

DoDAF Limitations and Enhancements for the Capability Test Methodology

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Abstract

The Joint Test and Evaluation Methodology (JTEM) joint test & evaluation (JT&E) program is currently developing an enterprise-level Capability Test Methodology (CTM) to deliver high quality joint capability assessments and evaluations across the acquisition life cycle. A key component of the JTEM program approach is the incorporation and refinement of CTM-related Department of Defense Architecture Framework (DoDAF) data models and representations to best support system of systems test evaluation at a joint mission level. To further mature the CTM before applying it to actual test event planning in 2007, the JTEM team has conducted a series of “rock drills”, or rehearsals, of each process within the overall methodology during 2006. One of the major process anomaly reports (PARs) coming from these rock drills highlights the need for joint mission system of systems (SoS)-level DoDAF products for test plan development. In order to enhance DoDAF’s ability to support capability assessments supporting joint missions, JTEM is developing executable product recommendations and extensions for DoDAF 1.5, as well as a capability evaluation metamodel (CEM) to provide DoDAF schema enhancements. These enhanced DoDAF products will better support the CTM’s evaluation approach incorporating measurement at system of systems, task, and mission performance levels.

1. INTRODUCTION

Innovative enterprise initiatives are currently occurring within the Department of Defense (DOD), which have the potential to enhance the effectiveness and efficiency of the

joint capabilities planning process. One initiative, focused on joint capability assessment and evaluation, is the Joint Test and Evaluation Methodology (JTEM) joint test & evaluation (JT&E) program. JTEM is currently developing an enterprise-level Capability Test Methodology (CTM) to deliver high quality joint capability assessments and evaluations across the acquisition life cycle. Another initiative is the evolution of the Department of Defense Architecture Framework (DoDAF). DoDAF version 1.0 is currently undergoing revisions to version 1.5, which is focused on providing guidance to begin representing net-centric architectural constructs within the DoDAF views and products. DOD is also discussing more significant architecture changes as part of a longer term development called DoDAF 2.0. The JTEM and DoDAF initiatives have supporting relationships to each other when considering assessment and evaluation challenges within the DOD joint capability planning process.

1.1. Joint Test and Evaluation Methodology Program Overview and Challenges

JTEM is a joint test and evaluation project tasked with developing and enhancing methods and processes (M&P) for system of systems testing in a joint mission environment. There are three specific test issues in the JTEM project. These test issues deal with assessing the effectiveness and suitability of the proposed M&P for designing and executing system of systems testing in a joint mission environment, as well as the M&P effectiveness for assessing performance pertaining to capabilities supporting joint missions. M&P development includes developing CTM processes as the foundation for deliverable templates, handbooks, and other best practice guidance for JTEM customers to execute the CTM. A key focus area within

CTM processes is the CTM evaluation thread, shown in Figure 1. Evaluation processes designated as critical challenges for JTEM are shown with a dark background. Pre-test evaluation processes include an evolution from a system of systems (SoS) capability test concept to test design where the test evaluation strategy and a joint operational context for the capability test are matured. Other critical challenges involve post-test capability evaluations involving SoS data analysis, SoS attribute and task performance assessments, and joint mission effectiveness evaluations.

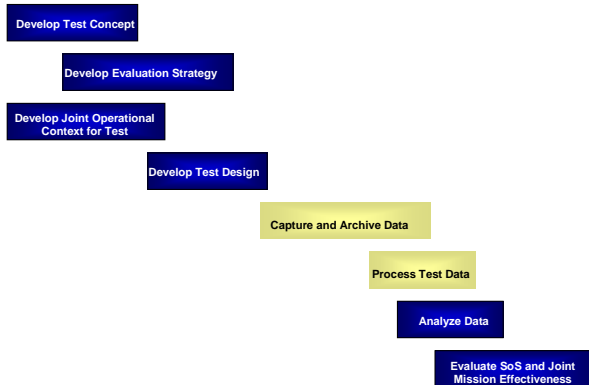


Figure 1. Capability Test Methodology (CTM) Evaluation Thread

1.2. DoDAF Relevance to JTEM

JTEM CTM developers are finding it essential to incorporate DoDAF products, as well as underlying DoDAF data classes and relationships, in the CTM ontology. In order to describe the joint operational context necessary for a capability system of systems test, operational and system descriptions are needed. DoDAF provides a structure to describe many essential aspects of this joint operational context for test, focused on a capability's task and information exchange requirements. This focus includes DoDAF products describing operational tasks, information exchange requirements (IER), system-level functionality, and system data interfaces. While providing part of the overall structure, there are limitations in DoDAF's ability to fully support the CTM's evaluation process thread, including the Joint Operational Context for Test.

