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27th Annual National Test and Evaluation Conference

"Test & Evaluation: Serving the Warfighter"

Tampa, FL

14 – 17 March 2011

Agenda

MONDAY, MARCH 14, 2011

TUTORIAL C – SESSION I

- 11653 - Test Planning — Advancing the Science, Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector
- 11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E, Dr. Mark Kiemele, President and Cofounder, Air Academy Associates

TUTORIAL G – SESSION I

- 11570 - A Day in the Life of a Verification Statement Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector

TUESDAY, MARCH 15, 2011

CONFERENCE KEYNOTE ADDRESS

- Honorable Dr. J. Michael Gilmore, *Director, Operational Test & Evaluation, OSD*

HOMELAND SECURITY T&E PERSPECTIVES

- Mr. Gary Carter, Director, Test & Evaluation and Standards Division, Department of Homeland Security

SESSION B: OTA'S (OPERATIONAL TEST AGENCY'S) ROUNDTABLE

Session B Chair and Roundtable Moderator: Dr. Catherine Warner, Science Advisor, DOT&E, OSD

SESSION C: ACQUISITION REFORM - THE IMPACT ON INDUSTRY

PENTAGON RESPONSE TO CONGRESSIONAL STRENGTHENING OF DT&E

- Mr. Chris DiPetto, Principal Deputy, Developmental Test & Evaluation

REPORT ON NDIA'S INDUSTRIAL COMMITTEE ON TEST & EVALUATION (ICOTE)

- Mr. James Ruma, *Chairman, NDIA ICOTE; Vice President, Engineering, GDLS*

CONCURRENT SESSIONS D – K

- 11627 - Assessing System Reliability Growth When Failure Modes are Masked, Dr. Patricia Jacobs, Naval Postgraduate School
- 11650 - Realistic and Measurable Suitability Requirements for Test, 1st Lt Andrew Passey, USAF, Air Force T&E Center, Detachment 6
- 11563 - Integrated Test and Independent Evaluation (IT&IE) and T&E Using Experimental Design Methodology, Mr. George Axiotis, DDR&E/DDT&E
- 11665 - OSD Perspective of DT&E in Navy Shipbuilding Programs, Mr. Patrick Clancy, OUSD(AT&L) DDR&E/DDT&E

- 11656 - An Industry Response to the Acquisition Changes, Mr. Steve Scukanec, Northrop Grumman Aerospace Sector
- 11499 - Emerging Methodology for Mission-Based Capability Assessments, Mr. William Landis, ARL/SLAD
- 11557 - Measures Development Standard Operating Procedure (SOP), Mr. John Smith, Operational Test & Evaluation Force
- 11666 - Understand the Mission - A “How-To” Guide for MBTE Practitioners, Mr. Britt Bray, DRC
- 11662 - Design Methodology for Expedient, Low Cost UAV Runways, Mr. Lorenz Eber, Naval Surface Warfare Center, Dahlgren
- 12878 - DoD Strategic Planning for Test and Evaluation, Mr. Lee Schonenberg, Whitney, Bradley and Brown Consulting
- 11709 – Decoupled Test, Evaluation, and Certification of a System of Systems, Mr. Robin Murray, JITC
- 11564 - The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results, Dr. Sultan Mahmood, Air Armament Center, AAC/EB
- End-to-End GPS Multi-Platform Integrated System Testing for MGUE, Dr. Sultan Mahmood, Air Armament Center, AAC/EB
- 11640 - Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements, Mr. Doug Weatherford, PM ITTS IMO
- 11645 - Holographic Radar Brings a New Dimension to Sensing and Instrumentation on T&E Ranges, Mr. Gary Kemp, Cambridge Consultants
- 11467 - Guiding the Engineer Through the T&E Process, Mr. Allen Brailey, Raytheon Company
- 11483 - How to Frame a Robust Sweet Spot Via Response Surface Methods (RSM), Mr. Mark Anderson, Stat-Ease, Inc.
- 11553 - MIL-PRF-XX613 and MIL-STD-X618: The Navy Gets Serious About Armor, Mr. Christopher Brown, Naval Surface Warfare Center, Crane
- 11541 - Fragment Analysis for the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC), Ms. Karen Pizzolato, U.S. Army Research Laboratory
- 11516 - Mission-Based Test and Evaluation Strategy: Progress Towards Uniting Combat Developer, Materiel Developer and T&E, Mr. Christopher Wilcox, U.S. Army Evaluation Center
- 11552 - Using Complementary Frameworks for Qualitative Data Collection During OT&E: Piggybacking on Operational Experiments, Ms. Chiesha M. Stevens, Pacific Science & Engineering Group, Inc.
- 11699 - Continuous Cost Reduction Feeds Back into Product Reliability, Mr. Jonathan Nikkel, Raytheon Missile Systems
- 11704 - Testing & Evaluating the Net- Ready Key Performance Parameter (KPP), Ms. Danielle Koester, JITC

WEDNESDAY, MARCH 16, 2011

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SESSION L: A RE-ENERGIZED DT&E
PANEL: T&E: SERVING THE WARFIGHTER IN A COST-CONSTRAINED ENVIRONMENT

Panel Moderator:

- Mr. Chris DiPetto, Principal Deputy, Developmental Test & Evaluation

Panelists:

- Mr. David K. Grimm, Acting Director, Deputy Under Secretary of the Army, T&E Office
- Mr. Steve Hutchison, DISA T&E Executive

SESSION M: RESPONSIVE AND AGILE INFORMATION SYSTEMS T&E PANEL

Session M Chair and Panel Moderator:

- Dr. Steve Kimmel, Chairman, NDIA C4ISR Division; Senior Vice President, Alion Science & Technology

SESSION N: IMPROVING THE T&E PROCESS
SOCOM T&E PERSPECTIVES: SERVING THE WARFIGHTER

- LTC Kevin Vanyo, USA, USSOCOM J8-O

CONCURRENT SESSIONS O – V

- 11560 - A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops, Mr. Stephen Swann, U.S. Army Research Laboratory
- 11529 - Expanding Use of the Probability of Raid Annihilation (PRA) Test Bed Across the Ship Self-Defense Enterprise, Mr. Richard Lawrence, AVW Technologies
- 11500 - Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E), Mrs. Beth Ward, U.S. Army Research Laboratory
- 11476 - A Paradigm for Modeling and Simulation in support of Mission-Based Test and Evaluation, Dr. James Walbert, SURVICE Engineering Company
- 11497 - Joint Mission Environment Test Capability (JMETC): Improving Distributed Capabilities, Mr. Chip Ferguson, JMETC
- 11508 - U.S.N. RDTE Project Support Aircraft, Mr. Charles Myers, U.S. Navy, NAWCAD
- 11626 - Dugway Proving Ground as the MRTFB Chem Bio Activity, Ms. Jean Baker, U.S. Army Dugway Proving Ground
- 11677 - Using Design of Experiments (DoE) to Integrate Developmental and Operational T&E, Dr. Mark Kiemele, Air Academy Associates
- 11549 - Probability Driven Experiments Design for Autonomous Systems, Mr. Troy Jones, Charles Stark Draper Laboratory
- 11532 - Design of Experiments: Managing Expectations, Mr. James Carpenter, AVW Technologies, Inc.
- 11538 - Personnel Injury Analysis of Reflective Spall, Mrs. Rebecca VanAmburg, U.S. Army Research Laboratory
- 11539 - Analytical Approach Using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA), Mr. Richard Moyers, U.S. Army Research Laboratory

- 11674 - Utilization of Model and Simulation for Network Waveform Characterization and Validation, Mr. Scott Rediger, Rockwell Collins
- 11676 - Model Based Systems Engineering and M&S Adding Value to T&E, Mr. Larry Grello, High Performance Technologies, Inc.
- 11554 - The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live Fire Test and Evaluation, Mr. Scott Hornung, U.S.Army Research Laboratory/ SLAD
- 11638 - Army Testing in a Services Oriented Architecture (SOA) Environment, Mr. Michael Phillips, Mantech International
- 11639 - The Test and Training Enabling Architecture (TENA) Enabling Technology for the Joint Mission Environment Test Capability (JMETC) in Live, Virtual, and Constructive (LVC) Environments, Mr. Gene Hudgins, TENA/JMETC
- 11682 - Advanced Range Data System (ARDS) Service Life Extension Program (SLEP) - "Ensuring GPS Based TSPI Remains a Viable T&E Range Instrumentation Asset", Mr. Dick Dickson,TYBRIN Corporation
- 11698 - Target Systems in Support of Test and Evaluation, Mr. James Schwierling,U.S. Army Targets Management Office
- 11524 - Ready for Scrum? Dr. Steven Hutchison, DISA
- 11649 - Affordable Test and Evaluation in a Complex World, Mr. Thomas Wissink, Lockheed Martin
- 11710 - Testing U.S. Systems for Coalition Interoperability, LTC Tim Timmons, USA,JITC
- 11659 - Impacts of the Learning Curve - Operational Test & Evaluation, Ms. Shannon Krammes, MCOTEA

THURSDAY, MARCH 17, 2011

SESSION W: TEST DESIGN, TEST CURRICULA AND STANDARDS

- 11690 - Doing More Without More - Scientific T&E Design Methodologies (STED in DOD Weapons Systems Aquisition), Ms. Darleen Mosser-Kerner, Deputy Director, Capabilities Development, Office of the Director, DT&E
- Report On Standards For DT&E, CDR Ernest Swauger, USN (Ret), JPEO-CBD/Chief, CM/HD Systems IPAT
- 11663 - Effective Combat Data Collection & Applicability to T&E, LtCol Michael Kennedy, USMC, Expeditionary Test Division, MCOTEA
- 11651 - Test & Evaluation Issues For Systems of Systems (SoS): Creating Sleep Aids For Those Sleepless Nights, Dr. Beth Wilson, Principal Engineering Fellow, Raytheon Company
- 11569 - T&E - Guarding The Requirements Intent, Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector

NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

FEATURING:

- Top Pentagon leadership presentations on T&E / acquisition policy and issues
- Industry leaders sharing T&E perspectives and responses to recent policy initiatives
- Special former NSA guest speaker addressing cyber security policy
- Over 80 speakers addressing a host of issues facing today's T&E community
- Parallel breakout sessions focused on specific T&E issues

27TH ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

"Test & Evaluation: Serving the Warfighter"

Co-Sponsored by the NDIA C4ISR & Systems Engineering Divisions

CONFERENCE AGENDA

MARCH 14-17, 2011

WWW.NDIA.ORG/MEETINGS/1910

MARRIOTT TAMPA WATERSIDE ▸ TAMPA, FLORIDA

EVENT #1910

CONFERENCE ANNOUNCEMENT

The 27th Annual National Test & Evaluation Conference is sponsored by the NDIA Test & Evaluation Division and supported by the Office of the Under Secretary of Defense (AT&L) and the Director, Operational Test & Evaluation (DOT&E). Co-sponsors of this symposium are the C4ISR and Systems Engineering Divisions of NDIA.

Test and Evaluation is often looked at by Program Managers, Program Executive Officers and other proponents of weapon systems as an unwelcome obstacle to the deployment of systems to the Department of Defense and Homeland Security. T&E is often seen as a source of bad news which can potentially delay the deployment of these systems and add to their eventual cost.

Most engineers, technicians and program administrators recognize that test and evaluation is an integral part of the scientific method of systematically assessing the effectiveness, suitability and survivability of hardware, software and personnel.

This national conference will focus on policies, methods, and approaches that could better serve the ultimate consumer of our T&E efforts, the Warfighter. Given that Tampa is the home of both the U.S. Special Operations Command and the U.S. Central Command, it will provide a fertile opportunity to see and hear first-hand about how T&E could better serve our fighting forces.

With the recent combat surge into Afghanistan and change in our operational support in Iraq, it is vital that we take note of the recent lessons learned in both rapid deployment as well as tailoring our responses to the changing environments and tactics our fighting forces are now facing.

Increasing fiscal pressures also prompt us to address T&E approaches to saving time and money as well as to examine those other disciplines which feed the T&E activity, including Systems Engineering, Logistics, C4ISR, and R&D and Training.

Recent policy initiatives will also be addressed as to their implications, applications and effectiveness. Discussions will include how the recent legislative initiatives requiring additional T&E statutory responsibilities for Developmental Test and Evaluation are being implemented. Multiple topic tracks and tutorial sessions will be included in the conference to enable more focused discussions of specific topics enabling additional time for Q&A as well.

CONFERENCE ATTIRE

Conference attire is business for civilians and Class A uniform for military. In addition, your identification badge, received upon conference check-in, must be worn at all times.

NDIA T&E EXECUTIVE BOARD

- **Mr. Joe Andrese,** *APG NDIA Chapter* *
- **Dr. Suzanne Beers,** *MITRE Corporation*
- **Dr. Keith Bradley,** *LLNL*
- **Mr. Britt Bray,** *DRC Corporation*
- **Mr. Sam Campagna,** *NDIA*
- **RADM David Crocker, USN (Ret),** *Booz Allen Hamilton*
- **Dr. Paul Deitz,** *AMSAA**
- **Mr. Dick Dickson,** *Tybrin Corporation*
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- **Dr. Mark Kiemele,** *Air Academy Associates*
- **Mr. Chuck Larson,** *SURVICE Engineering*
- **Mr. James O'Bryon,** *The O'Bryon Group, T&E Division Chair*
- **Mr. Brendan Rhatigan,** *Lockheed Martin*
- **Mr. Jack Sheehan,** *ORSA Corporation*
- **Dr. James Streilein,** *OSD, DOT&E**
- **Dr. Lowell Tonnessen,** *IDA*
- **Dr. Juan Vitali,** *OSD CBD**
- **Mr. Martin Woznica,** *Raytheon Company*
- **Mr. William Yeakel,** *ORSA Corporation*

***Government liaison to NDIA T&E Executive Board**

WALTER W. HOLLIS HONORS LUNCHEON

The Walter W. Hollis Award is presented annually in recognition of lifetime contributions and achievement in the area of defense Test & Evaluation. The award is presented in the name of Walter W. Hollis who is recognized for his dedicated and long-standing service in the field of Defense Test & Evaluation. This year's recipient, **Dr. James N. Walbert, *Chief Scientist, SURVICE Engineering Company,*** will be recognized at the conference Awards Luncheon on Tuesday, March 15.

Previous Recipients of this Award:
Dr. James J. Streilein, *Technical Director/Deputy to the Commander, U.S. Army Test and Evaluation Command (2010)*
Dr. Ernest Seglie, *Science Advisor to the Director, Operational Test & Evaluation, OSD (2009)*
Dr. Paul H. Deitz, *Technical Director, AMSAA, APG, MD (2008)*
Mr. James F. O'Bryon, *Former DDOT&E / LFT (2007)*
RADM Charles "Bert" Johnston, **USN (Ret),** *Wyle Laboratories (2006)*
Hon Thomas Christie, *DOT&E, OSD (2005)*
Dr. Marion Williams, *HQ AFOTEC (2004)*
Mr. James Fasig, *Aberdeen Test Center (2003)*
Mr. G. Thomas Castino, *Underwriters Laboratories, Inc. (2002)*
Hon Philip Coyle, **III,** *DOT&E, OSD (2001)*
Mr. Walter W. Hollis, *Department of the Army (2000)*

TESTER OF THE YEAR AWARDS LUNCHEON

These awards, presented to outstanding individuals in the field of Test & Evaluation, offer OSD and each Military Service Test & Evaluation Department the opportunity to select three award recipients for recognition as the Tester of the Year in specific categories. The three categories recognized are: Military, Civilian, and Contractor. Recipients will be recognized at the conference Awards Luncheon on Wednesday, March 16.

MAJ Brian Spurlock, USA
2010
Army
Military Tester of the Year

COL Steven Duke, USA
2010
OSD
Military Tester of the Year

Maj Ryan Voneida, USAF
2010
USAF
Military Tester of the Year

CDR John Verniest, USN
2010
Navy
Military Tester of the Year

Capt Todd Richardson, USMC
2010
Marine Corps
Military Tester of the Year

Ms. Patricia Frounfelker
2010
Army
Civilian Tester of the Year

Ms. Stephanie Koch
2010
OSD
Civilian Tester of the Year

Mr. William Nix
2010
USAF
Civilian Tester of the Year

Mr. Don Nelson
2010
Navy
Civilian Tester of the Year

Ms. Cam Donohue
2010
Marine Corps
Civilian Tester of the Year

Mr. Henry Waller
2010
Army
Contractor Tester of the Year

Mr. Patrick Matthews
2010
OSD
Contractor Tester of the Year

Mr. David Smith
2010
USAF
Contractor Tester of the Year

Mr. Douglas Cornell
2010
Navy
Contractor Tester of the Year

Mr. Eric Rannenberg
2010
Marine Corps
Contractor Tester of the Year

MONDAY, MARCH 14, 2011

10:00 AM - 6:00 PM	**CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION**
10:00 AM - 2:45 PM	**TUTORIALS A-D, SESSION 1 - SEE TRACK LAYOUT FOR ROOM ASSIGNMENTS** There is a $50 registration fee for tutorial attendance.
11:00 AM - 4:00 PM	**DISPLAY SET-UP - GRAND SALONS A-D**
12:00 NOON - 1:00 PM	**LUNCH BREAK** Lunch not included in conference or tutorial registration
2:45 PM - 3:00 PM	**AFTERNOON BREAK - GRAND BALLROOM FOYER** For tutorial registrants only
3:00 PM - 4:30 PM	**TUTORIALS E-H, SESSION 2 - SEE TRACK LAYOUT FOR ROOM ASSIGNMENTS**
4:30 PM	**TUTORIALS CONCLUDE**
5:00 PM - 6:00 PM	**KICKOFF RECEPTION IN THE DISPLAY AREA - GRAND SALONS A-D** Open to all conference registrants
6:00 PM	**CONFERENCE ADJOURNED FOR THE DAY**

MONDAY, MARCH 14, 2011 — *Tutorials*

10:00 AM - 2:45 PM

TUTORIAL	TUTORIAL A Session Chair: Dr. Paul Deitz, *AMSAA* Grand Salon G	TUTORIAL B Session Chair: Mr. Martin Woznica, *Raytheon Company* Grand Salon H	TUTORIAL C Session Chair: Dr. Suzanne Beers, *MITRE Corporation* Grand Salon I	TUTORIAL D Session Chair: Mr. Britt Bray, *DRS Corporation* Grand Salon J
	SESSION 1	SESSION 1	SESSION 1	SESSION 1
10:00 AM	11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E Dr. Mark Kiemele, *President and Co-founder, Air Academy Associates*	11694 - Efficient Modeling and Simulation (M&S) Using Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11653 - Test Planning — Advancing the Science Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11488 - Testing and Evaluating Intranets, Portals, and Enterprise Systems for Usability Dr. Patricia Chalmers, *Chief Science Advisor, U.S. Joint Forces Command*
	SESSION 1 CONTINUED	SESSION 1 CONTINUED	SESSION 1 CONTINUED	SESSION 1 CONTINUED
1:00 PM	11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E Dr. Mark Kiemele, *President and Co-founder, Air Academy Associates*	11694 - Efficient Modeling and Simulation (M&S) Using Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11653 - Test Planning — Advancing the Science Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11488 - Testing and Evaluating Intranets, Portals, and Enterprise Systems for Usability Dr. Patricia Chalmers, *Chief Science Advisor, U.S. Joint Forces Command*

3:00 PM - 4:30 PM

TUTORIAL	TUTORIAL E Session Chair: Dr. Lowell Tonnessen, *IDA* Grand Salon G	TUTORIAL F Session Chair: Mr. Dick Dickson, *Tybrin Corporation* Grand Salon H	TUTORIAL G Session Chair: Mr. Chuck Larson, *SURVICE Engineering* Grand Salon I	TUTORIAL H Session Chair: Mr. Brendon Rhatigan, *Lockheed Martin* Grand Salon J
	SESSION 2	SESSION 2	SESSION 2	SESSION 2
3:00 PM	11703 - Ships Are Different Mr. Mark Lucas, *Command Technical Director, Combat Direction Systems Activity*	11693 – Modern Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11570 - A Day in the Life of a Verification Statement Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11705 - Defense Information Systems Agency Joint Interoperability Test Command Interoperability Support for the Afghanistan Mission Network Mr. Jeffery Phipps, *CIAV Co-Chair, US Lead, JITC*

TUTORIAL DESCRIPTIONS — *Session 1*

TUTORIAL A: USING DFSS AS AN INTEGRATING FRAMEWORK FOR MBT&E AND DOT&E

This tutorial will provide attendees a comprehensive process to capture all of the activities in MBT&E and DOT&E needed to achieve a successful system acquisition. It will use DFSS in its more expansive connotation, namely Designing for Successful Systems vice Design for Six Sigma, the more common but limited meaning. DFSS starts with the voice of the warfighter (or customer) and the required operational capability. These requirements are then flowed down to the critical performance measures using tools that help to prioritize along the way. The performance measures may include KPPs, MOEs, MOSs, and CTPs. The critical performance measures are linked to key design parameters, and once this linkage is firm, performance optimization can be accomplished. Design of Experiments (DOE) is shown to be a critical player in the design and optimization phases, as well as in every facet of testing and evaluation. Once the design and performance is optimized, it must be validated and the capability rolled back up to the system level capability. DFSS will be shown as an interdisciplinary activity, spanning the activities of systems engineering, reliability engineering, design and optimization, test and evaluation, and system capability confirmation.

TUTORIAL B: EFFICIENT MODELING AND SIMULATION (M&S) USING DESIGN OF EXPERIMENTS (DOE) METHODS

Attendees will learn how Design of Experiments (DOE) methods can be used to extract the most useful information from computer simulation models. They will see how the sequential running of blocks of simulations can be used to conduct the overall fewest trials necessary to do sensitivity analysis of the factors being studied. They will also see how to develop a fast-running (seconds) surrogate model — which testers and analysts can interactively query — of a long-running (hours, days or weeks) simulation. Design solutions will include the application of traditional DOE methods to discrete event and agent-based simulations, and modern space-filling designs to more complex physics-based simulations such as Computational Fluid Dynamics (CFD). When to use, and how to choose between traditional linear regression approximation methods and spatial regression interpolation methods will be discussed. The effective practice of using checkpoint simulations for determining the accuracy of surrogate model predictions will be demonstrated.

TUTORIAL C: TEST PLANNING — ADVANCING THE SCIENCE

Test planning is rapidly becoming a lost art. Many test planning activities are based solely on corporate knowledge and "Like we did it last time" theories. Solidifying requirements development, improving the program's verification and validation activities, increased program collaboration and streamlined test programs are all benefits of a solid and well defined test planning approach. By increasing program collaboration and the overall time spent on the "engineering of a program" while significantly reducing the time required producing the engineering verification and validation artifacts, solid model based test planning can ensure that a test program is more effective across its lifecycle. This tutorial examines the test planning process. From verification to test plan modeling and test plan generation, participants will see the processes and tool sets in action. To demonstrate some of these capabilities, participants will generate test requirements and objectives, model the plan, optimize the plan and assign resources, and finally generate a simple test plan while maintaining connections to the original requirements intent.

TUTORIAL D: TESTING AND EVALUATING INTRANETS, PORTALS, AND ENTERPRISE SYSTEMS FOR USABILITY

This tutorial will teach attendees how to perform intranet, portal, and enterprise usability evaluations. Attendees are encouraged to come with a project in mind as they will be worked on throughout the tutorial. Attendees will learn how to analyze their stakeholders' goals and needs: How to decide who their stakeholders are, decide which stakeholders to include in their evaluation, choose a random sample of end users, and determine stakeholders' goals/needs. Attendees will learn how to design a Usability Evaluation: How to budget time, knowing what types of T&E methods are possible, deciding what methods to use, designing a first-rate survey, determining sample completion tasks, deciding how many methods to use, and how to quantify usability data. Attendees will write a design for their portal evaluation including topics discussed. Information will be provided on How to Evaluate Your Portal Usability Evaluation: Pilot evaluations, participant performance, survey understandability, task understandability, determining if tasks are too easy or too hard, understanding the data, feedback from participants, making improvements. Attendees will also learn how to write their reports. Portal evaluation samples will be provided.

TUTORIAL DESCRIPTIONS — *Session 2*

TUTORIAL E: SHIPS ARE DIFFERENT

Recent fleet concerns with surface ship and system performance have punctuated the need to evolve the Navy's ship T&E processes and practices in such a way that enables acquisition decisions that are based on a framework of mission area effectiveness and suitability. However, because any given ship supports multiple missions through the employment of a complex array of systems, sensors, and weapons, the aforementioned changes truly require a "system of systems" approach. This approach must take care in balancing multiple systems at differing states of lifecycle maturity through their development processes. This necessitates a progressive examination of systems maturity using mission-based, measureable, testable artifacts. This tutorial will discuss the Navy's Mission Based Test Design methodology and illustrate how its application through an Integrated Test process can be used in ship and ship systems acquisition. It will also discuss how this approach can enable improved rigor leading to a better understanding of risks and warfighting effects, thereby facilitating the information quality needed for effective ship deployment decisions.

TUTORIAL F: MODERN DESIGN OF EXPERIMENTS (DOE) METHODS

This tutorial will provide attendees the very latest experimental designs published since 2008. References will be provided for four new types of design that offer testers the ability to run either fewer trials or for the same number of trials, learn more about interactions or quadratic behavior. These recently peer-reviewed designs have not yet made it into textbooks. The new designs include non-regular orthogonal fractional-factorial, robust screening, alias-optimal, and Bayesian D-optimal supersaturated designs. Comparisons between these new alternative methods and traditional designs will be provided to show the new methods are superior or strong competitors.

TUTORIAL G: A DAY IN THE LIFE OF A VERIFICATION STATEMENT

One measure of the quality of a product requirement is that it be verifiable. Verifiability assessment is one of the exit criteria for the Systems Requirements Review and is necessary for requirement validity. Nomination of one or more verification methods (examination, analysis, demonstration or test) is often taken as the sole evidence of verifiability. A completed Verification Cross Reference Matrix is frequently considered as the final verifiability assessment and responsibility for the remainder of the verification effort is transferred to the test and evaluation and other implementing communities for completion. Lessons learned from many programs have shown that a more robust application of systems engineering should include the requirements engineers (with detailed knowledge of product requirement intent) working with the verification implementing organizations as the best combination to define the verification requirements. Such definition should include statement of the verification objectives, success criteria and environment. Including this information in the "Quality Assurance" section of the requirements document allows for buy-in by the customer well in advance of implementing the verification activities. This information is used by verification personnel to generate one or more verification plans and to develop the detailed verification program. Verification requirements are planned into verification events which are executed using the proper system elements and environments. These verification requirements are key to establishing long lead verification facilities, tools and laboratories. Early definition of these requirements helps prevent facility re-designs and verification re-plans that can cause expensive delays. Finally, verification data analysis is performed, and the information compiled into verification reports certifying system product requirements compliance. This robust verification approach will provide proof of requirements satisfaction, leading to systems that meet the customers' needs at a lower life-cycle cost. This presentation explores the value of well-crafted verification requirements developed early in the Program. A "Day in the Life of a Verification Requirement" shows the interaction and benefits of verification requirements to the verification execution teams. The presentation will offer a lifecycle description of the verification requirement from conception to certification.

TUTORIAL DESCRIPTIONS — *Session 2 Continued*

TUTORIAL H: DEFENSE INFORMATION SYSTEMS AGENCY JOINT INTEROPERABILITY TEST COMMAND INTEROPERABILITY SUPPORT FOR THE AFGHANISTAN MISSION NETWORK

USCENTCOM operates in a coalition environment and must be able to generate and pass critical information to U.S. and coalition partners. The Command and NATO, as members of the International Security Assistance Forces (ISAF), understand that widespread interoperability is a key component to achieve effective and efficient operations. These communication capabilities must include a wide variety of not only military governmental operations, but also non-governmental agencies and industrial partners. To that end, they've created the Afghan Mission Network (AMN) and commissioned the Defense Information Systems Agency's Joint Interoperability Test Command to develop the Coalition Test and Evaluation Environment (CTE2) testing arm of the Coalition Interoperability Assurance and Validation (CIAV) process. The AMN is the backbone or core infrastructure that will provide long-term communications and information system and satellite communication services to support the ISAF as it expands its operations across the country during the ongoing operations. This tutorial will discuss the eight core critical Coalition Mission threads, phases for testing, and how the JITC stood up a network and is testing the systems in a distributed hardware in the loop environment to ensure interoperability across the AMN. It will also discuss the applicability to other theaters that may need to implement a similar process.

TUESDAY, MARCH 15, 2011

7:00 AM - 6:30 PM **CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION**

7:00 AM - 8:00 AM **CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D**

8:00 AM **OPENING REMARKS - GRAND SALONS E-F**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

8:05 AM **TRIBUTE TO OUR NATION AND WARFIGHTERS, NATIONAL ANTHEM**

SESSION A: CONFERENCE WELCOME & KEYNOTES

8:10 AM **WELCOME AND CONFERENCE INTRODUCTORY REMARKS**

- Mr. James O'Bryon, *Chairman, NDIA T&E Division; The O'Bryon Group*

8:20 AM **CONFERENCE KEYNOTE ADDRESS**

- Honorable Dr. J. Michael Gilmore, *Director, Operational Test & Evaluation, OSD*

Honorable Dr. J. Michael Gilmore was sworn in as Director of Operational Test and Evaluation on September 23, 2009. A Presidential appointee confirmed by the United States Senate, he serves as the senior advisor to the Secretary of Defense on operational and live fire test and evaluation of Department of Defense weapon systems. Prior to his current appointment, he was the Assistant Director for National Security at the Congressional Budget Office (CBO), and was responsible for CBO's National Security Division. Dr. Gilmore is a former Deputy Director of General Purpose Programs within the Office of the Secretary of Defense, Program Analysis and Evaluation (OSD(PA&E)). Dr. Gilmore also has served as the Division Director of Operations Analysis and Procurement Planning, within the Office of the Deputy Director, Resource Analysis and as an Analyst for Strategic Defensive and Space Programs Division, Office of the Deputy Director, Strategic and Space Programs. Dr. Gilmore's service with Program Analysis and Evaluation covered 11 years. Early in his career, Dr. Gilmore worked at the LLNL, Livermore, California performing research in their magnetic fusion energy program. He has also worked with Falcon Associates, McLean, VA, and the McDonnell Douglas Washington Studies and Analysis Group. Dr. Gilmore is a graduate of MIT where he earned a B.S. in Physics. He subsequently earned a M.S. and Ph.D. in Nuclear Engineering from the University of Wisconsin.

TUESDAY, MARCH 15, 2011

9:00 AM **GUEST SPEAKER**

- Honorable Frank Kendall, *Principal Deputy Under Secretary of Defense, AT&L, OSD*

Mr. Frank Kendall was sworn in as Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics (PDUSD(AT&L)) on March 5, 2010. In his role as PDUSD(AT&L), Mr. Kendall is authorized to act for and provide assistance to the Under Secretary of Defense for Acquisition, Technology & Logistics (USD(AT&L)). He also advises and assists the USD(AT&L) in providing staff advice and assistance to the Secretary of Defense on the acquisition system; research and development; modeling and simulation; systems engineering; advanced technology and developmental test and evaluation. Within government, Mr. Kendall held the position of Director of Tactical Warfare Programs in the Office of the Secretary of Defense and the position of Assistant Deputy Under Secretary of Defense for Strategic Defense Systems. Mr. Kendall was also Vice President of Engineering for Raytheon Company. Mr. Kendall also spent ten years on active duty with the Army serving in Germany, teaching Engineering at West Point, and holding research and development positions. He is a Distinguished Graduate of the U.S. Military Academy at West Point and he holds a Masters Degree in Aerospace Engineering from California Institute of Technology, a Master of Business Administration degree from C.W. Post Center of Long Island University, and a Juris Doctoris from Georgetown University Law Center.

9:30 AM **HOMELAND SECURITY T&E PERSPECTIVES**

- Mr. Gary Carter, *Director, Test & Evaluation and Standards Division, Department of Homeland Security*

10:00 AM **MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION B: OTA'S (OPERATIONAL TEST AGENCY'S) ROUNDTABLE

Session B Chair and Roundtable Moderator: Dr. Catherine Warner, *Science Advisor, DOT&E, OSD*

10:30 AM **ROUNDTABLE**

- MG Genaro Dellarocco, USA, *Commander, ATEC*
- RADM David Dunaway, USN, *Commander, OPTEVFOR*
- Maj Gen David Eichhorn, USAF, *Commander, AFOTEC*
- Col David Reeves, USMC, *Commander, MCOTEA*
- COL Joseph Puett, USA, *Commander, JITC*

11:30 AM **WALTER W. HOLLIS HONORS LUNCHEON: PRESENTATION FOR OUTSTANDING LIFETIME ACHIEVEMENT IN DEFENSE TEST & EVALUATION - FLORIDA SALONS I-IV**

- Dr. James N. Walbert, *Chief Scientist, SURVICE Engineering Company*

Dr. Walbert has more than 35 years of DoD T&E and related experience including extensive and novel work as an interior and exterior ballistician, a vulnerability/lethality tester and analyst, a materials engineer, and an author and instructor. From 1974 to 1978, Dr. Walbert served as a mathematician and test director for the U.S. Army Material Testing Directorate, where he planned, analyzed, evaluated, and assessed a wide range of engineering test programs. From 1978 to 2000, he served as a research scientist/engineer for the Ballistic Research Laboratory (and then the Army Research Laboratory) and from 2001 to 2003, Dr. Walbert served as Chief Scientist for the DARPA Future Combat Systems Program Office. Since joining SURVICE in 2003 as the Chief Scientist, Dr. Walbert has developed numerous analytical processes for exploitation of ballistic test data. He has authored/co-authored more than 50 technical publications during his career, including the AIAA-published text *Fundamentals of Ground Combat System Ballistic Vulnerability/Lethality*, which was named ARL's Publication of the Year for 2009. Based on this text, Dr. Walbert also developed and teaches a highly acclaimed basic ballistic vulnerability course to Government and industry practitioners throughout the T&E community. Dr. Walbert holds a B.S., M.S., and Ph.D. in mathematics all from the University of Delaware.

11:30 AM LUNCHEON GUEST SPEAKER: SOME PROBLEMS OF CYBER SECURITY

- Mr. Robert L. Deitz, *former General Counsel, National Security Agency*

Robert L. Deitz is currently Distinguished Visiting Professor & CIA Officer-in-Residence at George Mason University. From 2006 until February 2009 he served as Senior Councillor to the Director of the Central Intelligence Agency. From September 1998 to September 2006 he was the General Counsel at the National Security Agency where he represented the NSA in all legal matters. He has also held positions as Acting General Counsel at the National Geospatial-Intelligence Agency and as Acting Deputy General Counsel, Intelligence, at the Department of Defense. Professor Deitz began his career as a law clerk to the Honorable Justices Douglas, Stewart, and White of the United States Supreme Court. He has also been in private practice and was Special Assistant to Deputy Secretary of State Warren Christopher and to Secretary of Health, Education and Welfare Joseph Califano during the Carter Administration. Professor Deitz received his J.D. (magna cum laude) from Harvard Law School, where he was the Supreme Court Note and Note Editor of the Harvard Law Review. He received an M.P.A. from the Woodrow Wilson School of Public and International Affairs at Princeton University, where he studied international politics and economics. He majored in English literature at Middlebury College where he received a B.A. (cum laude) and became a member of Phi Beta Kappa.

SESSION C: ACQUISITION REFORM - THE IMPACT ON INDUSTRY

Session C Chair: Dr. Suzanne Beers, *MITRE Corporation*

1:15 PM PENTAGON RESPONSE TO CONGRESSIONAL STRENGTHENING OF DT&E

- Mr. Chris DiPetto, *Principal Deputy, Developmental Test & Evaluation*

1:45 PM REPORT ON NDIA'S INDUSTRIAL COMMITTEE ON TEST & EVALUATION (ICOTE)

- Mr. James Ruma, *Chairman, NDIA ICOTE; Vice President, Engineering, GDLS*

2:15 PM - 5:25 PM CONCURRENT SESSIONS D - K

SESSION	SESSION CHAIR	2:15 PM	2:40 PM	3:05 PM
SESSION D Suitability/ Reliability Grand Salon G	Dr. James Streilein, *DOT&E, OSD*	11460 - Software Reliability Growth Test Approach Mr. Louis Gullo, *Raytheon Company*	11627 - Assessing System Reliability Growth When Failure Modes are Masked Dr. Patricia Jacobs, *Naval Postgraduate School*	11650 - Realistic and Measurable Suitability Requirements for Test 1st Lt Andrew Passey, USAF, *Air Force T&E Center, Detachment 6*
SESSION E How Re-Energized DT&E Can Better Support the Total Acquisition Process Grand Salon H	Mr. Tom Wissink, *Lockheed Martin*	11563 - Integrated Test and Independent Evaluation (IT&IE) and T&E Using Experimental Design Methodology Mr. George Axiotis, *DDR&E/DDT&E*	11665 - OSD Perspective of DT&E in Navy Shipbuilding Programs Mr. Patrick Clancy, *OUSD(AT&L) DDR&E/DDT&E*	11656 - An Industry Response to the Acquisition Changes Mr. Steve Scukanec, *Northrop Grumman Aerospace Sector*
SESSION F Mission-Based Capability Assessments (MBT&E) Grand Salon I	Dr. Paul Deitz, *AMSAA*	11499 - Emerging Methodology for Mission-Based Capability Assessments Mr. William Landis, *ARL/SLAD*	11557 - Measures Development Standard Operating Procedure (SOP) Mr. John Smith, *Operational Test & Evaluation Force*	11666 - Understand the Mission — A "How-To" Guide for MBTE Practitioners Mr. Britt Bray, *DRC*
SESSION G T&E In Support of Rapid Fielding for Combat Grand Salon J	CDR Ernest Swauger, USN (Ret), *CM/HD Systems IPAT*	11662 - Design Methodology for Expedient, Low Cost UAV Runways Mr. Lorenz Eber, *Naval Surface Warfare Center, Dahlgren*	11679 - Overview of the Joint/ Coalition Mission Thread Measures Development Standard Operating Procedure Mr. Max Lorenzo, *DISA*	

TUESDAY, MARCH 15, 2011

3:30 PM **AFTERNOON BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION	SESSION CHAIR	3:45 PM	4:10 PM	4:35 PM	5:00 PM
SESSION H Test & Evaluation of Systems of Systems Grand Salon G	Dr. James Streilein, *DOT&E, OSD*	11577 - Mission-Based Test Design for Complex Systems of Systems and Platforms Mr. Joseph Tribble, *AVW Technologies*	11642 - Joint Command and Control Assessments: Rapid Fielding, Integrated Testing and Implications, Approaches and Lessons Mr. Brian Eleazer, *SCRA/ATI*	12878 - DoD Strategic Planning for Test and Evaluation Mr. Lee Schonenberg, *Whitney, Bradley and Brown Consulting*	11709 - Decoupled Test, Evaluation, and Certification of a System of Systems Mr. Robin Murray, *JITC*
SESSION I Emerging T&E Range/ Instrumentation Needs Grand Salon H	Mr. Dick Dickson, *Tybrin Corporation*	11564 - The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results Dr. Sultan Mahmood, *Air Armament Center, AAC/EB*	End-to-End GPS Multi-Platform Integrated System Testing for MGUE Dr. Sultan Mahmood, *Air Armament Center, AAC/EB*	11640 - Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements Mr. Doug Weatherford, *PM ITTS IMO*	11645 - Holographic Radar Brings a New Dimension to Sensing and Instrumentation on T&E Ranges Mr. Gary Kemp, *Cambridge Consultants*
SESSION J Bigger Bang for the Dollar Invested - DT&E Grand Salon I	Dr. Mark Kiemele, *Air Academy Associates*	11467 - Guiding the Engineer Through the T&E Process Mr. Allen Brailey, *Raytheon Company*	11483 - How to Frame a Robust Sweet Spot Via Response Surface Methods (RSM) Mr. Mark Anderson, *Stat-Ease, Inc.*	11553 - MIL-PRF-XX613 and MIL-STD-X618: The Navy Gets Serious About Armor Mr. Christopher Brown, *Naval Surface Warfare Center, Crane*	11541 - Fragment Analysis for the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) Ms. Karen Pizzolato, *U.S. Army Research Laboratory*
SESSION K Bigger Bang for the Dollar Invested - OT&E Grand Salon J	Dr. Paul Deitz, *AMSAA*	11516 - Mission-Based Test and Evaluation Strategy: Progress Towards Uniting Combat Developer, Materiel Developer and T&E Mr. Christopher Wilcox, *U.S. Army Evaluation Center*	11552 - Using Complementary Frameworks for Qualitative Data Collection During OT&E: Piggybacking on Operational Experiments Ms. Chiesha M. Stevens, *Pacific Science & Engineering Group, Inc.*	11699 - Continuous Cost Reduction Feeds Back into Product Reliability Mr. Jonathan Nikkel, *Raytheon Missile Systems*	11704 - Testing & Evaluating the Net-Ready Key Performance Parameter (KPP) Ms. Danielle Koester, *JITC*

5:30 PM - 6:30 PM **RECEPTION IN THE DISPLAY AREA - GRAND SALONS A-D**

6:30 PM **CONFERENCE ADJOURNED FOR THE DAY**

WEDNESDAY, MARCH 16, 2011

7:00 AM - 5:25 PM **CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION**

7:00 AM - 8:00 AM **CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D**

8:00 AM **INTRODUCTION AND OPENING REMARKS - GRAND SALONS E-F**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

WEDNESDAY, MARCH 16, 2011 — *Continued*

SESSION L: A RE-ENERGIZED DT&E

Session L Chair: Mr. John Illgen, *Chairman, NDIA National Board; Northrop Grumman*

8:05 AM **PANEL: T&E: SERVING THE WARFIGHTER IN A COST-CONSTRAINED ENVIRONMENT**

Panel Moderator:

- Mr. Chris DiPetto, *Principal Deputy, Developmental Test & Evaluation*

Panelists:

- Mr. David K. Grimm, *Acting Director, Deputy Under Secretary of the Army, T&E Office*
- Mr. Steve Hutchison, *DISA T&E Executive*
- Mr. John Manclark, *Air Force T&E Executive*
- Ms. Amy Markowich, *Navy T&E Executive*
- Mr. Tom Wissink, *Director of Integration, T&E, Lockheed Martin*

9:00 AM **SPECIAL GUEST PRESENTATION:**
EVALUATION OF THE SINKING OF THE CHEONAN KOREAN NAVAL SHIP

- MG Jong Sung Yoon, *Republic of Korea Army (Ret), Leader of the International Investigation Team*

Rarely does one have the opportunity to fully investigate the circumstances leading up to the attack on and sinking of a warship and then be able to recover the ship and perform an extensive international investigation of the threat, the damage and casualties, the computer modeling of the damage and assessment of the causes and effects. MG Yoon led the international investigation team of which the US was an integral part into the sinking of the Republic of Korea's warship, the CHEONAN, this past year. His insights should be instructive and of great interest to the conference attendees. It is a privilege to welcome him to be a special part of our conference this year.

In addition, MG Yoon will be joined by Dr. Young Shin, Professor, Naval Postgraduate School and visiting Professor, Korean Advanced Institute for Science and Technology, to discuss the efforts of the International Investigation Team addressing the CHEONAN sinking.

MG Jong-Sung Yoon was born on April 4th, 1975 in Inje-gun, Gangwon-do, Korea. In 1981, he received his B.S. from the Korea Military Academy (37th); in 1999, MG Yoon received his M.S. in Science of public administration from Dongguk University; in 2008, he received his Ph.D. in Politics from Myongji University.

10:00 AM **MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION M: RESPONSIVE AND AGILE INFORMATION SYSTEMS T&E PANEL

Session M Chair and Panel Moderator: Dr. Steve Kimmel, *Chairman, NDIA C4ISR Division; Senior Vice President, Alion Science & Technology*

10:30 AM **PANEL**

Panelists:

- Dr. Steven Hutchison, *Director T&E, DISA*
- Dr. James Streilein, *Deputy Director, Net-Centric and Space Systems, DOT&E*
- Ms. Darleen Mosser-Kerner, *Deputy Director, Capabilities Development, Office of the Director, DT&E*
- Mr. Eustace King, *Chief, Acquisition and Technology, DOD-CIO/NII*

WEDNESDAY, MARCH 16, 2011

11:30 AM — **LUNCHEON - TESTER OF THE YEAR AWARDS - FLORIDA SALONS I-IV**

This awards event is a highlight of our annual conference since it provides the opportunity to recognize outstanding achievement in test and evaluation by members of our armed forces, DoD civilians and DoD contractors. Furthermore, what makes these awards particularly noteworthy is that the selections are made by the organizations of those being recognized. Congratulations to all who are being recognized for their 2010 accomplishments.

SESSION N: IMPROVING THE T&E PROCESS

Session N Chair: Dr. Lowell Tonnessen, *IDA*

1:15 PM — **T&E AND MISSION ASSURANCE**

- Mr. James W. Wade, *Vice President, Raytheon Company*

1:45 PM — **SOCOM T&E PERSPECTIVES: SERVING THE WARFIGHTER**

- LTC Kevin Vanyo, USA, *USSOCOM J8-O*
- Mr. Robert D. Werner, Jr., *Senior Test Officer, USSOCOM J8-O*

2:15 PM - 5:25 PM — **CONCURRENT SESSIONS O - V**

SESSION	SESSION CHAIR	2:15 PM	2:40 PM	3:05 PM
SESSION O T&E M&S for Specific Applications Grand Salon G	RADM Bert Johnston, USN (Ret), *Wyle Corporation*	11560 - A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops Mr. Stephen Swann, *U.S. Army Research Laboratory*	11529 - Expanding Use of the Probability of Raid Annihilation (PRA) Test Bed Across the Ship Self-Defense Enterprise Mr. Richard Lawrence, *AVW Technologies*	
SESSION P Approaches to Organizing an Effective M&S Program in Support of T&E Grand Salon H	Mr. Britt Bray, *DRS Corporation*	11500 - Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E) Mrs. Beth Ward, *U.S. Army Research Laboratory*	11476 - A Paradigm for Modeling and Simulation in support of Mission-Based Test and Evaluation Dr. James Walbert, *SURVICE Engineering Company*	
SESSION Q T&E Instrumentation Infrastructure - Maximum Utilization of Available Resources Grand Salon I	Mr. Dick Dickson, *Tybrin Corporation*	11497 - Joint Mission Environment Test Capability (JMETC): Improving Distributed Capabilities Mr. Chip Ferguson, *JMETC*	11508 - U.S.N. RDTE Project Support Aircraft Mr. Charles Myers, *U.S. Navy, NAWCAD*	11626 - Dugway Proving Ground as the MRTFB Chem Bio Activity Ms. Jean Baker, *U.S. Army Dugway Proving Ground*
SESSION R Applications of Design of Experiments (DoE) to T&E Grand Salon J	Mr. Martin Woznica, *Raytheon Company*	11677 - Using Design of Experiments (DoE) to Integrate Developmental and Operational T&E Dr. Mark Kiemele, *Air Academy Associates*	11549 - Probability Driven Experiments Design for Autonomous Systems Mr. Troy Jones, *Charles Stark Draper Laboratory*	11532 - Design of Experiments: Managing Expectations Mr. James Carpenter, *AVW Technologies, Inc.*

WEDNESDAY, MARCH 16, 2011 — *Continued*

3:30 PM **AFTERNOON BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION	SESSION CHAIR	3:45 PM	4:10 PM	4:35 PM	5:00 PM
SESSION S T&E M&S for Specific Applications (Cont...) Grand Salon G	Mr. Britt Bray, *DRS Corporation*	11538 - Personnel Injury Analysis of Reflective Spall Mrs. Rebecca VanAmburg, *U.S. Army Research Laboratory*	11539 - Analytical Approach Using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA) Mr. Richard Moyers, *U.S. Army Research Laboratory*	11674 - Utilization of Model and Simulation for Network Waveform Characterization and Validation Mr. Scott Rediger, *Rockwell Collins*	11708 - A Proposal for Robotic Entityy Safety Release Dr. Jeffrey Mosley, *OptiMetrics, Inc.*
SESSION T Approaches to Organizing an Effective M&S Program in Support of T&E (Cont...) Grand Salon H	CDR Ernest Swauger, USN (Ret), *CM/HD Systems IPAT*		11676 - Model Based Systems Engineering and M&S Adding Value to T&E Mr. Larry Grello, *High Performance Technologies, Inc.*	11554 - The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live Fire Test and Evaluation Mr. Scott Hornung, *U.S. Army Research Laboratory/ SLAD*	
SESSION U T&E Instrumentation Infrastructure — Maximum Utilization of Available Resources (Cont...) Grand Salon I	Dr. Suzanne Beers, *MITRE Corporation*	11638 - Army Testing in a Services Oriented Architecture (SOA) Environment Mr. Michael Phillips, *Mantech International*	11639 - The Test and Training Enabling Architecture (TENA) Enabling Technology for the Joint Mission Environment Test Capability (JMETC) in Live, Virtual, and Constructive (LVC) Environments Mr. Gene Hudgins, *TENA/ JMETC*	11682 - Advanced Range Data System (ARDS) Service Life Extension Program (SLEP) - "Ensuring GPS Based TSPI Remains a Viable T&E Range Instrumentation Asset" Mr. Dick Dickson, *TYBRIN Corporation*	11698 - Target Systems in Support of Test and Evaluation Mr. James Schwierling, *U.S. Army Targets Management Office*
SESSION V Developmental Testing & Operation Testing Challenges Grand Salon J	Mr. Chuck Larson, *SURVICE Engineering*	11524 - Ready for Scrum? Dr. Steven Hutchison, *DISA*	11649 - Affordable Test and Evaluation in a Complex World Mr. Thomas Wissink, *Lockheed Martin*	11710 - Testing U.S. Systems for Coalition Interoperability LTC Tim Timmons, USA, *JITC*	11659 - Impacts of the Learning Curve — Operational Test & Evaluation Ms. Shannon Krammes, *MCOTEA*

5:25 PM **CONFERENCE ADJOURNED FOR THE DAY**

THURSDAY, MARCH 17, 2011

7:00 AM - 12:00 NOON CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION

7:00 AM - 8:00 AM **CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D**

8:00 AM **INTRODUCTION AND OPENING REMARKS - GRAND SALONS E-F**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

THURSDAY, MARCH 17, 2011 — *Continued*

SESSION W: TEST DESIGN, TEST CURRICULA AND STANDARDS

Session W Chair: Dr. Paul Deitz, *former Technical Director, AMSAA*

8:05 AM	**SYSTEMS ENGINEERING PLANS: HOW TO RECOGNIZE PROBLEMS, SET GOALS AND IMPLEMENT IMPROVEMENTS** ▸ Dr. Don McKeon, *Defense Acquisition University*
8:30 AM	**11690 - DOING MORE WITHOUT MORE - SCIENTIFIC T&E DESIGN METHODOLOGIES (STED IN DoD WEAPONS SYSTEMS AQUISITION)** ▸ Ms. Darleen Mosser-Kerner, *Deputy Director, Capabilities Development, Office of the Director, DT&E*
8:55 AM	**WHAT ARE WE TEACHING OUR PMs AND ACQUISITION PROFESSIONALS ABOUT T&E?** ▸ Col Michael Bohn, USMC (Ret), *Faculty, Defense Acquisition University*
9:10 AM	**REPORT ON STANDARDS FOR DT&E** ▸ CDR Ernest Swauger, USN (Ret), *JPEO-CBD/Chief, CM/HD Systems IPAT*
9:35 AM	**11663 - EFFECTIVE COMBAT DATA COLLECTION & APPLICABILITY TO T&E** ▸ LtCol Michael Kennedy, USMC, *Expeditionary Test Division, MCOTEA*
10:00 AM	**MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**
10:30 AM - 2:00 PM	**BREAKDOWN OF DISPLAYS**

SESSION X: CONFERENCE SYNOPSIS FORUM

Session X Chair: Dr. Paul Deitz, *former Technical Director, AMSAA*

10:30 AM	**11651 - TEST & EVALUATION ISSUES FOR SYSTEMS OF SYSTEMS (SoS): CREATING SLEEP AIDS FOR THOSE SLEEPLESS NIGHTS** ▸ Dr. Beth Wilson, *Principal Engineering Fellow, Raytheon Company*
10:55 AM	**11569 - T&E - GUARDING THE REQUIREMENTS INTENT** ▸ Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*
11:25 AM	**CONFERENCE SYNTHESIS PANEL** ▸ Dr. Suzanne Beers, *T&E Group Leader, MITRE Corporation* ▸ Mr. Britt Bray, *Military Analyst and Department Manager, DRC Corporation* ▸ Mr. Brian Simmons, *Executive Technical Director/Deputy to the Commander, U.S. Army Test and Evaluation Command* ▸ Dr. James Streilein, *Deputy Director, OSD, DOT&E* ▸ Dr. Catherine Warner, *Science Advisor, OSD, DOT&E*
11:55 AM	**CLOSING REMARKS** ▸ Mr. James O'Bryon, *Chairman, NDIA T&E Division; The O'Bryon Group*
12:00 NOON	**CONFERENCE ADJOURNS**

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
11499	Emerging Methodology for Missions-Based Capability Assessments	Mr. Kevin Agan
11529	Expanding Use of the Probability of Raid Annihilation (PRA) Testbed Across the Ship Self-Defense Enterprise	Mr. Chris Hauser Mr. Steve Mulleavy
11532	Design of Experiments: Managing Expectations	Mr. Chris Hauser Mr. Steve Mulleavy Mr. Kenneth Culpepper
11538	Personnel Injury Analysis of Reflective Spall	Mr. Robert Kinsler
11539	Analytical Approach using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA)	Mrs. Penny Willard
11549	Probability Driven Experimental Design for Autonomous Systems	Mr. Stephen York Dr. Nicholas Borer Mr. Scott Ingleton
11552	Using Complementary Frameworks for Qualitative Data Collection during OT & E: Piggybacking on Operational Experiments	Ms. Chiesha Stevens
11560	A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops	Mr. Stephen Swann Mr. Gregory Dietrich
11563	Integrated Test and Independent Evaluation (IT&IE) and T&E using Experimental Design Methodology	Col Mickey Quintrall, USAF (Ret)
11564	The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results	Mr. Michael Flinn Mr. Emmanuel Piniero Mr. Gary Green Mr. Larry Vallot
11569	T&E - Guarding the Requirements Intent	Mr. Eric Kaplan
11627	Assessing System Reliability Growth when Failure Modes are Masked	Dr. Donald Gaver
11638	Army Testing in a Services Oriented Architecture (SOA) Environment	Dr. Philip Hammonds Mr. Frank Vitoria Mr. Malcolm Lee
11640	Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements	Mr. Minh Vuong
11642	Joint Command and Control Assessments: Rapid Fielding, Integrated Testing and Implications, Approaches and Lessons	Mr. Steve Reeder
11651	Test and Evaluation Issues for System of Systems: Creating Sleep Aids for Those Sleepless Nights	Ms. Darlene Mosser-Kerner Mr. Tom Wissink
11656	An Industry Response to the Acquisition Changes	Mr. Steve Scukanec
11659	Impacts of the Learning Curve — Operational Test & Evaluation	Ms. Brittney Cates
11663	Effective Combat Data Collection & Applicability to T&E	Mr. Mark Flannery
11665	OSD Perspective of DT&E in Navy Shipbuilding Programs	Mr. Michael Melvin Mr. Joseph Terlizzese, Jr.

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
11676	Model Based Systems Engineering and M&S adding value to T&E	Mr. Frank Salvatore Mr. Richard Swanson
11703	Ships Are Different	Ms. Megan Vanderberry Mr. Jeff Bobrow
11705	Defense Information Systems Agency Joint Interoperability Test Command Interoperability Support for the Afghanistan Mission Network	Mr. Byron Baker Mr. Todd Rissinger
11709	Decoupled Test, Evaluation, and Certification of a System of Systems	Mr. Harold Maynard
	Report on Standards for DT&E	Dr. Juan Vitali

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

Rockwell Collins is a pioneer in the design, production and support of innovative solutions for our customers in aerospace and defense. Our expertise in open architectures, advanced wireless communications, information management and assurance, and simulation and training is strengthened by our global service and support network spanning 27 countries. Working together, our global team of 20,000 employees shares a vision to create the most trusted source of communication and aviation electronics solutions.

We deliver on our commitments by developing new technology to enable network-centric operations and delivering range instrumentation solutions that enable the precise tracking of position and orientation of aircraft and ground vehicles. In addition, Rockwell Collins leverages industry-leading partners, proven technologies, multi-level encryption and open architectures that not only provide the technical capabilities needed today, but can be scaled to meet future needs.

We back our commitments by providing a level of service and support that increases reliability and lowers operational costs for our customers throughout the world.

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27TH ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

"Test & Evaluation: Serving the Warfighter"

MARCH 14-17, 2011
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March 12-15, 2012
Hilton Head Island, SC

Raytheon

Customer Success Is Our Mission

11467 – Guiding the Engineer through the T&E Process

Allen Brailey
Engineering Fellow
Raytheon Missile Systems
520.794.5641
acbrailey@raytheon.com
15 March 2011

Who We Are

Raytheon Corporation

Raytheon Missile Systems (RMS)

Engineering

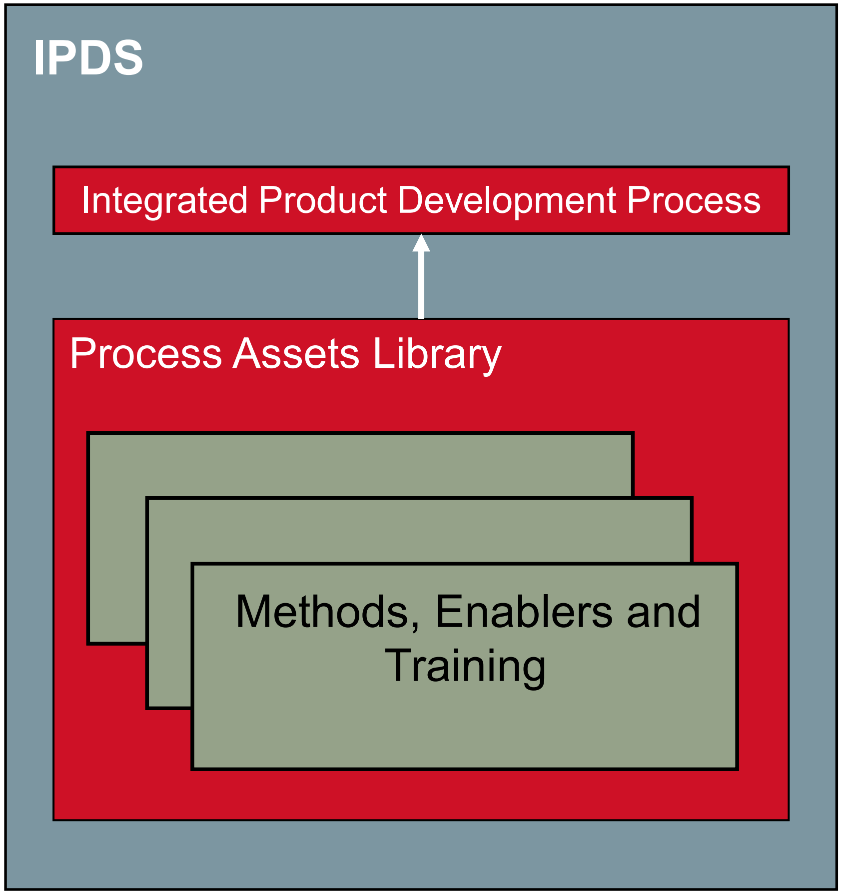
Systems Test Directorate

- System Test Director reports to RMS VP of Engineering
- Three Major Elements of Systems Test
  - Hardware in the Loop (HWIL) simulators
  - Special Test Equipment
  - Integration and Verification

Raytheon

Command Media

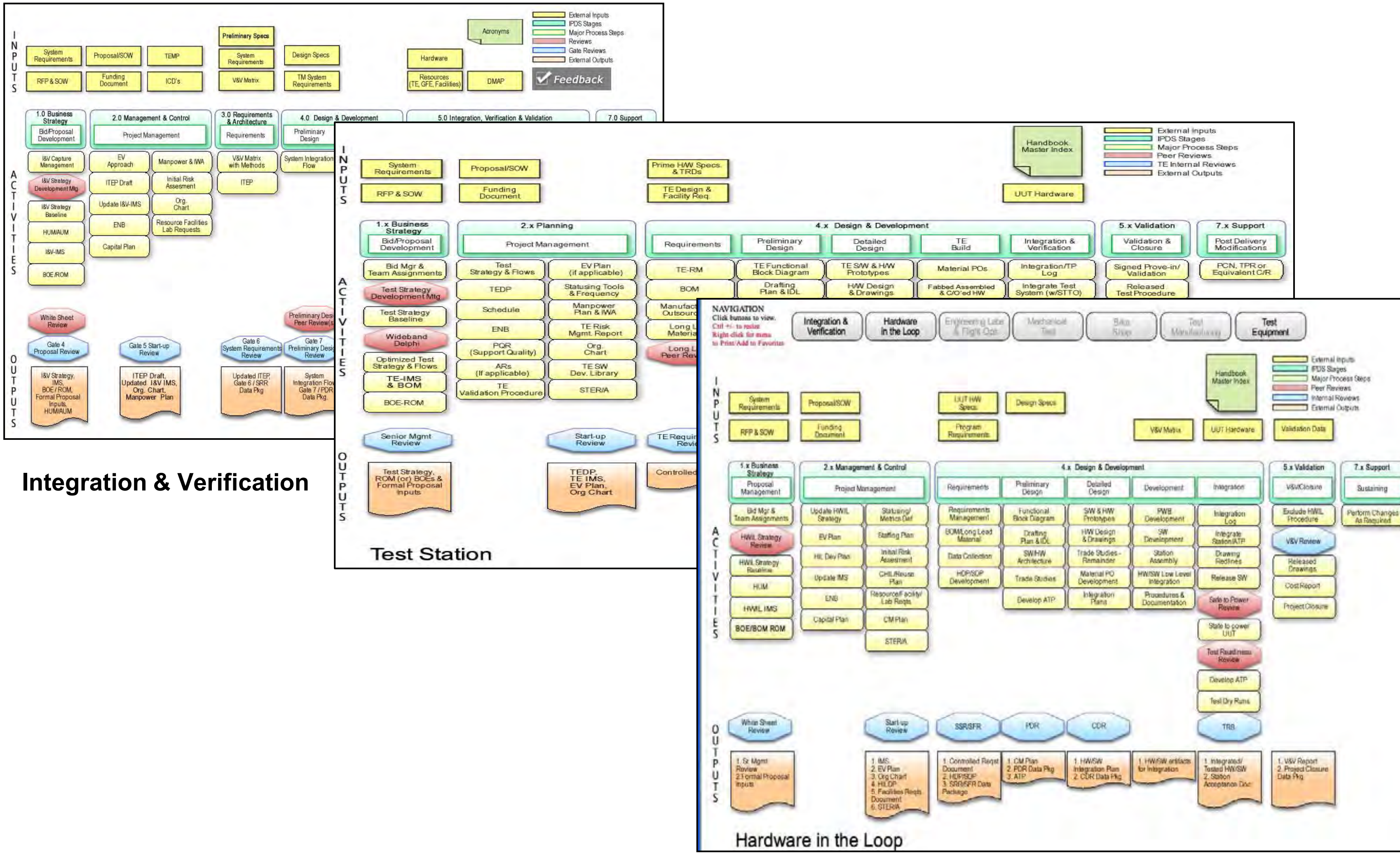
- Numerous sources for command media
  - Corporate: Integrated Product Development System
  - Business Unit (RMS) Directives
  - Organizational Directives
  - Program Directives



How We Do Our Job

Raytheon

One Page Process (1PP) tailored to discipline

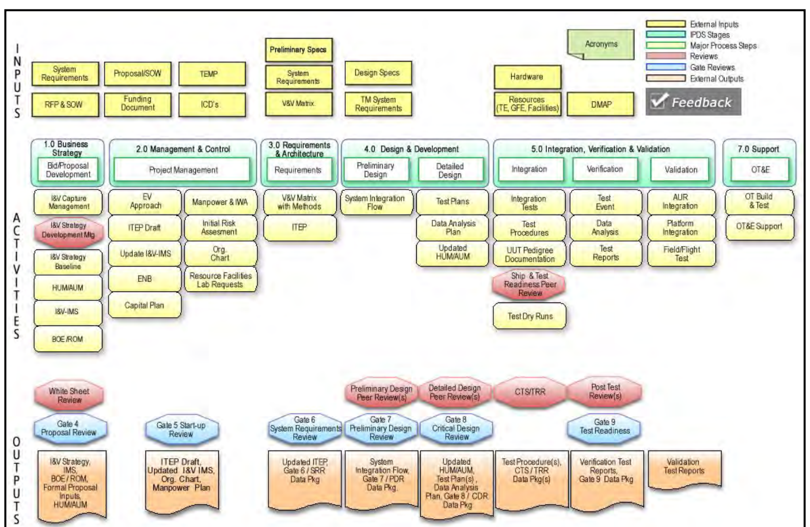


Integration & Verification

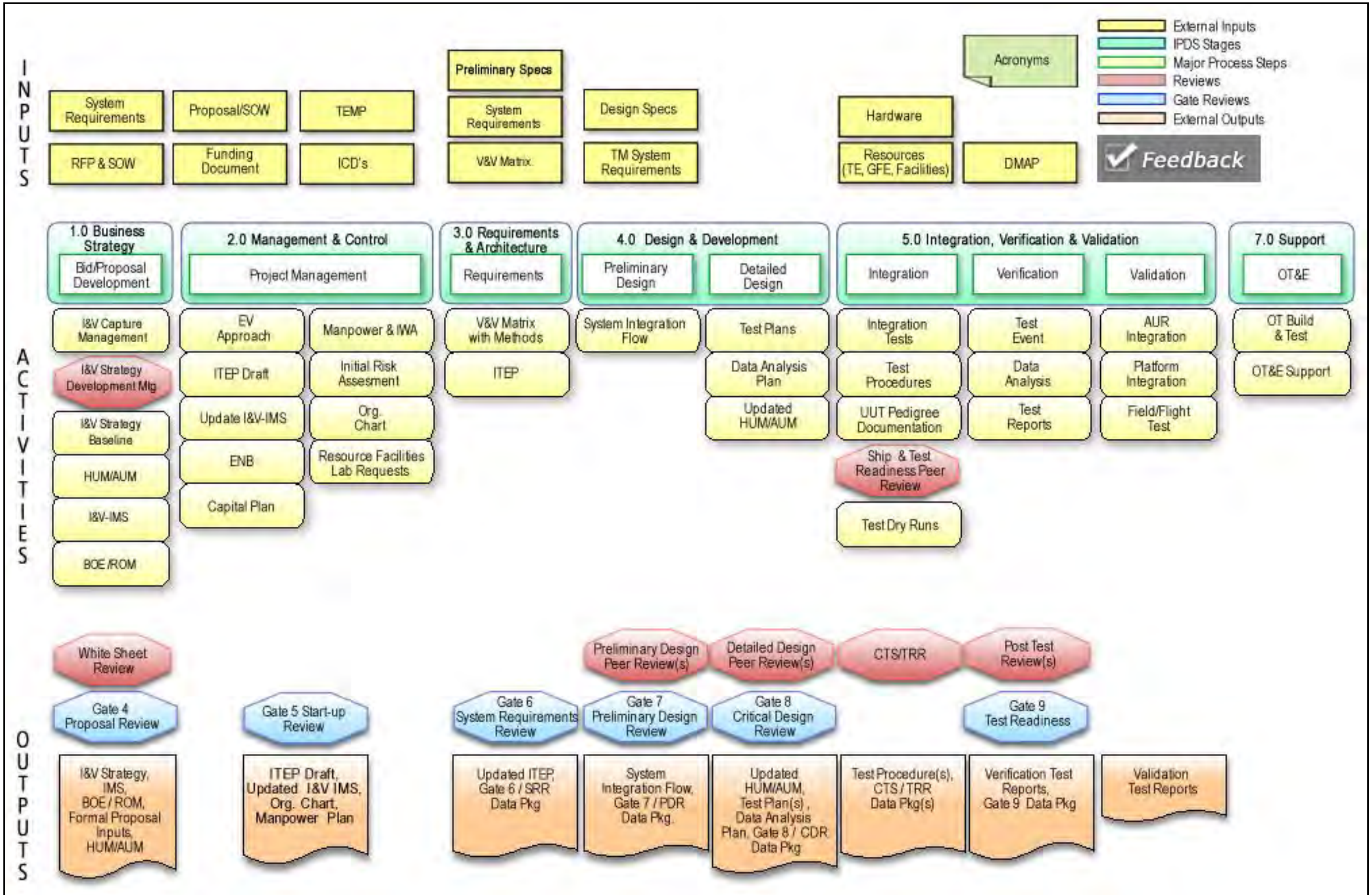
Designed to follow the life cycle of a program from proposal to production

One Page Process Web Page

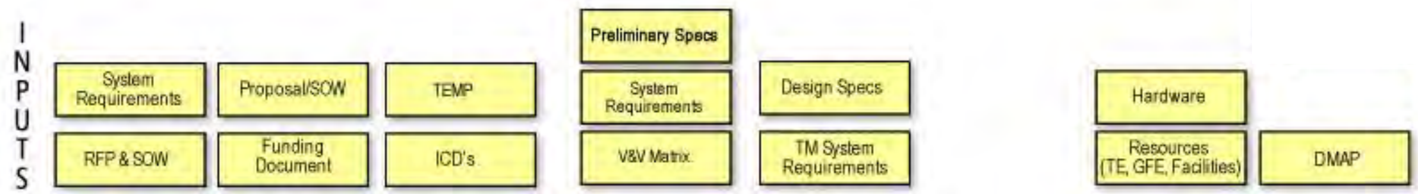
- Acts as a front end that provides linkages back to command media
- Includes Test Equipment, HWIL, I&V
  - continue to work to incorporate all functions in the directorate
- HTML/Web based & accessible from directorate home page



Details on I&V Process



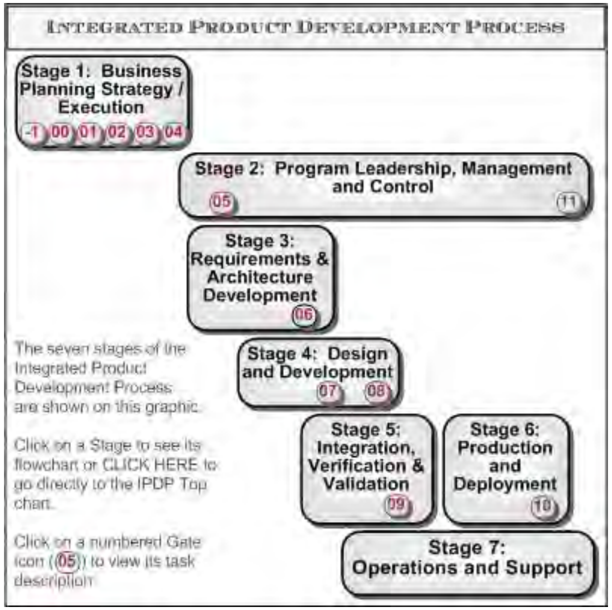
Input Across Top



Inputs: Documentation/Products which are expected to be received from **outside** the I&V organization

Stages

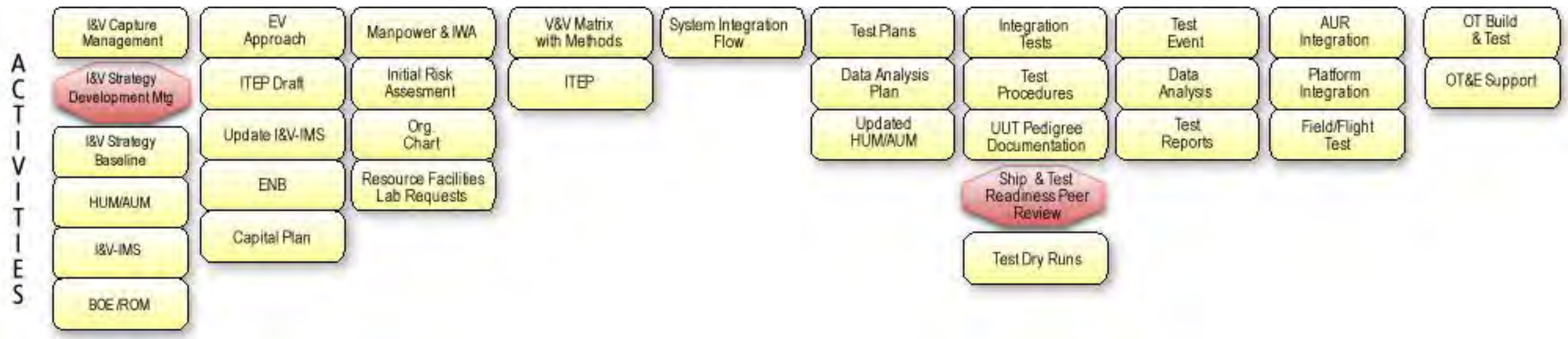
The One Page Process is structured around the existing IPDS process



Raytheon

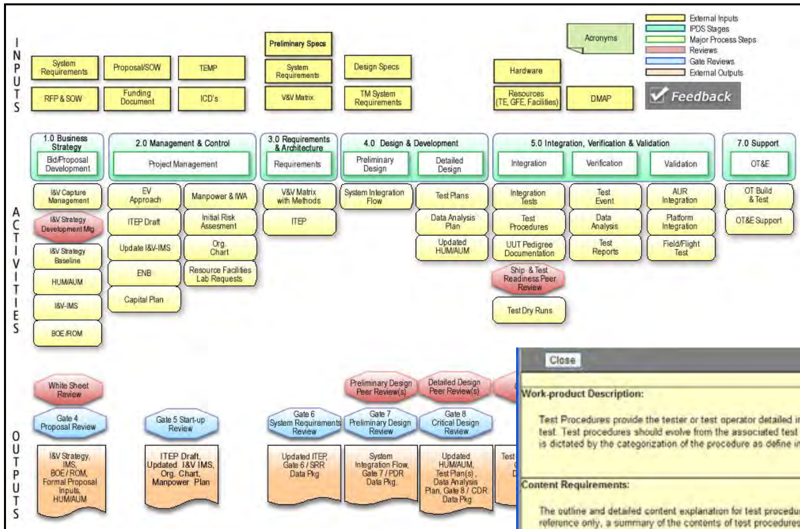
Activities

Activities: The core tasks that I&V accomplishes during the course of a program.

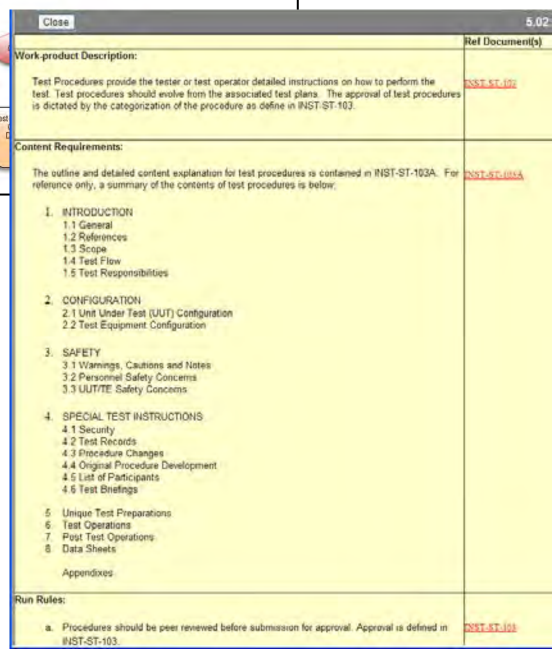


Note that activities can be repeated across multiple IPDS stages but are generally listed in the stage in which they are first completed

Activity Sheets

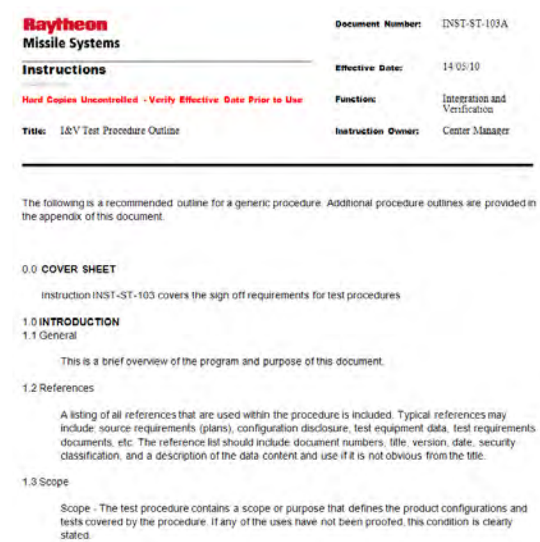


- Describe work activities in detail
- Links are provided to command media, templates, examples, etc.



Close 5.02

Work-product Description:	Ref Document(s)
Test Procedures provide the tester or test operator detailed instructions on how to perform the test. Test procedures should evolve from the associated test plans. The approval of test procedures is dictated by the categorization of the procedure as define in INST-ST-103.	INST-ST-103
Content Requirements: The outline and detailed content explanation for test procedures is contained in INST-ST-103A. For reference only, a summary of the contents of test procedures is below: 1. INTRODUCTION 1.1 General 1.2 References 1.3 Scope 1.4 Test Flow 1.5 Test Responsibilities 2. CONFIGURATION 2.1 Unit Under Test (UUT) Configuration 2.2 Test Equipment Configuration 3. SAFETY 3.1 Warnings, Cautions and Notes 3.2 Personnel Safety Concerns 3.3 UUT/TE Safety Concerns 4. SPECIAL TEST INSTRUCTIONS 4.1 Security 4.2 Test Records 4.3 Procedure Changes 4.4 Original Procedure Development 4.5 List of Participants 4.6 Test Briefings 5. Unique Test Preparations 6. Test Operations 7. Post Test Operations 8. Data Sheets Appendixes	INST-ST-103A
Run Rules: a. Procedures should be peer reviewed before submission for approval. Approval is defined in INST-ST-103.	INST-ST-103



Raytheon
Missile Systems

Instructions

Hard Copies Uncontrolled - Verify Effective Date Prior to Use

Document Number: INST-ST-103A
Effective Date: 14/05/10
Function: Integration and Verification
Title: I&V Test Procedure Outline
Instruction Owner: Center Manager

The following is a recommended outline for a generic procedure. Additional procedure outlines are provided in the appendix of this document.

0.0 COVER SHEET

Instruction INST-ST-103 covers the sign off requirements for test procedures

1.0 INTRODUCTION
1.1 General

This is a brief overview of the program and purpose of this document.

1.2 References

A listing of all references that are used within the procedure is included. Typical references may include: source requirements (plans), configuration disclosure, test equipment data, test requirements documents, etc. The reference list should include document numbers, title, version, date, security classification, and a description of the data content and use if it is not obvious from the title.

1.3 Scope

Scope - The test procedure contains a scope or purpose that defines the product configurations and tests covered by the procedure. If any of the uses have not been proofed, this condition is clearly stated.

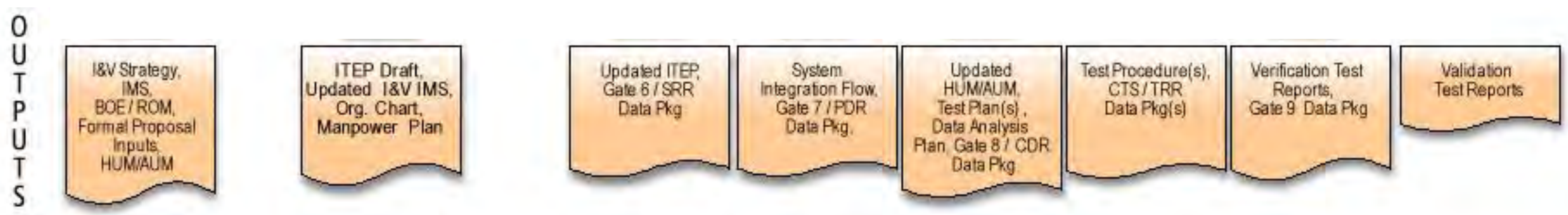
Reviews

Reviews are conducted before and after major activities and stages

Note that some reviews such as CTS/TRR can be repeated multiple times during the course of the program

Outputs

The products which are created during the course of the given stage



Conclusion

- All linked material is controlled and approved by management before release
- Future is to expand it to expand its use in the directorate and to other areas of engineering

A Paradigm for Modeling & Simulation in Support of Mission-Based Test & Evaluation

James N. Walbert, Ph.D.
Chief Scientist
SURVICE Engineering Company

March, 2011

TOPICS

What is Mission-Based Modeling and Simulation?

The Value of Intermediate Results

Applicability, Precision, and Accuracy

So, exactly what's in that Field and Test Data?
(and therefore, what should be in the Simulation Output?)

What constitutes a "good" model?

If you don't have a road map, don't take the M&S trip

What is Mission-Based Modeling and Simulation?

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All T&E is (should be) Mission-Based
All M&S is (should be) Mission-Based

The following three (evaluation) missions require
three different levels of data to evaluate, and
three different levels of modeling to simulate:

See ***if*** threat x can perforate target y

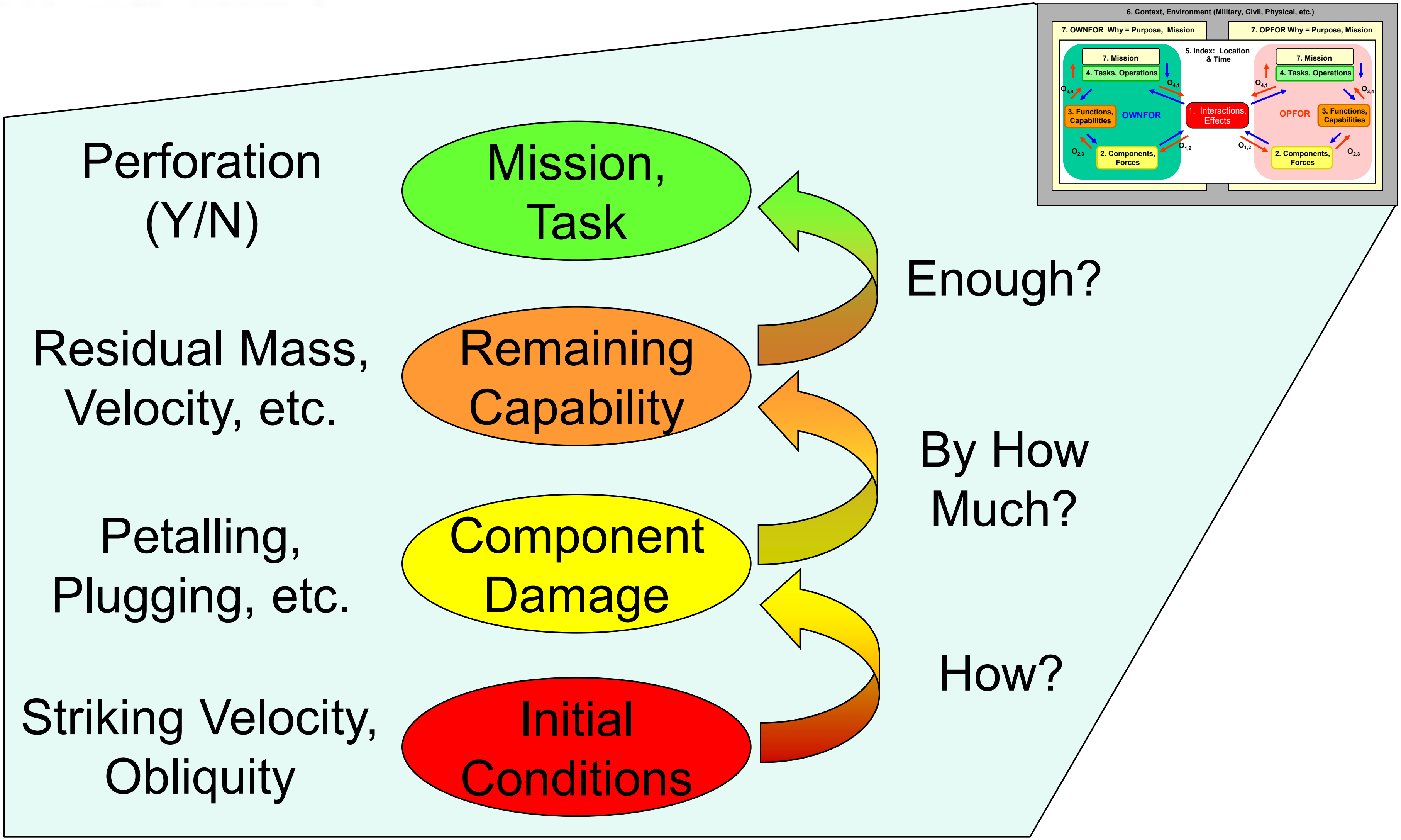
See ***by how much*** threat x perforates target y

See ***how*** threat x perforates target y

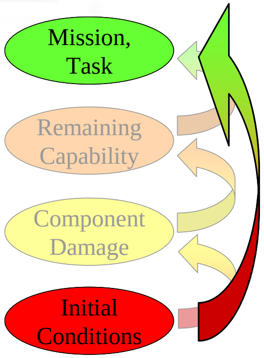
If I complete a certain (evaluation) mission, haven't I completed each (evaluation) mission above it?

NOT NECESSARILY!!

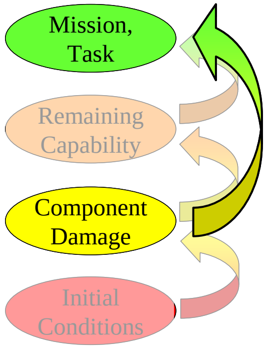
Mission-Based Test & Evaluation

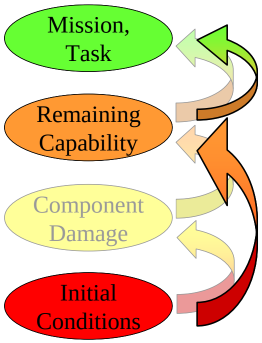


There are many possible paths

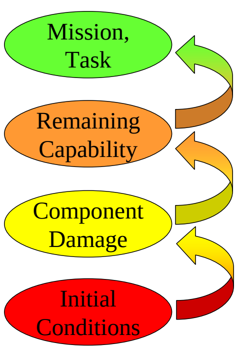


See *if* threat x can perforate target y





See ***by how much*** threat x perforates target y

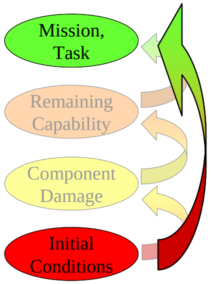


See ***how*** threat x perforates target y

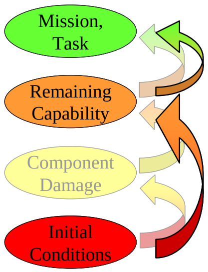
The Value of Intermediate Results

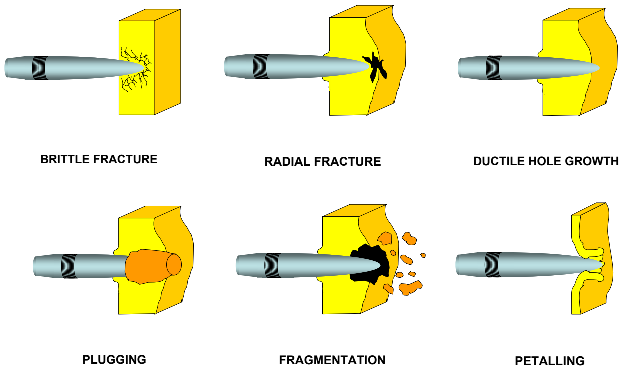
Mission-Based Test & Evaluation

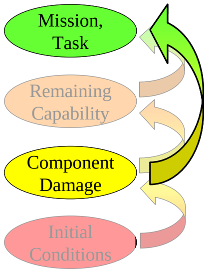
THREAT TYPE	VELOCITY (Ft/Sec)	MATERIAL TYPE	MATERIAL THICKNESS (Inches)	V50 (Ft/Sec)
X	500	ALUMINUM 5083	0.1250	288.39

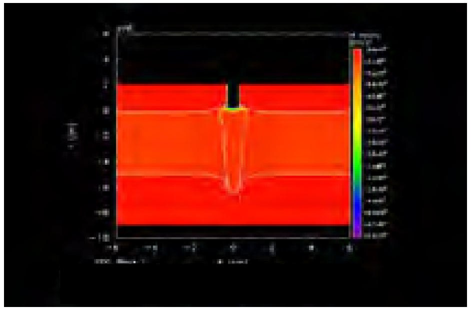


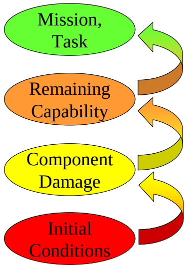
THREAT TYPE	VELOCITY (Ft/Sec)	MATERIAL TYPE	MATERIAL THICKNESS (Inches)	V50 (Ft/Sec)	RESIDUAL VELOCITY (Ft/Sec)	RESIDUAL MASS (Grains)	YAW (Degrees)
X	500	ALUMINUM 5083	0.1250	288.39	408.45	745.00	0.49







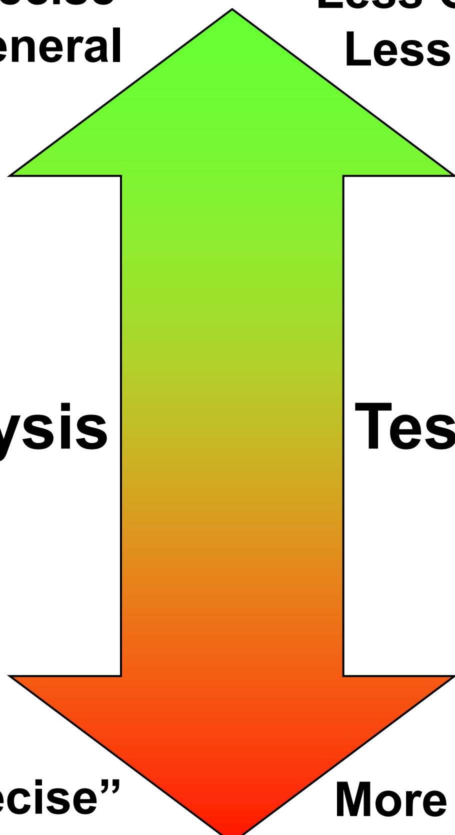




Mission-Based T&E and M&S

Less "Precise"
More General

Less Complex
Less Costly



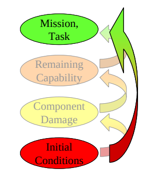
Analysis

Testing

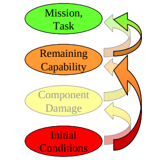
More "Precise"
Less General

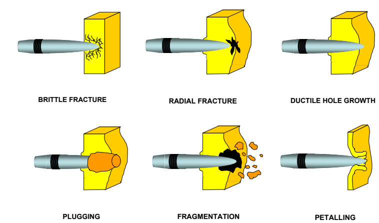
More Complex
More Costly

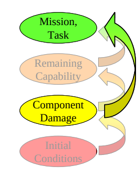
THREAT TYPE	VELOCITY (Ft/Sec)	MATERIAL TYPE	MATERIAL THICKNESS (Inches)	V50 (Ft/Sec)
X	500	ALUMINUM 5083	0.1250	288.39

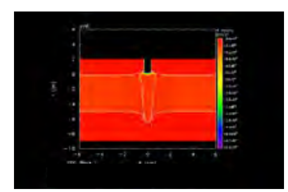


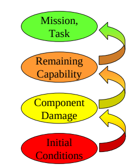
THREAT TYPE	VELOCITY (Ft/Sec)	MATERIAL TYPE	MATERIAL THICKNESS (Inches)	V50 (Ft/Sec)	RESIDUAL VELOCITY (Ft/Sec)	RESIDUAL MASS (Grains)	YAW (Degrees)
X	500	ALUMINUM 5083	0.1250	288.39	408.45	745.00	0.49











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The dangers of a very specific model

More Universally Accurate

M&S Applicability

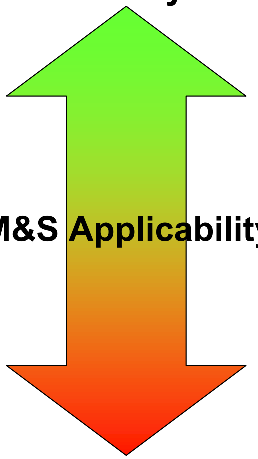
Less Universally Accurate

A President was Elected
(very general, but correct)

Thomas Dewey was Elected President
(very specific, but incorrect)

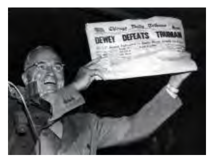
The dangers of a very specific model

More Universally Accurate



Less Universally Accurate

A President was Elected



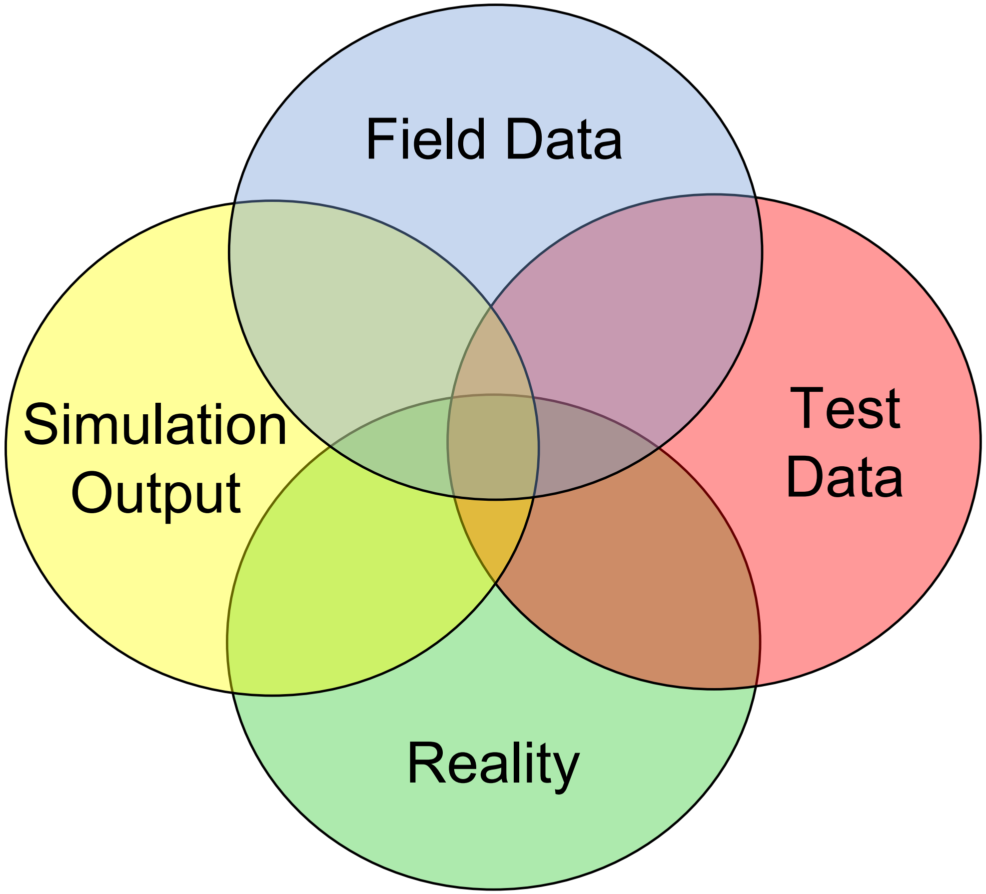
Thomas Dewey was Elected President

This very precise model does ***not*** explain ***how*** the President was elected. The model of at least one of the mappings is flawed; everything that follows is probably incorrect, such as ***by how much*** (how many votes).

If the prediction was precisely incorrect because 17 precincts voted the opposite from the assumption, then "tweaking" the model to change the way those 17 precincts vote may or may not to produce "better" results in the next election.

Applicability, Precision, and Accuracy

Walbert's view of the world**



**Not to scale

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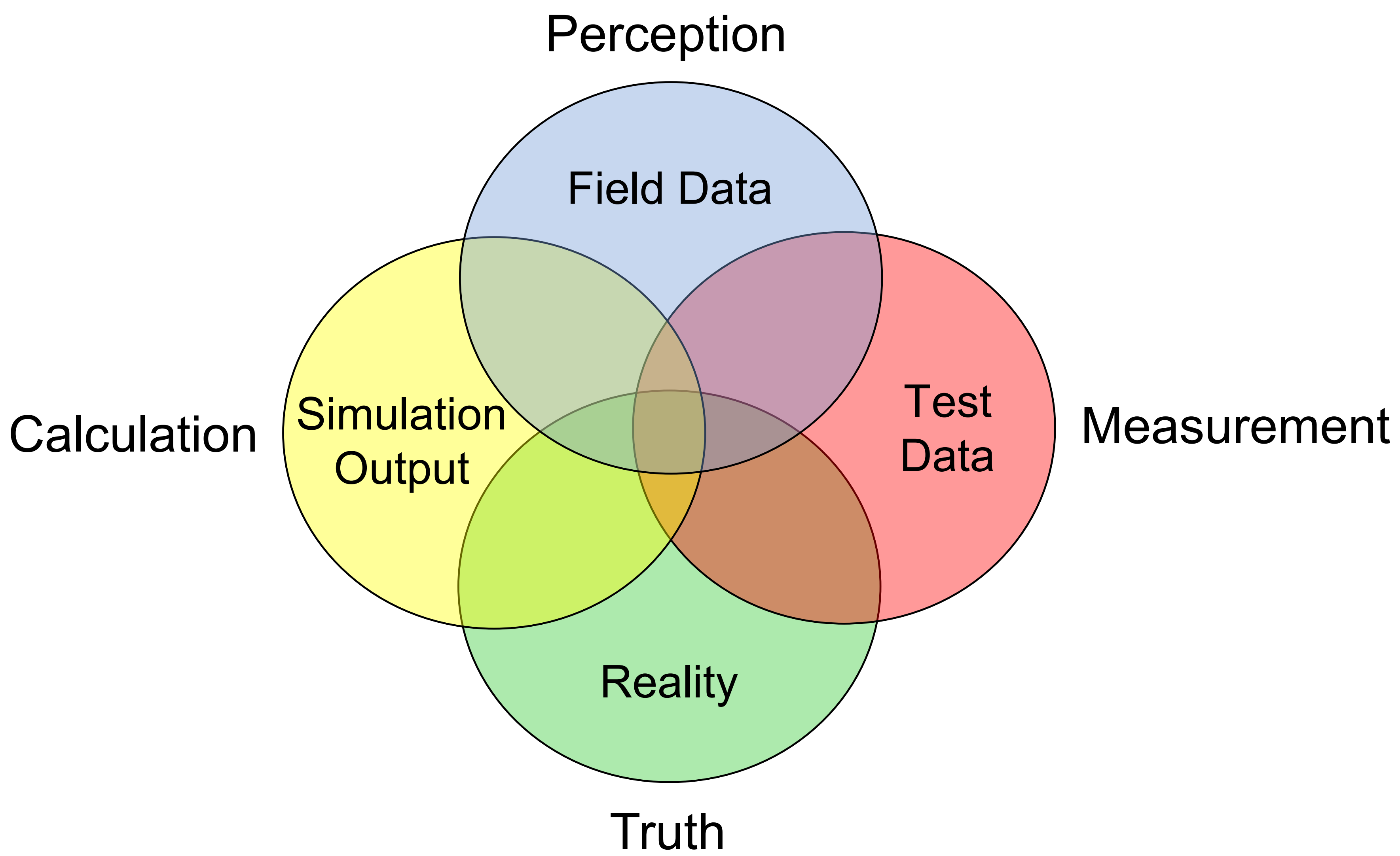
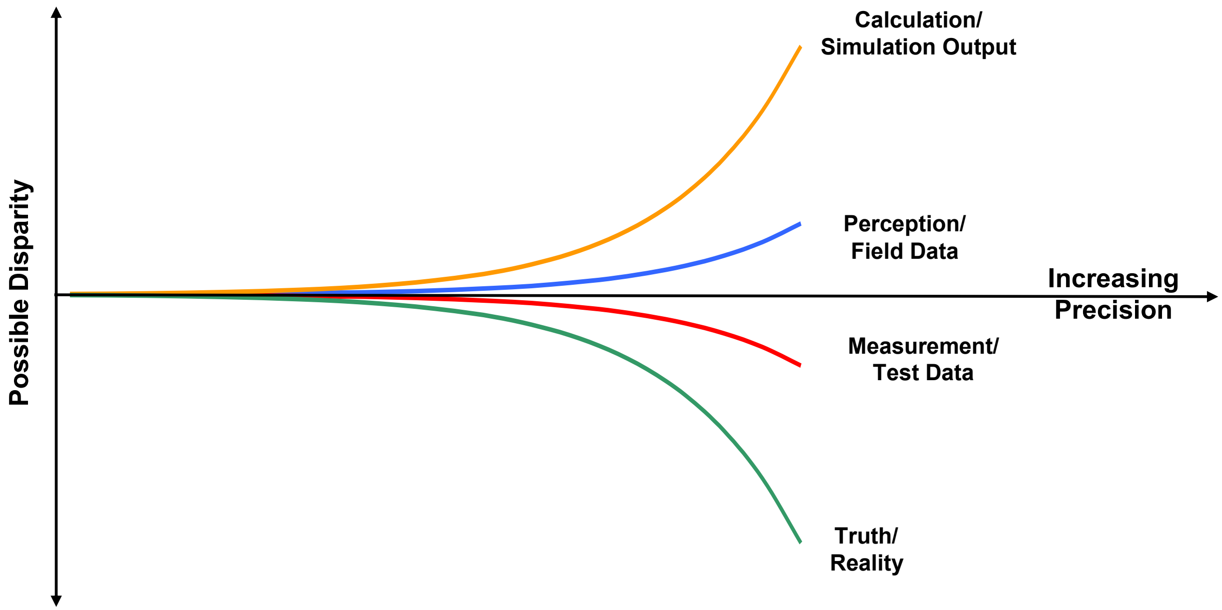
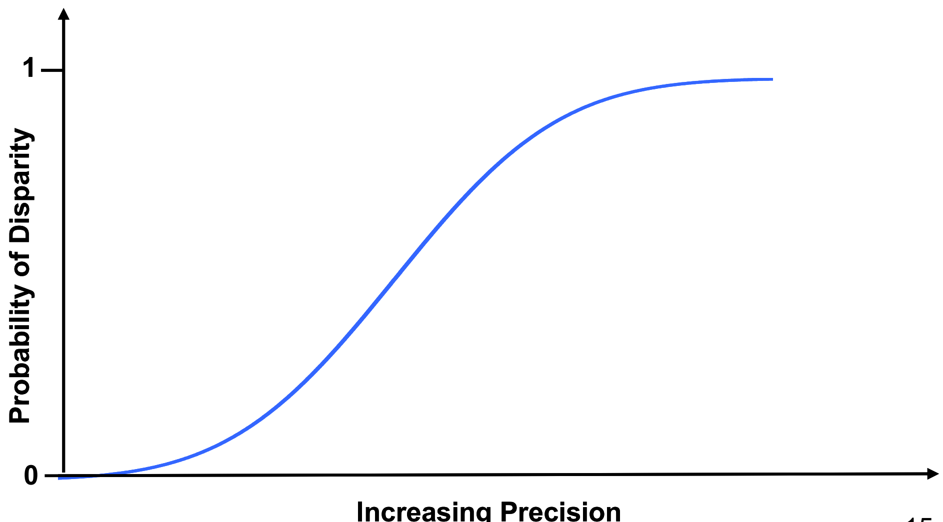
Walbert's view of the world



Walbert's view of the world



The greater the precision in any one of the domains, the more likely it is that it will disagree with the other domains.



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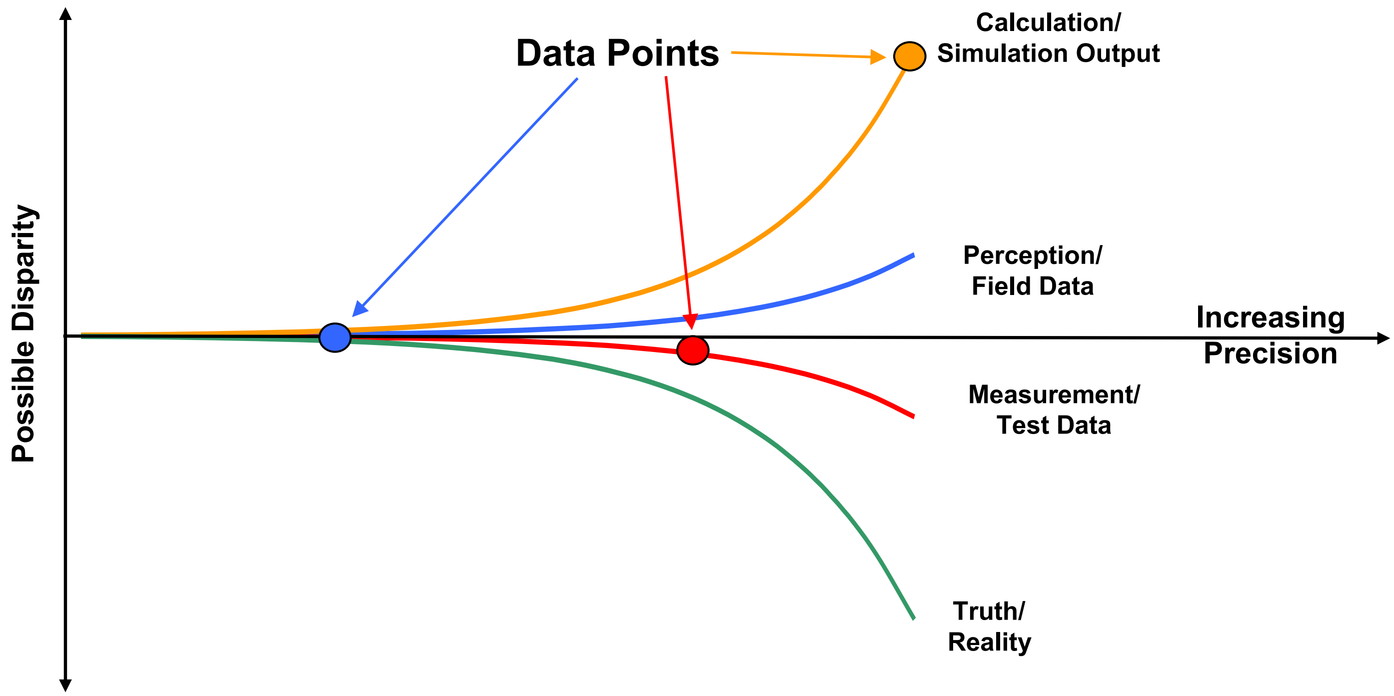
Walbert's view of the world: An Event (Field, Test, Simulation)



If the data points from the domains are at differing levels of precision (granularity), then comparison is "difficult."

The location of the data point on the "Truth" curve is unknown.

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So, exactly what's in that Field and Test Data?

(and therefore, what should be in the Simulation Output?)

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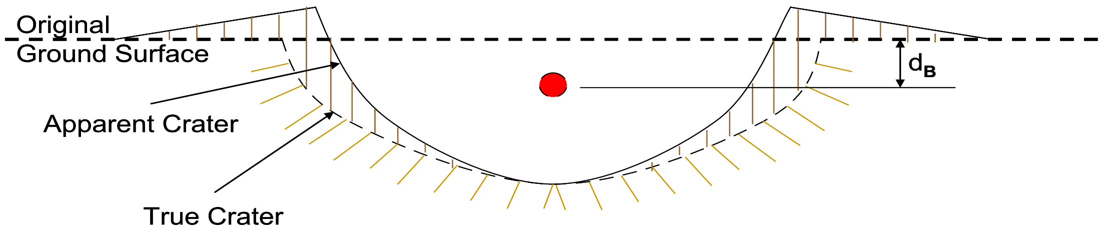
An Example: Craters

Truth



Perception/ Field Data

MEASURED DIAMETER feet	MEASURED DEPTH feet
13.00	4.00

Measurement/ Test Data

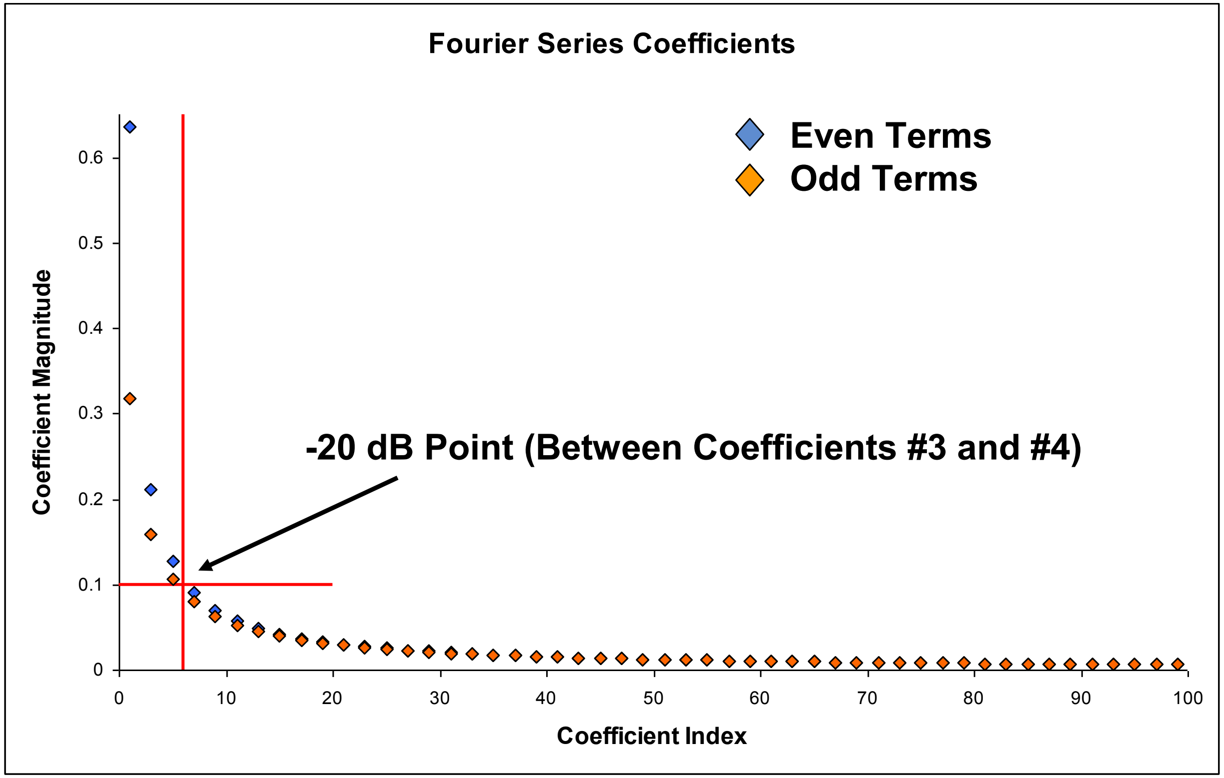
SOIL TYPE	MOISTURE CONTENT (% of Satur)	ENERGETIC MATERIAL	CHARGE WEIGHT lbs	DEPTH of BURST feet	MEASURED DIAMETER feet	MEASURED DEPTH feet
Mixed Soil	100	XXX	21.00	1.75	12.80	3.95

Calculation

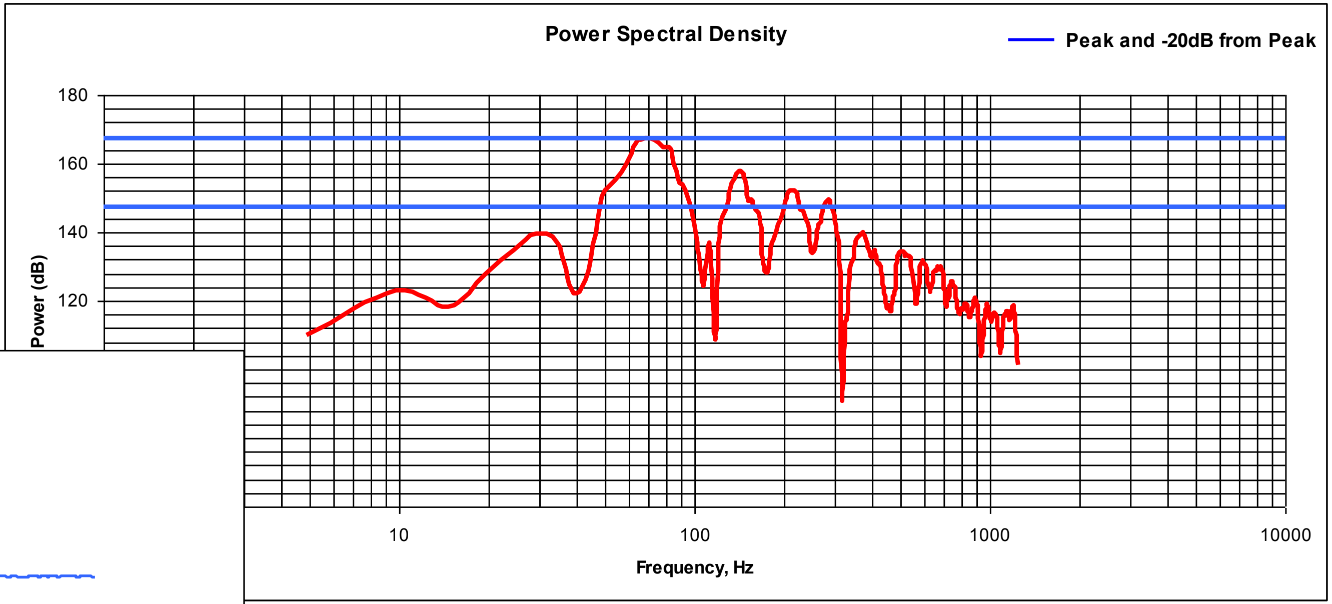
SOIL TYPE	MOISTURE CONTENT (% of Satur)	ENERGETIC MATERIAL	CHARGE WEIGHT lbs	DEPTH of BURST feet	ESTIMATED DIAMETER feet	ESTIMATED DEPTH feet
Mixed Soil	100	XXX	20.28	2.06	13.00	5.07
			22.49	8.18	13.00	4.23
			44.09	0.00	11.74	4.00
			64.82	13.16	16.09	4.00

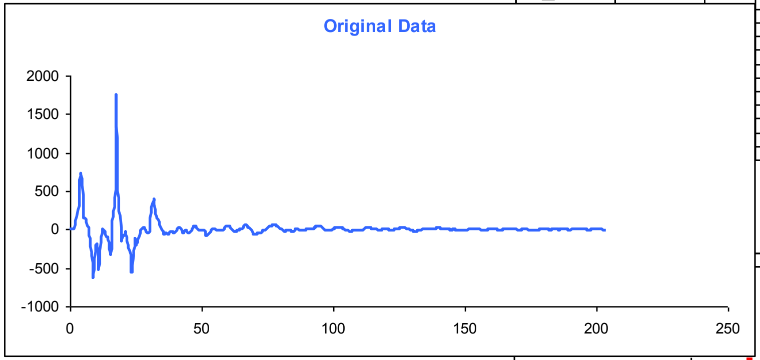
Match the analysis to the data content

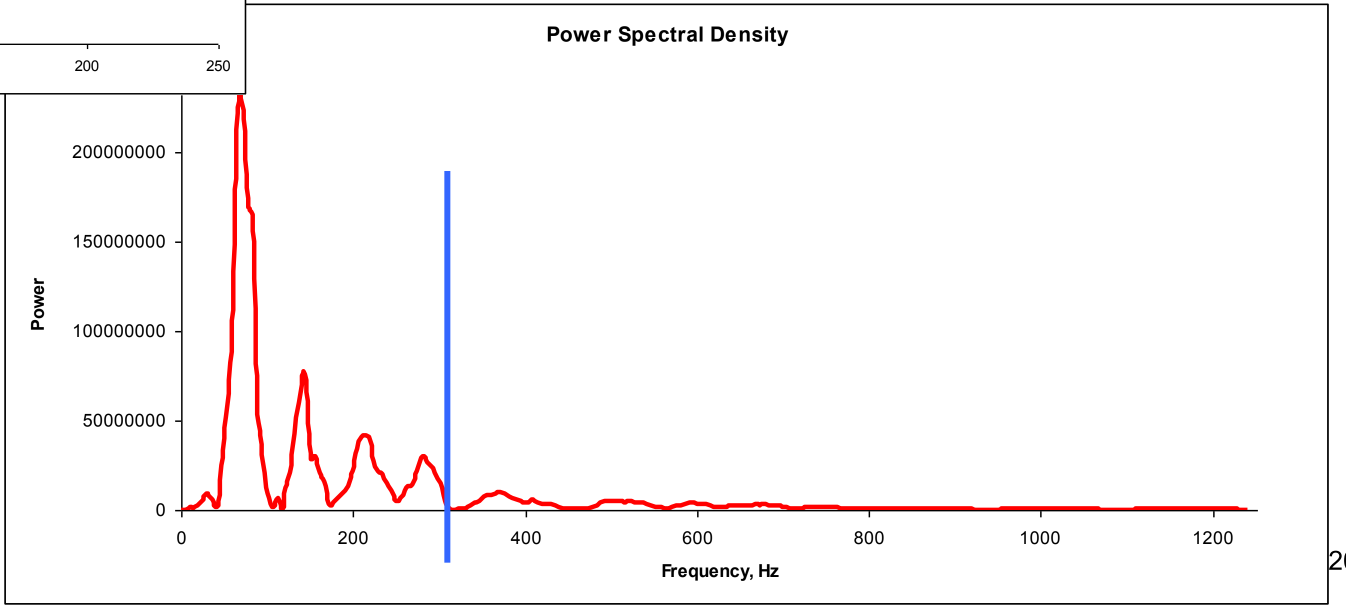
$$F(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \{a_n\cos(nt) + b_n\sin(nt)\}$$



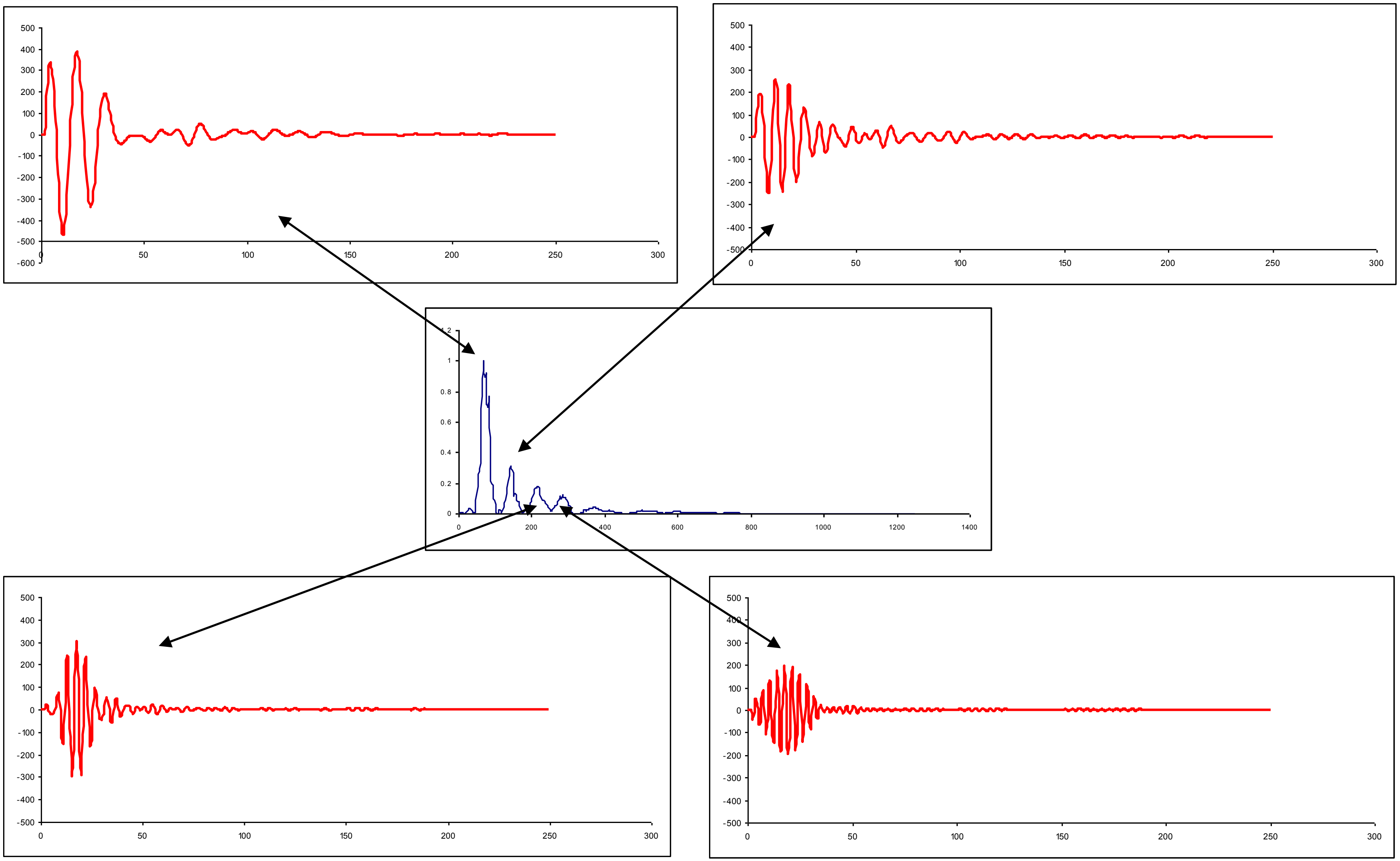
Match the analysis to the data content
An example: Acceleration Data







Match the analysis to the data content



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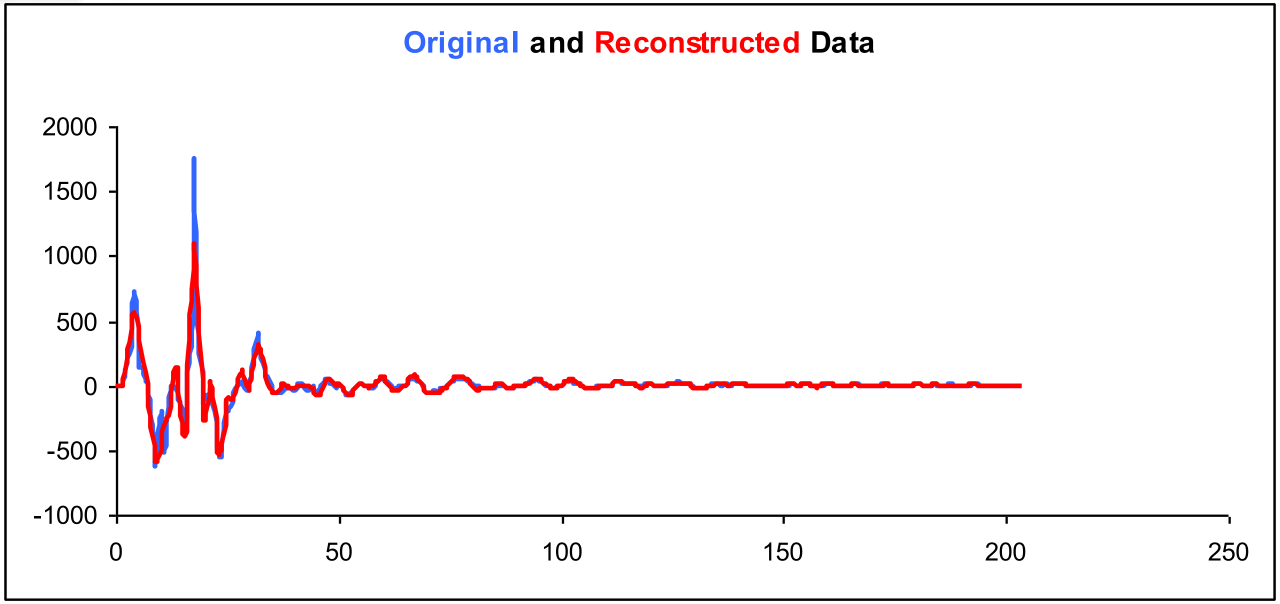
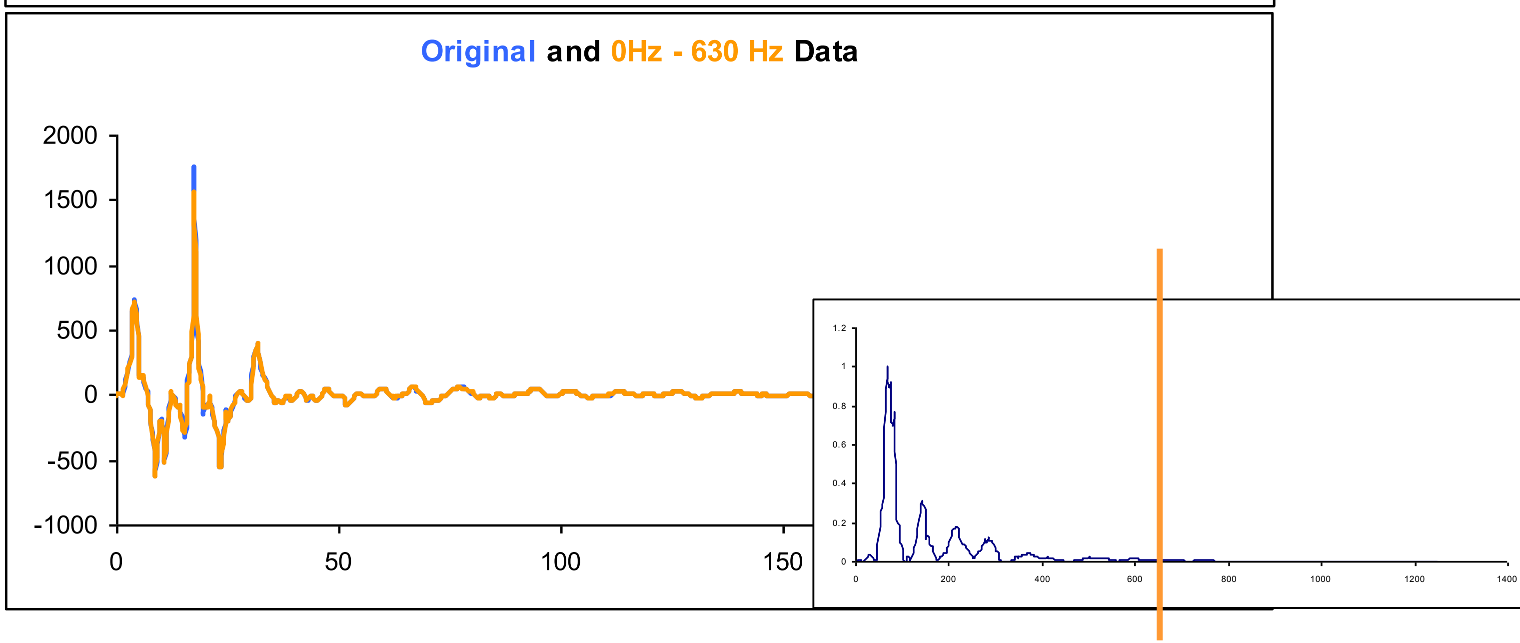
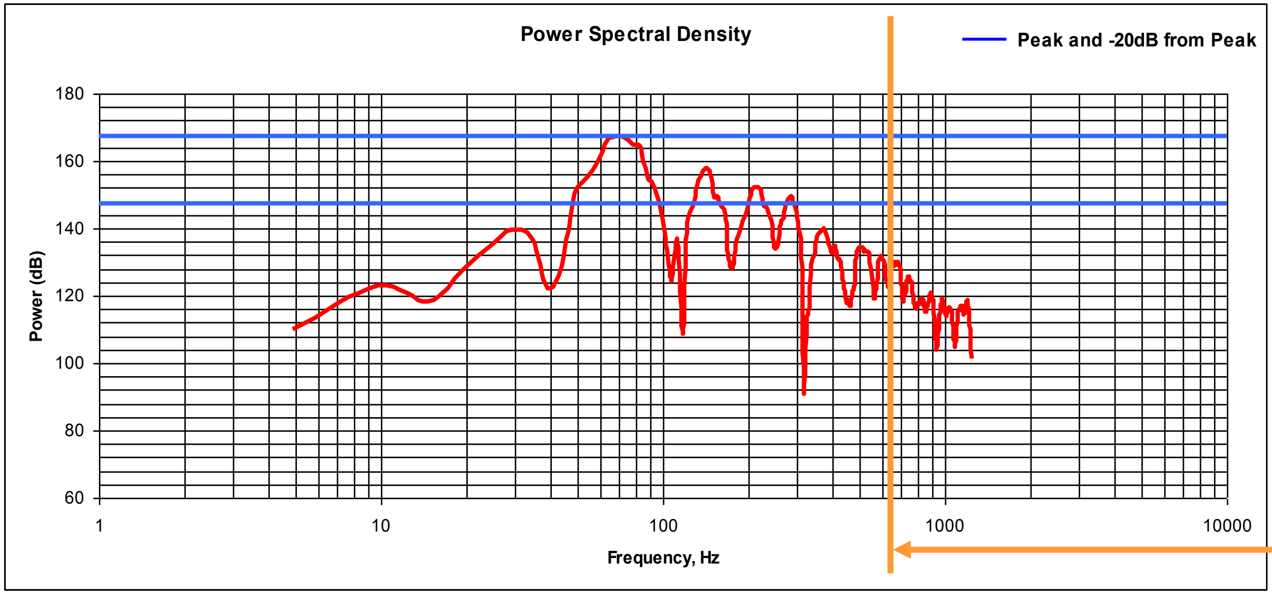
Match the analysis to the data content

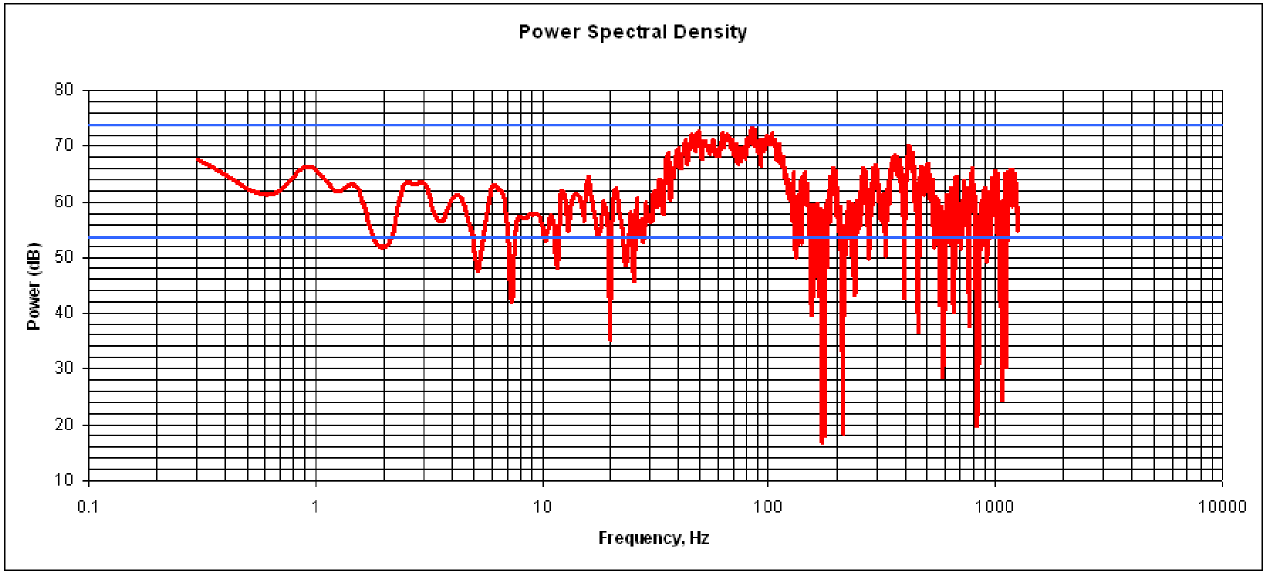




Match the analysis to the data content



630Hz is –40dB



You can't get blood from a turnip!

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What constitutes a “good” model?

HOW TO TELL A "GOOD" MODEL FROM A "BAD" MODEL

Which question is more appropriate?

1) How well did the model predict the outcome of the test?

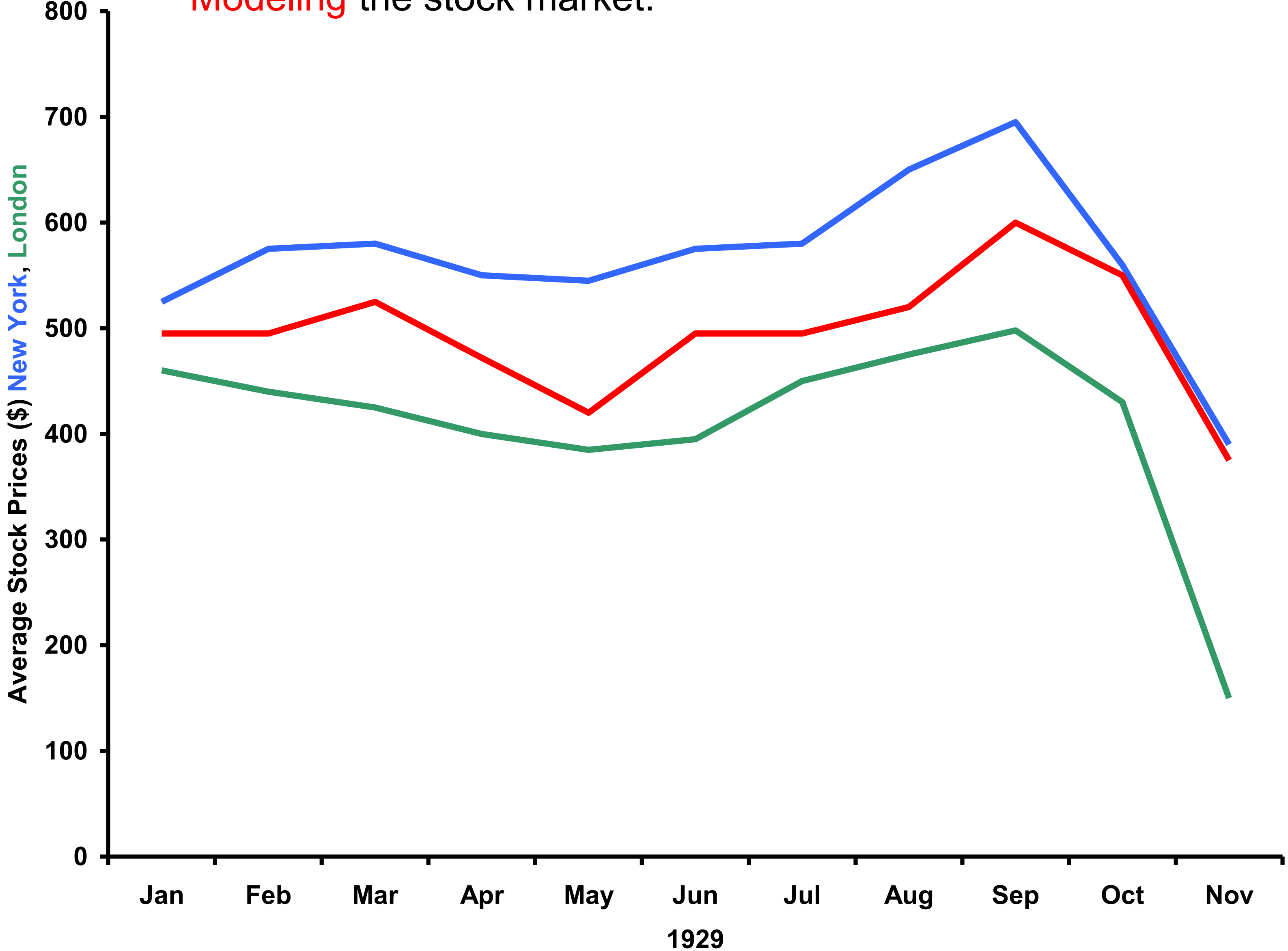
2) Was the outcome of the test a member of the population of possible outcomes predicted by the model?

If my model gets the "right" answer, doesn't that mean I understand the phenomenon?

NOT NECESSARILY!!

HOW TO TELL A “GOOD” MODEL FROM A “BAD” MODEL

Modeling the stock market:



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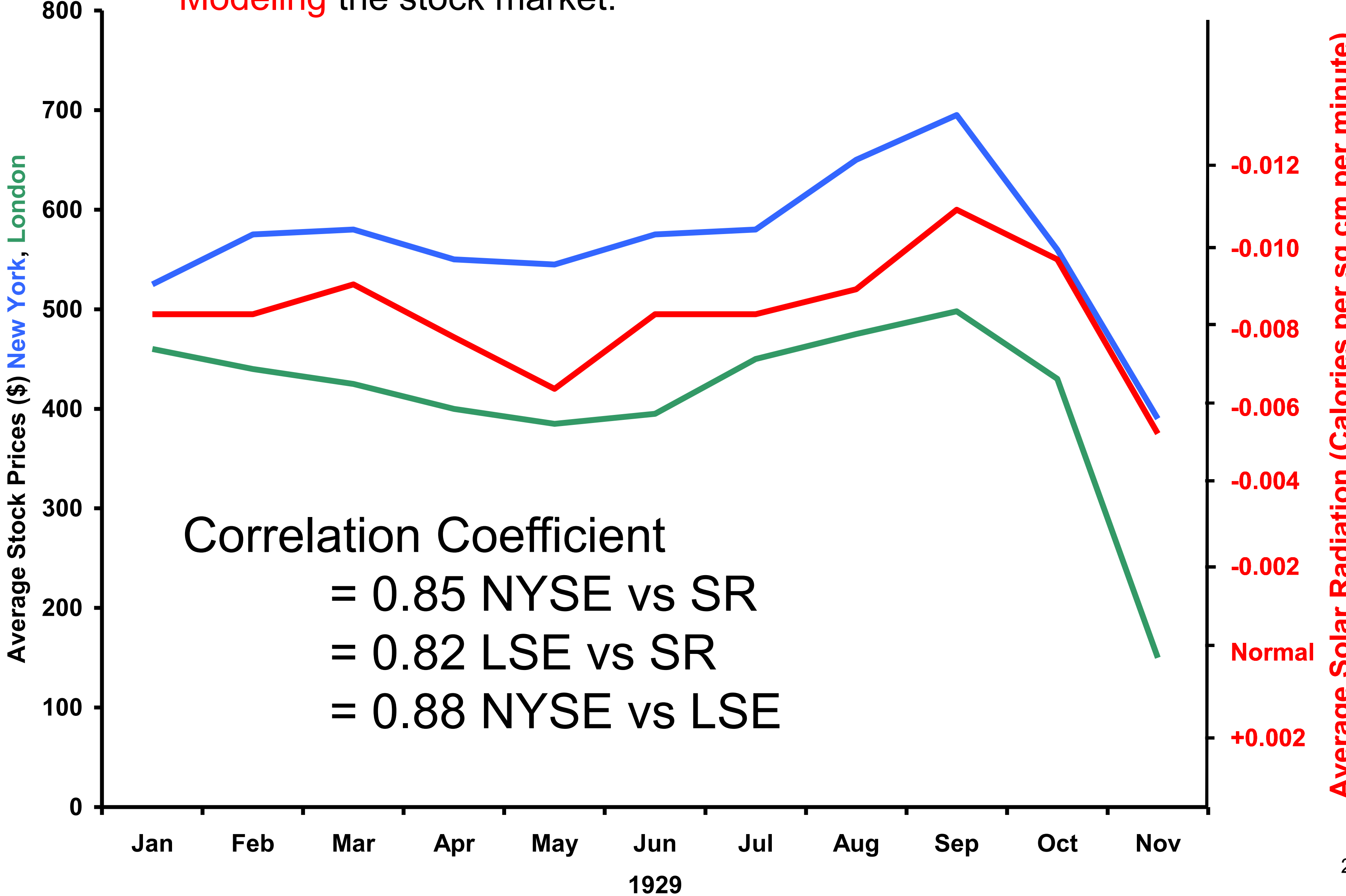
HOW TO TELL A “GOOD” MODEL FROM A “BAD” MODEL

Modeling the stock market:



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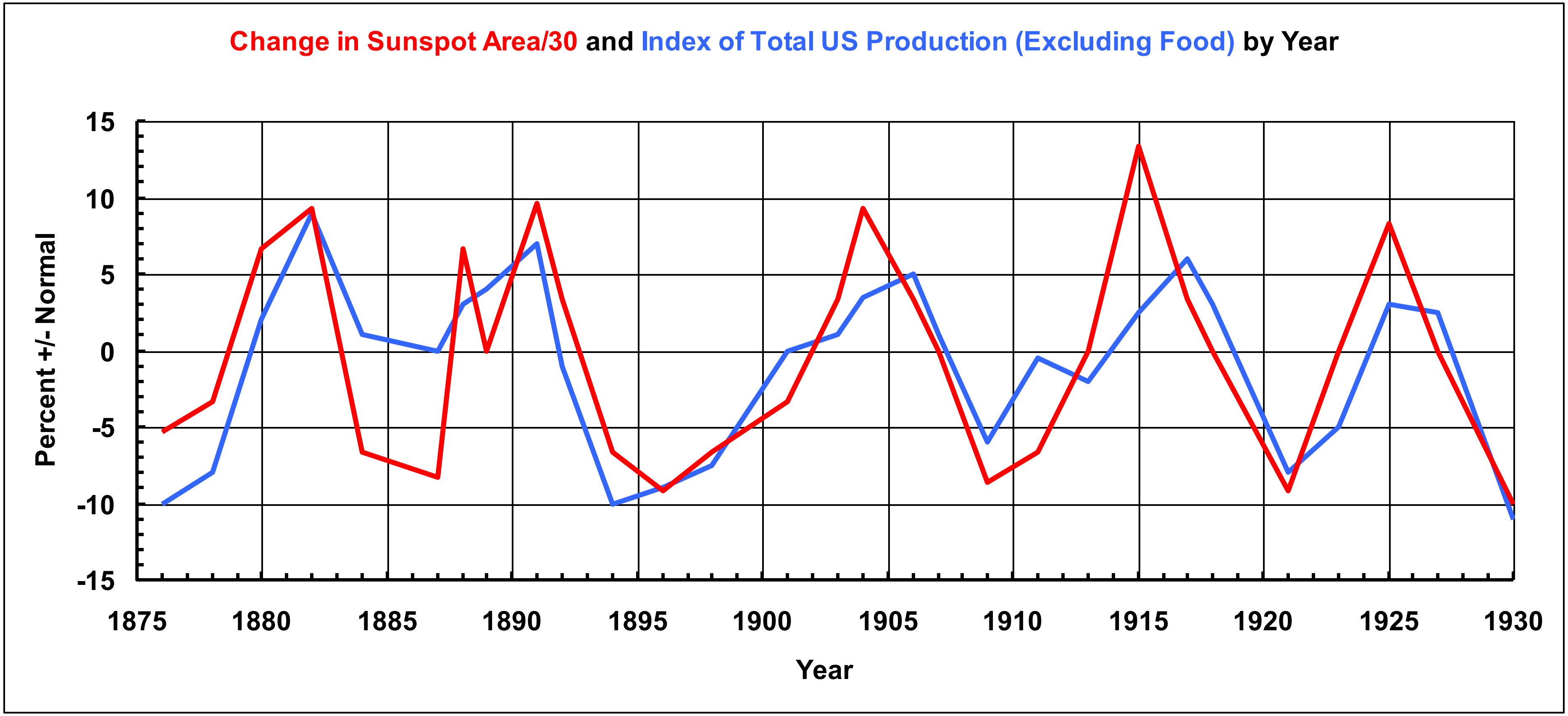
SO, YOU *STILL* THINK THAT'S FUNNY?

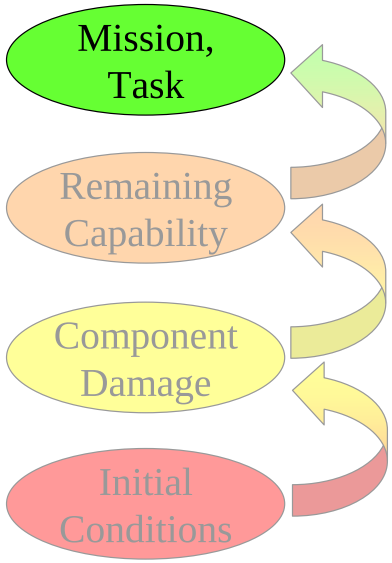


Correlation coefficient = 0.76

t-value = -1.15 (not in critical region, no stat. sign. diff. at 5% level)

Source: Center for Cosmic and Terrestrial Research, MIT, 1937

There may be no path at all!

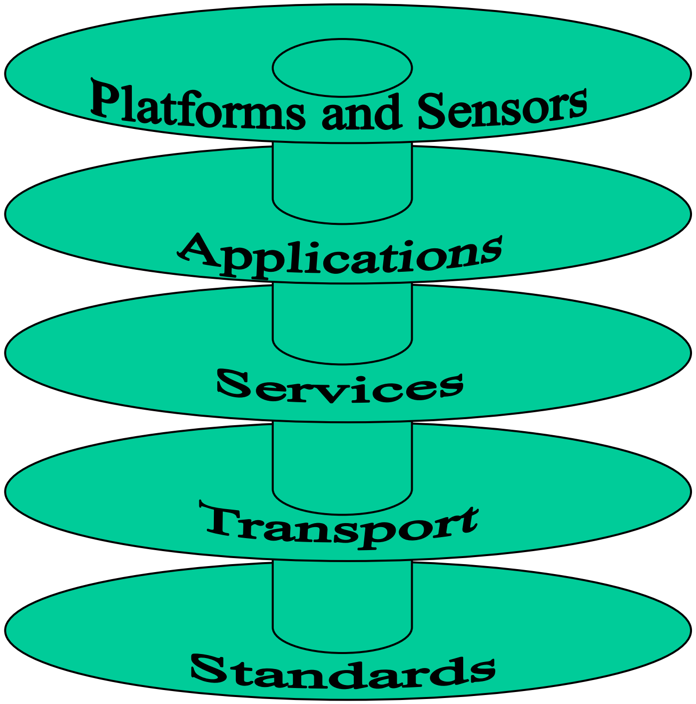


Does "Correlation" mean the same thing as "Cause and Effect?"

If you don’t have a road map,
don’t take the M&S trip

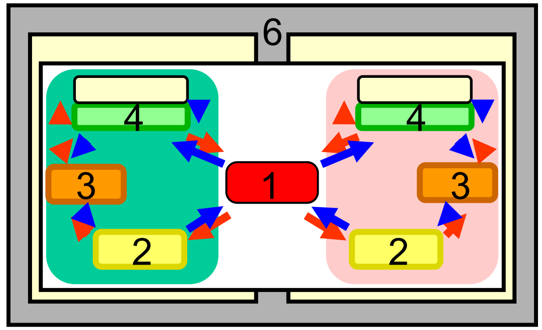
An Un-verifiable Model

Future Combat Systems
Network Conceptual Representation



The mission is to see if the network does its job (i.e.: is effective)

An Un-verifiable Model



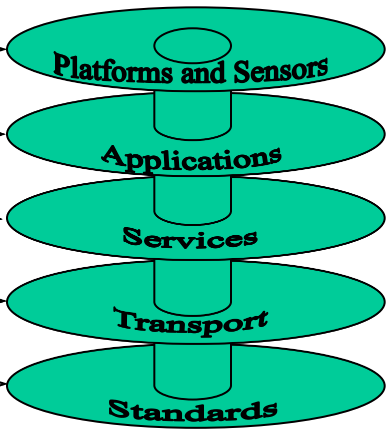
The platforms and sensors are the “components” at Level 2

The applications represent the tasks or operations at Level 4

The services represent the capabilities at Level 3

The transport layer corresponds to the interactions at Level 1

The standards represent the context at Level 6

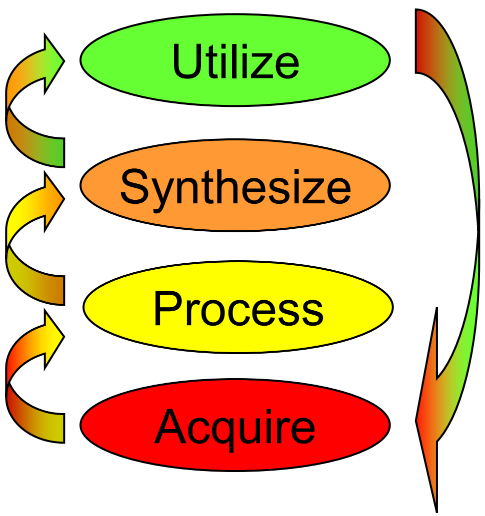


This conceptual representation has no reasonable logic flow

An Un-verifiable Model, Made Verifiable

If instead, we use the following:

Node Functional Logic Flow



This encompasses all requisite network functions...

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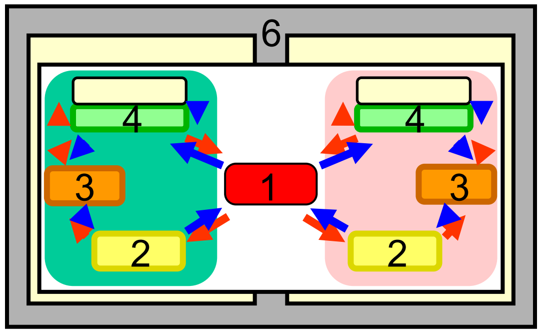
An Un-verifiable Model, Made Verifiable

...and follows a logical progression:

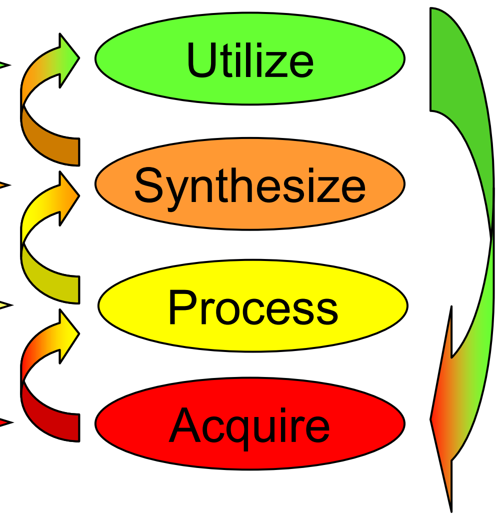


The utilize layer corresponds to task execution at Level 4

The synthesize layer corresponds to the capabilities at Level 3

The process layer corresponds to the “components” at Level 2

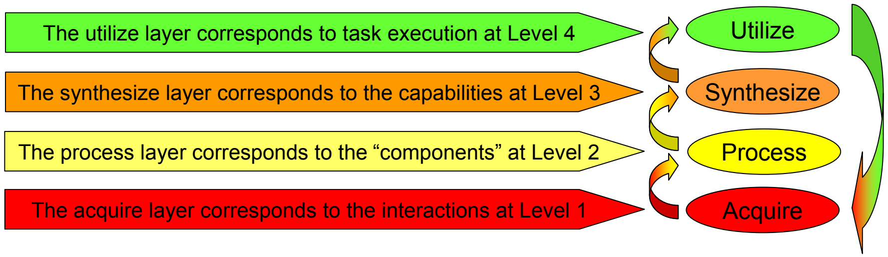
The acquire layer corresponds to the interactions at Level 1



If it all worked satisfactorily each time, the mission was completed. If not, the mission wasn’t completed.

An Un-verifiable Model, Made Verifiable

If it didn't work, why not?



Did the node

1) Get the information it needed when it needed it?

2) Understand the information?

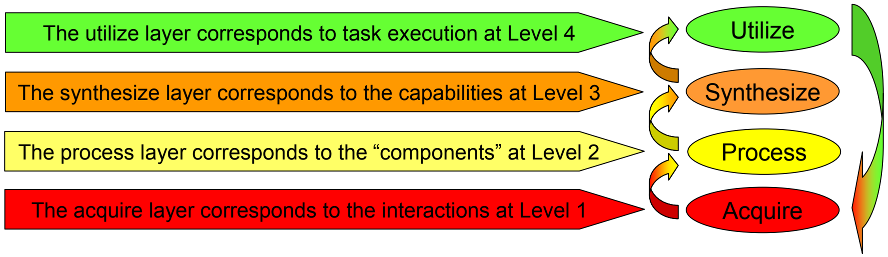
3) Process the information successfully?

4) Use the information?

All of these questions assume the information was in the appropriate context.

An Un-verifiable Model, Made Verifiable

If it didn't work, why not?

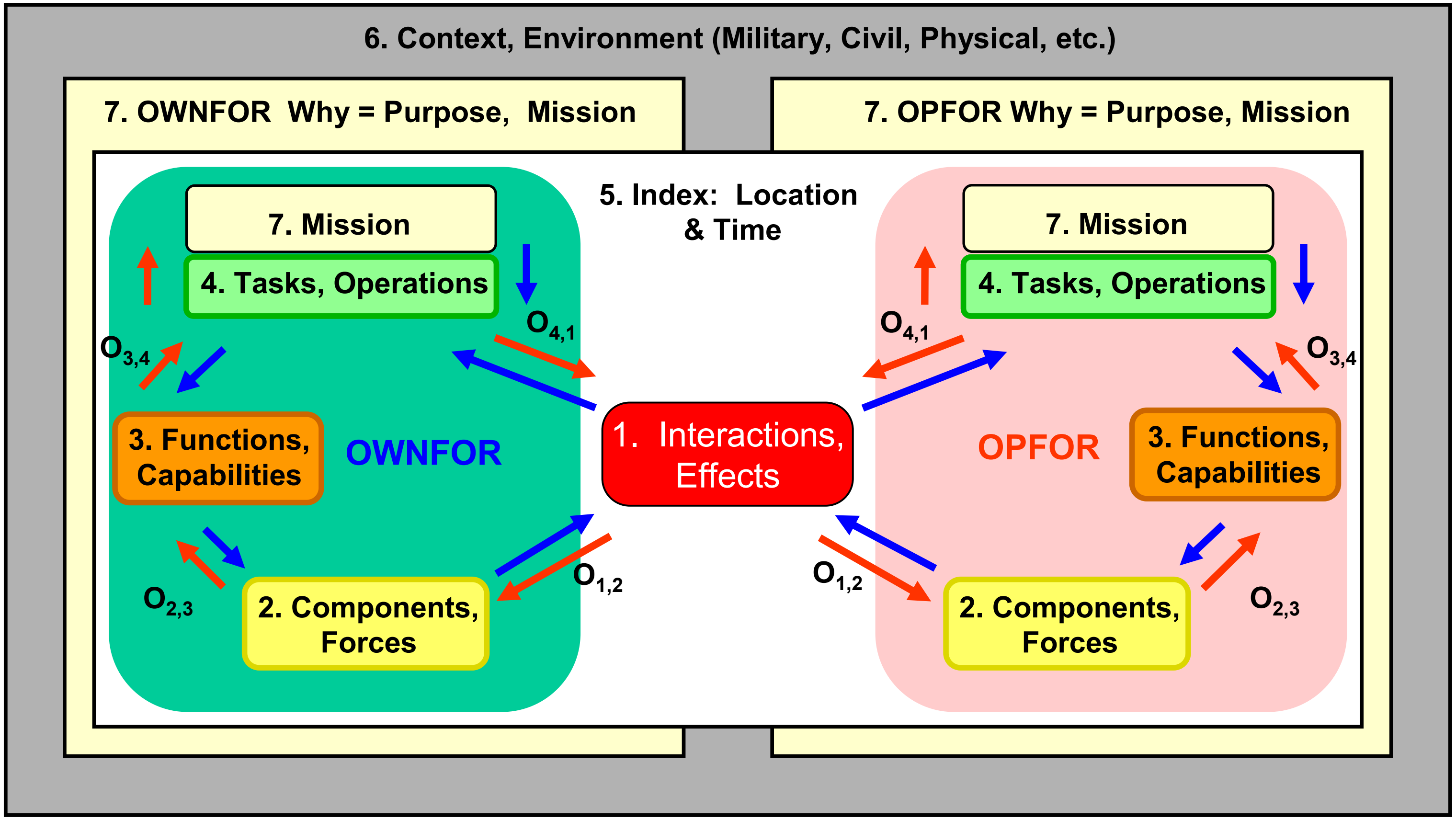


Did the node

1) Get the information it needed when it needed it?
   Did the Transport Layer work Properly?
2) Understand the information?
   Did the Platforms and Sensors Layer work Properly?
3) Process the information successfully?
   Did the Services Layer work Properly?
4) Use the information?
   Did the Applications Layer work Properly?

All of these questions assume the information was in the appropriate context. Did the Standards Layer work Properly?

The Missions and Means Framework



The blue arrows indicate "Planning"
The red arrows indicate "Execution"

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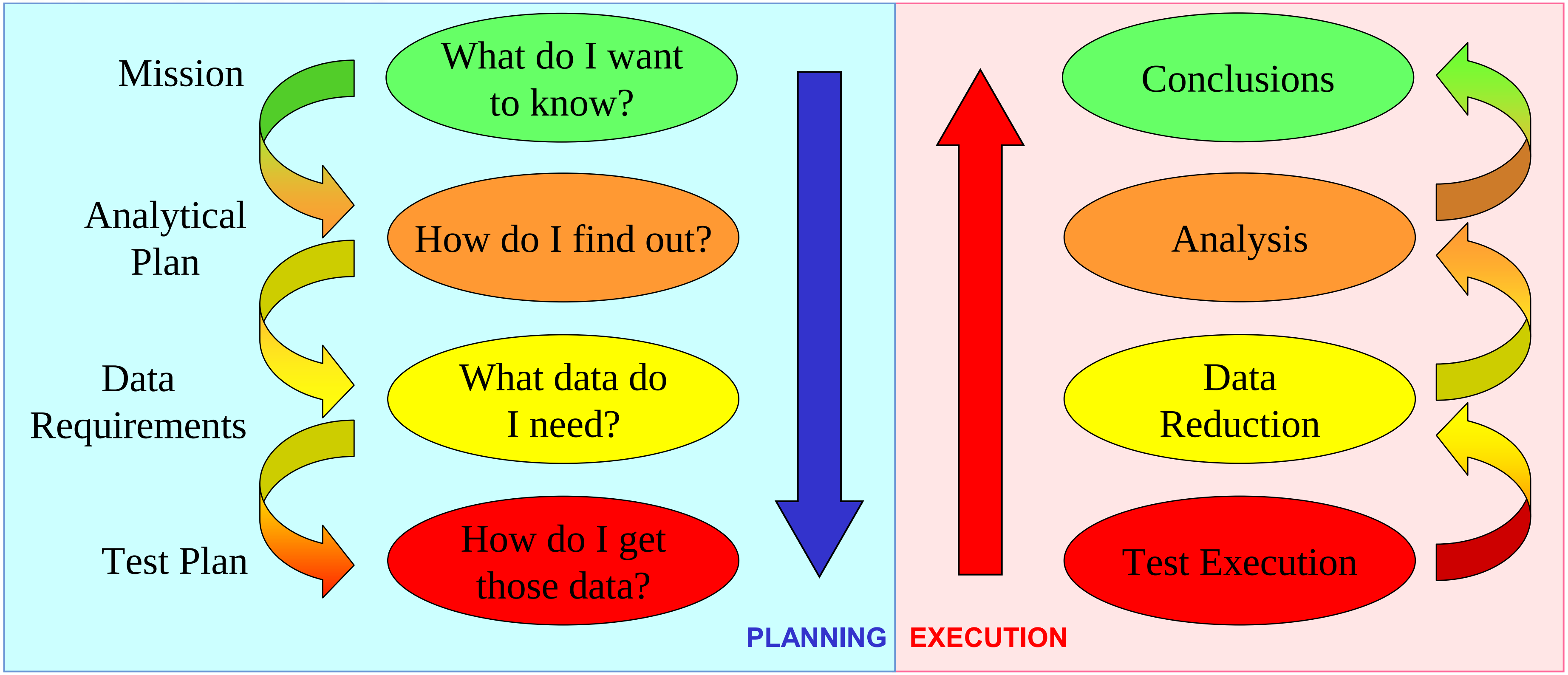
A *Very* Old Concept



The analytical plan is based on the mission.
The data requirements are based on the analytical plan.
The test plan is based on the data requirements.

ANY OTHER ORDER FOR THESE EVENTS IS NONSENSE!

The Paradigm

Organize the M&S and T&E using the logic flow of MMF.

Determine the number of levels (intermediate outputs) required.

Align the data collection (instrumentation) with the levels.

Develop the M&S to output the same intermediate levels (values).

Don't $\left\{\begin{matrix}\textbf{test}\\ \textbf{model}\end{matrix}\right\}$ ***more detail than you need, and***

don't $\left\{\begin{matrix}\textbf{model}\\ \textbf{test}\end{matrix}\right\}$ ***more detail than you*** $\left\{\begin{matrix}\textbf{test}\\ \textbf{model}\end{matrix}\right\}$ ***.***

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Points to Ponder

Should we always design a $\left\{\begin{array}{c}\textbf{test}\\ \textbf{model}\end{array}\right\}$ that fits all missions?

(just in case…*Scope, Time, Budget*)

Is it better to be ***precisely incorrect*** or ***approximately correct***?

("Dewey Beats Truman" vs "A President was Elected")

(If the test data value is 1.2 and the simulation output is 1.23564, which value is more nearly correct?)

Are we doing a certain level of M&S because we can, or because we need it to answer the "mission accomplished" question?

(How did we get to the moon without finite element codes?)

Don't be afraid to consider the possibility that there is ***no discernable cause/effect relationship*** in what you're trying to simulate.

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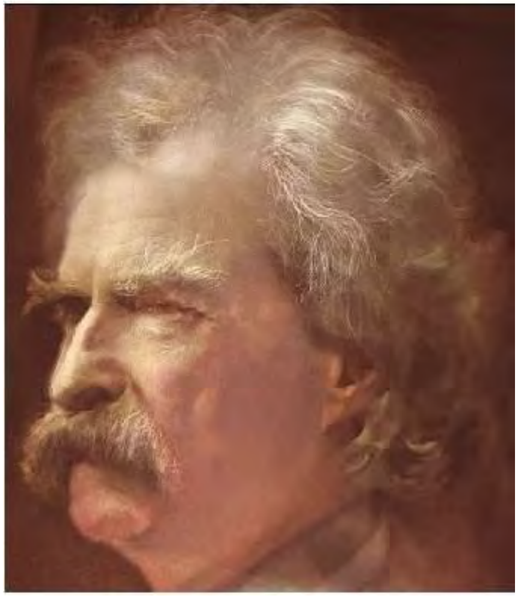
Sometimes, it's better to be lucky than good…

…but don't count on it!

"Noah had an absurd idea that he could navigate without any knowledge of navigation, and he ran into the only shoal place on earth."

-Mark Twain



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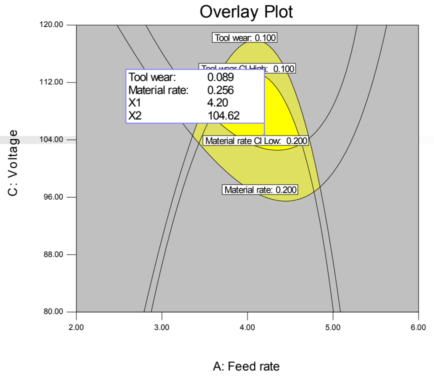
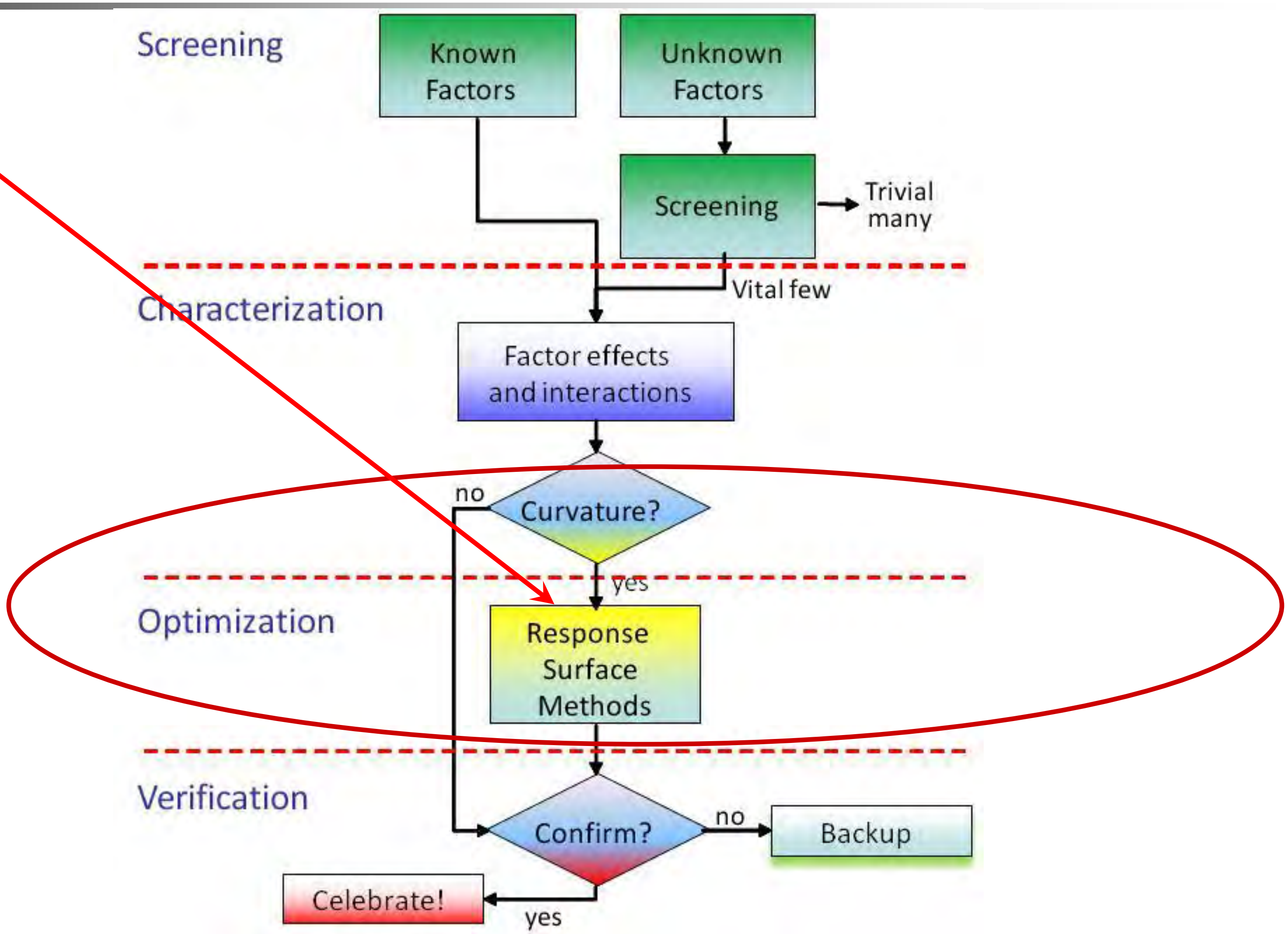


How to Frame a Robust Sweet Spot via Response Surface Methods (RSM)

By Mark J. Anderson, PE, CQE
Stat-Ease, Inc., Minneapolis, MN
mark@statease.com 612-746-2032

Strategy of Experimentation

RSM



Response Surface Methods (RSM)*

When to Apply It (Strategy of Experimentation)

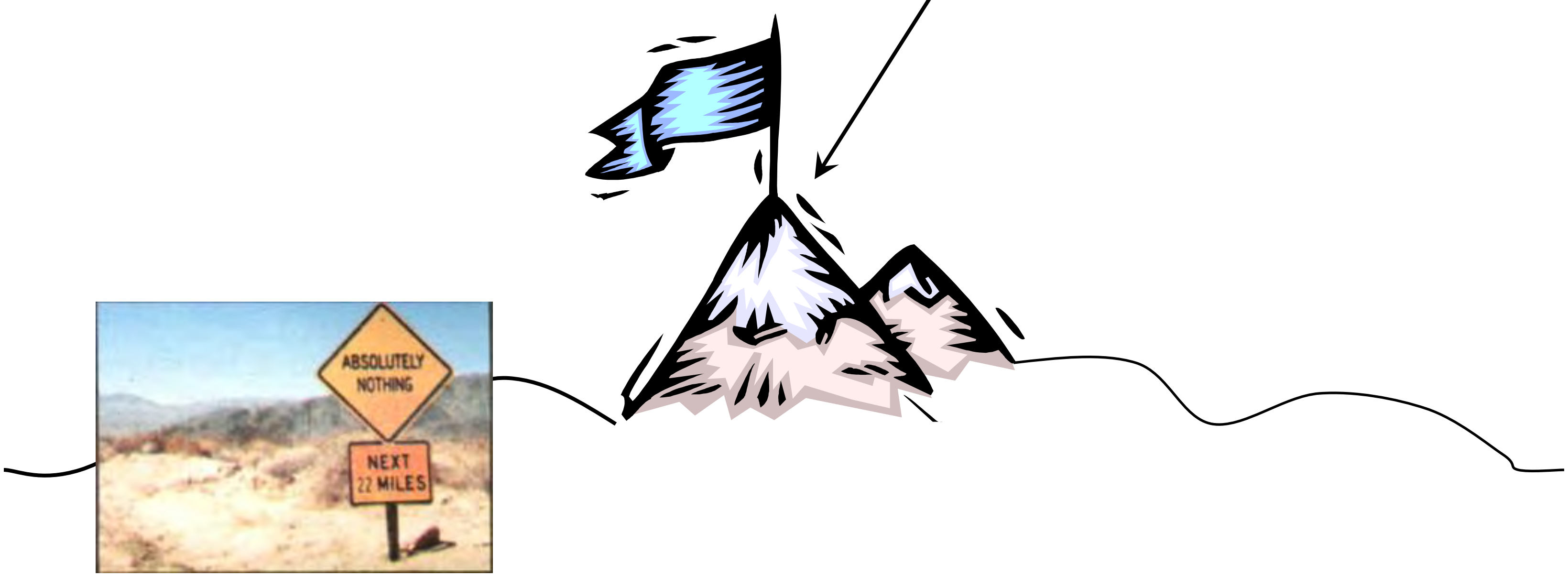
1. Fractional factorials for screening
2. High-resolution fractional or full factorial to understand interactions *(add center points at this stage to test for curvature)*
3. Response surface methods (RSM) to optimize.

Contour maps (2D) and 3D surfaces guide you to the peak.

RSM: When to Apply It

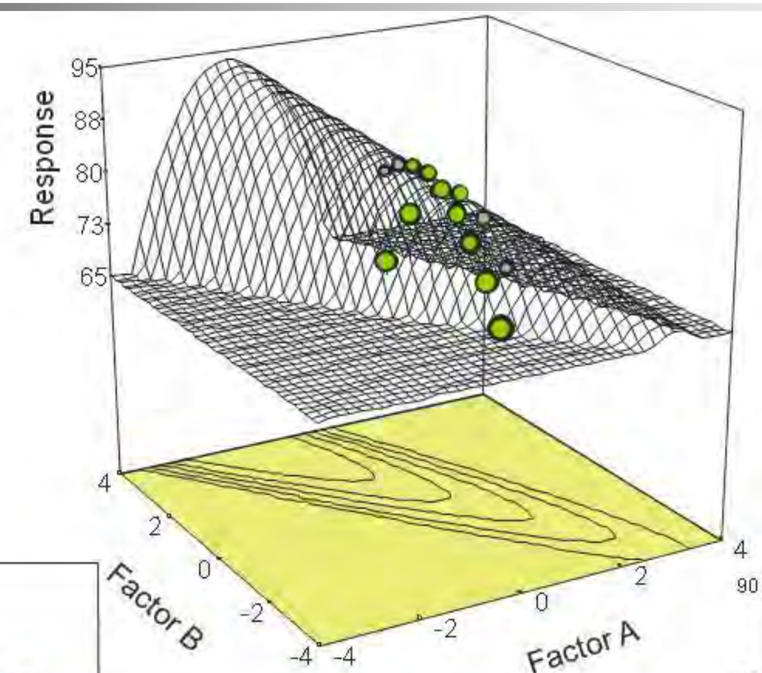
Use factorial design to get close to the peak. Then RSM to climb it.

Region of Interest

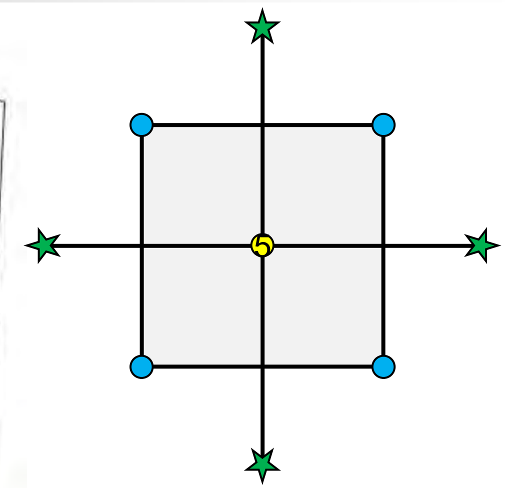


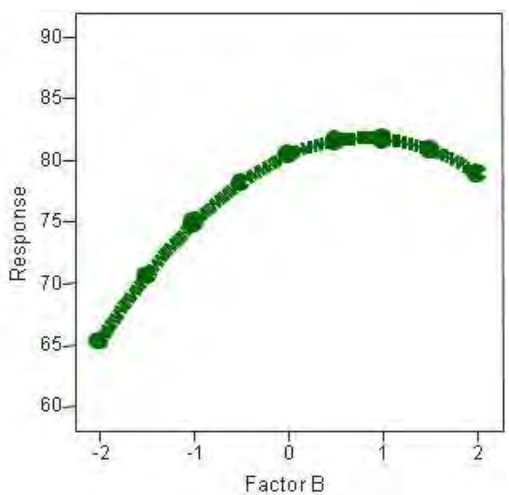
Region of Operability

RSM vs OFAT

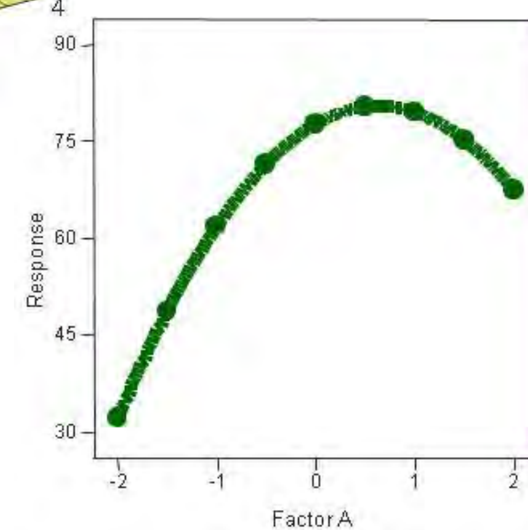


Response
95
88
80
73
65
Factor B
4
2
0
-2
-4
Factor A
-4
-2
0
2
4





Response
90
85
80
75
70
65
60
-2
-1
0
1
2
Factor B



Response
90
75
60
45
30
-2
-1
0
1
2
Factor A

RSM: Process Flowchart

Subject Matter Knowledge
(Plus Factorial Screening)

↓

Vital Few Factors (x's)

↓

Process → Measured Response(s) (y(s))

↓

↓

Polynomial Model

↓

Response Surface

"All models are wrong, but some are useful." - George Box

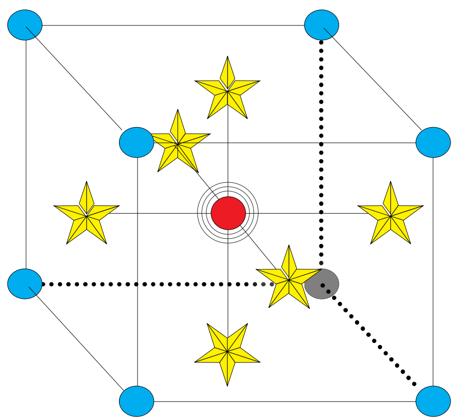
Case Study – RSM Design & Analysis

Aerospace Example*

Via a face-centered central composite design (FCD) aimed at minimizing weight of an active aeroelastic wing, aerospace engineers studied three vital structural factors:

A. Aspect ratio, 3–5.
B. Taper ratio, 0.2–0.4.
C. Thickness ratio, 0.03–0.06

"A designer knows he has achieved perfection <u>not</u> when there is nothing left to add, but when there is nothing left to take away."
- Antoine de Saint-Exupery

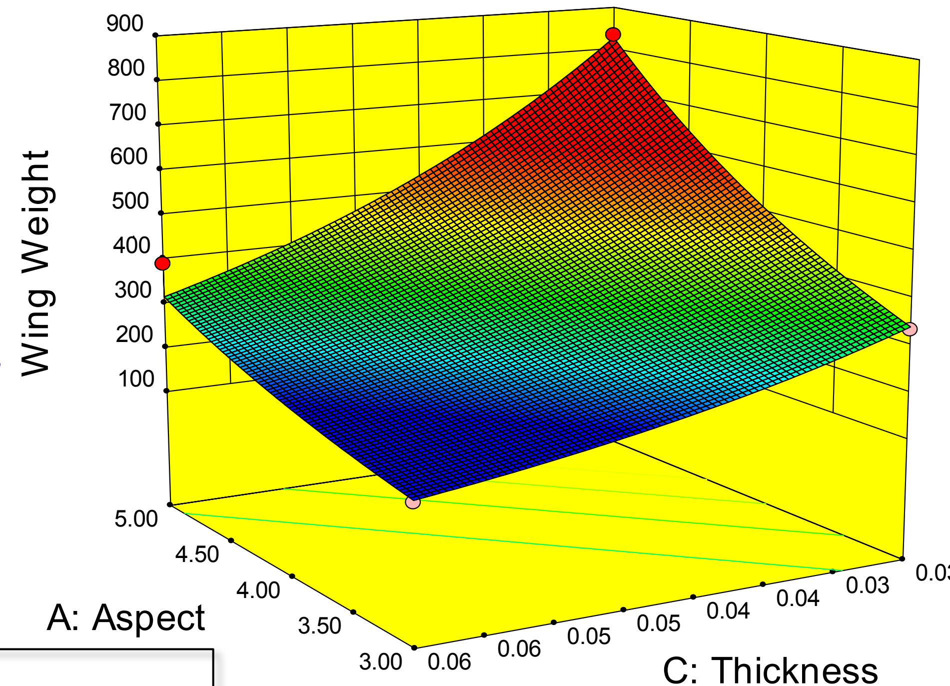


FCD

*(*RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments*, Mark J. Anderson & Patrick J. Whitcomb, Productivity Press, NY, NY (2007) Chapter 10, pp: 224–228.)

Response Surface Map for Wing Weight

The picture tells the story. It's generated by the fitted -equation (math model), which also provides a "transfer function" for numerical prediction and optimization.

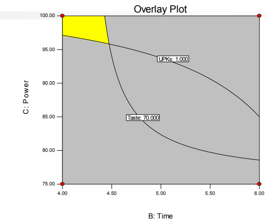


Equation in Terms of Coded Factors:
Log10(Wing Weight) = +2.56 + 0.19 A + 0.037 B - 0.21C

Equation in Terms of Actual Factors:
Log10(Wing Weight) =
+2.29660
+0.19251 * Aspect
+0.37457 * Taper
-13.86641 * Thickness

Data file: Wing weight

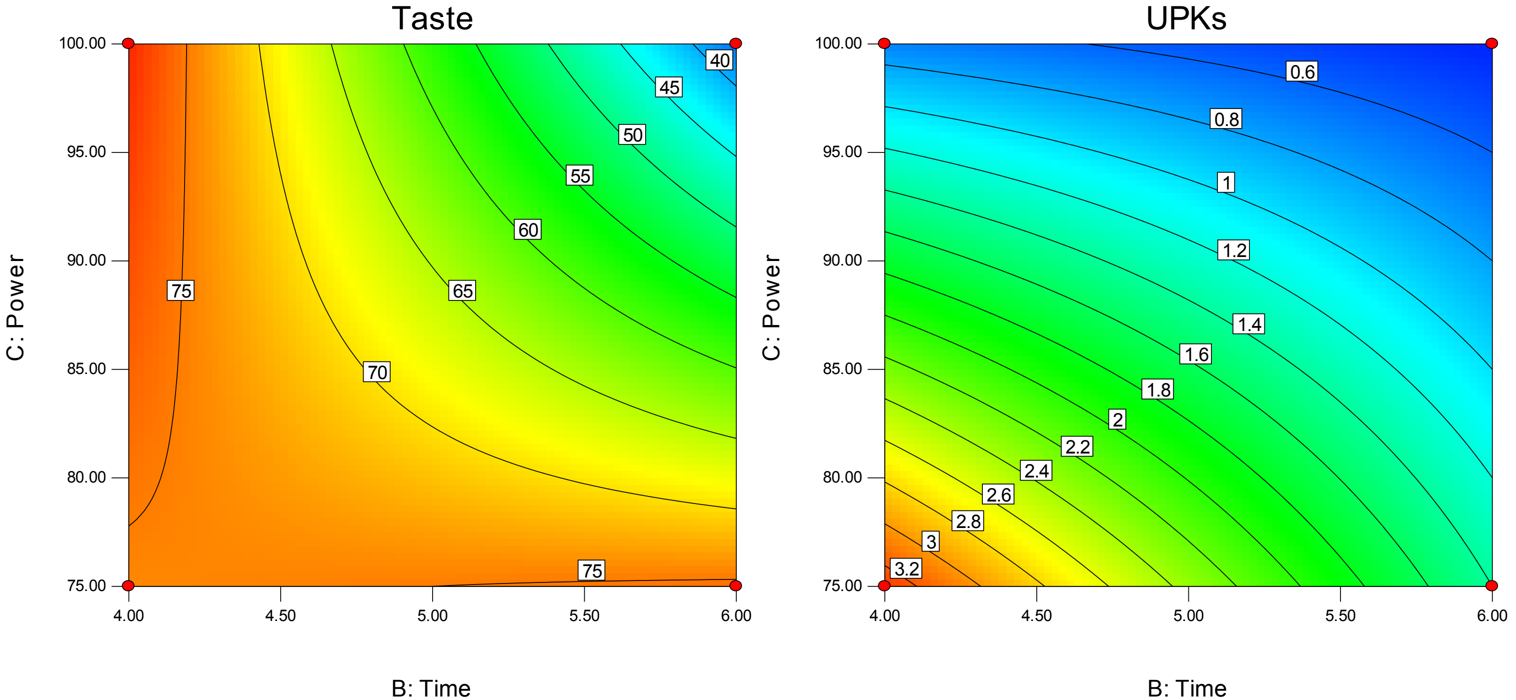
Graphical Optimization of Multiple Responses to Generate Design Space



By overlaying contour plots for multiple responses – shading out regions out of spec, one can view the <u>design space</u> (aka "operating window" or "sweet spot"). The FDA defines "design space" as the *"multidimensional combination and interaction of material attributes and process parameters that have demonstrated to provide assurance of quality."* This is a key element for their quality by design (QbD) initiative. <u>It merits attention for test and evaluation</u>.

Making Microwave Popcorn *(1/2)*

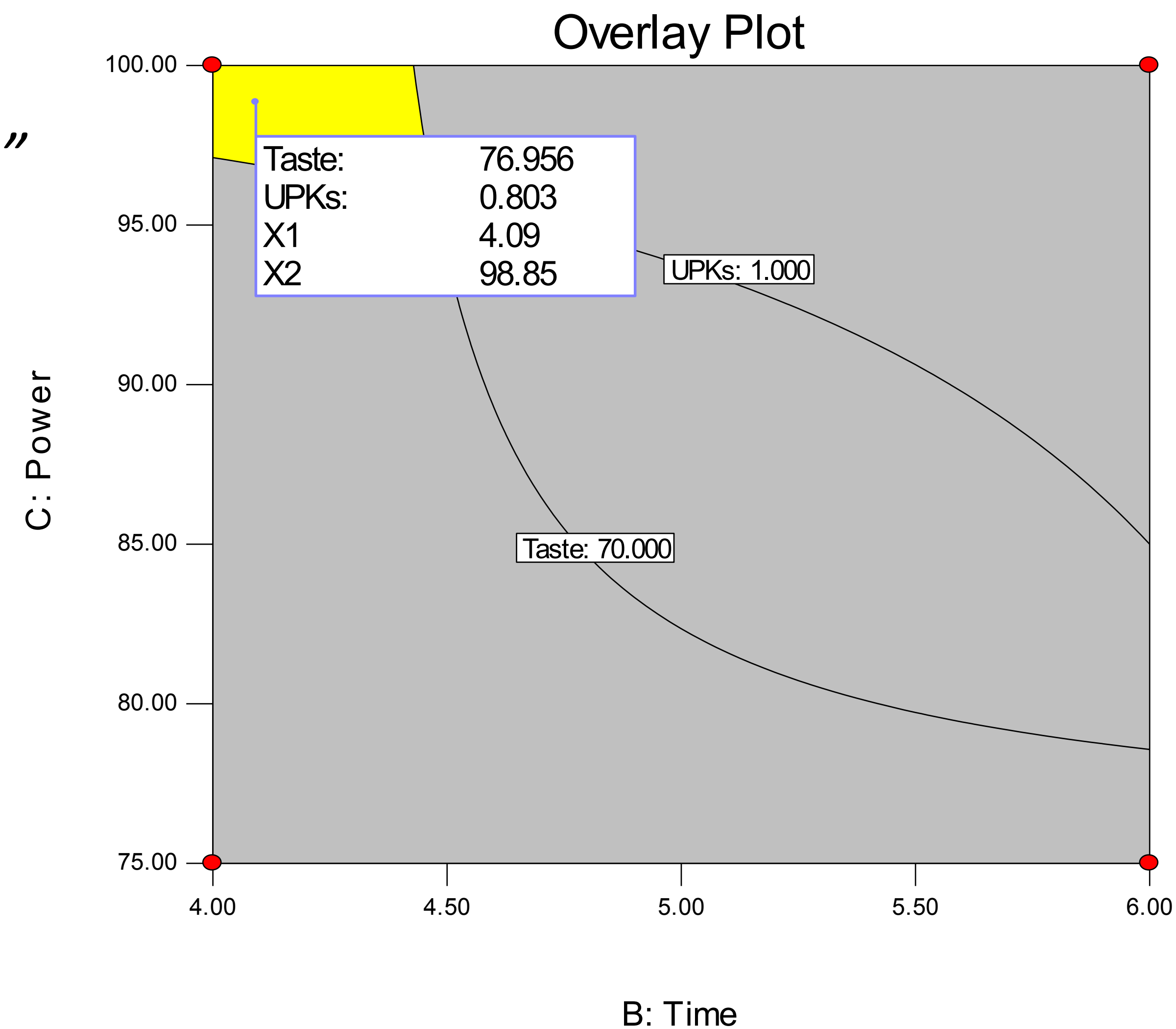
Try this experiment at home! *Where is the "sweet spot" for making popcorn?* (Hint: Want low unpopped kernels – UPK – and high taste rating.)



Data file: Popcorn

Simple Example of Design Space
Making Microwave Popcorn *(1/2)*

This is the "sweet spot" for making popcorn.



Case Study – Design Space

Aerospace Example*

Via an optimal RSM design aimed at characterizing a freejet nozzle's exit profile, aerospace engineers studied two vital factors:

A. Temperature, low to high.
B. Pressure, low to high.

Over an area of interest that required a linear constraint to cut off the region where both factors hit their high levels. The actual levels tested remain confidential. However, facility support testing at temperatures up to 4,700 degrees Rankine and pressures up to 2,800 psia.

*("Developing, Optimizing and Executing Improved Test Matrices," presented by Dusty Vaughn and Doug Garrard to the U.S. Air Force T&E Days 2009, approved by U. S. Government for public release via the American Institute of Aeronautics and Astronautics.)

Defining the Operating Constraints

This is a “burnt pudding” problem – too much temperature and time overcooks the food. DOE software makes it easy to avoid these unwanted combinations. The experimenter need only identify the constraint points.

Here, after entering dummy values for each factor, a constraint point is set for the level of temperature that cannot be exceeded when the system is at high pressure.

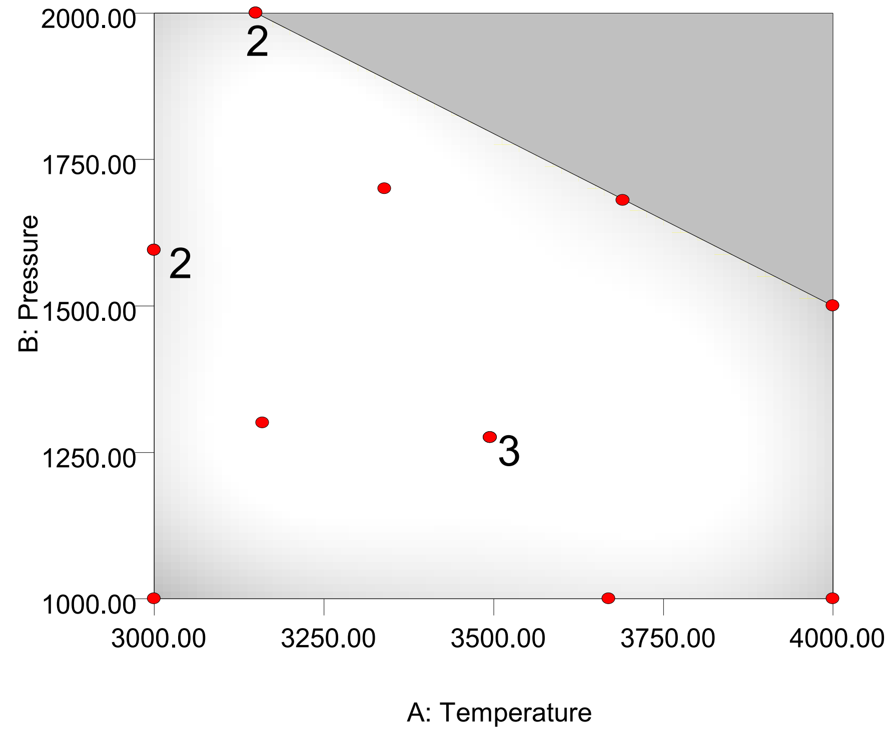
Conversely, a second constraint point is set for the maximum pressure level when temperature is at its highest level.

	Name	Low Actual	High Actual	Vertex	< > skip	Constraint Point
A:	Temperature	3000	4000	4000	A <	3150
B:	Pressure	1000	2000	2000	B <	1500

Laying Out an Optimal Design

Due to the demands of cost and schedule, the experimenters chose a minimum-run design of 6 points to fit the standard second-order (quadratic) RSM model. One point was replicated.

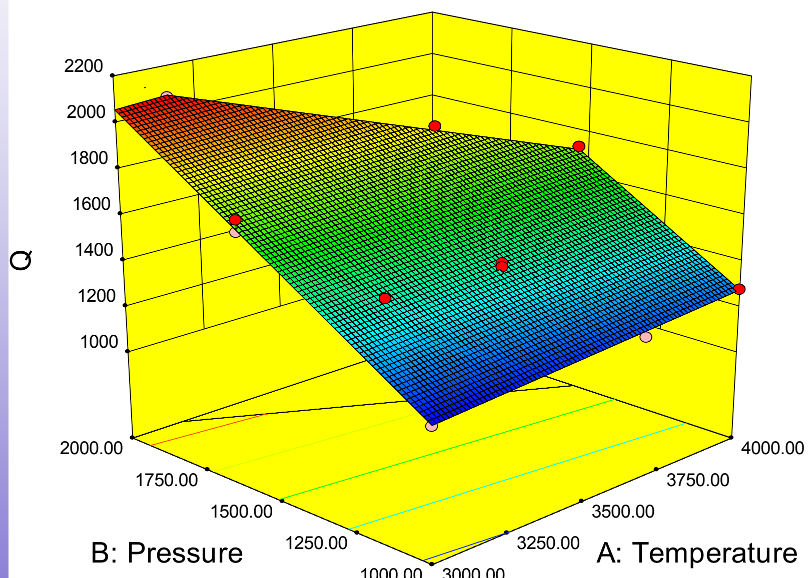
However, for expository purposes, here is a stouter design* with 4 additional test points to assess lack-of-fit and 4 points replicated for a stronger estimate of pure error. Also, the optimality criterion for this design is IV – now favored for RSM designs, not D-optimal as done by the experimenters.

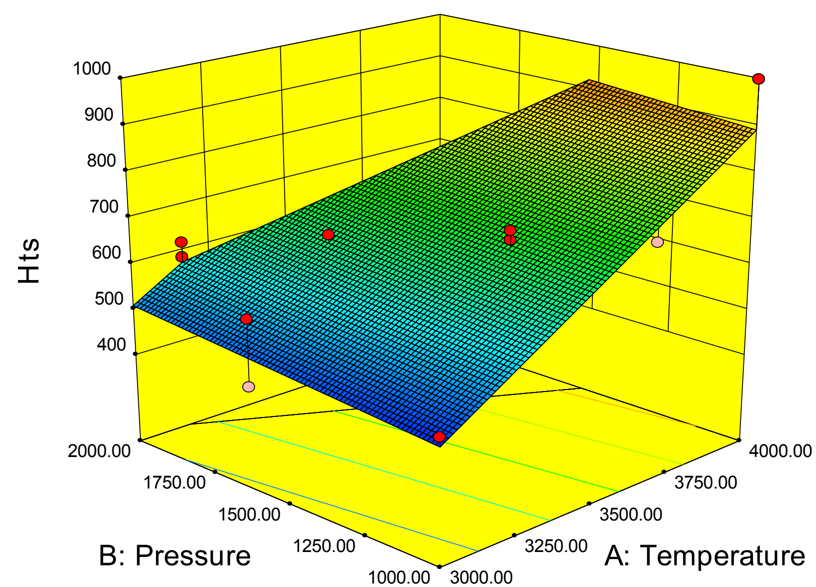


(How many test points will be needed is an issue of power, which goes beyond the scope of this talk. For details on design-sizing for RSM, see the Sept. '08 Stat-Teaser.)

Results

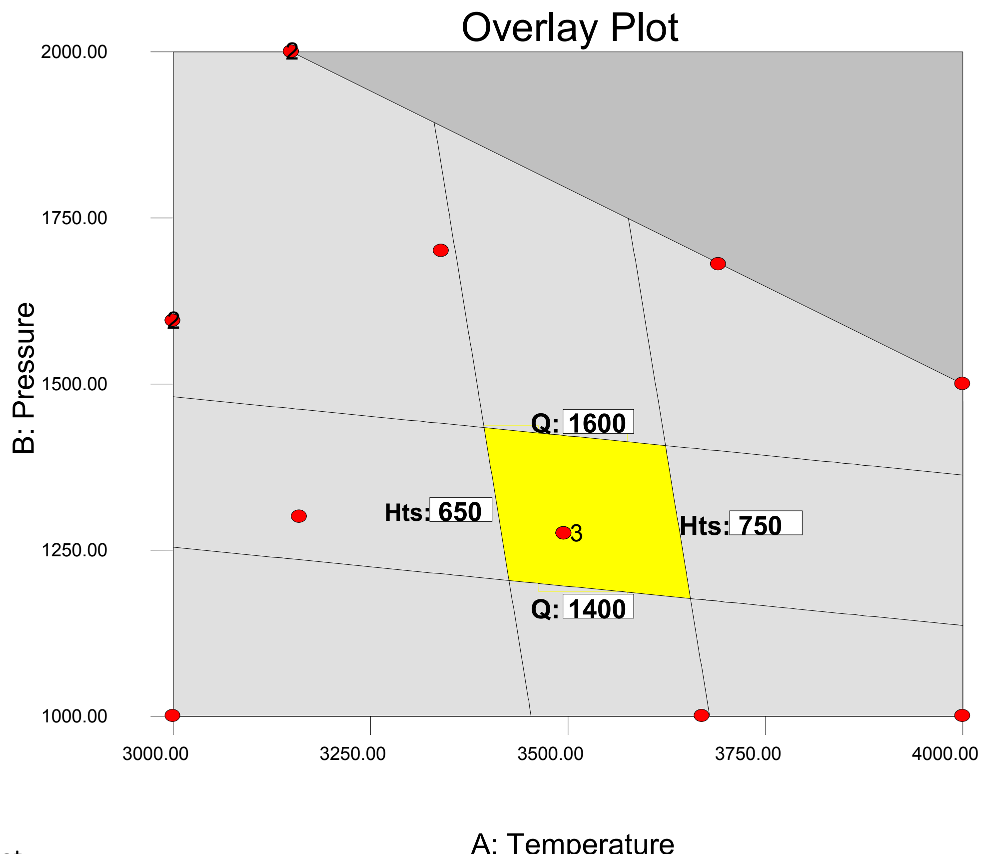
The following response surfaces were generated via re-simulation from predictive equations provided in coded form by the experimenters. The graphs closely resemble the published results for the key measures of dynamic pressure (Q) and total sensible enthalpy (Hts).





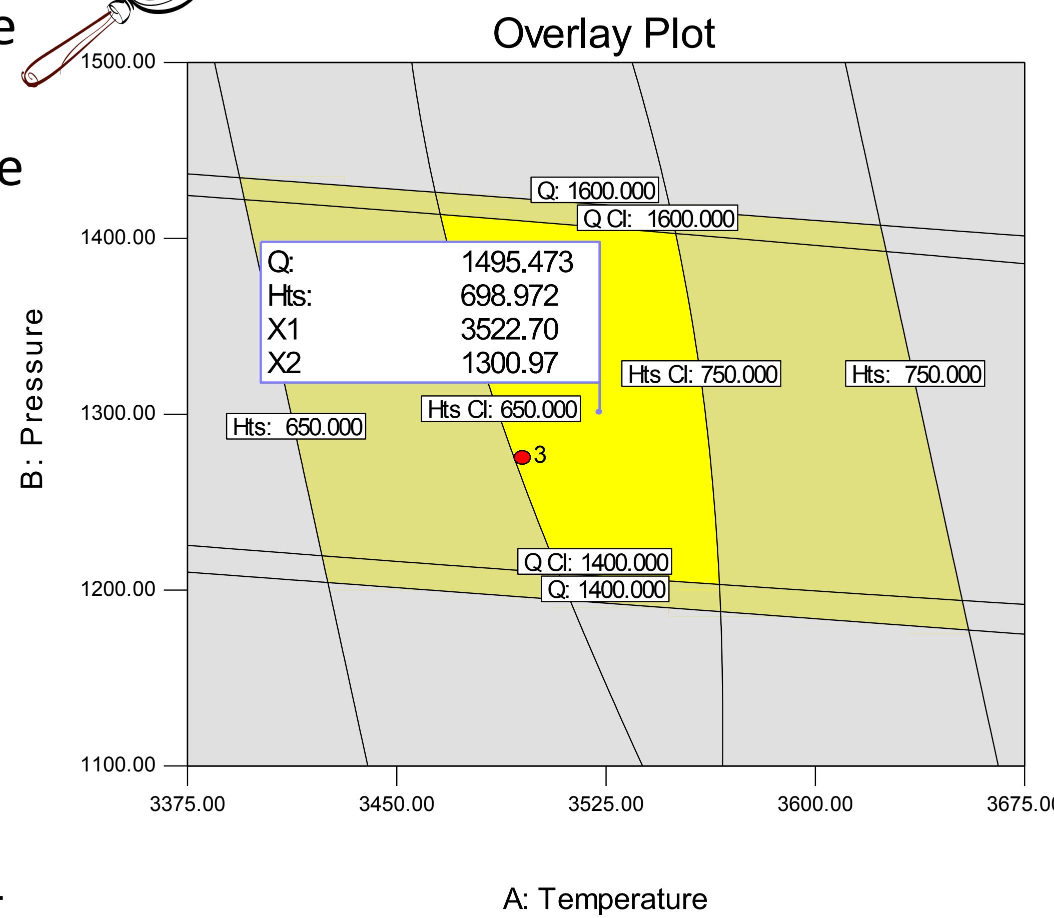
Sweet Spot (Hypothetical)

The customer requirements have not been revealed, but assume they are represented by the graphical overlay shown below.



Robust Sweet Spot

To be more conservative (robust) in framing the sweet spot, superimpose the confidence intervals (CI) – a function of the underlying standard deviation (provided by the original publication) and the power of the experiment design (stronger in our re-simulation). <u>The flag in the center might mark a good place to operate</u>!



Conclusion

Via application of response surface methods (RSM) experimenters in the field of test and evaluation can frame an operating window (aka "sweet spot" or "design space"). To be more conservative (robust), shade out the regions that fall within the confidence intervals of the boundary lines.

Best of luck for your experimenting!

Thanks for listening!

-- Mark

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Joint Mission Environment Test Capability (JMETC)
Improving Distributed Test Capabilities

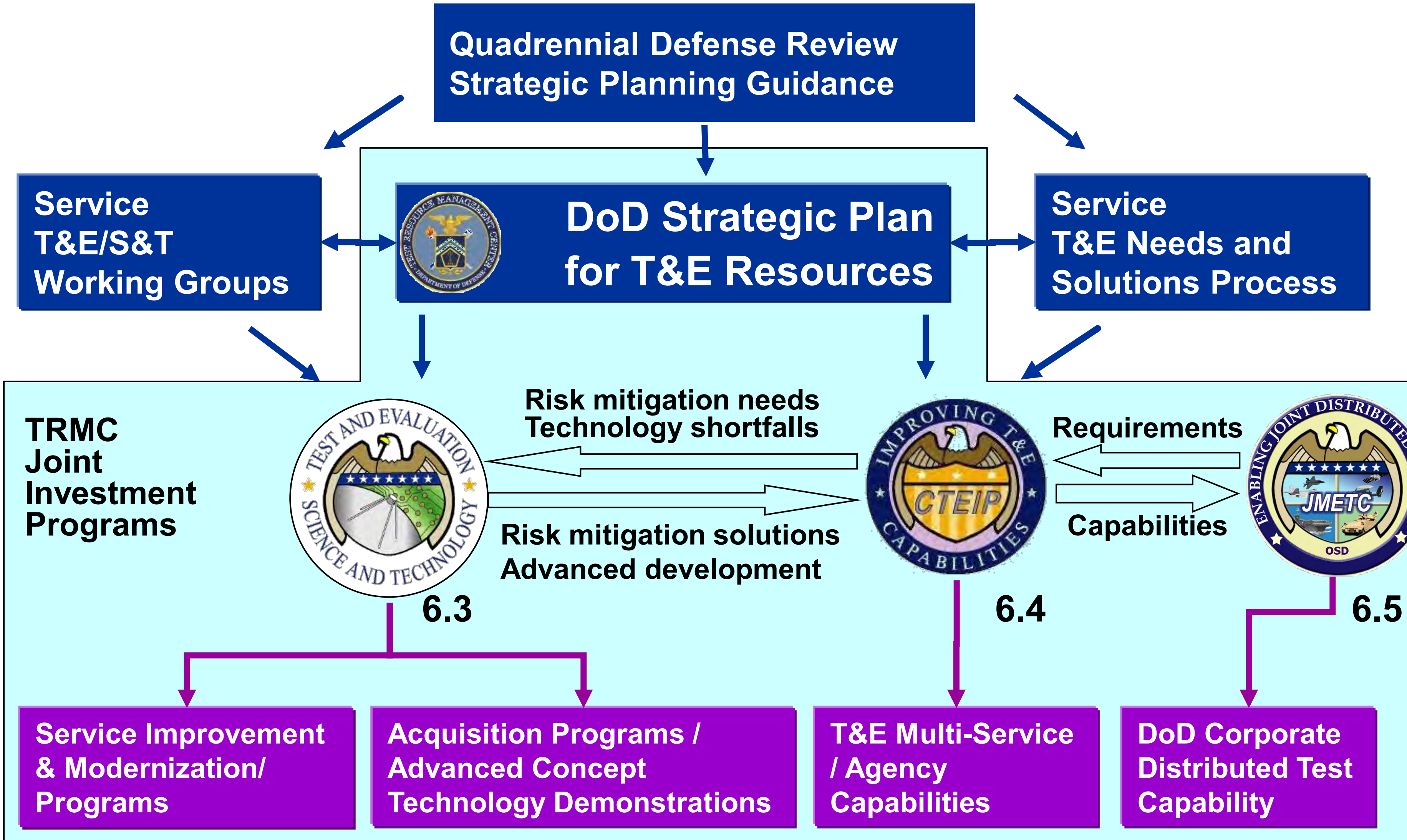
NDIA Annual T&E Conference

Chip Ferguson
Program Manager
March 16, 2011

Agenda

- TRMC
- Distributed Testing
- What is JMETC?
- JMETC Testing Successes
- JMETC Sites
- JMETC Customers and Events
- JMETC Users Group
- Summary

Relationship within TRMC
Synergy through Aligned Investment



What is Distributed Testing?

A process, preferably persistent and continuous, for linking various geographically separated Live, Virtual, and Constructive sites and capabilities together in a distributed environment, for use across the acquisition life cycle, to support and conduct the Test and Evaluation (T&E) of a system or systems-of-systems.

GOAL: Near Real-Time Test-Fix-Test

What is Distributed Testing?

A process, preferably persistent and continuous, for linking various geographically separated Live, Virtual, and Constructive sites and capabilities together in a distributed environment, for use across the acquisition life cycle, to support and conduct the Test and Evaluation (T&E) of a system or systems-of-systems.

A new way of thinking for many in the Test and Evaluation enterprise

Distributed Testing Impacts

- Distributed Testing has already demonstrated:
  - Time savings, risk reduction, cost savings
  - Efficiencies across the development and T&E process
    - Early identification of issues
    - Move data—not people
    - Near real-time Test-Fix-Test
- Distributed Testing, when fully implemented also:
  - Provides for agile, persistent T&E
  - Supports early integration of DT and OT
  - Gives SME’s an —Int ensive Lab” and connective relationship with other entities in the systems-of-systems environment that they wouldn’t have otherwise.

Why Consider Distributed Test?

- Do you have data exchange requirements within your system or within a system-of-systems (SoS)?
- Do you have a requirement to address SoS interoperability issues early in the acquisition process?
- Do you have adequate numbers of systems under test for live testing?
- Do you have adequate numbers of —supporting cast” (supporting systems, C4ISR assets, etc.) for live testing?
- Do you have adequate threat types, fidelity and density in realistic numbers at realistic ranges for live testing?

When Is Distributed Test Appropriate?

- **Examples Where Appropriate**
  - Interoperability testing
    - C4 Interoperability with higher, lower, and adjacent Joint force organizations
  - Data exchange in early DT testing
    - Interaction between sub-systems (latency may be a consideration)
    - Interaction between systems in a realistic environment
      - Provide the most realistic environment possible from concept exploration through Follow-On T&E
  - When it is too costly to bring all the player systems together on a single range
  - Gain or increase operational relevance
    - Virtual and Constructive capabilities to supplement live systems (e.g., red forces, white forces, terrain, immobile test assets)
- **Examples Where Inappropriate**
  - System performance tests that do not include other systems/subsystems
  - Reliability testing

Reduces Cost, Risk, and Time

Distributed Testing Challenges

Not unique to JMETC, but we are working:

- Classification
  - Multi-level security issue to peer to networks of higher classification levels
  - Solution
    - Short Term: Create separate enclaves for each level
      - Time and dollars issue to operate at higher levels of classification
    - Long Term: Develop an enterprise solution
      - Current CTEIP Project

- DOD Information Assurance Certification and Accreditation Process
  - Information Assurance Requirements for higher levels of classification
    - Time and dollars issue
  - DIACAP Tiger Team
    - Common lexicon and reciprocal acceptance
    - RDT&E Community won a mechanism for their voice to be heard by the policy makers
      - TRMC is now a non-voting member of the DIACAP Technical Advisory Group (TAG), where next-generation policy is being developed

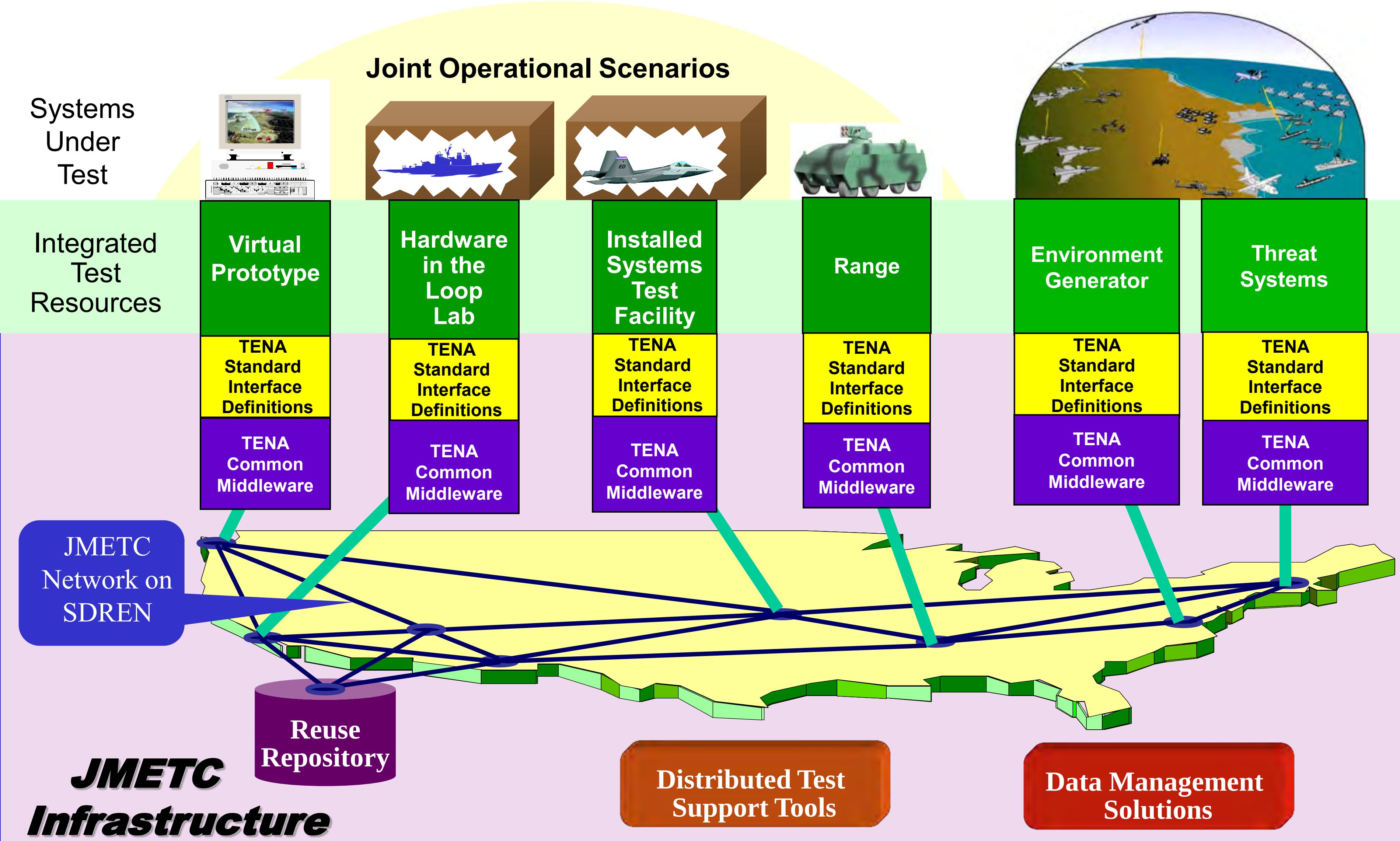
The JMETC Mission

JMETC provides the ***persistent and robust infrastructure (network, integration software, tools, reuse repository)*** and ***technical expertise*** to integrate live, virtual, and constructive systems for test and evaluation in a Joint Systems-of-Systems environment

What is JMETC?

- **DoD enterprise approach for linking distributed facilities currently being used by over 60 test facilities**
- **A core, reusable, and easily reconfigurable infrastructure**
- **Consists of the following products**:
  - Persistent connectivity
  - Middleware
  - Standard interface definitions and software algorithms
  - Distributed test support tools
  - Data management solutions
  - Reuse repository
- **Provides customer support team for JMETC products and distributed Live, Virtual & Constructive DT and OT**

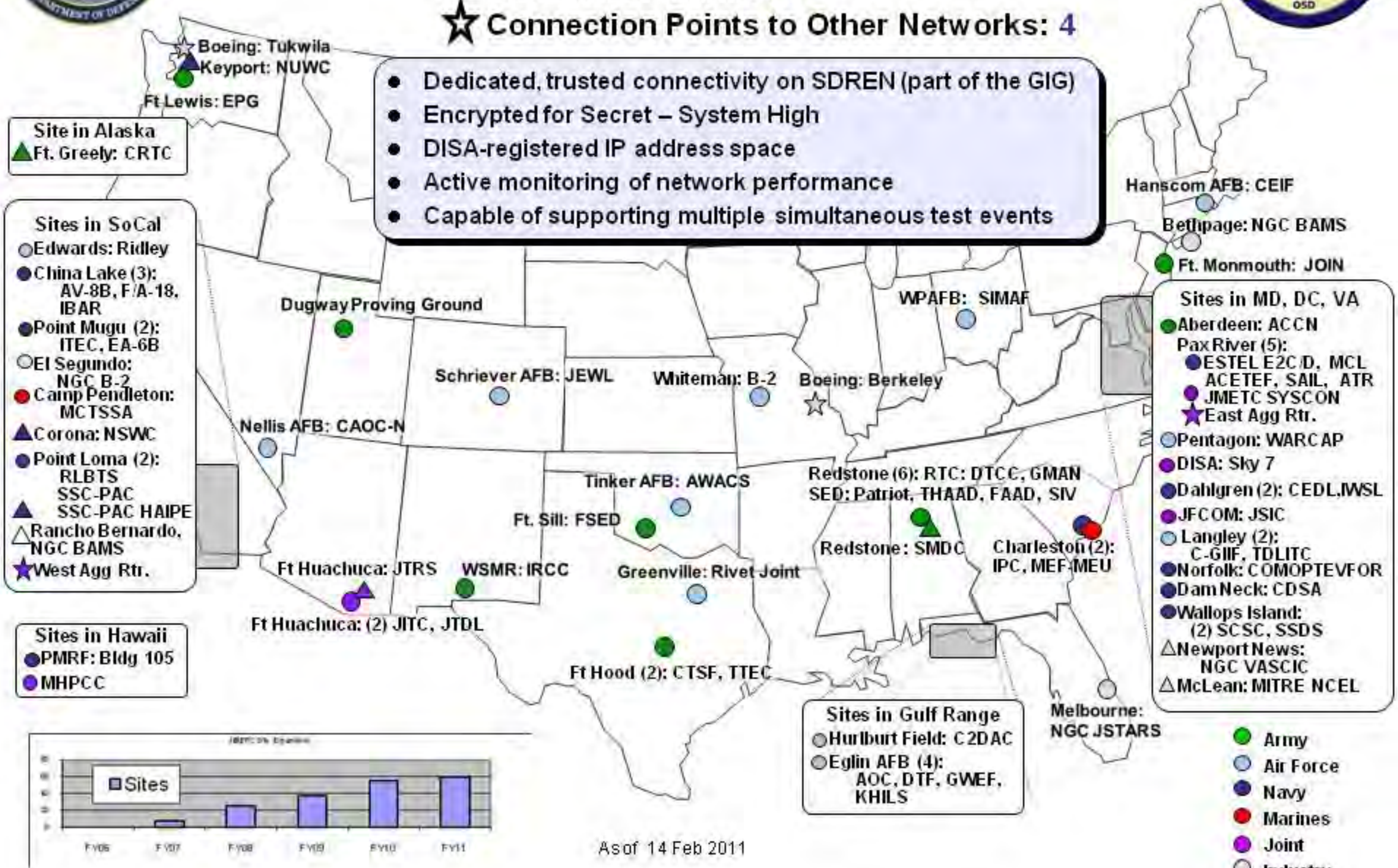
JMETC Enabled Distributed Testing



JMETC Connectivity

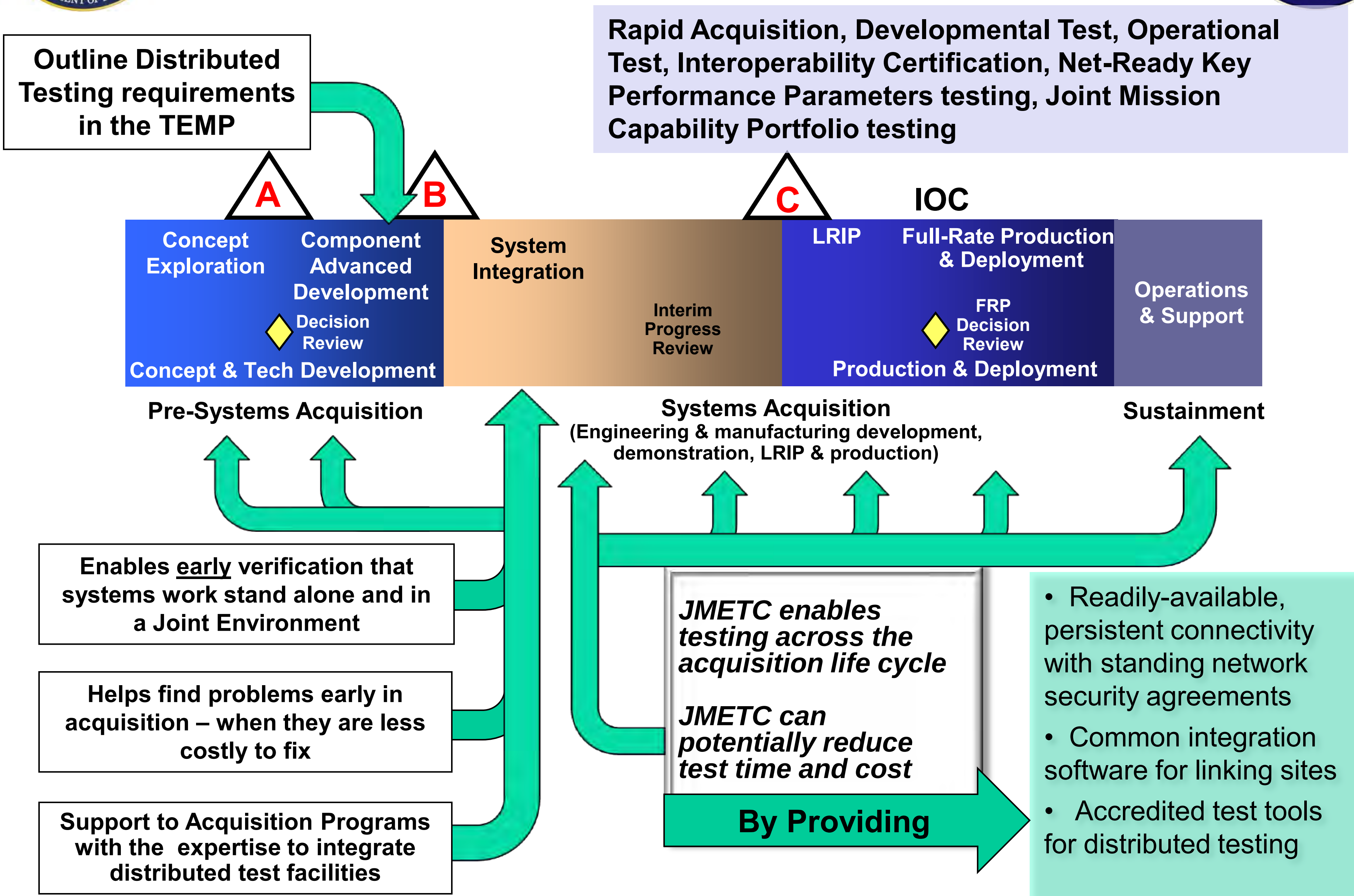
- ○ Functional Sites: 60
- △ New Sites Planned: 9
- ☆ Connection Points to Other Networks: 4

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



As of 14 Feb 2011

JMETC Allows You to "Test Early and Test Often" Across the Acquisition Life Cycle



FY10 JMETC Events

Customer	Event	Record Event Dates*
Air Force	JEFX 10-1/Spirit Ice (B2 Data Link Test)	October – November 2009
Navy	BAMS LVC DE	October – December 2009
Air Force	Battlefield Airborne Comm. Node (BACN) JUON (DT/OT)	November 2009 to September 2010
Air Force	Agile Fire 10-2	January 2010
Air Force	JEFX 10-2/3	February/April 2010
Joint	Joint Surface Warfare JCTD	February to September 2010
JS J8/JIAMDO	Joint Sensor Integration	April to September 2010
Air Force	B1-B Fully Integrated Data Link Testing	April 2010
JFCOM J84/89 (TEST WEEK)	JCAS Distributed Test	June 2010
JIAMDO (Navy Lead)	Correlation/Decorrelation Interoperability Test (C/DIT) Integration Events (Continuous)	July to September 2010
Army (Lead)	UAS in the National Airspace	July to September 2010
Air Force	Agile Fire 10-3	August 2010
Joint	JITC Joint Interoperability Tests	JIT 10-3 & 11-1
Discussions for Future Teaming		
Gerald R. Ford Class (CVN-78)	Joint Strike Fighter (JSF)	JIAMDO/Joint Track Manager
Brigade Combat Team (BCT) Modernization	Multi-Function Adv Data Link (MADL)	Multi-Mission Maritime Aircraft (MMA)

* **Each event is normally preceded by 1-3 spirals: Connectivity Check, Integration, and Dry Run**

15

JMETC FY10 Accomplishments

FY10 Example JMETC Customers

- Joint Integrated Air & Missile Defense Organization (JIAMDO)
- Broad Area Communications Node (BACN) JUON
- B1-B
- Broad Area Maritime Surveillance System (BAMS)
- Air-Ground Integrated Layer Exploration (AGILE)
- Joint Interoperability Test Command (JITC)

JMETC Accomplishments

- Supported 88 distinct customer test activities
- Expanded network from 38 to 57 sites
- ATIN and JTDL Networks transitioned to JMETC
- Upgraded JMETC support applications and utilities to TENA R6
- DIACAP Tiger Team report completed and recommendations being executed
- Enhanced JMETC services and capabilities provided by leveraging InterTEC, Services, and Industry
- Reuse Repository usability improvements

Selected Benefits to the DoD

- Integrated DT & OT on a Joint Urgent Operational Need for the warfighter
- Maximized usage of theater assets during limited maintenance windows
- Improved Joint track information sharing to ensure interoperability of systems in theater operations
- Coalition exchange and examination of real-time air picture data
- Identification of Air Force Initiatives ready for warfighter transition
- Investigated tactical UAS deployment in the National Airspace
- Employment of Net-Enabled Weapons
- JCAS immediate request & end-to-end processes —as is” characterization
- Determined distributed system components were not ready for full live integration testing
- Executed testing to support system-of-system interoperability certification

FY11 JMETC Events (More to Come)

Customer	Event	Record Event Dates*
Joint	JIAMDO Correlation/Decorrelation Interoperability Test (C/DIT) Integration Events (Continuous) OCONUS	October 2010
Navy	UAS in NAS Runs for Record	October 2010
Internal	InterTEC Spiral 3 Systems Acceptance Test	October - November 2010
Joint	JITC Joint Interoperability Tests JIT 11-1,2,3,4,5 (Continuous)	October 2010 – September 2011
Air Force	B1-B Fully Integrated Data Link Testing	November 2010
Air Force	AGILE Fire Phase III / JEFX 2011	December 2010 - February 2011
Joint	JTRS JPO -- JTRS Ground Mobile Radio	January 2011
Navy	Broad Area Maritime Surveillance (BAMS) (Continuous)	January – September 2011
Joint	Joint Track Manager Capability Demonstration (Continuous)	January – September 2011
Joint	JSF Initial M&S Interoperability (Continuous)	February – March 2011
Air Force	JSTARS Interoperability Test	May 2011
Joint	JS J8/JIAMDO Joint Sensor Integration	June – August 2011

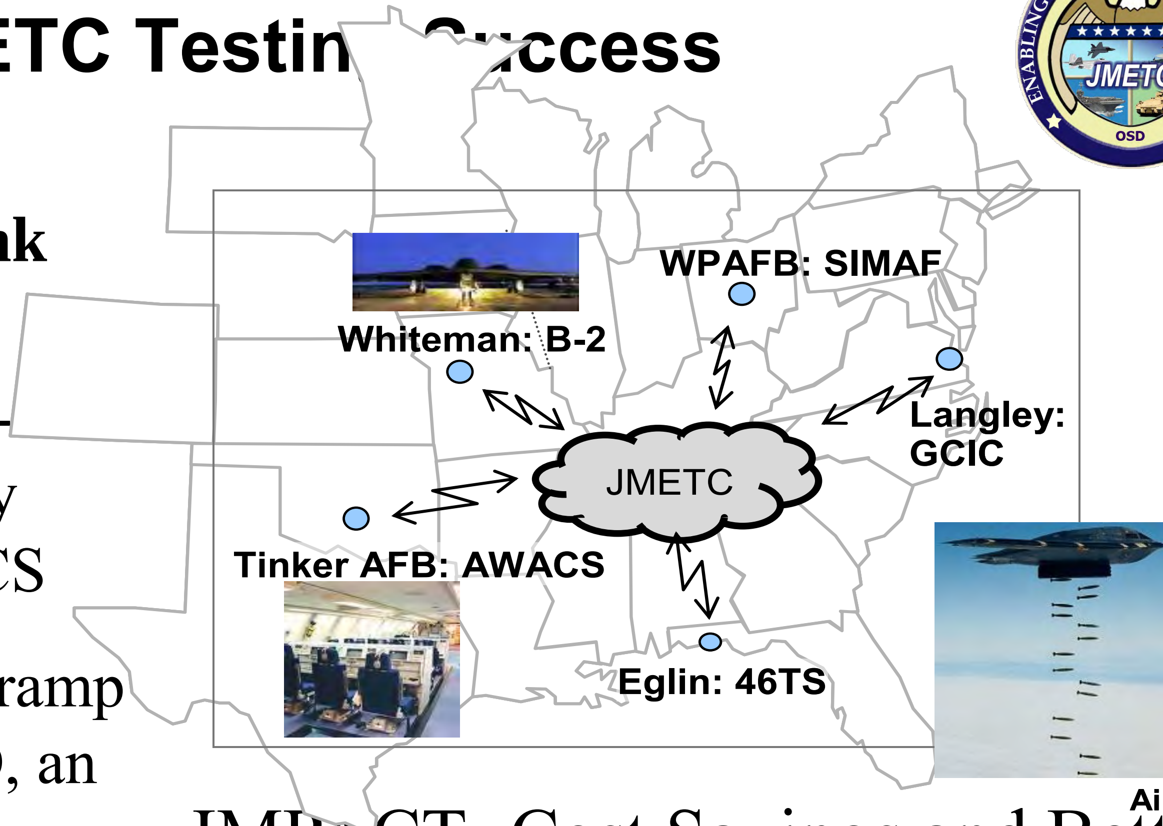
Discussions for Future Teaming		
Gerald R. Ford Class (CVN-78)	Global Hawk	GATOR
Brigade Combat Team (BCT) Modernization	F-22 FY12 Testing Planned	Multi-Mission Maritime Aircraft (MMA)

*** Each event is normally preceded by 1-3 spirals: Connectivity Check, Integration, and Dry Run**

JMETC Testing Success

B-2 Spirit ICE Data Link Test (Nov 2009)

- JEFX assessment of B- Link-16 interoperability challenges with AWACS
- Connected live B-2 on ramp at Whiteman AFB, MO, an AWACS HITL at Tinker AFB, OK, within a distributed C2 environment
- Time sensitive targeting scenarios with combat ready crews



As of 14 Sep 2009

my
Air Forc
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Industry

IMPACT--Cost Savings and Better Product!

•Early testing led to early identification and correction of Link 16 interoperability issues

•No range or flying costs!

JMETC Testing Success

Joint Surface Warfare JCTD

- Point Mugu Test Team demonstrated Net Enabled Weapon Link-16 capability using F/A-18E/F as launch platform, JSOW C-1 as weapon, and JSTARS as 3rd party target source
- Distributed Tests
  - 09-11 Mar 2010
  - 04-05 May 2010
  - 17-19 Jun 2010
  - 31 Aug – 01 Sept 2010

IMPACT--Efficiency, Lower Technical Risk, and Cost Savings!

- Program scheduled & executed short multiple tests for incremental software update evaluation
- Resources expended on test & analysis and not network setup and monitoring

JMETC Testing Success

Joint Integrated Air and Missile Defense Organization (JIAMDO)

- Correlation/Decorrelation Integrated Test (C/DIT-10) to improve interoperability of Aegis, E2C, CAC2S, AWACS, Patriot, and FAAD.
- During Oct 2010 testing, JMETC enabled multiple C/DIT runs with an average turnaround time of 11 minutes – two shifts per day

<u>IMPACT—Efficiency!</u>

- Near real time test-fix-test
- C/DIT FY-11 T&E events accelerated into FY10, w/no funding impacts to FY-10

Interoperability Certification

Joint Interoperability Test Command (JITC): Joint Tactical Data Link (JTDL) Testing

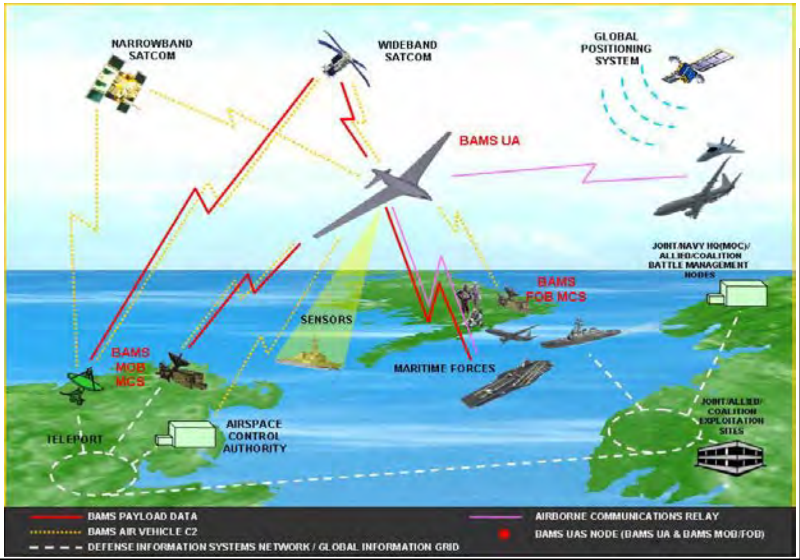
JITC conducts interoperability assessments, standards conformance and interoperability certification testing of joint tactical data links in HWIL and operationally realistic environments to validate the implementation of approved standards in a Joint environment.

JITC uses JMETC Connectivity and tools for JTDL Testing

<u>IMPACT--Test Commonality!</u>

- JITC Interoperability Certification is required for Net Ready KPP for all ACAT Programs
- JITs use JMETC infrastructure.

Broad Area Maritime Surveillance Unmanned Aircraft System (BAMS UAS)



System Architect v 10.1.11 Encyclopedia BAMS_PBSS (11 Jan 07)v1.1

Program Status/Events:

BAMS planned sites are: Bethpage – NGC MSSIL (existing), Rancho Bernardo – (Installing), Dam Neck C2/SA/TCC/MOC (existing), Palmdale NGC SIL (TBD), NAS Patuxent River (existing)

Current BAMS schedule: June 2012 (6-12 months) NGC lead. June 2013 – IOC Pax Lead

PSP signed by BAMS and JMETC August 6, 2010

Program Description:

BAMS UAS is an integrated Systems of System that will provide multi-sensor persistent maritime ISR to the Maritime Patrol and Reconnaissance Force

Program POC:

Jeff Sappington NAVAIR

Issues:

Working to peer with BAMS Classified Network (BCN) but may be separate agreement with NGC

ESP for flight test needs to be completed, ESP format changes under review by ENG/DOPS

Both BAMS and NGC are still discovering potential T&E requirements including various networks that BAMS interfaces with for flight

Last Contact:

BAMS Technical Exchange Meeting Rancho Bernardo, CA March 1-3, 2011

JMETC Users Group

- **Purpose is to focus on technical requirements and solutions relevant to current and future Distributed Testing needs.**
  - **Technical and Management level representatives identify core infrastructure requirements, and most importantly resolve issues**
- **Quarterly meetings of 250-300 JMETC customers, acquisition programs, test events, ranges, LVC sites, tools and network providers**
- **An established forum for the Distributed Test Community to:**
  - **Identify core infrastructure requirements and use cases**
  - **Identify, investigate, & resolve issues**
  - **Identify opportunities to collaborate**
  - **Discuss available solutions, tools, and techniques**
  - **Share lessons learned**

Next JMETC Users Group Meeting:
- Scheduled for March 22-23, 2011
- Location: Norfolk, VA
- Tracks:
  - User Requirements
  - Information Assurance / Security
  - Data Management
  - InterTEC (Current & Planned)
  - Networking

Summary

- Distributed Testing can save Acquisition T&E Programs time and money and result in better, more interoperable products while reducing technical risk!
- JMETC is here and proven!
  - Many Sites and Systems already connected via JMETC and well versed in TENA and the InterTEC tools
  - Demonstrated reliability with the capability to execute multiple events simultaneously, supporting high data rates and low latency requirements
  - Multiple examples of JMETC value added for customers
  - Provides Acquisition T&E Programs near real-time Test-Fix-Test capability
  - JMETC offers support to develop our customer’s distributed test requirements

You need only contact us

JMETC Program Points of Contact

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JMETC Lead Systems Engineer: **Ryan Norman** ryan.norman@osd.mil
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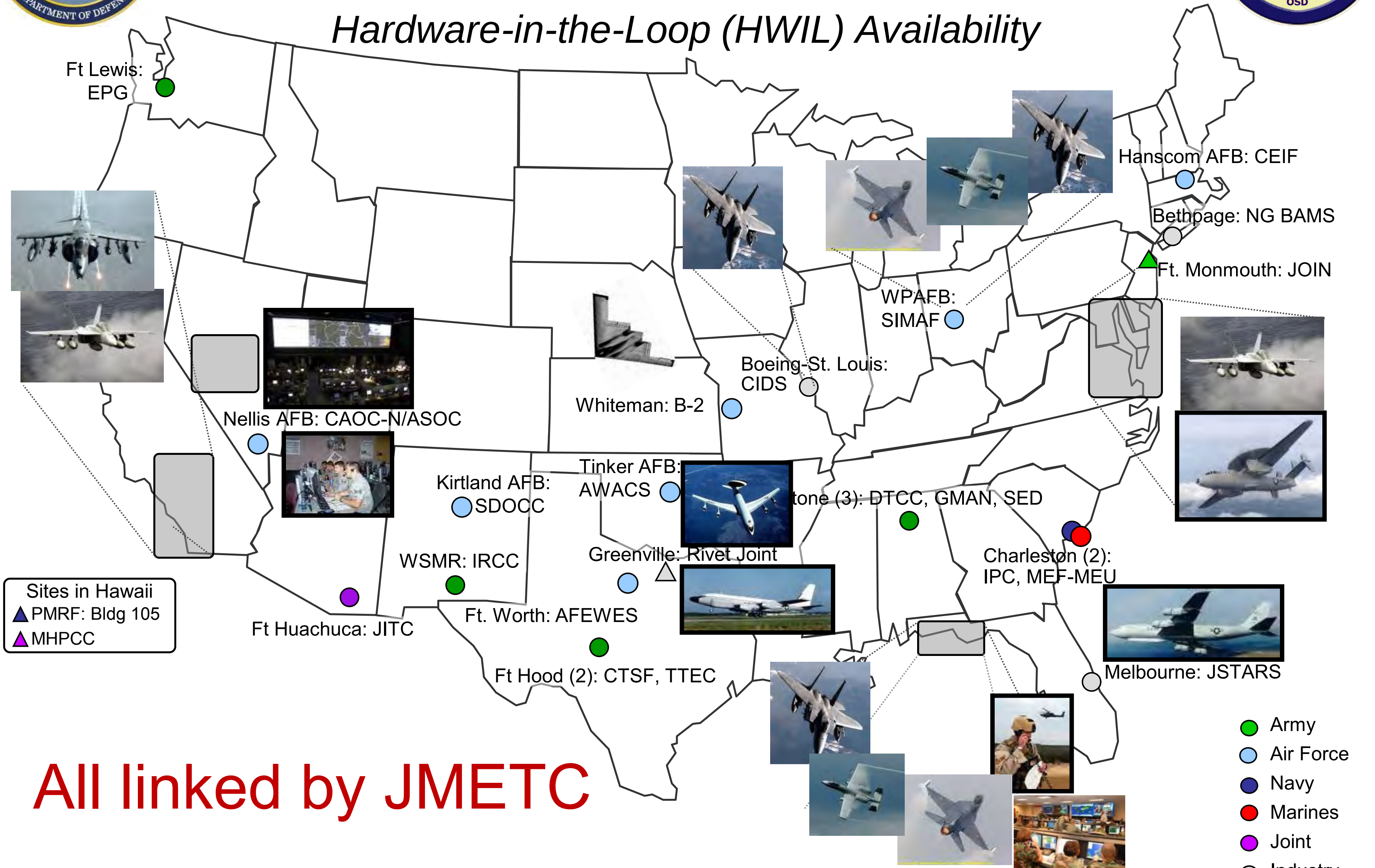
JMETC Lead Network Engineer: **Arjuna "AJ" Pathmanathan**
Arjuna.Pathmanathan@osd.mil
703-601-5214

JMETC Website: www.jmetc.org

Backup Slides

How an Air Force Customer Sees Distributed Connectivity

Hardware-in-the-Loop (HWIL) Availability



All linked by JMETC

JMETC Planning With 20+ Customers (Active and Prospective)

Joint and Service Initiatives

- Joint Tactical Data Link (JITC JTDL)
- Joint Expeditionary Forces Experiment (JEFX)
- Joint Integrated Air and Missile Defense Organization Corr/Decorr Interoperability Test and Joint Sensor Integration (JIAMDO C/DIT & JSI)
- Air-to-Ground Integrated Layer Exploration (AGILE Phase III and IV)
- Network Enabled Weapons Interoperability Working Group (NEW IWG)
- Unmanned Aircraft Systems in National Airspace (UAS in NAS)
- Digitally Aided Close Air Support (DACAS)
- Space Threat Assessment Testbed (STAT)
- Joint Unmanned Aircraft Systems Mission Environment (JUAS ME)
- Joint UAS Digital Information Exchange (JUDIE) Joint Test and Evaluation Program

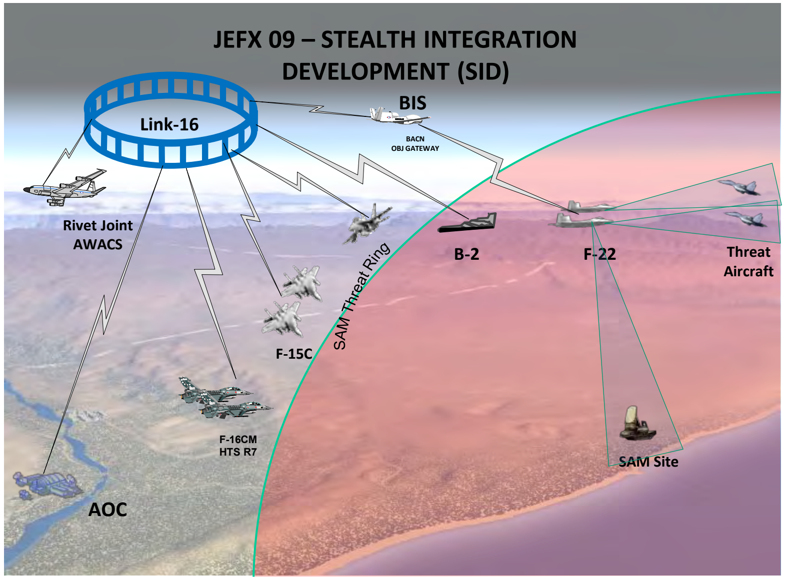
Acquisition Programs/PEOs

- Joint Strike Fighter
- F-22 Block 3.2 Link 16 Receive Testing
- Multi-Function Advanced Datalink (MADL)
- Battlefield Airborne Communications Node (BACN) Joint Urgent Operational Need
- B-1 Fully Integrated Data Link (FIDL)
- PEO Integrated Weapons Systems
- CVN-78
- Broad Area Maritime Surveillance System (BAMS)
- AN/SQQ-34 Combat System
- Brigade Combat Team Modernization Program
- Joint Tactical Radio System (PEO JTRS)
- Joint Tactical Radio System Airborne Maritime Fixed (JTRS AMF)
- Ground/Air Task Oriented Radar (GATOR)
- Common Air Command and Control System (CAC2S)
- Small Diameter Bomb, Incr II (SDB II)

JMETC Testing Success

Joint Expeditionary Force Experiment (JEFX)

- Chief of Staff of the AF directed series of experiments that combines LVC forces to create an operationally representative environment to assess selected initiatives.
- Goal is to rapidly transition enhanced capability to the warfighter.
- Quarterly events; some Live Fly, some distributed LVC
- JMETC Program support in place for two years



<u>IMPACT--Cost Savings!</u>

•JEFX Reported saving $4.0M in FY 09 using JMETC Connectivity and tools

•Using JMETC, JEFX able to now complete 3 or 4 distributed events per year

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An Emerging Methodology for Mapping Between a System's Components and Capabilities: *The System Capabilities Analytic Process (SCAP)*

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

William Landis
Richard Moyers
Kevin Agan
Army Research Laboratory
Survivability/Lethality Analysis Directorate
Aberdeen Proving Ground, MD

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Outline

ARL

- Issues
- Objective and results
- Overview of SCAP
- Sources of dysfunction
- The Functional Skeleton
- What about personnel?
- Meaningful results
- Application of the Functional Skeleton
- Examples
- Next steps and conclusion

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What are the issues?

- “Do I still have the capability to complete the mission following a damaging event?”
    - Key to Army’s Mission-Based Test and Evaluation (MBT&E)
    - Cannot be answered easily using traditional methods or metrics
    - Not necessarily a single answer

- The issue with using the traditional methods or metrics in MBT&E:
    - Traditional analysis results are **qualitative** values called loss of function (LoF).
    - MBT&E requires a **quantitative** understanding of a system’s remaining capability to define an effect on a mission.
    - The correlation to a specific mission context is not possible.

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Objective and results

Objective:

Create a methodology that will quantitatively map between a system's capabilities and a system's components.

Results:

- We have developed the System Capabilities Analytic Process (SCAP).
- SCAP produces a map between the system's capabilities and the system's components. These maps are known as the Functional Skeleton (FS).
- The FS provides the information required to determine the remaining capabilities, and therefore the course of action, following a damaging event.

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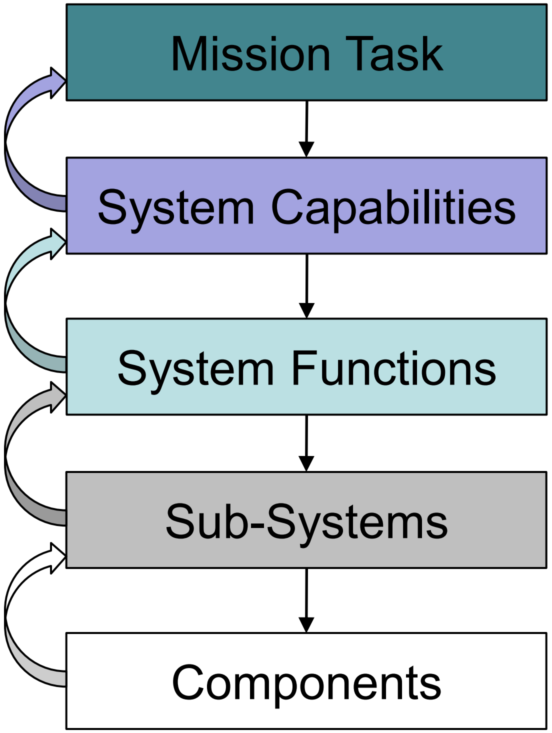
A preview of SCAP

- Components that are grouped into sub-systems perform functions that provide the capabilities to complete the mission task.
- SCAP is very similar to processes used in the consumer-product industry.
- The process reports metrics expressed in the language of the military user.
- The focus of SCAP is a system's remaining capability.



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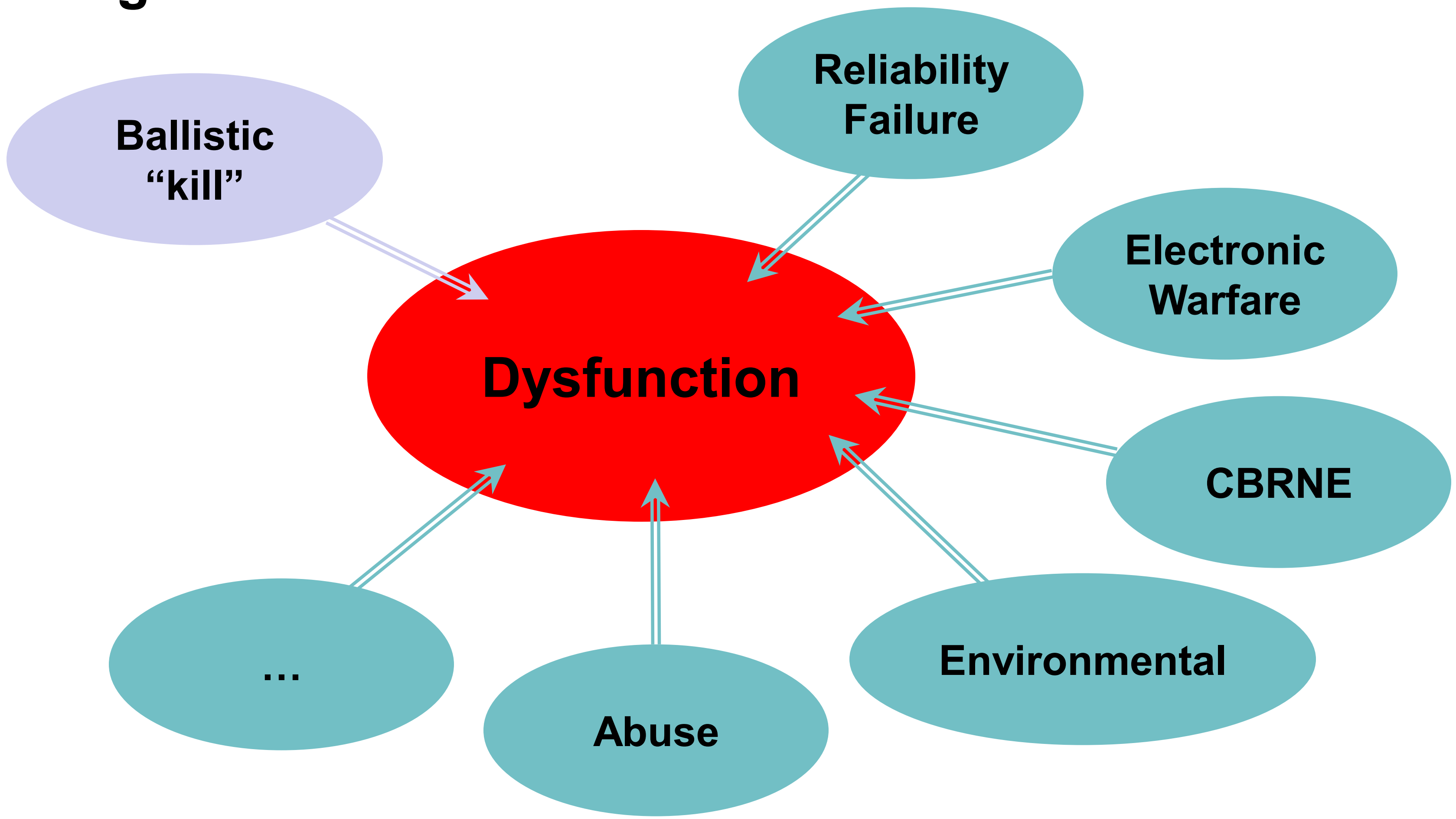
Sources of dysfunction

Dysfunction is defined as a component that is not functioning as it is intended.



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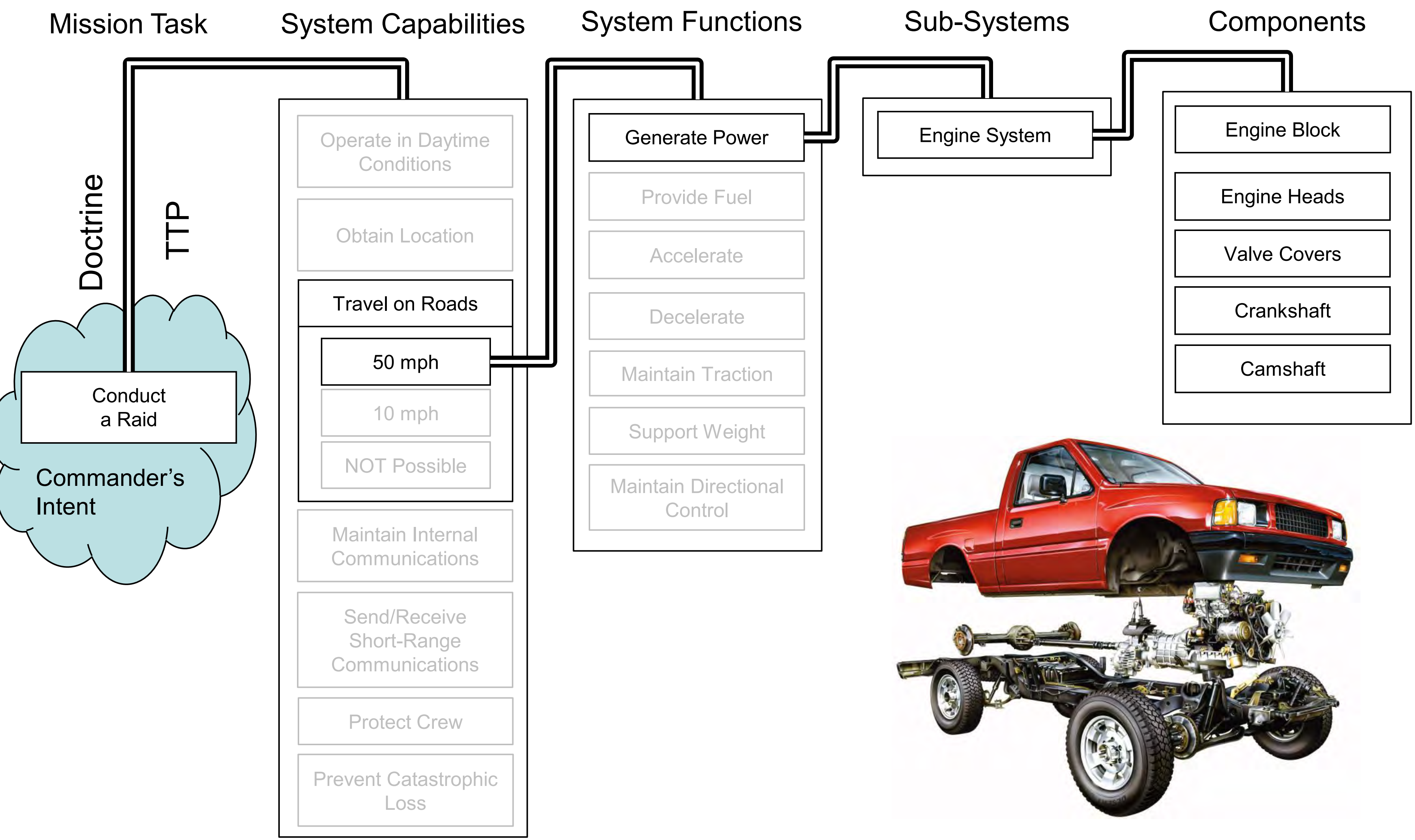
The Functional Skeleton: A map between component and capability

ARL



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How are personnel assessed?

ARL

- First, begin with the "battlefield insult." This is the actual mechanism that causes the injury / wounding.

- The injury is characterized both:
  - in a method to understand the medical severity, and
  - as a detailed mapping to the ability to perform certain functions post-wounding.

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What toolset assesses the crew?

Operational Requirement-based Capability Assessment (ORCA)

Battlefield Insult

Injury

Medical Assessment

Medical Casualty?

Begin with the battlefield insult.

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Medical Casualty

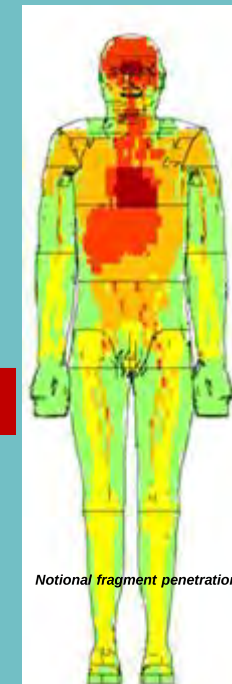
ARL

System Capabilities | System Functions | Sub-Systems

A high-resolution „shotline“ is drawn through the affected tissues to determine risk to life. This is communicated in terms of the Abbreviated Injury Scale© (AIS).*

None	Minor	Moderate	Serious	Severe	Critical	Maximal
0	1	2	3	4	5	6

The threshold of „3“ (serious) or greater is scored as a medical casualty.



Notional fragment penetration

- Protect Crew
  - Protect Crew from Ballistic
    - Driver
    - Commander
    - Gunner
  - Protect Crew from Fire

Medical Casualty

Warfighter has experienced an injury requiring evacuation from unit so that medical treatment can be administered.

* Abbreviated Injury Scale ©, 2005, Updated 2008, AAAM, Des Plaines, IL, 2008.

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Linking injuries to functionality

Operational Requirement-based Capability Assessment (ORCA)

Battlefield Insult

Injury

Medical Assessment

Medical Casualty?

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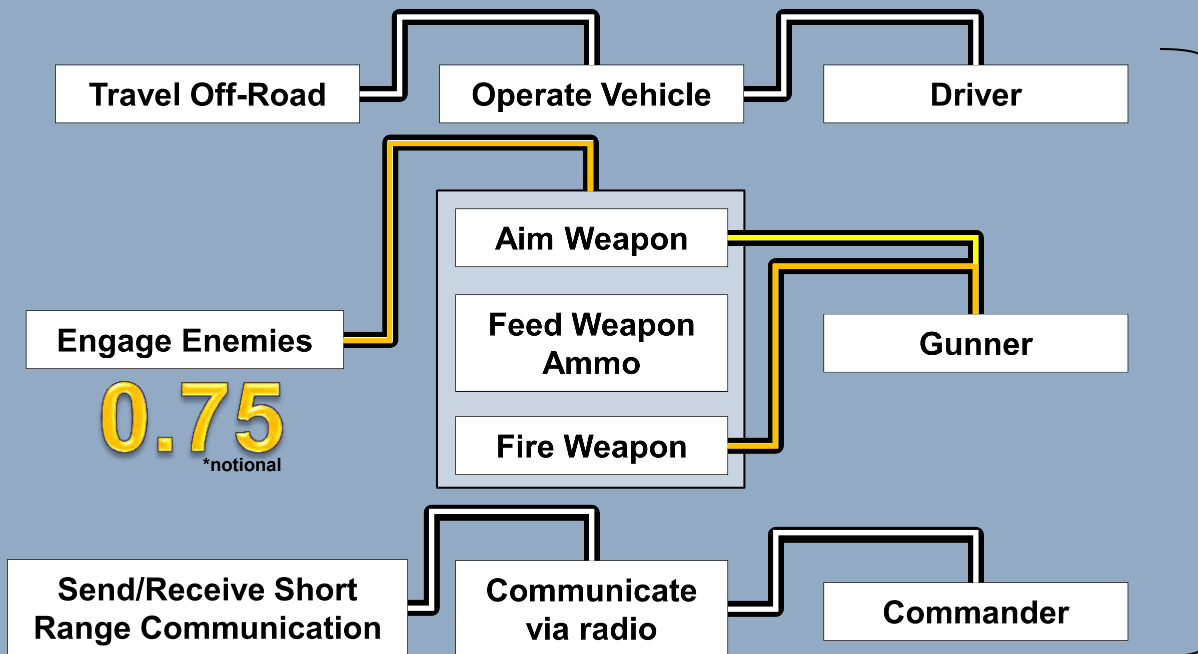
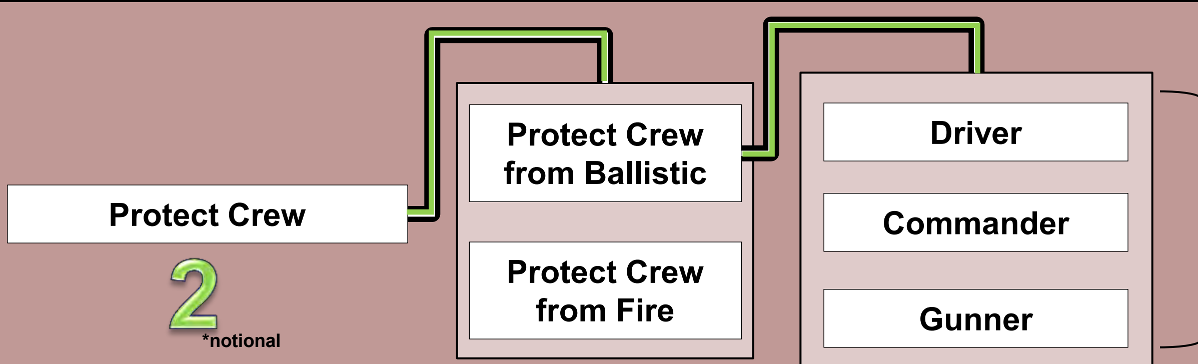
Operational Casualty

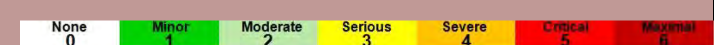
System Capabilities | System Functions | Sub-Systems



Incapacitation

Operational casualty is defined as a warfighter being unable to perform a required task or function.





Medical Casualty

Warfighter has experienced an injury requiring evacuation from unit so that medical treatment can be administered.

A paradigm shift: action-reaction-new assessment

In the preceding example, the gunner was the only one injured. After some time, the Commander & Gunner trade places*.

Initial Incident (time=0)

- Driver:
  - AIS: 0
  - Incapacitation: 0
- Commander:
  - AIS: 0
  - Incapacitation: 0
- Gunner:
  - AIS: 2
  - Incapacitation :0.75

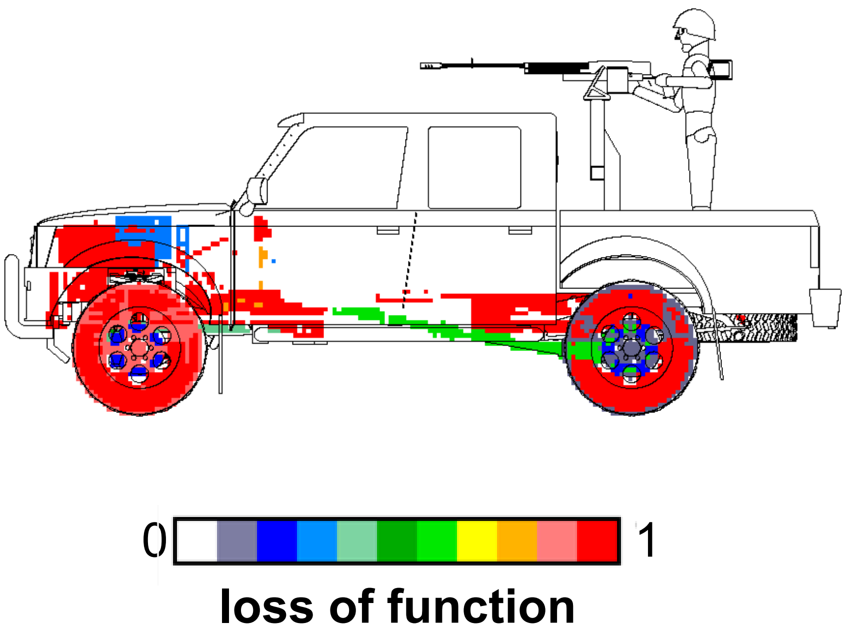
After Crew Drill(s)

- Driver:
  - AIS: 0
  - Incapacitation: 0
- Commander:
  - AIS: 2
  - Incapacitation: 0.1
- Gunner:
  - AIS: 0
  - Incapacitation: 0.1

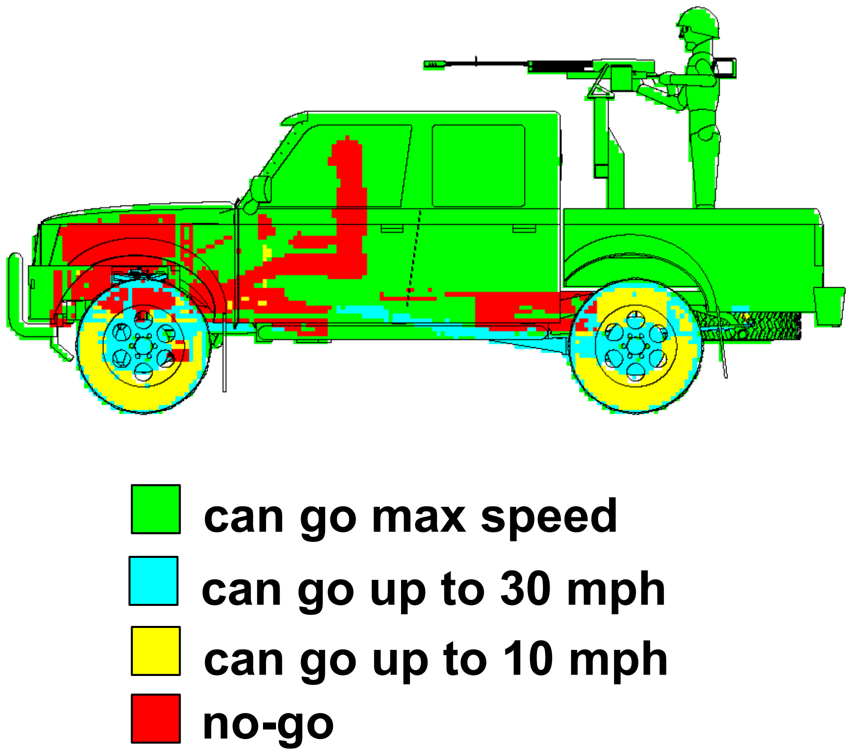
*assumptions include no deleterious effects & some loss of performance for weapon familiarity / zeroing.

Transition to meaningful results

Traditional: mobility kill



One possible SCAP metric: travel on roads



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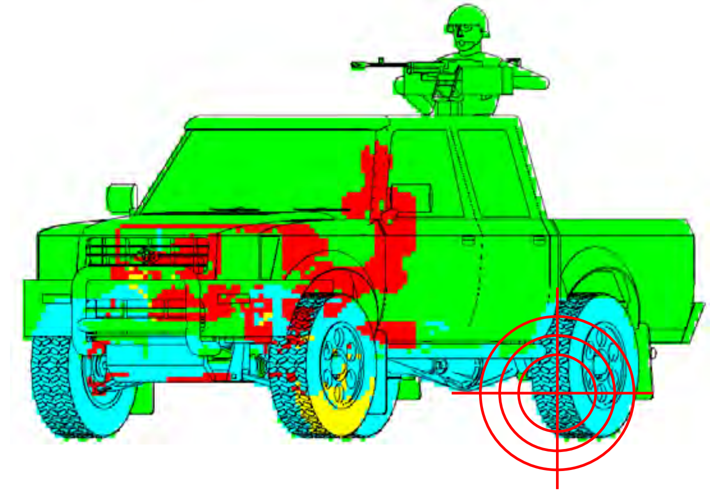
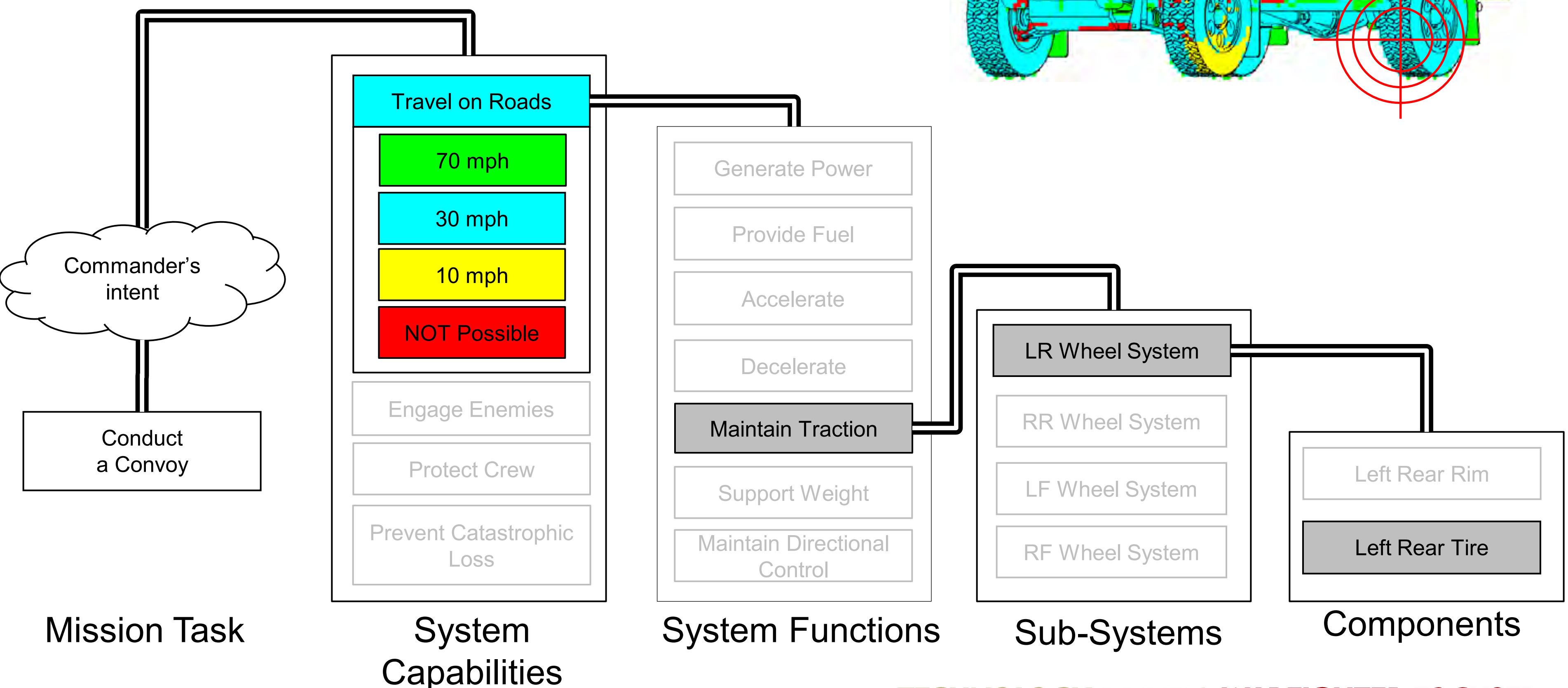
Truck functional skeleton

Because the truck was damaged, it’s capability to travel on roads is reduced.





