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Mobility Capabilities and Requirements Study 2016 Accreditation Report

Volume I: Summary

Dr. Jack Jackson

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Addendum:
Accreditation Recommendation, 10 October 2009

Each of the MCRS-16 Scenario Working Groups have reviewed their scenario input and output data. Their data have been provided to the JDS registry and their Data V&V activity reports are available from OSD/CAPE/JDS. Accreditation criteria 5, 6, and 7 have been satisfactorily completed.

The CMARPS modeling and simulation (M&S) team has completed its VV&A report for MCRS-16. CMARPS continues to perform as advertised by its long accreditation history. The MCRS-16 director should recommend accreditation of this model for the uses of the MCRS-16.

The Transportation Command's M&S team modified the AMP federation and its models to accommodate the MCRS-2016 scenarios through the end of the study. Before completing its final runs, the M&S team completed sensitivity testing to ensure that their models remain valid. Test results are available by contacting Dr. Jay Marcotte, at TRANSCOM Headquarters, jay.marcotte.ctr@ustranscom.mil, 618-220-5141/5133.

With the completion of these items, the MCRS-16 decision maker can conclude that the mobility and logistics M&S and their associated data have successfully navigated a demanding and rigorous set of VV&A processes designed to ensure that they are useful for addressing the issues raised in MCRS-16.

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Preface

This paper was prepared under the task order "Analysis Community Verification, Validation and Accreditation Use Case (VV&A Use Case)." This task order is for work to be performed by the Institute for Defense Analyses (IDA) under Contract W91WAW-09-C-0003 for the Director, Program Analysis and Evaluation and the Modeling and Simulation Coordination Office (MSCO) Office of the Deputy Under Secretary of Defense (Science and Technology). The objective of this task order is to support the development, sufficiency review, and acceptance of an Analysis Community VV&A Use Case including a draft Department of Defense VV&A guideline for studies manual ready for Department-level review. This effort was performed in close concert with ongoing Department-level studies projected for completion in the Summer and Fall of 2009. This paper reviews the MCRS-16 study efforts to implement proposed DoD VV&A guidelines. The guidelines developed by this pilot effort will be used by other M&S Communities to develop their own VV&A guidelines.

The author would like to thank the IDA staff who reviewed this paper and thereby significantly improved the product: Dr. Stuart Starr, Dr. Thomas Allen, Dr. Geoff Koretsky, and Mr. Jim Kurtz.

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MCRS-16 Accreditation Report Summary

Executive Summary

The effort described in this document is part of a proof of concept application of a new set of Validation, Verification, and Accreditation (VV&A) guidelines for analytic models and simulations developed for OSD/CAPE by the Institute of Defense Analyses (IDA). The guidelines were developed in response to Government Accountability Office (GAO) reports indicating inadequate Department of Defense (DoD) policy guidance for VV&A.[1] In concert with CAPE and building upon extensive information available through subject matter experts, a set of eight accreditation criteria (see pages 5–6) based on the guidelines were developed and applied to the mobility/ logistics models and simulations used in the production of results for the Mobility Capabilities and Requirements Study 2016 (MCRS-16). The case study demonstrated the viability of the guidelines and, based on their implementation, suggests that when the accreditation criteria are completely satisfied, the mobility/logistics models and simulations should be accredited for use in the MCRS-16 study.

Introduction

The MCRS-16 study is a joint, collaborative interagency study to assess the Joint Deployment Distribution Enterprise (JDDE) in support of the National Security Strategy as executed in the 2016 time frame. MCRS-16 supports the US Department of Defense's (DoD) Analytic Agenda by providing mobility and sustainment analyses used in Analytic Baselines. The objective of the MCRS-16 Accreditation Plan (in Volume 2) is to certify that all Models and Simulations (M&S) employed in MCRS-16 are acceptable to support mobility analysis within the Analytic Agenda and National Security Strategy. Study organization, analytical methods, management, and oversight are discussed in detail in the MCRS-16 Terms of Reference and Study Plan, which will likely be released in 2010 as part of the MCRS-16 Final Report.

