

User's Role in Verification, Validation, and Accreditation (VV&A) of New Development

The objective of this core document is to discuss the User's role in the verification, validation, and accreditation (VV&A) of a new simulation. The User is the driver for the overall application: the one who wants to use the simulation to provide an answer or solve a problem and the one who is concerned that the simulation can provide credible answers. The User defines the objectives and the requirements, scenarios, and use cases and generally serves as the subject matter expert (SME) for issues in the problem and user domains. The purpose of the overall VV&A effort is to provide evidence about the fitness of the simulation for the User's application. Ultimately the User is the one who decides whether the simulation is credible enough to use.

How Does the User Impact VV&A?

Although management of Verification and Validation (V&V) activities is normally not a User responsibility, the User should work with the V&V Agent, Accreditation Agent, and Modeling and Simulation (M&S) Program Manager (PM) to ensure that the V&V effort is sufficient to provide a clear understanding of the simulation's credibility and to identify simulation constraints and limitations with respect to the intended use.

The User is responsible for accreditation. The User designates the Accreditation Agent, approves the accreditation assessment plan and acceptability criteria, ensures that funding is available for the accreditation assessment, and makes the accreditation decision. Five accreditation options are possible:

- **Full accreditation** – The simulation produces results that are sufficiently credible to support the application.
- **Limited or conditional accreditation** – Constraints should be placed on how the simulation can be used to support the application.
- **Modification of the simulation is needed** – The simulation's capabilities are insufficient to support either full or conditional accreditation; modifications and subsequent V&V are needed to correct the deficiencies.
- **Additional information is needed** – The information obtained about the simulation is insufficient to support either full or conditional accreditation; supplemental verification, validation and/or testing should be conducted to provide the necessary information before the accreditation decision is made.

- **No accreditation** – The results of the assessment show that the simulation is not fit to support the application.

How Does VV&A Impact the User?

The User is concerned with the credibility of the outputs of the simulation and needs to know how well the simulation supports, or can be expected to support, the intended use. Because the focus of the overall VV&A effort is to provide information on the simulation's fitness for the intended use and the potential risks associated with its use, the User is directly affected by the quality, completeness, and timeliness of the VV&A effort.

Example:

Even if the model is a simple algorithm, such as an amortization table from the financial analysis community, the User needs to know that the answers produced (i.e., the payments and interest accrued) are correct.

For more complex simulations, such as an aircrew trainer, a much more rigorous VV&A program would be needed to ensure the simulator provides an environment that leads the aircrew member to desired learning outcomes. Precise "look" and "feel," as well as other fidelity issues, would be very important aspects of V&V for this class of simulation.

For complex simulations, it is generally considered impossible to prove the accuracy of the answers absolutely, so a rigorous examination of validity is needed to demonstrate the credibility of the answers (i.e., to determine how likely the answers are to be acceptable for the intended use).

The User must decide how to deal with simulation constraints and limitations that are identified during the V&V effort or accreditation assessment and should understand the objectives of the VV&A program, the development process, and how the simulation is to be used in the specified application.

What Are the User's Responsibilities in VV&A?

The User is the motivating force for the VV&A process. At the beginning of the process, the User establishes the objectives, defines the requirements, serves as the authority for the user domain and the problem domain, and provides subject matter expertise in these areas for both development and V&V activities. At the end of the process, the User is responsible for making the accreditation decision.

Throughout the process, the User serves as the final decision-maker for all issues that affect the ability of the simulation to address the needs of the application (e.g., changes affecting requirements, objectives, success criteria). The User should plan, direct when appropriate, and participate wherever his or her unique expertise and authority can provide the greatest leverage and benefit. The User should ensure that complete and accurate information is generated by all the VV&A activities so that an informed decision can be made. The User should establish the

boundaries of the overall VV&A program, guide the planning and resource allocation of the accreditation process, and monitor its implementation.

Throughout the entire Problem Solving Process, the User participates in a number of tasks that affect the VV&A effort. Typical User responsibilities are shown in the table below.

Typical Tasks	Typical User Responsibilities
Define Problem and Establish Objectives	<ul style="list-style-type: none"> • Provide a problem statement that identifies the issues to be resolved and the objectives that have to be met
Determine M&S Requirements	<ul style="list-style-type: none"> • Provide a complete and concise set of requirements and objectives to define the needs of the application to be addressed using simulation
Develop Scenario	<ul style="list-style-type: none"> • Provide scenarios, use cases, environments, situations, etc., that describe how the simulation entities, behaviors, and interactions should be represented
Select Accreditation Agent	<ul style="list-style-type: none"> • Designate an Accreditation Agent with appropriate experience (e.g., knowledge of problem and user domain; experience with accreditation assessment techniques) to conduct the accreditation assessment
Select SMEs	<ul style="list-style-type: none"> • Select user and problem domain SMEs to assist with problem definition, simulation development, and V&V activities
Define Measures and Acceptability Criteria	<ul style="list-style-type: none"> • Help select appropriate measures and standards and define acceptability criteria for each requirement
Establish V&V Priorities	<ul style="list-style-type: none"> • Determine the order in which requirements should be addressed based on risk
Identify Data Sources	<ul style="list-style-type: none"> • Identify appropriate, authoritative sources for data needed by the simulation
Verify Requirements	<ul style="list-style-type: none"> • Serve as SME for the user and problem domains
Validate Conceptual Model	<ul style="list-style-type: none"> • Serve as SME for the user and problem domains
Validate Results	<ul style="list-style-type: none"> • Serve as SME for the user and problem domains to prepare appropriate test cases, provide validation data, and participate in the evaluation of results
Review Products	<ul style="list-style-type: none"> • Review user manuals, documentation, etc.
Make Decisions	<ul style="list-style-type: none"> • Make decisions on problems that impact the ability of the simulation to meet the needs of the application
Make Accreditation Decision	<ul style="list-style-type: none"> • Make the accreditation decision based on the evidence provided by the V&V effort and accreditation assessment

What Challenges Does the User Face Relative to VV&A?

The User faces several challenges in planning and executing the accreditation decision, including:

- **Profiling the application** – determining which situations, scenarios, use cases, etc. can best address the application to ensure the correct representations are brought into the simulation

- **Analyzing risk and uncertainty** – identifying risks; establishing assessment priorities based on the risks
- **Tailoring** – finding cost-effective ways to assess the simulation; ensuring the V&V activities are appropriate and adequate to meet the needs of the application
- **Measuring success** – deciding how much evidence is needed to determine credibility