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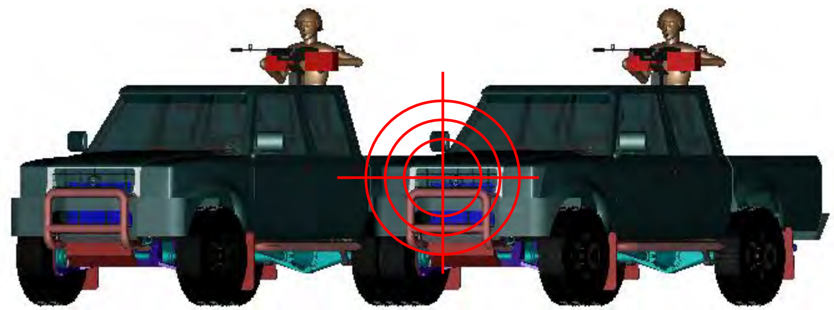
System-of-systems mission

ARL

Two trucks are operating in a convoy mission. By the commander's intent, the speed of the convoy is limited to the speed of the slowest vehicle.



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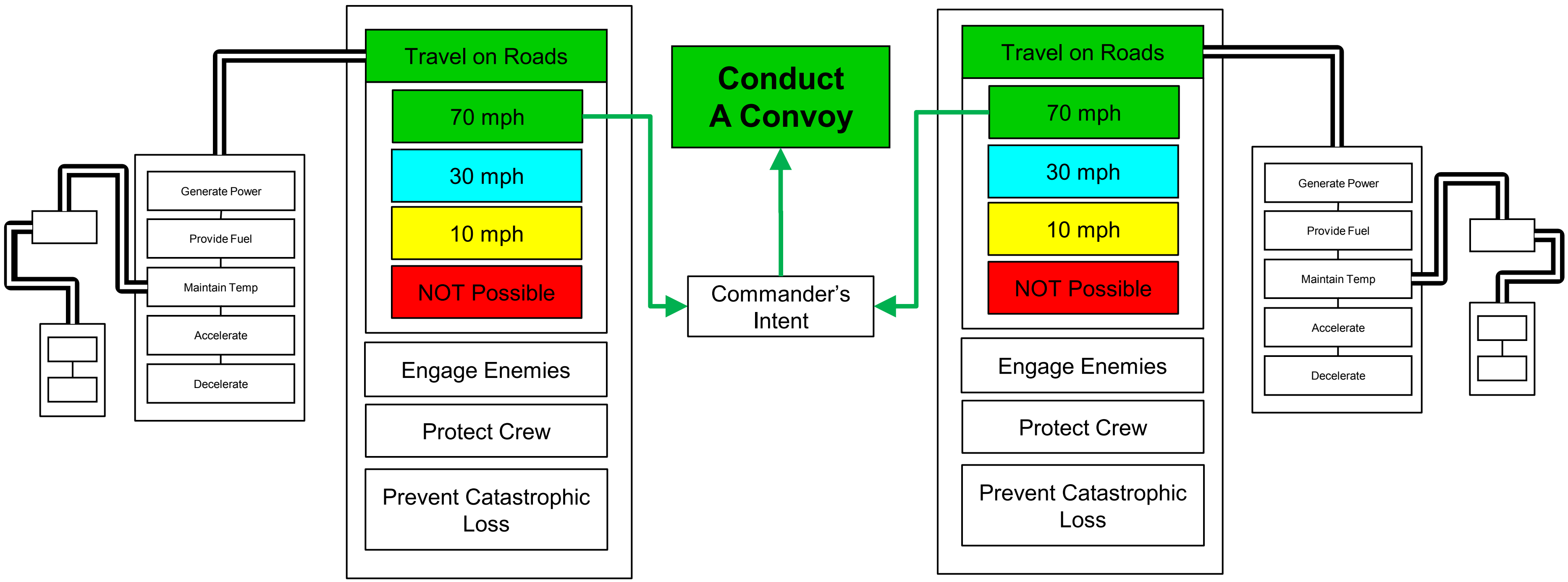

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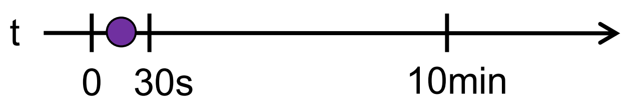
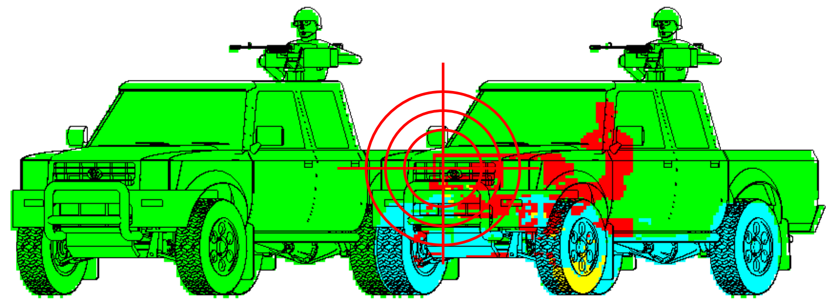
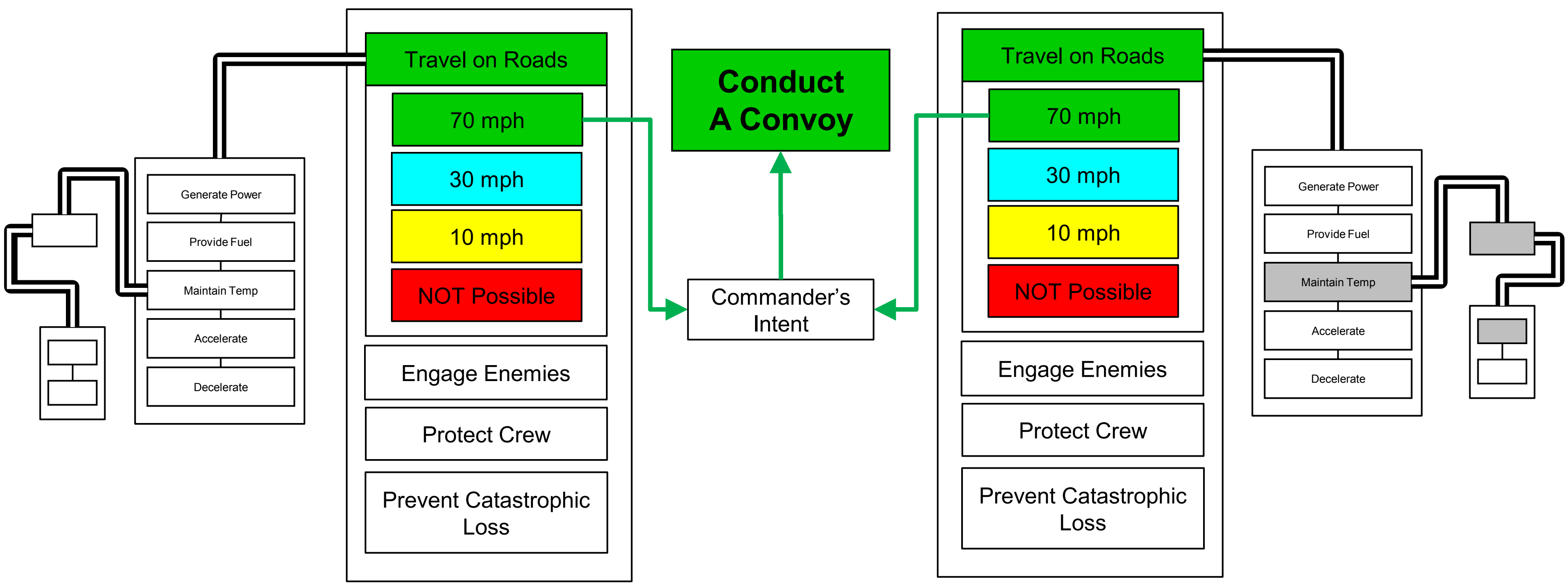
System-of-systems mission





Vehicle not damaged

Vehicle damaged



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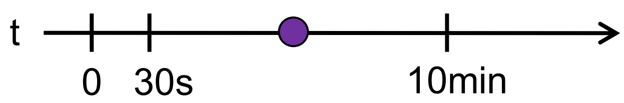
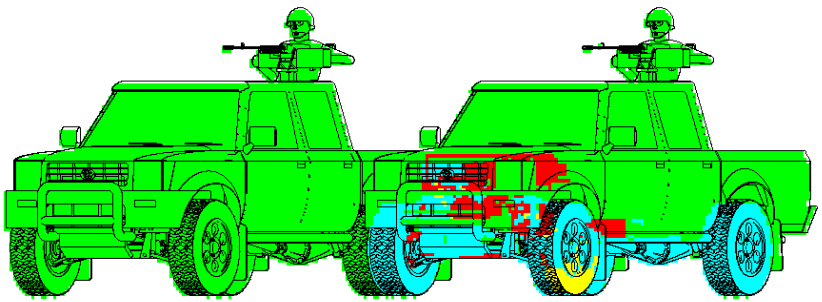
System-of-systems mission

ARL





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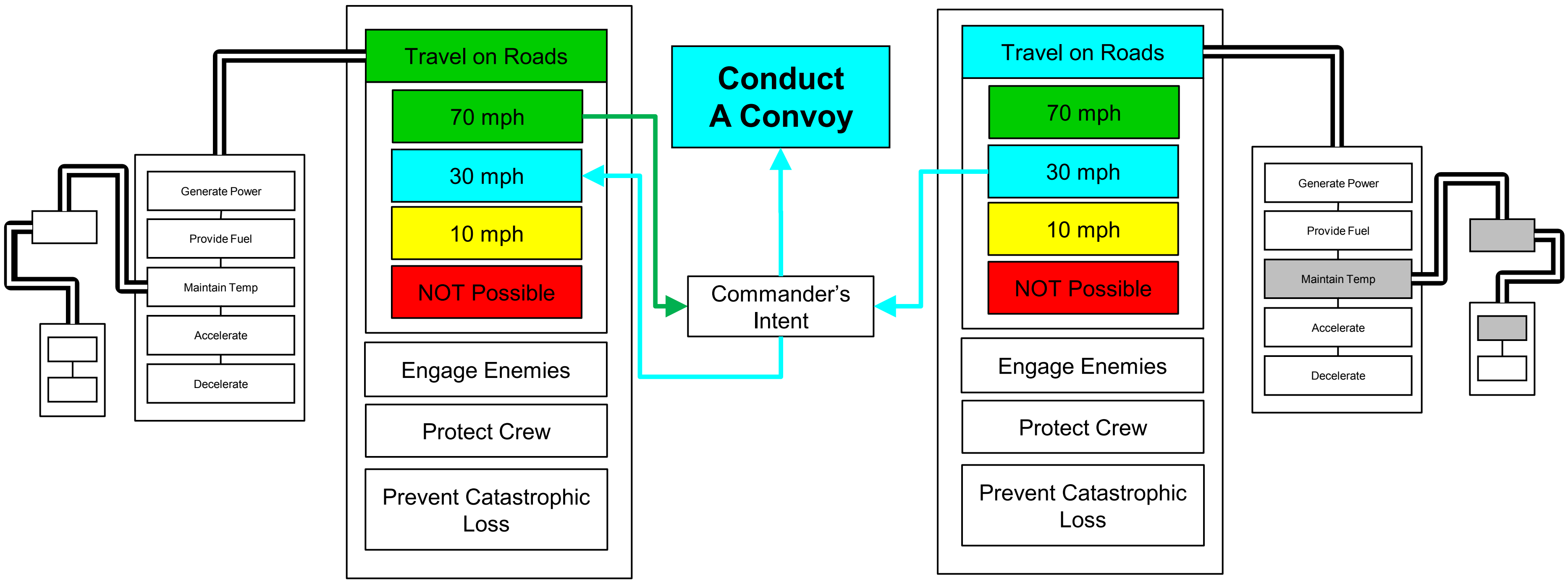
Vehicle damaged



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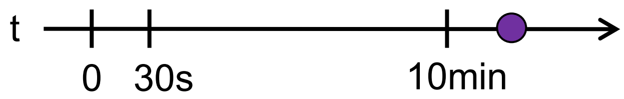
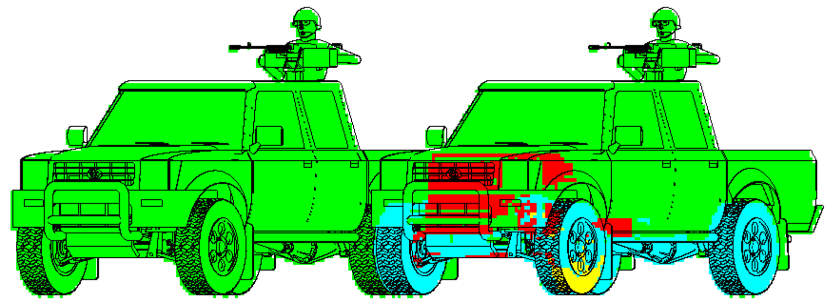
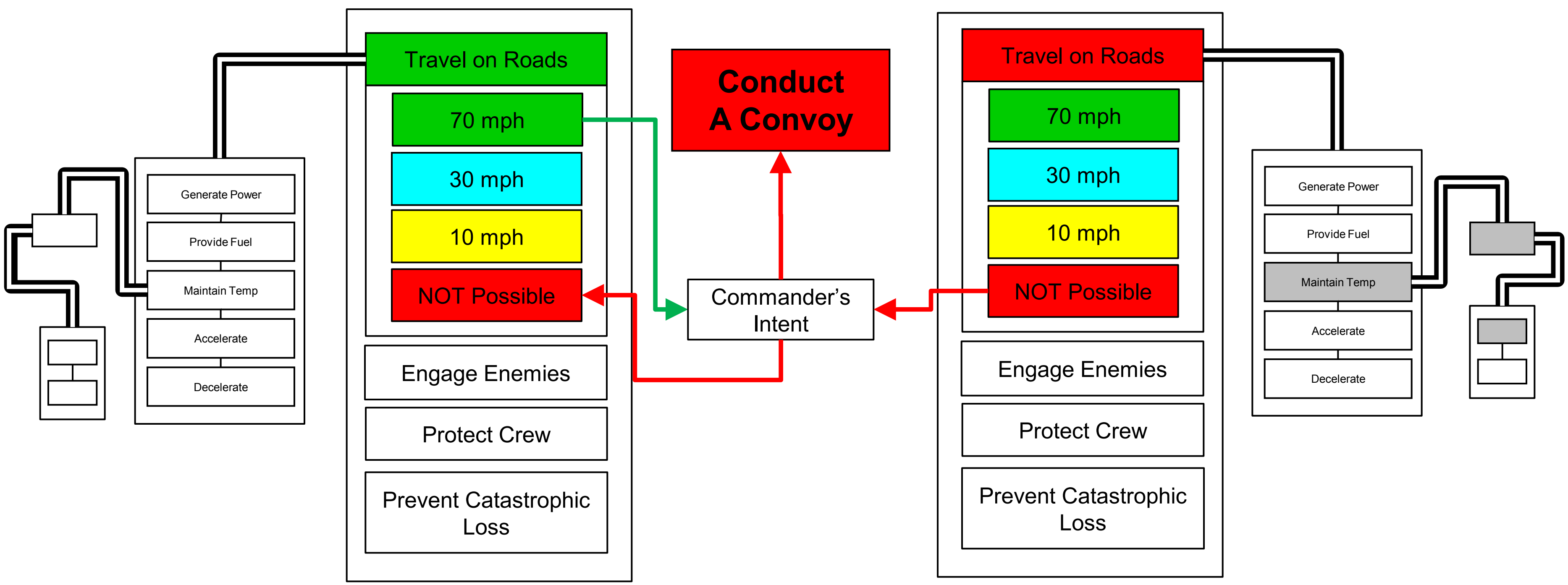
System-of-systems mission





Vehicle not damaged

Vehicle damaged



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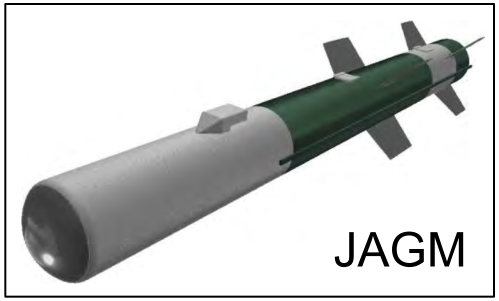
ARL's next steps

- Further explore and integrate crew metrics and time-dependent degradation
- Conduct SCAP-based analyses for the MBT&E pilots (JLTV, PIM, JAGM)



- Apply the Functional Skeleton in the System-of-Systems Survivability Simulation (S4)
- Explore the utility of the Functional Skeleton across the Army enterprise

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Summary and conclusions

ARL

- ARL/SLAD has developed SCAP to quantitatively map between a system's capabilities and a system's components.
- ARL/SLAD can use SCAP to generate quantitative data that defines a system's remaining capability after a component is no longer functioning.
- Based on AEC feedback, the metrics developed from SCAP meet the requirements of MBT&E.
- SCAP has potential application across the Army enterprise.

Existing Impact

- Briefed at:
  - 2010 March NDIA T&E Conference
  - 2010 October AORS
  - 2010 August JLTV LF IPT
- Program acceptance:
  - Accepted by AEC as **the** engineering-level methodology for MBT&E
  - Written in the JLTV and PIM Live-Fire Strategy
  - Development of Human Availability Technique (HAT)*
- Publications:
  - Jan 2010 MBT&E workshop first review of SCAP (ARL-SR-0218)
  - March 2010 NDIA T&E Conference presentation of SCAP (ARL-SR-0217)
  - Applying SCAP to the MBT&E of the JLTV (ARL-SR-206)
  - An Emerging Methodology: SCAP (ARL-TR-5415)

* Collaboration with HRED

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U.S. Army Research, Development and Engineering Command

Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E)

ARL

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Beth Ward
Survivability/Lethality Analysis Directorate
410-278-6315/beth.squier.ward@us.army.mil

27th Annual National Test & Evaluation Conference March 14-17, 2011

Purpose

The purpose of this presentation is to provide background on MBT&E, supporting tools, and modeling and simulation (M&S) applications.

Bottom line up front: M&S used in testing need to expand the linkages between materiel attributes and operational capabilities for MBT&E.

Outline

- Why and what is MBT&E?
- Approaches to organizing an effective M&S program for MBT&E
- M&S issues
- What are we doing to solve the issues?
- Summary
- Points of contact

Why was MBT&E developed?

- Drive operational mission context into all test and evaluation (T&E).
- Develop a T&E methodology that fully addresses recent acquisition initiatives.
- Provide "feedback" directly to the joint capabilities integration and development system (JCIDS) in terms of the war fighter's mission.
- Enable robust and systematic system-of-systems T&E.

<u>*Director, Operational Test and Evaluation*</u> – *"The evaluation of operational effectiveness [and system performance] is linked to* ***mission accomplishment****."*[1]

1. Memorandum, OSD DOT&E, subject: Reporting of Operational Test and Evaluation Results, 6 Jan 10.

Army Proven Battle Ready

Courtesy of Chris Wilcox, Army Evaluation Center, ATEC

What is MBT&E?

Mission-Based Test and Evaluation

is a methodology that focuses T&E on the **capabilities** provided to the warfighter. It provides a ***framework*** and ***procedure*** to:

– **link materiel system attributes to the operational capabilities;**

– **examine the SoS required** to enable the operational capability; and

– examine synergistic use of all **available data sources.**

Approaches to organize an effective M&S program

- Tools for test and evaluation planning
  - The test and evaluation support tool and example repository (TESTER)
  - Model-based systems engineering with Vitech CORE
- Models and simulations to augment costs of testing
  - OneSAF (semi-automated forces)
  - Infantry Warrior Simulation (IWARS)
  - Combined Arms Analysis Tool for the 21st Century (COMBAT XXI)
  - System of Systems Survivability Simulation (S4)
  - CORE

Critical to an effective M&S program is to understand model purpose, requirements, timelines, and limitations.

TESTER: Online MBT&E

Users
- Army Evaluation Center (AEC) Evaluators
- AEC System Team (AST) Members
  - Operational Test Command (OTC)
  - Developmental Test Command (DTC)
  - Analysts
  - Modeling & Simulation Representatives
- Other Stakeholders
  - Program Manager
  - Training & Doctrine Command (TRADOC)
  - Test Centers

Access System via CAC Login

List of Current Systems is provided by an Army Online Database

TESTER Process and Functions

Collect Source Documentation

Identify Issues & Standards
- Key Performance Parameters
- Key System Attributes
- Critical Operational Issues
- Etc.

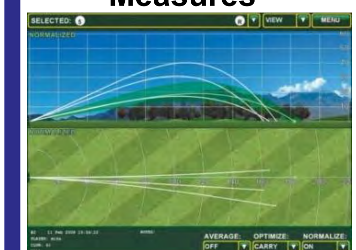
Define Missions & Tasks

Identify Components & Functions

- Fire
- Protect
- Maneuver
- Sense
- Etc.

Link Components & Functions to Missions & Tasks

Develop Measures



Capture Design of Experiments

Factor	Factor Level	Data Source	P/S	Control Technique
Terrain	Flat	LUT	P	Held Constant
	Rolling	OneSAF	P	Tactically Varied
Light Level	Full Sun	LUT	P	Uncontrolled
		OneSAF	S	Held Constant
	Night	LUT	P	Held Constant
Weather	Rain	OneSAF	P	Systematically Varied
	Dust	OneSAF	P	Random Assignment

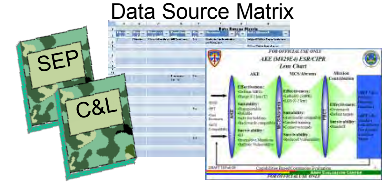
Identify Data Requirements

What data will need to be collected from test to answer measures.

Identify Data Sources

Develop Reports

Data Source Matrix



Reports can be generated to:
- Enable System Evaluations
- Assist in Test Planning
- Facilitate Design of Experiments planning and execution
- Ensure all needed data is collected for system evaluation

TESTER will streamline MBT&E System Evaluations and facilitate collaboration among distributed System Teams and other stakeholders.

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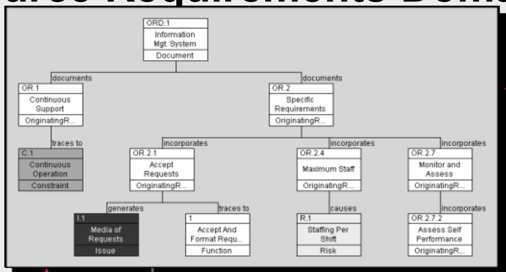
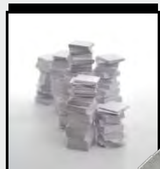
Courtesy of Jamie Pilar, Army Evaluation Center, ATEC

Systems Engineering with CORE

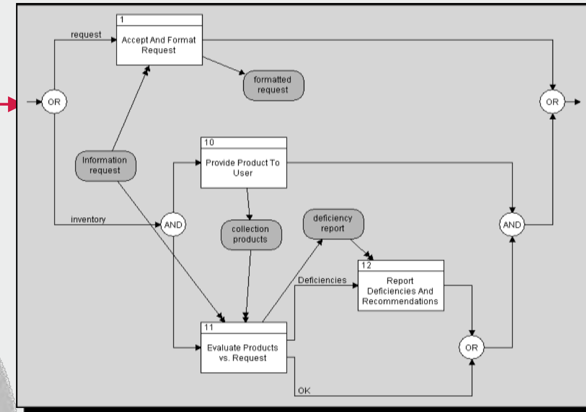
Source Requirements Domain

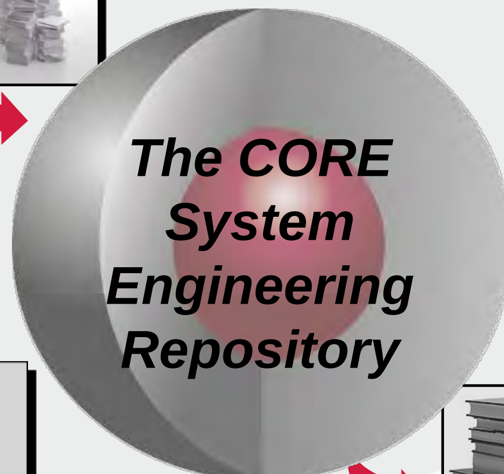




Originating requirements trace to behavior

Behavior Domain

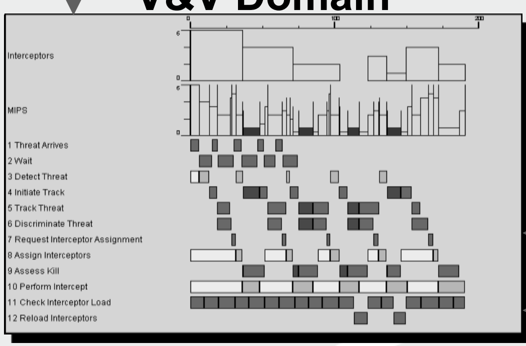




verified by

Behavior is allocated to physical components

V&V Domain



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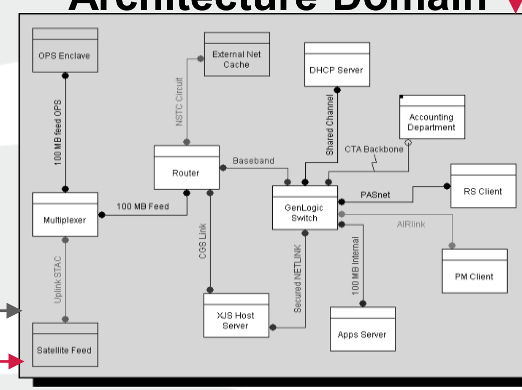
Architecture Domain



Originating requirements trace to physical components

Utilizing a layered approach to progressively clarify and elaborate all four domains concurrently ensures consistency and completeness.

M&S issues

The MBT&E strategy presents several issues in the application of modeling and simulation (M&S) to augment testing limitations and associated costs:

- The vulnerability/lethality (V/L) data and usage of that data in traditional M&S does not meet the requirements for MBT&E.
  - Historically, V/L data were generated by multiplying an *average* combat utility value to a loss-of-function (LoF) probability (i.e., how well the system can perform its mobility [M] or firepower [F] functions).
  - In Army M&S, the LoF values are then applied to all possible combat scenarios*.
- MBT&E aligns system **components** and **functions** to a specified tactical mission at a higher resolution than M/F LoF.
  - The approach then evaluates **system capability** requirements of a mission in addition to technical performance parameters.
- **M&S used in testing need to expand the linkages between materiel attributes and operational capabilities.**

* Deitz, Paul H., and Starks, Michael W., "The Generation, Use, and Misuse of "PKs" in Vulnerability/Lethality Analyses", U.S. Army Research Laboratory, APG, MD., ARL-TR-1640, MAR 1998.

MBT&E metrics example: materiel system attributes

System Capabilities Assessment Process (SCAP) Functional Skeletons		
Category	System Capability	SC bin
Move		
	Travel on primary roads	
		can go max speed
		primary up to 50 mph
		primary up to 30 mph
		primary up to 10 mph
		no-go
	Travel off roads	
		can go max speed
		primary up to 50 mph
		primary up to 30 mph
		primary up to 10 mph
		no-go
	Travel cross-country	
		up to 28 mph
		up to 18 mph
		up to 5 mph
	Emplace	
	Pivot steer	
		360° / 10 sec
		no-go
	Start engine	
		fully capable
		no-go
Shoot		
	Fire standard munition	
		4 rounds / min
		1 round / min
		NOT Possible
	Fire self-defense gun	
		Fully Capable
		no-go
	Aim main gun - direct fires	
		automatic lay
		manual lay
		no-go
	Aim main gun - indirect fires	
		automatic lay
		manual lay
		no-go

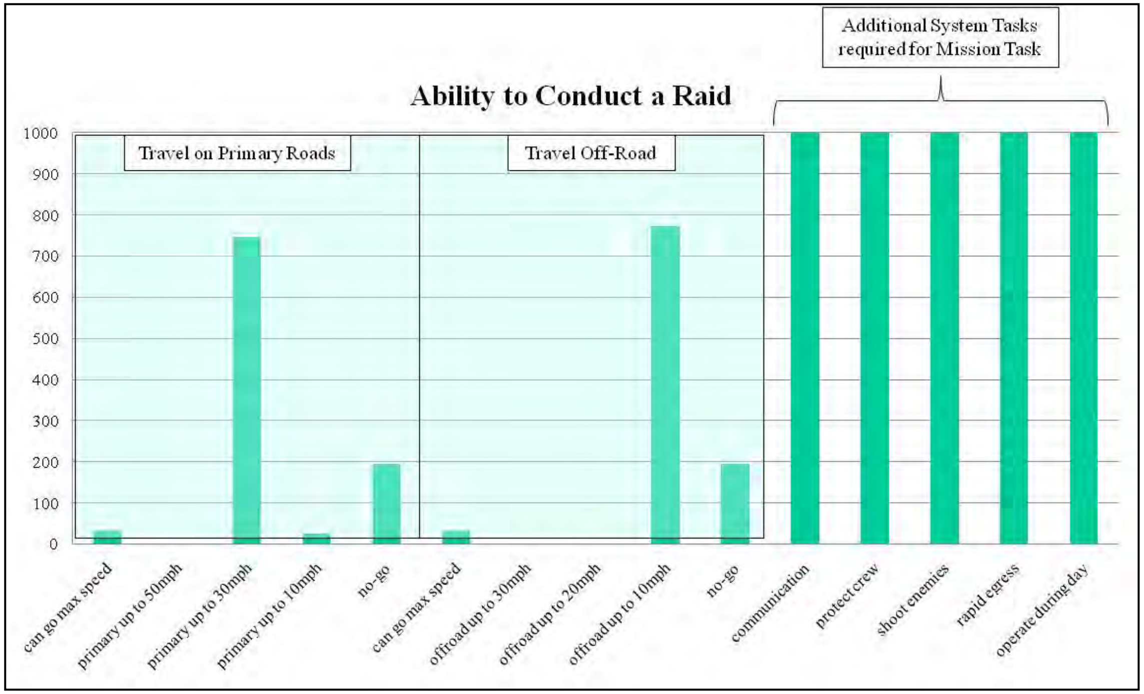
Survive		
	Protect Crew	
		protect crew from ballistic
		protect crew from CBRNE
		protect crew from rollover
	Prevent catastrophic loss	
		protect all energetic
		protect Munitions
		protect Propellant
		protect Fuel
		no-go
	Protect from NBC	
	Control fires (AFES)	
		fully capable
		no-go
	Protect from gun backblast / byproducts	
	Maintain internal enviromental conditions	
	Rapid egress	
		open all access
		bin 2
		no-go
	Prevent visible detection	
	Prevent thermal detection	
	Prevent signals detection	
Observe		
	Operate during day	
		fully capable
		no-go
	Operate during night	
		fully capable
		no-go
	Operate obscured	
		Define bins with TRADOC
	Identify location	
		GPS
		vehicle motion
		no-go
	Provide navigation	
	IFF	

Communicate		
	Communicate short range	
		Fully capable
		data only
		analog/voice
		no-go
	Communicate long range	
	SATCOM	all crew
	Communicate intra-system	
		fully capable
	Communicate inter-system	
	Communicate to dismount	
Unique attribute		
	Ammunition reload	
	Haul vehicle	
	Provide power from slaved vehicle	

MBT&E metrics example: materiel system attributes

ARL has developed the task-system capability matrix and functional skeletons for the High Mobility Multi Wheeled Vehicle (HMMWV) and the Joint Light Tactical Vehicle (JLTV).

The challenge is to determine how Army M&S can use these new metrics to benefit the evaluator.



Model resolution and metrics

	Use/Study	Resolution	Study Timeline*	Considerations
AWARS	Analysis of Alternatives (AoA)	Division and Brigade: Entity Level	Outside MBT&E requirement	Aggregate metrics built from high resolution data
OneSAF	AoA, Training, T&E	Brigade and Below: Item Level	Years	Formal process for requirements outside ATEC control but used in OT
IWARS/ COMBAT XXI/ S4	AoA, SoSA, Many on many	Brigade and Below: Item Level	Months	AMSAA M&S cell and studies could be leveraged
Ground Wars	AoA Few on few	Platoon: Item Level	Weeks	Earlier efforts can be leveraged to provide limited capability
RTCA	Operational Assessment	Platoon: Item Level	Months	New metrics in M&S at ATEC
CORE	Engineering and Requirements	Platform: Item Level	Weeks	System characterization repository linked to requirements

- **MBT&E metrics must replace loss-of-function data**
- **Decision tables must be developed to 'act' on system attributes (remaining capability)**

* Timeline includes model development, data generation and analysis

What are we doing to solve the issues?

- SLAD is collaborating with AMSAA , ATEC and TRADOC to develop an M&S methodology for MBT&E.
- Significant actions

1) **Establish a Language and Definition Working Group**. Purpose is to develop a lexicon for the terms/definitions used. An additional purpose would be to develop and coordinate a common framework that will support TRADOC, AMSAA, ARL and ATEC.

2) **Develop a category/attribute template**.
Can be done in conjunction with the language and definition working group. Purpose is to develop a universal set of attributes (and attribute levels) that sets the stage for rational of desired capabilities.

3) **Establish a Scenario Utility Working Group**.
Purpose is to: (a) learn what TRADOC does and how they do it when they develop scenarios; and (b) provide feedback from RD and T&E communities as to what we are looking for and how TRADOC's scenarios can support what we need.

SLAD, in collaboration with AMSAA, will propose how MBTE metrics could be used by TRADOC models.

What are we doing to solve the issues?

SLAD met with AMSAA SMEs to discuss ideas to develop a M&S test bed for MBT&E.

One approach to a M&S development could begin with a small unit simulation for high resolution data then incrementally progress to a larger simulation for lower resolution data (i.e., aggregated MBT&E metrics).

The expected results from the experimentation would include

- methods to input MBT&E metrics,
- algorithms for data usage,
- method to aggregate MBT&E metrics for higher level M&S,
- analysis techniques, and
- recommended practices.

Considerations

- MBT&E encompasses more than LFT in support of Army acquisition.

- ATEC must render evaluations based upon system use to accomplish combat missions (Joint context)

- Technical leadership is looking for higher resolution modeling to support evaluations with goals to include
  - improve understanding of data metrics
  - incorporate consistent data development methods and usage across varying resolutions

Desired end-state is a level of consistency in the metrics for Army acquisition.

Summary

- Critical to an effective M&S program is to understand model purpose, requirements, timelines, and limitations.
- The MBT&E strategy presents several challenges in the application of M&S, test planning/execution, and the analysis of data for system evaluation.
- AEC development of TESTER will streamline MBT&E system evaluations and facilitate collaboration among distributed System Teams and other stakeholders.
- M&S used in testing need to expand the linkages between materiel attributes and operational capabilities for MBT&E.
- SLAD is collaborating with multiple agencies to help develop the methodology to make those linkages possible in M&S.

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27th Annual National Test and Evaluation Conference

Mr. Charles P. Myers

Commercial Air Services
RDT&E Program Manager

16 March 2011

NAVAIR/NAWCAD CAS Teaming

Contract Industry
- Fleet Training
- Foreign Military Sales Support
- RDT&E

NAVAIRSYSCOM PMA-207 CAS concentrates of OP4 (Opposing Force Training) for the fleets. EW training, target towing, JTACT, and Airborne tanking

NAWCAD CAS supports FMS and RDT&E tasking for DoD.

F-18	NRL	ARROW Program
E-2C/D	RAAF	
Mode 5	Canadian Forces	
MIT (Advance Radar)	RAF	

Contracted Aircraft

F21C2 Kfir

6 aircraft split between NBVC Pt Mugu, CA and Newport News, VA

MK-58A Hawker Hunter

12 aircraft spread from Newport News, VA to NABVC Pt Mugu, CA to Kanenhoe, Hi to Atsugi, Japan


DANGER
265
RESCUE

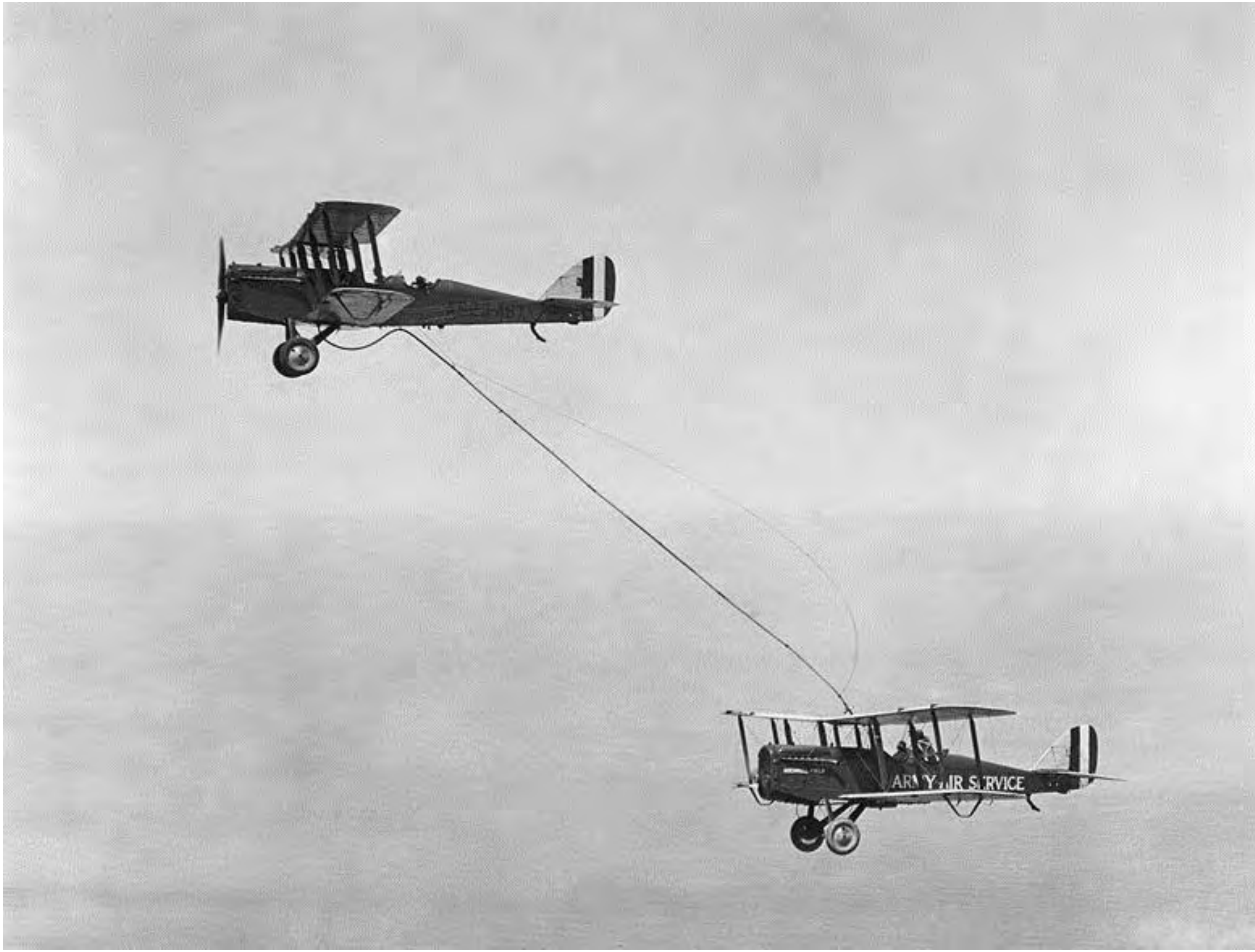
A4 Skyhawk

4 aircraft split between NBVC Pt MUGU, CA and Newport News, VA.

G3 and G2B Gulfstreams

Cartersville, GA.

Utilized primarily for Range Clearing



K-707 Commercial Tanker

2 Aircraft – Global Support

S-61N

2 Helicopters operating out of
Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii

G-1 Gulfstream

2 Aircraft - Standoff Jamming Based out of Cartersville, GA

Learjet 36 and 36ER (Extended Range)

13 Aircraft - Located at North Island , San Diego, CA (5) and Newport News, VA. (8)

Turboprops

2 aircraft operating out of Newport News, VA and North Island, San Diego, CA

61 AIRCRAFT 9 DIFFERENT TYPES

LEAR RDT&E AIRCRAFT

LEAR GENERIC EQUIPMENT RACK

LEAR BUZZER AIRCRAFT

LEAR NOSE ANTENNA MOUNT

LEAR TAIL ANTENNA MOUNT

LEAR RDT&E MODIFICATIONS

- Mission Power (9KVA, 60 Hz, 28VDC)
- Dual ARC-164 Cockpit UHF Radios
- Military ARN-118 TACAN System
- TSPI Data (GPS position, pitch, roll, heading, altitude)
- GPS Antenna Splitter (1x4)
- Operators ARC-182 VHF/UHF radio
- D Band Antennas (5 ea)
- C Band Antennas (3 ea)
- Nose and Tail Antenna Cabling and Locations
- Tracking Beacon Antenna
- Port and Starboard Wing RF Cabling
- Generic 19” Equipment Racks
- Divan Rack Test Equipment

LEAR RDT&E SYSTEMS

- Military IFF (APX-72 and APX-123)
- IFF Buzzer (nose and tail)
- B Band Buzzer (nose and tail)
- GPS Buzzer (nose and tail)
- DRFM (nose and tail)

RDTE CAS support:

- A central point for air assets
- Available To Government Agencies And Civilian Contractors Supporting Government Projects
- Accessible To Allied Forces
- OPSEC Capable
- Extensive Electronic Warfare Experience In Military Training, and supporting RDT&E projects
- 29 Years Experience Working With The FAA, Contractors, and DOD
- FAA Certification
- Airworthiness oversight.
- Engineering Oversight Office
- Worldwide Support Capabilities
- Aircraft Airframe And Avionics Modification To Meet Project specifications
- In-House Or Can Access: EA / ECM / Threat SIM / Chaff Pods, Tow Targets, Prototype EW Systems


QUESTIONS

27th Annual National Test and Evaluation Conference

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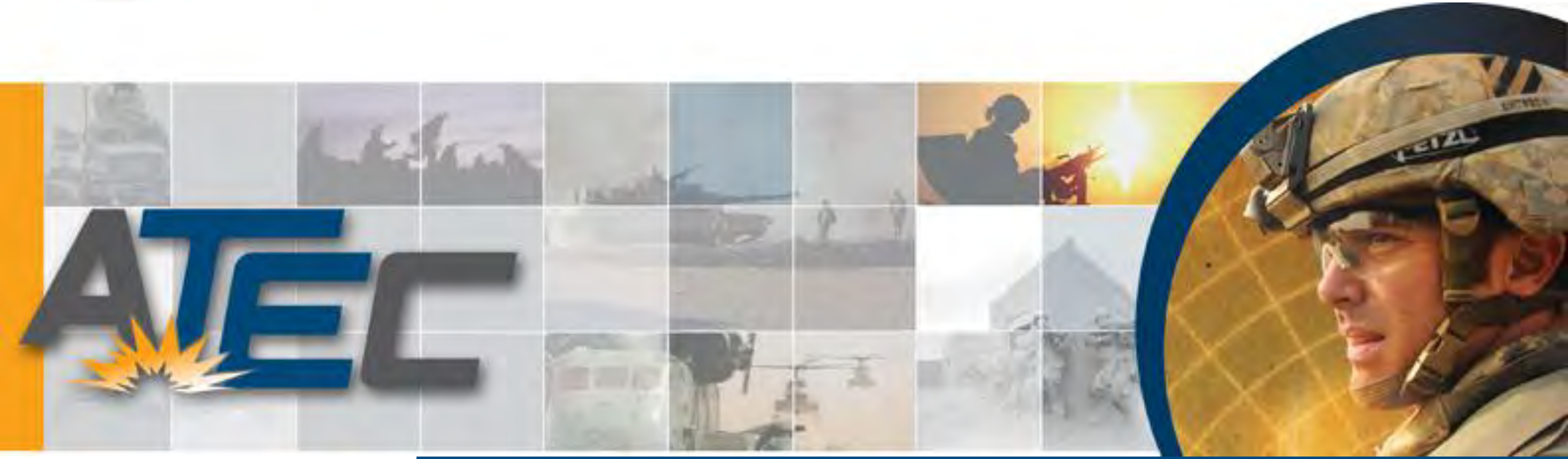
COMMERCIAL AIR SERVICES
PMA-207
RDT&E/FMS/FLEET

16 March 2011



Mission Based T&E Progress

Christopher Wilcox
Deputy/Technical Director
Fires Evaluation Directorate, US AEC

15 Mar 11

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Purpose and Agenda

- **Purpose: To review the status of the MBT&E methodology in the following areas:**
  - Implementation,
  - Lessons Learned, and
  - Current Development Focus Areas.

- **Agenda**
  - Background (Why and What)
  - Implementation (How)
  - Lessons Learned (Items to Sustain and Improve)
  - Current Development Focus Areas
  - Conclusions

Why? - Acquisition Initiatives

Common Focus on Mission Capability

DoD

DOD 5000.1 – "The primary objective of Defense acquisition is to acquire quality products that satisfy user needs with measurable **improvements to mission capability**…"[1]

JCS

Joint Capabilities Integration and Development System – The primary objective of the JCIDS process is to ensure the capabilities required by the joint warfighter are identified … **in order to successfully execute the missions assigned**."[2]

DOT&E

Director, Operational Test and Evaluation – "The evaluation of operational effectiveness is linked to **mission accomplishment**."[3]

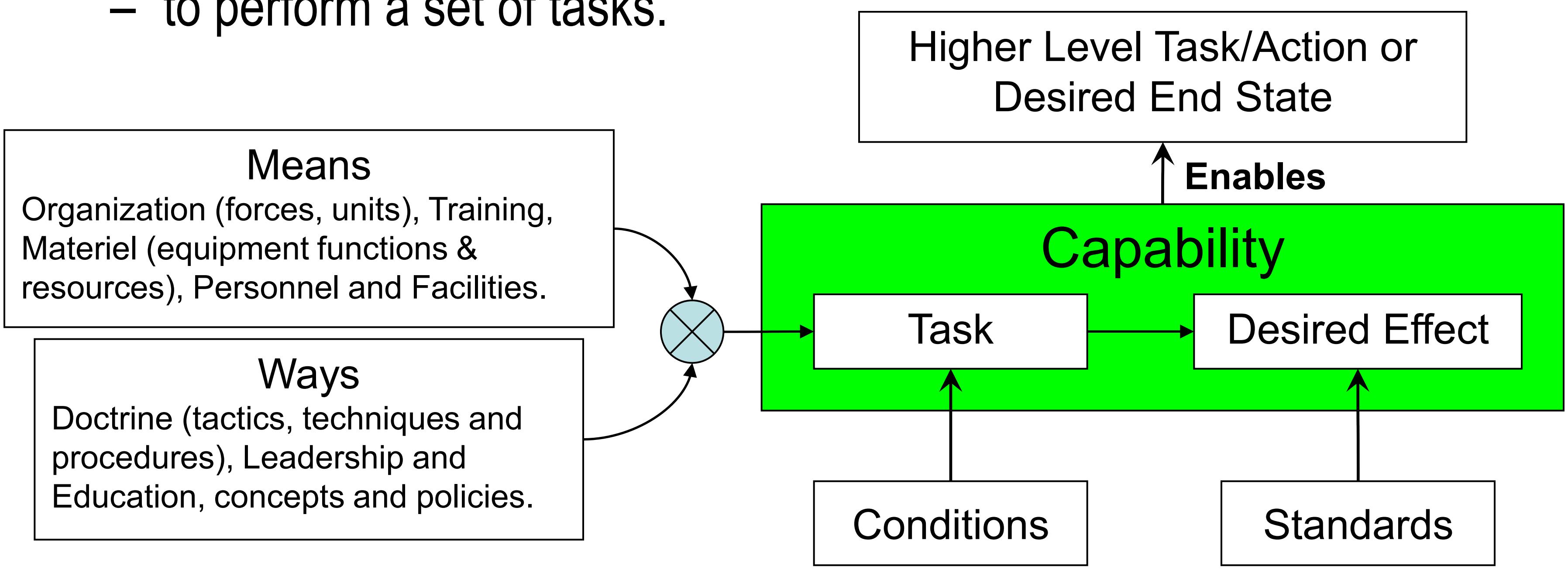
Goal: T&E Focused on Mission Capability

1. Office of the Under Secretary of Defense, Acquisition, Technology and Logistics, Department of Defense Directive Number 5000.1, 12 May 2003.
2. Office of the Joint Chiefs of Staff, Chairman of the Joint Chiefs of Staff Instruction 3170.01G, 1 Mar 09.
3. Memorandum, OSD DOT&E, subject: Reporting of Operational Test and Evaluation Results, 6 Jan 10.

What? - Framework Building Block

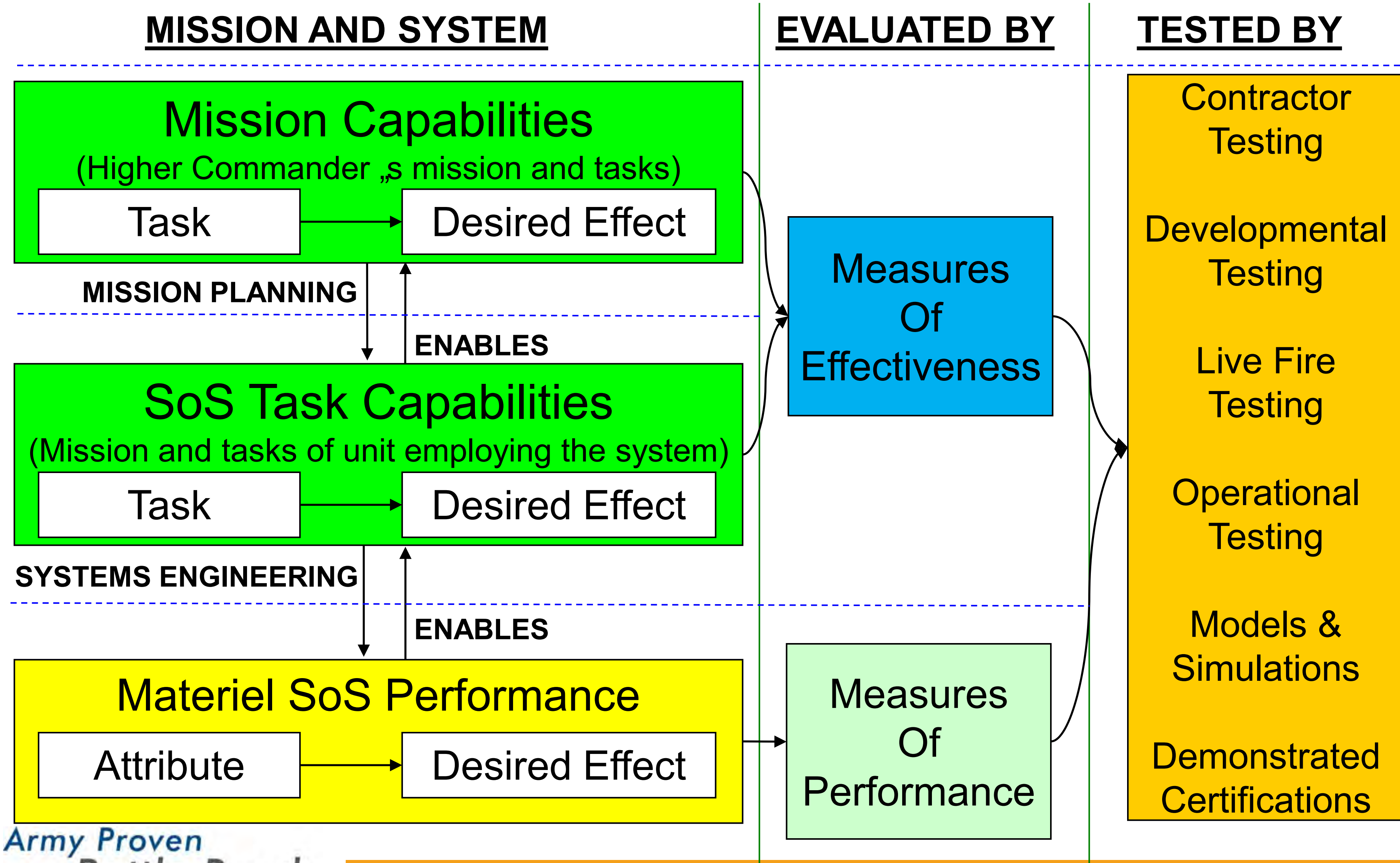
Capability[1] – The ability to achieve a **desired effect** [or result, outcome, or consequence of a task[2]] …

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



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

What? - MBT&E Framework



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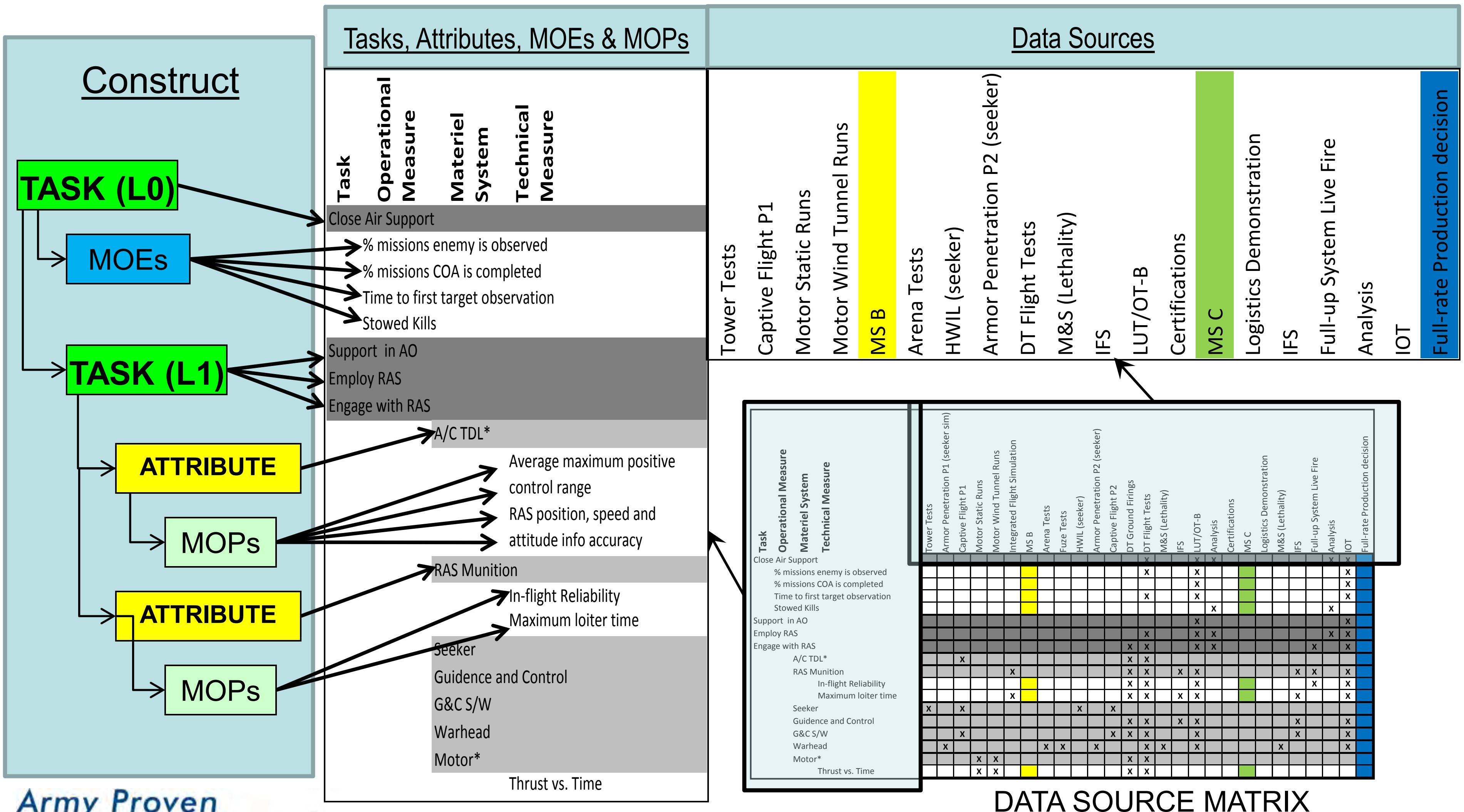
What? – Putting it all together

Link Measures to Data Sources

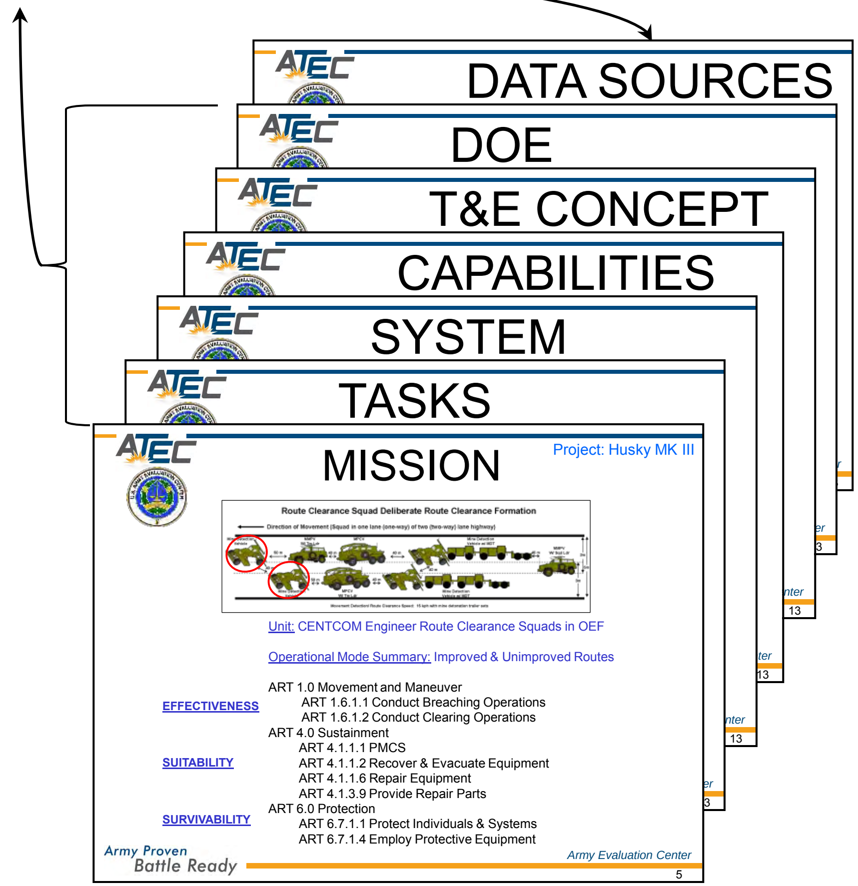


How? – Strategy Development

The T&E Strategy…

- Initial strategy development using MBT&E derived template;
- Links the attributes of the system to mission context; and
- Addresses Critical Operational Issues, Key Performance Parameters in the mission context.

Context for



Mission context driven from evaluation strategy through DT and OT.

How? - Use of Authoritative Task List

MBT&E Process: 1. Develop mission tasks. 2. Link to ATL

Army Universal Task List

ART 1.4.1 CONDUCT LETHAL DIRECT FIRE AGAINST A SURFACE TARGET

1-54. Engage enemy equipment and materiel, personnel, fortifications, and facilities with direct fire designed to destroy the target. These direct fires may be from fixed- or rotary-wing systems. (FM 3-90) (USACAC)

No.	Scale	Measure
01	Yes/No	Direct fires contributed to accomplishing unit mission.
02	Yes/No	Direct fire attack was conducted per established rules of engagement.
03	Yes/No	Unit used correct weapon to engage target.
04	Time	To get complete attack on direct fire target after detecting and identifying target.
05	Time	To suppress targets.
06	Percent	Of probability of suppressing a target.
07	Percent	Of probability of a hit.
08	Percent	Of probability of a kill given a hit.
09	Percent	Of missions flown and fired to achieve desired target damage.
10	Percent	Of available direct fire weapon systems engaging direct fire targets.
11	Percent	Of direct fire targets not engaged.
12	Percent	Of enemy performance degraded due to lethal direct fire attack.
13	Percent	Of lethal direct fire attacks that result in collateral damage.
14	Percent	Of lethal direct fire attacks that result in friendly or neutral casualties.
15	Number	Of lethal direct fire attacks that result in collateral damage.
16	Number	Of lethal direct fire attacks that result in friendly or neutral casualties.

T&E Plan

EFFECTIVENESS

ART 1.4.1: DIRECT LETHAL FIRES
End State: *Target is destroyed*

MOE: % Correct Weapon Settings

MOE: Time to Attack

MOE: Probability of kill

MOE: % Targets Engaged

MOE: % Collateral Damage

How? - Planning

The T&E Plan…

- Focuses on Soldier missions and tasks;
- Links the attributes of the system to mission context; and
- Addresses Critical Operational Issues, Key Performance Parameters in the mission context.

Mission and task capabilities are the highest level of the T&E dendritic.

Mobile Tower System Evaluation Plan

MEA: Mission Enabling Attribute. MOTS: Mobile Tower System

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How? - Reporting

- **OTA Evaluation Report**

- Conclusions focused on **Soldier tasks** and **how the system supports the mission**.

- COIs, Criteria and KPPs addressed, but conclusions are put in the context of the Soldier's mission and tasks.

All T&E results are related to the mission.

Route Clearance and Proofing System

2.1.1.1 ART 1.6.1.1 Conduct Breaching Operations

- End State: "creation of lanes through or over an obstacle to allow an attacking force to pass."

- Result: "The SYSTEM supports this task by detecting the threat obstacle, marking the threats (for interrogation) and towing the clearing set to „proof' the lane. The SYSTEM … is a significant improvement over dismounted IED detection, marking and proofing."

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Items to Sustain - Planning

- MBT&E strategies being developed.
  - Linking all T&E requirements to missions / tasks.
  - Leveling of expectations in T&E IPT.
- Mission context enhancing T&E design.
  - Mission context (desired results, conditions, standards) leads to integrated T&E.
  - Evaluation measure design focused on operational capability.
  - DT designed using operational techniques and procedures.
- SoS description aligned with PM's Work Breakdown Structure.
  - Facilitates sharing of T&E data during contractor testing.
  - Aligns Warfighter tasks with contractor requirements.

Mission context and SoS description -
keys to integrated T&E strategy

Items to Sustain - Reporting

- Mission Task to System Attribute Linkages.
  - Understanding how system technical performance impacted desired capabilities.
  - "Accumulated" evaluation of effectiveness, suitability and survivability.

- Conclusions more than a restatement of test results.
  - MBT&E Capabilities = **task + desired result**.
  - Conclusions telling "what the data means" in terms of capabilities.

Answering the "so what" question in the Warfighter's terms

Items Being Improved - Planning

- Linkages between tasks and system attributes are being developed.
  - Impact: Additional time to develop and coordinate linkages.
  - Mitigation: T&E IPT developing during project execution.
  - Path ahead: Develop linkages as capabilities based analysis is being conducted.
- Reference missions and tasks are being developed.
  - Impact: Additional time to develop, coordinate and “validate” reference missions.
  - Mitigation: Direct coordination with TRADOC School Houses.
  - Path ahead: Develop set of reference mission/tasks per Warfighting Function.

Items Being Improved - Reporting

- Mission/task standards (threshold/objective requirements) are being developed.
  - Impact: Qualitative results solely based on military judgment.
  - Mitigation: T&E IPT developing “expected” mission/task performance.
  - Path Ahead: Develop task, conditions and standards in requirements.

- Roll-up of system and operational performance into overall assessment of ESS is being developed.
  - Impact: ESS still based on met/not met technical requirements. Impact of sustainability/survivability on effectiveness not determined.
  - Mitigation: Providing capabilities and limitations as rationale for ESS assessment. Continue to use links to COIs and KPPs in parallel.
  - Path Ahead: Align Critical Operational Issues/Criteria with mission and tasks.

Current MBT&E Development Focus

- **Developing better understanding of the mission context.**
  - How will the Warfighter execute the mission?
  - What is needed to execute the mission?
  - Under what operational conditions are the capabilities needed?
- **Incorporating mission analysis into the requirements development process.**
  - What are the key Warfighter capabilities (task + desired result) needed for the mission?
  - How do you know that the capabilities are supporting mission accomplishment?
  - How do the attributers, KPPs, and COIs support assessment of capabilities?
- **Incorporating relationship between Systems Engineering and war fighter Task.**
  - How do the SoS components support the tasks?
  - What level of technical performance is necessary to support task accomplishment?

Collaboration between Combat Developer, Materiel Developer and Independent T&E.

Conclusions

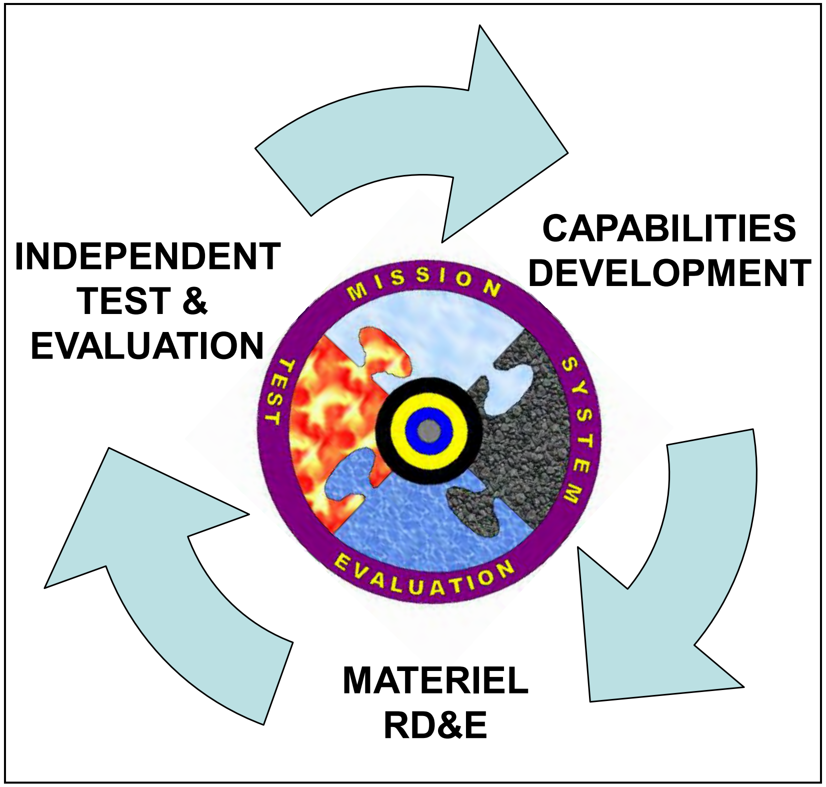
- **Implementation of MBT&E is showing:**
  - Mission and task capabilities are highest level (focus) of T&E strategy = results related to mission.
  - Providing conclusions in Warfighter's terms.
  - Mission context driven into DT and OT conduct = integrated T&E programs.

- **Items to Sustain:**
  - Use of ATLs, and especially the AUTL, as source of evaluation metrics.
  - SoS description aligned with PM's Work Breakdown Structure.
  - Use of mission context and SoS description to drive T&E requirements.

- **Items Being Improved:**
  - Linkages between Warfighter tasks and system attributes.
  - Reference missions and tasks and mission/task capabilities standards.
  - Procedures to roll-up system and operational performance into mission accomplishment.

Desired End State

- Synchronized with Combat Developer.
- Synchronized with systems research, development and engineering.



Collaborative environment defined by a common framework.

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MBT&E Point of Contact

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Defense Information Systems Agency
Department of Defense

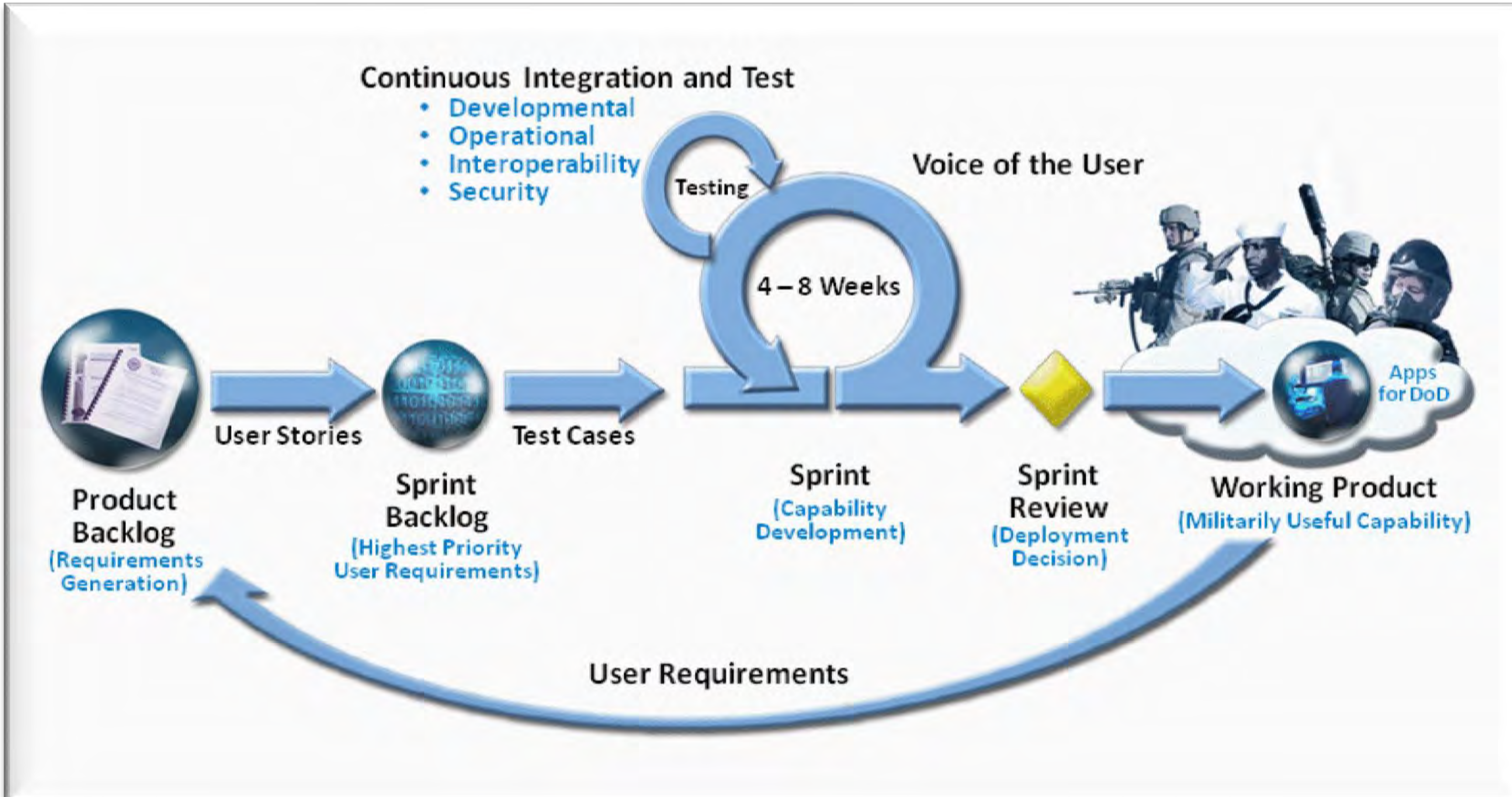
Ready for Scrum?

Steve Hutchison
DISA T&E

Presentation Tasks

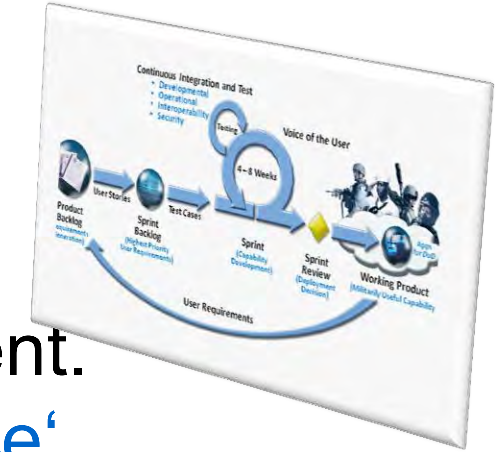
Backlog	In Progress	Done
Scrum Overview		
Role of Testing in Scrum		
Agile Testing		
Summary		

Scrum Overview



- Software development framework focused on delivering value according to customer priorities
- Delivers working software with fewer defects at a sustainable pace
- Removes impediments; teams self-organize and become —hyper-productive"

Why "Scrum"?



"This new emphasis on speed and flexibility calls for a different approach for managing new product development. The traditional sequential or 'relay race' approach to product development…may conflict with the goals of maximum speed and flexibility. Instead, a holistic or 'rugby' approach—where a team tries to go the distance as a unit, passing the ball back and forth—may better serve today's competitive requirements."

Takeuchi and Nonaka, "The New New Product Development Game," *Harvard Business Review*, January 1986.

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“Agile Manifesto”

individuals and interactions	over	processes and tools
working software	over	comprehensive documentation
customer collaboration	over	contract negotiation
responding to change	over	following a plan

www.agilemanifesto.org

—While there is value in the items on the right, we value the items on the left more.”

Key Features of Scrum

- Highly collaborative
- Documentation light
- Change resilient
- Fundamentally different requirements process
- Short duration development cycle: —Sprint”
- Continuous integration and testing
- Focused on priority needs of the customer: the Warfighter

Agile is about delivery of capability at —speed of need.”

3 Key Roles in Scrum

- Product Owner
  - define product features
  - prioritize features; adjust at each sprint
  - accept/reject sprint product
- Team
  - cross-functional, self-organizing
    - programmers, users, testers
  - membership does not change during sprints
- Scrum Master
  - enable collaboration across all roles and functions
  - ensure team productivity - remove impediments!

Inspect and Adapt

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The Product Backlog

- Requirements document
  - *not* a CDD
- Prioritized list of desired features
  - product Owner prioritizes
  - stated as –user story”
    - as a ___, I want to ___, so that I can ____
    - A ***Mission Thread*** likely consists of multiple user stories
- Continuously updated and re-prioritized
  - features added and removed to reflect customer needs

A high-priority user requirement may be just *one sprint away* from delivery

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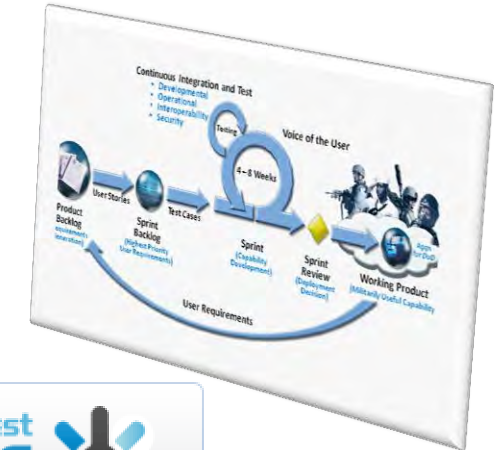
The Sprint

- Time-boxed development period
  - design, code, test
  - sustainable pace
  - —Sprint backlog”
  - highest priority features from product backlog
  - no changes (new features) during Sprint
- Test Driven Development
  - user stories translated into Test Cases
    - testing the capability as it is intended to be used
  - early involvement!

Outcome: potentially deployable capability

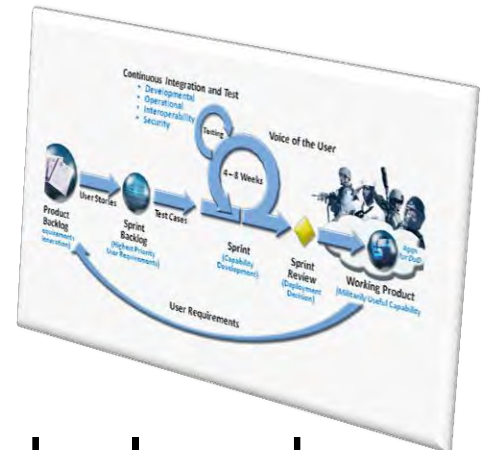
Continuous Integration and Test



- Testing is a shared resource
  - DT, OT, interoperability, security
  - continuous user involvement
  - one team!
- Reciprocity
- Risk-based, mission focused
- Maximizes use of test automation
  - virtualization
- Lightweight documentation: shift emphasis from TEMP to Test Cases

Do not sacrifice rigor in Agile testing

Sprint Review



- Deployment decision
  - not an FDDR
- Demo to stakeholders
- Working capability is eligible to be deployed
  - product owner, stakeholders decide
  - can be improved in subsequent sprint
  - defects returned to the product backlog
- Testers take on —continuous monitoring” role for deployed capability

Capability deployment: start small, scale rapidly

Task Board

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Agile Testing		
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Role of Testing in Scrum

If you think you're going to show up at the end and run a test, think again.

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What is Agile Testing?

- Is not testing on an Agile project
- —Early Tester Involvement”
  - drive development
- One team – no tester silos
  - customer focused
- Collaborative
  - with developer, customer
  - not —quality police”

> —Unfortunately, customers aren‘t generally good at articulating their requirements. Driving development with the wrong tests won‘t deliver the desired outcome.
>
> Crispin and Gregory, *Agile Testing*

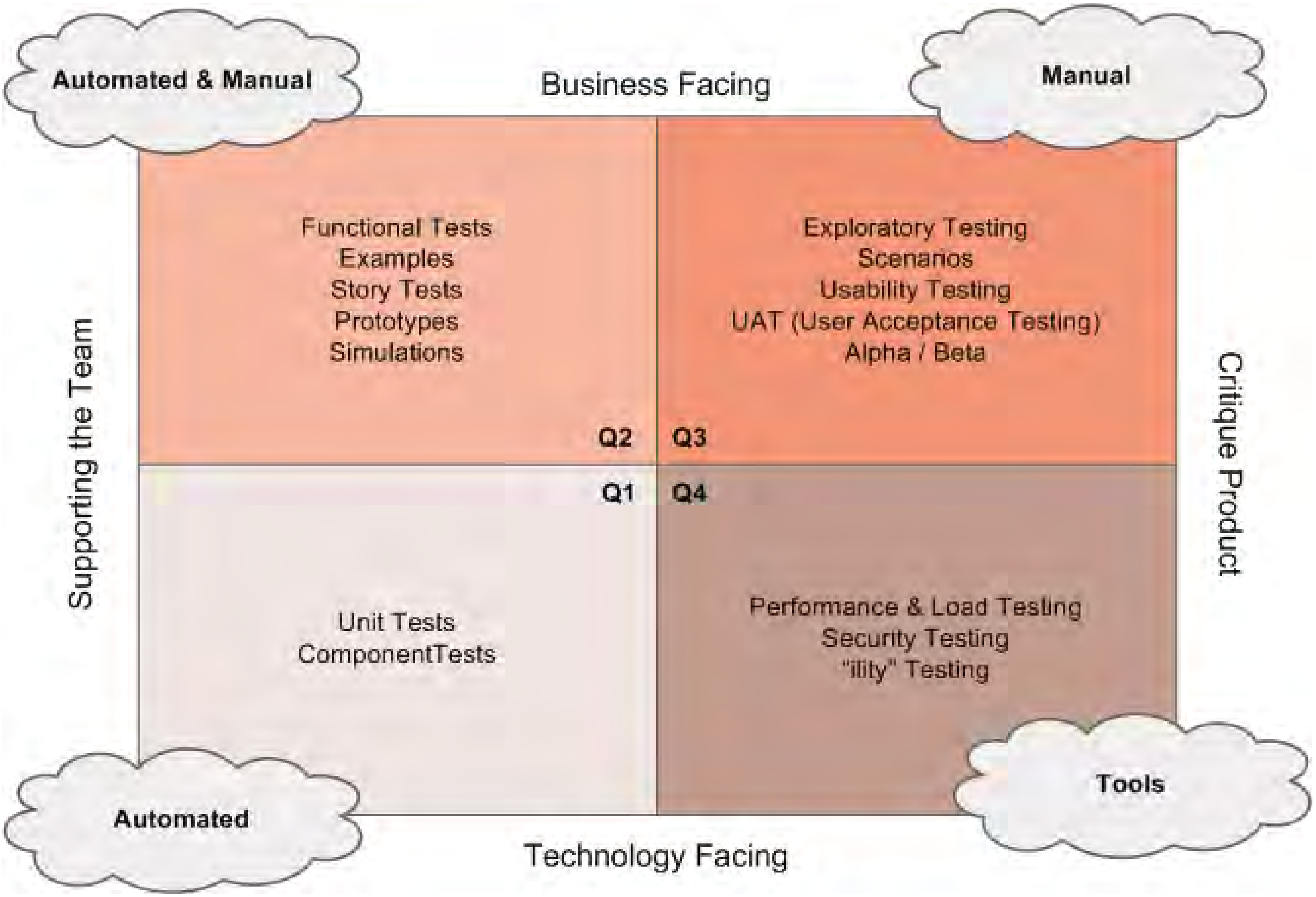
What Makes Agile Testing Different?

- Not a “phase” at the end
  - Can‘t test quality into the product
- Much earlier in the process
  - Coding and testing are integrated
    - A user story is not —done” until it has been tested
  - Drives a culture of feedback and improvement
    - Not a gatekeeper
- Lightweight process
  - Less documentation reliant
- Employs more automation

We define an agile tester this way: a professional tester who embraces change, collaborates well with both technical and business people, and understands the concept of using tests to document requirements and drive development.

Crispin and Gregory, *Agile Testing*

Agile Testing Quadrants



The Agile Testing Quadrants
Original idea by Brian Marick, www.exampler.com

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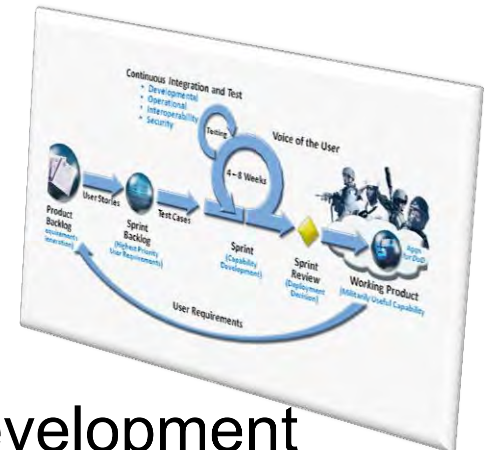
Challenges

- Test as a Service
  - On demand
- Persistent environment
  - Federate capabilities
  - Virtualize
- Education and training
  - PMs <u>and</u> Testers
- Agile DIACAP, Interoperability, oversight
- Community of Interest User base

Shift the paradigm: testing as <u>*an enabler*</u>
of improved acquisition outcomes

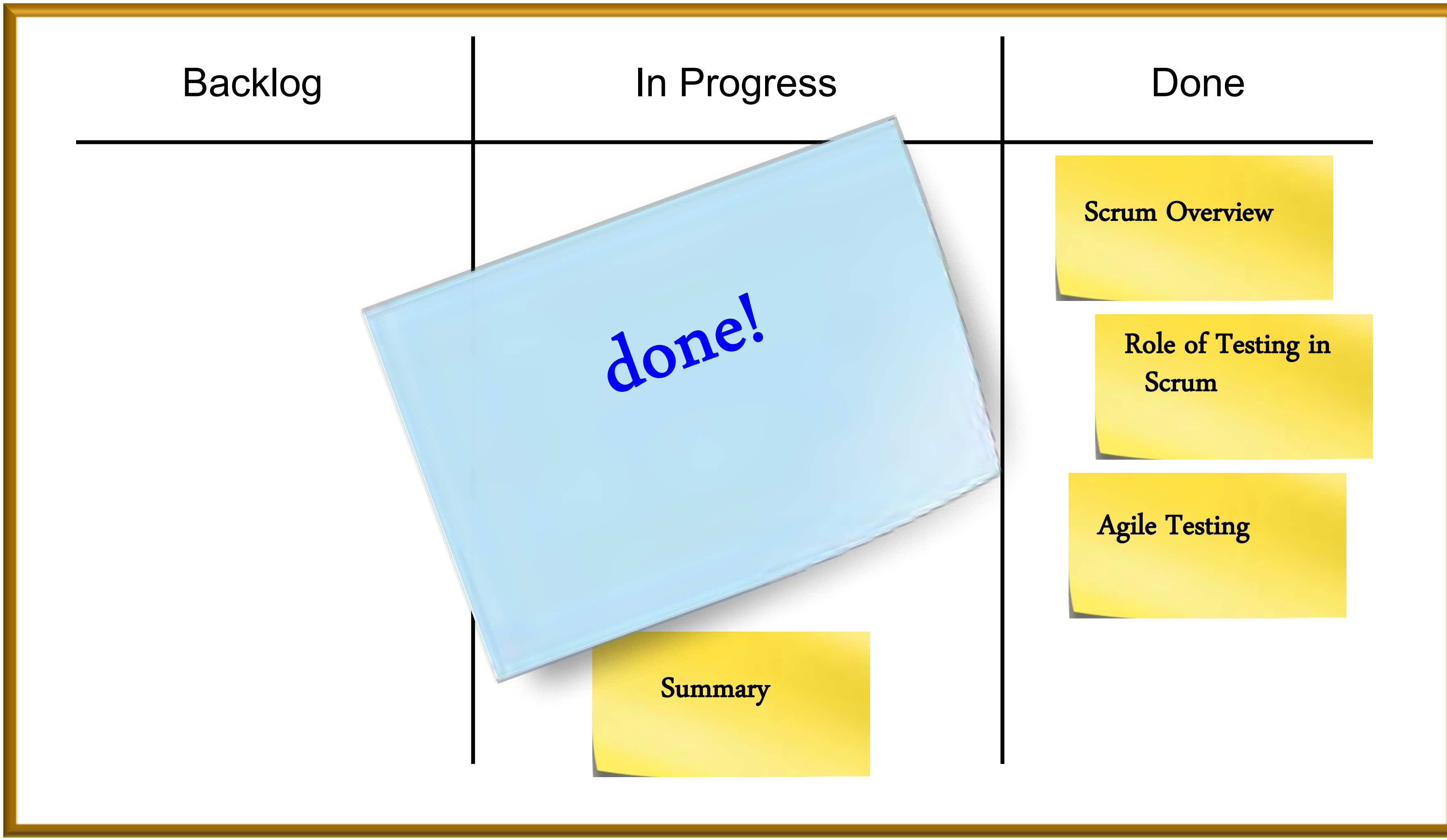
Summary



- New IT Acquisition model is coming
- TE&C processes must adapt
  - Responsive to iterative, incremental development
  - Responsive to *User* priorities
  - High optempo
- Dramatically reduced TE&C timelines

Objective: rapid fielding of enhanced IT capabilities to the Warfighter

Task Board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done!
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DEFENSE INFORMATION SYSTEMS AGENCY

Expanded Use of the Probability of Raid Annihilation (P_{RA}) Testbed

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Expanded Use of the Probability of Raid Annihilation (P_{RA}) Testbed

Introduction

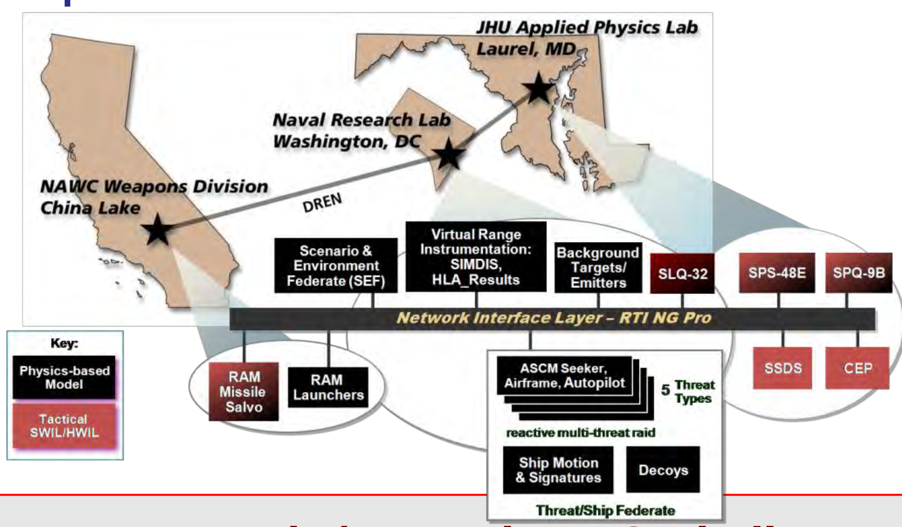
The P_{RA} testbed support to LPD-17 is complete, but the testbed itself is just maturing into a multi-use toolset . This toolset has possibilities of supporting other test events/systems outside of the confines of the current planned events. In order to realize and capitalize on the engineering research, development and subsequent refinements in the testbed it is well worth exploring all potential avenues for employing this federation of models.

Presentation Outline

- P_{RA} and the Enterprise
- Capitalization
- Areas for Expansion
- Fleet Tactics Development
- S/W Validation
- SSTAMDA vs AAW CRD
- Trade Studies
- Evolving Capabilities and Threats
- Predictive Analysis
- Conclusion

P_{RA} and the ENTERPRISE

- Probability of Raid Annihilation (P_{RA}) Testbed forms one of the core elements of the Enterprise Approach to Anti-Air Warfare Ship Self Defense (AAW SSD).
- Proven capability to provide answers for LPD 17 AAW SSD MOE and other Enterprise platforms/systems.
- Capability exists to answer other questions, to further expand the use of the testbed.



Fleet Tactics

Trade Studies

SSTAMDA

S/W Release Validation

Predictive Analysis

Evolving Capabilities and Threats

Future Upgrade/Expansion – Capitalize on today's foundation

Capitalization

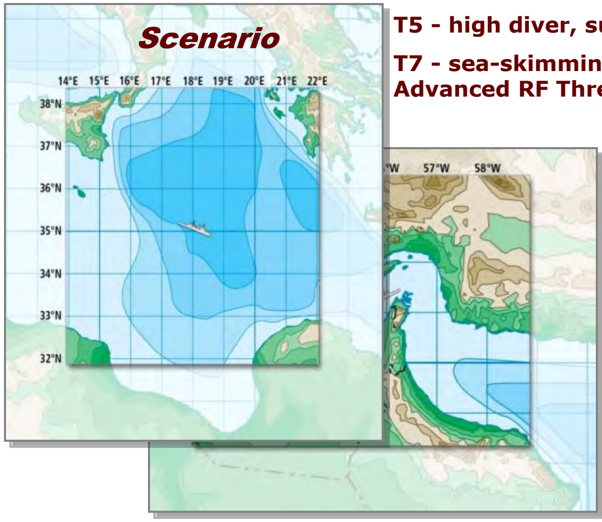
- Capitalize on engineering research & development completed to date:
  - Operationally relevant environments
  - Common/shared geographies, threats, and weapons
  - Sensor performance
  - Common Lethality Federate (CLF)*

T1R1 - sea-skimming, subsonic RF threat

T2 - sea-skimming, subsonic Imaging IR threat

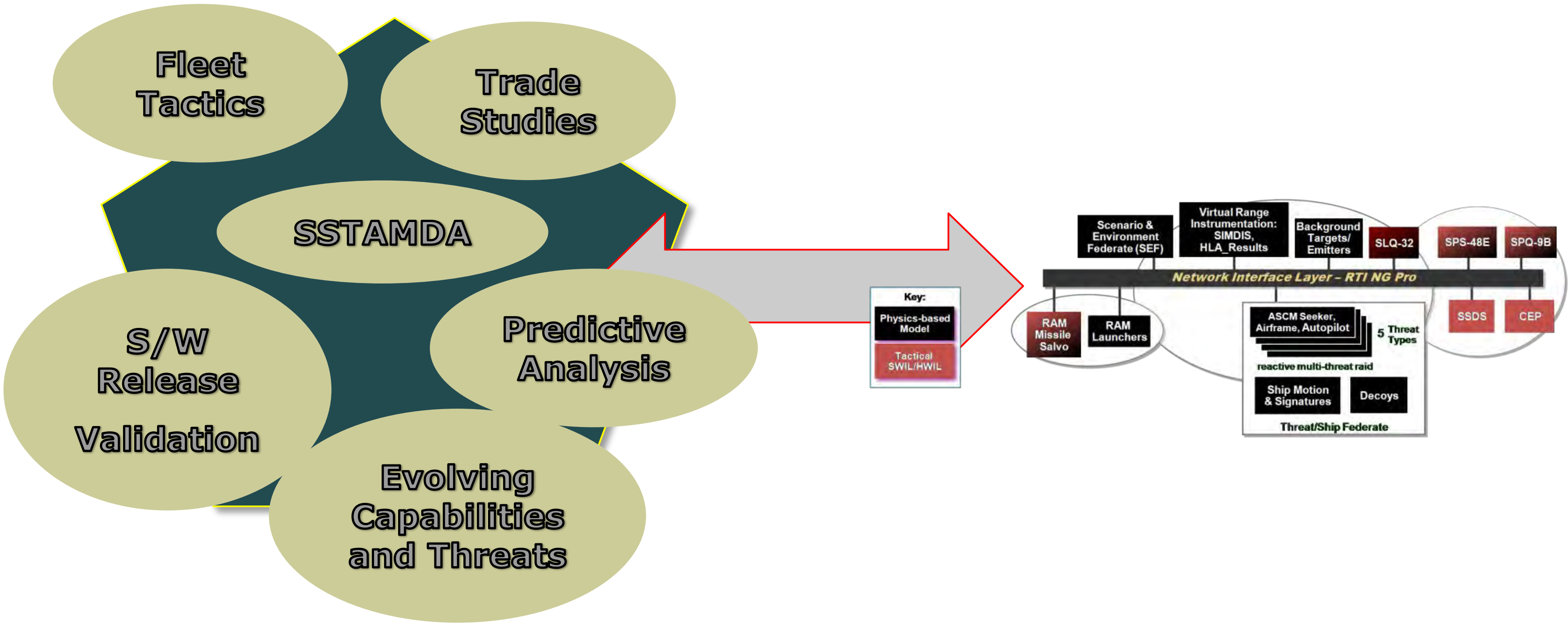
T5 - high diver, supersonic RF ARM threat

T7 - sea-skimming, maneuvering supersonic Advanced RF Threat



Areas for Expansion

- Six Preliminary Areas for consideration in Testbed Expansion

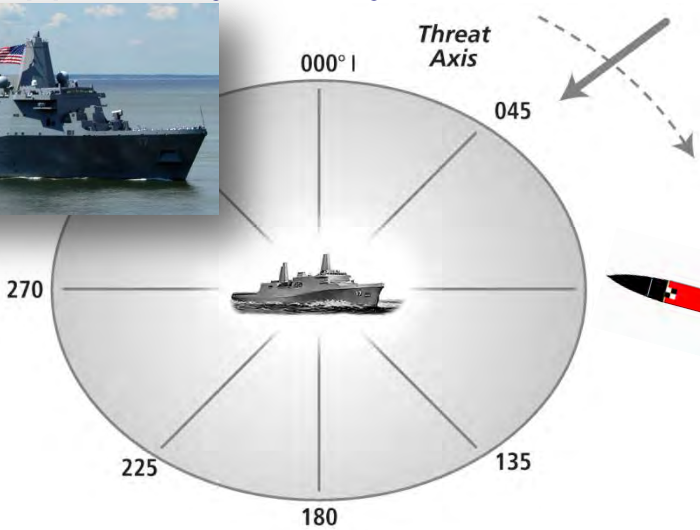


- These areas represent beginning possibilities.

- As other testbeds are developed, co-use opportunities arise – example is DDG 1000 MOE Testbed.

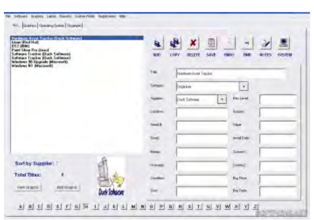
Fleet Tactics Development

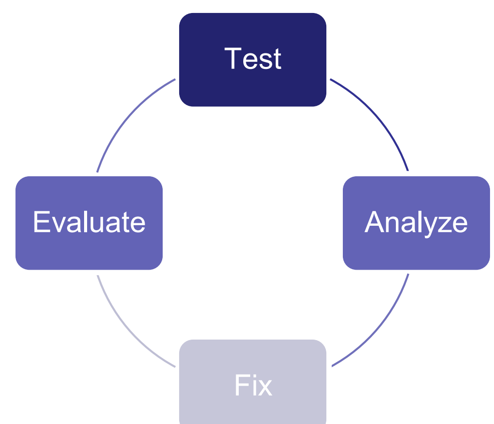
- Fleet Tactics
  - Currently developed using intelligence, threat assessments, M&S, and tactician analysis validated by **<u>limited, if any,</u>** formal live end-to-end test events.
  - Testbed can used to verify interim and experimental tactics techniques and procedures against hi-fi representations of appropriate threats in end-to-end fashion.
  - Ability to develop and verify tactics via modeling and simulations (M&S) affords the opportunity to vary the tactical environment.



S/W Validation

- Validation of Software Releases
  - Testbed could be used to test and validate tactical software updates, thereby eliminating the need to test and retest on fleet units or test facilities.
    - Ties up fleet assets
    - Scarce test resources
  - An invaluable tool to mitigate time and costs
  - Saves test resource usage





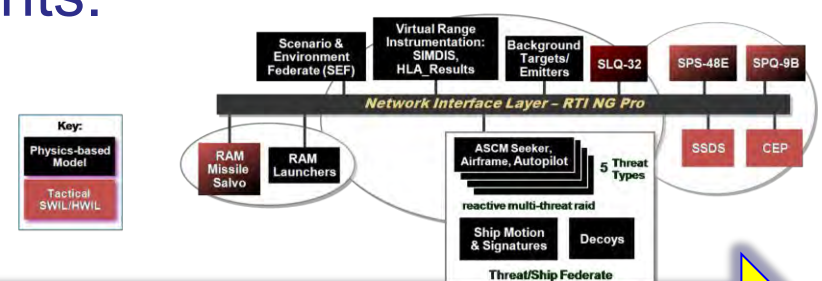
SSTAMDA VS AAW CRD

- SSTAMDA imposes P_{RA} requirements on future ship classes & and existing ships with significant combat system upgrades.

- Recommended P_{RA} for existing ship classes are different from AAW CRD.

- Future ship classes are required to demonstrate they meet the new P_{RA}.

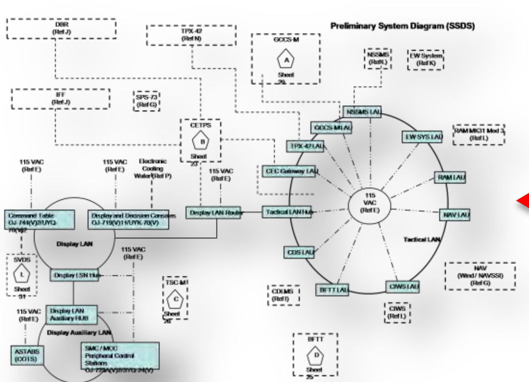
  - The Testbed easily adaptable to test virtual ship against the new requirements.

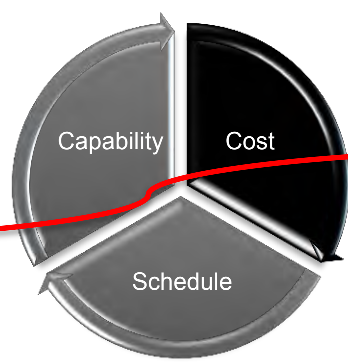


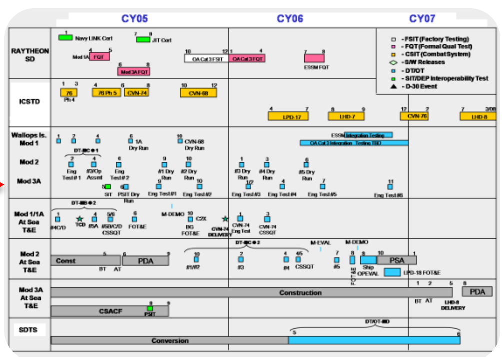
New Requirements tested in a Proven Fashion

Trade Studies

- Use of the Enterprise Testbed to determine:
  - If a particular combat system configuration will perform successfully to meet P_{RA} requirements.
  - Efficacy of future ship class combat systems variations investigated to an increased degree of accuracy.
    - Prior to full funding commitment or design.
    - Cost saver.

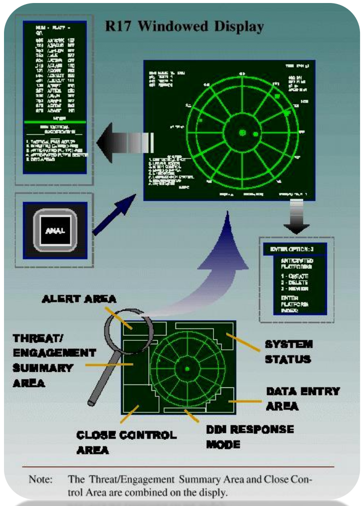






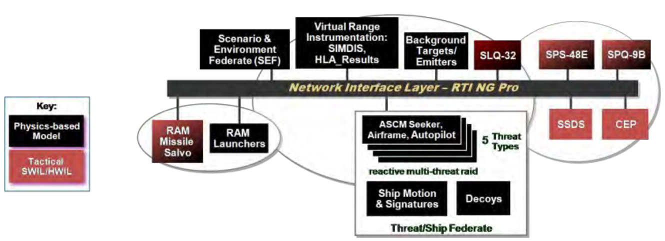
Evolving Capabilities and Threats

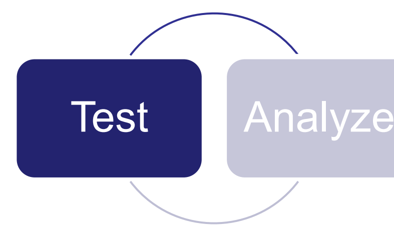
- Testing combat systems against evolving threats:
  - With low probability of intercept radars.
  - With coherent radars.
  - With low observable technologies.
- Navy's advancement with (SEWIP) Block II AN/SLQ-32 B, will require:
  - Higher fidelity emissions from threat surrogates (targets) and threat models.
- Use of the Testbed would realize cost savings and fill shortcomings imposed by a lack of capable targets.



Predictive Analysis

- Changes/updates to the appropriate model(s) in the Testbed would facilitate a sufficient number of Monte-Carlo'ed scenarios for pre-flight prediction.
- Provides ability to craft and run a number of scenarios to find the heart of & limits of the test envelope.
- Combine with Design of Experiments to define the test space and number of live events to achieve statistically significant results.





Expanded Use of the Probability of Raid Annihilation (P_{RA}) Testbed Conclusion

- Capability exists to answer other questions, to expand the use of the testbed.
- The initial development is complete and proven through the LPD 17 P_{RA} effort.
- A variety of efforts would benefit from a complementary M&S input:
  - Fleet TTP
  - Software validation
  - SSTAMDA
  - Trade Studies
  - Evolving Capabilities and Threats
  - Predictive Analysis

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Design of Experiments

"Managing Expectations"

James "JD" Carpenter
And
Chris Hauser

AVW Technologies, INC
www.avwtech.com

Agenda

"View from the trenches"

- Why test, Why learn?
- Why DOE makes sense
- Manage Expectations - What works (for us)
- Questions?

Why Test?

- Why Test?
  - To learn and bound capabilities
  - To answer some basic questions
    - Does system meet capability requirements?
    - What is actual system performance?
    - How is system best employed? (Tactics, Techniques and Procedures)

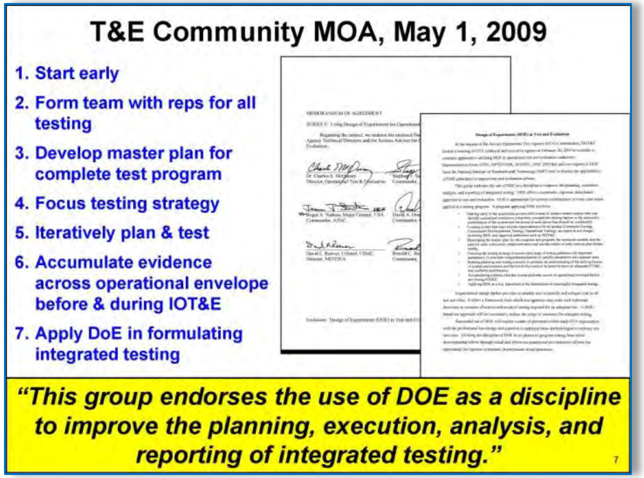
Why Learn?

- Why learn?
  - To discover the “truth” as best we can know it
  - <u>To enable knowledgeable program decisions</u>

Guidance

- Mandated use in Gov't T&E
  - DOT&E requires DOE in Operational Testing
  - Recent DDT&E guidance on Developmental Testing
  - Service OTAs have Joint MOA naming DOE as a best practice

DOT&E rejected TEMPS based on inadequate DOE



We don't need more guidance. We need incentives for PMs/Developers

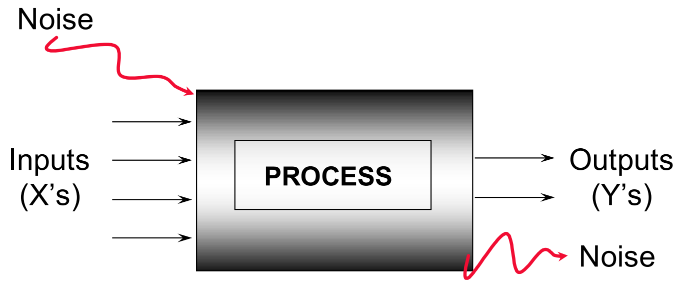
Why DOE?

Scientific Answers to Four Fundamental Test Challenges

Four Challenges faced by any test

1. *How Many?* A: Sufficient samples to control our twin errors – false positives & negatives
2. *Which Points and What's Good?* A: Span the battle-space with orthogonal run matrices using continuous measures tied to the test objectives
3. *How to Execute?* A: Randomize and block runs to exclude effects of the lurking, uncontrollable nuisance variation
4. *What Conclusions?* A: Build math-models* of input/output relations (transfer function), quantifying noise, controlling error

Design of Experiments effectively addresses all these challenges!



* Many model choices: regression, ANOVA, etc.

Tester’s Challenge

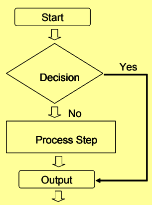
-Time to execute the test
- Resources to support the full scope of planned test
- Funding

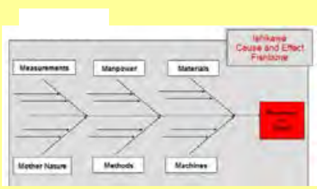



The best test may go unfunded while the “worst” test gets funding support

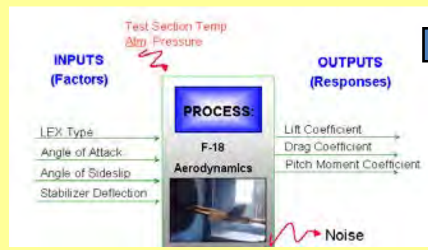
DOE Test Process:
Well-Defined From Blank Paper to Conclusions

Planning: Factors
Desirable and Nuisance

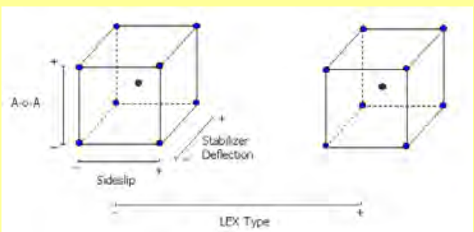




Desired Factors
and Responses



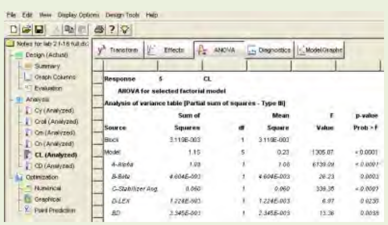
Design Points



Test Matrix

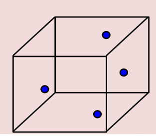
A-o-A	Sideslip	Stabilizer	LEX Type
2	0	5	-1
10	0	-5	1
10	8	5	-1
2	8	5	-1
2	8	-5	-1
2	0	-5	-1
10	8	-5	1
2	0	5	1
2	8	5	1
10	8	5	1
10	8	-5	-1
10	0	5	-1
10	0	-5	-1
2	8	-5	1
10	0	5	1
2	0	-5	1

Analysis and Model



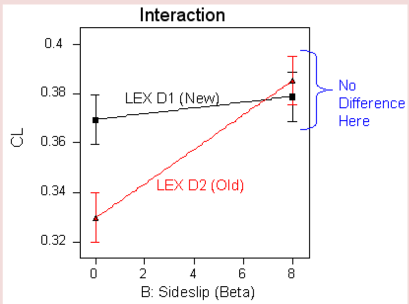
C_L = +0.38
+0.26 x A-o-A
+0.017 x Sideslip
+0.061 x Stabilizer Deflection
-.00875 x LEX Type
+0.012 x Sideslip x LEX Type

Validation



Actual	Predicted	Valid
0.315	(0.30 , .33)	✓

Discovery, Prediction

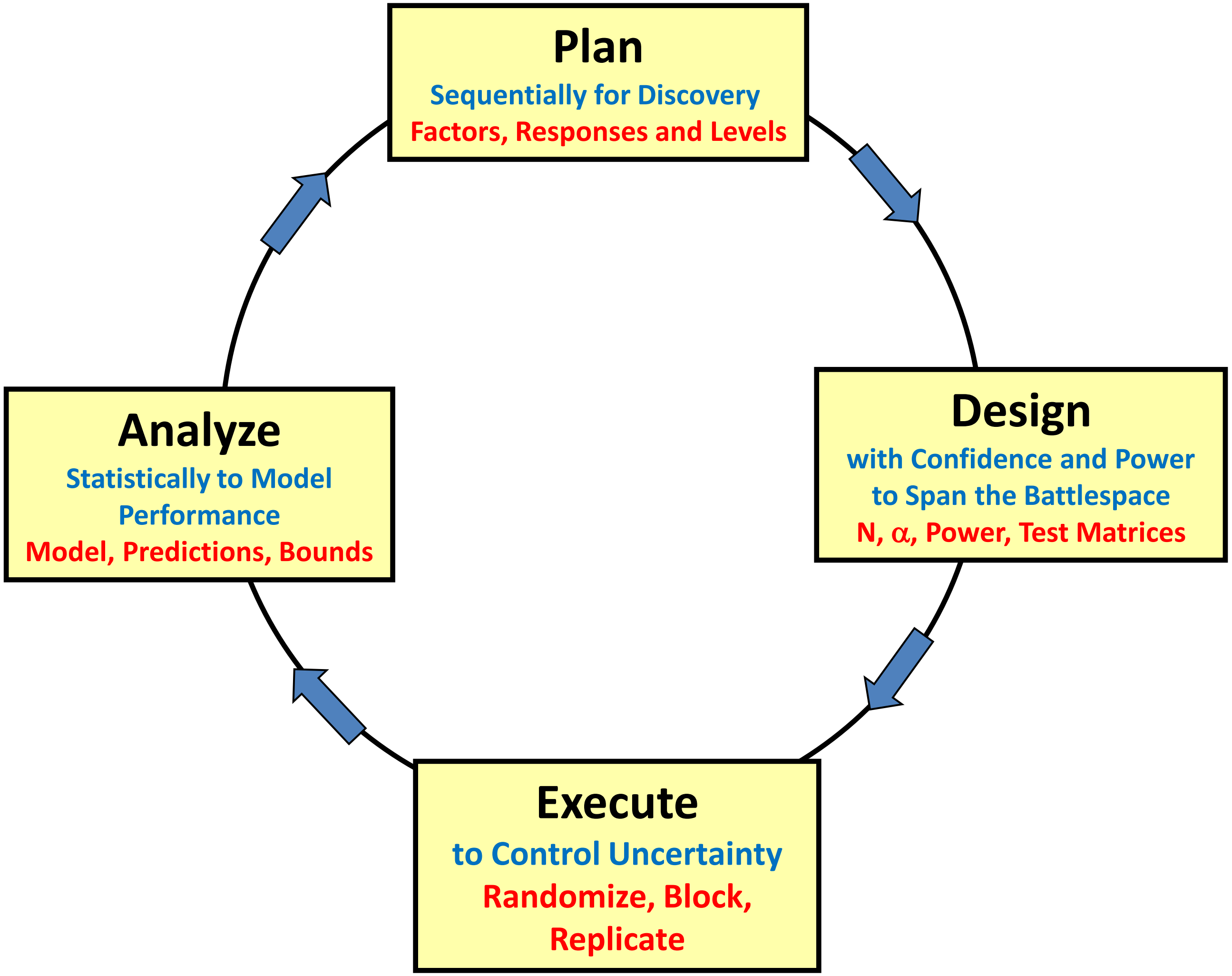


Not simple but doable with this systematic approach.

How to Execute

Four Stages

- Plan deliberately: problem, objective(s), outputs, inputs, background variables, phases
- Design for power in spanning battlespace: many choices of designs, depends on your system
- Execute with insurance against lurking variables and unknown-unknowns
- Objectively analyze with statistical methods (ANOVA/Regression) to determine what matters, direction, magnitude



Why DOE Makes Sense

DT&E: Science & Engineering are Vital to Success of our Tests

We already have good science in our DT&E!

We understand sys-engineering, guidance, aero, mechanics, materials, physics, electromagnetics …

DOE introduces the *Science of Test*

Why DOE Makes Sense

OT&E: Operations Skills are Vital to the Success of Test

Similarly: we already have good ops in our OT&E!

We understand attack, defense, tactics, ISR, mass, unity of command, artillery, CAS, ASW, AAW, armored cav…

DOE adds the *Science of Test*

We make decisions too important to be left to professional opinion alone…our decisions should be based on *mathematical fact*

Greg Hutto

Managing Expectations

Observation by a Practitioner

- At this point in history, (for OT) using DOE simply means laying out the primary factors that affect the response variable in at worst a notional design (<u>and at best a design that one could readily use with proper resources and leadership support</u>)

Dr. R. McIntyre Feb 2011

What Works (for us)

- *DOE provides for efficient testing and more useful results – but not necessarily at a reduced up front cost*
- *DOE is most effectively applied early in the development process where build a little, test little is cost effective*
- *Know your process; know the tool*
    - *Investing the time up front for process decomposition (MBTD/E) will pay great dividends in developing the experimental design*
    - *Use a DOE practitioner to assist in the actual design development (then execute the design)*
    - *Clearly articulate the pros and cons of each design (metrics scorecard)*
- *Ask better questions ;get better answers*
- *Even when DOE is not the correct tool to use for a particular application, it will at least aid you in discovering the most useful demonstrations to observe (May need to use other DOE-like tools – HTT)*

Design of Experiments

"Managing Expectations"

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Design of Experiments

"Managing Expectations"

QUESTIONS?

BACK-UPS

DOE Metrics Scorecard

	Basic Report Card - Designed Experiments				
Wheel	Design Alternative	0	1	2	3
	Design Name	Baseline	CCD x3Cat	2^5+4cp	2^5-1+4cp
Plan	Number of Factors				
	Levels ea Factor				
	Num Responses (MOPS)				
	Real-values?				
	Objective?				
Design	Test Events (N)				
	Savings (-Incr)				
	Aliasing/Res/Ortho/Confound				
	comparisons)				
	2 σ Power				
	Name Design Strategy				
Execute	Randomized?				
	Blocked or calibrated?				
	Replicates? True?				
Analy	Pred Model Supported				
	FDS Pred Err @50/95%				
	Leverage Avg/Max				
	VIF Avg/Max				

DOE expert assistance recommended

Aerial Tgts Example

	Aerial Target Report Card - Designed Experiments				
Wheel	Design Alternative	0	1	2	3
	Design Name	Baseline	Factorial	2^(6-1)x3	7v 2/3 D Opt
Plan	Number of Factors	3	3	7	7
	Levels ea Factor	2x2x3	2x2x3	2,3	2,3
	Num Responses (MOPS)	1	1	1	1
	Real-values?	no	no	no	no
	Objective?	no	no	no	no
Design	Test Events (N)	13	12	96 (12)	46 (6)
	Savings (-Incr)	--	8%	8%	54%
	Aliasing/Orthogonality	Res II (A=B)	Full Res	RV+	
	comparisons)	5%	5%	5%	5%
	2 σ Power	5-65%	50-82%	99.90%	99%
	Name Design Strategy	??	Factorial	FractionxCat	Dopt Fract
Execute	Randomized?	--	--	--	--
	Blocked or calibrated?	--	--	--	--
	Replicates? True?	--	--	--	--
Analy	Pred Model Supported	Main Eff	3 FI	3FI	2FI
	FDS Pred Err @50/95%	.72/1.1	.71/.71	.33/.42	.66/.77
	Leverage Avg/Max	.38/1	.5/.5	.375/.375	.37/.47
	VIF Avg/Max	2/2.5	1/1	1/1	1.2/1.3

- Summary thoughts … avoid binary, define test event, max events per sortie/mission, create design alternatives, exploit sequential experimentation

Personnel Injury Analysis of Reflective Spall

National Test and Evaluation Conference
14-17 March 2011

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Rebecca VanAmburg and Robert Kinsler

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Analysis Purpose and Approach

Issue:

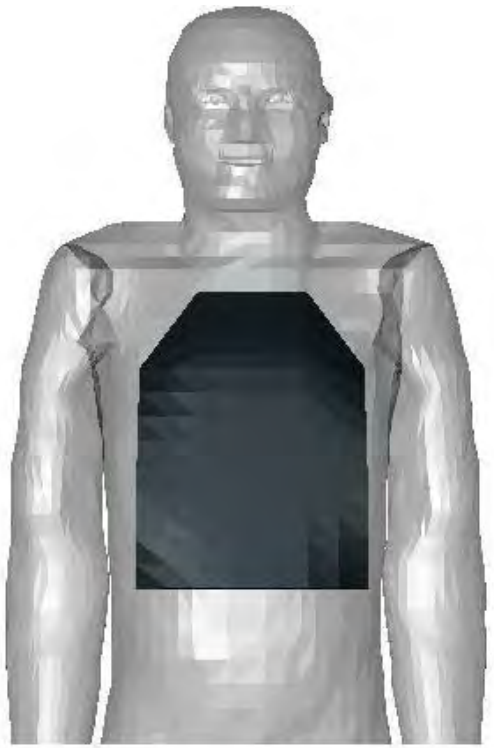
1. Current body armor test procedures do not quantify the potential threat to the Soldier from reflective spall.
   – Reflective Spall is fragmenting debris that results when a threat is defeated by the protective plates in body armor.
2. Current Army operating procedures mandate that a plate must be turned in if the ceramic tile is exposed. This means that any small rip in the protective nylon cover renders a plate unserviceable.

Problem:

1. Is there a risk of injury to the Soldier from reflective spall?
2. Is the risk of injury higher when the ceramic tile is exposed?

Approach:

- Perform custom experimental testing to collect fragmentation using ballistic gelatin.
- Conduct personnel vulnerability modeling and analysis using MUVES-S2.



Experimental Configuration

Target:
- Medium protective plate contained in a small/medium shoot-pack

Threat:
- Small caliber projectile

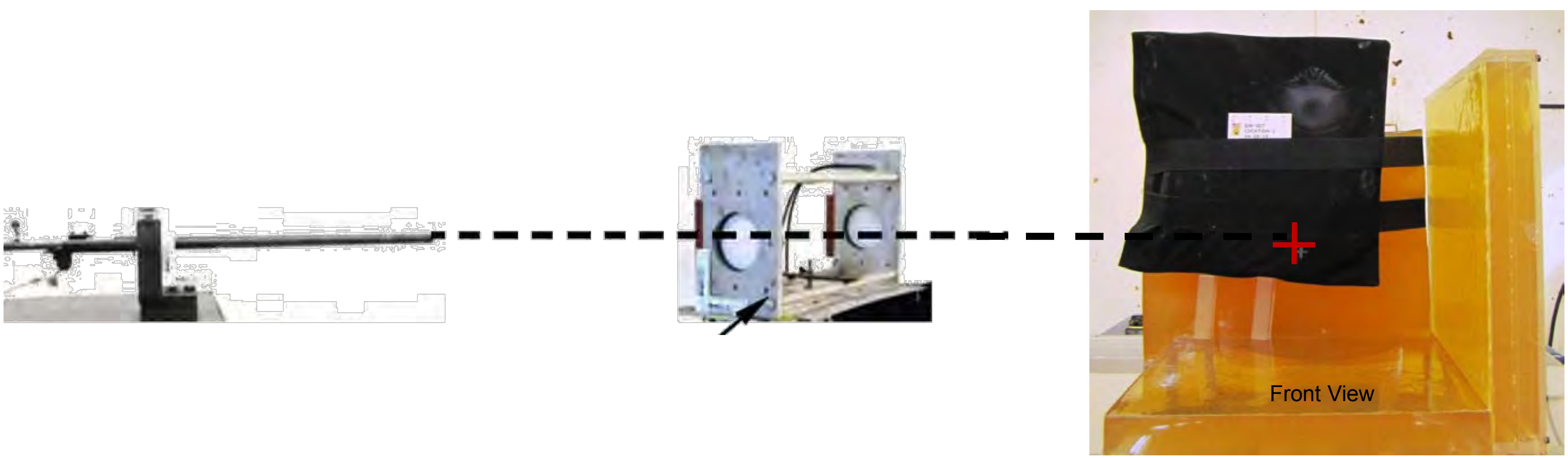
Test Matrix:
- 20 shots were fired at each shot location
    - 10 with the nylon cover on
    - 10 with the nylon cover off

Shot Locations

Gun Barrel

Velocity Break Screen

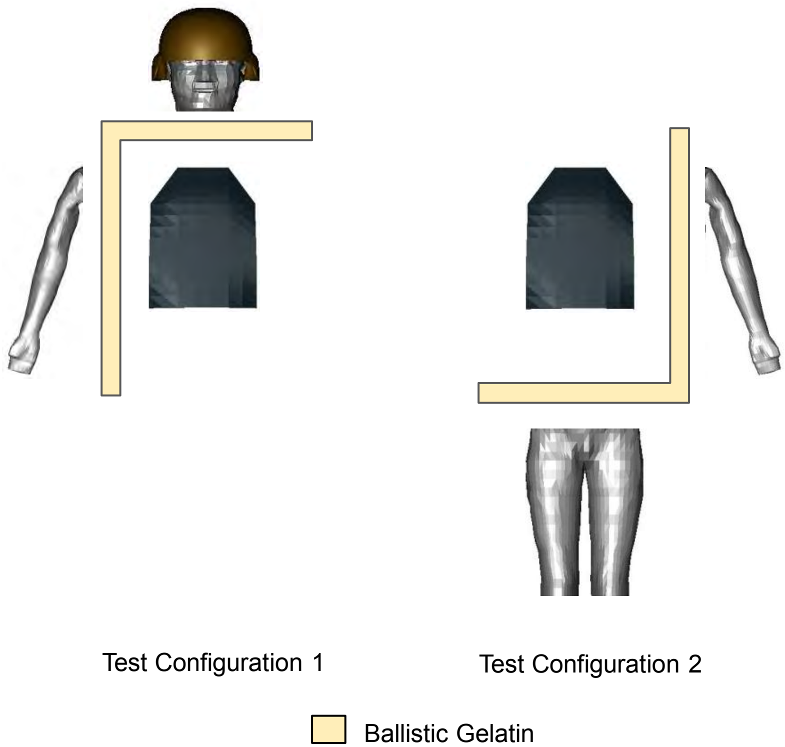
Target Configuration

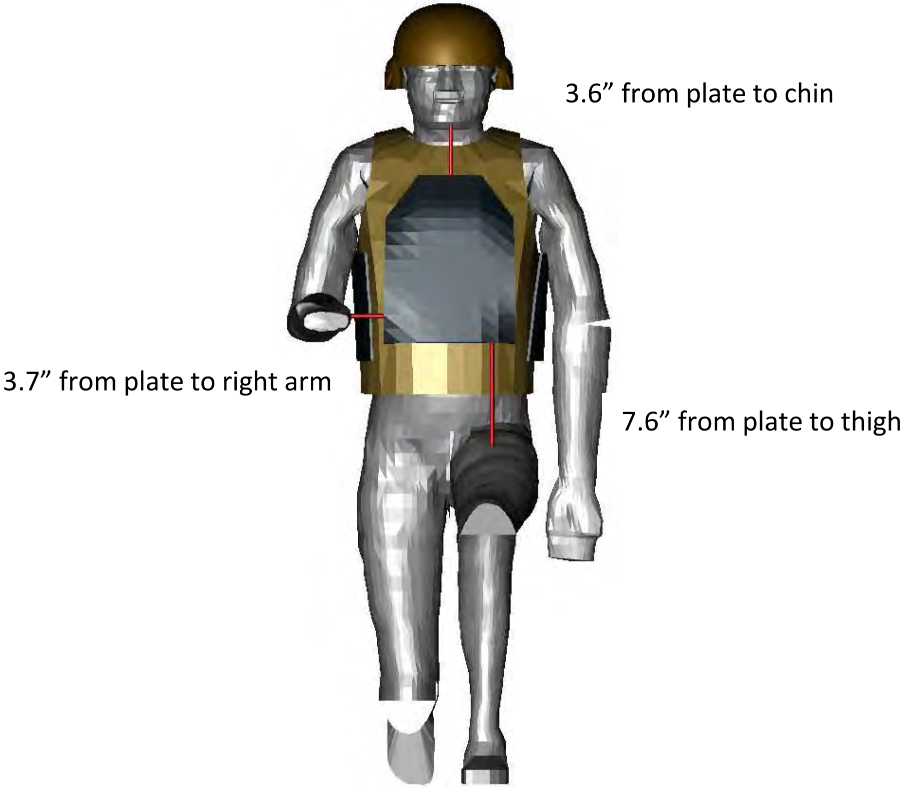


Target Design

For the experimental testing a custom target was designed to collect all of the fragmentation. The target consisted of a medium size protective plate with ballistic gelatin surrounding it. The gelatin blocks provided backing for the target, a medium size protective plate, as well as a witness collection medium for reflective spall that could potentially impact a Soldier's arms, legs, and head.

The distances between the plate and the gelatin were determined using the digital human reference anatomy used in ARL's Operational Requirement-based Casualty Assessment (ORCA) model.





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Personnel Injury Analysis

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- All fragments recovered in the ballistic gelatin were evaluated.
- For each observed occurrence, the fragmentation was characterized in terms of velocity, mass, shape factor, trajectory, entrance point, stopping point, density, and material type.
- The ORCA skin penetration equation was used to filter out fragments with less than a 50% probability of skin penetration. These fragments will cause a superficial injury or no injury at all.
- The angle the fragment traveled was used to evaluate if the fragment could potentially hit a body region.
- MUVES-S2 flew the fragment in 3-dimensions into the 3-dimensional ORCA human anatomy.
- ORCA modeled the permanent wound cavity of each fragment and scores the severity of each injury.
- The Maximum Abbreviated Injury Score (MAIS) was used to determine the likelihood of a significant injury.

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Analysis Injury Metric: MAIS

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MAIS – Maximum Abbreviated Injury Score (MAIS) is an anatomical measure of injury severity. This score classifies injury severity on the basis of the single injury having the greatest AIS[1] severity value. The MAIS is between 0 and 6.

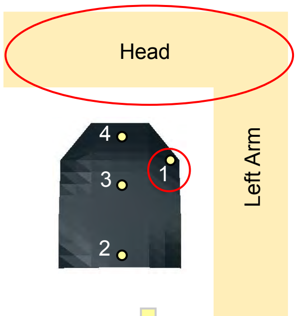
Serious Injury – *An injury that requires immediate medical* attention and the threshold criteria for **significant injury** for this analysis. Untreated serious injuries could deteriorate and cause loss of life.

MAIS	Injury Level	Head Injury Example	Type of Injury
1	Minor	Minor laceration of scalp	Superficial
2	Moderate	Major laceration of scalp, blood loss < 20%	Reversible injuries; medical attention required
3	Serious	Fracture of skull, penetration < 2 cm	Reversible injuries; hospitalization required
4	Severe	Depressed skull fracture, penetration > 2 cm	Life threatening; not fully recoverable without care
5	Critical	Depressed skull fracture, laceration of spinal artery	Non-reversible injuries; not fully recoverable even with care
6	Maximal	Massive brain stem crush	Nearly Unsurvivable

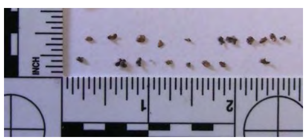
[1] "Abbreviated Injury Scale" (AIS) is an anatomically-based, consensus-derived, international severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale. AIS values provide information on the type, location, and severity of anatomical injuries. AIS scores each single injury.

Example of Personnel Injury Analysis for the Head Region

Ballistic Experimentation



Recovered Fragments



Fragment Characteristics:

- Mass
- Shape Factor
- Impact Point
- Stopping Point
- Material Type
- Material Density
- Striking Velocity

Filtering

Velocity, Mass, and Shape Factor

↓

ORCA Skin Penetration Equation

↓

Probability of Skin Penetration

↓

Greater than or equal to 50% ?

Yes ↓

Feasibility of Fragment Trajectory

↓

Fragments Used in Evaluating Injury Risk

Analysis

MUVES-S2

↓

MAIS

1	2	3	4	5	6

↓

Probability Calculation

↓

Probability of MAIS 3 or Greater

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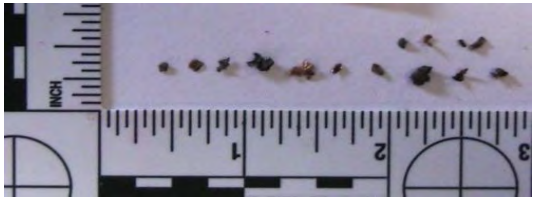
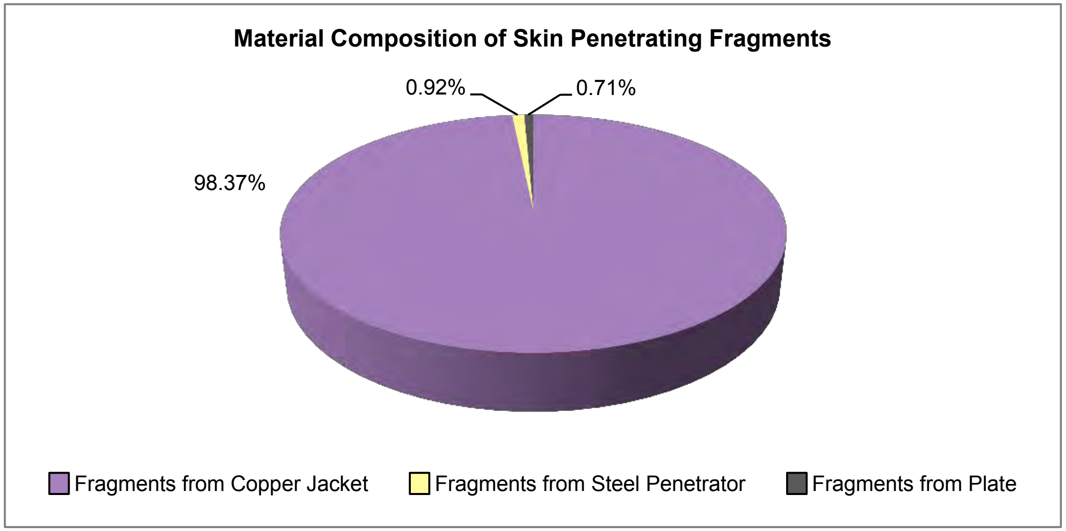
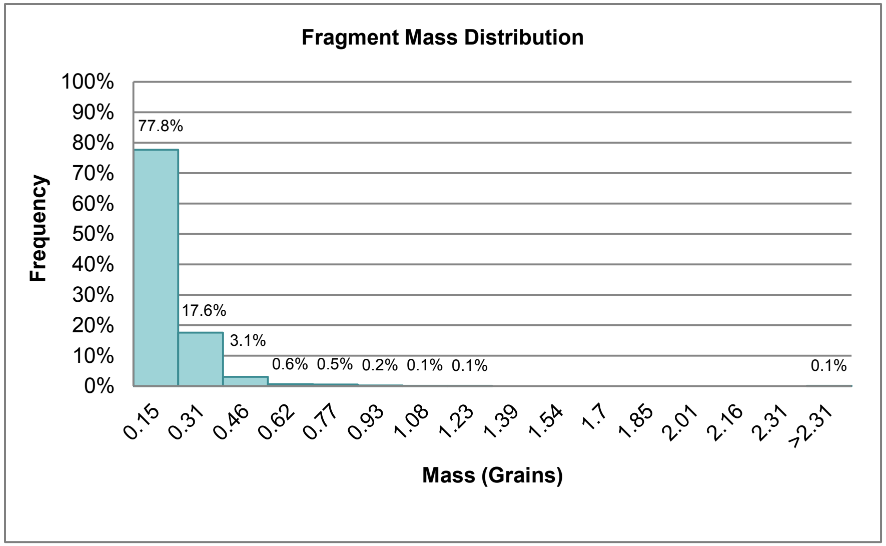
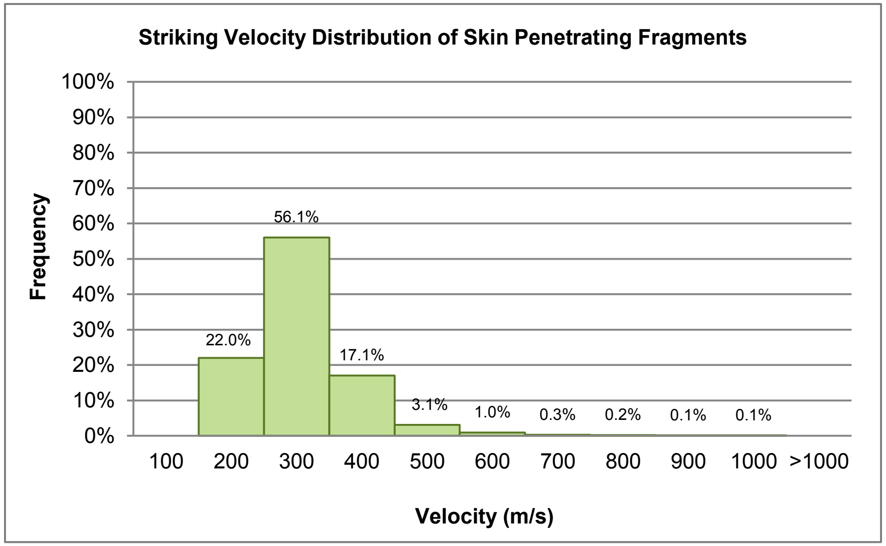
Analysis of Skin Penetrating Fragments

Recovered Fragments









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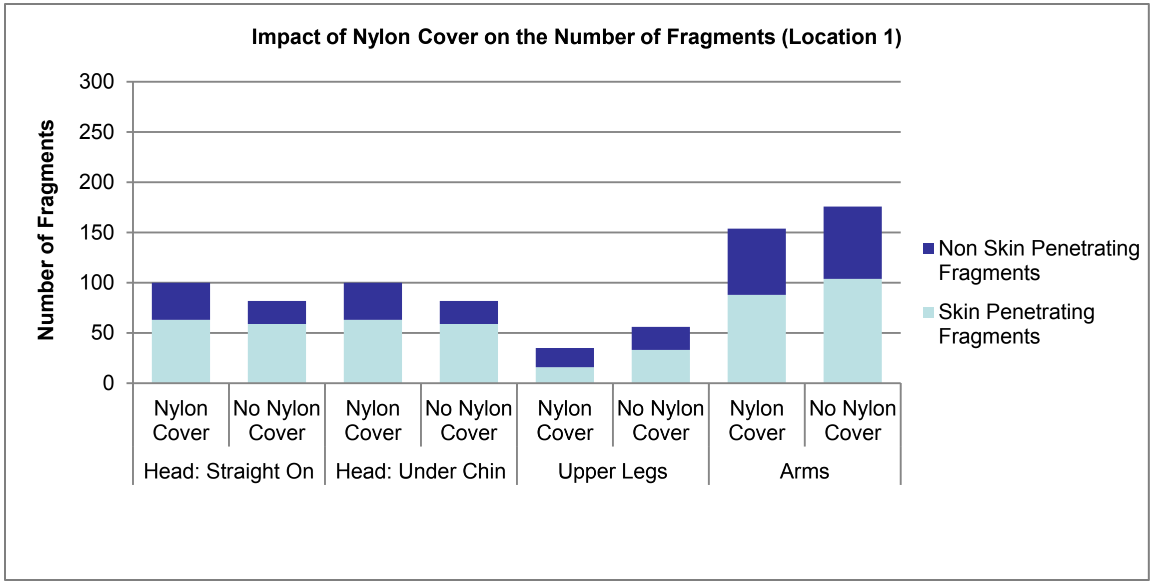
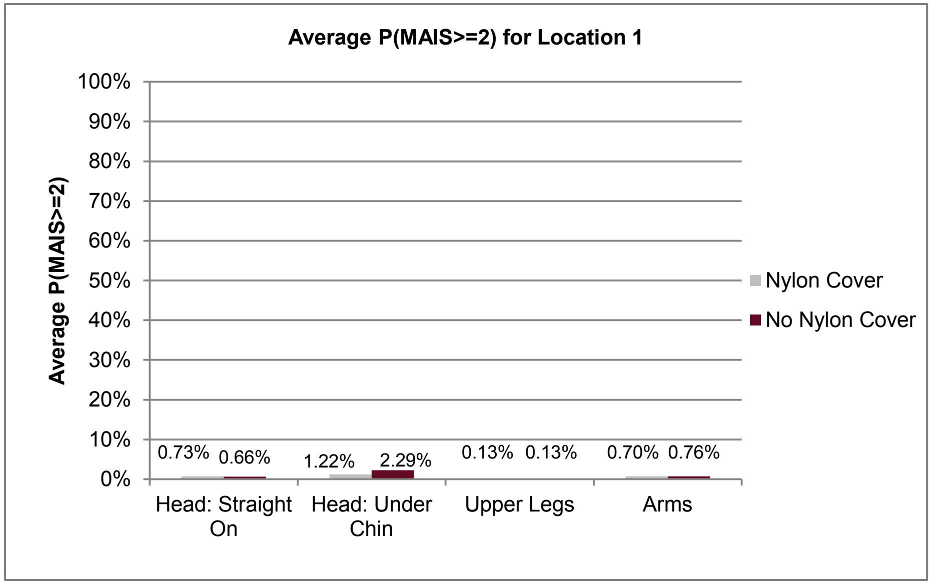
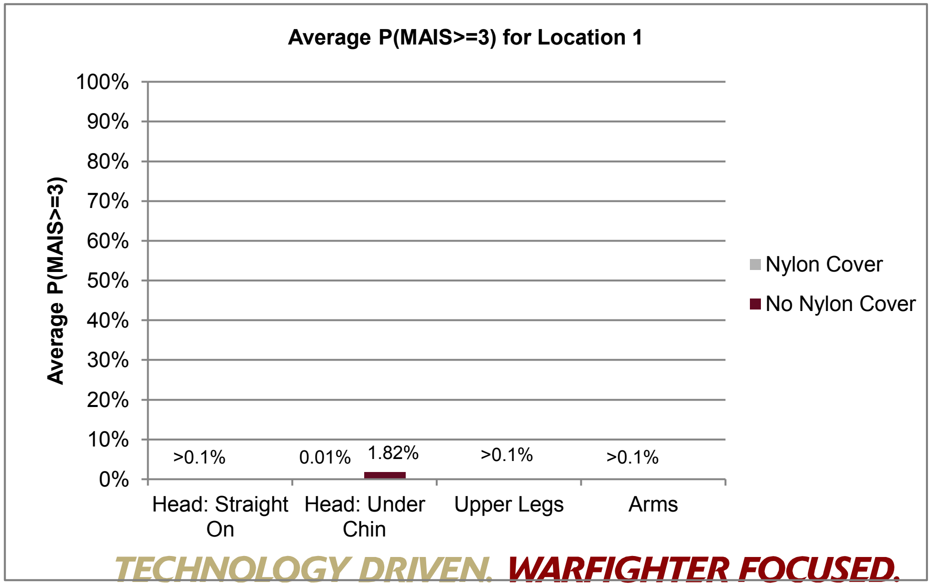
Probability of Injury for Shot Location One







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Probability of Injury for Shot Location Two

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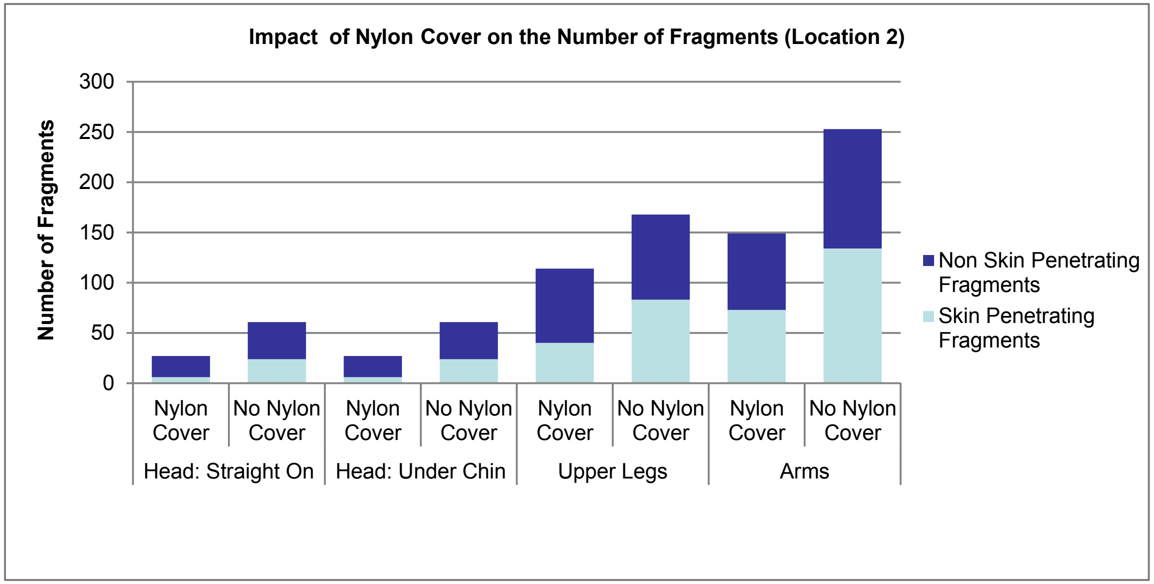

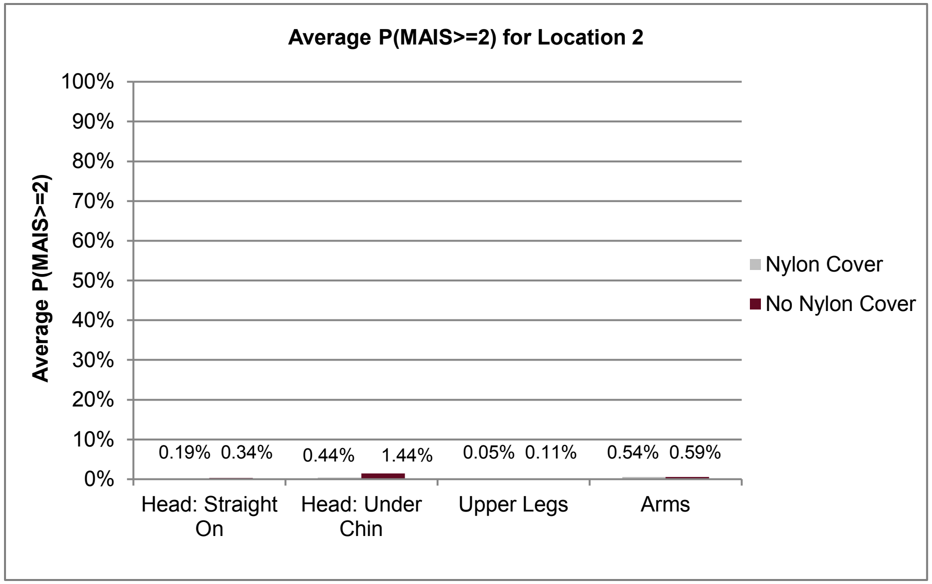

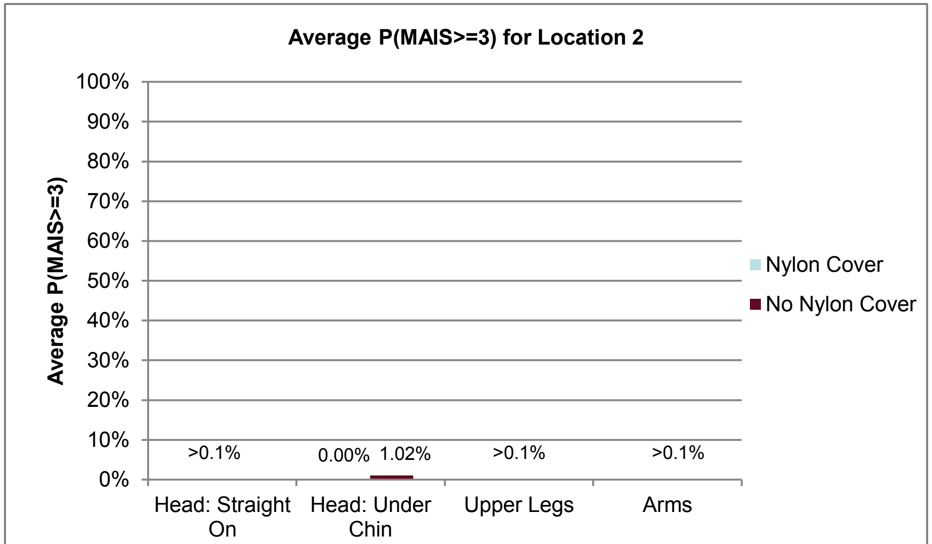

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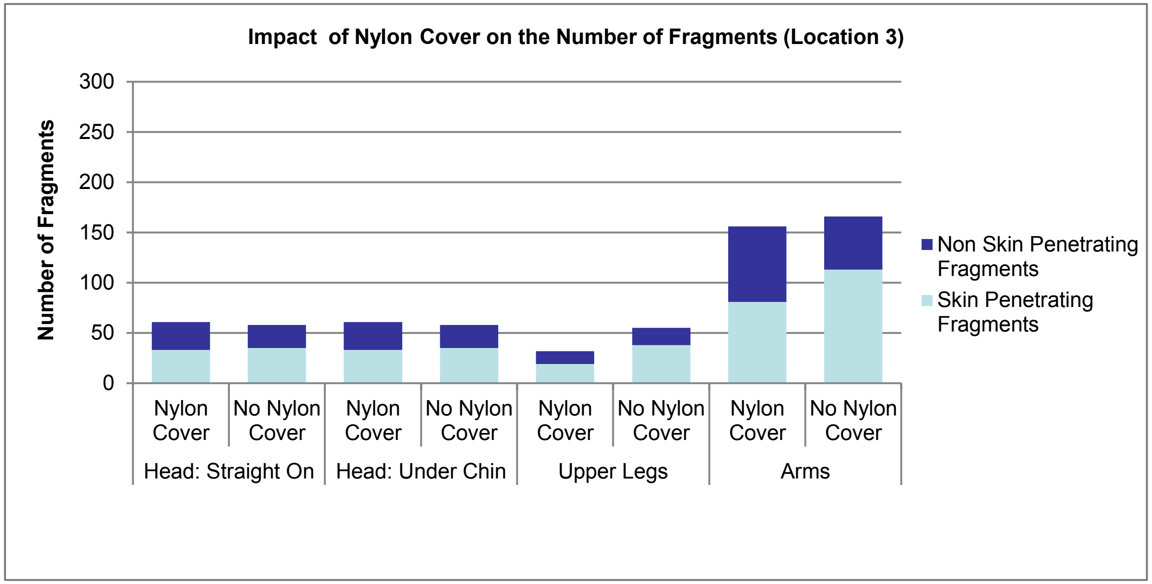
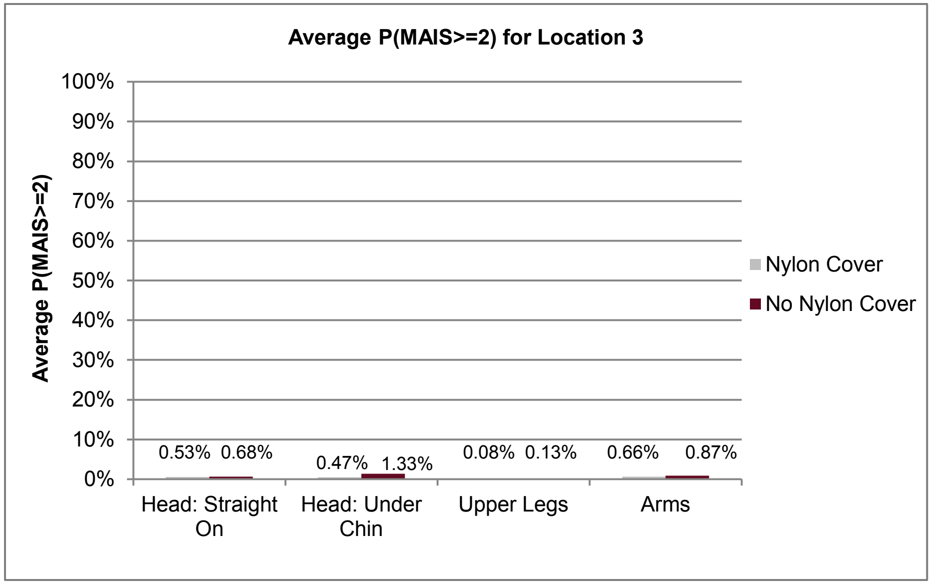
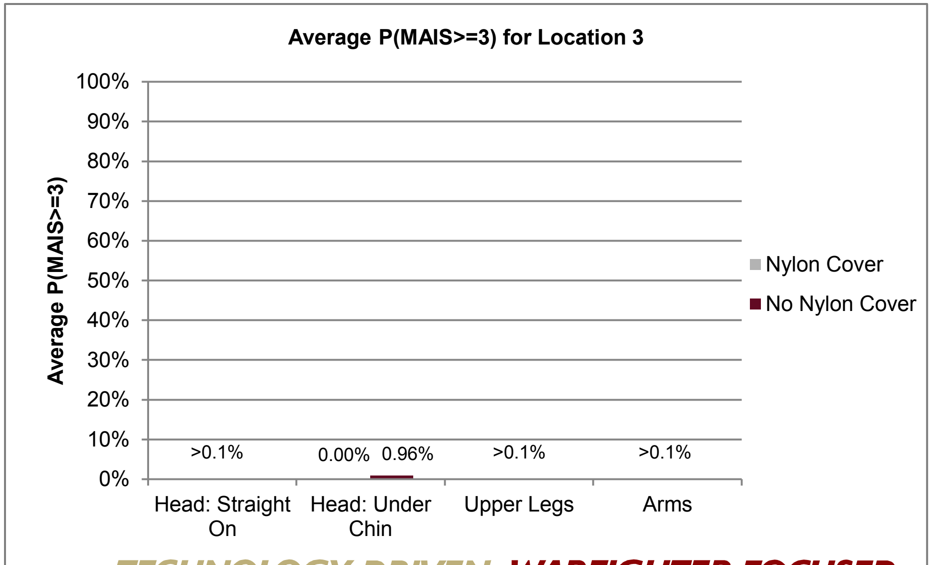
Probability of Injury for Shot Location Three







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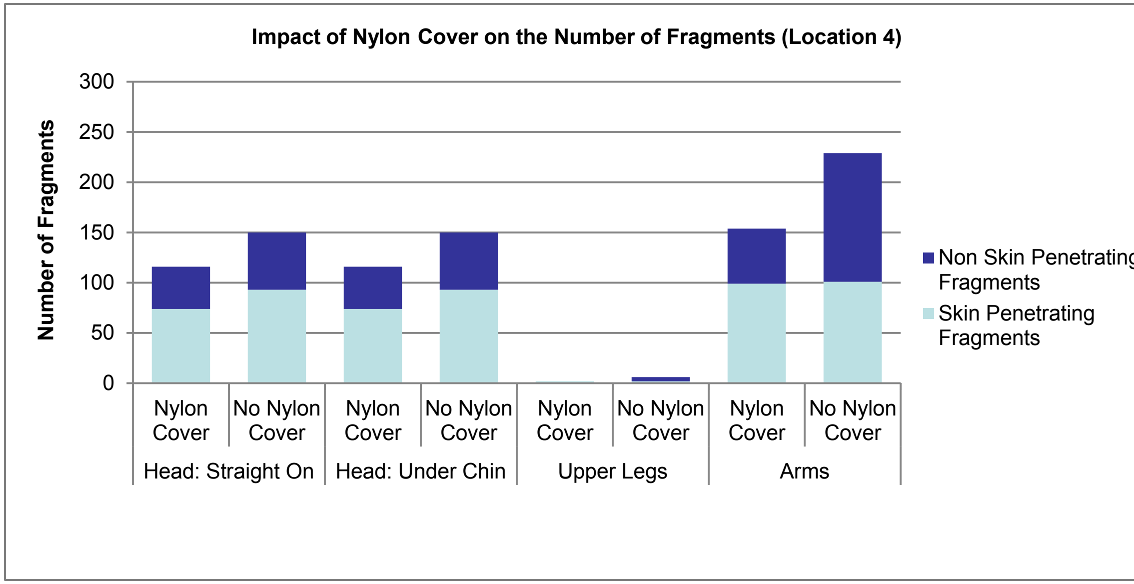
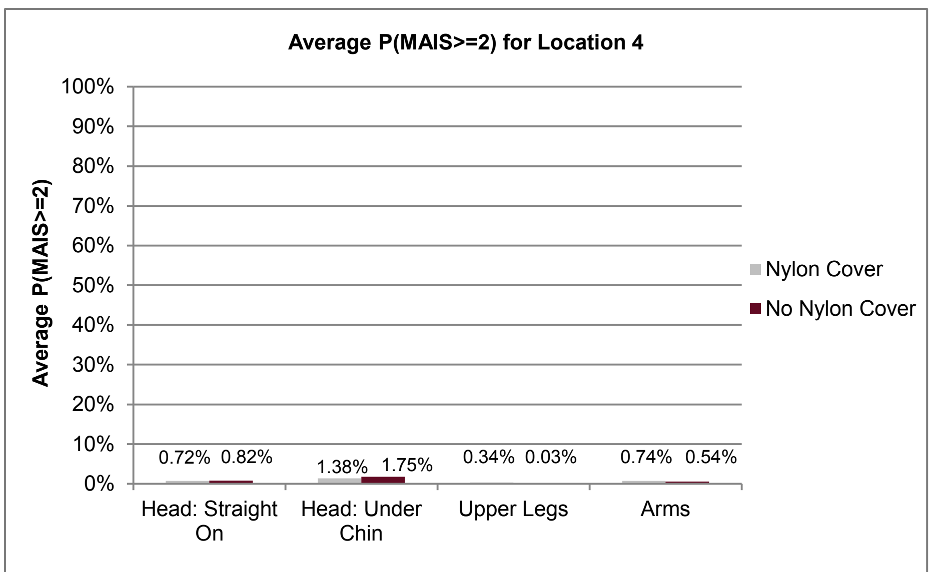
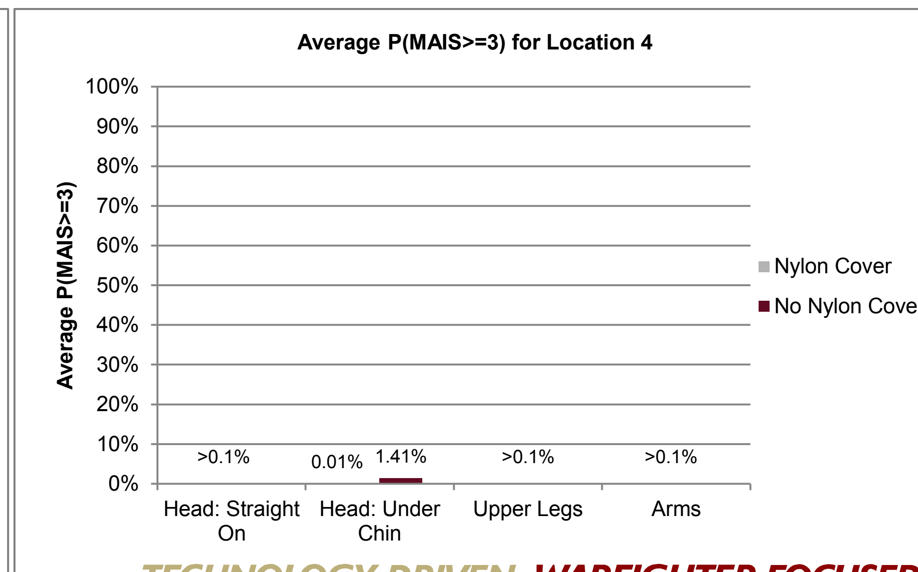
Probability of Injury for Shot Location Four







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Conclusions

Is there a risk of injury to the Soldier from reflective spall?

- 42% of all recovered fragments had a probability of skin penetration less than 50%.
- Of skin penetrating fragments
  - 77% have masses between 0.15 grains and 0.31 grains
  - 95% have a striking velocity less than 400 m/s
- Fragments impacting under the chin had the highest probability of MAIS 3 or greater and that probability was < 2% from all shot locations.
- Protective plate reflective spall is highly unlikely to cause a serious or greater injury to the Soldier.

Is the risk of injury higher when the ceramic tile is exposed?

- Of skin penetrating fragments < 1% from the plate material (99.2% from the threat)
- Typically a larger number of fragments, and skin penetrating fragments, are produced from the plates without nylon covers than the plates with nylon covers.
- No considerable difference in probability of serious or greater injury with or without the nylon cover.

Conclusions:

1. Soldiers are not at risk from reflective spall fragments.
2. Exposing the ceramic tile does not increase the risk of injury from reflective spall fragments.

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ARL

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U.S. Army Research, Development and Engineering Command

Analytical Approach using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA)

National Test and Evaluation Conference

16 March 2011

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Richard Moyers and Penny Willard

U.S. Army Research Laboratory
Survivability/Lethality Analysis Directorate

Outline

- Background
- ComputerMan/Pilot Survey (CMPS) Methodology
- Operational Requirement-based Casualty Assessment (ORCA) Methodology
- Job Description Development
- Joint Cargo Aircraft (JCA) Jobs
- Mission Scenarios
- ORCA Personnel Inputs
- JCA Vulnerability Analysis
- Conclusion

Background

- Ballistic vulnerability analysis was a joint effort between the U.S Army Research Laboratory, Survivability/Lethality Analysis Directorate (ARL/SLAD) and the U.S. Air Force Aeronautical Systems Center Engineering Directorate (ASC/ENDA)

- Two analyses were conducted:
  - Crew vulnerability analysis
  - System-level vulnerability analysis

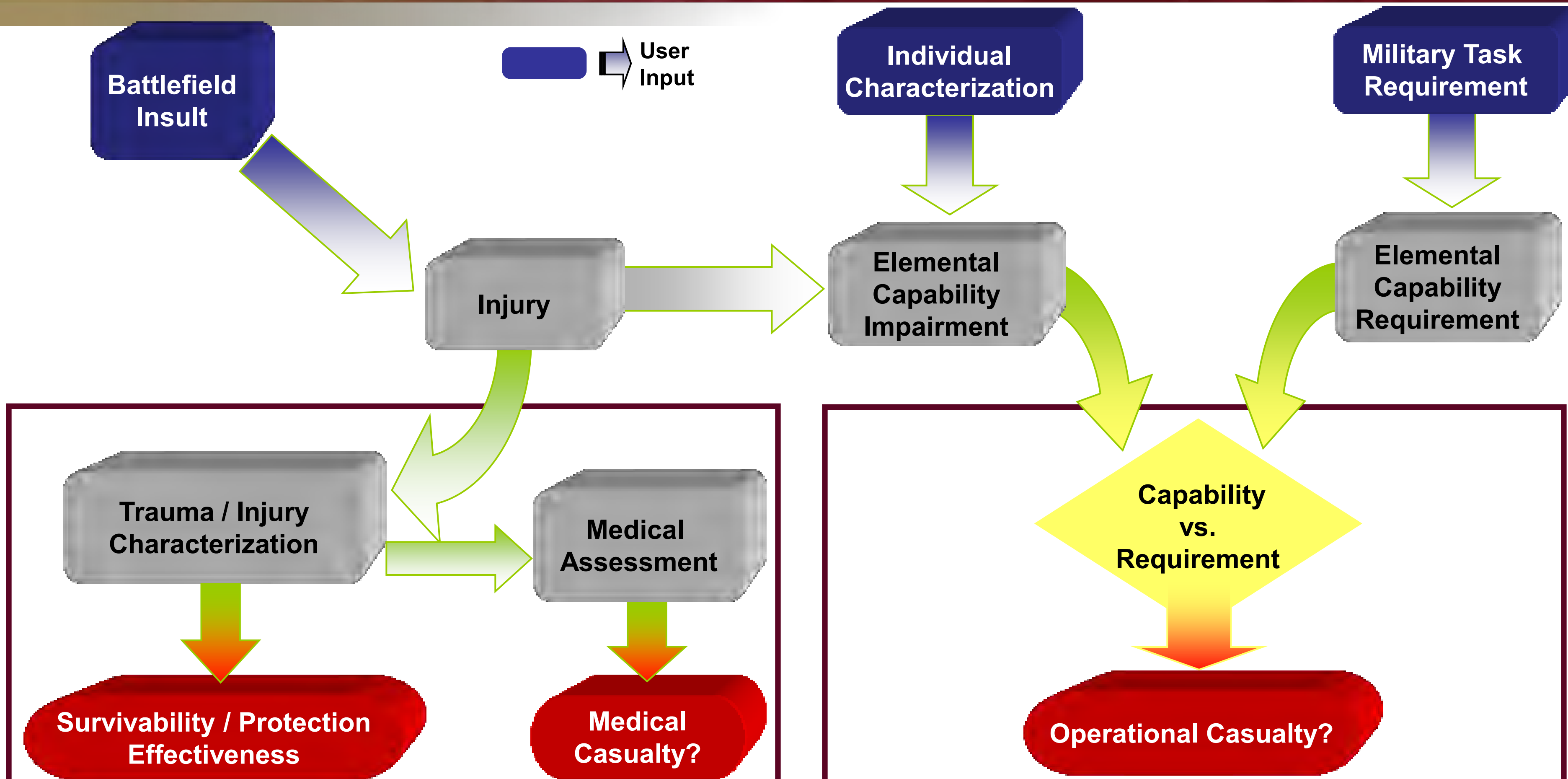
- Personnel configurations:
  - 4 Crew Members: pilot, copilot, two loadmasters
  - 44 Crew Members: pilot, copilot, two loadmasters, 40 troops in cargo area

CMPS Methodology

- ComputerMan/Pilot Survey (CMPS)
  - Evaluation methodology combined Computer Man‟s limb state performance with Pilot Survey results to predict residual functionality for an injured crew member
    - ➢ ComputerMan
      - Based on limb dysfunction
      - Assessed wound tract size and tissue retardation
      - Evaluated for 4 representative combinations: Defense - 30 seconds, Assault - 30 seconds, Assault - 5 minutes, and Supply -12 hours
      - Divided model into 81 Functional Groups (FGs)
      - Assessed against 3 levels of dysfunction: none, partial and total
    - ➢ Pilot Survey
      - Used to predict the crew‟s ability to continue to operate the aircraft after sustaining various levels of ballistic injury.

  - For aviation analyses, "Assault - 30 seconds" data was used to assess pilot and co-pilot residual functionality

ORCA Methodology



Survivability Metric (Injury)

- Typically Red on Blue analyses
- Focus is the survivability of Blue forces
- ORCA output metric: MAIS
- Example analysis: Vehicle up-armor programs

Lethality Metric (Incapacitation)

- Typically Blue on Red analyses
- Focus is the lethality of a Blue system
- ORCA output metric: Operational Casualty
- Example analysis: Munition lethality evaluation

Job Description Development

Job Description Process

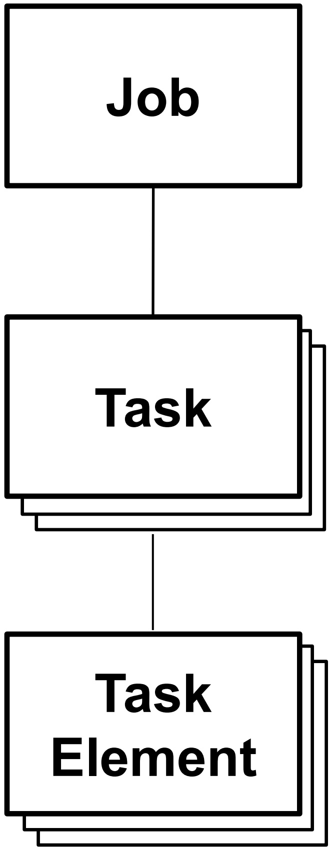
1. Identify the functional tasks that are likely to be called upon during the *context-sensitive* scenario.
    1. Define the scenario
    2. Confine the task list to the scenario!
2. Cull doctrinal / training manuals to decompose the tasks into their unique and discrete task elements (example: to get into the car, you must first open the door, followed by turning to seated position, and then close the door).
3. Consult SMEs and practical experience to quantify each task element into minimum (threshold) and full (objective) levels of performance within the Elemental Capability Vector (ECV).
4. Pursue verification and endorsement from SMEs.

Elemental Capability Vector *

Visual Acuity & Color Discrimination	Speech Articulation
Night Vision	Vocal Power
Visual Field of View	Right Leg Strength
Visual Binocularism & Motility	Left Leg Strength
Hearing Threshold – Low Freq.	Left Arm/Hand Strength
Hearing Threshold – High Freq.	Right Arm/Hand Strength
Binauralism	Left Arm/Hand Dexterity
Endurance	Right Arm/Hand Dexterity
Psychomotor Mental Processing	Torso Support
Cognitive Mental Processing	Head / Neck Movement
Visual Mental Processing	Somatic Senses
Auditory Mental Processing	Balance

*not in order

Job Decomposition



A *job* is defined as a list of an individual's *tasks*.

A *task* is made of *task elements*. A job can have one or more tasks.

A *task element* is a single activity with specific parameters. An instance of a task element is defined in the terms of elemental capabilities.

Example Job
Assaulting Infantry Rifleman

Engage Targets with an M4 or M4A1 Carbine

Load an M4 or M4A1 Carbine

Mount a NVS AN/PVS-4 on a M4/M4A1 Carbine

Zero a NVS AN/PVS-4 to a M4/M4A1 Carbine

Engage Tgts w/ M4/A1 Carbine Using NVS AN/PVS-4

Mount an AN/PAS-13 TWS on M4/M4A1 Carbine

Zero an AN/PAS-13 TWS to an M4 or M4A1 Carbine

Engage Targets with an M4/M4A1 Carbine Using a TWS

Engage Targets w/ M4/M4A1 Carbine Using an AN/PAS-13

Operate a Night Vision Sight AN/PVS-8

Operate a Thermal Viewer, AN/PAS-7

Perform Safety Checks on Hand Grenades

Employ Hand Grenades

Engage an Enemy with a Bayonet

Move as a Member of a Fire Team

Engage Tgts w/ M4/A1/Carbine Using NVS AN/PVS-4

- With sight in operation assume appropriate firing position based on situation
- Identify targets in designated sector of fire
- Determine range to targets using the AN/PVS-4 reticule
- Fire on target until destroyed or told to cease fire

Employ Hand Grenades

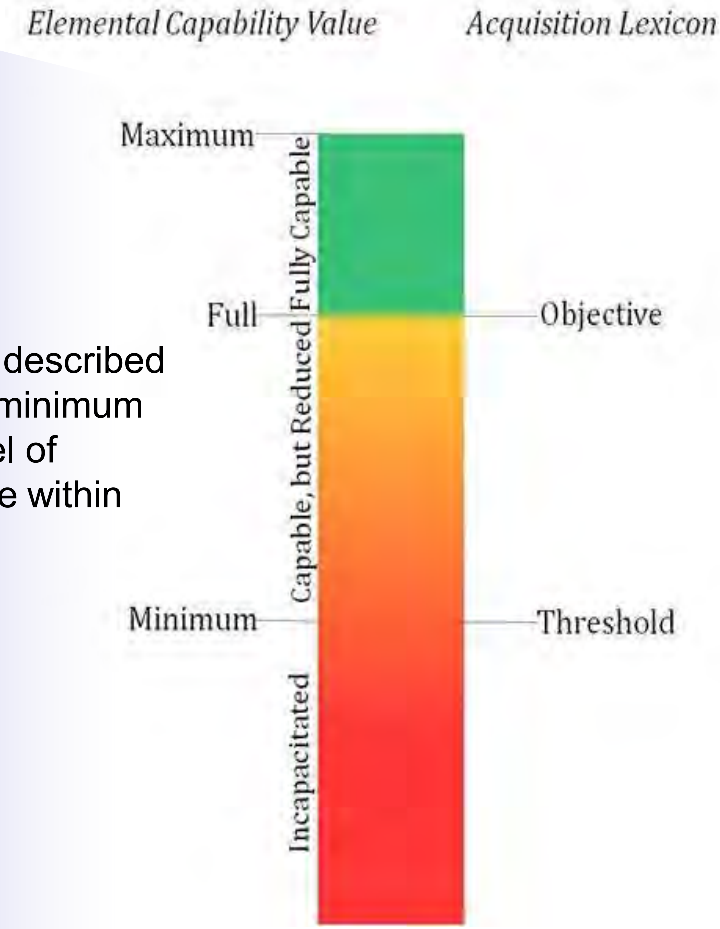
- Position body remaining covered
- Grip grenade with lever down and pull ring free
- Arm grenade by removing safety clip and ring
- Confirm body alignment and keep eyes on tgt
- Throw grenade overhand with eyes on target
- Return to cover and concealment

Elemental Capability Vector

Elemental Capability Vector *	
Visual Acuity & Color Discrimination	Speech Articulation
Night Vision	Vocal Power
Visual Field of View	Right Leg Strength
Visual Binocularism & Motility	Left Leg Strength
Hearing Threshold – Low Freq.	Left Arm/Hand Strength
Hearing Threshold – High Freq.	Right Arm/Hand Strength
Binauralism	Left Arm/Hand Dexterity
Endurance	Right Arm/Hand Dexterity
Psychomotor Mental Processing	Torso Support
Cognitive Mental Processing	Head / Neck Movement
Visual Mental Processing	Somatic Senses
Auditory Mental Processing	Balance

*not in order

Each EC is described in both the minimum and full level of performance within the ECV.



What Jobs are Required for JCA ?

Pilot / Co-Pilot: The two people charged to jointly fly the aircraft.
*** Assume *redundancy* of functions.**

- **Airborne through Landing**
- **Descent through Landing**

GIBs: Personnel in the aircraft cabin: loadmasters and troops
(aka “Guys in Back”)

- **GIB Egress**

What Assumptions Did We Make About the JCA Jobs?

Due to the assumption of redundancy, these jobs were built by reversing the direction of the traditional ORCA job architecture.

Traditionally, a *Job* is mapped to a person.

Vehicle Driver **= Crewman #1**

In the JCA, because the pilot and co-pilot have redundant capabilities dedicated to the singular purpose of flying the aircraft, the person was mapped to the *Job* functionally.

Crewmen #1 and #2 =
Pilot/Co-Pilot Airborne through Landing

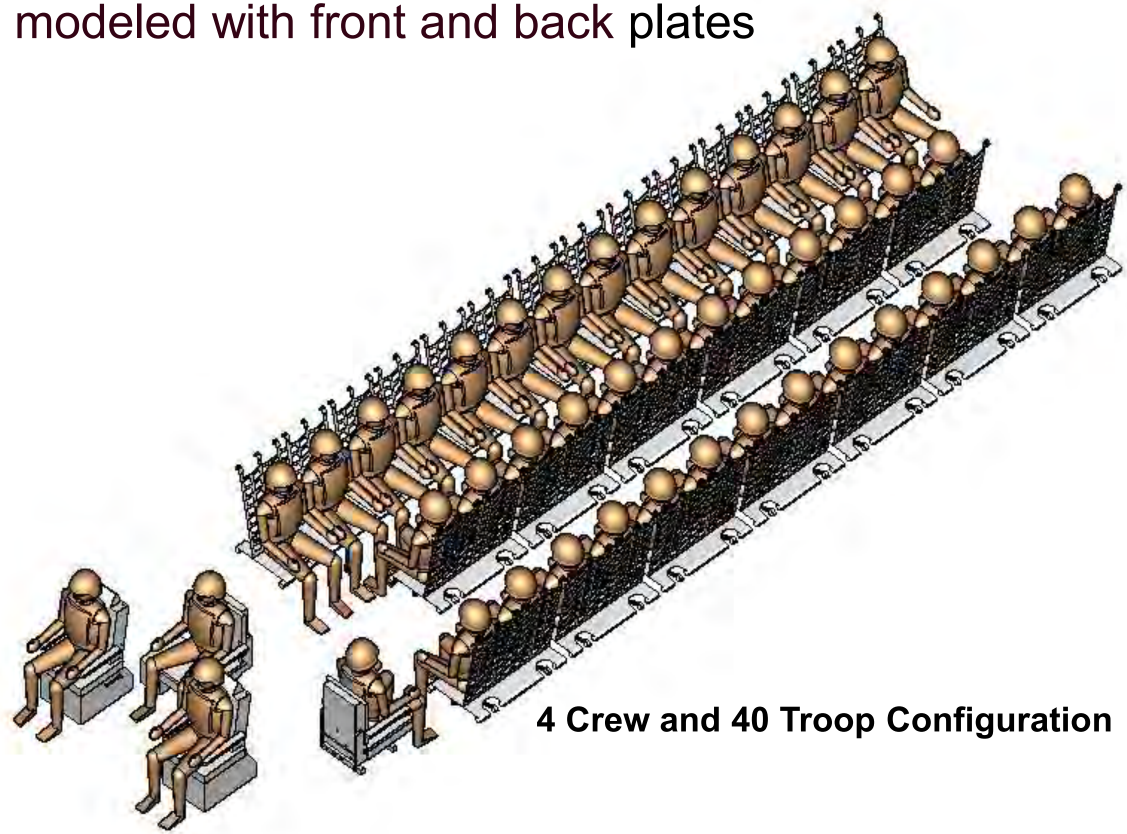
Mission Scenarios

		Mission Profiles		
		Long range cargo	Short range troop	Low altitude air drop
Vignettes	Takeoff	Threats: Armor-Piercing Incendiary (API) and Man-Portable Air Defense Systems (MANPAD) ORCA Job: Airborne → Landing	Threats: API‟s and MANPAD‟s ORCA Job: Airborne → Landing	N/A
	Cruise	Threats: High-Explosive Incendiary (HEI) ORCA Job: Airborne →Landing	Threats: HEI‟s ORCA Job: Airborne →Landing	Threats: API‟s and MANPAD‟s ORCA Job: Airborne →Landing
	Landing	Threats: API‟s and MANPAD‟s ORCA Job: Descent →Landing	Threats: API‟s and MANPADs ORCA Job: Egress & Descent →Landing	N/A

Personnel Inputs - Target Description

- The ORCA personnel geometry is inserted into the component-level target geometry and the ORCA man is articulated into the proper crew configuration.
- Body armor is modeled in the target geometry.
  - Pilot and Copilot modeled with front plates only and Air Warrior helmets
  - Loadmasters and troops modeled with front and back plates

ORCA man with front plate and helmet



4 Crew and 40 Troop Configuration

Personnel Inputs – Injury AIS/MAIS

- ORCA utilizes the Abbreviated Injury Scale© (AAAM, Version 2005 Update 2008)(AIS). AIS is an anatomically-based, consensus-derived, international severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale. AIS values provide information on the type, location, and severity of anatomical injuries. AIS scores each single injury.
- MAIS – Maximum Abbreviated Injury Score (MAIS) is an anatomical measure of injury severity. This score classifies injury severity on the basis of the single injury having the greatest AIS severity value. The MAIS is between 0 and 6.
- For the JCA analysis, if any crew member or troop received a serious or greater injury (MAIS ≥ 3) then the result is a mission abort.
- A serious Injury – An injury that requires immediate medical attention. Serious injuries present a serious threat to life.

MAIS	Injury Level	Type of Injury
1	Minor	Superficial
2	Moderate	Reversible injuries; medical attention required
3	Serious	Reversible injuries; hospitalization required
4	Severe	Life threatening; not fully recoverable without care
5	Critical	Non-reversible injuries; not fully recoverable even with care
6	Maximal	Nearly Unsurvivable

Personnel Inputs – Incapacitation Operational Casualty

ORCA provides operational metrics to determine if personnel have the capability to meet the requirements of the job under evaluation. There are six post-wounding times: immediate, 30 seconds, 5 minutes, 1 hour, 24 hours, and 72 hours.

- Operational „Casualty‟
  - Applied to each crew member for specific discrete times
  - If the task elements of all the tasks are greater than the minimum required performance level, then casualty equals 0 (able to perform job).
  - If one of the task elements is less than the minimum performance requirement, then casualty equals 1 (unable to perform job).

- For the JCA analysis, 3 failure modes were evaluated:
  - Loss of Pilot
  - Loss of Co-pilot
  - Loss of Pilot and Co-pilot

JCA Vulnerability Analysis

- System-Level Vulnerability Analysis:
  - Pilot and Copilot are assessed as any other flight critical subsystem
  - Pilot and Copilot are modeled as being multiply vulnerable; either crew member can fly and land aircraft

- Three System Kill Levels:
  - Attrition: Incapacitation of both Pilot and Copilot in less than 30 seconds
    - ➢ Assess the probability of pilot and copilot being capable of performing job
    - ➢ Use ORCA Operational Casualty metric
    - ➢ Determine if pilot and copilot fall below the minimum performance level
    - ➢ Assign crew member a 1 (can perform job) or a 0 (can not perform job)
  - Fly and Land: Inability to fly and land
    - ➢ Flying time is vignette specific with time periods of 5, 15 or 30 minutes
    - ➢ Use ORCA Operational Casualty metric
  - Mission Abort: Any crew or troop member receives a MAIS ≥ 3
    - ➢ A MAIS ≥ 3 is a serious injury that requires immediate medical attention
    - ➢ Attrition supersedes mission abort if both Pilot and Copilot are incapacitated

Conclusion

- Analysis data was used to support the JCA‟s Full Rate Production Milestone Decision.

- Higher-resolution survivability assessments are available for measuring the value of improved air systems.

- ORCA is an invaluable toolset in answering the questions of how the individual person is directly tied into the overall air system.

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RDECOM

Fragment Analysis for the JTAPIC Program

National Test and Evaluation Conference March 2011

Warfighter Survivability Branch

Karen Pizzolato

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Survivability/Lethality Analysis Directorate
Army Research Laboratory

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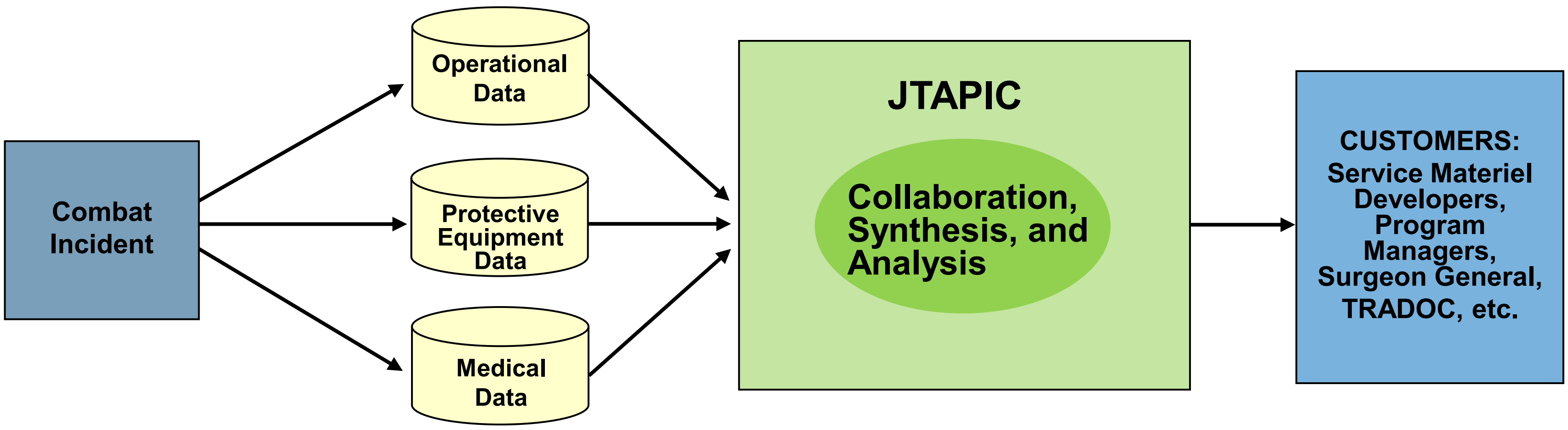
What is JTAPIC?



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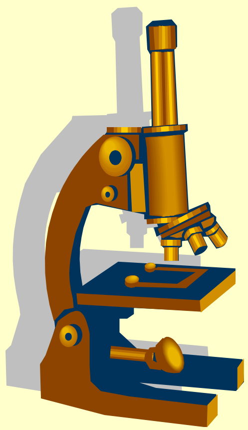
Fragment Processing

OAFME Delivery of Fragments

Physical Analysis



Radiation Scan

Evidence logged and tracked

Sterilization

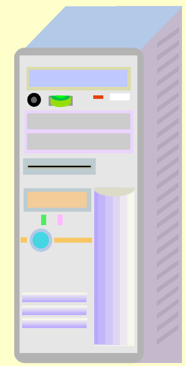
Scanned, weighed and photographed

Qualitative Analysis

Select Fragments

Quantitative Analysis

Storage



APG Fragment Storage

Fragment and Analysis Database

JTAPIC Portal

JTAPIC AKO-S Site

US ARMY RDECOM

Recorded Fragment Information

ARL

Mass: 2.25 g

Dimension: 12.7 × 10.3 × 3.2 mm

Density: 7.11 g/mL

Shape: Irregular

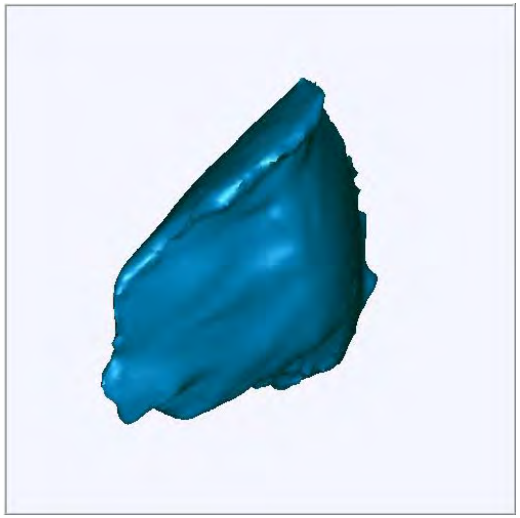
Recovery Location: Neck (pharynx)

Description: Smooth copper color. Top concave side has cut marks. Appears to be a fiber-like material attached to fragment. Specimen cut for analysis.

Predominant Materials: Copper and Iron

Photo

3-D Scan



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

SEM-EDS Fragment Characterization

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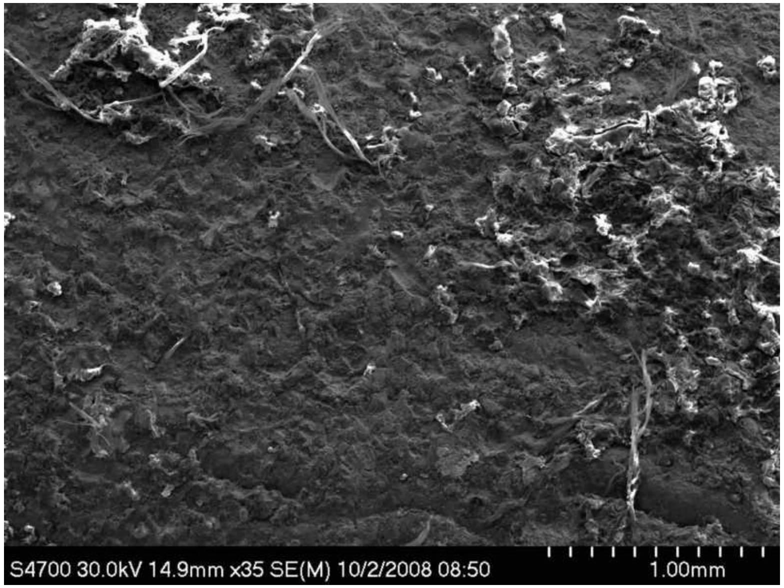
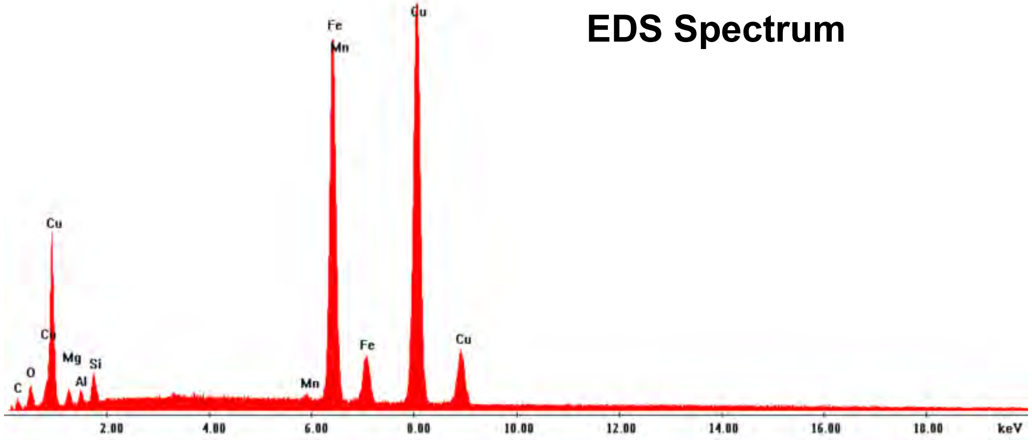
- Elemental results are specific to the nature of the sample and the surface area scanned.
- EDS provides a first approach, qualitative assessment of fragment material.

SEM Image



EDS Spectrum



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- Metals in trace amounts can be detected.
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Photograph Courtesy of Image from Lehigh Testing Laboratories, Inc. (www.lehightesting.com), used without permission

ICP-AES Sample Results

Case ID #	
Chemical Element	**Percent of Total (%)**
Carbon	0.46
Sulfur	0.024
Manganese	0.54
Silicon	.025
Chromium	0.39
Nickel	0.10
Phosphorus	0.009
Copper	0.16
Molybdenum	0.01
Cobalt	0.006
Aluminum	<0.002
Lead	<0.001
Vanadium	0.002
Iron	98.049

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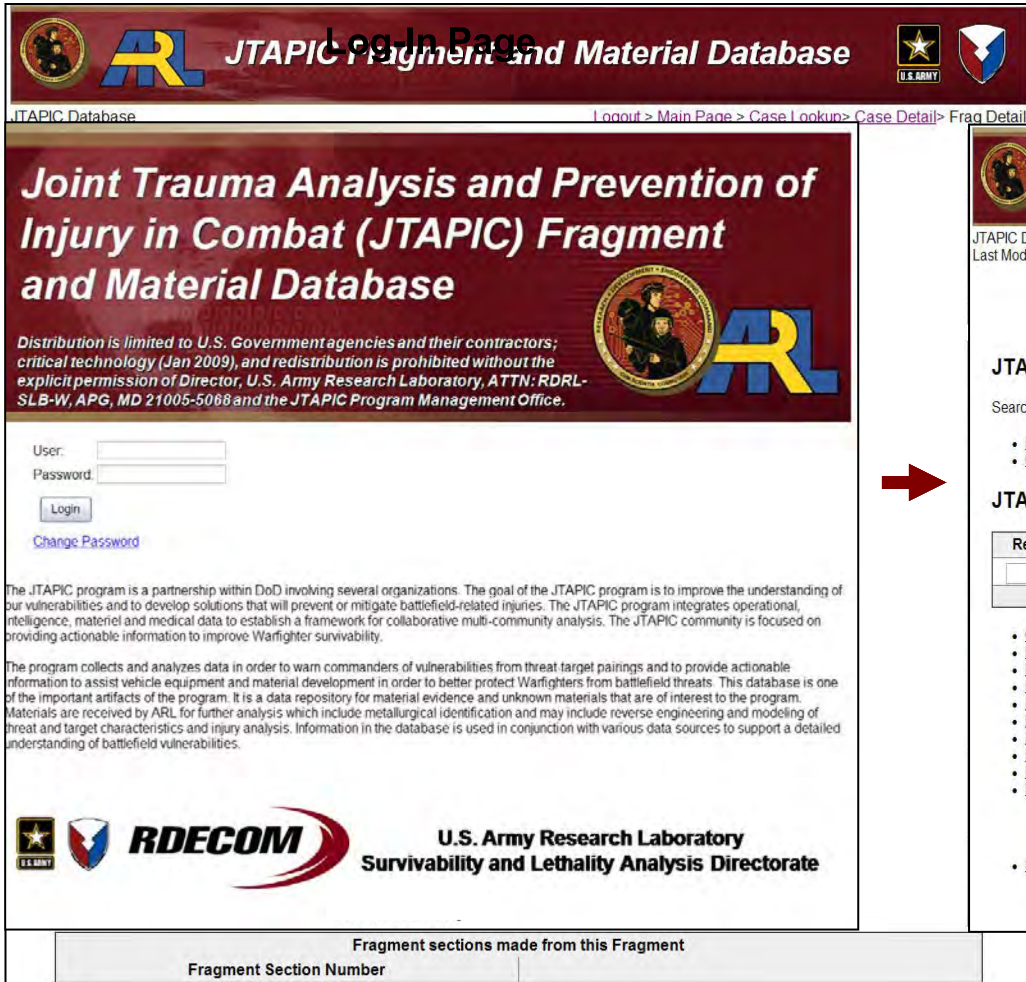
JTAPIC Fragment & Material Database

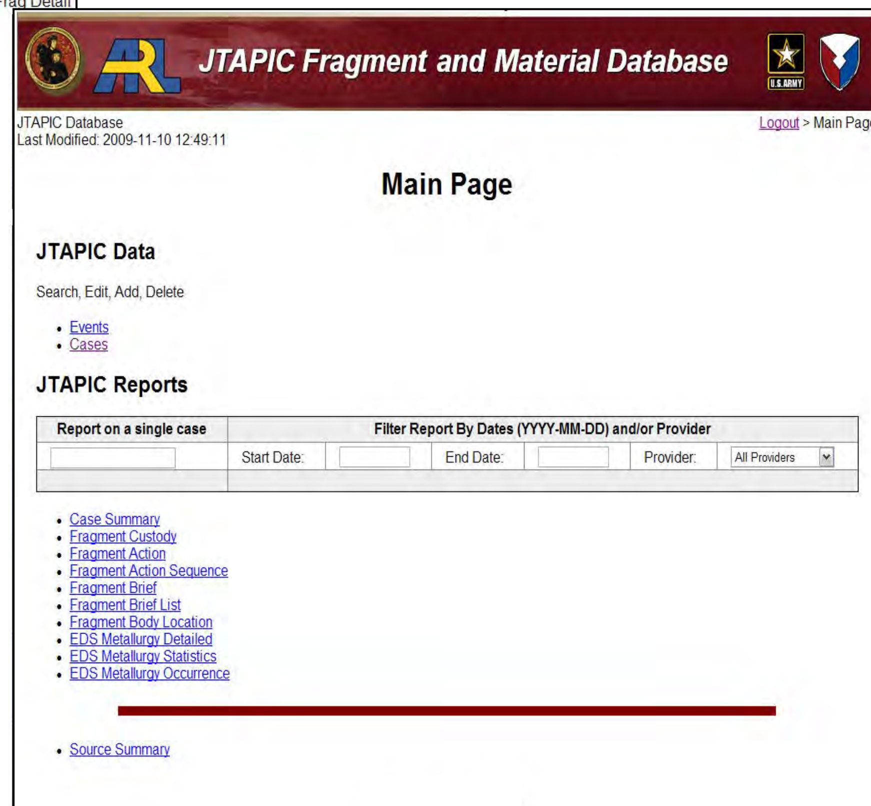
ARL

Fragment Detail Information

Log-In Page



Main Page



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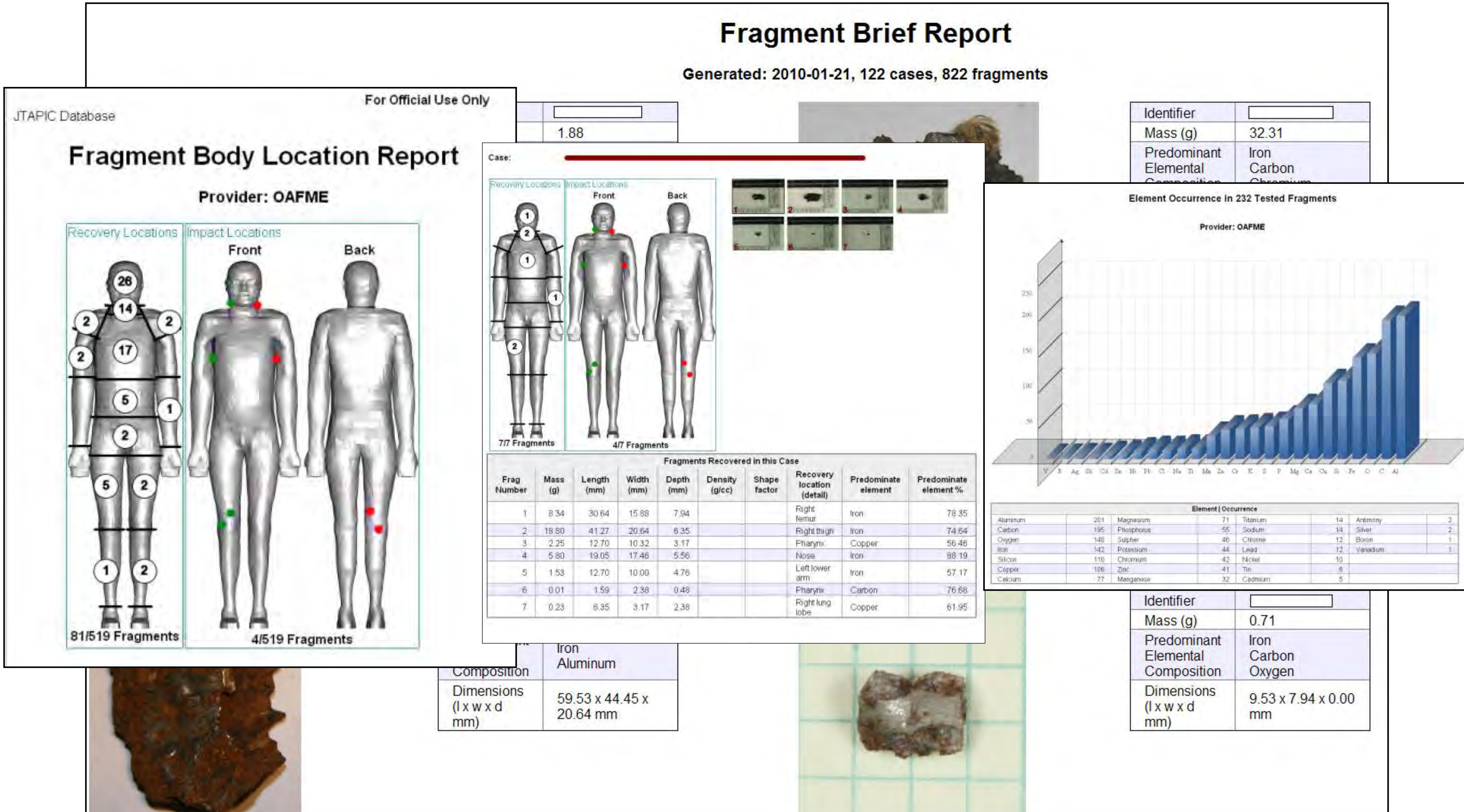
JTAPIC Database Reporting

Database Reporting



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3	2.25	12.70	10.32	3.17			Pharynx	Copper	56.46
4	5.80	19.05	17.46	5.56			Nose	Iron	88.19
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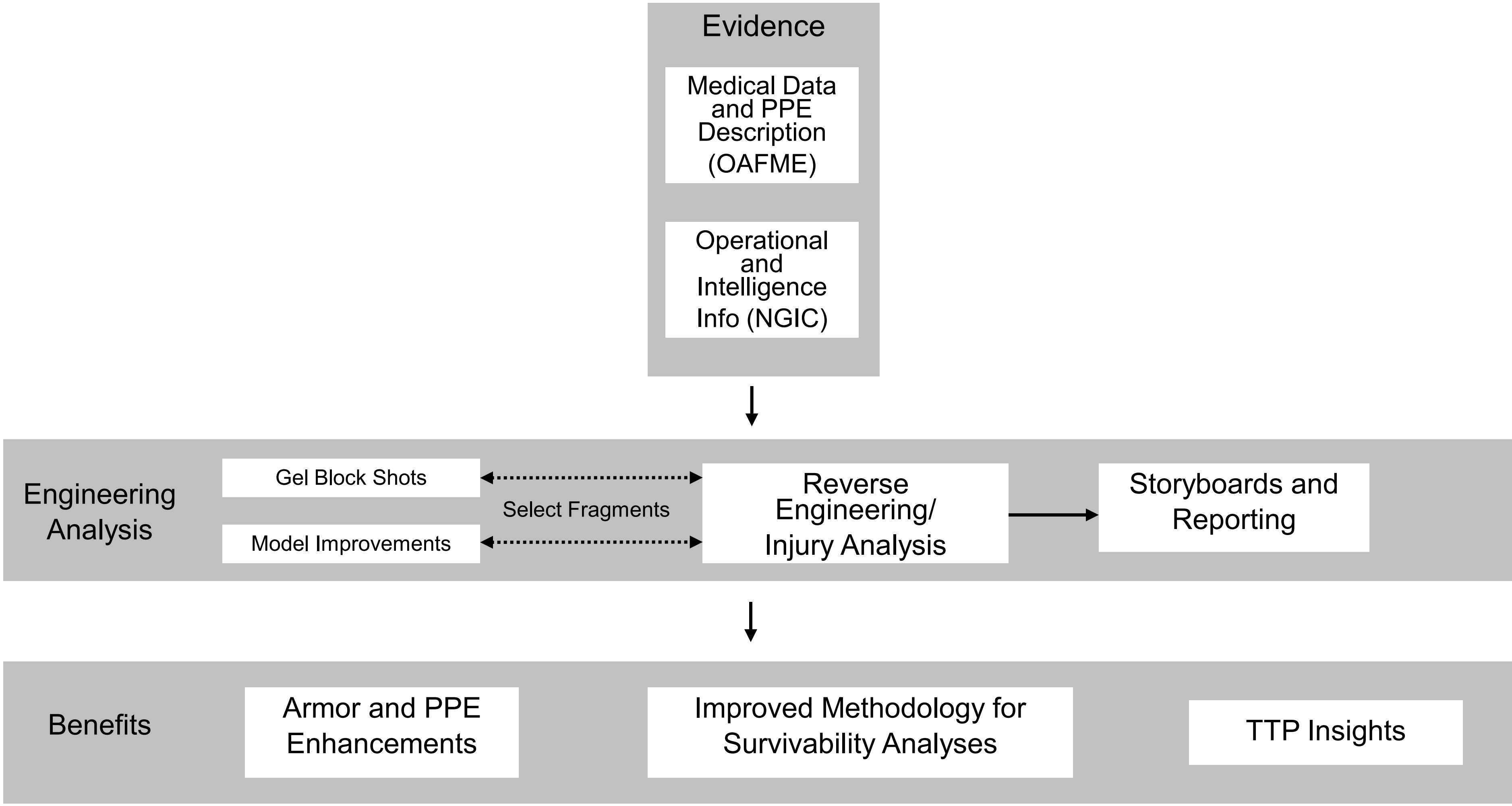
Incorporation of Fragment Analyses



Example of Event Recreation Using Modeling and Simulation

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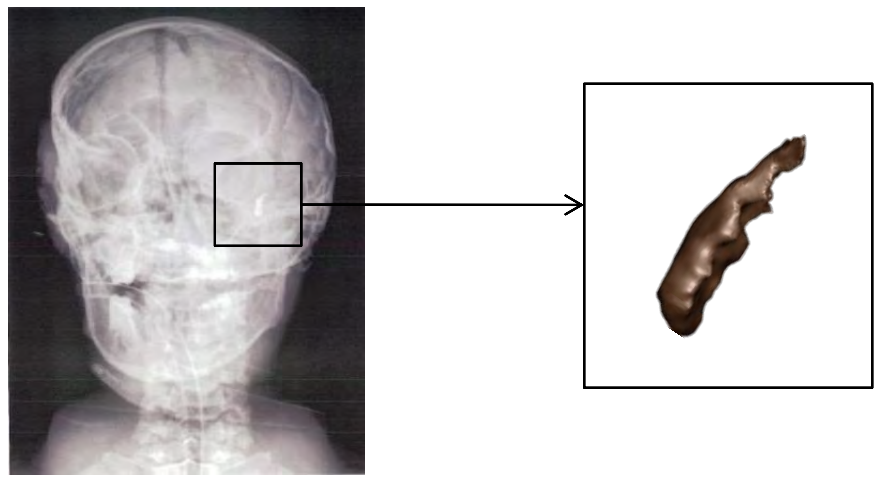

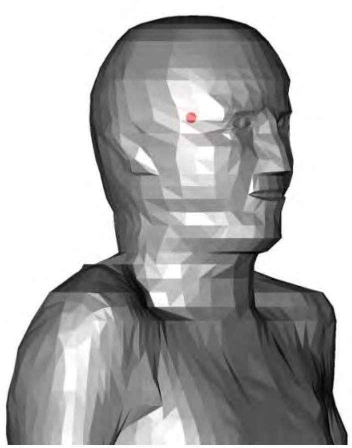

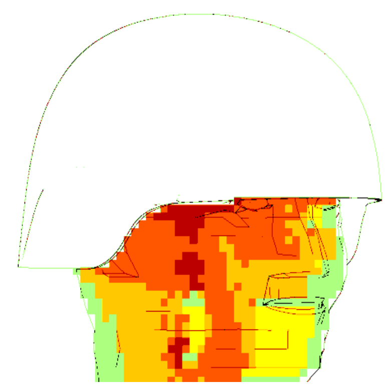

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Karen Pizzolato

U.S. Army Research Laboratory
Temporary Assignment, Armed Forces Medical Examiner System
Phone: 410-278-4102
Email: karen.pizzolato@us.army.mil or karen.pizzolato@us.af.mil

RDECOM

Fragment Analysis for the JTAPIC Program

National Test and Evaluation Conference March 2011

Warfighter Survivability Branch

Karen Pizzolato

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Survivability/Lethality Analysis Directorate
Army Research Laboratory

Acknowledgements: Barbara Wolfe, Daniel Snoha, Brad Klotz, and Lars Piehler

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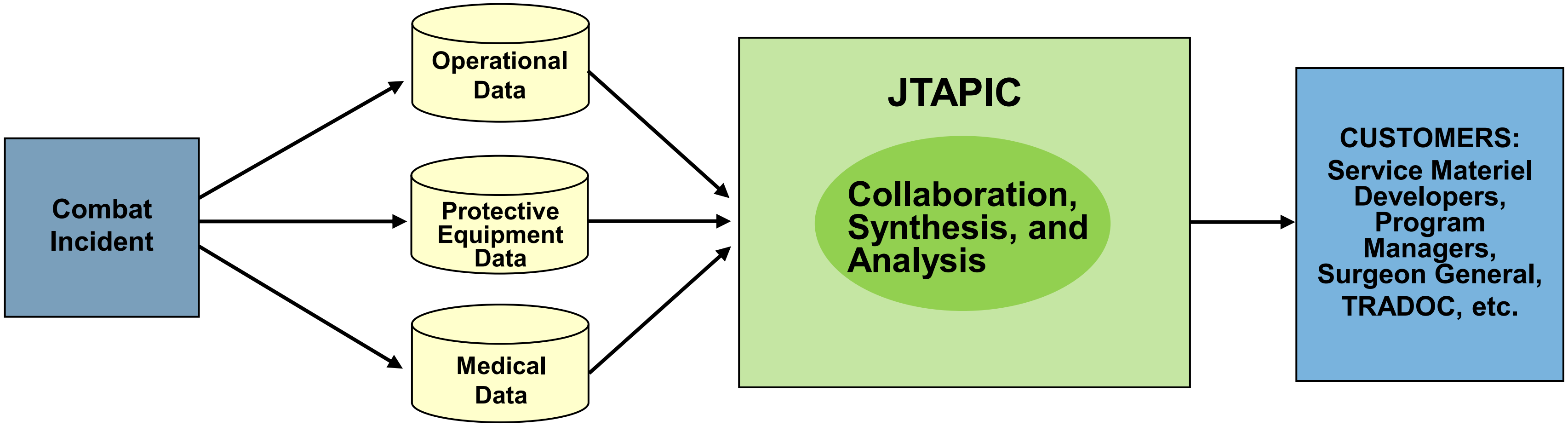

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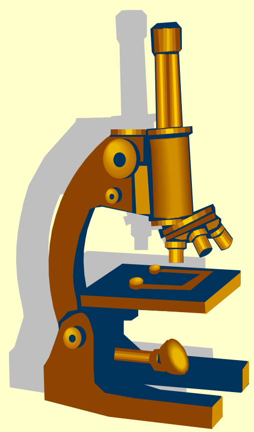

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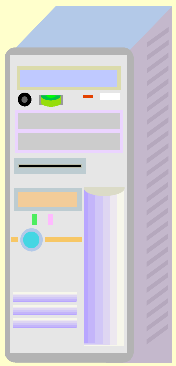

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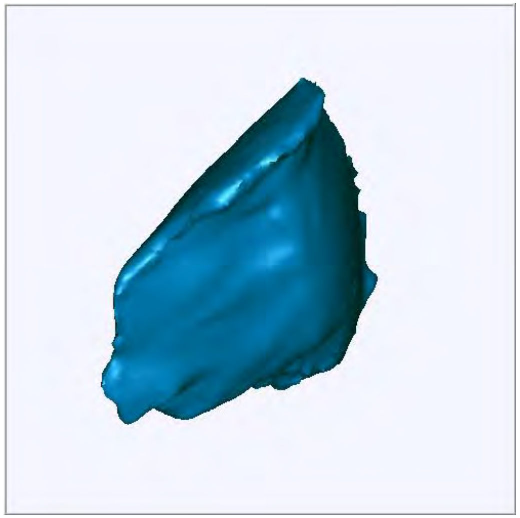

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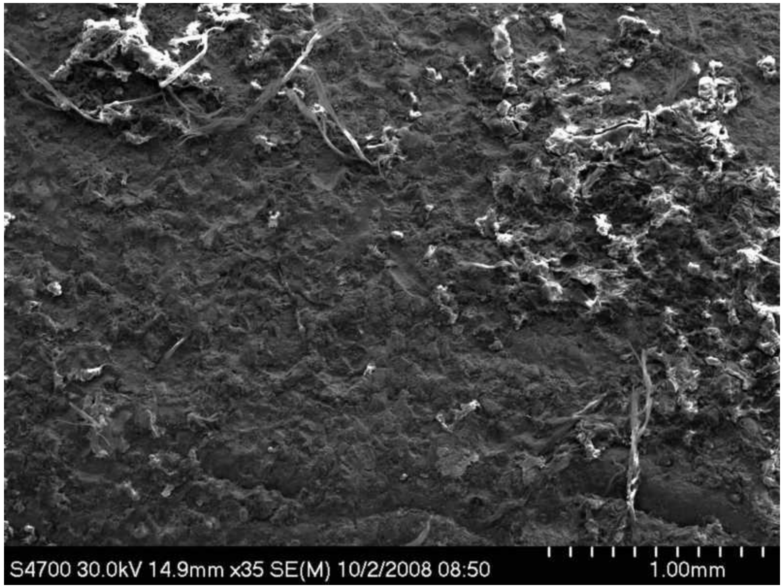

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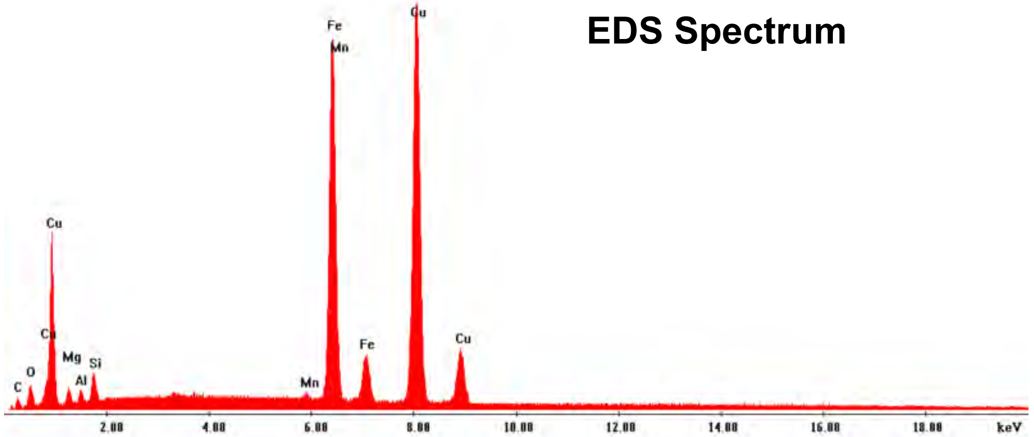

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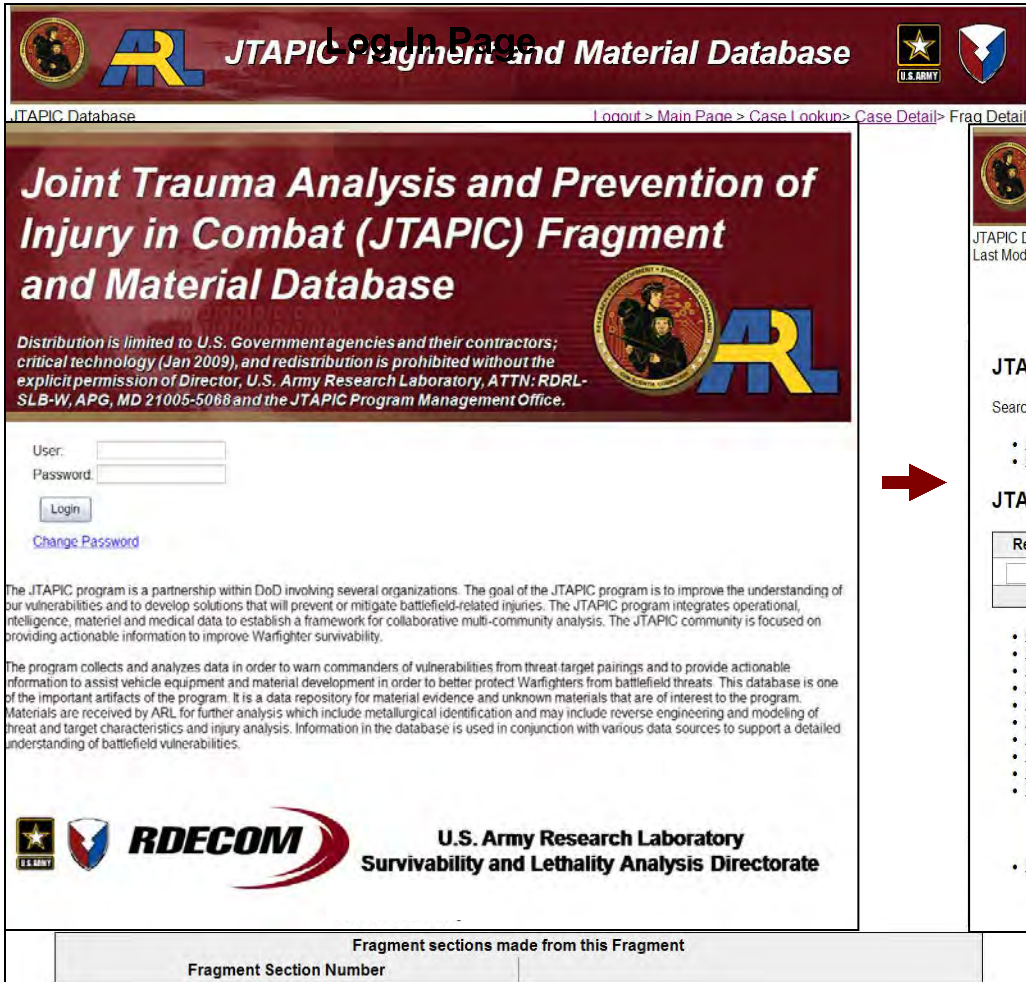

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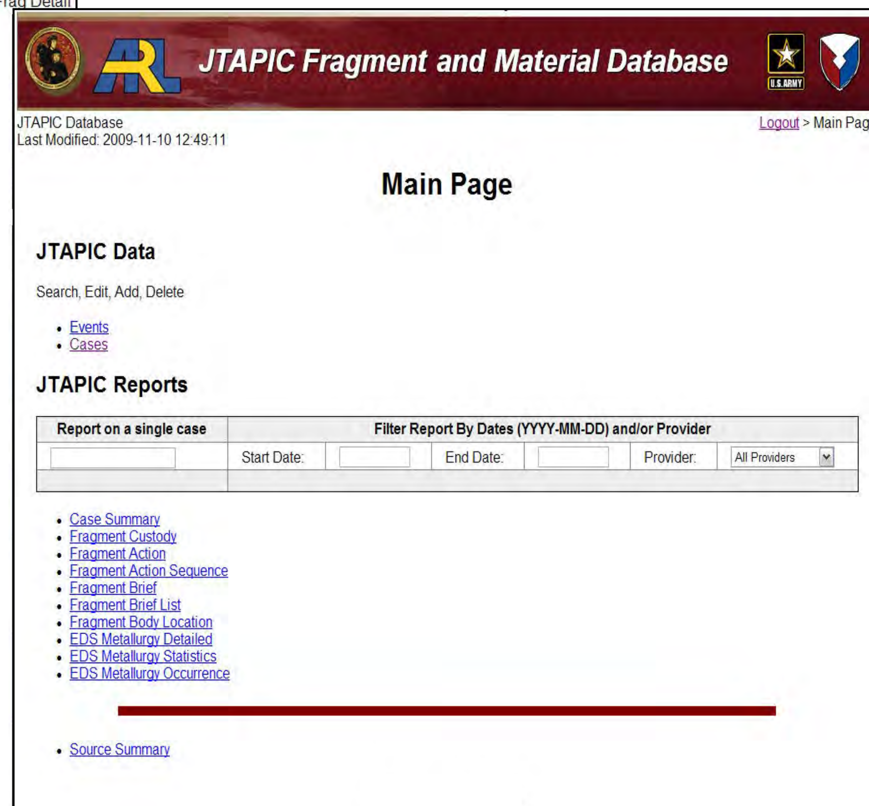

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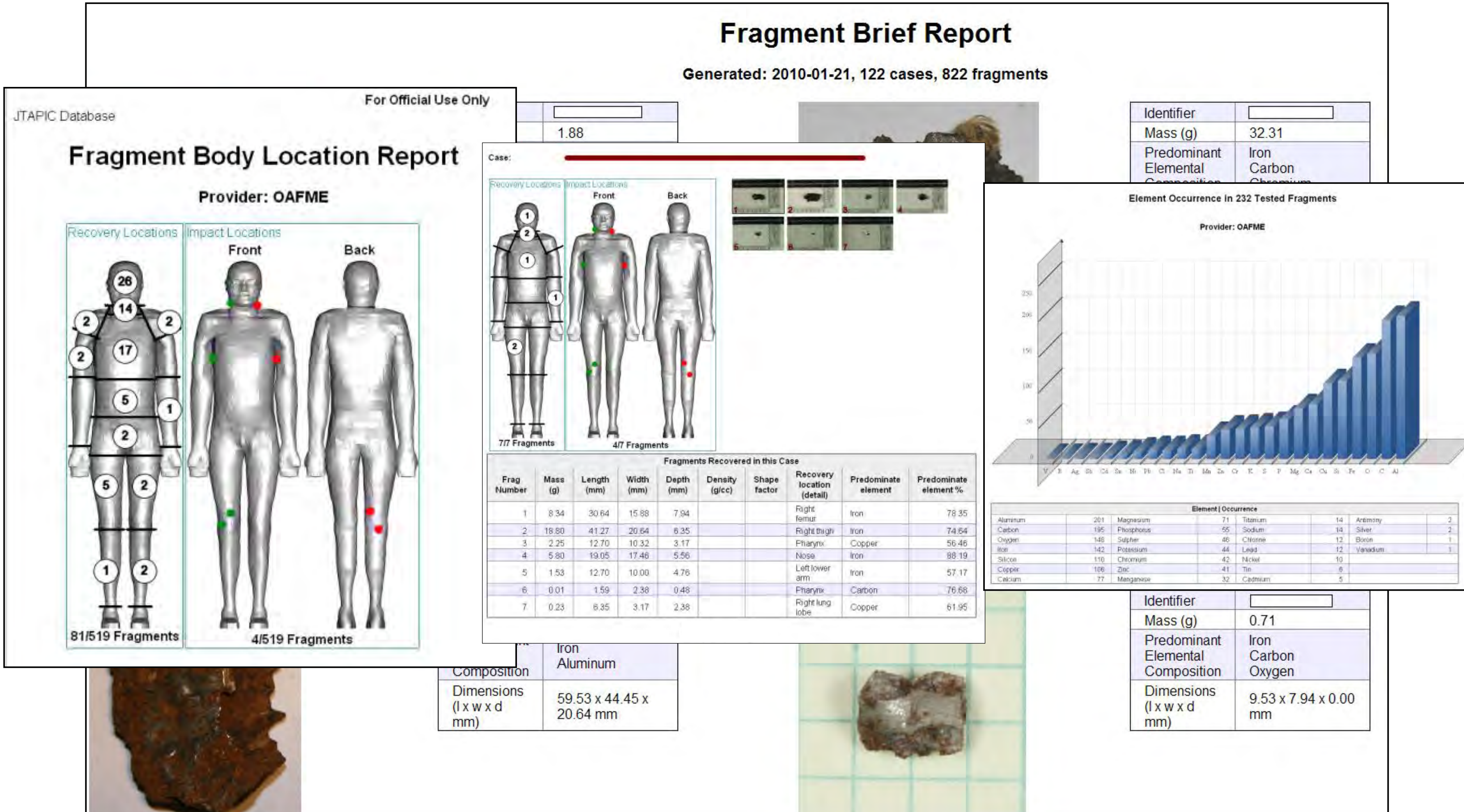

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Incorporation of Fragment Analyses

ARL

Evidence
- Medical Data and PPE Description (OAFME)
- Operational and Intelligence Info (NGIC)

Engineering Analysis
- Gel Block Shots
- Model Improvements
- Select Fragments
- Reverse Engineering/ Injury Analysis
- Storyboards and Reporting

Benefits
- Armor and PPE Enhancements
- Improved Methodology for Survivability Analyses
- TTP Insights

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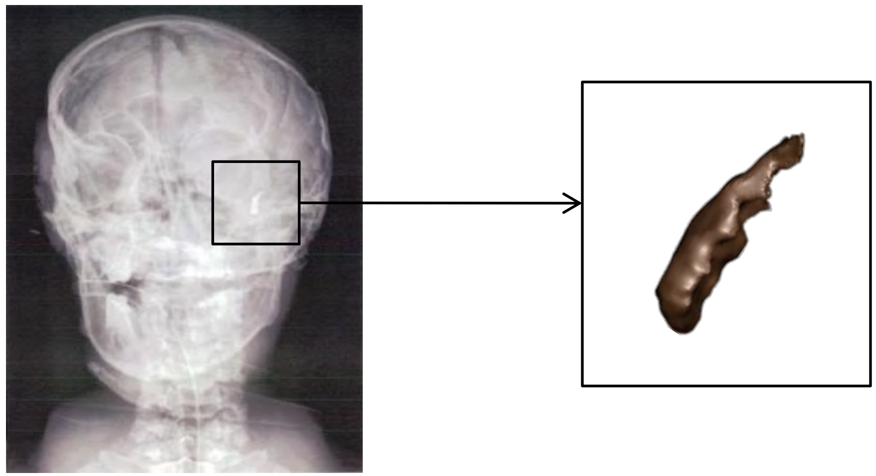

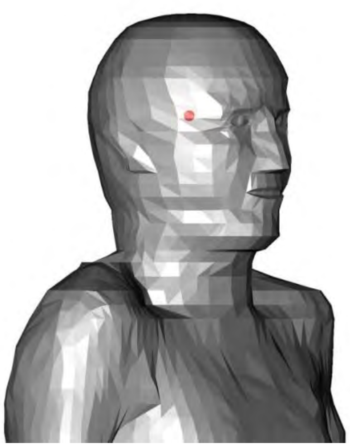

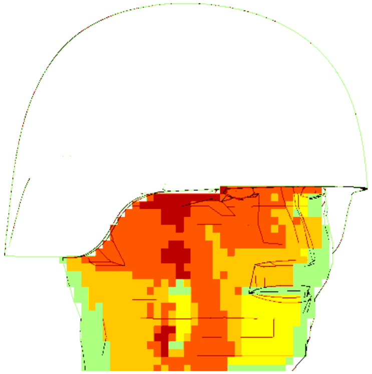

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Probability Driven Experimental Design for Autonomous Systems

Troy Jones
Autonomous Systems Capability Leader
troy@draper.com
(617) 258-2635

Team Members

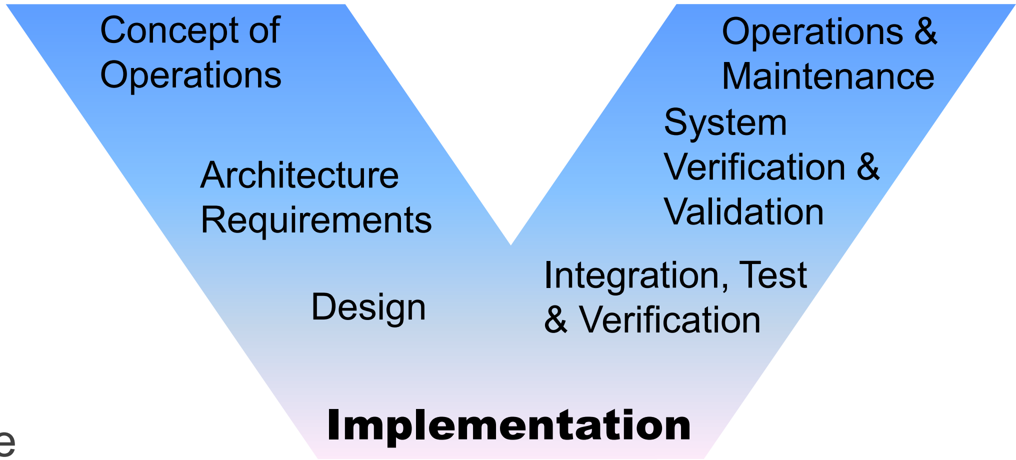
George Sass, Melissa Durfee, Nick Borer, Stephen York, Eric Nelson, Mike Ricard, Scott Ingleton

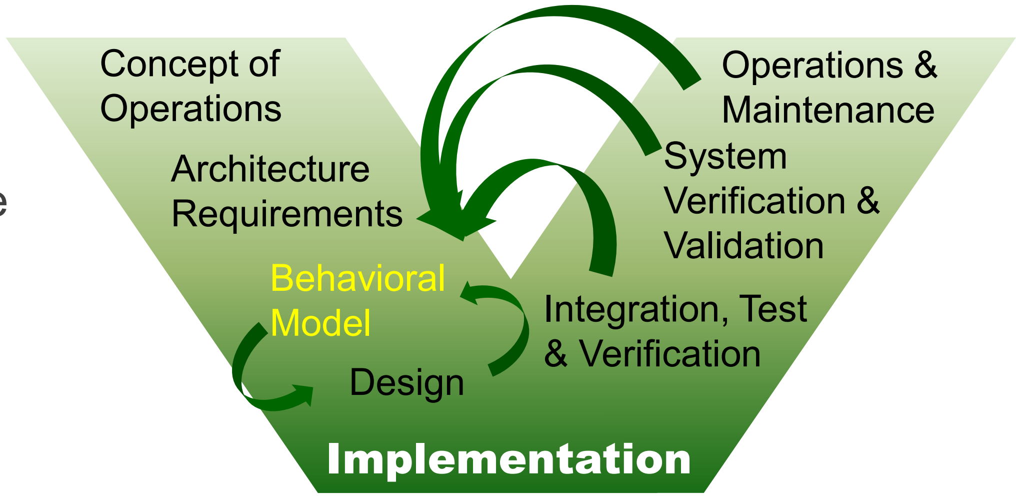
Motivation

- Across DoD, lack of common vision for how to assess performance of decision-making systems
  - Need to meet needs of commanders, acquisition, and warfighter communities who need to trust system performance when needed, safely
  - Low confidence of performance in difficult conditions
  - Intractable to physically test every possible condition
- Interesting Anecdotes
  - All deployed ground robots are tele-operated
  - Original iRobot Packbot had many autonomous driving features – they were removed
  - US Army tends to use automated Takeoff/Landing features of Predators, Air Force does not

Project Vision

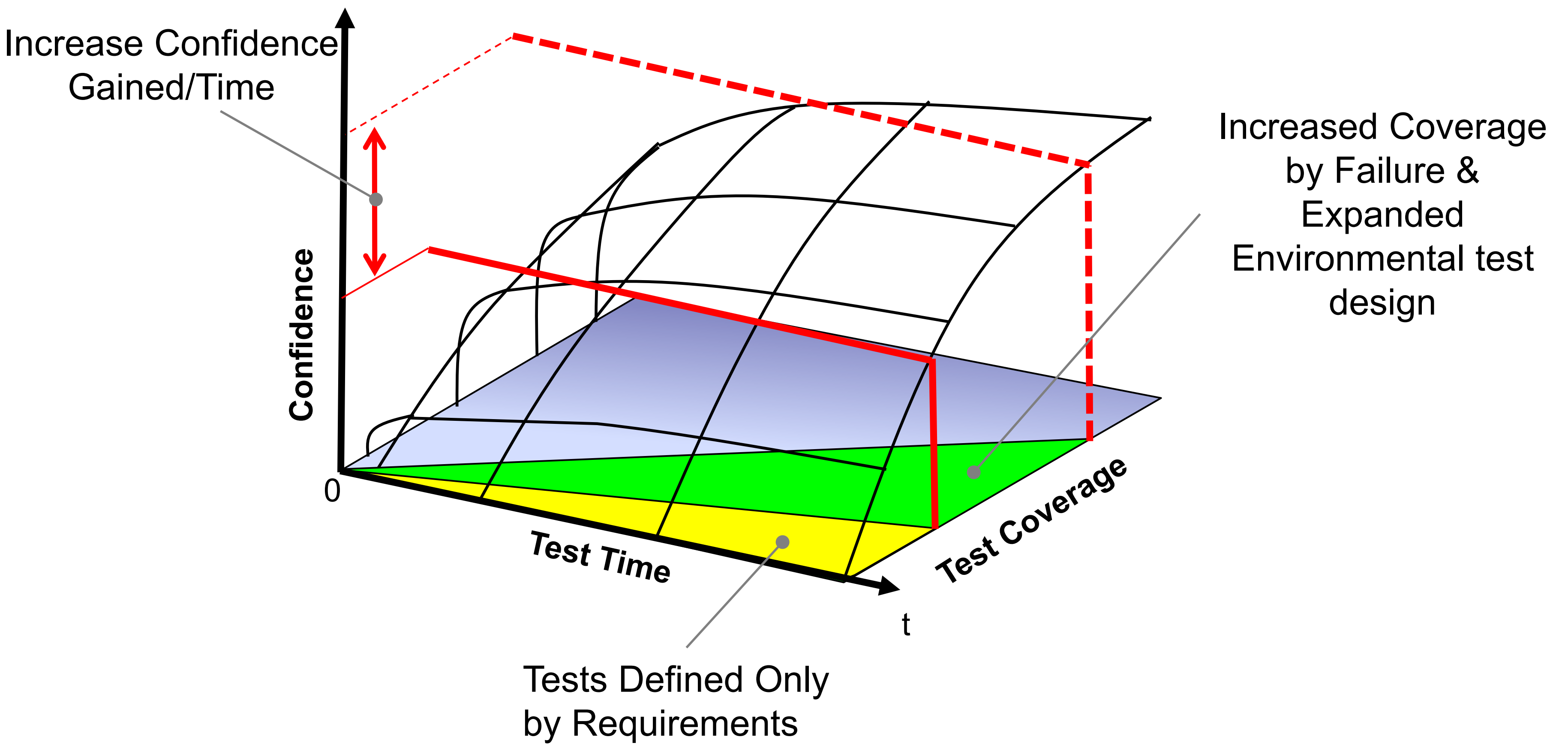
- Apply Draper experience in System Engineering, M&S, Reliability Analysis
  - Investigate use of Markov Reliability Analysis and DOE for System-Level test planning
  - Complementary with increasing emphasis on Model-Based design within DoD
  - Approach similar to human performance evaluation: Inject failure conditions during training to force off-nominal decisions
  - Feedback performance data to model over time to improve predictions of future reliability – continuous improvement
- Selected Unmanned Underwater Vehicle (UUV) for Case Study
  - Highly autonomous operations in complex environment
  - Strong interest from community in testing improvements





Testing Robustness to Build Confidence

Increase Test Coverage with Failure & Environmental Conditions



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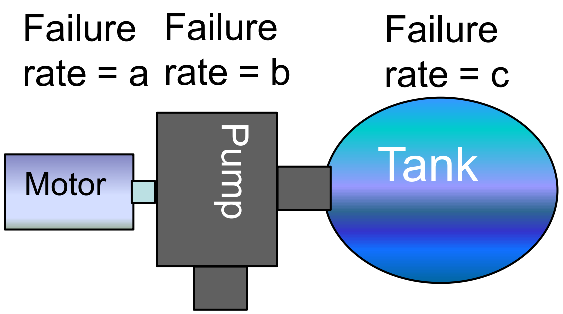
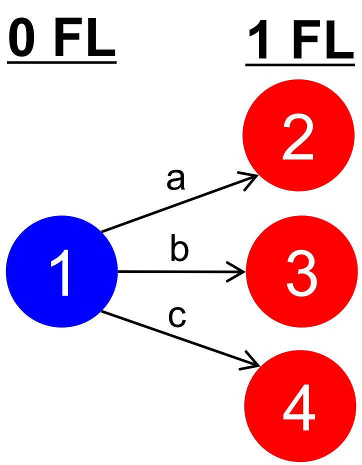
Behavioral Markov Reliability Analysis



- System Markov Model
  - System component connections & logical dependencies
  - Reliability values for each system component (MTBF)
- Model Outputs
  - Probabilities
    - Any failure condition over system life
    - System Loss
  - Reliability Metrics
    - Overall Reliability (not directly used in this project)
    - Sensitivity of Overall Reliability to failure rates of components (used to rank importance of failure modes)
- Draper developed PARADyM Tool

Operational State

System Loss State



$$\frac{dP_1}{dt} = -(a+b+c)P_1(t)$$

$$\frac{dP_2}{dt} = aP_1(t)$$

$$\frac{dP_3}{dt} = bP_1(t)$$

$$\frac{dP_4}{dt} = cP_1(t)$$

Solve

$$P_1(t) = e^{-(a+b+c)t}$$

$$P_2(t) = ae^{-(a+b+c)t}$$

$$P_3(t) = be^{-(a+b+c)t}$$

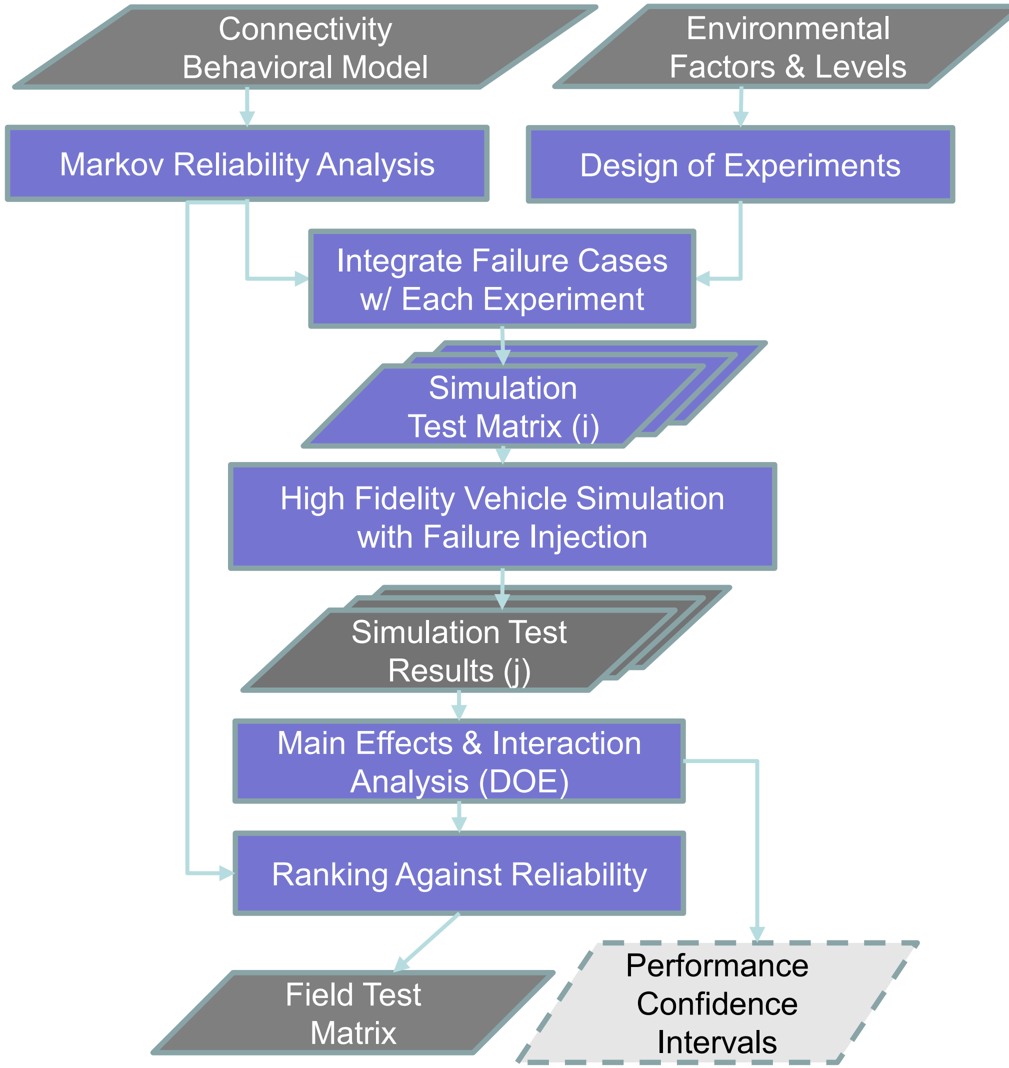
$$P_4(t) = ce^{-(a+b+c)t}$$

P(System Loss) = Σ(System Loss States)

Reliability = Σ(Operational States)

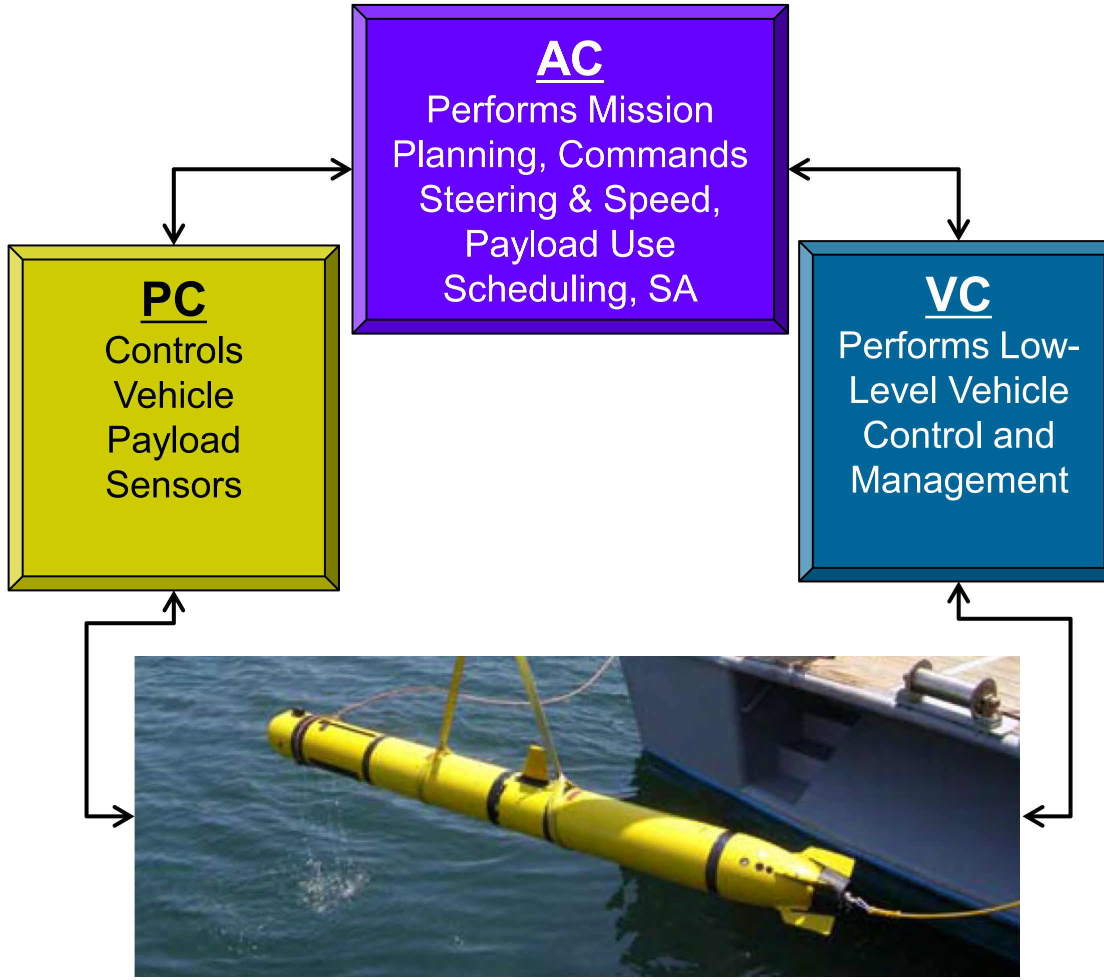
Process Summary

- Required Inputs
  - Behavioral Markov Model
  - Extreme types and ranges of environmental conditions
- Simulation Test Design
  - Perform Markov reliability sensitivity analysis
  - DOE for environmental conditions
  - Repeat all (or top subset) failure conditions for each experiment
- Simulation Execution & Analysis
  - Parallel execution of test cases
  - Analysis of Variance to find Main & Interaction Effects
  - Rank significant factors according to reliability sensitivity
- Final Results
  - Possible (not yet attempted) to extract confidence intervals for performance over bounds of operation
  - Highest significance subset of recommended tests to exercise in field



Case Study: Generic UUV

- Based on NUWC MARV UUV
  - 1’ Diameter, 12’ Long
  - Max Speed: 5 knots
  - Prop Driven with 4 Control fins
  - Forward, Left, Right, Down Looking Sonars
- ASTM F41 Software Architecture
  - Primary decision making in Autonomous Controller (AC)
  - Vehicle management by Vehicle Controller (VC)
  - Payload operations through Payload Controller (PC)
  - “Backseat Driver” Paradigm of control



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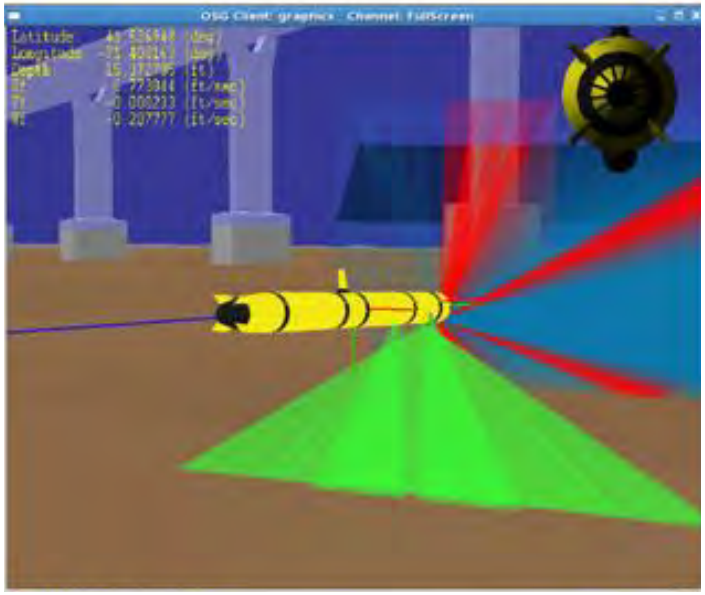
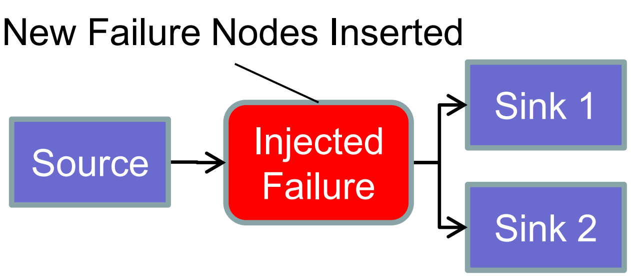
UUV Simulation Based Testing





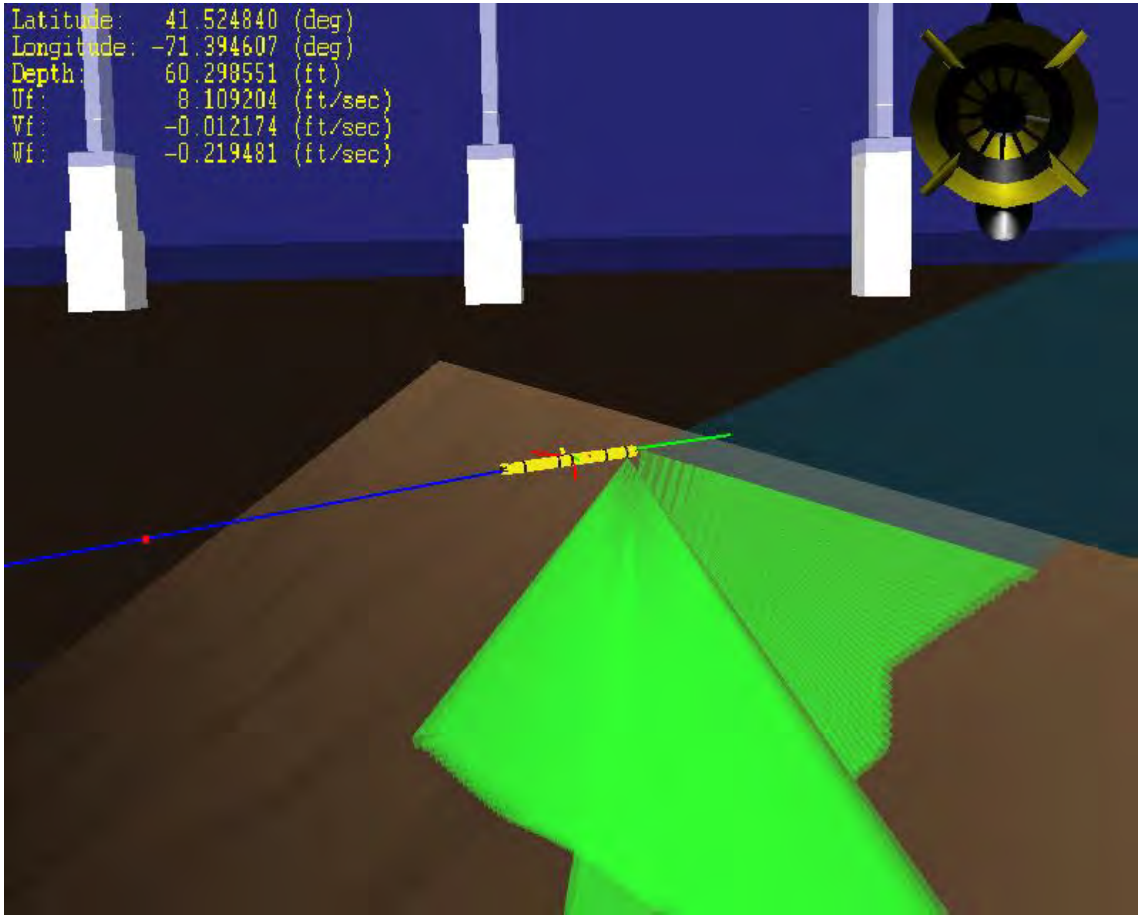
- Draper Simulation Framework (DSF)
  - Govt. Open Framework
  - Dynamics/Physics simulation
  - Soft to Hard Real-Time and faster
  - Built for Hardware-in-Loop
- MARV UUV Simulation
  - Validated vehicle dynamics
  - Simplified sensor models
  - Autonomy Controller running Software-in-Loop with simulated environment
- New Extensions to Simulation
  - Created generalized failure injection nodes for DSF
  - Failure types: Omission/Constant, Noise, Bias
  - Parallel execution of simulations & Autonomy Controllers

UUV System Responses

Response	Description	Rationale
Position Error (t)	Deviation from baseline mission path over time	Position errors cause data collection errors
Attitude Error (t) [φ,θ,ψ]	Deviation from baseline attitude over time	Attitude errors cause data collection errors
Speed Error (t)	Deviation from baseline speed over time	Speed influences execution time, stealth, energy
Energy Consumption	Energy consumption for mission	Must operate within available energy limits
Mission Time	Total mission time	Establish expectations for recovery/communication
Surface Position Error	Deviation from designated end-of-mission surface point	Large errors on surfacing impact recovery
Vehicle Recoverable	TRUE if vehicle surfaced	Lost at sea?

Case Study Evaluation Scenario

- Scenario Goals
  - Short, rapid to iterate
  - Exercises terrain avoidance
  - Exercises waypoint following
  - Varies ocean currents, map quality
- Case Study Scenario Design
  - Short mission, ~ 300 seconds
  - Approach & avoid terrain on way to waypoint
- Basis of all case study simulations
- Future Scenario Designs
  - Longer missions
  - More terrain complexity
  - Multiple time-varying objects of interest (ships, mines)



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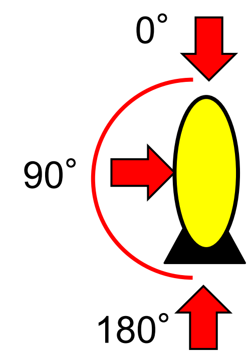
Environmental Experiment Design

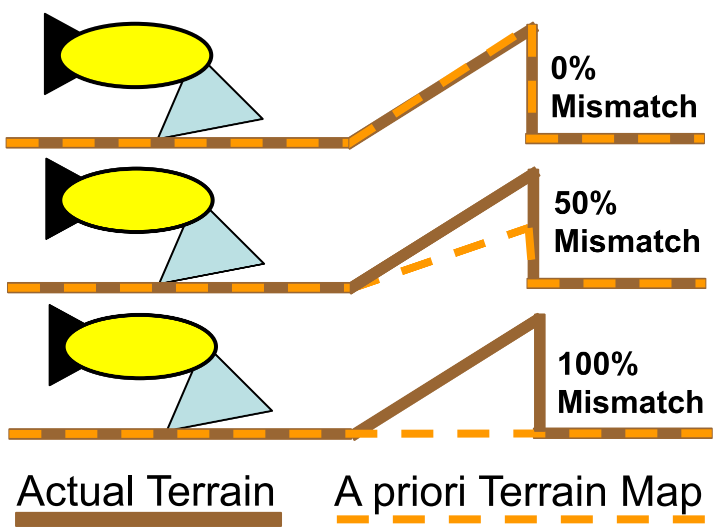
- Available Environmental Factors (3)
  - Uniform current magnitude & direction
  - Terrain under vehicle
- DOE Design
  - 2 Level, 3 Factor Full Factorial – using min/max levels, but adding median center point experiments
  - Center points show non-linearity in response, inform analysis

	Min	Median	Max*
Current Magnitude	0 Knots	**2** Knots	**4** Knots
Current Direction	0°	90°	180°
Map Mismatch	0%	50%	100%



Experiment Design with Center Points

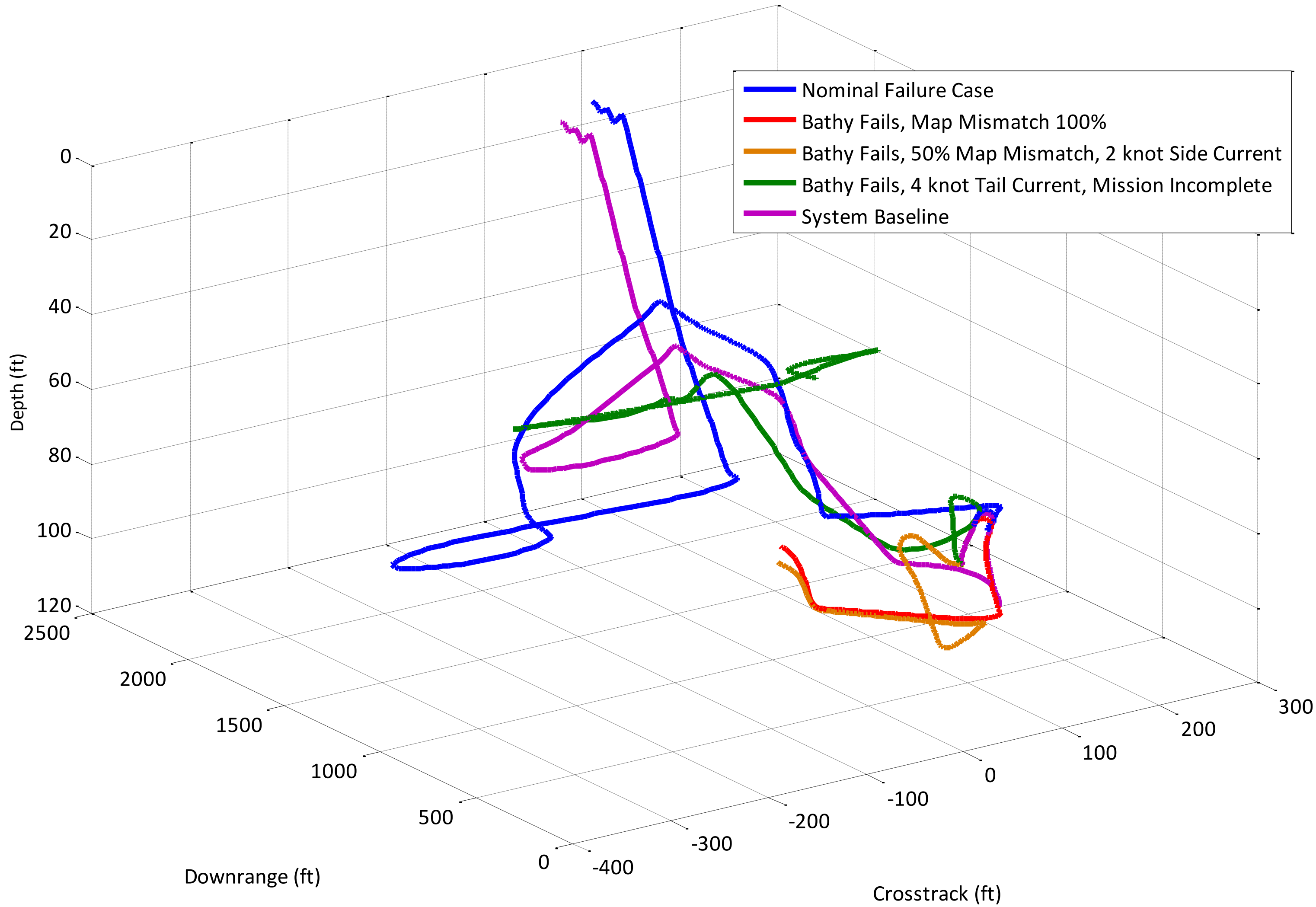
RunOrder	CenterPt	Current Magnitude (knots)	Current Direction (deg)	Map Mismatch (%)
1	1	4	0	100
2	1	4	180	100
3	1	0	0	100
4	0	2	90	50
5	0	2	90	50
6	1	0	0	0
7	1	4	180	0
8	0	2	90	50
9	1	0	180	100
10	1	4	0	0
11	0	2	90	50
12	1	0	180	0



3/8/11 – Learned 4knot 0deg current cases too strong for vehicle

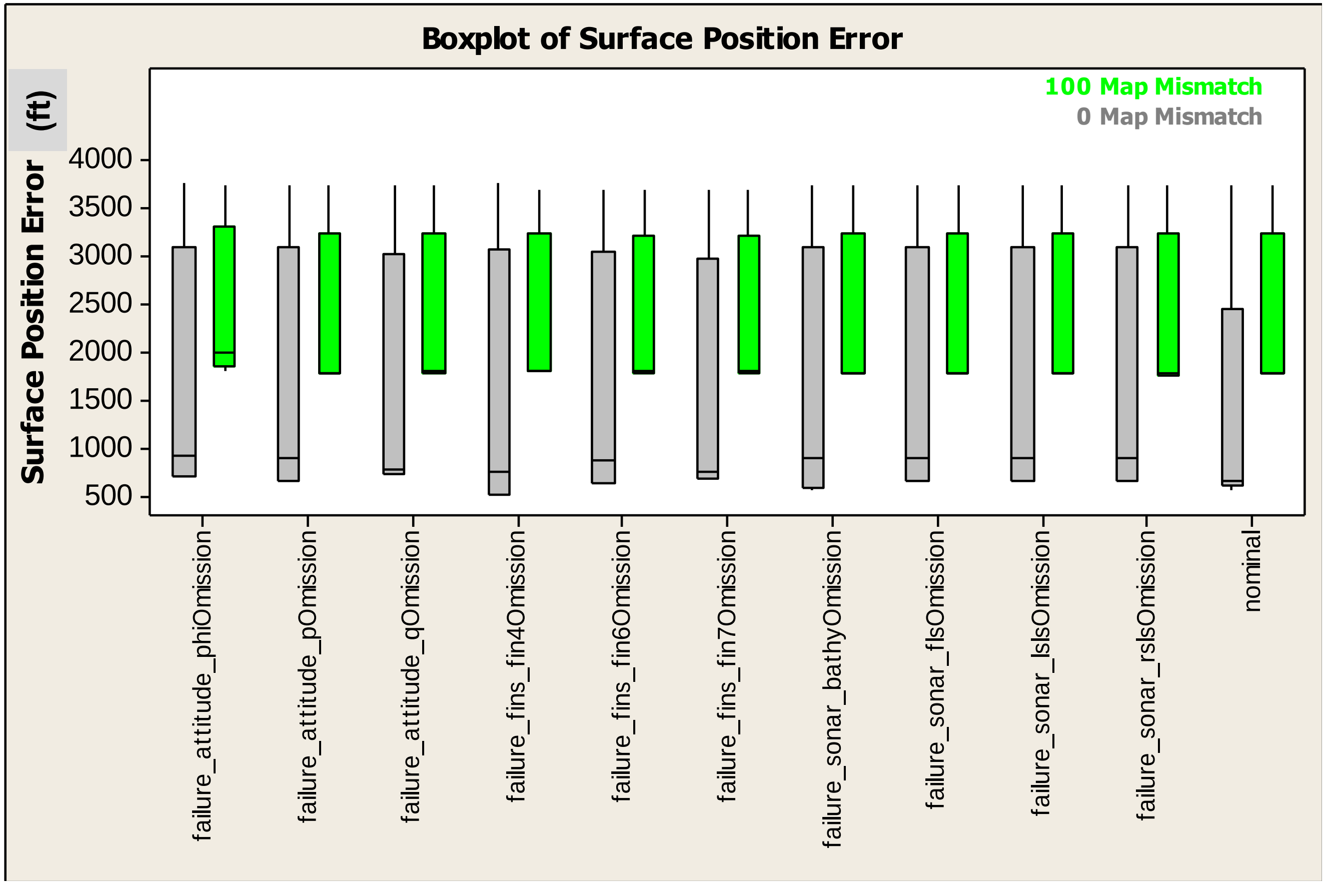
Example Results: Position Response

UUV Path During Select Bathymetric Sonar Failures



Example Results: Map Mismatch Effects

- Map Mismatch Significant Influence during Sonar Failures
  - Logical result
  - Almost 4 km Max Error in Surface Position
  - From Markov model, sonar failures drive reliability
  - Fin & attitude sensor failures much less probable
  - Failure effects same magnitude as environment only
  - *Suspect impact cases and 4knot head currents biasing results*
- Need to set bounds on responses
  - Define overall PASS/FAIL limits
  - Summarize high level results more clearly



Summary & Future Work

- Demonstrated Reliability + DOE Test Planning method on Generic UUV case
  - Reliability analysis indicated sonars, battery monitor, VC, and AC primary drivers of system reliability
  - DOE Planning and analysis indicated Map Mismatch, Current, subset of failure modes significant
- Need to complete analysis of simulated experiments
  - Review results with engineering, end-users, and customers to get feedback on usefulness
  - Rank effects and interactions against probability of failure conditions
- Invest in method & tool improvements
  - **Simulation Environment**: Needs more fidelity in water properties, coupled with higher fidelity sensor models
  - **Simulation Environment**: Integrate reliability calculations with dynamic system model -> Avoid second model creation effort
  - **Markov Analysis:** Sources of reliability values (MTBF) for each component
  - **Simulation Environment**: Add failure mechanisms for VC and AC during simulation
  - **Simulation Environment:** Integrate autonomous controller decision logs with response data
  - **Simulation Environment**: Add time-varying failure and environmental perturbations during simulation
  - **Design of Experiments**: Also consider for integration with Simulation
  - **Design of Experiments**: Selection of best designs and analysis strategies for higher-order experiments

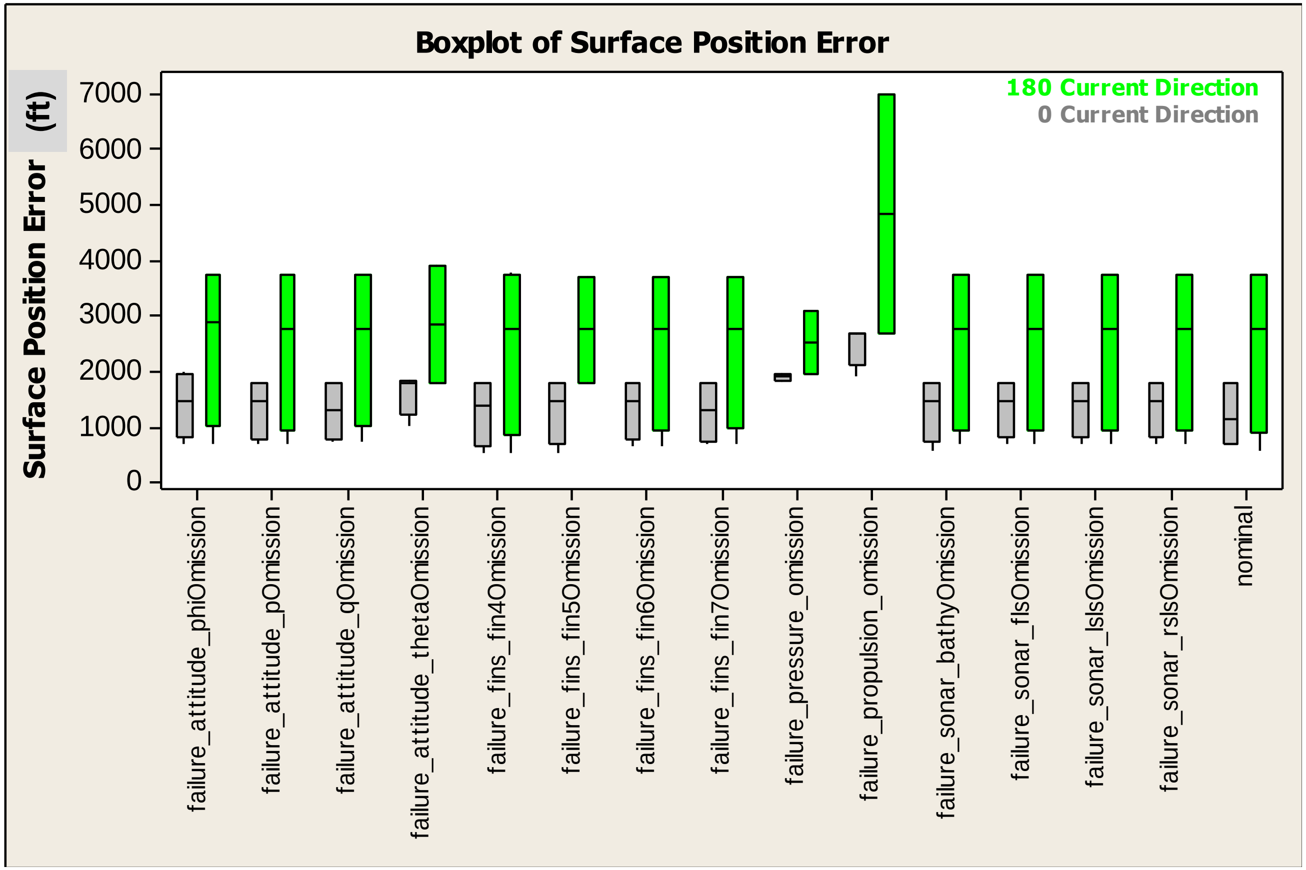
Supplemental Slides

Ongoing Testing Efforts of Note

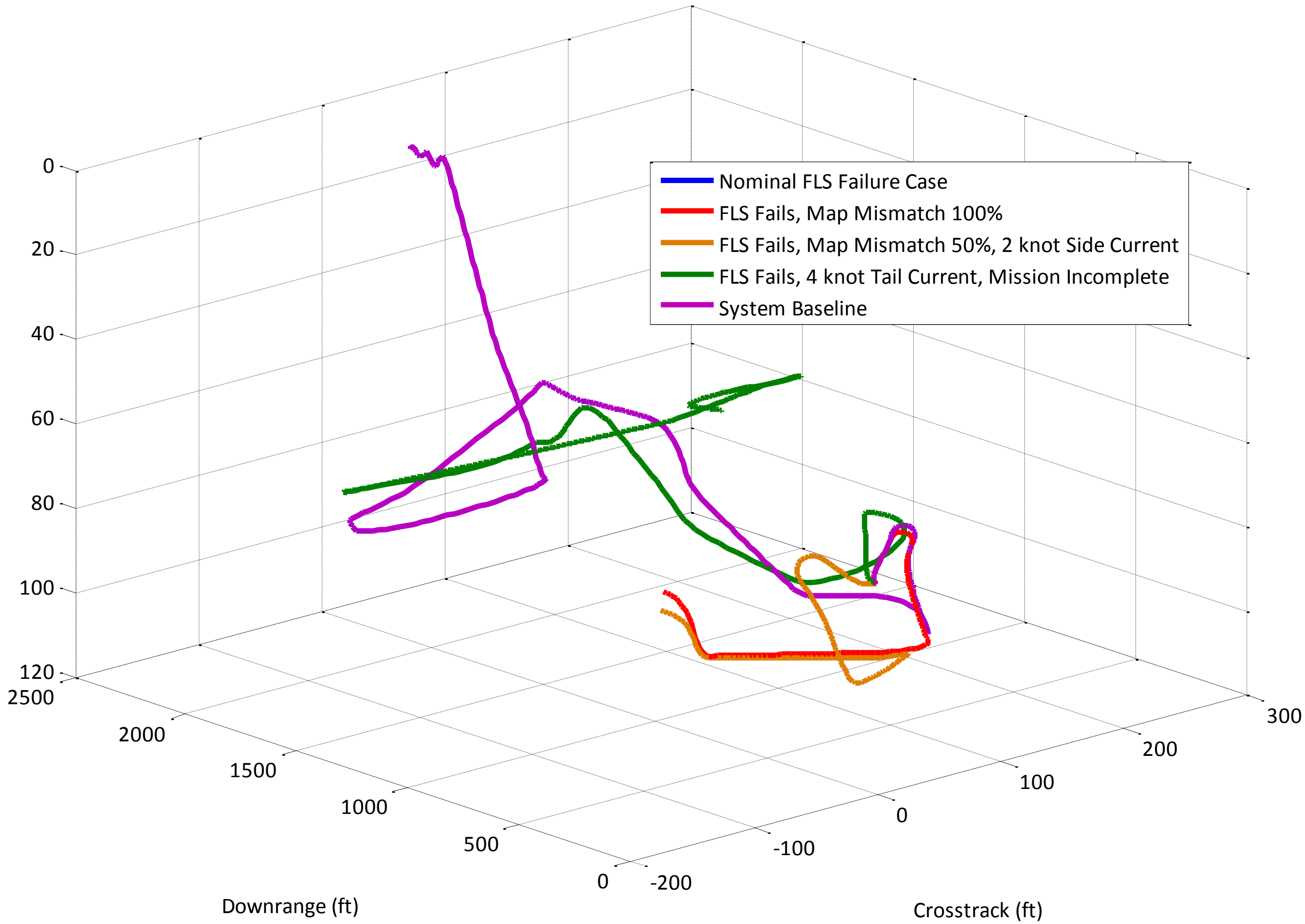
- Assistant Secretary of the Navy (ASN) Research Development and Acquisition (RDA)
  - Large scale multi-unit test scenarios with many interoperating systems
  - Amy Markowich
- Marine Corps Warfighting Lab
  - Extensive hands-on evaluation of aerial/ground robotics in relevant environments & missions
  - Jim Lasswell
- NAVSEA (Combatant Craft Division)
  - In-Water testing of USV, advocates for division of testing at key interfaces – Perception, Effectors, Planning & Control
  - Eric Hansen
- US Army Maneuver Battle Lab
  - Live/Virtual/Constructive testing with manned and unmanned systems
  - Harry Lubin
- Army Research Laboratory (ARL)
  - Autonomous ground vehicle behavior testing with NIST partnership
  - Marshal Childers
- MIT PATFrame
  - TRMC funded development of test planning framework for SoS
  - Ricardo Valerdi

Example Results: Current Direction Effects

- Current Direction Strong Effect
  - Logical result
  - Almost 4 km Max Error in Surface Position
  - From Markov model, sonar failures drive reliability
  - Fin, Prop, & attitude sensor failures much less probable
  - Failure effects same magnitude as environment
  - *Suspect impact cases and 4knot head currents biasing results*
- Need to set bounds on responses
  - Define overall PASS/FAIL limits
  - Summarize high level results more clearly



UUV Path For Select Forward-Looking Sonar Failures



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Pacific Science & Engineering

Using Complementary Frameworks for Qualitative Data Collection during OT&E: Piggybacking on Operational Experiments

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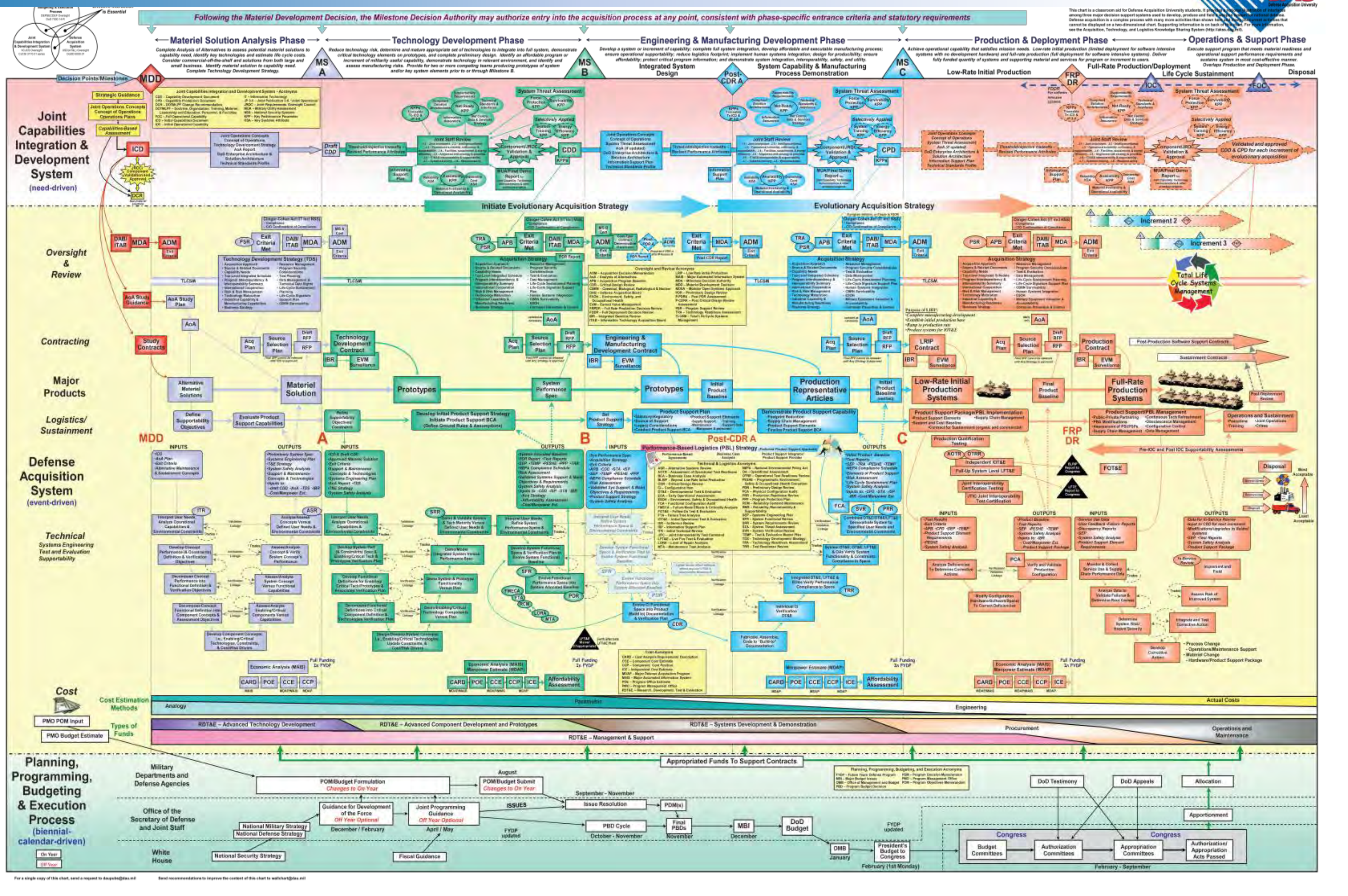
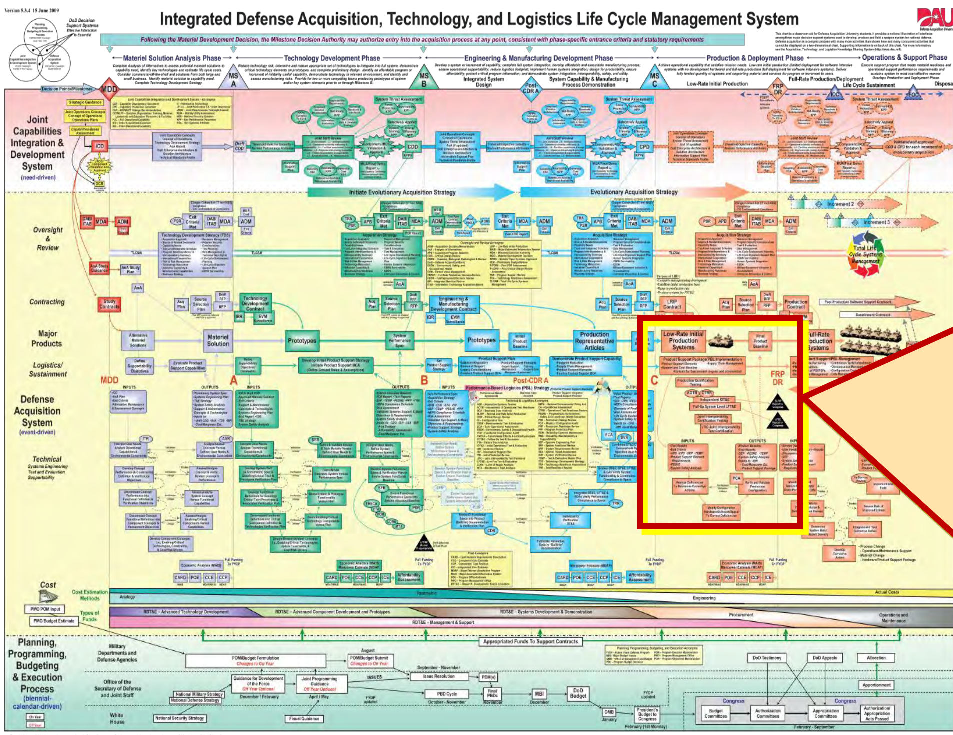
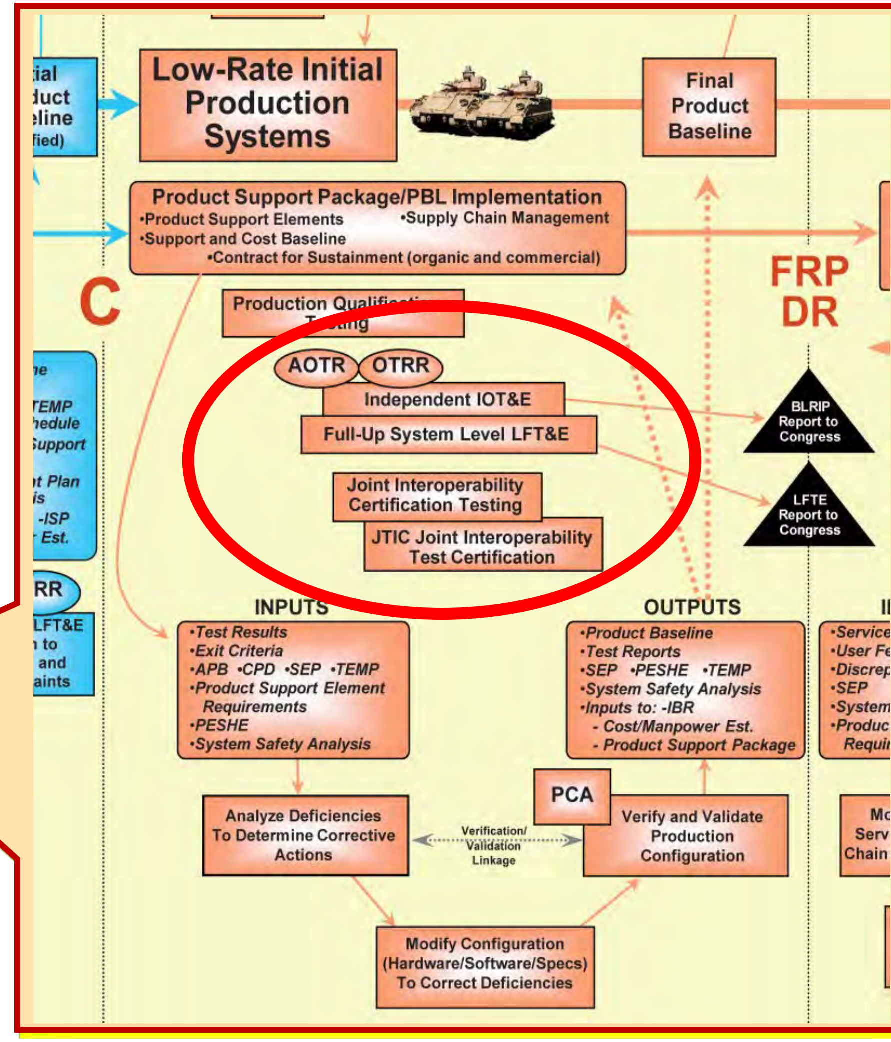
Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System



Low-Rate Initial Production Process



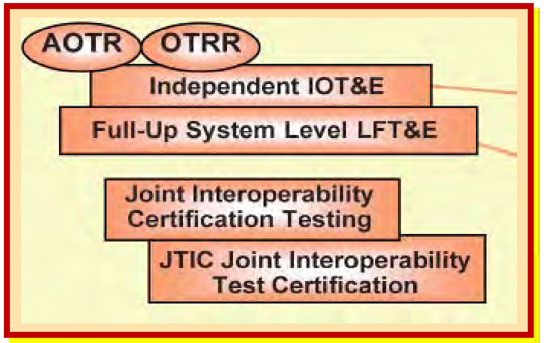


Operational Test and Evaluation (OT&E)

Used to determine the operational ***effectiveness*** and ***suitability*** of a system under realistic operational conditions, including joint combat operations;

- determine if thresholds in the approved Capability Production Document and critical operational issues have been satisfied;
- assess impacts to combat operations;
- and provide additional information on the system's operational capabilities.

