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Subject Matter Experts and VV&A

Introduction

Subject matter experts (SMEs) are widely used in modeling and simulation (M&S) development, evaluation, and use. SMEs can be part of M&S development or evaluation teams, come from outside those teams, or both. For example, some members of the verification, validation, and accreditation (VV&A) team who have special expertise, such as one with a Ph.D. in statistics and a reputation as a world-class statistician, may be treated as SMEs in VV&A reports to enhance credibility of M&S evaluation. Confusion sometimes arises from the multiple SME roles in M&S development, evaluation, and use. This Special Topic provides a basic definition for M&S VV&A-related SMEs, discusses use of SMEs in VV&A activities, provides suggestions about how to select and use SMEs effectively for VV&A activities, and discusses resources estimation and scheduling for SME usage in simulation VV&A. The guidance also addresses estimations from multiple SMEs.

What Is an SME?

Subject matter expert (SME): An individual who, by virtue of position, education, training, or experience, is expected to have greater-than-normal expertise or insight relative to a particular technical or operational discipline, system, or process, and who has been selected or appointed to participate in development, evaluation (i.e., VV&A), or use of a model or simulation.

The basic definition above accommodates both the person who possesses specialized knowledge (such as a technical specialist or military operator) and the person with special positional qualifications (such as a program office representative for weapons represented in the M&S).

This definition is compatible with “expert witness” or “technical expert” in legal parlance. For example, Rule 702 (Testimony by Experts) in the *Federal Rules of Evidence* states: “If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.” This triple perspective (qualification, reliable methods, and application of those methods) is an appropriate pattern to

apply in use of SMEs with models and simulations. Guidance in this Special Topic emphasizes using SMEs whose qualifications are clear and establishing the evidence and rationale upon which SME estimations are based.

Peer review is a standard part of quality software engineering as well as science, engineering, and other academic endeavors. For example, code peer reviews are a significant part of identifying and analyzing risk in an organization's qualification for a Software Engineering Institute Capability Maturity Model Integration achievement of level 3 or higher rating. A "peer" is one who possesses the knowledge and competence to evaluate something for factual and process soundness and to know if that something is already known, along with its strengths and weaknesses. There is another aspect to peer review. It implies relative independence on the part of the reviewer so that candor is more likely than might occur if the reviewer is dependent upon those whose material is being reviewed.

Peer Review: review by one (or more) who possess enough independence from those responsible for the item to be reviewed that candor is likely and who possess adequate knowledge and skill to evaluate the item so that flaws (if present) are likely to be detected and that general capabilities and limitations of the item can be understood and appreciated (i.e., put into a proper context and perspective).

Peer review stresses both competence and independence; technical experts and expert witnesses need both competence and communication ability (to satisfy legal requirements); and SMEs can be qualified because of vested interests, not just competence. This Special Topic uses the term "SME" for reviews and evaluation in M&S VV&A, whether that is done by one who might be called a peer, a technical expert, or an SME. Likewise, the term "expertise" is used whether the "expert knowledge" that is implied by this term is technical, application domain related, or a consequence of one's vested interests.

SME Use in Non-VV&A Roles in Simulation Development

SMEs can be used in many ways in a simulation's life cycle. Some of these ways are related to VV&A, others are not. Three important simulation uses of SMEs not directly related to VV&A are shown below. Each will be discussed briefly in this section.

- Domain expertise SMEs
- Simulation development SMEs
- Simulation use SMEs

Sometimes the same person serves as an SME in one of these ways and as a VV&A SME on the same simulation. Thus, it is important to understand these non-VV&A SME roles so that when they are discussed they are not confused with SME VV&A activities. Which authorities determine needs for non-VV&A SMEs in

simulation development and use, and how they identify, select, manage, and use such SMEs will vary with the particular situation. How these activities should be performed for non-VV&A SMEs is outside the scope of this Special Topic, but many of the ideas presented in this Special Topic for use of VV&A SMEs could apply for non-VV&A SMEs as well.

Domain Expertise SMEs

When simulation development begins (and sometimes before it begins), domain expertise SMEs are needed to create an authoritative description of the simulation application domain. This information is the basis for algorithms and processes used in the simulation. The information provides the context portion of the conceptual model used in simulation development. Once simulation objectives have been established and stated in a set of requirements for the simulation, development of the simulation conceptual model may begin. Sometimes conceptual model development will occur in parallel with development or refinement of simulation requirements. Normally, the first step in conceptual model development for the simulation is to collect authoritative information about the intended application domain that forms the simulation context. However, development of the conceptual model and collection of authoritative information about the application domain have enough “chicken or egg” intertwining characteristics that either can come first. Application domain SMEs are the source of such information, or they are guides to where the information may be obtained.

SMEs with domain expertise may be used to address a very limited part of the simulation. An example of this might be a sensor expert who provides algorithms for describing the behavior and performance of a sensor, such as a radar or sonar. The SME could provide both the algorithms that should be used and a review of the environment’s description to ensure that all pertinent factors were addressed. Other SMEs with domain expertise may be used to address the entire context for the simulation. An example of this might be a SME who is expert in chemical or biological warfare. The SME could review the description of the environment for the simulation to ensure that all pertinent factors were considered.

Simulation Development SMEs

SMEs having computer hardware or software expertise are essential to successful simulation development. SMEs with expertise in simulations similar to the one to be developed have significant potential to help M&S development. They may provide useful guidance about algorithms, simulation structure, relationships among parts of the simulation, etc. They enable a simulation development to use appropriate software development tools and techniques, to make good decisions about computer hardware and operating systems, to select an appropriate architecture for the simulation, to choose appropriate software language(s), to produce appropriate documentation efficiently, to employ appropriate simulation and software development paradigms, etc. Such expertise is particularly important when simulations are large and complex. Normally simulation development SMEs

are part of simulation development personnel, but sometimes outside experts may be tapped for particular items.

Simulation Use SMEs

Simulation Use SMEs (in contrast to SME use in VV&A activities) are concerned with issues related to using the simulation, such as facility arrangements and scheduling if the simulation employs shared resources. Arrangements for large, complex federations that may involve live, virtual, and constructive components are facilitated by experts who have set up and run such simulations before.

SME Use in VV&A Activities

Use of SMEs in any VV&A activity should be done within the context of any formal guidance that applies to the situation, such as the guidance in the VV&A Overlay for the High Level Architecture (HLA) Federation Development and Execution Process.¹ Normally decisions to use SMEs in VV&A activities and their identification, selection, assignments, management, and use will be under the auspices of VV&A leadership (the Accreditation Agent and the V&V Agent).

This section addresses the various VV&A SME types and the use of SMEs in VV&A. In subsequent sections, SME selection and management are discussed. Those discussions apply to all varieties of SMEs and their use in any aspect of VV&A.