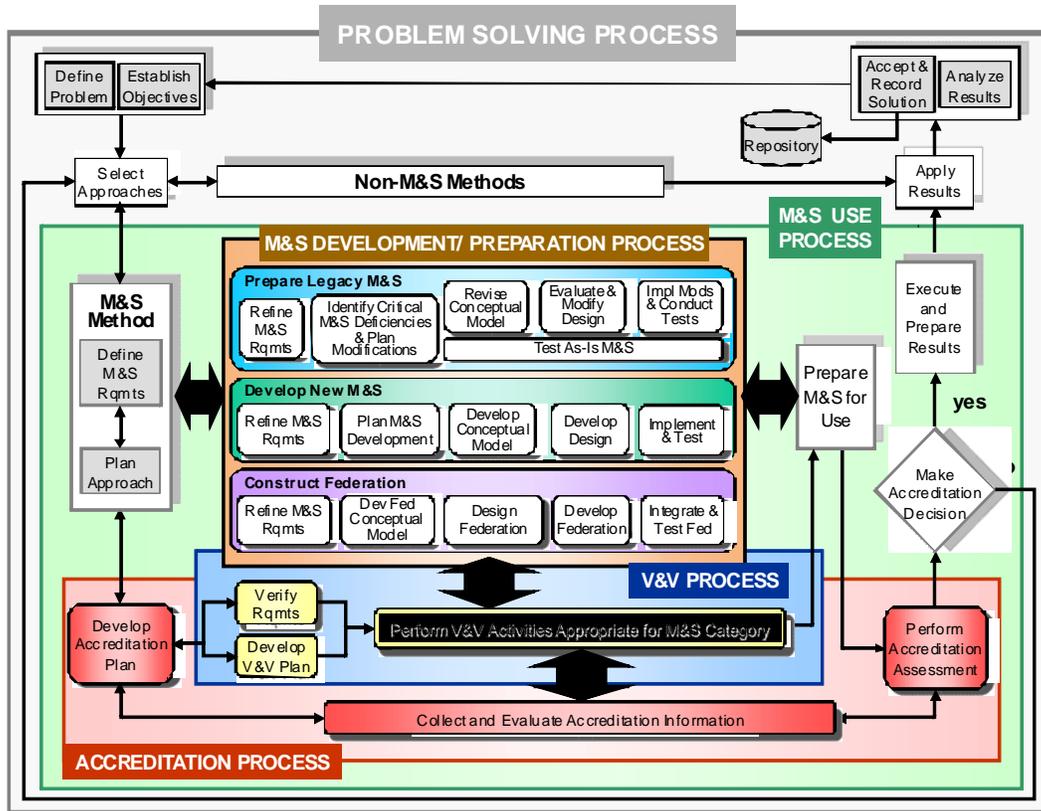
Example:

For large projects, the information generated during testing, verification, and validation serves as the basis for the accreditation assessment and decision. For a small project, however, such as an amortization model, the resources available for evaluation may be very limited and the User will need to rely more on personal experience and experimentation.

Role of the User in the Overall Problem Solving Process

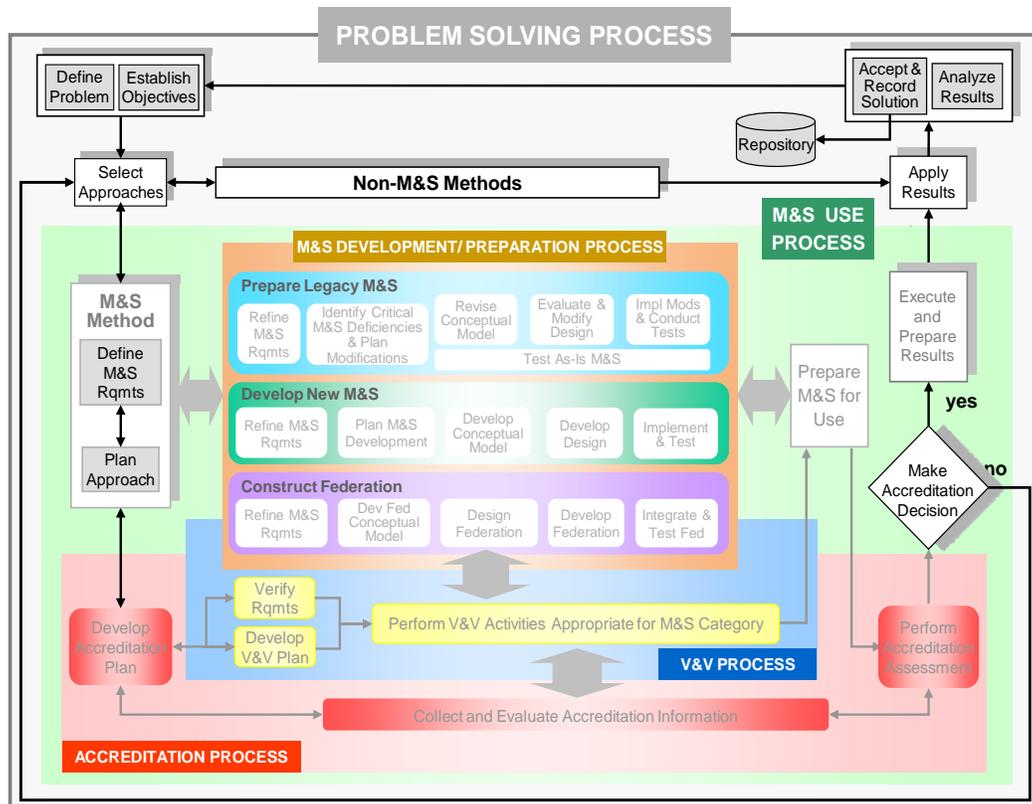
Problem Solving Process

The diagram below shows how the M&S life cycle fits into the overall Problem Solving Process. It depicts the relationships among the ***Problem Solving Process***, the ***M&S Use Process***, the ***M&S Development/Preparation Process***, the ***V&V Process***, and the ***Accreditation Process*** as a series of nested boxes. Each nested process contains a series of individual boxes that represent the basic individual activities, functions, and subprocesses considered essential to complete that process.



The Overall Problem Solving Process

The overall Problem Solving Process is the User's purview. However, as illustrated in the following figure, the User's primary areas of responsibility occur in the outermost box in the diagram, where the process begins and ends, and at major decision points throughout.



The User's Role in the Problem Solving Process

The User initiates the process by first defining the problem and establishing the objectives and then by selecting the method or methods (e.g., M&S, experimentation, statistical analysis, live testing) that will be employed to resolve it. The User completes the process by applying the methods (e.g., making the decision to accredit the simulation for use, running the simulation, accepting the simulation results) and analyzing, accepting, and recording the overall solution. How well these activities are performed, particularly those at the beginning, is critical to the success of the entire process.

Define Problem and Establish Objectives

In defining the problem, the User should first identify the issues involved and establish the objectives that have to be met to solve the problem. This can be done by addressing some basic issues, such as those shown in the table below.

Problem Domain Questions
<ul style="list-style-type: none">• What is the basic problem to be solved? What are the objectives? What questions need to be answered?
<ul style="list-style-type: none">• What particular aspects of the problem will the simulation be used to help solve? What is the application?
<ul style="list-style-type: none">• What is the scope of the problem? What boundaries or mission space apply?
<ul style="list-style-type: none">• What decisions will be made on the basis of simulation results?
<ul style="list-style-type: none">• What are the risks that might result from acceptance of erroneous simulation outputs or decisions based on them?