Typical users shall ***operate and maintain*** the system or item under conditions simulating combat stress and peacetime conditions.



The DoD OT&E Agencies

The four military departments have each formed operational test agencies that conduct OT&E *independently* of the acquiring organizations.

1. Army Test and Evaluation Command
   » Operational Test Command (OTC) and
   » Army Evaluation Center (AEC)
2. Navy Operational T&E Force (OPTEVFOR)
3. Marine Corps Operational T&E Agency (MCOTEA)
4. Air Force Operational T&E Command (AFOTEC)

Piggybacking on Operational Experiments

An operational experiment may be a suitable venue and afford efficiency of the IOT&E testing process

– Operational experimentation may occur as an experimental venue, or in conjunction with an operational exercise already being planned

Benefits:

– Temporary installation on operational platforms – ‘field test’
– Specifically-designed scenarios / test plans – ‘realistic combat conditions’
– Active-duty participants – ‘use by typical military users’
– Performance measurement; data collection, analysis, and evaluation – ‘determining effectiveness and suitability’

Operational Experiments Provide Administrative, Logistics, Data Collection

Administrative processes and resources

– Test design and planning through reporting

Target user populations

Official entrance to operational sites and platforms

– Access to networks at needed classifications
– Support for installation
– Specific needs accommodated as feasible

Test plan management and data collection resources

Independent, objective data collectors

An Integrated Data Collection Process

Assessment Plan

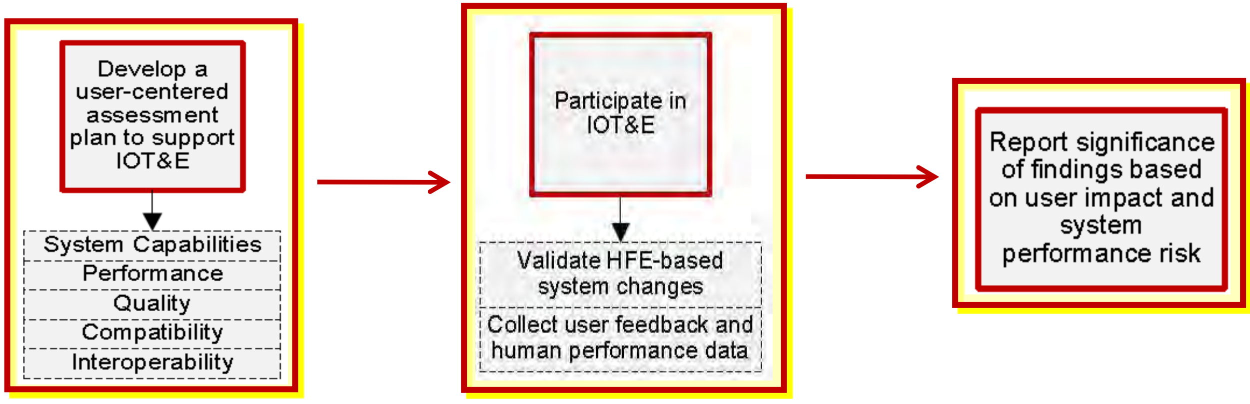
– Determine the system or technology's readiness to participate in the testing

Test Implementation

– Develop work process models for use of the systems or technologies in mission-based operational events

Results Reports

– Provide evaluations as to the operational readiness of each system or technology



A Sampling of Venues

Trident Warrior

- Sponsored by U.S. Fleet Forces Command
- Broad spectrum of technologies; multi-national annual focus

Empire Challenge

- Sponsored by Undersecretary of Defense for Intelligence
- ISR processes & government-sponsored technologies with minimum TRL of 5 or Milestone B

Talisman Saber

- Sponsored by U.S. Military and Australian Defence Force
- Technologies & processes for crisis action planning and contingency response

Valiant Shield

- Sponsored by U.S. Pacific Command
- Cooperative detection, tracking & engagement of units at sea, in air and on land

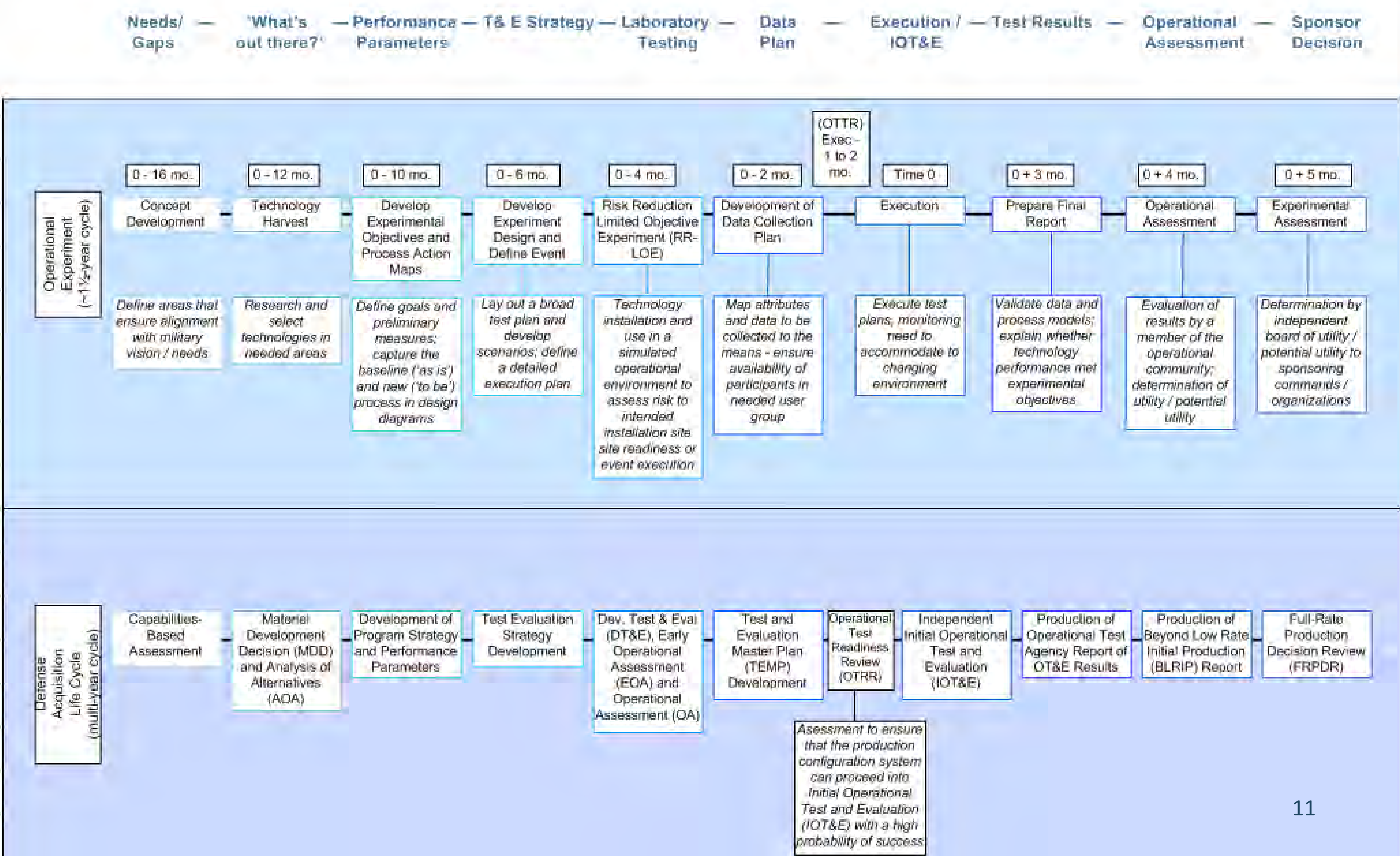
….And many more….

Complementary Data Collection & Analysis

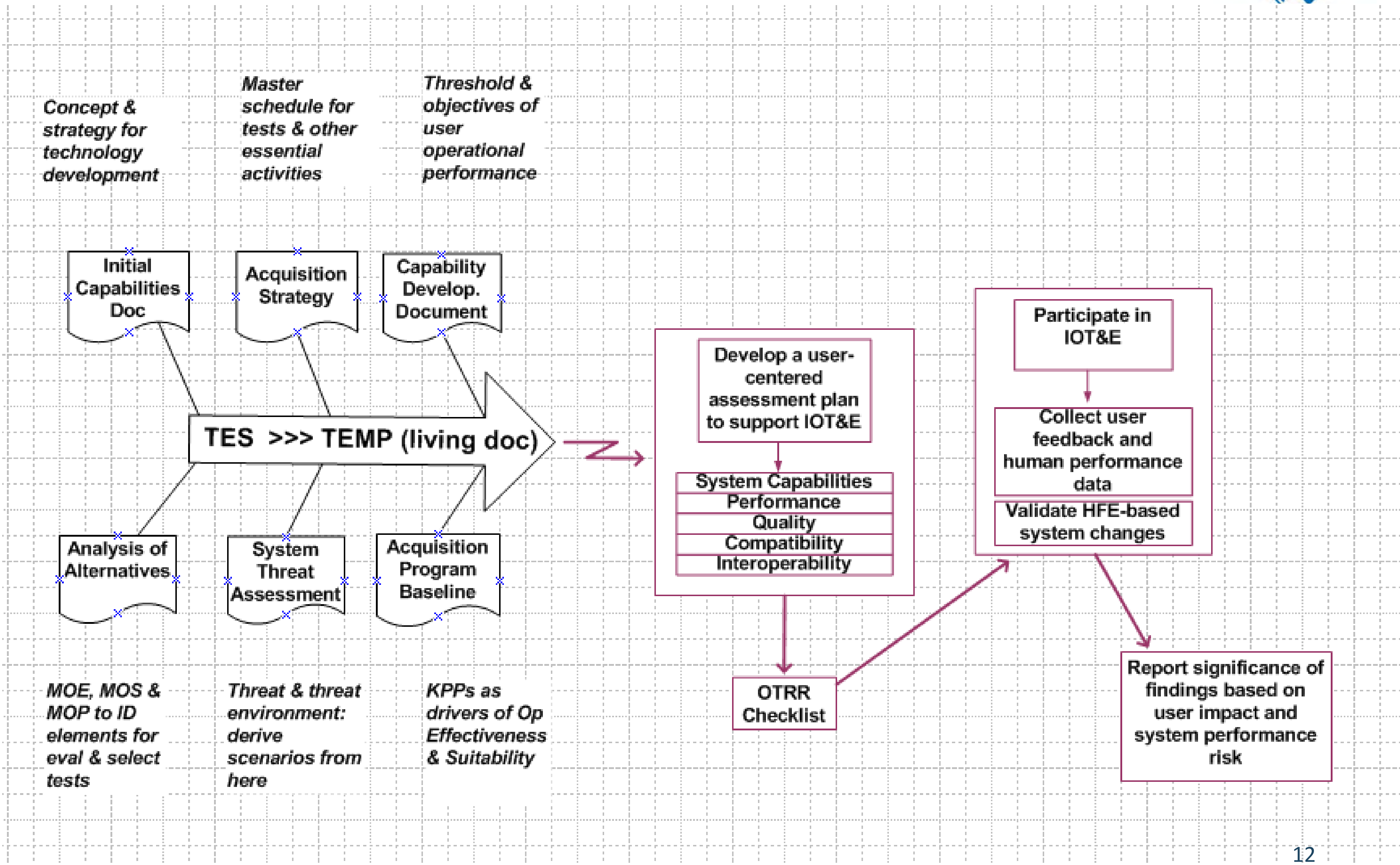
Operational experiments require – or can accommodate – the strict data collection requirements of IOT&E

- Specification of essential system attributes to be tested
  - Key Performance Parameters (KPPs)
  - Experimental question, with attributes, related to operational capability
- Specification of measures
  - Measures of Effectiveness (MOEs) and Measures of Suitability (MOSs)
  - Criteria
- Specification of method
  - Quantitative or qualitative
  - Coordination via test plan (location / activity / timing)
  - Multi-method for corroboration
- Specification of analysis
  - Tests / Comparisons to be performed

Parallel Activities: Acquisition Cycle & the Operational Experiment Cycle



Acquisition Cycle Source Document Content Used for Op Ex / IOT&E Test Plan



Example of Qualitative Templates – Building Blocks for Operational Experimentation

ACCESSIBILITY AND FUNCTIONALITY:

E A1. Were you able to navigate the system as instructed in the CONOPs or TTPs?

○Yes ○No ○N/A

If no, please explain:

E A2. Did you receive adequate training on the system for your participation in this event?

○Yes ○No ○N/A

If no, please explain:

S A3. How easily could this system be integrated with the operational routine already established in your organization?

○Very easily ○Easily ○Not easily ○Not at all ○N/A

Please explain:

E A4. Was it necessary to work-around any of the steps or operations provided in the system?

○Yes ○No ○N/A

If yes, please explain:

E A5. Did the steps or operations available to you appear to be the most direct method of navigating the information available in the system?

○Yes ○No ○N/A

If no, please explain:

E A6. Did this system provide acceptable conditions for usage (i.e., where it can be accessed, who can access it, and how many terminals will be available to access it)?

○Yes ○No ○N/A

If no, please explain:

OBSERVER LOG QUESTIONS:

1. How many times has the user (i.e. person you are observing) interacted with the system? (E)
2. How many total minutes did the user interact with the system? (E)
3. What task (or output) was the user attempting to perform (or create)? (S)
4. Was the user successful in performing the task or creating the output? (S)
5. If no to question 4, what were the causes of the failure? (S)
6. Did the user establish any workarounds (explicit or implied) during this exercise? (S)

Summary

T&E professionals can leverage operational experiments to efficiently fulfill requirements for IOT&E

- Operational experiments provide a management process foundation and materiel resources
- Acquisition cycle documents and reports match with needed operational cycle documentation – minimal reworking for participation
- IOT&E requirements for test components – venue, scenario, operators, customized and objective data collection – can be met
- Event execution can be overseen by operational test agency personnel for validation to the Director of Operational Test and Evaluation

For more information, please contact:

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ChieshaStevens@pacific-science.com
(858) 535-1661

Naval Surface Warfare Center
Crane

NAVSEA
WARFARE CENTERS
CRANE

Ballistic Shield Documentation Direction

Christopher Brown
3/15/2011

Joint Special Operations Response Department

Harnessing the Power of Technology for the Warfighter

Need Arises

- **USS Cole**
  - October 12, 2000
  - No force protection equipment, plans, or training
  - Killed 17 injured 39
- **Anti-Pirate patrols in Gulf of Aden and Indian Ocean**
  - Late 2007, US Navy began stepping up anti-piracy efforts when received permission to enter Somali territorial waters.
  - Jan 2009, the US Navy in conjunction with 20 other nations formed the international anti-piracy fleet, Task Force 151.

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Need Arises

- **Iran posturing in the Hormuz Strait**
  - **Iranian Navy consists primarily of small patrol boats.**
  - **Feb. of 2007, began an increase in probing of Iraqi territorial waters**
  - **March of 2007, held 15 British Marines and Sailors hostage for a short time**
  - **January 2008, five Iranian patrol boats took aggressive action and "maneuvered within 500 yards of our ships"**

Need Arises

- These missions require tracking and engagement of relatively small boats.
- The distances to the vessels are typically short range.
- The primary weapons employed are crew-served weapons.
- Placing sailors on the gunwales with crew-served weapons to engage a small craft bearing automatic weapons requires protection

History

- **Desert Shield/Storm**
  - **Ballistic shields were installed on selected ships at the crew served weapons stations while serving in the Persian Gulf in support of Operation Desert Shield/Storm.**
  - **Simple laminated Kevlar panels.**
  - **Represented current technology at the time**
- **Return to the Gulf**
  - **In 2003 CGs and DDG received shields for operations in the Gulf.**
  - **Initially, Desert Shield/Storm armor brought out of storage and reissues.**
  - **Some new design, but no development with respect to environment, installation constrains, or even threat level completed.**

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History

- **Degradation and replacement efforts**
  - Feb 2007, SEA06 AT/FP TWH email to OPNAV, FFC, CNSF urging shield resolution (i.e. life cycle support)
  - 2008 USS Barry realizes a need for replacement of degraded shields and sources own shield.
  - New shields not authorized, but life cycle support not in place for replacement or upgrade.
  - Dec 2008 – CNSF sends Crew Served Weapon Mount Ballistic Shield Requirements letter to Deputy CNO

Objectives

- This project will develop the requirements document and subsequently the performance specification that will be used to purchase shipboard ballistic shields.
- This project will improve the ability of all Navy combatant surface ships to meet AT/FP threats through the use of ballistic shields that meet requirements.
- Improved ballistic shields will reduce the risk of loss of life. Current ballistic shields insufficiently protect ship's personnel and equipment against documented fleet requirement. Loss of life safety risk exists with currently fielded ballistic shields.
- Standardization of ballistic shield requirements is expected to reduce overall fleet lifecycle cost.
- Performance spec will lead to a common ballistic shield product. There is currently no ballistic shield commonality across ship classes.
- Formalized performance specs will allow industry the ability to develop innovate and off the shelf solutions.

Approach

- Two document approach.
  - MIL-PRF document identifying issues unique to the installation and usage of the ballistic shields on naval vessels.
  - MIL-STD document addressing the majority of possible threat rounds both NATO and WARSPACT. It will provide comprehensive testing, qualification, and classification standards adaptable to all future Naval Ballistic Protection needs.

MIL-PRF-XX613

- Don‟tlimit innovation
  - Does not specify materials
  - Does not specify mounting methodology
- Encourage all solutions
  - Covers special considerations for permanent, semi-permanent, and removable designs.

NAVSEA WARFARE CENTERS CRANE

MIL-PRF-XX613

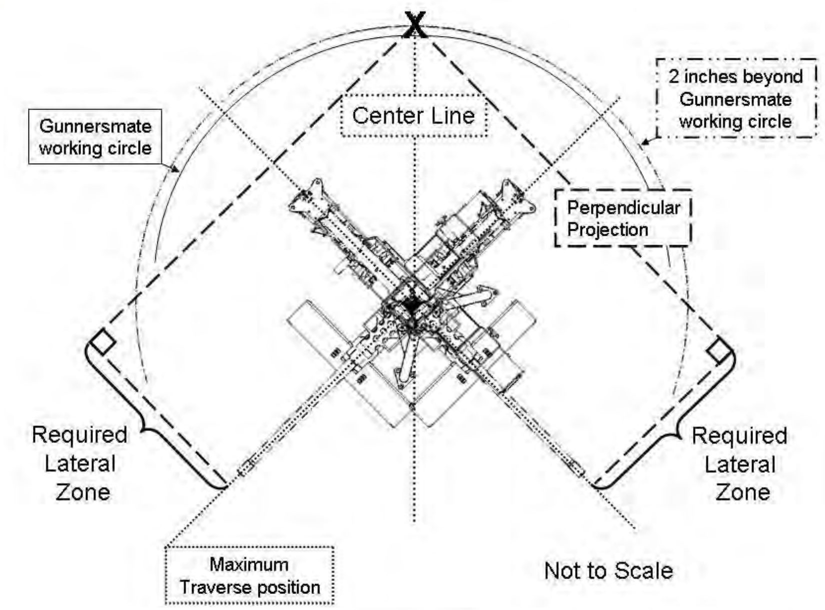
- **Provisions unique to stationary and removable shields.**
  - **Stationary Shields**
    - **Sea State Survivability**
    - **RF Signature**
    - **RF Reflectivity**
  - **Removable Shields**
    - **Two Man Portable (Weight, etc.)**
    - **Portability Provisions (Handles, etc)**
    - **Ease of Installation (Markings, Time to assemble, special tools, etc.)**
    - **Passage Way and Hatch compatible (Dimensional limits, etc.)**

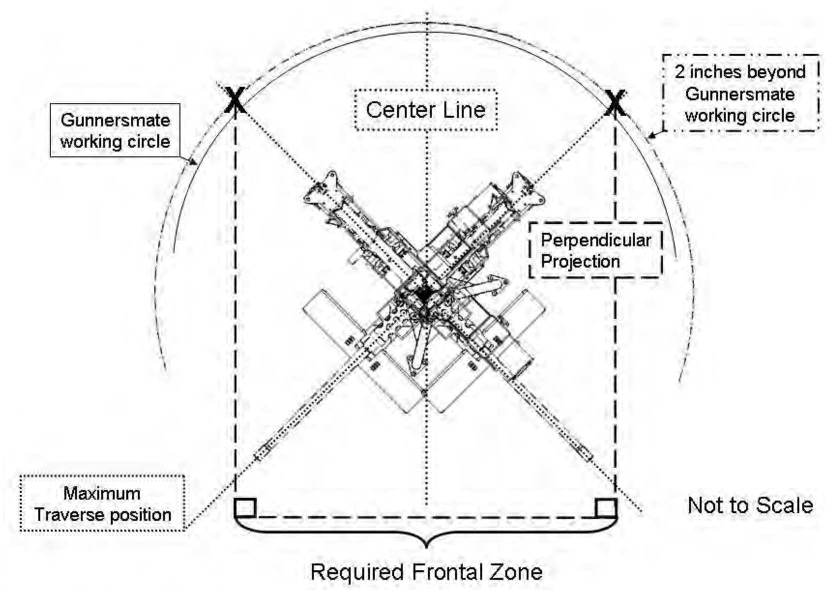
MIL-PRF-XX613

- Document all considerations and constraints
  - Includes
    - Material Handling
    - Coatings
    - Environmental Testing
    - Ship Unique Issues (Green water loading, vibrations, etc.)
    - Flight Operations
    - Storage Provisions
    - Ship's Operations

MIL-PRF-XX613

- Open to all ship classes
  - Dimensions are determined by the lateral traversing limits based on installation and the gunners working circle dimensions.
  - Height is measured based on the user
    - 48” from bottom of user‟s feet.
  - Weapon cut out is determined by the weapon mount.





NIJ 0101.06 and 0108.01

- NIJ pros/cons
  - Pros
    - Excellent and comprehensive procedures for body armor applications
  - Cons
    - Limited round sizes; not very many military rounds
    - Ambiguous multi-shot placement criteria.

Caliber	Round	Weapon	NIJ 0101_06
9 x 19	(9 mm; .40 S&W)	M9	IIA
	(9 mm; .357 Magnum)	Colt Python	II
11 x 41	(.357 SIG; .44 Magnum)	S & W Model 29	IIIA
7.62 x 39	Type PS	AK-47	
	API BZ M43		
5.45 x 39	5N7	AK-74	
5.56 x 45	M855	M16	
7.62 x 51	M80, M59	FN FAL	III
	AP M61		
7.62 x 63	M2	M1 Garand	
	AP M2		IV
7.62 x 54R	SOVIET, TYPE LPS	PKM	
	Type B32	Dragonuv	
12.7 x 108	12.7mm API&T, B32	DShK	
12.7 x 99	M2 Ball	M2 BMG	
	M2 AP		
14.5 x 114	14.5mm API-B32	KPV	
	14.5mm API-BS-41		
20 x 102	M75	M61 Vulcan	
	APT-M95		
	AP-T M602 (HVAP-T DM-43)		
23 x 152	23mm API-T BZT	2A14	
25 x 137	APDS-T M791	M242	
30mm	30 x 113mm	M230	
	30 x 165mm	GSh-30-1	
	30 x 173mm	GAU-8	

EN 1063

- **EN 1063 pros/cons**
  - Pros
    - Good multi-shot placement methodology
    - Included military significant rounds
  - Cons
    - No Warsaw Pact weapons
    - Limited threat size.

Caliber	Round	Weapon	EN 1063
9 x 19	(9 mm; .40 S&W)	M9	EN BR2
	(9 mm; .357 Magnum)	Colt Python	EN BR3
11 x 41	(.357 SIG; .44 Magnum)	S & W Model 29	EN BR4
7.62 x 39	Type PS	AK-47	
	API BZ M43		
5.45 x 39	5N7	AK-74	
5.56 x 45	M855	M16	EN BR5
7.62 x 51	M80, M59	FN FAL	EN BR6
	AP M61		EN BR7
7.62 x 63	M2	M1 Garand	
	AP M2		
7.62 x 54R	SOVIET, TYPE LPS	PKM	
	Type B32	Dragonuv	
12.7 x 108	12.7mm API&T, B32	DShK	
12.7 x 99	M2 Ball	M2 BMG	
	M2 AP		
14.5 x 114	14.5mm API-B32	KPV	
	14.5mm API-BS-41		
20 x 102	M75	M61 Vulcan	
	APT-M95		
	AP-T M602 (HVAP-T DM-43)		
23 x 152	23mm API-T BZT	2A14	
25 x 137	APDS-T M791	M242	
30mm	30 x 113mm	M230	
	30 x 165mm	GSh-30-1	
	30 x 173mm	GAU-8	

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MIL-STD-662

- 662 pros/cons
  - Pros
    - Excellent for categorizing the material properties of the armor
  - Cons
    - Doesn‟tgive yes or no
    - Allows „gaming‟of test by providing for obliquity and offset distance from muzzle
    - Without defined levels, difficult to develop off the shelf materials

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MIL-STD-X618

- **Reviewed the majority of armor related standards and specs**
  - **EN 1063**
  - **NIJ 0101_06**
  - **NIJ 0108_01**
  - **MIL-STD-662F V50 Ballistic Test for Armor**
  - **STANAG 4569**
  - **MIL-DTL-46100E Armor Plate Steel Wrought High Hardness**
  - **MIL-PRF-46103E Armor Lightweight Composite**
  - **MIL-PRF-46108C Armor Transparent**
  - **ATPD 2352P Transparent Armor Purchase Specification**
  - **MIL-B-29604(1) Body Armor Hard Small Arms Protective**
  - **MIL-DTL-46063H Armor Plate Aluminum Alloy, 7039**
  - **MIL-DTL-46077G Armor Plate Titanium Alloy Weldable**

MIL-STD-X618

- Selected best practices from among all reviewed documents
- Massaged given info
- Filled in gaps and loopholes
  - Current Standards primarily NATO rounds only.
  - Special considerations for tiled solutions
  - No obliquity allowances
  - Based on advertised muzzle velocity of given threat
  - Designed to easily cross-reference between threat round, common weapons, and ballistic properties.

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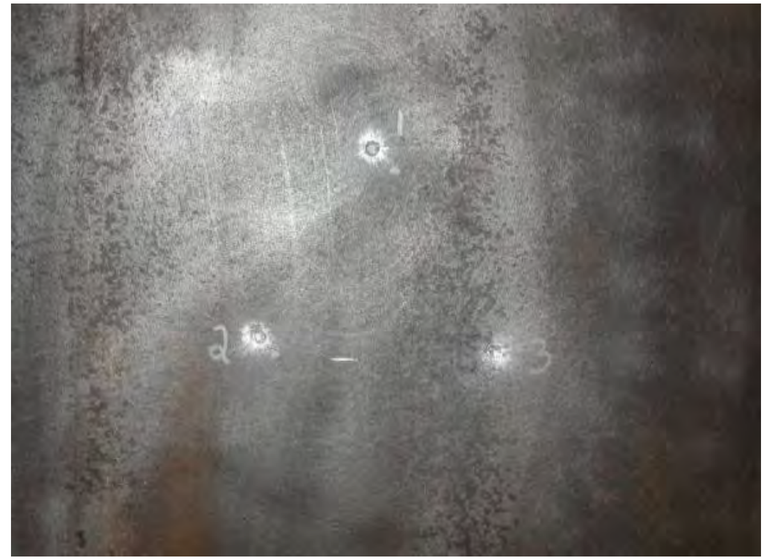
MIL-STD-X618

- **Don‟tlimit innovation**
  - **Does not specify materials**
    - **Encourages new chemical compositions of existing armor materials.**
- **Encourage all solutions**
  - **Allows for single shot or double**
  - **Allows for ball round or armor piercing**

MIL-STD-X618

- **Transparent and opaque**
  - **Allows transparent and opaque.**
  - **Provides small changes based on typical usage**
    - **Thinner witness plate for transparent**



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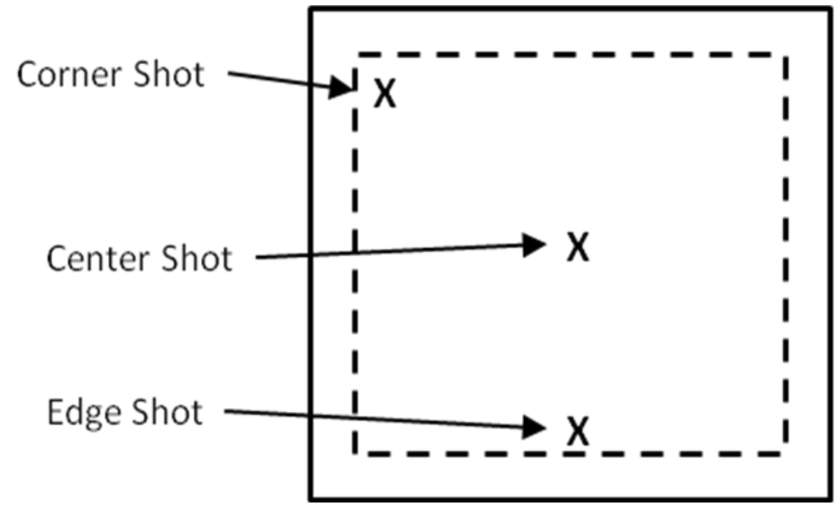
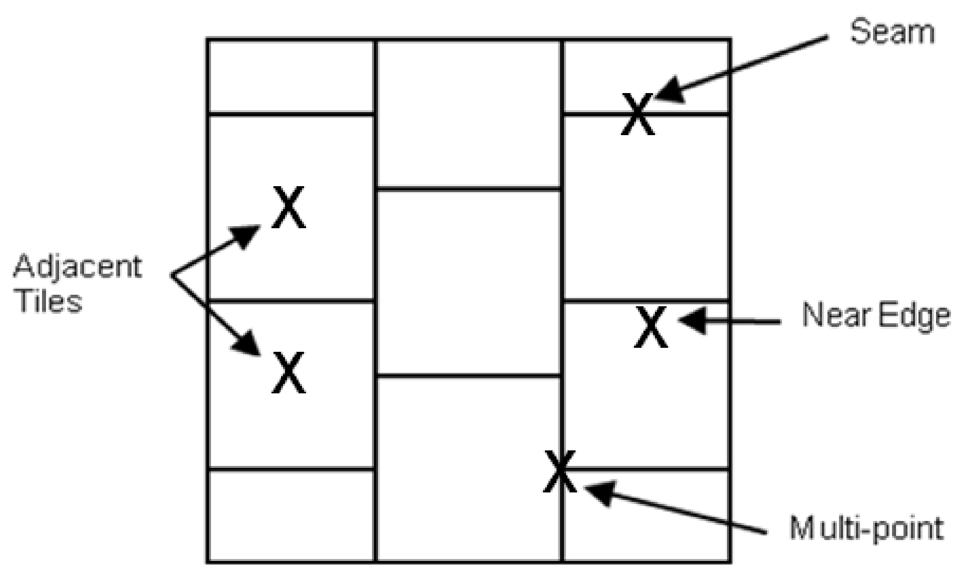
MIL-STD-X618

- **More specific shot placement**
  - **Multiple required locations for all coupons**
  - **Special considerations for tiled coupons**





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MIL-STD-X618

MIL-STD-X618			Threat Information			Existing Standards			
Type	Class		Caliber	Round	Weapon	NIJ 0101_06	UL 752	NATO STANAG 4569	EuroNorm EN 1063
I	A		9 x 19	9mm FMJ RN M882	M9	IIA	1,6		EN BR2
		B		9mm FMJ RN	Colt Python	II	2		EN BR3
II	A		11 x 41	.357 SIG FMJ FN AA19	S & W Model 29	IIIA	3		EN BR4
III	A		7.62 x 39	Type PS	AK-47				
		B		API BZ M43				Level 2	
IV	A		5.45 x 39	5N7	AK-74				
		B		7N22 AP					
V	A		5.56 x 45	M855	M16		7	Level 1	EN BR5
		B		AP M993					
VI	A		7.62 x 63	M2	M1 Garand		4		
		B		AP M2		IV	9		
VII	A		7.62 x 51	M80, M59	FN FAL	III	5,8	Level 1	EN BR6
		B		AP M61				Level 3	EN BR7
VIII	A		7.62 x 54R	SOVIET, TYPE LPS	PKM				
		B		Type B32	Dragonuv			Level 3	
IX		B	12.7 x 108	12.7mm API&T, B32	DShK				
X	A		12.7 x 99	M33	M2 BMG		10		
		B		M263					
XI	A		14.5 x 114	14.5mm API-B32	KPV			Level 4	
		B		14.5mm API-BS-41					
XII	A		20 x 102	M75	M61 Vulcan				
		B		APT-M95					
XIII		B	23 x 152	23mm API-T BZT	2A14				
XIV		B	25 x 137	APDS-T M791	M242			Level 5	
XV		B	30mm	M789 HEDP	M230				
XVI		B	30mm	30 x 165mm BT	GSh-30-1				

High-Lighted selections represent Warsaw Pact weapons

NAVSEA WARFARE CENTERS CRANE

Where Are We Now?

- MIL-PRF-XX613 and MIL-STD-X618 are in the Government Industry Review process.
- Both documents are slated to be signed and published in late March 2011.
- Following the signing of the documents, an SBIR will be released to encourage development of initial designs.
- The SBIR will bridge the gap until the funding request, currently in POM cycle, is approved allowing shields to be fielded on DDGs, FGs, and CGs.

NAVSEA WARFARE CENTERS CRANE

Where Are We Now?

- **NSWC Crane has created a Ballistic Test Group to provide the required government certification for the Navy.**
  - **Ballistic shots up to and including 30mm**
  - **Explosive blasts up to 500lbs**
    - **EFPs up to 10lbs**
    - **A 50lbs facility is being constructed.**

Questions?

Distribution unlimited;
Approved for public release

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live-Fire Test & Evaluation

16 March 2011

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Scott Hornung, 410.278.3263 (DSN:298.3263), scott.hornung@arl.army.mil

Ballistics & NBC Division

U.S. Army Research Laboratory, Survivability/Lethality Analysis Directorate

Overview

- Analysis Background
- Modeling Process Overview
  - —The MUVES-S2 Model for Ballistic Vulnerability / Lethality (V/L) Analysis
  - —The Model Process
  - —The Importance of Highly Detailed Target Geometry
- Target Geometry Development
  - —System Representation
  - —Shot-Line Sequence
  - —Conversion of Vendor CAD Files
  - —Building High-Fidelity CAD Geometry
- Conclusions

Analysis Background

• All vulnerability/lethality efforts follow the same “general” analysis procedures.

• Inputs, models, and methodologies are tailored to fit particular needs of the customer:
  — acquisition decisions (PMs / PEOs, LFT&E Community)
  — system design / armoring initiatives (PMs, rapid fielding initiatives)
  — personnel survivability studies (PMs / PEOs)
  — AoAs, Army Studies (AMSAA, TRADOC, CAA)
  — weaponeering decisions (JTCG)

• Fidelity of analysis varies from a high level of detail, as in component-level analyses, to a lower level of detail as dictated by customer requirements.

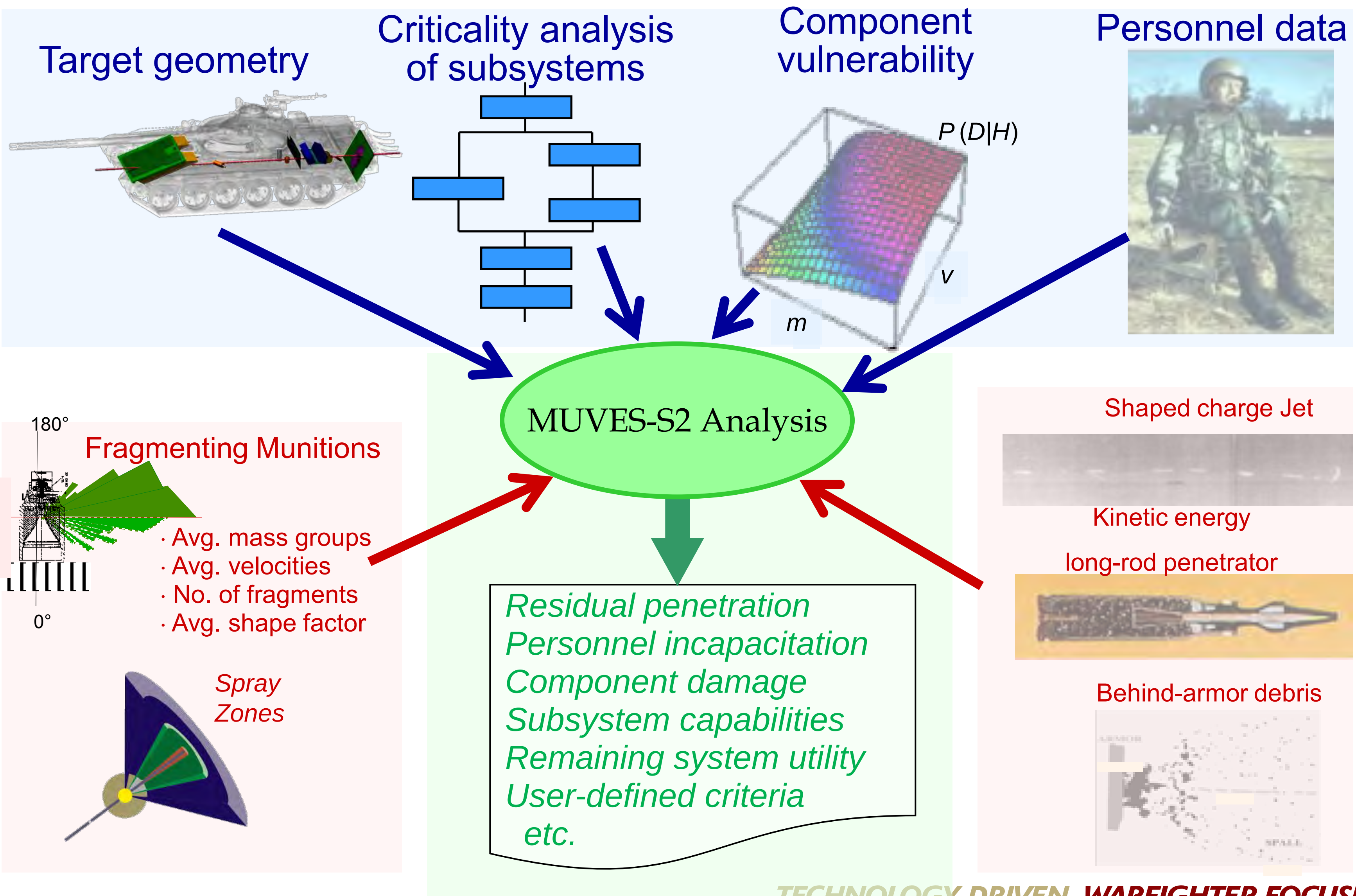
• Benefits of modeling and simulation (M&S) to the LFT&E community:
  — Provides a “global” interrogation of the target, utilizing results of live-fire events to validate MUVES-S2 M&S results.
  — Supplements (not substitutes) the LFT&E process with a more global interrogation of the vehicle.

• Results are highly dependent on the fidelity of the inputs.
  — Computer aided design (CAD) geometry is the foundation of these inputs.

US ARMY RDECOM

Modeling Process Overview

The MUVES-S2 Model for Ballistic Vulnerability/Lethality Analysis



The Model Process

Construct 3-D solid-geometry model of system
- Native CAD Conversion (Vendor Provided)
- Vehicle Interrogation (Measure/Build – Metrology)

→ Target Geometry Development

Characterize target/threat interaction
- Penetration Tests
- Behind-Armor Debris Tests
- Shock/Pressure Characterization

→ Threat/Armor Characterization

Model effect of damage on components
- Component Tests for Various Damage Effects

Characterize effect of component failure on subsystem capability (Fault trees)
- Controlled Damage Tests
- Subsystem Tests
- Intelligence Data
- Manuals

→ Engineering Criticality Analysis

Characterize system functionality (Mobility, Firepower,…)

→ Analysis Input/Output & Deliverables

The Importance of Highly Detailed Target Geometry

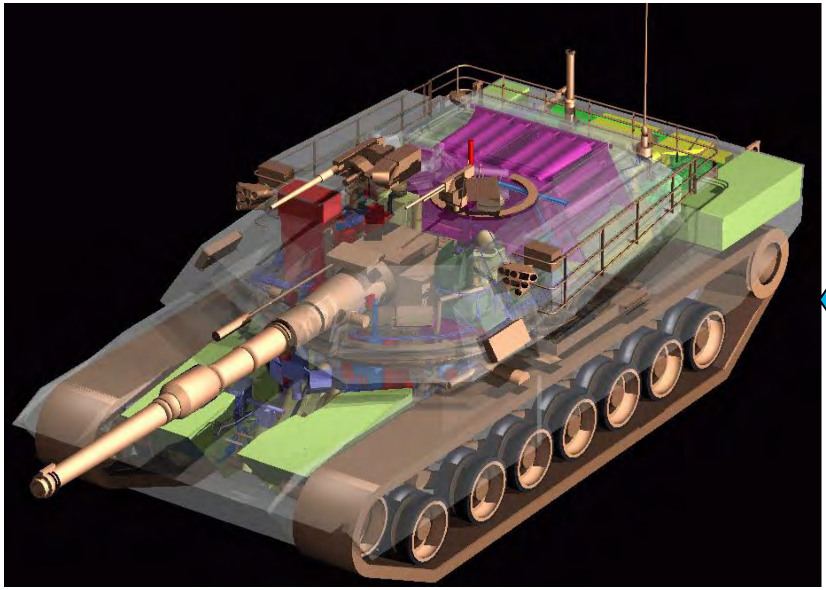
- MUVES-S2 analyses interrogate the target utilizing multiple shot-lines. Examples include:
    — Artillery rounds create multiple shot-lines that generate more opportunity to interact with subtle details of the geometry.
    — Behind armor debris evaluates interior components of the vehicle as the threat and all secondary effects interact with the vehicle geometry.

- Accurate geometry is essential to generate quality results.

Target Geometry Development

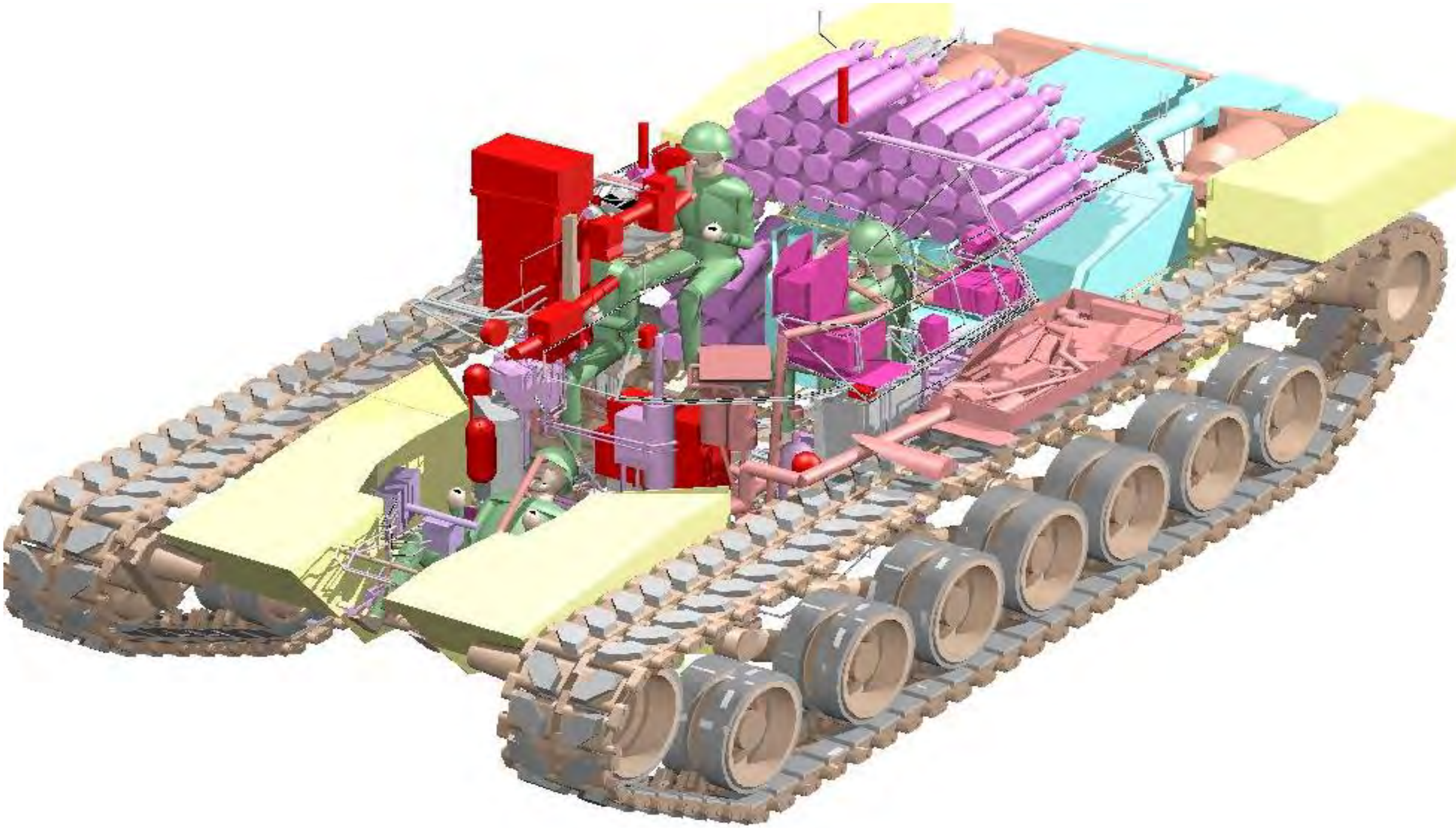
System Representation

Abrams Tank on Aberdeen Test Center Test Pad

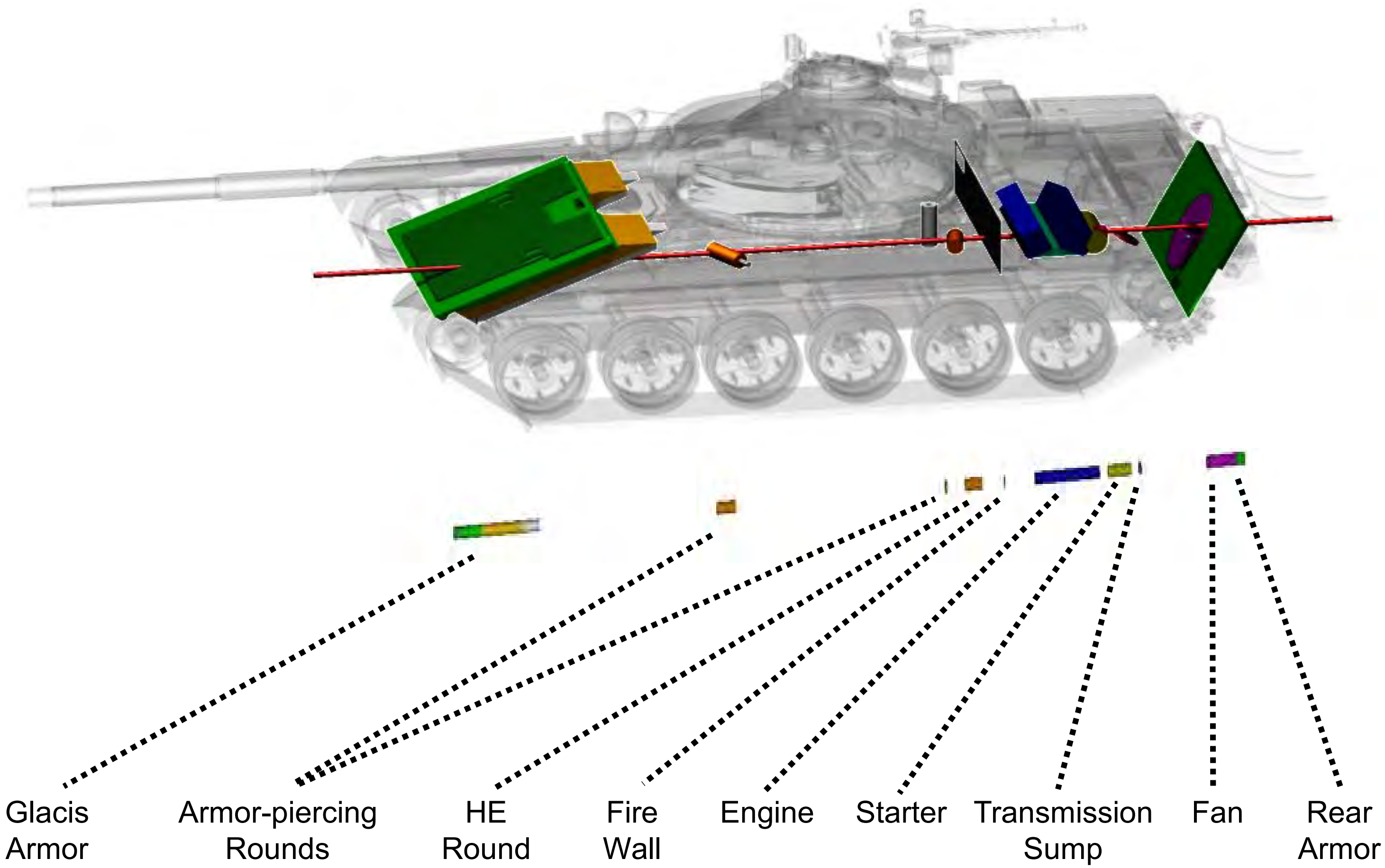


Construct 3D solid geometric model of system

High-Detail BRL-CAD™ Representation



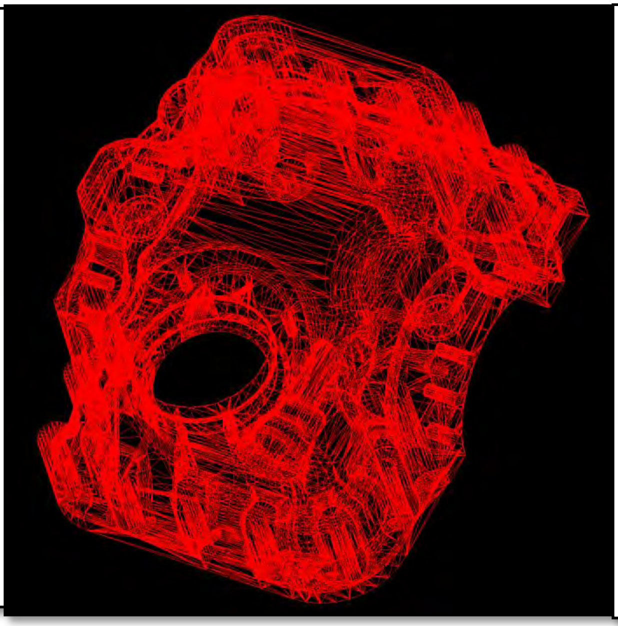
Sample Shot-Line Sequence



Conversion of Vendor CAD Files

- Native CAD files provide ARL/SLAD with higher resolution source data that facilitates the conversion into higher resolution BRL-CAD™ for M&S analyses.
  - — Vendor CAD files are preferred method of geometry development.
  - — ARL/SLAD has the tools to receive and convert multiple formats of CAD.

Vendor Provided Pro/E CAD



Wireframe Model

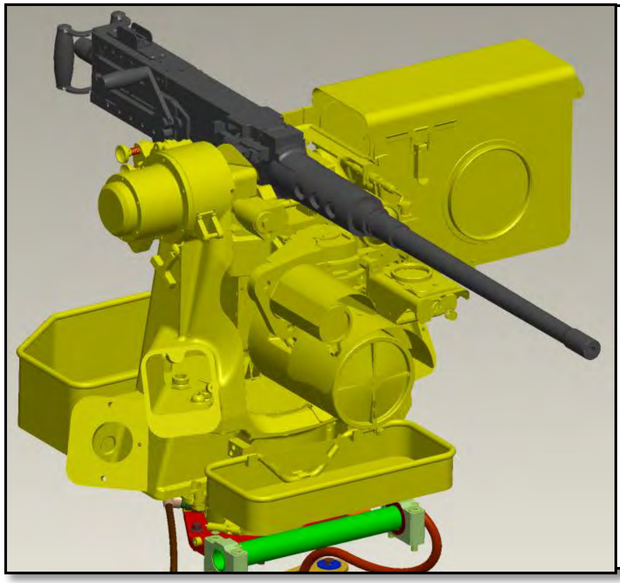
Final BRL-CAD™ Rendering

Conversion of Vendor CAD Files

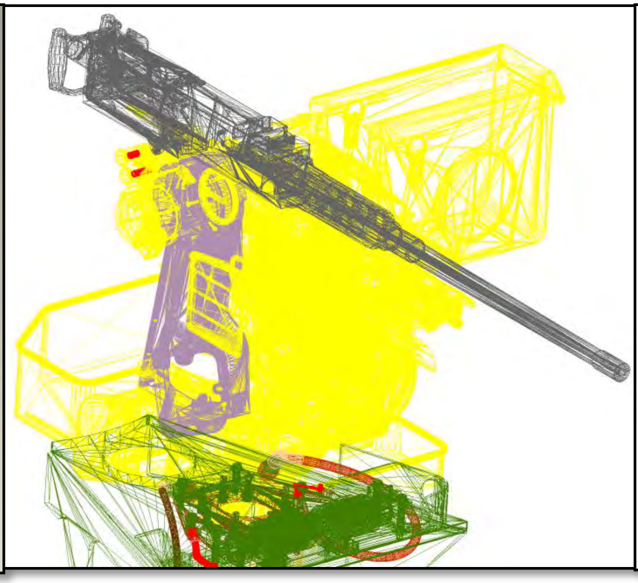
• A highly detailed component model, comprised of multiple solids, is reliant on a thorough understanding of that component's design.

• The quality of the resulting BRL-CAD™ geometry is highly dependent on the quality of the CAD that is provided.

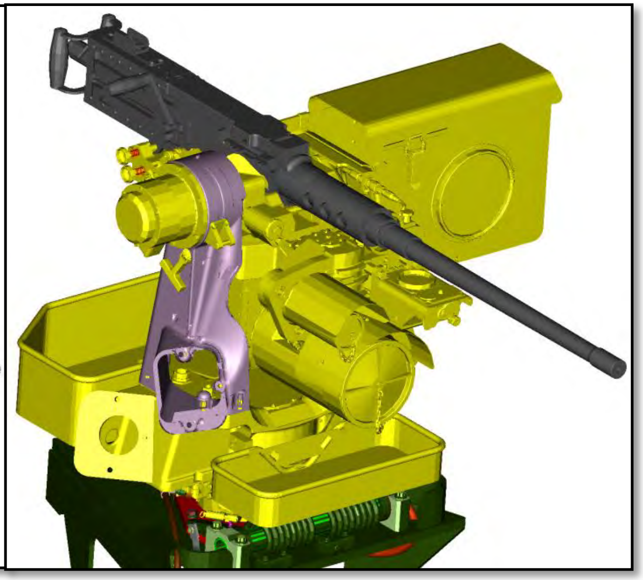
• Accurate component characteristics to include dimensions, thickness, and materials is desired and achievable with CAD files that include more detail than just surfaces (i.e., non-shrink wrapped source CAD).



Vendor Provided Pro/E CAD



Wireframe Model
More detail than just a surface model



Final BRL-CAD™ Rendering

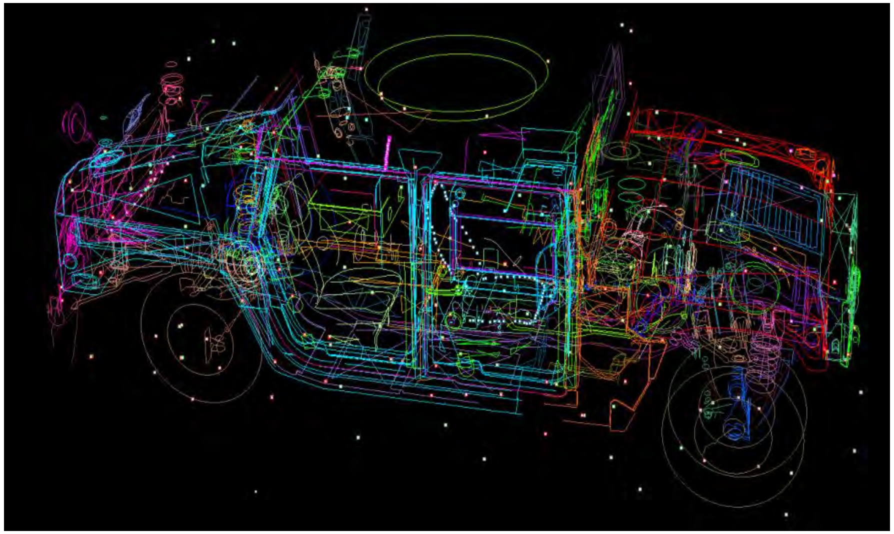
Building High-Fidelity CAD Geometry

• Utilization of various metrology equipment facilitates a high degree of accuracy in data collection.

— This process requires an extended period of time with the vehicle in a "stable" or semi-controlled environment.

— In order for the data collection process to be efficient, multiple personnel with various pieces of equipment are required.

Data Collection on M1151A1 HMMWV in ARL/SLAD Facility



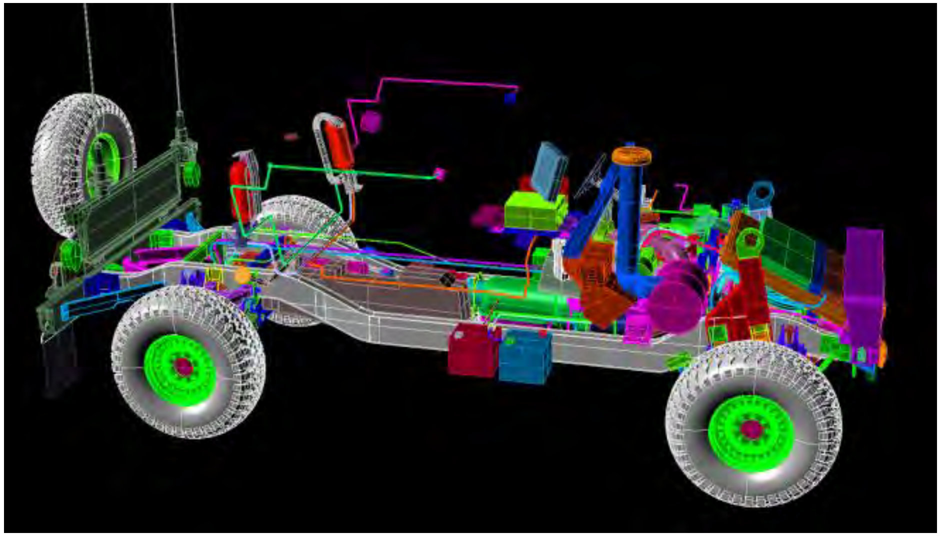
Raw Data Collected In Commercial CAD Software

Building High-Fidelity CAD Geometry

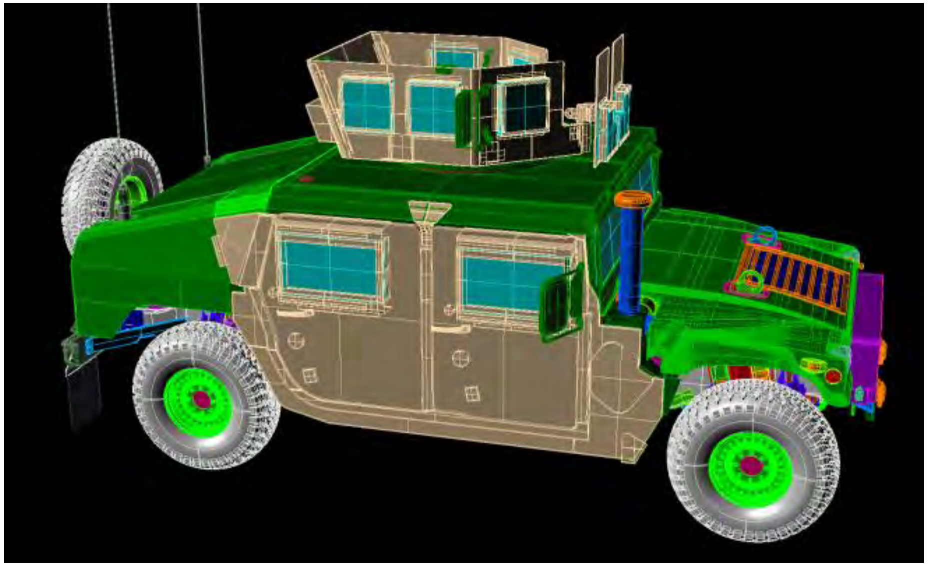
• While not the preferred form of geometry development, data collection through metrology equipment has seen advancements.

— Longer lead-time than conversion, but faster and much more accurate than older "hand measurement" techniques.

— Facilitates conversion from commercial CAD packages to BRL-CAD™ (necessary format for MUVES-S2 simulation).



M1151A1 HMMWV Subsystems Solids in Commercial CAD Software



Completed M1151A1 HMMWV Vehicle in Commercial CAD Software

Conclusions

- Modeling and simulation can supplement, but is not a substitute for, live-fire testing to provide a more thorough evaluation of vehicle vulnerabilities and armor design.
  — Provides a “global” interrogation of the target, saving assets (minimizing cost) as well as maximizing data while minimizing the test schedule.

- Accurate target geometry is the foundation to a MUVES-S2 analysis.
  — Accuracy is achieved by attaining quality vendor CAD geometry to convert into BRL-CAD™.
  — Adequate time on a representative asset is required to facilitate the necessary vehicle interrogation for geometry development.

US ARMY RDECOM

Questions?

Joint Test & Evaluation Methodology Transition (JTEM-T)

Mission Decomposition

An Approach to Enhanced Mission-Based Testing

presented to the

27th Annual National T&E Conference

March 15, 2011

Mr John Smith
JTEM-T Director
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Purpose

- What leads to a successful mission effectiveness assessment?
- How do you set yourself up for a successful design of experiment?

- I'll describe how a mission decomposition process leads to
    - Successful mission effectiveness assessments
    - Improved test design and design of experiments
    - Enhanced mission-based testing

- I'll provide an overview of a structured mission decomposition using the *Measures Development Standard Operating Procedure (SOP)* process steps as an example

Mission Decomposition
What is it?

- Methodology for understanding the contribution of a system under test (SUT) to the system-of-systems (SoS), task, and mission
  - Enables quantitative measurement of system and task(s)
  - Offers the ability to qualitatively evaluate the mission
- Disciplined and repeatable process for developing relevant mission, task, and system measures
  - Documented, methodical, and thorough
  - Therefore, it is not reliant on corporate knowledge
- An objective mission-based approach to designing vignettes
- A process to enhance requirements generation, capability development, and testing

Focused on the ability of the warfighter to perform tasks and achieve mission desired effects

Mission Decomposition
So What?

- Moves the focus from a "systems only" approach to one that deliberately addresses task and mission
- Enables sufficient conclusions of a system's impact on combat mission effectiveness
  - Decomposes a warfighting mission
  - Traces system, task , and mission relationships to warfighter requirements
- Enhances mission-based testing
  - Understanding the mission and task(s) enables better understanding of the system contribution to the warfighter and the mission
  - Better definition of test priorities (critical vs. "nice to have" measures)
  - Helps confirm that an identified gap has been successfully addressed
    - System-specific attributes alone will not do this

Identifies the right measures to answer the right questions at the right time

Mission Decomposition
An Enabler for DOE

- Assists with defining the problem
  - Based on a capability gap derived from a mission/task analysis
  - Mission, effects, capabilities
- Helps determine dependent and independent variables
  - Measures of mission effectiveness and task performance
  - Conditions of the environment, threat, and joint
- Scopes test design directly to the SUT capability gap
  - Leads to evaluating warfighter gap(s)
  - Supports scenario/vignette selection
  - Drives data requirements, test methods, and resource requirements
- Places focus of the design on warfighter requirements

"Not everything that can be counted counts and not everything that counts can be counted." – Albert Einstein

Mission Decomposition

Major Elements

Does your evaluation approach provide a way to determine system impact on task and mission?

- Mission Statement
- Objectives
- Desired Effects

- Tasks
- Sub-tasks
- Nodes

- Desired Effects attributes
- Task attributes
- SWarF attributes

- Attribute measures for mission and tasks

- Traceability of system attributes to task and mission desired effects

Mission Description

Describe the mission in terms of objectives and desired effects (outcomes).

- Identify the Mission Statement(s), Objectives and Desired Effects from authoritative sources:
  - JCIDS documents (ICD, CDD, CPD)
  - Analysis of Alternatives
  - Joint Mission Thread (if available)
  - Joint/Service Doctrine/CONOPS
  - SME input

Task Description

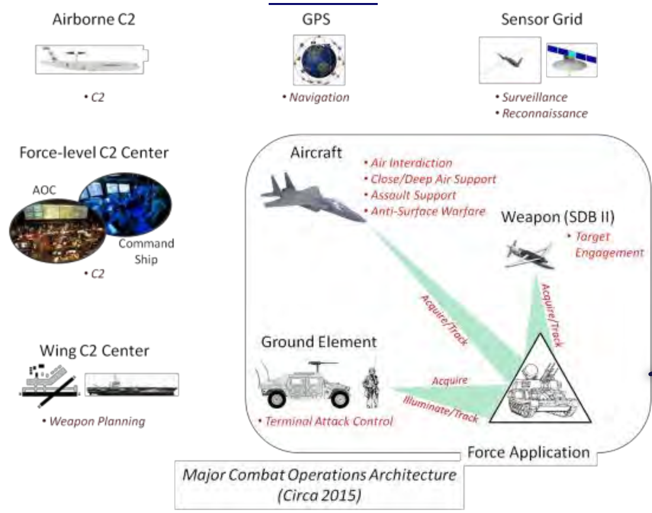
Decompose the mission into relevant tasks.

- Mission(s) decomposed to tasks (activities) and sub-tasks with key nodes identified
  - Functional performers/roles identified that perform the mission
  - Nodes identified as the "means" to performing tasks (e.g. from DoDAF products, joint mission threads, joint publications, CONOPS)
  - UJTLs and Service task lists may be included

Task Description
Example

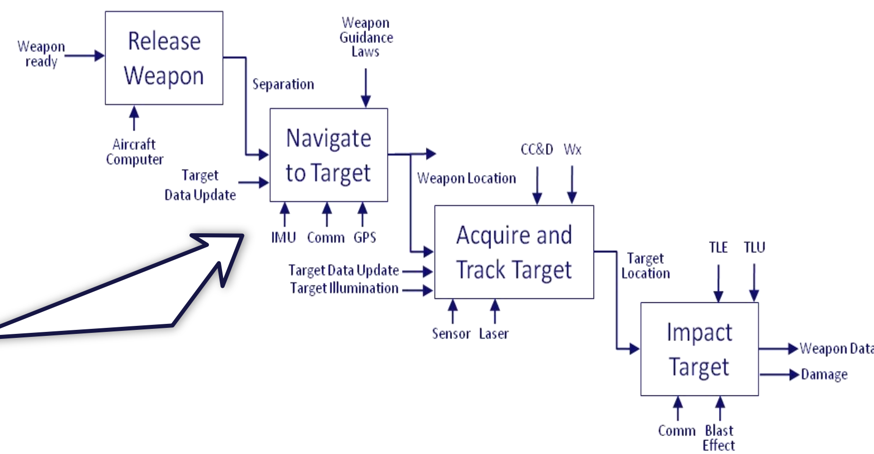
Decompose the mission into relevant tasks.

Nodes



SDB OV-1

Tasks (segment of the thread)



SDB OV-5b

Mission & Task Attributes

Identify the attributes (characteristics) of desired effects and tasks.

- Important and relevant characteristics of Desired Effects and Tasks are identified
- JCIDS prioritized list of capability attributes for enabling JCAs (the SWarF list: Battlespace Awareness, C2, Net-centric, Logistics)
- Dimensions of performance attributes (time, space, quality, action, etc) are directly linked to task and sub-task descriptions

Mission & Task Attributes

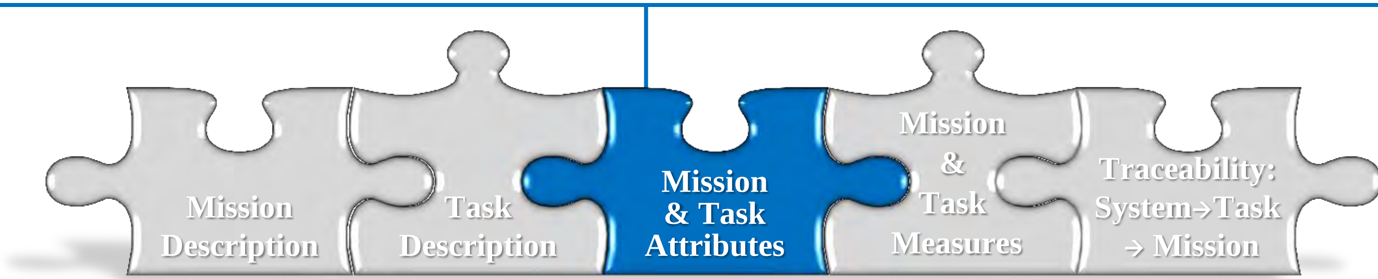
Example

Identify the attributes (characteristics) of desired effects and tasks.

	Task/Sub-Task Attributes			
Operational Task/Sub-Tasks	Accurate	Timely	Networked	Lethality
A5. Engage Mobile Target				
A51. Release Weapon		X	X	
A52. Navigate to Target	X		X	
A53. Acquire and Track	X		X	
A54. Impact Target	X			X
A6. Assess Effectiveness	X	X		

Matrix #5: Operational Task/Sub-Tasks vs Task/Sub-Task Attributes

Table showing SDB task/sub-tasks vs attributes



Mission & Task Measures

Ensure there are separate measures for the military effect (mission accomplishment), task performance, and system function.

- Mission Measures
  - Should assess an attribute of a desired effect
  - Consists of a scale and a description
- Task Measures
  - At least one measure for each task-attribute pairing (more may be required)
  - In addition to JCIDS, may come from the joint/service task lists (UJTL, UNTL, etc)

Mission & Task Measures

Example

Ensure there are separate measures for the military effect (mission accomplishment), task performance, and system function.

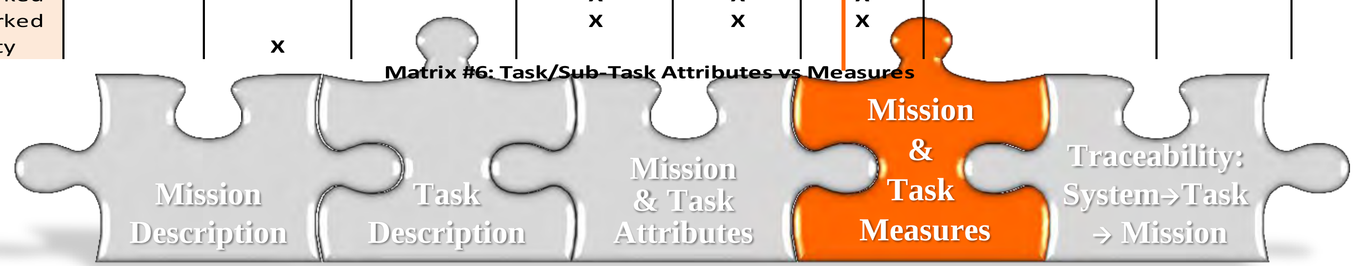
Objectives: 1) Achieve battlefield effects against Mobile Targets 2) Minimize Undesired Effects

	Measures				
Attributes	Percent of actions where CAS was employed and effectively reduced risk to attack	Time to effectively conduct CAS against mobile targets	Percent of CAS missions where fratricide (including bodily harm) occurred as a direct result of CAS	Percent of CAS missions where collateral damage from CAS was acceptable	Percent of systems integration that are successful
Precision	X		X	X	
Lethality	X				
Timeliness		X			
Flexibility	X				X

Matrix #3: Desired Effects Attributes vs Measures

	Task/Sub-Task Measures								
Attributes	Impact distance to center of target	Probability of Single Shot (Pssk)	Pct post release comm acknowledge	Pct successful target updates & retargeting	Pct successful weapon location updates	Pct successful weapon aborts	Avg delta in actual target location & weapon data target location	Pct accurate Bomb Hit Indication reports	Avg time to correctly assess BDA
A52. Accuracy							X		
A53. Accuracy							X		
A54. Accuracy	X						X		
A61. Accuracy								X	
A61. Timeliness									X
A51. Networked			X						
A52. Networked				X	X	X			
A53. Networked				X	X	X			
A54. Lethality		X							

Matrix #6: Task/Sub-Task Attributes vs Measures



Mission/Task/System Traceability

Ensure system attributes are traceable to task and mission.

- The ICD has a Capability Gap table that connects capabilities (task-based) with attributes and metrics (standards for assessment)
- Look for a connection between the measured system attributes (KPPs, KSAs, others) and the capability gap as expressed in the ICD

Mission/Task/System Traceability Example

Ensure system attributes are traceable to task and mission.

Priority	Tier 1 & 2 JCA	Description	Measure	Minimum Value	KPP, KSA, other attributes
1	e.g. Force Application Engagement	Capability 1			
		--Attribute 1	Description	Value	6.1, 6.2
		--Attribute *n*	Description	Value	6.2, 6.3, *n*
2	e.g. Force Application Engagement	Capability 2			
		--Attribute 1	Description	Value	6.1, 6.2. 6.3
		--Attribute *n*	Description	Value	6.4, 6.5, *n*

ICD Capability Gap table with system attributes traced to task.

Mission Decomposition Benefits

- Disciplined, repeatable, and sufficient process for developing mission, task, and system measures for testing
  - The *Measures Development SOP* provides this process
- Enables objective understanding of a system's contribution to the SoS, task performance, and mission effectiveness
- Provides traceability to warfighter requirements
- Enables validation of capability gap closure
- Moves the focus from "system only" to task and mission
- Helps design tests in accordance with the mission
- An enabler for Design of Experiments
- Enhances mission-based test design

Enables sufficient conclusions on combat mission effectiveness

Questions

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US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Evaluation of Collateral Hazards to Personnel from Active Countermeasures

27th Annual National Test and Evaluation Conference

14-17 March 2011

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Stephen P. Swann
Patricia S. Frounfelker
Gregory K. Dietrich

U.S. Army Research Laboratory
Survivability/Lethality Analysis Directorate

Agenda

- Introduction and Terminology
- Data Collection
- Data Analysis
  – Characterizing Each Fragment
  – Characterizing Events
- Conclusions

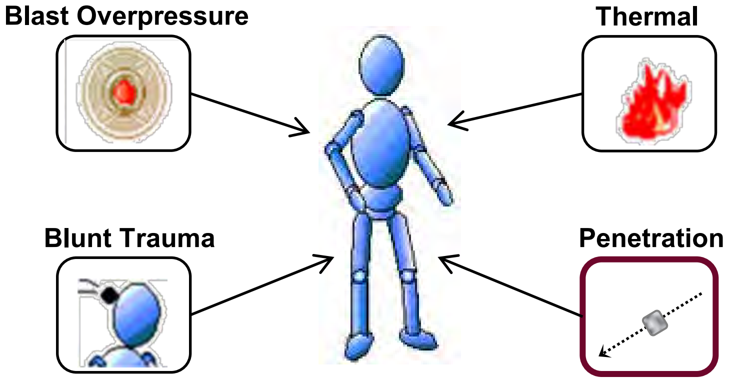
Example Vehicle Active Countermeasures (ACMs):

Reactive Armor

Active Protection System (APS)

Primary injury mechanisms for dismounted personnel:

- **Penetrating fragments**
  - **Injuries range from superficial skin penetration to maximum levels of trauma**
  - **Severity depends on size, density, velocity, and shape of penetrating fragments**
- Blast overpressure (BOP)
  - Lung damage
  - Eardrum rupture
- Blunt trauma
- Thermal energy



Terminology

Casualty (Joint Pub 1-02)**:**

Any person who is lost to the organization by reason of having been declared dead, duty status - whereabouts unknown, missing, ill, or injured

Injury:

Defined with the **Abbreviated Injury Scale (AIS) © ***. AIS is an anatomically-based, consensus-derived, international severity scoring system that classifies each injury by body region according to its relative severity on a 6-point ordinal scale. AIS scores each single injury. For multiple injuries, **Maximum Abbreviated Injury Score (MAIS)** is used as a anatomical measure of injury severity. The MAIS is between 0 and 6.

Our **threshold of unacceptable risk for crew and dismounted troops** is a **serious injury (AIS3)**. A serious injury is one that requires immediate medical attention. Untreated serious injuries could cause deterioration resulting in loss of life.

Our **threshold of unacceptable risk for civilians** is a **minor (AIS1) or moderate (AIS2) injury**. Minor/moderate injuries range from superficial to those that are fully reversible given medical attention and pose little threat to loss of life.

Personnel who exceed these thresholds of unacceptable risk would be considered a ***medical casualty***.

Incapacitation:

The inability to perform, at a level required for combat effectiveness, the physical or mental tasks required in a particular role at a specific time after wounding. Incapacitated personnel are impaired to a level below minimal capabilities and are considered an ***operational casualty*****.**

* Abbreviated Injury Scale © 2005 Updated 2008, AAAM, Des Plaines, IL, 2008.

Terminology

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MAIS	Injury Level	Head Injury Example	Type of Injury
0	None	No injury	None
1	Minor	Minor laceration of scalp	Superficial
2	Moderate	Major laceration of scalp	Reversible injuries; medical attention required
3	Serious	Fracture of skull	Reversible injuries; hospitalization required
4	Severe	Depressed skull fracture, penetration > 2 cm	Non-reversible injuries; not fully recoverable without medical care
5	Critical	Depressed skull fracture, laceration of spinal artery	Non-reversible injuries; not fully recoverable with medical care
6	Maximal	Massive brain stem crush	Virtually Unsurvivable

Threshold of Unacceptable Risk for Non-Combatants (between MAIS 0 and 1)

Threshold of Unacceptable Risk for Dismounted Troops (between MAIS 2 and 3)

Personnel who exceed these thresholds of unacceptable risk would be considered a ***medical casualty***.

Incapacitation:

The inability to perform, at a level required for combat effectiveness, the physical or mental tasks required in a particular role at a specific time after wounding. Incapacitated personnel are impaired to a level below minimal capabilities and are considered an ***operational casualty*.**

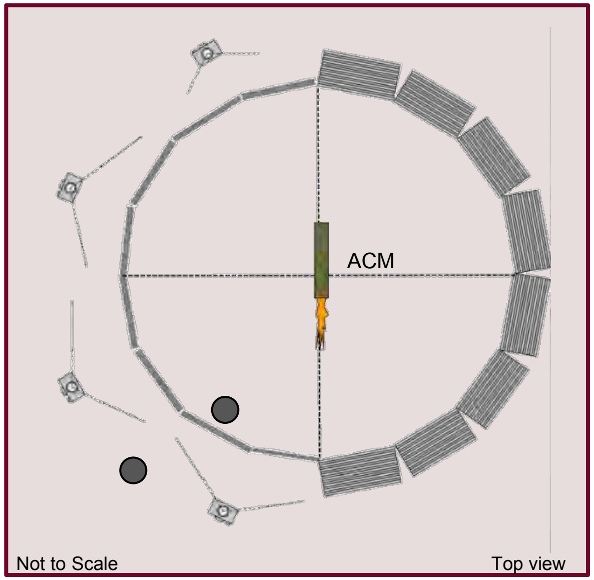
* Abbreviated Injury Scale © 2005 Updated 2008, AAAM, Des Plaines, IL, 2008.

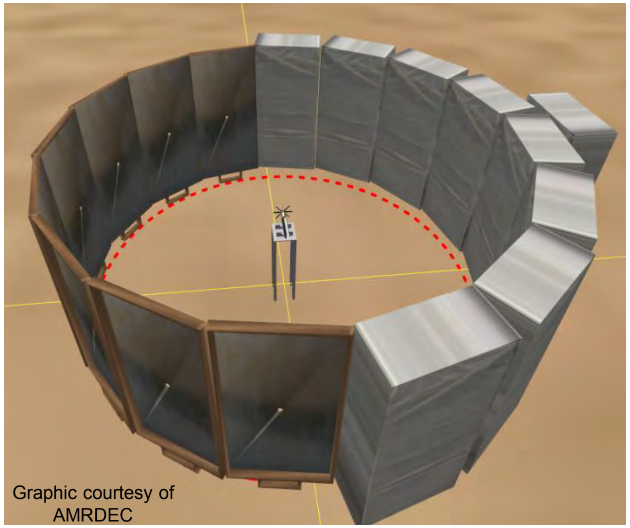
Objectives for Testing and Analysis

- Design cost-effective tests to capture primary damage mechanisms
- Define collateral hazards in terms of Probability of Injury (*P(I)*) – given a shot, given a hit, etc.
- Quantify and assess the hazards from penetrating insults and BOP for 1) the ACM, 2) the threat, and 3) the interaction of both
  - Map fragment spray of CM and threat
  - Determine probability of injury as a function of distance from detonation point
  - Determine where injury potential becomes negligible
- Compare hazards caused by different ACM solutions
- Caveats:
  - Based on a limited number of test events (typically time and funding do not permit statistically strong test matrices)
  - Limited to the test conditions
  - Not a safety assessment

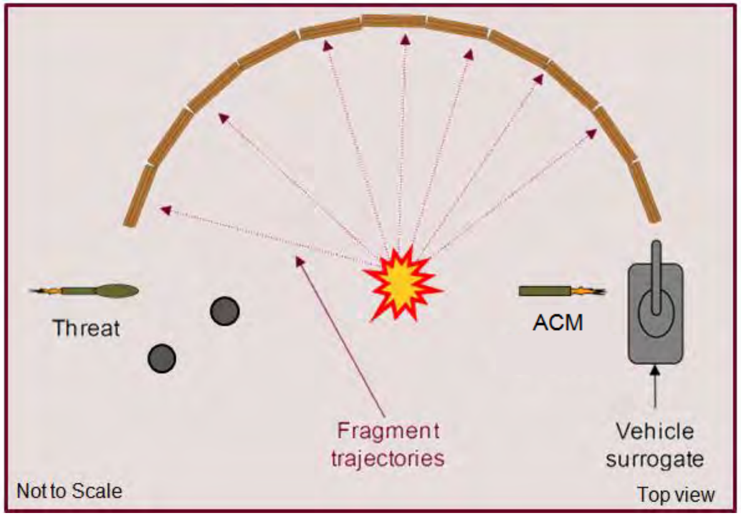
Test Configuration

Full-Scale Arena Events





Modified Arena Events

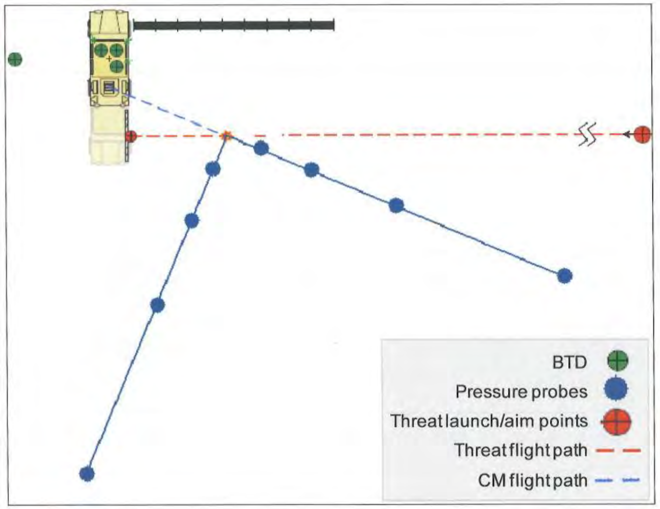


Data Analysis: Characterizing BOP

BOP Instrumentation:

- BTD
  - Arranged inside the vehicle
  - Arranged outside the vehicle if blast is main damage mechanism
- Free Field Blast Pressure Probes
  - Used in static arena tests
  - Used in dynamic flight tests if there is a high likelihood of fragmentation
    - Arranged outside of the vehicle
    - Assumed linear trajectories from single point of origin

Operational Requirement-based Casualty Assessment (ORCA) Model:



- Embedded INJURY 8.2 model used to predict lung tissue damage
- Embedded Department of Energy (DoE) auditory injury criterion used to predict ear drum rupture
- Pressure-time history traces from each location are used as inputs
- Personnel are modeled without hearing protection facing the direction of blast

Data Analysis: Characterizing Fragment Effects

ORCA Model:

Inputs:

- Uses fragment characteristics and the simulated dismounted troop properties
  - Fragment properties:
    - Mass
    - Striking velocity
    - Shape factor
    - Material density
  - Personnel properties:
    - Posture (i.e., standing, kneeling, prone)
    - Unarmored (without Personal Protective Equipment (PPE)) and Armored (With PPE)
    - Job or Combat Role

Assumptions:

- Probability of hit = 1
- Hit could have occurred anywhere on the body

Outputs:

- Models injuries caused by each shot line to provide severity characterization from each fragment
  - Probability of a serious or greater injury given a hit ($P(MAIS \geq 3 | hit)$)
  - Probability of a moderate or greater injury given a hit ($P(MAIS \geq 2 | hit)$)
- Models incapacitation for a particular combat role at a given post-wounding time

Notional results

Fragment A $P(MAIS \geq 3 | hit) = 0.2$

Fragment B $P(MAIS \geq 3 | hit) = 0.5$

Fragment C $P(MAIS \geq 3 | hit) = 0.8$

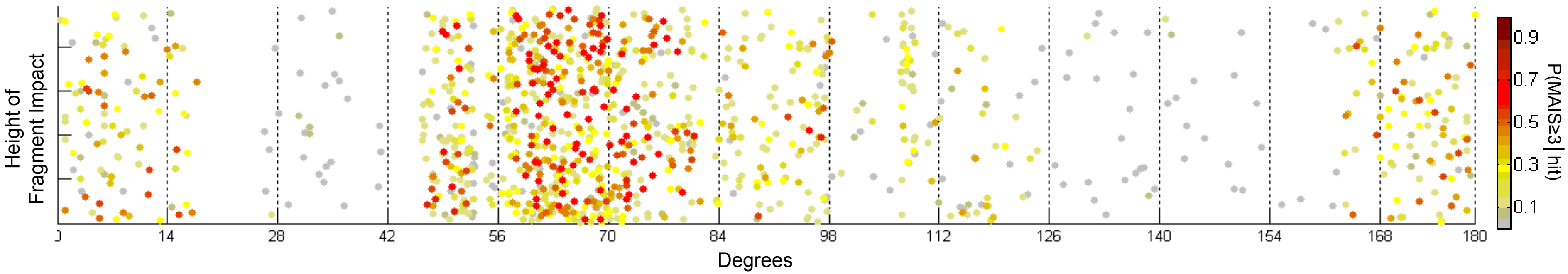
MAIS	Injury Level
0	None
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximal

Injury plots modeled using same fragment threat conditions with a uniform grid of shot lines in a front-only view with zero degrees azimuth and elevation

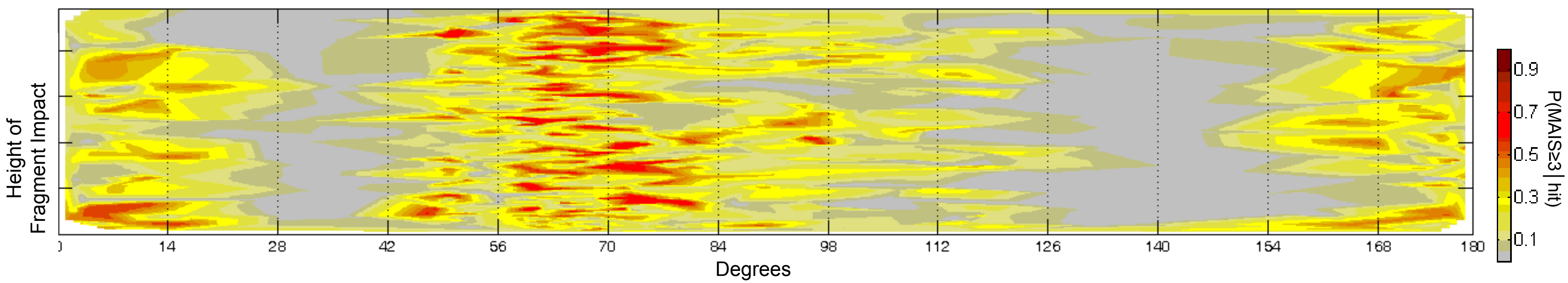
Example Analysis:
Characterizing Dispersion and Areas of Concern

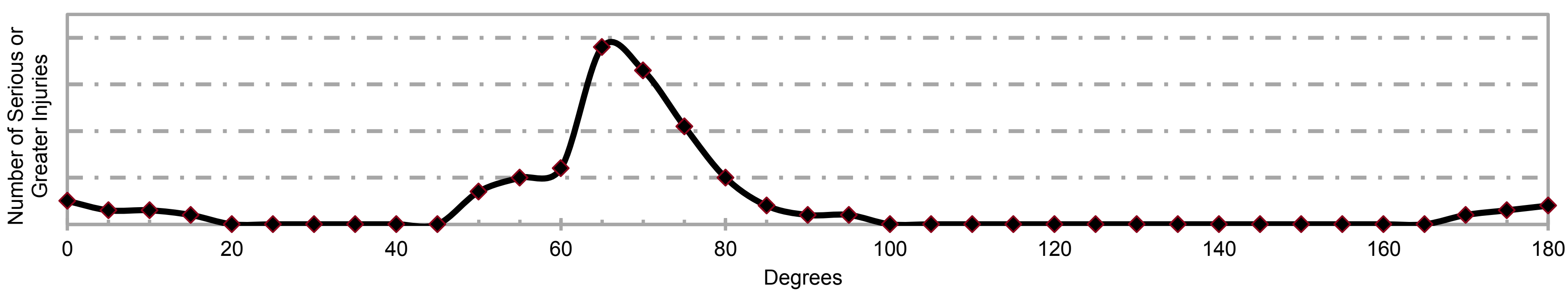
Notional results

Fragment Dispersion



Areas of Most Concern

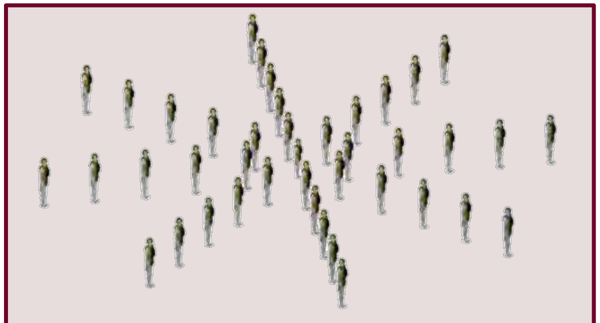




Data Analysis: Characterizing Each Trajectory

MUVES-S2/ORCA:

- Uses fragment characteristics, fragment trajectories, and a dismounted troop target array as inputs
  - Fragment trajectories:
    - Based on impact locations on panels
    - Assumed linear trajectories from single point of origin
  - Troop target arrays:
    - Polar array around detonation point
    - Grid array
    - Concentric array: facing detonation, along an 180 degree arc
    - Custom array variables:
      - Soldier postures
      - Distances away from ACM-threat interaction
      - PPE protection levels
      - Level, slanted, or uneven terrain
- Models each event's discrete trajectories
- Models velocity retardation from air drag for each distance
- Computes an injury or incapacitation level as a result of each fragment trajectory at each distance



Example Polar Array

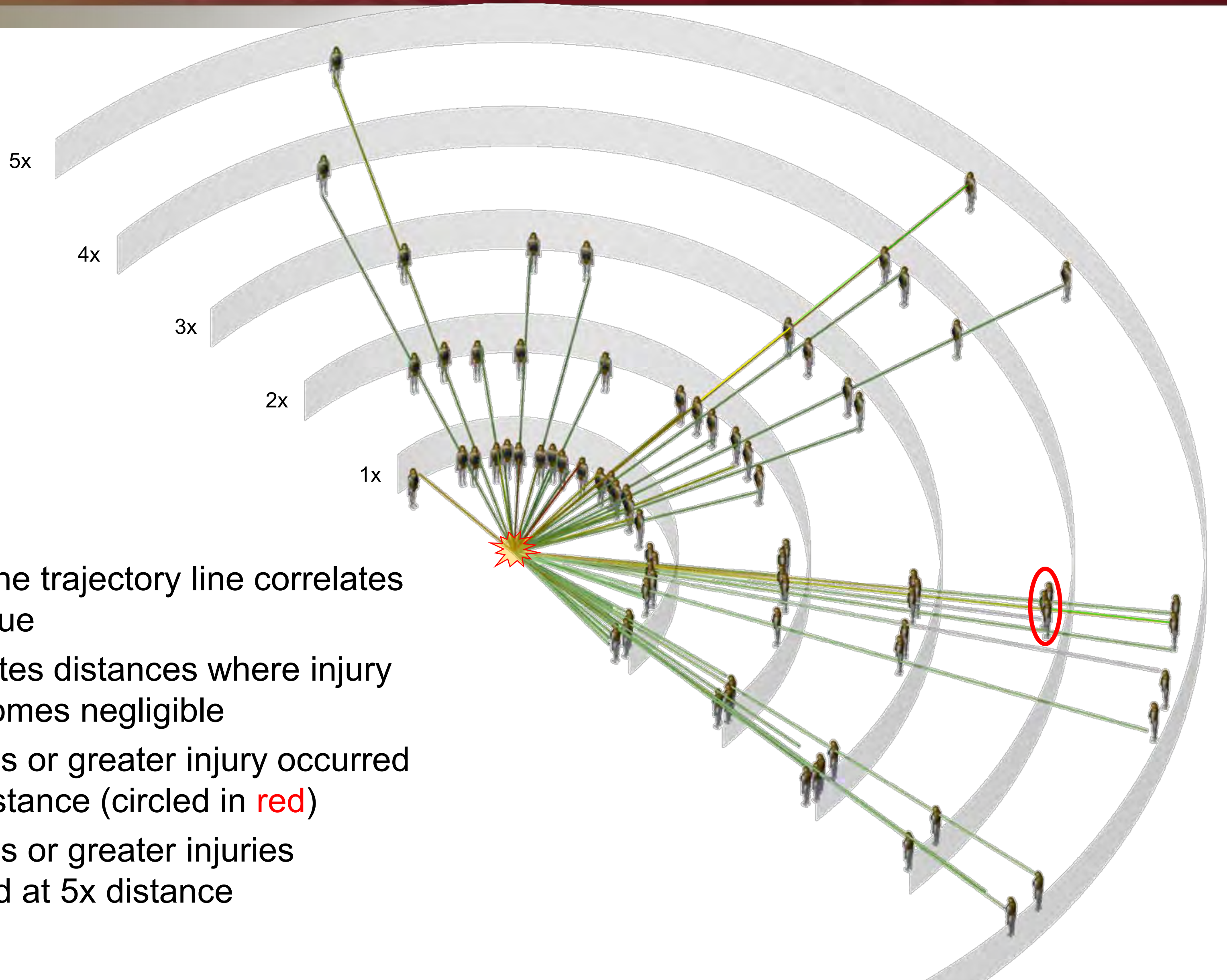
Example Grid Array

Example Concentric Array

Example Analysis: Characterizing Each Trajectory

Notional results

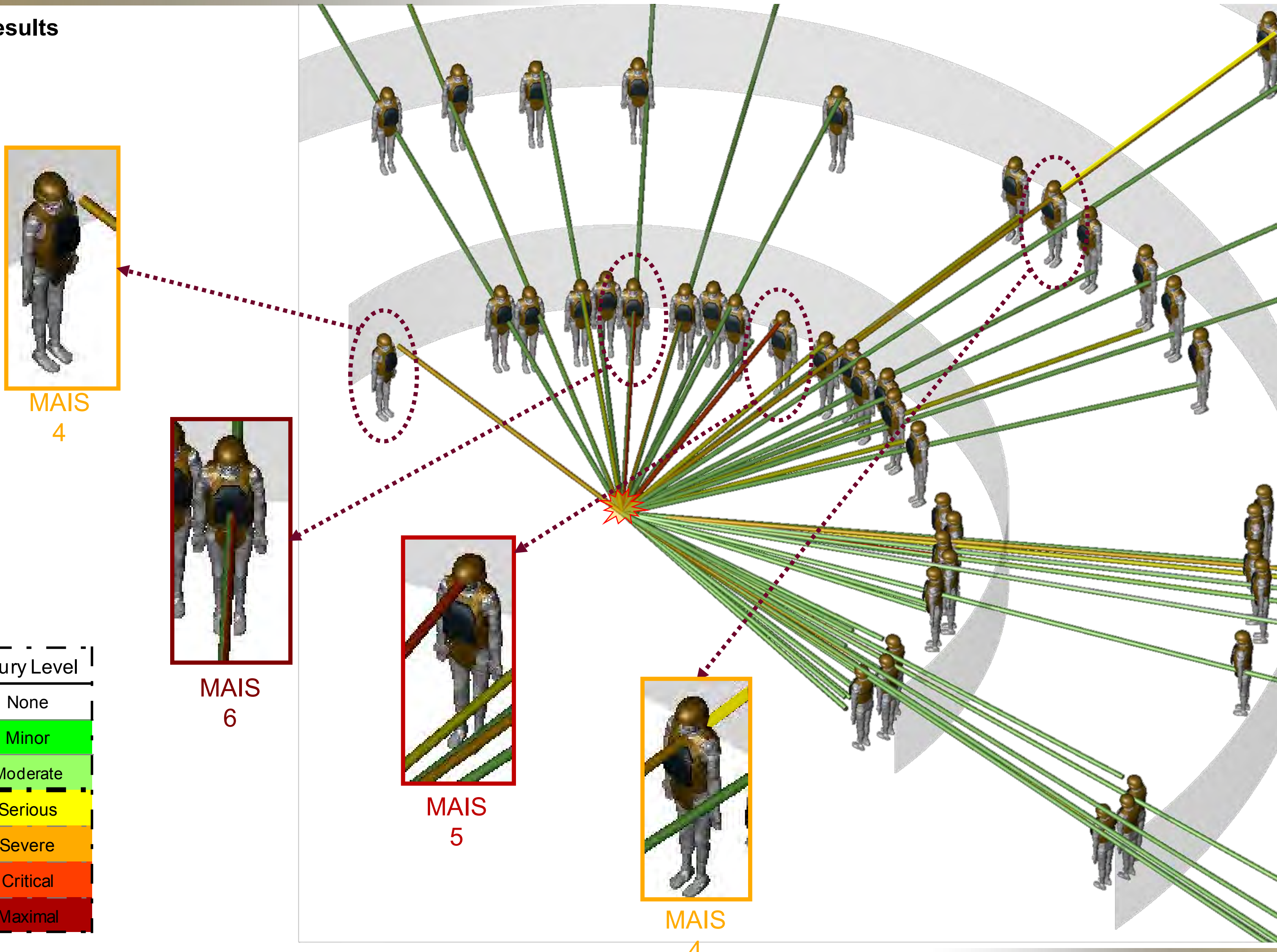
MAIS	Injury Level
0	None
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximal



- The color of the trajectory line correlates to a MAIS value
- Figure illustrates distances where injury potential becomes negligible
  - 1 serious or greater injury occurred at 4x distance (circled in red)
  - 0 serious or greater injuries occurred at 5x distance

Example Analysis Continued: Characterizing Each Trajectory

Notional results



MAIS	Injury Level
0	None
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximal

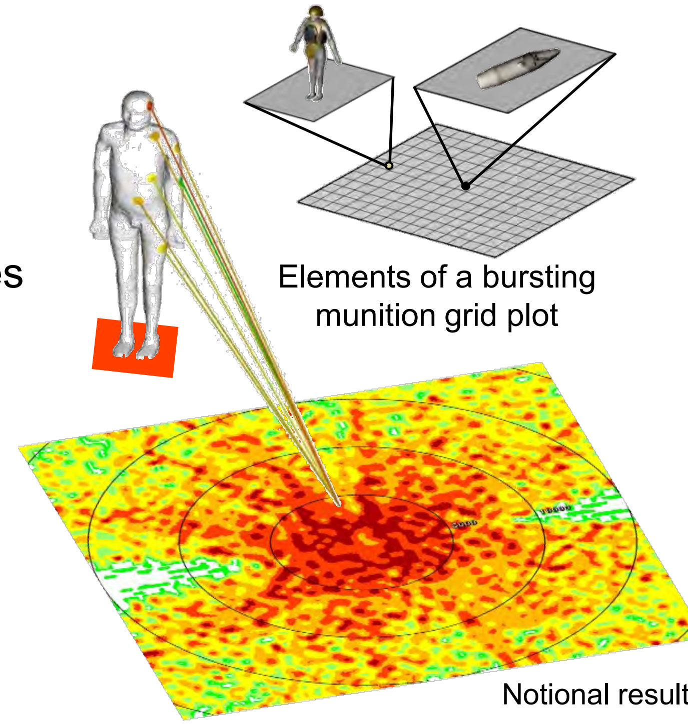
Data Analysis:
Characterizing Hazards Using MUVES-S2/ORCA

- Uses fragment characteristics, fragment trajectories, and a dismounted troop target array as inputs
  - Fragment trajectories:
    - Impact locations on panels from discrete events
    - Z-data file from arena test of ACMs and/or threats
  - Troop target arrays:
    - Typical arrays are grid arrays
    - Each dismounted Soldier in the array is independently evaluated for every cell
    - Custom array variables:
      - Soldier postures
      - Distances away from ACM-threat interaction
      - PPE protection levels
      - Level, slanted, or uneven terrain
      - Job or Combat Role
- Computes an injury or incapacitation level at various distances
- Sample analysis outputs:
  - MAIS value
  - Probability of a serious or greater injury given a hit
    (P(MAIS> 3 | hit))
  - Probability of a minor or greater injury given a hit
    (P(MAIS> 1 | hit))
  - Probability of hit
  - Vehicle outputs: Pk, Fkill, Kkill, Mkill


Example Target Array

Target: Dismounted Personnel

Threat: Fragmenting munition

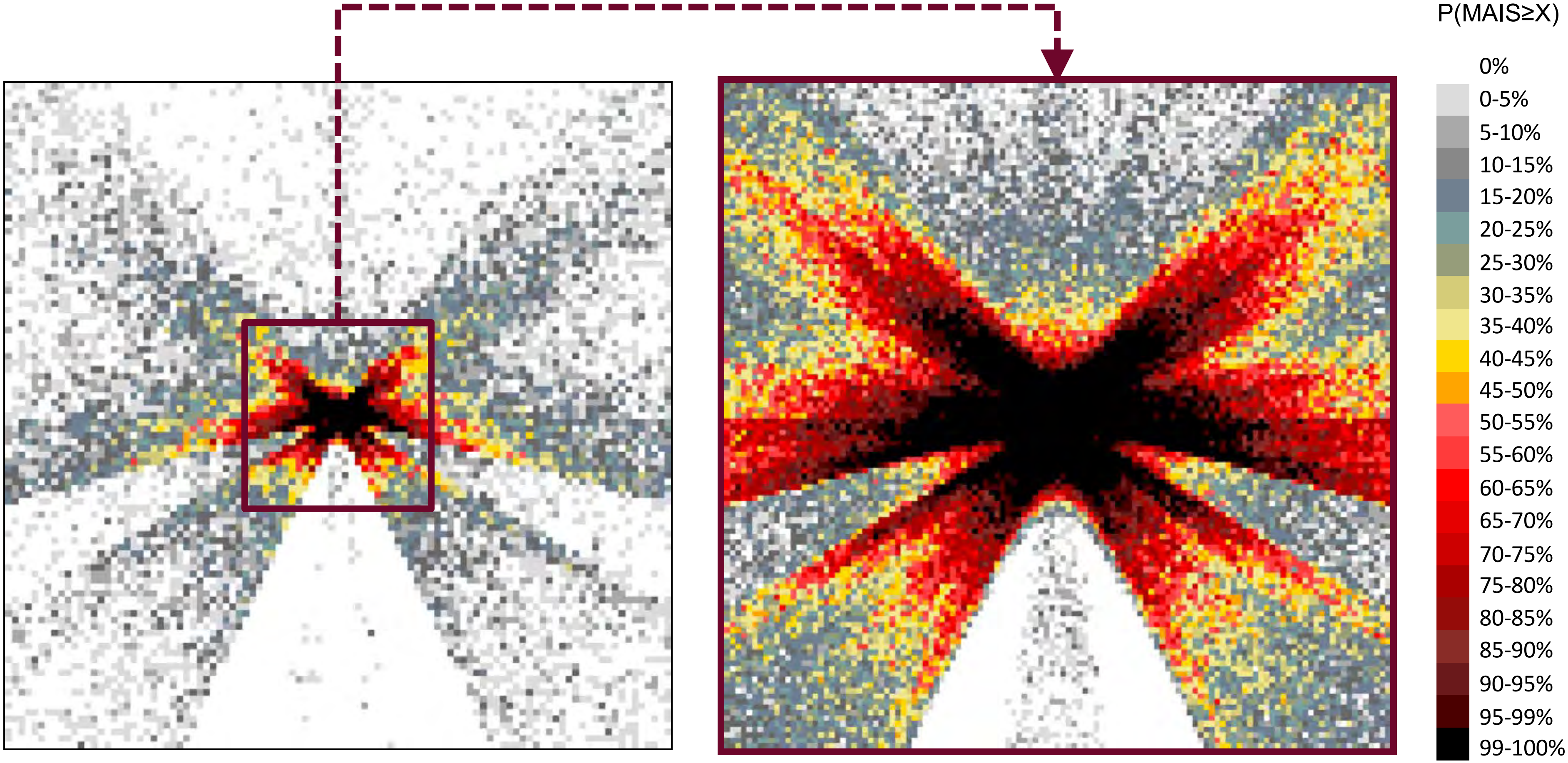


Elements of a bursting munition grid plot

Notional results

Example Analysis: Characterizing Events Examples

Notional results

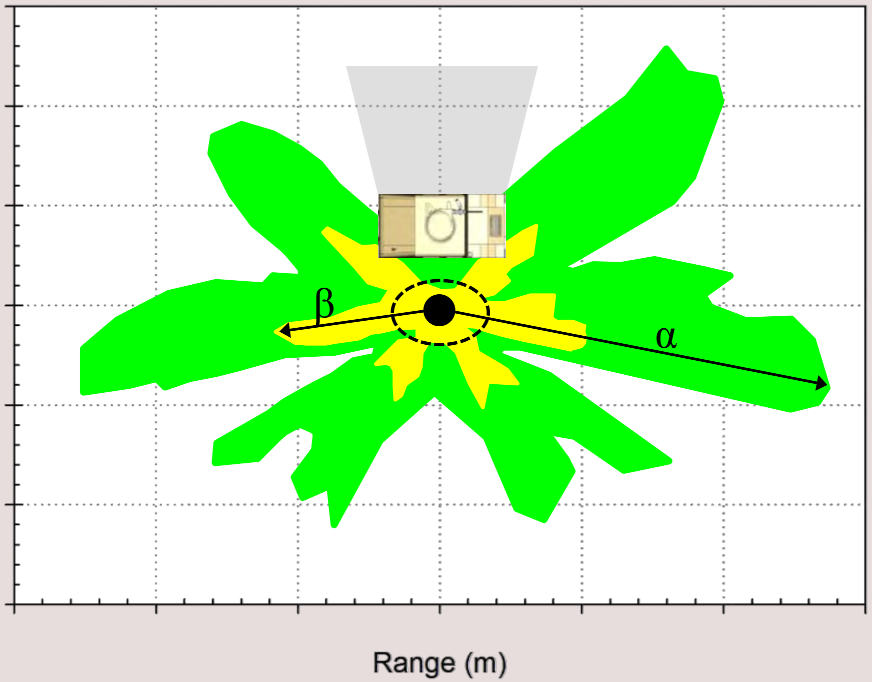


Low Resolution – Large Grid **High Resolution – Small Grid**

Example Analysis: Summary of Collateral Hazards

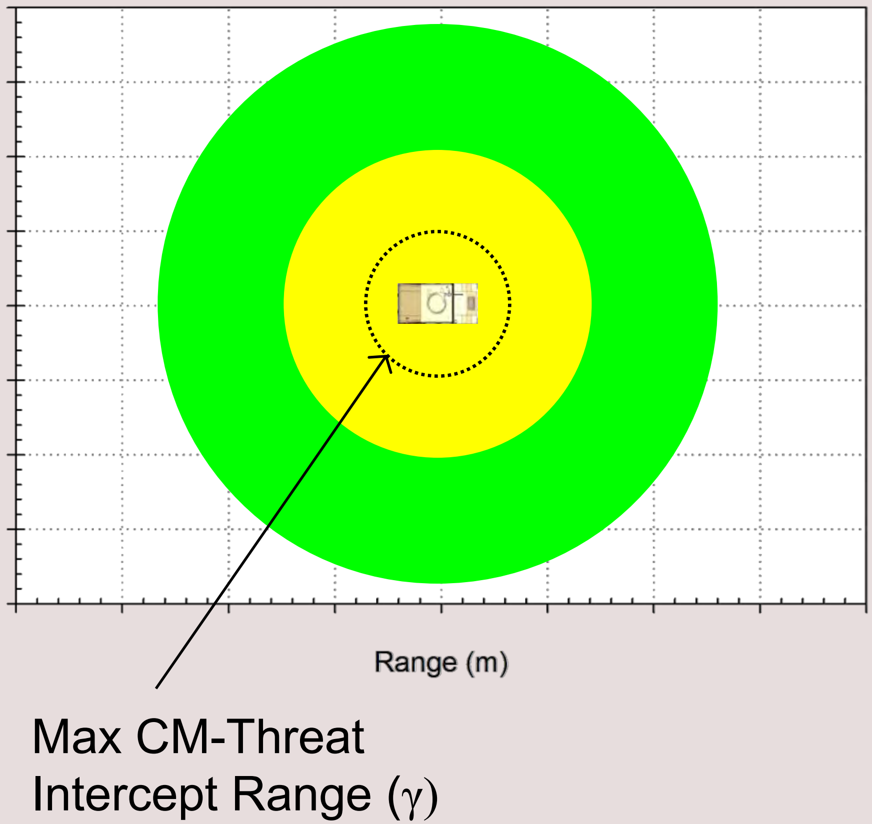
Notional results

Areas of Concern Given an Ideal Intercept



MAIS	Hazard Area (m^2)	Max Distance (m)
1	X	α
3	Y	β

Worst Case Ranges



BOP

CM-Threat Intercept Point

≥ 50% Chance of Minor Injuries (MAIS 1)

≥ 50% Chance of Serious Injuries (MAIS 3)

Conclusions

- Active counter measures present hazards to dismounted troops and non-combatants in the vicinity of ACM-equipped platforms
- The U.S. Army Research Laboratory has developed methodology using ORCA and MUVES-S2 to characterize these collateral hazards
- Collateral hazard results may be used to:
  - Compare hazardous areas between ACM solutions to assist with acquisition decisions
  - Develop Tactics, Techniques, and Procedures (TTPs) for combined arms operations requiring dismounted Soldiers to work near ACM-equipped platforms
  - Assist commanders deploying ACM-equipped platforms in MOUT operations near civilian populations

Contact Information

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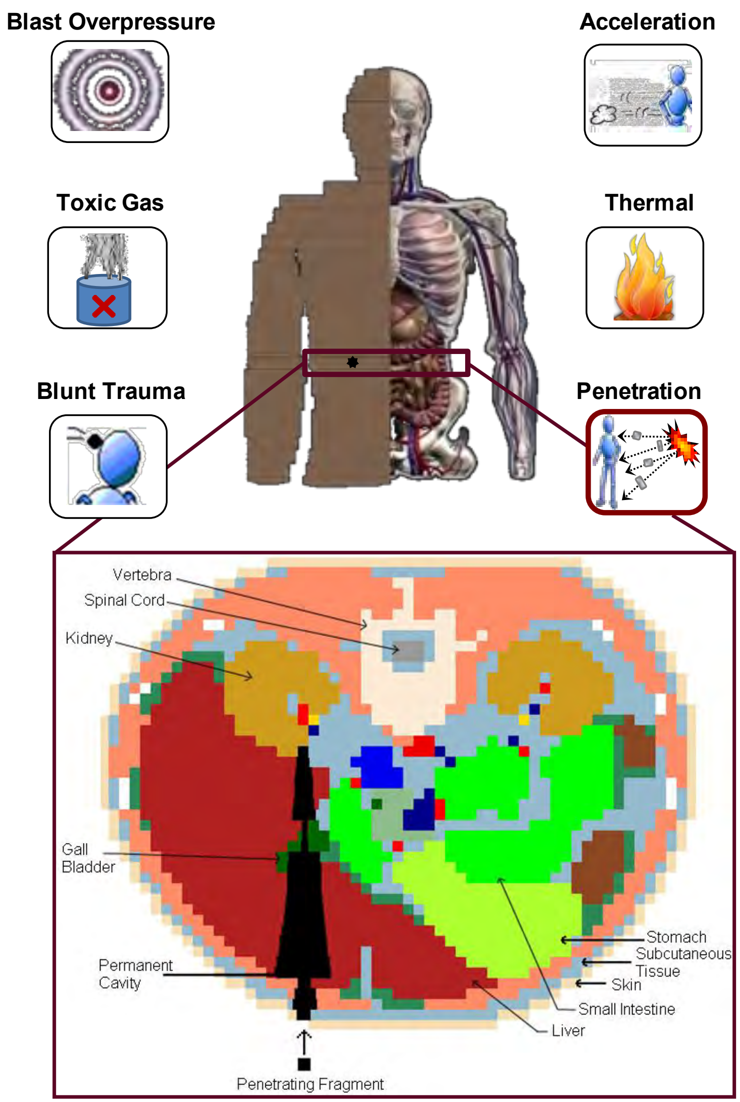
Back-up Slides

Operational Requirement-based Casualty Assessment

- ORCA is a high-resolution computerized human-vulnerability model that is used to assess the impact of various casualty-causing insults on personnel.
- ORCA calculates several injury-severity-trauma metrics that may be used to characterize both an individual injury as well as multiple injuries to a single person.
- ORCA is used to assess the impact of various casualty-causing mechanisms on the ability of military personnel to perform battlefield tasks.
  - It considers the operational tasks that personnel must perform, and determines the extent to which penetration and other battlefield insults degrade the ability to perform these tasks.
  - The model can be applied to personnel occupying any crew position and posture on any combat platform.
  - Based on a given insult or set of insults, ORCA assesses whether personnel become impaired to the extent that the person is incapacitated based on his specific job/military occupational specialty (MOS).

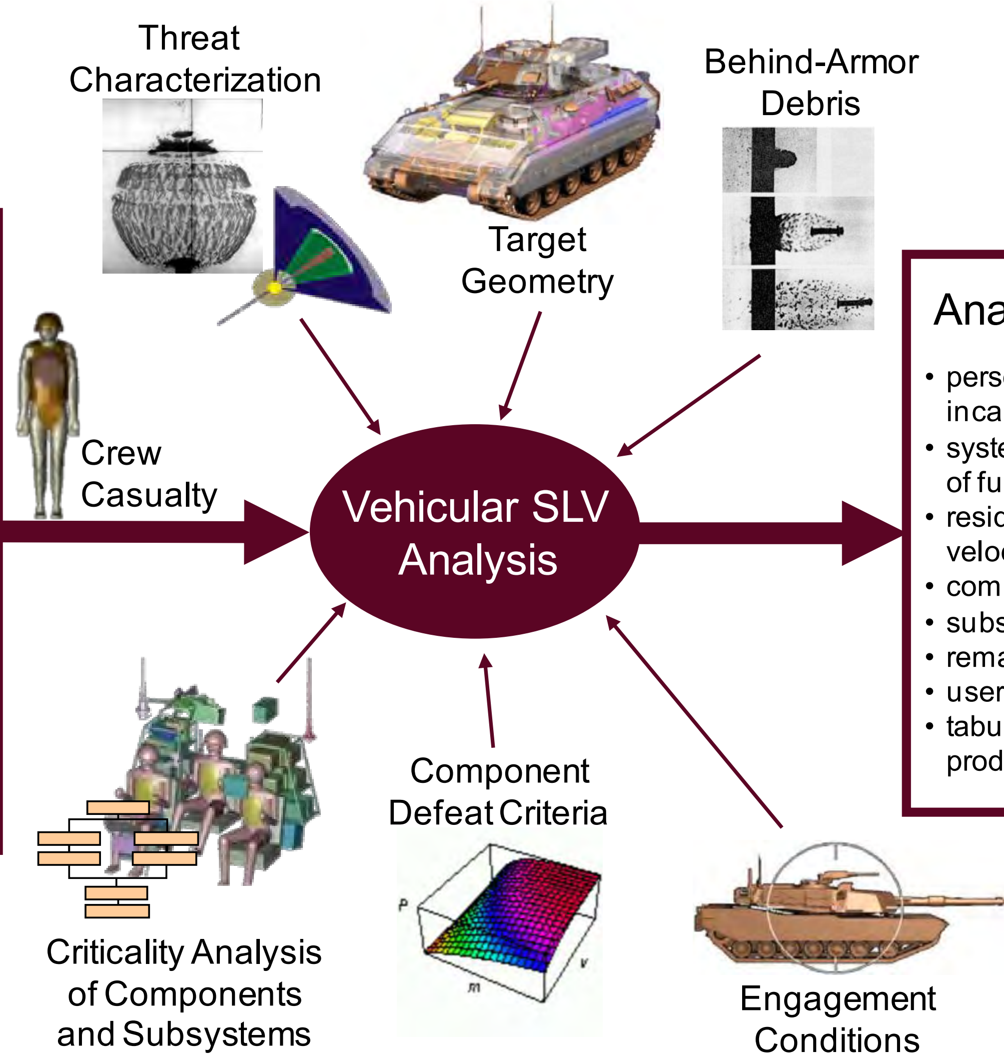


MUVES-S2 and ORCA

A Survivability/Lethality/Vulnerability (SLV) computer model capable of analyzing the effects of one or more munitions against aircraft or ground-mobile targets.

ORCA Methodology
allows for:

- discrete shot lines through anatomy based on orientation of threat trajectory to personnel
- projectile penetration mechanics through various anatomic structures
- velocity retardation of threat through wound track
- injury description by type, severity, and frequency
- in-depth description of operational effectiveness

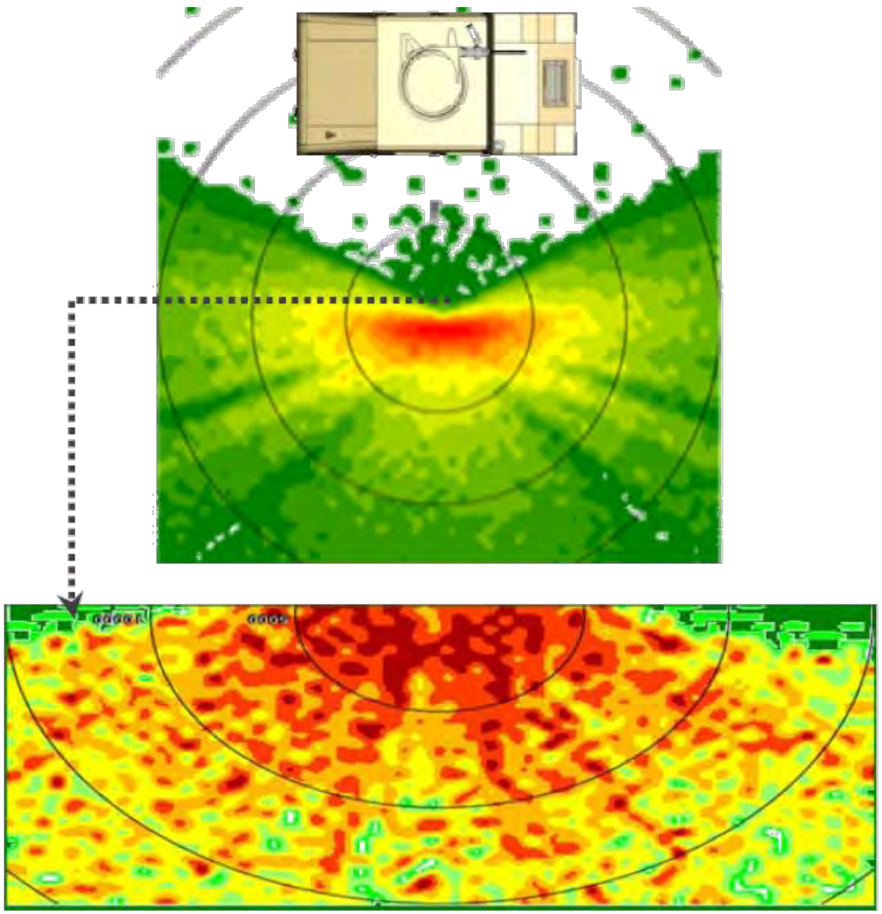


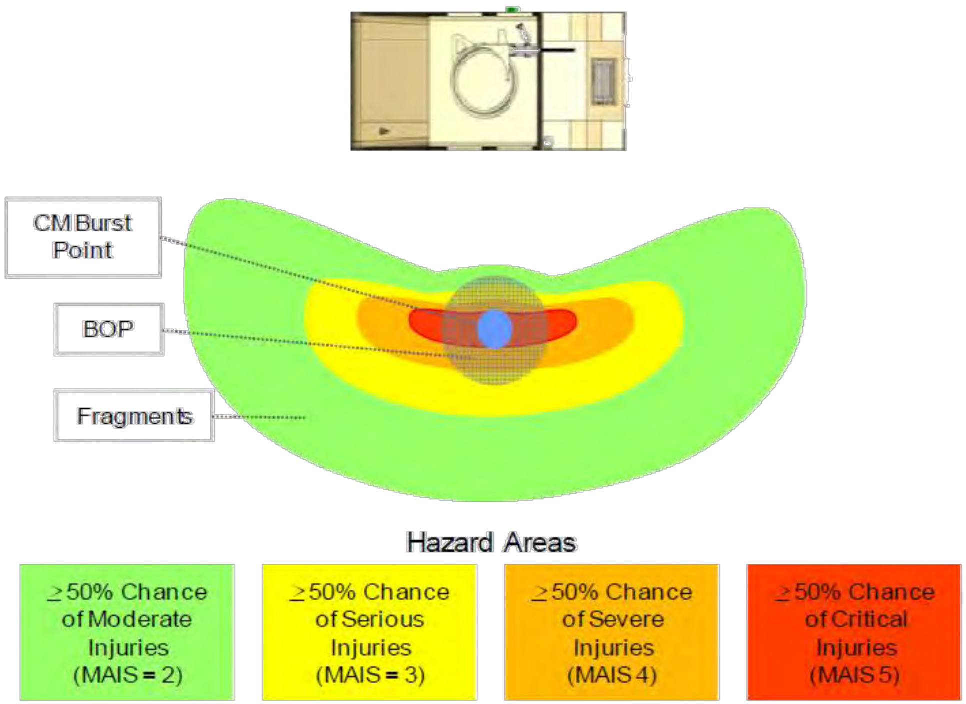
Analysis Outputs

- personnel injury and incapacitation
- system-level kills / loss of function
- residual penetration & velocity
- component damage
- subsystem capabilities
- remaining system utility
- user-defined criteria
- tabular & graphical products

Example Analysis Continued: Visualization Examples

Notional results





* Countermeasure (CM)

* Blast Overpressure (BOP)

* Maximum Abbreviated Injury Score (MAIS)

DT&E Using Scientific T&E Design

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NDIA Conference

March 15, 2011

Scientific T&E Design

Goal: *Understand process factors and their interaction with each other, so that their results produce an accurate prediction of the outcome.*

– Responses: Desired/Expected Outcomes

– Factors: Important Measures
[FACTORS are —broad categories of conditions that affect responses, " factors + levels = operational envelope," wrt scientific method: responses = dependent variables, factors = independent variables, the MEASURES should be chosen before identifying factors and levels]

– Levels: Possible Ranges/Extents for Factors

Benefits for testers…

- Plan based on statistical confidence

All Services use such methodologies for various reasons. OSD's emphasis is on planning for robust Integrated T&E

Deputy Undersecretary of Defense for Developmental T&E's Position

- "Integrated Testing is important to institute in order to attain test data that can be used across the acquisition processes… Early Planning for Integrated Testing sets up complementary individual [DT & OT] evaluation"

- STED puts discipline into T&E planning…through structured processes such as "Design of Experiments". STED is part of the T&E tool-bag for OSD Integrated Testing efforts"

DDT&E: *Integrated Testing and Evaluation Can be Aided by Applying STED Methods Across Entire Acquisition Development Cycle*

STED in DT&E Planning

- **Determine Optimum Test Runs, Test Points & Resources**
  - Based on Factors, Levels & Interactions
  - Utilize Statistical Tools
  - Forms the basis of Integrated T&E
- **Helps Allocate Test Requirements to Test Sequence**
  - Contractor Test, DT, OT
  - Component—Subsystem—System
  - Informs what is likely to be learned at key decision points
- **Iterative Process**
  - Can help re-vector test plan based on emerging results
  - Supports better use of Modeling and Simulation

Reduce test time and statistically consider interactions better than traditional one-factor-at-a-time methods

STED in the Acquisition Process

- **To MS B**
  - Determine what functions and influences are most important to T&E design and are worth close monitoring
  - Develop the T&E test space
  - Identify the likely T&E resources needs
  - Supports the time-phasing of CT-DT-OT

- **At MS C [and to FRP]**
  - Assess adequacy of T&E, compared to data accumulated
  - Determine future T&E priorities
  - Identify where T&E trades can be made given results

> The wise investigator expends his effort not in one grand design (necessarily conceived at a time when he knows least about unfolding reality), but in a series of smaller designs, analyzing, modifying, and getting new ideas as he goes.
>
> — *G. E. P. Box*

STED Benefits in an Integrated T&E Environment

- Everyone Understands the Test Problem, the Test Environment and How the System is Tested
- Statistical Tools Identify Optimum Factors, Test Points and Conditions to be Tested
- Performance being Assessed is Allocated to Specific Tests in Sequence
- Allows Comprehensive Body of Data to be Accumulated to Support Findings
- Facilitates Coordination of Test Events

DT Results Better Support OT Findings, Helping Scope OT

STED in Use

- **TEMP – DT&E Expectations**
  - Part III – Discuss the analytical methodology used to develop the DT/IT test program
  - Part III - Show the Test and Evaluation framework in chart form
  - Part IV – Ensure test resources are mapped to the T&E framework

- **Program examples:**
  - SDB-II, JAGM, AIM-9X, JASSM
    - Examine the power of contractor test plans
    - Develop a robust (power/confidence) integrated test approach CT/DT/OT with the minimum number of tests
    - Recognize scope of viable testing to support MS C
  - P-8, AWACS, JSTARS, F-35, MQ-9

Back-up Slides

DoD Policy on Integrated T&E

DoDD 5000.01:

- "Test and evaluation shall be integrated throughout the defense acquisition process"

DoDI 5000.02:

- "Integrate, . . . successive periods of DT&E, LFT&E, and IOT&E

DoDI 5000.02, Enclosure 2:

- "Developmental and operational test activities shall be integrated and seamless throughout the phase"
- "Evaluations shall take into account all available and relevant data and information from contractor and Government sources"

DOE Resources for Testers

- **USAF DoE Community of Practice**
  - Web-ex Mondays 1400 CT
  - Contact: https://connect.dco.dod.mil/eglindoe
    Gregory T. Hutto: Gregory.Hutto@Eglin.af.mil
- ***Design and Analysis Of Experiments*, 6th Ed., 2004**
  - Douglas C. Montgomery, ISBN 0-471-15746-5
- ***Design of Experiments*, 2nd Ed., 1957**
  - Cochran and Cox, Wiley and Sons
- ***Response Surface Methodology*, Process and Product Optimization Using Designed Experiments, 3rd Ed., 2009**
  - Raymond H. Myers and Douglas C. Montgomery
- ***Joint Test and Evaluation Program Handbook***
  - DOT&E, December 2008
- ***Efficient Simulation Using DOE Methods***
  - Dr. Tom Donnelly, SAS Institute: Tom.Donnelly@jmp.com
- **Sample Size, Confidence and Designed Experiments**
  - Dr. Mark Kiemele, President, Air Academy Associates: aaa@airacad.com

DOE in U.S. DoD T&E—*Army*

- **ATEC**
  - DoE used for planning system evaluations and individual data-collection events
  - Single table depicts how the individual test events will manage each factor
  - Be able to reconfigure for unforeseen events
  - Manage tradeoffs between operational realism and sufficient data
  - Requires detailed front-end planning

DOE in U.S. DoD T&E—*Navy*

- **COMOPTEVFOR**
  - DOE part of Mission-based Test Design (MBTD)
  - A shift functional-based to mission-based OT.
  - OT team provides detailed OT input earlier in program schedule.
  - OT designed around factorial design
  - Sharing of T&E responsibility, resources, and data throughout system development.
  - IOT&E as mission capability confirmation.

DOE in U.S. DoD T&E—*Air Force*

- **53RD Test Wing**
  - With digital simulations, screen 15-20 variables with fractional factorials and predict performance
  - In HWIL, confirm digital prediction (validate model) and further screen 8-12 factors; predict
  - In live fly, confirm prediction (validate) & test 3-5 most vital variables
  - Prediction Discrepancies provide opportunity to improve simulations

CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results

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AFMC AAC/EB (Eglin AFB)
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Distribution Statement A: Approved for Public Release. Distribution Unlimited.

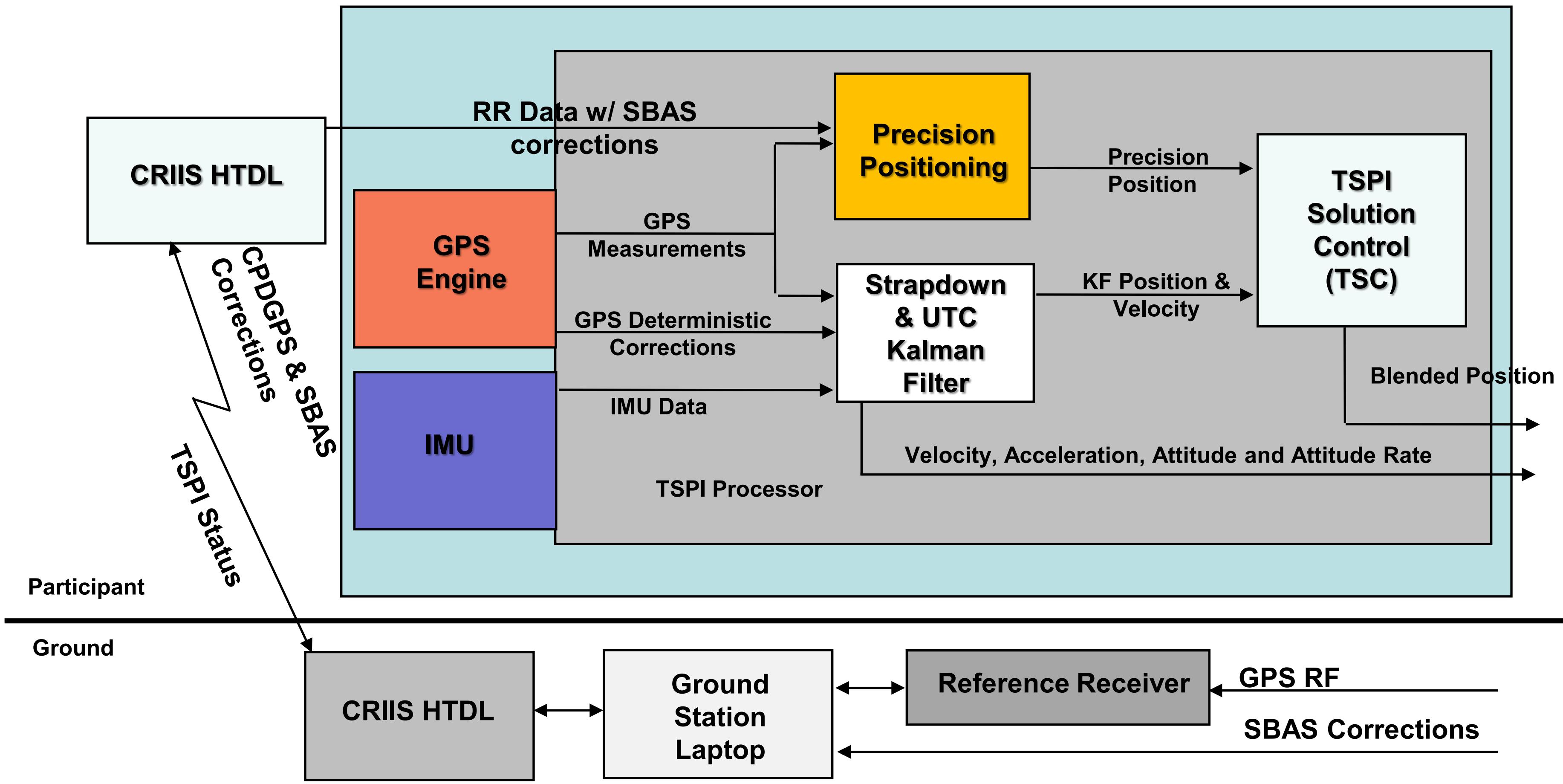
Outline

- CRIIS TSPI Architecture and Algorithms
  - RTK, UTC, SBAS, and RTK/UTC Blending
- TSPI Accuracy Validation Approach and Truth Source
  - M&S, HIL, Low Dynamic (Van, Roller-Coaster), High Dynamics
- HIL Simulation Results
- Roller Coaster Test Results – Lessons Learned
- Flight Test Results – TRL6 Discussion
- Conclusion

Overview

- TSPI Architecture and Algorithms
- TSPI Accuracy Validation Approach

CRIIS TSPI Architecture and Algorithms



SBAS= Precise Corrections for SV Position and Clock Errors (Sources: StarFire, JPL etc)

TSPI Level II
UTC GPS-Inertial Algorithm

- **UltraTight Coupling (UTC) is an Essential Part of High Accuracy Positioning in a High Dynamic Environment**
  - **Reduces TSPI Error Growth by Minimizing Duration of GPS Signal Loss**
  - **Signal Re-established Up to 30 Seconds After Signal Loss without the Need to Search**
- **Accurate Relative Timing between GPS, Kalman Filter, and IMU is Essential for Highest Accuracy TSPI Solution**
  - **TSPI Incorporates Synchronous Timing between GPS, Processor, and IMU**
  - **IMU Strobe is Required to Minimize Latency Error in IMU Measurements Used to Close GPS Signal Tracking Loops**
  - **Minimizes Error Growth Across GPS Outages**

TSPI Level II GPS-Inertial Design Built on Core UTC Approach Successfully Used in Phase I Demonstration

CRIIS TSPI Level II TSPI Verification and Truth Sources

Increasing Fidelity

MODEL-BASED DEVELOPMENT SIMULATIONS

- Includes nonlinear effects not addressed in covariance analysis
- Includes performance degradations associated with algorithm and software imperfections
- Uses all TSPI software, but runs in non-real-time environment

GPS/INERTIAL HIL SIMULATOR

- All real hardware except IMU
- High dynamics
- Repeatable
- 10x accuracy for truth source

STATIONARY LAB TESTING

- All real hardware
- Near perfect truth
- 10x position accuracy for truth source

LOW DYNAMICS (VAN) TESTING

- Production HW
- Relevant low dynamic environment
- Good positional truth via independent RTK solution
- Good non-positional truth

HIGH DYNAMICS (FLIGHT) TESTING

- Production HW
- Relevant high dynamic environment
- Good positional truth via independent RTK solution
- Good non-positional truth

Continued Use of Crawl, Walk, Run Approach Used in Phase I is Proven and will Continue as the Verification Model

CRIIS TSPI Demo Approach

Incrementally Phased

Table 5 – TSPI Level II accuracy requirements

	Position Horizontal (m RMS)	Position Vertical (m RMS)	Velocity Horiz/Vert (m/s RMS)	Acceleration Horiz/Vert (m/s2 RMS)	Attitude (deg RMS)	Attitude Rate (deg/s RMS)
Level II Real Time	0.3		0.03	0.03	0.1	0.2
Level II Post Processed	0.1		0.01	0.01	0.05	0.1

Test Phase	Test Objectives	Truth Source
Crawl: • Model-Based • Hardware-In-Loop • Stationary	Validate TSPI solution accuracy under • GPS simulation • Live Sky • RRs at Various Ranges	• GPS Simulator • Surveyed Antenna
Walk: Ground-Based Demonstrations • Van • Roller-Coaster	Validate TSPI solution accuracy under low and Moderate dynamics • RRs at Various Ranges	• SPAN (for Position) • Honeywell EGI (For Non-Positional TSPI Parameters)
Run: Flight Demos • T-38 Aircraft	Validate TSPI solution accuracy under high (flight) dynamics • RRs at Various Ranges	• SPAN • Honeywell EGI (For Non-Positional TSPI Parameters)

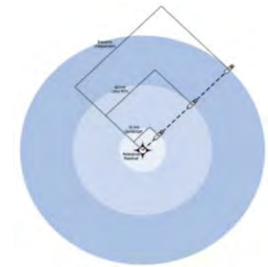
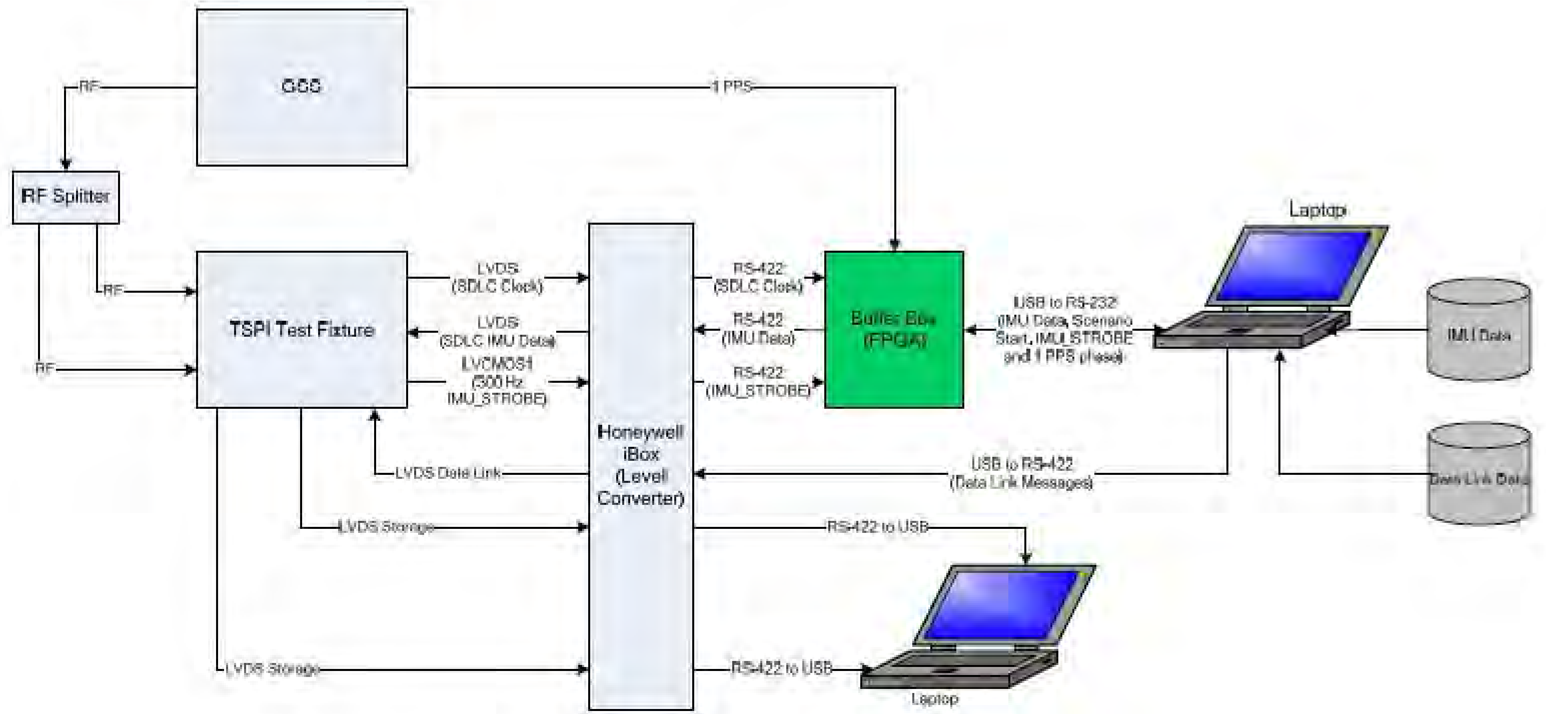


Figure 7 – Van Testing of Baseline Length

Figure 10 – AT-38B Talon

HIL Simulation Results

Hardware-In-The-Loop Tests



- NavStorm⁺ GPS Rx, TSPI Processor, RT Algorithms, and Simulated HG-1700 IMU
- Spirent Simulator for GPS RF
- Antenna Patterns, Error Models, and Simulated Datalink and GPS Outages
- Benefits:
  - Perfect Truth, Identifies Any Algorithmic Related Common Biases
  - Lends Credibility to Using SUT-o-SUT Comparison when 10X Truth Not Available

HIL Simulation of 50 nmi Flight Trajectory

- Used Actual TSPI Hardware and Software
- Atmosphere and IMU Modeled with AMPSAT
- Used T38 Antenna Gain Pattern
- Insensitive to Short Datalink Outages, Loss of All Reference Receiver Data, and SBAS Correction Data Outages
- Robust to Antenna Phase Effects

HIL – Nominal 50 nmi Jet Flight

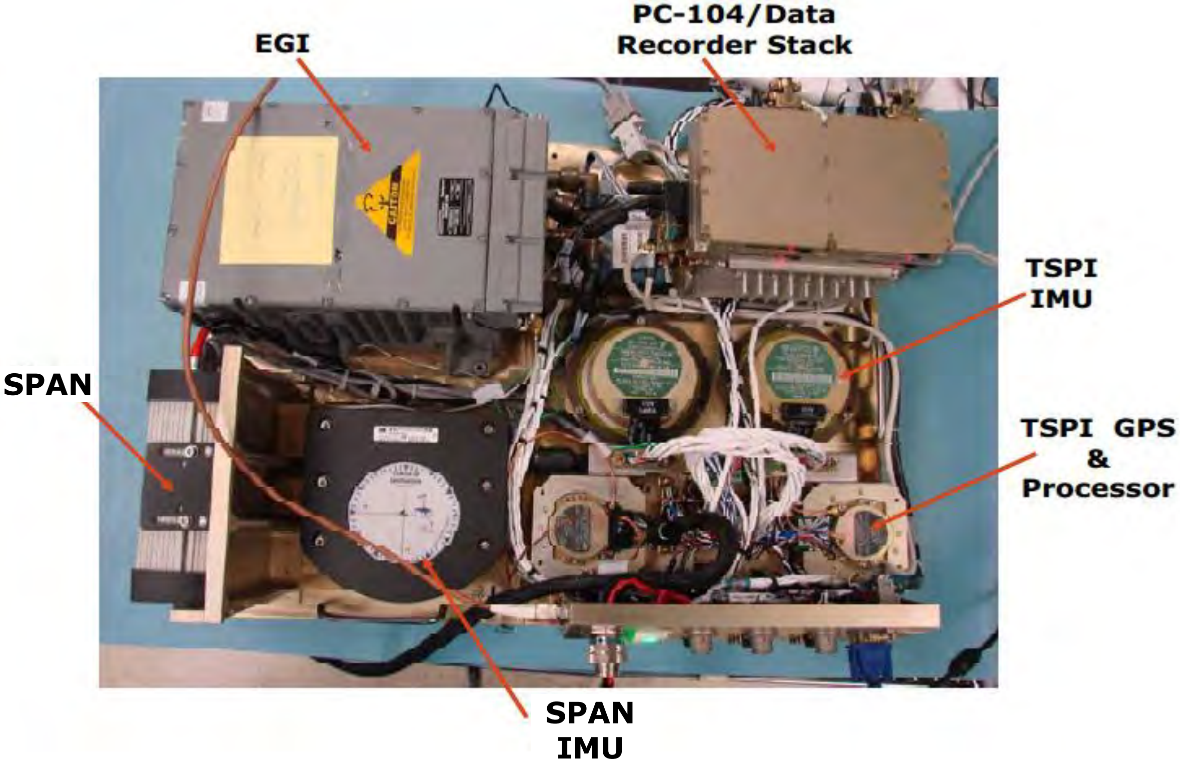
Segment #	1	2	3	4	5	6	7	Rqmt	Units
Acceleration H	0.031596	0.029654	0.030991	0.028738	0.031464	0.031421	0.035605	0.03	m/s/s
Acceleration V	0.017828	0.021379	0.018959	0.021449	0.018222	0.018126	0.023477	0.03	m/s/s
Velocity H	0.0062768	0.015176	0.01255	0.0079937	0.0057948	0.0061308	0.010889	0.03	m/s
Velocity V	0.0043504	0.0123	0.0065374	0.0054584	0.0050342	0.004428	0.0062275	0.03	m/s
Position H	0.044954	0.12879	0.10721	0.12939	0.24915	0.18462	0.055463	0.3	m
Position V	0.25932	0.25709	0.2305	0.18711	0.08161	0.13873	0.11449	0.3	m
Roll	0.0086153	0.0050646	0.011735	0.0057993	0.0061491	0.011675	0.013846	0.1	deg
Pitch	0.0072549	0.0071238	0.0066403	0.011235	0.0072613	0.019243	0.013018	0.1	deg
Heading	0.015395	0.010473	0.016771	0.017157	0.027976	0.027616	0.019956	0.1	deg
Roll Rate	0.01918	0.019233	0.018849	0.018982	0.019558	0.019212	0.024156	0.2	deg/s
Pitch Rate	0.019092	0.019313	0.019156	0.018596	0.018828	0.019171	0.019229	0.2	deg/s
Yaw Rate	0.018943	0.019033	0.01937	0.019036	0.019119	0.018952	0.019196	0.2	deg/s

- **HIL Test Predicts Good TSPI Performance Even with Maneuvers and Long Baseline**
- **Acceleration Errors Were Large Due to Lever Arm Amplification and IMU Inertial Sensor Assembly Relative Motion with Respect to Chassis**
  - **Resolved with Use of Filtered IMU Outputs for TSPI Acceleration**

Roller Coaster Live Test Results

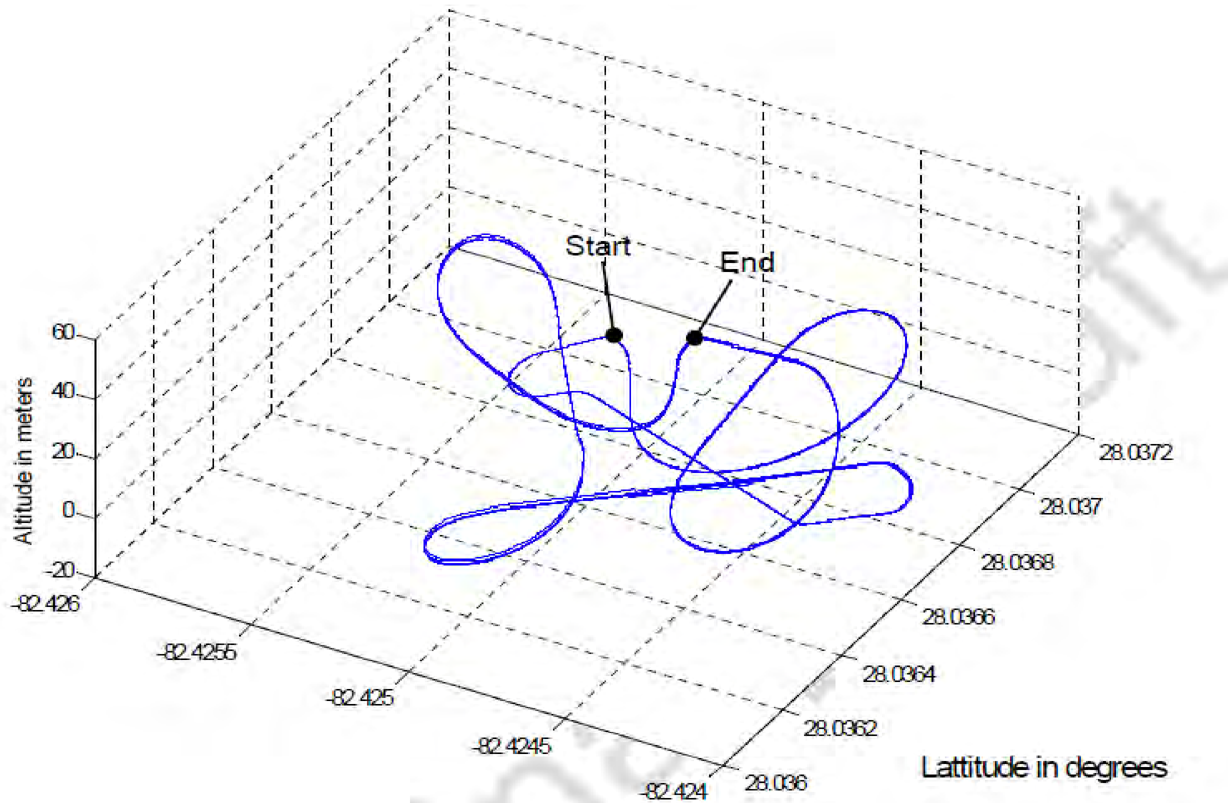
TSPI Plate Used for Demonstrations

Roller Coaster and Flight Tests



- Two CRIIS TSPI Prototype Systems Used for Comparison and Consistency Checking
  - CRIIS TSPI System Under Test (SUT): RCI NavStorm+ GPS Rx, HG-1700 IMU and TSPI Processor
- NovAtel SPAN Integrated with HG1700 for Post-Mission Reconstruction of Position Truth
- Honeywell HG-9900 Based Embedded GPS/INS (EGI) for Non-positional Truth
- GPS Antenna on T-38 Aircraft for GPS RF, HAFB L-Band Antenna for Reference Receiver Datalink

Roller-Coaster Maneuver Segment for Position Accuracy Analysis



- Blended Position Truth: Fixed Integer SPAN Position Solution and Integrated EGI Velocity
- Position Scoring Segment is from 'Start (top of first hill)' to 'Stop (Plateau of Next Hill) Only
  - Time Duration = 25 sec
  - SPAN Solution Corrupted for Remainder Segment (Poor GPS Signals, Multipath etc.)
- Non-Positional TSPI Parameters Scored Over Entire Roller-Coaster Trajectory

Roller-Coaster: Blended Truth Reference

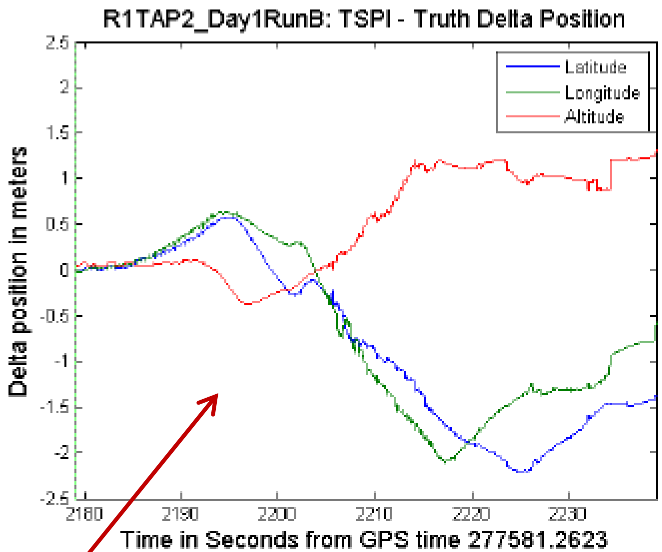
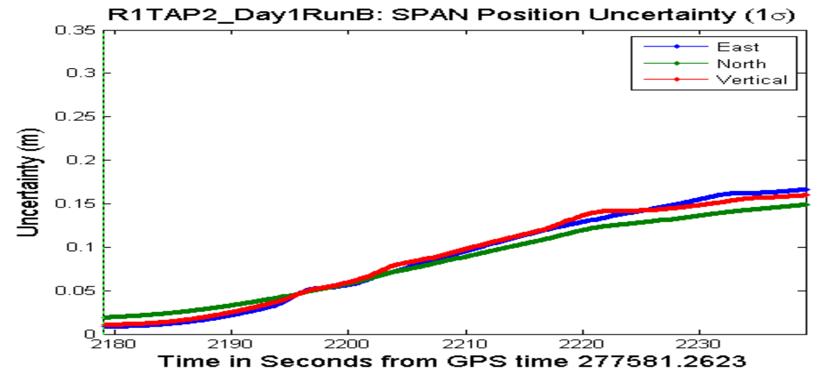
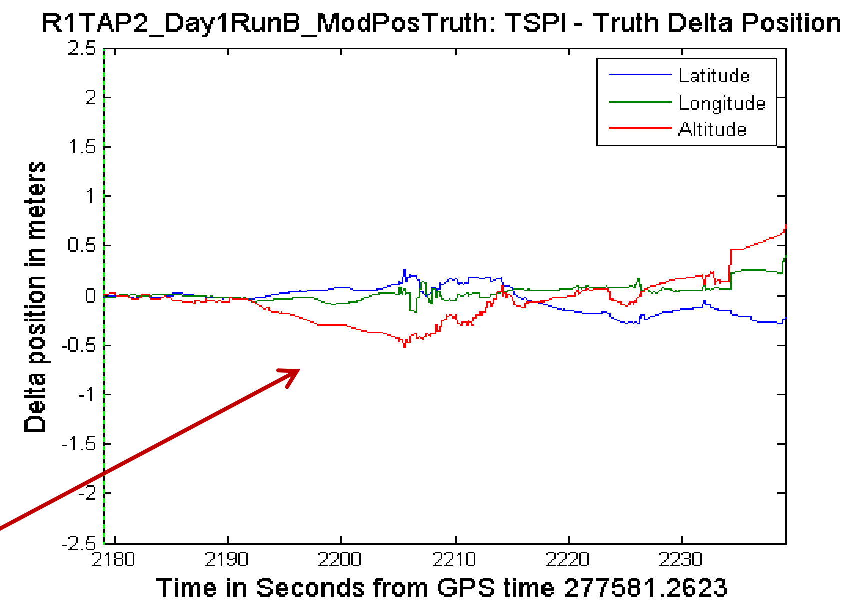


Figure 1: TSPI – SPAN





- **SPAN Truth Corrupted: Inconsistency Between SPAN Indicated Position Uncertainty and SPAN Position Solution During Non-RTK Mode**
- **Blended Position Truth: Used Initial Fixed Integer SPAN Solution Propagated by Integrated EGI Velocity**

Common Range Integrated Instrumentation System (CRIIS)

Common Range Integrated Instrumentation System (CRIIS)

Common Range Integrated Instrumentation System (CRIIS)

Common Range Integrated Instrumentation System (CRIIS)

Common Range Integrated Instrumentation System (CRIIS)

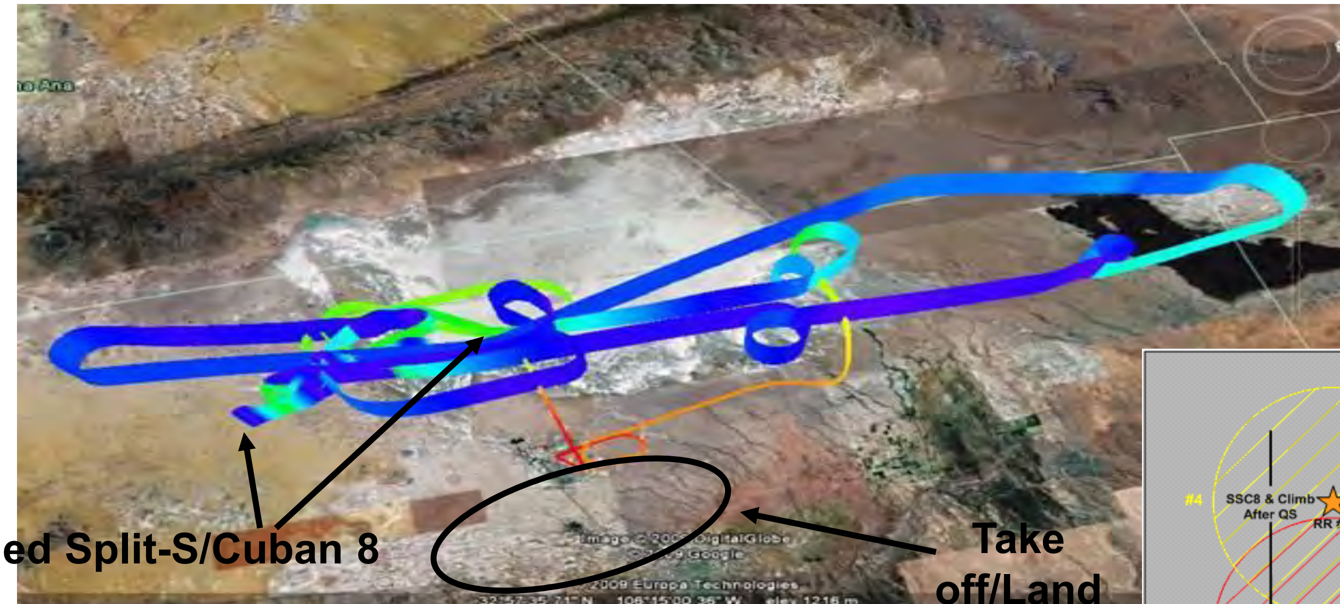
Dynamic Flight Test Results

Reference Receivers and Datalink Set-Up

- Four Reference Receivers Spaced ~ 20 nmi Apart at Surveyed Locations (CORS Used)
- Datalinks Set Up at Each End of the Range
  - Used for Uplinking SBAS Corrections and DGPS Measurements from RR
- Data from All Four RRs Used for Producing Truth, Post-Mission, Using SPAN
- To Accommodate Short and Long Baseline Requirements Data from One Appropriate RR Used in CRIIS TSPI Computation

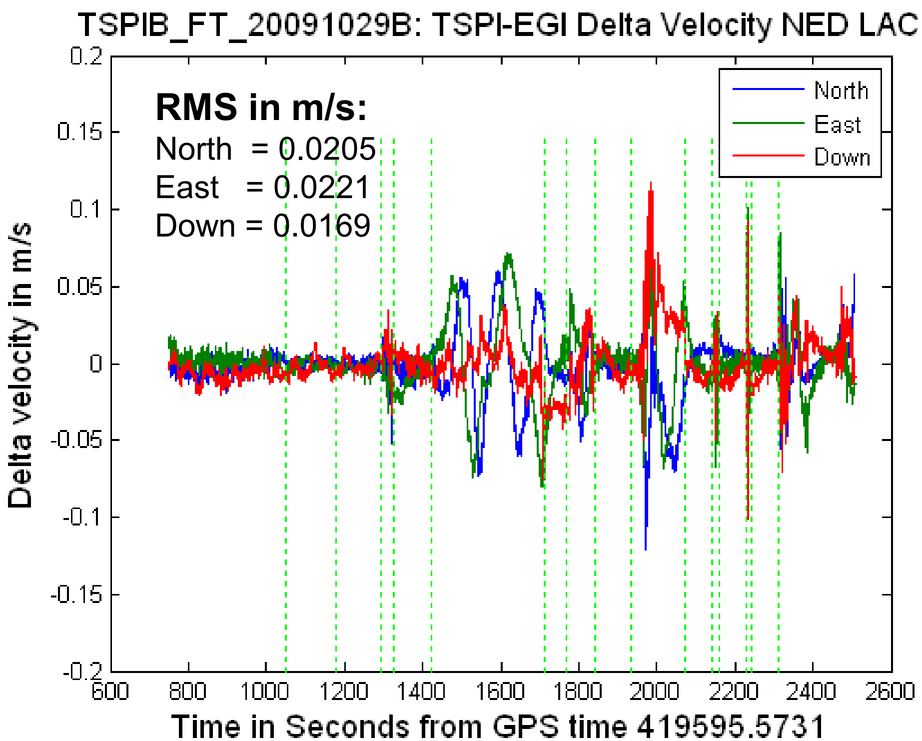
CRIIS TSPI High Dynamics

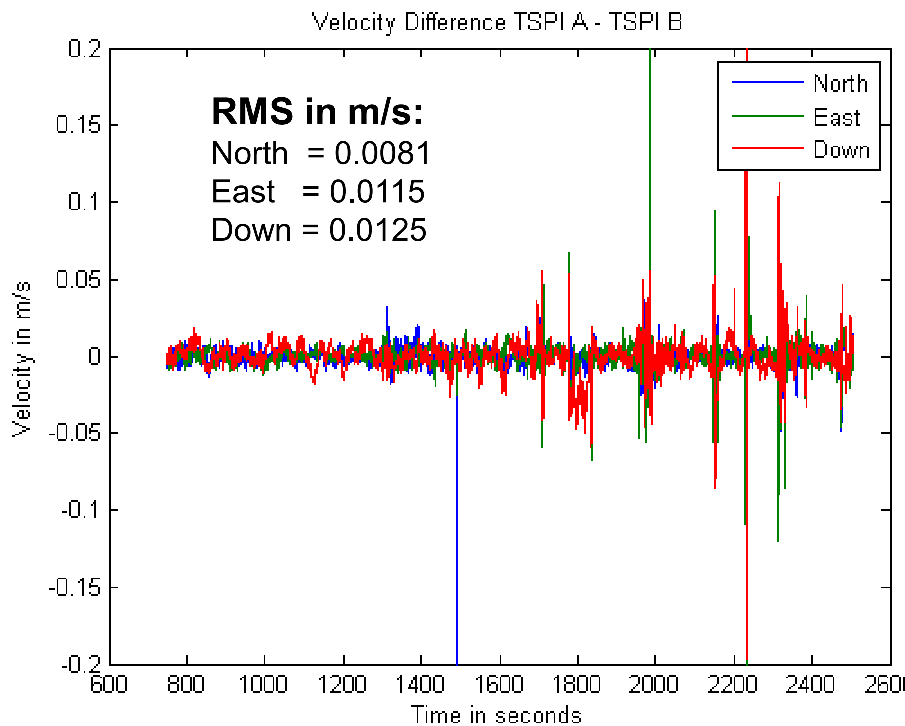
Flight Test 29 Oct 2009 – Holloman AFB



Flight Profile #1 Maneuvers		Flight Profile #1 Maneuvers
1 – Split S To Cuban 8		9 – Right Aileron Roll
2 – Orbit		10 – Straight And Level
3 – Climb		11 – Left Aileron Roll
4 – Straight And Level		12 – Straight And Level
5 – 3G Turn		13 – Max Accel
6 – Straight And Level		14 – Break Turns
7 – Max G Turn		15 – Straight And Level
8 – Straight And Level		16 - Orbit

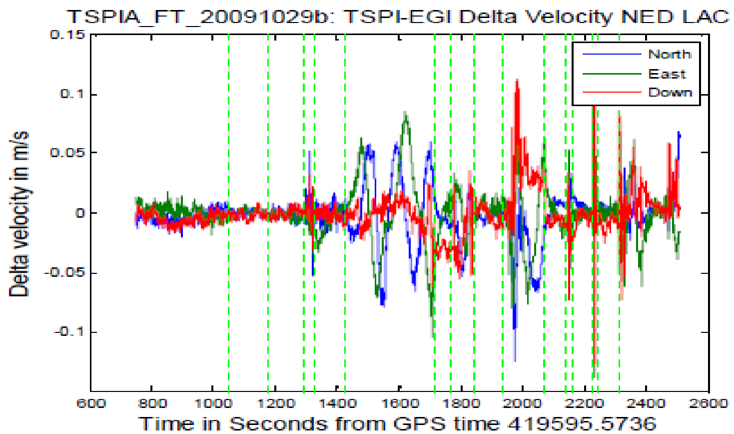
TSPI A to B Velocity Differences

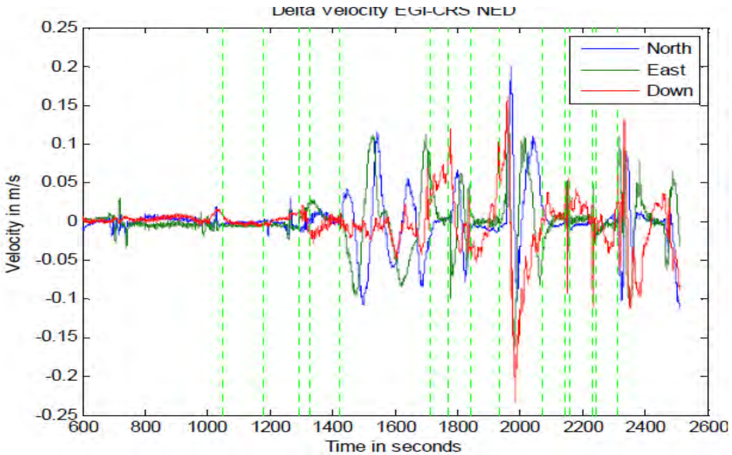




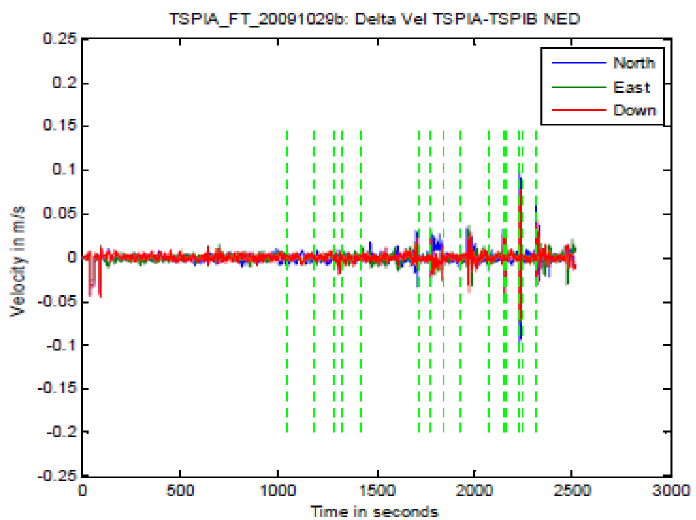
- **Horizontal Differences Between TSPI A & B are Less Than Half Those of TSPI B and EGI**
- **Lever Arm Errors in EGI IMU-to-GPS Antenna Are Suspected Cause**

Velocity Accuracy
Using SUT-1 to SUT-2 Difference

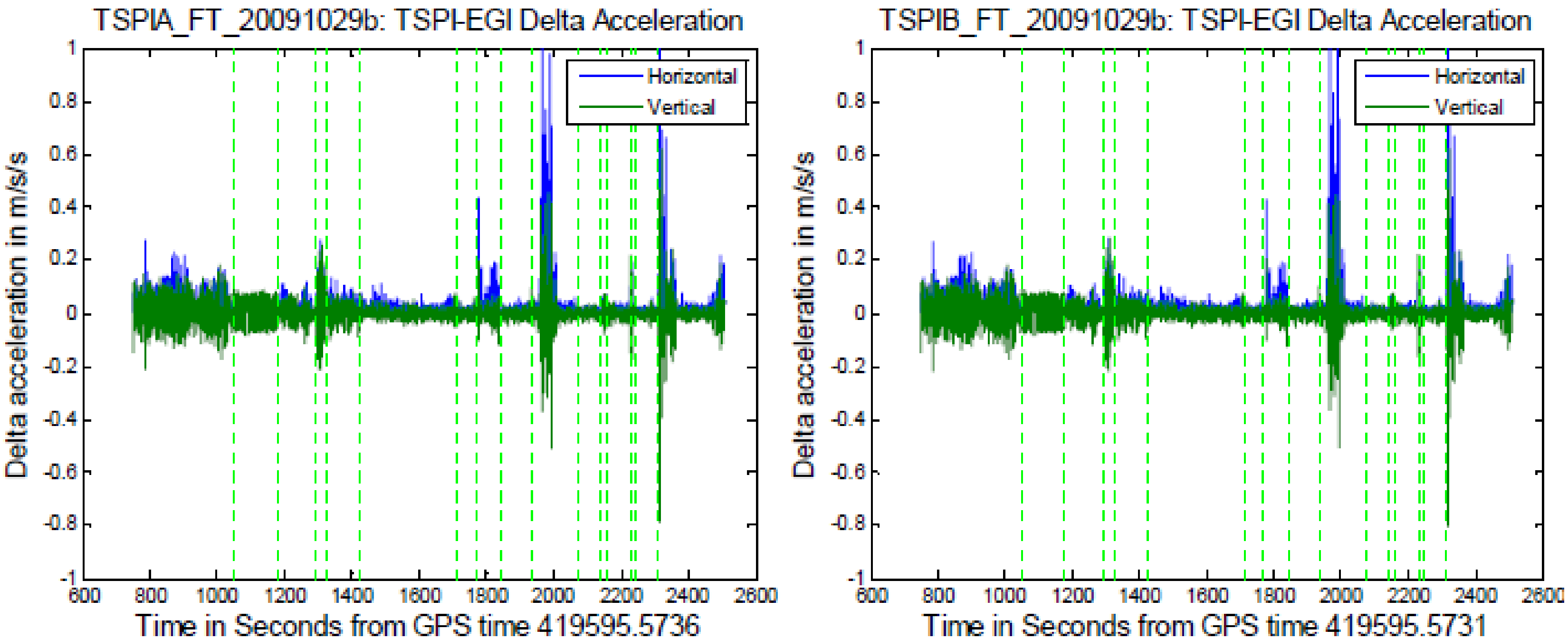




Key Observations:
- **Anomalies in CRIIS to EGI and CRS Velocity**
- **Differences During High Rotation Rate Maneuvers**
  - **Not Common Mode CRIIS Errors, Since Signatures for Each Truth Source is Different**
- **Anomalies in EGI to CRS Velocity Differences, Much Larger than SUTs Differences**
  - **Source of Anomalies is Lever Arm Errors**
- **CRIIS TSPI-A to TSPI-B Consistent**
  - **Method Can be Used for Accuracy Verification, Along With HIL (or Other Simulation to Verify Lack of Large Common-Mode Deterministic Errors)**



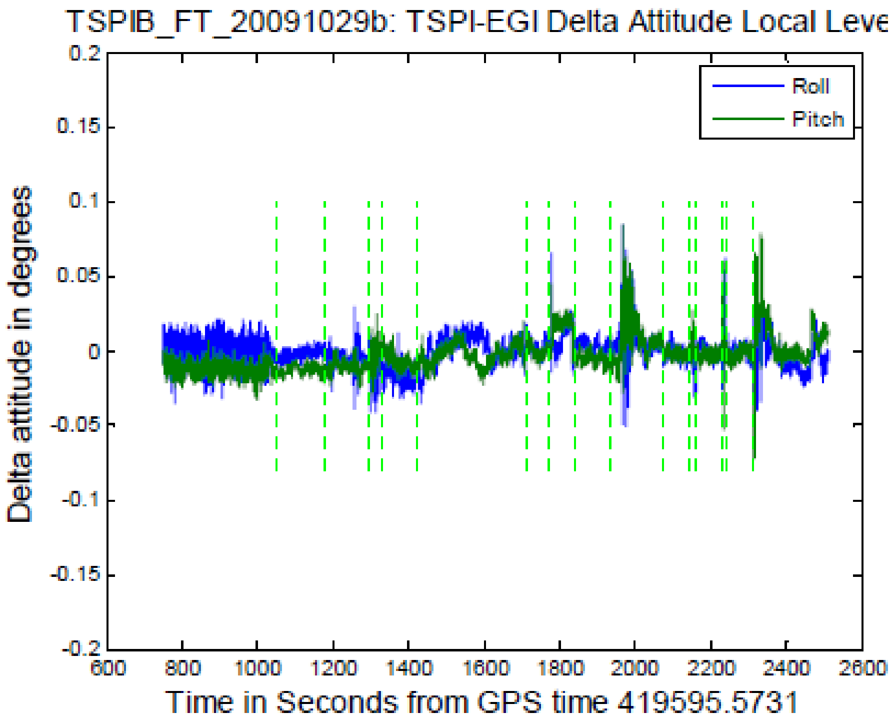
Acceleration Noise Issue

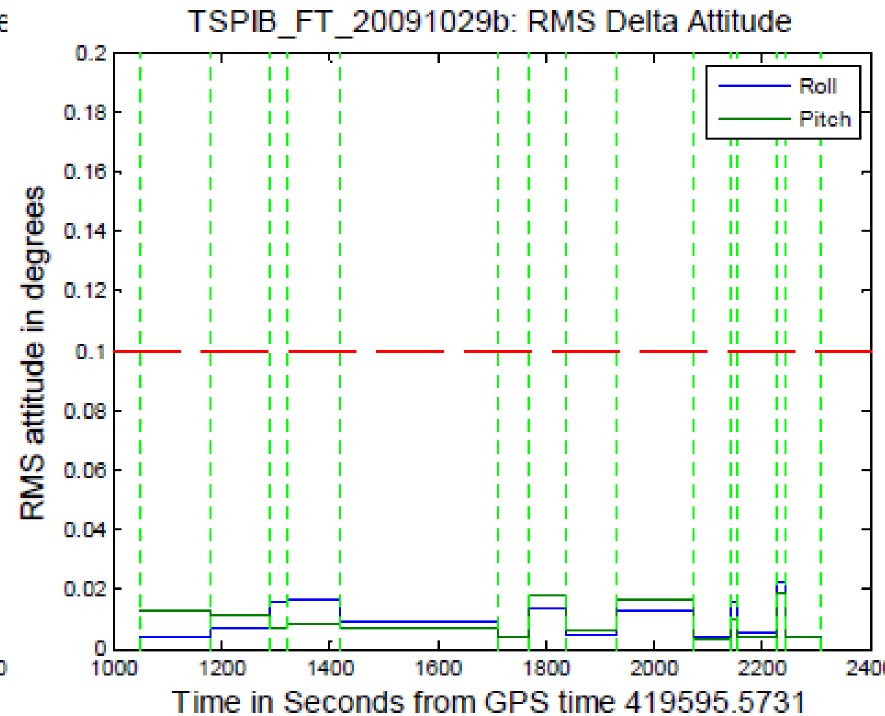


- **Vibrations During High G Maneuvers Added High Frequency Noise to Relative Acceleration Between EGI and TSPI**
- **Data Must Be Filtered to Below the Shock Roll-Off Frequency of Each Systems**
  - **High Frequency Noise and Shock mount Resonance Should be Above Filter BW**

Common Range Integrated Instrumentation System (CRIIS)

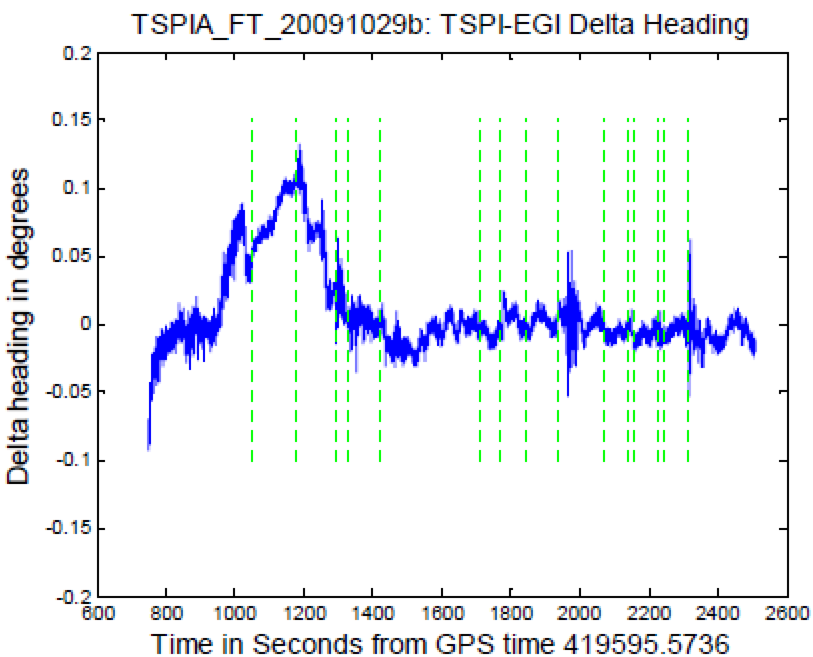
Attitude (Roll, Pitch) Accuracy

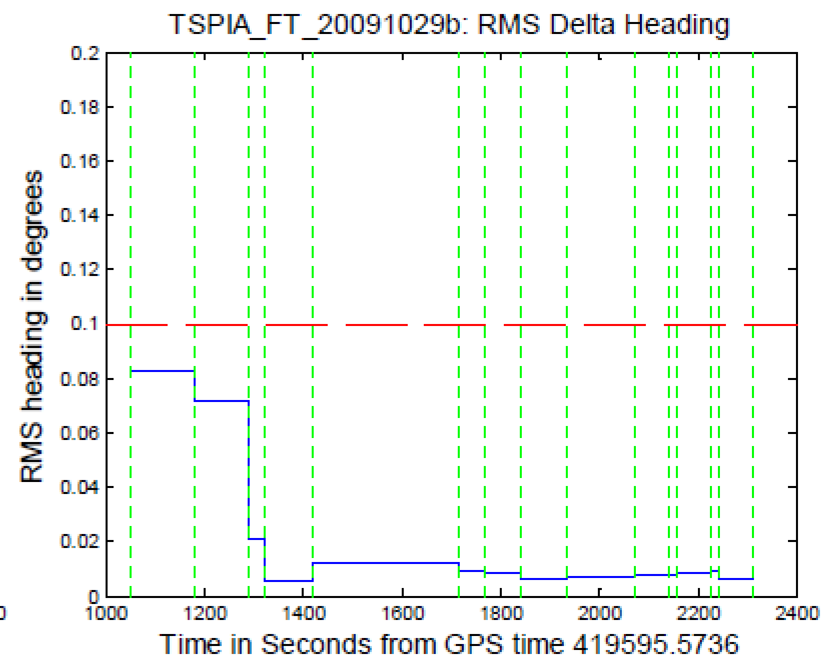




- **Attitude Accuracy Met Requirements with Margin Even Under High Dynamics**
  - **EGI Used as Truth**
  - **No Filtering Applied for Processing**
- **Segment by Segment RMS Values are Shown**

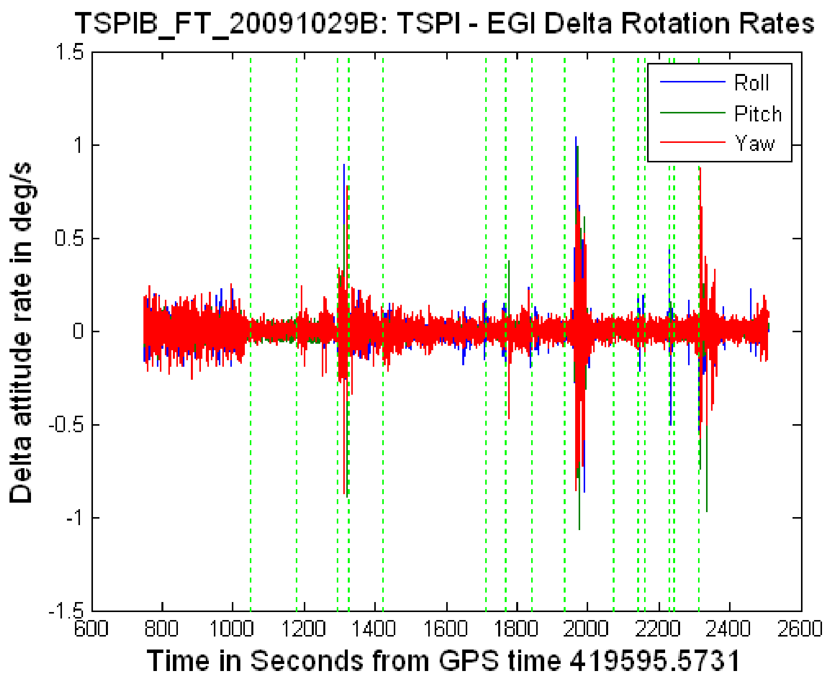
Attitude (Heading) Accuracy

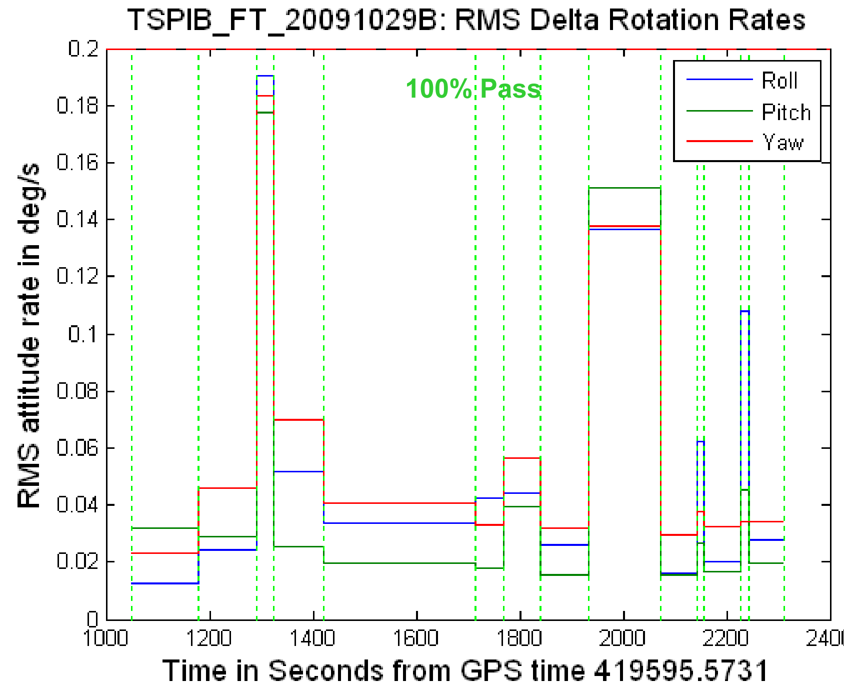




- **Heading was Well Aligned After Takeoff Roll**
- **Heading Accuracy Maintained During Maneuvers and Straight & Level Segments**
- **EGI Used as Truth (No Filtering Applied)**
  - **RMS Segment Errors Well within Spec**

Attitude Rates Performance





- **Attitude Rate Performance Good**
  - **Data Processed with 1 Hz Butterworth to Filter Out High Frequency Relative Motion between EGI and TSPI**

Flight Test Results
TSPI Level II Absolute Mode Summary

- **Absolute Mode Positioning Achieves Significant Margin**

Flight	27 Oct, Flight 1	27 Oct, Flight 1	27 Oct, Flight 1	27 Oct, Flight 1	27 Oct, Flight 1	Accuracy Rqmt
Maneuver Type	Cuban 8	180 2g Turn	360 3g Turn	360 5g Turn	360 Degree Aileron Roll	
Maneuver Segment (sec)	1926-2045	2292-2340	2350-2415	2540-2656	2725-2743	
Horizontal Position Accuracy (m)	0.3	0.7	0.6	0.7	0.7	3.0 m
Vertical Position Accuracy (m)	0.9	0.9	0.7	0.9	1.9	4.6 m
Horizontal Velocity Accuracy (m/s) (TSPI A-B)	0.02	0.01	0.01	0.04	0.02	0.05 m/s
Vertical Velocity Accuracy (m/s) (TSPI A-B)	0.01	0.01	0.01	0.01	0.01	0.05 m/s
Baseline (nmi)	NA	NA	NA	NA	NA	
RTK Mode	4,2,0	1	1	1,0	1,0	

Note: Velocity Accuracy Included in Absolute Mode as It is a Special Case Where No Datalink is Available

Flight Test Results
TSP Level II Position Accuracy

- **TSPI Level II Position Accuracy Met for Low and High Dynamic Maneuvers**
  - **Split-S Not Met in Post Processing but is Improved Over Real Time**

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flt 3	29 Oct, Flt 3	29 Oct, Flt 3	Rqmt (m)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	Split-S	Straight & Level	50 degree roll; 180 degree turn	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	1990-2084	3252-3393	3393-3490	
Real Time Horizontal Position Accuracy (m)	0.02	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3
Real Time Vertical Position Accuracy (m)	0.1	0.2	0.1	0.2	0.1	0.3	0.1	0.1	0.3
Post Mission Horizontal Position Accuracy (m)	0.02	0.1	0.05	0.1	0.1	0.2	0.1	0.04	0.1
Post Mission Vertical Position Accuracy (m)	0.02	0.1	0.1	0.2	0.05	0.2	0.1	0.1	0.1
Max Baseline (nmi)	1	16	10	18	6	40	50	54	50
RTK Mode	8	8,5,4,2,0	8,7,4,2	8,4,0	8	4	4	4,1	

Flight Test Results
TSPI Level II Non-Position Solution

- **Attitude Accuracy Passes with Significant Margin in Most Cases**
  - **TSPI Level II Attitude Accuracy as Scored by Holloman CRS in this Case**

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (deg)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Roll Accuracy (deg)	0.03	0.02	0.02	0.03	0.1	0.1
Real Time Pitch Accuracy (deg)	0.01	0.01	0.01	0.01	0.1	0.1
Real Time Heading Accuracy (deg)	0.01	0.01	0.02	0.02	0.1	0.1
Post Mission Roll Accuracy (deg)	0.005	0.01	0.01	0.01	0.005	0.05
Post Mission Pitch Accuracy (deg)	0.01	0.02	0.01	0.01	0.005	0.05
Post Mission Heading Accuracy (deg)	0.01	0.01	0.01	0.01	0.01	0.05

Flight Test Results
TSPI Level II Non-Position Solution

- Attitude Rate Accuracy Passes with Significant Margin in Most Cases
  - TSPI Level II Attitude Accuracy as Scored by Holloman CRS in this Case

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (deg/sec)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Roll Accuracy (deg)	0.04	0.04	0.1	0.1	0.1	0.2
Real Time Pitch Accuracy (deg/sec)	0.03	0.04	0.2	0.02	0.1	0.2
Real Time Heading Accuracy (deg/sec)	0.1	0.1	0.1	0.04	0.2	0.2
Post Mission Roll Accuracy (deg/sec)	0.1	0.1	0.1	0.1	0.02	0.1
Post Mission Pitch Accuracy (deg/sec)	0.02	0.03	0.1	0.02	0.01	0.1
Post Mission Heading Accuracy (deg/sec)	0.05	0.02	0.1	0.02	0.01	0.1

Flight Test Results
TSPI Level II Non-Position Solution

- **Uncorrelated Mechanical Vibration Modes between TSPI and Truth Sources Caused Large Velocity Errors at Point of Navigation (GPS Antenna for This Test)**
  - **Hence, Truth Sources Were Not Capable of Scoring the TSPIs**

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (m/s)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Horizontal Velocity Accuracy (m/s)	0.01	0.05	0.07	0.05	0.01	0.03
Real Time Vertical Velocity Accuracy (m/s)	0.01	0.04	0.07	0.06	0.04	0.03
Post Mission Horizontal Velocity Accuracy (m/s)	0.015	0.04	0.06	0.04	0.01	0.01
Post Mission Vertical Velocity Accuracy (m/s)	0.01	0.02	0.04	0.04	0.01	0.01

Flight Test Results
TSPI Level II Non-Position Solution

- TSPI Level II Velocity Consistency between TSPI A & B was Investigated, Since Truth was Severely Impacted by Lever Arm Length
- Consistency between TSPI Units is Very Good as Seen Below
  - TSPI A/B Comparison is an Indicator that Level II Velocity Can be Met

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (m/s)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Horizontal Velocity Accuracy (m/s)	0.005	0.017	0.04	0.013	0.004	0.03
Real Time Vertical Velocity Accuracy (m/s)	0.004	0.009	0.03	0.008	0.002	0.03
Post Mission Horizontal Velocity Accuracy (m/s)	0.003	0.01	0.01	0.030	0.002	0.01
Post Mission Vertical Velocity Accuracy (m/s)	0.003	0.005	0.01	0.01	0.001	0.01

Flight Test Results
TSPI Level II Non-Position Solution

- High Frequency Motion components were Aliased to Near DC in 50 Hz TSPI Acceleration Outputs
  - Primary Driver Was Vibratory Motion of Isolated Inertial Sensor Assembly Relative to IMU Chassis
  - Problem will be Addressed in CRIIS Phase-II via Additional Filtering of IMU Outputs Used Only for Generation of the TSPI Acceleration outputs

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (m/s/s)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Horizontal Acceleration Accuracy (m/s/s)	0.04	0.07	0.18	0.03	0.02	0.03
Real Time Vertical Acceleration Accuracy (m/s/s)	0.03	0.03	0.08	0.04	0.02	0.03
Post Mission Horizontal Acceleration Accuracy (m/s/s)						0.01
Post Mission Vertical Acceleration Accuracy (m/s/s)						0.01

PMP Acceleration Could Not be Scored Due to Measurement Aliasing

Flight Test Results
TSPI Level II Non-Position Solution

- **TSPI Level II Acceleration Accuracy was Evaluated for Consistency between TSPI A & B**
  - **Aliasing Found in 50 Hz Data and Not the Recorded 300 Hz Raw IMU Data**
  - **300 Hz IMU Data Used to Compare TSPI A & B**

Flight	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	29 Oct, Flight 2	Requirement (m/s/s)
Maneuver Type	Climb	360 degree 3g turn	360 degree 5g turn	360 degree aileron roll	Straight & Level	
Maneuver Segment (sec)	1325-1422	1770-1840	1935-2072	2143-2158	1840-1935	
Real Time Horizontal Acceleration Accuracy (m/s/s)	0.01	0.01	0.01	0.01	0.004	0.03
Real Time Vertical Acceleration Accuracy (m/s/s)	0.01	0.02	0.01	0.01	0.01	0.03
Post Mission Horizontal Acceleration Accuracy (m/s/s)						0.01
Post Mission Vertical Acceleration Accuracy (m/s/s)						0.01

300 Hz IMU Data Could Not be Used in PMP as it Operates Only on 50 Hz Data

Common Range Integrated Instrumentation System (CRIIS)

Conclusions

- CRIIS High Dynamic Real-Time TSPI Developed and Implemented Using State-Of-The-Art Processing Algorithms
- CRIIS TSPI Level-II Accuracies Successfully Demonstrated thru a Phased Approach
  – M&S, HIL, Van, Roller-Coaster Used to Identify issues and Tune/Fix Algorithms
  – High Dynamics Flight Test Results Demonstrate TRL6 Maturity (Performance in Relevant Environment)
- System Development in EMD Phase

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GUARDING THE INTENT OF THE REQUIREMENT

27th Annual National T&E Conference

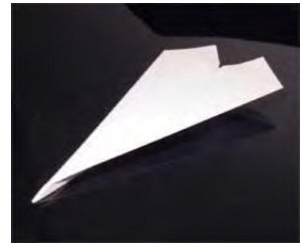
Marriott Tampa Waterside
March 17th, 2011

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

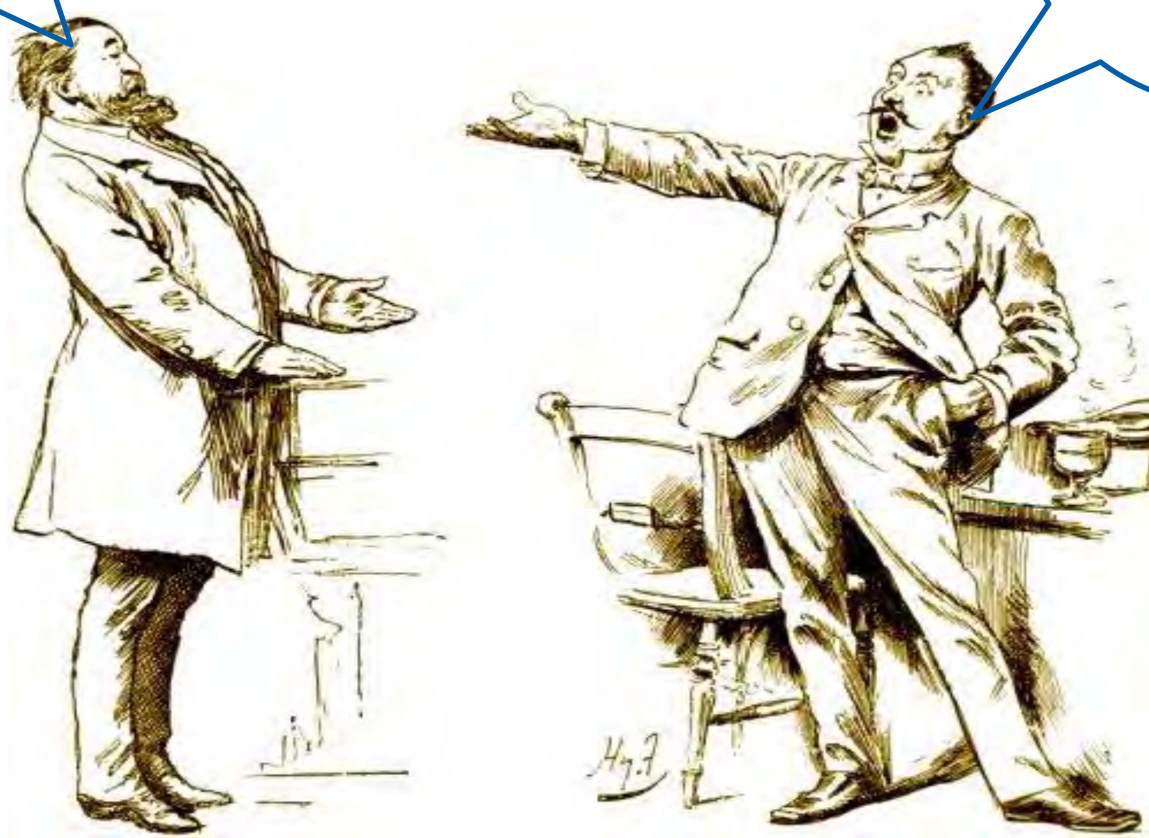
The Challenge – Avoid Creating a product Which Neglects the Warfighter's Needs

NORTHROP GRUMMAN

I hear you..
This is what
you want



This is
exactly
what I need



Establishing the Intent

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JCIDS

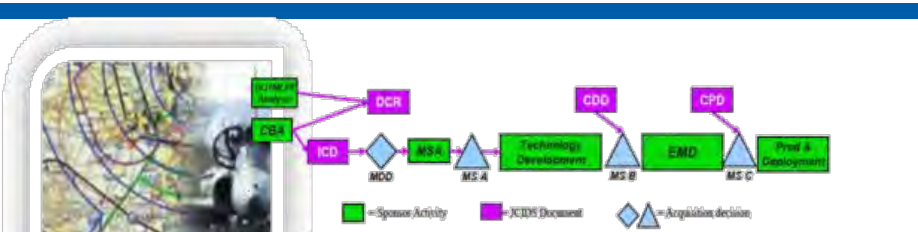
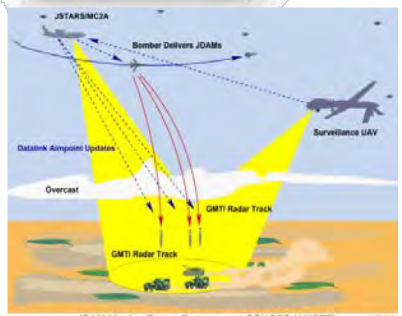


Figure A-1. Interrelationship of the JCIDS and Acquisition Processes

February 2009 Updated 31 July 2009

MANUAL FOR THE OPERATION OF THE JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM

CONOPS

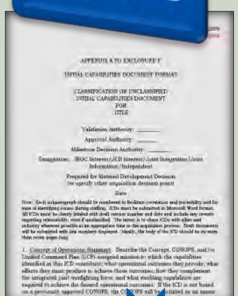


JDAM Moving Target Engagement CONOPS (AMSTE)

Mission needs result from assessments of current and projected capability requirements. Mission needs may establish a new operational capability, improve an existing capability, or exploit an opportunity to reduce costs or enhance performance. **MIL-HDBK-245D**

Rqmts

ICD



Test

TES

Test & Evaluation Strategy *(TES) is an early Test and Evaluation (T&E) planning document that describes the T&E activities starting with Technology Development and continuing through EMD into Production and Deployment.*

CDD

TEMP

Test and Evaluation Master Plan
The TEMP documents the overall structure and objectives of the Test and Evaluation (T&E) program. ....The TEMP identifies the necessary Developmental Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E), and Live Fire Test and Evaluation (LFT&E) activities.

This Is What is Needed

Template - ICD - JCIDS Manual - 31 July 2009.docx

https://acc.dau.mil/CommunityBrowser.aspx?id=29065

Flowing the Intent

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Rqmts

Capabilities
- Performance / Function / Interface
- KPPs

Design Requirements
- Translation of the capabilities to Design Requirements

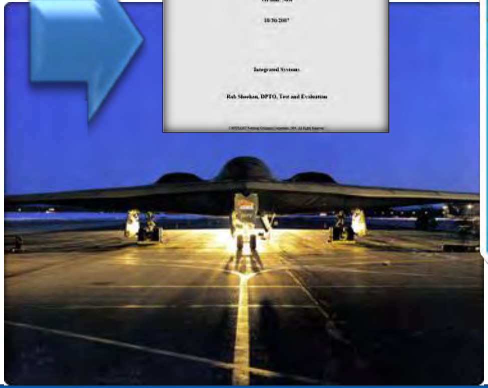
Formal Proof
- Agreed to Verification Activities

CDD → TEMP

System Spec (Contr)

Verification Plan

Integrated Test Program



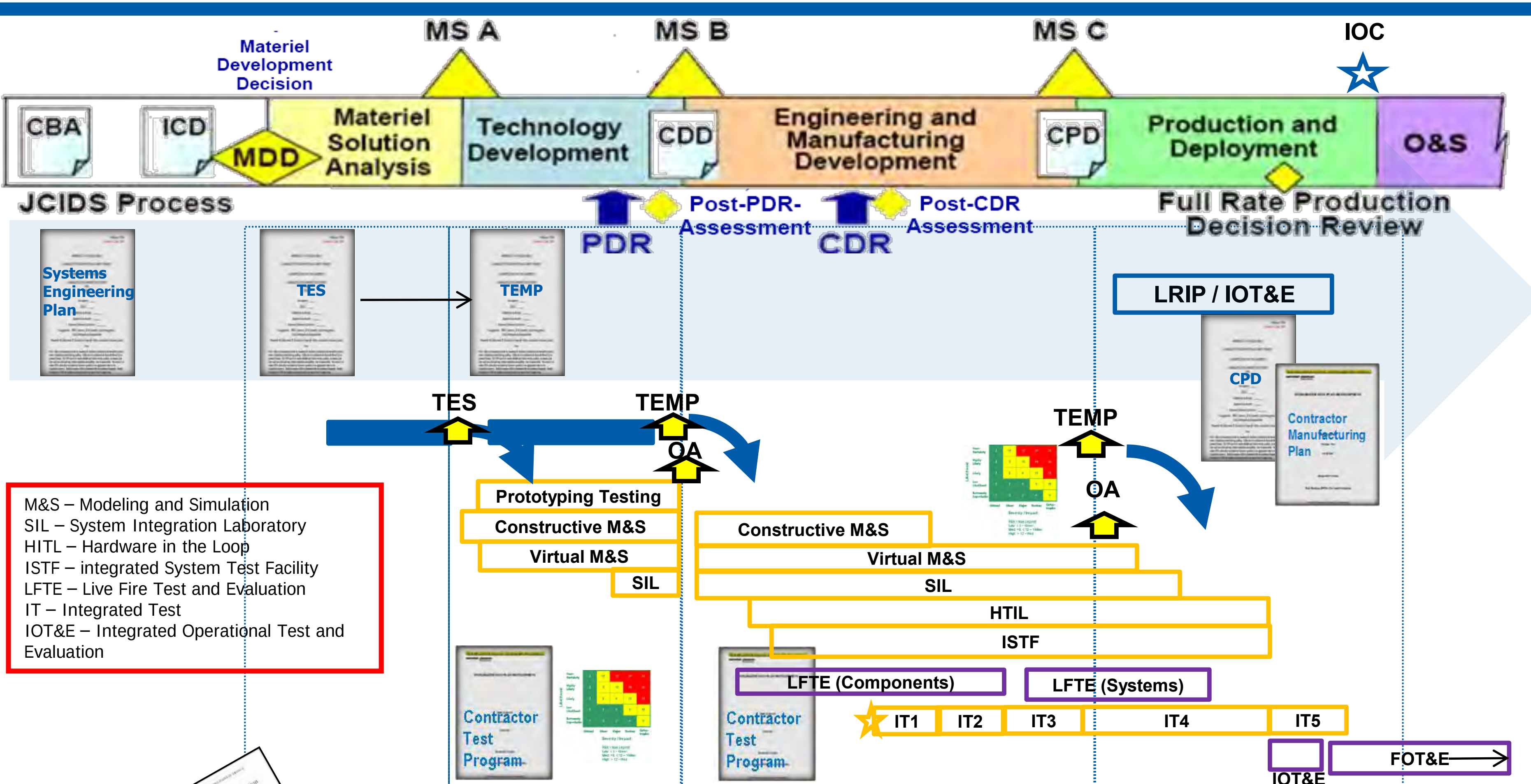
Test

Integrated Test Program and Strategy
- Total Test Approach, Environment, Needs

Documented Coordinated Contractor Test Program
- Definition of the Test Program (Formal and Informal) Activities Through Product Development

A Testing Program Aligned to the Intent of the Warfighter Needs

Guarding the Intent - A Lifecycle Look



T&E

- "….incorporation of T&E considerations and requirements begins at the onset of program planning during the Material Solutions Analysis and TD phases" (paragraph 2.1 Incorporating Test and Evaluation into Department of Defense Acquisition Contracts)

Intent must be maintained throughout the programs lifecycle to ensure warfighter need is provided

Pre-Milestone A
Pitfalls & Solutions

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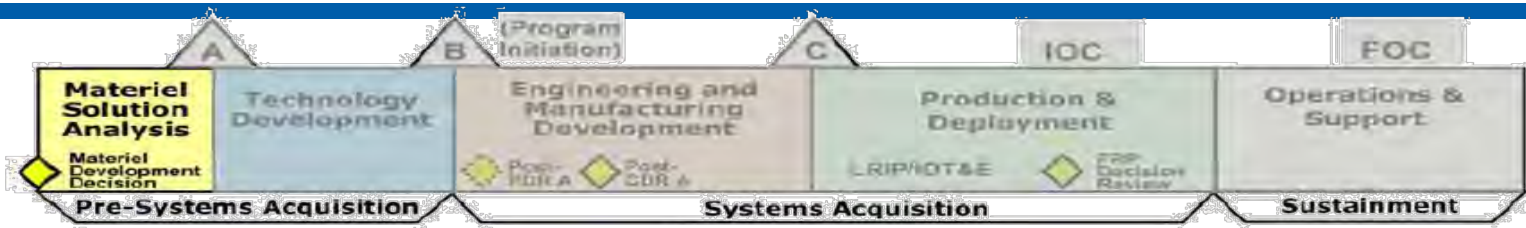
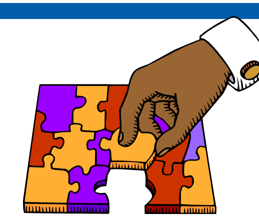




A lack of clear communication between those setting requirements and those in the acquisition process turning requirements into acquisition plans and contract specifications.
HOUSE ARMED SERVICES COMMITTEE PANEL ON DEFENSE ACQUISITION REFORM FINDINGS AND RECOMMENDATIONS March 23, 2010

"The Act [WSARA 2009] recognizes that 'unrealistic performance expectations' and 'immature technologies' are among the root causes of trouble in defense programs,"
DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

"… early stages of an acquisition program are in many ways the most critical. It is in the early stages that investments must be made in systems engineering, in acquiring technical data rights to support competition and system sustainment, and in robust developmental testing"
HOUSE ARMED SERVICES COMMITTEE PANEL ON DEFENSE ACQUISITION REFORM
FINDINGS AND RECOMMENDATIONS March 23, 2010

Solutions

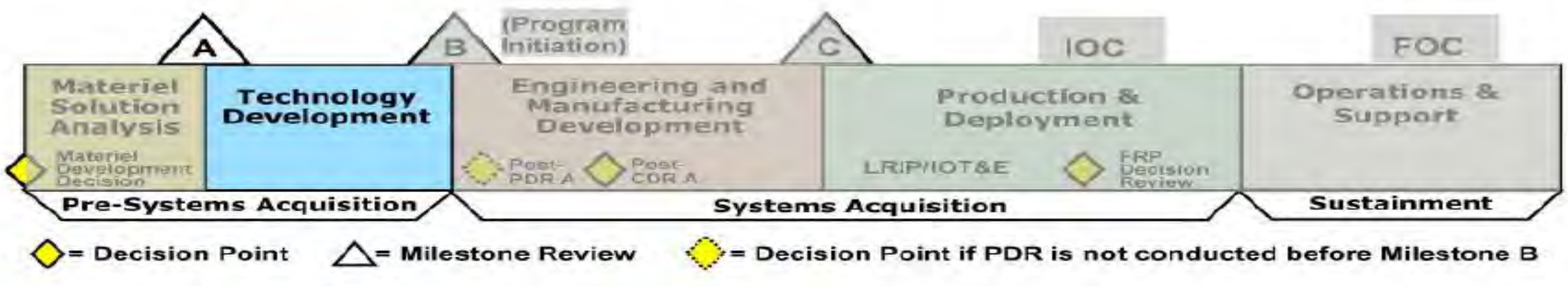
Fund The Program Correctly
Establish A robust Systems Engineering Community
Government / Industry Working Groups
Technical Reviews
Coordinated Capabilities– ICD
Contract Language Supporting Integrated Testing
TES – Test Strategy

5000.02

"The test and evaluation community can, during the requirements-setting process, identify such potential problems early in the life of programs."
DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

Starting a program right is essential to program success

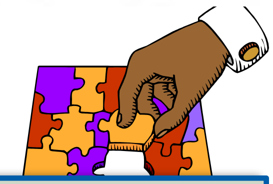
Technology Development Phase Pitfalls & Solutions



'….and 'immature technologies' are among the root causes of trouble in defense programs'
DOT&E Director J. Michael Gilmore Feb 24 2010 Aviationweek.com

Technology Development and Risk Assessment lacks Connectivity to Operational Mission
"immature technologies" entering EMD
Former DOT&E Director Charles McQueary Feb 2008 NDIA

Solutions



- A sound Technology Development Plan (TRL Maturation)
- A coordination between the TES and TEMP
- A capability Development Document that details the operational performance parameters for the anticipated system
- Test Planning establish Integrated Test Plans accounting for Risk Related Activities
- Implement Integrated Test Concept WIPT / CTF

5000.02

Technology Development must be performed within the intended operational environment

Engineering and Manufacturing Development- Pitfalls & Solutions

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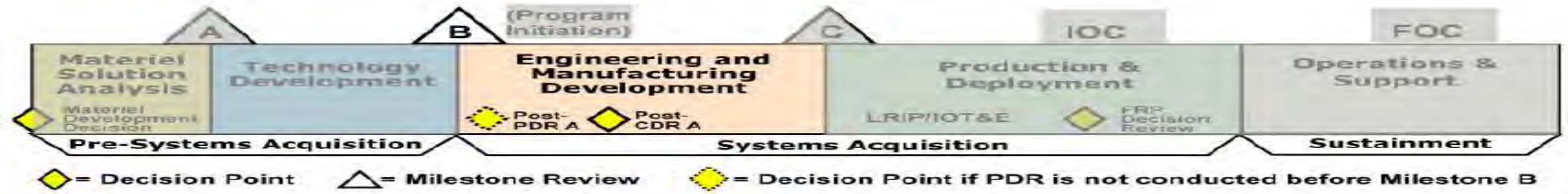


Requirements Creep - preclude destabilizing requirements changes 5000.02 Dec 08

PROCESS Charles "Pete" Adolph NDIA May 2010

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

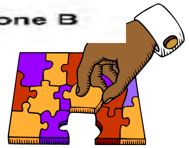
Section 231 Report to Congress Core T&E Principles - 2007

Verify technical design throughout normal operating envelope ASAP

Fly Before You Buy

PROCESS Charles "Pete" Adolph NDIA May 2010

Solutions



- Early and effective employment of systems engineering, applied in accordance with a well-structured Systems Engineering Plan.
    - Technical reviews that align capabilities to specifications
    - Identify potential management risks and issues in a timely manner.
- Configuration Steering Boards used to avoid requirements creep
- Integrate DT and OT test activities
- Evaluations shall include a comparison with current mission capabilities
- Use of WIPT / CTF concept ensuring Alignment of Government and Contractor Test Plans
- Contractors Development of a Modeled Executable Test Program that demonstrates excitability and accounts for the operational environment
- Coordinated data Sets to support OA's

Integrated Testing

Avoid Mindless Specification Verification / Test as you will Fly

Share the Data

Production and Deployment Pitfalls & Solutions

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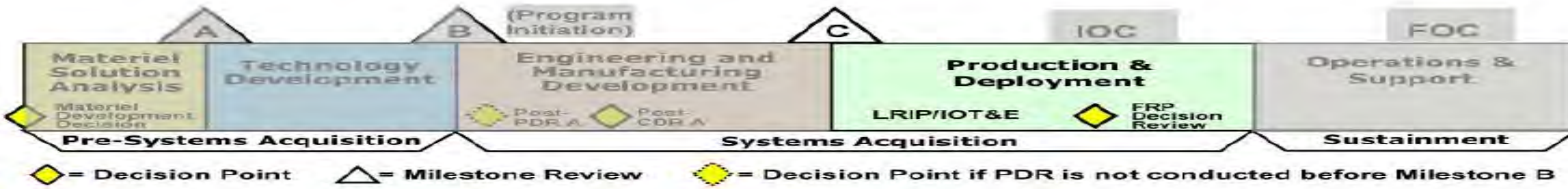
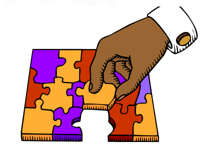


Solutions



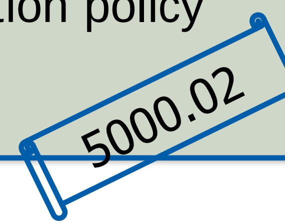
Requirements Creep - preclude destabilizing requirements changes 5000.02 Dec 08

PROCESS Charles "Pete" Adolph NDIA May 2010

Incomplete OA Assessments Prior to Authorization to LRIP / Production

Former DOT&E Director Charles McQueary Feb 2008 NDIA

- Updated TEMP and Comprehensive Capabilities Product Document (CPD)
- Contractor Production Plan consistent with CPD
- ATP's test with proper environment where applicable
- Implement Block update acquisition policy "Evolutionary Acquisition"



Build what you Intended – No More – No Less

Lessons Learned

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Program Problem	Issue	Fix
Incomplete and Ambiguous Requirements	Lack of Early Program Skill Mix inside SEIT prevented complete requirements Set Definition	Introduce and Program for Complete SEIT Skill including Specialty Engineering and Test and Evaluation Personnel Establish early verification program
Risk program not aligned with realistic operational environments	Technology development inconsistent with needs	Test Plan Integrated with SEP established Risk program waterfalls, planned early Contractor Test Program Integrated with TES and TEMP
Test Plan Intent not used during EMD	Test Plan not maintained throughout the EMD test program	Collaborative Test Plan Model Maintained throughout the Program Lifecycle (SE Model Tools Used to support Collaboration and Modeling) Contractor Test Plan Aligned with Requirements Verification and TEMP though SE traceability tool set
Data Rights Not Negotiated	Prevents OA using early test data	Good Contract Language and Propriety Information Agreements Established Early in a Program

Maintaining the Original Intent Delivers the Right Product to the Warfighter

Test Verification and Planning Guarding the Intent
A Contractor's Look at A Hybrid Solution

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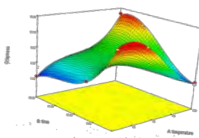
CDD, Requirements, TES TEMP, Risk Plan, Product Architecture, SEP, Program Management Plan

Test Verification &Planning

Integrated Test Team, Verification Requirements, Test Unique Requirements, Test Planning, Test Plan Modeling and Schedules, Architectural Refinement

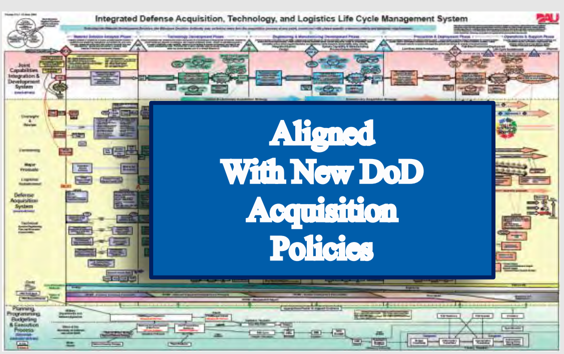
Team Products

- **Test Plan Strategy Developed and aligned with the TES and TEMP**
- **Test Strategy Coordinated and Optimized with ITT**
- **Major Range Coordination / Long Lead Planning Requirements Established**
- **Integrated T&E Strategy and Approach Addressing the Total Program Lifecycle**
- **Event Driven, Measurable Modeled Test Approach Logically Sequenced and Optimized**
- **Operationally Realistic Environments and Measurements Defined**
- **Verifiable Requirements with Established Completion Criteria**
- **Unique Test Requirements Needed to Complete the System Design Requirement Set**
- **Integrated Test Plan aligned with Program Risk Plan**



Program Values

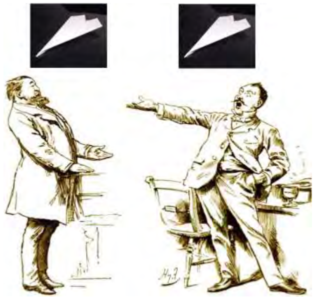
- **Early Test Plans and Facilities Definitions.**
- **Requirements Based on Tested Architecture**
- **Streamlined Testable Architecture**
- **Event Based Test Schedule Developed**
- **Integrated Risk Program**
- **Scientific and Statistical methods applied to Test Plan**
- **Verifiable Requirements &Verification Statements Developed**
- **Test Unique Design Requirements Developed.**
- **Embedded Operational Realism in Test Program**
- **Support to Operational Sustainment Assessment As Required**



TV&P Ensure Intent is Captured in the Verification Program

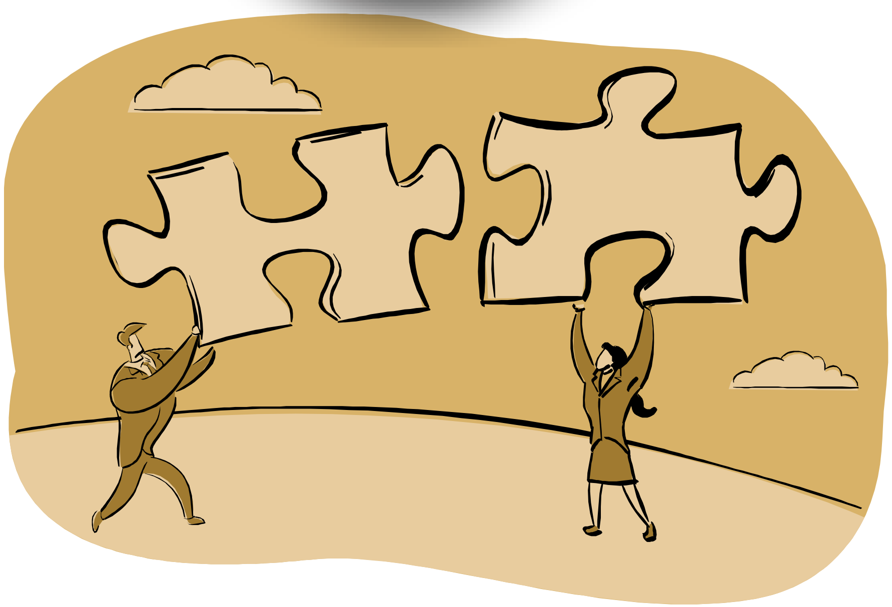
Conclusions:

- Maintaining the original intent of the product is mandatory for the Warfighter's success.
- Intent is sourced from multiple places
  - Mission Statement, TES , TEMP, OPSCON / CDD
- Attention to the intent must be maintained throughout the program's lifecycle
- Avoid the temptation to complete requirements verification to the "Letter of the Spec", remember how the product must perform the requirements.



- Tools and processes exist today to help avoid these pitfalls.
  - Modeled Test Plan
  - Modeled Tests
  - Coordinated Working Groups
  - Data Plan supporting a Program's Lifecycle including early will help offset total program costs
- Too many programs are driven by cost and schedule at the expense of performance
  - PMs must embrace the idea of Integrated Testing
  - Ensure Programs start with the proper skill mix

Questions



Contact Information

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A Day in the Life of a Verification Requirement- Tutorial

27th Annual National T&E Conference

Marriott Tampa Waterside
March 14th, 2011

Stephen Scukanec

Senior Test Engineering
Flight Test and Evaluation
Northrop Grumman
Aerospace Systems

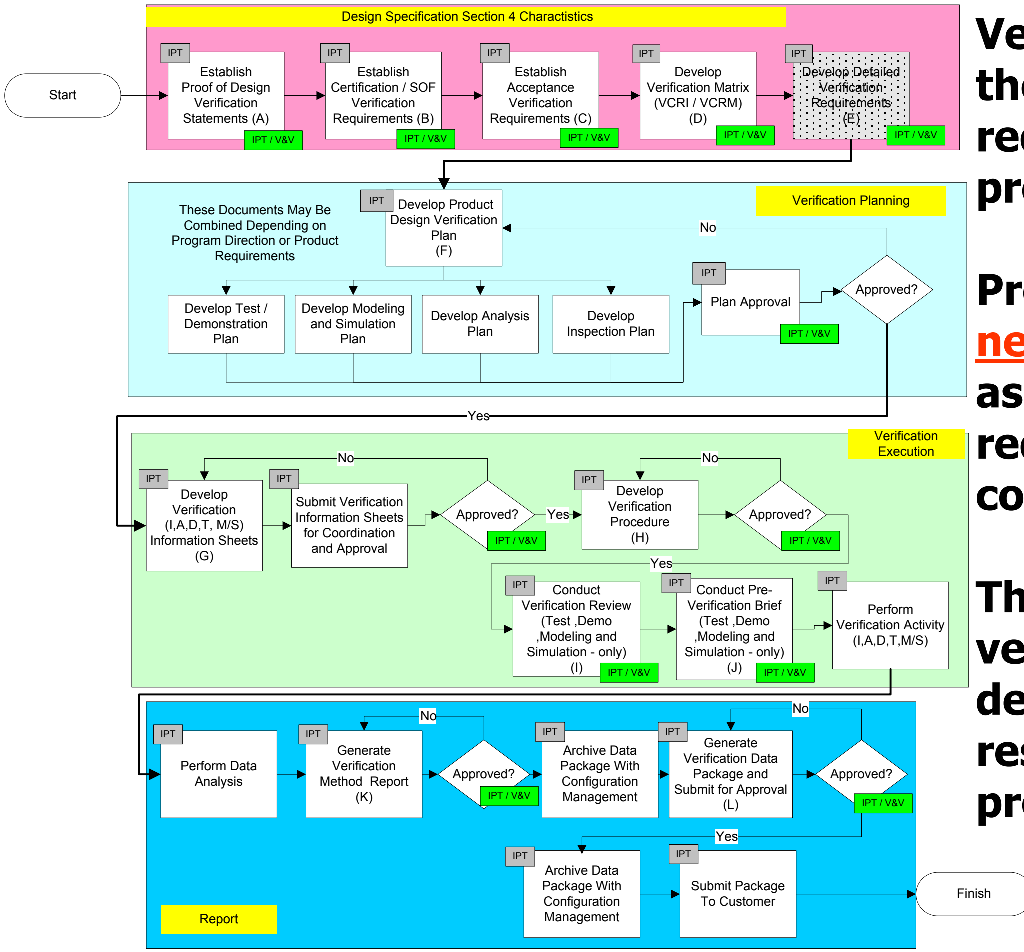
Verification Requirements – What Are They And Why Do We Need Them?

- Verification requirements specify the verification events needed to prove the satisfaction of the product requirements and help to define the verification process and environment

- Verification requirements are necessary for at least two reasons:
  - **Existence of verification requirements demonstrates verifiability of product requirements**
  - **Agreed-to verification requirements define the verification program by which the contractor shows that the product is what the customer contracted for**

A Day in the Life of a Verification Requirement

Product Requirements



Verification events satisfy the verification requirements, NOT the product requirements.

Product requirements are never complete until the associated verification requirements are completed

The culmination of the verification activity of the design requirements results in a verified product.

DD-250

Start with Product Requirements

- The verification process begins with authenticated product requirements
- Examples:
  - **PR-1:LRU markings***
    - **The product line-replaceable units shall be marked in accordance with MIL-STD-130M.**
  - **PR-2: Operational availability**
    - **The product shall have an operational availability (A_0) of 97.5% at IOC.**
  - **PR-3: Flight performance**
    - The Transportation Management Center shall handle up to 15 major incidents and 30 minor incidents during peak travel hours.
  - **PR-4: LRU accessibility***
    - **Each product line-replaceable unit shall be able to be removed and replaced without removing any other item or displacing any cables.**
  - **PR-5:Recovery force communication – nominal**
    - **The product shall provide a communications system capable of communicating with the recovery forces pre- and post- landing**

Verify <u>all</u> product requirements, not just functional/performance requirements

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Create Verification Criteria

Design Requirement

3.2.2.15.34 Recovery Force Communications
The product shall provide a communications system capable of communicating with the recovery forces pre- and post- landing

Design Verification

Verification Objective	Pass / Fail (Success Criteria)
Perform Integrated System Test of the communications system capability to provide a voice communications and beacon with recovery forces pre and post landing within an integrated hardware / software environment	**Testing will show that the communications system can transmit and receive audio at frequencies and ranges (power) represented by standard ground recovery force communications devices as defined in TBD**
Perform a demonstration of the communications systems capability to provide voice and beacon communications with recovery forces pre and post landing while within a representative environment and using a production equipment configuration	**Demonstration will show the ability for the communications systems to verbally communicate with the on-board communication production configuration equipment. The demonstration will also show beacon tracking within communication ranges established by TBD.**

Traceability

Verification Cross Reference Matrix

Paragraph #	N/A	I	A	M/S	D	T
3.2.2.15.34						VR-5T
3.2.2.15.34					VR-5D	

SE – Translates Operational Objectives into Design Requirements

Design – Provides assessment of requirements implementation

Test – Provides assessment of requirements verifiability

<u>SE</u> – Provides compliance of the design requirement

<u>Test / Implementation Group</u> –

Ensures Verification Implementation Feasibility

Advises alternatives to support programmatics

Assesses completeness

Provides verifiability assessment

SE – Verification Allocation and Traceability Assurance

Identifying a verification method is necessary, but not <u>sufficient</u>!

Verification Requirement Attributes

Verification Requirements
- Inspection
- Analysis
- Modeling and Simulation
- Demonstration
- Test

Must answer 5 Questions

☑Objective

What is the purpose of this verification?

☑Method

What method do you need performed? What are the verification circumstances (e.g., laboratory, desk-top analysis, flight test)?

☑Environment

What are the environmental conditions under which the item will be verified?

☑Special Conditions (if necessary)

Are there any unique conditions (e.g., item configurations) necessary for the execution of the verification?

☑Success Criteria

What results are to expected?

Verification Methods

- Inspection:
  - **An element of verification that is generally nondestructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; and mechanical and electrical gauging and measurement. (MIL-STD-961E; called Examination)**
- Analysis:
  - **An element of verification that uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements were met. (MIL-STD-961E)**
- Demonstration:
  - **An element of verification that involves the actual operation of an item to provide evidence that the required functions were accomplished under specific scenarios. The items may be instrumented and performance monitored. (MIL-STD-961E)**
- Test:
  - **An element of verification in which scientific principles and procedures are applied to determine the properties or functional capabilities of items. (MIL-STD-961E)**

Verification isn't <u>ONLY</u> test!

Sample Verification Requirements - 1

- **VR-1I: compliance of product markings shall be verified by examination of design drawings at the LRU supplier's location prior to the LRU CDR. The inspection will show that each marking on the LRU conforms to MIL-STD-130M.**

- **VR-2A: the product operational availability shall be calculated using the results of the government-accredited contractor-developed reliability and maintainability analyses performed during the design in conjunction with the design reference missions documented in report xxxx. The analysis will show that the product, in its operational environment, supported with its support equipment and personnel, across all missions, will have an operational availability of at least 97.5%.**

Sample Verification Requirements - 2

- VR-3MS: Verification of the TMC's handling of 15 major and 30 minor incidents during peak hours shall be shown through a live simulation. The TMC training simulator shall be configured for peak a peak-travel-hours training class and staffed with trained TMC operators. The training-simulator operator shall inject various combinations of major and minor incidents over the peak-travel period and the TMC performance shall be recorded digitally and using digital cameras. The simulation shall be repeated using different combinations of TMC operators and sets of incident combinations. Verification shall be achieved when the TMC handles all simulated sets of incidents with all combinations of operators with no equipment or software overloads or interrupts and with no operator overloads or interrupts.

- VR-4D: Removal and replacement of all LRU's shall be demonstrated on the aircraft to show that each LRU can be removed and replaced without removing any other items or moving any cables.

- VR-5D: Perform demonstration to provide a communications system capable of communicating with the ground command team while in a representative environment and production configuration. Demonstration will show capability to communicate with recovery forces at TBD distances in the TBD terrain environment.

Sample Verification Requirements - 3

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- **VR-5T: Prove that the product's communications system is capable of communicating with the ground command team by performing an integrated system test within an integrated hardware/software environment. Testing will show that the product can transmit and receive to standard ground recovery forces audio at frequencies represented by communications devices defined in (TBD).**

Verification Objective

Verification Method

Environment

Note – there are no Special Conditions

Success Criteria

Verification Requirements Flow and Traceability

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PR-1	PR-2	PR-3	PR-4	PR-5
VR-1I	VR-2A	VR-3MS	VR-4D	VR-5D VR-5T

Specification

Design Requirements

Verification Requirements

Verification Requirements Appear in the Same Specification as the Product Requirements to be Verified

Master Verification Plan

Inspection **VR-1I**
Analysis **VR-2A**
Modeling and Simulation
VR-3MS
Demonstration
VR-4D, VR-5D
Test
VR-5T

Product Requirement	N/A	Insp	Anal	M&S	Demo	Test	Verification Requirement
PR-1		X					VR-1I
PR-2			X				VR-2A
PR-3				X			VR-3MS
PR-4					X		VR-4D
PR-5					X	X	VR-5D VR-5T

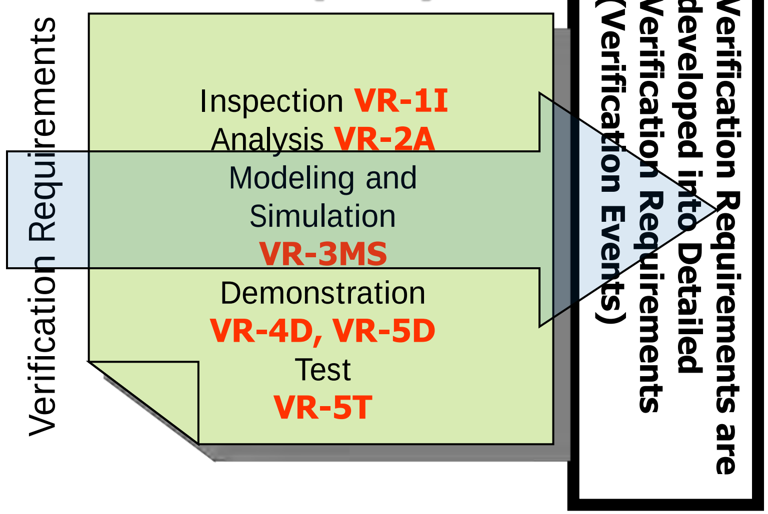
Verification Requirements

Verification Traceability

Create Detailed Verification Requirements (Verification Events)

Convert verification statements into detailed verification requirements (verification events) by ----

Master Verification Plan (MVP)

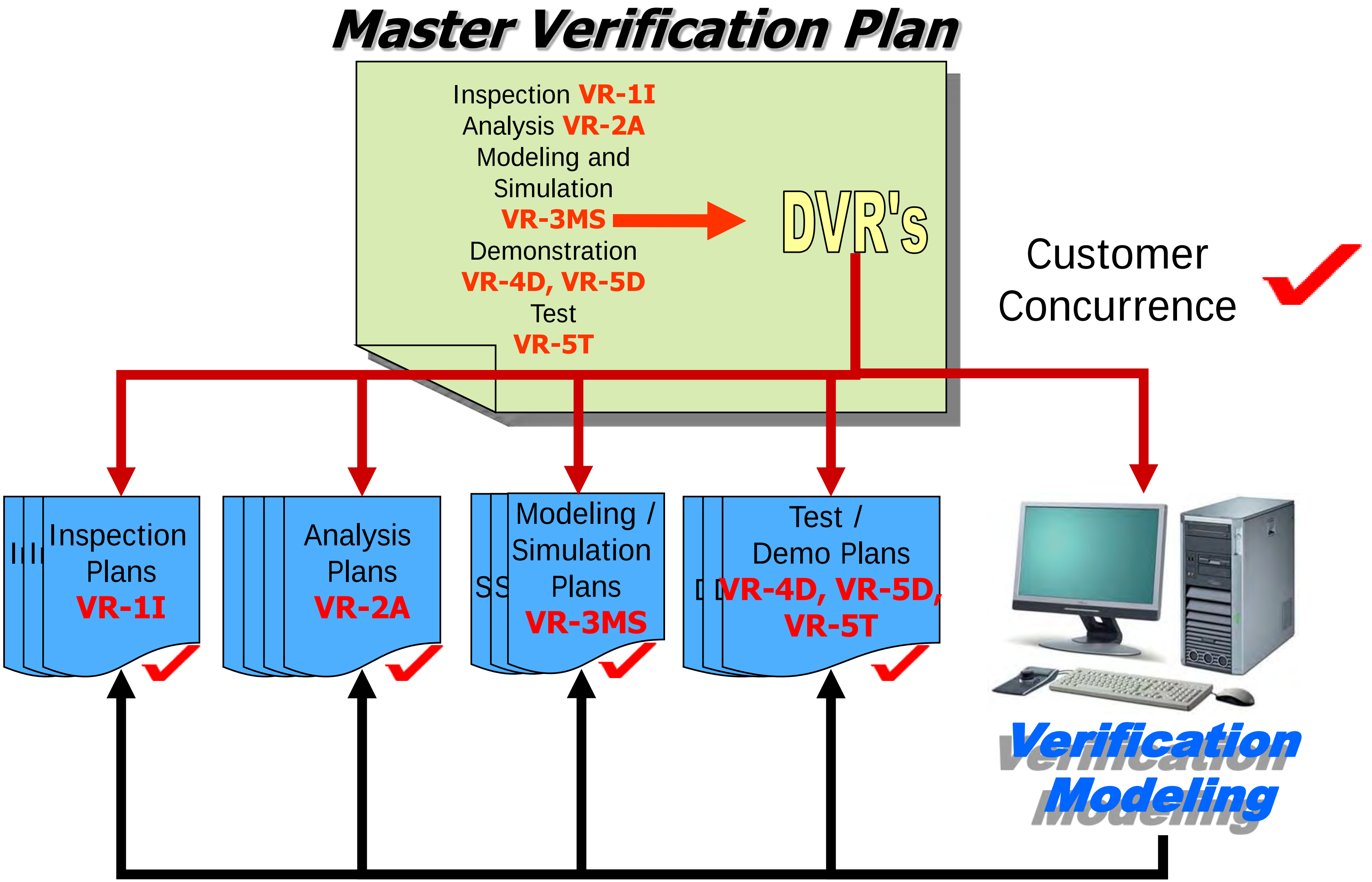


A One To One Relationship Exists Between the Verification Requirements and the DVRs

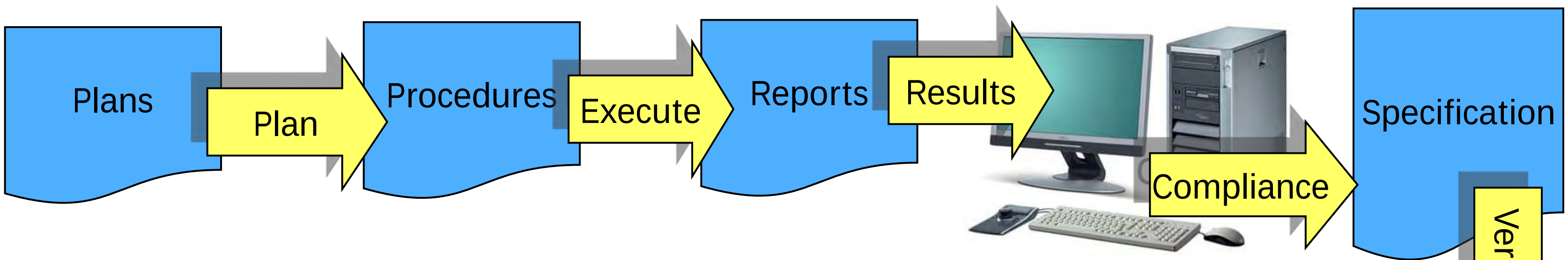
For each verification activity identified in the verification matrix, develop a detailed description of the activity including:

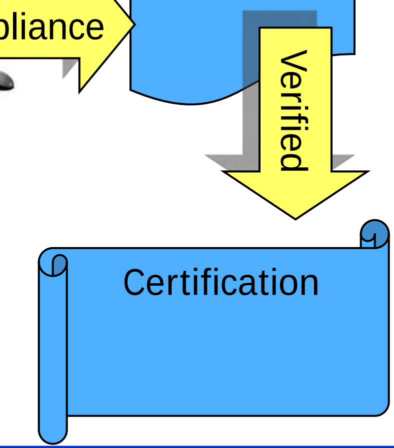
- **Verification configuration and its relationship to production configuration**
- **Associated prerequisites**
- **Constraints**
- **Objectives**
- **Procedures**
- **Relevant environmental conditions**
- **Pass/fail criteria- and necessary Data Set,**
- **Analysis models, if applicable.**
- **Sequence if applicable**
- **Verification Environment (e.g., Lab, Flight, Production)**

Master Verification Plan



Verification Execution Flow





Method	Organization	Early Verification Benefits
Inspection	**QA, Manufacturing, Mission Assurance**	**•Inspection Points Identified** **•Tooling Requirements Identified**
Analysis	**Systems Engineering Specialty Engineering** **Design**	**•Define / Build / Buy / Train Analysis Prior to Need Date** **•Accreditation of Analyses Tools Prior to Need Date**
Modeling and Simulation	**Systems Engineering Specialty Engineering** **Design, Operational Assessment**	**•Define / Build / Buy / Train Modeling and Simulation Tools Prior to Need Date** **•Accreditation of Models Prior to Need Date**
Demo & Test	**Ground and Flight Test** **Facilities Development**	**•Laboratory and Lab Software Requirements Identified** **•Facilities Requirements Identified** **•Long Lead Test Items Identified**

Early Verification Supports Multiple Organizational Functions' Long Lead Needs and Prevents Costly Late Program Re-Work

Planning for Verification Execution and Product Verification

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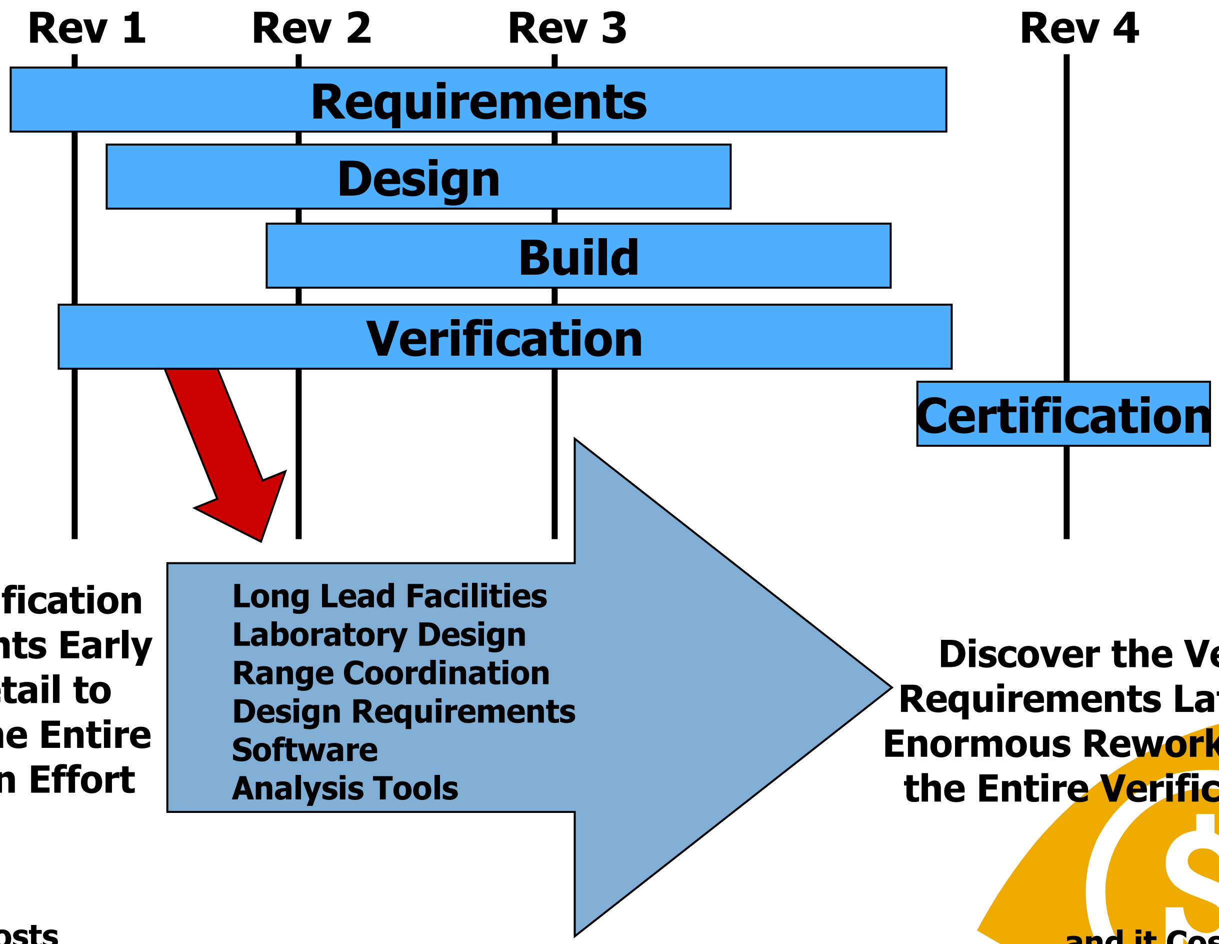


Define Verification Requirements Early and in Detail to Establish the Entire Verification Effort

… and it Costs Relatively little …

Discover the Verification Requirements Late and Have Enormous Rework to Establish the Entire Verification Effort

… and it Costs a Lot More …

Early Verification Is an Effective Cost Avoidance Approach

Requirements: The Good …

- **The (radio set) design shall allow trained operators and maintainers to perform all critical tasks required to install, operate and maintain the (radio set) correctly on the first attempt 90% of the time.**

- **The XYZ satellite shall be launched on a Delta IV EELV or on an Atlas V EELV.**

- **The XYZ spacecraft shall rendezvous with the ISS in accordance with the Interface Definition Document (IDD) for International Space Station (ISS) Visiting Vehicles (VVs), SSP 50235 .**

- **The XYZ spacecraft shall shall perform the precision approach maneuver to the ISS in accordance with the Interface Definition Document (IDD) for International Space Station (ISS) Visiting Vehicles (VVs), SSP 50235.**

- **The XYZ spacecraft shall dock with the ISS in accordance with the Interface Definition Document (IDD) for International Space Station (ISS) Visiting Vehicles (VVs), SSP 50235.**

Requirements: … The Bad …

- The ship and all systems shall be designed to minimize maintenance. Maintenance personnel shall be provided the necessary tools, information, technical documentation and skills to perform maintenance.

- The Product shall provide controls and displays to facilitate operator interaction in carrying out all assigned missions.

- And, of course, …
  The Product shall be user-friendly.

Requirements: … And The (Truly) Ugly.

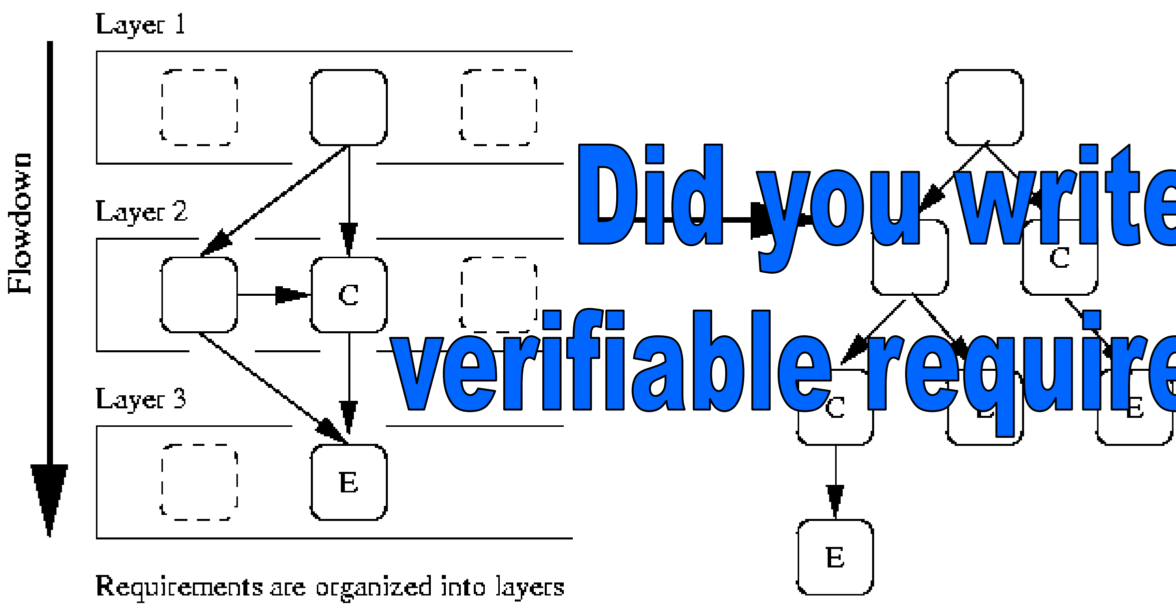
- **Human Systems Integration (HSI) characteristics and capabilities for (the ship) will include human factors engineering, personnel, habitability, manpower, training, environment, safety and occupational health (ESOH) and personnel survivability. HSI processes will be used to maximize human performance effectiveness, reliability, readiness and safety of the ship and crew while minimizing system life-cycle costs through iterative analysis and design tradeoffs.**

- **All systems shall be designed for maintainability. Reductions in manpower requirements for system maintenance (both planned and unscheduled) shall be achieved through an in-depth analysis of maintenance related tasks, early identification of maintenance concepts, and definition of maintenance requirements and constraints early in the design process. Burdens imposed on manpower, personnel and training related to system maintenance shall be identified as early as possible and refined throughout the development process.**

- **The ship shall be capable of being operated and maintained without requiring significant new knowledge, skills, abilities, aptitudes or physical characteristics of the core crew and mission package crews.**

Requirement Generation

- Class Exercise - Generate a good requirement as agreed to by the team and then let's test the theory
  - Generate a Requirement for the following Methods
    - Analysis
    - Test
    - Inspection



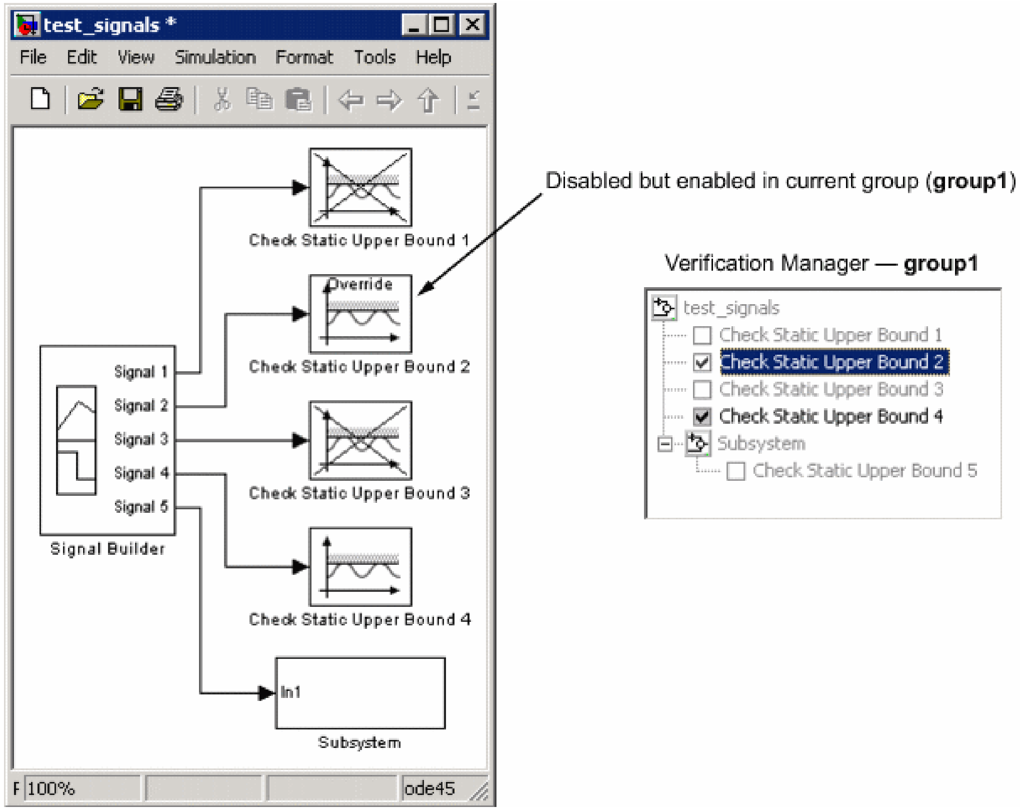
Did you write a verifiable requirement?

Requirements are organized into layers for team development.

What is Verification ?

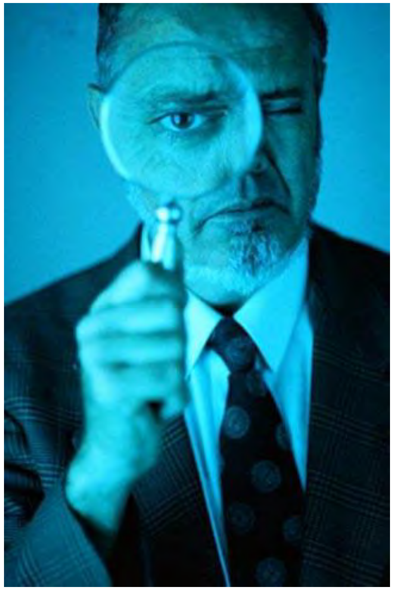
What is Verification?

- Confirmation, through the provision of acceptable objective evidence, that specified requirements have been fulfilled. (MIL-STD-961E)



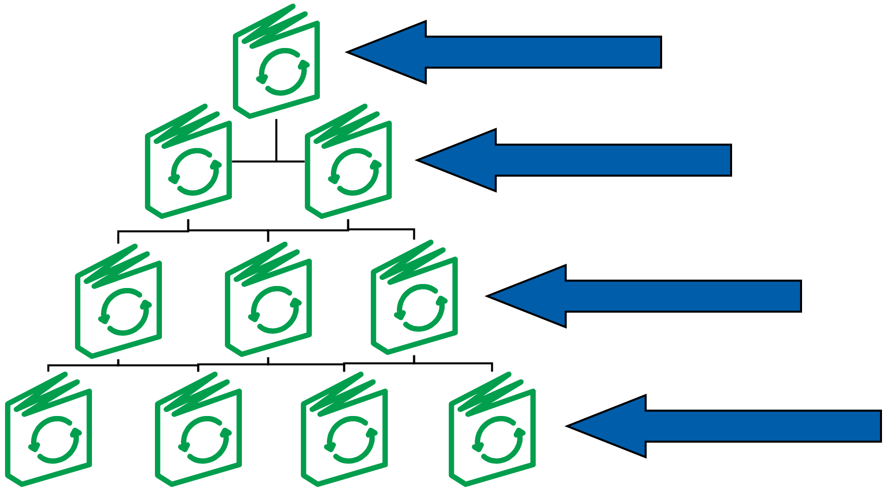
Verification Requirement

- A Verification Requirement's Purpose
  - Establishes the Requirements Intent
    - "If the Unit-Under-Verification (UUV) performs this way (or has characteristics), it is compliant with the requirement"
  - Establishes the completion criteria
    - "Requirement contract with the customer"



Verification Requirement

- Verification Requirement Levels
  - Developed for all specification levels (where ever there is a shall)
  - Written at the level of the unit configuration defined by the specification configuration item
    - "The Item Under Verification is the Title of the specification"
    - If you can't generate a Verification Requirement at the level of the specification-defined item, then the requirement is written at the wrong level"



Verification Requirement

- A one to many relationship exists between the “Shall” and the associated verification requirement's).
  - Example
    - The Product shall provide visual operator status of power to the unit when applied for both proper and improper power conditions established by ICD XXX.
    - Demonstration 1
      - Verify by Demonstration that when power is supplied to the unit in accordance with the established interface defined in ICD XXX the operator is provided visual status. Demonstration will show that when proper power is provided a continuous visual indication is provided to the operator.
    - Demonstration 2
      - Verify by Demonstration that when power is supplied to the unit outside of the limits established by ICD XXX the operator is provided a visual cue different than the nominal power indication. Demonstration will show that when invalid power is provided a visual indication of improper power is provided to the operator for as long as the improper power conditions exist.

- Note – this verification statement should alert the requirements team that a requirement for the unit to prevent unit damage in the event of improper power application should have been written. Another advantage of developing the Verification Requirement early Forgotten Requirements – helps to identify missing Product Requirements.

Verification Requirements

- Key points to writing a good verification requirement
  - Verify by (insert method here) that …..
  - The (use above method) will show that ……
- Ability to create a verification requirement ensures that the Product requirement is verifiable

Verification Requirement Attributes

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Verification Requirements
- Inspection
- Analysis
- Modeling and Simulation
- Demonstration
- Test

Must answer 5 Questions

☑Objective

What is the purpose of this verification?

☑Method

What method do you need performed? What are the verification circumstances (e.g., laboratory, desk-top analysis, flight test)?

☑Environment

What are the environmental conditions under which the item will be verified?

☑Special Conditions (if necessary)

Are there any unique conditions (e.g., item configurations) necessary for the execution of the verification?

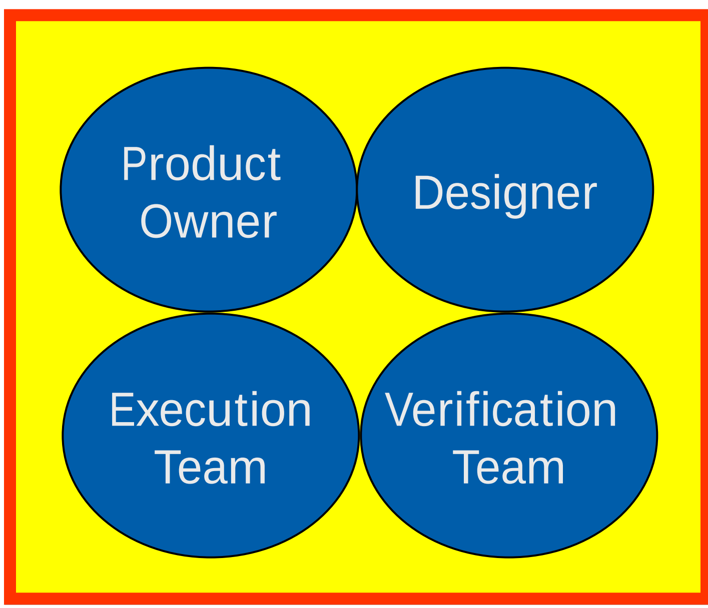
☑Success Criteria

What results are to expected?

What is Verification ?

