

JOURNAL OF CYBER SECURITY & INFORMATION SYSTEMS

MODELING & SIMULATION *Special Edition*



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Director's Introduction

Greetings,

Welcome to the inaugural special modeling and simulation (M&S) edition of the *Journal of Cyber Security & Information Systems*, published by the Cyber Security & Information Systems Information Analysis Center (CSIAC). In lieu of continuing publication of the quarterly *M&S Journal* we have transitioned to a more visible venue in collaboration with the CSIAC with this inaugural edition.



Where the CSIAC's journal normally carries two or three M&S-specific articles, this special edition focuses solely on M&S.

Since the Defense M&S Coordination Office (DMSCO) was established in 1991, two of our primary goals for the Department have been interoperability and reuse of M&S tools and data. But, you can't reuse what you don't know about.

As the focal point for Defense M&S, we work to enable interoperability and reuse by facilitating the sharing of information and benefits of M&S across the Defense M&S Community, to include industry, academia, and our international partners.

For example, within the Department's M&S management structure we conduct:

- (1) quarterly meetings of the Deputies of the DoD M&S Steering Committee;
- (2) weekly situation reports to the Deputies;
- (3) presentations and demonstrations at M&S Community events like the Interservice and Industry Training, Simulation, and Education Conference (IITSEC);
- (4) participation in NATO, The Technical Cooperation Program (TTCP), and bilateral activities;
- (5) visits to M&S stakeholder organizations; and
- (6) publishing articles in the CSIAC's journal.

My intent, working through the *M&S Journal* Editorial Board, is to produce an annual M&S special edition that focuses on a particular theme or topic. For this inaugural issue, we asked the Services and other DoD Components to provide a snapshot of the state of M&S in their organizations.

If you are reading this you are likely a member of the Defense M&S Community. I hope you find it informative and useful.

We would like your feedback. If you have comments or questions please contact the DMSCO at osd.mssc.secretariat@mail.mil.

If you would like to receive an email notification when the latest edition of the CSIAC's journal is published please subscribe at:

https://www.csiac.org/subscription_manager (Note: to subscribe, you must log in with a user ID and password: https://www.csiac.org/user/login?destination=%2Fsubscription_manager).

Finally, my thanks to the organizations who contributed to this first M&S special edition and to the CSIAC for working with us to make it possible.

Jesse Citizen

Director, DMSCO

The Modeling and Simulation Community has lost a true Champion, Friend & Patriot

By Peggy Gravitz

We recognize the passing of William F. (Bill) Waite, a true pioneer and champion of Modeling and Simulation (M&S). But, Bill was much more.



He was a great friend, a caring mentor and instrumental leader so very dear to his family and colleagues; simply, Bill was truly an extraordinary person. He co-founded The AEGIS Technologies Group, Inc. (AEGIS), a privately held aerospace and defense small business that grew under his leadership to over 300 persons. Bill tirelessly worked to raise the national and international awareness of M&S technology over the last 25 years. He transformed the industry's ability to collaborate and communicate by promoting the establishment of industry forums like the Alabama M&S Council (AMSC) and the Virginia

M&S Partnership (VMSP). He took this concept to a national and international scale, birthing the idea and supporting the full implementation of the international SimSummit Round Table and the National M&S Coalition (NM&SC). He twice led the Society for M&S International (SCSI) as Chairman of its Board of Directors, and he served twice on the Executive Committee of the Simulation Interoperability Standards Organization (SISO). Bill was also active in the National Training and Simulation Association (NTSA) and served the National Defense Industrial Association (NDIA) as a member of its Board of Trustees. He was instrumental in working

with the Congressional M&S Caucus in establishing House Resolution 487 that recognized M&S as a National Critical Technology. Bill was extremely active in promoting the M&S profession, workforce, industry and market and was impassioned about M&S education. He toiled to establish Masters and PhD programs in M&S at several universities including the University of Alabama in Huntsville (UAH), University of Central Florida (UCF), Old Dominion University and the Naval Post Graduate School and was an influential, active member of the M&S Professional Certification Commission (M&SPCC), which established the Certified M&S Professional (CMSP) program.

Air Force Analytics for Decision Support

By Dr. Mark A. Gallagher

Technical Director
Studies, Analyses and Assessments (A9)
HQ USAF, Pentagon
Washington, DC

In this article, I summarize Air Force Models and Simulations (M&S) policy initiatives and M&S enhancements for decision support analytics for warfighters and acquisitions. The policy initiatives include implementing an M&S governance structure, instantiating a study governance oversight, and evaluating the analytic capability across the Air Force. The various M&S enhancements span the levels from engagement, through mission area and campaign, to enterprise. The enhancements are all directed at improving the range and scope of decisions that we can support for operators, logistics, planners, and programmers.

The Air Force is taking various actions to improve M&S that are used for decision support. The following are my personal views on various initiatives from my perch in the operations research unit of the Air Staff. The advantage of these being my personal views is I can be much more candid and include my suggestions on the direction that the Air Force should precede. Another advantage is some of you may not agree with my perspective; any disagreement is a starting point on a dialog on the best approach for the Air Force. The disadvantage is that since these are preliminary, rather than coordinated and official statements, these may not be the direction that the Air Force actually pursues on these matters.

The first section presents a few definitions to set the stage for the remainder of the article. The next section describes organizational initiatives to make the Air Force analytic community more effective and efficient. In general, these policies and programs are intended to increase our ability to share data, models, and results. The subsequent section describes actions to improve specific M&S tools, whether models or simulations, for better analytic capability.

The following definitions, at least how I am using terms, should help clarify this discussion. Modeling and simulation is not well defined. The two terms are not even grammatically equivalent. In this article, I propose and use the following fundamental definitions:

- A model is representation or pattern, with the subset of analytic models are mathematical, symbolic, or algorithmic representations of reality or a system.
- A simulation is a representation of a system with entities or variables that change states over time.

With these definitions, we can classify various analysis tools as a model, simulation, both, or neither. A military exercise with combat units is a simulation, but not a model. Similarly, a regression equation, even with time as a variable, is a model and not a simulation because no entities change state. Any simulation that runs on a computer is also a model. See Table 1 for examples of models and simulations. Finally, I define M&S as the collection of analytic models and simulations.

Table 1. Example of Models and Simulations

	Analytic Model (mathematical representation)	Not an Analytic Model
Simulation (state changes)	Lanchester Equations	Military Exercise
Not a Simulation	System of Linear Equations	A calculator

The Live, Virtual, and Constructive (LVC) scheme is not comprehensive because LVC is used to describe how

individuals are portrayed. Pew and Mavor (1998) and Zacharias, MacMillan and Van Hemel (2008) present summaries on modeling human behavior. While some use “constructive” to describe any model that is not live or virtual, DoD (2015) defines constructive as simulating people, which implies their behavior is modeled. Most of our analytic models for decision support do not represent individual behavior at all. Hence, constructive simulations are only a subset of the analytic models and simulations.

I view that there is a spectrum from analyst-intensive M&S to hardware-intensive simulations, as shown in Table 2. Some in this community may wonder why I am using the adjective “analyst-intensive” versus “decision support;” I find decision support is not a meaningful discriminator as everyone in this field is supporting some decision-making process. Some apply the term simulators, rather than simulations, to the real-time realistic system representations that are used to train operators. Simulators are distinct from analytic simulations; hence, simulations and simulators are appropriate for different uses and require different management approaches. However, other hardware-in-the-loop simulations are used to develop operational procedures and evaluate potential new technologies; these are much closer to the use of analytic simulations. In fact, we mention in this article using the same system models in the analytic and virtual simulations. I want to be clear that no one type of model or simulation is better than another type; each of these simulation approaches has appropriate applications.

Wargames are also used for decision support. I define wargames as having humans, on competing sides, making inputs during play in a postulated military conflict, without actual military forces or real equipment involved (Perla and Branting 1986). Since no equipment is used, wargames are distinct from live or virtual simulations. Because wargames are played in time, they are always simulations. Most

Table 2. Spectrum from Analytic-Intensive to Hardware-Intensive Simulations

Characteristic	Analytic Models and Computer Simulations	Virtual Simulations with Human and/or Hardware-in-the-Loop	Live and Virtual Simulations (also called Simulators)
Goal	Better decisions	Better system performance, interfaces and concept of operations	Better training
Focus	Leaders, decision makers	System designers, testers	Trainers, operators for mission rehearsal
Purpose	Inform subsystem to force structure choices	Evaluate subsystem and system trades	Train operators
Scope	Simplifications to critical factors in decision	Representation needed for decision being supported	Realistic representation of training aspects
Resolution Level	Engineering to campaign and enterprise	Engineering to mission area	Engagement
Time	Faster than “real time”	Real time	Real time
Modeled Duration	Up to months	Hours to days	Hours
Primary Resources and Cost	Operations research analysts, mathematicians, and statisticians	Simulator, modelers, programmers, and data analysts	Hardware and software emulations
	Analyst Intensive		Hardware Intensive

wargames are adjudicated by a “white cell,” which may or may not use models or computer simulations. I recommend, when possible, a technical evaluation of outcomes. The focus of wargames is on the interaction of competing leaders making decisions for their organizations; hence wargames are particularly useful in evaluating strategy, operational concepts, and the associated decisions space, such as devising an appropriate strategy and related courses of action in a scenario.

The Office of Secretary of Defense (OSD) and the Joint Staff are revamping Support for Strategic Analysis (SSA). The Air Force and the other services are participating. They are searching how to build scenario baselines faster and an approach to support our decision makers through the integration of wargame results and analytic products. Where wargames are better at testing human organization decisions, I contend analytic approaches are better suited for evaluating the effectiveness of systems, including new technologies. Wargames and analysis should interface. For example, a strategist might use a wargame to assist in developing a strategy and types of forces desired in a scenario, and then analysts might use those results to build an analytic baseline for that scenario to evaluate various force mixes. Like the

hierarchy of analytic levels, depicted in Figure 1, we may need to develop scenario levels or degrees to indicate their analytic rigor. We also need a better categorization of wargames.