It is important to understand possible relationships between VV&A SMEs and the VV&A team for a simulation. In this Special Topic, “VV&A team” is a general term for the personnel assigned to the Accreditation Agent and V&V Agent for performing VV&A reviews and evaluating the simulation. Sometimes this VV&A team is a single individual, and sometimes its composition changes a number of times during a project. Some members of the VV&A team for a particular simulation may qualify as SMEs or technical experts because of technical expertise; however, such technical capabilities would not qualify that person for peer review, since peer review implies more independence than is likely for a member of the VV&A team. The principles and processes discussed in this Special Topic apply to any SME or technical expert regardless of their relationship to the VV&A team. Administrative arrangements, such as selection processes, depend on whether the SMEs, technical experts, and those involved in peer review are from inside or outside the M&S and VV&A teams.

VV&A SME and SME Use Varieties

Four varieties of VV&A SMEs and SME use are identified below. After this discussion, SME use in verification, in validation, and in accreditation is addressed.

- 1) SMEs with special expertise in V&V techniques and methodologies

- 2) SMEs who may be involved in producing estimates of simulation results that can serve as a surrogate for data in results validation when such real-world data are not available in acceptable quality and/or quantity to be used directly
- 3) Traditional use of SMEs in qualitative simulation assessment, especially in “face validation”
- 4) SME use in extending quantitative assessments

V&V Techniques and Technologies SMEs

There are many techniques and technologies that can be employed in M&S verification and validation (V&V). Unfortunately, as discovered at a 1999 workshop on simulation validation and emphasized in other forums since, some V&V and VV&A practitioners are not well-informed about many of the V&V techniques and lack the expertise needed for their effective use.² Thus, SMEs with the technical expertise to employ specific V&V techniques can improve the quality of M&S V&V when such techniques are needed. Advice from VV&A SMEs about which techniques should be employed for a particular simulation is invaluable when the SMEs are competent in V&V technologies (understanding their real capabilities and limitations) and familiar with both the simulation application domain and the technical characteristics of the model or simulation. Such advice can facilitate maximum correctness and credibility for the simulation given the resources and time that are available for simulation development, assessment, and refinement.

For more information about V&V techniques, see [Reference Documents>V&V Techniques](#).

SME Opinion as a Surrogate for Quantitative Data

SME judgments (i.e., opinions) may be used when quantitative data about the subject addressed by a simulation are limited or lacking. Typically SMEs will look at responses from the simulation or at the characteristics of a simulation (such as its algorithms) and then produce judgments about simulation capabilities or performance. This *post-factum* (*ex post facto*) approach is typical of “face validation” and other expert reviews. However, a key aspect of using SME opinion properly as a surrogate for quantitative data is the collection of SME expectations *before* the SME is exposed to simulation results.

When SMEs are used in this way, they must get adequate information to produce informed estimations of subject behavior and performance. It is helpful to have a number of SMEs involved so that there will be enough “data” from their expectations to have confidence that one has obtained enough information for reasonable conclusions. Adroit use of estimations from multiple SMEs creates opportunities to develop statistics about the estimations and to identify trends in the collective estimations that can enhance their credibility.

There is an inherent tradeoff between preserving SME evaluation independence (so that the opinion of one SME will not dominate or contaminate other opinions) and enabling SME synergy (so the whole is greater than the sum of the parts).

SME estimations should be directly relatable to simulation outputs so that questions of interpretation and translation from one parameter to another are avoided. Finally, standard statistical processes can be used to determine coherence of SME estimations in various situations as well as in comparisons of SME expectations with simulation results.

This kind of SME use in VV&A is distinguished from SME qualitative assessment (discussed below) by the formality of the methods used in its application.

Qualitative Assessment SMEs

When adequate real-world data does not exist to permit quantitative assessment, qualitative assessment, such as in qualitative validation, must be used. The qualitative assessment is based mainly upon SME estimations and peer review. Qualitative assessment is “subjective,” but it has to be remembered that quantitative assessment may also contain subjective elements: the choice of some parameters for assessment and not others, or the level of agreement between simulation results and real-world data that is deemed acceptable. Some M&S communities, especially those concerned primarily with M&S scientific applications such as computational fluid dynamics, do not use the term validation when real-world data are not available. However, in the spirit of the famous quote from George Box, former president of the American Statistical Association, “all models are wrong, but some are useful,” validation is a useful concept even when real-world data are not available.³ The most common form of qualitative validation assessment is called “face validation,” which means that the model or simulation performs as expected in the opinion of selected SMEs – the term “face validation” goes back at least to the mid-1960s, and many think it is the most common form of validation in some M&S communities.⁴

In the past, qualitative assessment was often done without rigor, either in regard to SME selection, SME evaluation criteria and processes, or other approaches used in the assessment processes, even though processes for proper use of expert judgments have existed for decades.⁵ Consequently, the quality of assessments varied widely; and, in general, there was little capacity for repeatability in qualitative validation assessment. This situation is very undesirable, and one would hope that it could be changed. Unfortunately, some mistakenly assume that such undesirable characteristics are intrinsic to qualitative assessment. Qualitative assessment should employ more rigor and standardization in SME selection, in evaluation criteria, and in assessment processes. A construct for elaboration of qualitative validation is presented below. Meaningful qualitative assessment is assessment whose significance is clearly understood and which has potential for consistency and possibly even for repeatability.

For meaningful qualitative validation: a *specified set of explicitly qualified SMEs* reviewing a model or simulation conclude that *specified characteristics* show expected responses for *specified portions of the mission space* (i.e., the application domain) for the M&S with *expected responses* identified.

Each of the italicized terms in the preceding sentence is discussed below.

- **Explicitly qualified SMEs** are SMEs who are qualified (and their qualifications are documented) by (1) expertise, and/or (2) vested interest. The **specified set of SMEs** used in a qualitative assessment should not only document why particular SMEs were selected for reasons of expertise and vested interests, but also indicate how SME evaluations are going to be used: will a single SME evaluation be adequate for a conclusion, will a majority of SME evaluations be adequate for a conclusion, or will all SME evaluations have to agree for a conclusion to be reached?
- **Specified characteristics** of the simulation (parameters and combinations of parameters) that are the primary basis for the qualitative assessment should be explicitly identified before the start of the assessment. Other characteristics of the simulation may also be used in the assessment, but not in a way that contradicts conclusions based on the specified characteristics.
- **Expected responses** of the simulation by the SMEs selected for the qualitative assessment should be specified before the start of the simulation assessment. Doing this is critical to making qualitative assessment consistent and possibly even repeatable. Many qualitative assessments have not required SMEs to explicitly state their expectations prior to examination of simulation results; this is one reason that past qualitative assessments have not been consistent or repeatable.
- A meaningful qualitative assessment is focused on a **specified portion of the mission space** that the simulation addresses. It is widely recognized that SME review is most reliable for normal and nominal conditions, and that SME review is not very reliable for assessments of unusual or rare conditions.² Specification before the assessment of the portion of the mission space that will be the primary basis of the qualitative assessment is important, and it helps the assessment to have logical and factual soundness.