This Accreditation Report addresses the primary VV&A efforts used to provide a basis for accrediting the mobility models, simulations, and associated data used for the MCRS-16. It covers the Analysis of Mobility Platform (AMP) Federation (which includes the Model for Intertheater Deployment by Air and Sea [MIDAS], the Enhanced Logistics Intra-theater

[1] "Study Limitations Raise Questions about the Adequacy and Completeness of the Mobility Capabilities Study Report," US Government Accountability Office, GAO-06-938, September 2006; and "Issues Concerning Airlift and Tanker Programs," US Government Accountability Office, GAO-07-566T, 7 March 2007.

Suppot Tool [ELIST], and AMP-Port Analysis Tool (AMP-PAT)), the Integrated Computerized Deployment System ICODES, the Combined Mating and Ranging Planning System v.12.16.8 (CMARPS), and the Air Refueling Combat Employment Model v.1.0 (ARCEM). Though this document addresses all mobility models used to support MCRS-16, it does not cover the VV&A for combat models associated with Analytic Baselines supported by MCRS-16. Those models will be addressed separately by proponent organizations, specifically by the OSD/CAPE Simulation and Analysis Center (SAC) and the Joint Staff, J-8.

The models in MCRS-16 simulate air/land/sea deployment to theater; sustainment and employment within the theater area of operations (AOR); and air refueling operations en route and within the AOR (see Figure 1). Within the AOR, MCRS-16 uses a combination of mobility/logistics models and warfighting models to develop the requirements for combat operations. Effectively, the mobility models drop off the assets at Air Ports of Debarkation (APODs) and Sea Ports of Debarkation (SPODs) in theater. Units move into position for the warfight, while support material (e.g., food, water, petroleum, oil and lubricants, ammo, spare parts) are stockpiled at the APODs, SPODs, and Tactical Assembly Areas (TAAs)

