compared to* the status quo using simple models

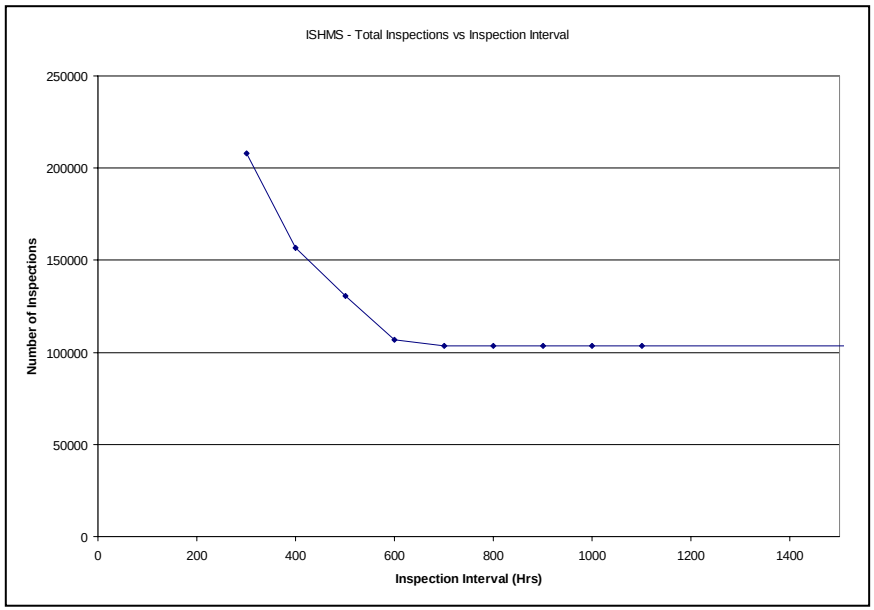
Simulation Methodology

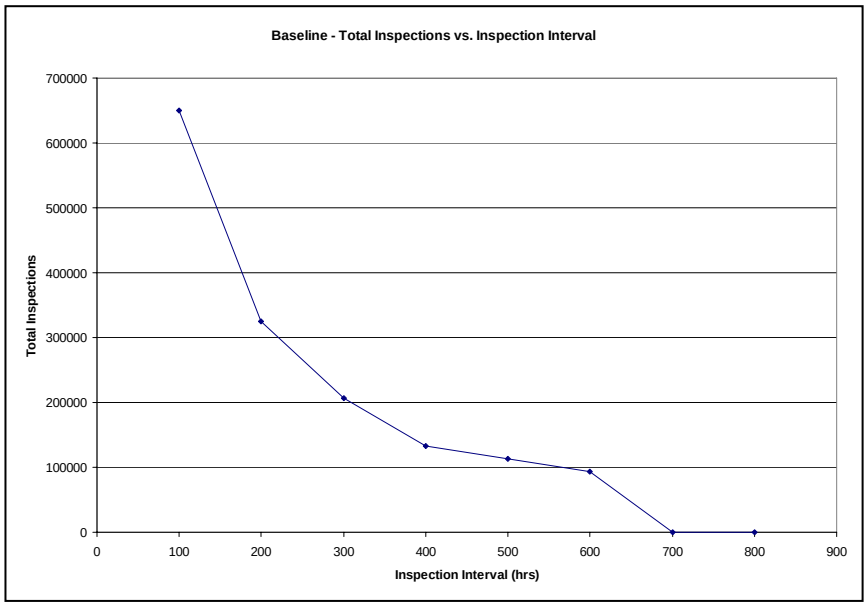
- Benefit
  - Failure rate per million flight hours (safety)
  - Total number of inspections (cost)
- Simulate Baseline (No ISHMS)
  - Check model
  - Establish benchmark for comparison to ISHMS
- Simulate With ISHMS
  - Began at 300 flight-hour interval
  - Increased interval
  - Compared results with Baseline (percentages)
- Sensitivity Analysis For Maintenance Probability Of Detection

Results

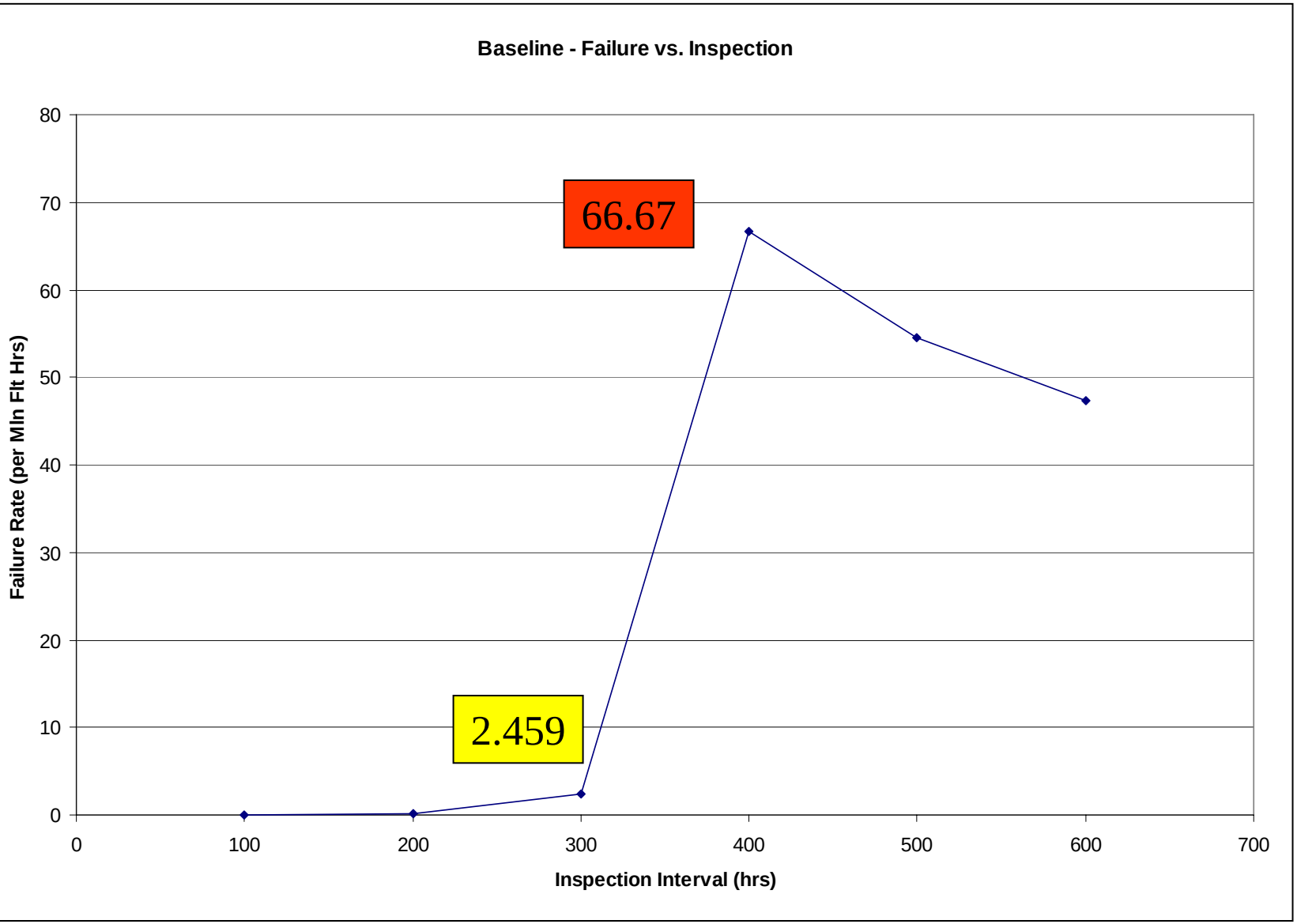

Baseline - Failure vs. Inspection
Failure Rate (per Mln Flt Hrs)
Inspection Interval (hrs)
0
10
20
30
40
50
60
70
80
0
100
200
300
400
500
600
700


ISHMS - Failure Rate vs. Inspection Interval
Failure Rate (per Mln Flt Hrs)
Inspection Interval (hrs)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
1200
1400

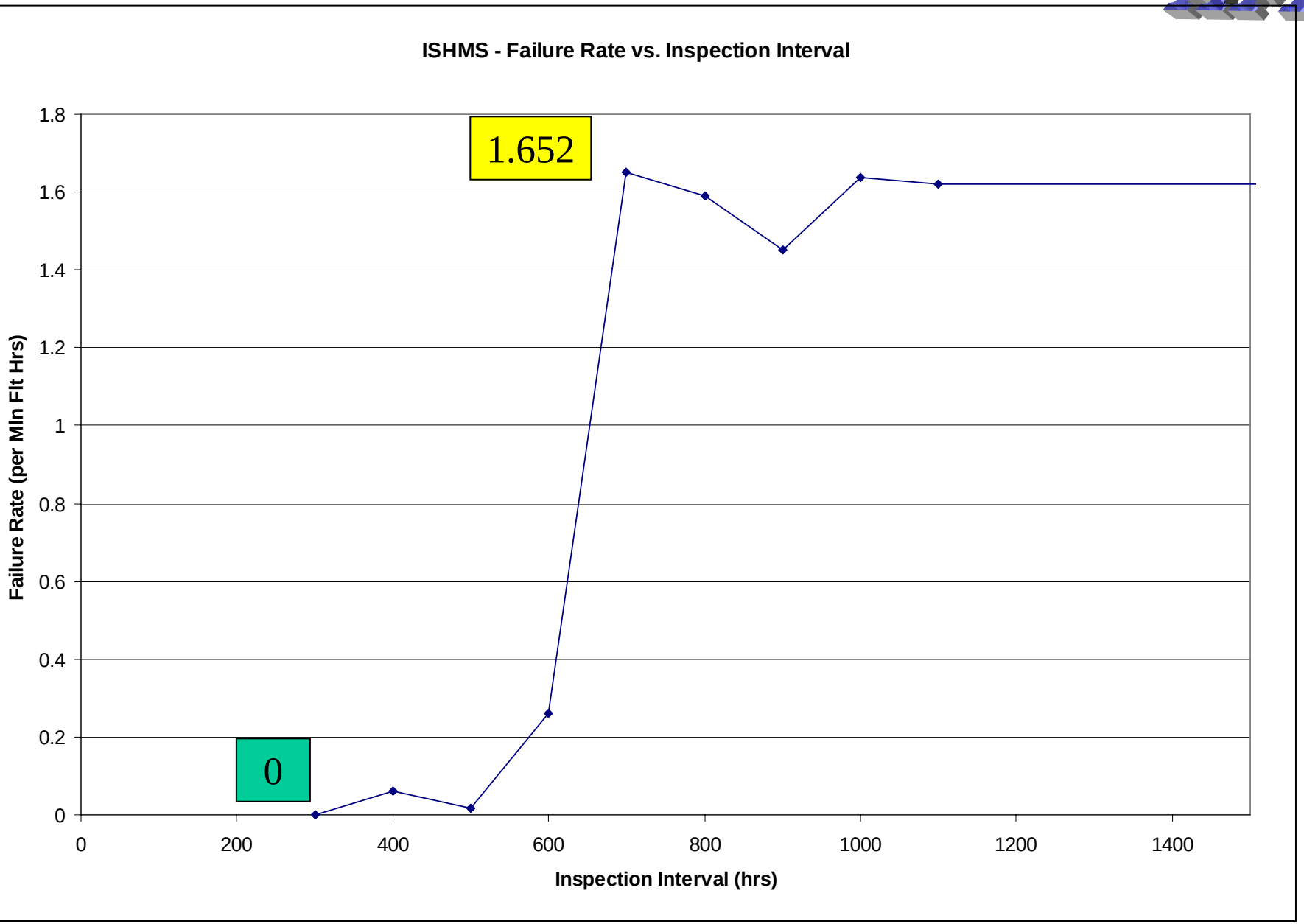

ISHMS - Total Inspections vs Inspection Interval
Number of Inspections
Inspection Interval (Hrs)
0
50000
100000
150000
200000
250000
0
200
400
600
800
1000
1200
1400


