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An Emerging DoD M&S Enterprise Data Strategy

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ABSTRACT: *Modeling and Simulation (M&S) has become more powerful and less expensive to implement due to dramatic advances in the underlying technologies. However, with resources within the U.S. Department of Defense (DoD) on the decline, and rapidly changing Department priorities, it remains essential to find improved ways to develop and field new M&S and training systems while maintaining current systems. The rapid expansion of the use of M&S data, services, and tools, along with improved processes to exploit them, has been accompanied by a lack of strategic approaches in the areas of M&S data product generation, M&S data visibility, M&S data standardization, and Department-wide management of the wide spectrum of data resources that support M&S.*

Within the Department today, there is a need for an overarching enterprise-level data strategy for M&S that is aligned with the DoD's Net-Centric Data Strategy and that provides efficiencies for M&S. For instance, the DoD benefits from having credible, authoritative data to use for representing characteristics of the natural environment that affect military operations. However, the process of developing operationally realistic representations from authoritative source data takes time and money. Furthermore, the complexity of this endeavor is not always well-understood at the leadership level, or in many cases, by the systems engineering and systems development communities. A comprehensive enterprise data strategy will help provide the overall vision, guidance, and initial policy recommendations needed to achieve governance of enterprise issues. It will also provide a roadmap for advancing the strategic objectives of M&S interoperability and reuse.

This paper identifies key concepts and important elements of an emerging DoD-wide M&S Enterprise Data Strategy that is in initial stages of development. Certain high visibility M&S data-related projects currently under development in the DoD M&S community will be influenced by this strategy. Also presented are other emerging data and data-related tools and services that enable the M&S Enterprise. The paper provides a summary of the necessary elements for the strategy and clarifies the benefits of enterprise implementation across M&S efforts in the Department.

1. Introduction

In May 2003, the Department of Defense (DoD) Chief Information Officer (CIO) published the DoD Net-Centric Data Strategy [1], which describes a vision for a net-centric environment for the DoD and the data goals for achieving that vision. The strategy was followed in December 2004 by a directive, Data Sharing in a Net-Centric DoD [2], and in April 2006, Guidance for Implementing Net-Centric Data Sharing [3], a guide providing implementation details of the strategy. These documents from the DoD CIO contain approaches to achieve seven overarching data goals for the Department:

- Make data visible.
- Make data accessible.
- Enable data to be understandable.
- Enable data to be trusted.
- Support data interoperability.
- Be responsive to user needs.
- Institutionalize data management.

In addition to these goals, the strategy also describes a DoD data vision that incorporates the concepts of the Community of Interest (COI) to address organization and maintenance of data, metadata for discovery of data assets, and Enterprise Services to help realize a

net-centric environment where tagged data can be searched, shared, and retrieved. The vision of net-centricity is to leverage all data as either enterprise assets or community assets. The intent is to decrease private data and increase enterprise and community data in a net-centric DoD, in order to enable increased discovery, sharing, and reuse of commonly usable data.

For the communities enabled by M&S within DoD, there have been some problem areas as well as some initial successes regarding the achievement of the goals of the Net-Centric Data Strategy. Yet these M&S communities do not currently have a definitive strategy that specifically addresses M&S enterprise data and the data discovery, sharing, and management issues for M&S.

Since the latest strategy for M&S is the dated M&S Master Plan [4], published in 1995, the need for a data strategy at the enterprise level is apparent. For instance, even though M&S data sharing exists within some DoD organizations and perhaps more within communities, it is still lacking in many areas at the enterprise level. Many of the data-related issues and goals of the original Master Plan are still being addressed today. In fact, at a Modeling and Simulation Steering Committee (M&S SC) strategic planning meeting in June 2010, much discussion centered on prevalent data issues in M&S. The resulting meeting minutes indicated a clear interest in a strategy for data, with key components to include:

- Sound strategic oversight, including management, policy, and oversight mechanisms
- Authoritative data, that has been certified and passed a Verification, Validation, & Accreditation (VV&A) process
- Data sharing, through proper access to data and standardized formats
- Reusable data
- Interoperability across communities and across models

As a result, the M&S SC directed that an M&S Enterprise Data Strategy be developed for DoD. This tasking led the Modeling and Simulation Coordination Office (M&S CO) to begin to formalize an emerging enterprise-level strategy for M&S data. Along with internal planning and discussions, and new activities within the M&S COI, this paper represents an important initial step of this effort.

