# COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

This instruction implements AFPD 16-10, *Modeling and Simulation Management,* by establishing policy, procedures, and responsibilities for the VV&A of Air Force- owned or -managed M&S. Forward proposed revisions to the M&S office of primary responsibility (OPR) for your command, who will in turn consolidate and forward them to HQ USAF/XOMT, Technical Support Division, Directorate of Modeling, Simulation, and Analysis, 1510 Air Force Pentagon, Washington D.C. 20330-1510. Major command (MAJCOM) OPRs must send their consolidations to HQ USAF/XOMT by 15 March of each year. A conference of MAJCOM OPRs will coordinate changes that require major alterations to the AFI. Terms and concepts, as defined by DoDD 5000.59-M, *Glossary of Modeling and Simulation (M&S) Terms,* are used in this instruction (see **Attachment 1**). Additional information on M&S VV&A standards and practices can be found in the Defense Modeling and Simulation Office's (DMSO) guide, *Introduction to VV&A Standards and Practices for DoD M&S.*

*Section A—General*

**1. Applicability.** This instruction applies to all Air Force-owned or -managed M&S that qualify as federation elements, common use, general use, joint use, or major M&S as defined in **Attachment 1**, section C. MAJCOMs, field operating agencies (FOAs), and direct reporting units (DRUs) will establish VV&A requirements and procedures for command-owned M&S that do not fit into one of these model use categories.

**2. Background.** Digital models and simulations (M&S) are becoming more numerous, complex, and capable. Current trends indicate that the results of M&S will play a larger role in supporting operational and acquisition decisions made by senior Air Force leaders. However, before decision makers vest the confidence in M&S results required to make decisions involving large costs or human lives, the model proponents must ensure that such confidence is justified. Verification, validation, and accreditation are processes by which M&S content and quality are investigated, documented, and authenticated. This instruction is based on the concept that verification and validation (V&V) will be a continuous process

throughout a model's life cycle. Air Force model V&V plans will emphasize an incremental "building block" approach where different V&V activities are sponsored by individual users to support their specific accreditation needs. These V&V results are maintained in a centralized location available, via the M&S Resource Repository (MSRR), to all model users. This approach, over time, produces an in-depth examination of the model, with the V&V costs being shared across the model's entire user community.

2.1. A systematic V&V plan will be an integral part of any Air Force M&S development, enhancement, maintenance, or upgrade activity. V&V will also be accomplished in concert with, and as part of, overall M&S configuration management actions according to AFI 16-1002.

2.2. Air Force M&S applications supporting either the major DoD decision making organizations or processes specified in DoD 5000.59 (paragraph D.8), Air Force input to these DoD organizations or processes, joint training, and joint exercises, will be accredited for their intended purpose. All executed V&V activities will support the model acceptance/accreditation requirements defined by the accreditation authority.

2.3. All Air Force-owned M&S will meet V&V requirements of the MAJCOM, FOA, or DRU exercising model management responsibility.

2.4. Air Force agencies using M&S owned by other DoD components will adhere to the terms and conditions specified in any memorandum of agreement (MOA) releasing the model for Air Force use. Unless otherwise specified, the Air Force using agency will be responsible for accomplishing model V&V activities according to model owner, MAJCOM, or (if applicable) Air Force guidance, whichever is the most appropriate for the intended model use.

2.5. The Air Force agency that is responsible for a contractor- or Federally Funded Research and Development Center (FFRDC)-developed M&S (either new major model development or enhancements) will ensure that V&V requirements are accomplished.

2.6. Model managers and developers are responsible for executing a practical transition plan to ensure compliance with the appropriate V&V requirements when an M&S classification changes (i.e., change in model usage requires it to be treated as a major model).

2.7. If applicable, V&V activities will include assessments of the representations of concepts, tactics, forces, processes, and doctrine from all protagonists' perspectives. Coordination with HQ USAF/INX is required to ensure that threat portrayals conform to current assessments.

## Section B—Responsibilities for V&V Management

### 3. HQ USAF Responsibilities.

3.1. The Assistant Vice Chief of the Air Force (HQ USAF/CVA) is the approval authority for M&S VV&A policy.

3.2. The Directorate of Modeling, Simulation, and Analysis (HQ USAF/XOM) is designated as the single point of contact for M&S VV&A issues and activities within the Air Force and represents the Air Force in joint, multi-service, and multi-agency M&S efforts. In conjunction with all Air Force M&S user communities, HQ USAF/XOM leads development of Air Force M&S policy for HQ USAF/CVA approval.

3.3. The appropriate HQ USAF Deputy Chief of Staff or Assistant Chief of Staff will approve the V&V report that accompanies the release of Air Force models and databases within their functional areas which meets two conditions:

- M&S will be used to support joint exercise or training activities.
- Portray Air Force capabilities, force structure, doctrine, or tactics when used in these activities.

