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June 2018



IDA Document NS D-9156
Log: H 18-000264

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**About This Publication**
This work was conducted by the Institute for Defense Analyses under contract HQ0034-14-D-0001, AI-8-4470, "Support to the Defense Modeling and Simulation Coordination Office" for the Director, DMSCO. The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.

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## ABSTRACT

Modeling and simulation (M&S) capabilities continue to grow within the Department of Defense (DoD), including expansion into novel areas. This evolutionary process invariably exposes some capability shortfalls where the technologies, policies, and/or personnel resources are insufficient to meet all demands, creating "gaps" in the spaces addressed by M&S capabilities. Several successful programs have established processes to understand these gaps and work towards their remediation. In recent years, there has not been an analogous DoD-level gap management framework, and nothing has existed to either provide an understanding of DoD-wide efforts in this area or to remediate emergent gaps. Instead, the DoD has relied on efforts and improvements made at the level of the M&S capability owner and user. This is a viable approach when the DoD use of the M&S capabilities is similar to original intent, but DoD-level adaptations often seek to extend M&S applications beyond those bounds. Additionally, a different class of gaps emerges when requirements at the DoD level dictate combining M&S capabilities in new ways to achieve a more complete representation of the full joint battlespace.

This paper describes a new Defense Modeling and Simulation Coordination Office (DMSCO) study for identification, prioritization, cataloguing, and remediation of M&S capability gaps with emphasis on those that impact M&S use at the DoD level. Current efforts to manage capability gaps that have proven valuable for other organizations are reviewed to understand their keys to success. The most successful characteristics (including securing community buy-in) are enumerated and the process of adapting these for application in the DoD M&S context is explained. The paper continues with a description of a first-year prototype evaluation, conducted through a process of stakeholder review and comment, and culminates with an explanation of how the revised DMSCO framework could be applied in other areas.

## ABOUT THE AUTHORS

**Frank Mullen** is a U.S. Coast Guard veteran and is currently on the research staff of the Institute for Defense Analyses. Prior to that he was for many years on the technical staff of the Charles Stark Draper Laboratory in Cambridge, Massachusetts, where he did research in solid-state physics, radio-frequency devices, and precision targeting. While at Draper, Mullen served a temporary assignment as an associate director at the Defense Modeling and Simulation Coordination Office (DMSCO). He is an alumnus of the U.S. Coast Guard Academy, the California Institute of Technology, and the U.S. Naval War College.

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## THE NEED FOR ENTERPRISE M&S GAP MANAGEMENT

Modeling and simulation (M&S) capabilities are continuing to improve and expand within the Department of Defense (DoD), as they must to keep pace with the evolving threat environment that faces the defense establishment. The process of M&S evolution invariably includes some capability shortfalls where the technologies, available funding, policies, and / or personnel resources are insufficient to meet all demands, creating "gaps" in the spaces covered by M&S capabilities. Some gaps are glaringly obvious while others are more subtle and require substantial analysis to become evident. However, the effectual significance of any individual gap is not directly related to its ease of identification; there are very subtle gaps that can invalidate M&S results.

This paper is focused on analyzing the gaps encountered by the Military Services and Combatant Commands and developing a framework and process to identify capability gaps that exist within the M&S capabilities across the DoD. Individual services and agencies within the Department have active efforts to identify, prioritize, and remediate shortfalls in the M&S programs and capabilities they own. The framework described herein must maintain visibility over all such efforts and use the information they offer to synthesize a Department-wide assessment of M&S gaps, their priorities and the status of each. An important capability of the framework is to support assessment of potential M&S gaps at the federated system level, which occur when individual service-owned M&S capabilities are joined together to represent the more complete joint environment typically necessary to address Department-level requirements. Some gaps may only exist at this level, and these are less likely to be discovered during the M&S capability owner's gap identification and remediation efforts since those efforts are primarily directed at their individual capabilities.

Other classes of gaps exist, including those identified within NATO and those that involve infrastructure (e.g., communication architectures such as the High Level Architecture -HLA). Further, there are unsolved problems for the M&S community (e.g., semantic interoperability, effective data sharing and reuse) that also represent gaps in capability. Some aspects of the current policies, oversight, and security requirements can also be seen as gaps that impact the M&S capabilities.

In addition to providing Department-wide visibility resulting in data to support further analyses, the framework process must also be inherently repeatable. Without repeatability, this effort is little more than a data call. With repeatability, the process can be used to inform Department leadership on the limitations of the supporting M&S capabilities and provide them with an opportunity to influence the remediation process. Almost all M&S capability available to the Department resides within the services and agencies. In this environment, repeatability implies the need to incentivize the M&S capability owners, not only to provide their own assessments of gaps, but also to participate in the discussion and analysis of joint-level gaps and to effect improvements that can reduce those gaps. Clearly, this places addition burden on the M&S capability owners, including some that they have not been funded to support. Thus, a framework that includes a repeatable process must address the need to provide the supporting M&S capability owners with a favorable return on their investment.

