SUMMARY of CHANGE

ATEC Pamphlet 73-21
Modeling and Simulation Verification, Validation, and Accreditation Methodology

This is a new ATEC pamphlet. It supersedes the following publications:


Test and Evaluation
MODELING AND SIMULATION VERIFICATION, VALIDATION AND ACCREDITATION METHODOLOGY

*History. This is a new pamphlet.

Summary. This pamphlet describes an integrated approach for the verification, validation, and accreditation (VV&A) processes required for models and simulations (M&S) used for supporting test and evaluation (T&E).

Applicability. This pamphlet applies to Headquarters (HQ) Army Test and Evaluation Command (ATEC) and all subordinate command activities (SCAs).

Supplementation. Supplementation of this pamphlet is prohibited without the prior approval of ATEC HQ (CSTE-TT). When supplements are approved and issued, one copy of each supplement will be furnished to ATEC HQ (CSTE-TT).

Suggested improvements. The proponent for this pamphlet is the Director, Test Technology, ATEC. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) through the chain of command to Commander, ATEC, ATTN: CSTE-TT, 4501 Ford Avenue, Alexandria, VA 22302-1458.

Distribution: BE
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Chapter 1
Introduction

1-1. Purpose

a. This methodology describes an integrated approach for the verification, validation, and accreditation (VV&A) processes required for models and simulations (M&S) used by the U.S. Army Test and Evaluation Command (ATEC). It provides guidance in support of ATEC Regulation 73-21.

b. The guidance contained in this document complies with current Department of Defense (DOD) and Department of the Army (DA) guidance on the VV&A of M&S. It supplements guidance in DOD Directive (DODD) 5000.59, Army Regulation (AR) 5-11, DA Pamphlet 5-11, AR 73-1, DOD Instruction (DODI) 5000.61, and the DOD M&S Office (DMSO) VV&A Recommended Practices Guide (RPG). Current DOD M&S VV&A guidance predominantly addresses issues associated with software solutions to M&S and does not address other implementations of M&S such as behavioral models (e.g., command, control, communications, computers, and intelligence (C4I) simulators and stimulators), hardware-in-the-loop, distributed testing, and physical models which are common in the test and evaluation (T&E) community. In addition, the DOD M&S VV&A community uses terminology that is more appropriate for war game simulations and training simulators.

c. ATEC requires terminology geared toward M&S used for acquisition and testing. This document addresses the following shortcomings and provides a VV&A methodology tailored for ATEC needs. New guidance is available in this methodology on:

   (1) ATEC accreditation of M&S for T&E (ATEC Regulation 73-21).
   (2) VV&A of federations of M&S.
   (3) Instrumentation certification procedures for hardware interfaces.
   (4) Preliminary DOD guidance regarding standardized VV&A documentation.

d. Additional guidance is provided in the appendices for the following topics:

   (1) Hybrid simulations.
   (2) The application of the Carnegie Mellon Software Engineering Institute (SEI) “Capability Maturity Model Integration (CMMI) for Software Engineering” to M&S software development.

1-2. Scope

This methodology applies to ATEC-developed modeling, simulation, and instrumentation (MS&I); to MS&I supporting Army and joint, inter-agency, and multi-national (JIM) tests and evaluations; and to customer-requested verification and validation (V&V) efforts. This methodology provides standardized formats for VV&A documentation; it also provides
references to tools and assets useful for VV&A efforts. There are categories of M&S that are exempt from this methodology. For example, there are standard evaluation “tools” that are endorsed and approved by the Army acquisition community. They are well-documented, widely used generic techniques that are applicable to virtually any support structure defined by their input data. These include linear regression, Program Evaluation and Review Technique (PERT), non-linear programming (NLP), inventory control, and other complex analysis programs used only to study results and not used to produce those results. These tools are typically well documented and widely recognized as suitable for the analysis functions intended, e.g., analysis of variance tools. These exempt tools are listed in appendix F.

1-3. References and standards

References, related publications, and standards are listed in appendix A.

1-4. Background

a. Per DODD 5000.1, “The conduct of T&E integrated with M&S shall facilitate learning, assess technology maturity and interoperability, facilitate integration into fielded forces, and confirm performance against documented capability needs and adversary capabilities.” The uses of M&S supporting T&E include but are not limited to the identification of test parameters and key measures, the determination of high risk areas, the approximation of system performance, allocation of resources, stimulation of the system under test (SUT), and the creation of a realistic environment to conduct developmental/operational test and evaluation of system capabilities.

b. Using the iterative Simulation, Test, and Evaluation Process (STEP), DOD integrates M&S and T&E to improve the acquisition process and reduce acquisition cycle time. Specifically, M&S predict system performance and effectiveness; tests provide empirical data to validate M&S and assess system maturity conformance with specifications, and determine system effectiveness, suitability, and survivability; and evaluation is the means to understand system military utility per AR 73-1.

c. AR 5-11 mandates that VV&A be an integral part of the life-cycle management process for all Army M&S developed after June 1992 and major modifications to legacy M&S begun after June 1992. V&V of M&S developed prior to June 1992 is strongly encouraged and should be accomplished as appropriate considering future applications, availability of resources, and future replacements for M&S.


1-5. Definitions

a. A model is a physical, mathematical, or otherwise logical representation of a real system, entity, phenomenon, or process (DOD 5000.59-P). A model must describe the real system in enough detail to provide valid predictions of the behavior of the real system. Figure 1-1 shows the concept of a model. The parameters of a model correspond with characteristics or attributes of the real system. Inputs to a model correspond with identified real system input. Output from a model allows inference about the performance or behavior of the real system. Physical models
could include globes, wind tunnels, or flight simulators. Mathematical and logical models could include chemical formulae, algorithms, circuit diagrams, flow charts, mathematical equations, and budgets. In the T&E community, the behavioral model could be a representation of the SUT or battlefield operational facilities (OPFACs) which correctly, accurately, and realistically simulates and stimulates the live OPFACs or systems.

![Figure 1-1. Concept of a Model](image)

b. *A simulation* is a method for implementing a model over time; also a technique for testing, analysis, or training where real-world systems are used or where real-world and conceptual systems are reproduced by a model (DOD 5000.59-P). Simulation is the operation or exercise of a model in order to study or accurately imitate the behavior of a system.

c. *Hybrid simulations* interface with something else such as instrumentation hardware, humans, and/or software. Hybrid simulations typically combine live (real people operating real systems), virtual (real people operating simulated systems), and/or constructive (simulated people operating simulated systems) simulations in a distributed environment.

d. *Verification* is the process of determining if a model and/or simulation (M&S) accurately represents the developer’s conceptual description and specifications and meets the needs stated in the requirements document (AR 5-11). The verification process establishes if the M&S correctly perform the intended functions and the extent to which the M&S have been developed using best practices. Best practices, as defined by this verification methodology, are practices similar to those outlined in the SEI CMMI.

e. *Validation* is the process of determining the extent to which the M&S accurately represent the real world from the perspective of the intended use of the M&S (AR 5-11). The validation of threat simulators/simulations and targets is the process of comparing simulators/simulations and targets to Defense Intelligence Agency (DIA)-approved threat data, documenting the variations, and assessing the impact of those differences on the potential use of the simulator, simulation, or target (DA Pamphlet 73-1).
f. **Accreditation** is the official determination that a model, simulation, or federation of M&S is acceptable for use for a specific purpose (AR 5-11). M&S may be optionally accredited for a generic class of applications by the Army official with general oversight responsibility for that class of applications (DA Pamphlet 5-11). The class of applications accreditation provides a baseline for focusing on the unique aspects of individual applications. Given that an M&S is accredited for a class of applications, each specific instance of use for that M&S requires accreditation.

g. **Acceptability criteria** are a set of requirements that a particular M&S or federation must meet to be accredited for a given use.

h. **Instrumentation certification** is the demonstration that instrumentation can perform its intended functions under conditions that replicate the operating environment without interfering with the SUT. In the case of instrumentation-simulation hybrids, instrumentation certification is an accreditation requirement for testing.

i. A **federation of M&S** is a system of interacting M&S with supporting infrastructure, based on a common understanding of the objects portrayed in the system. The VV&A of a federation of M&S will involve not only VV&A of each individual M&S and the certification of any instrumentation used but also the integrated system as a whole. The VV&A of a federation should consider system compliance, compatibility, and interoperability requirements (AR 5-11 and VV&A RPG).

1-6. **Rules of Accreditation**

a. **Accreditation Requirements.** M&S must be accredited for each intended use, except where the same M&S accreditation can be applied for follow-on tests without modification to the M&S or the intended use. The Accreditation Authority (AA) may accredit the M&S for a generic class of applications by the Army official with general oversight responsibility for that class of applications (DA Pamphlet 5-11). The class accreditation provides a baseline for later VV&A of the unique aspects of specific applications. If the AA accredits the M&S for a class of applications, each specific instance of use for that M&S will require accreditation. ATEC is responsible for conducting and/or supporting the VV&A of all M&S used in T&E and accrediting M&S that are used to support assigned system evaluation (AR 73-1). As needed, ATEC will designate an Accreditation Action Officer (AAO) who will be responsible for conducting the following tasks.

b. **Re-accreditation.** Re-accreditation typically applies to legacy M&S. If the M&S has been accredited for a generic set of applications, re-accreditation is required when the M&S is proposed for a new type of application, a new version of the M&S is released, or a period of 3 years of active use has passed since the last accreditation for that class. The process of re-accreditation is identical to the initial accreditation process except that more V&V information is likely to be available. Re-accreditation may involve reviewing past V&V activities to see if they are still adequate and/or conducting new V&V activities. When a legacy simulation is modified, changes may affect the simulation’s suitability for the intended use.

c. **Accreditation of Threat Simulators/Simulations.** Appendix Z of DA Pamphlet 73-1 describes the validation and accreditation procedures for threat simulators/simulations. Threat simulators/simulations portray actual threat system for user-identified test. A Threat Accreditation Working Group (TAWG) performs the accreditation assessment to determine if
the threat simulators/simulations are suitable for a specific test. The TAWG is chaired by ATEC or by its designated representative and is composed of representatives from the responsible Program Executive Officer (PEO), Program Manager (PM), T&E Working-Level Integrated Product Team (WIPT), intelligence, threat simulator and target developmental or operational organizations. The V&V of threat forces portrayed in M&S will be performed by the appropriate intelligence authority outlined in AR 381-11.

d. **Federation Accreditation.** This activity focuses on planning the federation accreditation activities. The resulting plan identifies the information required to support an acceptance decision and the tasks needed to develop that information. The federation accreditation plan is necessary for planning the V&V activities, guiding the accreditation process, and building the federation development and execution plan. An acceptance decision (i.e., a decision to use a federation’s results to serve an intended use) precedes federation use. A formal accreditation decision follows when required. The accreditation activities, and the planning for them, support either formal accreditation or informal acceptance. This activity analyzes the user/sponsor needs and the federation use impact assessment as well as other information to determine the needed accreditation tasks, then organizes those tasks into an executable sequence. For example, the accreditation tasks might include formulating the acceptability criteria, constructing the referent, performing a risk assessment, and developing the federation acceptance/accreditation recommendations. The federation accreditation plan also identifies the information that the V&V activities should produce. Finally, the accreditation tasks are arranged into a schedule and estimates of the resources needed to perform the accreditation are made. This activity assumes that the user/sponsor understands and has expressed their perspective on what they need for the federation to do, how correct it needs to be, and the process they intend to use to identify and assign resources to the accreditation and V&V processes. It also assumes that the user/sponsor understands the impact and risk of applying the federation to their intended use. See the VV&A RPG for more detail. Federation accreditation is required when the outputs are used for supporting T&E events. The federation integrator has overall responsibility for ensuring that each federate/model within the federation is adequately verified and validated prior to the federation integration. It is also the federation integrator’s responsibility to verify and validate the integrated federation. Each federate/model owner must provide V&V documentation and evidence to support the federation accreditation.
Chapter 2  
VV&A Roles  

2-1. Application sponsor  
The application sponsor is the organization that initiates the need of M&S for a specific application. For T&E, the application sponsor may be a user, such as a range commander, test director, T&E Integrated Product Team (IPT), PM, customer, ATEC System Team (AST), AAO, or AA. Funding is not necessarily a factor in sponsorship. The application sponsor determines the intended use(s), M&S requirements, and acceptability criteria for the M&S. The application sponsor should coordinate with the PM to ensure that planned VV&A requirements for M&S supporting system acquisition testing are kept up-to-date in the system’s test and evaluation master plan (TEMP) and simulation support plan (SSP).

2-2. M&S developer  
The *M&S developer* is 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 or may not be the same agency as the application sponsor.

2-3. Data producer  
The data producer is the agency that produces the data and metadata (i.e., data documentation) for the simulation use. The data producer is responsible for ensuring the data meet applicable data standards and business rules (DA Pamphlet 5-11). The data may be test results produced for comparison with simulation results for validation purposes or may be data produced for input into M&S. The data could also result from a simulation.

2-4. Data user  
The data user employs existing data for an M&S application which may involve transforming the data into M&S loadable and readable data. For example, this may involve transforming the data into a different format or unit of measure. The data user can also be the data producer.

2-5. V&V agent  
The *V&V agent* is responsible for ensuring the M&S and its usage data are adequately verified and validated and for establishing a team to do the V&V. The V&V agent selects the V&V team members based on their background in methods and technologies which are pertinent to the model being assessed. They may also be selected based on access to the technical community or other relevant resources (see reference *Simulation Validation, A Confidence Assessment Methodology*). For those M&S that represent threat entities and/or behaviors, V&V team membership should include at least one individual from the Threat Community. The V&V agent is the individual or agency responsible for accomplishing V&V activities for an M&S, to include developing V&V plans that address cost and schedule, identifying V&V activities, establishing the V&V team, developing the V&V report, and publishing the results in a format to facilitate reuse. Appendix B contains a VV&A Workbook to use as a guide to assist with accomplishing the VV&A activities. A V&V agent that is independent from the M&S developer (i.e.,
independent V&V (IV&V) agent) lends more credibility to the V&V results; however, there may be increased costs to perform the independent V&V activities.

2-6. V&V team

The V&V team, under the direction of the V&V agent, identifies and accomplishes V&V activities for an M&S, develops V&V plans (including cost and schedule) and report, and documents V&V results. There may be more than one V&V team. The V&V team must keep the application sponsor and the AAO informed of their activities. The M&S developer provides the V&V team with plans and documentation used for specification of requirements, design, development, configuration management, etc., either directly to the V&V team or via the application sponsor. The V&V team should be independent from the developer. If having an IV&V team is not possible, there needs to be a reasonable degree of organizational separation between the V&V team and the developer to ensure unbiased analysis.

2-7. Threat Validation Working Group

The Threat Validation Working Group (VWG) compares threat simulators/simulations and targets to threat data produced by the Service Production Centers under DIA Instruction 5000.002 paragraph 3.1 direction, “Distributed production responsibility,” documenting the variations and assessing the impact of those differences on its potential use. In accordance with DA Pamphlet 73-1, Test and Evaluation Management Agency (TEMA) will establish and charter a threat VWG for each target or threat simulator/simulation and usually for each validation requirement. Figure 2-1 shows the general functional areas, organizations, and membership of the threat VWGs. The members sign a completed validation report (VR) and forward it to the Director, TEMA and if required, to the Director, Operational Test and Evaluation for approval.

Figure 2-1. Threat VWG Membership Pool (DA Pamphlet 73-1)
2-8. Threat Accreditation Working Group

The Threat Accreditation Working Group (TAWG) is established under the auspices of the T&E WIPT by the PEO/PM whose weapon is being tested. For all tests of acquisition category (ACAT) I, ACAT II or Office of the Secretary of Defense (OSD) T&E oversight systems, ATEC will either chair or designate a TAWG chair. For ACAT III programs, ATEC will designate the TAWG chair with the assistance of the AST chair. The TAWG assesses whether threat simulators/simulations, surrogates, actual threat systems and targets are suitable for a specific test and compares data requirements to the latest intelligence and the capabilities of Army threat simulators/simulations and targets in the VR.

2-9. Responsibilities within ATEC

a. Commander, ATEC. The ATEC Commander accredits the M&S selected for T&E and may delegate the accreditation authority (AA) to a designee.

b. Accreditation Authority (AA). The AA is the approval authority for accreditation of models and simulations. The ATEC Commander or his/her designee serves as the AA. In general, the ATEC Technical Director (TD) accredits M&S in support of evaluation for ACAT I and OSD oversight programs, and the Director, Army Evaluation Center (AEC) accredits M&S in support of evaluation for other programs. The AA reviews and approves the accreditation plan prior to execution and the accreditation request prior to use of the M&S to support T&E.

c. Accreditation Action Officer (AAO). The AAO oversees the development and implementation of an independent ATEC accreditation. The ATEC System Team (AST) identifies the appropriate subordinate command activity (SCA) AAO to lead the accreditation for each model and simulation supporting a T&E program. In general, DTC or OTC will provide the AAO when the primary use of the M&S is test support, and AEC will provide the AAO when the primary use of the M&S is evaluation. The AAO will—

(1) Develop, with the AST/SCAs/proponent organization, coordinated accreditation plans and acceptability criteria.

(2) Coordinate with ATEC Test Technology Directorate (TTD) MS&I and Threat divisions to determine the role of threat representations in the M&S.

(3) Prepare and submit documentation (accreditation plan, report, and request) for AA approval.

(4) Coordinate accreditation efforts and provide oversight of V&V activities as required.

(5) Ensure that requirements for accreditation of M&S and for certification of instrumentation are satisfied in the case of instrumentation-simulation hybrids.

d. ATEC Test Technology Directorate (TTD). The ATEC TTD (MS&I and Threat divisions) provides support to and assists the ASTs. Once a decision is made to incorporate M&S as an element of the T&E strategy, ATEC TTD assists in developing accreditation plans and requests. The ATEC TTD will—

(1) Provide ATEC policy and guidance regarding the selection, use, and accreditation of M&S supporting T&E. For instrumentation having an M&S component, ensures that ATEC VV&A concerns are addressed (e.g., in the requirements for items being developed for ATEC by the Project Manager for Instrumentation, Targets, and Threat Simulators (PM ITTS)).
(2) Provide and update document examples (found at ATEC TTD intranet web page) for accreditation requirements to assist the ASTs in planning, conducting, and reporting results of VV&A activities.

(3) Advise on M&S threat representation and begin coordination with the Threat Intelligence Community (TRADOC Intelligence Support Activity (TRISA) and National Ground Intelligence Center (NGIC)) to support the AAO with the accreditation of M&S threat representation. Key elements are:

(a) Accurate representation of systems capabilities (NGIC and Army Materiel Systems Analysis Activity (AMSAA) data).

(b) Ability of the model to allow threat to execute unique tactics, techniques, and procedures (TTP) for both friendly and threat forces.

(c) Representation of the appropriate operational environment (e.g. population, urban terrain, etc.).

(4) Review accreditation plans and requests for ACAT I and DOD oversight programs.

(5) Maintain a library of approved VV&A plans, accreditation requests, and lessons learned.

e. **Subordinate Command Activities (SCAs).** The SCAs will—

(1) Provide AAO as required.

(2) Review accreditation plans and reports as part of the document staffing process. For M&S in support of ACAT I and DOD oversight programs, submit accreditation plans and reports (signed by the Commander/Director of the AAO) to the ATEC Commander with a short memorandum requesting approval.

(3) Resource, or identify for customer reimbursement, requirements for VV&A activities and M&S implementation.

(4) Develop implementation policy and guidance as appropriate and manage the support infrastructure necessary to ensure successful employment of M&S in support of T&E.

(5) Support the AST efforts to resource and verify, validate, and accredit M&S internally or through customer reimbursement as appropriate to support T&E.

(6) Plan, develop, sponsor, and implement test stimulation, including the preparation of resourcing estimates for the required test stimulation.

(7) Review formal support packages to ensure adequacy for use in support of system T&E and document findings in the appropriate test report.

f. **Test and Evaluation Working-Level Integrated Product Team (T&E WIPT).** The T&E WIPT will—

(1) Relate the planned use of the M&S to system requirements and evaluation issues and criteria.

(2) Identify the T&E goals and limitations that prompt the use of M&S.

(3) Identify the M&S resources required. Resources include software, hardware, labor, temporary duty (TDY), contract costs, facilities, VV&A, and any other projected requirements.
Chapter 3
VV&A Process

3-1. VV&A process outline

This chapter introduces the ATEC VV&A process. Figure 3-1 outlines the overall process and identifies the steps with responsible individuals and the information feeds into and out of each step. Many of the steps are done in parallel, and the process can return to previous steps when shortfalls are identified in the outputs. An abbreviated process, outlined in figure 3-2, is used for external ATEC customers requesting V&V support. Detailed descriptions of the steps are found in the subsequent paragraphs.