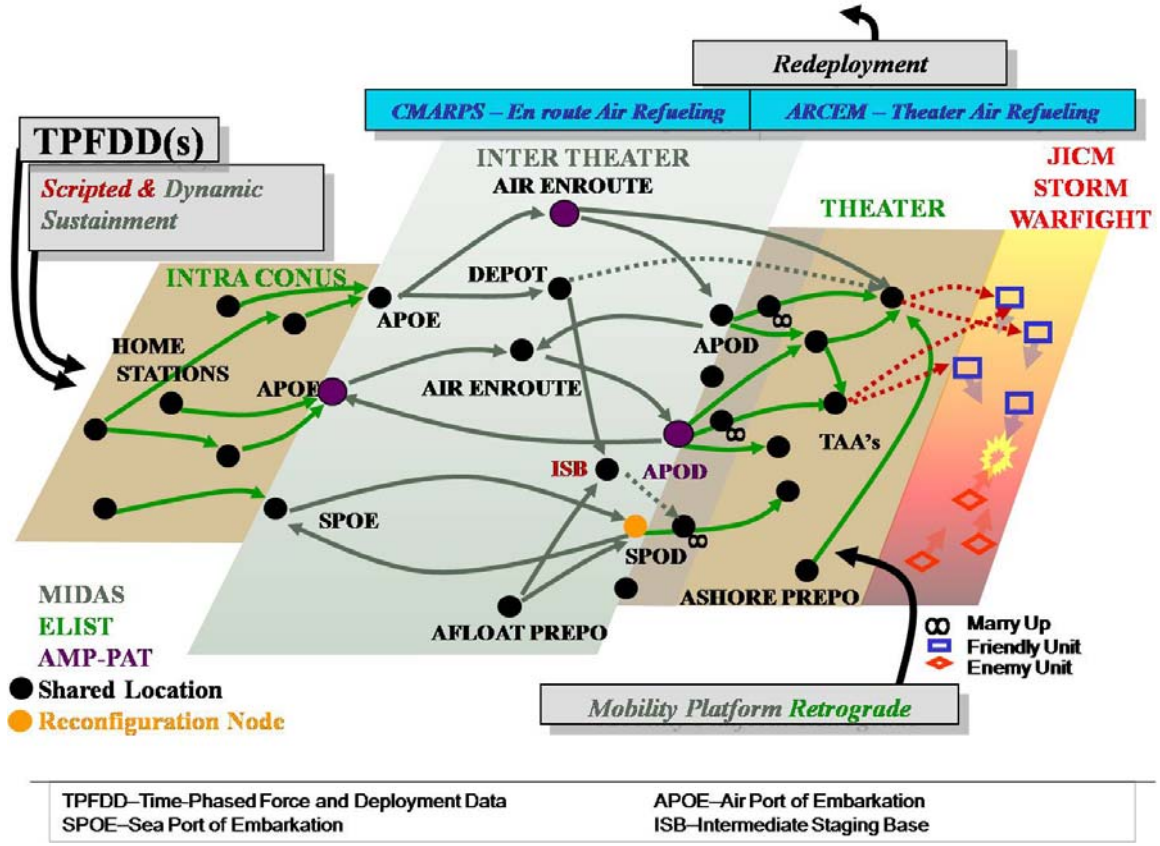

Figure 1. MCRS-16, Models and Simulation Overview

The AMP federation was used to track sustainment materiel by class and on-hand Days of Supply (DoS). AMP explicitly moved sustainment materiel to stock locations where they were consumed by local forces based on Logistics Factor Files (LFF) for the ongoing activity (e.g., attack, defense, patrol).

Because the *warfighting* models do not explicitly model the movement of logistics assets within theater, the warfighting models are run using the support materiel as necessary to support combat operations. The warfighting models assume perfect logistics and perfect command and control (C2). These assumptions mean that if the required materiel exists it is assumed to be moved to where it is needed just in time to be used. As these models run, an accounting is kept of the materiel used and where and when it is used. After the warfighting model runs are complete, the mobility/logistics models are re-run to ensure the JDDE system can meet the materiel distribution schedule.

This manner of connecting the mobility/logistics models to the warfight models has two problems that can be dealt with by the Study Director through sensitivity analysis. The first problem is the assumption of "perfect" C2. Because no operation ever attains perfect C2, the mobility/logistics models were run parametrically, ensuring an adequate buffer exists for less-than-perfect C2. This was handled in the analysis by examining the DoS available to combat and supporting units. The second problem has a similar solution. Note, that the preceding approach does not address Red attacks on Blue supply lines, which might interdict the movement of material or the stock of supplies on hand. Because no operation goes forward with zero losses, sensitivity analyses were performed in a similar parametric manner to examine the DoS needed to be maintained if specific percentage losses were assumed to be associated with Red activity.

Sensitivity analysis is an appropriate way to address previous objections to the novel approach connecting mobility and warfighting models and their outcomes used in MCRS-16 and in the predecessor MCS 2005 study.

VV&A Guidelines, the Accreditation Plan, and Accreditation Criteria

After an extensive review of the VV&A literature, interviews of over 100 key personnel from the military operations research community, and reviews of other large, campaign-level modeling and simulation efforts (principally MCS 2005, JAS, STORM, and JICM), guidelines was developed for the Resource Working Groups in MCRS-16. The guidelines were centered on basic steps that help demonstrate validity in a scientific context. They included:

1. Identifying the decisionmaker's issues and the M&S requirements to support addressing them.
2. Validating the conceptual model for each M&S.
3. Verifying that the software code for each M&S captures their conceptual model.
4. Verifying and validating that the data used in each M&S are the best available for the decisionmaker's purposes.
5. Validating the output from each M&S.
6. Identifying assumptions, limitations, and constraints for each M&S and assessing the risk associated with using each M&S to support the decision-maker.

The Resource Working Groups were briefed on those guidelines and the VV&A Working Group provided continual assistance as they worked to comply with the guidelines.

At the outset, the guidelines required the Resource Working Groups to perform a preliminary review of the modeling and simulation requirements for MCRS-16 and its Essential Elements of Analysis (EEAs). They ensured that their preliminary selection of M&S for possible use would support MCRS-16 objectives and EEAs. MCRS-16 had an ambitious timeline and set of objectives. Preliminary reports for each M&S were developed and reviewed to ensure each M&S could contribute to study objectives in a timely manner. The mobility M&S discussed here satisfied the preliminary review.

