



EXCERPT FROM THE
PROCEEDINGS
OF THE
TWENTY-THIRD ANNUAL
ACQUISITION RESEARCH SYMPOSIUM AND
INNOVATION SUMMIT

THURSDAY, MAY 7, 2026 SESSIONS
VOLUME II

“ACCELERATING WARFIGHTING CAPABILITIES”

**Stop Chasing the Perfect Requirement Specification:
Formalizing Conceptual Model Documentation in
Simulation Acquisition**

Published: April 30, 2026

Approved for public release; distribution is unlimited.

Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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The research presented in this report was supported by the Acquisition Research Program, Graduate School of Defense Management at the Naval Postgraduate School.

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Stop Chasing the Perfect Requirement Specification: Formalizing Conceptual Model Documentation in Simulation Acquisition

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Abstract

Across the U.S. military, modeling and simulation capabilities are increasingly sought to support analysis, experimentation, and training for the employment of complex capabilities in multi-domain operations. Many of the associated simulation acquisition efforts result in failure, despite extensive expenditures of manpower and funds. Efforts to avoid these outcomes have included rigorous specification of requirements and attempts to implement the Software Acquisition Pathway, with limited success. This paper highlights challenges associated with military simulation acquisition and recommends a new approach grounded in an understanding of simulation design and development best practices. To ensure a simulation's requirements and operating context are adequately understood, the simulation designer must provide the requirements owner, and other stakeholders, explicit documentation of the simulation conceptual model. Once the simulation conceptual model has been validated by the requirements owners, it serves as a blueprint for acquisitions partners in the development of the simulation. In addition to providing a clear guide for the development of the simulation, this process will also ensure the delivery of conceptual model documentation which is critical for supporting simulation verification and validation, use, and maintenance. With the Department of War undergoing a massive reevaluation of the acquisitions process, now is the time to revise the acquisition process for simulation design and development.

Keywords: Simulation, Conceptual Model Documentation, Requirements Transition, Acquisition

Introduction

Across the Department of War (DoW), virtual and constructive simulations are increasingly relied upon to support analysis, experimentation, acquisition, testing, training, mission engineering, and digital engineering. These include standalone simulation capabilities as well as distributed simulation environments, ranging from live, virtual, constructive (LVC) environments to simulation-supported wargaming. Increasing complexity of computer simulations and distributed simulation environments compounds challenges for the acquisition of new simulation capabilities, as well as management of existing simulations, increasing risks of failure for simulation acquisition programs.

While all acquisition efforts can face difficulties with the transition from requirements to capabilities, the fundamental nature of simulation design and development presents unique challenges. To ensure suitable and satisfactory design of simulations, it is not enough for requirements documents to specify the scope of the simulation and the required capabilities. Information must also be provided to specify how various entities, entity interactions, and phenomena will be represented. Requirements managers must specify what abstractions or simplifications, and levels of functional/visual fidelity, are necessary or acceptable relative to an intended use. The conventional JCIDS requirements documents (e.g., capability development document) are inadequate for conveying this complex and nuanced information.



It is well established in the modeling and simulation (M&S) domain that conceptual model documentation is a critical tool for ensuring a simulation is designed appropriately (Robinson, 2012). Conceptual model documentation also serves other important roles throughout a simulation's life cycle. This documentation is a prerequisite for execution of verification, validation, and accreditation (VV&A) activities, which are mandated for DoW simulations (DoD, 2024); facilitates more structured management of simulation parametric data and maintenance over the simulation life cycle; and provides the insights needed for users (analysts, wargamers, and training designers) regarding how to leverage a simulation in accordance with its capabilities and limitations (Aros, 2025).

Despite the important role of conceptual model documentation for mitigating risks to simulation acquisition programs, and the explicit requirement of it for simulation VV&A across the DoW, it is rare for a simulation acquisition program to generate conceptual model documentation. Even in the rare instance where conceptual model documentation is specified as a deliverable, limited understanding of conceptual modeling practices by acquisition professionals and industry partners can present obstacles to the delivery and use of conceptual model documentation in the acquisition and VV&A processes.