## CURRENT METHODS OF M&S GAP MANAGEMENT

In the early phase of the present effort, researchers queried nearly two dozen M&S organizations, most but not all of them in the DoD, regarding whether or not they had a process established to identify, validate, prioritize, and close M&S capability gaps. While all the organizations had encountered M&S gaps that could not be addressed at the program level, most had no documented, recurring process. In some cases, a process existed but was incomplete in that it identified M&S gaps and forwarded them to higher authority, but there was then no dedicated mechanism to

remediate the gaps. An example is Combatant Command Integrated Priority Lists (IPLs). Combatant Command staff can identify M&S gaps and raise them through Joint Staff procedures, but in the case of M&S gaps, there is then no established forum or process to systematically track and remediate the gaps.

Organizations that did have established M&S gap-management and remediation processes included the Air Force Agency for Modeling and Simulation (AFAMS), the Army Modeling and Simulation Office (AMSO) and the Test Resource Management Center (TRMC), an organization under the Office of the Under Secretary of Defense for Research and Engineering. AMSO's documentation is the more widely available so will serve as an example.

AMSO's M&S gap analysis process functions in the manner of the Army's Capabilities Portfolio Reviews (CPR) (Traylor, 2016). AMSO organizes and conducts an annual M&S Forum to investigate and refine M&S gaps across eight working group areas (Terrain, Fires, Intel, Sensor, Chemical Biological Radiological and Nuclear (CBRN), Cyber, Network, and Data). The working groups detail the gaps, research existing tools and capabilities, then crosswalk the gaps against the capabilities. After each working group refines and prioritizes the gaps, the Army M&S Council of Colonels prioritizes gaps and recommends selected gaps to the Army M&S General Officer Steering Committee (M&S GOSC) for remediation.

A similar structure for M&S gaps that exist across Services, or Combatant Commands, is not established at this time. Such a process would require funding and advocacy and would need to exist in both classified and unclassified forums.

## CHARACTERIZATION OF M&S GAPS

### Taxonomy of M&S Gaps

From the organizations that collected gaps, a catalogue of 250 representative capability gaps was assembled to understand the various gap management processes throughout the Department and within NATO. The gaps were originally recognized and maintained by several separate organizations, so the individual gaps exhibit a wide disparity in format and granularity. Two different taxonomies are used to help ease the burden of assessment, given the diversity in gap descriptions. The first taxonomy is designed to correlate with the principle components necessary to conduct a simulation event. The second is designed to help understand the type of resource necessary to begin remediation of the gaps. We note that many individual gaps could have been associated with more than one category in either taxonomic scheme. In all cases, gaps were associated with the category that appeared most relevant or predominant. While this was a subjective determination, the results of using this scheme provided useful information.

The first taxonomic organization scheme, aligned with the major components of conducting a simulation event, helps in understanding what portions of the event will be impacted. The categories in this scheme are described in Table 1 below.

**Table 1. Functional Area Taxonomic Scheme**

| Category Name | Category Description | Example Gap in this Category |
|---|---|---|
| Modeling the Environment | Shortfalls in representing a specific component, interactivity, or characteristic of the physical environment in the simulation environment | "There is no standard format for environmental representation (run time, across different systems)" |
| Simulation entities/platforms | Shortfalls in accurately modeling actors necessary to support a simulation event | "Aircraft do not get contaminated when flying through a CB contaminant" |
| Modeling human behavior | Shortfalls in the fidelity or accuracy of modeling human activities and/or individual behaviors | "Requirements for organizational and societal models are lacking. These requirements must span blue, red, and gray" |
| Infrastructure/equipment | Shortfalls in the physical or material support necessary to conduct a simulation event | "There is no consistently applied integrated architecture for linking LVC environments to achieve technical interoperability" |
| Multi-system interactions | Shortfalls that arise from combining and interacting between multiple simulation systems in a single event | "No easy/fast way to integrate Air Force simulations with Army (land) simulations" |
| Functional area | Shortfalls that arise in modeling operational areas (cyber, fires, etc.) not specifically named in other categories | "There is limited LVC functionality to stimulate space systems" |

| | | |
|---|---|---|
| C3I | Shortfalls in reporting, command, communications, or intelligence functional areas | "Insufficient capability for automated intelligence report generation – humans required to fill this role" |
| Supporting data/standards | Shortfalls that arise from an inability to access appropriate supporting data or from a lack of standardization or standards | "For live training, a standard for radio frequencies and data encryption across NATO is necessary" |
| Capability management | Shortfalls that arise from the lack of organizational capability, responsibility and/or availability | "No capability to have permanent federations – currently federations are built per exercise which takes too long and costs too much" |
| Exercise management | Shortfalls that arise before, during or after the simulation event itself | "Too many human operators are required" [during the simulation event]" |

A second taxonomic scheme was also devised where the major theme was that of gap remediation. The categories in the scheme are describe in Table 2 below. Again, there is subjectivity in assigning individual gaps to categories. The discriminant in this case was hierarchical. The first consideration was organizational: if no organization having responsibility for the gap could be identified or there was a fundamental lack of policy or standards, the gap would be categorized as organizational. If there were applicable policies and / or standards, and a specific organization could have responsibility for the gap remediation, but there were fundamental technological barriers to remediation, the gap was categorized as a technology / research gap. If neither of those characterizations applied, then the gap was classified as a resource area gap.

