Department of the Army
Pamphlet 5-11

Management

Verification, Validation, and Accreditation of Army Models and Simulations

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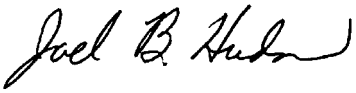
Verification, Validation, and Accreditation of Army Models and Simulations

By Order of the Secretary of the Army:

ERIC K. SHINSEKI
General, United States Army
Chief of Staff

Official:



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Secretary of the Army

History. This printing publishes a revision of this publication. Because the publication has been extensively revised, the changed portions have not been highlighted.

Summary. This pamphlet updates procedures for the Army Model and Simulation Management Program. It also provides new guidance for compliance with the High-Level Architecture (HLA) and revised instructions for the development, execution, and reporting of all verification, validation and accreditation activities.

Applicability. This pamphlet applies to the Active Army, the Army National Guard and the United States Army Reserves. It applies to models and simulations that are used within the Army. It does not include models and simulations embedded in weapons systems.

Proponent and exception authority. The proponent of this pamphlet is the Office of the Deputy Under Secretary of the Army for Operations Research ((DUSA(OR)). The DUSA(OR) has the authority to approve exceptions to this pamphlet that are consistent with controlling law and regulation. The DUSA(OR) may delegate this approval, in writing, to a division chief within the proponent agency in the grade of colonel or the civilian equivalent.

Suggested improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (recommended Changes to Publications and Blank Forms) or on DA Form 2028-E, if they are transmitted electronically, directly to HQDA (DAMO-ZS), Washington, DC 20310-0450.

Distribution. This publication is available in electronic media only and is intended for command levels C and D for the Active Army, the Army National Guard, and the U.S. Army Reserve.

* This pamphlet supersedes DA Pam 5-11, 15 October 1993.

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Summary of Change

DA Pam 5-11
Verification, Validation, and Accreditation of Army Models and Simulations

This revision–

- Designates Army Models and Simulations (M&S) fall under three mission activity domains: Training, Exercises, and Military Operations (TEMO); Research, Development, and Acquisition (RDA), and Advanced Concepts and Requirements (ACR) (para 1-4).
- Modifies data Verification, Validation, & Certification (VV&C) to data V&V and Accreditation (para 2-5 a.).
- Modifies the M&S life-cycle management to accurately represent what happens including model VV&A and data V&V and Accreditation (para 2-2).
- Incorporates Knowledge Acquisition and Knowledge Engineering in the M&S life cycle (paras 2-2 a(6) and (7)).
- Incorporates the Army M&S Standards Development Process (para 2-7).
- Incorporates guidance for the High-Level Architecture (HLA) for federates and federations (para 5-3).
- Incorporates M&S Resource Repository (MSRR) (para 6-6).
- Revises how data is used and managed in M&S (para 6-6).
- Identifies the Authoritative Data Source (ADS) Library as the location for DoD data sources (para 6-5).
- Identifies the Army Standards Repository System (ASTARS) as the location for data standards (para 6-7).

Chapter 1
Introduction

1-1. Purpose
This pamphlet gives procedures for the "Management of Army Models and Simulations" (AR 5-11). The objective of this pamphlet is to assist the models and simulations (M&S) developer, proponent, and application sponsor in conforming to the verification, validation, and accreditation (VV&A) policies prescribed in AR 5-11. This pamphlet also provides guidance for the development, execution, and reporting of all VV&A activities. This pamphlet also addresses data V&V and accreditation in reference to proper M&S use.

1-2. References
Required and related publications and prescribed and referenced forms are listed in appendix A.

1-3. Explanation of abbreviations and terms
Abbreviations and special terms used in this pamphlet are explained in the glossary.

1-4. Army M&S covered by AR 5-11
AR 5-11, paragraphs 1-4, 3-1, 3-2, 3-3, 5-1a, and the glossary, specify which Army M&S fall under the policies of AR 5-11. Specifically, M&S that are used in any of the three domains of mission activity: Training, Exercises, and Military Operation (TEMO), Advanced Concepts and Requirements (ACR), and Research, Development, and Acquisition (RDA) are to be responsive to the provisions of AR 5-11. Table 1-1 lists some sample activities and examples of M&S for each domain. Included are M&S that produce input for use by another M&S whose results are then used by Army decisionmakers. M&S that are developed and/or used by contractors or federally funded research and development centers (FFRDC) in support of Army activities must also comply with the policies of AR 5-11. Finally, simulators, semi-automated forces (SAFOR), and M&S that operate under the High-Level Architecture (HLA) are likewise included in this grouping, with the Army M&S proponent being ultimately responsible for conducting the corresponding V&V activities that are discussed in this pamphlet.

Table 1-1
Army model and simulation domains with sample activities.

Domain	Domain Activities	Simulations/Simulators
Training, Exercises and Military Operations (TEMO)	Individual and Collective Training Army Exercises Joint and Combined Exercises Mission Rehearsal Operations Planning	System Simulators Training M&S
Advanced Concepts and Requirements (ACR)	Force Design Operational Requirements Warfighting Experiments	Re-configurable Simulators Constructive M&S
Research, Development and Acquisition (RDA)	Basic Applied Research Weapons System Development Test and Evaluation	System Prototypes Engineering and Physics M&S Real Time Casualty Assessment (RTCA)

Chapter 2
Overview of VV&A

2-1. Introduction to VV&A

a. For introductory purposes, formal definitions of verification, validation, and accreditation are encapsulated as follows:

(1) Verification is the process of determining that an M&S accurately represents the developer's conceptual description and specifications. Verification evaluates the extent to which the M&S have been developed using sound and established software-engineering techniques.

(2) Validation is the process of determining the extent to that an M&S is an accurate representation of the real world from the perspective of the intended use of the M&S. Validation methods include expert consensus, comparison with historical results, comparison with test data, peer review, and independent review.

(3) Accreditation is the official determination that a model, simulation, or federation of M&S is acceptable for use for a specific purpose.

b. The term M&S, which is defined as Model(s) and Simulation(s), will refer to both its singular and plural use throughout this document.

c. During the life cycle of the M&S, teams of technical personnel, subject-matter experts (SME), and potential M&S application sponsors should work together to accurately assess the strengths and limitations of M&S and its data as they pertain to the M&S' intended use. One key aspect of VV&A is that it should be conducted in a cooperative atmosphere.

d. M&S are sometimes composed of several pieces of stand-alone software, such as input data preprocessor(s), the M&S itself, output data postprocessor(s) and interfaces. V&V must be performed on each software piece. This collection of software pieces as an M&S must then be verified and validated to ensure that the overall system produces the intended results when the individual pieces are correctly interfaced together. Likewise, Army M&S that are federates in an HLA federation must be individually verified and validated by the Army M&S proponent. The fully configured HLA federation must also be verified and validated (V&V' d) by a designated V&V proponent before being accredited by the M&S application sponsor to ensure the interfacing of the various components of the federation is correct, meaningful, and complete. If the Army is the HLA federation M&S application sponsor, then the Army should designate the V&V proponent.

2-2. VV&A in the life cycle of M&S

The generic life cycle approach to M&S VV&A activities are similar to the life cycle management (LCM) procedures for software in automated data processing systems. These systems are under Department of Defense (DoD) Directive DoDD-8120.1 and DoD Verification, Validation, and Accreditation Recommended Practices Guide. It must be recognized that V&V should be an integral part of the M&S development process. Too often, the V&V and accreditation processes are considered as separate functions from development and documentation of the M&S and its data. The V&V plans and process should begin on the first day of development and continue in such a manner that the same documentation used for requirements, design, development and configuration control also serves to support V&V activities. A well-documented V&V process will greatly assist in the accreditation performed on the M&S and its data for a specific use. Details on data V&V as part of accreditation are discussed in chapter 6, Data Use in M&S.

a. Figure 2-1 shows the typical life cycle of an M&S. Figure 2-2 integrates V&V and accreditation activities into the M&S life cycle from figure 2-1. The details of these figures are described below:

(1) *Define problem, determine requirements, and determine approach.* Once a problem has been identified and defined with preliminary criteria, its solution may be fulfilled by one of four approaches: the use of non-M&S methods, use of an available M&S as-is, modification of an existing M&S, or the creation of a new M&S. If a non-M&S method is selected, the results are documented and recorded in the Army M&S Resource Repository (MSRR). Otherwise, M&S requirements are determined by the M&S proponent in cooperation with the intended application sponsor and documented for its intended use complete with scope, features of the M&S and the data needed. Once the requirements are finalized the Army MSRR is queried for M&S that meet those requirements. A plan is developed to determine the M&S approach, which includes the specific methods and measures that will be used to evaluate its success. The Accreditation Acceptability Criteria are developed for determining when those M&S selected are acceptable for this application. Some critical factors in selecting an M&S are its associated costs, assumptions, limitations, releasibility, and V&V and accreditation history and status.

(2) *Use an M&S meeting requirements.* If an M&S meeting most of the requirements exists then it will be modified for that specific use. If no M&S exists then a new M&S will be created. When any of the M&S methods are selected, VV&A will be incorporated throughout the life cycle.

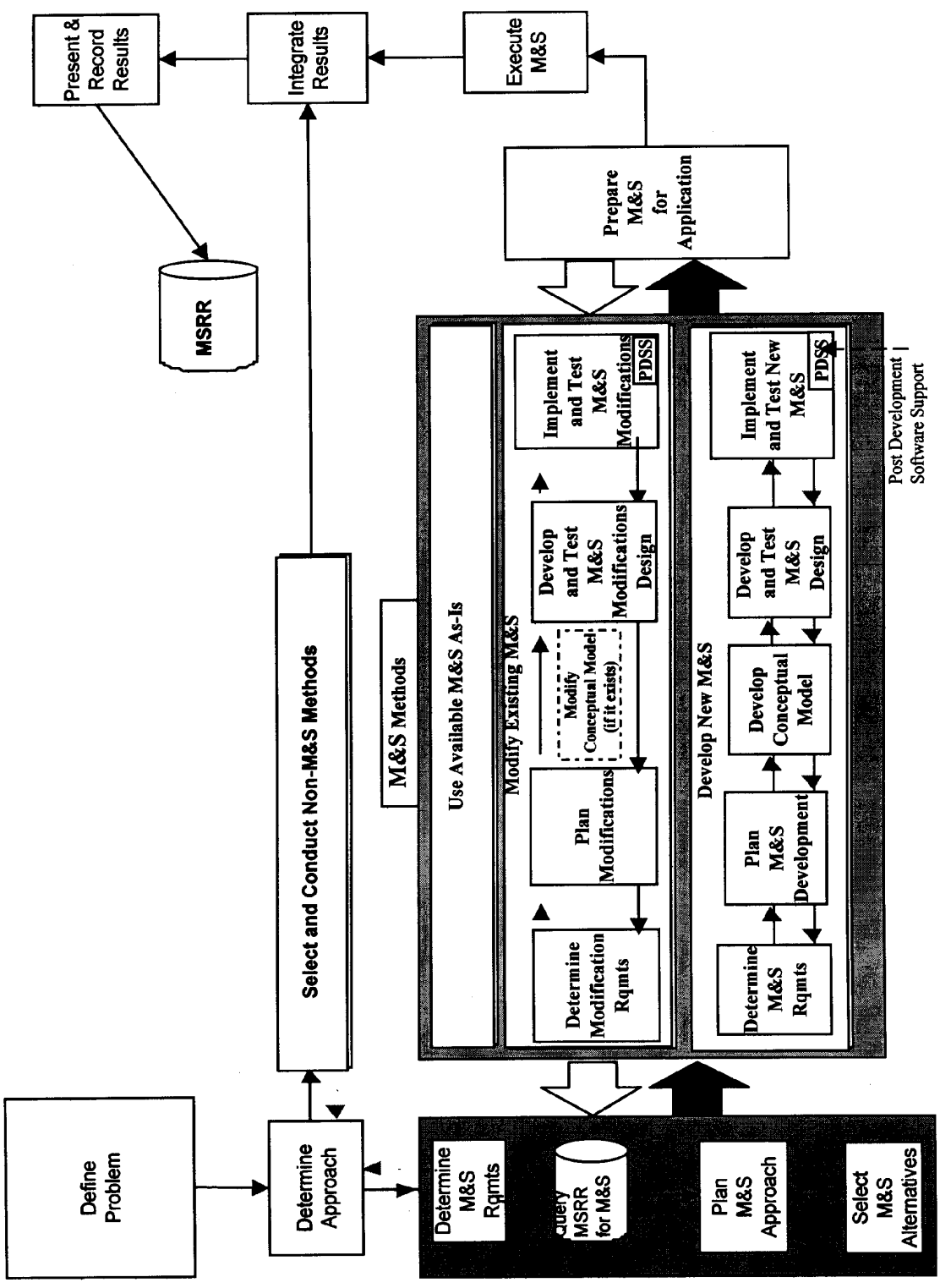

Figure 2-1. Army M&S Development Life-Cycle

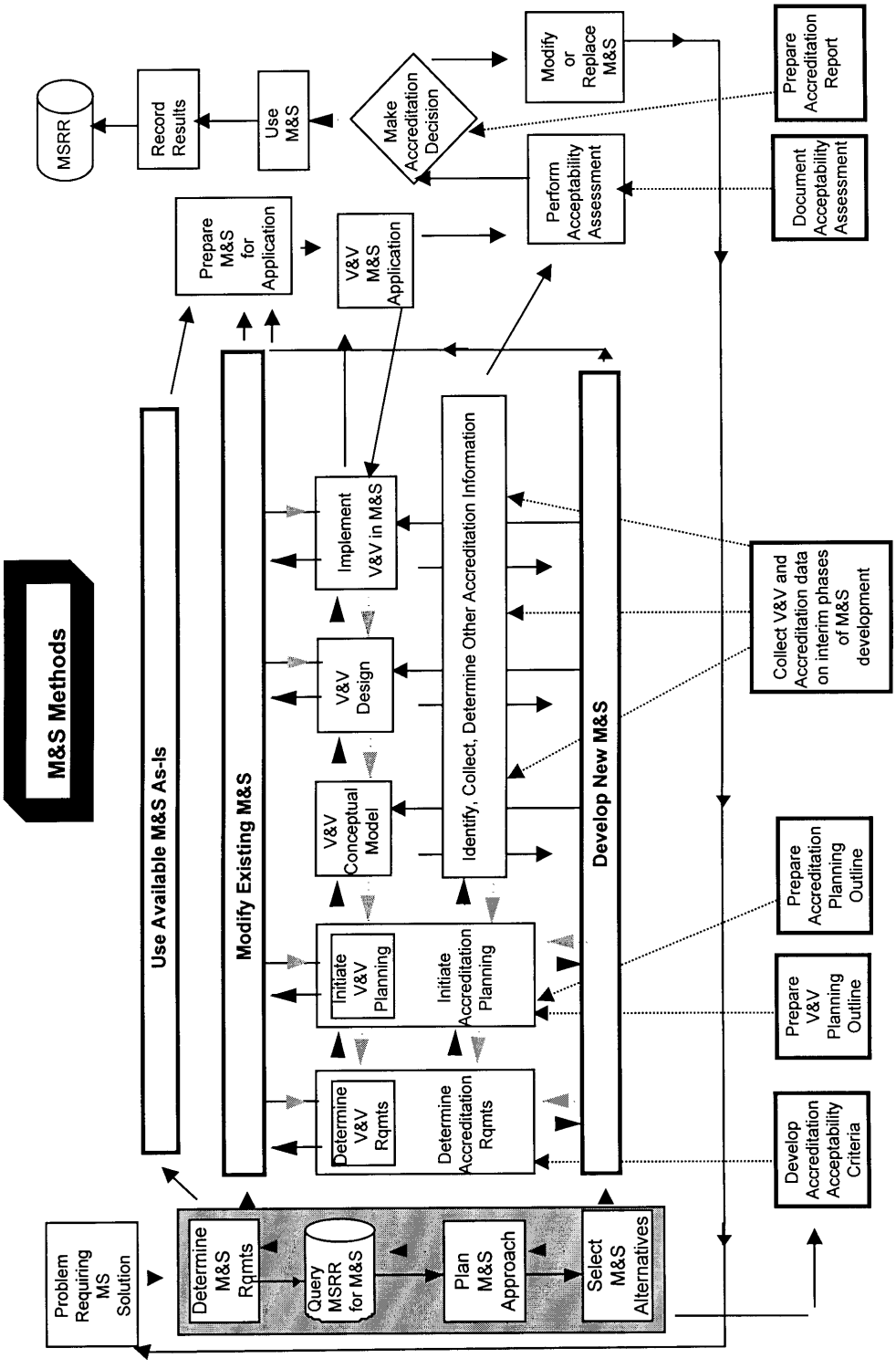

Figure 2-2. Typical Army M&S Life Cycle Incorporating VV&A

(3) *Use available M&S as-is.* If the M&S as-is option was selected, it will be V&V'd prior to executing the M&S. V&V evidence from the previous applications will be accumulated to serve as basis for the accreditation. Data V&V will receive the bulk of the attention.

(4) *Modify existing M&S and develop new M&S.* If modifying existing M&S is selected the steps to follow are determine modification requirements, plan modifications, modify conceptual model (if it exists), develop and test M&S modifications design, implement and test M&S modifications and last, post "development" software support (PDSS). However, if an M&S is not identified which meets the requirements then a new M&S is created. The steps to follow when developing a new M&S are; determine M&S requirements, plan M&S development, develop conceptual model, develop and test M&S design, implement and test new M&S and last, PDSS. The following phases apply to either "modify an existing M&S" or "develop a new M&S" as appropriate.

(5) *M&S requirements and planning phases.* New requirements are recorded in a formal document such as an Operational Requirements Document for large complex M&S or an M&S Requirements Document (MSRD) as described in TRADOC PAM 71-9. The development of these requirements is the responsibility of the M&S developer in conjunction with the user. The M&S proponent is responsible for reviewing the requirements to ensure their adequacy. Once the user's requirements are approved through TRADOC PAM 71-9, the development process moves into the planning phase. The developer and the proponent (representing the user) defines the M&S through its parameters and identifies associated resources, schedules and performance criteria necessary for development of the new M&S dictated by the requirements. The performance criteria is refined further to encompass measures of effectiveness (MOEs) and measures of performance (MOPs), scenarios, definitions, fidelity, human interfaces, real time vs. non-real time, interoperability with other M&S and connection with real world Command, Control, Communications, Computers and Intelligence (C4I) systems. The requirements are then broken down into pieces that can be modeled. This leads to the development of the conceptual model.

(6) *Develop or modify Conceptual Model Phase.* This phase serves as a bridge between the defined requirements and the M&S design, providing the M&S developer's interpretation of the requirements to which the M&S will be constructed. The conceptual model is a set of assumptions, limitations, algorithms, equations and preliminary listing of elements with possible connections to one another within the M&S related to the M&S' intended application. Developing the conceptual model is an iterative process, allowing the conceptual developer to communicate with data producers, intended data users and subject matter experts (SMEs). This process is called knowledge acquisition (KA), information to ensure proper representation of the real world. The knowledge gained bridges the gap between the M&S developer, the intended users and the SME. KA assists with the transition of the conceptual model into the design phase, which is the logical representation of the M&S. KA helps to prevent major inadequacies prior to the design and implementation phases. KA supports the V&V of the M&S' equations and algorithms that will be used, the limitations and constraints used, the assumptions made and the anticipated outcome. The availability of appropriate and

accredited input data for the new or revised conceptual model is also addressed. Once the conceptual model meets the requirements, the modified or new M&S is ready for the next phase.

(7) *Develop and test M&S Design Phase.* This phase is the M&S developer's blueprint and prototyping phase for the M&S. At this time Knowledge Engineering (KE) occurs between the M&S developer and the programmer and if necessary, the SME as they design the M&S' blueprint, based on the conceptual model. KE is the process of accurately coding the equations, algorithms, assumptions, limitations, constraints and procedures. During testing or prototyping, verification occurs through checking the M&S' functionality, information flow, ordering of processes, as well as the data's accessibility and executability. Testing must be performed on individual modules in detail before inclusion into the M&S system. This is known as functional decomposition (see 3-3f(3)). Prototyping is an iterative process that speeds up the completion of the development process and enables the user to have early input into the adequacy and fidelity of the emerging M&S product. This is extremely important in helping to determine if there are any modifications required for the M&S and/or data prior to module integration and final implementation.

(8) *Implement and test M&S Phase.* This phase may begin sometime during or immediately after the develop and test M&S design phase and requires the M&S application sponsor to participate in a very active role throughout the entire process. Upon completion of all modules, integration testing of the M&S system as a whole is necessary. Corrections are made as errors are found. Once the implementation of the software design is completed in code for the modified or new M&S, the resultant M&S is formally reviewed by the M&S developer. Following a successful V&V of the M&S software and hardware design, it is finally prepared for application by ensuring that the appropriate platforms are being used and that operators and humans-in-the-loop are properly trained. Additionally, during the V&V process of the M&S, V&V of the data will also be occurring. This execution of the M&S is an iterative process that will continue until the M&S and data meets their intended use.

(9) *Post "Development" Software Support (PDSS) Phase.* This phase, PDSS, takes the place of the more traditional post deployment or post production software support, since an M&S is typically not "deployed" in the same sense as a tactical system. Additionally, the only M&S that requires a "production phase" is a simulator, which has similar delivery requirements as a system. PDSS can be contractor-supported, government organic, or the responsibility of the M&S proponent. In addition to the documentation discussed in paragraph 2-3 below, PDSS requires a transition plan describing how the M&S will be maintained, controlled, and upgraded for its useful life. It also discusses the software engineering environment used to develop the M&S and how much of it will accompany the product into PDSS. The PDSS facility must maintain complete records on the organizations that request and ultimately use the M&S, including version numbers, applications and archival historical data received from the users. Thus, the profile about the various uses of the M&S will continue to build, improving the long-term validation and overall quality of the product. This data is collected, disseminated, and maintained.

(10) *Record M&S and data.* After an M&S is accredited, unclassified VV&A information on the M&S and its data must be recorded into the Army Model and Simulation Resource Repository (MSRR) according to appendix C.

b. There is no single step-by-step checklist of tasks or events or a single method of V&V that will apply for every M&S as it goes through its LCM. VV&A emphasis and methods used will vary depending on the particular phase and the maturity of the M&S and resources available. Both verification and validation efforts are required as the M&S is applied to new and different applications throughout the life cycle. Documenting the M&S development and configuration management (CM) of M&S activities is essential throughout the life cycle. Figure 2-3 emphasizes the reinforcing nature of documentation and CM to the VV&A process. Documentation is discussed in paragraph 2-3 and CM is discussed in paragraph 2-4.

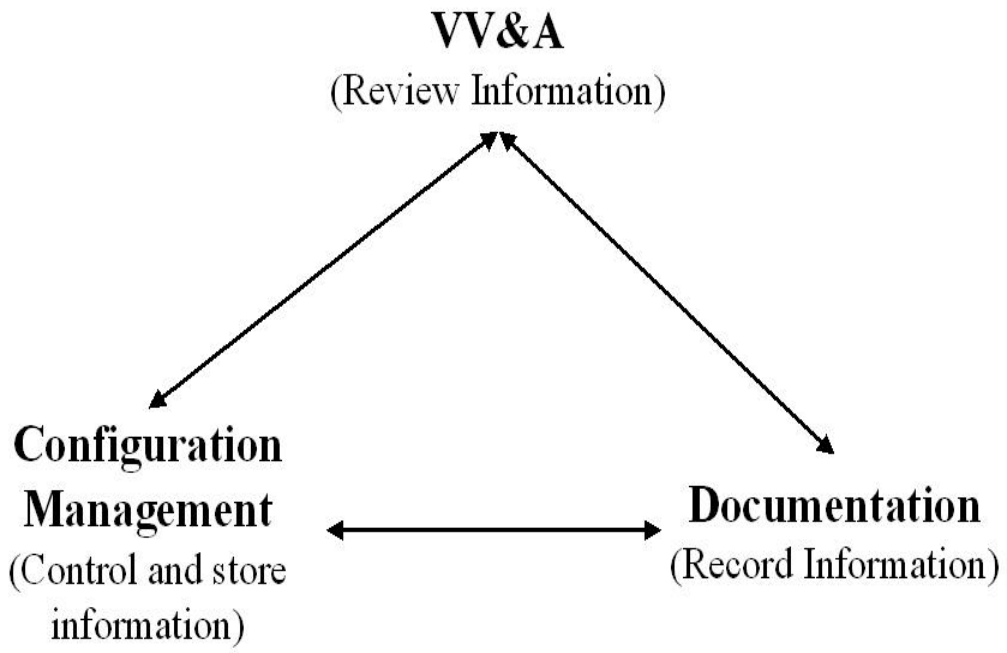

Figure 2-3. Interaction Between Major Management Tasks

2-3. M&S documentation in VV&A

Documentation is required throughout the life cycle of the M&S and is critical to successful VV&A activities. CM of the documentation provides a historical record that enables traceability, which is critical in understanding the M&S' original intended use based on initial assumptions, limitations and capability. Appendix D gives an overview of the types of M&S documentation that are essential to the VV&A process. As VV&A activities are conducted, it is crucial to fully document those activities and the associated findings. This will greatly aid future users, application sponsors, and maintainers of the M&S. VV&A activities must be documented and recorded in the Army MSRR (See appendix C for entries). Figure 2-4 shows the relationship of typical M&S documents to the life cycle of the M&S and its data with VV&A incorporated.