Answers to these questions can provide the information needed by the User to derive M&S requirements, identify appropriate measures and acceptability criteria and establish what constitutes fitness for the given application. The requirements derived from the objectives (i.e., problem domain and user domain requirements) should be defined as clearly and completely as possible, although additional details are expected to be added later. The problem itself should also be articulated clearly enough that decisions can be made about how to solve it. When a complex problem is involved, the User may need to conduct a formal problem analysis. The problem analysis need not be highly detailed but should achieve the following:

- Decompose the problem statement and objectives into discrete M&S requirements
- Identify the major representations required to address each requirement, including the entities and interactions implied in each
- Identify the probable level of precision or detail needed to represent each interaction (i.e., fidelity)
- Identify the metrics or types of measures needed to assess the simulation's ability to satisfy the objectives and requirements and the data the simulation needs to address them
- Identify the classes or categories of input data needed to support each major representation
- Identify and prioritize the representations that appear least likely to meet their requirements (i.e., identify the risks)

Problem analysis may need to be repeated as more information becomes available to ensure that simulation preparation and the V&V and accreditation efforts continue to focus on the priorities and needs of the application.

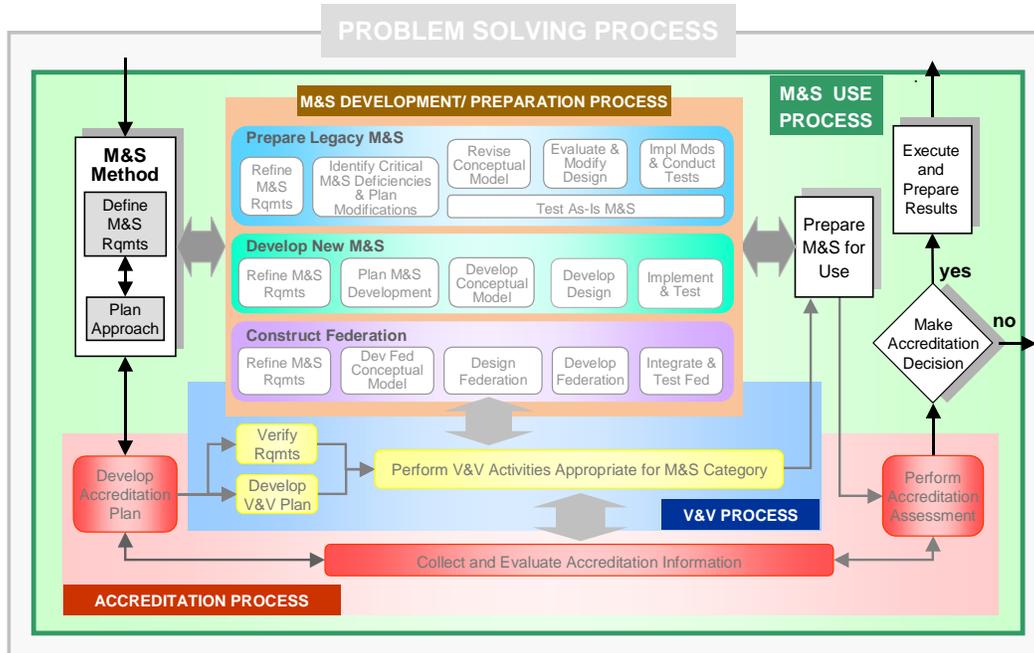
Select Approach

M&S is but one method that can be used to address the User's problem. Other methods that may be chosen to address all or part of the overall problem are beyond the scope of this document and will not be addressed. The decision to use M&S should not be taken lightly. A preliminary feasibility study should be performed to determine if use of M&S is reasonable and appropriate. Typical issues to examine are shown in the table below.

Factors Considered in Determining M&S Feasibility
<ul style="list-style-type: none">• Are there issues (e.g., treaty constraints, safety concerns, security problems) that prohibit the use of other methods (e.g., live testing)?
<ul style="list-style-type: none">• Can a model or simulation provide credible answers for this particular problem?
<ul style="list-style-type: none">• Are there other less costly methods that can provide answers of the same caliber?
<ul style="list-style-type: none">• Can an existing model, simulation, or federation meet the need? Are major modifications necessary?
<ul style="list-style-type: none">• Do all of the necessary component models or algorithms exist, or must some be developed?
<ul style="list-style-type: none">• Do all of the necessary data exist, or must some be developed?
<ul style="list-style-type: none">• Can it all be done in time and under budget?

M&S Use Process

Once M&S has been selected as the method to use, the first nested process in the Problem Solving Process, the **M&S Use Process**, illustrated below, begins. The first phase of this process, **M&S Methods**, is perhaps the most critical for successfully meeting the application objectives, because the activities performed and decisions made during this phase lay the foundation for a disciplined development process and a tailored and supportive VV&A effort.



M&S Use Process in the Problem Solving Process

Two basic activities are performed during this phase, **Define M&S Requirements** and **Plan Approach**. Specific tasks performed by the User during these activities that affect the VV&A effort are definition of the M&S requirements, planning of the approach, determination of the simulation type, designation of the M&S Program Manager (PM) and Accreditation Agent, and selection of subject matter experts (SMEs).

User Role in Defining M&S Requirements

The User provides the problem objectives and makes all decisions that may involve modifications or adjustments to requirements resulting from the limitations of the simulation. The User defines the M&S requirements from the user and problem domains, focusing on what is needed to solve the problem, and assists the Developer and M&S PM in defining simulation domain requirements that identify what is needed by the simulation to address the problem.

Example:

Problem: Train Air Force staff in developing Air Tasking Orders

Problem domain requirements: Command, Control, Communications, Computers and Intelligence, alternative brigade compositions, theater campaign level

User domain requirements: scenario locations, environmental conditions, force structure, operations manuals

Simulation domain requirements: computer hardware, coding language, data formats, architecture, interfaces

The M&S PM and Developer need to have a clear understanding of the requirements and objectives in order to know what to build. Without clearly articulated requirements, every step of the development process is more difficult and error prone, and the resulting simulation is less likely to do what the User needs it to do. For more information see [Advanced Topics>Special Topics>Requirements](#).

Problem analysis and risk assessment are complementary processes that help identify potential development problems before they become too large and expensive to resolve. Problem analysis helps ensure that the right problem is being addressed and that appropriate measures and acceptability criteria are identified. Risk assessment establishes priorities for both the development and the V&V efforts and helps ensure that simulation results provide correct answers for the problem. For more information see [Advanced Topics>Special Topics>Risk and Its Impact on VV&A](#).

User Role in Planning the Approach

Determine Simulation Type

The User must decide whether the circumstances merit using a federation or a stand-alone simulation and then whether to use a legacy simulation or develop a new one. The decision of whether to use a federation or a stand-alone simulation should be determined primarily by the nature of the problem itself. Determining whether to use a legacy simulation, if one exists, or to develop a new simulation is a business decision that should be based on a number of different factors affecting the overall costs involved and the level of risk incurred.

If an existing simulation can meet all of the M&S requirements of the current application with little or no modification, then using it may be the best approach. However, if existing simulations cannot address all of the M&S requirements, or if extensive modifications are needed to meet them, then developing a new simulation may be preferable. The User should carefully examine the risks and costs associated with each option before making a final decision. Additional information on choosing a legacy simulation is available at the [Legacy vs. New Simulation](#) link.