Class exercise

- Break into teams
  - 4 people per team
    - Product Requirement Owner (IPT, SEIT, Other)
    - Designer (Hardware, Software)
    - Verification Execution Representative (I&T, Q.A., Analyst etc;)
    - Verification Team

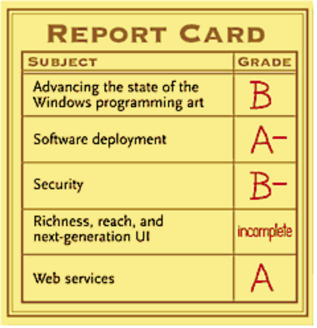


Class Exercise

- Product Requirement Owner
  - Establishes the requirement intent with a verification requirement
  - Creates the initial VR
- Design Team
  - Agrees that the design is capable of performing the success criteria
- Verification Team
  - Ensures depth and breadth of the requirements are met with the success criteria (nominal / off nominal, needed analysis, modeling and simulation techniques)
- Verification Execution team (T&E, Analysis Group, QA etc;)
  - Can the verification requirement be completed?
  - Is it cost effective ?

Verification Requirement Evaluation

- Evaluate the generated Product requirement and verification requirement(s) set
  - Did you have to re-write your Product requirement?
  - Did the Product requirement provide data to establish the success criteria?
  - Is the specified verification environment consistent with the operational objectives as established in the Product requirement?



Verification Benefits

Examine Programmatic Benefits

- The Customer Benefits ??
  - Knows how the Product requirements will be satisfied from the beginning
- Cost Benefits ??
  - Better Cost Estimates. You know what you need to do.
- Schedule Benefits ??
  - Better Schedule Estimates. You can scope the entire task early providing a better schedule
- The PMO Benefits ??
  - Knows what the needs are to prove satisfaction of the Product requirement. Knows what "Customer Satisfaction" means at the start of the program.
- Better Understanding of program change impacts
  - Establish impact of change early

Win, Win, Win

Early Verification Benefits Examples

Method	Customer / Organization	Early Verification Benefits
Inspection	QA, Manufacturing, Mission Assurance	•Inspection Points Identified •Tooling Requirements Identified
Analysis	Systems Engineering Specialty Engineering Design	•Define / Build / Buy / Train Analysis Prior to Need Date •Accreditation of Analyses Tools Prior to Need Date
Modeling and Simulation	Systems Engineering Specialty Engineering Design, Operational Assessment	•Define / Build / Buy / Train Modeling and Simulation Tools Prior to Need Date •Accreditation of Models Prior to Need Date
Demonstration and Test	Ground and Flight Test Facilities Development	•Laboratory and Lab Software Requirements Identified •Facilities Requirements Identified •Long Lead Test Items Identified

Verification Modeling

Verification Modeling

- Parent-Child Relationship
  - Method
  - Environment
  - Success Criteria
  - The Verification Pyramid
    - Verify at the lowest level
    - Verify Once
    - Verify under operational environmental conditions

Verification Modeling

By Configuration / Level

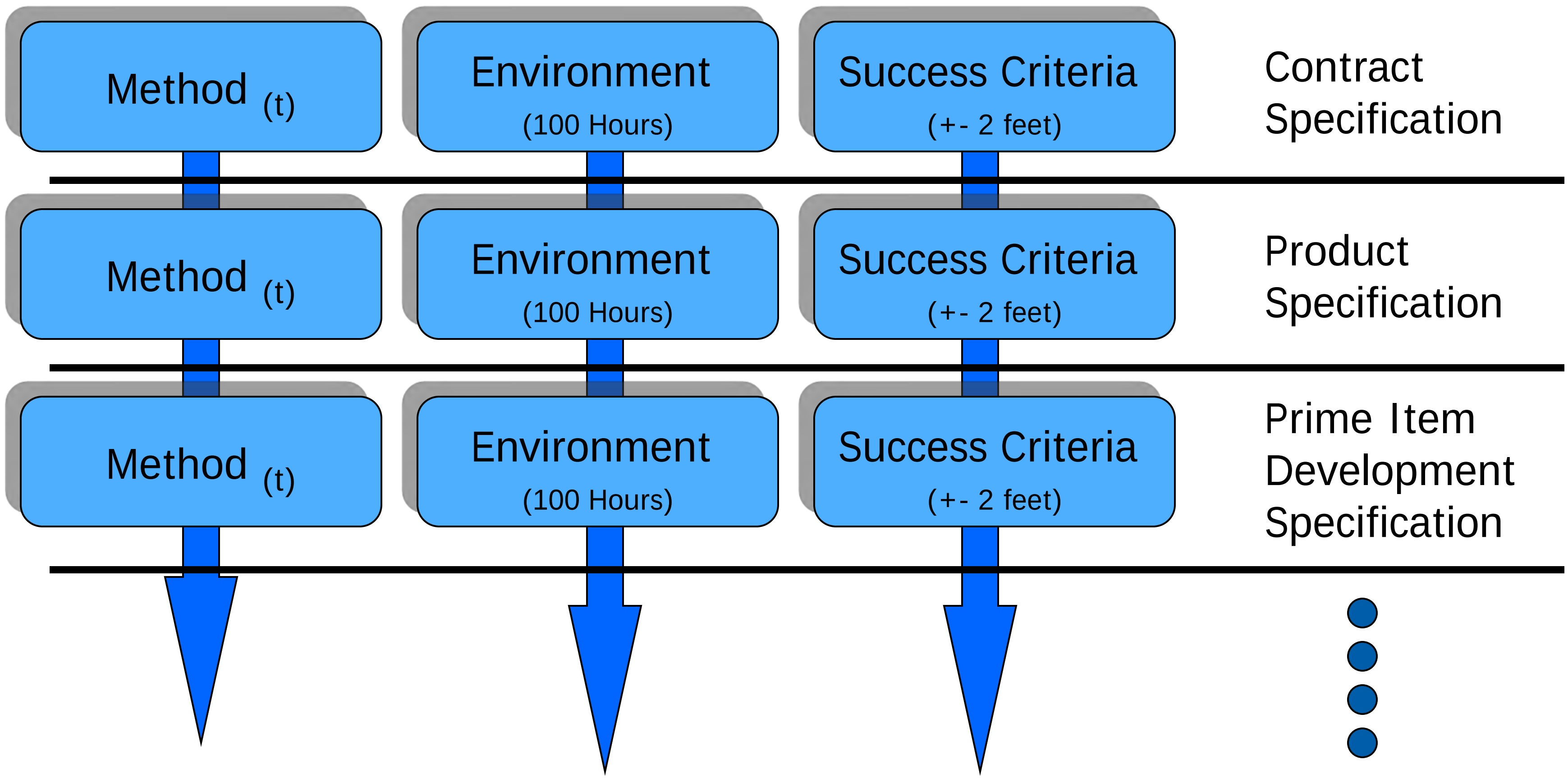
That Really Means

You only conduct environmental qualification on a UUV one time at the Box Specification level

Verification Modeling

NORTHROP GRUMMAN

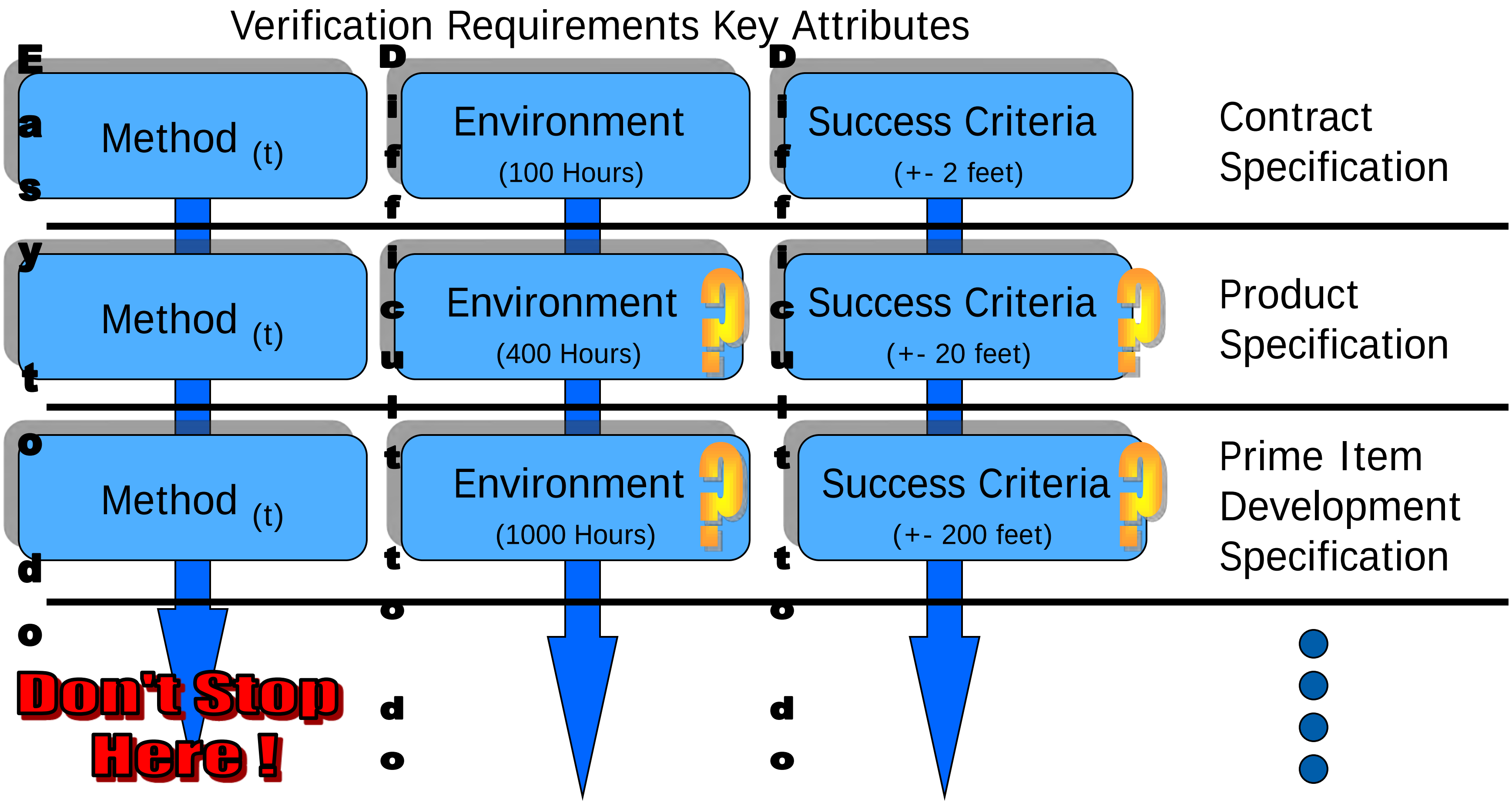
Verification Requirements Key Attributes



Looking at the verification requirement flow down ensures
a thorough and cost effect verification program

Verification Modeling Example

NORTHROP GRUMMAN



Looking at the verification requirement flow down ensures
A Consistent cost effective verification program

Verification Modeling – A Closer Look

NORTHROP GRUMMAN

Verification Requirements Key Attributes

Environment (100 Hours)	Success Criteria (+- 2 feet)	Contract Specification
Environment (400 Hours) 1	Success Criteria (+- 20 feet) 3	Product Specification
Environment (1000 Hours) 2	Success Criteria (+- 200 feet) 4	Prime Item Development Specification

Why Did You Change ?

1 Is 400 too much at this level?

2 Is 1000 too much at this level?

3 Is 20 feet over-constraining

4 Is 200 feet over-constraining

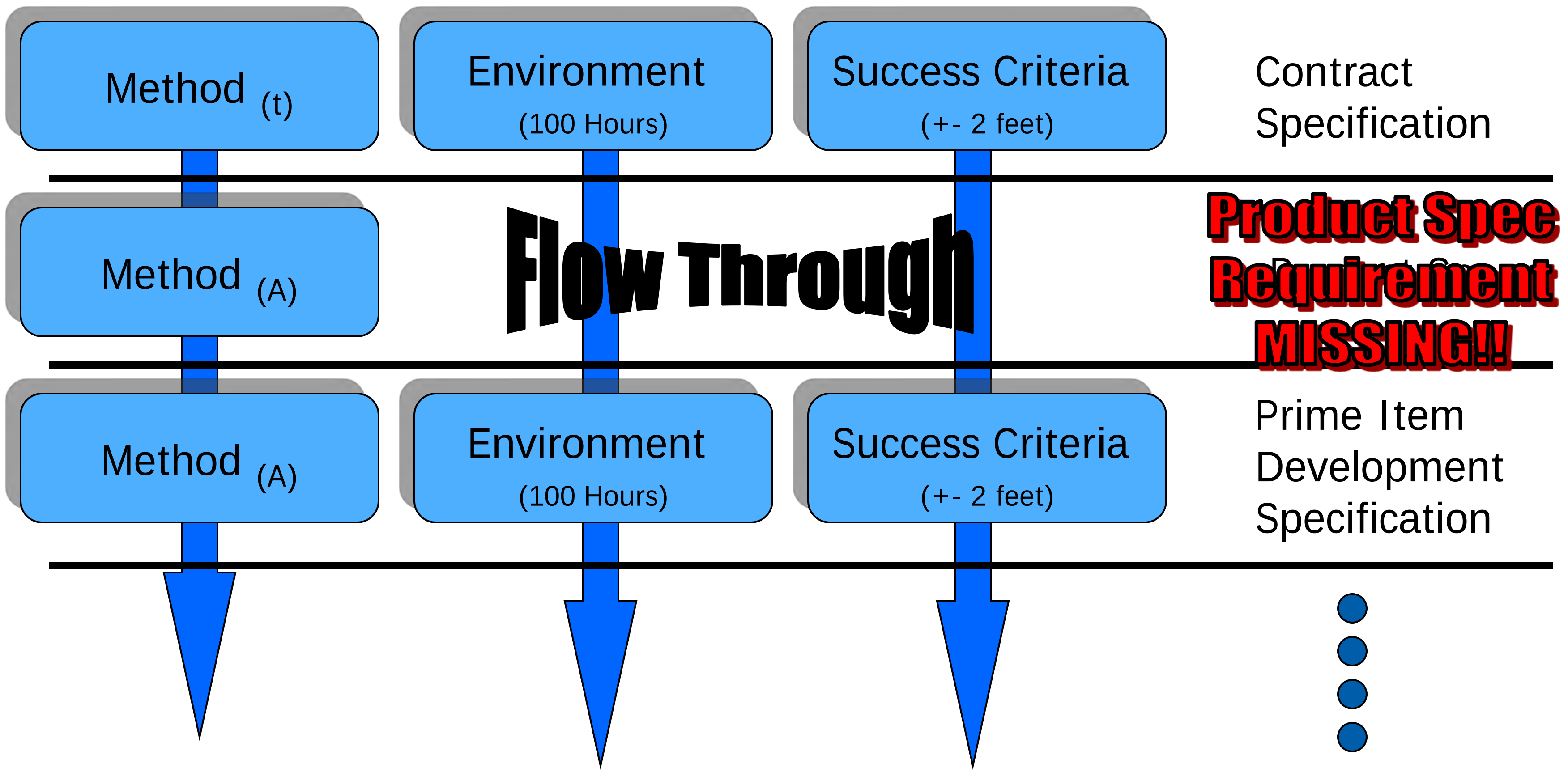
Over testing ? $$

Over Designing ? $$$

Verification Modeling Another Example

NORTHROP GRUMMAN

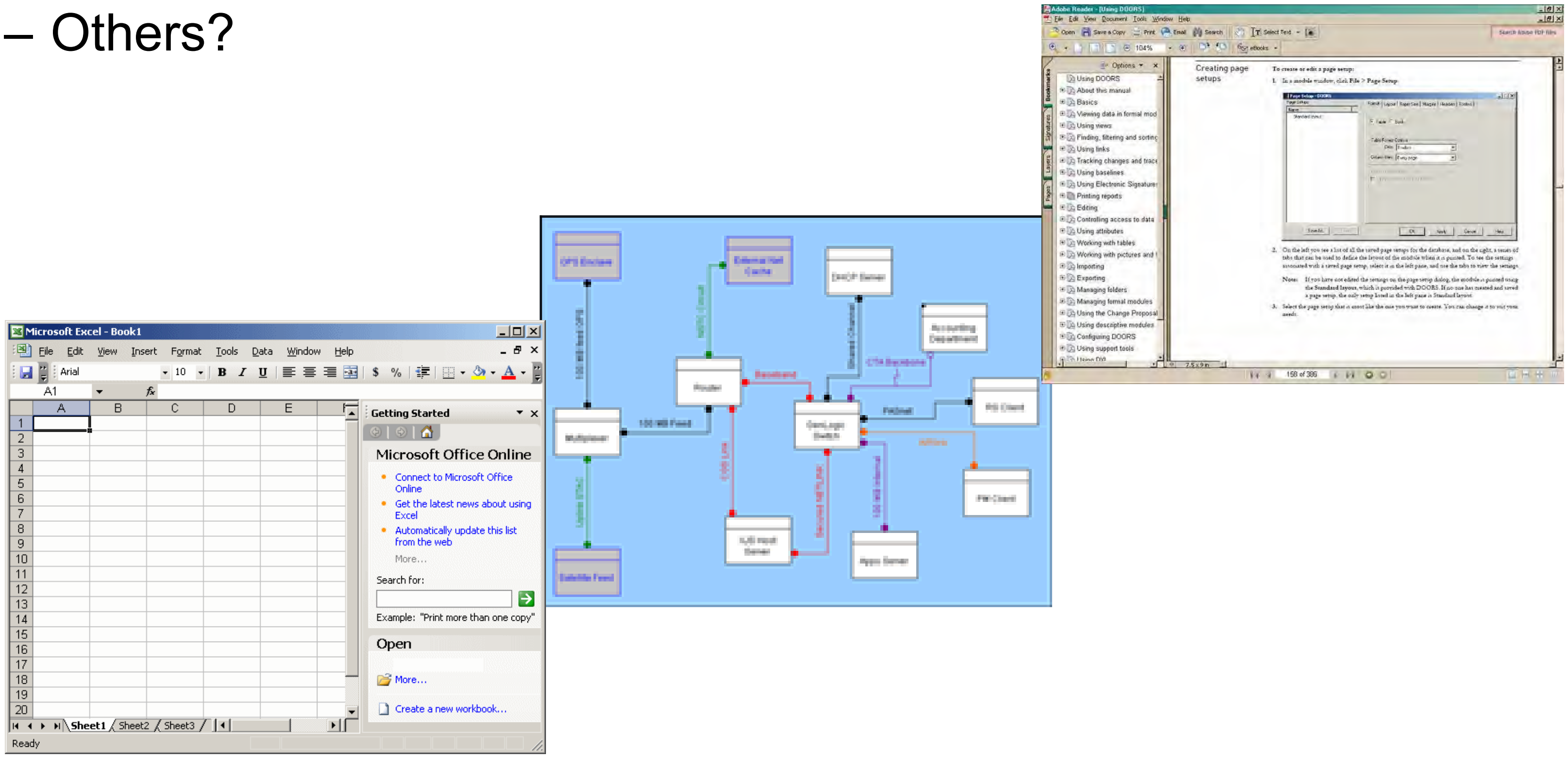
Verification Requirements Key Attributes



Flow through Requirements indicate missing requirements

Modeling Tools

- Several Standard tools exist to conduct the modeling activities:
  - DOORS
  - CORE
  - Excel (doable but it's the hard way)
  - Others?



Verification Modeling

- A technique to
  - Establish verification metrics
  - Track the verification program
  - Track risk activities assigned to the verification program
  - Ensure proper verification flow down
  - Ensure operational environment properly flowed
  - Help determine lost requirements
  - Help track design functions
  - Assist in verification program prioritization
- Can be connected to requirements traceability tools
- Allows for easier design completeness assessments

The Verification Cross Reference Index (VCRI)

- Why A VCRI*
  - A tool for tracking requirements compliance
  - A tool to quickly assess that at least one verification condition exists for each requirement
- What a VCRI is not
  - Not the verification requirement set
  - Not the definition of the verification requirements
- Some Conclusions
  - The VCRI results from the development of the Verification Requirement
  - Having only a VCRI can develops "Bad Habits"
  - Adds no value without the Verification Requirement

***Also known as the Verification Cross Reference Matrix (VCRM)**

Create Verification Cross-Reference Matrix

Design Requirement

3.2.2.15.34 Recovery Force Communications
The product shall provide a communications system capable of communicating with the recovery forces pre- and post- landing

SE – Translates Operational Objectives into Design Requirements
Design – Provides assessment of requirements implementation
Test – Provides assessment of requirements verifiability

Design Verification

Verification Objective	Pass / Fail (Success Criteria)
Perform Integrated System Test of the communications system capability to provide a voice communications and beacon with recovery forces pre and post landing within an integrated hardware / software environment	**Testing will show that the communications system can transmit and receive audio at frequencies and ranges (power) represented by standard ground recovery force communications devices as defined in TBD**
Perform a demonstration of the communications systems capability to provide voice and beacon communications with recovery forces pre and post landing while within a representative environment and using a production equipment configuration	**Demonstration will show the ability for the communications systems to verbally communicate with the on-board communication production configuration equipment. The demonstration will also show beacon tracking within communication ranges established by TBD.**

<u>SE</u> – Provides compliance of the design requirement
<u>Test / Implementation Group</u> –
Ensures Verification Implementation Feasibility
Advises alternatives to support programmatics
Assesses completeness
Provides verifiability assessment

Traceability

Verification Cross Reference Matrix

Paragraph #	N/A	I	A	M/S	D	T
3.2.2.15.34						VR-5T
3.2.2.15.34					VR-5D	

SE – Verification Allocation and Traceability Assurance

Identifying a verification method is necessary, but not <u>sufficient</u>!

Verification Program Events

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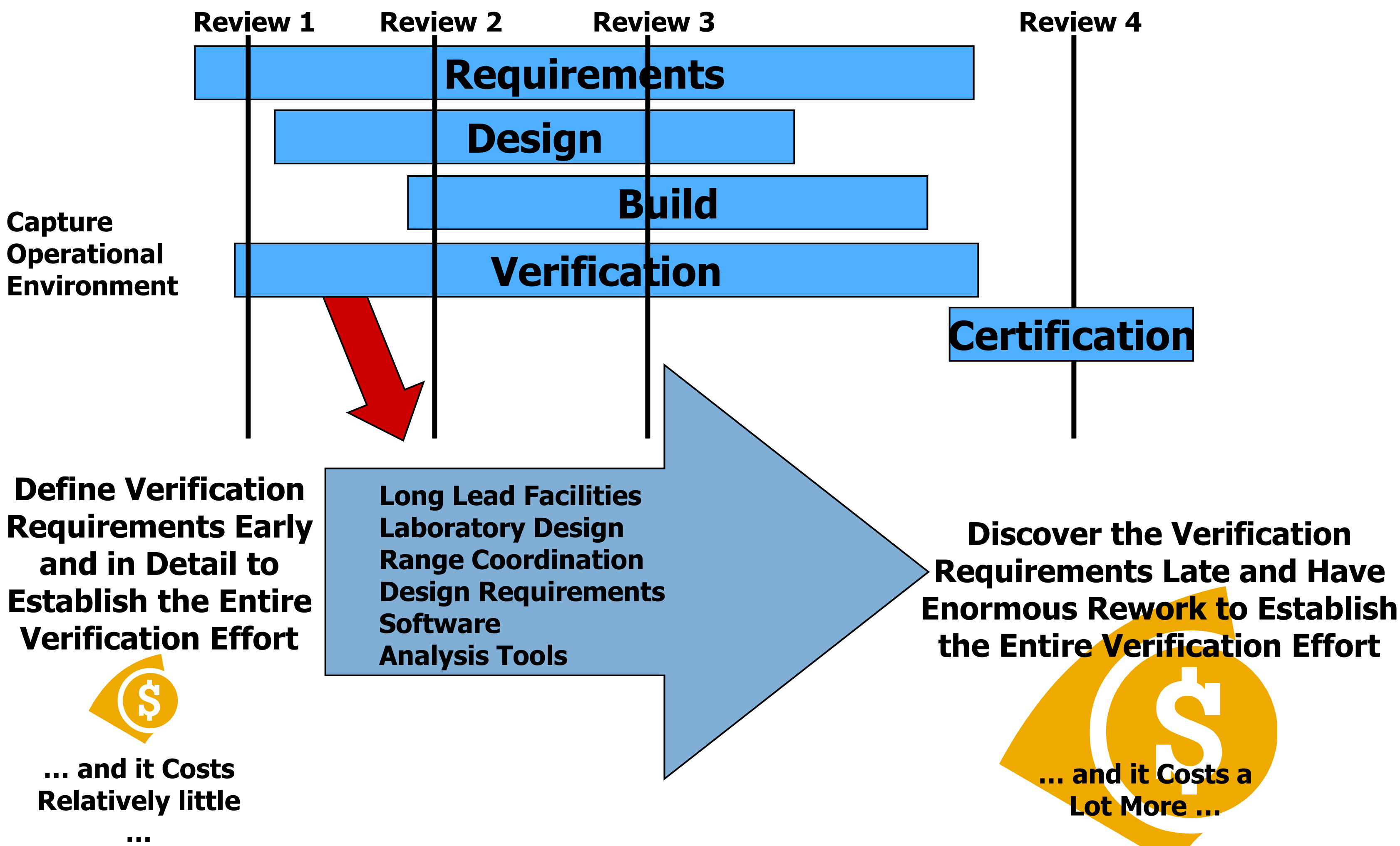
- Pre-Contract Award
  - Establish operational environment construct
    - Use system specification and develop verification criteria
      - Customer Should Pass operational environment to the contractor
- Contract Award
  - Establish Project Specification Verification Statements and get customer concurrence
- At Specification Requirements Review (SRR) / Subordinate reviews
  - Determine Requirements Verifiability

Verification starts when the program starts

Planning for Verification Execution and Product Verification



Early Verification Is an Effective Cost Avoidance Approach

Summary

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- Early development of verification requirements helps develop good product requirements
- Early development of verification requirements helps identify missing requirements
- Verification is the communications link to the design and execution teams
- Verification customers are across the entire program
- Verification identifies when the design is complete
- Early development of verification requirements can ensure the operational environment is captured across the test / demonstration program
- The VCRI / VCRM is necessary, but not sufficient, for verification
- Verification modeling helps develop a “one time only” verification program
- Verification increases the Program’s cost effectiveness

Contact Information

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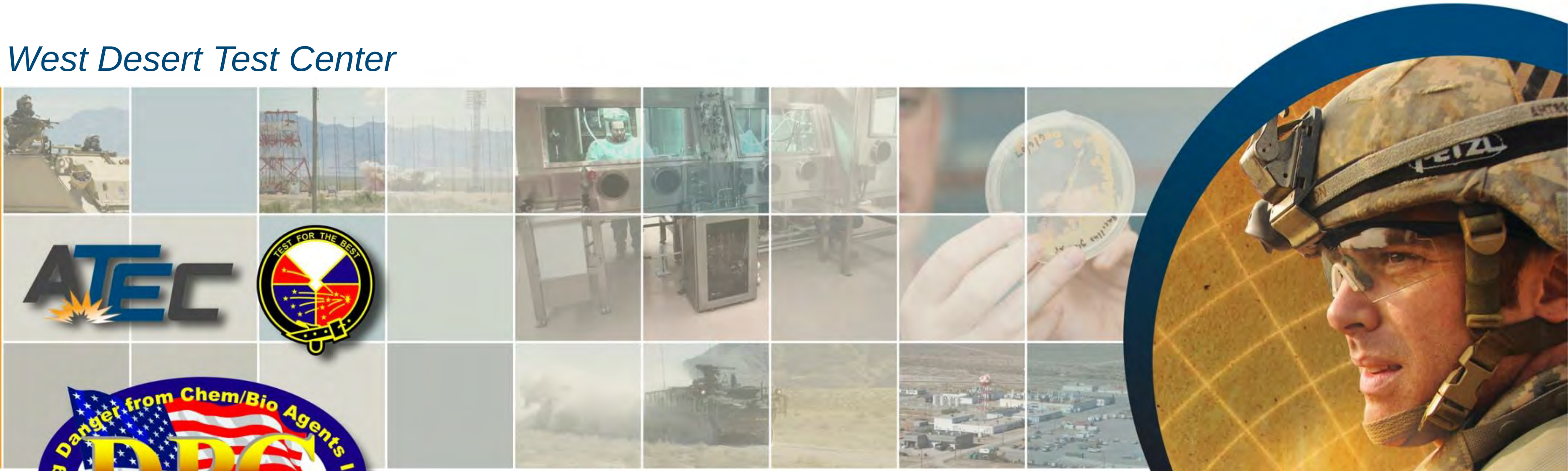
  Northrop Grumman
  Stephen.Scukanec@ngc.com

- 310-350-3156

West Desert Test Center



US Army
Dugway Proving Ground

DPG as the Chem/Bio MRTFB Activity

Jean Baker

16 March 2011

Major Range and Test Facility Base (MRTFB)

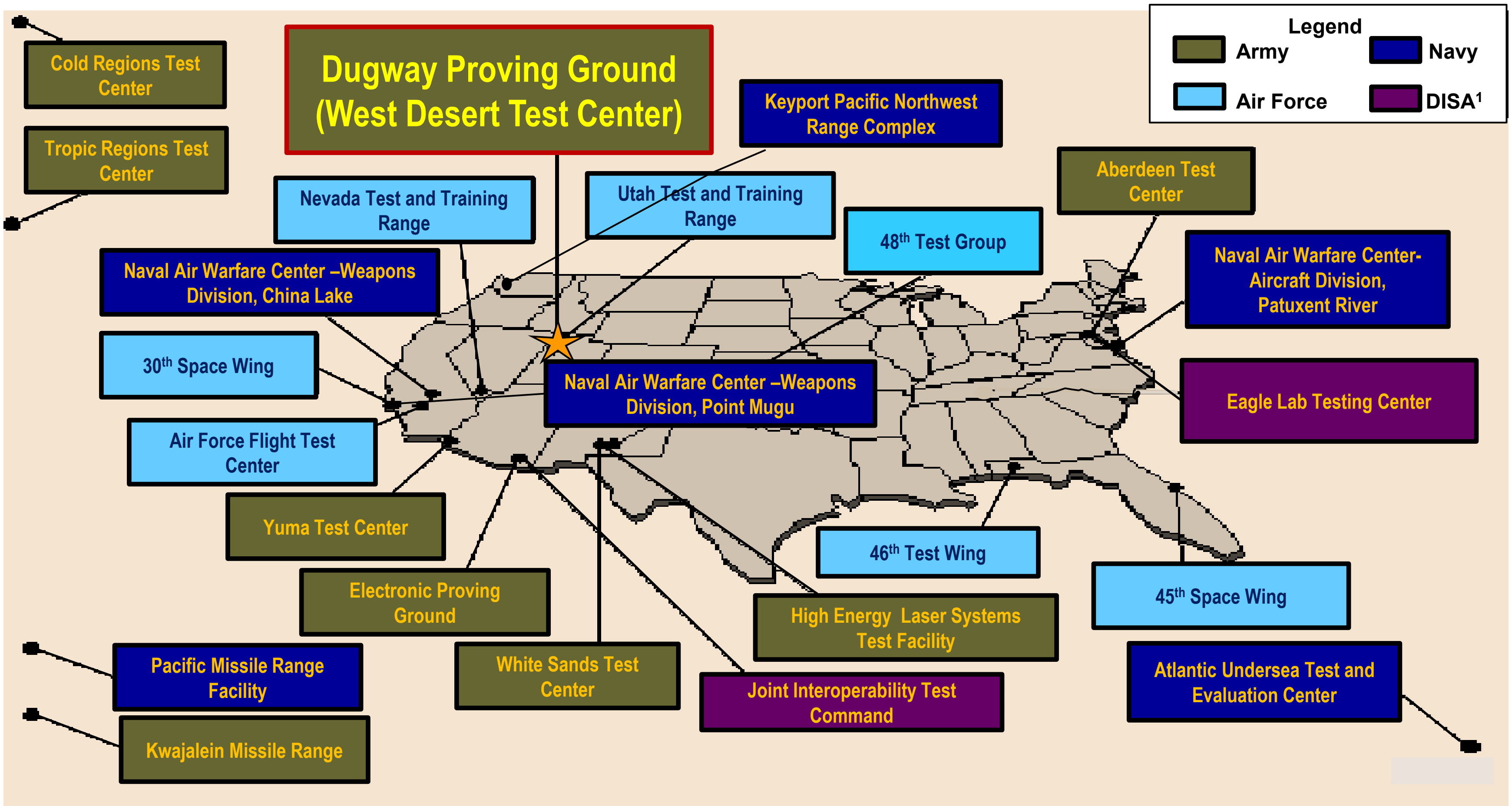


- 1971: DoD recognizes that large military test facilities represent national assets and establishes MRTFB
- Set of test installations, facilities and ranges
- Selected for unique T&E assets
- Includes installations from the Services, Joint Interoperability Test Command and range cooperatives



ATEC

MRTFB Activities



[1]Defense Information Systems Agency

Dugway Becomes Part of the MRTFB

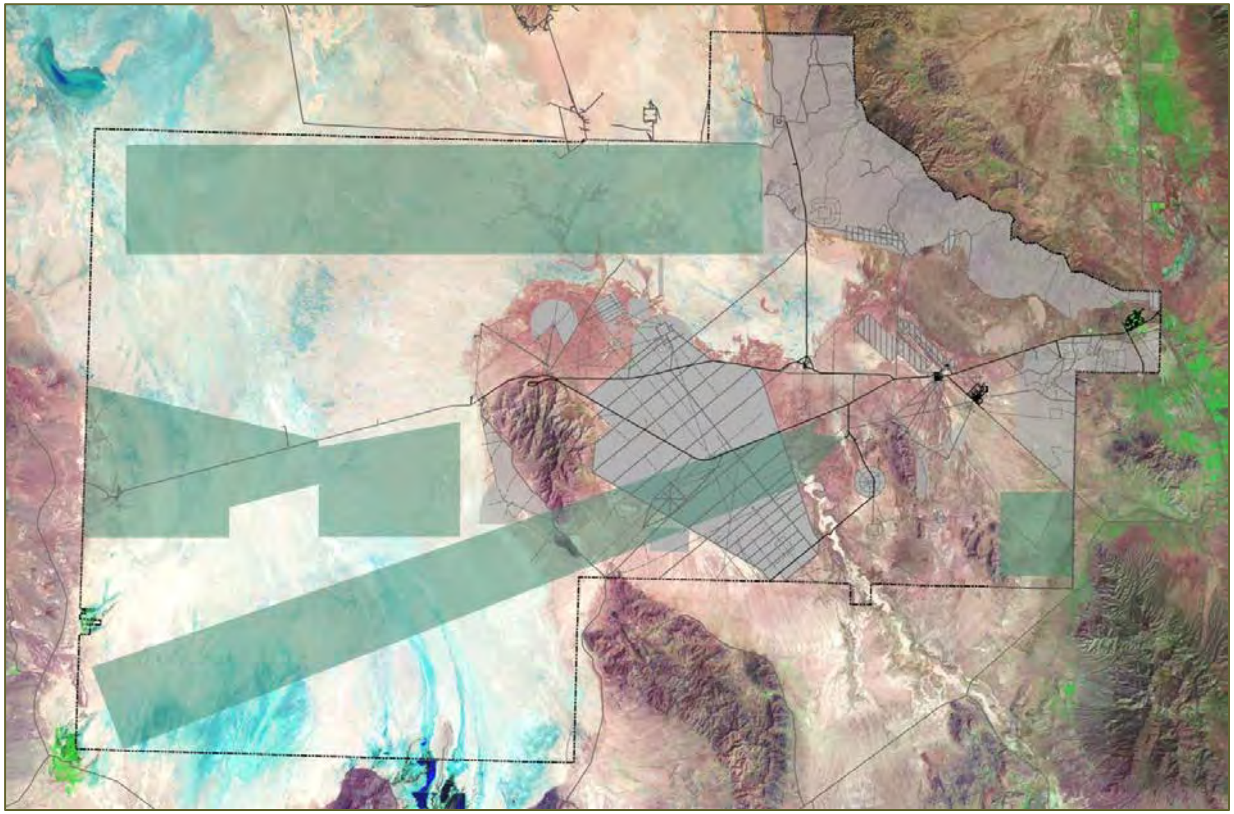
- Attack on Pearl Harbor prompted the formation of Dugway Proving Ground (DPG) by President Roosevelt in 1942
- Established to fill the need for supporting the Chemical Warfare program in WWII
- Became part of the MRTFB in 1971

West Desert Test Center (WDTC)

- WDTC is the mission side of DPG
- Primary mission: testing chemical and biological (CB) defense systems
- Perform nuclear, biological, and chemical (NBC) contamination survivability testing of defense materiel
- State-of-the-art laboratories and chambers
- Extensive field testing grids

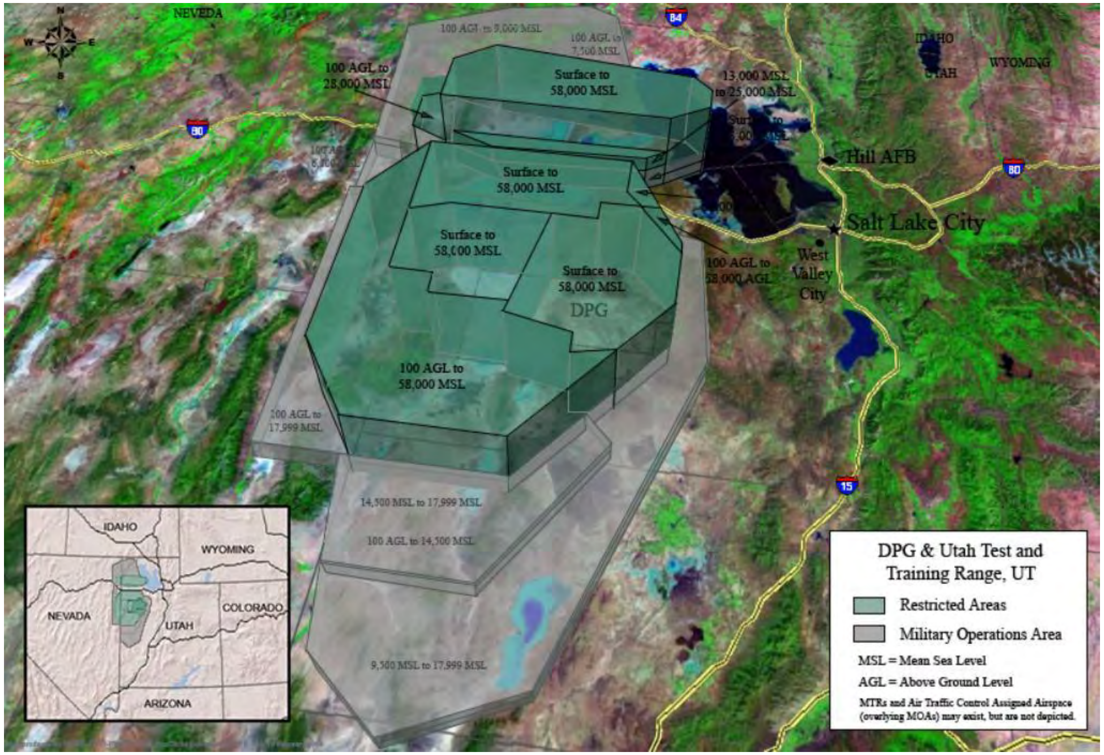
Terrain

798,214 acres of Great Basin desert terrain ranging from salt flats, to intermittent sand dunes and rugged mountains



Airspace

Adjacent U.S. Air Force gunnery and bombing ranges extend Dugway's restricted airspace to an area of about 90 x 70 miles and up to an elevation of 58,000 feet

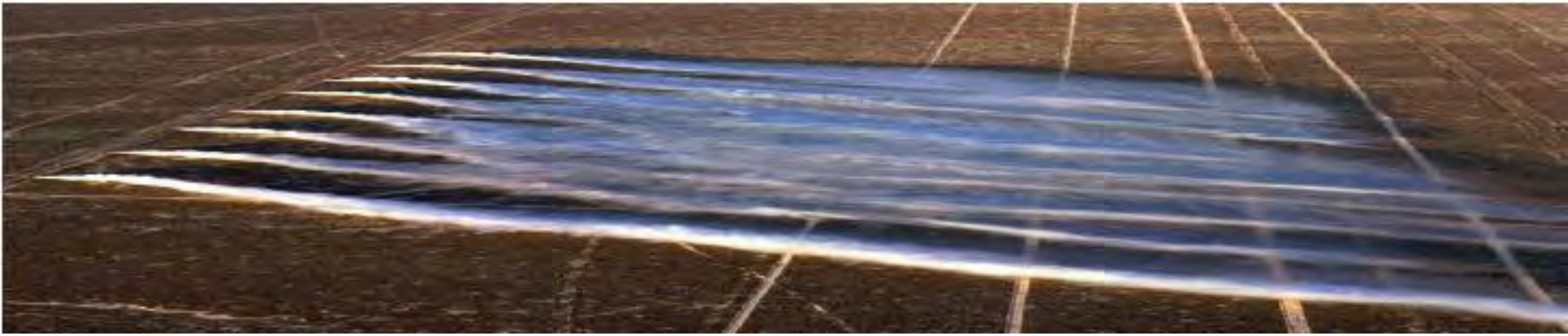


Test Grids, Test Grids, Test Grids

Test grid activities:
- CB detection systems
- Individual protection
- Collective protection
- Munitions
- Training

Field Testing

- CB simulant dissemination systems
- Referee instrumentation
- WiFi
- Management system to acquire, integrate, analyze, fuse, and visualize data during testing
- Smoke and obscurants
- Data network
- Fiber optic transmission of real-time test data
- Safari capability



Dissemination

- Vapor
- Explosive
- Powder
- Liquid
- Aerosol
- Aerial






Chemical Testing

- Collective Protection
- Individual Protection
- Contamination Avoidance
- Decontamination

Reginald Kendall Combined Chemical Test Facility

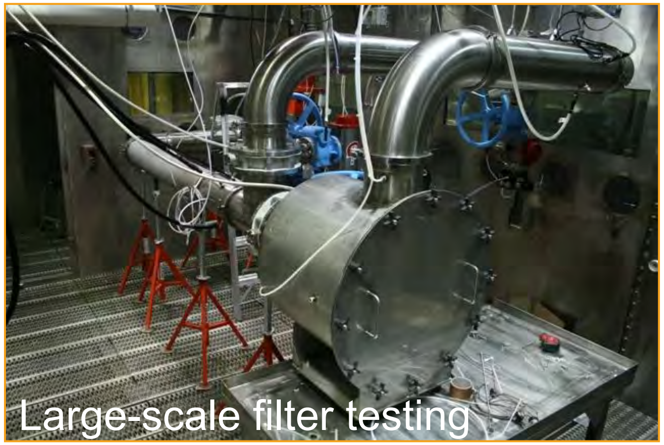
Decon pad

JSLSCAD Test Fixture

Collective Protection

- Chemical warfare agents (CWAs)
- Toxic industrial chemicals
- Battlefield contaminants
- Barrier materials swatch testing
- Component testing of closures and seams
- Air filter component and air filtration system testing
- Full-system tests in environmentally-controlled chambers using agents and simulants
- Outdoor field testing of full systems using CWA simulants


Closure and seam testing


Large-scale filter testing

Individual Protection

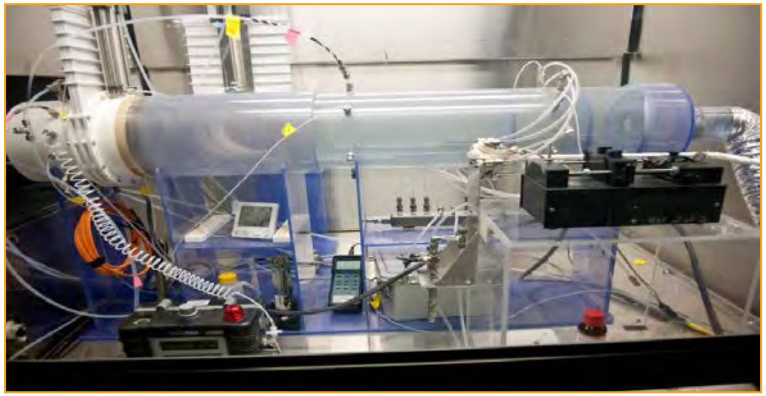
Component Testing

- Masks
- Boots
- Gloves

Swatch testing

Contamination Avoidance

Standoff detection systems



Point detection systems

Whole system testing

Decontamination

Decontamination Test Facility

- Will hold all Army tactical vehicles up to an M1A1 tank
- Allows for dissemination of any chemical or biological simulant
- Capable of using any current known decontaminant or decontamination system

Small Item Decontamination Test Fixture

- Any chemical warfare agents
- Environmentally controlled (60 to 110ºF and 10 to 80% RH)
- Will test actual fielded small equipment items (23”x23”x36”)
- Biosafety Level (BSL) 1 biological simulants

Biological Testing

Aerosol Simulant Exposure Chamber
Stainless steel-lined chamber designed to dispense and contain aerosol simulant clouds in a BSL-1 and BSL-2 environment under laboratory controls. Primarily used for testing biological point detectors, but can be used for any test requiring the control of factors that could not otherwise be controlled in another setting.

Containment Aerosol Chamber
One-of-a-kind BSL-3 chamber designed for testing biological aerosol detector systems by challenging the systems with aerosols generated inside the chamber.

Biological Testing, cont'd

Ambient Breeze Tunnel

- BSL-1
- Biological point and standoff detection systems
- Referee equipment
- Variety of disseminators (Micronair sprayers, Skilblowers™)
- Simulants
- Interferents (smoke, burning brush, burning tires, burning diesel fuel)
- Agent-like organisms

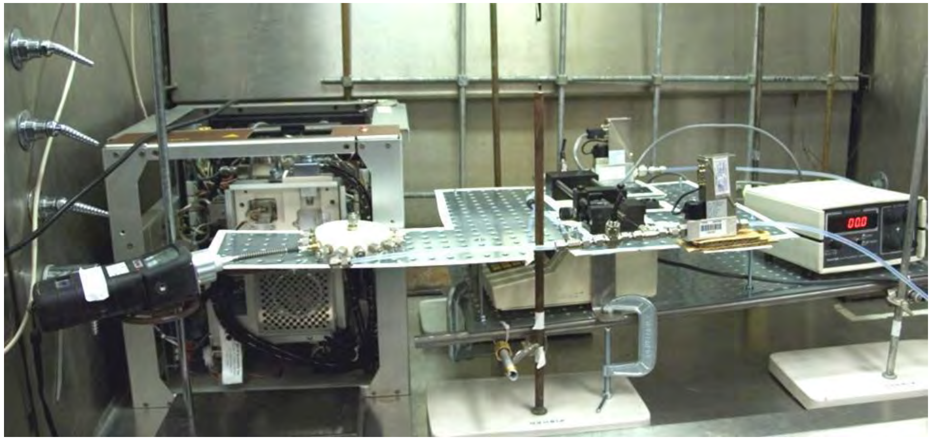
ATEC

Rendering Danger from Chem/Bio Agents Irrelevant

DPG

Materiel Test Facility

- Large, environmentally-controlled chambers
- Simulant and live agent capable
- Point and standoff detector testing
- Large equipment testing



Joint Ambient Breeze Tunnel Active Standoff Chamber

Active Standoff Chamber

- Static cloud conditions
- Calibrate referee instruments
- Evaluate standoff CB agent detectors
- Built-in dissemination system
- Aperture dimensions permit evaluation of CB detectors at ranges up to 3 km
- Containment system prevents simulant leakage

Joint Ambient Breeze Tunnel

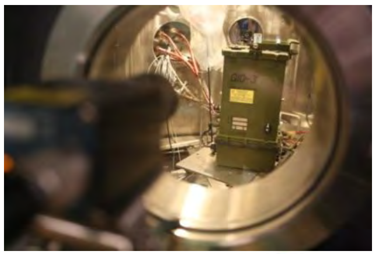
- Dynamic conditions
- Calibrate referee instruments
- Evaluate CB agent detectors
- Variable-pitch fans create airflow up to 6 meters/second.
- Disseminate CB simulants
- Evaluation of standoff detectors at ranges up to 3 km

Michael Army Air Field

- 11,000-foot runway for departures
- 10,000 feet for landings
- 9,000-foot taxiway
- 20,000-square-foot hangar
- Flight operations and ground support personnel

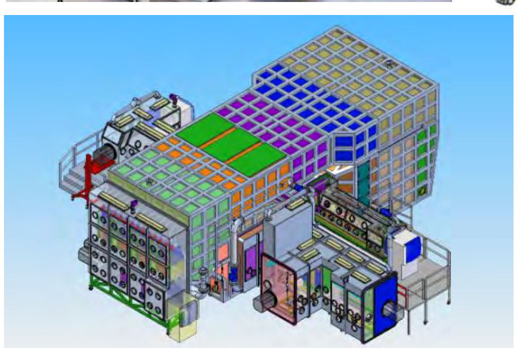


Future Capabilities



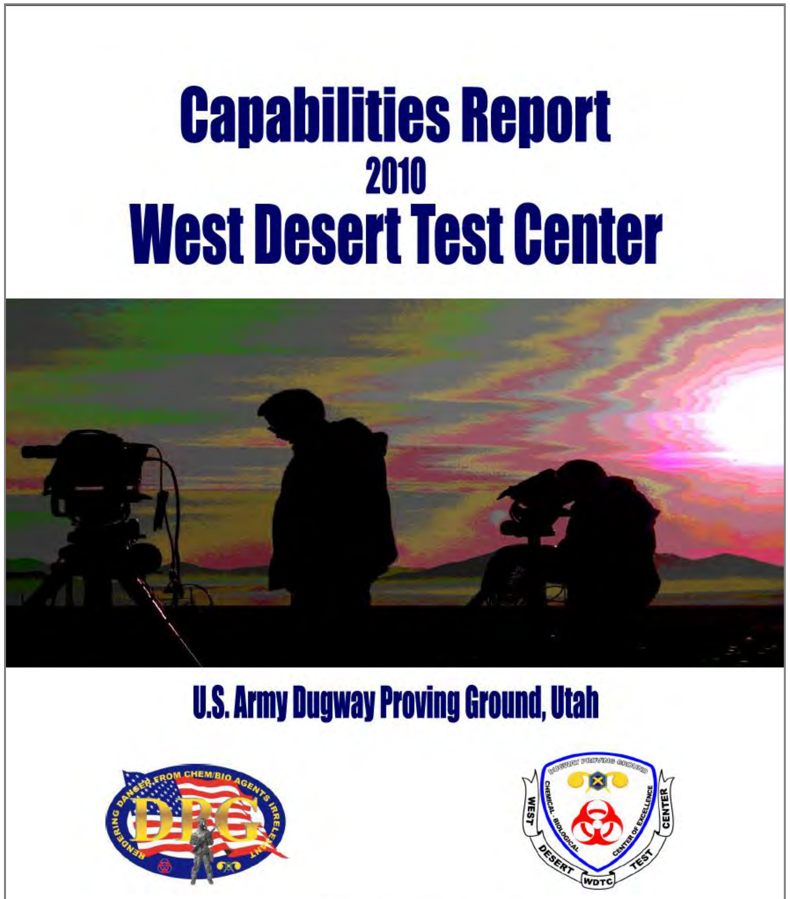
Dynamic Test Chamber
Designed to test chemical agent point detectors operating in several MIL-STD-810 environmental conditions.

Individual Protection Mannequin System
Robotic mannequin designed to simulate soldier activity in agent test facilities in order to evaluate individual protection ensemble performance.

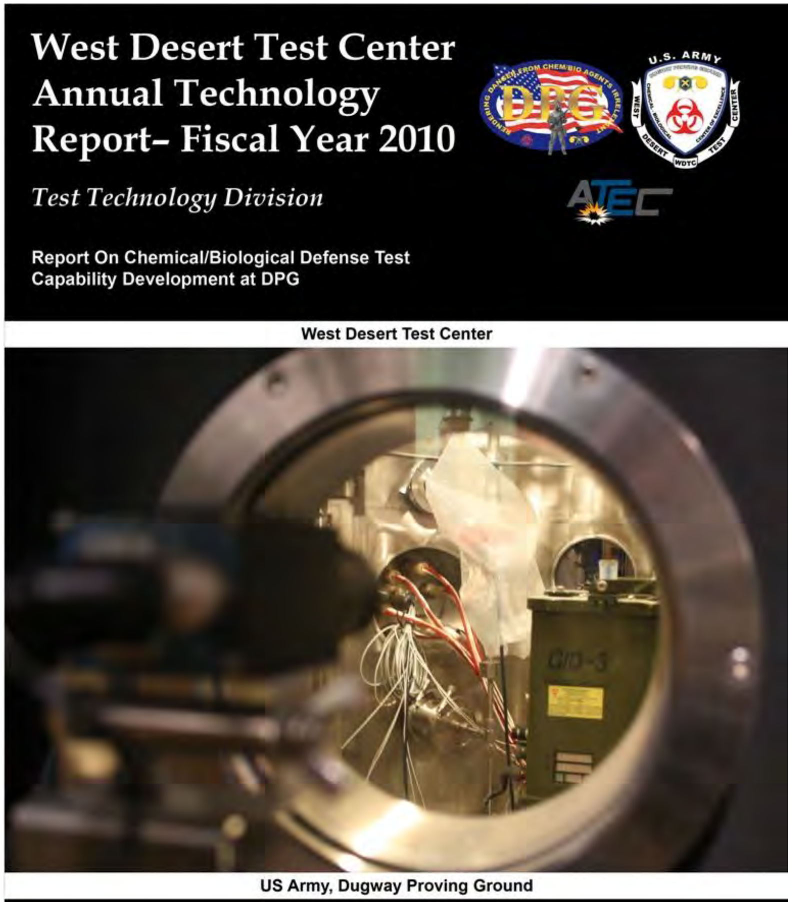


Whole System Live Agent Test Facility
A BSL-3 chamber large enough to dynamically test two side-by-side Joint Biological Point Detection Systems (JBPDS).

WDTC Capabilities Report
WDTC Annual Technology Report



https://www.kc.army.mil/wiki/Dugway_Proving_Ground#Dugway_Capabilities_Report



https://www.kc.army.mil/wiki/Dugway_Proving_Ground

DPG Tours

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Assessing System Reliability Growth When Failure Modes Are Masked

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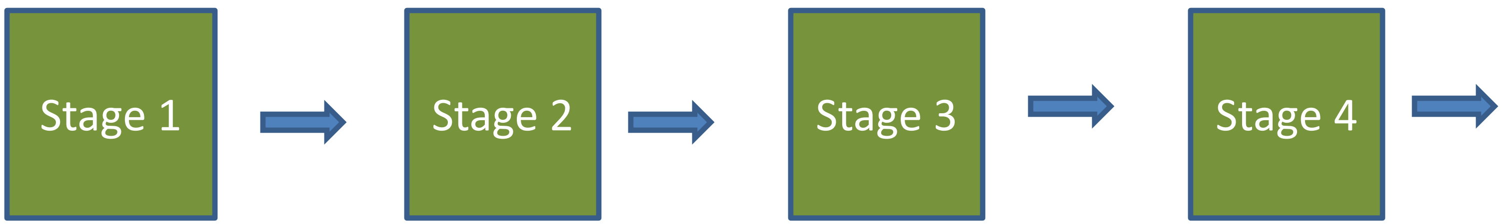
Naval Postgraduate School

Series System

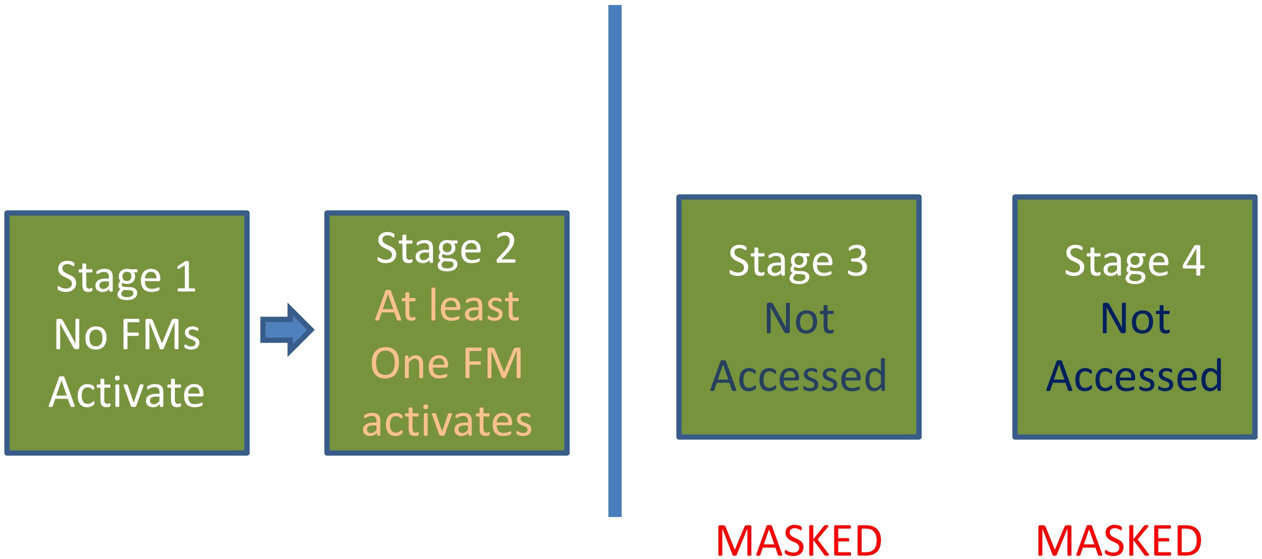


- Random Number of Design Faults/Failure Modes (FMs) in Each Stage/Interface
- When Stage is Accessed Each Remaining FM May Activate Independently of Other FMs with Probabilities Different for Each Stage

Failure Modes (FMs) and Masking

- Each Stage may contain FMs
- If at least one FM activates in stage s then test does not proceed to stages s+1,s+2,…,S
  - The FMs in subsequent stages are **MASKED**
- All activated FMs removed prior to next test

IF No FMs Activate In Stage 1 & At Least One FM Activates in Stage 2 Stages 3 & 4 Are Masked



$W(t;s)$=Number of Times Stage s is Accessed During Tests 1,2,…,t

- If at least one FM activates in stages 1,2,…,s-1 during test t+1, (Stages s, s+1,…,S MASKED)

$$W(t+1;s)=W(t;s)$$

- If no FMs activate in stages 1,2,…,s-1 during test t+1 (Stage s Accessed)

$$W(t+1;s)=W(t;s)+1$$

Model for Number of Failure Modes (FMs)

- Poisson number FMs, each Stage, prior to testing
  - m(0;s)= mean number FMs, stage s
- FM, stage s, activates with probability p(s) independently of other FMs
  - No masking of FMs within a stage
- If at least one FM activates in stage s then test does not proceed to stages s+1,s+2,…,S
  - FMs in subsequent stages MASKED
- Activated FMs removed prior to next test
  - (To be generalized)

Distribution of FMs Remaining

- Conditional distribution of number of FMs remaining in stage s after accessed W(t;s) times

  Poisson with mean $m(0;s)(1-p(s))^{W(t;s)}$.

- Conditional probability 0 FMs activate in stage s after accessed W(t;s) times

  $\mathrm{Exp}\{-m(0;s)(1-p(s))^{W(t;s)}p(s)\}$

- Independence within/between tests strongly assumed
  - No common cause or shocks (Later!)

Conditional Probability Stage s Accessed on Test t+1 Given W(t;1),…,W(t;s-1)

- Probability 0 FMs Activate in stages 1,2,…,s-1

$$a(t;s-1)=Exp\{-[A(t;1)+A(t;2)+\ldots+A(t;s-1)]\}$$

where

$$A(t;k)=m(0;k)p(k)(1-p(k))^{W(t;k)}$$

$$k=1,2,\ldots,s-1$$

Simulation for Test t+1

- For each test t+1 generate a uniform random variable on [0,1]: U_1

  $U_1 \le a(t;s-1)$ & $U_1 > a(t;s)$

  0 FMs activate in Stages 1,2,…,s-1 & at least one s-stage-FM activates on (t+1)th test

  Stages s+1,…,S MASKED

- If 0 FMs activate in Stages 1,2,…,S-1, generate a uniform random variable on [0,1]: U_2

  $$U_2 \le \mathrm{Exp}\{-m(0;S)(1-p(S))^{W(t;S)}p(S)\}$$

  0 FMs are activated in the last stage, S, or before

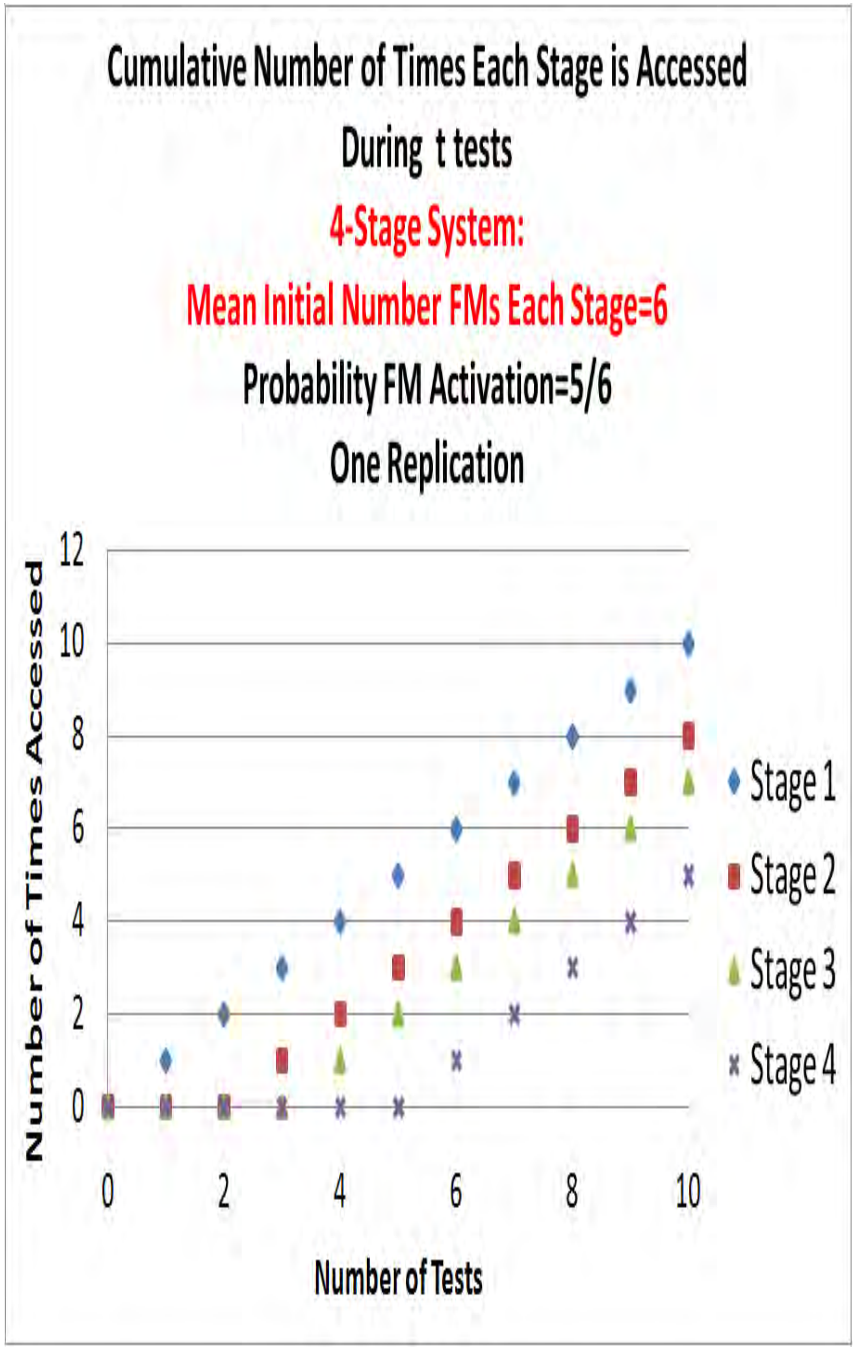
  &

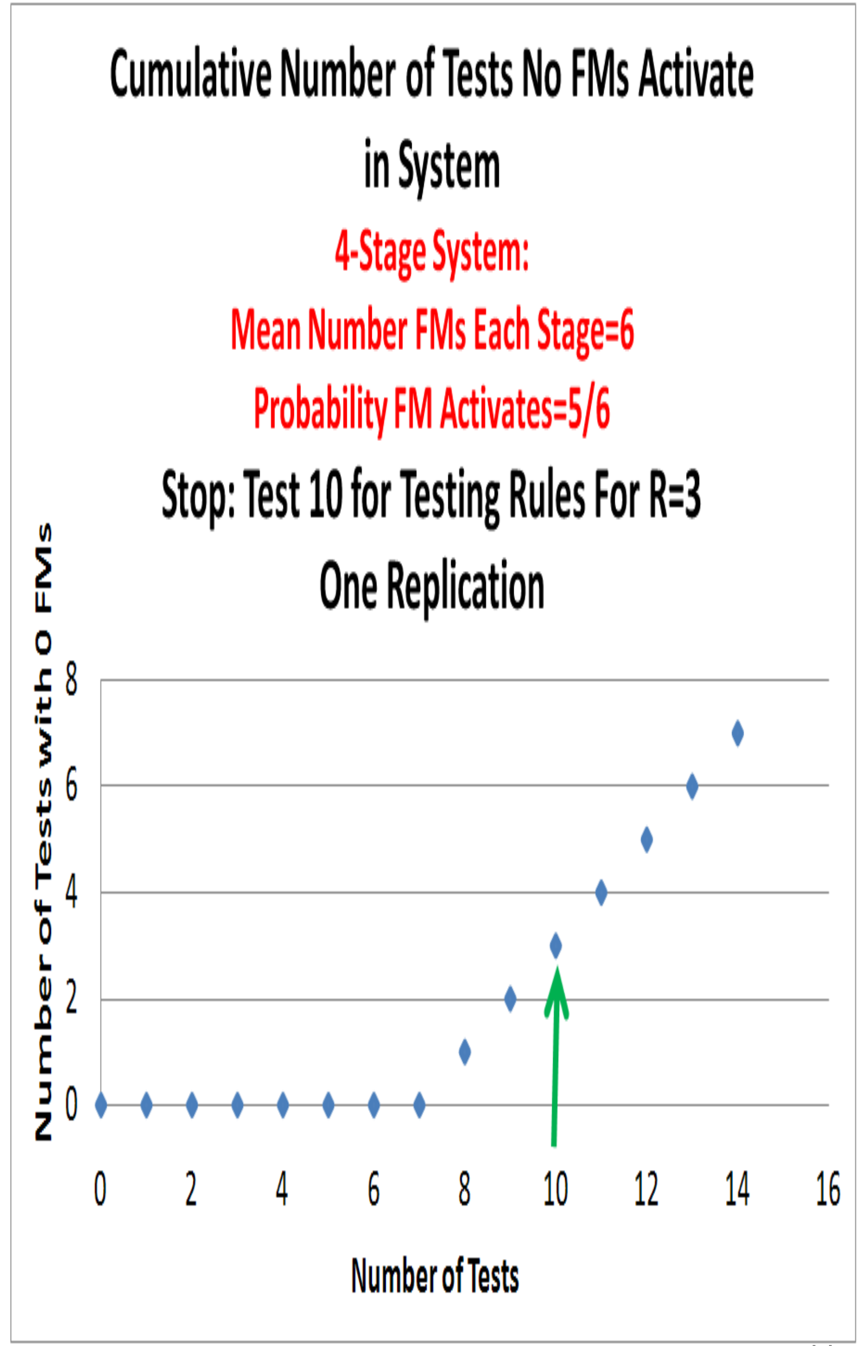
  0 FMs are activated in the entire system on test t+1

  (Optional: another test)

Stopping Rules

- Test: until 0 FMs activate, all stages, R tests
- Test: until 0 FMs activate, all stages, R consecutive tests
- Fixed Number of Tests
- Common Simulation Replication, Number Times Each Stage is Accessed & Number Times 0 FMs Activate, All Stages


Cumulative Number of Times Each Stage is Accessed
During t tests
4-Stage System:
Mean Initial Number FMs Each Stage=6
Probability FM Activation=5/6
One Replication
Number of Times Accessed
Number of Tests
Stage 1
Stage 2
Stage 3
Stage 4
0
2
4
6
8
10
12

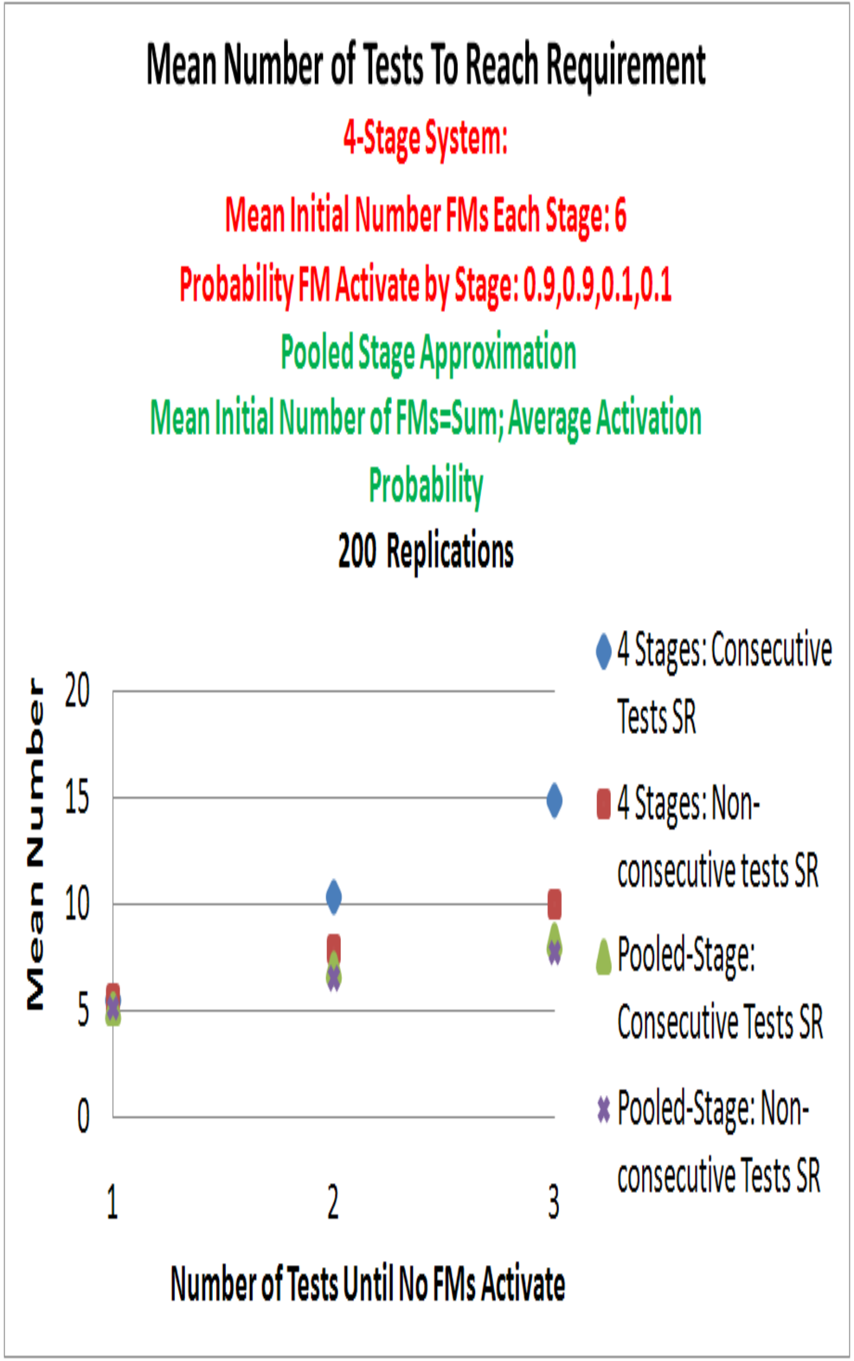

Cumulative Number of Tests No FMs Activate
in System
4-Stage System:
Mean Number FMs Each Stage=6
Probability FM Activates=5/6
Stop: Test 10 for Testing Rules For R=3
One Replication
Number of Tests with 0 FMs
Number of Tests
0
2
4
6
8
10
12
14
16

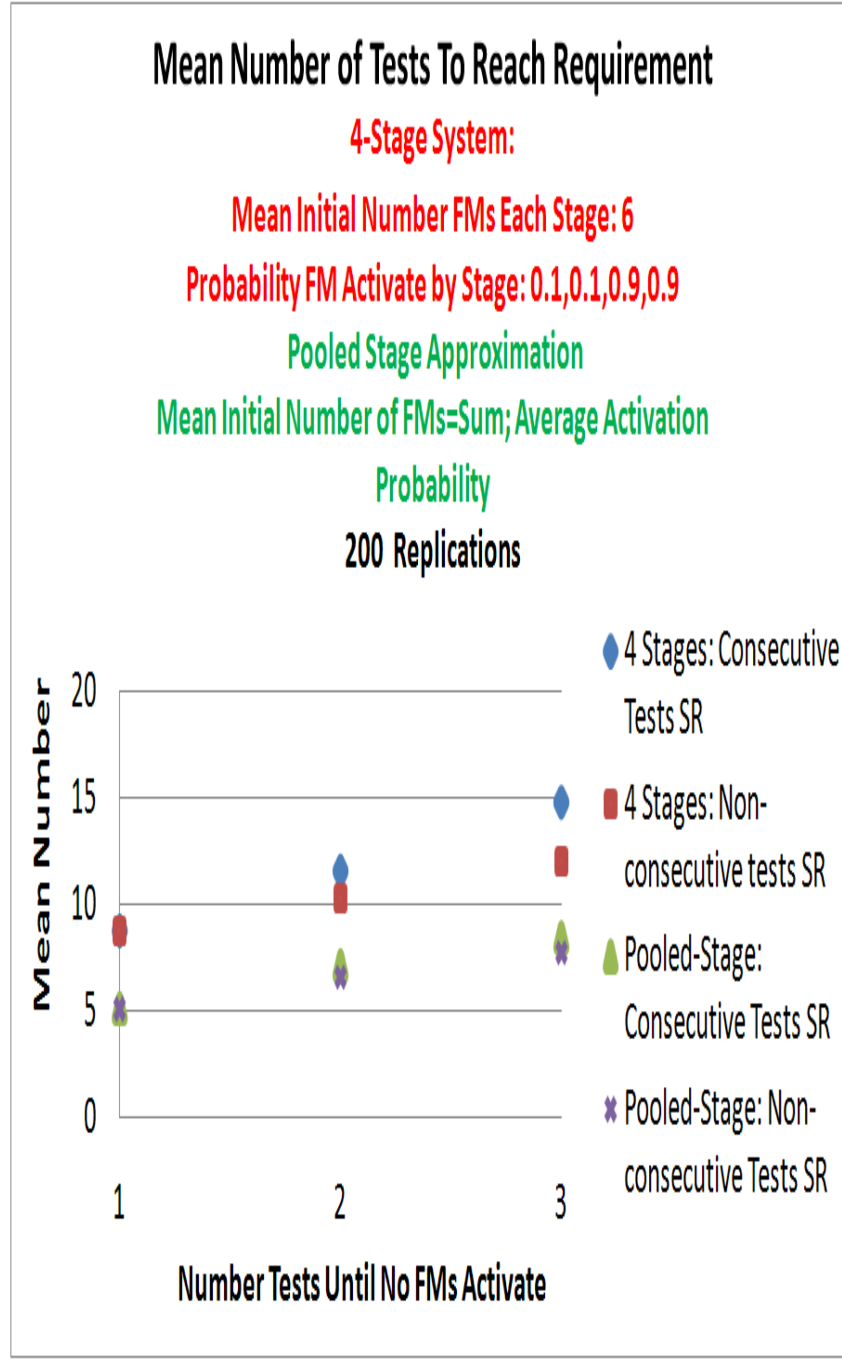
Approximate Pooled 1-Stage System

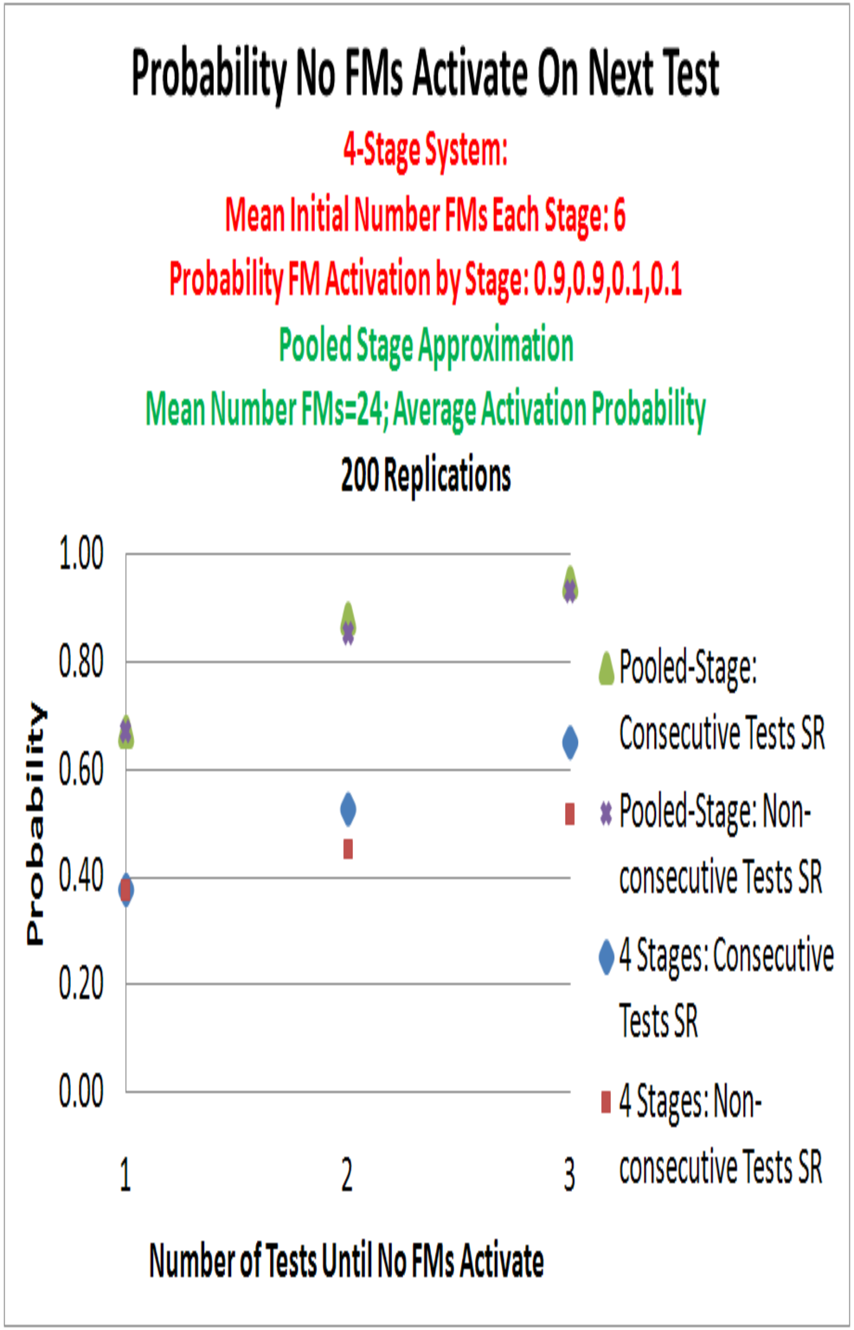
- Initial number FMs has Poisson distribution with mean the sum of the mean FMs in each stage
- Probability a FM activates =p
  - p=sum(m(0;s)p(s))/sum(m(0;s))
- Each Test: All remaining FMs are subject to activation (NO MASKING)

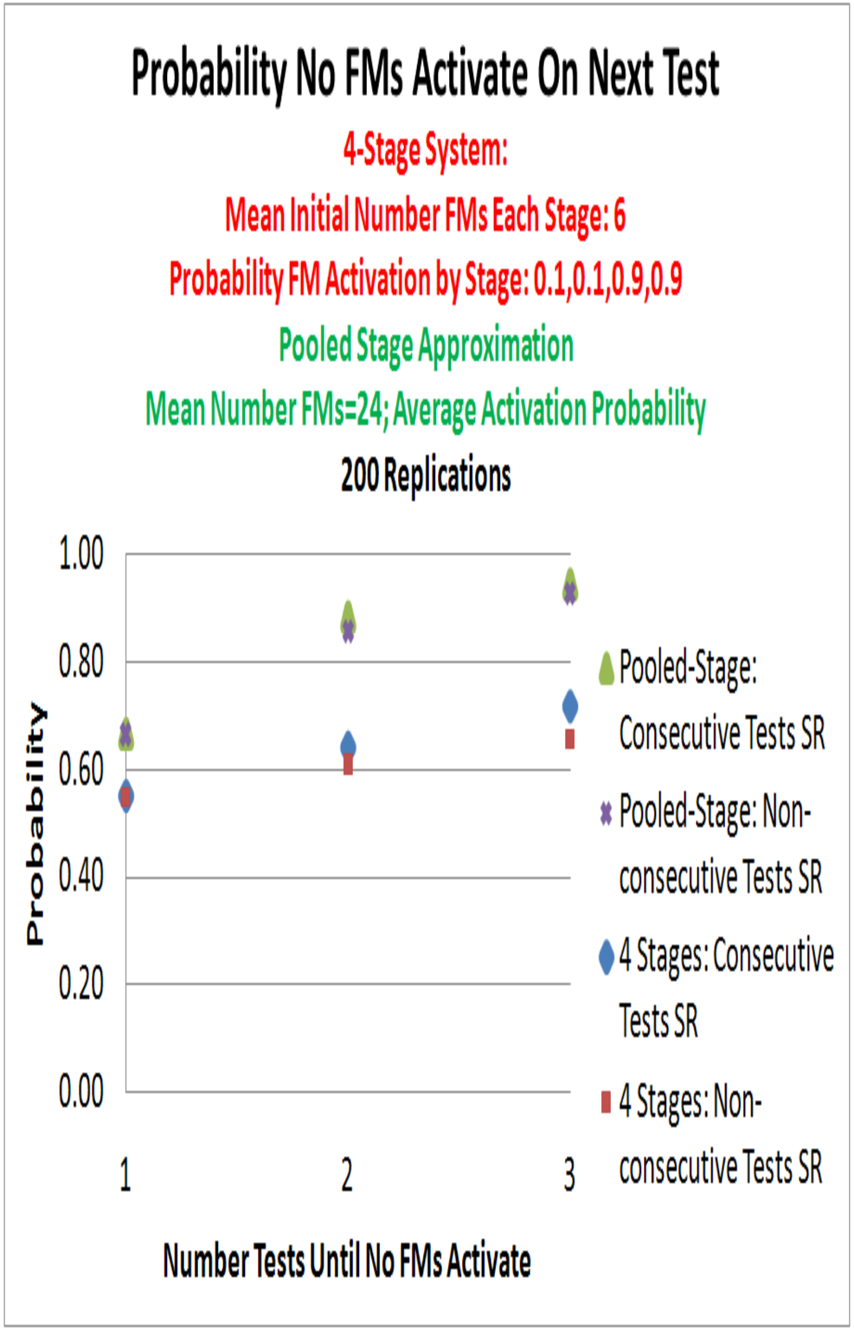
If All Accessed FMs have Same Activation Probability in Both S-Stage and Pooled Systems

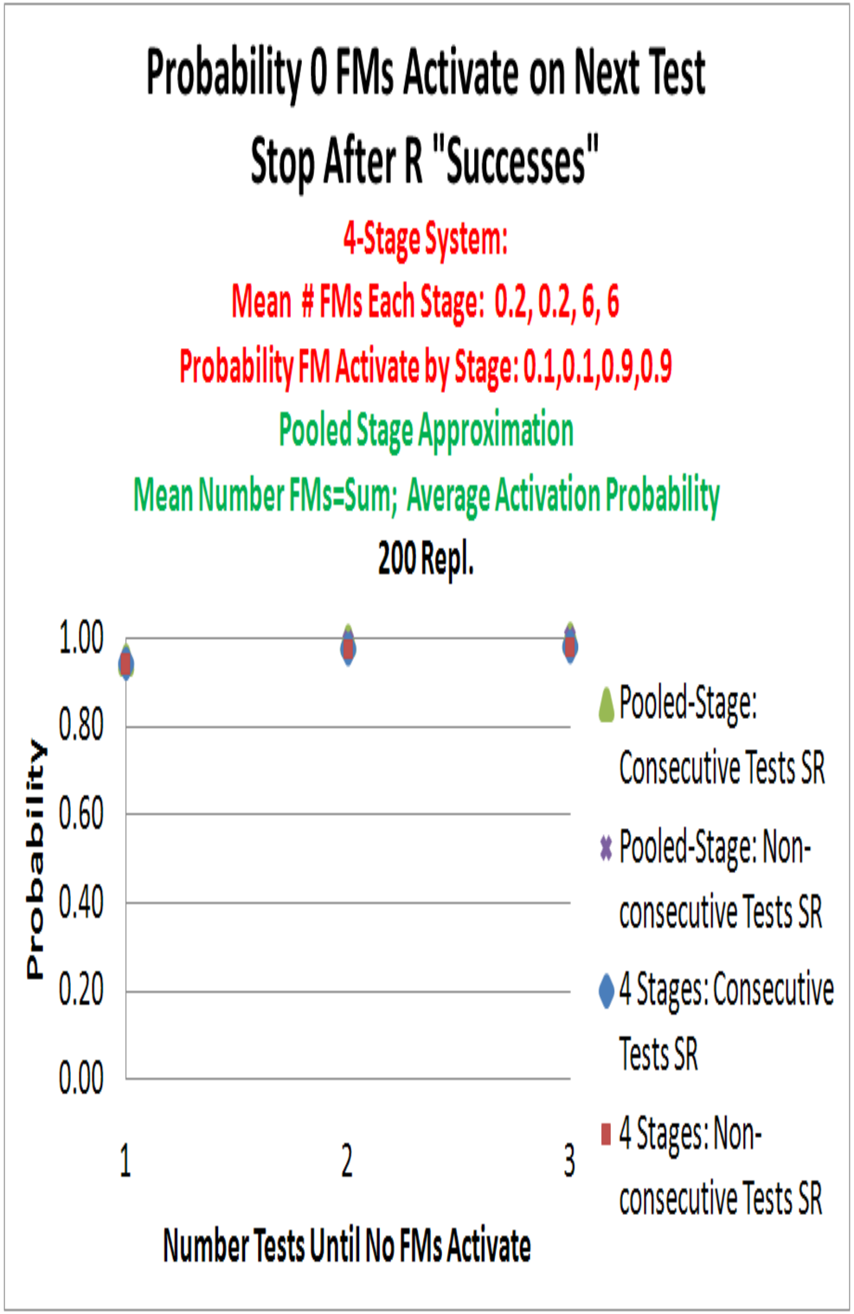
S-Stage System (MASKING)		Pooled 1-Stage System (NO MASKING) OPTIMISTIC
Number of tests until meet stopping criterion	Stochastically $\geq$	Number of tests until meet stopping criterion
Probability 0 FMs activate on one more test after stopping	$\leq$	Probability 0 FMs activate on one more test after stopping

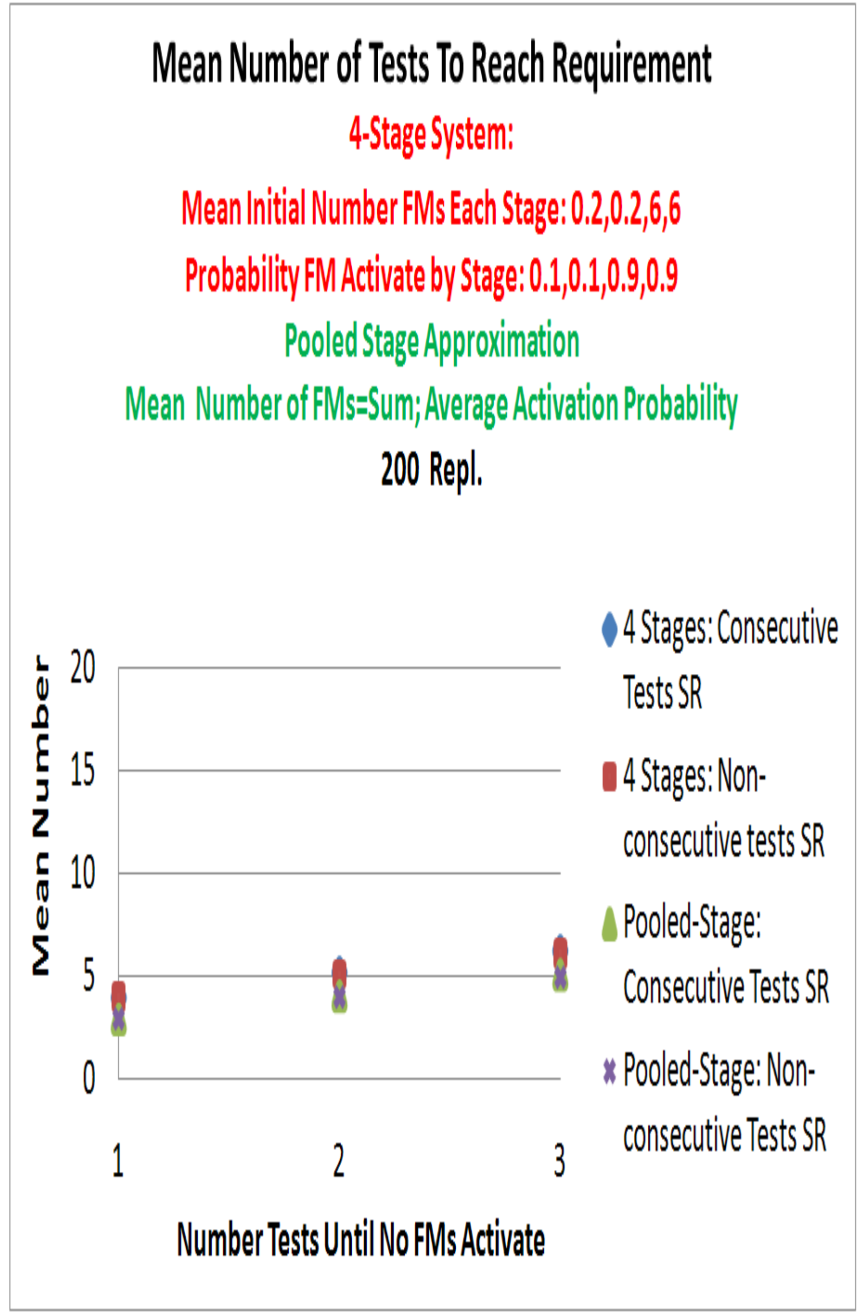

Mean Number of Tests To Reach Requirement
4-Stage System:
Mean Initial Number FMs Each Stage: 6
Probability FM Activate by Stage: 0.9,0.9,0.1,0.1
Pooled Stage Approximation
Mean Initial Number of FMs=Sum; Average Activation Probability
200 Replications
Mean Number
0
5
10
15
20
1
2
3
Number of Tests Until No FMs Activate
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive tests SR
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR

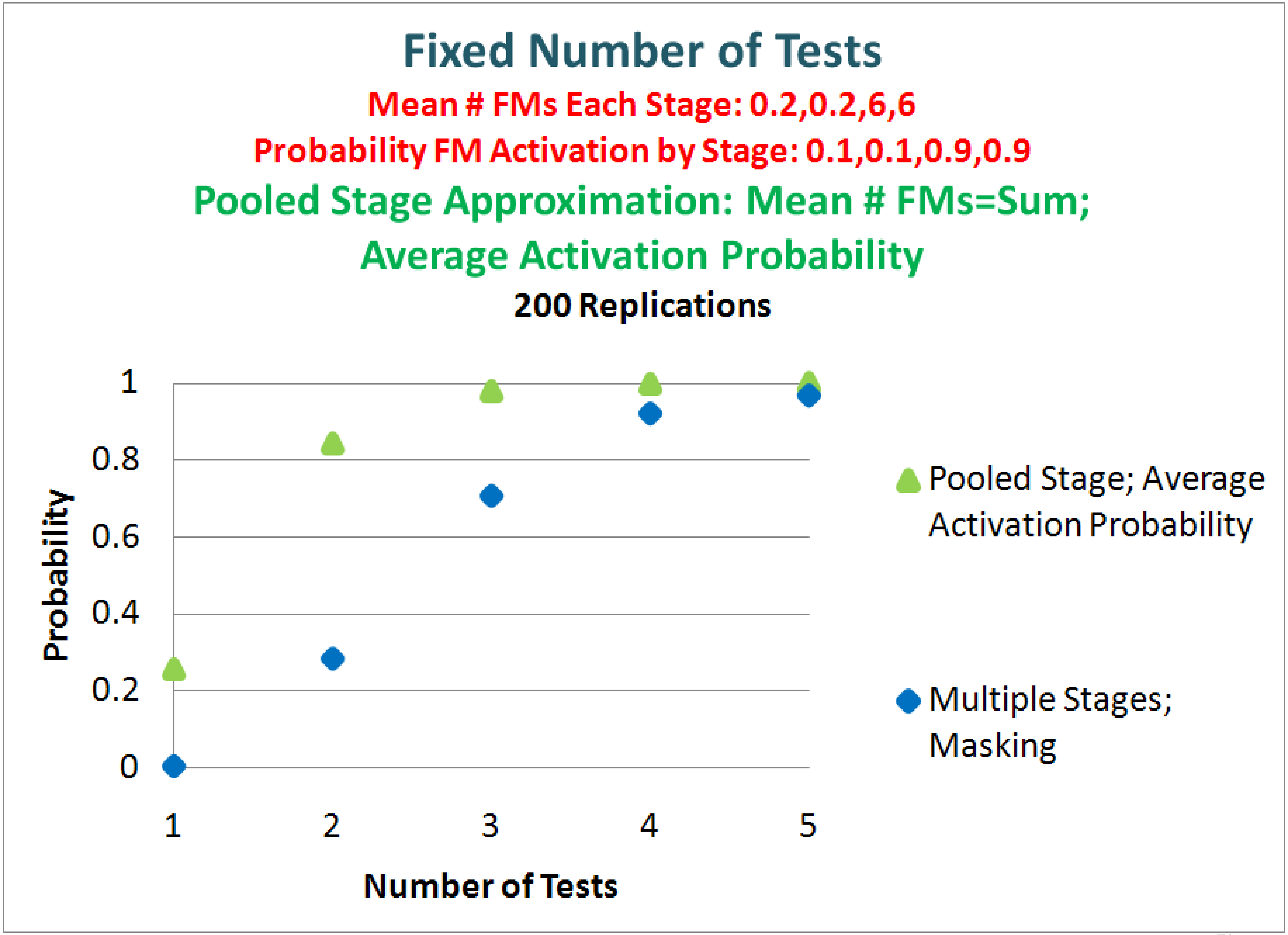

Mean Number of Tests To Reach Requirement
4-Stage System:
Mean Initial Number FMs Each Stage: 6
Probability FM Activate by Stage: 0.1,0.1,0.9,0.9
Pooled Stage Approximation
Mean Initial Number of FMs=Sum; Average Activation Probability
200 Replications
Mean Number
0
5
10
15
20
1
2
3
Number Tests Until No FMs Activate
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive tests SR
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR


Probability No FMs Activate On Next Test
4-Stage System:
Mean Initial Number FMs Each Stage: 6
Probability FM Activation by Stage: 0.9,0.9,0.1,0.1
Pooled Stage Approximation
Mean Number FMs=24; Average Activation Probability
200 Replications
Probability
1.00
0.80
0.60
0.40
0.20
0.00
1
2
3
Number of Tests Until No FMs Activate
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive Tests SR


Probability No FMs Activate On Next Test
4-Stage System:
Mean Initial Number FMs Each Stage: 6
Probability FM Activation by Stage: 0.1,0.1,0.9,0.9
Pooled Stage Approximation
Mean Number FMs=24; Average Activation Probability
200 Replications
Probability
1.00
0.80
0.60
0.40
0.20
0.00
1
2
3
Number Tests Until No FMs Activate
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive Tests SR


Probability 0 FMs Activate on Next Test
Stop After R "Successes"
4-Stage System:
Mean # FMs Each Stage: 0.2, 0.2, 6, 6
Probability FM Activate by Stage: 0.1,0.1,0.9,0.9
Pooled Stage Approximation
Mean Number FMs=Sum; Average Activation Probability
200 Repl.
Probability
1.00
0.80
0.60
0.40
0.20
0.00
1
2
3
Number Tests Until No FMs Activate
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive Tests SR


Mean Number of Tests To Reach Requirement
4-Stage System:
Mean Initial Number FMs Each Stage: 0.2,0.2,6,6
Probability FM Activate by Stage: 0.1,0.1,0.9,0.9
Pooled Stage Approximation
Mean Number of FMs=Sum; Average Activation Probability
200 Repl.
Mean Number
20
15
10
5
0
1
2
3
Number Tests Until No FMs Activate
4 Stages: Consecutive Tests SR
4 Stages: Non-consecutive tests SR
Pooled-Stage: Consecutive Tests SR
Pooled-Stage: Non-consecutive Tests SR


Fixed Number of Tests
Mean # FMs Each Stage: 0.2,0.2,6,6
Probability FM Activation by Stage: 0.1,0.1,0.9,0.9
Pooled Stage Approximation: Mean # FMs=Sum;
Average Activation Probability
200 Replications
Probability
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Number of Tests
Pooled Stage; Average Activation Probability
Multiple Stages; Masking

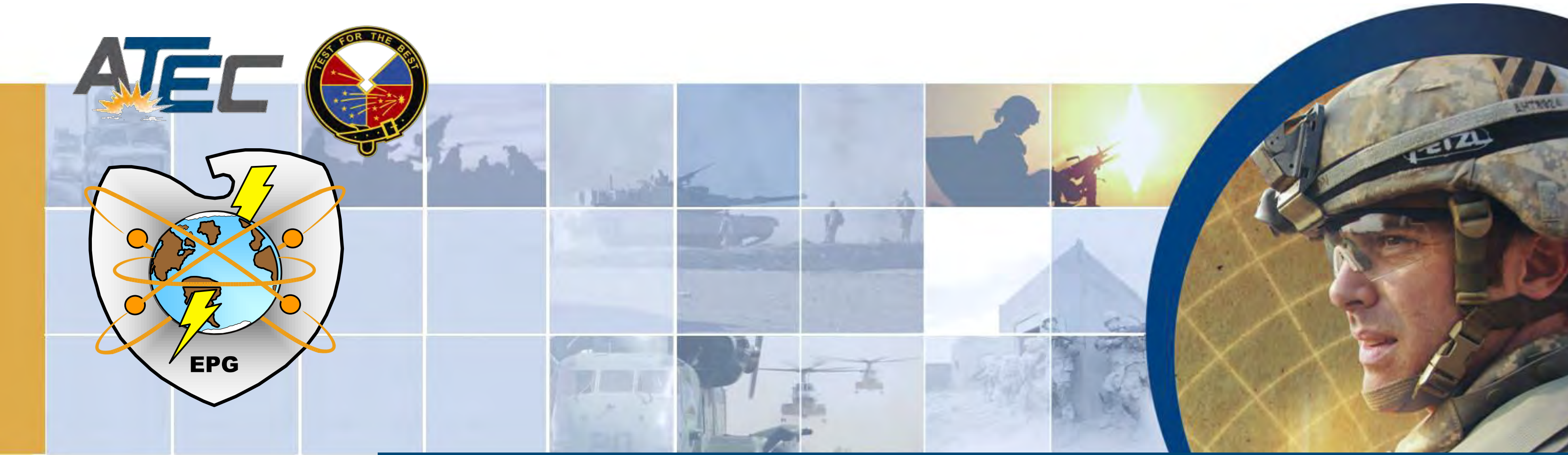
Summary

- The 1-Stage (Pooled) System can be optimistic compared to system with MASKING
  - Smaller Mean Number of Tests Until Obtain the Required Number of Successes
  - Larger Probability, next test activates no FMs, each stopping rule
- R Consecutive Successful tests versus R Successful tests
  - Larger number of tests,

    BUT
  - Larger probability one more test will not activate FM
- Fixed Number of Tests may not be enough
  - Testing to Learn

Reference

- D. P. Gaver, P. A. Jacobs, K. D. Glazebrook, and E. A. Seglie. “Probability models for sequential-stage system reliability growth via failure mode removal”. *International Journal of Reliability, Quality and Safety Engineering*, **10** (2003), 15-40.



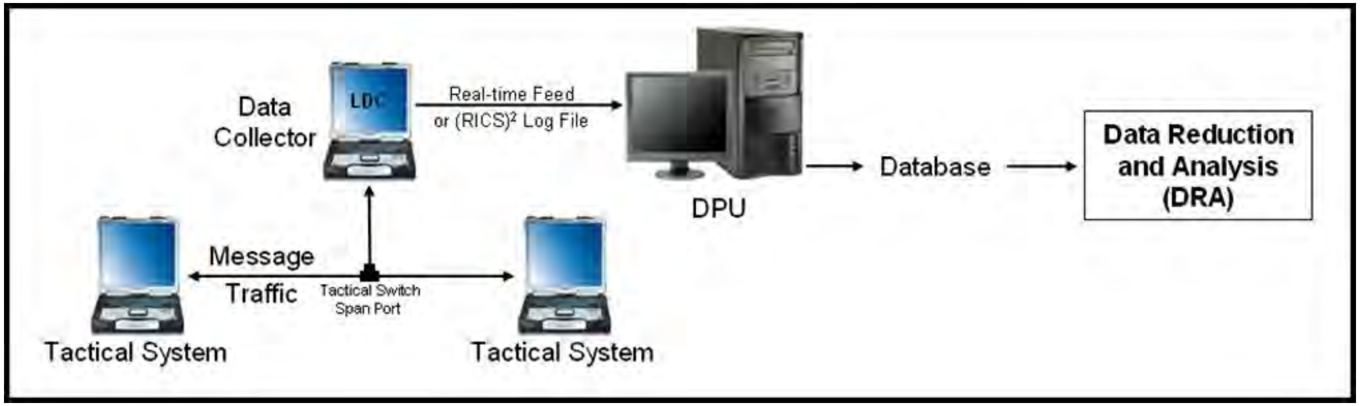
SOA Testing Tools

Army Testing in a Services Oriented Architecture (SOA) Environment

Michael Phillips
254-287-8258
ManTech International
Michael.Scott.Phillips@us.army.mil

Army Proven
Battle Ready

Instrumentation of the Past



- Testing Army computer systems before SOA
  - Collection
    - Attach to LAN and collect everything
    - Promiscuous non-intrusive methods
  - Reduction
    - Revolved around the parsing of formatted message traffic
      - Protocols
      - Message standards
  - Analysis
    - Metrics were essentially constant
      - Speed of Service
      - Message Completion Rate
      - Message Standards Compliance

Evolution of Instrumentation

- In the 2000s, changes in the Army Battle Command Systems drove changes in instrumentation methodologies
  - Joint Common Database (JCDB)
    - First attempt to maintain a common database by conducting database replication between information systems within a TOC
    - EPG developed new data collection methodologies
      - Data Collection Module (DCM) developed as an **Embedded Agent**
  - Army Information Server (AIS)
    - First Publish and Subscribe Service (PASS) architecture for intra-TOC exchanges
      - Fixed topic assignments for pub/sub (16 topics)
      - No advertising – subscribers had to poll to discover new topics
      - ABCS provided stove pipe comms for interoperability between TOCs
    - EPG developed new Stimulation, Data Collection, and Visualization tools
      - Bulk PASS as a **Surrogate Client** to publish and subscribe to the server
      - PASS Data Collector (PDC) as a **Surrogate Client** to capture encrypted exchanges
      - PASS Monitor as a **Custom Visualization Tool** for validation of transactions

Current Testing Environment

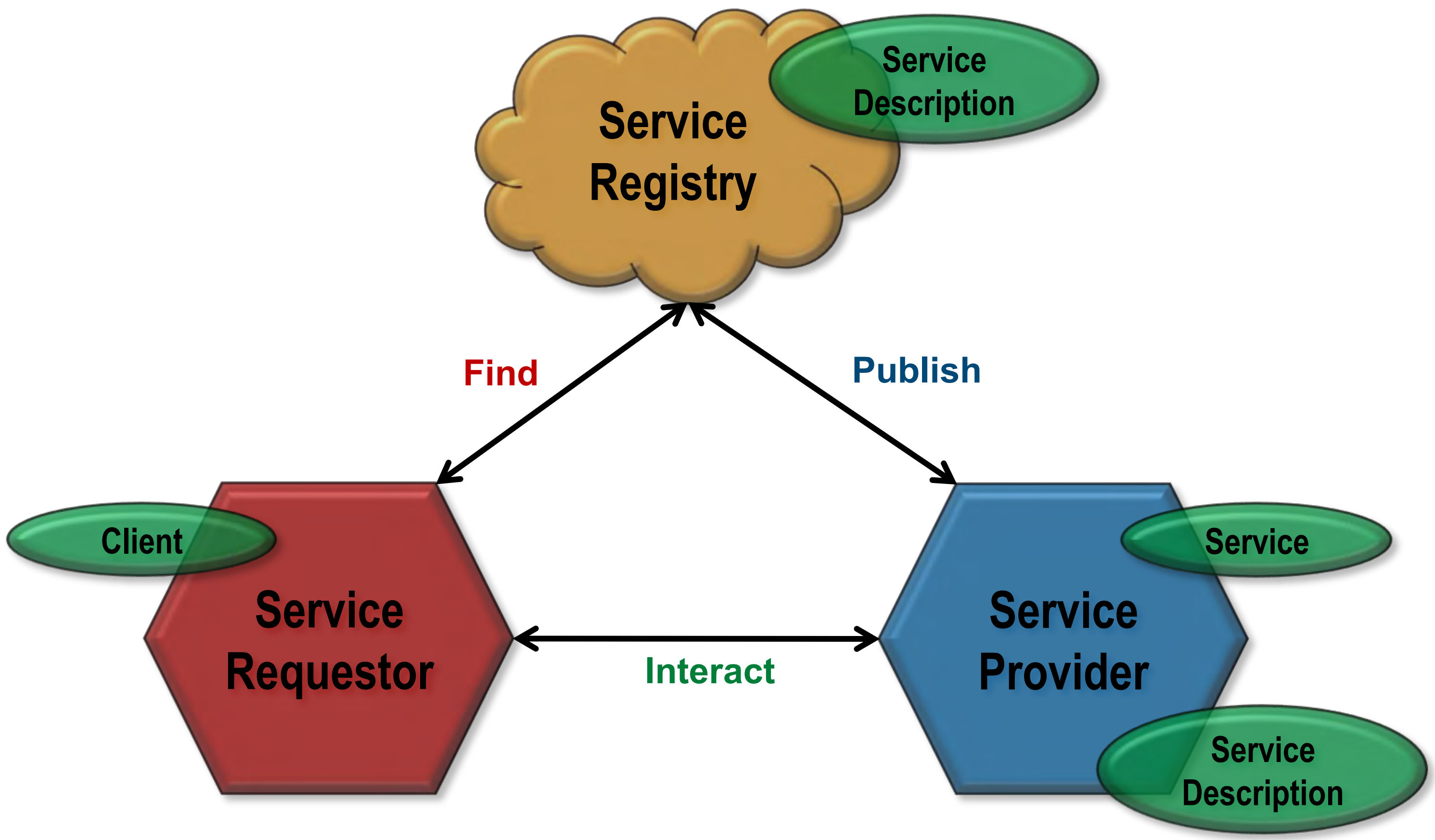
- Data Dissemination Service (DDS)
  - Replaces AIS
  - Introduces topic advertising (64 DDS advertising profiles)
  - Queries and dynamic subscriptions
  - Introduces Server-to-Server Peering
  - With DDS all LAN traffic is encrypted
- Instrumentation Requirements
  - Validate DDS server operation
  - Validate client publications against standards
  - Monitor JCR-DDS Interactions
- EPG Developed Solutions
  - Modify existing **Surrogate Clients**
    - Utilize DDS Client Interface (DCI)
    - Incorporate SDK from PM Battle Command
  - Modify existing **Embedded Agent**
  - Modify existing **Custom Visualization Tool**
  - Developed a method to **Decrypt Network Data**
  - Incorporate **Logs from the System Under Test (SUT)**

Soon, SOA will replace the majority of message exchanges

- DDS was the beginning of a move to Services Oriented Architecture

Intro to SOA

Service Oriented Architecture



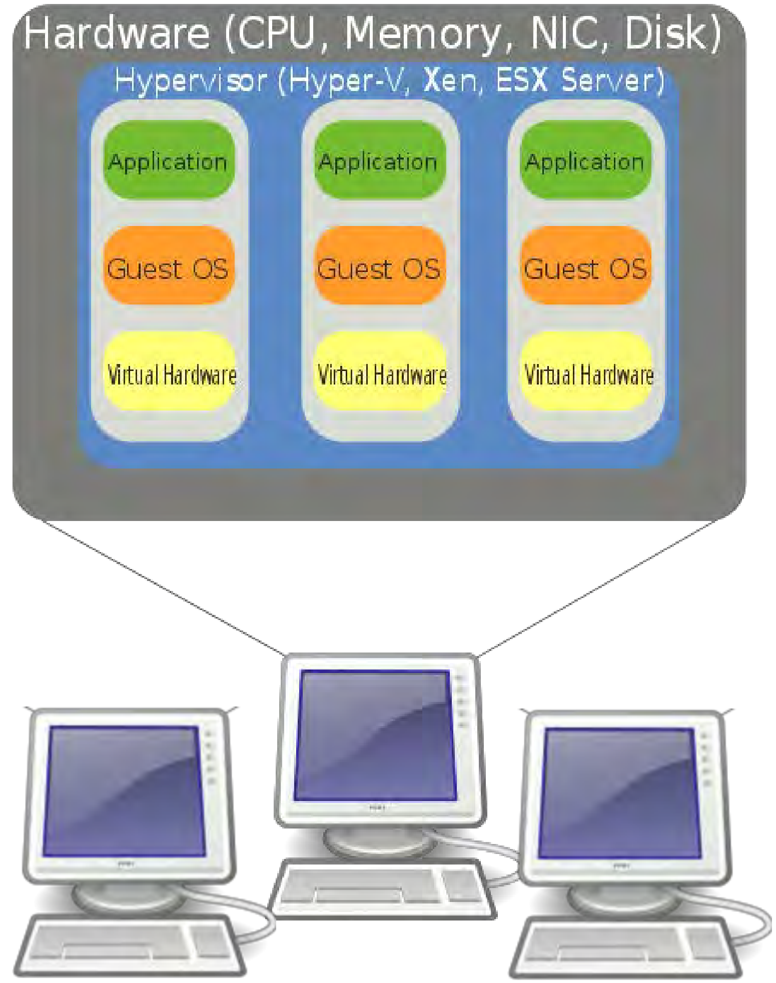
Impact of SOA

- SOA features will change current test paradigms
  - Encryption
    - Most LAN traffic will be encrypted
    - Listening promiscuously is no longer feasible
  - Thin Clients
    - Standalone applications gone, replaced by services
    - Most message-based communications obsolete

Intro to Virtualization

The intent of using virtual systems is to utilize increases in computer horsepower to reduce the number of physical systems necessary in an architecture.

It also allows systems to be easily interchanged while avoiding installation problems.



Intro to Virtualization Cont.

Application Software

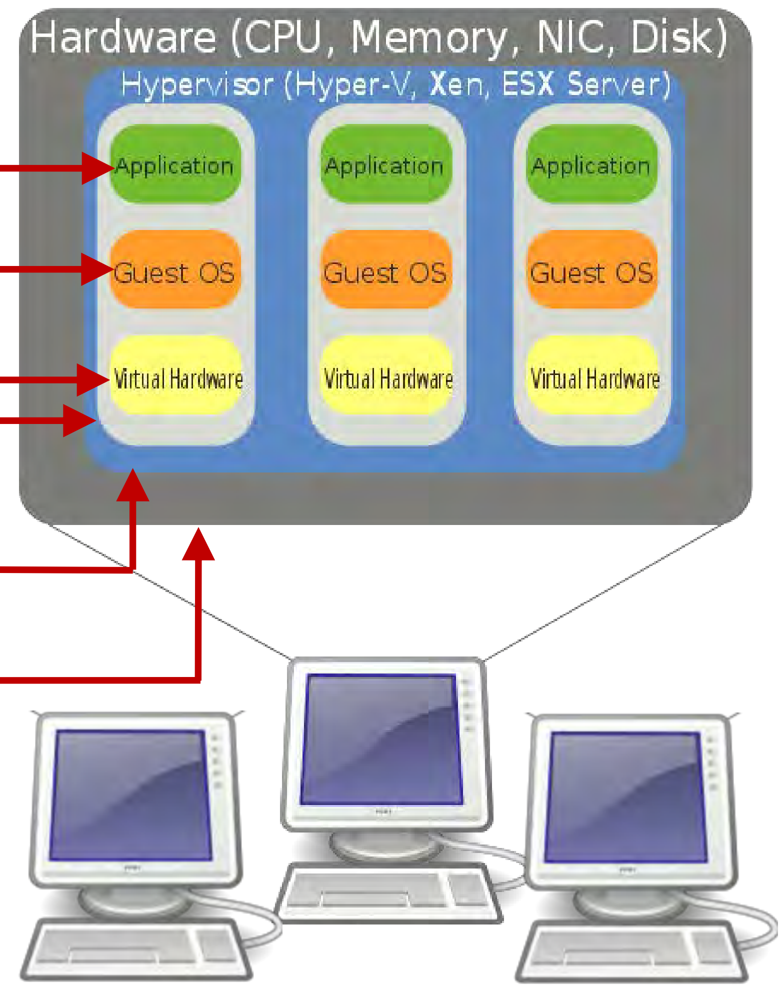
OS Installed on Virtual Hardware

Virtual Hardware

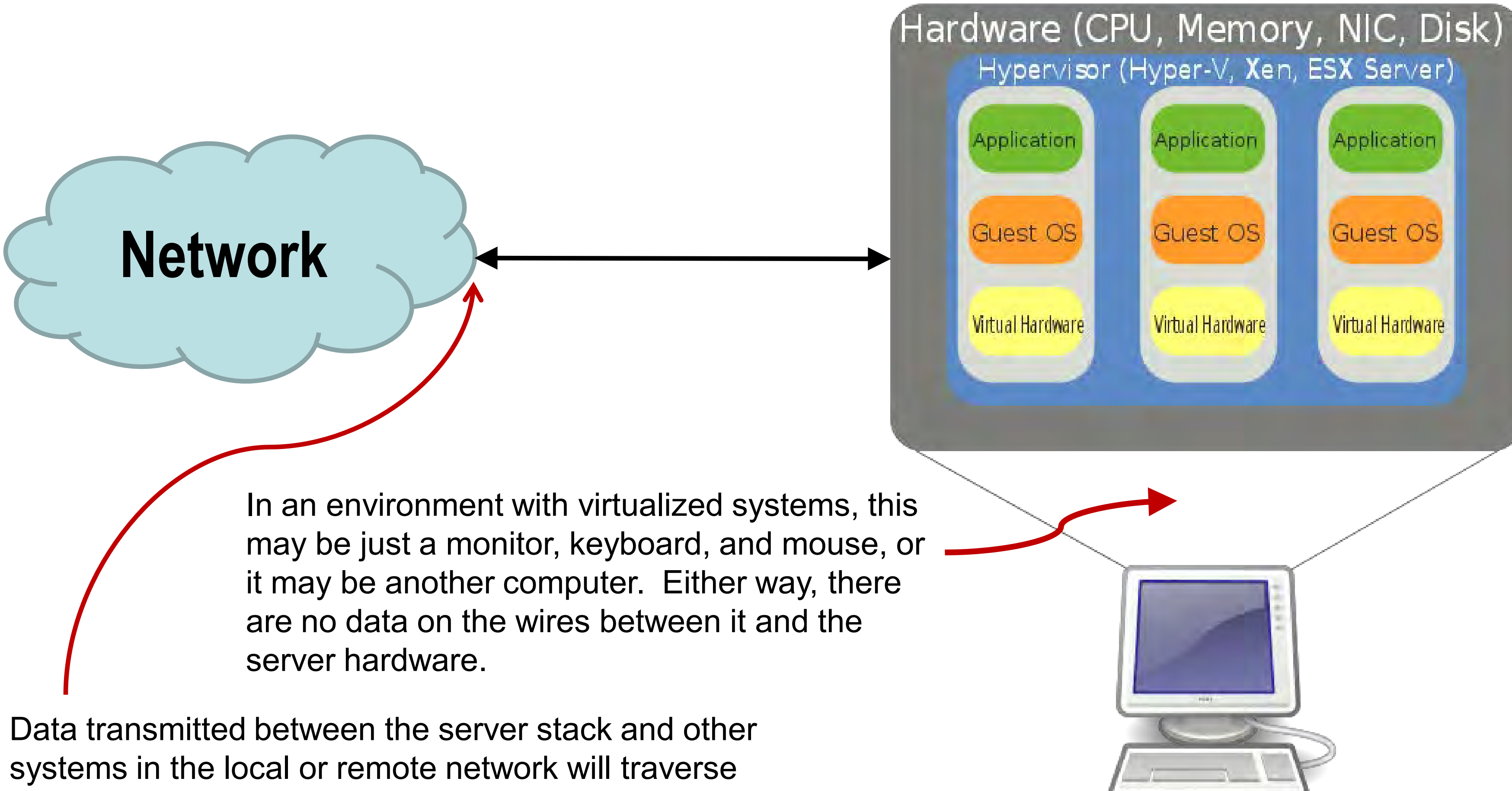
Virtual Machine

Hypervisor software (VMWare, etc.)

Real Server Hardware



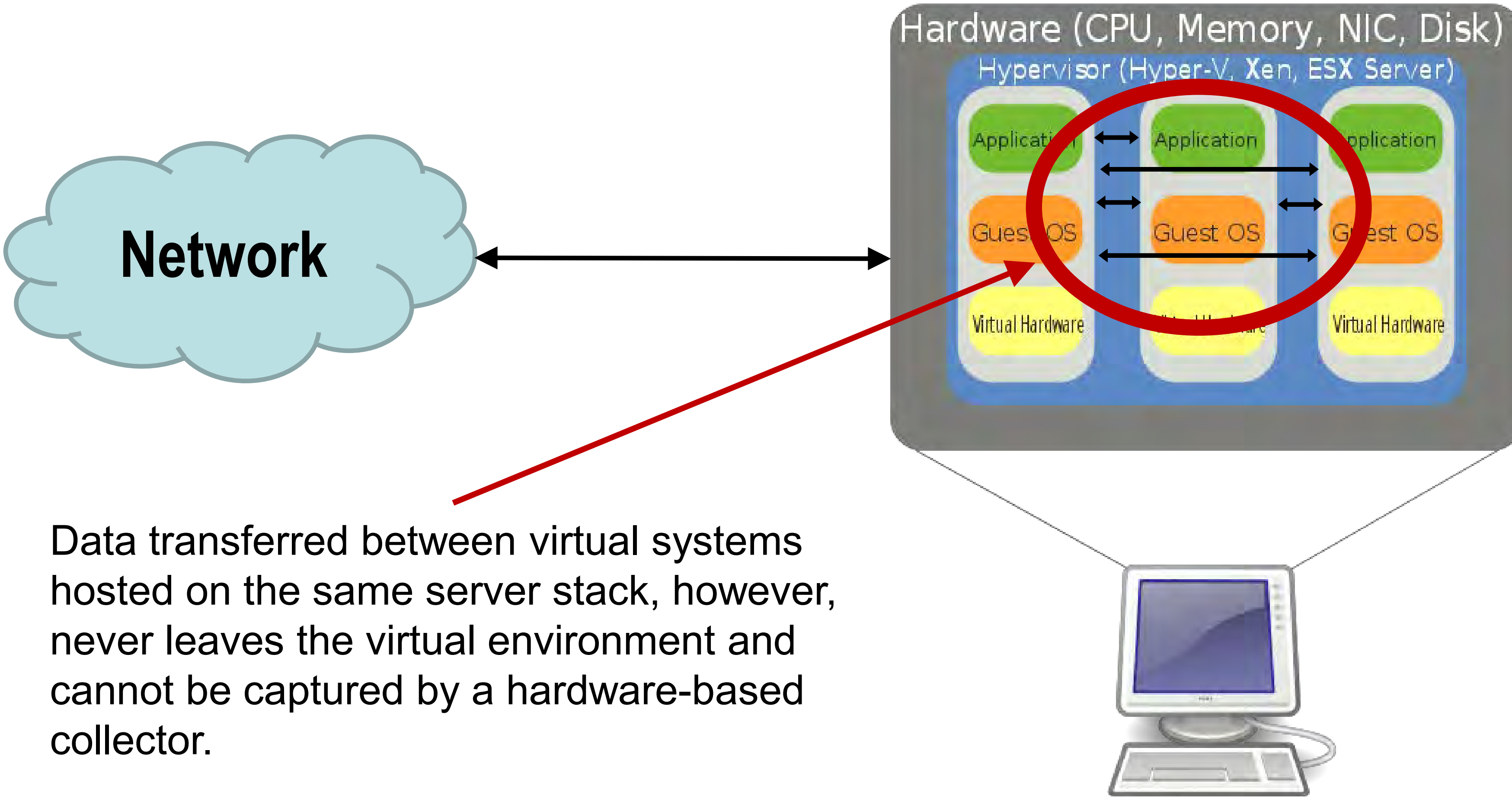
Impact of Virtualization



In an environment with virtualized systems, this may be just a monitor, keyboard, and mouse, or it may be another computer. Either way, there are no data on the wires between it and the server hardware.

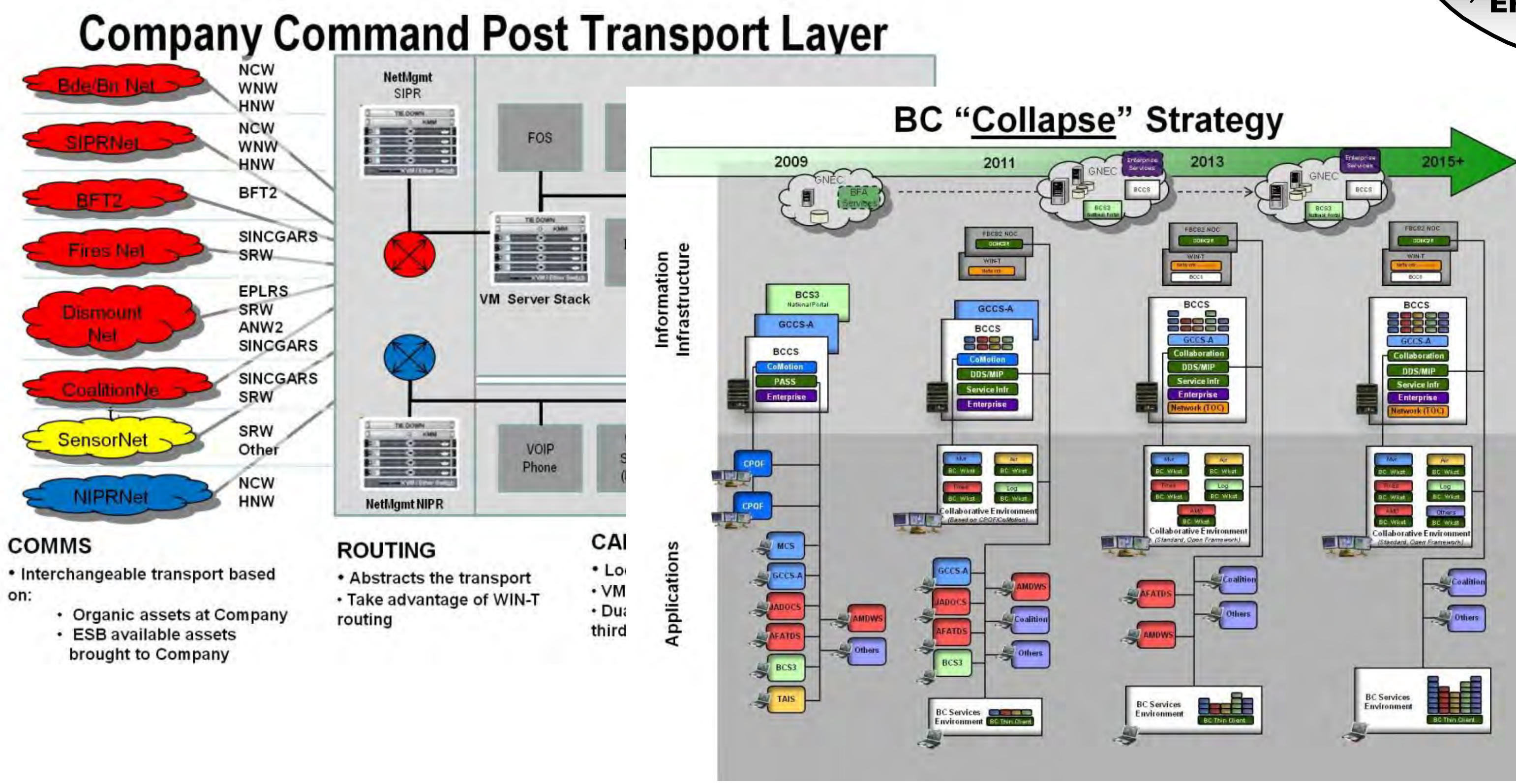
Data transmitted between the server stack and other systems in the local or remote network will traverse standard network equipment and be available for passive LAN collection at the switches.

Impact of Virtualization



Data transferred between virtual systems hosted on the same server stack, however, never leaves the virtual environment and cannot be captured by a hardware-based collector.

The Future Army Architecture



Existing instrumentation will not meet the Army's needs

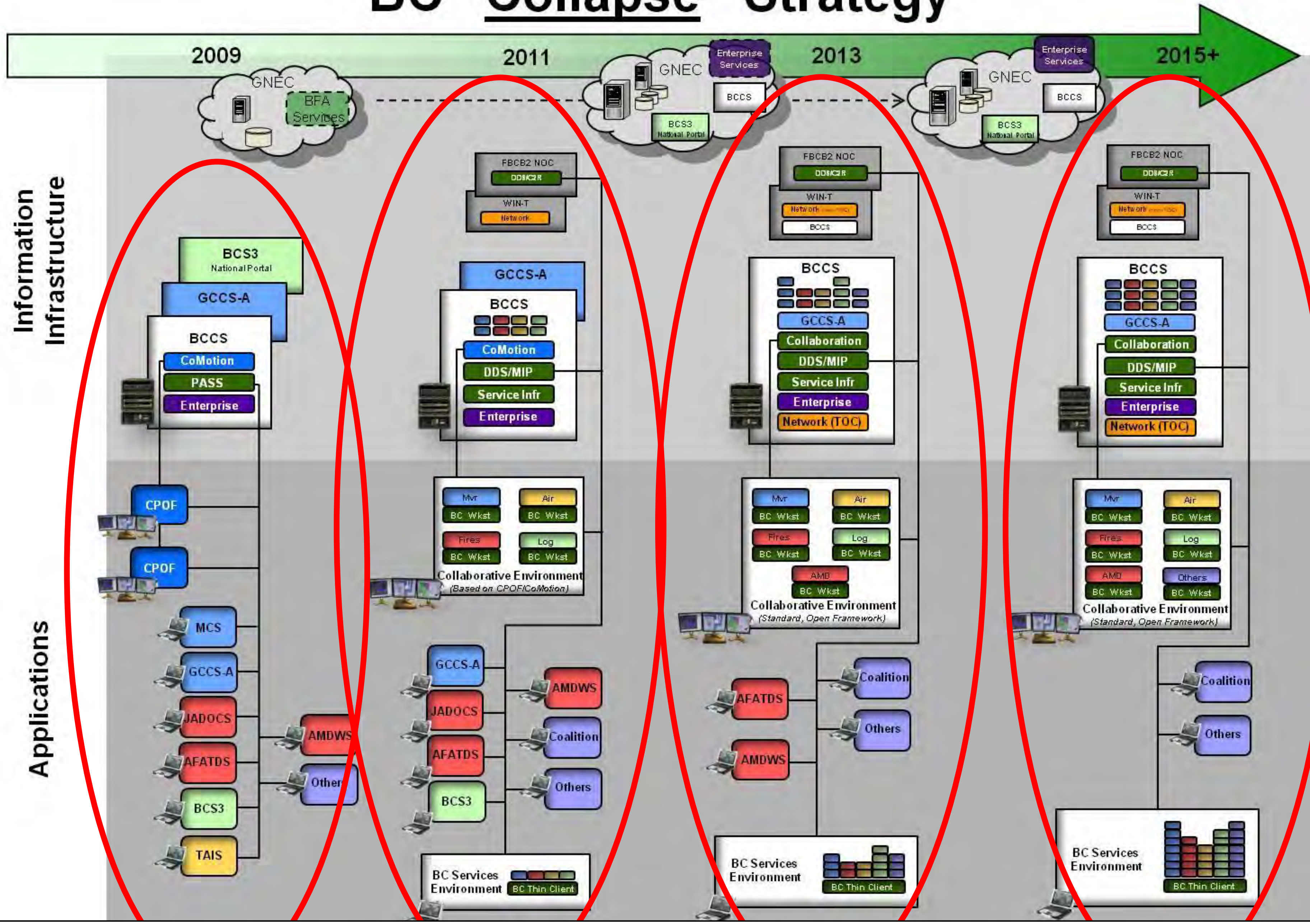
These architectures will begin testing at the CTSF very soon

August 2011

Army Proven Battle Ready

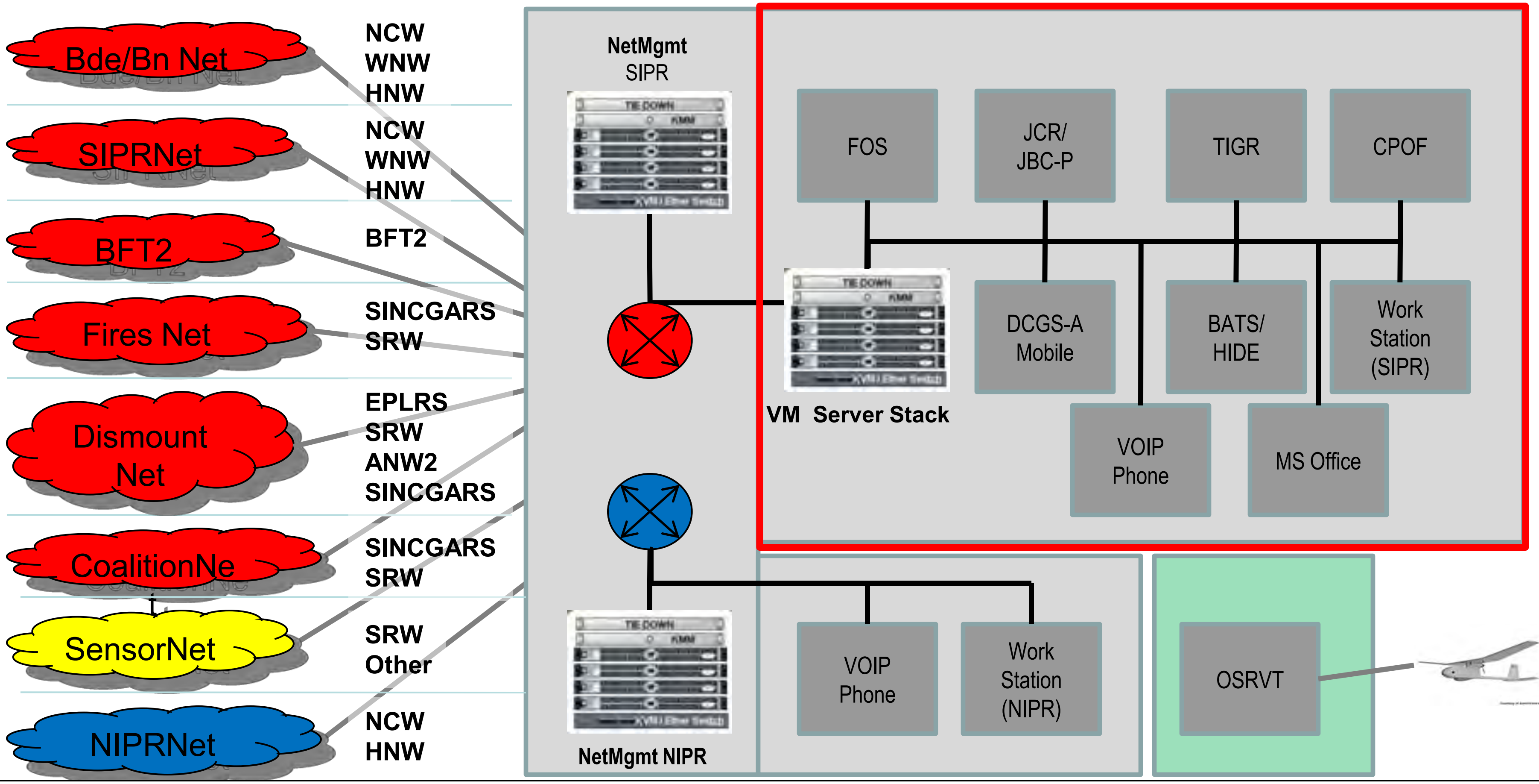
US Army Electronic Proving Ground

BC "Collapse" Strategy



In Five Years, no more standalone applications in the TOC

BCTM Company Command Post

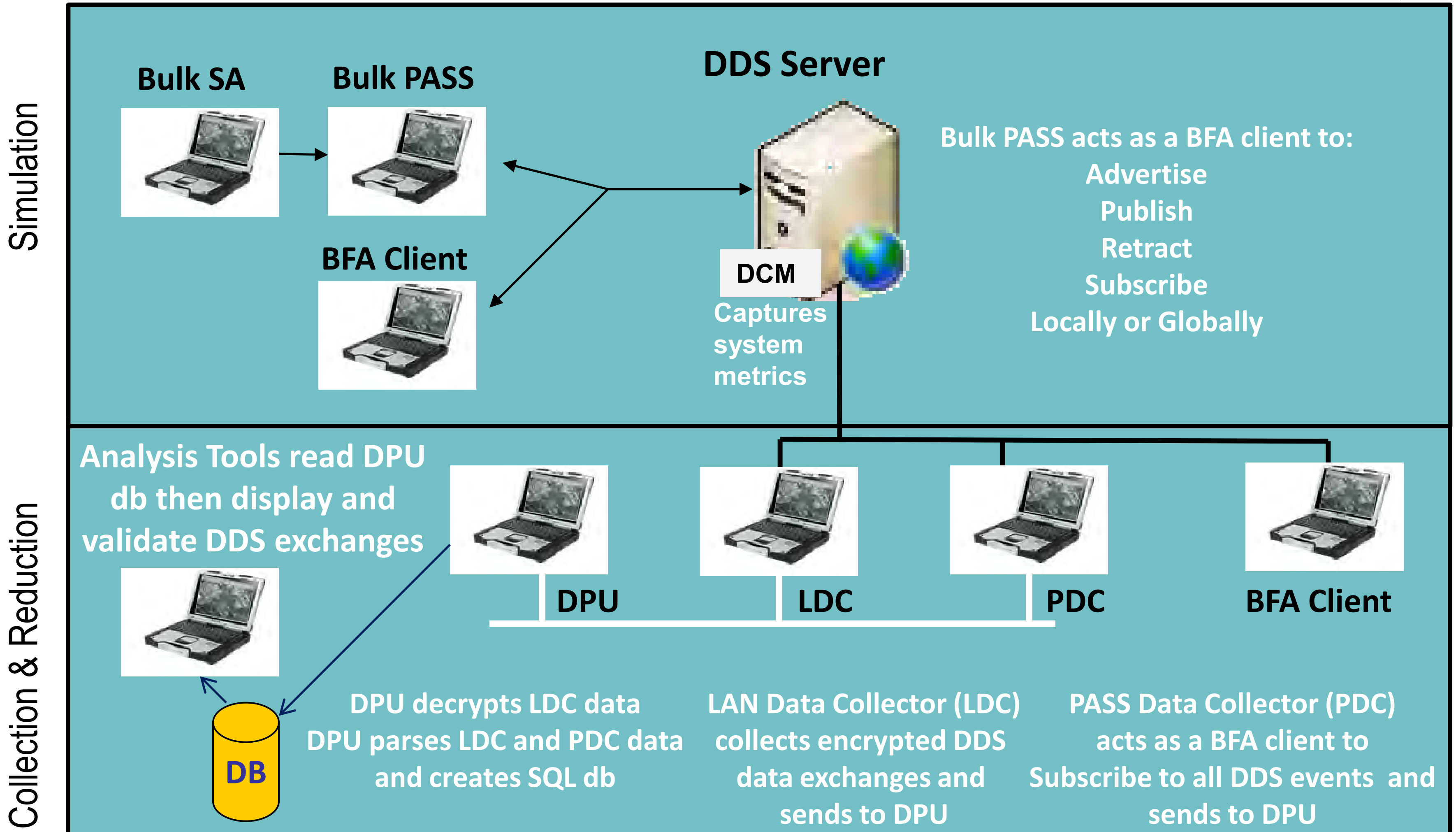


- Information Systems pushed down to the CO CP level.
  - Virtual systems within a single VM Server Stack.
- Black lines carry NO data.
  - Grey boxes in the picture represent only monitors and keyboards.
- Intra-TOC comms. will be invisible to hardware-based data collectors.

ATEC ToolKit

Testing these systems will require a multi-tool approach

EPG's SOA Tools



Bottom Line

- Current Instrumentation
  - Collection
    - Attach to LAN and collect everything
    - Promiscuous non-intrusive methods
  - Reduction
    - Revolved around converting raw data into something useable
      - Protocols
      - Message standards
  - Analysis
    - Metrics were essentially constant
      - Speed of Service
      - Message Completion Rate
      - Standards Compliance

Current Instrumentation will not work with SOA

- SOA-Compatible Instrumentation
  - Collection
    - LAN data important but not primary
      - Requires decryption
    - Active data collection methods
      - Surrogate Clients and Embedded Agents
      - Requires Cooperation with PMs
        - Early involvement in process
    - Flexibility Required
      - New methodologies
      - Custom solutions for each test
  - Reduction
    - Revolves around the big picture
      - Conformance
      - Data flow
      - Integration
  - Analysis
    - New Metrics will be developed
      - Yet to be determined
      - Likely to change rapidly

TENA and JMETC Enabling Interoperability Among Ranges, Facilities, and Simulations

Briefing for:

NDIA 27th Annual National T&E Conference

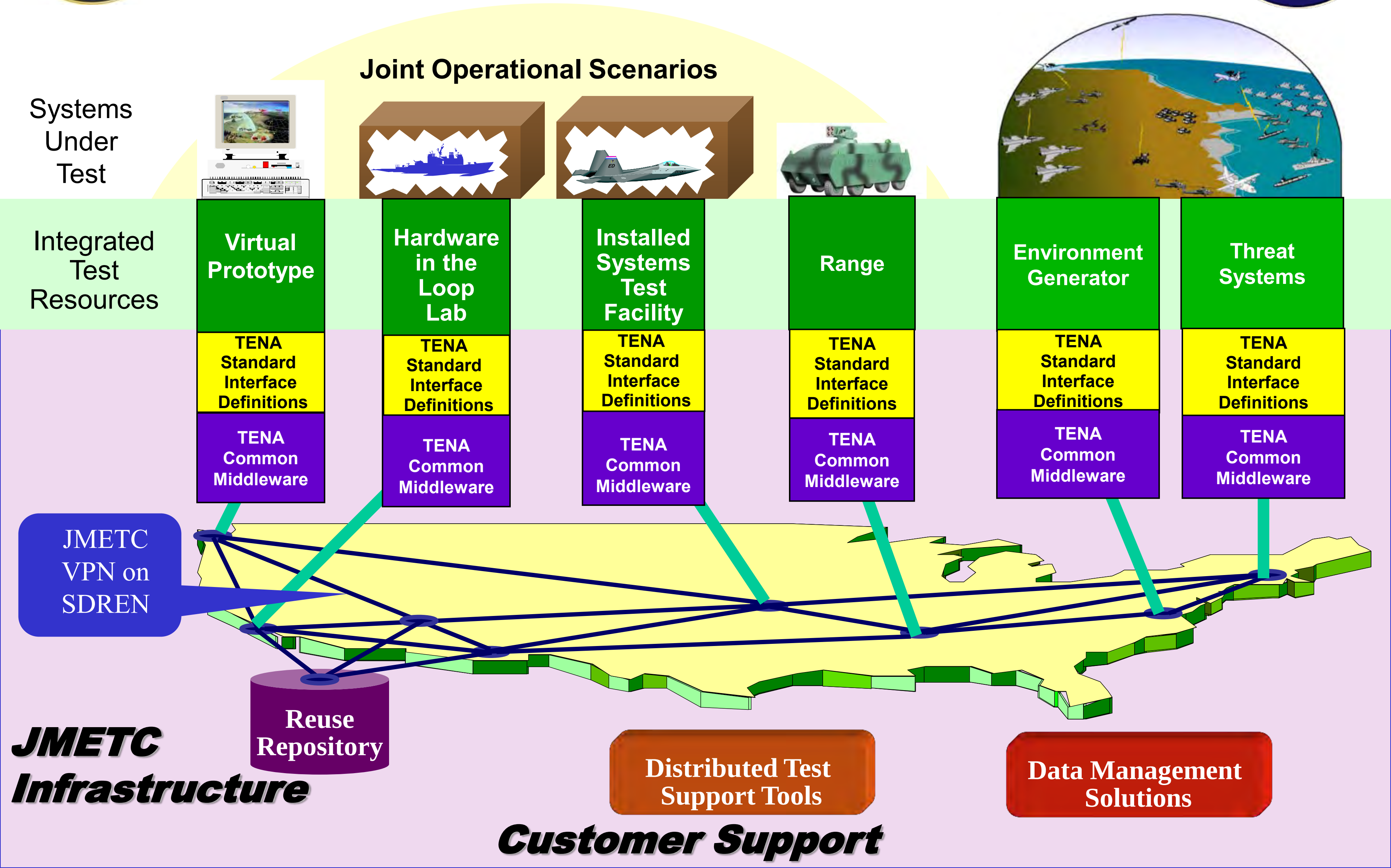
March 16, 2011

Gene Hudgins, TENA SDA User Support Lead

What is JMETC?

- **A corporate approach for linking distributed facilities**
  - Enables customers to efficiently evaluate their warfighting capabilities in a Joint context
  - Provides compatibility between test and training
- **A core, reusable, and easily reconfigurable infrastructure**
  - Consists of the following products:
    - Persistent connectivity
    - Middleware
    - Standard interface definitions and software algorithms
    - Distributed test support tools
    - Data management solutions
    - Reuse repository
- **Provides customer support team for JMETC products and distributed testing**

JMETC Enables Distributed Testing



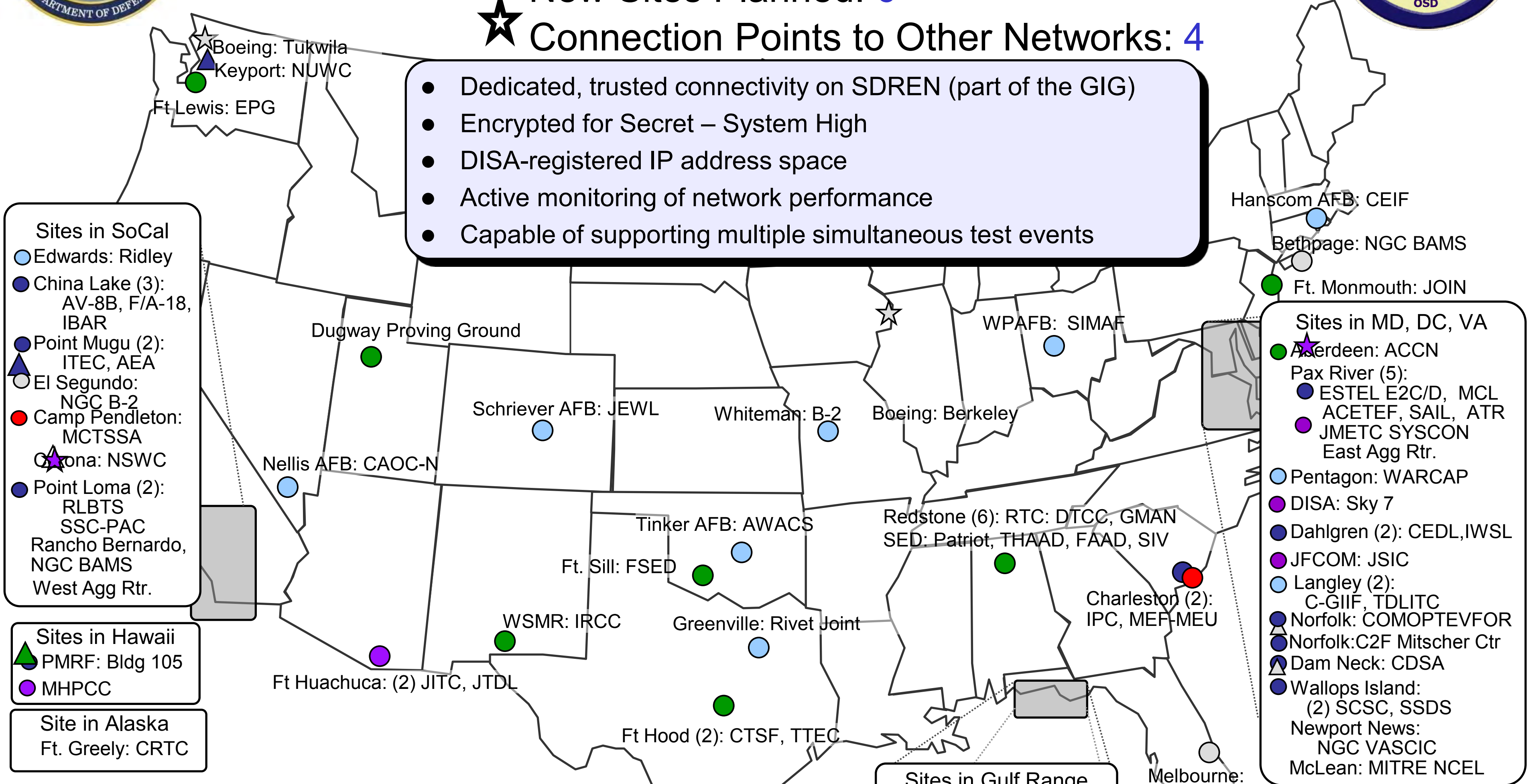
JMETC: Here and Now

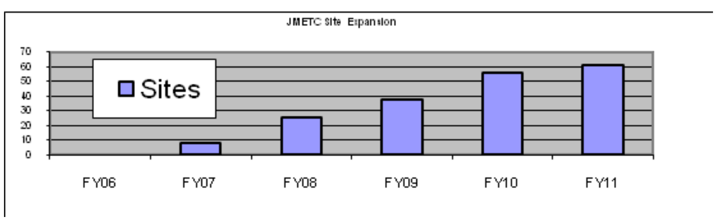
- **Uses the Secure Defense Research & Engineering Network (SDREN) for connectivity**
  - 61 sites currently on-line
- **Uses Test & Training Enabling Architecture (TENA)**
  - Gateways to link to existing DIS and HLA simulations
- **Incorporates InterTEC test tools**
- **Uses the JNTC-sponsored Network Aggregator to link together other networks**
- **Being expanded based on customer requirements**
- **Holding JMETC Users Group meetings to discuss emerging requirements and technical solutions**
  - Seeking the “best of breed” solutions across the community

JMETC Connectivity

- ○ Functional Sites: 61
- △ New Sites Planned: 6
- ☆ Connection Points to Other Networks: 4

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





As of 09 Dec 2010

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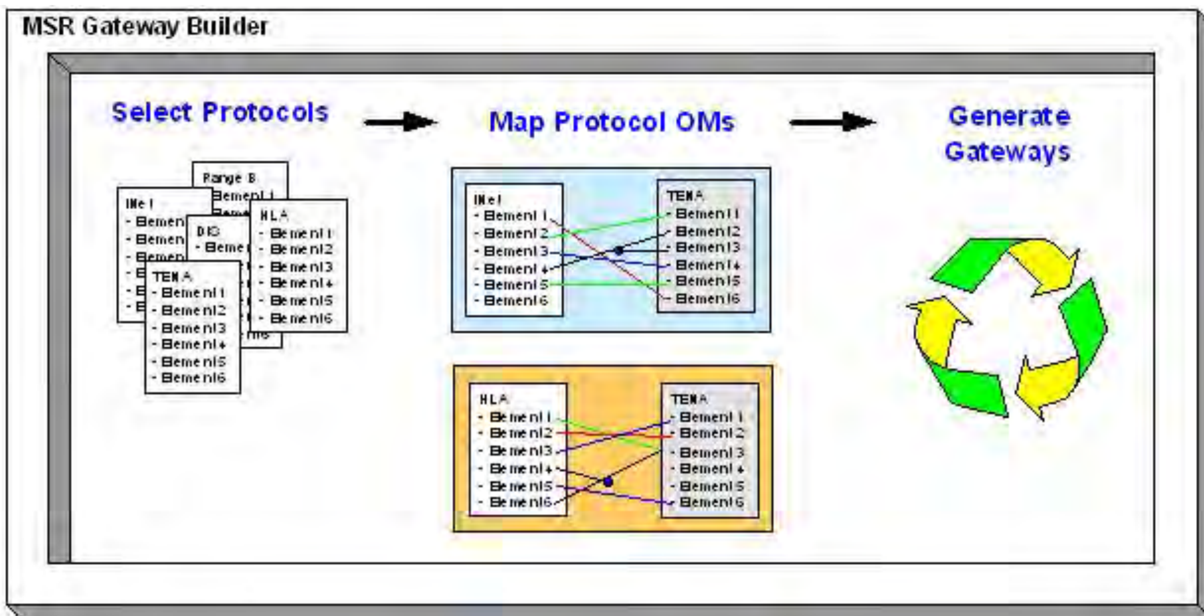
JMETC Uses TENA to Integrate Sites

(Can gateway to existing DIS and HLA simulations)

- TENA is:
  - Developed, upgraded, and sustained by CTEIP and JNTC
  - Middleware that provides a single, universal data exchange solution
  - Common for test and for training (core standard in JMETC and JNTC)
  - Available for download at www.tena-sda.org for free
- TENA provides:
  - Interoperability among range systems, hardware-in-the-loop laboratories, and simulations in a quick, cost-efficient manner
  - A capability to rapidly and reliably develop LVC integrations
  - A set of community-agreed object models that define the data elements used in LVC integrations – maximizes reuse from event to event
  - An auto-code generator to drastically reduce TENA incorporation time
- Newest version of TENA (version 6.0) provides:
  - Advanced data filtering (only data of interest sent over the wire)
  - Improved fault tolerance and embedded diagnostics
  - Downloadable on the TENA Website

Gateway Builder

- GWB is focused on integration of distributed live, virtual, and constructive (LVC) systems into a common synthetic battle space that comprises various simulation protocols, training ranges, live systems and platforms
- Gateway Builder streamlines integration process and reduces time and effort of creating gateways
- Gateway Builder is a flexible, extensible, graphically driven tool that automatically generates gateways to bridge simulation and live protocols
- Gateway Builder supports mappings between TENA, DIS, and HLA and message-based protocols using any object model



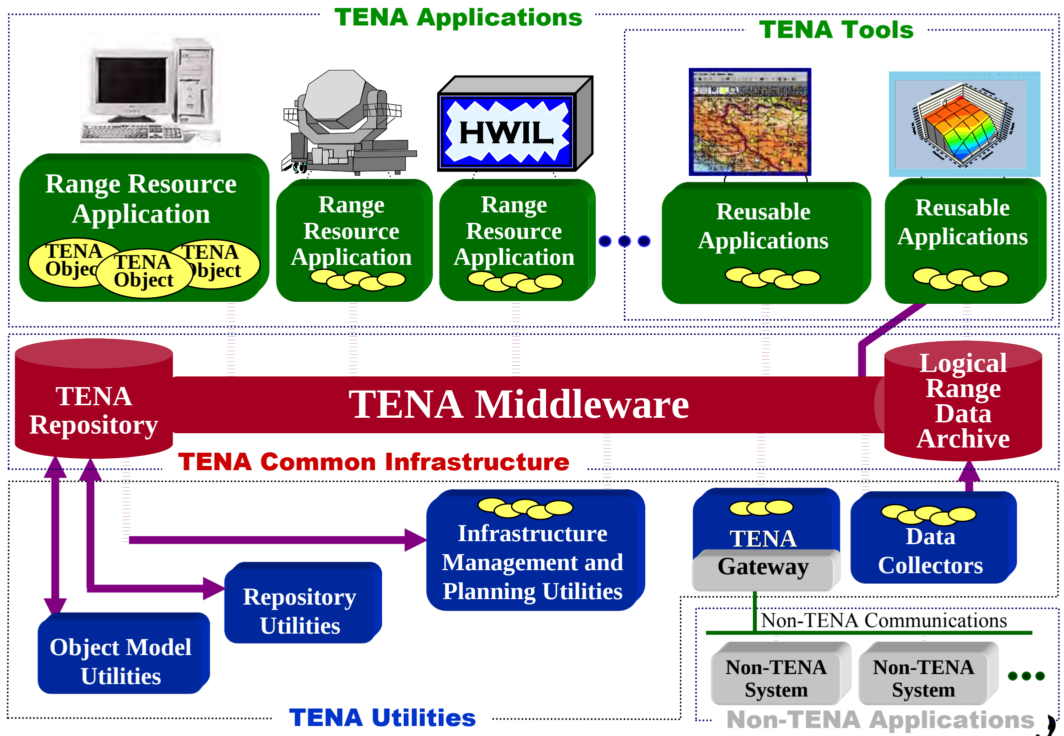
Gateway Builder Simplified Block Diagram

TENA Overview

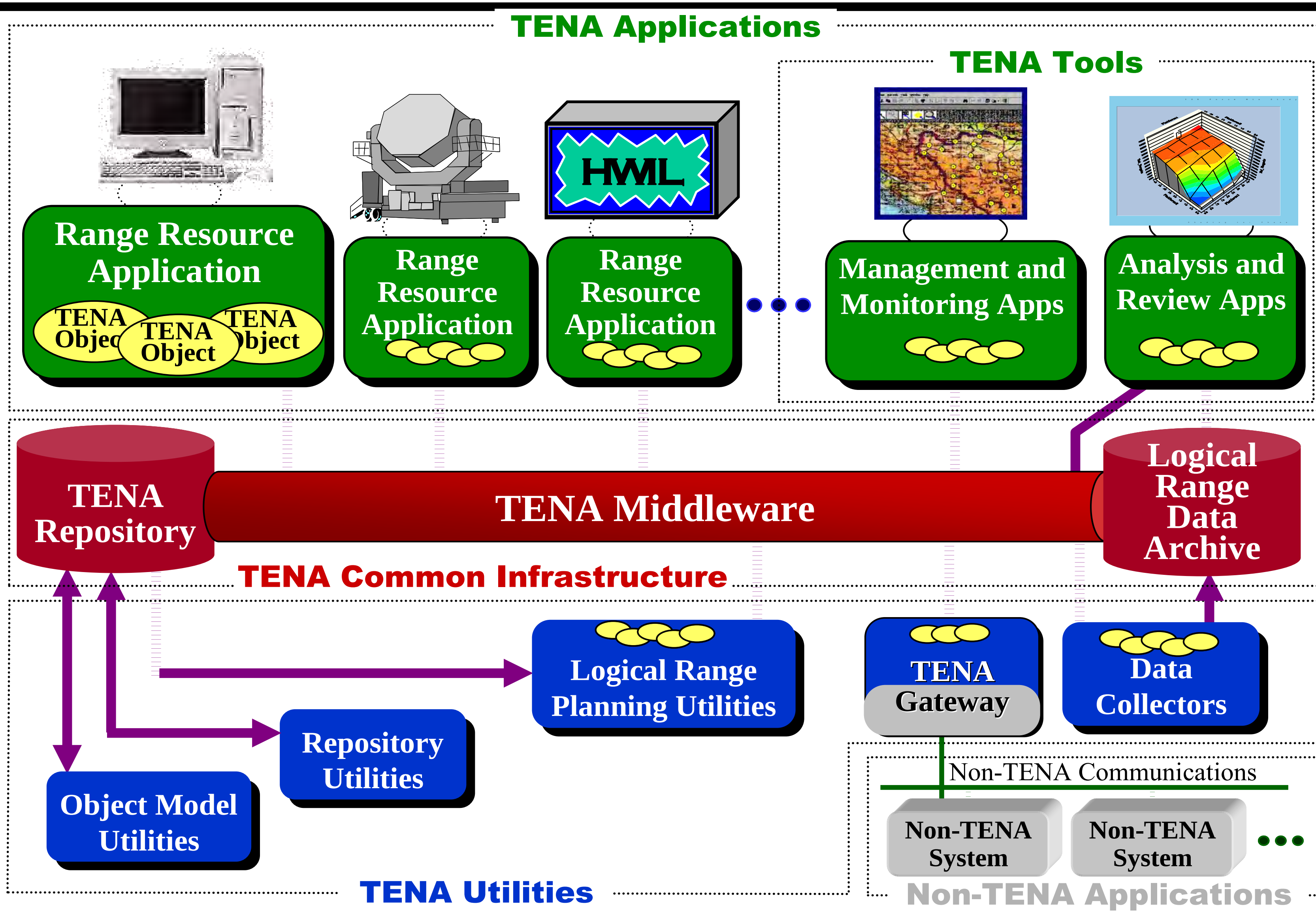
- **Requirements**
  - Interoperability
  - Reuse
  - Composability
  - **Support Rapid Integration**
  - **Gradual Deployment**

- **Supports**
  - **Testers & Trainers**
  - **Joint, Army, Navy, Air Force, Agencies**
  - **Live, Virtual, Constructive**
  - **Range, Laboratories, Simulations**
  - **Real-Time & Non-Real-Time**

- Guiding Principles
  - Provide middleware
  - Use real software objects
  - Maximize code generation
  - Management by users (AMT)
  - No license fee (GOTS)



TENA Architecture Overview



Key Release 6 Improvements and New Capabilities

New Middleware Capabilities

- Advanced Filtering
- OM Subsetting Support
- SDO State Processing Support
- Self-Reflection Option
- Object Reactivation
- Separate Inbound/Outbound ORBs

Metamodel and Model Improvements

- Fundamental Sized Type Aliases
- Const Qualifier
- Optional Attributes
- SDO Initializers
- Middleware Metadata
- Middleware IDs

New Event Management Capabilities

- Object Model Consistency Checking
- Remote Object Termination
- Execution Manager Fault Tolerance
- Embedded Diagnostics
- TENA Console

Usability Improvements

- Observer Pattern (with Callback Aggregation)
- Local Methods Factory Registration
- Code Installation Layout

Key Release 6 Improvements and New Capabilities

New Middleware Capabilities

- Advanced Filteri...
- OM Sub...
- S... ...pport
- ...ion
- ...ctivation
- ...parate Inbound/Outbound ORBs

•Enhanced data distribution
•Optimized network usage

Metamodel and Model Improvements

- Fundamental Si...
- Const O...
- C...
- ...
- ... Metadata
- ...dleware IDs

•Better ways to define data
•Remove ambiguity

New Event Management Capabilities

- Object Model C...
- Remot...
- ... Tolerance
- ...gnostics
- ...onsole

•Improved reliability
•Enhanced troubleshooting

Usability Improvements

- Observer Patt...
(with C...
- ...
- ...stallation Layout

•Easy to use
•Harder to use wrong

TENA in a Resource Constrained Environment (TRCE) S&T Background

- **Low Data Rate Networks**
  - **TENA must be able to establish and maintain data connections on low data rate networks**
  - **Need to optimize use of low data rate networks to support relevant operational scenarios**
- **Wireless Networks**
  - **Current range environments use wireless links extensively for various systems under test**
- **Variable Quality Networks**
  - **T&E systems poorly tolerate high loss, link failure, or heterogeneous links**
  - **Need to provide data continuity for degraded or heterogeneous networks**
- **Specification of Interests**
  - **Subscribers must be able to specify data "interests" to more efficiently use available & limited network resources**

TRCE Phase 1 will:

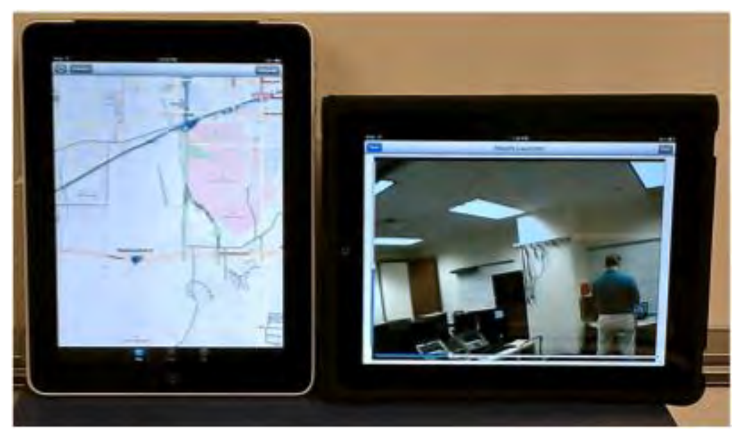
- **Developed Use Cases and Requirements**
- **Developed Proof-of-Concept Applications to Investigate Candidate Technologies**
- **Quantified Benefits of Candidate Technologies**
  - Representative Laboratory Environment
- **Successful Phase 1 Technology Demonstration**
- **Recommended Technologies for Further Development and Inclusion in the TENA Middleware**

TRCE is providing TENA for variable quality and low data rate network links including wireless networks

TRCE Use Case OV-1

Hands-on TRCE Current “Smartphone” Capabilities at the TENA/JMETC Booth

- Booth Demonstration Capabilities Using TENA RelayNode and TENA Video Distribution System (TVDS) with iPads and iPod Touch Devices
  - Display of Platform positions on static maps stored locally on the handheld devices
  - Selection and real-time viewing of available video streams managed by TVDS on handheld devices (iPhone/iPad/Android)
  - Pan/Tilt control of remote cameras (and firing of Nerf remote “missile launcher”) via TENA remote methods
- Highlights the Flexibility of TENA Middleware
  - Remote control of instrumentation via TENA Remote Methods
  - Use of wireless networks including 3G
  - Middleware implementations on small form factor computers such as Smartphones



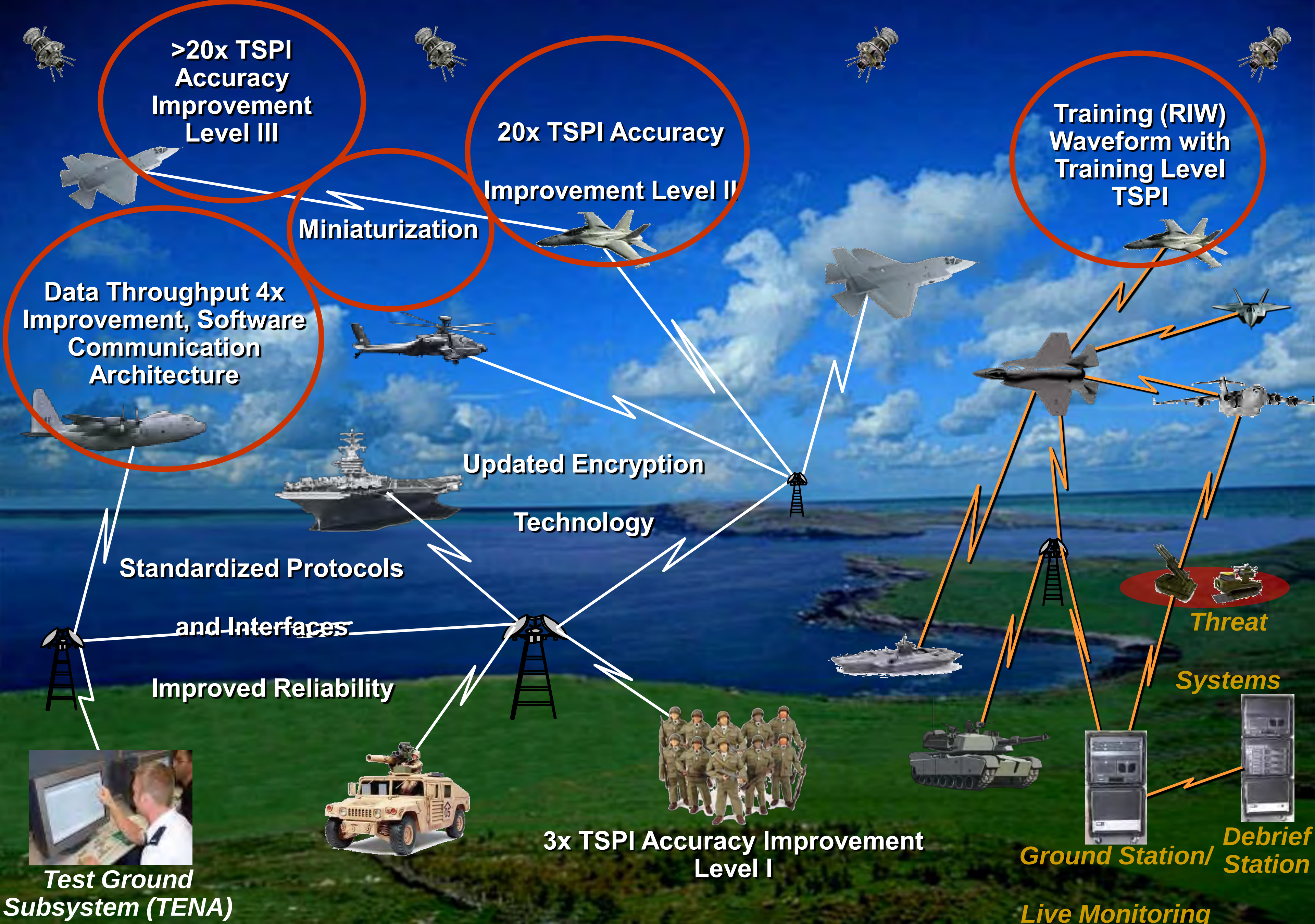
TENA and RRRP

- Use of TENA will facilitate Remote Operations and Interoperability of the Ranges' Radar Systems

- TENA Instrumentation Radar Object Models will be used for all communications external to the individual Radar Systems
  - Pointing data for optics, telemetry, or other radars
  - Remote Single Integrated Air Picture (SIAP)

- Development of TENA Instrumentation Radar Object Models
  - Developed initial Instrumentation Radar TSPI Object Model
    - Received input from Test Center SMEs
    - For CW Doppler and Pulse radar systems
  - Instrumentation Radar Object Models will be finalized after contract award

Common Range Integrated Instrumentation System

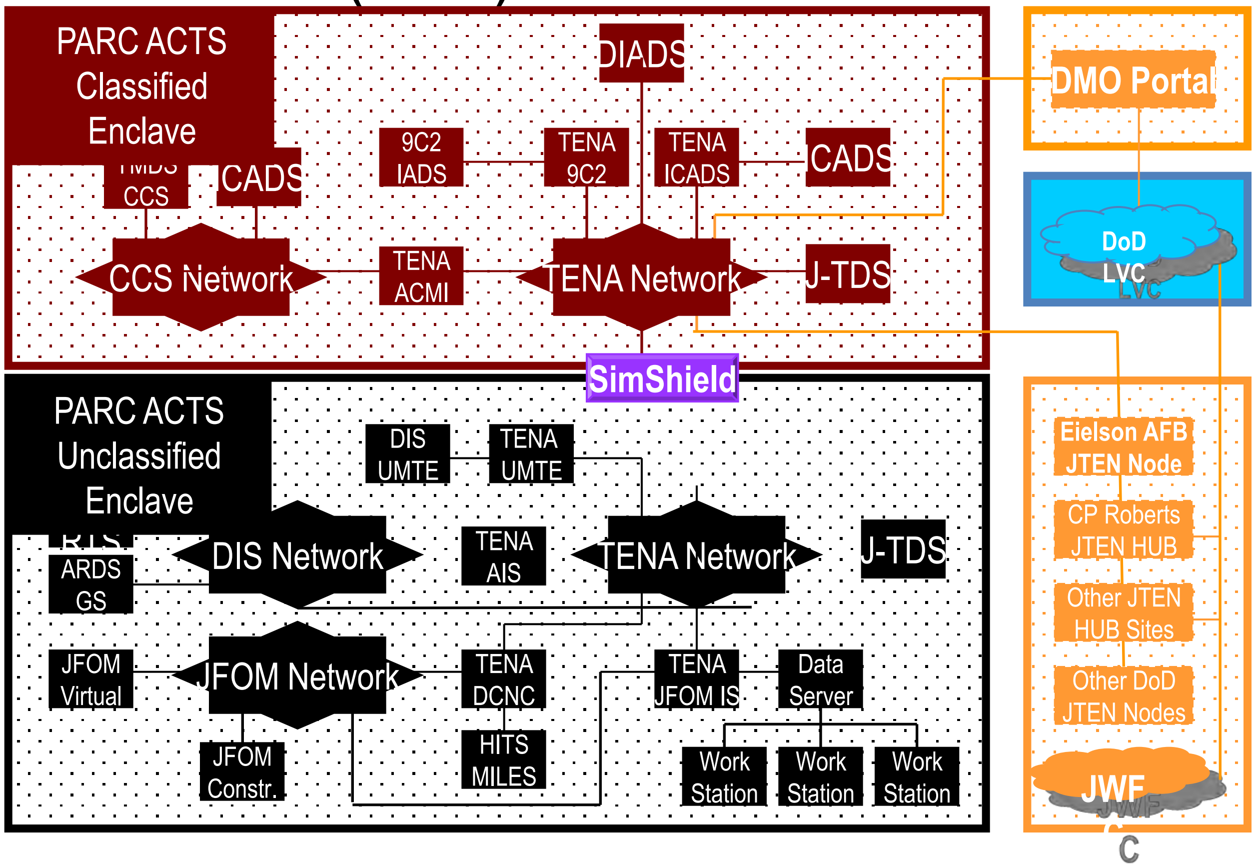


Alaska Training Range Evolution Program (ATREP) use of TENA

ATREP's intent is to enhance the existing Pacific Alaska Range Complex air and ground capabilities by providing a force-on-force (FOF) training capability that fully integrates and supports joint and coalition components for both air and ground training in live, virtual, and constructive (LVC) domains.

High Side
- TENA ICADS
- TENA ACMI
- TENA 9C2
- TENA DIADS
- TENA SimShield

Low Side
- TENA MOKKITS
- TENA MILES 2000
- TENA I-HITS
- TENA UMTE



Partial Listing of Recent Testing, Training, and Experiments Using TENA-Compliant Capabilities

- *Test Events*
  - SIAP JDEP Combined Hardware-in-the-Loop Phase 5, Jan-May 09
  - Digital Close Air Support – Integrated Model Test Event, Jan-Mar 09
  - Multi-Service System-of-Systems Test-bed, Jul 09
  - Strategic Integrated M&S Capability, May-Aug 09
  - Joint Electronic Warfare Assessment for Test and Evaluation, Sep 09
  - Tactical End-to-End Closed Loop Sim, Nov 09
  - Joint Distributed IRCM System Test Event, Mar 10
  - Joint Close Air Support Distributed Test, Jun 10
  - Battlefield Airborne Communications Node (BACN) Joint Urgent Operational Need (JUON), Aug 10
  - JIAMDO Air & Missile Defense Correlation / Decorrelation Interoperability Test (CDIT) CONUS, Sept 10
  - Unmanned Aircraft System (UAS) in National Air Space (NAS) Oct 09 and Oct 10
  - JITC Joint Interoperability Test (JIT) Sep-Nov 10
  - JIAMDO CDIT UK, Oct 10
  - Air-to-Ground Integrated Layer Exploration AGILE Fire III, Feb 11

- *Training Exercises*
  - Daily Training, Eielson AFB
  - Daily Training, Fallon AFB
  - Red Flag Alaska (RFA) 09-1, October 08, Pacific Alaska Range (PARC)
  - JDEWR Cope Tiger 09, Mar 09, PARC
  - RFA 09-2, April-May 09, PARC
  - Distant Frontier, May-June 09, PARC
  - Northern Edge 09, June 09, PARC
  - Talisman Sabre 09 - Australian Army and US Army, July 09, Shoalwater Bay, Queensland Australia
  - RFA 09-3, July-Aug 09, PARC
  - JDEWR Talisman Sabre 09, July 09, PARC
  - RFA 10-1, October 09
  - RFA 10-2, April 10
  - Northern Edge, June 10
  - RFA 10-3, Aug 10

- Experiments
  - Joint Surface Warfare JCTD, Feb 09 and Oct 10
  - Joint Expeditionary Force Experiment (JEFX) 09-1, 09-2, 09-3, Feb-Apr 09
  - JEFX 09-4 B-2 Test (Spirit ICE), Aug 09
  - JEFX 10-1, 10-2, 10-3, Jan-Apr 10

Distributed Events operated over the JMETC and JTEN Connectivity

JMETC: Here and Now

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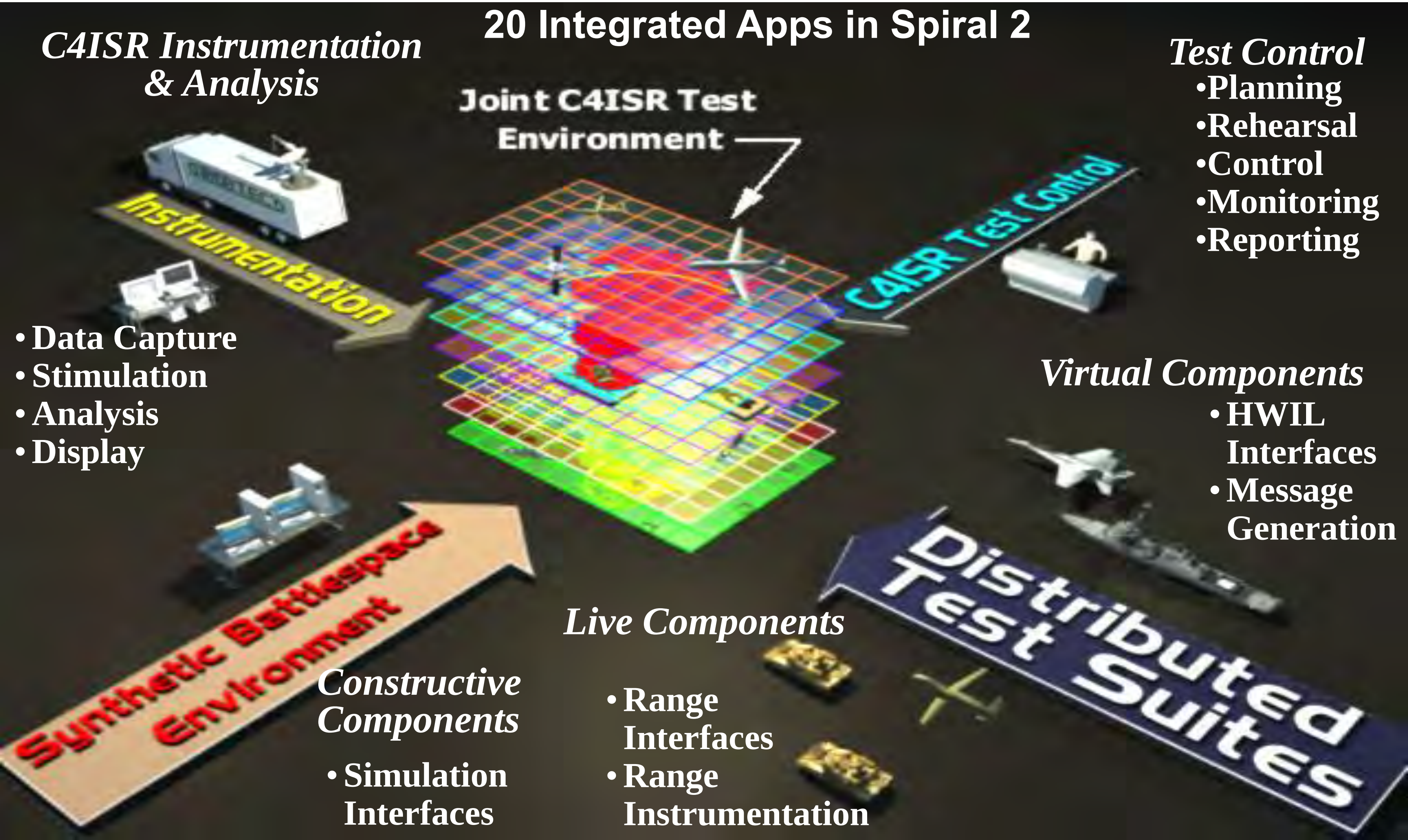
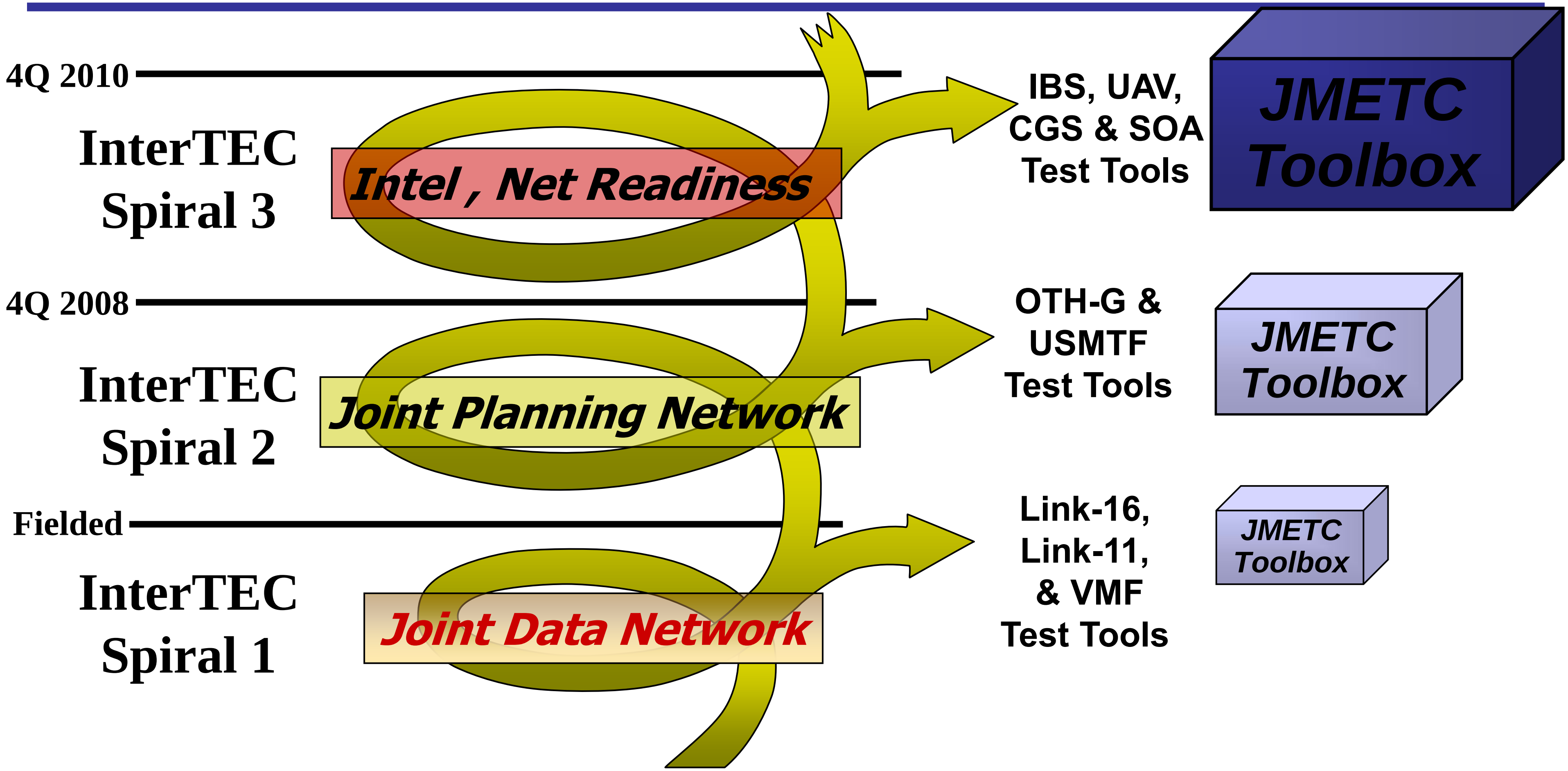
InterTEC Operational View-1

TENA-Based Integrated Test Tool Applications



InterTEC Integration with JMETC Inextricably Intertwined



- JMETC supports InterTEC during their spiral development
- InterTEC expands JMETC toolbox with certified C4ISR Test Tools

TENA Integrated Development Environment (TIDE)

- TIDE is a tool designed to assist developers in the creation, development, testing and deployment of TENA applications

- Initial Capabilities
  - Catalog installed object models on a user's machine
  - Migrate user applications between object model versions
  - Migrate user applications between middleware versions
  - Browse and download object models available in the TENA Repository
  - Request object model distributions from the TENA Repository

- TIDE 2.0 is the current version
  - Available at http://www.tena-sda.org/tide web site

TENA Tools used by JMETC Interface Verification Tool (IVT)

- Designed to support the integration testing of TENA applications
  - TENA Standard OM's
  - JNTC and InterTEC LROM's
- Provides real-time monitoring, logging and statistics gathering
- Operates in three different roles, either stand-alone or in combination:
  - Data Subscriber Role
  - Data Publisher Role
  - DIS to TENA Gateway Role
- Available at https://www.tena-sda.org/display/Tools/IVT

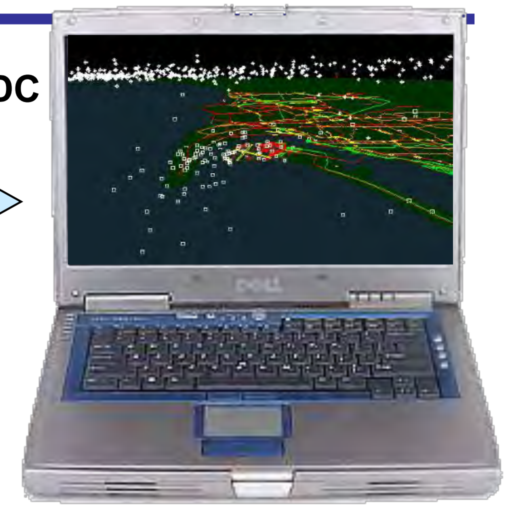
SIMDIS Use of TENA

SCORE TSPI Feed

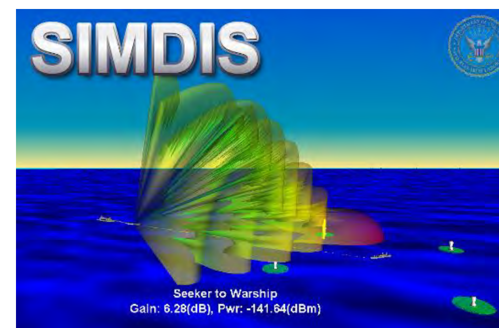
Southern California

TENA

NRL Washington, DC



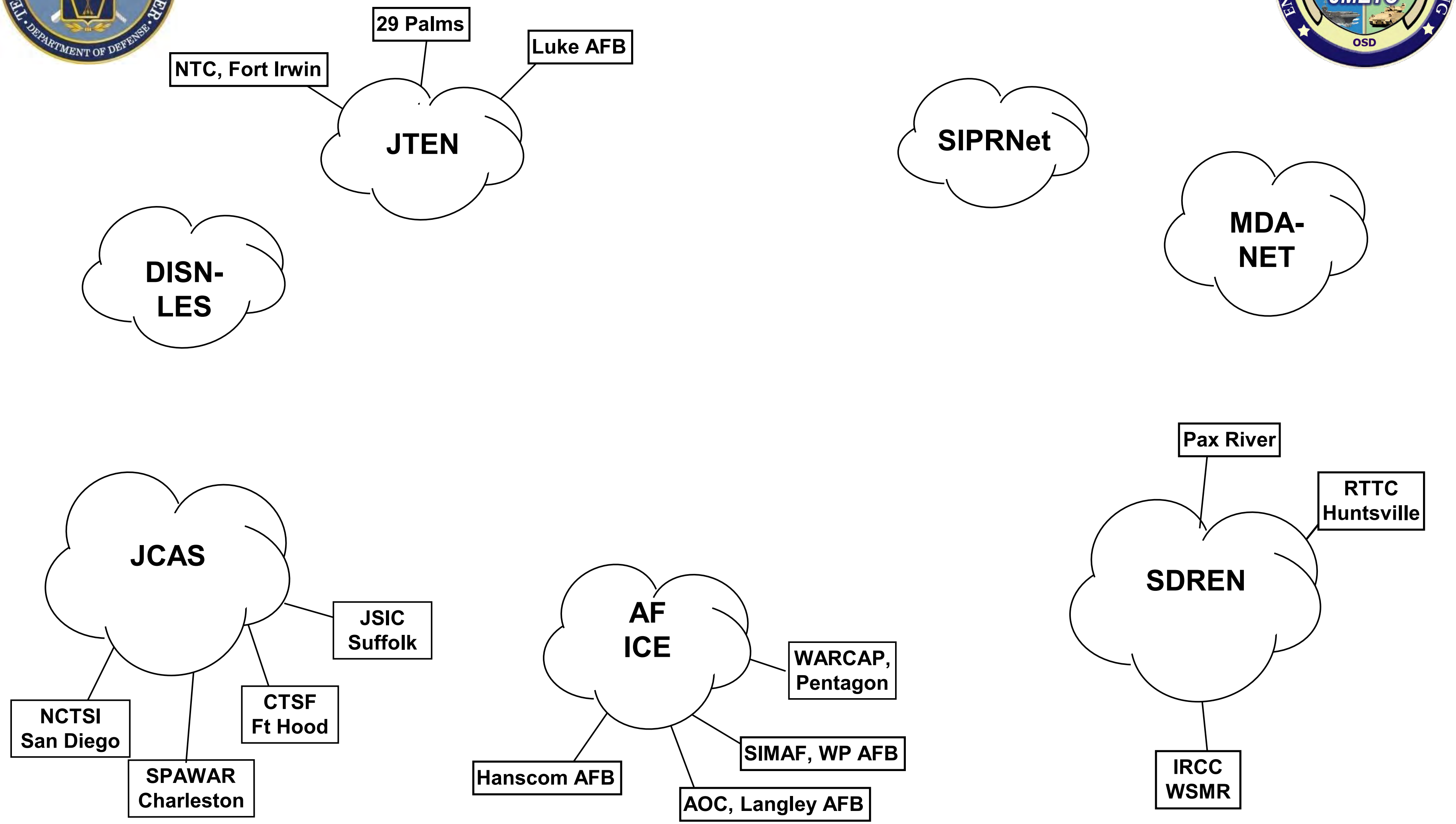
- **Duration testing using SCORE TSPI data feed**
  - Four consecutive days
    - Win XP, Red Hat 9, Solaris 5.8
    - Processed 180,000+ entities
  - Two consecutive days
    - Win XP, Red Hat 9
    - Processed 53,000+ entities
- **Results and observations**
  - No issues with discovery latency
  - No issues with update latency
  - No issues with CPU usage
  - No issues with memory usage



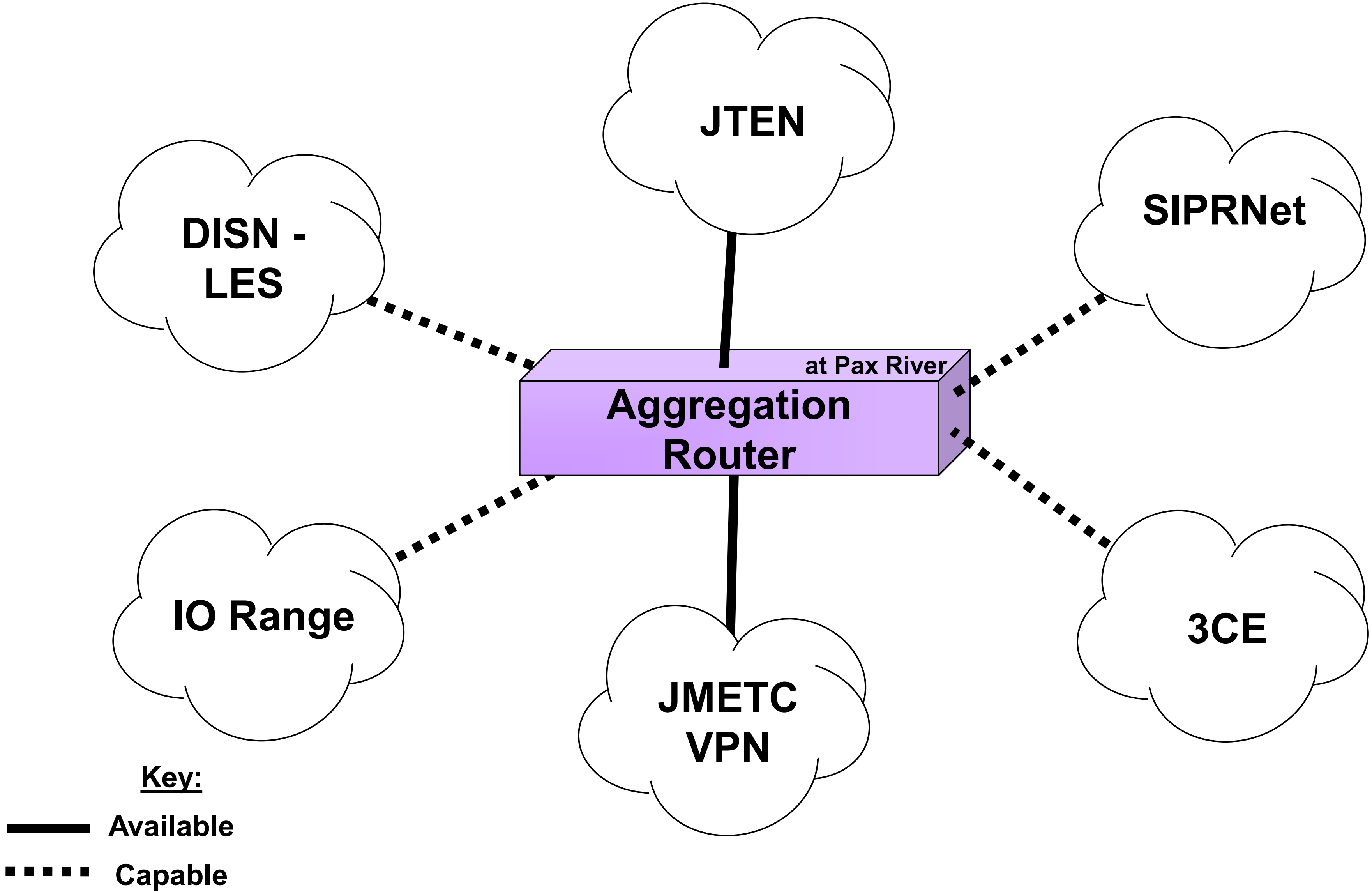
JMETC: Here and Now

- **Uses the Secure Defense Research & Engineering Network (SDREN) for connectivity**
  - 61 sites currently on-line
- **Uses Test & Training Enabling Architecture (TENA)**
  - Gateways to link to existing DIS and HLA simulations
- **Incorporates InterTEC test tools**
- **Uses the JNTC-sponsored Network Aggregator to link together other networks**
- **Being expanded based on customer requirements**
- **Holding JMETC Users Group meetings to discuss emerging requirements and technical solutions**
  - Seeking the “best of breed” solutions across the community

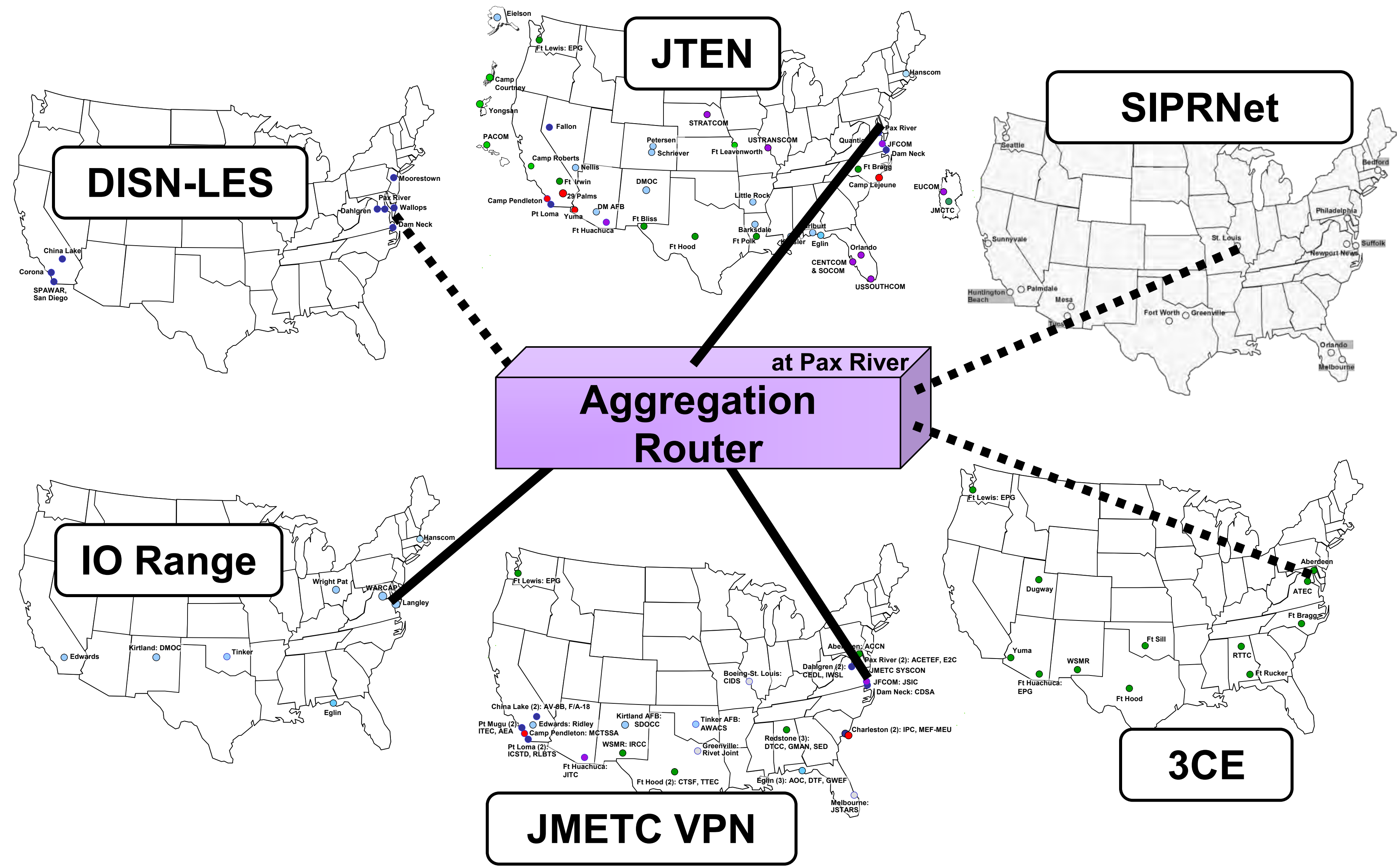
Traditional Network Dilemma



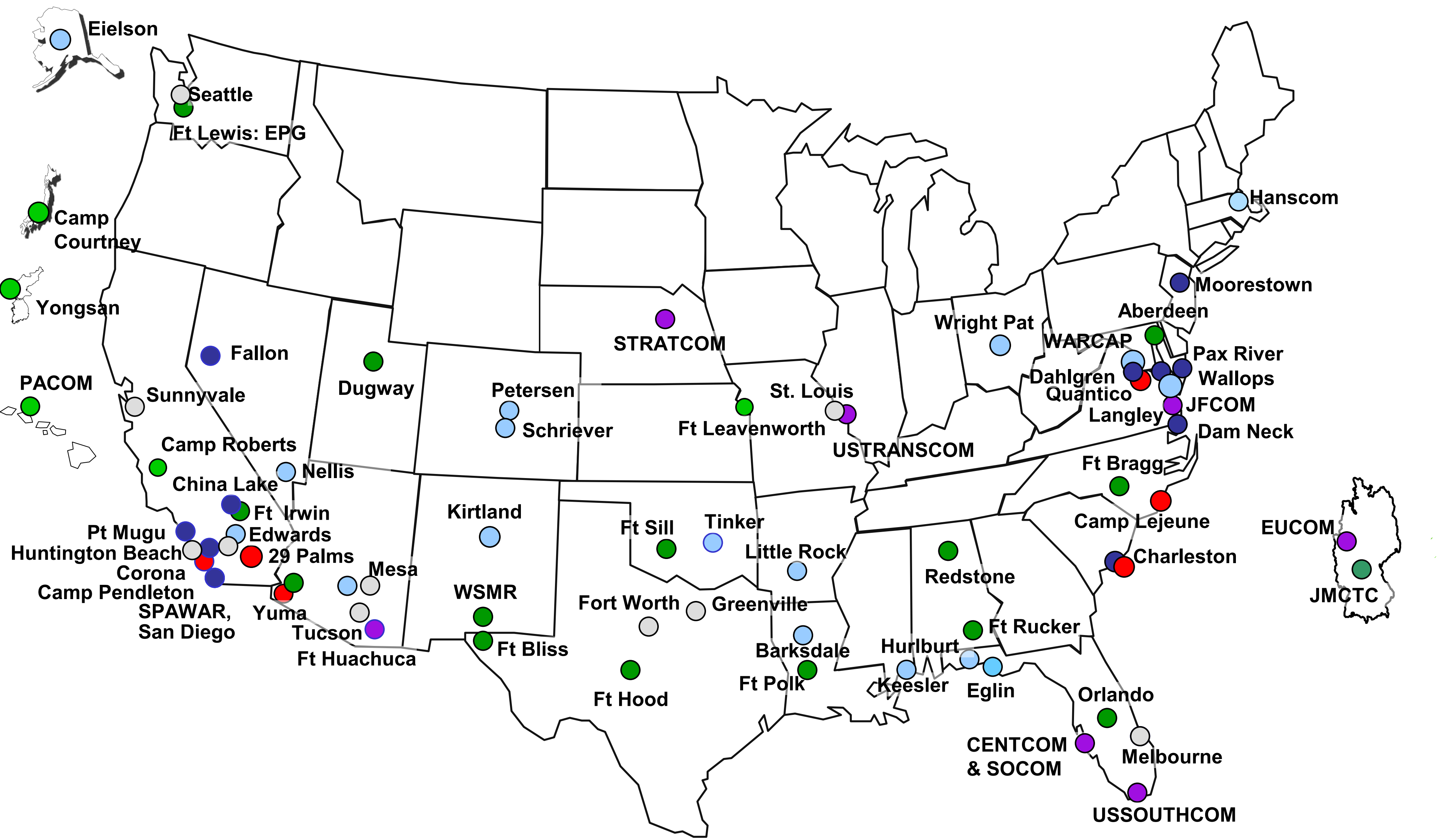
Network Aggregation Bridging Networks



Network Aggregation Bridging Networks



Available Sites from Integration of Test and Training Networks



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JMETC Users Group Meetings

- Identify core infrastructure requirements and use cases
- Identify, investigate, & resolve issues
- Identify opportunities to collaborate
- Discuss available solutions, tools, and techniques
- Share lessons learned

Next JMETC Users Group Meeting #13:

- Scheduled for 22-23 March
- Location: Norfolk, VA
- Potential Tracks:
  - User Requirements
  - Information Assurance / Security
  - Data Management
  - Networking

Users Group #01

Users Group #02

Users Group #03

Users Group #04

Users Group #05

Users Group #06

Users Group #07

Users Group #08

Users Group #09

Users Group #10

- 23-24 Feb 2010
- Orlando, FL
- ~300 participants
- Plenary session:
  - TRMC
  - Navy T&E
- Tracks:
  - User Requirements
  - IA / Security
  - Object Models
  - Networking
  - SOA

Architecture Management Team (TENA AMT)

- **AMT Members:**
  - 329 Armament Systems Group (329 ARSG)
  - Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD
  - Air Armament Center (AAC), Eglin AFB, FL
  - Air Force Flight Test Center (AFFTC), Edwards AFB, CA
  - Army Operational Test Command (OTC), Fort Hood, TX
  - Common Training Instrumentation Architecture (CTIA)
  - Dugway Proving Ground (DPG)
  - Electronic Proving Ground (EPG)
  - integrated Network Enhanced Telemetry (iNET)
  - Interoperability Test and Evaluation Capability (InterTEC)
  - Joint Fires Integration & Interoperability Team (JFIIT)
  - Joint National Training Capability (JNTC)
  - Naval Air Warfare Center – Aircraft Division
  - NAWC – Weapons Division
  - Naval Aviation Training Systems Program Office (PMA-205)
  - Naval Undersea Warfare Center (NUWC)
  - NAVSEA Warfare Center - Keyport
  - P5 Combat Training System (P5CTS)
  - Pacific Missile Range Facility (PMRF)
  - Redstone Technical Test Center (RTTC)
  - T&E/S&T Non-Intrusive Instrumentation
  - White Sands Missile Range (WSMR)

Meetings every 3 months

US Advising Members:
- **BMH Associates, Inc.**
- **Boeing**
- **Cubic Defense**
- **DRS**
- **Embedded Planet**
- **EMC**
- **Kenetics**
- **MAK Technologies**
- **NetAcquire**
- **Science Applications International Corporation (SAIC)**
- **Scientific Research Corporation (SRC)**
- **Scientific Solutions, Inc. (SSI)**

International Participation
- **Australia**
- **Denmark**
- **France**
- **Singapore**
- **Sweden**
- **United Kingdom**

- **Design Decisions / Trade-offs / Status / Technical Exchanges of Lessons Learned / Use Cases / Testing / Issues & Concerns Identification, Investigation & Resolution**

Summary

- JMETC supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads
  - CVN-21, JSF, MMA, NECC, DD1000, WWF, BAMS, JIAMDO
- TENA is the CTEIP architecture for future instrumentation, the JNTC architecture for Live integration and an enabling technology for JMETC
- TENA and JMETC:
  - Being built based on customer requirements
  - Partnering with Service activities and leveraging existing capabilities
  - Coordinating with JFCOM to bridge test and training capabilities
  - Provide a forum for users to develop and expand the architecture
    - JMETC User Groups, TENA AMT Meetings
    - Next Meeting is week of March 21 in Norfolk, VA

Important Contact Information

- **TENA Website:** **www.tena-sda.org**
  - Download TENA Middleware
- **JMETC Website:** **www.jmetc.org**

- **TENA Feedback:** **feedback@tena-sda.org**
  - Provide technical feedback on TENA Architecture or Middleware
- **JMETC Feedback:** **jmetc-feedback@jmetc.org**

- **TENA SDA Contact**
  - Telephone: (703) 601-5202
- **JMETC Program Office Contact**
  - Telephone: (703) 601-5280

Tri-Service Study 2011

27th Annual National Test and Evaluation Conference

Tampa, FL

15 March 2011

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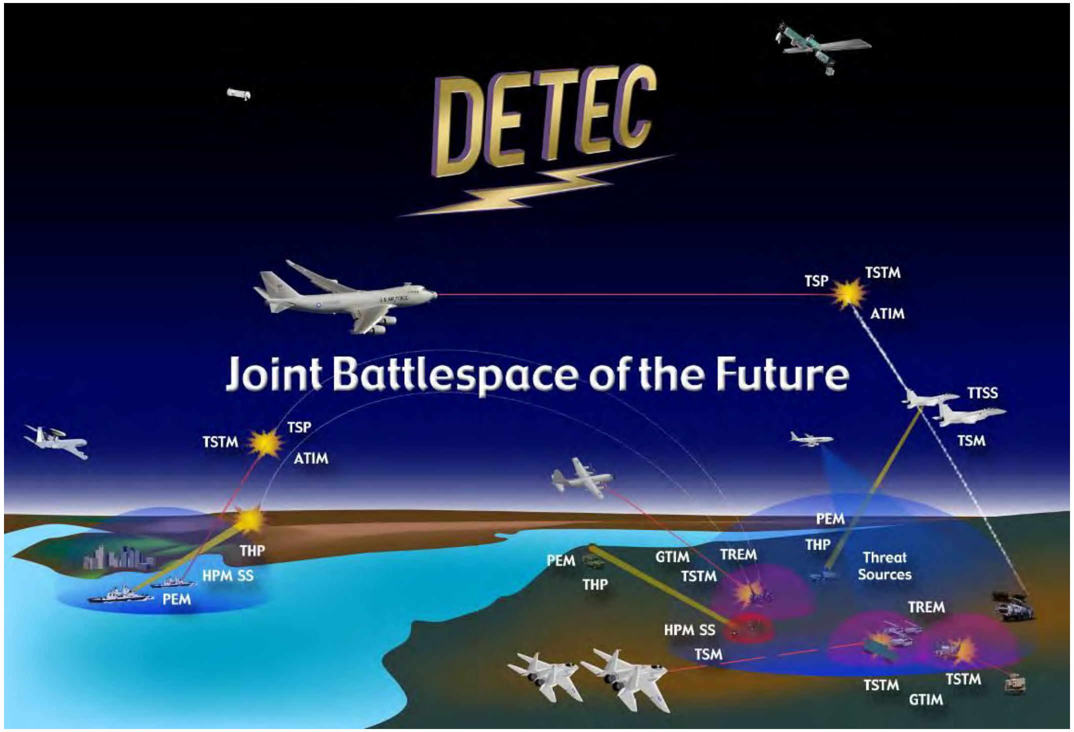
DETEC Project Director
(407) 384-5238 (DSN: 970)
Minh.Vuong@us.army.mil

Doug Weatherford
T-SS Lead, PEO STRI
(407) 384-5258
Doug.Weatherford@us.army.mil

DETEC Mission

DETEC is funded by the Central Test and Evaluation Investment Program

- Develop Joint T&E MRTFB infrastructure required for T&E of DEW systems
  - Instrumentation
  - Equipment
  - Software tools
- DEW systems supported
  - High energy laser (HEL)
  - High power microwave (HPM)
- Coordinate T&E needs with TRMC S&T efforts



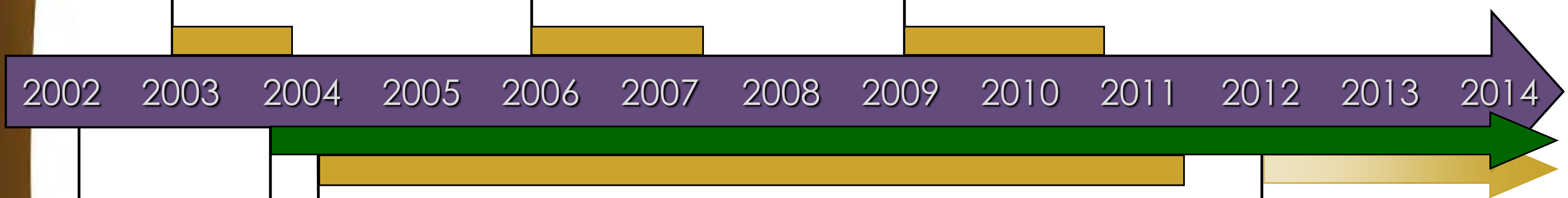
DETEC – Directed Energy Test and Evaluation Capability
MRTFB – Major Range and Test Facility Base
DEW – Directed Energy Weapon
TRMC – Test Resource Management Center
T&E – Test and Evaluation

DETEC History

T-SS Begins to identify and scope shortfalls in DE T&E infrastructure

T-SS Update (2007) Begins to capture current DE T&E infrastructure shortfalls for DETEC II, originally planned to start in 2010

T-SS 2011 Begins to capture most current DE T&E infrastructure shortfalls



DETEC Effort Proposed to CTEIP

DETEC Begins to resolve 12 high priority capabilities identified by the T-SS. DETEC is developing 16 systems (covering 40 shortfalls) to address these infrastructure shortfalls

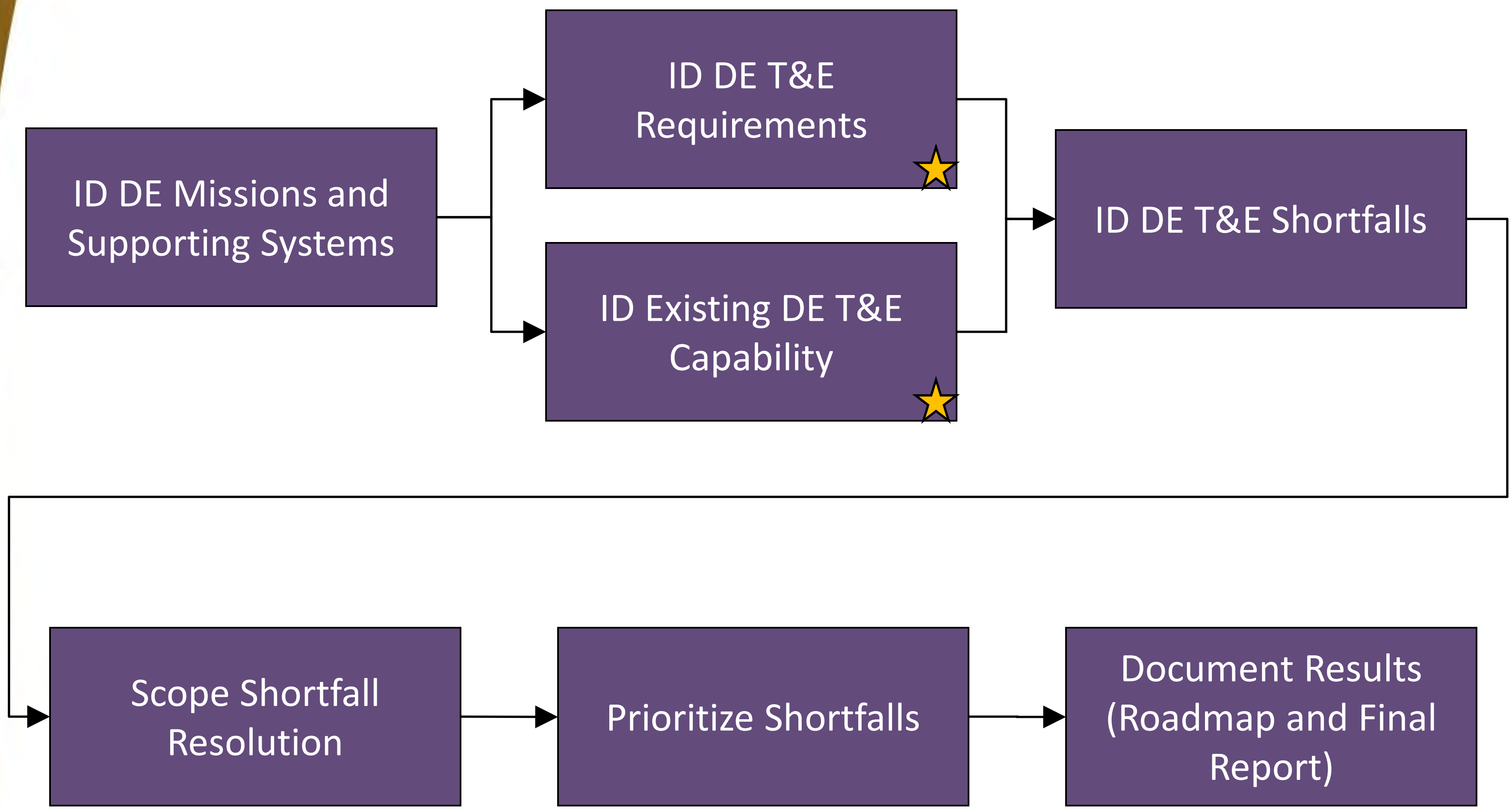
Projected Window to Begin to resolve the highest priority shortfalls identified by the T-SS 2011

DET S&T Begins to address high-risk, high-pay-off shortfalls identified by the T-SS. To date, DET S&T has delivered 20 systems

T-SS Overview

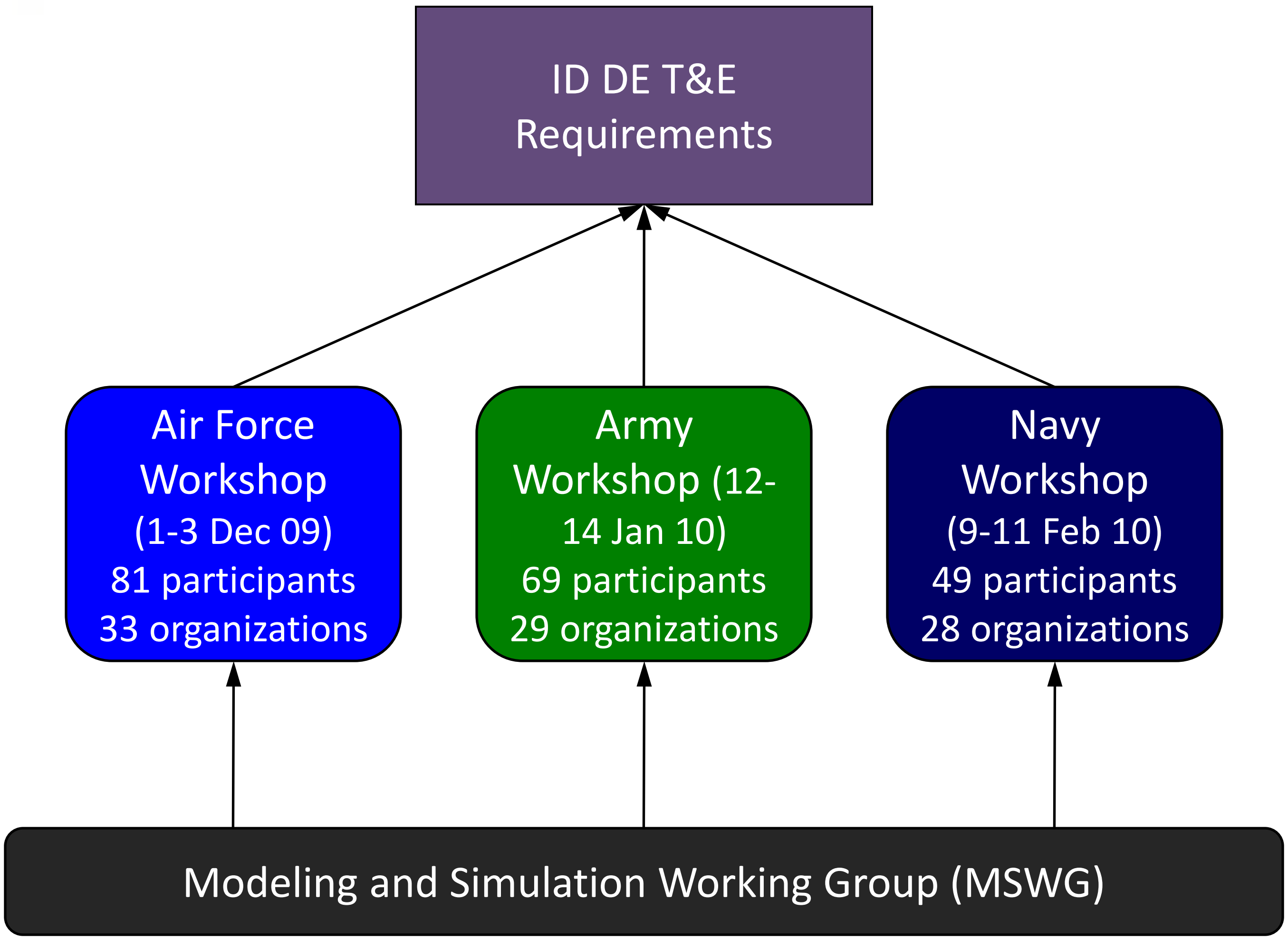
- Tri-Service Study
  - Objective: identify DE T&E infrastructure shortfalls emphasizing current changes to baseline
  - Goal: reduce DE weapons programs' need to pay for T&E infrastructure; prevent delays to programs awaiting T&E
- Scope
  - T&E infrastructure unique to DE testing
    - HEL and HPM domains
    - Impacts all test activities - modeling and simulation (M&S), developmental T&E (DT&E), operational T&E (OT&E), and live-fire T&E (LFT&E)
    - Across all phases of a test event (planning, rehearsal and execution, analysis)
    - Blue DEW vs. Red target and Red DEW vs. Blue target
  - Leverage existing MRTFB infrastructure

T-SS Process



★ Denotes Modeling and Simulation Working Group (MSWG) Participation

Service Workshops



Capability Call

ID Existing DE T&E Capability

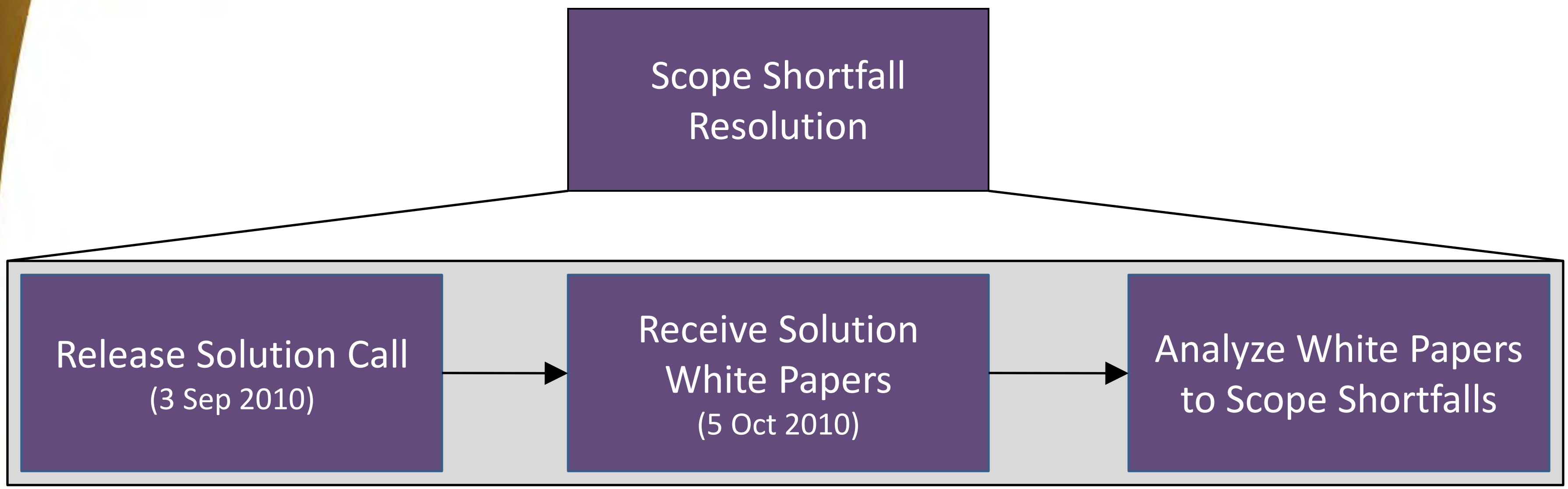
Release Capability Call Questionnaires
(6 Nov 2009)

Receive Completed Questionnaires
(18 Dec 2009)

Record Capabilities in Database

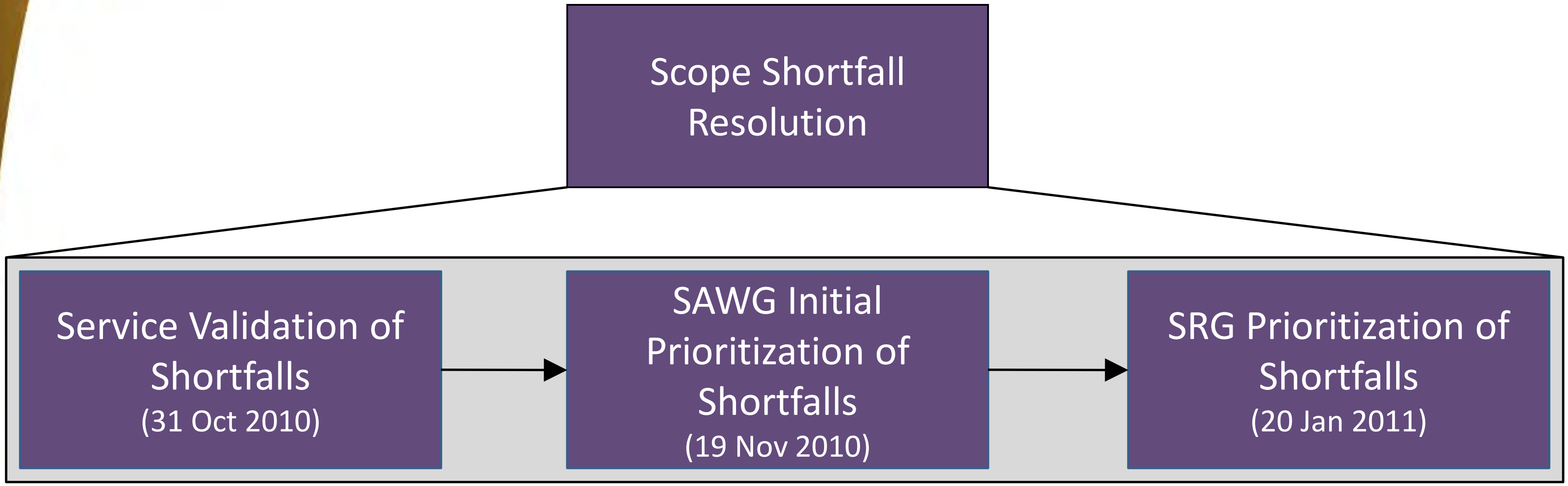
- Capability Call consists of four questionnaires to the DE community to assess what DE T&E capabilities currently exist
- Returned questionnaires were entered into the database for comparison with DE T&E requirements identified through Service Workshops
- Over 30 completed questionnaires received from 20+ organizations

Solution Call



- Solution Call requested a short white paper from the DE community
- Government, industry, and academia participated
- Responses help DETEC determine cost, schedule, and risk of T-SS 2011 identified shortfalls

SAWG and SRG Review



- Services met on 31 October to validate shortfalls Identified by the T-SS 2011
- Senior Analyst Working Group (SAWG) met on 19 November to establish initial priority of shortfalls
- Senior Review Group (SRG) composed of an SES from each service and a representative from the Electronic Combat (EC) Reliance Panel met on 20 January to finalize the T-SS 2011 shortfall priority

T-SS 2011 Results

#	Domain	Capability Shortfall
1	HPM	Non-intrusive E-field and B-field probes
2	HPM	X-band surrogate narrowband threat source
3	HEL	CW irradiance measurement on surface moving target board, towed airborne target board, and actual target
4	HPM	C-band surrogate narrowband threat source
5	HPM	Multiple node wireless data acquisition system
6	HEL	Imagery of airborne targets
7	HEL	Front target surface temperature
8	HEL	Dynamic hazard analysis tool (M&S)
9	HEL	Predictive avoidance and airspace deconfliction tools (M&S)
10	HPM	Beam propagation in and near surfaces (M&S)
11	HPM	THP/Builder integration (M&S)

Conclusion

- T-SS 2011 identified 11 high priority capability shortfalls
- In process of documenting final results and delivering to the Test Resource Management Center (TRMC)
- Collecting Service endorsements of the T-SS 2011 results

Holographic radar brings a new dimension to sensing and instrumentation on T&E ranges

Collision avoidance, wind farms and scoring

NDIA test and evaluation conference

Gary Kemp

2 March 2011

S4923-P-069 v0.2

A world leader in technology and product development

- Established in 1960
- 300 engineers and scientists based in Cambridge UK and Cambridge MA.
- We serve a wide range of industries – defence, wireless, transport, consumer, industrial, medtech
- We design, develop and manufacture innovative products, processes and systems using multi-skilled teams
- We have a long track record of technology based spin-out companies
- We manufacture and supply specialist radar systems

50 YEARS OF INNOVATION

THE QUEEN'S AWARDS FOR ENTERPRISE 2009

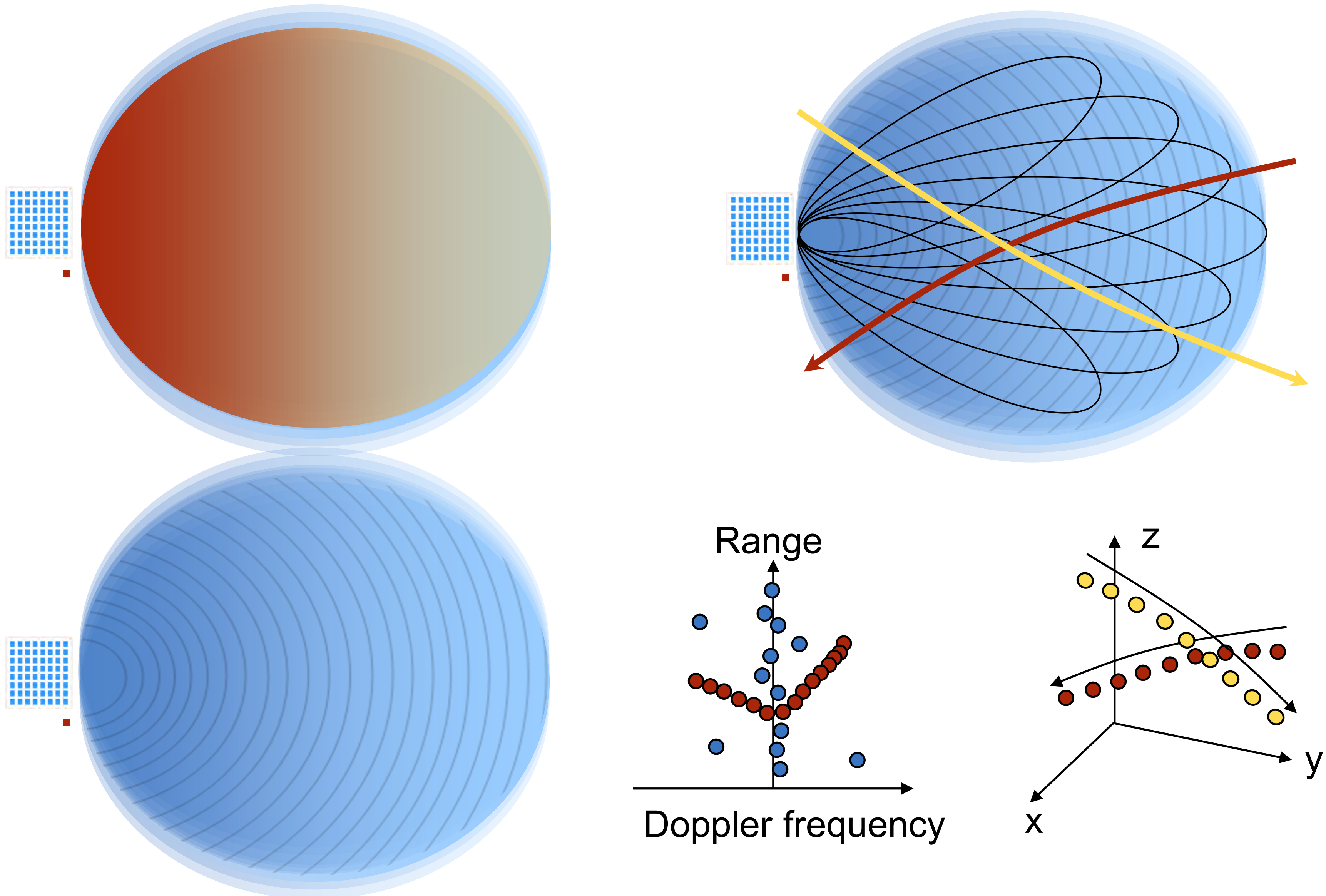
1	Short introduction to Cambridge Consultants
2	What is holographic radar?
3	Applications of holographic radar
4	Questions

Holographic radar implements Skolnik's vision of Ubiquitous Radar

- Holographic Radar looks continuously at a whole volume of space (rather than scanning).
- It acquires fully sampled amplitude and phase information from every object within the volume.
- It provides range, azimuth, elevation and Doppler information for every detected object.
- Tracking algorithms discriminate moving targets and clutter.
- Clutter is removed without loss of sensitivity.

- Practical holographic radar is possible in the modern day due to the availability of high-power processor devices at reasonable cost.

Holographic radar



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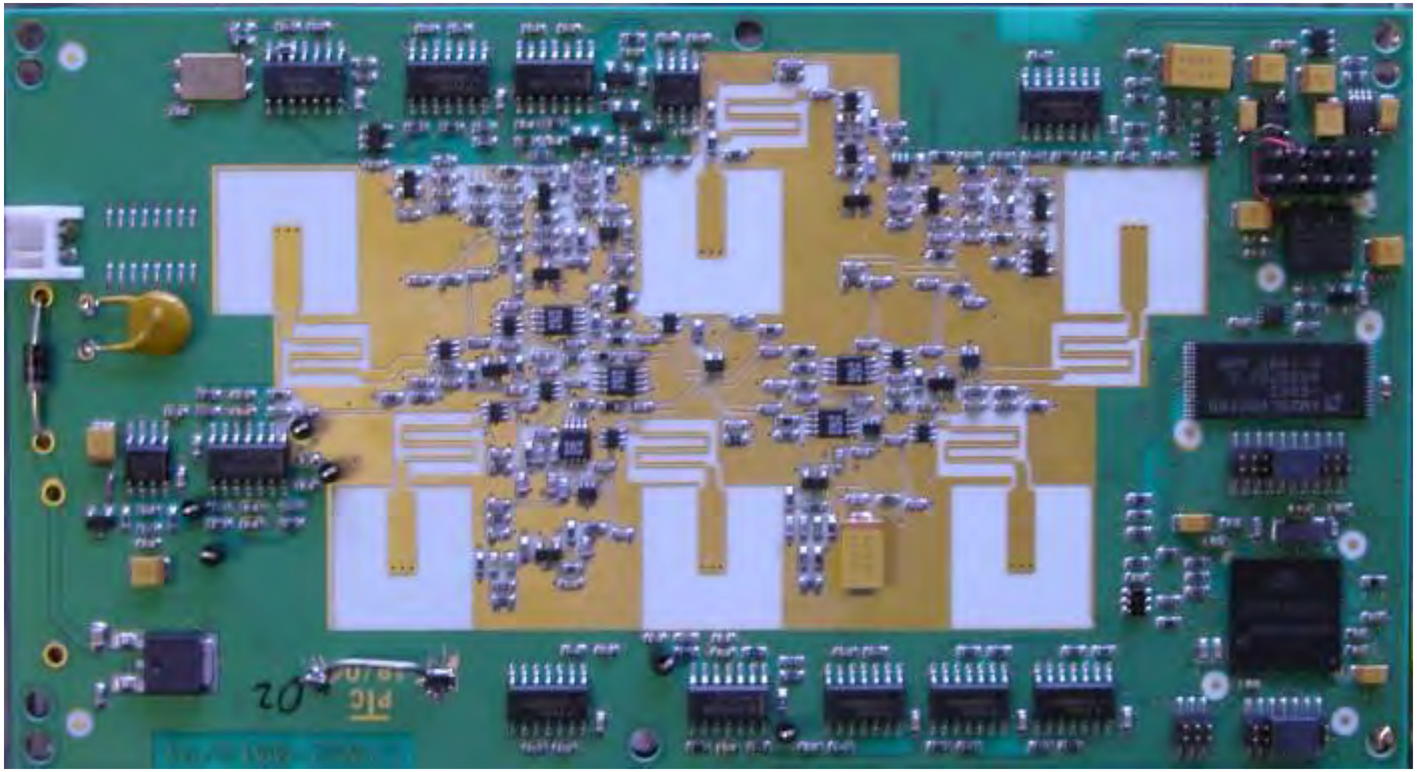
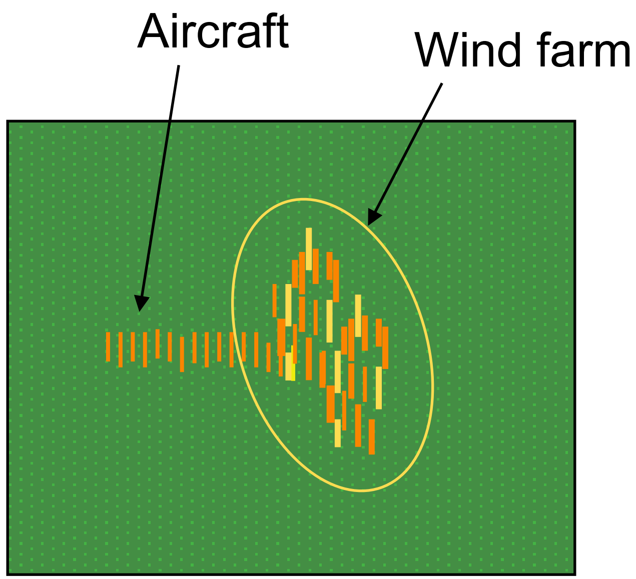


5-channel array for automotive pre-crash sensing – a minimum holographic array

Collision warning radar

Many wind farm planning applications are stalled

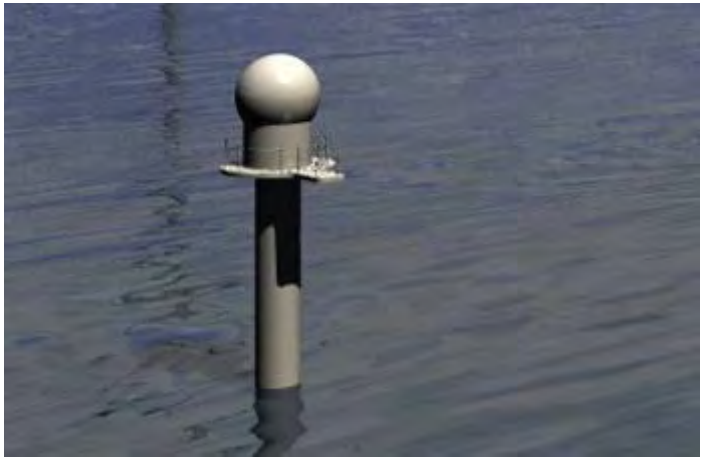


Absence of vertical discrimination combined with scan aliasing makes it impossible for a PSR to separate the track from the clutter.

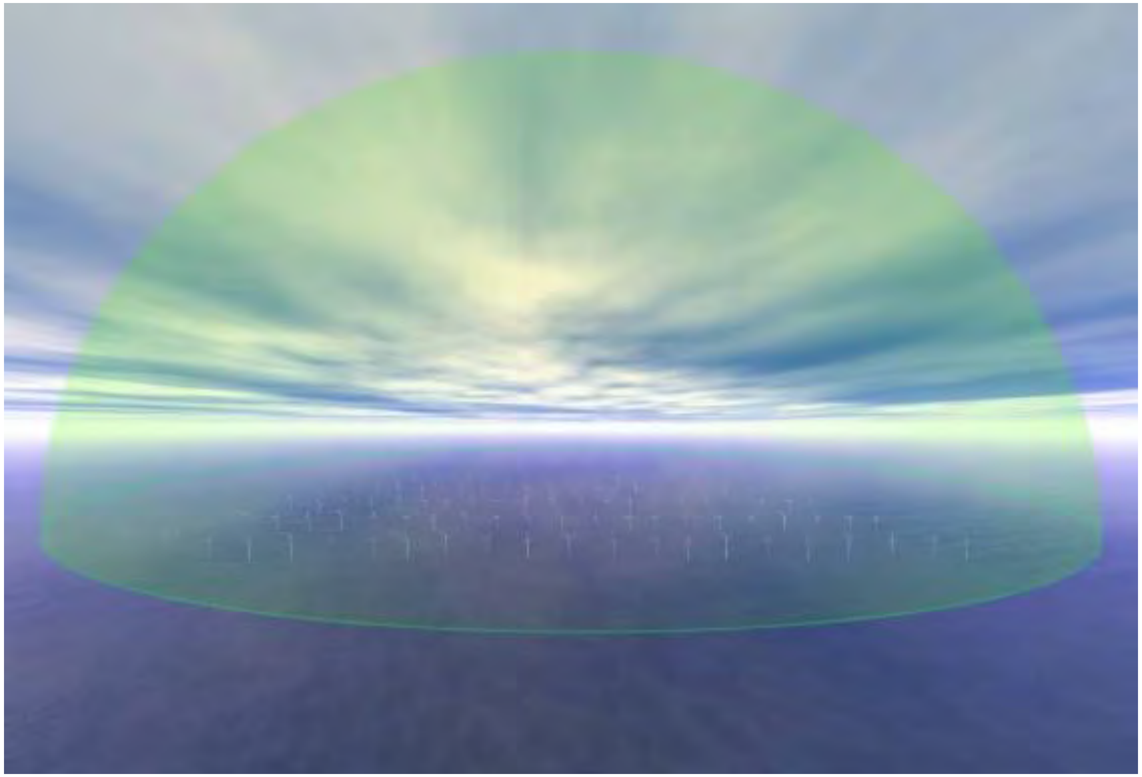
Holographic radar provides the solution.

CH-InFill is a holographic radar located at or near a wind farm to generate local, high-resolution, 3D infill data

- The sensor is located in or near the wind farm
- It sees through and around the turbines without disruption
- Nothing else has been shown to do this



- Range up to 13km / 43,000ft
- Reporting rate 3-10Hz



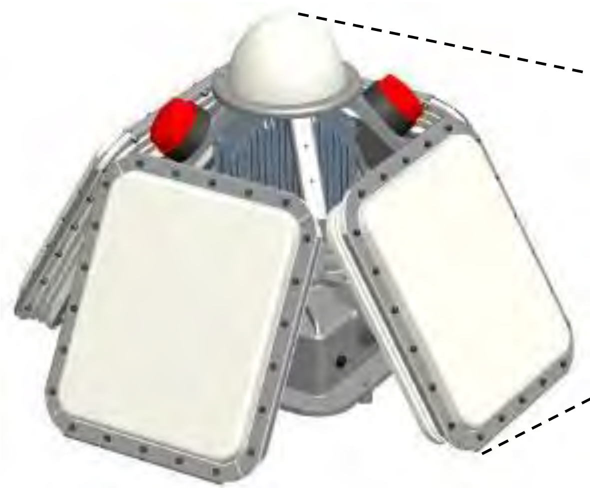
Wind farm infill radar - testing

66m diameter wind turbine

Remote-controlled helicopter with 2.2m^2 radar reflector

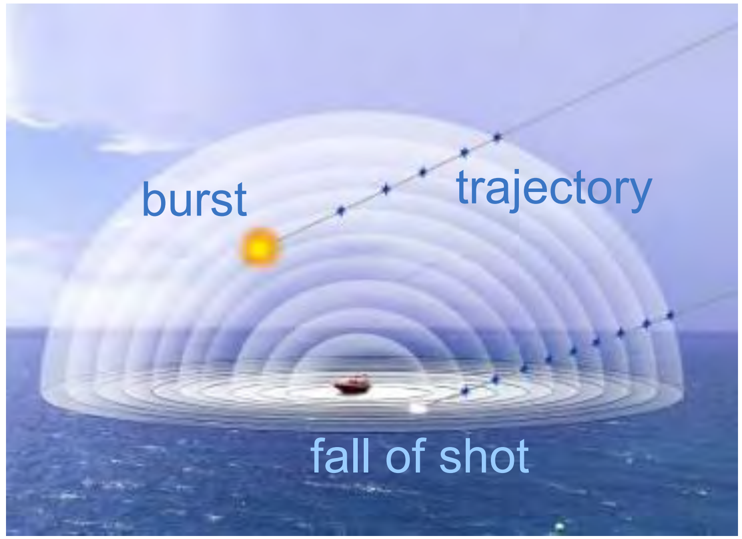
Land and Surface Target Scorer (LSTS) system – in development

- The Land and Surface Target Scorer is a real-time vector scoring system for highly mobile targets operating in very cluttered environments.
- LSTS application of the CH radar is funded by the OSD Target Management Initiative program, sponsored and managed by NAWC-WD, Point Mugu, Target Systems Division, 5.3.1



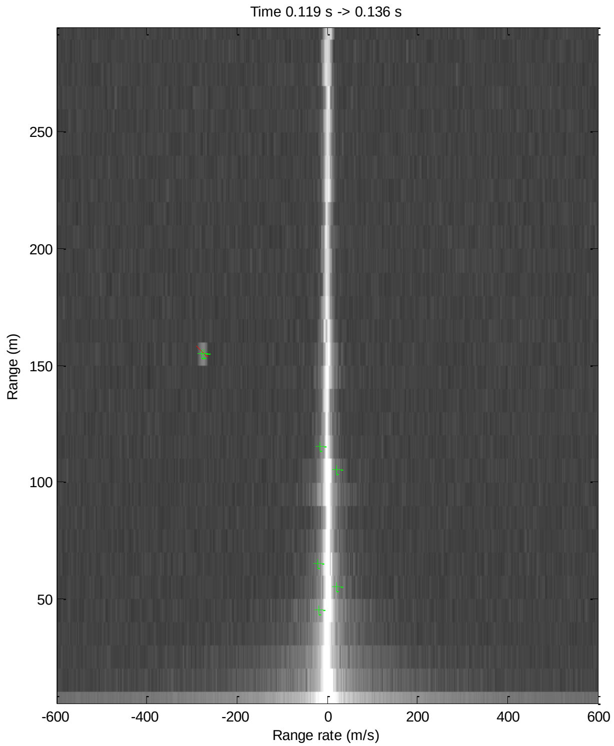
LSTS sensor head

HSMST



1000ft scoring volume

Two views of how LSTS will perform:



Migration process rejects clutter

Accuracy and throughput

Range (5" Shell)	50ft - 1000ft
Firing rate	Up to 20 rounds / minute
Along-track position accuracy	13ft / 5% at longer range
Target speed	Up to 46kts (at SS3) Up to 100mph (land)
Sea state	Up to sea state 3
Trajectory reporting	Within 3 seconds of projectile arrival

Performance measured to date:

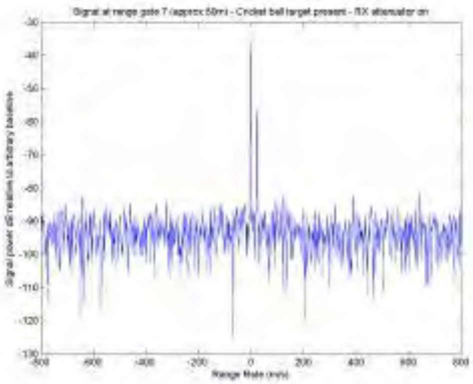
Cricket ball

RCS $0.004m^2$

Radar head

Cricket bowling machine – 100mph

Performance measured to date:

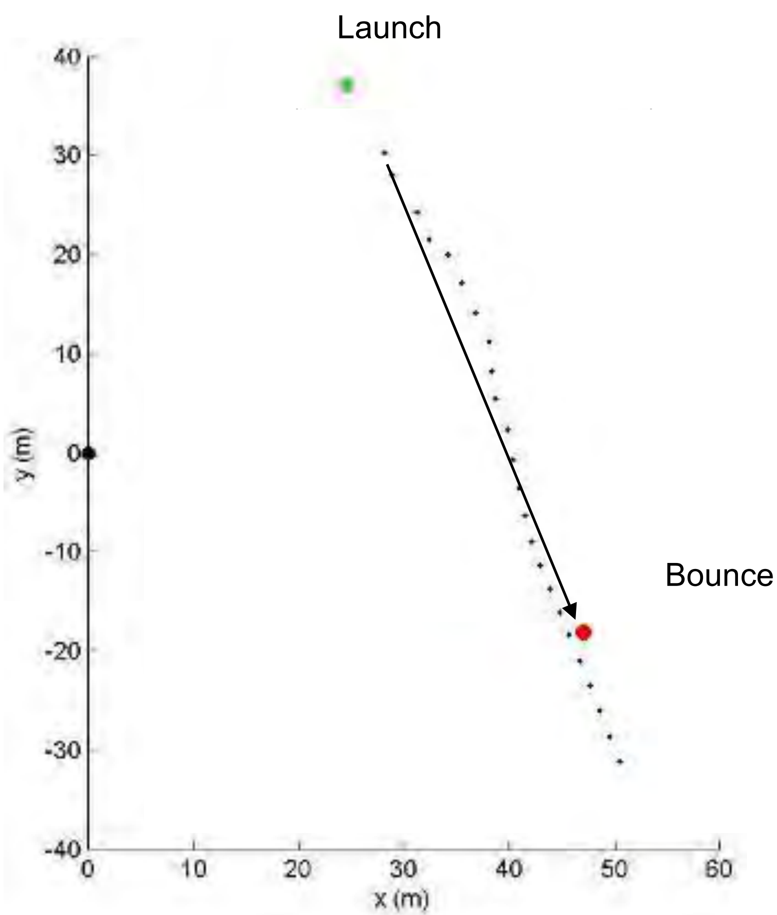


SNR at 80m 35dB (25W Tx)

Proof of concept trajectory processing takes 15 minutes

Beta Prototype trajectory output will be continuous and real-time

Detection, tracking and best-fit 3D trajectory



LSTS program

Proof of Concept Phase (system design and single face build)

- Start date: Jan 2010 ✓
- System Requirements Review: April 2010 ✓
- Preliminary Design Review: June 2010 ✓
- Critical Design Review: September 2010 ✓
- Test Readiness review: February 2011 ✓
- Proof of Concept System trials with 5” shell: March 2011 (in progress)

Beta-prototype phase (complete system build and test)

- Start date: April 2011
- Trials with 50 cal rounds: June 2011
- Sea trials on HSMST: December 2011

Holographic radar is the best you can do in very cluttered environments

- **Target and clutter separation**
  - Continuously gather signals from a large volume of space
  - Fully sampled amplitude and phase data from every target
  - Separate targets of interest from clutter through tracking processes
- **Applications** in collision avoidance, PSR infill, scoring, through-wall, asset protection, border monitoring, other…
- **LSTS system** under development
  - 5” and 50 cal projectiles
  - Land and sea surface targets
  - Proof of Concept sea trials underway

Contact details:

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Science Park, Milton Road
Cambridge, CB4 0DW
England

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Fax: +44(0)1223 423373

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Affordable Test & Evaluation in a Complex World

27th Annual National Test & Evaluation Conference

"Test & Evaluation: Serving the Warfighter"

March 2011

Thomas (Tom) L Wissink
Lockheed Martin Senior Fellow
tom.wissink@lmco.com
301-240-6244
Abstract Number: 11649

Agenda

- Increasing System / Software Complexity
- Increasing T&E Costs or more Delivered Defects
- What can T&E do to be more Affordable

Increasing System / Software Complexity

- The environment of systems is ever an increasing complexity with more and more software
  - One engine manufacturer predicts that the cars and trucks of 2020 will have over a billion lines of code

- It appears that every new weapon system has more and more software

- Testing this much software is impossible with current methods

Increasing System / Software Complexity

Some Background

Last years NDIA T&E Conference presentation titled “Closing the T&E Gap…”

– “The funding and research for testing & evaluating new technologies is not keeping pace with the rate of technology change”

The Exponential Times We Live In

Current Rates

- **New technology information doubles every 2 years.**
- **Adoption of technology is accelerating**
  - To Reach 50 million users
    - *Radio 38 years*
    - *TV 13 years*
    - *Internet 4 years*
    - *IPOD 3 years*
    - *Face Book 2 years*

Predictions

- **By 2013, a super computer exceeds capability of human brain**
- **By 2049 $1000 computer exceeds the capability of the entire human species.**

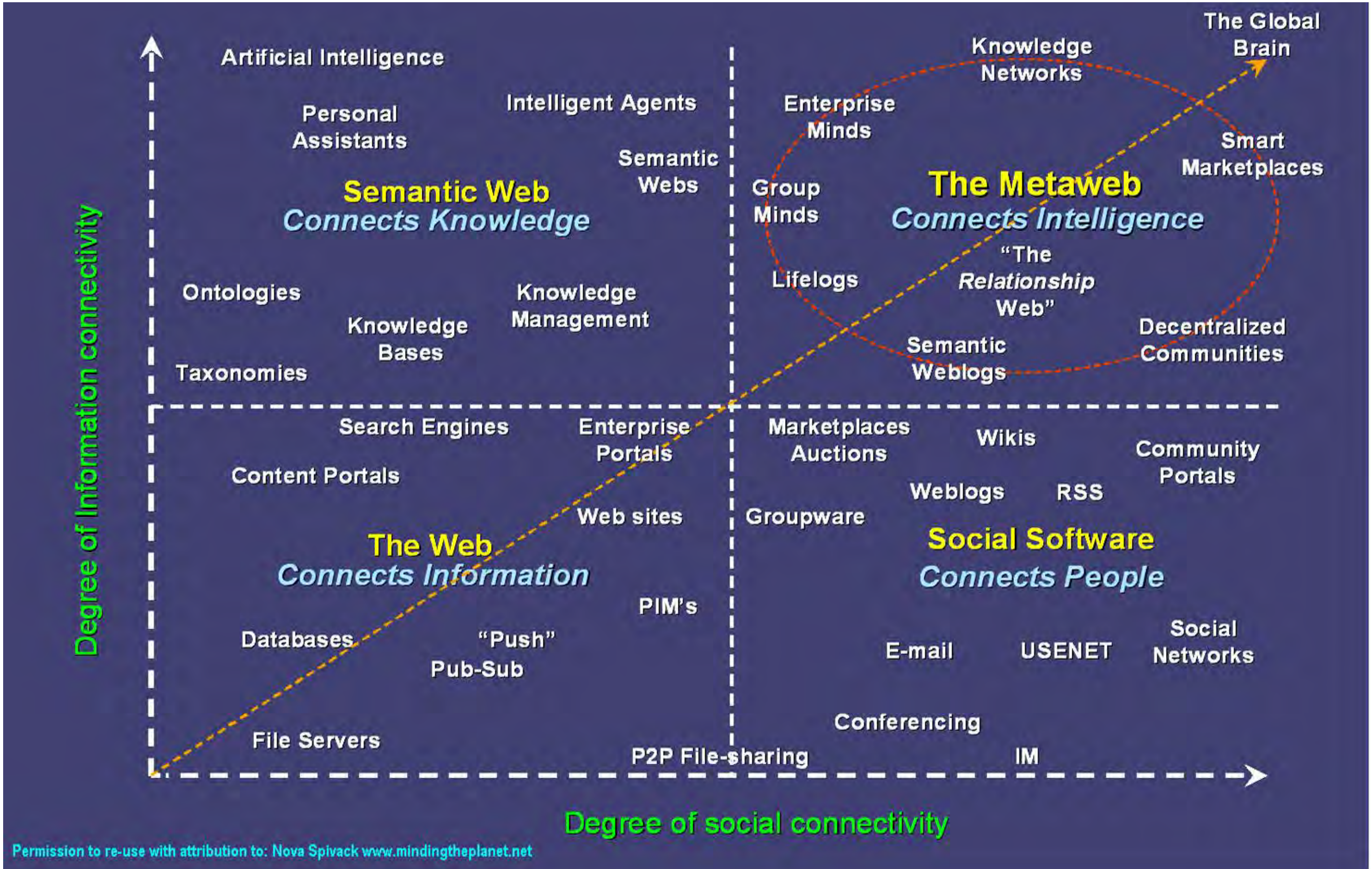
This data is from the "Did You Know" series

Compute Power and Bandwidth Increasing

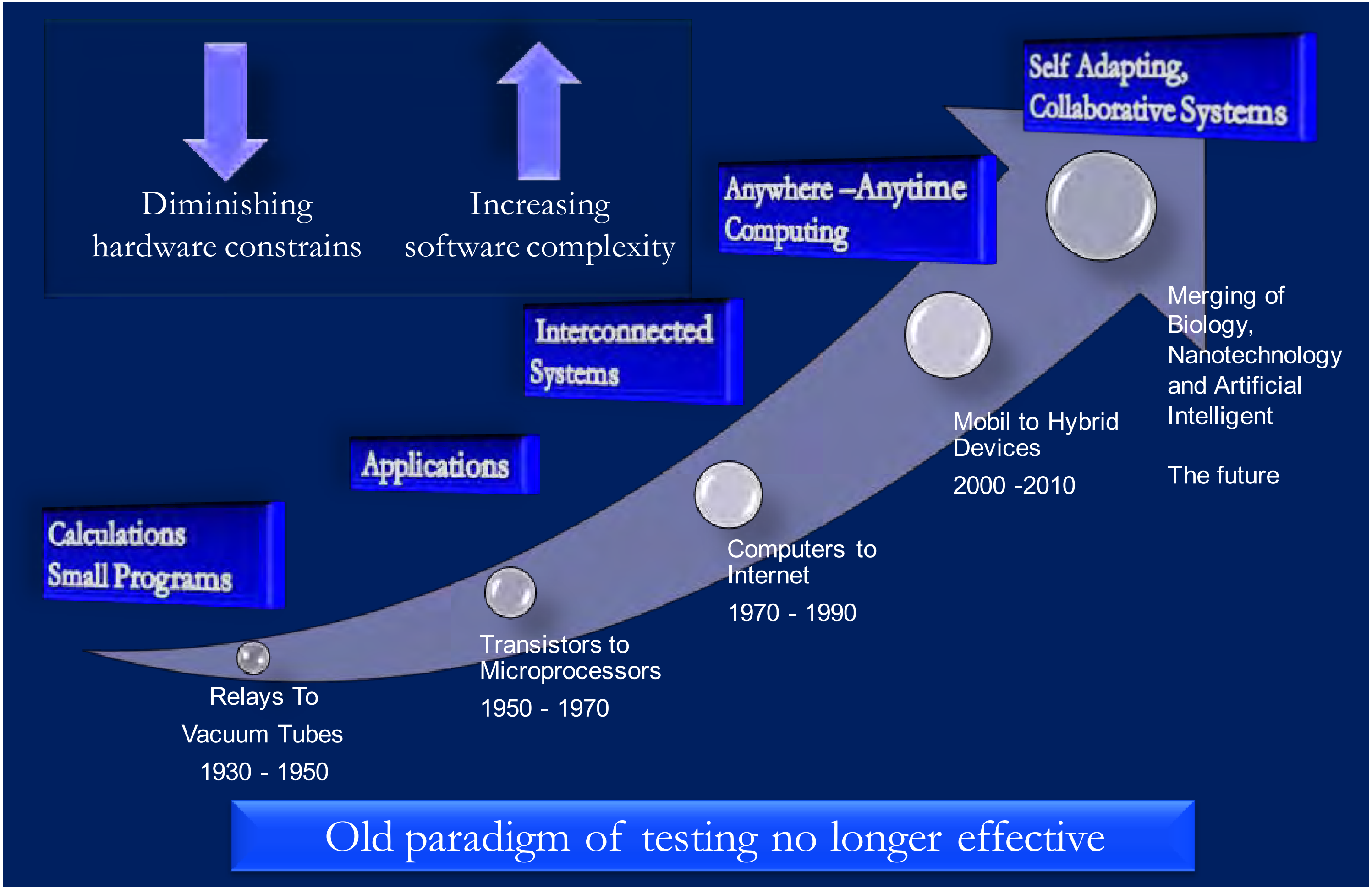
Compute capacity continues to grow

Hardware limitations no longer constrains the software

Where is Connectedness Headed?



Diminishing Constraints



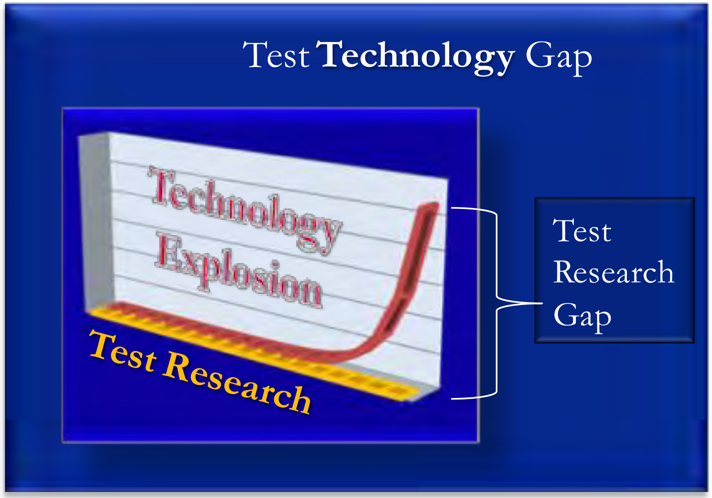
Increasing T&E costs or more delivered Defects

- The cost of T&E for these very complex systems is increasing significantly when there is a real attempt to detect defects before delivery

- My observation is that the following is occurring:
  - Some test automation is attempted with marginal success
  - Test times are not generally being increased so less test coverage of functionality is actually occurring
  - Results: more (complex) defects are being delivered

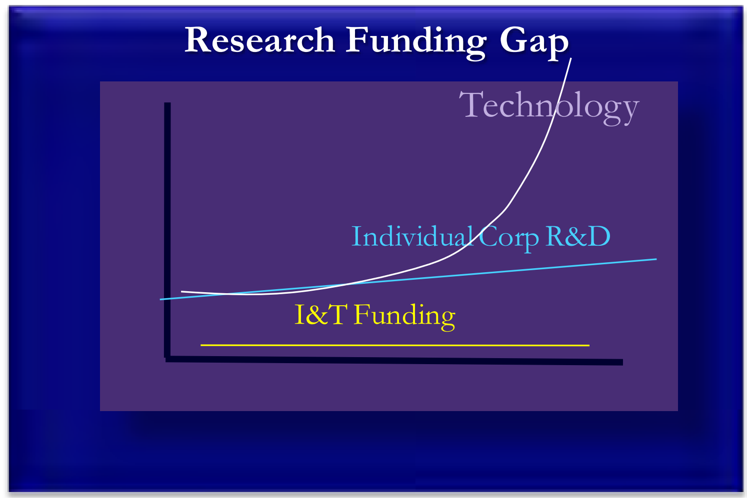
- Constant pressure to reduce T&E cost & schedule

Test Technology & Research Funding Gaps



What about the Technology Readiness Level Process?

What about T&E S&T and Corporate IRAD projects?



Bottom Line: T&E is not able to keep up with Technology

A Question

- Is all this complexity necessary?
  - Absolutely, it makes the Warfighters more effective, efficient and safer
- So what can we do as Test and Evaluation engineers?

T&E must become more Effective and Affordable

- Need more T&E Research in Government, Industry and Academia
  - Ensure Research is coordinated whenever possible (i.e. between Services, initiated / coordinated by Government, etc)
- Review the Technical Readiness Level processes to see if possible to add official T&E deliverables with TRL's at specific levels, especially in the range of TRL 4 & 5.

T&E must become more Effective and Affordable

- Much more automation should be in use today
  - Training and investment must be done and this will have a big return on investment

- Ensure the use of Scientific (or Analytical) Test Design methods and tools

- Ensure T&E is actively involved with the research and related activities in the Model-Based Development/Engineering arena

Q & A

Thomas L Wissinks Biography

Tom Wissink is the Lockheed Martin Corporate Engineering & Technology Director of Integration, Test & Evaluation and a Corporate Senior Fellow. He has worked in system/software integration and test, software development, configuration management, and several levels of management for more than 35 years, 30 of them with Lockheed Martin. He has worked on programs like the Space Shuttle and several Satellite Command and Control systems including the Global Positioning System and the Hubble Telescope Project. Tom has also been a teacher and mentor primarily in the area of integration and test.

Tom is also a corporate member of the National Defense Industrial Association (NDIA) co-chairing the DT&E Committee. He has been a presenter at the Aerospace Testing Seminar (ATS) and is a member of the ATS Advisory Board. He has also been a speaker at the NDIA SE Division Conference as well as a Keynote Speaker at STAREAST and at STARWESTs Leadership Session.

Tom grew up in Florida developing a desire to work in engineering watching the Space program. He has a Bachelors degree in Computer Science from Florida Atlantic University. Tom has been married for 37 years, has three boys and three grand kids.

Developing a Testable Reliability Requirement for F-15E Radar Modernization Program (RMP) IOT&E

1st Lt Andrew J. Passey

AFOTEC Detachment 6

(702) 404-4120

andrew.passey@nellis.af.mil

Release Date: 15 Mar 11

Overview

- Testable Requirements
- Why Reliability Growth?
- Reliability Growth Models
- PM2 – Assumptions
- PM2 – Parameters
- PM2 – Under the Hood
- F-15E Radar Modernization Program (RMP) Example
- Conclusions

Testable Requirements

- Testable requirements must be
  - Realistic
  - Measurable
  - Possible to evaluate
- Sometimes requirements are stated as a future need
  - We can’t evaluate to a point in the future
  - The decision authority must decide now if the system should be acquired
- AFI 10-601
  - “If the production threshold value is planned to be achieved following completion of IOT&E, include a testable value to be achieved/demonstrated for evaluation during the IOT&E.”

Why Reliability Growth?