In continuing to be bold – and for the sake of prompting thoughtful dialogue – I propose the following definitions of analyses, studies, and assessments. I will use the adjective analytic to distinguish from the wide application of these terms that are distinct from applications of M&S. The Institute for Operations Research and Management Science (INFORMS) (2015) states: “Analytics is the scientific process of transforming data into insight for making better decisions”. This transformation process often starts with raw data, such as system performance specifications, as input into one or several system models and examines the modeled outputs along with sensitivities. The process may continue with those results being input into another model or a series of models, perhaps at different resolution levels. Hence, an analytic analysis uses models or simulations to evaluate the impacts of alternative decisions. An analytic study is more extensive and more formal than an analysis, although there is no agreed upon division between these two. Generally, I expect that a study has a formal plan, final report, and encompasses a level of resources of more than one full-time equivalent, such as at least four analysts for three months. An analysis or study does not tell the decision maker the appropriate decision; rather it describes the impact of various choices. A study rarely encompasses all the variables or aspects that a decision maker should consider—certainly not on complex defense acquisition decisions that affect the industrial base and many political constituents. That said, once a decision maker has selected a direction, more focused analysis on implementing that choice is often prudent. Finally, an analytic assessment is a collection of metrics and measures to indicate the state of a system, without being focused on a particular decision (Clark and Cook 2008). With these definitions, I can frame the rest of this discussion.

The focus of this article is on analytic M&S, which are used to support decision makers. These analyses are categorized into levels based on the questions and issues being investigated. A widely-used hierarchy is shown in Figure 1. The large base indicates many models and simulations exist and are needed at the levels with more resolution; however, analysts use fewer more-encompassing models at more aggregate levels as they move up the pyramid depicted in Figure 1.

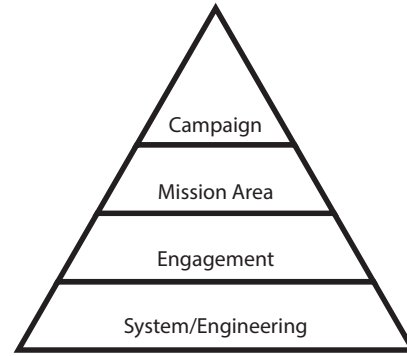


Figure 1. Common Analytic M&S Hierarchy

Individual models or simulations may be characterized by the issues and questions that they are designed to address. Figure 2 shows a hierarchy depicting how scope and resolution of any particular model differs, depending on the intended level of analysis. Even with increased speed of computers, use of these levels makes sense since they enable (Gallagher, Caswell, et al. 2014):

- (1) Modeled aspects to be relevant to the issue or question under investigation,
- (2) Wider applicability of results (consistent with data inputs of the models),
- (3) An efficient search of the decision-space, and
- (4) Focused and manageable data requirements for any particular analysis.

Analysis insights and results flow up and down the analysis hierarchy. We are documenting the general process to tune models or simulations across the levels of analysis.

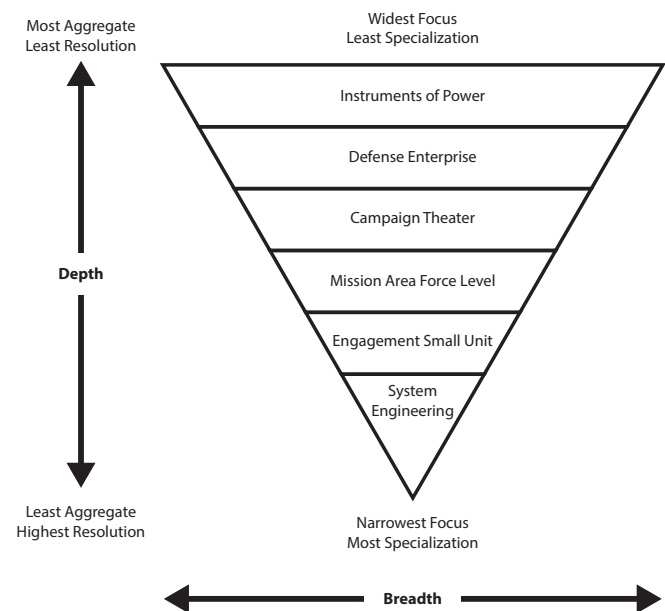


Figure 2. Conflict M&S Hierarchy (Gallagher, Caswell, et al. 2014)

In the following section, we discuss M&S governance initiatives, and, in the subsequent section, I describe some of our analytic M&S enhancements.

Organizing for Effectiveness

The Air Force is improving its Decision Support M&S governance. The goals are effectiveness and efficiency:

- (1) Understand how well the analytic M&S enterprise is functioning. Particularly, ensure that the analytic enterprise is delivering quality results in support of decision making.
- (2) Enable efficiency by aligning the many analytic organizations conducting multiple levels of M&S into a cohesive and coherent whole, particularly in sharing models and data along with expertise and results.

Several initiatives are laying the foundation for achieving these goals.

The Air Force conducted a rapid improvement event on M&S governance in 2010. The subsequent decision was that the Air Force would organize our M&S under the Tri-Chairs for virtual simulators (AF/A3), acquisition (SAF/AQ), and decision support (AF/A9). The AF/A3 focus is on the hardware-intensive simulators, whereas AF/A9 focuses on the analyst-intensive models and simulations. The acquisition community cooperates with both of these pillars for applications that affect their work. This article focuses on Air Force initiatives for analytic M&S for decision support and acquisition.

In 2012, when the Office of the Secretary of Defense (OSD) directed the DoD Components to reduce duplicative studies, the Air Force established a Studies Governance Board. This board initiated a study registry program to reduce duplication in studies. The initial focus was on contracted studies because the contracting actions make those study efforts easier to identify. I continue to recommend that we also include organic studies in the registry. Currently, the study approval process requires a literature review to establish what has been accomplished as a starting point for any new study. Additionally, we use the study registry to ensure that completed studies are archived in the Defense Technical Information Center (DTIC). One contentious aspect has been the definition of a study, which is why I earlier proposed a definition to

advance this discussion. Currently, the Studies Governance Board is broadening into other policy aspects to improve our study process.

Beginning in 2010, the Air Force implemented a risk assessment framework that evaluates risk against any activity in terms of its plan, particularly cost, schedule, and performance. For each metric, success and failure points are identified and the expected achievement is evaluated to determine the risk (Gallagher, MacKenzie, et al. 2015). The resulting risk assessments align with the Joint Staff risk schema. The Air Force Requirements Oversight Council (AFROC) reviews risk assessments in this prescribed format for each proposed requirement.

In 2014, the Air Force expanded the application of this risk assessment framework to each mission area within the Air Force under the program named the Comprehensive Core Capability Risk Assessment Framework (C3RAF). The Air Force organizes around 12 core functions, which are further subdivided into 45 core capabilities. The Chief of Staff of the Air Force directed that a set of metrics be developed for each of the core capabilities. As this process continues to evolve, establishing a standard set of metrics will enable the Air Force to integrate better information from operations, exercises, experiments, technology demonstrations, analyses, and wargames. With established metrics, integration of analytic results should be easier. As an analogy, performance results should be more like a book or movie series with same cast of characters in different settings, rather than completely unrelated stories. Furthermore, standard metrics will show changes, hopefully improvements, over time.

The Air Force has also started assessing its organic analytic capability and capacity, which is distributed throughout the Air Force. Typically, more military and civilian analysts are assigned within larger organizations, such as major command headquarters and the Air Staff. To evaluate capability of these dispersed analytic organizations, we need criteria. For an organization to accomplish analytic studies in any particular area requires four aspects:

- (1) Qualified analysts,
- (2) Relevant data,
- (3) Appropriate models, simulations and tools, and
- (4) Authority, including clearances.

We defined analytic capability ratings based on these four aspects as shown in Table 3. We evaluate our ability for each of the analysis levels hierarchy (see Figure 2) and across the core capabilities used in C3RAF. Our initial survey indicates that we need to improve our space, nuclear, and cyber analytic capability within the Air Force. We are using these insights to shape our modeling developments to close the identified analytic capability gaps.

the current evaluation of models. Another challenge for the AFSAT is the evolution from stand-alone models to simulation frameworks or environments in which many system models, like an F-22, may be incorporated into an application, such as an integrated air defense network. Both the system models and the applications should be vetted. AF/A9 currently intends to incorporate the applications, and not the frameworks, into the AFSAT.

Table 3. Organization Analytic Capability Ratings

Quality Level	Fair	Good	Excellent	Outstanding
Analyst Experience	Capable analyst learning this issue	Familiar with the issue, problem, and associated processes	Experienced analysts	Established experts
Data	Judgment	Reasonable information from various sources	Generally accepted (produced by a credible source)	Authoritative documented source
Models & Tools	Effects have not been quantified only general rules or heuristics exist	Effects metrics have been developed and tools capture first-order effects, however improvement is possible	Effects are well understood, and models depict effects and some of their interactions	Effects are well understood, and models represent the effects and their interactions well
Authority and Clearances	Not authorized and not cleared for relevant data	Disagreement about authorization and access available except for limited protected data	Within an established purview and access to most relevant data	Responsible and cleared for all relevant data

Another initiative is to revamp the Air Force Standard Analytic Toolkit (AFSAT), which lists accreditation of significant and enduring analytic models. The accreditation requires sufficient M&S support including documentation, validation and testing, training, and user groups. After our analysis community conducts a review and approves a model, AF/A9 lists that model in the AFSAT. In the past, the AFSAT had a single standard so that models were either in or out, with relatively few models actually registered in AFSAT. Moreover, as models develop and mature, their support may improve or become outdated. Therefore, AF/A9 is revising the AFSAT to be more flexible and better promote visibility and transparency of all M&S assets. We contend this added information will make it easier for everyone; model managers can plan their progress, and users will understand

The Analytic M&S policy initiatives are an important piece of AF trade space; however, the other important part is improving our analytic capability with enhanced analytic tools.

M&S Improvements

In this section, we describe some modeling improvements that reduce identified limitations to our current analytic capability. This discussion will start at the engagement-level and progress up the M&S conflict hierarchy, shown in Figure 2, to the enterprise level.

At the engagement-level, there are at least three major ongoing initiatives to improve our analysis capability. First,

A separate topic is preferred software applications. The Air Force perceives several advantages to establishing preferred software applications for analysis. First, training would be more widely applicable as analysts transition between organizations. Second, analysts could collaborate better and move between projects easier. Third, related applications could be interfaced more easily. We use “preferred” vice “required” software applications because we readily admit that some applications will be better performed with another analysis package.

one of our primary engagement M&S programs for air combat is BRAWLER, a time-oriented simulation of few-on-few fighter engagements. We have started listing the requirements for a follow-on M&S tool. The Australian Defence Science and Technology Group is also considering replacing their engagement-level air combat model. Hence, we are comparing requirements to improve both our lists.