Designate M&S Program Manager

Once the decision has been made to develop a new simulation, an M&S PM should be designated to oversee the M&S development program. The User and M&S PM work together to articulate the M&S requirements based on what aspects of the problem are to be addressed by modeling and simulation; determine what type of simulation should be employed; and begin planning the approach. Additional activities that may occur during this phase include selecting the Accreditation Agent and identifying SMEs to participate in development and V&V activities.

Designate Accreditation Agent

The User is responsible for the accreditation program. The User coordinates funding for it, designates the Accreditation Agent, and ensures that the program develops the information needed to make an informed decision about the ability of the resulting simulation to meet the need. The User relies on the Accreditation Agent to design the accreditation program, produce the accreditation plan, collect and assess the evidence, and provide a report with recommendations for the accreditation decision. The User should select an Accreditation Agent on the basis of experience with the type of simulation involved, knowledge of the problem domain, and experience in the field of accreditation assessment.

Select Subject Matter Experts

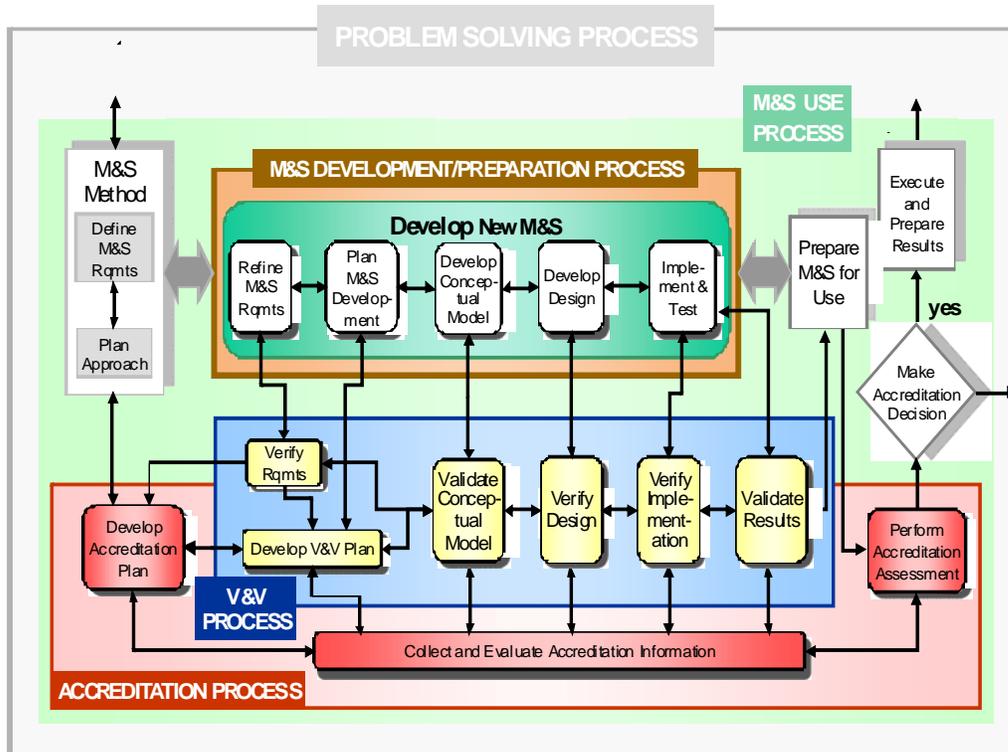
Since neither the Developer nor the V&V Agent is likely have all of the necessary expertise to speak for the problem or user domains, the User is counted on to provide expertise in these areas by either acting as an expert or by identifying additional SMEs to participate in both development and V&V activities. Such expertise is particularly critical to the V&V effort, where SMEs are needed to support requirements verification, conceptual model validation, results validation, and other areas where their special expertise can contribute to the accreditation decision. Problem and user domain SMEs are especially important during the development and validation of the conceptual model.

SMEs normally require some level of resourcing. Government employees (e.g., military experts) normally require travel costs at a minimum; experts from the private sector generally require compensation for their time as well. The User should verify that funding for SMEs is included in the M&S PM's budget.

M&S Development/Preparation Process

The next nested process, ***M&S Development/Preparation Process***, begins when the M&S PM designates the Developer. The M&S PM and Developer define the development profile, select the development paradigm, establish the development schedule, and initiate the plan.

The development process for new simulations consists of six basic phases, shown in the following figure.



M&S Development/Preparation Process for New M&S

Associated with each development phase is a corresponding V&V activity that examines and tests the progress in that phase, provides timely feedback, and collects evidence of the simulation's capabilities to be used in the accreditation assessment. The User role throughout simulation development involves a number of responsibilities that support the VV&A effort. These responsibilities are discussed in the following section.

VV&A Functions of the User Role in New M&S Development

Overview

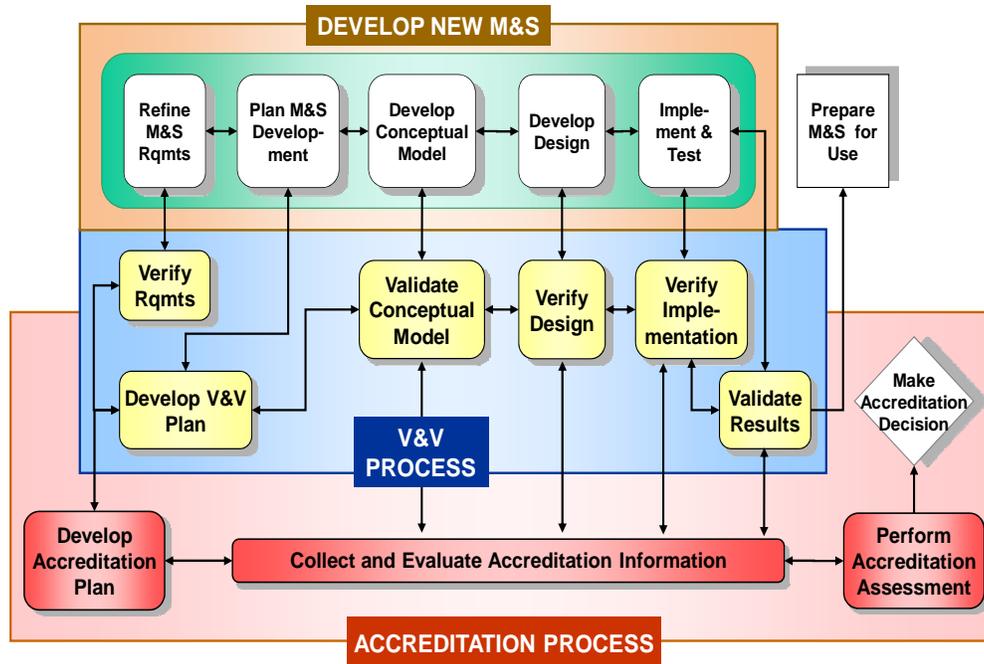
The User serves as the major decision-maker and advisor on all aspects of the development that involve the problem or specified application, including those that impact the VV&A effort. Throughout the development process, the User's role focuses on ensuring that the M&S requirements are well defined and appropriately represented and that sufficient evidence is gathered to be able to make the decision on accreditation. The User serves as the SME for matters that pertain to the problem and user domains and also ensures that appropriate SMEs are available for both the development and the V&V processes. Finally, the User serves as the primary decision-maker for all problems that impact the objectives of the application.

