Systems Engineering Initiatives for Verification, Validation and Accreditation of DoD Models and Simulations

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Acquisition Program Decision Support Relies on Credible M&S

DOD PROGRAMS

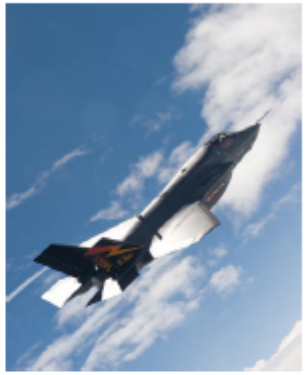
F-35 Lightning II Joint Strike Fighter (JSF)

Executive Summary

- F-35 verification and flight test did not reach the tempo planned for FY09 due primarily to late deliveries of the remaining 10 (of 13) System Design Demonstration (SDD) flight test aircraft. While other verification work continued in the hover pit, Cooperative Avionics Test Bed (CATB), and surrogate platforms, the Integrated Test Force accomplished only 16 of 168 flight test sorties planned for FY09. Completion of IOT&E of Block 3 capability could occur in early to mid-2016 provided the associated extension of SDD is supported with additional flight test aircraft, timely delivery of effective software, and an adequate pace of testing is maintained.
- Continued production concurrent with the slow increase in flight testing over the next two years will commit the DoD and Services to test, training, and deployment plans with substantial risk. Program management needs to emphasize maintaining robust engineering and test forces, early completion of detailed test plans, fully resourcing those plans, and rigorous accreditation of models and labs. Deliveries of assets for OT&E and initial training must be managed consistent with approved plans for OT&E.
- The mission capability of the low-rate initial production (LRIP) aircraft and support systems is unclear. This creates a problem for the Services as they plan for Initial Operational Capability. The process to accurately and credibly predict the mission capability of LRIP systems well before delivery needs to improve and LRIP contracts need to be tied explicitly to demonstrated progress in flight testing.
- The JSF Program Office (JPO) is executing a comprehensive, robust, and fully funded Live Fire test plan. However, the program's recent removal of shutoff fuses for engine fuel/hydraulics lines, coupled with the prior removal of dry bay fire extinguishers, has increased the likelihood of aircraft combat losses from ballistic threat induced fires. At present, only the Integrated Power Plant (IPP) bay has a fire suppression system. Though the JSF Executive Steering Board (JESB) has approved the JPO's request to remove these safety systems as an acceptable system trade to balance weight, cost, and risk, DOT&E remains concerned regarding the aircraft's vulnerability to threat-induced fires.

System

- The F-35 Lightning II program is a joint, multi-national, single-seat, single-engine family of strike aircraft consisting of three variants:
  - F-35A Conventional take-off and landing (CTOL)
  - F-35B Short Take-off and Vertical Landing (STOVL)
  - F-35C Aircraft carrier variant (CV)



- It is designed to survive in an advanced threat (year 2012 and beyond) environment using a blend of advanced technologies. It is also designed to have improved lethality compared to legacy multi-role aircraft.
- Using an Active Electronically Scanned Array (AESA) radar and other sensors, the F-35 is intended to employ precision guided bombs such as the Joint Direct Attack Munition and Joint Standoff Weapon, AIM-120C radar air-to-air missiles, and AIM-9 infrared air-to-air missiles.
- The program incrementally provides mission capability: Block 1 (initial), Block 2 (advanced), Block 3 (full).
- The F-35 is under development by a partnership of countries: the United States, Great Britain, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway.

Mission

- A force equipped with F-35 units should permit the Combatant Commander to attack targets day or night, in all weather, in highly-defended areas of joint operations.
- Targets include fixed and mobile land targets, enemy surface units at sea, and air threats, including advanced cruise missiles.