Baseline - Total Inspections vs. Inspection Interval
Total Inspections
Inspection Interval (hrs)
0
100000
200000
300000
400000
500000
600000
700000
0
100
200
300
400
500
600
700
800
900

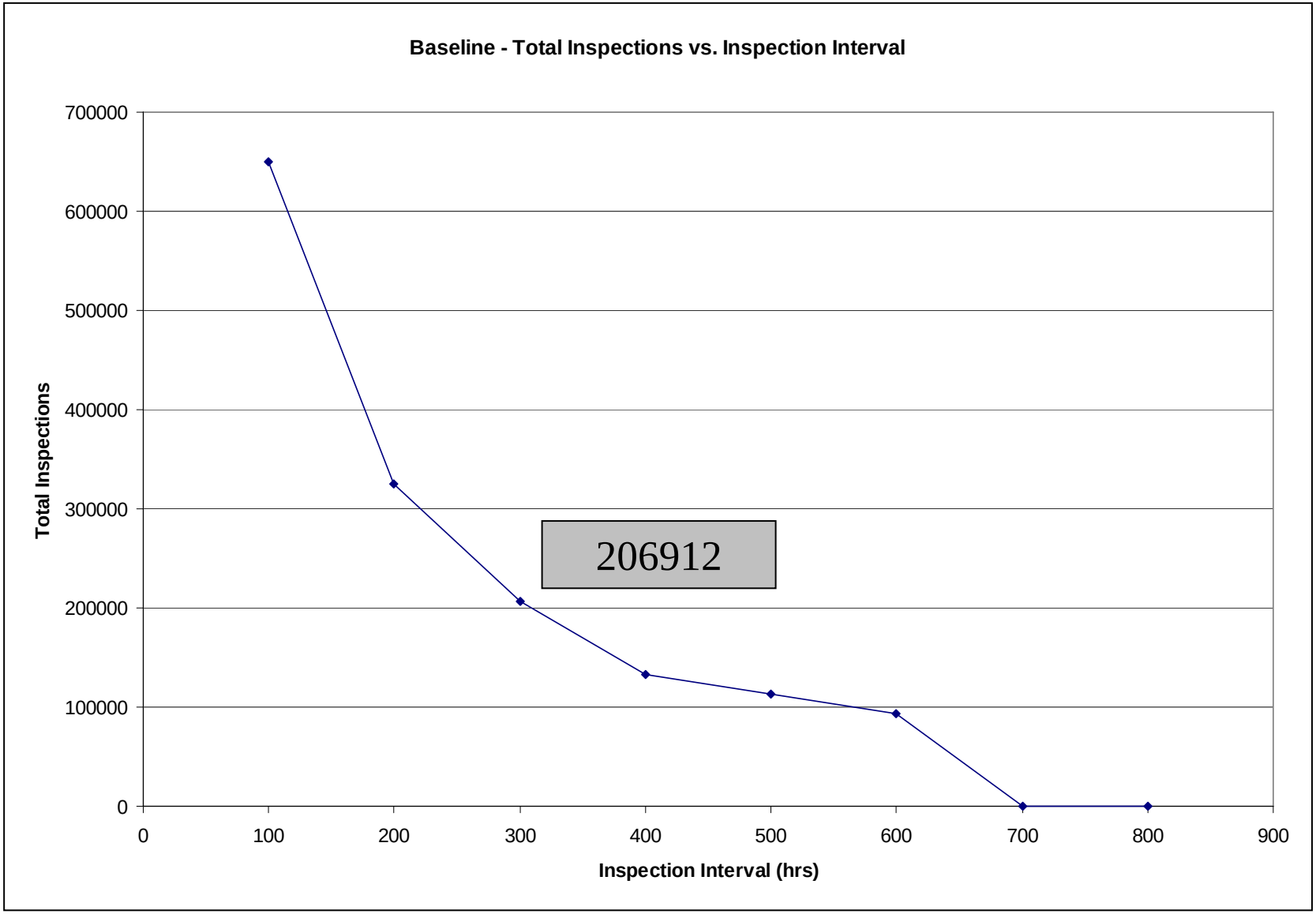
Baseline – Failure Rate



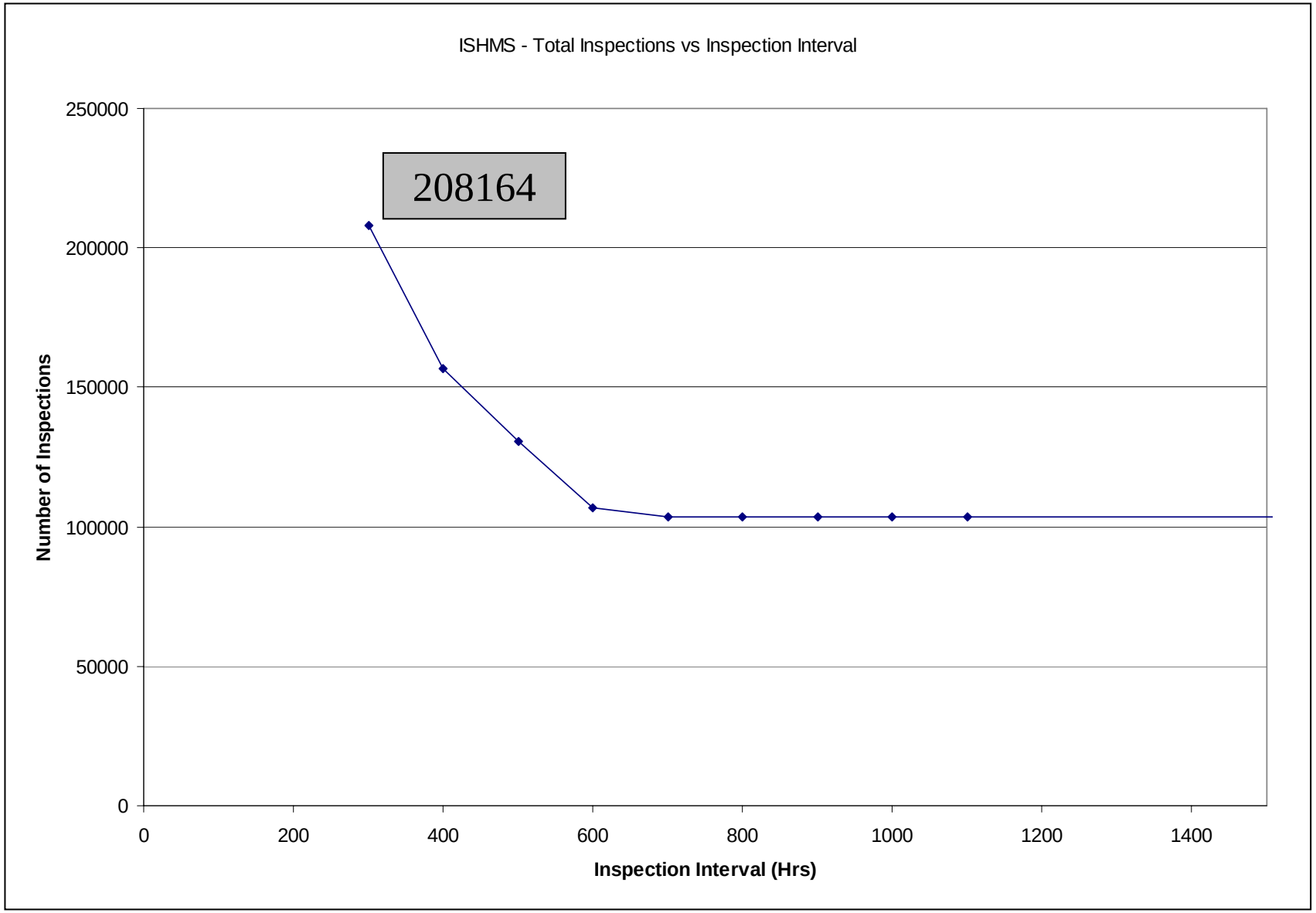
ISHMS – Failure Rate



Baseline - Inspections



ISHMS - Inspections



Simulation Results

- ISHMS Interval Selection
  - Failure rate closest to Baseline at 300 flight hours, but no worse than
  - User would ultimately choose
- Comparative Results
  - ISHMS - 700 flight hours inspection interval
  - Failure rate 32.8% lower (safety)
  - 49.8% Inspection Reduction (cost)
- Sensitivity Analysis
  - As probability of baseline crack detection increased, safety benefit decreased
  - Cost benefit stay relatively unchanged

Thesis Conclusions

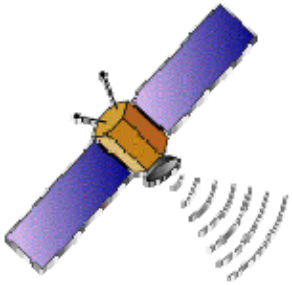
- Systems Engineering Process
  - Defining purpose sets the direction
  - Operational Concept is critical
  - Involved user is key
  - Requirements are cornerstone
  - Architectures tie it all together
- Benefit Analysis
  - ISHMS looks promising; need to define its use and design to optimize benefit