Legacy Requirements Specification and Transition Process for Simulation

The Joint Capabilities Integration and Development System (JCIDS) (defined by Chairman of the Joint Staff Instruction [CJCSI] 5123.01J) has historically provided the processes through which capability requirements were defined by requirements managers (RMs), and approved by various authorities for transition to acquisition program managers (PMs). The CJCSI specified requirements documents which needed to be produced in support of these processes, including the Initial Capabilities Document (ICD) and Capability Development Document (CDD). The CDD was the primary requirements document which was transitioned to acquisitions professionals (PMs), though it could be supplemented by additional documents.

The introduction of the Software Acquisition Pathway (DoD, 2020) provided an alternative acquisition approach for software under JCIDS and was developed to support software development best practices, replacing the CDD with a Capability Needs Statement (CNS). Unlike the CDD, the CNS is intended to be updated regularly as the software iterates through user testing and feedback, progressing from a minimum viable product to the fielded capability and subsequent refinements.

Under these JCIDS processes, the acquisition PM coordinated with a simulation developer to build an envisioned simulation based on the requirements documents. Unfortunately, these requirements documents were often inadequate for informing the myriad decisions which must be made by simulation developers, and there was no structured way for the requirements owner to ensure that the PM and developer appropriately interpreted the requirements and the intended use once the requirements were transitioned to the acquisition PM. In addition to meeting more tangible requirements for simulation functions, user interfaces, interoperability, and performance capabilities, simulation developers must make many decisions regarding how to abstract their representation of reality for numerous domains (e.g., terrain, electromagnetic spectrum, weather, logistics, human behavior, communications; Abdelmegid et al., 2022; Brooks & Wang, 2015). Decisions must be made about how to achieve different levels of visual and functional fidelity and what assumptions are acceptable relative to the intended use as they design a simplified, altered representation of reality.

The software acquisition pathway can potentially mitigate some of the issues that may arise during the PM / developer interpretation of requirements, since it requires an early minimum viable product to be produced and made available for end user testing and iterative



refinement. However, even under this approach there is no requirement for structured communication between the developer and the RM regarding the design of the simulation. Rather, the end users are only able to provide feedback regarding interface design and functions after almost all of the simulation design decisions have been made and, quite literally, codified in the computer simulation. Even domain subject matter experts will be limited in their ability to evaluate and provide feedback regarding most developer decisions in the design of the simulation and representation of entity attributes, behaviors, and interactions.

Ensuring that the simulation design decisions align with the intended use for a simulation requires extensive structured interaction between the RM, users, PM, and the developer. Conducting such reviews requires an intermediate product which can be understood by all parties and which lies somewhere between the requirements specification and the coded simulation. This intermediate product, often referred to as the blueprint for the simulation, is known as the simulation conceptual model (SCM), communicated via the SCM documentation (SCMD). Without documentation of the conceptual model that explains how various entity behaviors, interactions, and phenomena are represented under the hood of a simulation, along with the model logic and algorithms, the RM will be unable to assess the potential for undesirable effects of different design decisions made by the developer. A simulation provided without conceptual model documentation to explain internal design and logic is referred to as a “black box,” presenting monumental challenges for management, implementation, VV&A, use, and maintenance of the simulation.

It is important to note that the JCIDS is now defunct, and has been replaced with the Joint Force Requirements Process (JFRP; DoD, 2025b). This change is intended to decrease bureaucracy and increase speed in the acquisition process, by removing unnecessary steps and emphasizing value-added activities early in the acquisition process. Many questions remain regarding the implementation of this transition, particularly for acquisitions processes at the service level and below. The JFRP presents the services with more freedom to refine their acquisitions processes. It remains to be seen how many JCIDS-style processes and artefacts will continue to be maintained by the services. In light of this, this paper continues to refer to JCIDS processes for a discussion of how they may be replaced to support simulation acquisition.

Simulation Conceptual Modeling in the Design and Development of Simulations

An SCM is the abstracted representation of the system or thing to be simulated (i.e., simuland). An SCM “describes what is to be represented, the assumptions limiting those representations, and other capabilities needed to satisfy the user’s requirements” (Borah, 2003, p.35). The development and documentation of an SCM is key to the effective and efficient development of a computer simulation model, enabling coordination, collaboration, and identification of gaps prior to the coding of the model (Abdelmegid, et al., 2022; Brooks & Wang, 2015). It is also essential for the verification and validation (V&V) of the resulting simulation model. While it is possible for an SCM to exist merely in the mind of a modeler (Aros, 2025; Robinson et al., 2015), the documentation of an SCM is the tangible form of the SCM that facilitates the communication about, and use of, the SCM. Therefore, it is also important to explicitly discuss the SCM documentation where appropriate.

