Proceedings of the 1993 Winter Simulation Conference
G.W. Evans, M. Mollaghasemi, E.C. Russell, W.E. Biles (eds.)

NAVAL MODELING AND SIMULATION VERIFICATION, VALIDATION, AND ACCREDITATION

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ABSTRACT

Verification, validation, and accreditation (VV&A) for models and simulations used within the Defense community are becoming increasingly important. Greater emphasis is being placed upon confidence in the accuracy and correctness of model and simulation results which serve as surrogates for reality in design, analysis, testing, training, operational, and planning arenas. More attention is being paid to compatibility among models and simulations of different types and applications. Improvement in model and simulation management efficiency and effectiveness is being demanded by new Department of Defense (DoD) policies. This paper reviews VV&A processes developed as interim policy guidance for Navy managed models and simulations. The conceptual foundation and basic paradigm for these VV&A processes are examined as is VV&A for distributed simulations. Relationships of Navy interim policy guidance VV&A processes to other VV&A activities with DoD and elsewhere are discussed. Appreciation for these VV&A endeavors is essential for proper perspective about both technical and bureaucratic/administrative aspects of model and simulation VV&A.

1 BACKGROUND

Extensive concern about model and simulation management within the Department of Defense (DoD) led to the establishment of the Defense Modeling and Simulation Office (DMSO) in mid-1991. Overseen by an executive committee of senior representatives from the military services and defense agencies, DMSO published Defense Modeling and Simulation Initiative (1992) as guidance to enhance model and simulation capabilities, interoperabilities, and credibility. All kinds of models and simulations are addressed. These include distributed simulations which may involve "live forces" which are actual systems on instrumented ranges, "virtual forces" which are manned weapon simulators, and "constructive forces" which are represented completely by computer programs, perhaps with human interaction, and sometimes called computer generated forces or semi-automated forces (SAFOR). A related vision for model and simulation use with seamless interoperability across all dimensions of the "synthetic environment" of the electronic battlefield was articulated by the Defense Director of Research and Engineering (1992).

A forthcoming DoD directive on modeling and simulation will require each of the military services and defense agencies to establish a single modeling and simulation point of contact with other DoD components, a modeling and simulation master plan and investment strategy, and VV&A policies, procedures, and guidelines. In anticipation of this directive, the Army developed a model and simulation management regulation, AR 5-11 (1992), and is publishing an Army pamphlet on VV&A. The Navy developed interim policy guidance VV&A processes (1993) which will be the basis for the VV&A enclosure to a modeling and simulation management instruction that may cover Marine Corps models and simulations as well as those managed by the Navy. These Navy VV&A processes are the primary subject of this paper. The Air Force recently established an office to manage Air Force models and simulations. Work has begun on VV&A processes for Air Force models and simulations.

Throughout this paper, the VV&A definitions below will be used. These are taken from the forthcoming DoD modeling and simulation directive.

Verification: The process of determining that a model or simulation accurately represents the developer's conceptual description and specifications.

Validation: The process of determining the extent to which a model or simulation is an accurate

representation of the real-world from the perspective of the intended use of the model or simulation and the confidence that should be placed on this assessment.

Accreditation: The official certification that a model or simulation is acceptable for use for a specific purpose.

2 Navy VV&A Processes

The Navy Modeling and Simulation Office (N81/N812D within the Chief of Naval Operations), the single Navy point of modeling and simulation contact for other DoD components, promulgated interim policy guidance VV&A processes (1993) which are expected to form the basis for a VV&A enclosure to a modeling and simulation management instruction. The Space and Naval Warfare Systems Command (SPAWAR 31) Modeling and Simulation Technical Support Project developed these VV&A processes for the Navy Modeling and Simulation Office using a team led by personnel from The Johns Hopkins University Applied Physics Laboratory. This paper discusses three aspects of these VV&A processes: foundational VV&A ideas, the basic VV&A paradigm, and VV&A for distributed simulation.