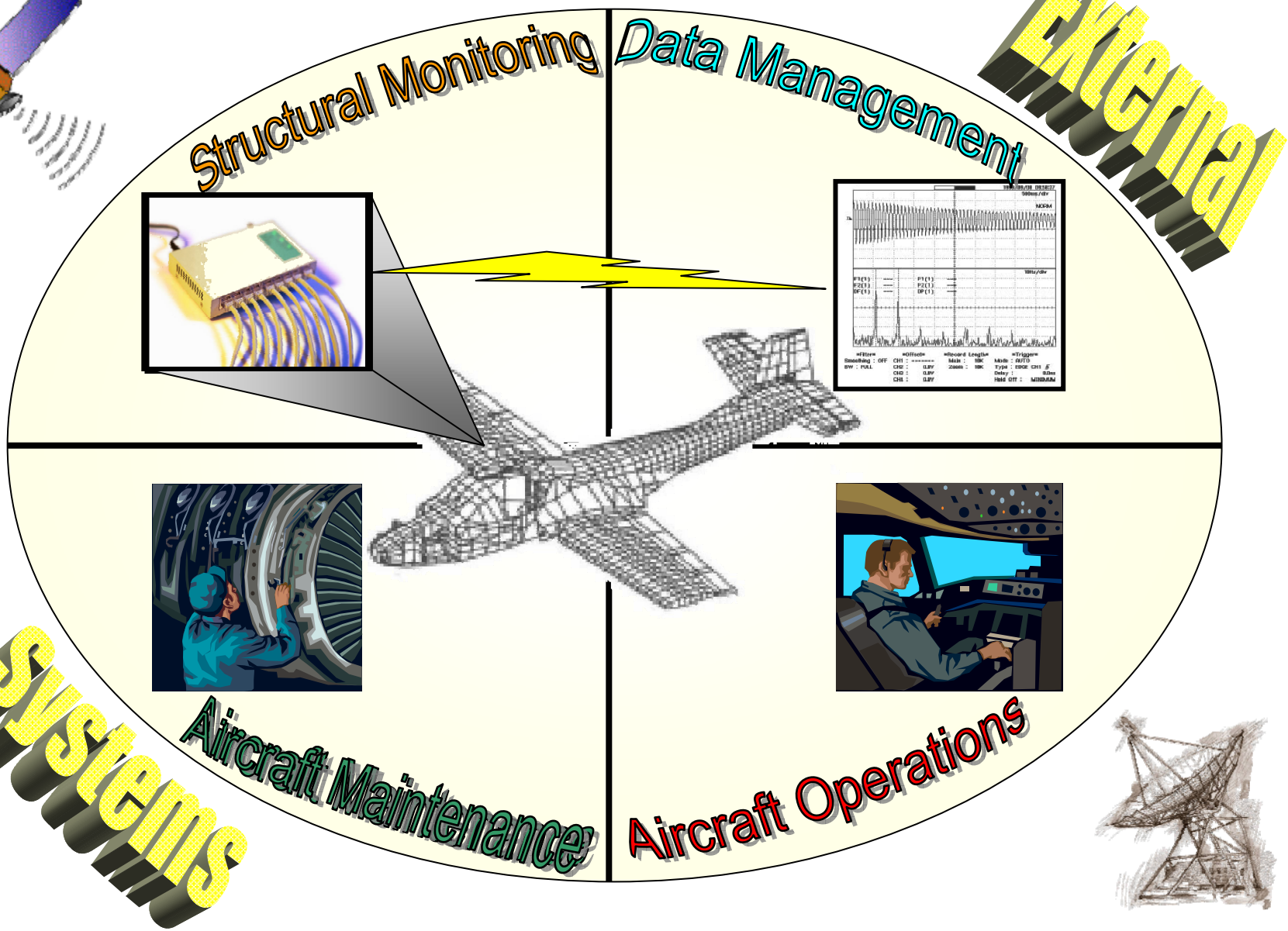
Starting off point for future efforts in the structural health monitoring field

Summary

- Problem Background
- Systems Engineering Process
- Benefit Analysis:
  - Modeling
  - Simulation
- Conclusions

Questions?




Structural Monitoring
Data Management
Aircraft Maintenance
Aircraft Operations
Extend
Systems

Airborne Warning and Control Systems Program Office

Integrity - Service - Excellence



Lessons Learned from a Mature DMSMS Program

9th Annual Systems Engineering Conference

U.S. AIR FORCE

SQNLDR P.D.Weeding
3 Eglin Street, Building 1612
Hanscom AFB, MA 01731
DSN 478-7714
Commercial (781)-377-7714
Fax (781)-377-1069

U.S. AIR FORCE

Overview



- **Scope of Effort**
- **DMSMS Goals**
- **Lessons Learned**
- **Summary**

U.S. AIR FORCE

Fleet Facts



- **Design:** **Modified Boeing 707/320**
- **Function:** **Airborne surveillance, command, control and communications (*High Demand*)**
- **Fleet Size:** **33 Aircraft (*Low Density - Small Fleet*)**
- **Age:** **30 years old**
- **Annual Hours:** **18,000**
- **Service Life:** **Extended to 2035+**
- **Community Partners:** **NATO 17, United Kingdom 7, Saudi Arabia 5, France 4, and Japan 4 Boeing 767 Aircraft**

U.S. AIR FORCE

Vision and Mission

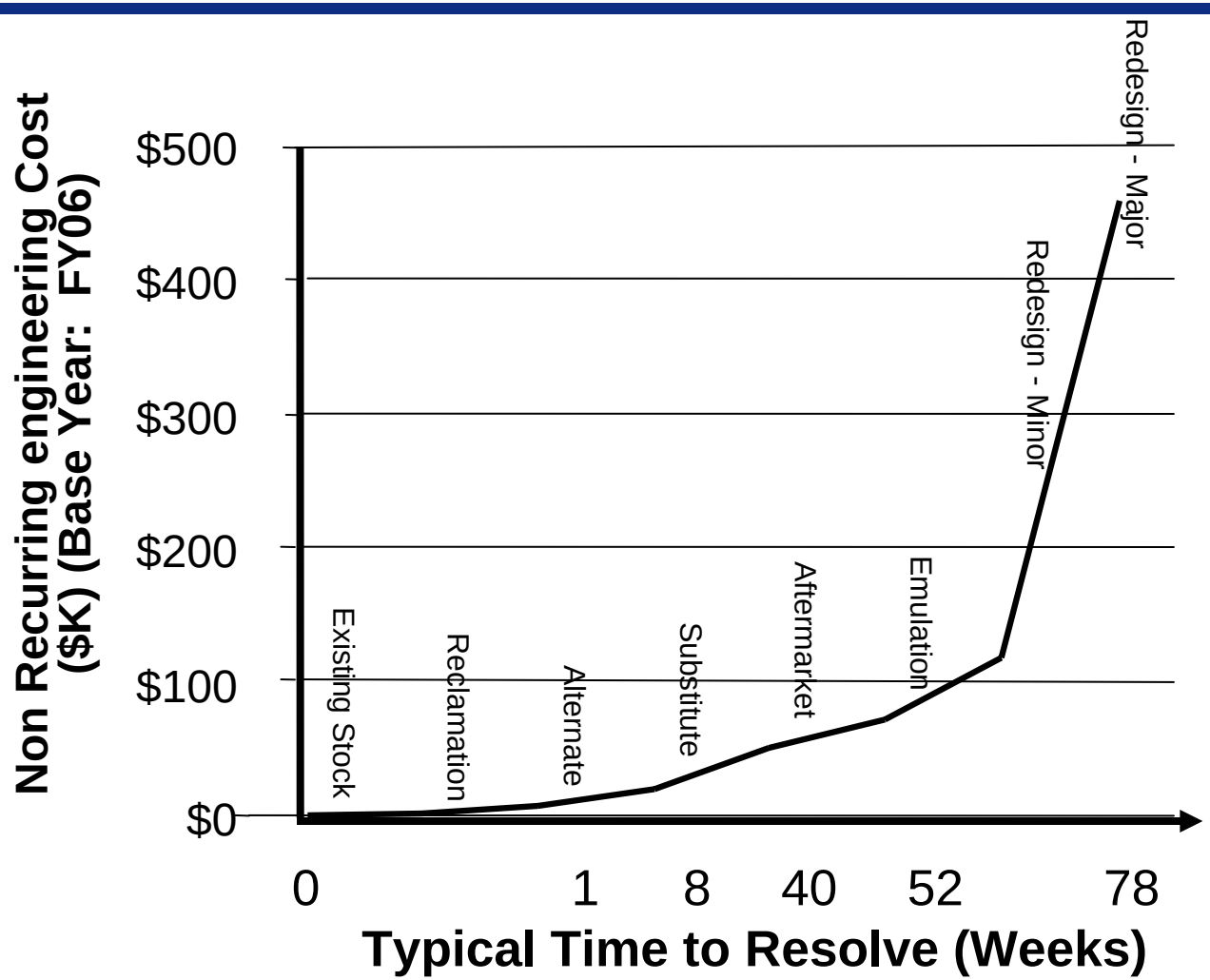


- **Vision - “To never have an AWACS E-3 become mission incapable due to the impact of DMSMS”**
- **Mission - “To develop and implement an integrated proactive DMSMS program in support of the AWACS Program Office”**
- **Goal - “Drive down Total Ownership Costs”**