2. DODAF LIMITATIONS RELATED TO JTEM GAPS, SEAMS, AND OVERLAPS

One of the JTEM M&P products that is improving the ability to conduct testing across the acquisition life cycle are the identification of gaps, seams, and overlaps related to testing in a joint environment. Process gaps are being documented and addressed in JTEM external process anomaly reports (PARs) that require policy, organizational, or resource application changes outside the scope of the test.

One of these PARs deals with modifications to DoDAF, where JTEM is working with the DoDAF community of interest and appropriate governance bodies to validate problems and identify possible solutions for DoDAF issues related to the CTM. To ensure proper analysis and implementation of DoDAF-related findings and recommendations, JTEM is: (a) identifying DoDAF limitations and causal dependencies for further M&P development, (b) performing operational assessment of the impact and likelihood of external DoDAF issues and recommended solutions, (c) validating DoDAF issues and formulating recommendations, and (d) vetting program-level findings and their recommendations through JTEM and DoDAF community of interest governance bodies.

2.1. JTEM Process Anomalies Concerning DoDAF

The JTEM "Modified DoDAF" PAR identifies limitations and potential enhancements to DoDAF products and supporting guidance. Individual DoDAF defined products are currently limited in their ability to describe essential CTM concepts including: system of systems means and ways across doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF); joint mission concepts; and measures at system of systems performance, task performance, and mission desired effect levels. The problem is not the wrong DoDAF products being identified in CTM templates, but deficiencies in various DoDAF products' effectiveness and suitability for CTM templates. These deficiencies have been identified through a series of events during JTEM's feasibility study and chartered program phases.

2.2. Traceability from Issue(s) to PAR

As JTEM transitions into its second year, the program has identified DoDAF-related issues in the current practice of conducting high quality joint capability test and evaluation through a variety of events. In a series of meetings in 2005, an M&P Working Group was formed, which identified issues in the following areas: describing and using a Joint Mission Environment (JME); JME program manager support; and acquisition program responsibilities. In August 2005, JTEM conducted a Multi-Service Distributed Event (MSDE) to help answer the following question: "What is the current ability of distributed Live, Virtual, and Constructive (LVC) assets to determine how well a number of test items support the accomplishment of joint tasks while also determining how well each item performs at the system level?" JTEM has also conducted four rock drills (May to October 2006) to further develop processes prior to the execution of full-scale tests. The rock drills focused on rehearsing and evaluating effectiveness and suitability for these specific phases of the CTM: (1) characterize test; (2) plan test; (3) implement the

live, virtual, constructive (LVC) distributed environment (DE), and (4) evaluate test.

During the above events, especially during JTEM rock drills, specific DoDAF-related issues were identified. DoDAF operational views (OVs) and system views (SVs) produced during events were focused at the engagement level, instead of at the capability mission level. Another critical deficiency was poor integration of test and evaluation (T&E) measures in relevant DoDAF products and the CTM test plan test matrix. DoDAF products were found to be useful for creating the CTM's Joint Mission Environment (JME), however a disconnect was noted between the DoD products and systems engineering methods. In particular, the participants stated that DoDAF views provide the customer valuable information for efficient and effective creation of a JME for test. However, model-driven DoDAF views need to be employed earlier in the process. Additional DoDAF products and compositions of products were identified as helpful in the creation of the Joint Operational Context for Test and the JME.

Gaps were also identified when comparing the CTM's evaluation business rule structure, called the Capability Evaluation Metamodel (CEM), and DoDAF's data model, called the Core Architecture Data Model (CADM), which can serve as an opportunity to provide enhancement recommendations for CADM to better support the CTM. CADM data model and business rule gap areas relevant to the CTM include; capability concepts from Joint Capabilities Integration and Development System (JCIDS) policy, joint mission concepts from the analytic agenda process, and measure definitions at the system of systems, task, and mission levels.