Based on the VV&A guidelines, an Accreditation Plan (included as Appendix A) was developed for MCRS-16, and all mobility/logistics M&S were subject to its requirements. As part of the Accreditation Plan, MCRS-16 personnel developed a set of accreditation criteria by which MCRS-16 M&S could be considered acceptable for use in MCRS-16; they included:

1. Suitability – The M&S is suitable to analyze the intended EEAs as identified in the MCRS-16 Study Plan. The simulations used were identified and included a description of the model and datasets including changes, updates, and upgrades. The Resource Working Group Leads explained any assumptions, limitations, or constraints.
2. Validated by Subject Matter Experts (SMEs) – The M&S and datasets were validated by SMEs for the intended use. SMEs reviewed logic, flow, decision trees, heuristics, and other diagrams as necessary to ensure the M&S and data fulfill a valid conceptual design and represent mobility assets and operations.

3. Verified by SMEs – The M&S and datasets were subjected to a sensitivity design of experiments based on EEAs. SMEs viewed the results to ensure the M&S responded to inputs and changes as expected. If results were not within expectations, SMEs and M&S proponents reassessed the capability for the M&S to address EEAs and provided recommendations to the Study Director.

4. Stable within Operating Environment – The M&S were confirmed to be stable within the operating domain of the study and did not require excessive artificial adjustments to successfully represent the MCRS-16 environments identified in the scenarios analyzed by the assigned EEAs.

5. Best Available Data – The M&S will use the best available data validated and accredit-ted by Study participants. All data shall be provided to the Joint Data Support with their accreditation pedigrees and appropriate meta-data to enable repeatability and review.

6. Valid within Scenario Environment – The appropriate Scenario Working Group Leads will review the M&S output to ensure the M&S have properly incorporated all condi-tions, data changes, environmental considerations, and other factors that would affect results and subsequent analyses.

7. Repeatable – The M&S will be repeatable by any authorized organization (this means an authorized organization will be able to obtain the exact version of the M&S and its associated data and reproduce the same Scenario results, ostensibly as a starting point for their own analytical purposes). All data and conditions of operations will be documented to enable independent operations. All modeling record runs will be archived with the appropriate versions of the model's executable code.

8. Valid Federation or Confederation – All M&S including federations will be examined holistically to ensure simulation and dataset interactions are understood relative to analytical considerations. Each element of the federation and/or confederation as well as the whole must be accredited to meet the standards described above.

Based on the Accreditation Plan, the Resource Working Groups and their M&S teams developed their own V&V plans and proceeded to V&V their M&S and data. Their V&V reports and Accreditation reports discuss at length how each satisfied the eight criteria above. Current copies of the V&V and Accreditation reports (in most cases drafts) accompany this report on a separate CD.

One model, ICODES, was judged to have already demonstrated a VV&A history that satisfied the OSD VV&A guidelines. Consequently, ICODES was judged to be accredited for

the MCRS-16 study. The documentation demonstrating their adequacy is included on the separate CD.

Reviews

MCRS-16 incorporated an extensive review process, including:

- A General Officer Executive Committee (EXCOM) and General Officer steering committee (GOSC) have met several times to review the MCRS-16 results and monitor the study progress.
- Council of Colonels and Captains (O-6) Board Review. Approximately 50 military and civilian personnel from across DoD conducted regular progress reviews of the study. These progress reviews considered the results each working group produced (e.g., Resources, Log CONOPS, Scenarios) throughout the study. Reviews at this level were extensive. Issues were consistently raised and dealt with; for a detailed examination of their extent contact Mr. Steve Ross of OSD/CAPE/JDS for his notes of these meetings. In particular, they reviewed the results from each Scenario Working Group and the outcomes of the Internal Review Boards for each simulation undergoing the VV&A processes.
- Internal Review Boards. The VV&A Working Group conducted internal reviews of each of the mobility simulations used in the study. Experts were drawn from outside the Resource Working Groups to review the VV&A efforts and the M&S efforts of the Resource Working Groups. Preliminary M&S reports, M&S documentation, configuration management plans, draft V&V reports, and draft Accreditation reports were reviewed by members of this body.
- The reviews covered a range of issues including M&S conceptual models, algorithms, datasets, input data, output results, sensitivity analyses, parameter settings, logistics, concepts of operations and how they were modeled, M&S limitations, M&S constraints, and M&S assumptions.
- Each M&S was reviewed until the entire set of board members was satisfied that all their questions were answered satisfactorily, then the M&S was deemed to have satisfactorily completed the Internal Review. These reviews were conducted during a period of four months and encompassed five days of questions and answers. The members of these internal reviews included:
    - Dr. Jack Jackson, Institute for Defense Analyses, campaign analysis and combat modeling expert