- Reliability is the ability of a system to perform required functions for a specified period of time
  - Ex: mean time between critical failures (MTBCF) for RMP
- Reliability growth is an increase in system reliability as a result of corrective actions
- Time between IOT&E and when the system must demonstrate reliability allows for growth
- Reliability growth plans improve:
  - Investment decisions
  - Operations and maintenance posturing
  - Assessment of progress over time

Reliability Growth Models

- Duane Model – 1964
  - Logarithmic growth
  - Formalized "test, analyze, and fix" process
- Crow-AMSAA Model – 1974
  - Failures as a stochastic process
  - Allows for statistical evaluation of growth
- MIL-HDBK-189 – 1981
  - DoD-specific guidelines for planning
  - Yardsticks for assessing growth
- Planning Model based on Projection Methodology – 2006
  - Introduces parameters based on programmatics
  - Combines programmatics and statistics

PM2 - Assumptions

- The number of failure modes present in the system at the beginning of the time period is inherently unknown
- Individual failure mode occurrences are independent of all other failure mode occurrences
- System usage and environment can be predicted throughout the reliability growth cycle
- Failures follow a nonhomogenous Poisson process
  - For a defined period of time, a certain number of failures are expected
  - Failures can happen at any time
  - Time between failures is independent
  - As reliability improves, the failure rate decreases

PM2 – Parameters

- **Define:**
  - **What is the required end-state of the system?**
    - **M_G: goal reliability**
  - **What proportion of fixes can you make?**
    - **MS: management strategy**
  - **How effective will implemented fixes be?**
    - **FEF: fix effectiveness factor**
  - **What is the best possible state the system can achieve?**
    - **K: ratio of goal reliability to growth potential reliability**
  - **How much operating time will the system accumulate?**
    - **T: total time**

PM2 – Under the Hood

- **Determine:**
  - **M_I: The initial reliability that enables reaching M_G**

$$M_I \geq (1 - FEF * MS) * \frac{M_G}{K}$$

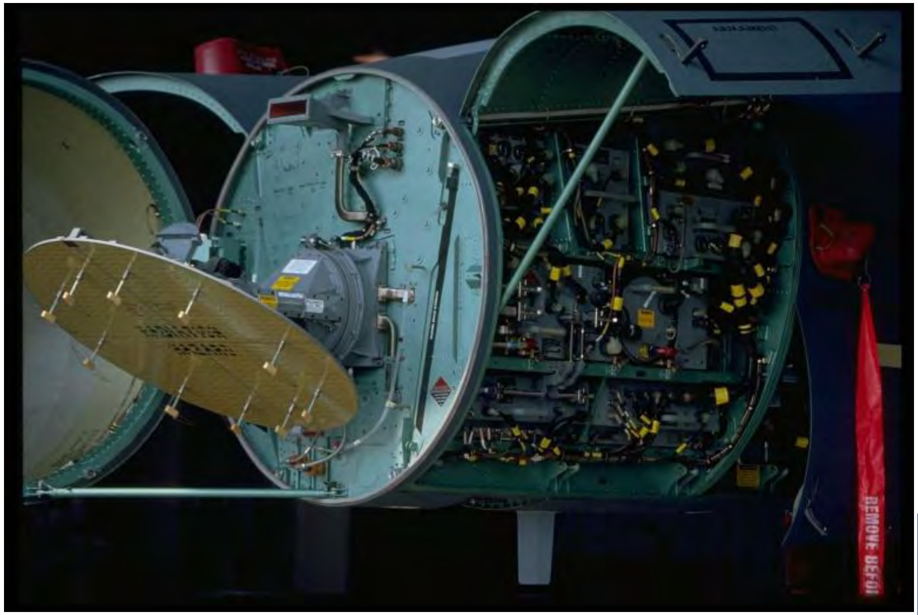
  - **β: The planning curve shape parameter**

$$\beta = \frac{1}{T}\left(\frac{1 - \frac{M_I}{M_G}}{MS * FEF - \left(1 - \frac{M_I}{M_G}\right)}\right)$$

  - **M(t): The expected reliability, in terms of cumulative time**

$$M(t) = \frac{M_I(1 + \beta * t)}{1 + \beta * t * (1 - MS * FEF)}$$

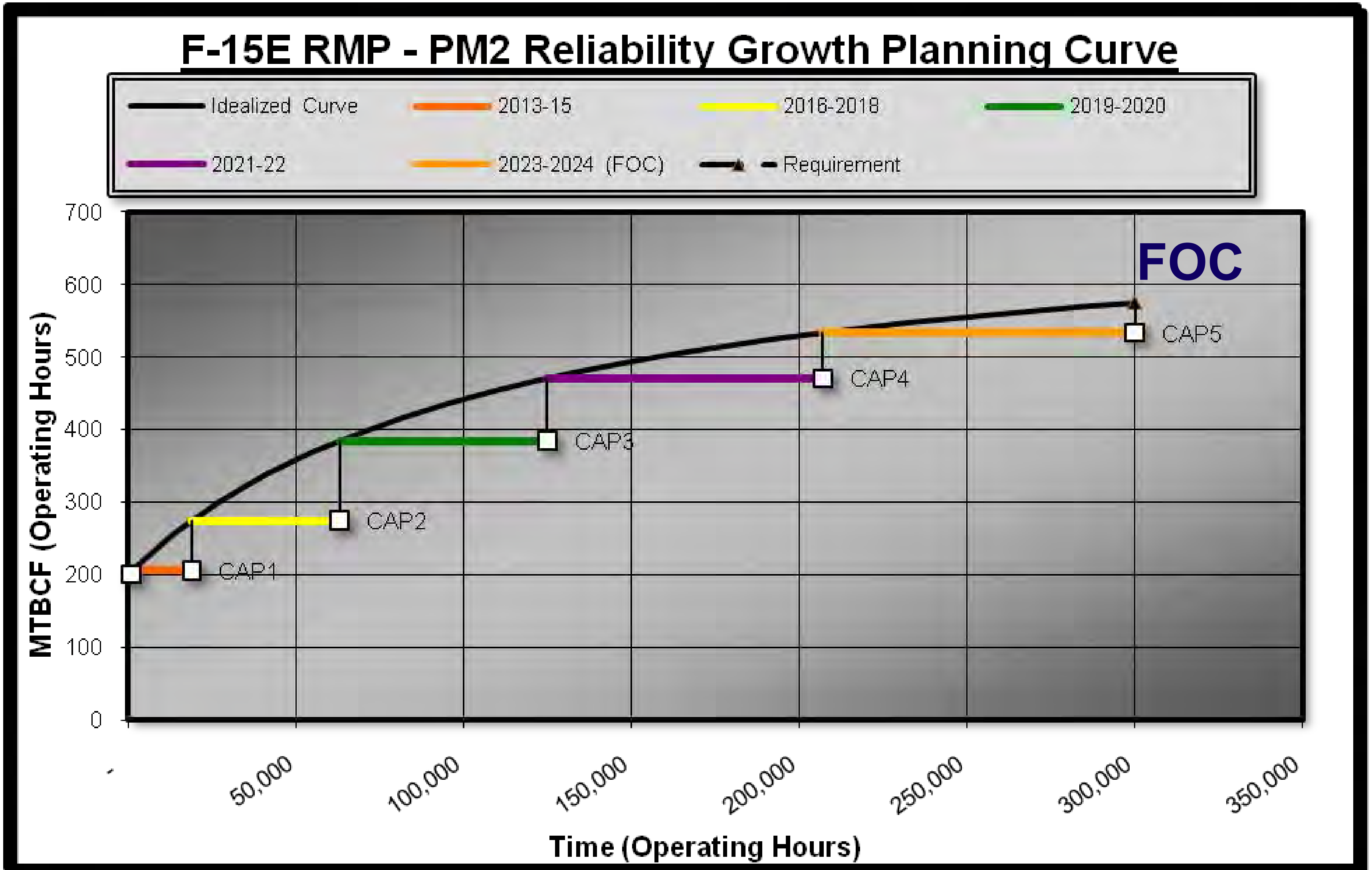
F-15E RMP Example



F-15E RMP Example

- Key performance parameter: radar MTBCF of 575 operating hours at full operational capability (FOC)
- 12-year gap between IOT&E and FOC
- 5 jets/1200 hours for IOT&E
- Parameters
  - M_G = 575 operating hours
  - MS = 0.9
  - FEF = 0.8
  - K = 0.8
  - T = 300K operating hours
- M_I ~ 200 operating hours

RMP Growth Curve



Conclusions

- Creating a reliability growth plan allows improved:
  - User planning for manpower and sustainment
  - Program office programming and budgeting activities
  - Test team evaluation of realistic and measurable metrics
  - System performance assessment in a transparent and objective manner
- The earlier the planning process takes place, the better
- Using rigorous statistical methods provides:
  - Credible and defensible results
  - Powerful techniques to assess progress
  - Quick "what-if" analysis

Questions

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Test and Evaluation Issues for Systems of Systems: Creating Sleep Aids for Those Sleepless Nights

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Strategic Initiative Coleads

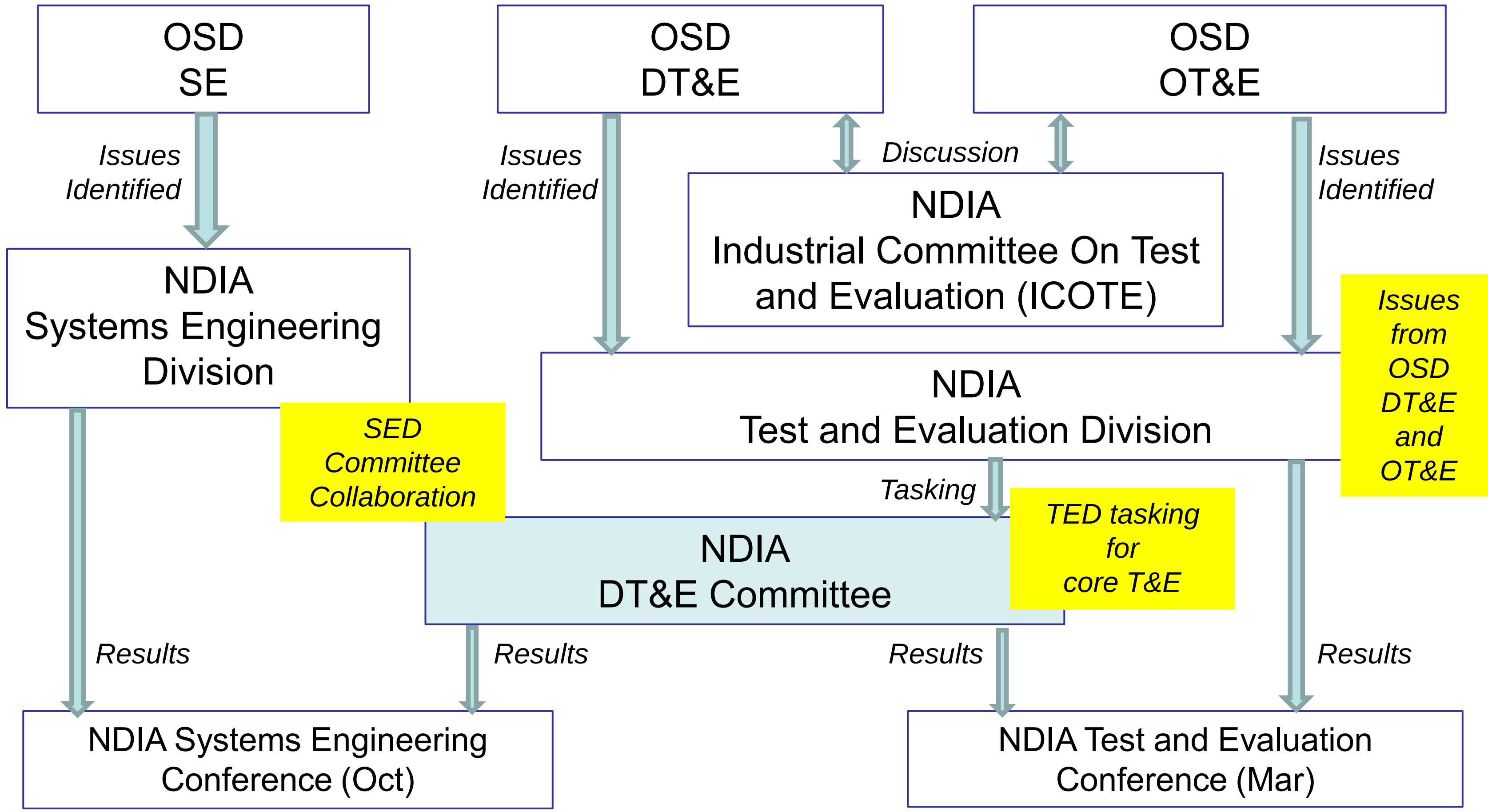
Abstract

In 2009, the NDIA System of Systems Committee developed a white paper describing test and evaluation issues that cause "sleepless nights".

In 2010, the NDIA SoS and DT&E Committees collaborated in a joint workshop to translate these issues into strategic initiatives and collaborative go-do activities as improvement areas. The issues included future T&E for systems brought together as SoS, requirements, metrics, systems changes, and end to end testing with systems not yet available.

This paper will summarize the results of that workshop and the progress being made to mitigate SoS T&E sleepless nights.

NDIA DT&E Committee Moved from SE to T&E Division



Focus of this Paper: DT&E Collaboration with SoS

Sleepless Nights: Test and Evaluation for SoS

- **Systems of Systems Topics Discussed in 2009:**
  - Compiled list of “what keeps me awake at night” topics for SoS
  - Test and evaluation for SoS topped the “Sleepless Nights” list
- **NDIA SoS and DT&E Committees Worked Jointly in 2009:**
  - Identified key T&E challenges for SoS
  - White paper described 5 top issues
  - Presented at 2009 NDIA SE Conference in joint SoS/T&E track
- **Focus for 2010: Joint Workshop August 17th**
  - Define a path from Sleepless Nights to Sominex
  - Evaluate challenges and underlying issues
  - Transition specific issues into strategic initiatives
- **Resulting Effort:**
  - 3 Strategic Initiatives
  - 1 Collaborative Go-Do

Workshop Defined Path to Find Sleep Aids

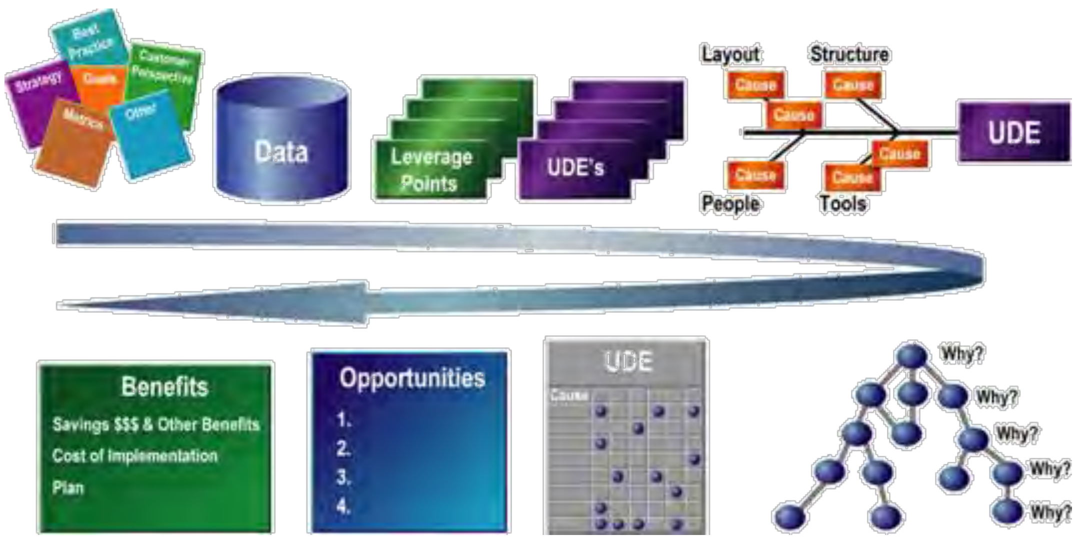
Reminder from 2009: T&E Challenges for SoS

1) **Future T&E:** If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?
2) **Requirements:** If „requirements‟ are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?
3) **Metrics:** What is the relationship between SoS metrics and T&E objectives?
4) **Systems Changes:** Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?
5) **End to End Testing:** How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results? What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

White Paper was Starting Point

Facilitated Workshop: The Technique

Data Collection:
SoS White Paper
SE Conference Papers



Potential Problem Areas

1) Future T&E for Systems brought together as SoS
2) Requirements
3) Metrics
4) Systems Changes
5) End to End Testing with systems not yet available

Potential Causes
If we could only fix one thing, it would be ________

Improvement Areas:
Strategic Initiatives
Collaborative Go-Do

		Cable	Tasks	Setup	Testing	Security
Facility	Signal cables wrong length or incorrect	X		X		
	Power/Cooling connections	X		X		
	Safety interconnect	X				
	Test equipment			X		
	Equipment in NFR	X		X		X
Schedule Dependencies	Signal cable delivery	X	X			
	REX/NBDC/SDP availability		X		X	
	REX array availability		X		X	
	Test results prior to string integration				X	
	Detailed tasks for integration/prep	X	X	X	X	
Security	Classified shipment					X
	Classified workstations					X
	Classified field returns					X
Integration Test Conduct	Procedures incomplete or incorrect		X	X	X	
	SDP emulator				X	
	Work-arounds required	X	X	X	X	X

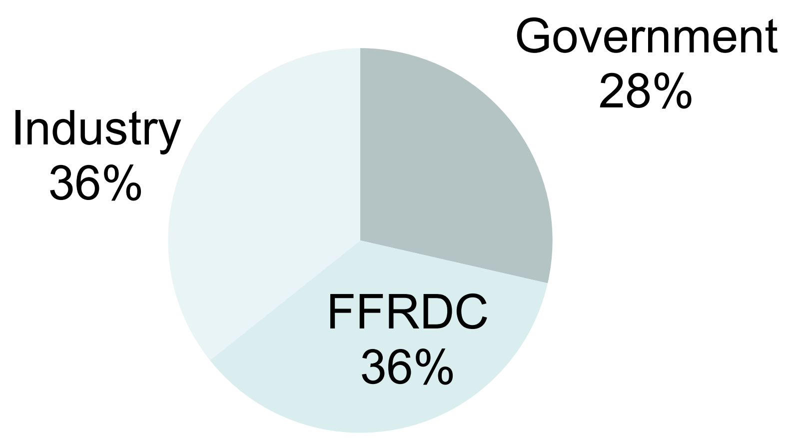
Leverage Matrix
Map Causes to problem areas

Transition from Problem Space to Solution Space

Facilitated Workshop: Attendees

Mr. Robert Aaron	Army	Government
Col (Ret) Suzanne M. Beers	MITRE	FFRDC
Dr. William D. Bell	MITRE	FFRDC
Mr. Aumber Bhatti	MITRE	FFRDC
Clyneice Chaney	MITRE	FFRDC
Mr. Peter H. Christensen	MITRE	FFRDC
Mr. David W. Coleman	MITRE	FFRDC
Dr. Judith S. Dahmann	MITRE	FFRDC
Ms. Indira Deonandan	MIT	Government
Mr. John W. Diem	OSD/ MSCO	Government
Mr. Mark E. Fenicle	DoD	Government
Mr. Tanya Gobel	SAIC	Industry
Mr. Robert Heilman	DOD	Government
CDR (Ret) Bryan Herdlick	JHU APL	Government

Dr. JoAnn Lane	USC CSSE	Industry
Mr. Steven S. Lee	DoD	Industry
Mr. Marty Leek (Facilitator)	Raytheon	Industry
Mr. Favio L. Lopez	Army	Industry
Mr. John R. Palmer	Boeing	Industry
Mr. George Rebovich Jr.	MITRE	FFRDC
Mr. Frank J. Serna	Draper	Industry
Mr. Michael Shanahan	USMC	Government
Dr. Carol A. Sledge	SEI	FFRDC
CDR (Ret) James D Smith II	SEI	FFRDC
Mr. Thomas Wissink	Lockheed Martin	Industry
Mr. Jack Zavin	OSD NII/DoD CIO	Government
Dr. Janice A. Ziarko	MITRE	Industry
Ms. Robin E. Ziradinovic	SAIC	Industry



Workshop Results

	Initiative Title	Action Plan	Initiative Vision Statement
Strategic Initiatives	Best Practices Model for SoS T&E	Define a best practices model	SoS T&E as a continuous improvement process supporting capabilities and limitations information for end users and feedback to SoS and System SE teams toward evolution of the SoS
	Radical Approach to SoS T&E	Define SoS capability test approach	Rethink T&E of systems in an operational context and systems interoperability away from system testing toward integrated capability SoS testing
	SoS Governance	Define characteristics of successful SoS T&E	Indentify the process by which we can change and influence the governance of SoS. Mature and improve templates to define a minimum set of characteristics that are required to govern SoS T&E efforts
Go-Do	SoS SE Policy and Guidance	Recognize and employ SoS guidance	Ensure that guidance or SoS SE (DoD SoS SE Guide) is recognized and employed on growing number of SoS

Initiatives Identified with Action Plans

Initiative Teams

#1	Best Practices
Leads	Judith Dahmann, (MITRE &ASD R&E/SE) Rob Heilman (TRMC)
Team Members	George Rebovich, (MITRE) Jim Buscemi (GBL&TRMC) Paola Pringle (Navy) Kent Pickett (MITRE) Chris Scrapper (MITRE) Aaron Budgor, (GBL Systems, TRMC) Laura Feinerman, (MITRE) Joe Lucidi, (Army OTC)

#2
Define SoS Capability Test

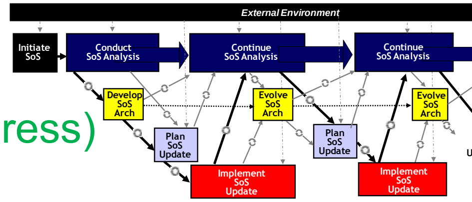
#3	Governance
Leads	Bob Aaron (ATEC) James Smith (SEI)
Team Members	John Palmer (Boeing) Carol Sledge, PhD (SEI) Robin Zivadinovic (JFCOM/Ctr)

2 Initiatives Launched, Will Feed Results into 3rd

#1: Best Practices Model Approach and Status

Complete
In Process
Planned

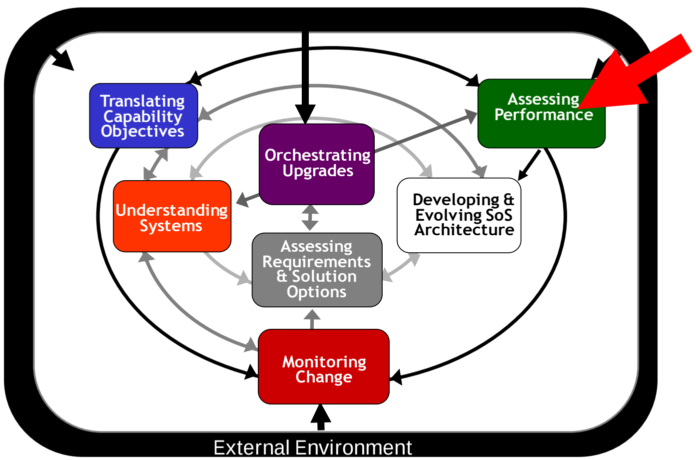
1. **Form core team (Complete)**
   - Core team will implement activities
   - Share results for feedback from SoS and DT&E committee
2. **Define scope (Complete)**
   - Focus on Acknowledged SoS *(SoS objectives, management, funding and authority; however systems retain their own management, funding and authority in parallel with the SoS)*
   - Investigating potential for Directed SoS *(SoS objectives, management, funding and authority; systems are subordinated to SoS)*
3. **Develop a draft description of the proposed model**
   - Review the workshop discussions (Complete)
   - Review current SoS SE guidance on T&E (Complete)
   - Framework for model and implementation approaches (In Progress)
   - Draft model description and circulate for review (Planned)
4. **Review use cases to support and/or adapt the model**
5. **Update the model based on use cases**
6. **Review and assess state and utility of the model**



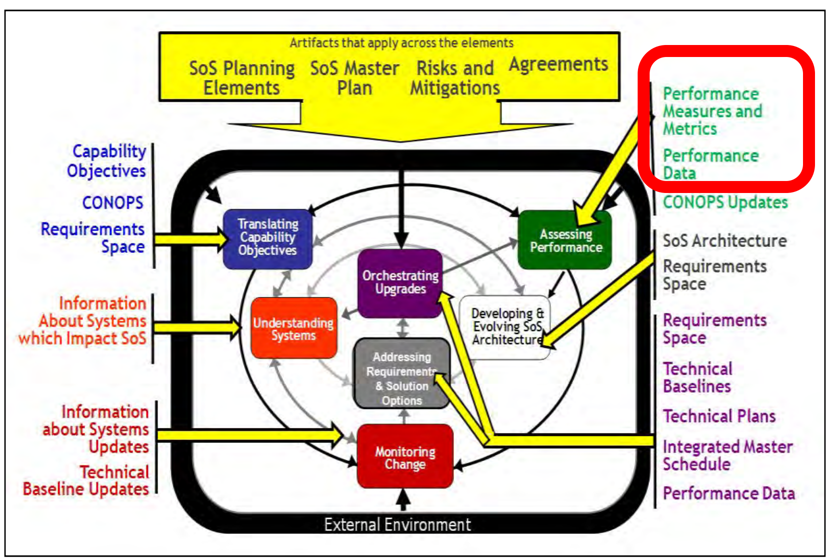
Identifying T&E inserts into SoS Wave Model
Soliciting Use Case Recommendations

#1: Best Practices Model
Role of T&E in SoS Models

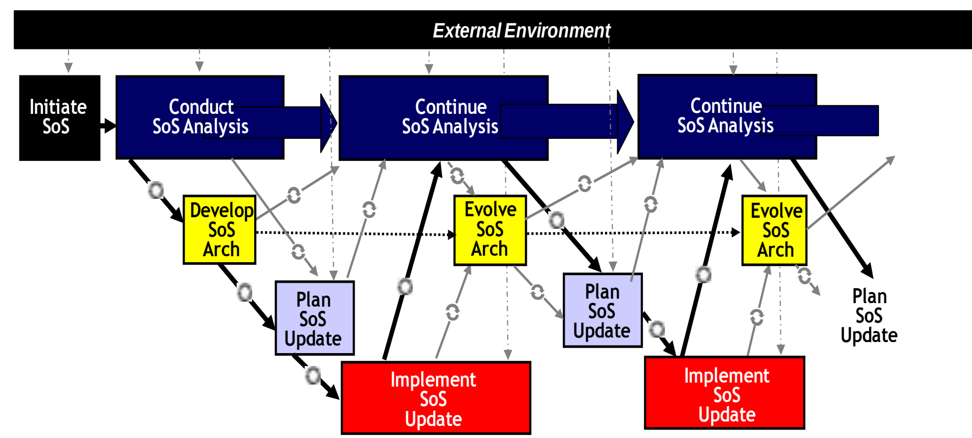
Trapeze Model



- SoS SE Guide Trapeze Model
  - "Assessing Performance" is a core element of SoS SE
- SoS SE Artifacts
  - Performance Measures and Metrics
- Wave Model
  - SoS T&E begins with SoS analysis and is addressed throughout the other steps



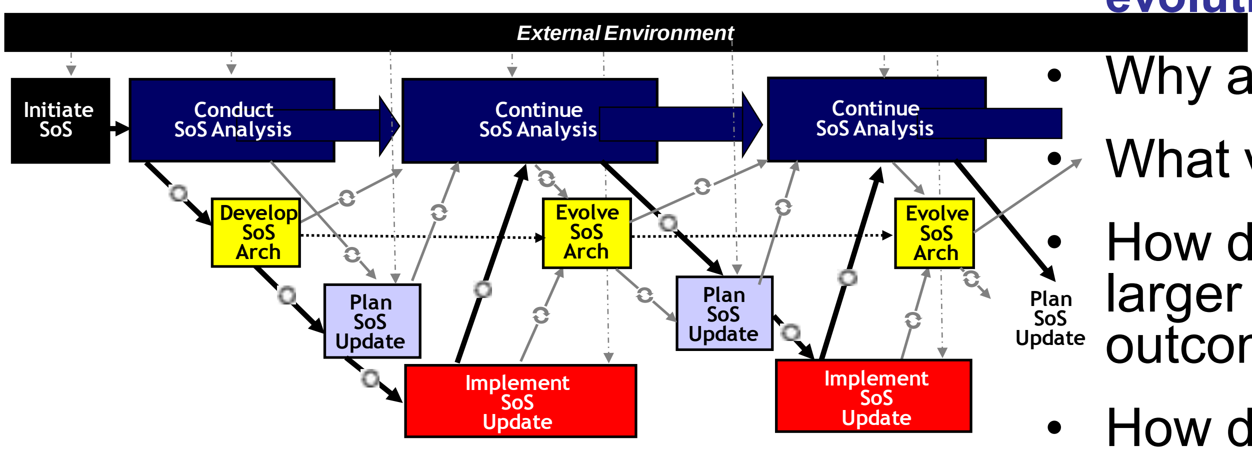
Wave Model



#1: Best Practices Model Framework for Description

SoS Wave Model

- Describe key activities at each stage as they relate to T&E of the SoS
  - Conduct (and Continue) SoS analysis
  - Develop and evolve SoS architecture
  - Plan SoS Updates
  - Implement SoS Updated



- What actions are taken at each step to support the model of SoS T&E as

"Continuous improvement process supporting capabilities and limitations information for end users and feedback to the SoS and system SE teams toward evolution of the SoS"

- Why are these important?
- What value to they add?
- How do they contribute to the larger SoS SE and T&E outcomes?
- How do they address the challenges?
- What methods or tools apply?

#3: Governance Approach and Status

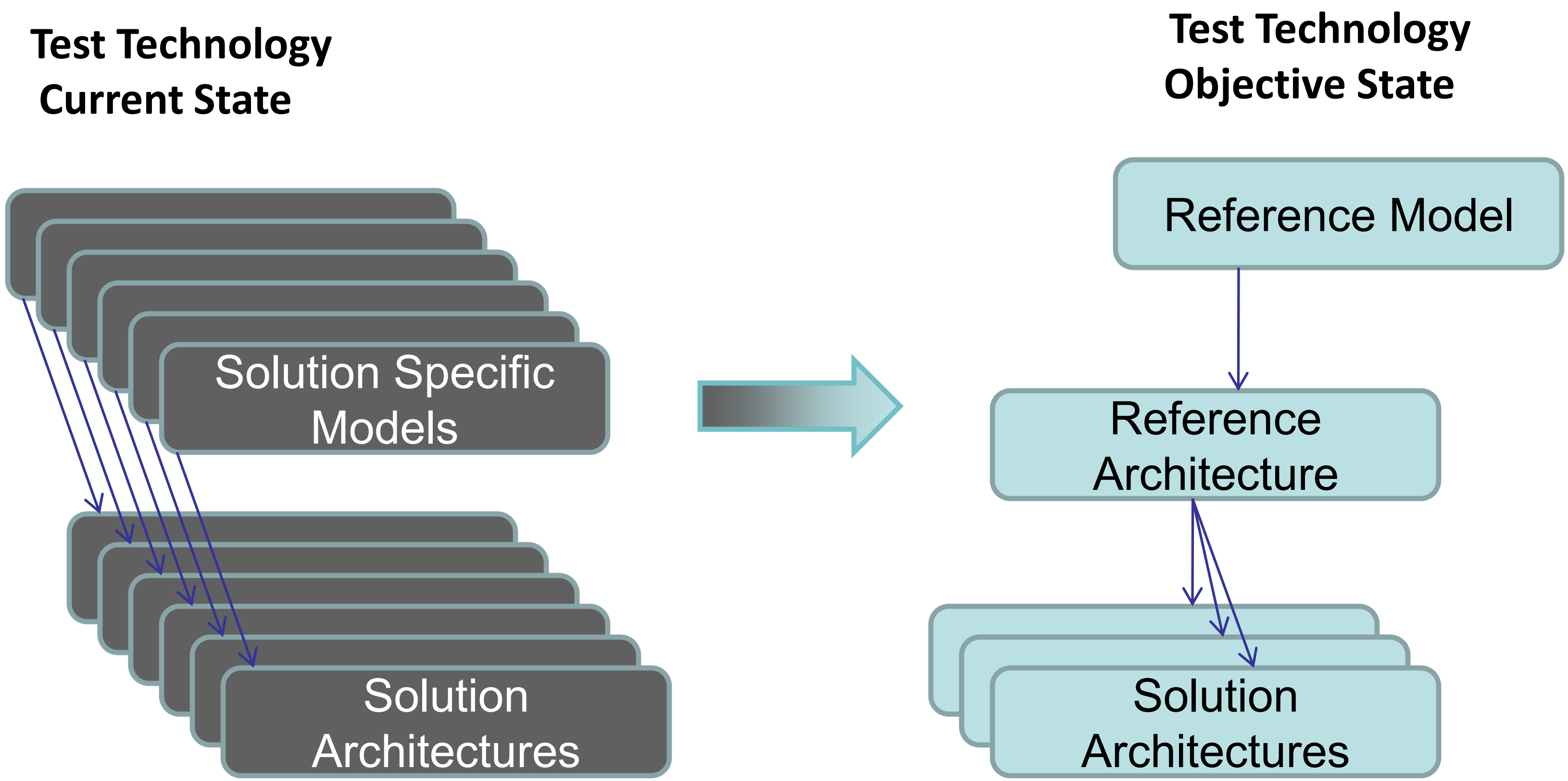
Complete
In Process
Planned

1. **Form core team (Complete)**
2. **Define scope (Complete)**
   - Purpose: to provide an integrated governance perspective for SOS development, deployment, and life cycle
   - Scope: Governance for overall acquisition, including T&E as a holistic/comprehensive view *(focus on Directed and Acknowledged SoS)*
3. **Identify Governance As-Is State (Complete)**
   - Fundamental Governance Concepts
   - Architecture Concepts & DODAF for managing complexity
4. **Develop Governance To-Be Fundamental Concepts (In Process)**
   - Organizations that produce reference models, reference architectures, and data engineering components including T&E considerations for measuring performance
   - Synchronized and aligned organizations (structures), policy, tools, technical approaches, and resources that support the selected option.
5. **Draft Recommendations to Achieve To-Be State**

Reference Architecture As Framework to Discuss Governance

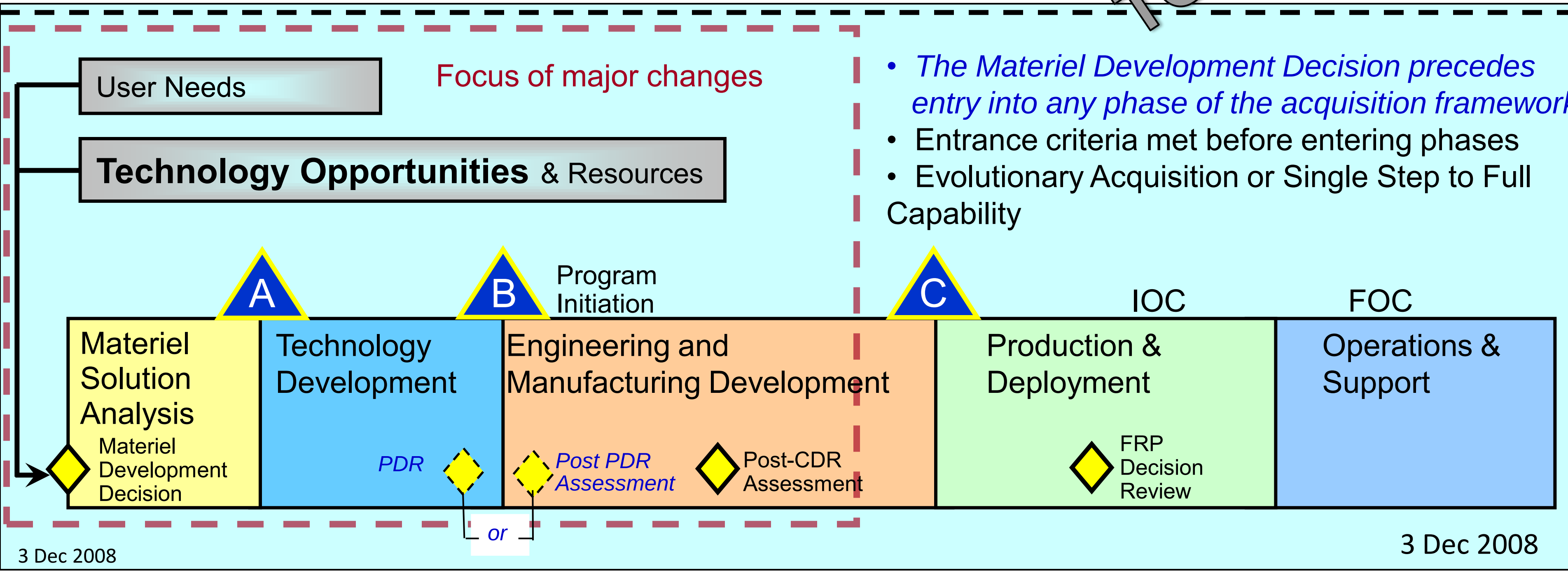
#3: Governance
Current and Objective State

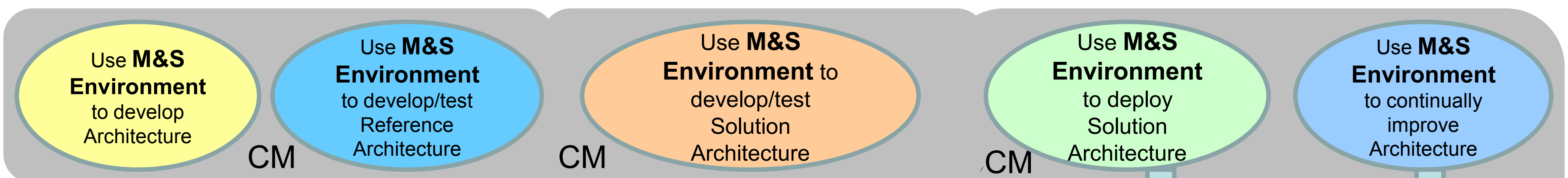
Our Architecture/Technology organizations should be designed how?



Creating the Environment for NR KPP – OV-1
(NR KPP WG - Draft)

TO-BE



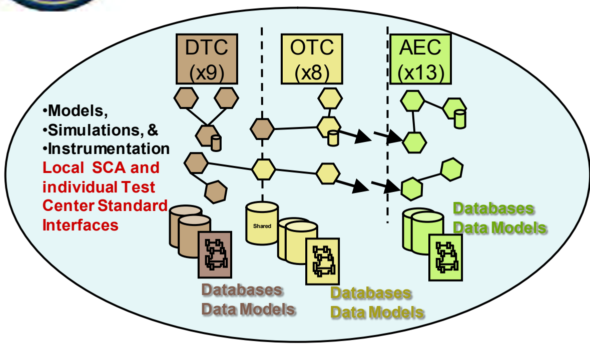


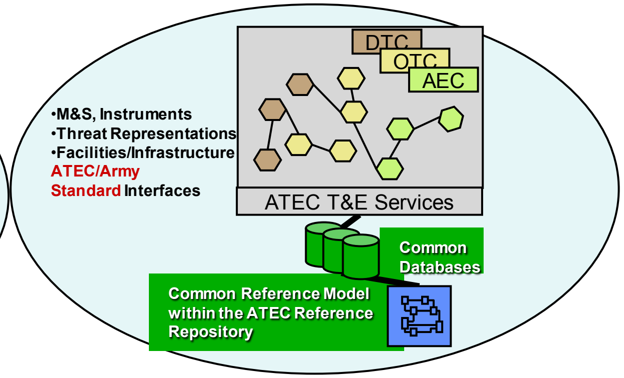
- Begins w. Reference Models
-Technology/Cost trade offs
- Model Driven Architecture (MDA)
- Integrated Development Environment (IDE) all under Configuration Mgmt
- Use M&S Environment to develop architecture and to the extent possible SOS DOTLMPS components
- Common/interoperable tools and tool kits for this acquisition domain

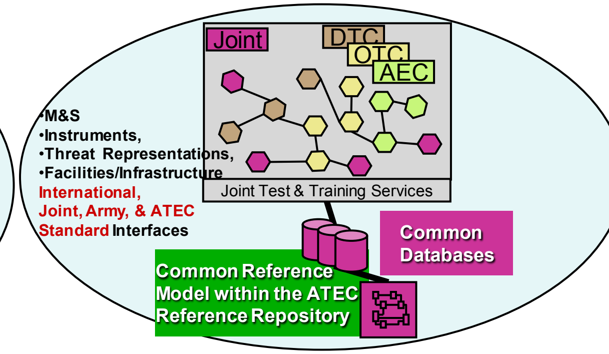
- User pulls down what he needs
- Each Phase Virtual using DOD COEs
- Designers push new patches

EXAMPLE ONLY

Test Technology "To-Be" System Evolution (SV-8)







CY08

- Initial Ref Architecture for TTD Review
- Initial Reference Repository with:
  - First AEC data models
  - Search, Submit, & Download Functions

FY09

- Initial Ref Architecture for Community Input
- Functioning Reference Repository with:
  - Initial CRM containing the following data models:
    - AEC T&E Reference Model & other available data models
    - TENA TSPI
    - Engineering Units DB

FY10

- Ref Architecture
  - Community involved in evolution
  - Initial Automation Support
- Operational Reference Repository with:
  - Initial Visualization functionality for data model comparison
  - Enhanced CRM that includes Planning metadata
  - Additional & Evolved data models

FY11

- Ref Architecture
  - Community Active in Evolution
  - Improved Automation Support
- Operational Reference Repository with:
  - Improved Visualization, Aggregation, Disaggregation functionality for data models
  - Evolved CRM that includes Execution metadata
  - Additional & Evolved data models
- Initial TT Investment Decision Support System

FY12

- Ref Architecture
  - Community Driven
  - Full Automation Support
- Reference Repository
  - Sophisticated Visualization, Aggregation, Disaggregation functionality for data models
  - Evolved CRM that includes metadata for all T&E phases
  - Additional & Evolved data models
- Improved TT Investment Decision Support System

More Automation - Less Manual Effort, Greater Accuracy, & Less Time
Increasing Community Involvement, Modeling and Governance – Greater Interoperability & Less Ambiguity
Growing Architectural Cohesion Enabling Informed Decision Making

#2: Capability Testing Approach Planned

Complete
In Process
Planned

1. **Assess inputs from Strategic Initiatives #1 and #3**
2. **Form core team**
3. **Define scope**
4. **Define SoS T&E As-Is State**
   - Build up of systems testing in operational context
   - Build up of systems interoperability
5. **Define SoS Capability T&E To-Be State**
   - Define gaps in implementation as integrated capability SoS
   - Identify barriers responsible for these gaps
6. **Draft Recommendations to Achieve Capability SoS T&E**

Rethink T&E of SoS in Operational Context

Summary

- **Successful Workshop with SoS and T&E Practitioners**
- **Framework Established for Continuing Collaboration**
- **Transition Discussion from Challenges to Solutions**
- **Strategic Initiatives to Develop T&E Solutions for SoS**:
  1. **Define a best practices model**
  2. **Define SoS capability test**
  3. **Define characteristics of successful SoS T&E**
  - **Recognize and employ existing guidance for SoS (DoD SoS SE Guide)**

Not Too Late to Join a Team!

BACKUP

Details on T&E Issue Discussions

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Discussion

- **Restatement of issue:**
  - How do we define, articulate, and enforce the relationship between the SoS and the constituent systems?
  - How does T&E support/help this?
- **Governance/Roles/Stakeholders**
  - Need a shepard (architect?) and support from users
  - Need to educate stakeholders
  - What are rules of governance?
  - What are the regulations, standards, and policies?
  - Need to obtain resources (funding, test assets, time)
  - SoS leadership focus: architecture views, who "owns"
  - Potential conflicts between SoS and constituents
  - Business case for PMs to do SoS
- **SoS T&E Focus**
  - SoS T&E operationally driven (vs. DT-ish)
  - SoS edge of the envelop
  - What is an AoA of SoS?
  - Emergent behaviors (good and bad)
  - SoS resource consumption (e.g. data pipeline)
  - Continual assessment (joint exercises, deployments)
  - How to define test strategies to efficiently continuously test?
  - How do we help the T&E process help the SoS work?
- **Understand SoS Capabilities**
  - What is the SoS expected to do?
  - Define and articulate relation between SoS and systems
  - Flexible composition
  - Artfully sub-optimize the systems in favor of the SoS
  - System performance bounds are not rigid in real operation
    - Candidate solution: SoS requirements document with annex for each constituent system (what is constituent contribution to SoS capability)

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Approach to addressing issue

- Define a minimal set of SoS governance characteristics of a successful acknowledged SoS
  - Roles/resources
  - Rules/regs/standards/policies
  - Managing conflicts
  - Establishing cooperation of constituent systems
  - Includes responsibility to define SoS capabilities, architecture, and associated test strategy
  - Concept of continual change and test in operational and training environment
  - Lean management, taking advantage of available opportunities
  - Recognize the large number of SoS across the DoD, and the fact that many systems support multiple SoS.anf the potential impacts of governance

Issue #2 If "requirements" are not clearly up front from a SoS, what is basis for T&E of an SoS?

Discussion

- Requirements vs expectations; Mission objective vs. technical requirements
- Mission threads linked to capability strands as architecture model
- Who/what has responsibility for architecture/requirement- another DOD layer?
- Standards for participating or acceptance of each system into SoS
- Requirements model for architecture encompassing time, space changes
- SoS level requirement T&E at program or SoS level balance?
- T&E of aggregation of systems level requirements (SOS level TEMP)
- Integrated development environment/ reference architecture as model
- Need operations/architecture view of SoS that individual systems must plug into- need someone responsible for this
- Prioritization of SoS capabilities at high (OSD) level required to permit constituent PM to manage development and delivery. With funding at SoS
- Measure and baseline SoS capability thru T&E w/o requirements. Where do we get metrics?
- Must have an "enforcer" capability manager - carrots and sticks
- Measure SoS capabilities when changes to SoS Baseline
- CONOPs vs innovative use of systems in face of changing threat
- Move from paper to 4 dimensions to capture SoS capabilities requirements.
- Use of modeling tools of SoS components delivered with each component to communicate requirements
- Capability flow down to systems, demo meeting systems capability

Issue 2: If "requirements" are not clearly defined up front for a SoS, what is basis for T&E of an SoS?

Approach to addressing issue

- The DOD needs a top-down (architecture, requirements, context, expectation) flow-process to systems within the SoS
- Needs authority & funding to enforce capability fulfillment
- Needs to be flexible enough to meet changing needs and threats and CONOPS/operator innovation.
- Determine the right balance between system test to sos- test to SOS level test

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Discussion

- SoS T&E is focused on continuous improvement of the SoS (as compared to system T&E which is focused on the field, fix, or don't field decision)
- Continuous SoS T&E requires
  - Stable/consistent metrics
  - Consistent approach to defining evolving baseline
  - A way to deal with emergent behavior (technical, organization, human) – positive or negative
  - Need to leverage wide range of opportunities for test environments
  - Continuous improvement means continuous testing ; Built in test instrumentation for feedback from field
- SoS metrics
  - Do not address discrete behaviors of systems (as do system metrics)
  - Do address end to end performance across systems in SoS toward capability objectives of the SoS
- What is objective of T&E for an SoS?
  - Development information on capabilities and limitations of SoS to inform end users and ongoing SoS evolution (as compared to system T&E which is assessment of whether system meets requirements)
- SoS T&E customers?
  - End user and SoS SE team (as compared to system T&E where aquisition community is the customer)
- SoS T&E should be risk driven: focus on areas of risk to SoS or systems

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Approaches to addressing issue

- Characterize SoS T&E as continuous improvement, document the approach and share with the community
- Radically change how we look at testing given the growing prevalence of SoS
  - Concepts of DT and OT don't really fit
  - Inefficient to address systems in operational SoS environment on a system by system basis (OT today)
  - Continue to test individual systems to assess whether we have developed what we asked for
  - Create a new approach to OT, by cross systems support for testing capabilities

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Discussion

- To address these issues you need to fix
  - Define the SoS and its performance objectives
    - Constituent systems that are part of the SoS
    - Which parts of the constituents contribute to the SoS objectives
  - Describe the current and future state of the changing systems (Baselines)
  - Assign ownership of SoS performance objectives
  - Big challenge; leadership issue, etc
    - More collaborative approach for stakeholders of SoS
- Emergent behavior – interaction of systems, humans, system and organization along with constant change of the parts
- Bounds of human impact
  - Operator – leader – mission
  - The people side of systems
- Training and development of the evaluators (and the end users)
- Expensive to assess if capabilities are realized (hard to do)
  - Doing more with less?
  - Disconnect thinking and reality?
- Leadership understanding of SE and SoS
  - Is there competency to make decisions and know the impact and implications?
    - Trades without know the desired outcome can be achieved
  - Evaluation on an SoS basis vs individua;l systems and their acquisitions
  - Timing and who benefits (lack of rewards systems)
  - Accountability for SoS
- Continued improvement, assessment, and alignment because objectives have changed
  - More data from fielded systems
- Connections to fielded side of the house (doesn't deal well with change)
- "Measurement system' for system
  - Analysis of impacts
  - M&S?
  - Risks; "we are not sure but…" with some mitigation
  - Regression testing and configuration of SoS
  - Comparative analysis

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Approaches to addressing issue

- Influence assigning leadership responsibility and ownership of defined SoS capability and associate performance objectives
- Establish incentives of constituent systems to collaborate and achieve SoS performance objectives
- Map SoS capabilities and performance objectives to constituent systems (under configuration control)
- Continual assessment, improvement, and realignment is required (incremental approach) focused on end user)
- Create a guidance framework for emergent behaviors of changing to be measured and managed

Issue 5

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Discussion

- Trying to assemble all piece parts for T&E
- So many variables that can impact T&E outcome
- Reliance on other programs (e.g., JTRS) for capabilities that can slip in schedule or are never delivered
- Spanning "use-case" space with a reasonable set of resources and schedule
- Need defined set of requirements (but, of course, this is part of the problem space)
- What does a T&E strategy look like?
- How account for "the network" and stresses to it?
- DoD should require programs to share/ make transparent to other programs their development, DT and other data (obstacles: proprietary/security)
- Recommend ways to systems instrument to enable post-fielding collection of "test" data
- Operations, exercises, training
- DoD should develop a common approach to accounting for "the network" as a constituent of all SoSs for purposes of T&E
- DoD articulate purpose of SoS T&E
  - Is it a capability demo ("what do we have?")
  - Is it a classical check against requirements?
  - The real purpose of SoS T&E is to answer:
    - Is the new capability operationally useful (whether or not it "met" requirements); what are risks?
  - How can the new capability be used?
  - What further changes are required?

Issue 5

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Approach

- M&S of piece parts that are not yet ready to be tested (but issues between M&S for individual system performance versus effects-based M&S) – potential solution to issue #1.
- Architectures and synchronizing them an enabler of T&E (provides well-defined baseline; can measure deltas against the baseline)
- Combinatorial test & design (suggested as potential solution to issue #2).
- Model-test-model approach suggested for way to accommodate emergent behavior
- Field exercises – instrumentation to collect data
- Training as a T&E opportunity
- No SoS requirement => no TEMP for SoS capabilities => no SoS T&E funding. Therefore need a capability (SoS) focused, cross-system, integrated test schedule that builds to a graduation-level event. (some disagreement re. existence of such an event). Push SoS T&E to fleet/operators as proof of IOC (need fleet experimentation funding).

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Test Planning – Advancing the Science Tutorial

27th Annual National T&E Conference

Marriott Tampa Waterside
March 14th, 2011

Stephen Scukanec
Senior Test Engineering
Flight Test and Evaluation
Northrop Grumman
Aerospace Systems

Test Planning –Advancing the Science

NORTHROP GRUMMAN

- Agenda
  - Some opening thoughts
  - Why develop a Test Plan?
  - What is a Test Plan?
  - What do you plan?
  - Where does a Test Plan's data come from ?
  - How do we plan?
    - Verification
    - Safe testing
    - Test Techniques
    - Test Tools
    - Test resources
  - Keeping it all straight
  - Let's Plan
  - Conclusions

"Let our advance worrying become advance thinking and planning"
Winston Churchill

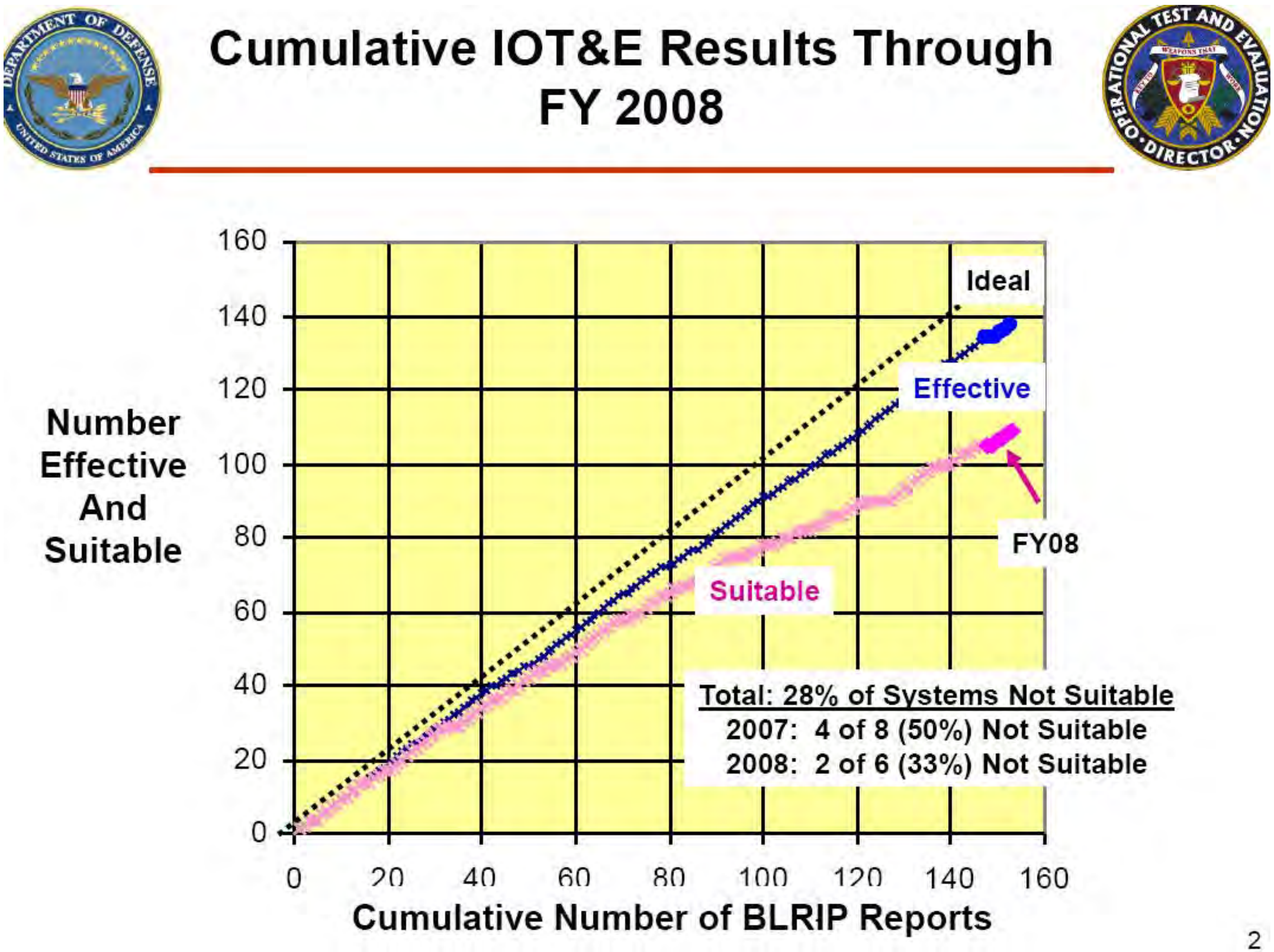
Test Planning

- —Approximately 20%-30% of the overall projects work should be allocated to testing.”

- —Regardless of how much testing is allocated for the project, it is important to note that acceptable test results do not necessarily require perfection. Acceptable testing is more about validating what is agreed to be done rather than being perfect or even exceeding expectations.”
  - Harold Kerzner’s book Project Management a Systems Approach to Planning, Scheduling, and Controlling John Wiley & Sons, Inc

STAY ON TARGET

Remember This?



NDIA 11th Annual System Engineering Conference Proceedings, Keynote Presentation, HON Charles McQueary, Director, Operational Test & Evaluation - October 2008

Tutorial Description

- From verification to test plan modeling and test plan generation, participants will see the processes and tool sets in action.

- To demonstrate some of these capabilities, participants will generate test requirements and objectives, model the plan, optimize the plan and assign resources, and finally generate a simple test plan while maintaining connections to the original requirements intent.

- Fools rush in
  Where wise men never go.

NORTHROP GRUMMAN

Tutorial Style

INTERACTIVE

IDEA SHARING

TEAM EXERCISES

Why Develop a Test Plan ?

How Do Plans Help The Program?

- Identifies the test program and test program resources
- Provides a method to manage the test program
- Optimized test plan saves program cost

- Ensures the test program is traceable to the product architecture (requirements)

- Test plan can help manage program changes
- Test plans foster communications

Advancing the Science

- Test planning typically relies on
  - Experience
  - Requirements
  - DWWDLT (Did What We Did Last Time)
  - Lessons learned
  - Working teams / meetings
  - Schedules

- Test planning must advance using:
  - Experience
  - Doing what is required (optimizing the test program)
  - Working teams / meetings
  - Schedules
  - Test plan modeling (utilizing SE based tool set)
  - Appropriate application of design of experiments
  - Collaborative techniques and tools to encompass the entire programs test program
  - Support rapid evaluation based on programmatic changes

Why Do We Plan?

•Planning allows one to stay on target, project the future, and assess the impact of change.

•Planning identifies problems and points the way to solutions. Just taking a systematic, thorough look at the current situation and thinking about the implications for the future, can bring these things to light.

•It helps us to do first things first. In other words, it provides a rationale for assigning priorities.

•A good plan will suggest answers to perplexing questions.

Planning is "intelligent cooperation with the inevitable."

The TEMP Lifecycle Value

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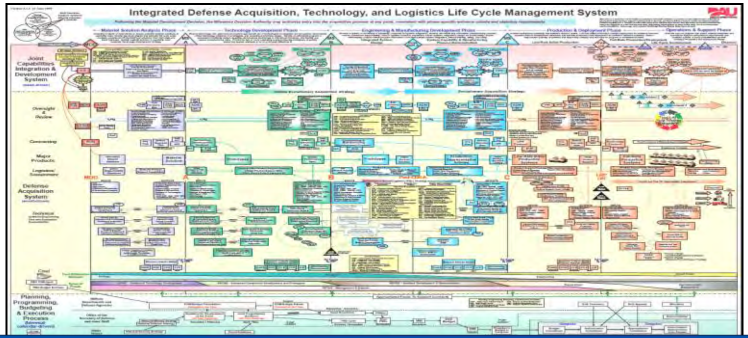
- The TEMP identifies and integrates all of the T&E requirements with the program's acquisition strategy and requirements. The temps for OSD oversight programs follow the DAG format and must be approved by the director, DT&E and the director, OT&E. Service approved temps are developed according to service regulations and guidance. The TEMP is used by the program office to:
  - Provide an overall test management plan within the acquisition strategy bounds,
  - Identify overall T&E activities by the government and system contractor,
  - Guide the development of specific test events and integration of detailed test plans for those activities by summarizing relevant performance requirements, and
  - Document T&E schedule and resource requirements



ACQuipedia - https://acc.dau.mil/ILC_T&EMP
Defense Acquisition University Web Site

Test Planning is a Lifecycle Event – Programs Must Not Dismiss the Test Plan Importance

What is a Test Plan?

What Is A Test Plan?

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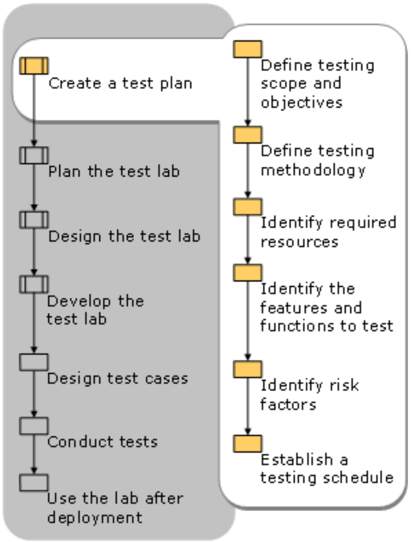
Microsoft



Early in the deployment planning phase, the testing team creates a test plan. The **test plan defines the objectives and scope of the testing effort, and identifies the methodology that your team will use to conduct tests**. It also **identifies the hardware, software, and tools required** for testing and the features and functions that will be tested. **A well-rounded test plan notes any risk factors that jeopardize testing and includes a testing schedule.**

TABLE OF CONTENTS

Microsoft Tech Net
http://technet.microsoft.com/en-us/library/cc781572(WS.10).aspx

http://technet.microsoft.com/en-us/library/ee221154(EXCHG.80).aspx

What Is A Test Plan?

CDC UNIFIED PROCESS PRACTICES GUIDE

TEST PLANNING PRACTICES GUIDE

There are a number of different testing techniques and approaches. However, regardless of which approach is use test planning is made up of three basic phases that include:

1. ***Preparing for Tests***
   Preparation for testing is a vital part of the test planning process. This stage outlines the tests to be performed, and if necessary, creates the environment in which to perform those tests. Some of the documents necessary to effectively prepare for testing include:
   - **Test Plan** - describes what testing will be done, to what quality standard, with what resource, within what timeframe, and outlines any risks/issues and how they will be addressed. A well defined test plan should also outline items such as:
     - Items to test and not to test such as test product features, interfaces, reporting tools
     - Risks, issues, mitigation strategies, and contingencies plans
     - Testing approach defining methods and tools to be used for testing
     - Item pass/fail criteria specifying what constitutes a successful test
     - Entry and exit criteria specifying what constitutes a completed test
     - Test deliverables such as a test plan, test cases, test tools
     - Environmental needs outlining any requirements for where testing will take place
     - Staffing and training needs

Center for Disease Control
2007
http://www2.cdc.gov/cdcup/library/practices_guides/CDC_UP_Test_Planning_Practices_Guide.pdf

INTRODUCTION
Purpose of The Test Plan Document
Compatibility testing
Test Risks / Issues
Items to be Tested / Not Tested
Test Approach(s)
Test Regulatory / Mandate Criteria
Test Pass / Fail Criteria
Test Entry / Exit Criteria
Test Deliverables
Test Suspension / Resumption Criteria
Test Environmental / Staffing / Training Needs
Conformance Testing
Functional Testing
Load Testing
Performance Testing
Regression Testing
Stress Testing
System Testing
Unit Testing
User Acceptance Testing
Test Plan Approval
Appendix A: References
Appendix B: Key Terms

Each *subsection* is repeated in each major section

www2.cdc.gov/cdcup/library/templates/CDC_UP_Test_Plan_Template.doc

What Is A Test Plan?

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The TEMP describes the acquisition program's planned T&E over the program's life cycle and identifies evaluation criteria for the testers. It serves as an executive summary of the overall test program. Building on the foundations laid in the TES, the TEMP identifies and integrates all of the T&E requirements with the program's Acquisition Strategy and requirements

DOD / Air Force TEMP TOC – 2 Levels Deep

PART 1 – INTRODUCTION
1.1PURPOSE
1.2MISSION DESCRIPTION
1.3SYSTEM DESCRIPTION

PART III – TEST AND EVALUATION STRATEGY
3.1T&E STRATEGY
3.2 EVALUATION FRAMEWORK
Figure 3.1 – Top-Level Evaluation Framework Matrix
3.3 Developmental Evaluation Approach
3.4 Live Fire Evaluation Approach
3.5 Certification for IOT&E
3.6 Operational Evaluation Approach
3.7 OTHER CERTIFICATIONS
3.8 RELIABILITY GROWTH
3.9 FUTURE TEST AND EVALUATION

PART II – TEST PROGRAM MANAGEMENT AND SCHEDULE
2.0 T&E MANAGEMENT
2.1.1T&E Organizational Construct
2.2Common T&E Data Base Requirements
2.3DEFICIENCY REPORTING
2.4 TEMP UPDATES
2.5INTEGRATED TEST PROGRAM SCHEDULE
Figure 2.1 – Integrated Test Program Schedule

PART IV – RESOURCE SUMMARY
4.1 Introduction
4.1.1Test Articles
4.1.2Test Sites and Instrumentation
4.1.3Test Support Equipment
4.1.4Threat Representation
4.1.5 Test Targets and Expendables
4.1.6Operational Force Test Support
4.1.7Models, Simulations, and Test-beds
4.1.8Joint Operational Test Environment
4.1.9Special Requirements
4.2 Federal, State, Local Requirements
4.3 Manpower/Personnel Training
4.4 Test Funding Summary
Table 4.1 Resource Summary Matrix
APPENDIX A – BIBLIOGRAPHY
APPENDIX B – ACRONYMS
APPENDIX C – POINTS OF CONTACT
ADDITIONAL APPENDICES AS NEEDED

What do We Plan?

What Do We Plan ?

- Tenet
  - a widely held belief; *especially* **:** one held in common by members of a group or profession

- Feature
  - a part or detail that stands out

<u>Define the tenets and features of a good test plan.</u>

<u>Break Into Teams</u>

•Select a Spokesperson

•Develop 3 – 4 Key Tenets Of a Good Test Plan

•Develop 3 – 4 Key Features of a Test Plan

•Write Them Down

•Share With Community

What Do We Plan ?

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- Tenets of a Good Test Plan
  - Defines Test Strategy
  - Establishes Test Program Management
  - Documents the Test Program
  - Identifies the Needed Resources

- Features of a Good Test Plan
  - Can be used to manage the test program lifecycle
  - Covers all program level test responsibilities
  - Traceable
  - Adjustable
  - Is used as the requirements document for test procedures
  - Avoids obsolescence

The Test Plan is the Test Procedure's Requirement Document

Tenet Characteristics - Strategy

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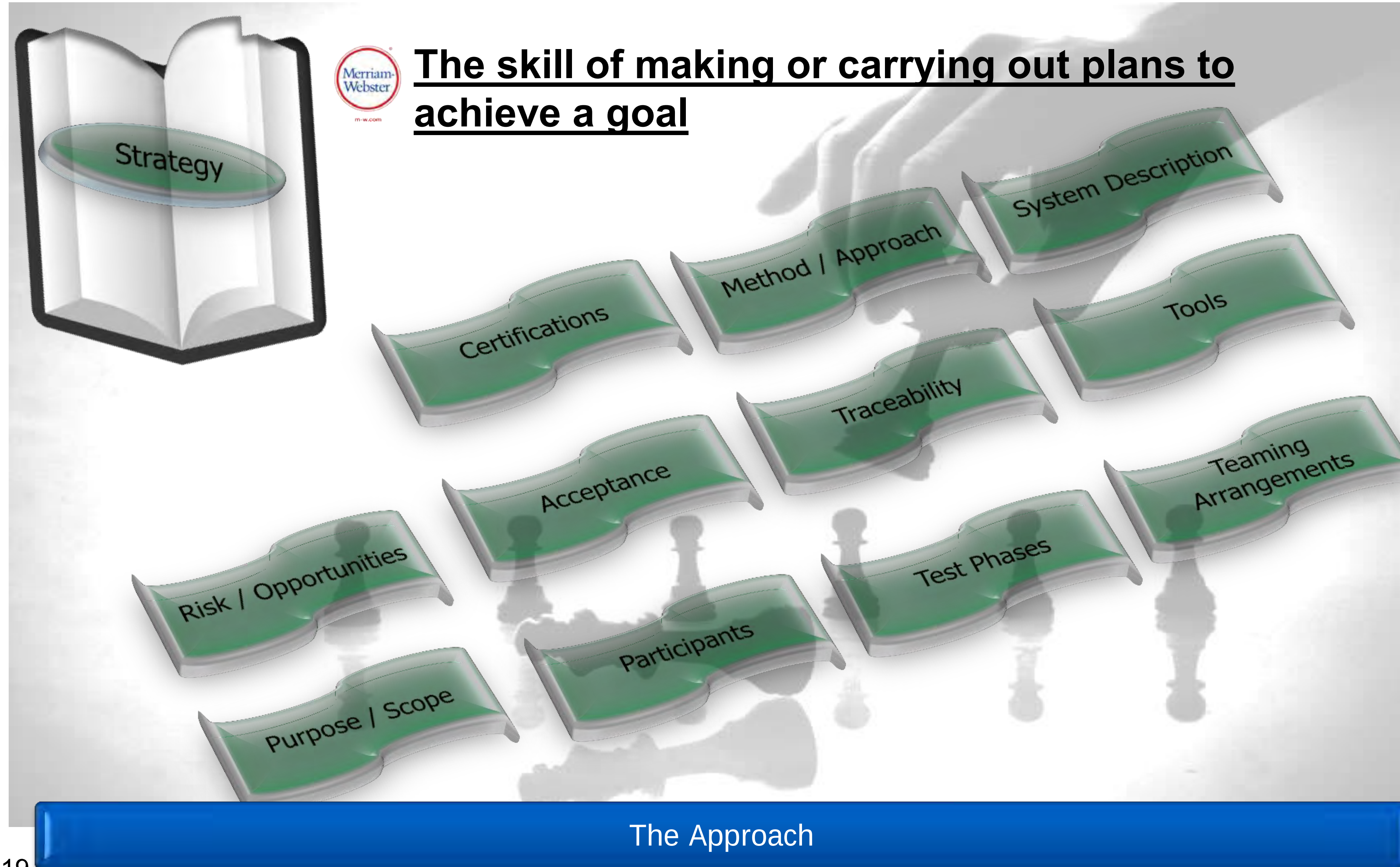
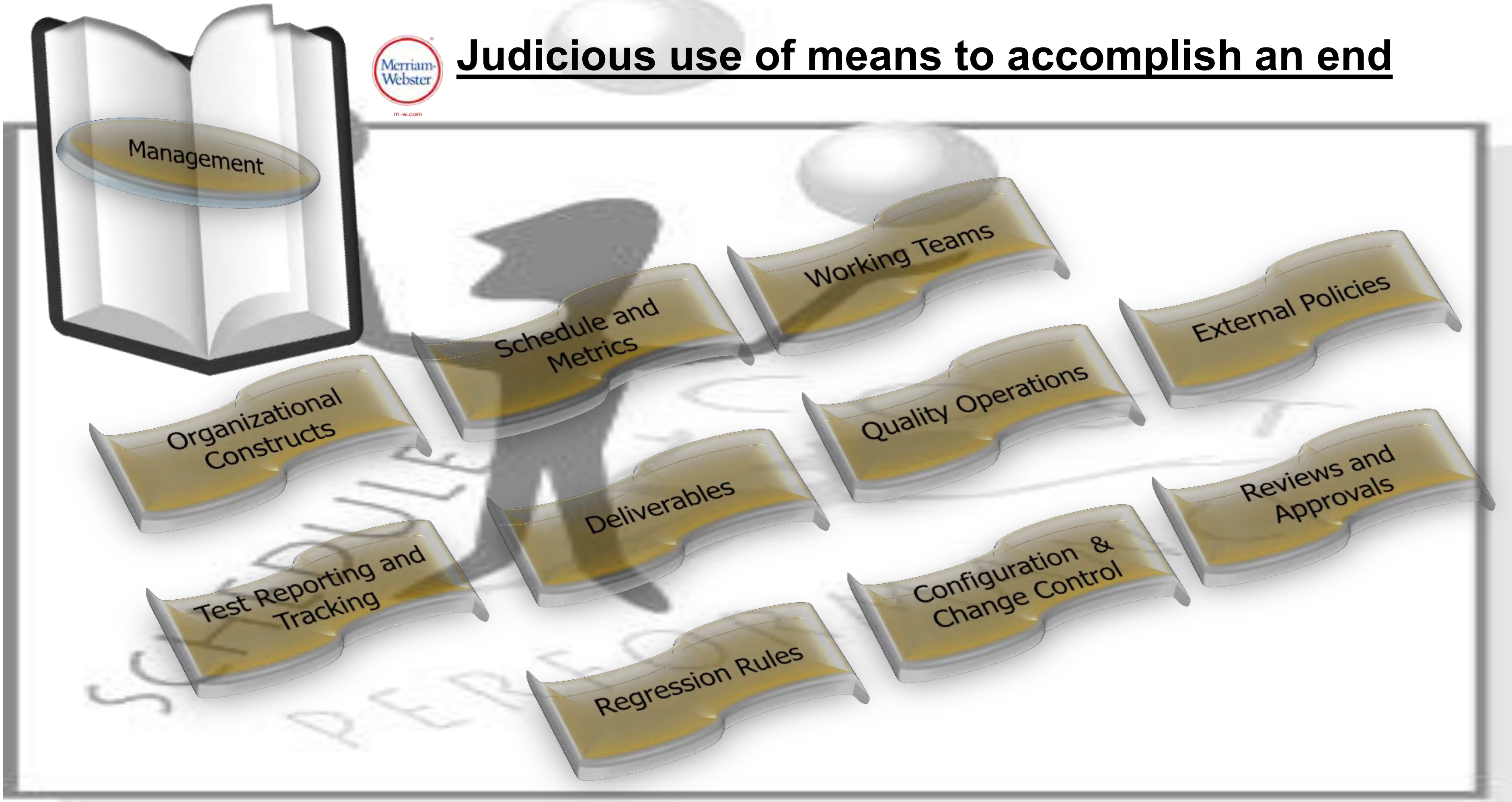


Tenet Characteristics - Management

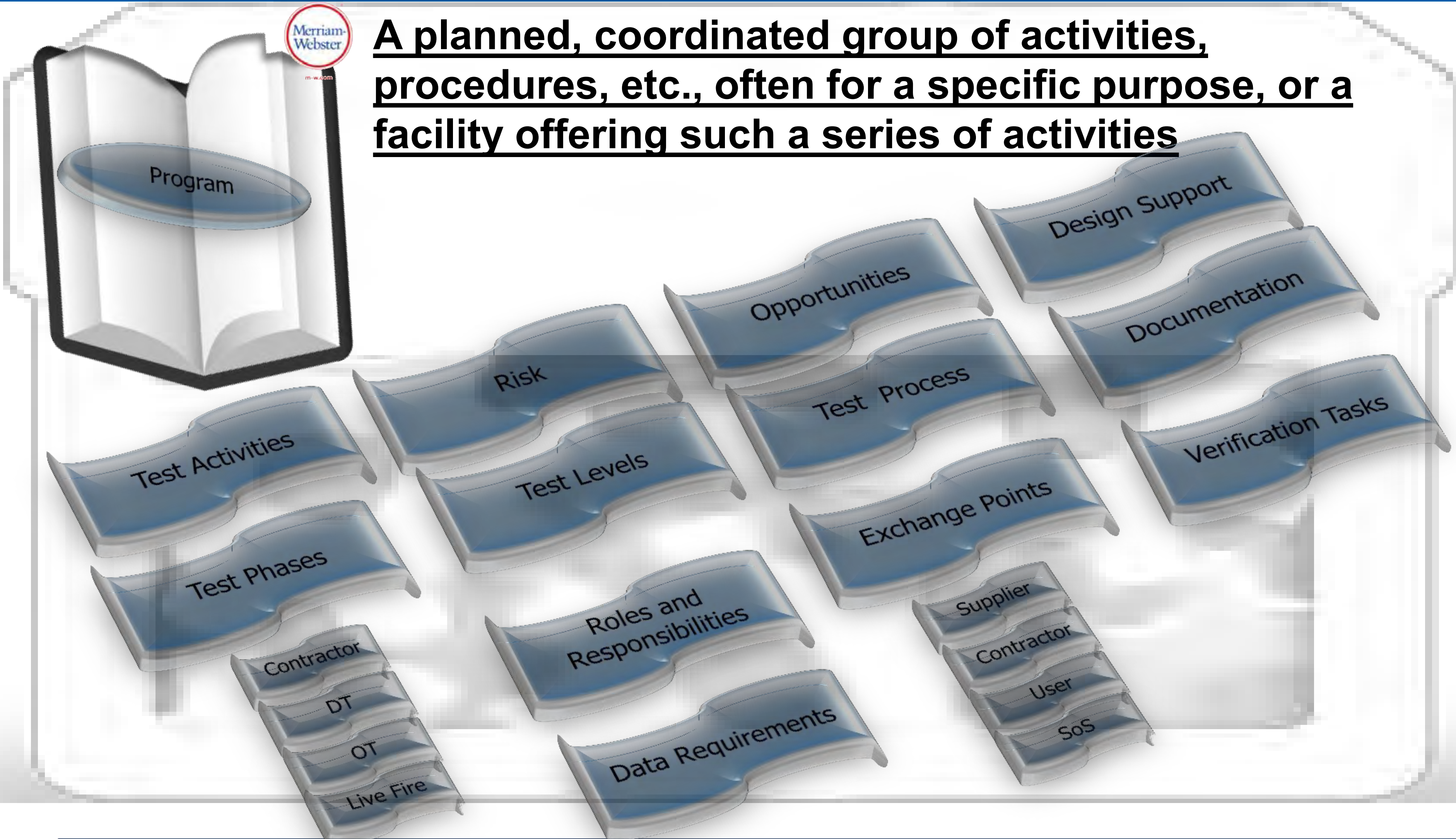
Judicious use of means to accomplish an end



Test Program Controls

Tenet Characteristics - Program

<u>A planned, coordinated group of activities, procedures, etc., often for a specific purpose, or a facility offering such a series of activities</u>



Detailed Program Activities

Tenet Characteristics - Resources

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A source of supply, support, or aid, esp. one that can be readily drawn upon when needed

Test Facilitators

Tenet Alignment ?

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Tenet	Microsoft	CDC	DoD	
Strategy	Test scope Lab test goals Not in test scope	Test Approach(s) Items to be Tested / Not Tested	Part 1&2	✔
Management	Metrics Schedule (Embedded)	Test Entry / Exit Criteria Test Deliverables Approval Schedule (embedded)	Part 3	✔
Program	Success criteria (objectives) / critical metrics risk factors Use cases	Test Pass / Fail Criteria Test Risks / Issues	Part 2	✔
Resource	Lab test participants Test tools	Test Environmental / Staffing / Training Needs	Part 4	✔

Test Plans Have Common Tenets Across Much of Industry and Government

Test Plan Data Sources

A Excerpt From The DAU T&E Course

- Test personnel must keep in mind that system test and evaluation is not limited to the technical performance of hardware and software.
- Evaluation of a complete system can include a wide range of factors, such as requirements, support requirements, arming distance, and weight.
- Evaluation of a complete system must include a wide range of factors in additional to purely technical ones, such as: training and human factor requirements, supportability and maintainability, facilities, etc.

DAU Fundamentals of Test and Evaluation Course Tst 102- Evaluation Considerations

Test Plan Input Sources
Military Program

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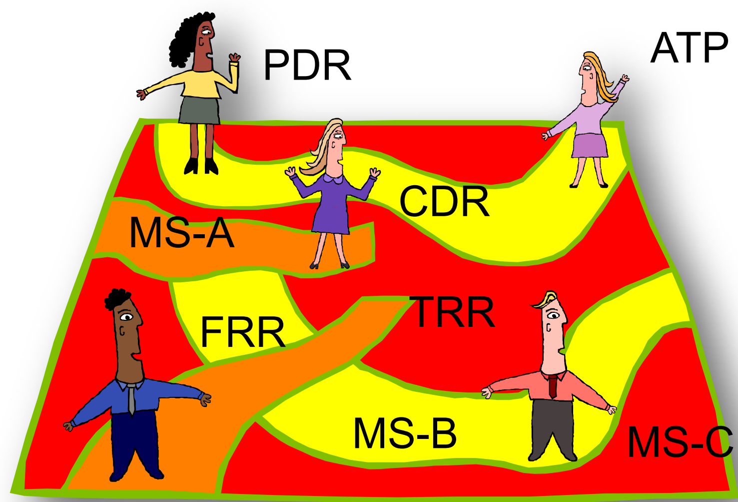
Source	Owner	Characteristic	Product	Test Plan Input
Operational Need	Sponsor	COIC, CTPs, Objectives & Thresholds	CDD, Evaluation Criteria	Measures of Effectiveness Key Performance Parameters
Test Strategy	Sponsor / Contractor	Environment	TES/TEMP/User	Test Conditions Resources
Requirements	SE	Compliance Criteria / Methodology	Specifications	Verification Criteria
Policies	Government / Sponsor Agencies/ Contractor	Environmental Concerns Accepted Approaches	Policies Standards Directives SEP	Accepted Test Approaches
Test Experience	T&E	Safe & effective test techniques	Lessons Learned, Previous Program Documentation	Test Techniques
Tech Maturation Plan	Design/ Eng	Risk Opportunities Tech Maturation	Tech Maturation Plan Risk Plan	Design Development Test Requirements
Manufacturing Strategy	Manufacturing	Acceptance Criteria	Manufacturing Plan	Testability Requirements Tools

When Do You Test Plan?

Does any of this Sound Familiar?

- How do You Plan for Testing?
  - We plan as we go
  - Our ITP / Master Test Plan is the Strategic Guide for the Test Program, we develop lower tiered plans for the detailed facility dependant tasks
  - We don't write an ITP we rely on the lowered tier plans
  - We write only what is necessary to get through the milestone delivery
  - The ITP / MTP is valid until CDR or it's equivalent
  - We use our program schedule as our test plan

- When do you Plan for Testing?
  - We build a strategic plan for early program milestones (PDR or later)
  - Our lower tier plans are developed before the test TRR
  - Once the lower tier plans are developed we rely on the test procedures to adjust the plan as necessary



When Do We Plan

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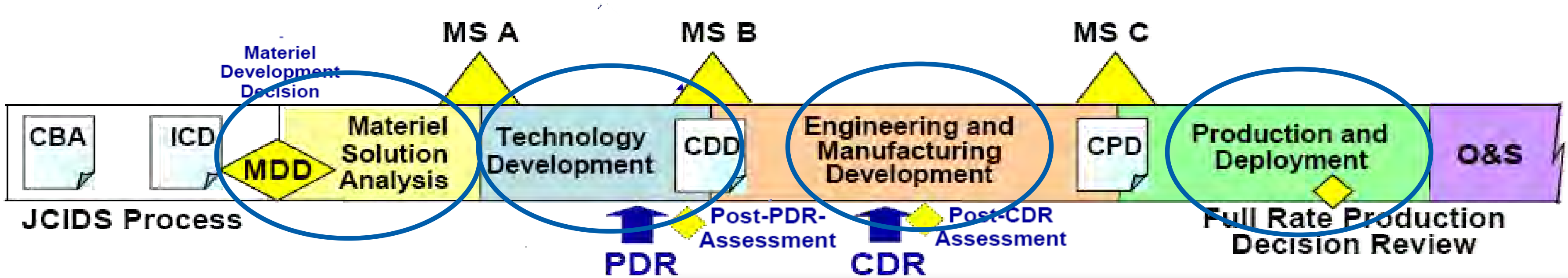
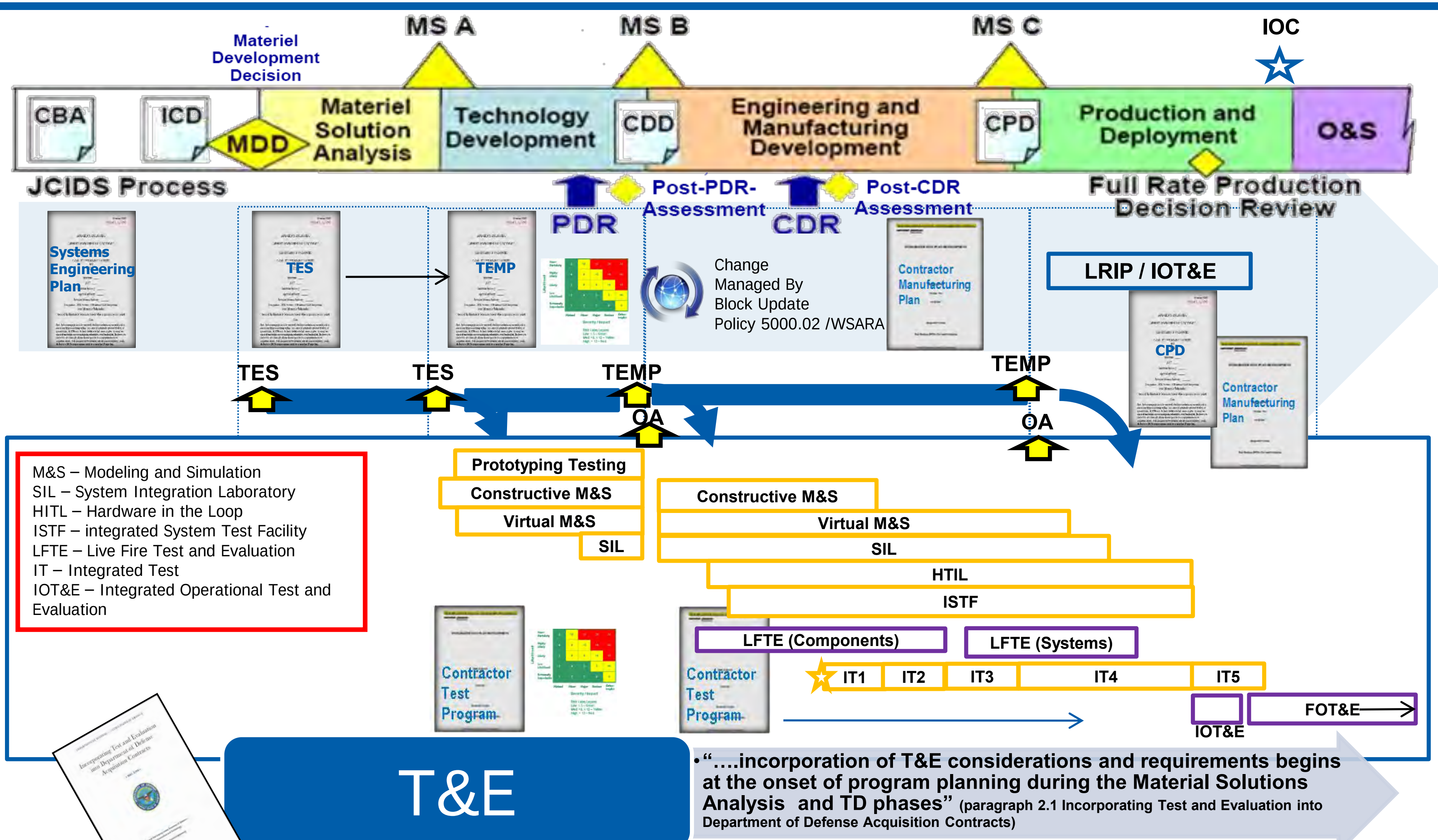


Break Into Teams

- Select a spokesperson
- Establish key test planning inputs by program phase
- Establish phases for TES, TEMP, contractor plan, DT&E and OT&E plans
- Decide the state (draft, 1st release, final, etc;) of the test strategy / plan at each program milestone
    - Ms-A, MS-B, MS-C, PDR, CDR, etc;
- Write them down
- Share with community

Test Planning- A Lifecycle Look



Intent must be maintained throughout the programs lifecycle to ensure warfighter need is provided

Test Planning – Advancing the Science

- Test planning starts at program inception
- Test planning support the development of product architecture and requirements
- Test planning requires the proper skill mix with lifecycle experience
- Test planning is a lifecycle task
- Test planning requires a collaborative, program integrated, model based tool set.
- Test planning should look front to back and not back to front
- Test planning should help decide the test techniques, not the other way around.
  - Just because you used a laboratory last time doesn't mean you need it this time.

How Do We Plan ?

How Do We Plan

- Pick a Planning Method(s)
- Pick a Planning Tool(s)
- Apply Experience
- Get Lessons Learned and Other Program Experience
- Get User Input

- Understand the Available Test Techniques
- Understand the Verification Needs
- Learn the Policies
- Determine the Sequences and Prerequisites
- Write it all Down

How Do We Plan?

- Consider an improved air-to-air missile system that requires testing—Missile A Improved. Suppose the original Missile A had an historical hit rate of 70%. The test design must evaluate whether the improved missile is at least equal to or better than the original in —taregt hit" success. How many shots do we need to make to determine the performance of the improved Missile A?

- Starting with a blank sheet of paper, the test engineer must define the appropriate number. But what is the number of shots necessary to verify the improved Missile A. Maybe the number is 3, because that is what the available time or money will support. Maybe the number is 8 because the engineer just likes 8. Maybe the number is 10 because the engineer is challenged by fractions. Or maybe the number is 30 because in life something good happens at 30! There is no statistical backing for any of these numbers, but all remain possibilities. For no particular reason, the engineer chooses 10.

Design of Experiments Applied to Flight Testing - Leslie L. Bordelon
U. S. Air Force Senior Executive Service Retired - RTO-EN-SCI-176

Traditional Test Planning Methods

- Test Team Planning Approach
  - Intuition – SME opinions, Quick and Easy, Not Much Detailed Planning Required
  - Do What We Did Last Time (DWWDLT) – Defined Trade Space, Cost and Schedule, May Not Examine New Capabilities Under Changed Environment
  - One Factor at a Time (OFAT) – Organized, repeatable, Non-interactive
  - Best Guess – Cost and Schedule Driven
  - Use Comparable Data – Adds Supporting Data, Lacks Fidelity to New Case

During the 1920s, a British statistician named Ronald Fisher put the finishing touches on a method for making breakthrough discoveries. Some 70 years later, Fisher's method, now known as design of experiments, has become a powerful tool for engineers and researchers.

Design of Experiments ?

Design Of Experiments

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"The 53d Wing (53 WG) of Air Combat Command (ACC) at Eglin Air Force Base (AFB), Florida, has used experimental design on over 25 operations in the past 14 years."

Design of Experiments Applied to Flight Testing Leslie L. Bordelon U. S. Air Force Senior Executive Service Retired RTO-EN-SCI-176

"As I review Test and Evaluation Master Plans (TEMPs) and Test Plans, I am looking for specific information. In general, I am looking for substance vice a 'cookbook' or template approach -each program is unique and will require thoughtful tradeoffs in how this guidance is applied. A "designed" experiment is a test or test program, planned specifically to determine the effect of a factor or several factors (also called independent variables) on one or more measured responses (also called dependent variables)."

Guidance on the use of Design of Experiments (DOE) in Operational Test and Evaluation J. Michael Gilmore Director OT&E 10-19-2010

Conclusion

- Some experts contend that if you are developing a new product or process, it is not the right time for DOE.
- Best suited for where interactions and effects among a handful of strictly controlled variables are of interest. In experiments with higher complexity, the number of variables must be reduced, which can result in omission of many of the possible combinations of interactions.

Bottom line: DT&E needs to investigate further, prior to issuing OSD TES and TEMP guidance on implementing DOE across the Acquisition Lifecycle

UNCLASSIFIED

12

Use of Design of Experiments to Determine the Critical Technical Parameters and Evaluation Framework in the T&E Strategy Darleen Mosser-Kerner, Mickey Quintrall 26th Annual National T&E Conference March 2nd 2010

DOE if Judicially Applied Can Aid in Test Planning Decisions

Verification
Is this Really Test?

Verification Requirements

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- Why are they Needed?
  - Verification requirements specify the verification events needed to prove the satisfaction of the product requirements and help to define the verification process and environment
  - Verification requirements are necessary for at least two reasons:
    - Existence of verification requirements demonstrates verifiability of product requirements
    - Agreed-to verification requirements define the verification program by which the contractor shows that the product is what the customer contracted for.

- How Do you Write One?
- Answer the Following Questions:
  1. **Objective - What is the purpose of this verification?**
  2. **Method - What method do you need performed? What are the verification circumstances (e.g., laboratory, desk-top analysis, flight test)?**
  3. **Environment - What are the environmental conditions under which the item will be verified?**
  4. **Special Conditions (if necessary) - Are there any unique conditions (e.g., item configurations) necessary for the execution of the verification?**
  5. **Success Criteria - What results are to expected?**

Early Test Planning Starts with Requirements Development

Verification Requirement Example

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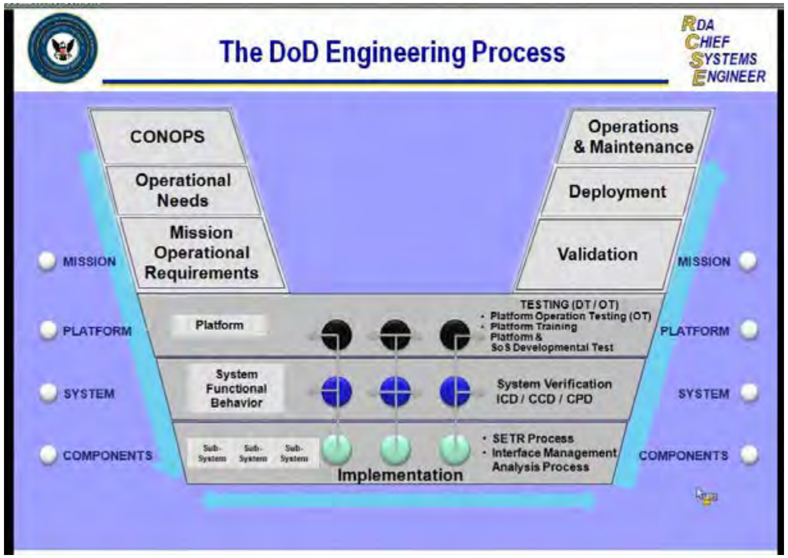
- **Requirement**
  - **The product shall provide a communications system (defined in Figure 1) capable of communicating with the recovery forces pre- and post- landing with both audio and digital communications.**
- **Verification Statement (1 of 3)**
  - **Prove that the product's communications system is capable of communicating with the ground command team by performing an laboratory within an integrated hardware/software environment. Testing will be conducted with the system operating under induced interference patterns as defined in Figure 7. Testing will show that the product can transmit and receive to standard ground recovery forces audio at frequencies represented by communications devices operating in the VHF/AM and S Band Frequency Bands. Voice communications will be measured using the Perceptual evaluation of speech quality (PESQ) P.862 defined method. Digital Communications will be measured by ensuring proper communications can be established by the receiving unit.**

Verification

- The verification program is:
  - Proof that the sponsor gets what they asked for
  - The collection of the data set which aids in the compliance assessment of a design requirement
  - The collection of data which aids in the assessment that A program has fulfilled its commitments
  - The main purposes of the test program



NDIA Systems Engineering Strategic Planning System Engineering Challenges in Naval System of Systems Ms. Helene Anderson
Office of ASN RDA CHSENG 8 December 2010 Miami, FL

Safe Testing Techniques

Safe Testing Considerations

- Apply appropriate test methodology
  - Pyramid, bottoms up, agile, regression
- Establish prerequisites to safe testing (people and product)
  - Hazardous material handling, personnel considerations, test point / envelope expansion, etc.
- Understand and comply with policies which effect test program plan
  - Ex; test range requirements ,FAA policies, space qualification standards
- Understand constraints
  - Test limits, data limits, environmental conditions
- Establish test rules and entry / exit criteria
  - Know when you have completed the test, know when you have good data
- Establish controls
  - Security, flight line policies, configuration management, equipment handling, software

Safe and Effective Testing a Mandate of Every Test Program

Test Technique Examples

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- Conduct a low speed taxi test
  - Evaluate Steering
    - Ensure aircraft travels down the runway (+/- 5 feet of center) at speeds up to and including 50 Knots.
  - Evaluate Communications
    - Ensure aircraft communications with ATC and Ground Station. Ensure no communication drop outs

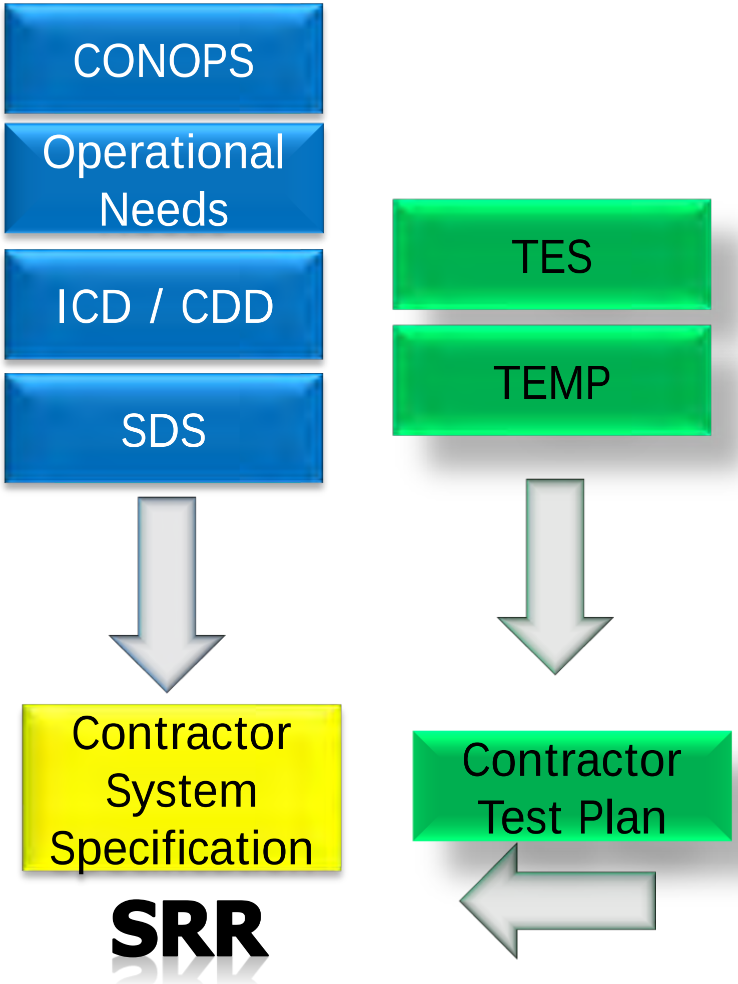
NOT EXPRESSLY VERIFICATION DRIVEN

EFFECTIVE AND SAFE TEST TECHNIQUE

A Controversy Do we or don't we?

Testing Techniques Drives Product Requirements

- The Test Plan can and often does drive product requirements
  - Flight termination system
  - Instrumentation
  - Weight
  - Power
  - Space / volume
  - Communications protocol
  - Frequency allocations
  - Others?
- T&E does generate requirements
  - Identify requirements early to avoid design impacts
    - Don't be late to need



Test Tools

Test Planning Tools

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- **What is the T&E Test Planning Tool Kit?**

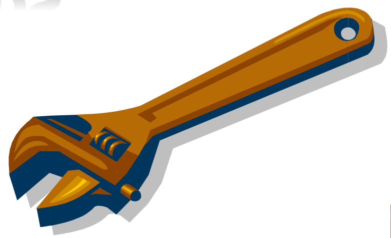
Planning	Test Design	Metrics	Assumptions
Control A Control C Control V			
Complete Model Based Test Planning – Re-plan Test Planning Streamlining Costing / Scheduling Auto Test Plan Documentation	Event Planning Test Design Test Plan Validation	Test Program Work Flow / Metrics	Test Planning Assumption Corroboration Apply and maintain Lessons Learned

If you keep doing what you're doing
You'll keep getting what you're getting!

Test Planning –vs. – Test Techniques

FLYING TEST BEDS

LABORATORIES



FLIGHT TEST

TEST RANGES

Test Planning Defines the Test Program Test Tools

Why These Techniques? – Some Examples

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LABORATORIES

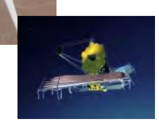
Off Nominal
Initial Integration
Interface Development
Problem Resolution
Functional Checkout

TEST RANGES

Installed Performance – Static
External Interface – Operational
Fit Checks
Low Speed Dynamics
Initial System Control
External Communications

FLYING TEST BEDS

Dynamic Integration
Dynamic Functional Design Development
High Risk Safety Activities
TRL development in Operational Environment
Targeted Off-Nominal Tests



FLIGHT TEST

Operational Environment
Operational Performance

Pick the Right Tools for the Right Job

Test Resources

Test Tools - Resources

- Name your Resources – How Many - How Long

Chambers

Engineers

Technicians

Test Range

Test Article

Test Stations

Instrumentation

Cleared for Public Release 11-0188 Stephen Scukanec Northrop Grumman 3/14/11

Test Tools - Resources

- Resources
  - Come in all varieties (facilities, equipment, people, tools)
  - Effect test execution
  - Have changing availability
  - Are required for test execution
  - Drive schedule
  - Drive cost

- Test Activities are Resource Dependant
  - There can be many resources required to execute a test
    - Think a SoS test activity
  - Resources can get lost in the change process

Test Planning Must Consider the Effect Of Resources at All Times

Putting it All Together

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Step 1
- Start the Program Right

Step 2
- Integrated Testing

Step 3
- Prove The System

Step 4
- Does it Meet the Need?

Requirements Development
- Develop Design Requirements
- Develop Test Unique Requirements
- Analyze Architecture
- Develop Verification Requirements

Test Planning
- Establish Test Model
- Establish Realistic Test Environment
- Build Integrated Test Team
- Develop Integrated Test Program

Product Verification
- Does the Product Meet the Design Criteria
- Has the Evaluations Been Conducted in a Realistic Environment
- Maintain Procedure requirements

Product Validation
- Operational Assessments
- Warfighter Use

The Test and Evaluation Skill mix is needed to help a program start on the right foot.

Effective Architecture
Solid Requirements
Verifiable Requirements
Initiate the DoD Integrated Test Program
Ensure the Design of a Realistic Test Program
Initiate Test Strategy and Integrated Planning aligned with Program Risk, Technology Development, EMD and Production
Determine Long Lead and Facilities Needs

Keeping it All Straight

The Test Planning Variables

- Collaborative
- Integrated
- Traceable
- Schedule
- Tools
- Resources
- Risk
- Techniques
- Adaptable
- Dependencies

- Facilities
- Verification
- Lifecycle Activities
- MoEs, KPPs
- Realistic Environments
- Operationally Relevant
- Deliverable
- Managed
- Sequences

AND NOW YOU WANT TO KNOW THE PROGRAM IMPACT TO A CHANGE?

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Help!!!!!!

Test Planning Tools – Minimum Requirements

- Need
  - Collaborative
  - Handle traceability
  - Can model the test plan
  - Support test optimization
  - Connected to requirements and architecture
  - Supports the verification and test planning criteria
  - Can produce test planning artifacts
  - Can provide configuration management
  - Flexible to adapt to program needs
  - Can show the —big picture"
  - Can be used by all program personnel – all skill mixes

Let's Plan

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- Review OV-1
- Review Requirements
  - Provide requirements assessment for requirements 2.5, 2.6, 2.7
  - Add verification requirement
  - Develop verification requirement for requirement 2.3.2
- Add traceability for requirement 2.3.2
- Develop test activities
  - Add flight test phase, (procedure development, test execution, report)
  - Connect appropriate verification requirements to test activities (2.3.1.C, procedure, execution, and report)
- Review Hierarchy
- Add Resources
- Connect flight test resources
- Optimize
  - Resources
  - Duration
- Produce Artifact
- Share Data

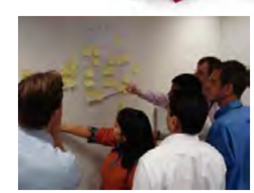

Table references are assumed to be developed correctly.

What We Covered

- Test Plan Values
- Test Plan Usages
- Test Plan Needs
- Test Plan Styles
- Design of experiments
- Test Plan Input Sources
- Verification
- Resources

- How to develop a test plan model
- How to optimize the plan
- How to produce an artifact
- How to advance the test planning science

Conclusions

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- The DNA of T&E must Change
  - Need a complete lifecycle experience
- Test planning must be recognized as the requirements set for the test program
  - Document is not just a deliverable
  - Plan does not become extinct
- Test verification and planning techniques
  - Links the systems engineering team with the test team
  - Enables collaboration
  - Fosters communication
  - Supports development of early lifecycle products
- Test tools kit must be evolved
  - Model based test plans (know you have the right plan)
  - Physics based test event validation (know your plan is right)
  - Tools must be program sizable (big to little)
  - Tools must be connected to the requirements process
  - Tools must be collaborative

Testing is More Science Than Art.

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An Industry Response to the Acquisition Changes

27th Annual National T&E Conference

Marriott Tampa Waterside

March 15th, 2011

Robert Sheehan
Director
Flight Test and Evaluation – Aerospace Systems

Steve Scukanec
Senior Test and Evaluation Engineer
Flight Test and Evaluation – Aerospace Systems

An Industry Response to the Acquisition Changes - Agenda

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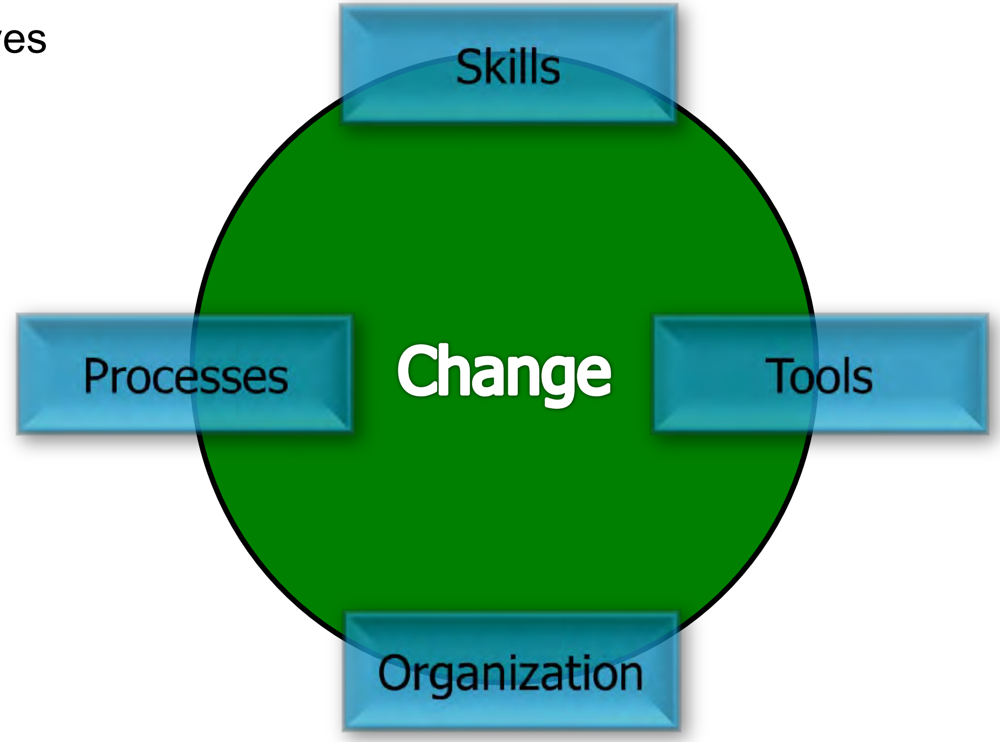
- Presentation Agenda
  - The Acquisition Reform and Initiatives
  - Change Analysis
  - T&E Keys Acquisition Tenets
  - The Transformation
  - Conclusions



"Let our advance worrying become advance thinking and planning" - Winston Churchill

An Industry Response to the Acquisition Changes

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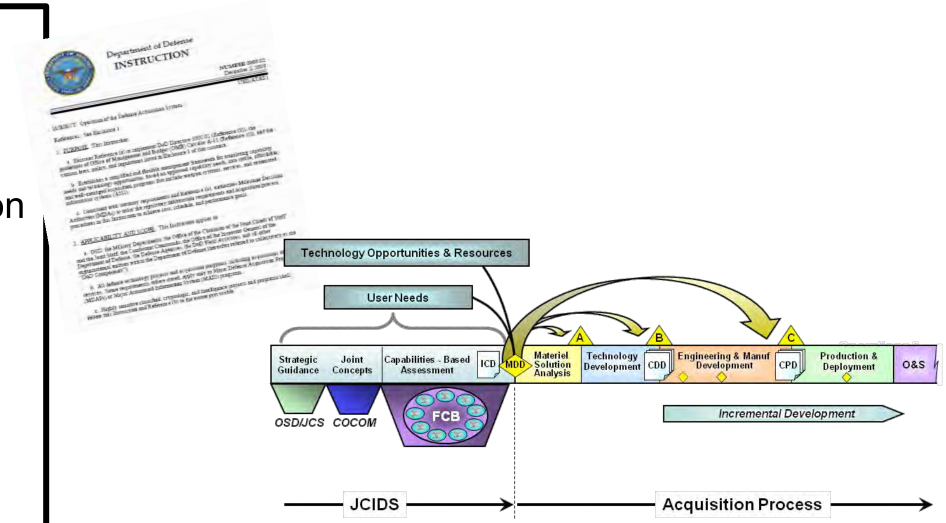
5000.02 (2008)

Significantly Revised Acquisition Policy

Earlier definition of scope, risk and cost
- Mandatory entry point
- Special procedures for IT services over $500 million

Risk Reduction
- Competitive prototyping
- Highly integrated T&E
- Evolutionary acquisition (NOT spiral development)

Enhanced Oversight
- More/more frequent assessments
- Peer reviews
- Configuration Steering Boards



WSARA (2009) Key Areas Affecting T&E

Creates Director, Developmental Test & Evaluation
- •Reviews and approves DT&E plan in the TES and TEMP for MDAPs and all programs on the OSD DT&E Oversight List
- •Monitors and reviews DT&E of MDAPs
- •Has access to all Component records and data necessary to carry out duties

DoDI5000.02&Implementation of the Weapon Systems Acquisition Reform Act of 2009 &New Changes to Policy Karen Byrd DAU Learning Capabilities Integration Center Learning Asset Program Manager May 2010

OT&E Initiatives

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- Field new capability rapidly
- Engage early to improve requirements
- Integrate developmental, live fire, and operational testing
- Substantially improve suitability before Initial Operational Test & Evaluation (IOT&E)

MEMORANDUM FOR DOT&E STAFF 24-Nov 2009 - J. Michael Gilmore Director DOT&E

Wherever practicable, **IOT&E will be conducted using low-rate initial production (LRIP) systems assembled using the parts, tools, and manufacturing processes intended for use in full-rate production**. The system will also utilize the intended production versions of software. In addition, the logistics system and maintenance manuals intended for use on the fielded system should be in place.

Memo - Use of Production-Representative Test Articles for Initial Operational Test and Evaluation (IOT&E) J. Michael Gilmore Director OT&E 18-October-2010

-"single most important step.. .is to ... execute a viable systems engineering strategy from the beginning, including a robust reliability, availability, and maintainability (RAM) program"
We know the problem persists. We know that it results in higher costs and less effective systems. We know more stringent engineering is required to deliver reliable products. To that end, **industry must be made aware that all our contracts will require, at a minimum, the system engineering practices of ANSI/GEIA STD-0009.**

MEMORANDUM FOR PRINCIPAL DEPUTY UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY AND LOGISTICS) SUBJECT: State of Reliability J. Michael Gilmore Director OT&E 30-June-2010

T&E excellence requires active leadership, **sound planning, and realistic integrated developmental testing (DT) and operational testing (OT).**

Incorporating Test and Evaluation into Department of Defense Acquisition Contracts - MAY 2009 – OUSD , AT&L

Industry Analysis of Acquisition Changes

- The New Policies Address The Hard Questions –
  - ✓Provides Good Answers
- Management of New Policies are Just Coming –
  - ✓Program Management (Customer & Contractor) Embrace the Changes
- Implementation Underway –
  - ✓New Program Implementation a Mixed Bag, Change is Hard

Policy Alone will Not Effect Change

Five (5) Acquisition Keys

Prototyping
Increase Modeling and Simulation
Focus on Needed Technology Development
Establish Operational Environment Early

Operational Realism
Establish WIPT Early
Early Test Planning
TEMP Alignment

Integrated Testing
Data Plans
Proper Contract Language
Early Identification of Data Needs
Evaluate in Proper Environment

Rapid Fielding
Slow the Requirements Growth
Test Operationally
Collaborative Test Planning

RAM
Early Manufacturing Inputs
Early RAM Simulations
Still Under Work

Key Acquisition Changes Which Drive T&E Change

The Transformation

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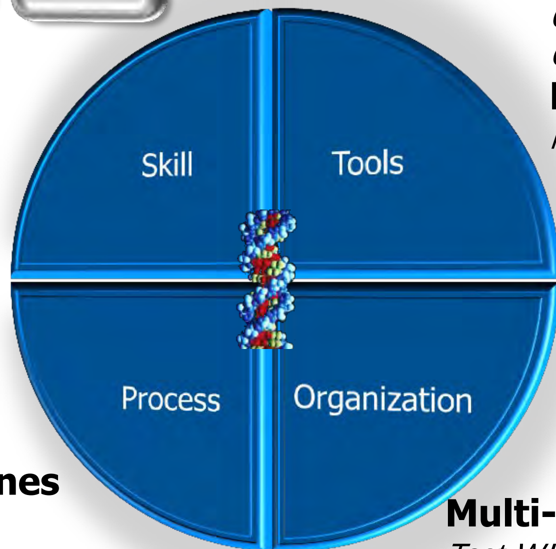
Prototyping
Integrated Testing
RAM

Training
Skill Mix Development
Enhance Test Techniques

Design Of Experiments
Modeling and Simulations
Develop RAM Test SME



Develop T&E Test Tools
Test Plan Modeling
Collaborative Test Program Dev.
Optimized Test Program
Modeling and Simulation
Physic Based , Dynamic
Test Event Evaluations

Prototyping
Integrated Testing
Operational Realism

Integrated Across Disciplines
Developed to Support Integrated Testing Concept
Establish RAM T&E Processes
Career Path Development
Rotational Programs Enhance Lifecycle Experience

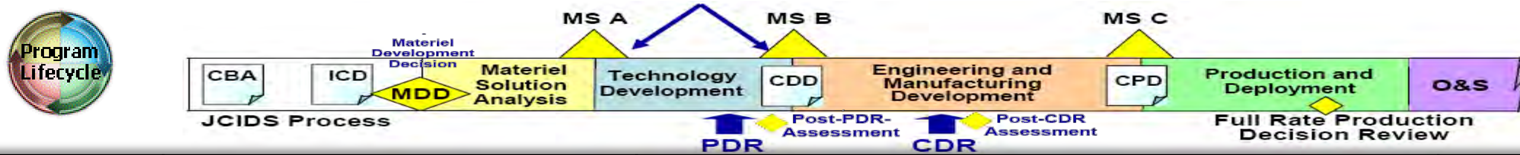
RAM
Rapid Fielding

Multi-disciplined Team
Test WIPT Established
Processes Based
Aligned / Coordinated & Integrated
Early Program Involvement
Support Good Program Start
Ensure T&E Needs Identified
Integrated Disciplines From the Start
Customer Aligned
Enhances Communications

Prototyping
Integrated Testing
Operational Realism
Rapid Fielding

The T&E DNA Requires Change to Implement the Policies

The Results



Phase	Task	Value	Product
MDD – M/S A	•Execute Architecture Analysis * •Establish Long Lead Test Program requirements •Establish Integrated Test Team •Develop Test Strategy including Technology development activities	•Testable Architecture •Initial Test Plans and Facilities Definitions Established. •Initial Requirements Based on Tested Architecture •Architecture Streamlined Testable, Essential Requirements Identified Aiding in Rapid Deployment •Event Based Test Schedule Developed	•Integrated Architecture •Schedule •Major Test Assets Identified •TES
TDP	•Conduct Requirements Verifiability Assessment * • Conduct Verification Requirement Development * •Develop Test Unique Design Requirements * •Conduct Required Prototyping / Risk Assessments •Establish Reliability Program •Establish Test Program Plan	•Verifiable Requirements &Verification Statements Development Avoids Requirements rework. •Test Unique Design Requirements Completes the Requirement Set. •Embedded Operational Realism in Test Program Helps Prove Product can meet its intended use •Support Technology Assessment / Maturation / Risk Reduction – Supply Valuable Decision Data •Support Operational Sustainment Assessment •Integrated Test Program Developed and Coordinated	•Solid Requirements •Integrated Test Program Identified and Planned •Prototyping data • Initial RMA Program Established (ANSI/GEIA STD-0009) •TEMP •Contractor Test Plan Draft
EMD	•Requirements Refined and Allocated •Integrated Test Planning •Facilities Planning and Development •Integrated Developmental Test Conduct	•Refined Verification Requirements •Conduct Consistent Test Program Through Development Cycle •On Time Establishment of Test Facilities •Coordinated Contractor /DT and OT Test Plans •Integrated and Verified Product •Initial Operational Assessments Supported	•Traditional Test Program Executed •Product Verification •Integrated DT / OT Data Available
Production	•Support Transition Support to Manufacturing	•Integrated and Tested Product	•Solid Manufacturing Process based on EMD Lessons Learned

* New Initiative To Improve Test Program Execution

Conclusions

- The Acquisition Changes when implemented will make effective changes to the Warfighter products
- The DNA of the Test Community must change to accommodate the intent of these changes
- Industry is transforming, policies and initiatives are forcing functions
- Early T&E can help programs start right
- PMs must account for early T&E in achieve the policy / initiative intent
- Change is slow, RFP language changes can increase industry change

An Industry Response to the Acquisition Changes

IN LIFE
QUESTIONS ARE GUARANTEED

ANSWERS
NOT SO MUCH

An Industry Response to the Acquisition Changes

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    Northrop Grumman Aerospace Systems
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Marine Corps Operational Test & Evaluation Activity

NDIA 27th Annual National Test and Evaluation Conference

Shannon Krammes, Decision Sciences Lead

March 2011

Impacts of the Learning Curve Operational Test and Evaluation

Operational Testing Challenges

NDIA Abstract (Agenda)

- In the conduct of operational testing MCOTEA often experiences operator learning curves.
- Operator learning curves can be a nuisance to distinguishing between true system operational performance and operator learning.
- How MCOTEA assesses the learning curve prior to commencement of the record test portion of operational testing.
- Application of the learning curve data as a means to evaluate new equipment training packages, training systems, and formal training programs.

MCOTEA Mission

MCOTEA provides operational testing and evaluation on behalf of the Marine Corps and conducts additional testing and evaluation as required to support the Marine Corps mission to man, train, equip and sustain a force in readiness.

Why Do We Care?

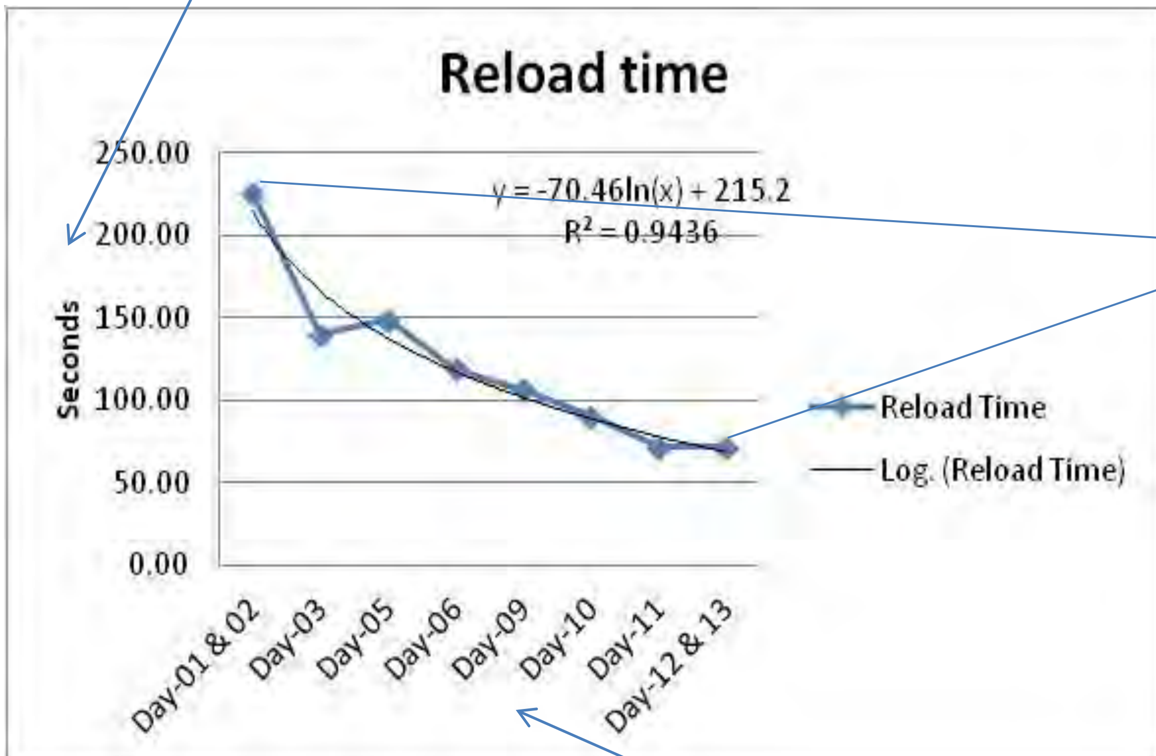
- MCOTEA evaluates the system…and the system includes the operators and training.
- Operational Test Readiness Review
  - Training documents have been provided to the OTA 30 days prior to the OTRR.
  - Training has been completed and is representative of that planned for fleet units.
  - The OT&E manning of the system is adequate in…experience level to simulate normal operating conditions.

What is a Learning Curve?

- When several trials are given in an experiment and measures of learning or of retention are obtained, these measures may be plotted in the graphic form known as a learning curve, a graph which affords a comparison of the performance on each trial with a performance on other trials.[1]

Learning Curve Example

Dependent Variable (reload time)

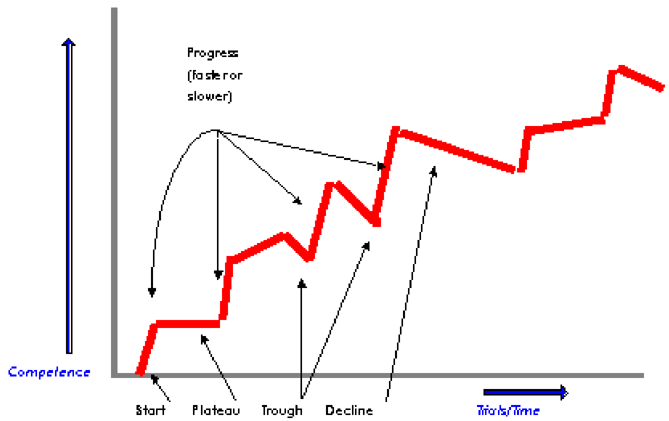


68.42% Improvement?

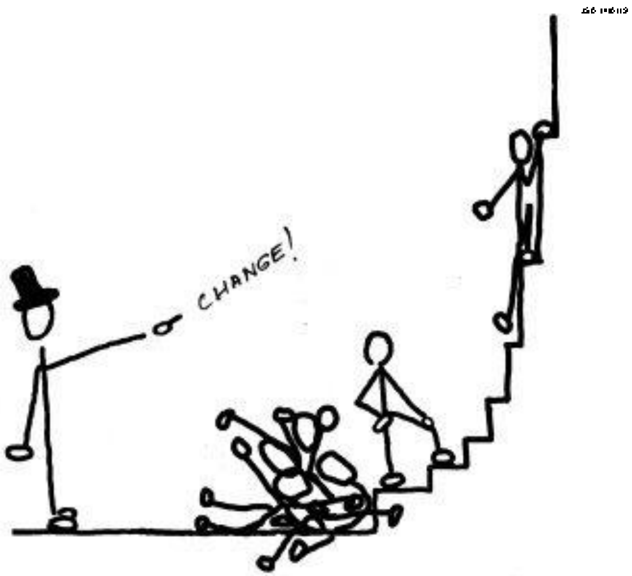
This example depicts a negative acceleration curve showing a decrease in the rate of gain.

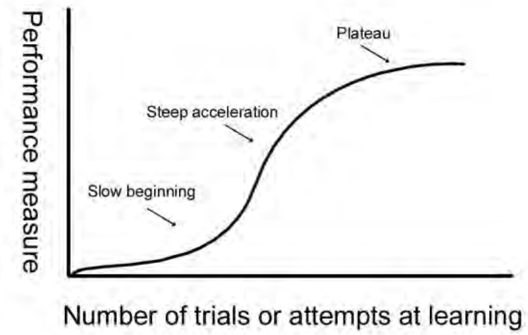
Independent Variable (trials)

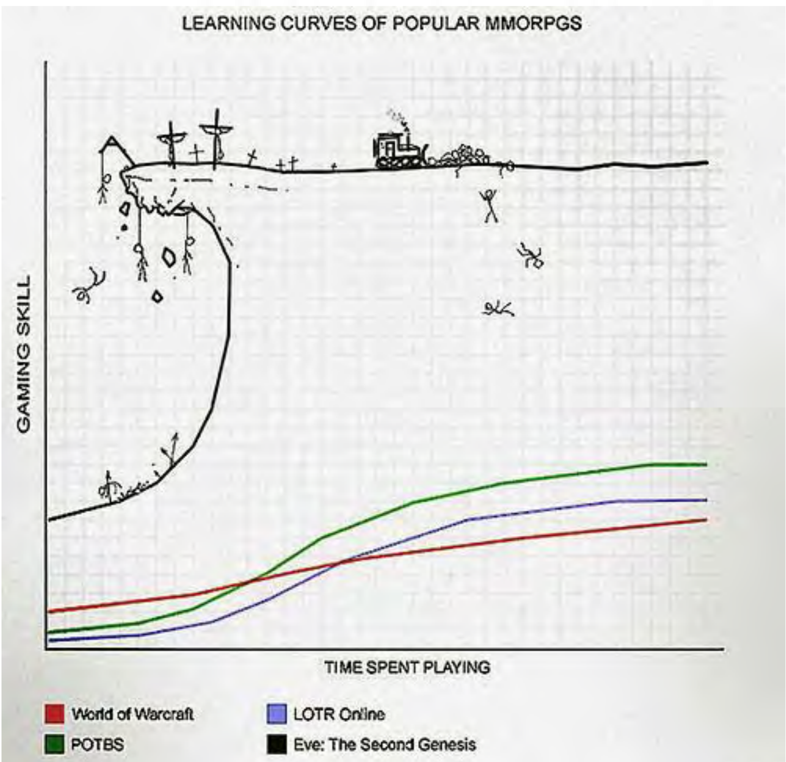
Other Learning Curves



A Learning "Curve" is far from a straight progression







Why Learning Curves?

- Operational testing lessons learned
  - New systems
  - Discovery of training inadequacy
  - Structure of forces (cohesion)
- Distinguishing between true operational performance and operator learning
- Training and proficiency

Mitigation Prior to Record Test

- Test Design
  - Randomization
  - Control
  - Replication
- New Equipment Training evaluation
- Extended pilot test
- Training certification
- Continuous evaluation

Learning Curve Applications

- New Equipment Training packages
- Training systems
- Formal training programs

Questions?

Marine Corps Operational Test and Evaluation Activity (MCOTEA)

Shannon Krammes

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BACKUP SLIDES

References

1. Garry, R., and Kingsley, H.L. The Nature and Conditions of Learning, Prentice-Hall, Inc., New Jersey, 1970.

Potential Models

- Henderson's Law (power law function)
  - $C_n = C_1 n^{-a}$
    - Where
      - C_1 is the cost of the first unit of production
      - C_n is the cost of the nth unit of production
      - n is the cumulative volume of production
      - a is the elasticity of cost with regard to output
- Exponential Model

Contact Information

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NAVSEA WARFARE CENTERS DAHLGREN

Low Cost UAV Runways

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Unmanned System Safety and Operations Director
NSWC Dahlgren, G66 Test and Evaluation,
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March 15, 2011

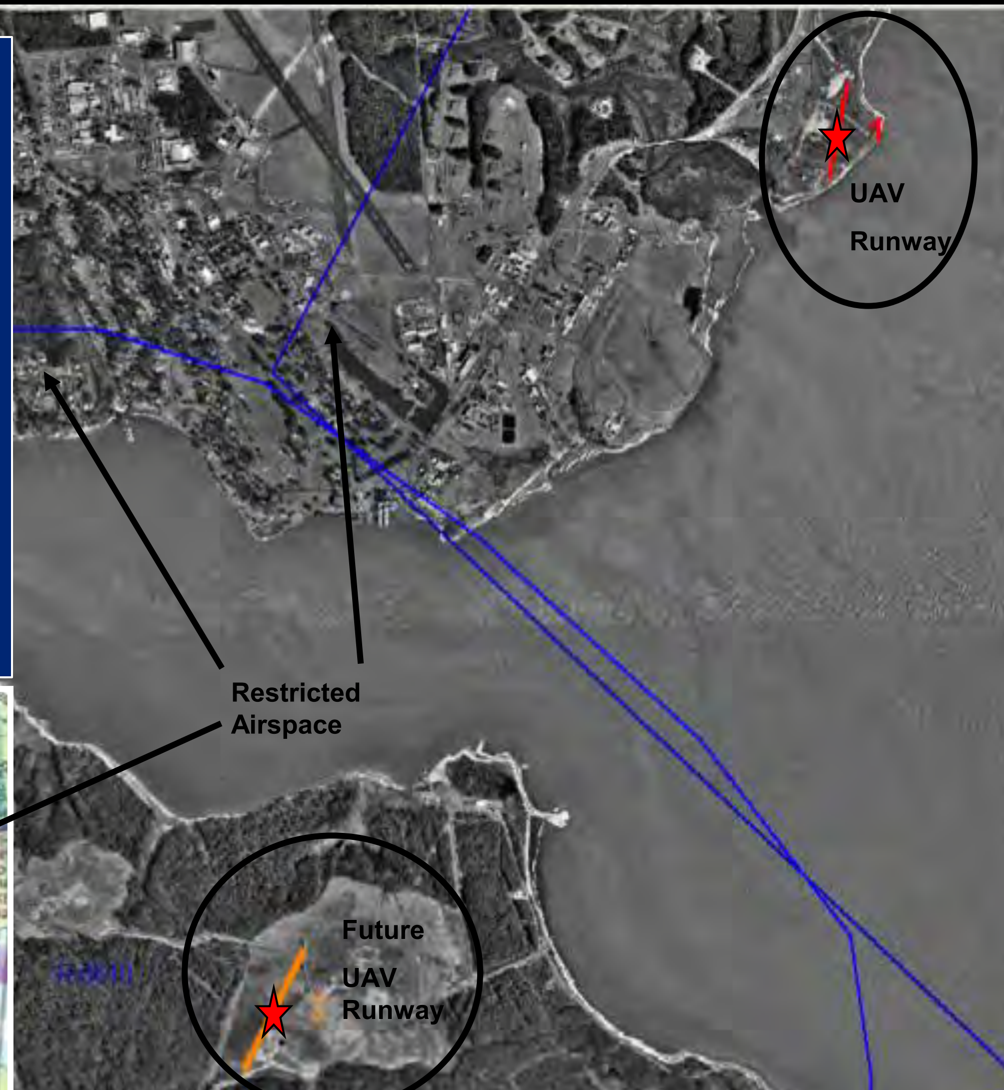
Why UAV Runways?

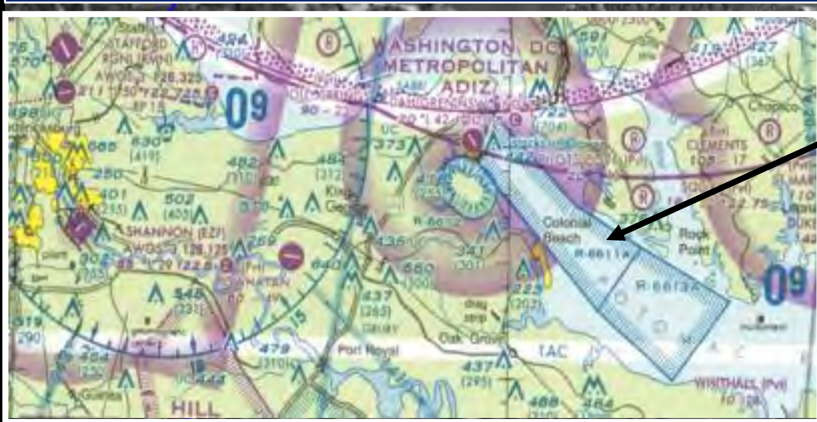
NSWC Dahlgren Base Runway outside the Restricted Airspace!

1. Launch & Land in Restricted Airspace (no FAA COA required)
2. Population or Building over-flight issues
3. Separating Manned & Unmanned Aircraft
4. Expeditionary Runways for Theater
5. Hazardous Testing at Remote Sites

Runway Siting

- Away from People and Property
- Within Restricted Airspace
- Minimal Terrain
- Minimal Obstructions
- Minimal Manned Air Traffic
- Align with Prevailing Winds
- Consider UAV Traffic Pattern
- Consider Environmental Factors
- Consider Required Approvals





UAV Runway Surface Types

- Concrete
- Asphalt
- Expeditionary Mats and Grids
- Dirt
- Chip Seal
- Geotextile ?

Geotextile Runways

UAV

RC

- ¼ the cost of Asphalt
- Can be expanded / re-configured
- Semi-Permanent
- 3-7 year life
- Permeable / Environmentally Friendly
- Can be paved later

Distribution Statement A

Runway Type Comparison

Type	Approx. Life (Years)	Approx. Max Wheel Load	Approx. Cost (UAV Application)
Concrete International Airport	20-30	>45,000 lb	$ 38 /SY (4”)
Asphalt National Airport	15-20	< 35,000 lb	$ 18 /SY (2”)
GFI Mats Military	15	<30,000 lb	$100/SY
Dirt Private Airport	1	0-30,000lb weather dependent	$ 2.75 /SY
Chip Seal NZ Light Duty Field	3-5	< 5,000lb	$ 6.25/SY
Geotextile RC and UAV field	3-7	150 lb Tested (higher likely)	$ 4.6 /SY

NAVSEA WARFARE CENTERS DAHLGREN

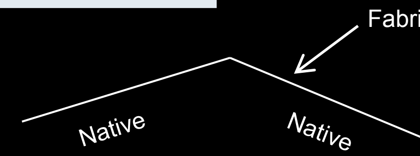
Geotextile Runway Life

Construction can be Phased

1

Fabric on Soil

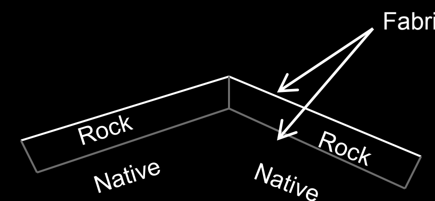
- 2-3 Year Life
- Expeditionary



2

Fabric on Rock

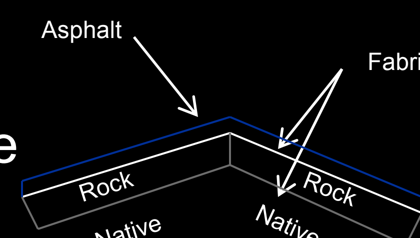
- 4-7 Year Life
- Semi-Permanent



3

Asphalt over Fabric

- 15-20 Year Life
- Permanent



Distribution Statement A

Cost Example 1350 ft x 60 ft

- Clear, Grub and Roll:
  - 3 men, Dozer, Loader, Truck and Roller; 1 week= *$25,000*
- Fabric Cost:
  - 10,350SY x $1.85= *$19,000*
  - 5 men 1 week= *$22,000*
- Paint and Misc=
  - *$ 8,000*

Construction Cost: $75,000

- Clear, Grub and Roll: *$25,000*
- Separator Fabric: *$5,400 + $5,300 labor*
- 6” Crushed Rock: *$55,000 + $25,000 labor*
- 2” Asphalt: *$160,000*
- Paint , Drainage and Misc: *$ 20,000*

Construction Cost: $295,000

Planning CONUS

- Site selection
- Approvals
  - Base / Municipality
  - FAA
  - Environmental Permits
  - Other: Explosive
- Topographic Survey
- Geotechnical Report
- Design
  - Size
  - Orientation
  - Cut & Fill
  - Drainage (crown 1-2%)
  - Pavement Section
  - Striping
  - Plans, Specs Estimates
- Contracts and Bids

Planning Time: 1-3 years

Planning Expeditionary

- Site selection
- Approvals
  - Base / FOB
  - Local Authorities
- Design
  - Size
  - Orientation
  - Striping
  - Drainage
- Organize Work Party

Planning Time: 1 month

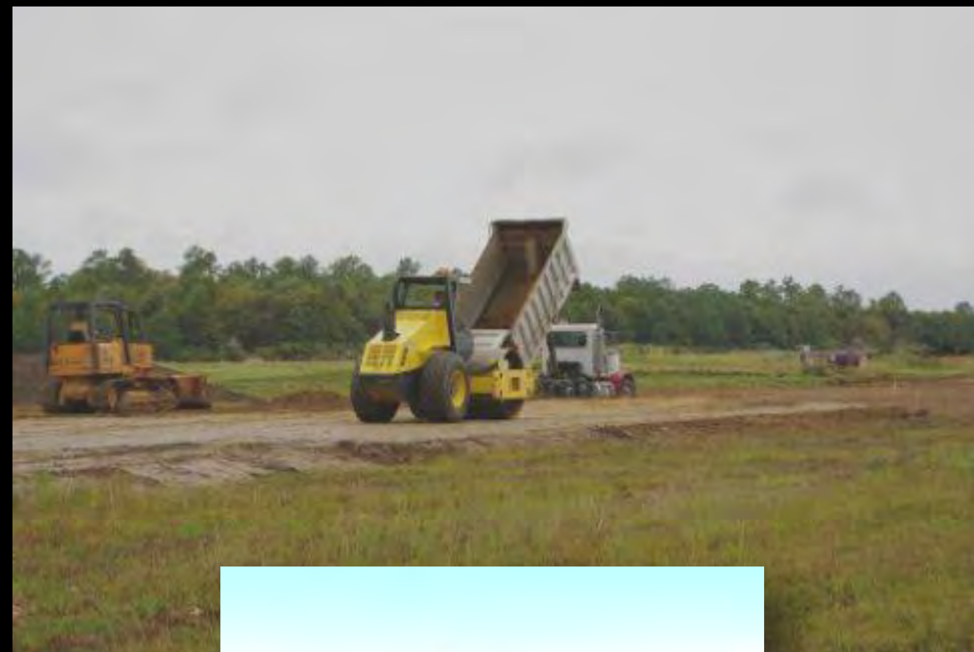
NAVSEA WARFARE CENTERS DAHLGREN

Construction Steps

Distribution Statement A

Construction Equipment

- Bulldozer
- Surveying Level
- Grader
- Roller
- Dump Trucks



Must have

at minimum**

Distribution Statement A

Construction Survey

- Transfers the design onto the ground
- Stake centerline
- Elevation stakes
- Survey Contract or simple $300 level

Excavate and Compact

- Remove Organics
- Remove obstructions
- Prepare and compact sub-grade
- Herbicide to prevent growth
- Pipes (if required)

Build up UAV Runway Section Expeditionary

Fabric on Soil

Staked US 230 Geotextile Surface

Graded & Compacted

Native soil

Build up UAV Runway Section Semi-Permanent

Fabric on Rock

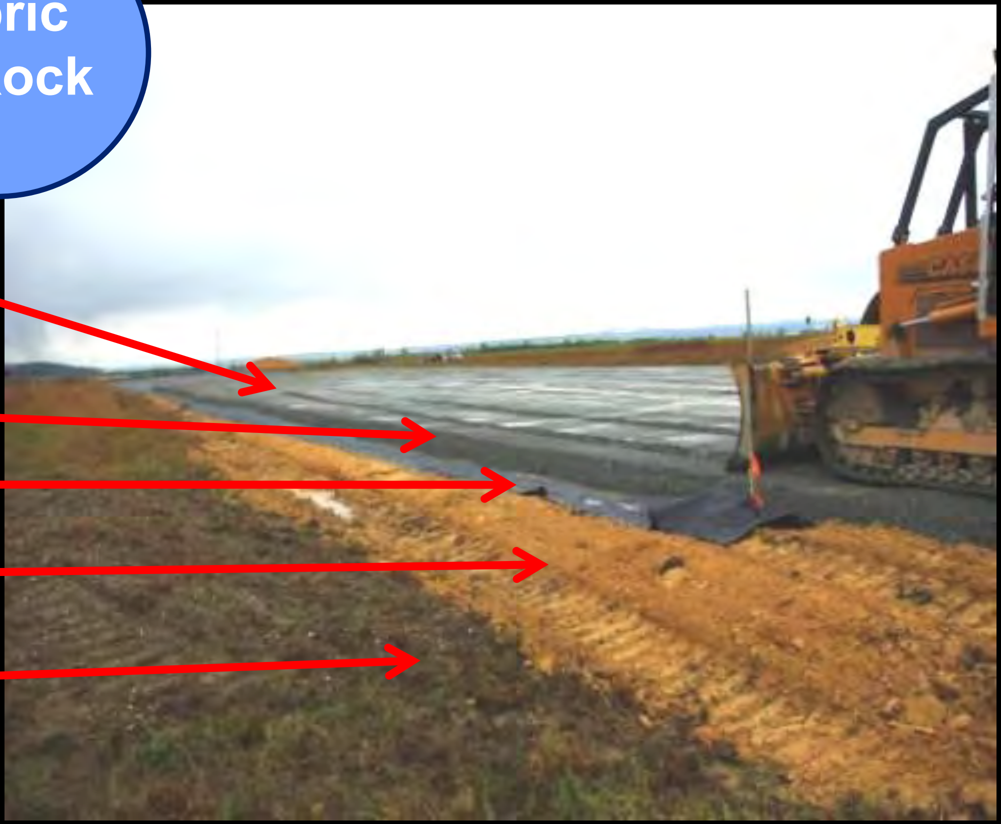
US 230 Geotextile Surface (not shown)

6” Crushed Gravel

US 200 Geotextile

Fill

Native soil



Distribution Statement A

Placing Geotextile Surface

- Check for tears at Roll ends and remove
- Keep Rolls running straight
- Apply Tar on seams 6” min, 12” max overlap
- Anchor runway edges under rock if available

Distribution Statement A

Staking Geotextile Surface

- Use landscape stakes or nails with washers on 1-2ft centers
- Fold horizontal seams and nail
- Do not pull fabric too tight. Leave some minor wrinkles
- Sun will heat and stretch surface ‘drum tight’

Striping the Surface

- Use Temporary X's
- Follow FAA Standards for Airport Markings

  AC NO.150/5340-1
- Do Not use Runway number markings. Use 'UAV' instead
- Use large 60' x 60' Yellow Xs every 1000' per AC 150/5340-1
- Standard Latex Road paint
- Paint 'Rotor Wing Prohibited' in 20' letters on center of runway

Final Touches

- Prevent Vehicles from driving on runway
- Remove Flight Obstructions
- Place Wind Sock
- Tar over Nails
- Seeding
- Access Ramps
- Electrical hook-up

Upkeep

- Walk Runway before every flight
- Remove debris and weeds
- Sweep if required
- Repair rips and tears with tar and patches
- Check for protruding Nails / Stakes

Questions ?

Distribution Statement A

Marine Corps Operational Test & Evaluation Activity

NDIA 27th Annual National Test and Evaluation Conference

LtCol Michael Kennedy

March 2011

Effective Combat Data Collection & Applicability to T&E

Agenda

- Background
- Command Relationships
- Applicability
- Collection Methods
- Data Opportunities
- Limitations
- Evaluation
- FOA XV
- Questions

Background

Forward Operational Assessment Data Collection:

2003 - Department of the Army G3/G8 tasking designated ATEC as the primary agent for OIF/OEF system assessments

2003 - Operational Assessment (OA) team I deploys for 47 days to Afghanistan, Iraq, and Kuwait

2004 - OA team II deploys for 33 days to Afghanistan and Kuwait

2005 - OA team III begins the first six month rotation of a continuing FOA presence to conduct operational assessments on systems that included Rapid fielding initiatives (RFIs) and equipment procured due to urgent materiel release (UMR) requests generated in theater

2010 - Discussions between MCOTEA and ATEC resulted in the attachment of a MCOTEA Assessment team with FOA XV from August 2010 through February 2011

2011 - FOA XVI is currently deployed with a MCOTEA team attached

Command Relationships

- Component Command
- ISAF Regional Commands
- Parent Command
- Mobility / Transportation
- Logistics and Communications

Applicability

- Data collected in a forward operations area can be used to supplement current, validate previous and guide future test and evaluation
- Data collected is from the system as used by deployed forces conducting actual missions and is subject to variables that would confound formal T&E
- Assessments based on available data, not controlled test events

Collection Methods

- Clearly identify your Data Collection Plan
- Understand the reality of the environment
- Flexibility during execution
- Minimize impact on Operational Units
- One chance to get it right
- CONUS data collection is preferred

Data Opportunities

- Maintenance Reports
- Logistics Reports
- Operations Logs / SIGEVENTS
- Electronic Data Collection
- Integrated Data Collection
- Forensics
- After Action Reports
- Surveys
- Interactive

Limitations

- Mission / Current Operations
- Access to system under assessment
- Availability of test instrumentation
- Unit exposure to system
- Tactics, Techniques and Procedures
- Environment
- Unit personnel turnover

Evaluation

- Understand what information decision makers need / want
- Assessment Evaluations should provide Operational Force Commanders with timely, concise, understandable information
- FOA is only one of multiple sources for gathering information
- Performance Conclusions should be limited to Data Adequacy inherent in a combat environment
- Operational Assessment data evaluation can identify issues for further investigation through formal T&E

FOA XV

- Systems assessed for USMC:
  - Counter IED Systems
  - Experimental (Green) Energy Systems
  - Biometrics Systems

Questions

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OSD Perspective of DT&E in Navy Shipbuilding Programs

Do Additional DT&E Opportunities Exist?

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15 March 2011

Outline

- Shipbuilding vs. other DoD acquisitions
- Challenge of Shipbuilding DT&E
- New Approach for DT&E on Ships
- Shipbuilding DT&E Best Practices
- PARMs
- Summary
- Q & A

Shipbuilding vs. Other DoD Acquisitions

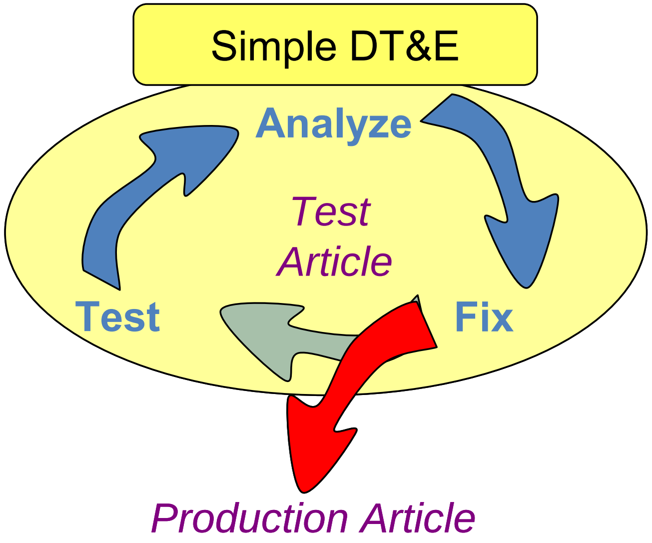
- Limited use of Prototypes, EDMs, "Fly-before buy"
  – Prohibitive cost for test articles
- Larger Scope
  – Long construction time leads to parallel design and building
- Complexity
  – Many programs in one (i.e., weapons, propulsion, aviation, C^{4}I, navigation, habitability, etc.)

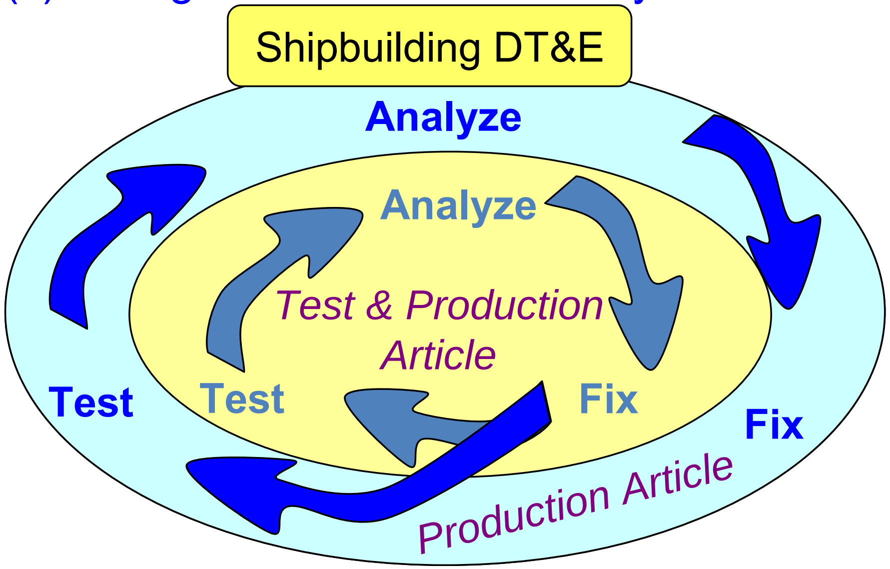
- System-of-systems (SoS)
  – Virtually all mission capabilities require interaction of numerous sub-systems and components
  – Many SoS consist of mix of new and old systems or components
- Performance and schedule highly dependent on Participating Acquisition Resource Managers (PARMs)

Shipbuilding T&E Process
Inherently Leads to a Different T&E Approach

Challenge of Shipbuilding DT&E

- First ship is the test article in shipbuilding T&E
  - Is ultimately a production article
  - Often no time for test-analyze-fix in shipbuilding trials
  - Multiple follow-on ships being built while DT/OT being conducted on first of class
- Fixes often limited to mission-critical discrepancies
- Lower priority discrepancies are often forward fit to future hulls
  - Possible back-fit to early hull(s) during future maintenance cycle





A New Approach for DT&E on Ships

- Opportunities for concurrent DT&E and OT&E throughout Shipbuilding T&E continuum
  - Industrial Stage Tests
  - Fast Cruise
  - Builder's Trials
  - Acceptance Trials
  - Post Delivery Test and Trials
  - Certifications
    - Aviation, ATO, HERO, UNREP SQT, CSSQT,etc

- Eliminate duplication, optimize efficiencies, increase opportunities to find & fix problems
- Requires access, partnerships, data sharing -- represents challenges
- A true acceptance of Integrated Testing across the T&E continuum

Taking Credit for ALL TESTING

Shipbuilding DT&E Best Practice

- Critical Risk Mitigation is done on Major Components at Land-Based Test Sites
  – Surface Combat Systems Center, Wallops Is
    - SSDS, AEGIS, DDG 1000
  – Test & Integration Facility (TIF), Charleston, SC
  – NAVSEA Panama City – LCS MCM MP
  – NAVSEA Dahlgren – LCS SUW MP
  – NUWC, Newport, RI – LCS ASW MP
  – DDG 1000 Integrated Power System LBTS, Philadelphia, PA
  – NAVAIR, EMALS/AAG, Lakehurst, NJ
  – NAVSEA Carderock, Acoustic Research Detachment – Lake Pend Oreille, Idaho
  – VASCIC, CVN-78,Newport News, VA
  – COATS, SSN-774,Groton, CT

What Other Testing is Being Done That Can be Used for DT&E Credit to Reduce Risk going into OT?

PARMs

- Participating Acquisition Resource Managers (PARMs) are responsible for developing their system independently, while meeting a defined in-yard date
  - Usually not under shipbuilding PM control
    - Relieves workload/But no direct authority
  - PARM can be resident from different PEO or SYSCOM
  - Matrix like: PM funds task/PARM funds staff

- PARMs add flexibility and efficiency by developing systems and equipment in parallel with ship construction
  - Ship PM defines interface specs
  - PARM develops sub-system solution
  - Ship schedule, cost and performance highly dependent on PARMs
- Challenge: Who is the systems integrator?

PARMs – Big Payoff if Successful

Summary

- Shipbuilding is different from other acquisition programs
  - Our approach to Shipbuilding T&E also needs to be different
  - Shipbuilding has a long cycle time to complete a test article
  - Test article is always a production article
  - Multiple follow-on ships are already well into construction when DT/OT are being conducted
  - All “fixes” need to be incorporated on all of these ships post-test
- Ships and their major components go through a plethora of testing before DT/OT
  - Many of these can be used as opportunities for DT/OT
  - Use of LBTS is a best practice that pays dividends
  - What other testing is being done that can contribute to DT&E?
- Must take advantage and credit for developmental testing
  - Will ultimately lead to more efficient and successful development

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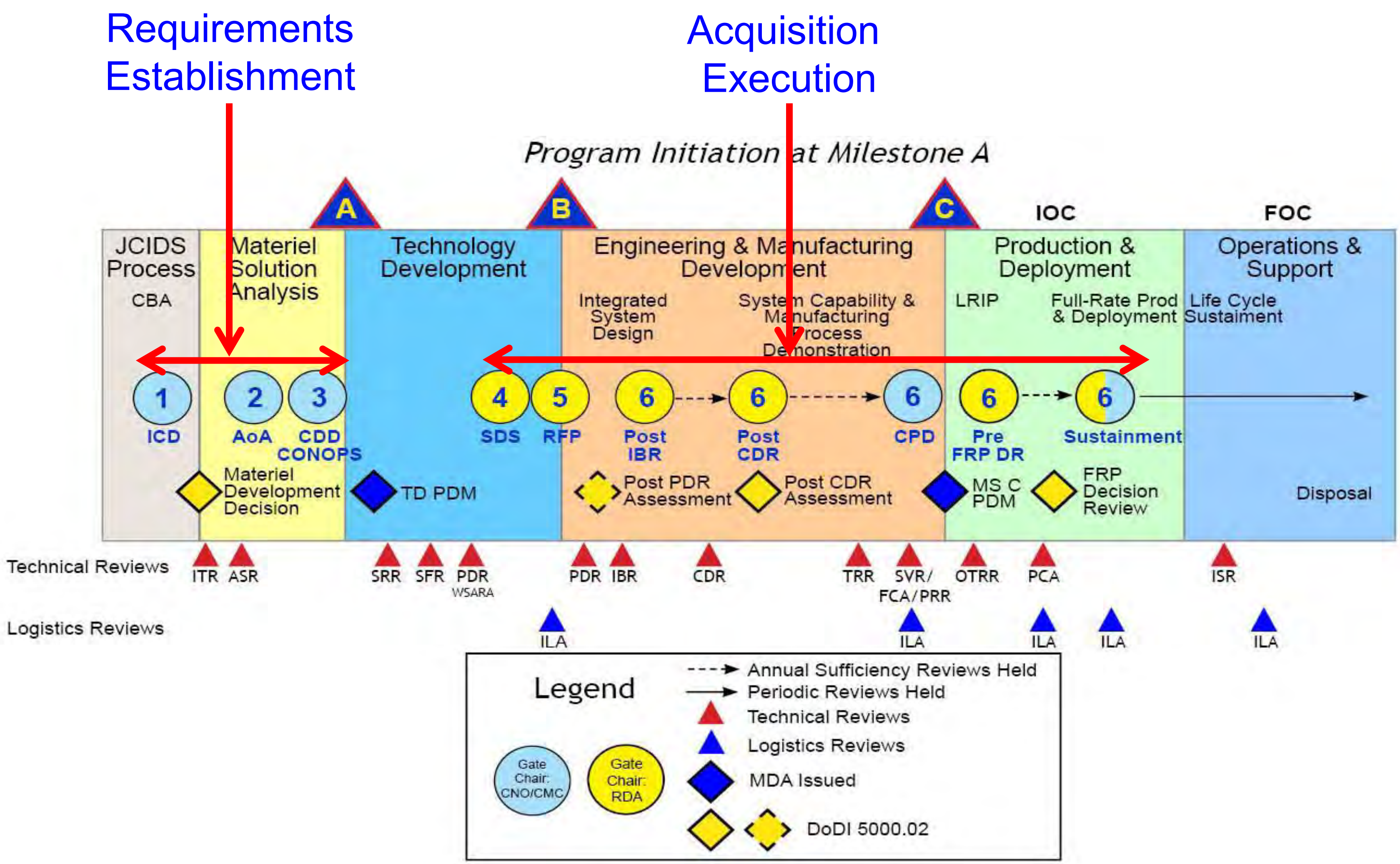
Visit our website: http://www.acq.osd.mil/dte/

Back-ups

Does NAVSEA Have an RTO?

- Not by name, but many programs have an RTO by function
- Example: NAVSEA Port Hueneme Division (NAVSEA PHD) is non-AEGIS ship combat system RTO
  - SSDS In-Service Engineering Agent (ISEA)
  - Combat systems test lead for CVN, LHA, LHD, LPD, LSD ship classes
  - Operates the Self Defense Test Ship
  - With NAVSEA Dahlgren Division, performs systems integration at the Carrier and Amphib Land Based Test Site at Wallops Island, VA
  - Test conductor for all DT&E events on Pt. Mugu, CA range
  - Frequently assigned as COMOPTEVFOR trusted agent for OT&E data collection and test support

Navy Gate Review Process



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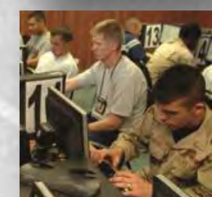
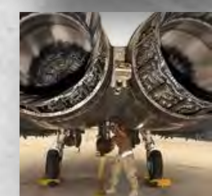
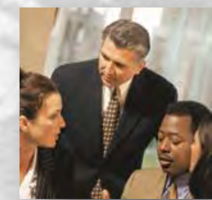




Understanding the Mission – A "How-To" Guide for MBT&E Practitioners

Large company practices. Small company responsiveness. Working for YOU.

Britt Bray
Department Manager and Senior Military Analyst
15 March 2011



Purpose and Agenda

- Purpose: To explain the process and logic for specifying an understanding of the mission (MBTE Step 1)
- Agenda
  - Introduction
  - Where the Mission fits in the MBT&E framework
  - Warfighting 101 – Analyzing the Mission
    - Mission? What Mission??
    - Analyzing the mission
    - Decomposing the mission into tasks
    - Determining conditions and standards (i.e. MoPs and MoEs)
  - Translating tasks from native language to common language
    - Authoritative Task Lists
    - Capturing the results
    - An alternative approach
  - Questions to ask

Mission Role in MBTE

ATEC

Why? - Acquisition Initiatives
Common Focus on Mission Capability

DoD

DOD 5000.1 – "The primary objective of Defense acquisition is to acquire quality products that satisfy user needs with measurable **improvements to mission capability**…"[1]

JCS

Joint Capabilities Integration and Development System – The primary objective of the JCIDS process is to ensure the capabilities required by the joint warfighter are identified … **in order to successfully execute the missions assigned**."[2]

DOT&E

Director, Operational Test and Evaluation – "The evaluation of operational effectiveness is linked to **mission accomplishment**."[3]

Goal: T&E Focused on Mission Capability

1. Office of the Under Secretary of Defense, Acquisition, Technology and Logistics, Department of Defense Directive Number 5000.1, 12 May 2003.
2. Office of the Joint Chiefs of Staff, Chairman of the Joint Chiefs of Staff Instruction 3170.01G, 1 Mar 09.
3. Memorandum, OSD DOT&E, subject: Reporting of Operational Test and Evaluation Results, 6 Jan 10.

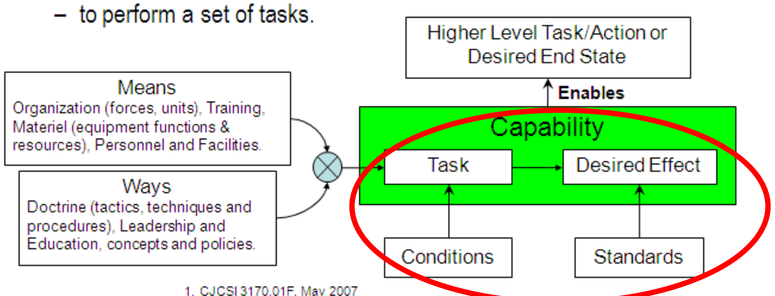
Army Proven Battle Ready

ATEC

What? - Framework Building Block

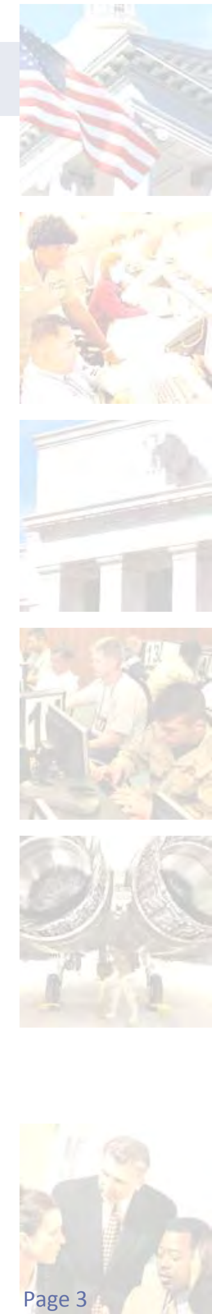
Capability[1] – The ability to achieve a **desired effect** [or result, outcome, or consequence of a task[2]] …

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



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

Army Proven Battle Ready



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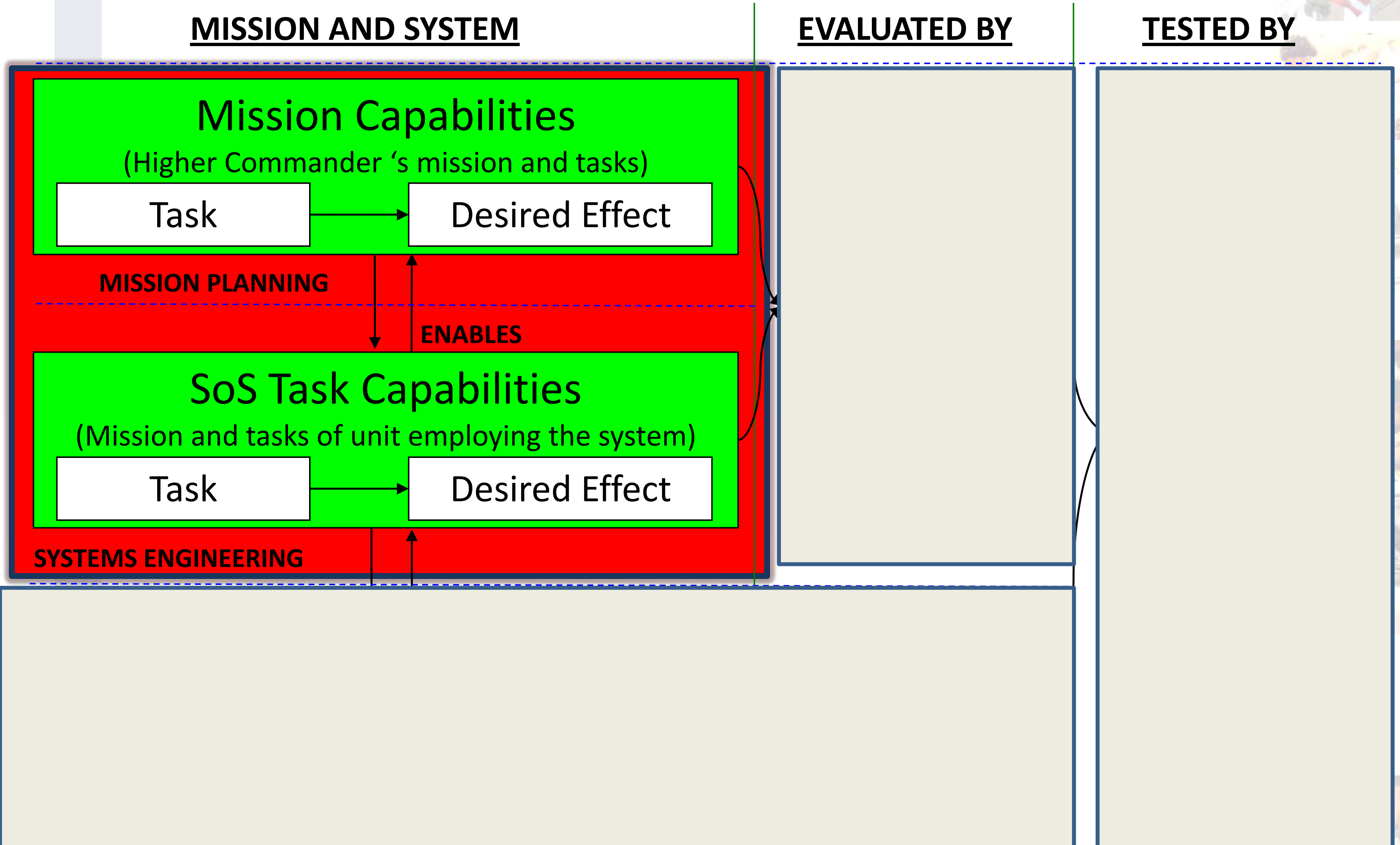
MBT&E Framework – Where's the Mission?



Mission? What Mission??

- For MBT&E purposes, want to know “What” the unit employing the system under test is supposed to do, and “Why”.
  - In the context of at least the next higher level headquarters mission
  - And a broader operational context (i.e. Operational Environment (OE) and Concept of Operations (CONOPS))
- What are some potential sources for the Mission?
  - Requirements documents from JCIDS/CBA analysis
  - Army Functional Concept (AFC) or Concept Capability Document (CCD)
  - CONOPS based on ongoing operations
  - Approved Defense Planning Scenarios (DPS) or Army Scenarios based on DPS – Often used for Analysis of Alternatives (AoA)
  - Lower level, higher fidelity vignettes based on above
  - Other CONOPS directed or approved for use by appropriate authority (i.e. Test Director, MDA, etc.)

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Analyzing the Mission

- FM 5.0, The Operations Process, dated March 2010, describes the Military Decision Making Process (MDMP).
  - Mission Analysis is step 2 of the MDMP

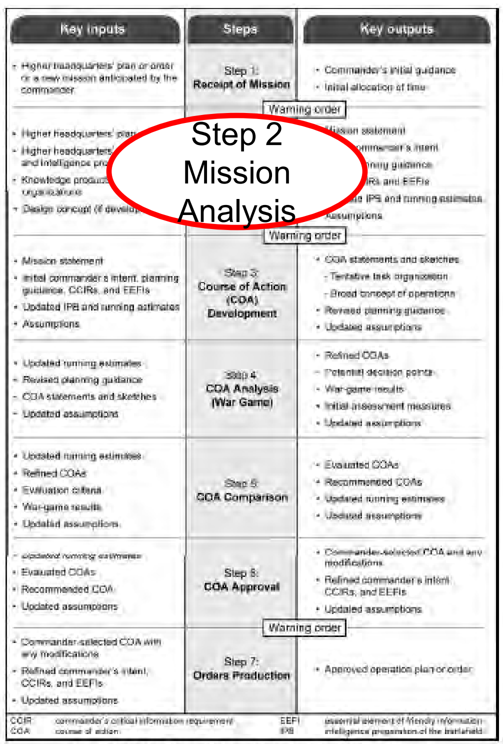
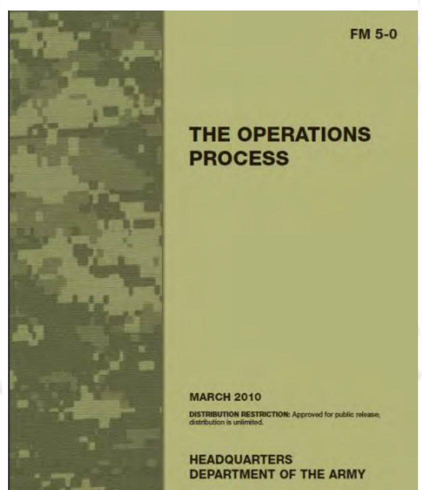


Figure B-1. The steps of the military decisionmaking process



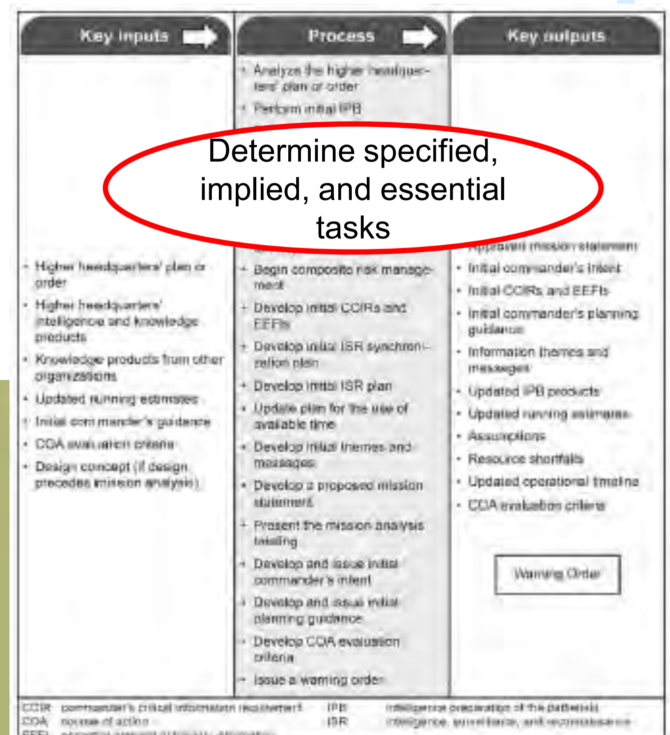


Figure B-2. Mission analysis

Decomposing the Mission into Tasks

Determine Specified, Implied and Essential Tasks

- The “what” of a mission statement is always a task.

- Analysis of the higher headquarters’ order and commander’s guidance identifies specified and implied tasks.

- In the context of operations, a task is clearly defined as a measurable activity accomplished by Soldiers, units, and organizations that may support or be supported by other tasks.

- Essential tasks are derived from the list of specified and implied tasks, and incorporated in the restated mission.

A <u>specified task</u> is a task specifically assigned to a unit by its higher headquarters

An <u>implied task</u> is a task that must be performed to accomplish a specified task or mission but is not stated in the higher headquarters’ order

An <u>essential task</u> is a specified or implied task that must be executed to accomplish the mission. Essential tasks are always included in the unit’s mission statement

Determining Conditions and Standards

Conditions

- Definition: (joint) Those variables of an operational environment or situation in which a unit, system, or individual is expected to operate and may affect performance. (JP 1-02)
- Condition variables that may effect performance are typically identified during the Intelligence Preparation of the Battlefield (IPB) process and further refined as a result of Course of Action (COA) Analysis, or Wargaming.

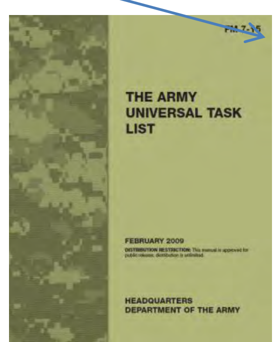
Standards

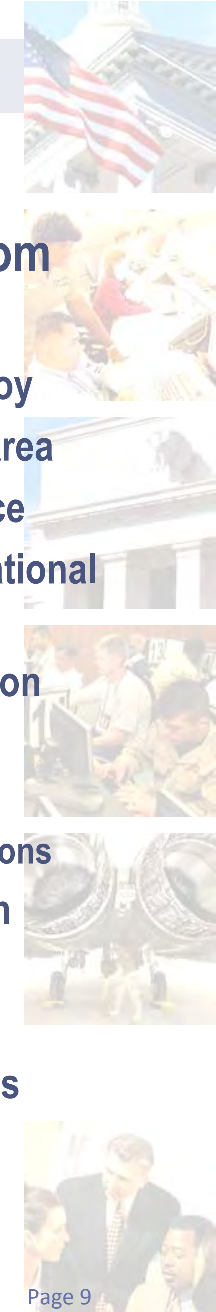
- Definition: A quantitative or qualitative measure and criterion for specifying the levels of performance of a task.(FM 7-0)
- For Mission Based Testing and Evaluation we want to determine Measures of Effectiveness (MoE) to measure whether a task had or is having the desired effect; and, Measures of Performance (MoP) to determine whether task performance meets or exceeds the minimum criterion for performance.
- Standards are derived from analysis of what it will take to accomplish assigned mission and tasks – normally via the wargaming process.

Translating Tasks into ATL Tasks

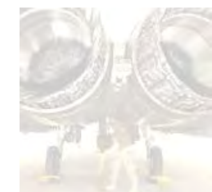
- Sample task list from mission analysis process
  - Specified Tasks
    - Move along Route Charlie
    - Occupy Assembly Area (AA) Mike
    - Secure roads and bridges leading into and out of Town in order to prevent infiltration by insurgents
  - Implied Tasks
    - Maintain situational awareness
    - Recon Route Charlie
    - Detect, locate and clear IEDs
    - Recon AA Mike
    - Maintain perimeter security
    - Establish traffic control points

- Corresponding tasks drawn from AUTL and other ATLs
  - ART 1.3.3 Conduct Tactical Convoy
  - ART 1.5.1 Occupy an Assembly Area
  - ART 7.5.19 Isolate an Enemy Force
  - ART 6.4.2 Maintain constant situational awareness
  - ART 2.3.3.1 Conduct a Route Recon
  - ART 1.6.1 Overcome barriers, obstacles, and mines
    - ART 6.12.3 Conduct IED Operations
  - ART 2.3.3 Conduct an Area Recon
  - ART 6.5.3.3 Establish Perimeter Security
  - ART 6.5.3.2 Establish Checkpoints





Capturing the Results



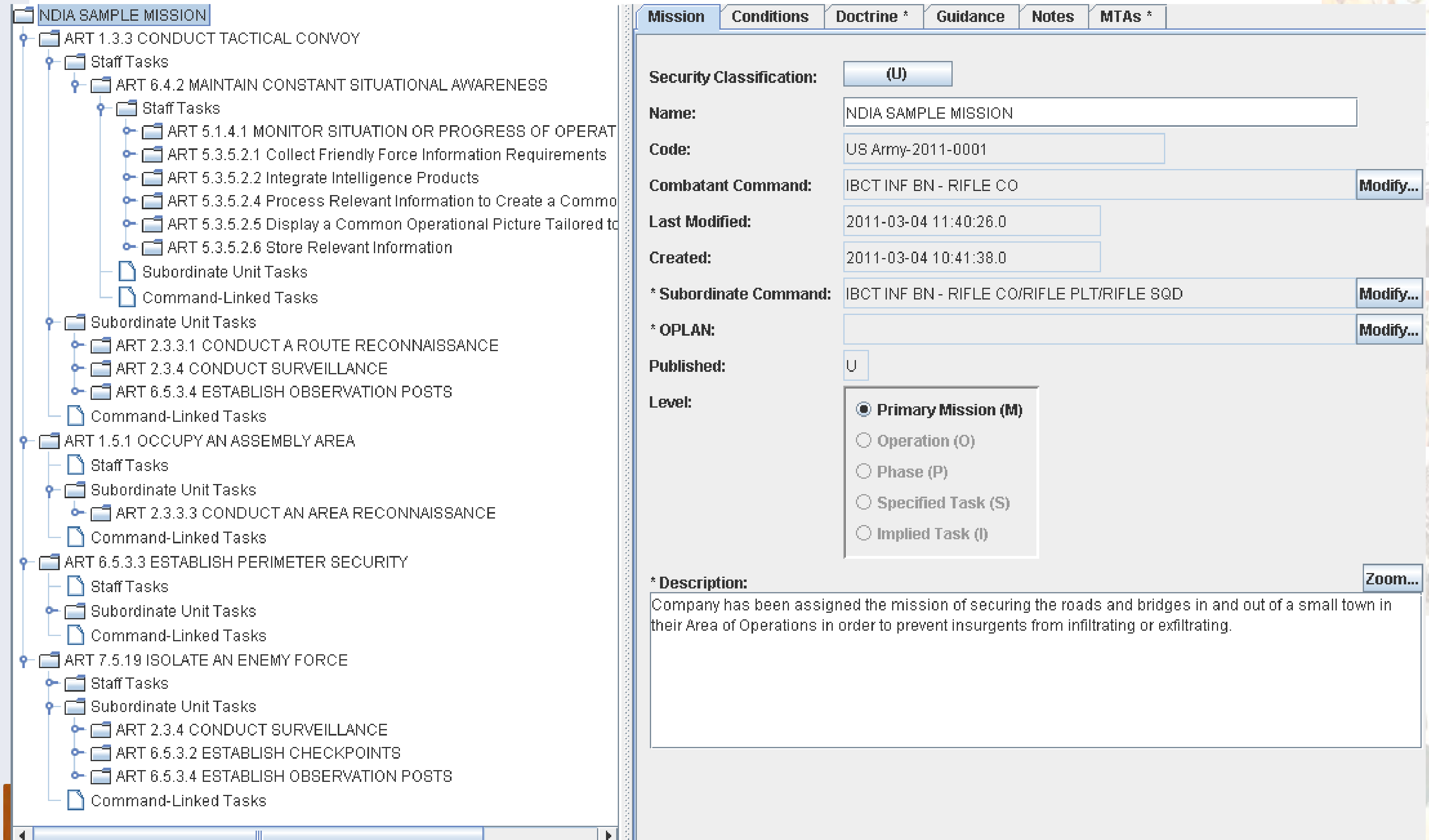
- **How is it done now?**
  - Manual look up?
  - Cut and paste from requirement documents?
  - Captured in PowerPoint, Word Tables, Excel Spreadsheets?
- **Why this may not be sufficient**
  - Manual look up
    - Currency of authoritative sources – ATL's updated regularly
    - Time consuming process
    - Increased chance of omission and/or fat-finger errors
  - Cut and paste from requirement documents
    - Conditions may have changed since publication
    - Potential for adopting faulty or incomplete analysis
  - Captured in PowerPoint, Word Tables, etc.
    - Suitability for Re-Use and/or collaborative development

An Alternative Approach

- Online, collaborative knowledge capture tool
  - Use to support the following functions:
    - Determine and document mission requirements in the form of tasks, conditions and standards for systems under test and associated operational context
    - Develop and document planning for Test and Evaluation events
    - Record and maintain task execution results
    - Record and maintain resulting assessment for each task
  - Participation and permissions limited to members of authorized user groups

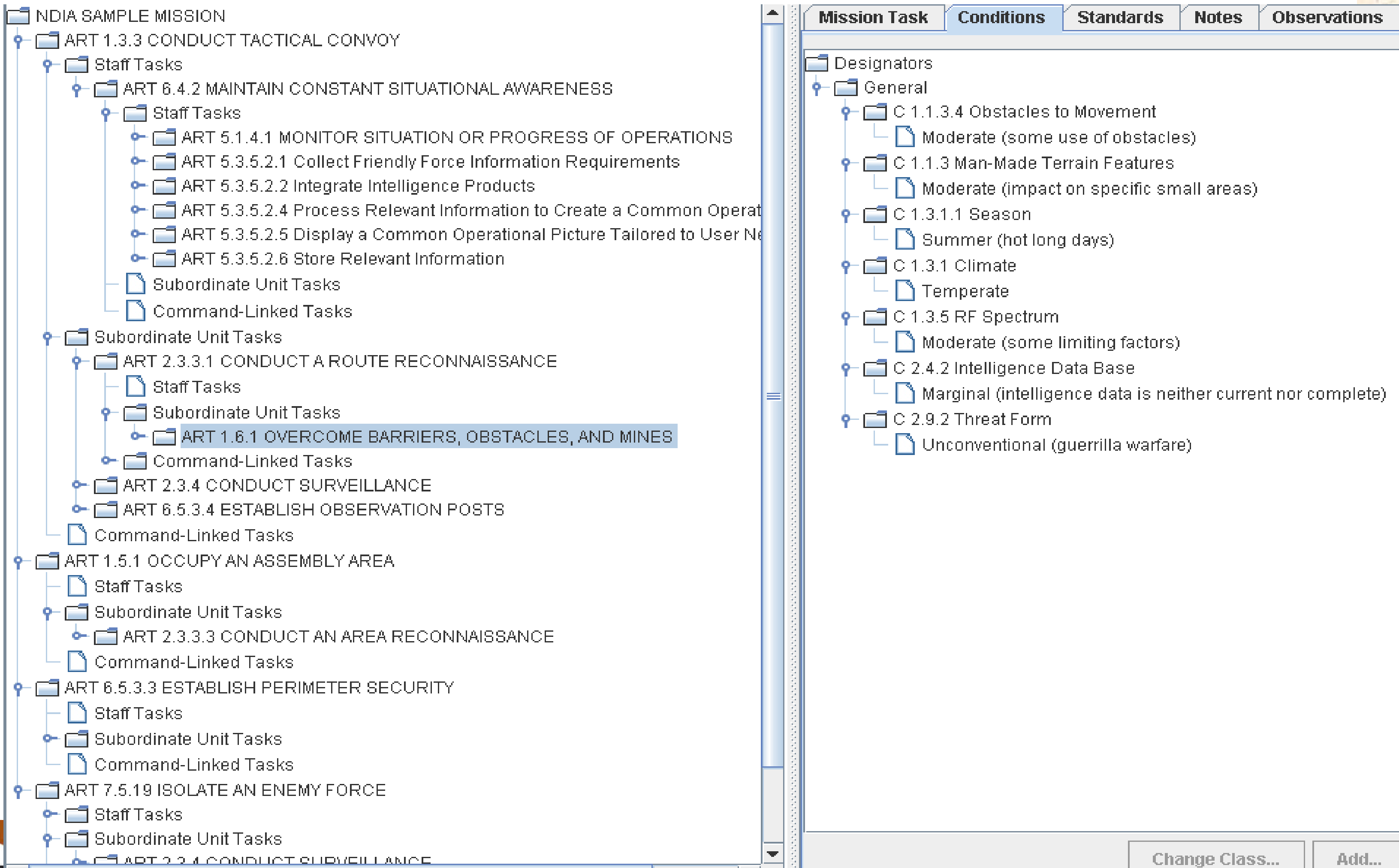
How it Works

Determine and document mission requirements – Converting to ATL Tasks



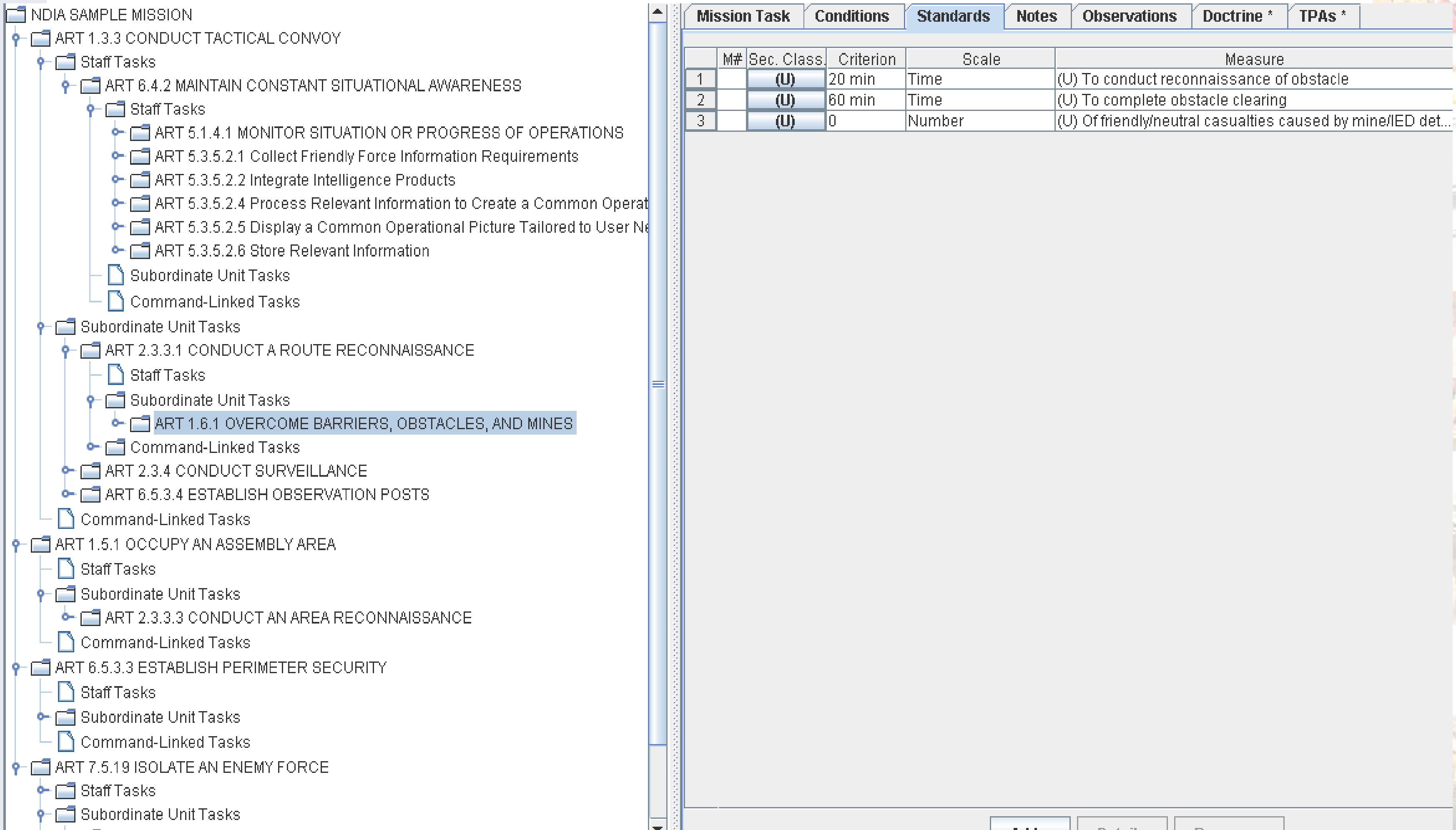
How it Works cont.

Determine and document mission requirements – Conditions



How it Works cont.

Determine and document mission requirements – Standards



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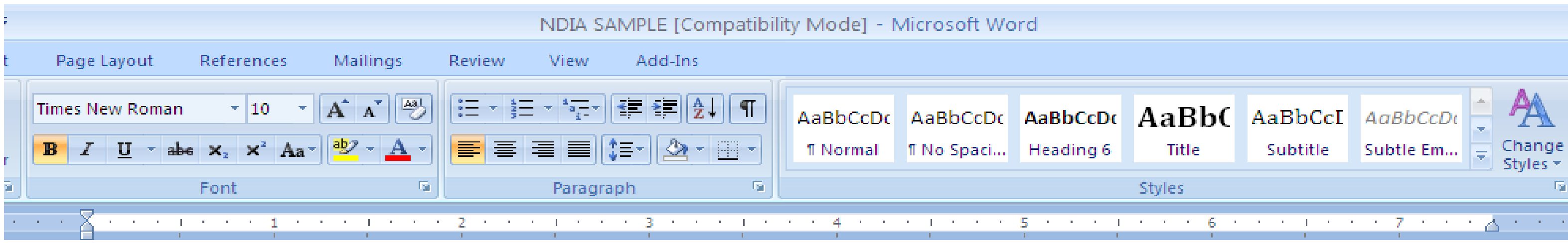
Mission Task Report in TEO Format



Mission: (U)NDIA SAMPLE MISSION

Task: (U)ART 1.3.3 CONDUCT TACTICAL CONVOY

Responsible Organization: IBCT INF BN - RIFLE CO

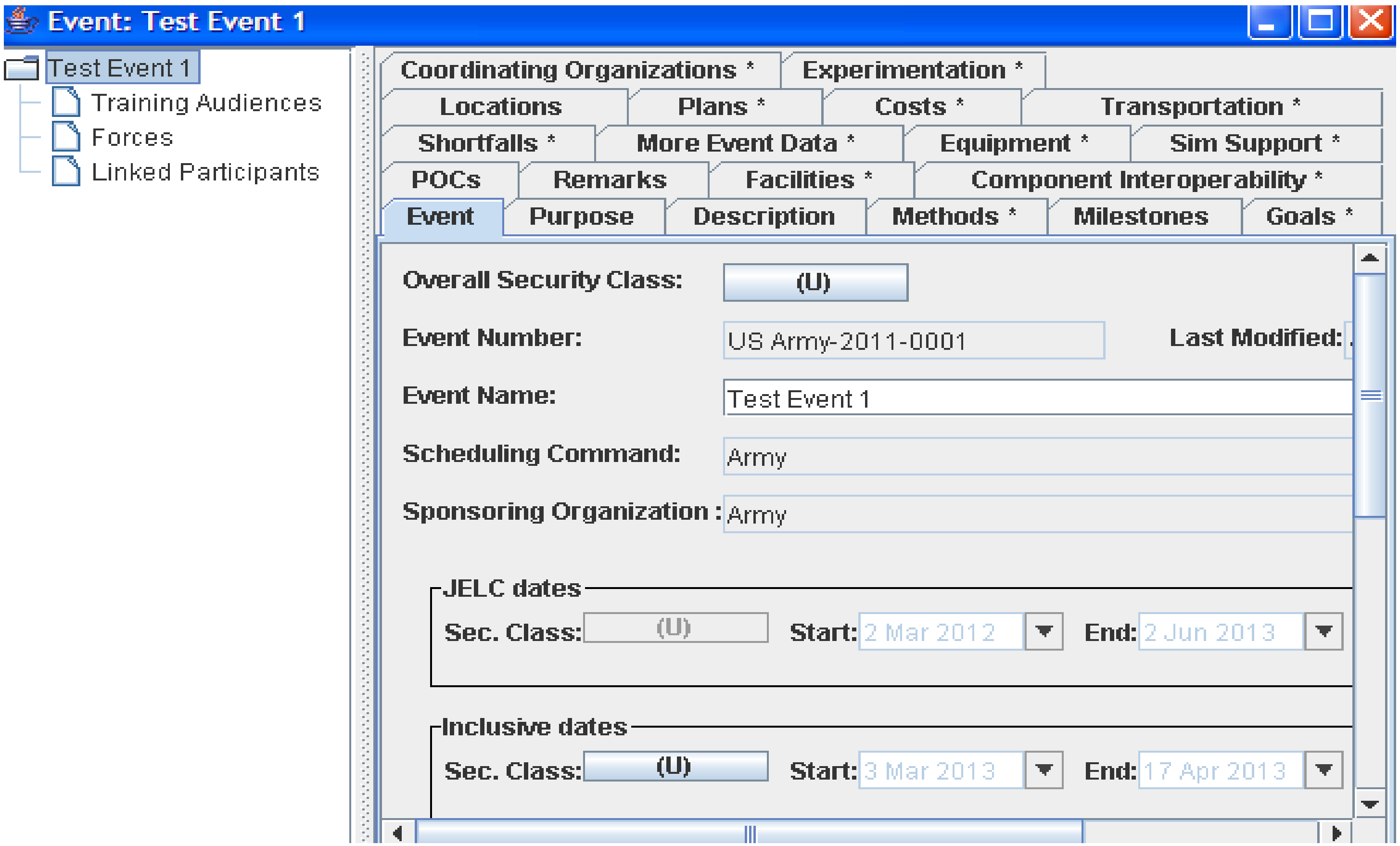
Description: 1-52. Conduct tactical convoys by employing one or a combination of three types of column formations: open, close, and infiltration. Tactical convoys are combat operations in which forces and materiel are moved overland from one location on the battlefield to another while maintaining the ability to aggressively respond to enemy attempts to impede, disrupt, or destroy elements of the convoy. (FM 55-30) (ALMC)

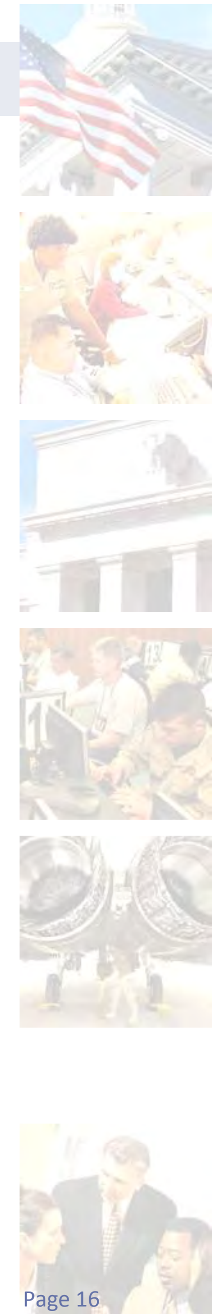
Standards:

M#	Criterion	Scale	Measure
M1	(U)	Y/N	(U) The SIR that prompted the conduct of reconnaissance was answered.
M2	(U)	Y/N	(U) Reconnaissance system/force orients on the reconnaissance objective.
M3	(U)	Y/N	(U) Recon system/force reports all information rapidly and accurately.
M4	(U)	Y/N	(U) Recon mission completed no later than time specified in the order.
M5	(U)	Y/N	(U) Support requirements for each reconnaissance asset are identified.
M6	(U)	Y/N	(U) Unit maintains continuous reconnaissance by employing multiple means.
M7	(U)	Time	(U) From receipt of tasking until reconnaissance assets are in place.
M8	(U)	Time	(U) To provide answers to IR/PIR to requesting agency.

How it Works cont.

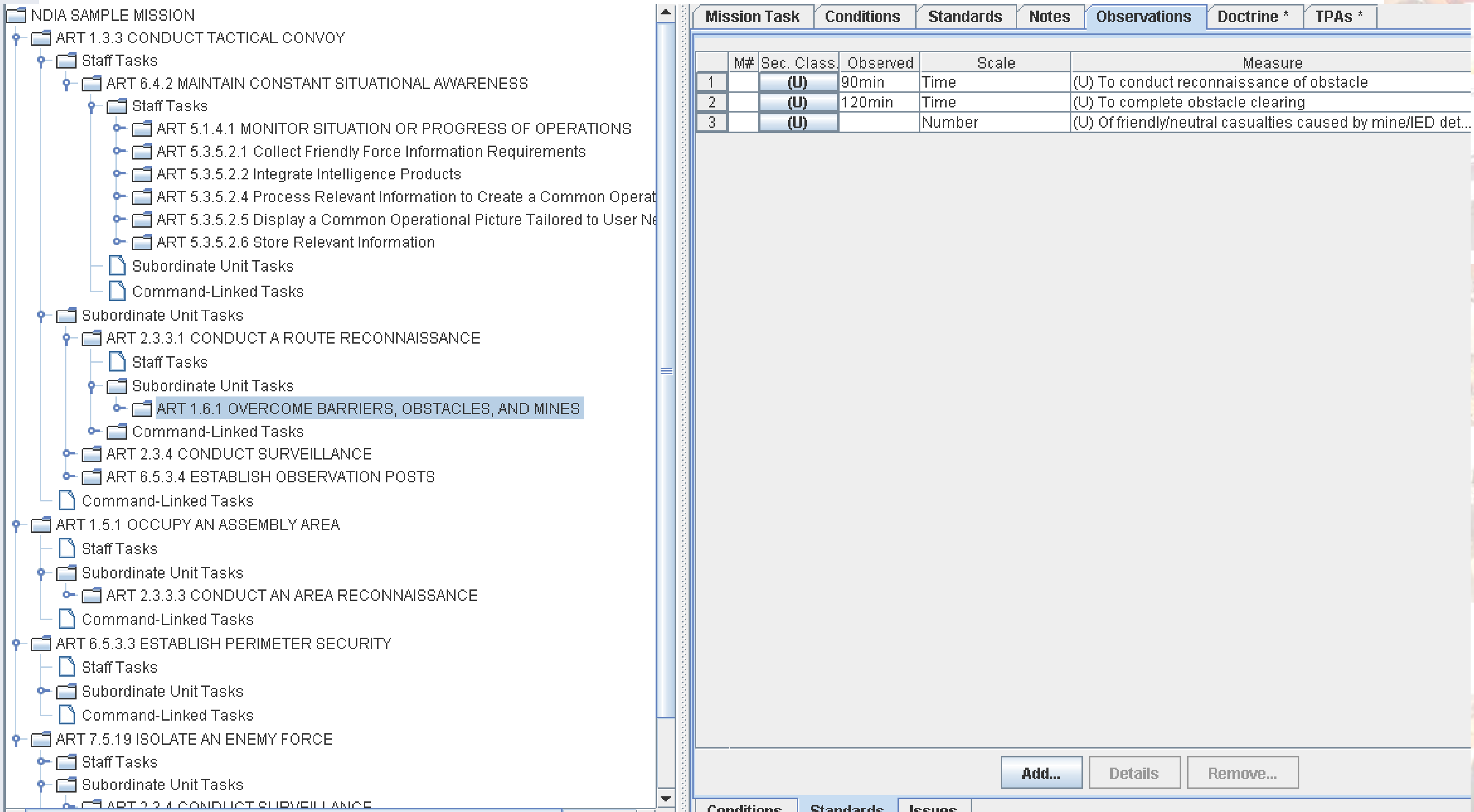
- Develop and document planning for test events

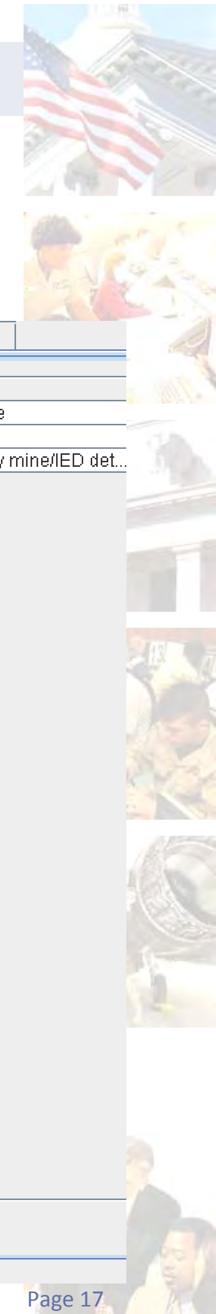




How it Works cont.

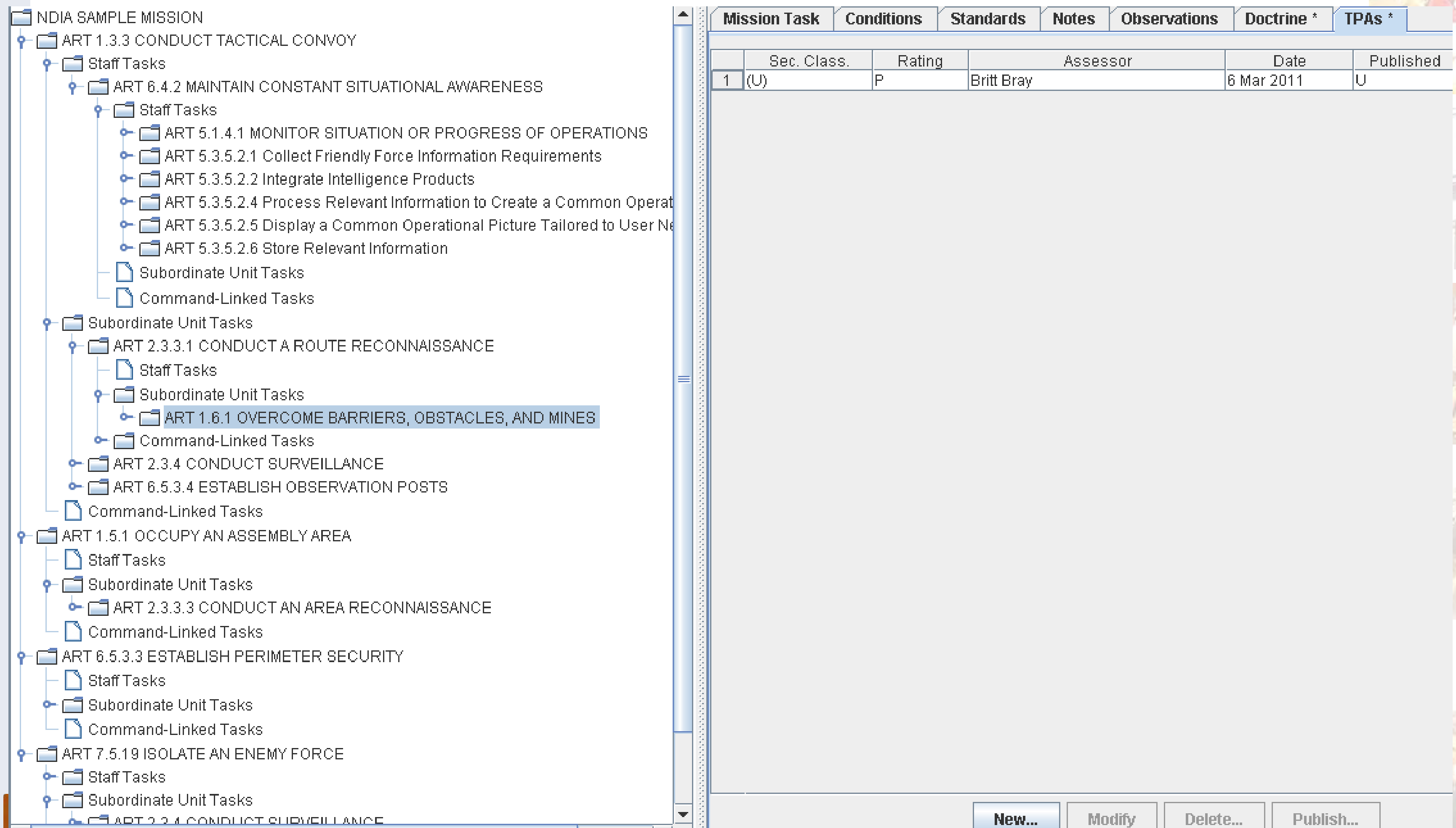
Record and maintain task execution results





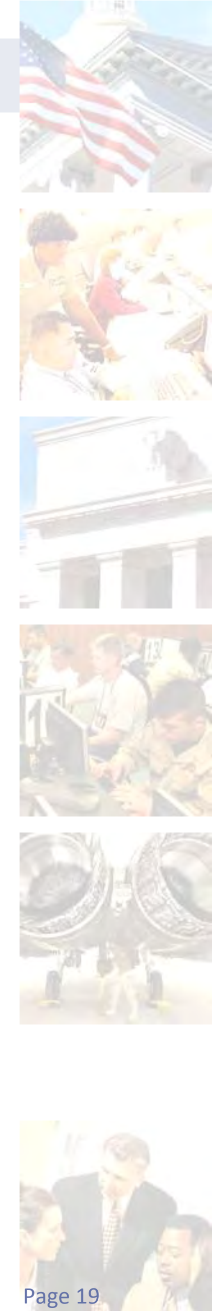
How it Works cont.

- Record and maintain task assessment results



Questions to Ask

- To properly describe mission context for Systems under test
  - What is the source scenario/vignette/CONOPS for the mission?
    - Is it the same CONOPS used to develop requirements for the system?
    - If not, why not? Valid reasons might include guidance from on high, changes in assessment of current and/or future operating environment, etc.
  - Are tasks already identified in one or more of the requirements documents (i.e. FAA, FNA, ICD, OMS-MP)?
    - As the independent evaluator, are you satisfied that all relevant tasks are included?
    - Do the tasks include conditions and standards? If not, where do they come from?
  - Are the tasks decomposed to level where they can be mapped to system attributes and functions?
    - Are they linked to other tasks and the mission? If not, how will you determine and justify an assessment of mission impact?



Summary

- **Major Points:**
  - Understanding the Mission is essential to MBT&E. Selecting the right Mission is also essential
  - The process for analyzing and specifying the Understanding of the Mission using a common, authoritative language is well defined and doctrinally based
  - Automated tools are available to assist in capturing, maintaining, managing and sharing results of Mission Analysis and conversion to ATL tasks as well as other T&E related functions
- **Recommendations/Way Ahead:**
  - Adopt and codify a "how-to" guide for specifying Mission Understanding
  - Evaluate and select existing GOTS and COTS tools to facilitate knowledge capture
  - Coordinate and collaborate with Joint and Service requirement communities (e.g. JFCOM/JS J7, TRADOC ARCIC, TRAC, etc) to clarify desired format for Scenario/CONOPS products

QUESTIONS?

FOR ADDITIONAL INFORMATION OR QUESTIONS PLEASE CONTACT:
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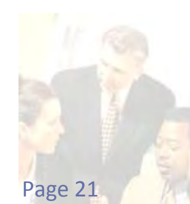

Utilization of Modeling and Simulation for Networked Waveform Characterization and Validation

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March 8, 2011

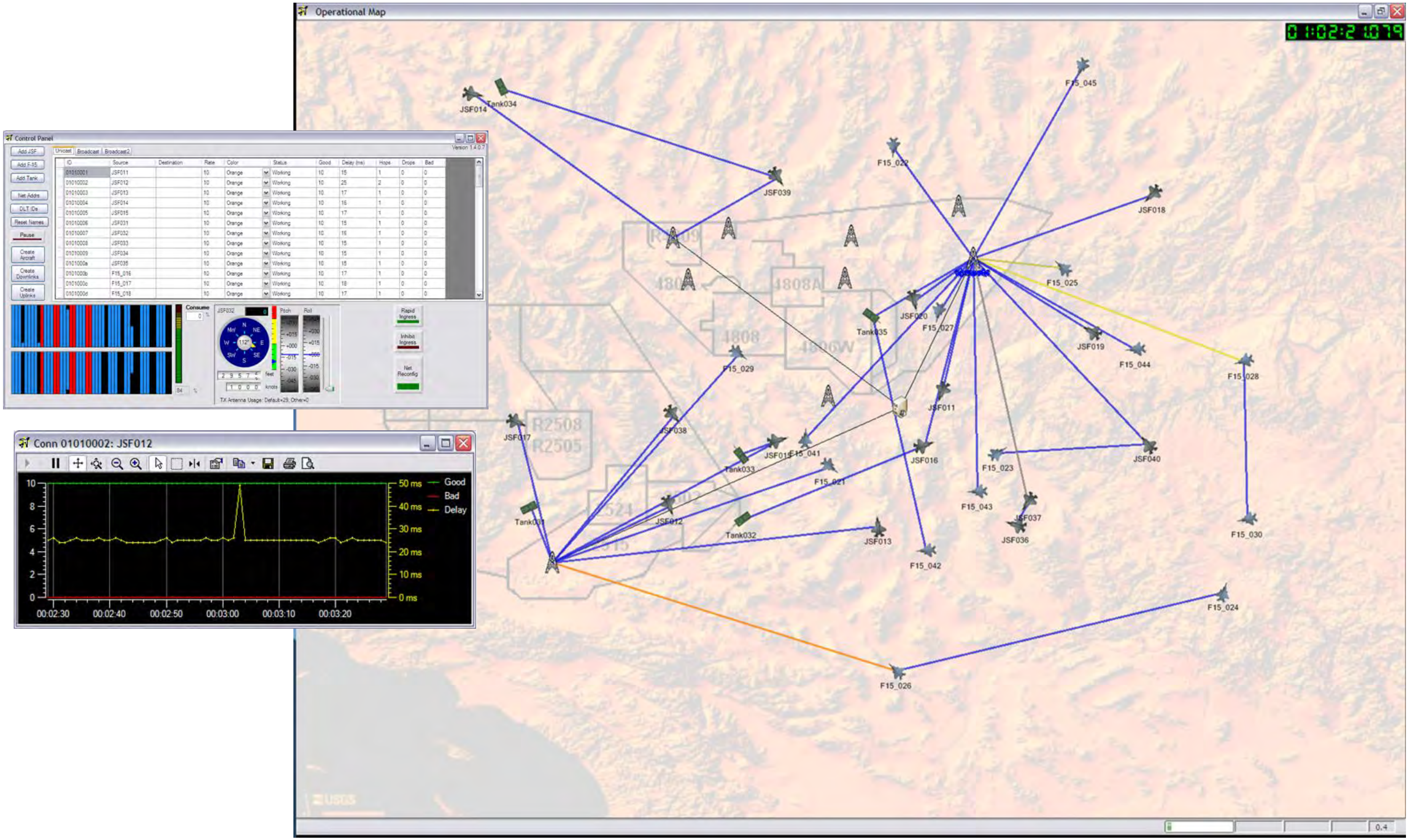
Agenda

- Discuss Modeling and Simulation used for Networked Waveform Development and Validation
  - What is a Networked Waveform?
  - Why is simulation required for Networked Waveforms
  - How Modeling and Simulation can be applied and utilized through the entire product lifecycle
  - Prerequisites for using Simulation
  - Examples of lessons learned from Networked Waveform Simulation

What is a Networked Waveform?

- Sometimes referred to as Mesh Network or Mobile Ad-Hoc Network
- Self-configuring network of nodes connected via wireless data links
  - Each node dynamically adapts to evolving network topologies
    - Network protocols ensure that all nodes are kept abreast of topology updates
    - Data can successfully route through the network with varying numbers of hops depending on the topology
- Nodes are free to physically move about in any direction
  - Nodes can be on land, sea, or air
- Network topology changes over time based on:
  - Each node's physical location
  - Vehicle/Aircraft dynamics
  - Node configuration changes
  - Environmental effects

Example Network Topology



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Example Network Topology

Why is Simulation Required?

- The number of variables involved in a networked waveform are far too many for static analysis
  - Vehicle/Aircraft types
  - Vehicle/Aircraft dynamics
  - Antenna patterns per vehicle/aircraft
    - including polarization and shadowing
  - Different network sizes
  - Traffic profiles
  - Different bandwidth usage profiles

- Networking is not about absolute determinism, but rather statistical probability
  - Requires repetitive testing to characterize a network
  - Requires both:
    - controlled sequences of events
    - random sequences of events

Why is Simulation Required?

- Testing network limits is impractical with real hardware
  - Maximum number of nodes (100+)
  - Maximum bandwidth utilization (90% - 100%)
    - With limited assets available, it requires unrealistic loading on individual nodes

- Validating a network design requires different types of testing:
  - Repetitive (Regression) testing *with fixed conditions* to ensure network behavior is deterministic to the desired degree
  - Repetitive (Regression) testing *with injected randomness* to discover hidden corner conditions and network heuristics
  - Human Gremlin - testing with an eye to breaking things
    - Intentionally stressing network in ways it may not be intended to be used
    - Ensuring it ends up in a known state and recovers under all conditions
  - Monte Carlo style testing
    - Automated running of tests with data collection and analysis to determine boundary conditions and statistical probabilities of the network

Testing and Characterization of a Networked Waveform is expensive and requires a comprehensive testing strategy

What comprises a Networked Waveform Simulator?

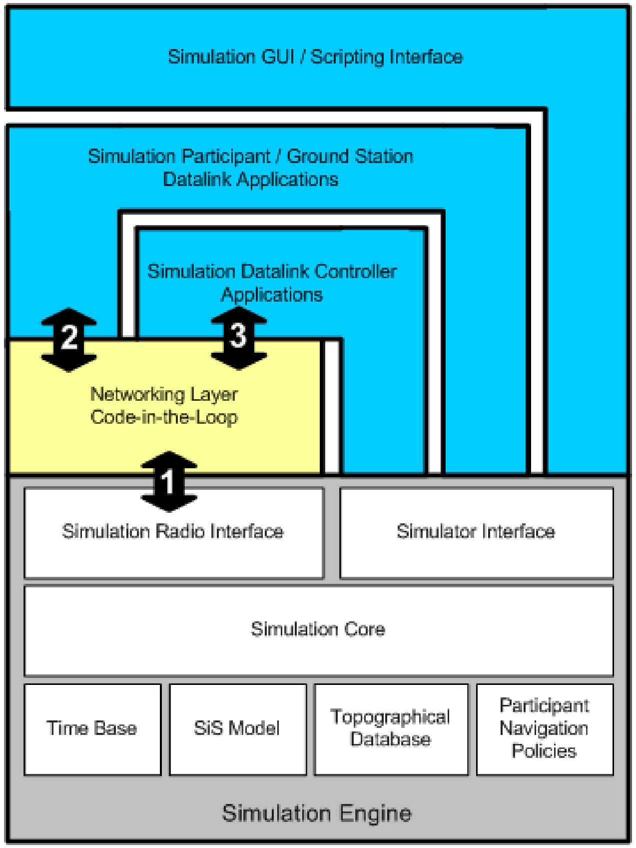
- A network simulator facilitates focused testing on the networking layer of a waveform
  - Simulates targeted non-networking aspects of the overall system

- Well-defined interfaces allow Code-in-the-Loop use of networking layer

1 Networking to SiS interface

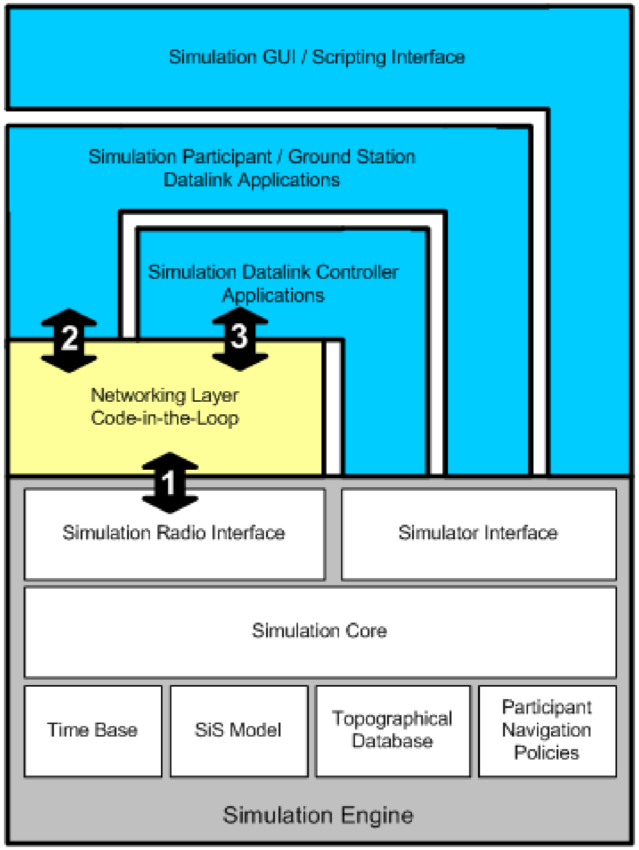
2 3 Upper Layer Applications

Well defined interfaces are key to facilitating effective Code-in-the-Loop simulation



What comprises a Networked Waveform Simulator?

- Simulator Engine
  - Provides a controlled, synthetic environment
    - Topography (physical terrain, obstructions)
    - Node Navigation / Mobility
    - Signal in Space Model
      - Antenna models
      - Physics of waveform modulation
      - Propagation delays / effects
    - Time
      - Simulation
      - Allows pausing of simulation for inspection
      - Allows simulation to run slower than real-time as model fidelity increases
      - Allows initial simulation to focus on networking algorithms themselves independent of real-time constraints



Considerations for Simulation

- Before you ever start, you should be able to answer these two questions:

  - **What are we trying to measure?**
    - Simulation Architecture Requirements

  - **What do we want to measure in the future?**
    - Refine Simulation Architecture Requirements
    - Tradeoff Criteria Determination

The answers to these two questions have a significant impact on the total cost of Simulation

Considerations for Simulation

- Determining what you *ARE NOT* simulating is almost as important as determining what you *ARE* simulating

- There is a tradeoff between the fidelity of the model and the hardware resources required to keep simulation real-time

What are Some Uses of Simulation through the Development Lifecycle?

- Proof of Concept
  - Determine if this is a viable network design
  - Determine risks in proposals (RFIs / RFPs)
  - Perform initial trade studies
    - Determine the right thresholds and objectives
- Network Design Validation
  - As the simulation model is matured, better assessments can be made for corner conditions and design constraints, as well as requirements trades
  - Prior to Hardware being built
- Real-time porting baseline and debugging tool
  - Once real hardware is available, INTEGRATION begins
  - Simulation provides a baseline characterization that can be used to diagnose and track down hardware porting issues

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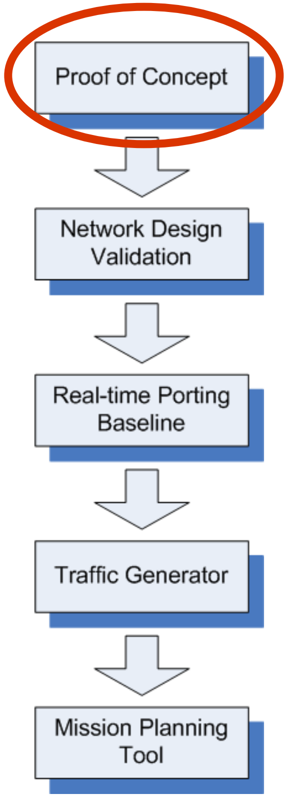
What are the Uses of Simulation through the Development Lifecycle?

- Traffic Generator
  - If the Simulation Environment is designed with proper hooks in place, the simulated nodes can generate network traffic
    - Lab bench testing of real hardware in a loaded condition
    - Flight testing can be with a loaded network as well

- Mission Planning Tool / Mission Playback Tool
  - Growth opportunity to enhance the simulation model fidelity such that missions can be validated via simulation before any aircraft deploy
    - Identify network choke points in mission plans
    - Ensure adequate network coverage for theater of operations
    - Test logistical aspects of larger networks

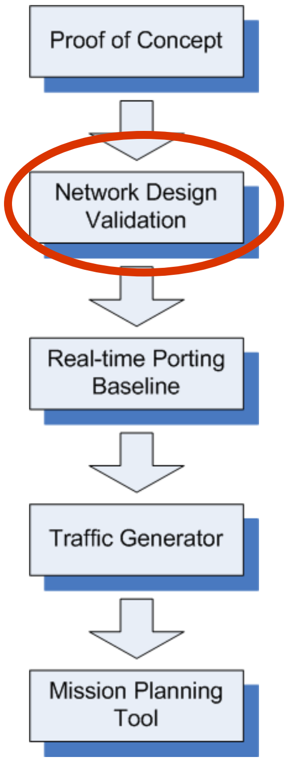
  - Playback allows captured flight data to be fed into Simulator
    - Allows refining of simulator model fidelity by comparing actual flight data to simulated flight data

Proof of Concept Phase



- Focus
  - Straw-man fleshing out of network algorithms
  - Discover dynamic aspects and corner conditions
  - Mitigation of High-Risk Items
  - Identification of key strengths and limitations
- Characteristics
  - Low-Fidelity physical environment modeling
    - Basic Signal in Space model
    - Basic antenna models
    - Basic topography models (maybe even 2-D vs. 3-D)
    - Entire Networking solution does not need to be implemented or simulated
      - Only that which is necessary to mitigate high risk items
- Special Considerations
  - Is this throw away code?

Network Design Validation

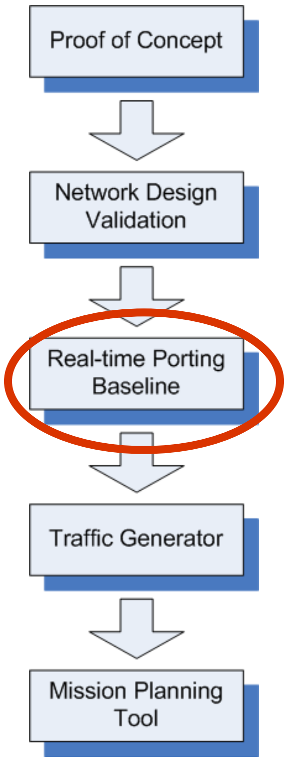


- Focus
  - Full development and demonstration of networking algorithms and services
  - Code-in-the-Loop simulation
  - High-Fidelity Signal in Space model (with antenna models)
  - High-Fidelity Topographical models
  - Uncovering and fixing any dynamic aspects and corner conditions
  - Mitigation of as many risk items as possible
  - Documentation of Network Design (with trades documented)

- Characteristics
  - Target hardware is not yet available

- Special Considerations
  - While waiting for real hardware, is there benefit to porting to an evaluation board?
  - Are accurate antenna models required for proving network design?
  - How accurate does our model need to be to adequately validate the network design?

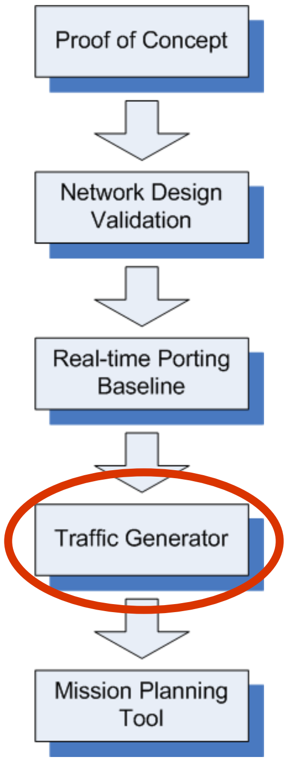
Real-time Porting Baseline



- Focus
  - Simulation is used as a performance baseline to isolate porting issues
  - As porting bugs are fixed, retest fixes in simulation (Code-in-the-Loop)

- Characteristics
  - Target specific simulation scenarios that validate issues found in porting process
  - Simulator capabilities are not further refined or developed, but rather used as a performance reference point
  - Whenever real-time bugs are fixed, the simulator code-in-the-loop must be rebuilt with fixes and retested in the simulation environment

Traffic Generator

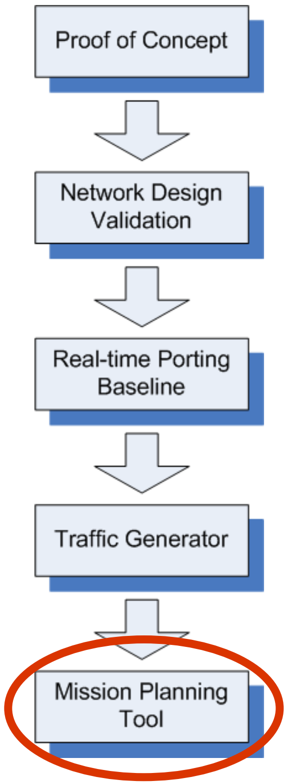


- Focus
  - Generating network traffic (network traffic loading)
  - Simulating real network nodes (network tree processing load)
  - Assessing real hardware performance with network loading
  - Make any simulator real-time performance enhancements (if necessary)
    - Must work in conjunction with real hardware
    - It is possible that fidelity must be reduced in certain simulation models in order to perform in real-time

- Characteristics
  - Focus in this phase is not networking algorithms, but rather how the real hardware performs in various loading conditions

Mission Planning Tool

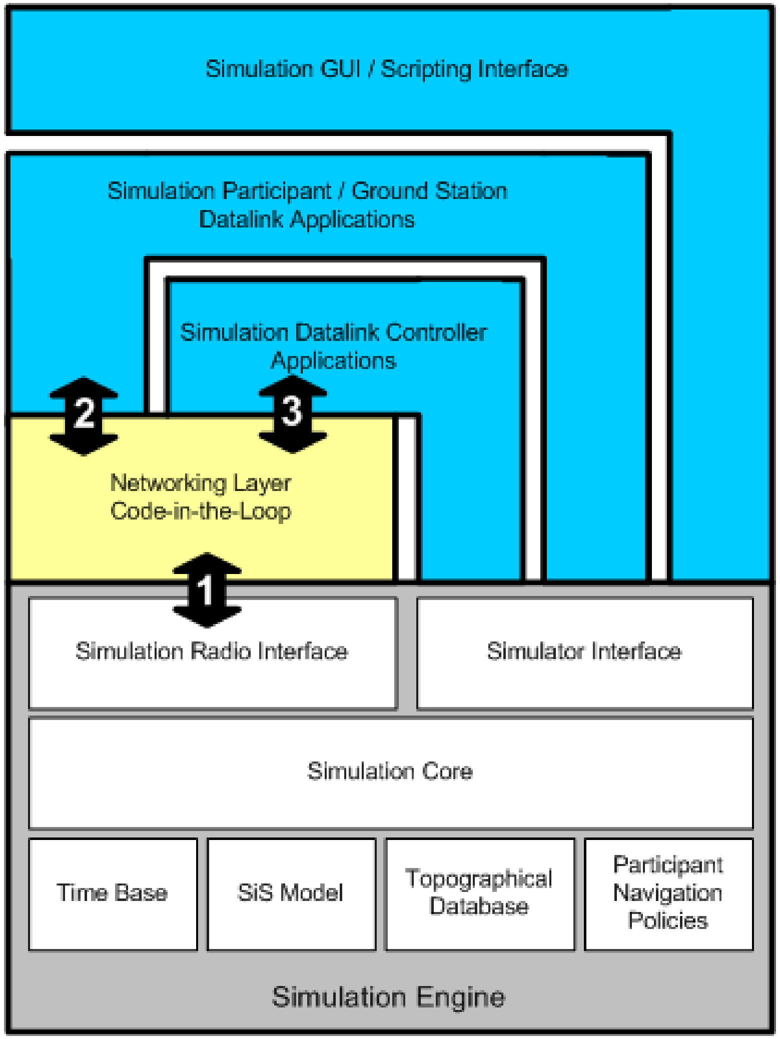
- Focus
  - Enhancing the simulation fidelity to the point where it can be reliably used to predict mission performance
    - Enhanced antenna models
    - Enhanced topography with terrain modeling (will slow simulation way down)
    - Close the loop on Signal-in-Space performance with real flight testing data
  - Real-time performance is not the focus, accuracy is the focus



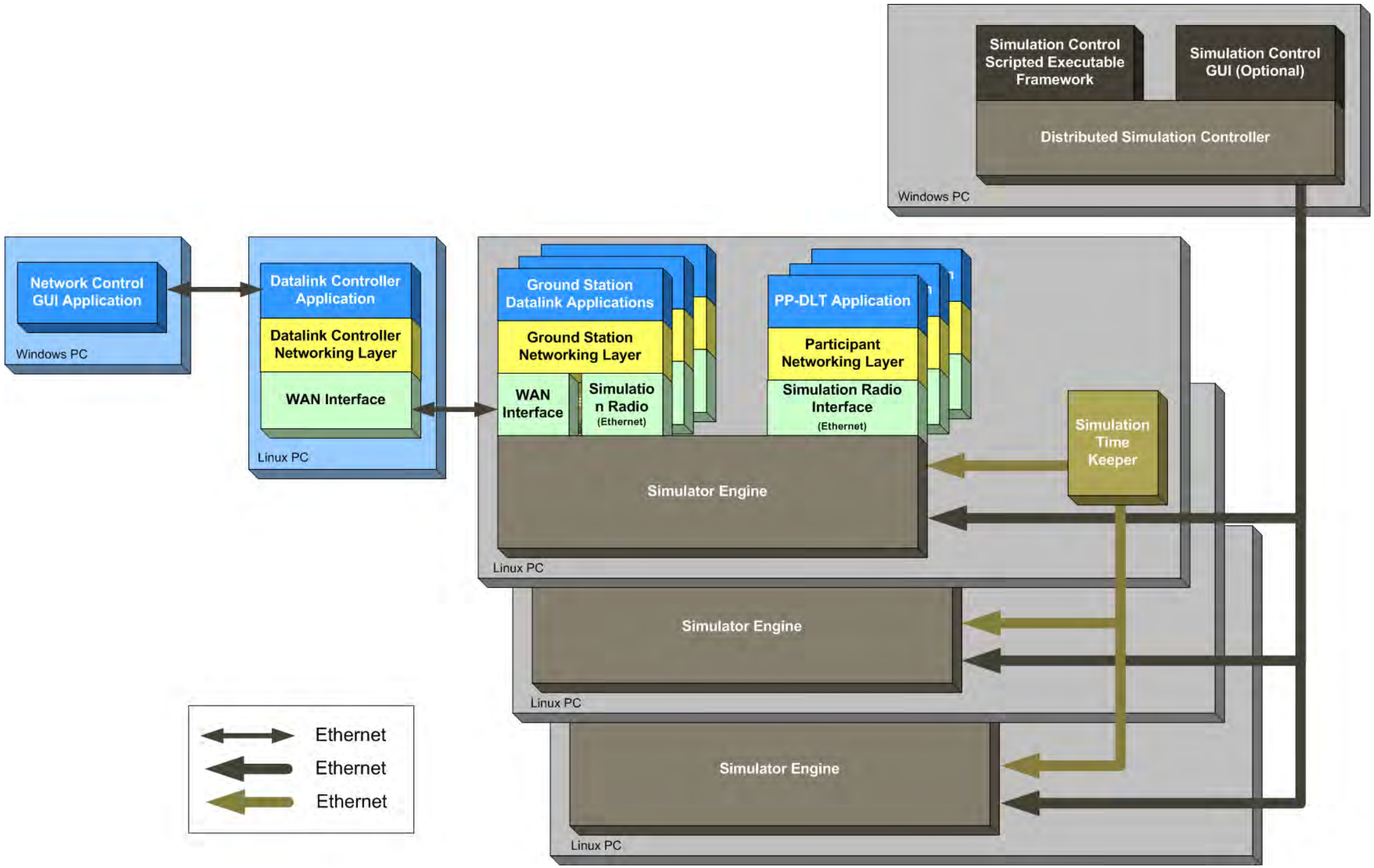
Simulator Architecture

Simulator Architecture and Features

- GUI front-end
- Optional scripting capability
  - Monte Carlo simulations
- Code-in-the-Loop capability
- 3-D physical model
- Earth curvature (WGS-84)
- Simulated Time Base
- Antenna models
- Antenna polarization
- Participant Navigation



Simulator Physical Architecture



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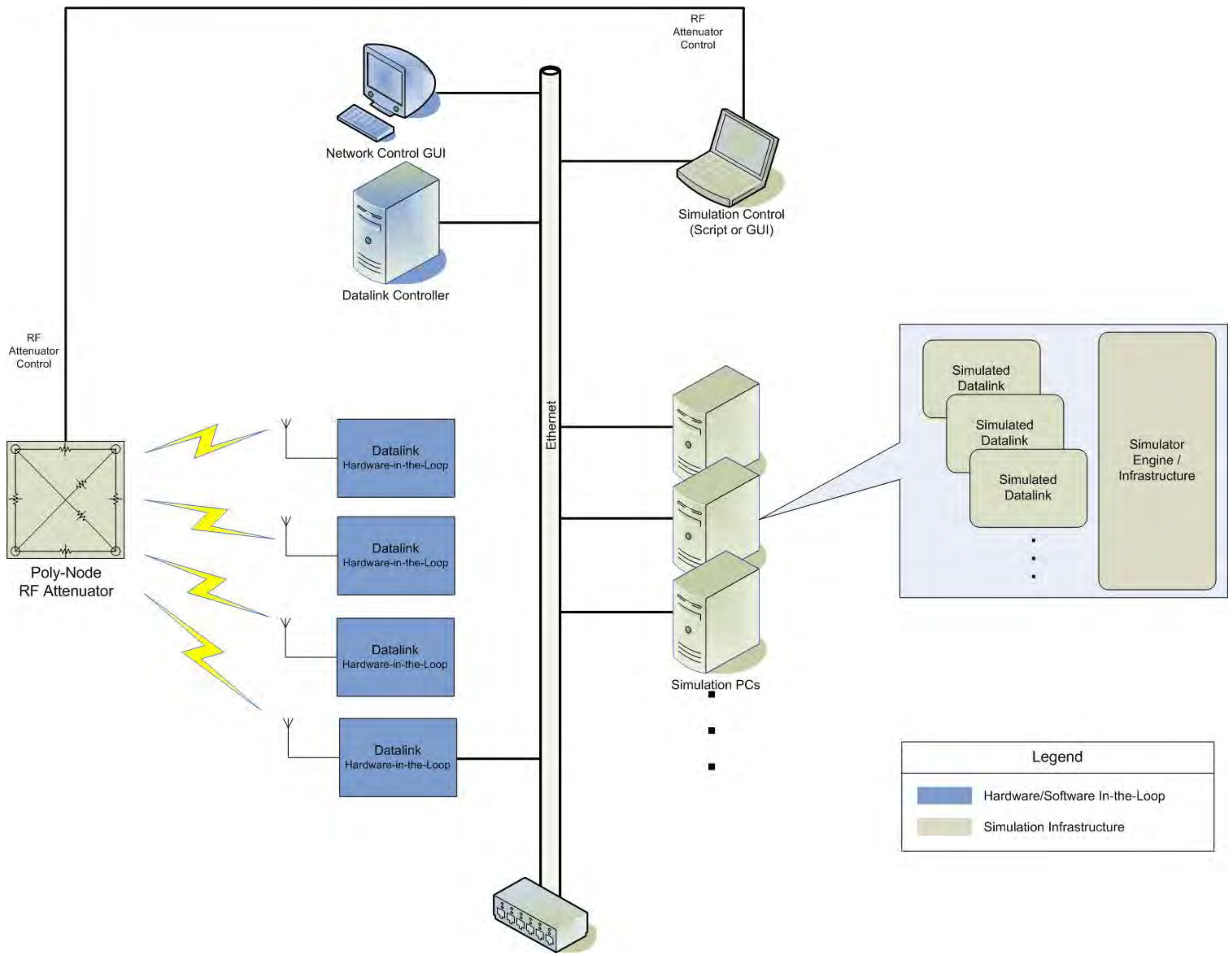
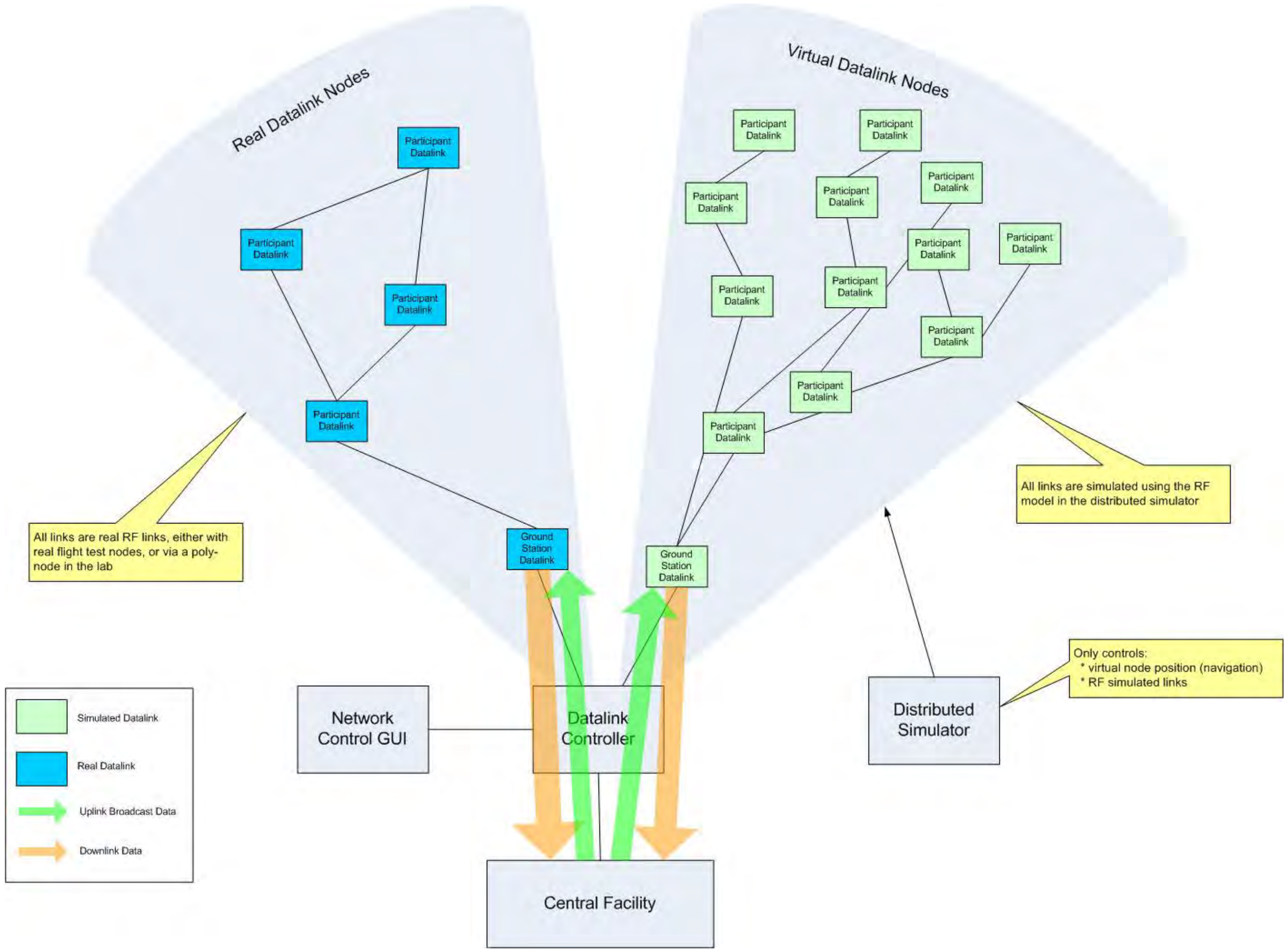
Simulator Physical Architecture – Hardware-in-the-Loop



Traffic Generation / Network Loading



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Software considerations with simulation

- Start with simulation in mind
  - Simulator architecture must be compatible with networking code
  - Concurrency model vs. Software Development Plan
    - Global/static variables
    - Threading models
    - Utilization of 3rd party tools
    - Abstraction layers to enable simulation
- Define clear interfaces between layers
- Make sure abstraction layers are efficiently implemented
  - Many of them are high iteration, and if not efficiently done can negatively impact the final code
- Iterative Development Cycles
  - Simulation model is not effective with waterfall development model

Examples of Real Simulation Findings

- Efficient slot allocation is very complex and can lead to computationally intensive calculations

- Early trade study on multiple networking modes uncovered the need for customized link quality thresholds that were dependent on mode of operation

- Three and four hop network spans do not happen easily - like water finding its level, the networking layer finds a shorter path before humans can see it visually

- Make-Before-Break paradigm for healing broken data paths was verified to reduce data loss and was weighed against the temporary increase in bandwidth required

NDIA – Test and Evaluation Conference

Model Based Systems Engineering (MBSE) and Modeling and Simulation (M&S) adding value to Test and Evaluation (T&E)

March 16, 2011

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Outline

- What was our Assignment
- The Approach to the Assignment
- Model Based Systems Engineering (MBSE)
- Systems Modeling (SysML)
- Pillars of SysML
- Capturing Requirements, Behavior, and Structure for our assignment
- Capturing Test Information
- Other Modeling Activities
- Planning Activities
- Lessons Learned

The Facility and the Assignment

HPTi

- Hardware in the Loop (HIL) Facility
  - Focus on testing of GPS-guided precision munitions
  - Desiring a cost effective means for mitigating risks
  - Capable of performing component and integrated component tests prior to gun launch testing
- Our Assignment
  - Capture Stakeholder Requirements
  - Capture System Requirements
  - Capture Test and Evaluation information that the HIL Facility offers
  - Traceability of Test and Evaluation information to the Requirements

How to capture the information for our assignment?

- Asked ourselves how to best accomplish our assignment
- Desire to capture Requirements, System Behaviors, and Test information in one location with traceability
- Desire to involve all stakeholders in the process and develop a common understanding early in the lifecycle
- Need to manage project risk
- Looked to a Model Based Systems Engineering Approach to help achieve this
- Focus on early developmental activities
  - Scoping the system of interest

Systems Engineering Approach

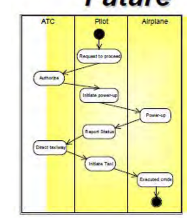
MBSE - General Definition

- **It is about System Modeling**
  - **System Model is a *cohesive*, *unambiguous* *representation* of what the System *is* and *does.***
- **It provides a description of**
  - **Requirements and**
  - **Technical Solution and**
    - Operational Scenarios
    - System Behavior (including I/O)
    - Physical Architecture (Structure, interfaces)
    - Dynamic Simulation (requires "executable" models)
  - **Verification Procedures**
- **MBSE is used to produce SE products**
- **It requires a Modeling Language that is computer interpretable**

Past

Document centric

Future



Model centric

Minimum Required to Define System

SysML Overview

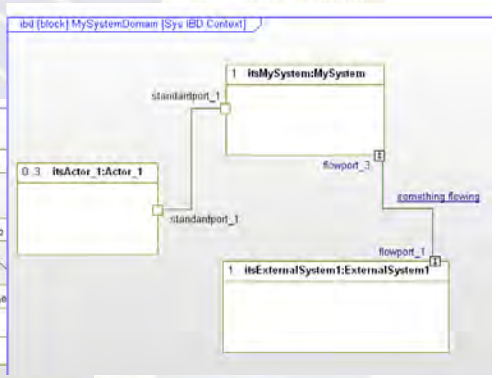
- **General Purpose Visual Modeling**
  - **Structure**
  - **Behavior**
  - **Requirements**
  - **Parametric**
- **Supports: specification, analysis, design, verification and validation**

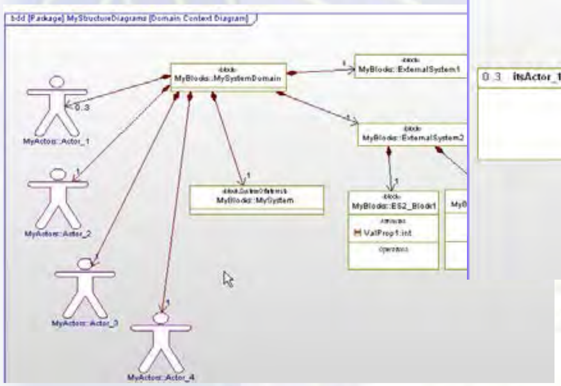
Descriptive Modeling

4 Pillars of SysML

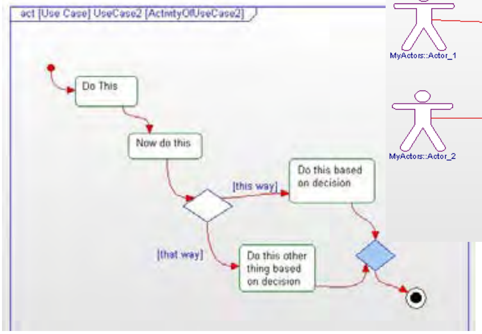
HPTi

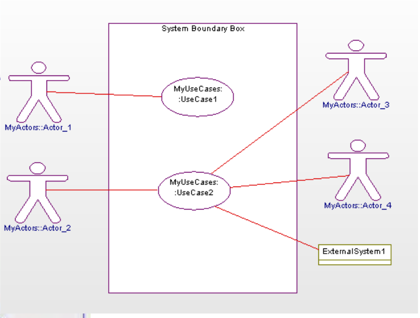
1. Structure

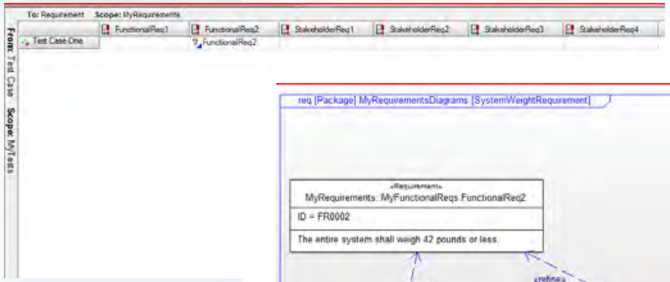


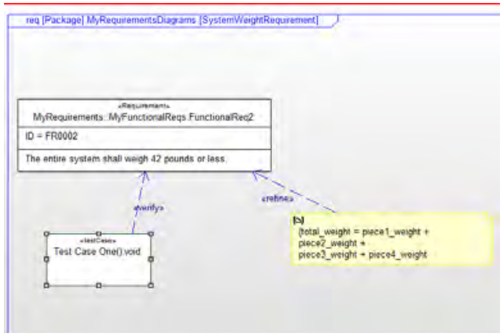


2. Behavior

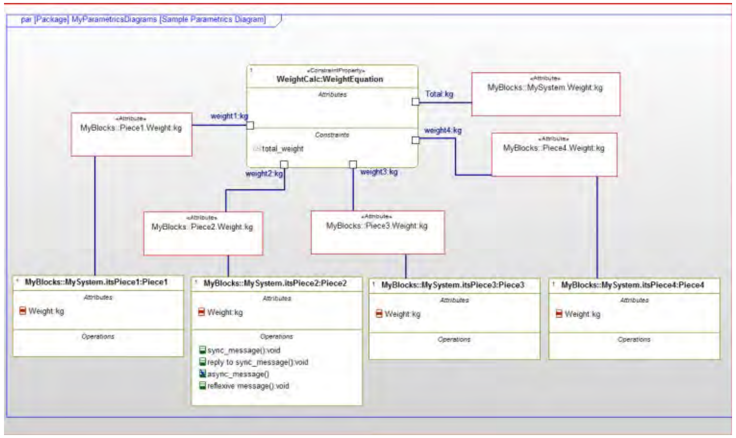








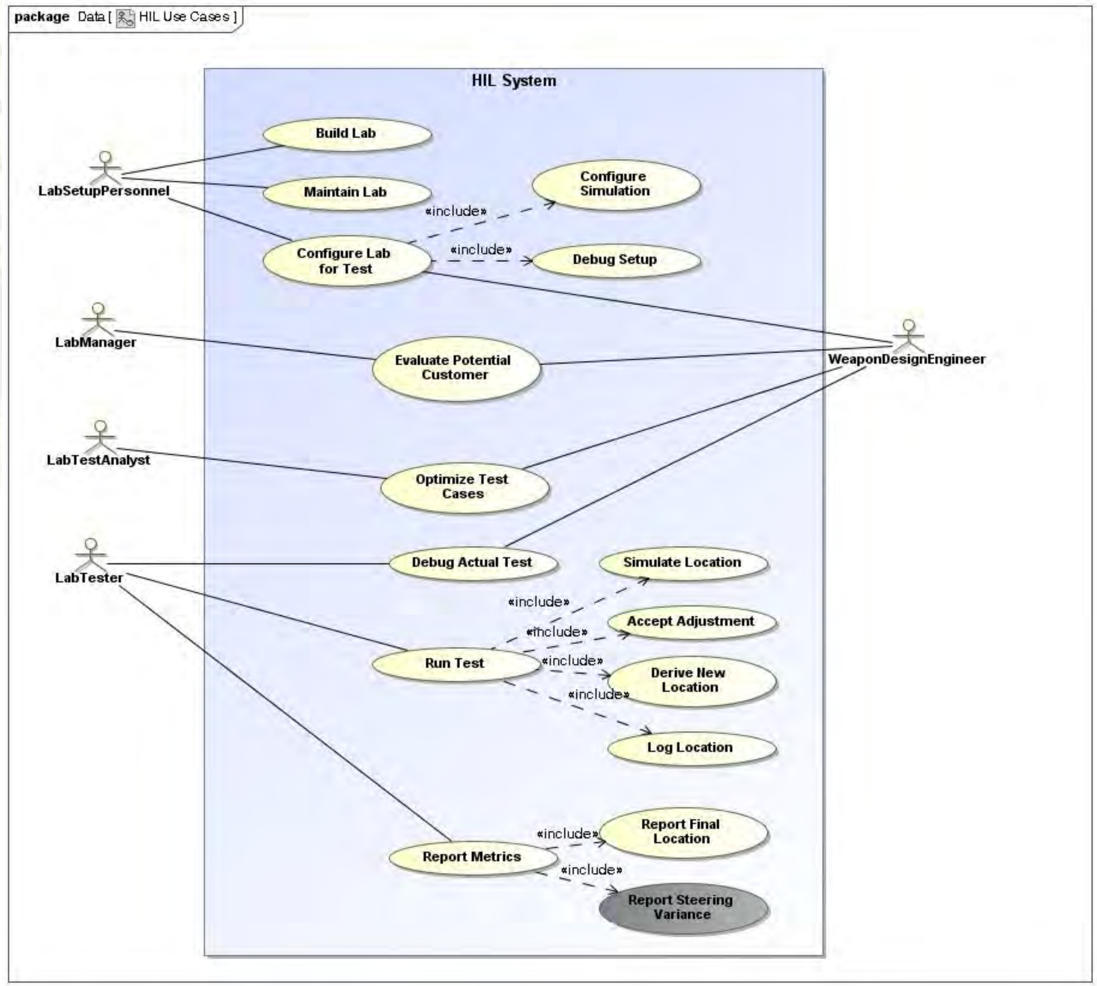
3. Requirements



4. Parametrics

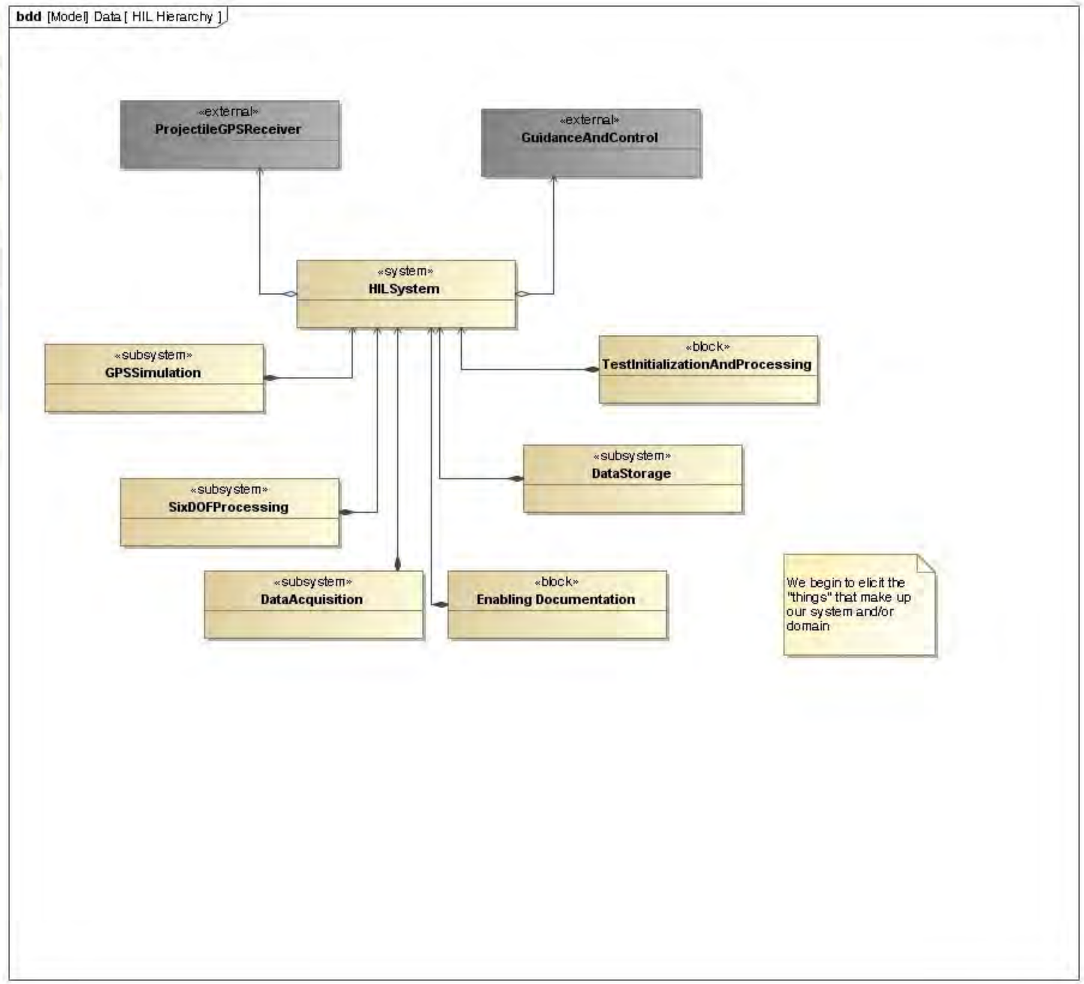
Capture Capabilities of the HIL

- **Eliciting Threshold and Objective Capabilities**
  - Actors
  - Use Cases (Goals)
- **Used to review with team**
- **Helped to come up with stakeholder requirements and informally trace behavior to requirements**
- **Looked at HIL facility as a project**



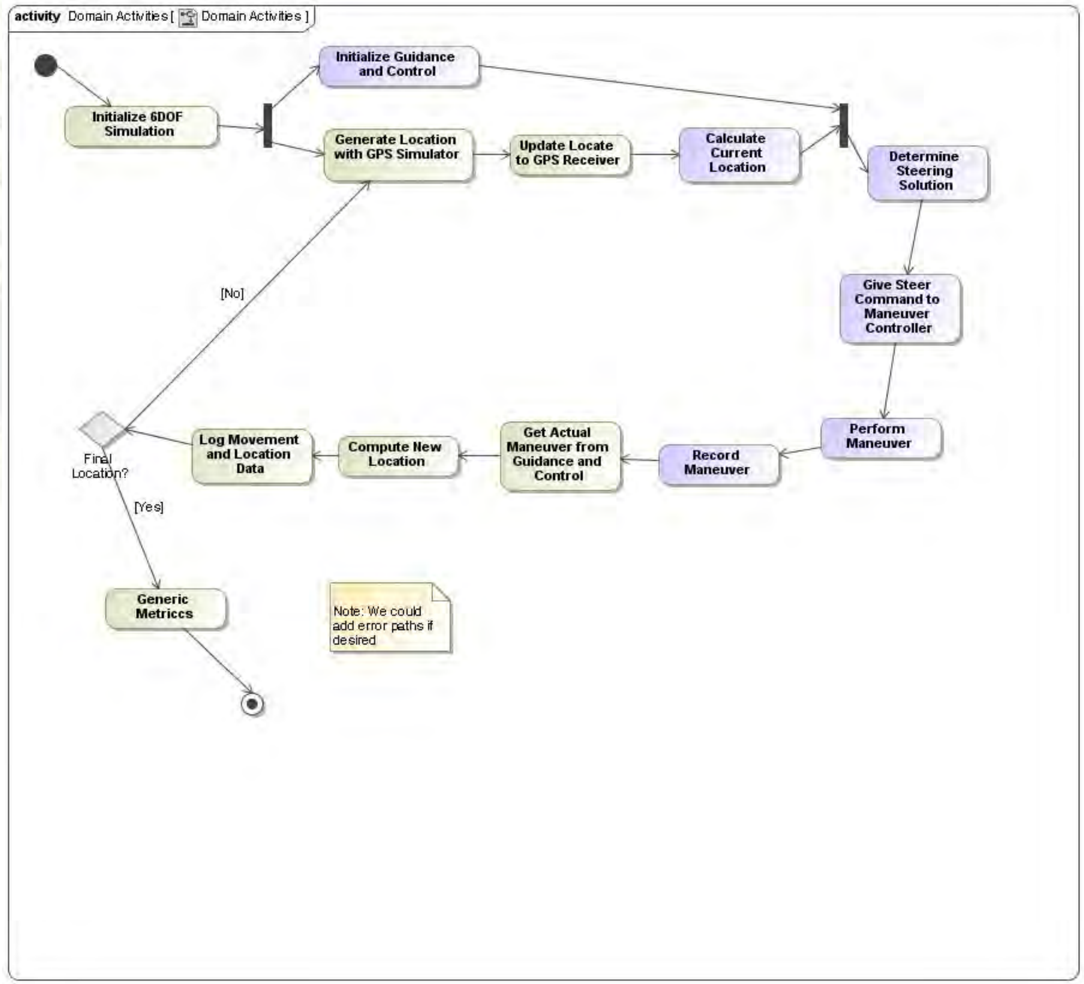
Capture Structure of the HIL

- **Eliciting Structure of the HIL**
  - What is part of the system
  - What is outside of system that interacts with our system
- **Logical Abstraction of "things" that may end up being:**
  - Physical Equipment
  - Software
  - Information (e.g. documented procedures/enabling products)



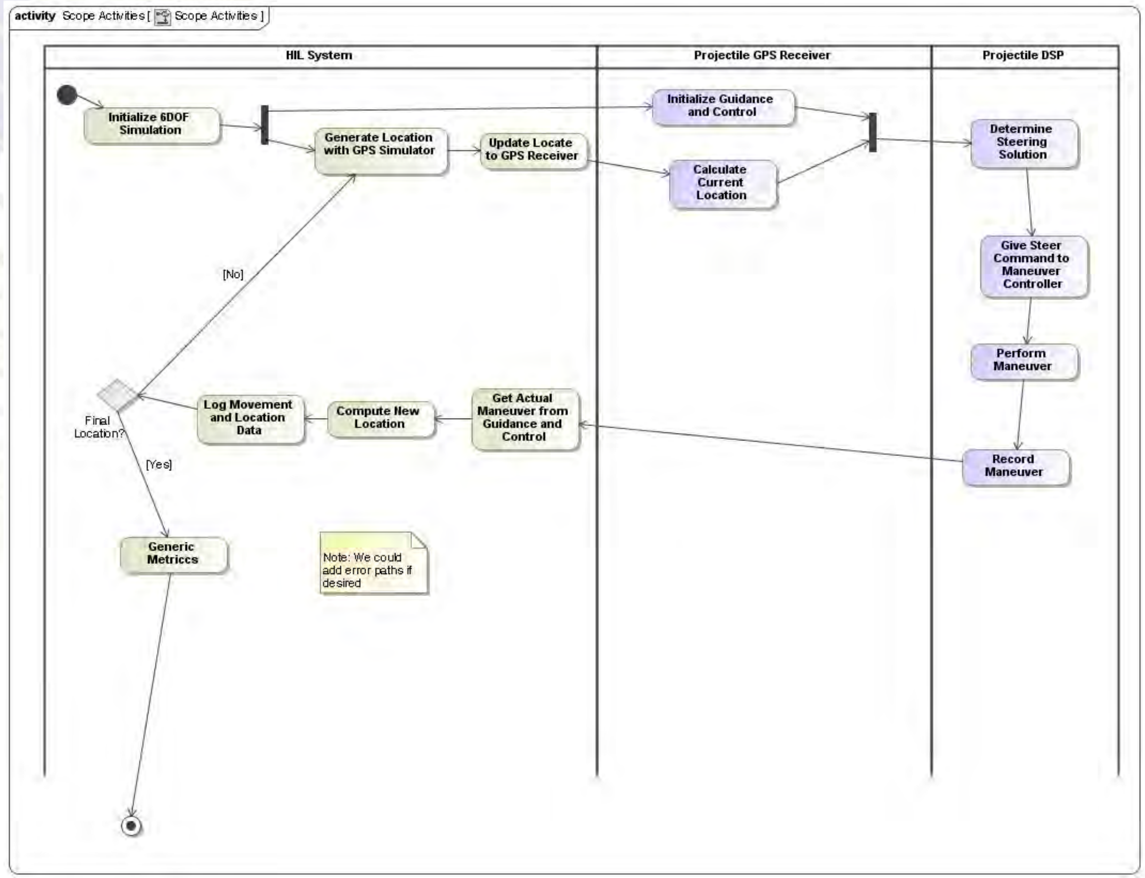
Capture Behavior of the HIL

- **Eliciting Behaviors of the HIL**
  - Could use Activity, Sequence, and/or State Diagrams
  - Can look at from a domain perspective (which we did here)
  - Here we elicit the actions for testing a weapon (which may or may not be tied to a specific capability)



Scope Behavior of the HIL

- **Scope Behaviors of the HIL**
  - Used the activity diagrams to review actions of a test
  - Next, it helped us decide what is part of the system and what is outside the system (i.e. allocation of behavior to structure in this case)



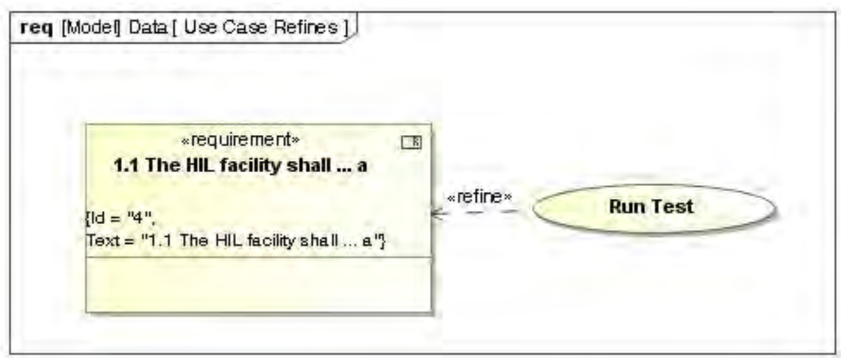
Capture Requirements of the HIL

HPTi

- **Capture Requirements of the HIL**
  - This was going on in parallel with capturing the capabilities, structure, and behavior
  - Can be done within a modeling tool, requirements management tool, or both
  - Relationships between the requirements and other model elements can be captured

System Requirements in a requirements management tool >>>

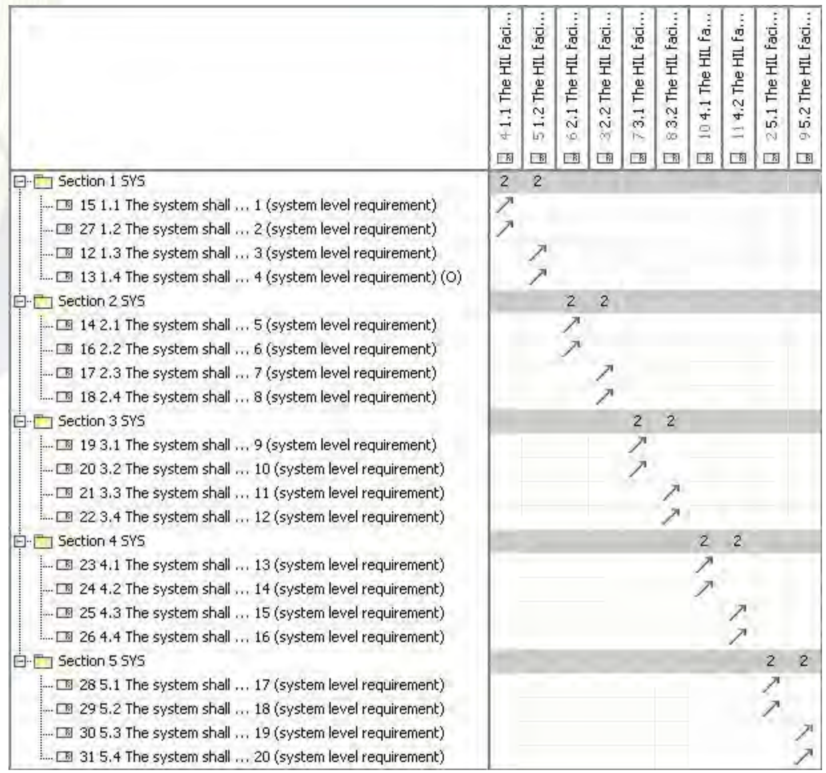
ID	Example System Level Reqs	Description of Test Information	Test Method
HIL-Sys1	1 HIL Program Requirements at System of Interest Level		
HIL-Sys2	1.1 The system shall ... 1 (system level requirement)	Test 1	Inspection
HIL-Sys4	1.2 The system shall ... 2 (system level requirement)	Test 2	Analysis
HIL-Sys16	1.3 The system shall ... 3 (system level requirement)	Test 3	Demonstration
HIL-Sys17	1.4 The system shall ... 4 (system level requirement) (O)	Test 4	Test
HIL-Sys5	2 HIL Facility Requirements at System of Interest Level		
HIL-Sys19	2.1 The system shall ... 5 (system level requirement)	Test 5	Inspection
HIL-Sys21	2.2 The system shall ... 6 (system level requirement)	Test 6	Analysis
HIL-Sys22	2.3 The system shall ... 7 (system level requirement)	Test 7	Demonstration
HIL-Sys23	2.4 The system shall ... 8 (system level requirement)	Test 8	Test
HIL-Sys12	3 HIL Test Requirements at System of Interest Level		
HIL-Sys32	3.1 The system shall ... 9 (system level requirement)	Test 9	Inspection
HIL-Sys33	3.2 The system shall ... 10 (system level requirement)	Test 10	Analysis
HIL-Sys34	3.3 The system shall ... 11 (system level requirement)	Test 11	Demonstration
HIL-Sys35	3.4 The system shall ... 12 (system level requirement)	Test 12	Test
HIL-Sys13	4 HIL Simulation Requirements at System of Interest Level		
HIL-Sys36	4.1 The system shall ... 13 (system level requirement)	Test 13	Inspection
HIL-Sys37	4.2 The system shall ... 14 (system level requirement)	Test 14	Analysis
HIL-Sys38	4.3 The system shall ... 15 (system level requirement)	Test 15	Demonstration
HIL-Sys39	4.4 The system shall ... 16 (system level requirement)	Test 16	Test
HIL-Sys14	5 HIL Reporting Requirements at System of Interest Level		
HIL-Sys40	5.1 The system shall ... 17 (system level requirement)	Test 17	Inspection
HIL-Sys41	5.2 The system shall ... 18 (system level requirement)	Test 18	Analysis
HIL-Sys44	5.3 The system shall ... 19 (system level requirement)	Test 19	Demonstration
HIL-	5.4 The system shall ... 20 (system level requirement)	Test 20	Test



Capture Requirements of the HIL

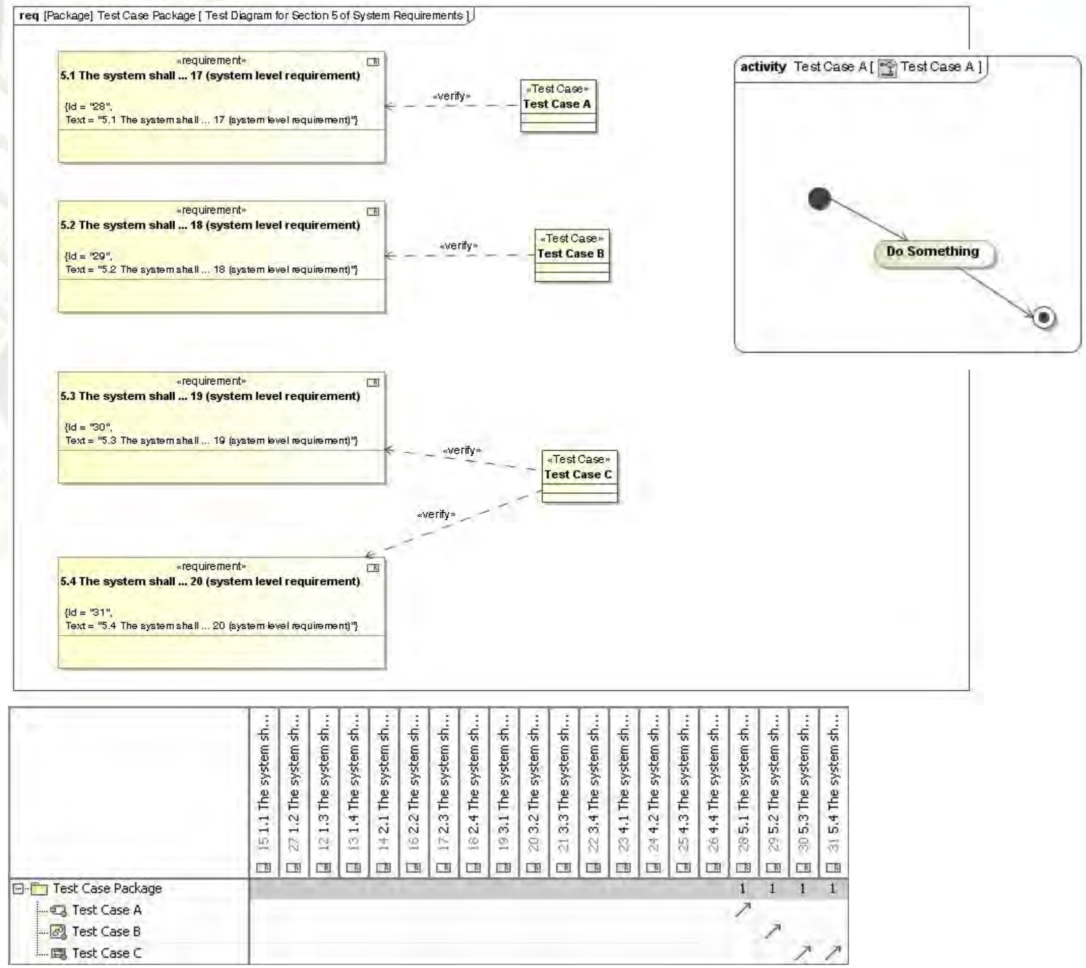
HPTi

- **Capture Requirements of the HIL**
  - A trace view may be more appropriate and manageable for large projects than a diagram
  - A trace view can be exported to a deliverable or format that can be used elsewhere (e.g. imported into a spreadsheet or requirements management tool).
  - Some tools provide tables that would allow you to managed requirements within the MBSE tool (if desired).



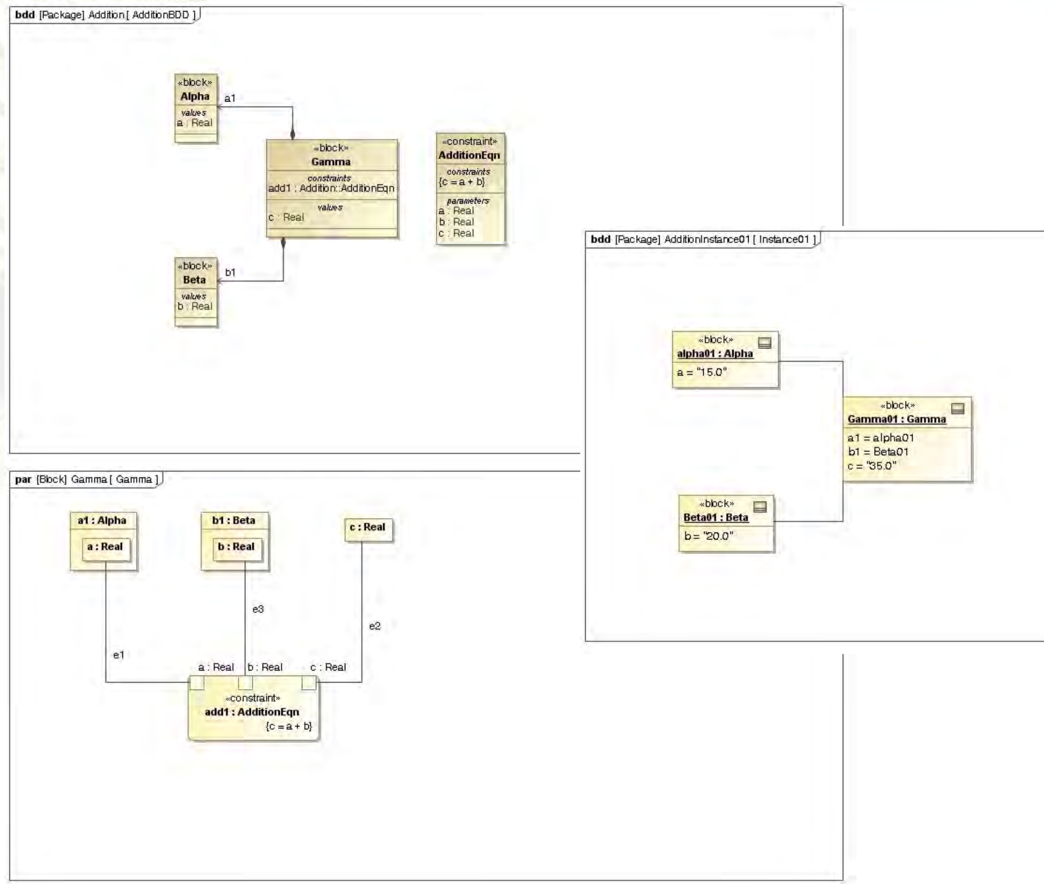
Capture Verification Information

- **Capture Verification Information for the HIL**
  - Assignment was also to capture how the system requirements were going to be verified.
  - MBSE can capture that information (e.g. relating verification to requirements).
  - This can be captured and displayed in requirements diagrams, trace views, and behavior diagrams).