Normally the User relies on the V&V Agent and Accreditation Agent to perform the necessary V&V analysis and accreditation assessment, respectively. These agents provide information to and, in the case of the Accreditation Agent, take direction from the User. To establish a close, cooperative working relationship with these agents, the User should participate in the planning sessions, coordination meetings, and information exchange meetings normally conducted by the M&S PM. By maintaining a presence in the development, V&V effort, and accreditation effort, the User can ensure that little problems don't develop into big ones and that errors, problems, and oversights are found early enough to prevent them from becoming show-stoppers. The User may want to implement a tracking mechanism to ensure continuity of information received from the various agents.

Although most tasks in the V&V process can be planned, the implementation of the plan is dynamic. Where and what problems will arise, what their impact will be, or how long they will take to solve cannot be known in advance. The User should continually coordinate with the V&V Agent to monitor progress and adjust priorities to changing challenges, issues, and problems.

An approach to oversight of the VV&A effort that has worked well in the past is the formation of an Integrated Product Team, or similar working group. This team normally is made up of the Developer, the V&V Agent, the Accreditation Agent, and the User and is supported by SMEs as needed. The goal should be to keep the focus on the most critical issues, and the team should act to modify plans and tasks accordingly. The team should conduct regularly scheduled interchange meetings, as well as separate, focused problem-solving sessions, and should produce regular reports.

The new M&S development process, ***Develop New M&S***, consists of six basic phases. Associated with each phase is a corresponding V&V activity, as shown in the figure below.



VV&A in New M&S Development

Within each development phase, the User is involved in a number of activities that impact the V&V effort. Associated with each development phase is a corresponding V&V activity that consists of a number of tasks in which the User can play a role.

Refine M&S Requirements Phase

User Role in Refining M&S Requirements

During this phase, the M&S requirements are examined to ensure they are defined in enough detail to be represented in the simulation. Requirements may be decomposed and additional requirements may be added. Major considerations for the User include:

Requirements Considerations and Rationale
M&S requirements should include requirements from all three domains,
If requirements are articulated from the perspective of only the one domain (e.g., the problem domain), then articulation of remaining domain perspectives is left up to the Developer, which will produce inconsistencies and less than satisfactory results.
M&S requirements should be measurable.
Measures (e.g., measures of effectiveness, measures of performance, and measures of opportunity) should derive logically from the requirements definitions.
M&S requirements should be traceable.
Each requirement and its associated components (e.g., measures, definitions) should be traceable to an objective, as elucidated in the problem statement.

Requirements Considerations and Rationale (continued)
Requirements should be stored to support traceability.
Requirements stored in a database should have a unique identifier that can support traceability throughout the various phases of the development process.
Acceptability criteria should describe how the simulation should perform when completed.
Acceptability criteria should be fully developed by the end of the conceptual modeling phase and should be continually reviewed throughout the development process to ensure that they remain appropriate and sufficient.

User Role in Verifying M&S Requirements

The User should provide information on the simulation's intended use and on the accuracy, completeness, and currency of the requirements statements. The User will also serve as the final decision-maker on resolving any inconsistencies.

Because the M&S requirements serve as the foundation for the entire simulation development process, it is essential that they be clearly articulated from the beginning and that they be well understood by all participants. A requirements tracing database or tool should be used to ensure that the requirements are correctly carried through into the conceptual model, design, implementation, and test phases of simulation development.

Plan M&S Development Phase

User Role in Planning

The M&S Development Plan, V&V Plan, and Accreditation Plan should be developed in concert. The User is concerned with a number of factors during this phase that impact all three planning efforts. These include profiling the application, analyzing risk and uncertainty, measuring success, developing scenarios, tailoring VV&A, and establishing the validation environment.

User Role in Profiling the Application

During the planning process, essential planning information (listed in the table below) is collected and filtered and used to shape the V&V process and accreditation assessment. As the spokesperson for both the problem and the user domains, the User can provide much of the necessary information and should help the V&V and Accreditation Agents locate and obtain the rest.

Typical M&S Planning Information
• Warfighting roles, missions, and operational objectives
• Environment, geography, engagement locations, terrain, ocean, space, etc.
• Scenario-driven and general operational capabilities
• Specifications and requirements on the system(s) being modeled
• Schedule for planned use (required accreditation date)
• Resources required (including participants)
• Requirements/expectations for reuse
• Development schedule, including conceptual model, design, implementation, and testing
• Known uncertainties and risks
• Miscellaneous planning information
• History of previous use and V&V and accreditation pedigrees

The scope and character of the VV&A effort take shape as these resources are reviewed and analyzed. This collection of information serves as the basis for formal VV&A planning as shown in the tables below:

Typical V&V Planning Information
• Schedule
• Number and location of sites involved
• Requirements of the simulation use
• Generalized scenario and operational constraints
• Acceptability criteria
• V&V event scheduling within the development and test program
• Risk and uncertainty factors
• Information to gather for accreditation assessment

Typical Accreditation Planning Information
• Schedule
• Number and location of sites involved
• Requirements of the application
• Generalized scenario and operational constraints
• Acceptability criteria
• Risk and uncertainty factors
• Information provided by V&V activities
• Additional assessment activities

User Role in Analyzing Risk and Uncertainty

Credibility should be the key driver in determining the acceptability of the simulation for the application. The User's belief that the simulation is credible will depend on how much risk the User is willing to accept. This question is often difficult to answer, because risks are seldom specified by the User in concrete, quantifiable terms.

To understand simulation credibility, it is necessary to first identify and quantify the operational risks. The User should begin by addressing the following issues:

Operational Risk Issues
• What risks would result from an incorrect decision based on simulation results?
• What kinds of risks are involved? (e.g., safety, financial, unit effectiveness, program jeopardy, etc.)?
• Who would be affected by these risks and to what extent?
• What visibility will an incorrect decision have?
• What specific issues or concerns associated with the application should be considered as risks?

If the risks associated with the expected decision can be identified, then impacts and probabilities can be bounded using explicit criteria, which can then be used to quantify the level of operational risk involved. The level of operational risk determines how much information is needed to make the accreditation decision. The higher the level of operational risk, the greater the information needed by the User. By satisfying this need for information, one can build the User's confidence that the simulation outputs are credible for the intended use and thus mitigate the operational risks associated with the intended use.

Overall risk may be reduced when:

- All participants are carefully briefed on the problem and objectives and have a thorough understanding of the requirements.
- Development plans and V&V plans have been coordinated so events are scheduled to interact appropriately.
- SMEs have been identified from appropriate fields of expertise to assist with different phases of the process.
- Appropriate, authoritative data are available.

For more information see [Advanced Topics>Special Topics>Risk and Its Impact on VV&A](#).