- CDR Phil Pournelle, OSD/PA&E, campaign analysis modeling and maritime transportation expert
- Dr. Geoff Koretsky, Institute for Defense Analyses, mobility modeling expert
- Ms. Cherie Emerson, HQ/US Army, ground transportation expert
- Mr. David Lyle, HQ/Transportation Command, maritime transportation expert
- LTC Ty Prevett, Air Force/A9, air mobility and air refueling modeling and air transportation expert
- Mr. Ray Miller, Air Force/A9C, logistics modeling expert
- Maj Elizabeth Hanson, Air Force/A9, air mobility modeling and transportation expert
- In addition, many of the reviews were attended by Mr. Dave Merrill, Air Force/AMC/A9 and Col Jean Mahan, Deputy MCRS-16 Study Director.

- Scenario Working Group reviews. The input data for each scenario were reviewed by each individual Scenario Working Group in conjunction with functional working groups as appropriate. For example, the CONOPS Working Groups reviewed the concept of operations for each Scenario Working Group. Working group membership was selected to be inclusive of each Service when appropriate. As results were produced from each model, the Scenario Working Groups reviewed and validated them. Anomalies were brought to the attention of the Study Director who along with his Council of Colonels assessed the model adequacy or the requirement for further sensitivity analysis.
- Resource Working Group (M&S Team) Evaluations. Each M&S analyst team was responsible for verifying and validating their particular simulation (including their conceptual models, configuration management plans, computer software, and simulation results). Each team had to submit VV&A documentation to the VV&A Working Group and Study Director for review before an accreditation recommendation. Within this documentation each M&S team identified any M&S assumptions, limitations, and constraints that could affect MCRS-16. Each team produced products to support the Working Group reviews, the Internal Review Boards, and the O-6 Council Review.

Each of the M&S completed the Internal Review Boards required by the VV&A Working Group. Each of the M&S has successfully negotiated the hurdles with each succeeding review. Though no known problems exist with completion, not all of the reviews are complete. In particular, as the study time frame has been extended, not all of the Scenarios Working Groups have completed their output data reviews. Because these reviews are not complete, the M&S and their data have also not yet been deposited into the Joint Data System (JDS) registry.

Extensive reviews have been conducted of the MCRS-16 mobility M&S, their associated data, and their output results. Members of the Internal Review Board are unanimous in recommending that the mobility/logistics M&S be accredited for MCRS-16.

Risk Assessment

Included as a classified Volume 2 of this report are the current draft V&V and Accreditation reports for each M&S used in the MCRS-16 study. Within those reports, readers will find listed each M&S's assumptions, limitations and any constraints on their usage. Each M&S's Accreditation report also contains a risk assessment made based on usage in MCRS-16.

A few additional comments deserve mentioning:

- Several of the models are in daily operational use by current operational planners. ICODES is used worldwide to manage and load maritime cargo. CMARPS has been in use since the early 1990s to plan daily air refueling missions and allocate scarce tanker assets to operational requirements. Both were accredited for their usage outside this study; ICODES by the Lloyd's Registry of London, United Kingdom, and CMARPS by AF/AMC/A9 for use in several previous tanker studies. In 2007, both the United States Government Accounting Office and the USAF Inspector General cited CMARPS for consistent VV&A practices during the Air Force KC-X study. Both models daily produce results that are measured and judged against actual results in the field.
- The other air refueling model used in MCRS-16, ARCEM, is regularly run against CMARPS using similar simulated conditions. Though not done for all scenarios and situations within the MCRS-16, ARCEM has consistently compared favorably and regularly matches CMARPS results.
- ARCEM and the AMP federation, as well as the set of underlying models (AMP-PAT, MIDAS, and ELIST) which compose the federation, were stress-tested to examine the maximum deviations from operational accuracy that might be expected through use of the mobility/logistics models. The expected accuracy consistently falls within 1–2% for key MCRS-16 metrics.