Besides the DoD Net-Centric Data Strategy, other currently emerging strategies, guidance, and planning efforts can inform the development of the M&S Enterprise Data Strategy. As recent as February 2010,

the North Atlantic Treaty Organization (NATO) Research and Technology Organization (RTO) published a technical report containing guidance for M&S for the NATO Network-Enabled Capability (NNEC) [5], similar to the DoD's Net-Centric Warfare (NCW) effort. This guide presents how M&S, as a lead science and technology investment, enables the realization of NNEC using a case study and evidence-based approach. In addition, the M&S CO is currently developing a strategic communication and outreach plan for the M&S data functional area, with the purpose being to increase the visibility of M&S data as an important foundation of the M&S environment and as a valuable resource for the entire Defense enterprise. This plan will be incorporated into the comprehensive M&S Enterprise Data Strategy and will provide specific outreach initiatives that further communicate the M&S CO's vision, goals, and priorities with respect to M&S data. These and other efforts will be leveraged in developing a strategy that will cover at least the next five years, which is a typical time frame for most rigorous strategic plans, business plans, and other strategy development efforts.

2. The M&S Enterprise

As defined in the "Data Sharing" directive [2], the Enterprise "refers to the Department of Defense, its organizations, and related Agencies." Accordingly, the M&S Enterprise is the portion of this Enterprise that is enabled by M&S. For the purposes of this discussion, the M&S Enterprise term actually refers to M&S across a broader set of defense community organizations: the DoD, other defense and intelligence related federal agencies, defense research laboratories, plus the defense industry and academic institutions that support defense.

The scope of the M&S Enterprise covers the aforementioned organizations, and specifically includes the Components within DoD: the Office of the Secretary of Defense (OSD), the Military Services: Army, Navy, Air Force, and Marine Corps, plus the Joint Staff and the Combatant Commands (COCOMs). The M&S Enterprise also covers the seven communities that DoD recognizes as highly enabled by M&S, which is an organizing framework used by DoD for M&S governance and management: Acquisition, Analysis, Experimentation, Intelligence, Testing, Training, and Planning communities (Figure 1). There are obvious overlaps within this framework among representatives of the Department's Components that work within these communities and community representatives that are aligned within the various Defense Components.

The M&S Enterprise
Components
Office of the Secretary of Defense
Joint Staff
Combatant Commands
Army
Navy
Air Force
Marine Corps
Communities Enabled by M&S
Acquisition
Analysis
Experimentation
Intelligence
Testing
Training
Planning

Figure 1. The Scope of the M&S Enterprise

M&S Stakeholders

The major stakeholders for M&S are found within all of these Components and within these seven communities enabled by M&S. M&S stakeholders are members of organizations internal to DoD, such as leadership and management offices, as well as organizations external to DoD, such as other federal departments and international defense partners. Some important M&S stakeholders and partners are listed here:

Internal:
- Leadership within DoD OSD staff organizations:
  - Acquisition, Technology and Logistics (AT&L)
  - Assistant Secretary of Defense for Research and Engineering – ASD(R&E).
  - Other OSD and Service Secretaries and staff
- Modeling and Simulation Steering Committee
- Army M&S Office (AMSO)
- Navy M&S Office (NMSO)
- Air Force Agency for M&S (AFAMS)
- Marine Corps M&S Management Office
- Joint IED Defeat Organization
- Cyber Command
- Service Research Laboratories
  - Army Research Laboratory
  - Naval Research Laboratory
  - Air Force Research Laboratory
- Other DoD Agencies and Organizations

External:
- M&S Congressional Caucus
- Federal Departments and Agencies (e.g., State, Energy, Homeland Security)
- Coalition and International Partners (e.g., NATO)
- Defense Industry
- Non-Governmental Organizations
- Academia (M&S Educators)
- Other Research Laboratories

The M&S Enterprise Data Strategy under development should address the goals and objectives of this wide set of M&S stakeholders. Although many data-related goals may be unique for individual stakeholders, the strategy should involve a set of goals that are applicable at the enterprise level and that align with a common vision. This emerging strategy on data will need to apply for all stakeholders within the M&S Enterprise. A good starting point is to consider the M&S Strategic Vision and Goals, and then focus on where data specific issues are addressed in these goals, and where there are gaps for data specific issues.