Second, the joint community supports the Cyber Joint Munitions Effectiveness Methods (JMEMs) effort led by the Director, Operational Test & Evaluation in OSD (OSD/DOT&E). We support JMEMs as a forum to exchange cyber related M&S approaches to calculate operational effectiveness of cyber operations. We propose that the cyber engineering-level analysis, which is often done under highly classified restraints, should produce planning factors or metadata at lower classification levels. These cyber effects could be incorporated into more traditional M&S for analytic studies that are attempting to account for the impact of cyber operations on warfighting scenarios.

Our third engagement-level initiative is to improve our capability to analyze the impacts of logistics. We constructed a Time-Phased Force Deployment Data (TPFDD) builder and evaluator. Our operational energy project models fuel consumption and electrical usage in warfighting scenarios. We have built a prototype model of aircraft availability that evaluates the ability of the various base-level logistic components to support flight operations; this model includes maintenance personnel, parts availability, along with failure and fix rates. We are developing a model to explore the impacts of adversary attacks on our bases and their infrastructure (fuel, runways, vehicles, maintenance facilities, etc.) and our ability to apply active and passive defenses to mitigate the impact of these attacks. We are constructing interfaces between several of our existing engagement models and simulations. With this suite of tools, analysts should be able to evaluate base resiliency to the impact of enemy attack on installations and their infrastructure. The goal is to inform analysis on the logistics capacity to generate support for flight operations.

We also have many initiatives to improve our mission-area-level M&S analysis. The Air Force is transitioning to two simulation frameworks or environments, both of which are government owned: the Extensible Architecture for the Analysis and Generation of Linked Simulations (EAAGLES) (Hodson 2006) and the Advanced

Framework for Simulation, Integration and Modeling (AFSIM). EAAGLES is for time-oriented hardware-in-the-loop simulations. AFSIM, is a discrete-event simulation environment (Zeh 2014). The Simulation and Analysis Facility (SIMAF) is testing whether the same system models may be run in both AFSIM and EAAGLES. The Air Force Research Laboratory is leading the collaboration among the analytic community to build AFSIM applications (equivalent to stand-alone models, like EADSIM or SUPPRESSOR) for integrated air defense systems (IADS) and fighter engagements. We have already incorporated satellites and their contributions into our AFSIM applications. These two frameworks greatly increase our ability for sharing and reuse of system models.

We are also improving our mission area analytic ability. We are enhancing the capabilities of our Combat Forces Assessment Model (CFAM). We are modifying this cost-constrained, mixed-integer force structure development/assessment tool to improve the fidelity of a number of interactions including air-to-air refueling, expected attrition, resource usage, logistics, and basing.

For Campaign-level M&S, we are pleased with our Synthetic Theater Operations Research Model (STORM) (Seymour 2014). However, we continue to improve its capabilities. A new initiative is to incorporate wide-area effects including nuclear detonations into STORM (Hefty, et al. 2014). We also intend to improve the modeling of collection and use of intelligence, surveillance, and reconnaissance (ISR) along with other satellite contributions into STORM.

As shown in Figure 2, I contend there is an enterprise-level that is more aggregate than the campaign level. The primary concept at the enterprise-level is to evaluate a force structure ability to conduct wars in more than one type of conflict and strategic environment. To assist our evaluation of enterprise-level force structure options, we are continuing to develop the Bayesian Enterprise Analysis Model (BEAM). The aggregation in BEAM is that only the quantities of unit types or platforms within a large geographic region, without any specific locations, are modeled. Our BEAM prototype demonstration was promising.

Many more model enhancements are underway. This list is biased to those at the headquarters because that is where

I sit and see what is happening. Under renewed emphasis within the Air Force on developmental programming and experimentation, the Air Force is assessing and improving its analytic capability.

Conclusion

The Air Force has two thrusts to improve the effectiveness and efficiency of its analytic M&S capability. We are defining M&S along with wargames, the meaning of studies, analysis, and assessments, and establishing standards for organizational analytic capability. M&S governance and oversight is being implemented to improve overall analytic enterprise performance and efficiency. We are better planning and coordinating our M&S developments and enhancements. The Air Force is improving its analytic tools at all levels of the Conflict M&S Hierarchy.

Disclaimer

The opinions expressed herein are those of the author, and are not necessarily representative of those of the United States Air Force or the Department of Defense.

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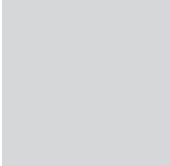
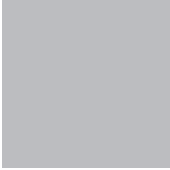
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About the Author



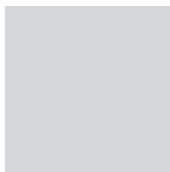
Dr. Mark A. Gallagher, Senior Leader, is the Technical Director of Headquarters Air Force Studies & Analyses, and Assessments (A9). In this position, he supports analyses, including development and application of modeling and simulation, across the spectrum of Air Force missions. Dr. Gallagher is

the government Executive Agent for RAND Project Air Force. His previous assignments include the Office of Secretary of Defense (OSD) Program, Analysis and Evaluation (PA&E) in the Cost Analysis Improvement Group (CAIG) and Chief of Missile Defense and Combating WMD Capabilities Division at US Strategic Command. Mark founded and chaired for four years the Cyber Joint Munitions Effectiveness Manual (Cyber JMEM); he continues to guide its progress to assess cyber operations. Dr. Gallagher served twice on the Military Operations Research Society (MORS) Board of Directors including as Vice-President of Society Services. Mark earned operations research and computer science degrees from the US Air Force Academy and operations research Master's and PhD from Air Force Institute of Technology (AFIT). Dr. Gallagher also was on the AFIT faculty and continues as an adjunct Associate Professor. He completed Air War College as a Distinguish Graduate and Harvard's Senior Executive Fellows course.



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A Marine Take on Live, Virtual, and Constructive Initiatives

By Brett Telford

Director
Marine Corps Modeling & Simulation Management Office
Quantico, VA

Introduction: Preparing to Win

“*Being ready is not what matters. What matters is winning after you get there.*”
Marine General Victor Krulak

Modeling and Simulation (M&S) will not win any battles for the Marine Corps. As has been the case for nearly two-and-a-half centuries, real Marines with real weapons and real ammunition will win our battles. But being ready is still a necessary condition for prevailing in combat. And because M&S is a monumentally important part of being ready, Marine Corps M&S needs to do everything it can to ensure that Marines are ready. With current fiscal constraints, M&S is particularly important, given its tendency to be far more affordable than alternatives.

In the Marine Corps, as in other services, the Title X tasks to “man, train, and equip” aren’t getting any easier. Indeed, the diversity of threats to our country is expanding and traverses nearly the entire spectrum of war. As the smallest service, the Marine Corps must employ the most efficient means available to ensure our forces have the tools, training, and support they need to meet these diverse threats. And when you’re talking about transforming the cumbersome and the expensive into the convenient and the affordable, you probably need to be talking about M&S.

Recognizing the value of M&S and the need to work closely with our joint counterparts, the Marine Corps recently reorganized its M&S management structure to match the M&S management structure in the Navy. Our managerial framework, like the Navy’s, now has four communities – acquisition, analysis, experimentation, and training. The Marine Corps M&S Management Office (MCMSMO) coordinates M&S activities across these four communities and reports to the Commanding General, Marine Corps Combat Development Command (CG, MCCDC). This structure lets our service share information

across M&S communities within the Marine Corps, and it lets us provide a single, coherent voice to our counterparts across the DoD M&S enterprise. Internal and external coordination is important to DoD in general, and to the Marine Corps in particular – we must leverage existing capabilities across services and across communities whenever doing so accelerates the achievement of an important goal.

Now, in 2015, when you think about Live-Virtual-Constructive (LVC) events in the Marine Corps, you are almost always thinking about training. However, LVC capabilities transcend a single community, as demonstrated by the DoD and our sister services, who are already actively planning to use LVC across multiple M&S domains. To avoid falling behind our sister services, the Marine Corps needs to plan for LVC to grow. This paper will outline how the Marine Corps can set the stage for a strong LVC future, and it will do so by providing context on the state of M&S in our M&S communities (not just the training community, which is the vanguard for how the Marine Corps will use LVC to support training).

The Urgency of Live/Virtual Constructive Initiatives

Perhaps no other category of M&S efforts holds as much promise as LVC initiatives. Currently, the training community is the big dog and very nearly the only dog, in Marine Corps LVC. Thus, talking about an LVC Training Environment (LVC-TE) in 2015 and talking about LVC in 2015 are two nearly identical conversations. Still, LVC-TE solutions devised in 2015 or 2016 shouldn’t bind Marine LVC-TE to 2015 or 2016. Likewise, LVC-TE solutions of today shouldn’t constrain broad, multi-community LVC in the future. Technological progress may hold situations in which LVC will matter to people outside the training world (i.e. analysts, acquisition specialists, or concept developers).

The Marine Corps needs to allow for progress, which invariably brings with it the unforeseen.

Before this discussion of LVC goes any further, a brief discussion of terms and definitions is in order. For those of you less familiar with LVC, it's helpful to think of the words this way:

- LIVE: Real people operating real systems
- VIRTUAL: Real people operating simulated systems
- CONSTRUCTIVE: Simulated people operating simulated systems

For those of you intimately familiar with LVC, we ask that you check any tendentious inclinations toward hair splitting. Yes, you can play semantic games for hours, tediously pontificating on the gray areas between live and virtual; virtual and constructive; and constructive and live. This paper is a discussion of issues and ideas. We can all dive into the rabbit holes later. (And most of us have lost many hours we'll never get back listening to explorations of the ambiguities in these three terms.)

Now that we have a handle on these terms that are attracting so much attention, we need to remind ourselves that when DoD gets excited about an idea, the Good Idea Fairy isn't far behind. Currently, LVC is the darling of the buzzword chanters and the PowerPoint prophets. Any number of DoD briefings promises full integration of countless M&S capabilities via LVC technology. There's a tantalizing air of legitimacy to pitches for on-demand distributed training, reuse of models, and operating from the cloud. It's easy to conjure visions of Marines immersed in a digital world that will meet their every need. Commanders are left with the impression that all they have to do is press a button, and they will have instantaneous, multi-echelon training (as well as analysis and experimentation). It will be just like Xbox Live*!