## 4.  MAJCOM/FOA/DRU Responsibilities.

4.1.  Establishes detailed guidance that identifies and manages the VV&A requirements for command owned and operated models that do not qualify as common use, general use, joint use, or major M&S as defined in **Attachment 1**, section C.  This will include the "threshold" criteria that require "prototype" computer code be treated as a model for V&V purposes.

4.2.  Establish a command point of contact responsible for V&V issues and activities.

4.3.  Establish a V&V manager for each command-owned or managed M&S.

4.4.  Provide resources to meet V&V management requirements within the command.

4.5.  Establish and maintain a list of command personnel that can serve on Technical Review Working Group (TRWG) teams as subject matter, problem domain, or technical experts (including model development, operation, and maintenance.)

4.6.  Identify personnel that can serve as Air Force focal points for joint distributed interactive simulation (DIS) exercises.

## 5.  V&V Manager Responsibilities.

5.1.  Provides expertise on current and previous V&V efforts to HQ Air Force or MAJCOM, FOA, or DRU technical review committees.

5.2.  Establishes, in conjunction with the model manager and user community, baseline V&V status (for legacy models). It is expected that the V&V baseline will be refined using the incremental approach paradigm mentioned in **Section A**, paragraph **2.**

5.3.  Develops, in conjunction with the model manager, a long-range plan that prioritizes V&V activities for known model deficiencies and upcoming model enhancements/upgrades.

5.4.  Coordinates on the V&V requirements related to proposed model maintenance, upgrade, and configuration changes.

5.5.  Establishes, operates, or maintains a repository of all current and historic V&V information on the particular M&S and provides M&S V&V status updates.

Users will be able to access the information via the DoD MSRR system.

5.6.  (DIS V&V managers) Guidance for DIS V&V is contained in the Institute of Electrical and Electronic Engineers (IEEE) document, *The IEEE Recommended Practices Guide for the Verification, Validation, and Accreditation of Distributed Interactive Simulations*, 5 Mar 96 (Draft).

5.7.  Advocate for resources needed to carry out the previously described M&S V&V management responsibilities.  This could include some "cost sharing" arrangements with the model's user community.

**6. Accreditation Authority Responsibilities.**

6.1.  Identifies pertinent parameters and constraints that impact the V&V planning and implementation process, including M&S acceptance and accreditation measures of effectiveness/measures of performance (MOEs/MOPs).

6.2.  Determines the need to form a TRWG for review of V&V plan and results.

6.3.  Selects or approves personnel that are involved in the M&S VV&A activities; i.e., verification, validation, or accreditation agents, optional TRWG members, other subject matter experts (SME), etc.

6.4.  Approves, funds, and monitors the implementation of all V&V activities that directly support the upcoming accreditation decision.

6.5.  Documents M&S application accreditation decisions after review of supporting accreditation reports.

6.6.  Ensures completion and dissemination of appropriate V&V or accreditation reports.

**7. Accreditation Agent Responsibilities.**

7.1.  Serves as a source of advice and expertise to the accreditation authority concerning VV&A issues.

7.2.  Assists accreditation authority in the identifying M&S acceptance and accreditation MOEs/MOPs.

7.3.  Performs M&S accreditation assessment and determines any deficiencies between documented M&S capabilities and accreditation requirements which require further V&V.

7.4.  Assists accreditation authority in determining the need to form a TRWG and, as the accreditation authority's representative, chairing subsequent TRWG proceedings.

7.5.  Ensures, as the accreditation authority's representative during the verification and validation planning and implementation process, that the approved plan will provide sufficient V&V to support the accreditation decision while remaining within accreditation authority-established constraints.

7.6.  Prepares accreditation report documentation for accreditation decision, and afterwards disseminates the completed accreditation report.

**8. Verification Agent or Validation Agent Responsibilities.**

8.1.  Serves as a source of advice and expertise to the accreditation authority and accreditation agent concerning V&V issues.

8.2.  Develops a plan, including resource requirements, that addresses the V&V deficiencies identified by the accreditation agent while remaining within the accreditation authority-identified constraints.  If this is not possible, the agent(s) will work with the accreditation agent to develop risk reduction and V&V plans that together will meet accreditation authority M&S acceptance criteria and constraints.

8.3.  Provides a suggested list of TRWG members to accreditation authority and accreditation agent, and actively participates in any subsequent TRWG meetings.

8.4.  Performs all V&V activities and prepares the final V&V report for submission to the accreditation agent and the M&S' V&V manager.

*Section C—V&V Management, Processes, and Tools*

**9. Verification.**  Verification is the process of determining that M&S accurately represent the developer's conceptual description and specifications.  This is accomplished by identifying and eliminating mistakes in logic, mathematics, or programming.  This process establishes that the M&S code and logic correctly perform the intended functions, and to what extent M&S development activities conform to state-of-the-practice software engineering techniques.