Development of an SCM is an integral part of the simulation model development process. Figure 1 provides a modeling and simulation development framework (Tolk et al., 2013) positioning the development of the conceptual model just prior to the development of the simulation. Importantly, this figure depicts the loop-back arrows that indicate ongoing V&V checks throughout the M&S development process. Development and refinement of an SCM provides a mechanism for collaboration between stakeholders to determine the capabilities of



the envisioned simulation (Robinson, 2008). The documentation of the SCM facilitates this collaboration. The inherent expectation of collaboration in the development of an SCM is clear in a NATO definition of the SCM as “an implementation-independent description of the content and internal representations that represent the sponsor’s, user’s and developer’s combined concept of the system or simulation under development including logic, architecture, algorithms, available data and explicitly recognising [*sic*] assumptions and limitations” (NATO, 2012, p. J-5).

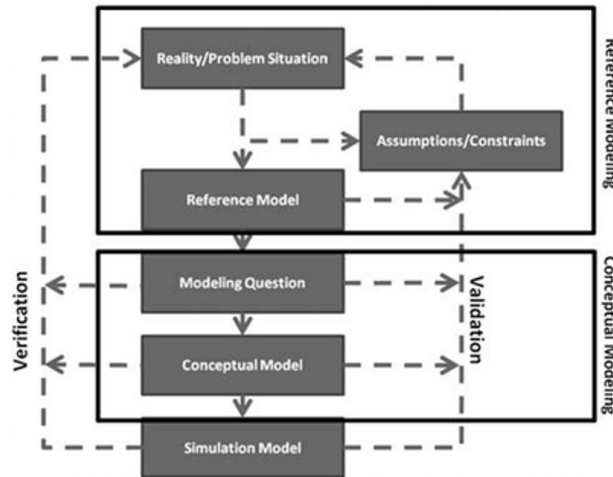


Figure 1. M&S Development Framework (Tolk et al., 2013, p. 6)

The diagram shown in Figure 2 provides additional details on the position of the SCM relative to other artifacts in the simulation development process. Figure 2 also uses dotted-line “comparison” arcs to depict how different artifacts are compared with each other during V&V efforts throughout the development process. Notably, this figure explicitly represents the different roles of requirements and the conceptual model of the simulation.

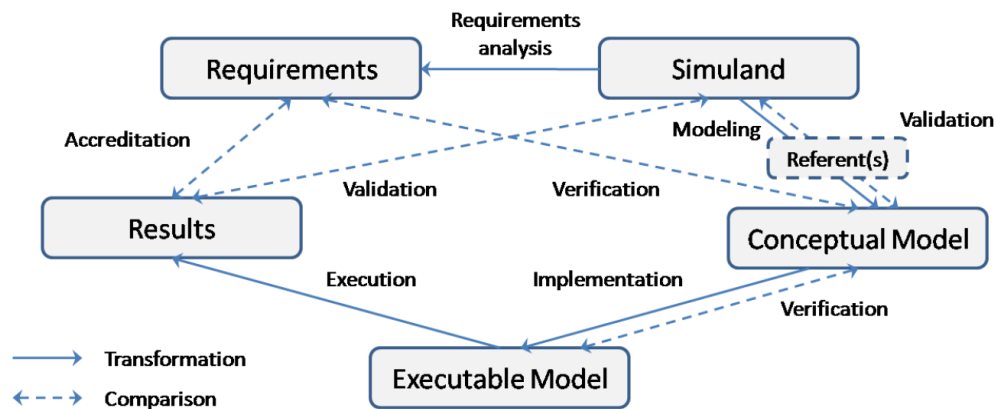


Figure 2. V&V Comparisons Using the Conceptual Model (Appleget, 2011, p. 29, from Petty, 2009)

Requirements Hand-Off during the Acquisition of Military Simulations

Under the JCIDS process, simulation conceptual model development has generally been viewed as occurring after the requirements have transitioned from the RM to the acquisition PM and developers, as seen in Figure 3.

