The Defense Standards Landscape for Digital Engineering, Modeling & Simulation

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ABSTRACT

In the Spring of 2024, the Simulation Interoperability Standards Organization (SISO) Simulation Innovation Workshop hosted the Director of Digital Engineering, Modeling & Simulation (DEM&S) in Office of the Under Secretary of Defense (Research & Engineering) to assess current Modeling & Simulation (M&S) standards processes and how they will translate to future M&S standards, to include data, tools, and infrastructure. Additionally, he commissioned the Institute for Defense Analyses (IDA) to examine current and legacy standards and stakeholder insights to better define the Defense M&S landscape.

Following preliminary research and literature review, IDA sought M&S stakeholder feedback on best practices, use cases, and insights in several focus areas, to include: roles, responsibilities and governance processes; involvement with Standard Development Organizations (SDO); and standardization activities to include workforce training and education programs. From a stakeholder perspective, IDA sought the depth and breadth of involvement across the acquisition lifecycle, and recommendations on improving awareness, technical gaps, and the prioritization of standardization activities.

A key objective of this study was to capture knowledge and best practices that can be shared with the DEM&S community. Through the course of this effort, including an interim study presentation at the 2025 SISO Simulation Innovation Workshop, the study team found pockets of excellence and best practices across the Service M&S Stakeholder, as well as Defense, Joint, and Allied Partner Stakeholders. In this paper, the study team will further highlight opportunities to identify and prioritize gaps, leverage collaboration and innovation initiatives, and standardization activities to streamline processes and improve efficiency developing capabilities. Ultimately, the DEM&S community will benefit when Defense M&S standards and standardization activities are accessible to a greater audience of practitioners, stakeholder leadership, and developers across industry, academia, and SDOs.

ABOUT THE AUTHORS

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INTRODUCTION

The Director of Digital Engineering, Modeling & Simulation (DEM&S) in the Office of the Under Secretary of Defense (OUSD), Research & Engineering (R&E) is responsible for advancing activities involving systems engineering, digital engineering (DE), and modeling and simulation (M&S) in support of the National Defense Strategy's desired end state of delivering rapid capabilities to the warfighter. As part of his initiative to assess current M&S standards processes and how they will translate to future M&S standards, to include data, tools, and infrastructure, he commissioned the Institute for Defense Analyses (IDA) to examine current and legacy standards and stakeholder insights to better define the Defense M&S standards landscape.

A key objective of this study was to capture knowledge and best practices that can be shared with the DEM&S community. Through the course of this effort (Figure 1), including an interim study presentation at the 2025 Simulation Interoperability Standards Organization (SISO) Simulation Innovation Workshop, the study team found pockets of excellence and best practices across the Service M&S Stakeholders, as well as Defense, Joint, and Allied Partner Stakeholders. In this paper, the study team will further highlight opportunities to identify and prioritize gaps, leverage collaboration and innovation initiatives, and standardization activities to streamline processes and improve efficiencies developing capabilities.

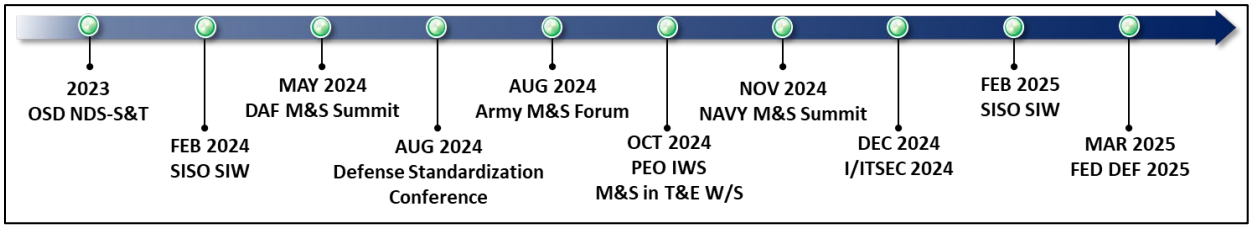

Figure 1. Stakeholder Engagements

A better understanding of the Defense M&S standards landscape, both legacy and current, will benefit leaders, practitioners, and developers including industry and academia. Equally important is the need for knowledge sharing of, and advocacy for, technical standards and standardization activities that are necessary to best support the Defense M&S Enterprise and DE community.