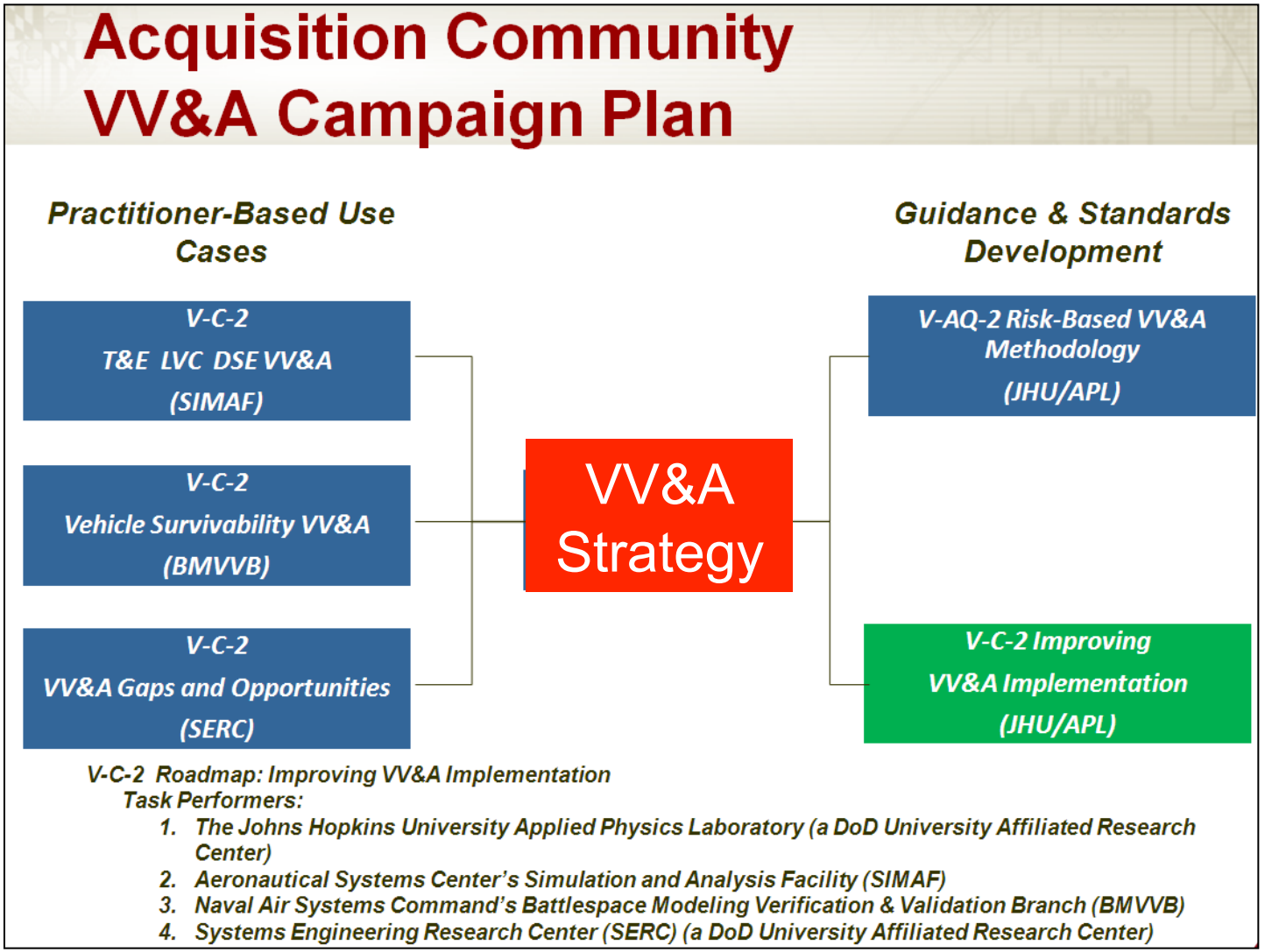
Prime Contractor

- Lockheed Martin, Aeronautics Division, Advanced Development Programs, Fort Worth, Texas

A Contemporary Example on the Need for Better VV&A Approaches

- The JSF Program Office initiated a roadmap for the verification, validation, and accreditation (VV&A) of the labs and models intended to become test venues, per the mid-course risk reduction strategy of 2007.
- The roadmap serves as a gauge to measure the contractor's progress in completing the accreditation support packages needed before success criteria can be resolved using the models.
- The current roadmap indicates that 50 percent of models will be accredited during the final year of flight testing, an approach with substantial risk.