**Table 2. Remediation Area Taxonomic Scheme**

| Category Name | Category Description | Example Gap in this Category |
|---|---|---|
| Organization/policy/standards | Shortfalls where remediation requires the formation of new organizations, the development of new policy or procedures and / or the development of new standards | "No technical services organization exists which is available to all M&S users in DoD to assist in the integration and implementation of LVC environments" |
| Technology/Research | Shortfalls where remediation requires fundamental research to acquire new knowledge or technology | "Common software components for simulation composition are not readily available" |
| Resources | Shortfalls that could be directly resolved by committing additional dollars, personnel or materiel resources (the technology and structure to remediate exist) | "There is no common interface / translator for every system or protocol" |

**Examples of Pervasive M&S Gaps in the DoD**

Figure 1 illustrates using these taxonomies to characterize the total set of reported gaps. The individual bars depict the number of gaps that have been grouped into one category from each of the two taxonomies. As an example, the small bar in the extreme lower right of the figure shows that there was a very small number of reported gaps related to shortfalls in the simulation representation of the natural environment that could be resolved by additional resources alone. Similarly, the graph show that the majority of gaps in the simulation representation of the natural environment appear to require advances in fundamental research or technology improvements. Summing across the entries in the Remediation Area taxonomic scheme shows that largest number of reported gaps in the Functional Area scheme are in the Data / Standards category.

Many of the reported gaps were independently described by multiple sources. From a Department of Defense level, these gaps merit increased attention as they are not isolated to a single reporting agency, activity or service. The gap that was most frequently reported (clearly) was that is it too expensive (time, labor, and other resources) to integrate different simulations into a single exercise. We note that the counts for this gap also included reported gaps equivalent to: "No persistent simulation federation exists and they must be constructed as "one-off" efforts, an expensive process." The desire for a continuously-available simulation resource has been discussed for many years and implementation of such a capability would be the large step towards remediating this shortfall.

There was also widespread mention of the lack of standard formats for data, particularly environmental and terrain-related data. At the Program Executive Office Simulation, Training and Instrumentation (**PEO STRI**), terrain data is being produced in as many as 58 different run-time formats. The lack of correlated source data to create the simulation environmental data was also noted multiple times. A closely related area is that of data discovery. There were multiple reports of the difficulty in understanding what data is potentially available for use (and reuse). Part of this shortfall can be attributed to the many gaps from the most populous category, Data/Standards. There were also multiple reports of missing, incomplete, or inadequate standards (and having such standards would enable greater data reuse). Specific standards that were mentioned included cyber effects, scenario specification, radio communications, after action reviews, lessons learned, sensor-derived geospatial data, metadata in general, and detailed standards specifying procedures and mechanisms for data sharing.