Figure 3-1. Outline of ATEC’s VV&A Process
3-2. **Step 1 – Determine need for M&S**

A feasibility study may be conducted to determine if an M&S is appropriate application. Once a decision is made to use a particular M&S as-is, modify or develop a model or simulation, the application sponsor will define and document the intended use and determine data requirements, as depicted in Figure 3-3. M&S may be used to support both an acquisition system and a non-acquisition (customer tests) program. When an M&S supports an acquisition system, the need is identified and approved at the Early Strategy Review (ESR) and documented in the system evaluation plan (SEP).

**Products of Step 1:**

a. An M&S intended use statement describes the problem to be addressed by M&S, including the system or process being represented and role it plays in the overall program. For M&S supporting T&E, briefly describe the SUT, identify the test name, acquisition category of the system, whether it is on the DOD oversight list, the milestone review decision or other review the event is providing input for.

b. An M&S application statement describes the roles of the M&S and the specific use or class of application. It describes the T&E events, test objectives, and evaluation measures that the M&S will support. This may include the desired level of realism such as number of entities and complexity of synthetic environment.
The DOD/Army Modeling and Simulation Resource Repository (MSRR) should be searched to determine what existing M&S could be applicable. (See appendix F for description of the MSRR.)

3-3. Step 2 – State M&S requirements

The application sponsor is responsible for providing M&S requirements specification to meet the intended use. The M&S requirements are published in documents such as acquisition strategy, test and evaluation master plan (TEMP), simulation support plan (SSP), M&S requirements document, etc. Figure 3-4 depicts the inputs, activity, outputs, and the responsible individuals in Step 2. The application sponsor provides the M&S requirements document to the M&S developer (Step 3), the AAO (Step 4), and the V&V agent (Step 6). The V&V agent and developers analyze the user requirements to ensure a shared understanding is reached. Any changes to the requirements should be analyzed for their impact and should implement configuration management (CM), including requirements traceability.

3-4. Step 3 – Modify/develop M&S solution

The M&S developer is responsible for identifying the conceptual M&S solution. If existing M&S does not meet the requirement(s), then the M&S developer will produce a plan to develop or modify the M&S conceptual model to include cost, schedule, and performance. The conceptual model identifies M&S components, interfaces, inputs/outputs, expected workloads, and other characteristics; when approved by the user, it forms the basis for the M&S design and its implementation. M&S developers should consider following the CMMI process at a minimum level 3 or better, as required. Figure 3-5 depicts the inputs, activities, and outputs. The M&S developer provides the outputs to the AAO and to the V&V agent/team.

Figure 3-4. Step 2 – State M&S Requirements

Figure 3-5. Step 3 – Modify/Develop M&S Solution
3-5. **Step 4 – Develop accreditation plan**

Once the AAO accepts the use of M&S for the intended purpose, then it is the AAO’s responsibility to provide the accreditation plan, which documents the acceptability criteria, data elements, resources, issues, participants, and methodology. The inputs to this activity are the M&S requirements documents from step 2 and, when available, the current conceptual model from step 3. The AAO should crosswalk the accreditation plan to the event design plan (EDP) to ensure that M&S are accredited in a timely manner and that the intended use of the M&S is properly documented. This includes the possible use of threat representations in the M&S. The AAO prepares a memorandum for approval of the accreditation plan. For ACAT I and DOD oversight programs, the accreditation plan is submitted through the appropriate SCA activities and the ATEC TTD to the ATEC Commander or designee (ATEC TD) for approval. For all other ACAT level programs, the accreditation plan is submitted to the AEC Director for approval. In accordance with AR 5-11, M&S is subject to re-accreditation under three circumstances: a new type of application, release of a new version, or when a period of 3 years of active use has passed since the last accreditation for that class. Figure 3-6 depicts the inputs, activities, and outputs.

![Diagram of Step 4 – Develop Accreditation Plan]

**Figure 3-6. Step 4 – Develop Accreditation Plan**

The following are additional instructions for developing accreditation plan (Step 4):

a. The AAO should accomplish the following tasks:
   
   1. Determine scope of accreditation.
   2. Identify accreditation issues (i.e., questions to answer) for each objective.
   3. Identify acceptability criteria.
   4. Write the accreditation plan identifying the resources and evaluation participants.
   5. Write the accreditation plan memorandum requesting approval.

b. **Determine the scope of accreditation.** The scope of accreditation is based on the maturity of the M&S, risk of the use, intended use, and resources.

c. **Identify accreditation issues.** The AAO should identify issues that will drive the V&V process. Accreditation issues are those relevant questions based on the intended M&S use. When identifying accreditation issues, the three most common and critical VV&A areas are model/federation, input data, and simulation output data. For each of the critical areas, the objective of verification is different from the objective of validation. Verification focuses on completeness, correctness, and consistency (CCC) of the technical structure and design of the model/federation while validation focuses on appropriateness of the intended use. This includes
the use of threat representations within the M&S, their intent and purpose, and the operational environment within which they will be used. The AAO should contact TTD (MS&I and Threat divisions) to discuss M&S and determine the need for threat representation. Respectively, figures 3-7, 3-8, and 3-9 provide examples of questions for addressing accreditation for both friendly and threat.

**Model/Federation Verification Issues:** The following are examples of CCC questions that need to be considered to support accreditation:

- Is the Model/federation developer’s configuration management CCC and satisfy the intended use?
- Model/federation objectives/requirement documents?
- Conceptual model design?
- Design specifications?
- Implementation of the design?

**Model/Federation Validation Issues:** The following are examples of questions of the appropriateness of the intended use to support accreditation:

- Are the input and output parameters of the Model/federation appropriate for the intended use?
- Structure descriptions?
- Dynamic behaviors?

**Figure 3-7. Model/Federation Accreditation Issues**

**Input/Comparison Data Verification Issues:** The following are examples of verifying input/comparison data:

- Is the data provider’s configuration management adequate for the intended use?
- Are the data and metadata (data documentation) CCC and satisfy the intended use?
- Is the format of the data correct for the intended use?
- Are the data in compliance with required data models?

**Input/Comparison Data Validation Issues:** The following are examples of validating input/comparison data:

- Is the data current enough for the intended use?
- Is the data source appropriate for the intended use?
- Is the measurement method appropriate for the intended use?

**Figure 3-8. Input Data Accreditation Issues**
**Simulation Output Data V&V Issues:** The following are examples of intended use that are dependent upon the runtime environment allowing proper simulation execution, the scenario, and/or design of experiments being appropriate with qualified people involved:

- Is the runtime environment (i.e., hardware, software, and interfaces) CCC with respect to the intended use?
- Do the scenario and/or design of experiments produce results appropriate for the intended use?
- Are evaluators, operators, and analysts appropriately skilled to analyze and/or employ results?

**Figure 3-9. Simulation Output Data Accreditation Issues**

d. **Identify Acceptability Criteria.** The acceptability criteria are developed from each accreditation issue. The acceptability criteria describe the essential elements that the M&S must address to be considered suitable for the intended use and meet the sponsor and user needs. A rationale should be included to describe the reasoning used for the acceptability criteria. Appendix B, paragraph B-3, provides examples and/or guidance on how each of the issues shown in figures 3-7, 3-8, and 3-9 can be decomposed into acceptability criteria. It is preferable to have acceptability criteria that are quantitative in nature. Results available from prior testing may be used in developing quantitative acceptability criteria for the M&S.

e. **Write Accreditation Plan.** The accreditation plan describes the intended use of the M&S, accreditation issues and criteria, resources planned, key participants, and the accreditation methodology. Figure 3-10 describes the contents of the accreditation plan. The use of the VV&A Documentation Tool can assist in writing the plan and is located in appendix F. Appendix G describes considerations for hybrid simulations.
Accreditation Plan Executive Summary. Summarize all paragraphs.

1. Problem Statement. (See paragraph 1 of Intended Use statement in figure 5-1.)

2. M&S Requirements and Acceptability Criteria. Describe the accreditation requirements/issues and the acceptability criteria that must be met to satisfy the requirements/issues. This paragraph may reference the VV&A Workbook (section B-3), which decomposes the requirements/issues into acceptability criteria.

   3.1 M&S Assumptions. Describe known assumptions about the M&S, the M&S capabilities, the data used in support of the M&S, and any constraints placed upon the M&S by the context of the problem.
   3.2 M&S Capabilities. Describe known capabilities of the M&S.
   3.3 M&S Limitations. Describe known constraints and limitations under which the M&S will be developed, tested, and used.
   3.4 M&S Risks/Impacts. Describe the risks and impacts associated with developing and/or using the M&S for the intended use including the risks resulting from identified constraints and limitations, and the risks associated with doing and/or not doing various VV&A tasks. Describe plans to reduce the risk.

4. Accreditation Methodology.
   4.1 Accreditation Information Needs. Describe the information needed to conduct the accreditation assessment.
   4.2 Information Collection Plan. Describe how, when, and from whom the information is to be obtained; the form in which the information is to be provided; and the priority for each item.
   4.3 Assessment Plan. Describe the assessment events including the assessment techniques to be used, the specific roles and responsibilities of the participants, the milestones to be achieved, and the products to be produced.

5. Accreditation Issues. Discuss any relevant unresolved issues, current and planned activities addressing these issues, and the likelihood of each activity’s success.

6. Key Participants. Identify responsible individuals (by name, title, and organization) participating in drafting the accreditation or V&V plan. All non-concurrences must include rationale and rebuttal statements.

7. Planned Accreditation Resources.
   7.1 Resource Allocations. Identify the resources needed to accomplish the accreditation. Include the names of the activities, tasks, events, and required resources needed to accomplish it; milestones; deadlines; and the point of contact. Identify any resource shortfalls.
   7.2 Accreditation Milestones and Timeline. Provide a chart of the overall program timeline with program, development, V&V, and accreditation milestones.

Signature Block. The Commander/Director of the AAO signs the accreditation plan.

Appendixes (as needed): M&S Description, References, Acronyms, Glossary, Distribution list.

Figure 3-10. Outline of an Accreditation Plan (Example)

f. Write the Accreditation Plan Memorandum. The AAO prepares a one-page memorandum requesting approval of the accreditation plan. A sample format for the memorandum is provided in figure 3-11. The AAO submits the memorandum and the accreditation plan (figure 3-10) to the AA.
MEMORANDUM THRU Director, Test Technology Directorate, U.S. Army Test and Evaluation Command (CSTE-TT), 4501 Ford Avenue, Alexandria, VA 22302-1458

MEMORANDUM FOR Commander, U.S. Army Test and Evaluation Command (CSTE), 4501 Ford Avenue, Alexandria, VA 22302-1458

SUBJECT: Accreditation Plan for the (name of M&S) in support of the (name of test)

1. Request approval of the enclosed Accreditation Plan for the (name of M&S or federation) in support of (test name, test type, and test dates).

2. The (name of directorate) will use the (name of M&S) to (describe requirement for the use of the M&S). Acceptability criteria have been established for this specific use of the M&S and are provided (either list on memorandum or make reference to location in plan). The (name of directorate) will conduct an accreditation event (provide dates or time frame) to validate this requirement.

3. The point of contact at (name of subordinate command/activity) is (name/title/phone number/e-mail address).

Encl Accreditation Plan

Signature Block of Requesting Director/Commander

Figure 3-11. Accreditation Plan Memorandum (Example)

3-6. Step 5 – Approve accreditation plan

The AA is responsible for approving the accreditation plan. If the M&S included in the accreditation plan contains threat representations, the TAWG Chair, upon approval, will provide to the AAO a threat accreditation report for inclusion as an annex to the accreditation plan. For ACAT I and OSD oversight programs using M&S to support T&E, the AA is the ATEC TD or Commander; the accreditation plan is submitted through the appropriate SCA Command/Director and the ATEC TTD to the AA for approval. For all other programs, the appropriate SCA Commander/Director is the AA. Figure 3-12 depicts the inputs, activities, and outputs. The AA approves the accreditation plan by initialing over his/her name on the accreditation plan memorandum signifying approval. If further coordination is required, the AAO will coordinate with the V&V agent, developer(s), AST, and others as appropriate. The AAO then provides the approved accreditation plan to the V&V agent.
3-7. **Step 6 – Plan V&V activities and verify requirements**

The V&V agent is responsible for determining and developing the V&V activities and plan based upon the M&S requirements, M&S development planning, and accreditation criteria. The V&V agent estimates V&V cost and schedule, establishes the V&V team, and defines the team’s responsibilities. The V&V plan and activities are described below. Appendix C provides recommended V&V tasks that may be applicable for this step. The V&V agent documents the planned V&V tasks and maps them to each of the acceptability criteria. The inputs for this activity are the M&S development plan, accreditation plan, and any existing M&S data and documentation (including the M&S requirements and conceptual model). The resultant outputs are the verified requirements and V&V plan. Figure 3-13 depicts the inputs, activities, and outputs.

The following paragraph highlights the V&V planning procedures for the V&V agent. Details for each procedure can be found in appendix C.

1. Gather information from the application sponsor, the M&S developer, and AAO.
2. Perform a risk and impact analysis to determine the risks associated with the intended use of the M&S, the accreditation requirements, and the M&S documentation.
3. Determine the V&V activities that address the acceptability criteria.
4. Write the V&V plan. An outline is provided below.
V&V Plan Executive Summary. Summarize all paragraphs.

1. Problem Statement. (See paragraph 1 in figure 3-10.)
2. M&S Requirements and Acceptability Criteria. (See paragraph 2 in figure 3-10.)
3. M&S Assumptions, Capabilities, Limitations & Risk/Impacts. (See paragraph 3 in figure 3-10.)
   4.1 Data V&V
      4.1.1 Data Verification
      4.1.2 Data Validation
      4.1.3 Data Certification
   4.2 Conceptual Model Validation
   4.3 Design Verification
   4.4 Implementation Verification
   4.5 Results Validation
   4.6 V&V Reporting. Outline the plan for producing and delivering the V&V report, e.g., content, delivery, and timing of interim reports and summary report; who receives the reports, etc.
5. V&V Issues. Discuss relevant unresolved issues, including administration, coordination, and execution. Report activities underway to address these issues and the likelihood of their success.
6. Key Participants. Identify responsible individuals (by name, title, and organization) participating in drafting the V&V plan.
7. V&V Resources.
   7.1 V&V Tasking and Funding. Identify the resources needed to accomplish the V&V activities and tasks to support milestones and objectives.
   7.2 V&V Timeline. Identify key events.
Appendixes: M&S Description, References, Acronyms, Glossary, Distribution list, etc.

Figure 3-14. V&V Plan
3-8. Step 7 – Perform V&V activities

The V&V agent, assisted by the V&V team, is responsible for conducting all V&V activities; however, the V&V activities for threat simulators/simulations and targets are conducted by the Threat VWG. The inputs into this activity are the V&V plan, M&S data, and V&V documentation (including the M&S requirements, conceptual model, and design specification). The resultant outputs are V&V report(s) containing the V&V results. Figure 3-15 depicts the inputs, activities, and outputs. The performance of V&V activities and reporting are described in paragraph 6-3 and appendix C. The V&V agent provides the V&V report(s) to the AAO. In some cases the AAO may require the V&V agent to compare pre-test simulation and field test results to validate the simulation. If the simulation is not within tolerance, then the V&V agent will propose a recommended fix. For threat simulators/simulations and targets, each Threat VWG member signs the validation report before staffing it through the TEMA Director to the Director, Operational Test and Evaluation (DOT&E) for approval.

![Figure 3-15. Step 7 – Perform V&V Activities](image-url)

The following paragraph highlights the V&V reporting procedures for the V&V agent. Details for each procedure can be found in appendix C.

1. Analyze V&V results.
2. Write V&V reports. An outline of the report is provided below.
3. Write a threat validation report for threat M&S, if applicable. An outline of the report is provided below.
V&V Report Executive Summary. Summarize each of the following paragraphs.

1. **Problem Statement.** (See paragraph 1 in figure 3-10.)
2. **M&S Requirements and Acceptability Criteria.** (See paragraph 2 in figure 3-10.)
3. **M&S Assumptions, Capabilities, Limitations & Risk/Impacts.** (See paragraph 3 in figure 3-10.)
4. **V&V Task Analysis.** Provide an overview of the results of the V&V inspection and testing activities.
   - 4.1 Data V&V
     - 4.1.1 Data Verification
     - 4.1.2 Data Validation
   - 4.2 Conceptual Model Validation
   - 4.3 Design Verification
   - 4.4 Implementation Verification
   - 4.5 Results Validation
   - 4.6 V&V Reporting. Describe the V&V activities.
5. **V&V Recommendations.** Discuss any unresolved issues relevant to the V&V effort. Report activities undertaken to address these issues and associated recommendations.
6. **Key Participants.** Identify responsible individuals (by name, title, and organization) participating in drafting the V&V report.
7. **Actual V&V Resources.** Document the actual costs. Identify the V&V tasks and activities not performed and the impact(s) due to reduced resources.
   - 7.1 Resource Allocations. Show where the resources were allocated to accomplish V&V activities. Include the name of the activities, tasks, events, required resources, milestones, deadlines, and the point of contact.
   - 7.2 V&V Timeline. Identify when activities were accomplished. Briefly describe each milestone event and its execution time. Include any events that were not accomplished, the circumstances, and possible impact.
8. **V&V Lessons Learned.** Provide recommendations for improvements based on lessons learned.

Appendixes: M&S Description, References, Acronyms, Glossary, Distribution list, etc.

**Figure 3-16. V&V Report**
Threat Validation Report (VR) Executive Summary. This section summarizes sections I through VI.

Section I Introduction.
1. Purpose. State the purpose or objective of the VR. State that the VR describes the status at that point in time, and there may have been changes in the threat definition or in the simulation since the VR was written.
2. Threat Representation. Briefly state what threat this simulation is expected to represent, what portion of the threat is included, what is left out, and the relationship of this simulation to others if it is a portion of a larger simulation or a modification of a larger simulation. State whether the simulation represents multiple variants of the threat, if such variants exist.
3. Points of Contact. Identify points of contact for users to gain additional information.

Section II Validation Procedures. Identify applicable directives and any documented limitations of the simulation. Describe any assumptions, constraints, methods employed, data, tools, and techniques used to conduct the validation.

Section III Threat Description. Briefly describe the threat currently required for representation in M&S. Include general threat order of battle to be portrayed including a listing of weapons systems, sensors and munitions that must be accredited. Describe any unique threat TTP that must be emulated in the model based on validated intelligence products or, when threat doctrine is unavailable, TTP from FM 7-100.1. State which data has been derived from validated intelligence products from Service Production Centers and DIA.

Section IV Simulation Description. Describe the overall capabilities and typical uses of the simulation, functional capabilities represented (system, behaviors, environment, and phenomenon), and the level of fidelity at which each function or object is represented. Address the assumptions involved in simulation development, user inputs, and model-generated outputs. Briefly describe the history of the simulation development and any previous validations conducted. Describe the degree to which the simulation output agrees with real world objects.

Section V Discussion of Differences and Limitations and Their Impacts. Address significant impacts on testing that may occur due to differences between the current threat intelligence and the simulation or from limitations of the simulation. Address intentional and unforeseen limitations, limitations resulting from known but uncorrected errors, and limitations pertaining to user inputs and model generated outputs. State the usability of the simulation for the specific systems designated to be tested against the simulation and other system types which can be projected.

Section VI Conclusions and Recommendations. Address the overall conclusions and recommendations based on the impacts of the differences between the current threat and the simulation or on the simulation limitations. State any implications for simulation use. For example, several impacts may affect only one type of test, leaving the simulation well suited for other tests, or the simulation may be so different that modification is recommended.

Section VII References. List all references used in the report.

Appendix A.
Section A1. Provide a summary table identifying significant entities represented in the simulation, function of each, indicator of the level of confidence in the representation of that entity and function and any comments.
Section A2. Include a representative sample of the results of tests or comparisons performed and described in the simulation validation plan. Include tests or comparisons that illustrate simulation errors, limitations, or differences from the threat.
Section A3. When applicable, this section should contain the standard validation criteria (SVC) from the appropriate appendix/annex of the DOD Threat Simulator Program Plan with all the threat simulator/target data. The range of programmability must be stated for programmable simulations. The validator’s notes and threat analysts’ comments should be identified in the remarks column and included at the end of this section. Do not leave out a portion of the SVC without explanation.

Figure 3-17. Validation Report Content for Threat M&S
3-9. **Step 8 – Prepare accreditation request**

The AAO is responsible for conducting acceptability assessment and preparing the accreditation request. The inputs into this activity are the V&V reports documenting baseline and final results from V&V activities. The resultant output is an accreditation report and a one-page accreditation request memorandum. The accreditation report identifies whether or not the acceptability criteria were met and recommends accreditation, as appropriate, with any needed limitations placed on the use of the M&S. The AAO then provides the accreditation report and accreditation request memorandum to the AA which is described in Step 9. For ACAT I and OSD oversight programs, the AAO will generally forward the accreditation requests through the ATEC SCAs and the ATEC TTD to the ATEC TD or Commander for approval. For other programs that support evaluation, the AAO will forward the accreditation request to the Director, AEC for approval. The accreditation request must be submitted no later than 30 days prior to the test event or other events that may produce data for evaluation. For non ACAT 1 and OSD oversight programs, use of M&S to support test but do not support a specific system evaluation, the accreditation request goes to the application sponsor. Figure 3-18 depicts the inputs, activities, and outputs.