User Role in Measuring Success

Once the requirements have been defined, the User and Accreditation Agent should determine how success for each requirement should be measured. This is accomplished by identifying appropriate measures (e.g., measures of effectiveness, measures of performance) and acceptability criteria (e.g., standards for success, boundary conditions) for each requirement.

The Accreditation Agent and the User are the primary participants in this process; however, participation by the Developer and V&V Agent is important. The Developer can provide metrics and criteria for simulation domain requirements and the V&V Agent can verify the accuracy and completeness of the data, simulation performance, and behavioral representations.

Although it is generally possible to specify what kinds of verification and validation tasks should be done to demonstrate fitness of the simulation for the application, the amount of verification and validation information required to establish credibility for a particular application ultimately depends on a clear understanding of how program decisions are affected by simulation outputs.

A precise relationship among program objectives, metrics, and the resulting simulation outputs is essential. Acceptability criteria are developed from the M&S requirements and used as the basis of comparison for simulation representations and capabilities. This comparison is an essential aspect of both V&V and accreditation planning, because it objectively justifies the selection of specific V&V tasks.

User Role in Developing Scenarios

The User is normally responsible for providing scenarios and use cases that help describe the characteristics and capabilities needed in the simulation. These scenarios and use cases are used during problem and requirements definition to bound the simulation environment for the specific application. The problem statement, by itself, is not sufficient to bound the M&S requirements. Additional information about the problem's "who," "where," "how," "when," and "why" is needed. This detailed information about the problem and M&S usage serves as the foundation of the conceptual model. Later, the scenarios and use cases are used during testing, validation, and accreditation assessment to evaluate the fitness of the simulation for the application.

User Role in Tailoring VV&A

Tailoring is an attempt to provide the most appropriate analysis possible within the constraints of time, resources, and cost. It applies to both the accreditation and the V&V processes.

- Tailoring the accreditation process involves using the information obtained during the risk analysis to identify high-risk areas, establish priorities, and

determine the information needed from the V&V effort to best address these areas.

- Tailoring the V&V effort involves the development of a reasonable, balanced V&V approach (i.e., neither excessive nor insufficient) by determining the verification and validation tasks needed to provide the information needed for the accreditation assessment and then by scoping the effort on the basis of the available resources.

In most instances, there are differences between what is desired, what is sufficient, and what is possible (i.e., what is affordable). Tradeoffs must be made. To ensure that the V&V effort provides the most evidence possible within the funding available, the User should provide guidance regarding the relative importance of the requirements (on the basis of problem analysis and risk assessment results). A carefully tailored V&V effort, including well-defined program objectives and an audit trail of decisions, can provide information the User needs to understand the limitations, constraints, and risks involved in using the simulation. For an example of tailoring, see [Resources>Reference Documents>Example of Tailoring](#).

User Role in Establishing the Validation Environment

- **Validation Data** – Frequently, no empirical validation data are available to compare with simulation results. If this is the case, SMEs from appropriate functional areas should be consulted for their “view of the real world,” commonly called the **referent**. The baseline they provide is used for the comparison. Because the User has in-depth knowledge of the problem and the application, the User or a User representative should participate in this activity as well. Additional information about validation data is available in the [Advanced Topics>Special Topics>Data V&V for New Simulations](#).
- **Validation Tests** – Validation tests, developed with guidance from the User and SMEs, should be capable of exercising the needed simulation capabilities. Validation tests should be run against the planned scenario(s) to obtain representative results.

Develop the Conceptual Model Phase

User Role in Developing the Conceptual Model

The conceptual model serves as a vehicle to move from the requirements to design and code. It functions as a blueprint by which the Developer and others can understand precisely what needs to be built. The User supports the Developer by articulating the appropriate level of abstraction of the real world to be modeled and providing the requirements, scenarios, use cases, and constraints that drive the conceptual model design. Additional detailed information about validation data is

available in the [Advanced Topics>Special Topics>Conceptual Model Development and Validation](#).

User Role in Validating the Conceptual Model

The User can participate in conceptual model validation by helping to ensure that the requirements are considered correctly and by selecting SMEs to participate in the validation process. Conceptual model validation assesses the degree to which the conceptual model accurately describes the real-world entities and processes that are candidates for representation. The entity attributes and cause-and-effect relationships governing behaviors should be defined as accurately as needed by the application. A comprehensive, validated conceptual model is necessary before an appropriate design can be developed, because it serves as the basis for the design. The validated conceptual model also serves as the referent against which simulation representations are compared during results validation.

User Role in Data Acquisition and Data V&V

The lengthy process of acquiring and preparing data should begin during conceptual model development. The earlier this process is begun, the more likely quality data will be available for the application. Once the model is designed and code is built, changes to resolve data problems become much more costly and time-consuming. The Developer identifies the data needs of the simulation (including the level of data fidelity), frequently without regard to whether or not such data actually exist. As the representative of the problem and user domains, the User should help identify both potential data sources (e.g., authoritative data sources, data producers, functional descriptions of the mission space) and SMEs. Once appropriate data are obtained, they need to be prepared for use (e.g., manipulated, transformed, and aggregated). Because of the wide variety of data types used in a simulation, multiple SMEs may be needed to support both data preparation and data V&V.

Data V&V activities are performed in concert with model V&V activities, beginning in the conceptual model phase and extending through testing and validation, to ensure that data are appropriate for use in a particular simulation for a specific application. SMEs (in particular, data producers) are frequently called upon to assist with data verification and validation activities. The User helps identify the SMEs to support individual tasks and monitors the overall process. If data or data source problems are discovered that impact the simulation's ability to satisfy the M&S requirements, it is the User's responsibility to decide whether to modify requirements, revise acceptability criteria, use available data that are not totally appropriate (i.e., accept the risk of reduced credibility), modify the simulation (which may reduce the simulation's fitness for purpose), or undertake a data production effort, which increases program costs and can result in program delays. Additional information about validation data is available in the [Advanced Topics>Special Topics>Data V&V for New Simulations](#).

Develop Design Phase

The User does not play a direct role in developing the design; however, because decisions may be required to resolve design issues, the User should monitor these events to ensure that the information being provided for the accreditation decision is complete and accurate. The User also relies on V&V information as a risk mitigation tool. By reviewing V&V results and products as they are produced, the User can use them as the basis for tradeoff decisions.

User Role in Verifying the Design

The User should ensure that that the design verification effort addresses essential issues of design integrity, performance, behavior, and credibility.

Implement and Test Phase

The User does not play a direct role in the Implement and Test Design phase; however, because decisions may be required to resolve coding issues, the User should monitor these events to ensure that the information being provided for the accreditation decision is complete and accurate. Again, the User should count on V&V information to help mitigate risk. By reviewing V&V results and products as they are produced, the User can use them as the basis for tradeoff decisions.

User Role in Verifying Implementation

The User should ensure that the implementation verification effort addresses essential issues of code integrity, performance, behavior, and credibility.

User Role in Validating Results

Results validation is conducted to determine the extent to which the simulation addresses the needs of the particular application. Because the data are inextricably intertwined with the simulation (i.e., if the data are not valid, then the validity of the models and algorithms that use the data cannot be demonstrated, and *vice versa*), data validation and simulation validation are conducted together.