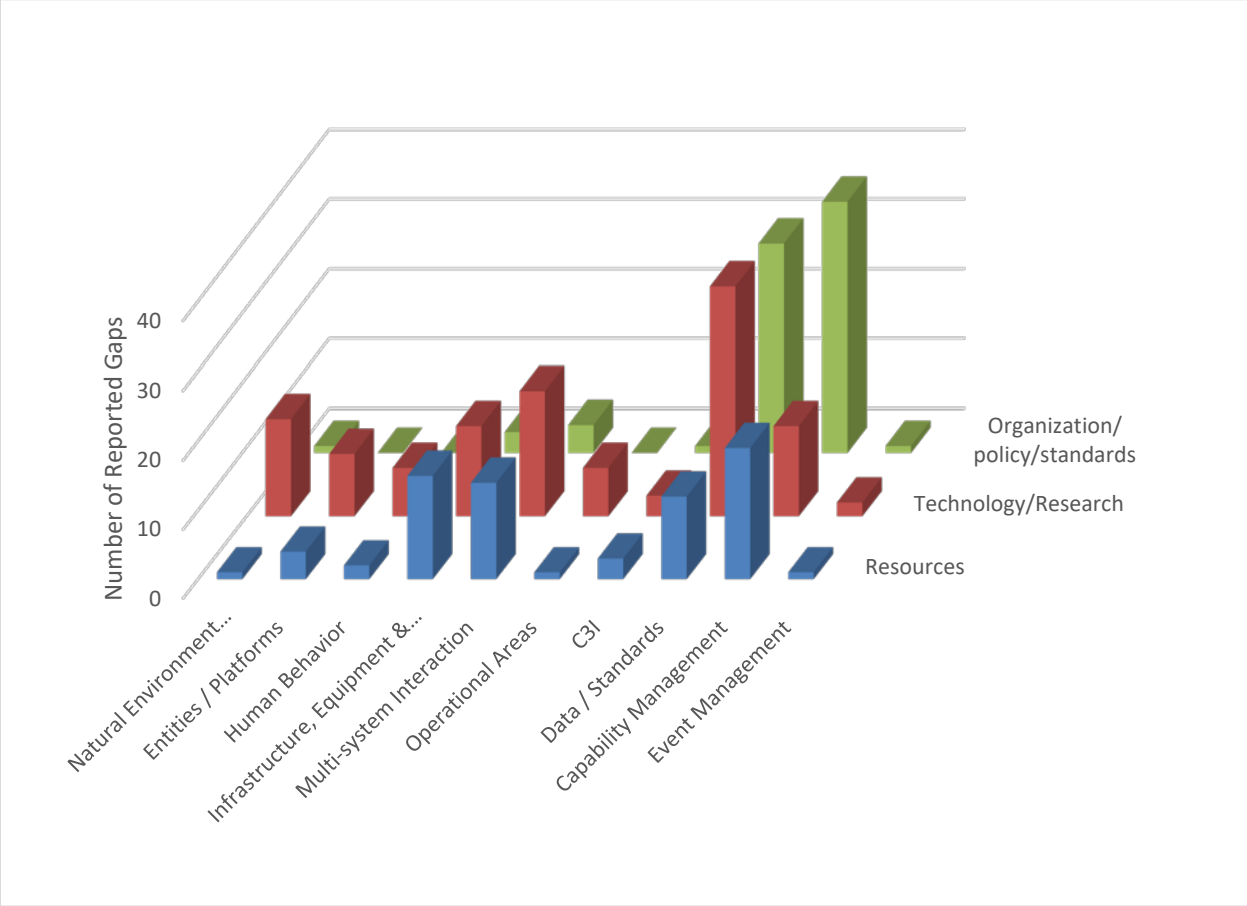


**Figure 1. Classification of gaps by functional and remediation area**

Another important and frequently-cited shortfall describes the difficulty in establishing interoperability between different simulation types. Establishing interoperability between live simulations and either virtual or constructive simulations is a widespread problem. Similarly, significant difficulty in establishing full interoperability between air, ground, and sea-based simulations was reported by multiple sources. Many of these gaps were categorized as "capability management" problems given that there does not seem to be an existing organization whose mission would include easing joint interoperability problems between simulations owned and managed by different services.

**Assessment and Discussion**

Some of the reported gaps appear relatively simple to resolve. As an example, multiple sources (including NATO) reported a problem similar to "understanding of what M&S is and how M&S can best be applied by those making business and funding decisions." There are multiple published works that address this issue (Iyengar et. al., 1999;

NTSA, Worley et al 1996), some of them relatively old and others that are much more recent. The effort then is to research these and many similar publications to refresh and synthesize them into a single resource. The Defense Modeling and Simulation Coordination Office (DMSCO) is a logical organization to sponsor this work. DMSCO has an existing resource, the Modeling and Simulation Catalog, which could be used to store the information and make it widely available. This effort could be achieved at modest cost, and no new development of technology is required.

Other reported shortfalls are far more difficult to resolve. These frequently appear in the "Organization/policy/standards" class, illustrated in Figure 2; it usually does not appear that any existing organization has the responsibility necessary to resolve the associated issues. Moreover, these difficult gaps typically lack supporting funding and require a significant amount of research to develop a technical solution. A good example of this kind of gap is the reported problem "No technical services organization exists which is available to all M&S users in the DoD to assist in the integration and implementation of LVC environments." If such an organization existed, it would necessarily reside at the Department level, but what would be the parent organization? Clearly, since no responsible organization exists, there are no funds allocated to support resolving this problem. Finally, as many gaps describe the difficulty in establishing meaningful interoperability between disparate simulations, particularly those belonging to different services, resolving this gap requires fundamental research. As many as 20 percent of the reported gaps are joint in nature so do not obviously fall to the responsibility of a single service or agency. Many of these will also be difficult to resolve because they do not have a "natural organizational home" at the Department level.

Some of the reported gaps have long-reaching implications. As an example, the lack of standard data formats limits the ability to share and reuse data, a capability that would greatly reduce the cost of establishing a simulation event as well as improving interoperability across multiple simulations. As noted above, the lack of standard formats is a widely-cited shortfall. Promulgation of standards is part of the responsibility of the DMSCO, so there is a natural home for resolving this class of gap. However, additional funding and some technical research is required as well.