U.S. AIR FORCE

"Theoretical" Solutions – Cost and Time





Data Source: DMEA Cost Metrics

U.S. AIR FORCE

Impact to AWACS



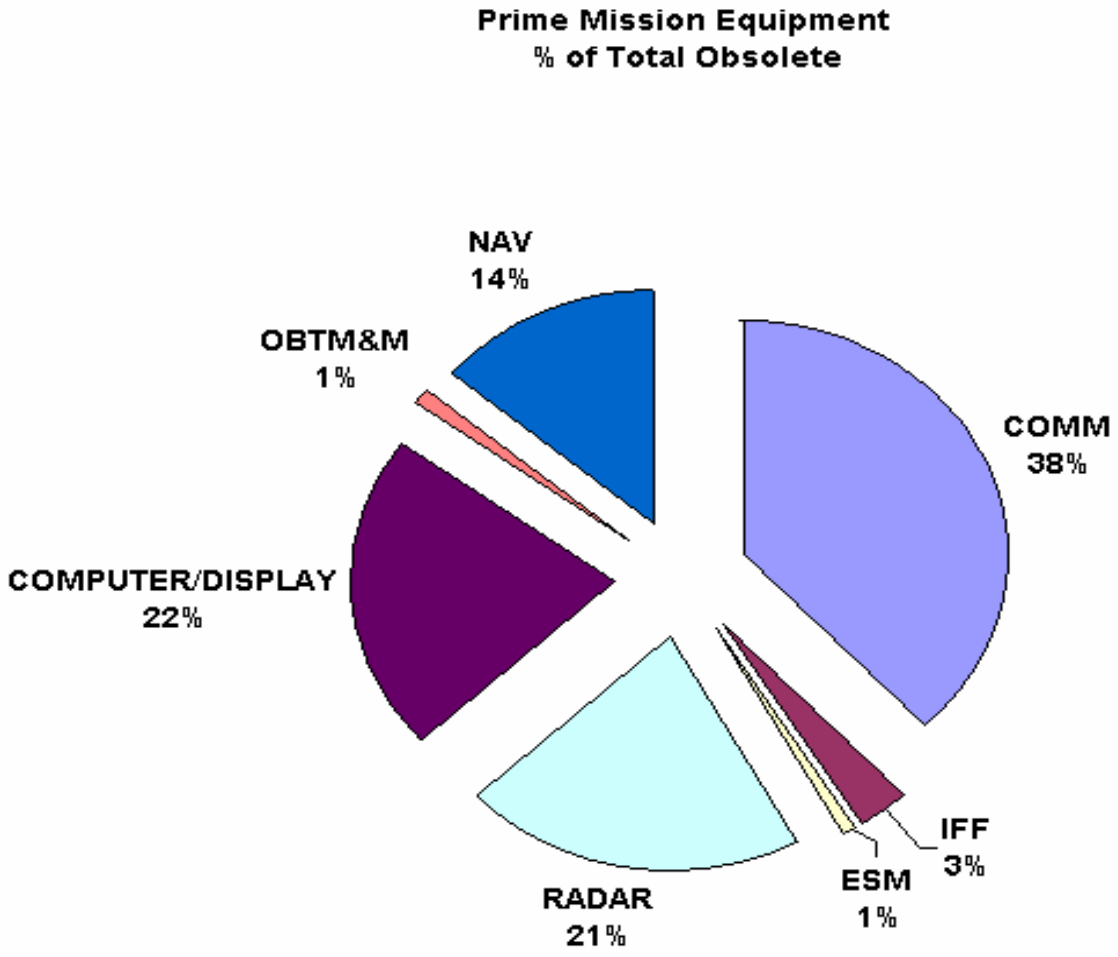
DMSMS Impacts all AWACS commodities

- **Air Frames**
  - **Cockpit, Fuselage, Leading Edge Panels and Doors**
- **Mechanical**
  - **Engines, Hydraulic, Landing Gear and Flight Controls**
- **Special Tooling and Jigs**
- **Avionics:**
  - **HF, VHF, UHF, Intercom, IFF and Emergency Comm**
- **AWACS Unique Equipment**
  - **Surveillance Radar, ESM IFF, etc.**

U.S. AIR FORCE

Prime Mission Equipment Obsolescence over next 6 years





U.S. AIR FORCE

551 ELSG DMSMS Objectives

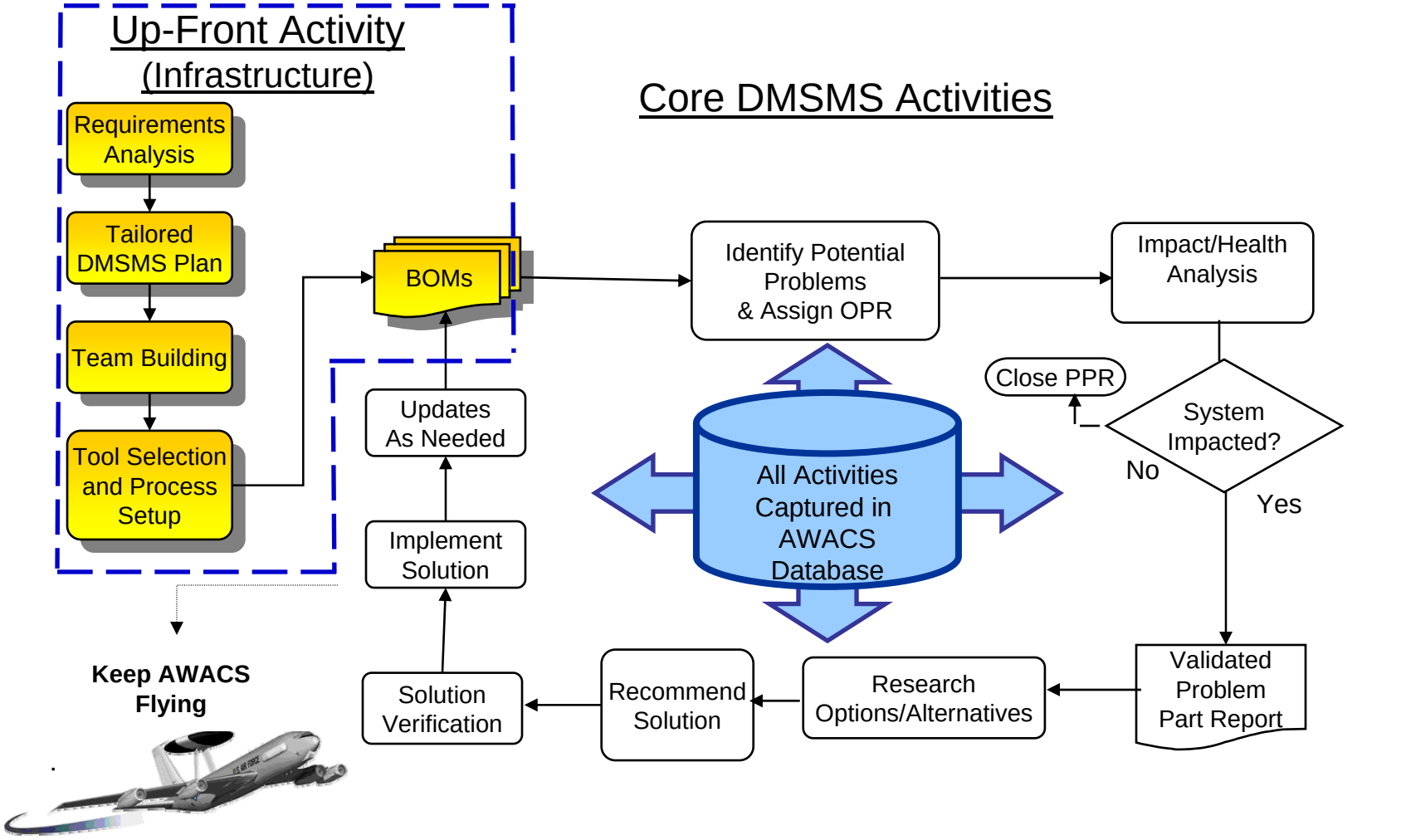


- Identify and capture existing aircraft configuration
- DMSMS focus on current issues and future mods
- Address present and future supportability concerns
- Preserve system and end-item OSS&E
- Coordinate and consolidate community efforts
- Integrate and implement resolutions *(recommendations)*
- Mitigate electronic and mechanical obsolescence
- Reduce both sustainment and development costs
- Institutionalize proactive DMSMS processes
  - Pinpoint end-item and system drivers to analyze
  - Track all DMSMS tasks (WG database)

U.S. AIR FORCE

551st DMSMS Process Flow





U.S. AIR FORCE

Operational Impact Analysis (OIA)*



MDS	Avg Operating Hours	Avg QPA	Avg App %
E003A		1	100
E003B	2715	1	100
E003C	1700	1	100

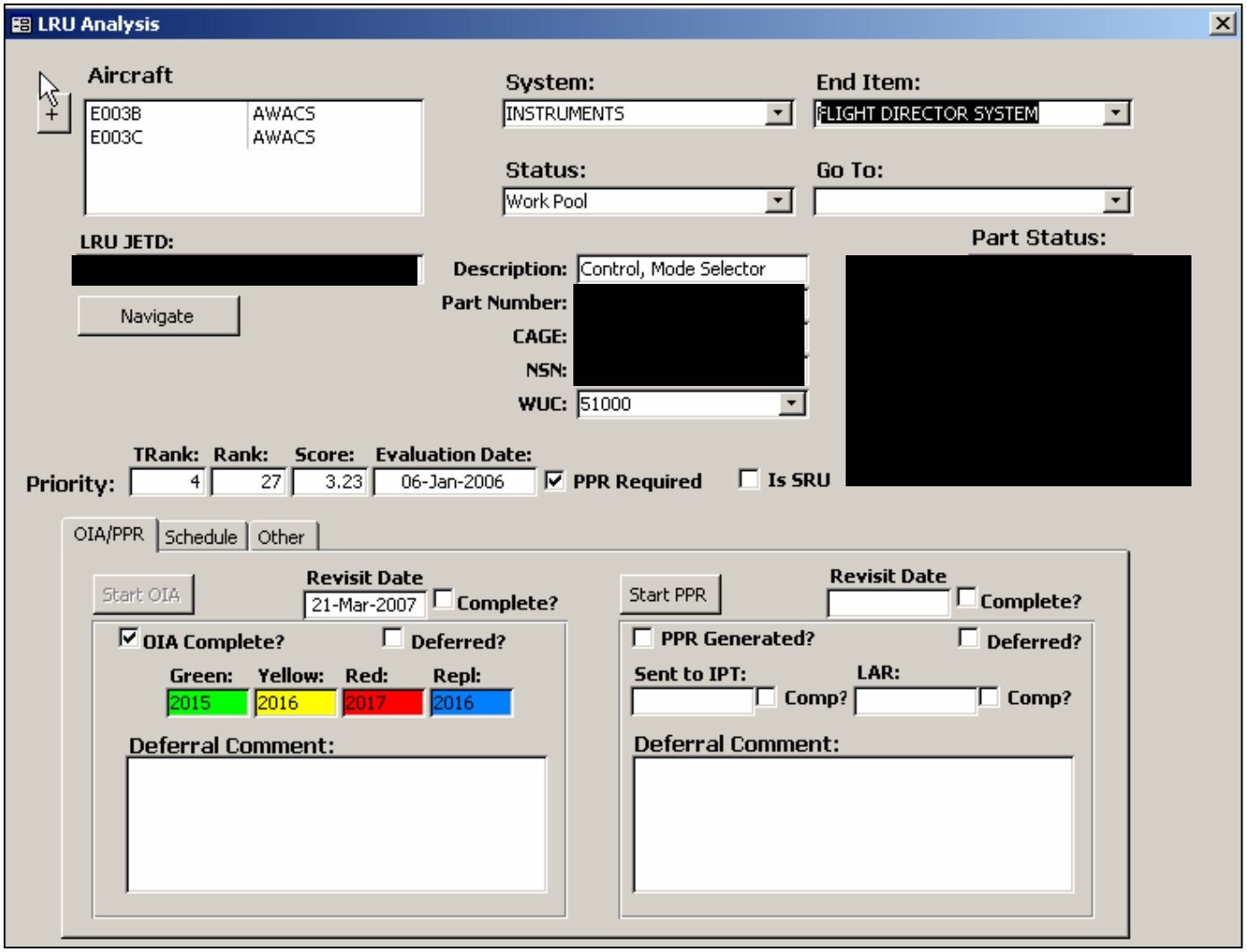
Part Number	Noun	NIIN	Initial QTY Spares	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
LRU																								
[redacted]	Air Speed Indicator	[redacted]	16	16	16	14	12	10	7	4	1	-2	-5	-8	-11	-15	-19	-23	-27	-31	-36	-41	-46	-51
				16900	17100	17000	16800	17100	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300	17300
SRUs																								
[redacted]	Bridge And Failure Monitor	[redacted]	3	2	0	-2	-4	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35	-39	-43	-47	-52	-57	-62	-67
[redacted]	Amplifier And Modulator	[redacted]	2	2	1	0	-1	-2	-4	-5	-7	-8	-10	-11	-13	-15	-17	-19	-21	-23	-25	-28	-30	-33