![Diagram](image)

**Figure 3-18. Step 8 – Prepare Accreditation Request**

The following paragraph highlights the procedures needed to prepare the accreditation request. Details for each procedure can be found in appendix C.

1. Oversee V&V activities in steps 6 and 7 of ATEC VV&A process.
2. Perform the accreditation assessment.
3. Assess the suitability of threat simulators/simulations and targets.
4. Write the accreditation report. An outline of the accreditation report is provided below.
5. Write the accreditation request memorandum. An outline of the memorandum is also provided below.
6. Write a letter of transmittal for threat M&S, if applicable. An outline of the letter is provided below:
Accreditation Report Executive Summary. Summarize each of the following paragraphs.

1. Problem Statement. (See paragraph 1 in figure 3-10.)

2. M&S Requirements and Acceptability Criteria. (See paragraph 2 in figure 3-10.)

3. M&S Assumptions, Capabilities, Limitations & Risk/Impacts. (See paragraph 3 in figure 3-10.)

4. Accreditation Assessment.
   4.1 Accreditation Information Used. Describe the information used in the accreditation assessment.
   4.2 Information Collection. Identify relevant source information to include dates, version, organization, etc.
   4.3 Assessment. Describe the events, including techniques used, participants involved, milestones achieved, and the resulting products.

5. Accreditation Recommendations. Provide recommendation(s) based on findings to include articulation of any unresolved issues along with resolution.

6. Key Participants. Identify responsible individuals (by name, title, and organization) participating in drafting the V&V report.

7. Actual Accreditation Resources. Document the actual costs. Identify the V&V tasks and activities not performed and the impact(s) due to reduced resources.
   7.1 Resource Allocations. Show where the resources were allocated to accomplish V&V activities. Include the name of the activities, tasks, events, required resources, milestones, deadlines, and the point of contact.
   7.2 V&V Timeline. Identify when activities were accomplished. Briefly describe each milestone event and its execution time. Include any events that were not accomplished, the circumstances, and possible impact.


Signature Block. The Commander/Director of the AAO signs the accreditation report.

Appendixes: M&S Description, References, Acronyms, Glossary, Distribution list, etc.

Figure 3-19. Outline of an Accreditation Report (Example)
MEMORANDUM THRU Director, Test Technology Directorate, U.S. Army Test and Evaluation Command (CSTE-TT), 4501 Ford Avenue, Alexandria, VA 22302-1458

MEMORANDUM FOR Commander, U.S. Army Test and Evaluation Command (CSTE), 4501 Ford Avenue, Alexandria, VA 22302-1458

SUBJECT: Accreditation Request for the (name of M&S) in support of the (name of test)

1. Request approval of the enclosed Accreditation Report for the (name of M&S) in support of (test name, test type, & test dates).

2. The enclosed report publishes the findings of the Verification and Validation of the (name of M&S) completed on (date). The system has no limitations on the specific use of the M&S for this test or in the subsequent evaluation. All criteria set forth in the accreditation plan were met during V&V. (NOTE: If there are limitations and/or criteria were not met, then briefly describe.)

3. The point of contact at (name of subordinate command/activity) is (name/title/phone number/e-mail address).

Encl Accreditation Report

Signature Block of Requesting Director/Commander

Figure 3-20. Accreditation Request Memorandum
3-10. Step 9 – Approve accreditation request

For M&S supporting T&E, the AAO will submit the request through the ATEC SCA to the AA. For events that produce data for evaluation, the SCA Commander/Director of the AAO signs the accreditation report and submits it to the AA requesting approval. Each request must be submitted to the AA no later than 30 days prior to the event. Scheduling of the accreditation request should be appropriately synchronized with the development of detailed test plans. The accreditation request is approved once the AA initials the memorandum. Figure 3-22 depicts the inputs, activities, and outputs.

Figure 3-21. Letter of Transmittal for Threat M&S

Figure 3-22. Step 9 – Approve Accreditation Request
There are different levels of accreditation based on the V&V and accreditation findings. The result could be one of the following (reference VV&A Recommended Practice Guide (RPG)):

1. **Full Accreditation** – The simulation is sufficiently credible to support the application.
2. **Limited or Conditional Accreditation** – Constraints are placed on how the simulation can be used to support the application.
3. **Modification of Simulation Needed** – The simulation requires modification and subsequent V&V to correct deficiencies because its capabilities are insufficient to support full or conditional accreditation.
4. **Additional Information Needed** – The information obtained about the simulation is insufficient to support either full or conditional accreditation; additional information should be generated or obtained, and/or supplemental verification, validation, and/or testing should be conducted to provide the necessary information before the accreditation decision is made.
5. **No Accreditation** – The results of the accreditation assessment show that the simulation is not fit to support the application.

3-11. **Step 10 – Archive VV&A documents**

The AAO provides the approved VV&A plan, accreditation request, and lessons learned to the ATEC TTD. Additionally, the AAO should archive the approved documents in the Versatile Information Systems Integrated On-line Nationwide (VISION), Primary Integrated View of Modeling and Simulation (PIVOMS), and MSRR databases. See appendix F for additional information. Figure 3-23 depicts the inputs, activities, and outputs.

![Figure 3-23. Step 10 – Archive VV&A Documents](image-url)
Chapter 4
VV&A Process Reference Guide

This chapter recaps the responsibilities, processes, and products as described in previous chapters and integrates the essential VV&A steps and tasks.

Table 4-1. Tasks and Responsibilities Crosswalk

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<thead>
<tr>
<th>Responsible</th>
<th>Step</th>
<th>Tasks and Activities</th>
<th>Products</th>
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</table>
| Sponsor/User                         | 1    | Determine need for M&S  
- Establish the criteria for evaluating alternatives.  
- Identify alternative solutions.  
- Select methods for evaluating alternatives.  
- Evaluate the alternative solutions using the established criteria and methods.  
- Select recommended solutions from the alternatives based on the evaluation criteria. | - M&S intended use statement  
- M&S application statement                                                   |
| Sponsor/User                         | 2    | State M&S requirements  
- Define detailed requirements to support the intended use.                                                   | - M&S requirement document  
- Inputs to test and evaluation master plan (TEMP) and simulation support plan (SSP) |
| M&S Developer                        | 3    | Modify/develop M&S solution  
- Plan M&S modification/ development  
- Configuration management  
- Modify/develop conceptual model  
- Modify/develop M&S design  
- Implement M&S design or design changes  
- Integrate and test M&S                                                      | - M&S development plan  
- Configuration management plan  
- Conceptual Model  
- Design Specification                                                        |
| Accreditation Authority Officer (AAO)| 4    | Develop accreditation plan  
- Determine scope of accreditation.  
- Identify accreditation issues (i.e., questions to answer) for each objective.  
- Identify acceptability criteria.  
- Write the accreditation plan identifying the resources and evaluation participants.  
- Write the accreditation plan memorandum requesting approval.                | - Draft accreditation plan  
- Accreditation plan memorandum  
- Input to event design plan (EDP)                                            |
| Accreditation Authority               | 5    | Approve accreditation plan                                                                               | - Approved accreditation plan  
- Initialed accreditation plan memorandum                                       |
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<tr>
<th>Responsible</th>
<th>Step</th>
<th>Tasks and Activities</th>
<th>Products</th>
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<tbody>
<tr>
<td>V&amp;V agent</td>
<td>6</td>
<td>Plan V&amp;V activities and verify requirements</td>
<td>- V&amp;V plan</td>
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<td>- Gather information from the application sponsor, the M&amp;S developer, and AAO.</td>
<td>- Verified requirements</td>
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<td>- Perform a risk and impact analysis to determine the risks associated with the</td>
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<td>intended use of the M&amp;S, the accreditation requirements, and the M&amp;S</td>
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<td>documentation.</td>
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<td>- Determine the V&amp;V activities that address the acceptability criteria.</td>
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<td>- Write the V&amp;V plan.</td>
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<td>V&amp;V agent</td>
<td>7</td>
<td>Perform V&amp;V activity</td>
<td>- V&amp;V report(s)</td>
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<td></td>
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<td>- Analyze V&amp;V results</td>
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<td>- Write V&amp;V report(s)</td>
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<td>AAO</td>
<td>8</td>
<td>Prepare accreditation request</td>
<td>- Accreditation report</td>
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<td>(1) Oversee V&amp;V activities in steps 6 and 7 of ATEC VV&amp;A process.</td>
<td>- Accreditation request</td>
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<td>(2) Perform the accreditation assessment.</td>
<td>memorandum</td>
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<td>(3) Assess the suitability of threat simulators/simulations and targets.</td>
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<td>- Approved M&amp;S accreditation</td>
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<td>AAO</td>
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<td>Consolidate and archive approved VV&amp;A documents</td>
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Chapter 5
Instrumentation Certification

5-1. Introduction
Operational test instrumentation certification is essential to overall test planning. The key to the process is for the instrumentation developers, testers, evaluators, and analysts to gain confidence in the instrumentation to be used with the SUT prior to operational testing. If use of instrumentation is required, certification must be accomplished prior to test execution. Upon completion of the instrumentation certification plan execution, analysis of the information acquired is documented in the certification report. Where instrumentation is included with M&S, it is recommended that it be done as a part of the accreditation process.

5-2. Policy
   a. Instrumentation certification should be viewed as a process by which the instrumentation developers, testers, evaluators, and analysts gain confidence in the instrumentation and SUT prior to operational testing. The certification test should, where possible, be used as the government’s instrumentation acceptance test. All instrumentation planned for use to support or supplement T&E events will be certified prior to use in the event except for instrumentation to support customer tests. Operational test (OT) certification includes the following steps:

      (1) Test planning, execution, and support.
      (2) Develop certification plan and reports.
      (3) Conduct and report instrumentation results from events.
      (4) Provide certification progress (instrumentation results and completed events) to the certification team.
      (5) Document the overall system configuration with instrumentation at the start, and any necessary changes during the course of each test or experiment.
      (6) Address the functional performance of instrumentation, instrumentation’s intrusiveness to the SUT, and the ability to reduce the captured data to a useable format that allows the evaluators and analysts to assess the SUT.

   b. Each certification supporting T&E events must demonstrate acceptable levels of required actions, activities, or operations in accordance with a certification plan prior to certification for use in the event. Results of the demonstrated levels of performance will be documented in a certification report supporting the certification request.

   c. Certification plans are not required to be submitted for approval prior to the start of the event. Preparation of the certification plan may be integrated with and follow the OT planning effort and the EDP for the event.

   d. Requests for certification and supporting reports will be submitted to the OTC Commander for approval not later than 85 days (T-85) prior to the start of the event. The OTC Commander will exercise the responsibilities of the AA for those events for which OTC is the sole user or will recommend action to the AA for those events for which the approval authority for the evaluative report is external to OTC.
e. The status of the certification requirement for each item to be used in support of the event will be provided at Operational Test Readiness Review (OTRR) #2, which is generally held at 60 days prior (T-60) to the start of the event.

f. Final certification will be completed prior to OTRR #3.

5-3. Responsibilities

a. ATEC Commander. The ATEC Commander is the instrumentation certification authority. The authority is delegated to the ATEC TD.

b. OTC Transformation Technology Directorate. The Transformation Technology Directorate will provide assistance to OTC test directorates, but certification responsibilities remain with the test directorates. The Transformation Technology Directorate will—

   (1) Develop and distribute policy and procedures for OTC elements for developing, coordinating, staffing, and distributing certification plans and reports and certification requests.

   (2) Provide assistance to test directorates for preparation of certification plans and reports and certification requests, when required.

   (3) Review certification plans and reports and requests for certification for completeness.

   (4) Serve as the OTC point of contact and headquarters staff element for processing certification plans and reports and requests for certification to the OTC Commander.

   (5) Support OTC test directorates, as required, for certification.

c. Test directorates. All test directorates will—

   (1) Include certification funding requirement in the outline test plan (OTP).

   (2) Serve as lead agency for instrumentation certification. Ensure principal players are notified and are encouraged to attend the actual instrumentation certification.

   (3) Identify certification requirements and notify instrumentation certification team principal players.

   (4) Conduct the instrumentation certification in accordance with ATEC instrumentation certification procedures, ensuring that instrumentation is compatible with operational test requirements.

   (5) Brief the instrumentation certification status at each OTRR.

   (6) Provide certification report to OTC Commander for approval. Certification report should address certification plan and results, and reflect concurrence between the test officer and the evaluator that the instrumentation performed to standard.

   (7) Establish audit methods for tracking system acquisition obligations and expenditures.

   (8) Prepare OTP paragraph 7, Instrumentation, for test specific instrumentation in coordination with the evaluator. A cost estimate for all instrumentation support will be itemized and totaled in section III, paragraph 2 (Direct Test Cost Estimates), line (j) of the OTP. Review
each OTP for adequacy and accuracy of instrumentation requirements and associated costs before its submission to ATEC Office of the Deputy Chief of Staff for Operations (ODCSOPS).

d. These requirements are discussed in more detail in the OTC Test Operating Procedure and Methodology (TOPM) 73-182.

5-4. Procedures

a. Concept.

(1) A fundamental tenet of certification policy is that any instrumentation used to support operational tests will be certified. Only instrumentation for initial operational tests (IOT), limited user tests (LUT), or the equivalent requires certification. Instrumentation for customer tests generally will not require certification, unless requested by the customer. Instrumentation requirements are identified for use in tests based upon test design parameters, technology requirements, resource constraints, or other reasons. Instrumentation is used to reduce identified limitations in test capabilities for the SUT or resource requirements that would be needed to provide a capability or environment if real physical assets had to be used. The instrumentation certification process is the methodology by which instrumentation chosen for use in a test are examined to determine actual capability to perform the test requirement, identify limitations, and certify that the instrumentation is creditable for the required purpose.

(2) The decision to use instrumentation to support T&E should be made as early in the acquisition cycle as possible so that timely requirements for new instrumentation or upgrades to existing instrumentation can be effected and the certification process can begin. The process must be briefed at OTRR II and OTRR III.

(3) Prior to any certification testing, the following considerations must be made. What are the data requirements to test the instrumentation? Data requirements are required for instrumentation and simulation selection, functional performance, and design. AEC determines evaluation requirements. The OTC test team defines the data requirements. The certification team is formed and managed by the test team. The certification team consists of the OTC test team member (Chair), the instrumentation developer, support contractor, OTC Transformation Technology Directorate, and the personnel determined by the test team as essential. This is depicted in figure 5-1.

(4) Previous instrumentation test results can be the starting point for specific instrumentation certification. System integration testing (SIT) and pilot tests can be used as events/data points for certification testing.

(5) OTC performs or supports the certification process for that instrumentation identified for use in operational tests. The forward test directorates are responsible for the conduct of the certification testing at the forward test directorates. The OTC test directorates test teams, with the assistance of Transformation Technology Directorate, are responsible for the conduct of the certification testing for tests that they are to conduct. There are three considerations:

(a) If the instrumentation is new or revised, certification of the instrumentation itself must be performed by the forward directorates in support of the forward test directorates or by Transformation Technology Directorate in support of Fort Hood test directorates. Results must be reported through the Operations Division of OTC Transformation Technology Directorate to
ATEC, as an attachment to the testing instrumentation certification request. The request must be prepared approximately 2 weeks prior to the pilot test.

(b) If the instrumentation is not resident within OTC, previous certification of the instrumentation itself must be reviewed. If results are available, a report detailing results must be provided through OTC Transformation Technology Directorate to ATEC. If they are unavailable, the procedures in (a) above must be followed.

(c) If the instrumentation to be used is unchanged from previous testing on the same SUT, the test directorate must submit a report based on the previous use and indicating no changes to the instrumentation.

(6) The OTC test team will define data reduction plans, analysis plans, and data product formats. The OTC test team, in conjunction with OTC Transformation Technology Directorate, will determine appropriate instrumentation. The OTC test team and AEC must concur with instrumentation selection. AEC will be a part of the entire process.

b. Methodology.

(1) The instrumentation certification process consists of the following steps:

(a) Assemble the certification team.
(b) Identify all instrumentation that will be used in the test.
(c) Determine if certification is required.
(d) If required, perform certification testing.
(e) Develop, staff, and obtain approval of the certification request for this based upon results of previous employment or execution of the plan.
(f) Forward the certification request to the OTC Transformation Technology Directorate, who will transmit the request through the TD of OTC for the OTC Commander and then forward to ATEC as required.
(g) If not required, request a waiver.

(2) Each of the major steps and supporting actions are depicted in the flowchart in figure 5-1. Instrumentation must be certified approximately 2 weeks before any operational test and can include the pilot test. The test team must provide the certification request to OTC Transformation Technology Directorate, who will submit to ATEC for approval and review by the OTC Commander. The request should address the certification plan and the results.

(3) As a minimum, the certification tests must address the following:

(a) Does the instrumentation perform as required?
   (i) The certification team must confirm the functional performance of instrumentation.
   (ii) The results are provided to test team as input to certification request.
(b) Does the instrumentation intrude on the SUT?
   (i) The certification team evaluates instrumentation’s intrusiveness upon the SUT.
(ii) The results are provided to test team as input to certification request.

(c) Is the captured data reducible to a useable format that allows the evaluators to assess the SUT?

(i) Data is reduced with representative personnel, equipment, applications, and procedures that will be used in the test into the format defined by the test team and AEC.

(ii) Data products from certification events are delivered to the evaluator for concurrence.

(iii) The certification request must include a statement that the evaluator agrees that the instrumentation provides the data needed for the evaluation.
Figure 5-1. Certification Sequence of Events
Appendix A
References, Related Publications, and Standards

Section I
Required Publications

AR 5-11
Management of Army Models and Simulations

AR 70-1
Army Acquisition Policy

AR 73-1
Test and Evaluation Policy

AR 381-11
Intelligence Support to Capability Development

ATEC Regulation 73-21
Accreditation of Models and Simulations for Test and Evaluation

CMU/SEI-2002-TR-029, ESC-TR-2002-029
Carnegie Mellon Software Engineering Institute (SEI) Capability Maturity Model Integration (CMMI) for Software Engineering (CMMI-SW, V1.1) Staged Representation, August 2002
http://www.sei.cmu.edu/cmmi/models/sw-staged.doc

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

DA Pamphlet 73-1
Test and Evaluation in Support of Systems Acquisition

DMSO VV&A Recommended Practices Guide
http://vva.dmso.mil/

DOD 5000.59-M
DOD Modeling and Simulation Glossary
http://www.dtic.mil/whs/directives/corres/pdf/500059m_0198/p500059m.pdf

DOD 5000.59-P
Modeling and Simulation (M&S) Master Plan
DOD 5000.1
The Defense Acquisition System

DOD 5000.59
DOD Modeling and Simulation (M&S) Management

DODI 5000.61
DOD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (V&V)

EIA-649

International Test Operating Procedure (ITOP) 01-1-002
FR/GE/UK/US General Procedure for Modeling and Simulation Verification and Validation Information Exchange, 13 May 2004

MIL-HDBK-881A
Work Breakdown Structures for Defense Materiel Items, 30 July 2005

The Army Model and Simulation Master Plan
October 1997

TOPM 73-182
Model and Simulation Accreditation and Instrumentation Certification Process in Support of Operational Testing and Experimentation

Section II
Related Publications

DA Memo 5-15
Management of Army Models and Simulations Army High Level Architecture (HLA) Implementation Procedures

Department of Defense Architecture Framework (DODAF)
15 August 2003
NOTE: DOD-related V&V information can be accessed on the World Wide Web (www) through the Defense Modeling and Simulation Office home page at http://www.dmso.mil. Links from this URL to other DOD and Service-level Web sites make this an excellent starting point for locating DOD V&V information on the Web.

DIA Instruction 5000.002
Intelligence Threat Support for Major Defense Acquisition Systems
DODI 5200.40
DOD Information Technology Security Certification and Accreditation Process (DITSCAP)

FM 7-100.1
Opposing Force Operations

IEEE 1516-2000
IEEE Standard for M&S HLA - Framework and Rules

IEEE 1516.1-2000
IEEE Standard for M&S HLA - Federate Interface Specification

IEEE 1516.2-2000
IEEE Standard for M&S HLA - Object Model Template (OMT) Specification

IEEE 1516.3-2003
IEEE Recommended Practice for HLA Federation Development and Execution Process (FEDEP)

IEEE/EIA Standard 12207.0
1996 Standard for Information Technology – Software Life Cycle Processes

IEEE/EIA Standard 12207.1

IEEE/EIA Standard 12207.2
1997 Software Life Cycle Processes – Implementation Considerations, 1 April 1998

TENA Architecture Reference Document
4 November 2002


Simulation Validation, A Confidence Assessment Methodology, 1993, Peter L. Kneppell, Deborah C. Arangno, IEEE Computer Society Press, Los Alamitos, CA


Appendix B
VV&A Workbook Template

The VV&A Workbook is an optional template for documenting critical data while performing VV&A. The Workbook is composed of the following five consecutive sections to support the appropriate VV&A steps.