Improved Decision Support Quality through a Balanced Approach



Acquisition Community-led VV&A High Level Task (HLT) Summaries

V-AQ-2: "Risk Based Methodology for Verification, Validation and Accreditation (VV&A)" The degree of VV&A required is explicitly tied to both M&S use and the user risk incurred if the M&S does not provide accurate results. A methodology that tailors VV&A planning and implementation based on known risk factors will provide a framework in which VV&A implementation trade-offs can be made, information/fidelity requirements can be assessed, and a VV&A cost model can be developed.

V-C-2: "Improving VV&A Implementation" Increase VV&A implementation and enhance M&S credibility by transforming VV&A practices from current subjective methods into objective examples or use cases. Explore emerging technologies, standards, and applicable methods that could be applied to reduce costs, schedule, and improve reuse.

Verification, Validation, & Accreditation

(M&S PE Funded V-C-2 & V-AQ-2)

FY: 09-10

V-AQ-2

Risk Based Accreditation

FY: 10-11

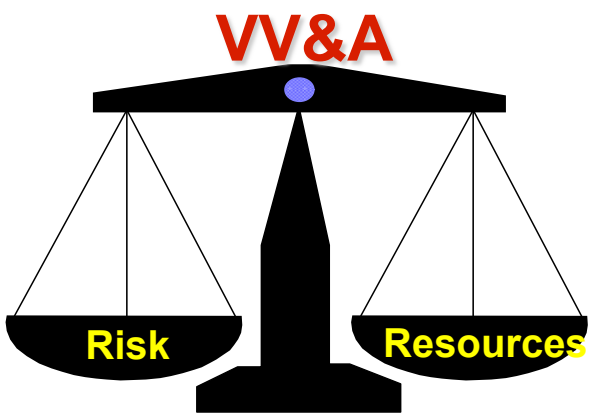
V-C-2

Improving VV&A Implementation

- Johns Hopkins APL
  - Improving VV&A Implementation
- Systems Engineering Research Center
  - VV&A Shortfalls & Needs
  - Complex Systems Modeling
- Pilot Implementations (SIMAF & NAVAIR)
  - VV&A/Distributed Joint VV&A/Vehicle Vulnerability
- Practitioners Forum
  - AMSWG VV&A Sub-Committee
  - ITEA LVC Sub-committee
  - "Gray Hairs" Study Support

Risk-Based VV&A

(M&S PE Funded V-AQ-2)



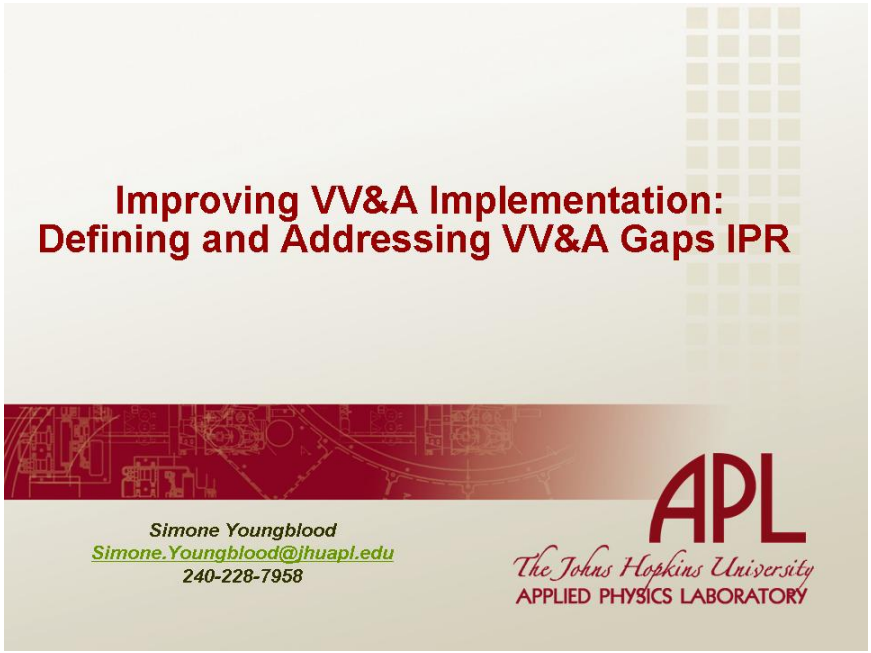
Balancing the cost of knowing against the risk of assuming.