BACKGROUND

During the course of this study, the leadership team within the OUSD (R&E) has continued to advocate for standards at conferences and collaborative events.

Standards are built into the technology that we use and rely on every day, and they play a very important role in the development and sustainment of the defense systems upon which our warfighters depend. The importance of standards was highlighted in May 2023 with the release of the first-of-its kind United State (US) Government National Standards Strategy that:

- renews the US commitment to, and seeks to protect, the international consensus-based standards system, and
- encourages participation with the private sector in standards development, particularly for critical and emerging technologies that are susceptible to undue influence by our strategic competitors.

The National Defense Science and Technology Strategy underscores this commitment as we focus on upgrading the Department of Defense (DoD's) digital infrastructure. "As we upgrade our digital infrastructure, we will reengage in the standards bodies that set technical specifications. We will also encourage industry, academia, and allies and partners to participate in standard-setting more actively." (Hettema, 2025)

As articulated by the DEM&S Director, only when standards, processes, and policies align do we achieve the DE vision. With a focus on the practitioner, their problem space will need some number of open and closed standards. There is often an issue that there are too many potential standards, resulting in challenges of uniformity and interoperability. Ideally, it becomes a best practice to identify three to five standards from the breadth of potential standards. How then does our community of practitioners assess current standards and modify them or determine the most relevant three to five? These are common conversations that the Director has between DoD, industry, and academia, along with his engagements with international partners in an effort to align engineering efforts.

> *"The nice thing about standards is that you have so many to choose from." (Tanenbaum, 2011)*

THE LEGACY LANDSCAPE OF DEFENSE M&S STANDARDS

For this study, we start the legacy section based on the publications of the *DoD M&S Related Standards and Best Practices Guide* in 2010 and the 2011 Winter Simulation Conference paper *Towards a Methodological Approach to Identify Future M&S Standard Needs*; both highlight foundational processes, community challenges, and relevant insights.

In the historical research there has been a common theme: the success of Defense M&S relies heavily on standards. These range from interoperability standards such as High-Level Architecture (HLA) and Test and Training Enabling Architecture (TENA), to standards processes. Initially, the standardization efforts focused on interoperability and reuse, with standards targeting specific models emerging in the past 15 years. (Tolk et al., 2011)

When examining the landscape of Defense M&S standards, there should be clarity of purpose between modeling standards and simulation standards. The distinction is important. A simulation interoperability standard enables simulation systems to be federated, allowing for middleware execution. A modeling standard provides a formal syntax and semantics. Both of these are important to a lifecycle framework. Not every instance of model or simulation development requires use of standards, some may have a best or recommended practice, others may just require guidance as defined below:

- ***M&S Process Standard****:* An authoritative and formal specification of an M&S process, which is substantiated or supported by documentary evidence and accepted by most authorities in the M&S field.
- ***M&S Process Best Practice****:* The definition of an M&S process that has proven to provide the best results based on the consensus opinion in the M&S field.
- ***M&S Process Recommended Practice****:* The definition of an M&S process that is recommended by an organization or society.
- ***M&S Process Guide / Guidebook****:* Tutorial information or instruction on how to conduct an M&S process.

Therefore, when examining the landscape of Defense M&S standards, there is a need to better understand both technical standards and standardization activities, to include process standards, best and recommended practices, and guides and guidebooks.

Where do the practitioners develop their plan for model standards? One noteworthy reference for this community is the DoD *Modeling and Simulation (M&S) Related Standards and Best Practices Guide*, referred to as the M&S Standards Guide. This document continues to be relevant and provides a set of M&S standards and best practices descriptions to support decision making on options for the use of M&S standards in support of DoD M&S activities. The DoD M&S Standards Guide is organized into seven main sections and four appendices, most noteworthy, "Section

5 – Standards of Interest" that provides a summary of M&S standards selected for each of nine functional areas: Data Standards, M&S Interoperability, M&S–Scenario & Miscellaneous, Modeling, Simulation System Engineering, Software Engineering, Verification and Validation (V&V), and Visualization.