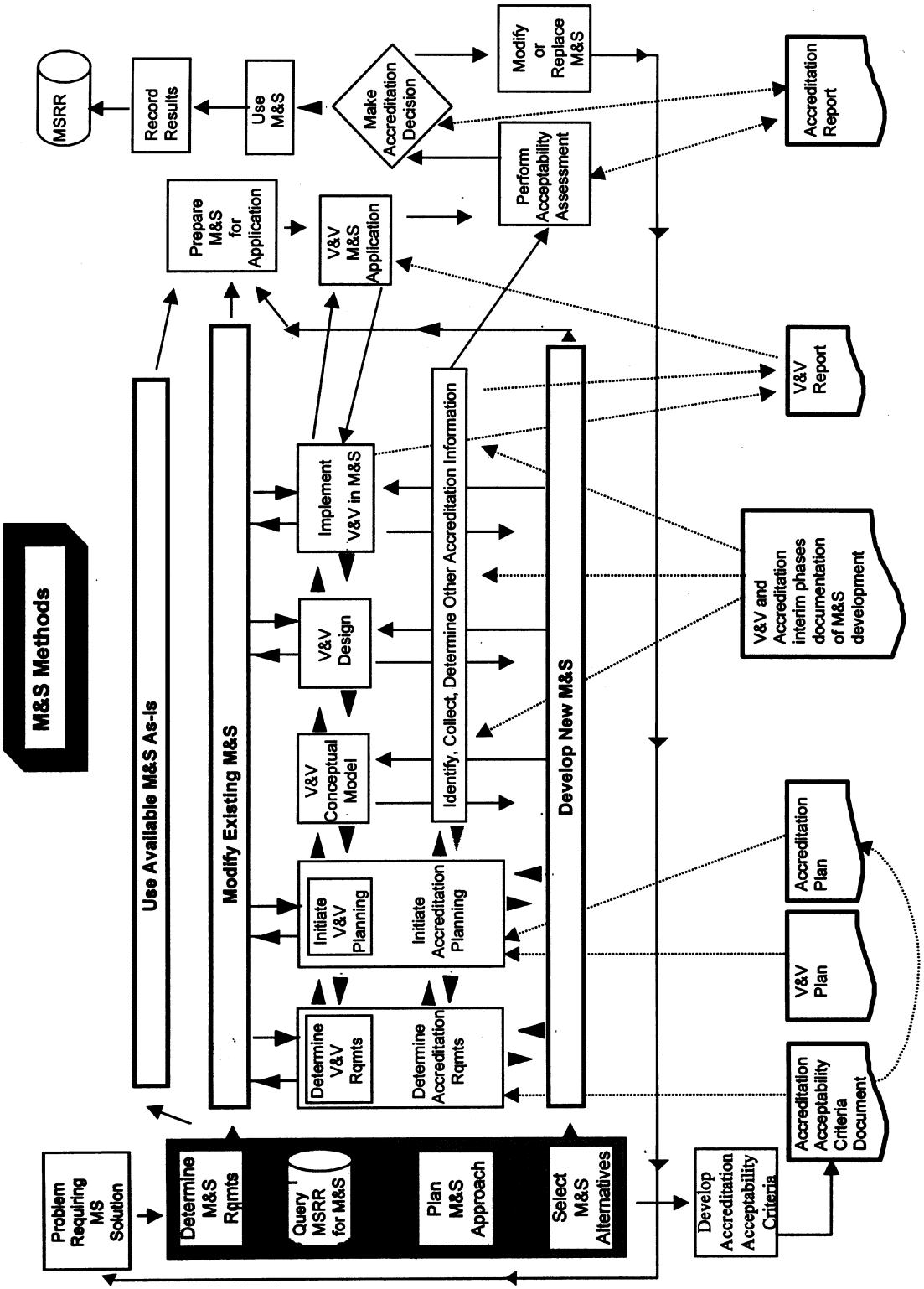

Figure 2-4. Documentation in the Army M&S Life-Cycle

2-4. Configuration Management

a. Although not always recognized as such, CM is an integral part of the VV&A process. CM is the meticulous control of an M&S' code, documentation, change history, and usage (see app E). Good CM precludes unauthorized modifications to the reference version of the M&S, which could invalidate previous VV&A efforts. In addition to being a quality control mechanism, the CM process documents significant events in the life cycle of an M&S, thus providing a consistent audit trail from the current state of the M&S back to the original requirements.

b. The goals of CM are–

(1) Ensure integrity of the code by version control management.

(2) Record the history of the M&S by archiving code and documentation changes as well as change requests and documented usage of the M&S.

(3) Provide a means by which M&S users and application sponsors can input to the M&S enhancement process.

c. To facilitate reaching these goals, the CM focuses on four areas of activity:

(1) Configuration identification. Selecting documents that identify and define the baseline configuration characteristics of the M&S.

(2) Configuration control. Controlling changes to the baseline configuration and its identification documents.

(3) Configuration status accounting. Recording and reporting changes to the baseline configuration and its identification documents.

(4) Configuration audit. Checking copies of the M&S in use for compliance with the baseline configuration.

2-5. VV&A functions

a. VV&A ongoing processes. VV&A activities are ongoing processes throughout the life cycle of the M&S and its data. Resources required to perform VV&A will be identified in Command Operating Budget (COB) submissions of M&S developers, users, and VV&A proponents as a part of the resource requirements for M&S development, application, data generation and maintenance. AR 5-11 directs that the M&S proponent is responsible for V&V. A Verification, Validation and Certification (VV&C) Tiger Team was formed in late 1997 under the auspices of the Defense Model and Simulation Office (DMSO) VV&A Technical Working Group. The VV&C Tiger Team report states there is a distinction between the data producer V&V activities and data V&V activities that will be conducted in conjunction with the M&S V&V activities. Data producer V&V equates to data quality, which is discussed in more detail in Chapter 6-4 c. Additionally, templates are available in appendix K. Data user V&V activities are an integral part of the M&S V&V and accreditation. Both M&S and data V&V activities are complementary, interdependent upon each other and are ultimately the responsibility of the M&S V&V agent. Execution responsibility of M&S V&V may be delegated to a verification agent and a validation agent separately, or to one V&V agent serving both verification and validation functions. Often the M&S developer performs the duties of the verification agent of the M&S and assists the validation agent or the M&S proponent during validation. The M&S application sponsor is responsible for the accreditation of the M&S with help from the M&S proponent or designated V&V agent. Table 2-1 summarizes the general responsibilities of the various parties in the VV&A process. Paragraph 2-5 b describes V&V activities, which lead toward accrediting the M&S and its data.

b. VV&A activities. The M&S V&V agent and M&S Accreditation agent will accomplish specific activities and collect supporting data (as appropriate) at each stage of the M&S life cycle as outlined in the following paragraphs and shown in figure 2-2. The documentation for the VV&A process is shown in figure 2-4.

(1) *VV&A activities associated with M&S requirements.* The VV&A activities associated with the determine M&S requirements, determine approach, planning M&S approach, develop acceptability criteria, and using available M&S as is phases are discussed in paragraphs 2-2a(1)-(3).

(2) *Modify existing M&S and develop new M&S.* M&S that will be modified/developed shall be V&V'd with its data in accordance with the phases listed below. Once the M&S and its data have been approved for this intended use then the M&S and its data will be accredited for this intended use.

(3) *Determine Accreditation Requirements and determine V&V Requirements.* Both the accreditation requirements and V&V requirements are initiated concurrently. The accreditation process begins with determining accreditation requirements, based on the acceptability criteria developed. As a starting point, sample high-level acceptability criteria are provided in figure 4-1. The accreditation requirements include the V&V requirements as well as other additional M&S characteristics needed which are vital to the support of the accreditation of the M&S. V&V requirements will determine the level of effort for the V&V process and techniques that will be used. Key M&S functions will be derived from the acceptability criteria and then prioritized in order of importance to the application. The V&V status of each M&S function will be reviewed based on whether the V&V was performed, its quality and findings. If the V&V performed are sufficient for this application, no further V&V is required. However, if no V&V were performed or the V&V accomplished were insufficient for this application, then a V&V requirement will be generated. The M&S characteristics which are most critical in the decision of M&S accreditation are M&S development and historical use; operational environment requirements; configuration management status; status of documentation; the known capabilities and limitations of the M&S; and the supporting databases. Information such as the V&V agent, number of hours required, hardware and software needed, and an estimate of the overall costs will be identified.

(4) *Initiate V&V Planning and initiate Accreditation Planning.* V&V and accreditation activities are initiated concurrently and both will be documented as the respective V&V and Accreditation plans. The V&V Plan is focused on identifying the tasks required that match and complement the M&S Development plan for modification or development, requirements, resources, constraints, data and timelines. There may be formal guidance related to cost and schedule which places constraints on the V&V of the M&S and its data, operational capability, accreditation efforts and identification of the appropriate evaluation techniques and measures. Initially, the plan developed is a draft and serves as a working document that evolves with the application. When new information is available or changes occur, the plans are reviewed and updated as appropriate. This evolving plan serves as input to the V&V report, the Acceptability Assessment and the Accreditation report, which are discussed later. (Please see para 3-4 for description of the V&V plan and the V&V report.) The Accreditation plan will discuss how the accreditation re-

quirements and the Accreditation Acceptability Criteria can be satisfied (Please see para 4-4 for a description of the Accreditation Plan and the Accreditation Report.)

(5) *V&V Conceptual Model.* During the conceptual model phase, the intended algorithms, equations, limitations, assumptions and methodologies are reviewed and documented. Additionally, the sources of data, along with its accessibility, assumptions, limitations, fidelity and interoperability are reviewed and documented. The M&S proponent, assisted by the intended application sponsor, has the responsibility to ensure the correctness, consistency, completeness, adequacy, and balance of the M&S conceptual model and M&S design. Verification that the M&S in the conceptual model phase meet the specifications is important as it helps to ensure accurate incorporation. As an M&S is refined and V&V'd so are its data, since they are dependent upon each other.

(6) *V&V design.* In this phase, V&V of the M&S design maintains consistency, traceability and integrity with the conceptual model phase. Specific V&V design techniques are logical verification and structural validation, which are discussed in paragraphs 3-2b(1) and 3-3a(1) respectively. Other V&V design activities are reflected in the DoD VV&A Recommended Practices Guide.

(7) *Implement V&V in M&S.* The M&S' design and data are again verified and validated in the implement and test (modification or new) M&S phase. Verification that the M&S code meets the specifications and design are performed and documented by the verification agent. The testing performed in this phase establishes the baseline set of data to be used whenever the code is changed. Validation that this M&S is an accurate representation of the real world from the perspective of the intended use of the M&S and its data is the responsibility of the validation agent. The M&S validation agent and intended user work together to select and perform the necessary methods to test the M&S and its data and prepare the required validation documentation. See chapter 3 for various V&V techniques. The V&V conducted in this phase may be an iterative process based on the modifications needed to properly code the M&S and for data to meet the intended use of this specific application. Whenever M&S and its data are adjusted during the development and test phase then these adjustments and new baseline set of data must be verified and validated. These V&V checks are crucial and lend consistency towards accreditation of the M&S and its data.

(8) *Identify, collect, and determine other accreditation information.* All the VV&A efforts conducted and findings identified during the V&V conceptual model, V&V design and the implement V&V M&S phases will be collected and documented in an interim V&V document. This information will serve as input for the acceptability assessment and V&V report.

(9) *V&V M&S for application.* Once the M&S have been prepared and ready for execution, the application context needs to be V&V'd. This includes such housekeeping tasks as ensuring that the appropriate platforms are being used and that operators and humans-in-the-loop are properly trained.

(10) *Perform Acceptability Assessment.* This step reviews the information collected during the V&V assessment of the M&S for use in the intended application. This is the final step before deciding to accredit and use the M&S for the intended application. Data supporting the acceptability assessment includes the M&S application requirements compared to the M&S capabilities and limitations; M&S development and historical use; M&S operating requirements and costs; implications of the M&S' limitations and constraints for use in this application; description of the degree of satisfaction for which the Accreditation Acceptability Criteria were met; and recommendations for changes.

(11) *Make accreditation decision.* The decision to accredit or not to accredit an M&S and its data is based on the findings of the acceptability assessment and other information and considerations (see paragraph 4-3a(3)). The findings are documented in the Accreditation report. If the decision is not to accredit, the process may begin again with modification of the selected M&S, a different M&S or a non-M&S method. Otherwise, the M&S with its data will be accredited prior to execution followed by integrating the results and recording the M&S and its data in the MSRR.

c. Accreditation functions. Accreditation is a management responsibility of the application sponsor, assisted by the M&S proponent or designated V&V agent. The application sponsor may designate an accreditation agent to conduct an accreditation assessment for that specific application. Often the accreditation agent establishes an accreditation team consisting of SMEs and intended users to assist in performing the accreditation. The accreditation agent serving as the user surrogate defines the acceptability criteria and the accreditation agent reviews the configuration management procedures, M&S documentation, and the V&V findings that will be used to make the determination on accreditation. These items become a part of the accreditation plan, which is the responsibility of the M&S application sponsor with the advice and assistance of the M&S proponent. The M&S proponent further assists the M&S application sponsor by making available all data and information needed to make an accreditation determination. All information considered in the accreditation process must be documented in the accreditation report; this report is the responsibility of the M&S application sponsor and is produced with the assistance of the M&S proponent.

2-6 M&S Development Paradigms

The M&S life cycle in paragraph 2.2 is generic in nature. Please note, that the development of new M&S is based on requirements (specifically the ORD, MSRD and Simulation Support Plan (SSP)) established by the user/customer as described in TRADOC PAM 71-9. Actual development cycle paradigms have evolved over time and new ones will continue to evolve. Some sample cycles are discussed below:

a. Waterfall development cycle. The traditional method of developing a new M&S has been the “waterfall” approach. This progressed from the early days of automation when hardware comprised the major portion of development costs. The waterfall method is highly structured and is relatively inflexible since it is tied to a series of discrete developmental phases, each of which must be completed before starting the next phase. Additionally, user involvement has usually been limited until the final completion of each phase, which for complex M&S resulted in outdated functionality, unsatisfied users, and exceedingly long development times. The waterfall approach is often used when M&S development is outsourced to contractors.

b. Spiral development cycle. Technology has shifted functionality from hardware to software solutions and has resulted in higher software development and maintenance costs coupled with higher risk in meeting cost, performance, and schedule. The "spiral" development cycle does not usually start with fully fleshed out, approved requirements. Rather, preliminary requirements may be sufficient to begin an evolutionary M&S build. Cost-As-An-Independent-Variable (CAIV) techniques will be used as a governing factor to scale requirements in each spiral. The aspects of the system, which are the most understood can serve as a baseline and then be enhanced by the involvement of users and experimentation. The spiral development cycle is characterized by an iterative "build-a-little, test-a-little" philosophy that provides continuous partial advancements with user review and involvement through the use of prototypes. The spiral development cycle is shown in figure 2-5.

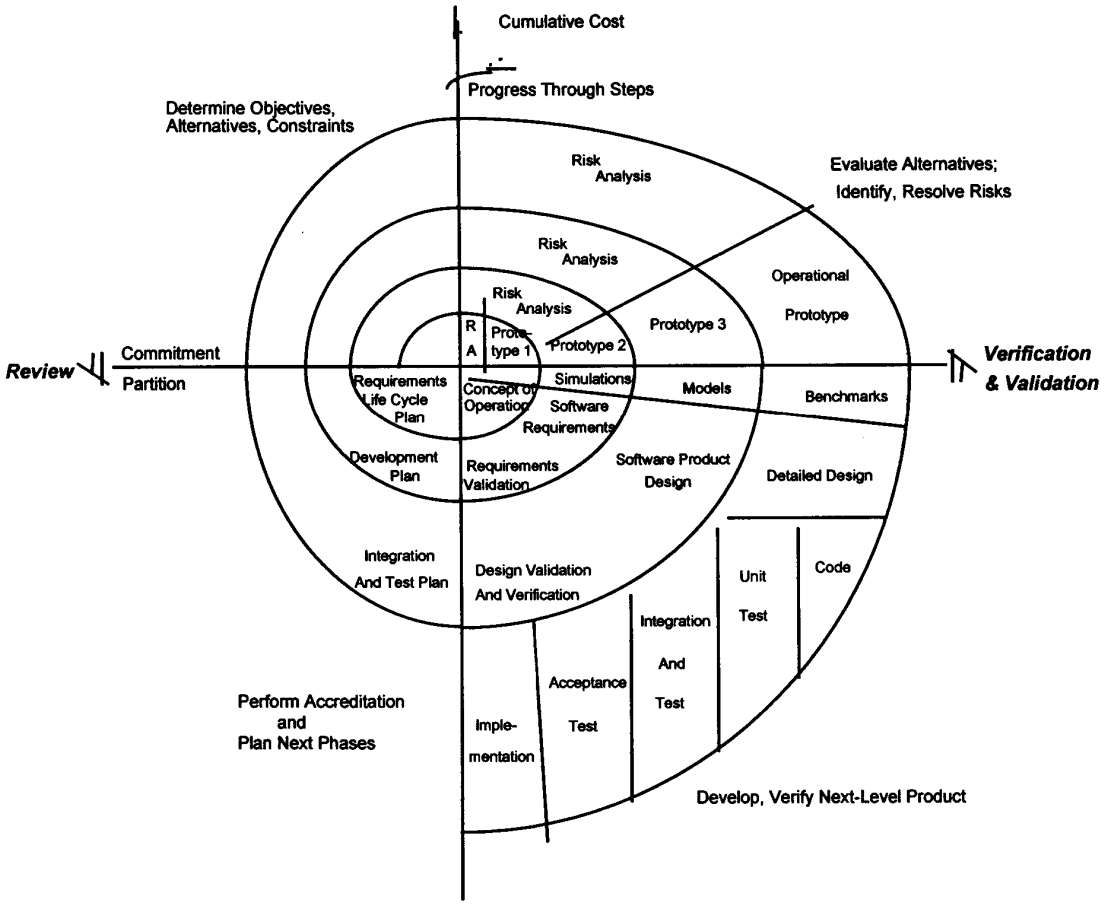

Figure 2-5. Spiral Development Cycle

c. *Future development cycle initiatives.* The need to reduce acquisition times, resources, and risk while increasing the quality, military utility, and supportability of system acquisitions is reflected in DoD's Simulation Based Acquisition (SBA) initiative /Simulation and Modeling for Acquisition, Requirements and Training (SMART). SBA/SMART goals are to establish a collaborative environment to share ideas, foster reuse, and promote interoperability. Although specifically aimed at materiel system acquisition, the principles of early collaboration can be applied to development of complex M&S as well. Future M&S development environments will need to facilitate user collaboration in all phases of M&S development to explore and clarify requirements, experiment with technologies, and understand the "human factor" associated with M&S usage. One example of early user involvement might be a virtual laboratory environment where a U.S. Army Training and Doctrine Command (TRADOC) Battle Laboratory with a multidisciplinary team consisting of the user and subject matter experts would rapidly prototype concepts based on initial but incomplete requirements. Interfaces and support tools such as after action review tools and scenario generation tools could be designed and prototyped as well. The prototypes may be inelegant, inefficient, and contain simplistic algorithms but their overall behaviors and interactions are supposed to be representative of real world behaviors and interactions desired by the user. As the operational prototype is refined, knowledge engineers and end users further develop the definition of requirements. When the prototype is representative of the "final" requirements, it would be turned over to the materiel developer and contractors for formal development. The formal development would finalize the conceptual model, adhere to applicable standards in the Joint Technical Architecture-Army (JTA-Army) and ensure the M&S is stable, robust, scaled, and documented. The user would again be heavily involved with system integration and end item delivery. Participation by the user facilitated by rapid prototyping tools should result in M&S that have demonstrated user buy-in while being more responsive to cost and schedule.

d. *V&V incorporation in the development cycle.* V&V must be incorporated in the development cycle selected and must be considered from Day One. The need for requirements approval (paragraph 2-2a(5)) is paramount prior to actual development. In the spiral development case (paragraph 2-6b), the philosophy should be "build-a-little, test-a-little, while V&Ving-a-little". In the future initiatives case (paragraph 2-6c), early user collaboration in V&V is facilitated by selecting and utilizing approved M&S standards from Army Standards Repository System (ASTARS) (paragraph 2-7c). In both cases as the M&S gains maturity, the V&V effort must ensure that the elements of V&V as discussed in paragraph 2-5 are adequately addressed.

2-7. The Army's M&S Standards Development Process

a. *Background.* The development of standards within the Army M&S processes is a vital step toward achieving the economies, efficiencies and technological potential of M&S. Through standards, the Army M&S community shares techniques, procedures, processes and applications. It builds on the work of others and advances the art and science of M&S in tandem with technological advances. Thus standards development is an iterative process and standards are approved based on consensus. This ongoing process directly supports the achievement of both the Army and the Department of Defense M&S objectives. The Army's Standards Development Process occurs within a continuous and iterative seven-step process. Figure 2-6 shows the process graphically.