The purpose of this effort is to:

- **Improve Department of Defense (DoD) Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A) by establishing an effective risk-based methodology for VV&A.**

Since the cost of verifying and validating simulations is often high, V&V investments should be weighed against the risk of making a bad decision because of unreliable M&S results.

JHU/APL VV&A Implementation:
Defining & Addressing Gaps
(M&S PE Funded V-C-2)



The purpose of the effort is to:

- **Support the identification of VV&A gap areas that inhibit effective implementation of VV&A processes;**
- **Develop supplemental capability required to implement the Risk-based Accreditation (RBA) methodology; and**
- **Evolve technology, in the form of automated tools and metadata specifications, that increase VV&A implementation efficiencies.**

Systems Engineering Research Center (SERC)
VV&A Topic

(M&S PE Funded V-C-2)

Proposed SERC research topic:

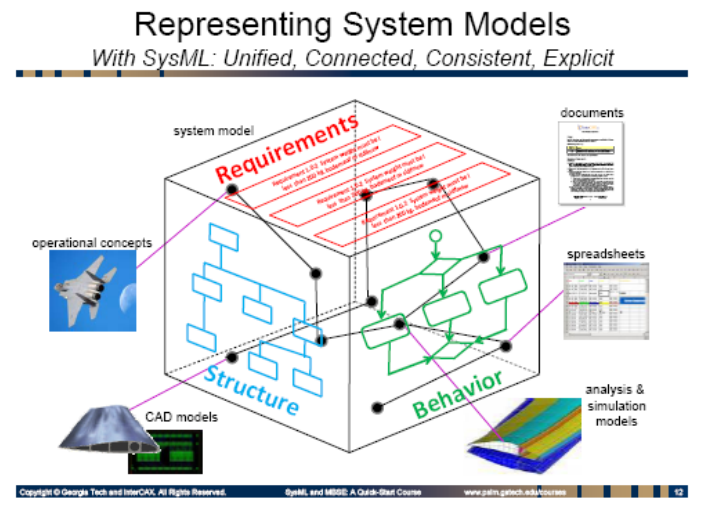
Explore & promote a deeper understanding of emerging & current approaches, technologies, or practices underway within the academic community & gain a broader perspective on their potential applicability to the M&S community V&V needs

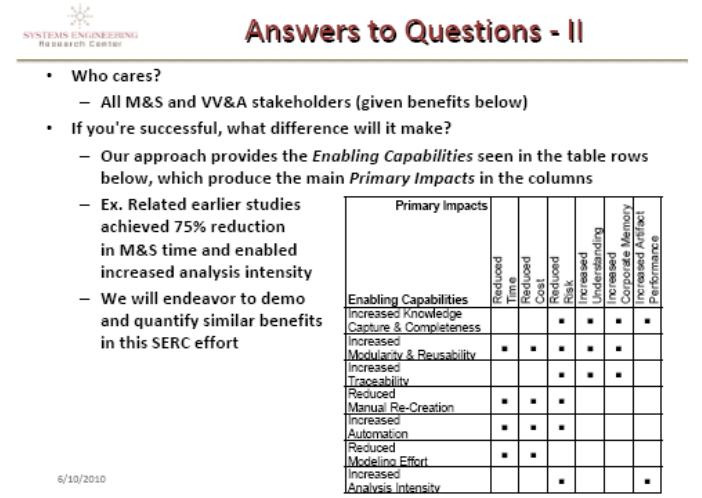
The 19 SERC university partners generated six responses, with selection of two proposals for implementation lasting 6 to 12 months