The validity of the simulation has to be demonstrated and measured through comprehensive retesting and analysis. In one view, validation can be perceived as calibration, where simulation performance is observed, quantified (where possible), and adjusted within the range of data values under which it is intended to operate. The validation process continues until the User is satisfied that the acceptability criteria have been met and the simulation is stable and operating as expected.

Prepare M&S for Use Phase

Once the User has accepted the results of the validation effort, the Developer can begin to prepare it for use in the actual application. However, before the simulation is used, the User needs to make the accreditation decision.

User Role in Accreditation

Accreditation is the official certification that a simulation and its associated data are acceptable for use in the specified application. Although accreditation is often perceived as occurring at the end of a development process, the actual assessment process should begin as early as possible. This will help ensure that the results of V&V and testing activities will provide appropriate and sufficient information to support the accreditation decision. The User provides information regarding the problem objectives and M&S requirements and identifies SMEs who can be used in the assessment process.

The Accreditation Agent assesses the fitness of the simulation on the basis of evidence collected during the V&V effort and accreditation assessment process and prepares an accreditation report for the User. This report should include the results of the assessment, with detailed explanations of the risks associated with using the simulation as intended and any constraints, limitations, and permissible ranges of use, as well as an accreditation recommendation.

The User, as the accreditation authority, evaluates the information provided and makes the accreditation determination. If the results of the V&V effort indicate that the simulation meets the acceptability criteria, and the User concurs with the findings of the accreditation assessment, the accreditation decision should follow easily. However, when the accreditation assessment shows that actual simulation performance falls short of the needs of the application, the User must first understand the risks involved and then decide among the following alternatives:

- **Full accreditation** – using the simulation as is (accepting the risks)
- **Limited accreditation** – constraining the application to minimize the risks
- **Modification of the simulation is needed** – corrections can be made that can reduce the risk but they also increase costs and cause delays
- **Additional information is needed** – more information is needed to understand the risks involved and instill confidence in the simulation's fitness
- **No accreditation** – determining that the risks involved in using the simulation and the costs involved in fixing it are both too great

If the User chooses limited accreditation, then the constraints and limitations should be clearly identified and the ranges of permissible usage clearly defined.

User Role in Verifying Documentation

The quality and usability of instructional material and user manuals have a direct impact on the successful operation of the simulation. All manuals and materials delivered with the simulation should be reviewed for completeness, appropriateness, utility, and currency. If this activity is not included in the V&V plan, the User should lead this effort. When documentation verification is conducted as part of the V&V effort, the User should provide subject matter expertise.

User's Relationship with Other Roles

Overview

The User is the authority on the application (i.e., problem, use) and serves as the final decision-maker on all issues that impact the application. As such, the User is responsible for providing information shown in the table below to all participants:

Information the User Provides
• Problem domain requirements
• User domain requirements
• Authoritative data sources
• Subject matter experts (SMEs)
• Planned scenarios and use cases
• General information about the simulation usage including locations, facilities, organizations, etc.
• Other critical usage needs which may drive accreditation criteria

User's Relationship with the M&S Program Manager

In addition to the information listed above, the User provides the M&S PM with clear and complete problem statements and requirement definitions, detailed information (i.e., expertise) about the user and problem domains (e.g., what is to be represented, how the simulation will be used), and decisions regarding potential changes and problem resolution.

The User looks to the M&S PM to provide appropriate funding and support for the V&V effort, frequent updates on the status of the development and the V&V effort, and support in resolving issues and in keeping both efforts on track. The User is the ultimate decision-maker regarding all changes affecting the ability of the simulation to meet the needs of the application and therefore should be called upon to decide between cost overruns and schedule delays, modification of requirements, or limitations in simulation capability.

User's Relationship with the M&S Developer

The Developer relies on the User to:

- Define the problem and requirements
- Locate authoritative data sources and SMEs
- Help define acceptability criteria
- Serve as a domain expert for the user and problem domains
- Make decisions regarding potential changes

The User should work closely with the Developer to ensure that the requirements are faithfully converted through the conceptual model to the design and finally into the code.

The Developer also plays a major role in the V&V effort. A development effort that adheres to good software engineering practices will produce formal products that can be instrumental to the V&V effort. Additionally, tools used during the development effort should also support the V&V effort (e.g., a built-in code verifier can provide signification information). In most instances, the V&V Agent works closely with the Developer to obtain information; however, under some circumstances (e.g., low budget, low need for detailed representations, uncomplicated simulation), the Developer may conduct the entire V&V effort. The main danger in having the Developer responsible for the entire V&V effort is difficulty in maintaining independent viewpoints. A Developer's primary concern is to ensure that the code does what it is supposed to do; the V&V effort is expected to go beyond this and evaluate if the simulation provides results that are sufficiently credible to be used in the application.

Most important to the User is the generation of development, test, and V&V products so that the requirements can be traced through the design and the design can be verified. In addition, the User relies on the Developer to generate other system products, such as operations and maintenance manuals, for employment of the simulation.

User's Relationship with the V&V Agent

The V&V Agent relies on the User to provide expertise regarding user and problem domain requirements and the intended use and to resolve issues arising during the V&V process. The User relies on the V&V Agent to provide evidence of the simulation's credibility, to identify the risks associated with using it, and to provide timely reports and recommendations concerning problems throughout the development process.

When problems are uncovered during V&V activities, the V&V Agent typically reports directly to the M&S PM who, in turn, consults the User for decisions about cost, schedule, and performance issues.

User's Relationship with the Accreditation Agent

Because normally the User cannot personally gather and evaluate all of the information needed for the accreditation decision, an Accreditation Agent is designated to conduct the assessment. The Accreditation Agent works directly for and with the User to ensure that the accreditation assessment process can provide sufficient information to support an accreditation decision.

The Accreditation Agent supports the User in developing acceptability criteria based on the requirements of the application. Additionally, the Accreditation Agent produces the overall accreditation plan and provides resource and cost estimates for the conduct of the accreditation program. The User should assist in the development of acceptability criteria and provide subject matter expertise and information regarding the problem and user domain requirements as needed. The Accreditation Agent assesses the information gathered and provides a report and recommendations to the User for the accreditation decision based on documentation of any previous and current V&V efforts and personal knowledge of the requirements that the simulation will support.

User's Relationship with Others

The User's concern about the simulation's fitness for the intended use can result in relationships with additional organizations and agencies that can provide important information.

Testing

To leverage efforts that can provide information and reduce costs, the User should encourage cooperation and collaboration between the V&V effort and testing efforts (e.g., developmental testing, operational testing, and Test and Evaluation when the simulation itself is an acquisition product). Combining tests, sharing data, and comparing results can help reduce overall cost and improve the comprehensiveness of the information collected. Involving outside organizations in reviews and spot testing can provide additional evidence regarding the fitness and credibility of the simulation.

Subject Matter Experts

SMEs are relied on to provide information on a variety of topics (e.g., operational doctrine, tactics, and procedures; software languages; data; physical and natural laws and relationships; hardware).