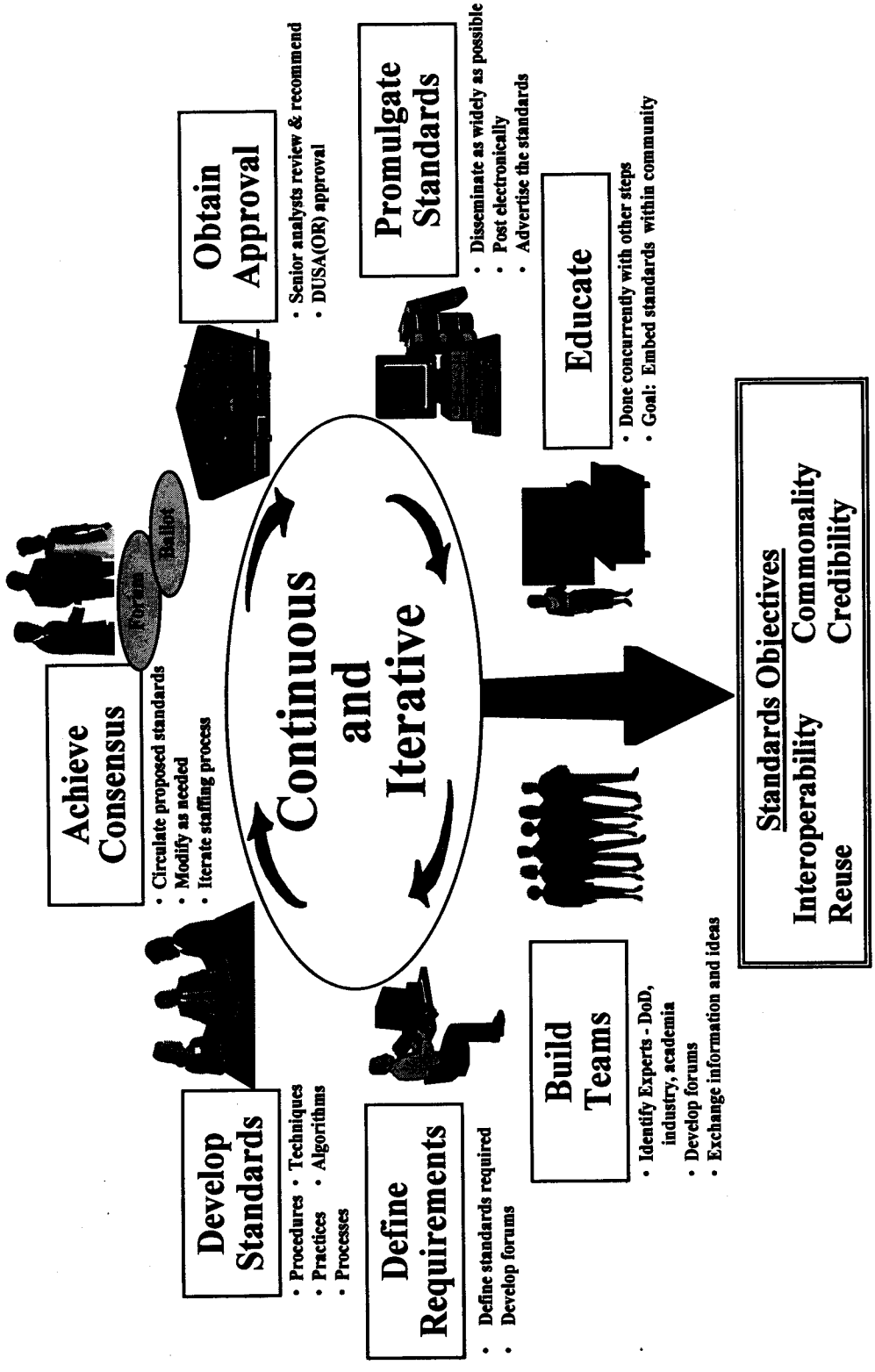

Figure 2-6. Standard Development Process

b. *Definition.* The term Army M&S Standard is applied in the broadest context to include procedures, practices, processes, techniques, and algorithms. Standards for M&S cover a variety of topics and the type and source of relevant standards will vary with each of the 19 standards categories. The standards categories represent the M&S technical functions that, taken as a whole, cover the M&S technological spectrum. For more detailed information about the process read the Army M&S Master Plan, Chapter 3, which is dated October 1997 or visit the Army Model and Simulation Office (AMSO) website at http//www.amso.army.mil.

c. *Supporting VV&A.* Through the application of M&S Standards the V&V process can be accomplished faster and easier. By using approved standards M&S developers have a solid foundation upon which to build. M&S developers can begin their design efforts by querying ASTARS to see if a standard presently exists to meet their needs. If a standard is found it can be used directly or a Standards Requirements Document can be submitted to modify the standard for this particular use. Standards in ASTARS have been vigorously reviewed and approved by consensus then are submitted for approval by the DUSA(OR). Specifically, verification is enabled by the fact that the components of the M&S have been previously examined to ensure compliance to sound software-engineering techniques. Validation is enhanced because the standards have been reviewed by subject matter experts and senior analysts to ensure the standard in question is a valid representation of its real world counterparts. All approved standards will be documented thus providing both V&V and Accreditation agents information on the utility and limitations of a standard.

2-8. Tailoring

The VV&A effort shall be commensurate with the relative importance and stage of development of the M&S or federation to which they apply. If there are any issues that need to be addressed, they shall be tailored as appropriate to satisfy an intended need consistent with common sense, sound business management practice, applicable DoD level regulations, and the time sensitive nature of the requirements themselves. In addition, tailoring may be applied differently to the various phases of the M&S development process. The depth of analysis involved with the V&V of an established legacy or commercial off-the-shelf (COTS) M&S would be different from the development of a new M&S. Likewise, the available information for the accreditation of legacy and COTS M&S might be based more on historical performance than results from the step-by-step V&V process outlined in this document for a new M&S.

Table 2-1.
Army VV&A Responsibilities.

Role	Responsibility
Accreditation Agent	The organization designated by the application sponsor to conduct an accreditation assessment for an M&S application including data.
Application Sponsor	The organization that utilizes the results or products from a specific application of a model or simulation.
Configuration Manager	The organization responsible for the application of technical and administrative direction and surveillance to identify and document the functional and physical characteristics of an M&S, control changes, and record and report change processing and implementation status.
Data Producer - Valida-	The data producing organization responsible to assess the

Table 2-1.
Army VV&A Responsibilities.

Role	Responsibility
tion	data for the intended application based on the stated criteria and assumptions.
Data Producer - Verification	The data producing organization responsible to ensure data meets constraints defined by data standards and business rules derived from process and data modeling.
Data User - Validation	The intended user organization responsible to assess data and determine if it is appropriate for the intended application. Please note that data user validation is part of the M&S VV&A process when a M&S is being developed or modified. However, when new data is being generated for a M&S it will be validated for that intended application.
Data User - Verification	The intended user organization responsible to ensure data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly. Please note that data user verification is part of the M&S VV&A process when a M&S is being developed or modified. However, when new data is being generated for a M&S it will be verified for that intended application.
M&S Developer	The organization responsible for developing, managing, or overseeing M&S developed by a DoD component, contractor, or Federally Funded Research and Development Center (FFRDC). The developer may be the same agency as the proponent agency.
M&S Proponent	The organization responsible for initiating the development and directing control of the baseline version of a model or simulation. The proponent will develop and execute a viable strategy for development and maintenance throughout the life cycle of the M&S and for directing the investment of available resources in same. The M&S proponent serves as the advocate and final authority on their M&S. The proponent will advise the DUSA(OR) on release of the M&S to foreign countries, and will advise the Major Command (MACOM) or Organizational Release Authority for domestic release. Except where responsibilities are specifically designated to an acquisition official by DoD or DA policy e.g. DoD 5000.2 or AR 70-1, the M&S proponent is responsible for, but may delegate execution of: M&S Development; Configuration Management; Preparation and Maintenance of Simulation Object Models (SOMs) as appropriate; all aspects of Verification and Validation; and maintenance of current information in all catalogs and repositories.
Validation Agent	The organization designated by the M&S proponent to perform validation of a model, simulation, or federation of M&S. Additionally, data validation is performed as an integral part of the M&S validation process.
Verification Agent	The organization designated by the M&S proponent to perform verification of a model, simulation, or federation of M&S. Additionally, data verification is performed as an integral part of the M&S verification process.
V&V Agent	The organization designated by the M&S proponent to perform verification and validation (V&V) of a model, simulation,

Table 2-1.
Army VV&A Responsibilities.

Role	Responsibility
	or federation of M&S. Additionally, data V&V is performed as an integral part of the M&S V&V process.
V&V Proponent	The Government agency responsible for ensuring V&V is performed on a specific M&S or federation of M&S.

Chapter 3
Verification and Validation

3-1. Concept

a. Many software-engineering textbooks define and describe the science of software verification and validation. These texts provide a general set of procedures that test the stability and integrity of the software. V&V of most Army M&S must go a step beyond classic software V&V to focus on M&S issues such as representation. A determination of validity must often be made in the absence of any measurable real-world phenomena for comparison. Although this makes the V&V task daunting, V&V is as necessary for Army M&S as for any other software. Although the M&S developer or proponent requires a high initial investment, considerable manpower savings can result from increased V&V in lieu of necessary rework from errors found later in the life cycle.

b. While verification and validation activities occur in conjunction with each other, each focuses on different aspects of the M&S. Verification answers the general question, does the M&S work as intended? While validation answers the question, is the M&S realistic? This chapter expands upon the concepts of verification and validation and suggests specific procedures applicable in each area. The V&V procedures listed in paras 3-2b and 3-3d-f are generally accepted methods, however application of techniques will vary (see para 2-8 on tailoring) for individual V&V programs.

3-2. Verification

Verification of a M&S is the process of determining that an M&S accurately represents the developer's conceptual description and specifications. Verification also evaluates the extent to which the M&S have been developed using sound and standard software engineering techniques. In large-scale M&S development, verification is applied at each stage of the life cycle to ensure that the products of that stage accurately implement the output from the previous stage and contribute to the overall goal of meeting requirements. The verification process thereby establishes whether the M&S code and logic correctly perform the intended functions. The verification process must include an analysis and determination of which verification methods are the most cost effective and which will build the most confidence in the structural integrity of the M&S. The DoD Verification, Validation and Accreditation Recommended Practices Guide, the Institute of Electrical and Electronics Engineers (IEEE), and other professional association standards are useful sources of procedures that can be used in conducting verification activities (see app B). This pamphlet discusses methods of software engineering that are applicable to Army M&S and two key verification components, logical verification and code verification. Figure 3-1 shows the relationship between the components of verification and the life cycle of an M&S.

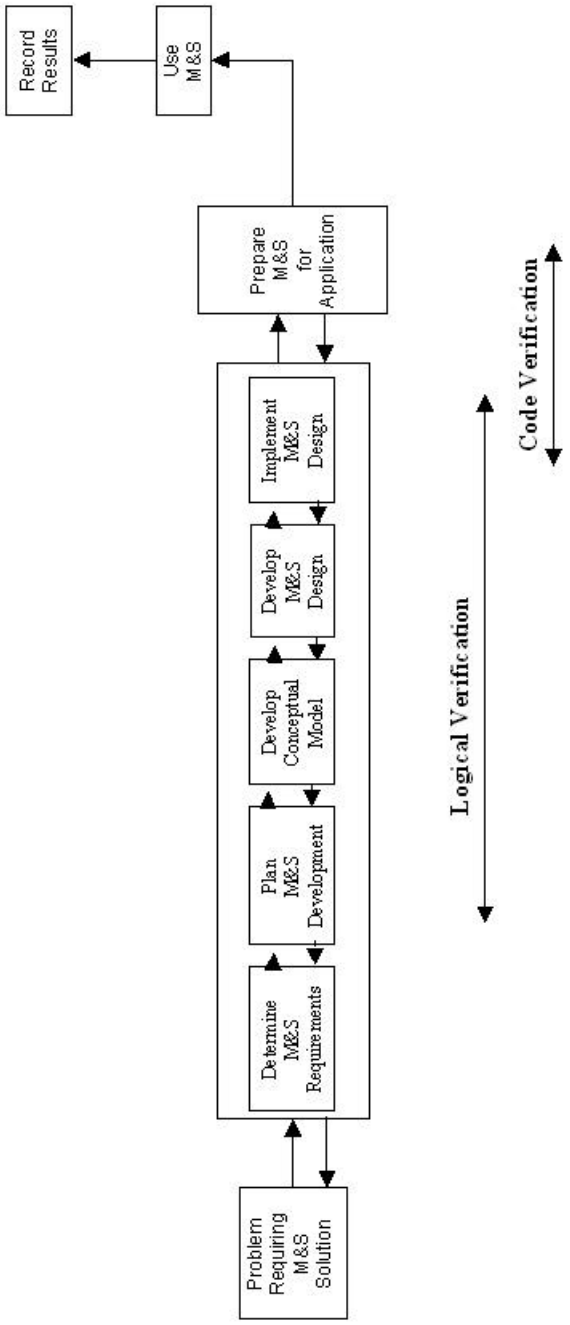

Figure 3-1. Verification in M&S Life-Cycle

a. *Components.* The two main components of the verification activity are described below. Some useful methods are described in paragraph 3-2b. The choice of methods depends on the design characteristics of the M&S and is at the discretion of the proponent and V&V agent.

(1) *Logical verification.* This is a review process to assure that the M&S algorithms correctly represent the intended processes in relation to the M&S requirements and specifications and verification of the M&S' design. For example, the assumption that certain events are independent is an area of concern under logical verification. Another item of review may be the comparison of the pseudocode logic with the implementation of the actual code. Performing logical verification early in the life cycle of the M&S makes it possible to detect and correct errors in design prior to actual coding.

(2) *Code verification.* This includes a rigorous audit of all compilable codes to ensure that the representations of verified logic have been properly implemented in the code. It ensures that the code faithfully mirrors the design algorithms and that no errors such as division by zero occur at boundary conditions. Ensuring the stability of mathematical properties in a specific computer hardware/software environment is an example of code verification.

b. *Methods.* The verification process includes selection of appropriate methods based on the specific characteristics of each M&S (such as, deterministic or stochastic, real time or non-real time) as well as overall complexity and hardware requirements. All methods selected for verification must be carefully documented along with the results achieved. The methods are described in this section only as they apply to the verification process; their usefulness in the validation process will be discussed in paragraph 3-3. It is important to note that the test data need not be accredited (e.g., if the data required is classified); however, extreme care should be used in the development of the data for verification. Real data, for example, empirical data, should be used if available but this is not a requirement. In fact, for some of the tests, data values that lie at the extremes are more suitable to stress the M&S. Refer to paragraph 6-2 for discussion on data V&V and Accreditation. Figure 3-4 provides a list of the common verification techniques and methods, some of which are described in the following paragraphs. Note that some methods may apply to both types of verification.

(1) *Logical verification methods.*

(a) Review. A review is a high-level technique that seeks to ascertain that tolerable levels of quality are being attained. The review team consists of managers to ensure that the design and specifications encompass the M&S requirements and that they represent a balanced and correct approach. It also includes reviewing the specification document and design documentation, to ensure that all of the requirements are addressed in an appropriate and complete manner. The requirement verification step should be conducted before code is written but also after the code is completed to assure their intent is still consistent. If M&S requirements include contradictory or mutually exclusive elements, M&S developers are responsible for documenting these items and their solutions. Care should be taken to ensure that data requirements and accredited data sources are adequate and available at the resolutions required by the algorithms before proceeding with coding.

(b) *Design walk-throughs.* This is a review of the design for the M&S by a group of peers or SMEs. It is intended to detect and document faults as opposed to determine performance. Documented design walk-throughs greatly aid the verification process because they represent a milepost in the history of the evolution of the M&S design. Formal design walk-throughs with the M&S proponents or intended users represent the quickest way to ensure that the design matches the expectations and requirements of the user community. Walk-throughs are usually done on a piecewise basis with all functional area designers presenting their areas of responsibility. This provides an opportunity for the group to verify the interactions of each component of the M&S as well as to review the total design for completeness and balance. The group should have ample opportunity to ask questions and interact with the designer to gain an in-depth understanding of the assumptions, restrictions, and design.

(c) *Model interface analysis and traceability assessment.* The products at the end of each phase of M&S development must be compared with the products of the previous phase. Model interface analysis examines submodel-to-submodel interfaces within a model, or federate-to-federate interfaces within a federation, and determines if the interface structure and behavior are sufficiently accurate. The product of the first phase of M&S development is a document or statement of the requirements for the M&S. At the completion of the second phase, a traceability assessment matches the conceptual model to the requirements to ensure the user's requirements are addressed. Once the pseudocode or other design documents have been written, a logical check against the specifications is necessary to assure all specifications have been implemented. This is especially necessary in the case where the user, designer, and implementer are not the same. Verification of the design is the connecting link reconciling the actual code to the requirements and conceptual model.

(2) *Code verification methods.*

(a) *Sensitivity analyses.* These are checks of the algorithms and code to ensure that the M&S is reacting to varying sets of input in an expected, mathematically predictable manner. These analyses include preparing and running tests to compare results for systematically varied sets of input data to see if the expected trends in output are demonstrated. Testing with boundary data values reflecting the anticipated extremes in conditions or with combinations of data values estimated to cause the most extreme results are known as stress tests. These tests may be run at nearly any level of the code by examining the output of individual routines, functional modules, or events. Generally, the finer the level of detail, the greater the degree of confidence in the tests results. The level of detail that is examined will ultimately be a function of the feasibility of decomposition and the relative increase in confidence to be gained given time and cost considerations. Functional decomposition (see paragraph 3-3f(3)) coupled with sensitivity analysis facilitates the verification process by highlighting the effects of input data changes on functional outputs of the code. Most combat M&S use a large number of variables and, in these cases, it may be necessary to use data aggregation or factor screening techniques to identify key variables to monitor and test.

(b) *Code walk-throughs.* Code walk-throughs are usually conducted with members of the development team and involve detailed analysis and discussions about the implementation of the algorithms that make up the M&S. These walk-throughs are designed to ensure efficiency, correctness, consistency and completeness in the implementation. They often serve as a forum for team members to discuss interfaces between code modules. Documented code walk- throughs also serve as a historical record of changes in implementation. It is important to document both the change and the rationale for the change. Formal code walk-throughs with independent agents help to highlight M&S capabilities and limitations.

(c) *Automated test tools.* These range from commercially available applications to custom designed computer programs developed specifically for the M&S. These may include variable name spell checkers, memory maps, subroutine call trees and call frequency monitors. A highly useful tool is the static code analyzer, which performs a comprehensive inspection of code for variable usage, data flow, control flow, structure, standards violations, and complexity measurement.

(d) *Mathematical stability testing*. Unstable M&S characteristically produce radically different or unexpected results when moved across computer platforms or in response to otherwise insignificant input data changes. This is caused in large part by the differences in precision of the computer arithmetic and code/logic branching when using precise thresholds. Testing for these types of instabilities requires careful planning of test data sets that will stress the sensitivity of the M&S to changes in inputs. It is important to note that this type of testing is not only necessary but is costly and time consuming.

(e) *Units check*. This is a check to ensure that the proper units of measure result from equations used in the algorithms and code, (for example, d (kilometers) = r (km/hr) * t (hr).) This process should be documented either within detailed design documents or within the code itself.

(f) *Statistical test design for repeatable stochastic M&S.* The verification of stochastic M&S results must be approached differently from deterministic M&S. Algorithms that contain random numbers must be tested with appropriate statistical tests to ensure that the outputs fit the postulated distributions. The number of replications that are required to produce stable output should be verified and documented. Sensitivity analysis of repeatable stochastic M&S can be performed with assurance that the resulting change in output is a result of the corresponding change in input. However, each use of the random number generator must be tested to ensure that the intended distributions result.

(g) *Statistical test design for non-repeatable stochastic M&S.* Types of stochastic M&S that are not repeatable are those which 1) do not use seeded random number generators or 2) are those distributed on asynchronous networks. The class of M&S that incorporates direct human input introduces non-repeatable stochastic behavior. Sensitivity analysis is most difficult in this class. M&S with human decision-makers in the loop require analysis to determine if the decisions of the humans were within the realm of possibilities and that the resulting outcomes are reasonable.

(h) *Verification of rule-based systems.* Verification of rule-based systems must address the completeness (no unreachable or undefined conclusions) and the correctness (no conflicting or circular rules) of the knowledge base. Although rule redundancy (identical rules or subsumed rules) normally only affects run speed and not logic, it is important to detect and eliminate such redundancies since they may ultimately cause inconsistencies and other difficulties with maintenance and expansion over time. SMEs familiar with the intended use of the system should verify rules.

(3) *Methods that apply to both.*

(a) *Algorithm checks.* This involves inspection of design documents to compare equation and algorithm methodology to outside documentation. Comparison to other accepted methodology is also possible. A key issue here is determining whether the documented equations match those found in other publications or other successful M&S. This is done both at the design level and at the pseudocode level because the mathematical expressions may change when going from symbolic form into pseudocode form. Likewise, these expressions may change from the pseudocode form when implemented on a specific computer platform or in a specific programming language. This may be especially true for implementations where hardware and software-driven mathematical rounding precision can alter values and results.

(b) *Peer review.* This is a review by independent, but knowledgeable, experts of the algorithms and code used in the M&S. The review includes procedural flowcharts, top-down structured diagrams, pseudocode, data flow diagrams, or applicable object-oriented diagrams. Some of these presentation means are also used in design walk-throughs but the flow diagram review is more detailed. Presentations may be briefings or design papers that are used as a means of pictorially presenting the specifics of design and interfaces of each of the major areas of the M&S. Ideally, one of these presentation methods is chosen to provide a consistent basis to display information for all parts of a particular M&S. Peer review often highlights hidden assumptions made by the modelers in the implementation. Documented peer review findings provide a record of these assumptions and their impact on the results. Peer review often results in more efficient design and code implementations. Proper peer reviews may require considerable preparation time and resources.

(c) *Computer-aided software engineering (CASE) tools.* CASE tools assist in converting logical process descriptions into computer-based methodologies. CASE tools are commonly used to help the developer define a complete and consistent design, as well as create user interfaces, reports, and tests for the M&S. Additionally, many of these tools provide software metrics that have been demonstrated to empirically predict more troublesome and less reliable software modules. Typically, they also have self-documenting features that assist in describing the M&S features for later V&V efforts.

3-3. Validation

Validation is the rigorous and structured process of determining the extent to which an M&S accurately represents the intended real world phenomena from the perspective of the intended use of the M&S. It has two main components: conceptual model validation and output validation. Since verification and validation are complementary processes, some results from the tests used in verification are used as input to the validation process. Ultimately, the combined purpose of verification and validation is to support the accreditation process and ensure the M&S provides credible results and satisfies the users operational needs. Figure 3-2 depicts the relationship of the components of validation to the life cycle of the M&S.

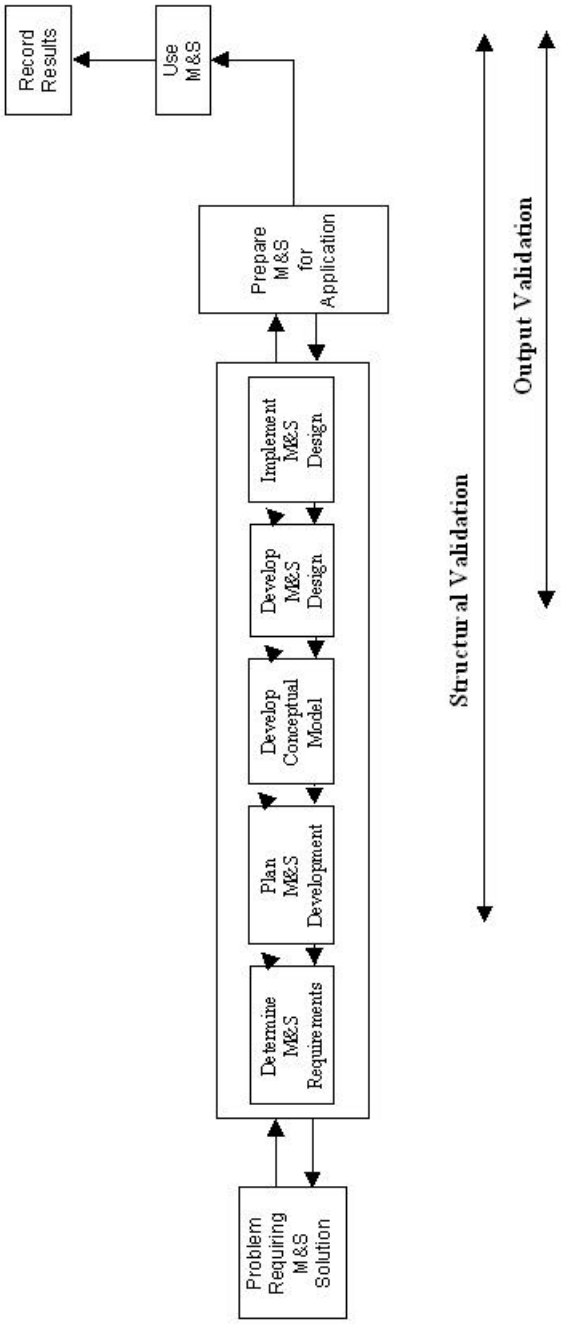

Figure 3-2. Validation in M&S Life Cycle

a. Components. Figure 3-3 provides an overview of the components of validation. Both conceptual model and output validations are to be performed for all M&S.

(1) *Structural validation.* Structural validation focuses upon the internal portion of the M&S, which includes examination of M&S assumptions and review of the M&S architecture and algorithms in the context of the intended use. Questions that are addressed during structural validation include the following:

(a) Is the M&S sensitive to the proper input data items; such as, does the difference between two sets of M&S results reflect a possible/believable result given the variation in the input data sets?

(b) Do the individual pieces (functional areas, weapon systems, units, behaviors and so forth) of the M&S adequately represent their counterparts in the real world?

(c) Is the M&S complete and are the functions adequately modeled?