Two performers:
Georgia Institute of Technology
University of Alabama Huntsville

Georgia Institute of Technology
VV&A Study

(M&S PE Funded V-C-2)



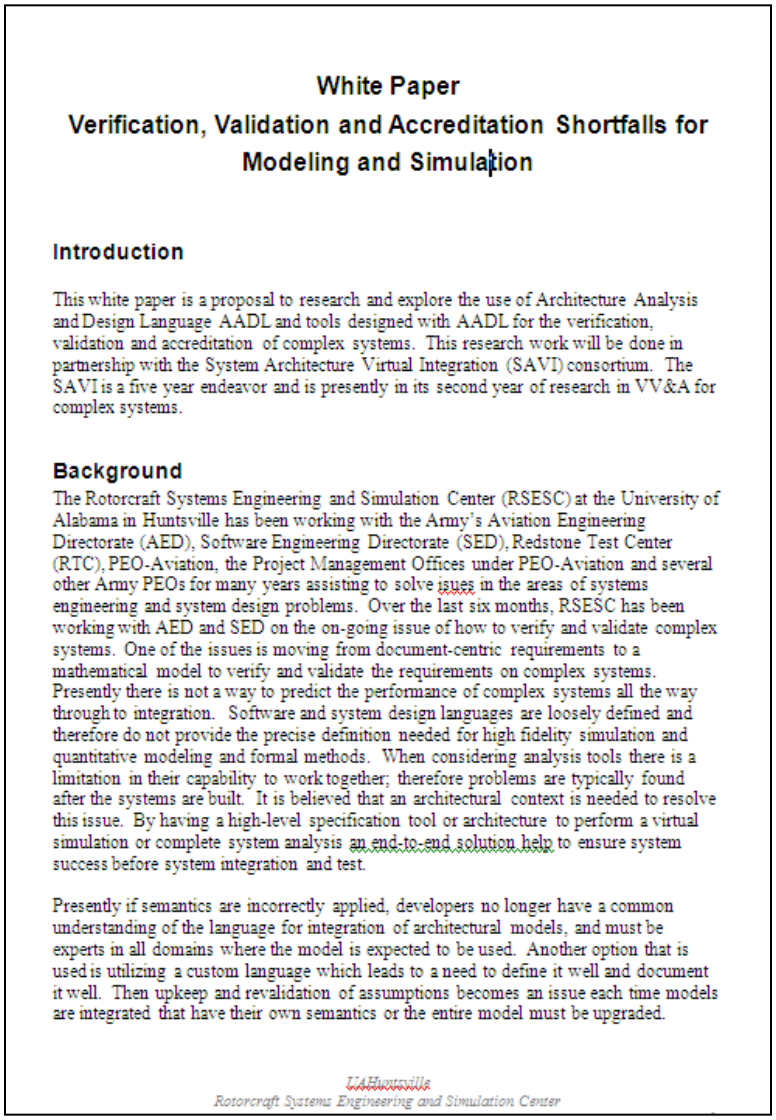


The purpose of this SERC effort :

- **Demonstrate how to address many of the gaps identified in this VV&A Research Topic by applying SysML and MBE/MBSE technology**
- **Engage practitioners in the DoD ecosystem to prioritize needs and to test resulting concepts**
- **Apply concepts in one or more key DoD test beds**

University of Alabama at Huntsville VV&A Study

(M&S PE Funded V-C-2)



White Paper

Verification, Validation and Accreditation Shortfalls for Modeling and Simulation

Introduction

This white paper is a proposal to research and explore the use of Architecture Analysis and Design Language AADL and tools designed with AADL for the verification, validation and accreditation of complex systems. This research work will be done in partnership with the System Architecture Virtual Integration (SAVI) consortium. The SAVI is a five year endeavor and is presently in its second year of research in VV&A for complex systems.