The objective of the M&S Standards Guide is to provide guidance regarding M&S standards and processes to the DoD communities enabled by M&S, as well as DoD organizations that have to effectively use M&S in support of their requirements. Furthermore, this guidance sets in motion: (1) a framework of M&S functional areas and standards/processes maturity levels that is then reviewed annually; and (2) a process to determine what type of technology should be standardized. This is a foundational document to determine the standards gaps and prioritize what each practitioner needs for the instantiation. (DoD M&S Guide, 2010)

DoD Standards Adoption Processes

Within OUSD(R&E), the Director of DEM&S has M&S responsibilities within two DoD Standards Adoption Processes: the Defense Standardization Program (DSP) and the Information Technology Standards Program (ITSP). For DSP, DEM&S is the Lead Standardization Activity (LSA) with coordination responsibilities through Service representatives. The scope of the DSP and LSA include DoD-prepared documents and selected international standardization agreements, such as Northern Atlantic Treaty Organization (NATO) standards ratified by the US and adoption notices for selected non-government standards. Furthermore, the LSA leverages the DSP ASSIST database that helps DoD maintain centralized control over the physical and electronic storage, indexing, cataloging, printing, and distribution of specifications and standards used by DoD.

Similarly for ITSP, DEM&S is a voting member of the Joint Enterprise Standards Committee (JESC) and leads the M&S Technical Working Group (MSTWG) that conducts the technical work of the JESC and addresses collective stakeholder interests. The MSTWG is responsible for analysis, evaluation, and resolution of technical issues and recommendations on standards citations for JESC consideration and placement in the DoD Information Technology Standards Registry (DISR). The MSTWG follows standards collection criteria (interoperability, technical maturity, implementation, and public availability) and lifecycle reviews (Emerging, Mandated, Retired/Inactive, and Information Guidance) in the DISR. Furthermore, the MSTWG identifies emerging technology standards needed for secure information sharing, scalability, and interoperability. Lastly, the MSTWG reviews of Information Guidance include DoD Directives, Instructions, and Policy documents; Handbooks and Manuals; as well as Procedures and Best Practices.

THE CURRENT LANDSCAPE OF DEFENSE M&S STANDARDS

Beginning with IDA's research and literature review, the study team further sought M&S Stakeholder feedback on best practices, use cases, and insights in several focus areas, to include: roles, responsibilities, and governance processes; involvement with Standard Development Organizations (SDOs); and standardization activities to include workforce training and education programs. From a stakeholder perspective, we sought (a) the depth and breadth of involvement across the acquisition lifecycle, and (b) recommendations on improving awareness, technical gaps, and the prioritization of standardization activities.

Many of you reading are asking the same question we asked ourselves…What is different? Why do we need another new look? The answer is the evolving emphasis on DE and finding ways to instantiate M&S standards in the DE practice. How do we transition the knowledge base from the M&S enterprise and the M&S standards to the DE practitioners?

The following sections will highlight relevant standardization activities across multiple organizations. While there were notable best practices and noteworthy pockets of excellence, there were also differences between the traditional M&S community and DE practitioners when addressing Defense M&S standards. Simply restated, there is a need for clarity of purpose between modeling standards and simulation standards, and when necessary, to highlight those efforts that drive model integration and simulation interoperability.