SME Extension of Quantitative Assessment

Quantitative assessment can be used when assessment can be based upon specific, measurable aspects of M&S results, such as comparison of specific simulation parameters with real-world data to determine the accuracy of representation of those parameters in the simulation. Obviously more confidence is likely to be placed in the correctness of simulation results when quantitative assessment is possible than when one has only qualitative assessment. However, for many simulations, a combination of qualitative and quantitative assessment processes will be needed to address the full scope of simulation capabilities.

Quantitative assessments, just as in the case of qualitative assessments, have often been conducted in *ad hoc* and unsystematic ways so that one is not always certain what is meant by the assessment for a particular simulation even when quantitative approaches are used. Often assessment for a particular simulation has been asserted on the basis of visual comparison of simulation parameter

values on a chart that also shows real data. While such a comparison may make for impressive presentation, it does little to significantly quantify the relationship of simulation results to real-world data.

The question of how to meaningfully perform quantitative assessments is complex. It is necessary to determine the uncertainties associated with the real-world data used as the basis of comparison, and then to specify exactly what kind of statistical comparisons are to be performed. This brings significant challenges. Often uncertainties in the real-world data used are not appropriately characterized.

For meaningful quantitative assessment of *specified data* about the real world (the system, process, or phenomena represented by the simulation), *specified parameters* available both from data and M&S results must satisfy *specified statistical relationships*.

Each of the italicized terms in the preceding sentence is discussed below.

- **Specified data** – Data may come from experiment, test, observation, or specified subsets of these. All data have associated uncertainties; unfortunately, such uncertainties may not be well characterized (identified, estimated, and documented). Such uncertainties include not only resolution and accuracy limits of measurements and observations, but also less than complete and accurate descriptions of the conditions under which the data were collected. The later uncertainties can make it difficult to assure that simulation inputs correspond exactly to the conditions for which the data pertain. The specified data identify which of the potentially pertinent data will be used for comparison in quantitative assessment. Sometimes one may specify that all possible data are to be used. Other times one may specify only the data from a particular test (such as data from a particular missile test flight) or set of tests (such as only those tests conducted by a particular organization with a good reputation for conducting tests well). Explicitly identifying the data sources that will be used in the assessment is the first step in meaningful quantitative assessment.
- **Specified parameters** – Modern complex simulations contain many parameters. Some simulations have many thousands of equations, and some even have millions of equations.⁶ This kind of complexity makes it impossible to compare every simulation parameter with real-world data. There just isn't enough time to do so, even if one had no other resource constraint. Thus, one must select specific parameters for comparison. There are two fundamental principles to guide that selection in quantitative validation assessments. First, data about a parameter selected must be available both from the simulation and from the real world. Second, the parameter should be a significant one from the perspective of the intended use for the simulation.
- **Specified statistical relationships** – When specific parameters from simulation results are compared with real-world data, specified statistical relationships have to be demonstrated for quantitative assessment. Preferably, the evaluation criteria for the assessment (the particular

statistical relationships that have to be satisfied) are specified before the assessment begins, not as a result of the assessment. It is much better to be able to say, “this is how good things must be in the assessment,” than to say, “this is the best that we can do.” Full-up operational tests of complex systems are chronically under-sampled. Of the thousands (or millions) of possible scenario combinations, only a few (and sometimes only one) are actually measured.

SME Use in Verification

Persons with special understanding of software verification are essential for complex software systems. Such special understanding may include knowledge of computer-aided software engineering tools used in developing the software of the simulation or knowledge of tools that could perform some of the verification functions automatically. Sometimes these SMEs are part of the simulation development team, and sometimes they are part of an independent V&V effort. They participate in various design reviews and code walkthroughs. They may perform requirements tracing to track requirements through the conceptual model and simulation design to the implementation. They may perform, observe, or review simulation tests (at all levels). In most situations, they will work closely with the software quality assurance personnel of the simulation development team.

For legacy simulations that are not being modified, SMEs used in simulation verification may help to design the minimum set of tests necessary to confirm critical simulation capabilities relative to the intended use given the information available in simulation documentation and other records.

For new simulation developments and for modifications to legacy simulations, SMEs may play a special role in requirements verification. Requirements are established by the User. Although the User can state what the simulation needs to be able to do, often the User is not expert in requirements engineering and may not produce a comprehensive, consistent, and cogent set of requirements that provide all the information needed to ensure that the simulation will satisfy its objectives. Requirements verification SMEs help to ensure that the requirements are adequately defined, appropriately formatted, and fully representative of the User interests and desires.

For more information, see [Advanced Topics>Special Topics>Requirements](#).

SME Use in Validation

In addition to the conceptual validation and results validation SMEs identified below, validation SMEs can play an important part in VV&A planning for a simulation to ensure that

- V&V endeavors are tailored either to provide the highest level of confidence in the simulation allowed by available VV&A resources, or to determine minimum V&V resources necessary to provide the scope and quality of assessment information necessary to provide acceptable confidence in simulation results

- Adequate V&V endeavors are planned to support desired accreditation for the simulation

Validation of data, scenarios, and human behavior representations involved in a simulation is an important part of successful simulation employment. Sometimes the special insight of an SME from outside the simulation development team is required to prevent use of data from incompatible sources, inappropriate combinations of simulation assets, etc. Additional information on SME involvement throughout the validation process can be found at [Advanced Topics>Special Topics>Validation](#), [Advanced Topics>Special Topics>Data V&V of New Simulations](#), and [Advanced Topics>Special Topics>Validation of Human Behavior Models](#).

SME Use in Conceptual Validation

Conceptual validation is assessment or evaluation of the simulation's conceptual model (or part of it). Conceptual validation consists of conceptual validation reviews performed on all or part of the conceptual model (one or more simulation elements, the simulation context, the simulation concept, or a combination of these). The full conceptual validation for a simulation consists of the accumulation of these reviews coupled with a conceptual validation review of the simulation concept. A conceptual validation review performed on a simulation element determines the fitness of the representation of that item in the simulation. A conceptual validation review of the simulation concept assesses the overall capability of the simulation. Conceptual validation reviews of simulation elements and the simulation concept are the only basis for judgment about simulation capabilities for any condition other than those specifically tested. This makes conceptual validation extremely important in simulation assessment, since only a small part of simulation capabilities can be tested for any large simulation. A conceptual validation review may even be performed on the simulation context to ensure that the constraints and boundary conditions imposed upon the simulation concept are appropriate.

SMEs are often involved in conceptual validation reviews. They may bring insights from their knowledge of similar simulation endeavors. They may have domain knowledge that permits them to assess algorithms and equations in the conceptual model, to determine if they are standard or if they are not the best ones to use. They may find structures, algorithms, assumptions, etc. in the conceptual model that are similar to ones that have caused difficulties in other models or simulations.

For more information see [Advanced Topics>Special Topics>Conceptual Model Development and Validation](#).