2.1 Foundational Ideas for VV&A

Five foundational ideas undergird the Navy VV&A processes. First, VV&A should be an integral part of model and simulation development (or enhancement), beginning in the initial phases of development and continuing throughout the model or simulation's life cycle as part of normal model and simulation management.

Second, in order to be affordable, verification and validation should begin as early in the model or simulation life cycle as possible. Early detection and correction of software defects is much less expensive than later detection and correction of those faults (Miller etal., 1993). A review by Lewis (1992) of more than 5,000 corrected software defects indicated that the majority of these defects could have been detected at an earlier phase of software development by more vigorous verification and validation.

Third, increasing automation of VV&A holds the same promise for advances in consistent, comprehensive, and affordable VV&A as computer-aided software engineering (CASE) tools have demonstrated for software documentation and configuration management. The areas with the greatest promise of near term VV&A automation advances are improvements in software documentation and configuration management, automatic code generation from specifications, using databases for benchmarking and reference cases in results validation comparisons, and use of CASE tools to reverse engineer code for existing models and simulations as an aid in verification and validation reviews.

Fourth, VV&A processes must be formal and documented in order for subsequent VV&A endeavors to have a reliable foundation upon which to rest, obtaining synergistic benefit from prior VV&A efforts.

Fifth, limitations on data and resources (time and funds) make a variety of accreditation levels essential. The Navy interim policy guidance VV&A processes have four possible levels of accreditation. In a strict scientific sense, some simulations cannot be validated since the reality that they represent is unknown or even unknowable (Hodges and Dewer 1992). In other cases, anticipated usage of a simulation may not warrant expenditure of the resources required for the highest level of accreditation.

2.2 VV&A Paradigm

The primary paradigm of the Navy VV&A processes defines six review steps. These reviews may be applied to models and simulations developed under interactive software development paradigms (such as rapid prototyping) as well as those developed under the traditional "waterfall" software development paradigm. Each of the reviews is described briefly below. A fuller description of the paradigm may be found in the Navy interim policy guidance VV&A processes or in Pace (1993).

2.2.1 Conceptual Validation

An explicit conceptual model defining assumptions, algorithms, architecture, intended application, and anticipated input data availability should exist for every model and simulation. Conceptual validation is a review that states why (or why not) the conceptual model is expected to be acceptable for anticipated applications for the model or simulation.

2.2.2 Design Verification

Software requirements and specifications based upon a validated conceptual model should be the basis for the model or simulation design. Design verification is a review whose purpose is to ensure that the specifications of the design accurately reflect the validated conceptual model.

2.2.3 Code Verification

Code verification is simply a review to ensure that the software implementation of the model or simulation accurately reflects the specifications. Design verification is separated from code verification because code verification is more amenable to automation and because separating the two aspects of verification may allow more appropriate allocation of verification resources.

2.2.4 Results Validation

Conceptual validation addresses the conceptual framework upon which a model or simulation rests. Results validation is a review that demonstrates compatibility of the simulation results with information about the reality represented and provides the basis for an informed judgment that the correspondence between simulation results and the reality is adequate (or not) for intended applications.

2.2.5 Domain Accreditation

Domain accreditation is a review of information about the model or simulation to determine if its verification and validation reviews provide an adequate basis for assurance of acceptable performance for the problem domain specified. Some within the DoD VV&A community have grave reservations about domain accreditation for fear that it will be abused by extension of "accreditation" beyond the specified domain for a particular model or simulation.

2.2.6 Application Specific Accreditation

The review for an application specific accreditation includes not only the expected performance of the simulation but also the appropriateness of input data for the simulation and the qualification of personnel (as participants, operators, or analysts). Some in the Navy feel that application specific accreditation should not be used for simulation accreditation, but that kind of certification should be left to study approval processes.