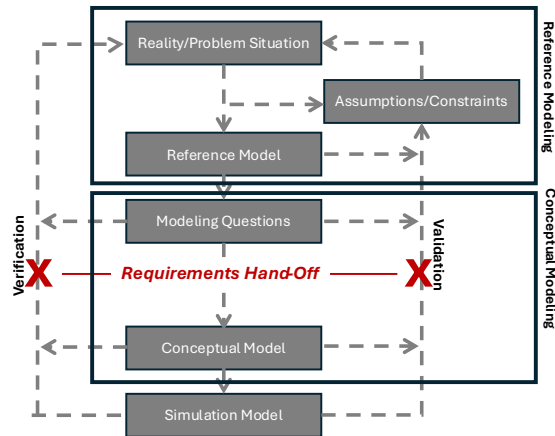


Figure 3. Adapted from M&S Development Framework (Tolk et al., 2013); Shows Effects of a Requirements Hand-Off prior to Conceptual Model Development

This hand-off of simulation requirements, and the lack of an explicit acquisition requirement for SCM documentation, often results in the conceptual model being viewed as a low-priority deliverable rather than a critical tool for informing the design and development of the simulation capability. Consequently, RMs attempt to produce written requirements documents that fully specify all simulation requirements, while also attempting to comply with the “Goldilocks principle” of requirements specification (not too much, not too little). This requirements hand-off also requires the acquisition professional to develop a conceptual model based on their interpretation of the requirements document. This is at odds with established best practices for conceptual modeling in simulation design and development, negatively impacting both acquisition and long-term management of DoW simulations. The Distributed Simulation Engineering and Execution Process (DSEEP) explicitly states that requirements generation should occur after conceptual modeling is conducted: “As the conceptual model is developed, it will lead to the definition of a set of detailed requirements for the simulation environment” (IEEE, 2022).

The steps in the conventional requirements hand-off from the RM to the PM / developers are depicted in Figure 4 using a swim-lane process flowchart to clearly delineate roles and responsibilities. Under the JCIDS process, after requirements documents were generated by the RM and transitioned to the acquisition PM, the RM had no mechanism for ensuring the requirements were correctly interpreted; rather, it was up to the PM / developers to decide whether they would request additional clarification of the requirements from the RM. This can be seen in Figure 4, where the decision diamond appears in the “PM / Developers” swim-lane.

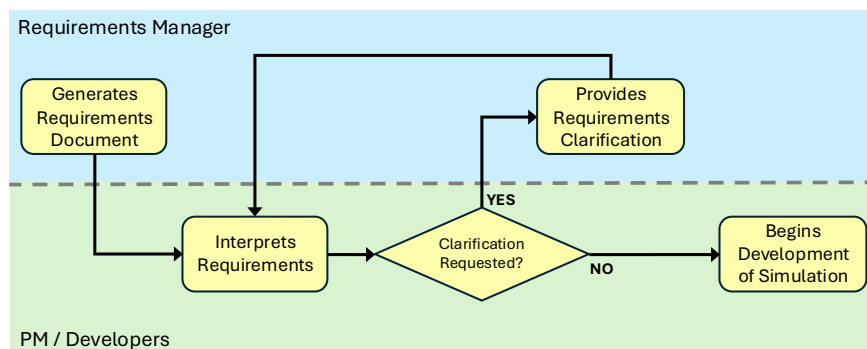


Figure 4. Existing Simulation Requirements Transition Process

For conventional military systems (e.g., vehicles, weapon systems) miscommunication in the requirements transition process can be mitigated to some extent through efforts to enhance clarity and specificity in capability requirements documents. However, for computer simulations, it is more challenging to clearly and concisely specify system capabilities and user interface considerations that include a comprehensive description of the referent, the intended use, and requisite/acceptable abstractions and simplifications. The difficulties associated with succinctly, accurately communicating this information is why conceptual model documentation is so critical for simulation design and development.

Under the JCIDS requirements generation and transition process, RMs are told to avoid providing too much detail in their requirements, which might restrict acquisition professionals' ability to explore the potential solution space. At the same time, RMs aren't provided a feedback loop that would allow them to ensure appropriate interpretation of requirements specification by their acquisition counterparts. This results in an over-specification paradox where RMs are faced with conflicting demands. If they provide too great a level of detail, they restrict acquisitions professionals' abilities to find or craft a desirable solution. If they provide too little, the requirements may be misinterpreted, yielding a capability inappropriate for the intended use. Requirements managers faced with this situation have attempted to find a way to craft simulation requirements that will succeed under these conflicting demands. Meanwhile, the tool that can significantly mitigate the risk of requirements misinterpretation for simulations, SCM development and documentation, has been underemployed across the DoW.