B-1. Transfer Report: Step 8 (Prepare Accreditation Request)
B-2. Accreditation Assessment: Step 8 (Prepare Accreditation Request)
B-3. Decomposition of Issues into Criteria:
   - Decomposition of issues into criteria in Step 4 (Develop Accreditation Plan)
   - Mapping of criteria to V&V Tasks in Step 6 (Plan V&V Activities)
   - Conclusions in Step 8 (Prepare Accreditation Request)
B-4. Planned V&V Tasks: Step 6 (Plan V&V Activities)
B-5. Summary of V&V Results: Step 7 (Perform V&V Activities)

Sections B-1 and B-2 are self explanatory. Section B-3 should capture the accreditation issues and criteria and be included with the accreditation plan. B-4 documents the V&V tasks required and maps to the acceptability criteria captured in B-3 with an assigned V&V Task Number. Both sections B-3 and B-4 should be included with the V&V plan. The V&V results of each task are entered into section B-5 and then maps to the acceptability criterion or criteria it supports via the V&V Task Number. Sections B-3, B-4, and B-5 are included with the V&V report. The AAO analyzes the V&V results in section B-5 and the mapping to the acceptability criteria in section B-3. The AAO enters his/her conclusions about each acceptability issue (i.e., answers each issue) in section B-3 and summarizes the results in sections B-1 and B-2. All sections (B-1 through B-5) are included with the Accreditation report.
B-1. VV&A History Report

This section provides information used when archiving or reporting the VV&A findings in addition to VV&A plans and reports.

Summary of Contents:

M&S Usage History:

Required Input Data (if applicable):

User Documentation (if applicable):

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<tr>
<th>Points of Contact</th>
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<tr>
<td>Organization</td>
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<td>V&amp;V agent</td>
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<td>Accreditation Authority</td>
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<td>Program Manager</td>
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<td>M&amp;S Developer</td>
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<td>Data Provider</td>
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</table>
B-2. V&V Results and Summary

This section summarizes the results from the V&V tasks used for the accreditation assessment. This section should specifically identify the M&S, federation, input data sets, etc., that are being verified and/or validated. A summary of the M&S products examined should be listed, including version numbers. The M&S intended use, input data, use risk and impact, assumptions, constraints/limitations, strength and weaknesses, resources, and results must be captured.

<table>
<thead>
<tr>
<th>V&amp;V Summary &amp; Conclusions</th>
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<td>Input Data Set -1</td>
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<td>Input Data Set -2</td>
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<td>Simulation Output Data Set -1</td>
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- Summary of Overall Strengths and weaknesses based upon V&V conclusions:
- Limitations/Workarounds recommended for the M&S/federation based upon strengths and weaknesses:
B-3. **Issues, Criteria, and Tasks**

This section supports Accreditation Plan Development, Step 4. This will assist in defining accreditation issues, criteria, and tasks to accomplish verification or validation of the model/federation, input/comparison data, and simulation output data. These are three most common and critical VV&A areas. Verification focuses on correctness, completeness, and consistency (CCC) of the technical structure and design of the model/federation while validation focuses on appropriateness of the intended use. A table is provided below for each area.

<table>
<thead>
<tr>
<th>Issues &amp; Criterion #</th>
<th>Decomposition of Issues into Criteria</th>
<th>V&amp;V Task (State the tasks)</th>
<th>Status/Conclusion</th>
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### Federation Verification or Validation Issues, Criteria, and Tasks for *(insert federation name here)*

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<th>Decomposition of Issues into Criteria</th>
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**B-4. V&V Tasks Details**

This section expands information on the V&V tasks to include details on artifacts evaluated, V&V methods used, standards/referents, participating subject matter experts (SMEs), runtime configuration, scenario/experiment, schedule, and current status. The V&V tasks are those identified in B-3 for each of the acceptability criteria. Multiple tasks may apply to one criterion, or the same task may be applicable to multiple criteria.
V&V Tasks

The tables following this one record additional detail on each aspect of the tasks below.

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<thead>
<tr>
<th>V&amp;V Task (Carry forward the tasks from B-3)</th>
<th>Artifact</th>
<th>V&amp;V Method</th>
<th>Referent/Standard</th>
<th>SME Name</th>
<th>Runtime Configuration</th>
<th>Scenario or Experiment</th>
<th>Start Date</th>
<th>End Date</th>
<th>Current Status</th>
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</table>

The tables below record additional details on the artifacts evaluated, V&V methods used, referent/standards used, participating SMEs, runtime configuration, and the factors and conditions that are abbreviated in the table above. Examples are provided on how to fill in portions of the tables.

a. **Artifacts.** List the appropriate artifacts examined to support each task. Listed below are examples.

### Example of Artifacts Evaluated (Items of Evidence)

<table>
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<tr>
<th>Artifact</th>
<th>Artifact Name</th>
<th>Version #</th>
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<td>M&amp;S CM Procedures</td>
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<tr>
<td>Problem Def</td>
<td>Problem Definition and Objectives</td>
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<tr>
<td>TEMP</td>
<td>Test and Evaluation Master Plan</td>
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<tr>
<td>SEP</td>
<td>Simulation Evaluation Plan</td>
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<tr>
<td>SSP</td>
<td>Simulation Support Plan</td>
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</tr>
<tr>
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<td>Description</td>
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<td>Concept of Operations</td>
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b. **V&amp;V Method.** Listed below are examples of V&amp;V methods used, and select the appropriate methods and techniques that correspond to each task.

### Example of V&amp;V Methods Used
*See appendix C for description of V&amp;V tasks*

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<thead>
<tr>
<th>V&amp;V Method</th>
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<th>Tools Used</th>
<th>Description and Role</th>
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<td>Requirements Documentation Review</td>
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<td>Federation Objectives Review</td>
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<td>Conceptual Model Documentation Review</td>
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<td>Design Documentation Review</td>
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<td>Conceptual Model Review</td>
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<td>Verify TENA Compliance</td>
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<td>Federate Architecture Interface Review</td>
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<td>Turing Tests (SME differentiate between model and real world)</td>
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<td>Assess Qualifications of Operators and Analysts</td>
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c. **Standards.** For verification, list the standards used and select the appropriate standards provided below for each task.

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</table>
d. **Referents.** For validation, provide the referents (i.e., representations of the “real world”) for comparison. Examples are listed below.

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<th>Name of Referent</th>
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e. **Participating SMEs.** List each person involved in the V&V and any related effort and their area of expertise, training, and experience.

<table>
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<th>SME Name</th>
<th>Organization</th>
<th>Area of Expertise</th>
<th>Qualifications (e.g., yrs experience, training)</th>
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</tr>
</tbody>
</table>
f. **Runtime Configuration.** Describe the configuration used in performing the V&V effort.

<table>
<thead>
<tr>
<th>Runtime Component</th>
<th>Version</th>
<th>Description and Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers used and operating systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware used</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

g. **Scenario/Experiment.** List the factors and conditions under which the V&V implementation was performed. Examples are shown below.

<table>
<thead>
<tr>
<th>Scenario/Experiment Name</th>
<th>Factor</th>
<th>Control</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light conditions</td>
<td>Systematically varied</td>
<td>Day, night</td>
</tr>
<tr>
<td>1</td>
<td>Target Movement</td>
<td>Systematically varied</td>
<td>Moving, stationary</td>
</tr>
<tr>
<td>1</td>
<td>Enemy action</td>
<td>Systematically varied</td>
<td>Attack, defend</td>
</tr>
<tr>
<td>1</td>
<td>Enemy target</td>
<td>Tactically varied</td>
<td>Troops, vehicle, bunker</td>
</tr>
<tr>
<td>1</td>
<td>Terrain</td>
<td>Tactically varied</td>
<td>Flat, mountainous</td>
</tr>
<tr>
<td>1</td>
<td>Weather</td>
<td>Uncontrolled</td>
<td>Rain, dry, snow</td>
</tr>
<tr>
<td>1</td>
<td>Doctrine/tactics</td>
<td>Held constant</td>
<td>In accordance with support package</td>
</tr>
<tr>
<td>1</td>
<td>Organization</td>
<td>Held constant</td>
<td>Battery level</td>
</tr>
</tbody>
</table>
B-5. Summary of V&V Results

This section summarizes the V&V results for the accreditation issues and acceptability criteria. It also identifies any problem found and the status of the problem. Provide recommendations and remedies to unresolved problems.

<table>
<thead>
<tr>
<th>Issues &amp; Criteria</th>
<th>Description of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue #1</td>
<td></td>
</tr>
<tr>
<td>Criterion #1.1</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Issue #2</td>
<td></td>
</tr>
<tr>
<td>Criterion #2.1</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V&amp;V Problems</th>
<th>Description of Specific Problems Found/Fixed</th>
<th>Resolved? (Y/N) Provide remedies to unresolved problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issues &amp; Criteria</td>
<td>Problem Title</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td></td>
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Appendix C
Description of V&V Tasks

This appendix describes V&V tasks for M&S verification (C-1), M&S validation (C-2), federation verification (C-3), federation validation (C-4), input data verification and validation (C-5), simulation results V&V (C-6), and metrics (C-7).

C-1. M&S verification

a. Configuration Management Procedures Review. Configuration management (CM) is an integral part of the systems engineering management process for system definition and control. CM normally employs three types of configuration baselines—functional (e.g., requirements documentation), allocated (e.g., conceptual model), and product (e.g., design documentation, source/ executable code, engineering drawings). Once a baseline has been established, the developer must control and maintain the originals of the currently approved configuration documentation. The V&V team should verify that the developer/maintainer is doing the following throughout the M&S life cycle:

(1) Prepare/update a CM plan for the M&S.
(2) Use the CM plan as the basis for performing CM activities.
(3) Internal Control: Control changes to baselines according to a documented procedure. Internal control includes:
   (a) Establishing a documentation library and implementing procedures for controlling the documents residing within the documentation library.
   (b) Establishing a drawing library and implementing procedures for controlling the drawings, computer aided design (CAD), and computer aided manufacturing (CAM) instructions residing within the drawing library.
   (c) Creating software products from the software baseline library and establishing the library as a repository for software baselines. Users and developers should not be able to change baseline versions of the source and executable code stored in the software baseline repository. They may check out and modify a copy (not the original) of a software baseline obtained from the library in order to establish a new software baseline that they will later check into the library.
   (d) Recording the status of configuration items/units according to a documented procedure.
   (e) Providing a means by which M&S users and application sponsors can provide input to the M&S enhancement process.
   (f) Initiating, recording, reviewing, approving, and tracking change reports and problem reports for all configuration items/units according to a documented procedure. This includes documenting the following:
      (i) The reason for the change.
      (ii) Description of the change.
      (iii) Impact on users.
(iv) Expected impact on M&S results.

(g) Developing standard reports documenting CM activities and the contents of baselines. Making reports available to affected groups and individuals.

(4) External Control: Control the release of these products according to a documented procedure (DA Pamphlet 5-11). This includes:

(a) Documenting all M&S release requests, and if approved, an archived copy of the released code.

(b) Establishing and administering user group activities found in AR 5-11, paragraph 6-5:

(i) Configuration of the reference version.

(ii) Proposed enhancements to the next reference version.

(iii) Methodologies for V&V of the reference version and changes thereto.

(iv) Documentation of enhancements made by users other than the Configuration Manager.

(c) Establishing and administering procedures through which users may receive quick response help and debugging assistance.

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

b. Configuration Audits. Configuration audits include the functional configuration audit (FCA) and the physical configuration audit (PCA). The FCA is a formal examination of the functional characteristics of a configuration item, prior to acceptance, to verify that the item has achieved the requirements specified in its functional and allocated configuration documentation. The PCA is a formal examination of the “as-built” configuration of a configuration item against its technical documentation to verify the configuration item’s product baseline. See EIA-649 and previous task for additional information.

c. Documentation Review. A document review involves reviewing documentation for:

(1) Structure: Verify that the document is adequately organized. Some specific questions to answer are:

(a) Is the table of contents correct?

(b) Is there a bibliography of prerequisite publications?

(c) Are the references complete enough to locate the publication?

(d) Are the references available?

(e) Does the organization of the document contribute to the ease of finding information?

(f) Does the format comply with applicable standards?

(2) Readability: Verify that the document is readable. Salient contributors to readability include paper size, use of color, print font, print size, size of figures, etc.
(3) Consistency: Verify internal consistency within the document and between it and other M&S documents.

(4) Clearness: Verify that the document is unambiguous. Some specific questions to answer are:

(a) Are examples clear?
   (i) Used where necessary?
   (ii) Relevant where used?
   (iii) Contribute to understanding?

(b) Are diagrams, pictures, or the visual materials clear?
   (i) Used where necessary?
   (ii) Relevant where used?
   (iii) Contribute to understanding?
   (iv) Clearly rendered?
   (v) Appropriate level of detail?

(c) Is the terminology clear?
   (i) Consistent throughout the document?
   (ii) Consistent with other system documents?
   (iii) Conforms to applicable standards?
   (iv) Is there a glossary, if appropriate?
   (v) Are the acronyms utilized correctly?
   (vi) Are definitions clear and correct?

(5) Completeness and correctness: Some specific questions to answer are:

(a) Are all essential topics complete?
(b) Is there completeness in detail, assumptions, facts, unknowns?
(c) Is there excessive dependence on external references?
(d) Are there any errors of fact?
(e) Do all elements have function (no extraneous items) and potential?

(d. Requirements Documentation Review. In addition to the documentation review activities, SMEs should additionally do the following:

(1) Verify that each requirement can only be interpreted one way by all readers. For example, “The simulation shall seem real to the user” is an unclear requirement, because the phrase “seem real” can be interpreted differently by different people. Such a requirement should be rewritten to clarify what is wanted. An example of a requirement more clearly stated is, “The color scheme of all M1A1 tanks seen in the simulation shall be visually indistinguishable from that of an actual M1A1 tank painted in desert camouflage colors.”
(2) Verify that the success of meeting a requirement can be determined with a finite and reasonable set of test cases. For example, “The system shall have a user-friendly interface” is entirely non-testable because user-friendly is undefined. On the other hand, “The system shall allow the user to enter the functional parameters of the missile under test via a pop-up window” is entirely testable. All the tester has to do is determine if a reasonable means has been provided to produce a pop-up window for the required data entry.

(3) Verify adequacy of system engineering requirements. Review requirements documentation for adequacy of system engineering requirements. The system-level requirements describe the M&S as a whole and may be composed of hardware and/or software. This task includes ensuring the following types of requirements are adequately included, as appropriate, in the requirements documentation: (These were adapted from the MIL-STD 498 Software Development and Documentation, System/Subsystem Specification Data Item Description.)

(a) Adaptation: Requirements concerning installation-dependent data that the M&S is required to provide and operational parameters that the M&S is required to use that may vary according to operational needs.

(b) Safety: Requirements concerned with preventing or minimizing unintended hazards to personnel, property, and the physical environment. This applies to both hardware and software systems.

(c) Security and Privacy: Requirements concerned with maintaining security and privacy. This should include, as applicable, the security/privacy environment in which the system must operate, the type and degree of security or privacy to be provided, the security/privacy risks the system must withstand, required safeguards to reduce those risks, the security/privacy policy that must be met, the security/privacy accountability the system must provide, and the criteria that must be met for security/privacy accreditation. All DOD information systems must be certified and accredited in accordance with DOD Instruction 5200.40. See DOD Instruction 5200.40 for additional information.

(d) Information Assurance: Requirements for protecting and defending information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. This includes providing for restoration of information systems by incorporating protection, detection, and reaction capabilities.

(e) Environmental: Requirements regarding the environment in which the system must operate. For software, this would include computer hardware and the operating system on which the software must run. For hardware, this would include environmental conditions the system must withstand during transportation, storage, and operation, such as conditions in the natural environment (e.g., wind, rain, temperature, geographic location) and the induced environment (e.g., motion, shock, noise, electromagnetic radiation).

(f) Computer Resources: Requirements regarding computer hardware that must be used by the software, or incorporated into the M&S hardware. This includes, as applicable, number of each type of equipment, type, size, capacity, and other required characteristics of processors, memory, input/output devices, auxiliary storage, communications/network equipment, and other required equipment.
(g) Design and Construction Constraints: Requirements that constrain the design and construction of the hardware and/or software. For hardware, this would include the physical requirements imposed on the system.

(h) Manpower and Personnel Integration (MANPRINT): Requirements to accommodate the number, skill levels, duty cycles, training needs, or other information about the personnel who will use or support the system. Human factors engineering requirements should include, as appropriate, considerations for the capabilities and limitations of humans, foreseeable human errors under both normal and extreme conditions, and specific areas where the effects of human error would be particularly serious. Examples include requirements for adjustable-height workstations, color and duration of error messages, physical placement of critical indicators or buttons, and use of auditory signals.

(i) Logistics-Related: Requirements concerning logistics considerations, including system maintenance, software support, system transportation modes, supply-system requirements, impact on existing facilities, and impact on existing equipment.

(j) Packaging: Requirements for packaging, labeling, and handling the system and its components for delivery. Applicable military specifications and standards may be referenced if appropriate.

(4) Verify adequacy of quality requirements. Review requirements documentation for M&S quality assurance factors. This includes ensuring that the following types of requirements are adequately included, as appropriate, in the requirements documentation:

(a) Functionality: the ability to perform all required functions.

(b) Reliability: the ability to perform with correct, consistent results.

(c) Maintainability: the ability to be easily serviced, repaired, or corrected.

(d) Availability: the ability to be accessed and operated when needed.

(e) Flexibility: the ability to be easily adapted to changing requirements.

(f) Portability: the ability to be easily modified for a new environment.

(g) Reusability: the ability to be used in multiple applications.

(h) Testability: the ability to be easily and thoroughly tested.

(i) Usability: the ability to be easily learned and used.

(j) Reducibility: the ability to be easily produced.

(k) Interoperability: the ability to work effectively together toward a common goal.

(l) Effectiveness, suitability, and survivability: the ability to support a particular purpose.

e. Conceptual Model Review. In addition to the documentation review activities, the V&V team should verify that the conceptual model specifies, as applicable, the following:

(1) Essential scenarios and vignettes.

(2) Number and types of entities.
(3) Entity requirements including required attributes and components, dynamic interactions and static relationships with other objects.

(4) Fundamental interactions between entities.

(5) The logical context of required processes.

(6) Required processes and their relationships are adequately described.

(7) Input data requirements and authoritative sources are identified.

(8) Fidelity requirements are specified.

f. **Design Documentation Review.** In addition to the documentation review activities, this should include:

(1) For the software design:
   
   (a) Unit Checks: Check equations to ensure that measurement units are consistent throughout the equations.

   (b) Algorithm Checks: Compare algorithms and equations to authoritative documentation to determine their fitness for use in the target application. Comparison to other acceptable methodologies is also applicable. This check attempts to determine whether acceptable, standard algorithms and equations have been used in M&S development. Verify correct implementation of algorithm.

   (c) SME Review: Independent, knowledgeable experts review algorithms and equations used in the M&S. Such reviews often highlight hidden assumptions, and their impacts on M&S results can result in more efficient design and implementation.

   (d) Rule Verification: SMEs familiar with the intended use of the system should verify the rules. Verification of rule-based systems must address the completeness and correctness of the knowledge base. It is also important to detect rule redundancy since this affects run-time performance and may cause inconsistencies and other difficulties during the maintenance phase.

(2) For the hardware design:

   (a) Review adequacy of drawings including schematic diagrams.

   (b) Review adequacy of the design in the following areas, as appropriate:

   (i) Electrical design.

   (ii) Mechanical design.

   (iii) Power generation and grounding.

   (iv) Electrical and mechanical interface compatibility.

   (v) Mass properties.

   (vi) Physical properties.

   (c) Review the adequacy of interface control drawings.

  
g. **Requirements traceability matrix.** The requirements should be traceable through the conceptual model components/elements, design and test cases. Higher-level requirements that
are not traceable to lower-level requirements indicate functionality that is being left out. If the M&S contain higher- and lower-level requirements, they should be traceable and consistent with each other. If the developer created a traceability matrix for the requirements, the V&V team should verify it is correct. If the developer has not developed a traceability matrix, the V&V team should create one. To create a traceability matrix, the V&V team should create a table or spreadsheet with the higher-level requirements across and the lower-level requirements down (or vice versa). Compare each higher-level requirement with each lower-level requirement. When a higher-level requirement in a particular column is met by a lower-level requirement in a particular row, enter an “M” in the corresponding cell in that row and column. If a particular requirement is not met, enter an “N” in the appropriate cell. For each requirement only partially met, enter a “P” in that cell. Do the same thing for each lower-level requirement. After each requirement is compared, the V&V team determines if a requirement is completely traceable. Lower-level requirements that are not traceable to higher-level requirements indicate functionality not required and may mean additional cost down the road if not corrected.