(d) Is there a balance of representation across all M&S components?

(e) Is there adequate and consistent representation of terrain and environment across all M&S components?

(2) *Output validation.* Output validation answers questions on how well the M&S results compare with the perceived real world. Example questions that output validation addresses are--

(a) Does the M&S produce results that are feasible?

(b) Is the output/result reasonable relative to the inputs?

(c) Does a difference in input produce the expected proportional change in the output?

(d) How does the M&S output compare to historical data, test data, laboratory data or exercise data?

(e) Are graphical outputs and visualization realistic?

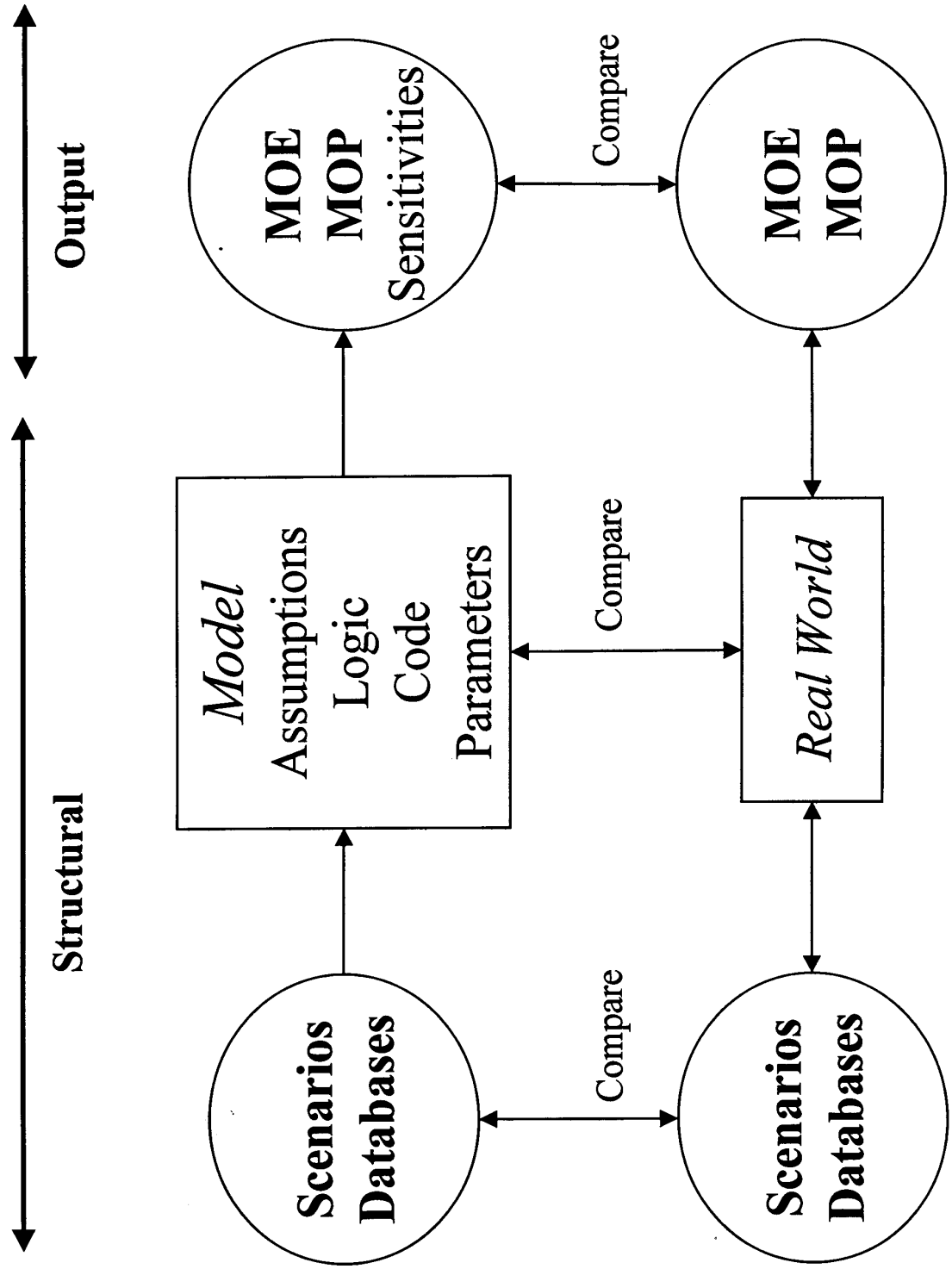

Figure 3-3. Validation Components

b. *Components and methods.* The components of validation (structural and output) should be used as a guide to describe what activities are needed to validate a specific M&S. The technical methods described in paragraph 3-3f can be used in the conduct of either structural or output validation activities. All should be considered in the initial development of the V&V plan for the M&S and modified based upon time and resources available. The results of structural and output validation activities are an integral part of the M&S validation documentation and are to be considered during all accreditation reviews.

c. *The validation process.* The two issues that must be addressed in the definition of the problem are identification of the real world being modeled and identification of the key structural characteristics and output parameters that are to be used for comparisons during the validation process.

(1) *Identification of the real-world.* Validation involves the comparison of the M&S behavior and results to the data obtained from another credible domain. The credible domain is either believed to be the real-world, has been proven to closely approximate the real world, or is from a source that is recognized as expert on the relevant characteristics of the real world. The standard of quality that the M&S is expected to meet is a part of this identification process. This is a critical part of the validation process because the real world is frequently not a tangible or empirically measurable entity, particularly in the realm of combat modeling. The leader of the validation effort must define the specific sources of information, concepts, and SMEs that will represent the real world and will be used as the baseline for both the structural and output comparisons. A description of some typical real world data sources follows.

(a) *SMEs or other recognized individuals in the field of inquiry.* The process by which experts compare M&S structure and M&S output to their estimation of the real world is called face validation, peer review, or independent review.

(b) Scientific theory and accepted algorithms defines the ranges of acceptable behavior in response to given inputs.

(c) Laboratory test, developmental test, system operational test or other engineering data that provide a set of empirical data points, which correspond to specifically identified input data.

(d) Training facility measurements and live fire training and tests results that may provide data points for comparison.

(e) *Comparison with historical values.* Measurements of the phenomena of war, such as the number of casualties in a given battle, may provide only one or a small sample of relevant data points for comparison. Caution must be exercised if comparing the M&S to one historical data point because, if that one data point is an outlier rather than a norm, incorrect conclusions about the nature of the real world and the validity of the M&S may result. However, comparison with history, when combined with comparisons to other sources, forms a strong basis for credibility.

(2) *Identification of key structural characteristics and output parameters that are of interest for the intended use of the M&S.* The identification of the intended use can assist in designing the appropriate technical approach needed to conduct validation at the required fidelity. Each Army M&S domain has special characteristics and uses that may require different validation approaches.

(a) ACR. These M&S support analyses used in force design and in the design and development of new weapon systems and equipment or engineering product, which improve existing weapon systems. A high level of fidelity is required for these M&S. Validation will therefore emphasize completeness and balance of algorithms. Validation items of importance will include the portrayal of subsystems, components and system parameters, physical phenomena, and interactions with environment. The capability to run at speeds much faster then real time has validation implications

(b) RDA. These M&S support activities (typically physics-based engineering level M&S) that assess effectiveness and suitability of equipment, systems, devices, and their components (especially in environments which may not be available for test, such as space, multi-corps context, and so forth). A validation methodology, built into the M&S to determine the degree to which the M&S results accurately reflect the equipment test results, is desirable. M&S are also used to stimulate the system under test to perform its functional activity. The M&S outputs are examined by SMEs to determine the adequacy of the input to the system under test. The validation method typically chosen for this category of M&S is face validation.

(c) TEMO. These M&S primarily emphasize education and training of soldiers and staff. Validation centers on human interactions and interfaces and the quality of after action reviews. Education and training M&S need to provide feedback immediately, operate in real-time, and have the look, feel and response of the real-world situation to provide maximum benefit to the users.

d. Methods development.

(1) Methods development for a validation effort requires careful planning. Each validation task should address some portion of the questions identified as part of the validation plan. These questions should correspond to either structural or output validation of some aspect of the M&S. Each task should identify the method, tools, or techniques needed to perform the task and identify the data values, algorithms, and so forth, to be compared. The resulting analysis should address–

(a) The sensitivity of M&S outputs to inputs and parameters and how this sensitivity compares to the major influencing factors in the baseline real world.

(b) The assumptions made by M&S developers, the impact the assumptions have on M&S usage, and whether or not these assumptions seriously affect the ability of M&S to portray, explain, or predict the relevant portions of the real world.

(c) The interfaces between M&S objects/processes and how well they parallel the real-world interactions.

(d) The completeness and balance of the M&S logic across the M&S components.

e. Procedural approaches.

(1) *Peer review.* Peer review is a validation approach that involves conducting critical and detailed examinations of internal representations of data inputs, key parameters, and resulting output. The members of the peer review are personnel who are knowledgeable about modeling the functional areas represented in the M&S. Additionally, the peer review is a procedure that may be used in the verification process.

(2) *Independent review.* Competent, objective reviewers who are independent of the M&S developer perform an independent review. This review may include a detailed verification, as well as a detailed validation, of the M&S; or it may consist only of an examination of the adequacy and completeness of the verification and validation methods already performed by the M&S developer.

f. Technical methods.

(1) *Face validation.* This is the process of determining whether an M&S, on the surface, seems reasonable to personnel who are knowledgeable about the system or phenomena under study. This method applies the knowledge and understanding of experts in the field and is subject to their biases. It can produce a consensus of the community if the number and breadth of experience of the experts represent the key commands and agencies. Face validation is a point of departure to determine courses of action for more comprehensive validation efforts.

(2) *Comparison to other M&S.* This uses results or output from internal algorithms or M&S already accredited for use in similar applications as part of both structural and output validation. Direct comparison of code, documentation, input data, and results are the primary techniques used. For example, graphical displays of missile fly-outs, the battlefield, or output results may be compared among several M&S. This comparison, with data points resulting from another M&S, has the limitation that the resulting degree of real-world fidelity is only as good as that of the M&S with which it is being compared. Although not the real world, it may be the best that is reasonably available for comparison.

(3) *Functional decomposition (sometimes known as piecewise validation).* Decomposing the M&S into functional components is often a great aid in the validation process. In large complex M&S, functional decomposition provides a logical means of performing piece-wise test design, testing, and analysis. Functional area SME for each part of the M&S are brought in to examine in detail the documentation, code, and output to determine the validity of each segment of the decomposed M&S. Then an analysis of how well the pieces fit together is conducted, with the result being an overall validation of the M&S. Decomposition of the M&S should be sensitive to the intended uses of the M&S as this may drive the functional split and the level to which the decomposition is done. Validation by functional decomposition will encourage software reuse as well as more extensible and modular M&S. When used in conjunction with face validation of the overall M&S results, functional decomposition is extremely useful in reconfirming previous validation of a recently modified portion of the M&S.

(4) *Stress tests and sensitivity analysis.* During verification, the key variables to which the M&S are most sensitive are identified. Given the results of these tests, the SME validates whether the M&S provide proper output responses to input across the entire spectrum of valid input data.

(5) *Animation, graphics play back and visualization.* These techniques allow the analyst to see the M&S' behavior through time. This is particularly useful for validating representations of vehicle/unit movement, weapons firings and interactions.

(6) *Turing tests.* These tests ask experts in the operation of a system to differentiate between data flow, controls and outputs of the real world system and the M&S results.

(7) *Model-Test-Model (M-T-M).* M-T-M is a method that uses test and evaluation results in an iterative method of successive M&S improvement, with each successive step increasing overall validity. The M-T-M process is accomplished through the following steps: model the scenario; observe test play; constrain the M&S to test conditions; compare M&S measures to observations; adjust the M&S; rerun the M&S and repeat the cycle as necessary. The basic components of M-T-M are: pretest modeling, M&S measures and test observations comparison, and post-test modeling. These phases are run successively until the desired degree of validity is achieved. M-T-M methods are comparable to other similar activities such as model-exercise-model (M-E-M) for Advanced Warfighting Experiments.

(a) Pretest modeling component. This component estimates a range of test results prior to conduct of record trials/events. Pretest modeling focuses upon such test design issues as tactical soundness, adequacy of scenarios to address all critical issues and test objectives, and the identification of appropriate data to be collected during the test. M&S support personnel must be thoroughly familiar with the Test and Evaluation Master Plan (TEMP), the ORD, MSRD, or SSP for the system, the design parameters of the test phase, and test site information relating to data collection and timing. This ensures the full spectrum of M&S capabilities needed to approximate the environment, the systems, and the scenario is available. Piecewise validation is a useful technique during this phase to ensure that selected portions of the M&S can represent specific test objectives. M&S support personnel and test support personnel, whom are part of the overall test team, should work closely together in the test planning phase. This is done well in advance of the actual field testing, to ensure that test data are collected in a form usable by the M&S, that all required data are collected (for example, data describing engagement procedures, environmental conditions, system performance, and so forth). Results from the pretest-modeling phase can be used to assist in planning the field test and in planning details of the data collection and analysis effort.

(b) *M&S measures and test observations comparison.* This phase begins with the conduct of the test. Afterwards, the actual field test results are compared to the pretest modeling results as part of the M&S validation process (Does the M&S predict behaviors or physical phenomena that are actually observed in a test?). Next the M&S, if needed, is refined for further iterations of the M-T-M.

(c) *Post test modeling component.* M&S personnel must integrate the test data to demonstrate that the M&S can replicate the observed test results within reasonable tolerances. The M&S algorithms or accompanying databases may require modification so that the model yields results that correlate with observed test results. The successful completion of this phase provides the capability to extend the scope of the test to address issues (environment, threat, terrain, weather, and so forth) that may not have been possible to address within the constraints of the test itself.

3-4. V&V documentation

As mentioned in paragraph 2-2b, it is crucial to document the application and findings of the V&V process because these documents are the primary source documents for the V&V and accreditation processes. The V&V plan and report are part of the standard documentation set for all M&S. These documents should be controlled under configuration management procedures in conjunction with the M&S code and other documentation. They are updated as the M&S undergoes enhancements and fixes.

a. V&V plan. The V&V plan is the road map for the V&V proponent in that it lays out all sources of information about the M&S that may be of use in the V&V process. It also identifies the V&V methods to be applied. Note that there is significant effort in producing a comprehensive V&V plan. Appendix F contains a sample format for the V&V plan and a description of the recommended items for inclusion. In general, the V&V plan outlines the approach that will be taken to accomplish V&V, and the agencies involved in the V&V process, along with their roles and responsibilities. It must be coordinated with all agencies that will expend any resources or have any responsibilities in the V&V process.

b. V&V report. Appendix G contains a sample format for the V&V report and a description of the recommended items for inclusion in it. An executive level overview of the process and findings begins the report. It also contains a detailed description of the V&V processes that were conducted and the results of the V&V effort including the capabilities and limitations that were identified. This document must be coordinated with all agencies involved in the V&V process. The executive-level overview portion is to be forwarded to AMSO for record.

Logical verification methods

Review

Walk-throughs

Comparison of specifications to requirements and comparison of design to specifications

Code verification methods

Sensitivity analyses and stress tests

Code walk-throughs

Automated test tools

Mathematical stability across platforms

Units check

Statistical test design for repeatable stochastic M&S

Statistical test design for non-repeatable stochastic M&S

Rule-based systems

Methods that apply to logical and code verification

Algorithm checks

Peer review

Computer Aided Software Engineering Tools

***Note*. There are other methods not specifically addressed in this document. Therefore, this figure should not serve to limit the use of other applicable methods. Refer to DoD Verification, Validation and Accreditation Recommended Practices Guide for additional methods.**

Figure 3-4. Verification methods

Chapter 4
Accreditation

4-1. Accreditation overview

Accreditation is the official determination by the M&S application sponsor that a model, simulation, or federation of M&S is acceptable for a specific purpose. The accreditation process, as described in this chapter, is the procedure that the M&S application sponsor follows in order to make the accreditation determination. It must be recognized that M&S are, by definition, abstractions and may not duplicate actual observed phenomena but rather provide an approximation of observed behavior. Therefore, accreditation procedures are the formal process by which the M&S application sponsor gains confidence in the model and simulation for its intended purpose. Any use of the results of an M&S is considered de facto accreditation and the M&S application sponsor will be held responsible for the results of an M&S that has not been formally accredited. However, the preferred method of accreditation involves a determination that the M&S is appropriate before use. This chapter describes the process of this preferred method of accreditation in terms of acceptability criteria, which can assist the decisionmaker in determining whether to accredit an M&S.

4-2. Acceptability criteria

The accreditation process answers the question; “Will this M&S meet my objectives?” The M&S application sponsor appoints an accreditation agent to establish a set of acceptability criteria by which to determine the suitability of the M&S for the intended use. These acceptability criteria are unique to each problem and give key insights to potential solutions. Acceptability criteria become, therefore, a set of standards that a particular M&S must meet to be accredited for a given use. Examples of overall high-level categories of acceptability criteria to be used as a starting point are listed in figure 4-1. These examples do not constitute a comprehensive list nor do they represent a minimum set of criteria. Further, they are provided as a starting point to guide the accreditation agent in developing specific detailed criteria that focus on V&V activities. In all cases, the accreditation agent determines the acceptability criteria. Failure of an M&S to achieve a particular acceptability criterion does not automatically result in disqualification. Such an occurrence may result in an evaluation of the criticality of the criterion to overall success and may merely serve to restrict the range of applicability of the M&S at hand.

4-3. Accreditation procedures

a. *General procedures.* The following procedures are general in nature and are applied to both application specific and class accreditation.

(1) *Establishing acceptability criteria.* The first task for the accreditation agent or accreditation team (see paragraph 2-2a(1)) is to officially establish the accreditation acceptability criteria to fit the use of the M&S. The principal focus of this effort is to establish those essential elements which the M&S must be capable of addressing to prove useful in solving the problem at hand.

(2) *M&S review.* The second step is to review the M&S. This documented review becomes the foundation upon which the accreditation decision is made. Typically, this includes reviewing the audit trail for the development and use of the M&S, the V&V documentation, configuration management procedures and records, M&S assumptions, previous successful uses, and how well the M&S has been accepted by other users and application sponsors. This review process is undertaken to determine the degree to which the M&S meet the previously established acceptability criteria. Accreditation is subject to review by the Army Model and Simulation Executive Council (AMSEC).

(3) *Other.* Other factors, which impact the decision for approval should be considered. These factors might include the developers past history, hardware configuration required, software support environment, personnel, security and known limitations.

b. Class of uses. M&S can be accredited for a generic set of applications (such as, a class of applications) by the Army official with general oversight responsibility for that class of applications (such as, battalion level battle forces training, analysis of alternatives (AoA), and so forth). Class accreditation provides a core accreditation report that serves as a baseline for focusing VV&A efforts on the unique aspects of individual specific applications. As long as the M&S application falls within the guidelines of the class accreditation, the entire M&S need not undergo V&V for a new application. Rather, the extent to which the M&S meets the new intended application will be examined and only the subsets of the M&S modified to address the new application will require V&V. Classes of applications for M&S will be defined as necessary by the AMSEC. Note that M&S accredited for a class of applications must be accredited for each specific use (see AR 5-11, paragraph 5-3e).

c. Application specific. M&S, which have been accredited for a class of applications, require each specific instance of use for that M&S to be accredited. The application sponsor is responsible for accreditation for that specific application after ensuring that the M&S will provide results which are responsive to the essential requirements of the intended use.

4-4. Accreditation documents

a. Appendix H contains a sample format for the accreditation plan and a description of the recommended items for inclusion in this document. In general, the accreditation plan defines the intended purpose of the M&S for which accreditation is being sought and it outlines the approach that will be taken to assess the capabilities and limitations of the M&S for that use. The Accreditation Acceptability Criteria are included. It also lists the agencies and members of the accreditation team that will be involved in the process and their roles and responsibilities. The accreditation plan must be coordinated with all agencies that will expend any resources or have any responsibilities in the accreditation process. The accreditation plan is the road map for the organizations doing the work in that it lays out all sources of information about the M&S that may be of use in the process. It also identifies the methodologies to be applied including data V&V and accreditation. See figures 2-2 and 2-4 to see where the accreditation plan fits into the Army M&S Life-cycle.

b. Appendix I contains a sample format of the acceptability assessment and the accreditation acceptability criteria that are addressed in the accreditation report. Additionally, it provides a description of the recommended items for inclusion. See figures 2-2 and 2-4 to see where the accreditation report fits into the Army M&S Life-cycle. An executive level, stand-alone section that explicitly states the result of the accreditation process is a mandatory part of the accreditation documentation. This executive overview must specifically grant or deny accreditation of the M&S and briefly describe the nature of the application. The body of the accreditation report contains items of information necessary to clarify the overview and provides a more detailed description of the accreditation processes that were conducted. This document must be coordinated with all principals in the accreditation process. The executive level overview portion is to be forwarded to AMSO for record. AMSO will forward the accreditation recommendation to the AMSEC for review if M&S accreditation is being recommended for a class of applications.

c. The report will contain background, description of the M&S to include version number(s), data V&V and accreditation results, evaluation of the M&S, V&V activities that support accreditation, and accreditation agent recommendations as they affect the appropriateness of the M&S or federation for the intended purpose. The report will include the assumptions; scenarios; representations of concepts, tactics, techniques, and procedures; and forces, processes, and doctrine from both friendly and opposing force perspectives as used in the M&S.

d. The report will include the application sponsor's decision on whether or not to accredit the specific M&S or federation for the intended application. Based on the determined risk (if any) of using the M&S or federation for the intended application, the M&S or federation could be accredited as is, M&S improvements could be implemented followed by further V&V and reassessment, another M&S could be considered, or a different approach could be utilized. The report will be provided to the M&S proponent, the appropriate Domain Agent and AMSO.

e. A federation is defined as a system of interacting M&S with supporting infrastructure, based on a common understanding of the objects portrayed in the system. The accreditation of a federation of M&S shall include a determination that—

(1) Federation elements can appropriately exchange data.

(2) Data items being exchanged are accurate and comparable across the federation to the extent required.

(3) Response times are commensurate across all system elements.

(4) The federation is complete when it meets real world behavior, appearance, performance, fidelity, and interoperability expectations for its intended purpose.

(5) Security classification levels of the federation and data are appropriate and commensurate with the application.

4-5. Re-accreditation

In accordance with AR 5-11, M&S accredited for a class of applications are subject to re-accreditation under three circumstances; a new type of application; release of a new version; or when a period of three years of active use has passed since the last accreditation for that class. The process for re-accreditation is identical to the process for initial accreditation except that more information may be available upon which to base the re-accreditation decision. To support this process of re-accreditation, it may be necessary to review some V&V activities or even to conduct new V&V activities. For example, if an M&S is being proposed for a new application, then logical verification may be required to determine that the structure of the M&S is appropriate for the new application.

4-6. Accreditation of older M&S

Legacy M&S (M&S which are still in use but are not implemented using today's V&V standards) or commercial off-the-shelf (COTS) M&S often do not have documented V&V plans and reports and are, therefore, more difficult to accredit. The procedure to accredit, however, remains the same. First, a clear understanding of how the M&S is intended to be used and a list of acceptability criteria that highlight the necessary M&S characteristics must be developed. Second, all available information about the M&S must be gathered. Some degree of supplementary verification and validation activity may be necessary to meet these criteria. Often only documentation of past V&V efforts is required. It is the application sponsor who accredits the M&S for its intended use based upon confidence in the M&S. This confidence as a result of documented past successes/experiences with the M&S in question may be an overriding consideration for continued accreditation.

The levels of force structure and interaction have sufficient fidelity and resolution.

The M&S is suitable for the overall intended use (e.g., training, explanatory, predictive).

The M&S output/results may be used clearly, adequately and appropriately to address the problem.

The CM policy is in effect and responsive to the anticipated needs of the M&S users.

All required data values are well defined and data sources for obtaining accredited data have been identified.

The M&S runs may be accomplished and results analyzed within the project timelines. Excessive run time, however, does not discredit the appropriateness of the M&S for the problem or class of problems being addressed. (NOTE: This acceptability criterion should not use terms such as "fast", "quick-turnaround", etc. Terms should be explicit in nature, e.g., "overnight", "one week per case", etc.)