M&S Strategic Vision

The following vision was published and signed in August 2007 by the M&S SC:

Empower DoD with M&S capabilities that effectively and efficiently support the full spectrum of the Department's activities and operations. End State: A robust M&S capability enables the Department to more effectively meet its operational and support objectives across the diverse activities of the services, combatant commands, and agencies. A defense-wide M&S management process encourages collaboration and facilitates the sharing of data across DoD components, while promoting interactions between DoD and other government agencies, international partners, industry, and academia.

M&S Goals

The M&S SC also endorsed five overarching goals that support achieving the above vision, summarized here:

1. Shared accessible standards, architectures, networks and environments.
2. Policies at the enterprise level that promote the use of common capabilities and minimize unnecessary duplication.
3. Management processes that promote sharing, reuse, and cost effective development of M&S tools and data.
4. Tools and authoritative data that are available to credibly support the full range of DoD interests.
5. Well-trained workforce.

Data issues are inherent in all of these five M&S goal categories, yet they are seldom called out explicitly in the full text of these goals, shown in the first column "M&S Goals" of the table in Figure 2. By identifying gaps in these goals related to data at the enterprise level, and filling those gaps with actionable enterprise goals, a more comprehensive and accurate five year strategy can be developed for M&S enterprise data. The first step towards this end is indicated in the second column of the table, "M&S Data Goals."

M&S Goals	M&S Data Goals
The M&S SC endorsed five goals that support achieving the M&S Strategic Vision. Data is mentioned in these goals wherever highlighted in **blue**.	To address goals for M&S data explicitly, the following M&S Data Goals are proposed, using the construct of the initial five goals. Data-related issues are added and emphasized wherever highlighted in **blue**.
1.Standards, architectures, networks and environments that: • Promote the sharing of tools, **data**, and information across the enterprise • Foster common formats • Are readily accessible and can be reliably applied by users	**1.**Standards, architectures, networks and environments that: • Promote **discovery and sharing of data across the enterprise, through consistent metadata development** • Foster **standard data formats and specifications**. • Are readily accessible and can be reliably applied by users, allowing readily accessible **authoritative M&S data**
2. Policies at the enterprise level that: • Promote interoperability and the use of common M&S capabilities • Minimize duplication and encourage reuse of M&S capabilities • Encourage research and development to respond to emerging challenges • Limit the use of models and **data** encumbered by proprietary restrictions • Leverage M&S capabilities across DoD, other government agencies, international partners, industry, and academia	**2.** Policies at the enterprise level that: • Promote interoperability and common capabilities for **M&S data generation, M&S data resource management** • Minimize duplication and encourage reuse of M&S data, both raw and authoritative source data & datasets • Encourage R&D for emerging challenges in areas of **data farming, cloud computing, grid computing** • Limit the use of **proprietary M&S data** • Leverage **solutions for M&S data** across DoD, government agencies, international partners, industry, academia
3. Management processes for models, simulations, and **data** that: • Enable M&S users and developers to easily discover and share M&S capabilities and provide incentives for their use • Facilitate the cost-effective and efficient development and use of M&S systems and capabilities • Include practical validation, verification, and accreditation guidelines that vary by application area.	**3.** Management processes **for data** that: • Enable M&S users and developers to easily **discover and share M&S data** and provide incentives for their use • Facilitate the cost-effective and efficient development and use of **M&S data generation tools, M&S data production systems, and M&S data-centric web services** • Include practical validation, verification, and accreditation guidelines that vary by application area
4. Tools in the form of models, simulations, and **authoritative data** that: • Support the full range of DoD interests • Provide timely and credible results • Make capabilities, limitations, and assumptions easily visible • Are usable across communities.	**4. Data and associated tools** that: • Support the full range of DoD interests, across the **M&S enterprise data spectrum, from raw authoritative source data to full authoritative simulation-ready datasets** • Provide timely and credible results, especially for **rapid production of simulation-ready datasets** • Make capabilities, limitations, and assumptions easily visible through proper use of **metadata-based discovery tools** • Are usable and understandable across communities, by the **appropriate M&S data consumers**
5. People that: • Are well trained • Employ existing models, simulation, and **data** to support departmental objectives • Advance M&S to support emerging departmental challenges.	**5.** People that: • Are well trained on the technical understanding of **M&S data challenges and emerging data-centric technologies** • Employ **existing M&S data, as well as create useful M&S datasets**, to support departmental objectives • Advance **M&S and the intelligent management of M&S data** to support emerging departmental challenges