The R&E Community

In 2020, the former Defense Modeling and Simulation Coordination Office initiated an effort to identify M&S pain points through a newly revitalized DoD M&S Community of Practice (COP) Working Group (WG). The WG members ranked simulation interoperability strategy as the number one priority for action, and more specifically joint simulation interoperability as described by the 2017 DoD Simulator Interoperability Senior Steering Group that addressed interoperability issues raised by US Special Operations Command. As a result, the COP WG established a Tiger Team to investigate and develop a strategy, ultimately comprised of a menu of recommendations and published as the "Simulation Interoperability Strategy White Paper." (Simulation Interoperability Strategy Tiger Team, 2021)

Two use cases, training and analysis, were used to address key technical and business process issues that impacted live, virtual, and constructive M&S. After completing the use case analyses, the Tiger Team proposed comprehensive recommendations in five categories: (1) business models; (2) common capabilities; (3) methodologies and standards; (4) simulation documentation; and (5) interoperability planning. As described in the "Simulation Interoperability Strategy White Paper," the Tiger Team recognized that success would rely on making tradeoffs relating to cost and organizational independence, which was clearly not feasible. Instead of a succinct strategy, the white paper created a menu of recommendations to support higher-level direction to develop a strategy and implementation plan.

Of emerging significance, the Federal Digital Engineering Forum (FED DEF) is a multi-agency forum for DE practitioners and decision makers to collaborate, share best practices, and address challenges. In October 2023, the first FED DEF was hosted by OUSD (R&E) DEM&S. The forum enabled active participation in a variety of sessions through a series of succinct talks, deep dive workshops, workshop result out-briefs, and special presentations. From the 10 working groups on critical areas of interest, such as Emerging Technologies, Digital Ecosystems, and Model Integration, the Industry & Government Standards Working Group resulted in a strong interest in ongoing collaboration to drive cross-agency partnerships for effective implementation of DE principles.

The Standards WG of FED DEF discussed critical areas within DE that need standards, and participants identified strong common themes, such as DE lexicon/nomenclature definitions, overlaps of standards to determine which standards should be a subset of others, and ontology standards and DoD 5000 standards that are not generally DE-ready or consistent. The group discussed the next steps and identified the following areas of engagement: (1) partner with societies to release standards versus the government releasing standards; (2) use professional society conferences as a vetting platform; (3) establish a review body for standards discussion; (4) improve contract language and create incentives for the vendor base to provide feedback on standards; and (5) identify enablers vs inhibitors to identify standards that hinder progress or are essential to evolve.

For the 2025 FED DEF, one of five working groups included Model Integration & Standards, which conducted three virtual sessions to address their challenge questions: (1) How are you ensuring seamless model integration across different levels (system, subsystem, component) and across different stakeholders? and (2) What standards and frameworks guide your approach? The working group meetings were a combination of presentations from leadership/management (Chief Technology Officer, Chief Engineer, or enterprise subject matter experts), practitioners (use cases and best practices) and developers (SDO, industry, and academia). Additionally, there were feedback mechanisms and surveys to complement the presentations. These sessions highlighted examples of both successes and obstacles, encouraged collaboration across organizations, and initiated conversations and recommendations for the FED DEF out brief in July.

The Test and Training Communities

Many of the M&S standards for the training community are inherent in the standards organizations. DoD has had a forward-reaching Government-Industry-Academia partnership in training simulators and simulations for over 30 years. The result of this partnership is that the Defense training community continues to be active in integration and cross-functional models, simulations, and environments. One example of this is highlighted below in the TENA.

Within OUSD(R&E), the office of Developmental Test, Evaluation and Assessment (DTE&A) initiated two relevant standardization activities impacting the Defense M&S standards landscape. First, was the developmental Test & Evaluation (T&E) as a Continuum (dTEaaC)—a new approach that moves T&E from a serial set of activities conducted largely independently of Systems Engineering and Mission Engineering activities to a new agile and

integrative framework. dTEaaC will be a key enabler that is critical to the delivery of capability at the speed and scale of need. (Collins, 2024)

Second, DTE&A published the *Modeling and Simulation for Developmental Test abnd Evaluation Guide* (M&S Developmental T&E Guidebook) to provide guidance on the use; development; and verification, validation, and accreditation (VV&A) of M&S activities that support developmental test objectives. Aimed at describing recommended best practices, the guidebook includes M&S test design and analysis of M&S results to communicate uncertainty quantification to program managers. (DoD M&S Guide, 2024)