There is availability of baseline scenarios, terrain data, threat data, and weapon performance data for the M&S.

The algorithms, terrain and environment representations are functionally adequate to address the issues.

The clarity, fidelity, complexity and level of detail of the simulated entities are acceptable for its intended usage.

The documentation, user training, and user help are adequate.

The M&S stability has been investigated and found acceptable for the hardware and software platforms which will be utilized.

M&S demonstrate appropriate sensitivity to data perturbations and response at boundary (limiting value) cases.

Figure 4-1. Examples of high-level acceptability criteria to be used as a starting point

Chapter 5
VV&A of Distributed M&S

5-1. Distributed M&S

Distributed systems (DS) of M&S include applications of HLA federations, Distributed Interactive Simulation (DIS), Aggregate Level Simulation Protocol (ALSP), and other M&S architectures which contain distributed components that make up a larger overall M&S system. The VV&A of these systems are more complicated than for stand-alone M&S since it requires investigation of the representations and interactions among the individual M&S. Also, different levels of resolution and their resultant data flows contribute to the complex nature of VV&A for distributed M&S. However, the generic VV&A process as discussed in the preceding chapters can also be used effectively for distributed M&S with a minimum of modifications.

5-2. Process overview

a. General. The process of VV&A consists of verifying that the M&S performs as designed, validating that the M&S is realistic, and accrediting that the M&S is adequate for the specific application. This procedure is directly applicable to distributed M&S. The M&S application sponsor (trainer, experimenter, or analyst) must examine the requirements for the application and identify candidate M&S for inclusion in the distributed architecture. The individual candidate M&S may be running on different processors and at various sites. The distributed architecture can be treated as a single M&S that has been functionally decomposed for V&V. This means that each M&S must be individually verified and validated in its own right. As with stand-alone M&S that have been decomposed, V&V of the components is not sufficient; the entire architecture for the application must also be verified and validated. After this has been done, the distributed system is a candidate for accreditation for the intended use.

b. Unique characteristics of the process.

(1) The availability of compatible data values for use across the individual M&S databases must be investigated early in the VV&A process. Ideally, a single database of common data items is shared by all of the individual M&S. However if this is not possible, then the data items that are common must be identified and the approved source determined.

(2) The challenge of VV&A for a distributed system is the V&V of the system as a whole. Representational differences arising from varying levels of resolution must be investigated. It must be determined that the components can *not only* exchange data appropriately using standard protocols and formats but also *use* data appropriately to provide a level playing field and a fair fight to the fidelity required. This also includes having adequate response times for the components (assurance that latency factors are acceptable for the combination of components). A determination must be made that the system of components is complete as is and no application-significant component is missing. Validation must assess the overall performance, credibility, and realism of the integrated system operating as an entity. Validation must determine if the integrated environment will provide sufficient and meaningful outcomes for the intended application.

c. *V&V functions.* V&V of the individual components of the distributed application are the responsibility of the M&S proponents. Due to the complex nature of the proposed distributed systems, an overall V&V proponent for the distributed system as a whole will be designated by the application sponsor. The M&S proponents must assist in all VV&A activities to ensure their M&S are V&V'd for the proposed application domain. The M&S application sponsor remains responsible in all cases for accreditation.

5-3. High-Level Architecture Federation Development Process

a. *DoD mandated architecture.* The DoD mandated architecture to support DoD interoperability is the High-Level Architecture (HLA) [Kaminski; Memorandum, subject: DoD HLA for Simulations, dated September 10, 1996]. The HLA provides a common architecture, which includes a run time infrastructure, rules, interface specifications, and object model templates. There is a basic desire to avoid unnecessary constraints on how HLA applications are constructed, especially since the development and execution of HLA federations could vary significantly within or across different user communities. Therefore, at the abstract level very basic steps have been identified as a guide in the development and execution for all HLA federations. The goal of HLA is to reduce the cost and time of M&S development by promoting interoperability and reuse. This process is shown in figure 5-1 and is discussed in detail below.

b. *Define Federation objectives.* It begins with the application sponsor's problem that seeks a solution using distributed M&S. The federation sponsor and federation development team define and agree on a set of objectives, and document what must be accomplished to achieve those objectives. The federation developers use high-level requirements to define a scenario in which the given problem is studied and solved. The scenario includes the major entities represented in the federation, a conceptual description of their capabilities, behavior, and interactions over time, and a specification of environmental factors and conditions.

c. *Develop Conceptual Model of the Federation (CMF).* A conceptual analysis decomposes the scenario into conceptual-level components, which are usually expressed as objects and interactions. The specification of this list of objects required for the federation under development, and their fidelity, requirements, operations, associations, interactions, components and attributes is called the CMF. The CMF draws upon the Conceptual Models of the Mission Space (CMMS) also known as the Functional Description of the Mission Space (FDMS). CMMS are first abstractions of the real world domain of interest. They capture basic information about entities, their actions/tasks, and interactions from a simulation-neutral viewpoint. CMMS content is validated by authoritative data sources from the warfighter and intelligence communities. A CMMS has broad application to the M&S in general, whereas, the CMF is specific to the exercise or test in question. The CMF contains an extraction of mission and operations information and data residing in the CMMS for use in developing the specific federation design. Existing CMMS resources are retrieved from the Model and Simulation Resource Repository (MSRR). The CMF provides a framework for design of a federation that has all the capabilities to satisfy the high-level requirements.

d. *Design and Develop Federation.* Design of the federation occurs after the development of the CMF. During this phase resources are retrieved from the MSRR including the histories of previous VV&A efforts on federates and federations that are similar in application or that may be considered for application or modification in the current federation. Existing Federation Object Models (FOMs) and Simulation Object Models (SOMs) from the MSRR or other repositories are reviewed for potential reuse in the federation under development. If federation participants have not been determined, they will be identified. If the FOM does not exist it must be developed to explicitly document information exchange requirements and responsibilities. During this phase, the objects and processes identified in the CMF are expanded into greater detail. The primary emphasis is the identification of the principal components of the federation and negotiation among these federates as to how the federation will be developed. Other tasks include defining the objects, attributes, and interactions that will be exchanged among federates and outlining specific responsibilities of each federate. The FOM common simulation functionality and data needed to support the federation scenario are identified and developed collaboratively among federates. Common simulation functionality comprises those tasks that all the federates need to do, such as a common clock, a common data base, or shared common algorithms that ensure a fair fight when the simulations run together.

e. *Integrate and Test Federation.* All necessary federation implementation activities are performed, and testing is conducted to ensure interoperability requirements are being met. There are two kinds of tests, HLA compliance testing and federation functional integration testing. The first test determines whether information is passed correctly among federates when the federation is connected to the Runtime Infrastructure (RTI). The second test examines the logical interactions between federates, checking if the information that is passed among federates produces reasonable and expected outcomes. Completing the development of a federation requires the RTI. This sub-step with the federation integration and testing step is important because the RTI provides services to federates in a way that is analogous to how a distributed operating system provides services to applications.

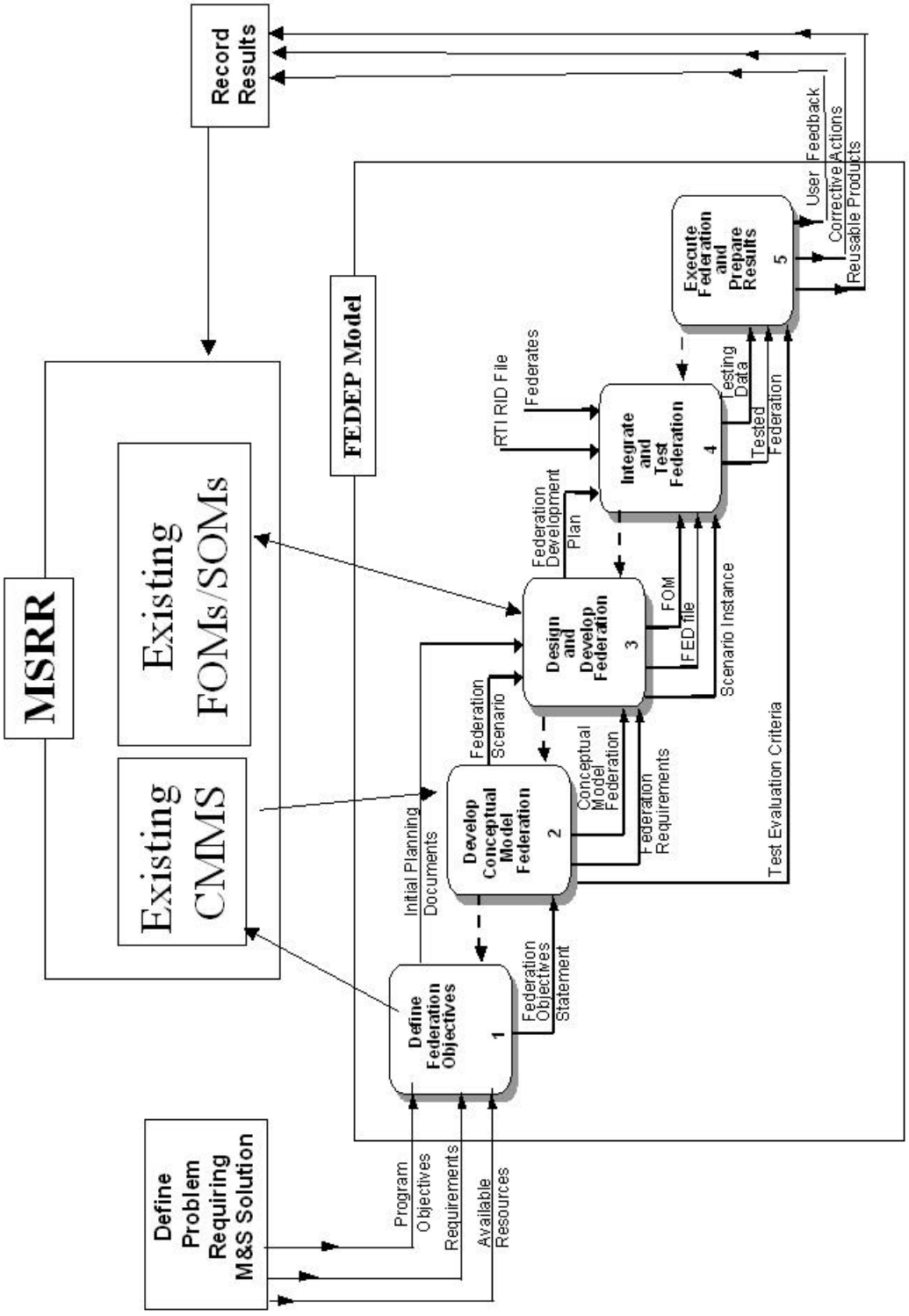

Figure 5-1. HLA M&S Life Cycle

f. *Execute Federation and Prepare Results.* Finally, the federation is executed, the results are analyzed, and feedback provided to the federation sponsor. This step answers the questions posed at the very beginning and provides the decision-maker with recommendations and a proposed solution.

g. *Record results.* Once the executed federation meets all the requirements of the initial problem, it will be recorded in the MSRR, only if it is unclassified.

h. *Federation Development and Execution Process (FEDEP) Model.* The FEDEP Model, which is embedded in the HLA M&S Life-cycle (see fig 5-1), is an ongoing evolving process that describes a high-level framework for the development and execution of HLA federations. The current version of the FEDEP is located at http://hla.dmso.mil/hla/. The intent of the FEDEP Model is to specify a set of guidelines for federation development and execution that federation developers can leverage to achieve the needs of their application.

5-4. VV&A of M&S using the HLA

a. *Overlay of VV&A.* The overlay of VV&A onto the HLA M&S Life-Cycle is reflected in figure 5-2. VV&A planning begins when federation objectives are defined. Planning includes drafting of accreditation acceptability criteria and preparing formal V&V plans and Accreditation plans.

b. *CMF planning process.* The planning process is amplified in the CMF stage of HLA federation development. V&V of the CMF generally examines four aspects:

(1) *Requirements and planning factors verification.* Verification of the planning factors examines scenario development to determine the degree of V&V that is required to ensure accurate representation of major entities and their interactions. Environmental conditions also must be verified and validated to ensure consistency with conceptual intent and real-world accuracy at the level that is appropriate to the intended use of the model. The MSRR contains a library of CMMS that should be consulted for selection and extraction of specific missions, operation profiles and task lists specifically for the simulation in question.

(2) *Mission and operations verification.* Definitions and specifications of mission, operation and tasks represented in the CMMS are verified. Checks are conducted to assure that the transfer of knowledge from the CMMS into the design specifications is done correctly and no errors are introduced. This phase of the V&V process includes examination of the selection of specific operations and missions to ensure that the right choices are sufficient.

(3) *CMF trade-off analyses.* Whenever alternatives exist in the CMF, V&V assists in converging on the best solution based on criteria such as maturity, cost, availability, VV&A history, and proven technical capabilities.

(4) *CMF validation.* This validation process evaluates the completeness, feasibility, and reasonableness of the CMF with respect to its ability to satisfy the requirements, plans, and mission set down by the application sponsor. Thorough validation at this point helps throughout the remainder of the development effort by "building in" authoritative knowledge and quality. The scenario is validated as part of this effort.

c. *Federation design.*

(1) Identification of federates and their individual responsibilities are one focus of Federation Design. Here, V&V plays a major role in checking the V&V history of the federates and determining the additional V&V that is required to make those simulations credible for the purposes of the current federation. Emphasis is placed on the realistic representations of required systems and their interactions.

(2) Both FOMs and SOMs need to be validated against the federations and simulations they represent to ensure currency and consistency in their descriptions.

d. Federation Integration and Test. As design features become more detailed, V&V is performed to ensure that they accurately reflect the intent of the conceptual design. Information from the MSRR is verified to ensure compatibility and to validate object interactions across federates. V&V of the implementation of the federation involve the products of the federation development process, the RTI initialization data, representations and the federation test. Federation documents generated during development offer excellent traceability for V&V activities. RTI initialization data show the physical implementation of the rules, interface specifications, and object model. These data serve as valuable conduits through which verification is performed to ensure that the implementation of the federation accurately reflects the intended design. Representations and interactions are specifically investigated during the implementation. Additionally, this includes both HLA compliance testing (see app J) and federation integration testing. The former ensures that, when the federation is connected to the RTI, the interface specifications are handled properly and information is passed correctly. This correlates directly to a component of verification, which checks the implementation against the developer's conceptual description and specifications. A similar parallel can be drawn between integration testing, which looks for logical interactions and ensures that the information that is passed makes sense, and a component of validation, which tests the credibility of the implementation against the real world. The Federation Execution Planner's Workbook is completed.

e. Federation Execution and Analysis. All federation participants will be exercised as an integrated whole to generate required outputs to determine if the federation objectives were achieved. A successful federation execution, which is a precondition for this phase, can be traced based on two principal coordination activities, the implementation of managing the federate participants and data collection, which are documented in the V&V report. This information also supports the analysis that reviews and compares the application of the federation with its requirements, limitations, development and use history, constraints and recommendations for changes to allow for reduced risk in executing the federation and technical improvements. This includes the estimates of errors due to inaccuracies in measurement and sampling, which should be accounted for during analysis of the data. The information gathered from these activities contributes to the federation's accreditation. The Accreditation Report and the accreditation decision are published.

f. *Record Results.* This phase assumes all federation objectives have been achieved, thus the federation is prepared and stored in the MSRR for reuse with proper federation product(s) identification. At a minimum, this would include storing the FOM and any modifications to the SOMs of federation participants in the Object Model Library (OML). However, several other federation products may also be reusable, such as new Object Model Data Dictionary (OMDD) entries, the Federation Scenario Specification (FSS), and the Conceptual Model of the Federation (CMF). In fact, it may be advantageous in some instances to capture the full set of federation products required to reproduce the federation execution. Determination of which federation products have potential for reuse in future applications is at the discretion of the federation development team.

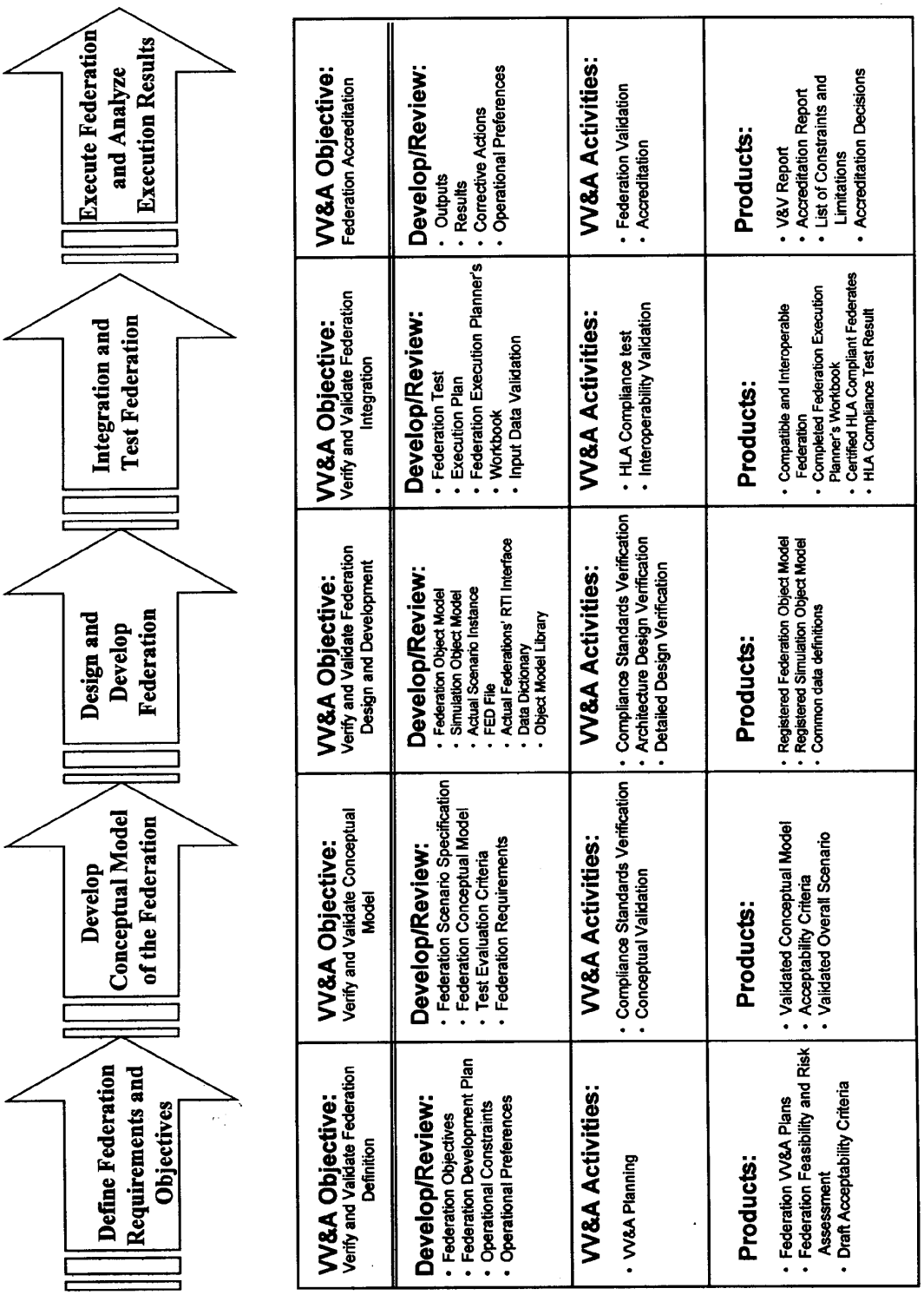

Figure 5-2. VV&A and the Five HLA Development Phases

Chapter 6
Data Use in M&S

6-1. Introduction to data use in M&S

a. Army M&S depend upon data for successful operation. The conceptual model with its algorithms, parameters and units of measures dictates the type of data that are to be used in the development and V&V of the M&S as well as during the accreditation for an application. Data are sought either from existing sources or, if necessary, new data are collected. Sources for data include those resulting from actual physical measurements and experiments. Data may also be generated from other M&S. The M&S developer can use the data during the implementation and actual use of the M&S. The role of data in the M&S life cycle is illustrated in figure 6-1.

b. In practice, the data requirements are not solely dictated by the needs of M&S. Most data sets are the result of work performed by organizations that were required to address problems not related to Army M&S. For example, many research and development data sets are the outcome of detailed investigations that were not originally associated with M&S, but are nevertheless useful or necessary for new M&S. Therefore, it is important to realize that the data is generated and used by two groups. These groups are the data producers who create the data and the data users who will put the data to use. The needs of these two groups are different and the manner in which they evaluate the same data is different as well.

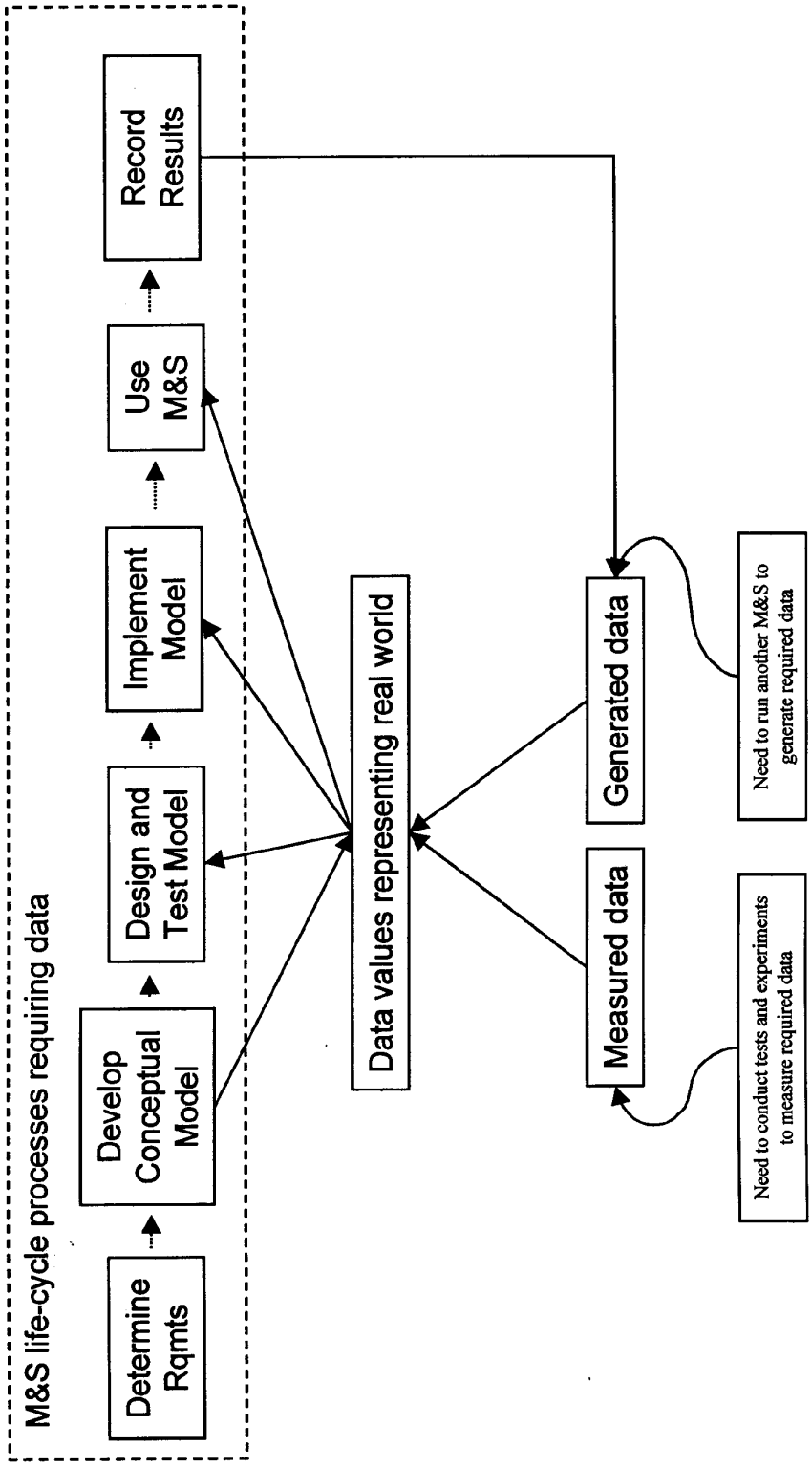

Figure 6-1. Role of Data Use in M&S Life Cycle

c. There are two primary roles in the production and use of data. The Data Producer has the responsibility for a data collection or database. This includes developing the requirements for the data and determining or creating data values, in conjunction with the proponent/customer, to represent the object or phenomena appropriately in the M&S. The Data User employs existing data in the course of their M&S application. In some situations, both are the same entity.

d. V&V and accreditation of the M&S and its data are essential to gain the confidence of the user community such that, the M&S outcomes are representative of the real world. This ensures that M&S and data are reasonably correct and acceptable for a specific purpose. V&V should be performed throughout the life cycle of the M&S as discussed in paragraph 2-2. For the purpose of this document, the definitions of verification, validation and accreditation of data are:

(1) *Data verification.* Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.