Of course, the reality is much different. Budgets aren't unlimited; DoD isn't the entertainment industry; and the speed of our bureaucracy can handicap us as we try to keep pace with the speed of technological progress.

The Marine Corps recognizes these challenges at the same time it recognizes the importance of LVC. The Marine Corps must review its LVC plan, as Gen. Joseph Dunford

* Xbox Live* is a registered trademark of the Microsoft Corporation.

wrote in his recently published "Commandant's Planning Guidance." "We will particularly focus on better leveraging modern immersive training and simulation technologies." Significantly, Gen. Dunford also directs that any efforts the Marine Corps takes should be based on understood priorities and requirements. In other words, the Marine Corps will pursue LVC capabilities where they make sense, but uttering the acronym "LVC" doesn't give you carte blanche to hook up assorted M&S systems just for the sake of hooking them up. Integration between independent capabilities should only occur where it needs to occur.

The spectrum of uses for LVC environments is rapidly increasing across multiple M&S communities. However, the cost in time, personnel, and resources for setting up LVC can increase too, if you're not careful (and even if you are). Many existing environments don't effectively reuse common capabilities. Instead, there are LVC environments that are highly customized for specific operational requirements, and these environments must be built/dismantled for individual events. Needless to say, these one-off LVC events are costly, inefficient, and un conducive to technological progress. In order to correct this trend, CG, MCCDC will help guide the development of a Marine Corps-wide LVC capability.

Distributed Simulation Engineering and Execution Process

Several systems engineering processes exist, but the Distributed Simulation Engineering and Execution Process (DSEEP) articulates the specific steps that are most appropriate for distributed M&S capabilities. The Simulation Interoperability and Standards Organization (SISO) and the Institute of Electrical and Electronics Engineers (IEEE) have produced an overlay that accommodates environments requiring multiple architectures; in other words, SISO and IEEE have created an approach that handles LVC environments such as the ones DoD employs.

LVC requires a strategic vision that rests upon a strong foundation of where technology is and how this status quo came to be. For USMC LVC, MCCDC will look to formalize the LVC enterprise; that means devising a vision, strategy, and management approach. This vision will reflect the concepts of the Marine Air-Ground Task Force (MAGTF), and will reach across our four M&S communities to see how they can leverage LVC capabilities. This approach necessitates a detailed understanding of the LVC requirements for each element of the MAGTF.

To help understand these issues, MCCDC will produce a white paper identifying the Marine Corps requirements that M&S working via LVC can support. The requirements will be arranged in blocks and placed in a hierarchy. In turn, Marine Corps planners will be better able to harness LVC. It's worth noting that executing LVC in the present and the near future is only half the battle and is currently limited to the training domain. The ultimate key is a Marine Corps service-level LVC policy that enables capabilities to grow and be used in unforeseen ways, i.e., a policy that doesn't constrain future LVC with the perspectives of the bureaucrat or technician stuck in 2015.

LVC Needs To Be Something Like TurboTax^{®**}

When the Marine Corps has the LVC capability it would like to have, it's likely the user interface won't be prominent. Indeed, in the case of training audiences, the LVC user interface probably will be invisible – completely behind the scenes.

While those using LVC might see very little of the LVC infrastructure, there definitely needs to be some LVC infrastructure.

An example of a good role model for LVC infrastructure would be TurboTax[®], said Col. Walter Yates, the program manager for Training Systems (TRASYS), Marine Corps Systems Command.

You want a web-based service like TurboTax[®], Col. Yates said. You specify what needs to be live, what needs to be virtual, and what needs to be constructive. And then you specify what you're doing; e.g., what type of training task is involved. Then, just as TurboTax[®] software walks you through the administrative hassles of paying your taxes, the LVC infrastructure would resolve such matters as what needs to be connected to what, or which Information Assurance (IA) documents are required. Whether LVC occurs on the Marine Corps Enterprise Network (MCEN), the Navy Continuous Training Environment (NCTE), or some network that hasn't even been created yet, this tax preparation software-style tool will need to provide a dashboard linked to such assets as the Marine Corps training schedule and pertinent databases.

Of course, we're a long way from that future, Col. Yates said.

** TurboTax[®] is a registered trademark of Intuit, Inc.

Whether you're talking about a good administrator or a good administrative tool (such as automated tax preparation software), the essence of what you're discussing is mapping. Someone or something needs to connect the dots so that everything that needs to be synchronized, registered, or linked gets handled properly. This idea certainly applies to LVC in general and LVC-TE in particular.

As Col. Yates noted, we need to know what our current M&S capabilities are. In the case of training, we need to know how our M&S capabilities map to our Training & Readiness (T&R) portfolio. Too often, Col. Yates continued, we have acquired M&S because experts said those tools had promise. Also, we often acquire training M&S with an exaggerated sense of urgency, which means we end up with M&S that isn't quite suitable for our purposes.

The Training and Education Command (TECOM) has established the Simulation Assessment Working Group (SAWG) to take inventory of training M&S and note the differences between what M&S allows us to do and what M&S actually needs to do. Many of the M&S training systems fielded during the ramp-up to support wars in Afghanistan and Iraq were done using accelerated acquisition methods that never tied system capabilities to specific training requirements. TECOM will use their findings from the SAWG to formalize how specific simulations will be used to support established Marine Corps Training and Readiness (T&R) requirements. So, in the future, when training systems such as the Combat Convoy Simulator (CCS), Supporting Arms Virtual Trainer (SAVT), or the Deployable Virtual Training Environment (DVTE) are available for use, commanders will know specifically what T&R tasks can be supported with each system, and whether the systems are used individually or in concert with one another.

We do not want a situation where LVC means the Marine Corps has to buy new systems, Col. Yates said. For example, if the MAGTF Tactical Warfare Simulation (MTWS) needs to connect with the Combined Arms Command & Control Trainer Upgrade System (CACCTUS), then that's exactly what you want to do. You want to connect MTWS with CACCTUS. You don't want to go out and purchase LVC-specific systems that do what MTWS and CACCTUS already do.

In short, Col. Yates said, LVC needs to be about making tools interoperable (once you've established that they need to be interoperable).

The Near-Term Need for LVC Is Not Universal

The key to efficient and cost-effective fielding of a capability is based in large measure on a clear understanding of requirements. Each of the four Marine Corps M&S communities use their M&S tools in unique and distinct ways to meet their mission requirements. As a result, the requirement each community has for LVC capability will vary. As discussed above, in the training community, it is easy to see that LVC will play an ever increasing role in supporting the training of Marines. However, the Marine Corps analysis community may not need the same level of integration of their M&S tools in the near-term.

For example, consider the Maritime Prepositioning Force Cycle Resource Forecast Model (MMC-RFM). This model helps identify the budgetary requirements associated with changing how many pre-positioned supply ships are available to the Marine Corps. The MMC-RFM requires data from data systems the Marine Corps no longer uses. Consequently, a new model that can use available data is being developed by Logistics Operations Analysis Division (LX), Headquarters Marine Corps (HQMC), Installations and Logistics (I&L). Kids don't get these kinds of headaches playing on the PlayStation® 4^{***}, but these sorts of challenges are basic facts of life for many military M&S users.

Because LVC, M&S, and data pose myriad challenges, users must be focused when they use such tools. If a tool is best used in relative isolation, then it probably should be used in relative isolation. Indeed, many M&S tools don't need to be a part of LVC. Some examples include the Combined Arms Analysis Tool for the 21st Century (COMBAT XXI) and the Synthetic Theater Operations Research Model (STORM), both of which are used by MCCDC's Operations Analysis Division (OAD).

Lieutenant Col. Dan Reber, the director of operations research at LX, HQMC, I&L, said analysts attacking logistics problems tend to have no need for LVC.

For example, when logistics analysts turn to M&S, they might use a tool such as the Combat Attrition Replacement Factor – Statistical Analysis Tool (CARF-STAT). This tool calculates how much equipment needs to be kept in reserve for certain types of Marine operations. A tool like this is very useful, but like the OAD tools cited above, probably doesn't need to be part of LVC.

^{***} PlayStation is a registered trademark of Sony Computer Entertainment, Inc.

And that is an important point. While LVC capability may enable the Marine Corps to integrate any number of M&S tools, not all tools need to be integrated. As a result, even though the Marine Corps analysis community is a heavy user of M&S tools, they likely will not need to be big players in the early stages of Marine Corps LVC.

Who's The Mastermind Behind All Of This?

When you talk about M&S, there's a tendency to think that the tool will do all the work for you. When you talk about LVC, there's a tendency to start hooking things together willy-nilly, without any consideration for the effort involved and the payoff that results. And when you talk about data, there's a tendency to believe that it's all there and that it can all be taken at face value.

All of those tendencies are bad tendencies. People with both knowledge and intelligence need to be steering M&S activities, especially LVC activities.

For example, M&S users in the Marine Corps experimentation community certainly have some tools they like to use. One is the Joint Conflict and Tactical Simulation (JCATS), which can represent troops, vehicles, and weapons. Another valuable tool for experimentation is Experimental Planning, Intelligence & Collaboration (EPIC), a constructive tool that can touch on both analysis and training issues.

But the tools probably aren't as important as the people, said Capt. Gabriel Diaz, the M&S officer at the Marine Corps Warfighting Lab (MCWL). When Futures Directorate hands MCWL a problem, Capt. Diaz said, MCWL has to be able to think broadly. It needs to look at top-level characteristics, e.g., consider the capabilities for a new vehicle. Then MCWL has to work with available tools and data to answer the questions that Futures Directorate posed.

So, Capt. Diaz continued, you want M&S personnel who are well educated. They need skills. "Analysis is still huge," he continued. There's a lot of "data crunching."

The Marine Corps can't just go out and "get some LVC." Educated, trained professionals must ensure that the Marine Corps approaches LVC wisely. To ensure that the Marine Corps has some officers who are properly educated about M&S, the Marines have the 8825 Military Occupational Specialty. Those Marines are graduates of the Modeling,

Virtual Environments and Simulation (MOVES) Program at the Naval Postgraduate School (NPS). To ensure the appropriate level and type of education for these Marines, MCMSMO recently completed a curriculum review for the MOVES Institute. One of the major additions to the program is the inclusion of hands-on LVC activities: e.g., planning, preparation, execution, and assessment.

Think of LVC Like Building A House

Just as Capt. Diaz believes that people who know what they're doing are the key to M&S activities in general (and to LVC activities in particular), so does Luis Velazquez, the deputy director of the M&S division for Systems Engineering, Interoperability, Architecture & Technology (SIAT) at Marine Corps Systems Command.