**10. Valadation.**  The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model.  Validation process can be used to identify model improvements, where necessary.  It has two main components:  structural validation, which includes an internal examination of M&S assumptions, architecture, and algorithms in the context of the intended use; and output validation, which determines how well the M&S results compare with the perceived "real world."

**11. V&V Report.** The V&V report, submitted by the verification or validation agent(s), formally documents V&V activities, their results, and recommendations for major Air Force M&S.  This document, maintained by the V&V manager as part of the M&S' V&V history, is used to support current and future accreditation decisions, feasibility assessments, and future enhancements using this particular M&S.  The report, at a minimum, will:
- Specify M&S *reference* version number, plus all hardware and software identification or version numbers used in supplying model inputs.
- Identify model input data suppliers.
- Identify key V&V planning, technical review, and implementation participants or organizations, and their V&V responsibilities.
- Describe V&V methodologies, implementations, and their results.
- Describe verification, validation, and certification (VV&C) activities performed on input data sets used in V&V activities.
- Identify V&V criteria (MOEs/MOPs).
- Describe any additional model strengths, weaknesses, or limitations identified as a result of the V&V activity, with recommended remedial actions.

**12. Accreditation.**  Accreditation is the official determination by the accreditation authority that the M&S is acceptable for a specific purpose.  This determination considers the V&V status of a specific model version, its data support (source, quality, and VV&C) and the analysts/users that operate the model and interpret its results.  The accreditation authority is the individual who is responsible and accountable for decisions or actions based upon the specific M&S usage.  The decision to accredit a model or simulator rests solely with the accreditation authority.  Likewise, determining the level of effort supporting a particular accreditation, whether conducting additional V&V activities or simply reviewing the existing

M&S documentation and past VV&A history, rests solely with the accreditation authority. The following accreditation requirements listed in the following paragraph are not all-inclusive but reflect those items considered to be of greatest importance. The validation documentation of M&S application results correlating M&S results with test or other data describing behavior of the subject being modeled will be reviewed during the M&S accreditation assessment.

12.1. Accreditation Requirements. The following are the minimum requirements that must be assessed by the accreditation authority (or the designated accreditation agent) each time the model is accredited for a particular application:

- Review the M&S's development history, summarize past application(s), and define its application domain based upon a description of capabilities by the M&S developer.

- Review the adequacy of the model's configuration version control; and complete an acceptable face validation examination, if appropriate.

- Compare the M&S's capabilities and credibility, based on V&V status, to the application criteria. Assess risk of accepting M&S capabilties if they do not meet application criteria thresholds, or have not had sufficient V&V.

- Ensure that model documentation exists and is current/sufficient for the intended use. This documentation will normally include the M&S conceptual model, user's guide, programmer's and analyst's manual(s).

- Ensure that data sources have been identified and both producer and user data VV&C activities were accomplished.

12.2. Accreditation Report. This report summarizes the evidence used to support the accreditation decision. The report contains the information outlined in the draft DoDI 5000.XX, 6 Feb 96, paragraph F.6.

**13. VV&A Process.** The following key actions/elements, shown in **Figure 1.**, constitute a flexible process that accommodates VV&A activities throughout the M&S' life cycle--initial model development, model enhancement, or problem domain expansion. (The DIS VV&A process is discussed in the next paragraph.) The accreditation authority is responsible for funding and implementing the assessment and V&V activities supporting his/her specific model (application) accreditation. V&V activities will be coordinated with the model and V&V managers.