(1) Table C-1 is an example of a traceability matrix that compares system and software configuration item (CI) requirements. In this case, each system requirement should be traceable to the CI requirements and each CI requirement should be traceable back to a system level requirement.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CI</td>
<td>Req</td>
<td>S-1</td>
<td>S-2</td>
<td>S-3</td>
</tr>
<tr>
<td>2</td>
<td>CI-1-1</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CI-1-2</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CI-2-1</td>
<td>P</td>
<td></td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CI-2-2</td>
<td>P</td>
<td></td>
<td></td>
<td>P</td>
</tr>
<tr>
<td>6</td>
<td>CI-2-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M, N, or P?</td>
<td>M</td>
<td>P</td>
<td>M</td>
<td>N</td>
</tr>
</tbody>
</table>

(2) The matrix in the example shows the following:

(a) Requirement CI-1-1 is met by requirement S-1. This is indicated by the “M” in cell B2. Since both of these requirements are totally met, there is an “M” entered in cell F2 and B7.

(b) Requirement CI-1-2 is partially met by requirements S-2 and S-3 – indicated by a “P” in cells C3 and D3. Since all of requirement CI-1-2 is met by S-2 and S-3, there is an “M” in cell F3.

(c) Requirement CI-2-1 is partially met by S3 – indicated by “P” in cell D4. Since this requirement is only partially met, there is a “P” in cell F4.

(d) Requirement CI-2-2 is partially met by requirement S-2 – indicated by the “P” in cell C5. Since this requirement is only partially met, there is a “P” in cell F5.
(e) Since requirement CI-2-3 is not met by any of the system requirements, there is an “N” in cell F6. This indicates that requirement CI-2-3 may not be needed.

(f) Requirement S-2 is partially met by requirements CI-1-2 and CI-2-2. Since these two requirements do not totally satisfy S-2 there is a “P” in cell C7.

(g) Requirement S-3 is totally met by CI-1-2 and CI-2-1 together – indicated by the “M” in cell D7.

(h) Requirement S-4 is not met by any of the CI requirements. This indicates missing functionality.

h. Participate in requirements review(s). The V&V team should participate in any planned requirements reviews. The V&V team should request requirements reviews when necessary to ascertain the adequacy of the requirements and/or resolve open issues regarding the specified requirements. Some things that could be reviewed at a requirements review include intended use of the model; clearness, completeness, and testability of the requirements; traceability; system engineering factors; quality assurance factors; interfaces; cost effectiveness; risk analysis; test planning; configuration management plans; and schedules.

i. Participate in conceptual model review(s). The V&V team should participate in any planned conceptual model reviews. The V&V team should request conceptual model reviews when necessary to ascertain the adequacy of the conceptual model and/or to resolve open issues regarding the specified requirements. To be successful, it must not be used as a performance appraisal of the conceptual modeler.

j. Participate in design review(s). The V&V team should participate in any planned design reviews. The V&V team should request design reviews when necessary to resolve open issues regarding design decisions. Some things that could be reviewed at a design review include clearness and completeness of the design; adequacy of software and/or hardware design; adequacy of meeting system engineering requirements; adequacy of meeting quality assurance requirements; adequacy of meeting interface requirements; traceability of design, conceptual model, and requirements; cost effectiveness; risk analysis; test planning; configuration management; and schedules.

k. Participate in test readiness review. The V&V team should participate in planned test readiness reviews (TRR). When necessary, the V&V team should request a TRR to resolve open issues regarding one or more of the following: status of the test environment, test cases and procedures for qualification testing, and status of M&S to be tested. Some specific things that could be reviewed include requirements changes, design changes, test plans and descriptions, test procedures, test cases, results of previous tests, test resources, test limitations, implementation problems, schedules, and documentation updates.

l. Participate in design walk-throughs/inspections. Design walk-throughs and inspections involve a more detailed examination of the design than a design review. Design walk-throughs and inspections involve an intricate line-by-line examination of the design. The main thrust of a walk-through or inspection is to detect and document faults. To be successful, it must not be used as a performance appraisal of the developmental team. A walk-through is less formal, has fewer steps, and does not use a checklist to guide or a written report to document the team’s work. By comparison, an inspection takes much longer than a walk-through; however, the extra time can be justified because an inspection is a powerful and cost-effective way of
detecting faults early in the M&S developmental cycle. (Reference DOD VV&A Recommended Practices Guide for more information.)

m. **Participate in code walk-throughs/inspections.** Code walk-throughs and inspections involve an intricate line-by-line examination of the code. This task should be done only for specific high-risk areas of the code. The main thrust of a walk-through or inspection is to detect and document faults. It is not to be used as a performance appraisal of the developmental team. See “Participate in design walk-throughs/inspections” for more information about walk-throughs and inspections.

n. **Interface analysis.** This technique is especially useful for V&V of interactive and simulation federates (DOD 5000.59-P). Interface analysis consists of the following:

   (1) Model Interface Analysis. A model interface analysis examines sub-model-to-sub-model interfaces within a model, hardware-software interfaces, or federate-to-federate interfaces within a federation, and determines if the interface structure and behavior are sufficiently accurate.

   (2) User Interface Analysis. A user interface analysis examines the model’s user-interface and determines if it is human engineered to prevent errors during the user’s interactions with the model. It also assesses how accurately this interface is integrated into the overall M&S.

o. **Witness tests to ensure design functions are tested.** The V&V team should first verify that the test cases address every design function and then verify that the test plan is followed.

p. **Test design conformance.** Test the model to determine if all design functions were implemented. The test plan should be traceable to the design.

q. **Acceptance test.** Operationally test the model with the actual hardware and data to determine whether all requirements are satisfied. The V&V team should first verify that the test cases address all of the required model functionality. Acceptance testing is usually conducted by either the VV&A Agent and the M&S application sponsor or the developer’s quality control group in the presence of the sponsor’s representatives (reference DOD VV&A Recommended Practices Guide).

r. **Compliance testing.** Compliance testing compares the simulation to required security and performance standards. Compliance testing techniques include:

   (1) Authorization testing: Test how accurately different levels of security access authorization are implemented in the simulation and how they comply with established rules and regulations. The test can be conducted by attempting to execute a classified model within a federation or by using classified input data to run a simulation without proper authorization.

   (2) Information Technology Certification and Accreditation: Document the system mission, environment, and architecture; identify the threat; define the levels of effort; identify the certification authority and the designated approving authority; and document the necessary security requirements. Verify compliance of the system with previously agreed security requirements. Evaluate the fully integrated system to validate system operation in a specified computing environment with acceptable level of residual risk. Monitor the system management and operation to ensure an acceptable level of residual risk is preserved. Security management, change management, and periodic compliance validation reviews are conducted. See DODI
5200.40 for additional information. All DOD information systems must be certified and accredited in accordance with DODI 5200.40.

(3) Performance testing: Test whether all performance characteristics are measured and evaluated with sufficient accuracy and if all established performance requirements are satisfied.

(4) Security testing: Test whether all security procedures are implemented correctly. For example, penetrating the simulation while it is running and breaking into classified components such as secure databases can be attempted. Security testing evaluates the adequacy of protective procedures and countermeasures.

(5) Standards testing: Substantiate that the M&S application is developed with respect to the required standards, procedures, and guidelines.

s. **Static Analysis.** Static analysis verification assesses the structural characteristics of the source code without execution. This differs from inspections and walk-throughs by the use of automated tools. These tools search for questionable coding practices and departures from coding standards as well as detecting structural errors. For example, an automated static analyzer may find a variable that is not initialized on all paths or a variable that is set but not used any paths.

t. **Data Flow Inspections.** Data flow inspections trace a datum through the simulation from input through calculations to output. Items checked involve data being passed correctly, data being correctly manipulated and being passed to the correct routine with consistent units.

C-2. M&S validation

a. **Face Validation.** Face validation is the process in which potential users and people knowledgeable about the real world system use their professional judgment to compare the model with real world behaviors. The comparison is accomplished subjectively under identical input conditions, and judgment is made as to whether the model and its results are reasonable. Face validation is useful mostly as a preliminary approach to validation in the early stages of development. Except for a mature model with an extensive, well-documented VV&A history, viable validation efforts must generally use additional validation techniques (DOD 5000.59-P).

b. **Validate conceptual model.** Preliminary conceptual model reviews can be performed on partial and preliminary conceptual models; however, the final complete conceptual model should always be evaluated when available. Ideally the scope of the review would cover everything, but due to time, cost and/or schedule constraints, the review may be restricted to the most significant aspects of the simulation. Conceptual model validation is normally based upon SME professional judgment. The review may include quantitative assessments such as sensitivity analyses and comparison with data from various sources. Some specific questions to ask are:

(1) Are all elements and aspects of the item (entities, states, behaviors, actions, tasks, etc.) to be represented included? If any were omitted, are they pertinent for the intended simulation application?

(2) Are all assumptions identified? Are the implications of these assumptions clearly and correctly identified? What assumptions were omitted and what implications need clarification?
(3) Do the algorithms provide adequate fidelity (as expressed in terms of accuracy, resolution, etc.) for the simulation to support the intended applications, to satisfy simulation requirements, and to comply with criteria given as guidance for the conceptual model validation review? Are algorithms appropriate with acceptable authoritative pedigrees? What is the relation of these algorithms to “standard” algorithms used elsewhere within the Defense community?

c. **Functional decomposition validation.** Validate the simulation’s functional components and then validate how well the components fit together. Decomposing the M&S into functional components is often a technique used in validating a model, especially large complex M&S. Functional area SMEs examine in detail the documentation, code, and output to determine the validity of each segment of the decomposed M&S. The SME examines interoperability of the functional components to determine how well the pieces fit together and the overall validation of the model. The SME should be sensitive to the intended uses of the M&S since this may drive the level of decomposition. 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 (DA Pamphlet 5-11).

d. **Comparison validation.** Validate the model by comparison to similar accredited M&S. This compares code/units, documentation, input data, and test results with the test results of a model that has already been accredited for a similar use. For example, graphical displays of missile fly-outs, the battlefield, and output results may be compared among several M&S. This comparison 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 information that is reasonably available for comparison (DA Pamphlet 5-11).

e. **Output validation (or operational validation).** Output validation provides more credibility than other validation methods. It involves the direct comparison of model results to real world data that will specifically validate the model. The following outline contains the steps necessary to validate an M&S using output validation.

1. Identify and/or define the intended use of the model. The V&V team should include a description of the intended use in the V&V implementation plan.

2. Identify those elements of the model where accurate representations of reality are critical to support this intended use.

3. Prioritize these elements.

4. Identify sources of real world data that can be used to provide comparisons to the model characteristics or responses identified in step 2.

5. Outline the evaluation criteria in the V&V implementation plan. Describe how the model results and the real world data will be compared.

6. Run the simulation and compare the results from the model to the real world data. Standard statistical tests can sometimes be used to determine whether the differences in the means, variances, and probability distributions generated by the two sets of data are significantly different. Time-dependent behavior of the data may also be statistically compared. If the data cannot be statistically analyzed, the V&V team should ask personnel familiar with the behavior of the real system if they can differentiate between the two data sets.
(7) Document both the tests and all of the results. Consider using graphical representations of the results versus providing only the raw data. Include a discussion of both the strengths and weaknesses of the model to support the intended application(s). Note: Perfect validation is not possible. The intent is to demonstrate how well or how poorly the model results compare to what is expected in the real world. The accreditation process will determine if the match is good enough for the accreditation agent’s intended purpose.

f. **Model-Test-Model.** Interactively use T&E results for model improvements until adequately validated. The Model-Test-Model approach is part of the System Test and Evaluation Process (STEP) and the Simulation and Modeling for Acquisition and Training (SMART) concepts, where test data are collected to make the model more accurately represent the actual system and operating environment as time progresses (Draft STEP Guidelines). The Model-Test-Model process is accomplished with 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 phases of Model-Test-Model are:

1. **Pretest Modeling Phase.** Estimate a range of test results prior to the conduct of record trials/events. Pretest modeling focuses on test design issues such 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, the operational requirements, and/or capabilities documents for a 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. During this phase, functional validation is a useful technique to ensure that selected portions of the M&S can represent specific test objectives. M&S support personnel and test support personnel, as part of an overall test team, should work together well in advance of the actual field testing, to ensure that test data are collected in a form usable by the models and simulations, that all required data are collected (for example, data describing engagement procedures, environment conditions, system performance, and so forth). Results from pretest modeling phase can be used to assist in planning the field test and in planning details of the data collection and analysis effort (DA Pamphlet 5-11).

2. **M&S Measures and Test Observation Comparison Phase.** This phase begins with conducting the test. The actual field test results are then compared to the pretest modeling results as part of the M&S validation process, and to fine tune the M&S (if needed) for further iterations of the Model-Test-Model.

3. **Post-Test Modeling Phase.** 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 addressed within the constraints of the test itself (DA Pamphlet 5-11).

g. **Ask experts to differentiate between model and real world data flow, controls, and outputs (i.e., Turing test).** A Turing test is based upon the expertise of people knowledgeable
about the real world system. The experts compare two sets of results, one from the model and one from the real world system, under the same input conditions. Without knowing which data set is which, the experts try to differentiate between the two. If the experts cannot differentiate between the two, confidence in the model’s validity is increased (DOD VV&A Recommended Practices Guide).

h. **Graphically compare model variables with real world variables.** Graphical comparison is a subjective, inelegant, and heuristic, yet practical approach, especially as a preliminary validation step. The V&V team graphs model and real world variables over time to investigate characteristics such as similarities in periodicity, skew, number, and location of inflection points; logarithmic rise and linearity; phase shift; trend lines; and exponential growth constants (DOD VV&A Recommended Practices Guide).

i. **Compare animation/graphics playback of simulation with real world.** Visualization and animation greatly assist in model V&V. This method is particularly useful for validating representations of vehicle/unit movement and weapon firings (DA Pamphlet 5-11). Displaying graphical images of internal and external dynamic behavior of a model is very useful in uncovering errors. Visualizing model output as it executes and comparing it with real world can help identify discrepancies. It does not, however, guarantee model correctness and should be used with caution (DOD VV&A Recommended Practices Guide).

j. **Predictive validation.** Predictive validation requires past input and output from the system being modeled. The model, driven by the past input data, produces output that is compared with the corresponding past output data. The results validate the predictive ability of the model (DOD 5000.59-P).

k. **Sensitivity analysis and/or stress tests.** Sensitivity analysis is performed by systematically changing the values of model input variables and parameters over some range of interest and observing the effect upon model behavior. Stress testing strains the M&S to determine where and when it will break. Sensitivity analysis and stress testing can be applied to both verification and validation. Some special input tests that the V&V team performs are (DOD VV&A Recommended Practices Guide):

   1. **Boundary Value Testing.** Examine model accuracy by testing boundaries of input data. The underlying rationale is that most error-prone test cases lie along the boundaries.

   2. **Equivalence Partitioning Testing.** Partition the model input domain into equivalence classes in a way that a test of a representative value from a class is assumed to be a test of all values in that class.

   3. **Extreme Input Testing.** Run the M&S with only minimum values, maximum values, or an arbitrary mixture of minimum and maximum values for the model input variables. For example, this technique allows the model user to test a proposed weapon system against extreme conditions that may not be obtainable in actual system testing.

   4. **Invalid Input Testing.** Run the M&S under incorrect input data to determine whether the model behaves as expected. Unexplained behavior may reveal errors.

   5. **Real-Time Input Testing.** Use real-time input data collected from a real system to capture the timing relationships and correlation between data points.
(6) **Self-Driven Input Testing.** Run the M&S under input data randomly sampled from probabilistic models representing random phenomena in a real or future system.

(7) **Stress Testing.** Test the model under extreme workload conditions.

(8) **Trace-Driven Input Testing.** Run the M&S under input trace data collected from a real system. For example, a system can be instrumented with monitors that collect data by tracing all system events. The raw trace data are then refined to produce the real input data for testing the M&S.

(9) **Statistical testing for repeatable stochastic M&S.** Sensitivity analysis for repeatable stochastic M&S can be performed with assurance that the resulting change in output is a result of the corresponding change in input. 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 is unique to testing stochastic M&S that should be verified and documented (DA Pamphlet 5-11).

(10) **Statistical testing for non-repeatable stochastic M&S.** Sensitivity analysis is most difficult in M&S that incorporates direct human input since it introduces non-repeatable stochastic behavior. 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 (DA Pamphlet 5-11).

C-3. **Federation verification**

a. **Federation Objectives Review.** In addition to documentation review activities, SMEs should review the federation objectives and requirements and provide the following:

   (1) Verification that the objectives/requirements are readable, internally consistent, unambiguous, complete, and correct.

   (2) Verification that the federation objectives are consistent with the user/sponsor needs.

   (3) Technical expertise and guidance related to existing and/or emerging technical capabilities that could impact the objectives.

   (4) Assessment of the feasibility of technologies and identification of any concerns that should be included in the federation’s formal risk assessment and risk mitigation plans.

   (5) Examination of networking requirements, security requirements and facility concerns and identification of operational constraints, limitations, preferences, and program risks.

b. **Federation Conceptual Model/Scenario Review.** SMEs should review the federation conceptual model/scenario document and verify the following:

   (1) The descriptions of the federation scenarios are readable, internally consistent, unambiguous, complete, and correct.

   (2) Detailed scenario descriptions are consistent with high-level scenario descriptions.

   (3) The federation scenarios are consistent with the federation objectives and the user/sponsor needs.
(4) The federation conceptual model is readable, internally consistent, unambiguous, complete, and correct.

(5) The federation conceptual model is consistent with the federation scenarios.

c. **Federation Design Review.** SMEs should review the federation design documentation and verify the following:

(1) The federation design is readable, internally consistent, unambiguous, complete, and correct.

(2) The federation design is consistent with the federation objectives/requirements and conceptual model.

d. **Verify Architecture Compliance.** Architecture compliance is the measurement of how much a given system follows its precepts and implements its policies.

(1) **For High Level Architecture (HLA),** this task verifies whether federates have complied with HLA Rules in the DMSO HLA Compliance Checklist. HLA compliance certifies that:

(a) The federates’ simulation object models (SOMs) conform to the object model template (OMT).

(b) The implementation and use of the runtime infrastructure (RTI) services correctly support defined objects and interactions.

(c) The federation object model (FOM) conforms to the OMT.

(d) The federates’ application program interface (API) designs correctly identify the HLA interface specification services that support the objects and interactions specified within their SOMs and FOM.

(e) The federates within the federation exchange all FOM data via the RTI, in accordance with the HLA Rules, OMT, and interface specification.

(f) Federates can adhere to federation time management strategies.

(2) **For Test and Training Enabling Architecture (TENA),** this task verifies whether the architecture follows the rules for using TENA. The rules are divided into three different categories, representing the three different levels of TENA compliance. The three categories of rules (and their associated compliance levels) are paraphrased below:

(a) **Level 1—Minimal Compliance:**

(i) Applications must use the standard API when interacting with each other via the TENA Middleware.

(ii) Logical ranges must have a logical range object model (LROM) defined.

(iii) All objects in the LROM must conform to the TENA meta-model.

(b) **Level 2—Extended Compliance:**

(i) All execution-time communication between applications must be via the TENA Middleware.
(ii) Application designers must describe the data their applications produce and consume.

(iii) All applications must implement time properly.

(iv) All applications must describe the mechanism and accuracy of their time measurements.

(c) Level 3—Full Compliance:

(i) All applications must publish an Application Management Object.

(ii) Applications may not use object definitions that conflict with the standard TENA Object Model.

(iii) Applications must use the Logical Range Data Archive for all data storage.

e. Verify Functionality. This task focuses on ensuring the design and development activities support the federation’s connectivity and interoperability requirements and include verifying the following:

1. The FOM/LROM is internally consistent, complete, and correct.

2. The FOM/LROM is consistent with the federation design, conceptual model, scenarios, requirements, needs, and objectives.

3. The FOM/LROM is consistent with descriptions of objects or interactions drawn from authoritative sources.

4. Federation plans and agreements are consistent, complete, and correct.

5. The federation infrastructure is consistent with the federation design and development plans and meets documented infrastructure requirements.

6. The configuration, initialization, and operation of all network components are correctly achieved.

7. The installation and operation of the architecture infrastructure is correct.

8. All federation members have properly adhered to the infrastructure requirements and associated configurations/initializations.

9. The implemented infrastructure supports the execution and intercommunication of all federation components.

10. The infrastructure design, implementation, configuration, and initialization do not adversely affect the ability of the federation to meet the representational requirements defined by the federation acceptability criteria.

11. The effects of all special procedures required for starting, stopping and conduction of each execution run do not adversely affect the validity of the simulation/federation.