Within OUSD(R&E), the Test Resource Management Center (TRMC) manages two relevant standardization activities impacting the Defense M&S Standards landscape. First, TRMC manages the Cloud Hybrid Edge-to-Enterprise Evaluation & Test Analysis Suite (CHEETAS) framework to provide a common tool suite for building evaluation infrastructure for disparate acquisition portfolios. CHEETAS provides a common Government-off-the-Shelf (GOTS) analytics framework that (1) enables existing analysts to become data scientists; (2) emphasizes user time spent on analysis rather than data gathering; (3) provides consistent access regardless of data location and/or amount; and (4) promotes sharing and reuse of tools and techniques across the community. (Norman, 2024)

Second, TRMC manages the TENA to provide the necessary enterprise-wide architecture and common software infrastructure to (1) enable interoperability among ranges; command, control, communications, computers, intelligence, surveillance, and reconnaissance; and simulation systems across facilities and labs; (2) leverage range infrastructure investments; and (3) foster reuse of range assets and reduce cost of development. (Norman, 2024)

Service Communities

To provide effective M&S standards and associated processes, the Service M&S Management Offices remain active in the JESC and M&S Technical Working Group to review and approve existing and proposed interoperability standards, as well as innovate in areas of standardization practices, needs, and DoD priorities. Additionally, the Services ensure standards are complementary to foundational activities to include VV&A, Data and Data Management, Knowledge Management, and Workforce Development.

One of the most compelling initiatives across the Services is the Department of Air Force (DAF) M&S Council Standards Cross Functional Team, to lead initiatives and partnerships in the M&S Community. Within several lines of effort, they have published a DAF M&S Standards Handbook—a primer for the DAF M&S Community. With guidance to various levels of standards related resources, the handbook looks to (1) shape and influence M&S standards development; (2) share knowledge on emerging technologies; (3) capture and identify gaps in standards; and (4) expand the process to identify, assess, advocate, and recommend standards.

Noteworthy is the DAF M&S Gateway**.** The vision of the M&S Gateway is an integrated, collaborative storefront that provides the federated DAF M&S community easy access to extensible models, simulations, artifacts, data, and knowledge to enable decision superiority and operational readiness. The M&S Gateway is bucketed into six overarching categories: Data Management, Knowledge Management, Tool Management, Job Management, Software Deployment Management, and Learning Management. Ultimately a "Gateway to Standardization," the initiative will standardize flows for M&S processes; standard integration with multiple compute types; and standard workflows across classifications and environment, leading to a Standardized User Experience. (Litton, 2025)

Also noteworthy is the Department of Navy Integrated Modeling Environment (IME)**.** Its purpose is to address the disparate, stove-piped, and disconnected engineering capabilities across the acquisition lifecycle. The IME provides a government owned and managed enterprise digital ecosystem comprised of comprehensive, enterprise-wide capabilities that provides tools, information technology, and infrastructure that accelerate delivery of fully integrated capabilities which are designed, developed, and sustained in a Model Based Digital Environment. In addition to speed and cost saving, the benefits of reuse and interoperability are achieved by enterprise licensing; data exchange, storage, and curation; and collaboration with DoD, industry, and academia. (Belleavoine, 2024)

Standards Development Organizations

The primary objective of SDOs is to develop, maintain, and promote technical standards that ensure uniformity and consistency across various industries and sectors. These organizations aim to create a common understanding and set of practices for products, services, and processes, which can lead to improved efficiency, safety, and quality. SDOs achieve this by engaging with a diverse range of stakeholders, including industry experts, government agencies, and consumers, to ensure that the standards are relevant and effective.