In its comment on the National Defense Authorization Act for 2018, the Senate Armed Services Committee (SASC, 2017) wrote: "The committee directs the Secretary of Defense to take actions to identify and address data collection, analysis, and sharing issues that are limiting development of more robust modeling and simulation capabilities." Many of the associated problems are reported as gaps, but there is far more to the problem than the lack of standards. As an example, consider the reported gap that it is difficult to establish interoperability between the simulators of different Services and place it in the context of creating the simulated representation of the battlefield's surface and features (e.g., the land environment). Simulators for aircraft operations typically need to have access to a large expanse of the land environment. This implies a relatively low resolution land environment will be used because of processing constraints as well as the limited impact of high resolution features when viewed at great distances. Simulators for ground forces typically require a much smaller land environment for operations, but one that has much higher resolution so that ground-based forces can exploit cover and concealment opportunities. (Note that this fundamental difference in representing the land environment has great implications for interoperability.) Sharing data between these kinds of systems is difficult. The higher-resolution land environment could be sampled to create lower-resolution data, but it would not cover a large extent. The lower-resolution data could cover the necessary extent, but does not admit any possibility of providing the required resolution (assuming geo-specific data is necessary). Thus, even though data sharing and reuse has been a goal for many years, the technical problems can be very difficult and, in some cases, seem impossible to resolve.

Of course, such difficulty is not always the case. There are some data sharing opportunities that can be realized and there are efforts underway to take advantage of genuine opportunities. The Enterprise Data Services (EDS) effort (Scrudder and Rutherford, 2017) is chartered to serve as a data-broker, allowing users to identify data for potential reuse and to reach out to the owners of that data for sharing. EDS is the only full-scale implementation of the Net-centric Data Strategy guidance (DoD 8320-series) in the DoD. It encompasses order of battle, environmental, logistics, electronic order of battle, and several other types of data.

In summary, some gaps appear to be very easily resolved, although these types of gaps are not numerous. Others only require funding and time. A larger class can be resolved given technology development and the supporting funding, although some of these appear very technically challenging. Finally, there are a significant number of shortfalls requiring remediation efforts that do not align with the responsibilities of any existing organization. These gaps will be very difficult to remediate. This last class of gaps will benefit the most from a framework to address the gaps at a higher level.

## A GENERAL M&S GAP MANAGEMENT FRAMEWORK

Analysis revealed that many of the M&S gaps have no mechanism that can be used to address and mitigate the gaps at a cross-Service or Combatant Command level. A generalized framework for M&S gap management was derived from the salient features of these successful examples and is shown in Figure 1. The framework is envisioned as a recurring process with cycle time dependent on need and the ability of participating staffs to complete their respective tasks.

The rectangular blocks in Figure 2 outline the key activities and their sequencing in the overall process. Intermediate arrows are labeled to indicate outputs from preceding activities, which become inputs to subsequent activities. More detailed descriptions of these activities appear below. These activities are not assigned to a responsible office at this point, but rather are simply stated as required actions. A discussion of potential performers for these activities appears in a subsequent section on implementation.