SME Use in Results Validation

Results validation consists of comparisons of simulation results with accepted standards (i.e., the validation referent) – whether from test data, other simulation results, real-world observations, or SME judgments – during simulation testing (and use). SMEs are important in identifying appropriate information to use as the validation referent or standard for comparison with simulation results and for

evaluating the simulation results. The knowledge of such SMEs provides insight about where the validation referent or “standards” may not be as reliable as one would like and helps identify areas where simulation results must be as expected if confidence is to be placed in simulation results. Roache⁷ provides valuable discussion of concerns about experimental (test) data, its limitations and uncertainties, its generation, and its relationship to simulation V&V. Sometimes inadequate attention is given to potential problems with the quality (correctness and comprehensiveness) of information to which simulation results are compared.

Large, complex distributed simulations (federations) involving live, virtual, and constructive elements pose special results validation problems since they may have a number of simultaneous objectives (training, concept development, performance assessment, etc.). SMEs can be very helpful in sorting through such issues.

SME Use in Accreditation

The User typically is given an accreditation report by the Accreditation Agent. The Accreditation Agent may have employed a variety of SMEs conducting the accreditation assessment or preparing this report. Such accreditation SMEs may have special knowledge about the objectives of the application and can help shape the accreditation report so that it will be most useful to the User. In some cases, the User will have SMEs review the accreditation report to ensure that it has addressed all areas of User concern.

SME Selection

The responsibility for identifying and selecting SMEs varies with how the V&V and accreditation efforts are managed. Typically, the SMEs participating in V&V activities are identified and selected by the V&V Agent; likewise, SMEs participating in the accreditation assessment are identified and selected by the Accreditation Agent. Such SME selections may be subject to explicit approval by the User, M&S Program Manager, or Developer. Those with expertise in the problem domain may need User approval; those with expertise in simulation design or implementation may need Developer approval. In other circumstances (e.g., when budget constraints and scheduling considerations limit SME participation), the actual selection of SMEs may be performed by the User, M&S Program Manager, or Developer.

Selection Considerations

Two primary considerations must be addressed in selecting SMEs for simulation VV&A activities. The first question is, “Why?” What is the SME’s function? An indication of potential SME VV&A roles in simulation development was presented earlier. These roles imply some of the kinds of functions that SMEs might perform. SMEs can be used to provide timely, relevant, and credible information about the subject area of interest, especially about the following:

- The extent to which a theory has been or can be tested
- Whether a theory or technique is generally accepted as valid and relevant
- Uses of a theory or technique in other communities
- Uncertainties related to a theory or technique

The “Why?” question should be addressed explicitly before proceeding to the second question, “Who?” Can the SMEs be found within the simulation development team? Must at least some of the SMEs be drawn from outside the team? In most simulation developments, members of the simulation development team can satisfy many SME functions. However, in most simulation developments, at least some SME functions can be satisfied only by experts outside the simulation development team. Wisdom is needed for decisions about which functions can be addressed adequately by simulation development personnel and which functions should be addressed by SMEs outside the simulation development team. At times, lack of resources or administrative (contracting) structures may limit or even preclude use of SMEs outside the simulation development team.

Desirable SME Attributes

SMEs involved in simulation VV&A activities require several attributes to be effective. This discussion uses the plural “SMEs” for situations that involve one or more experts. In many situations, a single SME is adequate to accomplish the required function.

Independence

SMEs must have adequate independence for honest and probing assessments. Great importance has long been attached to independent verification and validation, in both software development and simulation.^{8,9} The importance of independent V&V was also indicated when NASA established its independent verification and validation program in 1993, after the Space Shuttle Challenger accident, within its Office of Safety and Mission Assurance. NASA uses a separate facility for assessing software systems (which can include simulations) to be used in critical functions. However, to be effective, SMEs involved in simulation assessment must be at least quasi-members of the simulation team. Otherwise they are unlikely to have the information access they need. Some of the information needed may exist only in people’s minds and memories, and may not be documented anywhere.

The extent of independence required for a review team will vary with circumstances, but this factor should be addressed explicitly in planning simulation VV&A activities. Both real independence and the appearance of independence of team members are important. Real independence can impact simulation correctness; the appearance of independence impacts simulation credibility. It may be difficult to arrange convenient funding of “independent” members of the validation review team, (i.e., people who do not belong to the M&S Program Manager, Developer, or User organizations) unless those responsible for the

simulation development have created convenient mechanisms for such funding. Such mechanisms include contracts, agreements with other organizations, and similar arrangements.

Sometimes independent V&V is criticized for the way it is performed. Usually this happens when the SMEs involved in the independent V&V have not been properly oriented to the intended use of the simulation or the aspects of it that they are expected to assess. Sometimes it happens because the SMEs have not fully or correctly understood the simulation.

Recognized Competence

Competence is required for simulation correctness. Recognition of that competence can enhance simulation credibility. Competence requires the total collection of SMEs on a V&V review team to possess the knowledge and expertise required to perform the specified function for which SMEs are needed. The review team typically needs a variety of expertise. Members of the simulation development team may possess some of this expertise, and some may be found only outside the team. Experience with simulations similar to the one being reviewed and with simulations of subjects similar to that represented by the simulation is also important for the review team. That background enables the review team to know where to expect problems. The team should be able to select a collection of V&V techniques and tools that will be capable of detecting both the most common kinds of simulation faults and the faults that have the greatest potential impact for damage to validity of the simulation's results.

Normally competence is related to knowledge or skill in a technical area, such as statistics, V&V technology, or one of the subjects addressed in the simulation. However, for a SME who is representing a party's vested interest, that SME's "competence" is the acceptance by that party of the SME as a representative in the V&V activities.

Trust of the Participants

The M&S Program Manager, User, Developer, V&V Agent, and Accreditation Agent need to trust and feel comfortable with the SMEs. It helps if at least some of them know the individuals who will serve as SMEs, not just their organizations. Without confidence that SMEs have no hidden agenda detrimental to the simulation development, the Developer is unlikely to "bare his soul" about the simulation's potential issues. Without knowing all of the potential problems of the simulation that the Developer knows, SMEs cannot do a thorough assessment.

Good Judgment

SMEs must exhibit good judgment so that they can determine when the topic (requirements, simulation context, conceptual model, simulation results, etc.) has been sufficiently examined because exhaustive examination of a topic normally is not possible (too much time and resources are needed in most cases).

Perspective

SMEs must have the right objective. The purpose of a review team is to determine capabilities and limitations so that the simulation can be used appropriately and so that appropriate confidence can be placed in simulation results. That constructive objective must always dominate a review team's efforts. The table below summarizes desirable characteristics of a review team.

Desirable Review Team Member Characteristics
Understanding of the subject (or parts of it) represented by the simulation under review
Familiarity with the simulation (usually obtained from the simulation development team)
Appropriate simulation technical expertise (in the software, hardware, etc., expected to be used in the simulation)
Background in similar simulations
Vested interests in the simulation are represented in the team (this community usually includes the M&S Program Manager, the User, and those related to potentially competitive simulations). If a review team includes representatives from all of these groups – or at least reflects their interest – the review is likely to be more thorough and thereby have more credibility for the simulation's applications.