**Figure 1. Air Force Verification, Validation, and Accreditation Process.**
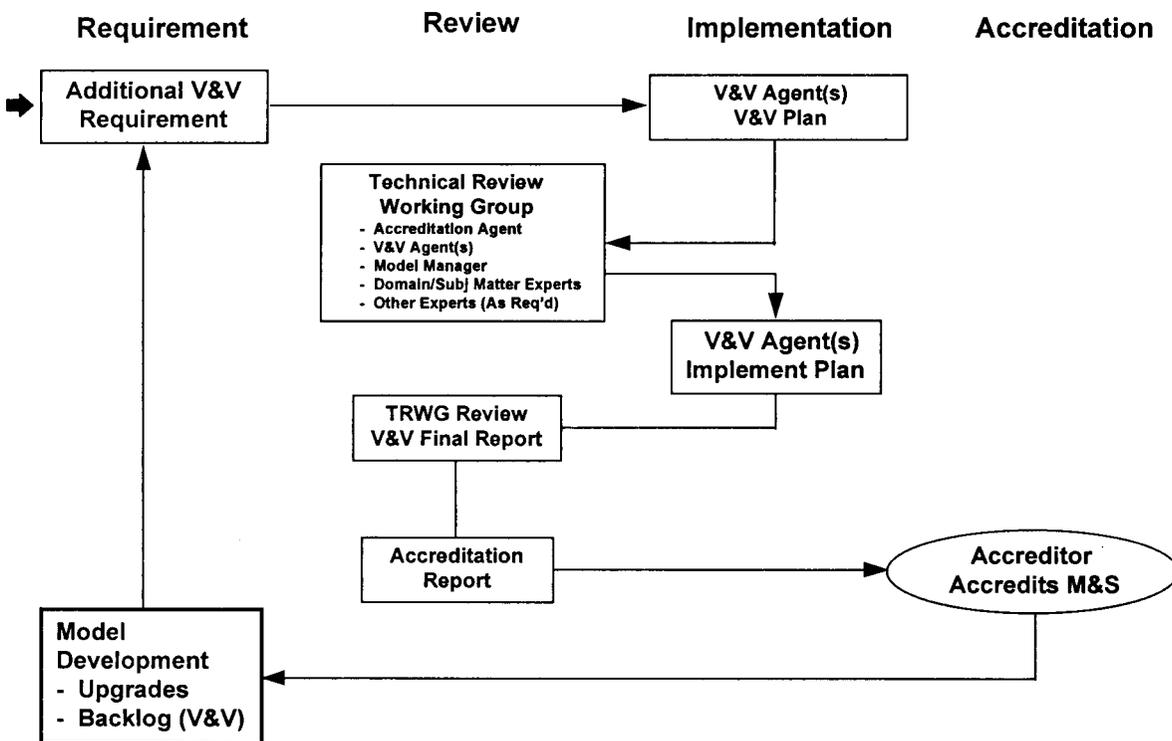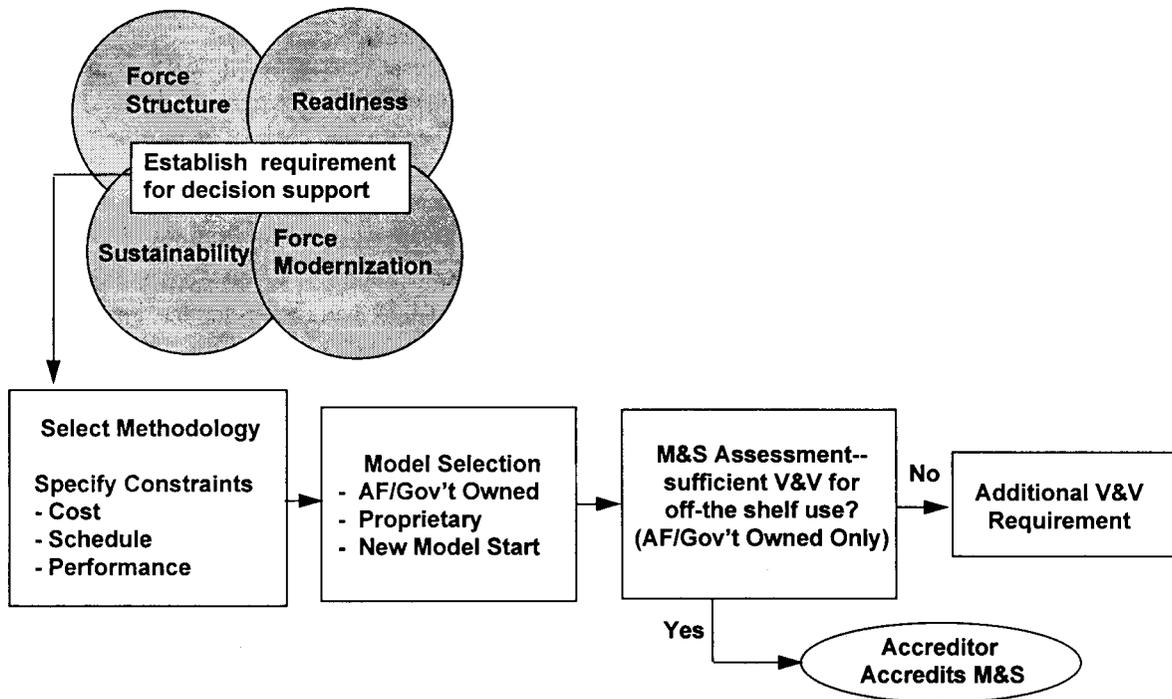
13.1. M&S Requirements Identification. The accreditation authority and accreditation agent (usually the responsible study/project team lead) first establish guidance impacting M&S support for a given project, including (but not limited to) available manpower and funding resources; project constraints (cost, schedule, performance); requirements that will be supported using M&S; and acceptability/ accreditation criteria including pertinent MOEs/MOPs. The accreditation agent then identifies the particular model(s)--including requisite modifications or enhancements--from available Air Force/ DoD M&S repositories that appears to meet these parameters.

13.2. M&S Assessment. The accreditation agent will assess the M&S to determine if its proposed usage falls within a previously V&V'd application domain. Accreditation agent will identify any V&V deficiencies that must be corrected for the M&S to meet the accreditation authority's acceptability criteria.

13.2.1. Proposed application may be accredited if documented V&V history sufficiently supports specified acceptance and accreditation MOEs/MOPs. (See paragraph **12.1.** for accreditation requirements).