Current State of SCM in DoW Simulation Acquisition

Despite the well-established utility of conceptual model documentation for supporting development, maintenance, and employment of M&S capabilities, it is rare to find SCM documentation for DoW M&S capabilities (Pace, 2011). This lack of SCM documentation presents challenges across several stages in the acquisition life cycle, including maintenance and modernization, simulation database management, and informing user employment of simulations. Conceptual model documentation provides an implementation-agnostic representation of how entities and entity interactions are, or will be, represented by a simulation. They provide insight into how a simulation represents entities, interactions, and phenomena, and specify the logic and algorithms of the simulation. This documentation is a critical resource for supporting simulation design and development of both individual and distributed simulations, and is referenced as a prerequisite artefact for multiple steps in the DSEEP standard for guiding design and development of distributed simulation environments (IEEE, 2022).

The Simulation Conceptual Modeling in the Design and Development of Simulations section explained the important role of the conceptual modeling process, and development of SCM documentation, in supporting the design and development of new simulations. The maintenance of SCM documentation is also critical for supporting the maintenance of simulations, enabling engineers to better understand implications of engineering changes. Simulation users rely on SCM documentation to inform their decisions regarding which simulation(s) to use to address a research question for experimentation or analysis, or to support training. The integration of multiple simulations into distributed simulation environments is a challenge that is largely unique to military simulation communities, and conceptual model documentation is necessary for informing decisions regarding semantic and conceptual interoperability of simulations.

The absence of SCM documentation among DoW simulations serves as a significant obstacle to compliance with the DoW directives for conducting VV&A activities in support of DoW simulations (DoD, 2024; Roca, 2013). Execution of VV&A, and verification in particular, depends on the availability of current conceptual model documentation. The U.S. Navy VV&A



Implementation Handbook provides thorough guidance for the execution of simulation V&V activities. A particularly notable distinction provided by this handbook is the distinction between two types of simulation verification. Requirements verification refers to the determination of how thoroughly the simulation aligns with the list of required capabilities specified in the requirements documentation. Design verification refers to the evaluation of how well the simulation aligns with the conceptual model documentation.

While both of these verification activities are important for the VV&A process, the design verification activity is particularly important for the M&S domain and depends on the availability of conceptual model documentation. Design verification helps ensure that all aspects of the intended simulation design are reflected in a simulation sufficiently to support its intended use. This is unique to M&S capabilities, and it may be easy for an acquisition organization to overlook the design verification requirement.

There are additional benefits of SCM documentation for supporting implementation of the Modular Open Systems Approach (MOSA) to simulation acquisition and management. MOSA is a well-documented acquisition and design approach that seeks to leverage existing standards in support of system use. MOSA couples technical and business architectures to facilitate components to be added or removed throughout a life cycle to help realize more efficient operation while encouraging innovative competition in system development (DoD, 2025a). The statute Title 10, U.S.C. 4401 requires MOSA for all DoD acquisition programs to the maximum extent possible. Recent guidance from the SECWAR highlights the importance of MOSA for supporting system interoperability and enabling “cost-effective and responsive modernization and sustainment of weapon systems” (DoD, 2025a). These benefits of MOSA apply equally to its implementation for M&S capabilities, and the directives correspond to a mandate for conceptual model development and maintenance for simulations. Complying with implementation of MOSA for M&S capabilities would require first ensuring the delivery and maintenance of the conceptual model documentation to inform consideration of system reuse and interoperability.

Shifting the Focus from Requirements to Simulation Development Process

The requirements transition process of the JCIDS acquisition process was not conducive to refinement of the simulation conceptual model documentation, which is critical in the early stages of simulation design and development. With the retiring of JCIDS and transition to the JFRP, the DoW has an opportunity to incorporate simulation design and development best practices in its acquisition process.

Modernizing the Simulation Requirements Transition Process

Simulation conceptual model documentation, which has heretofore been treated as a nice-to-have artifact in the simulation acquisition process, should be used as the linchpin in the transition of requirements specifications to the acquisition PM. Far from adding a bureaucratic obstacle, this focus on development of conceptual model documentation offers a tangible path for accelerating the acquisition process.