“When you go to build your house, you don't go talk to an electrician, you go talk to the general contractor,” said Velazquez. If you talk to a good contractor, you know that he'll find the right plumbers, electricians, brick-layers, and so forth.

Having a framework is the key to LVC, Velazquez said. Indeed, that's why SIAT has been so enthusiastic about the Framework for Assessing Cost and Technology (FACT). The idea behind FACT is to allow different users distributed across different locations to integrate their work in real time. For example, a systems engineer might look at design tradeoffs while a cost analyst looks at budgetary tradeoffs. If all the tradeoffs are modeled concurrently, then everyone involved is on the same page at the same time.

Velazquez has emphasized that FACT isn't a model – it's a framework.

And that's probably a good pitch to use for LVC, too – LVC isn't something unto itself, but it's an infrastructure that ought to make users more efficient as they pursue their daily responsibilities.

Building The Marine Corps “LVC” House

In order to better define the requirements, the unique problem space that the Marine Corps must operate within must be defined in a way that makes sense to Marines. Much like a house can be thought of as a collection of electrical systems, plumbing systems, air conditioning systems, etc., LVC for the Marine Corps can be decomposed into discrete

capabilities, organized into a collective framework, and analyzed for cross-system seams. Simply using “LVC” as a single word that invokes a universal panacea is not sufficient. The devil is in the details.

As discussed earlier, this paper does not seek to have a philosophical debate on a layman's understanding of what is “live” versus “virtual” versus “constructive” simulation. However, as one thinks about LVC and how the capability may evolve, it is likely the clear distinction between each element will become more opaque. For instance, imagine live, dismounted Marines on a training range using augmented reality see-through goggles to interact with a simulated, virtual world. This type of capability would certainly decrease the current frustration a squad feels when the range instructor informs them that they have all just been killed by a simulated artillery barrage that they never heard or saw coming. In addition, if the Marine Corps seeks to integrate live assets, such as aircraft and vehicles, planning must occur so platform sensors send and receive the necessary data to enable their integration with constructive and virtual assets without compromising the operator's safety. This paper could craft several, if not dozens, of other examples of how LVC capabilities will blend live, virtual, and constructive technologies. The point is not to provide an exhaustive set of use cases, but to demonstrate the challenge the Marine Corps, and all DoD users of LVC capabilities, face in understanding and scoping requirements to meet current and future uses. Compounding the problem is the fact that each community has its own hierarchy of intended uses. For the training community, TECOM arranges the training audience hierarchy as individual; collective and unit; and staff. These individual audiences are being brought together during combined training events, and each audience has its own competing priorities and requirements. Lastly, each M&S community has to define their hierarchy and clearly articulate what LVC capability is needed to accomplish their missions.

The final bit of added complexity is the nature of the Marine Corps, something that can be confusing to the uninitiated. The Marine Corps is the only service that must simultaneously operate in the land, air, sea, and cyber domains performing the functions of the Command Element (CE), Ground Combat Element (GCE), Air Combat Element (ACE), and Logistics Combat Element (LCE). To date, these challenges have been so daunting that few have tried to comprehend them. The result has been isolated, stand-alone M&S tools that perform very well for a specific use case. In the age when “smart interoperability” is required, Marine Corps planners are going back to

the basics taught in the Marine Corps Planning Process (MCWP 5-1). The first step is Problem Framing, which “enhances understanding of the environment and the nature of the problem.” The MCMSMO will produce a problem framing whitepaper as a way to synchronize the enterprise’s individual efforts that will be brought together in the appropriate ways to form the Marine Corps LVC House.

Who Should Lead The Capability Push?

LVC can be viewed as a capability or a service, which will require a large underlying infrastructure that will enable the Marine Corps to link our existing and future M&S tools and databases together where necessary. This is not without significant challenges, primarily in identifying requirements, programming for the necessary resources, and coordinating efforts to ensure all parties are in sync.

In some respects, the evolution of LVC requires a soft touch. In other respects, the evolution of LVC requires a robust framework. As an example of the soft touch, consider all the M&S in the status quo. Not all of that M&S needs to communicate with each other (or with other systems) in an LVC environment. So, in that sense, a little restraint guided by knowledge of legitimate, no-kidding requirements is in order. As an example of the need for a robust framework, consider the future. Whatever we do with LVC now needs to allow for breathing room down the road. The LVC ideas of 2015 and 2016 can’t be so rigid and small-minded that they block out unforeseen requirements and technologies that will undoubtedly enter the picture in the years ahead.

If the Marine Corps seeks to integrate live forces – real Marines, moving across real ranges, shooting at real targets – with synthetic virtual or constructive forces, a significant effort will have to take place to instrument our existing ranges and platforms to support this requirement. This has implications across the Marine Corps and coordination will have to occur from Headquarters Marine Corps to the Marine Corps base level. It is unrealistic to expect this capability to occur overnight, but if this vision is to be met it needs to be planned for now so our initial steps down the LVC path take us in the right direction.

Going in the right direction includes looking beyond just how LVC can support training. While training will be a significant user of LVC capabilities, and may very well lead the way, LVC capabilities can help support the full range of Marine Corps requirements. For example, many of the same capabilities needed to support the training of

Marines can be used to support the operational tests of new platforms. Networks needed to support integration of training systems can be used to support distributed joint wargaming and campaign analysis efforts. Analytical data models being stored in cloud-based servers can be shared by engineers, cost analysts, and research personnel using shared tools. While each community will always have their unique requirements, there are seams between our communities that need to be sealed to take full advantage of what LVC can bring the Marine Corps.

Identifying and filling these seams will be a MCCDC challenge. The technical and policy issues associated with aligning the various levels of fidelity and resolution of models, fielding the required network capability, addressing cyber security requirements, and associated range safety concerns, are not insurmountable, but will require a dedicated and persistent effort. Working with our Marine Corps M&S community leads as well as joint partners, we will establish an LVC capability based on coherent policy, common standards, and coordinated resources. By doing this, we will ensure that the Marine Corps is well positioned to take advantage of LVC so that real Marines, with real ammunition, will continue to win battles.

NOTE: Any reference, direct or implied, to a commercially available product, service, or software application is for illustration only, and is not a Marine Corps endorsement of that product or software

About the Author



Mr. Brett Telford is the Director of the Marine Corps M&S Management Office. He began working for the Marine Corps in 2007 following a 20 year career in the United States Air Force (USAF). In this capacity, Mr. Telford acts as the Marine Corps point of contact for the development of Joint and Service level M&S policy. In addition, he leads the Marine Corps M&S Integrated Product Team (IPT) that seeks to leverage activities across the fleet and improve the use of M&S throughout the Marine Corps. Mr. Telford entered military service in 1987 upon graduation from the USAF Academy. During his career he served in a variety of operational and program management positions ranging in scope from supporting wing level operations to the development of Air Staff budget submissions. As a certified Acquisition Professional Development Program (ADAP) Level III program manager he has led the development and fielding of classified aircrew trainers, constructive simulations, and engineering level models.

Army Modeling and Simulation Enterprise

By COL Joseph M. Nolan

Deputy Director
Army Modeling and Simulation Office (AMSO)
Fort Belvoir, VA

Modeling and Simulation (M&S) capabilities enhance the ability of the Department of Defense to meet strategic and operational challenges in a complex and fiscally constrained environment. The Army recognized the importance of M&S and developed a robust framework and governance structure to provide technology and capabilities to leaders and soldiers. The Chief of Staff of the Army and the Secretary of the Army signed the Army M&S Strategy in July 2014. The Strategy defines the Army's M&S vision and goals, underscored by strong management and governance processes and practices. As part of the Strategy, the Army's M&S Governance structure is currently evaluating priorities and gaining insights to guide implementation.

The Army's M&S Enterprise is composed of six communities that actively use M&S in their processes and activities. The six communities are: Acquisition, Analysis, Experimentation, Intelligence, Test and Evaluation, and Training. It addresses over 30 Programs of Record with resources directly identifiable in the Army Program Objective Memorandum (POM). Additionally, the Army M&S activities include hundreds of technology tools and resources embedded in over 100 Program Elements. While the Army Communities own their resources and requirements, the Army M&S Governance structure informs and synchronizes cross-community, intra-community, and cross-Defense issues (Figure 1).

Additionally, the Army updated their regulation on M&S Management, AR 5-11 on 30 May 2014. In the update, the regulation prescribes appointment of general officer or senior executive service lead for each of the six M&S communities. This advocacy, together with the governance structure outlined, has set up the management to execute the Vision and Goals of the Strategy.

One of the current efforts using the Army's M&S Governance Structure is the Live Synthetic Enterprise Architecture (LSEA). This endeavor is one example of how, through a governance process, M&S can provide capabilities to many communities in an integrated shared approach. The LSEA, with active participation

from the Army Modeling & Simulation Office, Army Operational Test Command, and the Program Executive Office for Simulation, Training, and Instrumentation addresses the requirements for interoperability, reuse, adaptability, and net-centric data exchange for effective synchronization of acquisition efforts across the Army. The LSEA conceptual framework evaluated common interests with an opportunity to inform efficiencies. These include Live-Synthetic M&S capabilities, Service-Oriented Architecture, Mission Command System M&S interface, interoperability, Common Operating Environment compliance, and geospatial information.

In the past year, the M&S Governance bodies have been actively involved in cross-Army efforts on the Live-Synthetic Training and Test and Evaluation (LSTTE) Enterprise Architecture proof of concept to the LSEA. The LSTTE-Enterprise Architecture is developing the reference architecture, business model, and governance structure necessary to enable sharing of common services and capabilities via service-oriented-architecture. It is essential for building interoperability and common operating environment compliance into material solutions of the future.

The initial focus is on Training and Test & Evaluation communities, but many federates and tools are leveraged by, or derived from, other M&S communities.