Figure 2. M&S Data Goals

M&S Governance

In fall 2005, DoD senior leadership directed a revision of the Department's approach to managing M&S. Resulting from this was:

1. A new DoD Directive on M&S Management [6].
2. The creation of an M&S Steering Committee (M&S SC) supported by an M&S Integrated Process Team (M&S IPT).
3. A repurposed Defense Modeling and Simulation Office (DMSO), simultaneously re-designated as the M&S Coordination Office (M&S CO).

The M&S SC's goals are to enable improvements in the efficiencies, effectiveness, visibility, accessibility, commonality, reuse, and interoperability of M&S that affect the billions of dollars spent annually by DoD on M&S. Central to the directive on M&S Management are best practices for corporate and cross-cutting M&S data, services, and tools that are designed to support and integrate M&S activities across the Department. In addition, it is imperative that the gaps and issues regarding enterprise-level M&S data and data-related tools and services, as recognized and socialized by the M&S SC, M&S IPT, and M&S CO, are addressed in the emerging M&S Enterprise Data Strategy.

M&S Enterprise Investments

The current M&S enterprise investment strategy is based on an M&S Program Element (PE), managed by M&S CO, which influences and effects the billions of dollars spent on M&S annually. It is important to make wise investments for the Enterprise that can affect the most stakeholders. This means that there must be a focus on enterprise projects with limited Service or domain-unique projects. If project proposals are not M&S or not affecting the Enterprise in some way, the M&S PE will most likely not fund it.

In addition, the M&S investments are based on the current budget environment in general. The recent Memo by the Secretary of Defense and the efficiency initiative that followed indicate a more prudent approach to enterprise investment decisions. Since M&S is recognized as a critical enabler that allows many organizations to be more efficient, any specific initiatives that affect the Enterprise will be considered higher priorities. If there are better M&S technologies for gaining those efficiencies, the communities enabled by M&S need to know about and use them.

In addition, since many M&S data issues have been hot topics recently, it is even more urgent to get an M&S enterprise data strategy developed and in place. The strategy will need to emphasize M&S Data as an enabler and as a foundation. It should phrase the discussions about M&S tools with respect to data, M&S services with respect to data, and M&S best practices with respect to data. And since the DoD Net-Centric Data Strategy is still is the main guidance for enterprise data in DoD, it is useful to tie this M&S strategy to it where applicable.

3. The M&S Community of Interest

The strategy for M&S enterprise data should also include the M&S Community of Interest and its mission with respect to the organization and maintenance of M&S data. A Community of Interest is "a collaborative group of users that must exchange information in pursuit of its shared goals, interests, missions, or business processes and therefore must have shared vocabulary for the information it exchanges," as defined in [2]. The M&S COI is an important aspect of implementing an M&S enterprise data strategy, and an M&S COI Data Management Working Group (DMWG) recently stood up to further advance the COI concept for the M&S Enterprise. The stated mission of the M&S COI is:

> *To make M&S data and data-related tools and services viable and visible to M&S communities and Components; align M&S with the DoD Net-Centric Data Strategy; and provide a collaborative forum to influence, advise, and educate the global community with regard to M&S Enterprise Data issues.*

The M&S COI is currently active and effective for COI internal projects. The DMWG and other proposed working groups within the COI will focus on data-related technical issues and activities, and they will report regularly to the M&S Integrated Process Team (IPT) and the M&S SC on their progress. Funded projects can also make use of the DMWG and other working groups, where applicable, for technical products and solutions and for enterprise-level data issues.