*** The OIA is an ARINC Proprietary Tool**

U.S. AIR FORCE

AWACS Priority Database





- SQL Database
- Stores
- Calculates
- Exports
- Schedules

*** The Priority Database is an ARINC Proprietary Tool**

U.S. AIR FORCE

DMSMS Approach



LRU

SRU

Component

Problem Part Report

Summary Report

SE Review

Implementation

Drill down assembling and analyzing Logistics and Engineering data along the entire path

Roll up of all data points including resolution with costs comparisons

- Applicable drawing and its revision
- Type of drawing and item reviewed
- Configuration and design
- Next higher assembly and end item applicability
- Potential resolutions to the obsolete components

DMSMS WG

Engineering Authority

U.S. AIR FORCE

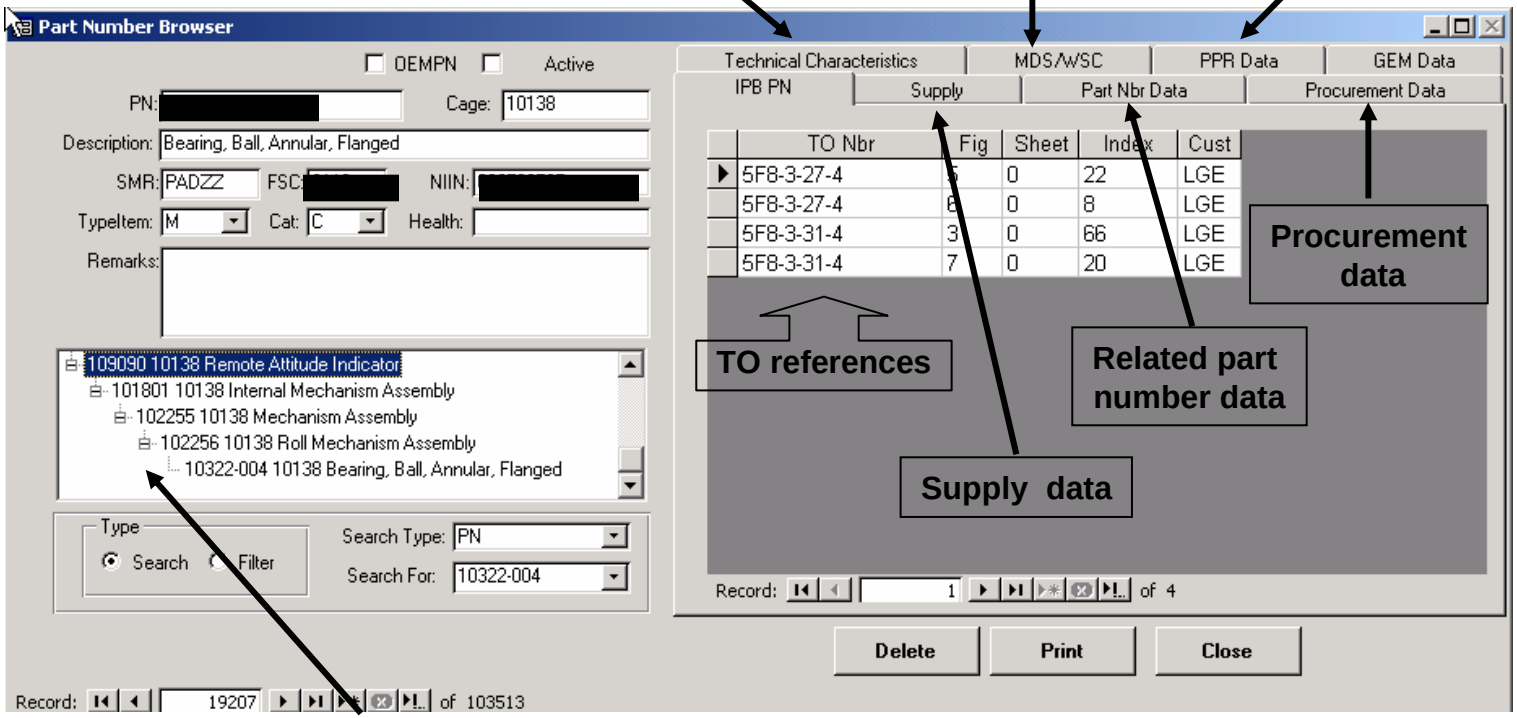
551st ELSG Data Repository



Aircraft/System application

Technical characteristics

PPR/Resolution data



Indenture Tree

U.S. AIR FORCE

ALARM© Shapshot



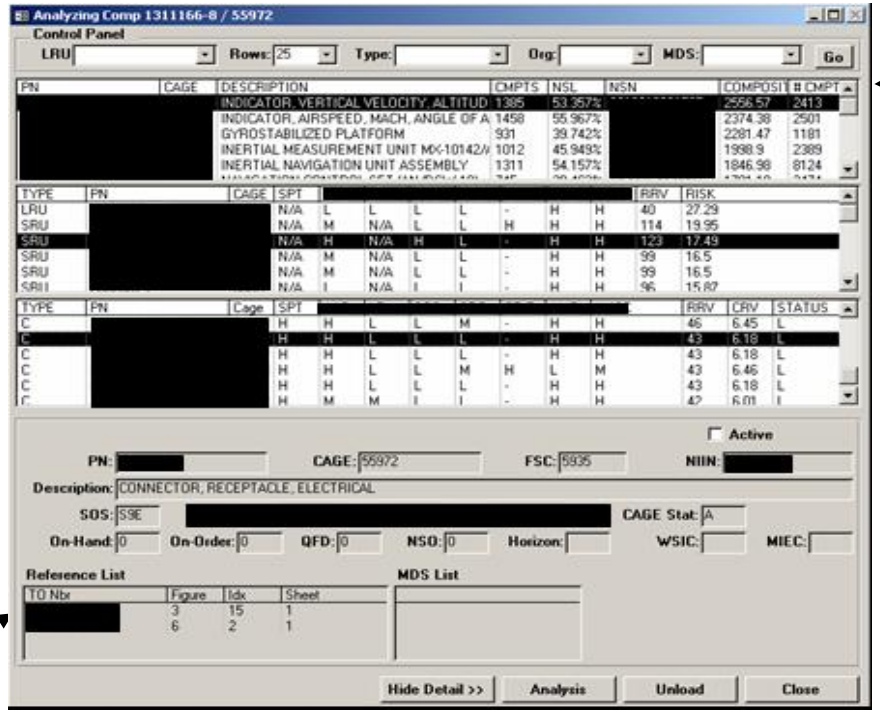
- **ARINC Process: Assess obsolescence characteristics of each component in an end item BOM, assign risk rating, roll up to LRU rating, and rank the LRU relative to other LRUs:**

LRU Individual Risk

SRU Individual Risk

Component Risk Associated With SRU (High Risk Only)

As you mine down from The first to the third list box, general information about the LRU/ SRU/ Component is displayed



LRU Rank Order by Composite Risk

Can be reported by:
- **Specified LRU**
- **Top 25, 50, 100**
- **Type (electronic vs. Mechanical)**
- **By organization within specified MDS**

ALARM© Shapshot

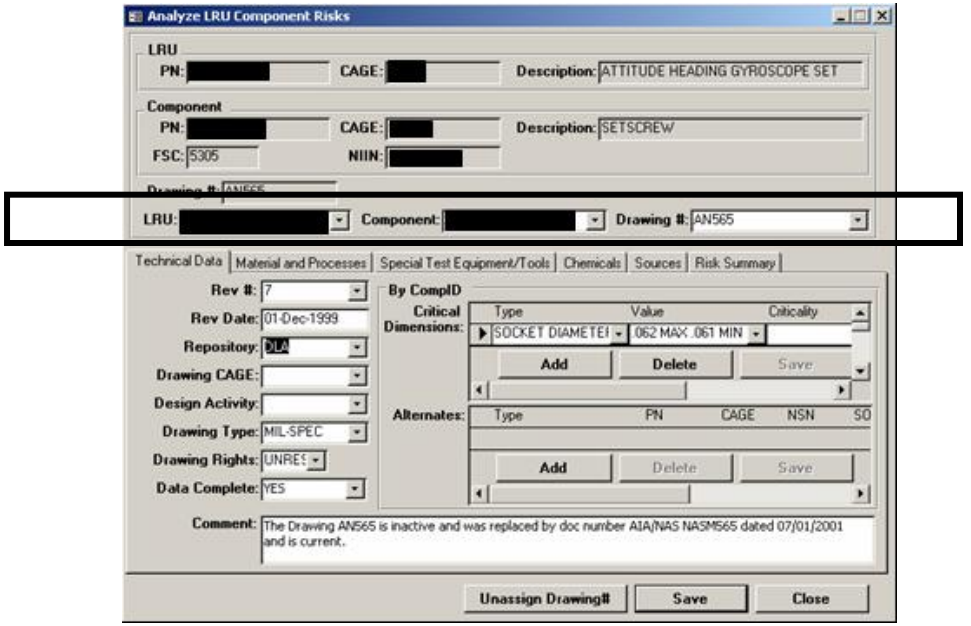


- **ARINC Process**

Identify "High" risk component items and perform engineering assessment to determine unique component characteristics contributing to obsolescence risk:

- **Technical data completeness**
- **Special material and processes**
- **Special test equipment/tools**
- **Chemicals**
- **Sources**

Manual Process

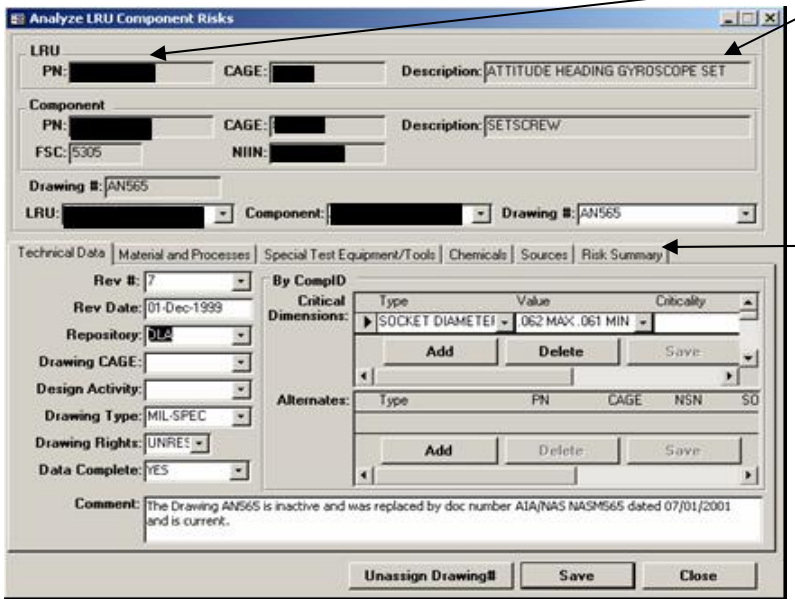


U.S. AIR FORCE

ALARM© Shapshot



- **ARINC Process**
  - **Create mechanical attribute library**
    - **Data availability**
    - **Applicable specifications/standards and their status**
    - **Tool availability**
    - **Banned chemicals**
    - **Sources no bid**