3. PROPOSED DODAF ENHANCEMENTS RELATED TO THE CTM

The evolution of DoDAF, including DoDAF 1.5 and DoDAF 2.0, offers the potential to address current limitations and potential enhancements concerning the DoDAF's ability to support joint capability test and evaluation. In order to explore this opportunity, an overview of DoDAF changes, the CTM ontology approach, and selected DoDAF enhancements related to the CTM ontology are now described.

3.1. Evolution towards DoDAF Versions 1.5 and 2.0

DoDAF 1.5, Volume 2, incorporates a net-centric framework whose architecture is integrated within a series of views: Operational Views (OV), Systems Views (SV), and a Technical Standards View (TV). These views include architecture products that are interrelated to each view and are further defined by the CADM.

The overall volume structure of DoDAF 1.5, Volume 2, describes DoDAF 1.5 framework products in order to assist in guiding managers, program managers, architects, and engineers with budgeting, product definition, acquisition, resource decisions, and decision support analysis. Proposed enhancements in DoDAF 1.5 are focused on providing guidance to begin representing net-centric architectural constructs within the DoDAF views and products. DOD architecture concepts are further described in sections organized by all-views, operational view, systems view, technical standards view, details of architecture data elements, and product relationships. Related DoDAF 1.5, volume 2 terminology is defined in appendixes B (Dictionary of Terms), C (Dictionary of UML Terms) and D (CADM Key Entity Definitions). [1]

During the DoDAF Working Group meeting held on November 6, 2006, it was recommended that DoDAF 1.5, volume 2 incorporate changes to include clarification of key terms such as service, capability, information and capabilities to maintain consistency with net-centric principles. In addition, it was recommended that DoDAF 1.5 volume 2 include: clarification on operational connectivity diagram (OV-2) mapping to system interface descriptions (SV-1), enhance product examples, include standardized UML definitions and guidance, and further clarify net-centric examples of DoDAF 1.5 products.

Substantive commentary provided by various participants of the DoDAF 1.5, Volume 2 working group incorporated overall themes of clarification of the scope for the audience and users of DoDAF 1.5, Volume 2, aligning and refining net-centric content, updating UML references, and further clarifying OV-1 through OV- 5 with relation to operating in a net-centric environment. At present, the way ahead for DoDAF 1.5, Volume 2 includes: streamlining content to support DoDAF 1.5 goals, and further refinement of the CADM to support an object model of CADM 1.02. Longer term DoDAF 2.0 requirements are currently in development, which could modify the type and composition of DoDAF products and underlying data models. Approaches for DoDAF 2.0 include the architecture specification model (ASM), activity based methodology (ABM) and guidance for the use of DoDAF in various analysis domains, such as T&E [2]. To compare to the evolution of DoDAF structures, an overview of the CTM ontology is now described.

3.2. The CTM Ontology Approach

In order to provide conceptual consistency and an underlying business rule structure for the CTM, JTEM is employing an ontology approach. An ontology can be defined as "an explicit formal specification of how to represent the objects, concepts and other entities that are

assumed to exist in some area of interest and the relationships that hold among them [3].” In keeping with this definition, the ontology supporting the CTM evaluation thread incorporates a JTEM lexicon and capability evaluation metamodel (CEM) to provide underlying conceptual definitions and relationships for the CTM. The JTEM lexicon is a cross-domain dictionary of CTM-relevant DOD terminology and definitions. Authoritative DOD sources are used, where possible, for JTEM terms and definitions. When modifications or additional terms are needed for the CTM, these are noted in the lexicon as proposed by JTEM, requiring feedback from JTEM to authoritative DOD lexicon sources.