13.3. V&V Plan Development. Verification and validation agent(s), based on V&V deficiencies identified during the accreditation agent's M&S assessment, will develop a plan that ensures sufficient, documented model V&V to support accreditation acceptance criteria.

13.3.1. Executive Agent will be consulted if V&V activities will be performed on portions of the M&S that lie with the EA's problem domain.

13.3.2. V&V plan will identify data sources to obtain verified, validated, and certified input data. Scenario data--reflecting current threat representations--will be obtained from or coordinated with appropriate intelligence source. HQ USAF/INX will be consulted on questions concerning appropriate intelligence sources.

13.3.3. For non-government owned models or for new model starts, plan must include establishment and operation of V&V management mechanisms and responsibilities by the accreditation sponsor.

13.3.4. Plan will identify and source estimated planning and implementation manpower/funding.

13.4. V&V Technical Review Working Group Review. This working group review is intended to develop a community consensus that, within identified constraints, an approved V&V methodology, with associated risk mitigation strategies, will be adequate to support proposed model accreditation decision. This group, whose membership is tailored to the model and proposed application, is formed on an as-needed basis. Working group composition includes:

- Accreditation Agent
- Verification and Validation Agent(s)
- Model manager
- V&V manager (if different from model manager)
- Executive Agent (if V&V activities directly involve the EA's problem domain)
- User's group chair (if applicable)*
- Other technical cognizance (organizational) representatives*
- Independent Technical Review representative*

- Data Source(s) VV&C representative*
- HQ USAF/XOM and other Service representatives**
- Other OSD representatives**

*Membership optional

**When multi-Service participation required

13.5.  V&V Technical Review Working Group Final Review.  Upon completion of V&V activities, the committee can be reconvened to review actual versus planned V&V implementation and results; review or perform a risk assessment (for any unaccomplished V&V activities), and provide a written summary of their findings and recommendations to the V&V agents.  The V&V agents will then prepare the V&V report that summarizes overall findings and recommendations.

13.6.  V&V agents will forward the V&V report and supporting documentation to the accreditation agent for inclusion into the accreditation report.  A copy of this report and documentation is forwarded to the appropriate M&S V&V manager for update and archiving purposes.

13.7.  Accreditation agent, based on the accreditation assessment, along with any additional V&V and IV&V activities, and independent endorsements from bodies with appropriate technical/domain expertise, will prepare an accreditation report.

The accreditation authority will make and document the model accreditation decision.  The accreditation agent will forward a copy of the accreditation report to the appropriate M&S V&V manager for update and archiving purposes.

**14.  Distributed Interactive Simulation  (DIS) V&V.**  Distributed systems of M&S include DIS applications, M&S linked by aggregate level simulation protocol (ALSP), and other M&S architecture which contain distributed components that make up an overall M&S.  In general, each component M&S for inclusion in the distributed architecture would be identified and separately V&V'd for intended DIS usage.  The entire distributed architecture is then assembled and V&V'd as a single entity, with the V&V level of effort tailored to support acceptability criteria given accreditation authority-identified constraints.

14.1.  Models that are individual components in a DIS architecture will be V&V'd for the specified use.  Accreditation sponsor is responsible for implementing and funding those VV&A activities required to prepare and subsequently integrate the stand-alone model into the DIS exercise.

14.1.1.  For joint DIS exercises, Air Force constructive models portraying force structure, doctrine, and tactics representations will be V&V'd for use in the particular exercise according paragraph **5.** of this section, and approved for use by the appropriate HQ USAF DCS or ACS (or designated representative). All other models--whether being submitted for first time DIS use, or reuse of a model currently residing in a DIS repository--would be V&V'd and approved for use via MAJCOM, FOA, or DRU procedures.

14.2.  When the Air Force is the DIS accreditation sponsor, *The IEEE Recommended Practices Guide for the Verification, Validation, and Accreditation of Distributed Interactive Simulations*, 5 Mar 96 (DRAFT) should be referenced for the tailoring and constructing of the DIS exercise.  This document identifies specific points for development of both the V&V plan and report.

14.3.  An Air Force V&V focal point, normally a member of the Air Component Commander's staff, will be designated for joint ALSP exercises that use models portraying Air Force force structure, doc-

trine, and tactics representations. Otherwise, the focal points for a joint DIS exercises will be identified by the participating Air Force agencies and approved by HQ USAF/XOM.

**15. V&V Manager.** Every major Air Force model will have a single V&V manager throughout its life cycle. Depending on model size and complexity, this function will be assigned to the model manager or to the agency with model management responsibility. For new models, the V&V manager will be identified at the start of model development activities. Otherwise, for existing models, V&V manager will develop a time-phased plan to comply with these V&V responsibilities within 2 years of the effective date of this instruction. A fuller explanation of V&V manager responsibilities were outlined in **Section B**.