The Object Management Group® Standards Development Organization (OMG® SDO) is an international (27 countries), membership-driven (230+ organizations) and not-for-profit consortium. The OMG mission is to generate technology standards (250+) that provide quantifiable real-world value to all vertical industries. OMG is dedicated to bringing together its international membership community of end-users, researchers, and vendors in academia, government, and industry to develop and revise standards as technologies change over time. In the area of specifications, 260+ OMG specifications are developed and maintained by its members. In the area of ISO, 15 OMG specifications were adopted by ISO. (OMG, 2025)

Figure 2. OMG Overview (OMG, 2025)

Current OMG communities that are relevant to DEM&S standardization activities include the Model-Based Acquisition User Group Community and the Digital Engineering Ecosystem Working Group. A brief list of OMG Standards used or influenced by the DoD and the National Aeronautics and Space Administration includes: Common Object Request Broker Architecture® (CORBA®); Data Distribution Service® (DDS®); DoD Architecture Framework (DoDAF) 2.02; Systems Modeling Language® (SysML®); Unified Modeling Language® (UML®); UAF Profile for Model Based Acquisition™ (MBAcq™); and Meta-Object Facility™ (MOF™).

Of note, the Meta-Object Facility is the foundational abstract definition that undergirds the modeling and data standards that have been created by the OMG. Utilizing this common definition allows models to be utilized in a very modular way. It is the foundation for UM, SysML, and UAF to name a few.

The Open Geospatial Consortium (OGC) is a global network of leaders across government, business, research institutions, startups, and the geospatial community. For over 30 years, OGC has been the trusted hub for collaboration, empowering diverse voices to come together and drive solutions to the world's most pressing challenges—from climate change to urban planning and food security. OGC standards are internationally recognized specifications developed by the OGC to facilitate the sharing and interoperability of geospatial data—defining how geospatial data should be organized, encoded, accessed, and visualized.
(OGC, 2025)

The OGC Common Database (CDB) is a time-invariant (static) representation of the natural earth and man-made synthetic environment for the field of simulation, that includes terrain, terrain features, ocean, ocean features, and 3D models of structures and vehicles. CDB is a representation of the Synthetic Environment for use in real-time distributed simulation, for a variety of simulation applications and attributed for use by any simulation application.

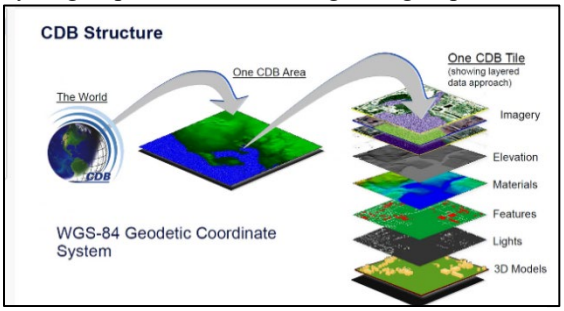

Figure 3. OGCCDB - Overview (OGC, 2025)

The Simulation Interoperability Simulation Organization (SISO) is an international organization dedicated to the promotion of M&S interoperability and reuse for the benefit of a broad range of M&S communities. SISO's mission is to develop, manage, maintain, and promulgate user-driven M&S standards that improve technical quality and cost efficiency of M&S implementations across the world-wide M&S community. SISO has developed and currently maintains three SISO/Institute for Electrical and Electronics Engineers standards, 31 SISO standards, nine guidance products, and 10 reference documents. Key areas of interest include: Cyber Modeling & Simulation; Simulation & Wargaming; Scenario Development; HLA; Space Reference Federation Object Model; Urban Combat Advanced Training Technologies; Exploration of Next Generation Technology Applications to M&S; Command & Control Simulation; and Digital Engineering / Digital Twins. (SISO, 2025)

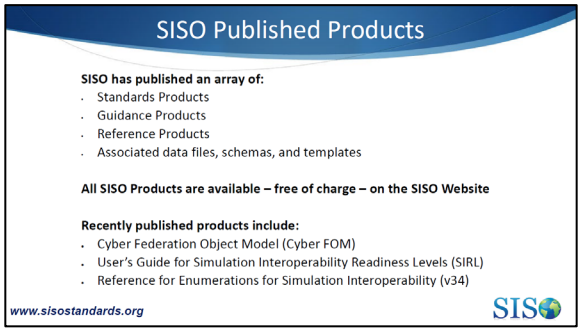

Figure 4. SISO Overview (SISO, 2025)

Given the depth and breadth of Defense M&S Standards, a body of knowledge could be helpful for practitioners to navigate and understand the importance of technical standards and standardization activities. SISO has initiated a M&S Standards Body of Knowledge Standing Study Group to investigate the need for, and possible standardization of, a central digital hub for identifying, and in some cases, accessing core resources for M&S Standards and related information supporting M&S Standards.