An advanced approach that will be part of the emerging M&S Enterprise Data Strategy is to increase the cooperation and collaboration between the M&S COI and multiple existing COIs that have missions and data related to M&S, such as for Order of Battle data (the Global Force Management (GFM) COI), Geospatial data (the Geospatial Intelligence (GEOINT) Standards COI), and Command and Control data (the C2 Interoperability COI). It is important that the COIs are "Active," meaning they are actively working on a data

sharing problem, and/or "Effective," meaning that they are able to effect changes, i.e. Operational Requirements Documents (ORDs) and Program Objective Memorandums (POMs) are being affected. Other registered COIs may be "Proposed," meaning they are in the initial stages of organizing, or "Dormant," meaning they are currently inactive. Figure 2 portrays this collaboration concept. These eight COIs shown here are a primary focus for general collaboration with regard to the M&S COI, while the darker ones are especially important to initial DMWG efforts within the M&S COI this year.
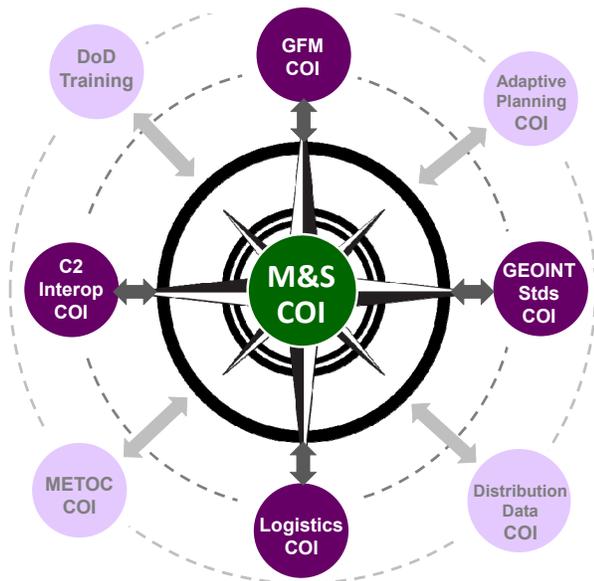

Figure 2. Collaboration among COIs

4. The Spectrum of M&S Data

M&S Data is the data used to develop models or simulations, the data used as input to models and simulations, and the data produced by models and simulations. There is a very wide spectrum of M&S data categories, which all must be organized and maintained by the communities enabled by M&S. This M&S data is the foundation for the various models, simulations, training scenarios, mission rehearsals, and exercise events used or executed by the various M&S communities. Much of this M&S data represents source data for the production of simulation-ready M&S data sets built for training, simulations, and major exercises. Many of these categories are important at the enterprise level and are considered to be cross-cutting in terms of the M&S communities they apply to, while some categories may be specific to individual communities. A general category list of M&S data includes, but is not limited to, the following:

Environmental / Geospatial Representation Data

- Terrain Data
- 3D Representations: Buildings, Infrastructure
- Oceanographic Data
- Atmospheric Data
- Space Data
- Environmental Effects Data

Simulation/Exercise Initialization Data

- Date and Time (for Start of Simulation)
- Simulated Entity Definition
  - Vehicles/Platforms (e.g., tanks, ships, aircraft)
  - Weapon systems
  - Personnel
  - Sensors
  - Equipment
- 3D Models of These Entities
- Unit data
  - Unit Definition
  - Unit Formations
  - Unit Task Organization (UTO)
  - Unit Order of Battle (UOB) data
- Command and Control (C2) and Support Relationships
- Electronic Order of Battle (EOB) data
- OPORDs, Annexes, Overlays, Matrixes
- Battle Management Data
- Communications Structures, Nodes, & Networks
- Frequencies, IP Addresses, Aliases, URNs
- Unit Specific Tactics, Techniques, and Procedures (TTPs), Tactical SOPs
- Entity Position/Location and Orientation
- Man-made Obstacles and Fighting Positions
- Entity/Unit Logistical Status
- Enemy Information
- Weather Conditions