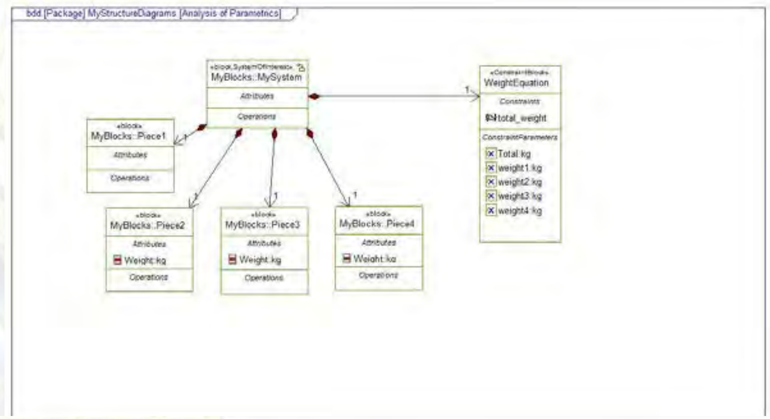
Capturing Parametrics

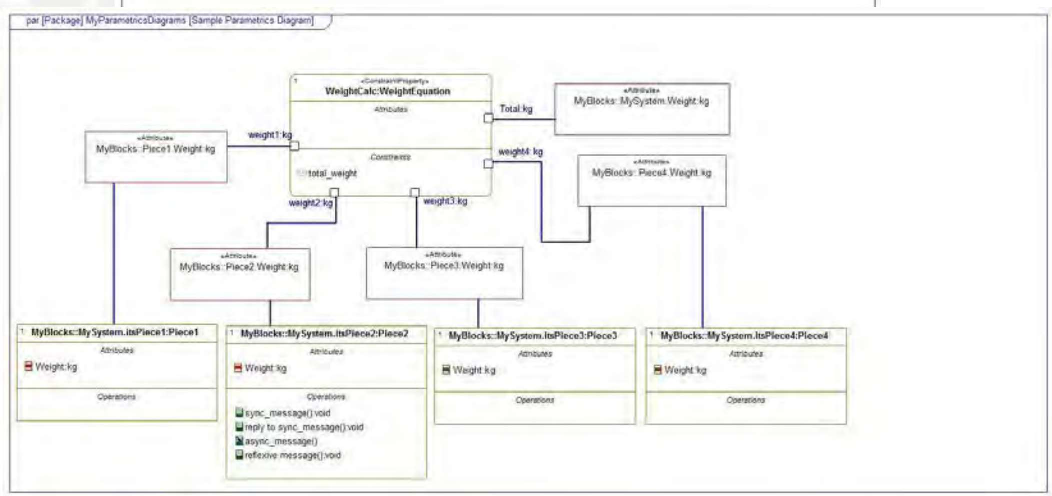
- Capturing equation data for your system of interest
- Interface with solvers to solve your equations
- Can create instances to look at different possible solutions (e.g. trade comparisons)
- Some examples of possible use: timeline analysis, failure analysis, reliability analysis, budgeting (e.g. weight, cost), aeroballistics model, optimize test set, model risk



Capturing Parametrics

- Simple example here is for a weight budget.
- The data for the equation is gathered in the block definition diagram.
- The “wiring” together of weight equation is done within a parametric diagram.
- The data can now be analyzed (which may mean interaction with a plug-in to the MBSE tool that serves a equation solver).

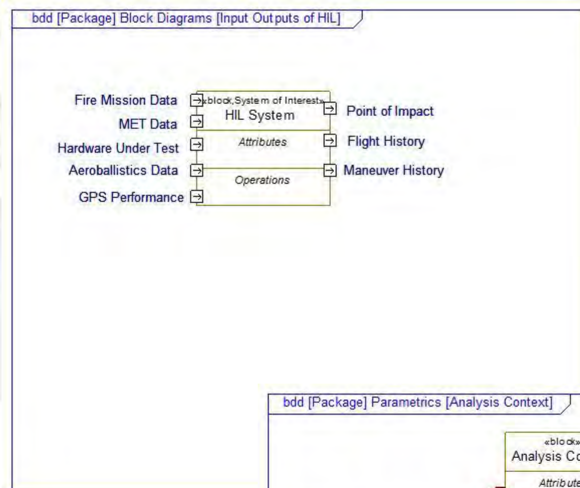


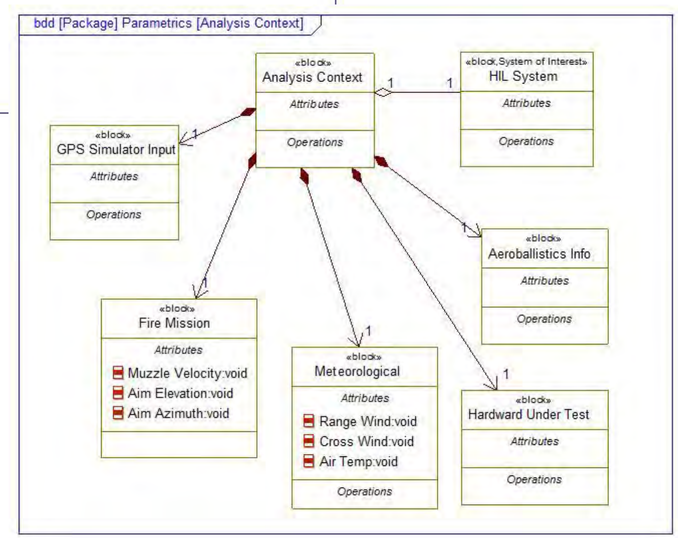


Capturing Parametrics

HPTi

- For our HIL task assignment, we did some capturing of parametric data (informal).
- Interfaced with System Analysis team to explain the HIL testing related to the simulated projectile flight information.
- The diagrams to the right is a high level abstraction of that information (representative example).





Model Animation and Execution

HPTi

- MBSE tools can be used to animate/execute behavior of your system of interest
  - Executing an Activity Diagram
  - Executing a State Machine Diagram
  - Executing a Sequence Diagram
- Model animation can help with gap analysis
- Model animation identify interfaces within your system and domain
- Model animation can be used to prototype your system (or prototype different solutions/alternatives)
- An executable model provides the potential to auto-generate useful model artifacts

Planning Considerations

- Scoping the effort (and where modeling fits in for specific project)
- Need a MBSE process to follow (an approach)
- Common Modeling Language (e.g. SysML, UML)
- A Modeling Tool to capture the information
- Who is going to model the information (and be able to convey the information to the reviewers who aren't expected to be system modelers themselves)
- Who is going to review the information (impacts the scoping of the effort as well)

Conclusions/Lessons Learned

HPTi

- Developed a common understanding of our system and what we needed to verify
- Assisted in defining and confirming: capabilities, requirements, structure, interfaces, and test information
- Formally documented the system and related verification information
- Didn't cause extra work (was part of the work; modeling assisted in delivering on schedule and quality work)
- Provided confidence to leadership that the project was meeting requirements and being verified

Using Design of Experiments (DOE) to Integrate Developmental and Operational T&E

Dr. Mark J. Kiemele
Air Academy Associates

NDIA 2011 Test & Evaluation Conference
Tampa, FL
16 March 2011

11-DOELE-3A

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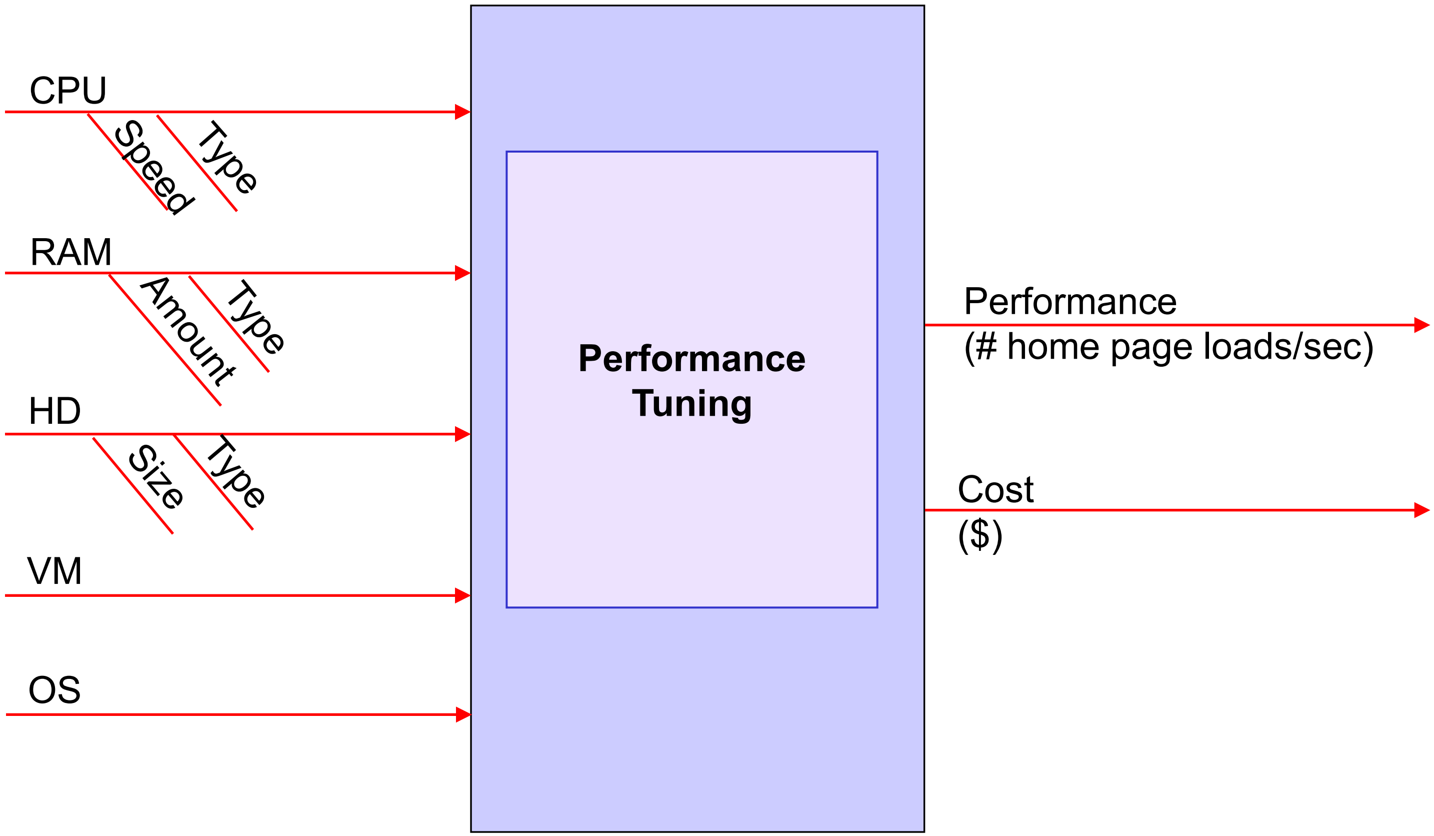
Agenda

- **Various Approaches to Testing Multiple Factors**
- **What makes Design of Experiments so special?**
- **Using DOE to build transfer functions in DT&E**
- **Critical Parameter Management: linking the functions together**
- **High Throughput Testing in OT&E**

Web-Based Test Scenario



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Performance Tuning Terminology

Factors/Inputs (X's)	Levels (Choices)	Performance/Outputs (Y's)
CPU Type	Itanium, Xeon	# home page loads/sec
CPU Speed	1 GHz, 2.5 GHz	Cost
RAM Amount	256 MB, 1.5 GB	
HD Size	50 GB, 500 GB	
VM	J2EE, .NET	
OS	Windows, Linux	

Which factors are important? Which are not?
Which combination of factor choices will maximize performance?
How do you know for sure? Show me the data.

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Approaches to Testing Multiple Factors

- **Traditional Approaches**
  - One Factor at a Time (OFAT)
  - Oracle (Best Guess)
  - All possible combinations (full factorial)

- **Modern Approach**
  - Statistically designed experiments (DOE) … full factorial plus other selected DOE designs, depending on the situation

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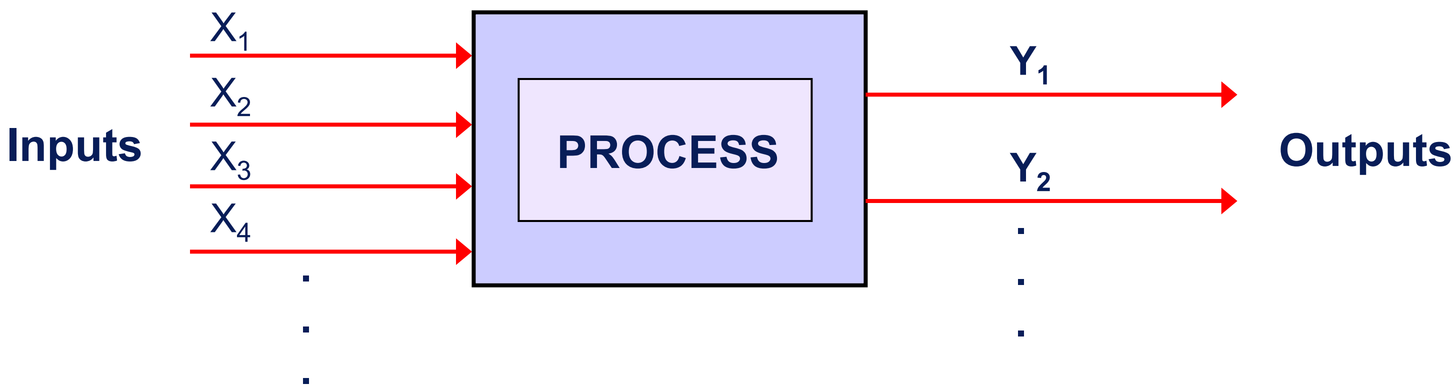
What is a Designed Experiment?

Purposeful changes of the inputs (factors) in order to observe corresponding changes in the output (response).



Run	X_1	X_2	X_3	X_4	Y_1	Y_2	. . . . . .	$\bar{Y}$	S_Y
1									
2									
3									
.									
.									

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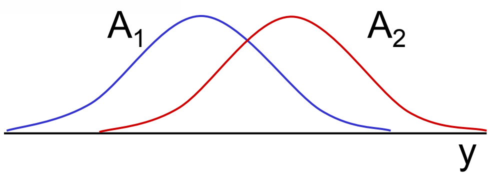
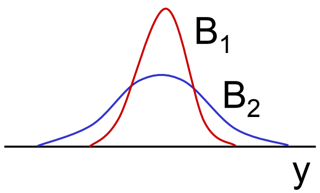
DOE Helps Determine How Inputs Affect Outputs

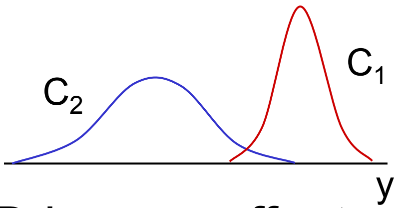
i) Factor A affects the average of y



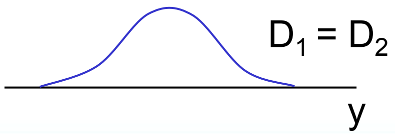
ii) Factor B affects the standard deviation of y



iii) Factor C affects the average and the standard deviation of y



iv) Factor D has no effect on y



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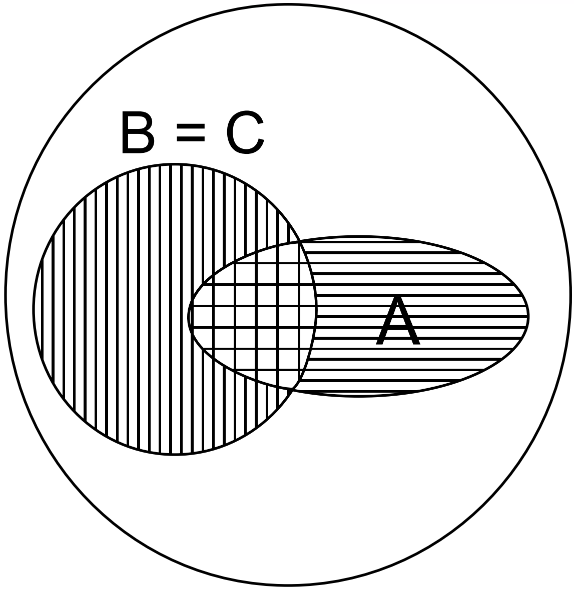
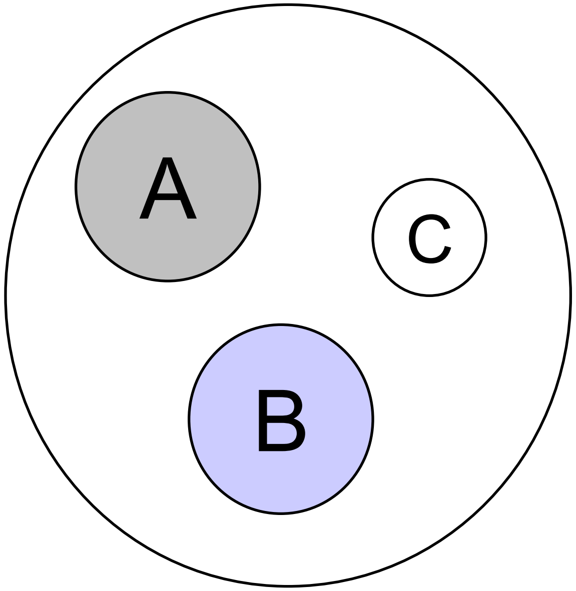
Evaluating the Effects of Variables on Y

We don't want this:



What we need is a design to provide independent estimates of effects:



How do we obtain this independence of variables?

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Statistically Designed Experiments (DOE):
Orthogonal or Nearly Orthogonal Designs

- FULL FACTORIALS (for small numbers of factors)
- FRACTIONAL FACTORIALS
- PLACKETT - BURMAN
- LATIN SQUARES
- HADAMARD MATRICES
- BOX - BEHNKEN DESIGNS
- CENTRAL COMPOSITE DESIGNS
- NEARLY ORTHOGONAL LATIN HYPERCUBE DESIGNS

Taguchi Designs

SIMPLE DEFINITION OF TWO-LEVEL ORTHOGONAL DESIGNS

Run	Actual Settings			Coded Matrix			Responses
	(5, 10) A: Time	(70, 90) B: Temp	(100,200) C: Press	(A) Time	(B) Temp	(C) Press	
1	5	70	100	-1	-1	-1	
2	5	70	200	-1	-1	+1	
3	5	90	100	-1	+1	-1	
4	5	90	200	-1	+1	+1	
5	10	70	100	+1	-1	-1	
6	10	70	200	+1	-1	+1	
7	10	90	100	+1	+1	-1	
8	10	90	200	+1	+1	+1	

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What Makes DOE so Powerful? (Orthogonality: both vertical and horizontal balance)

A Full Factorial Design for 3 Factors A, B, and C, Each at 2 levels:

Run	A	B	C	AB	AC	BC	ABC
1	-	-	-	+	+	+	-
2	-	-	+	+	-	-	+
3	-	+	-	-	+	-	+
4	-	+	+	-	-	+	-
5	+	-	-	-	-	+	+
6	+	-	+	-	+	-	-
7	+	+	-	+	-	-	-
8	+	+	+	+	+	+	+

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Design of Experiments (DOE)

- An optimal data collection methodology
- “Interrogates” the process
- Used to identify important relationships between input and output factors
- Identifies important interactions between process variables
- Can be used to optimize a process
- Changes “I think” to “I know”

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Google on DOE
(quotes* from Daryl Pregibon, Google Engineer)

"From a user's perspective, a query was submitted and results appear. From Google's perspective, the user has provided an opportunity to test something. What can we test? Well, there is so much to test that we have an Experiment Council that vets experiment proposals and quickly approves those that pass muster."

" We <u>evangelize</u> experimentation to the extent that we provide a mechanism for advertisers to run their own experiments.

. . . allows an advertiser to run a (full) factorial experiment on its web page. Advertisers can explore layout and content alternatives while Google randomly directs queries to the resulting treatment combinations. Simple analysis of click and conversion rates allows advertisers to explore a range of alternatives and their effect on user awareness and interest."

*** Taken From: *Statistics @ Google* in Amstat News, May 2011**

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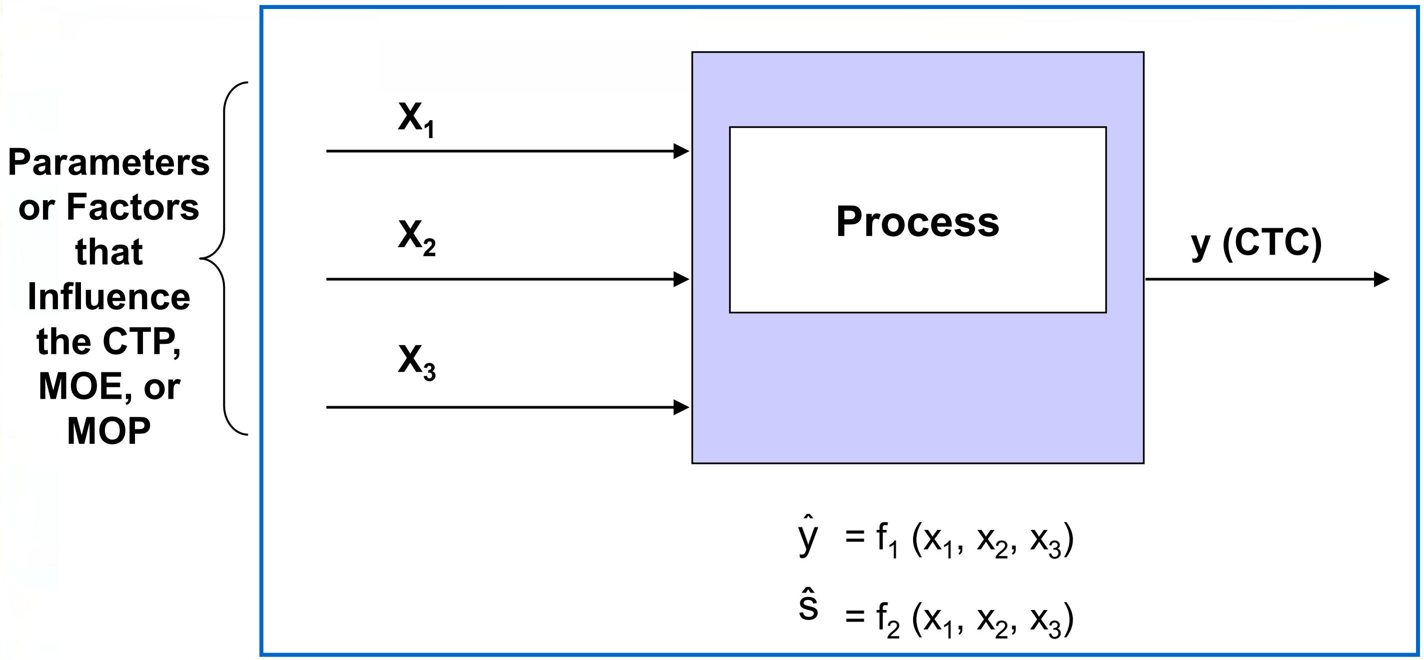
Transfer Function: A Key DT and OT Concept

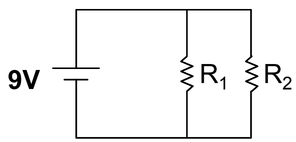


Where does the transfer function come from?

- **Exact transfer function**
- **Approximations**
  - **DOE**
  - **Historical Data Analysis**
  - **Simulation**

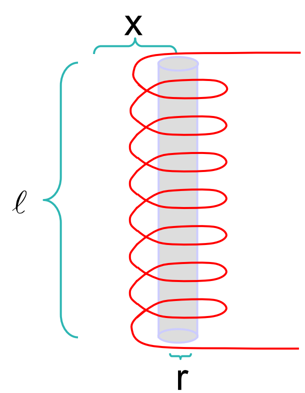
Exact Transfer Functions

- Engineering Relationships
  - $V = IR$
  - $F = ma$



The equation for current (I) through this DC circuit is defined by:

$$I = \frac{V}{\dfrac{R_1 \cdot R_2}{R_1 + R_2}} = \frac{V(R_1 + R_2)}{R_1 \cdot R_2}$$



The equation for magnetic force at a distance X from the center of a solenoid is:

$$H = \frac{NI}{2\ell}\left[\frac{.5\ell + x}{\sqrt{r^2 + (.5\ell + x)^2}} + \frac{.5\ell - x}{\sqrt{r^2 + (.5\ell - x)^2}}\right]$$

Where

	N:	total number of turns of wire in the solenoid
	I :	current in the wire, in amperes
	r :	radius of helix (solenoid), in cm
	ℓ :	length of the helix (solenoid), in cm
	x :	distance from center of helix (solenoid), in cm
	H :	magnetizing force, in amperes per centimeter

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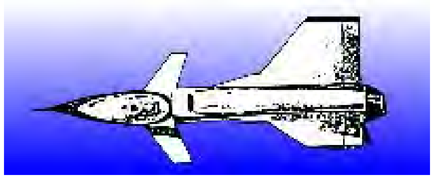
Value Delivery: Reducing Time to Market for New Technologies



INPUT

OUTPUT

Pitch <) (0, 15, 30)

Roll <) (0, 15, 30)

W1F <) (-15, 0, 15)

W2F <) (-15, 0, 15)

W3F <) (-15, 0, 15)

Modeling Flight Characteristics of New 3-Wing Aircraft

Six Aero-Characteristics

Total # of Combinations $= 3^5 = 243$

Central Composite Design: n = 30

Patent Holder: Dr. Bert Silich

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Aircraft Equations

C_L = .233 + .008(P)^2 + .255(P) + .012(R) - .043(WD1) - .117(WD2) + .185(WD3) + .010(P)(WD3) - .042(R)(WD1) + .035(R)(WD2) + .016(R)(WD3) + .010(P)(R) - .003(WD1)(WD2) - .006(WD1)(WD3)

C_D = .058 + .016(P)^2 + .028(P) - .004(WD1) - .013(WD2) + .013(WD3) + .002(P)(R) - .004(P)(WD1) - .009(P)(WD2) + .016(P)(WD3) - .004(R)(WD1) + .003(R)(WD2) + .020(WD1)^2 + .017(WD2)^2 + .021(WD3)^2

C_Y = -.006(P) - .006(R) + .169(WD1) - .121(WD2) - .063(WD3) - .004(P)(R) + .008(P)(WD1) - .006(P)(WD2) - .008(P)(WD3) - .012(R)(WD1) - .029(R)(WD2) + .048(R)(WD3) - .008(WD1)^2

C_M = .023 - .008(P)^2 + .004(P) - .007(R) + .024(WD1) + .066(WD2) - .099(WD3) - .006(P)(R) + .002(P)(WD2) - .005(P)(WD3) + .023(R)(WD1) - .019(R)(WD2) - .007(R)(WD3) + .007(WD1)^2 - .008(WD2)^2 + .002(WD1)(WD2) + .002(WD1)(WD3)

C_{YM}= .001(P) + .001(R) - .050(WD1) + .029(WD2) + .012(WD3) + .001(P)(R) - .005(P)(WD1) - .004(P)(WD2) - .004(P)(WD3) + .003(R)(WD1) + .008(R)(WD2) - .013(R)(WD3) + .004(WD1)^2 + .003(WD2)^2 - .005(WD3)^2

C_e = .003(P) + .035(WD1) + .048(WD2) + .051(WD3) - .003(R)(WD3) + .003(P)(R) - .005(P)(WD1) + .005(P)(WD2) + .006(P)(WD3) + .002(R)(WD1)

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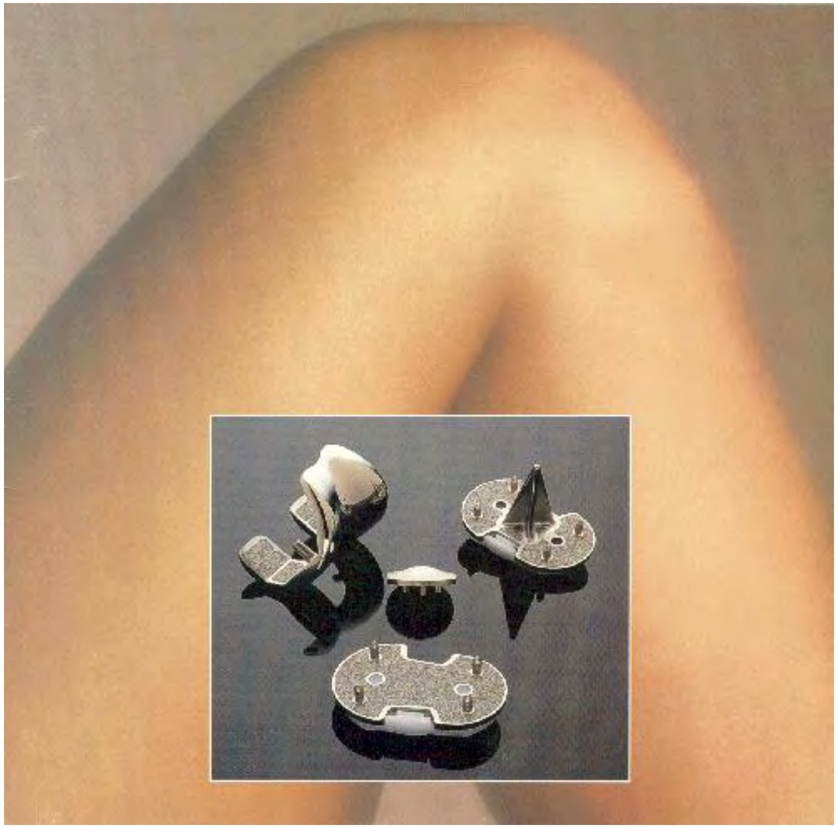
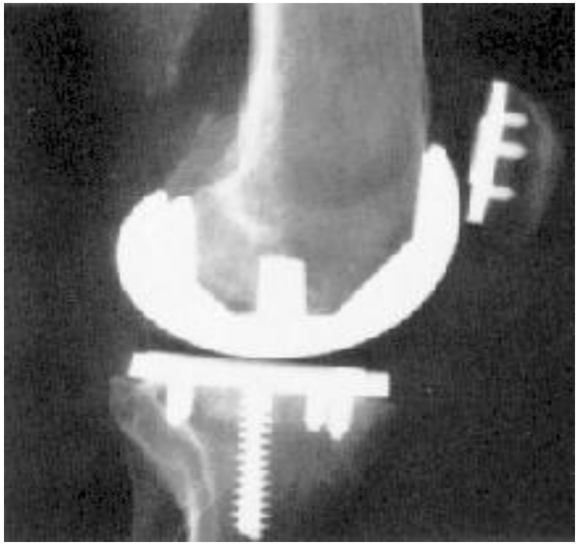
Fusing Titanium and Cobalt-Chrome





Courtesy Rai Chowdhary

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DOE “Market Research” Example (cont.)

Question: Choose the best design for evaluating this scenario

Answer: L_{18} design with attributes A - H in the inner array and factors J, K, and L in the outer array, resembling an L_{18} robust design, as shown below:

									L	-	+	-	+	-	+	-	+		
									K	-	-	+	+	-	-	+	+		
									J	-	-	-	-	+	+	+	+		
Run*	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**		y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	$\bar{y}$	s
1	-	-	-	-	-	-	-	-											
2	-	-	0	0	0	0	0	0											
3	-	-	+	+	+	+	+	+											
4	-	0	-	-	0	0	+	+											
5	-	0	0	0	+	+	-	-											
6	-	0	+	+	-	-	0	0											
7	-	+	-	0	-	+	0	+											
8	-	+	0	+	0	-	+	-											
9	-	+	+	-	+	0	-	0											
10	+	-	-	+	+	0	0	-											
11	+	-	0	-	-	+	+	0											
12	+	-	+	0	0	-	-	+											
13	+	0	-	0	+	-	+	0											
14	+	0	0	+	-	0	-	+											
15	+	0	+	-	0	+	0	-											
16	+	+	-	+	0	+	-	0											
17	+	+	0	-	+	-	0	+											
18	+	+	+	0	-	0	+	-											

Segmentation of the population or

<u>Respondent Profiles</u>

* 18 different product profiles

Modeling The Drivers of Turnover*

① External Market Factors
(Local Labor Market Conditions)
- Local Unemployment Rate
- Local Employment Alternatives
- Company's Market Share

② Organizational Characteristics and Practices
- Supervisor Stability
- Lateral / Upward Mobility
- Layoff Climate

③ Employee Attributes
- Time Since Last Promotion
- Education Level
- Job Stability History

Process of Deciding to Stay / Leave

Turnover Rate

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*Adapted from Harvard Business Review article on Boston Fleet Bank, April 2004, pp 116-125

The Value of Transfer Functions

- Provide a <u>simple and compact way of understanding relationships</u> between performance measures or response variables (y's) and the factors (x's) that influence them.
- Allow for the <u>prediction of the response variable</u> (y), with associated risk levels, <u>before</u> any change in the product or process is made.
- Allow for the <u>assessment of process or product capability</u> in the presence of uncontrolled variation or noise.
- Allow the <u>very quick manipulation of complex systems</u> using a meta-model derived from a simulator via DOE.
- Provide a <u>very easy way to optimize performance</u> via robust or parameter design and tolerance allocation.
- Make <u>sensitivity analysis easy</u> and straightforward.
- Greatly <u>enhance one's knowledge</u> of a product or process.
- In general, they are the <u>gateway to systematic innovation.</u>
- Provide a <u>meaningful metric for the maturity in DFSS</u> for any organization.

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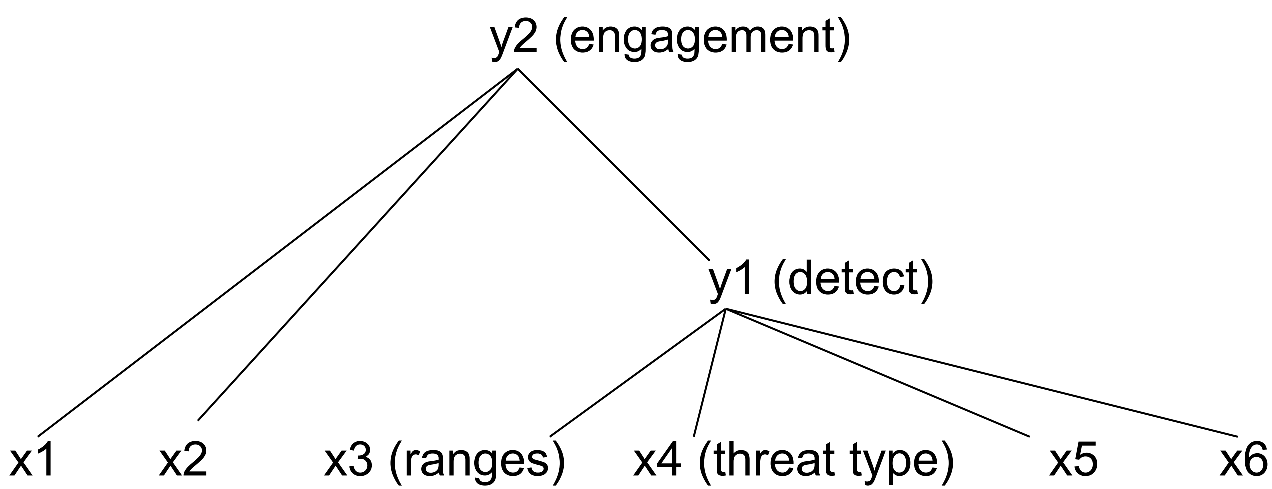
Critical Parameter Management and COIs

– A Critical Operational Issue (COI) is linked to operational effectiveness and suitability.

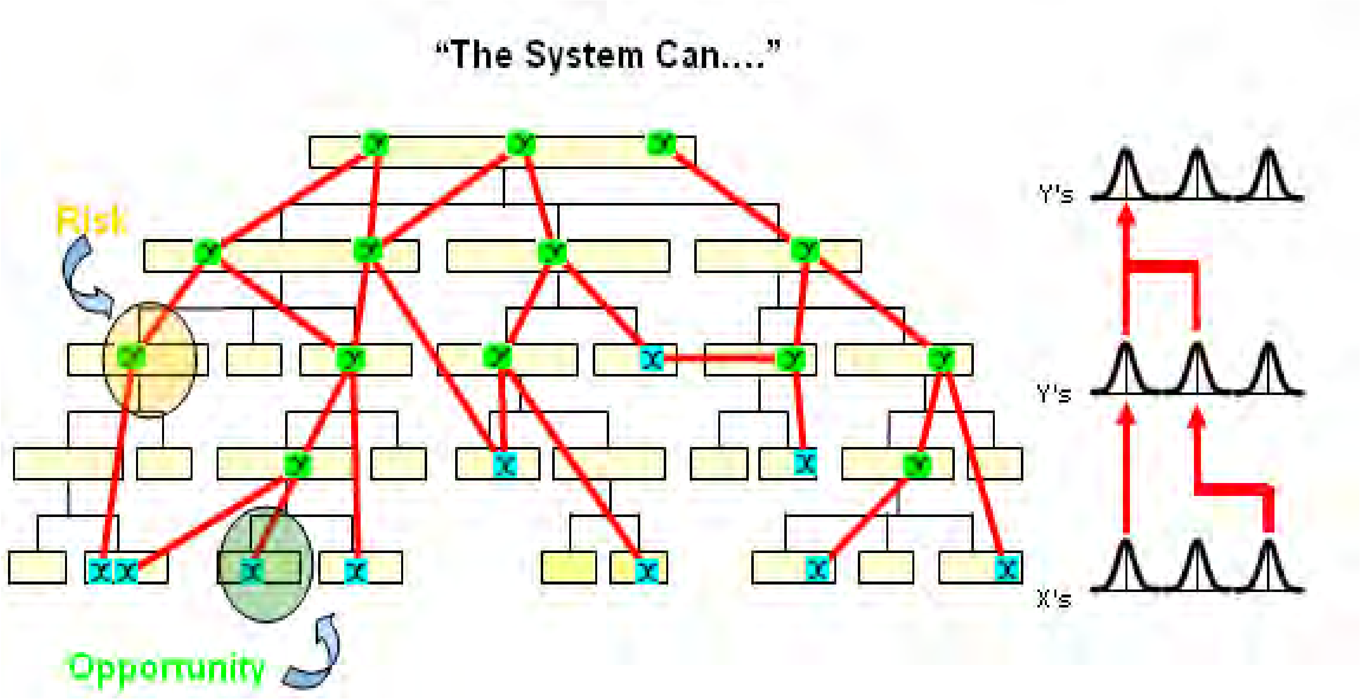
– It is typically phrased as a question, e.g.,

Will the system ***detect*** the ***threat*** in a ***combat environment*** at adequate ***range*** to allow for successful ***engagement***?

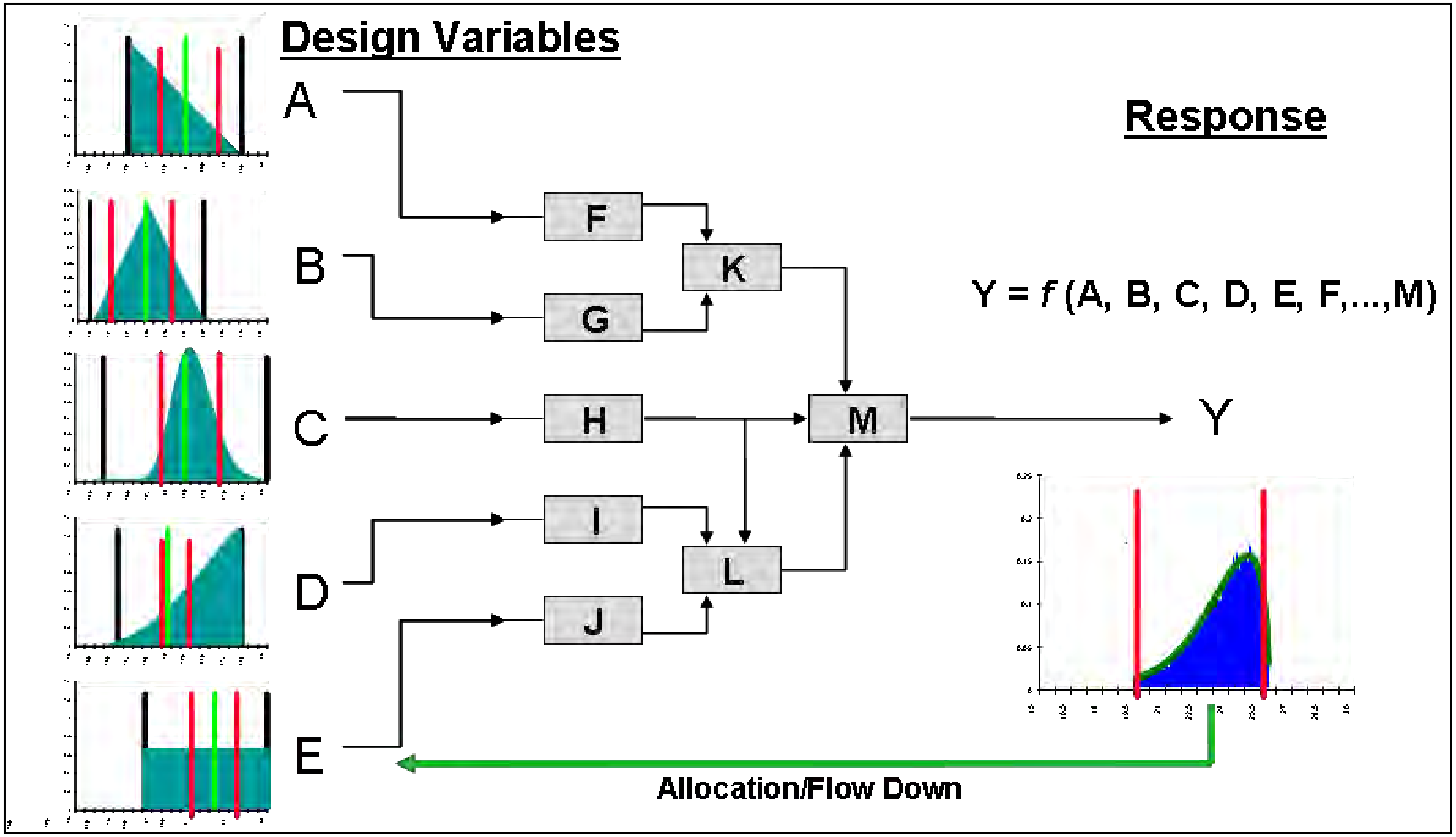


DOE Enables Critical Parameter Management (CPM)

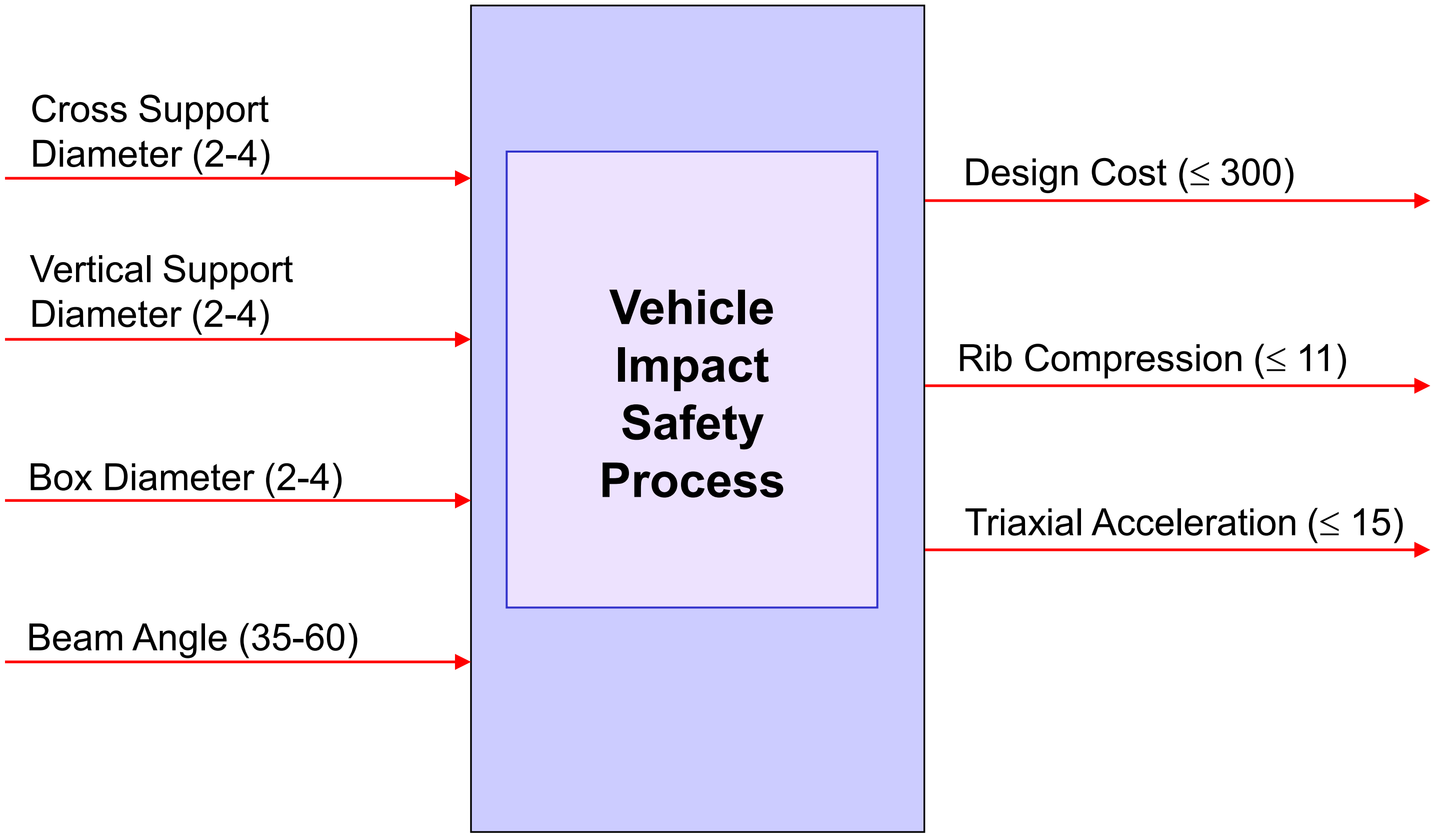
CPM is a systems engineering best practice that is extremely useful in managing, analyzing, and reporting technical product performance. It is also very useful in decomposing COIs and developing linkages between measures and task capabilities/system attributes.



DOE Enables the Composition of Functions



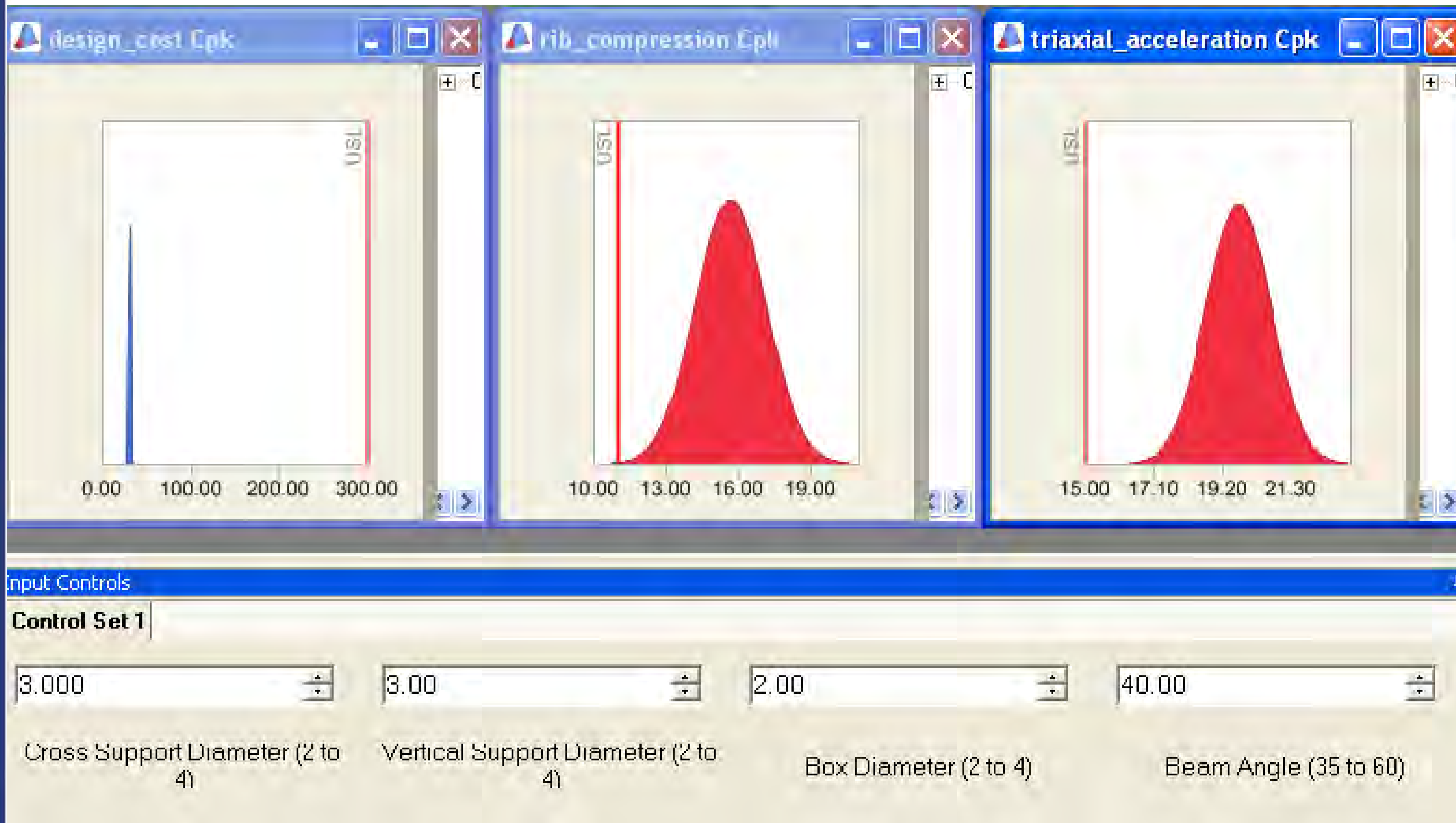
Multiple Response Optimization Simulation* Example



* From **SimWare Pro** by Philip Mayfield and Digital Computations

Multiple Response Optimization (cont.)

Capability Prior to Optimization



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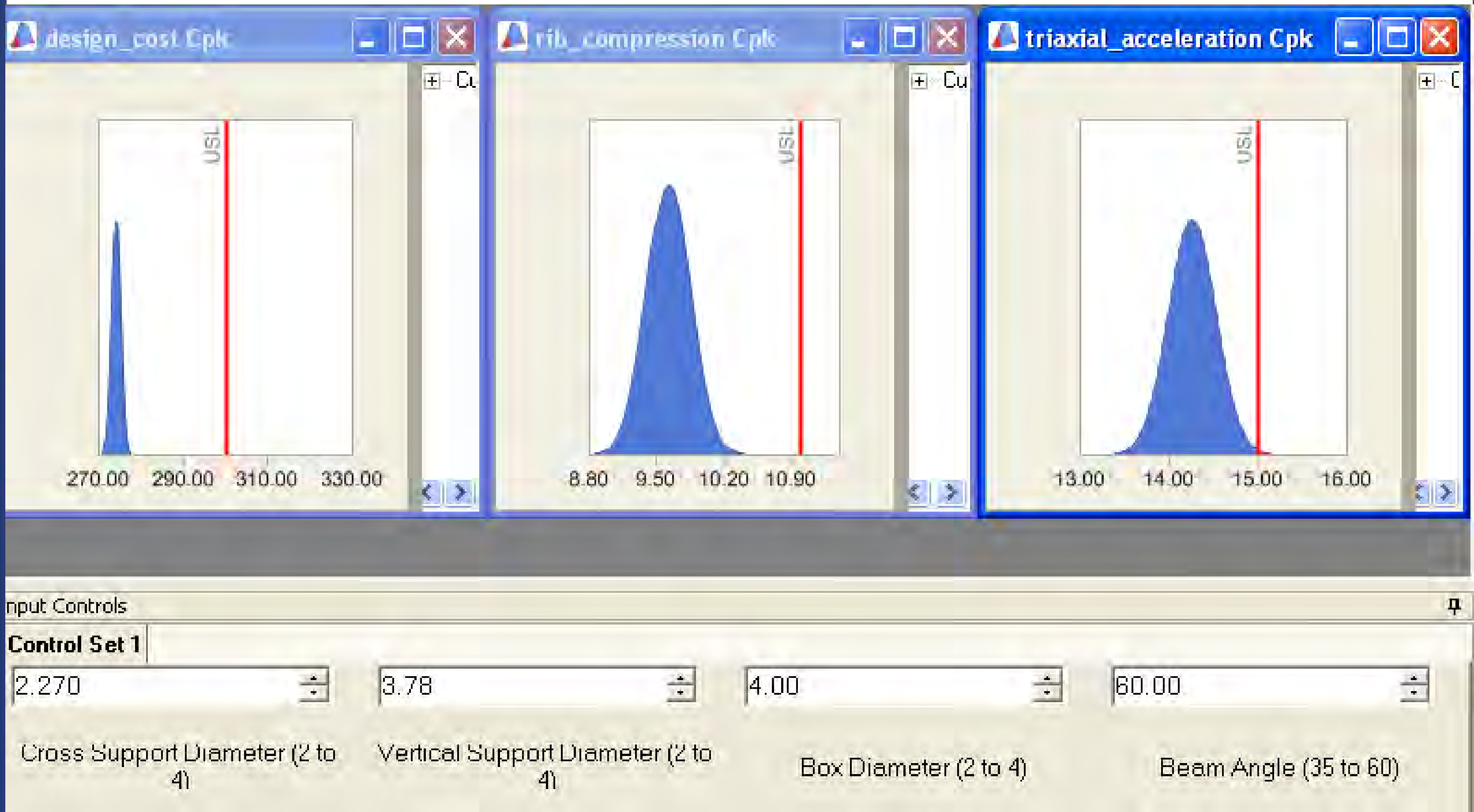
Multiple Response Optimization (cont.)

Capability After Optimization



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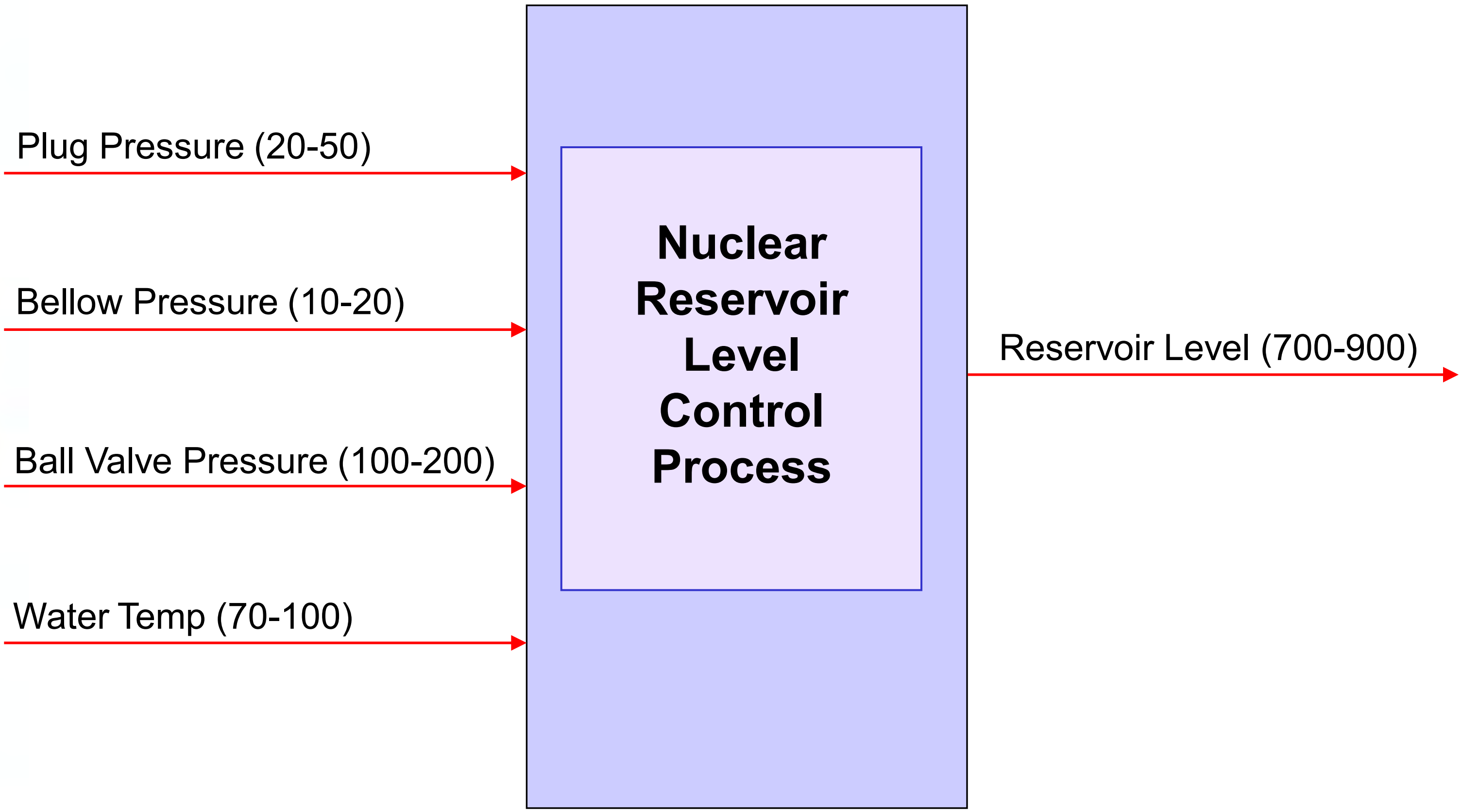
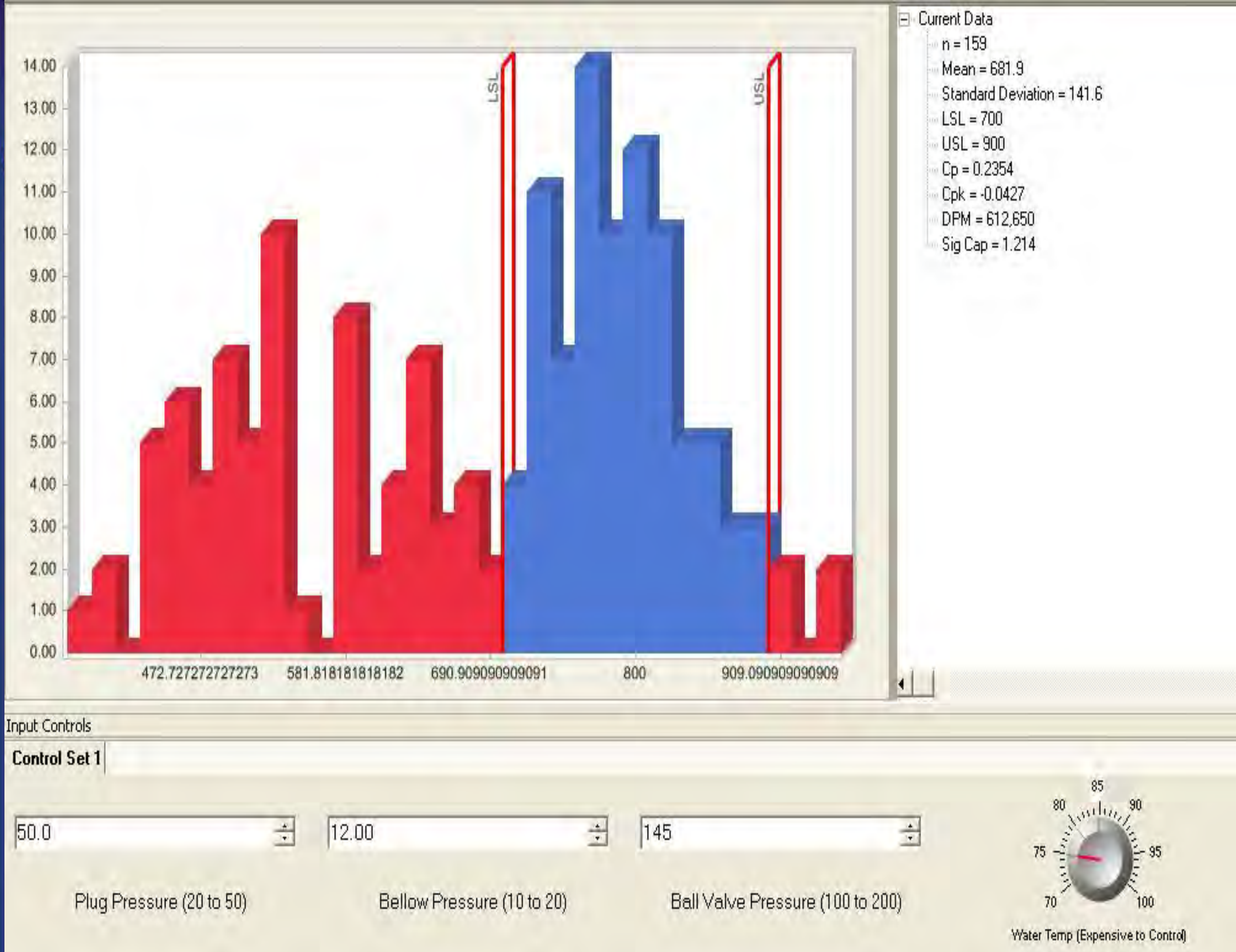
Robust (Parameter) Design Simulation* Example



* From **SimWare Pro** by Philip Mayfield and Digital Computations



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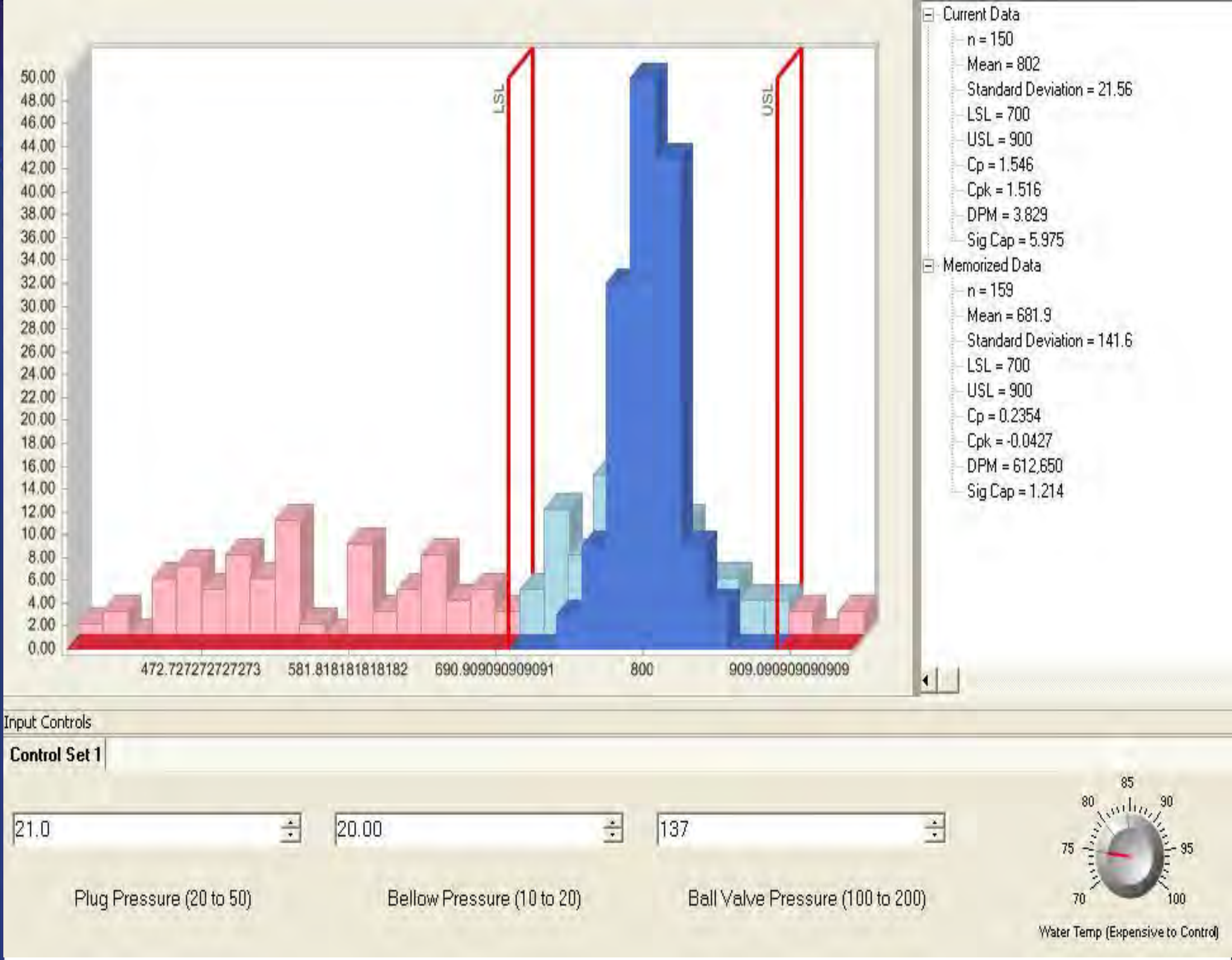

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Introduction to High Throughput Testing (HTT)

- A recently developed technique based on combinatorics
- Used to test myriad combinations of many factors (typically qualitative) where the factors could have many levels
- Uses a minimum number of runs or combinations to do this
- Software (e.g., ProTest) is needed to select the minimal subset of all possible combinations to be tested so that all 2-way combinations are tested.
- HTT is not a DOE technique, although the terminology is similar
- A run or row in an HTT matrix is, like DOE, a combination of different factor levels which, after being tested, will result in a successful or failed run
- HTT has its origins in the pharmaceutical business where in drug discovery many chemical compounds are combined together (combinatorial chemistry) at many different strengths to try to produce a reaction.
- Other industries are now using HTT, e.g., software testing, materials discovery, integration and functionality testing (see example on next page).

Submarine Threat Detection Example

- Suppose we want to perform a verification test with the following 7 input factors (with their respective settings):
  - Submarine Type (S1, S2, S3)
  - Ocean Depth (Shallow, Deep, Very Deep)
  - Sonar Type (Active, Passive)
  - Target Depth (Surface, Shallow, Deep, Very Deep)
  - Sea Bottom (Rock, Sand, Mud)
  - Control Mode (Autonomous, Manual)
  - Ocean Current (Strong, Moderate, Minimal)
- All possible combinations would involve how many runs in the test?
- If we were interested in testing all pairs only, how many runs would be in the test? Pro Test generated the following test matrix.

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Submarine Threat Detection Example (cont.)

The following 15 test cases will test all pairwise combinations.

	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E	Factor_F	Factor_G
Factor Name	Submarine Type	Ocean Depth	Sonar Type	Target Depth	Sea Bottom	Control Mode	Ocean Current
Case 1	S3	Deep	Passive	Very Deep	Mud	Manual	Minimal
Case 2	S1	Very Deep	Passive	Surface	Rock	Autonomous	Strong
Case 3	S2	Shallow	Active	Shallow	Rock	Manual	Moderate
Case 4	S2	Deep	Passive	Deep	Sand	Autonomous	Moderate
Case 5	S1	Shallow	Active	Surface	Sand	Manual	Minimal
Case 6	S1	Very Deep	Passive	Shallow	Mud	Autonomous	Minimal
Case 7	S3	Very Deep	Active	Deep	Mud	Manual	Strong
Case 8	S2	Very Deep	Active	Very Deep	Sand	Autonomous	Strong
Case 9	S3	Shallow	Passive	Shallow	Mud	Autonomous	Strong
Case 10	S3	Deep	Active	Surface	Rock	Manual	Moderate
Case 11	S1	Shallow	Active	Deep	Rock	Autonomous	Minimal
Case 12	S1	Deep	Passive	Very Deep	Rock	Manual	Moderate
Case 13	S2	Very Deep	Active	Surface	Mud	Autonomous	Moderate
Case 14	S3	Deep	Active	Shallow	Sand	Manual	Strong
Case 15	S2	Shallow	Active	Very Deep	Rock	Manual	Minimal

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Command & Control Test Example

(15 factors each at various levels)
Total Combinations: 20,155,392

Variable or Factor	Levels	(# of levels)
Mission Snapshots	Entry, Operations, Consolidation	(3)
Network Size	10 Nodes, 50 Nodes, 100 Nodes	(3)
Network Loading	Nominal, 2X, 4X	(3)
Movement Posture	ATH, OTM1, OTM2	(3)
SATCOM Band	Ku, Ka, Combo	(3)
SATCOM Look Angle	0, 45, 75	(3)
Link Degradation	0%, 5%, 10%, 20%	(4)
Node Degradation	0%, 5%, 10%, 20%	(4)
EW	None, Terrestrial, GPS	(3)
Interoperability	Joint Services, NATO	(2)
IA	None, Spoofing, Hacking, Flooding	(4)
Security	NIPR, SIPIR	(2)
Message Type	Data, Voice, Video	(3)
Message Size	Small, Medium, Large, Mega	(4)
Distance Between Nodes	Short, Average, Long	(3)

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Command & Control Test Example

(All Pairs Testing from ProTest generates 26 test cases)

	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E	Factor_F	Factor_G	Factor_H	Factor_I	Factor_J	Factor_K	Factor_L	Factor_M	Factor_N	Factor_O
Factor Name	Mission	Network Size	Network Load	Movement	SATCOM Band	SATCOM Angle	Link Degradation	Node Degradation	EW	Interoperability	IA	Security	Message Type	Size of Message	Node Distance
Case 1	Entry	100 nodes	4X	OTM2	Combo	0	0%	0%	None	NATO	None	SIPIR	Voice	Medium	Short
Case 2	Consolidation	10 nodes	Normal	ATH	Ka	45	5%	5%	GPS	NATO	Spoofing	NIPR	Video	Large	Normal
Case 3	Operation	50 nodes	2X	OTM1	Ku	75	20%	20%	Terrestrial	Joint Serv	Hacking	NIPR	Voice	Small	Long
Case 4	Entry	50 nodes	2X	ATH	Ku	45	10%	10%	None	NATO	Flooding	NIPR	Data	Mega	Short
Case 5	Operation	100 nodes	Normal	OTM1	Combo	75	10%	10%	GPS	NATO	Spoofing	SIPIR	Data	Small	Normal
Case 6	Operation	10 nodes	4X	OTM2	Combo	45	0%	5%	Terrestrial	Joint Serv	None	NIPR	Video	Mega	Long
Case 7	Consolidation	100 nodes	4X	ATH	Ka	75	20%	10%	Terrestrial	NATO	Hacking	SIPIR	Video	Medium	Long
Case 8	Operation	10 nodes	Normal	ATH	Ka	0	20%	0%	Terrestrial	Joint Serv	Flooding	NIPR	Data	Large	Short
Case 9	Consolidation	10 nodes	2X	OTM2	Ku	45	5%	20%	None	Joint Serv	Flooding	SIPIR	Voice	Medium	Normal
Case 10	Consolidation	50 nodes	2X	OTM1	Combo	0	0%	20%	GPS	NATO	None	NIPR	Data	Mega	Normal
Case 11	Entry	50 nodes	Normal	OTM2	Ka	75	10%	5%	GPS	Joint Serv	Hacking	SIPIR	Voice	Large	Long
Case 12	Entry	50 nodes	4X	OTM1	Ku	0	5%	0%	None	Joint Serv	Spoofing	SIPIR	Video	Small	Long
Case 13	Consolidation	100 nodes	4X	OTM2	Ku	45	20%	5%	GPS	Joint Serv	Flooding	NIPR	Data	Small	Short
Case 14	Entry	10 nodes	2X	OTM1	Ka	75	5%	0%	None	Joint Serv	Hacking	SIPIR	Data	Mega	Normal
Case 15	Entry	50 nodes	2X	ATH	Ka	75	0%	20%	Terrestrial	NATO	Spoofing	NIPR	Video	Large	Short
Case 16	Consolidation	10 nodes	4X	ATH	Ku	0	10%	20%	Terrestrial	NATO	None	NIPR	Video	Small	Normal
Case 17	Operation	50 nodes	Normal	OTM1	Ku	75	0%	5%	None	Joint Serv	Flooding	NIPR	Data	Medium	Short
Case 18	Operation	10 nodes	Normal	OTM1	Ka	75	20%	10%	None	Joint Serv	None	SIPIR	Video	Large	Normal
Case 19	Operation	100 nodes	2X	OTM2	Combo	0	5%	10%	Terrestrial	NATO	Hacking	SIPIR	Data	Large	Short
Case 20	Consolidation	100 nodes	Normal	ATH	Combo	0	20%	20%	Terrestrial	Joint Serv	Spoofing	NIPR	Voice	Mega	Short
Case 21	Consolidation	50 nodes	2X	OTM1	Ka	45	10%	0%	GPS	Joint Serv	Spoofing	SIPIR	Data	Medium	Normal
Case 22	Entry	100 nodes	Normal	OTM1	Combo	0	20%	5%	GPS	NATO	Flooding	NIPR	Video	Medium	Long
Case 23	Operation	10 nodes	Normal	ATH	Ka	45	0%	10%	None	NATO	Hacking	SIPIR	Voice	Small	Normal
Case 24	Entry	50 nodes	4X	ATH	Ku	45	5%	20%	None	NATO	None	NIPR	Video	Large	Long
Case 25	Consolidation	10 nodes	2X	ATH	Ku	75	10%	5%	None	Joint Serv	Spoofing	NIPR	Data	Large	Long
Case 26	Consolidation	100 nodes	Normal	OTM2	Combo	45	5%	20%	GPS	Joint Serv	Spoofing	NIPR	Voice	Mega	Normal

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HTT Applications

- Reducing the cost and time of testing while maintaining adequate test coverage
- Integration, interoperability and functionality testing
- Creating a test plan to stress a product and discover problems
- Prescreening before a large DOE to ensure all 2-way combinations are feasible before discovering, midway through an experiment, that certain combinations are not feasible
- Developing an “outer array” of noise combinations to use in a robust design DOE when the number of noise factors and settings is large

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Using DFSS as an Integrating Framework for MBT&E and DOT&E

Dr. Mark J. Kiemele
Air Academy Associates

NDIA 2011 Test & Evaluation Conference
Tampa, FL
14 March 2011

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11-DFSSLE-3A

Warm-Up Exercise

- **Goal: full concentration on the subject**
- **Eliminate extraneous issues that could inhibit that**
- **Write down the top issue on a plain sheet of paper**
- **Jettison this issue by doing the following:**

  - Design a paper airplane that will help you deposit this issue in the waste basket.

  - Launch your paper airplane at the waste basket from your seating area. You may stand or even move around to launch if you wish.

  - Goal is to put the issue in the waste basket, which is obviously symbolic of —putting the issue away."

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Food for Thought .... True or False?

The systems and products that deliver value to our warfighters are perfectly designed to achieve the results we are getting today.

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Session Goals and Objectives

1. Know what DFSS is and understand that it is a strategy that uses DOE and other powerful methods to design, develop, and field successful systems.
2. Understand the DFSS process—Identify, Design, Optimize, Validate (IDOV)—and know that it focuses heavily on the Voice of the Warfighter.
3. Know that the DFSS process translates requirements, i.e., task capabilities and system attributes, into measures of effectiveness and measures of performance and then subsequently into design parameters which are then optimized to produce highly capable products and services.
4. Relate to some of the powerful tools that are unique to the DFSS process.
5. Understand what a transfer function is, be able to comprehend its value, and see that it can be used to develop linkages between Critical Operational Issues (COIs) and measures of performance/effectiveness.
6. Comprehend the opportunity for DFSS in your organization with regard to MBT&E and DOT&E.

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Agenda

- **Introduction and Review**
- **The Motivation for DFSS**
- **The DFSS Process: Identify, Design, Optimize, Validate (IDOV)**
  - The **Identify** Phase
    - –The DFSS Scorecard
    - –Voice of the Customer (VOC)
  - The **Design** Phase
    - –Translating the VOC (Requirements Flowdown)
    - –Concept Generation and Selection
    - –Transfer Functions
    - –Critical Parameter Management
  - The **Optimize** Phase
    - –Multiple Response Optimization
    - –Expected Value Analysis Using Monte Carlo Simulation
    - –Parameter Design
    - –Tolerance Allocation
  - The **Validate** Phase
    - –High Throughput Testing
- **Recap of DFSS with MBT&E and Designing the Test and Evaluation**
- **DFSS Success Stories**

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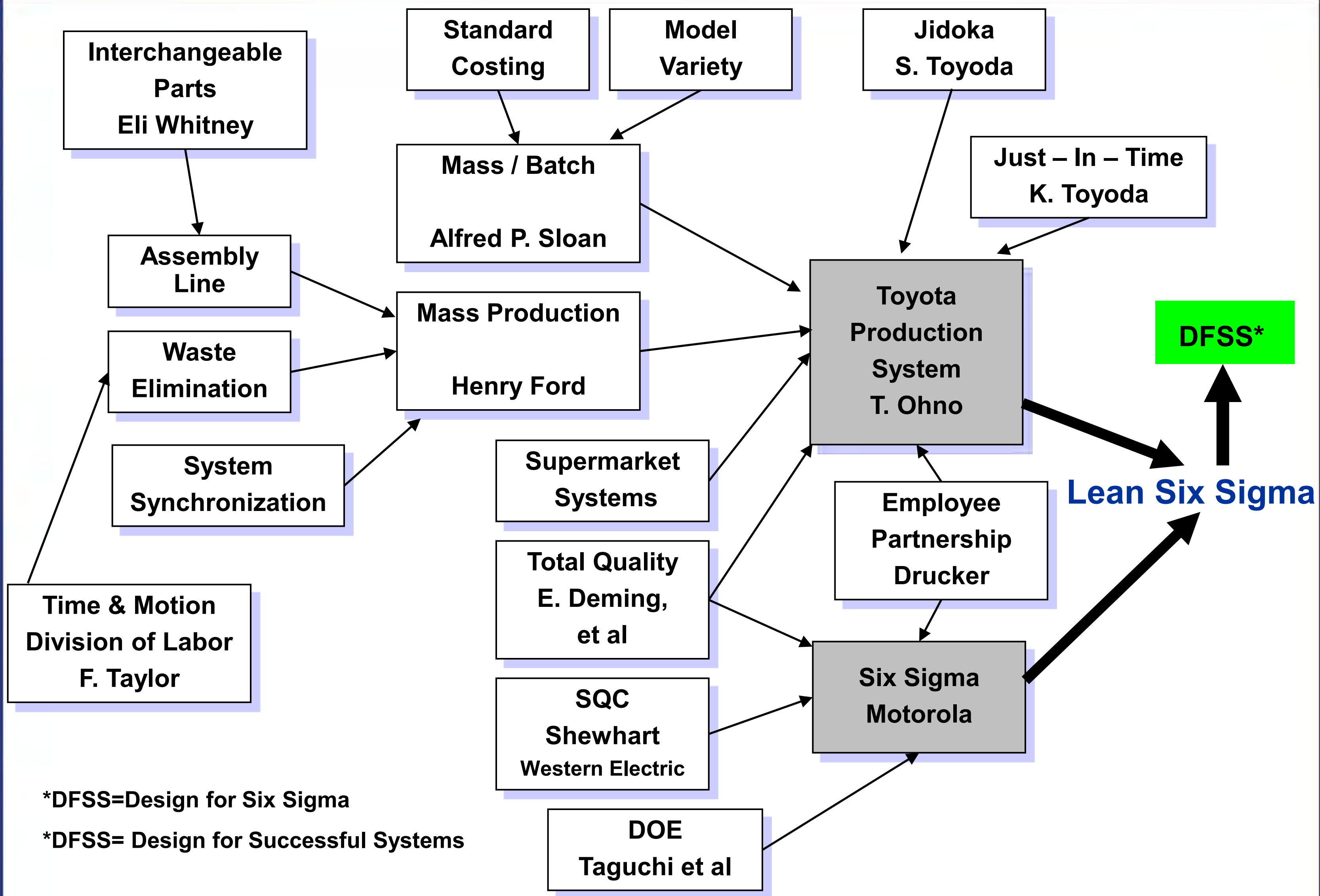
Introduction and Review

Performance Improvement Evolution



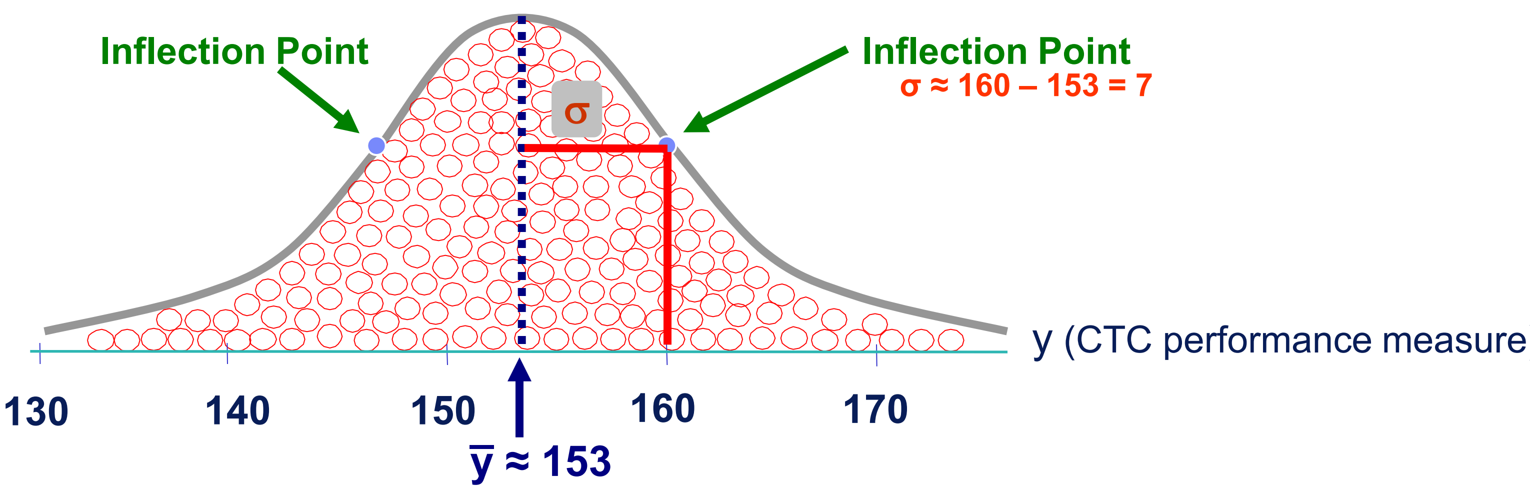
*DFSS=Design for Six Sigma

*DFSS= Design for Successful Systems

Graphical Meaning of $\bar{y}$ and σ

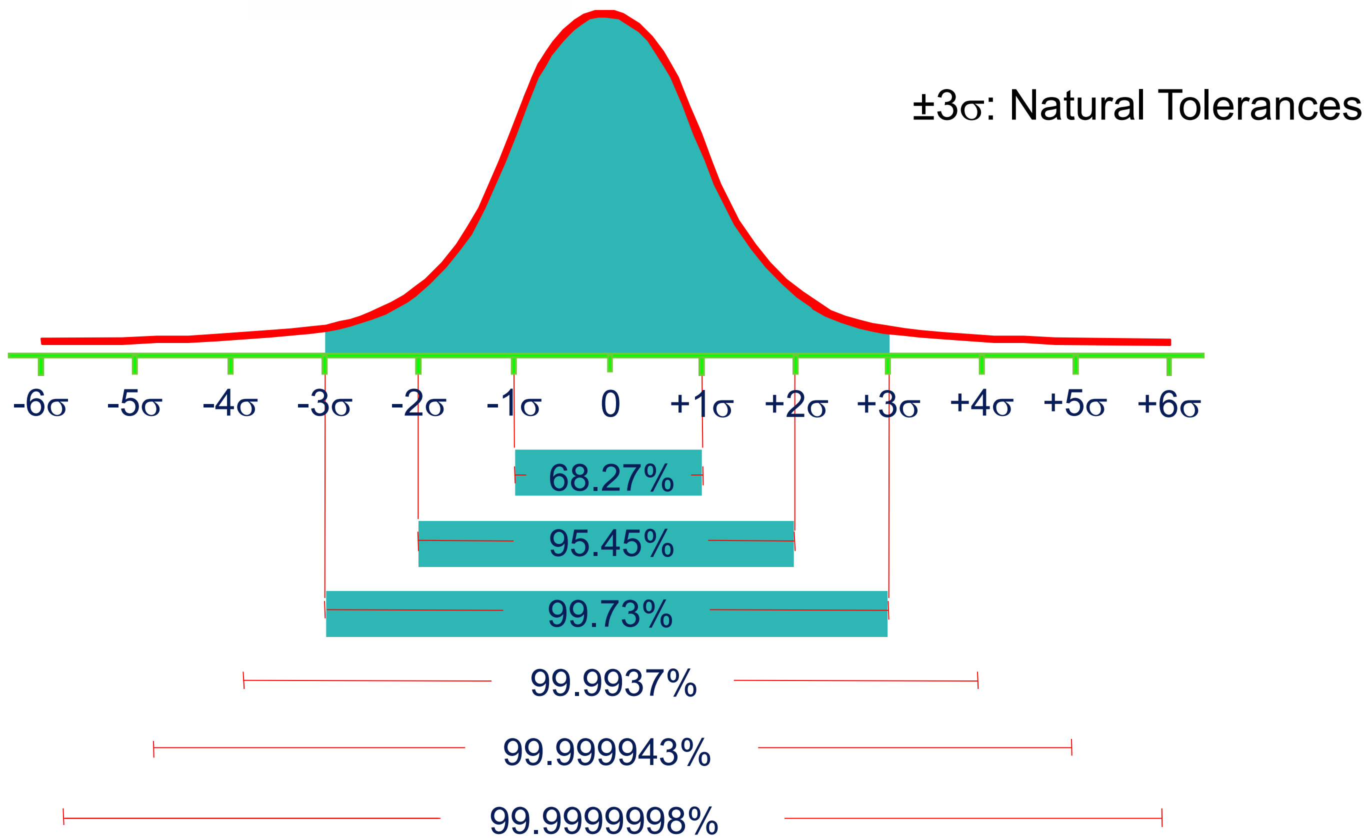
$\bar{y}$ = Average = Mean = Balance Point

σ = Standard Deviation



σ ≈ average distance of points from the centerline

Graphical View of Variation

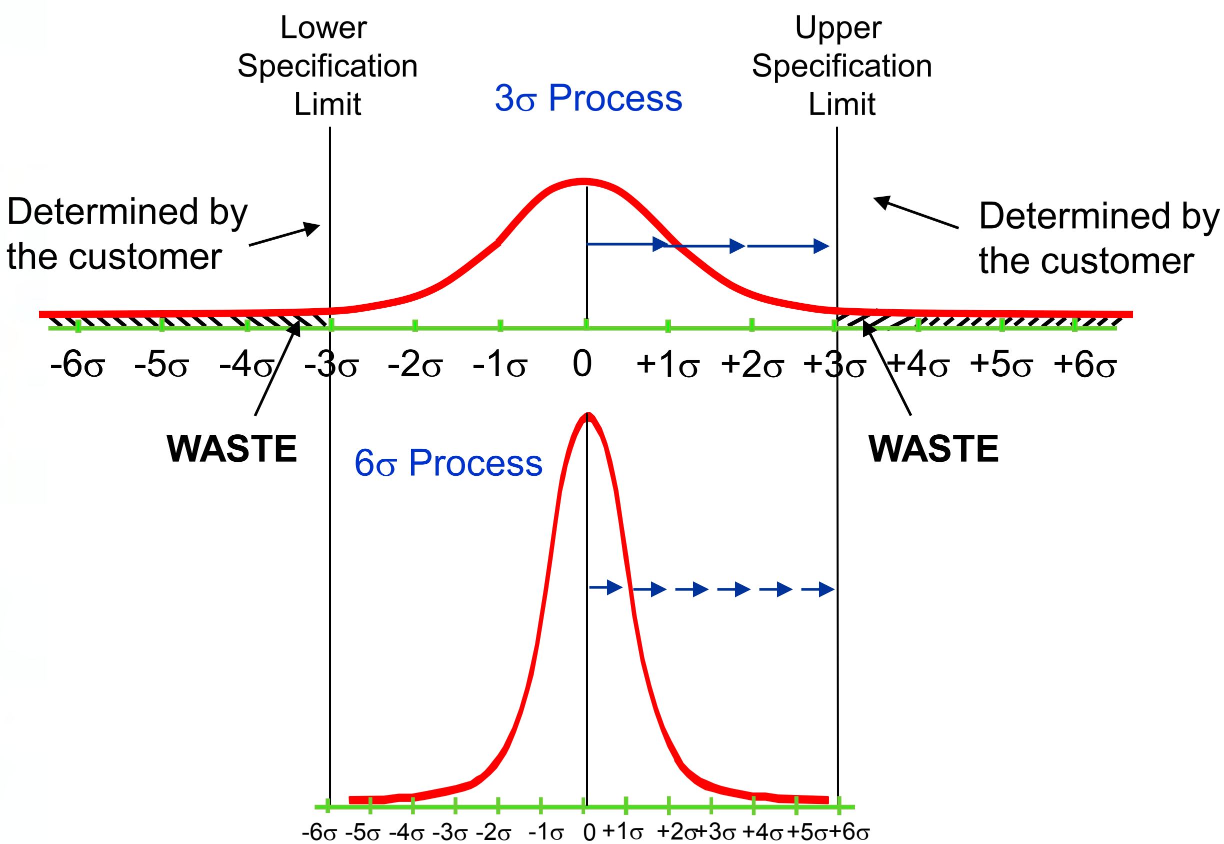


Typical Areas under the Normal Curve

Graphical View of Variation and Performance Capability

The Sigma rating/capability of a process performance measure is the result of comparing the **Voice of the Process** with the **Voice of the Customer**, and it is defined as follows:

The **number of Sigmas** between the center of a process performance measure's distribution and the nearest specification limit



<u>3σ Process Centered</u>

- Process is WIDER than the specifications, causing waste and cost of poor quality

<u>6σ Process Centered</u>

- Process FITS well within the specifications, so even if the process shifts, the values fall well within tolerances

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Sigma Ratings Measure Process Capability

Sigma Capability is a measure of quality. It compares the Voice of the Process with the Voice of the Customer and is correlated to the defect rate. It is computed from DPMO.

Yield is the probability that whatever we are producing (manufactured part, PO, shipped part, etc.) will pass through the entire process without rework and without defects.

σ Capability*	DPMO*	RTY
2	308,537	69.1%
3	66,807	93.3%
4	6,210	99.4%
5	233	99.97%
6	3.4	99.99966%
Process Capability	Defects per Million Opportunities	Rolled Throughput Yield

Six Sigma is a standard of Excellence.
It means less than 4 Defects per Million Opportunities.

* Assumes a 1.5 sigma shift in average if the performance measure is normally distributed

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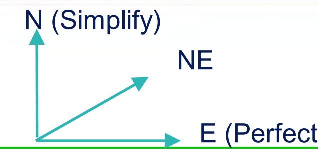
Relationship Between Lean, Six Sigma and DFSS

Perfect → Six Sigma



Lean ↑ Simplify

OVERALL YIELD vs SIGMA
(Distribution Shifted ±1.5σ)

# of Parts (Steps)	±3σ	±4σ	±5σ	±6σ
1	93.32%	99.379%	99.9767%	99.99966%
7	61.63	95.733	99.839	99.9976
10	50.08	93.96	99.768	99.9966
20	25.08	88.29	99.536	99.9932
40	6.29	77.94	99.074	99.9864
60	1.58	68.81	98.614	99.9796
80	0.40	60.75	98.156	99.9728
100	0.10	53.64	97.70	99.966
150	- - -	39.38	96.61	99.949
200	- - -	28.77	95.45	99.932
300	- - -	15.43	93.26	99.898
400	- - -	8.28	91.11	99.864
500	- - -	4.44	89.02	99.830
600	- - -	2.38	86.97	99.796
700	- - -	1.28	84.97	99.762
800	- - -	0.69	83.02	99.729
900	- - -	0.37	81.11	99.695
1000	- - -	0.20	79.24	99.661
1200	- - -	0.06	75.88	99.593
3000	- - -	- - -	50.15	98.985
17000	- - -	- - -	1.91	94.384
38000	- - -	- - -	0.01	87.880
70000				78.820
150000				60.000

DFSS

Use for Benchmarking

Source: Six Sigma RESEARCH INSTITUTE Motorola University Motorola, Inc.

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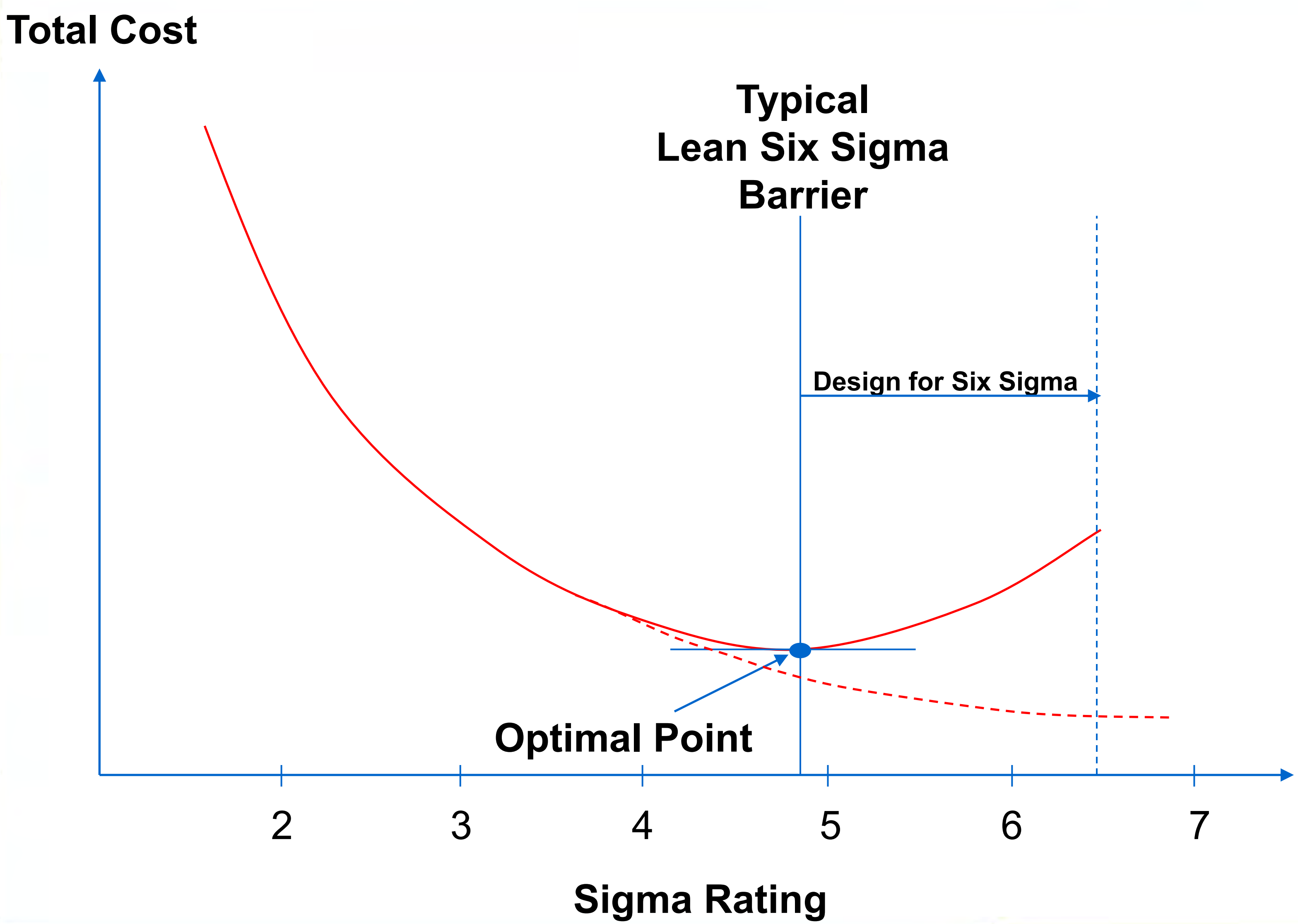
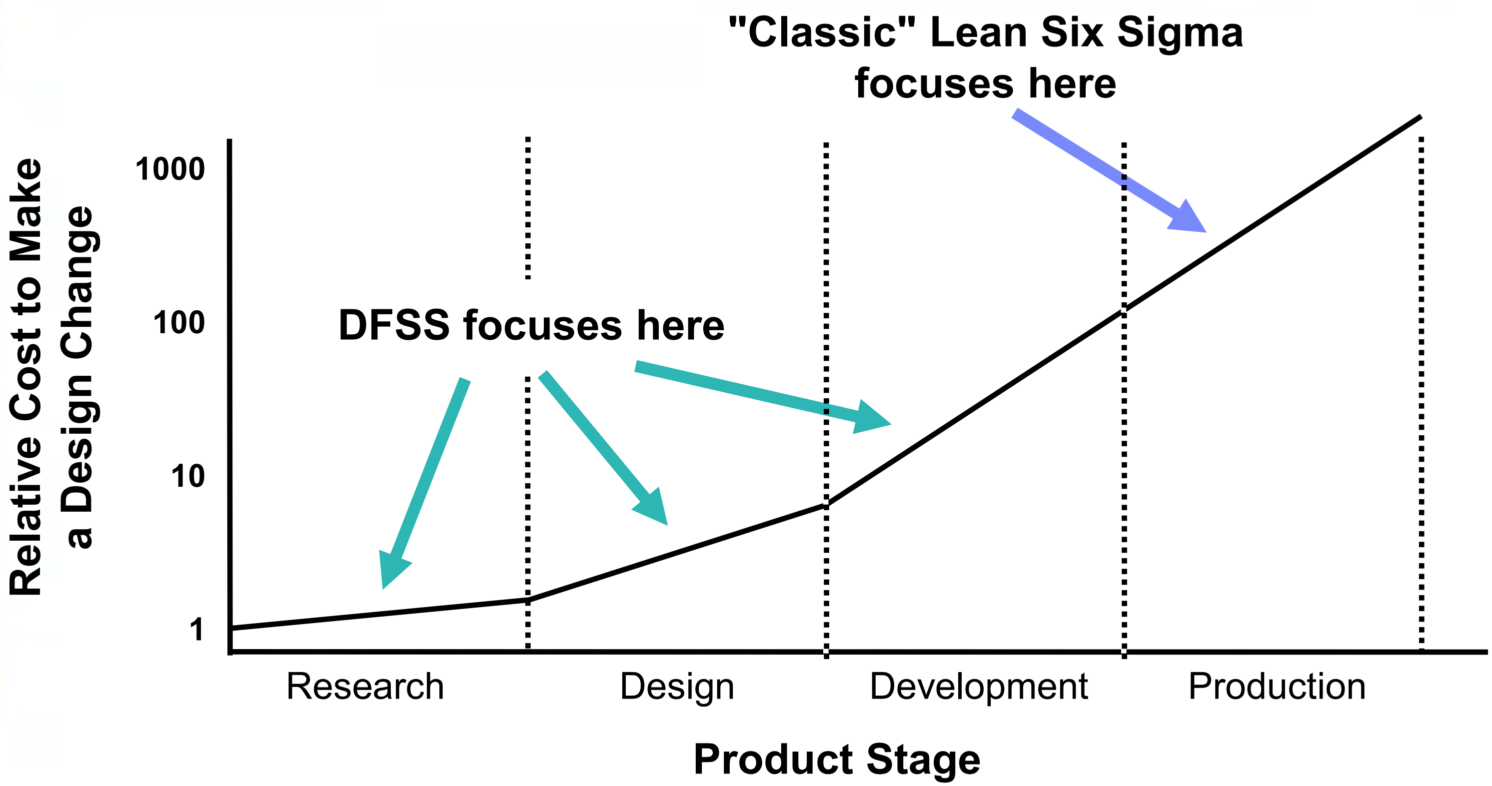
The Motivation for DFSS

What Have We Learned from LSS (DMAIC)?



DFSS: Getting to the Next Level (the high hanging fruit)

Why DFSS



- Gain knowledge when costs are lowest
- Design in quality right from the start

DFSS Goals

- ***Reduce Cycle Time in the Design and Development Process***
- ***Reduce the Time to Money (TTM)***
- ***Reduce the Cost of Poor Quality***
- ***Improve Predictability of QCD (Quality, Cost, Delivery)***

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General Electric Testimonial (Dr. Norm Kuchar*, GECRD, Oct 2011)

- **Quality increases of at least +1σ at launch over previous designs**
- **Time to Market decrease by at least 25% over previous launches**
- **Cost savings due to total resources utilized in the 20-40% range**

* Norm was responsible for the worldwide deployment of GE‟s DFSS initiative.

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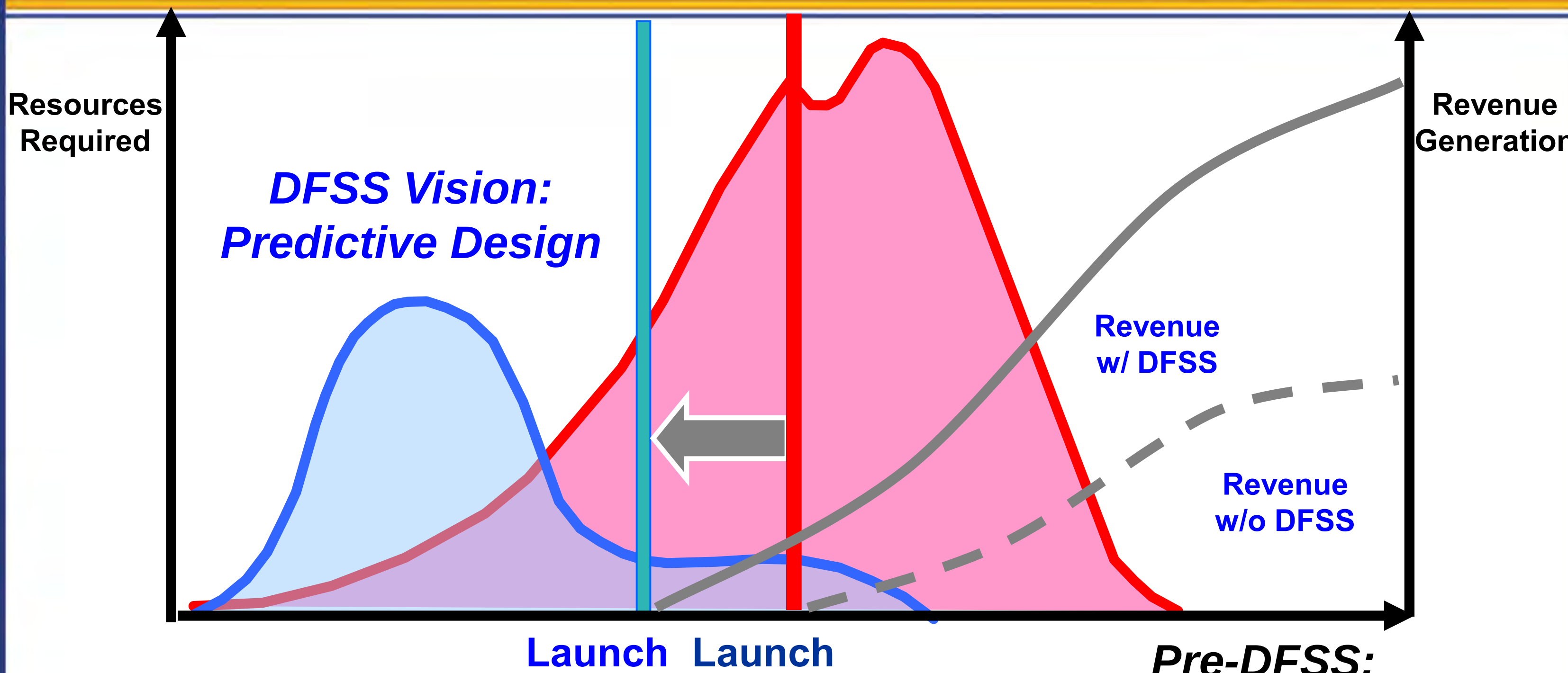
The Benefits of DFSS



Pre-DFSS: Reactive Design

- Early problem identification; solution when costs low
- Faster market entry: earlier revenue stream, longer patent coverage
- Lower total development cost
- Robust product at market entry: delighted customers
- Resources available for <u>next</u> game-changer

- Unhappy customers and employees
- Unplanned resource drain
- Skyrocketing costs
- Next product compromised

- **Upfront investment is most effective and efficient**
- **Show customers highly capable products right from the start**

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The Vision of DFSS

Reactive Design Quality → **DFSS** → **Predictive Design Quality**

From	To
• Evolving design requirements	• Disciplined requirements flowdown
• Extensive design rework	• Controlled design parameters
• Product performance assessed by –build and test”	• Product performance modeled and simulated
• Performance and producibility problems fixed <u>after</u> product in use	• <u>Designed</u> for robust performance and producibility
• Quality –tested in”	• Quality –designed in”

- **Lean Six Sigma (DMAIC) fixes known problems.**
- ***DFSS prevents unknown problems from occurring.***

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Infamous Quote

"As we know, there are known knowns. These are the things we know we know.

We also know there are known unknowns.
That is to say we know there are
some things we do not know.

But there are also unknown unknowns, the ones we don"t know we don"t know."

Donald Rumsfeld
Department of Defense news briefing
February 12, 2002

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Overview of the DFSS Process

Identify-Design-Optimize-Validate (IDOV*) Model

** The **IDOV** four-phase DFSS process originated with Dr. Norm Kuchar at GE CRD and is used with permission.*

I – Identify
- Define and scope the project; Commission team
- Develop project plan, schedule, etc.
- Gather customer requirements, develop CTCs and prioritize
- Initiate performance scorecard

D – Design
- Determine specs for all CTCs
- Develop alternate design concepts, evaluate risk, and select best design
- Translate CTCs/functional requirements into product design characteristics
- Obtain transfer functions for CTCs; update scorecards

O – Optimize
- Perform Expected Value Analysis (EVA) for CTCs
- Perform Parameter Design (Robust Design) analysis
- Perform Tolerance Allocation analysis
- Perform DfX and capability analysis; update scorecards

V – Validate
- Perform sensitivity analysis
- Develop Prototypes, Test Cases, Conduct Pilots, etc.
- Compare predicted and actual capability; Complete gap analysis if required
- Update scorecards, drawings, control plans, etc.

Key Deliverables:

Identify:
- strategic plan
- benchmarking results
- customer requirements; prioritized, measurable CTCs (HOQ #1)
- Initial performance scorecard

Design:
- Design concepts and selection results
- Requirements flowdown
- Prioritized product design characteristics (HOQ #2)
- Design risk assessments
- Transfer functions
- Updated scorecards

Optimize:
- Capability and reliability studies
- X-ability assessment
- Optimized design
- Capability analysis
- Tolerances for key Xs
- Updated scorecards (capability flowup)

Validate:
- Sensitivity analysis
- Pilots / prototypes and capability analysis
- Validated processes and products
- Updated scorecards
- Control plan

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Methods and Tools Used in DFSS

Identify	Design	Optimize	Validate
Project or Study Charter	Assign Specifications	Histogram	***Sensitivity Analysis***
Strategic Plan	to CTC"s	***Distributional Analysis***	***Gap Analysis***
Cross-Functional Team	***Axiomatic Design***	***Empirical Data Distribution***	FMEA
Voice of the Customer	***Critical Parameter Mgt.***	***Expected Value Analysis (EVA)***	Fault Tree Analysis
Customer Retention Grid	Formulate Design Concepts	***Adding Noise to EVA***	Control Plan
Benchmarking	***Pugh Concept Generation***	Non-Normal Output Distributions	PF/CE/CNX/SOP
KANO"s Model	***TRIZ***	Design of Experiments	Run/Control Charts
Questionnaires	FMEA	***Multiple Response Optimization***	Mistake Proofing
Focus Groups	Fault Tree Analysis	***Robust Design Development***	MSA
Interviews	Brainstorming	***Using S-hat Model***	Reaction Plan
Internet Search	QFD	***Using Interaction Plots***	***High Throughput Testing***
Historical Data Analysis	Scorecard	***Using Contour Plots***	
Design of Experiments	***Transfer Function***	***Parameter Design***	
Quality Function Deployment	Design of Experiments	***Tolerance Allocation***	
Pairwise Comparison	***Deterministic Simulators***	***Design For Manufacturability and Assembly***	
Analytical Hierarchy Process	***Discrete Event Simulation***	Mistake Proofing	
Performance Scorecard	Confidence Intervals	Product Capability Prediction	
Flow Charts	Hypothesis Testing	***Part, Process, and SW Scorecard***	
FMEA	MSA	***Risk Assessment***	
Visualization	Computer Aided Design	***Reliability***	
	Computer Aided Engineering	***Multidisciplinary Design Optimization (MDO)***	

****Unique to DFSS***

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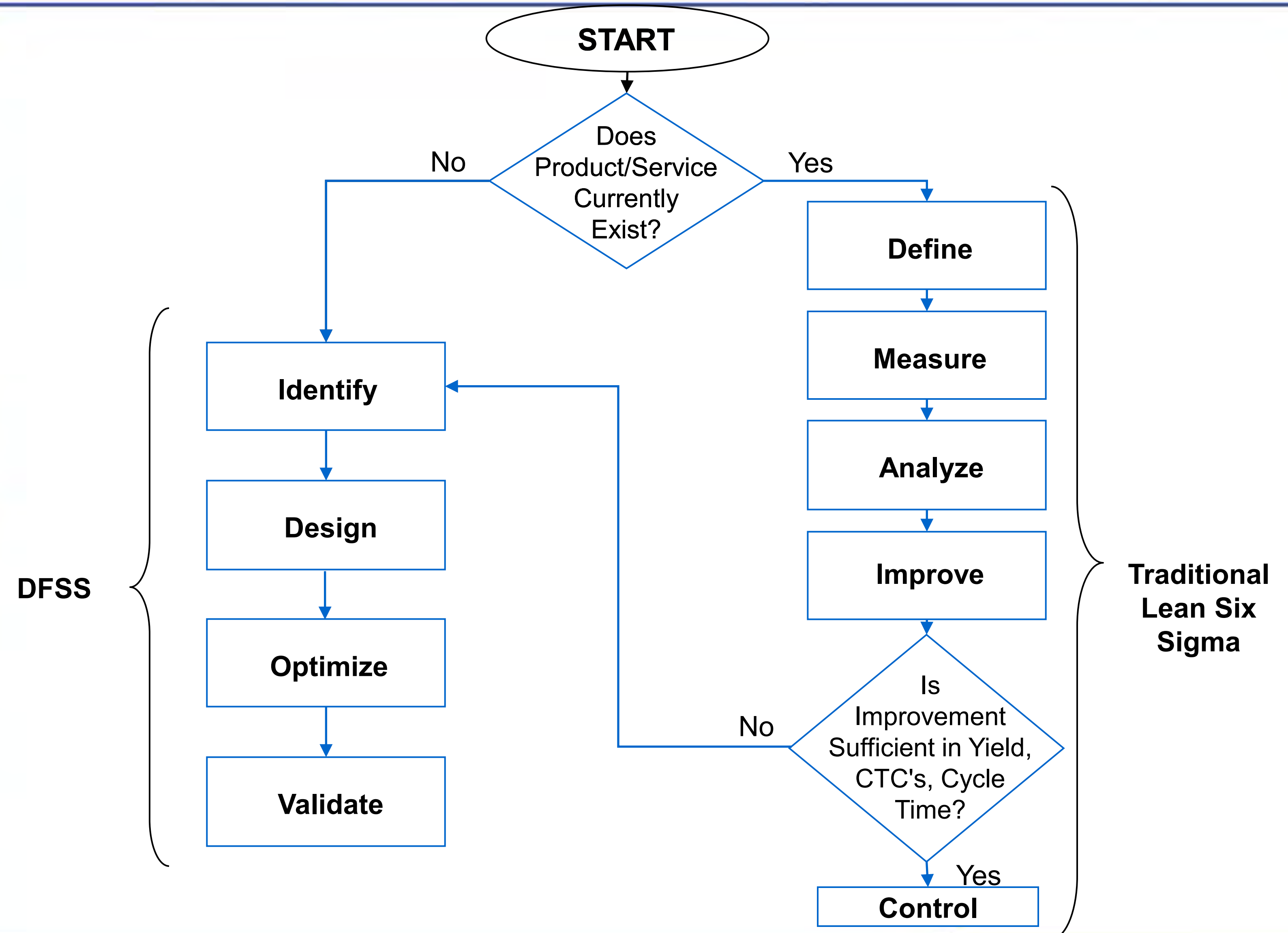
DFSS vs DMAIC



Project Selection: "DMAIC" or –DFSS"?

- In general,

  - "DMAIC" approach and tools work best when goal is to improve an existing product or process, with baseline performance metrics.

  - "DFSS" approach and tools work best when goal is to design a new product or process, with no baseline performance metrics available, or to redesign an existing product or process that is not meeting the performance requirements.

- Many projects contain elements of both; use appropriate tools, without concern about "purity" of approach

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The Identify Phase

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The DFSS Process: Identify, Design, Optimize, Validate

– ***The Identify Phase***
  - ***–The DFSS Scorecard***
  - ***–Voice of the Customer (VOC)***

– The **Design** Phase
  - –Translating the VOC (Requirements Flowdown)
  - –Concept Generation and Selection
  - –Transfer Functions
  - –Critical Parameter Management

– The **Optimize** Phase
  - –Multiple Response Optimization
  - –Expected Value Analysis Using Monte Carlo Simulation
  - –Parameter Design
  - –Tolerance Allocation

– The **Validate** Phase
  - –High Throughput Testing

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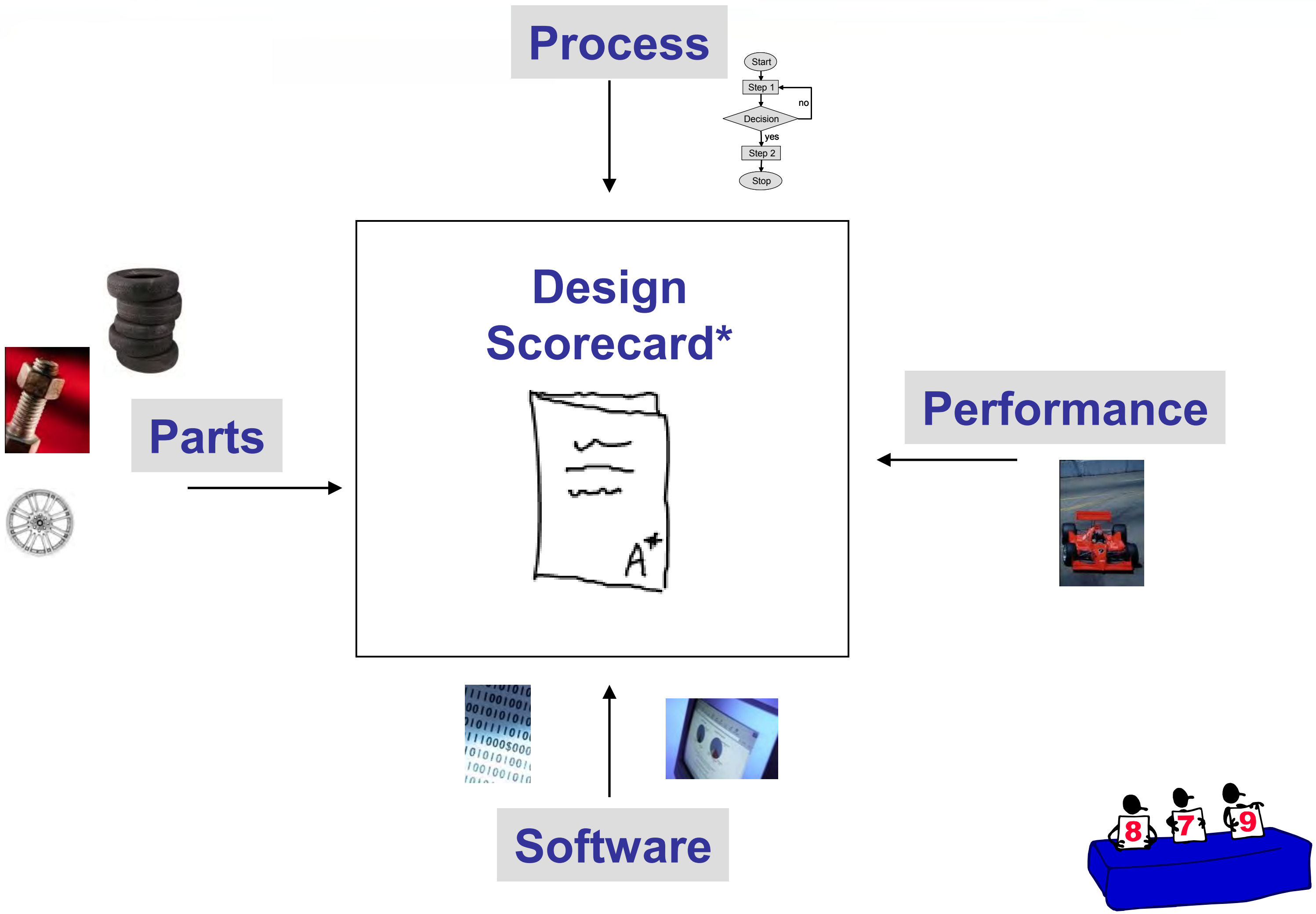
DFSS Scorecard and its Components



* The DFSS Design scorecard concept originated at Texas Instruments (Defense Systems and Electronics Group) in the early 1990s, and has been adapted and used by DFSS practitioners over the past decade(s).

Examples of Parts, Process, Performance

	Refrigerator	Engraved Nameplate	Statapult®
PARTS	*shelves*	*metal plate*	*pull-back arm*
	drawers	*sealant*	*pins*
	evaporator		*cup*
	thermostat		*rubber band*
PROCESS	*weld sheet metal*	*align plate*	*attach protractor*
	attach handle	*engrave*	*attach cup*
	attach handle	*apply sealant*	*drill holes*
	spray protective coating		*assemble side panels to base*
PERFORMANCE	*noise level*	*plate flatness*	*ball/cup fit*
	cooling speed	*engraving quality*	*lateral dispersion*

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Examples* of Scorecard Entries for MBT&E

Task	*Measure*
Employ Lethal Fire Support	Time to Target (< 15 min)
Conduct Lethal Direct Fires	Positive Control Range (> 50 nm) Pssk (> .80)

System Attribute	*Measure*
Aircraft TDL	link range (> 60 nm)
Provide Lethal Effects	Pk/h (> .95)
Guide Munition	Ph/s (> .90)

* These examples are taken from Chris Wilcox's MBT&E Tutorial (page 23) at NDIA T&E 2010.

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Scorecard Construction

- The scorecard is broken down into 4 major areas:
  - Parts
  - Process
  - Performance
  - Software
- A total dpu is computed for each of the four areas
- The 4 dpu's are summed to obtain a total (overall) dpu for the entire product

Part DPU + Process DPU + Performance DPU + Software DPU

= Total DPU

- First Pass Yield (FPY) is estimated using the approximation:

$$FPY = e^{-dpu}$$

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Scorecard Example (Nameplate)

Part Scorecard

				Continuous Variable						Sample Size Known		ppm Only
#	Part Name	DPU	Qty	Target	Mean	Std Dev	LSL	USL	UOM	Sample Size	# Defective	ppm
1	plate thickness	0.0001083	1	0.0625	0.0614	0.008	0.03125	0.09375	in.			
2	plate width	0.0004306	1	1.5	1.51	0.015	1.44	1.56	in.			
3	sealant	0.00005	1									50

Process Scorecard

					Continuous Variable						Sample Size Known		ppm Only
#	Process Step	DPU	Qty	Opps	Target	Mean	Std Dev	LSL	USL	UOM	Sample Size	# Defective	ppm
1	align plate in fixture	0.0005000	1	1									500
2	engrave	0.0020000	1	1							1500	3	
3	apply sealant	0.0073333	1	1							1500	11	

Performance Scorecard

				Continuous Variable						Sample Size Known		ppm Only
#	Performance	DPU	Qty	Target	Mean	Std Dev	LSL	USL	UOM	Sample Size	# Defective	ppm
1	plate flatness	0.0009977	1		0.091	0.011		0.125	in.			
2	engraving quality	0.00025	1							4000	1	

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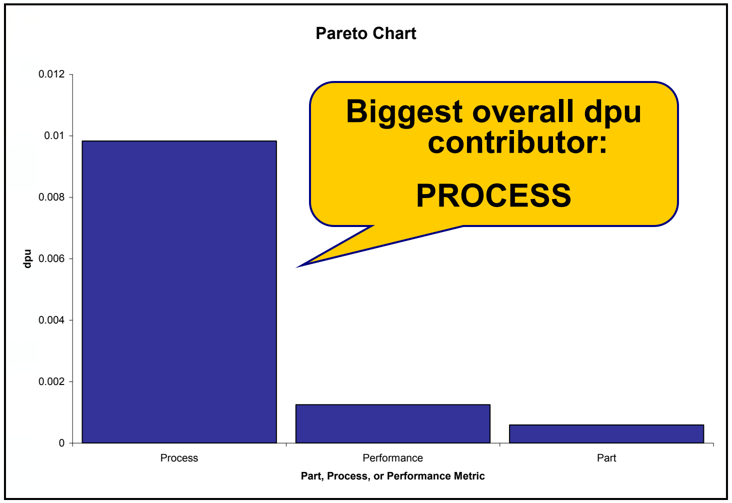
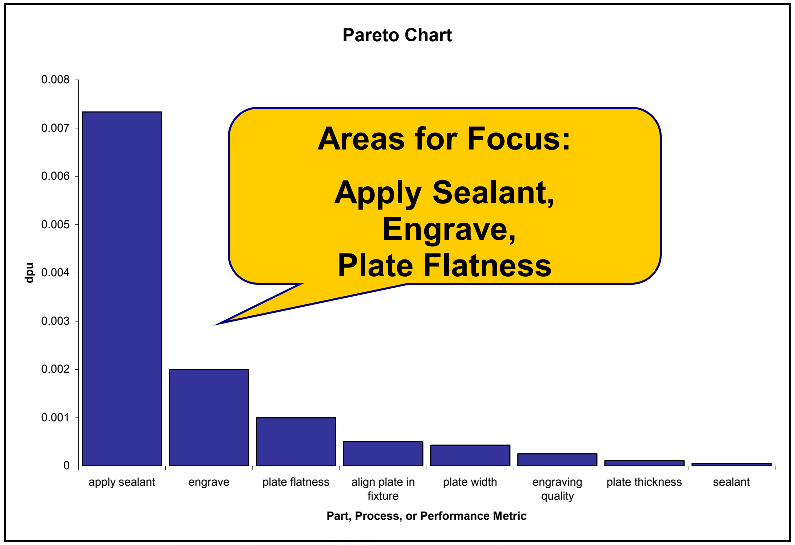
Scorecard Example (Nameplate, cont.)

Overall Scorecard (Roll-Up)

Scorecard Summary						
	# Steps/Parts	Total dpu	Yield	dpmo	ST Sigma	LT Sigma
Part	3	0.000589	99.94%	196.31	5.04	3.54
Process	3	0.009833	99.02%	3,277.78	4.22	2.72
Performance	2	0.001248	99.88%	623.86	4.73	3.23
Software	0					
Total	**8**	**0.011669983**	**98.84%**	**1458.748**	**4.476**	**2.976**





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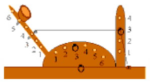
Statapult Scorecard Summary



Scorecard Summary	# Steps/Parts	Total dpu	Yield	dpmo	ST Sigma	LT Sigma
Part	34	0.225959	79.78%	6,645.86	3.98	2.48
Process	77	0.260752	77.05%	3,386.39	4.21	2.71
Performance	4	0.010783	98.93%	2,695.69	4.28	2.78
Software	0					
Total	115	0.497494041	60.81%	4,326.035	4.126	2.626

				Continuous Variable						Sample Size Known		ppm Only
#	Part Name	DPU	Qty	Target	Mean	Std Dev	LSL	USL	UOM	Sample Size	# Defective	ppm
1	Base	2.8666E-07	1	0.75	0.76	0.012	0.68	0.82	inches			
2	Side Plates	0.13137951	2	0.75	0.747	0.027	0.7	0.8	inches			
3	Cup	0.05714286	1							140	8	
4	Cup Screw	0.000014	1									14
5	Front Fixed Arm	0.00147276	1	0.75	0.745	0.015	0.7	0.8	inches			
6	Pull Back Arm Length	9.0705E-05	1	14.5	14.55	0.12	14	15	inches			
7	Pull Back Arm Width	0.00095062	1	0.75	0.752	0.015	0.7	0.8	inches			
8	Angle Scale	0.0014	1							10000	14	
9	Angle Pointer	0.00015	1							20000	3	
10	Removable Pins	0.00006	3									20
11	Nameplate	0.00025	1									250
12	Eye Bolt	0.0004995	1							2002	1	
13	Wing Nut	0.002	2							2000	2	
14	Stop Pad	0.000031	1									31
15	Ball	3.1672E-05	1	1.5	1.51	0.01	1.45	1.55	inches			
16	Rubber Band	0.0001	1									100
17	Metal Pins	0.00039992	2							10002	2	
18	Wooden Peg	0.00987425	1	0.375	0.373	0.0075	0.355	0.395	inches			
19	Wood Screw	0.00008	8									10
20	Plastic Cap	0.000032	2									16
21	Adhesive	0.02	1							100	2	

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Statapult Scorecard Summary (cont.)

#	Process Step	DPU	Qty	Opps	Continuous Variable Target	Mean	Std Dev	LSL	USL	UOM	Sample Size Known Sample Size	# Defective	ppm Only ppm
1	drill cb through holes	0.0039000	6	2									650
2	drill non-cb through holes	0.0072000	18	1									400
3	drill cs holes	0.0040000	1	2							2000	8	
4	drill blind holes	0.0270000	9	2							1000	3	
5	assemble fixed arm and side	0.0000000	1	6		7.8	0.045	5		N			
6	install wood screws	0.1538462	2	1							26	2	
7	install caps	0.0080000	2	1							1000	4	
8	install wooden peg	0.0006667	1	1							3000	2	
9	install angle scale	0.0196078	1	2							102	2	
10	attach angle pointer	0.0020000	1	2							1000	2	
11	attach rubber stop pad	0.0013316	1	2							1502	2	
12	install cup on arm	0.0010000	1	1									1000
13	install removable pins	0.0002000	2	1							10002	1	
14	insert arm between side plat	0.0020000	1	2							1000	2	
15	assemble rubber band	0.0200000	1	3							150	3	
16	attach name plate	0.0100000	1	2							100	1	

#	Performance	DPU	Qty	Continuous Variable Target	Mean	Std Dev	LSL	USL	UOM	Sample Size Known Sample Size	# Defective	ppm Only ppm
1	gap	0.006252391	1		0.06	0.014	0.005	0.095	inches			
2	distance	0.003830381	1		162	4.5	150		inches			
3	life	0.0002	1									200
4	wood grain quality	0.0005	1							4000	2	

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Who is known to have said this?

If we‟re not keeping score,

we‟re only practicing.

Hint: a famous football coach

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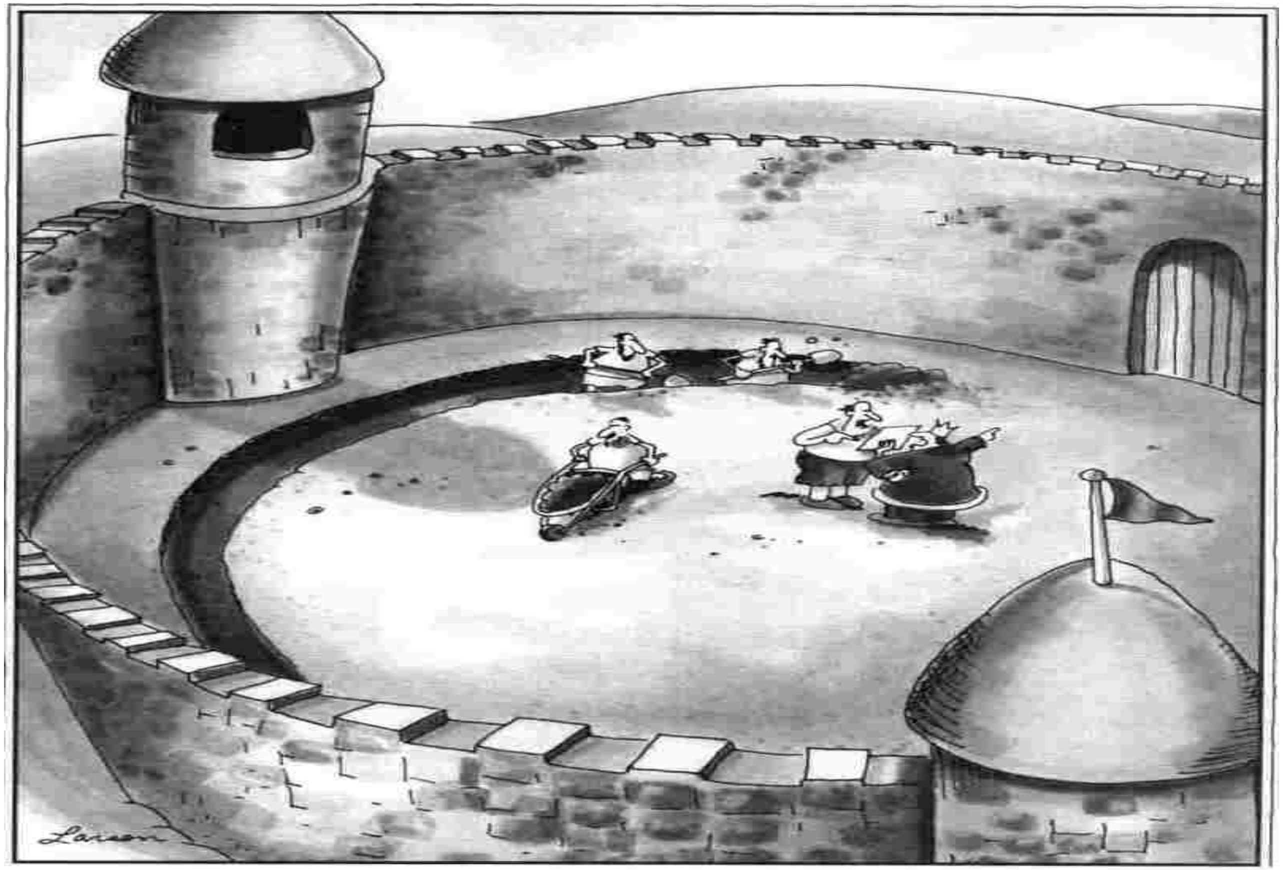
Understanding the Voice-of-the-Customer (VOC)



Suddenly, a heated exchange took place
between the king and the moat contractor.

Source: The Far Side

The Far Side Millennium Off-the-Wall Calendar 2000

Far Works, Inc.

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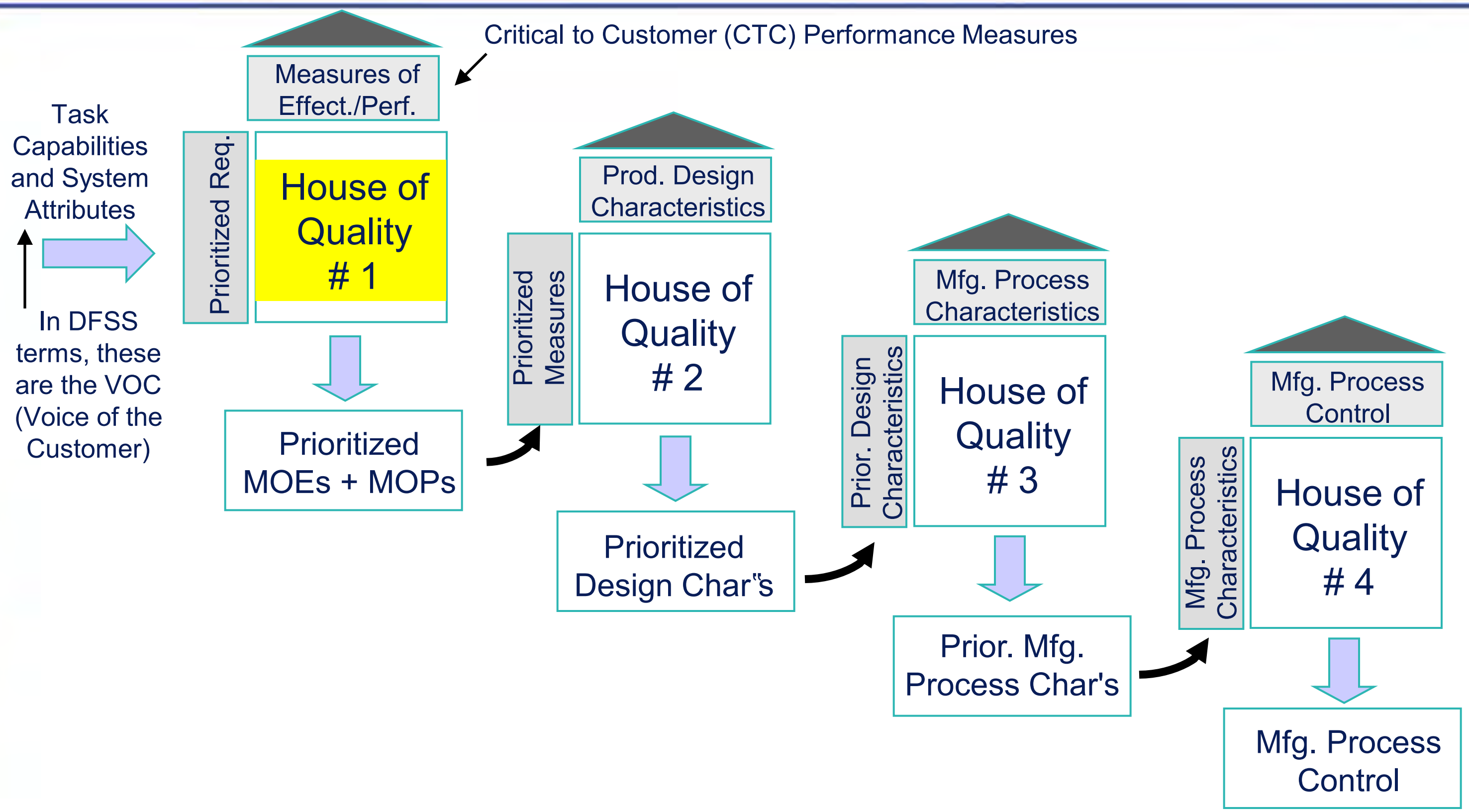
Quality Function Deployment (QFD)



Marketing
- Features
- Quality
- Performance
- Cost

Design Engineering
- Performance
- Reliability
- Cost

Mfg. Engineering
- Manufacturability
- Cost

Manufacturing
- SPC
- Process Capability

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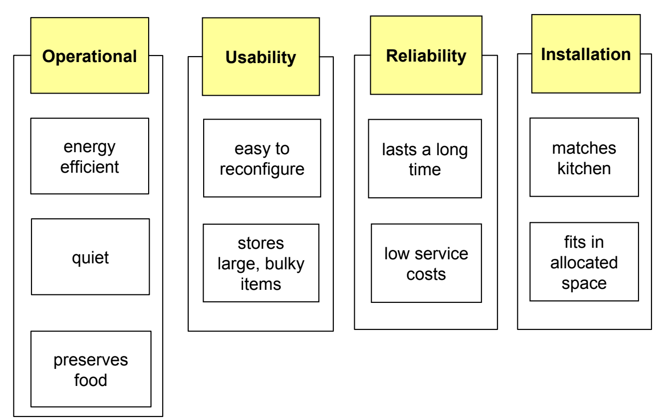
Voice of the Customer (Refrigerator)

VOC

- —Want it to be energy efficient"
- —Want it to be quiet"
- —Needs to preserve food"
- —Want to be able to easily reconfigure the shelves"
- —Want to fit large, bulky items"
- —Should last a long time"
- —Would like it to match my kitchen"

Affinity Diagrams Can Help



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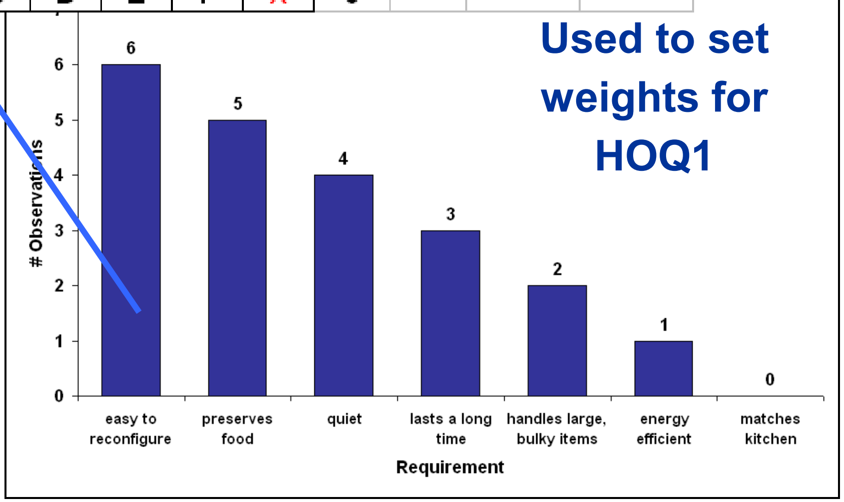
Use Pairwise Comparison to Prioritize

	Customer Requirements	A	B	C	D	E	F	G	Total
A	energy efficient	X	X	X	X	X	X	X	1
B	quiet	B	X	X	X	X	X	X	4
C	preserves food	C	C	X	X	X	X	X	5
D	easy to reconfigure	D	D	D	X	X	X	X	6
E	handles large, bulky items	E	B	C	D	X	X	X	2
F	lasts a long time	F	B	C	D	F	X	X	3
G	matches kitchen	A	B	C	D	E	F	X	0

Column headers (diagonal): A energy efficient, B quiet, C preserves food, D easy to reconfigure, E handles large, bulky items, F lasts a long time, G matches kitchen



Used to set weights for HOQ1

<u>Example:</u> "Easy to reconfigure" won 6 times.

Place Customer Requirements & Rating into HOQ #1 (Refrigerator Example)

Grouped customer requirements

Rating

Performance Measures

A: energy efficient	2							
B: quiet	4							
C: preserves food	5							
D: easy to reconfigure	5							
E: handles large, bulky items	3							
F: lasts a long time	4							
G: matches kitchen	1							

Rating:

5: Must have for performance
4: Highly desirable feature
3: Desirable feature
2: Usable feature but not critical
1: Nice feature but not critical

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Fill in Performance Measures Across Top

Peformance Measures (CTCs) →		energy efficiency rating	noise level (db)	temperature range	cooling speed (sec. per degree)	% adjustable shelves	disassy / reassy time (sec)	shelf depth and width (in.)	door tray depth (in.)	mean time to failure (hrs)	# available colors
A: energy efficient	2										
B: quiet	4										
C: preserves food	5										
D: easy to reconfigure	5										
E: handles large, bulky items	3										
F: lasts a long time	4										
G: matches kitchen	1										

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Relationships

- Now, determine the strength of the relationships between the customer requirements and the CTCs. Rate the relationship between each customer requirement and each CTC according to the scale below.

9:	Strong Relationship
3:	Medium Relationship
1:	Weak Relationship
Blank:	No Relationship

- Compute a Rank-Ordered Sum for each CTC (multiply strength • rating and add)

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HOQ # 1 …. Prioritizes the Performance Measures

CTCs/FPs
(Functional Domain)

VOC
(Customer Domain)

Customer Requirements:	Importance Rating	energy efficiency rating	noise level (db)	temperature range	cooling speed	% adjustable shelves	disassy / reassy time (sec.)	shelf depth and width (in.)	door tray depth (in.)	mean time to failure	# available colors
A: energy efficient	2	9	1	3	9			1	1	1	
B: quiet	4	3	9	1	3						
C: preserves food	5	3		9	9			1	1	1	
D: easy to reconfigure	5					3	9				
E: handles large, bulky items	3					9	1	9	9		
F: lasts a long time	4	1			1					9	
G: matches kitchen	1										9
Weighted Sums >>>		49	38	55	79	42	48	34	34	43	9

Task Capabilities and System Attributes are mapped to Performance Measures

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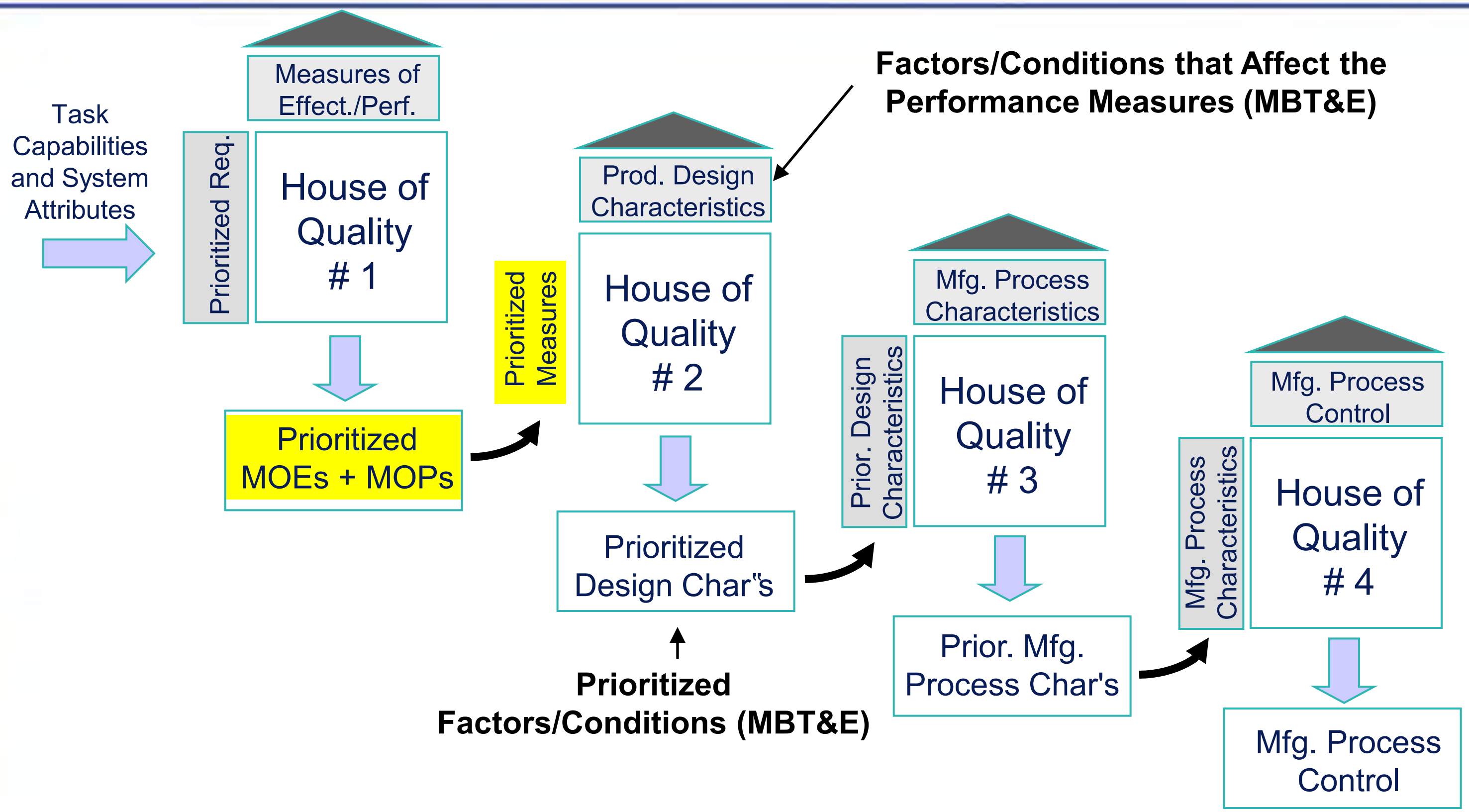
Prioritized Measures Become Side of HOQ # 2



Marketing
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Mfg. Engineering
- Manufacturability
- Cost

Manufacturing
- SPC
- Process Capability

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Case Study: OnTech Self-Heating Container

Identify

Key Features (VOC)

- Self-heating
- Activated by button on bottom of can
- Used for hot beverages and soups
- Disposable
- Environmentally compatible

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Affinitization of Consumer Appeal

Identify

Customer Appeal

CONCEPT	**PRODUCT**
(Packaging)	**(Taste)**
▪ —Portable”	▪ —Not bitter”
▪ —Self Heating”	▪ —Fresh”
▪ —Easy to Use”	▪ —Smooth”
▪ —Unique”	▪ —Varieties”

Simply...

I want to be able to buy one cup with a button on it, press the button, and it gets hot, and tastes great, then I can throw it away when I’m done.

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Pairwise Comparison

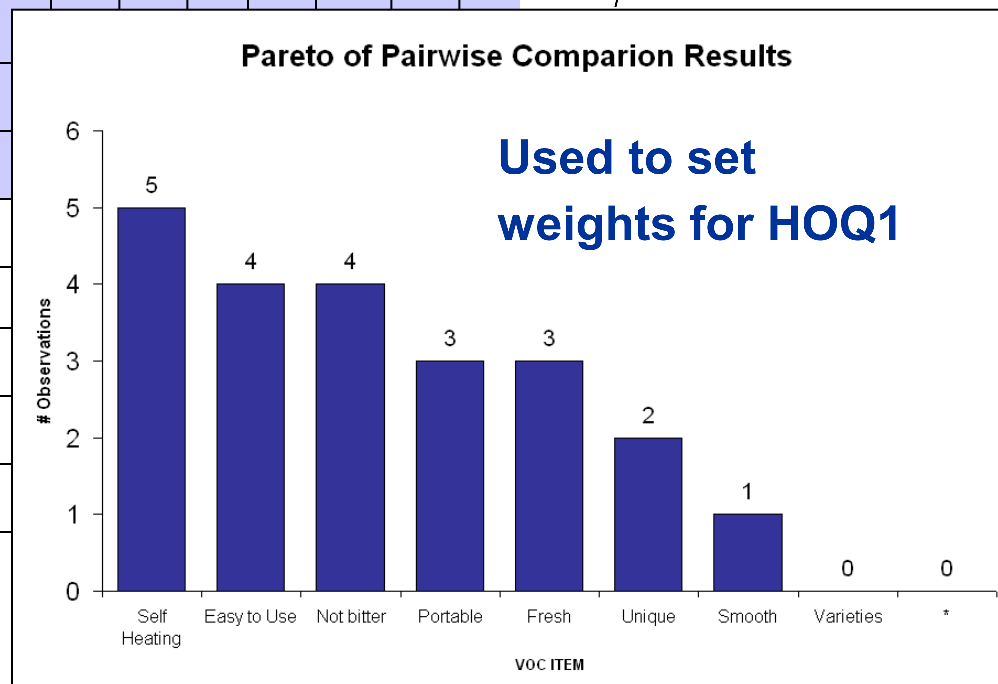
Identify

VOC Prioritization

A B C D E F G H . .

		Portable	Self Heating	Easy to Use	Unique	Not bitter	Fresh	Smooth	Varieties	.	.	.
A	Portable											
B	Self Heating	A										
C	Easy to Use	A	B									
D	Unique	A	B									
E	Not bitter	.										
F	Fresh	.										
G	Smooth	.										
H	Varieties											
.	.											
.	.											
	.											

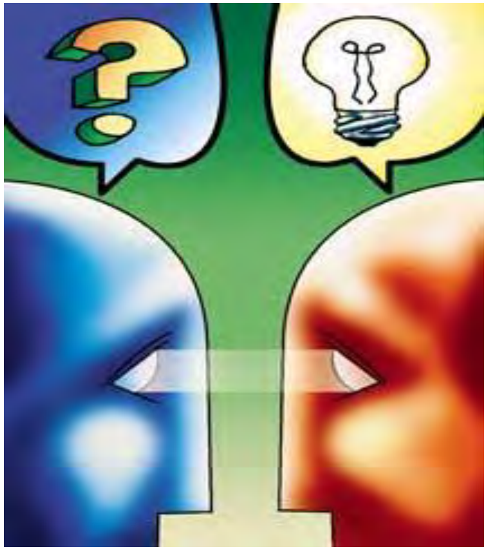
Example:
"Self-Heating" won 5 times.



VOC ➡ CTCs

Identify

Customer Domain Language to
Functional Domain Language



1st HOQ and Functional Domain

Identify

CTCs/Perf.Measures
(Functional Domain)

VOC
(Customer Domain)

	wt	Dimensionality/Shape	Beverage Temperature	Time (sec) to use	Can Temperature	Weight	Taste	..	
Portable	3	9	3	9	3	3			
Self Heating	5	3	9	9	9	3			
Easy to Use	4	3	1		3	3			
Unique	2								
.									
.									
.									
Prioritized CTCs		54	58	72	66	36	.	.	

Voice of the Customer is mapped to Functional or Performance Measures

Scores are multiplied by weights and summed below

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The Design Phase

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The DFSS Process: Identify, Design, Optimize, Validate

– The **Identify** Phase
  – The DFSS Scorecard
  – Voice of the Customer (VOC)

– The Design Phase
  – Translating the VOC (Requirements Flowdown)
  – Concept Generation and Selection
  – Transfer Functions
  – Critical Parameter Management

– The **Optimize** Phase
  – Multiple Response Optimization
  – Expected Value Analysis Using Monte Carlo Simulation
  – Parameter Design
  – Tolerance Allocation

– The **Validate** Phase
  – High Throughput Testing

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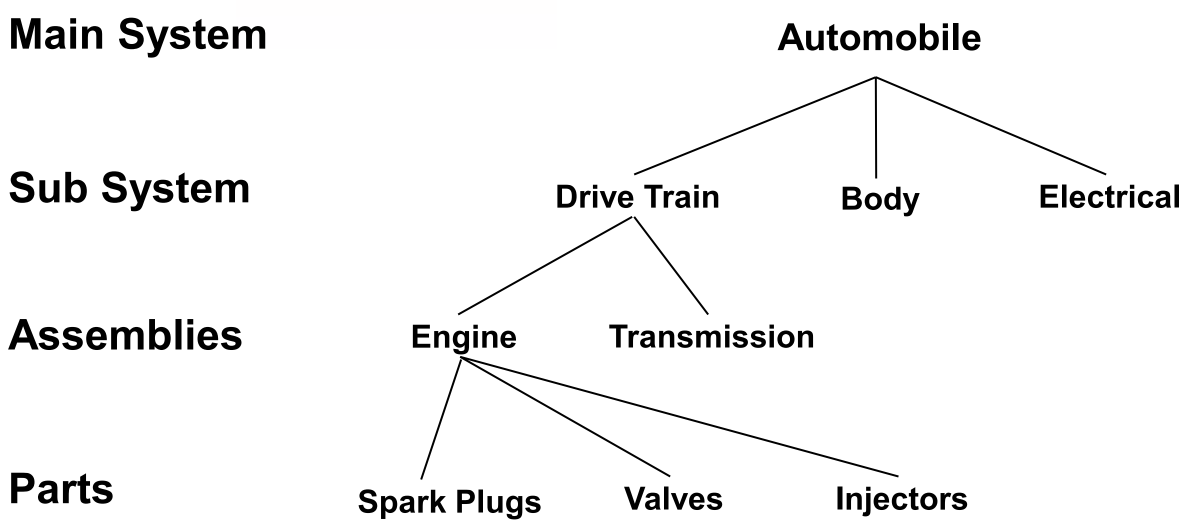
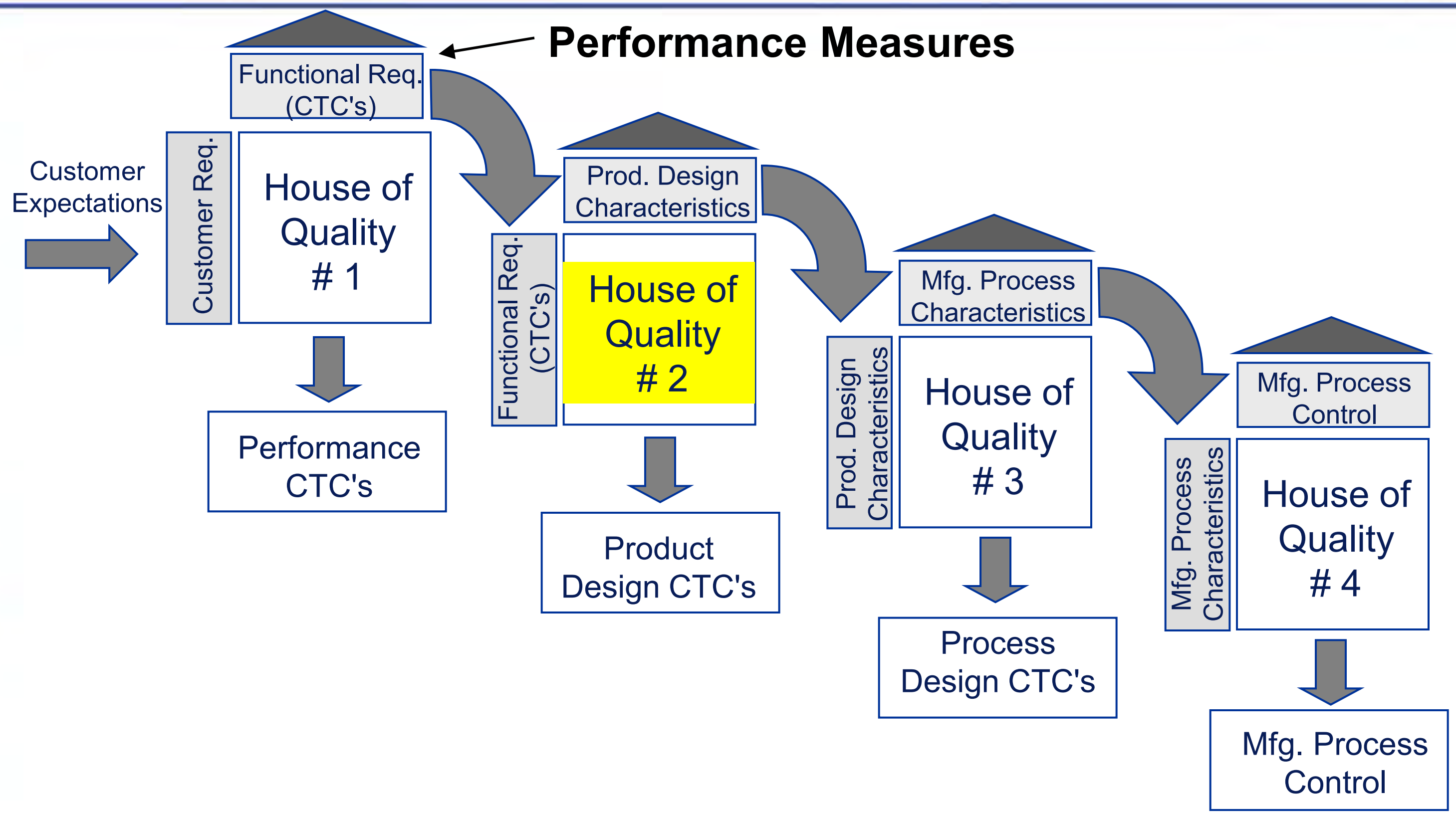
Systems Engineering



- **Complex products may require the "Divide and Conquer" approach.**
- **Requirements are flowed down, while capabilities are rolled up.**
- **System Engineers are the masters of the scorecard and make tradeoff decisions.**

Requirements Flowdown Using QFD



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Formulate Design Concepts

- Create alternative designs that fulfill CTC‟s.
- Compare designs with functional requirements (CTC‟s)
- Choose the best design
  - How do we decide which is the best approach?
- Assess risk of chosen design.
- Tools for Concept Generation and Selection
  - Axiomatic Design
  - TRIZ
  - Pugh Concept Selection

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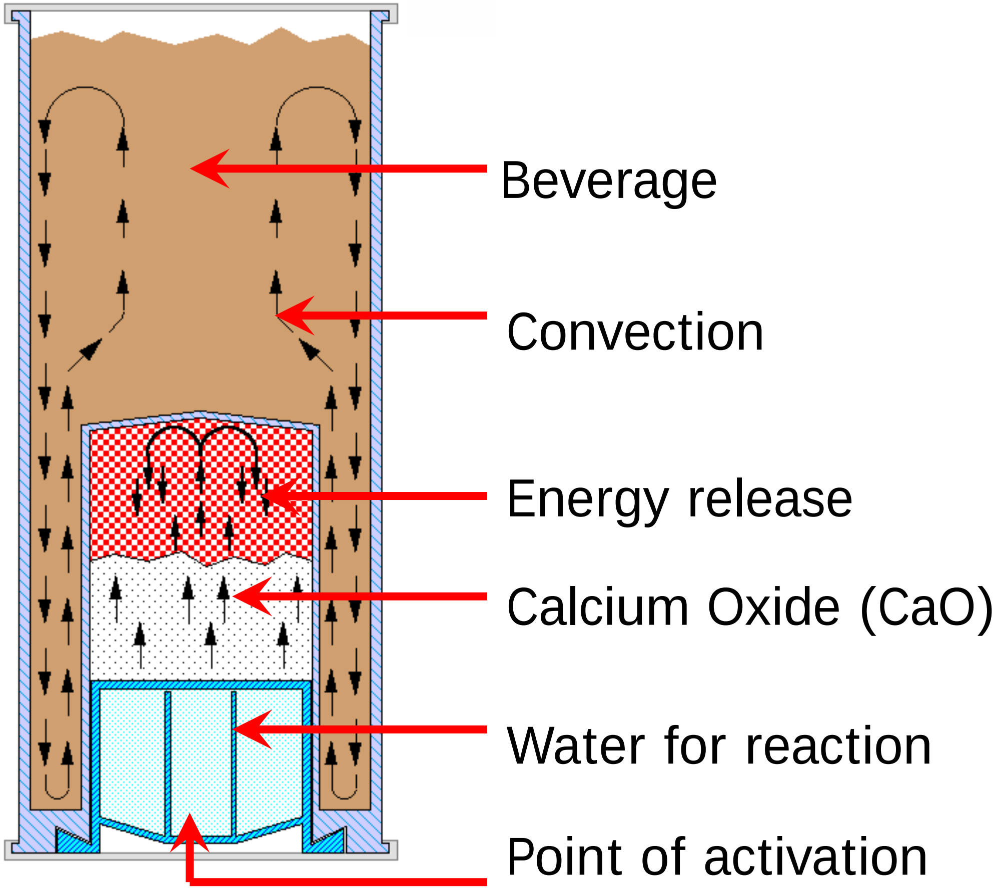
Case Study: General Design Concept

Design



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FAST (Functional Analysis System Technique)

Design

FAST allows us to quickly design the key functionality of the product (system).

HEAT BEVERAGE — GENERATE HEAT — CAUSE A REACTION — FLOOD CALCIUM OXIDE — BREAK WATER CELL — PRESS BUTTON

HOW? → → → → → → →

← ← ← ← ← ← ← *WHY?*

All of the "hows" and "whys" must be answered (both directions).

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2nd HOQ: Functional → Physical Domain

Design

DPs
(Physical Domain)

CTCs (FPs)
(Functional Domain)

CTCs (FPs)	wt	Wall thickness	CaO mass	H_20 volume	Button force to activate	.	.
Can Temp	4	9	3	1			
Time to Use	5	3	9	9			
Dimensionality	3	1	3	3			
Beverage Temp	3	1	3				
.							
.							
Prioritized DPs		57	75	67	.	.	.

Functional Parameters are mapped to Design Parameters

Scores are multiplied by weights and summed below

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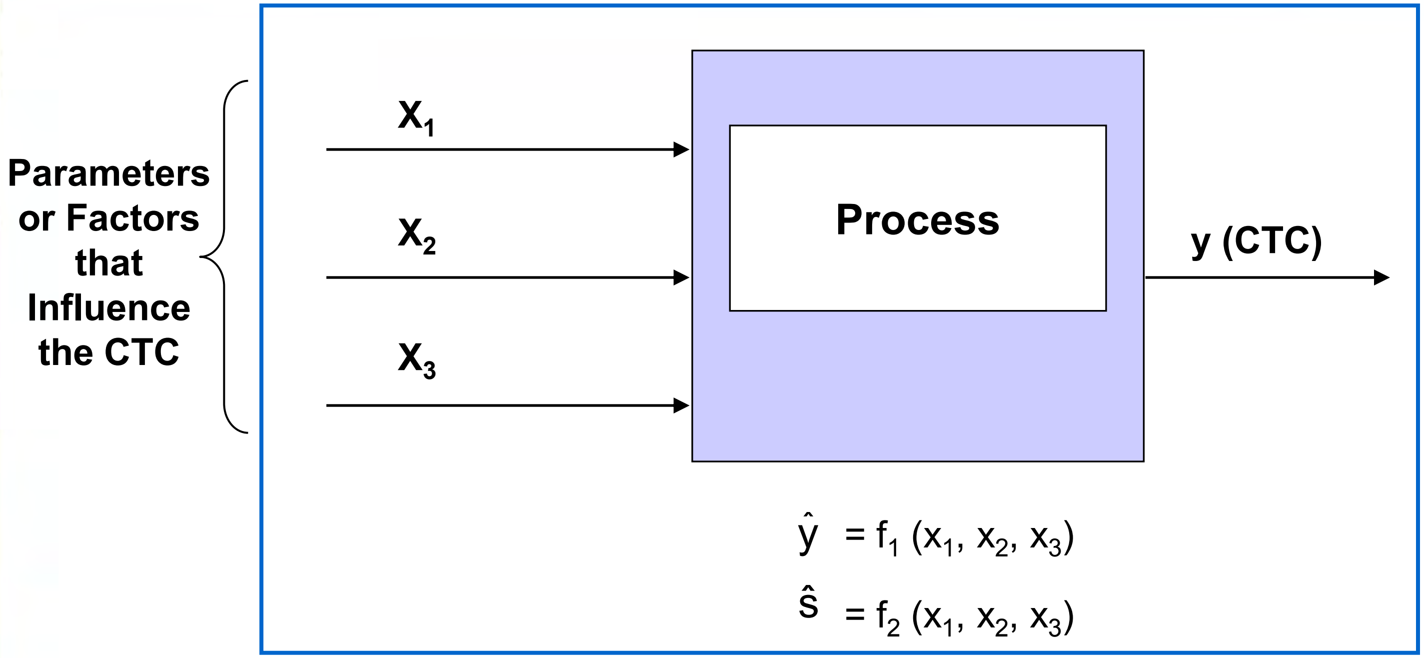
Transfer Function: The Bridge to Innovation



Where does the transfer function come from?

- **Exact transfer function**
- **Approximations**
  - **DOE**
  - **Historical Data Analysis**
  - **Simulation**

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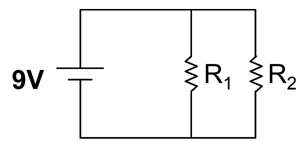
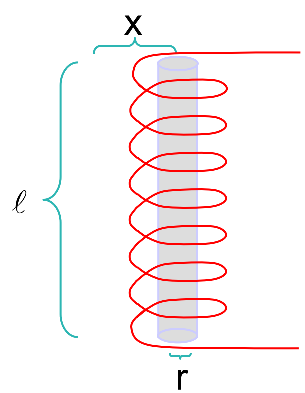
Exact Transfer Functions

- Engineering Relationships
  - V = IR
  - F = ma



The equation for current (I) through this DC circuit is defined by:

$$I = \frac{V}{\frac{R_1 \cdot R_2}{R_1 + R_2}} = \frac{V(R_1 + R_2)}{R_1 \cdot R_2}$$



The equation for magnetic force at a distance X from the center of a solenoid is:

$$H = \frac{NI}{2\ell}\left[\frac{.5\ell + x}{\sqrt{r^2 + (.5\ell + x)^2}} + \frac{.5\ell - x}{\sqrt{r^2 + (.5\ell - x)^2}}\right]$$

Where

N:	total number of turns of wire in the solenoid
I :	current in the wire, in amperes
r :	radius of helix (solenoid), in cm
ℓ :	length of the helix (solenoid), in cm
x :	distance from center of helix (solenoid), in cm
H :	magnetizing force, in amperes per centimeter

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Hierarchical Transfer Functions

$$Y = \text{Gross Margin} = \frac{\text{Gross Profit}}{\text{Gross Revenue}}$$

$$Y = f(y_1, y_2, y_3, y_4, y_5, y_6)$$

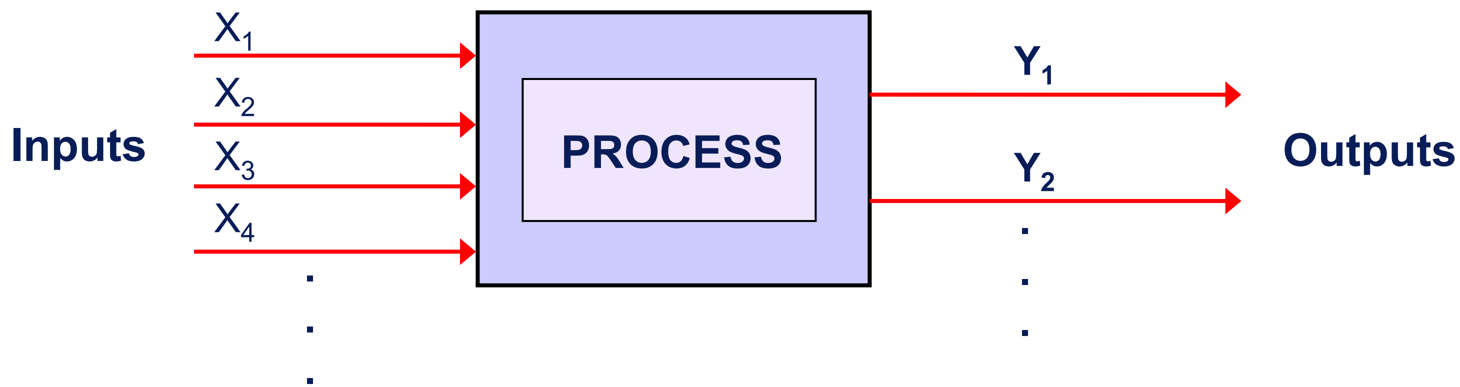
$$= \frac{(\overset{y_1}{Rev_{equip}} - \overset{y_2}{COG}) + (\overset{y_3}{Rev_{post\ sales}} - \overset{y_4}{Cost_{post\ sales}}) + (\overset{y_5}{Rev_{fin}} - \overset{y_6}{Cost_{fin}})}{y_1 + y_3 + y_5}$$

$$\overset{y_4}{Cost_{post\ sales}} = f(\overset{x_1}{\text{field cost}}, \overset{x_2}{\text{remote services}}, \overset{x_3}{\text{suppliers}})$$

$$x_1 = f(\text{direct labor, freight, parts, depreciation})$$

What is a Designed Experiment?

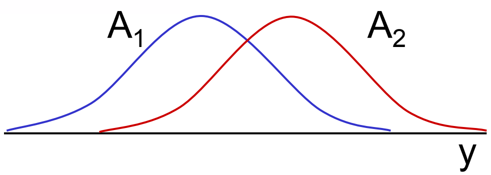
Purposeful changes of the inputs (factors) in order to observe corresponding changes in the output (response).



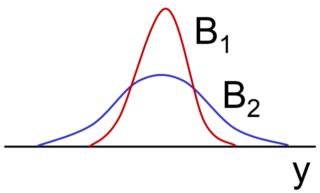
Run	X_1	X_2	X_3	X_4	Y_1	Y_2	. . . . . .	$\bar{Y}$	S_Y
1									
2									
3									
.									
.									

DOE Helps Determine How Inputs Affect Outputs

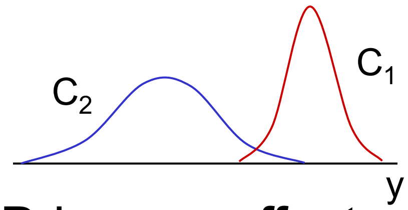
i) Factor A affects the average of y



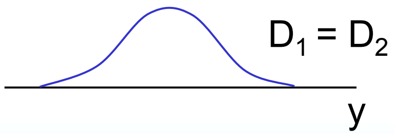
ii) Factor B affects the standard deviation of y



iii) Factor C affects the average and the standard deviation of y



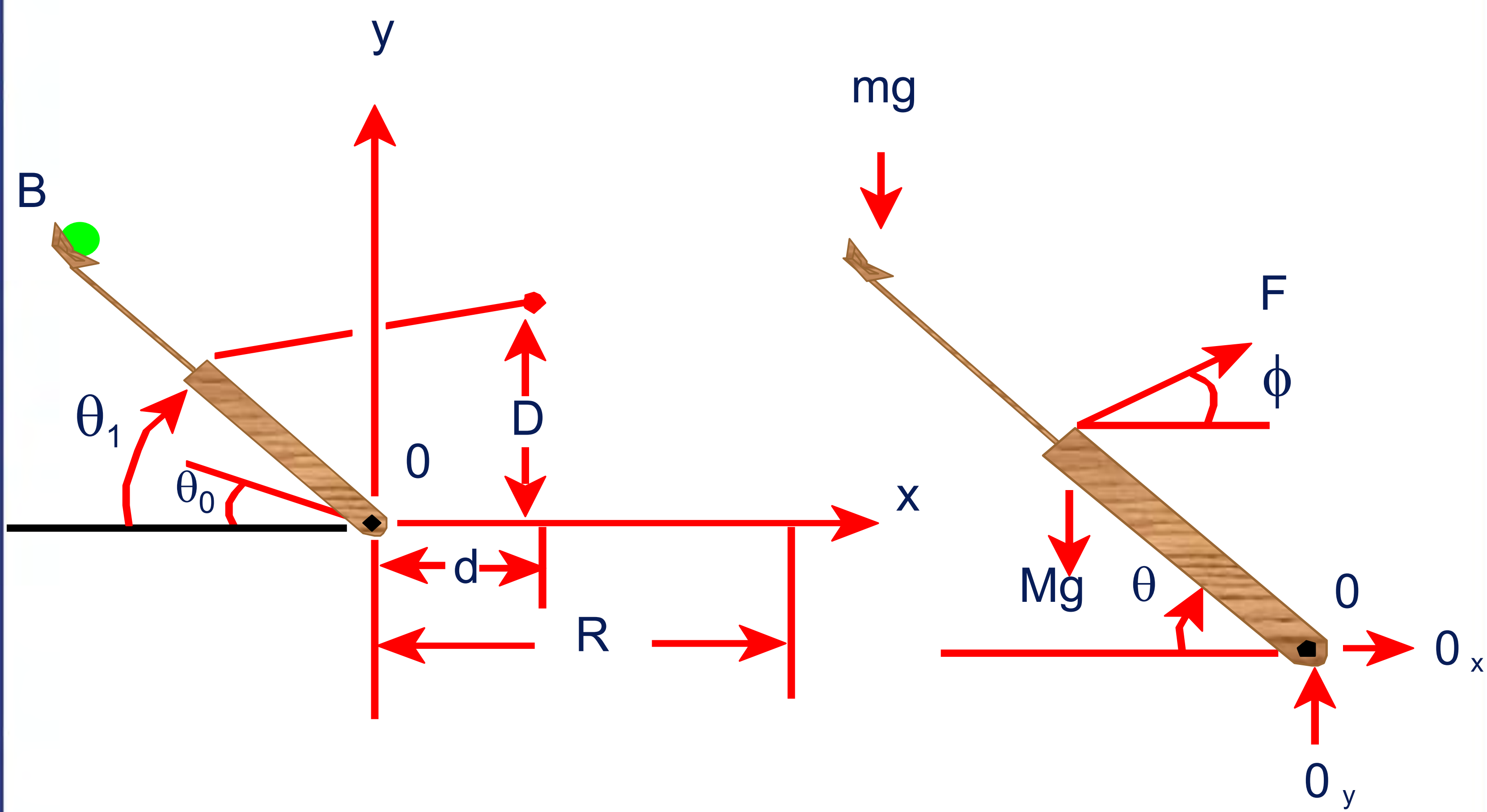
iv) Factor D has no effect on y



Catapulting Power into DFSS

Statapult® Catapult

The Theoretical Approach



The Theoretical Approach (cont.)

$$I_0\ddot{\theta} = r_F F(\theta)\sin\theta\cos\varphi - (Mgr_G + mgr_B)\sin\theta \qquad \tan\phi = \frac{D - r_F\sin\theta}{d + r_F\cos\theta},$$

$$\frac{1}{2}I_0\dot{\theta}^2 = r_F\int_{\theta_0}^{\theta} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta - \sin\theta_0)$$

$$\frac{1}{2}I_0\dot{\theta}_1^2 = r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

$$x = v_B\cos\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}r_B\cos\theta_1 \qquad y = r_B\sin\theta_1 + v_B\sin\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}gt^2.$$

$$r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right) - \frac{g}{2V_B^2}\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)} = 0.$$

$$\frac{gI_0}{4r_B}\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)\left[r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right)\right]}$$

$$= r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\phi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

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Statapult® DOE Demo
(The Empirical Approach)

	Actual Factors		Coded Factors			Response Values			
Run	A	B	A	B	AB	Y_1	Y_2	$\bar{Y}$	S
1	144	2	-1	-1	+1				
2	144	3	-1	+1	-1				
3	160	2	+1	-1	-1				
4	160	3	+1	+1	+1				

What Makes DOE so Powerful?
(Orthogonality: both vertical and horizontal balance)

A Full Factorial Design for 3 Factors A, B, and C, Each at 2 levels:

Run	A	B	C	AB	AC	BC	ABC
1	-	-	-	+	+	+	-
2	-	-	+	+	-	-	+
3	-	+	-	-	+	-	+
4	-	+	+	-	-	+	-
5	+	-	-	-	-	+	+
6	+	-	+	-	+	-	-
7	+	+	-	+	-	-	-
8	+	+	+	+	+	+	+

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Value Delivery: Reducing Time to Market for New Technologies

INPUT | **OUTPUT**

Pitch <) (0, 15, 30)

Roll <) (0, 15, 30)

W1F <) (-15, 0, 15)

W2F <) (-15, 0, 15)

W3F <) (-15, 0, 15)

Modeling Flight Characteristics of New 3-Wing Aircraft

Six Aero-Characteristics

- Total # of Combinations $= 3^5 = 243$
- Central Composite Design: n = 30

Patent Holder: Dr. Bert Silich

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Aircraft Equations

C_L = .233 + .008(P)^2 + .255(P) + .012(R) - .043(WD1) - .117(WD2) + .185(WD3) + .010(P)(WD3) - .042(R)(WD1) + .035(R)(WD2) + .016(R)(WD3) + .010(P)(R) - .003(WD1)(WD2) - .006(WD1)(WD3)

C_D = .058 + .016(P)^2 + .028(P) - .004(WD1) - .013(WD2) + .013(WD3) + .002(P)(R) - .004(P)(WD1) - .009(P)(WD2) + .016(P)(WD3) - .004(R)(WD1) + .003(R)(WD2) + .020(WD1)^2 + .017(WD2)^2 + .021(WD3)^2

C_Y = -.006(P) - .006(R) + .169(WD1) - .121(WD2) - .063(WD3) - .004(P)(R) + .008(P)(WD1) - .006(P)(WD2) - .008(P)(WD3) - .012(R)(WD1) - .029(R)(WD2) + .048(R)(WD3) - .008(WD1)^2

C_M = .023 - .008(P)^2 + .004(P) - .007(R) + .024(WD1) + .066(WD2) - .099(WD3) - .006(P)(R) + .002(P)(WD2) - .005(P)(WD3) + .023(R)(WD1) - .019(R)(WD2) - .007(R)(WD3) + .007(WD1)^2 - .008(WD2)^2 + .002(WD1)(WD2) + .002(WD1)(WD3)

C_{YM}= .001(P) + .001(R) - .050(WD1) + .029(WD2) + .012(WD3) + .001(P)(R) - .005(P)(WD1) - .004(P)(WD2) - .004(P)(WD3) + .003(R)(WD1) + .008(R)(WD2) - .013(R)(WD3) + .004(WD1)^2 + .003(WD2)^2 - .005(WD3)^2

C_e = .003(P) + .035(WD1) + .048(WD2) + .051(WD3) - .003(R)(WD3) + .003(P)(R) - .005(P)(WD1) + .005(P)(WD2) + .006(P)(WD3) + .002(R)(WD1)

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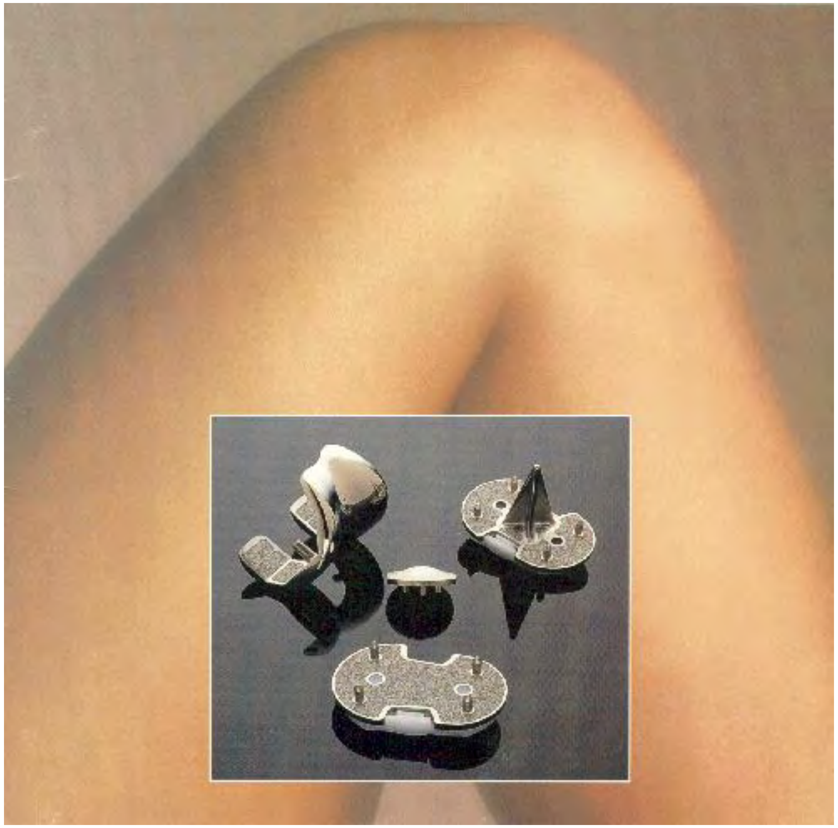
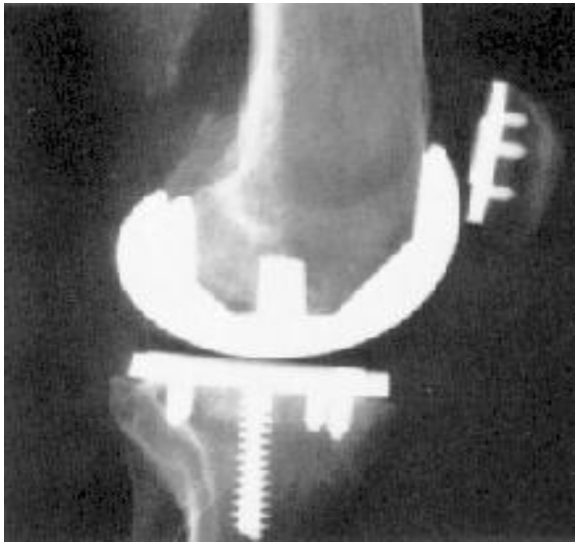
Fusing Titanium and Cobalt-Chrome





Courtesy Rai Chowdhary

DOE —Market Research” Example

Suppose that, in the auto industry, we would like to investigate the following automobile attributes (i.e., factors), along with accompanying levels of those attributes:

A: Brand of Auto:	**-1 = foreign**		**+1 = domestic**
B: Auto Color:	**-1 = light**	**0 = bright**	**+1 = dark**
C: Body Style:	**-1 = 2-door**	**0 = 4-door**	**+1 = sliding door/hatchback**
D: Drive Mechanism:	**-1 = rear wheel**	**0 = front wheel**	**+1 = 4-wheel**
E: Engine Size:	**-1 = 4-cylinder**	**0 = 6-cylinder**	**+1 = 8-cylinder**
F: Interior Size:	**-1 ≤ 2 people**	**0 = 3-5 people**	**+1 ≥ 6 people**
G: Gas Mileage:	**-1 ≤ 20 mpg**	**0 = 20-30 mpg**	**+1 ≥ 30 mpg**
H: Price:	**-1 ≤ $20K**	**0 = $20-$40K**	**+1 ≥ $40K**

In addition, suppose the respondents chosen to provide their preferences to product profiles are taken based on the following demographic:

J: Age:	**-1 ≤ 25 years old**	**+1 ≥ 35 years old**
K: Income:	**-1 ≤ $30K**	**+1 ≥ $40K**
L: Education:	**-1 < BS**	**+1 ≥ BS**

DOE —Market Research” Example (cont.)

Question: **Choose the best design for evaluating this scenario**

Answer: **L_{18} design with attributes A - H in the inner array and factors J, K, and L in the outer array, resembling an L_{18} robust design, as shown below:**

									L	-	+	-	+	-	+	-	+		
									K	-	-	+	+	-	-	+	+		
									J	-	-	-	-	+	+	+	+		
Run*	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**		y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	$\bar{y}$	**s**
1	-	-	-	-	-	-	-	-		Segmentation of the population or <u>Respondent Profiles</u>									
2	-	-	0	0	0	0	0	0											
3	-	-	+	+	+	+	+	+											
4	-	0	-	-	0	0	+	+											
5	-	0	0	0	+	+	-	-											
6	-	0	+	+	-	-	0	0											
7	-	+	-	0	-	+	0	+											
8	-	+	0	+	0	-	+	-											
9	-	+	+	-	+	0	-	0											
10	+	-	-	+	+	0	0	-											
11	+	-	0	-	-	+	+	0											
12	+	-	+	0	0	-	-	+											
13	+	0	-	0	+	-	+	0											
14	+	0	0	+	-	0	-	+											
15	+	0	+	-	0	+	0	-											
16	+	+	-	+	0	+	-	0											
17	+	+	0	-	+	-	0	+											
18	+	+	+	0	-	0	+	-											

* 18 different product profiles

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Modeling The Drivers of Turnover*

① External Market Factors (Local Labor Market Conditions)

- Local Unemployment Rate
- Local Employment Alternatives
- Company's Market Share

② Organizational Characteristics and Practices

- Supervisor Stability
- Lateral / Upward Mobility
- Layoff Climate

③ Employee Attributes

- Time Since Last Promotion
- Education Level
- Job Stability History

Process of Deciding to Stay / Leave

Turnover Rate

*Adapted from Harvard Business Review article on Boston Fleet Bank, April 2004, pp 116-125

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The Value of Transfer Functions

- Provide a simple and compact way of understanding relationships between performance measures or response variables (y's) and the factors (x's) that influence them.
- Allow for the prediction of the response variable (y), with associated risk levels, before any change in the product or process is made.
- Allow for the assessment of process or product capability in the presence of uncontrolled variation or noise.
- Allow the very quick manipulation of complex systems using Monte Carlo Simulation (i.e., Expected Value Analysis) for the purpose of assessing risk.
- Provide a very easy way to optimize performance via robust or parameter design and tolerance allocation.
- Make sensitivity analysis easy and straightforward.
- Greatly enhance one's knowledge of a product or process.
- In general, they are the gateway to systematic innovation.
- Provide a meaningful metric for the maturity in DFSS for any organization.

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Case Study: Transfer Functions

Design

Example: —Time to use” and —Can temp” as a function of —Wall thickness”, “CaO mass”, and —H_2O volume”

Wall thickness (X1) →
CaO mass (X2) →
H_20 volume (X3) →

$Y1=f_1(X1, X2, X3)$
$Y2=f_2(X1, X2, X3)$

→ **Time to use (Y1)**
→ **Can temp (Y2)**

How do we find the functions f_1 and f_2?

- First principle equations
  (Physics / Engineering equations)
- Analytical Models (Simulation and Regression)
  FEA, CFD, etc.
- Empirical models (Design of Experiments)

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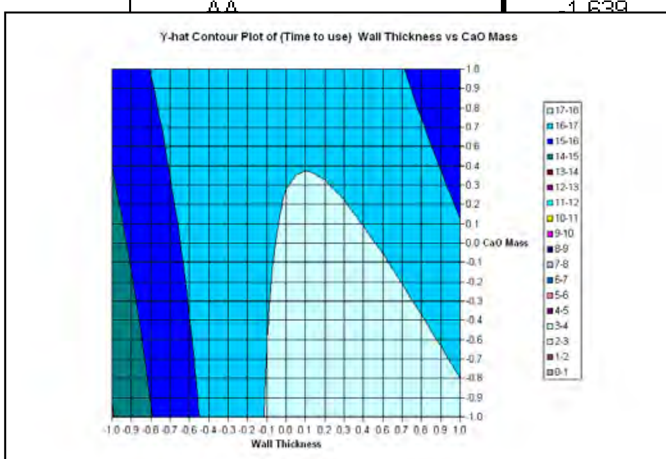
Empirical Modeling via DOE

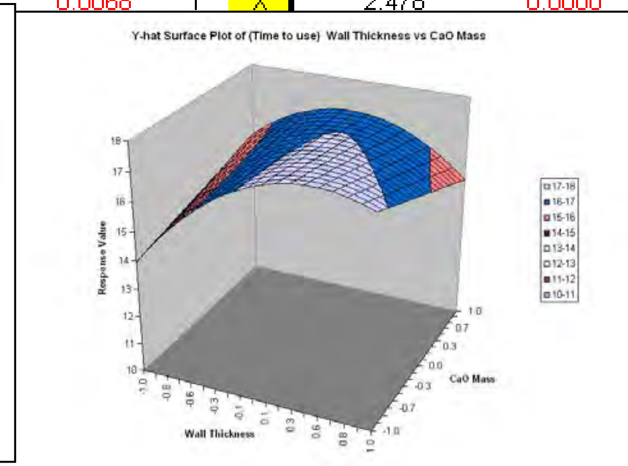
Design

Factor	A	B	C		Time to use				
Row #	Wall Thick	CaO Mass	H2O Volume		Y1	Y2	Y3	Y4	Y5
1	-1	-1	-1		15.41278	16.572	15.81977	10.29423	10.92083
2	-1	-1	1		15.16945	16.6466	14.76726	9.096769	12.39497
3	-1	1	-1		13.12958	16.93513	17.3345	13.11604	11.0545
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Factor	A	B	C		Max can temp				
Row #	Wall Thick	CaO Mass	H2O Volume		Y1	Y2	Y3	Y4	Y5
1	-1	-1	-1		108.1381	103.948	107.5071	102.9392	104.3727
2	-1	-1	1		109.8235	105.5967	108.1956	109.2639	104.0185
3	-1	1	-1		108.0081	109.2598	110.8279	109.7068	109.4276

Y-hat Model		Time to use				Max can temp			
Factor	Name	Coeff	P(2 Tail)	Tol	Active	Coeff	P(2 Tail)	Tol	Active
Const		17.055	0.0000			106.91	0.0000		
A	Wall Thickness	0.73753	0.0444	1	X	0.71745	0.0302	1	X
B	CaO Mass	-0.17772	0.6237	1	X	0.56822	0.0842	1	X
C	H2O Volume					0.49940	0.1282	1	X
AB		-0.91022	0.0269	1	X	-1.564	0.0001	1	X
AC						-1.128	0.0027	1	X
AA		-1.639	0.0068	1	X	2.478	0.0000	1	X





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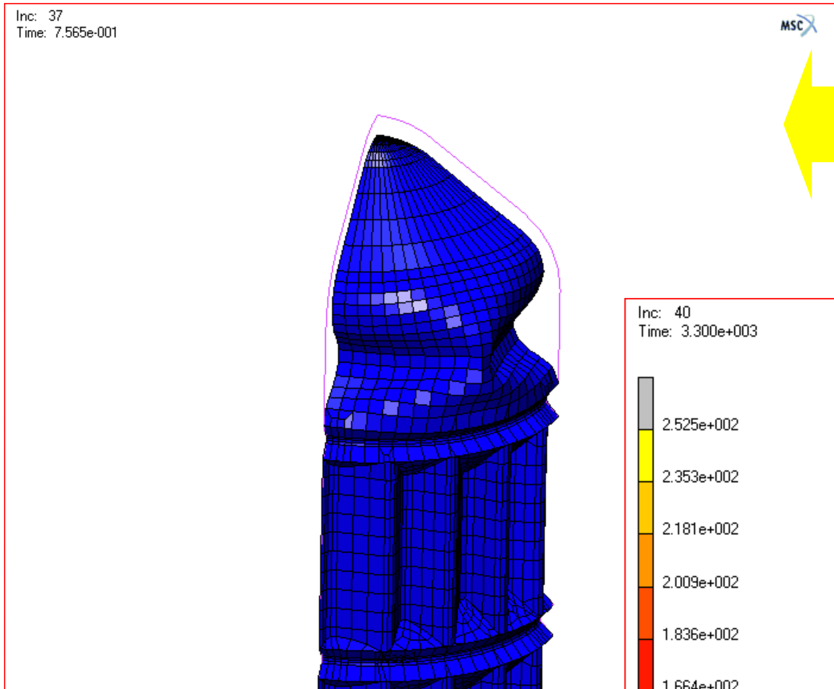
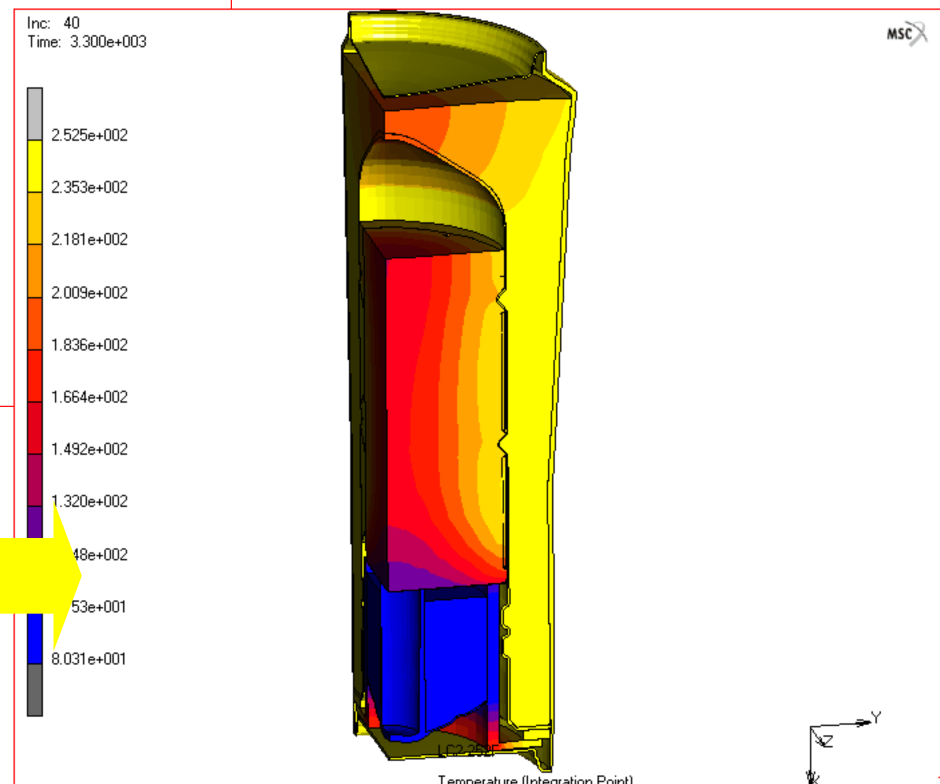
Analytical Modeling via FEA/CFD

Design



Finite Element Analysis (FEA) for modeling structural components



Computational Fluid Dynamics (CFD) for modeling temperature (fluid) components

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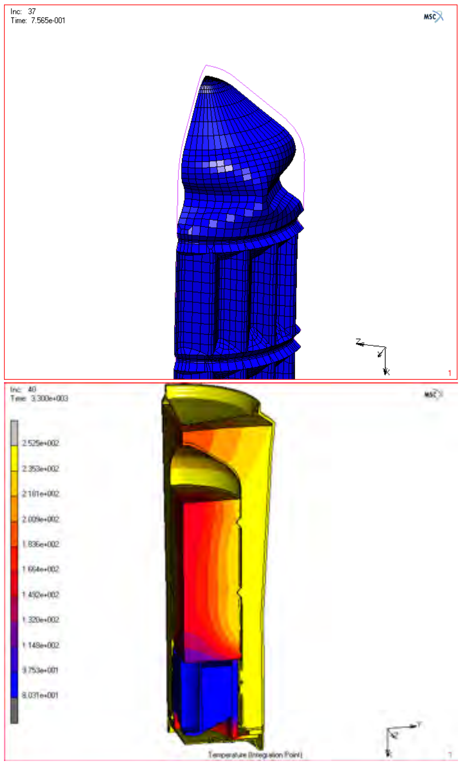
Analytical Modeling with Regression

Design

FEA / CFD Model



Predicted results validated in model

Regression Modeling

Y-hat Model Factor	Name	Response #1 Coeff	P(2 Tail)	Tol	Active	Response #2 Coeff	P(2 Tail)	Tol	Active	Response #3 Coeff	P(2 Tail)	Tol	Active
Const		-0.45862	0.9726			10.817	0.3815			-8.245	0.4975		
A	A												
B	B												
C	C												
AB													
AC													
BC													
ABC													
AA													
BB													
CC													
	Total	290055.5	79			271616.0	79			241854.9	79		

Factor	A	B	C		Response #1				
Row #	A	B	C		Y1	Y2	Y3	Y4	Y5
1	-1	-1	-1		-12	-79	4	-1	18
2	-1	-1	1		-63	87	6	83	-63
3	-1	1	-1		-47	57	32	38	68
4	-1	1	1		-81	74	70	-54	11
5	1	-1	-1		71	-89	-31	-50	79
6	1	-1	1		62	49	-37	-68	74
7	1	1	-1		-55	-67	95	25	31
8	1	1	1		-94	-62	54	-95	43
9	0	0	0		96	-66	65	22	41
10	0	0	0		-100	11	95	-65	-70
11	-1	0	0		25	-16	-83	74	-23
12	1	0	0		45	44	23	-8	58
13	0	-1	0		78	-50	-31	91	-69
14	0	1	0		-18	-54	-3	-43	-75
15	0	0	-1		-90	-30	85	48	73
16	0	0	1		-53	18	-94	-26	61

Prediction

Factor	Name	Low	High	Exper
A	Wall Thickness	-1	1	-1
B	CaO Mass	-1	1	-1
C	H2O Volume	-1	1	-0.943791176

Multiple Response Prediction

	Y-hat	S-hat	99% Confidence Interval Lower Bound	99% Confidence Interval Upper Bound
Time to use	13.9460	0.6050	12.131	15.761
Max can temp	105.0000	1.1425	101.573	108.428

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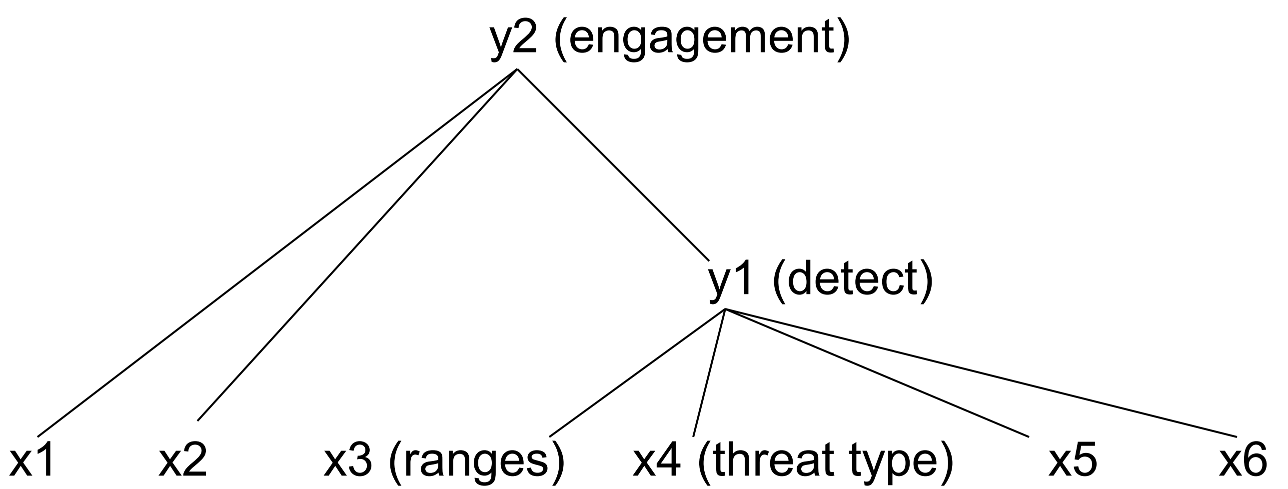
Critical Parameter Management and COIs

– A Critical Operational Issue (COI) is linked to operational effectiveness and suitability.

– It is typically phrased as a question, e.g.,

Will the system ***detect*** the ***threat*** in a ***combat environment*** at adequate ***range*** to allow for successful ***engagement***?



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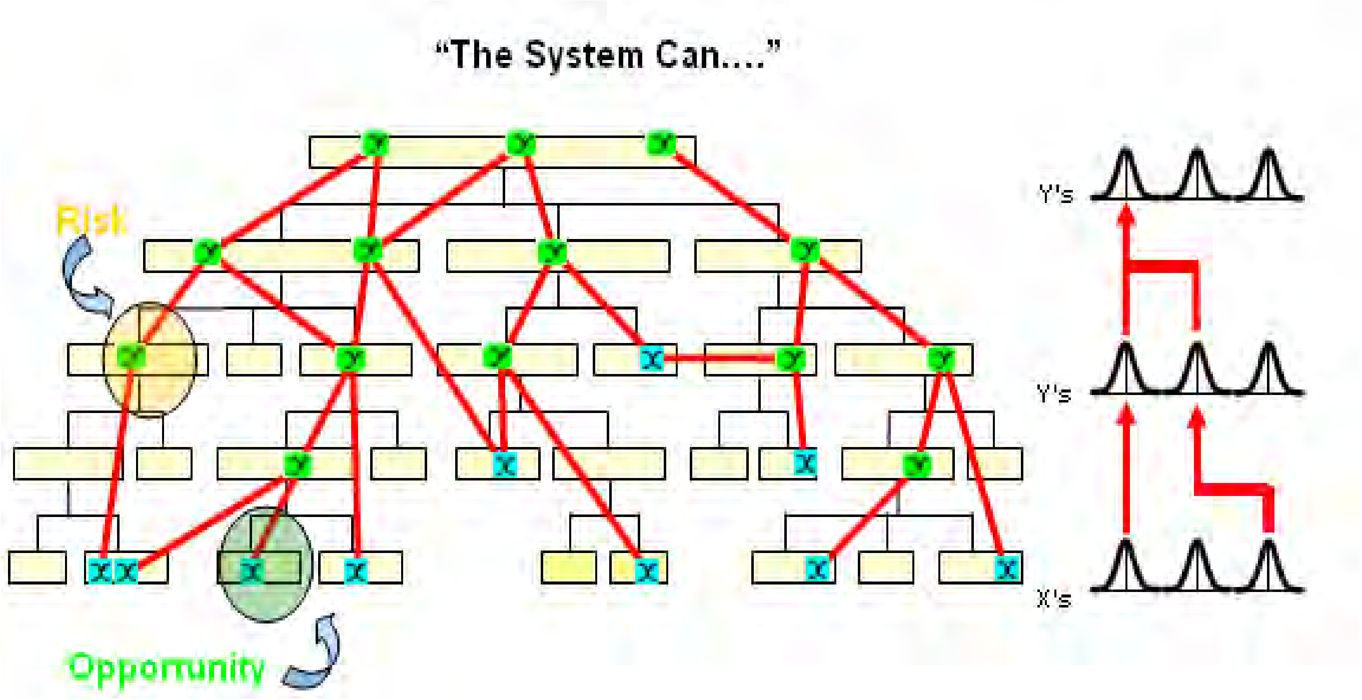
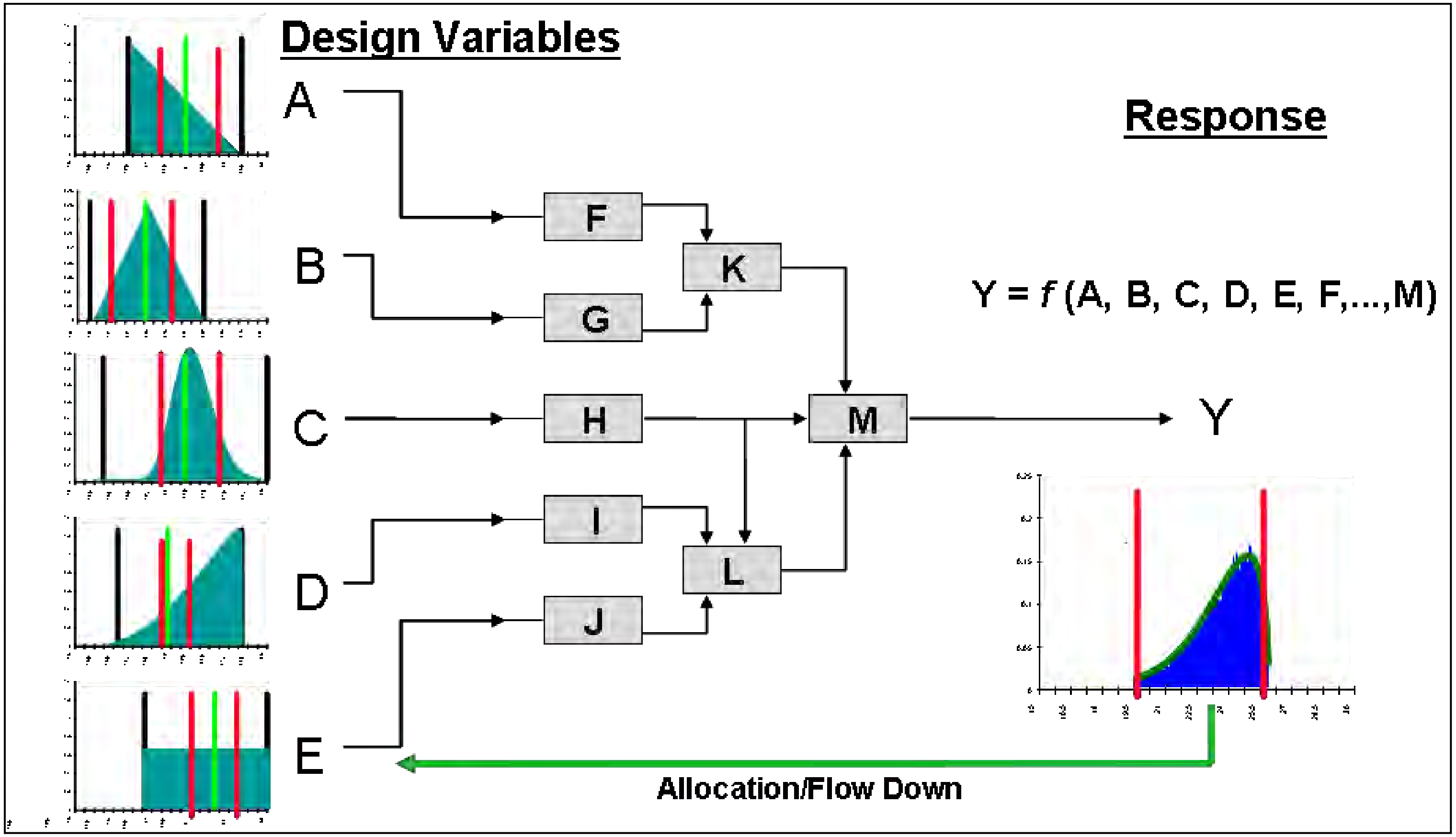
DOE Enables Critical Parameter Management (CPM)

CPM is a systems engineering best practice that is extremely useful in managing, analyzing, and reporting technical product performance. It is also very useful in decomposing COIs and developing linkages between measures and task capabilities/system attributes.



DOE Enables the Composition of Functions



The Optimize Phase

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The DFSS Process: Identify, Design, Optimize, Validate

– The **Identify** Phase
- –The DFSS Scorecard
- –Voice of the Customer (VOC)

– The **Design** Phase
- –Translating the VOC (Requirements Flowdown)
- –Concept Generation and Selection
- –Transfer Functions
- –Critical Parameter Management

–The Optimize Phase
- ***–Multiple Response Optimization***
- ***–Expected Value Analysis (Monte Carlo Simulation)***
- ***–Parameter (Robust) Design***
- ***–Tolerance Allocation***

– The **Validate** Phase
- –High Throughput Testing

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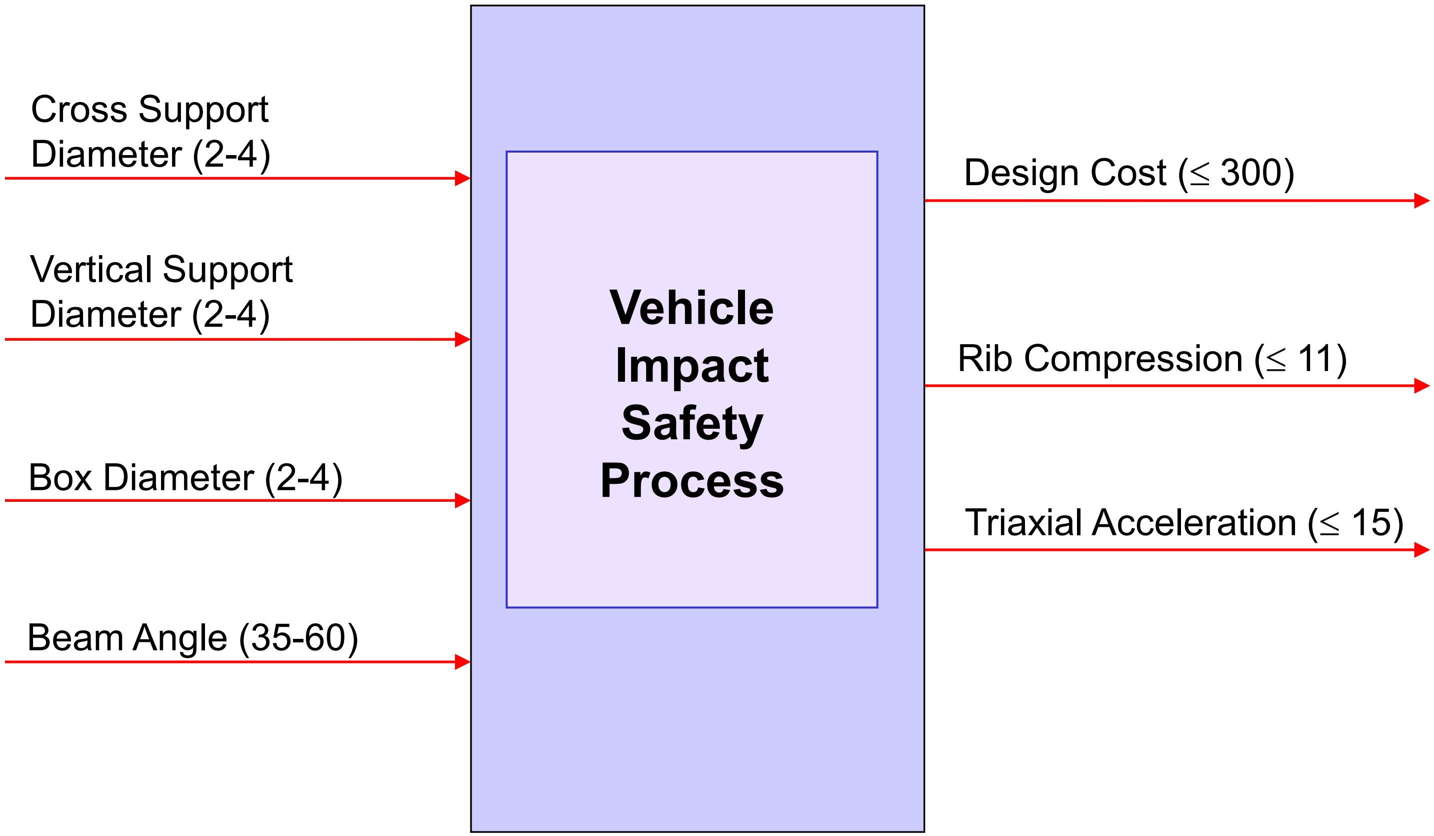
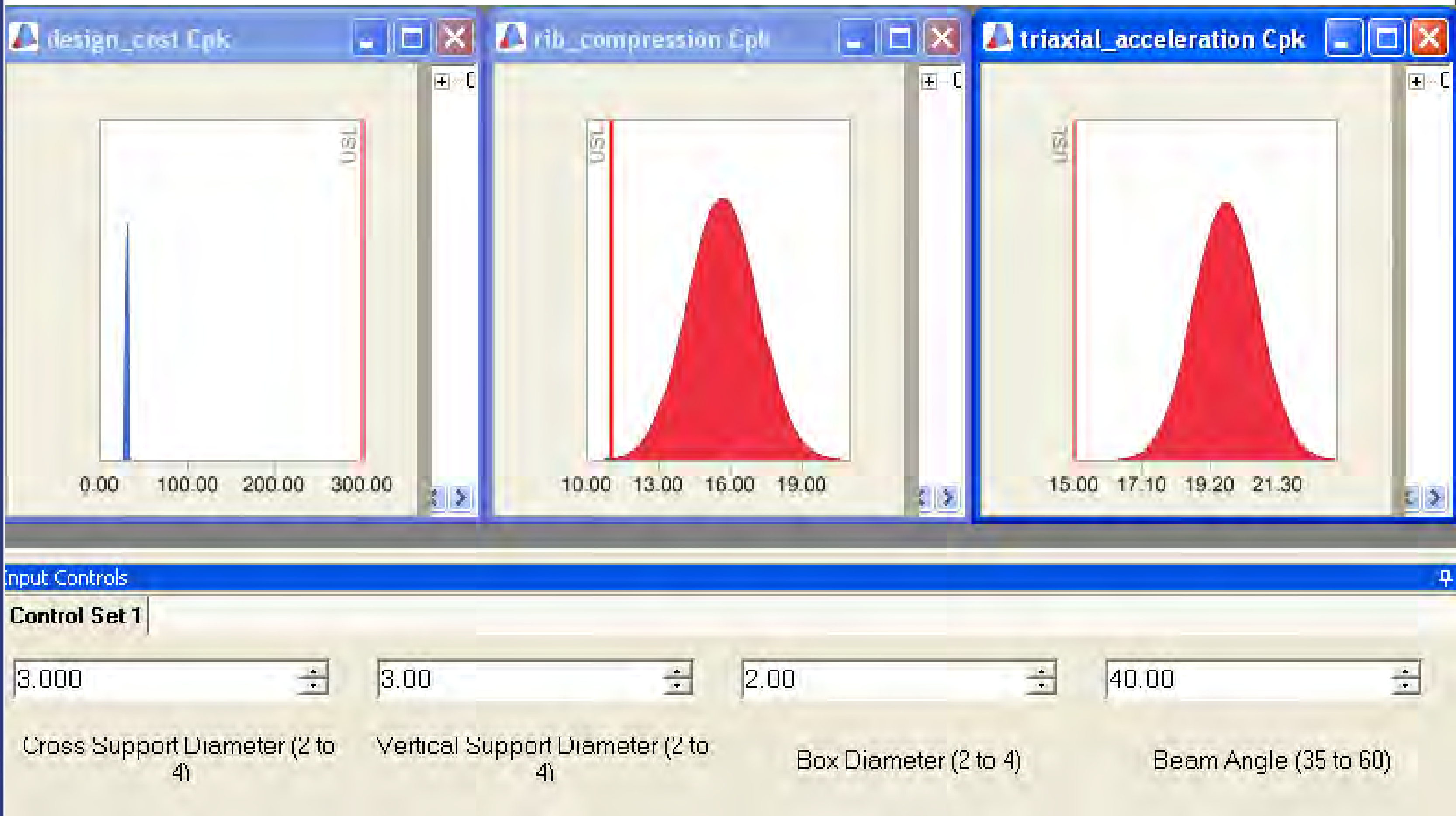
Multiple Response Optimization Simulation* Example



* From **SimWare Pro** by Philip Mayfield and Digital Computations

Multiple Response Optimization (cont.)

Capability Prior to Optimization



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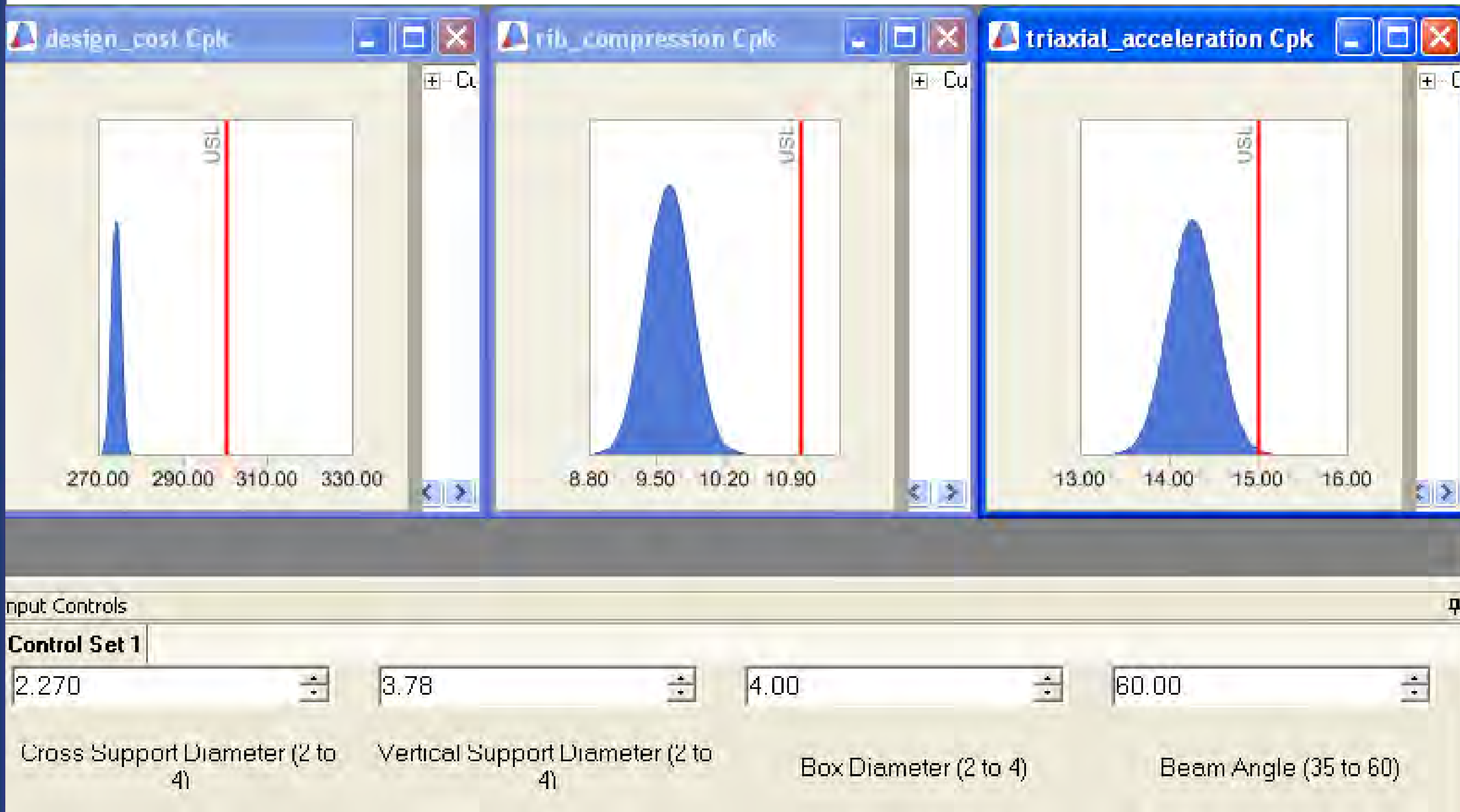
Multiple Response Optimization (cont.)

Capability After Optimization



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DFSS with Monte Carlo Simulation

- **Expected Value Analysis**
- **Robust (Parameter) Design**
- **Tolerance Allocation**

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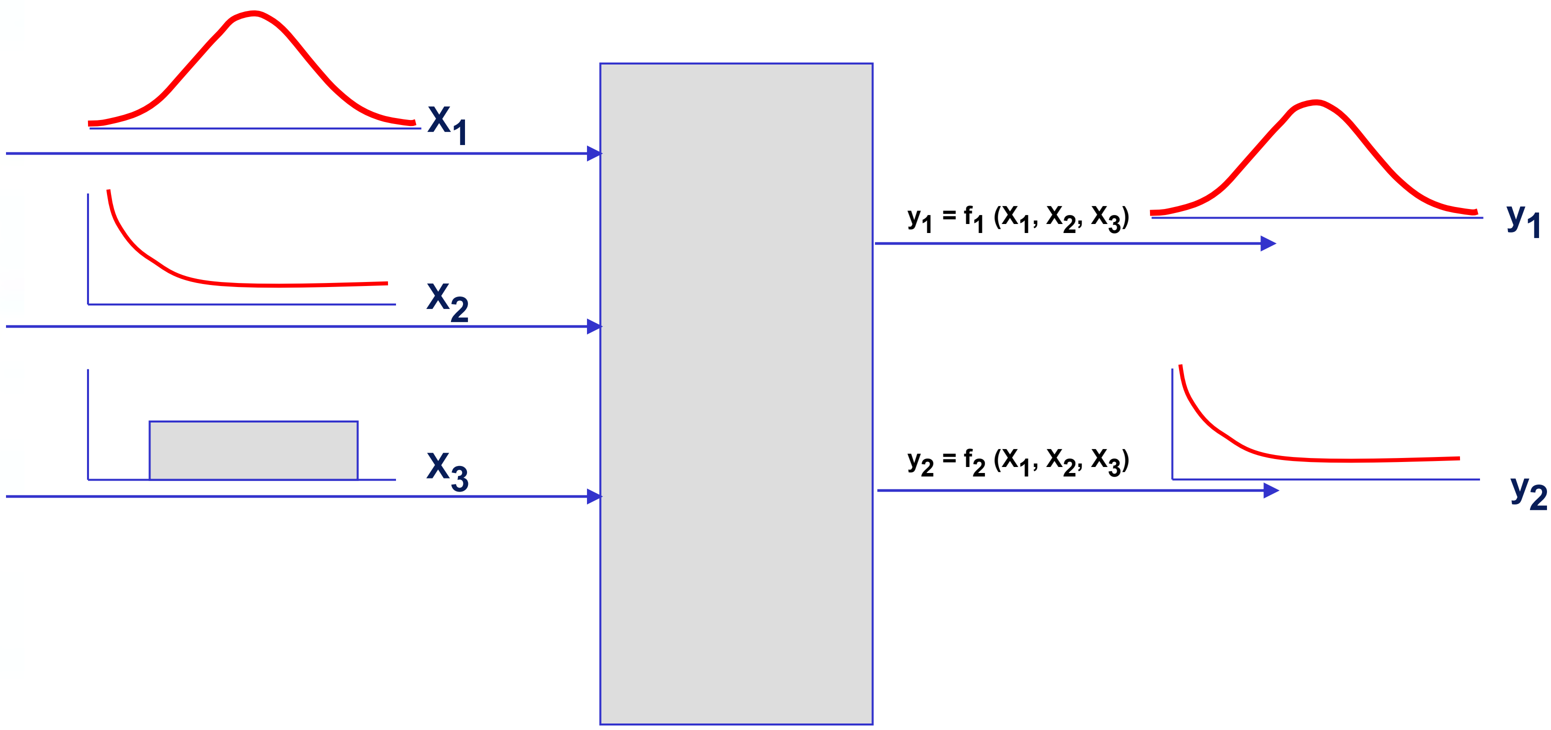
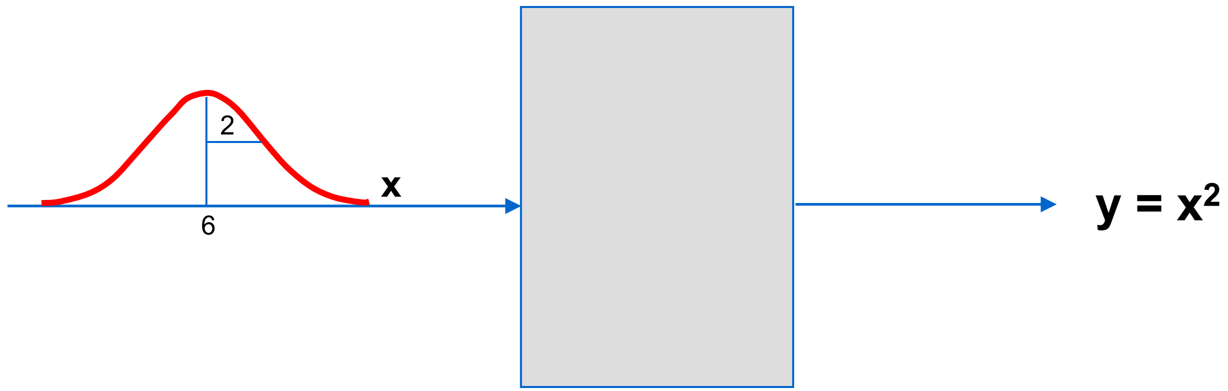
Expected Value Analysis (EVA)

EVA is the technique used to determine the characteristics of the output distribution (mean, standard deviation, and shape) when we have knowledge of (1) the input variable distributions and (2) the transfer functions.



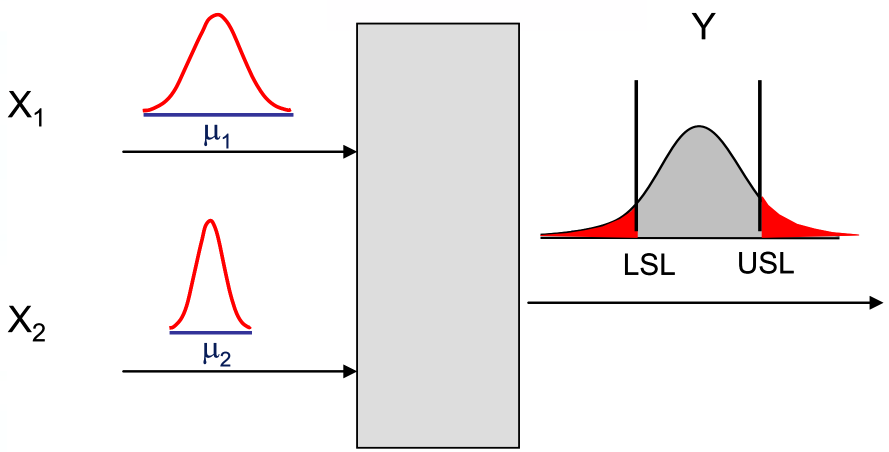
Expected Value Analysis Example



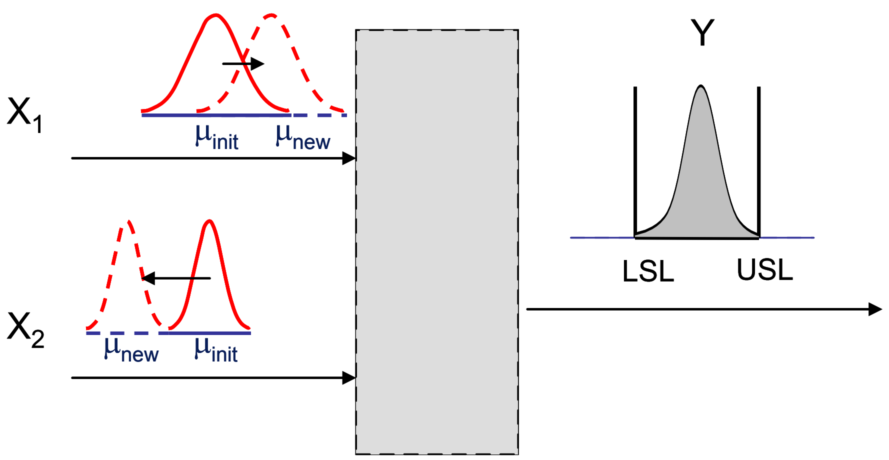
What is the mean or expected value of the y distribution?

What is the shape of the y distribution?

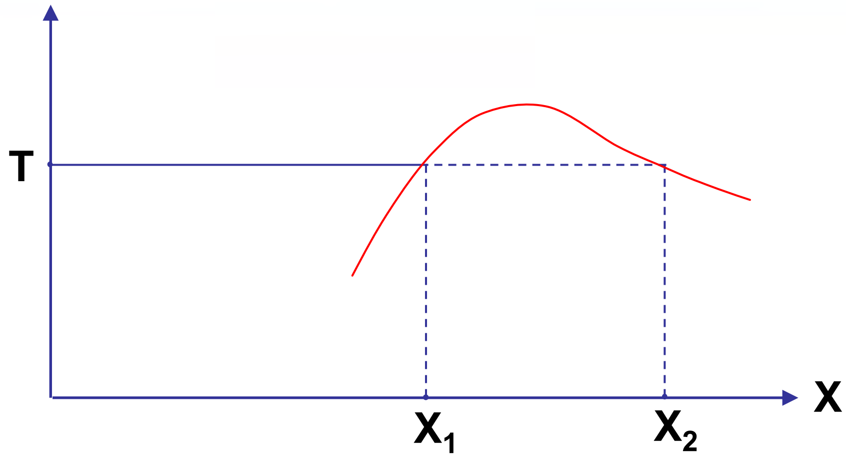
Parameter Design (Robust Design)



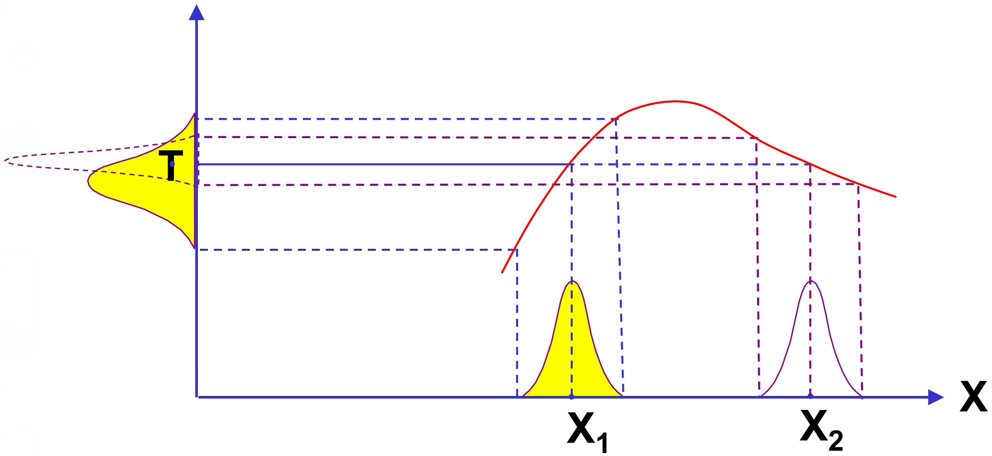
Process of finding the optimal mean settings of the input variables to minimize the resulting dpm.



Parameter Design (Robust Design)

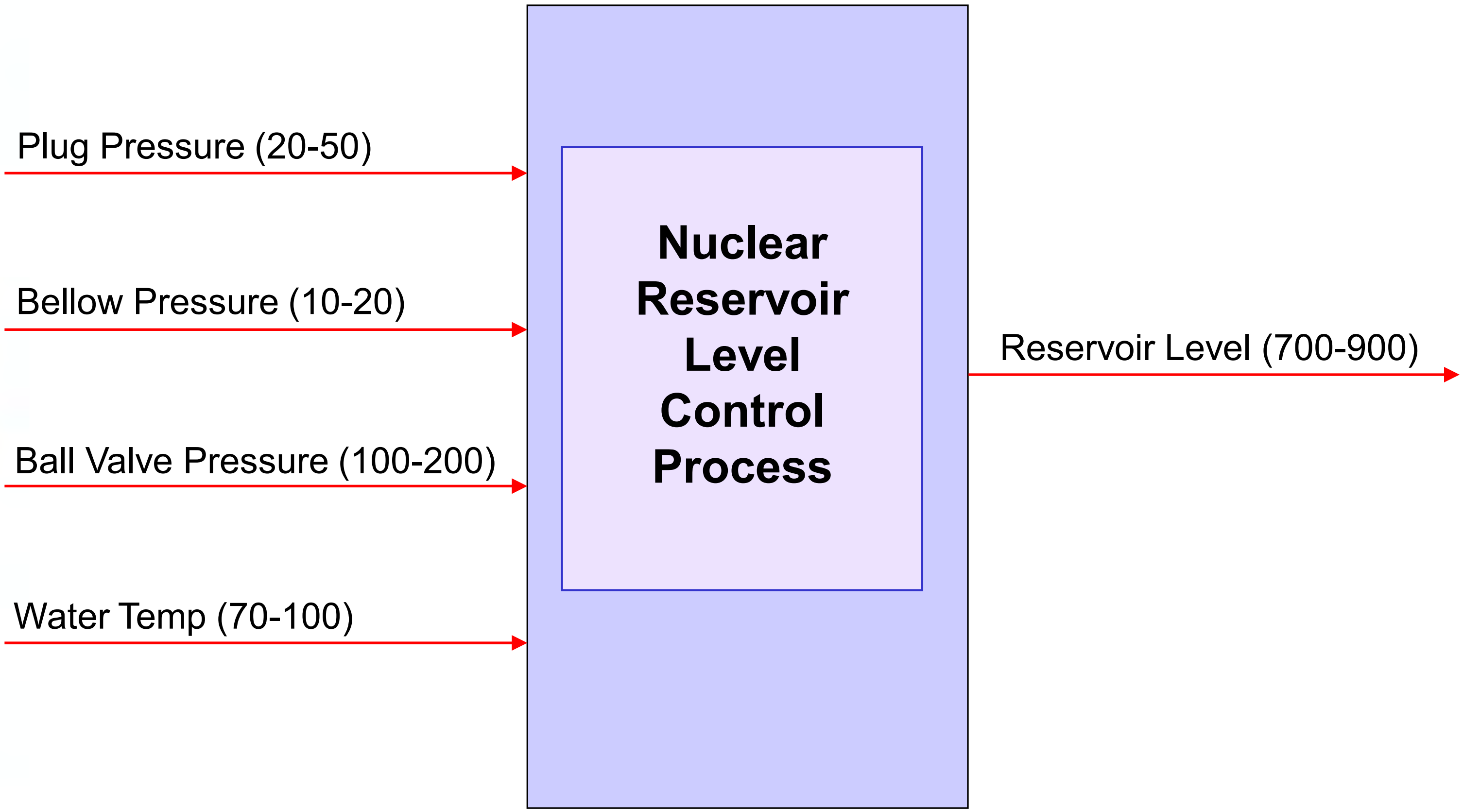


If you"re the designer, which setting for X do you prefer?

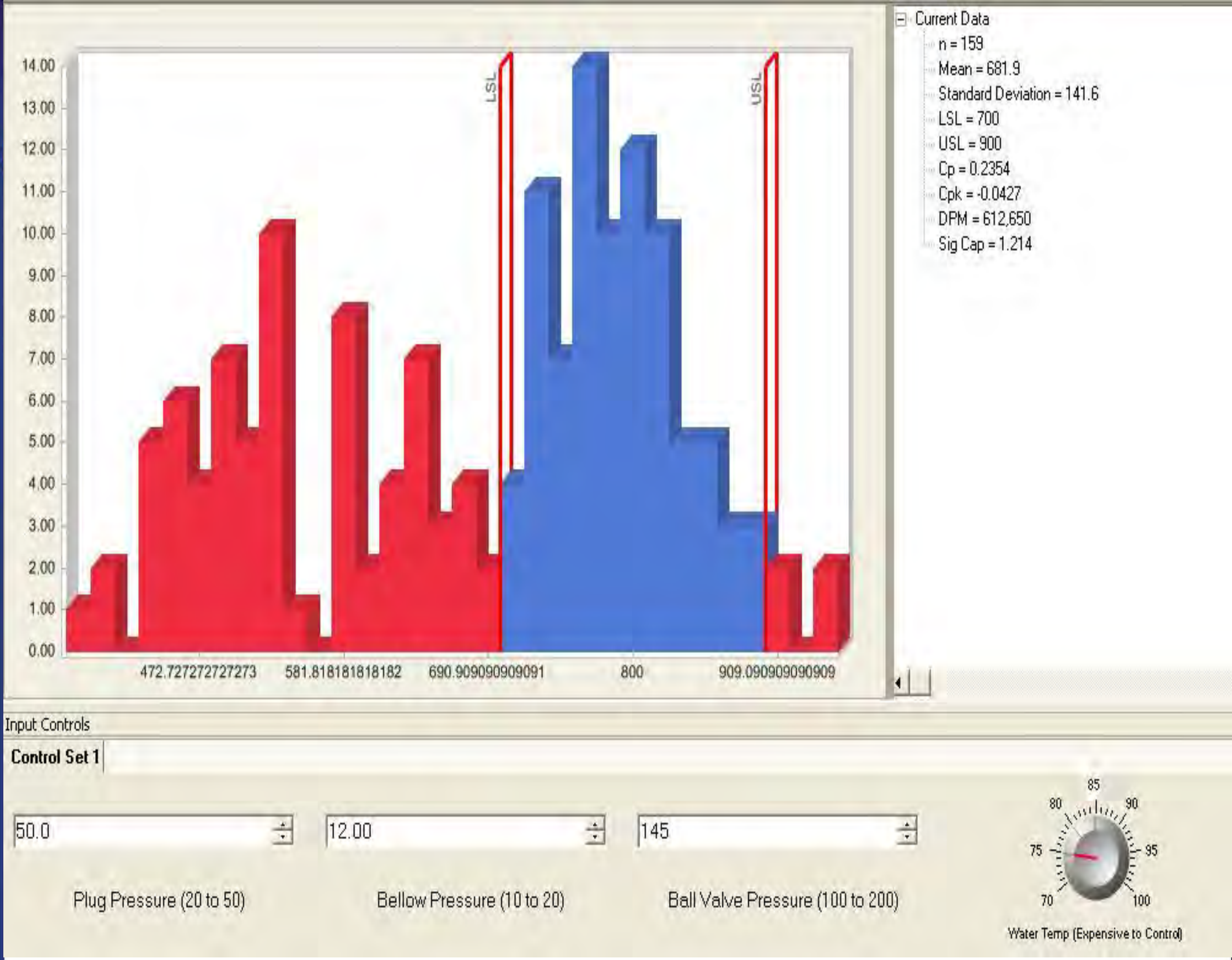


Changing the mean of an input may possibly reduce the output variation!

Robust (Parameter) Design Simulation* Example



* From **SimWare Pro** by Philip Mayfield and Digital Computations



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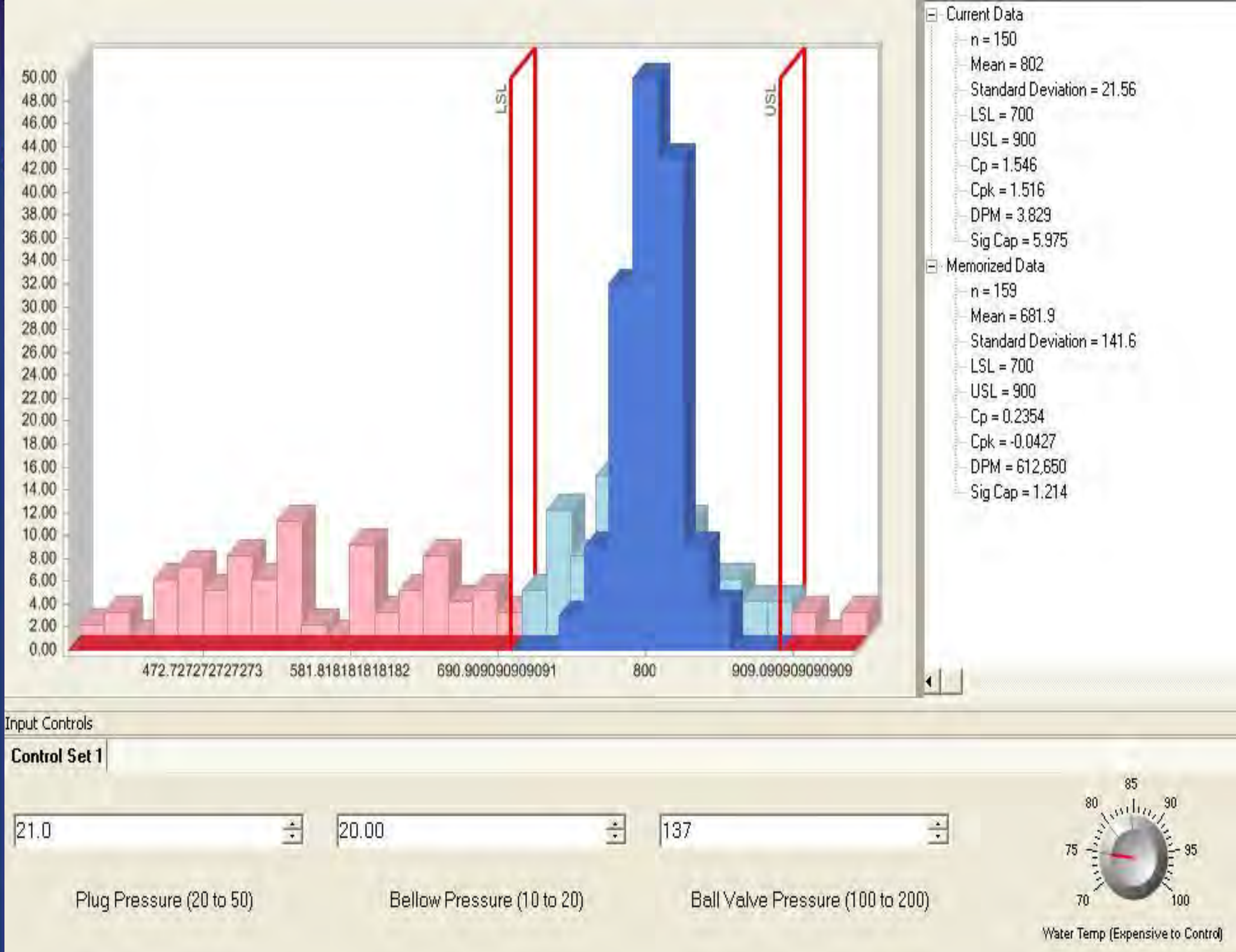

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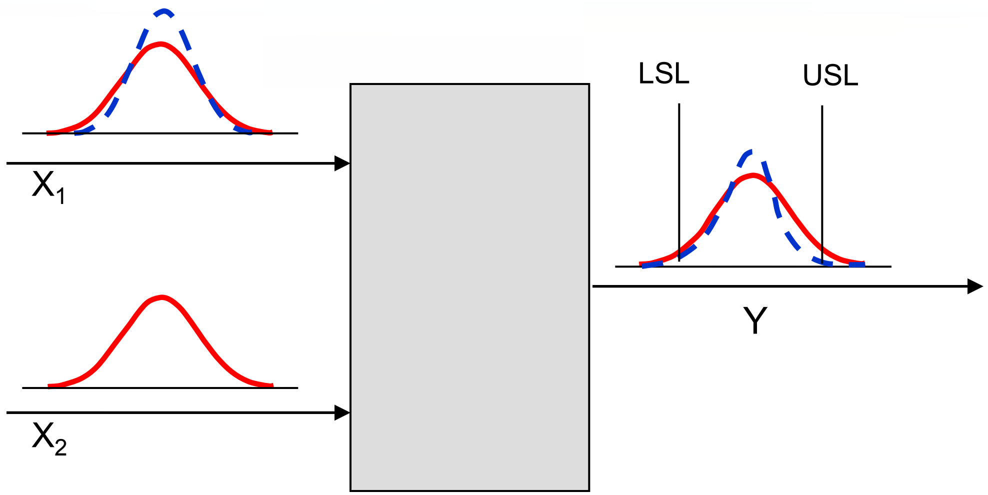
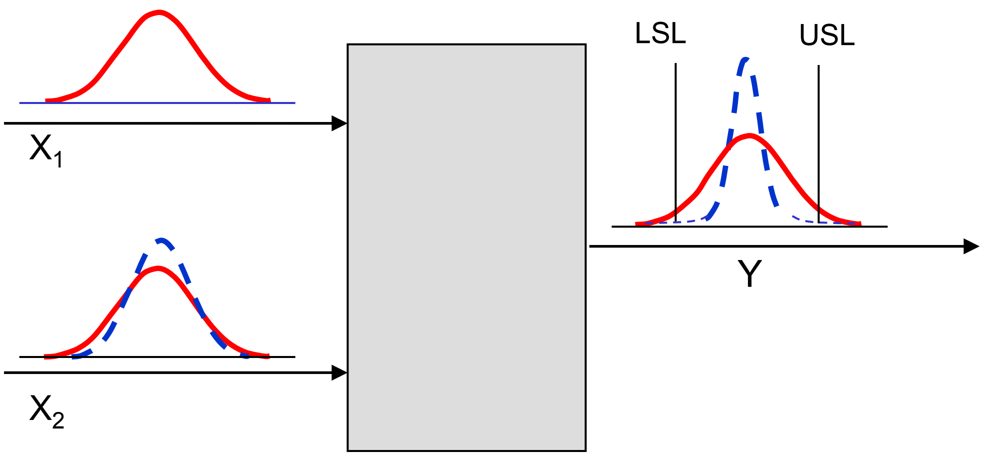
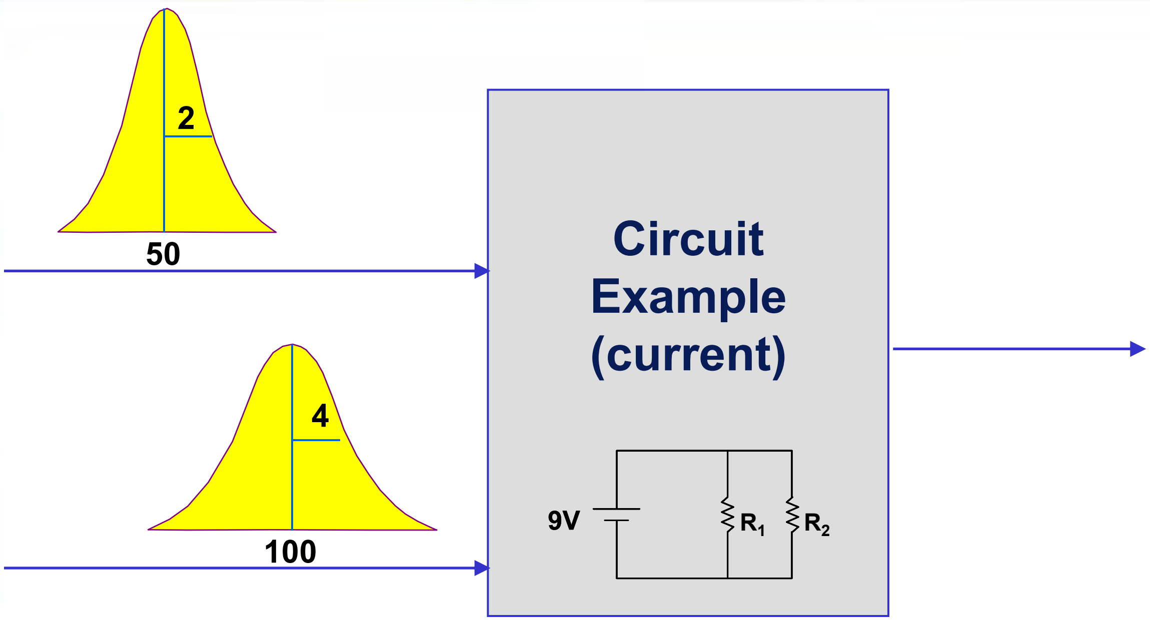
Tolerance Allocation



Which input standard deviations have the biggest effect on the output variation?



Tolerance Allocation Example



$$I = \frac{9(R_1 + R_2)}{R_1 \cdot R_2}$$

LSL = .255

USL = .285

Which resistor's standard deviation has the greater impact on the capability of I?

Tolerance Allocation Example (cont.)

A reduction in R_1's standard deviation (sigma) significantly reduces the dpm while a reduction in R_2's standard deviation has a smaller effect.

Tolerance Allocation Table

Process Inputs			
Factor	Distro	First Parameter	Second Parameter
R1	Normal	50	2
R2	Normal	100	4

N = 10,000 (in dpm)		
current Table (Normal dpm)		
	R1	R2
-50% Sigma	2,897	45,852
-25% Sigma	21,912	53,427
-10% Sigma	46,150	58,483
Nominal	63,975	63,438
+10% Sigma	88,478	69,198
+25% Sigma	127,102	83,522
+50% Sigma	196,089	100,553

A reduction in R_1's standard deviation by 50% (from 2 ohms to 1 ohm) combined with an increase in R_2's standard deviation by 25% (from 4 ohms to 5 ohms) results in a dpm = 9,743.

(This result is not shown in the table.)

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Case Study: Optimization Strategy

Wall thickness (X1) →
CaO mass (X2) →
$H_2$0 volume (X3) →

$Y1=f_1(X1, X2, X3)$
$Y2=f_2(X1, X2, X3)$

→ Time to use (Y1)
→ Can temp (Y2)

Optimize

How do we best set X1, X2, X3 to optimize Y1 and Y2?

- Expected Value Analysis (EVA)
  - a form of Monte Carlo simulation
- Robust Design methods
  - including computer-based Parameter Design
- Tolerance Allocation
  - via computer-based tolerance analysis

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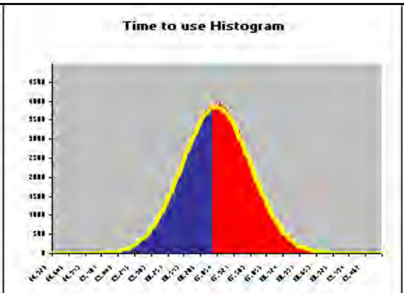
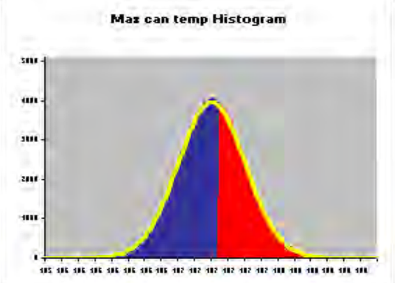
EVA – Monte Carlo Simulation

Process Inputs						Process Outputs			
Factor	Distro	1st Parameter	2nd Parameter	Exper		Name	Function	LSL	USL
Wall Thickness	Normal	0	0.089	0		Time to use	17.05547		17
CaO Mass	Normal	0	0.0765	0		Max can ten	106.9074		107
H2O Volume	Normal	0	0.04123	0					
Noise_Time to use	Normal	0	0.55075436	0					
Noise_Max can temp	Normal	0	0.29526055	0					

Expected Value Analysis





Optimize

Process Inputs			
Factor	Distro	First Parameter	Second Parameter
Wall Thic	Normal	0	0.089
CaO Mas	Normal	0	0.0765
H2O Volu	Normal	0	0.04123
Noise_Tir	Normal	0	0.550754
Noise_Ma	Normal	0	0.295261

Process Outputs	Time to use	Max can temp
# of Simulations	1,000,000	1,000,000
Mean	17.0426	106.9269
StdDev	0.5554	0.3073
LSL		
USL	17	107
Normal Distro Statistics		
KS Test p-Value (Normal)	0.211	0.217
dpm	530,572.305	405,965.585
Cpk	-0.026	0.079
Cp		
Sigma Level	-0.077	0.238
Sigma Capability	-0.077	0.238

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Parameter (Robust) Design

Parameter Ranges

Select the range for each input parameter

Wall Thickness	Mean	From	-1	to	1
CaO Mass	Mean	From	-1	to	1
H20 Volume	Mean	From	-1	to	1
Noise_Time to use	Mean	From	0	to	0
Noise_Max can	Mean	From	0	to	0

Help | Cancel | << Back | Next >> | Finish

Computing Optimal Parameters

Calculating

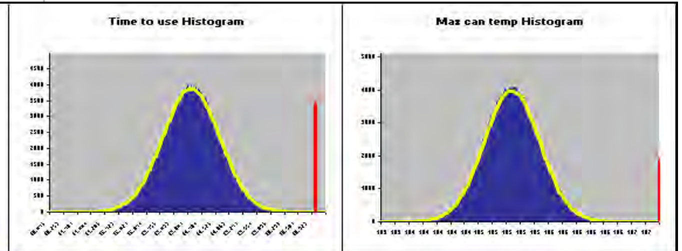
Total Weight = 100

Inputs
Wall Thickness = -1.0
CaO Mass = -0.99998
H20 Volume = -0.93404
Noise_Time to use = 0.0
Noise_Max can temp = 0.0

Outputs
Time to use = 4.445 dpm
Max can temp = 0.03 dpm

Stop Parameter Design

Expected Value Analysis



Process Inputs

Factor	Distro	First Parameter	Second Parameter
Wall Thic	Normal	-1	0.089
CaO Mas	Normal	-0.999978	0.0765
H2O Volu	Normal	-0.934036	0.04123
Noise_Tir	Normal	0	0.550754
Noise_Ma	Normal	0	0.295261

Process Outputs

	Time to use	Max can temp
# of Simulations	1,000,000	1,000,000
Mean	13.9331	105.0354
StdDev	0.7062	0.374
LSL		
USL	17	107
Normal Distro Statistics		
KS Test p-Value (Normal)	0.0	0.0
dpm	7.039	.075
Cpk	1.448	1.751
Cp		
Sigma Level	4.343	5.252
Sigma Capability	4.343	5.252

Optimize

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Tolerance Allocation

Tolerance Allocation Table

Process Inputs			
Factor	Distro	First Parameter	Second Parameter
Wall Thick	Normal	-1	0.089
CaO Mass	Normal	-0.9999782	0.0765
H2O Volur	Normal	-0.9340357	0.04123
Noise_Tim	Normal	0	0.5507544
Noise_Ma:	Normal	0	0.2952605

N = 1,000,000 (in dpm)

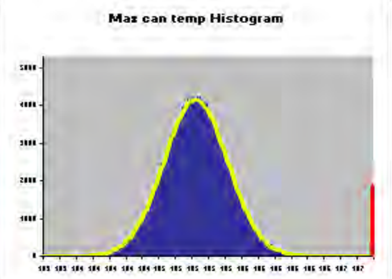
Time to use Table (Normal dpm)

	Wall Thickness	CaO Mass	H2O Volume	Noise_Time to use	Noise_Max can temp
-50% Sigma	.1416	6.722	7.021	.00198	7.042
-25% Sigma	1.023	7.009	7.084	.1988	7.117
-10% Sigma	3.26	6.997	7.096	1.947	7.117
Nominal	7.048	7.134	7.056	6.943	6.989
+10% Sigma	14.48	7.197	7.074	21.25	7.055
+25% Sigma	40.3	7.344	7.065	89.5	6.995
+50% Sigma	171.0	7.621	7.085	531.3	7.061

Expected Value Analysis

By variance reduction

Optimize



Process Inputs			
Factor	Distro	First Parameter	Second Parameter
Wall Thic	Normal	-1	0.06
CaO Mas	Normal	-0.999978	0.0765
H2O Volu	Normal	-0.934036	0.04123
Noise_Tir	Normal	0	0.550754
Noise_Mε	Normal	0	0.295261

Process Outputs	Time to use	Max can temp
# of Simulations	1,000,000	1,000,000
Mean	13.9396	105.0247
StdDev	0.6279	0.3578
LSL		
USL	17	107
Normal Distro Statistics		
KS Test p-Value (Normal)	0.012	0.0
dpm	.546	.017
Cpk	1.625	1.84
Cp		
Sigma Level	4.874	5.521
Sigma Capability	4.874	5.521

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The Validate Phase

The DFSS Process: Identify, Design, Optimize, Validate

– The **Identify** Phase
  – The DFSS Scorecard
  – Voice of the Customer (VOC)

– The **Design** Phase
  – Translating the VOC (Requirements Flowdown)
  – Concept Generation and Selection
  – Transfer Functions
  – Critical Parameter Management

– The **Optimize** Phase
  – Multiple Response Optimization
  – Expected Value Analysis Using Monte Carlo Simulation
  – Parameter Design
  – Tolerance Allocation

– ***The Validate Phase***
  – ***High Throughput Testing***

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The Validate Phase

- Validating performance
- Performing sensitivity analysis
- Comparing Predicted capability with actual
- Gap analysis (reasons for lack of confirmation)
- Updating scorecards

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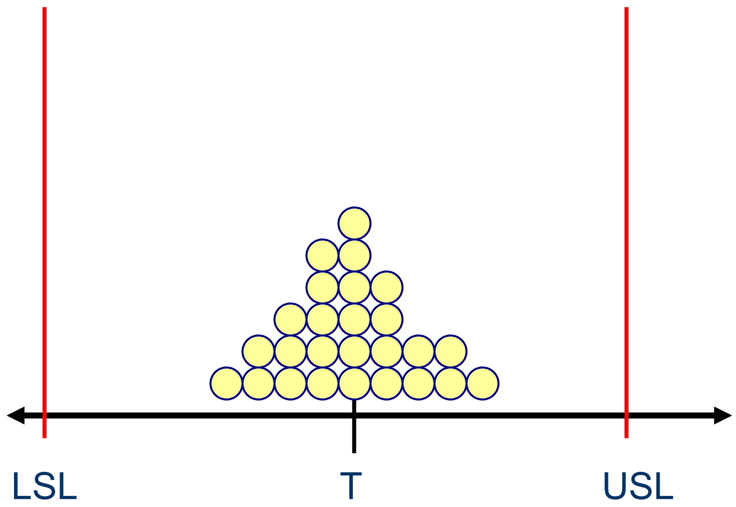
Validate

Critical parameters are validated against predictions from models.



<u>Methods may include</u>

- Prototypes
- Lab scale production
- Test-fixturing of subassemblies

If validation is poor ……… gap analysis!

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Introduction to High Throughput Testing (HTT)

- A recently developed technique based on combinatorics
- Used to test myriad combinations of many factors (typically qualitative) where the factors could have many levels
- Uses a minimum number of runs or combinations to do this
- Software (e.g., ProTest) is needed to select the minimal subset of all possible combinations to be tested so that all 2-way combinations are tested.
- HTT is not a DOE technique, although the terminology is similar
- A run or row in an HTT matrix is, like DOE, a combination of different factor levels which, after being tested, will result in a successful or failed run
- HTT has its origins in the pharmaceutical business where in drug discovery many chemical compounds are combined together (combinatorial chemistry) at many different strengths to try to produce a reaction.
- Other industries are now using HTT, e.g., software testing, materials discovery, integration and functionality testing (see example on next page).

Submarine Threat Detection Example

- Suppose we want to perform a verification test with the following 7 input factors (with their respective settings):
  - Submarine Type (S1, S2, S3)
  - Ocean Depth (Shallow, Deep, Very Deep)
  - Sonar Type (Active, Passive)
  - Target Depth (Surface, Shallow, Deep, Very Deep)
  - Sea Bottom (Rock, Sand, Mud)
  - Control Mode (Autonomous, Manual)
  - Ocean Current (Strong, Moderate, Minimal)
- All possible combinations would involve how many runs in the test?
- If we were interested in testing all pairs only, how many runs would be in the test? Pro Test generated the following test matrix.

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Submarine Threat Detection Example (cont.)

The following 15 test cases will test all pairwise combinations.

	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E	Factor_F	Factor_G
Factor Name	Submarine Type	Ocean Depth	Sonar Type	Target Depth	Sea Bottom	Control Mode	Ocean Current
Case 1	S3	Deep	Passive	Very Deep	Mud	Manual	Minimal
Case 2	S1	Very Deep	Passive	Surface	Rock	Autonomous	Strong
Case 3	S2	Shallow	Active	Shallow	Rock	Manual	Moderate
Case 4	S2	Deep	Passive	Deep	Sand	Autonomous	Moderate
Case 5	S1	Shallow	Active	Surface	Sand	Manual	Minimal
Case 6	S1	Very Deep	Passive	Shallow	Mud	Autonomous	Minimal
Case 7	S3	Very Deep	Active	Deep	Mud	Manual	Strong
Case 8	S2	Very Deep	Active	Very Deep	Sand	Autonomous	Strong
Case 9	S3	Shallow	Passive	Shallow	Mud	Autonomous	Strong
Case 10	S3	Deep	Active	Surface	Rock	Manual	Moderate
Case 11	S1	Shallow	Active	Deep	Rock	Autonomous	Minimal
Case 12	S1	Deep	Passive	Very Deep	Rock	Manual	Moderate
Case 13	S2	Very Deep	Active	Surface	Mud	Autonomous	Moderate
Case 14	S3	Deep	Active	Shallow	Sand	Manual	Strong
Case 15	S2	Shallow	Active	Very Deep	Rock	Manual	Minimal

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HTT Applications

- Reducing the cost and time of testing while maintaining adequate test coverage
- Integration and functionality testing
- Creating a test plan to stress a product and discover problems
- Prescreening before a large DOE to ensure all 2-way combinations are feasible before discovering, midway through an experiment, that certain combinations are not feasible
- Developing an —outer array" of noise combinations to use in a robust design DOE when the number of noise factors and settings is large

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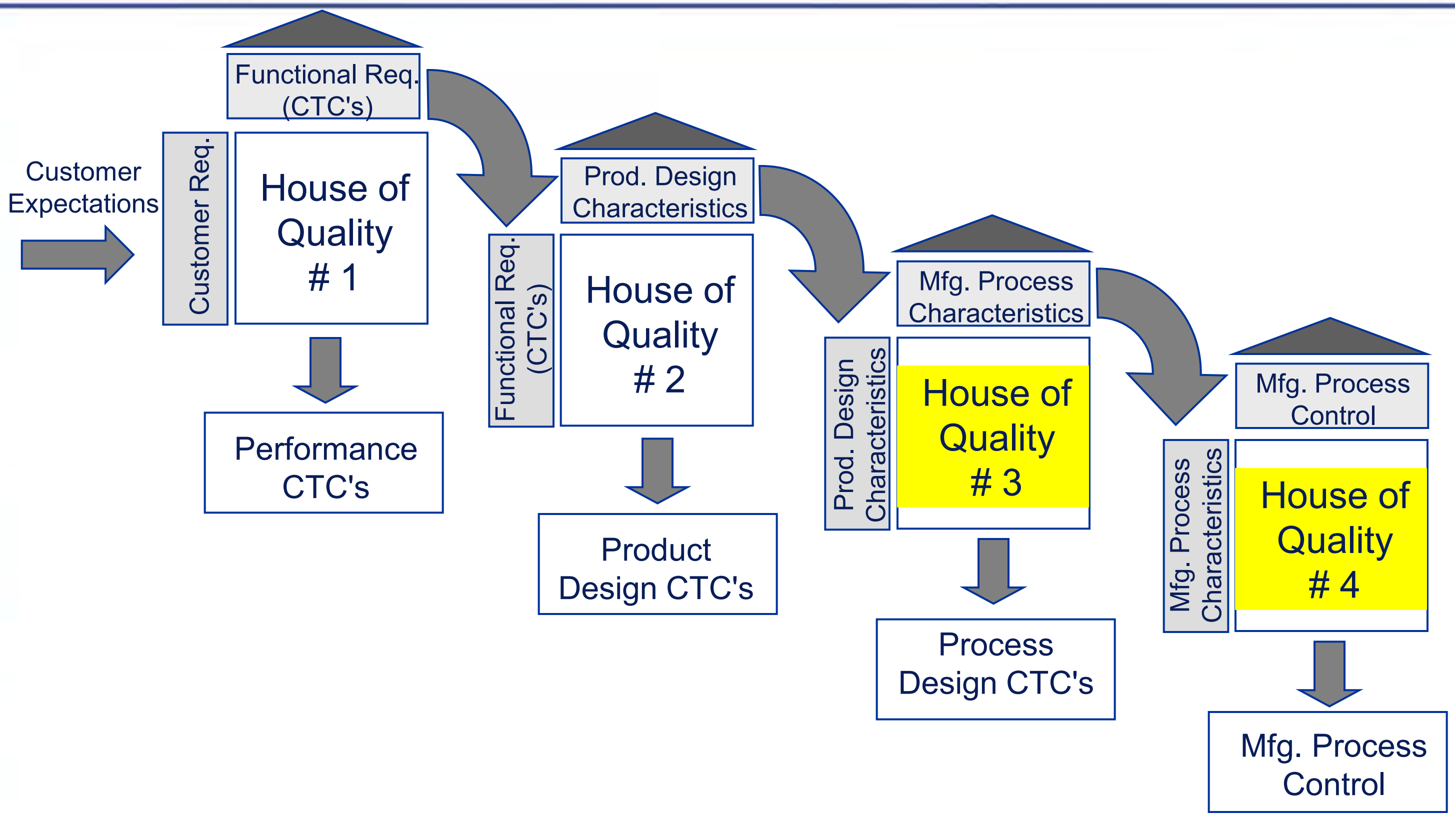
Requirements Flowdown Using QFD



Marketing
- Features
- Quality
- Performance
- Cost

Design Engineering
- Performance
- Reliability
- Cost

Mfg. Engineering
- Manufacturability
- Cost

Manufacturing
- SPC
- Process Capability

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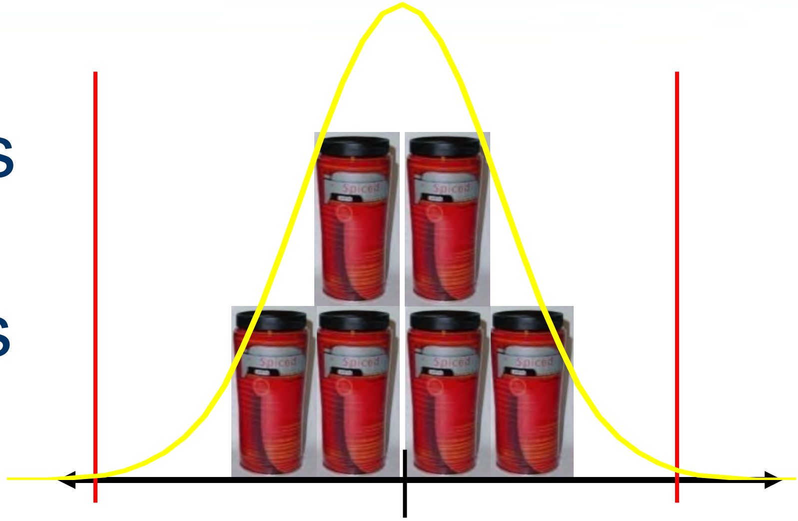
Case Study: Validation

Critical parameters are validated against predictions from models.



<u>Methods may include</u>

- Prototypes
- Lab scale production
- Test-fixturing of sub-assemblies

Validate

3rd HOQ: Physical Domain → Process Domain

PPs
(Process Domain)

DP
(Physical Domain)

	wt	Mold Temp	Injection Speed	Clamp Force	Injection Pressure	Seamer roll force	.
Wall thickness	3	9	3		3		
CaO mass	5	3	9				
H2O volume	4	3					
Button force	2						
.							
.							
Prioritized PPs		75	69	50	62	17	.

Design Parameters are mapped to Process Parameters

Validate

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4^{th} HOQ: Process Domain → Process Control

Process Control

PP
(Process Domain)

PP	wt	Temp Xbar-R Chart	Machine SOP	Machine 1 SOP	Machine 2 SOP	Force IMR Chart	.	
Mold Temp	5	9	3		3			
Injection Speed	4	3	9					
Clamp Force	2							
Injection Pressure	3							
Seamer roll force	1							
.								
Prioritized PCs		67	71	19	45	67	.	

Process Parameters are mapped to Process Controls

Mfg.