Data stored based on drawing, allows multiple PNs within drawing to be documented and retained

PN specific data stored separately

As library grows for each category of data, less information to manually document

U.S. AIR FORCE

Lessons Learned



- **VHF radio**
  - **One of the first systems on which an evaluation a DMSMS was developed**
    - **Assumed configuration in predictive health tool was correct**
    - **Performed assessment even though OIA showed no support impacts up to 2024**
    - **Did not research if system was to be replaced**
  - **Learned configuration in predictive health tool did not include all SRUs (Over 20 CCAs not assessed)**
    - **Researched drawing data to extract correct configuration**
  - **Found out system was scheduled to be replaced in 2010**
  - **Changed process to include system manager in determining if DMSMS assessment required and when system was scheduled for replacement**

U.S. AIR FORCE

Lessons Learned



- **Standardized Central Air Data Computer (SCADC) and UHF Radio**
  - **USAF program offices and FMS customers concerned that a new modified SCADC would not be supportable**
  - **UHF radio DMSMS issues raised by FMS community**
  - **DMSMS assessments initiated**
    - **OIAs for the SCADC and UHF radio showed that no obsolescence impact to mission support due to large number of spares in the supply system**
      - SCADC removed from decommissioned fleet (C-141, 2 per), and spares placed in inventory (over 400)
      - UHF radio inventory build up due to replacement of radio on some fleets
  - **Determined that even though obsolescence may adversely impact SRUs:**
    - **If enough LRU spares (serviceable and reparable) exist, obsolescence impacts are negated because cannibalization can support extended requirements**
    - **Use preliminary OIA to determine which LRUs to assess (if green through 2026 or green past replacement date, defer analysis**
  - **Must take supply chain into account versus only obsolescence data**

U.S. AIR FORCE

Lessons Learned



- **Large Systems**
  - **Radar**
    - **Over NNN LRUs in the radar system**
    - **Top NN obsolescence LRUs in the radar**
    - **Inundated the engineering authority for the radar with proposed resolutions to obsolescence**
  - **Decision made to alternate between radar and other system LRUs**
  - **Otherwise could have spent entire contract period on a single system**
  - **Need to show DMSMS working for all stakeholders in the your community**

U.S. AIR FORCE

Lessons Learned



- Data key to success
  - Configuration data
  - Technical Data
  - Market Surveys for COTS
- Teaming Required
  - MOAs mapped out and agreed upon
  - WG responsibilities defined
    - Due to differing DMSMS methodologies across user community
- Return on Investment (ROI)
  - None experienced without implementation of solutions
  - POM justification can be generated in proactive program
  - DMSMS focus on current issues and future mods
- Data points
  - Just a starting point…no one tool is enough
  - Prioritization…assessment of Supply Chain can focus resources
  - Focus on areas with greatest impact

U.S. AIR FORCE

Lessons Learned



- **Proactive…Cost Avoidance growth per year**
  - **2003- $823,500**
  - **Resolutions- 153**
  - **ROI- 4.1 to 1**
  - **2004- $2.56M**
  - **Resolutions- 354**
  - **ROI- 5.6 to 1**
  - **2005- $3.80M**
  - **Resolutions- 184**
  - **ROI- 16.1 to 1**
  - **To date 2006- $2.96M**
  - **Resolutions- 146**
  - **ROI- 15.7 to 1**

U.S. AIR FORCE



QUESTIONS





A System-of-Systems Approach to Component Commonality

Ivan W. Wolnek

Associate Technical Fellow

The Boeing Company

9Th Annual NDIA Systems Engineering Conference

October 2006

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Agenda

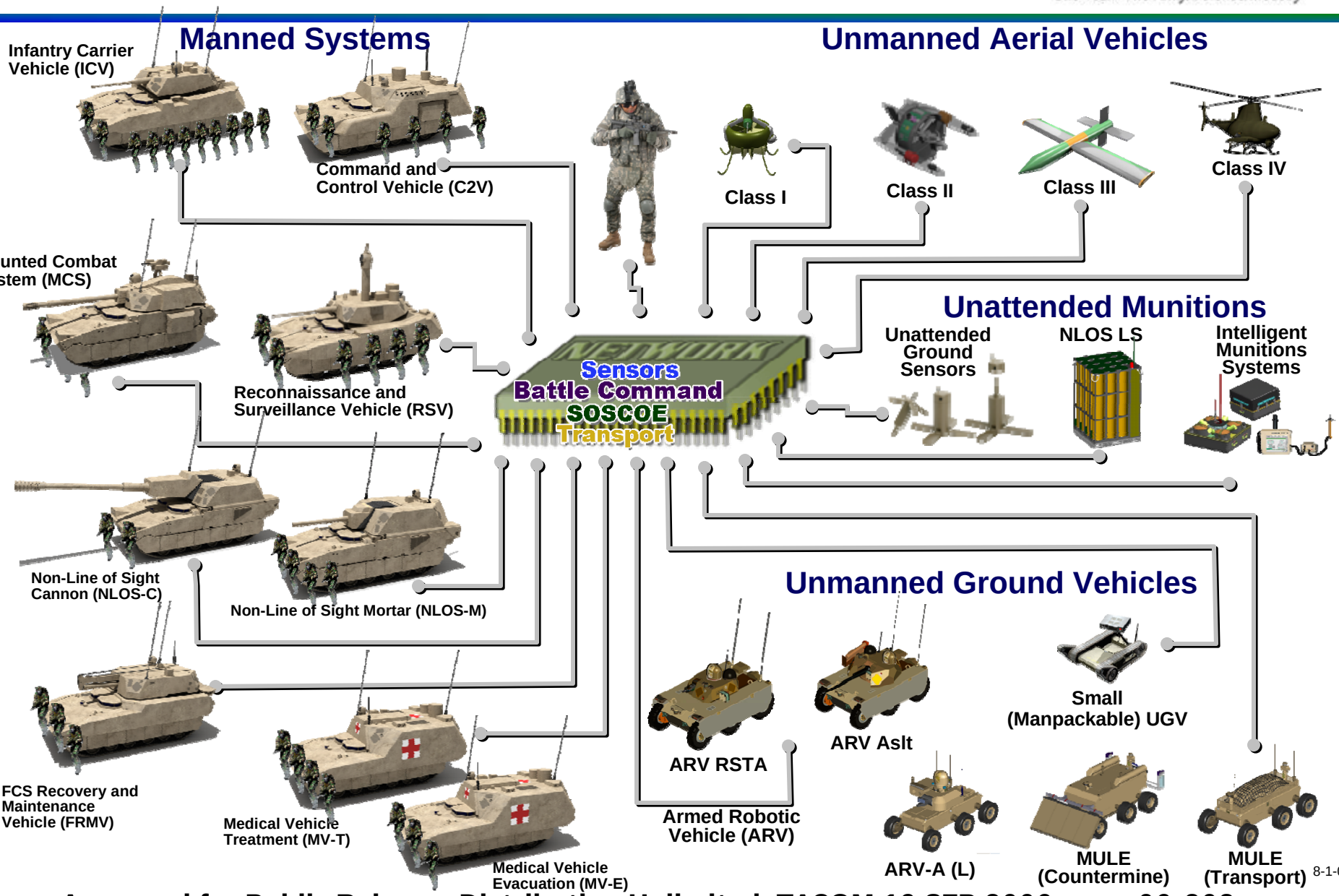
FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Defining Commonality Requirements for FCS**
  - **The Purpose of Commonality**
  - **Commonality Definition**
  - **Commonality Requirements Allocation**
  - **Status of Commonality on FCS**
- **Considerations in Pursuing Commonality**
- **Measuring Commonality Implementation**
- **Summary**
- **Questions**

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

FCS System-of-Systems (SoS)

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry



Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Commonality Requirement

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

The System-of-Systems shall maximize platform and component commonality within each system class to a level of 70%.

- **The Problem:**
  - **What does the requirement mean … at a SoS Level?**
  - **How does the requirement apply to individual systems?**
  - **What does it mean to be "common"?**
  - **How do you measure/verify performance?**
- **This requirement interacts with other requirements for common tools, common lubricants, common batteries, commonality in communications equipment, and others.**

Need to Translate the User's Requirement into Engineering Language

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Commonality Focus

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

Commonality in the Factory

- Decrease production cost
  - Fewer unique tasks
  - Reduced training requirements
  - Reduced manufacturing complexity
- Streamline supply chain

Commonality in the Field

- Simplify sustainment
- Reduce sustainment
- Support multi-functionality
- Reduce personnel requirements
- Reduce training requirements

User Focus is Commonality in the Field

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Why Commonality?

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Achieve Efficiencies in Maintainability**
  - Fewer unique installations
    - Fewer unique maintenance/repair procedures
      - Reduces training requirements
      - Requires fewer unique skills
      - Accelerates repair/replacement
- **Achieve Efficiencies in Operational Availability**
  - Less down time due to
    - Faster repair/replacement of failed components
    - Reduced spares requirements / Less dependency on the supply chain
    - Ability to swap like components between systems to meet mission needs
- **Achieve Efficiencies in Life Cycle Cost**
  - Fewer unique parts
  - Reduced spares requirements
  - Reduced training requirements

Commonality is a Key Ingredient to Meeting the FCS Program Objective to Reduce Logistics Footprint

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

What does it mean to be “common”?

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

A part is considered “common” if the following criteria are met:

(a) The part is designated as a field-replaceable part

(b) The part is functionally required on multiple systems in a specific class

(c) The part, with the same NSN number, is equally qualified for use on all systems in a specific class without modification.

<u>Common Component</u>: A field replaceable LRU/LRM that is used in the same application on multiple systems in a system class, and has the same NSN number regardless of system application.

Establish a Common Set of Expectations

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Definition of the System Classes

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

For the purposes of component commonality, the systems classes are defined as follows:

Class	Systems Included	Commonality Requirement
MGV	All	Applies
MULE	MULE-T, MULE-C, ARV-A(L)	Applies
ARV	ARV-A, ARV-RSTA	Applies
SUGV	Self	Does Not Apply
Class 1 UAV	Self	Does Not Apply
Class 2 UAV	Self	Does Not Apply
Class 3 UAV	Self	Does Not Apply
Class 4 UAV	Self	Does Not Apply
T-UGS	Self	Does Not Apply
U-UGS	Self	Does Not Apply
NLOS-LS	Self	Does Not Apply
IMS	Self	Does Not Apply

Apply Commonality Where it Makes Sense

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Requirement Development

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

User Requirement

The System-of-Systems shall maximize platform and component commonality within each system class to a level of 70%.