Additional Categories of Initialization Data

- Intelligence Data
- Facilities and Infrastructure Data
- Characteristic and Performance (C&P) Data
- Weapon Effects Data
- Doctrine Data
- Human Behavior and Performance Data

Other M&S Related Data

- Emerging environmental data requirements from M&S communities, currently being compiled in a data requirements survey/study
- Metadata describing this M&S Data, that will be entered into M&S Catalog and M&S Repositories

5. The Generation, Discovery and Sharing of M&S Data

Currently, there are several critical issues regarding M&S data generation, discovery and sharing. Typically, each community and Service independently develops their own M&S data within their area of responsibility. The end results of this are that it ends up being too costly for the Department, too time consuming to build, and when built, it is very difficult to find the data or it is not accessible. Often, the data is not shared, not enhanced, and not correlated. And once the data is used, whether for a specific experiment, operational test, or training event, it is not reused across the communities. Generating simulation-ready data from disparate datasets takes considerable time and money, and is on the critical path to successful M&S execution. The strategy to be developed must address these problems and limitations of current practice.

There is also currently a critical need to discover these existing M&S assets for enabling their effective reuse and for reducing the amount of duplicative M&S efforts in the DoD. Visibility and accessibility are keys to optimizing the investment of billions spent each year by the DoD on M&S. The mantra of reuse has been known and communicated for some time now, but since M&S asset reuse is not as effective or frequent as it could be, the potential benefits are still not being realized across the DoD enterprise.

Standardized metadata is used to describe the M&S data intended to be discoverable and shared via the use of cataloging and repository systems. This metadata represents the data and/or datasets that are input to or output from models and simulations, including data from authoritative data sources (ADS), and can also represent informational and technical documents, database schemas, and other management data related to M&S. As part of the strategy, the overall goals of (1) reducing similar or duplicative M&S data sets, such as geospatial and terrain databases, and (2) reducing the time and cost it takes to generate them should be included as important elements. As more M&S assets are cataloged for discovery and sharing throughout the DoD M&S (and other) communities, the closer we move to a more efficient M&S Enterprise.

Two current efforts have further advanced the net-centric goals of data visibility, accessibility, and understandability for M&S: the M&S COI Discovery Metadata Specification (MSC-DMS) development and the M&S Catalog tool development. Leveraging the legacy M&S Resource Repositories (MSRRs)

developed by the Services, as well as the DoD M&S Information System (MSIS), the M&S Catalog can discover and present metadata information about M&S resources from these repositories. The M&S Catalog also can present metadata information via metadata cards entered using the MSC-DMS format, or via metadata entered manually using tools. The Catalog and the MSC-DMS supports M&S Data resources that are in M&S usable format and that is produced by M&S, as well as M&S data models (structural metadata).

Until now, the MSC-DMS and M&S Catalog teams have had informal coordination of their related efforts. Close collaboration between the MSC-DMS and the M&S Catalog will be more formalized in 2011 under a single architectural and management construct of an M&S COI-based working group. The strategy to be developed will address this formal coordination and provide specific goals and objectives related to how the metadata production and asset discovery process will be standardized, managed, and enhanced. This strategy will also address how the MSC-DMS is expanded for additional metadata set extensions, as well as how the M&S Catalog tool is maintained and enhanced where necessary.