12. Each federate operates as documented.

13. The integrated federation as a whole behaves according to the FOM/LROM design.

14. The federation operates semantically correct (substantive interoperability).
(15) Communication over the network is possible and network capacity and latency is appropriate for clear communication during execution.

f. **Compatibility Verification.** This task includes:

(1) Reviewing the federation execution plan to see if it meets all federation requirements. This involves identifying and verifying risk mitigation strategies for high-risk requirements and identifying unfulfilled requirements as limitations of the federation.

(2) Participating in federation integration testing, ensuring federates can exchange data and interact with each other. This testing normally begins with pair-wise integration of closely coupled federates to test the common objects and interactions and verifying the correctness of the implementation and representation of scenario elements. This testing sequence is repeated on an expanding set of federates until all avenues of communication among the federates and all elements of the scenario are tested.

C-4. **Federation validation**

a. **Federation Validation.** This task addresses the issue of result validation. It is concerned with the interoperability within the federation. V&V representatives should do the following:

(1) Evaluate the behaviors and performances by comparing the federation operation to real-world situations and the judgments of experts from the user and technical communities.

(2) Identify the limitations and constraints of the federation, establishing its credibility boundaries.

b. **Interoperability Validation.** Validate the behaviors and performance of each federate against their respective set of requirements including validation of:

(1) Input data.

(2) Operation of the federate within the synthetic environment.

(3) Interoperability with other interfacing federates.

(4) Federate performance and behavior.

C-5. **Input data verification and validation**

a. **Review Data Configuration Management Procedures.** The benefits of data configuration are to ensure data integrity and promote good data management practices encompassing:

(1) Data identification – the process of differentiating between similar data files (e.g., file name, version identifier, metadata, traceable history).

(2) Data status level management – the application of business rules based on the status of the data (e.g., rules for version identification, data format, access privileges, approval requirements and method of approval, and archiving based on the state of data such as draft, released, submitted, approved, or archived).
(3) Maintenance of data configuration relationship – the management of key relationships (e.g., using the correct data with the correct model) within a specific configuration (not an earlier or later configuration) ensuring controlled data access or retrieval by users.

(4) Data version control – the management of the data review process to establish an audit trail of comments or annotations by reviewers and their disposition.

(5) Data transmittal – the process for ensuring data products are usable and that physical media such as compact disks have appropriate identification clearly identifying its contents. The suppliers instructions (e.g., read me files) should include as applicable, the identification of the data files transferred, the purpose of the transmittal, data assembly instructions, naming conventions, how changes from previous versions are indicated, how to acknowledge receipt of data or provide comments, and time constraints.

(6) Data access control – the process of limiting access to applicable users varying according to status of the data, the nature of the data, and the user requirements ensuring users get the correct version of data they are entitled to.

b. **Input Data Verification.** Data producer verification is the process of determining if the input data meets the constraints defined by data standards and business rules derived from process and data modeling. Data user verification additionally includes determining if data are converted to the correct input formats and units of measure and have values within the allowable range as specified in the design of the M&S.

(1) For hardware M&S, data verification could include:
   (a) Checking the calibration of instrumentation or sensors used in a test.
   (b) Verifying the processed data have been converted properly from the raw data.
   (c) Checking for clipped data.
   (d) Checking that meters and recorders are zeroed or nulled.
   (e) Checking the functioning of data recorder trigger thresholds.

(2) Metadata should be verified to determine if it satisfactorily describes the characteristics of the data, information about the data, descriptive information about an organization’s data, data activities, systems, and holdings. Without metadata, data sets and databases are difficult to interpret. The user must know some general information about the data before it is used in M&S. This should include information such as what the data represent, the format of each data field, and how the data was generated. (DA Pamphlet 5-11)

(3) 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 are used to develop and maintain DOD standard data elements. Models should be created using standard methodologies. The management of Army M&S data is governed by DODD 8320 series. (DA Pamphlet 5-11)

c. **Input Data Validation.** Data validation is the review of the data to compare them to corresponding known real world or data-estimate values. Data producer validation determines if the data is within stated criteria and assumptions. Data user validation determines if the data is appropriate for use in an intended model and use. The metadata should be reviewed to determine
if the data satisfactorily characterizes the data for the given application (e.g., data currency, availability, quality assessment history, usage in similar applications, fidelity, and other quality characteristics). Results should be documented. (DOD VV&A RPG)

C-6. Simulation results V&V

a. **Assess the correctness of the runtime environment.** This task assesses whether there are any errors in runtime environment, including the hardware, software, and interfaces.

b. **Assess adequacy of scenario for intended use.** Assess the environment representations (e.g., terrain, weather) for adequate fidelity to address the intended use. Assess the clarity, fidelity, complexity, and level of detail of simulated entities to determine if they are acceptable for the intended usage. Results should be documented.

c. **Federation scenario.** During federation testing, ensure that federates share common environmental and spatial references, and that all federates meet “fair fight” criteria.

d. **Assess qualifications of operators and analysts.** Operators and analysts should be adequately trained and qualified to respectively operate and analyze simulation results. This assessment can be via biographies and interviews with the operators and analysts. Assess whether supporting documentation (e.g., user manuals, tutorials, etc.) is aimed at the targeted skill levels of the operators and analysts using the simulation. Results should be documented.

C-7. Metrics

a. **Complexity metric report.** The metric is commonly applied to large software developmental efforts. Source code or program design language (PDL) is the material examined for determining complexity. Automated tools should be used to compute the measures accurately and consistently. The complexity metric provides a means to measure and evaluate the structure of software units. Software that is more complex is harder to understand, test adequately, and maintain. Additionally, a highly complex unit is more likely to contain embedded errors than a unit of lower complexity. The Army complexity metric allows selection from five different measures: (See DA Pamphlet 73-1 for additional information about this metric.)

   (1) McCabe’s cyclomatic complexity: Relative degree of effort to test or maintain a software unit (based on the number of ways control could flow through the unit).

   (2) Halstead’s length, vocabulary, and volume: Relative degree of effort to test or maintain a software unit (based on the amount of data and number of operations performed on them).

   (3) Control flow: “Unstructured” changes in control flow though unit.

   (4) Lines of source code: Size.

   (5) Percent comment lines: Understandability and maintainability.

b. **Breadth of testing metric report (% requirements tested and % requirements passed).** This metric addresses the degree to which required functionality is successfully demonstrated as well as the amount of testing performed. This metric is commonly applied to large software developmental efforts. See DA Pamphlet 73-1 for detailed information about how to use this metric.
c. **Depth of testing metric report (% tested and passed testing).** This metric is commonly applied to large software developmental efforts. Automated tools may be used to compute this measure. The depth of testing metric measures the amount of testing achieved on the software architecture, that is, the extent and success of testing the possible control and data paths and conditions within the software. This is often described as “white box” testing since there is visibility into how the software is constructed.

   (1) The four depth attributes and criteria for success are:
      
      (a) Path: Path is successfully executed at least once.
      
      (b) Statement: Statement is successfully executed at least once.
      
      (c) Input: Input is successfully tested with at least one legal entry and one illegal entry.
      
      (d) Decision point: Decision point is successfully exercised with all classes of legal conditions as well as one illegal condition.

   (2) The test coverage measure equals the number of attribute occurrences tested divided by the number of occurrences of the attribute. Overall success equals the number of attribute occurrences passed divided by the number of occurrences of the attribute. See DA Pamphlet 73-1 for more information.

d. **Fault profiles report (open versus closed anomalies).** This metric is commonly used in software developmental efforts. The fault profiles metric is a summary of problem/change report data collected by the corrective action system. This metric provides insight into the number and type of deficiencies in the current baseline, as well as the developer’s ability to fix known faults. A common display is the cumulative numbers of faults detected (problem reports opened) and closed, over time. See DA Pamphlet 73-1 for more information.

e. **Reliability metric report (mean time between failures).** The reliability metric expresses the contribution to reliability. Number of system failures and the time it takes to restore the system to its previous operational condition are tracked. See DA Pamphlet 73-1 for more information.

f. **Cost metric report.** The cost metric provides insight into the actual cost expenditures for developmental tasks, compared to the initial cost estimates. The cost/schedule control systems criteria described in DA Pamphlet 73-1 are used to track cost, schedule, and technical performance. The first step in applying the cost metric is to identify the appropriate work tasks, or activities, as cost elements in a program. Cost accounting elements are identified through the use of a work breakdown structure (WBS). Procedures for developing a WBS and its hierarchy of levels are defined in MIL-HDBK-881A. The following data items are collected for each reported WBS activity (see DA Pamphlet 73-1 for more information):

   (1) Budgeted cost of work scheduled.

   (2) Budgeted cost of work performed.

   (3) Actual cost of work performed.

 g. **Schedule metric report.** The schedule metric indicates the degree to which program events adhere to a work schedule plan and complement the schedules typically used on programs. The changes to the schedule will indicate the level of risk associated with achieving
future program milestones and providing key deliverables on time. For each item selected for schedule metric monitoring, collect:

1. Planned start date.
2. Planned end date.
3. Actual start date.
4. Actual end date.

h. **Computer resource utilization metric report.** This metric shows the degree to which estimates and measurements of computer resources are changing or approaching the limits of resource availability. Constraints in computer resource utilization can lead to poor performance in the operational environment. The primary objective is to determine whether computer resources are adequate to handle the most demanding of the anticipated operational workloads. A second objective is assurance that reserve capacity for future maintenance and enhancement exists prior to initial fielding. The minimum sets of resources to monitor are central processing units (CPUs), input/output channels, storage devices, and memory. See DA Pamphlet 73-1 for more information.

i. **Manpower metric report.** Track planned and actual effort and staffing. See DA Pamphlet 73-1 for more information.

j. **Developmental progress metric report.** Track planned and actual work unit completed. See DA Pamphlet 73-1 for more information.

k. **Requirements stability metric report.** The requirements stability metric indicates the degree to which changes in the software requirements or changes in the developer’s understanding of the requirements are affecting the developmental effort. For each software configuration item, collect: (See DA Pamphlet 73-1 for more information.)

1. Software requirements discrepancy status (cumulative total detected and cumulative total resolved).
2. Total number of lines of source code (LOSC).
3. Total number of requirements.
4. Number requirements added due to approved engineering change proposals (ECPs).
5. Number of requirements modified due to approved ECPs.
6. Number of requirements deleted due to approved ECPs.
7. Number of LOSC affected by approved ECPs.
8. Number of software units affected by approved ECPs.
9. Number of ECPs generated from requirements changes.

l. **Design stability metric report.** This metric is composed of two measures. The design stability measure tracks changes made to the design of software. The design progress measure shows how the completeness of the design is advancing over time and provides a context for viewing the design stability measure in relation to the total projected design. See DA Pamphlet 73-1 for more information.
Appendix D
V&V Activities Planning and Reporting

D-1. V&V Planning and development. This paragraph describes the procedures for V&V planning. The V&V agent should—

   (1) Gather information from the application sponsor, M&S developer, and AAO.
   (2) Perform a risk and impact analysis to determine the risks associated with the intended use of the M&S, the accreditation requirements, and the M&S documentation.
   (3) Determine the V&V activities that address the acceptability criteria.
   (4) Write the V&V plan.

a. Gather Information. Gathering information involves talking with the application sponsor, M&S developer, and AAO to—

   (1) Obtain the approved accreditation plan (figure 3-10) from the AAO or AA.
   (2) Obtain the documented intended use (Step 1).
   (3) Obtain the M&S requirements. These should already be listed in the M&S requirements document.
   (4) Obtain the conceptual model (appendix E) when available.
   (5) Gather all other available M&S documentation, including all information written about the model and, if applicable, the model from which it was or will be derived. This could include:

   Interface standards
   Developmental plans
   Previous V&V plans
   Quality assurance management plans
   Configuration management plans
   Design standards and specifications
   Coding/building standards
   Test plans, procedures, and results
   Data collection plan and procedures
   Data generation plan and procedures
   Data validation plan and procedures
   Internal security verification plans
   Problem reports/discrepancy report
   Studies and analysis

b. Perform a Risk and Impact Analysis. The risk and impact analysis involves reviewing the information gathered for potential problem areas. For models already built, this information provides a basis for assessing the model’s appropriateness for its new intended use and provides information about areas the V&V agent needs to further analyze due to lack of previous analysis or documented problems. For models currently in development, this information provides an assessment of critical areas that should be closely monitored. The V&V agent should reassess risks and impacts periodically to determine if there are new risk areas. Some risk areas to consider are:

   Supportability of the intended use
   Adequacy of the design
   Missing requirements documentation
   Adequacy of implementation
   Adequacy of the requirements
   Missing design documentation
   Adaptation to various operational needs
   Missing test plans and test cases
   Safety
   Adequacy of test plans/cases
Before deciding to use a model, risk and impact of use should be considered. The following are examples.

<table>
<thead>
<tr>
<th>Personal safety (e.g., death, injury)</th>
<th>Reliability (loss of functionality)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment safety</td>
<td>Project schedule/cost</td>
</tr>
<tr>
<td>Occupational illness</td>
<td>Mission impact (loss or degradation)</td>
</tr>
<tr>
<td>System damage</td>
<td>Criminal liability</td>
</tr>
<tr>
<td>Environmental damage</td>
<td>Civil liability (civil suits)</td>
</tr>
<tr>
<td>Operator workload</td>
<td>Maintenance burden</td>
</tr>
<tr>
<td>Financial loss</td>
<td>Political or public impact</td>
</tr>
<tr>
<td>Security breach</td>
<td>Delivered system performance (e.g., design does not meet requirements)</td>
</tr>
</tbody>
</table>

The level of impact/risk is outlined in figure D-1.

<table>
<thead>
<tr>
<th>Impact Level</th>
<th>Impact descriptor</th>
<th>Worst credible consequence of using wrong or inappropriate model, data or simulation results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Negligible</td>
<td>Trivial: injury, occupation illness, mission impact, financial loss, system or environmental damage, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Marginal</td>
<td>Minor: injury, occupation illness, mission impact, financial loss, system or environmental damage, legal implications, etc.</td>
</tr>
<tr>
<td>3</td>
<td>Critical</td>
<td>Major: injury, occupation illness, mission loss, financial loss, system or environmental damage, political implications, etc.</td>
</tr>
<tr>
<td>4</td>
<td>Catastrophic</td>
<td>Single or multiple deaths, loss of system, impact on campaign, severe occupational illness or environmental impact, severe financial loss, etc.</td>
</tr>
</tbody>
</table>

**Figure D-1. Level of Impact**

c. **Determine the V&V Activities.** Based upon the information gathered and the risk/impact analysis, the V&V agent determines the V&V activities required to address the acceptability criteria and the M&S requirements. In conjunction with determining the V&V activities, the V&V agent should verify the correctness, completeness, and consistency (CCC) of all sources of requirements and the acceptability criteria. The V&V agent/team records their V&V tasks and maps the tasks to the acceptability criteria in the V&V report.
d. Write the V&V Plan. The V&V agent should write a V&V plan in coordination with the AAO that describes the agreed-upon tasks. Figure 3-14 describes the contents of the V&V plan. The use of the VV&A Documentation Tool can assist in writing the plan and is located in appendix F. The V&V agent will update the cost estimate and schedule as appropriate.

D-2. V&V Reporting

a. Analyze V&V Results. The V&V agent/team summarizes their findings; analyzes the V&V results; and determines the capability of the model, data, and/or use to meet the stated acceptability criteria. Based upon the V&V results, the V&V agent can determine how well the stated acceptability criteria, issues, objectives, and goals for accreditation were met (or not met) and provide the associated rationale explaining the logic used to reach these conclusions. From this evaluation, the V&V agent can determine the strengths and weaknesses of the model, input data, or simulation results. Whenever an acceptability criterion or criteria has not been met, the V&V agent should determine what workarounds or limitations should be recommended.

b. Write V&V Report(s). The outline for the V&V report is in figure 3-16. The use of the VV&A Documentation Tool can assist in writing the report and is located in appendix F. The Threat VWG for M&S with threat representation will produce a VR as outlined in figure 3-17. VRs for threat simulators/simulations and targets require the signature of each member of the Threat VWG and staffing through the TEMA Director to DOT&E for final approval as required. The V&V report(s) describe the results of V&V tasks, assumptions, capabilities, limitations, impacts, resources, recommendations, participants, and lessons learned. If the V&V team is doing V&V concurrently with the development or a major modification effort, the V&V agent should provide interim status reports. If there is more than one V&V report, the V&V agent should prepare a final V&V report that summarizes the findings of all previous reports.

c. Prepare Accreditation Request.

(1) Oversee V&V Activities. The AAO oversees the V&V planning and performance. The AAO should ensure that the V&V tasks contained in the V&V plan are sufficient to address all the acceptability criteria. The V&V agent/team documents and maps the tasks to the acceptability criteria. The V&V findings are documented in the V&V report. The final V&V report records results and status of the V&V tasks. The summary of the results should identify how well each acceptability criterion was met or not met.

(2) Perform the Accreditation Assessment. The AAO should evaluate the M&S and V&V information produced by the M&S developer and V&V agent to assess the utility and sufficiency of the products to meet the M&S requirements and to identify any deficiencies. This assessment forms the foundation for the accreditation decision. In accordance with the RPG, the evaluation of the simulation’s fitness for the intended use should include:

(a) Capability – What the simulation can do in terms of functional representations, behaviors, relationships, and interactions.

(b) Correctness – Lack of known errors or problems.

(c) Accuracy – Fidelity of the representation and how closely the results correspond to the intended view of reality (i.e., the referent).
(d) **Usability** – Existence and sufficiency of user-support features (e.g., manuals and training) which will enable the user to properly execute the simulation and analyze and/or employ results.

d. **M&S Comparison.** The AAO should review all the V&V reports to compare the M&S requirements with the M&S information and identify any deficiencies. Examples of the M&S requirements, information, and deficiencies in support of the accreditation decision are shown in figure D-2. If one or more criteria are not met, the accreditation report and accreditation request memorandum should include or reference a risk/impact assessment and list of potential workarounds, limitations, and/or associated risks.

![Figure D-2. Accreditation Assessment](image)

- **M&S Requirements**
  - Current M&S Requirements
  - Current Acceptability Criteria
  - Required Fidelity
  - Required Simulation Capability

- **Identify Deficiencies**
  - M&S Capabilities and Limitations
  - Code Correctness
  - Representational Accuracy

- **M&S Information**
  - M&S Documentation
  - VV&A History
  - Previous M&S Usage
  - Conceptual Model
  - Design Documentation
  - Configuration Management

- **Identify Workarounds**

- **Accreditation Decision**

  e. **Assess Threat Simulators/Simulations and Targets.** For threat representations in M&S, a TAWG compares test data requirements to the latest intelligence information and the capabilities of Army threat simulators/simulations and targets as shown in current VR. The TAWG examines any parametric differences to determine their impacts on the test. In cases where VRs are not available, or where other constraints make validation unfeasible, exceptions/validation waivers can be forwarded to TEMA for approval. ATEC will not proceed to accredit threat systems for OT unless TEMA approves a VR or a waiver. A complete validation of a threat system prior to accreditation/OT should provide sufficient documentation of the threat system’s operational status, permitting analysts to quickly eliminate or include the threat system performance or its overall condition as a contributing factor to failed test event by a SUT (DA Pamphlet 73-1).

  f. **Write the Accreditation Report.** After the AAO determines that the V&V effort is complete, the AAO prepares the accreditation report. The accreditation report states whether the acceptability criteria were met and recommends accreditation with any limitations required for
its use. Figure 3-19 describes the contents of the accreditation report. The use of the VV&A Documentation Tool can assist in writing the accreditation report and is located in appendix F.

g. **Write Accreditation Request Memorandum.** The AAO prepares a one-page accreditation request memorandum for approval as outlined in figure 3-20. For M&S with threat representation, the accreditation request memorandum shall contain a transmittal letter with the signatures of the threat community senior member and TAWG members. Figure 3-21 contains the format for the transmittal letter as specified in DA Pamphlet 73-1.
Appendix E
M&S Development/Modification Activities Approach with Recommended Capability Maturity Model Integration (CMMI) Application

E-1. Recommended Practices for applying CMMI

This chapter outlines the recommended practices for applying CMMI to improve the quality of the M&S products. The CMMI guidance can be used in any of the steps in chapter 3, but the following section focuses on step 3, and CMMI levels 2 and 3. All five maturity levels of CMMI are listed below and are described in appendix H.