System-of-Systems Design Requirement

The FCS Platforms shall use common LRUs/LRMs to allow for 70% interchangeability within the classes for each major FCS system.

System/Platform Design Requirement

The PRIME ITEM shall have 70% common and interchangeable LRUs/LRMs within each class.

Commonality Definitions Facilitate Allocation of Meaningful Requirements at Multiple Levels in the FCS Product Structure

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Status of Commonality on FCS

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Component commonality is a contractual program requirement, specified in the ORD and Statement of Work (SOW)**
- **Commonality requirements are defined in the System-of-Systems Specification**
- **Commonality requirements are included in the Prime Item Development Specifications (PIDS) which establish the requirements baseline for each FCS system**
- **Incorporation of component commonality into the system design is required in each One Team Partner's SOW**
- **Expectations for component commonality across the SoS are clearly defined**

The FCS Program is Committed to Achieving Component Commonality Objectives

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Agenda

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- ✓ **Defining Commonality Requirements for FCS**
- ➢ **Considerations in Pursuing Commonality**
  - **Identifying Common Functionality**
  - **Program Set-up**
- **Measuring Commonality**
- **Summary**
- **Questions**

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Considerations in Pursuing Commonality

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Establish commonality objectives where it makes sense, taking into consideration:**
  - System functionality
  - System performance
  - System maintenance concepts
  - Life Cycle Cost
- **The opportunity for commonality is greatest between systems that have common or similar functionality**
  - Identify common functions between multiple systems
  - Focus commonality objectives on the systems/subsystems that perform similar functions
  - Adapt definition and allocation of functions within the system architecture to facilitate the use of common components

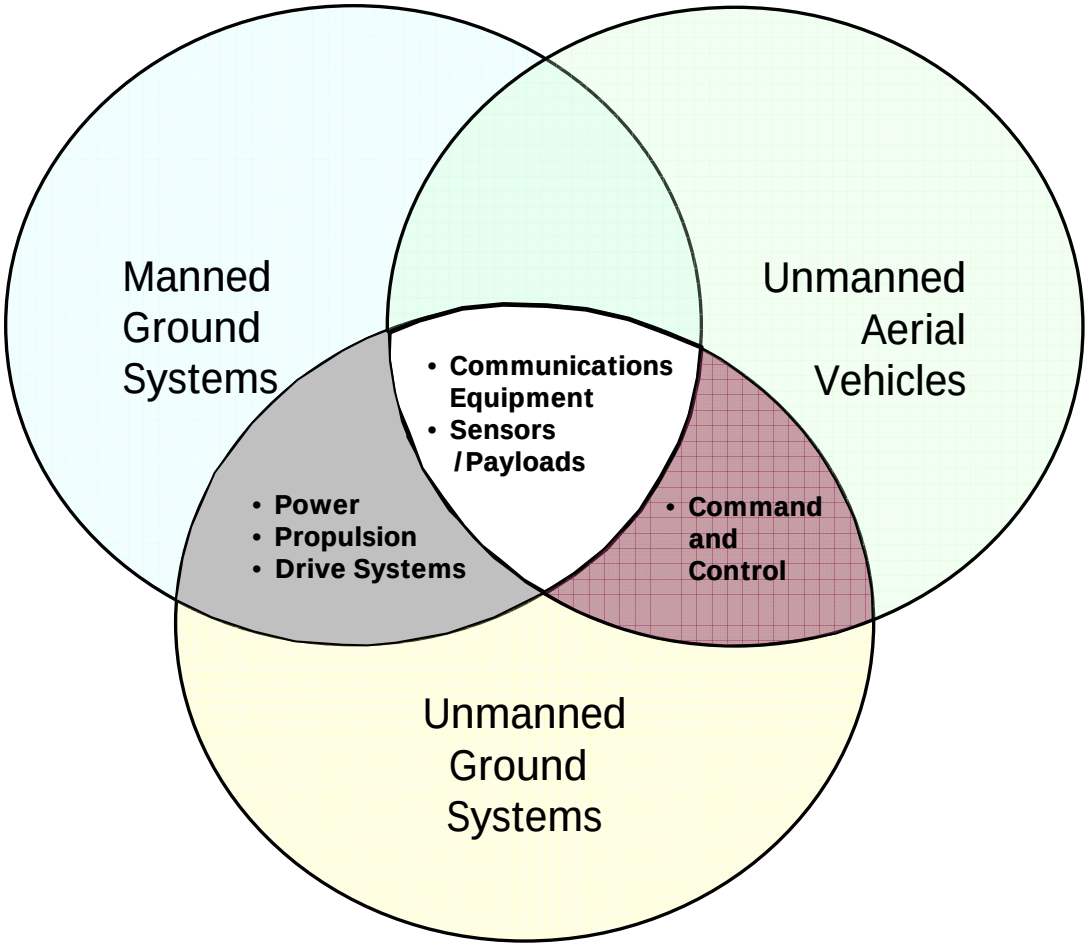
Expectations for commonality need to be realistic

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Identifying Common Functions – SoS Level

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

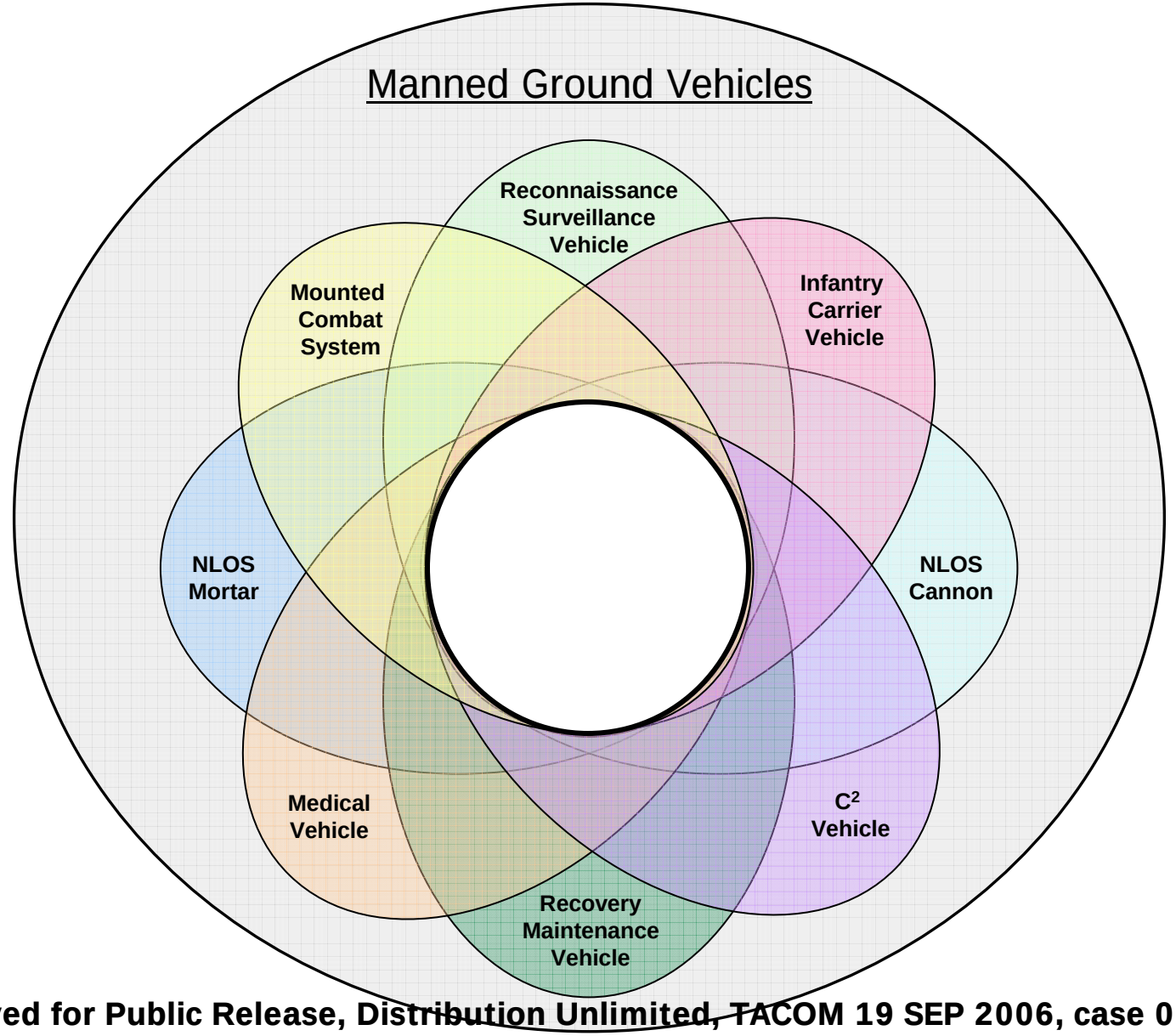
- **Identify the Systems Classes**
- **Identify common functions between systems = where it would be logical to have common components**



Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Identifying Common Functions – System Level