(2) *Data validation.* Data validation is the documented assessment of data by subject area matter and its comparison to known values. Data producer validation is an assessment within stated criteria and assumptions. Data user validation is an assessment as appropriate for use in an intended model.

(3) *Data accreditation.* Data accreditation is the determination that data has been verified and validated. *Data producer* accreditation is the determination by the data producer that data has been verified and validated against documented standards or criteria. Some data producers “certify” that their data have been verified and validated against documented standards or criteria. These certification statements may be explicit in formal declarations or implicit with the provision of their data. Data user accreditation is inherently a part of the M&S accreditation procedures. *Data user* accreditation is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage.

6-2. Data V&V and Accreditation

a. A relationship clearly exists between producer data V&V activities and user data V&V requirements throughout the M&S life cycle. However there is a distinction (beyond the definition) between data V&V activities performed by the producer and by the user. Producer data V&V equates to Data Quality (DQ), which intuitively is defined as the measure of how well the data serve the purpose intended. All data are produced for a purpose, and the quality of that produced data is directly tied to whether it meets the requirements of that purpose.

b. The link between producer and user is where the M&S users put the producer DQ information to use in conducting their M&S V&V and accreditation. Users rely on producer statements about DQ as a basis for their V&V and accreditation. That is, M&S users include data as an integral part of their M&S during the assessment of V&V and accreditation. These V&V and accreditation activities are accomplished to ensure "best" data available are used with their algorithms to support M&S credibility. In application, the user cannot separate data from the algorithm. It is the combination of both that produces a result, and therefore data should be validated as part of the model accreditation. The data user applies the producer's DQ metadata to support V&V and accreditation. User data accreditation is implicit in the acceptance of the data for accreditation of the M&S.

6-3. Data Quality Metadata Template

a. *Definition.* Metadata is information describing the characteristics of data; data or information about data; descriptive information about an organization's data, data activities, systems, and holdings.

b. *Data set and database.* Each data set and database contains numerous specific entries that make it difficult to readily interpret. A user must know some general information and characteristics about the data before it can be considered as a candidate data set for their M&S. Such general information ranging from the basic, "what the data represents" to the specific "each data field is in the following numeric format" and "how the data was generated" needs to be made available. This additional multi-level data describing the data is an example of metadata.

c. *Data Quality Metadata Template.* The Data Quality Metadata Template has been developed to assist data users in identifying the type of producer-generated DQ information they should be looking for to support their V&V and accreditation activities. It presents a comprehensive list of metadata fields which, when filled out by the data producer, should improve the understanding of the quality of data specifically used in M&S. It will also provide significant information that can be used in completing the V&V and accreditation process. The template is designed at three levels of data and with three priorities for the metadata (see app K). A data dictionary is provided with the template to define each metadata item. Users should use the template as a guide for tailoring their own metadata requirements, or to judge the adequacy of producer DQ, for their unique needs. Users should provide feedback to producers to encourage completion of the Data Quality Metadata Template.

6-4. Data transformation

a. Data that has already undergone data producer DQ may need to be transformed or repackaged for M&S applications. These changes may be relatively simple such as map coordinate transformations or they may be complex in cases of aggregation. An example of aggregation occurs when data that is applicable at the item/system level must be aggregated into higher player's units for use in a division-level M&S (for example, data for an individual tank must be transformed into data representing an armor battalion unit). The resulting data transformation amounts to a secondary data production.

b. Data users who perform transformations generally do so to fit the format and context required by their M&S application but they do not generally propagate such changes to others and may not have the resources or responsibility to report data changes to the original data producer. In any case, the ultimate responsibility for evaluating the appropriateness of the data falls on the user. The question of data aggregation is often solved by the data producer (i.e., the item system level) and the data user (i.e., the division-level M&S application) working together to ensure that the transformed data is appropriate for the M&S application.

6-5. Locating DoD data sources

Knowing where to locate and access sources for data is just as important as producing high quality data. DoD data sources used to support M&S which are cataloged through the M&S Resource Repository (MSRR) are found in the Authoritative Data Source (ADS) Library. The intent of the ADS Library is to expedite the search process that occurs with each M&S development and/or implementation event. The ADS Library, managed by DMSO, is available at the following MSRR web site: http://roux.colsa.com.

6-6. Data management

a. Management of M&S data. The management of Army M&S data is governed by the DoDD 8320 series. The Army adheres to these procedures when standardizing data and supports the Army Information Resources Management Program (AR 25-1). AR 25-1 establishes the necessary framework for identifying, organizing, and managing Army data to support the development and implementation of information systems which are interoperable within and among the tactical, operational, strategic and sustaining base environments. The data management program addresses the management of manually processed and automated data from data modeling to the data element level. Data and information that are communicated and shared across organizational boundaries will conform to the policies and standards outlined in the JTA-Army. The data management program requires the active involvement of both functional experts and materiel developers. The program assists the Army in understanding what the information requirements are, where official Army data is maintained, and who uses the data. The program includes the activities of strategic data planning, data element standardization, data synchronization, data security, information management control, and database development and maintenance.

b. Management goals. To ensure consistent results from all Army M&S, M&S data management goals must conform to the goals of the Army data standards program. These goals are to:

(1) Provide a common set of verified, validated, and accredited data which can be shared by Army M&S activities.

(2) Facilitate internal, joint, and combined interoperability through the standardization and use of common data.

(3) Improve data quality and accuracy.

(4) Minimize the cost of data production and data maintenance according to the DoDD 8320 series.

c. Management guidelines. Data, information, and information technologies used in support of M&S are corporate assets and shall adhere to the information management policies contained in DoDD 8000.1.

d. Data and activity models. Data and activity models must be developed to support management activities for data and information, as well as activities required to achieve the mission, business goals, and objectives of DoD data management programs. Data and activity models provide the link needed to unify functional planning, modeling, and implementation activities into a coherent organization or functional activity. These models are used to develop and maintain DoD standard data elements. Models should be created using standard methodologies as reflected in the JTA-Army. Standardization of data such as prime words, data elements, class words, and generic elements will be done in accordance with the procedures in DoDD 8320.1-M (app E). The Defense Data Repository System (DDRS) is a centrally controlled DoD-wide data repository to receive, store, support access to, and manage standard data definitions, data formats, usage, and structures (e.g., architecture, subject area models, and other data model products). DoDD 8320.1-M-1, DoD Data Elements Standardization Procedures, describes the procedure for developing and submitting candidate standard data. Director of Information Systems for Command, Control, Communications, and Computers (DISC4) is designated Component Data Administrator (CDAd) for Army. AMSO is designated by DISC4 as the CDAd for Army M&S standards.

6-7. Identifying Data Standards

In addition to the DOD Defense Data Repository System (DDRS), the Army Model and Simulation Office has set up the Army Standards Repository System (ASTARS). ASTARS is a web-based storage application that allows standards documents to be stored viewed, searched and, when appropriate, browsed and downloaded from a central location. Data standards, in this context, are defined as procedures, practices, processes and algorithms providing a template to develop data for use in M&S. Knowing what data standards exist promotes reuse in M&S and greater confidence in the data employed for each intended use. ASTARS, managed by AMSO, is available at the following web site: http://www.msrr.army.mil/astars.

Appendix A
References

Section I
Required Publications

AR 5-11
Management of Army Models and Simulations, July 10, 1997 (Cited in para 1-1.)

Section II
Related Publications
A related publication is merely a source of additional information. The user does not have to read it to understand this publication.

AR 70-1
Army Acquisition Policy

AR 71-9
Materiel Objectives and Requirements, April 30, 1997

DA Pamphlet 100-1
Force XXI Institutional Army Redesign, March 5, 1998

DoD Directive 5000.59
DoD Modeling and Simulation (M&S) Management, January 4, 1994

DoD Instruction 5000.61
DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), April 29, 1996

The DoD Verification, Validation and Accreditation Recommended Practices Guide, November 1996, the Defense Modeling and Simulation Office, www.dmso.mil/docslib/#mspolicy

The Army Model and Simulation Master Plan, October 1997.

Kaminski, Dr. Paul, Memorandum, subject: DoD High-Level Architecture (HLA) for Simulations, dated September 10, 1996.

Defense Modeling and Simulation Office, High-Level Architecture Rules, Version 1.0, 15 August 1996.

Defense Modeling and Simulation Office, High-Level Architecture Federation Development and Execution Process (FEDEP) Model, Version 1.3, 9 December 1998.

Defense Modeling and Simulation Office, High-Level Architecture Object Model Template, Version 1.1, 12 February 1997.

DOD 5000.2-M
Defense Acquisition Management Documentation and Reports

DoD Regulation 5000.2-R
Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs

DoD 5000.59-M
Glossary of Modeling and Simulation Terms

DoD 5000.59-P
Department of Defense Modeling and Simulation Master Plan, 1995.

DODI 5000.2
Defense Acquisition Management Policies and Procedures

MIL-STD-973
Configuration Management - Engineering Changes, Deviations and Waivers

TRADOC Pamphlet 71-9
Requirements Determination

The Army Plan.
Simulation Support Plan Guidelines, Department of the Army, May 1997.

HQDA White Paper, The Army Vision for M&S After Next, AMSO, 1997.

Section III
Prescribed Forms
There are no entries in this section.

Section IV
Referenced Forms
There are no entries in this section.

Appendix B
Selected Bibliography on VV&A

B-1. The following magazines, conference proceedings, and reports are provided for additional information.

a. Lewis, Robert O. and Gary Q. Coe. " A Comparison Between the CMMS and the Conceptual Model of the Federation," 97 Fall Simulation Interoperability Workshop, September 1997, pp. 1-11.

b. Rothenberg, Jeff, Walter Stanley, George Hanna, and Mark Ralston. Data Verification, Validation and Certification (VV&C): Guidelines for Modeling and Simulation, RAND PM-710-DMSO, August 1997.

c. Rothenberg, Jeff. A Discussion of Data Quality for Verification, Validation and Certification (VV&C) of Data to be Used in Modeling, RAND PM-709-DMSO, August 1997.

B-2. Books

a. Knepell, Peter L. and Deborah C. Arangno. Simulation Validation: A Confidence Assessment Methodology, IEEE Computer Society Press, 1993.

b. Banks, Jerry (editor). Handbook of Simulation Principles, Methodology, Advances, Applications and Practices, John Wiley and Sons, Inc., 1998.

Appendix C
Army Model and Simulation Resources Repository (Army MSRR)

C-1. Army MSRR

a. The Army MSRR is a collection of Modeling and Simulation (M&S) resources that meet the requirement of AR 5-11 to provide a central and comprehensive catalog of Army M&S. The Army MSRR includes information on models, simulations, simulators, algorithms, documents, tools and utilities.

b. The Army MSRR concept calls for a collection of resources hosted on a distributed system of resource servers. These servers are accessible to the World Wide Web (WWW) using the Internet for the unclassified Army MSRR. The Army MSRR provides the registration of resources and users, description and quality information of resources, and specialized search capabilities.

c. All Army MSRR M&S are computerized and represent entities and processes of interest to the Army, have an Army proponent responsible for maintaining the M&S, and currently are in use or in active development.

C-2. VV&A Entry Formats

Each M&S record in the Army MSRR may have as many fields as required that pertain to the state and history of the VV&A process. The recommended formats for VV&A entries are outlined in Table C-1.

Table C-1.
Format for verification, validation and accreditation's history

VERIFICATION AND VALIDATION HISTORY
Verification Proponent
Validation Proponent
Configuration Management Proponent
Description of V&V Performed: (An on-going record of the V&V work, including dates and a description of the process.)
V&V Documents
ACCREDITATION HISTORY
(Model history may include multiple entries of the information below.)
Date of Accreditation
Accrediting Agency
Types of Use(s) For Which Accredited
Study(s) For Which Accreditation Applies
Limitations of Accreditation
Accreditation Documents

Appendix D
Types of M&S Documentation

D-1. Introduction

The following paragraphs describe types of M&S documentation that aid in the VV&A process. This is only a general collection of documentation items and is not to be construed as a mandatory set. The actual documentation produced should describe the baseline version of the M&S in current production usage. M&S programs are often developed under MIL-STDs and have standard software development documentation.

D-2. Typical Set of Documentation for an M&S

A typical set of documentation for an M&S includes the following items:

a. Executive overview. This is a broadly scoped document that describes the general characteristics of the M&S. It should contain appropriate administrative and technical information that a potential M&S user or application sponsor will find helpful in selecting an M&S for a particular application. Suggestions for common terminology to be used in the executive overview can be found in AR 5-11, appendix B. A representative listing of topics for inclusion in the executive overview follows:

(1) *M&S background/history*. Defines M&S purpose, objectives, and pertinent history to include M&S developer, M&S proponent, and actual/potential M&S users and application sponsors. This may also include a summary of the original requirements.

(2) *Description.* Short description of the functional areas represented (such as, close combat, artillery, maneuver, re-supply, and so forth).

(3) *Level.* M&S force level (such as, corps, theater, and so forth).

(4) *Resolution*. M&S level of resolution (identifies the smallest, discrete entities-such as, item, company, and so forth).

(5) *M&S architecture*. This should include time management (such as, event-stepped, time-stepped, hybrid, and so forth), structural characteristics (such as, object-oriented, expert system, procedural, and treatment of randomness), and input/output processor descriptions.

(6) *Hardware/software requirements.* This includes such information as computer hardware type, manufacturer, size, model number, and any limitations, such as memory needs, disk space, need for peripherals, and so forth. Minimum and preferred suite of computer components should be enumerated. Hardware/software requirements also include the computer software licenses required, computer language, data base management system, network protocols, graphics systems, operating system, and any other required supporting software by release version number and vendor (if applicable).

(7) *Configuration management*. This section of the documentation should include a summary of key features of the CM practices and procedures that govern the use of the M&S. Some key features are the M&S developer, the M&S proponent agency and the proprietary status of the M&S components. Additional features include the support structure to provide post “development” software support (PDSS), a summary of current VV&A status, previous uses and users of the M&S, the data sources, and the availability of approved scenarios.

(8) *Limitations*. The overview documentation should outline any limitations in the use of the M&S. It should address limitations due to availability of data, maximum numbers of units and systems, size of geographical areas, highest and lowest echelons, and any other factors that may limit the M&S use.

b. User's manual. M&S may be composed of one or more software components. It is not unusual for most complex M&S to have one or more data preprocessors, the M&S and one or more post processors. Each component of the M&S system should be documented in a user's manual. Typically, a user's manual will contain the following information.

(1) *Installation guide.* This is a set of detailed instructions that walks a user through the installation of all M&S components. It should include items such as the required hardware configuration, required system software releases, required system parameter settings (such as size of swap space, special permissions, and file access settings). It should also include directory and file(s) setup and load procedures from the distribution media, test data, test procedures, and sample output to ensure proper installation.

(2) *Operator instructions.* This is a set of detailed instructions that provides the user with the knowledge necessary to use the M&S system efficiently and effectively. This may include such items as the initialization procedures and parameter definitions, default settings, and range of values. It may also include detailed descriptions of all run parameters, menu items, and manual actions and options; normal exiting procedures; error codes, messages, and recovery actions; and sample terminal sessions and runs.

c. *Data dictionary*. To utilize properly an M&S, the user must understand the data necessary to run the M&S. The M&S data dictionary should provide a listing of all input data items or groups of input data items. For combat M&S, data typically includes:

(1) *Weapon system, and system component characteristics and performance data.* These data items are normally supplied by Army Materiel Systems Analysis Activity (AMSAA) and describe the individual systems represented in the M&S.

(2) *Scenario data.* This includes data concerning geographical area, time frame, enemy and friendly forces, force structure, weapon systems, and logistical supplies, all of which may be provided by outside organizations. User-provided scenario data often include operations plans and orders, missions, tactics, and doctrine and other scenario-driven battle constraints.

(3) *Environmental data.* This includes basic terrain, environmental, and weather data to support the scenario's locale and time of year.

(4) *Other data.* Examples of other data include logistical data, schemes of maneuver, and rules of engagement.

d. *Analysts guide.* This guide is a detailed, comprehensive, technical description of the M&S algorithms and methodologies. This is vital documentation because it provides the user with an in-depth understanding of the M&S functionality, the implicit and explicit assumptions, and the interactions of the M&S algorithms. Typical content of an analyst guide includes the following:

(1) M&S architecture and general algorithmic flow.

(2) Algorithm design to include a call tree and verbal description, flow diagram or pseudocode, and input/output descriptions for each major procedural area.

(3) Object descriptions that include attributes, assets, method descriptions, and interfaces/interactions with other objects.

(4) Output descriptions that define record formats, record fields, and normal postprocessor reports.

(5) Other tips, hints, or cautions to aid analysts.

e. *Source code documentation.* Each major module of the source code should have clear concise documentation embedded within the code as well as header documentation. Items normally included in the header portion are:

(1) Name and description.

(2) Input/output parameter descriptions.

(3) Sample input/output.

(4) Calling and called routines.

(5) Revision history - when and why.

f. *Test and Evaluation Master Plan (TEMP) Requirements.* Current policy guidelines require that any use or development of M&S in support of T&E be documented in the TEMP for the materiel acquisition program. This TEMP input must include a description of the M&S, its intended application, and its VV&A status and plans. A brief summary of the accreditation status of the M&S in question must also be included in the TEMP. An M&S appendix can be attached to the TEMP, if necessary but requires early coordination between the T&E group and the M&S support agency responsible for the test.

g. *Simulation Support Plan (SSP).* The intent of the SSP is to provide the Program Manager (PM) a tool to use in thinking through M&S requirements throughout the acquisition life cycle (see fig D-1). The purpose in providing these guidelines to PMs is to assist in the development of a Simulation Based Acquisition (SBA) to reduce time, resources, and risks as well as improve program implementation. In addition, these guidelines will:

   (1) Explain the thought process in SSP development to achieve a living plan the PM uses to advance the acquisition

   (2) Provide a framework for understanding, developing, and implementing the SSP

   (3) Support the objectives contained in the Army M&S Master plan to include HLA, VV&A, and DIS.

h. *Operational Requirements Document (ORD).* The ORD is the definitive statement describing the operational capabilities needed to satisfy a mission need. It concisely states the minimum essential operational information needed for the acquisition of the materiel solution. The acquisition of the materiel solution must fully consider the impact on Doctrine, Training, Leader Development, Organizations, Materiel and Soldiers (DTLOMS). The ORD is used for large complex M&S.

i. *Model and Simulation Requirements Document (MSRD).* The MSRD is the definitive statement describing the model and simulation operational capabilities needed to satisfy a mission need. It concisely states the minimum essential operational information needed for the acquisition, development or modification of a model and simulation materiel solution. This MSRD is used for single or non-complex M&S.

Approval page.

Coordination page.

Abstract. One page summary of the key points of SSP.

Purpose. Provide a concise statement of purpose.

System Description. Provide brief description of the weapon system.

Program Acquisition Strategy. Weapon system acquisition strategy emphasizing where M&S will reduce cost, as well as the schedule and performance.

Program Simulation Approach/Strategy. Provide a detailed presentation of M&S strategy that supports and enhances the system acquisition strategy.

Management. Provide information about key personnel managing the M&S.

Facilities/Equipment Requirements. Describe the required facilities for all M&S.

Funding. Provide fiscal year and cumulative M&S program expenditures in tabular format.

Remark/additional information. Include any additional information

SSP Appendixes. Include definitions, acronyms and abbreviations along with references

Note: Refer to Simulation Support Plan Guidelines, May, 1997 for more details.

Figure D-1. Simulation Support Plan Format

Appendix E
Configuration Management

E-1. Components of configuration management

The components of configuration management are applied throughout the life cycle of all M&S to ensure continuing operational consistency among the M&S versions.

E-2. Internal control

Internal control is the physical management of the M&S code and documentation. This is the primary function of the configuration manager and continues throughout the life cycle of the M&S.

a. Internal control includes a scheme that permits code access and changes to the baseline to be made only under direct control of the configuration manager. Users and developers normally have read only access to the baseline version of the source code.

b. The configuration manager is also responsible for ensuring that code changes do not produce unexpected results. A process to submit code changes for inclusion into the baseline version of the M&S should be established. This includes the code developer/maintainer documenting the following:

(1) The reason for the change.

(2) Description of the change.

(3) Impact on users.

(4) Expected impact on M&S results.

c. It is extremely important to keep a proper audit trail of the code changes so that causes of unexpected errors can be traced.

d. The configuration manager is also responsible for archiving the M&S code and documentation at key points in the M&S life cycle, for example, the release of a major version.

E-3. External control

External control is the prime function of the configuration manager after M&S release to a user community. Configuration control after M&S release encompasses all of the functions of internal control with the following additions.

a. Documentation of all M&S release requests and, if the request is approved, a documented, archived copy of the released code.

b. Establishing and administering user group activities as described in paragraph 7-4 of AR 5-11.

c. Establishing and administering procedures through which users may receive quick response help and debug assistance.

d. Establishing procedures that allow users to report code and documentation errors. This includes correlating fixes applied to reported difficulties.

E-4. Archiving of M&S uses

Archiving is the management of a historical record of the M&S and its applications. The documentation and storage of M&S results are important functions of configuration management. M&S users should perform this function but archived data should be available to the proponent and other users of the M&S. Items normally archived include:

a. Source code and executable code.

b. Input data.

c. Output data.

d. Documentation of the use of M&S results.

E-5. Storage

Storage of this information that results from each major use of the M&S will ensure a proper audit trail and library of data for use in future VV&A procedures. The application of a particular M&S constitutes an accreditation of the M&S for that specific use. Documentation and archiving of this use will assist in future accreditation procedures.

Appendix F
Verification and Validation (V&V) Plan

F-1. Sample format

The outline of a sample V&V plan is shown at figure F-1. If an M&S is large-scale and complex or if verification and validation are conducted as two distinctly separated efforts, there may be a verification plan and a validation plan.

a. Purpose.
b. Background.
(1) General M&S description.
(2) Configuration management procedures.
(3) Identification of agencies.
c. V&V responsibilities.
d. Intended uses of the M&S.
e. Information sources.
(1) M&S documentation.
(2) M&S developers.
(3) SMEs.
(4) Identification of comparison data.
(5) Previous V&V.
f. Verification plan
(1) Methodology design.
(2) Tasks and milestones.
(3) Report procedures and deliverables.
g. Validation plan.
(1) Methodology design.
(2) Evaluation criteria.
(3) Tasks and milestones.
(4) Report procedures and deliverables.
h. Required resources tied to V&V methodologies.
i. Appendixes.

Figure F-1. Sample format for V&V plan

F-2. Description of V&V plan

The following paragraphs explain the elements of the V&V plan:

a. Purpose. This is a general statement that describes the purpose of the document.

b. Background.

(1) *General M&S description.* Include several paragraphs that describe its characteristics, features, and areas that are modeled. A diagram of the M&S architecture is included in the general description of the M&S and the original developer and current development activities are identified.

(2) *Configuration management procedures.* Include the identification of the version of the M&S that is to undergo the V&V process, and the identification of the version numbers and location of the hardware, software, and data structures to be used in the V&V process. Identification of the configuration manager and procedures as they pertain to the V&V process are also essential elements of information.