SME Nomination Forms

Many have found SME nomination forms useful in SME selection and management. Many organizations that use technical experts have developed forms related to their particular needs. Samples of such forms may be found on the internet under Peer Review Nomination, Expert Questionnaire, and similar titles. In general, these forms usually have several sections for the kinds of information indicated below:

- SME contact information: name, organization, position, address, phone/FAX, email, etc.
- SME qualifications: education, experience, positions, etc.
- SME simulation knowledge (knowledge of the simulation in question and of simulation in general)
- SME availability
- Other information

The nomination form may also have sections for recording contact with the SME, decisions about the SME's suitability, use of the SME, etc. A spreadsheet or database program can be very useful for maintaining such information about SMEs. Documentation about SME qualifications (whether positional, such as a representation of a vested interest like the program office developing a system represented by the simulation, or technical, such as qualifications that might be indicated for a world-class radar SME) can help to minimize criticism of SME reviews. Such documentation can also help a simulation sponsor and User

develop a stable of SME candidates for use with a simulation at different points in the simulation's life cycle.

Locating Suitable SMEs

Suggestions presented in this portion of the Special Topic must be implemented in a manner that is consistent with all legal requirements and policies of the organization under whose authority VV&A activities are conducted. Locating appropriate SMEs depends in part upon the SME function.

If an SME is to represent a vested interest, such as a program office responsible for a system represented in a simulation, then contacting the program manager for that system is the best place to start. This approach will normally identify an SME whom the Program Manager believes has appropriate technical competence and a sufficient understanding of the system and its program to play an important role in assessing the system's representation by the simulation. However, two important issues often arise with such SMEs: their availability to participate in reviews at the desired time, and payment for their participation in the reviews.

Likewise, locating suitable SMEs with expertise in a particular subject is usually done by

- Contacting those with whom the User, M&S Program Manager, developer, V&V Agent, or Accreditation Agent are familiar
- Seeking recommendations from knowledgeable sources (such as DoD and Service modeling and simulation offices, the National Academy of Sciences, professional associations, experts in the field, etc.)
- Advertising the need for specific skills in trade journals or professional periodicals, at academic institutions, and via the internet

Regardless of how one identifies a prospective SME, use of the kind of nomination form for SME candidates described above is likely to prove very helpful.

SME Management

Efficient management of SMEs requires an assignment and report tracking system. The sophistication needed for such a tracking system depends upon the number of SMEs that are involved, the size and importance of the simulation being assessed, and the importance of its application. The importance of comprehensive, formal tracking of SME assignments and reviews increases with the importance of the application. Simulation requirements and acceptability criteria specify which simulation representations and capabilities require validation assessments. Therefore, the tracking system should make it easy to determine what capabilities have been reviewed and to promptly identify the reports related to the reviews and the conclusions of assessments. The tracking system should also allow monitoring of SME assignments; it should quickly show whether SMEs are not being used or if some are being used extensively. Any modern database or

spreadsheet package can be used for such a tracking system. However, whenever possible, the tracking system should be incorporated into the larger management process employed for the simulation. SME VV&A activities should be addressed in the same way that other elements of the simulation development and use are addressed (for scheduling, status, document control, etc.).

Effective use of SMEs requires appropriate orientation; careful attention to evaluation criteria, review processes, and reporting procedures; and diligence to keep SME use focused on the activities for which the SMEs are being used.

Orientation

SME orientation is essential for effective use of SMEs in simulation VV&A. SME orientation has four fundamental parts, each of which is discussed below.

Orientation Part 1: General Information

This part of the orientation identifies the simulation's purpose and provides information about its history or pedigree, who is developing it, who is expected to use it and how, how it is being developed (software and hardware considerations, development paradigm, and the like), the development timeline, etc. This kind of information helps the SME gain general understanding of the simulation.

Orientation Part 2: Perspective Pertinent to the Particular Review

In this part of the orientation, the SME is exposed to pertinent simulation requirements and acceptability criteria in order to gain an understanding of the purpose and scope of the review in which the SME will participate. Information is also provided about pertinent standards or processes that are to be followed in assessing the simulation in its structure, interfaces, representation, etc. Information is also provided about the referent that is to be used as the standard for comparison of both the representational fidelity and the functional capabilities of the simulation. A common mistake SMEs make is to apply an inappropriate standard when reviewing a simulation. For example, a human-in-the-loop simulation-based wargame normally does not need the same representational fidelity that may be required of a high-fidelity system simulation supporting hardware-in-the-loop capabilities.

Orientation Part 3: Review Process

This part of the orientation describes, in terms of both form and content, what kinds of information will be available to the SME (as shown in the table below), how the review is to be performed (i.e., processes to be used), and whether the SMEs will be able to interact with others (e.g., Developer, User) or rely only upon review documents. Reports related to the review are discussed later.

Kinds of Information That May Be Available to the SME Reviewer
Full set of simulation requirements
Acceptability criteria
A complete description of the simulation conceptual model (or of pertinent parts)
Simulation design documentation
Simulation code
Operational version of the simulation
Test results for the simulation and VV&A reports/reviews about it
Information sources for simulation algorithms and data
Results from related simulations
Results from past applications of the simulation
Discussion with development personnel and simulation users

Orientation Part 4: Special Topics

The fourth part of the SME orientation will address any special topics required to facilitate the SME reviews. For example, if the simulation conceptual model is described in a simulation design format (such as using Unified Modeling Language notation and constructs, or using one of the formal methods paradigms like Z++), it may be necessary to teach SMEs about the descriptive format to increase the likelihood that they will correctly understand the materials that they review. Erroneous SME conclusions because of misunderstanding the simulation are not helpful to anyone involved in the assessment, and every effort should be extended to ensure that they do not occur.

Orientation Methodology

Whether SME orientation is done with SMEs as a group, with individual SMEs, by merely providing each SME with an orientation document, or by some more elaborate method will depend upon many factors and will have to be decided for each simulation and its associated evaluations. Availability of SMEs and availability of personnel to provide orientation are prime considerations.

SME Review Guidelines

SME review guidelines should emphasize the importance of thorough documentation of the reviews. Such reporting of SME reviews should be structured to facilitate incorporation of information from the SME reviews into standard VV&A documentation, such as specified in MIL-STD-3022.¹⁰ ([Reference Documents>MIL-STD-3022](#))

The goal of each SME review, regardless of the VV&A aspect to which it pertains, is to provide enough evidence for a sound conclusion about the appropriateness of the simulation (or the part reviewed) for the specified intended use. This requires the review guidelines to emphasize logical and factual sufficiency (i.e., the review will produce adequate information to support a sound conclusion). This means that

the critical issues must be identified and the data and information required to settle them must be specified (as well as the uncertainties associated with both the data or information and the review process). It is helpful if the review guidelines can separate data and information from their interpretation so that disputes about “facts” (if they should arise) can be separated from the “significance” attached to interpretation of the facts.