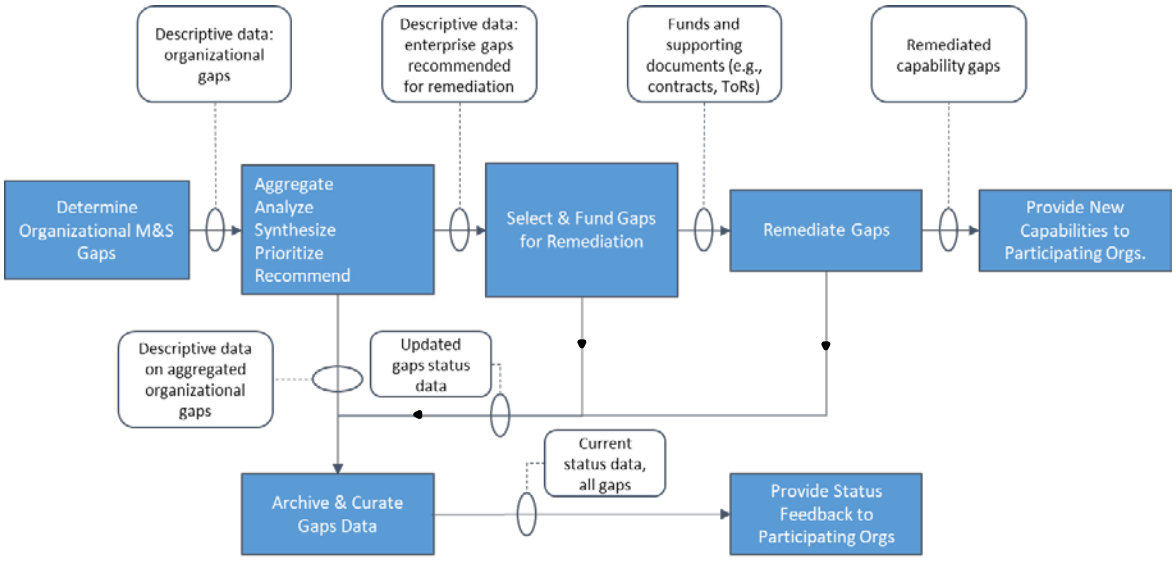


**Figure 2: General Framework for M&S Gaps Management**

Determine Organizational M&S Gaps. The organizations that executed enterprise gap-management processes had, in addition, process participants, often in the form of peer-level organizations, clients, or communities of practice focused on particular applications of M&S. In most cases these were M&S practitioners with intimate understanding of their particular capabilities and unmet requirements. The first activity in the framework is for participating organizations to determine their own M&S gaps prior to entering them into the larger enterprise framework.

Aggregate, Analyze, Synthesize, Prioritize, Recommend. While these activities are distinct, they appear in a single block, partly in anticipation of an implementation scheme, for they are all coordination tasks.

- Aggregate: Aggregation involves collecting and documenting, in a standardized format (part of the "normalization" step of Antommarchi, 2008), M&S gaps provided by participating organizations.
- Analyze: Analysis characterizes gaps according to a schema appropriate to the diverse practices of M&S. Analysis looks for commonly occurring gaps across organizations in order to identify where remediation resources may be applied for greatest impact. Analysis also attempts to validate the gap ensuring that each gap has not already been resolved by a process not visible to the gap reporter.
- Synthesize: Synthesis looks for emergent, cross-cutting gaps, i.e., those implied by the aggregation of individual gaps but not articulated as such by participating organizations.

- Prioritize: Prioritization ranks M&S gaps according to urgency, impact, or similar criteria that may vary with time and circumstances.
- Recommend: Recommendation forwards the list of prioritized gaps to funding-decision authority in the subsequent step. Recommendations should be accompanied sufficient justification to enable the decision authority to understand the nature and extent of gaps and potential impact if remediated.

Select & Fund Gaps for Remediation. This activity is performed by a funding decision authority and is the most critical step in the framework. Without the potential for remediation funds, there is little incentive for M&S organizations to participate in the process. In this case, organizational gaps will remain within their respective organizations, and the M&S enterprise as a whole will not gain an overall view of common gaps and opportunities for shared solutions. This step essentially provides the fuel that keeps the framework operating.

Remediate Gaps. Funding and supporting documentation, such as contracts and requirements, are provided to organizations capable of remediating particular gaps or selected elements of gaps. Often these will be process participants whose understanding of particular unfilled requirements or experience in previous mitigation efforts makes them especially suited to the task. In other cases a consortium of process participant will be advantageous in order to focus the right mix of skills and resources. In select cases it may be necessary to include organizations in addition to or instead of process participants.

Provide New Capabilities. The objective is to mitigate M&S gaps and to provide new or improved M&S capabilities to participating organizations and to the rest of the M&S enterprise. In the development of these capabilities, greatest advantage will be derived from making them usable by as many organizations as can derive value from them. To that end, collaborative development of technical specifications and compliance with applicable M&S standards should be required to the extent feasible.

Archive and Curate Gaps Data. At each stage of the framework process, data is recorded and actively curated to ensure consistent format, nomenclature, and status. Active curation requires that data entered in the archive be regularly reviewed for accuracy, currency, and completeness in order to preserve value to users. Data is recorded both for gaps selected for remediation and for those not selected. The data archive then becomes an historical record of gaps over time, which may inform prioritization decisions.

Provide Status and Feedback. Regular feedback is essential for any sustainable process. Both active feedback, in the form of correspondence sent to participants, and passive feedback, where participants can access information on demand and at their convenience, are valuable for keeping participants informed, giving them assurances that their input is being acted upon, and maintaining process schedules.

## IMPLEMENTING THE FRAMEWORK FOR THE DEFENSE M&S ENTERPRISE

Participation in the framework by Defense M&S organizations is envisioned as voluntary, as there are no policies in place to mandate participation, and these organizations answer to their respective Services or Defense agencies. They must each see some benefit to participation; the opportunity for outside funding is key. But given that organizations choose to participate, their entry into the framework is the identification of internal M&S gaps that they wish to submit to the "Aggregate…Recommend" activity block. Determining which gaps to submit is left to the respective participants, constrained only by conformance to a normalized format to facilitate subsequent activities.

Central to the establishment and sustainment of the gaps framework just described is an office responsible for its functioning. The Defense Modeling and Simulation Coordination Office (DMSCO), as the "focal point for coordinating all matters related to DoD M&S" (DoDI 5000.70, 2017), is the logical choice. This is not only because of the role assigned to it by policy and its expertise in staff coordination roles, but also because of its longstanding relationships with M&S organizations distributed throughout the department. The framework activities that naturally adhere to this office are those in the blocks labeled "Aggregate…Recommend," "Archive & Curate," and "Provide Status Feedback." In particular, the DMSCO could utilize the established M&S Catalog to both record gaps and to provide status on demand.