(3) *Identification of agencies.* Identify the M&S developers, proponents, intended M&S users and application sponsors, and other contributors that assist in the M&S development or maturation to include data sources.

c. V&V responsibilities. List the agencies that have an active part in the V&V process along with their roles and responsibilities.

d. Intended uses of the M&S. State the purposes for which the M&S is intended to be used and for which validation will be performed. This helps focus the validation efforts.

(1) Identify the M&S domain and, if applicable, the subdomain as an aid in determining an appropriate V&V methodology.

(2) Define the problem which the M&S is intended to solve, including specific questions that the M&S will be expected to contribute to answering.

(3) Define the original problem for which the M&S was designed.

e. Information sources. This section should specifically provide a list of the pertinent information sources on the M&S. This section should include the following.

(1) *M&S documentation.* Identification of all M&S documentation.

(2) *M&S developers.* Identification of personnel who played a part in the development of the M&S.

(3) *SMEs.* Identification of SMEs or other personnel who will define the real world as it pertains to the application of the M&S.

(4) *Identification of comparison data.* Identification of real world data points for use as comparative data.

(5) *Previous V&V.* Identification of any previous V&V efforts.

f. Verification plan. Describe the overall verification effort and identify the components to be evaluated.

(1) *Methodology design.* Describe the design of the methods for logic and code verification that are planned. Include reasons for selection of these methods. Define the scope of the problem and any limitations that may hinder the analysis. Include the depth of the planned tests, any decomposition strategy and the intended depth of the investigation effort.

(2) *Tasks and milestones.* Include any specific agency tasking and responsibilities; resource requirements; verification organization and personnel assignments; and schedule for completion of each task. Describe any interdependencies among tasks.

(3) *Report procedures and deliverables.* Describe the planned verification portion of the V&V report and any other deliverables.

g. Validation plan. Describe the overall validation effort and identify the components to be evaluated.

(1) *Methodology design.* Describe the design of the methods for structural and output validation that are planned. Include reasons for selection of these methods. Define the scope of the problem and any limitations that may hinder the analysis. Include the depth of the planned tests, any decomposition strategy and the intended depth of the investigation effort.

(2) *Evaluation criteria.* Source(s) of the real-world comparison data sets.

(3) *Tasks and milestones.* Include any specific agency tasking and responsibilities, resource requirements, validation organization and personnel assignments, schedule for completion of each task and a description of any interdependencies among tasks.

(4) *Other*. Report procedures and deliverables.

h. Required resources tied to V&V methodologies. For each major V&V methodology effort (e.g., M-T-M), identify the necessary resources in terms of staff months, facilities, tools, key personnel, data collection and data documentation.

i. Appendixes. Add whenever the M&S must undergo verification and/or validation of any M&S enhancements. There should be one appendix for each enhancement or modification that will include:

(1) Why the new V&V needs to be performed.

(2) A description of the V&V to be performed to the level of detail as described in the body of this pamphlet.

Appendix G
Verification and Validation (V&V) Report

G-1. Sample format
The outline of a sample V&V report is shown in figure G-1:

G-2. Description of V&V report
The following paragraphs explain the elements of the sample V&V report.

a. Executive summary of the V&V results. This stand-alone section identifies critical issues, trends, and/or sensitivities of the M&S. It should also present the results of a reasonable, systematic examination of the V&V process of the M&S. This section should give an objective picture of the strengths and weaknesses in terms of the intended use. A specific statement regarding the confidence and credibility associated with the M&S in the context of its intended application is made in this section.

b. Overview of the V&V plan.

(1) Identification of the V&V plan document. Include a description of where and/or how the actual V&V effort differed from the original plan.

(2) Personnel. Identification of the agencies/personnel that performed the V&V.

c. *Description of the verification process and/or tests.* Include the descriptions of the decomposition and the level of depth achieved.

(1) *Logical verification.* Include any test descriptions and results of such tests. Note any differences compared to the original plan.

(2) *Code verification.* Include any test descriptions and results of such tests. Note any differences compared to the original plan.

(3) *Unresolved issues.* Provide a description of any verification that resulted in anomalies.

d. *Description of the validation process and/or tests.* Include the description of the decomposition and level of depth achieved if different from the verification description.

(1) *Evaluation criteria.* Describes the real-world data that were chosen for comparison and/or a brief background of any SMEs.

(2) *Structural validation.* Includes any test description and results of such tests. Note any differences compared to the original plan. Describe which methods were used to perform structural validation.

(3) *Output validation*. Includes any test descriptions and results of such tests. Note any differences compared to the original plan. Describe which methods were used to perform output validation.

(4) *Unresolved issues.* Provide a description of any validation tests that resulted in anomalies.

e. *Identified assumptions, constraints and limitations.* A description of assumptions that were made but had not been documented previously. Any factors that were discovered (e.g., only daylight environment) which would affect the overall intended purpose of the M&S should be identified as a constraint or limitation.

f. *Planned V&V activities.* Any ongoing or currently planned V&V activities or additional V&V requirements resulting from this V&V effort should be identified here.

g. *References/attachments.* V&V plan and any other M&S related documents needed to describe the V&V effort.

h. *Appendixes.* To be added in the future whenever the M&S must undergo V&V of enhancements. There should be one appendix for each addition that includes--

(1) Why the new V&V was performed.

(2) A summary of the findings from the new V&V activities.

(3) A description of the tests to the level of detail described in the body of this pamphlet.

a. Executive summary of the V&V results.

b. Overview of the V&V plan.

c. Description of the verification process and/or tests.

(1) Logic verification.

(2) Code verification.

(3) Unresolved issues.

d. Description of the validation process and/or tests.

(1) Evaluation criteria.

(2) Structural validation.

(3) Output validation.

(4) Unresolved issues.

e. Identified assumptions, constraints and limitations

f. Planned V&V activities.

g. References/attachments.

h. Appendixes.

Figure G-1. Sample format for a V&V report

Appendix H
Accreditation Plan

H-1. Sample format
The outline of a sample accreditation plan is shown at figure H-1.

```
a. Background

b. Accreditation responsibilities.

c. Schedules, milestones, and resources.

d. Intended uses of the M&S.

e. Information sources.

f. Acceptability criteria.

g. Proposed accreditation methodology.
```

Figure H-1. Sample format for accreditation plan

H-2. Description of the accreditation plan.
The following paragraphs explain the elements of the sample accreditation plan.

a. *Background.* A statement of why this M&S was chosen and to what problem it will be applied. This paragraph may duplicate the background paragraph of the V&V plan. It should include a general description of the M&S, a list of all the M&S developers and proponents, and a statement on which version of the software is targeted for accreditation.

b. *Accreditation responsibilities.* Give a brief synopsis of the personnel and agencies involved in the accreditation process and why they were chosen. The M&S application sponsor, the accreditation agent and members of the accreditation team should also be identified.

c. *Schedules milestones and resources.* Itemize the resources required for accomplishing accreditation. Include a schedule, with appropriate milestones, and briefly describe the event(s) that constitute each milestone.

d. *Intended Uses of the M&S.* Describe the roles for which the M&S is intended to be used and the specific use or class of application that this accreditation process is addressing.

e. *Information sources.* Give a short summary of the sources being used to form the basis of the accreditation decision. The items to include in this paragraph are--

(1) Identification of the M&S documentation.

(2) Identification of personnel who played a significant part in the development of the M&S.

(3) Identification of personnel/agencies that were involved in the V&V process.

(4) Identification of the V&V plan document, report document, and findings.

f. *Acceptability criteria.* Acceptability criteria are the most important content of the accreditation plan and should be presented as minimum criteria for accreditation. This paragraph should describe these criteria, how and why they were established, and how the degree of satisfaction of these criteria will be assessed.

g. *Proposed accreditation methodology.* Describe the overall accreditation effort, emphasizing technical tasks to be performed, and the impact of any known limitations or constraints that may affect a complete evaluation of the M&S application (for example, insufficient resources, unavailable or out-of-date documentation). Of utmost importance is a description of the steps or process of assessing whether the acceptability criteria have been adequately met to determine appropriateness of the M&S to the application. Because accreditation will constitute a qualitative assessment, it must be convincing and it must provide the decisionmaker with a relatively high degree of confidence in the recommendations.

Appendix I
Accreditation Report

I-1. Sample format
The outline of a sample accreditation report is shown in figure I-1.

```
a. Executive summary

b. Acceptability Assessment.

(1) Accreditation results and recommendations.

(2) List accreditation limitations for class of use.

c. Acceptability criteria.  List the criteria used for the basis
of the accreditation decision.
```

Figure I-1. Sample format for an accreditation report

I-2. Description of the accreditation report.
The accreditation report must be written in a manner that will allow it to be read and understood as a stand-alone document. Although references to other VV&A plans and reports may be made as necessary, full understanding of the accreditation report must not rest upon the premise that the reader has a detailed understanding of them. The following paragraphs explain the elements of the sample accreditation report.

a. *Executive summary of the accreditation results and recommendations.* Briefly (1-2 pages) describe the major findings, limitations and accreditation recommendations.

b. *Acceptability Assessment.* Present an analysis, which clearly conveys all evidence that the M&S will or will not perform as advertised and that it is appropriate for this class of applications or for this specific application. State also the recommendations for the M&S based on the information given. Specific areas to be included in this paragraph are as follows:

(1) The overall issues and findings of the accreditation process for the M&S.

(2) Highlights of the M&S strengths and limitations, especially in terms of the intended use (training, explanatory, or predictive.)

(3) Identification of agencies/personnel responsible for performing the accreditation.

(4) Recommendations should consist of a statement that explicitly approves or rejects use of the M&S based on the information in the sections above. Any ramifications of proceeding with this application, i.e., all acceptability criteria were not used based on judgment, should be stated in qualitative terms. These terms should reflect the M&S application sponsor's degree of confidence in or the credibility of the results of the M&S in this application.

c. *Acceptability criteria summary*. This section should describe these criteria, how and why they were established, and how the degree of satisfaction of these criteria was assessed. This section should correspond with its counterpart in the accreditation plan. If there is any deviation, it should be so stated and the reasons explained. Information on each criterion chosen should include:

(1) A description of each criterion.

(2) Any possible ratings given. (Give a brief description of the reason for the rating. This may be subjective and should be a discussion of the M&S capability or limitations under this criterion.)

(3) A summary of why this item is important for the intended use of the M&S. Include some degree of criticality of the item.

Appendix J
HLA Federate Compliance Test System

J-1. HLA Federate Compliance Test System.

Note: Refer to http://www.dmso.mil for current information on HLA.

a. In an effort to support the M&S community, the Defense Model and Simulation Office (DMSO) is maintaining two versions of the HLA Specifications, version 1.1 and 1.3. Compliance Tests for Version 1.1 tests against the HLA 1.1 Specifications, while Compliance Tests for Version 1.3 tests against the HLA 1.3 Specifications. Please note that if you have passed testing under version 1.1 and wish to test under 1.3, you need to apply under 1.3. More information on the differences between the HLA Specifications can be obtained from the reference library.

b. A customer requesting an HLA Compliance Test for a federate must submit a test application as described below to DMSO. Once the request is reviewed and approved, the federate developer is responsible for submitting a Federate Compliance Notebook, as described in step 2. When the federate developer has received the Object Model Test results, Test Environment information must be submitted in step 3. The process culminates in a test of the use of the Interface Specification in step 4. A federate that successfully completes the federate compliance test process receives a certification of HLA Compliant.

J-2. STEP 1: APPLICATION

a. In Step 1, the developers of a federate request an HLA Federate Compliance Test from the Federate Certification Agent by completing a test application. Upon receipt, the Federate Certification Agent will check the federate official compliance database to determine the federate's priority for compliance testing. It is important to note that the federate compliance test process is initiated by the federate developer, not the Federate Certification Agent, and it is the responsibility of the federate developer to ensure that the federate under test (FUT) represents a stable, mature release of code. Ideally, the test process should be initiated late in beta testing, so that the actual tests are performed on the release version of the code.

b. To revise a previous request record, supply the User ID Number and Password from the e-mail provided by the HLA Federate Test Certification Agent.

J-3. STEP 2: Federate Compliance Notebook

a. In Step 2 of the HLA federate compliance test process, the federate developer submits the Federate Compliance Notebook which includes the Simulation Object Model (SOM), the Federate Compliance Statement (CS), and (optional) Scenario Data. The Federate Certification Agent checks the SOM for compliance to the OMT ("SOM Compliance Test") and, if successful, checks the SOM against the CS for consistency ("Compliance Cross-Check"). Test results are then returned to the federate developer.

b. The CS may be submitted by completing it online or by using the file upload feature provided below. The recommended means to submit the SOM and (optional) Scenario Data is by file upload. Alternatively, the CS and SOM may be emailed to the test Federate Certification Agent at the email address listed below.

c. The formats for the data in each of the elements of the Federate Compliance Notebook can be found in the Federate Test Reference Library. *Note:* In order to complete a Compliance Statement online or upload files, an user ID and password must be established from Step 1. After successfully completing Step 1, the user ID and password is provided by e-mail to the email address provided on the request form.

J-4. STEP 3: Test Environment

a. In Step 3 of the HLA federate compliance test process, the federate developer will review the Test FOM and Test Sequence generated by the Certification Agent and will submit test environment data to the Certification Agent. Both the federate developer and the Certification Agent will confirm a test date and time.

b. In order to execute the interface test, the federation under test (FUT) must be able to connect to the RTI that is instrumented for testing (v 1.0.2 or higher) and must be prepared to conduct the test sequence multiple times.

c. An important part of this process requires knowledge of the test environment. The required test environment these data include:

(1) API Used.

(2) Federation Execution Host Information.

(3) Operating System.

(4) Hardware Information. (Also required are the *.rid and *.fed files associated with the FUT. These files should be sent with the Step 3, the file upload feature. Another means to submit *.rid and *.fed files is by e-mail to hlatest@msosa.dmso.mil.)

d. *Note:* As with completing Step 2, the User ID and Password must be entered before test environment data and *.rid/*.fed files can be submitted.

J-5. STEP 4: Interface Test

a. In Step 4 of the federate compliance test process, the IF test is executed by the federate developer and the Certification Agent. The IF Test has two parts; the Nominal Test, which ensures that the FUT can invoke and respond to all services for which it is capable, per its CS; and the Representative SOM (RepSOM) test, which ensures that the FUT is capable of invoking and responding to services using a range of data contained in its SOM. The Certification Agent will email a Test Sequence to the federate developer prior to the scheduled date for the IF Test. The Test Sequence will include all the necessary service calls required to satisfy the Nominal Test and the Representative SOM test.

b. The federate developer will review the Test sequence and will be prepared to execute it on the scheduled IF Test date.

c. The Federate Certification Agent will log service data from the test, analyze the data, generate results, and return a Certification Summary Report (CSR) to the federate developer. The CSR is the official record of HLA compliance for the specific version of the federate code tested. Note: Steps 1 through 3 must be completed before starting Step 4.

d. Please submit any questions regarding the HLA compliance test process to hlatest@msosa.dmso.mil.

Appendix K
Data Quality (DQ) Metadata Template

K-1. DQ Metadata Template

a. In chapter 6-3 it is stated that quality metadata is described for three levels which are: the Database (DB) level, the Data Element (DE) level and the Data Value (DV) level. Each of these quality metadata levels has three components: descriptive information, specification information and quality information. Examples of the suggested templates of the DB level for all three components are shown in tables K-1 to K-3.

b. The data producer should capture the DQ metadata from a top down approach. Metadata should be filled out at the DB level first, followed by the DE level and finally by the DV level. The DE level metadata would only be needed if they were different from the DB level metadata; also the DV level metadata would only be needed if they were different from the DE level metadata. The highest level of metadata is usually a general statement of the specific metadata at the lower levels. This top down approach is illustrated in templates, tables K-1, K-4 and K-5, for the descriptive information component for all three levels.

c. Quality metadata should be included with the data in a way that makes capturing and subsequent access to the information most efficient. It should provide a characterization of the data, the organization providing the data and the activities that resulted in the creation of the data. The metadata design should be sufficient to describe the data inputs, internal data processes, transformation and outputs to the user.

K-2. Metadata Prioritization

a. The list of metadata needed to support the user V&V and accreditation is extensive, if every metadata field were required. This would overwhelm the data producer and dilute the effort to provide a core set of metadata in support of the user V&V and Accreditation. Therefore, to set a reasonable scope for producer DQ, each item is ranked based on its relevant importance to the M&S user. The rankings are: 1=Essential; 2=Recommended; and 3="Nice to have."

Table K-1.
DQ Metadata at the Database (DB) Level - Descriptive Information.

Priority	Metadata	Definition
1	Description including meaning of exceptions, nulls, uncertainties	An overall textual characterization of the DB, including a discussion of its intended range of appropriate uses and any constraints on its intended use. Includes a discussion of the meaning of exceptions, nulls, and uncertainties within the DB.

Table K-1.
DQ Metadata at the Database (DB) Level - Descriptive Information.

Priority	Metadata	Definition
1	Access requirements	Information about the requirements for gaining access to the DB, including owning agency, point of contact (phone and FAX numbers, e-mail, and postal addresses, etc.), what restrictions apply to its access and use, and any copyright or foreign distribution requirements or constraints that apply to it. Also includes any user requirements, such as special S/W or H/W, special pre- or post-processing, etc.
1	Resolution and rationale	A description of the overall level of resolution of the data in the DB, including the reasons for choosing this level, in terms of the stated purpose of the DB and its design, source, and relationship to other DBs. If the DB cannot be characterized as having a single, uniform level of resolution, the lack of consistency must be explicitly stated and justified in terms of the intended use of the database.
1	Usage (who, when, for what, with what model)	The history of the DB, including a POC for each instance of use and a description of what the DB was used for. * (Linked to V&V audit trail)
1	V&V audit trail	A history of quality assessment efforts applied to the DB, including records of V&V results. This should be linked to the usage history metadata above and to the metadata for the V&V audit trail at the data element and data value
1	Classification	Simple statement about the security level of the database.
1	Release authority	Organization/Agency and/or POC authorized to release all or part of the DB for use.
2	Data Sources	Discussion of where the source information contained within the DB came from (immediate source and original source) including agency/organization, POC, etc.
2	Source credibility	Discussion of the credibility of the agency/organization/POC providing the data in the database. Identify who has certified the immediate and original data sources as credible.
2	Descriptions of processes used	A discussion of the processes that are used to derive, generate, collect, and transform the data (and metadata) in the DB.
2	Version history	Explicit version documentation showing which agents revised the DB at which times and what kinds of changes they made, including descriptions of changes to structure, content, or meaning of both data and metadata at the conceptual level. An official record of changes to a DB by the agency or organization that owns and has responsibility for maintaining it.
3	Overall database status	Concise statement of the condition of the DB, indicating whether it is in transition, how stable it is, and what expected future changes will affect it. This includes 'configuration management' information that explains how versions are maintained and by whom, and references to descriptions of any standard methodology of software used for version control.
3	Description /rationale for structure and design	A textual characterization of the DB design and structure and a discussion of their rationale, relating them to the intended purpose and use of the DB. It should include such overall aspects as the language and format of the DB. The rationale serves as consistency check against the discussion of intended use.
3	Global relationships to other databases	An explicit description of the overall relationship of this DB to any others. It should explain any semantic and/or historical relationships between this DB and any others, making clear whether the relationship is expected (or required) to continue to hold true.

Table K-1.
DQ Metadata at the Database (DB) Level - Descriptive Information.

Priority	Metadata	Definition
3	Reproducibility	The ability of the producer to provide exact replications of a previously supplied DB (new database instance). **
3	Cross DE distribution measurement info	A description of statistical checks to be applied to distributions of values across different data elements in the DB. (Metadata for such checks applied to distributions of values of single data elements should be specified at the data element level.)
3	Rationales for using the processes	Discussion of the reasons for choosing each process used for the derivation, generation, collection, and transformation of data (and metadata) within the DB.
3	Owners of the processes (development, maintenance, execution)	Agents responsible for choosing and developing the processes used for the derivation, generation, collection, and transformation of data (and metadata) within the DB, including agency/organization, POC, etc.
3	Update cycle information	A statement of how often, how regularly, and how extensively the DB is expected to be updated. Overlaps with 'currency' metadata, but the emphasis here is on giving an overview of when, how, and by whom the DB is revised or reissued, rather than on how current the information within it may be at any given time.

* *Note:* Instance Data is defined as exact values in a specific field within the data set.
** *Note:* Instance/Session of a DB is defined as an individual, populated data set.

Table K-2.
DQ Metadata at the Database (DB) Level - Specification Information

Priority	Metadata	Definition
2	System specification and design document	Formal description of the database structure and content.
2	Standards	Compliance with International, National, DoD, or M&S Community data standards, e.g., DDDS.
2	Specific Data Sets	Instances/sessions of the DB**. A discussion of each data set for which the given DB design is used. Each instance of a DB may be static or dynamic, and this aspect should be documented as part of its description.
3	DBMS information including version and CM	Description of database management system current version, version history.
3	Logical Data Models	Discussion/depiction of the data that must be stored in order to satisfy user needs, and its interrelationships.
3	Physical Data Models	Discussion/depiction of how data elements are implemented and stored in the DB.
3	Process Flow Models	Discussion/depiction of process streams and associated data elements.
3	Data Flow Models	Discussion/depiction of how data flows and is processed within the DB.

***Note*: Instance/Session of a DB is defined as an individual, populated data set.

Table K-3.
DQ Metadata at the Database (DB) Level - Quality Information

Priority	Metadata	Definition
1	Accuracy according to positional and attribute specs	A discussion of the degree of agreement between a datum and source assumed to be correct (real world).
1	Completeness in features and attributes	A discussion of how the DB satisfies all data content demands or requirements.
1	Currency	A discussion of how up-to-date the DB is.
2	Logical consistency	A discussion of how the DB is maintained so it is free from excessive variation or from contradiction of expected/standard ranges.

2	Flexibility of design	A discussion of the potential ability of the DB design to support 'non-traditional' uses.
3	Clarity of design	A discussion of how the DB is designed to allow ease of understanding of the underlying structure and content.
3	Timeliness	A condition that requires that a DB be provided at the time required or specified. A discussion of how quickly the DB can be generated from the time of request.

Table K-4.
DQ Metadata at the Data Element (DE) Level - Descriptive Information

Priority	Metadata	Definition
1	Description including meaning of exceptions, nulls, uncertainties	An overall textual characterization of the semantics of the DE, including a discussion of what it is intended to represent and what it is not. Includes a textual characterization of the meaning of nulls or any exceptional, special, or unknown values of this DE.
1	Degradation information	The 'mode' in which values of a DE are expected to degrade over time: some values become continuously less accurate or less meaningful as they age, whereas others remain entirely valid until they 'expire', i.e, when some event changes the reality which they represent.
1	Aggregation, derivation, or transformation information	Whether and how values for this DE are derived from other data, including a discussion of any grouping or other derivation method used to generate this DE, and any other data values used in this derivation, or any transformations that are applied in generating this DE
1	Resolution and precision	The level of detail and number of significant digits in numerical values of this DE, including any representation issues (such as precision limits imposed by field-length or encoding).
1	V&V audit trail	A high-level history of quality assessment efforts applied to the DE, allowing certification results to be recorded. This should be linked to the usage history metadata above and to the metadata for the V&V audit trail at the database and data value
2	Source or sources and deconflicting processes and rationales	Where the source information contained within the DE came from (immediate source versus original source) including agency/organization, POC, etc. Includes a qualitative, textual discussion of the 'goodness' of the DB including information about the agency/organization, POC, etc making the credibility assessment.
2	Changes or modifications of source element and effect on this DE	The update-cycle metadata for the DB as a whole, focusing on the revision of a particular DE, which may be different for different DEs within the DB. Different levels of revision may occur, corresponding to more or less complete revisions by more or less authoritative sources or agents.
2	Accessibility	The state of maintaining a DE in a condition that provides the ability to retrieve the specific information needed by the user.
2	Release authority	Organization/Agency and/or POC authorized to release the DE.
2	Process control data	A historical record of how the generation of the DE was controlled, including descriptions of process modeling methodology, or external descriptions of the process in some appropriate form or publication.
2	Audit trail of changes to element	A history of any changes to the definition of this DE, i.e., its type, domain, units, or meaning including times and sources of any such modifications and the changes themselves.
2	History of changes or modifications	Explicit version documentation showing which agents revised the DE at which times and what kinds of changes they made, including descriptions of changes to structure, content, or meaning of both data and metadata at the conceptual level. An official record of changes to a DE by the agency or organization that owns and has responsibility for maintaining it.
3	Update cycles	How often, how regularly, and how extensively the DE is expected to be updated. Overlaps with 'currency' metadata, but the emphasis here is on giving an overview of when, how, and by whom the DE is revised or reissued, rather than on how current the information within it may be at any given time.
3	Reproducibility	The ability for the users to reuse the data elements retrieved.
3	Classification	Simple statement about the security level of the data element.
3	Constraints	A description of any limitations or restrictions that apply to this DE, beyond those implied by its domain and data type, including desirable constraints such as DB 'business rules'.
3	Relationships to other data/DB Description	How this DE relates to other DEs in this DB or other DBs, including descriptions of consistency or statistical checks to be applied to distributions of values of single DE.