- Level 1: Initial
- Level 2: Managed
- Level 3: Defined
- Level 4: Quantitatively Managed:
- Level 5: Optimizing

E-2. Applying CMMI to Step 3 (Modify/develop M&S solution)

Step 3 involves developing or modifying the M&S if it will not be used as-is. The tasks that need to be accomplished in this step are—

1. Plan M&S modification/development.
2. Configuration management.
3. Modify/develop conceptual model.
4. Modify/develop M&S design.
5. Implement M&S design or design changes.
6. Integrate and test M&S.

a. Plan M&S Development. Factors to consider when planning M&S development are the M&S requirements, scope of the project, tasks and work products, technical approach, project life-cycle, schedule, historical data, and a methodology to determine estimates. A top-level WBS can provide the structure for the initial estimate. The estimate should consider the reuse of existing work products. The developer should coordinate the documented M&S modification/development plan with relevant stakeholders to gain their commitment including external suppliers, the PM, AAO, and V&V agent/team. The documented plan is the basis for monitoring activities, communicating status, and taking corrective actions. CMMI Level 2 Project Monitoring and Control process area covers monitoring the project against the plan and managing corrective actions to closure.

b. Configuration management (CM). CM is critical and integral to supporting VV&A activities, and is the responsibility of the developer. This task corresponds with CMMI Level 2 CM process. The goals of CM are to ensure integrity of the M&S and its documentation using configuration identification, control, status accounting, and audits. The CM process provides a consistent audit trail from the original to the current version of the product. Effective CM
procedures also prevent unauthorized modifications that would invalidate previous VV&A efforts. In addition, if the configuration is not properly managed, the credibility of the simulation and its output can be jeopardized. CM involves—

1. Establishing baselines through the identification of configuration items (items designated for CM). The M&S baseline includes the M&S requirements, conceptual model, design, and implementation. Authorization from a configuration control board is required prior to creating or releasing baselines of configuration items.

2. Tracking and controlling changes to maintain established baselines. Change requests are submitted to address new or changed requirements, as well as failures and defects in work products. The developer analyzes change requests to determine their impact on the work product, related work products, schedule, and cost.

3. Establishing integrity of baselines. The records describing configuration items and performing configuration audits should be established and maintained. Information includes a revision history of configuration items, change log, change requests, status of configuration items, and differences between baselines. CM audits determine the accuracy of baselines and documentation and helps track action items.

c. Modify/Develop Conceptual Model. Figure E-1 is an outline for the conceptual model (based on DMSO’s VV&A Recommended Practice Guide). The preliminary design (i.e., conceptual model) establishes product architecture, including product partitions, product-component identifications, system states and modes, major inter-component interfaces and external product interfaces. The developer uses operational concepts and scenarios to generate use cases and scenarios to refine the architecture and evaluate their suitability. This paragraph corresponds with the technical solution process area of CMMI Level 3.
1. **Conceptual Model Identification.** Uniquely identify the conceptual model. Include date for completing or releasing the conceptual model.

2. **Principal Points of Contact.** Identify specific individuals associated with this conceptual model, for example, developers, reviewers, and subject matter experts. Contact information should include name, telephone number, fax number, e-mail address, and specific area of responsibility.

3. **Requirements and purposes.** Briefly describe what the conceptual model is supposed to do. Include the specific perspective to be employed when that representation is reviewed. Map simulation requirements to simulation elements.

4. **Overview.** Provide a general description of the simulation. Specify the interactions and interfaces of the simulation elements.

5. **General Assumptions.** Identify assumptions such as the nature of an algorithm, how other parts of the simulation or federation function, sources and availability of information and data, and the significance of the fidelity of different parts of the simulation.

6. **Basic Elements of the Entities and Processes.** Describe possible states, tasks, actions, behaviors, relationships, interactions, events, parameters, and factors. Identify dependencies and interdependencies among actions, events, processes, etc. It can be useful to use several complementary views to ensure completeness such as data view (data flow between simulation elements), functional view (hierarchy and static relations between simulation elements) and behavioral view (dynamics such as states, transitions, and interactions between simulation elements).

7. **Identification of algorithms.** Describe all algorithms and their relationships to entities and processes shown. Describe the sources (pedigrees) of algorithms and the data to be used in them. Specify the relationship of selected algorithms with similar algorithms. Express algorithms in standard scientific and technical notation, avoiding technical jargon where possible. Specify data elements of algorithms. If precise values of data elements are not available, then identify expected data sources and a postulated value or range of possible values for the data parameter.

8. **Simulation development plans.** Describe the plans for the evolutionary development of the conceptual model over the life cycle of the simulation. Include the time frame when enhancements would occur and the implications of its development.

9. **Summary and synopsis.** Clearly identify the limitations of the conceptual model and summarize its expected capabilities. Explicitly identify any parts of the conceptual model that are incomplete and completion dates. Identify any caveats about the conceptual model that should be known.

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**Figure E-1. Outline of an M&S Conceptual Model**

- **Modify/Develop M&S Design.** The detailed design fully defines the structure and capabilities of the product components. This paragraph corresponds with the technical solution process area of CMMI Level 3. During detailed design, the product architecture details are finalized, product components are completely defined, and interfaces are fully characterized. Developers may evaluate the use of legacy or commercial off-the-shelf (COTS) products for the product components. The developer should document the design of interfaces and the rationale for the selection of the interfaces and evaluate whether the product components should be developed, purchased, or reused.

- **Implement M&S Design or Design Changes.** The developer implements the design changes or product components from the design. This paragraph corresponds with the technical solution process of CMMI Level 3. The implementation usually includes unit testing of the product components prior to product integration and the development of end-user documentation. Some examples of the implementation is coded software, documented data, fabricated electrical and mechanical parts, documented processes, and constructed facilities. The
developer should develop and maintain end-user documentation including training materials, user’s manual, operator’s manual, maintenance manual, and on-line help.

f. *Integrate and Test M&S*. The developer assembles the product from components and ensures that the integrated product functions properly. This paragraph corresponds with the technical integration process of CMMI Level 3. A critical aspect of the product integration is managing the compatibility among the internal and external interfaces. Prior to assembly, the developer should confirm that each required product component is properly identified; functions as designed; and interfaces comply with interface descriptions. Appendix G addresses special integration considerations that should be made for hybrid simulations (simulations that interface with something else). The integrated product is examined and tested for performance, suitability, or readiness. When implementing an integrated product or federation, IEEE 1516.3 provides guidance for developers on how to develop and execute High Level Architecture (HLA). For those federations requiring Test and Training Enabling Architecture (TENA) compliance, the TENA Architecture Reference Document provides guidance.
Appendix F
VV&A Tools

F-1  VV&A Documentation Tool

The Navy Modeling and Simulation Office has an automated documentation tool for filling out accreditation and VV&A plans and reports. The DOD VV&A Technical Working Group is in the process of making this tool a DOD-level standard. This pamphlet uses this standard with slight modification. The main differences are that this pamphlet includes signature blocks on the accreditation plans and reports and uses the VV&A Workbook (appendix B) in place of a traceability matrix. To access the VV&A Documentation Tool, go to http://nmso.navy.mil and follow these directions:

1. Click Verification, Validation, & Accreditation.
2. Click Implement the VV&A Process Efficiently and Effectively.
3. In the VDT: VV&A Documentation Tool paragraph, click registering as a new user and fill out the form and submit. Your userid and password will be e-mailed automatically.
4. Once you are armed with a certificate, userid, and password, repeat steps D-1a and D-1b above and click VDT: VV&A Documentation Tool.
5. Click VDT Portal Login.

F-2.  Army and DMSO Modeling and Simulation Resource Repository (MSRR)

To access the DMSO MSRR, go to http://www.msrr.dmso.mil/MainPage.jsp. The DMSO MSRR has links to the Army MSRR, Defense Intelligence MSRR (DIMSRR), and other DOD-related M&S repositories. AEC updates the Army MSRR quarterly for ATEC using PIVOMS utilities.

F-3.  Primary Integrated View of Modeling and Simulation (PIVOMS)

Each ATEC SCA ensures that M&S developed by that activity is entered properly into the PIVOMS database. Newly developed M&S should be entered into PIVOMS upon initial operational capability. PIVOMS should be updated upon changes of capabilities, points of contact, or VV&A status. AEC manages and supports the PIVOMS database. AEC uses PIVOMS to update the Army MSRR quarterly. Each entry into PIVOMS should contain—

1. The official title, acronym, version, and proponent of the M&S tool.
2. A point of contact name, phone number, e-mail address; and directions for how to obtain the M&S tool, including a Web address (if available).
3. A description of the M&S tool type.
4. A short description of the M&S tool, and of each of the main subcomponents or federates.
5. The M&S tool’s current VV&A status or pedigree.

Note that PIVOMS is an unclassified system. Classified discussions of threat M&S can be made on the DIMSRR.

For access to the VISION Digital Library, go to http://vision.atc.army.mil/ and select VISION DIGITAL LIBRARY. Each ATEC SCA will maintain a database on VISION where M&S metadata, VV&A documentation, and other relevant information will be stored, updated, and submitted to PIVOMS quarterly.

F-5. TENA Repository

This repository is a Web-based system for sharing TENA products including object models and their related distributions. To access the TENA Repository, go to http://www.tena-sda.org/. For download privileges, new users must register with the Web site and request approval to download software. Approval typically takes 1 or 2 days. Approved users will receive the login information required for downloading by e-mail. The TENA Repository link is on the left-hand side of the Web page.

F-6. Special Case Tools

a. Definition. Historically, the T&E community has used tools (models and applications) for special T&E needs. The special case models may be used early in the T&E process to either set up the test or look at early concepts for validity. They are endorsed and approved by the Army acquisition community. They are widely used generic techniques that are applicable to virtually any support structure defined by their input data to study the information results. They are typically well documented and widely recognized as suitable for the analysis functions. However, if all or part of such an analysis tool were part of a model or simulation, it would be subject to the V&V of that M&S accreditation as outlined in this document.

b. Categories. The special case models that are exempt from this methodology fall into the following categories:

1. Reliability growth models.
2. Linear regression.
4. Non-linear programming (NLP).
5. Inventory control.
6. Industry standard COTS models such as physics- or mathematical-based models.
7. Complex analysis.

c. Examples. Examples of currently used special case models are:

1. Selected Essential-Item Stockage for Availability Method (SESAME).
2. Computerized Method for Predicting and Analyzing Support Structures (COMPASS).
3. Improved Performance Research Integration Tool (IMPRINT).
4. Optimum Stock Requirements Analysis Program (OSRAP).
Appendix G
Hybrid Simulations

The developer(s), V&V agent/team, and AAO should ensure that the integration of the non-simulation components of a hybrid simulation support the intended use. Hybrid simulations are simulations that interface with something else such as instrumented hardware (e.g., hardware-in-the-loop stimulators and distributed testing), humans (e.g., human-in-the-loop simulators) and/or software (e.g., tactical command and control stimulators). A hybrid simulation may also be a federation that includes non-simulation components that are hardware, humans, or software. Hybrid simulations used in T&E normally simulate or stimulate the SUT and/or its operational environment. Although ATEC does not normally develop SUT models, ATEC does produce data that is used in the development and validation of SUT models. The VV&A of hybrid simulations should include testing of each component of the hybrid simulation plus the integration of all the components. The paragraphs below discuss special considerations required for each type of hybrid simulation.

G-1. Hardware-in-the-loop (HWIL)

The accreditation of instrumentation-simulation hybrids, such as HWIL stimulators and distributed testing, requires the instrumentation components be certified. Chapter 5 contains the procedures for instrumentation certification. Instrumentation systems that use M&S are often employed to provide realistic simulation of combat environments (weapons simulator; nuclear, biological, and chemical detector simulator; C4I stimulator) and generate data for systems to use in lieu of having actual forces in the field (combat simulations and stimulation). The objective of the certification is to demonstrate that the instrumentation can perform its intended functions without intruding on the performance of the SUT. The instrumentation should be tested under conditions that replicate the operating environment as closely as possible. Each piece of the instrumentation suite should undergo technical testing and component qualification before final certification testing. Once the components are validated, an integration test of the entire instrumentation suite should occur, as well as an integration test with the simulation components.

G-2. Human-in-the-loop (HITL)

The development and VV&A of HITL simulations/simulators should take into account the suitability of the simulation operators and/or role-players and the adequacy of the human interaction with the M&S software and/or physical models. The operators and/or role players should be adequately qualified and trained to perform their required functions. The assessment can be via biographies and interviews with the operators and/or role-players. Supporting documentation (e.g., user manuals, tutorials, etc.) should be aimed at the targeted skill level. HITL simulators with human decision-makers require analyzing the decisions made to see if they were within the scope of possibilities and if the results were reasonable. HITL simulators normally operate in real-time and need to have an adequate look, feel, and response to the user as it would in the real world as required for the intended use. HITL simulators can enable soldiers to interact with system models.

G-3. Software-in-the-loop (SWIL)

SWIL stimulators use M&S to stimulate a software SUT to replicate the conditions of the targeted environment that cannot be created with testing due to test constraints and limitations.
For example, the M&S could simulate other battlefield entities in a virtual battlefield such as inputting command and control messages into a communication system to stimulate the system to a level similar to battlefield conditions. M&S can also enhance T&E through the examination of more conditions than those tested. VV&A of the SWIL stimulator involves examining M&S outputs to determine the adequacy of the input to the SUT and that the stress levels are commensurate with those to which the mature system will be subjected to in the targeted operating environment.
Appendix H
Capability Maturity Model Integration (CMMI)

H-1 General

This chapter describes the M&S development processes that are required to support the VV&A of M&S for each intended use. Army acquisition policy (AR 70-1) requires software capability evaluations of potential developers of software that meet specified criteria for size, cost, and criticality to determine their software development capability and process maturity in accordance with the Software Engineering Institute (SEI) maturity model or its equivalent. As a result, this methodology uses the SEI CMMI to define the best practices. A maturity model is a structured collection of elements that describe the characteristics of effective processes and a framework for prioritizing actions to improve those processes. A capability maturity model is a reference model of mature practices in a specified discipline, used to improve and appraise a group’s capability to perform that discipline. This chapter focuses on the software engineering discipline but is easily integrated with other disciplines also covered by the CMMI (systems engineering, integrated product and process development, and supplier sourcing).

H-2 CMMI levels

The CMMI defines a maturity level as a well-defined evolutionary plateau of process improvement. There are five maturity levels. Each level is a layer in the foundation for continuous process improvement beginning with basic management practices and progressing through a predefined path of successive levels. The requirements for previous levels must be met before achieving higher levels. The CMMI levels are—

- Level 1: Initial
- Level 2: Managed
- Level 3: Defined
- Level 4: Quantitatively Managed:
- Level 5: Optimizing

a. **CMMI Level 1: Initial.** Most organizations are at level 1 prior to beginning process improvement since their development processes normally do not meet all the requirements for level 2. Processes are ad hoc and chaotic. Success depends on competence and heroics and not on proven processes. Products/services often work but frequently exceed budget and schedule.

b. **CMMI Level 2: Managed.** A managed process is essential for instituting an adequate M&S verification, validation, and accreditation process. The CMMI defines a “managed process” as a performed process that is planned and executed in accordance with policy; employs skilled people having adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled and reviewed; and is evaluated for adherence to its process description. A managed process includes monitoring a project against its plans and taking corrective actions as appropriate. The maturity level 2 process areas are as follows:

   - Requirements management.
• Project planning.
• Project monitoring and control.
• Supplier agreement management.
• Measurement and analysis.
• Process and product quality assurance.
• Configuration management.

c. **CMMI Level 3: Defined.** A “defined process” is a managed process that is tailored from the organization’s set of standard processes according to the organization’s tailoring guidelines; has a maintained process description; and contributes work products, measures, and other process-improvement information to the organizational process assets. Compliance with SEI Level 3 (or its equivalent) is an Army goal for contractors participating in software development on all acquisition programs. It is required for software development contracts that meet specific criteria for size, cost, and criticality and for ACAT I or IA programs. AR 70-1 defines an acquisition program as a directly funded effort that provides a new, improved, or continuing materiel, weapon, or information system or service capability in response to an approved need. In addition, AR 70-1 requires Army software activities meeting certain criteria to establish a Software Process Improvement Program for continuous improvement in software development capability. (See AR 70-1 for additional information.) The Future Combat System (FCS) program, for example, requires that all its software suppliers be appraised or assessed at CMMI Level 3 or higher maturity unless a waiver is granted. M&S and data (including specifications/documentation) used in support of FCS should be of sufficient quality to support a CMMI Level 3 process. The maturity level 3 process areas include all the level 2 process areas plus the following:
• Requirements development.
• Technical solution.
• Product integration.
• Verification.
• Validation.
• Organizational process focus.
• Organizational process definition.
• Organizational training.
• Integrated project management.
• Risk management.
• Decision analysis and resolution.
d. **CMMI Level 4: Quantitatively Managed.** Quantitative objectives for quality and process performance are established and used as criteria in managing processes. The maturity level 4 process areas include all level 2 and 3 process areas plus the following:

- Organizational process performance.
- Quantitative project management.

e. **CMMI Level 5: Optimizing.** Processes are continually improved based on quantitative understanding of the common causes of variation inherent in process. The maturity level 5 process areas include all the level 2, 3 and 4 process areas plus the following:

- Organizational innovation and deployment.
- Causal analysis and resolution.
Glossary

Section I
Acronyms

AA
Accreditation Authority

AAO
Accreditation Action Officer

ACAT
acquisition category

AEC
Army Evaluation Center

AMSA
Army Materiel Systems Analysis Activity

API
application program interface

AR
Army regulation

AST
ATEC System Team

ATEC
Army Test and Evaluation Command

C4I
command, control, communications, computers, and intelligence

CAD
computer aided design

CAM
computer aided manufacturing

CCC
correct, complete, and consistent

CI
configuration item

CM
configuration management
CMMI
Capability Maturity Model Integration

COMPASS
Computerized Method for Predicting and Analyzing Support Structure

CONOPS
caption of operations

COTS
commercial off-the-shelf

CPU
central processing unit

DA
Department of the Army

DIA
Defense Intelligence Agency

DIMSRR
Defense Intelligence Modeling and Simulation Resource Repository

DMSO
Defense Modeling and Simulation Office

DOD
Department of Defense

DODD
Department of Defense directive

DODI
Department of Defense instruction

DOT&E
Director, Operational Test and Evaluation

DTC
Developmental Test Command

ECP
engineering change proposal

EDP
event design plan

ESR
Early Strategy Review
FCA
functional configuration audit

FCS
Future Combat System

FOM
federation object model

HITL
human-in-the-loop

HLA
High Level Architecture

HQ
Headquarters

HWIL
hardware-in-the-loop

ICD
initial capabilities document

IEEE
Institute of Electrical and Electronic Engineering

IMPRINT
Improved Performance Research Integration Tool

IOT
initial operational test

IPT
Integrated Product Team

ITOP
International Test Operating Procedure

IV&V
Independent Verification and Validation

JIM
joint inter-agency multi-national

LOSC
lines of source code

LROM
logical range object model
LUT
limited user test

M&S
model(s) and simulation(s)

MANPRINT
manpower and personnel integration

MIL-HDBK
military handbook

MS&I
modeling, simulation, and instrumentation

MSRR
Modeling and Simulation Resource Repository

NATO
North Atlantic Treaty Organization

NGIC
National Ground Intelligence Center

NLP
non-linear programming

ODCSOPS
Office of the Deputy Chief of Staff for Operations

OMT
object model template

OPFAC
operational facility

ORD
operational requirements document

OSD
Office of the Secretary of Defense

OSRAP
Optimum Stock Requirements Analysis Program

OT
operational test

OTC
Operational Test Command
OTP
outline test plan

OTRR
Operational Test Readiness Review

PCA
physical configuration audit

PDL
Program Design Language

PEO
Program Executive Officer

PERT
Program Evaluation and Review Techniques

PIVOMS
Primary Integrated View of Modeling and Simulation

PM
Program Manager

PM ITTS
Program Manager for Instrumentation, Targets, and Threat Simulators

RID
RTI Initialization Data

RPG
Recommended Practices Guide

RTI
Runtime Infrastructure

SCA
subordinate command activity

SEI
Software Engineering Institute

SEP
system evaluation plan

SIT
system integration testing

SMART
Simulation and Modeling for Acquisition and Training
V&V
verification and validation

VISION
Versatile Information Systems Integrated On-line Nationwide

VR
Validation Report

VV&A
verification, validation, and accreditation

VWG
Validation Working Group

WBS
Work Breakdown Structure

Section II
Terms

Abstraction
1. The process of selecting the essential aspects of what is to be represented in a model or simulation while ignoring those aspects that are not relevant to the purpose of the model or simulation. The set of elements produced by this process.
2. The act or process of separating the inherent qualities or properties of something from the actual physical object or concept to which they belong.

Acceptability criteria
A set of standards that a particular M&S or federation must meet to be accredited for a given use.

Accreditation
An official determination by management that an M&S or a federation and its associated data are acceptable for use for a specific purpose.

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

Accreditation Authority
1. The organization or individual responsible to approve the use of a model, simulation, or federation of simulations for a particular application.
2. An individual occupying a position with the appropriate rank, grade, responsibility, and/or authority to accredit a model, simulation, or federation of simulations for a particular purpose or purposes.

Accreditation plan
The plan of action for certifying a model, simulation, or federation as acceptable for specific purposes. The accreditation plan specifies the reviews, testing, and other accreditation
assessment processes, as appropriate, needed to certify that the model or simulation has met the acceptability criteria.

**Accreditation process**
The procedure followed by the M&S application sponsor (user) that culminates in the accreditation determination.