6. The Emerging Strategy

Some elements of the needed strategy have begun to come to light with respect to the task of producing M&S datasets for simulations used in training, mission rehearsal, and exercises. It was evident that a long term investment strategy was in order for the creation of an enduring DoD enterprise M&S data production capability. The emerging M&S Enterprise Data Strategy can be informed by the lessons learned from pilots and related projects that have addressed the rapid generation of simulation-ready M&S data sets. The strategy should define the order in which implementation steps will need to occur to achieve M&S data production and sharing goals, based on incremental capability development and investment. Also, the strategy should incorporate a technical understanding of a common data production environment, based on a service-oriented architecture (SOA) and best practices for data discovery and sharing. Figure 3 below shows a conceptual five year timeline for an M&S Enterprise Data Strategy. Previous to this year, the focus has been on individual M&S projects and not on the Enterprise. The overall plan going forward is to introduce categories of M&S data, important at the enterprise level, into the production environment in two year increments overlapping across the five years. For instance, a two year effort on developing Order of Battle data services
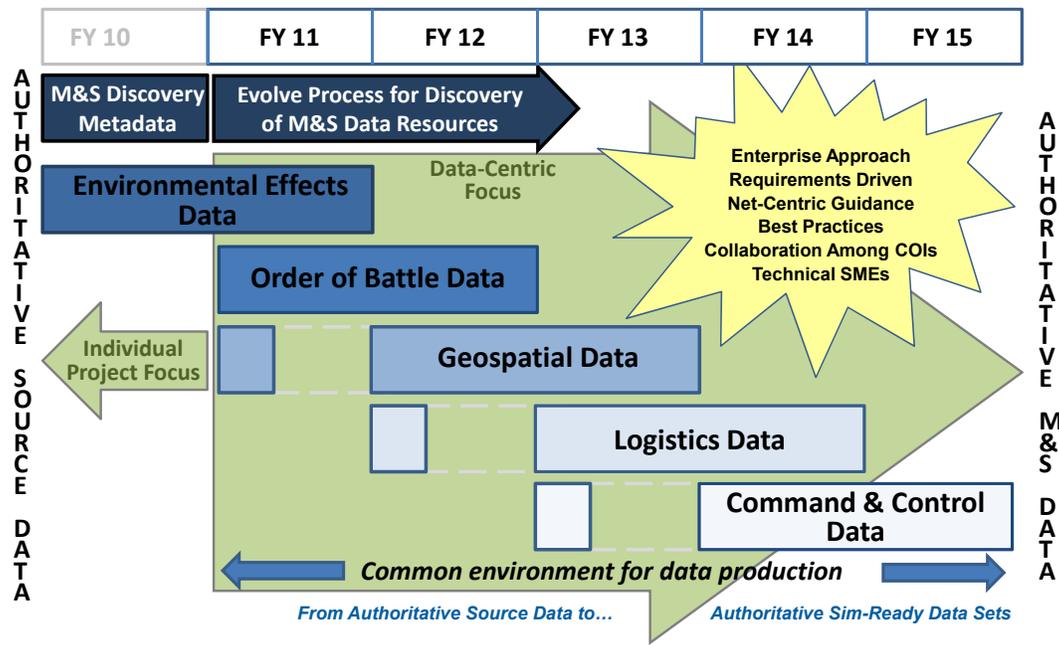
Figure 3. Conceptual Timeline for an M&S Enterprise Data Strategy

will be the initial step towards an enterprise implementation. Then the more complex effort to develop Geospatial data services will be tackled, followed by introducing Logistics data services and Command and Control (C2) data services into the production environment. After the OOB implementation, the order of the other services' development could potentially change, based on various factors or emerging priorities.

The plan is to develop a detailed strategy document that will advance the M&S Enterprise towards a more efficient use of M&S data. Efficiencies should be achieved through better and faster M&S data production, easier discovery of M&S data assets, and increased sharing of M&S data across the enterprise to fulfill the important strategic objectives of interoperability and reuse.

7. Summary

The DoD is in need of a strategy that lays out the goals, objectives, and way forward for addressing M&S enterprise data. Although there have been great advancements in the technologies that drive M&S, there is still dated guidance and policy regarding much of M&S governance and management, especially in the area of M&S data. This paper has provided the basic background on the enterprise level issues and needs, and recommends completing the development of an overarching and comprehensive M&S Enterprise Data Strategy, covering a five year timeline, that will further

advance the M&S Strategic Vision and Goals from a data perspective. Although the strategy is still emerging, it must be carefully and completely documented and communicated in order to reduce the problems of stovepipes and private data and increase the level of reusability and interoperability of M&S data, and data-related tools and enterprise services.

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Author Biographies

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