The conventional requirements generation and transition process breaks the iterative design and communication dynamics that are critical for the simulation design and development process. The simulation requirements and conceptual model transition process that we propose, depicted in Figure 5, fixes this by restoring iterative design and communications to the process by moving the final transition of the requirements (from the RM to the PM) until after an initial conceptual model has been developed and reviewed. This empowers the RM to ensure the simulation is appropriately designed to support the intended use. This process also provides the acquisition PM with a more value-added artifact, a blueprint for the simulation, to guide their



consideration of available resources and engage with potential vendors for simulation development. Figure 5 details the proposed process flow, making explicit the iterative nature of the communications between the RM and the PM / developers in the comparison of the SCM against the requirements, and also clarifies that it is the RM who determines when the PM / developers have sufficiently understood the requirements and developed the SCM appropriately. Ultimately, the transition of the program to the acquisition PM takes place after the initial conceptual model documentation has been validated by the RM.

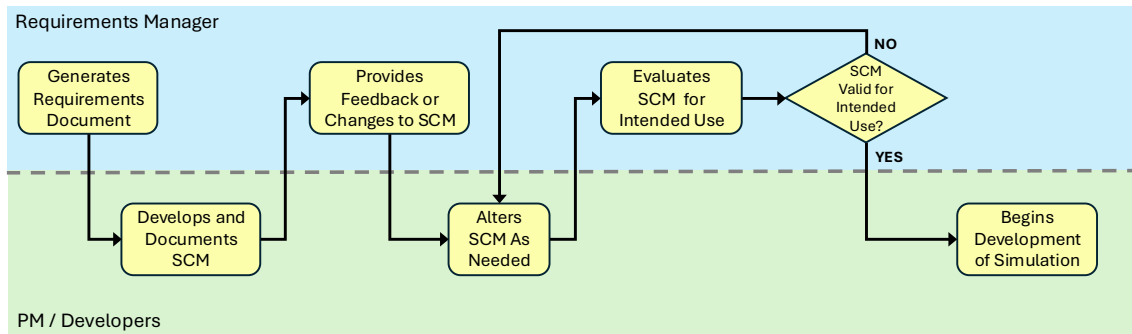


Figure 5. Proposed Simulation Requirements and Conceptual Model Transition Process

This proposed adjustment aligns with the intent behind the DoW transition from JCIDS to the JFRP, with the RM supporting the design of more tangible, value-added artifacts in the design of capability solutions. Rather than making such SCM development the sole responsibility of the PM, it would instead require increased collaboration between the RM and the acquisition PM’s team, working together to refine conceptual model documentation to meet the needs of both parties.

M&S capabilities are unlikely to rise to the level of the Joint Operational Problems (JOPs) supported by the JFRP’s Mission Engineering and Integration Activity (MEIA; JCS, 2026). That said, the JFRP provides services the autonomy to implement a similar approach, moving the requirements generation and transition process away from lengthy, bureaucratic requirements documents toward more value-added mission engineering artifacts. This presents an opportunity for increased collaboration between RMs and acquisition PMs in the iterative design and validation of conceptual model documentation for simulation capabilities. Successfully implementing this change to the requirements generation and transition process will require changes by both the RM and the acquisition PM.

The RM must go beyond writing a requirements document that lists required simulation capabilities. To facilitate the conceptual modeling process, the RM must also provide more thorough descriptions of the intended use(s) under which the simulation capability will be employed. In some cases, the RM will be describing existing environments where simulation capabilities are being replaced. More challenging situations, where explicit definition of intended use is even more important, are those where the RM will have to anticipate (or prescribe) how organizations’ processes will change. The explicit definition of different intended use constructs will provide the baseline for the development of simulation conceptual model documentation (e.g., one set of SCM documents describes how the simulation will be used to support individual training; another set will illustrate its capabilities and limitations for an LVC staff training environment, etc.). Both the RM and the acquisition PM must share a common understanding of the simulation’s intended use and participate in the refinement of the simulation conceptual model documents, to ensure these artifacts address the needs of both parties.