Background

The Rotorcraft Systems Engineering and Simulation Center (RSESC) at the University of Alabama in Huntsville has been working with the Army's Aviation Engineering Directorate (AED), Software Engineering Directorate (SED), Redstone Test Center (RTC), PEO-Aviation, the Project Management Offices under PEO-Aviation and several other Army PEOs for many years assisting to solve issues in the areas of systems engineering and system design problems. Over the last six months, RSESC has been working with AED and SED on the on-going issue of how to verify and validate complex systems. One of the issues is moving from document-centric requirements to a mathematical model to verify and validate the requirements on complex systems. Presently there is not a way to predict the performance of complex systems all the way through to integration. Software and system design languages are loosely defined and therefore do not provide the precise definition needed for high fidelity simulation and quantitative modeling and formal methods. When considering analysis tools there is a limitation in their capability to work together; therefore problems are typically found after the systems are built. It is believed that an architectural context is needed to resolve this issue. By having a high-level specification tool or architecture to perform a virtual simulation or complete system analysis an end-to-end solution help to ensure system success before system integration and test.

Presently if semantics are incorrectly applied, developers no longer have a common understanding of the language for integration of architectural models, and must be experts in all domains where the model is expected to be used. Another option that is used is utilizing a custom language which leads to a need to define it well and document it well. Then upkeep and revalidation of assumptions becomes an issue each time models are integrated that have their own semantics or the entire model must be upgraded.

UAHuntsville
Rotorcraft Systems Engineering and Simulation Center

The purpose of this SERC effort :

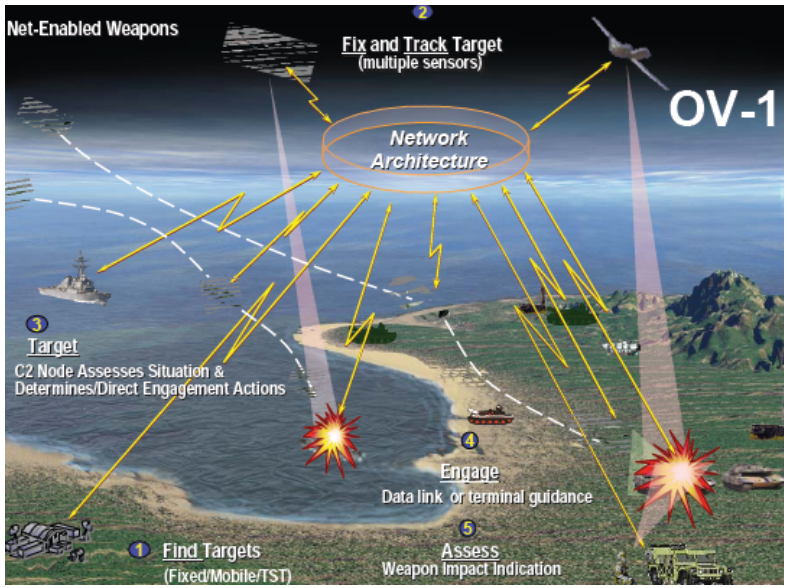
- **Focus on verification & validation (V&V) of complex systems**
- **Identification of existing useful tools**

Leverages experience working the government customers in the Army Aviation Directorate, Software Engineering Directorate, Redstone Test Center, and PEO-Aviation.

Will benefit from insights resulting from Systems Architecture Virtual Integration (SAVI), an international industry consortium involving Boeing, Airbus, Lockheed Martin, BAE, FAA, SEI, etc

SIMAF VV&A of a Live, Virtual, Constructive (LVC) Environment Use Case

(M&S PE Funded V-C-2)



Joint Command and Control Joint Control For Net--Enabled Weapons from 7 March 2007 Col Richard W. Leibach, USAF Director JT&E presentation

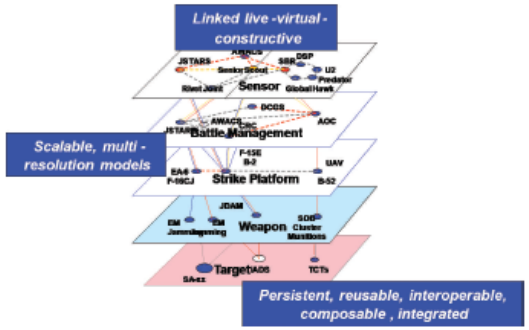


Figure 1. Representation of data flow in a virtual environment.