The CEM provides a conceptual model to relate key CTM test and evaluation lexicon concepts, including capability, system of systems, mission, task, and various types of measures. Key concept hubs of the CEM are represented in Figure 2 as boldly outlined rounded rectangles. A central CEM concept hub is Joint Capability and it is expanded in Figure 2 to show its main relationships. Capability is defined in the DOD Joint Capabilities Integration and Development System (JCIDS) instruction as “the ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks” [4]. This definition is reflected in the CEM’s Joint Capability hub relationships. A Blue (Friendly) System of Systems (SoS) provides the means and ways for a Joint Capability to perform a set of Universal Joint Tasks. Such Universal Joint Tasks help accomplish Missions, whose Endstate is specified through Desired Effects. The JCIDS capability definition also mentions Conditions, which can be related as variables (e.g., environmental, disparate forces) affecting the performance of Universal Joint Tasks. Although not mentioned in the JCIDS capability definition, the concept of mission is important to relate Universal Joint Tasks to Desired Effects. Joint Capability hub relationships complete with Joint Capability being an ability to achieve Desired Effects. The Blue SoS identified in the Joint Capability hub is an instance of the System of Systems concept hub, which incorporates non-materiel and materiel aspects across the resource construct of doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF). The joint operational context for evaluating Mission Desired Effects is to be defined by a Test Scenario or Mission Thread and guided by authoritative sources from the DOD Analytic Agenda concept hub involving Defense Planning Scenario (DPS) and more detailed Multi-Service Force Deployment Document (MSFDD) descriptions. DOD also develops the Joint Operations Concepts (JOPsC) Family, including subordinate Joint Operating Concepts (JOC), supporting Joint Functional Concepts (JFC), and detailed Joint

Integrating Concepts (JIC) that amplify a portion of a JOC or JFC. JOPsC Family Concepts inform the development of Analytic Agenda products and guide joint task requirements of future Joint Capabilities.

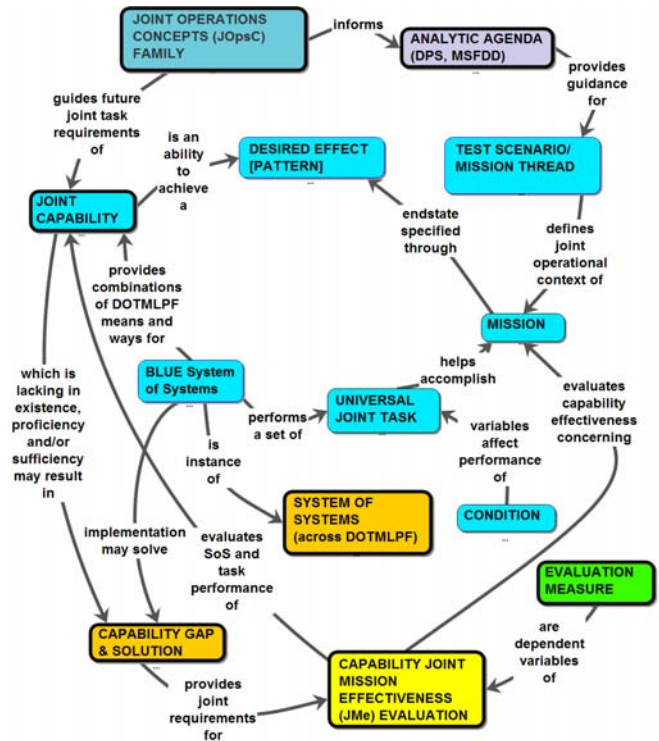


Figure 2. Capability Evaluation Metamodel (CEM) Concept Hubs

The JCIDS process is also reflected in the CEM Capability Gap and Solution concept hub, since a Joint Capability which is lacking in existence, proficiency, and/or sufficiency may result in a capability gap and corresponding solution approach. Application of one or more DOTMLPF-related resource changes of a Blue SoS may implement such capability solutions, which are joint requirements. Such SoS implementations need to be evaluated in terms of their ability to meet JCIDS and other joint mission requirements. All the previously described concept hubs in the CEM set the stage for defining the Capability Joint Mission Effectiveness (JMe) Evaluation concept hub, where evaluation measures are dependent response variables collected during a capability test. The CEM uses the Evaluation Measure concept hub to categorize measures into SoS attribute key performance parameters (KPPs), task measures of performance (MOPs), and mission-level measures of effectiveness (MOEs).