Table K-5.
DQ Metadata at the Data Value (DV) Level - Descriptive Information

Priority	Metadata	Definition
1	Definition (if more specific than at DE or if applied to data value groupings)	An overall textual characterization of the actual instance values of data.
1	Aggregation, derivation, or transformation information	Whether and how this DV was derived from other data, including a discussion of any grouping or other derivation method used, and any other data values used in this derivation, or any transformations that are applied in generating this DV.
1	V&V audit trail	All evaluations that have been performed on the data value, linked to usage history and the V&V Audit Trail information at the database and DE levels.
2	Source	Discussion of where the DVs came from, including agency/organization, POC, etc.
2	Caveats or exceptions (for DV acceptance if not within accepted values)	Textual annotations to explain DB instance-specific data values, including any annotations or comments about exceptional values or missing data.
2	Process control data	A discussion/depiction of how the generation of the DV was controlled, including descriptions of process modeling methodology, or external descriptions of the process in some form or publication.
3	Time of generation	Date/time ‘stamp’ of the DV generation.
3	Cross data value, associative data value, or data value grouping information	A description of consistency restrictions or limitations across different DVs.
3	Update cycle or next expected update	A statement of how often, how regularly, and how extensively the DV is expected to be updated emphasizing an overview of when, how, and by whom the DV is revised or reissued, rather than on how current the information within it may be at any given time.

Glossary

Section I
Abbreviations

AAE
Army Acquisition Executive

ACR
Advanced Concepts and Requirements

ADE
Army Data Encyclopedia

ADO
Army Digitization Office

ADS
Advanced Distributed Simulation

ADS Library
Authoritative Data Source Library

AEA
Army Enterprise Architecture

AFOR
Automated Forces

AI
Artificial Intelligence

AIS
Automated Information System

ALSP
Aggregate Level Simulation Protocol

AMC
U.S. Army Materiel Command

AMG
Architecture Management Group

AMIP
Army Model Improvement Program

AMSAA
Army Materiel Systems Analysis Activity

AMSCAT
Army Model and Simulation Catalog

AMS GOSC
Army Model and Simulation General Officer Steering Committee

AMSEC
Army Model and Simulation Executive Council

AMSO
Army Model and Simulation Office

AMSMP
Army Model and Simulation Management Program

AMSMP WG
Army Model and Simulation Management Program Working Group

AoA
Analysis of Alternatives

AR
Army Regulation

ARI
U.S. Army Research Institute for Behavioral and Social Sciences

ASA (ALT)
Assistant Secretary of Army for Acquisition, Logistics and Training

ASA (FM&C)
Assistant Secretary of Army for Financial Management and Comptroller

ASA (M&RA)
Assistant Secretary of the Army (Manpower and Reserve Affairs)

ASTARS
Army Standards Repository System

AWC
U.S. Army War College

C4I
Command, Control, Communications, Computers, and Intelligence

CAA
U.S. Army Center for Army Analysis

CASE
Computer Aided Software Engineering

CASTFOREM
Combined Arms and Support Task Force Evaluation Model

CDAd
Component Data Administrator

CG, TRADOC
Commanding General, U.S. Army Training and Doctrine Command

CGF
Computer Generated Forces

CINC
Commander-in-Chief

CM
Configuration Management

CMF
Conceptual Model of the Federation

CMMS
Conceptual Models of the Mission Space

COB
Command Operating Budget

COE
Corps of Engineers

COTS
Commercial Off-The-Shelf

CS
Compliance Statement

CSA
Chief of Staff of the Army

CSR
Certification Summary Report

DAB
Defense Acquisition Board

DARPA
Defense Advanced Research Projects Agency

DAS (R&T)
Deputy Assistant Secretary for Research and Technology

DCG
Deputy Commanding General

DCSINT
Deputy Chief of Staff for Intelligence

DCSLOG
Deputy Chief of Staff for Logistics

DCSOPS
Deputy Chief of Staff for Operations and Plans

DCSPER
Deputy Chief of Staff for Personnel

DDL
Delegation of Disclosure Letter

DDDS
Defense Data Dictionary System

DDRS
Defense Data Repository System

DEA
Data Exchange Annex

DIS
Distributed Interactive Simulation

DISA
Defense Information Systems Agency

DISC4
Director of Information Systems for Command, Control, Communications, and Comput-erstitleense Modeling and Simulation Office

DoD
Department of Defense

DoDD
Department of Defense Directive

DPRB
Defense Planning and Resources Board

DQ
Data Quality

DS
Distributed Simulations

DSI
Defense Simulation Internet

DTD
Digital Topographic Data

DUSA (IA)
Deputy Under Secretary of the Army for International Affairs

DUSA(OR)
Deputy Under Secretary of Army for Operations Research

EUSA
Eighth U.S. Army

EXCIMS
Executive Council for Modeling and Simulation

FED
Federation Execution Data

FDMS
Functional Description of the Mission Space

FFRDC
Federally Funded Research and Development Center

FMS
Foreign Military Sales

FOA
Field Operating Agency

FOM
Federation Object Model

FORSCOM
U.S. Army Forces Command

FUT
Federate/Federation Under Test

FY
Fiscal Year

GO
General Officer

HLA
High Level Architecture

HOL
High Order Language

HQDA
Headquarters, Department of Army

IA
International Agreement

IAC
Information Analysis Center

IDEF
Integrated Definition Language

IEA
Information Exchange Annex

IEEE
Institute of Electrical and Electronic Engineers

IPG
Interim Policy Guide

IPR
In-Process Review

ISTC
Integrated System Test Capability

IV&V
Independent Verification and Validation

JROC
Joint Requirements Oversight Council

JTA - Army
Joint Technical Architecture – Army

LCM
Life Cycle Management

LOA
Letter of Agreement

MACOM
Major Army Command

MAIS
Major Automated Information Systems

MAISRC
Major Automated Information Systems Review Council

MAP
Mandatory Procedures for Major Defense Acquisition Programs

MDA
Milestone Decision Authority

MDEP
Management Decision Package

M-E-M
Model-Exercise-Model

MOA
Memorandum of Agreement

MOE
Measure of Effectiveness

MOP
Measure of Performance

M&S
Model(s) and Simulation(s)--Used in singular and plural

MSEA
M&S Executive Agent

MSIS
Model and Simulation Information System

MSRD
Model & Simulation Requirements Document

MSRR
Model and Simulation Resource Repository

M-T-M
Model-Test-Model

MTMCTEA
Military Traffic Management Command Transportation Engineering Agency

NGB
National Guard Bureau

NIMA
National Imagery and Mapping Agency

NSTD
Non-System Training Device

OCAR
Office of the Chief, Army Reserve

OGC
Office of the General Counsel

OMA
Operations and Maintenance, Army

OPA
Other Procurement, Army

OPTEC
U.S. Army Operational Test and Evaluation Command

ORD
Operational Requirements Document

OSA
Office of Secretary of the Army

P&A
Price and Availability

PAED
Army Program Analysis and Evaluation Directorate

PAO
Public Affairs Official

PDSS
Post Development Software Support

PDU
Protocol Data Unit

PEG
Program Evaluation Group

PEO
Program Executive Officer

PM
Program Manager

POC
Point of Contact

POM
Program Objective Memorandum

PPBES
Planning, Programming, Budgeting, and Execution System

PPBS
Planning, Programming, and Budgeting System

PBD
Program Budget Decision

QA
Quality Assurance

QC
Quality Control

R&D
Research and Development

RDA
Research, Development and Acquisition

RDT&E
Research, Development, Test and Evaluation

RFP
Request for Proposal

RIC
Requirements Integration Council

RID
Runtime Infrastructure Initialization Data

RIWG
Requirements Integration Working Group

RPG
Recommended Practices Guide

RTCA
Real Time Casualty Assessment

RTI
Runtime Infrastructure

S&T
Science and Technology

SAF
Semi-automated Forces

SBA
Simulation Based Acquisition

SCC
Standards Category Coordinator

SDIO
Strategic Defense Initiative Organization

SES
Senior Executive Service

SIMTECH
Simulation and Technology Program

SMART
Simulation and Modeling for Acquisition, Requirements and Training

SMDC
U.S. Army Space and Missile Defense Command

SME
Subject Matter Expert

SNE
Synthetic Natural Environment

SOM
Simulation Object Model

SOW
Statement of Work

SSA
Staff Support Agency

SSP
Simulation Support Plan

STOW
Synthetic Theater of War

T&E
Test and Evaluation

TAFIM
Technical Architecture Framework for Information Management

TEA
U.S. Army Transportation Engineering Agency

TEC
U.S. Army Topographic Engineering Center

TEMO
Training Exercises and Military Operations

TEMP
Test and Evaluation Master Plan

TPO
Technical Project Officer

TRAC
Training and Doctrine Command Analysis Center

TRADOC
U.S. Army Training and Doctrine Command

TRANSCOM
U.S. Transportation Command

UJTL
Uniform Joint Task List

USACAA
U.S. Army Center for Army Analysis

USACE
U.S. Army Corps of Engineers

USAREUR
U.S. Army Europe

USARPAC
U.S. Army Pacific

USARSO
U.S. Army, South

USASAC
U.S. Army Security Assistance Command

USASOC
U.S. Army Special Operations Command

VCSA
Vice Chief of Staff of the Army

V&V
Verification and Validation

VV&A
Verification, Validation, and Accreditation

Section II
Terms

Accreditation
The official determination that a model, simulation, or federation of M&S is acceptable for use for a specific purpose.

Accreditation Agent
The organization designated by the application sponsor to conduct an accreditation assessment for an M&S application.

Accreditation Criteria
A set of standards that a particular model, simulation, or federation of M&S must meet to be accredited for a specific purpose.

Advanced Concepts and Requirements (ACR) Domain
One of the three domains for Army M&S applications. ACR includes experiments with new concepts and advanced technologies to develop requirements in doctrine, training, leader development, organizations, materiel and soldiers that will better prepare the Army for future operations. ACR evaluates the impact of horizontal technology integration through simulation and experimentation using real soldiers in real units.

Advanced Distributed Simulation (ADS)
A set of disparate M&S operating in a common synthetic environment within which humans may interact at multiple sites networked using compliant architecture, modeling, protocols, standards, and databases. The ADS may be composed of three modes of simulation-- live, virtual, and constructive, which can be seamlessly integrated.

Analysis
A broad category of study and investigation which includes support to operational, tactical, and strategic decision making.

Analysis of Alternatives (AoA)
A study conducted to provide support for acquisition decisions in the acquisition cycle. The AoA illuminates the relative advantages and disadvantages of the alternatives being considered showing the sensitivity of each alternative to possible changes in key assumptions (e.g., threat) or variables (e.g., performance capabilities). There shall be a clear linkage between the AoA, system requirements, and system evaluation measures of effectiveness.

Application
A specific, individual project session that requires or uses an M&S to achieve its purpose.

Application Sponsor
The organization that utilizes the results or products from a specific application of a model or simulation.

Architecture
The structure of components in a program/system, their relationships, and the principles and guidelines governing their design and evolution over time.

Army Enterprise Architecture (AEA) Master Plan
An integrated plan of action for accomplishing Army-wide information technology and investment strategies to accomplish the Joint Vision and the Army Vision 2010. It documents the total AEA and specifies the information systems programs and resource requirements necessary to support stated sessions and objectives.

Army Model and Simulation Standards Report
The Army Model and Simulation Standards Report contains the yearly status of Army efforts to standardize model and simulation techniques and procedures. It also reflects the Army's yearly model and simulations investments throughout the Army Model Improvement Program (AMIP) and the Simulation Technology (SIMTECH) Program.

Army Standards Repository System (ASTARS)
ASTARS is a web-based storage application that allows standards documents to be stored viewed, searched and, when appropriate, browsed and downloaded from a central location.

Automated Information System (AIS)
A combination of information, computer hardware, software, personnel, and telecommunications resources that collects, records, processes, stores, communicates, retrieves, and/or displays information.

Common Use M&S
M&S applications, services, or materials provided by a DoD Component to two or more DoD components.

Computer Generated Forces (CGF)
A capability/technology where computer generated forces are a doctrinally correct representation of both friendly and opposing forces. These forces will support simulations by providing opposing forces, supporting forces, and forces needed to permit a smaller number of personnel to represent a much larger force.

Configuration Management (CM)
The application of technical and administrative direction and surveillance to identify and document the functional and physical characteristics of an M&S, control changes, and record and report change processing and implementation status.

Constructive M&S
M&S that involve real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems.

Data
A representation of facts, concepts, or instructions in a formalized manner, suitable for communication, interpretation, or processing by human or by automatic means.

Data Accreditation
The determination that data have been verified and validated. Data user accreditation is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage and are included as part of the M&S VV&A process. Data producer accreditation is the determination by the data producer that data have been verified and validated against documented standards or criteria.

Data Exchange Standard
Formally defined protocols for the format and content of data messages used for interchanging data between networked simulation and/or simulator nodes used to create and operate a distributed, time and space coherent synthetic environment. Current standards include ALSP and DIS Protocol Data Units.

Data Proponent
The agency or organization that has primary responsibility for data collection or data base. The proponent develops the requirement for the data.

Data Standards
A capability that increases information sharing effectiveness by establishing standardization of data elements, data base construction, accessibility procedures, system communication, data maintenance and control.

Data Validation
The documented assessment of data by subject area experts and its comparison to known values. Data user validation is an assessment as appropriate for use in an intended M&S. Data producer validation is an assessment within stated criteria and assumptions.

Data Verification
Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.

Defense Simulation Internet (DSI)
A wide band telecommunications network operated over commercial lines with connectivity to both military and civilian satellites allowing users to be linked on a worldwide, wide area network.

Distributed Interactive Simulation (DIS)
A subset of advanced distributed simulation, which interfaces through the use of DIS Protocol Data Units.

Dynamic Environment
The constantly changing environment as a result of man-made efforts (battlefield smoke) and natural phenomenon (weather). Incorporating dynamic environment into real time simulations provides a more realistic test bed for weapons, equipment, and personnel.

Emulator
A physical M&S which duplicates the behavior, properties, or performance of another system. Emulators are frequently used to generate inputs for other M&S.

Fair Fight
Two or more simulations may be considered to be in a fair fight when differences in the simulations' performance characteristics have significantly less effect on the outcome of the conflict than actions taken by the simulation participants.

Federation Element
Term applied to an individual M&S that is part of a federation of models and simulations. Federation elements may be distributed.

Federation of Models and Simulations
A system of interacting M&S with supporting infrastructure, based on a common understanding of the objects portrayed in the system.

Firmware
The combination of a hardware device and computer instructions or computer data that reside as read-only software on the hardware device. The software cannot be readily modified under program control.

General-use M&S Applications
Specific representations of the physical environment or environmental effects used by, or common to, many M&S (e.g., terrain, atmospheric, or hydrographic effects).

High-Level Architecture (HLA)
Major functional elements, interfaces, and design rules, pertaining, as feasible, to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined.

Independent Verification and Validation (IV&V)
The conduct of verification and validation of M&S by individuals or agencies that did not develop the M&S. IV&V does not require complete organizational independence, but does imply a reasonable degree of organizational separation to assure unbiased analysis.

Interoperability
The ability of a set of M&S to provide services to and accept services from other M&S and to use the services so exchanged to enable them to operate effectively together.

Live Simulation
A representation of military operations using live forces and instrumented weapon systems interacting on training, test, and exercise ranges which simulate experiences during actual operational conditions.

Management Threshold
The threshold or limit, as defined by management, when an M&S passes from the management considerations of one category or level to the management considerations of another category.

Measure of Effectiveness (MOE)
A qualitative or quantitative measure of the performance of a model or simulation or a characteristic that indicates the degree to which it performs the task or meets an operational objective or requirement under specified conditions.

Measure of Performance (MOP)
Measure of how the system/individual performs its functions in a given environment (e.g., number of targets detected, reaction time, number of targets nominated, susceptibility of deception, task completion time). It is closely related to inherent parameters (physical and structural) but measures attributes of system behavior. See also measure of effectiveness.

Model
A model is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

Model Types.
Physical model. A physical representation of the real world object as it relates to symbolic models in the form of simulators.
Mathematical model. A series of mathematical equations or relationships that can be discretely solved. This includes M&S using techniques of numerical approximation to solve complex mathematical functions for which specific values cannot be derived (e.g., integrals).
Procedural model. An expression of dynamic relationships of a situation expressed by mathematical and logical processes. These models are commonly referred to as simulations.

M &S Developer
The organization responsible for developing, managing or overseeing M&S developed by a DoD component, contractor, or Federally Funded Research and Development Center. The developer may be the same agency as the proponent agency.

M&S Proponent
The organization responsible for initiating the development and directing control of the reference version of a model or simulation. The proponent will develop and execute a viable strategy for development and maintenance throughout the life cycle of the M&S and for directing the investment of available resources. The M&S proponent serves as the advocate and final authority on their M&S. The proponent will advise the DUSA(OR) on release of the M&S to foreign countries, and will advise the MACOM or Organizational Release Authority for domestic release. Except where responsibilities are specifically designated to an acquisition official by DoD or DA policy e.g. DoD 5000.2 or AR 70-1, the M&S proponent is responsible for, but may delegate execution of: M&S Development; Configuration Management; Preparation and Maintenance of Simulation Object Models (SOMs) as appropriate; all aspects of Verification and Validation; and maintenance of current information in all catalogs and repositories.

Modeling and Simulation (M&S)
The development and use of live, virtual, and constructive models including simulators, stimulators, emulators, and prototypes to investigate, understand, or provide experiential stimulus to either (1) conceptual systems that do not exist or (2) real life systems which cannot accept experimentation or observation because of resource, range, security, or safety limitations. This investigation and understanding in a synthetic environment will support decisions in the domains of research, development, and acquisition (RDA) and advanced concepts and requirements (ACR), or transfer necessary experiential effects in the training, exercises, and military operations (TEMO) domain.

Non-System Training Device (NSTD)
A training device or simulation which is not directly identified with a unique weapons system, but rather has application over a wide spectrum of potential users (e.g., WARSIM). The NSTD process is governed by the AR 70 series.

Open Systems Environment
The fielding of hardware and software products is interoperable and portable. The objective is to promote competition by allowing systems developed by multiple vendors and nations to interoperate through a common set of computer and communications protocols.

Pre-Processor
A software (and sometimes hardware) unit which conditions or prepares data before the data is input into a model or simulation. For example, a code which converts metric data from Cartesian (rectangular) coordinates to flight coordinates (Euler angles) prior to its being input into an aircraft or guided missile model.

Post Processor
A software (and sometime hardware) unit which conditions data after it is output by a model or simulation, in order to adapt it to a human analyst/observer or to another model. For example, a code, which converts streams of metric measurement data from a simulation into a graphic representation of a scene as viewed from the perspective of an aircraft or missile.

Proponent
See M&S Proponent or Data Proponent.

Protocol Data Unit (PDU) Standards
In accordance with IEEE Standard 1278, formally defined data exchange standards established for each of the several primary classes of functionality, which is represented, in the DIS synthetic environment (e.g., movement, weapons, firing effects, collisions, etc.).

Reference Version
The most recent version of an M&S which has been released for community use by, and under configuration management of, the M&S users group executive committee.

Research, Development, and Acquisition (RDA) Domain
One of the three domains for Army M&S applications. Includes all M&S used for design, development, and acquisition of weapons systems and equipment. M&S in the RDA domain are used for scientific inquiry to discover or revise facts and theories of phenomena, followed by transformation of these discoveries into physical representations. RDA also includes test and evaluation (T&E) where M&S are used to augment and possibly reduce the scope of real world T&E.

RTI Initialization Data (RID) File
This file is associated with the specific runtime infrastructure (RTI) implementation being used within the current federation under execution.

Simulation
A method for implementing a model(s) over time.

Simulator
A device, computer program, or system that performs simulation.
For training, a device, which duplicates the essential, features of a task situation and provides for direct practice.
For Distributed Interactive Simulation (DIS), a physical model or simulation of a weapons system, set of weapon systems, or piece of equipment which represents some major aspects of the equipment's operation.

Sponsoring Agency
The agency which sponsors the development or use of M&S utilizing either in-house, other government agency, or contract resources.

Standard
A rule, principle, or measurement established by authority, custom, or general consent as a representation or example.

Standards Categories
The elements of the framework for M&S standards development. The standards framework contains all the things the Army M&S community seeks to represent algorithmically, devolved into categories which are assigned to the Army agencies best suited to coordinate development and maintenance of standards in the technical regime represented by that category.

Stimulator
A hardware device that injects or radiates signals into the sensor system(s) of operational equipment to imitate the effects of platforms, munitions, and environment that are not physically present.
A battlefield entity consisting of hardware and/or software modules which injects signals directly into the sensor systems of an actual battlefield entity to simulate other battlefield entities in the virtual battlefield.

Symbolic M&S
M&S which represent a real system using mathematical equations or computer programs. Symbolic M&S are contrasted from other representations such as maps, board games, field exercises, and mockups.

Synthetic Environments (SE)
Internetted simulations that represent activities at a high-level of realism from simulations of theaters of war to factories and manufacturing processes. These environments may be created within a single computer or a vast distributed network connected by local and wide area networks and augmented by super-realistic special effects and accurate behavioral models. They allow visualization of and immersion into the environment being simulated.

Technical Architecture
A minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements that together may be used to form an information system, and whose purpose is to insure that a conformant system satisfies a specified set of requirements.

Test and Evaluation (T&E)
Test and evaluation includes engineering, developmental, and operational tests.

Training Effectiveness Analysis (TEA)
A study conducted by TRADOC Analysis Center (TRAC) to determine the adequacy of the operator, maintainer, unit, and institutional training for new equipment that is fielded. TEAs evaluate training environment, training devices, soldier hardware-software interface, and military occupational specialty selection criteria.

Training, Exercises, and Military Operations (TEMO) Domain
One of the three domains for Army M&S applications. TEMO includes most forms of training at echelons from individual simulation trainers through collective, combined arms, joint, and/or combined exercises. TEMO includes mission rehearsals and evaluations of all phases of war plans. Analysis conducted during the rehearsal or evaluation validates the plan as best as the simulation environment will allow.

Validation
The process of determining the extent to which an M&S is an accurate representation of the real world from the perspective of the intended use of the M&S. Validation methods include expert consensus, comparison with historical results, comparison with test data, peer review, and independent review.

Validation Agent
The organization designated by the M&S sponsor to perform validation of a model, simulation, or federation of M&S.

Verification
The process of determining that an M&S accurately represents the developer's conceptual description and specifications. Verification evaluates the extent to which the M&S have been developed using sound and established software-engineering techniques.

Verification Agent
The organization designated by the M&S sponsor to perform verification of a model, simulation, or federation of M&S.

V&V Agent
The organization designated by the M&S sponsor to perform verification and validation of a model, simulation, or federation of M&S.

V&V Proponent
The government agency responsible for ensuring V&V is performed on a specific M&S.

Virtual M&S
A synthetic representation of warfighting environments patterned after the simulated organization, operations, and equipment of actual military units.

Index

This index is organized alphabetically by topic and subtopic within topic. Topics and subtopics are identified by paragraph number.