- During the development process, SMEs are often called upon during requirements definition, scenario development, and conceptual model development.
- During the V&V effort, SMEs help establish the validation environment by providing validation data in the absence of empirical data and participate in verification, conceptual model validation, data validation, and results validation.
- During the accreditation assessment, SMEs may serve as members of the assessment team.

The User is normally expected to identify, select, or approve SMEs with expertise in the problem and user domains. For more information, see [Advanced Topics>Special Topics>Subject Matter Experts and VV&A](#).

Documentation Requirements

Information about the V&V and accreditation efforts should be collected, documented, and archived throughout the VV&A effort. Documentation should be approached realistically. Careful planning can result in products that serve both current and future Users, Developers, V&V Agents, and Accreditation Agents.

Status Reports

The User should receive regular status reports summarizing V&V and accreditation activities and costs from the V&V Agent through the M&S PM and Accreditation Agent. Although some variance between actual and planned performance and events is acceptable, the User should take immediate action in concert with the M&S PM if the reports show an adverse trend.

Archives

The User generates only the documentation pertaining to the problem statement (e.g., objectives and requirements) and the accreditation decision. However, the User should recognize the importance of maintaining a complete pedigree of VV&A information and work to ensure that an accurate, comprehensive record of all VV&A activities is kept. VV&A information to be archived should include, at a minimum, the information listed in the table below:

VV&A Information
• Problem statement
• M&S approach statement
• M&S Requirements statement
• Acceptability criteria and metrics
• Conceptual model description
• V&V plan
• Accreditation plan
• Requirements Verification report
• Conceptual Model Validation report
• Design Verification report
• Implementation Verification report
• Validation report
• Accreditation Assessment report

Additional information about VV&A archive documentation is available at the [VV&A archive](#) link.

The VV&A archive should be specific enough to demonstrate the rigor of the V&V and accreditation activities and comprehensive enough to fully describe the overall VV&A process that was executed. Two major reasons for maintaining this information are accountability and model reuse.

- **Accountability** – A well-documented VV&A effort provides a record of how and why decisions were made in the application process. This information can serve to increase confidence in the simulation by providing the rationale behind its development. A well-recorded VV&A history is invaluable when challenges are raised regarding a simulation's capabilities and limitations.
- **Model reuse** – By keeping an archive of VV&A activities during simulation development and application, its fitness for reuse in new applications should be much easier to assess.

Cost Implications and Resourcing

Cost Factors

The V&V costs that the User is directly concerned with are those associated with the accreditation effort. These costs depend on a variety of factors.

Application-Related Factors

The credibility demanded by the User for the application shapes the V&V and accreditation efforts. Credibility is directly related to operational risk. If the operational risk is great, the User will demand proof that the simulation is fit for use (credible). In general, greater operational risk increases the need to accumulate evidence to prove the simulation's fitness for use.

The complexity of the application (use) impacts the complexity of the development which, in turn, impacts the number and types of activities, the number and variety of SMEs involved in the V&V effort, and the amount of evidence needed for the accreditation assessment. In general, greater complexity implies greater risk and requires that more evidence be accumulated.

The quality of the problem definition, requirements identification, and planning has a direct impact on development of the simulation. This, in turn, impacts the amount of verification and validation needed to ensure that sufficient evidence is available for the accreditation assessment. Ambiguous objectives, inconsistent requirements, and incomplete planning result in development delays and additional verification and validation tasks that increase costs and reduce the amount of time available for the accreditation assessment.

Simulation-Related Factors

The type of simulation involved (e.g., new, legacy, federation, constructive, human in the loop, virtual) helps determine what V&V tasks are needed to provide the evidence used for the accreditation assessment. In general, it costs more to collect the necessary information for a new simulation development than for a legacy simulation that has an extensive history.

Accreditation-Related Factors

The amount of time available for the accreditation assessment impacts the amount of manpower and resources required. If there is a short suspense, additional manpower may be needed to complete the assessment (e.g., additional technical personnel to conduct tests and gather results, SMEs and analysts to assist with the assessment, and administrative personnel to prepare reports).

The experience of the people involved, i.e., their knowledge, skills, and capabilities relative to the tasks involved, determines how much time and training they need to perform those tasks.

Example:

Selection of participants in the accreditation effort can have major cost impacts. Participants who do not have the right experience or background or who cannot provide the time to prepare for and participate in assessment activities can lead to unnecessary work by others, last-minute workarounds, disruptions, delays, and compromised assessments.

Tools

Tools and technology also impact costs. Tools should be carefully selected so that the savings involved in using them are greater than the cost of purchasing them, training people to use them, and maintaining them. Special consideration should be given to ensure that tools are useful for both development and V&V activities. Knowledge acquisition (KA) products, e.g., functional descriptions of the battle space, can be the single most expensive part of the development and the assessment. If an archive of validated functional descriptions pertaining to the problem space is available, KA costs can be reduced. Good documentation of the functional descriptions can also reduce the level of effort needed for V&V activities.

Cost Estimation

Cost estimation for both V&V and accreditation is complex and varies depending on the type of simulation involved and the nature of the evidence to be collected and assessed. The V&V and Accreditation Agents should prepare cost estimates and provide them to the User for review. The User does not need to be an expert on cost estimating but should become familiar with the cost estimating tools and processes used to ensure that the resulting plans will provide the information needed to support the accreditation decision.

Cost estimation focuses on those factors that most directly impact the risk or uncertainty of the project. Additional factors should be considered as well:

- Specialized V&V tools
- Use of SMEs for particular tasks
- Travel and temporary duty
- Specialized training
- Special computers or devices
- Communications and networking equipment
- Maintenance contracts, licenses, etc.

The costs associated with these factors should be added to the cost matrix after adjustments and calculations have been made, since they are not affected by the risk or uncertainty of the project itself.

Controlling Costs

Working with the Accreditation Agent and V&V Agent, the User can take a number of steps to control costs:

- Plan the accreditation effort based on clearly defined application and credibility needs
- Conduct a risk assessment to determine the minimum essential V&V evidence needed to justify an accreditation decision based on the level of output errors that can be tolerated
- Plan an efficient V&V effort designed to reduce development cost and risk (A well-planned V&V effort can be expected to more than pay for itself by reducing errors and rework in development.)
- Analyze objects and behaviors identified in the requirements to determine which are most critical (i.e., have the greatest impact on the simulation outputs)
- Encourage the V&V effort to focus on the most critical objects and behaviors
- Determine an appropriate level of error tolerance for the critical objects and their behaviors

Documentation standards can benefit both initial and future Users. They can reduce preparation time, help ensure that appropriate, complete information is provided, and reduce the time needed for reviews and editing. Documentation standards also allow future users to rapidly find the particular information elements they need.

Acronyms

DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
KA	Knowledge Acquisition
M&S	Modeling and Simulation
PM	Program Manager
RPG	Recommended Practices Guide
SME	Subject Matter Expert
V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation

The appearance of hyperlinks does not constitute endorsement by the DoD, M&S CO, the administrators of this website, or the information, products or services contained therein. The DoD does not exercise any editorial control over the information found at these locations. Such links are provided consistent with the stated purpose of this website.