The functions in the "Aggregate…Recommend" block, though the responsibility of the DMSCO, are envisioned as collaborative activities among the participating M&S organizations. In diverse enterprises such as Defense M&S, no single person or office has insight into all application areas sufficient to conduct such activities unilaterally. Collaboration is necessary in recognition of the scope of expertise and opinion natural in such a case.

In contrast, the "Archive & Curate" activities belong to the DMSCO directly, as it has the experience, expertise, and tools available. It is likely that collaboration among participating organizations will be required to determine the particulars of the necessary descriptive data to archive, but once that is done the actual operation of the archive falls to the DMSCO. Experience has shown that this level of control is necessary to maintain the accuracy, currency, and completeness of the data.

Similarly, the DMSCO's traditional coordination and communications role as secretariat to the DoD M&S Steering Committee make it the natural choice for "Provide Status Feedback" activity. It has the necessary electronic mailing lists for providing occasional updates, and it also has online tools that could be used as is or adapted to on-demand feedback to participants.

The "Select and Fund" activity is expected to be performed by a higher-level organization within the Office of the Secretary of Defense (OSD) that has access to sufficient funds and an interest in seeing M&S gaps closed. It is natural to look to the branch of OSD to which the DMSCO belongs (currently the Office of the Undersecretary of Defense for Research and Engineering, OUSD(R&E)), but the composition of the Defense M&S Steering Committee, which includes representatives from OUSD (Personnel and Readiness), OUSD (Intelligence), and others, suggests a broader base from which funds might derive. In addition, participating organizations within the M&S gaps framework may choose to decompose and distribute remediation tasking among themselves.

The "Remediate Gaps" activity is performed by organizations capable of carrying out the required remediation measures. For resource or research/technology gaps, this may be one or more participating organizations or their contractors who are funded to remediate gaps on behalf of the entire enterprise. Management or policy gaps may be addressed directly by the DMSCO as part of its normal functions. (Characterization of M&S gaps is described in the section below.)

In the end the objective of remediation is to close the gaps and return the improved capabilities to the participating organizations.

## LESSONS LEARNED

Any voluntary association must provide value to its participants. Among existing M&S gap management processes, the most effective are those that have funding and executive advocacy at the enterprise level. Enterprise funding and executive advocacy encourage participation by offering the potential for extra resources and by demonstrating organizational commitment. The framework proposed here will require similar advocacy and funding.

Working through the problems of creating a framework for Department-level gap management provides multiple insights:

- Identification and cataloging of gaps is not a trivial undertaking and is not enough by itself. A viable gap management strategy must also include a means to remediate those gaps.
- Remediation of gaps requires a funding source that is both reliable and consistent. When an organization depends upon appeals to excess funds or programmatic altruism, remediation efforts will be piecemeal or non-existent.
- Communication and publicity of gaps and remediation efforts are fundamentally necessary. During data collection for this effort, numerous identical gaps were reported by multiple sources. Funding to remediate these gaps is scarce, so multiple efforts for remediation need to be avoided and sharing the result of efforts needs to be encouraged.
- There are insights to be gained by looking at a categorization of gaps. Applying fundamental research to a problem that also requires organizational change may amount to poorly allocated effort given the presence of other shortfalls

- To be successful, a gaps management framework requires a process owner. That owner must be capable of performing several functions including recognizing and implementing framework changes when necessary and organizing and adjudicating gaps to prevent redundant effort and prioritize effort. Another important function is to validate gaps when they may be based on the gap reporter being unaware of relevant, existing resources.
- A suitable gaps management and remediation framework can be very generic and applicable across several communities including defense, industrial, and international. Implementation of the framework needs to be tailored to specific organizational requirements and would thus likely vary across organizations.

## THE WAY FORWARD

The general framework described above is generic; it includes the components that will be required for any viable gap management effort. The implementation discussed above is recommended as well-suited to the DoD needs. However, it would require fundamental organizational change and support from the leadership to reach its potential for success. This framework is also well-suited to be applied to other organizations with industry, academic, or international participation that require a need for M&S gaps management.

## ACKNOWLEDGEMENTS

The authors sincerely thank the many people who were able to contribute information supporting this effort. Contributions were provided by personnel from the Army Modeling and Simulation Office, the Air Force Agency for Modeling and Simulation, Special Operations Command, North Atlantic Treaty Organization, Program Executive Office for Simulation, Training and Instrumentation (U.S. Army), the United States Strategic Command, Joint Staff (J-7), Department of Homeland Security Science and Technology Directorate, U.S. Army Night Vision Laboratory, Defense Threat Reduction Agency, Marine Corps Modeling and Simulation Office, Navy Modeling and Simulation Office, Program Executive Office for Integrated Warfare Systems (U.S. Navy), and Test Resource Management Center.