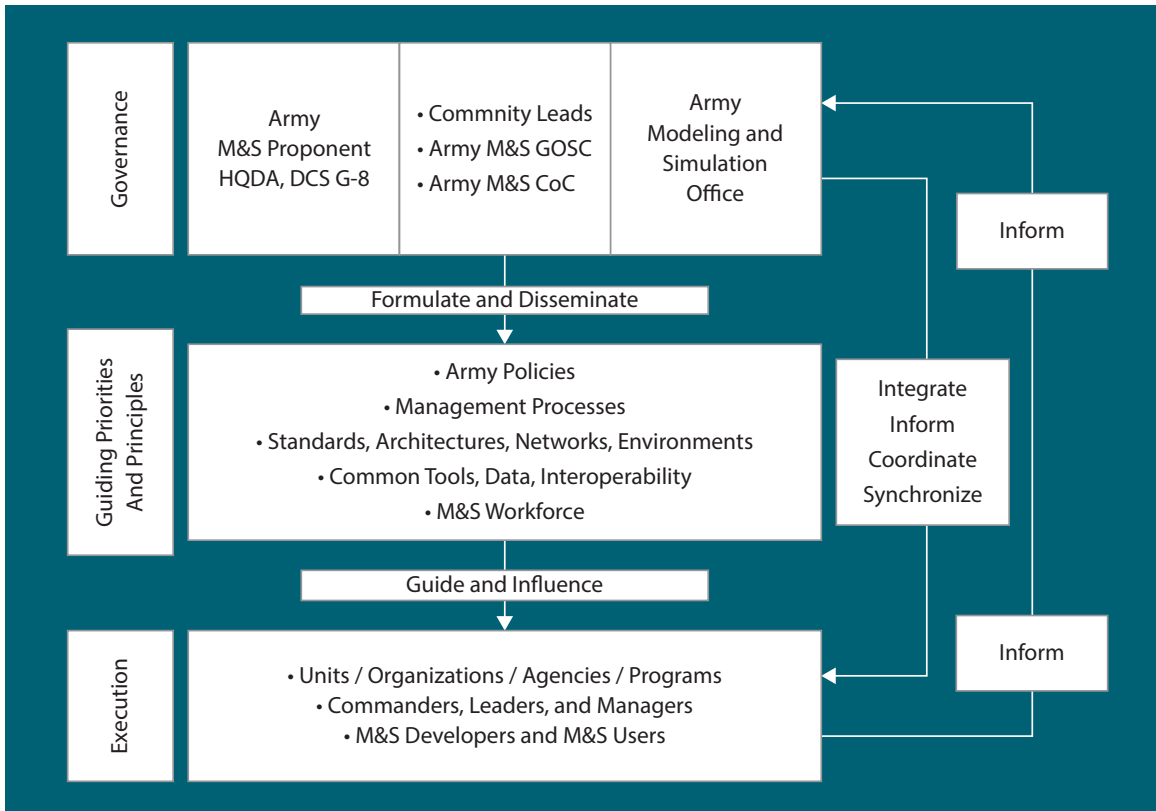


Figure 1. Army M&S Governance Structure

The M&S Governance conducted an M&S Capability Portfolio Review to provide a holistic review of the Army M&S Enterprise, strategy, resourcing, and priorities. Though M&S is not considered a Portfolio, rather it is a cross-cutting capability that spans other portfolios, this framework was helpful to provide priorities to guide Army M&S Strategy Implementation activities, and will inform the Army POM for 2018.

All six of these communities were represented in the first Army M&S Capability Portfolio Review (CPR). The CPR identified an initial baseline of nearly 400 Army M&S tools in active use across the Army, including 48 Joint Defense tools and 22 Commercial-Off-the-Shelf products. Another significant outcome of the CPR was identification of common gaps across the Enterprise that provide focus for near-term investment and cross-community solutions. Not surprisingly, these gaps echo some of the Defense priority areas for M&S as discussed at the Training and Simulation Industry Symposium. The 2015 M&S CPR Cross-Community Gaps are: Cyber; Network Modeling; CBRN; Intel Environment; Terrain; Sensor; Resourcing; and Workforce Training. Many of the issues revealed in these gaps are expected to be addressed in the M&S Enterprise

Architecture plan to be published in 2016. Other gaps will be addressed in the Draft M&S Data Strategy, being developed now. The CPR addressed each gap in terms of Issues; Community Impacts; Current Efforts; and Way-ahead.

As an example, Cyber Gaps are an immediate priority. The Army, along with other Defense agencies, needs to develop M&S capabilities to replicate cyber and its impacts in various models and simulations; to include impacts on aggregation at higher levels.

The Army has current efforts that will mitigate aspects of these gaps. The DoD Cyber Strategy (April 2015) directs the establishment of an enterprise-wide cyber modeling and simulation capability. There are also some Army efforts for Corps and below, and the Army’s inclusion in a broader DoD effort for Cyber Test Analysis and Simulation Environment Program. The Army’s M&S Enterprise Architecture plan (anticipated in 2QFY16) is expected to establish policies and standards that will update the current practices to include cyber. Of course, the issues raised are bigger than Army M&S, but the work being done now can be leveraged to affect other requirements.

Similar top-level assessments address the other gaps in areas of Network Modeling; Terrain; Chemical, Biological, Radiological, and Nuclear Defense (CBRN); Fires and Effect; Intel Environment.

The CPR Framework established the need for collaboration among the communities for current network modeling efforts. The M&S Governance structure is a reasonable mechanism that can develop and provide improved policies and standards to the Army's M&S Enterprise Architecture plan (anticipated in 2QFY16).

The Army is currently drafting an M&S data strategy that is needed by all six communities and is a priority for the Army. Managing data and providing timely and effective access to the broad range of type, use, content and resolution will require cross-community coordination. The M&S Governance structure is ideal to leverage and advance the many capabilities and technologies that impact data and data products.

The Army is building a plan of action that will help reduce the time to prepare data products; minimize costs to produce integrated data products; improve the quality of data and products; and coordinate data initiatives. Many of the data and data products already exist in some form, however, investment is still needed to migrate those tools and services into available, multi-use tools and services. Other capabilities will require development and coordination to meet the vision and goals of the M&S data strategy.

Summary

In the past year, the Army has embraced a new M&S Strategy and is working on viable implementation actions across all six M&S communities. The Governance structure if functioning well has leadership advocacy to ensure cross-Army involvement in executing the priority actions. Laying the groundwork in the Live-Synthetic Enterprise Architecture, the Army M&S Enterprise endorsed the requirements for interoperability, reuse, adaptability, and net-centric data exchange for effective synchronization of acquisition efforts across the Army.

The M&S Governance bodies have made progress toward the Enterprise goals in developing the M&S data strategy, conducting the M&S Capability Portfolio Review, and partnership of the M&S communities in the Live-Synthetic Training and Test and Evaluation (LSTTE) Enterprise

Architecture and Infrastructure Architecture. These initiatives will be the basis for further cross-Army efforts in creating efficiencies and effectiveness critical to posture the Army for mission success.

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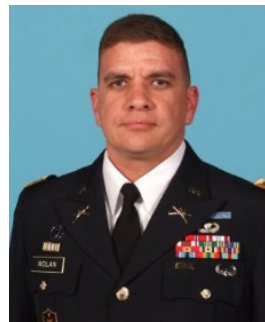
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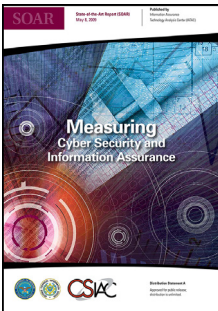
COL Joseph Nolan serves as the Deputy Director of U.S. Army Modeling and Simulation Office (AMSO) which includes Army enterprise-level M&S policy and strategy (Strategy and Resource Division), and M&S workforce development and management (Simulation Proponent Division).

COL Nolan returns to CAA with over 23 years of military service, most recently as the Chief of Simulations, U.S. Air Force Central Command's Integrated Air and Missile Defense Center, Al Dhafra Air Base, UAE. He has served in various operational positions including infantry platoon leader, mortar platoon leader and battalion S4 with 5-87 IN(L) - Panama, BDE AS4, Infantry & HHC Company Commands with 3 BDE, 3 ID(M) – Fort Benning, GA. His staff assignments include U.S. Joint Forces Command where he served as an exercise planner and Chief – Joint Advanced Training Technology Laboratory – Suffolk, VA and HQDA as the FA57 Proponent Officer - Fort Belvoir, VA. His awards and decorations include BSM, EIB, Basic Parachutist and Air Assault badges, and the Ranger Tab.

COL Nolan graduated from the University of Detroit-Mercy Army ROTC program in 1993 with a BA in Political Science. He holds a Masters of Modeling, Virtual Environments and Simulations from the Naval Postgraduate School. He is a graduate of the U.S. Army Infantry Basic and Advance Courses, the U.S. Command and General Staff Course, the U.S. Army War College as an Old Dominion University Fellow, and Functional Area 57 Qualification and Advanced courses.

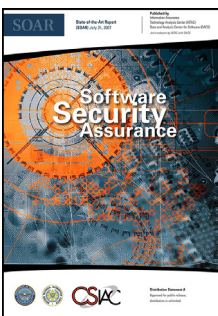
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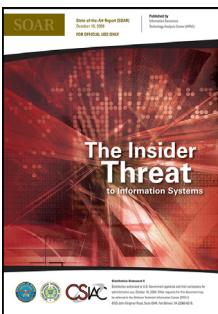
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Rediscover the Defense Modeling & Simulation Catalog

By Hart Rutherford and Frank Mullen

SimVentions, Inc.
Fredericksburg, VA

This paper first appeared at MODSIM World 2015 and was published by the National Training and Simulation Association (NTSA)

The new Defense Modeling & Simulation (M&S) Catalog, which achieved full operational capability in November 2014, represents a complete hardware, software, and conceptual upgrade from its predecessor. Based on operational and maintenance experience with the previous version of the Catalog, combined with considerable input from users, the Defense Modeling & Simulation Coordination Office (DMSCO) initiated the upgrade in 2013. The result is a far more capable and user-oriented system designed to advance DMSCO's aim of achieving the goals of the Department of Defense (DoD) Net-Centric Data Strategy [1]. These include making data products visible, understandable, trusted, and accessible by "authorized but unanticipated users." The design of the new Defense M&S Catalog makes these goals achievable.

The previous version M&S Catalog was a proof-of-concept system that, because of its initial success, was adopted as an interim operational product. It continued in regular use for nearly three years, but it was apparent that long-term sustainment would require system upgrades and capability enhancements. Maintenance of the Catalog had become problematic. Support for the commercial software at the heart of the system began to decline and eventually became unavailable after the original vendor was acquired by a competitor. Of equal concern was that the server on which the Catalog was hosted in the Pentagon had reached the end of its service life and was to be retired without replacement.