3.3. Selected DoDAF Lexicon Enhancements

In order to better use DoDAF structures in the CTM, JTEM is proposing T&E-related enhancements to future

DoDAF dictionaries and products, including the incorporation of cross-cutting DOD capability concepts, joint mission concepts, and capability evaluation measures from the JTEM lexicon and CEM. Such cross-DOD capability terms are essential for supporting critical DOD capability analysis, including joint capability portfolio analysis involving JCIDS, acquisition, and test and evaluation. CEM Joint Capability hub terms, such as Capability, Task, Conditions, and System of Systems need to be incorporated in DoDAF dictionaries and product representations. CEM Capability Gap and Solution hub terms such as Attribute, Capability Characteristic, Capability Gap, and Capability Increment can serve to further outline some of the critical elements that are necessary in defining joint capability requirements involved in the CTM's test processes and methodology.

DoDAF capability terms and relationships can be further enhanced and refined by including selected JOpsC Family and Analytic Agenda hub concepts from the CEM. JOpsC Family key characteristic terms, such as Adaptable/Tailorable, Agile, Enduring/Persistent, Expeditionary, Fast, Knowledge Empowered, Networked, Precise, and Resilient are necessary to relate joint force key characteristics to a capability's operational tasks and SoS functionality. Analytic Agenda hub concepts including: Scenario; Concept of Operations; Forces, Units, and Equipment; and Characteristics and Performance provide further structure for describing aspects of capability test scenarios and vignettes using DoDAF products.

Joint mission terminology contributes to the overall assessment of joint capability concepts and it is essential for DoDAF products to support mission descriptions of DOD system of systems for test and evaluation, experimentation and training analysis. JTEM is proposing to refine joint mission terminology in DoDAF data models and products, including purpose, task, and actions to be taken, as outlined in JP 1-02. Further mission-related refinements of DoDAF, using CEM concepts of Objective, End State, and Desired Effect are proposed so DoDAF products can help define test evaluation designs at the mission level.

CEM Evaluation Measure concepts involving SoS attribute key performance parameters (KPPs), task measures of performance (MOPs), and mission-level measures of effectiveness (MOEs) need to be incorporated in DoDAF to provide enhanced support for DOD system of systems test and evaluation. In order for DoDAF to show enhanced value to acquisition decision makers, operational and systems view products need to map to mission effectiveness, operational task and information exchange performance, and SoS attribute performance assessment structures. This mapping is difficult when using the current

DoDAF products and underlying data relationships. The addition of CEM evaluation measure concepts and relationships in CADM and the modification or addition of DoDAF evaluation views can address these limitations

3.4. Selected DoDAF Business Rule Enhancements

Based on JTEM's initial assessment, it appears that key high-level operational concepts and business rule relationships, necessary for DoDAF to support net-centric DOD SoS test & evaluation, experimentation and training analysis, are not included in the DoDAF 1.5, Volume 2 product descriptions. For example, DOD decision makers involved with JCIDS, joint test & evaluation, and other acquisition decision support are not getting the sufficient joint capability operational concept descriptions from current DoDAF products. It is JTEM's recommendation to: (1) include data classes involving Capability, Effect, Objective, End State, Task, System of Systems, DOTMLPF Resources, Mission Scenario concepts in the High-Level Operational Concept description in DoDAF, currently called an OV-1, and (2) incorporate the following data class relationships in the Business Rules for a Capability's OV-1. Examples of proposed OV-1 enhanced business rules are:

- Capability is provided through combinations of DOTMLPF means and ways called System of Systems
- System of Systems performs a set of Tasks
- Tasks are used to accomplish Mission
- Mission purpose is defined by Objective
- Objective achievement is defined by Endstate
- Endstate is defined by conditions called desired Effect
- Mission joint operational context is defined by Mission Scenario
- System of Systems operated or supported by Organization
- System of Systems actions guided by Doctrine
- System of Systems trained by Training
- System of Systems automation provided by Materiel
- System of Systems actions informed by Information
- System of Systems controlled by Leadership
- Education creates professional competencies for Personnel
- Training creates readiness competencies for Personnel
- Facility houses Materiel

The System Performance Parameters Matrix (SV-7) is the only DoDAF product that currently contains any effectiveness or performance evaluation descriptions. However, key mission level System of Systems attribute performance measures, task performance measures, and mission effectiveness measures are not adequately represented in this product. Key concepts and business rule relationships necessary for the SV-7 to support net-centric