## REFERENCES

Antommarchi, Sidney N., A Process for Modeling and Simulation Capability Gap Analysis, *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2008*.

Iyengar, J. V., *et al.* (1999). Military Development and Applications of Simulation Systems, Journal of International Information Management Volume 8, Issue 2. Pages 57 – 68.
(see http://scholarworks.lib.csusb.edu/cgi/viewcontent.cgi?article=1208&context=jiim ).

NTSA, Why Use Simulation? – Return on Investment.
http://www.trainingsystems.org/publications/simulation/roi_effect.cfm

Worley, D. R., *et al,* (1996). UTILITY OF MODELING AND SIMULATION IN THE DEPARTMENT OF DEFENSE: INITIAL DATA COLLECTION, IDA DOCUMENT D-1825, Institute for Defense Analyses report prepared for the Defense Modeling and Simulation Office.
(see http://www.dtic.mil/dtic/tr/fulltext/u2/a312153.pdf )

SASC (2017). National Defense Authorization Act for Fiscal Year 2018 Report, Report 115-125, United States Government Publishing Office, Page 79.

Scrudder, R. and Rutherford, H. (2017), Enterprise Solutions for M&S Asset Discovery and Reuse, 2017 Interservice / Industry Training, Simulation and Education (I/ITSEC), Tutorial # 1720.

Traylor, Rebeca, LTC Craig Johnson, Jeffery Gavlinski, Jamie Pilar, Modeling and Simulation Capability Portfolio Review and Gap Analysis, *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2016*.

| REPORT DOCUMENTATION PAGE | | | *Form Approved OMB No. 0704-0188* |
|---|---|---|---|



| 1. REPORT DATE (DD-MM-YYYY) | 2. REPORT TYPE | 3. DATES COVERED (From – To) |
|---|---|---|
| 15 June 2018 | Study (Final) | |

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NO. |
|---|---|
| Mind the Gap: A Modeling and Simulation Gap Management Framework | HQ0034-14-D-0001 |
| | 5b. GRANT NO. |
| | 5c. PROGRAM ELEMENT NO(S). |

| 6. AUTHOR(S) | 5d. PROJECT NO. |
|---|---|
| Frank Mullen and Robert Richbourg, JAWD; Anne Patenaude, STD; Leigh Yu, DMSCO | 5e. TASK NO. AI-8-4470 |
| | 5f. WORK UNIT NUMBER |

| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) | 8. PERFORMING ORGANIZATION REPORT NO. |
|---|---|
| Joint Advanced Warfighting Division (JAWD)<br>Institute for Defense Analyses (IDA)<br>4850 Mark Center Drive, Alexandria, VA 22311-1882 | IDA Doc NS D-9156<br>Log no. H 18-000264/1 |

| 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR'S / MONITOR'S ACRONYM(S) |
|---|---|
| Defense Modeling and Simulation Coordination Office<br>4800 Mark Center Drive, Ste. 16E08-08<br>Alexandria, VA 22350-0002 | DMSCO |
| | 11. SPONSOR'S / MONITOR'S REPORT NO(S). |

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Unclassified

14. ABSTRACT

Modeling and simulation capabilities continue to grow within the Department of Defense, including expansion into novel areas. This evolutionary process invariably exposes some capability shortfalls where the technologies, policies, and/or personnel resources are insufficient to meet all demands, creating "gaps" in the spaces addressed by M&S capabilities. Several successful programs have established processes to understand these gaps and work towards their remediation. In recent years, there has not been an analogous DoD-level gap management framework, and nothing has existed to either provide an understanding of DoD-wide efforts in this area or to remediate emergent gaps. Instead, the DoD has relied on efforts and improvements made at the level of the M&S capability owner and user. This is a viable approach when the DoD use of the M&S capabilities is similar to original in-tent, but DoD-level adaptations often seek to extend M&S applications beyond those bounds. Additionally, a different class of gaps emerges when requirements at the DoD level dictate combining M&S capabilities in new ways to achieve a more complete representation of the full joint battlespace. This paper describes a new Defense Modeling and Simulation Coordination Office study for identification, prioritization, cataloguing, and remediation of M&S capability gaps with emphasis on those that impact M&S use at the DoD level. Current efforts to manage capability gaps that have proven valuable for other organizations are reviewed to understand their keys to success. The most successful characteristics (including securing community buy-in) are enumerated and the process of adapting these for application in the DoD M&S context is explained. The paper continues with a description of a first-year prototype evaluation, conducted through a process of stake-holder review and comment, and culminates with an explanation of how the revised DMSCO framework could be applied in other areas.

15. SUBJECT TERMS

capability gaps, Modeling and Simulation (M&S)

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NO. OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| | | | UU | 17 | Mr. Jesse Citizen, Jr., Director |
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | 19b. TELEPHONE NUMBER (Include Area Code) |
| U | U | U | | | 571-372-6787 |

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