2.3 VV&A for Distribution Simulation

VV&A processes for distributed simulation are embryonic. A series of interoperability workshops, led by the Institute of Simulation and Training of the University of Central Florida under sponsorship from DMSO and the Army, are being used to develop draft standards related to distributed interactive simulation (DIS), the follow-on to SIMNET, a distributed simulation capability developed by the Defense Advanced Research Projects Agency (DARPA) and the Army. Draft DIS standards are then submitted to IEEE for approval and subsequent publication as IEEE standards. The September 1993 draft standard for DIS exercise control is expected to include the following VV&A elements. The term "integrated" in association with standard VV&A terms indicates distributed simulation VV&A.

Distributed simulation control (DSC) is the organization that performs compliance testing of models and simulations proposed for use in a distributed simulation environment to ensure that protocols and networking requirements of that distributed simulation environment are satisfied. DSC also maintains a repository of VV&A information about models and simulations judged compliant for the distributed simulation environment. The repository also contains information about models and simulations used in distributed simulation exercises. DSC also advises distributed simulation users about model or simulation suitability for intended purposes of an exercise.

Integrated verification is a review by the user to ensure that every model and simulation for a distributed simulation exercise complies with network protocols for the distributed simulation environment.

The collection of models and simulations proposed for use in a distributed simulation exercise and the architecture that relates them one to another is the integrated conceptual model. In integrated conceptual validation, the user ascertains that the models and simulations of the integrated conceptual model are functionally compatible.

Integrated results validation is a review by the user to determine if the models, simulations, and the architecture that connects them in the integrated conceptual model are not only mutually compatible but also appropriate for the intended purpose of the distributed simulation exercise. The two integrated validation reviews are separated because different techniques and data will be used in performing the reviews.

The integrated accreditation review determines if the models, simulations, the architecture that ties them together, and any equipment, data, and personnel involved in the distributed simulation exercise are appropriate for its intended purposes. Results of this review are presented to the accreditation authority for action.

3 Relationship of Navy VV&A Processes to Other VV&A Activities

The basic paradigm and constructs of the Navy interim policy guidance VV&A processes were initially

developed during the fall of 1992. The Army regulation on model and simulation management had been issued in June of that year. It and preliminary versions of the Army VV&A pamphlet were used in development of the Navy VV&A processes. Since then, VV&A ideas have been exchanged between the personnel drafting Army and Navy VV&A materials to their mutual refinement and for articulation of common ideas. The basic verification and validation construct used in the strategic plan for the Director of Defense Research and Engineering's "synthetic environment" is essentially the same as in the Navy VV&A processes. Both the VV&A bibliography developed as part of the preparation for the Navy VV&A processes and the processes themselves have been widely used by others in their VV&A activities.

Since initial development of the Navy VV&A processes, several significant VV&A publications have been issued that employ VV&A constructs and ideas similar to those of the Navy VV&A processes, suggesting that consensus is developing in contemporary best professional judgment about VV&A processes. These publications include those of Lewis (1992), Wallace etal. (1992), Kliejnen (1993), Knepell and Arangno (1993), and Miller etal. (1993).

A number of other VV&A activities are underway in the Defense community: the Joint Aeronautical Commanders Group SMART Project, the Ballistic Missile Defense Office VV&A plans for its Integrated System Test Center and the (VV&A) Analytical Tool Box for the National Testbed, various VV&A initiatives within the Air Force, and a DMSO VV&A Infrastructure Task Force which is tasked to produce a DoD VV&A instruction.

There is a deliberate effort to ensure that coherence will exist among the various Defense community VV&A efforts, at least in terms of the technical aspects of VV&A. The DIS VV&A structure is intended to be compatible with the larger VV&A movements within the services and other parts of DoD.

4 Conclusion

VV&A is important. Navy interim policy guidance VV&A processes are in the mainstream of contemporary VV&A and are influencing other VV&A endeavors. Description of the Navy VV&A processes in this paper exposes them to another part of the modeling and simulation community facilitating consideration of them so that these processes may be refined and elaborated by debate and discussion within that community.

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