15.1. At any one point in time there can be only one clearly designated V&V manager for a given model; however, there is no restriction to the transfer of V&V management responsibility between organizations. For example, the developing agency could simultaneously transfer both model management and V&V management responsibility to the model manager when delivering the completed model.

15.2. The following guidelines will be used to identify the Air Force organization with V&V management responsibility for a particular M&S.

15.2.1. For M&S under development, either in-house or under contract by a sponsoring Air Force agency, the sponsoring Air Force agency is responsible.

15.2.2. For M&S which do not have a designated model manager, and are operated and maintained by a single Air Force agency, that agency is responsible.

15.2.3. For M&S which do not have an designated model manager, and have multiple users or separate users and maintainers:

- If a configuration management or users group exists, the agency chairing this group is responsible.
- If a configuration management or users group does not exist, the predominant Air Force user is responsible (XOM will be the final authority for determining predominant Air Force user).

15.2.4. V&V manager for threat M&S will normally be the appropriate Air Force intelligence agency, as determined by HQ USAF/INX.

15.2.5. Distributed interactive simulation (DIS) or Aggregate Level Simulation Protocol (ALSP) V&V focal point (manager):

- For a DIS or ALSP environment owned by the Air Force, the Air Force accreditation sponsor is responsible for overall management responsibilities (component model, VV&A, and configuration management).
- For a joint DIS or ALSP environment, and Air Force is not designated as the accreditation sponsor, the Air Force exercise POC (or his designated representative) will represent the Air Force on issues concerning the DIS or ALSP environment and Air Force models within the DIS or ALSP confederation. This Air Force (DIS or ALSP) focal point will coordinate the VV&A requirements with the joint DIS or ALSP manager.

**16. V&V Repository.** In conjunction with the model manager, the V&V manager will establish, operate, or maintain a repository accessible via the DoD Modeling and Simulation Resource Repository (MSRR)

system.  The V&V manager will ensure his/her repository is consistent and compatible to the DoD MSRR.  Repository operations must facilitate M&S community queries and data access to establish the current model version's baseline V&V status and model VV&A and usage history.  Additionally, the repository will contains pointers to documentation on all ongoing and completed VV&A (stand-alone and DIS-related) activities, such items as test input data sets, V&V plans, and documented conceptual and data models, that will allow potential users to evaluate the model's capabilities against their M&S requirements.

**17.  Waivers.**  In extenuating circumstances, HQ USAF/XOM may approve requests for waivers to the requirements of this document.  Under such conditions, a simple request for waiver letter, with rationale, must be forwarded through the appropriate chain of command to HQ USAF/XOM.  Unless specifically exempted for particular applications or periods of time, the waiver must be submitted, reviewed, and approved on an annual basis.

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## Attachment 1

## GLOSSARY OF REFERENCES, ABBREVIATIONS, ACRONYMS, AND TERMS

*References*

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

DoD Directive 5000.59-M, *Glossary of Modeling and Simulation (M&S) Terms*, 29 August 1995 (DRAFT)

DoD Instruction 5000.XX, *DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)*, 6 February 1996 (DRAFT)

AFPD 16-10, *Modeling and Simulation Management*, 30 January 1995

AFI 16-1002, *Modeling and Simulation Management*, 26 July 1995 (DRAFT)

IEEE 1278.4, *The IEEE Recommended Practices Guide for the Verification, Validation, and Accreditation of Distributed Interactive Simulations*, 5 March 1996 (DRAFT)

Defense Modeling and Simulation Office Guide, *Introduction to VV&A Standards and Practices for DoD M&S*, 30 September 95 (DRAFT)