Feedback from Catalog users indicated other necessary changes. Users wanted a less complicated search interface, one that was more intuitive and required no special knowledge of the organizational plan (the "schema") of the metadata. (Metadata is descriptive information concerning, in this context, an M&S data product such as a computer model.) Because of limitations in the Catalog software, support personnel were unable to make the desired interface modifications.

In addition, organizations that regularly contributed or updated metadata records to the Catalog wanted to have full control of those records—to publish them to

the Catalog when they were ready, to retract them when obsolete—without requiring intervention from the Catalog support staff. As the previous Catalog was configured, it was necessary for the support staff to perform manual transformations on all incoming metadata before it could be published. Retracting metadata records from the Catalog could also be done only by the support staff. Commercial online transactions today are routinely conducted without humans other than the user involved. Defense M&S Catalog users wanted similar levels of automation and convenience.

Finally, for DoD organizations to place full confidence in the Defense M&S Catalog, it had to comply with expanded information assurance (IA) requirements. The previous version of the Catalog did not fully comply, and while this defect was not entirely a consequence of the hardware and software deficiencies described above, it made sense to remedy the IA problem while implementing the necessary hardware and software upgrades.

Upgrading the Defense M&S Catalog

Objectives for the current Defense M&S Catalog were to provide users updated, intuitive interfaces for searching and publishing metadata on upgraded and sustainable hardware and software, compliant with DoD IA requirements, and

available via the DoD's Nonsecure Internet Protocol Router Network (NIPRNet) in the "dot-mil" domain.

New commercial servers were acquired as part of a routine hardware refresh for DMSCO's M&S Core Tools Suite [2] in early 2013. Requirements gathering for the software components of the current version of the M&S Catalog began during the autumn of 2012. This was followed during the subsequent winter and spring of 2013 by an analysis of alternatives (AoA). This consisted of an expert panel of government and government contractor technical personnel conducting interviews with prospective software vendors and comparing capabilities against a matrix of requirements. Numerical grades were assigned based on compliance with the various requirements, and these were aggregated to determine the most suitable solution.

In May 2013 the selection panel presented its findings and recommendation to the DMSCO Director, who concurred and ordered that development begin immediately.

System Description

The Defense M&S Catalog constitutes a key component of the data management concept envisioned in the DoD Net-Centric Data Strategy within the DoD M&S communities. It serves as a repository of metadata about M&S products—models, initialization data, output data, user notes, etc.—sufficiently detailed that users other than the originators can discover the existence of, evaluate the utility of, gain access to, and reuse those products. The objective is to enable authorized but unanticipated users of M&S data products to leverage investments of time and funds made elsewhere in the Department—a process termed "discovery and reuse"—in order to accelerate decision cycles, increase efficiency, avoid unnecessary costs, and improve interoperability.

Users

The intended users of the M&S Catalog are organizations and individuals whose duties involve the creation, maintenance, or use of M&S data products for DoD missions. Because M&S is used throughout the DoD in support of operations, training, program and system analysis, acquisition, and other activities, no specific bounds are placed on the organizations or individuals within the Department who may gain access.

Access is controlled differently depending on the user's role—whether the user merely searches the Catalog's records or, in addition, is a registered user, or is a member of a source-

contributor organization. Various levels of access are controlled as part of the Catalog's information assurance regimen.

Information Assurance

The Catalog system complies with the Defense Information Assurance Certification and Accreditation Process (DIACAP). In addition to DIACAP activities, tasks, and management practices, the Catalog has additional business rules designed to enhance its IA posture. Access to the Catalog is controlled by Common Access Card (CAC) or equivalent certificates obtained from an External Certification Authority (ECA) [3]. All CAC or ECA certificate holders may access the Catalog for the purpose of searching its holdings. Publishing to the Catalog is more restricted, however. To publish M&S metadata records to the Catalog, the user's organization must be registered with the Catalog system administrator as a source contributor, and the user must be indicated by the source contributor organization as an authorized publisher.

To make its holdings as broadly available as possible within an IA-compliant environment, the Defense M&S Catalog is available via NIPRNet (<https://mscatalog.msco.mil/>). All metadata in the Catalog is unclassified (though it may describe classified M&S products as long as the description remains unclassified).

System Components

Major system components of the Defense M&S Catalog are shown in Figure 1.

- The DoD M&S Catalog block contains the commercial cataloguing software providing metadata indexing, storage, search, and retrieval capabilities. It also manages the web-services that enable data and metadata transfer among system elements.
- The Enterprise Metacard Builder Resource (EMBR) block is an integrated user toolkit that enables local management of user-controlled M&S metadata. Tools include a menu-driven metadata record ("metacard") builder, a locally-controlled database to store metacards and associated M&S data products, and a locally-controlled publishing option to send metacards from the originator to the M&S Catalog for department-wide visibility by authorized but unanticipated users.
- The Federated Search blocks represent other DoD catalogs and data repositories that the Defense M&S Catalog can search at a user's option. Shown here as

currently working examples are the DISA Enterprise Catalog and the Defense Technical Information Center (DTIC) publicly available holdings.

- The User Systems block represents repositories of M&S metadata created and stored locally by M&S Catalog user organizations. Data transformations make it possible for such systems to publish their metadata holdings to the M&S Catalog. This is an option available to user organizations and is not mandatory.
- The Catalog Users block represents individual users and user organizations in several modes of interaction. These include conducting searches of existing M&S metadata in the M&S Catalog; conducting broader federated searches of other catalogs and repositories; creating M&S metacards using the EMBR toolkit; and managing user-controlled M&S metadata or data products in the user-controlled partition of the EMBR database.

Deployment Concept

The Defense M&S Catalog and its integrated EMBR capabilities are hosted at a central computer facility. User organizations who become contributors to the M&S Catalog are assigned a logical partition of the EMBR database, and this partition remains under their local control. With the integrated tools, this partition becomes the contributing organization's work area for the purpose of managing M&S metadata and data products and collaborating among the organization's M&S practitioners. At the option of the local organization, metacards can be published to the M&S Catalog, becoming discoverable from there throughout the DoD.

Experience has shown that where the anticipated benefits of discovery and reuse have been best realized is among M&S practitioners who share a common understanding of a related family of systems or who share common technical methodologies. These conditions are most commonly found within organizations whose M&S activities are focused either on related systems, related technical methodologies, or both. Examples include Program Executive Offices, Defense laboratories, training centers, and so on.

For this reason the M&S Catalog deployment concept is designed to deliver value to local user organizations such as these. The EMBR toolkit integrated with the M&S Catalog was originally designed for, and was initially used by, just such organizations for the purposes of creating, modifying, and storing metacards, managing M&S data products, and collaborating among M&S practitioners within those organizations. These are the elements of successful discovery and reuse.

Integration of EMBR as a component of the M&S Catalog enables a two-component concept of operations known as "local management, enterprise discovery." The EMBR toolkit delivers intrinsic value to local user organizations in the form of information management tools to immediately enable local discovery and reuse. The intrinsic value of the tools is alone incentive for organizations to adopt them. At the same time the M&S Catalog provides free, redundant, and fully IA-compliant backup for the local organization's metadata records. The marginal cost for an organization to publish its holdings to the M&S Catalog, and thus make them discoverable enterprise-wide, is near zero: it is a matter of a few mouse clicks.

Thus the Defense M&S Catalog deployment concept is to establish and grow a constellation of M&S practitioner organizations all benefiting individually from the immediate

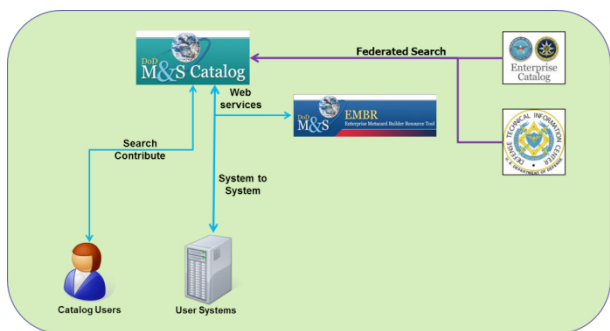


Figure 1. Defense M&S Catalog System Components

The M&S Catalog re-indexes its metacard holdings hourly. New metacards submitted by users for publication in the M&S Catalog will be discoverable by all other authorized users generally within an hour.

Metadata records created using the EMBR toolkit conform to the Modeling & Simulation Community of Interest Discovery Metadata Specification (MSC-DMS) [4], an extension of the Defense Discovery Metadata Specification (DDMS). While conforming to DDMS, MSC-DMS includes additional descriptive elements particular to the M&S Community of Interest, such as fields to describe the Verification, Validation, and Accreditation (VV&A) status of a product. This provides more relevant information for M&S practitioners than is available from DDMS alone.

value of the EMBR toolkit, and all selectively publishing their records to the M&S Catalog in order to gain the benefit of free, IA-compliant, redundant storage. As the number and variety of the contributing organizations in the constellation grows, it becomes more likely that individuals or groups of M&S practitioners in one organization will share an understanding of similar systems or common technical methodologies with those of other organizations. In this way it is anticipated that the benefits of discovery and reuse can be propagated from the local level to the enterprise level.

The M&S Catalog deployment concept is illustrated in Figure 2.



Figure 2. Deployment Concept

Organizational Considerations

Adoption of the Defense M&S Catalog as an information management tool within an organization requires no additional personnel and no advanced training. Modeling & simulation practitioners typically have sufficient computer skills to exercise the Catalog’s capabilities with only slightly more than the amount of familiarization typical for general-use software. Catalog training materials are available online, and a help desk is available for particular needs.

Adoption of the Defense M&S Catalog requires no organizational changes. However, adoption has been found to sometimes prompt organizational modifications in order to take best advantage of the benefits of local management. The particular modifications are at the discretion of the adopting organization and will vary depending on size, scope of M&S activities, and a variety of other factors. As an example, Figure 3 is a schematic of the internal establishment of an M&S integrated product team (IPT) by a Program Executive Office that was an early adopter.

The role of the IPT is coordination among the elements of the organization. It conveys the Program Executive Officer’s intent to achieve internal savings through discovery and

reuse, elimination of duplication of effort, and other means, so that savings in one element can be redirected to emerging needs in another. The management and collaboration tools available in the EMBR component of the M&S Catalog provide the technical means to gain visibility into how M&S assets are being used across the organization, thus giving the IPT members the ability to discover opportunities for cost savings and other improvements in efficiency.