Tim Menke & W. Walter March, ITEA Journal 2009; 30: 469-472

Develop a Use Case for VV&A of a LVC Distributed Simulation Environment (DSE):

- **Document lessons learned from prior VV&A efforts related to LVC DSEs.**
- **Document applications of IEEE std 1516.4TM-2007; MIL-STD-3022 & Risk Based Approach for VV&A**
- **Consolidate documented best practices methodology for establishing acceptability criteria for DSE.**
- **Using the methodology; plan, conduct, & document a "use case" for VV&A of a LVC DSE.**
- **Insert another accredited simulation into the LVC DSE to re-verify, re-validate, & re-accredit the DSE.**
- **Recommend best practices for VV&A of a LVC DSE in a final report.**

Domain-relevant "Best of Breed" M&S Tool Suite VV&A NAVAIR Use Case

(M&S PE Funded V-C-2)

Multiple communities within the Department of Defense are interested in accelerating schedules, improving credibility, and reducing costs of technical execution of M&S support to decision-makers through tailored accreditation support

The scope of this effort was to:

- **Bring knowledge of existing VV&A "best practices" to funded implementation of credibility assessments of high-priority DoD M&S applications;**
- **Examine the practicality of leveraging Service-specific VV&A for domain-relevant Department-wide tool suite applications; and**
- **Identify Service-specific needs & estimate both cost-avoidance & incremental costs for plan to address.**

VV&A Program Management & Integration

(M&S PE Funded V-C-2)

ACQUISITION MODELING & SIMULATION WORKING GROUP

VERIFICATION, VALIDATION, AND ACCREDITATION SUBCOMMITTEE

TERMS OF REFERENCE

May 14, 2010

Purpose

These terms of reference describe the purpose and structure of the Verification, Validation, and Accreditation (VV&A) Subcommittee. The subcommittee is subordinate to the Acquisition M&S Working Group (AMSWG). The terms of reference document the subcommittee's scope, stakeholders, roles, responsibilities, and general administrative functions; and will remain valid until cancelled by the AMSWG.

Scope

Contributions from the VV&A Subcommittee will support Action 4-5 in the Acquisition M&S Master Plan (AMSMP) and Goal 3 of the M&S Steering Committee's Strategic Vision for DoD M&S.

- AMSMP Action 4-5
  - Foster cost-effective VV&A
- Strategic Vision for DoD M&S (Goal 3)
  - Provide management processes for models, simulations, and associated data that include practical guidelines for their VV&A

The VV&A Subcommittee will:

- Coordinate with the AMSWG Chairman on proposed responses to Congressional inquiries regarding VV&A of models, simulations, and associated data used in the acquisition process
- Be the Acquisition Community conduit for sharing VV&A information by:
  - providing a virtual VV&A brain trust for the Acquisition Community
  - responding to requests for VV&A information from Acquisition Community members
  - establishing web access to pertinent VV&A information relevant to the Acquisition Community
- Conduct periodic technical interchange meetings to:
  - promote the importance of VV&A
  - make VV&A information available
  - be the "go to" place where VV&A information is shared and exchanged
  - identify Acquisition Community members' VV&A needs and issues
- Help evolve the practice of VV&A by:
  - Reviewing and commenting on VV&A studies
  - Providing input to the review and update of VV&A policy and standards

Membership

Participation is voluntary. Membership will comprise government organizations engaged in VV&A activities (implementation, policy, guidance, standards, etc.).

The VV&A Subcommittee is a coalition of the willing.