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Methods & Tools Used in Case Study

	QFD	Axiomatic Design	TRIZ	Analytical Modeling & Simulation	LSS/DFSS
Identify	VOC → HOQ1 → CTCs (FPs)	CUSTOMER DOMAIN → FUNCTIONAL DOMAIN	8 PATTERNS SYSTEMS VIEW		SURVEYS INTERVIEWS FOCUS GROUPS PAIRWISE COMPARISON BASES
Design	CTCs (FPs) → HOQ2 → DPs	FUNCTIONAL DOMAIN (VIA AXIOMATIC DESIGN) → PHYSICAL DOMAIN	FUNCTIONAL MODEL TC & PC ALGORITHMS RESOURCES	FEA, CFD: ANSYS FLUENT COSMOS	Functional Analysis System Technique (FAST)
Optimize	DPs	INDEPENDENCE & INFORMATION OPTIMIZATION (DECOUPLING)	FUNCTIONAL MODEL TC & PC ALGORITHMS		DOE / EVA MONTE CARLO / DS PARAMETER DESIGN TOLERANCING
Validate	DPs → HOQ3 → PPs	PHYSICAL DOMAIN → PROCESS DOMAIN	TC & PC ALGORITHMS	CONFIRMATION	HYPOTHESIS TESTS CONFIRMATION
Mfg.	PPs → HOQ4 → PC	PROCESS DOMAIN → PROCESS CONTROL	TC & PC ALGORITHMS		SPC CONTROL PLANS POKA YOKE

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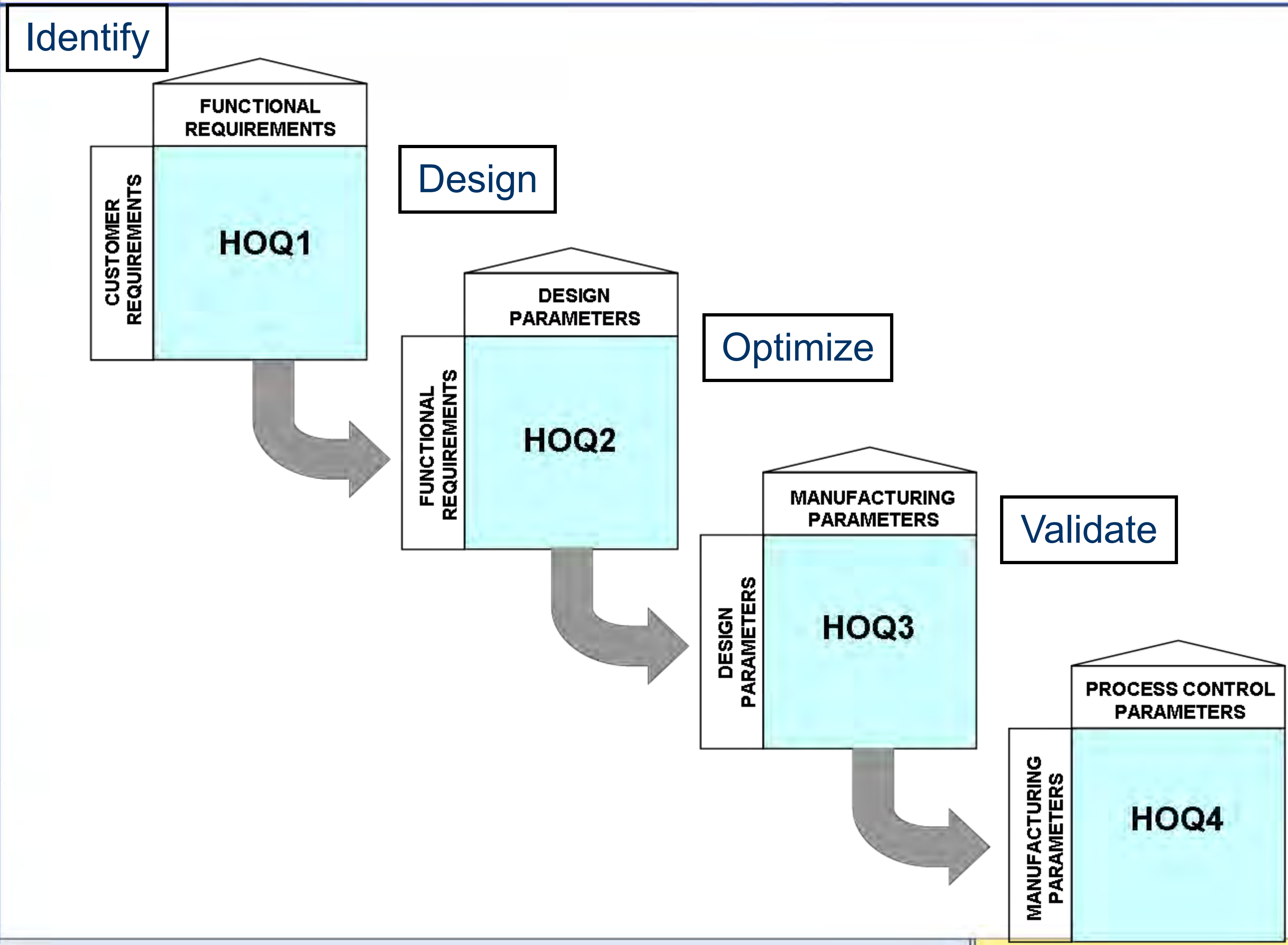
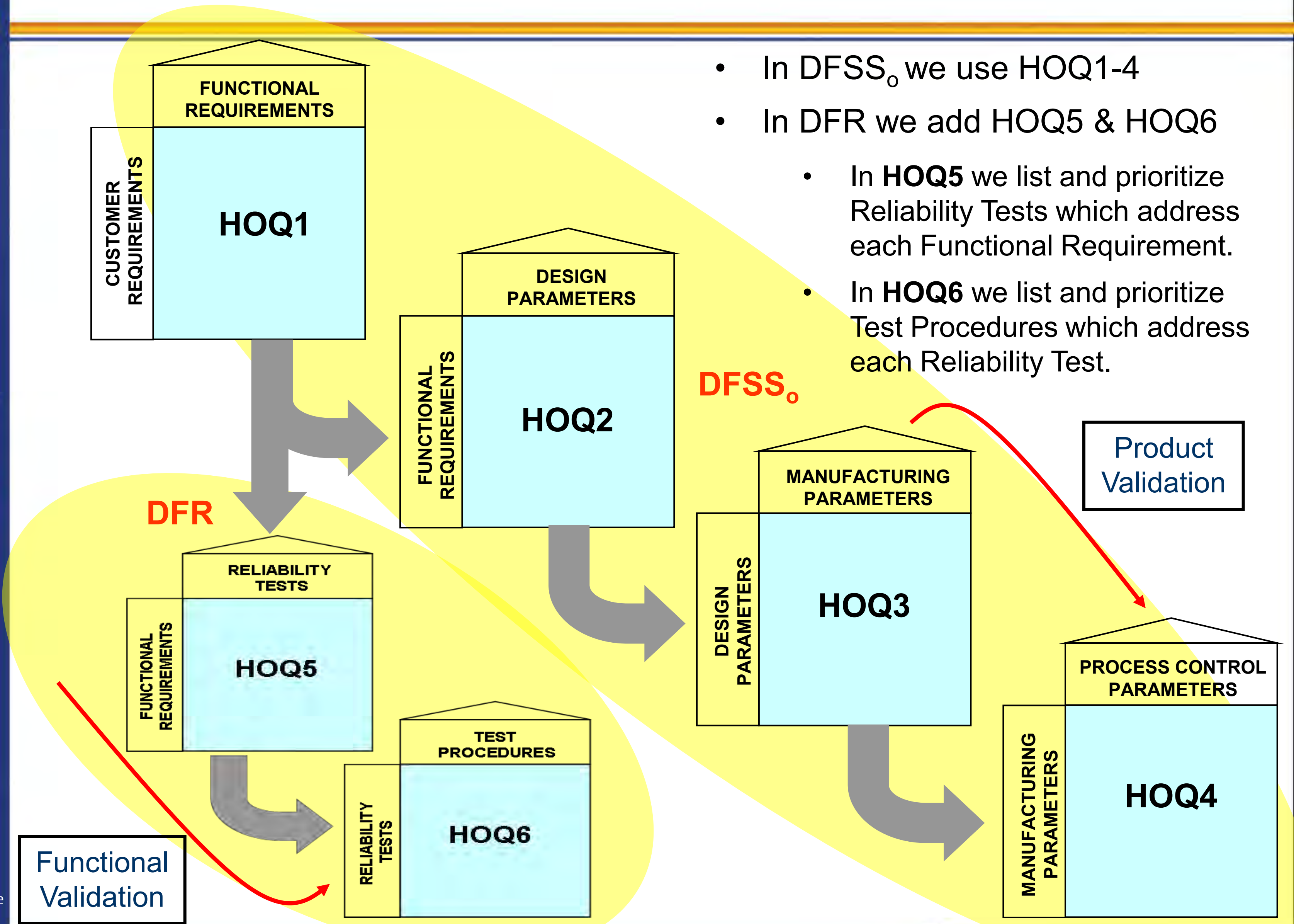
The Original DFSS (Design for Six Sigma)



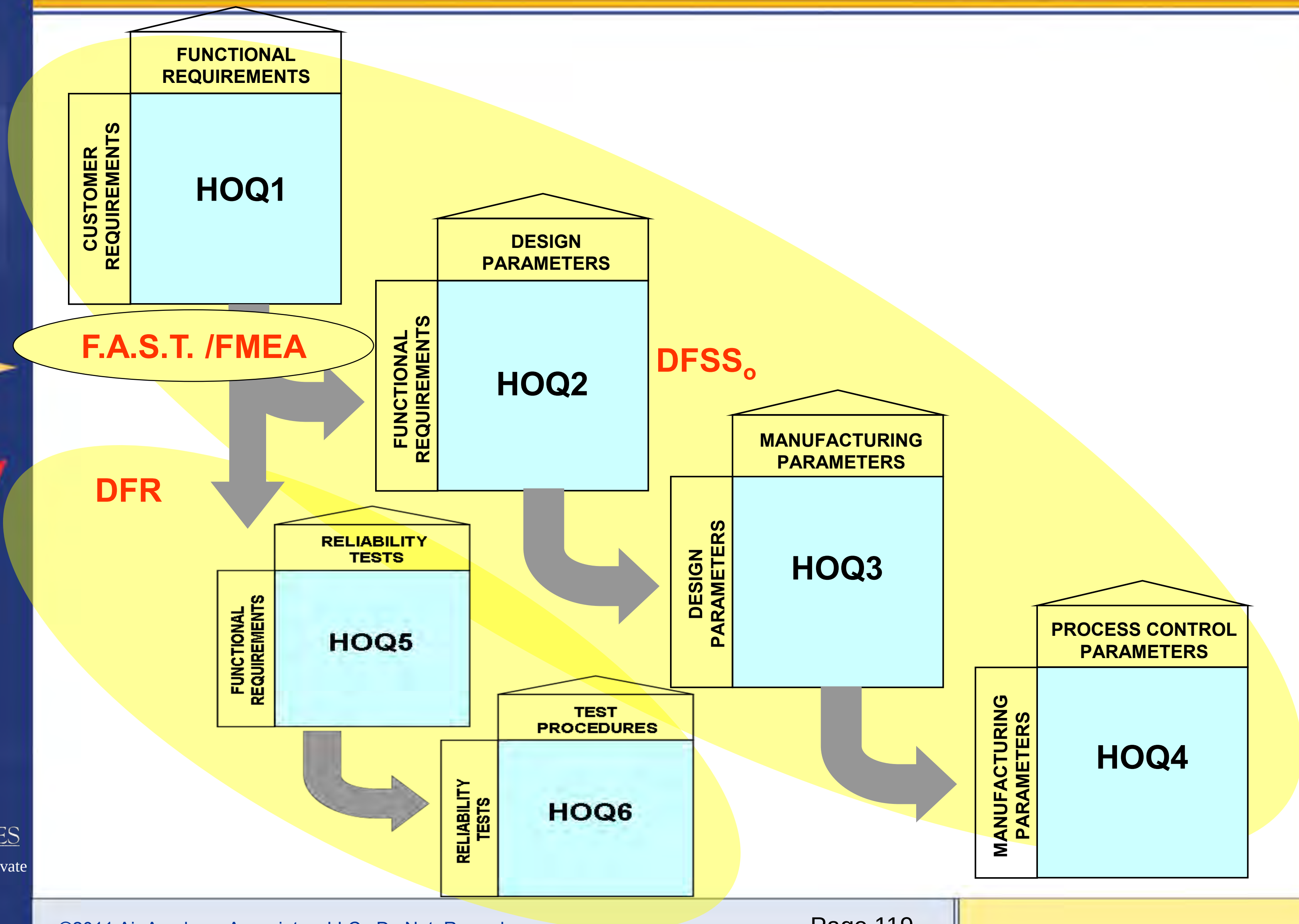
Design for Successful Systems ($DFSS_o$+DFR)

- In $DFSS_o$ we use HOQ1-4
- In DFR we add HOQ5 & HOQ6
  - In **HOQ5** we list and prioritize Reliability Tests which address each Functional Requirement.
  - In **HOQ6** we list and prioritize Test Procedures which address each Reliability Test.



Evolution of Design for Successful Systems

(DFSS$_o$ + DFR + FAST/FMEA)



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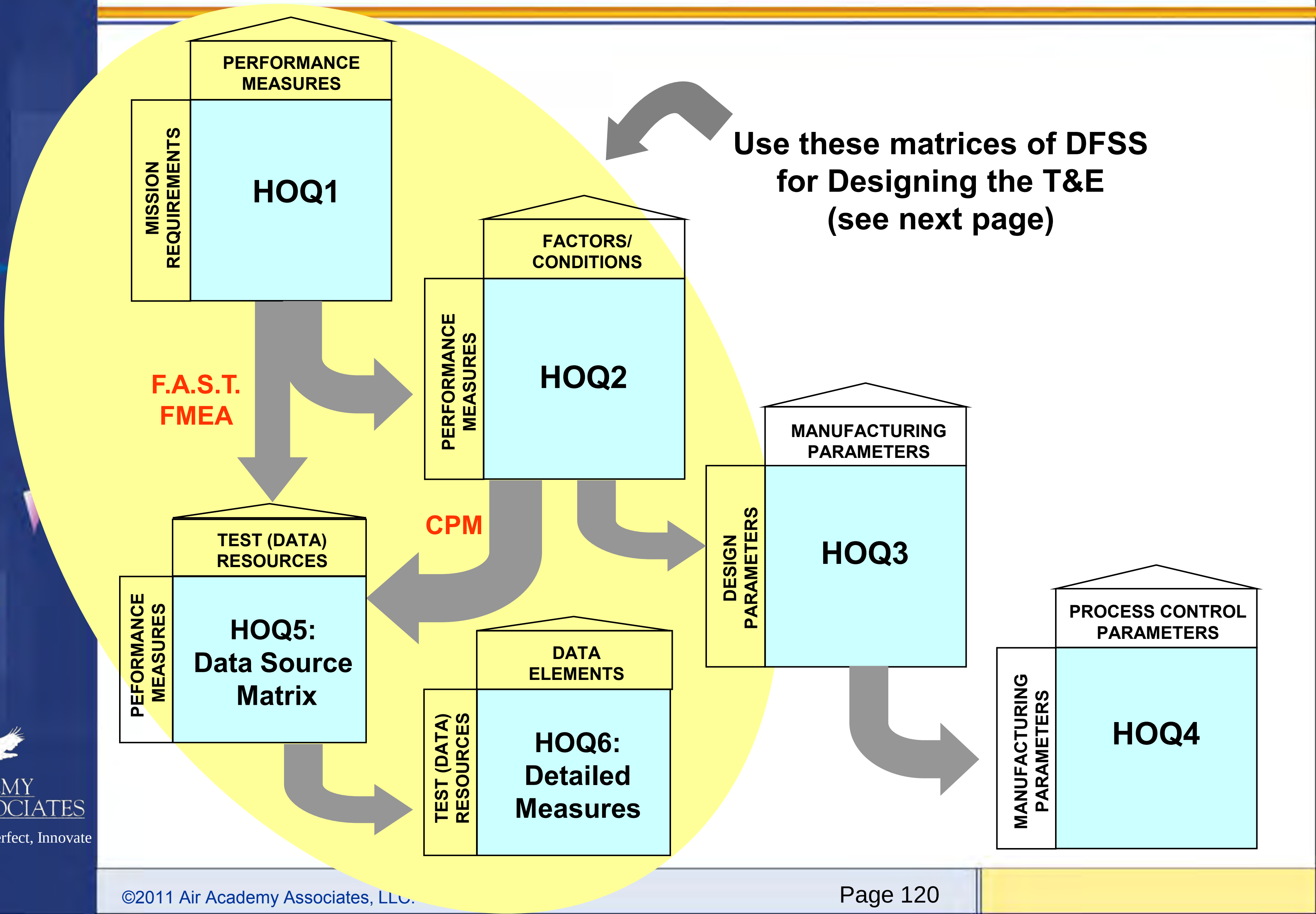
MBT&E with Design for Successful Systems



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Steps for Designing the Test and Evalution*

Tools and Methods from DFSS that can help accomplish these steps are in parentheses:

- **Develop the measures of effectiveness from the task capabilities and the measures of performance from the system attributes. (HOQ 1)**
- **Determine the operational factors and conditions. (HOQ 2)**
- **Develop linkages between measures and COIs. (CPM)**
- **Complete linkages from measure-to-system-to-task. (CPM)**
- **Assign one or more data sources to each evaluation measure. (HOQ 5)**
- **Determine the operational conditions that can or cannot be addressed by the identified data sources. (HOQ 2, CPM, and HOQ 5)**
- **Develop detailed measure design. (HOQ 6)**
- **Develop design of experiments. (HOQ 2, CPM, HOQ 5, HOQ 6)**

*** These steps are taken from Chris Wilcox's MBT&E Tutorial (page 25) at NDIA T&E 2010.**

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DFSS Success Stories

Partial Listing of Who Has Used Our DFSS Process and Tools

- Xerox
- Gates Rubber Company
- Hyundai
- Timken
- GE Medical Systems
- Medtronic
- St. Jude Medical
- Sony
- John Deere
- Delphi
- Sensis
- Nokia
- Bose Corporation
- PerkinElmer
- Samsung
- ATMI
- Pollak Industries
- Sandia National Laboratory
- Abbott Laboratory Diagnostics
- GlaxoSmithKline
- General Dynamics Land Systems

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GEMS LightSpeed™ CT Scanner

GE's First DFSS System ('98): Full Use of Six Sigma/DFSS Tools

- Key customer CTQs identified
  - Image quality
  - Speed
  - Software reliability
  - Patient comfort
- Disciplined systems approach: 90 system CTQs
- 33 Six Sigma (DMAIC) or DFSS projects/studies
- Scorecard-driven
- Part CTQs verified before systems integration

Leading-Edge Technology

- World's first 16-row CT detector
- Multi-slice data acquisition
- 64-bit RISC computer architecture
- Long-life Performix™ tube

Results

Better image quality
- Earlier, more reliable diagnoses
- New applications; vascular imaging, pulmonary embolism, multi-phase liver studies,…

- Much faster scanning:
  - Head: from 1 min to 19 sec (9 million/yr)
  - Chest/abdomen: from 3 min to 17 sec (4 million/yr)
- Clinical productivity up 50%
- 10x improvement in software reliability
- Patient comfort improved – shorter exam time
- Development time shortened by 2 years
- High market share; significant margin increase

"Biggest breakthrough in CT in a decade," Gary Glazer, Stanford

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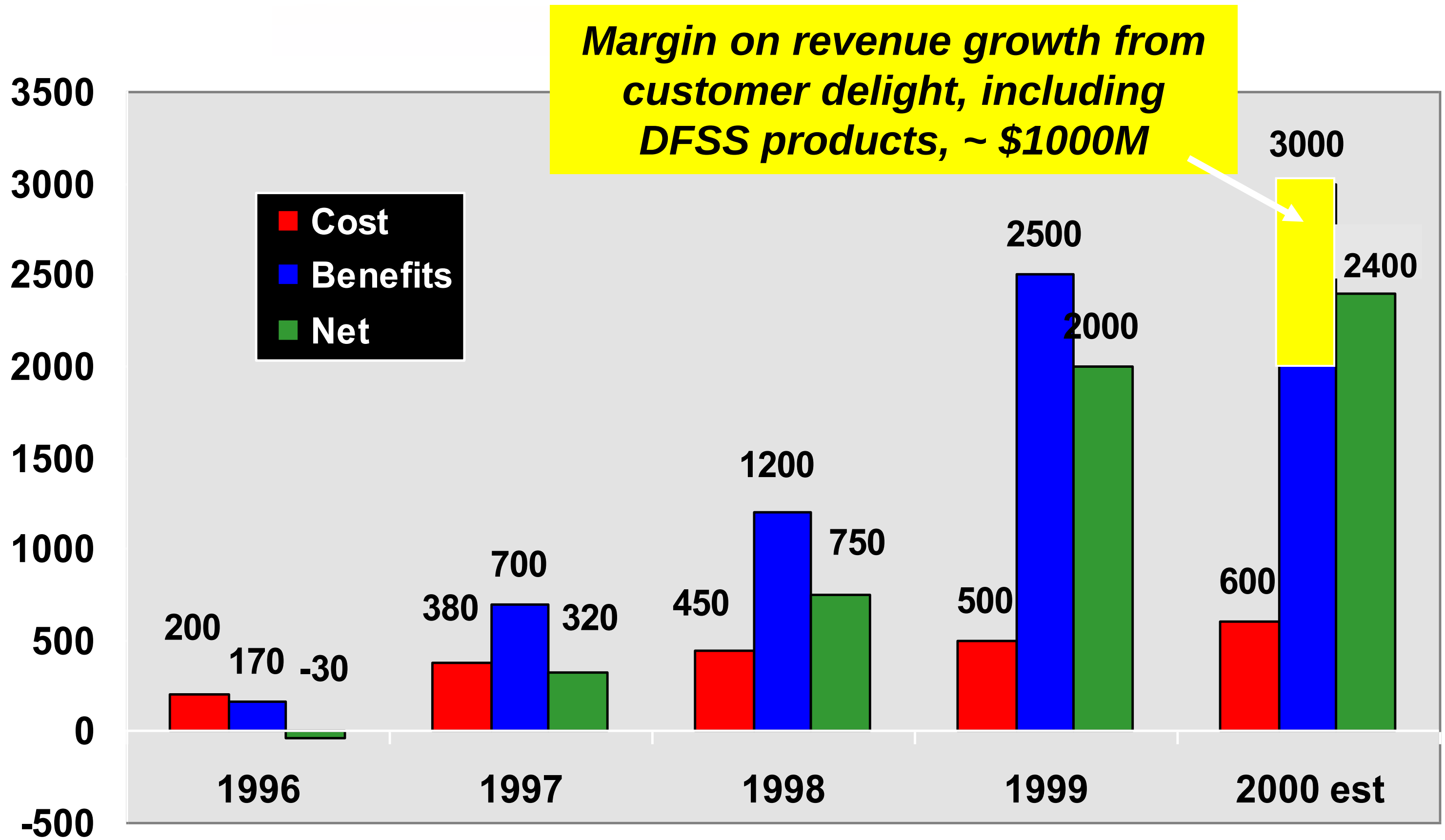
GE‘s Six Sigma/DFSS Financial Benefits: ‗96- ‗00



- Major impact on the bottom line
- Significant benefits from customer delight, including DFSS

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Xerox Develops New Paper

Wall Street Journal:
Xerox Develops a „Green" Paper, But Will Firms Add it to Fold?
By William M. Bulkeley
July 30, 2007; Page B3

Xerox has invented an environmentally friendly copy paper that costs less. The new cut-sheet "High-Yield Business Paper" requires half as many trees, fewer chemicals and less energy to manufacture and it weights less, reducing postage and trucking costs. Merilyn Dunn of InofTrends suggests the paper will be used for transactions such as invoices and phone bills where people don"t care about long-term archiving of documents. Xerox and others have tried to use cheap newsprint in copiers and laser printers in the past, but "you always had catastrophically bad results related to the curl in a digital printer," said Steve Simpson, Xerox"s vice president in charge of paper and supplies. Bruce Katz, a paper technologist in Xerox"s research facility in Webster, said he was able to overcome the curling problem by figuring out how to make cellulose fibers in the paper line up evenly, so they would shrink at the same rate when the toner fusing process took place.

Note: Bruce Katz, a Xerox DFLSS GB, used the DesIgNNOVATION™ methods to accomplish this.

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Photoreceptor Belt Tensioning System

iSixSigma Magazine
July/August 2007, pp 47-55
By Bob Hildebrand, Xerox DFLSS Black Belt

The Xerox Corp. designs, manufactures and markets iGen3, a color printer that can produce photo-quality prints at 110 pages per minute. When the current iGen3 was to be modified, the engineering team was tasked with redesigning the belt tensioning mechanism on the photoreceptor into a smaller package without adjusting the length of the belt. The redesign had to take several noise factors into account. The outcome of the project was a design that met the constraints placed on it by the system. This IDOV project is a practical example of how Design for Lean Six Sigma (DFLSS) can bring about the best option available in a constrained design.

Please see the referenced article for a detailed presentation of this case study.

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Some Results From Other DFSS Studies

Accelerated Testing of a Proprietary Product

- Time to qualify process changes reduced from a year to 5 weeks – 860% test cost reduction
- 5 years benefit of $48.5M based on accelerated placement of lower cost units

Regression Analysis to Predict Life of a Proprietary Product

- $2M ∆NPV Improvement
- 24 hours to develop right material
- Overall length of project: 3 months (vs. 2 years using traditional approach)
- Life expectancy improvement: over 4x!

Modeling to Reduce Development Costs and Improve TTM

- Matured the new design to last for >5 Million cycles in 6 months
- Demonstrated that following DFSS can accelerate Time to Market
- Established the importance that all QMS parts go through the DFSS process

Identifying Critical Parameters

- 25% cost reduction of part: $3M savings
- Leveraged the new accurate measuring process across product lines
- Short term solution in two months, long term took a year

Supply Problem Resolution Using Simple Hypothesis Testing

- $2M immediate savings and saved the product from being withdrawn from field
- Took just four months to resolve a problem that had lingered for 10 years
- Gained control of infant mortality (i.e., failures within first 6 months)

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Using DFSS to Improve Reliability Growth

FEF = Fix Effectiveness Factor

Historical data from reliability growth models indicates an overall average of .7
(Source: Larry Crow's RAMS 2011 presentation, page 68)

Using a DFSS FEF of at least .9, we can see that the number of iterations can be reduced substantially to achieve the same goal.

	FEF = .7	**FEF = .9**
Start	1,000,000	1,000,000
After 1st Iter.	300,000	100,000
After 2nd Iter.	90,000	10,000
After 3rd Iter.	27,000	1,000
After 4th Iter.	8,100	100
After 5th Iter.	2,430	10
After 6th Iter.	729	1
After 7th Iter.	218	.1
After 8th Iter.	65	.01
After 9th Iter.	20	.001

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Advanced Range Data System (ARDS) Service Life Extension Program (SLEP)

"Ensuring GPS Based TSPI Remains a Viable T&E Range Instrumentation Asset"

By

Mr. Dick Dickson

Tri-Service GPS Sustainment Management Office IPT Lead

TYBRIN Corporation

Presented at
NDIA
27TH ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

March 2011
Tampa, FL

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ARDS SLEP Background

- **The Advanced Range Data System (ARDS) is a GPS based TSPI instrumentation suite originally fielded in the early 1990's.**
  - Full Scale Engineering Development (FSED) and Low Rate Initial Production (LRIP).
- **Full Rate Production (FRP) hardware was fielded in 1997-1998.**
  - Total investment including all CTEIP and I&M funding from conception to FRP hardware was just over $500M.
- **The expected life span was 8-10 years.**
  - Production hardware was delivered with numerous components already deemed obsolete requiring immediate obsolete component replacement programs.
- **The initial effort to retrofit and upgrade the system in 1998-1999 alleviated the obsolete component issues present when the FRP hardware was delivered.**

ARDS SLEP Background

- **Preparations for a new follow on CTEIP program called the Enhanced Range Applications Program (EnRAP) began in 2001.**
- **This program was targeted at providing significant enhancements and improvements to the existing ARDS hardware suite**
  - Improved performance and TSPI solution accuracy.
  - Significant component miniaturization.
  - More efficient data link system.
- **EnRAP hardware was supposed to be the next generation GPS TSPI hardware suite that would replace ARDS starting in 2007.**
  - Timed to be fielded at the end of the original 10 year expected service life of the ARDS full rate production hardware suite.
  - The contract was awarded in 2005.

ARDS SLEP Background

- **The EnRAP program started experiencing problems shortly after it began and was canceled in March 2006.**
- **The T&E ranges involved in the EnRAP program immediately initiated a Service Life Extension Program (SLEP) on the ARDS hardware suite.**
- **T&E ranges involved in the ARDS SLEP established the following objectives and goals.**
  - Replace the obsolete and soon to be obsolete components identified in the most cost efficient manner possible.
  - Develop form-fit-function replacements where possible.
  - If not form-fit-function, develop replacements that required the least amount of changes to the system overall (wiring harnesses, mounting rail, software mods, etc.).
  - Procure life time supply of parts identified as soon to be obsolete.

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ARDS SLEP GOALS

- **Focus on replacing obsolete hardware with equivalent capabilities.**
  - Enhancements and improvement in performance not the primary goal.
  - Maintain current performance capabilities as a minimum.
  - Driven by what the available funding was allowed to be spent on.
- **Eliminate proprietary hardware and software wherever possible.**
- **Develop multiple sources of procurement for key components.**

ARDS SLEP Background

- **The ARDS SLEP began officially in FY07.**
  - The majority of the SLEP efforts are being executed through the Tri-Service GPS Sustainment Management Office (GPS SMO) out of the Naval Air Warfare Center Weapons Division, China Lake.
  - There are two key in-house obsolete component replacement efforts being executed by the 46th TW at Eglin AFB.
    - **Replacement for the Advanced Digital Interface Unit (ADIU)**
    - **Replacement for the Intelligent Flash Solid Sate Recorder (IFSSR)**
  - Key T&E ranges involved are China Lake, Pax River, Eglin AFB, Edwards AFB, and White Sands Missile Range (WSMR).
  - Also involved are two German T&E ranges that have the same hardware fielded and operational.

ARDS SLEP Background

- **The ARDS SLEP is divided up into several areas.**
  – Development of new hardware to replace obsolete hardware where no current off-the-shelf solution exists.
  – Life time buy of hardware that will soon be obsolete.
- **Develop multiple sources of procurement for key components.**
  – DLT – Modem and Power Amplifier
  – ADIU
  – IFSSR
  – Power Supplies – Red and Black
  – ARDS Pod Cable Harnesses
  – GPS Receiver

ARDS SLEP
Components Involved

- **ARDS components being addressed in the current SLEP.**
  - Data Link Transceiver (including the modem and power amplifier).
    - **Procure new backwards compatible modems from DRS Defense Solutions.**
    - **Procure new replacement DLT power amplifiers from DRS Defense Solutions (developed by Aethercomm to a DRS specification).**
    - **Develop and procure a replacement DLT power amplifier to the current government owned SCD from Nanowave Technologies (the original manufacturer).**
    - **Take the government owned Multi-Service Target Control System (MSTCS) DLT and migrate it to a fully ARDS compatible DLT (form-fit-function).**
    - **Develop a new ARDS compatible miniaturized DLT for use in onboard installations in the JSF, F-22, UAV applications, etc.**

ARDS SLEP
Components Involved

- **ARDS components being addressed in the current SLEP (Cont…).**
  - AC/DC Converter (DLT power supply).
    - **Procure more of the current power supplies from Technipower LLC (One of two original equipment manufactures).**
  - GPS receiver
    - **Procure the new form-fit-function replacement DRS Integrated GPS System (DIGS) receiver from DRS Defense Solutions to replace the obsolete Rockwell Collins GNP-10.**
    - **Develop two separate NovAtel commercial receiver solutions to replace the GNP-10.**
  - Advanced Digital Interface Unit (ADIU).
    - **Procure a new ADIU from DRS Defense Solutions.**
    - **Develop and manufacture a new government owned ADIU**

ARDS SLEP
Components Involved

- **ARDS components being addressed in the current SLEP (Cont…)**
  - Intelligent Flash Solid State Recorder (IFSSR)
    - **Procure a new IFSSR from DRS Defense Solutions.**
    - **Develop and manufacture a new government owned IFSSR.**
  - DC/DC Power Supply
    - **Develop a new DC/DC power supply.**
    - **Competed the development – awarded to Technipower (now Unipower) LLC.**
    - **Government developed a new updated equipment specification**
  - New Red, Black, and REM by-pass Cable Harnesses
    - **Develop a second source of procurement.**
  - ARDS Pod Tube Hangers – Forward, Center, and Aft

ARDS SLEP
Current Progress

- **Replacement DLT power amplifier manufactured by Nanowave.**
  - Nanowave was the original manufacture of the Full Rate Production ARDS DLT power amplifier.
  - German T&E ranges, via the Tri-Service GPS SMO and FMS cases, funded the development of a replacement DLT power amplifier built to the same SCD as the original DLT power amplifier.
- **The initial requirement was for the procurement of 52 new DLT power amplifiers.**
  - Additional orders were placed bringing the total ordered to 105.
  - All 105 power amplifiers have been delivered and accepted.
- **The DD Form 1494 frequency approval process has been completed.**

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ARDS SLEP
Current Progress

- **Replacement DLT power amplifier manufactured by Aethercomm and sold through DRS Defense Solutions.**
  - Developed by Aethercomm for DRS and designed to a new DRS proprietary specification.
  - The DD Form 1494 approval process has been completed.
- **Multi-Service Target Control System (MSTCS) DLT conversion effort.**
  - The MSTCS DLT was developed under a separate CTEIP program and was based on the ARDS DLT architecture.
  - The government owns the rights to the MSTCS DLT hardware and software design (modem and power amplifier)
  - Current ARDS SLEP activities include funding the conversion of the MSTCS DLT to operate as a fully compatible ARDS DLT.

ARDS SLEP
Current Progress

- **MSTCS DLT Conversion Effort (cont…)**
  - Conversion efforts include repackaging the converted MSTCS DLT into the ARDS form factor.
  - Delivery includes just the single modem CCA and a repackaged power amplifier.
  - Government engineers at the 46th TW at Eglin will perform the final assembly into ARDS modem and power amplifier housings – form factor.
  - Government is performing all the environmental stress screening, EMI/EMC, and shock/vibration testing in-house.

ARDS SLEP
Current Progress

- **Miniaturized ARDS DLT development effort.**
  - The T&E ranges developed a miniaturized ARDS compatible DLT capability to instrument smaller test platforms several years back.
  - The “ARDS Lite” package utilized COTS FreeWave radios that were coupled to a special data link relay (FMIU) in order to work in the ARDS network.
    - **Obsolescence issues were present with this system as well.**
    - **Allowed only 1/3 of the RF throughput of a true ARDS DLT.**
    - **Utilized a truncated or compressed ARDS message format.**
    - **Required a dynamic translation of ARDS messages into their ARDS "Lite" equivalents (and vice versa) in real time.**

ARDS SLEP
Current Progress

- **Miniaturized ARDS DLT development effort (Cont…).**
  - The current miniaturized ARDS DLT development effort took the existing ARDS "Lite" transceiver and replace it with a ARDS capable miniature DLT with most of the functionality of the current DLT
    - **Does not currently have a relay capability.**
    - **Utilizes F1 frequency only.**
    - **Encryption capability not currently present.**
  - The new miniaturized DLT development resulted in a small, low cost ARDS DLT.
    - **The baseline production hardware has been received and accepted by the government.**
    - **The DD Form 1494 frequency approval process is in work.**
  - Funded improvements to the baseline product include adding a link-less capability and a live monitor mode.

ARDS SLEP
Current Progress

- **AC/DC Power Supply.**
  - Technipower LLC, formerly Transchem, was one of two original manufactures of the 96150400 AC/DC power supply.
    - The second manufacture Keltec, no longer manufactures this power supply.
  - CM approved AC/DC power supply for ARDS.
  - Source Control Drawing in the ARDS documentation package.
  - Originally thought to be obsolete and out of production.
  - This power supply is still a standard production line for Technipower in accordance with the government owned SCD.
  - All power supplies ordered have been delivered and accepted.

ARDS SLEP
Current Progress

- **GPS Receiver Replacement.**
  - Current GNP-10 GPS receiver manufactured by Rockwell Collins is obsolete and can no longer be procured.
  - Failed GNP-10 units sent in for repair are starting to be returned "Beyond Economical Repair" (BER).
  - No drop in replacement available from Rockwell Collins without extensive NRE ($5-6M).
  - DRS Defense Solutions developed a GNP-10 replacement for use on the P-5 program.
    - DRS Integrated GPS System (DIGS).
    - NRE was covered 100% by other DRS programs and internal R&D funding.
  - The T&E ranges were able to procure this new "form-fit-function" replacement GPS receiver without any NRE expenses.

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ARDS SLEP
Current Progress

- **GPS Receiver Replacement (Cont…).**
  - TYBRIN initiated contract actions to procure DRS Defense Solutions new replacement DIGS GPS receiver.
    - Accuracy and performance problems were discovered during several rounds of low dynamic truck tests and flight tests conducted at Eglin.
    - Problems were also discovered during attempts to post process raw data from the DIGS.
  - DRS has made significant progress in resolving the problems identified.
  - Low dynamic flight testing on the redesigned DIGS receiver (new Kalman filter) has been completed.
  - High dynamic accuracy testing is tentatively scheduled for April 2011.

ARDS SLEP
Current Progress

- **GPS Receiver Replacement (Cont…).**
  - Navy integration of the Novatel Synchronous Position, Attitude and Navigation (SPAN) SE GPS/INS receiver.
    - Worked with NovAtel to develop and evaluate a new NovAtel commercial receiver GPS/INS (LN-200) instrumentation package to replace the current GNP-10/LN-200 instrumentation package.
    - Designed for use in the new F/A-18 internal mount configuration.
    - Not designed for use in the ARDS pod.
    - Objective – achieve the same performance and TSPI accuracy as the current GNP-10/LN-200 configuration.
    - The new GPS/INS system has been tested and evaluated in ground tests (van), low dynamic flight testing (Baron prop plane), and high dynamic flight testing on the F/A-18.
    - Successful flight testing and TSPI accuracy testing has been completed.
    - Development of production internal mount configurations is underway.

ARDS SLEP
Current Progress

- **GPS Receiver Replacement (Cont…).**
  - Air Force (Eglin) 46th TW Development and Integration of the Eglin NovAtel SPAN GPS Receiver (ENGR).
    - Worked with NovAtel to develop and evaluate a new Kinematic Carrier Phase capable NovAtel SPAN commercial GPS receiver coupled with the LN-200 Inertial Measurement Unit (IMU) instrumentation package to replace the current GNP-10/LN-200 TSPI instrumentation package.
    - Repackaged into a GNP-10 form factor - ARDS Pod configuration.
    - Objective – achieve the same Method I performance and TSPI accuracy as the current GNP-10/LN-200 configuration.
    - Outputs both GNP-10 format messages and NovAtel messages via USB or Ethernet – NovAtel messages used for the post processing.
    - Primary difference between the GNP-10 and ENGR is that the ENGR will accomplish Differential GPS (DGPS) via WASS corrections versus the RAJPO DGPS format.
    - Dynamic flight testing comparing the ENGR performance against the GNP-10 and other TSPI sources is underway now.

ARDS SLEP
Current Progress

- **ADIU and IFSSR development efforts.**
  - Two development efforts are underway for a replacement ADIU and IFSSR.
  - The 46th TW at Eglin AFB is developing a replacement ADIU and IFSSR in-house.
    - All hardware and software design will be owned by the government.
  - A major T&E range customer procured a follow-on DRS developed replacement for the ADIU and IFSSR as well.
    - Schedule requirements dictated that the replacements would be needed before the in-house government effort at Eglin would be completed.
    - Hardware and software for the DRS development will be proprietary to DRS.
    - All hardware ordered has been delivered.

ARDS SLEP
Current Progress

- **ADIU and IFSSR development efforts (Cont…).**
  - The current ARDS hardware configuration utilizes a R^3 interface between the ADIU and DLT.
  - A new Synchronous Data Link Control (SDLC) interface has been developed to resolve problems with utilizing the Range Encryption Module (REM).
  - The new DRS developed ADIU will only work in the SDLC mode and is not backwards compatible with the R^3 interface.
    - The Navy does not currently plan to transition to the SDLC configuration.
  - The Eglin in-house developed ADIU (referred to as the EDIU) is backward compatible with the R^3 interface and will also work with the new SDLC interface.
    - The Air Force and Army have hard requirements to use the REM and are migrating to the SDLC configuration as a result.

ARDS SLEP
Current Progress

- **ADIU and IFSSR development efforts (Cont…).**
  - The new DRS IFSSR requires a new end cap be incorporated in the pod rail as well as installing a new battery holder in front of the DLT.
  - The Eglin in-house developed IFSSR (referred to as the EFSSR) is a form-fit-function drop in replacement and does not require the new end cap or the relocation of the batter holder.
  - The new Eglin EDIU and EFSSR hardware and software development is complete.
    - Qualification testing has been completed including environmental stress screening, vibration and shock, and EMI/EMC.
    - Certified Manufacturing has been placed on contract to build up 100 production units for both the EDIU and EFSSR.
    - Production deliveries are underway.

ARDS SLEP
Current Progress

- **Replacement DC/DC power supply.**
  - No form-fit-function drop in replacement was currently available.
  - A new DC/DC power supply equipment specification was created based on previous SCD's.
  - A limited open competition was conducted between previous power supply providers.
  - TYBRIN awarded a contract to Technipower LLC on 1 December 2008.
  - The government owns the full re-procurement data rights to the new design.
  - Delivery of 91 production power supplies is underway and will be completed by April 2011.

ARDS SLEP
Current Progress

- **ARDS Pod Cable Harnesses.**
  - The government qualified a new cable harness supplier to manufacture the current ARDS cable harness set.
  - The government now has two qualified sources to procure the ARDS Red, Black, and REM By-pass cable harnesses from.
  - The new cable harness supplier provides a significant cost savings while maintaining superior quality workmanship.
  - Modifications have been incorporated into the REM By-pass cable harness to allow it to be interchangeable with the R^3 configuration and the SDLC configuration.
    - Previously, the REM-By-pass cable had to be modified to work in the SDLC configuration and once modified, could no longer be used in the R^3 configuration.

ARDS SLEP
Current Progress

- **New ARDS Pod Tube Hanger Configurations.**
  - The ARDS pod tubes currently have the 1,500 hour AIM-9 forward, center and aft hangers installed.
    - Poses significant problems when flown on the F/A-18.
    - Limited number of flight hours before they have to be inspected for stress and cracks.
    - Downtime for inspection is lengthy.
  - The Navy has decided to move to the new DRS proprietary P-5 TCTS forward hanger and government owned P4RC center and aft hanger configuration.
    - Allows significantly longer flight hours before inspections are required.
    - Allows replacement of the hanger shoe on the forward hanger without replacing the entire hanger band assembly

ARDS SLEP
Current Progress

- **New ARDS Pod Tube Hanger Configurations (Cont…).**
  - The ARDS flight clearance for the new Navy hanger configuration has been approved, and all hanger retrofits have been completed.
  - The Army also incorporate the Navy hanger configuration since they have to support test operations with the F/A-18 as well as the F-15, F-16, and A-10.
    - Migrated to the hanger configuration that will support the most stringent requirements they have to meet – F/A-18 E/F wingtip.
  - The 46th TW is migrating to the P4RC forward, center, and aft hanger configuration.

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ARDS SLEP
Current Progress

- **New ARDS Pod Tube Hanger Configurations (Cont…).**
  - Edwards AFB (AFFTC) will stay with the 1500 hour configuration.
  - New Nomenclatures were established for the hanger configurations.
    - AN/ARQ-52B (V)17 Modified (AFFTC and UTTR configuration)
    - AN/ARQ-52C (V)17 New Navy and WSMR Configuration
    - AN/ARQ-52D (V)17 New Eglin Configuration
  - SEEK EAGLE fleet wide flight clearance approval in process for all three configurations for Air Force F-15, F-16, and A-10 aircraft.

ARDS SLEP
Issues

- **The major issue in the ARDS SLEP has been documentation, documentation, documentation!**
  - Incomplete documentation.
  - Missing documentation.
  - Documentation not procured.
    - Too many proprietary parts.
  - Undocumented hardware and software changes to the system.
  - Documentation not properly validated and verified.
  - Configuration Management and the documentation package was the responsibility of the SPO at Eglin that procured the ARDS hardware up until late 2002.
  - Responsibility for CM and all the documentation was transferred to the Tri-Service SMO in a formal transfer agreement.

ARDS SLEP
Issues

- **In preparation for the ARDS SLEP, the T&E ranges realized how poor the documentation package transferred from the acquisition SPO was.**
- **System performance specifications in general and descriptions of how the DLT (network interfaces) and ADIU operated and interfaced were virtually non-existent (two key components of the ARDS hardware suite).**
  - No documentation had been procured in many cases.
  - Documentation procured had been lost and was no longer available.
  - Many undocumented changes (from an ECP standpoint) had been made to the DLT and ADIU software.
    - **These components became proprietary to the OEM.**
  - Source Control Drawings for proprietary components had not been procured in in an effort to cut costs in the original acquisition.
  - Existing SCD's used in the SLEP were found to have glaring errors that should have been discovered in the initial validation/verification process.

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ARDS SLEP Lessons Learned

- **The original FSED & LRIP ARDS development produced a complete build to print Level III drawing package.**
  - All software source code was available.
  - All hardware drawings were available.
  - All system specifications were current and accurate.
  - Allowed for open competition for the full rate production hardware.
- **By the time Full Rate Production was completed, approximately 50% of the documentation package was no longer valid.**
  - Obsolete components encountered during production were engineered around without proper documentation.
  - Enhancements added toward the end of the production cycle (Option II on the contract) were incorporated with no documentation procured.
  - What started as a 100% government owned hardware and software system became a system where all the key components were proprietary.

ARDS SLEP
Lessons Learned

- **When originally procured and fielded, no thought was given to having to potentially sustain the system beyond its projected life expectancy.**
- **Emphasis was on buying more hardware and less documentation.**
- **Maintaining and properly archiving documentation from the initial development (FSED & LRIP) was not accomplished.**
  - Not available for ARDS SLEP use.
- **Proper validation/verification was not completed on the documentation package that was maintained.**
- **The lack of proper documentation has resulted in a tremendous amount of additional cost and time to develop suitable replacements for key subsystems during the ARDS SLEP.**

ARDS SLEP Conclusions

- **Failure of the EnRAP program resulted in having to keep the ARDS hardware suite operational long past its projected life expectancy.**
  - Planned operation after the SLEP is through 2017.
- **The ARDS hardware had a significant number of obsolete components.**
- **A large effort has been made to develop multiple sources of procurement for many key ARDS components.**
- **The government is working hard to reduce or eliminate proprietary components.**
  - Regain control and ownership of the hardware and software.
  - Allow for lower cost and quicker turnaround in future enhancements and obsolete component replacement efforts.
- **The ARDS documentation package was very incomplete complicating the ARDS SLEP greatly.**
- **Future CTEIP programs should focus more on ensuring the proper documentation is procured and reduce the amount of proprietary components.**

Developmental Test & Evaluation

Ms. Darlene Mosser-Kerner
Deputy Director, Space Systems
Developmental Test & Evaluation

March 2011

www.acq.osd.mil/dte/

Agenda

- **New DT&E organization- who, what, where**
- **T&E Megatrends**
  - WSARA and Title 10
  - SecDef Efficiencies
  - Initiatives
- **Implications for the Community**

Test and Evaluation in OSD

Secretary of Defense
The Honorable Robert M. Gates

Under Secretary of Defense
AT&L
Hon Ashton B. Carter

Director, Operational
Test and Evaluation
Hon Dr. Michael Gilmore

Assistant Secretary of
Defense, Research
and Engineering
Hon Zachary J. Lemnios

Director,
Test Resource
Management Center (TRMC)
Mr. Edward Greer

Deputy Assistant
Secretary of Defense,
DT&E
Mr. Edward Greer

Megatrends/Imperatives

- **Better Acq: WSARA and the new DT&E Office**
  - Acquisition Reform is still front burner issue
  - Usual suspects
- **Budget Reality: SecDef Efficiency Initiatives**
  - Overview
  - Implications for T&E
    - DOE, Reliability, M&S, IT…..
- **Imperatives**
  - Current
  - Future
    - Cyber

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What's Wrong with Acquisition?

THE USUAL (?) SUSPECTS

Cost

Over Budget

– GAO: 96 MDAPs, $300B over initial estimates

Schedule

Late to Need

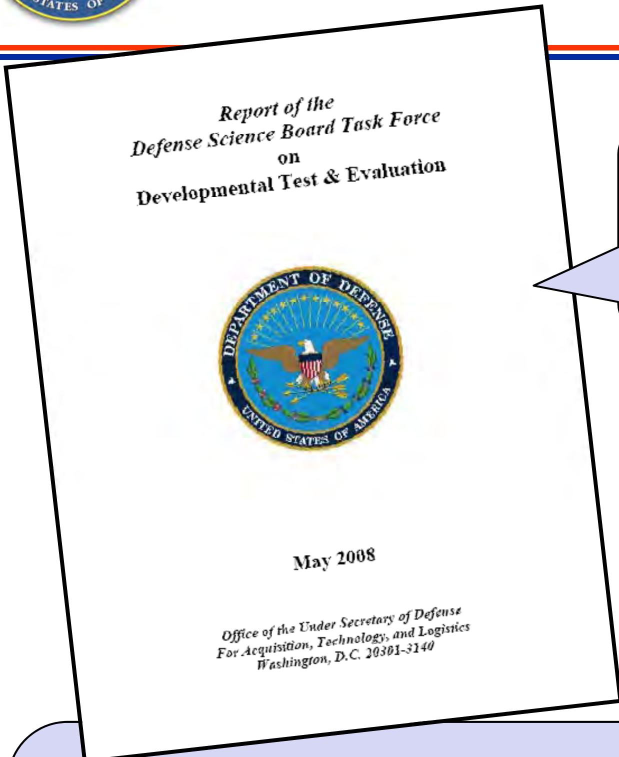
– Getting capability to the user to meet urgent needs

Performance

Programs failing Operational Test

– Suitability issues
– Late discovery of failure modes
– Performance shortfalls
– Interoperability

Sez Who?


Report of the
Defense Science Board Task Force
on
Developmental Test & Evaluation

May 2008

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

"*Approximately 50% of programs completing IOT&E since 2000 have been assessed as not operationally effective and/or suitable.*"

2008 DSB Report


GAO

United States Government Accountability Office
Report to Congressional Committees

March 2008

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

GAO-08-467SP

"*. . .beginning production before successfully demonstrating that the weapon system will work as intended increases the potential for discovering costly design changes…and usually requires substantial modification costs at a later time.*"

2008 GAO Assessments of Selected Weapon Programs

Bottom Line

DoD Systems take too long to field, cost too much and don't perform as required

……. enter the Weapons System Acquisition Reform Act

Purpose - Eliminate waste and inefficiency in defense projects

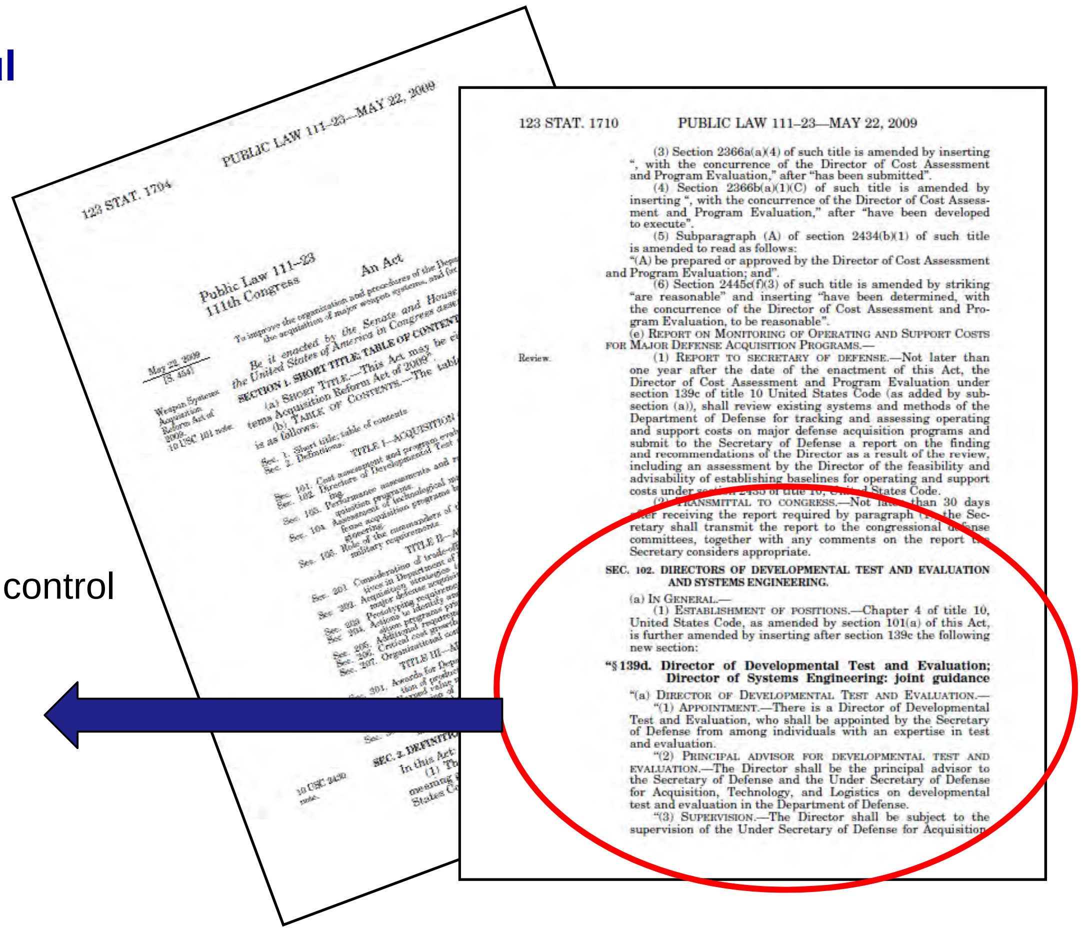
Why - President noted that the wasteful spending stems from:

- Out of the ordinary requirements
- No-bid contracts
- Lack of oversight

Concern - Schedule delays and cost overruns

How - Strengthen oversight and accountability

- Appoint officials to closely monitor and control costs
- New offices of SE and **DT&E**
  - Greater focus on testing new weapons
  - Ensure technologies are mature
  - Ensure programs are started right
- Improve competition
- End conflicts of interest


123 STAT. 1710 PUBLIC LAW 111–23—MAY 22, 2009

(3) Section 2366a(a)(4) of such title is amended by inserting ", with the concurrence of the Director of Cost Assessment and Program Evaluation," after "has been submitted".

(4) Section 2366b(a)(1)(C) of such title is amended by inserting ", with the concurrence of the Director of Cost Assessment and Program Evaluation," after "have been developed to execute".

(5) Subparagraph (A) of section 2434(b)(1) of such title is amended to read as follows:

"(A) be prepared or approved by the Director of Cost Assessment and Program Evaluation; and".

(6) Section 2445c(f)(3) of such title is amended by striking "are reasonable" and inserting "have been determined, with the concurrence of the Director of Cost Assessment and Program Evaluation, to be reasonable".

(e) REPORT ON MONITORING OF OPERATING AND SUPPORT COSTS FOR MAJOR DEFENSE ACQUISITION PROGRAMS.—

Review.

(1) REPORT TO SECRETARY OF DEFENSE.—Not later than one year after the date of the enactment of this Act, the Director of Cost Assessment and Program Evaluation under section 139c of title 10 United States Code (as added by subsection (a)), shall review existing systems and methods of the Department of Defense for tracking and assessing operating and support costs on major defense acquisition programs and submit to the Secretary of Defense a report on the finding and recommendations of the Director as a result of the review, including an assessment by the Director of the feasibility and advisability of establishing baselines for operating and support costs under section 2435 of title 10, United States Code.

(2) TRANSMITTAL TO CONGRESS.—Not later than 30 days after receiving the report required by paragraph (1), the Secretary shall transmit the report to the congressional defense committees, together with any comments on the report the Secretary considers appropriate.

SEC. 102. DIRECTORS OF DEVELOPMENTAL TEST AND EVALUATION AND SYSTEMS ENGINEERING.

(a) IN GENERAL.—

(1) ESTABLISHMENT OF POSITIONS.—Chapter 4 of title 10, United States Code, as amended by section 101(a) of this Act, is further amended by inserting after section 139c the following new section:

"§ 139d. Director of Developmental Test and Evaluation; Director of Systems Engineering: joint guidance

"(a) DIRECTOR OF DEVELOPMENTAL TEST AND EVALUATION.—

"(1) APPOINTMENT.—There is a Director of Developmental Test and Evaluation, who shall be appointed by the Secretary of Defense from among individuals with an expertise in test and evaluation.

"(2) PRINCIPAL ADVISOR FOR DEVELOPMENTAL TEST AND EVALUATION.—The Director shall be the principal advisor to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology, and Logistics on developmental test and evaluation in the Department of Defense.

"(3) SUPERVISION.—The Director shall be subject to the supervision of the Under Secretary of Defense for Acquisition

WSARA and DT&E

The DDT&E is the principal advisor to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology and Logistics on developmental test and evaluation in the DoD

Responsibilities:

- Program Oversight
- Policy and Guidance
- T&E Strategy (TES) / TEMP
- Acq DT&E workforce
- Component T&E Capability
- Annual Report to Congress

DT&E in Title 10, USC, Section 139d

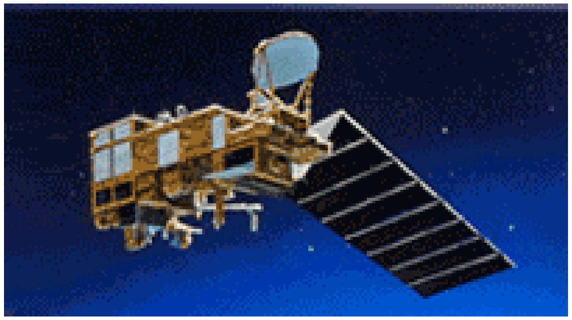
WSARA signed May 22, 2009

D,DT&E Mission

Improve acquisition outcomes by …….

Supporting:

- **Acquisition programs (planning, advocacy)**
- **DT&E workforce and community (advocacy)**
  - **Capability and competencies**
  - **Advancing "state-of-the-practice"**
  - **Policy development**
- **Decision Makers**
  - **Performance assessment**
- **Warfighters**



….. and minimize Discovery in IOT&E

Megatrends/Imperatives

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- **Budget Reality: SecDef Efficiency Initiatives**
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DoD Budget Realities

- Although the U.S. faces significant economic challenges and growing budget deficits, Defense base funding must have **real growth to sustain force structure** and needed modernization
  - Fighting Two Wars
  - Confronting ongoing terrorist threats around the globe
  - Facing major powers investing heavily in their military
- Sustaining current force structure and needed modernization requires 2-3% real growth
- The current and planned base defense budget has steady, but modest growth of 1% per year
- To make up the difference and **preclude reductions in needed military capability**, the difference of 1-2% a year will be made up elsewhere in DoD
- In May, SecDef began a hard, unsparing look at how DoD is staffed, organized, and operated

"…in May I called on the Pentagon to take a hard and unsparing look at how the department is staffed, organized and operated. I concluded that our headquarters and support bureaucracies, military and civilian alike, have swelled to cumbersome and top-heavy proportions, grown over-reliant on contractors and grown accustomed to operating with little consideration to cost." ….Secretary of Defense Robert M. Gates

….. enter the SecDef Plan for Efficiency

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

(L) Secretary of Defense Robert M. Gates
(R) USD AT&L Dr Ashton B. Carter

"Consumers are accustomed to getting more for their money – a more powerful computer, wider functionality in mobile phones – every year. When it comes to the defense sector, however, the taxpayers had to spend significantly more in order to get more. We need to reverse this trend." ….Secretary of Defense Robert M. Gates

Why Test?

- Iterate/Mature the Design
- Failure Mode Discovery

Material Developer

- Inform Acquisition Decisions

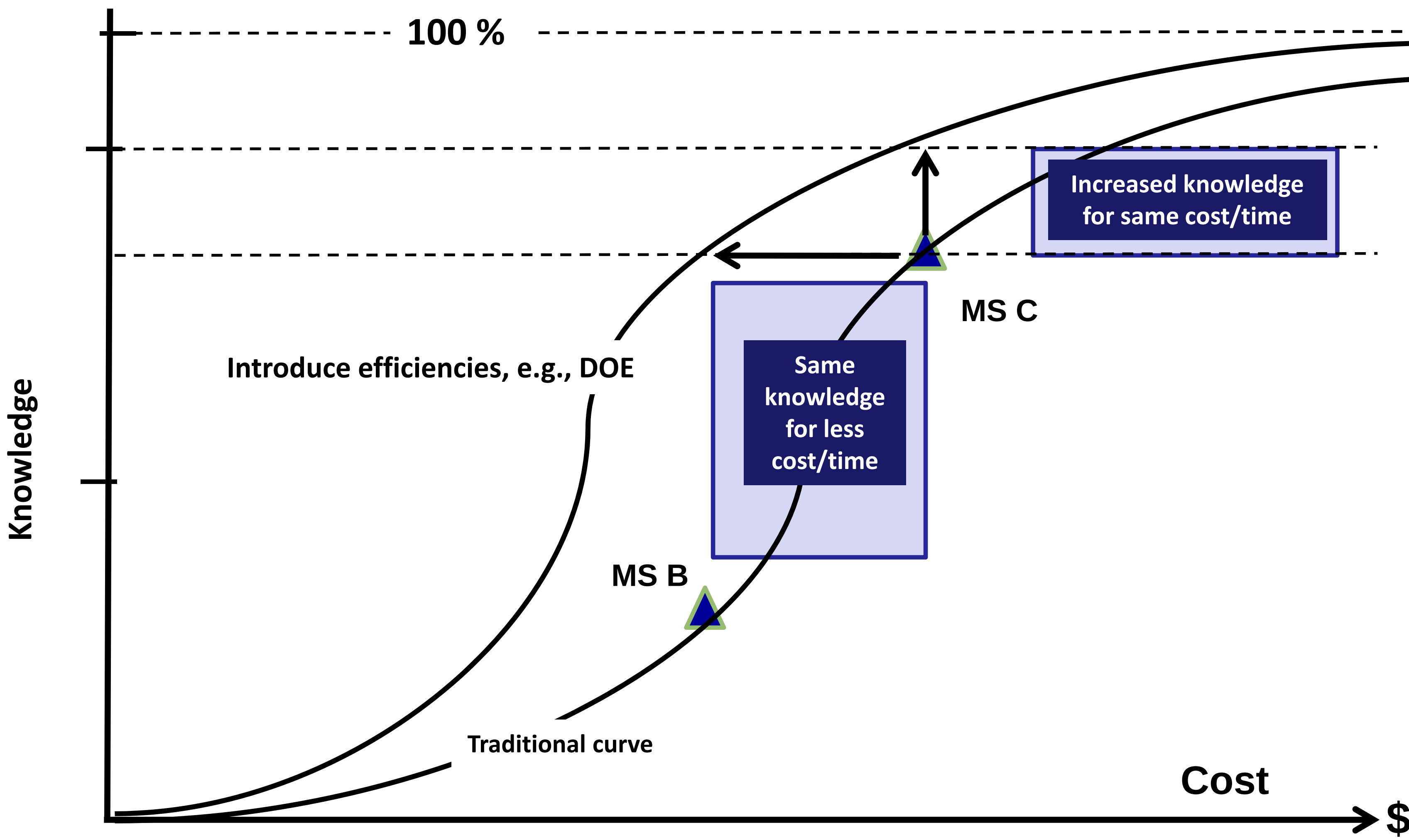
Decision Authority

- Confirm Performance
- Safety
- Capabilities and Limitations

Warfighter

"Testing is the Conscience of Acquisition"
William J. Perry - former SecDef

Knowledge vs Cost



T&E Challenge: most knowledge for the least resources.

Challenges to doing good?

1. **"Testers like to test"**
   – Who requires, who pays?

2. **"A dollar spent on test is a dollar spent on bad news"**
   – Incentives matter

3. **"Testing is driving up our costs"**
   – Now vs. later?

4. **"We can't afford it "**
   – See #3

….. and how can T&E help?

- **Enterprise Perspective**
  - Acquisition Savings
    - Mature Systems
    - Reliability
    - Early discovery
  - Adequate testing (early)

- **T&E Cost**
  - Too much
  - Bad news
  - Late T&E Requirements

- **Test Community Perspective**
  - Recognize our role
  - Manage our appetite
  - Support the risk-based level of information needed
  - Do our job more efficiently

- **T&E Savings**
  - STED (e.g., DOE)
  - Distributed
  - CRIS
  - Capital Utilization
  - Integrated Test

Megatrends/Imperatives

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DT&E Challenges/Imperatives

- **Support Acquisition (WSARA)**
  - Robust, efficient, risk-based T&E
  - Early engagement (Rqmts, AoA, RFP, SS….)
  - Performance Assessment (inform the decision makers)
- **Support SecDef Initiatives (Efficient T&E (doing more with less)**
  - Integrated Test
  - DOE
  - Capital Utilization
  - M&S, ground testing
  - Distributed testing
- **Reliability**
- **IA and IO**
- **Cyber**
- **Rapid Fielding**
- **Workforce skill mix**

Cyber Warfare

Computer Network Operations

– Months, days, hours…uSecs
– Attribution
– Role?   DoD, Federal, Civil

Attack (CNA)

– Precision strike
– Kinetic effects

Defense (CND)

– Cyber missiles
– Mission critical tasks, functions

Exploitation (CNE)

– Intelligence

"The best-laid defenses on military networks will matter little unless our civilian critical infrastructure is also able to withstand attacks." …..Deputy Secretary Bill Lynn

Cyber Warfare

What's the role for T&E?

Scope: Focus on CND and MDAPs?

– Define cyber defense issues in network environments
– What systems are most vulnerable?
  – Weapon systems?
  – IT systems?
– Rigorous cyber defense testing
– Develop a cyber defense T&E framework
– Institutionalize cyber defense IT

With hundreds of legacy and new programs in development each entering our networks, we cannot afford the chaos of each one individually planning or just not testing for cyber defense.

OD,DT&E How-Goz-It?

- **Establish ODDT&E/DDR&E**
- **Organizational Relationships**
- **Staffing**
- **Director**
- **POM 11**
- **1st Annual Report**

Implications for the Test and Acquisition Communities

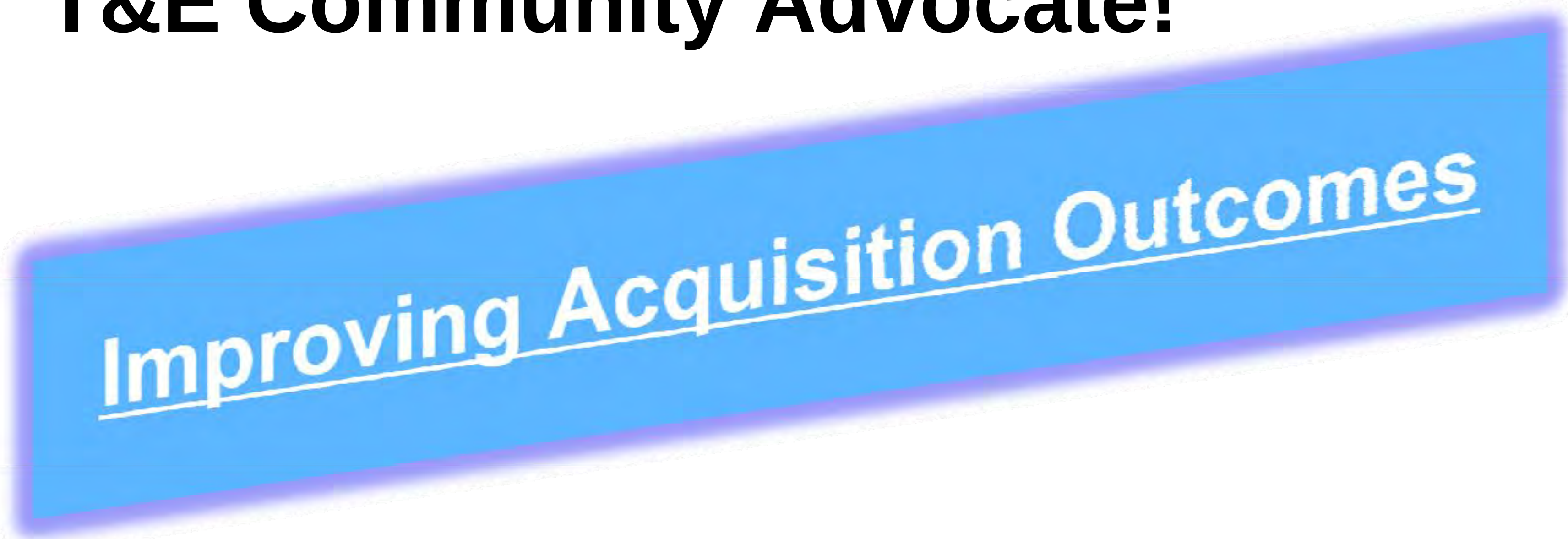
- **Enterprise will manage risk**
  - Oversight and Accountability
  - Rapid vs. Deliberate Acquisition
- **Visibility**
  - More emphasis on DT
  - DT&E voice at DAB
  - Increased planning rigor/fidelity
    - D,DT&E TEMP approval
  - Efficiencies: DOE, IT, M&S……..
- **Acquisition**
  - Accept less risk at MS decisions
  - More DT less OT?
    - Confirmation vs Discovery
  - More informed decisions

DDT&E is . . . .

✓ **Back!**

✓ **T&E Community Advocate!**

✓



Questions?

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS

Developmental Test & Evaluation

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Room 3B941
Washington, DC 20301-3090

Email: ddre-dte@osd.mil

www.acq.osd.mil/dte

The right information, to the right decision maker, at the right time, for *better* decisions

Back-Up

SecDef Efficiency Objectives

- Deliver the warfighting capability we need for the dollars we have
- Get better buying power for warfighter and taxpayer
- Restore affordability to defense goods and services
- Improve defense industry productivity
- Remove government impediments to leanness
- Avoid program turbulence
- Maintain a vibrant and financially healthy defense industry

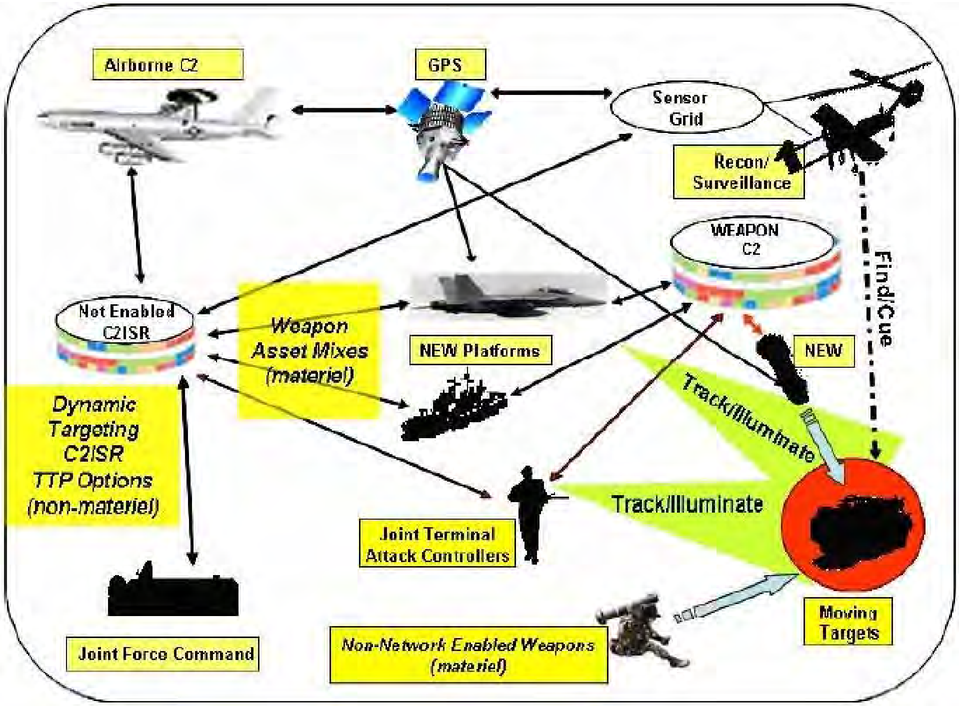
Obtain 2-3% net annual growth in warfighting capabilities without commensurate budget increase by identifying and eliminating unproductive or low-value-added overhead and transfer savings to warfighting capabilities. Do more without more.

T&E Challenges

- **Rapid Fielding**
  - Safety
  - Caps and Lims
- **Emerging Technologies**
  How/where to test?
  - Hypersonics
  - Autonomous systems
  - Weaponized unmanned systems
  - Net-enabled weapons
- **Range Encroachment**
  - OCS exploration/drilling ?
  - Spectrum?
  - Wind generators… !!!!!

T&E Challenges (continued)

- **Complex Systems**
  - System of Systems
  - Interdependent systems?
  - Data fusion
  - S/W intensive systems



- **Balancing Adequacy vs Speed to Field, Cost…..**
  - DOE?
  - How much is enough? Risk management
  - How much M&S? LVC?
  - Other tools

T&E Challenges (continued)

- **Reliability**
  - 50% of MDAPs are failing OT (Suitability)
  - DOT&E imperative – RAM growth testing
- **Rigor – Realistic Environments?**
  - Stressing countermeasures (GPS jamming), clutter….. Operationally relevant scenarios
  - Threat representations
- **End-to-End testing**
  - Mission Context
    - Mission threads
  - Interoperability and IA

Encourage Efficiency

ADOPTING "SHOULD-COST" AND "WILL-COST" MANAGEMENT: Use historically informed independent cost estimation ("will-cost" estimates) to inform managing of programs to cost objectives ("should-cost" estimates).

STRENGTHENING THE ACQUISITION WORKFORCE: Achieve SECDEF goal of adding to government acquisition workforce with increased skill levels. Leverage unique qualities of non-profit FFRDCs and UARCs to augment acquisition workforce capability.

IMPROVING AUDITS: Improve consistency and quality of government audits, and focus them on value-added content.

MANDATING AFFORDABILITY AS A REQUIREMENT: In new programs such as the SSBN-X nuclear missile submarine, the Presidential Helicopter, the Ground Combat Vehicle, and the Air Force/Navy Long Range Strike Family of Systems, cost considerations must shape requirements and design.

STABILIZING PRODUCTION RATES: To ensure more programs are in stable, economically favorable rates of production and avoid cost escalation, program managers may not adjust production rates downward without head of component authority.

ELIMINATING REDUNDANCY WITHIN WARFIGHTING PORTFOLIOS: Emulate the Army's Precision Fires Capability Portfolio approach to identify where multiple programs are pursuing similar objectives.

ESTABLISHING SENIOR MANAGERS FOR PROCUREMENT OF SERVICES: Follow the Air Force lead in establishing a Program Executive Officer for services in each DOD component to focus on improving policy and practice in this high-dollar-value area.

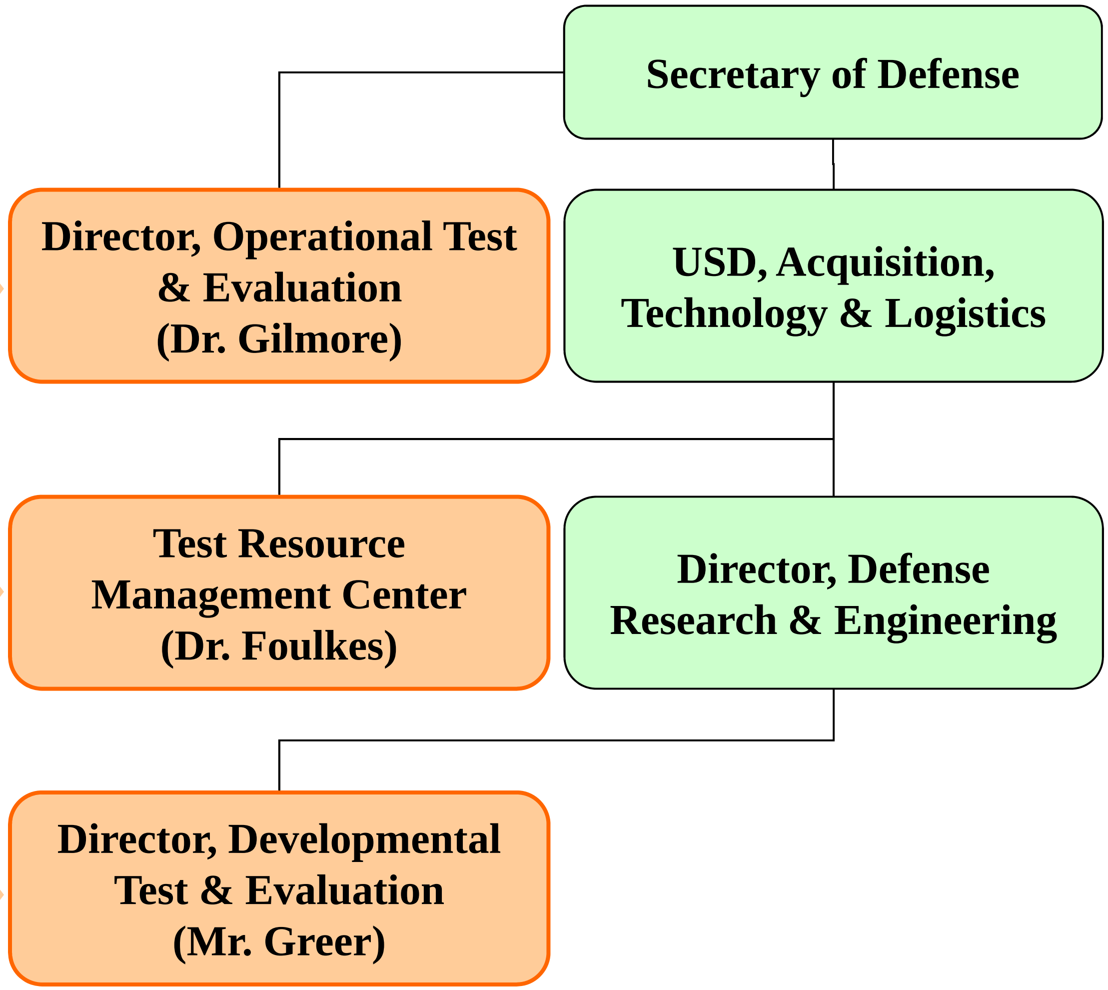
PROTECTING THE TECHNOLOGY BASE: Protect the future by sustaining investment while focusing on high value-added work.

DoD HQ Testing*

Policy, guidance, and oversight to ensure OT&E is adequate to confirm operational effectiveness and suitability in combat use

Planning and assessment of the adequacy of the Major Range and Test Facility Base to provide testing in support of defense acquisition

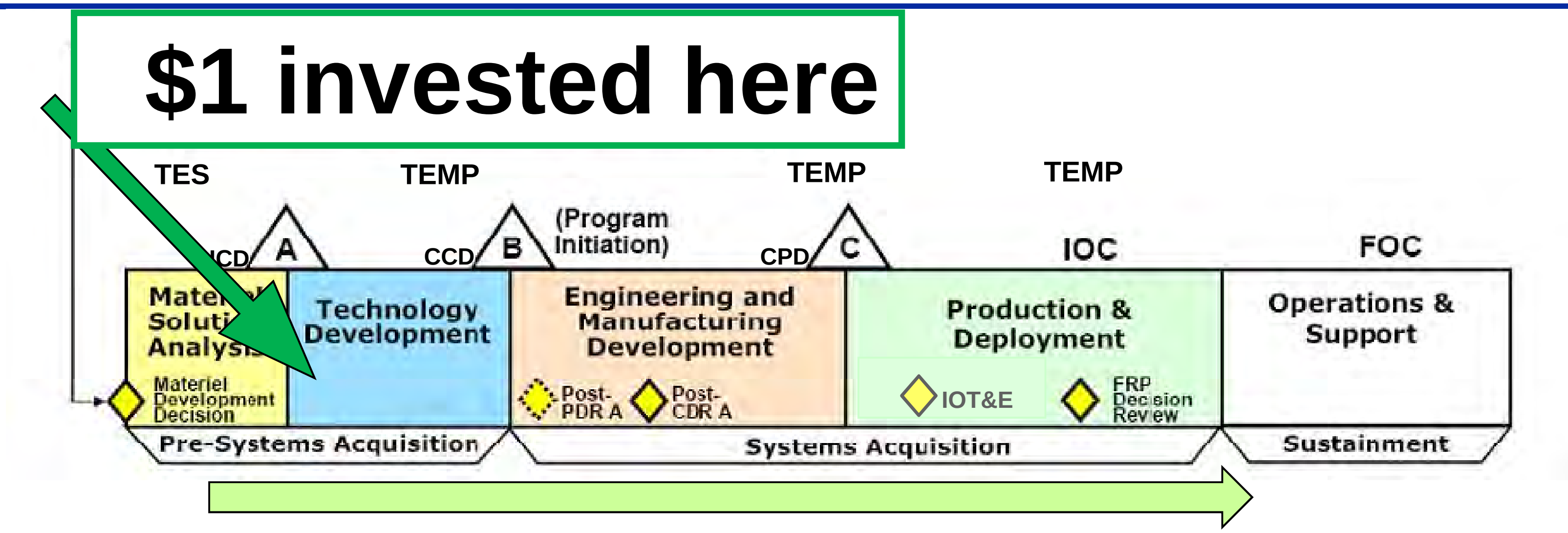
Policy, guidance, and oversight to ensure DT&E is adequate to support program development and assess system performance for decision authority



DT&E is approximately 80% of the overall program T&E effort

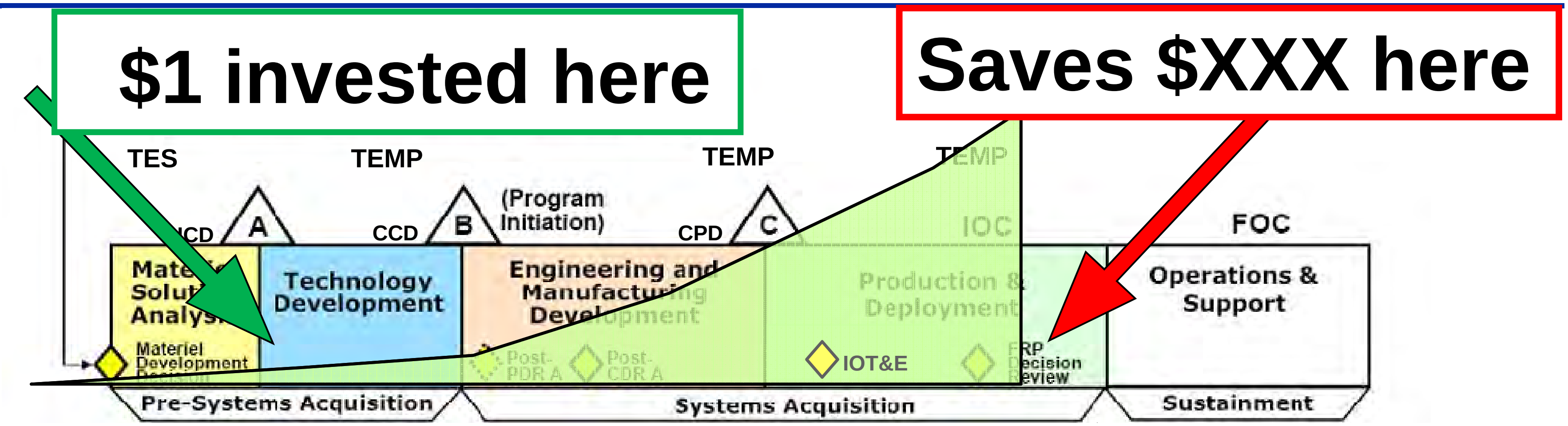
*Chart does not reflect entire OSD Organization

DDT&E in DoD: Engage Early



▪ Test Evaluation Strategy (TES) ▪ Technology Development Strategy (TDS) ▪ Identify emerging T&E capability requirements ▪ Identify T&E resources ▪ Develop T&E requirements in RFP ▪ Support AoA technical analysis	▪ Test and Evaluation Master Plan (TEMP) ▪ Acquisition Strategy ▪ Support T&E Program Execution ▪ Provide T&E results for OIPT/DAB Reviews ▪ CDD requirements for testability and ability to evaluate ▪ Support TRL Evaluation ▪ T&E requirements in RFP ▪ Report of performance measures, metrics and evaluations	▪ Update TEMP ▪ Support T&E Program Execution ▪ Provide T&E results for OIPT/DAB Reviews ▪ Support PDR/CDR and all technical reviews ▪ CPD requirements for testability and ability to evaluate ▪ Support TRL Evaluation ▪ T&E requirements in RFP ▪ Discovery and deficiencies ▪ Report of performance measures, metrics and evaluations	▪ Update TEMP ▪ Support T&E Program Execution ▪ Characterize system capabilities and limitations ▪ Provide T&E results for OIPT/DAB Reviews ▪ AOTR / OTRR ▪ Support training for IOT&E ▪ Report of performance measures, metrics and evaluations	▪ Update TEMP for Follow-on DT&E and OT&E ▪ Verification of corrections for deficiencies ▪ Develop T&E programs to support upgrades, modifications, and increments ▪ Support T&E Program Execution ▪ Report of performance measures, metrics and evaluations

DDT&E in DoD: What and When



A few DDT&E observations:

- **Lack of DT&E expertise during program formulation**
- **DT&E program planning and resourcing not adequate**
- **System immaturity at MS C or at OTRR**
- **Inadequate reliability growth programs**

Where are We Going?

As Is	To Be
Serial Testing	Integrated Test/Training
Platform-Based	System of Systems
Threat-Based	Complex Capabilities
Contract Compliance	Mission Context
Interoperability	Joint Mission Thread
Deliberate	Rapid/Responsiveness

Our T&E process needs to evolve to support faster product cycles, more adaptable products and address challenges

Guidance Roadmap

Target Affordability and Control Cost Growth

- Mandate affordability as a requirement
  - At Milestone A set affordability target as a Key Performance Parameter
  - At Milestone B establish engineering trades showing how each key design feature affects the target cost
- Drive productivity growth through Will Cost/Should Cost management
- Eliminate redundancy within warfighter portfolios
- Make production rates economical and hold them stable
- Set shorter program timelines and manage to them

Incentivize Productivity & Innovation in Industry

- Reward contractors for successful supply chain and indirect expense management
- Increase the use of FPIF contract type where appropriate using a 50/50 share line and 120 percent ceiling as a point of departure
- Adjust progress payments to incentivize performance
- Extend the Navy's Preferred Supplier Program to a DoD-wide pilot
- Reinvigorate industry's independent research and development and protect the defense technology base

Promote Real Competition

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

Improve Tradecraft in Services Acquisition

- Create a senior manager for acquisition of services in each component, following the Air Force's example
- Adopt uniform taxonomy for different types of services
- Address causes of poor tradecraft in services acquisition
  - Assist users of services to define requirements and prevent creep via requirements templates
  - Assist users of services to conduct market research to support competition and pricing
  - Enhance competition by requiring more frequent re-compete of knowledge-based services
  - Limit the use of time and materials and award fee contracts for services
  - Require that services contracts exceeding $1B contain cost efficiency objectives
- Increase small business participation in providing services

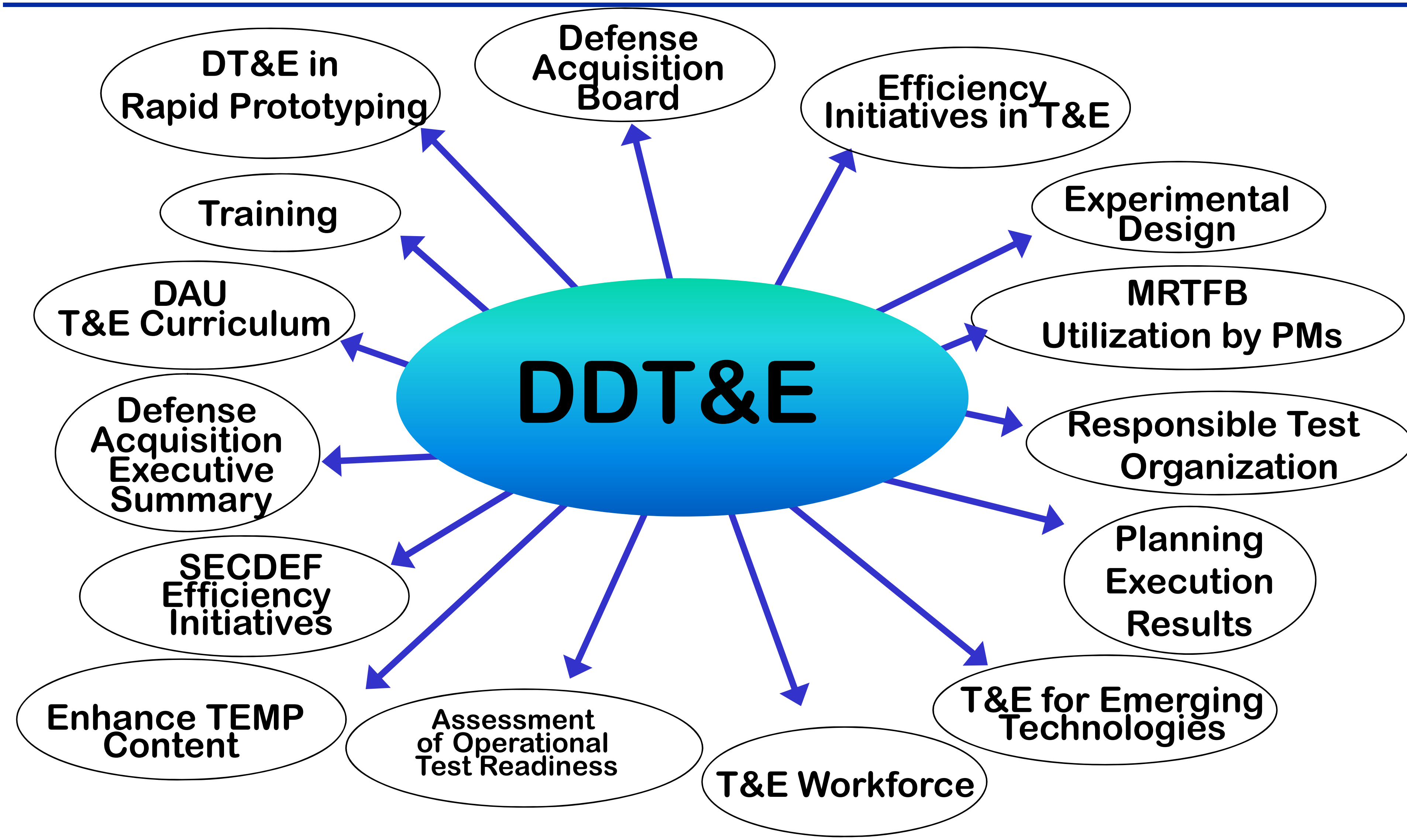
Reduce Non-Productive Processes and Bureaucracy

- Reduce the number of OSD-level reviews to those necessary to support major investment decisions or to uncover and respond to significant program execution issues
- Eliminate low-value-added statutory processes
- Reduce by half the volume and cost of internal and congressional reports
- Reduce non-value-added overhead imposed on industry
- Align DCMA and DCAA processes to ensure work is complementary
- Increase use of Forward Pricing Rate Recommendations (FPRRs) to reduce administrative costs

Providing Incentives for Greater Efficiency in Industry

- **LEVERAGING REAL COMPETITION: Avoid directed buys and other substitutes for real competition. Use technical data packages and open systems architectures to support a continuous competitive environment.**
- **USING PROPER CONTRACT TYPE FOR DEVELOPMENT AND PROCUREMENT: Phase out award-fee contracts and favor fixed-price or cost-type incentive contracts in which government and industry share equally in overruns and underruns, and overruns have analytically-based caps. Use cost-reimbursement contracts only when either government requirements or industry processes cannot be adequately specified to support pricing. Adjust sole-source fixed-price contracts over time to reflect realized costs. Work down undefinitized contract actions. Seek authority for multi-year contracts where significant savings are possible.**
- **USING PROPER CONTRACT TYPE FOR SERVICES: Phase out Time and Material and sole-source ID/IQ contracts wherever possible. Utilize fixed-price performance-based contracts when requirements are firm and can be measured, with payments tied to performance. Utilize fixed-price level of effort or cost-plus-fixed-fee contracts (with profit/fee tied to weighted guidelines) when requirements are still being defined. Award fees should be used only by exception. Maximize the use of multiple-source, continuously competitive contracts.**
- **ALIGNING POLICY ON PROFIT AND FEE TO CIRCUMSTANCE: Align opportunity to earn profits/fees to both value to the taxpayer and risk to the contractor. Apply weighted guidelines to profit/fee levels. Reward higher productivity with higher profits. Incentivize investment in innovation.**
- **SHARING THE BENEFITS OF CASH FLOW: Ensure that taxpayers receive adequate consideration (price reductions) for improved cash flows. Progress payments must reflect performance but can be increased above customary levels in return for consideration by the contractor. Reduce over time the gap between proposed and actual rates in forward price rate agreements.**
- **TARGETING NON-VALUE-ADDED COSTS: Identify and eliminate non-value-added overhead and G&A charged to contracts. Limit fees for subcontractor management to reflect actual value provided (risk assumed by prime and continuous subcontractor risk reduction). Limit B&P allowable costs in sole source contracts and encourage effective use of IRAD.**
- **INVOLVING DYNAMIC SMALL BUSINESS IN DEFENSE: When establishing multiple award contracts for services, make every effort to provide for small business participation. If at least two small businesses are deemed capable of performing on such a contract, consider setting aside that work for competition among them.**
- **REWARDING EXCELLENT SUPPLIERS: Emulate the Navy's pilot program to provide special benefits to consistently excellent industrial performers.**

Environmental Scan



National Defense Industrial Association
27th Annual Test and Evaluation Conference
Tampa, FL

T&E Instrumentation Infrastructure – Maximum Utilization of Available Resources Session

16 March 2011

Briefed by:
Jim Schwierling
Lead Project Director, PMITTS, PEO STRI
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FALSE IMPRESSION CAVEAT

It should be explicitly noted that the U.S. Government makes no official commitment nor obligation to provide any additional detailed information or an agreement of sale on any of the systems or capabilities portrayed during this presentation that have not been authorized for release.

OUTLINE

- Who We Are
- Mission
- Activities
- Organization
- Products
- Future Efforts
- Summary

ORGANIZATION

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TMO MISSION

- MANAGE TOTAL LIFE CYCLE OF TARGETS, OPERATIONAL THREAT VEHICLES, TARGET CONTROL SYSTEMS AND GROUND RANGE SYSTEMS USED IN LIVE AND VIRTUAL TESTING, AND TRAINING.

- PROVIDE BEST VALUE ACQUISITION, SUPERIOR LIFE CYCLE SUSTAINMENT AND OPERATION FOR THE U.S. ARMY, DoD, AND INTERNATIONAL CUSTOMER.

- EXECUTE MISSIONS AS ASSIGNED OR DIRECTED BY PEO STRI AND PM ITTS.

PRIMARY ACTIVITIES

Based on Customer Target Requirements

- **Aerial – Fixed and Rotary Wing**
- **Mobile Ground / Foreign Materiel**
  (both conventional and unconventional)
  - **- Foreign Systems**
  - **- Surrogates**
- **Virtual – Models and Simulations**
- **Precision Targetry Systems**
- **Auxiliary / Ancillary Equipment**

WHAT WE DO

MATERIAL DEVELOPER

Develop products

Acquire Products

CUSTOMER SUPPORT

Fly

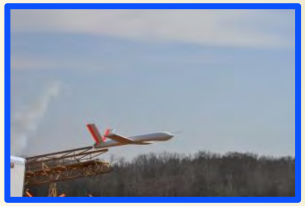
Drive

Sustain

AERIAL TARGETS

Remote Piloted Vehicle Target

- **Turnkey Operations**
- **Target systems flight services supporting Army and Tri-service test and training and FMS requirements**
- **Low Cost**



UAS-T

Simulate Aerial Threats World-Wide in Live and Virtual Domains

BroadSword and Outlaw

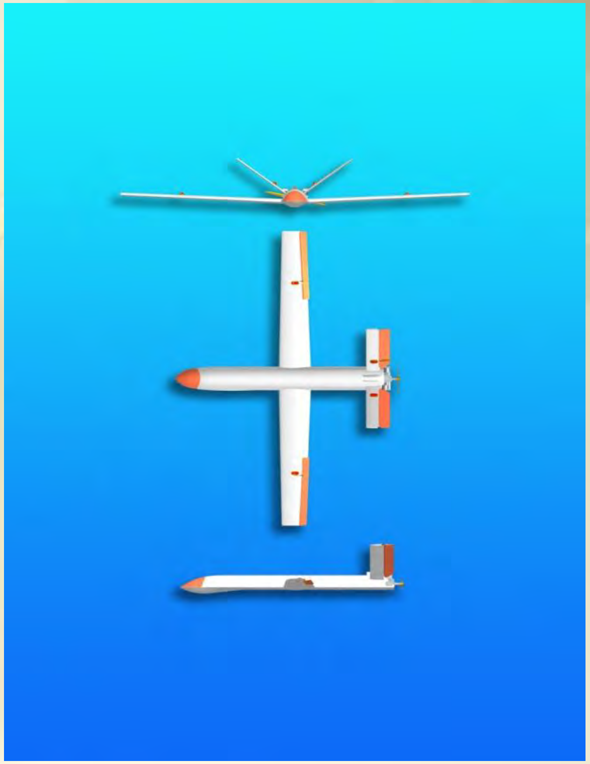
BroadSword

Length………………….13.7 ft (4.2 m)
Wingspan………………17.21ft (5.2 m)
Speed…………………..132 mph
Average Basic Weight...350 lbs
Gross Weight…………..550 lbs

BroadSword is available in carbon fiber or fiberglass for variable radar signatures

Payload is a trade between required airspeed, altitude, and flight duration

Outlaw



Length…… 8.4 ft (2.56 m)
Wingspan…13.6 ft (4.15 m)
Speed…..125 mph
Average Basic Weight...70 lbs
Gross Weight… 120 lbs

AERIAL TARGETS

MOBILE GROUND TARGETS

Centrally Manage and Execute:

- **Over 340 assets**
- **Mobile Ground Targets for development and operational testing**
- **Multiple usage options:**
  - **Rent**
  - **Lease**
  - **Buy**
- **Provide accreditation support**

Threat Representative Targets in Live and Virtual Domains

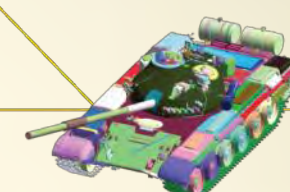
MOBILE GROUND TARGETS

VIRTUAL TARGETS

- ***Virtual Targets Project*: Building simulation target models capable of being used in synthetic signature prediction analysis software programs**

- ***Target Generation Laboratory*: Transitioning CAD models into simulation compliant visual, infrared, and radar frequency simulation target models**

- ***Army Model Exchange*: Distributing simulation target models to simulation developers throughout the Army T&E community**



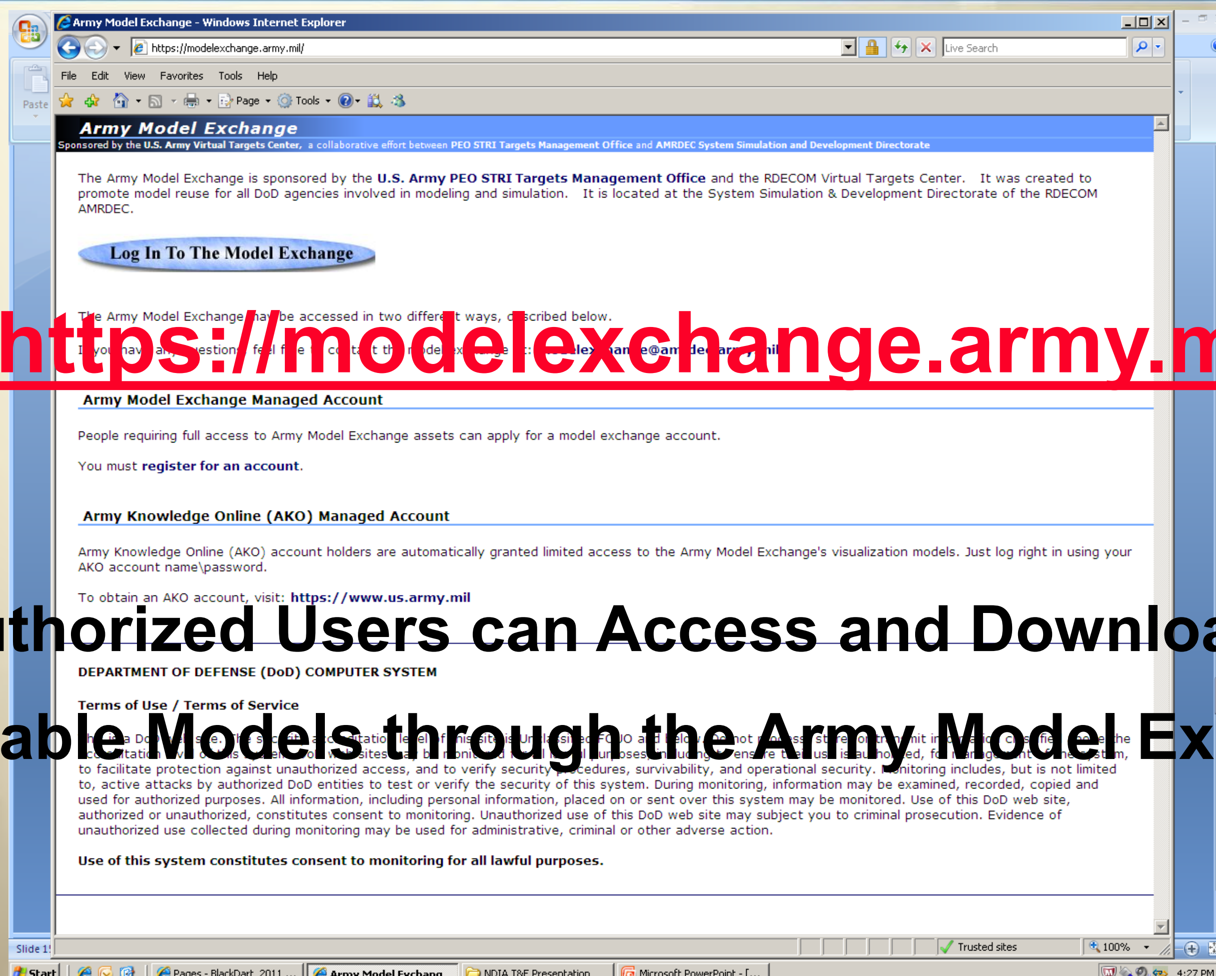
PEO STRI

PM ITTS

TMO

TARGETS MANAGEMENT OFFICE

Army Model Exchange



https://modelexchange.army.mil

Authorized Users can Access and Download all Available Models through the Army Model Exchange

WHAT WE HAVE DEVELOPED/ PURCHASED RECENTLY

Precision Target Signature

URAL 375

T-72

BMP-2

UAS-Ts

Virtual Targets

JCHAAT

FIVE YEAR FORECAST TO DEVELOP/PURCHASE

Medium Speed Aerial Targets

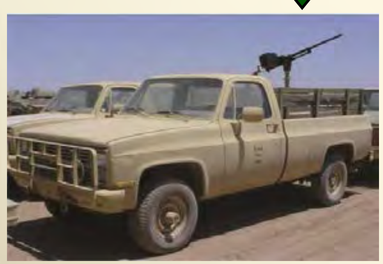
High Speed Aerial Targets

Precision Targets - Mobility

Looking at technology areas to enhance current capabilities

Rotary Wing Targets

Fully Mission Capable Threat Targets



Technical Vehicle w/crew representation

Common Control System

SUMMARY

TMO:

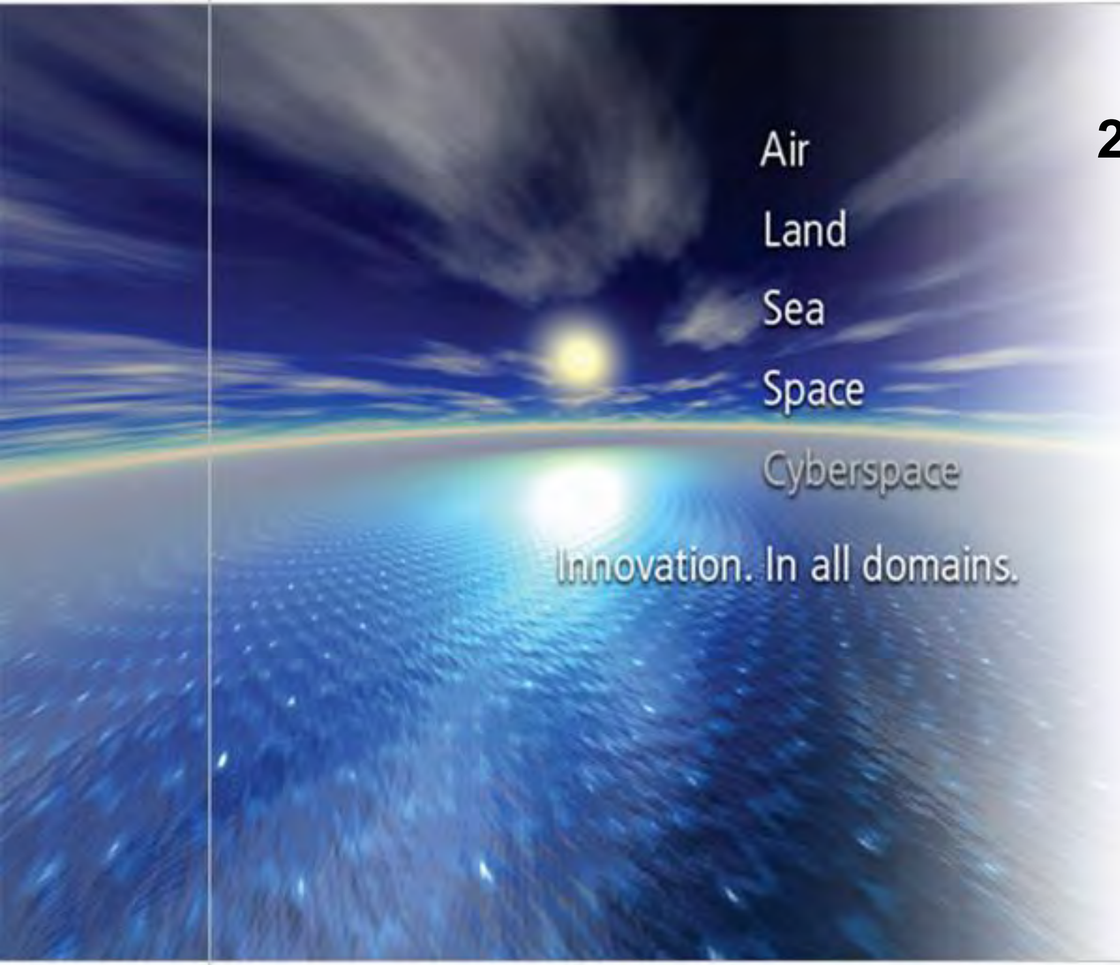
- **ALWAYS LOOKING FOR A BETTER, FASTER, CHEAPER PRODUCT FOR OUR CUSTOMERS**
- **RECOGNIZED LEADER OF AERIAL AND GROUND TARGETS**
- **READY TO RESPONSIVELY AND RESPONSIBLY SUPPORT T&E AND SPECIAL TRAINING REQUIREMENTS**

NEED INDUSTRY TO CONTINUE PROVIDING REASONABLY PRICED, STATE OF THE ART TECHNOLOGIES FOR ADAPTATION AND INCORPORATION INTO TARGETRY

PROVIDING/OPERATING AERIAL, GROUND & VIRTUAL TARGETS

Raytheon

Customer Success Is Our Mission



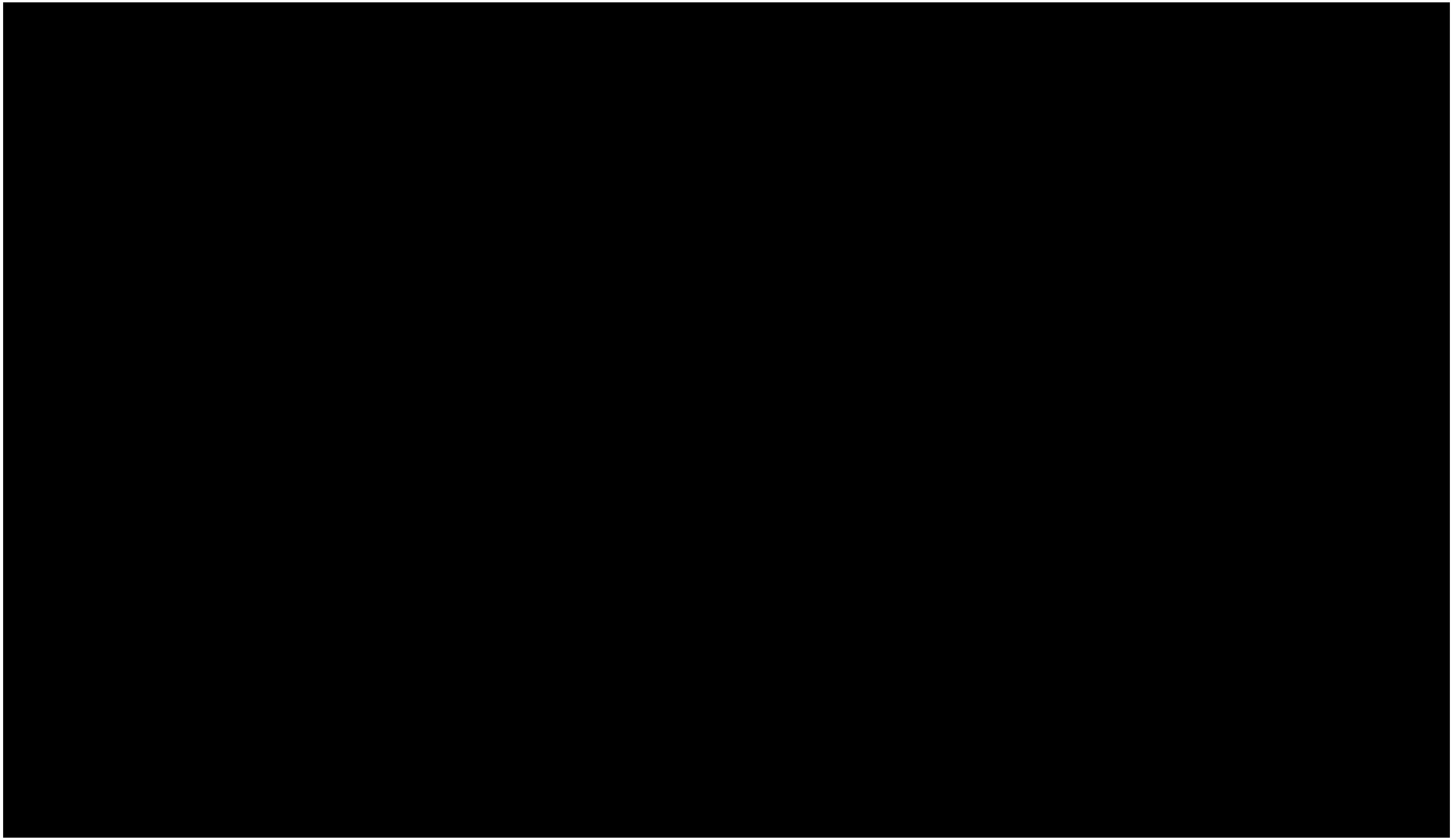
2011 NDIA Test and Evaluation Conference

Continuous Cost Reduction Feeds Back Into Product Reliability

Author: Jonathan Nikkel

Raytheon Missile Systems

120GM Dagger™ Introduction



120GM Dagger^{TM}

Raytheon
Missile Systems

- Advanced Precision Mortar Initiative
  - 2009-Present Urgent Need Effort to Expedite Guided 120mm Mortars to Field
  - RMS was awarded a Phase 1 contract
  - APMI Phase 2 contract (sole source) was awarded to ATK

- Raytheon 120GM Dagger^{TM} GPS-only Design was updated during APMI Phase 1 to include
  - Standard Weapon Interface Compatibility
  - SAASM GPS
  - Telemetry
  - Tri-Mode Fuze (Standard M734A1 Mortar Fuze)

Reliability

Raytheon
Missile Systems

- Many definitions, a good definition:
  - "The probability that a *functional unit* will perform its required functions for a *specified interval* under *stated conditions*."
- How is reliability scored/evaluated?
  - Analytical Methods (mostly pre-CDR)
    - Our program conducted minimal effort here (quick turn, no time)
    - Created fault trees, use of Built-in-Test
  - Test and Evaluation (mostly post-CDR)
    - Heavy emphasis on component/system level repeatability testing and All-Up-Round Flight Testing
    - Simple sequence: Test system, find problems, fix them, test again.
- In general, product reliability is proportional to
  - Man-hours Invested in T&E
  - Number of Hardware Units Built/Delivered

Reliability

Raytheon
Missile Systems

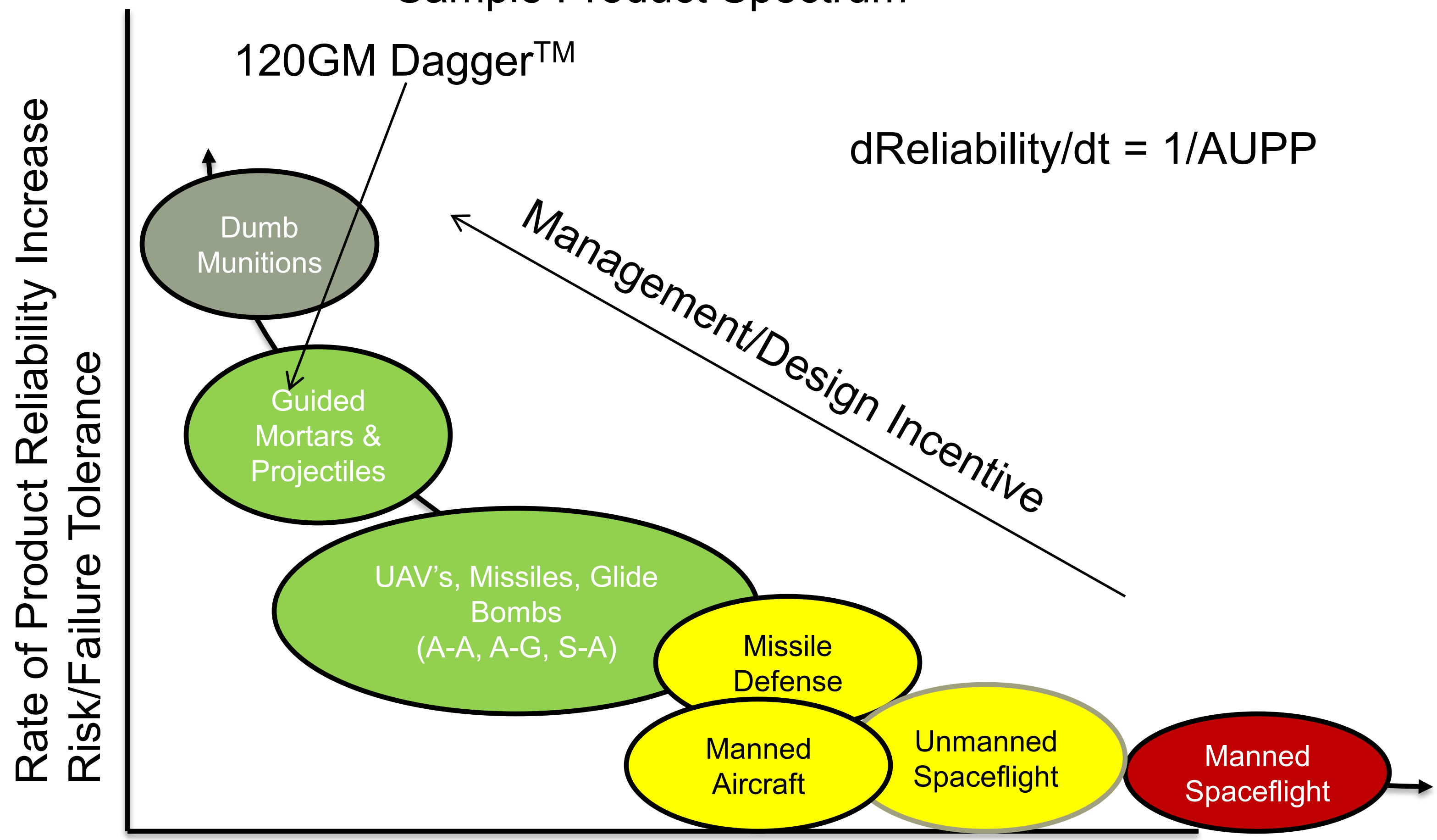
- Understanding and Achieving Reliability in Missile/Projectile Business can be a Difficult Problem Due to Intrinsic Nature of Expendable Systems

  (not to say it isn't difficult elsewhere…)
  - Long dormant storage life requirements
  - 1-shot devices (squibs)
  - No/minimal design capacity for built-in redundancy
  - Minimal information from systems under test (sometimes must disturb system to extract information)
  - Difficult environmental requirements
  - Shoe-string, leap-frog budgets
  - Tight schedules when money is present

Complex Technology Products Reliability Incentives

Raytheon
Missile Systems

Sample Product Spectrum



All Up Production Price (AUPP), Product Complexity

Location on this curve largely dictates T&E behavior.
We should strive to move towards less complexity/price!

Sources of Product Maturity

- Laboratory Testing
  - Use case parameter exploration with hardware
  - Software parameter exploration
  - Functional testing
  - **Repeatability testing**
    - **Extremely Boring, Extremely Effective!**
- Simulation
  - Some mix of real and simulated hardware and physics
  - Performance optimization
  - Rapid software evolution
  - Software parameter exploration
- Field/Flight Testing
  - Real product hardware in tactical or near-tactical environment

Optimal Mixture is Product Dependent

- Optimal Test Mixture Depends on Location in Product Space
- High Failure Tolerance/Low Production Price
  - Laboratory testing as necessary
  - Minimalistic (low fidelity) simulation necessary to mature software algorithms and generate course performance estimates
  - Heavy weighting towards field/flight testing with real hardware, as soon as possible (10's to 100's of flights per year)
- Low Failure Tolerance/High Production Price
  - Heavy laboratory testing
  - Heavy work in low, medium, and high fidelity simulations
  - Field/Flight test minimally, and only once high confidence in success is achieved (1-10 flights per year)

120GM Dagger™

Raytheon
Missile Systems

Types of T&E – Pros/Cons

	Laboratory/Simulation Testing	Field/Flight Testing
PRO	•Usually Cheaper than Flight Testing (both monetarily and politically) •Easy to control, homogenize and selectively explore product parameter space •Failures have minimal political impact	•Highest Fidelity •High Political Impact •Exposes Product Issues Quickly •True Performance Estimates
CON	•Lower Fidelity than Flight Testing •Mountains of Data •Time Consuming •Inaccuracy in Performance Estimates due to Modeling Fidelity	•High (Negative) Political Impact •Expensive •Tendency to heavily script events due to political risks •Larger Non-Homogeneous, Random Parameter Space that is Difficult to Quantify/Measure/Control/Understand

Raytheon
Missile Systems

On the “Fire and Fix” Mentality

- Thomas Edison vs. Nicola Tesla
  - Tesla hated the experimental, non-theoretical methods Edison used
  - Tesla was (and is still) revered for his theoretical prowess
  - In the end, Tesla was not a successful businessman – he was too academic!
  - Edison did not need to *fully* understand the underlying physics to make something work
- When time is short, and hardware is (relatively) cheap, one can resort to experimental methods.
- Even though it does not sound as “smart” (because it is not!), experimental methods can be (and have been for us) a legitimate approach to maturing a product.
- Both men and their methods represent extremes – a mix of laboratory, simulation, and flight testing is best

Risk Aversion

- Why do we fear failure?
  - Yields Negative Customer Perception: “This Widget Will Never Meet Performance/Reliably Within a Schedule We Care About.”
- Certainly, life is cozier if we never fail
- Failure is often a necessary step in maturing a product
  - We must increase our appetite to budget for failure, and build failure into (some) programs…this is difficult to sell in an era of declining expenditures.
  - Desire is to work testing towards the edge of the performance envelope, out of the cushy nominal areas, as political landscape allows. We want to understand where and why a widget fails!
  - Failure-tolerant programs are more likely to be successful in the end.
- Failure Often Yields More Knowledge and Product Improvement than Success, because Engineers are Forced to Dig Deeper
- Don’t Dread the Failure Review Board – Embrace the Opportunity to Learn Something New

Product Maturity Incentives

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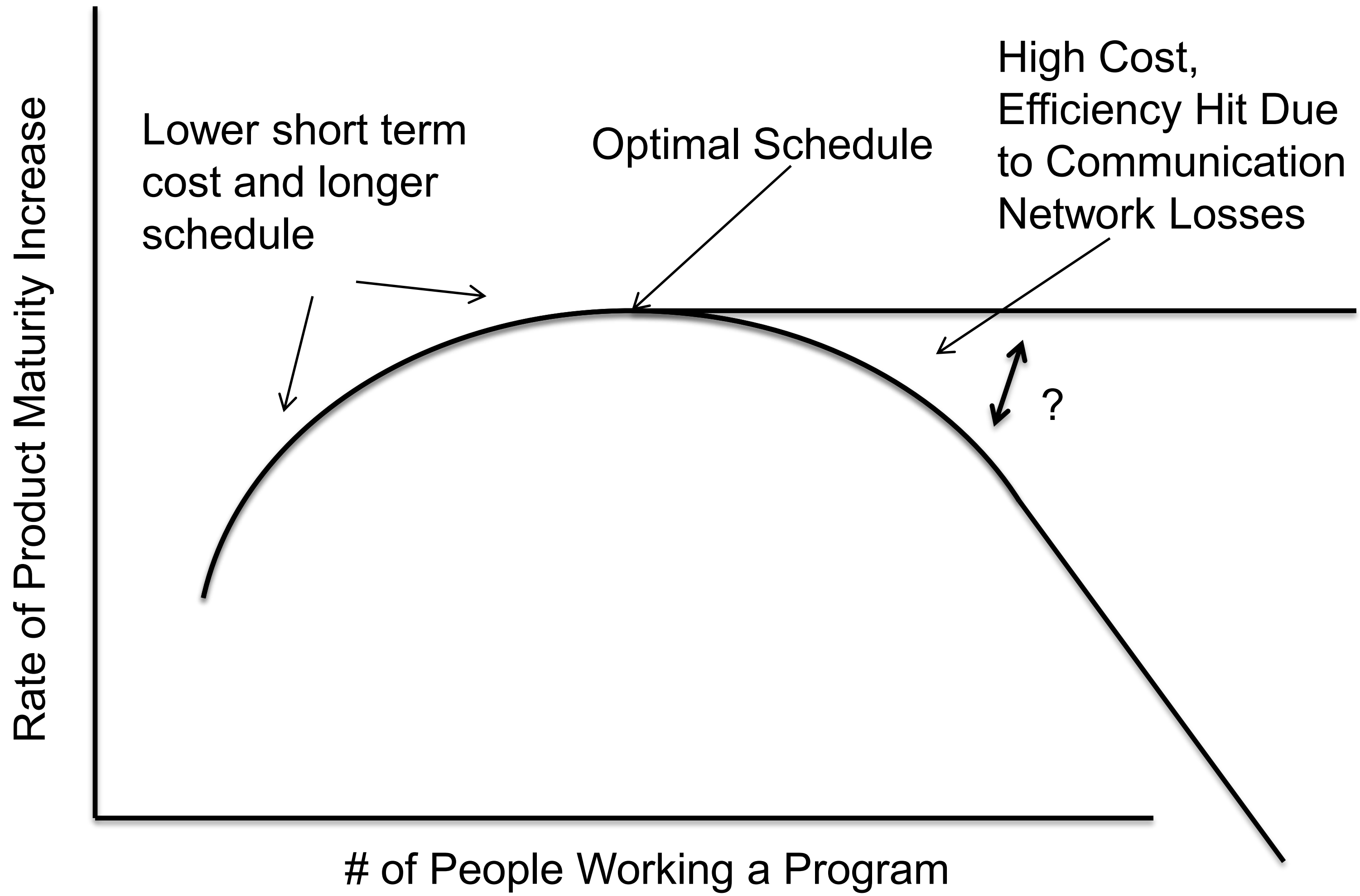
Missile Systems



More People != Success

Example AUPP vs. Flight Test Quantities Economies of Scale

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- Unit Cost Reduction Feeds Back Into Product Reliability by Allowing Us To Extract more Knowledge from a Given Budget
- Notional Analysis - synthetic costing/budget numbers, not real data
  - Values used are for example purposes only
  - Low Quantity or Initial AUPP: $19k
  - Notional ~Logarithmic Price Breaks
  - FYXX T&E Materials Budget: $800,000
    - Ie, customer gives us $800k for flight testing this year. What can we do with it?

AUPP vs. Flight Test Quantities (cont)

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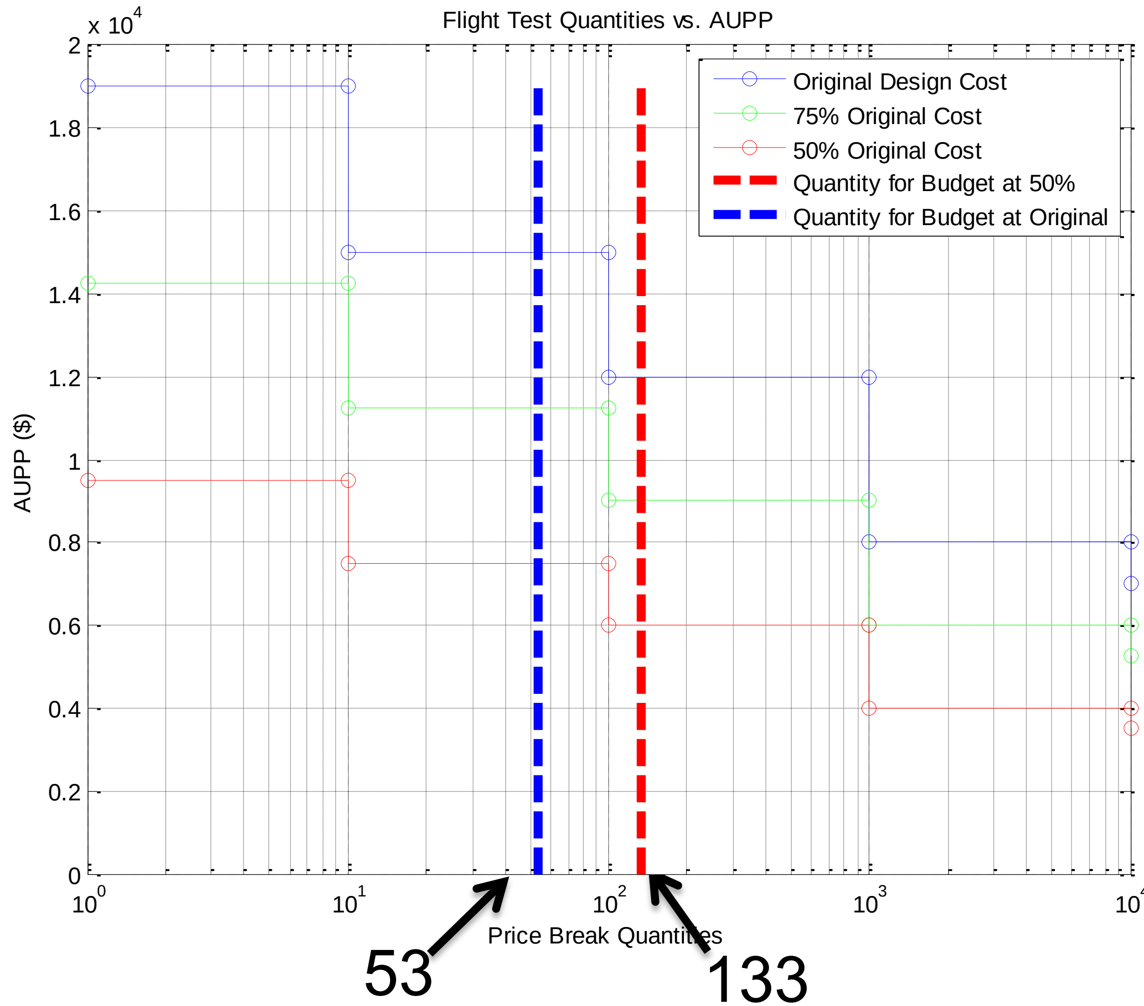
(Synthetic Information, Not Real Costing Data)

Example: Achieving 50% cost reduction more than doubles our test articles at this budget level, because we hit the next level of price break.

Accelerates us into regime of finding/fixing the nitty-gritty 1% failures!



Incentive: Cost Reduction Increases Impact of Price Breaks on Test Article Quantities

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How Do We Minimize Cost?

- A Few Strategies Employed
  - Migration functionality of multiple CCA's into a single CCA
  - No wheel re-invention - use of proven COTS component parts
  - Move from milled to extruded or cast metal parts where possible
  - Reduce number of metal parts
  - Phase in next generation component parts (vendor produces a lower cost alternative)
  - Minimize Test Equipment NRE
  - Automate assembly and test processes to reduce test time

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Where We Are

- Status
  - Post-APMI Phase 1, team size was significantly reduced
  - Reliability improvement work has continued on a shoe-string budget
  - An unconventional first: This program validated improvements in flight test with re-used spent flight hardware (shot out of a gun, impacted the ground), in one case with 3x re-use (guidance electronics only, no structural components). Third HW flight after problem fixes missed target by <1m!
  - We have conducted many recent successful firing tests, with major hardware components donated by suppliers!
  - We wish to thank our supporters at Picatinny Arsennal, Yuma Proving Ground, and New Mexico Tech
- 120GM Dagger™
  - Extended Range
  - High Accuracy, Even in Moderate Winds
  - No MET data required
  - Tri-mode Fuze

Impact Video from APMI Shoot-Off

Flight Test Results
June 2010 Reliability Improvements

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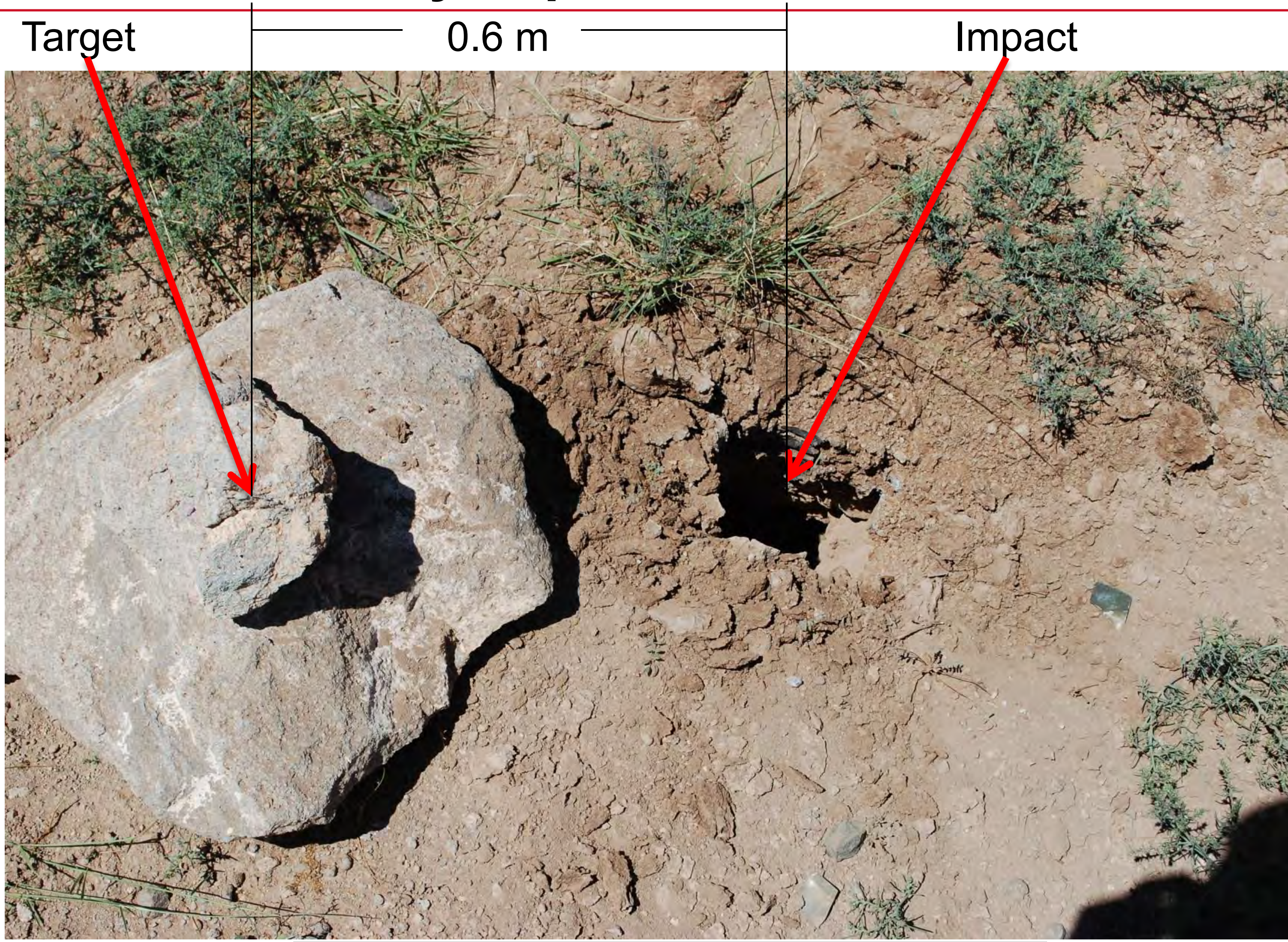

Fired with 2.5 deg ballistic azimuth offset from target!

Energy On Target!

Conclusions - Necessary Mindsets

- Drive Down Cost Early in the Design Cycle to Reap the Rewards of Economies of Scale
- Change is necessary to mature a product
- Challenge Consensus
  - The fact that 10 people believe something and agree with each other does not make them correct!
  - Just because something has always been done a certain way, does not imply it is correct!
  - Be the outlier…ask the question, even if you think you are going to get laughed out of the room!

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Conclusions (cont)

- Abnormal/variable product behavior under constant conditions, even if it does not result in a high level product failure is not ok!
  – Don’t be the one who says: **“Oh it’s ok…it just does that sometimes…”**

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Defense Information Systems Agency

A Combat Support Agency

Test & Evaluation of the NR-KPP

Danielle Mackenzie Koester

Chief, Engineering and Policy Branch

March 15, 2011

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Purpose

Provide an overview of the policies, processes and procedures for assessing compliance with the Net-Ready Key Performance Parameter

Goal: Establish a measurable, testable, and operationally relevant approach to Joint interoperability (IOP) engineering, test, evaluation & certification (TE&C)

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Policy Overview

JS - Interoperability Certification

DODD 4630.5
"IT and NSS interoperability shall be verified early, and with sufficient frequency throughout a system's life ..."

CJCSI 6212.01E
"All IT and NSS must be evaluated and certified for Joint interoperability by DISA (JITC)."

Title 10
United States Code (USC)
Section 2223
IT: Additional Responsibilities of DoD CIO
"Ensure the interoperability of Information Technology and National Security Systems throughout the DoD."

DODI 4630.8
"All IT and NSS ... must be tested for interoperability before fielding ... and certified by DISA (JITC)."

CJCSI 3170.01G
Establishes JCIDS w/ NR-KPP for CDD and CPD

DoD 5000 series
"For IT systems, including NSS, .. JITC shall provide system interoperability test certification memoranda ... throughout the system life-cycle and regardless of ACAT"

DOT&E - Operational Test Reports

DODD 5105.19, "DISA"
Directs DISA to establish an OTA

DODD 5141.2, "DOT&E"
Lists the five recognized OTAs, including (JITC).

Title 10
United States Code (USC)
Section 139: "The Director [OT&E] shall prescribe... policies and procedures for the conduct of OT&E in the DoD...and report test results to Congress..."
Section 2399: OT&E must be adequate, and determine operational effectiveness and suitability

DODI 5010.41, JOINT TEST & EVALUATION (JT&E) PROGRAM
"A JT&E is OT&E that brings Military Departments together to assess Service interoperability in joint operations."

DISA INSTRUCTION 640-195-1 TEST & EVALUATION (T&E) OTA MISSION
"JITC shall perform the OTA mission... The Commander, JITC, will report directly to the Director, DISA, on OT&E matters."

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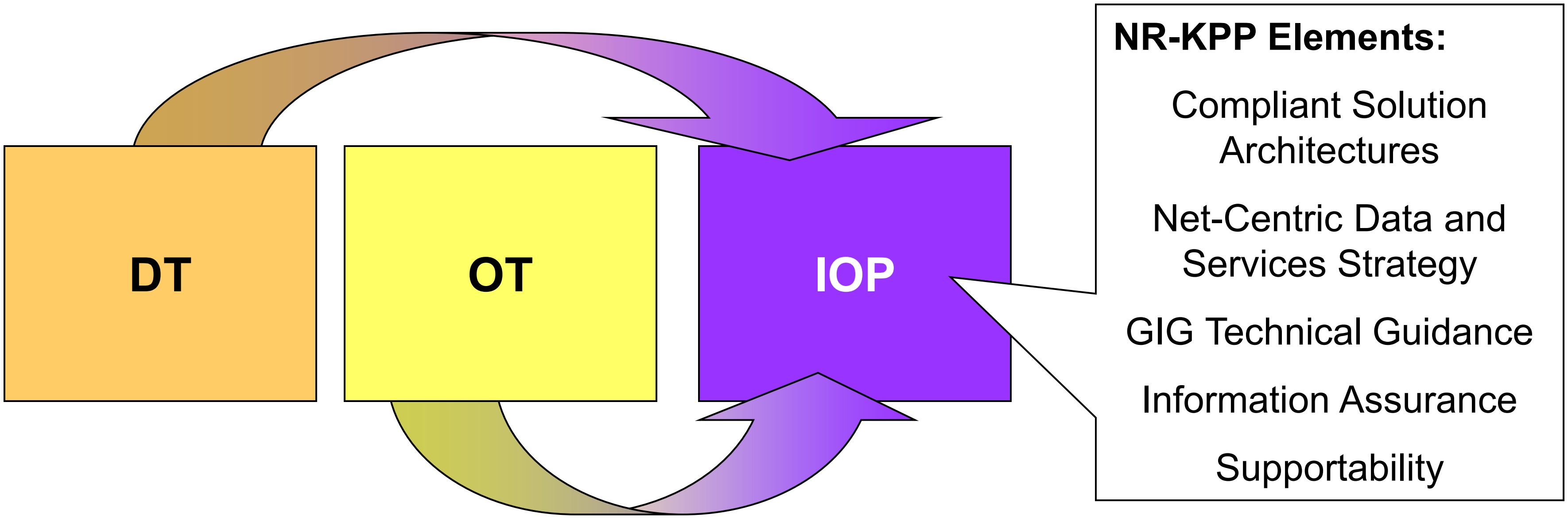
Joint Interoperability Test Certification Overview



- **The NR-KPP elements define the areas JITC evaluates for interoperability certification**
- **JITC uses data collected during DT, OT, demonstrations, exercises, or other reliable sources for interoperability evaluations**

Success = Minimizing separate interoperability testing by leveraging DT/OT

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Joint Interoperability Certification Process

Joint Staff J-6

Interoperability & Supportability Certification Documents:

CDD, CPD, ISP, ISP Annex and TISP

JITC Test & Certification

Risk

Developmental and Operational Test & Evaluation

Analysis

DATA

Joint Interoperability Test Certification

Expires after 4 years, or upon changes affecting interoperability (system or environment)

NOTE: Interoperability changes require reentering process at appropriate point:

- ✓ Requirements updates
- ✓ J-6 I&S Certification
- ✓ JITC Test & Certification

NR-KPP Statement

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Testable?

KPP	Threshold	Objective
Net-Ready: The capability, system, and/or service must support Net-Centric military operations. The capability, system, and/or service must be able to enter and be managed in the network, and exchange data in a secure manner to enhance mission effectiveness. The capability, system, and/or service must continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a Net-Centric military capability.	The capability, system, and/or service must fully support execution of joint critical operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.	The capability, system, ... support execution of all ... information exchanges ... Enterprise Archite... based on integrated DODAF ... satisfy the technical requi... Net-Centric military operations ... 1) Solution architecture prod... co...an...h DoD Enterprise Architecture ...sed o... integr...d DODAF content, including s...ecified ...peration...lly effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.

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NR-KPP Requirements Source

Testable!

Document	Supportability Compliance	DOD Enterprise Architecture Products (IAW DODAF) (see Note 5)																		
		AV-1 /AV-2	OV-1	OV-2	OV-3	OV-4	OV-5	OV-6C	OV-7	SV-1	SV-2	SV-4	SV-5	SV-6	SV-11	TV-1	TV-2			
ICD			X																	
CDD	X	3	X	X	X	X	X	X			X	X	X	X		2	2	1	X	X
CPD	X	3	X	X	X	X	X	X	1		X	X	X	X	1	2	2	1	X	X
ISP	X	3	X	X	X	X	X	X	4		X	X	X	X	4	2	2	1	X	X
TISP	X	3	X		X		X	X		X			X	X		2	2	1	X	X
ISP Annex (Svcs/ Apps)	X	3	X				X				X	X	X	X		2	2	1	X	X

X	Required (PM needs to check with their Component for any additional architectural/regulatory requirements for CDDs, CPDs, ISPs/TISPs. (e.g., HQDA requires the SV-10c)
Note 1	Required only when IT and NSS collects, processes, or uses any shared data or when IT and NSS exposes, consumes or implements shared services,
Note 2	The TV-1 and TV-2 are built using the DISRonline and must be posted for compliance.
Note 3	The AV-1 must be uploaded onto DARS and must be registered in DARS for compliance
Note 4	Only required for Milestone C, if applicable (see Note 1)
Note 5	The naming of the architecture views is expected to change with the release of DODAF v2.0 (e.g., StdV, SvcV, StdV, DIV). The requirements of this matrix will not change.

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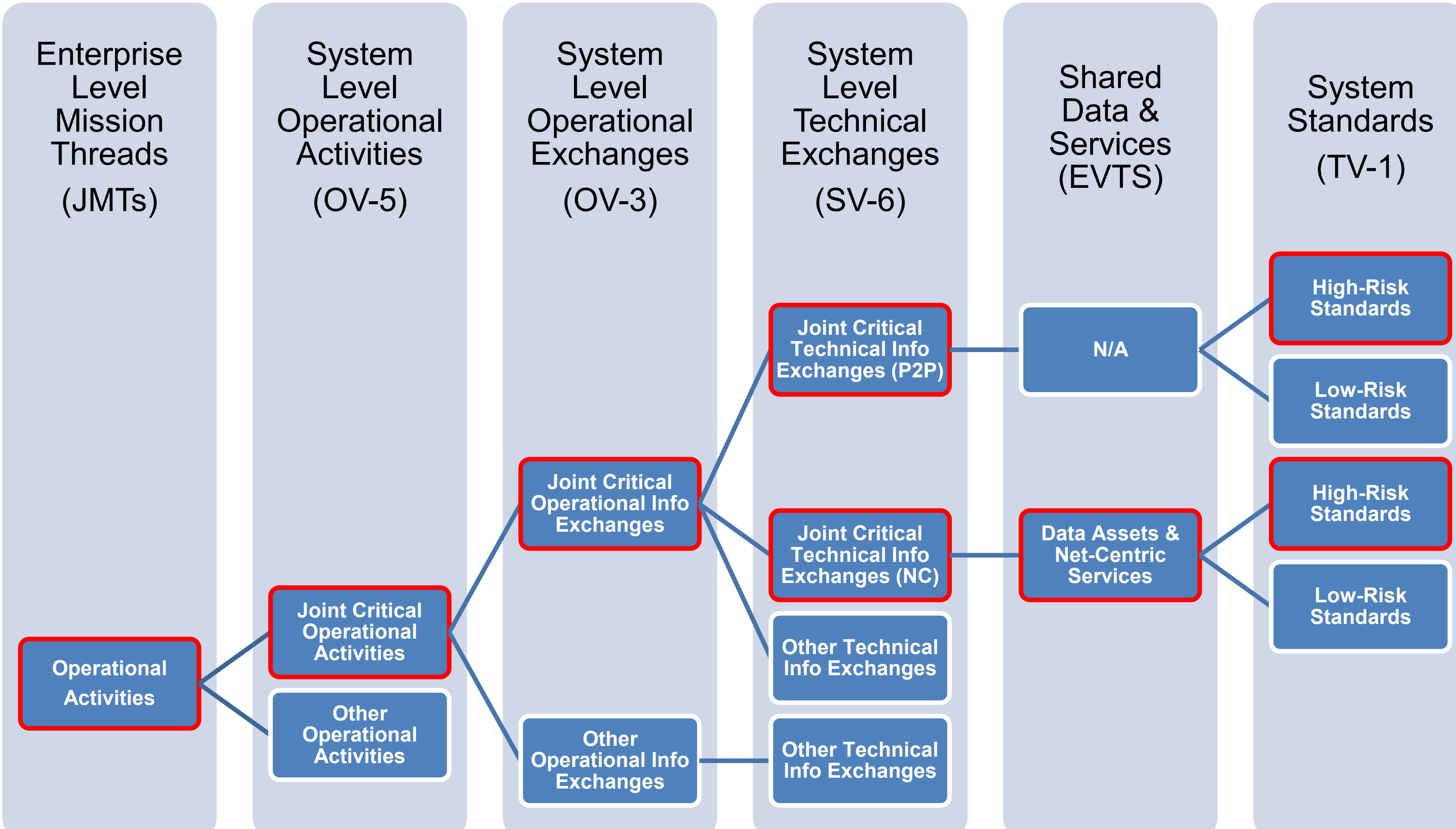
Mapping NR-KPP to Operational Impact



Universal Joint Task Metrics

Universal Joint & Service Task Metrics

Secure, Timely, Accurate, and Usable as Defined in OV-3

Secure, Timely, Accurate, and Usable as Defined in SV-6

Visible, Accessible, Understandable, Secure, Interoperable

No Conformance Issues Resulting in Critical Operational Impact

Operationally Effective Information Exchanges

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KPP	Threshold	Objective
Net-Ready: The capability, system, and/or service must support Net-Centric military operations. The capability, system, and/or service must be able to enter and be managed in the network, and exchange data in a secure manner to enhance mission effectiveness. The capability, system, and/or service must continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a Net-Centric military capability.	The capability, system, and/or service must fully support execution of joint critical operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: **1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges** 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.	The capability, system, and/or service must fully support execution of all operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: **1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges** 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.

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Operationally Effective Information Exchanges

- Requirements Analysis
  - What missions and activities does the system support?
    - Joint Mission Threads
    - OV-6c
    - OV-5
  - What information exchanges are necessary to execute those missions and activities?
    - OV-3
    - SV-6
- Test Planning and Execution
  - Must be on production representative system in an operationally realistic environment

Did the system meet all *joint critical* information exchange requirements?

Data & Services Strategies

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KPP	Threshold	Objective
Net-Ready: The capability, system, and/or service must support Net-Centric military operations. The capability, system, and/or service must be able to enter and be managed in the network, and exchange data in a secure manner to enhance mission effectiveness. The capability, system, and/or service must continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a Net-Centric military capability.	The capability, system, and/or service must fully support execution of joint critical operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges **2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications** 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.	The capability, system, and/or service must fully support execution of all operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges **2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications** 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.

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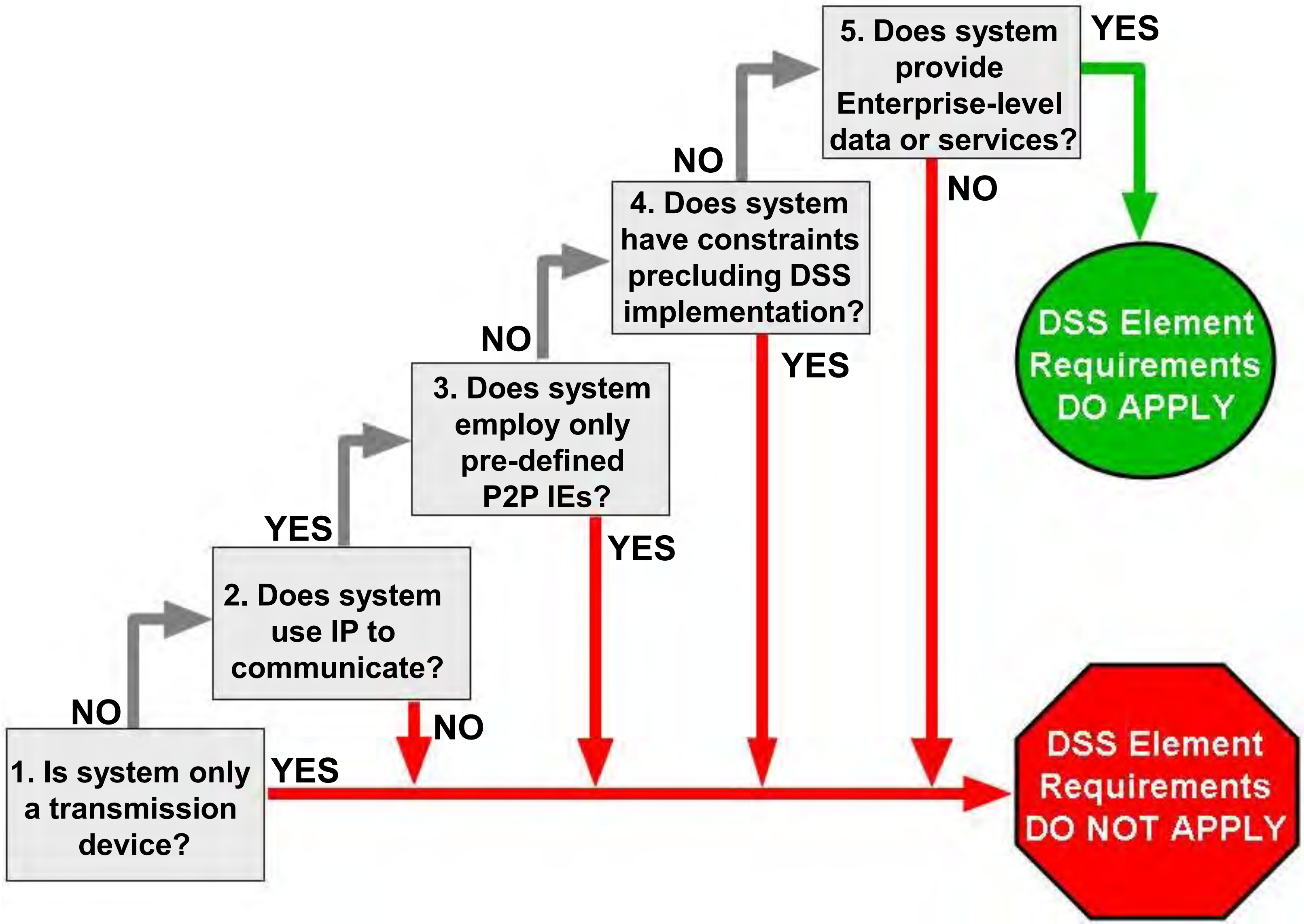
Data & Services Strategies

Does it apply?



Data & Services Strategies

Requirements

Data Strategy Compliance
Visible
Accessible
Data Management
Understandable
Trusted
Interoperable
Responsive to User's Needs

Services Strategy Compliance
Provide Services
Use Services
Govern the Infrastructure and Services
Monitor and Manage Services via GIG NetOPS

DoD Information Enterprise Architecture Compliance
Data and Services Deployment
Secured Availability
Shared Infrastructure Environment
Computing Infrastructure Readiness
NetOPS Agility

Data & Services Strategies

Requirements

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Data Strategy Compliance
Visible
Accessible
Data Management
Understandable
Trusted
Interoperable
Responsive to User's Needs

"Discovery Metadata shall conform to DDMS"

"Post descriptions of access mechanisms"

"Associate data pedigree metadata"

Services Strategy Compliance
Provide Services
Use Services
Govern the Infrastructure and Services
Monitor and Manage Services via GIG NetOPS

"Use DoD CIO mandated Core Enterprise Services"

"Define and advertise Service Level Agreements"

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Data & Services Strategies

Requirements

Net-Centric Data Requirement
Data is Visible Post discovery metadata in an Enterprise Catalog: Department of Defense (DoD) Discovery Metadata Specification (DDMS)- conformant discovery metadata is posted in the Net-Centric Enterprise Services (NCES) Enterprise Catalog or other compatible/federated enterprise catalog that is visible to the Enterprise. Use appropriate keywords for discovery: Discovery keywords should reflect common user terms, be appropriate for mission area or data type, be understandable, and conform with MDR requirements that map back to COI identified mission data.
Data is Accessible Post data to shared space: Data asset is available in a shared space, i.e., a space that is accessible to multiple end users. Provide access policy: If data is not accessible to all users, a written policy on how to gain access is available and accurate. Provide serving (access) mechanism: Shared space provides serving (access) mechanisms for the data. I.e., a service provides users with access to the data. Publish active link to data asset: The Enterprise Catalog DoD Discovery Metadata Specification (DDMS) entry contains an active link (e.g., Uniform Resource Identifier (URI)) to the data asset.
Data is Understandable Publish semantic and structural metadata - Semantic and structural metadata are published in the Enterprise Catalog. Register data artifacts in DoD MDR - XML schema definitions (XSD), eXtensible Markup Language (XML) instances, data models (such as entity relationship diagrams) and other appropriate artifacts are registered in the DoD Metadata Registry (MDR).
Data is Interoperable Base vocabularies on Universal Core (UCore) - Semantic vocabularies reuse elements of the Universal Core (Ucore) standard. Comply with COI data-sharing agreements - Semantic and structural metadata conform to interoperability agreements promoted through communities, e.g., Community of Interest (COI). Conform to DDMS - All metadata, including record-level database tagging and in-line document tagging, complies with DDMS.
Data is Trusted Provide information assurance and security metadata - All metadata, including record-level database tagging and in-line document tagging, includes data pedigree and security metadata, as well as an authoritative source for the data (when appropriate).

Net-Centric Services Requirement
Services are Visible Publish a description of the service or access mechanism - Descriptions (metadata) for the service or access mechanism are published in an enterprise service registry, e.g., the NCES Service Registry. Comply with enterprise-specified minimum service discovery requirements - The data access mechanism complies with enterprise-specified minimum service discovery requirements, e.g., a Universal Description, Discovery and Integration (UDDI) description to enable federated discovery.
Services are Accessible Provide an active link to the service in the enterprise catalog - Active link (e.g., Uniform Resource Identifier (URI)) to the specified service is included in the enterprise catalog metadata entry (i.e., metacard) for the specified service. Provide an active link to the service in the NCES Service Registry - URIs as the operational end points for services shall be registered in the NCES Service Registry by referencing the WSDL (that is in the MDR).
Services are Understandable Publish a description of the service or access mechanism to the NCES Service Registry - Metadata for the service or access mechanism are published in the NCES Service Registry. Publish service artifacts to DoD MDR - Web Service Description Language (WSDL) documents, and other appropriate artifacts are registered in the DoD Metadata Registry (MDR). Provide service specification or Service Level Agreement (SLA) - A service specification or Service Level Agreement (SLA) exists for services and data access mechanisms.
Services are Trusted Operate services in accordance with SLA - The service meets the performance standards in the SLA Include security mechanisms or restrictions in the service specification - The service specification describes security mechanisms or restrictions that apply to the service Enable continuity of operations and disaster recovery for services - The service has a defined and functional Continuity of Operations Plan Provide NetOps Data (NetOps Agility) - Services and data access mechanisms provide operational states, performance, availability, and security data/information to NetOps management services, e.g., Enterprise Management, Content Management, and Network Defense services
Use of Core Enterprise Services (CES) - Core Enterprise Services (CES) are used in accordance with DoD CIO mandates

Data & Services Strategies

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- **Requirements Analysis**
  - Do the net-centric requirements apply?
  - What enterprise-level shared data and service assets are documented in the Exposure Verification Tracking Sheets?
  - What data and service assets support a joint critical operational activity?

- **Test Planning and Execution**
  - Static analysis (e.g., registration of assets)
  - Conformance/compliance testing (e.g., schema conformance)
  - Mission effectiveness (e.g., visibility, accessibility)

Did the system meet all *joint critical* net-centric requirements?
(Visible, Accessible, Understandable, Trusted, Interoperable)

GIG Technical Guidance

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KPP	Threshold	Objective
Net-Ready: The capability, system, and/or service must support Net-Centric military operations. The capability, system, and/or service must be able to enter and be managed in the network, and exchange data in a secure manner to enhance mission effectiveness. The capability, system, and/or service must continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a Net-Centric military capability.	The capability, system, and/or service must fully support execution of joint critical operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications **3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views** 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.	The capability, system, and/or service must fully support execution of all operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications **3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views** 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and 5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.

GIG Technical Guidance

Standards Conformance

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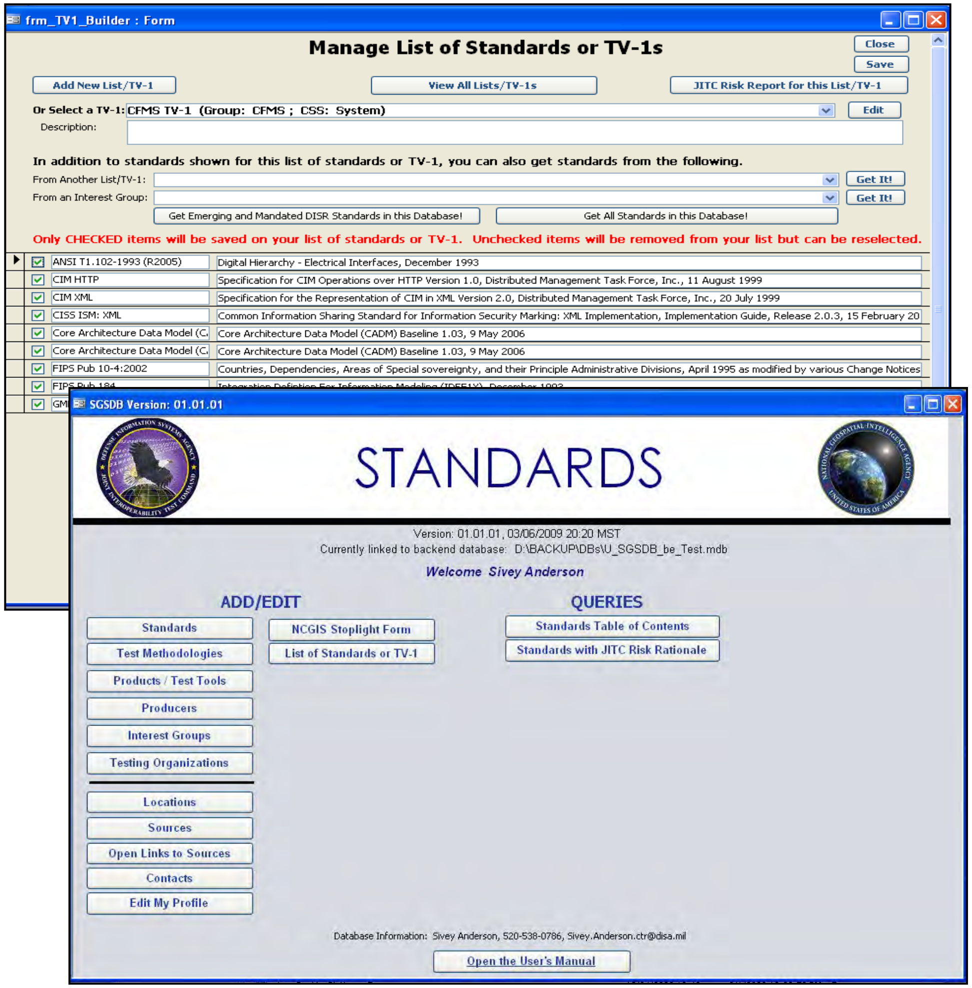
- **Requirements Analysis**
  - Risk analysis on standards identified in system TV-1

- **Test Planning and Execution**
  - Leverage commercial and government test results, as appropriate
  - Execute standards conformance testing, as appropriate



Did the system have any conformance-issues that could result in a critical operational impact?

Information Assurance

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KPP	Threshold	Objective
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Information Assurance

- **Requirements Analysis**
  - What Certification and Accreditation (C&A) process (DIACAP, NISCAP, ICD 503) does the system fall under?
- **Test Planning and Execution**
  - Ensure the system is operating in the approved IA configuration during interoperability/operational testing
  - Verify IATO/ATO
  - Execute required additional IA testing

Has the system received an Interim Authority to Operate (IATO)/Authority to Operate (ATO)?

Supportability

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KPP	Threshold	Objective
Net-Ready: The capability, system, and/or service must support Net-Centric military operations. The capability, system, and/or service must be able to enter and be managed in the network, and exchange data in a secure manner to enhance mission effectiveness. The capability, system, and/or service must continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a Net-Centric military capability.	The capability, system, and/or service must fully support execution of joint critical operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and **5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.**	The capability, system, and/or service must fully support execution of all operational activities and information exchanges identified in the DoD Enterprise Architecture and solution architectures based on integrated DODAF content, and must satisfy the technical requirements for transition to Net-Centric military operations to include: 1) Solution architecture products compliant with DoD Enterprise Architecture based on integrated DODAF content, including specified operationally effective information exchanges 2) Compliant with Net-Centric Data Strategy and Net-Centric Services Strategy, and the principles and rules identified in the DoD Information Enterprise Architecture (DoD IEA), excepting tactical and non-IP communications 3) Compliant with GIG Technical Guidance to include IT Standards identified in the TV-1 and implementation guidance of GIG Enterprise Service Profiles (GESPs) necessary to meet all operational requirements specified in the DoD Enterprise Architecture and solution architecture views 4) Information assurance requirements including availability, integrity, authentication, confidentiality, and non-repudiation, and issuance of an Interim Authorization to Operate (IATO) or Authorization to Operate by the Designated Accrediting Authority (DAA), and **5) Supportability requirements to include SAASM, Spectrum and JTRS requirements.**

Supportability

- **Threshold = Objective**
  - **Spectrum Supportability**
    - **Verify the system has an approved (Stage 4) DD Form 1494 (for any spectrum dependent system) (DoDI 5000.02)**
    - **Verify completion of applicable requirements of DODD 3222.2, “DOD Electromagnetic Environmental Effects (E3)”**
  - **Selective Availability Anti-Spoofing Module (SAASM)**
    - **Verify any GPS receivers procured are SAASM compliant or that a waiver has been obtained from ASD(NII)**
  - **Joint Tactical Radio System (JTRS)**
    - **Verify a JTRS solution or waiver from ASD(NII) for any radio solution operating within the 2MHz to 2 GHz range***

****Reference: (ASD(NII)/DOD CIO memorandum, 23 May 2005, “Temporary Suspension of the Joint Tactical Radio Systems (JTRS) Waiver Process” and ASD(NII)/DOD CIO memorandum, 12 January 2007 “Reinstatement of the Joint Tactical Radio, (JTRS) Waiver Process for Handheld Radio Procurements”)***

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Interoperability Certification Products

Certification	Description	System can be fielded (Y/N)?
Standards Conformance Certification	System is certified for conformance to a standard/standards profile	No
Joint Interoperability Test Certification	Full system certification. System meets at least all critical interoperability requirements	Yes
Limited Joint Interoperability Test Certification	System meets subset of critical interoperability requirements	Yes, with ICTO
Interim Joint Interoperability Test Certification	Capability module has adequately demonstrated interoperability for at least all critical threshold requirements identified for the increment	Yes
Special Interoperability Test Certification	Certification is based on other J-6 approved requirements other than the NR-KPP, e.g., use of UCR for voice switches	Yes
Non-Certification	Critical operational impacts expected Provides a warning to the warfighter	No
Interoperability Assessment	PM would like to determine interoperability status. System may lack J-6 certified requirements	No

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Contact Information & Resources

- **Hotline**
  - 24/7 C4I Technical Support
  - 1-800-538-JITC (5482)
  - hotline@disa.mil
  - http://jitc.fhu.disa.mil/support.html
- **Joint Interoperability Tool (JIT)**
  - http://jit.fhu.disa.mil
  - Lessons Learned reports
  - NATO Interface Guide
- **System Tracking Program (STP)**
  - https://stp.fhu.disa.mil
  - Test events
  - Test plans and reports
  - Certification results
- **NR-KPP Helpdesk**
  - NR-KPP_Helpdesk@disa.mil
- **NR-KPP Testing Guidebook**
  - https://www.us.army.mil/suite/doc/23429848
- **CJCSI 6212 Resource Page**
  - https://www.intelink.gov/wiki/Portal:CJCSI_6212_Resource_Page

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Questions?

Danielle Mackenzie Koester
Chief, Engineering & Policy Branch
Joint Interoperability Test Command
March 15, 2011

DEFENSE INFORMATION SYSTEMS AGENCY

A Proposal for Robotic Entity Safety Release

NDIA 27th Annual National Test and Evaluation Conference

Presenter: Dr. Jeffery V. Mosley
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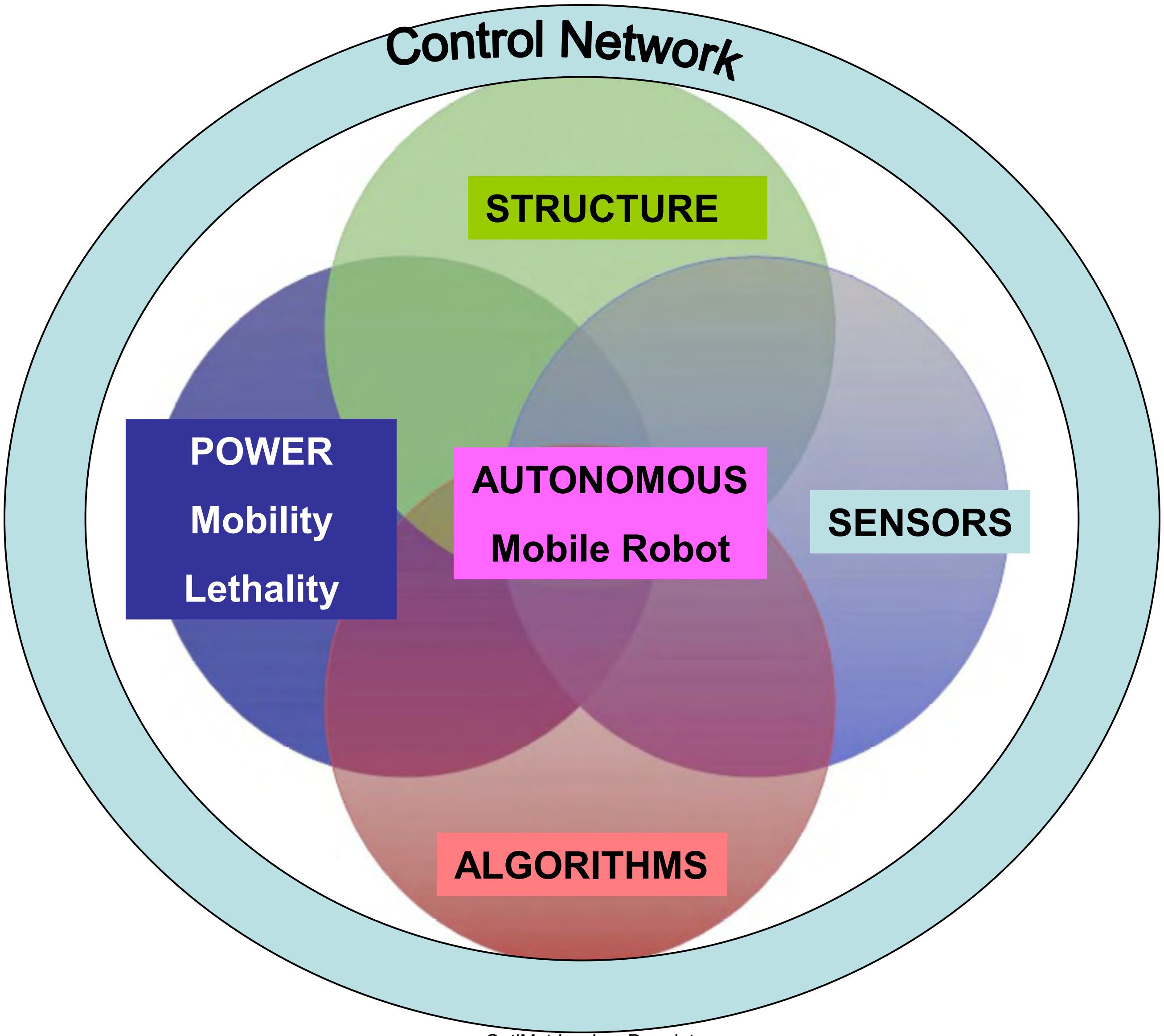
A Proposal for Robotic Entity Safety Release

Definitions



Objective

- To reduce the high risk nature for the OSD T&E safety releases and confirmations involving collaborative and autonomous robotic missions for the Armed Forces
- Effective Risk Mitigation Requires Established:
    - Measures of Performance
    - Relevant COICS
    - Relevant KPPs
    - Relevant TPMs
    - Ability to Reliably Replicate the Intended Environment for use

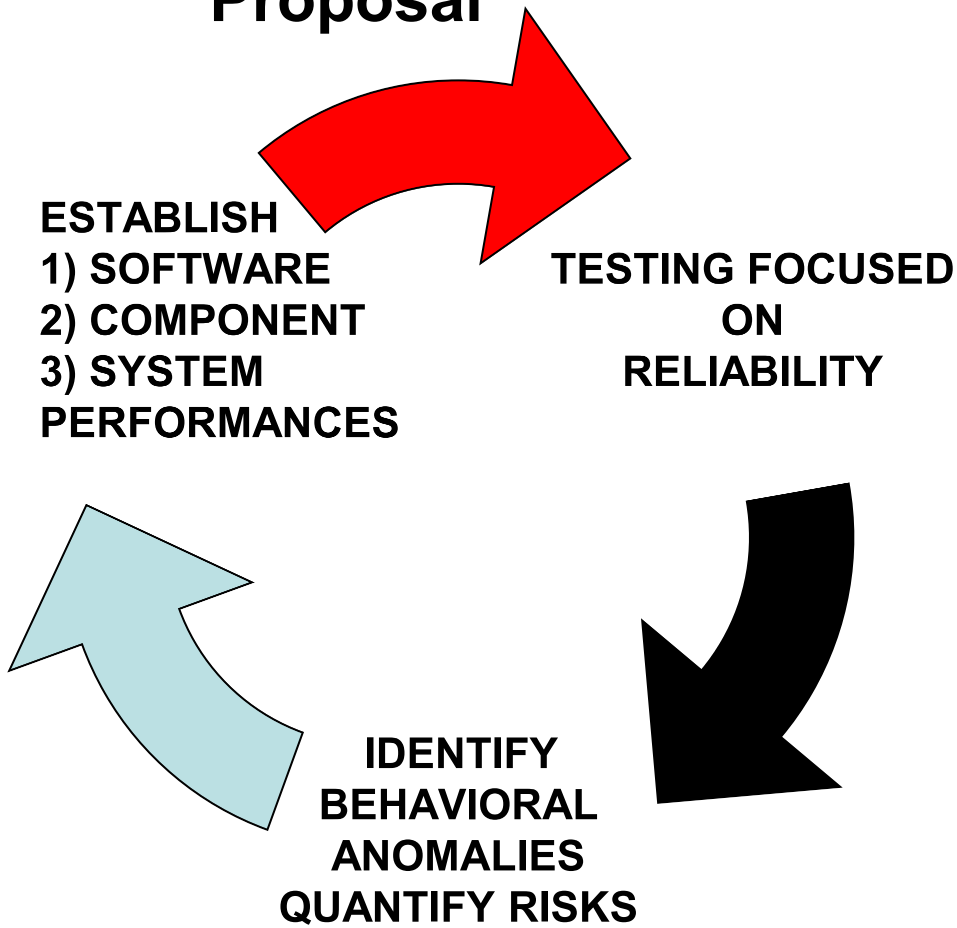
Scope

There can be a process implemented where the affected Project Management offices, the Warfighter, and T&E organizations can utilize advanced simulation, component level testing, and iterative limited user testing to achieve the goal of a full safety confirmation for human and robotic collaborative operations.

Automate as much testing as possible to support T&E and PM and Warfighter requirements

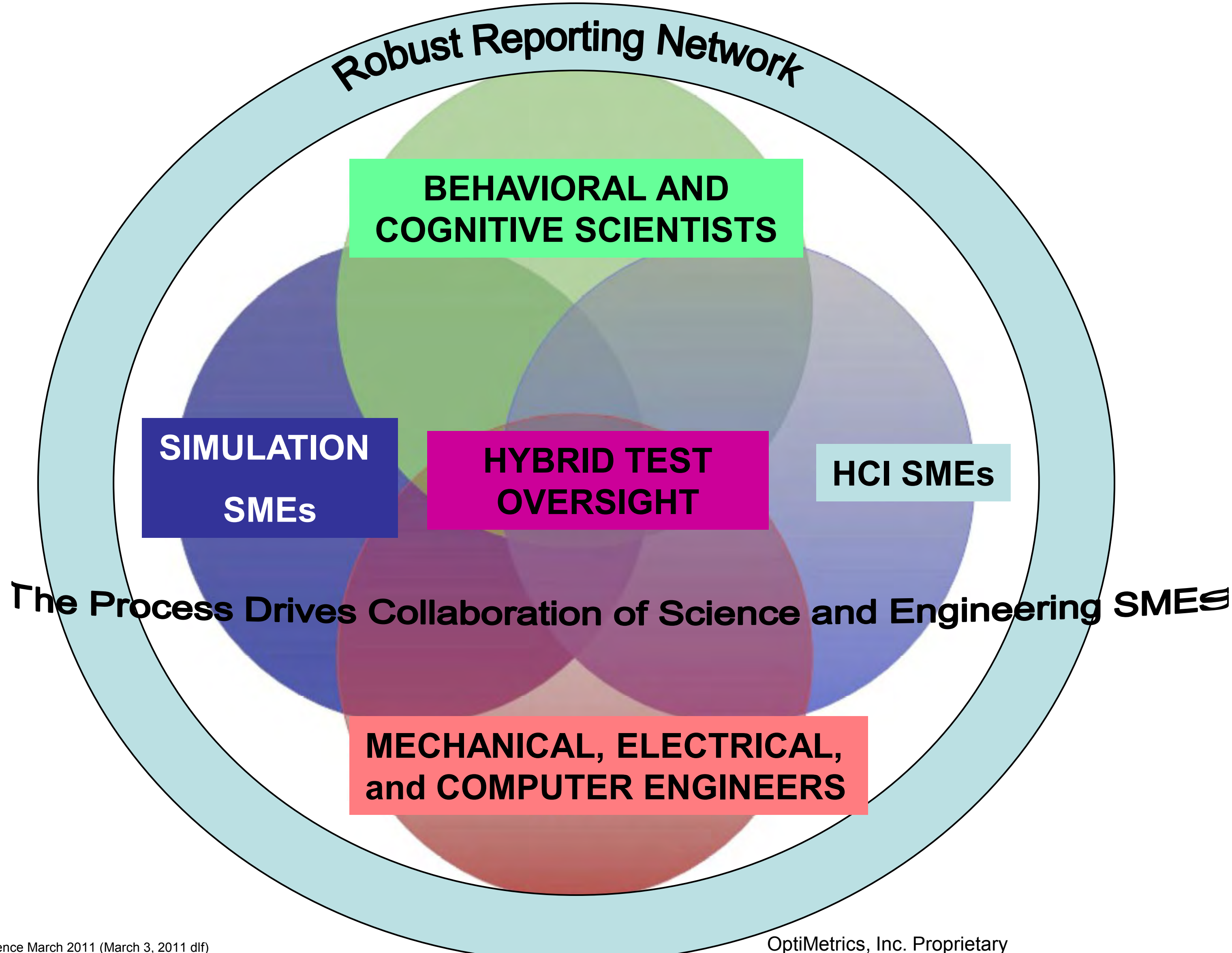
A Proposal for Robotic Entity Safety Release

Proposal



The process not only establishes system performance, but supports system confidence and quantifies system reliability

New Categories of Testers/Evaluators



Challenges

- Environment Accreditation
- Exponential Permutations in Software Code
- Potential for Concomitant Affects
- Potential for Critical System Bugs

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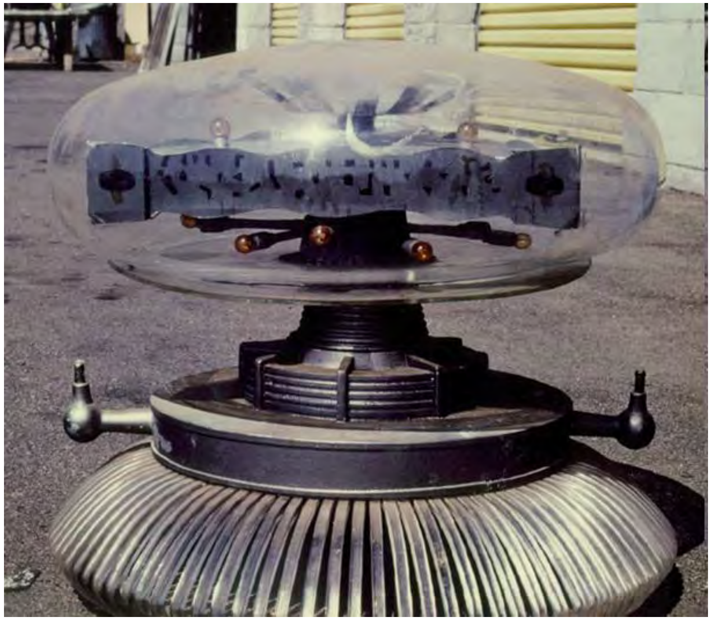
Software Cybernetics

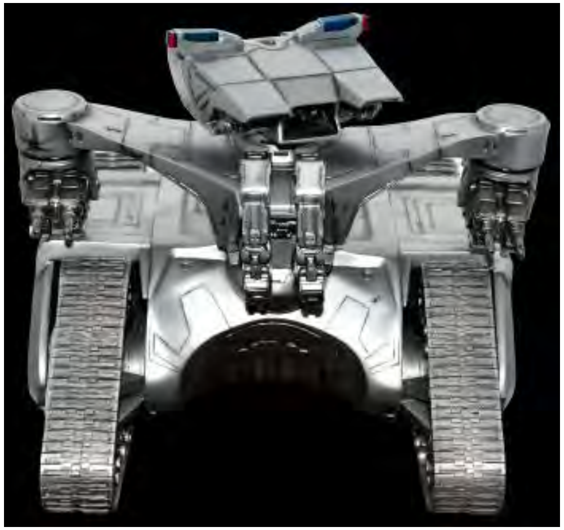
- T&E Scope
- Multi-dimensional Nature
- Potentially non-linear T&E
- Simultaneous and Conditional Channels of Information (increased I/O)
- Level of Cognition
- Open Questions



Developmental Testing

Successful Safety Testing for Release and Confirmation Leads to Acceptable Risk for Developmental Test

- Establish Performance Envelopes
- Assess Degraded States/Error Conditions
- Extrapolate Operational Profiles
- Test for Reliability as a Function of Capability
- Establish Risk of Action (Correct and Incorrect)
- Identify Failures Impacting Reliability of Operation



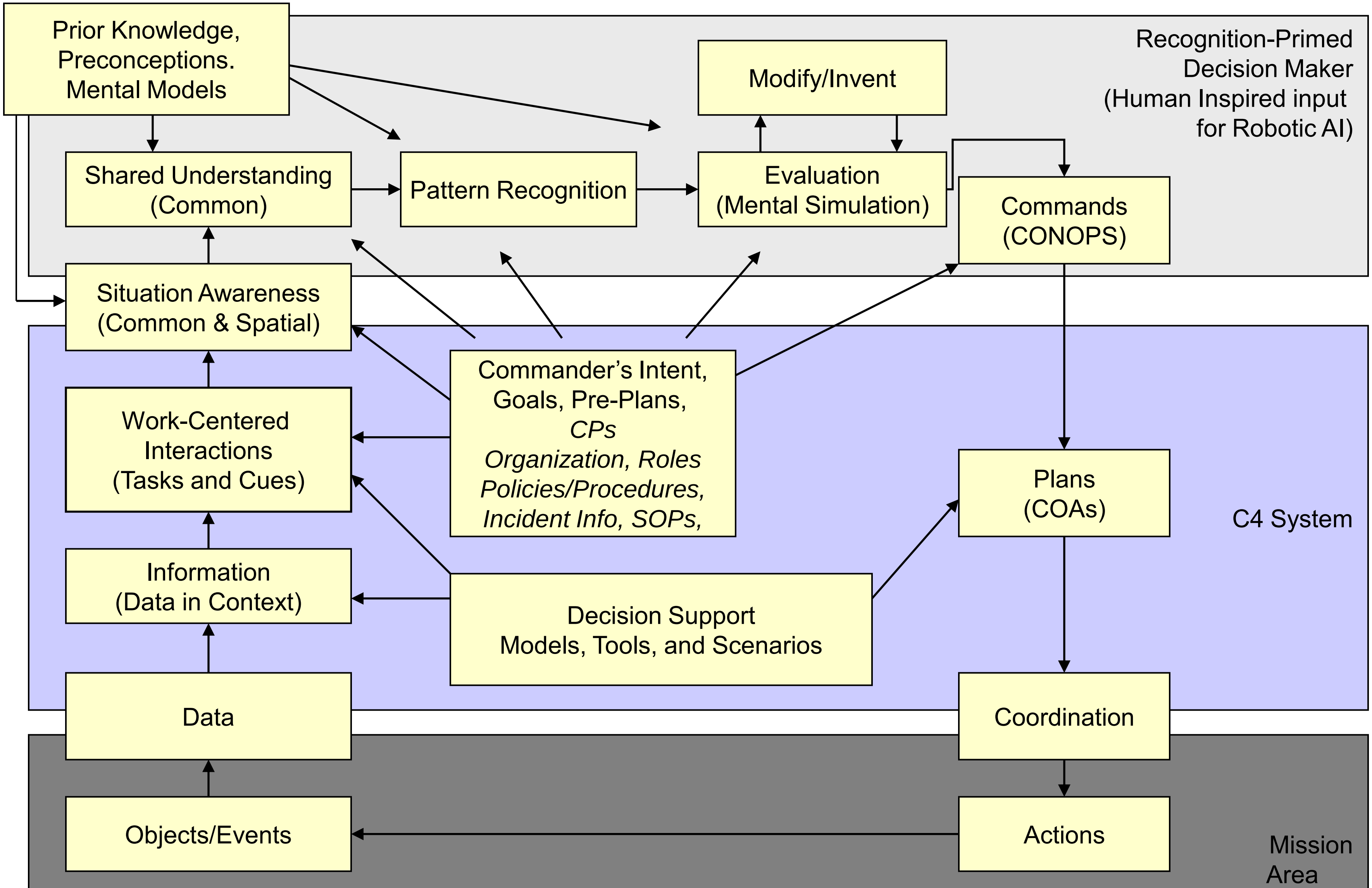
A Proposal for Robotic Entity Safety Release

Something New

1) Assess Robotic Behavioral defects against their impacts on Performance baseline and successively more difficult test cases; Defects and anomalies are quantified to assess risk of failure or range of potential actions and their risks to mission reliability/success
2) The process begins with software and is continued for all system components and systems
3) The evaluation of the System of Systems is accomplished through repetition of mission environments
4) Outcomes establish mission norms and protocols for operation

Robotic behaviors will be synonymous with mechanical system function in the future

A Potential Schema for Robotic Development and Evaluation



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Operational Test/Usage Requirements

- Getting the Right Technology to the Warfighter
- Focused Operational Testing
- Allowing Conditional Autonomy
- Validation of Degraded States of Operation
- Trust and Confidence of Operation and Performance
- Error Tolerant Systems
- Ability to Adapt to Social Cues
- Ability to Operate in a Variety of Dynamic Environments

"Soldiers must be able to control autonomous systems to suite conditions as they change over time." (LTG Vane U.S. Army)

New Tools

- Leverage of OGA Technology Rodeo and Challenge Events
- Adaptive Software Testing
- Use of Genetic Algorithms
- Enhanced Simulation Environments
- Development of Reality Arenas

The process will require multiple looks at the system under test

A Proposal for Robotic Entity Safety Release

Outcome

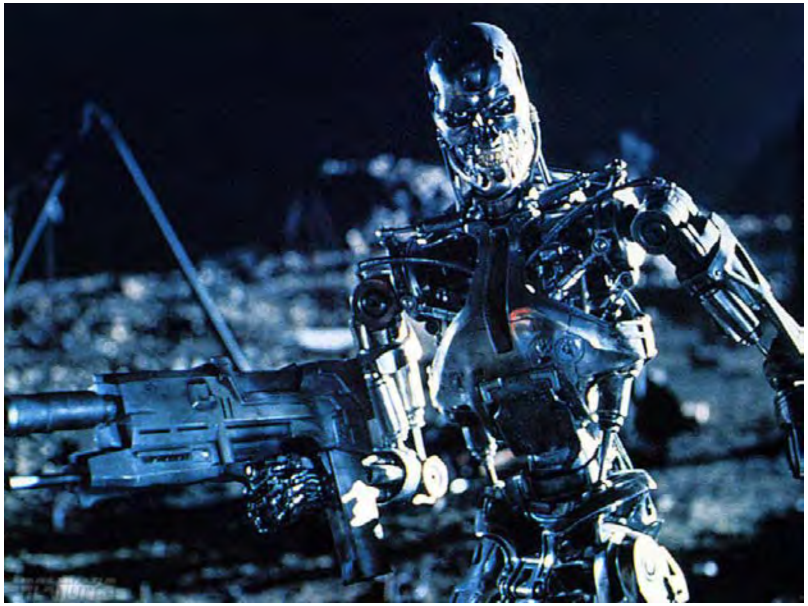
The OSD T&E community will have supported the development and institutionalization of a repeatable process and robust tools that can be re-used across many robotic platforms and potentially provided to robot vendors, and usable by the PMO for simulation based acquisition

We must plan now, how to evaluate the technology of tomorrow, today

A Proposal for Robotic Entity Safety Release

Additional Considerations

- Interactive Training (Embedded) in Robotic Systems
- Robotic Puckstering
- Co-existence (social/work networking)
- Far-reach Maintenance Operations






A Proposal for Robotic Entity Safety Release

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Defense Information Systems Agency

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Defense Information Systems Agency

Joint Interoperability Test Command

Decoupled Test, Evaluation, and Certification of a System of Systems (SoS)

15 March 2011

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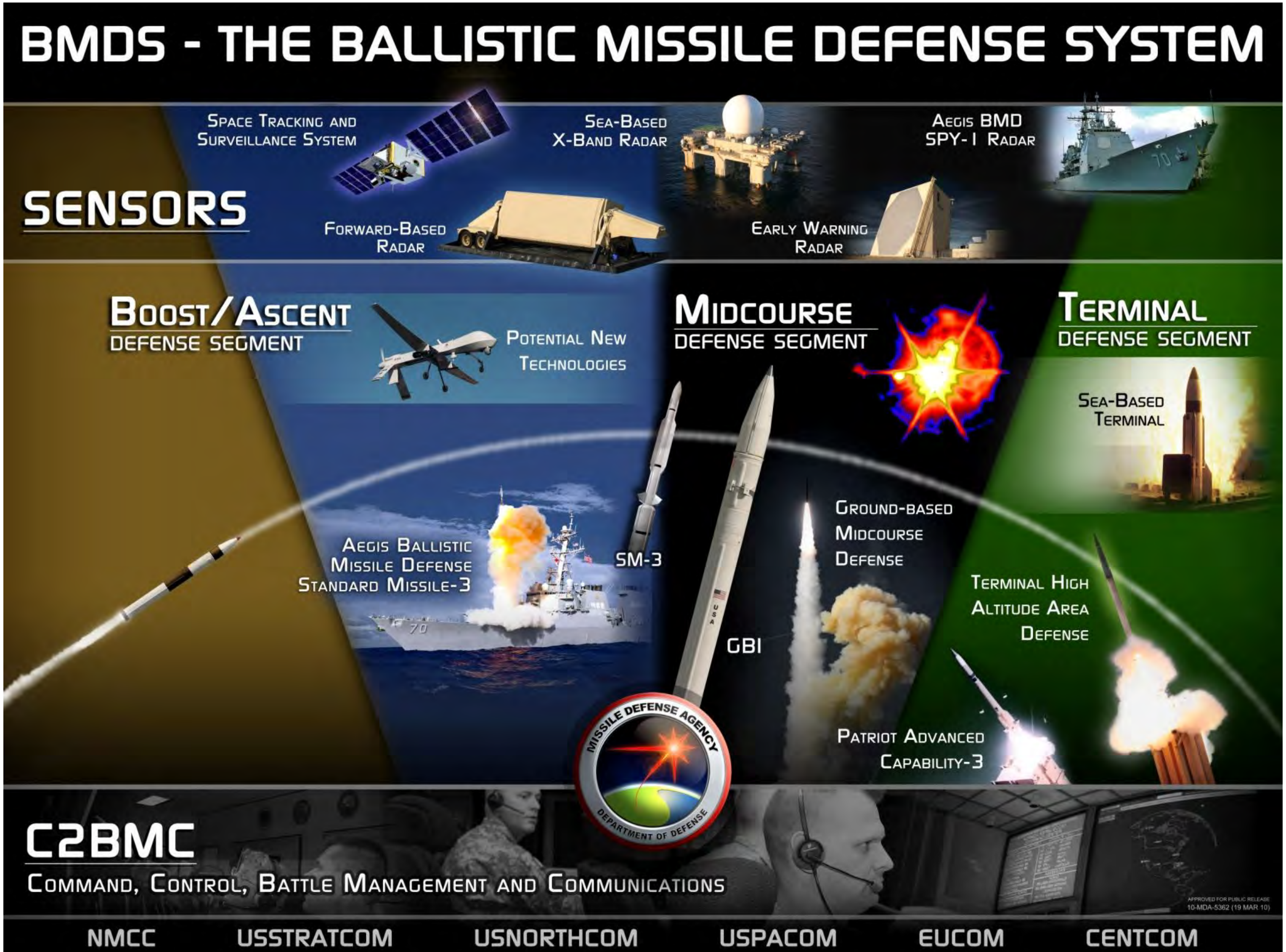
Overview

- This presentation outlines the use of agile testing concepts, decoupled testing, to reduce risk and accelerate a Joint Interoperability assessment/ characterization of a highly complex System of Systems (SoS) that does not have an overarching Joint Staff (JS)-approved set of requirements

- Our example is the Ballistic Missile Defense System (BMDS), which has no JS-approved requirements, and its elements (THAAD, Patriot, JTAGS, AEGIS, etc.), which do have JS-approved requirements


BMDS - THE BALLISTIC MISSILE DEFENSE SYSTEM
SENSORS
Space Tracking and Surveillance System
Sea-Based X-Band Radar
Aegis BMD SPY-1 Radar
Forward-Based Radar
Early Warning Radar
Boost/Ascent Defense Segment
Potential New Technologies
Midcourse Defense Segment
Terminal Defense Segment
Sea-Based Terminal
Aegis Ballistic Missile Defense Standard Missile-3
SM-3
GBI
Ground-based Midcourse Defense
Terminal High Altitude Area Defense
Patriot Advanced Capability-3
Missile Defense Agency
Department of Defense
C2BMC
Command, Control, Battle Management and Communications
APPROVED FOR PUBLIC RELEASE 10-MDA-5362 (19 MAR 10)
NMCC
USSTRATCOM
USNORTHCOM
USPACOM
EUCOM
CENTCOM

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Background

- Secretary Rumsfeld memo dated 2 January 2002:
  - Directed that the BMDS will not be subject to the traditional requirements generation process
  - Directed a capability-based requirements process for MD
  - Directed the Services to procure the BMDS elements
  - Directed that Service BMDS elements will enter the formal DoD acquisition cycle at MS C
  - Directed use of rapid decision making cycles for MD

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Background (cont.)

- Individual elements of the BMDS have gone through the Joint Capabilities Integration Development System (JCIDS) process and developed applicable architecture documents, etc.
- BMDS has no Joint Staff (JS)-approved requirements and no intention to develop “JCIDS-like” documents
- Assess-to Criteria (AtC) document
  - BMDS Warfighter-developed requirements document
  - Development is on hold and future is unknown
  - Unlikely it would be formally approved by the JS

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Decoupled Testing

- **DECOUPLED TESTING:**
  - Each component/element test stands on its own, not dependent upon or being impacted by the results of other tests
  - Identifies the separation of capability blocks whose development shouldn't depend on each other
  - Allows system designers to have as little dependencies as possible
  - Reduces the risk of malfunction in one part of a system of systems when other parts are changed
  - Does not need a detailed requirements specification/speculation
    - Need architecture diagrams
    - Need a scope overview
  - Instead of testing against the specification, the independent testing effort will focus on:
    - production-level system integration testing
    - formal usability testing
  - Supports DoD 5000.02 concept of Integrated T&E

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IAP Development

- JITC develops an Interoperability Assessment Plan (IAP) to look at System of System BMDS interoperability requirements
- Similar in concept to the JITC Interoperability Certification Evaluation Plan (ICEP)
  - Establishes a test and evaluation strategy for evaluating interoperability requirements in:
    - the most efficient and effective manner
    - in an operationally-realistic environment
  - Test and evaluation strategy identifies:
    - Data necessary to support an interoperability evaluation
    - Test events/environments planned to produce that data
  - Certification vs. Assessment

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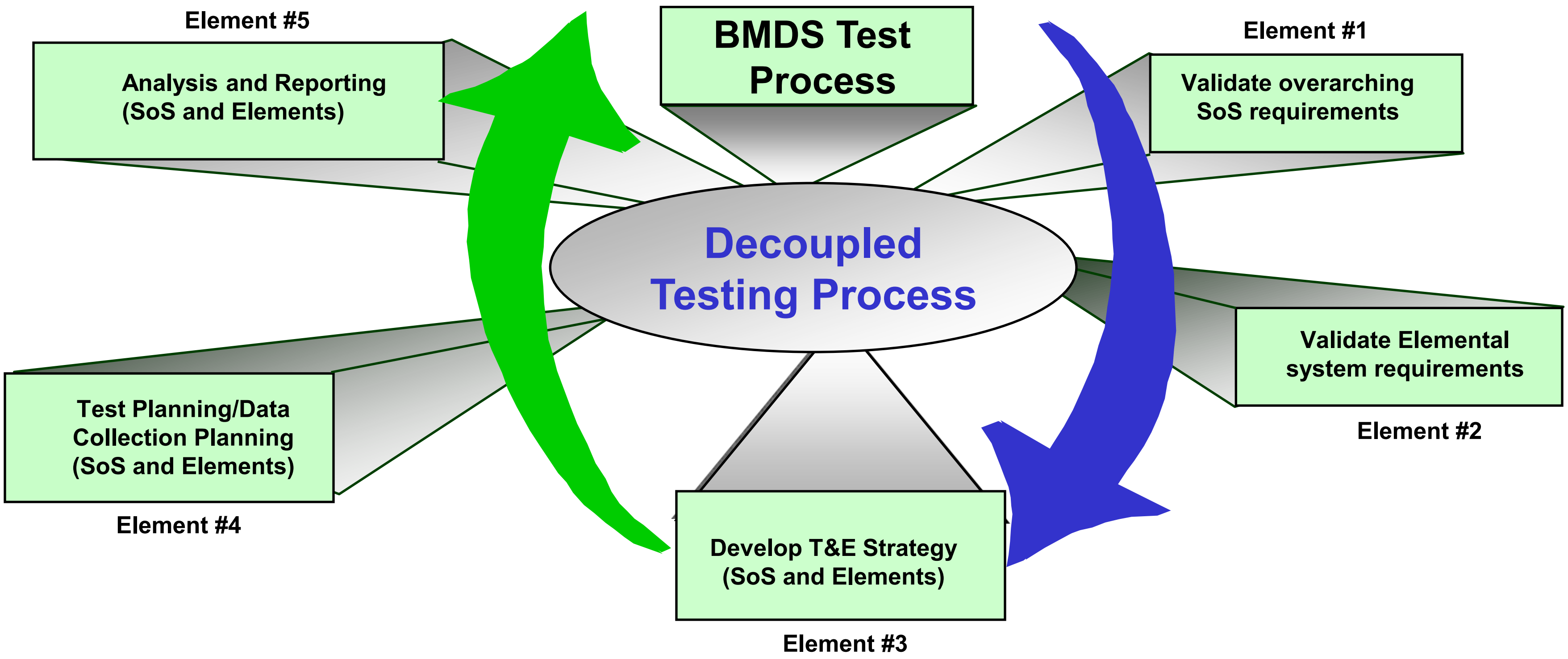
Elements of the IAP

JITC, Fort Huachuca, AZ



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Element #1: Validate Overarching SoS Requirements

- JCIDS
- Capability Portfolio Manager (CPM)
- Communities of Interest (COIs)
- Department of Defense Technology Standards and Profile Registry (DISR)
- Concept of Operation (CONOP)
- Concept of Employment (CONEMP)
- Joint Mission Threads (JMT)
- Meta Data Registry (MDR)
- Tactics/Techniques/Procedures (TTPs)
- IMTP
- M&S Plan

Element #2: Validate Elemental System Requirements

- Same as SoS requirements for each elemental system multiplied (times the number of associated component systems)
- Must identify commonality and deltas between each element requirements and the SoS requirements (times the number of associated component systems)
- Must identify commonality and deltas between each element requirements and the requirements of other elements of the SoS (times the number of associated component systems)

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Element #3: Develop T&E Strategy (SoS and Elements)

- Test and Evaluation Master Plan (TEMP)
- Combined Test Team (CTT)/Integrated Test Team/Integrated Product Team, etc
- Development Test (DT) Test Organization documents
- Operational Test (OT) Test Organization documents
- Interoperability Test Organization documents
- Modeling and Simulation Analysis (Do models and simulations exist which support test requirements?)
- Major Range and Test Facility Base (MRTFB) analysis (What existing infrastructure exists to support test requirements?)
- Analysis of emerging technologies (What new test methods and equipment might be required to support test requirements?)

Element #4: Test Planning/Data Collection Planning (SoS and Elements)

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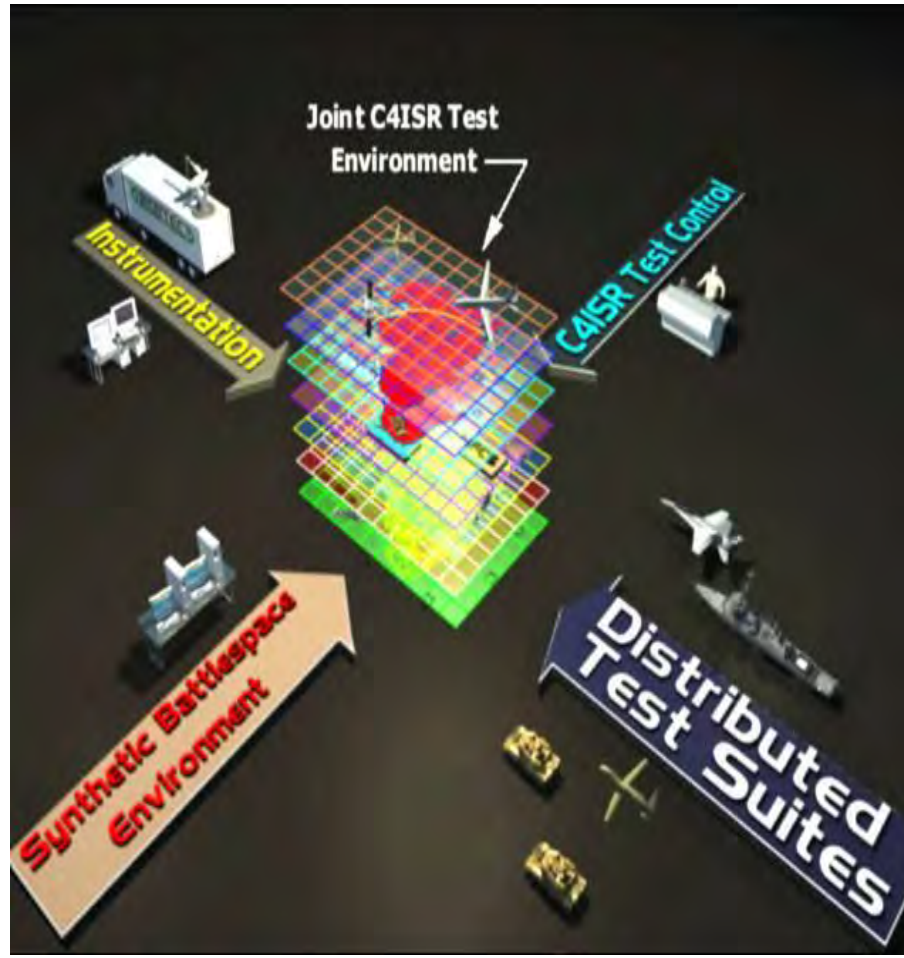
- Develop IAP
  - Standards Conformance Testing Requirements and testing organizations
  - Interoperability Testing Requirements and testing organizations
  - OT Requirements and testing organizations
  - Service Level Testing and Developmental Testing
  - Test Venues
    - Laboratory (Contractor/Government)
    - Service Level Testing and DT
    - JITC
    - Operational Test
    - Combined/Joint exercises
    - Post fielding assessment in the theater
  - Types/amount/formats of data
  - Use of Design of Experiments
  - Tools (Data Collection & Analysis)



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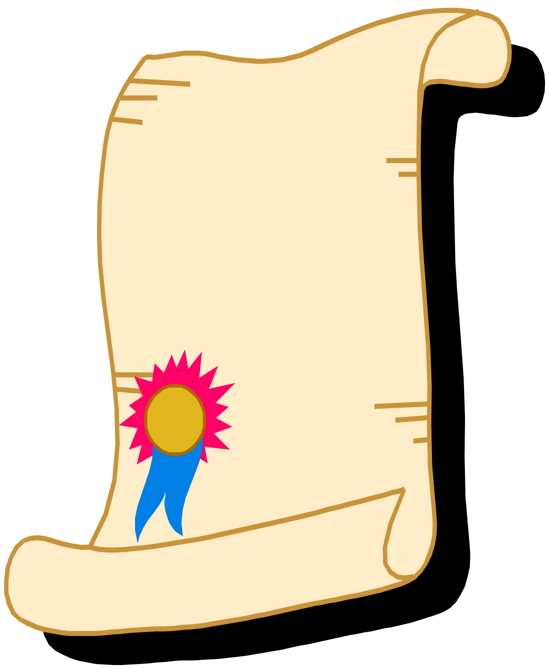
Element #5: Analysis and Reporting (SoS and Elements)

- Information Assurance Results
- Spectrum Results
- Standards Conformance Testing Results
- Interoperability Testing Results
- Capabilities and Limitations
- Data Analysis Group (DAG)/Data Analysis Working Group (DAWG)
- DT Results
- OT Results
- Net Readiness – Key Performance Parameter (NR-KPP) Status
- Status of Interoperability Report (SIR)
- Test Incident Report Database
- System Tracking Program



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IAP Data/ Information Sources

- **MDA/Element Events**
  - FTG
  - FTD
  - GTD/GTI
  - FTT
  - FTM
  - FTP
  - FTO
  - Exercises/Live Events
  - Element LUTs

- **JITC Events**
  - TDL JIT
  - DICE
  - GCN Testing

- **Other Events**
  - IA Testing
  - Juniper Cobra

LEGEND:
DICE – DoD Interoperability Communications Exercise
FTD – Flight Test Distributed
FTG – Flight Test GMD
FTM – Flight Test Standard Missile
FTO – Flight Test Operational Patriot
FTP – Flight Test Patriot
FTT – Flight Test THAAD
GCN – GMD Communication Network
GTD – Ground Test Distributed
GTI – Ground Test Integrated
JIT – Joint Interoperability Test
LUT – Limited User Test
TDL – Tactical Data Link

IAP Test Venues

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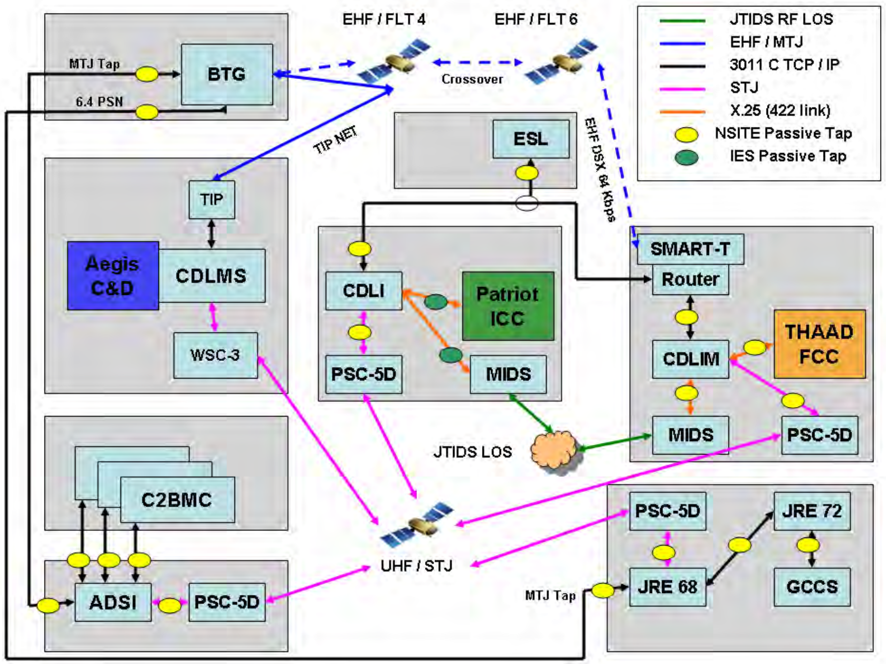

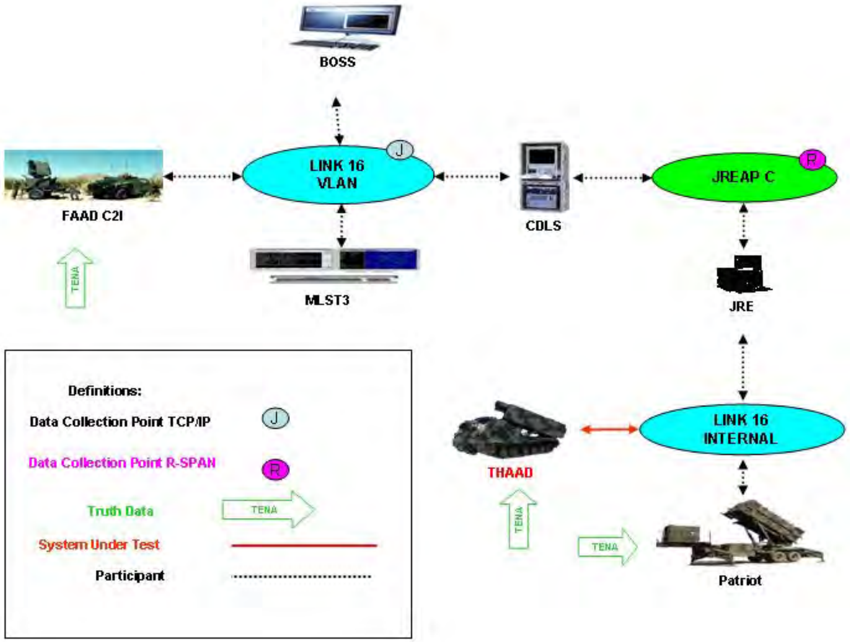

Summary

- Use of decoupled testing will reduce risk and accelerate a Joint Interoperability assessment/ characterization of the BMDS System of Systems

- The development of the BMDS IAP will enable JITC to provide a more thorough assessment and characterization of BMDS capabilities and limitations, and provide the BMDS Warfighter a better understanding of the systems they are using.

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Questions?

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Abstract ID #: 11710

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Defense Information Systems Agency
Department of Defense

Testing US Systems for Coalition Interoperability

LTC Timothy Timmons
Joint Interoperability Test Command
16 March 2011

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Outline

- Purpose
- The Reality
- The Problem
- Consequences
- Current Working Solutions
- Planning Tool
- Limitations
- Future Way Ahead
- Summary

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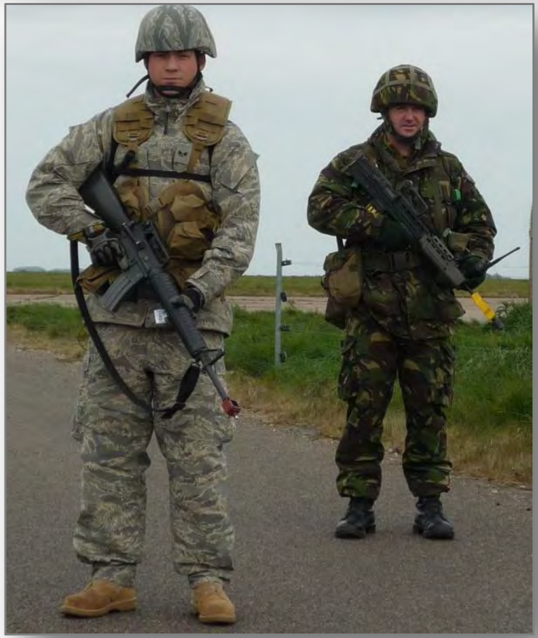
Purpose

Considering the difficulties facing the US T&E community in its efforts to achieve intra- and inter- service interoperability, the problems associated with trying to tackle coalition interoperability can seem insurmountable.

This briefing defines the current problem, discusses current ways US Combatant Commands are addressing the issue, and proposes a way ahead.

The Reality

- US expects to work in concert with allied and coalition forces in nearly all future operations
- Since US participates in coalitions when undertaking both combat and noncombat operations, interoperability needs to be addressed across the entire spectrum of operations
- US will not hold back on the pursuit and acquisition of technologically advanced systems
- Downside of unrestricted advancement is the potential to become a "technology island"



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JOINT INTEROPERABILITY TEST COMMAND

The Problem

- Many complexities conspire to make coalition interoperability a difficult issue to resolve
- Consider the challenges:
  - Shrinking defense budgets
  - No enforcement mechanism
  - Various levels of C2 sophistication
  - Loose or nonexistent international standards
  - National interoperability first and foremost
  - National proprietary equipment
  - Different national requirements and priorities
  - Diverse procurement methods
  - A constantly moving target
  - Coalition task organization variables

The opportunities to diverge versus converge are great

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Consequences of Failing to Address the Problem

- Examples abound in almost every multinational combat, peacekeeping, humanitarian assistance and disaster relief operation in recent history
  - Desert Shield/Desert Storm
  - Somalia
  - Bosnia
  - Kosovo
  - Pacific Tsunami
  - Haiti Earthquake
  - Iraq
  - Afghanistan
- Detrimental impact on mission, lives & resources

The battleground should not be the testing ground

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Current Working Solutions: Endeavor Workshops

- **Several US COCOMs are actively tackling the issue of coalition interoperability**

- **EUCOM, AFRICOM, PACOM conduct annual workshops**

- **EUCOMs Combined Endeavor exercise is the oldest, largest and most sophisticated of the three**

- **Endeavor Workshops:**
  - A testing venue for potential coalition partners
  - Comprised predominantly of fielded systems
  - Field assessments of interoperability, not laboratory testing
  - Identified interoperability issues serve as a catalyst for follow on in-depth testing
  - Results thoroughly documented and archived to produce a useful field guide for both planners and operators

Planning Tool: Interoperability Guides

- Interoperability Guide published at the completion of each Endeavor
- Single most important product to come out of the exercise
- DVD media
- Java based
- Includes:
  - all assessments that have been verified and validated (912+ at CE10)
  - archive of all assessments since workshop inception
  - Equipment Specifications
- Extensive search and query capability
- Multiple success stories of guides use by participants

Limitations with Current Solutions

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- Endeavor programs are a step in the right direction but they have limitations:
  - Only identify interoperability after the fact
  - Occurs only once a year
  - Brief test window
  - Logistically intensive
  - Limited to nations in a geographic area
  - More focus on equipment vs. systems
  - Limited scope
  - No enforcement mechanism
  - Limited external synchronization

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Future Way Ahead

- Greater strides in coalition interoperability can and must be made
- Discussion should start between countries at the highest international strategic level to sort out the competing priorities
- Greater strategic direction to working groups
- Addressing interoperability during the development process
- Establishment of a persistent federated on-demand multinational test environment
- Incentives and enticements
- Expanded Endeavor coverage

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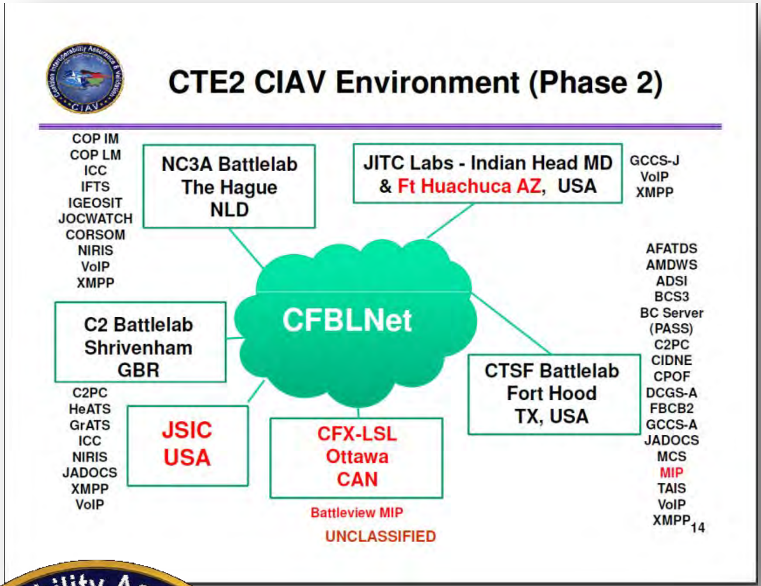
Future Way Ahead: CIAV, CTE2

- AMN Coalition Interoperability Assurance and Validation Working Group is building this model test environment today
- Coalition Test & Evaluation Environment (CTE2)
  - Year-round interoperability testing and certification environment
  - Federation of distributed test facilities based on the CIAV model
  - Test sites in US, UK, Canada, Italy and Belgium
  - Emulates the AMN operational environment
  - Mission thread focus
  - Scope all encompassing
- Required certification before introduction into AOR



Future Way Ahead: GCIP, Predictive Interoperability

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- **Global Communications Interoperability Program**
  - A online application with a single interface to simultaneously references multiple, existing interoperability databases
  - Query data/results from all 16,137 field assessments (since 1995)
- **JITC's Value Added**
  - We're building this unique capability "Out-of-Hide"
  - Leveraging its years of experience supporting COMBINED ENDEAVOR, AFRICA ENDEAVOR, and PACIFIC ENDEAVOR to affect the future…
  - Databases are updated/expanded, functionality increased with every Endeavor event JITC supports
- **Impact to the Warfighter**
  - Within minutes, GCIP provides quick, accurate, concise system interoperability answers for right-now support
  - J-6 planners can predict network and system interoperability—both good and bad—and plan accordingly
  - COCOMs can deploy to any theater, with almost any Nation and be able to predict what will work, and what will not work

GCIP Today
Contains system data from over 90 Nations

Summary

- Coalition operations are here to stay
- Coalition interoperability has emerged as a critical but complex issue, fraught with great advantages and extremely difficult problems
- Ample opportunities abound for divergence, but convergence will take determination
- COCOM Endeavor workshops are tackling coalition interoperability today
- The future is a <u>persistent</u>, <u>federated</u>, <u>on-demand</u> multinational test environment
- Most nations agree the costs are worth the headaches

The battleground should not be the testing ground

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Abstract ID #: 11710

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DoD Strategic Plan for Test and Evaluation Resources

15 March 2011

Mr. Lee Schonenberg
Strategic Planning Division

Outline

- Purpose
- Goals and Objectives
- DoD Strategic Plan for T&E Resources
- Processes
- Products

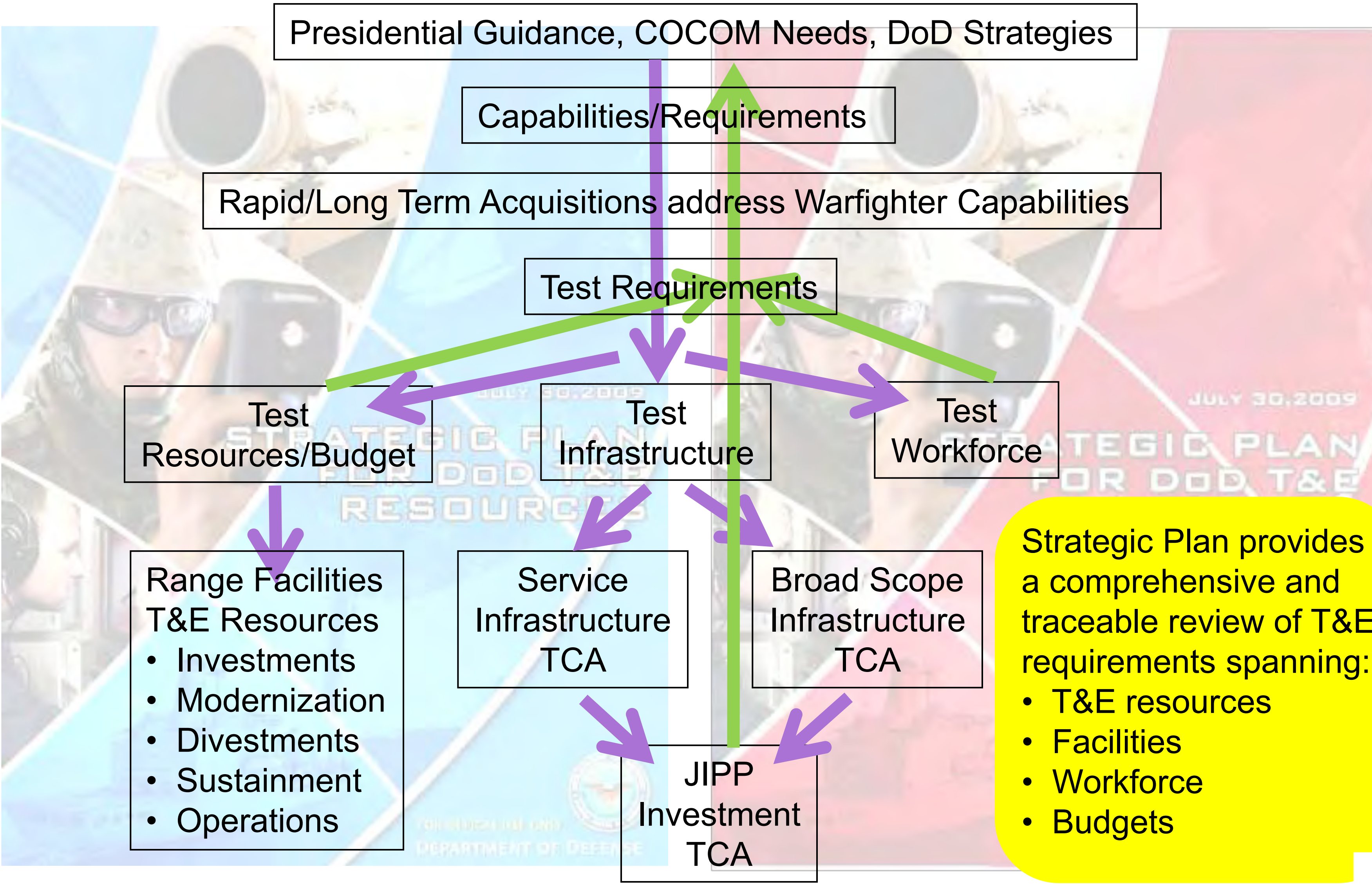
Strategic Planning Purpose

- Provide a vision of the capabilities and investments needed to support the testing of future warfighting capabilities
- Assess T&E resources from DoD T&E, non-DoD government, commercial, academia, and international
- Include requisite workforce, infrastructure, and funding resulting in a T&E capability, by means of the T&E processes
- Influence Service/Agency T&E POM and Needs and Solutions investments through the budget certification process

Goals and Objectives

- Translate top-level (National, OSD, & JCS) strategic guidance into strategic direction for the sustainment, improvement, and modernization of the DoD test resource infrastructure
- Guide the service & agency investment process (Service POM, CTEIP, T&E/S&T, Reliance)
- Assess the state of the current T&E infrastructure
- Provide a foundation for budget certification

Comprehensive Review



Strategic Plan provides a comprehensive and traceable review of T&E requirements spanning:

- T&E resources
- Facilities
- Workforce
- Budgets

SASC Assessment of the 2010 Strategic Plan

"We view the Strategic Plan as an important tool for identifying gaps in T&E resources and plans for addressing them. We review it with a particular eye to the grading system -- to evaluate how well DOD is meeting identified needs -- and to the identified gaps and recommended actions. We believe that the report is a valuable document which should be useful not only to us, but to the Department. The whole point of the strategic plan is to guide the Department's actions with an analytic approach to ensure that we have the T&E resources that we need in place when we need them."

- Congressional Staff Member

T&E as an OSD Enterprise

Working closely with other oversight groups helps TRMC achieve its mission and align plans/ guidance overall

Interlocking Oversight Tasks

DT&E
reviews and approves the developmental test and evaluation plan within the test and evaluation master plan for each major defense acquisition program

ASD R&E SE
works with DT&E to ensure development test and evaluation activities are consistent with DoD processes for systems engineering & development plans

ASD R&E
works with DT&E to assess technological maturity and integration risk of MDAP program critical technologies before Milestone B

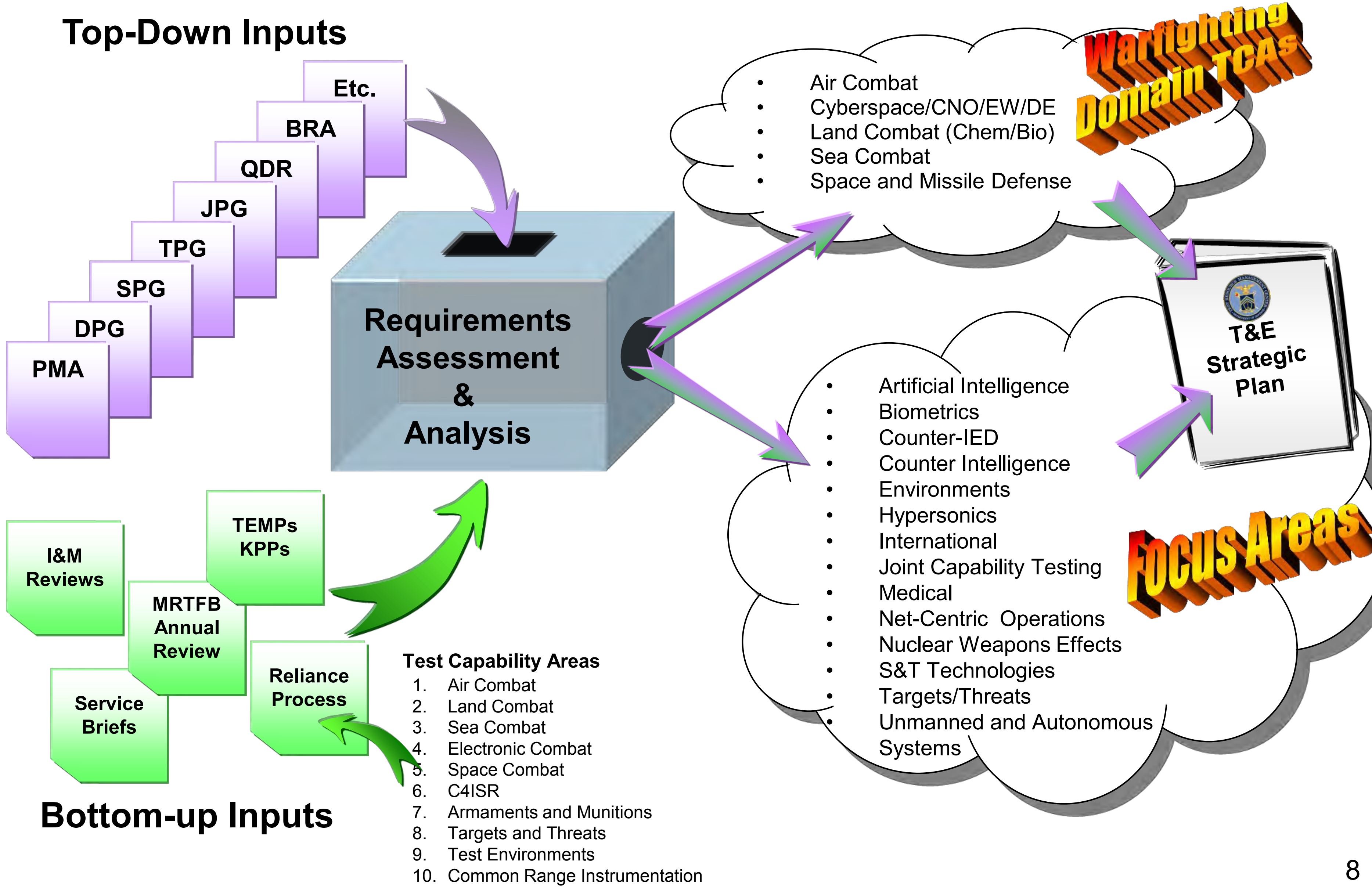
DOT&E
guides SECDEF on all budgetary and financial matters relating to operational test and evaluation, including operational test facilities and equipment

TRMC SP
oversees budgets for the test and evaluation facilities and resources, completes and maintains the strategic plan, and administers the CTEIP program

These groups share guidance responsibilities – E.g.

- Develop policies and guidance for developmental T&E activities (DT&E)
- Guide and oversee operational testing efforts (DOT&E)
- Govern test processes (AS R&E SE)
- Provide insight into future needs (ASD R&E S&T)
- Review and guide expenditures for all T&E resources and facilities within and outside the Department (TRMC)
- Review T&E requirements and assess adequacy to meet requirements (TRMC)

Building the DoD Strategic Plan



Traceability: Warfighter Needs

Warfighter requirement needs → testing → back to mission capability

Main External POC & Critical Questions

OSD, Executive, DIA, S&T	***AT&L, COCOMs***	***DT&E, DOT&E, Experts***	***SE, MDAP, T&E Users***	***Services, OMB, CAPE, Congress***
What are the emerging trends and threats?	***What are the capability requirements and warfighter needs?***	***What tests are needed given likely missions and future demands?***	***What resources and facilities are required to facilitate T&E?***	***What investments are being made to fulfill resource demands?***

Global Context & Challenges
Threats & Trends
Strategic Objectives
Complex Operating Environments

↔

Warfighter Missions / Needs
Technology Development (ACTD)
Acquisition
. . .

↔

T&E Capability
Current (available) vs.. Future Need (for current acquisition programs and future warfighter needs)

↔

T&E Enablers
Resources
Infrastructure
Specialties
Processes
. . .

↔

Programs & Investments
T&E S&T
Service POM
CTEIP
. . .

← **Systematically Map End-to-End** →

Partial / illustrative depiction

Traceability: Top-Level Guidance

- *2010 BMDR*
- *2010 QDR*
- *2006 Space Policy*
- *Etc.*

Global Context & Challenges
Threats & Trends
Strategic Objectives
Complex Operating Environments

Space and Missile Defense Strategic Objectives

Objective	Area
Reliable, Affordable, & Timely Access to Space	*Space*
Protect Space Capabilities from Interference	*Space*
Enable Defense and Intelligence Operations	*Space*
Ensure Space Situational Awareness	*Space*
Deny Enemy Use of Hostile Capabilities	*Space*
Provide Global Warning for Missile Defense	*Missile Defense*
Defend the Homeland and Allies vs.. BMD Attack	*Missile Defense*
Ensure BMD Fiscal Sustainability & Flexibility	*Missile Defense*

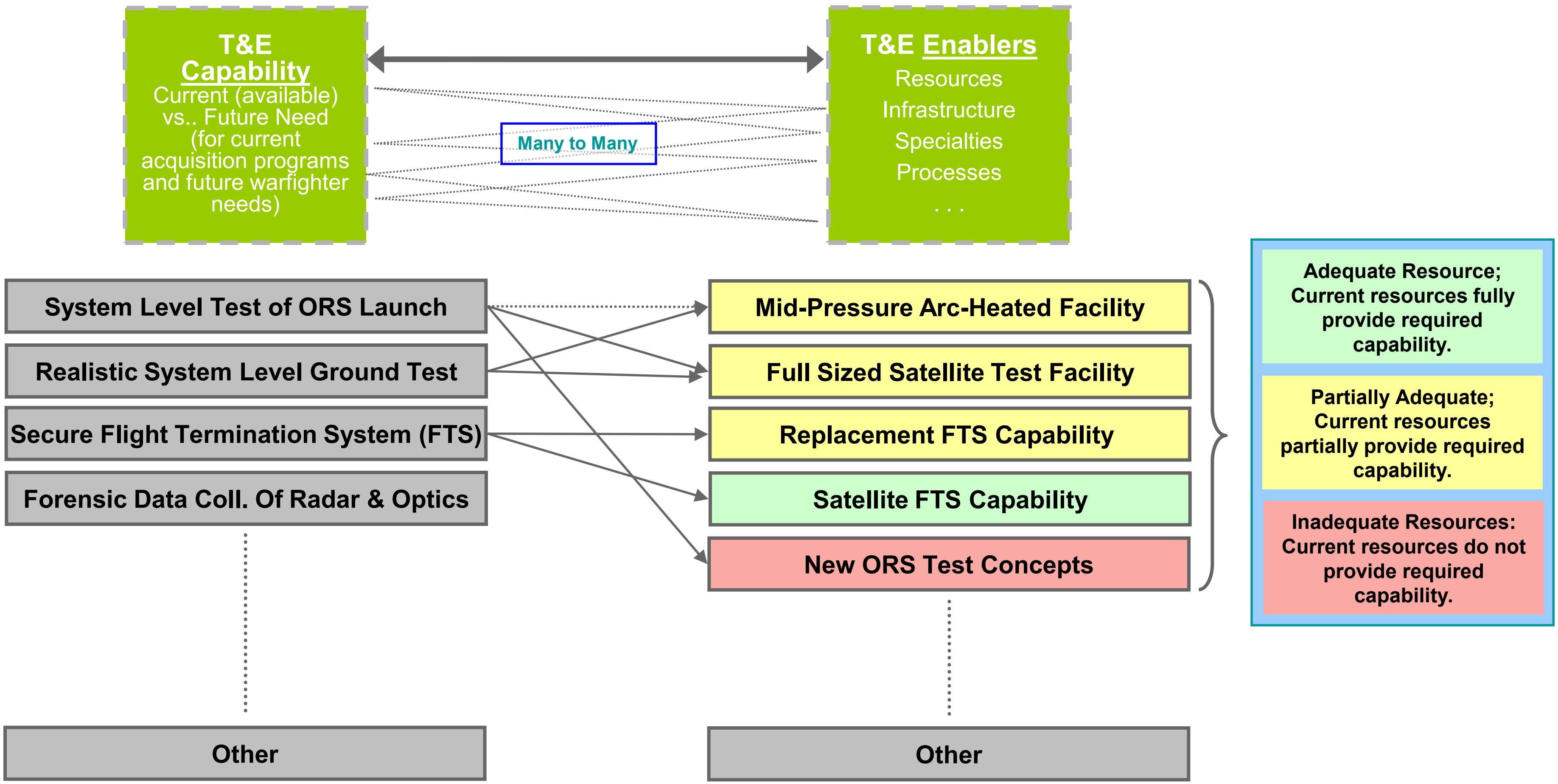
ILLUSTRATIVE LISTING

Traceability: Mapping Needs to Objectives to Requirements

Reliable, Affordable, & Timely Access to Space	**X37 B**	**System Level Test of ORS Launch**
Protect Space Capabilities from Interference	**EELV**	**Realistic System Level Ground Test**
Enable Defense and Intelligence Operations	GPS Block III	**Secure Flight Termination System**
Ensure Space Situational Awareness	Minuteman III	**Forensic Data Coll. of Radar & Optics**
Deny Enemy Use of Hostile Capabilities	NPOESS / IJPS	
Provide Global Warning for Missile Defense	SBIRS HIGH	
Defend the Homeland and Allies vs.. BMD Attack		
Ensure BMD Fiscal Sustainability & Flexibility	Other	**Other**

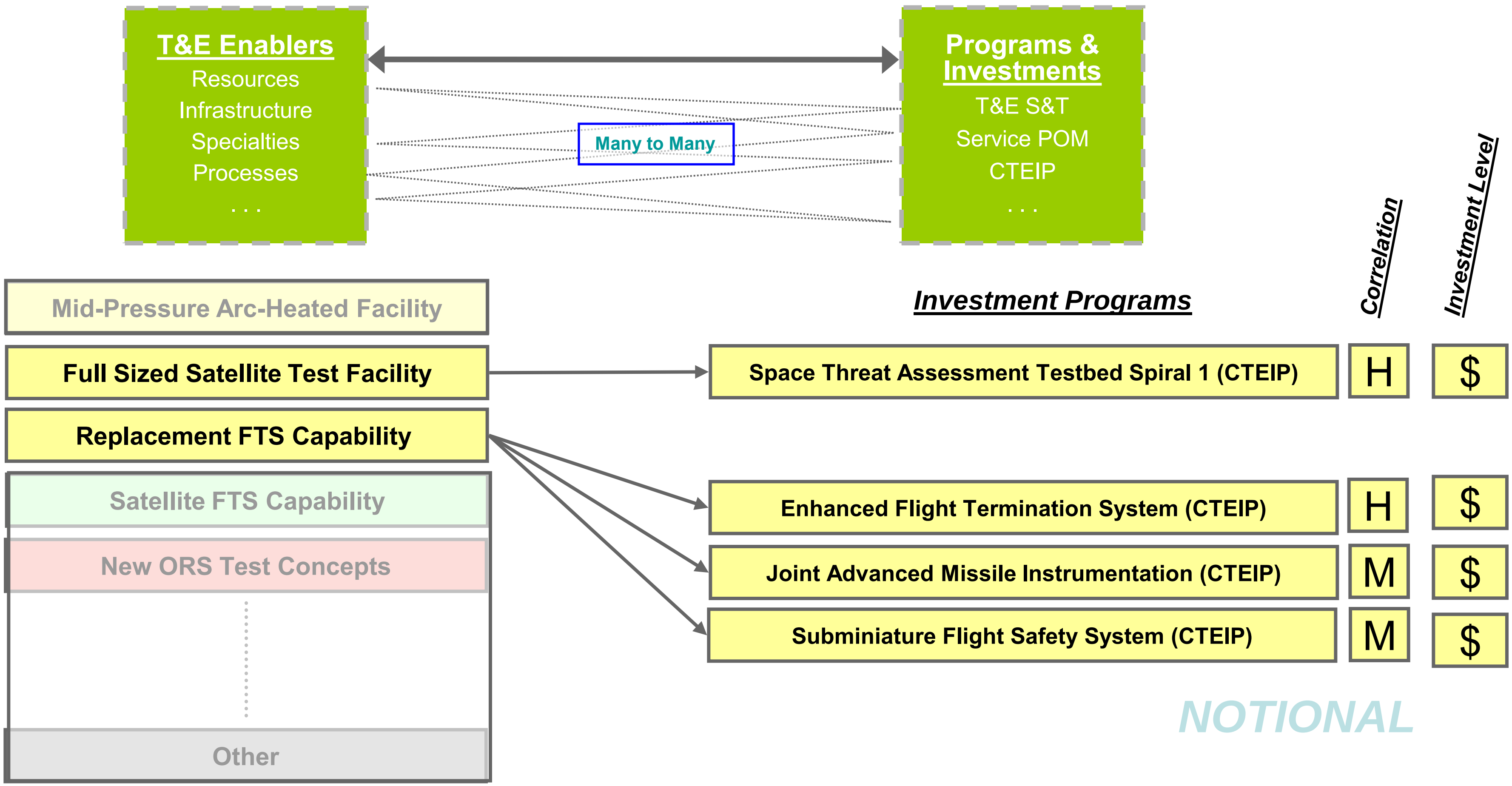
ILLUSTRATIVE LISTING

Traceability: Identify T&E Enablers



ILLUSTRATIVE LISTING

Traceability: Identify candidate investment methods



Traceability example: Space Access

Systematically Map End-to-End

Global Context & Challenges	Warfighter Missions / Needs	T&E Capability	T&E Enablers	Programs & Investments		
Threats & Trends Strategic Objectives Complex Operating Environments	Technology Development (ACTD) Acquisition . . .	Current (available) vs.. Future Need (for current acquisition programs and future warfighter needs)	Resources Infrastructure Specialties Processes . . .	T&E S&T Service POM CTEIP . . .		
Reliable, Affordable, & Timely Access to Space	**X37 B**	System Level Test of ORS Launch	Mid-Pressure Arc-Heated Facility	Space Threat Assessment Testbed Spiral 1 (CTEIP)	H	$XM
Protect Space Capabilities	EELV	Realistic System Level Ground Test	Full Sized Satellite Test Facility			
Enable Defense and Intelligence Operations	GPS Block III	**Secure Flight Termination System**	**Replacement FTS Capability**	**Enhanced Flight Termination System (CTEIP)**	H	$
Ensure Space Situational Awareness	Minuteman III	Forensic Data Coll. Of Radar & Optics	DMSP-F15 FTS Capability	**Joint Advanced Missile Instrumentation (CTEIP)**	M	$
Deny Enemy Use of Hostile Capabilities	NPOESS / IJPS		New ORS Test Concepts	**Subminiature Flight Safety System (CTEIP)**	M	$
Provide Global Warning for Missile Defense	SBIRS HIGH					
Defend Homeland and Allies vs. BMD Attack						
Ensure BMD Fiscal Soundness & Flexibility	Other	Other	Other			

ILLUSTRATIVE

Traceability: Warfighter Needs

Warfighter requirement needs → testing → back to mission capability

Main External POC & Critical Questions

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Global Context & Challenges
Threats & Trends
Strategic Objectives
Complex Operating Environments

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Resources
Infrastructure
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Processes
. . .

↔

Programs & Investments
T&E S&T
Service POM
CTEIP
. . .

Systematically Map End-to-End

Partial / illustrative depiction

Products and Effects of the Strategic Plan

Strategic Plan

- T&E Requirements
- Performance Measures
- T&E Facilities and Resources needed
- Investments needed
- Budgetary Resources needed

Inform Congress for Appropriations and Legislation

T&E Operations and Investments

Investments

New Testing Challenges

- Cyber
- Artificial Intelligence
- Autonomy
- Nanotechnology
- Environments (GPS-denied, Domains, LVC, etc…)
- Space and Missile Defense
- Soldier systems (medical, human behavior/decision-making)
- Directed Energy
- Biometrics
- Hypersonics
- Energy/Power

The Strategic Plan and Budget Certification

- The Strategic Plan:
  - Is central to the TRMC mission and associated budget certification process
  - Provides guidance for the planning, programming, and budgeting of T&E resources
  - Forecasts a period of 10 years
- T&E gaps identified in the Strategic Plan are used during the budget certification process to ensure DoD T&E capabilities exist to support current and future acquisition programs

Strategic Planning Products

- Biennial Strategic Plan for DoD T&E Resources
- Studies and Analyses
  - 2010 T&E Manpower Conversion Report to Congress (currently working)
  - 2010 Airborne Laser Study to Congress (TRMC Member of study group)
  - 2010 Tri-Service Electronic Warfare Test Capabilities Study
  - 2009 Joint Urban Test Capabilities Study (Lead)
  - Impact Report to Congress on High Energy Laser Systems Test Facility (HELSTF) and Plan for T&E of High Energy Laser Systems April 2009
- OSD AT&L Joint Analysis Teams
  - Space and Missile Defense Launch and Test (DAB/DAE Review) (TRMC/SIO Leads)
  - Counter Improvised Explosive Device (Lead), 2010
- Other
  - Senior Oversight Group for Nuclear Weapons Effects T&E (Co-Chair with DTRA)
  - Rapid Acquisition Initiatives (TRMC and DDR&E joint effort)
  - OPM and OBM 2009 Reform Initiative Senior Working Group for Civilian Hiring (TRMC Member)

Note: DoD internal studies are not available to public

Summary

- Provide a vision of the capabilities and investments needed to support the testing of future warfighting capabilities
- Foundational document that uses a systems engineering process to identify DoD T&E resource investments and gaps
- Collaboration with OSD, military departments, non-DoD government Agencies, and commercial, academia, and international organizations
- Influence Service/Agency T&E POM investments through the budget certification process

Contact Information

For a copy of the 2010 Strategic Plan for T&E Resources, please contact:

TRMC

Deputy Director, Strategic Planning

Dr. Suzanne V. Strohl

Suzanne.Strohl@osd.mil

Background

Resource Categories

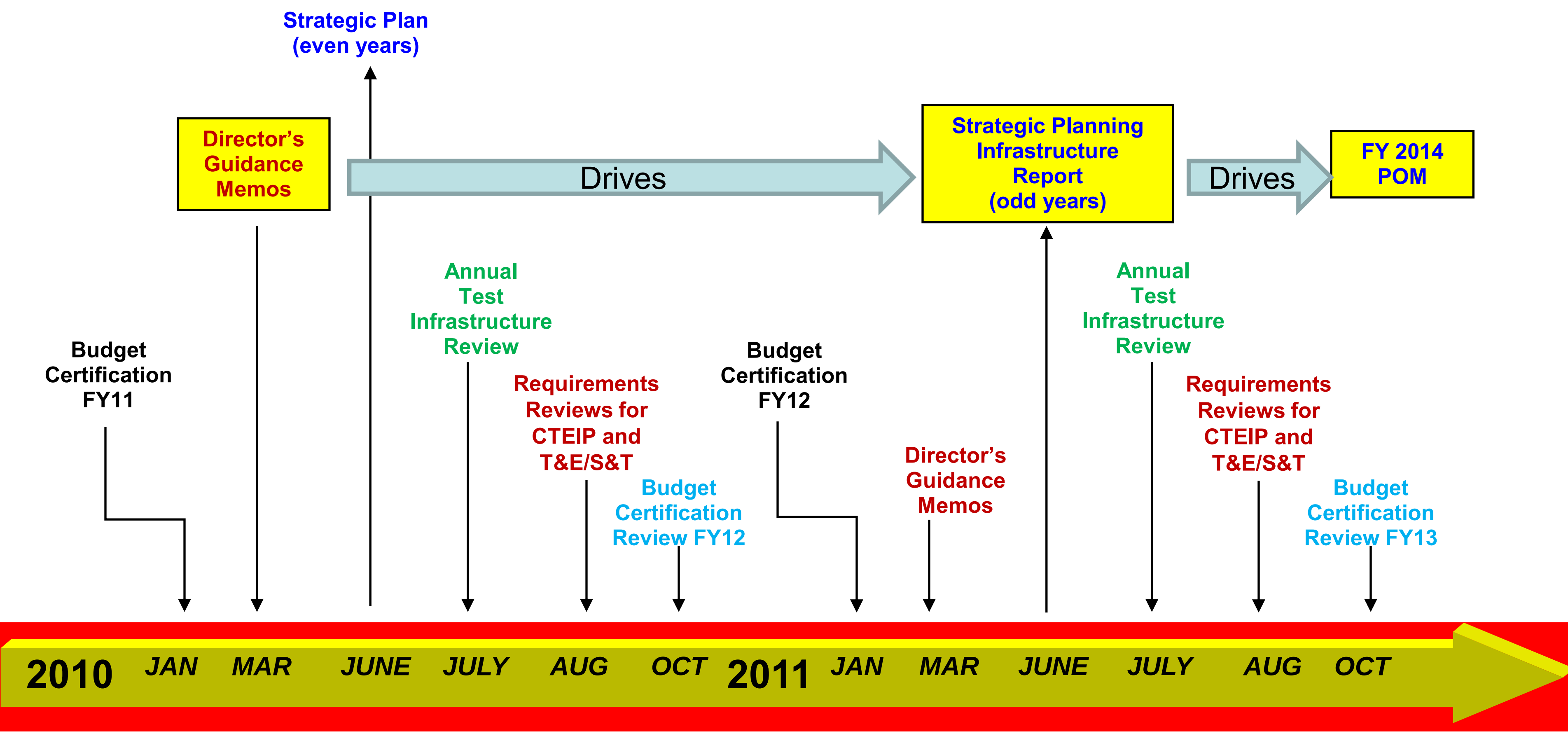
Scope:

Review must be specific to each acquisition AND specific to each range/facility

Review considers capabilities inside and outside of the MRTFB

- Investment
  - Gap in existing Test Capabilities
  - New Test Capabilities
- Modernization
- Sustainment
- Workforce
- Operations
- Divestment (Helps in funding the above)

Development Timeline



The STEWARD of the DoD Test Infrastructure

Major Range and Test Facility Base (MRTFB): The "Critical Core"

24 Sites: Army-9; Navy-6; Air Force-7; Defense Agency-2

30,000 personnel
Military, Gov, Contractor

18,000 sq. mi. of land
180,000 sq. mi. of air space
(> ½ of all DoD land)

Replacement Value = $30B

NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

FEATURING:

- Top Pentagon leadership presentations on T&E / acquisition policy and issues
- Industry leaders sharing T&E perspectives and responses to recent policy initiatives
- Special former NSA guest speaker addressing cyber security policy
- Over 80 speakers addressing a host of issues facing today's T&E community
- Parallel breakout sessions focused on specific T&E issues

27TH ANNUAL NATIONAL TEST & EVALUATION CONFERENCE

"Test & Evaluation: Serving the Warfighter"

Co-Sponsored by the NDIA C4ISR & Systems Engineering Divisions

CONFERENCE AGENDA

MARRIOTT TAMPA WATERSIDE ▸ TAMPA, FLORIDA

MARCH 14-17, 2011

WWW.NDIA.ORG/MEETINGS/1910

EVENT #1910

CONFERENCE ANNOUNCEMENT

The 27th Annual National Test & Evaluation Conference is sponsored by the NDIA Test & Evaluation Division and supported by the Office of the Under Secretary of Defense (AT&L) and the Director, Operational Test & Evaluation (DOT&E). Co-sponsors of this symposium are the C4ISR and Systems Engineering Divisions of NDIA.

Test and Evaluation is often looked at by Program Managers, Program Executive Officers and other proponents of weapon systems as an unwelcome obstacle to the deployment of systems to the Department of Defense and Homeland Security. T&E is often seen as a source of bad news which can potentially delay the deployment of these systems and add to their eventual cost.

Most engineers, technicians and program administrators recognize that test and evaluation is an integral part of the scientific method of systematically assessing the effectiveness, suitability and survivability of hardware, software and personnel.

This national conference will focus on policies, methods, and approaches that could better serve the ultimate consumer of our T&E efforts, the Warfighter. Given that Tampa is the home of both the U.S. Special Operations Command and the U.S. Central Command, it will provide a fertile opportunity to see and hear first-hand about how T&E could better serve our fighting forces.

With the recent combat surge into Afghanistan and change in our operational support in Iraq, it is vital that we take note of the recent lessons learned in both rapid deployment as well as tailoring our responses to the changing environments and tactics our fighting forces are now facing.

Increasing fiscal pressures also prompt us to address T&E approaches to saving time and money as well as to examine those other disciplines which feed the T&E activity, including Systems Engineering, Logistics, C4ISR, and R&D and Training.

Recent policy initiatives will also be addressed as to their implications, applications and effectiveness. Discussions will include how the recent legislative initiatives requiring additional T&E statutory responsibilities for Developmental Test and Evaluation are being implemented. Multiple topic tracks and tutorial sessions will be included in the conference to enable more focused discussions of specific topics enabling additional time for Q&A as well.

CONFERENCE ATTIRE

Conference attire is business for civilians and Class A uniform for military. In addition, your identification badge, received upon conference check-in, must be worn at all times.

NDIA T&E EXECUTIVE BOARD

- **Mr. Joe Andrese,** *APG NDIA Chapter* *
- **Dr. Suzanne Beers,** *MITRE Corporation*
- **Dr. Keith Bradley,** *LLNL*
- **Mr. Britt Bray,** *DRC Corporation*
- **Mr. Sam Campagna,** *NDIA*
- **RADM David Crocker, USN (Ret),** *Booz Allen Hamilton*
- **Dr. Paul Deitz,** *AMSAA**
- **Mr. Dick Dickson,** *Tybrin Corporation*
- **Dr. Anne Hillegas,** *ARA Corporation*
- **Mr. John Illgen,** *Northrop Grumman*
- **RADM Bert Johnston, USN (Ret),** *Wyle Corporation*
- **Dr. Mark Kiemele,** *Air Academy Associates*
- **Mr. Chuck Larson,** *SURVICE Engineering*
- **Mr. James O'Bryon,** *The O'Bryon Group, T&E Division Chair*
- **Mr. Brendan Rhatigan,** *Lockheed Martin*
- **Mr. Jack Sheehan,** *ORSA Corporation*
- **Dr. James Streilein,** *OSD, DOT&E**
- **Dr. Lowell Tonnessen,** *IDA*
- **Dr. Juan Vitali,** *OSD CBD**
- **Mr. Martin Woznica,** *Raytheon Company*
- **Mr. William Yeakel,** *ORSA Corporation*

***Government liaison to NDIA T&E Executive Board**

WALTER W. HOLLIS HONORS LUNCHEON

The Walter W. Hollis Award is presented annually in recognition of lifetime contributions and achievement in the area of defense Test & Evaluation. The award is presented in the name of Walter W. Hollis who is recognized for his dedicated and long-standing service in the field of Defense Test & Evaluation. This year's recipient, **Dr. James N. Walbert, *Chief Scientist, SURVICE Engineering Company,*** will be recognized at the conference Awards Luncheon on Tuesday, March 15.

Previous Recipients of this Award:
Dr. James J. Streilein, *Technical Director/Deputy to the Commander, U.S. Army Test and Evaluation Command (2010)*
Dr. Ernest Seglie, *Science Advisor to the Director, Operational Test & Evaluation, OSD (2009)*
Dr. Paul H. Deitz, *Technical Director, AMSAA, APG, MD (2008)*
Mr. James F. O'Bryon, *Former DDOT&E / LFT (2007)*
RADM Charles "Bert" Johnston, **USN (Ret),** *Wyle Laboratories (2006)*
Hon Thomas Christie, *DOT&E, OSD (2005)*
Dr. Marion Williams, *HQ AFOTEC (2004)*
Mr. James Fasig, *Aberdeen Test Center (2003)*
Mr. G. Thomas Castino, *Underwriters Laboratories, Inc. (2002)*
Hon Philip Coyle, **III,** *DOT&E, OSD (2001)*
Mr. Walter W. Hollis, *Department of the Army (2000)*

TESTER OF THE YEAR AWARDS LUNCHEON

These awards, presented to outstanding individuals in the field of Test & Evaluation, offer OSD and each Military Service Test & Evaluation Department the opportunity to select three award recipients for recognition as the Tester of the Year in specific categories. The three categories recognized are: Military, Civilian, and Contractor. Recipients will be recognized at the conference Awards Luncheon on Wednesday, March 16.

MAJ Brian Spurlock, USA
2010
Army
Military Tester of the Year

Ms. Patricia Frounfelker
2010
Army
Civilian Tester of the Year

Mr. Henry Waller
2010
Army
Contractor Tester of the Year

COL Steven Duke, USA
2010
OSD
Military Tester of the Year

Ms. Stephanie Koch
2010
OSD
Civilian Tester of the Year

Mr. Patrick Matthews
2010
OSD
Contractor Tester of the Year

Maj Ryan Voneida, USAF
2010
USAF
Military Tester of the Year

Mr. William Nix
2010
USAF
Civilian Tester of the Year

Mr. David Smith
2010
USAF
Contractor Tester of the Year

CDR John Verniest, USN
2010
Navy
Military Tester of the Year

Mr. Don Nelson
2010
Navy
Civilian Tester of the Year

Mr. Douglas Cornell
2010
Navy
Contractor Tester of the Year

Capt Todd Richardson, USMC
2010
Marine Corps
Military Tester of the Year

Ms. Cam Donohue
2010
Marine Corps
Civilian Tester of the Year

Mr. Eric Rannenberg
2010
Marine Corps
Contractor Tester of the Year

MONDAY, MARCH 14, 2011

10:00 AM - 6:00 PM	**CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION**
10:00 AM - 2:45 PM	**TUTORIALS A-D, SESSION 1 - SEE TRACK LAYOUT FOR ROOM ASSIGNMENTS** There is a $50 registration fee for tutorial attendance.
11:00 AM - 4:00 PM	**DISPLAY SET-UP - GRAND SALONS A-D**
12:00 NOON - 1:00 PM	**LUNCH BREAK** Lunch not included in conference or tutorial registration
2:45 PM - 3:00 PM	**AFTERNOON BREAK - GRAND BALLROOM FOYER** For tutorial registrants only
3:00 PM - 4:30 PM	**TUTORIALS E-H, SESSION 2 - SEE TRACK LAYOUT FOR ROOM ASSIGNMENTS**
4:30 PM	**TUTORIALS CONCLUDE**
5:00 PM - 6:00 PM	**KICKOFF RECEPTION IN THE DISPLAY AREA - GRAND SALONS A-D** Open to all conference registrants
6:00 PM	**CONFERENCE ADJOURNED FOR THE DAY**

MONDAY, MARCH 14, 2011 — *Tutorials*

10:00 AM - 2:45 PM

TUTORIAL	TUTORIAL A Session Chair: Dr. Paul Deitz, *AMSAA* Grand Salon G	TUTORIAL B Session Chair: Mr. Martin Woznica, *Raytheon Company* Grand Salon H	TUTORIAL C Session Chair: Dr. Suzanne Beers, *MITRE Corporation* Grand Salon I	TUTORIAL D Session Chair: Mr. Britt Bray, *DRS Corporation* Grand Salon J
	SESSION 1	SESSION 1	SESSION 1	SESSION 1
10:00 AM	11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E Dr. Mark Kiemele, *President and Co-founder, Air Academy Associates*	11694 - Efficient Modeling and Simulation (M&S) Using Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11653 - Test Planning — Advancing the Science Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11488 - Testing and Evaluating Intranets, Portals, and Enterprise Systems for Usability Dr. Patricia Chalmers, *Chief Science Advisor, U.S. Joint Forces Command*
	SESSION 1 CONTINUED	SESSION 1 CONTINUED	SESSION 1 CONTINUED	SESSION 1 CONTINUED
1:00 PM	11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E Dr. Mark Kiemele, *President and Co-founder, Air Academy Associates*	11694 - Efficient Modeling and Simulation (M&S) Using Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11653 - Test Planning — Advancing the Science Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11488 - Testing and Evaluating Intranets, Portals, and Enterprise Systems for Usability Dr. Patricia Chalmers, *Chief Science Advisor, U.S. Joint Forces Command*

3:00 PM - 4:30 PM

TUTORIAL	TUTORIAL E Session Chair: Dr. Lowell Tonnessen, *IDA* Grand Salon G	TUTORIAL F Session Chair: Mr. Dick Dickson, *Tybrin Corporation* Grand Salon H	TUTORIAL G Session Chair: Mr. Chuck Larson, *SURVICE Engineering* Grand Salon I	TUTORIAL H Session Chair: Mr. Brendon Rhatigan, *Lockheed Martin* Grand Salon J
	SESSION 2	SESSION 2	SESSION 2	SESSION 2
3:00 PM	11703 - Ships Are Different Mr. Mark Lucas, *Command Technical Director, Combat Direction Systems Activity*	11693 – Modern Design of Experiments (DOE) Methods Dr. Tom Donnelly, *Principal Customer Advocate, Systems Engineer, JMP*	11570 - A Day in the Life of a Verification Statement Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*	11705 - Defense Information Systems Agency Joint Interoperability Test Command Interoperability Support for the Afghanistan Mission Network Mr. Jeffery Phipps, *CIAV Co-Chair, US Lead, JITC*

TUTORIAL DESCRIPTIONS — *Session 1*

TUTORIAL A: USING DFSS AS AN INTEGRATING FRAMEWORK FOR MBT&E AND DOT&E

This tutorial will provide attendees a comprehensive process to capture all of the activities in MBT&E and DOT&E needed to achieve a successful system acquisition. It will use DFSS in its more expansive connotation, namely Designing for Successful Systems vice Design for Six Sigma, the more common but limited meaning. DFSS starts with the voice of the warfighter (or customer) and the required operational capability. These requirements are then flowed down to the critical performance measures using tools that help to prioritize along the way. The performance measures may include KPPs, MOEs, MOSs, and CTPs. The critical performance measures are linked to key design parameters, and once this linkage is firm, performance optimization can be accomplished. Design of Experiments (DOE) is shown to be a critical player in the design and optimization phases, as well as in every facet of testing and evaluation. Once the design and performance is optimized, it must be validated and the capability rolled back up to the system level capability. DFSS will be shown as an interdisciplinary activity, spanning the activities of systems engineering, reliability engineering, design and optimization, test and evaluation, and system capability confirmation.

TUTORIAL B: EFFICIENT MODELING AND SIMULATION (M&S) USING DESIGN OF EXPERIMENTS (DOE) METHODS

Attendees will learn how Design of Experiments (DOE) methods can be used to extract the most useful information from computer simulation models. They will see how the sequential running of blocks of simulations can be used to conduct the overall fewest trials necessary to do sensitivity analysis of the factors being studied. They will also see how to develop a fast-running (seconds) surrogate model — which testers and analysts can interactively query — of a long-running (hours, days or weeks) simulation. Design solutions will include the application of traditional DOE methods to discrete event and agent-based simulations, and modern space-filling designs to more complex physics-based simulations such as Computational Fluid Dynamics (CFD). When to use, and how to choose between traditional linear regression approximation methods and spatial regression interpolation methods will be discussed. The effective practice of using checkpoint simulations for determining the accuracy of surrogate model predictions will be demonstrated.

TUTORIAL C: TEST PLANNING — ADVANCING THE SCIENCE

Test planning is rapidly becoming a lost art. Many test planning activities are based solely on corporate knowledge and "Like we did it last time" theories. Solidifying requirements development, improving the program's verification and validation activities, increased program collaboration and streamlined test programs are all benefits of a solid and well defined test planning approach. By increasing program collaboration and the overall time spent on the "engineering of a program" while significantly reducing the time required producing the engineering verification and validation artifacts, solid model based test planning can ensure that a test program is more effective across its lifecycle. This tutorial examines the test planning process. From verification to test plan modeling and test plan generation, participants will see the processes and tool sets in action. To demonstrate some of these capabilities, participants will generate test requirements and objectives, model the plan, optimize the plan and assign resources, and finally generate a simple test plan while maintaining connections to the original requirements intent.

TUTORIAL D: TESTING AND EVALUATING INTRANETS, PORTALS, AND ENTERPRISE SYSTEMS FOR USABILITY

This tutorial will teach attendees how to perform intranet, portal, and enterprise usability evaluations. Attendees are encouraged to come with a project in mind as they will be worked on throughout the tutorial. Attendees will learn how to analyze their stakeholders' goals and needs: How to decide who their stakeholders are, decide which stakeholders to include in their evaluation, choose a random sample of end users, and determine stakeholders' goals/needs. Attendees will learn how to design a Usability Evaluation: How to budget time, knowing what types of T&E methods are possible, deciding what methods to use, designing a first-rate survey, determining sample completion tasks, deciding how many methods to use, and how to quantify usability data. Attendees will write a design for their portal evaluation including topics discussed. Information will be provided on How to Evaluate Your Portal Usability Evaluation: Pilot evaluations, participant performance, survey understandability, task understandability, determining if tasks are too easy or too hard, understanding the data, feedback from participants, making improvements. Attendees will also learn how to write their reports. Portal evaluation samples will be provided.

TUTORIAL DESCRIPTIONS — *Session 2*

TUTORIAL E: SHIPS ARE DIFFERENT

Recent fleet concerns with surface ship and system performance have punctuated the need to evolve the Navy's ship T&E processes and practices in such a way that enables acquisition decisions that are based on a framework of mission area effectiveness and suitability. However, because any given ship supports multiple missions through the employment of a complex array of systems, sensors, and weapons, the aforementioned changes truly require a "system of systems" approach. This approach must take care in balancing multiple systems at differing states of lifecycle maturity through their development processes. This necessitates a progressive examination of systems maturity using mission-based, measureable, testable artifacts. This tutorial will discuss the Navy's Mission Based Test Design methodology and illustrate how its application through an Integrated Test process can be used in ship and ship systems acquisition. It will also discuss how this approach can enable improved rigor leading to a better understanding of risks and warfighting effects, thereby facilitating the information quality needed for effective ship deployment decisions.

TUTORIAL F: MODERN DESIGN OF EXPERIMENTS (DOE) METHODS

This tutorial will provide attendees the very latest experimental designs published since 2008. References will be provided for four new types of design that offer testers the ability to run either fewer trials or for the same number of trials, learn more about interactions or quadratic behavior. These recently peer-reviewed designs have not yet made it into textbooks. The new designs include non-regular orthogonal fractional-factorial, robust screening, alias-optimal, and Bayesian D-optimal supersaturated designs. Comparisons between these new alternative methods and traditional designs will be provided to show the new methods are superior or strong competitors.

TUTORIAL G: A DAY IN THE LIFE OF A VERIFICATION STATEMENT

One measure of the quality of a product requirement is that it be verifiable. Verifiability assessment is one of the exit criteria for the Systems Requirements Review and is necessary for requirement validity. Nomination of one or more verification methods (examination, analysis, demonstration or test) is often taken as the sole evidence of verifiability. A completed Verification Cross Reference Matrix is frequently considered as the final verifiability assessment and responsibility for the remainder of the verification effort is transferred to the test and evaluation and other implementing communities for completion. Lessons learned from many programs have shown that a more robust application of systems engineering should include the requirements engineers (with detailed knowledge of product requirement intent) working with the verification implementing organizations as the best combination to define the verification requirements. Such definition should include statement of the verification objectives, success criteria and environment. Including this information in the "Quality Assurance" section of the requirements document allows for buy-in by the customer well in advance of implementing the verification activities. This information is used by verification personnel to generate one or more verification plans and to develop the detailed verification program. Verification requirements are planned into verification events which are executed using the proper system elements and environments. These verification requirements are key to establishing long lead verification facilities, tools and laboratories. Early definition of these requirements helps prevent facility re-designs and verification re-plans that can cause expensive delays. Finally, verification data analysis is performed, and the information compiled into verification reports certifying system product requirements compliance. This robust verification approach will provide proof of requirements satisfaction, leading to systems that meet the customers' needs at a lower life-cycle cost. This presentation explores the value of well-crafted verification requirements developed early in the Program. A "Day in the Life of a Verification Requirement" shows the interaction and benefits of verification requirements to the verification execution teams. The presentation will offer a lifecycle description of the verification requirement from conception to certification.

TUTORIAL DESCRIPTIONS — *Session 2 Continued*

TUTORIAL H: DEFENSE INFORMATION SYSTEMS AGENCY JOINT INTEROPERABILITY TEST COMMAND INTEROPERABILITY SUPPORT FOR THE AFGHANISTAN MISSION NETWORK

USCENTCOM operates in a coalition environment and must be able to generate and pass critical information to U.S. and coalition partners. The Command and NATO, as members of the International Security Assistance Forces (ISAF), understand that widespread interoperability is a key component to achieve effective and efficient operations. These communication capabilities must include a wide variety of not only military governmental operations, but also non-governmental agencies and industrial partners. To that end, they've created the Afghan Mission Network (AMN) and commissioned the Defense Information Systems Agency's Joint Interoperability Test Command to develop the Coalition Test and Evaluation Environment (CTE2) testing arm of the Coalition Interoperability Assurance and Validation (CIAV) process. The AMN is the backbone or core infrastructure that will provide long-term communications and information system and satellite communication services to support the ISAF as it expands its operations across the country during the ongoing operations. This tutorial will discuss the eight core critical Coalition Mission threads, phases for testing, and how the JITC stood up a network and is testing the systems in a distributed hardware in the loop environment to ensure interoperability across the AMN. It will also discuss the applicability to other theaters that may need to implement a similar process.

TUESDAY, MARCH 15, 2011

7:00 AM - 6:30 PM **CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION**

7:00 AM - 8:00 AM **CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D**

8:00 AM **OPENING REMARKS - GRAND SALONS E-F**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

8:05 AM **TRIBUTE TO OUR NATION AND WARFIGHTERS, NATIONAL ANTHEM**

SESSION A: CONFERENCE WELCOME & KEYNOTES

8:10 AM **WELCOME AND CONFERENCE INTRODUCTORY REMARKS**

- Mr. James O'Bryon, *Chairman, NDIA T&E Division; The O'Bryon Group*

8:20 AM **CONFERENCE KEYNOTE ADDRESS**

- Honorable Dr. J. Michael Gilmore, *Director, Operational Test & Evaluation, OSD*

Honorable Dr. J. Michael Gilmore was sworn in as Director of Operational Test and Evaluation on September 23, 2009. A Presidential appointee confirmed by the United States Senate, he serves as the senior advisor to the Secretary of Defense on operational and live fire test and evaluation of Department of Defense weapon systems. Prior to his current appointment, he was the Assistant Director for National Security at the Congressional Budget Office (CBO), and was responsible for CBO's National Security Division. Dr. Gilmore is a former Deputy Director of General Purpose Programs within the Office of the Secretary of Defense, Program Analysis and Evaluation (OSD(PA&E)). Dr. Gilmore also has served as the Division Director of Operations Analysis and Procurement Planning, within the Office of the Deputy Director, Resource Analysis and as an Analyst for Strategic Defensive and Space Programs Division, Office of the Deputy Director, Strategic and Space Programs. Dr. Gilmore's service with Program Analysis and Evaluation covered 11 years. Early in his career, Dr. Gilmore worked at the LLNL, Livermore, California performing research in their magnetic fusion energy program. He has also worked with Falcon Associates, McLean, VA, and the McDonnell Douglas Washington Studies and Analysis Group. Dr. Gilmore is a graduate of MIT where he earned a B.S. in Physics. He subsequently earned a M.S. and Ph.D. in Nuclear Engineering from the University of Wisconsin.