It is a good general practice to have all SMEs involved with the VV&A of a simulation use the same guidelines in their reviews. This facilitates comparison of reviews by different SMEs, and also makes it easier to assimilate the reviews of different parts of the simulation into a coherent whole.

Review guidelines should emphasize the importance of thorough documentation of all reviews.

SME Review Reporting

Report of a SME review should contain the following basic information:

Information Expect in Report of SME Review
What was reviewed – by name, version, date, etc. of the simulation or simulation element – and the purpose of the review (conceptual validation, results validation, requirements tracing to preliminary design, unit or integration test, etc.)
Who participated – name, contact information, etc.
What information was used – documents, interaction with simulation development team members by name and date, etc.
Scope and criteria – for representational assessment and other evaluation criteria employed in the review
Assumptions, algorithms, functional capabilities, tests, etc. – explicitly related to the purpose of the review, addressed in appropriate detail to allow full understanding of bases for conclusions drawn by the review team

Information Expect in Report of SME Review (continued)
Uncertainties – associated with the information obtained and the process employed
Conclusion and synopsis of the review findings – clearly separating fact from interpretation and explaining the significance of the findings
Recommendations – to improve simulation correctness or credibility, or to improve the review process

Where possible, it is helpful to include an indication of the Developer’s attitude toward conclusions and recommendations presented in the review, with clear statements of the Developer’s rationale when there is disagreement with conclusions or recommendations of the review. Of special importance is an indication of whether such disagreements are related to the “facts” about the simulation or to interpretation regarding the significance of the facts. This usually involves letting the Developer have an opportunity to comment on a preliminary or draft version of the report. It is far better to resolve any misunderstandings or other

similar problems at this stage, before the report is finalized and submitted. Such a procedure also facilitates greater trust between review SMEs and the Developer so that free flow of information to the SMEs is more likely.

Resource Estimation and Scheduling for SMEs in VV&A Activities

Resource estimation and scheduling are challenging for any project. This is especially true for M&S development and use. In this subsection, two topics are addressed: resource estimation for SMEs in VV&A activities and scheduling for SMEs in VV&A activities.

Resource Estimation for SMEs in VV&A Activities

A few principles are presented for resource estimation relative to SME use in VV&A activities.

Principle 1: Determine desired SME resources to support planned VV&A activities. This principle has several aspects. First, identify expertise needed to assess the simulation in ways that produce the quality of information required to produce an acceptable level of simulation use risk for the intended use. This requires determining what part of that expertise exists in the VV&A team and whether VV&A plans permit use of team members in these ways, given other responsibilities expected for the VV&A team. Any differences between expertise needed and that which could be provided by the VV&A team determines the first portion of the desired SME resources. Second, identify issues that create special concern for stakeholders. Determine if expertise not provided by the previous consideration is required. If so, this determines the second portion of the desired SME resources. The desired SME resources to support planned VV&A activities are the sum of the two portions.

Some of the desired SME resources may be duplicative. For example, to satisfy stakeholder concerns, it may be necessary to have a SME from outside the VV&A team perform the same assessment performed by a member of the VV&A team. Or, for a capability that has particular importance in the simulation's intended use, it may be desirable for that capability to be assessed by more than one assessment method, and more than one SME may be required, each employing a different methodology.

Determination of desired SME resources involves more than a determination of the expertise desired. Special software or equipment may be required to support SME use. For example, a particular software license may be required to support SME activities at the assessment site. Costs for such resources must be included in estimation of the SME resources required.

Principle 2: Identify possible sources for desired SME resources. If financial resources for SME use in VV&A activities are limited, it is wise to determine if any SMEs are available *gratis*. SMEs from program offices whose systems are represented in the simulation may be available *gratis*. SMEs who had been involved in developing the simulation may be available without charge to VV&A, etc. When potential *gratis* SMEs have been identified, then sources for the

remaining needed SMEs can be identified and associated costs estimated. If it should appear that anticipated funds for SME use in VV&A are inadequate to provide the requisite SMEs (after potential *gratis* SMEs have been considered), it will be necessary to advise the V&V Agent and/or Accreditation Agent that the expected scope and quality of VV&A information from SMEs is unlikely to be obtained. This means either additional resources are required or the information quality must be lowered.

- **A caveat about gratis SMEs** – It may be more difficult to engage *gratis* SMEs according to required timelines. While a *gratis* SME may fully intend to fulfill the commitment made, circumstances may make it hard for the SME to do that, and the VV&A team may not learn that the SME will not fulfill expectations until it is time for the SME to appear and perform.
- **A caution about all SMEs who are not part of the on-going VV&A endeavor** – SMEs who are not a regular part of the VV&A team typically come to the M&S assessment site when they are expected to perform their assignments. Obviously their initial assignment is to become oriented appropriately. All subsequent assignments depend upon availability of information, M&S development products, or test results. If a SME is scheduled to be at the assessment site for some period of time (a day, several days, a week, whatever) and arrives, but the information, M&S development product, or test results upon which the SME's assessment depends are not available, then that SME will have to return at a later time to perform the assigned assessment. This increases the cost of using that SME since compensation will be required for both the initial visit to the assessment site and any subsequent visits. Consequently, it is necessary to include funds in the budget for SME use in VV&A to account for such repetitive visits.

This is a financial consideration and it also has schedule impacts, since SMEs' calendars do not always have flexibility to accommodate numerous changes, or at least not to accommodate them rapidly.

There is yet another wrinkle to this issue. If a SME's assessment identifies serious problems in the simulation, it may be necessary to have the SME make multiple assessments to ensure that a detected problem has been corrected without introducing other problems, but resource planning may have allowed only for one assessment by the SME.

Estimating resources for SME use in VV&A must account for all of these possibilities. How much should be placed in reserve to ensure that VV&A activities will not be unduly compromised or delayed by such problems depends largely upon the previous track record of the M&S Developer. Has that Developer usually been on time with M&S development products and test results, or does that Developer have a history of being late? Does the Developer have a track record of producing high-quality software and effective M&S products? When the track record of a Developer is not known, a quality rating of the Developer's organization, such as the standards to which they comply or Capability Maturity

Model Integration level they have achieved, can provide an indication of the likely quality and timeliness of Developer performance.

Principle 3: Account for desired SME resources in accordance with project accounting guidance and processes. Once the desired resources for SME use in VV&A activities have been determined, potential *gratis* SMEs identified, and costs estimated for the other SMEs (with appropriate reserves), then a plan for procuring needed SME services can be developed. This plan should comply with the project's accounting guidance and processes. How the requisite funds are treated is likely to vary from one project to another. In some cases, all of the costs may be considered VV&A costs. In other situations only some, or perhaps none, of the SME costs will be classified as VV&A costs. In some situations, individual contracts will be issued for SMEs. In others, a different approach may be used. The principle is to work the plan for SME use in VV&A activities in a manner that is compatible with the project's guidance and accounting processes.