Noteworthy to Defense collaboration with Allied Partners, SISO signed a Technical Cooperation Agreement (TCA) with the NATO Modeling and Simulation Group (NMSG) in 2007, and signed a revised TCA in 2019. SISO and NMSG work together with close coordination through NMSG Activities and Task Group. (Siegfried, 2025)

The mission of the NMSG is to promote co-operation among Alliance bodies and NATO member nations to maximize the effective utilization of M&S. The NATO M&S Master Plan provides strategic guidance and M&S implementation plans with five key objectives: to establish a common technical framework, provide coordination and common services, develop models and simulations, employ simulations, and incorporate technological advances. Within the NMSG Standards Development Task Group, relevant products include Allied M&S Publications, Standardization Recommendations, and Standardization Agreements.

CONSIDERING THE DEFENSE M&S STANDARDS LANDSCAPE

Much of what we've discussed so far in standards can be binned into four areas for Models and Simulations:

- Directed and Legacy Standards
- Standards Organizations
- Collaborative Efforts
- Independent Efforts

Figure 5. Elements of the Defense M&S Standards Landscape

Although directed and legacy standards were developed three decades ago, Distributed Interactive Simulation (DIS), High Level Architecture (HLA), and Synthetic Environment Data Representation and Interchange Specification (SEDRIS) are still viable tools in model and simulation development. Other tools such as Military Standard 3022,

Distributed Simulation Engineering and Execution Process, DISR, International Organization for Simulation (ISO) Standards, and ASSIST are the baseline of the Standards foundation.

Standards organizations provide forums for collaboration and advocacy and some key efforts were discussed previously. Primarily as coalitions of Defense organizations and representatives of the Defense Industrial Base, these organizations have been key in shaping valuable standards for the simulation community: SISO, OGC, and OMG.

Building on the baseline standards and leveraging the standards organizations, the Defense M&S community has benefitted from the collaboration of Government-led efforts to structure and seek out standards that results in excellence. Some noteworthy collaborative efforts in standards led by the Government and working with the Industrial Base continue to add value to the DoD:

- TENA. Developed under a joint interoperability initiative within the U.S. DoD, TENA is enabling interoperability among ranges, facilities, and simulations in a quick and cost-efficient manner, and fostering reuse of range resources and range system developments.
- Integrated Threat Analysis Simulation Environment (ITASE). ITASE was funded under the centralized management of Defense M&S and has become a classified environment hosted by the Intel community and utilized by the Services and Agencies as they continue to integrate simulations for a common synthetic environment.
- DoD Architecture Framework (DoDAF). DoDAF is a data centric process that can provide decision-making data to Defense managers. Conforming to the DoDAF allows information reuse and common understanding of models and artifacts. This comprehensive framework and conceptual model shares information across policy, operations, acquisition, engineering, and programming and budget.

The independent efforts in the fourth bin are not executed in stovepipes; the Services and some agencies make an effort to participate and learn from other efforts. One example of this are the Service-specific conferences including the DAF M&S Summit which is a great example of the Public/Private Partnership for Standards as mentioned in the Background section.

Significant to examining the landscape is that DE practitioners do not have a current readily accessible pipeline of best practices from simulation standardization activities that can be used to assess and modify modeling standard gaps. The DE community seeks to leverage this excellence across government agencies in the FED DEF discussed in the section on R&E. This is key to creating similar collaboration and advocacy on model standards for DE, and leveraging the decades of simulation standardization activities from the traditional M&S community.