*Abbreviations and Acronyms*

**ACAT**—Acquisition Category

**ACS**—Assistant Chief of Staff

**ADS**—Advanced Distributed Simulation

**AFI**—Air Force Instruction

**AFPD**—Air Force Policy Directive

**AI**—Artificial Intelligence

**AIS**—Automated Information System

**ALSP**—Aggregate Level Simulation Protocol

**C3I**—Command, Control, Communications, and Intelligence

**C4I Intelligence**—Command, Control, Communications, Computers, and

**CASE**—Computer Aided Software Engineering (development tools)

**CAX**—Computer Aided Exercise

**DCS**—Deputy Chief of Staff

**DoDD**—Department of Defense Directive

**DoDI**—Department of Defense Instruction

**DIA**—Defense Intelligence Agency

**DIS**—Distributed Interactive Simulations

**DMSO**—Defense Modeling and Simulation Office

**DRU**—Direct Reporting Unit

**FFRDC**—Federally Funded Research and Development Centers

**FOA**—Field Operating Agency

**I/DB**—Information/Database

**IDEF**—Integrated Computer-Aided Manufacturing Definition

**IEEE**—Institute of Electrical and Electronic Engineers

**IV&V**—Independent Verification and Validation

**LCC**—Life Cycle Cost

**M&S**—Modeling and Simulation

**MS&A**—Modeling, Simulation, and Analysis

**MAJCOM**—Major Command

**ModSAF**—Modular Semi-Automated Forces

**MOA**—Memorandum of Agreement

**MOE**—Measure of Effectiveness

**MOO**—Measure of Outcome

**MOP**—Measure of Performance

**MORS**—Military Operations Research Society

**MSMP**—M&S Master Plan

**MSRR**—Modeling and Simulation Resource Repository

**SAFOR**—Semi-Automated Forces

**SMART**—Susceptibility Model Assessment and Range Test

**SME**—Subject Matter Experts

**T&E**—Test and Evaluation

**TRWG**—Technical Review Working Group

**V&V**—Verification and Validation

**VV&A**—Verification, Validation, and Accreditation

**VV&C**—Verification, Validation, and Certification

**WAN**—Wide Area Network

*Terms*

**Accreditation**—The official determination that a model or simulation is acceptable for use for a specific purpose.

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

**Accreditation Authority**—An individual occupying a position with the appropriate responsibility or authority to accredit a model, simulation, or federation of models or simulations for a particular purpose or purposes.

**Accreditation Sponsor**—The DoD Component or other organization with the responsibility for accrediting a model, simulation, or federation of models or simulations for a specific use or series of uses (e.g., for joint training or a Defense Acquisition Board milestone review.)

**Advanced Distributed Simulation (ADS)**—A set of disparate models or simulations operating in a common synthetic environment in accordance with the Distributed Interactive Simulation standards. The ADS may be composed of three modes of simulation: live, virtual, and constructive, which can be seamlessly integrated within a single exercise. See also: live simulation; virtual simulation; constructive simulation.

**Aerospace M&S Hierarchy**—The level or levels of resolution at which a model is operating. The four levels related to simulation of aerospace power are:

- Campaign. Simulations that attempt to emulate all elements of aerospace power over the duration of a conflict and across the theater or theaters of operations. Time scale normally in days to weeks. Represents the strategic and operational levels of warfare.

- Mission. Simulations of one or more interacting elements of aerospace power across all or part of the theater of operations. Time scale normally in hours. May represent the operational and tactical levels of warfare.

- Engagement/Sub-mission. Simulations of weapon system and/or support system performance in a limited environment. Engagements ranging from one on one to many on many, or a portion of full system capability. Time scale normally in seconds to minutes. Represents the tactical level of warfare.

- System/Subsystem/Component. Detailed engineering or scientific simulation of a single system, subsystems, and components across ranges of operations and environments. Time scales range from micro-seconds to minutes or more. May represent the tactical level of warfare.

**Aggregate Level Simulation Protocol (ALSP)**—A family of simulation interface protocols and supporting infrastructure software that permit the integration of distinct simulations and war games. Combined, the interface protocols and software enable large-scale, distributed simulations and war games of different domains to interact at the combat object and event level. The most widely known example of an ALSP confederation is the Joint/Service Training Confederation (CBS, AWSIM, JECEWSI, RESA, MTWS, TACSIM, CSSTSS) which has provided the backbone to many large, distributed, simulation-supported exercises. Other examples of ALSP confederations include confederations of analytical models that have been formed to support US Air Force, US Army, and US TRANSCOM studies.

**Analytical Model**—A model consisting of a set of solvable equations; for example, a system of solvable equations that represents the laws of supply and demand in the world market.

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

**Behavior**—For a given object, how attribute value changes effect (or are effected by) the object value changes of the same or other objects.

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

**Business Rule**—A statement or fact that defines the constraints and relationships between data elements.

**Classes of Simulation**—See Live, Virtual, and Constructive Simulation.

**Common-Use M&S**—M&S applications, services, or materials provided by a DoD Component to two or more DoD Components.

**Conceptual Model**—A statement of the content and internal representations which are the user's and developer's combined concept of the model. It includes the logic and algorithms and explicitly recognizes assumptions and limitations.

**Configuration Management**—The application of technical and administrative direction and surveillance to identify and document the functional and physical characteristics of a model or simulation, control changes, and record and report change processing and implementation status.

**Data**—Representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.

**Data Certification**—The determination that data have been verified and validated. Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. Data producer certification is the determination by the data producer that data have been verified and validated against documented standards or criteria.

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

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

**Data Verification, Validation, and Certification (VV&C)**—The process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user processes.

**Distributed Interactive Simulation (DIS)**—(1) Program to electronically link organizations operating in the four domains: advanced concepts and requirements; military operations; research, development, and acquisition; and training. (2) A synthetic environment within which humans may interact through simulation(s) at multiple sites networked using compliant architecture, modeling, protocols, standards, and data bases.

**DoD Components**—The office of the Secretary of Defense (OSD), the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant commands, the Inspector General of the Department of Defense, the Defense Agencies; and the DoD Field Activities.

**DoD Executive Agent**—A DoD Component to whom the USD (A&T) has assigned responsibility and

delegated authority for the development and maintenance of a specific area of M&S application, including relevant standards and databases, used by or common to many models and simulations.