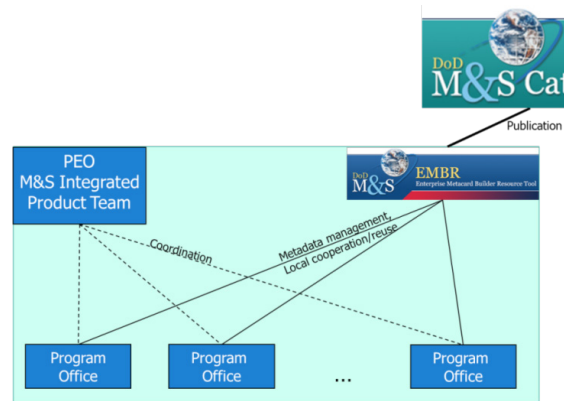


Figure 3. Organization of an M&S IPT

User Features

There are many new features that Defense M&S Catalog users will find useful and convenient. The two most apparent and perhaps consequential are the revised user interface and the capability to create and publish metacards directly from the user’s desktop.

User Interface

The user interface of the previous version of the M&S Catalog was relatively complex and could not be simplified due to limitations in the software. It essentially presented the user with a menu comprising nearly the entire metadata schema, scores of terms from which the user could select. There was also a simple keyword search pane, but the “real estate” of the screen was so dominated by the array of terms from the metadata schema that first-time users were generally overwhelmed and hesitant to proceed.

The new user interface is similar to internet search engines available online and with which everyday users are familiar. It is a simple keyword search pane. Typing one or several keywords and pressing “Enter” is all that is required. The Catalog searches its records for each instance of the keywords and returns the appropriate records, just as internet search engines do. There are additional features for more experienced users to narrow search results, but to get started using the Catalog requires no more computer

expertise, no more modeling and simulation experience, and no more knowledge of metadata schema than ordinary computer users these days already possess. Figure 4 shows the home page of the new Defense M&S Catalog.

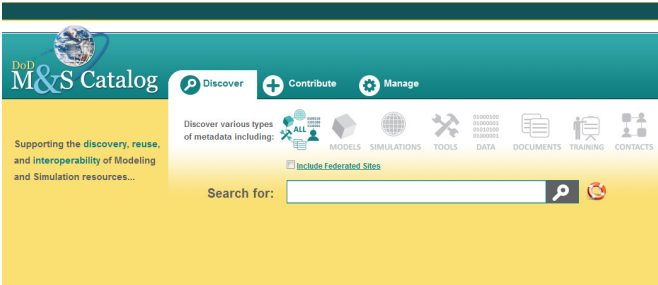


Figure 4. Defense M&S Catalog Home Page

Metacard Builder

Among the features most requested from users during the requirements gathering phase for the new Catalog was the ability to create and publish metacards without intervention of the Catalog support staff, as was previously required. This has now been achieved by integrating into the Catalog a suite of tools called the Enterprise Metacard Builder Resource (EMBR). The EMBR tools are accessed by opening the “Contribute” tab on the Catalog home page. Full instructions are included in the User Guide (see “Additional User Resources,” below), but many users find they can perform basic EMBR operations intuitively.

Among those is creation of a new metacard. The EMBR tool that facilitates this is a simple on-screen template similar to many such templates in common use today by internet businesses. Required fields are marked with an asterisk and, when appropriate, fields are equipped with drop-down menus. The number of required fields is small—only seven—so that a valid metacard can be created in just a few minutes.

When complete, simply pressing a “Save” button puts the metacard in the user’s local EMBR library. The resulting metacard is automatically created in MSC-DMS without requiring the user to know anything at all about metadata schema. Figure 5 shows the top portion of the online metacard builder form.

Local Management of Metacards

Once created, metacards reside in the local user’s organizational partition of the EMBR database and are visible to other users in the local organization, but they

are not yet visible throughout the DoD via the Catalog. Publication of metacards to the Catalog, allowing them to be discovered throughout the Department, is at the discretion of the user organization; the Catalog does not “crawl” the EMBR database looking for new metacards.

When the originating organization decides to publish metacards to the Catalog, this is very simply achieved from the EMBR home page by selecting a check-box next to the metacard title and clicking a “Publish Resource to Catalog” link. Within an hour the metacard will appear in the Catalog holdings and is visible by all other Catalog users.

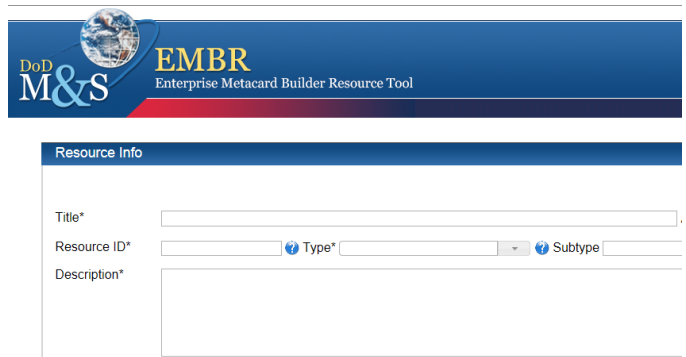


Figure 5. Metacard Builder

Additional User Resources

The Defense M&S Catalog is located at <https://mscatalog.msco.mil>. It is accessible by all CAC and ECA certificate holders. Becoming a registered user is not required, but some advanced Catalog search features, such as saving search parameters and subscribing to regularly updated search results, are available only by becoming a registered user. Registration is automated, easily accomplished via links on the Catalog home page, and requires no more personal information than is already contained in the CAC or ECA certificate.

An online User Guide is accessed from the Catalog home page by pressing the life ring icon to the right of the keyword search pane (see Figure 4). For particular questions or detailed help, or to register as a source contributor, send e-mail to the Catalog Help Desk (MSCatalogHelpDesk@MSCatalog.msco.mil).

Sustaining a User-Oriented M&S Catalog

While the Defense M&S Catalog has achieved full operational capability, it is not a static system. To ensure the Catalog remains responsive and valuable to its users, DMSCO will convene a Defense M&S Catalog User Group in early 2015. The User Group’s role will be to recommend

to the DMSCO Director capability enhancements, business rule modifications, and similar technical or procedural changes that maintain or increase the Catalog's usefulness to the M&S Community of Interest in an environment of rapid technical and organizational change.

In addition to periodic formal meetings of the User Group, an online page has been established to enable users to interact with, and provide feedback to, Catalog management, development, and administrative staff. This online forum, similar in appearance and in function to popular social media sites, is hosted on DTIC's R&E Gateway and is known as DoD TechSpace. The Defense M&S Catalog User Group's page (<https://www.dtic.mil/REGateway/groups/defense-modeling-simulation-catalog-users/>) contains useful documents, such as the Catalog User Guide and the Concept of Operations, and allows users to engage Catalog developers or other users directly through easy-to-use text panes.

With new hardware and software, new tools and the new deployment concept enabled by them, and with plentiful means for users to contribute to future development, the Defense M&S Catalog will make efficiencies through discovery and reuse possible for years to come.

Acknowledgements

The authors wish to thank the Defense Modeling & Simulation Coordination Office for promotion of the goals of the DoD Net-Centric Data Strategy within the Modeling & Simulation Community of Interest and for continued advocacy of the Defense M&S Catalog. We also gratefully acknowledge the collaboration of the University of Central Florida Institute for Simulation & Training as co-developers of the modern Defense M&S Catalog.

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- [1] Stenbit, John P., DoD Net-Centric Data Strategy, DoD Chief Information Officer memorandum, May 9, 2003
- [2] The M&S Core Tools Suite comprises the Defense M&S Catalog, the Enterprise Metacard Builder Resource (EMBR), the Project Management Tool (PMT), the Verification, Validation, and Accreditation Documentation Tool (VDT), and the Standards Vetting Tool (SVT). The M&S Core Tools Suite is maintained by the University of Central Florida Institute for Simulation and Training (UCF-IST) under a DMSCO-funded contract.
- [3] Details on the External Certification Authority Program are available at <http://iase.disa.mil/pki/eca/>.
- [4] The Modeling & Simulation Community of Interest Discovery Metadata Specification (MSC-DMS), ver. 1.5 (<https://www.csiac.org/sites/default/files/standards/DoD%20M&S%20COI%20Discovery%20Metadata%20Spec%20%282010%29.pdf>) MSC-DMS ver. 1.5 conforms to DDMS ver. 4.1, the version currently mandated in the Defense Information Technology Standards Registry (DISR). Initial planning is in process to update MSC-DMS in the event that the recently developed DDMS ver. 5.0 is mandated in the future.

About the Authors



Hart Rutherford is the Modeling & Simulation Program Manager at SimVentions where he leads a team with broad experience in developing tools and strategies for M&S resource management. Mr. Rutherford has over 20 years of professional experience as a combat systems engineer and program manager including technical leadership of software development and M&S for U.S. Navy surface ship programs. Over the last 5 years in support of the Department of Defense Modeling & Simulation Coordination Office (DMSCO), he and his team have developed new operational concepts and deployed new M&S metadata standards and tools to increase the efficiency of M&S reuse throughout the DoD. His team is the co-developer of the new Defense M&S Catalog and provides ongoing technical support. Mr. Rutherford's military background includes active duty service in the United States Navy. He holds a Master's degree in Systems Engineering from Old Dominion University and B.S. in Computer Information Systems from Chapman University.



Frank Mullen is a senior scientist at SimVentions and was previously an associate director at the Defense Modeling & Simulation Coordination Office where he contributed to development of the Defense M&S Catalog. He gained over twenty-five years of defense-related engineering and management experience at the Charles Stark Draper Laboratory in Cambridge, Massachusetts, where he specialized in integrated circuits and microwave devices, and contributed to development of tactical and strategic guidance systems. Mullen is an alumnus of the US Coast Guard Academy, the US Naval War College, Defense Acquisition University, and the California Institute of Technology. He holds degrees in electrical engineering and physics.

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CONTACT INFORMATION:

CSIAC

100 Seymour Road Suite C102
Utica, NY 13502
Phone: (800) 214-7921
Fax: 315-351-4209

Michael Weir, CSIAC Director
John Dingman, Managing Editor
Email: info@csiac.org

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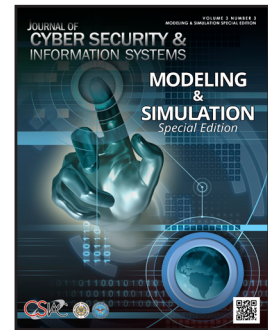
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