Consideration of the three principles above leads to the following algorithm for estimation of resources required to support SME use in VV&A activities.

Estimated resources (\$) = NP + Travel + [(Cost/hr) × (# non-*gratis* SME hrs)] + Reserve

NP	Non-personnel costs such as software or equipment needed for SME use
Travel	Estimated travel costs for SMEs to the assessment site (may have to include travel costs for both <i>gratis</i> and non- <i>gratis</i> SMEs)
Cost/hr	Estimated charge per hour for SME time (if a number of SMEs are used, different rates may be used for different kinds of SMEs)
# of non-<i>gratis</i> SME hrs	The amount of time expected for SMEs who are paid from funds for SME use in VV&A activities
Reserve	Funds to account for extra use of SMEs as discussed above because information is not available when expected, <i>gratis</i> SMEs cannot perform as planned and have to be replaced with non- <i>gratis</i> SMEs, etc.

A substantial treatment of VV&A resource estimation may be found in Kilikauskas et al.¹¹

Scheduling for SME Use in VV&A Activities

Many practical considerations affect review scheduling, such as

- Availability of information from the Developer (e.g., conceptual validation reviews cannot be performed until the Developer has completed description of the conceptual model for the simulation), of personnel with whom the SME may need to interact, or of facilities and equipment that may be needed for the SME review and assessment
- Availability of referent information for comparison with M&S results in results validation reviews (along with information about all uncertainties involved)

- Availability of SMEs and other personnel

As a general rule, reviews should be scheduled at the earliest time that required information and personnel can support them efficiently in order to permit detection of problems at the earliest possible time, but the paradigm employed in simulation development can have a major impact on such schedules. In spiral and other iterative development paradigms, preliminary and partial M&S development products may be offered early to the VV&A team for review, but final versions may not be available until very late in simulation development. VV&A resources, especially those for SMEs, may not be adequate for iterative reviews of items. This will push the VV&A reviews to very late in M&S development, since it is essential that final versions of items be assessed.

Creativity is required for effective scheduling of SME use in VV&A activities. The simplest thing to schedule is SME orientation. It depends only upon SME schedules and that of the VV&A team. Even so, it may be difficult to find a convenient time for even a few SMEs to be available at the same time for the orientation. Consequently, multiple orientation sessions may be necessary, and sometimes it may be more convenient for a member of the VV&A team to travel to an area where several SMEs are, and orient them there, instead of having them come to the assessment site.

Depending upon how SME reviews are to be performed, scheduling may have to account for SME availability, information availability (such as simulation development products or test results), personnel availability (if the SME is to interact with development personnel and others), and facilities and/or equipment availability (if the SME is to see demonstrations of simulation capabilities, participate in simulation testing, etc.).

It is always wise to try to develop a schedule for SME use that does not negatively impact important items on the project's schedule if the SME use has to be rescheduled.

Common Problems and Concerns

Several problems are commonly encountered with SMEs. These problems can be grouped as perspective problems, performance problems, and perception problems. Each kind of problem is discussed in turn.

Perspective

Some SMEs have difficulty in assessing a simulation relative to its intended use. The SME may want to evaluate the simulation in some other context. For example, an SME may inappropriately fault the simulation for using approximations instead of more detailed and more accurate algorithms, even though the approximations provide adequate accuracy for the intended and expected uses of the simulation. Appropriate orientation for the SME can minimize this kind of problem, but it may also be necessary to take corrective action in managing SMEs should it become

apparent that this problem has arisen. Typically a reminder to the SME is all that's required. Sometimes the review report from a SME needs to be revised so that it does not reflect an inappropriate perspective.

Sometimes SMEs have a particular agenda that they will pursue during their involvement in a V&V review. The agenda may be overt, or it may be hidden. Every SME who represents a vested interest can be assumed to have an agenda of looking out for that interest during the review process. The potential problems arising from such agendas should be addressed in two ways. First, every SME assessment should strive to make the factual and logical bases of the assessment explicit and clear. This forces any "hidden" agenda to have a solid factual and logical foundation. Second, it is helpful to have a variety of perspectives (agendas) represented within the SME team so that no particular agenda can be pursued without challenge from the assessment of those with a contrary or different agenda.

Performance

Sometimes an SME will have trouble complying with the review and reporting schedule because of other demands on his or her time. This problem can be avoided, or at least minimized, with realistic estimates of how long it should take an SME to perform a review and report on it, coupled with reasonable schedules based upon SME availability, required information availability, etc.

Sometimes SMEs will not follow specified review and reporting procedures. Typically this kind of problem can be resolved by a reminder to the SME about the procedure and, where it makes sense, modification of the procedure at the SME's suggestion.

Sometimes an SME will have difficulty understanding the simulation and may make an assessment based upon misconceptions. Allowing the Developer an opportunity to respond to a preliminary version of the SME report provides an opportunity to correct such misconceptions prior to their becoming public and helps to ensure that the assessment is more complete than it might be otherwise.

Perception

M&S developers, users of legacy simulations, and others with vested interest in the simulation's acceptance often cast a jaundiced eye on SMEs from outside their sphere and may have suspicions about SME competence, objectivity, etc. They will sometimes criticize a SME for not using appropriate perspective in the assessment, for not understanding the simulation correctly, for having a hidden agenda, etc. These kinds of problems can be ameliorated by use of a SME nomination form that explicitly documents a SME's qualifications, by use of a specified review and reporting process that emphasizes the facts and logic upon which an assessment is based, and by providing the simulation Developer, User, etc. with an opportunity to respond to preliminary versions of SME reports and having a specified mechanism for such responses to become part of the final assessments (should the SME and the responder not come to a common view).

Another kind of potential perception problem arises when a SME has a special relationship to the simulation sponsor (or other significant stakeholder in the M&S application). That SME's assessment may carry additional weight because of the trust that is invested in the SME. This kind of situation should be recognized, when it exists, and every effort made to ensure that the SME's assessment is factual and logically sound. This kind of situation can also be exploited legitimately by adroit selection of who briefs validation assessments.

Resources

Estimation of resources for SME use in VV&A activities was discussed earlier. Those ideas will not be repeated here. Seldom are VV&A resources so plentiful that all useful VV&A can be performed. VV&A activities have to be tailored to produce assessment information with adequate quality and scope to support acceptable levels of M&S use risk for employment of the model or simulation within its intended use. SMEs typically help to achieve either VV&A scope or quality that might not be obtained without their participation. SMEs, especially those from outside the VV&A team or Developer personnel, have the potential to increase credibility given to the M&S assessment because of assumed competence and objectivity. This factor should be considered in tailoring VV&A resources for SME use.

Special Considerations

Four topics are addressed in this subsection: how to combine assessments from multiple SMEs, SME use with legacy simulations, SME use with new or modified simulations, and SME use with distributed simulations.