New OSD VV&A Guidelines will include a risk assessment scale based on the work of Clemence and Hartley, *et al.*[2] The risk assessment scale seeks to measure the risk associated within the conceptual model and data validation and ranges from zero to five:

[2] From Table 1, *VV&A Final Report for PMESII Models*, by Evidenced Based Research Inc., July 2007.

5 – expresses fully validated theory, e.g., Newtonian physics

4 – expresses well-researched theory with considerable data checks and peer review, e.g., published in textbooks

3 – expresses theory supported by data and peer reviewed literature, e.g., published in refereed journals

2 – expresses theory and data with rational basis accepted by SMEs as plausible, vetted in open forums, conferences, etc.

1 – expresses codified theory

0 – uncodified theory with mental model of uncertain consistency and completeness

Campaign-level models typically expect to be assessed between levels 0 and 2 on this scale. In fact, some M&S used in MCRS-16 meet a higher standard on this scale. ICODES and CMARPS would rate a 4 on this scale because they are in daily operational and war planning use and express well-researched theory with considerable data checks and peer review. For MCRS-16, the M&S team using ARCEM completely rescrubbed all internal data with USAF/AMC/ Stan Eval. AMC/Stan Eval are the USAF air-refueling data experts; their certifycation of the ARCEM data is contained in the ARCEM V&V and Accreditation Reports. ARCEM is often compared with CMARPS and would score only slightly below CMARPS. The AMP federation and its sub-models rate a risk assessment of 2, as they represent rational theory and data. Their theory, data, and results are regularly vetted in open forums and conferences.

Accreditation Recommendation

Each of the MCRS-16 mobility/logistics models has a documented conceptual model and an active configuration management plan. Each mobility model has satisfied the eight accreditation criteria, with the exception that a few of the Scenario Working Groups have not completed their Scenario reviews of output data; their data have not been provide to JDS registry, and therefore has not been posted to the JDS website. Consequently, accreditation criteria 5, 6, and 7 have not yet been satisfied. They should be completed with dispatch as the study is completed.

Draft V&V reports have been prepared and reviewed for each of the mobility/logistics models. Draft Accreditation reports have been prepared for the AMP federation, ICODES, and ARCEM. Each of the draft reports has been reviewed and minor comments provided to the authors.

CMARPS has a long VV&A history and though no Accreditation Report has been produced yet, no problems are expected by their modeling and simulation team in completing their activities and reports in a timely manner with the MCRS-16 study completion.

The Transportation Command M&S team has continued to modify the AMP federation and its models to accommodate the MCRS-16 scenarios. They expect when final scenario results are produced that they will include complete sensitivity testing to ensure their models remain valid. They will then complete the final V&V and Accreditation reports for the MCRS-16 Study Director review.

With completion of the items above, the MCRS-16 decision-maker can conclude that the mobility and logistics M&S and their associated data have completed a demanding and rigorous set of VV&A processes designed to ensure the M&S and their data are useful for addressing the issues raised in the MCRS study.

With the completion and review of the items mentioned above, the Study Director should recommend the MCRS-16 mobility models and their associated data be accredited by the Study Sponsor, the Deputy Secretary of Defense.

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14. ABSTRACT

The effort described in this document is part of a proof of concept application of a new set of Validation, Verification, and Accreditation (VV&A) guidelines for analytic models and simulations developed for OSD/CAPE by the Institute of Defense Analyses. In concert with CAPE and building upon extensive information available through subject matter experts and the military, a set of eight criteria were developed and applied to all mobility and logistics models used in the production of results for the Mobility Capabilities and Requirements Study 2016. The study demonstrated the viability of the guidelines and, based on their implementation, suggests that when the final elements are completed, the models and simulations should be accredited for use in this study. There is a classified Volume 2 to this paper containing supporting documentation.

15. SUBJECT TERMS

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