DOD system of systems test & evaluation, experimentation, and training analysis have not been included in the proposed version of DoDAF 1.5, Volume 2. Joint test & evaluation and other acquisition decision support processes do not currently contain a rigorous set of mission-level capability measures from a DoDAF product, such as the SV-7. The SV-7 is not required as part of the JCIDS Capability Development Document (CDD), which is a critical input into developmental test and evaluation. JTEM's recommendation is to: (1) include data classes involving Key Performance Parameter, Measure of Performance, and Measure of Effectiveness concepts in the SV-7 and (2) incorporate data class relationships in the Business Rules for a Capability's Effectiveness and Performance Parameters description in DoDAF, currently called an SV-7. Examples of proposed SV-7 enhanced business rules are:

- Capability Evaluation Measure measures performance or mission effectiveness of a System of Systems
- Capability Evaluation Measure types are Key Performance Parameters, Measures of Performance, and Measures of Effectiveness
- Measure of Effectiveness assesses achievement of a Desired Effect
- Task specifies performance level of Standard, which provides feasible levels for a Measure of Performance
- Threshold Level provides feasible level for a Key Performance Parameter
- Capability means and ways called a System of Systems will be assessed by DOTMLPF performance attributes called Key Performance Parameters

4. CONCLUSION

In order to enhance DoDAF's ability to support capability test and evaluation supporting joint missions, JTEM is developing executable product recommendations and extensions for DoDAF 1.5, as well as a capability evaluation metamodel (CEM) to provide DoDAF schema enhancements. These enhanced DoDAF products will better support the CTM's evaluation approach incorporating measurement at system of systems, task, and mission performance levels. Proposed DoDAF ontology enhancements focus on underlying CADM data model classes and business rule relationships necessary for capability tests in a joint mission environment. Future DoDAF product compositions supporting the CTM's Joint Operational Context for Test descriptions and Capability Test Evaluation Designs have the potential to significantly enhance capability test and evaluation within the DOD joint capability planning process.

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Biography

Dr. David Dryer is the Lead Systems Engineer for the Joint Test and Evaluation Methodology Program and President of Visense Inc., a systems engineering consulting company. He received his B.S. from the United States Military Academy in 1980, M.S. in Operations Research from the Naval Postgraduate School in 1989, and Ph.D. in Industrial Engineering from the University of Central Florida in 1996. Dr. Dryer has over 19 years of combined industry and U.S. Army experience in systems engineering, modeling, simulation, and human-computer interaction specializing in simulation analysis, combat modeling, virtual environments and information visualization design. Other recent projects include; front-end enterprise architecture analysis for the Army Training Support System (TSS), and Joint National Training Capability (JNTC) advanced training technology certification development.

Tom Bock is a consultant and information technology professional, specializing in data management, systems analysis, business process design and implementation. He has over 15 years of experience working in multi-cultural, international business environments. Tom is employed by Scientific Research Corporation as a senior analyst working at Joint Test and Evaluation Methodology (JTEM). In this capacity, he analyzes actual and predictable interacting operational activities of military, governmental, or business systems to obtain a quantitative, rational basis for decision-making or resource allocation. He currently pursues his M.E. in Modeling and Simulation from Virginia Modeling Analysis and Simulation Center (VMASC) at Old Dominion University. His modeling and simulation interest is in distributed virtual simulation and networked multimedia

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Maria Broschi is a joint test and evaluation professional specializing in data management, and data media. She has over 15 years working within military and multi-cultural environments to include work with previous tests such as Joint Battle Damage Assessment (JBDA) and Joint Methodology to Assess C4ISR Architectures (JMACA). Maria is employed by Scientific Research Corporation as a data media librarian and is part of the data management team for *Joint Test and Evaluation Methodology*. She holds a B.S. in Human Services from Old Dominion University.

Mr. Timothy Beach is Chief, Methods and Process Development and Analysis Division for the Joint Test and Evaluation Methodology (JTEM) Joint Test and Evaluation program in Suffolk, VA. He is a graduate of the United States Naval Academy and holds a Master's degree from the University of Virginia in Systems Engineering. He is responsible for defining feasible, repeatable distributed range methods and processes for acquisition managers to enable effective system of systems testing in a realistic joint mission environment; and the evaluation of system contributions to joint mission effectiveness. After active duty assignments as a naval surface warfare officer, he worked as an engineer and scientist for NAVSEA Combat Direction Systems Activity Dam Neck and Joint Forces Command in Suffolk, VA.