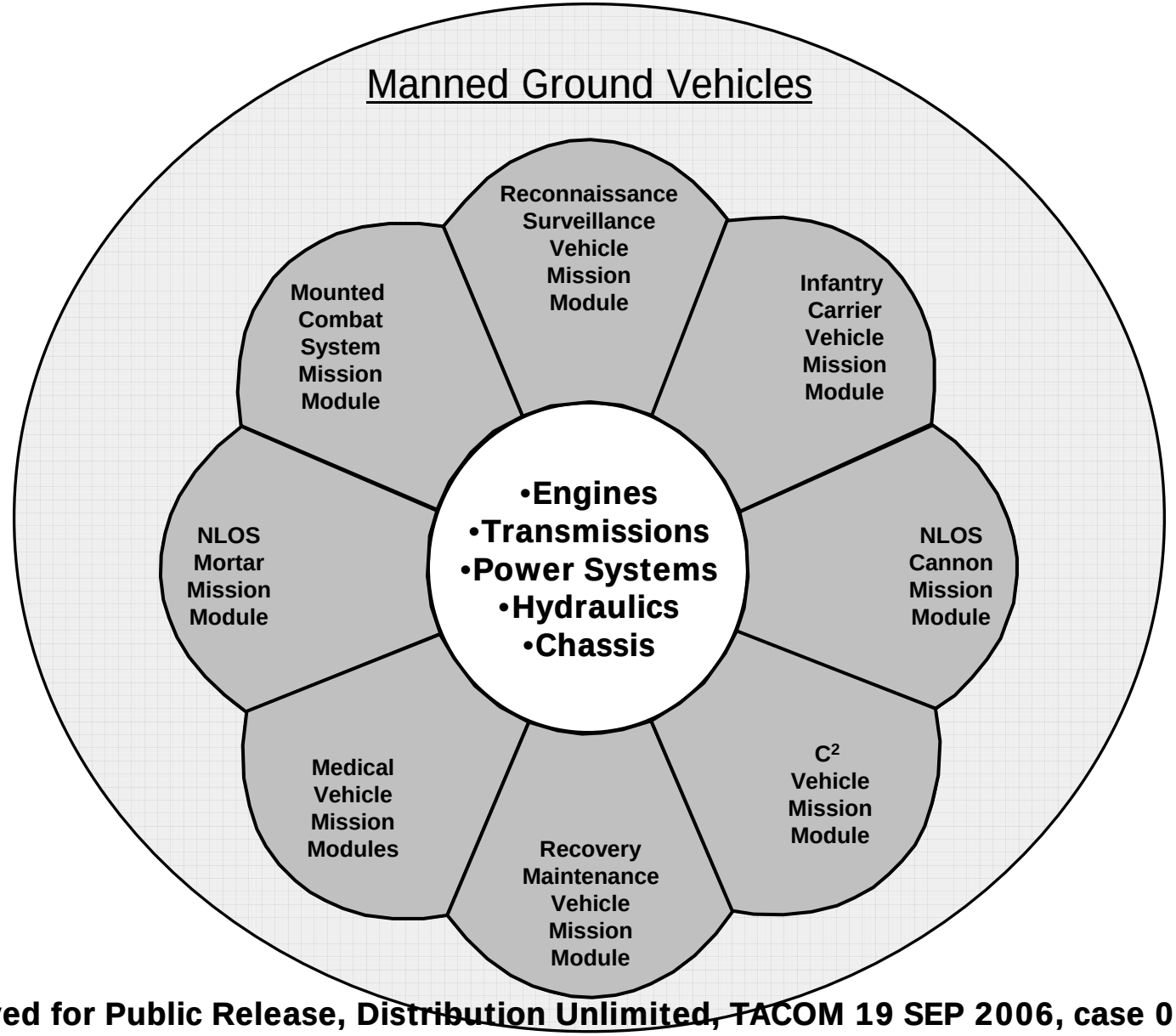
FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry



Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Identifying Common Functions – System Level

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry



Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Program Setup

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Commonality objectives integrated early in the development effort**
  - Program goals and objectives
  - Identification of the system functionality and performance
  - Definition of the product structure
- **Commonality is more than a requirements issue**
  - Concept of Operations
    - Commonality needs to be driven by user goals and objectives
  - Business Management
    - Commonality objectives need to be part of the program business model
  - Supplier Management
    - Suppliers need to be contractually obligated and incentivized to achieve commonality objectives

Commonality Needs to be Built Into the Basic Foundations of a Program

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Agenda

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- ✓ **Defining Commonality Requirements for FCS**
- ✓ **Considerations in Pursuing Commonality**
- ➢ **Measuring Commonality**
- **Summary**
- **Questions**

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Compliance with Commonality Requirements

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Early attempts on FCS to define an methodology for determining compliance with the commonality requirements looked at statistical analysis**
  - Resulted from many different interpretations of what it meant to be common and how it applied to the FCS systems
  - Lacked relevance - difficult to relate back to desired design characteristics and performance
- **Establishment of the commonality definitions facilitated discussions on how to count common versus unique LRUs/LRMs**
  - Perceived as a more tangible assessment of compliance
  - Directly related to the system design
  - Discussed as Approach 1 on the next chart
- **Consideration of commonality as a SoS requirement being addressed in a system design/development environment leads to the proposal of Approach 2**
  - Potential for more realistic expectations
  - Allows for consistent assessment between system and SoS perspectives

Commonality Approaches are Still Evolving

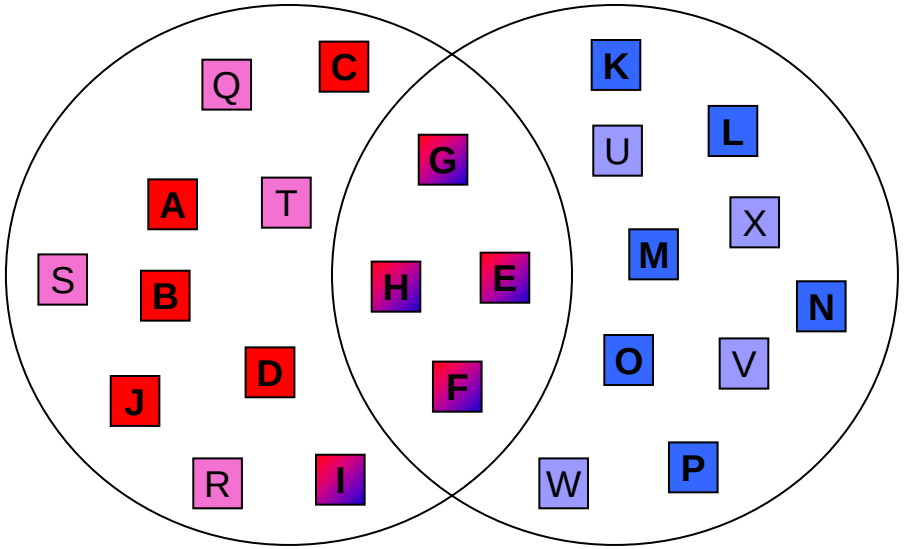
Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Measuring Commonality – Approach 1

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

$$\text{Commonality Requirement } (C_R) = \frac{\text{Total Number of LRUs/LRMs that should be common}}{\text{Total Number of LRUs/LRMs}}$$

$$\text{Commonality Performance } (C_P) = \frac{\text{Total Number of LRUs/LRMs that are common}}{\text{Total Number of LRUs/LRMs}}$$



- Each box is a part
- Bold indicates a part that has been designated as an LRU/LRM
- ■ Indicates an LRU/LRM that should be common
- Of the LRUs/LRMs that should be common, only the ones in the intersection actually are common

System 1
14 Parts
10 LRUs/LRMs (Bold)
5 LRUs/LRMs should be common
4 LRUs/LRMs are common

C_R = 5/10 = 50 %
C_P = 4/10 = 40 %

System of Systems
24 Parts
16 LRUs/LRMs (Bold)
5 LRUs/LRMs should be common
4 LRUs/LRMs are common

C_R = 5/16 = 31 %
C_P = 4/16 = 25 %

System 2
14 Parts
10 LRUs/LRMs (Bold)
4 LRUs/LRMs should be common
4 LRUs/LRMs are common

C_R = 4/10 = 40 %
C_P = 4/10 = 40 %

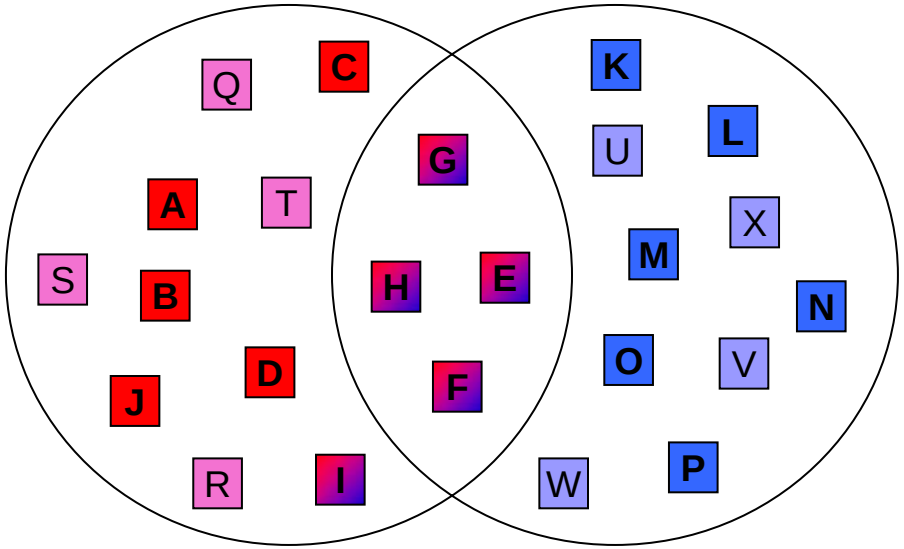
Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Measuring Commonality – Approach 2

FUTURE COMBAT SYSTEMS FCS One Team-The Army/Defense/Industry

$$\text{Commonality Potential } (C_p) = \frac{\text{Total Number of LRUs/LRMs that } \textbf{could} \text{ be common}}{\text{Total Number of LRUs/LRMs}}$$

$$\text{Commonality Ratio } (C_r) = \frac{\text{Total Number of LRUs/LRMs that are common}}{\text{Total Number of LRUs/LRMs that } \textbf{could} \text{ be common}}$$



- Each box is a part
- Bold indicates a part that has been designated as an LRU/LRM
- ■ Indicates an LRU/LRM that should be common
- Of the LRUs/LRMs that should be common, only the ones in the intersection actually are common

System 1
14 Parts
10 LRUs/LRMs (Bold)
5 LRUs/LRMs could be common
4 LRUs/LRMs are common

C_p = 5/10 = .5
C_r = 4/5 = .8

System of Systems
24 Parts
16 LRUs/LRMs (Bold)
5 LRUs/LRMs could be common
4 LRUs/LRMs are common

C_p = 5/16 = .3
C_r = 4/5 = .8

System 2
14 Parts
10 LRUs/LRMs (Bold)
4 LRUs/LRMs could be common
4 LRUs/LRMs are common

C_p = 4/10 = .4
C_r = 4/4 = 1

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Measurement Observations

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **Approach 1**
  - Percentages, as a definition of the level of commonality to be exhibited by a system to be designed, do not translate well into design requirements
  - Percentages, as an assessment of performance or compliance, can be misleading
- **Approach 2**
  - A measure of “Commonality Potential”, based on the evaluation of common functions in a conceptual design, can provide more realistic expectations for a specific development effort
  - A “Commonality Ratio” provides an assessment of commonality that is more consistent across multiple systems in a SoS environment

Assessment Approach Needs to be Developed Concurrently with Definitions and Requirements

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Agenda

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- ✓ Defining Commonality Requirements for FCS
- ✓ Considerations in Pursuing Commonality
- ✓ Measuring Commonality
- ➢ Summary
- Questions

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Summary

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- **FCS is actively working to meet the program commonality objectives**
- **The FCS program SoS approach to commonality is based upon:**
  - A clear definition of Commonality
    - What is Commonality?
    - What is the purpose of Commonality on a specific program?
    - How are Commonality criteria applied to the system architecture?
  - Commonality objectives included in the initial formulation of a program
  - Commonality objectives synchronized with the system architecture and conceptual design
- **Measures of achievement of commonality objectives are being developed using the same definitions and expectations that established the commonality requirements**

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.

Agenda

FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- ✓ Defining Commonality Requirements for FCS
- ✓ Considerations in Pursuing Commonality
- ✓ Measuring Commonality
- ➢ Questions

Approved for Public Release, Distribution Unlimited, TACOM 19 SEP 2006, case 06-202.