INSIGHTS and CONSIDERATIONS

Our preliminary research and literature review, as well as M&S Stakeholder feedback on best practices, use cases, and insights in standardization activities, led the study team to recognize the need for clarity of purpose between modeling standards and simulation standards to best impact Defense DEM&S efforts to achieve interoperability and reuse. Not surprisingly, the stepping stones to continued improvement require more emphasis on (1) collaboration, (2) advocacy, and (3) shared solution space.

When comparing the legacy landscape to the current landscape of M&S standards, there are several insights from the Tolk paper in 2011 that still resonate in 2025. (Tolk, 2011)

- *Successful interoperation of solutions requires integratability of infrastructures, interoperability of systems, and composability of models. Successful standards for interoperable solutions must address all three categories.*
- "*….standards are needed for the simulation level, the modeling level, and also for the application level. These efforts have to be well orchestrated, while reducing complexity and uncertainty and coping with the limits of uncomputability, and metrics are needed to measure success. This requires a common theory to align the methods that will drive standardized solutions, and may require a shift in our culture as well."*
- *"…. challenges require a solution on the conceptual level, not just temporary on-the-spot solutions on the implementation level."*

Considering the depth and breadth of standardization activities by DEM&S Stakeholders, the capability to achieve model integration and simulation interoperability will be driven by continued collaboration across the acquisition lifecycle and advocacy for the awareness and prioritization of technical gaps. This is currently achieved in select niche areas and efforts; however, organizations like SISO, OMG, and FEDDEF are a coalition of the willing and interested partners. There are no longer Departmental-level governance advocates for all DEM&S stakeholders across the Defense M&S landscape.

Since the Defense M&S Steering Committee was disestablished, there is not a channel for advocacy for M&S Standards at the Senior levels of the DoD. This has resulted in elevating the importance of the collaborative and independent efforts we noted in this paper. Forums such as the DAF M&S Summit allow participants from across the DoD to work through relevant topics including M&S and DE standards. Additionally, the DAF leadership advocacy with their M&S Standards Cross Functional Team continues to push the boundaries of collaboration and integration. Similarly, many of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) Signature Events are from DoD, Industry, and International Senior-level advocates for continued standards, interoperability, and integration of M&S. Other examples are the NDIA SE, and the NMSG.

The standardization activities by SDOs, and the capability to develop, maintain, and promote technical standards that ensure uniformity and consistency across the Defense M&S enterprise will require a dedicated commitment of engagement across a diverse range of stakeholders. This high-level advocacy needs to include industry experts, but more importantly, government practitioners to ensure that the standards are relevant and effective.

Finally, there are many examples of research centers, such as the Systems Engineering Research Center; conference proceedings such as I/ITSEC and NDIA SE; and standards organizations previously discussed that shared their efforts, research, artifacts, and standards. For a shared solution space to be truly useful, it would be helpful to have discovery through a single source. For communities with practitioners in both DE and simulation&S, the need is greater to have references more accessible.

SUMMARY

In this paper, the team explored the need for knowledge sharing of, and advocacy for, technical standards and standardization activities that are necessary to best support the Defense M&S Enterprise and DE community. Based on stakeholder engagements, we highlighted opportunities to identify and prioritize gaps in M&S standards needed when developing capabilities. Furthermore, we recognized many references that exist to assist practitioners in this regard. A single source to assist in this determination is the DoD *M&S Related Standards and Best Practices Guide*.

Additionally, the study team found pockets of excellence and best practices with standardization activities across the Service M&S Stakeholders, as well as Defense communities, Standard Development Organizations, and Allied Partners. While this knowledge and best practices is often shared with the DEM&S community, there is currently no single avenue by which these can be shared. It often remains tribal knowledge.

Sharing the successes and continuing the collaboration of best practices will benefit leaders, practitioners, and developers including industry and academia, to include:

- leading knowledge sharing efforts to ensure awareness of the M&S standardization activities, to include legacy achievements and current initiatives;
- advancing the engineering practice with research based on gaps, priorities, and return on investments; and
- advocating the mission essentiality of M&S standards to drive Model integration and Simulation interoperability.

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