Proposed Process Alignment with VV&A and MOSA Requirements

In addition to facilitating a more effective requirements transition, the proposed simulation requirements and conceptual model transition process would provide guardrails for ensuring compliance with DoW VV&A regulations and achieving MOSA and reuse for M&S capabilities. The proposed process would ensure SCM documentation is available to support VV&A activities, even formalizing an early VV&A activity step that can easily be overlooked: conceptual model validation. By requiring the RM to validate that the SCM aligns with the intended use and requisite representation of the referent, the proposed process can ensure the conceptual model documentation is appropriately scoped to support simulation development and subsequent VV&A activities (Çilden et al., 2023; Tolk et al., 2013).

In supporting explicit SCM documentation and subsequent execution of VV&A activities, the formalization of conceptual model documentation delivery also supports another priority in DoW M&S management: reuse. More than just a cost saving measure, M&S capability reuse is critical due to the increasing demand for highly specialized simulations. Analysis, experimentation, and training communities rely on combinations of simulations with varying levels of detail and fidelity across different domains (e.g., electromagnetic warfare, space, and maritime operations). DoD Instruction 5000.61 identifies the need for VV&A standards to “foster reuse of DoD models, simulations, distributed simulations, and associated data.” Just as VV&A documentation is necessary for substantiating analysis findings, SCM documentation is necessary for providing different stakeholders with an understanding of (and confidence in) simulation capabilities to support M&S capability reuse.

By ensuring the delivery of SCM documentation, the proposed process also provides a path forward for enhanced compliance with DoW mandates for implementation of MOSA. That said, the narrow focus of this recommended process refinement would only address the initial conceptual model documentation generation and not the maintenance of that documentation that must be conducted throughout the simulation’s life cycle. To increase opportunities for reuse, conceptual model documentation should also be expanded as stakeholders find new intended uses. The reason for this is best illustrated through consideration of human-in-the-loop (HitL) simulations. Many HitL simulations are employed in different ways. The JCATS simulation can be used to train an individual servicemember who interacts directly with the simulation’s GUI or it can be used behind the scenes to support a large staff training exercise, stimulating command and control systems with direct interaction only occurring with response cell personnel. Developing a single set of conceptual model documentation for the simulation under these vastly different intended uses would be challenging if not impossible due to the need for the CM documentation to include the nature of user interactions (e.g., environmental cues provided to the user, affordances provided to the user for interactions with entities, feedback on user actions necessary for facilitating learning).

Overcoming Obstacles to Implementation

Despite the demonstrated value of conceptual modeling in the simulation development process, and requirements for conceptual model documentation throughout DoW simulations’ life cycles, DoW M&S practitioners face several obstacles in the implementation of these best practices. The term “conceptual model” is often misunderstood and misused, resulting in a perception among industry and government stakeholders that the practice itself is overly ambiguous, convoluted, and unnecessary. Simulation developers often perceive conceptual model documentation as a risk to their intellectual property and may be hesitant (or outright opposed) to providing it. These obstacles are largely due to a misunderstanding of simulation conceptual modeling aims and methodologies. While the DoW M&S community has long sought



to overcome these obstacles (Pace, 2011), success is unlikely without clearly addressing the perceived obstacles and securing buy-in from the DoW acquisitions professionals.

Conceptual Model Documentation as Deliverables

Under the legacy JCIDS-based acquisitions process, SCM documentation was often viewed as a “nice-to-have,” low priority deliverable with limited impact on the requirements generation and transition process. The proposed process depicted in Figure 5 would change this situation, enabling RMs, acquisition professionals, and simulation developers to leverage simulation design and development best practices for enhanced communication and collaboration. Under this process, the SCM documentation is a critical tool that augments and enhances the design and development process to improve the alignment between simulation design and requirements, rather than an optional artefact to be generated after simulation development.

Simulation Conceptual Model Documentation Methodologies and Notations

A common refrain from industry and government acquisition professionals, when asked to provide simulation conceptual model documentation, is that there is insufficient guidance regarding conceptual modeling methodologies and standards for their implementation. Despite several papers, standards, and books providing guidance regarding simulation conceptual modeling approaches and best practices, there is no universal modeling notation or conceptual modeling methodology. The DoD Architecture Framework (DoDAF) provides a framework which may support the organization of some conceptual model documentation, but it does not provide guidance or standards for specific modeling notations to use for different simulation types or domains (van den Berg & Lutz, 2015).