**Entity**—A distinguishable person, place, thing, event, or concept about which information is kept.

**Federation**—A system of interacting models and/or simulations, with supporting infrastructure, based on a common understanding of the objects portrayed n the system.

**Federation Element**—Term applied to an individual model and/or simulation that is part of a federation of models and simulations.

**Fidelity**—(1) The similarity, both physical and functional, between the simulation and that which it simulates. (2) A measure of the realism of a simulation. (3) The degree to which the representation within a simulation is similar to a real world object, feature, or condition in a measurable or perceivable manner. See also: model/simulation validation.

**General-Use M&S Applications**—Specific representations of the physical environment or environmental effects used by, or common to, many models and simulations; e.g., terrain, atmospheric, or hydrographic effects.

**Independent Verification and Validation (IV&V)**—The conduct of V&V of M&S by individuals or agencies that did not develop the model or simulation.

**Joint M&S**—Representations of joint and Service forces, capabilities, equipment, materiel, and services used by the Joint community or by two, or more, Military Services.

**Legacy Model**—A model developed in the past which is still in use that was not implemented using today's standards (e.g., software, communication, DIS, ALSP, etc.). Some legacy models have been modified with interfaces to some of the current standards extending their usefulness and interoperability with newer, standards based models.

**Live, Virtual, and Constructive Simulation**—The categorization of simulation into live, virtual, and constructive is problematic, because there is no clear division between these categories. The degree of human participation in the simulation is infinitely variable, as is the degree of equipment realism. This categorization of simulations also suffers by excluding a category for simulated people working real equipment (e.g., smart vehicles).

- **Live Simulation.** A simulation involving real people operating real systems.
- **Virtual Simulation.** A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop (HITL) in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communications skills (e.g., as members of a C4I team).
- **Constructive Model or Simulation.** Models and simulations that involve real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems.

**Logical Verification**—The identification of a set of assumptions and interactions for which the M&S correctly produces intended results. It determines the appropriateness of the M&S for a particular application and ensures that all assumptions and algorithms are consistent with the conceptual M&S.

**Major Model and Simulation(M&S)**—Includes, but not limited to M&S: whose intended application will require accreditation by DoD or Component policy; that will be elements of a federation of models

and simulation; that are intended for reuse; whose application involves safety of life; and, whose development will involve the commitment of significant DoD resources. (DoDI 5000.XX)

**Measure of Effectiveness (MOE)**—A qualitative or quantitative measure of a M&S's performance or a characteristic that indicates the degree to which it performs the task or meets a requirement under specified conditions.

**Measure of Outcome (MOO)**—Metrics that define how operational requirements contribute to end results at higher levels, such as campaign or national strategic outcomes.

**Measure of Performance (MOP)**—A quantitative measure of the lowest level of physical performance (i.e., range, velocity, throughput, payload, etc.).

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

**Object**—Physical or logical structures (models) that keep their characteristics and behavior together.

**Open System**—A system in which the components and their composition are specified in a non-proprietary environment, enabling competing organizations to use these standard components to build competitive systems. There are three perspectives on open systems: portability - the degree to which a system component can be used in various environments, interoperability - the ability of individual components to exchange information, and integration - the consistency of the various human-machine interfaces between an individual and all hardware and software in the system.

**Protocol**—A set of rules used to control/regulate the interaction between entities in a system (e.g., computers communicating on a network). Often implemented as hierarchy of "layers" in which each level provides a defined set of services to the layer above.

**Real-Time System**—A system that computes its results as quickly as they are needed by a real-world system. Such a system responds quickly enough that there is no perceptible delay to the human observer. In general use, the term is often perverted to mean within the patience and tolerance of a human user.

**Reference Version**—The most recent version of a model or simulation which has been released by, and under configuration management of an approval authority.

**Resolution**—The level of detail or smallest unit considered as the basic element, smallest dimension of time and space employed, or most basic intermediate variable in a computer model. High resolution has a lot of detail.

**Requirement**—An established need that justifies the timely allocation of resources to achieve a capability to accomplish approved military objectives, missions, or tasks.

**Scenario**—The entire spectrum of environmental considerations that have interaction with system(s) under analysis or those of interest for training purposes. The spectrum includes physical environment, threat conditions, rules of engagements, and systems performance and effectiveness.

**Simulation**—A method for implementing a model over time. Also a technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model.

**Synthetic Environments**—Representations of present or future, factory-to-battlefield, environments generated by models, simulations, simulators, and wargames. May include a mix of real and simulated objects accessible from widely dispersed locations. One of the Science and Technology Thrust areas.

**Validation**—Validation is the rigorous and structured process of determining the extent to which an M&S accurately represents the intended "real world" phenomena from the perspective of the intended M&S use.

**Verification**—Verification is the process of determining that M&S accurately represent the developer's conceptual description and specifications.