Help evolve the practice of VV&A by:

- **Reviewing and commenting on VV&A studies**
- **Providing input to the review and update of VV&A policy and standards**

Supported by:

- **ITEA LVC Sub-committee**
- **"Gray Hair" Support to Key Activities**

Key Acquisition M&S Contact Information

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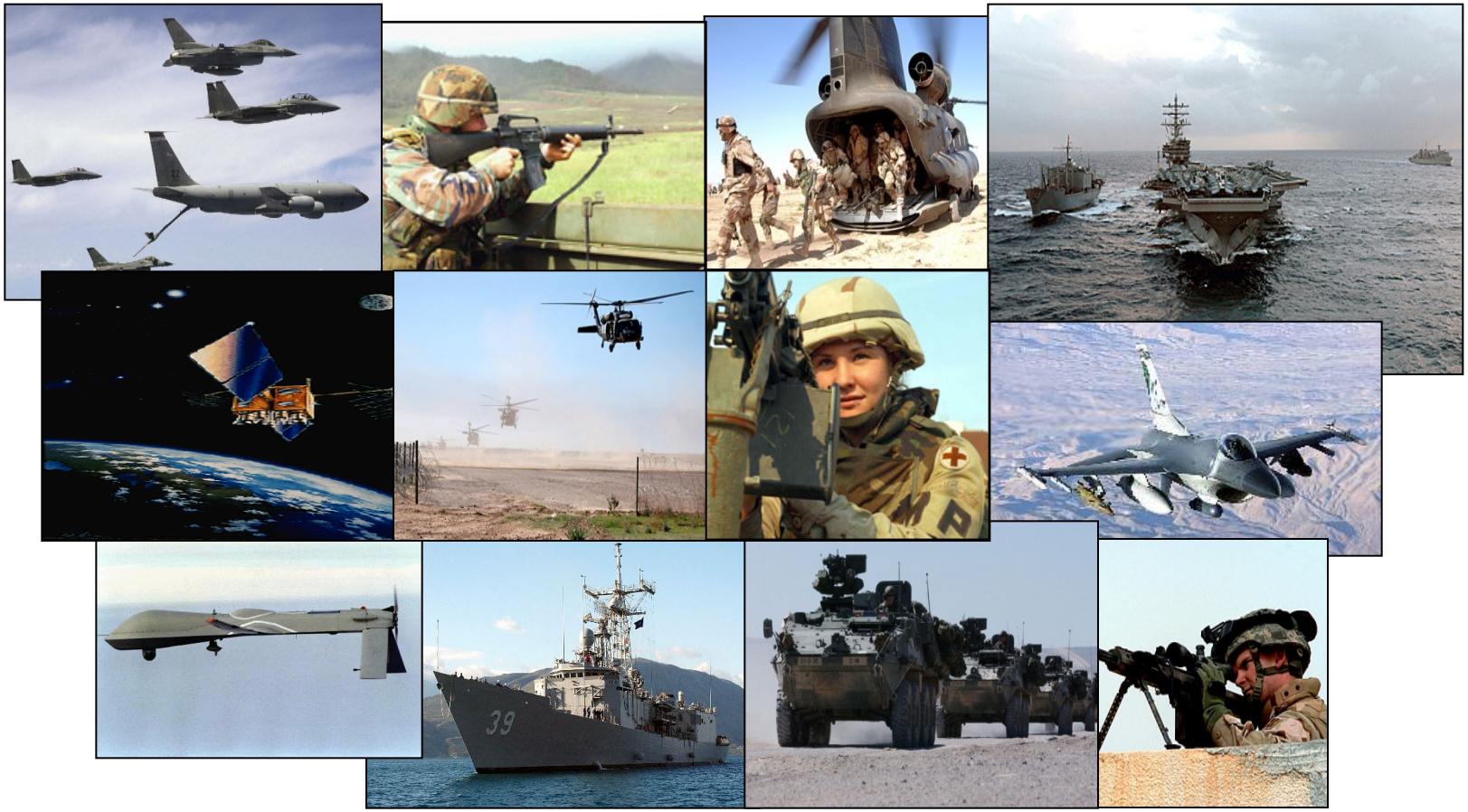
Systems Engineering: Critical to Program Success



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