TUESDAY, MARCH 15, 2011

9:00 AM **GUEST SPEAKER**

- Honorable Frank Kendall, *Principal Deputy Under Secretary of Defense, AT&L, OSD*

Mr. Frank Kendall was sworn in as Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics (PDUSD(AT&L)) on March 5, 2010. In his role as PDUSD(AT&L), Mr. Kendall is authorized to act for and provide assistance to the Under Secretary of Defense for Acquisition, Technology & Logistics (USD(AT&L)). He also advises and assists the USD(AT&L) in providing staff advice and assistance to the Secretary of Defense on the acquisition system; research and development; modeling and simulation; systems engineering; advanced technology and developmental test and evaluation. Within government, Mr. Kendall held the position of Director of Tactical Warfare Programs in the Office of the Secretary of Defense and the position of Assistant Deputy Under Secretary of Defense for Strategic Defense Systems. Mr. Kendall was also Vice President of Engineering for Raytheon Company. Mr. Kendall also spent ten years on active duty with the Army serving in Germany, teaching Engineering at West Point, and holding research and development positions. He is a Distinguished Graduate of the U.S. Military Academy at West Point and he holds a Masters Degree in Aerospace Engineering from California Institute of Technology, a Master of Business Administration degree from C.W. Post Center of Long Island University, and a Juris Doctoris from Georgetown University Law Center.

9:30 AM **HOMELAND SECURITY T&E PERSPECTIVES**

- Mr. Gary Carter, *Director, Test & Evaluation and Standards Division, Department of Homeland Security*

10:00 AM **MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION B: OTA'S (OPERATIONAL TEST AGENCY'S) ROUNDTABLE

Session B Chair and Roundtable Moderator: Dr. Catherine Warner, *Science Advisor, DOT&E, OSD*

10:30 AM **ROUNDTABLE**

- MG Genaro Dellarocco, USA, *Commander, ATEC*
- RADM David Dunaway, USN, *Commander, OPTEVFOR*
- Maj Gen David Eichhorn, USAF, *Commander, AFOTEC*
- Col David Reeves, USMC, *Commander, MCOTEA*
- COL Joseph Puett, USA, *Commander, JITC*

11:30 AM **WALTER W. HOLLIS HONORS LUNCHEON: PRESENTATION FOR OUTSTANDING LIFETIME ACHIEVEMENT IN DEFENSE TEST & EVALUATION - FLORIDA SALONS I-IV**

- Dr. James N. Walbert, *Chief Scientist, SURVICE Engineering Company*

Dr. Walbert has more than 35 years of DoD T&E and related experience including extensive and novel work as an interior and exterior ballistician, a vulnerability/lethality tester and analyst, a materials engineer, and an author and instructor. From 1974 to 1978, Dr. Walbert served as a mathematician and test director for the U.S. Army Material Testing Directorate, where he planned, analyzed, evaluated, and assessed a wide range of engineering test programs. From 1978 to 2000, he served as a research scientist/engineer for the Ballistic Research Laboratory (and then the Army Research Laboratory) and from 2001 to 2003, Dr. Walbert served as Chief Scientist for the DARPA Future Combat Systems Program Office. Since joining SURVICE in 2003 as the Chief Scientist, Dr. Walbert has developed numerous analytical processes for exploitation of ballistic test data. He has authored/co-authored more than 50 technical publications during his career, including the AIAA-published text *Fundamentals of Ground Combat System Ballistic Vulnerability/Lethality*, which was named ARL's Publication of the Year for 2009. Based on this text, Dr. Walbert also developed and teaches a highly acclaimed basic ballistic vulnerability course to Government and industry practitioners throughout the T&E community. Dr. Walbert holds a B.S., M.S., and Ph.D. in mathematics all from the University of Delaware.

TUESDAY, MARCH 15, 2011 — *Continued*

11:30 AM — LUNCHEON GUEST SPEAKER: SOME PROBLEMS OF CYBER SECURITY

▸ Mr. Robert L. Deitz, *former General Counsel, National Security Agency*

Robert L. Deitz is currently Distinguished Visiting Professor & CIA Officer-in-Residence at George Mason University. From 2006 until February 2009 he served as Senior Councillor to the Director of the Central Intelligence Agency. From September 1998 to September 2006 he was the General Counsel at the National Security Agency where he represented the NSA in all legal matters. He has also held positions as Acting General Counsel at the National Geospatial-Intelligence Agency and as Acting Deputy General Counsel, Intelligence, at the Department of Defense. Professor Deitz began his career as a law clerk to the Honorable Justices Douglas, Stewart, and White of the United States Supreme Court. He has also been in private practice and was Special Assistant to Deputy Secretary of State Warren Christopher and to Secretary of Health, Education and Welfare Joseph Califano during the Carter Administration. Professor Deitz received his J.D. (magna cum laude) from Harvard Law School, where he was the Supreme Court Note and Note Editor of the Harvard Law Review. He received an M.P.A. from the Woodrow Wilson School of Public and International Affairs at Princeton University, where he studied international politics and economics. He majored in English literature at Middlebury College where he received a B.A. (cum laude) and became a member of Phi Beta Kappa.

SESSION C: ACQUISITION REFORM - THE IMPACT ON INDUSTRY

Session C Chair: Dr. Suzanne Beers, *MITRE Corporation*

1:15 PM — PENTAGON RESPONSE TO CONGRESSIONAL STRENGTHENING OF DT&E

▸ Mr. Chris DiPetto, *Principal Deputy, Developmental Test & Evaluation*

1:45 PM — REPORT ON NDIA'S INDUSTRIAL COMMITTEE ON TEST & EVALUATION (ICOTE)

▸ Mr. James Ruma, *Chairman, NDIA ICOTE; Vice President, Engineering, GDLS*

2:15 PM - 5:25 PM — CONCURRENT SESSIONS D - K

SESSION	SESSION CHAIR	2:15 PM	2:40 PM	3:05 PM
SESSION D Suitability/ Reliability Grand Salon G	Dr. James Streilein, *DOT&E, OSD*	11460 - Software Reliability Growth Test Approach Mr. Louis Gullo, *Raytheon Company*	11627 - Assessing System Reliability Growth When Failure Modes are Masked Dr. Patricia Jacobs, *Naval Postgraduate School*	11650 - Realistic and Measurable Suitability Requirements for Test 1st Lt Andrew Passey, USAF, *Air Force T&E Center, Detachment 6*
SESSION E How Re-Energized DT&E Can Better Support the Total Acquisition Process Grand Salon H	Mr. Tom Wissink, *Lockheed Martin*	11563 - Integrated Test and Independent Evaluation (IT&IE) and T&E Using Experimental Design Methodology Mr. George Axiotis, *DDR&E/DDT&E*	11665 - OSD Perspective of DT&E in Navy Shipbuilding Programs Mr. Patrick Clancy, *OUSD(AT&L) DDR&E/DDT&E*	11656 - An Industry Response to the Acquisition Changes Mr. Steve Scukanec, *Northrop Grumman Aerospace Sector*
SESSION F Mission-Based Capability Assessments (MBT&E) Grand Salon I	Dr. Paul Deitz, *AMSAA*	11499 - Emerging Methodology for Mission-Based Capability Assessments Mr. William Landis, *ARL/SLAD*	11557 - Measures Development Standard Operating Procedure (SOP) Mr. John Smith, *Operational Test & Evaluation Force*	11666 - Understand the Mission — A "How-To" Guide for MBTE Practitioners Mr. Britt Bray, *DRC*
SESSION G T&E In Support of Rapid Fielding for Combat Grand Salon J	CDR Ernest Swauger, USN (Ret), *CM/HD Systems IPAT*	11662 - Design Methodology for Expedient, Low Cost UAV Runways Mr. Lorenz Eber, *Naval Surface Warfare Center, Dahlgren*	11679 - Overview of the Joint/ Coalition Mission Thread Measures Development Standard Operating Procedure Mr. Max Lorenzo, *DISA*	

TUESDAY, MARCH 15, 2011

3:30 PM AFTERNOON BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D

SESSION	SESSION CHAIR	3:45 PM	4:10 PM	4:35 PM	5:00 PM
SESSION H Test & Evaluation of Systems of Systems Grand Salon G	Dr. James Streilein, *DOT&E, OSD*	11577 - Mission-Based Test Design for Complex Systems of Systems and Platforms Mr. Joseph Tribble, *AVW Technologies*	11642 - Joint Command and Control Assessments: Rapid Fielding, Integrated Testing and Implications, Approaches and Lessons Mr. Brian Eleazer, *SCRA/ ATI*	12878 - DoD Strategic Planning for Test and Evaluation Mr. Lee Schonenberg, *Whitney, Bradley and Brown Consulting*	11709 - Decoupled Test, Evaluation, and Certification of a System of Systems Mr. Robin Murray, *JITC*
SESSION I Emerging T&E Range/ Instrumentation Needs Grand Salon H	Mr. Dick Dickson, *Tybrin Corporation*	11564 - The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results Dr. Sultan Mahmood, *Air Armament Center, AAC/EB*	End-to-End GPS Multi-Platform Integrated System Testing for MGUE Dr. Sultan Mahmood, *Air Armament Center, AAC/EB*	11640 - Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements Mr. Doug Weatherford, *PM ITTS IMO*	11645 - Holographic Radar Brings a New Dimension to Sensing and Instrumentation on T&E Ranges Mr. Gary Kemp, *Cambridge Consultants*
SESSION J Bigger Bang for the Dollar Invested - DT&E Grand Salon I	Dr. Mark Kiemele, *Air Academy Associates*	11467 - Guiding the Engineer Through the T&E Process Mr. Allen Brailey, *Raytheon Company*	11483 - How to Frame a Robust Sweet Spot Via Response Surface Methods (RSM) Mr. Mark Anderson, *Stat-Ease, Inc.*	11553 - MIL-PRF-XX613 and MIL-STD-X618: The Navy Gets Serious About Armor Mr. Christopher Brown, *Naval Surface Warfare Center, Crane*	11541 - Fragment Analysis for the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) Ms. Karen Pizzolato, *U.S. Army Research Laboratory*
SESSION K Bigger Bang for the Dollar Invested - OT&E Grand Salon J	Dr. Paul Deitz, *AMSAA*	11516 - Mission-Based Test and Evaluation Strategy: Progress Towards Uniting Combat Developer, Materiel Developer and T&E Mr. Christopher Wilcox, *U.S. Army Evaluation Center*	11552 - Using Complementary Frameworks for Qualitative Data Collection During OT&E: Piggybacking on Operational Experiments Ms. Chiesha M. Stevens, *Pacific Science & Engineering Group, Inc.*	11699 - Continuous Cost Reduction Feeds Back into Product Reliability Mr. Jonathan Nikkel, *Raytheon Missile Systems*	11704 - Testing & Evaluating the Net-Ready Key Performance Parameter (KPP) Ms. Danielle Koester, *JITC*

5:30 PM - 6:30 PM RECEPTION IN THE DISPLAY AREA - GRAND SALONS A-D

6:30 PM CONFERENCE ADJOURNED FOR THE DAY

WEDNESDAY, MARCH 16, 2011

7:00 AM - 5:25 PM CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION

7:00 AM - 8:00 AM CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D

8:00 AM INTRODUCTION AND OPENING REMARKS - GRAND SALONS E-F

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

WEDNESDAY, MARCH 16, 2011 — *Continued*

SESSION L: A RE-ENERGIZED DT&E

Session L Chair: Mr. John Illgen, *Chairman, NDIA National Board; Northrop Grumman*

8:05 AM **PANEL: T&E: SERVING THE WARFIGHTER IN A COST-CONSTRAINED ENVIRONMENT**

Panel Moderator:

- Mr. Chris DiPetto, *Principal Deputy, Developmental Test & Evaluation*

Panelists:

- Mr. David K. Grimm, *Acting Director, Deputy Under Secretary of the Army, T&E Office*
- Mr. Steve Hutchison, *DISA T&E Executive*
- Mr. John Manclark, *Air Force T&E Executive*
- Ms. Amy Markowich, *Navy T&E Executive*
- Mr. Tom Wissink, *Director of Integration, T&E, Lockheed Martin*

9:00 AM **SPECIAL GUEST PRESENTATION:**
EVALUATION OF THE SINKING OF THE CHEONAN KOREAN NAVAL SHIP

- MG Jong Sung Yoon, *Republic of Korea Army (Ret), Leader of the International Investigation Team*

Rarely does one have the opportunity to fully investigate the circumstances leading up to the attack on and sinking of a warship and then be able to recover the ship and perform an extensive international investigation of the threat, the damage and casualties, the computer modeling of the damage and assessment of the causes and effects. MG Yoon led the international investigation team of which the US was an integral part into the sinking of the Republic of Korea's warship, the CHEONAN, this past year. His insights should be instructive and of great interest to the conference attendees. It is a privilege to welcome him to be a special part of our conference this year.

In addition, MG Yoon will be joined by Dr. Young Shin, Professor, Naval Postgraduate School and visiting Professor, Korean Advanced Institute for Science and Technology, to discuss the efforts of the International Investigation Team addressing the CHEONAN sinking.

MG Jong-Sung Yoon was born on April 4th, 1975 in Inje-gun, Gangwon-do, Korea. In 1981, he received his B.S. from the Korea Military Academy (37th); in 1999, MG Yoon received his M.S. in Science of public administration from Dongguk University; in 2008, he received his Ph.D. in Politics from Myongji University.

10:00 AM **MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION M: RESPONSIVE AND AGILE INFORMATION SYSTEMS T&E PANEL

Session M Chair and Panel Moderator: Dr. Steve Kimmel, *Chairman, NDIA C4ISR Division; Senior Vice President, Alion Science & Technology*

10:30 AM **PANEL**

Panelists:

- Dr. Steven Hutchison, *Director T&E, DISA*
- Dr. James Streilein, *Deputy Director, Net-Centric and Space Systems, DOT&E*
- Ms. Darleen Mosser-Kerner, *Deputy Director, Capabilities Development, Office of the Director, DT&E*
- Mr. Eustace King, *Chief, Acquisition and Technology, DOD-CIO/NII*

WEDNESDAY, MARCH 16, 2011

11:30 AM — **LUNCHEON - TESTER OF THE YEAR AWARDS - FLORIDA SALONS I-IV**

This awards event is a highlight of our annual conference since it provides the opportunity to recognize outstanding achievement in test and evaluation by members of our armed forces, DoD civilians and DoD contractors. Furthermore, what makes these awards particularly noteworthy is that the selections are made by the organizations of those being recognized. Congratulations to all who are being recognized for their 2010 accomplishments.

SESSION N: IMPROVING THE T&E PROCESS

Session N Chair: Dr. Lowell Tonnessen, *IDA*

1:15 PM — **T&E AND MISSION ASSURANCE**

- Mr. James W. Wade, *Vice President, Raytheon Company*

1:45 PM — **SOCOM T&E PERSPECTIVES: SERVING THE WARFIGHTER**

- LTC Kevin Vanyo, USA, *USSOCOM J8-O*
- Mr. Robert D. Werner, Jr., *Senior Test Officer, USSOCOM J8-O*

2:15 PM - 5:25 PM — **CONCURRENT SESSIONS O - V**

SESSION	SESSION CHAIR	2:15 PM	2:40 PM	3:05 PM
SESSION O T&E M&S for Specific Applications Grand Salon G	RADM Bert Johnston, USN (Ret), *Wyle Corporation*	11560 - A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops Mr. Stephen Swann, *U.S. Army Research Laboratory*	11529 - Expanding Use of the Probability of Raid Annihilation (PRA) Test Bed Across the Ship Self-Defense Enterprise Mr. Richard Lawrence, *AVW Technologies*	
SESSION P Approaches to Organizing an Effective M&S Program in Support of T&E Grand Salon H	Mr. Britt Bray, *DRS Corporation*	11500 - Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E) Mrs. Beth Ward, *U.S. Army Research Laboratory*	11476 - A Paradigm for Modeling and Simulation in support of Mission-Based Test and Evaluation Dr. James Walbert, *SURVICE Engineering Company*	
SESSION Q T&E Instrumentation Infrastructure - Maximum Utilization of Available Resources Grand Salon I	Mr. Dick Dickson, *Tybrin Corporation*	11497 - Joint Mission Environment Test Capability (JMETC): Improving Distributed Capabilities Mr. Chip Ferguson, *JMETC*	11508 - U.S.N. RDTE Project Support Aircraft Mr. Charles Myers, *U.S. Navy, NAWCAD*	11626 - Dugway Proving Ground as the MRTFB Chem Bio Activity Ms. Jean Baker, *U.S. Army Dugway Proving Ground*
SESSION R Applications of Design of Experiments (DoE) to T&E Grand Salon J	Mr. Martin Woznica, *Raytheon Company*	11677 - Using Design of Experiments (DoE) to Integrate Developmental and Operational T&E Dr. Mark Kiemele, *Air Academy Associates*	11549 - Probability Driven Experiments Design for Autonomous Systems Mr. Troy Jones, *Charles Stark Draper Laboratory*	11532 - Design of Experiments: Managing Expectations Mr. James Carpenter, *AVW Technologies, Inc.*

WEDNESDAY, MARCH 16, 2011 — *Continued*

3:30 PM **AFTERNOON BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

SESSION	SESSION CHAIR	3:45 PM	4:10 PM	4:35 PM	5:00 PM
SESSION S T&E M&S for Specific Applications (Cont...) Grand Salon G	Mr. Britt Bray, *DRS Corporation*	11538 - Personnel Injury Analysis of Reflective Spall Mrs. Rebecca VanAmburg, *U.S. Army Research Laboratory*	11539 - Analytical Approach Using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA) Mr. Richard Moyers, *U.S. Army Research Laboratory*	11674 - Utilization of Model and Simulation for Network Waveform Characterization and Validation Mr. Scott Rediger, *Rockwell Collins*	11708 - A Proposal for Robotic Entityy Safety Release Dr. Jeffrey Mosley, *OptiMetrics, Inc.*
SESSION T Approaches to Organizing an Effective M&S Program in Support of T&E (Cont...) Grand Salon H	CDR Ernest Swauger, USN (Ret), *CM/HD Systems IPAT*		11676 - Model Based Systems Engineering and M&S Adding Value to T&E Mr. Larry Grello, *High Performance Technologies, Inc.*	11554 - The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live Fire Test and Evaluation Mr. Scott Hornung, *U.S. Army Research Laboratory/ SLAD*	
SESSION U T&E Instrumentation Infrastructure — Maximum Utilization of Available Resources (Cont...) Grand Salon I	Dr. Suzanne Beers, *MITRE Corporation*	11638 - Army Testing in a Services Oriented Architecture (SOA) Environment Mr. Michael Phillips, *Mantech International*	11639 - The Test and Training Enabling Architecture (TENA) Enabling Technology for the Joint Mission Environment Test Capability (JMETC) in Live, Virtual, and Constructive (LVC) Environments Mr. Gene Hudgins, *TENA/ JMETC*	11682 - Advanced Range Data System (ARDS) Service Life Extension Program (SLEP) - "Ensuring GPS Based TSPI Remains a Viable T&E Range Instrumentation Asset" Mr. Dick Dickson, *TYBRIN Corporation*	11698 - Target Systems in Support of Test and Evaluation Mr. James Schwierling, *U.S. Army Targets Management Office*
SESSION V Developmental Testing & Operation Testing Challenges Grand Salon J	Mr. Chuck Larson, *SURVICE Engineering*	11524 - Ready for Scrum? Dr. Steven Hutchison, *DISA*	11649 - Affordable Test and Evaluation in a Complex World Mr. Thomas Wissink, *Lockheed Martin*	11710 - Testing U.S. Systems for Coalition Interoperability LTC Tim Timmons, USA, *JITC*	11659 - Impacts of the Learning Curve — Operational Test & Evaluation Ms. Shannon Krammes, *MCOTEA*

5:25 PM **CONFERENCE ADJOURNED FOR THE DAY**

THURSDAY, MARCH 17, 2011

7:00 AM - 12:00 NOON CONFERENCE REGISTRATION OPEN - 2ND LEVEL REGISTRATION

7:00 AM - 8:00 AM **CONTINENTAL BREAKFAST IN THE DISPLAY AREA - GRAND SALONS A-D**

8:00 AM **INTRODUCTION AND OPENING REMARKS - GRAND SALONS E-F**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*

THURSDAY, MARCH 17, 2011 — *Continued*

SESSION W: TEST DESIGN, TEST CURRICULA AND STANDARDS

Session W Chair: Dr. Paul Deitz, *former Technical Director, AMSAA*

8:05 AM — **SYSTEMS ENGINEERING PLANS: HOW TO RECOGNIZE PROBLEMS, SET GOALS AND IMPLEMENT IMPROVEMENTS**

- Dr. Don McKeon, *Defense Acquisition University*

8:30 AM — **11690 - DOING MORE WITHOUT MORE - SCIENTIFIC T&E DESIGN METHODOLOGIES (STED IN DoD WEAPONS SYSTEMS AQUISITION)**

- Ms. Darleen Mosser-Kerner, *Deputy Director, Capabilities Development, Office of the Director, DT&E*

8:55 AM — **WHAT ARE WE TEACHING OUR PMs AND ACQUISITION PROFESSIONALS ABOUT T&E?**

- Col Michael Bohn, USMC (Ret), *Faculty, Defense Acquisition University*

9:10 AM — **REPORT ON STANDARDS FOR DT&E**

- CDR Ernest Swauger, USN (Ret), *JPEO-CBD/Chief, CM/HD Systems IPAT*

9:35 AM — **11663 - EFFECTIVE COMBAT DATA COLLECTION & APPLICABILITY TO T&E**

- LtCol Michael Kennedy, USMC, *Expeditionary Test Division, MCOTEA*

10:00 AM — **MORNING BREAK AND NETWORKING IN THE DISPLAY AREA - GRAND SALONS A-D**

10:30 AM - 2:00 PM — **BREAKDOWN OF DISPLAYS**

SESSION X: CONFERENCE SYNOPSIS FORUM

Session X Chair: Dr. Paul Deitz, *former Technical Director, AMSAA*

10:30 AM — **11651 - TEST & EVALUATION ISSUES FOR SYSTEMS OF SYSTEMS (SoS): CREATING SLEEP AIDS FOR THOSE SLEEPLESS NIGHTS**

- Dr. Beth Wilson, *Principal Engineering Fellow, Raytheon Company*

10:55 AM — **11569 - T&E - GUARDING THE REQUIREMENTS INTENT**

- Mr. Steve Scukanec, *Senior Test Engineer, Northrop Grumman Aerospace Sector*

11:25 AM — **CONFERENCE SYNTHESIS PANEL**

- Dr. Suzanne Beers, *T&E Group Leader, MITRE Corporation*
- Mr. Britt Bray, *Military Analyst and Department Manager, DRC Corporation*
- Mr. Brian Simmons, *Executive Technical Director/Deputy to the Commander, U.S. Army Test and Evaluation Command*
- Dr. James Streilein, *Deputy Director, OSD, DOT&E*
- Dr. Catherine Warner, *Science Advisor, OSD, DOT&E*

11:55 AM — **CLOSING REMARKS**

- Mr. James O'Bryon, *Chairman, NDIA T&E Division; The O'Bryon Group*

12:00 NOON — **CONFERENCE ADJOURNS**

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
11499	Emerging Methodology for Missions-Based Capability Assessments	Mr. Kevin Agan
11529	Expanding Use of the Probability of Raid Annihilation (PRA) Testbed Across the Ship Self-Defense Enterprise	Mr. Chris Hauser Mr. Steve Mulleavy
11532	Design of Experiments: Managing Expectations	Mr. Chris Hauser Mr. Steve Mulleavy Mr. Kenneth Culpepper
11538	Personnel Injury Analysis of Reflective Spall	Mr. Robert Kinsler
11539	Analytical Approach using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA)	Mrs. Penny Willard
11549	Probability Driven Experimental Design for Autonomous Systems	Mr. Stephen York Dr. Nicholas Borer Mr. Scott Ingleton
11552	Using Complementary Frameworks for Qualitative Data Collection during OT & E: Piggybacking on Operational Experiments	Ms. Chiesha Stevens
11560	A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops	Mr. Stephen Swann Mr. Gregory Dietrich
11563	Integrated Test and Independent Evaluation (IT&IE) and T&E using Experimental Design Methodology	Col Mickey Quintrall, USAF (Ret)
11564	The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results	Mr. Michael Flinn Mr. Emmanuel Piniero Mr. Gary Green Mr. Larry Vallot
11569	T&E - Guarding the Requirements Intent	Mr. Eric Kaplan
11627	Assessing System Reliability Growth when Failure Modes are Masked	Dr. Donald Gaver
11638	Army Testing in a Services Oriented Architecture (SOA) Environment	Dr. Philip Hammonds Mr. Frank Vitoria Mr. Malcolm Lee
11640	Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements	Mr. Minh Vuong
11642	Joint Command and Control Assessments: Rapid Fielding, Integrated Testing and Implications, Approaches and Lessons	Mr. Steve Reeder
11651	Test and Evaluation Issues for System of Systems: Creating Sleep Aids for Those Sleepless Nights	Ms. Darlene Mosser-Kerner Mr. Tom Wissink
11656	An Industry Response to the Acquisition Changes	Mr. Steve Scukanec
11659	Impacts of the Learning Curve — Operational Test & Evaluation	Ms. Brittney Cates
11663	Effective Combat Data Collection & Applicability to T&E	Mr. Mark Flannery
11665	OSD Perspective of DT&E in Navy Shipbuilding Programs	Mr. Michael Melvin Mr. Joseph Terlizzese, Jr.

ADDITIONAL AUTHORS

Abstract ID	Abstract Title	Additional Authors
11676	Model Based Systems Engineering and M&S adding value to T&E	Mr. Frank Salvatore Mr. Richard Swanson
11703	Ships Are Different	Ms. Megan Vanderberry Mr. Jeff Bobrow
11705	Defense Information Systems Agency Joint Interoperability Test Command Interoperability Support for the Afghanistan Mission Network	Mr. Byron Baker Mr. Todd Rissinger
11709	Decoupled Test, Evaluation, and Certification of a System of Systems	Mr. Harold Maynard
	Report on Standards for DT&E	Dr. Juan Vitali

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USABILITY TEST AND EVALUATION: INTRANETS AND ENTERPRISE PORTALS

27th Annual National Defense Industry Association (NDIA) National Test and Evaluation Conference 2011

Systems Engineering Division
Command, Control, Communication and Computer Intelligence, Surveillance, and Reconnaissance (C4ISR) Division

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MODULE 1: INTRODUCTION

First, a few important notes before we begin: If you have questions, please feel free to ask them as we go through this tutorial or, if you prefer, write your questions on page 22 and we can address them at the end of class if we have time. Also please write any feedback on page 23. I take all comments seriously and I appreciate any and all feedback.

Introduction to Attendees. For our coursework today, first we will introduce ourselves. Please tell the audience your name, a little background about yourself, why you are here and if you can, think of a usability test/evaluation to which you would like to apply this tutorial. Your introductions will help me know which modules to stress to accommodate your needs. This introduction will also help you identify colleagues who may have backgrounds or interests similar to your own. You may want to network with each other during our break or during the conference this week.

Activity: Let's introduce ourselves to the rest of the attendees, and, again, try to mention one project to which you could apply this tutorial.

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Discussion. I usually have people from many backgrounds and with varied levels of experience. I'll try to accommodate you all in my presentation, but please stop me or slow me down if there is anything you do not understand.

Introduction to Coursework. In order to clarify the process of measuring usability and the process of choosing which method or methods for measuring, I'll first define a few usability terms: usability, usability metrics, test, evaluation, stakeholder, and user (Module 2). Next, we will review reasons for using usability metrics and applications for this tutorial (Module 3), and why it's important to apply what you learn today (Module 4). Next we'll talk about Stakeholder Goals and Requirements (Module 5). Next, the tutorial steps through the process of deciding what portal usability methods to use (Module 6) as well as when, where, and how to use them (Module 7). Then, we will evaluate our metrics (Module 8), and the methods we used to obtain those metrics (Module 9). And finally, I'll walk you through a sample portal evaluation report (Module 10).

MODULE 2: DEFINITIONS AND APPLICATIONS

For the purpose of this tutorial, I define usability as user effectiveness, efficiency, and satisfaction; and usability metrics as the measures, in numbers, of user effectiveness, efficiency, and satisfaction. Also, I will use the Defense Acquisition University's definition of test to include a procedure designed to obtain, verify, or provide data for an evaluation; and the Defense Acquisition University's definition of evaluation as the process for review and analysis of all data obtained from a design review, hardware inspection, Modeling and Simulation (M&S), testing, or operational usage of equipment. To understand the difference between test and evaluation, think of evaluation as the big umbrella – and sometimes testing is included in the evaluation (or under the umbrella), and sometimes testing is not included. Also, for this tutorial, the term, stakeholder includes anyone affected by your test/evaluation. Of all these definitions, I take the definition of "stakeholder" most seriously, because if I don't consider all my stakeholders in my test/evaluation, my results may not be credible, my recommendations may not be followed, or, people who feel marginalized may be tempted to be uncooperative. I've seen a few definitions of the word user: One definition equates the end user with the user. One equates the user with the customer. For this tutorial, when I speak of the user, I mean the end user.

Psychology experiments show that if we can apply course material *to our lives*, we learn that course material much more easily than if we cannot apply it. We also know that presenting our ideas in front of colleagues can help us learn and remember material. And finally, we know that presenting our ideas in front of colleagues can also help us see other points of view and add to our knowledge immensely. In fact, conferences such as this one are a perfect example of a forum for learning, open discussion, questions, and even criticism of theories, ideas, and concepts.

Activity: So, with that in mind, think of a test/evaluation project you are going to apply this tutorial to, and then enter it into the box on page 5. It can be a project you've conducted in the past or are conducting now. But it can also be a project you will be doing in the future, or would like to do in the future. If you cannot discuss your project,

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Usability Test/Evaluations to Which I Would Like to Apply This Tutorial:____

MODULE 3: THE IMPORTANCE OF STAKEHOLDERS

In Module 2 we talked about the definition of stakeholders. That definition included anyone affected by your evaluation. In the box below I've written some ideas to start us thinking about who are stakeholders are.

Activity: Now, for the project you brought to this tutorial, the one you wrote on page 5, circle the stakeholders (e.g., present end users, potential end users, designers, developers, funders, senior staff, and help desk personnel) who you think you may affect by your usability test/evaluation project). Then write in the space next to the ones you circled, who those people are, if you know their names. If you don't know their names, write down who you would contact to find out who those people are.

I purposely did not include all types of stakeholder groups, because I was hoping you could think of a few more. There is a space at the bottom of the list for any additional stakeholders you may think of who I do not have listed.

If you are finished early, take a look at the discussion questions to prepare for a discussion of this topic.

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Present End Users:

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Potential End Users:

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Designers:___________________________________

Developers: ________________________________

Funders:____________________________________

Senior Staff__________ ______________________

Help Desk Personnel: _________________________

Additional
Stakeholders:_____________________________

____

____

____

Discussion Questions:

Who are your end users or potential end users?

Do you agree that end users, funders, senior staff, are help desk personnel are stakeholders? Can you think of any other stakeholders?

Do you see any problem with involving these people?

Do you see any problems if you don't involve certain people?

MODULE 4: THE IMPORTANCE OF METRICS

Potential customers usually want to know how they will benefit if they conduct a usability test/evaluation, and they may want numbers to measure those benefits, or calculate a return on investment. Do you know what a return on investment is? It is the value (usability value for this tutorial's purposes), in monetary terms: In this case, the value of the test/evaluation you are about to plan. However, many professionals become confused when customers ask them to measure usability value, in monetary terms – if any of you are confused about how to measure usability value, we'll cover that also. During Modules 5-10 I'll walk you through your project, explain steps to using good metrics, the methods to obtain those metrics, evaluating your metrics and methods, and reporting your metrics. First, though, I'd like to briefly talk about the reasons that good metrics are important in a test and evaluation.

Reasons to employ portal usability metrics include, but are not limited to:
1. Assisting stakeholders in understanding the need for portal usability
2. Calculating a return on investment for former or potential users
3. Helping your stakeholders easily visualize portal usability findings (for example, via graphs, pie charts, and bar charts)
4. Clearly conveying the results of usability test/evaluations to stakeholders
5. Advancing the field of usability
6. Evaluating yourself – to realize if you have served your stakeholders
7. Helping your boss evaluate you
8. Winning awards ☺

Activity: Note if any of the eight sample motives I just mentioned (and repeated in the box below) apply to your project. Write down any additional motives that apply to your project.

Motivations to Use Metrics	***Applies to My Project?***
1. Assist stakeholders to understand the need for portal usability	
2. Calculate a return on investment	
3. Help stakeholders visualize findings (via graphs and charts)	
4. Clearly convey results	
5. Advance the field of usability	
6. Evaluate myself	
7. Help my boss evaluate me	
8. Award	
Other Motivators?	

Discussion Questions:

Which of the motivators applied or did not apply to your work? Why or why not?
What additional motivators did you identify?

MODULE 5: DETERMINE YOUR METRICS BY ANALYZING GOALS/REQUIREMENTS

In previous modules we talked about who we are and why we are here, I defined terms, we talked about applying this tutorial to your projects, and the importance of metrics. Now we can start our tests and evaluations. But, Where to start?...How to start? I always start by analyzing my stakeholders' goals/requirements because those requirements will determine my metrics and the metrics will determine my methods. For example, if the customer wants decreased time to perform tasks, my metrics should include time to complete representative tasks. If end users want to experience certain emotions (such as satisfaction with the system, trust in the system) my metrics should measure those emotions. If customers want end users to remember on-line training, I will need to measure users' recall of the training material. Here are some more examples of how to determine your metrics: Note that I always use stakeholder goals/requirements to determine metrics.

CUSTOMER REQUIREMENTS AND EXAMPLES OF METRICS TO MEASURE THOSE REQUIREMENTS

1) For a **Redesigned Portal**: A customer's goal may be to increase collaboration within the organization. In this case, you might measure the number of **cross division collaborations** after portal improvements compared to the number of collaborations **before** portal improvements
2) For a **Data Repository**: A customer's goal may be to enable users to find information efficiently. In this case, you may tally the number of minutes it takes users to find information in the data repository.
3) For a **Portal Training Program**: A customer's goal may include passable scores on tests following an on-line training course. You may conduct tests immediately after on-line training to measure short-term recall, as well as at longer intervals after training to measure long-term retention.
4) For a **Portal Training Program**: A customer's goal may be to ensure user satisfaction with the on-line training. In this case, you may develop a survey to measure self-reported satisfaction.
5) For a **Portal Command and Control Program**: If a customer's goal is to decrease errors by command and control operators, you can measure the number of errors, fatal errors, and/or successes in accomplishing tasks in a simulation situation, or in an actual situation.

EXAMPLES OF METRICS

Numerical Metrics

- Number of keystrokes to perform a task
- Number of clicks to reach information
- Number of positive responses to the portal
- Number of negative responses to the portal
- Number of help queries
- Number correct on a test

Economic Metrics

- Estimated return on investment
- Actual return on investment

Time Metrics

- Time to complete a task.
- Time to Train.
- Time to Reach Fatigue
- Latency time to upload information

Percentage Metrics

- Percent of users who score "very satisfied," "somewhat satisfied," "somewhat dissatisfied," … on a survey **before** usability improvements.
- Percent of users who scored "very satisfied," "somewhat satisfied," " somewhat dissatisfied," … on a survey **after** usability improvements
- Percent of participants who noted boredom
- "   satisfaction
- "   ease of use
- Percent of users who return to the portal to find new information
- Percent of users who are successful in making new collaborations
- Percent of pages that comply with usability guidelines
- Percent of participants who make errors
- Percent of participants who make fatal errors
- Percent of participants who successfully complete all tasks

Activity: For the usability test/evaluation project you wrote on page 5, write in the space below a few sample goals/requirements of your customers (or potential customers) and other stakeholders. Try to choose goals/requirements that you anticipate would be the most challenging to measure. Then, opposite each goal, write the metrics that would show if the portal you are testing/evaluating meets those goals/requirements.

STAKEHOLDER GOALS/REQUIREMENTS	***METRICS TO MEASURE IF THE SOFTWARE MEETS THOSE GOALS***

Discussion Questions:

What are a few of your customers' goals/requirements?
Using those goals/requirements, what are your metrics?
If you have trouble determining metrics for your customer's goals what are they?

MODULE 6: DETERMINE YOUR TEST/EVALUATION METHODS

When analyzing their test/evaluation projects, usability professionals determine: W**ho** will participate in the usability test/evaluation project, **What** you will test/evaluate, **When** you will test/evaluate, **Where** you will test/evaluate, and **How** you will test/evaluate.

Activity: Return to page 9 and note a few of the stakeholder goals/requirements you need to meet. Enter them below under the first column. Then, answer questions in the next columns for each of your requirements.

Goal or Req'ment and **Metric** to Measure	**Who** will I measure? Novices? Experts? Actual Users? Represent "? Number of users?	**What** will I measure? Simulated Tasks? Real Tasks? Adherence to Guidelines?	**When** will I measure? Before Learning? After Learning? Formative? Interim? Summative?	**Where** will I measure? At user's work station? In a lab?	**How** will I measure? Objective test? Subjective test (survey)? Observation? Cognitive Walk-Through? Comparative Experiment? Data Collection? Technical Trackers?	**How** will I recruit ?

Discussion Questions: Share with the audience one or your usability test/evaluation projects, along with your metrics, and methods. What challenges do you anticipate facing?

MODULE 7: IMPLEMENT YOUR METHODS

A Sample of Guidelines for Implementing Your Methods:

1. Before starting, determine if your method will fit into your schedule and budget.
2. Before starting, consult with colleagues to get their opinion of your methods.
3. Before starting, discuss your metrics & methods with your team.
4. Consider a pilot test/evaluation. The beauty of doing a small preliminary test/evaluation is that you can determine if you have problems with your method before doing your test/evaluation project.
5. Use appropriate numbers of participants for an experiment (30 in each group), use proper statistical tests, note the p value (the percent chance of error) in your results, & draw participants from a random sample that is representative of typical end users.
6. Be consistent with all participants.
7. In-brief participants; provide a consent form; provide out-brief.
8. Demonstrate impartiality to the product so you do not influence the participants.
9. Remind participants: You are not testing/evaluating them, you are testing/evaluating the portal
10. Read from a script when giving instructions
11. Note variations in types of participants: Gender, Age, Experience Levels, Comfort Levels, Fatigue Levels, Intelligence Levels, and Education Levels – anything that may skew results.
12. For a cognitive walk-through:
    Capture all user comments while remaining impartial to the design and comments
    Follow up on nuances (furrowed brow, nervous speech, sighs...)
13. For a behavioral observation:
    Establish inter-rater reliability if more than one observer.
    Establish intra-rater reliability.
    Consider audio/video technology (for example Morae technology).
    Remain inconspicuous, but available in case of problems.
14. For a heuristic evaluation (how well a portal design follows usability guidelines):
    Choose heuristics for which research shows effectiveness.
    If you look at all screens, you can then make statements such as, “75% of pages on the portal complied with the guideline to provide consistency of look and feel.”
15. For tests: Test on tasks that are representative of end users’ tasks.
16. For surveys: Use an appropriate number of points (1-5 or, better yet, 1-7).

Discussion Questions:

Do you see any problems with any of the above methodology guidelines?

If costs and/or time were constrained, would you eliminate or reduce effort on any of the above methodology guidelines?

This is simply a sample of methodology guidelines. Can you think any more guidelines?

MODULE 8: EVALUATE YOUR PROJECT'S USABILITY METRICS

Please note that up to this point, when I used the word "evaluation," I used it to describe evaluating a portal. However, in this module and the next one, I speak of evaluation in terms of evaluating yourself; in other words, in terms of evaluating your own usability project: your metrics, your method/s.

A Few Guidelines for Evaluating Your Metrics

Evaluate iteratively – this means you evaluate yourself throughout the analysis, design, development, and implementation of your test/evaluation.

Consult with a mentor or your peers to get their opinions of your metrics. Be open to their critiques.

Consult peer-reviewed literature to keep up on metric guidelines, their effectiveness, and the advantages and disadvantages of using certain metrics.

Attend local usability meetings, national conferences, and international conferences to present your ideas and to obtain critiques.

Activity:
Review the metrics you wrote on page 10 under the column "What Will I Measure?" and ask yourself:

Were my metrics appropriate?
Do I need additional metrics?
Will my stakeholders be satisfied with the metrics I obtained? Why or why not?

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Discussion Questions:
Do you understand the difference between evaluating a portal and evaluating yourself?
What are some pitfalls to be aware of when you evaluate your own metrics?
What are some advantages to evaluating your metrics?

MODULE 9: EVALUATE YOUR USABILITY PROJECT METHODS

In addition to evaluating your metrics, as you did in the previous module, you should also evaluate your methods.

The next time you conduct a usability test/evaluation, go to page 11 and carefully evaluate your methodologies against those guidelines, as well as any other guidelines developed here and elsewhere.

As with metrics, the following apply to methods:

Evaluate iteratively – this means you evaluate your method throughout the analysis, design, development, and implementation of your test/evaluation.

Consult with a mentor or your peers to get their opinions of your methods. Be open to their critiques.

Consult peer-reviewed literature to keep up on usability methodology guidelines, their effectiveness, their advantages, and disadvantages.

Attend local usability meetings, national conferences, and international conferences to present your ideas and obtain critiques.

Activity: Review page 11 and note below, on page 13, if you did or did not follow those guidelines, as well any other guidelines we developed as a class, or that you obtain from peer-reviewed literature and conferences.

NOTES

Discussion Questions:

What are some pitfalls to be aware of when you evaluate your own methods?
What are some advantages to evaluating your methods?

MODULE 10: REPORT YOUR TEST/EVALUATION FINDINGS

Guidelines for Reporting Your Results:

1) In addition to simply verbalizing problems, I prefer to **use screen captures** for illustration. It is helpful to note the exact pages where problems occur.

2) In addition to pointing out usability **problems**, also include usability **successes –** no one wants to just hear a list of criticisms. I have never seen a usability test/evaluation project that has absolutely no qualities. In addition, if customers do not know what is working, they may inadvertently delete a feature that is actually working for them. Note the successes in the Conclusion section of the sample Evaluation **Report** on pages 16-17.

3) Note also that I removed all **identifiers** from the evaluation report.

4) Pointing out not only problems, but also offering **recommendations**, is very helpful to customers who may not know about usability and how to make it better. See examples in Appendix A, under the "Recommendations" section on page 17.

5) Using bar **charts** and tables are great ways of capturing the overall essence of a report in picture-form. See examples in Appendix B on page 21.

6) See the information provided in the tutorial if you are doing a usability **heuristic evaluation** (an evaluation of a portal against **usability guidelines)**. This example of one guideline is especially useful to customers because it not only references the guideline, but also makes useful comments. In addition, the example gives the "strength of importance" to most end users, the "strength of evidence" supporting the guideline, and the sources to back up the guideline. Please see "Research-Based Web Design and Usability" by Sanjay J. Koyani, Robert W. Bailer, and Janice R. Nall for more great examples. Their work explains the "Strength of Importance" and the "Strength of Evidence" scales and gives many more usability guidelines and examples. Also, you may be able to see more at *http://usability.gov/pdfs/guidelines.html*.

APPENDIX A

USABILITY HEURISTIC, OR GUIDELINE, CHECKLIST & USABILITY EVALUATION REPORT

Following is an example of a heuristic evaluation. I selected heuristics that my stakeholders deemed important and also heuristics that I deemed important over years of consulting. I then looked at a representative sample of portal pages to determine if the portal adhered to the heuristics. Below is a sample checklist followed by conclusions, recommendations, and a note of thanks on page 19 for the opportunity to conduct the test/evaluation.

USABILITY CHECKLIST

Visibility of System Status:

1. Does the portal enable users to know where they are within the portal?
2. Does the portal enable users to know where they are in a process?
3. Does the portal enable users to know how much time a process will take?
4. Does the portal provide the user with a way to go back to topics without repeatedly keying the Back button?

Consistency

1. Does the portal use consistent terminology?
2. Does the portal use consistent color?
3. Does the portal use consistent layout?
4. Does the portal use consistent font?
5. Does the portal use consistent input and output formats?

Speaking the User's Language:

1. Does the portal use natural language (not jargon, acronyms, or system terms)
2. If stakeholders insist on jargon, acronyms, and system terms, is there a glossary?

Giving the User Control and Freedom

1. Does the portal provide shortcuts for frequent users?
2. Does the portal support Undo/Redo commands
3. Does the interface make it difficult to perform irreversible actions?

Error Prevention and Error Recovery

1. Are potential errors noted?
2. When errors occur, can the user see the source of the error?
3. When errors occur, can the user see possible corrections?
4. Does the portal support Back and Forward commands?
5. Does the portal support Auto Infill and Auto Backfill?
6. Does the portal offer a phone number for off-line help?
7. Does the portal offer email contact for on-line help?
8. Does the portal write error messages in natural language?
9. Can the user see the help screen and the process screen at the same time?
10. Does the interface have adequate contrast between background & foreground?

Recognition

1. Does the portal provide "mouse overs" describing icon buttons
2. Does the portal have a search engine?
3. If there is a search engine, does it support advanced search capabilities?

Aesthetic and Minimalist Design

1. Is the interface pleasing to the eye?
2. Is the interface uncluttered?

Provide Contact Information

1. Does the interface provide personnel addresses for email contact?
2. Does the interface provide personnel numbers for phone contact?
3. Does the interface provide fax numbers?

Avoid Information Overload

Does the interface "chunk" information into seven plus or minus 2 chunks?

Provide the "Inverted Pyramid" Style of Writing

1. Does the interface provide the most important information at the top?
2. Does the interface provide the least important information at the button?

Keep Download and Response Time Low

Does information download occur within five seconds?

Make Content Easy to Visually Scan

Are key words and phrases easily visible (for example, by highlighting)?

Make Content Easy to Print

1. Are pages easily marked so users can print a few, or a specified number of, pages?
2. Are printed pages free of right-sided or left-sided "cut offs"?
3. Are color pages readable in black and white?

Dr. Patricia Chalmers developed this guidelines from work compiled by:

Nielsen, Jacob and Mack, Robert L. 1994. Usability Inspection Methods. New York, NY: John Wiley and Sons, Inc.

Pearrow, Mark, 2000. Web Site Usability Handbook. Rockland, MA: Charles River Media, Inc.

Shneiderman, Ben, 1987. Designing the User Interface. Reading, MA: Addison-Wesley.

USABILITY EVALUATION REPORT

CONCLUSIONS

Visibility of System Status. This portal scores low in visibility of system status. The portal does not enable users to know where they are within the portal. Users should be able to know where they are at all times. They should be able to easily return to previous topics without having to repeatedly activate the "Back" button. However, on a few pages, the user could link back to certain sections of the portal and **this is commendable.**

Consistency. The portal scores excellent in providing consistency. Consist terminology, color, and layout are present throughout all pages. Only a few, font changes were evident – found in the sections titled, ____ and _______.

Speaking the User's Language. The portal scores low on speaking the user's language as almost every page contained at least one acronym. Also, when the evaluator deliberately made an error, users could not understand the error message because the portal used system terms and no glossary of terms was available.

Giving the User Control and Freedom. The portal scores average on giving the user control and freedom. The interface provided some shortcuts for frequent users.

Error Prevention and Error Recovery. The portal scores low on error prevention and error recovery. The portal does not offer a “Help” section, on-line support, or off-line support. When filling out forms, many actions were irreversible. Users could not be save forms. Auto infill and backfill features were not available for forms. Error messages were confusing and, in many instances, the portal did not offer steps to recover from errors. The forms contained no instructions for infill. However, Back and Forward commands were available and this is commendable.

Recognition. The portal scores low in recognition rather than recall. The portal has no links to describe icons in case the user forgets the meanings of icons. In addition, the portal supports no search engines and advanced search capabilities.

Aesthetic and Minimalist Design. The portal scores above average on aesthetic and minimalist design. Some pages have light blue background with dark blue text. This may cause difficult or slow reading of the text. However, there are only a few pages with this problem. The home page looks somewhat disjointed and cluttered, but most pages are easy to view and present no readability problems.

Provide Contact Information. The portal scores poor on providing contact information. Some pages have telephone numbers and some pages have email addresses. However, the portal scores high on providing Portal master email contact information, as this information appears on every page. However, when I tried to email the Portal master, no one replied for three days.

Keep Download Response Time Low. The portal scores excellent on keeping download and response times low. All information downloaded within three seconds.

Make Content Easy to Visually Scan. The portal scores average on making content easy to visually scan. Occasionally I needed to decrease the size of the side bar or scroll to the right in order to see complete pages. However, the use of color changes, font size changes, and bolding do make important information visible. We commend the portal for being easy to visually scan.

Make Content Easy to Print. I tried to print a few select pages, guessing at the page numbers, as they were not available. I misjudged and printed the wrong pages. Some pages did not offer the “printer friendly” option and came off the printer with information cut off on the right side.

RECOMMENDATIONS

Know Your Users. It is essential to know your users. The first question to answer is, “Who do we want our users to be? The portal development team should identify desired users, canvas a sampling of those users, and request their feedback via a quick and anonymous form. You may not be able to design your portal for everyone in your organization, but you do want to design it for as many people as possible, especially for users who you are targeting. If the portal could make the most important group of users happy, who would those users they be? The sooner you identify your key users, the more time and cost you will save.

Know What Your Users Need to Do to Accomplish Their Work. Equally important is knowing what your users need to do to accomplish their tasks. The next question to answer is, "What is the purpose of the portal? For example, is the purpose to convince users to do something? Or to provide information? Or to seek input? All of the above? Answering these questions and providing fast and easy ways for your users to accomplish their tasks will help your portal be most effective.

Visibility of System Status. Users should know where they are in a process at all times. You can help users in a number of ways. For example, the use of page identifiers (for example, by tabs which show all levels the user has gone down) is one way. Use of breadcrumbs is another way. Also, noting that the portal is processing a request and the time it expects to take is another way to provide the user with system status. The use of a slide bar is yet another way.

Consistency. There is excellent consistency of terminology, color, and layout. The evaluator recommends these consistencies remain. The one exception is that layout at various levels vary slightly from level to level. However, these inconsistencies can enhance understanding of differences in the levels if they are not too different from the portal's main look and feel. There are a few instances of font changes. The evaluator recommends these sections comply with the consistent font of the other pages.

Speaking the User's Language. Knowing that at least 25% of the hits for this portal come from new employees, speaking the user's language will be extremely important. Therefore, avoid all acronyms, or at least provide a mouse over for acronyms if your stakeholders insist on using acronyms . This will enable all users to quickly and easily comprehend portal contents.

Error Prevention and Error Recovery. The evaluator recommends the portal maintain the "Back" and "Forward" buttons as these are helpful to many users, especially if they are navigating a new part of the portal. The evaluator also recommends the portal incorporate a "Help" section, on-line support, and off-line support for error prevention and recovery. Also, when an error occurs the system should inform users of 1) the error, 2) how the error occurred, and 3) how the user can recover from the error.

Form fill-in is especially prone to errors, especially if users are filling out a form for the first time. A form that does not promote easy error recovery can frustrate users quickly. Therefore, the evaluator recommends the portal provide instructions (e.g., "no dashes" for a phone number entry) and examples (e.g., "dd/mm/yyyy"). Allow users to save their filled in forms. Also, provide auto infill and backfill features.

Recognition. The evaluator recommends the portal provide a glossary in case the user cannot recognize or remember the definition of a term. The evaluator recommends a glossary via a "mouse over" so users do not have to lose their train of thought, which occurs when users need to leave a page, go to another page to find a definition, then return to their original page, and incorporate the definition into the sentence. The evaluator recommends a search engine with advanced search capabilities to support users who may remember only parts of a keyword or keyword phrase. Since no provision for legends describing icon buttons are present, the evaluator recommends mouseovers describing icon buttons.

Aesthetic and Minimalist Design. The portal scores above average on aesthetic and minimalist design, providing adequate contrast between background and foreground on all pages. Pages were clear, simple, and users could easily and efficiently read all text. There were very few cluttered pages.

Provide Contact Information. The evaluator recommends the system give users an email addresses, phone numbers, and a fax numbers to enable users to reach the appropriate points of contact. View this recommendation in light of the answers to the questions, "What is the purpose of the portal?" If the answer is: to "sell a product or service," to "seek user input," to "provide a meeting place," or to "draw in users" then I would recommend complete contact information on most, if not all, pages.

Keep Download Response Time Low. On this guideline the portal scores excellent. All information downloaded within three seconds. This is highly commended.

Make Content Easy to Visually Scan. The evaluator recommends the portal reduce the size of sidebars or eliminate sidebars completely. In general, other techniques for making information easy to scan include: highlighting, shading, bolding italicizing, or underlining.

Make Content Easy to Print. The evaluator recommends enabling users to print a few select pages, without having to guess at page numbers. In addition, a "printer friendly" option should be available.

Iterative Evaluations: The evaluator recommends two more **usability evaluations**: once after the first prototype is developed (interim evaluation) and once again before sending out the "finished product" (summative evaluation).

Usability Testing. The evaluator also recommends **usability testing** as part of the evaluation. Usability testing enables the portal development team to measure improvement in user performance. For example, testing can include counting the number of keystrokes needed for users to find what they want in a sample scenario, then comparing the numbers at different phases of development. These comparison numbers will give the development team feedback regarding the effects of their changes. The evaluator also recommends cognitive walk-throughs. These involve users telling the evaluator what they are thinking when they try to complete a task, find a page, or try to find information on a page. The evaluator also recommends that test/evaluation measures be quantifiable.

THANK YOU! I would like to again thank you for the opportunity to evaluate your portal. I found your development team, senior leaders, and end users very dedicated and a pleasure to work with. I look forward to working with you again at the next stage of your development.

APPENDIX B

SAMPLE TABLES

Note the table in Figure 1 below. This fictitious table shows is impressive; however, it may be hard for some people to picture the results.

Figure 1. Tables Showing Results

Category	Score Before Redesign	Score After Redesign
Satisfaction	1.0 on a Score of 1-7	2.0 on a Score of 1-7
Excitement	1.0 on a Score of 1-7	7.0 on a Score of 1-7
Simulated Task Accomplishment	10% Able to Complete	60% Able to Complete
Desire to Buy	40% Want to Buy	70% Want to Buy

Look at Figure 2 below. This is the same table with red, yellow, and green colors to indicate, alarm, caution, or commendation.

Figure 2. Color-coded table Showing Results

Category	Score Before Redesign	Score After Redesign	STATUS AFTER REDESIGN
Satisfaction	1.0 on a Score of 1-7	2.0 on a Score of 1-7	
Excitement	1.0 on a Score of 1-7	7.0 on a Score of 1-7	
Simulated Task Accomplishment	10% Able to Complete	60% Able to Complete	
Desire to Buy	40% Want to Buy	70% Want to Buy	

Remember, however, that many people are color blind and the most common form of color blindness is an inability to differentiate red from green. Also, colors mean different things in different cultures, so know your audience.

A better chart might include icons, such as a smiling face, frowning face, and a straight line across the mouth for something in between. See the next page for an example of a chart.

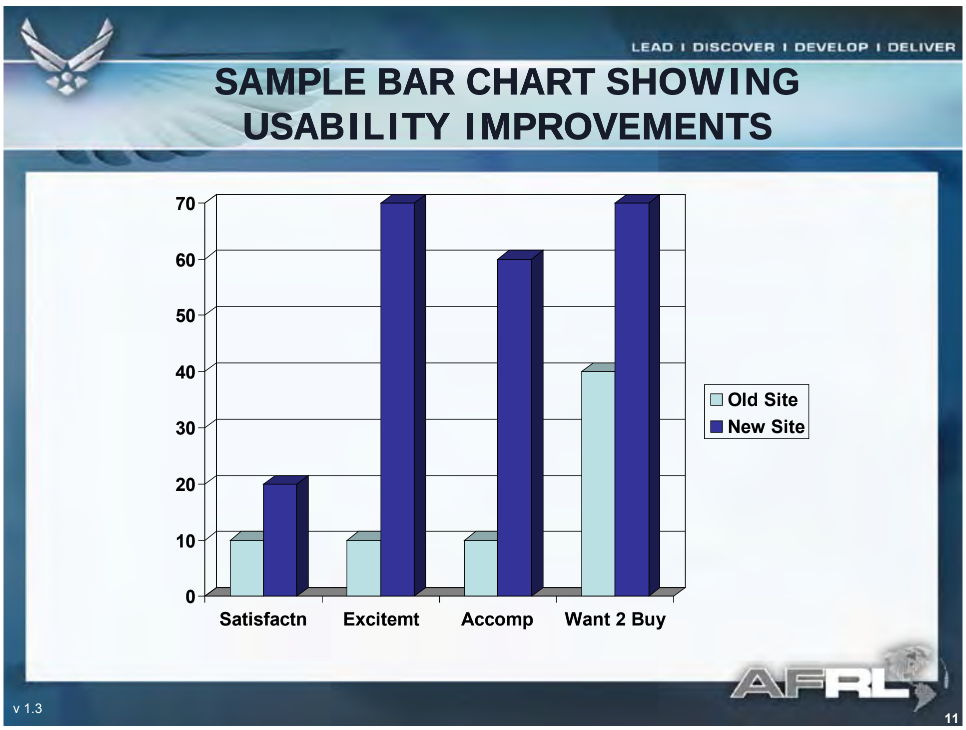
See the next page for an example of a chart, vice a table.

APPENDIX B

SAMPLE BAR CHART

Bar charts, rather than tables, may be easier for most people to understand at a glance. Note the bar chart below in Figure 3. This fictitious chart shows changes in the user's desired qualities before the user's portal was redesigned (light blue bars), and after the user's portal was redesigned (dark blue bars). In general, bar charts are easier for people to picture. See the next page for another idea.

Figure 3. Bar Chart Showing Results



QUESTIONS AND ANSWERS

Feel free to ask questions during this course. However, if you think of additional questions after each module, I will address them at the end of the session as time permits.

Activity: Please write your questions below

Discussion: The presenter answers final questions from the audience

FEEDBACK

Estimated time to complete this survey: 3 minutes.

Please answer the questions below, then tear the page out of this book and turn it in to the Feedback Box. I very much appreciate your feedback so I can improve my presentation!

Number of years' experience in usability ______

Modules that presenter could cover more quickly (circle any that apply)

1-Introduction 2-Definitions 3-Applying Tutorial 4-Motivations for Metrics

5- Determine Your Metrics 6-Determine Your Method 7-Implement Method

8-Evaluating Your Metrics 9-Evaluating Your Methods 10-Reporting Findings

---

Modules that presenter could cover more slowly (circle any that apply)

1-Introduction 2-Definitions 3-Applying Tutorial 4-Motivations for Metrics

5- Determine Your Metrics 6-Determine Your Method 7-Implement Method

8-Evaluating Your Metrics 9-Evaluating Your Methods 10-Reporting Findings

---

Your satisfaction with the content of the material presented (circle one)

extremely unsatisfied	very unsatisfied	somewhat unsatisfied	Neutral	somewhat satisfied	very satisfied	extremely satisfied

---

Your satisfaction with the timing of the material presented (circle one)

extremely unsatisfied	very unsatisfied	somewhat unsatisfied	Neutral	somewhat satisfied	very satisfied	extremely satisfied

---

Your physical comfort during the presentation (circle one):

I was uncomfortable 0% of the time 25% 50% 75% 100% of the time

Reason:

Your level of energy during the class (circle one)

extremely tired very tired somewhat tired somewhat alert very alert extremely alert

What can the presenter do to enhance this tutorial? ______________________________

____

What can the presenter eliminate from this tutorial?

____

Was there anything you liked about the tutorial? If so, what did you like?

____

Are there any further comments you would like to add? Use back of this page if needed

____

MANY THANKS FOR YOUR TIME IN COMPLETING THIS FEEDBACK AND GOOD LUCK IN YOUR USABILITY PROJECT/S!

REFERENCES

Koyani, Sanjay J., Bailer, Robert W., Nall, Janice R. (Retrieved July, 2007 from http://usability.gov/pdfs/guidelines.html). *Research-Based Web Design and Usability*.

Nielsen, Jacob and Mack, Robert L. 1994. Usability Inspection Methods. New York, NY: John Wiley and Sons, Inc.

Pearrow, Mark, 2000. Web Site Usability Handbook. Rockland, MA: Charles River Media, Inc.

Shneiderman, Ben, 1987. Designing the User Interface. Reading, MA: Addison-Wesley.

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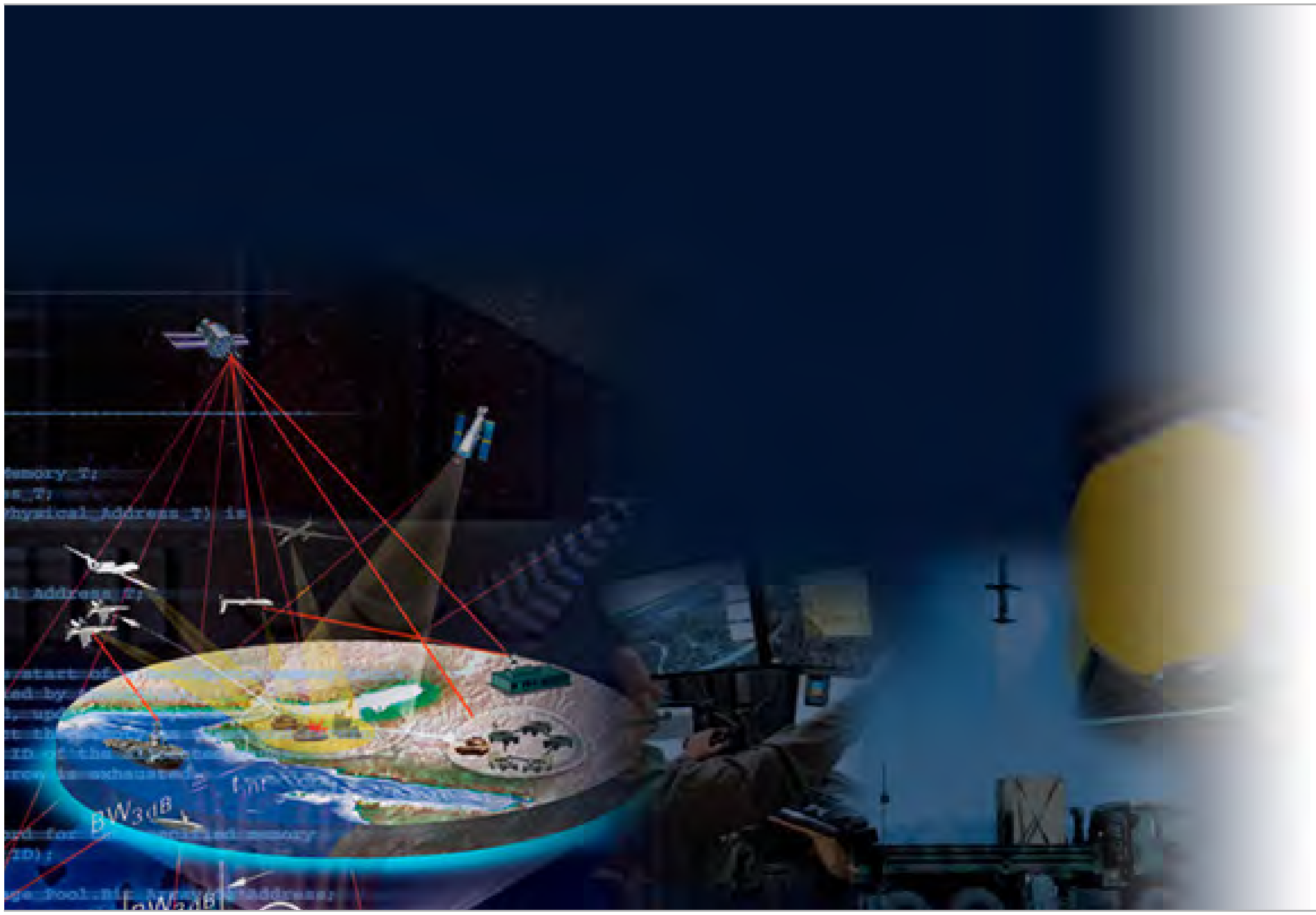
Customer Success Is Our Mission



Software Reliability Growth Test Approach

Lou Gullo

March 15, 2011

Raytheon

Overview

1. Software Reliability Definitions
2. Reliability Growth Introduction
3. Integration of the Software Reliability into System Development Process
4. IEEE 1633 and the 3 Step Process
5. Sample CASRE Data
6. Correlation Between the 3 Steps
7. Sample Results that Demonstrate Growth
8. IOS and Ao
9. Value Added Benefits
10. Software Reliability Innovation – Path Forward
11. SW Reliability References

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Software Reliability Definitions

- The American Institute of Aeronautics and Astronautics (AIAA) - "the application of statistical techniques to data collected during system development and operation to specify, predict, estimate, and assess the reliability of software-based systems."
- IEEE 1633:
  - **(A)** The probability that software **will not cause the failure of a system** for a specified **time** under specified **conditions**.
  - **(B)** The ability of a program to perform a required **function** under stated **conditions** for a stated period of **time**.
- IEC 62628:
  - Software Dependability - ability of the software to perform as and when required when integrated in system operation

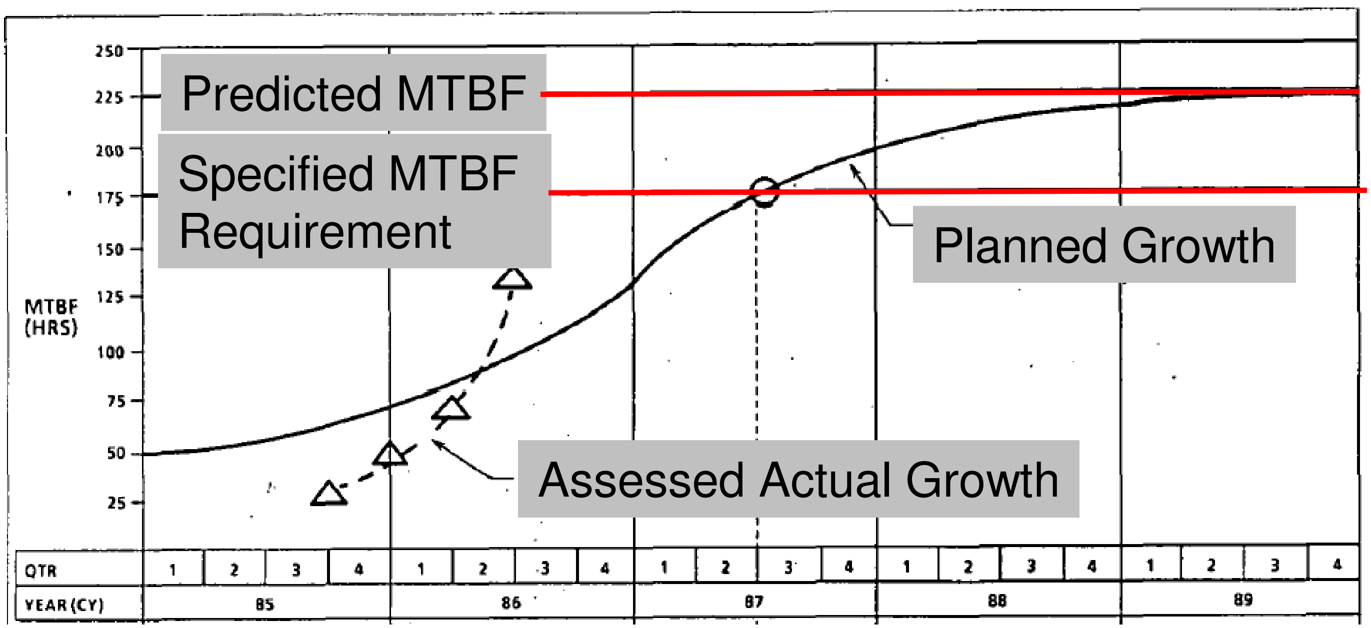
NOTE: Software Dependability includes Software Reliability as well as other measures of software performance and capability

Reliability Growth Introduction

- Purpose of Reliability Growth Planning is to develop a reliability growth planning curve which specifies the plan for achieving specified reliability values
- Provides a means for tracking reliability growth and monitoring progress as the test proceeds
- Growth is achieved from software design changes that effectively correct software defects that cause system failures
- Detailed guidelines are provided in MIL-HDBK-189
- Example of a reliability growth planning curve is provided in a figure (modification of MIL-STD-781, Figure 103-1) on the next slide.

Reference MIL-STD-781D, Task 103

Traditional Reliability Growth Curve



Modified Graph from MIL-STD-781

Notional Software Reliability Growth Curve Divided into Phases

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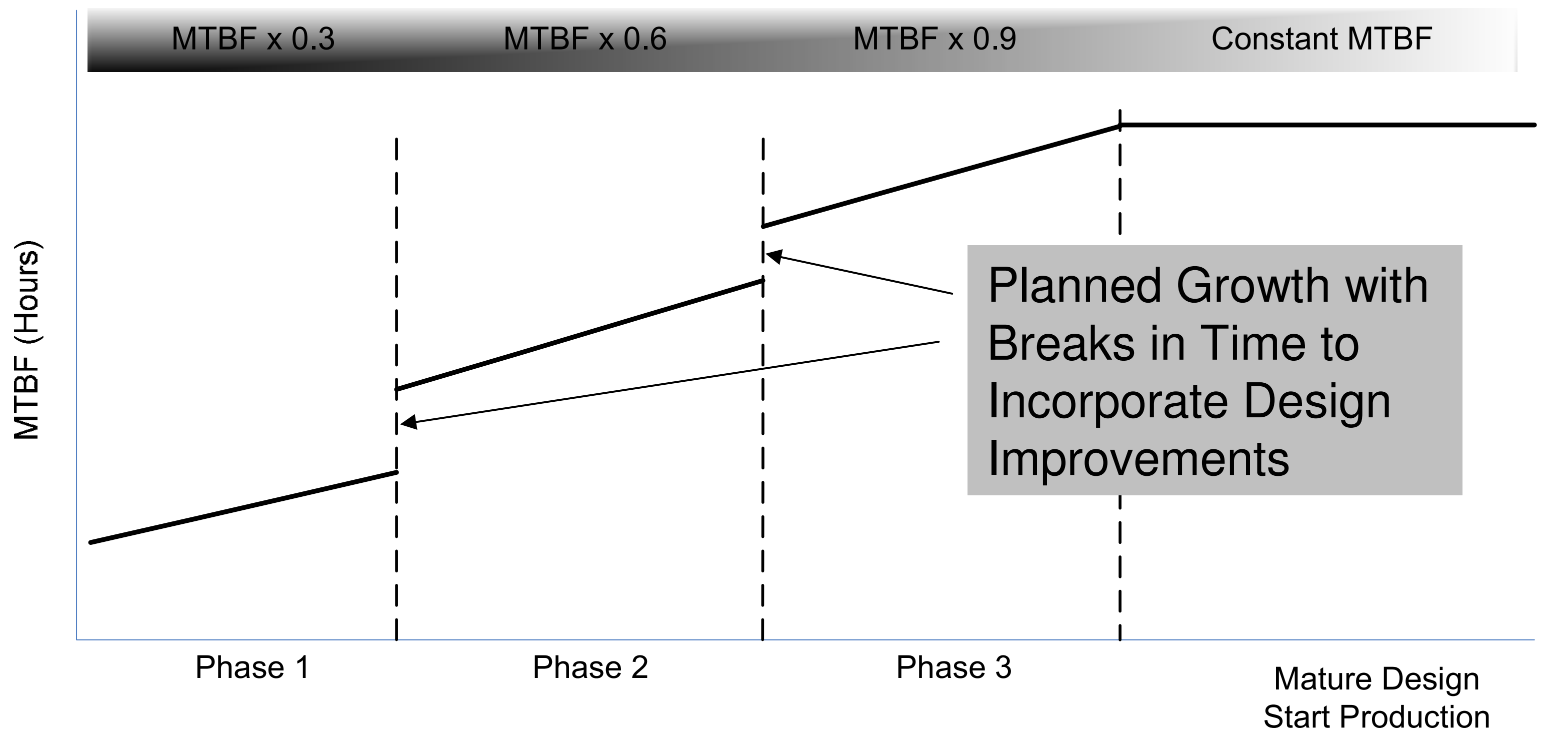

Integration of the Software Reliability Growth into Software/System Development Process

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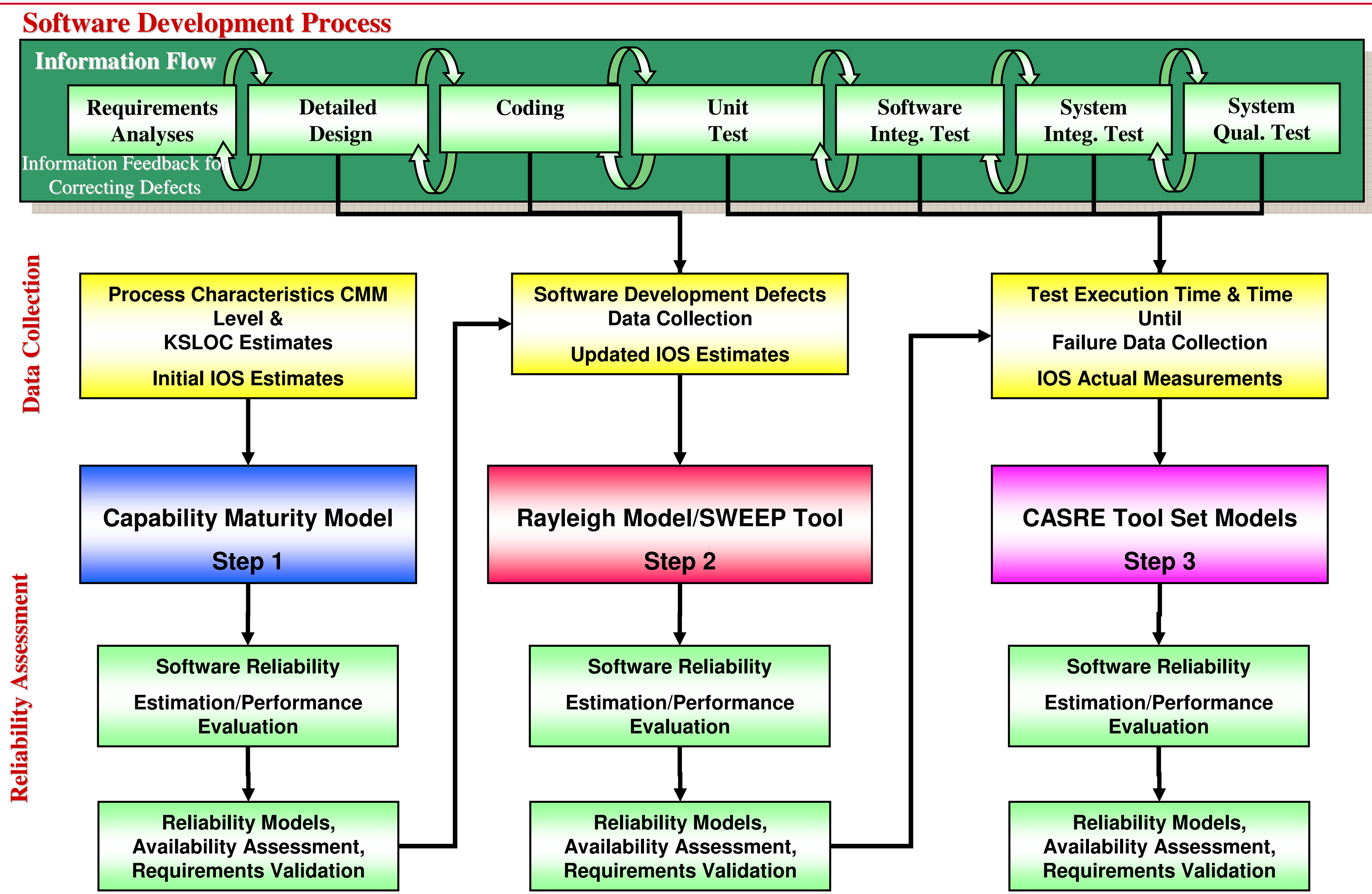

IEEE 1633

IEEE 1633 – IEEE Recommended Practice on Software Reliability (SR)

- Developed by the IEEE Reliability Society in 2008
- Purpose of IEEE 1633
  - Promotes a systems approach to SR predictions
  - Although there are some distinctive characteristics of aerospace software, the principles of reliability are generic, and the results can be beneficial to practitioners in any industry.

IEEE 1633 is Useful for Tailoring Software Reliability Prediction & Measurement Processes Depending on the Particular Needs

How to Apply IEEE 1633 to Align with Your SW Development Process

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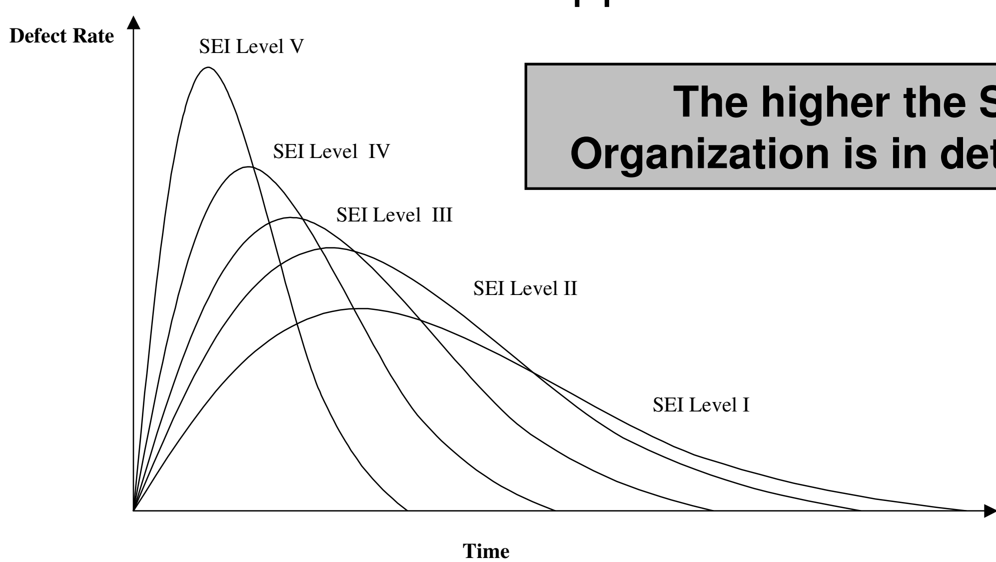
3 step process leveraging IEEE 1633:

- Step 1 – Keene Model for early software predictions
  - Weighs SEI CMMI Process Capability (e.g. CMMI Level 5 achieved by IDS) to Software Size (e.g. 10KSLOCs)
- Step 2 – SWEEP Tool for tracking growth of Software Trouble Reports (STRs) and Design Change Orders
- Step 3 – CASRE Tool for tracking failures in software testing

Software Reliability Prediction & Measurement Process

Capability Maturity Model (Keene Model) Step 1

- The Capability Maturity Model provides a <u>preliminary</u> prediction based on:
  – Estimated size of the code in KSLOC
  – Software Engineering Institute's (SEI) Capability Maturity Model (CMM) rating of the software developer
  – The assertion is that the software process capability is a predictor of the latent faults shipped with the code.



The higher the SEI Level the more efficient and Organization is in detecting defects early in development

The better the process, the better the process capability ratings and the better the delivered code will perform….**<u>defects will be lower</u>**.

Keene Model is Useful for Establishing Software Reliability Requirements

SWEEP (Software Error Estimation Program) Step 2

- **The SWEEP tool enables you to:**
  - Predict and track the rate at which defects will be found
  - Predict the latent defect content of software products
  - Plot design changes over time – demonstrate growth
  - Analyze estimated errors injected in each phase of the software development cycle
  - Determine the detection effectiveness and leakage of errors to subsequent phases.
  - Measure percentage of critical failures that feedback into the Keene model
- **Data Collection**
  - Data is typically collected using Software Trouble Reports (STR)
  - Data can be organized by development phase or time increments.

SWEEP is Useful for Curve Fitting Software Coding and Test Defect Data With the Rayleigh Distributions

CASRE (Computer Aided Software Reliability Estimation) - Step 3

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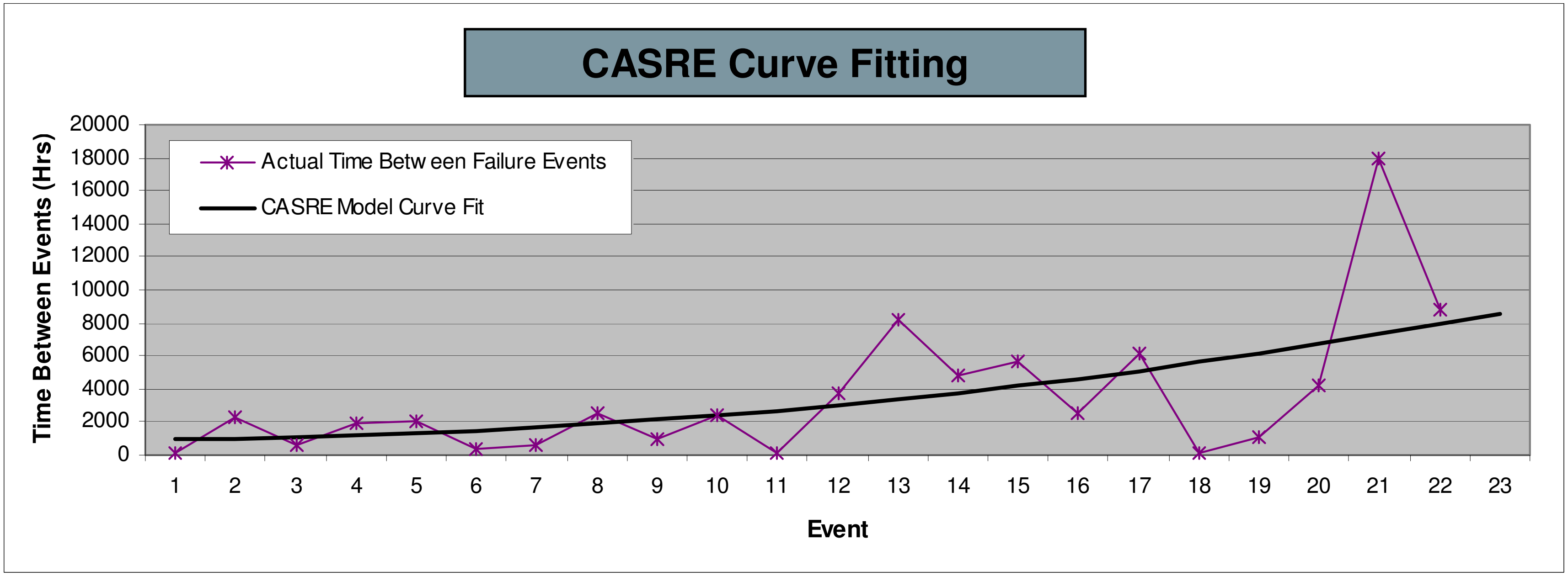
- CASRE is a software reliability measurement tool which collects and analyzes software test failures over time or phases in development
- The modeling and analysis capabilities provided by the reliability package SMERFS (Statistical Modeling and Estimation of Reliability Functions for SW).
- In implementing CASRE, the original SMERFS user interface has been discarded, and the SMERFS modeling libraries have been linked into the user interface developed for CASRE.
- Data Collection – CASRE can accept two types of data files:
  - Times between successive failures
  - Failure counts per test interval
- Experience shows that at the start of software test, modules having more than about 2000 source lines of executable code will tend to have enough faults to produce at least 40 to 50 failures.

CASRE is Useful for Curve Fitting Software Test Failure Data with Multiple Distributions

Sample CASRE Data Models and Output



<u>Times Between Failures Models</u>

Geometric
Jelinski-Moranda
Littlewood-Verrall Linear
Littlewood-Verrall Quadratic
Musa Basic
Musa-Okumoto

<u>Failure Counts Models</u>

Generalized Poisson
Schneidewind
Shick-Wolverton
Yamada S-shaped

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Correlation Between the 3 Steps

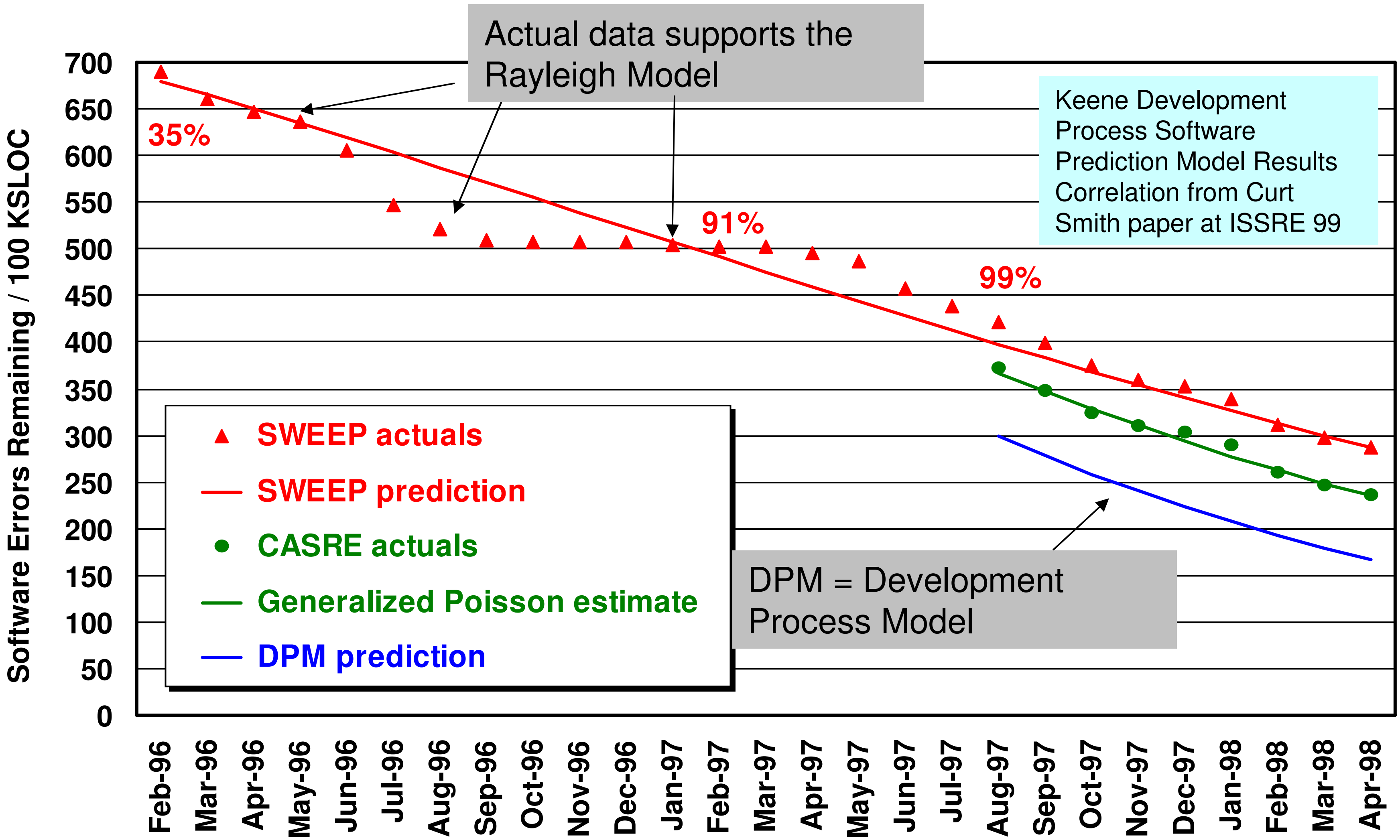
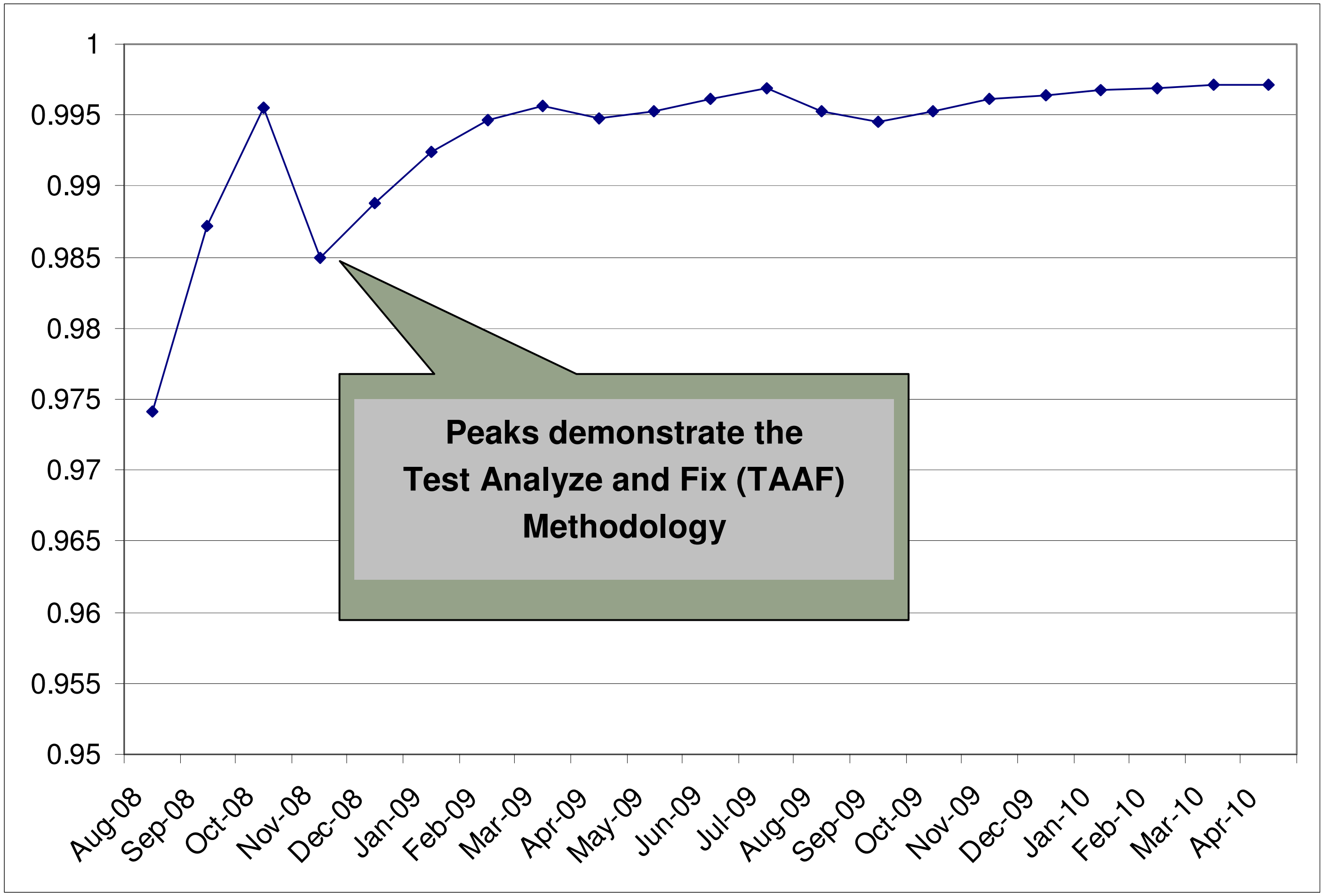


Figure reproduced by permission of the author and the IEEE © 10th International Symposium on Software Reliability Engineering

Sample Results that Demonstrate Growth



Demonstrates Traditional Growth Curve

IOS and Ao Calculations
Added Steps 4 and 5

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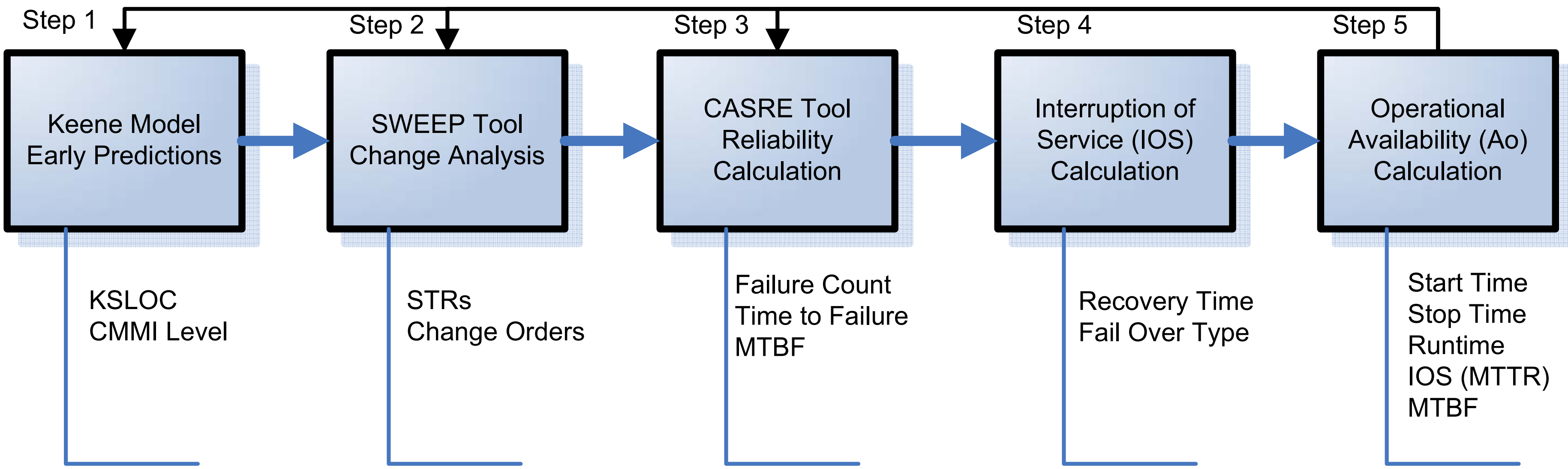

Closed Loop System with Step 5 Feedback to Steps 1 -3

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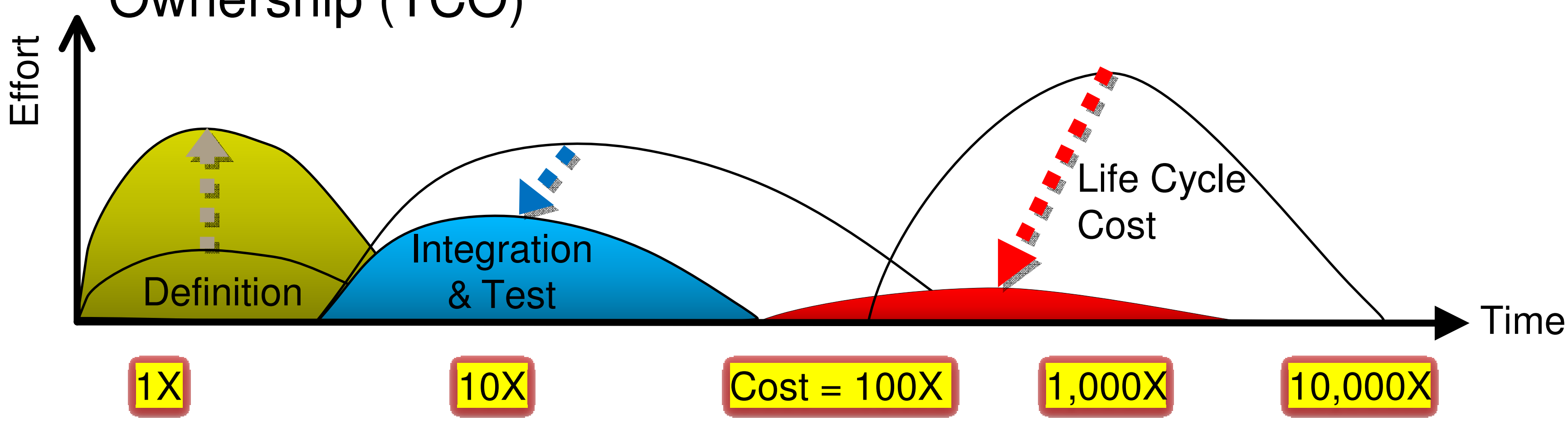
Value Added Benefits

- Reduce cost of failures later in the software development process
- Track failure trends during all phases of software test focusing on probabilistic conditions (e.g. race conditions) and systemic process-related issues
- Drive software design corrective actions to improve reliability results in a lower customer Total Cost of Ownership (TCO)



Save Cost over the Entire System Life Cycle

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Software Reliability Innovation – Path Forward

Initiatives to Increase SW Reliability Growth and Accelerate Deliveries of Mature / Dependable SW to the Warfighter:

- Continue improvement of software reliability growth testing processes and tools
- Continue decreasing SW fault density significantly during SW production, prior to testing
- Continue to develop new standards or sustain existing standards (e.g. IEEE 1633 and IEC 62628)
- Develop more rigorous software development processes

Raytheon Approach Accommodates Increased SW Complexity & Reliability

SW Reliability References

- Metrics and Models in Software Quality Engineering, Stephen Kan, Addison Wesley Publishing
- Handbook of Software Reliability Engineering, Michael Lyu, McGraw Hill Publishing
- Software Reliability: Measurement, Prediction, Application, John D. Musa, Anthony Iannino, and Kazuhira Okumoto, McGraw-Hill Book Company
- IEEE 1633: Recommended Practice on Software Reliability (SR)
- IEC 62628: Guidance on Software Aspects of Dependability

Biography

– Lou Gullo, Raytheon, Integrated Defense Systems, Whole Life Engineering Directorate. Leader on several Enterprise-wide Engineering Council-sponsored special projects including software reliability methods and the automation of electrical stress analysis methods. 30 years experience in military, space and commercial programs. Retired US Army Lieutenant Colonel. Senior Member of the IEEE. IEEE Reliability Society Standards Committee Chair. Member of the Reliability and Maintainability Symposium (RAMS) Management Committee.

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27th Annual National Test and Evaluation Conference

"Test & Evaluation: Serving the Warfighter"

Tampa, FL

14 – 17 March 2011

Agenda

MONDAY, MARCH 14, 2011

TUTORIAL C – SESSION I

- 11653 - Test Planning — Advancing the Science, Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector
- 11678 - Using DFSS as an Integrating Framework for MBT&E and DOT&E, Dr. Mark Kiemele, President and Cofounder, Air Academy Associates

TUTORIAL G – SESSION I

- 11570 - A Day in the Life of a Verification Statement Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector

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TUESDAY, MARCH 15, 2011

CONFERENCE KEYNOTE ADDRESS

- Honorable Dr. J. Michael Gilmore, *Director, Operational Test & Evaluation, OSD*

HOMELAND SECURITY T&E PERSPECTIVES

- Mr. Gary Carter, Director, Test & Evaluation and Standards Division, Department of Homeland Security

SESSION B: OTA'S (OPERATIONAL TEST AGENCY'S) ROUNDTABLE
Session B Chair and Roundtable Moderator: Dr. Catherine Warner, Science Advisor, DOT&E, OSD

SESSION C: ACQUISITION REFORM - THE IMPACT ON INDUSTRY

PENTAGON RESPONSE TO CONGRESSIONAL STRENGTHENING OF DT&E

- Mr. Chris DiPetto, Principal Deputy, Developmental Test & Evaluation

REPORT ON NDIA'S INDUSTRIAL COMMITTEE ON TEST & EVALUATION (ICOTE)

- Mr. James Ruma, *Chairman, NDIA ICOTE; Vice President, Engineering, GDLS*

CONCURRENT SESSIONS D – K

- 11627 - Assessing System Reliability Growth When Failure Modes are Masked, Dr. Patricia Jacobs, Naval Postgraduate School
- 11650 - Realistic and Measurable Suitability Requirements for Test, 1st Lt Andrew Passey, USAF, Air Force T&E Center, Detachment 6
- 11563 - Integrated Test and Independent Evaluation (IT&IE) and T&E Using Experimental Design Methodology, Mr. George Axiotis, DDR&E/DDT&E

- 11665 - OSD Perspective of DT&E in Navy Shipbuilding Programs, Mr. Patrick Clancy, OUSD(AT&L) DDR&E/DDT&E
- 11656 - An Industry Response to the Acquisition Changes, Mr. Steve Scukanec, Northrop Grumman Aerospace Sector
- 11499 - Emerging Methodology for Mission-Based Capability Assessments, Mr. William Landis, ARL/SLAD
- 11557 - Measures Development Standard Operating Procedure (SOP), Mr. John Smith, Operational Test & Evaluation Force
- 11666 - Understand the Mission - A "How-To" Guide for MBTE Practitioners, Mr. Britt Bray, DRC
- 11662 - Design Methodology for Expedient, Low Cost UAV Runways, Mr. Lorenz Eber, Naval Surface Warfare Center, Dahlgren
- 12878 - DoD Strategic Planning for Test and Evaluation, Mr. Lee Schonenberg, Whitney, Bradley and Brown Consulting
- 11709 – Decoupled Test, Evaluation, and Certification of a System of Systems, Mr. Robin Murray, JITC
- 11564 - The CRIIS High Accuracy TSPI Architecture and Technical Maturity Demonstration Test Results, Dr. Sultan Mahmood, Air Armament Center, AAC/EB
- End-to-End GPS Multi-Platform Integrated System Testing for MGUE, Dr. Sultan Mahmood, Air Armament Center, AAC/EB
- 11640 - Directed Energy Test Tri-Service Study 2011: Identifying Directed Energy Test & Evaluation Infrastructure Requirements, Mr. Doug Weatherford, PM ITTS IMO
- 11645 - Holographic Radar Brings a New Dimension to Sensing and Instrumentation on T&E Ranges, Mr. Gary Kemp, Cambridge Consultants
- 11467 - Guiding the Engineer Through the T&E Process, Mr. Allen Brailey, Raytheon Company
- 11483 - How to Frame a Robust Sweet Spot Via Response Surface Methods (RSM), Mr. Mark Anderson, Stat-Ease, Inc.
- 11553 - MIL-PRF-XX613 and MIL-STD-X618: The Navy Gets Serious About Armor, Mr. Christopher Brown, Naval Surface Warfare Center, Crane
- 11541 - Fragment Analysis for the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC), Ms. Karen Pizzolato, U.S. Army Research Laboratory
- 11516 - Mission-Based Test and Evaluation Strategy: Progress Towards Uniting Combat Developer, Materiel Developer and T&E, Mr. Christopher Wilcox, U.S. Army Evaluation Center
- 11552 - Using Complementary Frameworks for Qualitative Data Collection During OT&E: Piggybacking on Operational Experiments, Ms. Chiesha M. Stevens, Pacific Science & Engineering Group, Inc.
- 11699 - Continuous Cost Reduction Feeds Back into Product Reliability, Mr. Jonathan Nikkel, Raytheon Missile Systems
- 11704 - Testing & Evaluating the Net- Ready Key Performance Parameter (KPP), Ms. Danielle Koester, JITC

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WEDNESDAY, MARCH 16, 2011

-

SESSION L: A RE-ENERGIZED DT&E
PANEL: T&E: SERVING THE WARFIGHTER IN A COST-CONSTRAINED ENVIRONMENT

Panel Moderator:

- Mr. Chris DiPetto, Principal Deputy, Developmental Test & Evaluation

Panelists:

- Mr. David K. Grimm, Acting Director, Deputy Under Secretary of the Army, T&E Office
- Mr. Steve Hutchison, DISA T&E Executive

SESSION M: RESPONSIVE AND AGILE INFORMATION SYSTEMS T&E PANEL

Session M Chair and Panel Moderator:

- Dr. Steve Kimmel, Chairman, NDIA C4ISR Division; Senior Vice President, Alion Science & Technology

SESSION N: IMPROVING THE T&E PROCESS
SOCOM T&E PERSPECTIVES: SERVING THE WARFIGHTER

- LTC Kevin Vanyo, USA, USSOCOM J8-O

CONCURRENT SESSIONS O – V

- 11560 - A Comprehensive Approach to Characterizing the Hazards of Explosive Countermeasures With Respect to Dismounted Troops, Mr. Stephen Swann, U.S. Army Research Laboratory
- 11529 - Expanding Use of the Probability of Raid Annihilation (PRA) Test Bed Across the Ship Self-Defense Enterprise, Mr. Richard Lawrence, AVW Technologies
- 11500 - Modeling and Simulation for Mission-Based Test and Evaluation (MBT&E), Mrs. Beth Ward, U.S. Army Research Laboratory
- 11476 - A Paradigm for Modeling and Simulation in support of Mission-Based Test and Evaluation, Dr. James Walbert, SURVICE Engineering Company
- 11497 - Joint Mission Environment Test Capability (JMETC): Improving Distributed Capabilities, Mr. Chip Ferguson, JMETC
- 11508 - U.S.N. RDTE Project Support Aircraft, Mr. Charles Myers, U.S. Navy, NAWCAD
- 11626 - Dugway Proving Ground as the MRTFB Chem Bio Activity, Ms. Jean Baker, U.S. Army Dugway Proving Ground
- 11677 - Using Design of Experiments (DoE) to Integrate Developmental and Operational T&E, Dr. Mark Kiemele, Air Academy Associates
- 11549 - Probability Driven Experiments Design for Autonomous Systems, Mr. Troy Jones, Charles Stark Draper Laboratory

- 11532 - Design of Experiments: Managing Expectations, Mr. James Carpenter, AVW Technologies, Inc.
- 11538 - Personnel Injury Analysis of Reflective Spall, Mrs. Rebecca VanAmburg, U.S. Army Research Laboratory
- 11539 - Analytical Approach Using MUVES-S2/ORCA Modeling in Support of the Joint Cargo Aircraft (JCA), Mr. Richard Moyers, U.S. Army Research Laboratory
- 11674 - Utilization of Model and Simulation for Network Waveform Characterization and Validation, Mr. Scott Rediger, Rockwell Collins
- 11676 - Model Based Systems Engineering and M&S Adding Value to T&E, Mr. Larry Grello, High Performance Technologies, Inc.
- 11554 - The Impact of High Accuracy Target Geometry in Modeling and Simulation to Support Live Fire Test and Evaluation, Mr. Scott Hornung, U.S.Army Research Laboratory/ SLAD
- 11638 - Army Testing in a Services Oriented Architecture (SOA) Environment, Mr. Michael Phillips, Mantech International
- 11639 - The Test and Training Enabling Architecture (TENA) Enabling Technology for the Joint Mission Environment Test Capability (JMETC) in Live, Virtual, and Constructive (LVC) Environments, Mr. Gene Hudgins, TENA/JMETC
- 11682 - Advanced Range Data System (ARDS) Service Life Extension Program (SLEP) - "Ensuring GPS Based TSPI Remains a Viable T&E Range Instrumentation Asset", Mr. Dick Dickson,TYBRIN Corporation
- 11698 - Target Systems in Support of Test and Evaluation, Mr. James Schwierling,U.S. Army Targets Management Office
- 11524 - Ready for Scrum? Dr. Steven Hutchison, DISA
- 11649 - Affordable Test and Evaluation in a Complex World, Mr. Thomas Wissink, Lockheed Martin
- 11710 - Testing U.S. Systems for Coalition Interoperability, LTC Tim Timmons, USA,JITC
- 11659 - Impacts of the Learning Curve - Operational Test & Evaluation, Ms. Shannon Krammes, MCOTEA

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THURSDAY, MARCH 17, 2011

SESSION W: TEST DESIGN, TEST CURRICULA AND STANDARDS

- 11690 - Doing More Without More - Scientific T&E Design Methodologies (STED in DOD Weapons Systems Aquisition), Ms. Darleen Mosser-Kerner, Deputy Director, Capabilities Development, Office of the Director, DT&E
- Report On Standards For DT&E, CDR Ernest Swauger, USN (Ret), JPEO-CBD/Chief, CM/HD Systems IPAT
- 11663 - Effective Combat Data Collection & Applicability to T&E, LtCol Michael Kennedy, USMC, Expeditionary Test Division, MCOTEA
- 11651 - Test & Evaluation Issues For Systems of Systems (SoS): Creating Sleep Aids For Those Sleepless Nights, Dr. Beth Wilson, Principal Engineering Fellow, Raytheon Company
- 11569 - T&E - Guarding The Requirements Intent, Mr. Steve Scukanec, Senior Test Engineer, Northrop Grumman Aerospace Sector

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NDIA 27th Annual National Test and Evaluation Conference

Joint Program Executive Office for Chemical and Biological Defense

Need for Test Standards in Developmental Testing

Ernest Swauger
Juan Vitali
JPEO-CBD
T&E LNO
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Date of Briefing:
17 March 2011

Why Do Developmental Testing?

- **Provide Information for informed decision making**
- **Verification and Validation of the Systems Engineering Process**
- **Provide confidence that the system design solution is on-track to satisfy the desired capabilities**

Reduce Technical Risk and increase probability of a successful program

Understanding the Capability

- Use Developmental Testing to:
  - To stress the system and understand its limitations
  - To operate it for sufficient periods of time--in a relevant environment--to derive/predict future RAM
  - To prosecute it in a relevant environment to understand its survivability and safety in combat
- To know why it works/how it works
- To ensure the delivered performance can withstand scrutiny from challenges by Users/Industry
- To ensure that it <u>can repeat its performance under operational conditions with actual operators</u>

Laboratory Tests

- Controlled environments
  - Temp, Humidity, Air Pressure, Concentrations, etc.
- Measured inputs, outputs
  - Linear and non-linear events in linear and non linear methodologies ?
- Methodology (Test Procedures, Test Data, and Test Tools) needs to be specific
  - Include calibration, identification of all parts and components, and detailed procedures for all steps
  - Functional and interoperable requirements
  - Referenced Standards
  - Derived test requirements based on the functional and interoperable requirements and referenced standards
  - Assumptions which may influence the selection of a specific test method or scope of testing

Demonstrate, Test, Evaluate and Introduce Technology

- Potential solution is tested/evaluated to determine how well it addresses the intended functional requirement
- Introduction of solution into practice
- Develop performance standards and guides, as appropriate, to ensure safety and effectiveness

Not all new solutions will require the publication of new standards and guides

Performance vs. Method Standards

- **Performance vs. Method Standards**
  - **Performance: Limit to be met**
  - **Methodology: Detailed description of how a test is to be conducted, under what conditions, calibration accuracy and interval, materials, etc.**

Methodology Development Needs

- **Development, validation, and application of new analytical methods**

- **Development of new analytical reference materials and operation of proficiency testing programs**

- **Full range of sophisticated measuring techniques and state-of-the-art laboratories**

Standards Organizations

- International Standards Organizations
  - ISO, IEC, ITU, etc.
  - ASTM International
- Regional Standards Organizations
  - CEN, ETSI, IRMM, PASC, etc.
- National Standards Bodies
  - ANSI, JISC, NFPA
- Standard Developing Organizations/Bodies:
  - IEEE, DoD
  - Peer Reviewed, Inclusive of all Stakeholders

DoD Policy: Use NGO STDs

DoD Policy on the Use of Non-Government Standards: DoD is committed to the adoption and use of voluntary consensus standards (defined in DoD 4120.24-M as "non-Government standards (NGS)"), where practical, instead of developing new or updating existing government specifications and standards. This policy is consistent with P.L. 104-113, the National Technology Transfer and Advancement Act of 1995 (NTTAA) and with Office of Management and Budget (OMB) Circular No. A-119 (Revised), "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities," dated February 10, 1998.

Repeatability, Reproducibility

- Repeatability: Ability to repeat test in same laboratory, same tester

- Reproducibility: Ability to reproduce test in different laboratories, different testers

- Parameters to be included in future test reporting?

Lab Management Practices

- **How Do We Ensure Quality Control in Processes?**
  - **ISO/IEC 17025: Industry standard, used also by facilities across the gov't**
    - **ISO 17025 is the leading international laboratory quality management system (QMS) standard. ISO 17025 is compatible with, but not equivalent to ISO 9001. ISO 17025 connects the laboratory quality management system to all other laboratory processes.**
    - **It specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling.**
    - **It covers testing and calibration performed using standard methods, non-standard methods, and laboratory-developed methods.**
    - **It is applicable to all organizations performing tests and/or calibrations. These include, for example, first-, second- and third-party laboratories, and laboratories where testing and/or calibration forms part of inspection and product certification.**
    - **It is applicable to all laboratories regardless of the number of personnel or the extent of the scope of testing and/or calibration activities.**

ISO/IEC 17025

- There are many commonalities with the ISO 9000 standard, but ISO/IEC 17025 adds in the concept of competence.
- The contents of ISO/IEC 17025 - The ISO/IEC 17025 standard itself comprises five elements that are Scope, Normative References, Terms and Definitions, Management Requirements and Technical Requirements. The two main sections in ISO/IEC 17025 are Management Requirements and Technical Requirements. Management requirements are primarily related to the operation and effectiveness of the quality management system within the laboratory. Technical requirements includes factors which determines the correctness and reliability of the tests and calibrations performed in laboratory.

ISO/IEC 17025

- **Laboratories use ISO/IEC 17025 to implement a quality system aimed at improving their ability to consistently produce valid results. It is also the basis for accreditation from an Accreditation Body. Since the standard is about competence, accreditation is simply formal recognition of a demonstration of that competence.**

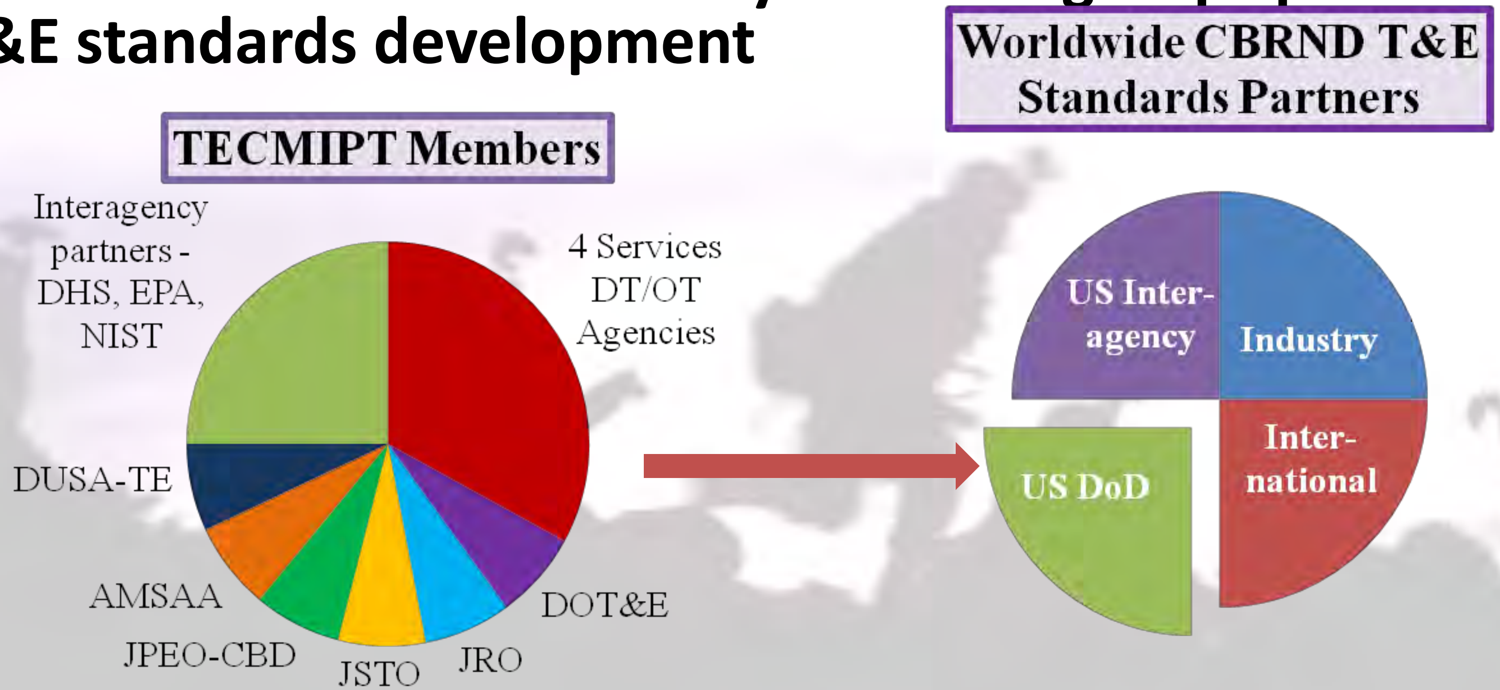
- **A prerequisite for a laboratory to become accredited is to have a documented quality management system. The usual contents of the quality manual follow the outline of the ISO/IEC 17025 standard.**

Need to Standardize Test Processes, Facility Mgmt

- It enhances credibility
- It enhances repeatability, reproducibility
- It defends against legal challenges
- It supports efficient use of resources and best data quality

DoD Process for Establishing T&E Standards

- **CBRND T&E Executive establishes DoD CBRND T&E standards through T&E Capabilities and Methodologies IPT (TECMIPT)**
- **SMEs in TECMIPT commodity area sub-groups provide rigor to T&E standards development**



How? TECMIPT Process

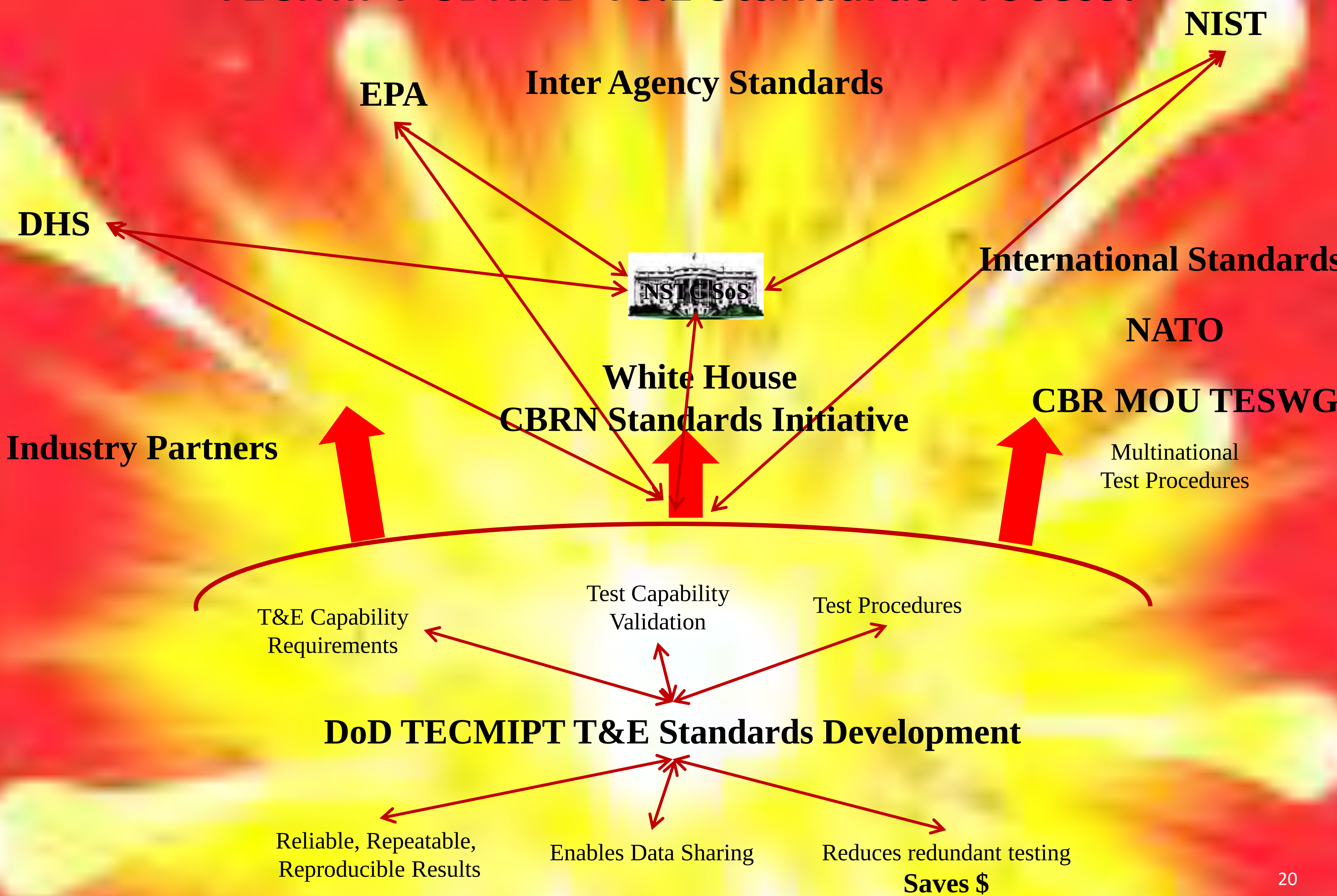
Provides joint, cross-community subject matter expertise and rigor to establish T&E Standards

- **JPEO-CBD, JSTO, JRO, ATEC (AEC, OTC, DTC, DPG), MCOTEA, OPTEVFOR, AFOTEC, ECBC, DOT&E, NSWC-Dahlgren, AMSAA (serves as TECMIPT Chair for DUSA-TE), NIST, DHS, EPA**
- **Identifies T&E capability gaps for DUSA-TE's POM submission**
- **June 2009 – Instructions to the TECMIPT: Develop/review/recommend T&E standards documents for CBRND T&E Executive approval**
- **July 2010 – CBDP T&E Standards Development Plan signed into policy by CBRND T&E Executive**
  - **Includes plans for QA - obtain outside certification of all DoD CBDP test labs**

TECMIPT Mechanism for T&E Standards Development

- **Seven Capability Area Process Action Teams (CAPATs) develop/review/recommend T&E standards documents for CBRND T&E Executive approval**
- **CAPATs:**
  - Chemical Detection
  - Biological Detection
  - Individual Protection
  - Collective Protection
  - Decontamination
  - Radiological/Nuclear (cross-commodity)
  - M&S (cross-commodity)

Explosion of Interest in TECMIPT CBRND T&E Standards Process!



Principles and Key Actions

- Rigorous Testing is Required to Ensure Vendor and System Compliance with Standards
- Standards and Conformity Assessment Processes Must be Identified and Adopted Across all Agencies to Ensure Full Interoperability
- Timely Adoption and Use of Appropriate Standards is Critical to Achieving Goals


Questions?

Operational Test Agency Roundtable

Moderator: Dr. Catherine Warner

Science Advisor

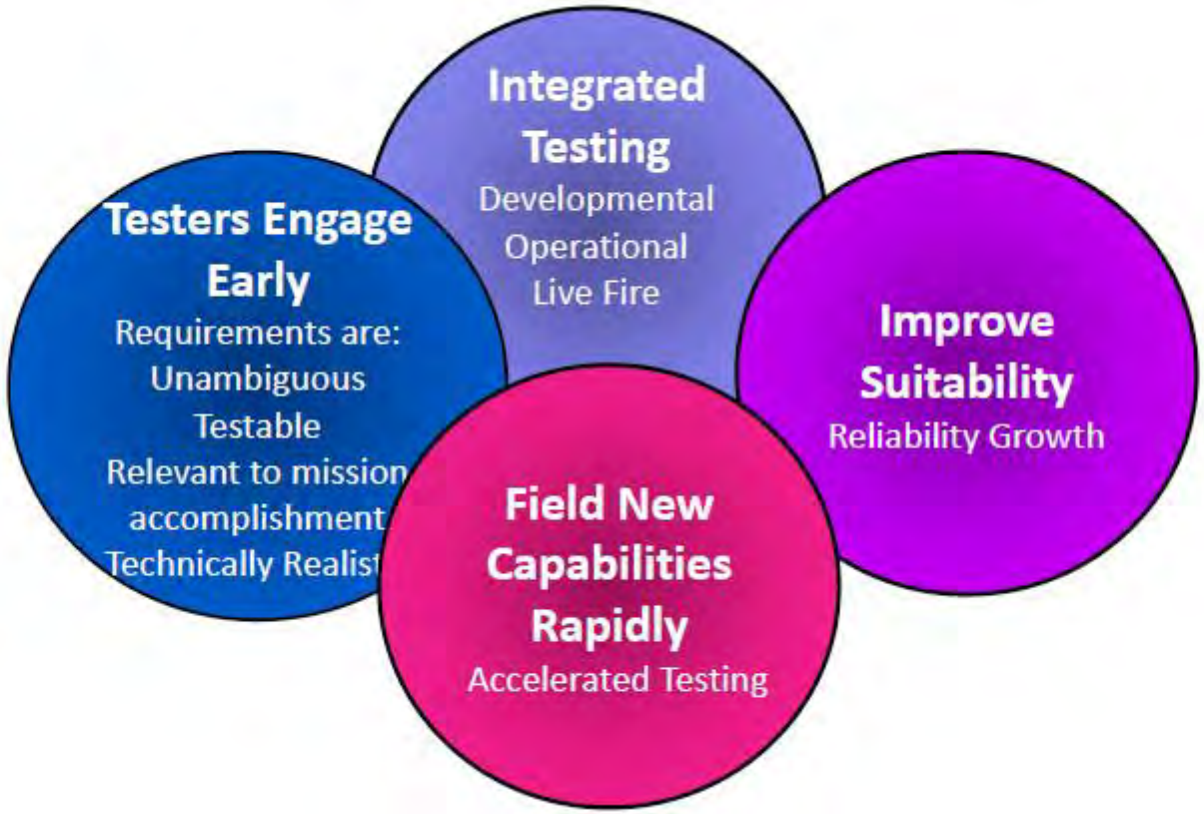
Director of Operational Test and Evaluation

NDIA T&E Conference March 15, 2011

Roundtable Participants

- Major General Genaro Dellarocco, USA, Commander, ATEC
- Rear Admiral David Dunaway, USN, Commander, OPTEVFOR
- Major General David Eichhorn, USAF, Commander, AFOTEC
- Colonel David Reeves, USMC, Commander, MCOTEA
- Colonel Joseph Puett, USA, Commander, JITC

Current DOT&E Initiatives



Today's focus – Integrated Testing

Integrated Test and Evaluation

- **What is it?**
  - Testing early in mission context and realistic environments
  - An efficient continuum of tests throughout DT, OT, LFT
  - Using data from one type of test for insight into other types
  - Using *all* test data to support evaluations
  - Not a replacement for independent OT&E

- **Why is it important?**
  - Discover problems early when they are cheaper and easier to fix
  - Understand system performance across operational envelope
  - Increase confidence in test results

Scientific Approaches Necessary for Successful Integrated T&E

- **Structured and rigorous statistical tools**
  - Stochastic simulations to supplement field tests
  - Methods for rigorous assessments of small sample sizes
  - Methods to combine data from disparate sources

- **Design-of-experiments (DOE) principles**
  - Quantitative response variables – mission-based for OT
  - Breadth of coverage of the operational environment – including realistic threats
  - Methods for strategically varying operational conditions
  - Objective measures of "How much testing is enough?"
  - Presentation of confidence based results

Opening Question #1

- How does your command define the mission context to be used in operational tests?
  - What is your view of how mission accomplishment should be evaluated?

Question #2

- How can (does?) your command enable Integrated Testing to occur in realistic operational environments?
  – How much influence can (do?) you have on the developmental test program?

A “Tail” of Getting Adequate LFT&E Funding

Original planned buy of 120 C-17, approximate acquisition cost **$3B**

-Cost of the LFT&E program **$30M (1%)**

Eventual buy over 200 aircraft

-Cost of one tail of one C-17, provided information to improve survivability for over 200 aircraft

Question #3

- **The cost of DT and OT is a small percentage of a program's acquisition costs; however the cost of testing is a large percent of the budget in the fiscal years in which it occurs.**
  - **The current environment of efficiencies appears to exacerbate concerns about the cost of testing.**
- **What do you think can be done to increase the relevance and perceived importance of government testing both DT&E and OT&E - to demonstrate its "worth"?**

Question #4

- Interoperability is key to US military operations.
  - Testing interoperability in a lab environment is straightforward. What are your challenges with testing interoperability in realistic environments?
  - What can be done in terms of an incentive structure to get PEOs and PMs to assess their systems early on in a joint interoperability laboratory environment?

Question #5

- How do you see the role of M&S in the conduct of OT&E?
  - How can DT enable better use of M&S tools in OT?
  - How do you foster an appropriate and adequate VV&A program/plan?

Developmental Test & Evaluation

Pentagon Response to Strengthening DT&E

Presented to NDIA T&E Conference

Chris DiPetto
Principal Deputy
Deputy Assistant Secretary of Defense, Developmental Test & Evaluation

March 15, 2011

www.acq.osd.mil/dte/

Megatrends

What's new in DT&E?

DT&E Focus Areas

Megatrends

- **WSARA**
  OSD response

- **Acquisition Efficiencies**
  Better Buying power

SECDEF Press Conference
6 JAN 2011

2 Last

"This department simply cannot risk continuing down the same path – where our investment priorities, bureaucratic habits, and lax attitudes towards costs are increasingly divorced from the real threats of today, the growing perils of tomorrow, and the nation's grim financial outlook."

Secretary of Defense Robert M. Gates

WSARA and DT&E

Principal advisor to the Secretary of Defense and AT&L on DT&E in the DoD

Responsibilities:

- Program Oversight
- Planning (TEMP /s/)
- Policy and Guidance
- Acq DT&E workforce
- Component Capability
- Annual Report

DT&E in Title 10, USC, Section 139d

Pentagon Plan for Efficiency

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

(L) Secretary of Defense Robert M. Gates
(R) USD AT&L Dr Ashton B. Carter

"Consumers are accustomed to getting more for their money – a more powerful computer, wider functionality in mobile phones – every year. When it comes to the defense sector, however, the taxpayers had to spend significantly more in order to get more. We need to reverse this trend."

Secretary of Defense Robert M. Gates

Implications for the Test and Acquisition Communities

- **Enterprise will manage risk**
  - Rapid vs. Deliberate Acquisition
- **Visibility**
  - DT&E voice at DAB
  - Increased planning rigor/fidelity
  - Efficiencies: DOE, IT, M&S……..
- **Acquisition**
  - Oversight and Accountability
  - Accept less risk at MS decisions
  - Improving Process Effectiveness
  - More DT less OT?
    - Confirmation vs Discovery
  - Affordability

What's new in DT&E?

- **Director, DT&E is now DASD (DT&E)**
- **Concurrent Service TRMC/DT&E**
- **Major Leverage Points**
  - TEMP Approval
  - Defense Acquisition Board Engagement
  - Peer Reviews
  - Assessment of Operational Test Readiness
- **Annual Report: 2nd in the hopper**
- **Policy Changes:**
  - Key Leadership Positions

5 Last

….. DASD(DT&E) Focus Areas

DASD (DT&E)

- T&E Workforce (Inherently Gov Work)
- DAU T&E Curriculum
- Metrics - WSARA requirement
- DOE
- Responsible Test Organization




SecDef Efficiencies

- TES / TEMP Consolidation
- Use of Government T&E Facilities
- Concurrent Service TRMC/DT&E

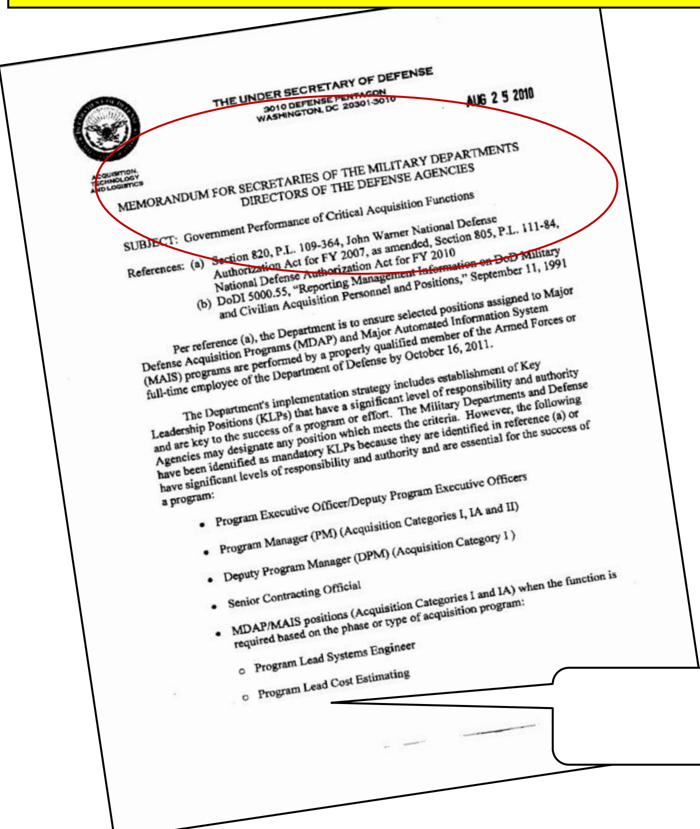
10 Last

T&E Workforce:

Government Performance of Critical Acquisition Positions

T&E Workforce divided:

- **DAWIA coded**
- **Non-DAWIA coded**
- **Service Support Contractors**



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

AUG 2 5 2010

ACQUISITION, TECHNOLOGY AND LOGISTICS

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Government Performance of Critical Acquisition Functions

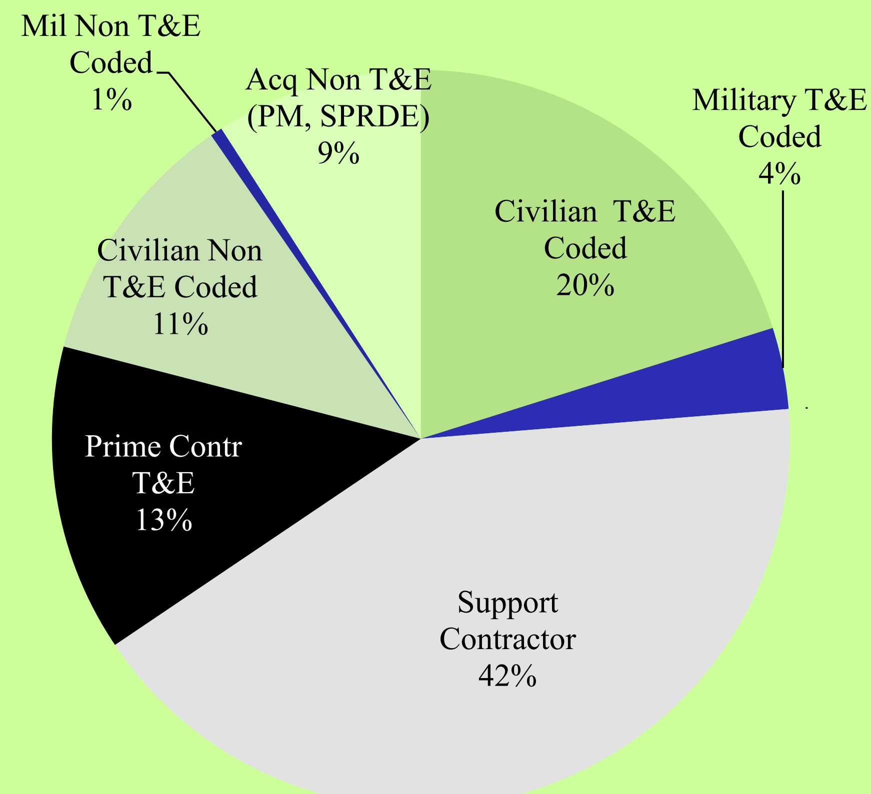
References: (a) Section 820, P.L. 109-364, John Warner National Defense Authorization Act for FY 2007, as amended, Section 805, P.L. 111-84, National Defense Authorization Act for FY 2010
(b) DoDI 5000.55, "Reporting Management Information on DoD Military and Civilian Acquisition Personnel and Positions," September 11, 1991

Per reference (a), the Department is to ensure selected positions assigned to Major Defense Acquisition Programs (MDAP) and Major Automated Information System (MAIS) programs are performed by a properly qualified member of the Armed Forces or full-time employee of the Department of Defense by October 16, 2011.

The Department's implementation strategy includes establishment of Key Leadership Positions (KLPs) that have a significant level of responsibility and authority and are key to the success of a program or effort. The Military Departments and Defense Agencies may designate any position which meets the criteria. However, the following have been identified as mandatory KLPs because they are identified in reference (a) or have significant levels of responsibility and authority and are essential for the success of a program:

- Program Executive Officer/Deputy Program Executive Officers
- Program Manager (PM) (Acquisition Categories I, IA and II)
- Deputy Program Manager (DPM) (Acquisition Category I)
- Senior Contracting Official
- MDAP/MAIS positions (Acquisition Categories I and IA) when the function is required based on the phase or type of acquisition program:
  - Program Lead Systems Engineer
  - Program Lead Cost Estimating

○ Program Lead Test and Evaluation



Data from Services’ 2009 Self Assessment

DAU T&E Curriculum

T&E curriculum out of date

- **DT&E actively involved with DAU**
- **Training for Non-DAWIA coded workforce**
- **DAU T&E Curriculum Re-Certified**
- **Incorporate practical training**

Improved training for entire T&E Workforce

Responsible Test Organizations (RTOs)

Lack of DT&E expertise and impartial evaluation

- Immature systems going into OT&E
- Lack of government access to contractor data
- Lack of impartial evaluations of system performance
- No single government point of contact for DT&E

- Way Ahead:
  - Finalize RTO definition with T&E Execs and Components
  - DoD 5000.02 Policy Change: Require designation of Gov RTO
  - Update Defense Acquisition Guidebook

Impartial & early reporting of system deficiencies

TES/TEMP Consolidation

Acquisition documents being streamlining

- TES development duplicates TEMP development
- Not enough transparency on T&E resources at Milestone A
- Eliminate the TES at Milestone A
- Incorporate into a TEMP at Milestone A

Earlier planning & identification of T&E resources

Use of Government T&E Capabilities

Government paying twice for T&E capabilities

- **DoD owns a National resource of T&E capabilities**
- **$5.6 *Billion* investment and operating cost in FY10**
- **Need to realize maximum value from capital investments**
- **Reinforce and Require adherence to Policy & Guidance**

Improves capital utilization of existing facilities

DT&E Opportunities

RTA's Wanted !

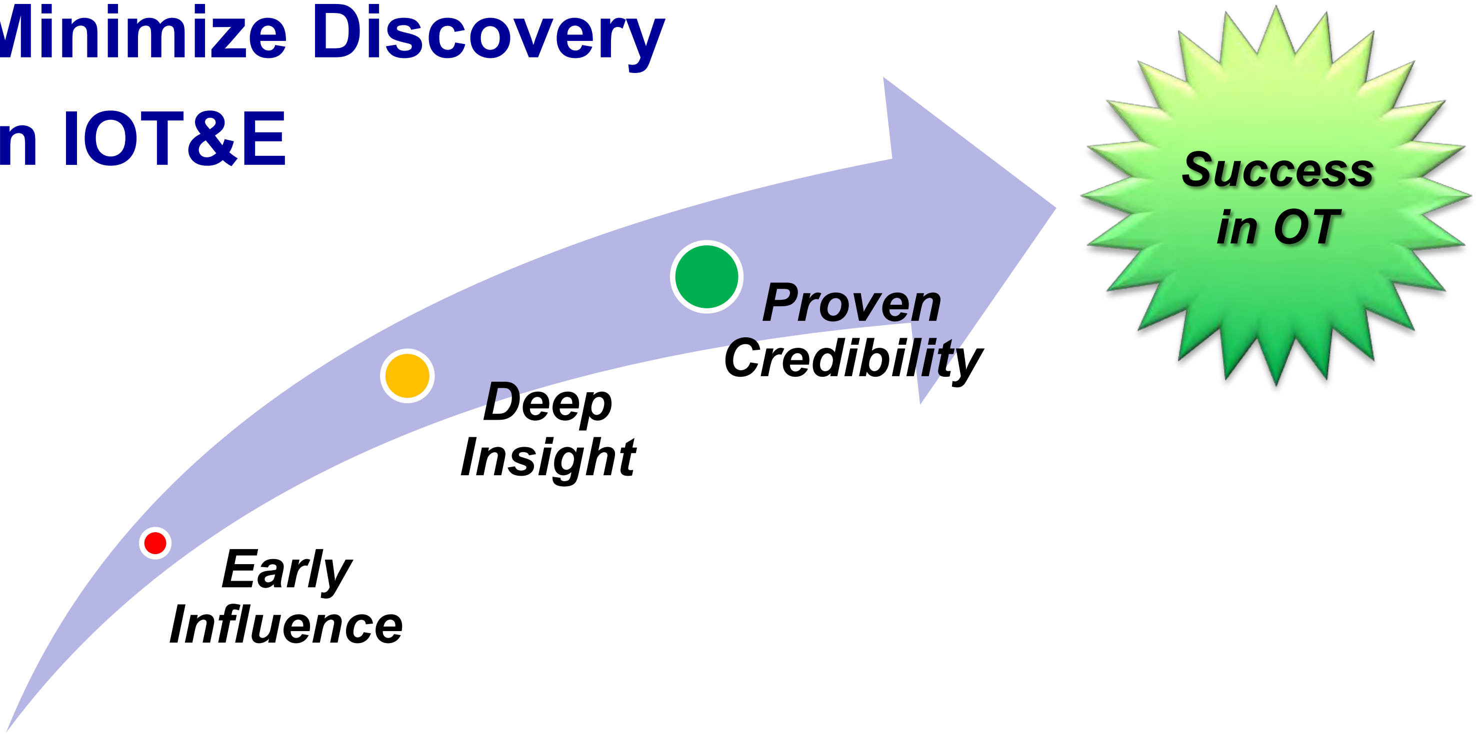
Rotational Training Assignees sought for 1 year professional development assignment in OSD / DT&E

- **1 Yr minimum tour length**
- **DT&E covers mission TDY costs**
- **Outstanding Professional development**
- **Perfect for GS-13/14/15 seeking OSD experience**
- **Contact DT&E for more info!**

DT&E's Vision

- **Improving Acquisition Outcomes**
  - *"Going from red to green…"*
- **Early & Continuous Program Engagement**
- **Minimize Discovery**

  In IOT&E



Questions?

OFFICE OF THE SECRETARY OF DEFENSE

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS

DEVELOPMENTAL TEST & EVALUATION

3090 Defense Pentagon
Room 5A1076
Washington, DC 20301-3090

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www.acq.osd.mil/dte

The right information, to the right decision maker, at the right time, for *better* decisions

Back-Up

Testing in OSD

Secretary of Defense
The Honorable Robert M. Gates

Under Secretary of Defense
AT&L
Hon Ashton B. Carter

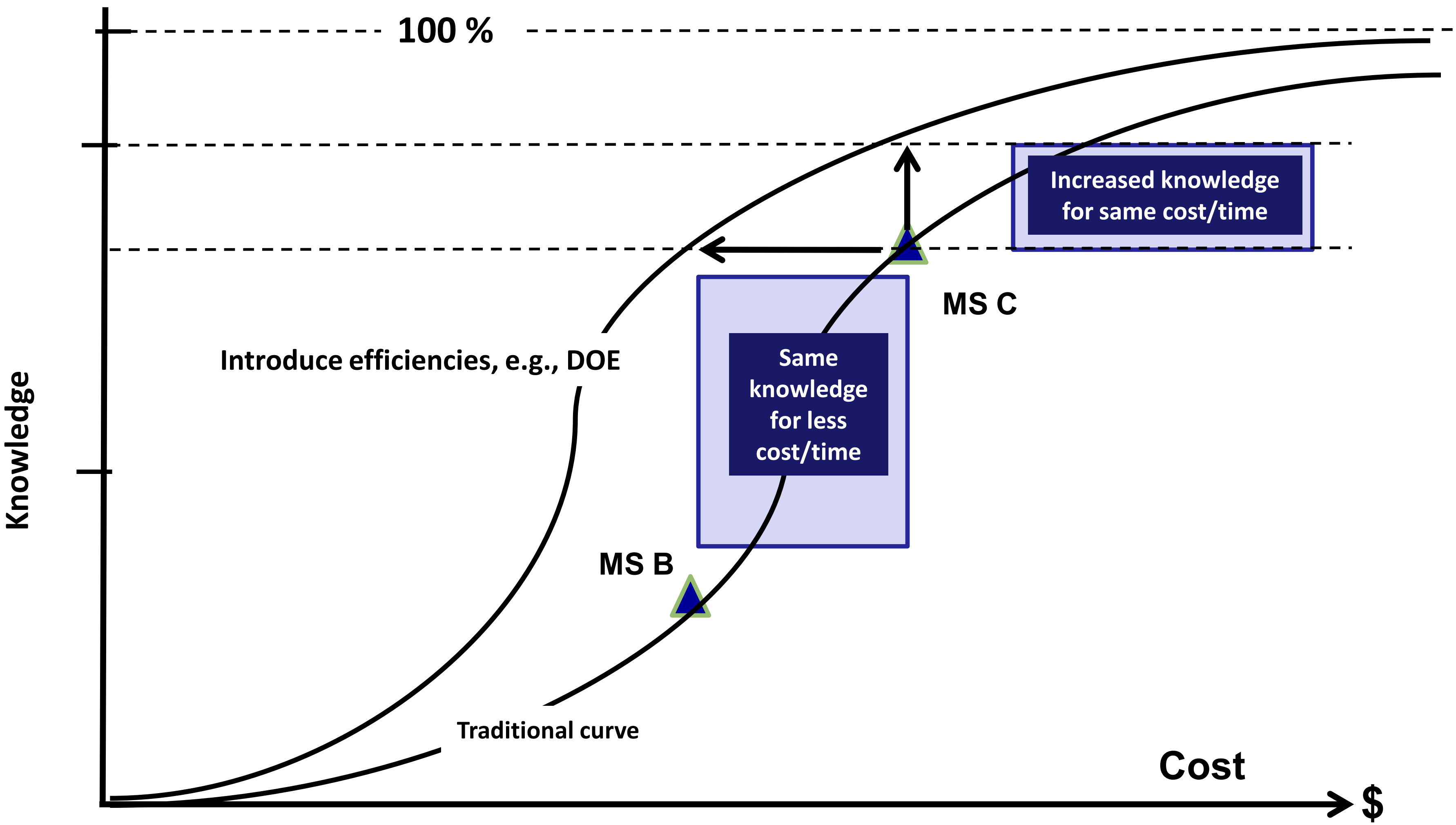
Director, Operational
Test and Evaluation
Hon Michael Gilmore

ASD, Defense
Research
and Engineering (DDR&E)
Hon Zachary J. Lemnios

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

DASD, Developmental
Test and Evaluation (DT&E)
Mr. Edward Greer

Knowledge vs Cost



T&E Challenge: most knowledge for the least resources.

Challenges to doing good?

1. **“Testers like to test”**
   – Who requires, who pays?

2. **“A dollar spent on test is a dollar spent on bad news”**
   – Incentives matter

3. **“Testing is driving up our costs”**
   – Now vs. later?

4. **“We can’t afford it ”**
   – See #3

….. and how can T&E help?

- **Enterprise Perspective**
  - Acquisition Savings
    - Mature Systems
    - Reliability
    - Early discovery
  - Adequate testing (early)
- **T&E Cost**
  - Too much
  - Bad news
  - Late T&E Requirements

- **Test Community Perspective**
  - Recognize our role
  - Manage our appetite
  - Support the risk-based level of information needed
  - Do our job more efficiently
- **T&E Savings**
  - DOE
  - Distributed
  - CRIS
  - Capital Utilization
  - Integrated Test

What's Wrong with Acquisition?

THE USUAL (?) SUSPECTS

Cost

Over Budget

- GAO: 96 MDAPs, $300B over initial estimates

Schedule

Late to Need

- Getting capability to the user to meet urgent needs

Performance

Programs failing Operational Test

- Suitability issues
- Late discovery of failure modes
- Performance shortfalls
- Interoperability

Why Test?

- Iterate/Mature the Design
- Failure Mode Discovery

Material Developer

- Inform Acquisition Decisions

Decision Authority

- Confirm Performance
- Safety
- Capabilities and Limitations

Warfighter

"Testing is the Conscience of Acquisition"
William J. Perry - former SecDef

Cyber Warfare

Computer Network Operations

- Months, days, hours…uSecs
- Attribution
- Role? DoD, Federal, Civil

Attack (CNA)

- Precision strike
- Kinetic effects

Defense (CND)

- Cyber missiles
- Mission critical tasks, functions

Exploitation (CNE)

- Intelligence

"The best-laid defenses on military networks will matter little unless our civilian critical infrastructure is also able to withstand attacks." …..Deputy Secretary Bill Lynn

Cyber Warfare

What's the role for T&E?

Scope: Focus on CND and MDAPs?

- Define cyber defense issues in network environments
- What systems are most vulnerable?
  - Weapon systems?
  - IT systems?
- Rigorous cyber defense testing
- Develop a cyber defense T&E framework
- Institutionalize cyber defense IT

With hundreds of legacy and new programs in development each entering our networks, we cannot afford the chaos of each one individually planning or just not testing for cyber defense.

SecDef Efficiency Objectives

- Deliver the warfighting capability we need for the dollars we have
- Get better buying power for warfighter and taxpayer
- Restore affordability to defense goods and services
- Improve defense industry productivity
- Remove government impediments to leanness
- Avoid program turbulence
- Maintain a vibrant and financially healthy defense industry

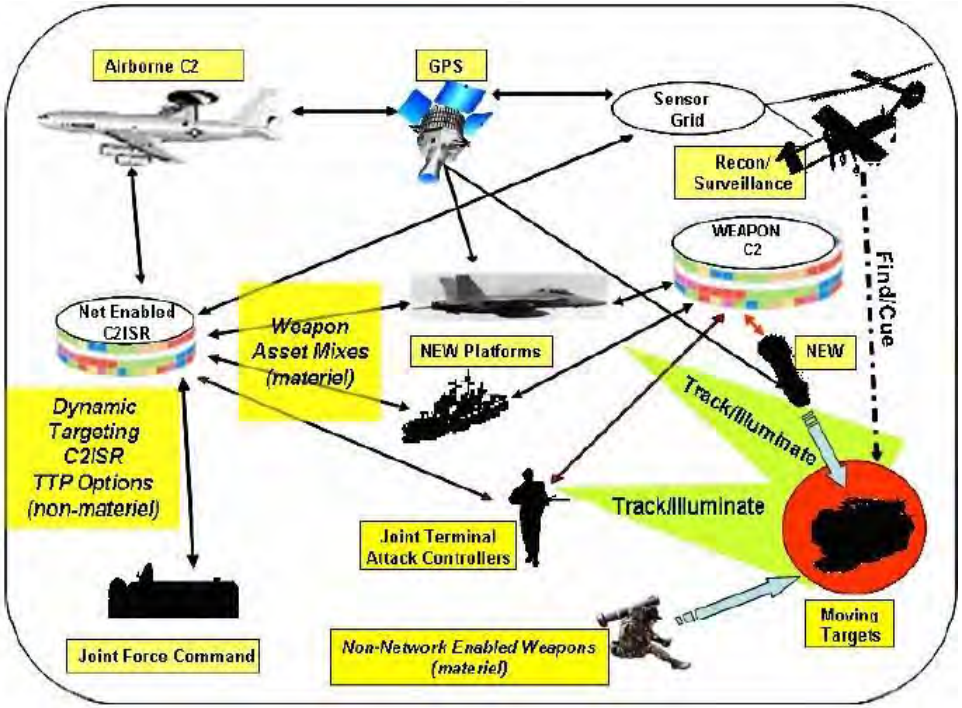
Obtain 2-3% net annual growth in warfighting capabilities without commensurate budget increase by identifying and eliminating unproductive or low-value-added overhead and transfer savings to warfighting capabilities. Do more without more.

T&E Challenges

- **Rapid Fielding**
  - Safety
  - Caps and Lims
- **Emerging Technologies**
  How/where to test?
  - Hypersonics
  - Autonomous systems
  - Weaponized unmanned systems
  - Net-enabled weapons
- **Range Encroachment**
  - OCS exploration/drilling ?
  - Spectrum?
  - Wind generators… !!!!!

T&E Challenges (continued)

- **Complex Systems**
  - System of Systems
  - Interdependent systems?
  - Data fusion
  - S/W intensive systems



- **Balancing Adequacy vs Speed to Field, Cost…..**
  - DOE?
  - How much is enough? Risk management
  - How much M&S? LVC?
  - Other tools

T&E Challenges (continued)

- **Reliability**
  - 50% of MDAPs are failing OT (Suitability)
  - DOT&E imperative – RAM growth testing
- **Rigor – Realistic Environments?**
  - Stressing countermeasures (GPS jamming), clutter….. Operationally relevant scenarios
  - Threat representations
- **End-to-End testing**
  - Mission Context
    - Mission threads
  - Interoperability and IA



Where are We Going?

As Is	To Be
Serial Testing	Integrated Test/Training
Platform-Based	System of Systems
Threat-Based	Complex Capabilities
Contract Compliance	Mission Context
Interoperability	Joint Mission Thread
Deliberate	Rapid/Responsiveness

Our T&E process needs to evolve to support faster product cycles, more adaptable products and address challenges

DT&E Challenges/Imperatives

- **Support Acquisition (WSARA)**
  - Robust, efficient, risk-based T&E
  - Early engagement
  - Performance Assessment (inform the decision makers)
- **Support SecDef Initiatives (Efficient T&E)**
  - Integrated Test
  - DOE
  - Capital Utilization
  - M&S, ground testing
  - Distributed testing
- **Reliability**
- **Cyber**

Department of Homeland Security Testing and Evaluation

Serving the Warfighter

March 15, 2011

Mr. Gary Carter
Director, T&E and Standards
Director, Operational T&E
Science and Technology Directorate
Department of Homeland Security

Approved by OCC (CCD)

Agenda

- DHS Warfighters
- Department of Defense and Department of Homeland Security Testing & Evaluation
  - Similarities
  - Differences
- Conclusion

United States Coast Guard

USCG safeguards our Nation's maritime interests in the heartland, in the ports, at sea, and around the globe. They protect the maritime economy and the environment, they defend our maritime borders, and they save those in peril.

MH-65 Helicopter
U.S. Coast Guard photo by Petty Officer 3rd Class Sabrina Elgammal

HH-60 Helicopter
U.S. Coast Guard photo by Petty Officer 3rd Class David Weydert

Response Boat
U.S. Coast Guard photo by Petty Officer 3rd Class Erik Swanson

Homeland Security

Science and Technology

Transportation Security Administration

TSA protects the Nation’s transportation systems to ensure freedom of movement for people and commerce.

Backscatter X-Ray Technology
TSA Photo

Millimeter Wave detection Technology
TSA Photo

Advanced Imaging Technology
TSA Photo

Customs and Border Protection

CBP protects America's way of life while collecting revenue, enforcing intellectual property and other laws at the border, and facilitating legitimate commerce and travel.

Homeland Security
Science and Technology

Port of Long Beach, the largest and busiest port in the US, is one location where OT is planned for CBP **Advanced Spectroscopic Portal** radiological/nuclear detection equipment.
Photos Courtesy CBP

Homeland Security
Science and Technology

Immigration and Customs Enforcement

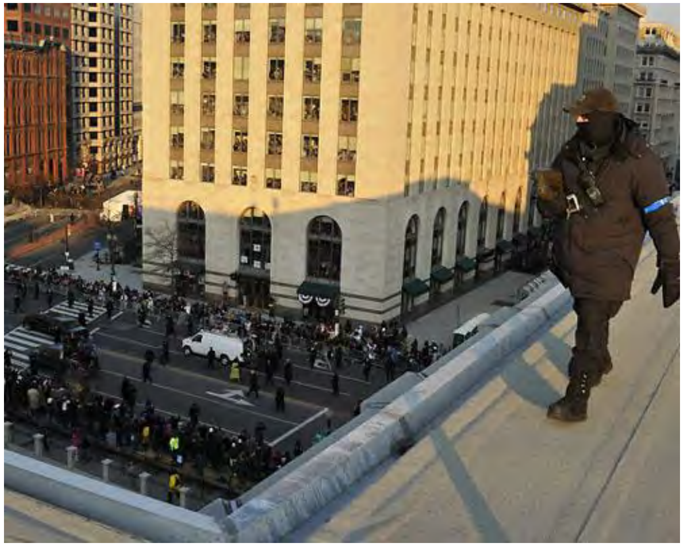
ICE promotes homeland security and public safety through the criminal and civil enforcement of federal laws governing border control, customs, trade, and immigration.

Images Courtesy of ICE

Homeland Security
Science and Technology

United States Secret Service

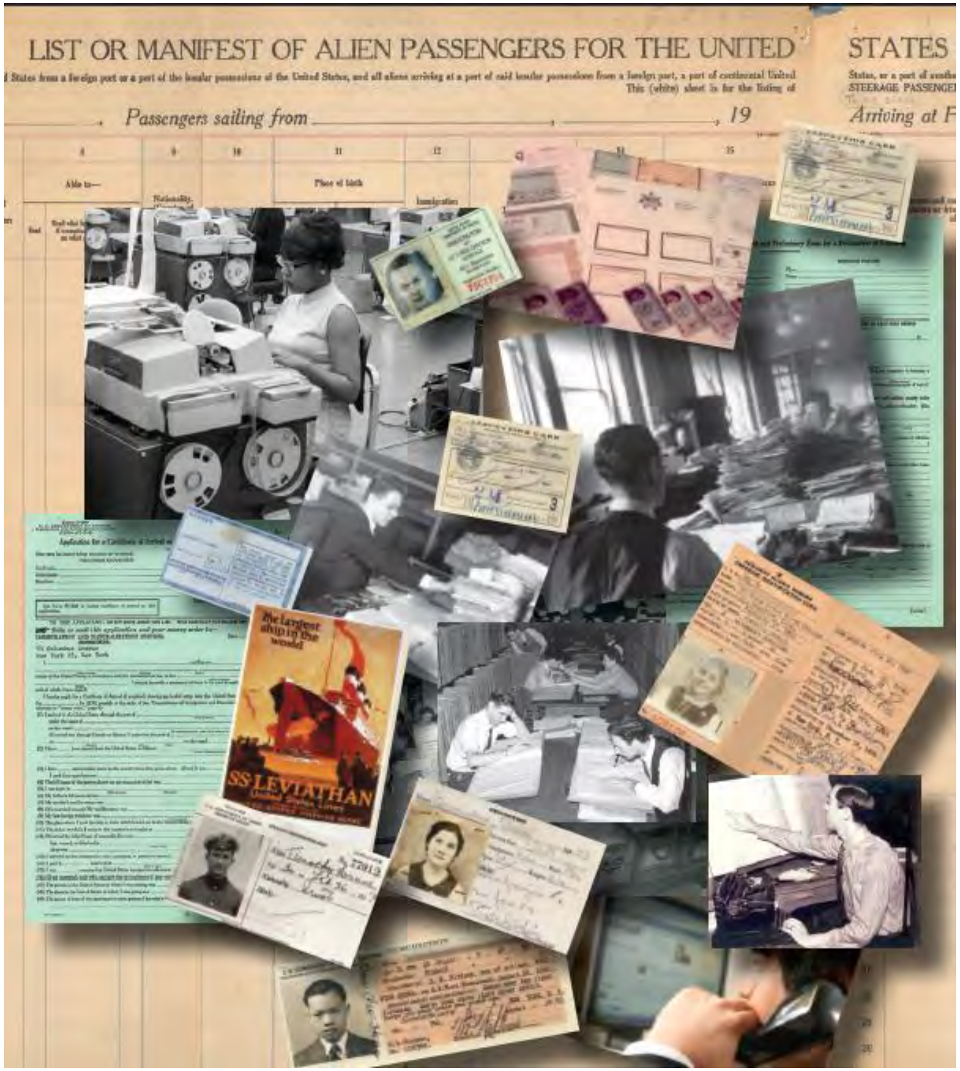
Dual mission "to safeguard the nation's financial infrastructure and payment systems to preserve the integrity of the economy, and to protect national leaders, visiting heads of state and government, designated sites and National Special Security Events."



Photos courtesy US Secret Service

U.S. Citizens and Immigration Services

USCIS provides accurate and useful information, grants immigration and citizenship benefits, promotes an awareness and understanding of citizenship, and ensures the integrity of our immigration system.



OMB No. 1615-0008; Expires 06/30/2011

G-325, Biographic Information

Birth vvvv)	Citizenship/Nationality	File Number

OMB No.1615-0037; Expires 01/31/12

I-730, Refugee/Asylee Relative Petition

USCIS OFFICE ONLY

OMB 1615-0096; Expires 04/30/2012

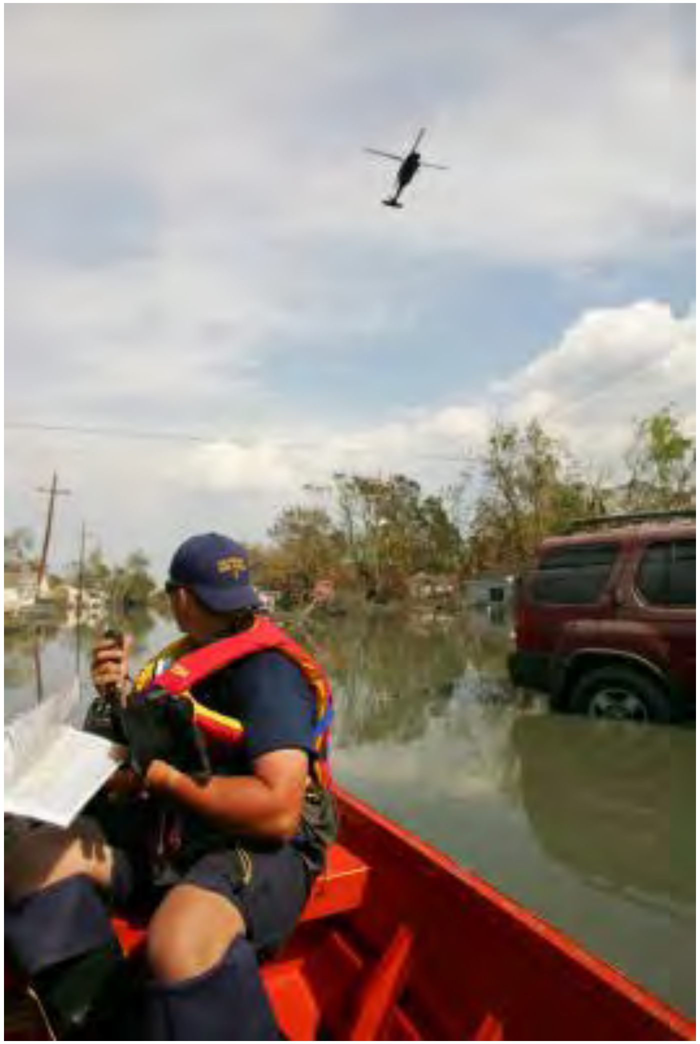
G-1041A, Genealogy Records Request

Photo courtesy USCIS

Homeland Security
Science and Technology

Federal Emergency Management Agency

FEMA supports the citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.



Natural Disaster requiring intensive FEMA planning and coordination aided by **integrated IT systems**
FEMA photo by Bob McMillan

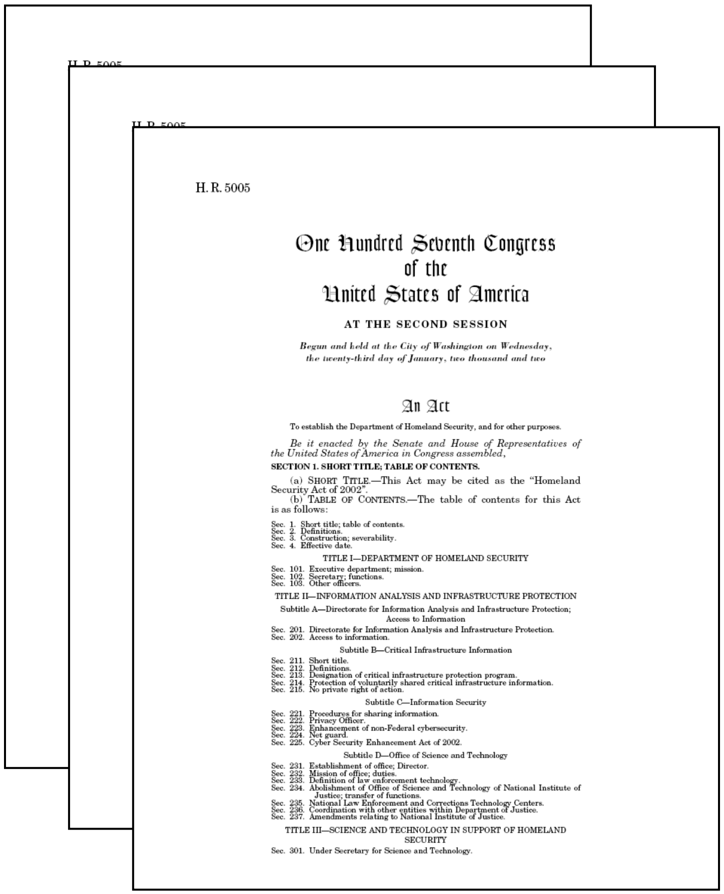
FEMA photo by Aaron Skolnik

FEMA photo by Bill Koplitz

DHS and DoD Test & Evaluation Similarities

- Acquisition Policy
  - DoD Directive 5000
  - DHS Directive 102
- Acquisition Framework
  - Both Phase/Gate Processes with Acquisition Decisions
- Acquisition Categories
  - DoD based on RDT&E Cost
  - DHS based on Lifecycle Cost
- Acquisition Certification
  - DoD Defense Acquisition University
  - DHS developing Certification Processes and Courses
- Require Operational Test and Evaluation
  - DoD by law - Title X
  - DHS by policy - Directive 026 Test and Evaluation
- Have a DOT&E
  - DoD by law - Title X
  - DHS by delegation – Delegation 10003

DHS and DoD Test & Evaluation Differences


H. R. 5005

One Hundred Seventh Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Wednesday, the twenty-third day of January, two thousand and two

An Act

To establish the Department of Homeland Security, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Homeland Security Act of 2002".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

Sec. 302 (12) S&T responsible for "…coordinating and integrating all research, development, demonstration, testing, and evaluation activities of the Department …"

DHS T&E Law

DHS and DoD Test & Evaluation Differences

No DHS Operational Test Agency

- Component internal test organization
- DoD OTAs
- Non-system contractors

Homeland Security
Science and Technology

DHS and DoD Test & Evaluation Differences

Systems Under Test often Interface Directly with the Public

- Systems must not only detect, but cannot hold up commerce
- Cannot invade "privacy"
- Public opinions often in the news

DHS and DoD
Test & Evaluation Differences

Operational Testing Conducted in Actual Environment

- Must continue to do mission
- Cannot interfere with daily operations
- Test may encounter actual threat
  - Explosives
  - Undocumented aliens
- Tests very realistic but Tester loses some control
- Must follow SOPs in place even if they don't make sense

DHS and DoD
Test & Evaluation Differences

Systems Under Test may be Tested but not Acquired by DHS

- Qualified Product List
  - OT multiple vendors
  - Additional vendors may require OT later

Homeland Security
Science and Technology

DHS and DoD Test & Evaluation Differences

Some DHS Warfighters are Local First Responders

- System Assessment or Validation of Emergency Responder (SAVER) equipment
  - Conducts impartial, practitioner-relevant, operationally oriented assessments and validations of commercial off-the-shelf equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).
- Standards/Conformity Assessment
  - GRaDER- Graduated Rad/Nuc Detector Evaluation and Reporting




Conclusion

Although DHS and DoD T&E have unique challenges, both support the "Warfighter"

End-to-End GPS Multi-Platform Integrated System Testing for MGUE

Angelo Trunzo, Paul Benshoof, *746th Test Squadron, Holloman AFB, NM*
Dr. Sultan Mahmood, *AFMC AAC/EB, Eglin AFB, FL*
Dr. Ray DiEsposti, Mitch Markota, Joe Hewlett, *NAVAIR, China Lake, CA*

ION GNSS 2010
Portland, OR

Themes

- E2E integrated multi-platform/multi-UE system testing for risk reduction
- Legacy to MGUE transition complexities
- Test COE
- Test standards
- Cost-effective test approaches, e.g. AWFS
- Joint service standards

Outline

- Intro to GPS Modernization and MGUE
- E2E system testing for risk reduction
- Test Center of Expertise (COE)
- Proposed test standards
- Topics in test standards
- Testing to specification
- E2E system testing for UE transition
- AJ testing using AWFS (Dr Sultan Mahmood)
- Joint service standards
- Conclusions

Intro to GPS Modernization and MGUE

- Some features
  - New signals: L1 & L2 M-code, L2 C, L5
  - Flexible NAV messages
    - Improved ephemeris and clock messages
    - New almanac messages

  New interfaces for Hot Start of integrated systems
  - Flex power
  - GPS III (L1 C, spot beam, high-speed cross links, integrity, …)
- MGUE
  - YMCA capable Modernized GPS UE which will eventually replace legacy and SAASM-based UE

Integrated System Test (IST)

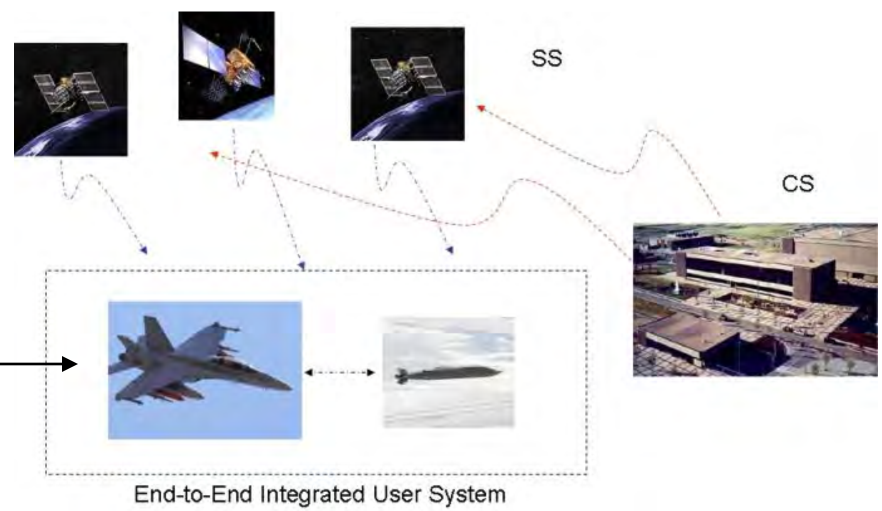
- SAASM testing emphasizes IST, including the SS, CS and representative sets of SAASM receivers
  - IST2-4
- Similar IST test concept is advocated for MGUE
  - MGUE TEMP
- But --- “What is a system?” – see next chart

E2E System Testing for Risk Reduction

- End-to-End (E2E) system is defined as the SS, CS and integrated multi-platform/UE systems
- Integrated System Test (IST) should include testing of the functionality of the interfaces connecting integrated UE systems

Example of Integrated System of Multi-Platform and multi-UE's

Host platform UE supplies initialization function to weapon UE



Test Center of Expertise (COE)

- Led by the GPSW & 746th TS at Holloman AFB
- Cooperative agreement between Air Force, Navy, and Army government test centers:
  - Roles and responsibilities of test centers
  - Cooperation between the test centers
  - Planning for efficient use of limited test resources
  - Identification of any deficiencies in test resources and development of proposals for correction
  - Development of test requirements, test architectures, standards, standardized test plans and procedures for cost-effective testing
- The RTO members of the COE propose an E2E testing service to the GPSW and user services

Proposed Test Standards

- Sets of test documents which need to be developed, with the format and content of each
- Approach for progressive verification, e.g. developmental and component level testing by UE developers, operational, integrated E2E system level testing performed by government labs
- Testing approaches for functional, performance and interface requirements
- Cost-effective testing approaches, e.g. use of PC simulations, use of HITL testing with GPS simulators, range and flight testing
- Standardized testing architectures for different types of UE
- How to test as an “integrated” system when various components are developed and available at different schedules, e.g. making use of simulators
- What performance or test criteria to declare a system as operational
- Development or acquisition of test resources

Topics in Test Standard Documents

- What to include in test standard documents
- Reuse or tailoring of existing standards
- Definitions
- Development of standard scenarios for testing: how many scenarios, how to link requirements to scenarios, how to define a "minimal set" of scenarios to completely cover and test requirements in specification and interface documents
- Standardized test procedures
- Standardized methods to compute deterministic and statistical performance
- Design-in of "testability"
- Automated testing approaches
- Development and use of standard test resources, equipment and facilities

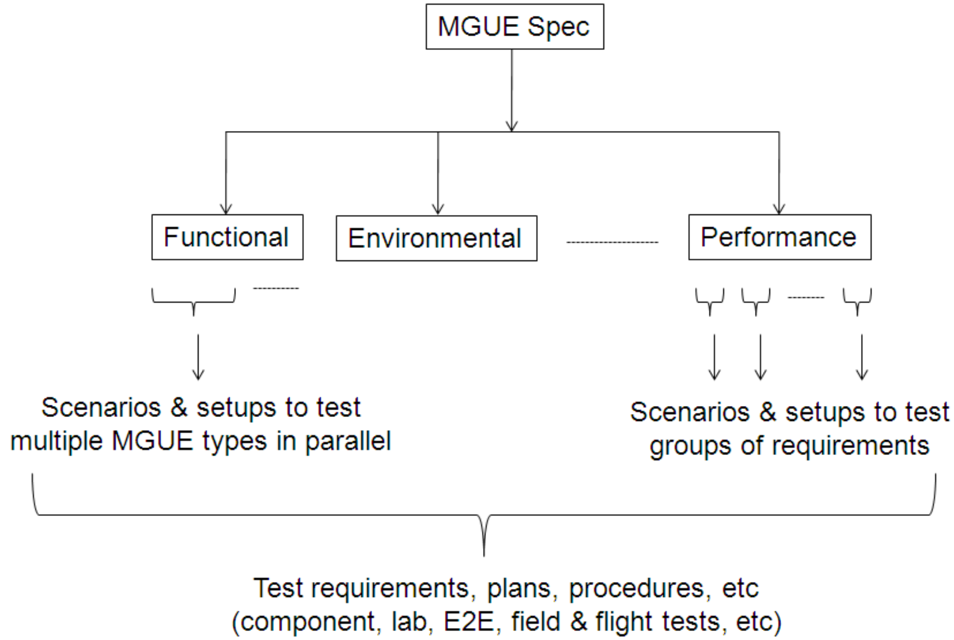
Typical Documents

- Test method
- Diagnostic design specifications
- Manufacturing test requirements design spec
- Design for testability
- Test plan
- Test procedures
- Test equipment
- Operations and maintenance (O&M) manuals

Testing to Specifications

- Some requirements (e.g. functional) may be cost-effectively tested with sets of receivers installed in racks and subject to the same scenarios
- Some requirements (e.g. performance) are UE specific so must be tested in real or simulated operational environment

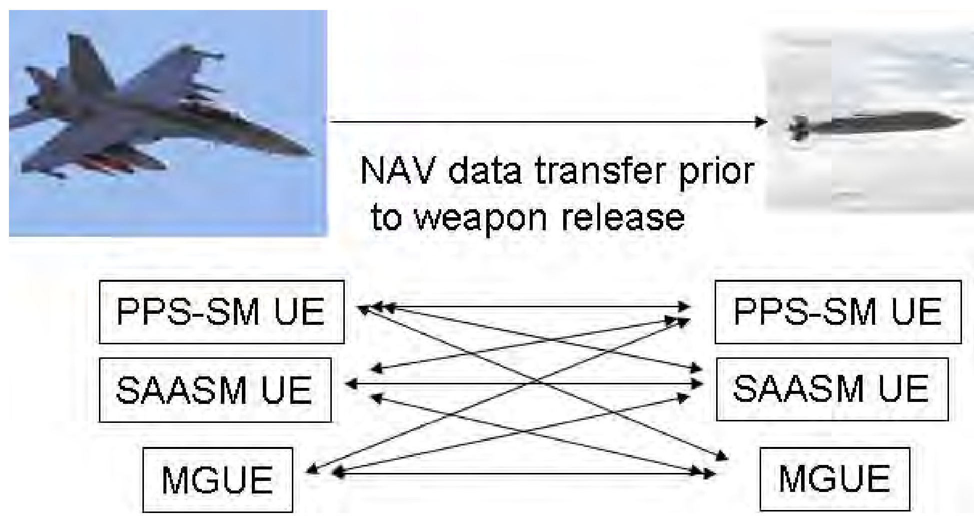
Allocation of spec requirements for testing of many UE in parallel in “equipment racks” vs. UE specific test setups



E2E System Testing for UE Transition

- Multiple generations of multi UE may need to interface in an “integrated system,” including spot beam capable
- Interfaces for MGUE will also most likely change
- MGUE and all interfaces need to be interoperable and backward compatible

E2E integrated systems need to be interoperable and backward compatible with multi generations of UE



Also spot beam UE

AJ testing using AWFS

Dr. Sultan Mahmood
AFMC AAC/EB, Eglin AFB, FL

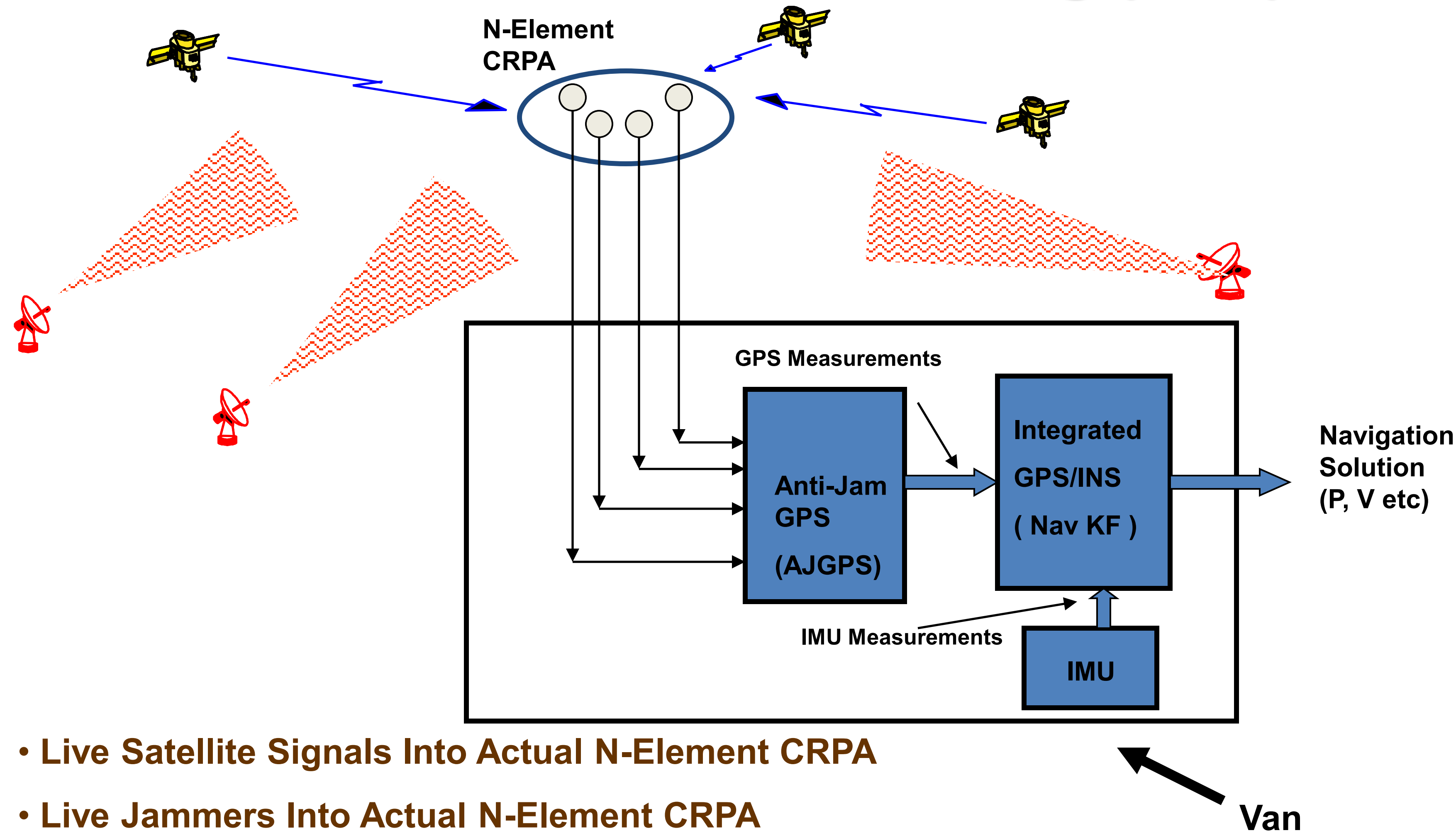
Cost Effective Test Approaches

- **Stand-Alone and Integrated MGUE Performance Testing Under Dynamics and Jamming:**
  - Lab Testing: Hardware-In-The-Loop (HITL) Using Antenna Wave-Front Simulator (AWFS)
  - Van/Flight Testing Using AWFS
  - Integrated Weapon and Aircraft Testing Using AWFS
    - Test Various Hot Start Data Requirements
    - Test Mixed Mode Receiver Operations

Testing for MGUE Specs and Inter-Operability

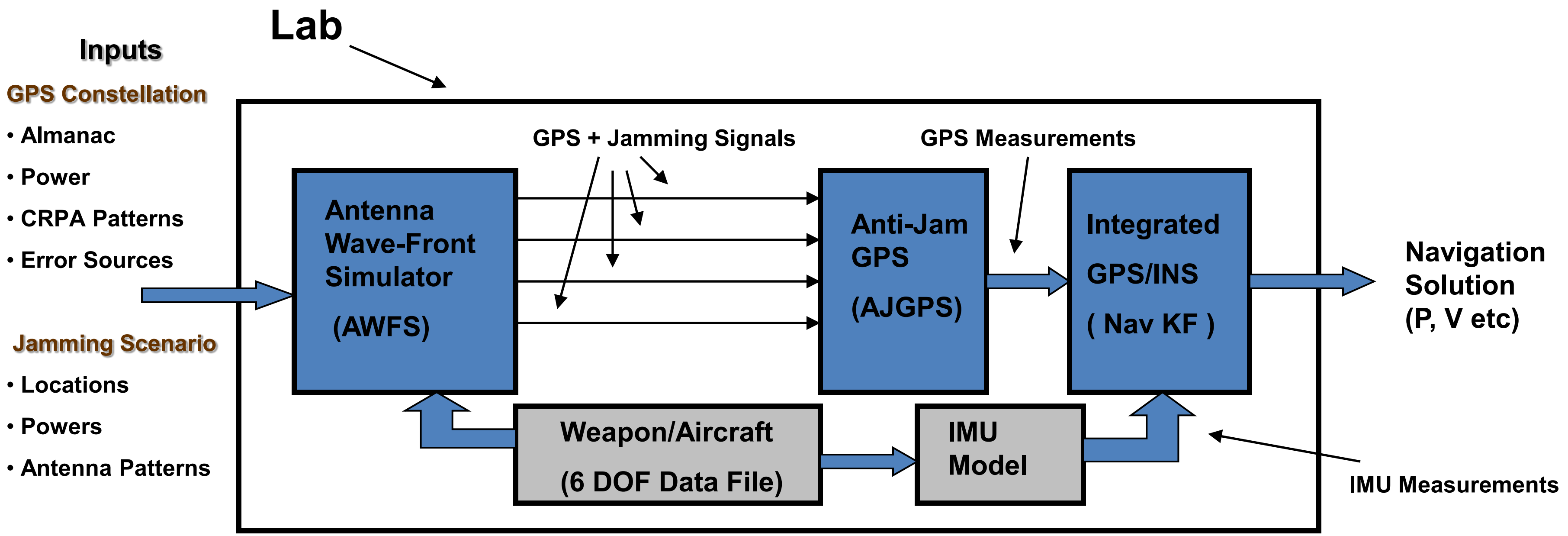
- Stand-Alone or Integrated Tests
- Requirements for Standardized Tests:
  - Realistic Dynamics and Flight Trajectories
  - Realistic GPS SV and Jammer Motion, Power Profiles
  - Environment (Temp, Vibration)
  - EMI/EMC
  - Realistic Initialization Data for Hot Start, Transfer Alignment, Differential Corrections etc
  - Developmental or Operational Navigation/AJ etc Software
  - Multiple Host/Weapon Receiver Combinations
    - Legacy
    - SAASM
    - M-Code or YMCA
  - Multiple Power Levels (Standard, Flex, Spot Beam)
  - Ability to conduct Excursions, and What Ifs

Conventional Ground Testing (Van)



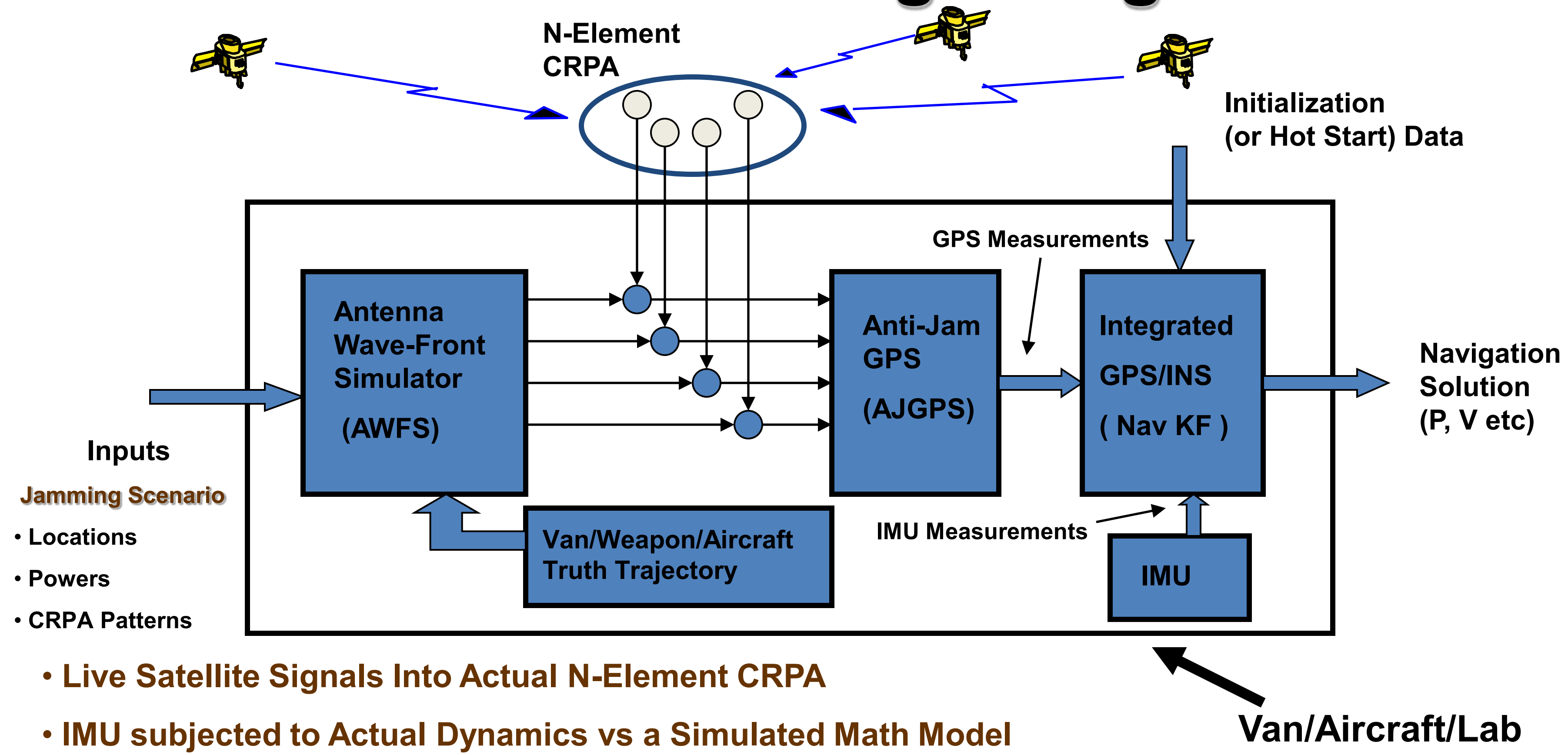
- Live Satellite Signals Into Actual N-Element CRPA
- Live Jammers Into Actual N-Element CRPA
- Frequency Clearance, Jammer Scenario Set-Up Issues

HITL – Using AWFS



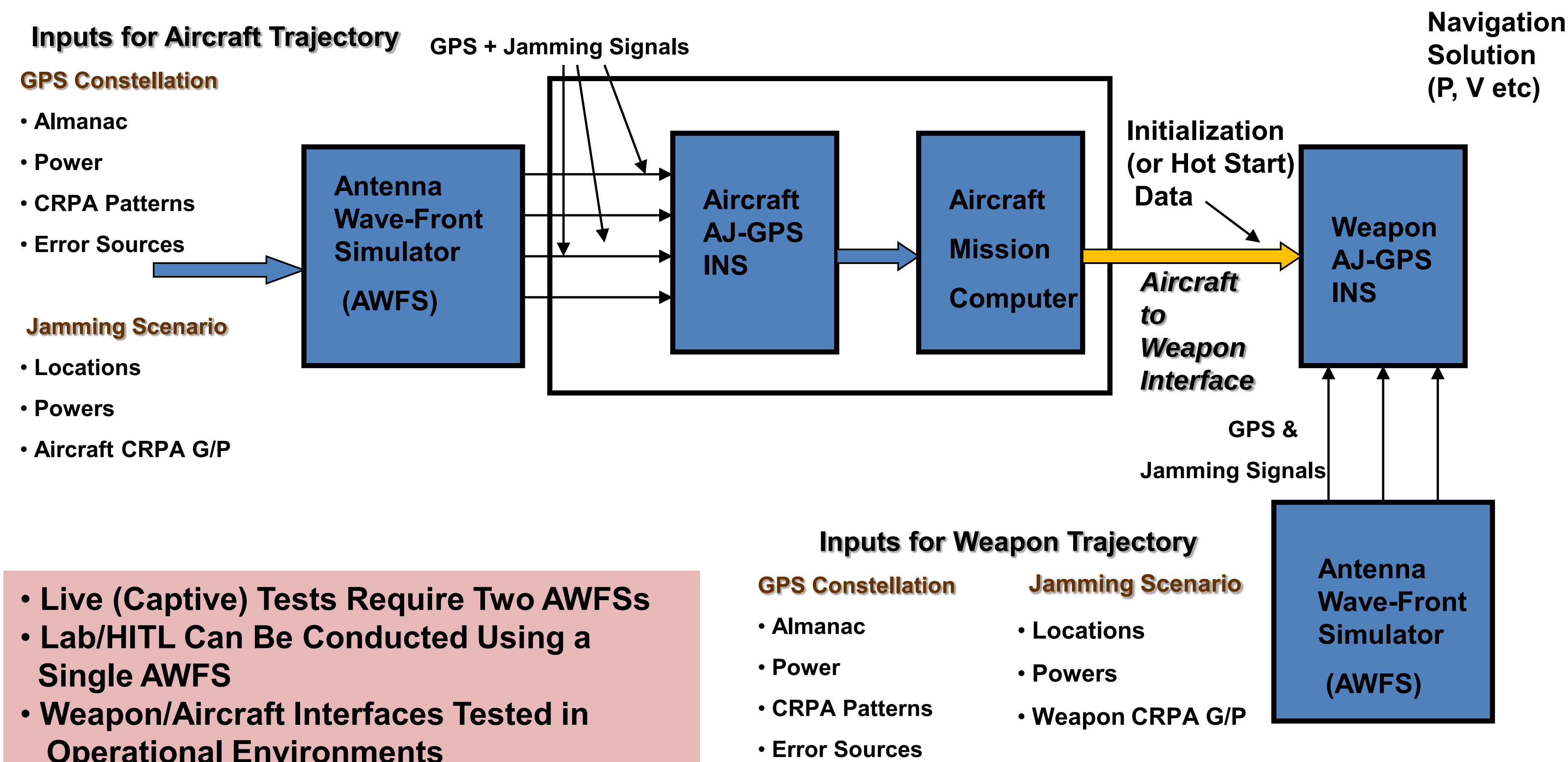
- Simulated GPS and Jammer Signals as Received by Each CRPA Element
    - CRPA Antenna Element Model Includes Body Masking Effects
- AJGPS System Excited with RF Signals From Simulated GPS and Jammers
- Simulated IMU Measurements
- 6 DOF Generates Actual Weapon/Aircraft Dynamics and Flight Trajectories, Initialization Data

Ground and Air Testing Using AWFS



- Live Satellite Signals Into Actual N-Element CRPA
- IMU subjected to Actual Dynamics vs a Simulated Math Model
- Jammer Scenario and CRPA Model Used in AWFS
    - AWFS Generates Actual Jammer RF as Received at Individual Elements
- AJGPS System Excited with Actual GPS and Jammer Signals

Integrated Weapon/Aircraft Testing Using AWFS



- Live (Captive) Tests Require Two AWFSs
- Lab/HITL Can Be Conducted Using a Single AWFS
- Weapon/Aircraft Interfaces Tested in Operational Environments

Conclusions

- Integrated System Test (IST) should include testing of interfaces and generations of UE multi-platform/multi-UE integrated systems
- GPS Test Center of Expertise (COE) offers a means to coordinate and manage the large test effort needed
- Need test standards!
- Need cost effective test approaches, e.g. AWFS
- Recommend Joint Service Standards

Integrated Test: Challenges & Solutions

Honorable Dr. Michael Gilmore
Director, Operational Test & Evaluation

Presentation to NDIA

March 15, 2011

Outline

- DOT&E Initiatives
- Integrated Test
- Challenges to Integrated Test
- Integrated Test Solutions
- Design of Experiments and Integrated Testing
- Conclusions

DOT&E Initiatives

Integrated Testing
Developmental
Operational
Live Fire
Use Scientific Test Design
(e.g. DOE)

Testers Engage Early
Testable, Mission-oriented Requirements

Field New Capabilities Rapidly
Accelerated Testing

Improve Suitability
Reliability Growth

Integrated Test

- What is Integrated Testing?
  - A cohesive test and evaluation plan that spans all stages of testing.
  - Integrated test is **NOT** simply combining data from different test events.
  - Integrated test is **NOT** a replacement for dedicated OT.

- Integrated Test methods:
  - Using data from CT, DT, and OT to inform the next stage of testing
  - When appropriate, combine CT, DT, and OT data
    - Reduce test time, increase statistical confidence and power
  - Integrate DT and OT test objectives
    - Enhance operational realism in DT to reduce OT requirements
  - Design of Experiments helps plan efficient, integrated testing
    - Plan testing as a sequence of tests

Integrated Test Can Be A Challenge

- Not business as usual
  - Unclear responsibilities. Who is in charge of the test?
- Contractual issues
  - Limited access to contractor test data and test procedures
- DT and OT test objectives conflict
  - Combining tests maybe impossible
- Combining data maybe irresponsible
  - How the test is executed affects results
  - How the system design evolves affects results
- Late involvement of OT testers
  - Affects all of the above

Integrated Testing Makes Sense!

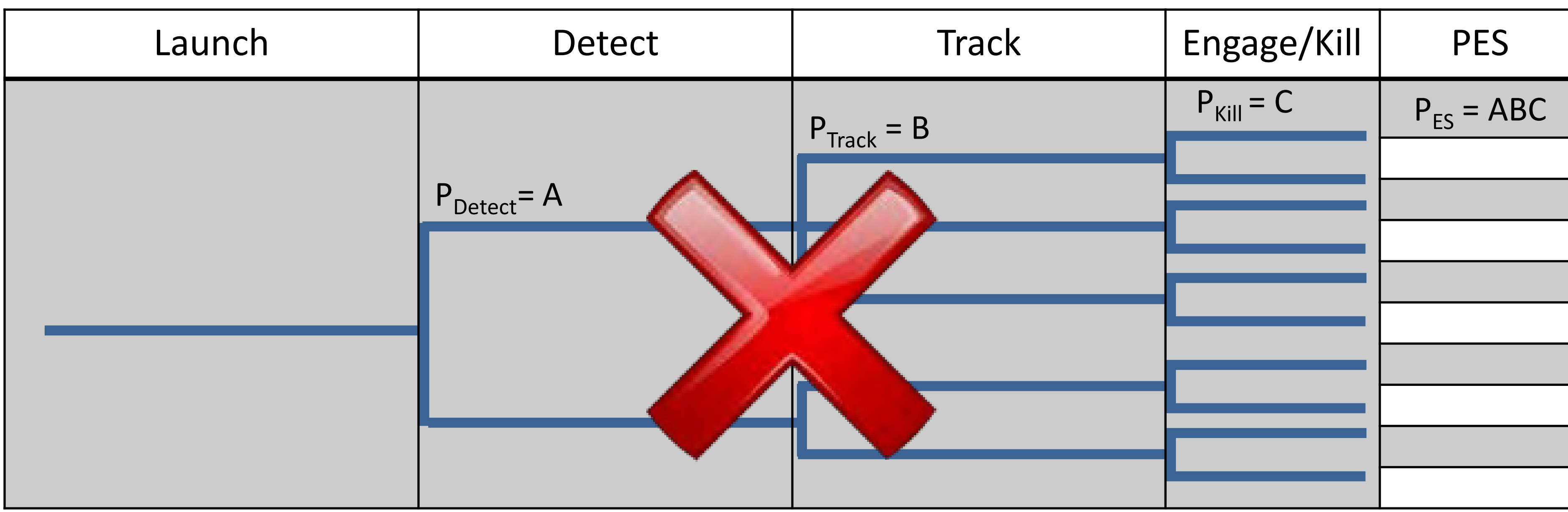
- Enables efficient testing
  - OT assessments can take advantage of CT and DT data
- Assessing system performance as the design matures requires consolidation of data
  - e.g., reliability growth
- System-of-systems requiring coordination of multiple test programs are increasingly common
- Discovery in OT is expensive
  - We need to find problems early in DT
- Design of Experiments facilitates efficient, integrated testing.

Integration of Available Data

Ballistic Missile Defense

Ballistic Missile Defense

- Motivation: Estimate system effectiveness with small sample sizes
- Probability of Success (PES) is the probability of successfully negating a ballistic missile threat using the Ballistic Missile Defense System (BMDS)
- Traditional probability based approaches are data intensive
  - Conditional probability model requires lots of data in each stage



PES for Ballistic Missile Defense

- DOT&E turned probability problem into sampling problem
  - PES = (# Kills)/(# Launches)
  - PES = (# Kills)/(# Detections) • (# Detections)/(# Launches)
  - PES = (# Kills)/(# Tracked) • (# Tracked)/(# Detections) • (# Detections)/(# Launches)
  - … repeat …

	Launch	Detect	Track	…	Intercept	Kill
Test 1	xx	xx				
Test 2			xx	xx	xx	
Test 3	xx	xx	xx	xx	xx	xx
Test 4	xx	xx	xx	xx	0	
Test 5	xx	xx	xx	xx	xx	xx

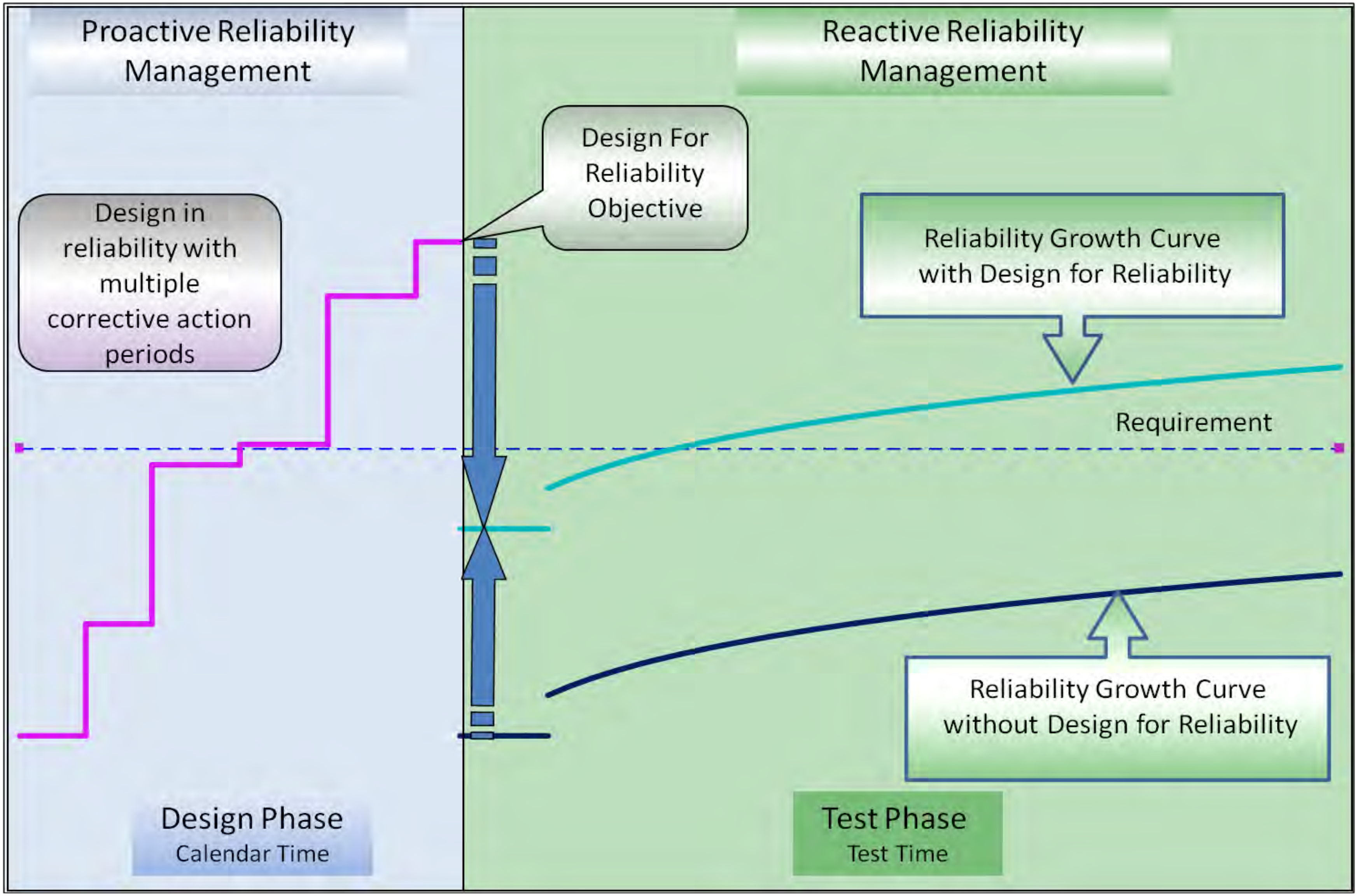
Partial Tests

Failure at Intercept Stage

- DOT&E PES methodology applied to Patriot data
  - Produces similar results to traditional analysis for large datasets (validates method)
  - Validation indicates that the similar results were achieved with less data
- DOT&E PES methodology applied to Aegis BMD (smaller dataset)
  - Refines the results from simple success/failure analysis to account for partial tests
  - Results included in DOT&E Report to Congress

Maximize use of data from relevant test events

Integrated Testing for Reliability



ANSI/GEIA-STD-0009

1. Understand user requirements and constraints
   – Reliability requirements include the anticipated use environment

2. Design for Reliability (DFR) and Re-design for Reliability
   – This means that user needs will be allocated through system model to reliability specifications at lowest component levels.
   – Lowest level reliability specifications include internal stresses and impacts of use environment
   – Redesign as needed to meet allocated reliability requirements

3. Produce reliable systems
   – During DT, all sub-assemblies, components, etc should demonstrate required reliability in anticipated use environments
   – Meeting reliability requirements will often require reliability growth programs for components utilizing repeated DT experiments

4. Monitor and assess user's experienced reliability

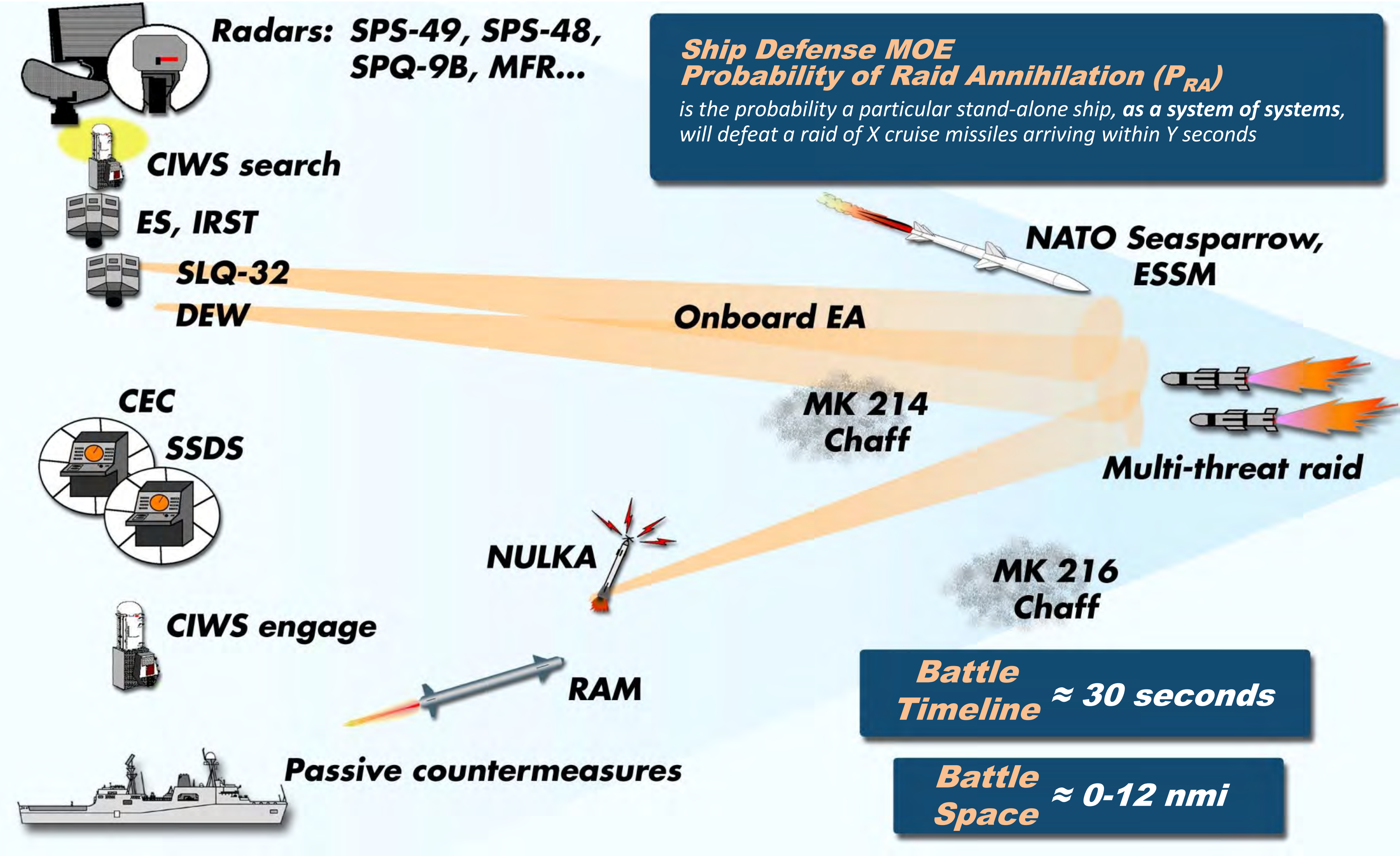
Integrated Reliability: Each stage informs the next

Stryker NBCRV Design For Reliability

1. Production Verification Testing (PVT) was halted prematurely due a large number of System Aborts
   - Did not meet the user requirement of 1000 Mean Miles Between System Aborts (MMBSA) for the base vehicle
   - No reliability requirement for NBC sensors
2. System contractor implemented Design For Reliability to improve base vehicle reliability (2007-2008)
3. NBCRV underwent 8000 mile Reliability Growth Test (RGT) in 2009 to determine whether reliability had improved.
   - Base vehicle reliability dramatically improved over PVT (2000 MMBSA).
   - Little change in NBC sensor reliability.
4. Dramatic improvement in reliability between PVT and RGT but no reliability growth seen during RGT itself.
5. Requirements drove the focus of DFR, but requirements addressed only the base vehicle and not the NBC sensors
6. DFR is a powerful tool to improve reliability, but must address entire system to be effective

Integrated Testing for System of Systems

Air Warfare Ship Self-Defense Enterprise



Air Warfare Ship Self-Defense Enterprise

- Combat systems for aircraft carriers and amphibious ships composed of systems from various program offices
  - Previously, each program office developed its own test program
  - Each test program focused on an individual system, not on the integrated combat system or the overall air defense mission
- Ship Self-Defense Enterprise coordinated these various test programs
  - Provides significantly better end-to-end testing of the ***integrated*** combat system, focusing on the air self-defense mission
  - Used principles of Design of Experiments to develop test plan
- For air self-defense, the Navy estimates:
  - Before Enterprise, testing cost about $1.1 Billion FY05 through FY15
  - Enterprise saved $240 Million out of $1.1 Billion

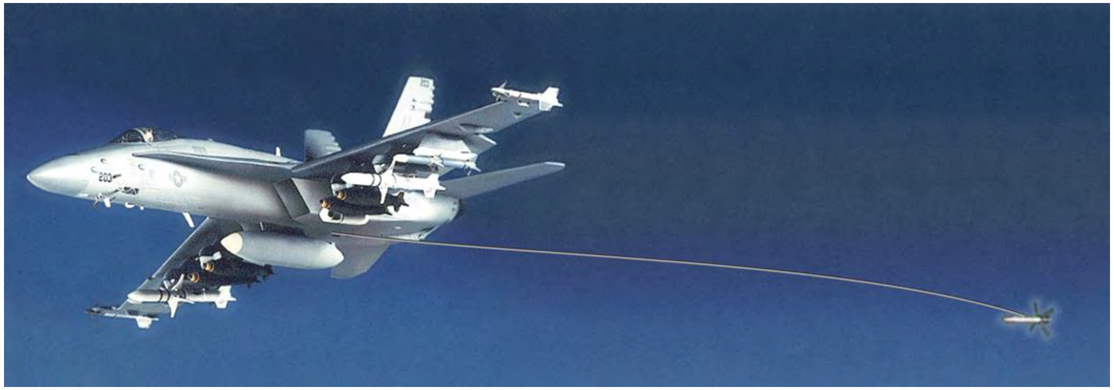
Better testing for less money

Integrated Testing to Avoid Late Problem Discovery

Integrated Defensive Electronic Countermeasures (IDECM)

&

Miniature Air Launched Decoy (MALD)



Late Discovery of Problems IDECM and MALD

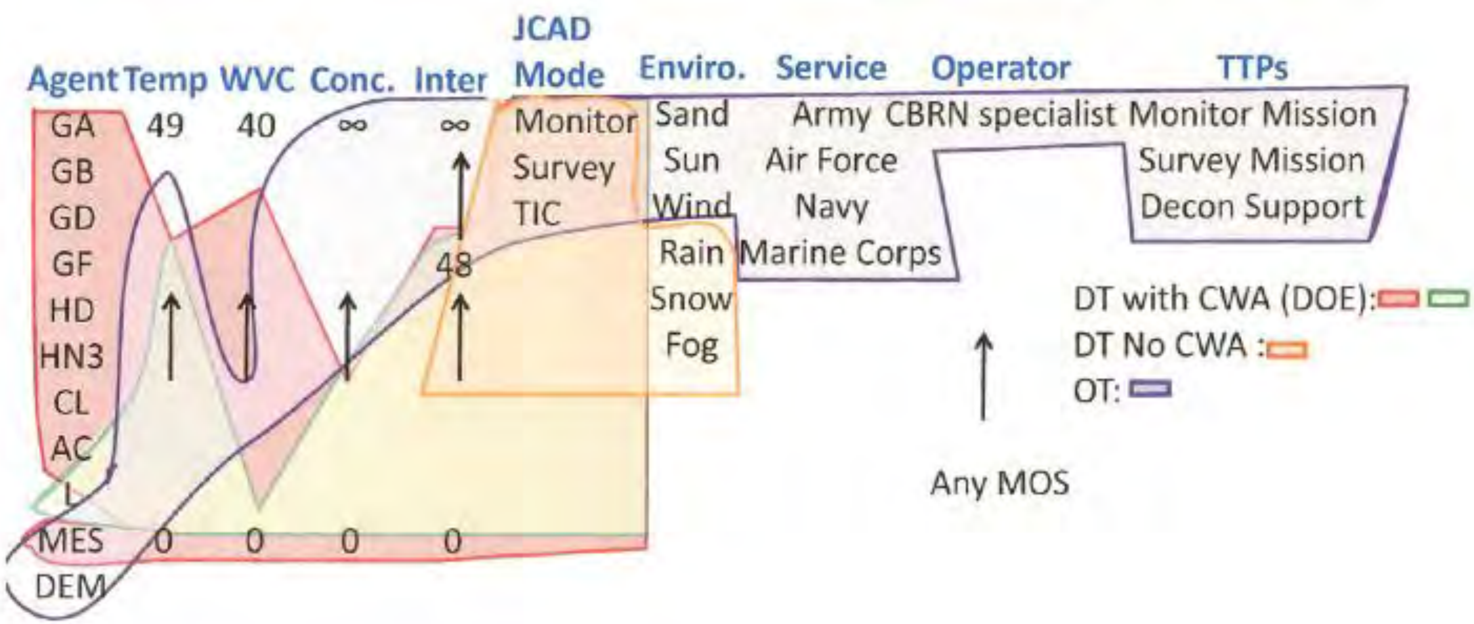
- Limited operational realism in early testing
  - IDECM – use of special DT equipment to reduce test costs
  - MALD – no long-duration carriage of decoys
- Significant problems discovered in IOT&E
  - IDECM
    - Uncommanded deployments and problems severing decoys created safety problem for ground crew
    - Intermittent failures resulted in decoys being prematurely discarded and in poor reliability
  - MALD
    - Long-duration flight caused premature failures when decoys were launched.

Design of Experiments (DOE)

- A method for planning efficient integrated testing.
- For integrated testing, DOE can inform:
  - Plan testing as a sequence of tests
  - Screen out insignificant factors in DT to focus OT
  - Control factors in DT that are difficult to control in OT
  - Split factors across test periods
  - Ensure that operational envelope is covered
- DOE is an Industry Best Practice
  - DOE traditionally applied in DT context, but we are seeing great gains using the methodology in integrated testing and operational testing
- Example of DOE in DT: wind tunnel testing
  - Characterize the aerodynamic behavior of the X-31 Enhanced Fighter
  - Traditional techniques would require 1000 + test points
  - DOE applied & testers were able to characterize aerodynamic performance in 104 test points.

Example of Integrated Testing Employing DOE Joint Chemical Agent Detector

- Problem: Agents are unable to be tested in an OT.
  - Agent, temperature, water vapor content, operating mode and agent concentration were systematically varied in DT using a Response Surface Design.
  - Allowing for operational factors affecting performance to be assessed in OT (Service, environment, and mission tactics)



Conclusions

- Efficient integrated testing is a must.

- Integrate Test solutions are as unique as the challenges
  – Plan CT and DT tests to enable OT use of the data.
  – Assessing system reliability requires integrated test.
  – System-of-systems requires integration of multiple test programs.
  – Operational realism in DT allows problems to be discovered early

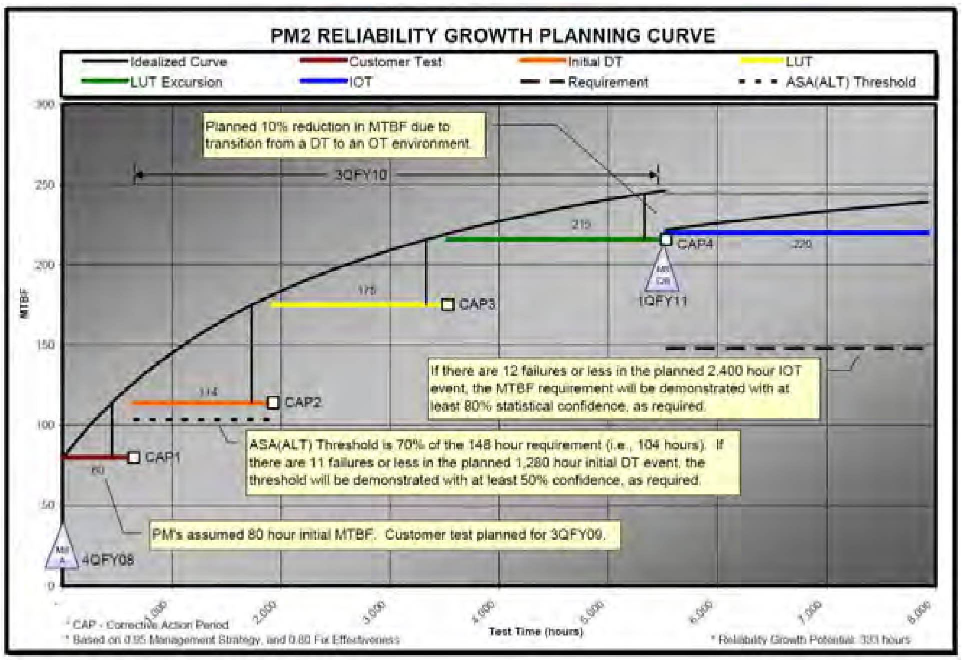
- Key Ingredients for Integrated Testing
  – Early engagement of Operational Testers
  – Robust data collection and documentation
  – Experimental Design
    - Can help ensure integrated testing is comprehensive
    - Provide confidence and power across the operational envelope

Every Program and every challenge has a unique solution to Integrated Testing

Backups/Extras

Integrated Testing for Reliability

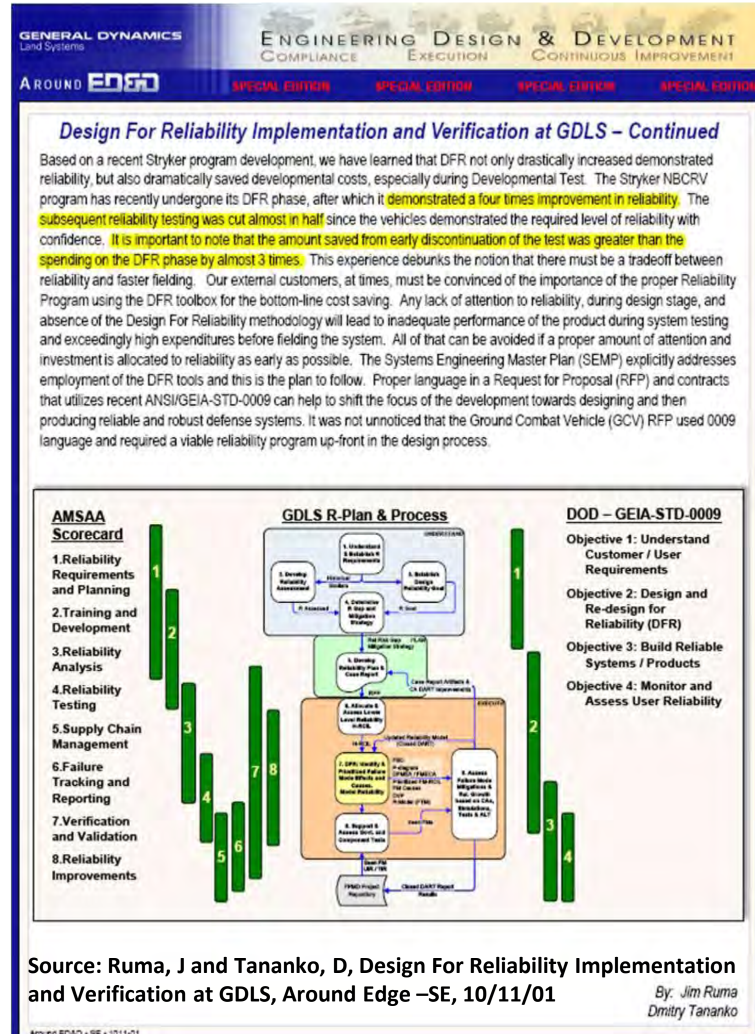
Design for Reliability
&
Reliability Growth



Stryker NBCRV
Design For Reliability Case Study

- **Reduced Risk:** "… program has recently undergone its DFR phase, after which it demonstrated a four times improvement in reliability."
- **Reduced Acquisition Time:** "… subsequent reliability testing was cut almost in half since the vehicles demonstrated the required level of reliability."
- **Reduced Cost:** "…the amount saved from early discontinuation of the test was greater than the spending on the DFR phase by almost 3 times."

The Cost AND Schedule Optimal Solution is to Design for Reliability


GENERAL DYNAMICS
Land Systems

ENGINEERING DESIGN & DEVELOPMENT
COMPLIANCE EXECUTION CONTINUOUS IMPROVEMENT

AROUND ED&D SPECIAL EDITION SPECIAL EDITION SPECIAL EDITION SPECIAL EDITION

Design For Reliability Implementation and Verification at GDLS – Continued

Based on a recent Stryker program development, we have learned that DFR not only drastically increased demonstrated reliability, but also dramatically saved developmental costs, especially during Developmental Test. The Stryker NBCRV program has recently undergone its DFR phase, after which it demonstrated a four times improvement in reliability. The subsequent reliability testing was cut almost in half since the vehicles demonstrated the required level of reliability with confidence. It is important to note that the amount saved from early discontinuation of the test was greater than the spending on the DFR phase by almost 3 times. This experience debunks the notion that there must be a tradeoff between reliability and faster fielding. Our external customers, at times, must be convinced of the importance of the proper Reliability Program using the DFR toolbox for the bottom-line cost saving. Any lack of attention to reliability, during design stage, and absence of the Design For Reliability methodology will lead to inadequate performance of the product during system testing and exceedingly high expenditures before fielding the system. All of that can be avoided if a proper amount of attention and investment is allocated to reliability as early as possible. The Systems Engineering Master Plan (SEMP) explicitly addresses employment of the DFR tools and this is the plan to follow. Proper language in a Request for Proposal (RFP) and contracts that utilizes recent ANSI/GEIA-STD-0009 can help to shift the focus of the development towards designing and then producing reliable and robust defense systems. It was not unnoticed that the Ground Combat Vehicle (GCV) RFP used 0009 language and required a viable reliability program up-front in the design process.

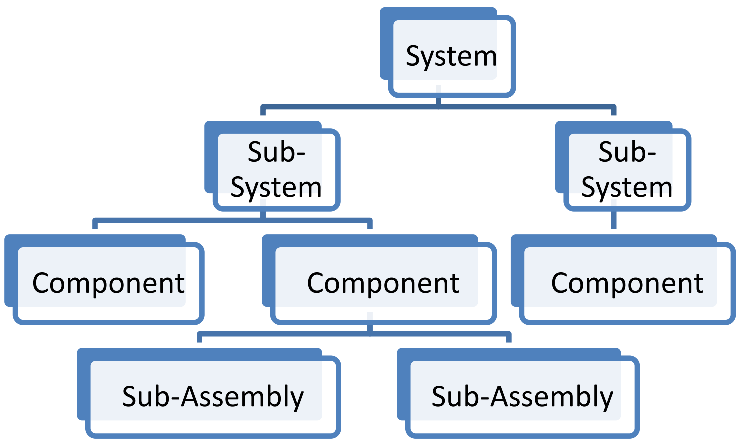
Source: Ruma, J and Tananko, D, Design For Reliability Implementation and Verification at GDLS, Around Edge –SE, 10/11/01

By: Jim Ruma
Dmitry Tananko

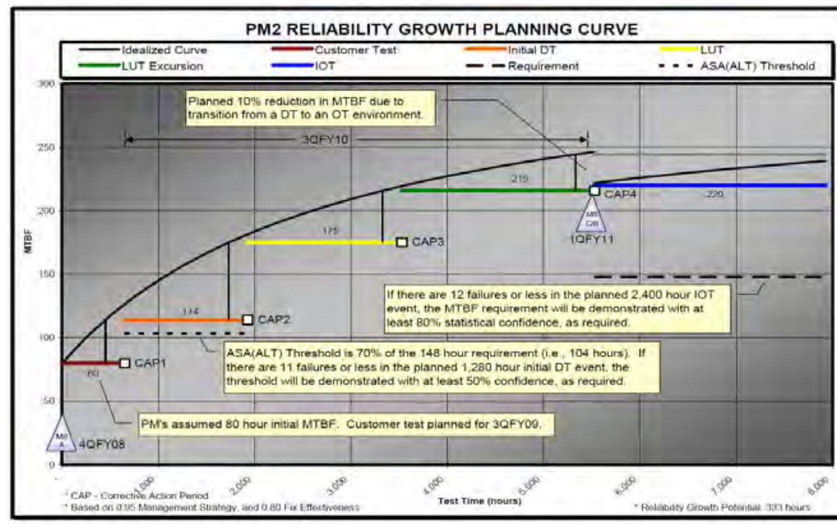
Around ED&D - SE - 1011-01

Reliability growth depends on two distinct reliability models

- Full system model guides integrated testing.
  - Provides an initial guess at system reliability
  - The goal is NOT to create a complete model of what will fail when and why



Full system model used to allocate system reliability down to required reliability at lowest levels.



Growth model used to track and predict reliability of individual pieces(sub-systems, etc) in DT/IT and of full system in IT/OT

As design matures…Reliability Growth

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NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Industrial
Committee
On
Test &
Evaluation

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

Mr. James Ruma, Chairman, NDIA ICOTE; Vice President, GDLS


• Meet Quarterly
• Senior Leadership Participation
– Government & Industry Support

Participants

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Raytheon

THE O'BRYON GROUP
James F. O'Bryon * National Defense and Security Consultant

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& ASSOCIATES
HIGH IMPACT SOLUTIONS

ALION
SCIENCE AND TECHNOLOGY

NORTHROP GRUMMAN

GENERAL DYNAMICS
nassco

NAVISTAR
DEFENSE

SAIC
An Employee-Owned Company

AF OPERATIONAL TEST & EVALUATION CENTER

DEFENSE INFORMATION SYSTEMS AGENCY

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

DEFENSE INFORMATION SYSTEMS AGENCY
JOINT INTEROPERABILITY TEST COMMAND

MARINE CORPS OPERATIONAL TEST & EVALUATION ACTIVITY
MCOTEA

DEPARTMENT OF THE ARMY
UNITED STATES OF AMERICA
1775

DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA

JOINT PROGRAM EXECUTIVE OFFICE
JPEO-CBD
CHEMICAL AND BIOLOGICAL DEFENSE

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

U.S. DEPARTMENT OF HOMELAND SECURITY

DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA
MCMXLVII

DEPARTMENT OF THE NAVY
UNITED STATES MARINE CORPS

INDUSTRY

AGENCIES

ICOTE Mission

Provide forum *for senior Test and Evaluation representatives from Defense Department & U.S. defense system manufacturers to* ***meet and review issues*** *of common interest and concerns.* ***Discuss T & E policies and procedures*** *impacting weapons systems development, test, procurement and use.*

Takeaways

- **Discuss & Gain Feedback**
- **OSD Policies and Emerging Issues**
- **ICOTE Cooperation to Benefit Warfighters**
- **Topics of Interest**

Major T&E Web Sites

OSD	http://www.dote.osd.mil/pub/otherrep.html
OSD	http://www.acq.osd.mil/dte/pg/index.html
Army	http://www.atec.army.mil/images/ATEC_FINAL_20100929_low.pdf
Air Force	http://www.afotec.af.mil/index.asp
Marines	http://www.marines.mil/unit/hqmc/mcotea/Pages/index.aspx
Navy	http://www.cotf.navy.mil/index.htm
NDIA	http://www.ndia.org/DIVISIONS/INDUSTRIALWORKINGGROUPS/INDUSTRIALCOMMITTEEONTESTANDEVALUATION/Pages/default.aspx

ICOTE Initiatives

- Include Systems Engineering and Developmental Test Disciplines
- Emphasis Continues on Reliability
- Systems Focus on Survivability, Effectiveness and Suitability
- Ship Sub Committee
- Testing of Cyber
- Field New Capability Rapidly
- Engage Early to Improve Requirements

Test and Evaluation

"Serving the Warfighter in a Cost Constrained Environment"

16 March 2011

Mr. Chris DiPetto

Office of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation

DoD Budget Realities

- Defense base funding must have **real growth to sustain force structure** and modernization
  - Fighting Two Wars
  - Confronting ongoing terrorist threats around the globe
  - Facing major powers investing heavily in their military
- Requires 2-3% real growth
  - The current and planned base defense budget has steady, but modest growth of 1% per year
  - To preclude reductions in needed military capability, the difference of 1-2% a year will be made up elsewhere in DoD
- In May, SecDef began a hard, unsparing look at **how DoD is staffed, organized, and operated**

"…in May I called on the Pentagon to take a hard and unsparing look at how the department is staffed, organized and operated. I concluded that our headquarters and support bureaucracies, military and civilian alike, have swelled to cumbersome and top-heavy proportions, grown over-reliant on contractors and grown accustomed to operating with little consideration to cost." ….Secretary of Defense Robert M. Gates

….. enter the SecDef Plan for Efficiency

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

(L) Secretary of Defense Robert M. Gates
(R) USD AT&L Dr Ashton B. Carter

"Consumers are accustomed to getting more for their money – a more powerful computer, wider functionality in mobile phones – every year. When it comes to the defense sector, however, the taxpayers had to spend significantly more in order to get more. We need to reverse this trend." ….Secretary of Defense Robert M. Gates

Look at Acquisition?

THE USUAL (?) SUSPECTS

Cost

Over Budget

- GAO: 96 MDAPs, $300B over initial estimates

Schedule

Late to Need

- Getting capability to the user to meet urgent needs

Performance

Programs failing Operational Test

- Suitability issues
- Late discovery of failure modes
- Performance shortfalls
- Interoperability

Where Can the T&E Community Find Efficiencies?

- **Reduce the amount of testing**
  (manage our appetite, don't "test for testing's sake")
  - What is an "adequate" amount of testing to support the required evaluation?
- **Increase the efficiency of testing**
  (e.g., lower cost per test point or knowledge gained)
  - Tools Design of Experiments (DOE)
  - Capital Utilization
  - M&S
- **Use T&E as a means to reduce the cost of acquisition**
  (the "test-earlier" part)
  - Discovering failure modes early
  - Fully inform decision makers

Panel

Bios

Biographies

Mr. Jack Manclark, Air Force T&E Executive

Mr. Manclark (Jack) is the Director of Test and Evaluation, Headquarters U. S. Air Force in Washington D.C. He is responsible for all Air Force policy, resources and oversight of developmental and operational testing, and is the focal point for foreign material acquisition and exploitation.

Mr. David K. Grimm, Acting Director, Deputy Under Secretary of the Army, T&E Office

Mr. Grimm (Dave) is the acting Assistant Deputy Under Secretary of the Army for Test and Evaluation. He is responsible for all Army Acquisition Category (ACAT) I and II programs and the Chemical Biological Defense Program. He serves as the integrator and primary agent for the Secretary of the army in coordinating T&E issues, positions and reports with the other Military Departments, the Office of the Secretary of Defense, the Joint Staff and Congress.

Biographies

Dr. Steve Hutchison, DISA T&E Executive

Dr. Hutchison (Steve) assumed the duties as the Test and Evaluation (T&E) Executive in August 2005, to oversee strategic planning, resourcing, and execution of the T&E mission for the Agency, and represent DISA to the DoD T&E community. Dr. Hutchison supervises the activities of the Joint Interoperability Test Command and the Office of the T&E Executive. Prior to his arrival in DISA, Dr. Hutchison served in the office of the Director, Operational Test and Evaluation (DOT&E) and the Army Test and Evaluation Command (ATEC).

Ms. Amy Markowich, Navy T&E Executive

Ms. Markowich (Amy) currently serves as the Deputy, Department of the Navy Test and Evaluation, Executive Office of the Assistant Secretary of the Navy (Research, Development and Acquisition (RD&A). In this role she is responsible for the integration of Test and Evaluation (T&E) across the Navy and Marine Corps, enhancing the T&E workforce and infrastructure, and ensuring complete adequate testing to demonstrate suitable and effective operations in the joint battle space.

Biographies

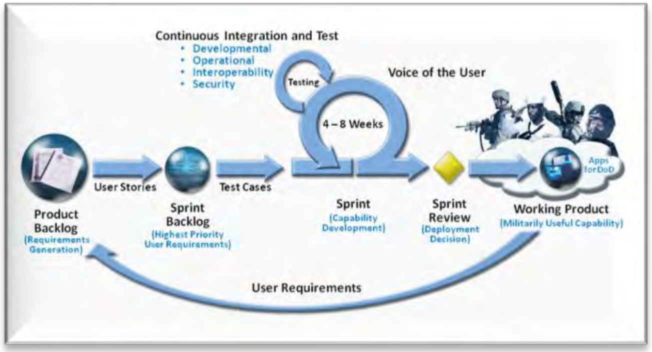
<u>Mr. Tom Wissink, Director of Integration, T&E, Lockheed Martin</u>

Mr. Wissink (Tom) is the Lockheed Martin Corporate Engineering & Technology Director of Integration, Test & Evaluation and a Corporate Senior Fellow. He has worked in system/software integration and test, software development, and configuration management for more than 35 years.

DISA
A Combat Support Agency

Efficiency Initiatives

- IT Acquisition Reform
  - fully integrated test, evaluation, and certification
- Federate DoD Capabilities – "Joint IT Range"
  - find, connect, collect, release
- T&E network convergence
  - common DoD T&E network
- Test as a Service
  - enterprise Test Tools
- Virtualization
  - move to cloud and virtual testing concepts



Test Forge.mil

Making Acquisition Processes and Infrastructure
Responsive to the Warfighter

NDIA T&E Conference Plenary Panel

T&E: Serving the Warfighter in a Cost Constrained Environment -- Army Perspective

Acting Assistant Deputy Under Secretary of the Army (Test and Evaluation)

Mr. David K. Grimm

16 March 2011

Army T&E: Serving the Warfighter in a Cost Constrained Environment

<u>How can we:</u>

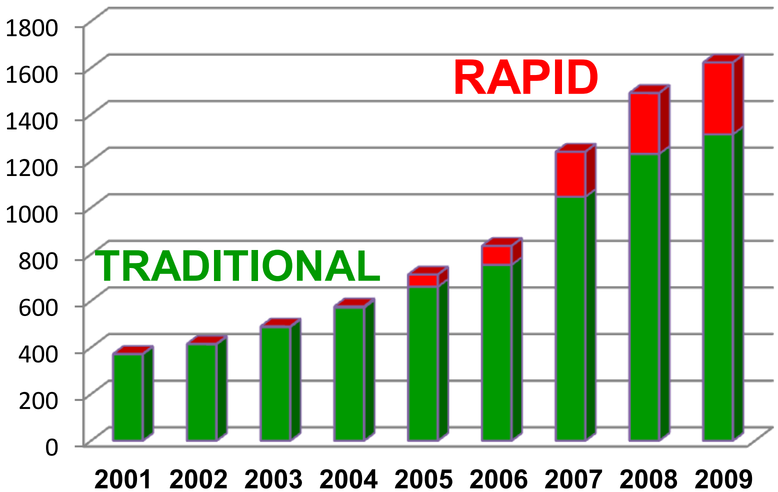
- Reduce Amount of Testing?
- Increase Efficiency of Testing?
- Use T&E to Reduce the Cost of Acquisition?

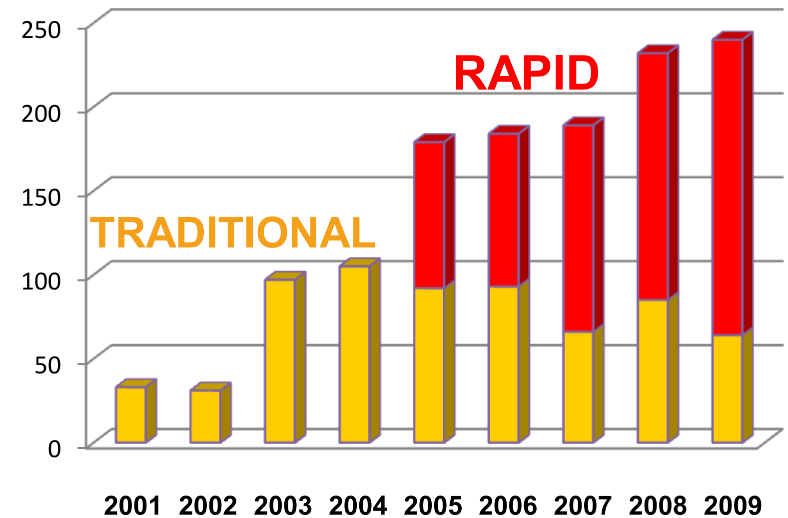
- Some Risk Factors…
  - Technology
  - Integration
  - Program (cost, schedule, performance)

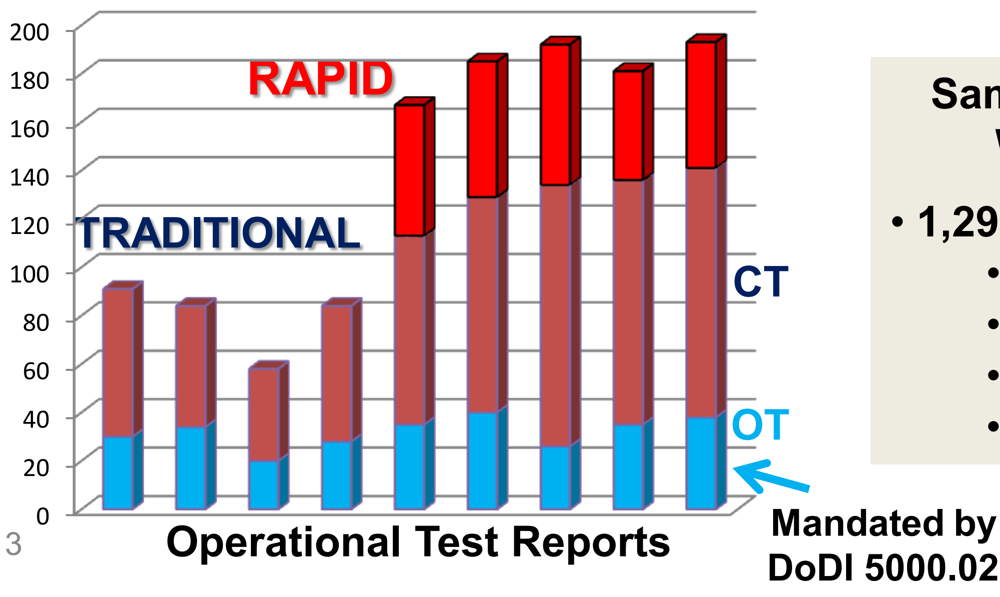
<u>Army is:</u>

- Synchronizing T&E ICW Integrated Network Efficiencies Effort
- Driving T&E Investment Collaboration
- Leveraging BRAC Relocations, Organizational Realignments, Process / Cultural Shifts
- Integrating Tests w / Training & Readiness Exercises
- Supporting Competitive Prototyping and All Available Data Sources

Context: Army Testing in a Time of War
"The Warfighter Needs to Know"







Sample of Army Test „Battle Rhythm"
Week of 24 APR – 01 MAY 2009

- 1,299 Active Test Projects
    - 129 Rapid Fielding Events
    - 237 Joint Tests / Projects
    - 663 Non-Eval Program Tests
    - 270 MDAP "PORs"

Responsive and Agile IT T&E

Tampa, Fl

March 16, 2011

Sources of Stakeholder Recommendations

- Defense Science Board
  - Developmental Test and Evaluation, May 2008
  - DOD Policies and Procedures for the Acquisition of Information Technology, March 2009

- 2010 National Defense Authorization Act (Sec 804)
  - Implementation of a New Acquisition Process for Information Technology Systems

- NDIA-OUSD (AT&L) System Engineering Division/Development T&E Committee and Software Industry Experts
  - Software T&E Summit/Workshop September 2009
  - Joint Authored White Paper, Dec 2009

- National Academies of Science Study
  - Achieving Effective Acquisition of Information Technology in the Department of Defense, December 2009

DOD Agile IT Precepts

1) achieve significant time and cost resource efficiencies

2) support software application “sprints”

3) provide tailored test environments established on demand

4) create a virtual library of systems and services to avoid having to stand up physical systems for every test

5) establish a DOD wide accepted restructured IT T&E process

Panel Members

Panel Chair	Dr Steven Kimmel Senior VP Alion Science and Technology
Interop/Network Cert/Assurance	Dr Steven Hutchison Test and Evaluation Executive, DISA
OT&E	Dr James Streilein Dep Dir DOT&E (Comm & Space Systems)
DT&E	Ms Darlene Mosser-Kerner Dep Dir, DT&E (AT&L/DDRE)
OSD/NII	Mr Eustace King DIACAP Tiger Team

National Defense Industrial Association

Panel Introduction

Approach

Engage with the AUDIENCE to understand and explore the community of challenges, issues and solutions via Q & A's vice death by ppt.

GOAL

Achieve an integrated T&E responsive, effective and efficient (mission-focused on-demand) agile capability

NDIA National Defense Industrial Association

Panel Focus

Customer complaint: IT testing is a serial process that costs too much and takes too long to complete.

The Challenge:

1) **How to integrate users and testers such that a common set of standards can address joint interoperability and information assurance testing into an agile, mission focused team.**

AFEI ntsa PSA WID

Panel Focus

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The Challenge:

1) How to integrate users and testers such that a common set of standards can address joint interoperability and information assurance testing into an agile, mission focused team.

How to network DOD testing capabilities so that we are able to test things in parallel, i.e., establish a realistic test environment whereby one test affords sufficient & thorough "stakeholder" data collection

NDIA National Defense Industrial Association

Panel Focus

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The Challenge:

1) How to integrate users and testers such that a common set of standards can address joint interoperability and information assurance testing into an agile, mission focused team.

2) How to network DOD testing capabilities so that we are able to test things in parallel, i.e., establish a realistic test environment whereby one test affords sufficient & thorough "stakeholder" data collection

How stovepipe test beds be melded together to enable testers to locate needed assets, connect them into the test, collect the data needed, then release the asset when the test has been completed.

AFEI ntsa PSA WID

Opening Panel Question

What are the impediments to achieve a “virtual” network that can satisfy a “parallel” efficient IT T&E process?

Panel Question # 2

What are the technical, policy or procedural obstacles that need to be overcome to --

1) **achieve an operationally realistic environment whereby IT test data can be shared across DT-OT-IA-certifications and accreditation?**
2) **“test by one, accept by all”, e.g., IT T&E reciprocity**

Closing Comments

- IT systems are different than weapons systems…current DOD 5000 inappropriate for both
- DOD agile developed IT systems/applications are on the horizon……IT "sprints" projects will cause closer collaboration between users, developers and testers
- "Soda straw" or serial T&E to be replaced by parallel acceptance, certification, accreditation, interoperability and integration– test once, accept by all.

Information Systems Summit II
“What’s All This Agile Stuff About, Anyway?”

April 4-6, 2011

Event #1750

Hyatt Regency Baltimore

Baltimore, MD

US Special Operations Command

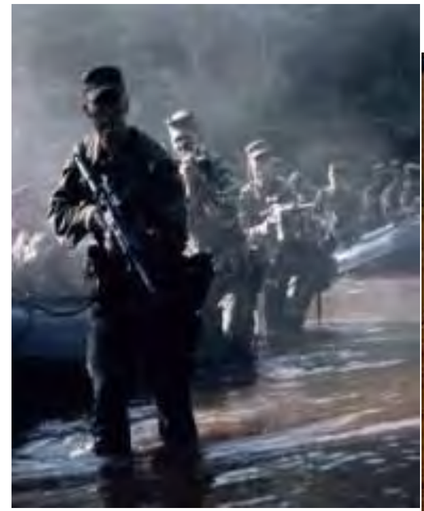
Operational Test & Evaluation Overview

HQ USSOCOM J8-O
LTC Kevin Vanyo
16 March 2011

The overall classification of this briefing is:
UNCLASSIFIED

Agenda

- OT&E Authority
- Mission and Tenants
- Responsibilities
- Operationally Effective, Suitable, & Safe
- Documentation
- Environment
- T&E Implementation
- Examples
- Conclusion



Authority

Concurrent with Title 10 USC Authority and Head of Agency responsibilities, USSOCOM ensures that the systems, products, and equipment fielded to Special Operations Forces (SOF) are operationally effective, suitable, and safe. These assurances are gained through the test and evaluation process.

USSOCOM Directive 71-5, Operational Test and Evaluation
10 USC 139

Mission

WHAT WE DO…..

Ensure that USSOCOM Acquisition Program System Capabilities, <u>Independently Evaluated</u>, are Measured Against Validated Requirements Under Realistic Operational Conditions to Determine a System's Operational Effectiveness, Suitability and Survivability Prior to Fielding to Special Operations Forces

T&E Tenants

FAIR

FLEXIBLE

ACCOUNTABLE

INDEPENDENT

RESPONSIBLE

T&E Tenants – "Flexibility"

Operational Test Agencies

SOCOM	ARMY	NAVY	AIR FORCE	MARINE CORPS
All Services: AFOTEC ATEC COMOPTEVFOR MCOTEA	Army Test & Evaluation Command (ATEC)	Commander, Operational Test & Evaluation Force (COMOPTEVFOR)	Air Force Operational Test & Evaluation Center (AFOTEC)	Marine Corps Test & Evaluation Activity (MCOTEA)
JITC National Assessment Group (NAG)	JITC	JITC	JITC	COMOPTEFOR JITC
USASOC Test & Evaluation Division (TED)				
18th Flight Test Squadron (AFSOC)				
MCPD, NAVSEA NAVAIR, SPAWAR, WARCOM				

UNLIKE MOST OF THE SERVICES, USSOCOM HAS MULTIPLE SOURCES FOR OT&E

J8-O Responsibilities

- Oversee OT&E for SOF Acquisition Programs
- Develop and Implement OT&E Policy via USSOCOM Directive 71-5
- Assess and Determine system:
  - Effectiveness
  - Suitability
  - Interoperability
  - Safety
- With J4 and PEO, issue a System Production Certification (SPC) and/or Fielding and Deployment Release (F&DR)
- Review Requirement Documents for Relevancy and Testability
- Assist / Approve the Test Strategy in the Single Acquisition Management Plan or the Test and Evaluation Master Plan
- Coordinate w/ Program Manager in Selection of the Operational Test Agency
- Observe Critical Operational Test Activities
- Validate New Equipment Training (NET)
- Independent of SORDAC; Directly communicate with CDR USSOCOM

Operationally Effective

- The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, survivability, vulnerability and threat.

- SOCOM OT&E Focus
  - Linked to Mission Accomplishment
  - What Operational Capabilities are Critical to Mission Accomplishment
  - Test Environment Adequate

Meets Technical and Operational Performance Requirements

Operationally Suitable

- The degree to which a system can be satisfactorily placed in field use, with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower, supportability, logistics supportability, documentation, and training requirements

- SOCOM OT&E Focus
  - Linked to Mission Accomplishment
  - What Operational Capabilities are Critical to Mission Accomplishment
  - Test Environment Adequate

Compatible With U.S./DOD/Service Processes and Facilities

Operationally Safe

- Identify Hazards and Eliminate or Mitigate those Hazards to an Acceptable Level
- Concurrently Satisfy the Technical Performance Parameters in CPD, CDD, or equivalent
- USSOCOM System Safety Risk Assessment
- Safety Certification Authorities

Safe to Use, Handle, Transport, Store and Demilitarize

Documentation- F&DR

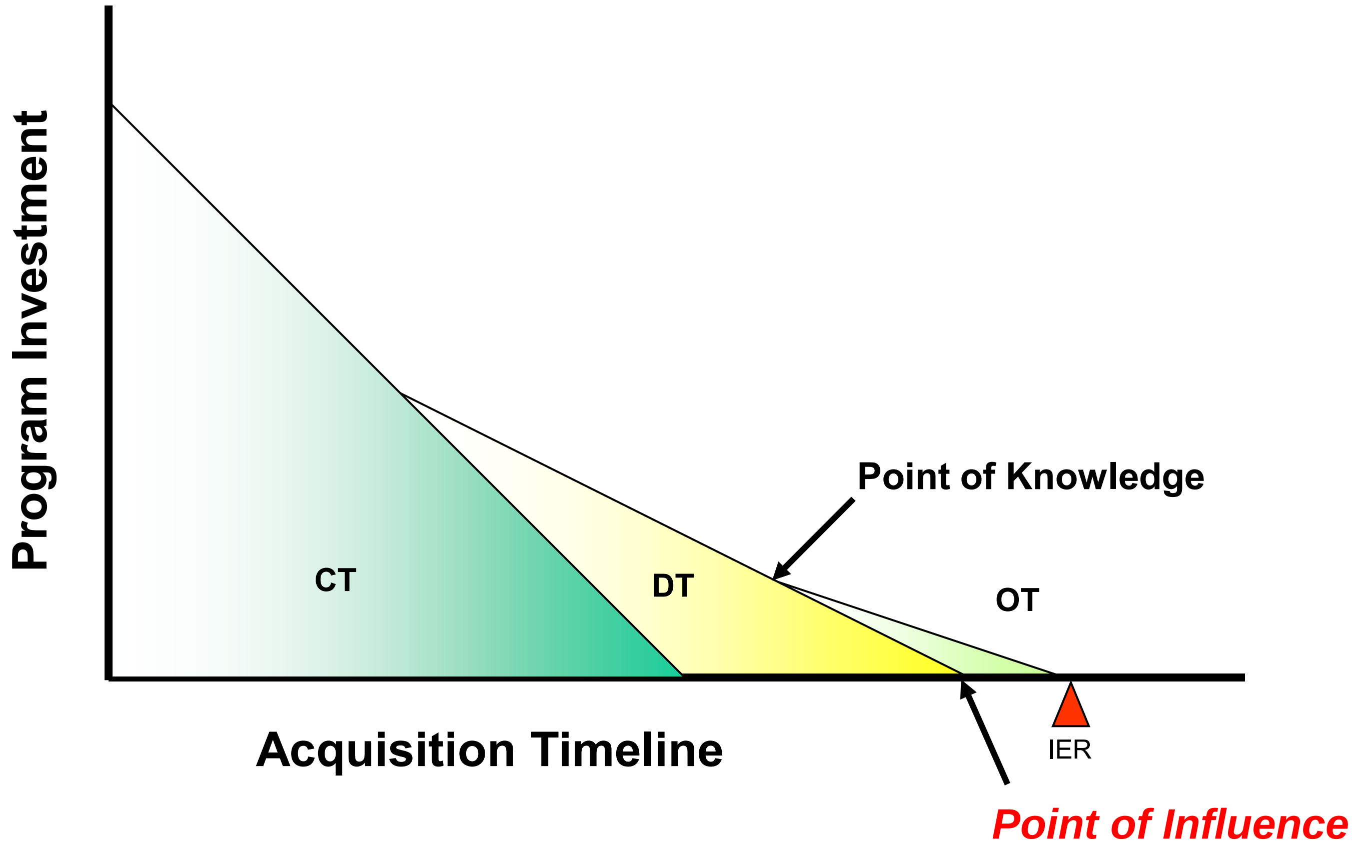
Fielding and Deployment Release (F&DR) is the Final Documentation Required to Certify that a SOCOM System is Ready for Fielding:

- J4 Document (Logistics)
- Certification to the Milestone Decision Authority that all Issues Identified in SPC are Satisfied – Addressing Primarily the Effectiveness, Suitability, Reliability, Safety.
- Can be a Combined SPC/F&DR Depending upon how System is Managed

SOCOM T&E Environment

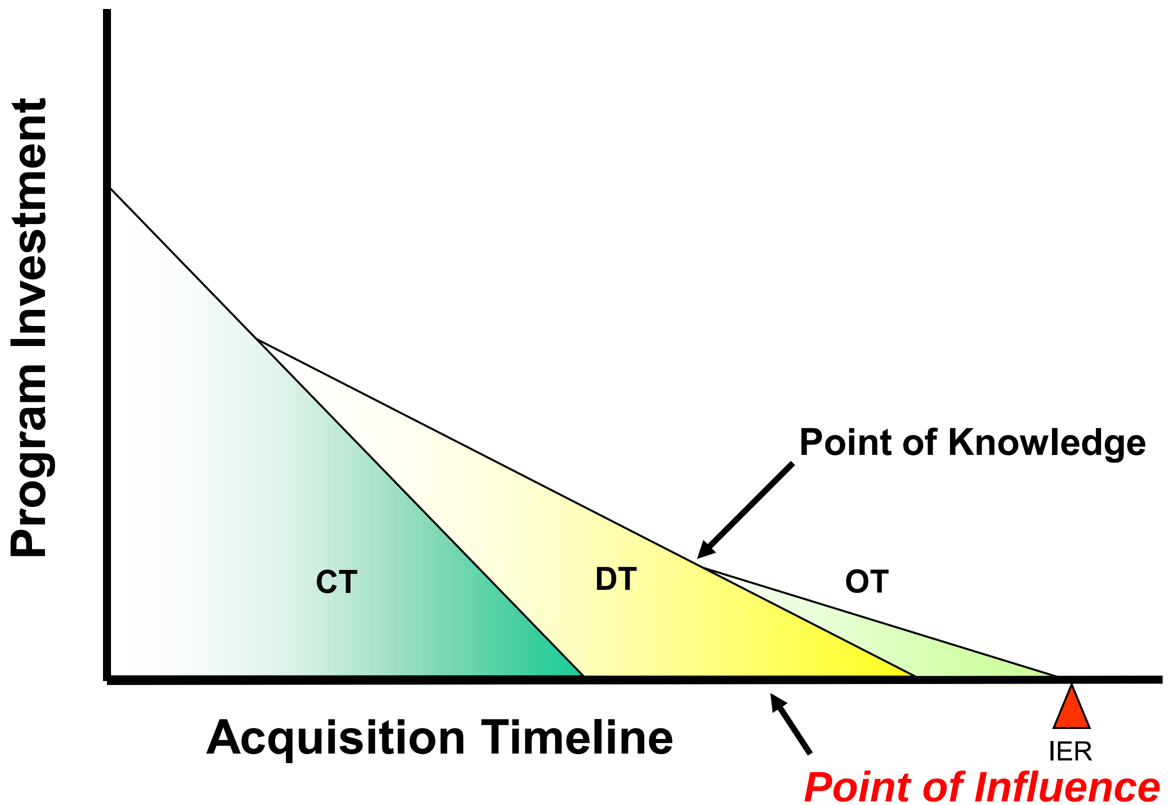
- **High Risk Environment**
  - Delayed Point of Knowledge
  - Further delayed Point of Influence
- **Medium Risk Environment**
  - Delayed but synchronized Point of Knowledge and Point of Influence
- **Low Risk Environment: Integrated DT/OT**
  - Up-front/ Early Point of Knowledge and Point of Influence

High Risk Environment



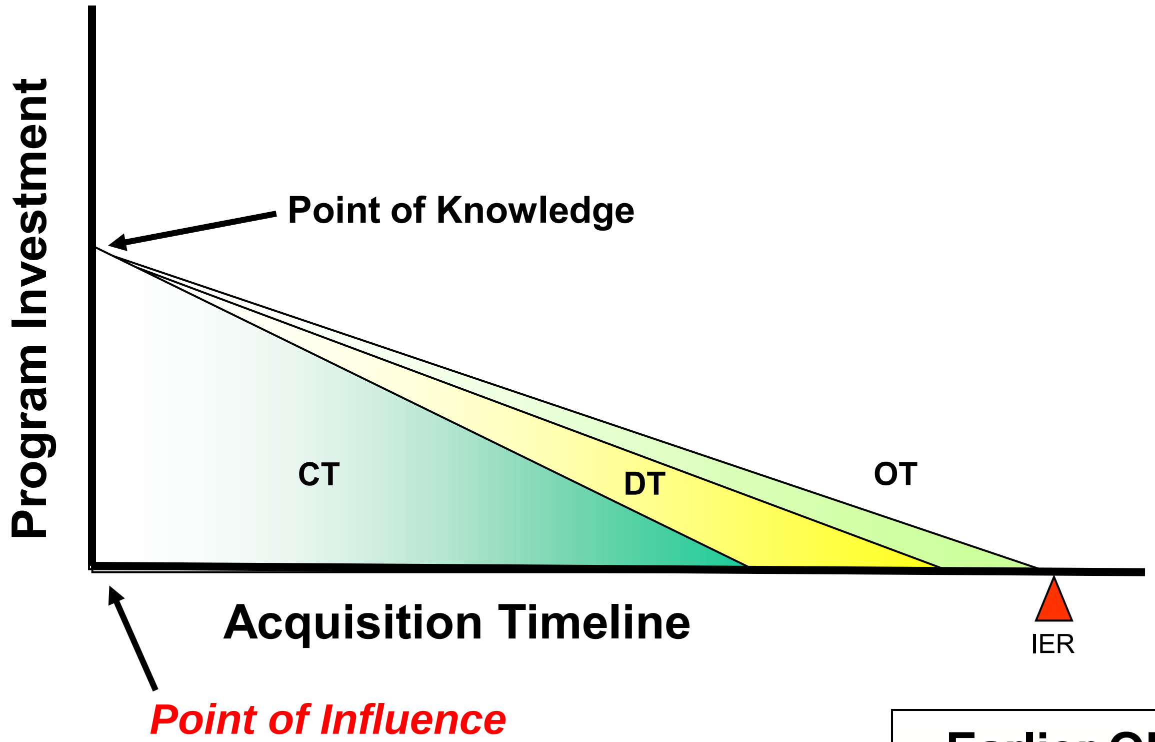
Just-in-Time OE/OS

Medium Risk Environment



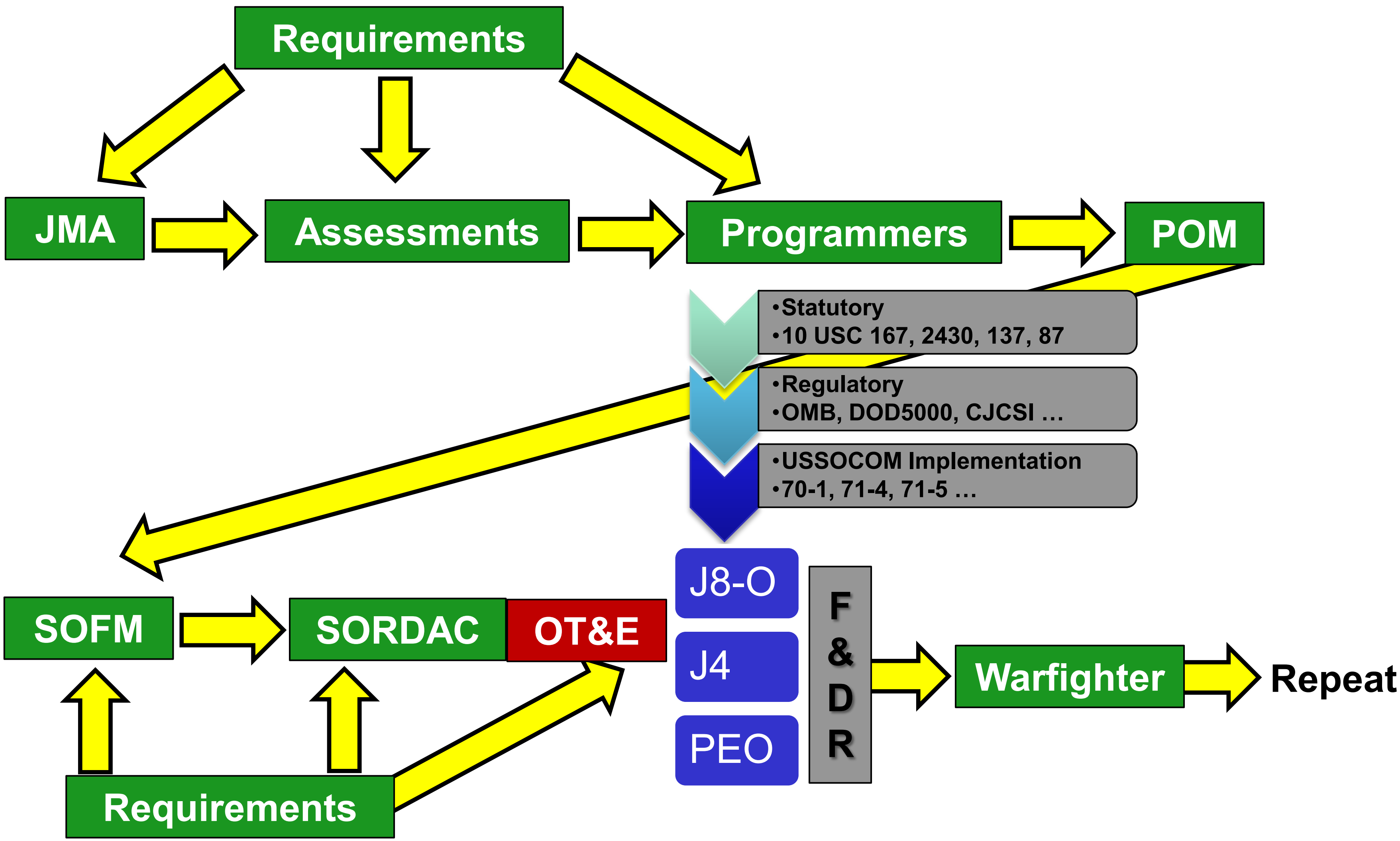
Just-in-Time OE/OS
Plus
Executability Insight

Low Risk Environment- *Integrated T&E*



Earlier OE/OS Insight
Plus
Executability Insight
Plus
Affordability Insight

T&E Implementation



Example:
MK 20 MOD 0 Sniper Support Rifle (SSR)

Example:
MK 20 MOD 0 Sniper Support Rifle (SSR)

- Originally competed as "SV" in CAR Solicitation
- User Assessment (UA)
  - Conducted at Camp Billy Machen, CA: 22-27 Feb 2009
  - 9 Test Operators
  - NSW, USASOC & MARSOC
- Developmental Test (DT)
  - Conducted (Endurance) at FNMI, Columbia, SC: 8-11 Nov 2009
  - NSWC Crane Personnel Participated
- Operational Test & Evaluation (OT&E)
  - Conducted at Camp Billy Machen, CA: 6-18 Dec 2009
  - 10 Test Operators
  - NSW, USASOC & MARSOC
- Achieved Joint Safety Approval on 1 June 2010
- Achieved F&DR on 18 Aug 10
- Note: Core Operators continued throughout this process

Example:
SOF Tactical Combat Casualty Care

Echelon of Care I+

Operator Kits

Point of Wounding

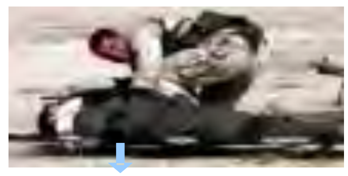
SOF Medic

Medic Kits

Extraction Set Locate & Gain Access to Casualty

Mobility Set Rigid Flexible Litters & Litter Aids

Casualty Collection Point



Unit Medical Officer

Echelon 1 Plus Care

TCCC SOF Trauma Mgmt Set

Transport Set Adapt SO Land, Sea, & Air Platforms for CASEVAC

Theater CASEVAC Pick Up Zone

Definitive Care Capabilities

Extraction
Locate & Gain Access

* Water & Night
* High Angle
* Pry & Cut

Mobility
Litters & Aids

* Transport
* Various Vehicles

Sustainment
Stabilization

* Vitals
* Cardiac
* Inspired Oxy
* Blood/Fluid
* Hypothermia
* Secure Equipment

Transport
Land, Sea, Air

* Blood Loss
* Advanced Airway

Example:
SOF Tactical Combat Casualty Care (TCCC)

- PMO involved with J8-O early, during establishment of Acquisition Program Baseline, to ensure OT adequately included in plan
  - J8-O test input reflected in Section M of Contract Solicitation
- Source Selection Evaluation Board (SSEB) conducted 7-18 Jun 2010
  - 9 members with user reps from: NSW, AFSOC, MARSOC & USASOC
- Developmental Testing (DT)
  - Received DTC Safety Release ISO Operational Testing: Nov 2010
  - USAARL: Air Worthiness and environmental (ongoing)
  - USAAMA: Medical Sustainability (ongoing)
- Operational Test & Evaluation (OT&E)
  - Conducted product demonstration Phase 1: Fort Carson, CO - Jan/ Feb 11
    - 15 Test Operators: NSW, AFSOC, MARSOC & USASOC
  - Conduct product demonstration Phase 2: Crawfordsville, AR – Mar/ Apr 11
    - 16 Test Operators: NSW, AFSOC, MARSOC & USASOC

Conclusion-
USSOCOM Acquisition Challenges

- Diversity of Platforms, Users, Systems, Operating Environments, and Program Management Structures

- Mandate to Rapidly Respond to Emergent Warfighter Requirements
  - 80% Solutions
  - Take Risk and Manage It
  - Many SOCOM Systems Installed in Platforms Owned and Developed by Others (Services, MILDEPS)
  - Contractor-off-the-shelf / Non-developmental Items

Our Reason for Being