**Accuracy**
1. The degree to which a parameter or variable, or set of parameters or variables, within a model or simulation conforms exactly to reality or to some chosen standard or referent.
2. Fidelity of the representations; quality, and precision of the input data; how closely the results correspond to the intended view of reality (i.e., the referent).

**Aggregation**
The ability to group entities while preserving the effects of entity behavior and interaction while grouped. See disaggregation.

**Allocated baseline**
The initially approved documentation describing an item’s functional, interoperability, and interface characteristics that are allocated from those of a system or a higher level CI; interface requirements with interfacing CIs; additional design constraints; and the verification required to demonstrate the achievement of those specified characteristics.

**Allocated configuration documentation**
The approved allocated baseline plus approved changes.

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

**Application sponsor**
The agency that utilizes the results/products/output from a specific application of M&S.

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

**Attribute**
A property or characteristic of one or more entities; for example, COLOR or WEIGHT. Also a property inherent in an entity or associated with that entity for database purposes.

**Authoritative data source**
A data source whose products have been verified, validated, and certified.

**Authoritative representation**
Models, algorithms, and data that have been developed or approved by a source that has accurate technical knowledge of the entity, phenomenon, or effects to be modeled.

**Baseline**
Configuration documentation formally designated during a CI’s life cycle. Configuration baselines, plus approved changes from those baselines, constitute the currently approved configuration documentation. There are three formally designated configuration baselines in the life cycle of a CI, namely the functional, allocated, and product baselines.
Behavior
1. For a given object, how attribute value changes affect (or are affected by) the object attribute value changes of the same or other objects.
2. The classical cognitive functions, as well as the effects of moderators such as stress, injury, fatigue, discomfort, motivation, and emotions. Any form of human representation, including individuals, aggregates of individuals, and organizations. Also referred to as human behavior.

Benchmark
1. The activity of comparing the results of a model or simulation with an accepted representation of the process being modeled.
2. An accepted representation or standard of a process being modeled or simulated against which the results of other models or simulations are compared or judged.

Benchmarking
The comparison between a model’s output and outputs of other models or simulations, all of which represent the same input and environmental conditions.

Boundary condition
The values assumed by the variables in a system, model, or simulation when one or more them is at a limiting value at the edge of the domain of interest.

Capability
What the model or simulation can do in terms of functional representations, behaviors, relationships, and interactions. See fitness.

Conceptual analysis
The step in the federation development and execution process that establishes the conceptual framework for the federation. It feeds the design of the overall federation structure.

Conceptual model
1. The developer’s description of what the model or simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user’s requirements.
2. A collection of assumptions, algorithms, relationships (i.e., architecture), and data that describe a developer.

Condition
The values assumed at a given instant by the variables in a system, model, or simulation.

Configuration
The functional and physical characteristics of existing or planned hardware, firmware, software, or a combination thereof as set forth in technical documentation and ultimately achieved in a product.

Configuration control
The systematic proposal, justification, evaluation, coordination, approval or disapproval of proposed changes, and implementation of all approved changes, in the configuration of a CI after establishment of the configuration baseline(s) for the CI.
Configuration documentation
The technical documentation that identifies and defines the item’s functional and physical characteristics. The configuration documentation is developed, approved, and maintained through three distinct evolutionary, increasing levels of detail. These levels are the functional configuration documentation, the allocated configuration documentation, and the product configuration documentation.

Configuration item (CI)
An aggregation of hardware or software that satisfies an end-use function and is designated for separate configuration management.

Configuration management
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.

Configuration management plan
The document that defines how configuration management will be implemented (including policies and procedures) for a particular program.

Constant
A quantity or data item within a model or simulation whose value cannot change during the course of execution.

Constraint
A boundary or limitation imposed on a simulation by external forces, such as the objectives and requirements of the problem being addressed or the policies under which the simulation is expected to operate.

Constructive simulation
System involving real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems. Simulations of this class typically build or construct a model over a period of time that is less than, equal to, or greater than real time. This technique is particularly valuable in building simulations of events which occur over very long time periods (weeks, months, or years) or over very short time periods (milliseconds or less). Once a simulation run is completed, the output data can be manipulated with data viewing and analysis tools to precisely isolate events at different points in simulation time.

Context
1. The material surrounding an item that helps define its meaning.
2. The circumstances or situation in which a particular event occurs.

Correctness
Error-free; appropriate authoritative input data.

Credibility
The relevance that the user sees in a model and the confidence that the user has that a model or simulation can serve his purpose.

Data
1. A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.
2. Assumed, given, measured, or otherwise determined facts or propositions used to draw a conclusion or make a decision.

**Data attribute**
A characteristic of a unit of data such as length, value, or method of representation.

**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. Data user accreditation is inherently a part of the M&S accreditation procedures. Data user accreditation is the determination that data have been verified and validated as appropriate for the specific M&S usage.

**Data element**
1. A basic unit of information having a meaning and subcategories (data items) of distinct units and values (e.g., address).
2. A single component of a data set. See data and data value.

**Data integrity**
In information processing, the condition in which data are accurate, current, consistent, and complete.

**Data modeling**
The representation of data objects in a software system.

**Data producer**
The agency or organization responsible for gathering or developing data and assessing their quality.

**Data proponent**
The agency that has primary responsibility for a data collection or database. The proponent develops the requirement for the data.

**Data quality**
The correctness, timeliness, accuracy, completeness, relevance, and accessibility that make data appropriate for use.

**Data representation**
1. A format used to describe some type of data.
2. A variety of forms used to describe a terrain surface, the features placed on the terrain, the dynamic objects with special 3-D model attributes and characteristics, the atmospheric and oceanographic features, and many other forms of data.

**Data source**
1. A subject matter expert, group of subject matter experts, or organization who, because of either mission or expertise, collects or produces the data used in a model, simulation, or simulation federation.
2. A document or publication that serves as an authoritative source of data used in a model, simulation, or simulation federation. See authoritative data source.
Data standards
A capability that increases information sharing effectiveness by establishing standardization of data elements, database construction, accessibility procedures, system communication, data maintenance, and control.

Data validation
Review of the data to compare them to the corresponding, known real world or best-estimate values. Data user validation is an assessment that data are appropriate for use in an intended M&S. Data producer validation is an assessment that data are within stated criteria and assumptions.

Data value
A value associated with a data element. One of the allowable values of a data element.

Data verification
Review of the data values to ensure they are converted and formatted properly for input into the M&S and are consistent with M&S concept and logical design. 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 meet user-specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.

Defect
A problem in the code, hardware, or data used in a simulation that results in an error or failure.

Developing agency
The agency that actually develops an M&S or the agency that is overseeing the M&S development by a contractor or federally funded research and development center. The developing agency and the sponsoring agency may be the same.

Disaggregate
The activity that decomposes an aggregated entity into multiple entities representing its components.

Disaggregation
The ability to represent the behavior of an aggregated unit in terms of its component entities. If the aggregate representation did not maintain state representations of the individual entities, then the decomposition into the entities can only be notional.

Distributed interactive simulation
Any combination of virtual, constructive, and live simulations that are distributed over a network and interact through standard protocols.

Distributed simulation
Multiple executable applications executing on one or more CPUs physically or logically distributed over a digital network. Common distributed M&S architectures include distributed interactive simulation, HLA, and various tactical standards used within DOD. The most immediately recognizable trait of a distributed simulation is its reliance on a digital telecommunications network for transfer of information between its various simulation components.
**Documentation review**
The collection and review of any existing documentation of an M&S to ensure logical consistency with current documentation efforts.

**Domain**
The physical or abstract space in which the entities and processes operate. The domain can be land, sea, air, space, undersea, a combination of these, or an abstract domain, such as an n-dimensional mathematical space, or economic or psychological domains.

**Effects**
Observable changes in model or simulation results based upon changes to input variables represented by algorithmic formulations that attempt to mimic real-world phenomena without precisely representing all factors that bear on the phenomena (e.g., killer-victim scores, red kills, blue kills, stimuli to the user/trainee to prompt some activity or behavior).

**Empirical**
Pertaining to information that is derived from observation, experimentation, or experience.

**Entity**
A distinguishable person, place, unit, thing, event, or concept about which information is kept. An element of the synthetic environment that is created and controlled by a simulation application (e.g., tanks, submarines, carriers, fighter aircraft, missiles, bridges). A simulation application may control more than one simulation entity.

**Environment**
The texture or detail of the natural domain (e.g., terrain relieve, weather, day or night, terrain cultural features) and external objects, conditions, and processes that influence the behavior of a system.

**Error**
1. The difference between an observed, measured, or calculated value and a reference value.
2. An incorrect result of a model or simulation that occurs during testing or any time other than when in use for its intended purpose. See failure.

**Event**
1. A change of object attribute value, an interaction between objects, an instantiation of a new object, or a deletion of an existing object that is associated with a particular point on the federation time axis. Each event contains a time stamp indicating when it is said to occur.
2. An individual stimulus from one object to another at a particular instant in time.

**Exercise**
The execution of a simulation configured with specific parameters, characteristic data, initial conditions, players, and external systems intended to represent a specific of general scenario.
Face validation
The process of determining whether a model or simulation seems reasonable to people who are knowledgeable about the system under study.

Failure
An incorrect result or outcome from a model or simulation that occurs when the model or simulation is being used for its intended purpose. See error.

Fair fight
When the differences between two or more simulations’ performance characteristics have significantly less effect on the outcome of the conflict than actions taken by the simulation participants.

Fault
An incorrect model, simulation, or federation component.

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

Federation
1. A system of interacting M&S with supporting infrastructure, based on a common understanding of the objects portrayed in the system.
2. A system of interacting federates, a common federation object model, and supporting infrastructure relying upon a common understanding of the simulated objects and used as a whole to achieve a specific purpose.

Federation execution
The actual operation, over time, of a subset of the federates and the runtime infrastructure initialization data taken from a particular federation; the step of running executable code to conduct an exercise and produce the data required of the federation.

Federation Object Model (FOM)
An identification of the essential classes of objects, object attributes, and object interactions that are supported by a high level architecture (HLA) federation. In addition, optional classes of additional information may also be specified to achieve a more compete description of the federation structure and/or behavior.

Federation objective
1. Statements intended as a foundation for generating federation requirements (i.e., translating high-level user expectations into more concrete, measurable federation goals.)
2. The statement of the problem that the establishment and execution of a federation addresses. The description of the problem domain implicit in the objectives statement is critical for focusing the domain analysis activities in the conceptual analysis phase. It specifies the top-level goals of the federation, and may specify the operational need or shortfall from which federation developers will derive a scenario for the federation execution. The federation objectives drive this specification, as the scenario development phase must utilize the statement of the objectives to generate a viable context for system evaluations intrinsic to the federation objectives. High-level testing requirements implied in the federation objectives may also drive the identification of well defined “test points” during development of the federation scenario.
Fidelity
The degree to which aspects of the real world are represented in the M&S.

Fitness
1. Providing the capabilities needed or being suitable for some purpose, function, situation, or application.
2. Providing the capabilities, correctness, accuracy, and usability needed for the intended use or current application.

Functional baseline
The initially approved documentation describing a system’s or item’s functional, interoperability, and interface characteristics and the verification required to demonstrate the achievement of those specified characteristics.

Functional configuration audit
The formal examination of functional characteristics of a CI prior to acceptance, to verify that the item has achieved the requirements specified in its functional and allocated configuration documentation.

Functional configuration documentation
The approved functional baseline plus approved changes.

High level architecture
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.

Hybrid simulations
A simulation that combines constructive, live, and/or virtual simulations, typically in a distributed environment. Such simulations typically combine simulators with actual operational equipment, prototypes of future systems, and realistic representations of operational environments.

Implementation
The means by which a model or simulation or portion of a model or simulation is realized.

Independent reviewer (or independent V&V agent)
An outside agency or contractor (usually individuals or an agency that did not develop the M&S) responsible for the accomplishment of verification and validation activities of an M&S. IV&V does not require complete organizational independence, but a reasonable degree of organizational separation should be observed to assure unbiased analysis.

Infrastructure
An underlying base or foundation; the basic facilities, equipment, and installations (e.g., system and applications, communications, networks, architectures, standards and protocols, and information resource repositories) needed for the functioning of a simulation implementation.

Input
1. An event external to a system that modifies the system in any manner.
2. Something introduced into a system or expanded in its operation to attain a result or output.
3. The externally supplied data to which a simulation responds and from which it calculates its
output (e.g., operator controls, weapon detonation, wind speed, and direction).

**Intended use**
The application, experiment, or study for which the model has been proposed or chosen as a tool.

**Interaction**
1. An explicit action taken by an object that can optionally (within the bounds of the federation object model) be directed toward other objects, including geographical areas, etc.
2. The way in which objects, components, systems, models, or simulations affect or influence each other’s behavior.

**Interoperability**
The ability of a model or simulation to provide services to and accept services from other models and simulations and to use the services so exchanged to enable these M&S to operate effectively together and completely without anomaly.

**Latency**
1. The time required for a device to begin physical output of a desired piece of data once processing is complete.
2. The time interval required for a simulation to begin its response to a stimulus after it has been presented with a stimulus or stimuli (e.g., input of data, occurrence of an event).

**Live simulations**
Real people operating real systems. A live simulation contains minimal simulation components. It consists of an instrumented live entity that can participate in a multi-player simulation scenario as if it were part of the virtual environment. Live simulations typically contain sensor and/or display systems and a data transmission system. The sensor system captures salient entity parameters in data that are passed to the data transmission system that couples the data into a computer simulation. If one exists, the display system allows the live entity to visualize some portion of the virtual battle space and be stimulated by its live and virtual entities and other environmental features. Live simulation systems are most commonly employed in distributed battlefield simulations where actual participation of live forces in an otherwise virtual event is desirable or for real time visualization of ongoing hardware tests. Like virtual simulations, the outcome of a live simulation is not repeatable due to the nature of human behavior.

**M&S developer**
The agency that actually develops or modifies an M&S or the agency that is developing, managing, or overseeing the M&S development or modification by a contractor or federally funded research and development center.

**M&S user**
Those who apply M&S to specific applications.

**Metadata**
Information describing the characteristics of data; data or information about the meaning of data; descriptive information about an organization’s data, data activities, systems, and holdings.

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

**Modeling and simulation**
The development and use of live, virtual, and constructive models including emulators, prototypes, simulations, and stimulators, either statically or over time, to either investigate, understand or provide experiential stimulus to either (1) conceptual systems that do not exist or (2) real life systems that cannot accept experimentation or observation because of resource, range, security, or safety limitations. The terms “modeling” and “simulation” are often used interchangeably.

**Object**
A fundamental element of a conceptual representation for a federate that reflects the “real world” at levels of abstraction and resolution appropriate for federate interoperability. For any given value of time, the state of an object is defined as the enumeration of all its attribute values.

**Object model**
A specification of the objects intrinsic to a given system, including a description of the object characteristics (attributes) and a description of the static and dynamic relationships that exist between objects.

**Output**
1. Any change produced in the surroundings by a system.
2. The data produced by a computer from a specific input.
3. The aspects of the simulated system being modeled that are calculated during each pass in response to inputs and time passing, and normally output for external use; values providing a snapshot of the current state of the simulated system (e.g., position, velocity, alive-or-dead).

**Output validation**
The process of determining the extent to which the output (outcome distributions for the M&S and/or sub-models) represents the significant and salient features of distributions or real world systems, events, and scenarios.

**Parameter**
1. A constant or variable that distinguishes special cases of a general mathematical expression; for example, the general form of the equation for a line, \( y = mx + b \) contains the parameters \( m \) and \( b \), representing the gradient and \( y \)-intercept of any specific line.
2. A constant in a mathematical program, but one that could vary outside the control of the decisions.
3. That which determines the structure of a system. Parameters themselves can be changed by inputs, but usually the parameters determine how input will be transformed into outputs.
4. A named characteristic of an interaction.

**Physical configuration audit**
The formal examination of the “as-built” configuration of a CI against its technical documentation to establish or verify the CI’s product baseline.

**Precision**
1. The quality or state of being clearly depicted, definite, measured, or calculated.
2. A quality associated with the spread of data obtained in repetitions of an experiment as
measured by variance; the lower the variance, the higher the precision.

3. A measure of how meticulously or rigorously computational processes are described or performed by a model or simulation.

**Process model**
A model of the processes performed by a system; for example, a model that represents the software developmental process as a sequence of phases.

**Product baseline**
The initially approved documentation describing all of the necessary functional and physical characteristics of the CI and the selected functional and physical characteristics designated for production acceptance testing and tests necessary for support of the CI. In addition to this documentation, the product baseline of a CI may consist of the actual equipment and software.

**Product configuration documentation**
The approved product baseline plus approved changes.

**Prototype**
A preliminary type, form, or instance of a system that serves as a model for later stages or for the final, complete version of a system.

**Reality**
The quality or state of being actual or true.

**Real world**
1. The set of real or hypothetical causes and effects that simulation technology attempts to replicate. When used in a military context, the term is synonymous with real battlefield to include air, land, and sea combat.
2. One standard against which fidelity is measured that includes both imagined and material reality in order to accommodate assessment of simulation fidelity when future concepts and systems are involved.

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

**Representation**
1. Something that stands in place of or is chosen to substitute for something else.
2. An embodiment of a specified quality.
3. A model or simulation.

**Resolution**
The degree of detail and precision used in the representation of real world aspects in the M&S.

**Runtime infrastructure (RTI)**
The general-purpose distributed operating system software that provides the common interface services during the runtime of an HLA federation.

**Scenario**
1. An initial set of conditions and timeline of significant events imposed on systems to achieve exercise objectives.
2. An identification of the major entities that must be represented by the federation; a conceptual description of the capabilities, behavior, and relationships (interactions) between these major entities over time; and a specification of relevant environmental conditions (e.g., terrain, atmospherics). Initial and termination conditions are also provided.
3. A part of the M&S database that contains the force structure, its mission and plans, and the terrain in which the simulated engagement occurs.

**Sensitivity**
The ability of a component, model, or simulation to respond to a low-level stimulus.

**Simulation**
A method for implementing a model or models over time.

**Simulation object model (SOM)**
A specification of the intrinsic capabilities that an individual simulation offers to federations. The standard format in which SOMs are expressed provides a means for federation developers to quickly determine the suitability of simulation systems to assume specific roles within a federation.

**Sponsoring agency**
The agency that 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 representation or example.

**State**
1. The internal status of a simulation entity (e.g., fuel level, number of rounds remaining, location of craters).
2. A condition or mode of existence of a system, component, or simulation (e.g., the pre-flight state of an aircraft navigation program or the input state of a given channel).
3. The values assumed at a given instant by the variables that define the characteristics of a system, component, or simulation; system state.

**Stimulate**
To provide input to a system in order to observe or evaluate the system’s response.

**Structural validation**
The process of determining that the M&S assumptions, algorithms, and architecture provide an accurate representation of the composition of the real world as relevant to the intended use of the M&S.

**Subject matter expert (SME)**
An individual who, by virtue of education, training, or experience, has greater than a journeyman’s expertise in a particular technical or operational discipline, system, or process and has been selected or appointed to participate in the V&V of a model or simulation.

**Synthetic environment**
Representation of the test ranges, facilities, background, and conditions in which the item-under-test is to operate.
Synthetic stimuli
Presentation of signals (targets, signatures, network messages, etc.) to a sensing device of the item-under-test to imitate the effects of the system.

System
A collection of components organized to accomplish a specific function or set of functions.

Tailoring
The careful selection of V&V tasks to address the needs of the application.

Threat representations
Models, simulations, simulators, emulators, foreign materiel (that is, actual systems), and aerial and ground targets that portray specific foreign military weapon systems or civilian devices used in an adversarial military role.

Tolerance
1. The maximum permissible error or the difference between the maximum and minimum allowable values in the properties of any component, device, model, simulation, or system relative to a standard or referent. Tolerance may be expressed as a percent of nominal value, plus and minus so many units of a measurement, or parts per million.
2. The character, state, or quality of not interfering with some thing or action.

Usability
The existence and sufficiency of user-support features (e.g., manuals, training) that enable a user to properly execute a model or simulation and analyze and/or employ the result.

User
1. The individual, group, or organization that employs or will employ a model, simulation, or federation, its products, or its services to achieve a set of objectives. The user may also be involved in the evolution of such products and services.
2. The individual, group, or organization that utilizes the results or products from a specific application of a model or simulation. In a broader sense, the user is the customer, the one for whom the model or simulation is assembled and developed, and also the one who makes the accreditation decision.

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.

Verification
The process of determining the extent to which an M&S accurately represents the developer’s conceptual description and specifications. Verification evaluates the extent to which the M&S has been developed using sound and established system engineering techniques.

Verification and Validation (V&V) Agent
The agency designated by the M&S sponsor responsible for ensuring V&V is performed on a specific model, simulation, or federation of M&S.
Virtual M&S
A synthetic representation of warfighting environments patterned after the simulated organization, operations, and equipment of actual military units.