Guidance For Combining Inputs from Various SMEs

For small simulations (or for simulations with very limited VV&A resources), only a single SME may be involved in simulation review. In such cases, the guidance of this section is not needed. For larger simulations, and for those whose VV&A resources allow more than one SME to be involved, guidance is needed for how to combine inputs from various SMEs, especially when the assessments by the SMEs contradict one another.

The first principle is to give priority (i.e., more consideration) to the assessment of a SME who is expert in the particular topic of the assessment than to other SMEs. For example, if two SMEs are reviewing representation of a military radar system in a simulation and one SME is a radar engineer and the other SME is a military officer with experience in using that kind of radar, whose assessment should be given priority would depend upon the specific aspect of the radar representation being addressed.

The second principle is to give priority to the SME assessment that incorporates the more substantial factual and logical evidence. For example, if one SME showed that the derivation of an algorithm used in the simulation omitted a factor, or had errors or low-fidelity approximations within it that could cause significant

problems under some conditions, while the other SME simply showed that the algorithm produced acceptable results for simple conditions, the first SME is the one whose assessment should be given the most weight.

The third principle is to make sure that SME assessments are actually addressing the same situation if some form of arbitration among them seems to be required. In many cases, what seem to be contradictory or inconsistent assessments by SMEs are actually supplementary assessments because the SMEs have focused on slightly different situations. In such cases, the SME assessments can simply be combined into a more complete assessment of the simulation.

The fourth principle is to make sure that all SME assessment perspectives are included in VV&A reports about the simulation, and to explain why more emphasis is placed upon some SME assessments than on others. This kind of candor can be embarrassing at times, but it always enhances simulation credibility and confidence in its capabilities when it is clear that all assessments were given due consideration.

Finally, when SME assessments agree, it adds credibility to their conclusions, particularly if the SMEs come from different communities. Credibility of the simulation based upon SME assessments can be enhanced if the diverse backgrounds of SMEs are described along with their conclusions about the simulation.

Statistics about estimations from multiple SMEs – When the principles stated above have been applied to estimations from multiple SMEs, statistics can be calculated on the estimations just as statistics can be calculated about the data from tests and experiments. Information about the size of the spread in SME estimations helps to determine if a parameter is well understood so that the estimations can be given substantial credibility, or if the estimations are so widely spread that little confidence can be placed in any estimation of the parameter. Likewise, statistical analysis of SME estimations may reveal trends that increase the credibility of the estimations. Application of the principles stated above is similar to what test personnel do when they examine test results to remove bad data (from faulty instrumentation, etc.) from test results so that the results are not contaminated by bad data.

Use of VV&A SMEs with Legacy Simulations

Documentation of the conceptual model for many legacy simulations may be limited or nonexistent. Documentation of previous assessments of the simulation may be equally spotty. This requires either substantial effort to re-engineer (develop) such information or validation endeavors that treat the simulation as a black box. There are significant logical limitations on both the level and the scope of validation assessments when the black box approach is taken. VV&A SMEs can help determine how to efficiently obtain the maximum quality assessment information for the available resources.

In addition, a legacy simulation's reputation may color any validation assessment, since a negative finding might call into question decisions and actions taken on the

basis of previous results. Even a positive finding about the simulation may not impart the desired level of credibility to its results if significant parts of the community retain negative impressions about prior usage of this simulation. This makes it important for the potential User of the simulation to have a clear understanding of the legacy simulation's reputation prior to initiation of validation reviews, so that the validation reviews can be designed with these concerns in mind and can be conducted by people who have a reasonable possibility of accomplishing their function. VV&A SMEs with broad knowledge of the relevant M&S community can help provide such insights for the User.

Sometimes VV&A activities have to comply with particular guidance. Such guidance may come from Service policies, directives, instructions, etc. Sometimes the guidance is to comply with pertinent standards and guidelines from professional societies in order to enhance the credibility of simulation results. VV&A SMEs can be very helpful in providing information and insight needed to ensure that VV&A plans and activities comply with such guidance efficiently and effectively.

See [Core Documents>Legacy Simulations>V&V Agent](#) for additional information.

Use of VV&A SMEs with New or Modified Simulations

For purposes of this discussion, there is no difference between a new simulation development and a modification of an existing simulation, since each involves substantial development effort.

V&V reviews have the greatest potential impact with a new simulation or with a major modification to a legacy simulation. However, to be most effective and efficient, it is important that the reviews be performed at appropriate times and in appropriate ways. Advice in this area from VV&A SMEs can be very helpful. Sometimes the appropriate ways (such as use of V&V techniques that produce high-quality assessment information) may require expertise not available within the VV&A team. VV&A SMEs can make it possible to employ such techniques instead of being forced to use techniques that produce lower-quality assessment information because of VV&A team expertise limitations. The Validation Process Maturity Model provides a useful paradigm for determining the quality of assessment information produced in V&V.¹²

Sometimes VV&A activities have to comply with particular guidance. Such guidance may come from Service policies, directives, instructions, etc. Sometimes guidance is included in the M&S development contract. An example of such guidance would be a contractual requirement that the M&S development (including its assessments) comply with various standards. Sometimes the guidance is to comply with pertinent standards and guidelines from professional societies in order to enhance credibility of simulation results. VV&A SMEs can be very helpful in providing information and insight needed to ensure that VV&A plans and activities comply with such guidance efficiently and effectively.

See [Core Documents>New>V&V Agent](#) for additional information.

Use of VV&A SMEs with Distributed Simulations (Federations)

Distributed simulations play increasingly important roles in DoD simulations as the technology for this capability continues to develop. A variety of distributed simulation standards exist that support the development of distributed simulation environments, including the High Level Architecture, the Distributed Interactive Simulation (DIS) protocols, and the Test and Training Enabling Architecture (TENA)¹⁵. Guidance in the form of Institute of Electrical and Electronics Engineers (IEEE) standards exist for the VV&A of both HLA and DIS simulations.^{1,13}

Distributed simulations pose special VV&A challenges since the assessment not only has to address normal representational fidelity issues, but also must deal with numerous implementation issues (such as communication bandwidth and timeliness, or representativeness of systems and personnel in live simulations). VV&A SMEs who are familiar with the formal guidance or with similar federations can be very helpful. Their information and insights can help the VV&A team avoid or overcome problems that might otherwise seriously hinder VV&A activities.

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Acronyms

AIAA	American Institute of Aeronautics and Astronautics
DoD	Department of Defense
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling and Simulation Office
DSEEP	Distributed Simulation Engineering and Execution Process
HLA	High Level Architecture
IEEE	Institute of Electrical and Electronics Engineers
JMETC	Joint Mission Environment Test Capability
LVC	Live Virtual Constructive

M&S	Modeling and Simulation
MORS	Military Operations Research Society
RPG	Recommended Practices Guide
SME	Subject Matter Expert
T&E	Test and Evaluation
TENA	Test and Training Enabling Architecture
V&V	Verification and Validation
VV&A	Verification, Validation and Accreditation

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