In the 1990s, the DoD attempted to develop a comprehensive conceptual modeling methodology that could support documentation for many types of domains. This effort was abandoned, however, as the growing number and complexity of domains supported by modern simulations makes any such effort infeasible. Instead, guidance regarding the selection and application of conceptual modeling notations and methodologies must be developed for different communities, drawing on conceptual modeling best practices for developing SCM documentation that best supports critical simulation development and management activities (e.g., design and development, VV&A, database management).

Various researchers have provided frameworks to guide the development of simulation conceptual models and explain their role in the simulation design and development process. The conceptual modeling framework presented by Robinson (2008) provides guidance regarding various actions which should be taken throughout the conceptual modeling process, such as defining simulation inputs/outputs and documenting simulation simplifications and abstractions. Robinson briefly identifies some potentially useful diagrammatic modeling notations for simulation conceptual modeling (e.g., process flow diagrams, activity cycle diagrams, event graphs, simulation activity diagrams). Turnitsa and Tolk (2011) provide a taxonomy of conceptual models to provide additional context for consideration of different conceptual modeling techniques. The Multi Viewpoint Conceptual Modeling (MVCM) methodology presents lower-level guidance for how different notations and viewpoints may be combined in a conceptual modeling methodology approach that is tailorable to support broad use across different domains (Morse & Drake, 2020).

When considering which conceptual modeling methodologies or notations to employ, it is critical for all stakeholders to remember the purpose of the documentation. In the acquisition process, the SCM documentation is intended to support communication between the stakeholders. This communication will be for different purposes, at times requiring greater or lesser detail for different types of content (Aros, 2025). Different kinds of information may be



best communicated using different conceptual modeling documentation methodologies. No one specific modeling notation will be sufficient. Instead, stakeholders must collaborate to identify the SCM documentation methodologies that best capture simulation design considerations and make them accessible to appropriate stakeholders. Identification of appropriate modeling notations and methodologies for reuse in support of different domains will also yield benefits in the comparison of simulations for reuse and interoperability considerations.

Developer Reluctance to Share Simulation Design Documentation

A primary hesitancy expressed by some simulation developers and acquisition professionals relates to the disclosure of proprietary information. This may reflect a misunderstanding of conceptual modeling; simulation conceptual models are implementation agnostic, so they don't provide insights into the details regarding how the simulation code is structured or implemented. That said, in some situations there may be a legitimate concern regarding proprietary design elements detailed in the SCM, such as unique logic or algorithms that necessitate protection from competitors. In these situations, conceptual model documentation can be protected through appropriate controlled unclassified information designation and handling procedures.

Some vendors are also reluctant to provide insight into simulations' limitations. The illumination of simulation limitations should not be considered to be a detriment. All simulations consist of abstractions, and are inherently limited in their representation of the referent in some way. It may appear counterintuitive to highlight the limitations of one's simulation's ability to represent a domain; however, providing this insight will likely make the simulation more useful to analysts and training designers who may consider leveraging it. If the limitations of a simulation are unknown to an analyst who is designing a study, they incur an unknown amount of risk if they employ the simulation. On the other hand, if an analyst has a less powerful simulation available, but they understand the nature of the simulation's abstractions, the analyst may be able to design a study to account for the simulation's abstractions, providing higher confidence in the results.

Discussion and Conclusions

The U.S. military M&S community has long recognized a need for reform, to increase compliance with industry best practices for simulation design and development. Limited employment of conceptual modeling practices presents a risk to simulation development programs. Limited availability of conceptual model documentation for existing M&S capabilities degrades the U.S. military's ability to effectively employ, manage, and reuse these capabilities. Despite multiple efforts by DoW M&S leadership and practitioners to increase the employment of conceptual modeling, the fundamental structure of the legacy requirements generation and transition process disincentivized use of conceptual model documentation. Reform is needed to ensure acquisition professionals are provided clear guidance for how to meet the intended use. Requirements managers must also be empowered to collaborate on the development of conceptual models rather than having to extensively document all requirements in an effort to provide complete clarity before the requirements hand-off. With the end of JCIDS comes an opportunity to implement industry best practices in the acquisition process for M&S capabilities. The proposed simulation requirements and conceptual model transition process presents a way to capitalize on this opportunity and to restructure the simulation acquisition process to leverage industry best practices by formalizing the role of simulation conceptual model documentation.

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